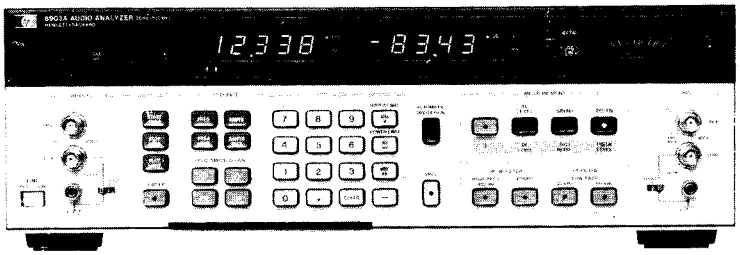
HP 8903A

OPERATING AND SERVICE MANUAL

8903A
AUDIO ANALYZER

THIS MANUAL COVERS A SPECIAL MODIFICATION OF THE INSTRUMENT. SEE INSIDE COVER



HEWLETT
PACKARD

HP 8903A

CERTIFICATION

Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Bureau of Standards, to the extent allowed by the Bureau's calibration facility, and to the calibration facilities of other International Standards Organization members.

WARRANTY

This Hewlett-Packard instrument product is warranted against defects in material and workmanship for a period of one year from date of shipment. During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace products which prove to be defective.

For warranty service or repair, this product must be returned to a service facility designated by HP. Buyer shall prepay shipping charges to HP and HP shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to HP from another country.

HP warrants that its software and firmware designated by HP for use with an instrument will execute its programming instructions when properly installed on that instrument. HP does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error free.

LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HP SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

EXCLUSIVE REMEDIES

THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. HP SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

ASSISTANCE

Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

OPERATING AND SERVICE MANUAL

8903A
AUDIO ANALYZER

(Including Option 001)

SERIAL NUMBERS

This manual applies directly to instruments with serial numbers prefixed 2016A.

With changes described in Section VII, this manual also applies to instruments with serial numbers prefixed 1942A and 2006A.

For additional important information about serial numbers, see INSTRUMENTS COVERED BY MANUAL in Section I.

HEWLETT
PACKARD

1501 PAGE MILL ROAD, PALO ALTO, CALIFORNIA, U.S.A.

OPERATING AND SERVICE MANUAL PART NO. 08903-90023
Operating Manual Part No. 08903-90024
Microfiche Operating and Service Manual Part No. 08903-90025

Printed: JANUARY 1981

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SAFETY CONSIDERATIONS

GENERAL

This product and related documentation must be reviewed for familiarization with safety markings and instructions before operation.

This product is a Safety Class I instrument (provided with a protective earth terminal.

BEFORE APPLYING POWER

Verify that the product is set to match the available line voltage and the correct fuse is installed.

SAFETY EARTH GROUND

An uninterruptible safety earth ground must be provided from the main power source to the product input wiring terminals, power cord, or supplied power cord set.

SAFETY SYMBOLS

⚠ Instruction manual symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual (refer to Table of Contents).

ϟ Indicates hazardous voltages.

⏚ Indicates earth (ground) terminal.

WARNING The WARNING sign denotes a hazard. It calls attention to a procedure, practice, or the like, which if not correctly performed or adhered to, could result in personal injury. Do not proceed beyond a WARNING sign until the indicated conditions are fully understood and met.

CAUTION The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product. Do not proceed beyond a CAUTION sign until the indicated conditions are fully understood and met.

WARNINGS

Any interruption of the protective (grounding) conductor (inside or outside the instrument) or disconnecting the protective earth terminal will cause a potential shock hazard that could result in personal injury. (Grounding one conductor of a two conductor outlet is not sufficient protection). In addition, verify that a common ground exists between the unit under test and this instrument prior to energizing either unit.

Whenever it is likely that the protection has been impared, the instrument must be made inoperative and be secured against any unintended operation.

If this instrument is to be energized via an autotransformer (for voltage reduction), make sure the common terminal is connected to the earth terminal of the power source.

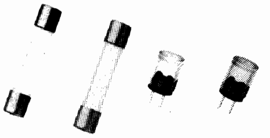
Servicing instructions are for use by service-trained personnel only. To avoid dangerous electric shock, do not perform any servicing unless qualified to do so.

Adjustments described in the manual are performed with power supplied to the instrument while protective covers are removed. Energy available at many points may, if contacted, result in personal injury.

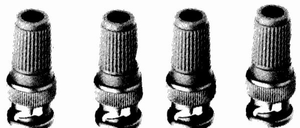
Capacitors inside the instrument may still be charged even if the instrument has been disconnected from its source of supply.

For continued protection against fire hazard, replace the line fuse(s) only with 250V fuse(s) of the same current rating and type (for example, normal blow, time delay, etc.). Do not use repaired fuses or short circuited fuseholders.

MODEL 8903A

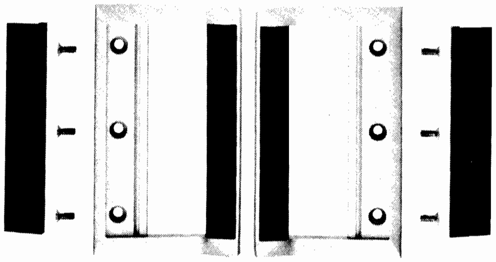


SPARE INTERNAL FUSES

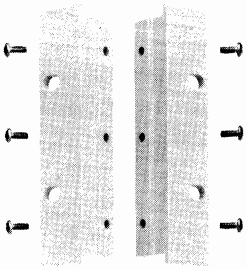


BNC TO BANANA PLUG ADAPTERS

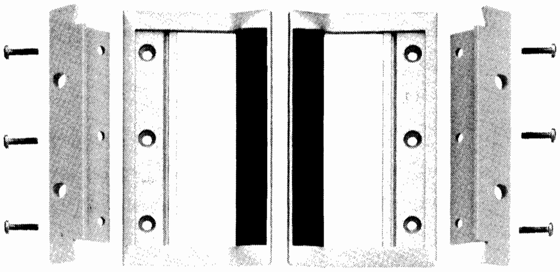
LINE POWER CABLE



OPTION 907
FRONT HANDLE KIT



OPTION 908
RACK FLANGE KIT



OPTION 909
RACK FLANGE AND FRONT
HANDLE COMBINATION KIT

NOTE: Refer to ACCESSORIES SUPPLIED, for more details.

Figure 1-1. HP Model 8903A Accessories Supplied, and Options 907, 908, and 909

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION

This manual contains information required to install, operate, test, adjust, and service the Hewlett-Packard Model 8903A Audio Analyzer. The Audio Analyzer is shown in Figure 1-1 with all of its externally supplied accessories. This manual also documents Audio Analyzers supplied with Option 001.

This section of the manual describes the instruments documented by the manual and covers instrument description, options, accessories, specifications, and other basic information. This section also contains principles of operation on a simplified block diagram level and basic information on audio measurements. The other sections contain the following information:

Section II, Installation: provides information about initial inspection, preparation for use (including address selection for remote operation), and storage and shipment.

Section III, Operation: provides information about panel features, and includes operating checks, operating instructions for both local and remote operation, and maintenance information.

Section IV, Performance Tests: provides the information required to check performance of the instrument against the critical specifications in Table 1-1.

Section V, Adjustments: provides the information required to properly adjust the instrument.

Section VI, Replaceable Parts: provides ordering information for all replaceable parts and assemblies.

Section VII, Manual Changes: provides manual change information necessary to document all serial prefixes listed on the Service Manual title page.

Section VIII, Service: provides the information required to repair the instrument.

Two copies of operating information are supplied with the Audio Analyzer. One copy is in the form of an Operating Manual. The Operating Manual is simply a copy of the first three sections of the Operating and Service Manual and should stay with the Audio Analyzer for use by the operator. Additional copies of the Operating Manual can be ordered separately through your nearest Hewlett-Packard office. The part number is listed on the title page of this manual.

Also on the title pages of each of these manuals, below the manual part number, is a microfiche part number. This number may be used to order 100 x 150 mm (4 x 6 inch) microfilm transparencies of the Operating and Service Manual. Each microfiche contains up to 96 photo-duplicates of the manual pages. The microfiche package also includes the latest Manual Changes supplements.

1-2. SPECIFICATIONS

Instrument specifications are listed in Table 1-1. These are the performance standards, or limits against which the instrument may be tested. Characteristics listed under Supplemental Information, Table 1-2, are not warranted specifications but are typical characteristics included as additional information for the user.

1-3. SAFETY CONSIDERATIONS

This product is a Safety Class I instrument (i.e., provided with a protective earth terminal). The Audio Analyzer and all related documentation must be reviewed for familiarization with safety markings and instructions before operation. Refer to the Safety Considerations page found at the beginning of this manual for a summary of the safety information. Safety information pertinent to the task at hand (installation, performance testing, adjustment, or service) is found throughout the manual.

1-4. INSTRUMENTS COVERED BY MANUAL

Options. Electrical Option 001 and various mechanical options are documented in this manual. The differences are noted under the appropriate paragraph such as Options in Section I, the Replaceable Parts List, and the schematic diagrams.

INSTRUMENTS COVERED BY MANUAL (Cont'd)

Serial Numbers. Attached to the instrument is a serial number plate. The serial number is in the form 1234A00123. The first four digits and the letter are the serial prefix. The last five digits form the sequential suffix that is unique to each instrument. The contents of these manuals apply directly to instruments having the same serial number prefix(es) as listed under SERIAL NUMBERS on the title page. For information concerning a serial number prefix not listed on the title page or in the Manual Changes supplement, contact your nearest Hewlett-Packard office.

1-5. MANUAL CHANGES SUPPLEMENT

An instrument manufactured after the printing of this manual may have a serial number prefix that is not listed on the title page. This unlisted serial number prefix indicates the instrument is different from those described in this manual. The manual for this instrument is supplied with a Manual Changes supplement that contains "change information" that documents the difference.

In addition to change information, the supplement may contain information for correcting errors in the manual. To keep this manual as current and accurate as possible, Hewlett-Packard recommends that you periodically request the latest Manual Changes supplement. The supplement is identified with the print date and part number that appears on the title page. Complimentary copies of the supplement are available from Hewlett-Packard.

1-6. DESCRIPTION

1-7. General

The HP Model 8903A Audio Analyzer is a complete audio measurement system covering the frequency range of 20 Hz to 100 kHz. It combines a low-distortion signal source with a signal analyzer. The analyzer can perform distortion analysis, frequency count, and ac level, dc level, SINAD, and signal-to-noise measurements. The Audio Analyzer reduces the number of instruments required in many applications involving audio signal characterization.

The Audio Analyzer is easy to use. All measurements are selected by one or two keystrokes. For distortion measurements, the Audio Analyzer automatically tunes to and levels the input signal. Measurement and output ranges are automatically selected for maximum resolution and accuracy. Furthermore, tuning is independent of the source. Thus, the source can be set to one frequency while the analyzer is measuring the distortion on a signal at another frequency (i.e., there is no need to tune the analyzer to the source).

The combined capabilities of the instrument are enhanced by microprocessor control, resulting in more capability than would be available from separate instruments. For example, when making signal-to-noise measurements, the Audio Analyzer monitors the ac input level while turning the source on and off. The microprocessor then computes and displays the ratio of the on and off levels. The ratio can be displayed in either % or dB. In addition, the source can be swept. This makes measurements such as frequency response or complete distortion characterization simple to perform. Microprocessor control allows flexible entry of source parameters and versatile display formats. For example, ac level can be displayed in V, mV, dBV, watts, or as a ratio (in % or dB) referenced to an entered or measured value.

Virtually all functions are remotely programmable through the Hewlett-Packard Interface Bus (HP-IB[1]). Programming is easy and straightforward, and all measurements are made through a single input connector. This eliminates the need to switch between multiple inputs under remote control and reduces software development time and hardware costs.

The Audio Analyzer measures the true rms level on all measurements. True rms measurements assure greater accuracy when measuring complex waveforms and noise. Accurate distortion measurements typically can be made to less than 0.003% (−90 dB) between 20 Hz and 20 kHz at a 1V level.

1-8. Audio Testing

The Audio Analyzer has numerous features which make audio testing simple and convenient. These include flexible data entry and display formats, convenient source control, and swept measurement capability. For example, distortion results can be displayed in % or dB. AC level measurements can be displayed in volts, dBV, or watts. Measurement results can be displayed in % or dB relative to a measured or entered value. Finding the 3 dB points of filters and amplifiers is simpli-

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[1] HP-IB. Not just IEEE-488, but the hardware, documentation and support that delivers the shortest path to a measurement system.

Audio Testing (Cont'd)

fied by using the source increment and decrement keys together with the relative display feature. A major contribution of the Audio Analyzer is its ability to make swept measurements. When sweeping, the Audio Analyzer steps its tuning in logarithmic increments. With an x-y recorder, hardcopy measurement results can be obtained. X-axis scaling is determined by the entered start and stop frequencies. Y-axis scaling is determined by the measurement units selected and the plot limits entered through the keyboard. Any valid display units (except mV) are allowed when plotting. To change the scaling from frequency response to swept distortion plots, simply key in new values for the plot limits. No adjustment of the x-y recorder is necessary. The Audio Analyzer also features high accuracy. The instrument can typically measure flatness to 0.5% (0.05 dB) over the range of 20 Hz to 20 kHz and swept distortion over the same range to 0.003% (−90 dB). See Figures 1-2 and 1-3.

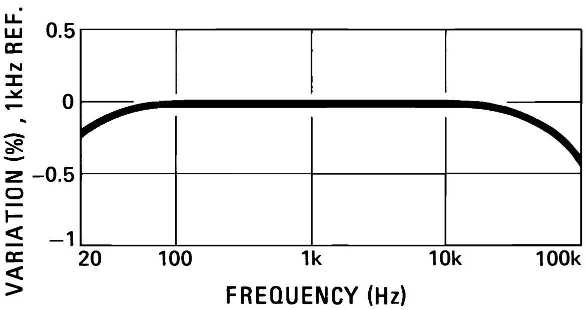

Figure 1-2. Typical Combined Source and AC Level Flatness

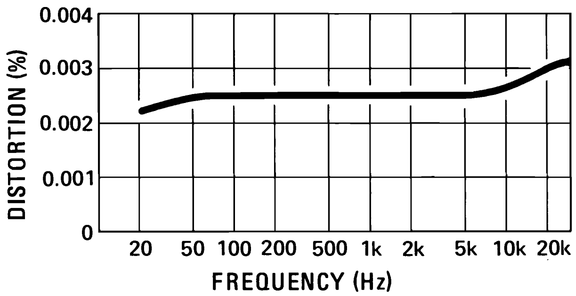

Figure 1-3. Typical Combined Source and Analyzer Residual Distortion

1-9. Transceiver Testing

The Audio Analyzer has several measurements and features specifically designed for transceiver testing. It has SINAD and signal-to-noise measurements for receiver testing, a psophometric filter for testing to CEPT recommendations, a reciprocal counter for measuring squelch tones, and a 400 Hz high-pass filter for eliminating squelch tones when measuring transceiver audio distortion.

SINAD is one of the most basic receiver measurements. It must be made repeatedly when performing sensitivity or adjacent channel sensitivity tests. In the Audio Analyzer, the SINAD measurement is more heavily filtered than the distortion measurement in order to smooth the noisy signals encountered in receiver testing. The filtering is optimized for excellent repeatability and speed (2 readings/second typical). Some automatic distortion analyzers have a tendency to become unlocked when measuring SINAD on noisy signals. The Audio Analyzer overcomes this problem by fixing the notch filter to the source frequency when measuring SINAD. SINAD measurement results are indicated both by the digital display and a front-panel analog meter. The meter is specifically marked for EIA and CEPT sensitivity and selectivity. For SINAD ratios less than 25 dB, the digital display is automatically rounded to the nearest 0.5 dB to reduce digit flicker.

AM receiver test signal-to-noise measurements are also filtered for improved repeatability and speed (1 reading/second typical), and automatic display rounding is provided. For accurate noise measurements, the Audio Analyzer uses true rms detection for both SINAD and signal-to-noise measurements. Most older instruments employ average detection which reads low for noise. The discrepancy can be 1.5 dB or greater and varies with the ratio being measured. If it is necessary to correlate results with past test data, the Audio Analyzer's detector can be converted to average responding.

For transceivers, the Audio Analyzer has a seven-pole 400 Hz high-pass filter for rejecting squelch tones. Rejection of squelch tones up to 250 Hz is greater than 40 dB. Therefore, audio distortion measurements to 1% accuracy can be made without disabling the transmitter squelch tones.

Under remote control, the Audio Analyzer can generate or count burst tone sequences. Typically the maximum count rate is 8 ms/reading and the minimum tone duration is 12 ms. This is fast enough for applications such as unsquelching pagers (see Figure 1-4).

1-10. Systems

The Audio Analyzer features capabilities for general systems applications. The audio source is

Systems (Cont'd)

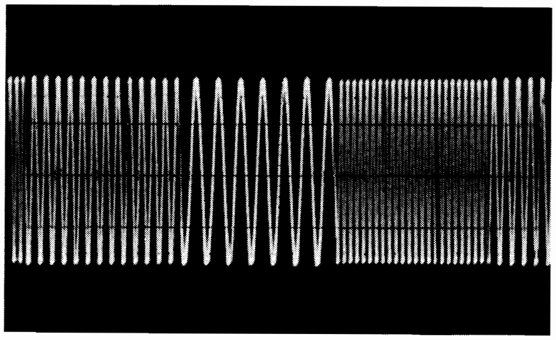

Figure 1-4. Three-Tone Burst Sequence (15 ms Duration)

programmable in both frequency and level and has very low distortion. The distortion measurements are fully automatic, programmable, and fast. The typical time to tune and return the first distortion measurement is 1.5 seconds with a measurement rate of 2 readings/second thereafter. The combined distortion of the internal source together with the measurement section is typically 0.003% (−90 dB) between 20 Hz and 20 kHz at a 1V level.

Often systems applications involve measuring low level ac signals. The Audio Analyzer features a full range ac level display of 0.3000 mV with an accuracy of 4% of reading (2% of reading for levels >50 mV and from 20 Hz to 20 kHz). The ac detector is true rms for correct noise measurements, and the 3 dB measurement bandwidth is greater than 500 kHz.

Since many systems have noise problems, the Audio Analyzer has both 30 and 80 kHz low-pass filters to reject high frequency noise. In addition, the 400 Hz high-pass filter attenuates line-related hum and noise by more than 68 dB.

Two special binary programming modes are available in remote operation. A rapid frequency count mode provides a packed, four-byte output for fast counting. Also, a rapid source binary programming mode is available which allows the internal oscillator tuning to be programmed directly with five bytes of data.

1-11. OPTIONS

1-12. Electrical Option 001

This option provides rear-panel (instead of front-panel) connections for both the INPUT and OUTPUT HIGH and LOW jacks (fuse protected).

1-13. Mechanical Options

The following options may have been ordered and received with the Audio Analyzer. If they were not ordered with the original shipment and are now desired, they can be ordered from the nearest Hewlett-Packard office using the part number included in each of the following paragraphs.

Front Handle Kit (Option 907). Ease of handling is increased with the front-panel handles. Order HP part number 5061-0089.

Rack Flange Kit (Option 908). The Audio Analyzer can be solidly mounted to the instrument rack using the flange kit. Order HP part number 5061-0077.

Rack Flange and Front Handle Combination Kit (Option 909). This is not a front handle kit and a rack flange kit packaged together; it is composed of a unique part which combines both functions. Order HP part number 5061-0083.

1-14. HEWLETT-PACKARD INTERFACE BUS (HP-IB)

1-15. Compatibility

The Audio Analyzer is compatible with HP-IB to the extent indicated by the following code: SH1, AH1, T5, TE0, L3, LE0, SR1, RL1, PP0, DC1, DT1, C0. The Audio Analyzer interfaces with the bus via open collector TTL circuitry. An explanation of the compatibility code can be found in IEEE Standard 488, "IEEE Standard Digital Interface for Programmable Instrumentation" or the identical ANSI Standard MC1.1. For more detailed information relating to programmable control of the Audio Analyzer, refer to Remote Operation, Hewlett-Packard Interface Bus in Section III of this manual.

1-16. Selecting the HP-IB Address

The HP-IB address switches are located within the Audio Analyzer. The switches represent a five-bit binary number. This number represents the talk and listen address characters which an HP-IB controller is capable of generating. In addition, two more switches allow the Audio Analyzer to be set to talk only or listen only. A table in Section II shows all HP-IB talk and listen addresses. Refer to HP-IB Address Selection in Section II of this manual.

1-17. ACCESSORIES SUPPLIED

The accessories supplied with the Audio Analyzer are shown in Figure 1-1.

a. The line power cable may be supplied in several configurations, depending on the destination of the original shipment. Refer to Power Cables in Section II of this manual.

b. Time delay fuses with a 1.25A rating for 100/120 Vac operation (HP 2110-0305) and a 0.5A rating for 220/240 Vac operation (HP 2100-0202) are supplied. One fuse is factory installed according to the voltage available in the country of original destination. Refer to Line Voltage and Fuse Selection in Section II of this manual.

c. Four additional fuses are supplied as replacements for those in series with the Audio Analyzer INPUT and OUTPUT HIGH and LOW connectors. For the INPUT HIGH line, a spare 0.032A fuse is supplied (HP 2110-0337). For the INPUT LOW line, a spare 0.062A fuse is supplied (HP 2110-0011). For the OUTPUT HIGH and LOW lines, spare 0.125A fuses are supplied (HP 2110-0513).

d. Four type BNC-to-banana-plug adapters (HP 5021-0844) are also supplied for use when double-ended inputs or outputs are desired. The conductor of the banana jack is connected to the center conductor of the BNC connector adapted to. These adapters are used when the front-panel INPUT or OUTPUT FLOAT switches are set to FLOAT.

1-18. ELECTRICAL EQUIPMENT AVAILABLE

(Also refer to Service Accessories, Table 1-5.)

1-19. HP-IB Controllers

The Audio Analyzer has an HP-IB interface and can be used with any HP-IB compatible computing controller or computer for automatic systems applications.

1-20. Front-to-Rear-Panel Connectors Retrofit Kit

This kit contains all the necessary components and full instructions for converting instruments with front-panel connections for INPUT and OUTPUT HIGH and LOW to rear-panel connections. Order HP part number 08903-60100. After installation and calibration, performance will be identical to the 8903A Option 001.

1-21. Rear-to-Front-Panel Connectors Retrofit Kit

This kit contains all the necessary components and full instructions for converting instruments with rear-panel connections for INPUT and OUTPUT HIGH and LOW to front-panel connections. Order HP part number 08903-60101. After installation and calibration, performance will be identical to the standard 8903A.

1-22. MECHANICAL EQUIPMENT AVAILABLE

1-23. Chassis Slide Mount Kit

This kit is extremely useful when the Audio Analyzer is rack mounted. Access to internal circuits and components or the rear-panel is possible without removing the instrument from the rack. Order HP part number 1494-0018 for 431.8 mm (17 in.) fixed slides and part number 1490-0023 for the correct adapters for non-HP rack enclosures.

1-24. Chassis Tilt Slide Mount Kit

This kit is the same as the Chassis Slide Mount Kit above except it also allows the tilting of the instrument up or down 90°. Order HP part number 1494-0025 for 431.8 mm (17 in.) tilting slides and part number 1490-0023 for the correct adapters for non-HP rack enclosures.

1-25. RECOMMENDED TEST EQUIPMENT

Table 1-3 lists the test equipment recommended for use in testing, adjusting, and servicing the Audio Analyzer. If any of the recommended equipment is unavailable, instruments with equivalent minimum specifications may be substituted. Table 1-3 also includes some alternate equipment listings. These alternate instruments are highlighted in Table 1-4 which also indicates the possible advantages of using them as substitutes.

1-26. PRINCIPLES OF OPERATION FOR SIMPLIFIED BLOCK DIAGRAM

The HP Model 8903A Audio Analyzer combines three instruments into one: a low-distortion audio source, a general-purpose voltmeter with a tuneable notch filter at the input, and a frequency counter. Measurements are managed by a microprocessor-based Controller. This combination forms an instrument that can make most common measurements on audio circuits automatically. To add to its versatility, the Audio Analyzer also has selectable input filters, logarithmic frequency sweep, x and y outputs for plotting measurement result vs. frequency, and HP-IB programmability.

PRINCIPLES OF OPERATION (Cont'd)

The operation of the instrument is described in the following order: Voltmeter and Notch Filter, Counter, Source, and Controller. Refer to Figure 1-5.

1-27. Voltmeter and Notch Filter

The amplitude measurement path flows from the INPUT jacks (HIGH and LOW) to the MONITOR output (on the rear panel) and includes the Input and Output RMS Detectors, dc voltmeter (the Voltage-to-Time Converter and Counter), and SINAD meter circuitry. Measurements are made on the difference between the signals at the HIGH jack and the LOW jack (or ground). Differential levels can be as high as 300V. Signals that are common to both the HIGH and LOW jacks are balanced out. Common-mode levels must not exceed 4V peak.

The input signal is ac coupled for all measurement modes except dc level. The signal is scaled by the Input Attenuator to a level of 3V or less. To protect the active circuits that follow, the Over-Voltage Protection circuit opens whenever its input exceeds 15V. The differential signal is converted to a single-ended signal (i.e., a signal referenced to ground) and amplified. In the dc level mode, the dc voltage is measured at this point by the dc voltmeter. The signal is further amplified by a Programmable Gain Amplifier which is ac coupled. The gain of this amplifier and the Differential-to-Single-Ended Amplifier are programmed to keep the signal level into the Input RMS Detector and Notch Filter between 1.7 and 3 Vrms to optimize their effectiveness and accuracy, particularly in the distortion and SINAD modes.

The output from the first Programmable Gain Amplifier is converted to dc by the Input RMS Detector and measured by the dc voltmeter. The output of the detector is used to set the gain of the input circuits and becomes the numerator of the SINAD measurement and the denominator of the distortion measurement (refer to Basics of Audio Measurements). The Input RMS Detector is not used to make the ac level measurement, the Output RMS (Avg) Detector is used for this measurement. For dc level measurements, the Input RMS Detector also monitors the ac component (if there is one) and lowers the gain of the input path if the signal will overload the input amplifiers; otherwise, the gain of the input path is determined by measuring the dc level. At this point, either a 400 Hz high-pass filter or a psophometric filter can be inserted into the signal path. The 400 Hz high-pass filter is usually used to suppress line hum or the low-frequency squelch tone used on some mobile transceivers. The psophometric filter has a bandpass frequency response that simulates the "average" response of human hearing. In the SINAD, distortion, and distortion level modes, the frequency of the input signal is counted at the output of the HP/BP Filters.

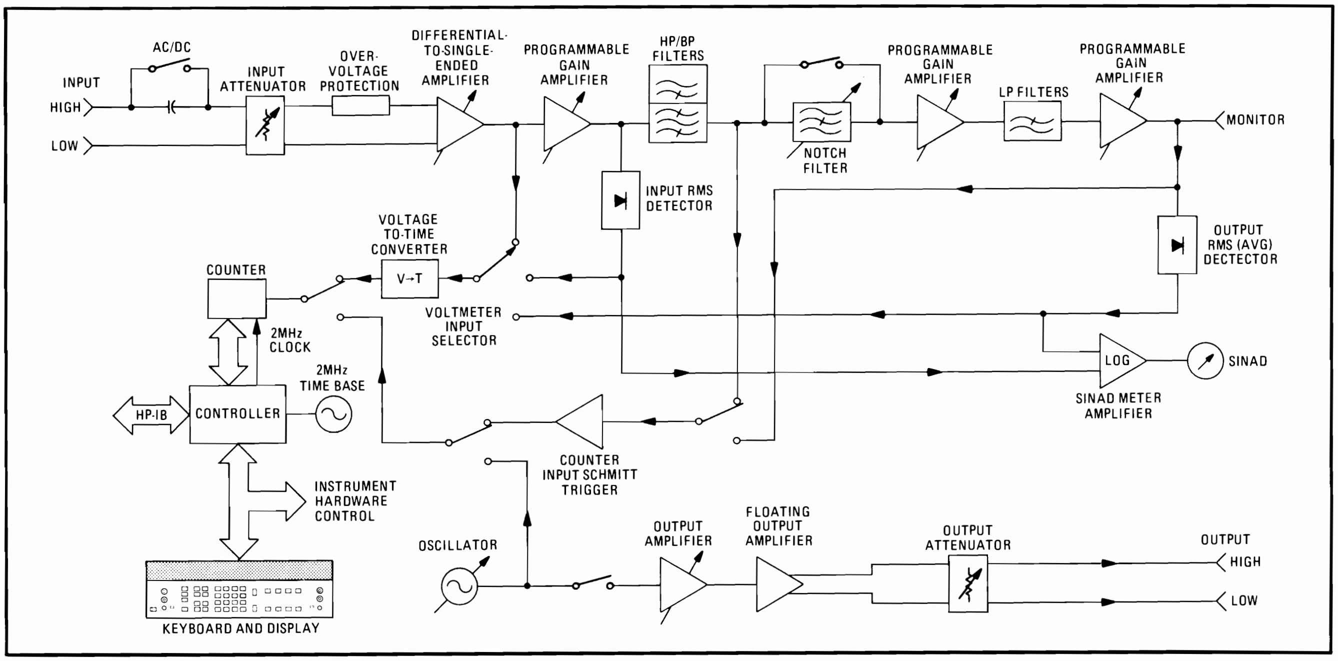

Figure 1-5. Simplified HP 8903A Audio Analyzer Block Diagram

Voltmeter and Notch Filter (Cont'd)

When measuring SINAD, distortion, or distortion level, the fundamental of the signal is removed by the Notch Filter. The output from the filter is the distortion and noise of the signal. In the ac level and signal-to-noise modes the Notch Filter is bypassed. After amplifying and low-pass filtering, the output from the Notch Filter is converted to dc by the Output RMS (Avg) Detector and measured by the dc voltmeter.

When measuring distortion or distortion level, the Notch Filter is automatically tuned to the frequency counted at the input to the filter. Coarse tuning is via the Controller. Fine tuning and balance are via circuitry internal to the Notch Filter. When measuring SINAD, the Notch Filter is coarse tuned by the Controller to the same frequency as the internal source. Thus, a SINAD measurement is normally only made with the internal source as the stimulus and permits measurements in the presence of large amounts of noise (where the Controller would be unable to determine the input frequency). If an external source is used in the SINAD measurement mode, the source frequency must be within 5% of the frequency of the internal source. The two Programmable Gain Amplifiers, following the Notch Filter, amplify the low-level noise and distortion signals from the Notch Filter. The overall gain of the two amplifiers is normally set to maintain a signal level of 0.3 to 3V at the MONTIOR output.

The 30 kHz and 80 kHz LP Filters are selected from the Keyboard. With no low-pass filtering, the bandwidth of the measurement system is approximately 750 kHz. The filters are most often used to remove the high-frequency noise components in low-frequency SINAD and distortion measurements. The output from the second Programmable Gain Amplifier drives the rear-panel MONITOR output jack. The frequency of this signal is also measured by the Counter in the ac level and signal-to-noise measurement modes because of the increased sensitivity at this point.

The Output RMS (Avg) Detector is read by the dc voltmeter in the ac level, SINAD (the denominator), distortion (the numerator), distortion level, and signal-to-noise measurement modes. It is also used to set the gain of the two Programmable Gain Amplifiers. The detector can be configured internally to respond to the absolute average of the signal instead of the true rms value.

In the SINAD mode the outputs from the Input and Output RMS Detectors are converted to a current representing the log of the ratio of the two signals by the SINAD Meter Amplifier to drive the SINAD panel meter. Since SINAD measurements are often made under very noisy conditions, the panel meter makes it easier to average the reading and to discern trends. The Voltage-to-Time Converter converts the dc inputs into a time interval which is measured by the Counter.

1-28. Counter

The Counter is a reciprocal counter. To measure frequency, it counts the period of one or more cycles of the signal at its input, then the Controller divides the number of periods by the accumulated count. The reference for the Counter is the 2 MHz Time Base which also is the clock for the Controller. The Counter has four inputs and three modes of operation:

1. **Voltage Measurement.** The time interval from the Voltage-to-Time Converter is counted. The accumulated count is proportional to the dc voltage. For direct measurements (ac level, dc level, and distortion level), the count is processed directly by the Controller and displayed on the right display. For ratio measurements (SINAD, distortion, and signal-to-noise), the counts of two successive measurements are processed and displayed. For SINAD and distortion, the ratio of the outputs of the Input and Output RMS Detectors is computed. For signal-to-noise, the ratio of two consecutive outputs from the Output RMS Detector is computed. One output is with the Oscillator on and the other is with the Oscillator off.

2. **Input Frequency Measurement.** The signal from the last Programmable Gain Amplifier or the HP/BP Filters is conditioned by the Counter Input Schmitt Trigger to make it compatible with the Counter's input. The period of the signal is then counted, the count is processed by the Controller, and the frequency is displayed on the left display.

3. **Source Frequency Measurement.** The Counter measures the frequency of the internal source only when the Oscillator is being tuned. The frequency is normally not displayed. To make a measurement of the source frequency, the output of the Oscillator is fed into the Counter,

Counter (Cont'd)

the period measured, and the result processed by the Controller.

1-29. Source

The source covers the frequency range of 20 Hz to 100 kHz. It is tuned to the frequency entered from keyboard by the Controller using a tune-and-count routine. (Note that the frequency is not obtained by frequency synthesis.) The switch following the Oscillator is normally closed except in the signal-to-noise measurement mode or when an amplitude of 0V is entered from the keyboard. The output from the Oscillator is approximately 3V.

The Output Amplifier sets the source output level in fine steps. The Floating Output Amplifier converts the single-ended input into a balanced signal (either output can be grounded or floated up to 10V peak). The Output attenuator sets the output level in coarse steps. The maximum signal to the OUTPUT jacks is 6V into an open circuit or 3V into 600 ohms.

1-30. Controller

The entire operation of the instrument is under control of a microprocessor-based Controller. The Controller sets up the instrument at turn-on, interprets Keyboard entries, executes changes in mode of operation, continually monitors instrument operation, sends measurement results and errors to the front-panel displays, and interfaces with HP-IB. In addition, its computing capability is used to simplify circuit operation. For example, it forms the last stage of the Counter, converts measurement results into ratios (in % or dB), etc. It also contains routines useful for servicing the instrument.

1-31. BASICS OF AUDIO MEASUREMENTS

The "audio" frequency range is usually taken to be from 20 Hz to 20 kHz. Few people have hearing that good, but the term is a convenient one to describe sub-RF frequencies encountered in electronics. The frequency range of the Audio Analyzer extends beyond the audio range to include fundamentals of up to 100 kHz.

Electronic instrumentation provides most of the tools for quantitative analysis of audio signals. Thus, if the signal is non-electrical (e.g., mechanical or acoustic), it must be converted to an electrical signal by a transducer of some sort (e.g., a strain gauge or microphone) before it can be analyzed. Apart from attentive listening to a hi-fi system, the most intuitive way of analyzing an electrical signal in the audio range is visually with an oscilloscope. Here you get a feeling for the signal's size (loudness), frequency (pitch), and shape (timbre). You can also determine if these parameters change with time or are stable, and you can even make some quantitative measurements on it (e.g., peak level, dc offset, period, risetime, etc). Many times, however, the parameter sought does not lend itself to easy visual analysis. Therefore, the Audio Analyzer was designed. It combines into one instrument a series of general and specialized instruments, under microprocessor control, that make it easy for the user to obtain accurate, quantitative measurements on audio signals of any general waveshape.

1-32. AC Level

Consider the very common measurement of a signal's ac rms level. To make this measurement with an oscilloscope, you must first decide the nature of the signal, because from it, the relationship of the peak level to the rms level can be mathematically determined. If it is sinusoidal, for example, the rms value is the peak amplitude divided by $\sqrt{2}$.

This measurement is greatly simplified with an rms voltmeter which electronically measures the rms level and displays the result. However, no other information about the signal is provided. The Audio Analyzer contains an rms voltmeter. The rms level of the signal is displayed whenever the AC LEVEL mode is selected. A special function is also provided which converts the measurement result into watts into a specified (external) load resistance.

Another important ac signal characteristics is the variation in level vs. frequency (flatness). Of course you can easily set a reference level (such as 1V) at a particular frequency (such as 1 kHz) and monitor the change in level as the input frequency is changed. (The source's level is assumed to be flat; otherwise, it too must be checked.) The Audio Analyzer makes this measurement easier in three ways. First, it contains a flat, wide-range oscillator that can be used as the stimulus. Second, the reference can be set to 100% or 0 dB by the press of a button (the RATIO key). Third, the measurement can be automatically swept and the results can be plotted by connecting an x-y recorder to the (rear-panel) X AXIS and Y AXIS outputs.

AC Level (Cont'd)

An additional parameter related to ac level is gain, and more often gain vs. frequency. To make a gain measurement, measure the input to the device, then the output, and take the ratio. This measurement is made easier by the Audio Analyzer when used with its internal oscillator. You first key in the desired input level, then either measure it and set it as a reference (press RATIO) or key in the level as the ratio reference. Then measure the output. The result can be expressed in either % or dB. If desired, the input can be swept and the gain plotted as a function of frequency (since the frequency plots logarithmically, the result is a Bode plot if dB is used).

1-33. Frequency

Another common and basic measurement is frequency. With an oscilloscope, you simply determine the time interval between like points on the repetitive waveform and take the reciprocal. With a frequency counter, frequency is measured electronically and displayed. The measurement is easier and usually much more accurate than could be made visually with an oscilloscope.

The Audio Analyzer contains a counter which displays the frequency of the input signal for all ac measurements. It should be noted that the counter is a reciprocal type; it measures the period of the signal (as you do with an oscilloscope) and computes the reciprocal to obtain the frequency. The advantage of this technique is that for low (audio) frequencies, higher resolution is obtained in a shorter measurement time.

1-34. DC Level

Although not part of an audio signal, dc level is a quantity often encountered in audio equipment (e.g., bias voltages and outputs from ac-to-dc converters). Sometimes plots of dc level vs. frequency are desired (as in the case of an ac-to-dc converter). The Audio Analyzer has dc level as one of its measurement modes.

1-35. Signal Impurities

Distortion, SINAD, and signal-to-noise ratio are used to describe the impurity content of a signal. These terms are somewhat related and can often be confused. A pure signal is defined as a perfect sinusoid, i.e., one whose frequency spectrum contains only a single spectral component.

Impurities are not always undesirable. Impurities, for example, are what add character to the sound of musical instruments. Pure signals in music sound monotonous. However, when testing a linear audio system, if a pure signal is applied to the input, anything but a pure signal at the output indicates that the system is degrading the signal. There are several common classifications of impurities: harmonic distortion (harmonics of a the fundamental); intermodulation distortion (beat signals of two or more non-related signals); noise (random signals); and spurious signals (e.g., line hum and interference). All but intermodulation distortion are easily measured by the Audio Analyzer.

1-36. Distortion

Harmonic distortion on a spectrally pure signal is created by non-linearities in the circuit through which it passes. The non-linearities can arise in the transfer characteristics of the active devices or by running the active device into saturation or cutoff. Often, distortion can be reduced by reducing the signal level, filtering, or adding negative feedback. According to Fourier mathematics, the non-linear terms in the circuit's transfer function give rise to harmonics of the signal. Total harmonic distortion (THD) is usually defined as the ratio of the rms sum of the harmonics to the rms level of the fundamental. The ratio is usually converted to % or dB. An oscilloscope gives only a rough indication of the amount of distortion present on a signal. A general rule of thumb is that if the non-linearity causing the distortion is "gentle" (e.g., not clipped), a trained eye can discern distortion as low a 5% on an oscilloscope display. Figure 1-6 shows several examples of waveforms with 5% THD and the components that combined to produce them. (5% distortion would be considered quite high in a quality hi-fi amplifier.) An audio spectrum analyzer, which allows the user to see the magnitude of all harmonics, is perhaps the best instrument to measure harmonic distortion. The audio spectrum analyzer method, however, requires a fairly expensive instrument and some mathematical manipulation. The traditional method of measuring distortion (accepted by the Institute of High Fidelity[2] and others) is with a distortion analyzer. The method is simple and adequate for most situa-

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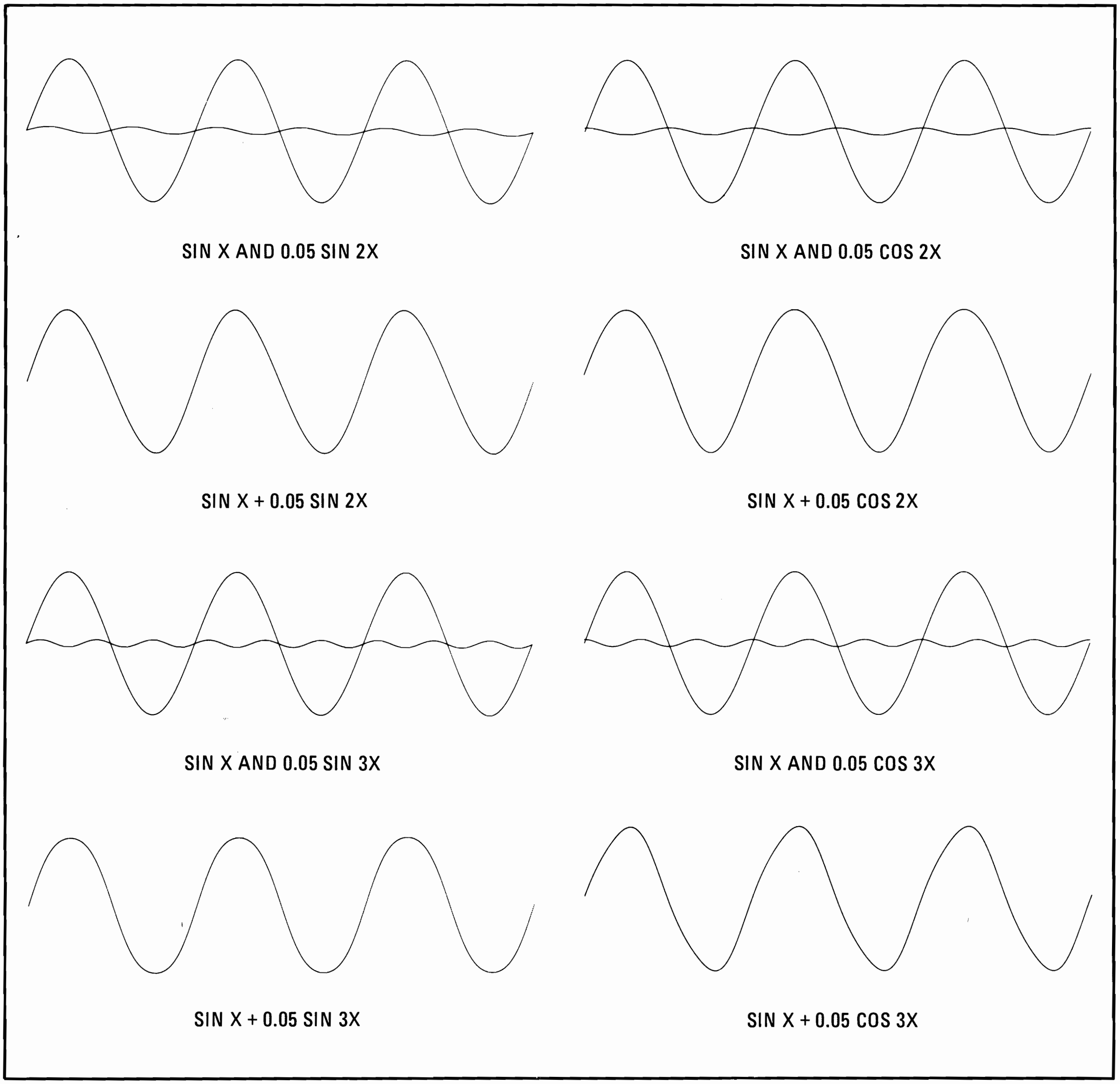
[2] *The Institute of High Fidelity, Inc., Standard Methods of Measurement for Audio Amplifiers,* The Institute of High Fidelity, Inc., New York (1978), p. 9.

Distortion (Cont'd)

tions. With a distortion analyzer, you simply measure the signal level and set it up as a reference, then you insert a notch filter, tuned to the frequency of the fundamental, and measure the output of the filter relative to the input. This is the method used by the Audio Analyzer in the DISTN mode where the tuning and measuring are done automatically. When using the distortion analyzer method, it is important to understand that the measurement result is not "total harmonic distortion" as defined above except under the condition that the distortion is not too excessive but that it does predominate over any other signal impurities. Some examples will illustrate these restrictions.

Consider the case of excessive harmonic distortion. Let us use the example of a signal with 10% actual total harmonic distortion in which all the distortion comes from the second harmonic. The second harmonic is then 20 dB below the funda-



SIN X AND 0.05 SIN 2X

SIN X AND 0.05 COS 2X

SIN X + 0.05 SIN 2X

SIN X + 0.05 COS 2X

SIN X AND 0.05 SIN 3X

SIN X AND 0.05 COS 3X

SIN X + 0.05 SIN 3X

SIN X + 0.05 COS 3X

Figure 1-6. Several Waveforms each with 5% THD and the Signal Components Which Produced Them

Distortion (Cont'd)

mental as viewed on a spectrum analyzer. When this signal is measured by a distortion analyzer, an error results from the first part of the measurement (measuring the input level) because the input level is not quite the same as the level of the fundamental. If the fundamental level were 1 Vrms, the second harmonic level would be 0.1 Vrms (one-tenth of the fundamental). The total input level (measured with a true rms voltmeter) is the rms sum of the two components, namely,

$$\text{Input} = \sqrt{(1)^2 + (0.1)^2} = 1.005 \text{ V}$$

or 0.5% high. Thus, the measurement result would be 9.95% distortion instead of the true 10%. Actually you can see that the distortion must really be excessive to affect the measurement significantly.

Now consider the case where other types of impurities are significant. Suppose the actual total harmonic distortion is 1% but that there is a hum component that has a level that is 1% of the fundamental level. The distortion measured by a distortion analyzer will be 1.4% (i.e., 40% or 3 dB high). How, then, can you be sure that the result is a valid measurement of distortion? One way is to observe the (rear-panel) MONITOR output with an oscilloscope. If the waveform is clean and harmonically related to the fundamental, the measurement is actual total harmonic distortion. If it is not, selectable filters are provided to remove unwanted signals. Use the 400 Hz HIGH PASS FILTER to remove line hum. Use the 30 kHz or 80 kHz LOW PASS FILTER to remove out-of-band noise. However, select only filters that do not affect the fundamental and the harmonics of interest. Sometimes it is desired to include hum and noise as part of the "distortion" measurement. For this reason, the measurement is often referred to as a THD+N (total harmonic distortion plus noise) measurement.

1-37. SINAD

For most practical purposes the SINAD measurement, as made by the Audio Analyzer, is equal to the reciprocal of the distortion measurement. It is usually expressed in dB. The one subtle distinction is that the notch filter is coarsely programmed to the frequency of the internal source (but fine tuned to the signal at its input). This permits measurements in the presence of large amounts of impurities and assures that the fundamental is tuned out. If an external source is used, it must be within 5% of the frequency setting of the internal source.

SINAD is an acronym for SIgnal, Noise, And Distortion. The ratio (normally expressed in dB) computed in the SINAD measurement is

$$\text{SINAD} = 20 \log \left(\frac{\text{rms value of signal, noise, and distortion}}{\text{rms value of noise and distortion}} \right)$$

The equation eliminates the two restrictions discussed in connection with the distortion measurement.

SINAD is used most often in determining the sensitivity of a receiver. Receiver sensitivity is defined as the RF level that, when modulated in a specified manner with a pure audio tone, creates a certain SINAD (usually 10 or 12 dB) at the receiver's audio output. (The tone can just be discerned in the noise.) Sometimes a psophometric (i.e., noise measuring) filter is required in the receiver sensitivity measurement. The psophometric filter weights the frequency response of the Audio Analyzer with a bandpass characteristic that approximates the response of human hearing and gives predominance to 1 kHz (where human hearing is best). The filter in the Audio Analyzer is specified by the C.C.I.T.T.[3]

1-38. Signal-to-Noise Ratio

Measurement of the signal-to-noise ratio requires the use of the Audio Analyzer's internal source. The Audio Analyzer simply turns the source (set to a specified level) on and off and measures the ac level for both conditions. This is similar to the experience you have when listening to a recording at a comfortable volume, then lifting the tone arm and listening to the level of the residual hiss and hum.

1-39. Internal Source

The internal source is used when a low-distortion stimulus for the device under test is desired. Its distortion is about the same as that of the Audio Analyzer's measurement system. The combination permits measurements of distortion as low as 0.01% (–80 dB).

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[3] *The International Telegraph and Telephone Consultative Committee (C.C.I.T.T.), Fifth Plenary Assembly, 1972, Telephone Transmission Quality,* The International Telecommunication Union (1973), pp. 87-91.

1-40. Plotting

When used in conjunction with the sweep mode, any of the measurements vs. frequency can be plotted using the rear-panel X and Y AXIS outputs and an x-y recorder. The internal source is used as the stimulus. This simplifies traditionally time consuming measurements such as flatness, gain, distortion, and SINAD vs. frequency, and does not require the use of an external controller (although this too can be used via HP-IB).

Table 1-1. Specifications (1 of 4)

All parameters describe performance in automatic operation or with properly set manual controls.

	SOURCE	
Characteristic	**Performance Limits**	**Conditions**
FREQUENCY		
Range	20 Hz to 100 kHz	
Resolution	0.3% increments	
Accuracy	0.3% of setting	
OUTPUT LEVEL		
Range	0.6 mV to 6V	Open circuit
Resolution	Better than 0.3%	
Accuracy	±2% of setting	60 mV to 6V; open circuit; 20 Hz to 50 kHz
	±3% of setting	6 mV to 60 mV; open circuit; 20 Hz to 100 kHz
	±5% of setting	0.6 mV to 6 mV; open circuit; 20 Hz to 100 kHz
Flatness	±0.7%	20 Hz to 20 kHz; 1 kHz reference
	±2.5%	20 Hz to 100 kHz; 1 kHz reference
Distortion and Noise (the higher of)	−80 dB or 30 μV	20 Hz to 20 kHz; 80 kHz BW
	−70 dB or 95 μV	20 Hz to 50 kHz; 500 kHz BW
	−65 dB or 169 μV	50 kHz to 100 kHz; 500 kHz BW
Impedance	600Ω ±1%	
	MEASUREMENT	
SINAD		
Fundamental Frequency Range	20 Hz to 100 kHz	
Display Range	0 to 99.99 dB	Residual noise and distortion same as for distortion
Accuracy	±1 dB	20 Hz to 20 kHz
	±2 dB	20 kHz to 100 kHz
Input Voltage Range	50 mV to 300V	
SIG/NOISE		
Frequency Range	50 Hz to 100 kHz	
Display Range	0 to 99.99 dB	
Accuracy	±1 dB	
Input Voltage Range	50 mV to 300V	
Residual Noise (the higher of)	−80 dB or 30 μV	80 kHz BW
	−70 dB or 95 μV	500 kHz BW

Table 1-1. Specifications (2 of 4)

MEASUREMENT (Cont'd)		
Characteristic	**Performance Limits**	**Conditions**
DISTORTION		
Fundamental Frequency Range	20 Hz to 100 kHz	
Display Range	0.001% to 100% (−99.99 to 0 dB)	
Accuracy	±1 dB	20 Hz to 20 kHz
	±2 dB	20 kHz to 100 kHz
Input Voltage Range	50 mV to 300V	
Residual Noise and Distortion (the higher of)	0.01% (−80 dB) or 30 μV	20 Hz to 20 kHz; 80 kHz BW
	0.032% (−70 dB) or 95 μV	20 kHz to 50 kHz; 500 kHz BW
	0.056% (−65 dB) or 169 μV	50 kHz to 100 kHz; 500 kHz BW
AC LEVEL		
Full Range Display	300.0V, 30.00V, 3.00V, .3000V, 30.00mV, 3.00mV, .3000 mV	
Overrange	33%	Except on the 300.0V range
Accuracy	±2%	30V to 300V; 20 Hz to 1 kHz
	±2%	50 mV to 30V; 20 Hz to 20 kHz
	±4%	0.3 mV to 30V; 20 Hz to 100 kHz
DC LEVEL		
Full Range Display	300.0V, 48.00V, 16.00V, 4.00V	
Overrange	33%	Except on the 300.0V range
Accuracy	±0.75% of reading	400 mV to 300V
	±3 mV	<400 mV
FREQUENCY		
Measurement Range	20 Hz to 150 kHz	In ac level mode
	20 Hz to 100 kHz	In distortion, SINAD, and signal-to-noise modes
Resolution	5 digits	Frequencies >100 Hz
	0.01 Hz	Frequencies <100 Hz
Accuracy	±0.004% ±1 digit	
Sensitivity	50 mV	Distortion and SINAD modes only
	5.0 mV	In ac level and signal-to-noise modes only

Table 1-1. Specifications (3 of 4)

MEASUREMENT (Cont'd)		
Characteristic	**Performance Limits**	**Conditions**
AUDIO FILTERS		
400 Hz High-pass Filter		
3 dB Cutoff Frequency	400 ±40 Hz	
Rolloff	140 dB/decade	
Psophometric Filter		CCITT Recommendation P53
Deviation from Ideal Response	±0.2 dB	At 800 Hz
	±1 dB	300 Hz to 3 kHz
	±2 dB	50 Hz to 3.5 kHz
	±3 dB	3.5 kHz to 5 kHz
30 kHz Low-pass Filter		
3 dB Cutoff Frequency	30 ±2 kHz	
Rolloff	60 dB/decade	
80 kHz Low-pass Filter		
3 dB Cutoff Frequency	80 ±4 kHz	
Rolloff	60 dB/decade	
GENERAL		
TEMPERATURE		
Operating	0° to 55°C	
Storage	–55° to 75°C	
INPUT IMPEDANCE		
Resistance	100 kΩ ±1%	Except in dc level mode
	101 kΩ ±1%	In dc level mode only
Shunt Capacitance	<300 pF	Low terminal grounded; except Option 001
	<330 pF	Low terminal grounded; Option 001 only
COMMON MODE REJECTION RATIO (at 60 Hz)	60 dB	<2V differential input voltage
	36 dB	<48V differential input voltage
	30 dB	>48V differential input voltage
REMOTE OPERATION	IEEE STD 488-1978 Compatibility Code: SH1, AH1, T5, TE0, L3, LE0, SR1, RL1, PP0, DC1, DT1, C0	The Hewlett-Packard Interface Bus (HP-IB) is Hewlett-Packard Company's implementation of IEEE Std. 488-1978, "Digital Interface for Programmable Instrumentation". All functions except the line switch, the ×10 and ÷10 keys, and the low terminal float/ground switches are remotely controllable.

Table 1-1. Specifications (4 of 4)

GENERAL (Cont'd)

Characteristic	Performance Limits	Conditions
POWER REQUIREMENTS		
Line Voltage		
100, 120, 220, 240 Vac	+5%, −10%	48 to 66 Hz
100, 120 Vac	+5%, −10%	48 to 440 Hz
POWER DISSIPATION	100 V·A maximum	
CONDUCTED AND RADIATED INTERFERENCE (EMI)	MIL STD 461A, VDE 0871, and CISPR publication 11	Conducted and radiated interference is within the requirements of methods CE03 and RE02 of MIL STD 461A, VDE 0871, and CISPR publication 11.
CONDUCTED AND RADIATED SUSCEPTIBILITY	MIL STD 461A-1968	Conducted and radiated susceptibility meets the requirements of methods CS01, CS02, and RS03 (1 volt/metre) of MIL STD 461A dated 1968.
NET WEIGHT	12.3 kg (27 lb)	
DIMENSIONS (Full Envelope)		
Height	146 mm (5.75 in.)	Note: For ordering cabinet accessories, the module sizes are 5¼H, 1MW, and 17D.
Width	425 mm (16.8 in.)	
Depth	462 mm (18.2 in.)	

Table 1-2. Supplemental Information (1 of 2)

All parameters describe performance in automatic operation or with properly set manual controls.

SOURCE

Frequency Switching Speed: <3 ms (does not include HP-IB programming time).

Output Level Switching Speed: 20 ms (does not include HP-IB programming time).

Sweep Mode: Logarithmic sweep with up to 500 points/decade or 255 points total between entered start and stop frequencies.

MEASUREMENT

SINAD

Detection: true rms (average detection selectable by internal modification).

Resolution: 0.01 dB for ratios >25 dB. For ratios <25 dB, the display is rounded to the nearest half dB to reduce digit flickering with noisy signals. (Full resolution is available by defeating this feature using Special Function 16.1.)

Table 1-2. Supplemental Information (2 of 2)

MEASUREMENT (Cont'd)

SINAD

Analog Meter: active in SINAD only and for SINAD ratios <18 dB (or 24 dB using Special Function 7.1).

Accuracy: 1 dB typical.

Tuning: notch filter is tuned to analyzer source frequency.

Time to Return First Measurement: 1.5s typical.

Measurement Rate: 2.0 readings/s typical.

SIG/NOISE

Resolution: same as SINAD.

Detection: true rms (average detection selectable by internal modification).

Time to Return First Measurement: <2.5s typical.

Measurement Rate: 1 reading/s typical.

Operation: The Audio Analyzer displays the ratio of the input voltages as the internal source is switched on and off.

DISTORTION

Measurement Bandwidth: 10 Hz to 500 kHz.

Detection: true rms (average detection selectable by internal modification).

Displayed Resolution:

0.0001% (<0.1% distortion)
0.001% (0.1% to 3% distortion)
0.01% (3% to 30% distortion)
0.1% (>30% distortion)

Time to Return First Measurement: 1.5s typical.

Measurement Rate: 2 readings/s typical.

AC LEVEL

High Level Accuracy: ±2%; 30 to 300V; 20 Hz to 20 kHz.

AC Converter: true rms responding for signals with crest factor of <3 and harmonics up to 80 kHz.

3 dB Measurement Bandwidth: >500 kHz.

Time to Return First Measurement: <1.5s typical.

Measurement Rate: 2.5 readings/s.

DC LEVEL:

Time to Return First Measurement: <1.5s typical.

Measurement Rate: 3 reading/s.

FREQUENCY MEASUREMENT

Measurement Rate: same as measurement mode selected.

Counting Technique: reciprocal with 2 MHz time base.

AUDIO FILTERS

400 Hz High-Pass Filter Rejection: >40 dB at 240 Hz; >65 dB at 60 Hz.

REAR-PANEL INPUTS AND OUTPUTS

Recorder Outputs:

X Axis: 0 to 10 Vdc corresponding to the log of the oscillator frequency.

Output Resistance: 1 kΩ.

Y Axis: 0 to 10 Vdc corresponding to the displayed value and entered plot limits.

Output Resistance: 1 kΩ.

Pen Lift: TTL output.

Monitor Output

Output Impedance: 600Ω.

In ac level mode, provides scaled output of measured input signal.

In SINAD, distortion, and distortion level modes, provides scaled output of input signal with the fundamental removed.

Table 1-3. Recommended Test Equipment (1 of 2)

Instrument Type	Critical Specifications	Suggested Model	Use*
AC Calibrator and High Voltage Amplifier	Accuracy: 0.1%, 30 to 300V, 20 Hz to 1 kHz; 0.25%, 30 mV to 300V, 20 Hz to 100 kHz Flatness: ±0.1%, 20 Hz to 100 kHz, <6V Output Current: 50 mA Frequency Accuracy: ±5%	HP 745A and HP 746A	P, A
Audio Oscillator	Frequency Range: 20 Hz to 500 kHz Frequency Accuracy: ±5% Output Range: 3V into 600Ω Output Attenuation Accuracy: ±0.075 dB, to 0.3 mV range	HP 651B	P, A
Attenuator	Attenuation Range: 0 to 40 dB Frequency Range: 20 Hz to 100 kHz Accuracy: ±1 dB Impedance: 600Ω Maximum Power Dissipation: 100 mW	HP 4437A	P
Computing Controller	HP-IB compatibility as defined by IEEE Std. 488 and the identical ANSI Std. MC1.1: SH1, AH1, T2, TE0, L2, LE0, SR0 PP0, DC0, DT0, and C1, 2, 3, 4, 5.	HP 9825A/ 98034A/98213A or HP 9835A/ 98034A/98332A (see Table 1-4)	C, T
Counter	Frequency Range: 20 Hz to 100 kHz Level Sensitivity: 25 mV Input Impedance: >1 MΩ Maximum Resolution: 0.001 Hz	HP 5300B/ 5307A	P
DC Standard	Output Range: 3 mV to 300V Accuracy: ±0.1% ±0.3 mV	HP 740B or Fluke 893AR (see Table 1-4)	P
Digital Voltmeter	AC Accuracy: ±0.2% at 6 Vrms and 1 kHz DC Accuracy: +0.2% at 1V	HP 3455A	A, T
Feedthrough Termination	Impedance: 600Ω Impedance Accuracy: ±1% Maximum Dissipation: 100 mW	HP 11095A	P, A
Frequency Standard	Frequency: 0.1, 1, 2, 5, or 10 MHz Accuracy: ±1 ppm	House Standard	A
Oscilloscope	Bandwidth: less than 3 dB down 0 to 10 MHz Sensitivity: 5 mV per division minimum Input Impedance: 1 MΩ Triggering: Internal and External	HP 1740A	C,A,T
Resistor 100Ω	Accuracy. ±0.1%	HP 0698-7497	P

*C = Operator's Checks; P = Performance Tests; A = Adjustments; T = Troubleshooting

Table 1-3. Recommended Test Equipment (2 of 2)

Instrument Type	Critical Specifications	Suggested Model	Use*
Signature Analyzer	Because the signatures documented are unique to a given signature analyzer, no substitution is recommended.	HP 5004A	T
Test Oscillator	Frequency: 1 kHz Output: 30 Vpp	HP 3310A	T
True RMS Voltmeter	Type: true rms responding Level Range: 100 mV to 10V Frequency Range: 20 Hz to 500 kHz Accuracy: ±0.2% of range ±0.2% of reading Coupling: ac	HP 3403C	P
* = Operator's Checks; P = Performance Tests; A = Adjustments; T = Troubleshooting			

Table 1-4. Recommended Alternate Test Equipment

Instrument Type	Suggested Alternate	Instrument Replaced	Advantages of Alternate
Computing Controller	HP 9835A/98034A/ 98332A	HP 9825A/98034A/ 98213A	CRT Display ANSI BASIC Larger Memory
DC Standard	Fluke 893AR	HP 740B	Availability

Table 1-5. Service Accessories*

Accessory*	Specifications	Suggested Model
Digital Test/ Extender Board	No substitution recommended	HP 08903-60018
Extender Board	44 contacts (2 × 22)	HP 08901-60084
Extender Board	30 contacts (2 × 15)	HP 08901-60085
Foam Pad	Conductive polyurethane foam, 12 × 12 × 0.25 inches (nonmagnetic)	HP 4208-0094
*Refer to Section VIII, paragraph 8-11, of this manual for application.		

NOTE

The performance tests, adjustments, and troubleshooting procedures are based on the assumption that the recommended test equipment is used. Substituting alternate test equipment may require modification of some procedures.

SECTION II
INSTALLATION

2-1. INTRODUCTION

This section provides the information needed to install the Audio Analyzer. Included is information pertinent to initial inspection, power requirements, line voltage selection, power cables, interconnection, environment, instrument mounting, storage, and shipment. In addition, this section also contains the procedure for setting the internal HP-IB talk and listen address switches.

2-2. INITIAL INSPECTION

WARNING

To avoid hazardous electrical shock, do not perform electrical tests when there are signs of shipping damage to any portion of the outer enclosure (covers, panels, meters).

Inspect the shipping container for damage. If the shipping container or cushioning material is damaged, it should be kept until the contents of the shipment have been checked for completeness and the instrument has been checked mechanically and electrically. The contents of the shipment should be as shown in Figure 1-1. Procedures for checking electrical performance are given in Section IV. If the contents are incomplete, if there is mechanical damage or defect, or if the instrument does not pass the electrical performance test, notify the nearest Hewlett-Packard office. If the shipping container is damaged, or the cushioning material shows signs of stress, notify the carrier as well as the Hewlett-Packard office. Keep the shipping materials for the carrier's inspection.

2-3. PREPARATION FOR USE

2-4. Power Requirements.

WARNING

To avoid the possibility of hazardous electrical shock, do not operate this instrument at line voltages greater than 126.5 Vac with line frequencies greater than 66 Hz. Leakage currents at these line settings may exceed 3.5 mA.

The Audio Analyzer requires a power source of 100, 120, 220, or 240 Vac, +5% to −10%, 48 to 66 Hz single phase or 100, 120 Vac, +5% to −10%, 48 to 440 Hz single phase. Power consumption is 100 V·A maximum.

WARNINGS

This is a Safety Class I product (i.e., provided with a protective earth terminal). An uninterruptible safety earth ground must be provided from the main power source to the product input wiring terminals, power cord, or supplied power cord set. Whenever it is likely that the protection has been impaired, the product must be made inoperative and be secured against any unintended operation.

If this instrument is to be energized via an external autotransformer, make sure the autotransformer's common terminal is connected to the earthed pole of the power source.

2-5. Line Voltage and Fuse Selection

CAUTION

BEFORE PLUGGING THIS INSTRUMENT into the Mains (line) voltage, be sure the correct voltage and fuse have been selected.

Verify that the line voltage selection card and the fuse are matched to the power source. Refer to Figure 2-1, Line Voltage and Fuse Selection.

Fuses may be ordered under HP part numbers 2110-0305, 1.25A (250V, time delay) for 100/120 Vac operation and 2110-0202, 0.5A (250V, time delay) for 220/240 Vac operation.

2-6. Power Cables

WARNING

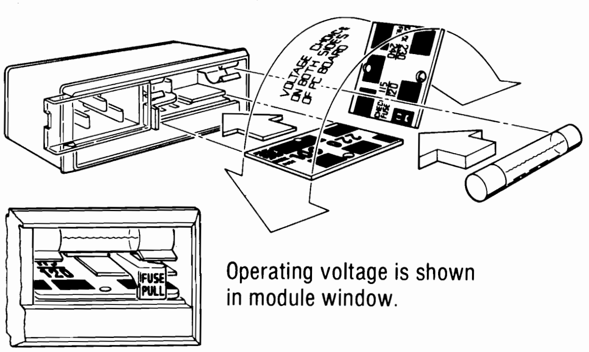
BEFORE CONNECTING THIS INSTRUMENT, the protective earth terminals of

(continued)

Power Cables (Cont'd)

WARNING (Cont'd)

this instrument must be connected to the protective conductor of the (Mains) power cord. The Mains plug shall only be inserted in a socket outlet provided with a protective earth contact. The protective action must not be negated by the use of an extension cord (power cable) without a protective conductor (grounding).



Operating voltage is shown in module window.

SELECTION OF OPERATING VOLTAGE

1. Open cover door, pull the FUSE PULL lever and rotate to left. Remove the fuse.
2. Remove the Line Voltage Selection Card. Position the card so the line voltage appears at top-left cover. Push the card firmly into the slot.
3. Rotate the Fuse Pull lever to its normal position. Insert a fuse of the correct value in the holder. Close the cover door.

WARNING

To avoid the possibility of hazardous electrical shock, do not operate this instrument at line voltages greater than 126.5 Vac with line frequencies greater than 66 Hz (leakage currents at these line settings may exceed 3.5 mA).

Figure 2-1. Line Voltage and Fuse Selection

This instrument is equipped with a three-wire power cable. When connected to an appropriate ac power receptacle, this cable grounds the instrument cabinet. The type of power cable plug shipped with each instrument depends on the country of destination. Refer to Figure 2-2 for the part numbers of the power cables available.

2-7. HP-IB Address Selection HP-IB

WARNINGS

This task should be performed only by service trained persons who are aware of the potential shock hazard of working on an instrument with protective covers removed.

To avoid hazardous electrical shock, the line (Mains) power cable should be disconnected before attempting to change the HP-IB address.

In the Audio Analyzer, the HP-IB talk and listen addresses are selectable by an internal switch. The following procedure explains how the switches are to be set. Refer to Table 2-1 for a listing of the talk and listen addresses. The address is factory set for a Talk address of "\" and a listen address of "<" (in binary, this is 11100; in decimal it is 28.) To change the HP-IB address, the top cover of the Audio Analyzer must be removed.

a. Disconnect the line (Mains) power cable.

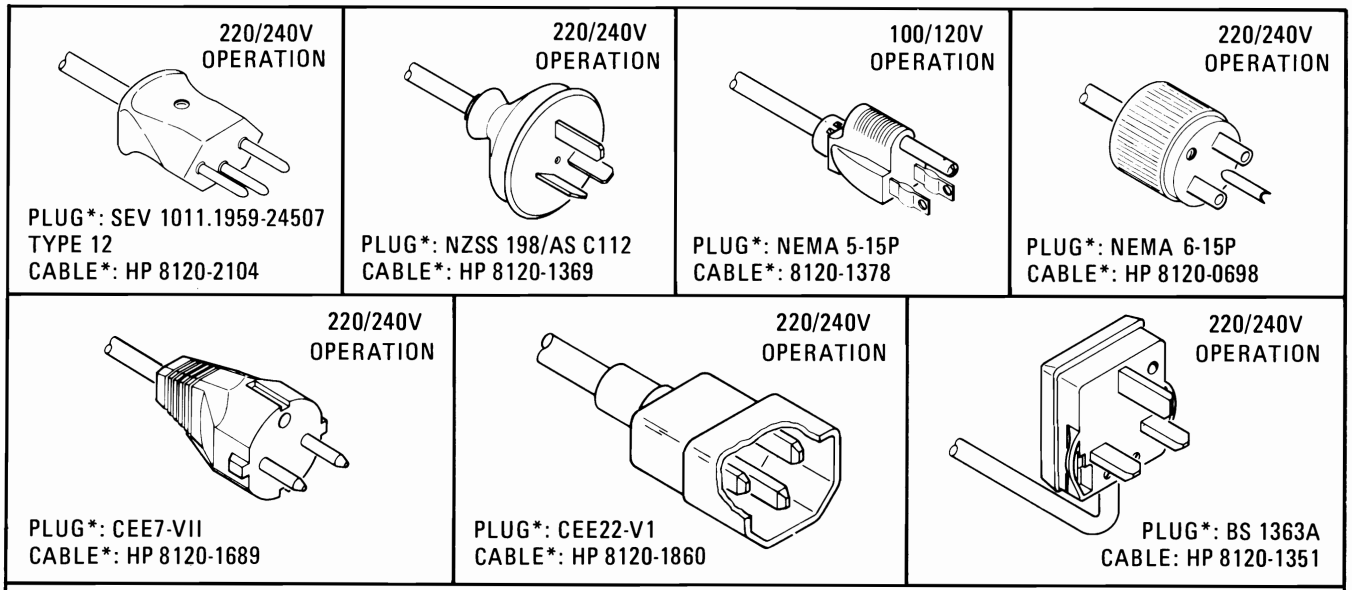
b. Remove any HP-IB cables or connectors from the HP-IB connector.

c. Remove the Audio Analyzer top cover.

1. Remove the two plastic feet from the rear of the top cover by removing the pan-head Pozidriv screw within each foot.
2. Unscrew the Pozidriv screw at the center of the rear edge of the top cover. This is a captive screw and will cause the top cover to pull away from the front frame.
3. Lift off the top cover.

d. Locate the HP-IB address switch accessible through a hole near the center rear of the internal shield cover.

e. Use a pencil to set the switches to the desired HP-IB address and Talk Only (TON) or Listen Only (LON) condition. The switch is illustrated in Figure 2-3. Facing the board, the left hand switch (marked with a "5") is the most significant address



*The number shown for the plug is the industry identifier for the plug only.
The number shown for the cable is an HP part number for a complete cable including the plug.

Figure 2-2. Power Cable and Mains Plug Part Numbers

HP-IB Address Selection (Cont'd) HP-IB

bit (A5 in Table 2-1). Setting a switch toward the printed circuit board places it in its "1" position. If the TON and LON switches are both set to "1", the Talk Only setting will override. If the address switches and the TON switch are all set to "1", the Audio Analyzer will output one byte (the status byte) each measurement cycle. (Setting all switches to "1" defeats HP-IB operation.)

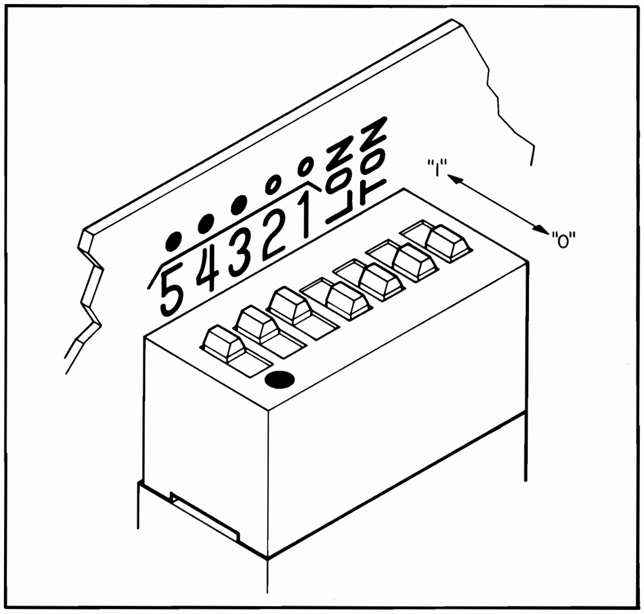


Figure 2-3. The HP-IB Address Switch Shown as Set by the Factory. The Address Shown is 11100 in Binary with Both Talk Only and Listen Only Off.

f. Reinstall the top cover by reversing the procedure in step c above.

g. Connect the line (Mains) power cable to the Line Power Module and reconnect the HP-IB cable to the HP-IB connector.

h. To confirm the setting, refer to HP-IB Address in the Detailed Operating Instructions in Section III of this manual.

2-8. Interconnections

Interconnection data for the Hewlett-Packard Interface Bus is provided in Figure 2-4.

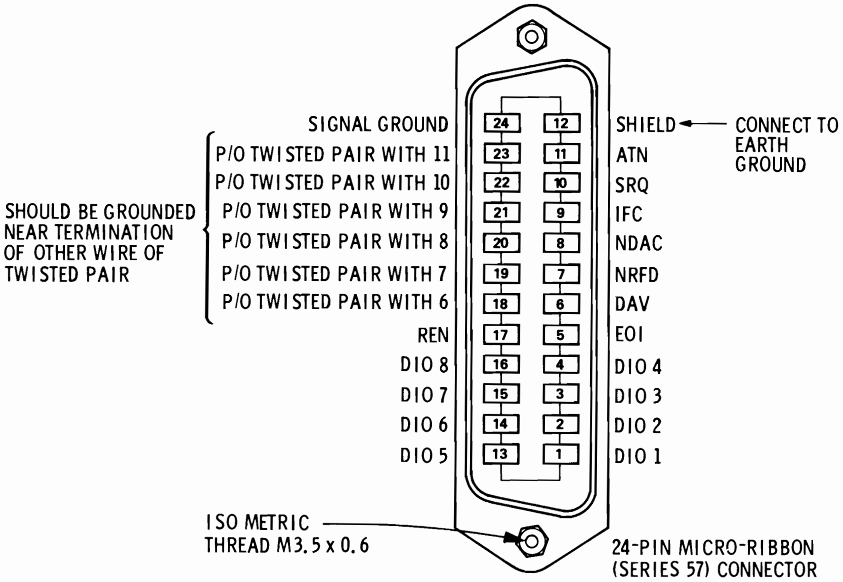
2-9. Mating Connectors

Interface Connector. The HP-IB mating connector is shown in Figure 2-4. Note that two securing screws are metric.

Coaxial Connectors. Coaxial mating connectors used with the Audio Analyzer should the 50-ohm BNC male connectors.

2-10. Operating Environment

The operating environment should be within the following limitations:



Logic Levels

The Hewlett-Packard Interface Bus Logic Levels are TTL compatible, i.e., the true (1) state is 0.0 Vdc to +0.4 Vdc and the false (0) state is +2.5 Vdc to +5.0 Vdc.

Programming and Output Data Format

Refer to Section III, Operation.

Mating Connector

HP 1251-0293; Amphenol 57-30240.

Mating Cables Available

HP 10833A, 1 metre (3.3 ft), HP 10833B, 2 metres (6.6 ft)
HP 10833C 4 metres (13.2 ft), HP 10833D, 0.5 metres (1.6 ft)

Cabling Restrictions

1. A Hewlett-Packard Interface Bus system may contain no more than 2 metres (6.6 ft) of connecting cable per instrument.

2. The maximum accumulative length of connecting cable for any Hewlett-Packard Interface Bus system is 20.0 metres (65.6 ft).

Figure 2-4. Hewlett-Packard Interface Bus Connection HP-IB

Operating Environment (Cont'd)

Temperature .... 0°C to +55°C
Humidity .... <95% relative
Altitude............... <4570 metres (15 000 feet)

HP-IB Table 2-1. Allowable HP-IB Address Codes

Address Switches					Talk Address Character	Listen Address Character	Decimal Equivalent
A5	A4	A3	A2	A1			
0	0	0	0	0	@	SP	0
0	0	0	0	1	A	!	1
0	0	0	1	0	B	"	2
0	0	0	1	1	C	#	3
0	0	1	0	0	D	$	4
0	0	1	0	1	E	%	5
0	0	1	1	0	F	&	6
0	0	1	1	1	G	'	7
0	1	0	0	0	H	(	8
0	1	0	0	1	I	)	9
0	1	0	1	0	J	*	10
0	1	0	1	1	K	+	11
0	1	1	0	0	L	,	12
0	1	1	0	1	M	–	13
0	1	1	1	0	N		14
0	1	1	1	1	O	/	15
1	0	0	0	0	P	0	16
1	0	0	0	1	Q	1	17
1	0	0	1	0	R	2	18
1	0	0	1	1	S	3	19
1	0	1	0	0	T	4	20
1	0	1	0	1	U	5	21
1	0	1	1	0	V	6	22
1	0	1	1	1	W	7	23
1	1	0	0	0	X	8	24
1	1	0	0	1	Y	9	25
1	1	0	1	0	Z	:	26
1	1	0	1	1	[	;	27
1	1	1	0	0	\	<	28
1	1	1	0	1	]	=	29
1	1	1	1	0	^	>	30

2-11. Bench Operation

The instrument cabinet has plastic feet and foldaway tilt stands for convenience in bench operation. (The plastic feet are shaped to ensure self-aligning of the instruments when stacked.) The tilt stands raise the front of the instrument for easier viewing of the front panel.

2-12. Rack Mounting

WARNING

The Audio Analyzer is heavy for its size (12.3 kg, 27 lb). Care must be exercised when lifting to avoid personal injury. Use equipment slides when rack mounting.

Rack mounting information is provided with the rack mounting kits. If the kits were not ordered with the instrument as options, they may be ordered through the nearest Hewlett-Packard office. Refer to paragraph 1-13, Mechanical Options, in Section I.

2-13. STORAGE AND SHIPMENT

2-14. Environment

The instrument should be stored in a clean, dry environment. The following environmental limitations apply to both storage and shipment:

Temperature .... –55°C to +75°C
Humidity .... <95% relative
Altitude............. <15 300 metres (50 000 feet)

2-15. Packaging

Tagging for Service. If the instrument is being returned to Hewlett-Packard for service, please complete one of the blue repair tags located at the end of this manual and attach it to the instrument.

Original Packaging. Containers and materials identical to those used in factory packaging are available through Hewlett-Packard offices. Mark the container "FRAGILE" to assure careful handling. In any correspondence refer to the instrument by model number and full serial number.

Other Packaging. The following general instructions should be used for re-packaging with commercially available materials:

a. Wrap the instrument in heavy paper or plastic. (If shipping to a Hewlett-Packard office or service center, complete one of the blue tags mentioned above and attach it to the instrument.

b. Use a strong shipping container. A double-wall carton made of 2.4 MPa (350 psi) test material is adequate.

Packaging (Cont'd)

c. Use enough shock-absorbing material (75 to 100 mm layer; 3 to 4 inches) around all sides of instrument to provide firm cushion and prevent movement in the container. Protect the front panel with cardboard.

d. Seal the shipping container securely.

e. Mark the shipping container "FRAGILE" to assure careful handling.

SECTION III
OPERATION

3-1. INTRODUCTION

3-2. General

This section provides complete operating information for the Audio Analyzer. Included in this section are descriptions of all front- and rear-panel controls, connectors, and indicators, remote and local operator's checks, operating instructions, and operator's maintenance.

3-3. Operating Characteristics

Table 3-1 briefly summarizes the major operating characteristics of the Audio Analyzer. The table is not intended to be an in-depth listing of all operations and ranges but gives an idea of the instrument's capabilities. For more information on the Audio Analyzer capabilities, refer to the description in Section 1; Table 1-1, Specifications; and Table 1-2, Supplemental Information. For information on HP-IB capabilities, refer to the summary contained in Table 3-3, Message Reference Table.

3-4. Turn-On Procedure

WARNINGS

Before the Audio Analyzer is switched on, all protective earth terminals, extension cords, auto-transformers, and devices connected to it should be connected to a protective earth socket. Any interruption of the protective earth grounding will cause a potential shock hazard that could result in personal injury. In addition, verify that a common ground exists between the unit under test and the Audio Analyzer prior to energizing either unit.

For continued protection against fire hazard, replace the line fuse with a 250V time delay fuse of the same rating. Do not use repaired fuses or short circuited fuseholders.

CAUTIONS

Before the Audio Analyzer is switched on, it must be set to the voltage of the power source, or damage to the instrument may result.

Do not apply greater than +15V or less than −15V (ac + dc) to the INPUT LOW terminal or damage to the instrument may result. Do not allow the voltage at the SOURCE OUTPUT LOW terminal to be greater than +10V or less than −10V (ac + dc) or damage to the instrument may result.

If the Audio Analyzer is already plugged in, set the LINE switch to ON. If the power cable is not plugged in, follow these instructions.

1. Check that the line voltage setting matches the power source (see Figure 2-1).
2. Check that the fuse rating is appropriate for the line voltage used (see Figure 2-1). Fuse ratings are given under Operator's Maintenance on this foldout.
3. Plug in the power cable.
4. Set the LINE switch to ON.

NOTE

When the LINE switch is set to ON, all front-panel indicators will light for approximately 4 seconds after which the instrument is ready to be operated.

3-5. Local Operation

Information covering front-panel operation of the Audio Analyzer is given in the sections described below. To rapidly learn the operation of the instrument, begin with Simplified Operation and Operator's Checks. Once familiar with the general operation of the instrument, use the Detailed Operating Instructions for in-depth and complete information on operating the Audio Analyzer.

Simplified Operation. Located on the inside of this fold, Simplified Operation provides a quick introduction to front-panel operation of the Audio Analyzer. It is designed to rapidly orient the novice

Local Operation (Cont'd)

user with basic operating procedures and therefore is not an exhaustive listing of all Audio Analyzer functions. However, an index to the Detailed Operating Instructions appears opposite the fold to guide the operator to the more complete discussion of the topic of interest.

Panel Features. Front-panel controls, indicators, and connectors are illustrated and described in Figures 3-2 to 3-4. These figures describe the functions of the various key groups and summarize briefly how to use them. Rear-panel features are shown in Figure 3-5. The figure provides a good quick reference for rear-panel signal levels and also includes the impedance at the rear-panel connections.

Detailed Operating Instructions. The Detailed Operating Instructions provide the complete operating reference for the Audio Analyzer user. The instructions are organized alphabetically by subtitle. Not only do the instructions contain information on the various measurements that can be made (listed under titles such as AC Level, Distortion, etc.) but there are also individual discussions of nearly all controls, inputs, and outputs (e.g., Amplitude, Monitor, etc.). Also included are instructions for using the many User Special Functions (e.g., Hold Settings, Error Disable, Special Functions, etc.). The Detailed Operating Instructions are indexed by function in Table 3-2.

Each section contains a general description which covers signal levels, ranges, and other general information. Following the description are related procedures, an operating example, the relevant HP-IB codes, front-panel indications, and, where pertinent, a description of the technique the Audio Analyzer uses to make the measurement. At the end of each discussion are comments intended to guide the user away from measurement pitfalls and to help him get the most out of the Audio Analyzer. Also included are references to other sections which contain related information. The Detailed Operating Instructions are designed so that both casual and sophisticated users can rapidly find at one location all the information needed to apply the instrument to the task at hand.

Operating Information Pull-Out Cards. The Operating Information pull-out cards are flexible plastic reference sheets attached to the Audio Analyzer by a tray located below the front-panel. They contain a complete listing of HP-IB codes and data and error output formats, Error codes, and User Special Functions. The cards are intended to be a reference for the user who already has a basic understanding of front-panel operation.

Supplemental Information. In addition to the information described above several other discussions pertinent to operating the Audio Analyzer to its fullest capabilities are contained in Section I of this manual. Principles of Operation for a Simplified Block Diagram is a fundamental description of what the Audio Analyzer is and how it works. This information supplements the block diagrams given in the Detailed Operating Instructions and provides a basis for applying the Audio Analyzer to various measurement situations. Basics of Audio Measurements is a general discussion of audio measurements. It is intended to provide an intuitive understanding of audio measurements rather than an in-depth mathematical analysis.

FRONT-PANEL FEATURES
AND SIMPLIFIED OPERATION ➡

3-6. Remote Operation HP-IB

The Audio Analyzer is capable of remote operation via the Hewlett-Packard Interface Bus (HP-IB). Instructions pertinent to HP-IB operation cover all considerations and instructions specific to remote operation including capabilities, addressing, input and output formats, the status byte, and service requests. At the end of the discussion is a complete summary of all codes and formats.

In addition to the section described above, information concerning remote operation appears in several other locations. Address setting is discussed on page 2-2. A summary of HP-IB codes and output formats appear on one of the Operating Information pull-out cards, and numerous examples of program strings appear throughout the Detailed Operating Instructions described under Local Operation above.

3-7. Operator's Checks

Operator's Checks are procedures designed to verify the proper operation of the Audio Analyzer's main functions. Two procedures are provided as described below.

Basic Functional Checks. This procedure requires an oscilloscope and interconnecting cables. It assures that most front-panel controlled functions are being properly executed by the Audio Analyzer.

HP-IB Functional Checks. This series of procedures require an HP-IB compatible computing controller and an HP-IB interface and connecting cable. The HP-IB Functional Checks assume that front-panel operation has been verified (e.g., by performing the Basic Functional Checks). The procedures check all of the applicable bus messages summarized in Table 3-3.

3-8. Operator's Maintenance

WARNING

For continued protection against fire hazard, replace the line fuse with a 250V time delay fuse of the same rating only. Do not use repaired fuses or short circuited fuseholders.

The only maintenance the operator should normally perform is the replacement of the primary power fuse located within the Line Power Module (A14). For instructions on how to change the fuse, refer to Figure 2-1, steps 1 and 3.

Fuses may be ordered under HP Part Numbers 2110-0305, 1.25A (250V, time delay) for 100/120 Vac operation and 2110-0202, 0.5A (250V, time delay) for 220/240 Vac operation.

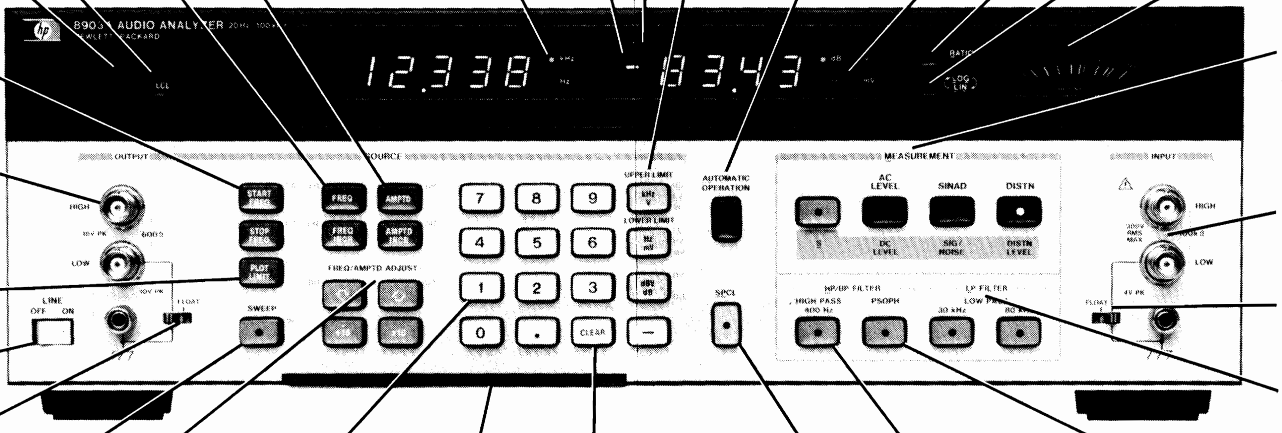
NOTE

If the instrument does not operate properly and is being returned to Hewlett-Packard for service, please complete one of the blue repair tags located at the end of this manual and attach it to the instrument. Refer to Paragraph 2-15 for packaging instructions.

Table 3-1. Operating Characteristics Summary

Operating Parameter	Capabilities
Output Limits	Frequency: 20 Hz to 100 kHz. Level: 0.6 mV to 6V (open circuit). Impedance: 600Ω; floating output can be selected.
Input Limits	Frequency: 20 Hz to 100 kHz (150 kHz, ac level) Level: ≈0 to 300V ac or dc. Impedance: 100 kΩ (except dc level); 101 kΩ (dc level); floating input can be selected.
Measurements (including counter frequency measurements except in DC Level)	AC LEVEL: ≈0 to 300 Vac; 20 Hz to 150 kHz. Full range display from .3000 mV to 300.0V in seven ranges. DC LEVEL: 0 to 300 Vdc. Full range display from 4.000V to 300.0V in four ranges. SINAD: 50 mV to 300V; 20 Hz to 100 kHz. Display range 0 to 99.99 dB. SINAD meter marked for EIA and CEPT readings. SIG/NOISE: 50 mV to 300V; 50 Hz to 100 kHz. Display range 0 to 99.99 dB. DISTN: 50 mV to 300V; 20 Hz to 100 kHz. Display range −99.99 to 0 dB. DISTN LEVEL: Similar to ac level except that the notch filter is used in the measurement.
Detection	True rms (average detection selectable by internal modification).
Swept Measurements	All measurements can be swept and frequency vs measurement result can be plotted using an external X-Y recorder.
Audio Filters	HP/BP FILTER HIGH PASS 400 Hz: 400 ±40 Hz (3 dB cutoff). PSOPH: approximates CCITT Recommendation P53. LP FILTER LOW PASS 30 kHz: 30 ±2 kHz (3 dB cutoff). 80 kHz: 80 ±4 kHz (3 dB cutoff).
Manual Operation	Output level and frequency, input attenuation, ratio, log/linear, display resolution, measurement selection, and many other operations can be manually controlled.
Remote Operation	All Audio Analyzer operations except the LINE switch, the two FLOAT switches, and the ÷10 and ×10 FREQ/AMPT ADJUST keys can be controlled via the Hewlett-Packard Interface Bus.

FRONT-PANEL FEATURES



AMPTD and **AMPTD INCR** keys display or initiate entry of the amplitude or amplitude increment of the source.

FREQ and **FREQ INCR** keys display or initiate entry of the frequency and frequency increment of the source.

LCL (local) key returns the Audio Analyzer to keyboard control from remote (HP-IB) control.

HP-IB Annunciators indicate remote operation status.

START and **STOP FREQ** keys display or initiate entry of the start and stop frequencies of the sweep.

SOURCE OUTPUT provides 0.6 mV to 6V (open circuit), 20 Hz to 100 kHz signal (fuse protected).

PLOT LIMIT key displays or initiates entry of plotter limits.

LINE switch applies power to the Audio Analyzer when set to ON.

FLOAT switch provides floating output when required.

SWEEP key initiates or restarts a logarithmic sweep between the START and STOP FREQ settings.

FREQ/AMPTD ADJUST keys change the source frequency or amplitude in specified increments. The x10 and ÷10 keys modify the specified increment.

The two **Numeric Displays** show the frequency, measurement results, numeric key entries, error codes, or instrument or Special Function status.

MEASUREMENT CYCLE indicator blinks after each measurement cycle.

Frequency Display Annunciators indicate the frequency units.

Numeric keys are used for manual entry of frequency, amplitude, limits, RATIO references, and selection of Special Functions.

OPERATING INFORMATION pullout cards are quick operating references that list Special Function, HP-IB, and error codes.

CLEAR key erases keyboard entries in progress. In remote hold, CLEAR initiates a Trigger with Settling measurement cycle.

Unit keys select units and complete manual data entry.

AUTOMATIC OPERATION key switches instrument to automatic (i.e., functions allowed to automatically range as appropriate).

Measurement Display Annunciators indicate the measurement result units.

RATIO key causes measurements to be displayed in % or dB relative to a reference.

LOG/LIN key causes results to be displayed in logarithmic or linear units.

SINAD meter is marked for EIA and CEPT sensitivity and selectivity readings (when within limits).

MEASUREMENT keys command the Audio Analyzer to make and display the selected measurement.

INPUT couples measurement signal into the instrument (fuse protected).

FLOAT switch provides floating input when required.

LOW PASS 30 kHz and 80 kHz filters reject high frequency noise.

PSOPH (psophometric) filter for receiver testing to CEPT requirements.

HIGH PASS 400 Hz filter rejects line related noise and squelch tones.

SPCL key completes entry of Special Function codes for accessing instrument operations additional to those having dedicated front-panel keys. Also permits reading of Special Function or hardware status.

For more on panel features, see Figures 3-2 through 3-4.

Figure 3-1. Front-Panel Features

SIMPLIFIED OPERATION

SOURCE FREQUENCY AND AMPLITUDE

Frequency

To set source frequency to 500 Hz,

press: FREQ 5 0 0 Hz mV .

Amplitude:

To set source amplitude to 3V,

press: AMPTD 3 kHz V .

Frequency Increment

To set frequency increment step to 10 Hz,

press: FREQ INCR 1 0 Hz mV .

Amplitude Increment

To set amplitude increment step to 200 mV,

press: AMPTD INCR 2 0 0 Hz mV .

Stepping Increments

To step frequency up 10 Hz (as set above),

press: FREQ ⇧ (holding ⇧ down causes frequency to move up slowly in 10 Hz steps).

MEASUREMENT

For ac level, SINAD, or distortion measurements,

press: AC LEVEL ● or SINAD ● or DISTN ● .

For dc level, signal-to-noise, or distortion level measurements,

press: ● S ● DC LEVEL or ● S ● SIG/NOISE or ● S ● DISTN LEVEL .

FILTERS

HP/BP Filter

To activate the PSOPH (psophometric) filter, press: PSOPH ● .

LP Filter

To activate the LOW PASS 30 kHz filter, press: LOW PASS 30 kHz ● .

SWEEP

Start Frequency

To set the start frequency of the sweep to 100 Hz,

press: START FREQ 1 0 0 Hz mV .

Stop Frequency

To set the stop frequency of the sweep to 10 kHz, press: STOP FREQ 1 0 kHz V .

Starting the Sweep

To start the frequency sweep, press: SWEEP ● .

RATIO and LOG/LIN

RATIO

To set the displayed measurement as the ratio reference, press: ● RATIO .

LOG/LIN

To convert from linear to logarithmic (or from logarithmic to linear) measurement units,

press: (LOG LIN) .

Measurement Mode	RATIO on		RATIO off	
	LIN	LOG	LIN	LOG
AC LEVEL	%	dB	V or mV	dBV
DC LEVEL	%	dB	Vor mV	dBV
SINAD	%	dB	%	dB
SIG/NOISE	%	dB	%	dB
DISTN	%	dB	%	dB
DISTN LEVEL	%	dB	V or mV	dBV

NOTE

During power up, the Audio Analyzer is initialized and set to AUTOMATIC OPERATION.

Table 3-2. Detailed Operating Instructions Table of Contents (Functional Listing)[1]

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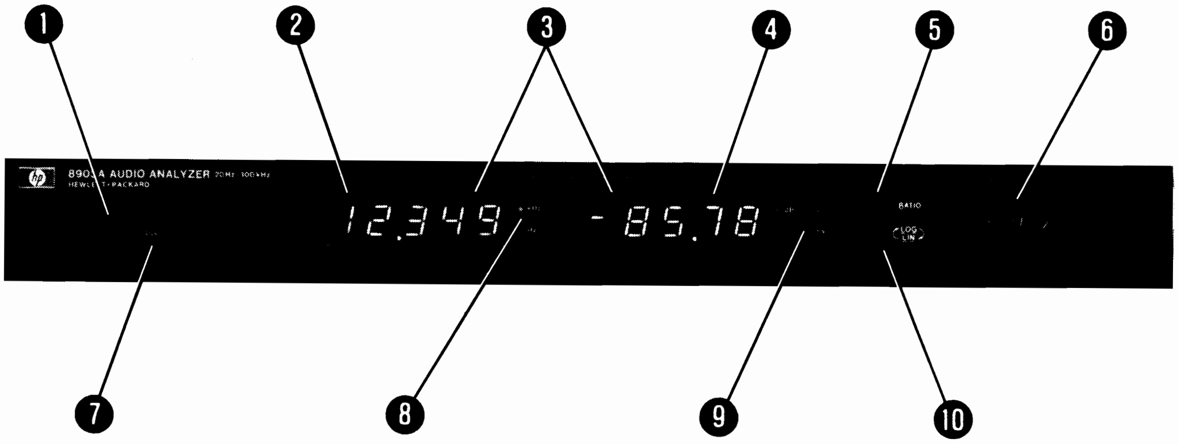
[1] The detailed operating instructions are arranged in alphabetical order at the end of the Operation section.

[2] ⚠ Do not apply more than 300 Vrms to the INPUT.



① **HP-IB Annunciators** display remote operation status. The REMOTE Annunciator lights when the instrument is in remote mode. The ADDRESSED annunciator lights whenever the instrument is addressed via the HP-IB (regardless of whether or not the instrument is in remote).

② **Left Display.** During normal operation, displays the frequency of the input signal (except in dc level). Also, when entering numeric data, it displays the entries.

③ **Both numeric displays** are also used in combination to display error codes or instrument or Special Function status.

④ **Right Display.** During normal operation, displays the measurement results. In addition, it is used for the two special error displays "— —" and "— — — —".

⑤ **RATIO Key.** Causes measurement results to be displayed in % or dB relative to a reference. The reference can be either the current measurement result or the desired reference can be entered using the unit keys and then pressing RATIO.

⑥ **SINAD** measurement results are indicated by both the right display and the SINAD meter (when within range). The meter is marked for EIA and CEPT sensitivity and selectivity.

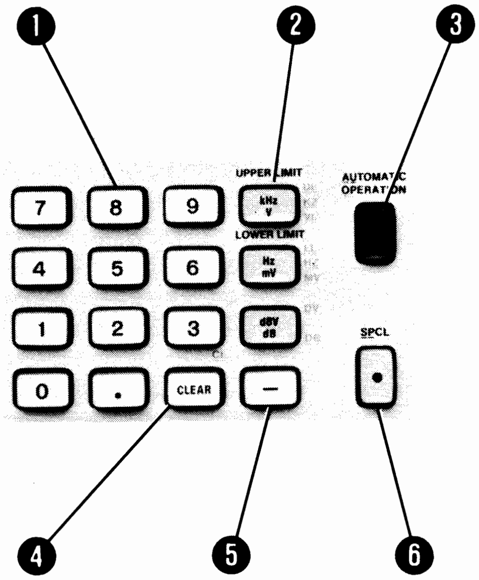
⑦ **LCL** (local) key returns the Audio Analyzer to local keyboard control from HP-IB (remote) control provided the instrument is not in Local Lockout.

⑧ **Frequency Display Annunciators** indicate the frequency units.

⑨ **Measurement Display Annunciators** indicate the measurement result units.

⑩ **LOG/LIN Key.** Causes measurement results to be displayed in logarithmic or linear units. If RATIO is on, results are displayed in % or dB. If RATIO is off, displayed units depend upon the current measurement mode.

Figure 3-2. Readout Panel Features



① **Numeric Keys.** Used to enter source frequency and amplitude, incremental values, ratio references, sweep start and stop frequencies, plot limits, and to select Special Functions. Numeric entries are completed by the RATIO, kHz/V (UPPER LIMIT), Hz/mV (LOWER LIMIT), dBV/dB, or SPCL keys. Numeric entries in progress are cleared by the CLEAR key.

② **Suffix Keys.** Terminate the keyboard entries (if properly sequenced) by entering the programmed value in memory. Instrument operation is modified as appropriate.

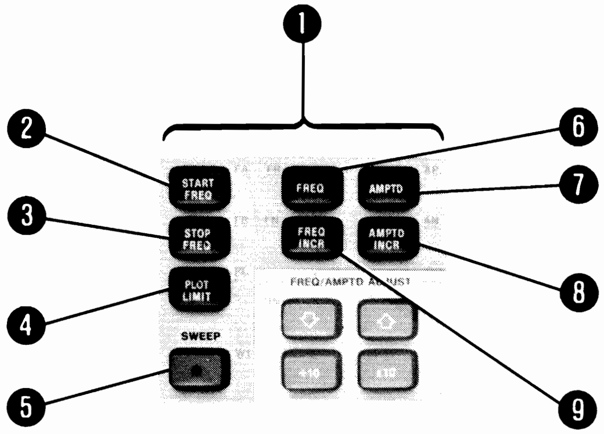
③ **AUTOMATIC OPERATION Key.** Switches the instrument functions to automatic (i.e., each function is allowed to automatically range to the appropriate setting). It also cancels all of the Special Functions that light the SPCL key.

④ **CLEAR Key.** Removes any keyboard entry in progress. If no entry is in progress, CLEAR turns off some Special Functions. In remote hold only (HP-IB code T1), the CLEAR key remains active and acts as a manual trigger with settling (HP-IB code T3).

⑤ **– (Minus) Key.** Used as a prefix for RATIO or dBV/dB entries. If the Minus key is pressed while entry is in progress, the minus is inserted into the leftmost digit. However, if it is pressed after five digits have been entered, it is ignored. If the minus is not allowed for the selected entry, Error 21 is displayed.

⑥ **SPCL Key.** Completes the keyboard entry of a Special Function code. Special Functions are instrument operations in addition to those accessible from dedicated front-panel keys. If pressed alone once, the SPCL key causes the requested modes of Special Functions 1 through 8 to be displayed. If pressed again while the requested modes are being displayed, the SPCL key causes the actual instrument settings to be displayed.

Figure 3-3. Source and Output Features (1 of 3)



❶ **Source Prefix Keys.** In addition to the functions described, the following keys are used to prefix numeric entries for the specified functions: START FREQ, STOP FREQ, PLOT LIMIT, FREQ, FREQ INCR, AMPTD, AMPTD INCR. The same specified function can be changed repeatedly without repressing the same prefix key as long as no other prefix key is pressed.

❷ **START FREQ Key.** Holding key down causes the programmed starting frequency of the sweep to appear in the left display. Note that the source is tuned to this frequency whenever the key is pressed. (Also see prefix keys.)

❸ **STOP FREQ Key.** Holding key down causes the programmed stopping frequency of the sweep to appear in the left display. Note that the source is tuned to this frequency whenever the key is pressed. (Also see prefix keys.)

❹ **PLOT LIMIT Key.** Holding key down causes the programmed plot limits to appear in the displays. The lower limit is in the left display and the upper limit is in the right display. (Also see prefix keys.)

❺ **SWEEP Key.** Initiates or restarts the sweep function. If the sweep is off, it initiates one sweep cycle and turns on the SWEEP LED. When cycle is completed, the LED is turned off. The source frequency remains at the last sweep point initiated before termination. If the sweep is on, pressing this key restarts the sweep. Use the CLEAR key to stop the sweep.

❻ **FREQ Key.** Holding key down causes the programmed frequency of the source to appear in the left display. (Also see prefix keys.)

❼ **AMPTD Key.** Holding key down causes the programmed amplitude of the source to appear in the right display. (Also see prefix keys.)

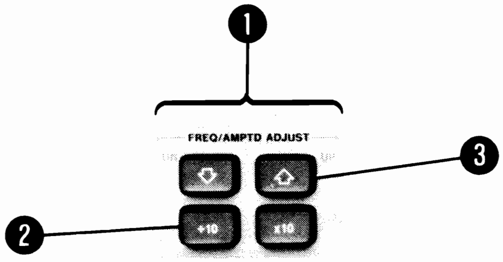
❽ **AMPTD INCR Key.** Holding key down causes the programmed amplitude increment to appear in the right display. (Also see prefix keys.)

❾ **FREQ INCR Key.** Holding key down causes the programmed frequency increment to appear in the left display. (Also see prefix keys.)

NOTE

Some delays may be noted when pressing keys during sweeps with an x-y recoder enabled. These delays allow the pen to lift before moving. However, the keys are recognized and it is unnecessary to hold them down while waiting for the Audio Analyzer to respond.

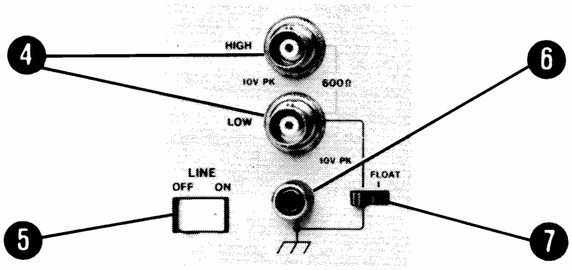
Figure 3-3. Source and Output Features (2 of 3)



① **FREQ/AMPTD ADJUST Keys.** These keys are used to manually adjust the frequency and amplitude of the source.

② **÷10 (or × 10) Keys.** Divides (or multiplies) the programmed frequency or amplitude increment value by a factor of 10 (the parameter changed depends upon whether FREQ INCR or AMPTD INCR was pressed last). If the source limits are exceeded, Error 21 is displayed.

③ **↑ (or ↓) Keys.** Increments (or decrements) the programmed frequency or amplitude of the source by the current frequency or amplitude increment (the parameter changed depends upon whether FREQ INCR or AMPTD INCR was pressed last). Holding the ↑ or the ↓ key down causes the increment (or decrement) to be repeated once each measurement cycle. If the source limits are exceeded, Error 21 is displayed.



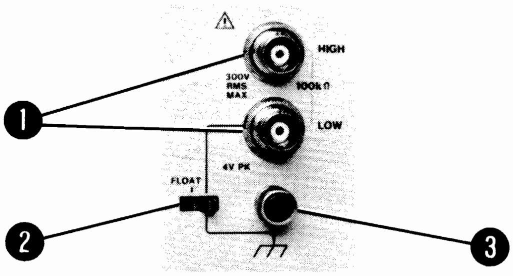
④ **OUTPUT HIGH and LOW Connectors.** Used to connect the source to the device under test. When the FLOAT switch is in the FLOAT position, both connectors are used. If the switch is in the grounded position, a single BNC-connector can be connected to the HIGH output. Output at the connectors is 0.60 mV to 6V (open circuit), 20 Hz to 100 kHz, with 600 Ω impedance.

⑤ **LINE Switch.** Applies power to the Audio Analyzer when set to the ON position.

⑥ **Ground Connector.** Convenient grounding point for source output cables.

⑦ **FLOAT Switch:** Used to select a floating or grounded LOW OUTPUT when required. Refer to FLOAT detailed operating instruction for additional information.

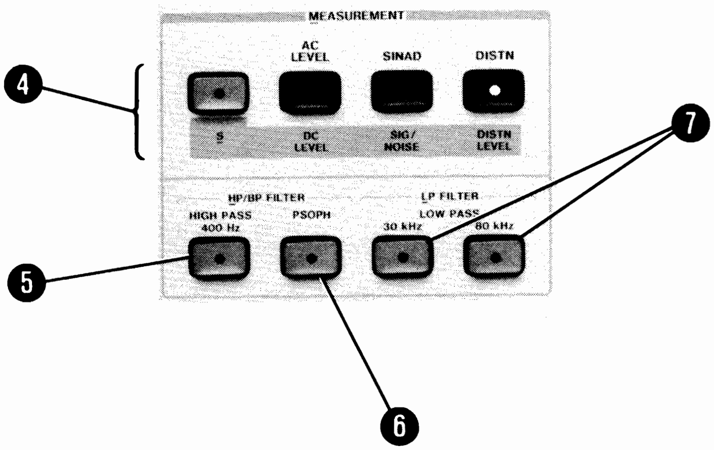
Figure 3-3. Source and Output Features (3 of 3)



❶ **INPUT HIGH and LOW Connectors.** Used to connect the device under test to the analyzer. When the FLOAT switch is in the FLOAT position, both connectors are used. If the switch is in the grounded position a single BNC-connector can be connected to the HIGH input. Input impedance is 100 kΩ (101 kΩ, dc level only).

❷ **FLOAT Switch.** Used to select a floating or grounded HIGH INPUT when required. Refer to FLOAT detailed operating instruction for additional information.

❸ **Ground Connector.** Convenient grounding point for input cables.



❹ **MEASUREMENT Keys.** Automatically configure the Audio Analyzer to make and display the measurement selected. To select a measurement labeled above a key, press the key. To select a measurement labeled below a key, press the S (Shift) key, then the MEASUREMENT key.

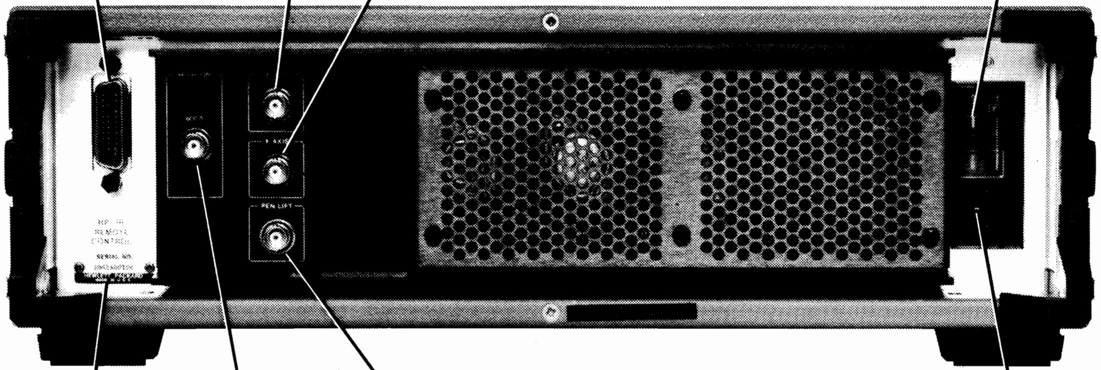
❺ **HIGH PASS 400 Hz** filter rejects line related noise and squelch tones.

❻ **PSOPH** (psophometric) filter for receiver testing to CEPT requirements.

❼ **LOW PASS 30 kHz and 80 kHz** filters reject high frequency noise.

Figure 3-4. Measurement and Input Features

REAR-PANEL FEATURES



HP-IB Connector connects the Audio Analyzer to the Hewlett-Packard Interface Bus for remote operations. When in remote mode, the front-panel REMOTE annunciator lights.

X AXIS. A scaled voltage output representing the log of the oscillator frequency range from the start to the stop frequencies. The start frequency equals 0V and the stop frequency equals 10V. Output impedance is 1 kΩ.

Y AXIS. A scaled voltage output representing the amplitude range from the lower to the upper limit of the plot. The lower limit equals 0V. The upper limit equals 10V. Output impedance is 1 kΩ.

Fuse. 1.25A (250V, time delay) for 100/120 Vac. 0.5A (250V, time delay) for 220/240 Vac.

Line Power Module permits operation from 100, 120, 220, or 240 Vac. The number visible in window indicates nominal line voltage to which instrument must be connected (see Figure 2-1). Center conductor is safety earth ground.

PEN LIFT. TTL compatible output that is used for pen control. TTL high signal is used to lift pen.

MONITOR. In ac level mode, provides a scaled voltage output representing the input signal. In SINAD, distortion, and distortion level modes, provides a scaled voltage output of the input signal with the fundamental removed. Output impedance is 600Ω.

Serial Number Plate. First four numbers and letter comprise the prefix that denotes the instrument configuration. The last five digits form the suffix that is unique to each instrument.

Figure 3-5. Rear Panel Features

3-9. OPERATOR'S CHECKS

3-10. Basic Functional Checks

DESCRIPTION: Using only an oscilloscope, the overall operation of the Audio Analyzer is verified.

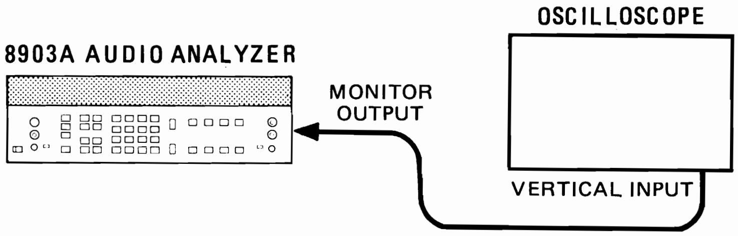


Figure 3-6. Basic Functional Checks Setup

EQUIPMENT: Oscilloscope .... HP 1740A

NOTE

The following checks are made using the rms responding voltmeter. If the Audio Analyzer has been changed to an average responding voltmeter configuration, the readings will differ slightly from those shown in these procedures.

PROCEDURE: **Preliminary Check**

1. Remove any cables from the Audio Analyzer's INPUT or OUTPUT. Set LINE switch to OFF, and then back to ON and note that the front-panel LED annunciators, display segments and decimal points, and key lights turn on. All LEDs should light for approximately four seconds.
2. After the turn-on sequence, the left display should show 0.000 kHz and the right display should show a low flickering value in mV. In addition, the measurement cycle annunciator in the upper left-hand corner of the right display should be blinking and the AC LEVEL and LOW PASS 80 kHz keys should light.
3. Connect a BNC-to-BNC cable between the OUTPUT HIGH jack and the INPUT HIGH jack and set both FLOAT switches to the grounded position.
4. Connect the oscilloscope to the MONITOR output on the rear-panel (see Figure 3-6).

AC LEVEL Check

5. Press the AMPTD key and note that the source is set to 0.00 mV as shown in the right display. Next, press the 1 and the V keys to set the amplitude to 1V. The left display will now show between 960 and 1040 Hz (the frequency that the source is set to during power up). The right display will show between 960 and 1040 mV. The oscilloscope should show a 1kHz (1 ms period) sine wave of approximately 7 Vp-p.

OPERATOR'S CHECKS

6. Press the RATIO key. The right display will show 100%.
7. Set OUTPUT FLOAT switch to FLOAT. The right display will show approximately 90%.
8. Set INPUT FLOAT switch to FLOAT. The right display will show approximately 50%.
9. Set both FLOAT switches to the grounded position.
10. Press the STOP FREQ key. The left display will show 20.000 kHz (the stop frequency that the source was set to during power up). Next, press the 1 0 0 kHz keys. The left display will show between 99.70 and 100.30 kHz.
11. Press the LOW PASS 80 kHz key and verify that the key's LED goes off.
12. Press the SWEEP key. Verify that the key's LED lights and that the source's frequency starts sweeping from 20 Hz to 100 kHz. During this sweep observe the right display and verify that it continues to show between 96 and 104% throughout the entire sweep. (Press SWEEP again if required to reinitiate the sweep.)

Filter Checks

13. Press the LOG/LIN key and verify that the right display annunciators switch to dB.
14. Press the LOW PASS 80 kHz key.
15. Use the FREQ, numeric data, and units keys to set the source to 80 kHz. Verify that the right display shows between −2 and −4 dB.
16. Press the LOW PASS 30 kHz key.
17. Set the source frequency to 30 kHz and verify that the right display shows between −2 and −4 dB.
18. Press the HIGH PASS 400 Hz key.
19. Set the source frequency to 400 Hz and verify that the right display shows between −2 and −6 dB.
20. Press the PSOPH key and set the source frequency as shown below. Verify that the right display is within the limits shown for each frequency.

Source Frequency (Hz)	RATIO Limits (dB)
300	−12.1 to −9.1
800	−0.4 to +0.4
3000	−7.1 to −4.1
3500	−11.5 to −5.5
5000	−40.0 to −32.0

OPERATOR'S CHECKS

SINAD Meter Check

21. Press the SINAD key and verify that the LED in the SINAD key lights.

22. Set the source frequency to 1 kHz.

23. Set the source frequency increment to 100 Hz.

24. Key in 6.1 then press the SPCL key.

25. Press the FREQ/AMPTD ADJUST ↓ key. The left display should show 900 Hz and the right display should show approximately 14 dB. The SINAD meter should read within ±1 dB of the right display.

DISTN, SINAD, and SIG/NOISE Check

26. Press AUTOMATIC OPERATION and PSOPH keys. Right display should show 80 dB or more.

27. Press DISTN key. Right display should show 0.01% or less.

28. Press S (Shift) and SIG/NOISE keys. Right display should show 80 dB or more.

SWEEP, X AXIS, Y AXIS, and PEN LIFT Check

29. Disconnect the cable from the OUTPUT, and reconnect it to the X AXIS connector on the rear panel.

30. Press the S (Shift) and DC LEVEL keys.

31. Press the SWEEP key. The right display will show an evenly spaced rising voltage from approximately 0V to 10V.

32. Disconnect the cable and reconnect it to the Y AXIS connector.

33. Press the START FREQ key. The right display will show between −0.01 and +0.01V.

34. Press the STOP FREQ key. The right display will show between 9.6 and 10.4V.

35. Disconnect the cable and reconnect it to the PEN LIFT connector.

36. Press the SWEEP key. The right display will momentarily show a TTL high level (greater than 2.4V), then drop to a TTL low level (less than 0.4V), and remain there until the sweep is complete. The display then shows a TTL high level.

3-11. HP-IB Functional Checks

DESCRIPTION: The following ten procedures check the Audio Analyzer's ability to process or send all of the applicable HP-IB messages described in Table 3-3. In addition, the Audio Analyzer's ability to recognize its HP-IB address is checked and all of the bus data, handshake, and control lines except DIO8 (the most significant data line which is not used by the Audio Analyzer) are set to both their true and false states. These procedures do not check whether or not all Audio Analyzer program codes are being properly interpreted and executed by the instrument, however, if the front-panel operation is good, the program codes, in all likelihood will be correctly implemented.

The validity of these checks is based on the following assumptions:

- The Audio Analyzer performs properly when operated via the front-panel keys (that is, in local mode). This can be verified with the Basic Functional Checks.
- The bus controller properly executes HP-IB operations.
- The bus controller's HP-IB interface properly executes the HP-IB operations.

If the Audio Analyzer appears to fail any of these HP-IB checks, the validity of the above assumptions should be confirmed before attempting to service the instrument.

The select code of the controller's HP-IB interface is assumed to be 7. The address of the Audio Analyzer is assumed to be 28 (its address as set at the factory). This select code-address combination (that is, 728) is not necessary for these checks to be valid. However, the program lines presented here would have to be modified for any other combination.

These checks are intended to be as independent of each other as possible. Nevertheless, the first four checks should be performed in order before other checks are selected. Any special initialization or requirements for a check are described at its beginning.

INITIAL SETUP: The test setup is the same for all of the checks. Connect the Audio Analyzer to the bus controller via the HP-IB interface. Do not connect any equipment to the Audio Analyzer's INPUT.

EQUIPMENT:	HP-IB Controller	HP 9825A/98213A (General and Extended I/O ROM)
	—or—	HP 9835A/98332A (I/O ROM)
	—or—	HP 9845A (with HP-IB I/O capability)
	HP-IB Interface	HP 98034A (use "revised" version with 9835A and 9845A)

Address Recognition

NOTE This check determines whether or not the Audio Analyzer recognizes when it is being addressed and when it is not. This check assumes only that the Audio Analyzer can properly handshake on the bus. Before beginning this check, set the Audio Analyzer's LINE switch to OFF, then to ON.

OPERATOR'S CHECKS

3-11. HP-IB Functional Checks (Cont'd)

Description	HP 9825A (HPL)	HP 9835A and 9845A (BASIC)
Set the Remote Enable (REN) bus control line false.	lcl 7	LOCAL 7
Send the Audio Analyzer's listen address.	wrt 728	OUTPUT 728

OPERATOR'S RESPONSE Check that the Audio Analyzer's REMOTE annunciator is off and that its ADDRESSED annunciator is on.

Unaddress the Audio Analyzer by sending a different address.	wrt 715	OUTPUT 715

OPERATOR'S RESPONSE Check that both the Audio Analyzer's REMOTE and ADDRESSED annunciators are off.

Remote and Local Messages and the LCL Key

NOTE This check determines whether the Audio Analyzer properly switches from local to remote control, from remote to local control, and whether the LCL key returns the instrument to local control. This check assumes that the Audio Analyzer is able to both handshake and recognize its own address. Before beginning this check, set the Audio Analyzer's LINE switch to OFF, then to ON.

Description	HP 9825A (HPL)	HP 9835A and 9845A (BASIC)
Send the Remote message (by setting Remote Enable, REN, true and addressing the Audio Analyzer to listen).	rem 728	REMOTE 728

OPERATOR'S RESPONSE Check that both the Audio Analyzer's REMOTE and ADDRESSED annunciators are on.

Send the Local message to the Audio Analyzer.	lcl 728	LOCAL 728

OPERATOR'S RESPONSE Check that the Audio Analyzer's REMOTE annunciator is off but its ADDRESSED annunciator is on.

Send the Remote message to the Audio Analyzer.	rem 728	REMOTE 728

OPERATOR'S RESPONSE Check that both the Audio Analyzer's REMOTE and ADDRESSED annunciators are on. Press the LCL key on the Audio Analyzer. Check that the Audio Analyzer's REMOTE annunciator is now off, but that its ADDRESSED annunciator remains on.

OPERATOR'S CHECKS

3-11. HP-IB Functional Checks (Cont'd)

Sending the Data Message

NOTE This check determines whether or not the Audio Analyzer properly issues Data messages when addressed to talk. This check assumes that the Audio Analyzer is able to handshake and recognize its own address. Before beginning this check, set the Audio Analyzer's LINE switch to OFF, then to ON, then after the power-up sequence is complete, press the DISTN key.

Description	HP 9825A (HPL)	HP 9835A and 9845A (BASIC)
Address the Audio Analyzer to talk and store its output data in variable V. (The output is E96 since there is no signal at its INPUT.)	red 728,V	ENTER 728;V
Display the value of V.	dsp V	PRINT V

OPERATOR'S RESPONSE Check that the Audio Analyzer's REMOTE annunciator is off but that its ADDRESSED annunciator is on. The controller's display should read 9009600000.00 (HP 9825A) or 9009600000 (HP 9835A and 9845A).

Receiving the Data Message

NOTE This check determines whether or not the Audio Analyzer properly receives Data messages. The Data messages sent also cause the 7 least significant HP-IB data lines to be placed in both their true and false states. This check assumes the Audio Analyzer is able to handshake, recognize its own address and properly make the remote/local transitions. Before beginning this check, set the Audio Analyzer's LINE switch to OFF, then to ON.

Description	HP 9825A (HPL)	HP 9835A and 9845A (BASIC)
Send the first part of the Remote message (enabling the Audio Analyzer to remote).	rem 7	REMOTE 7
Address the Audio Analyzer to listen-(completing the Remote message), then send a Data message (selecting the SINAD measurement).	wrt 728,"M2"	OUTPUT 728;"M2"

OPERATOR'S RESPONSE Check that both the Audio Analyzer's REMOTE and ADDRESSED annunciators are on. Check also that its SINAD key light is on.

Local Lockout and Clear Lockout/Set Local Messages

NOTE This check determines whether or not the Audio Analyzer properly receives the Local Lockout message, disabling all front-panel keys. The check also determines whether or not the Clear Lockout/Set Local message is properly received and executed by the Audio Analyzer. This check assumes that the Audio Analyzer is able to handshake, recognize its own address, and properly make the remote/local transitions. Before beginning this check, set the Audio Analyzer's LINE switch to OFF, then to ON.

OPERATOR'S CHECKS

3-11. HP-IB Functional Checks (Cont'd)

Local Lockout and Clear Lockout/Set Local (Cont'd)

Description	HP 9825A (HPL)	HP 9835A and 9845A (BASIC)
Send the first part of the Remote message (enabling the Audio Analyzer to remote).	rem 7	REMOTE 7
Send the Local Lockout message.	llo 7	LOCAL LOCKOUT 7
Address the Audio Analyzer to listen (completing the Remote message).	wrt 728	OUTPUT 728

OPERATOR'S RESPONSE Check that both the Audio Analyzer's REMOTE and ADDRESSED annunciators are on. Press the Audio Analyzer's LCL key. Both its REMOTE and ADDRESSED annunciators should remain on.

Send the Clear Lockout/Set Local message	lcl 7	LOCAL 7

OPERATOR'S RESPONSE Check that the Audio Analyzer's REMOTE annunciator is off but its ADDRESSED annunciator is on.

Clear Message

NOTE This check determines whether or not the Audio Analyzer properly responds to the Clear message. This check assumes that the Audio Analyzer is able to handshake, recognize its own address, make the remote/local changes and receive Data messages. Before beginning this check set the Audio Analyzer's LINE switch to OFF, then to ON.

Description	HP 9825A (HPL)	HP 9835A and 9845A (BASIC)
Send the first part of the Remote message (enabling the Audio Analyzer to remote).	rem 7	REMOTE 7
Address the Audio Analyzer to listen (completing the Remote message), then send a Data message that selects the SINAD measurement.	wrt 728,"M2"	OUTPUT 728;"M2"

OPERATOR'S RESPONSE Check that both the Audio Analyzer's REMOTE and ADDRESSED annunciators are on and that the SINAD key light is also on.

3-11. HP-IB Functional Checks (Cont'd)

Clear Message (Cont'd)

Send the Clear message (setting the Audio Analyzer's measurement to AC LEVEL).	clr 728	RESET 728

OPERATOR'S RESPONSE

Check that both the Audio Analyzer's REMOTE and ADDRESSED annunciators are on and that the AC LEVEL key light is on.

Abort Message

NOTE

This check determines whether or not the Audio Analyzer becomes unaddressed when it receives the Abort message. This check assumes that the Audio Analyzer is able to handshake, recognize its own address, make the remote/local changes, and enter serial-poll mode. Before beginning this check, set the Audio Analyzer's LINE switch to OFF, then to ON.

Description	HP 9825A (HPL)	HP 9835A and 9845A (BASIC)
Send the Remote message to the Audio Analyzer.	rem 728	REMOTE 728

OPERATOR'S RESPONSE

Check that both the Audio Analyzer's REMOTE and ADDRESSED annunciators are on.

Send the Abort message, unaddressing the Audio Analyzer to listen.	cli 7	ABORTIO 7

OPERATOR'S RESPONSE

Check that the Audio Analyzer's ADDRESSED annunciator is off. Note that the HP 9835A and 9845A ABORTIO statement sends both the Abort message *and the Local message.* Thus if the HP 9825A is being used, the Audio Analyzer's REMOTE annunciator should remain on. If the HP 9835A or 9845A is being used, the Audio Analyzer's REMOTE annunciator should turn off.

Send the Local message (HP 9825A only).	lcl 7	(The Local message was already sent with the ABORTIO 7 statement above.)
Address the Audio Analyzer to talk and store its output data in variable V.	red 728,V	ENTER 728;V

OPERATOR'S RESPONSE

Check that the Audio Analyzer's REMOTE annunciator is off but that its ADDRESSED annunciator is on.

Send the Abort message, unaddressing the Audio Analyzer to talk.	cli 7	ABORTIO 7

3-11. HP-IB Functional Checks (Cont'd)

Abort Message (Cont'd)

OPERATOR'S RESPONSE Check that both the Audio Analyzer's REMOTE and ADDRESSED annunciators are off.

Send the serial-poll-enable bus command (SPE) through the interface to place the Audio Analyzer in serial-poll mode.	wti 0, 7; wti 6, 24	SENDBUS 728; 1, 24

OPERATOR'S RESPONSE On the Audio Analyzer, key in 61.3 SPCL. The right display should show 1.0. This indicates the Audio Analyzer is in serial-poll mode (indicated by the "1").

Send the Abort message, removing the Audio Analyzer from serial-poll mode.	cli 7	ABORTIO 7

OPERATOR'S RESPONSE Check that the Audio Analyzer's right display shows 0.0. This indicates the Audio Analyzer properly left serial-poll mode upon receiving the Abort message.

Status Byte Message

NOTE This check determines whether or not the Audio Analyzer sends the Status Byte message in both the local and remote modes. This check assumes that the Audio Analyzer is able to handshake, recognize its own address, and make the remote/local changes. Before beginning this check, set the Audio Analyzer's LINE switch to OFF, then to ON.

Description	HP 9825A (HPL)	HP 9835A and 9845A (BASIC)
Place the Audio Analyzer in serial-poll mode and address it to talk (causing it to send the Status Byte message).	rds (728)→ V	STATUS 728;V
Display the value of V.	dsp V	PRINT V

OPERATOR'S RESPONSE Check that Audio Analyzer's REMOTE annunciator is off. Depending upon the vintage of the HP-IB interface (HP 98034A) used, the Audio Analyzer's ADDRESSED annunciator may be either on or off. The controller's display should read 0.00 (HP 9825A) or 0 (HP 9835A and HP 9845A).

Send the Remote message.	rem 728	REMOTE 728
Place the Audio Analyzer in serial-poll mode and address it to talk (causing it to send the Status Byte message).	rds (728) → V	STATUS 728;V
Display the value of V.	dsp V	PRINT V

3-11. HP-IB Functional Checks (Cont'd)

Status Byte Message (Cont'd)

OPERATOR'S RESPONSE Check that the Audio Analyzer's REMOTE annunciator is on. Depending upon the vintage of the HP-IB interface (HP 98034A) used, the Audio Analyzer's ADDRESSED annunciator may be either on or off. The controller's display should read 0.00 (HP 9825A) or 0 (HP 9835A and HP 9845A).

Require Service Message

NOTE This check determines whether or not the Audio Analyzer can issue the Require Service message (set the SRQ bus control line true). This check assumes that the Audio Analyzer is able to handshake, recognize its own address, make the remote/local changes, and receive Data messages. Before beginning this check, set the Audio Analyzer's LINE switch to OFF, then to ON, then after the power-up sequence is complete, press the DISTN key.

Description	HP 9825A (HPL)	HP 9835A and 9845A (BASIC)
Send the first part of the Remote message (enabling the Audio Analyzer to remote).	rem 7	REMOTE 7
Address the Audio Analyzer to listen (completing the Remote message) then send a Data message (enabling a Require Service message to be sent upon Instrument Error).	wrt 728,"22.4SP"	OUTPUT 728;"22.4SP"
Make the controller wait 2 seconds to allow time for the Audio Analyzer to send the Require Service message. (This step is not necessary if sufficient time is allowed.)	wait 2000	WAIT 2000
Read the binary status of the controller's HP-IB interface and store the data in variable V (in this step, 7 is the interface's select code).	rds (7) → V	STATUS 7; V
Display the value of the SRQ bit (in this step, 7 is the SRQ bit, numbered from 0).	dsp"SRQ=",bit (7,V)	PRINT "SRQ=";BIT (V,7)

OPERATOR'S RESPONSE Check that the SRQ value is 1, indicating the Audio Analyzer issued the Require Service message.

OPERATOR'S CHECKS

3-11. HP-IB Functional Checks (Cont'd)

Trigger Message and Clear Key Triggering

NOTE This check determines whether or not the Audio Analyzer responds to the Trigger message and whether the CLEAR key serves as a manual trigger in remote. This check assumes that the Audio Analyzer is able to handshake, recognize its own address, make the remote/local changes, and send and receive Data messages. Before beginning this check, set the Audio Analyzer's LINE switch to OFF, then to ON, then, when the power-up sequence is complete, press the DISTN key.

Description	HP 9825A (HPL)	HP 9835A and 9845A (BASIC)
Send the first part of the Remote message (enabling the Audio Analyzer to remote).	rem 7	REMOTE 7
Address the Audio Analyzer to listen (completing the Remote message), then send a Data message (placing the Audio Analyzer in Hold mode).	wrt 728, "T1"	OUTPUT 728; "T1"
Send the Trigger message.	trg 7	TRIGGER 7
Address the Audio Analyzer to talk and store the data in variable V.	red 728, V	ENTER 728; V
Display the value of V.	dsp V	PRINT V

OPERATOR'S RESPONSE Check that both the Audio Analyzer's REMOTE and ADDRESSED annunciators are on. The controller's display should read 9009600000.00 (HP 9825A) or 9009600000 (HP 9835A and HP 9845A).

Address the Audio Analyzer to talk and store the data in variable V.	red 728, V	ENTER 728;V

OPERATOR'S RESPONSE Check that the controller's "run" indicator is still on indicating that it has not received data from the Audio Analyzer. Press the Audio Analyzer's CLEAR key. The controller's "run" indicator should turn off.

3-12. REMOTE OPERATION, HEWLETT-PACKARD INTERFACE BUS

The Audio Analyzer can be operated through the Hewlett-Packard Interface Bus (HP-IB). Bus compatibility, programming, and data formats are described in the following paragraphs.

Except for the LINE switch, the ÷10 and ×10 keys, the low terminal ground/FLOAT switches, and the Controller Reset Service Special Function, all Audio Analyzer operations (including service related functions) are fully programmable via HP-IB. In addition, rapid source tuning and rapid frequency count capabilities (not available from the front-panel) are provided in remote operation.

A quick test of the HP-IB I/O is described under HP-IB Functional Checks. These checks verify that the Audio Analyzer can respond to or send each of the applicable bus messages described in Table 3-3.

For more information about HP-IB, refer to IEEE Standard 488, ANSI Standard MC1.1, the Hewlett-Packard Electronic Systems and Instruments catalog, and the booklet, "Improving Measurements in Engineering and Manufacturing" (HP part number 5952-0058).

3-13. HP-IB Compatibility

The Audio Analyzer's complete bus compatibility (as defined by IEEE Standard 488, and the identical ANSI Standard MC1.1) is described at the end of Table 3-3. Table 3-3 also summarizes the Audio Analyzer's HP-IB capabilities in terms of the twelve bus messages in the left-hand column.

3-14. Remote Mode

Remote Capability. In remote, most of the Audio Analyzer's front-panel controls are disabled (exceptions are the LCL and CLEAR keys). However, front-panel displays and the signal at various outputs remain active and valid. In remote, the Audio Analyzer may be addressed to talk or listen. When addressed to listen, the Audio Analyzer will respond to the Data, Trigger, Clear (SDC), and Local messages. When addressed to talk, the Audio Analyzer can issue the Data and Status Byte messages. Whether addressed or not, the Audio Analyzer will respond to the Clear (DCL), Local Lockout, Clear Lockout/Set Local, and Abort messages, and in addition, the Audio Analyzer may issue the Require Service message.

Local-to-Remote Mode Changes. The Audio Analyzer switches to remote operation upon receipt of the Remote message. The Remote message has two parts. They are:

- Remote enable bus control line (REN) set true
- Device listen address received once (while REN is true)

When the Audio Analyzer switches to remote, both the REMOTE and ADDRESSED annunciators on its front panel will turn on.

3-15. Local Mode

Local Capability. In local, the Audio Analyzer's front-panel controls are fully operational and the instrument will respond to the Remote message. Whether addressed or not, it will also respond to the Clear, Local Lockout, Clear Lockout/Set Local, and the Abort messages. When addressed to talk, the instrument can issue Data messages and the Status Byte message, and whether addressed or not, it can issue the Require Service message.

Remote-to-Local Mode Changes. The Audio Analyzer always switches to local from remote whenever it receives the Local message (GTL) or the Clear Lockout/Set Local message. (The Clear Lockout/Set Local message sets the Remote Enable control line [REN] false.) If it is not in Local Lockout mode, the Audio Analyzer switches to local from remote whenever its front panel LCL key is pressed.

3-16. Addressing

The Audio Analyzer interprets the byte on the bus' eight data lines as an address or a bus command if the bus is in the command mode: attention control line (ATN) true and interface clear control line (IFC) false. Whenever the Audio Analyzer is being addressed (whether in local or remote), the ADDRESSED annunciator on the front-panel will turn on.

The Audio Analyzer talk and listen addresses are switch selectable as described in paragraph 2-7. Refer to Table 2-1 for a comprehensive listing of all valid HP-IB address codes. To determine the present address setting, refer to the discussion titled HP-IB Address in the Detailed Operating Instructions near the end of this section.

Local Lockout. When a data transmission is interrupted, which can happen by returning the Audio

Table 3-3. Message Reference Table (1 of 2)

HP-IB Message	Applicable	Response	Related Commands and Controls	Interface Functions*
Data	Yes	All Audio Analyzer operations except the LINE switch and FLOAT switches and the ÷10 and ×10 functions are bus-programmable. All measurement results, special displays, and error outputs except the "— — — —" display are available to the bus.		AH1 SH1 T5, TE0 L3, LE0
Trigger	Yes	If in remote and addressed to listen, the Audio Analyzer makes a settled measurement according to previously programmed set-up. It responds equally to bus command GET and program code T3, Trigger With Settling (a Data message).	GET	DT1
Clear	Yes	Sets SOURCE to 1 kHz at 0 mV, MEASUREMENT to AC LEVEL with the 80 kHz LP FILTER on, and sets the trigger mode to free run. Resets many additional parameters as shown in Table 3-5. Clears Status Byte, RQS bit, Require Service message (if issued) and Local Lockout. Sets the Service Request Condition to the 22.2 state. Responds equally to Device Clear (DCL) and Selected Device Clear (SDC) bus commands.	DCL SDC	DC1
Remote	Yes	Remote mode is enabled when the REN bus control line is true. However, remote mode is not entered until the first time the Audio Analyzer is addressed to listen. The front-panel REMOTE annunciator lights when the instrument is actually in the remote mode. When entering remote mode, no instrument settings or functions are changed, but all front-panel keys except LCL and CLEAR are disabled, and entries in progress are cleared.	REN	RL1
Local	Yes	The Audio Analyzer returns to local mode (front-panel control). Responds equally to the GTL bus command and the front-panel LCL key. When entering local mode, no instrument settings or functions are changed but entries in progress are cleared. In local, triggering is free run only.	GTL	RL1
Local Lockout	Yes	Disables all front-panel keys including LCL and CLEAR. Only the controller can return the Audio Analyzer to local (front-panel control).	LLO	RL1
Clear Lockout/Set Local	Yes	The Audio Analyzer returns to local (front-panel control) and local lockout is cleared when the REN bus control line goes false. When entering local mode, no instrument settings or functions are changed, but entries in progress are cleared. In local, triggering is free run only.	REN	RL1
Pass Control/ Take Control	No	The Audio Analyzer has no control capability.		C0

*Commands, Control lines, and Interface Functions are defined in IEEE Std. 488. Knowledge of these might not be necessary if your controller's manual describes programming in terms of the twelve HP-IB Messages shown in the left column.

Table 3-3. Message Reference Table (2 of 2)

HP-IB Message	Applicable	Response	Related Commands and Controls	Interface Functions*
Require Service	Yes	The Audio Analyzer sets the SRQ bus control line true if an invalid program code is received. The Audio Analyzer will also set SRQ true, if enabled by the operator to do so, when measurement data is ready or when an instrument error occurs.	SRQ	SR1
Status Byte	Yes	The Audio Analyzer responds to a Serial Poll Enable (SPE) bus command by sending an 8-bit byte when addressed to talk. If the instrument is holding the SRQ control line true (issuing the Require Service message) bit 7 (RQS bit) in the Status Byte and the bit representing the condition causing the Require Service message to be issued will both be true. The bits in the Status Byte are latched but can be cleared by: 1) removing the causing condition, and 2) reading the Status Byte.	SPE SPD	T5, TE0
Status Bit	No	The Audio Analyzer does not respond to a parallel poll.		PP0
Abort	Yes	The Audio Analyzer stops talking and listening.	IFC	T5, TE0 L3, LE0

*Commands, Control lines, and Interface Functions are defined in IEEE Std. 488. Knowledge of these might not be necessary if your controller's manual describes programming in terms of the twelve HP-IB Messages shown in the left column.

Complete HP-IB capability as defined in IEEE Std.488 and ANSI Std.MC1.1 is: SH1, AH1, T5, TE0, L3, LE0, SR1, RL1, PP0, DC1, DT1, C0.

Addressing (Cont'd)

Analyzer to local mode by pressing the LCL key, the data could be lost. This would leave the Audio Analyzer in an unknown state. To prevent this, a local lockout is recommended. Local lockout disables the LCL key (and the CLEAR key) and allows return-to-local only under program control.

NOTE

Return-to-local can also be accomplished by turning the Audio Analyzer's LINE switch to OFF, then back to ON. However, this technique has several disadvantages.

- *It defeats the purpose and advantages of local lockout (that is, the system controller will lose control of a system element).*
- *There are several HP-IB conditions that reset to default states at turn-on.*

3-17. Data Messages

The Audio Analyzer communicates on the interface bus primarily with data messages. Data messages consist of one or more bytes sent over the 8 data bus lines, when the bus is in the data mode (attention control line [ATN] false). Unless it is set to Talk Only, the Audio Analyzer receives data messages when addressed to listen. Unless it is set to Listen Only, the Audio Analyzer sends data messages or the Status Byte message (if enabled) when addressed to talk. Virtually all instrument operations available in local mode may be performed in remote mode via data messages. The only exceptions are changing the LINE switch or FLOAT switch settings, using the ÷10 or ×10 functions, or the Controller Reset Service Special Function. In addition, the Audio Analyzer may be triggered via data messages to make measurements at a particular time.

3-18. Receiving the Data Message

Depending on how the internal address switches are set, the Audio Analyzer can either talk only, talk status only, listen only, or talk and listen both (normal operation). The instrument responds to Data messages when it is enabled to remote (REN control line true) and it is addressed to listen or set to Listen Only. If not set to Listen Only, the instrument remains addressed to listen until it receives an Abort message or until its talk address or a universal unlisten command is sent by the controller.

Listen Only. If the internal LON (Listen Only) switch is set to "1", the Audio Analyzer is placed in the Listen Only mode when the remote enable bus control line (REN) is set true. The instrument then responds to all Data messages, and the Trigger, Clear, and Local Lockout messages. However, it is inhibited from responding to the Local or Abort messages and from responding to a serial poll with the Status Byte message.

Listen Only mode is provided to allow the Audio Analyzer to accept programming from devices other than controllers (e.g., card readers).

Data Input Format. The Data message string, or program string, consists of a series of ASCII codes. With the exception of the Rapid Source mode, each code is typically equivalent to a front-panel keystroke in local mode. Thus, for a given operation, the program string syntax in remote mode is the same as the keystroke sequence in local mode. (For information about RS, Rapid Source, refer to Rapid Source in the Detailed Operating Instructions.) Example 1 shows the general case programming order for selecting Audio Analyzer functions. Specific program order considerations are discussed on page 3-27. All functions can be programmed together as a continuous string as typified in Example 2. The string in Example 2 clears most Special Functions (with Automatic Operation), programs the source to 440 Hz at 1V, selects a distortion measurement with 30 kHz low-pass filtering and log units, then triggers a settled measurement.

Program Codes. All of the valid HP-IB codes for controlling Audio Analyzer functions are summarized in Table 3-6. All front-panel keys except the LCL key and the ÷10 and ×10 keys have corresponding program codes.

Table 3-4 shows the Audio Analyzer's response to various ASCII characters not used in its code set. The characters in the left-hand column will be ignored unless they appear between two characters of a program code. The characters in the right-hand columns, if received by the Audio Analyzer, will always cause Error 24 (invalid HP-IB code) to be displayed and a Require Service message to be generated. The controller recognizes the invalid code entry and clears the Require Service condi-

EXAMPLE 1: General Program Syntax and Protocol*

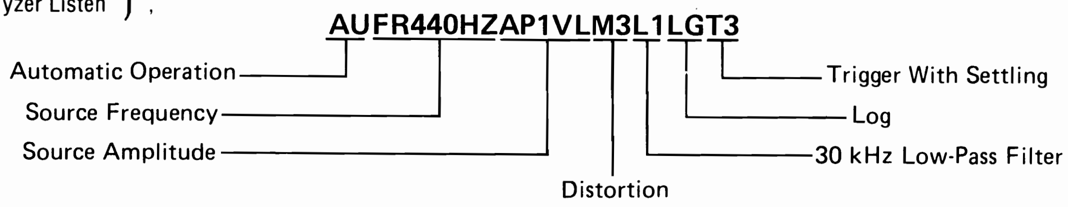
{ Controller Talk
Audio Analyzer Listen }

[Automatic Operation] [Source Frequency] [Source Amplitude] [Measurement] [Filters] [Special Functions] [Log/Lin] [Ratio] [Start Frequency]. . . . . .[Stop Frequency] [Plot Limit] [Sweep] [Trigger]

*Excluding Rapid Source or Rapid Frequency Count Modes.

EXAMPLE 2: Typical Program String

{ Controller Talk
Audio Analyzer Listen } ,



Receiving The Data Message (Cont'd)

Table 3-4. Audio Analyzer Response to Unused ASCII Codes

Ignored†	Generate Error 24	
!	@	[
“	B	\
”	E	]
#	G	^
%	I	_
&	J	{
(	N	|
)	Q	}
*	Y	~
,	Z	DEL
/		

†Except when inserted between two characters of a program code.

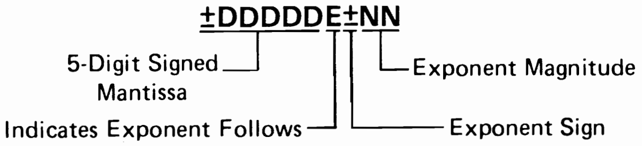
tion. Thereafter, the invalid code entry is ignored, and subsequent valid entries are processed in normal fashion. As a convenience, all lower case alpha characters are treated as upper case.

Turning Off Functions. When operating in local mode, the High-Pass, Bandpass, and Low-Pass Filters, and Ratio functions toggle on and off with successive keystrokes. In remote mode, these functions do not toggle on and off. Instead, each of the above groups has a specific code which turns off all the keys in the group. The HP-IB codes for turning off these functions are given in the table below.

Function	HP-IB Code
HP/BP FILTERS all off	H0
LP FILTERS all off	L0
RATIO off	R0
SWEEP off	W0

Programming Numeric Data. When programming source amplitude or frequency, entering ratio references, plot limits, or issuing any numeric data (other than specific HP-IB codes) to the Audio Analyzer, certain precautions should be observed. Numeric data may be entered in fixed, floating point, or exponential formats. Usually, numeric data consists of a signed mantissa of up to five digits (including leading zeros), one decimal point, and one- or two-digit signed exponent. The decimal point may fall between any two digits of the mantissa but should not appear ahead of the first digit. If it does, a leading zero will be automatically inserted by the Audio Analyzer. Any digit beyond the five allowed for the mantissa will be received as zero. The general format for numeric data entry is given below, followed by several examples illustrating various entries and the resulting data as received by the Audio Analyzer.

General Numeric Data Input Format:



Example: + .12345E+01 issued
0.12340E+01 received by
Audio Analyzer

Example: +123456E+01 issued
123450E+01 received by
Audio Analyzer

Example: +00012345 issued
12000 received by
Audio Analyzer

In general, do not issue numeric data with more significant digits than can be displayed on the Audio Analyzer's five-digit left display.

NOTE

The above numeric data input format information does not apply to the Rapid Source mode. Refer to Rapid Source in the Detailed Operating Instructions.

Triggering Measurements with the Data Message. A feature that is only available via remote programming is the selection of free run, standby, or triggered operation of the Audio Analyzer. During local operation the Audio Analyzer is allowed to free run, outputting data to the display as each measurement is completed. In remote (except in sweep), three additional operating modes are allowed: Hold, Trigger Immediate, and Trigger with Settling. In addition, the CLEAR key can act as a manual trigger while the instrument is in remote. The trigger modes and use of the CLEAR key are described below.

Free Run (T0). This mode is identical to local operation and is the mode of operation in effect when no other trigger mode has been selected. The measurement result data available to the bus are constantly being updated as rapidly as the Audio

Receiving the Data Message (Cont'd)
Analyzer can make measurements. A Device Clear message or entry into remote from local sets the Audio Analyzer to the Free Run mode.

NOTE

Free Run triggering (code T0) is the only trigger mode allowed when using the sweep function (code W1). Any other triggering (codes T1, T2, or T3) or use of CLEAR key triggering will cause only the start frequency point to be displayed, plotted, and read to the HP-IB. Both the rear-panel X AXIS and Y AXIS outputs will be inhibited from continuing beyond the start frequency point.

Hold (T1). This mode is used to set up triggered measurements (initiated by program codes T2 or T3, the Trigger message, or the CLEAR key). In Hold mode, internal settings can be altered by the instrument itself or by the user via the bus. Thus, the signal at the MONITOR output can change. However, the instrument is inhibited from outputting any data to the front-panel key lights and display, to the rear-panel X AXIS or Y AXIS outputs, or to the HP-IB except as follows. The instrument will issue the Require Service message if an HP-IB code error occurs. The instrument will issue the Status Byte message if serial polled. (A serial poll, however, will trigger a new measurement, update displays and return the instrument to Hold.)

Upon leaving Hold, the front-panel indications are updated as the new measurement cycle begins. The Status Byte will be affected (and the Require Service message issued) by the events that occur during the new measurement cycle. The Audio Analyzer leaves Hold when it receives either the Free Run, Trigger Immediate, Trigger with Settling codes, or the Trigger Message, when the CLEAR key is pressed (if not in Local Lockout), or when it returns to local operation.

Trigger Immediate (T2). When the Audio Analyzer receives the Trigger Immediate code, it makes one measurement in the shortest possible time. The instrument then waits for the measurement results to be read. While waiting, the instrument can process most bus commands without losing the measurement results. However, if the instrument receives GTL (Go To Local), GET (Group Execute Trigger), or its listen address or if it is triggered by the CLEAR key, a new measurement cycle will be executed. Once the data (measurement results) are read onto the bus, the Audio Analyzer reverts to the Hold mode. Measurement results obtained via Trigger Immediate are normally valid only when the instrument is in a steady, settled state.

Trigger with Settling (T3). Trigger with Settling is identical to Trigger Immediate except the Audio Analyzer inserts a settling-time delay before taking the requested measurement. This settling time is sufficient to produce valid, accurate measurement results. Trigger with Settling is the trigger type executed when a Trigger message is received via the bus.

Triggering Measurements with the CLEAR Key. When the Audio Analyzer is in remote Hold mode and not in Local Lockout, the front-panel CLEAR key may be used to issue a Trigger with Settling instruction. First place the instrument in Hold mode (code T1). Each time the CLEAR key is pressed, the Audio Analyzer performs one Trigger with Settling measurement cycle, then waits for the data to be read. Once the data is read out to the bus, the instrument returns to Hold mode. If data is not read between trigger cycles, it will be replaced with data acquired from subsequent measurements.

Special Considerations for Triggered Operation. When in free-run mode, the Audio Analyzer must pay attention to all universal bus commands, for example, serial poll enable (SPE), local lockout (LLO), etc. In addition, if it is addressed to listen, it must pay attention to all addressed bus commands, for example, go to local (GTL), group execute trigger (GET), etc. As a consequence of this, the Audio Analyzer must interrupt the current measurement cycle to determine whether any action in response to these commands is necessary. Since many elements of the measurements are transitory, the measurement must be reinitated following each interruption. Thus, if much bus activity occurs while the Audio Analyzer is trying to take a measurement, that measurement may never be completed.

Trigger Immediate and Trigger with Settling provide a way to avoid this problem. When the Trigger Immediate (T2) and Trigger with Settling (T3) codes are received, the Audio Analyzer will not allow its measurement to be interrupted. (Indeed, handshake of bus commands is inhibited until the measurement is complete.) Once the measurment is complete, bus commands will be

Receiving the Data Message (Cont'd)
processed, as discussed under Trigger Immediate above, with no loss of data. Thus, in an HP-IB environment where many bus commands are present, Trigger Immediate or Trigger with Settling should be used for failsafe operation.

NOTE

Free Run triggering (code T0) is the only trigger mode allowed when using the sweep function (code W1). Any other triggering (codes T1, T2, or T3) or use of CLEAR key triggering will cause only the start frequency point to be displayed, plotted, and read to the HP-IB. Both the rear-panel X AXIS and Y AXIS outputs will be inhibited from continuing beyond the start frequency point.

Reading Data from the Right or Left Display. The Audio Analyzer can only read data to the HP-IB once for each measurement made. Only the information on one display can be read each time. Use the codes RR (read right display) or RL (read left display) to control which information is read. The selected display will remain enabled until the opposing display is specified (or until a clear message is received or power-up occurs). Errors (which occupy two displays) are output as described above, and DC LEVEL measurement results (always occupying the right display only) are placed on the bus (when requested) regardless of which display is enabled.

Program Order Considerations. Although program string syntax is virtually identical to keystroke order some program order considerations need highlighting.

AUTOMATIC OPERATION (AU). As in local mode, when AUTOMATIC OPERATION is executed in remote it sets all Special Functions prefixed 1 through 8 to their zero-suffix mode and also affects many other Special Functions. Thus when AUTOMATIC OPERATION is used, it should appear at the beginning of a program string.

Frequency or Amplitude Increment Step Up or Steep Down (UP or DN). When a Step Up (UP) or Step Down (DN) is executed, the frequency or the amplitude is modified as determined by the established increment. The parameter changed is dependent upon which increment command was executed last. To insure the correct modification, program either Frequency Increment (FN) or Amplitude Increment (AN) immediately before the UP or DN command.

Trigger Immediate and Trigger with Settling (T2 and T3). When either of the trigger codes T2 or T3 is received by the Audio Analyzer, a measurement is immediately initiated. Once the measurement is complete, some bus commands can be processed without losing the measurement results. However, any HP-IB program code sent to the Audio Analyzer before the triggered measurement results have been output will initiate a new measurement Thus, trigger codes should always appear at the end of a program string, and the triggered measurement results must be read before any additional program codes are sent.

3-19. Sending the Data Message

Depending on how the internal address switches are set, the Audio Analyzer can either talk only, talk status only, listen only, or talk and listen both (normal operation). If set to both talk and listen, the instrument sends Data messages when addressed to talk. The instrument then remains configured to talk until it is unaddressed to talk by the controller. To unaddress the Audio Analyzer, the controller must send either an Abort message, a new talk address, or a universal untalk command.

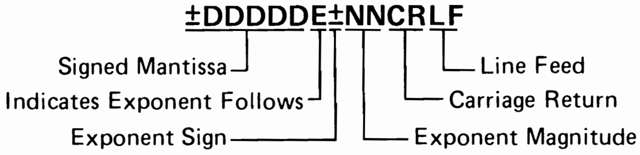
Talk Only Mode. If the internal address switches are set to a valid Talk address and the TON (Talk Only) switch is set to "1", the Audio Analyzer is placed in the Talk Only mode. In this mode instrument is configured to send Data messages whenever the bus is in the data mode. Each time the measurement is completed, the measurement result will be output to the bus unless the listening device is not ready for data. If the listener is not ready and the Audio Analyzer is not in a trigger mode, another measurement cycle is executed.

Talk Status Only Mode. If all the internal address switches and the TON (Talk Only) switch are set to "1", but the LON (Listen Only) switch is set to "0", the Audio Analyzer is placed in the Talk Status Only mode. In this mode the instrument is configured to send a one-byte data message whenever the bus is in the data mode. The byte sent is an exact copy of the Status Byte. Each time this byte is successfully sent on the bus, the internal Status Byte is cleared. The Data Valid (DAV) handshake line is pulsed each time the one-byte Data message is sent.

Sending the Data Message (Cont'd)

Data Output Format. As shown below, the output data is usually formatted as a real constant in exponential form: first the sign, then five digits (leading zeros not suppressed) followed by the letter E and a signed power-of-ten multiplier. (Refer to Rapid Frequency Count in the Detailed Operation Instructions for the only exceptions to this format.) The string is terminated by a carriage return (CR) and a line feed (LF), string positions 11 and 12. Data is always output in fundamental units (e.g., Hz, volts, dB, %, etc.), and the decimal point (not sent) is assumed to be to the right of the fifth digit of the mantissa. Data values never exceed 4 000 000 000.

Data Output Format:

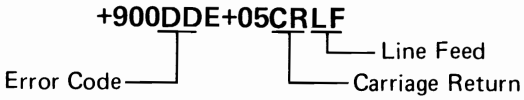


NOTE

For the only exception to the above format, refer to Rapid Frequency Count in the Detailed Operating Instructions.

When an error is output to the bus, it follows the same twelve-byte format described above except most of the numeric digits have predetermined values as shown below. Error outputs always exceed 9 000 000 000. The two-digit error code is represented by the last two digits of the five-digit mantissa. The error code can be derived from the string by subtracting 9×10^9, then dividing the results by 100 000.

Error Output Format:



3-20. Receiving the Clear Message

The Audio Analyzer responds to the Clear message by assuming the settings detailed in Table 3-5. The Audio Analyzer responds equally to the Selected Device Clear (SDC) bus command when addressed to listen, and the Device Clear (DCL) bus command whether addressed or not. The Clear message clears any pending Require Service message and resets the Service Request Condition (Special Function 22) such that the Require Service message will be issued on HP-IB code errors only (22.2 SPCL).

3-21. Receiving the Trigger Message

When in remote and addressed to listen, the Audio Analyzer responds to a Trigger message by executing one settled-measurement cycle. The Audio Analyzer responds equally to a Trigger message (the Group Execute Trigger bus command [GET]) and a Data message, program code T3 (Trigger with Settling). Refer to Triggering Measurements with the Data Message, page 3-25.

3-22. Receiving the Remote Message

The Remote message has two parts. First, the remote enable bus control line (REN) is held true, then the device listen address is sent by the controller. These two actions combine to place the Audio Analyzer in remote mode. Thus, the Audio Analyzer is enabled to go into remote when the controller begins the Remote message, but it does not actually switch to remote until addressed to listen the first time. No instrument settings are changed by the transition from local to remote, but the Trigger mode is set to Free Run (code T0). When actually in remote, the Audio Analyzer lights its front-panel REMOTE annunciator. When the Audio Analyzer is being addressed (whether in remote or local), its front-panel ADDRESSED annunciator turns on.

3-23. Receiving the Local Message

The Local message is the means by which the controller sends the Go To Local (GTL) bus command. If addressed to listen, the Audio Analyzer returns to front-panel control when it receives the Local message. If the instrument was in local lockout when the Local message was received, front-panel control is returned, but lockout is not cleared. Unless it receives the Clear Lockout/Set Local message, the Audio Analyzer will return to local lockout the next time it goes to remote. No instrument settings are changed by the transition from remote to local, but all measurements are made in a free run mode.

When the Audio Analyzer goes to local mode, the front-panel REMOTE annunciator turns off. However, when the Audio Analyzer is being addressed (whether in remote or local), its front-panel ADDRESSED annunciator lights.

If the Audio Analyzer is not in local lockout mode, pressing the front-panel LCL (local) key might

Table 3-5. Response to a Clear Message

Parameter	Setting
Start Frequency	20 Hz
Stop Frequency	20 kHz
Plot Limits	
Lower	–100.0
Upper	+100.0
X-Y Recorder	Enabled
Frequency	1000.0 Hz
Frequency Increment	1000.0 Hz
Amplitude	0.00 mV
Amplitude Increment	0.100V
Measurement	AC Level
Low-Pass (LP) Filter	80 kHz Low-Pass On
High-Pass (HP)/ Bandpass (BP) Filter	All off
SPCL	All Special Functions off or set to their zero-suffix mode except Service Request Condition set to 22.2 (HP-IB code error).
Ratio	Off
Log/Lin	Linear (refer to RATIO and LOG/LIN Detailed Operating Instructions.)
Right Display Read	Enabled
Service Request Condition	HP-IB Code Error Only
Status Byte	Cleared
Trigger Mode	Free Run (Code T0)
Local Lockout	Cleared

Receiving the Local Message (Cont'd)

interrupt a Data message being sent to the instrument, leaving the instrument in a state unknown to the controller. This can be prevented by disabling the Audio Analyzer's front-panel keys entirely using the Local Lockout message.

3-24. Receiving the Local Lockout Message

The Local Lockout message is the means by which the controller sends the Local Lockout (LLO) bus command. If in remote, the Audio Analyzer responds to the Local Lockout Message by disabling the front-panel LCL (local) and CLEAR keys. (In remote, CLEAR initiates a Trigger with Settling cycle.) The local lockout mode prevents loss of data or system control due to someone accidentally pressing front-panel keys. If, while in local, the Audio Analyzer is enabled to remote (i.e., REN is set true) and it receives the Local Lockout message, it will switch to remote mode with local lockout the first time it is addressed to listen. When in local lockout, the Audio Analyzer can be returned to local only by the controller (using the Local or Clear Lockout/Set Local messages) or by setting the LINE switch to OFF and back to ON or by removing the bus cable.

3-25. Receiving the Clear Lockout/Set Local Message

The Clear Lockout/Set Local message is the means by which the controller sets the Remote Enable (REN) bus control line false. The Audio Analyzer returns to local mode (full front-panel control) when it receives the Clear Lockout/Set Local message. No instrument settings are changed by the transition from remote with local lockout to local. When the Audio Analyzer goes to local mode, the front-panel REMOTE annunciator turns off.

3-26. Receiving the Pass Control Message

The Audio Analyzer does not respond to the Pass Control message because it cannot act as a controller.

3-27. Sending the Require Service Message

The Audio Analyzer sends the Require Service message by setting the Service Request (SRQ) bus control line true. The instrument can send the Require Service message in either local or remote mode. The Require Service message is cleared when a serial poll is executed by the controller or if a Clear message is received by the Audio Analyzer. (During serial poll, the Require Service message is cleared immediately before the Audio Analyzer places the Status Byte message on the bus.) An HP-IB code error will always cause a Require Service message to be issued. In addition, there are two other conditions which can be enabled to cause the Require Service message to be sent when they occur. All three conditions are described below.

- Data Ready: When the Audio Analyzer is ready to send any information except error codes or the Status Byte.
- HP-IB Code Error: When the Audio Analyzer receives an invalid Data message. (This condition always causes a Require Service message to be sent.)

NOTE

The "----" display indicates a transient condition. After 128 attempts to make a measurement, it is replaced by Error 31 which causes the Require Service message to be sent.

- Instrument Error: When any Error is being displayed by the Audio Analyzer including HP-IB Code error, E24.

3-28. Selecting the Service Request Condition

Use Special Function 22, Service Request Condition, to enable the Audio Analyzer to issue the Require Service message on any of the conditions above (except HP-IB code errors which always cause the Require Service message to be sent). The Service Request Condition Special Function is entered from either the front panel or via the HP-IB. The conditions enabled by Special Function 22 are always disabled by the Clear message. A description of the Service Request Condition Special Function and the procedure for enabling the various conditions are given under Service Request Condition in the Detailed Operation Instructions.

Normally, device subroutines for the Audio Analyzer can be implemented simply by triggering measurements then reading the output data. In certain applications, the controller must perform other tasks while controlling the Audio Analyzer. Figure 3-7 illustrates a flow chart for developing device subroutines using the instrument's ability to issue the Require Service message when data is ready. This subroutine structure frees the controller to process other routines until the Audio Analyzer is ready with data.

3-29. Sending the Status Byte Message

The Status Byte message consists of one 8-bit byte in which 3 of the bits are set according to the enabled conditions described above under Sending the Require Service Message.

If one or more of the three conditions described above are both enabled and present, all the bits corresponding to the conditions and also bit 7, the RQS bit, will be set true (and the Require Service message is sent). If one of the above conditions occurs but has not been enabled by Special Function 22, neither the bit corresponding to the condition nor the RQS bit will be set (and the Require Service message will not be sent). The bit pattern of the Status Byte is shown on page 3-32.

Once the Audio Analyzer receives the serial poll enable bus command (SPE), it is no longer allowed to alter the Status Byte. When addressed to talk (following SPE), the Audio Analyzer sends the Status Byte message.

NOTE

Since the Audio Analyzer cannot alter the Status Byte while in serial poll mode, it is not possible to continually request the Status Byte while waiting for a condition to cause a bit to be set.

After the Status Byte message has been sent it will be cleared if the Serial Poll Disable (SPD) bus command is received, if the Abort message is received, or if the Audio Analyzer is unaddressed to talk. Regardless of whether or not the Status Byte message has been sent, the Status Byte and any Require Service message pending will be cleared if a Clear message is received. If the instrument is set to Talk Only, the Status Byte is cleared each time the one-byte Data message is issued to the bus.

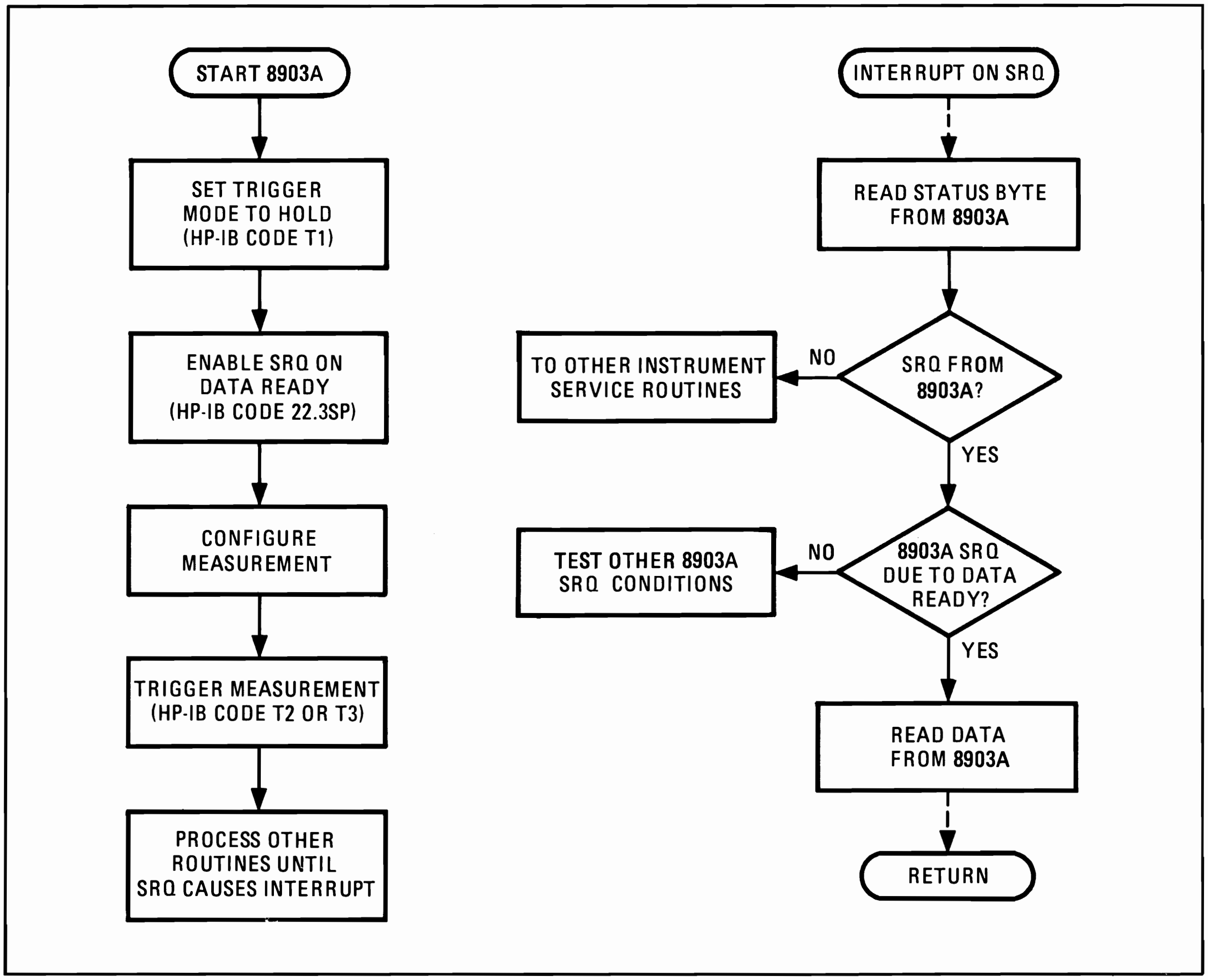


Figure 3-7. Example Flow Chart for Driving the Audio Analyzer Using the Require Service Message (SRQ)

3-30. Sending the Status Bit Message

The Audio Analyzer does not respond to a Parallel Poll Enable (PPE) bus command and thus cannot send the Status Bit message.

3-31. Receiving the Abort Message

The Abort message is the means by which the controller sets the Interface Clear (IFC) bus control line true. When the Abort message is received, the Audio Analyzer becomes unaddressed and stops talking or listening.

HP-IB SYNTAX AND CHARACTERISTICS SUMMARY

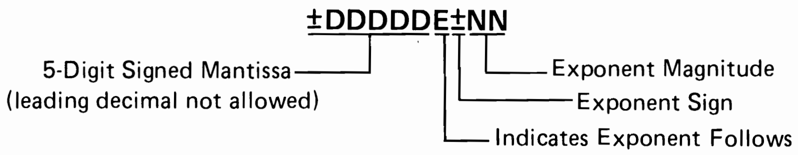
Address:

Set in binary by internal switches — may be displayed on front panel using Special Function 21, HP-IB Address. Factory set to 28 decimal; 11100 binary.

General Operating Syntax: (Excluding Rapid Frequency Count and Rapid Source modes.)*

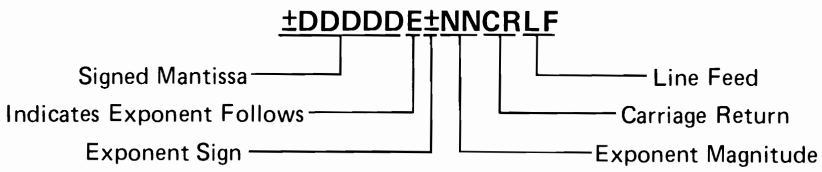
[Automatic Operation] [Source Frequency] [Source Amplitude] [Measurement] [Filters] [Special Functions] [Log/Lin] [Ratio] . . . . . . [Start Frequency] [Stop Frequency] [Plot Limit] [Sweep] [Trigger]

Numeric Data Input Format: (Except in Rapid Source mode.)*

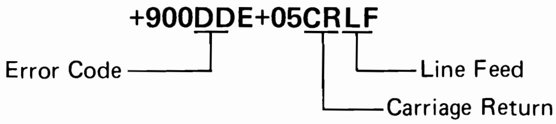


Output Formats: (Except in Rapid Frequency Count mode.)*

Data (valid data output value always <4 ×10⁹ and in fundamental units):



Errors:



Return to Local:

Front panel LCL key if not locked out.

Manual Trigger:

Front panel CLEAR key initiates **Trigger with Settling** measurement.

Status Byte:

Bit	8	7	6	5	4	3	2	1
Weight	128	64	32	16	8	4	2	1
Service Request Condition	0 (always)	RQS Bit Require Service	0 (always)	0 (always)	0 (always)	Instrument Error	HP-IB Code Error	Data Ready

Notes:
1. The condition indicated in bits 1 and 3 must be enabled to cause a Service Request by Special Function 22, Service Request Condition.
2. The RQS bit (bit 7) is set true whenever an HP-IB code error occurs or when any of the conditions of bits 1 and 3 are enabled and occur.
3. Bits set remain set until the Status Byte is cleared.

Complete HP-IB Capability (as described in IEEE Std 488, and ANSI Std MC1.1):

SH1, AH1, T5, TE0, L3, LE0, SR1, RL1, PP0, DC1, DT1, C0.

---

*For information on Rapid Frequency Count or Rapid Source modes refer to them by name in the Detailed Operating Instructions.

Table 3-6. Audio Analyzer Parameter to HP-IB Code Summary

Parameter	Program Code	Parameter	Program Code
Source		Measurements	
Function		AC Level	M1
Start Frequency	FA	SINAD	M2
Stop Frequency	FB	Distortion	M3
Plot Limit	PL	DC Level	S1
Frequency	FR	Signal-to-Noise	S2
Frequency Increment	FN	Distortion Level	S3
Amplitude	AP		
Amplitude Increment	AN	HP/BP Filters	
Data		400 Hz HP Filter on	H1
– (minus)	–	Psophometric BP Filter on	H2
*Clear	CL	All HP/BP Filters off	H0
0—9	0—9		
. (decimal point)	.	LP Filters	
Units		30 kHz LP Filter on	L1
kHz	KZ	80 kHz LP Filter on	L2
V	VL	All LP Filters off	L0
Upper Limit	UL		
Hz	HZ	Ratio	
mV	MV	On	R1
Lower Limit	LL	Off	R0
dB	DB		
dBV	DV	Log/Lin	
		Log	LG
		Lin	LN
Sweep on	W1		
Sweep off	W0	Trigger Modes	
↑ (step up)	UP	Free Run	T0
↓ (step down)	DN	Hold	T1
		Trigger Immediate	T2
		Trigger with Settling	T3
Automatic Operation	AU		
		Miscellaneous	
		Read Left Display	RL
SPCL	SP	Read Right Display	RR
SPCL SPCL	SS	Rapid Frequency Count	RF
		Rapid Source	RS

*Not to be confused with Clear message which is defined in Table 3-3.

Table 3-7. Audio Analyzer HP-IB Code to Parameter Summary

Program Code	Parameter	Program Code	Parameter
AN	Amplitude Increment	PL	Plot Limit
AP	Amplitude		
AU	Automatic Operation	RF	Rapid Frequency Count
		RL	Read Left Display
*CL	Clear	RR	Read Right Display
		RS	Rapid Source
DV	dBV	R0	Ratio on
DB	dB	R1	Ratio off
DN	↓ (step down)		
		SP	SPCL
FA	Start Frequency	SS	SPCL SPCL
FB	Stop Frequency	S1	DC Level
FN	Frequency Increment	S2	Signal-to-Noise
FR	Frequency	S3	Distortion Level
HZ	Hz	T0	Free Run
H0	All HP/BP Filters off	T1	Hold
H1	400 Hz Filter on	T2	Trigger Immediate
H2	Psophometric BP Filter on	T3	Trigger with Settling
KZ	kHz	UP	↑ (step up)
		UL	Upper Limit
LG	Log		
LN	Linear	VL	V
LL	Lower Limit		
L0	All LP Filters off	W0	Sweep off
L1	30 kHz LP Filter on	W1	Sweep on
L2	80 kHz LP Filter on		
		–	– (minus)
MV	mV	0—9	0—9
M1	AC Level	.	. (decimal point)
M2	SINAD		
M3	Distortion		

*Not to be confused with Clear message which is defined in Table 3-3.

Table 3-8. Audio Analyzer Special Function to HP-IB Code Summary (1 of 2)

Special Function	Program Code	Special Function	Program Code
Input Level Range		Post Notch Detector Response	
(except DC Level)		(except in SINAD)	
Automatic Selection	1.0SP	Fast Detector	5.0SP
300V range	1.1SP	Slow Detector	5.1SP
189V range	1.2SP		
119V range	1.3SP	Notch Tune	
75.4V range	1.4SP	Automatic notch tuning.	6.0SP
47.6V range	1.5SP	Hold notch tuning.	6.1SP
30.0V range	1.6SP		
18.9V range	1.7SP	SINAD Meter	
11.9V range	1.8SP	Range	
7.54V range	1.9SP	0 to ≈18 dB range	7.0SP
4.76V range	1.10SP	0 to ≈24 dB range	7.1SP
3.00V range	1.11SP		
1.89V range	1.12SP	Error Disable	
1.19V range	1.13SP	All errors enabled	8.0SP
0.754V range	1.14SP	Disable Analyzer errors	8.1SP
0.476V range	1.15SP	(Errors 12-17, 31, and 96)	
0.300V range	1.16SP	Disable Source errors	8.2SP
0.189V range	1.17SP	(Error 18 and 19)	
0.119V range	1.18SP	Disable both Analyzer and	8.3SP
0.0754V range	1.19SP	Source errors	
Input Level Range		Hold Settings	
(DC Level only)		Hold input level ranges, post-	9.0SP
Automatic Selection	2.0SP	notch gain, decimal point and	
300V range	2.1SP	notch tuning at present settings.	
64V range	2.2SP		
16V range	2.3SP	Display Source Settings	
4V range	2.4SP	Display source settings as en-	10.0SP
		tered. Frequency in left display;	
Post Notch Gain		amplitude in right display.	
Automatic Selection	3.0SP		
0 dB gain	3.1SP	Re-enter Ratio Mode	
20 dB gain	3.2SP	Restore last RATIO reference	11.0SP
40 dB gain	3.3SP	and enter RATIO mode if	
60 dB gain	3.4SP	allowed.	
		Display RATIO reference.	11.1SP
Hold Decimal Point			
Automatic Selection	4.0SP	Signal-to-Noise Measurements	
DDDD. range	4.1SP	Delay	
DDD.D range	4.2SP	Automatic Selection	12.0SP
DD.DD range	4.3SP	200 ms delay	12.1SP
D.DDD range	4.4SP	400 ms delay	12.2SP
0.DDDD range	4.5SP	600 ms delay	12.3SP
DD.DD mV range	4.6SP	800 ms delay	12.4SP
D.DDD mV range	4.7SP	1.0s delay	12.5SP
0.DDDD mV range	4.8SP	1.2s delay	12.6SP

Table 3-8. Audio Analyzer Special Function to HP-IB Code Summary (2 of 2)

Special Function	Program Code
Signal-to-Noise Measurements Delay (Cont'd)	
1.4s delay	12.7SP
1.6s delay	12.8SP
1.8s delay	12.9SP
X-Y Recorder	
Enable plot.	13.0SP
Disable plot.	13.1SP
Time Between Measurements	
Minimum time between measurements.	14.0SP
Add 1 s between measurements.	14.1SP
SINAD and Signal-to-Noise Display Resolution	
0.01 dB above 25 dB; 0.5 dB below 25 dB	16.0SP
0.01 dB all ranges	16.1SP
Sweep Resolution (maximum 255 points/sweep)	
10 points/decade	17.0SP
1 points/decade	17.1SP
2 points/decade	17.2SP
5 points/decade	17.3SP
10 points/decade	17.4SP
20 points/decade	17.5SP
50 points/decade	17.6SP
100 points/decade	17.7SP
200 points/decade	17.8SP
500 points/decade	17.9SP
Display Level in Watts	
Display level as watts into 8 ohms.	19.0SP
Display level as watts into NNN ohms.	19.NNNSP
Read Display to HP-IB	
Read right display.	20.0SP
Read left display.	20.1SP
HP-IB Address	
Displays HP-IB address (in binary) in left display; right display in form TLS where T=1 means talk only; L=1 means listen only; S=1 means SRQ.	21.0SP
Displays HP-IB address in decimal.	21.1SP
HP-IB Service Request Condition	
Enable a Condition to cause a service request, N is the sum of any combination of the weighted conditions below: 1—Data Ready 2—HP-IB error 4—Instrument error The instrument powers up in the 22.2 state (HP-IB) error.	22.NSP

Table 3-9. Commonly Used Code Conversions

ASCII	Binary	Octal	Decimal	Hexa-decimal
NUL	00 000 000	000	0	00
SOH	00 000 001	001	1	01
STX	00 000 010	002	2	02
ETX	00 000 011	003	3	03
EOT	00 000 100	004	4	04
ENQ	00 000 101	005	5	05
ACK	00 000 110	006	6	06
BEL	00 000 111	007	7	07
BS	00 001 000	010	8	08
HT	00 001 001	011	9	09
LF	00 001 010	012	10	0A
VT	00 001 011	013	11	0B
FF	00 001 100	014	12	0C
CR	00 001 101	015	13	0D
SO	00 001 110	016	14	0E
SI	00 001 111	017	15	0F
DLE	00 010 000	020	16	10
DC1	00 010 001	021	17	11
DC2	00 010 010	022	18	12
DC3	00 010 011	023	19	13
DC4	00 010 100	024	20	14
NAK	00 010 101	025	21	15
SYN	00 010 110	026	22	16
ETB	00 010 111	027	23	17
CAN	00 011 000	030	24	18
EM	00 011 001	031	25	19
SUB	00 011 010	032	26	1A
ESC	00 011 011	033	27	1B
FS	00 011 100	034	28	1C
GS	00 011 101	035	29	1D
RS	00 011 110	036	30	1E
US	00 011 111	037	31	1F
SP	00 100 000	040	32	20
!	00 100 001	041	33	21
"	00 100 010	042	34	22
#	00 100 011	043	35	23
$	00 100 100	044	36	24
%	00 100 101	045	37	25
&	00 100 110	046	38	26
'	00 100 111	047	39	27
(	00 101 000	050	40	28
)	00 101 001	051	41	29
*	00 101 010	052	42	2A
+	00 101 011	053	43	2B
,	00 101 100	054	44	2C
—	00 101 101	055	45	2D
.	00 101 110	056	46	2E
/	00 101 111	057	47	2F
0	00 110 000	060	48	30
1	00 110 001	061	49	31
2	00 110 010	062	50	32
3	00 110 011	063	51	33
4	00 110 100	064	52	34
5	00 110 101	065	53	35
6	00 110 110	066	54	36
7	00 110 111	067	55	37
8	00 111 000	070	56	38
9	00 111 001	071	57	39
:	00 111 010	072	58	3A
;	00 111 011	073	59	3B
<	00 111 100	074	60	3C
=	00 111 101	075	61	3D
>	00 111 110	076	62	3E
?	00 111 111	077	63	3F
@	01 000 000	100	64	40
A	01 000 001	101	65	41
B	01 000 010	102	66	42
C	01 000 011	103	67	43
D	01 000 100	104	68	44
E	01 000 101	105	69	45
F	01 000 110	106	70	46
G	01 000 111	107	71	47
H	01 001 000	110	72	48
I	01 001 001	111	73	49
J	01 001 010	112	74	4A
K	01 001 011	113	75	4B
L	01 001 100	114	76	4C
M	01 001 101	115	77	4D
N	01 001 110	116	78	4E
O	01 001 111	117	79	4F
P	01 010 000	120	80	50
Q	01 010 001	121	81	51
R	01 010 010	122	82	52
S	01 010 011	123	83	53
T	01 010 100	124	84	54
U	01 010 101	125	85	55
V	01 010 110	126	86	56
W	01 010 111	127	87	57
X	01 011 000	130	88	58
Y	01 011 001	131	89	59
Z	01 011 010	132	90	5A
[	01 011 011	133	91	5B
\	01 011 100	134	92	5C
]	01 011 101	135	93	5D
^	01 011 110	136	94	5E
_	01 011 111	137	95	5F
`	01 100 000	140	96	60
a	01 100 001	141	97	61
b	01 100 010	142	98	62
c	01 100 011	143	99	63
d	01 100 100	144	100	64
e	01 100 101	145	101	65
f	01 100 110	146	102	66
g	01 100 111	147	103	67
h	01 101 000	150	104	68
i	01 101 001	151	105	69
j	01 101 010	152	106	6A
k	01 101 011	153	107	6B
l	01 101 100	154	108	6C
m	01 101 101	155	109	6D
n	01 101 110	156	110	6E
o	01 101 111	157	111	6F
p	01 110 000	160	112	70
q	01 110 001	161	113	71
r	01 110 010	162	114	72
s	01 110 011	163	115	73
t	01 110 100	164	116	74
u	01 110 101	165	117	75
v	01 110 110	166	118	76
w	01 110 111	167	119	77
x	01 111 000	170	120	78
y	01 111 001	171	121	79
z	01 111 010	172	122	7A
{	01 111 011	173	123	7B
¦	01 111 100	174	124	7C
}	01 111 101	175	125	7D
~	01 111 110	176	126	7E
DEL	01 111 111	177	127	7F

AC Level

Description The Audio Analyzer contains a wideband, true rms voltmeter with high accuracy and sensitivity. The AC LEVEL key causes the Audio Analyzer to measure the differential ac voltage between its HIGH and LOW INPUT jacks. Signals that are common to both the HIGH and LOW jacks are rejected.

Procedure To make an ac level measurement, press the AC LEVEL key. AC level results can be displayed in V, mV, dBV, watts, or as the ratio to an entered or measured value. The Audio Analyzer powers up displaying ac level in linear units (mV or V). To obtain a display in dBV (that is, dB relative to 1 volt), press the LOG/LIN key. To return to linear, simply press the LOG/LIN key again. If the ac level is to be displayed relative to a reference, refer to RATIO and LOG/LIN.

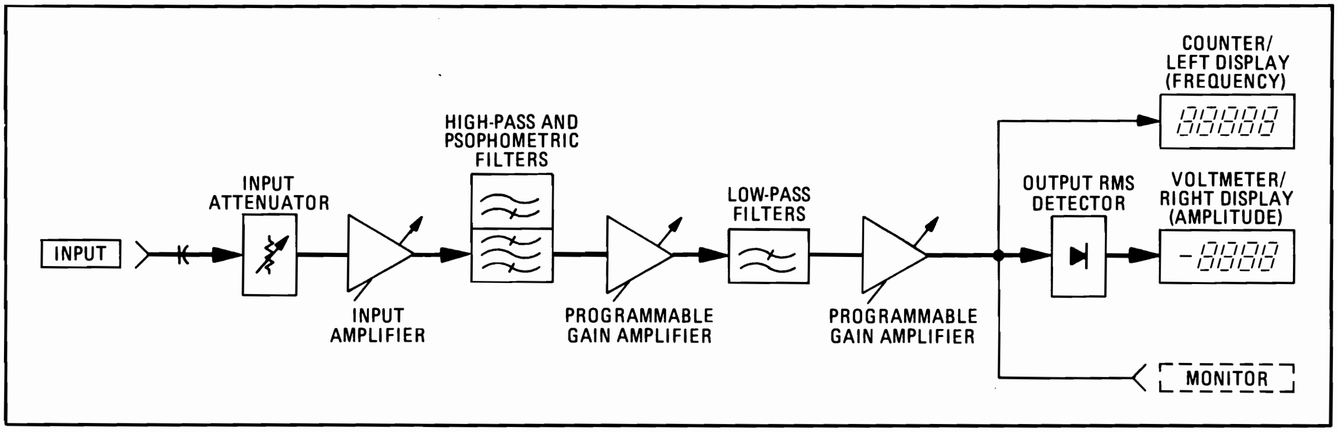
Example To measure the ac level of a signal at the INPUT jacks:

LOCAL (keystrokes)	Measurement AC LEVEL ●
HP-IB (program codes)	M1 Measurement

Program Code HP-IB M1 is the program code for AC LEVEL.

Indications When ac level is selected, the LED within the AC LEVEL key will light. The right display shows the ac level with the appropriate units. The Audio Analyzer automatically ranges for maximum resolution and accuracy. The left display shows the input signal frequency. If the input level to the frequency counter is too small, the left display will show 0.000 kHz. (This will often occur when the signal is in the stop band of the high-pass or psophometric filters, but not usually with the low-pass filters.)

Measurement Technique In ac level the Audio Analyzer acts as an ac voltmeter. The Audio Analyzer automatically sets the input attenuation and the gain settings of the various amplifiers so that the input signal amplitude lies within the range of the output rms detector. The output rms detector converts the ac level to a dc voltage which is then measured by the dc voltmeter and after correction for input gain and attenuation, displayed in appropriate units. The frequency of the input signal is also measured and displayed.



AC Level Measurement Block Diagram

AC Level (Cont'd)

Comments

The Audio Analyzer powers up in the ac level measurement mode with the 80 kHz low-pass filter activated. The 80 kHz low-pass filter reduces the measurement bandwidth from 500 kHz to 80 kHz.

NOTE

Common mode levels must not exceed 4V peak. Higher common mode levels may cause inaccurate measurements.

The Audio Analyzer employs a true rms detector. When measuring complex waveforms or noise, a true rms detector will provide a more accurate rms measurement than an average-responding detector which has been calibrated to indicate the rms value of a sine wave. For a sine wave, both the true rms and the average-responding detectors give correct rms readings. However, when the signal is a complex waveform, or when significant noise is present, the average-responding detector reading can be in error. The amount of error depends upon the particular signal being measured. For noise, an average-responding detector reads low.

Many ac voltmeters employ an average-responding detector. For those applications requiring the use of an average-responding detector the Audio Analyzer can be converted by altering internal jumpers. The jumpers are installed at the factory for true rms detection. (See Service Sheet 6 in Section VIII.)

Related Sections

Display Level in Watts
Filters
Monitor
RATIO and LOG/LIN
Special Functions

Amplitude

Description The Audio Analyzer contains a low-distortion audio source. The AMPTD key, the numeric data and the unit keys are used to program the output level of the source. The source level can be entered in V, mV, or dBV (that is, dB relative to 1 volt). The amplitude entered is the open-circuit value. The output impedance is 600 ohms. The AMPTD key is also used to display the currently programmed output level. The amplitude range is 0.6 mV to 6V. The maximum resolution is better than 0.3 percent.

Procedure To set the source output level, press the AMPTD key and then the appropriate numeric data and unit keys. Once the AMPTD key has been pressed, new data and unit entries can be made to select different amplitudes until another source function key (for example, the FREQ key) is pressed. To display the currently programmed amplitude, press and hold the AMPTD key.

Example To set source output level to 1.5V:

LOCAL (keystrokes)	Function — Data — Unit AMPTD 1 . 5 kHz/V
HP-IB (program codes)	AP1.5VL Function — Data — Unit

Program Code HP-IB AP is the program code for the AMPTD key.

Indications When the AMPTD key is pressed, the right display shows the currently programmed output level. As the new output level data is entered, it will appear on the left display. When the units key is pressed, the left display returns to show the input signal frequency. When the amplitude is set to 0V, the output is opened up but the oscillator remains on.

Comments The Audio Analyzer powers up with the source amplitude set at 0 volts. When the amplitude is set to 0V, the output is opened up but the oscillator remains on.

When the AMPTD key is pressed and held the right display shows the currently programmed amplitude. It is important to realize the value shown in the right display is the programmed value which can differ from the actual value at the OUTPUT. For example, since the source output impedance is 600 ohms, the voltage developed across an external 600-ohm load will be half the programmed value.

Related Sections

Display Source Settings
Frequency
Increment

Automatic Operation

Description

The AUTOMATIC OPERATION key sets the instrument functions to automatic (i.e., each function is allowed to automatically range to the appropriate setting). It also cancels all of the functions that light the SPCL key light.

Procedure

To set the Audio Analyzer to automatic operation, press the AUTOMATIC OPERATION key.

Example

To set the Audio Analyzer to automatic operation:

LOCAL (keystrokes)	AUTOMATIC OPERATION ▯
HP-IB (program codes)	AU Function

Program Code HP-IB

AU is the HP-IB code for AUTOMATIC OPERATION.

Indications

When the key is pressed, the right display blanks and then shows four dashes. When the key is released, the display is dependent upon the current measurement mode and input.

Comments

If the Audio Analyzer is in the 10.0 Special Function (Display Source Settings), the instrument returns to the ac level measurement mode.

The converse of the automatic operation mode is the Hold Settings Special Function (prefixed 9). Refer to Hold Settings.

For information on which specific Special Functions are turned off by the AUTOMATIC OPERATION key refer to Special Functions. Since AUTOMATIC OPERATION affects Special Functions, it is a good practice to place the AU code at the beginning of a program string when used in programming.

Related Sections

Display Source Settings
Hold Settings
Special Functions

DC Level

Description

The DC LEVEL key causes the Audio Analyzer to measure the differential dc voltage between its HIGH and LOW INPUT jacks. Signals that are common to both the HIGH and LOW jacks are rejected.

Procedure

To make a dc level measurement, press the S (Shift) key, then the DC LEVEL key. The voltage can be expressed in either volts, or, if the voltage is positive, in dBV (that is, dB relative to 1 volt). To obtain a display in dBV, press the LOG/LIN key. To return to linear, simply press the LOG/LIN key again. If the dc level is to be displayed relative to a reference level, refer to RATIO and LOG/LIN.

Example

To measure the dc level at the INPUT jacks:

LOCAL (keystrokes)	S DC LEVEL
HP-IB (program codes)	S1 Measurement

Program Code HP-IB

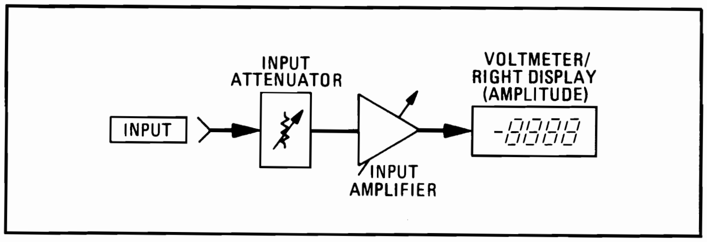
S1 is the HP-IB code for DC LEVEL.

Indications

When dc level is selected, the LEDs within the DC LEVEL key and the S (Shift) key will light. The right display shows the dc level with the appropriate units. The Audio Analyzer automatically ranges for maximum resolution and accuracy. In the dc level measurement mode the left display is blanked even though an ac signal may be present.

Measurement Technique

In the dc level measurement mode the Audio Analyzer automatically sets the input attenuation and the gain of the input amplifier so that the signal amplitude lies within the proper range of the dc voltmeter. The signal is then measured by the dc voltmeter and after correction for input gain and attenuation, displayed in appropriate units.



DC Level Measurement Block Diagram

Comments

Common-mode levels must not exceed 4V peak.

In the dc level measurement mode only the ac component of the input signal is coupled to the MONITOR output. The ac component also affects the input gain.

Related Sections

RATIO and LOG/LIN
Special Functions

Default Conditions and Power-up Sequence

Description

When first turned on, the Audio Analyzer performs a sequence of internal checks after which the instrument is ready to make measurements. During the power-up sequence, all front-panel indicators light to allow the operator to determine if any are defective. After approximately four seconds, this sequence is completed and the Audio Analyzer is preset as follows:

START FREQ	20 Hz
STOP FREQ	20 kHz
PLOT LIMIT	
LOWER LIMIT	−100.0
UPPER LIMIT	100.0
FREQ	1000.0 Hz
FREQ INCR	1000.0 Hz
AMPTD	0.00 mV
AMPTD INCR	0.100V
MEASUREMENT	AC LEVEL
LP FILTER	LOW PASS 80 kHz
HP/BP FILTER	Off
RATIO	Off
Ratio Reference	0
LOG/LIN	LIN (see RATIO and LOG/LIN Detailed Operating Instruction)
Left Display	Input Frequency
Right Display	Input AC Level
Service Request Condition	HP-IB Code Error Only
Status Byte	Cleared
Trigger Mode	Free Run (Code T0)
SPCL	All Special Functions off or in their zero suffix, except Service Request Condition which is set to 22.2 (HP-IB Code Error).
Plotter	Enabled
X AXIS, Y AXIS	0V
PEN LIFT	TTL high

Related Sections

RATIO and LOG/LIN
Service Request Condition

Display Level in Watts

(Special Function 19)

Description The measurement mode can be set to read the ac input power level in watts into a specified external load resistance by using Special Function 19. The range of the selectable load resistance is an integer value from 1 to 999 ohms.

Procedure To set the measurement to display the ac level in watts into a specified resistance, key in the corresponding Special Function code; and then press the SPCL key.

Resistance (ohms)	Special Function Code	Program Code HP-IB
8 1-999	19.0 SPCL 19.NNN SPCL (where NNN corresponds to the load resistance)	19.0SP 19.NNNSP

Example To set the right display to read INPUT signal level in watts into an external 16 ohm speaker:

LOCAL (keystrokes)	Code 1 9 . 1 6	Function SPCL •
HP-IB (program codes)	19.16SP Code	Function

Program Codes HP-IB For HP-IB codes, refer to Procedure above.

Indications As the numeric code is entered, both displays will blank and the entered code will appear in the left display. When the SPCL key is pressed, the SPCL key will light if it is not already on. If it is on, it will remain on. The right display shows a four-digit readout of the ac power in watts but no units are indicated. All measurement LEDs go off.

Comments The load resistance in ohms must be entered in integers (e.g., a resistance of 5.8 ohms cannot be entered). The decimal point has already been used when entering the Special Function. An attempt to enter a second decimal point is ignored.

Remember that the instrument assumes that the input voltage is being developed across the specified external load resistance. If an incorrect resistance is entered, the readout in watts is shown for the resistance entered.

Zeros immediately following the decimal point are optional. For example,when setting the load resistance to 1 ohm, 19.1 is equivalent to 19.01 and 19.001. However, 19.1 is not equivalent to 19.10 or 19.100. Note that 19.0 and 19.8 are equivalent (i.e., they both specify an 8 ohm load resistance).

Display Level in Watts (Cont'd)

(Special Function 19)

Comments (Cont'd)

The displayed power level is accurate regardless of distortion unless the Audio Analyzer's audio detector is configured as average responding.

Neither the RATIO nor the LOG function can be used with this Special Function.

Related Section

AC Level

Display Source Settings

(Special Function 10)

Description The currently programmed frequency and amplitude of the source can be simultaneously displayed by using Special Function 10. The programmed frequency is displayed in the left display and the programmed amplitude (open-circuit) is displayed in the right display.

Procedure To display the currently programmed frequency and amplitude of the source, press 10.0 and then the SPCL key.

Example To display the source settings:

	Code	Function
LOCAL (keystrokes)	1 0 . 0	SPCL •
HP-IB (program codes)	10.0SP Code	Function

Program Code HP-IB 10.0SP is the HP-IB code for Special Function 10.

Indications As the numeric code is entered, both displays will blank, and the entered code will appear in the left display. When the SPCL key is pressed, the SPCL key LED will light if it is not already on. If it is already on, it will remain on. The displays then show the source's currently programmed frequency in the left display and its currently programmed amplitude in the right display.

Comments It is important to realize that neither display is a measurement of the source output. Therefore, the actual values at the OUTPUT jack may differ from the programmed values. In the case of frequency, there is usually only a very slight difference. In the case of amplitude, the difference is dependent upon the load impedance. For example, since the output impedance is 600 ohms, a load impedance of 600 ohms causes the amplitude at the OUTPUT jack to be half of the programmed value.

Related Sections

Amplitude
Automatic Operation
Frequency
Special Functions

Distortion

Description

The Audio Analyzer measures distortion by first determining the following value:

$$D = \frac{\text{noise} + \text{distortion}}{\text{signal} + \text{noise} + \text{distortion}}$$

It then converts D into the appropriate measurement units as follows:

$$\%\ \text{units} = D \times 100\%$$

$$\text{dB units} = 20\log D$$

The RATIO key can be used to compare the measured results to a predetermined ratio reference value (refer to RATIO and LOG/LIN).

A distortion measurement can be made on signals from 20 Hz to 100 kHz and from 50 mV to 300V.

Procedure

To make a distortion measurement, press the DISTN key. If the internal source is to be used as the stimulus signal, key in the desired frequency and amplitude. Use the filters to limit noise, hum, spurious signals, etc. The Audio Analyzer powers up with the LOW PASS 80 kHz filter activated.

Example

To measure the distortion of an external source in a 30 kHz bandwidth:

LOCAL (keystrokes)	Measurement — Filter DISTN ● — LOW PASS 30 kHz ●
HP-IB (program codes)	M3L1 Measurement — Filter

Program Code HP-IB

M3 is the HP-IB code for the distortion measurement.

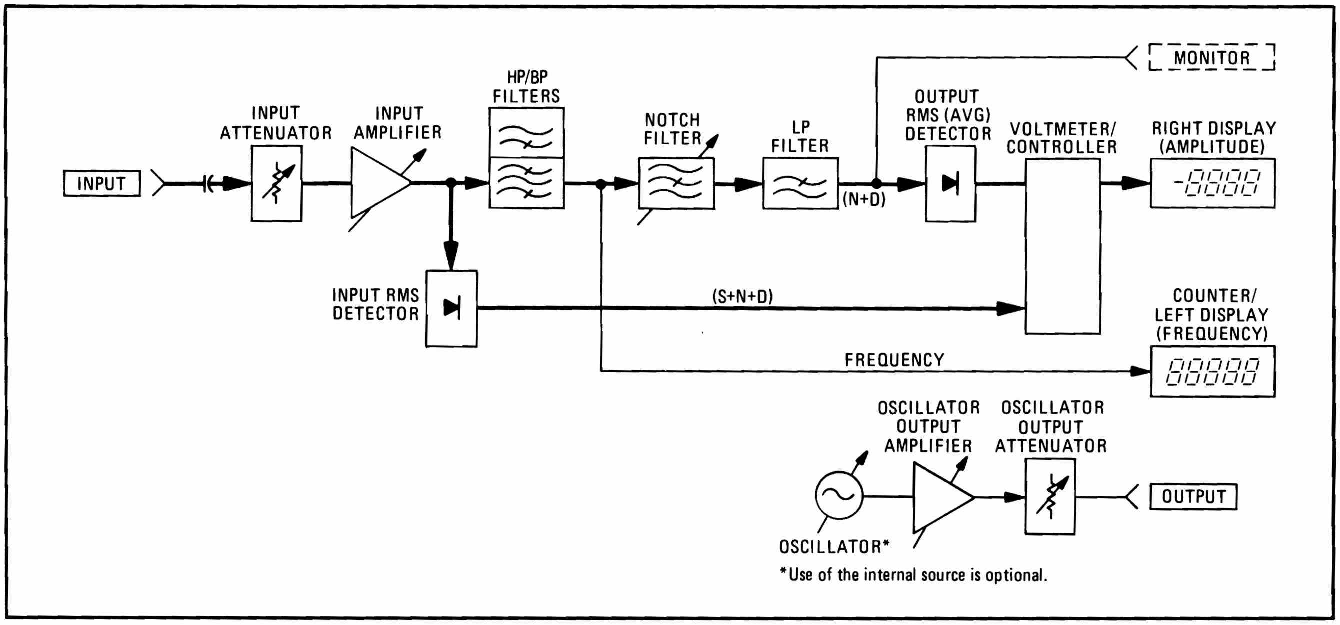
Indications

When distortion is selected, the LED within the DISTN key will light. The frequency and distortion of the input signal are displayed and the appropriate annunciators are lighted (see Description above).

Measurement Technique

In the distortion measurement mode, the controller automatically sets the input attenuation and the gain settings of various amplifiers. This control ensures that the signal amplitude is within the proper range for the input and output rms detectors. The input rms detector converts the ac level of the combined signal + noise + distortion to dc. The notch filter removes the fundamental signal. The notch filter automatically tunes to the component whose frequency is measured by the counter (usually the fundamental of the input signal). The output rms detector converts the residual noise + distortion to dc. The dc voltmeter measures both dc signals. The controller then corrects for the programmed gain and attenuation, computes the ratio of the two signals , and displays the results in appropriate units. The frequency of the input signal is also measured and displayed.

Distortion (Cont'd)



Distortion Measurement Block Diagram

Related Sections	Distortion Level Filters Notch Tune RATIO and LOG/LIN

Distortion Level

Description

The Audio Analyzer measures the distortion level by removing the fundamental of the input signal and then measuring the ac level of the remaining noise and distortion. The mV and V units are displayed in the linear mode or the values are converted to dBV (i.e., dB relative to 1V). The RATIO key can be used to compare the measured results to a predetermined ratio reference (refer to RATIO and LOG/LIN).

Procedure

To make a distortion level measurement, press the S (Shift) and DISTN LEVEL keys. If the internal source is to be used as a stimulus signal, key in the desired frequency and amplitude. The filters are used to limit the bandwidth. The Audio Analyzer powers up with the LOW PASS 80 kHz filter activated.

Example

To measure distortion level on an external source signal in a 30 kHz bandwidth:

LOCAL (keystrokes)	Measurement ● S ● DISTN LEVEL Filter LOW PASS 30 kHz ●
HP-IB (program codes)	S3L1 Measurement Filter

Program Code

HP-IB

S3 is the HP-IB code for distortion level.

Indications

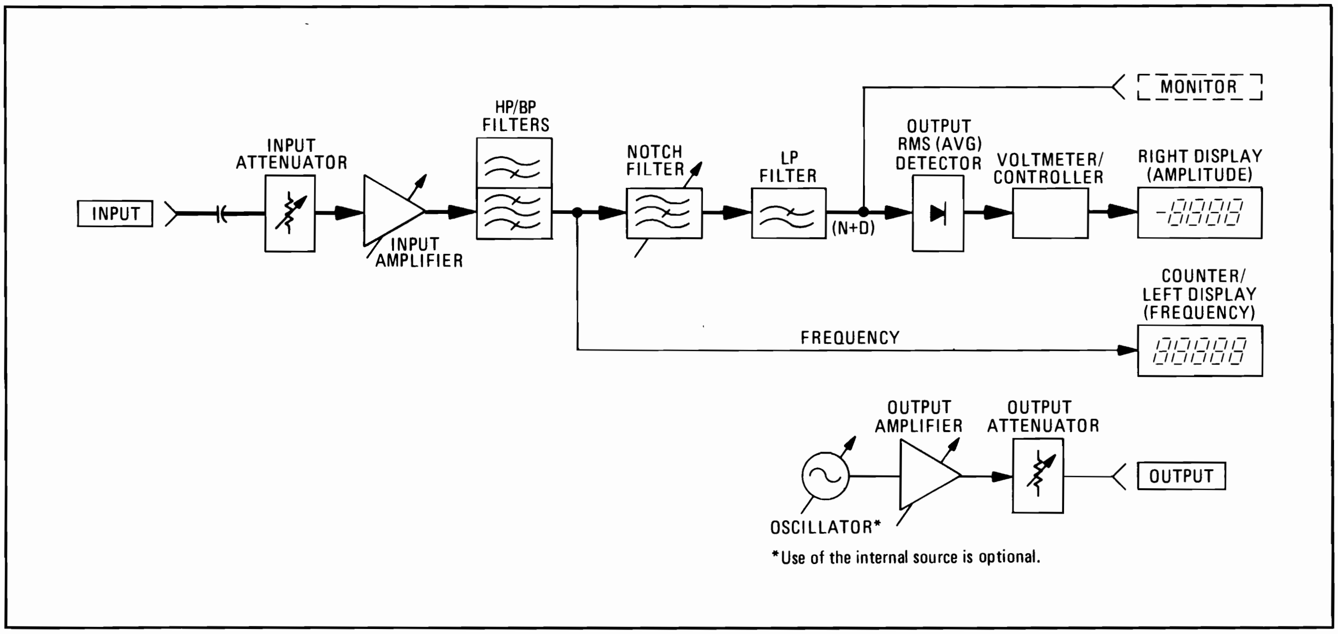
When distortion level is selected, the LEDs in the S (Shift) key and the DISTN LEVEL key will light. The frequency and amplitude of the input signal are displayed and the appropriate annunciators will light (see Description above).

Measurement Technique

In the distortion level measurement mode, the controller automatically sets the input attenuation and the gain settings of various amplifiers. This control ensures that the signal amplitude is within the proper range for the output rms detector. The notch filter removes the fundamental from the input signal. The notch filter automatically tunes to the component whose frequency is measured by the counter (usually the fundamental of the input signal). The output rms detector converts the residual noise + distortion to dc. The dc voltmeter measures the signal and the controller corrects for the programmed gain and attentuation. The results are then displayed in the appropriate units. The frequency of the input is also measured and displayed.

(Distortion Level Block Diagram on next page)

Distortion Level (Cont'd)



Distortion Level Measurement Block Diagram

Related Sections	Distortion Filters Monitor Notch Tune RATIO and LOG/LIN

Error Disable

(Special Function 8)

Description The Error Disable Function is used to selectively disable operating error messages. Using the 8.N Special Function allows the user to enable all operator error messages, disable analyzer errors (measurement related errors), disable source errors (output related errors), or disable both analyzer and source errors.

Procedure To selectively disable (or enable) operator error messages, key in the corresponding Special Function code; and then press the SPCL key.

Error Message Status	Special Function Code	Program Code HP-IB
All error messages enabled.	8.0 SPCL	8.0SP
Disable analyzer error messages (Errors 12-17, 31, and 96).	8.1 SPCL	8.1SP
Disable source error messages (Errors 18 and 19).	8.2 SPCL	8.2SP
Disable both analyzer and source error messages.	8.3 SPCL	8.3SP

Example To disable the source error messages:

LOCAL (keystrokes)	Code Function SPCL 8 . 2 •
HP-IB (program codes)	8.2SP Code Function

Program Codes HP-IB For HP-IB codes refer to Procedure above.

Indications As the numeric code is entered, both displays will blank, and the entered code will appear in the left display. When the SPCL key is pressed, the SPCL key will light (except for Special Function 8.0) if it is not already on. If it is already on, it will remain on (except for Special Function 8.0). Both displays then return to the display that is appropriate for the currently selected measurement mode.

Comments The error messages can be selectively disabled to prevent the analyzer error messages from halting the operation of the source section of the Audio Analyzer and vice-versa.

Error Disable (Cont'd)

(Special Function 8)

Comments (Cont'd)

The error messages can also be selectively disabled to prevent unwanted error interrupts to the HP-IB bus controller.

Error messages are one means by which the instrument safeguards accurate measurements. When these safeguards are disabled, erroneous measurements can result under certain conditions. This should be kept in mind when operating the instrument with error messages disabled.

Related Sections

Automatic Operation
Error Message Summary
Special Functions

Error Message Summary

Description

The instrument generates error messages to indicate operating problems, incorrect keyboard entries, or service related problems. The error message is generally cleared when the error condition is removed. (Error 31 is an exception.) The Error Messages are grouped by error code as follows:

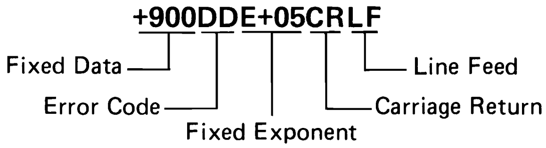
Error 10 through Error 39 and Error 90 through Error 99. These are Operating and Entry Errors which indicate that not all conditions have been met to assure a calibrated measurement or that an invalid key sequence or keyboard entry has been made. Operating Errors can usually be cleared by using the front-panel controls. The Error Disable Special Function (8.N) can be used to selectively disable certain operating error messages. Entry Errors require that a new keyboard entry or function selection be made.

Error 65 through Error 89. These are Service Errors which provide additional service related information. Service Errors must be enabled to appear and do not necessarily represent failures within the instrument. Service Errors are discussed in the Service Section (VIII) of this manual.

HP-IB Output Format

HP-IB

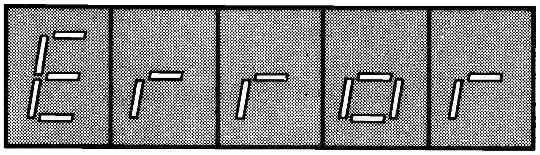
The HP-IB output format for errors is shown below:

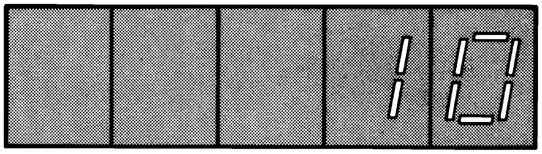


For example, Error 10 is output to the HP-IB as +90010E+05CRLF. This format differs from normal data outputs since normal data outputs will never exceed 4 × 10^9. Once an error has been input to the computing controller, the error code is simply derived by subtracting 9 × 10^9 from the input number, then dividing the result by 100 000.

Error Displays

Shown below and on the next page are three types of error displays. The first is typical of most error displays and is shown as a general case. The second and third have specific meaning and occur often.

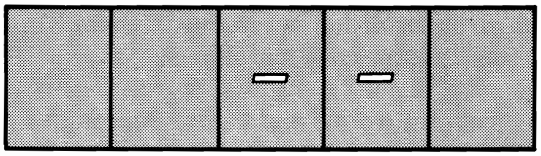




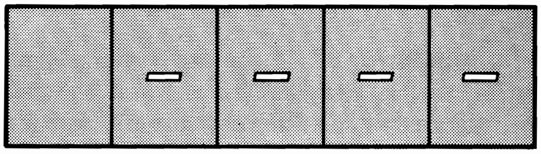
This display shows the general error display format. These errors are output to the HP-IB as shown under the HP-IB format above.

Error Message Summary (Cont'd)

Error Displays (Cont'd)



This display means that no signal has been sensed at the input. This display is output to the HP-IB as Error 96 using the HP-IB format shown above.



This display means that a signal has been detected but for various reasons a measurement result is not yet available. This display is never output to the HP-IB and typically indicates a transitory state in instrument operation. After 128 successive occurrences, the display changes to Error 31. Error 31 is output to the HP-IB using the HP-IB format shown above.

Error Messages

The table below describes all Operating and Entry errors. The error code, message, and the action typically required to remove the error-causing condition are given. Additional information pertaining to particular errors is also given.

Error Code	Message	Action Required/Comments
	Operating Errors	
10	Reading too large for display.	This error code indicates that although the required calculation is within the capability of the instrument, the result of the calculation exceeds the display capabilities.
11	Calculated value out of range.	Enter new RATIO reference. Refer to RATIO and LOG/LIN.
13	Notch cannot tune to input.	Adjust input frequency to within specified limits. Refer to Table 1-1.
14	Input level exceeds instrument specifications.	This error code indicates that the input overload detector has tripped (not in range hold). This could be caused by too large an ac signal, or too much ac on a dc signal.

Error Message Summary (Cont'd)

Error Messages (Cont')

Error Code	Message	Action Required/Comments
	Operating Errors (Cont'd)	
	NOTE *Although error codes 17, 18 and 19 are officially listed here under Operating Errors, they should be considered rather as diagnostic indications.*	
17	Internal voltmeter cannot make measurement.	This error code indicates that the counter (A8) has failed to return a value. This can only be caused by a malfunction in the counter. Refer to Service Sheet 14.
18	Source cannot tune as requested.	This error code indicates a malfunction in the counter (A8) and/or the oscillator (A5). Refer to Service Sheets 8, 9 and 14.
19	Cannot confirm source frequency.	This error indicates that in notch routine, the frequency could not be measured, and thus the notch could not be adjusted. This usually indicates a counter (A8) problem. Refer to Service Sheet 14.
25	Top and bottom plotter limits are identical.	This error code indicates that the user has entered the same upper and lower limits to scale the sweep of the X-Y plotter output. This would cause a division by zero. The user should enter some realistic plot limits. Refer to X-Y Recording, and, more particularly, to Plot Limit.
26	RATIO not allowed in present mode.	This error code indicates that use of the RATIO key does not make sense in the current mode. Refer to RATIO and LOG/LIN.
30	Input overload detector tripped in range hold.	This error code indicates that the input signal is too high for the selected range. Press CLEAR key and then enter a more realistic range setting, or press AUTOMATIC OPERATION key to allow the Audio Analyzer to seek the correct input range. Refer to Automatic Operation.
31	Cannot make measurement.	This error code indication occurs when the input signal is changing too quickly for the Audio Analyzer to make consistent measurements. The "— — — —" display indicates that the instrument is trying to make a measurement. After 128 unsuccessful tries, Error 31 is displayed.
32	More than 255 points total in a sweep.	Although sweep resolution can be changed with Special Function 17, care should be taken to ensure that it will not result in more than 255 points in the total sweep. Refer to Sweep Resolution.
96 HP-IB	(HP-IB only) No signal sensed at input.	This error is sent on the HP-IB when the "— — " display is shown.

Error Message Summary (Cont'd)

Error Messages (Cont')

Error Code	Message	Action Required/Comments
	Entry Errors	
20	Entered value out of range.	Re-enter new value.
21	Invalid key sequence.	Check for compatibility of functions selected.
22	Invalid Special Function prefix.	Check, then re-enter correct Special Function code. Refer to Special Functions.
23	Invalid Special Function prefix.	Check, then re-enter correct Special Function code. Refer to Special Functions.
24 HP-IB	Invalid HP-IB code.	Check, then re-enter correct HP-IB code. This error causes a Require Service message to be sent on the HP-IB. Refer to Table 3-4 and accompanying text.
	Service Errors	
65—89	Service related errors.	Refer to Paragraph 8-12, Service Errors.

Related Sections

Automatic Operation
Plot Limit
RATIO and LOG/LIN
Sweep Resolution
X-Y Recording

Filters

Description The HP/BP (high-pass/bandpass) and LP (low-pass) FILTER keys cause the respective filters to be inserted into the audio signal path. The filters limit the measurement bandwith. The HP/BP filters are inserted before the notch filter (control of the notch filter is covered in the Notch Tune discussion). The LP filters are inserted after the notch filter. When in use, the HP/BP and LP FILTERs always affect the signal at the rear-panel MONITOR output.

Procedure Select the desired signal filters by pressing the appropriate keys. Only one HP/BP and one LP filter can be in at a time. To turn a filter off, press the key again or select another filter in the same group. HP-IB codes for the different filter keys (shown below) turn on the selected filter (defeating others in the group if on). To turn an HP/BP or LP filter off via HP-IB, use code H0 or L0 respectively or select the alternate filter in the pair.

Example To select the 400 Hz HP filter and the 30 kHz LP filter:

LOCAL (keystrokes)	High-Pass Filter HIGH PASS 400 Hz ●	Low-Pass Filter LOW PASS 30 kHz ●
HP-IB (program codes)	H1 High-Pass Filter	L1 Low-Pass Filter

Program Codes HP-IB

HP/BP Filter	Program Code HP-IB	LP Filter	Program Code HP-IB
Both off	H0	Both off	L0
HIGH PASS 400 Hz	H1	LOW PASS 30 kHz	L1
PSOPH	H2	LOW PASS 80 kHz	L2

Indications When a filter is activated (by either automatic or manual selection), the LED within that filter's key will light.

Comments The selected filters are always in the path of the audio signal.

With all filters off, the 3 dB measurement bandwidth is approximately 10 Hz to 750 kHz.

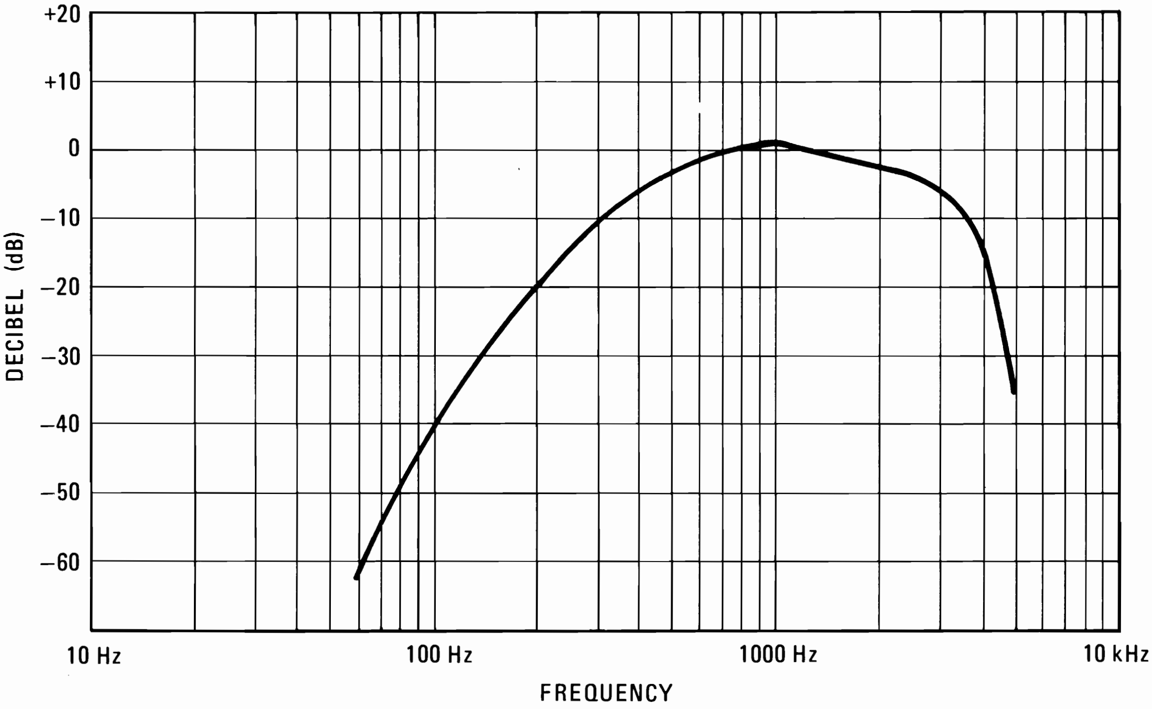
The HP/BP filters affect the signal being counted; however, the LP filters usually do not. Repeating the HP-IB command to turn on a specific filter has no effect (i.e., the filters cannot be toggled on and off using the same HP-IB command).

The individual filter characteristics are given in Table 1-1, Specifications and in Table 1-2, Supplemental Information.

Filters (Cont'd)

Comments (Cont'd)

The bandpass, or psophometric (PSOPH), filter weights the frequency response of the Audio Analyzer as shown in the following curve. The psophometric bandpass characteristic approximates the response of human hearing and is a standard of the C.C.I.T.T.*.



Characteristic Curve of Psophometric Filter

Related Sections

AC Level
Distortion
Distortion Level
Signal-to-Noise
SINAD

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*The International Telegraph and Telephone Consultative Committee

Float

Description To minimize measurement errors caused by ground loops, both the source output and the analyzer input can be floated. Floating the analyzer input improves rejection of low-frequency, common mode signals (e.g., line-related hum and noise). The two front-panel FLOAT switches determine whether the input and output circuitry are floating or single-ended. Note that the FLOAT switches are not HP-IB programmable.

Procedure To float either the analyzer input or the source output, set the corresponding FLOAT switch to the FLOAT position. In the float mode the LOW center conductor is isolated from chassis ground. In the single-ended mode (the FLOAT switch in the grounded position) the LOW center conductor is connected directly to chassis ground.

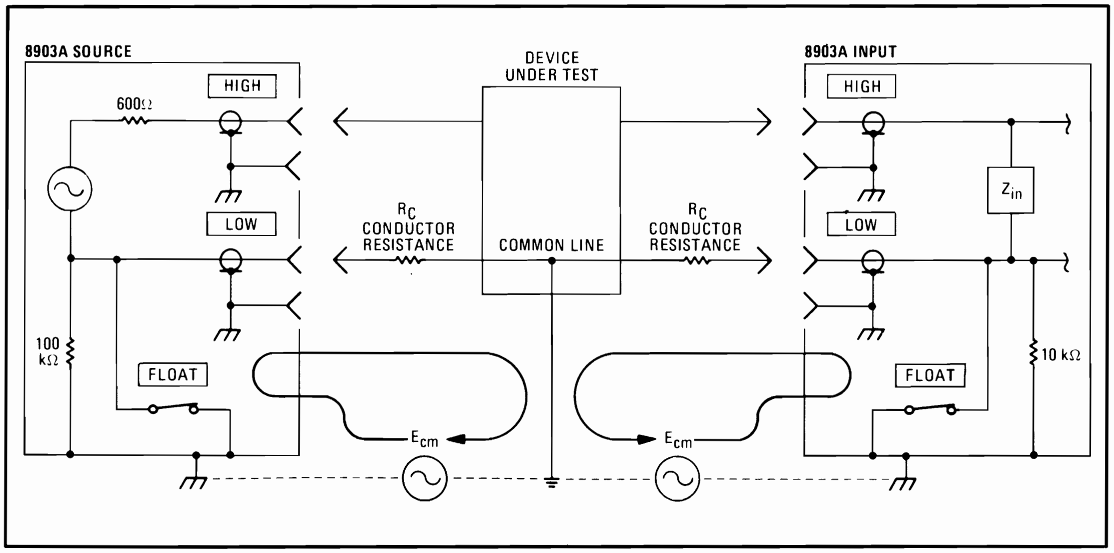
Comments The INPUT and OUTPUT BNC connectors allow the attachment of shielded cables, which minimize electromagnetic interference (EMI). This is important if the Audio Analyzer is operated near a transmitter or in the presence of large RF signals.

The outer conductor of each BNC connector is connected directly to chassis ground. When the FLOAT switch is in the grounded position the center conductor of the LOW connector is also connected to chassis ground. Thus, no connection to the LOW connector is required if a BNC coaxial cable is connected to the HIGH connector. In this configuration, the BNC cable shield serves as a return path. When the FLOAT switch is in the FLOAT position, both the LOW and HIGH connectors must be connected.

NOTE

Since the input attenuators are on the HIGH side, care must be taken to avoid inserting the signal at the LOW connector. No damage will be done to the instrument, but incorrect readings will be provided which could be mistaken for valid data, particulary at higher frequencies.

If EMI shielding is not critical, banana-type connnectors can be used. Four BNC-to-banana adapters are supplied with the instrument to convert the BNC input and output to dual banana with standard 3/4 inch spacing. The adapters connect the conductor of the banana jack to the center conductor of the BNC connector. These adapters are normally used when the FLOAT switches are set in the FLOAT position.



Effect of Multipoint Ground System (FLOAT Switch Closed)

One major source of error which must be considered when measuring low level ac signals or when making low distortion measurements is error introduced by ground

Float (Cont'd)

Comments (Cont'd)

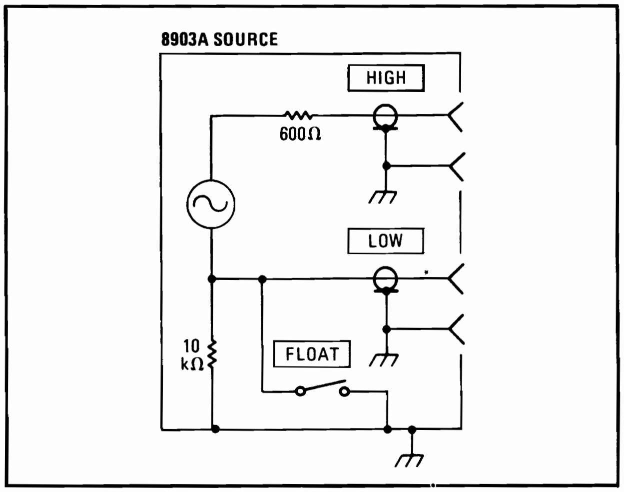
loops. The figure above illustrates a typical measurement setup using the Audio Analyzer. In the figure the system common line is connected to chassis or earth ground at two separate points: the chassis of the Audio Analyzer and the common point of the device under test. Since two physically separate ground points are seldom at the same ground potential, current will flow in the system common line. Due to conductor resistance (R_C) in the system common line, the current causes a voltage drop. This voltage drop (a common mode voltage) sums with the signal under measurement and can cause erroneous readings. Grounding the system common line at a single point minimizes the effect of common mode voltages caused by ground loops. Floating the Audio Analyzer input and output circuitry isolates the LOW center conductor of the Audio Analyzer from chassis ground. Thus the Audio Analyzer input and output circuits are grounded only through the device under test. Note that the system common line is now grounded at a single point.

In the FLOAT mode the INPUT LOW connector can be floated up to 4V peak.

CAUTION

To prevent damage to the Audio Analyzer input circuitry, do not apply greater than +15V or less than −15V (ac + dc) to the INPUT LOW terminal.

A simplified diagram of the source output circuit is shown below. Note that in the float mode, there is no ground present at the output (actually, the center conductor of the LOW terminal is connected to chassis ground through a 10 kΩ resistor).



Simplified Schematic of the Audio Analyzer Source Output

In the float mode the output can be used as a summing circuit. An external source (either ac or dc) can be applied to either the HIGH or LOW connectors. The output signal is the sum of the internal source plus the external source. The OUTPUT LOW and HIGH connectors can be floated up to 10V peak.

CAUTION

Do not allow the voltage at the OUTPUT LOW or OUTPUT HIGH connector to be greater than +10V or less than −10V(ac + dc).

Frequency

Description The Audio Analyzer provides a low distortion sine wave output from 20 Hz to 100 kHz. The FREQ key along with numeric data and unit keys are used to program the frequency of the source. The FREQ key is also used to display the currently programmed frequency.

Procedure To program a source frequency, press the FREQ key and then the appropriate numeric data and unit keys. Once the FREQ key has been pressed, new data and unit entries can be made to select different frequencies until another source function key (for example, the AMPTD key) is pressed. To display the currently programmed source frequency press and hold the FREQ key.

Example To set the source frequency to 500 Hz:

LOCAL (keystrokes)	Function Data Unit FREQ 5 0 0 Hz mV
HP-IB (program codes)	FR500HZ Function Data Unit

Program Codes HP-IB

Keys	Program Code HP-IB
FREQ Hz kHz	FR HZ KZ

Indications When the FREQ key is pressed, the left display shows the currently programmed frequency setting. As the new frequency data is entered, it will appear on the left display. When the unit key is pressed, the left display returns to show the input signal frequency.

Comments When the FREQ key is pressed and held the left display shows the currently programmed frequency. It is important to realize the value shown in the left display is the programmed value which can differ from the actual frequency at the OUTPUT. This difference is caused by the fact that the source is a programmable oscillator and not a synthesizer. However, the source frequency is within ±0.3% of the entered value. Also realize that the displayed count is the frequency of the input signal and is the same as the source frequency only if the source is the stimulus for the input.

For an alternate method of programming frequency with high rapidity (3 ms typical), see Rapid Source. For a method which permits a more rapid reading of the frequency, see Rapid Frequency Count.

Related Sections

Amplitude
Increment
Rapid Frequency Count
Rapid Source

Hold Decimal Point

(Special Function 4)

Description The position of the decimal point in the right display can be held in a specific location by using Special Function 4.

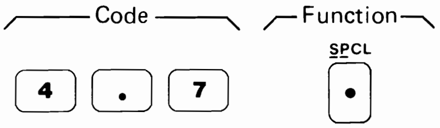
Procedure To hold the decimal point in the right display to a specific position, key in the corresponding Special Function code; and then press the SPCL key.

Decimal Point Hold Position	Special Function Code	Program Code HP-IB
Automatic Selection	4.0 SPCL	4.0SP
DDDD. V Range*	4.1 SPCL	4.1SP
DDD.D V Range	4.2 SPCL	4.2SP
DD.DD V Range	4.3 SPCL	4.3SP
D.DDD V Range	4.4 SPCL	4.4SP
0.DDDD V Range**	4.5 SPCL	4.5SP
DD.DD mV Range	4.6 SPCL	4.6SP
D.DDD mV Range	4.7 SPCL	4.7SP
0.DDDD mV Range**	4.8 SPCL	4.8SP

* The decimal point does not appear on the display. It is shown to establish the position it would appear in the numeric value of the readout.

** The zero does not appear on the display. It is shown to clarify the position of the decimal point.

Example To hold the decimal point after the first digit of a mV Range (D.DDD mV):

LOCAL (keystrokes)	
HP-IB (program codes)	4.7SP Code Function

Program Codes For HP-IB codes refer to Procedure above.

HP-IB

Indications As the numeric code is entered, both displays will blank, and the entered code will appear in the left display. When the SPCL key is pressed, the SPCL key LED will light if it is not already on. If it is already on, it will remain on. The right display will show the amplitude with the decimal held in the position requested. The left display provides the normal information associated with the selected measurement mode.

Comments It is possible to use the Hold Decimal Point Special Function to set the display for a readout that exceeds the resolution of the instrument. For example, in the dc level measurement mode, 4.7 SPCL will set the display to a mV range. In this case, the three digits following the decimal point will always be zeros and are not significant digits in the amplitude readout.

Related Sections

Automatic Operation
Special Functions

Hold Settings

(Special Function 9)

Description The Hold Settings Special Function is used to freeze the instrument in the presently selected settings for the input level ranges, the post-notch gain, the decimal point position, and the notch tuning.

Procedure To hold the presently selected settings for the functions above, press 9.0 and then the SPCL key.

Example To hold the present settings of the specified functions:

LOCAL (keystrokes)	Code Function SPCL 9 . 0 •
HP-IB (program codes)	9.0SP Code Function

Program Code For HP-IB code, refer to Example above.

HP-IB

Indications As the numeric code is entered, both displays will blank, and the entered code will appear in the left display. When the SPCL key is pressed, the SPCL key LED will light if it is not already on. If it is already on, it will remain on. The displays will then show the normal readings for the currently selected measurement mode.

Comments Using Special Function 9 is equivalent to entering the following Special Functions from the keyboard:

1.N Input Level Range (Except DC Level)
2.N Input Level Range (DC Level Only)
3.N Post-Notch Gain
4.N Hold Decimal Point (Right Display Only)
6.1 Hold Notch Tuning

For Special Functions 1 through 4, N is set equal to the currently selected value that the instrument is using for that function. These values can be read by using the Special Special Display (refer to Special Functions).

Note that using the Hold Settings Special Function can cause inaccurate measurements under some circumstances.

Once settings have been held by the Hold Settings Special Function, one or more of them can be reset to their automatic modes by issuing the 0 suffix code of the corresponding Special Function code. As an example, Hold Settings places the instrument in hold notch tuning mode. Use 6.0 SPCL to re-enter the automatic notch tuning mode.

Related Sections Automatic Operation
Special Functions

HP-IB Address

(Special Function 21)

Description

The Audio Analyzer's present HP-IB address can be displayed by using Special Function 21. This display is in binary or decimal. When in binary (Special Function 21.0), the right display shows whether the instrument is set to talk only or listen only, and whether it is at present issuing a service request. The left display shows the address in binary. When in decimal (Special Function 21.1), the display is shown as"Addr= NN" (where NN is the HP-IB decimal address). The address set at the factory is 28 (11100 in binary).

Procedure

To display the HP-IB address, key in the appropriate Special Function code on the numeric keys, then press the SPCL key. To clear the display, press the CLEAR key. The instrument then reverts to the previous measurement mode. A list of the Special Function codes is given below:

Display Format	Special Function Code	Program Code HP-IB
Binary	21.0 SPCL	21.0SP
Decimal	21.1 SPCL	21.1SP

A list of the allowable addresses for the Audio Analyzer is given below:

Allowable HP-IB Address Codes

Address Switches					Talk Address Character	Listen Address Character	Decimal Equivalent
A5	A4	A3	A2	A1			
0	0	0	0	0	@	SP	0
0	0	0	0	1	A	!	1
0	0	0	1	0	B	"	2
0	0	0	1	1	C	#	3
0	0	1	0	0	D	$	4
0	0	1	0	1	E	%	5
0	0	1	1	0	F	&	6
0	0	1	1	1	G	'	7
0	1	0	0	0	H	(	8
0	1	0	0	1	I	)	9
0	1	0	1	0	J	*	10
0	1	0	1	1	K	+	11
0	1	1	0	0	L	,	12
0	1	1	0	1	M	–	13
0	1	1	1	0	N	.	14
0	1	1	1	1	O	/	15
1	0	0	0	0	P	0	16
1	0	0	0	1	Q	1	17
1	0	0	1	0	R	2	18
1	0	0	1	1	S	3	19
1	0	1	0	0	T	4	20
1	0	1	0	1	U	5	21
1	0	1	1	0	V	6	22
1	0	1	1	1	W	7	23
1	1	0	0	0	X	8	24
1	1	0	0	1	Y	9	25
1	1	0	1	0	Z	:	26
1	1	0	1	1	[	;	27
1	1	1	0	0	\	<	28
1	1	1	0	1	]	=	29
1	1	1	1	0	^	>	30

Indications

As the numeric code is entered, it will appear on left display. When the SPCL key is pressed, the light within the key will turn on and all measurement key lights and annunciators will turn off. If the 21.0 Special Function was entered, the left display will show a binary number of the form AAAAA where AAAAA is the HP-IB address in binary. The right display will show a binary number of the form TLS where the T, L, and S have the meaning indicated in the table below:

HP-IB Address (Cont'd)

(Special Function 21)

Indications (Cont'd)

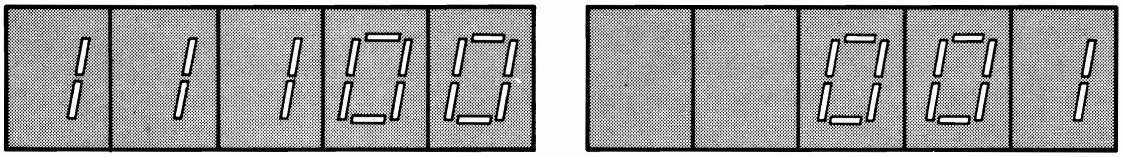
	T	L	S
0	NOT TALK ONLY	NOT LISTEN ONLY	NOT REQUESTING SERVICE
1	TALK ONLY	LISTEN ONLY	REQUESTING SERVICE

If T and L are both 1, the instrument is set to talk only (talk overrides listen). If all the A digits are set to 1 and T is 1, the instrument will be in talk status only (i.e., output the status byte only). (If all digits AAAAA.TL are 1 but S is 0, the Remote Interface board is not installed.) If the 21.1 Special Function was entered, the left display will show the statement "Addr=" and the right display will show the decimal value of the instrument's HP-IB address (28 if it has not been changed).

Examples To display the HP-IB address in binary and the status of the T, L, and S bits:

LOCAL (keystrokes)	Code: 2 1 . 0 Function: SPCL •
HP-IB (program codes)	21.0SP Code Function

If the following is displayed:



then the HP-IB address is 11100 in binary (28 in decimal). In ASCII, the talk address is \, and the listen address is <. The instrument is not set to talk or listen only, but it is issuing a service request (setting the SRQ control line true).

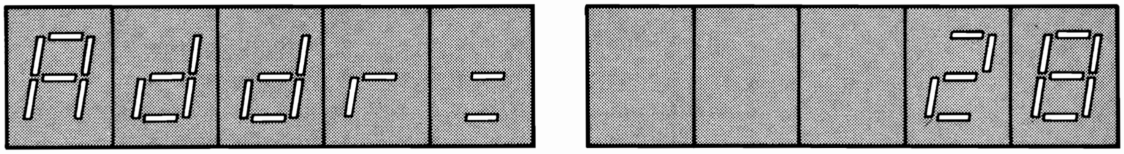
To display the HP-IB address in decimal:

LOCAL (keystrokes)	Code: 2 1 . 1 Function: SPCL •
HP-IB (program codes)	21.1SP Code Function

HP-IB Address (Cont'd)

(Special Function 21)

Examples (Cont'd) Assuming the same address, the following will be displayed:



Program Codes For HP-IB codes refer to Procedure.
HP-IB

Comments The HP-IB address display is continuously updated. This makes setting the address easy since the result of changing a switch setting is immediately visible on the display. For information on setting the HP-IB address of the Audio Analyzer, refer to Section II of this manual. The factory-set address is, as shown in the examples, decimal 28. The T and L bits are set to 0. The S bit powers up at 0.

Related Sections Special Functions
Remote Operation, Hewlett-Packard Interface Bus

Increment

Description The frequency and amplitude of the source can be incremented (or decremented) using the proper combination of the FREQ, FREQ INCR, AMPTD, AMPTD INCR, ÷10, ×10, and FREQ/AMPTD ADJUST keys. These keys provide a convenient method of controlling the source when it is used in applications such as locating the 3 dB point of filters and amplifiers.

Procedure The general procedure to change the source parameters is to use either the FREQ INCR or AMPTD INCR key to establish which parameter is to be changed and the initial increment size. The FREQ/AMPTD ADJUST keys are then used to modify the source output.

Examples To set the amplitude increment to 1.5V:

LOCAL (keystrokes)	Function: AMPTD INCR Data: 1 . 5 Unit: kHz V
HP-IB (program codes)	AN1.5VL Function: AN Data: 1.5 Unit: VL

To increment the currently programmed source amplitude value +1.5V:

LOCAL (keystrokes)	Function: ⇧
HP-IB (program codes)	UP Function: UP

To divide the currently programmed amplitude increment by 10 (i.e., to set the amplitude increment to 0.15V):

LOCAL (keystrokes)	Function: ÷10
HP-IB (program codes)	This function is not programmable.

NOTE

In the last two examples above, either the programmed amplitude or amplitude increment would be changed only if either the AMPTD or AMPTD INCR key was pressed last. If either the FREQ or FREQ INCR key had been pressed last, the programmed frequency or frequency increment would be changed. Note that when using HP-IB program codes, the UP or DN commands increment or decrement the parameter that was last implemented; for example, FN (or FR) or AN (or AP).

Increment (Cont'd)

Program Codes HP-IB

Parameter	Program Code HP-IB
Frequency Increment	FN
Amplitude Increment	AN
↑ (step up)	UP
↓ (step down)	DN
Frequency Units (Hz, kHz)	HZ, KZ
Amplitude Units(V, mV, dB)	VL, MV, DB

Indications

The specific indications depend on the manner in which the keys are pressed. For example, momentarily pressing the FREQ INCR key will cause the currently programmed frequency increment to appear in the left display for approximately two seconds. Pressing and holding the FREQ INCR key down will cause the currently programmed frequency increment to remain displayed until the key is released. The AMPTD INCR key can be used in a similar manner to display the currently programmed value of the amplitude increment. When using the ↑ (step up) or ↓ (step down) keys, the parameter that is incremented depends upon which of the source parameter keys (i.e., FREQ, FREQ INCR, AMPTD, or AMPTD INCR) was pressed last. Momentarily pressing ↑ causes the parameter to be incremented one step. The new value of the source parameter can be observed by pressing FREQ or AMPTD as appropriate. Remember that the programmed values for the source can differ from the displayed measurement values. Pressing and holding the ↑ or ↓ keys down causes the parameter to be stepped continuously. The effect of the change on the measurement results can be seen on the displays.

Pressing the ÷10 or ×10 keys modifies the currently programmed parameter that is active as indicated. Note that to repeat the division or multiplication of the parameter the key must be pressed again. Holding these keys down do not cause additional multiplication or division of the source parameter.

Comments

Neither the ÷10 or the ×10 keys are HP-IB programmable.

Remember that all FREQ/AMPTD ADJUST key operations depend upon source parameter information previously input to the Audio Analyzer (e.g., FREQ, AMPTD, etc.).

The amplitude can be incremented in either linear units (V or mV) or logarithmic units (dB) regardless of the units used to program the amplitude orginally.

Related Sections

Amplitude
Frequency

Input Level Range (DC Level)

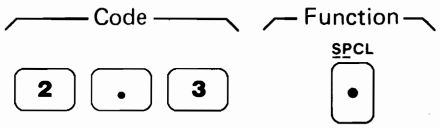
(Special Function 2)

Description In all measurement modes the input level range can be manually set by keyboard entry using the SPCL key. The following discussion describes this function for dc level mode only. Refer to Input Level Range (Except DC Level) for additional information. In the automatic operation mode, the input level range is determined by both the dc and ac (if there is one) level of the input signal.

Procedure To set the input level range to a selected range or to re-enter the automatic selection mode, key in the corresponding Special Function code, then press the SPCL key.

Input Level Range (Full Scale)	Input Attenuation	Special Function Code	Program Code HP-IB
Automatic Selection	—	2.0 SPCL	2.0SP
300V range	40 dB	2.1 SPCL	2.1SP
64V range	24 dB	2.2 SPCL	2.2SP
16V range	12 dB	2.3 SPCL	2.3SP
4V range	0 dB	2.4 SPCL	2.4SP

Example To set the input level range to the 16V range:

LOCAL (keystrokes)	
HP-IB (program codes)	2.3SP Code Function

Program Codes HP-IB For HP-IB codes, refer to Procedure above.

Indications As the numeric code is entered, it will appear on the left display. When the SPCL key is pressed, the left display blanks out. Note that for all measurement modes except dc level, the left display will return to show the input signal frequency after the SPCL key is pressed. Unless Special Function code 2.0 was entered, the light within the SPCL key will turn on if not already on. If the light is already on, it will remain on.

Comments When the Audio Analyzer powers up or when AUTOMATIC OPERATION is selected, the input level range is placed in the automatic selection mode.

If the input level range is set such that the input signal level causes the input overload detector to trip, Error 30 will be displayed.

Manually selecting the gain of the input level circuitry can cause measurement error. Measurement accuracy is not specified whenever the gain of the input level circuitry is manually selected because the selected gain setting may be less than optimum. It is important to note that error messages indicating invalid measurements due to incorrect gain settings are not generated unless overload conditions occur. Automatic operation ensures accurate measurements for all combinations of input signals and measurement modes.

Related Sections

Automatic Operation	Input Level Range (Except DC Level)	Special Functions
DC Level	Monitor	

Input Level Range (Except DC Level)

(Special Function 1)

Description In all measurement modes the input level range can be manually set by keyboard entry using the SPCL key. The following discussion describes this function for all measurement modes except DC Level mode. Refer to Input Level Range(DC Level) for additional information. The input circuitry consists of a programmable attenuator and two programmable amplifiers. In automatic operation mode, the gain of the attenuator-amplifier section of the input is automatically set according to the level of the input signal.

Procedure To set the input level range to a selected range or to re-enter the automatic selection mode, key in the corresponding Special Function Code, then press the SPCL key.

Input Level Range (Full Scale)	Special Function Code	Program Code HP-IB
Automatic Selection	1.0 SPCL	1.0SP
300V	1.1 SPCL	1.1SP
189V	1.2 SPCL	1.2SP
119V	1.3 SPCL	1.3SP
75.4V	1.4 SPCL	1.4SP
47.6V	1.5 SPCL	1.5SP
30.0V	1.6 SPCL	1.6SP
18.9V	1.7 SPCL	1.7SP
11.9V	1.8 SPCL	1.8SP
7.54V	1.9 SPCL	1.9SP
4.76V	1.10 SPCL	1.10SP
3.00V	1.11 SPCL	1.11SP
1.89V	1.12 SPCL	1.12SP
1.19V	1.13 SPCL	1.13SP
0.754V	1.14 SPCL	1.14SP
0.476V	1.15 SPCL	1.15SP
0.300V	1.16 SPCL	1.16SP
0.189V	1.17 SPCL	1.17SP
0.119V	1.18 SPCL	1.18SP
0.0754V	1.19 SPCL	1.19SP

Example To set the input level range to the 30.0V range:

LOCAL (keystrokes)	Code: 1 . 6 Function: SPCL •
HP-IB (program codes)	1.6SP Code Function

Program Codes HP-IB For HB-IB codes, refer to Procedure above.

Input Level Range (Except DC Level) (Cont'd)

(Special Function 1)

Indications

As the numeric code is entered, it will appear on the left display. When the SPCL key is pressed, the display returns to show the input signal frequency. Unless Special Function code 1.0 was entered, the light within the SPCL key will turn on if not already on. If the light is already on, it will remain on.

Comments

When the Audio Analyzer is first powered up or when AUTOMATIC OPERATION is selected, the input level range is placed in the automatic selection mode. If the input level range is set such that the input signal level creates an overrange condition, an error message will be displayed. The error message generated depends on instrument settings and the input signal level. For example, if the input level range is set such that the input signal level causes the input overload detector to trip, Error 30 will be displayed. For a complete listing of the error messages, refer to Error Message Summary.

Manually selecting the gain of the input level circuitry can cause measurement error. Measurement accuracy is not specified whenever the gain of the input level circuitry is manually selected because the selected gain setting may be less than optimum. It is important to note that error messages indicating invald measurements due to incorrect gain settings are not generated unless overload conditions occur. Automatic operation ensures accurate measurements for all combination of input signals and measurement modes.

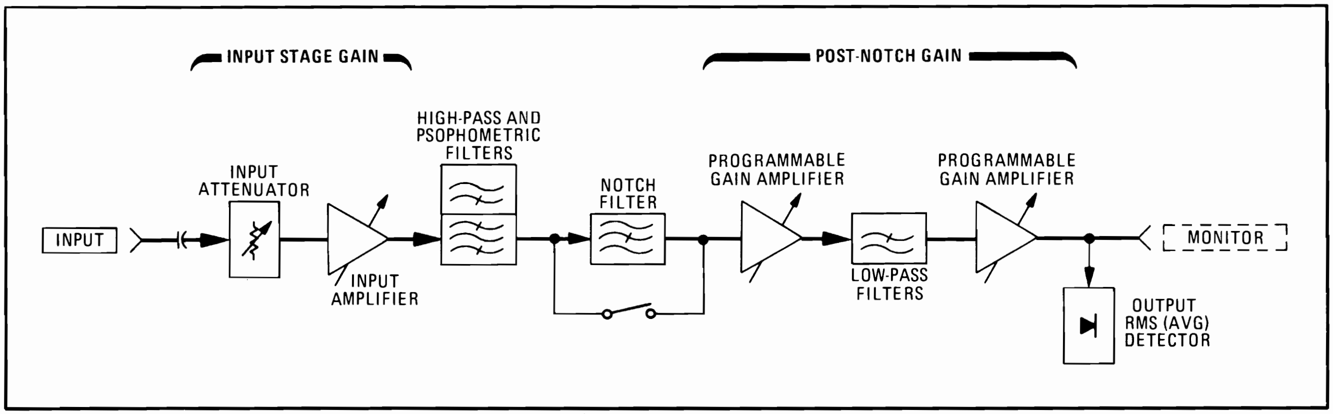
Related Sections

AC Level
Automatic Operation
Input Level Range (DC Level)
Monitor
Special Functions

Monitor

Description The rear-panel MONITOR output provides a means of monitoring the ac signal into the output rms detector. The auto-ranging MONITOR output level is normally a 0.3 to 3 Vrms signal which is proportional to the input signal. In ac level and dc level the MONITOR output provides a scaled representation of the ac component of the input signal. In SINAD, distortion, and distortion level the MONITOR output provides a scaled representation of the input signal with the fundamental removed. The output is dc coupled with a 600 ohm output impedance and a BNC female connector. The MONITOR output can be used to drive other test instruments, such as an oscilloscope, wave analyzer, or spectrum analyzer for further analysis.

Block Diagram A simplified block diagram of the Audio Analyzer measurement circuits illustrating the relationships between the MONITOR output and the other circuit blocks is shown below. The MONITOR output block diagram illustrates the signal path from the INPUT to the MONITOR output. The diagram is that of a programmable gain amplifier with a tunable notch filter. In ac level, dc level, and signal-to-noise, the notch filter is bypassed. IN SINAD, distortion, and distortion level the notch filter is switched into the signal path, removing the fundamental frequency.



Monitor Output Block Diagram

Comments The MONITOR output gain and sensitivity (that is, the net signal gain from the INPUT to the MONITOR output) are dependent on the input stage gain and the post-notch gain. Both the input stage gain and the post-notch gain can be determined by viewing the Special Special Display (refer to Special Functions).

The input stage gain and post-notch gain for various instrument settings are listed in the tables below.

Monitor (Cont'd)

Comments (Cont'd)

INPUT STAGE GAIN (except dc)			
Special Special Display 1.NN	Input Level Range	Gain	
		Log (dB)	Linear
1.1	300V	-40	0.0100
1.2	189V	-36	0.0158
1.3	119V	-32	0.0251
1.4	75.4V	-28	0.0398
1.5	47.6V	-24	0.0631
1.6	30.0V	-20	0.1000
1.7	18.9V	-16	0.1585
1.8	11.9V	-12	0.2512
1.9	7.54V	-8	0.3981
1.10	4.76V	-4	0.6310
1.11	3.00V	0	1.00
1.12	1.89V	+4	1.58
1.13	1.19V	+8	2.51
1.14	0.754V	+12	3.98
1.15	0.476V	+16	6.31
1.16	0.300V	+20	10.00
1.17	0.189V	+24	15.85
1.18	0.119V	+28	25.12
1.19	0.0754V	+32	39.81

POST-NOTCH GAIN		
Special Special Display 3.N	Gain	
	Log (dB)	Linear
3.1	0	1
3.2	+20	10
3.3	+40	100
3.4	+60	1000

The measurement system net gain equals the combined gain of the two stages. To calculate the net gain use the following formulas:

Net Gain (LOG) = Input Stage Gain (LOG) + Post-Notch Gain (LOG)

or

Net Gain (LIN) = Input Stage Gain (LIN) × Post-Notch Gain (LIN)

In ac level the MONITOR output is a scaled replica of the input signal. The MONITOR output level is calculated as:

$$V_{out} = V_{in} \times \text{Net Gain}$$

where V_{in} is the input signal level and the linear net gain is used.

In SINAD, distortion, and distortion level, the fundamental frequency is removed (suppressed by more than 80 dB). The output after the notch filter includes all harmonics of the fundamental plus any noise, hum, and other spurious signals that may be present. These signal impurities are amplified and are available at the MONITOR for further analysis.

Monitor (Cont'd)

Comments (Cont'd)

The following equations express the MONITOR output level as a function of the parameter being measured (the displayed reading). (Use linear Net Gain.)
For distortion:

$$V_{out} = \frac{\text{Displayed Reading (in \%)} \times V_{in} \times \text{Net Gain}}{100}$$

or

$$V_{out} = 10^{\text{Displayed Reading (in dB)}/20} \times V_{in} \times \text{Net Gain}$$

For distortion level:

$$V_{out} = \text{Displayed Reading (in volts)} \times \text{Net Gain}$$

or

$$V_{out} = 10^{\text{Displayed Reading (in dBV)}/20} \times \text{Net Gain}$$

For SINAD:

$$V_{out} = \frac{100}{\text{Displayed Reading (in \%)}} \times V_{in} \times \text{Net Gain}$$

or

$$V_{out} = 10^{-|\text{Displayed Reading (in dB)}|/20} \times V_{in} \times \text{Net Gain}$$

In the above equations V_{out} is the MONITOR output level as measured with a true rms voltmeter and V_{in} is the input signal level.

In the SIG/NOISE measurement mode the source is turned on and off. Therefore the signal level at the MONITOR output is constantly alternating.

The MONITOR output does not respond to dc signals presented at the INPUT. In the dc level measurment mode only the ac components of the input signal are presented at the MONITOR output.

Related Sections

AC Level
DC Level
Distortion
Distortion Level
Input Level Range (DC Level)
Input Level Range (Except DC Level)
Signal-to-Noise
SINAD
Special Functions

Notch Tune

(Special Function 6)

Description In distortion and distortion level modes, the Audio Analyzer automatically tunes the notch filter to the input frequency. In the SINAD mode, the notch filter is tuned to the frequency of the internal source. However, by means of keyboard entry using the SPCL key, the notch filter can be held to the current notch filter frequency setting.

Procedure To freeze the notch filter enter Special Function code 6.1, then press the SPCL key. To return to the automatic tuning mode press the AUTOMATIC OPERATION key or key in the Special Function code 6.0, then press the SPCL key.

Notch Tune	Special Function Code	Program Code HP-IB
Automatic Notch Tuning	6.0 SPCL	6.0SP
Hold Notch Tuning	6.1 SPCL	6.1SP

Example To freeze the notch filter:

LOCAL (keystrokes)	Code: 6 . 1 — Function: SPCL •
HP-IB (program codes)	6.1SP Code: 6.1 — Function: SP

Program Codes HP-IB For HP-IB codes, refer to the Procedure above.

Indications As the numeric code is entered, it will appear on the left display. When the SPCL key is pressed, the display returns to show the input signal frequency. When Special Function code 6.1 is entered and the SPCL key is pressed, the LED within the SPCL key will turn on. The LED will not turn on for Special Function code 6.0.

Comments When the Audio Analyzer first powers up or when AUTOMATIC OPERATION is selected, the Audio Analyzer is placed in the automatic notch tuning mode.

In the automatic tuning mode the Audio Analyzer counts the frequency of the input signal, then coarsely tunes the notch filter to that frequency. The notch filter is then fine tuned via circuitry internal to the notch filter. In the hold tune mode, the notch filter is no longer coarsely tuned, however the fine tune circuitry still remains operational. Thus the notch filter still automatically tunes, but now over a limited range. In the hold tuning mode the tuning or nulling range of the notch filter is approximately 5% of the frequency of the original notch filter setting.

Related Sections

Automatic Operation
Distortion
Distortion Level
SINAD
Special Functions

Plot Limit

Description

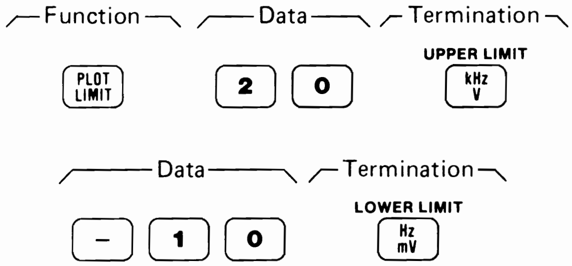
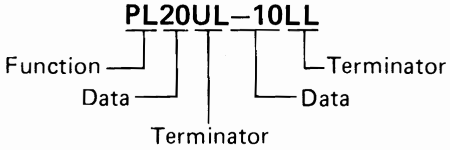
The PLOT LIMIT, UPPER LIMIT, LOWER LIMIT, and the numeric data keys are used to program the upper and lower plot limits. The upper and lower plot limits correspond to the respective upper and lower scaling points of an X-Y plot. For more information on X-Y plots, refer to X-Y Recording. The Y-axis scaling is determined by the displayed measurement unit in the right display and the programmed upper and lower plot limit. The PLOT LIMIT key can be also used to display the currently programmed upper and lower plot limits.

Procedure

To enter new plot limits, first press the PLOT LIMIT key to initiate entries. To enter an upper plot limit, press the appropriate numeric data keys, then the UPPER LIMIT key. Similarly, to enter a lower plot limit, press the appropriate numeric data keys, then the LOWER LIMIT key. Once the PLOT LIMIT key has been pressed, new plot limits can be succesively entered until another source function key (for example, FREQ key) is pressed. To display the currently programmed plot limits press and hold the PLOT LIMIT key.

Example

To enter an upper plot limit of 20 and a lower plot limit of –10:

LOCAL (keystrokes)	
HP-IB (program codes)	

Program Codes HP-IB

Key	Program Code HP-IB
PLOT LIMIT	PL
UPPER LIMIT	UL
LOWER LIMIT	LL

Indications

When the PLOT LIMIT key is pressed, both displays will show the currently programmed plot limits. The upper limit appears on the right display and the lower limit appears on the left display. As a new upper or lower plot limit is entered, it will appear on the left display. When the UPPER LIMIT or LOWER LIMIT key is pressed, the left display returns to show the input signal frequency and the right display returns to show the measurement previously selected.

Comments

The Audio Analyzer powers up with an upper and lower plot limit of 100 and –100 respectively.

The plot limit values can range from –1099 to 1099 in steps of 0.001. The values entered for the upper and lower plot limits are dimensionless. The plot limit units are

Plot Limit (Cont'd)

Comments (Cont'd)

the same as the right display measurement unit. For example, if an upper plot limit of 20 and a lower plot limit of −10 are entered and the measurement result is displayed in dB, the upper plot limit would correspond to 20 dB and the lower plot limit would correspond to −10 dB. If the measurement result had been displayed in % instead of dB, the upper plot limit would have corresponded to 20% while the lower plot limit would have corresponded to −10%. The plot limit units can be any of the following fundamental units: V, dB, dBV, and %. Note that, mV cannot be used as a plot limit unit.

If the upper and lower plot limits are identical and the SWEEP key is pressed, Error 25 will be displayed. If plot limits are entered whereby the lower limit is greater than the upper limit, no error code is displayed. In this case, the Y-axis output ranges from approximately 10 Vdc for the lower plot limit value to 0 Vdc for the upper plot limit value, and the X-Y plot obtained is simply inverted. For example, if an upper plot limit of −10 and a lower plot limit of 20 are entered, and the measurement result is displayed in dB, the upper plot limit would correspond to −10 dB, and the lower plot limit would correspond to 20 dB.

Related Sections

X-Y Recording
RATIO and LOG/LIN

Post-Notch Detector Response (Except SINAD)

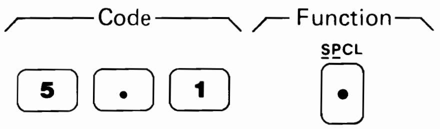
(Special Function 5)

Description The Audio Analyzer normally makes audio measurements using a fast-responding detector. By means of keyboard entry using the SPCL key, additional low-pass filtering can be added after the post-notch detector. The additional low-pass filtering (slow detector) is useful in stabilizing measurements on unstable or noisy signals or whenever display jitter is considered excessive.

Procedure To change the Audio Analyzer post-notch detector response from fast to slow or vice versa, enter the corresponding Special Function code, then press the SPCL key.

Post-Notch Detector Response	Special Function Code	Program Code HP-IB
Fast Detector	5.0 SPCL	5.0SP
Slow Detector	5.1 SPCL	5.1SP

Example To enter a slow detector response mode:

LOCAL (keystrokes)	
HP-IB (program codes)	5.1SP Code Function

Program Codes HP-IB For HP-IB codes, refer to the Procedure above.

Indications As the numeric code is entered, it will appear on the left display. When the SPCL key is pressed, the display returns to show the input signal frequency. When Special Function code 5.1 is entered and the SPCL key is pressed, the LED within the SPCL key will turn on if not already on. If the light is already on, it will remain on. The LED will not turn on if Special Function code 5.0 is entered.

Comments When the Audio Analyzer is first turned on or when AUTOMATIC OPERATION is selected, the fast detector is selected.

In SINAD the slow detector response is always used. The fast detector cannot be selected by means of keyboard entry using the SPCL key when in SINAD.

Related Sections

Automatic Operation
Special Functions

Post-Notch Gain

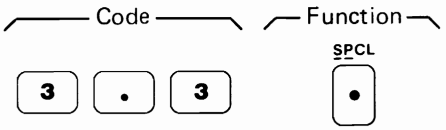
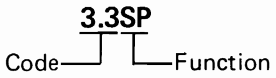
(Special Function 3)

Description The overall stage gain of the post-notch circuit can be manually set by keyboard entry using the SPCL key. The gain is selectable from 0 dB to 60 dB in 20 dB steps. In automatic operation mode, the instrument will automatically select the optimum post-notch gain.

Procedure To manually set the gain of the post-notch circuit or to re-enter the automatic selection mode, key in the corresponding Special Function code, then press the SPCL key.

Post-Notch Gain	Special Function Code	Program Code HP-IB
Automatic Selection	3.0 SPCL	3.0SP
0 dB gain	3.1 SPCL	3.1SP
20 dB gain	3.2 SPCL	3.2SP
40 dB gain	3.3 SPCL	3.3SP
60 dB gain	3.4 SPCL	3.4SP

Example To set the post-notch gain to 40 dB:

LOCAL (keystrokes)	
HP-IB (program codes)	

Program Codes For HP-IB codes, refer to Procedure above.
HP-IB

Indications As the numeric code is entered, it will appear on the left display. When the SPCL key is pressed, the display returns to show the input signal frequency. Unless Special Function code 3.0 was entered, the light within the SPCL key will turn on if not already on. If the light is already on, it will remain on.

Comments When the Audio Analyzer is first powered up or when AUTOMATIC OPERATION is selected, the Audio Analyzer is placed in the automatic selection mode.

If the post-notch gain is set such that the input signal level causes the post-notch circuitry to be overdriven, four dashes will be displayed on the right display. If this overload condition is not corrected within 128 measurement cycles, Error 31 will be displayed.

Manually selecting the gain of the post-notch circuit can cause measurement error. Measurement accuracy is not specified whenever the gain of the post-notch circuitry is manually selected because the selected gain setting may be less than optimum. It is important to note that error messages indicating invalid measurements due to incorrect gain settings are not generated unless overload conditions occur. Automatic operation ensures accurate measurements for all combination of input signals and measurement modes.

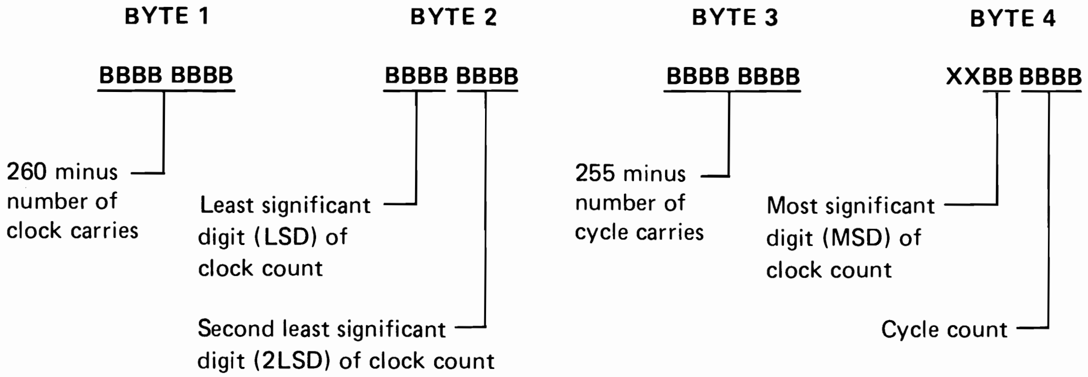
Related Sections
Automatic Operation
Monitor
Special Functions

Rapid Frequency Count

Description Rapid Frequency Count mode allows a remote controller to partially bypass the Audio Analyzer's own internal controller. The advantage is that frequency count measurements can be obtained from the Audio Analyzer much more quickly. The data obtained, however, is in a packed binary form, and thus requires additional processing to produce the final results in hertz. Once the Rapid Frequency Count mode is entered, data will be placed on the bus in four-byte sequences until the mode is terminated. Rapid Frequency Count mode is terminated whenever the Audio Analyzer receives a bus command or whenever it is sent new programming data.

Procedure To use the Rapid Frequency Count mode, the remote controller must be able to read the four-byte compacted frequency data using a binary specifier. First, place the Audio Analyzer into the ac level measurement mode, set it to measure the input signal (i.e., the signal before the notch filter), and to trigger with settling. The HP-IB codes for this configuration are M146.1SPT3. Next, issue the HP-IB code for Rapid Frequency Count (RF) and then read the frequency data from the Audio Analyzer. The Audio Analyzer does not send carriage return, line feed, or any other characters as delimiters.

The frequency data will be in the form shown below:



To obtain the frequency, compute:

Total clock counts = LSD + 16(2LSD) + 256(MSD) + 1024(260 − BYTE 1)

Total cycle counts = Cycle count + 16(255 − BYTE 3)

$$\text{Frequency} = \frac{\text{Total cycle counts}}{\text{Total clock counts}} \times (2 \cdot 10^6)$$

Where:

LSD = Least significant digit of clock count
2LSD = Second least significant digit of clock count
MSD = Most significant digit of clock count.

Using a Hewlett-Packard Model 9825A Desktop Computer, the computation is set up in five steps as shown below.

ENTER 728 USING "#,B"; R1,R2,R3,R4

```
0: wrt 728,"RF"
1: fmt , z, 4b; red 728, r1, r2, r3, r4
2: shf (r2, 4) +16 (band (r2, 15) + band (r4, 48) ) +1024 (260—r1) → r5
3: band (r4, 15) +16 (255—r3) → r6
4: 2e6r6/r5→B; dsp B
```

Rapid Frequency Count (Cont'd)

Procedure (Cont'd)

0: Place the Audio Analyzer in the Rapid Frequency Count mode (RF).

1: Establish a format suitable for reading four binary bytes from the Audio Analyzer. Take the readings and store the value in four "r" variables. The value stored is the decimal equivalent of the binary word.

2: Shift various bytes around and weight their value by the proper amount (in accordance with the routine given) to obtain the number of Audio Analyzer clock counts. Assign that value to variable "r5".

3: Position bits correctly and weight appropriately to determine the number of cycle counts. Assign that value to variable "r6".

4: Since the Audio Analyzer uses a reciprocal counter the frequency of the input signal equals the number of input cycles (r6) divided by total time elapsed during these input cycles. The denominator is determined by counting the number of 2 MHz clock counts that occur during these input cycles and multiplying by the frequency of the clock (2 MHz). Total time equals number of clock counts divided by $2 \cdot 10^6$.

$$\text{Total time (seconds)} = \frac{r5}{2 \cdot 10^6}$$

Thus:

$$\text{Input frequency (Hz)} = \frac{r6}{r5/2 \cdot 10^6} = \left(\frac{r6}{r5}\right) \times 2 \cdot 10^6$$

Program Code HP-IB

Program Code RF is the HP-IB code that initiates the Rapid Frequency Count mode.

Indications

When in Rapid Frequency Count mode, the Audio Analyzer's left display will show "— — — — —" (five dashes).

Comments

The major advantage of Rapid Frequency Count mode is that data can be taken in rapid sequence and stored in an array in the computing controller. Then, at a later time when operations do not require immediate controller attention, the packed binary data can be converted into decimal frequency data. This way the time required for the Audio Analyzer to process the data into decimal frequency is eliminated. This greatly increases its measurement speed for measuring tone burst sequences.

Related Section

Rapid Source

Rapid Source

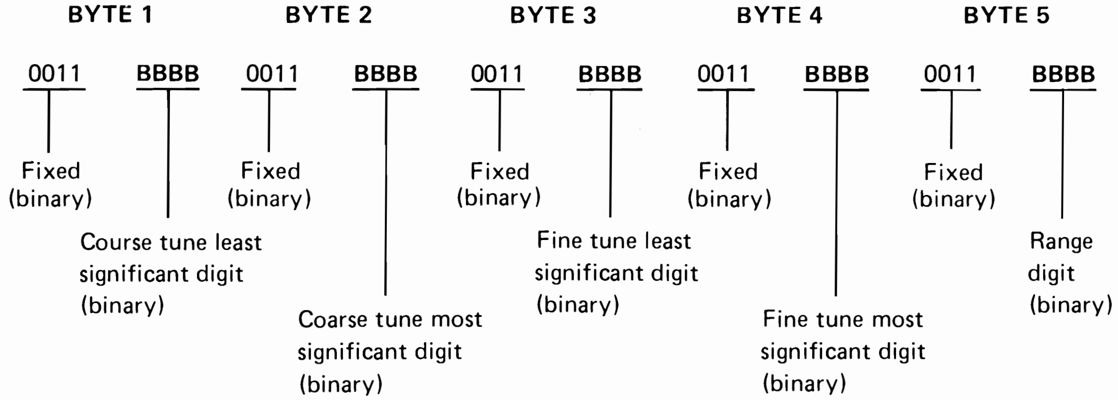
Description Rapid Source mode allows a remote controller to partially bypass the Audio Analyzer's internal controller and tune the source portion of the instrument directly. The main advantage of this function is that by directly controlling the source with binary data, the time the Audio Analyzer's controller needs to convert decimal frequency information to the binary control data is eliminated. Typically, in this mode, the source can be programmed in less than three milliseconds. This makes generation of tone burst sequences practical.

Procedure To use the Rapid Source mode, two procedures must be performed. First, the packed binary tuning data must be obtained from the Audio Analyzer. Second the instrument is placed into the Rapid Source mode and the five-byte binary tuning data is sent.

NOTE

When using the 55, 56, and 57 Special Functions, entering 55. SPCL, 56. SPCL, and 57. SPCL will give a readback of the present instrument settings. Entering 55.0 SPCL, 56.0 SPCL, and 57.0 SPCL will actually set the instrument settings to 0. This is a different default condition than is used with most Special Functions. Normally, omitting the 0 following the decimal has the same result as entering it. However, in the case of 55, 56, and 57 Special Functions, two different functions are performed. For additional information refer to the Service Special Functions in Section VIII.

Acquiring the Tuning Data. Three values must be acquired from the Audio Analyzer: coarse tune data, fine tune data, and range data. To do this, first tune the Audio Analyzer to the desired frequency either manually or via the HP-IB. Then use the 55., 56., and 57. Special Functions to determine the range, coarse tune, and fine tune values respectively. Then build the five-byte sequence as follows:



As shown above, the upper four bits of each byte sent to the Audio Analyzer are always 0011. This places the resulting codes in the ASCII range of "0" (decimal 48) to "?" (decimal 63). (Refer to Table 3-9, Commonly Used Code Conversions.) To build the five-byte sequence, convert the decimal data obtained via the Special Functions into binary. In the case of the coarse and fine tune data, split the eight bits into two groups of four (representing the most and least significant digits). Insert each four-bit packet into its respective byte.

Rapid Source (Cont'd)

Procedure (Cont'd)

NOTE

The binary data obtained to tune the Audio Analyzer to a particular frequency may vary both with warm up and between instruments. Therefore, when maximum accuracy is desired, it is recommended that this data be reacquired approximately each hour or each time a different Audio Analyzer is used.

Entering and Terminating Rapid Source Mode. Rapid Source mode is entered immediately when the Audio Analyzer receives the HP-IB code RS. Rapid Source mode is terminated whenever any Audio Analyzer front-panel key is pressed or whenever the Attention bus control line is set true (i.e., whenever any bus command or talk or listen address is placed onto the bus).

NOTE

Once the Rapid Source code has been issued to the Audio Analyzer, no bus activity should occur until the tuning is completed. Bus activity will cause the Rapid Source mode to be prematurely terminated.

Example

To obtain the tuning data to tune the Audio Analyzer to 1000 Hz, first tune the Audio Analyzer by conventional techniques:

	Function	Data	Unit
LOCAL (keystrokes)	FREQ	1	kHz V
HP-IB (program codes)	FR1KZ Function	Data	Unit

Now use the Special Functions to obtain the tuning data. First get the range data:

	Code	Function
LOCAL (keystrokes)	5 5 .	SPCL •
HP-IB (program codes)	55.SP Code	Function

For example, the right display on the Audio Analyzer shows a 1 (decimal) which equals 0001 in binary.

Rapid Source (Cont'd)

Example (Cont'd)

Now obtain the coarse tune data:

LOCAL (keystrokes)	Code: 5 6 . Function: SPCL •
HP-IB (program codes)	56.SP Code: 56. Function: SP

For example, the right display reads 147 (decimal) which equals 1001 0011 in binary.

Now, obtain the fine tune data:

LOCAL (keystrokes)	Code: 5 7 . Function: SPCL •
HP-IB (program codes)	57.SP Code: 57. Function: SP

For example, the right display reads 128 (decimal) which equals 1000 0000 in binary.

Now combine the data into the required five-byte sequence:

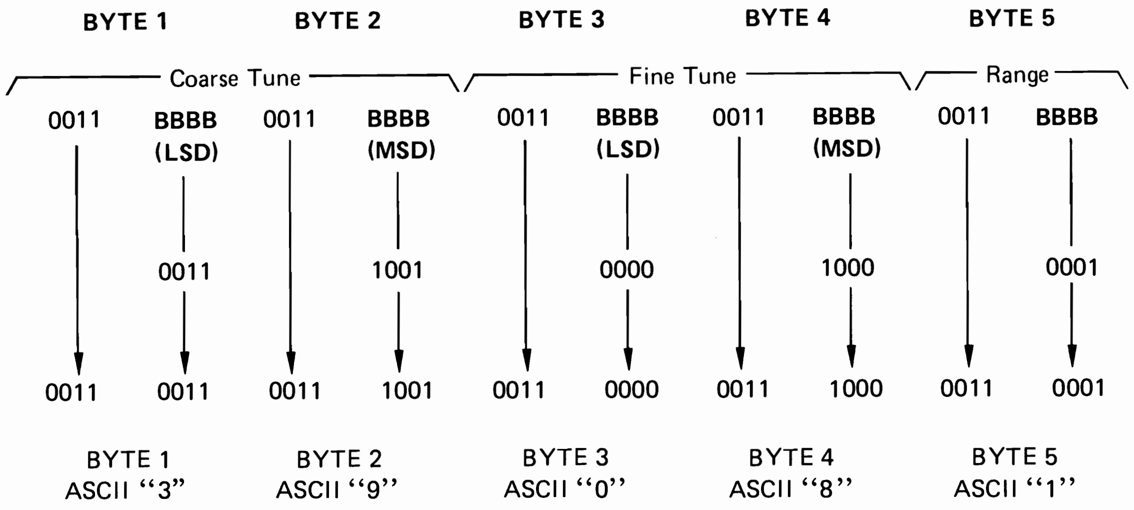
Range (55. SPCL) = 1 (decimal) = 0001

Coarse Tune (56. SPCL) = 147 (decimal) = 1001 0011
(MSD) (LSD)

Fine Tune (57. SPCL) = 128 (decimal) = 1000 0000
(MSD) (LSD)

Rapid Source (Cont'd)

Example (Cont'd)



To select the Audio Analyzer's Rapid Source mode, issue the HP-IB code "RS". To tune the Audio Analyzer to 1 kHz in the Rapid Source mode, issue the ASCII string "39081".

Using a Hewlett-Packard Model 9825A Desktop Computer, issue the command:
wrt 728, "RS39081"

When using a series of Rapid Source mode commands to create a tone burst, issue delays between commands. For example, when using an HP 9825A, to obtain an approximate delay of 200 ms, issue the command:
wait 200

Program Codes HP-IB HP-IB

RS is the program code for initiating the Rapid Source tuning mode. The table below summarizes the Special Functions needed to acquire the tuning data.

Function	Program Code HP-IB
Range	55.SP
Coarse Tune	56.SP
Fine Tune	57.SP

Indications

When in Rapid Source mode, the Audio Analyzer's left display shows "— — — — —" (five dashes).

Comments

Within a single frequency range, frequency switching is phase-continuous. In the Rapid Source mode, the Audio Analyzer's leveling circuitry is disabled. For frequencies between 200 Hz and 5 kHz, the level errors are typically less than 5% (0.5 dB).

Related Section

Rapid Frequency Count

RATIO and LOG/LIN

(Special Function 11)

Description The RATIO key can be used to compare any measurement (except frequency) to a reference value. The reference value can be the result of a previous measurement or a keyboard entry. The LOG/LIN (logarithmic/ linear) key can be used to express the results in logarithmic or linear units. The following table shows which units are applicable to the individual measurement modes:

Measurement Mode	RATIO On		RATIO Off*	
	LIN	LOG	LIN	LOG
AC LEVEL	%	dB	V or mV*	dBV
DC LEVEL	%	dB	V or mV	dBV
SINAD	%	dB	%	dB*
SIG/NOISE	%	dB	%	dB
DISTN	%	dB	%*	dB
DISTN LEVEL	%	dB	V or mV*	dBV

*After initial power on, switching measurement mode results in the configuration indicated by the asterisks. In subsequent operations, the last setting of the LOG/LIN key is remembered for each measurement mode and applied to the new measurement.

When the RATIO LED is on, the measurement result is compared to a reference value. The reference value can be the result of a previous measurement or a keyboard entry. The LOG/LIN key allows any measurement result to be viewed in linear or logarithmic format.

The Audio Analyzer stores only one ratio reference at a time. When in ratio, if a new measurement is selected, ratio is disabled.

When returning to the previous measurement, it is possible to re-enter the ratio mode with the same factor as before using Special Function 11.0. Additionally, the ratio reference can be displayed using Special Function 11.1.

Procedure To use the RATIO key, set the display to the desired reference value. This can be done by adjusting the signal parameter being measured to a reference setting or by entering the reference on the numeric keys and then pressing RATIO. If the numeric keys are used to enter the ratio reference, the entry must be made in fundamental units (e.g., for a ratio reference of 60 mV enter .06 regardless of the displayed value). The display will show the measurement result relative to the reference value. The units used with the right display depend upon the setting of the LOG/LIN key (see table above). Pressing the LOG/LIN key alternates the display between the LOG and the LIN functions. When the measurement modes is changed, the last setting of the LOG/LIN key for that mode is remembered and applied to the new measurement.

To re-enter ratio with the previous ratio reference or to read the reference, key in the corresponding Special Function code, and press the SPCL key. The Special Function codes are listed as follows:

RATIO and LOG/LIN (Cont'd)

(Special Function 11)

Ratio Operation	Special Function Code	Program Code
Re-enter ratio with the previous reference.	11.0 SPCL	11.0SP
Read ratio reference.	11.1 SPCL	11.1SP

Examples If the display shows 100 mV, to enter this value as the RATIO reference for future measurements:

LOCAL (keystrokes)	Ratio • RATIO
HP-IB (program codes)	R1 Ratio

If the display shows 0.100V, to compare this to a value of 2V:

LOCAL (keystrokes)	Data Ratio 2 • RATIO
HP-IB (program codes)	2R1 Data Ratio

Program Codes HP-IB The HP-IB codes for re-entering ratio or for reading the reference are given above. The HP-IB codes for the RATIO and LOG/LIN keys are given below:

Function	Program Code
LOG	LG
LIN	LN
RATIO Off	R0
RATIO On	R1

Indications When the instrument is displaying a ratio measurement, the RATIO key lights. The status of the LOG/LIN key can be determined by observing the the current measurement mode, the measurement unit lights, and the table above.

Comments The ratio mode can also be used to view an extra digit of resolution when the right display is only showing three digits. Depending upon the current value displayed, pressing either 100 RATIO or 1 RATIO will cause an unscaled right display readout (i.e., the numbers are correct but the decimal point may not be in the correct position). However, an extra digit of resolution is displayed (e.g., if 1.58 was orginally dis-

RATIO and LOG/LIN (Cont'd)

(Special Function 11)

Comments (Cont'd)

played, the new display might indicate 1.576). Note that the units annunciator will change to % and should be interpreted properly.

Ratio cannot be used with a frequency measurement. Also, if a negative reference is entered, the ratio indication will be displayed in absolute (unsigned) value.

The LOG function cannot be used with a reference that is zero or negative. If the reference is zero, Error 20 (entered value out of range) is displayed. If the reference is negative, Error 11 (calculated value out of range) is displayed.

Related Sections

AC Level
DC Level
Distortion
Distortion Level
Error Message Summary
Signal-to-Noise
SINAD
Special Functions

Read Display to HP-IB

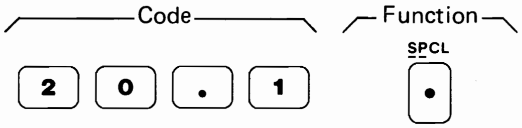
(Special Function 20)

Description The Audio Analyzer can be set to read the information shown in either the left or right display to the HP-IB. Special Function 20 allows the operator to manually determine which display's information will be placed on the HP-IB. This capability is typically used in the Talk Only Mode when logging data to a monitoring device. (Note that when set to Listen Only, the Audio Analyzer can not place data on the bus. If it is set to talk and listen both, front-panel control is relinquished and HP-IB codes RR and RL determine the data output.)

Procedure To set the Audio Analyzer to output data to the HP-IB from either the left or right display, key in the corresponding Special Function code; and then press the SPCL key.

Display Read	Special Function Code	Program Code HP-IB
Right	20.0 SPCL	20.0SP (or RR)
Left	20.1 SPCL	20.1SP (or RL)

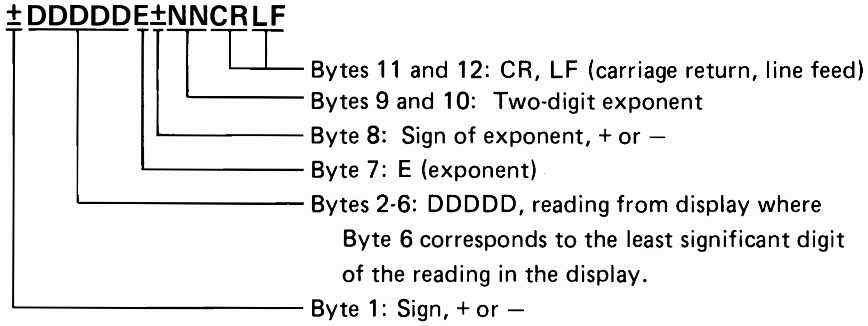
Example To read the left display to the HP-IB:

LOCAL (keystrokes)	
HP-IB (program codes)	20.1SP (OR RL) Code Function

Program Codes HP-IB For HP-IB codes, refer to the table in the Procedure above.

Indications As the numeric code is entered, both displays will blank, and the entered code will appear in the left display. When the SPCL key is pressed, the SPCL key does not light. However, both displays will again blank and four dashes will momentarily appear in the right display. Both displays then return to the display that is appropriate for the current measurement mode.

HP-IB Output HP-IB The instrument outputs data from the display in the following format:



±DDDDDE±NNCRLF

Bytes 11 and 12: CR, LF (carriage return, line feed)
Bytes 9 and 10: Two-digit exponent
Byte 8: Sign of exponent, + or –
Byte 7: E (exponent)
Bytes 2-6: DDDDD, reading from display where Byte 6 corresponds to the least significant digit of the reading in the display.
Byte 1: Sign, + or –

Read Display to HP-IB (Cont'd)

(Special Function 20)

HP-IB Output (Cont'd)

Data is always output in fundamental units (i.e., Hz, %, dB, or V).

Error messages and the voltage value in dc level mode are always read out regardless of the status of the Read Display to HP-IB commands.

Related Section Special Functions

Service Request Condition

(Special Function 22)

Description The Audio Analyzer will issue a Require Service message under various circumstances. For example, a Require Service message will always be issued if an HP-IB code error occurs. Using the keyboard and the SPCL key, the operator may enable one or more conditions to cause the Require Service message to be issued. Whenever the enabled condition occurs, it sets both the bit corresponding to the condition and bit 7 (RQS bit) in the Status Byte. The bits set in the status byte and the Require Service message are not cleared unless the status byte is read (by serial polling), a Clear message is received and executed by the Audio Analyzer, or a Controller Reset or Controller Clear Service Special Function is performed. The enabled Service Request conditions are always disabled again whenever a Clear message is received and executed by the Audio Analyzer or whenever a Controller Reset or Controller Clear Service Special Function is performed. Automatic operation does not clear a Require Service message.

Procedure To enable one or more conditions to cause the Audio Analyzer to issue a Require Service message, sum the weights of the conditions to be enabled (from the table below). This sum becomes the code suffix of Special Function 22. Enter the Special Function code (prefix, decimal, and suffix) via the numeric keyboard, then press the SPCL key. An HP-IB code error (weight 2) will always cause a Require Service message. This condition cannot be disabled, and if the weight is not summed in, it will be assumed by the instrument.

Condition	Weight
Data ready	1
HP-IB code error	2
Instrument error	4

Example To set the Audio Analyzer to send a Require Service message when an instrument error occurs (or when an HP-IB code error occurs) first compute the Special Function suffix by summing the weights corresponding to those conditions:

(2)+4 = 6

Then enter the code:

LOCAL (keystrokes)	Code: 2 2 . 6 Function: SPCL •
HP-IB (program codes)	22.6SP Code — Function

Program Codes HP-IB Compute the Special Function code as described under Procedure above. SP is the HP-IB code for the SPCL key.

Service Request Condition (Cont'd)

(Special Function 22)

Indications

As the numeric code is entered, it will appear on the front-panel display. When the SPCL key is pressed, the display returns to show the measurement previously selected. Special Function 22 has no effect on the SPCL key light. When any enabled condition occurs, both the RQS bit and the bit corresponding to the enabled condition are set in the status byte, and the SRQ control line on the HP-IB will be set true. The Audio Analyzer's status byte is shown below for reference.

Audio Analyzer's Status Byte

Bit	8	7	6	5	4	3	2	1
Weight	128	64	32	16	8	4	2	1
Condition	0 (always)	RQS	0 (always)	0 (always)	0 (always)	Instrument Error	HP-IB Code Error	Data Ready

Comments

For more information on HP-IB operation, serial polling, and the Status Byte message, refer to the HP-IB discussion titled HP-IB Operation appearing earlier in Section III of this manual.

The HP-IB Address Special Function provides a convenient means to determine at any time whether a Require Service message is being issued by the Audio Analyzer.

Related Sections

HP-IB Address
HP-IB Operation (appears earlier in Section III)

Signal-to-Noise

Description The instrument uses its internal source to make signal-to-noise measurements. The source is set to a specified value and alternately turned on and off. The measurement is made by first determining the following value:

$$D = \frac{\text{signal} + \text{noise}}{\text{noise}}$$

D is then converted into the appropriate measurement units as follows:

$$\% \text{ units} = D \times 100\%$$

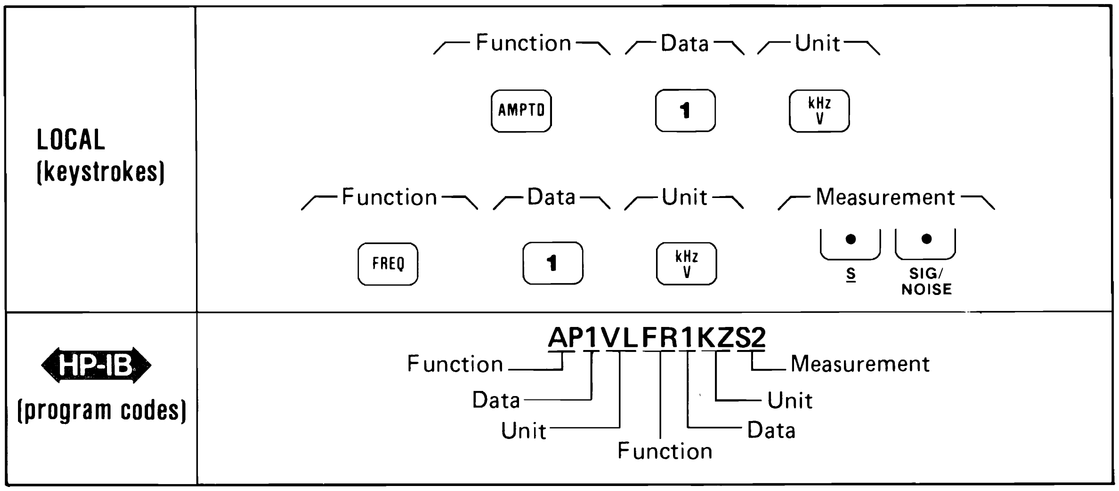
$$\text{dB units} = 20\log D$$

The RATIO key can be used to compare these values to a predetermined ratio reference (refer to RATIO and LOG/LIN).

The signal-to-noise measurement can be made on source signals from 50 Hz to 100 kHz and from 50 mV to 300V.

Procedure Set the internal source to the desired frequency and amplitude. Press the S (Shift) key and then the SIG/NOISE key.

Example To make a signal-to-noise measurement at 1V and 1 kHz:



Program Code HP-IB S2 is the HP-IB code for the signal-to-noise measurement.

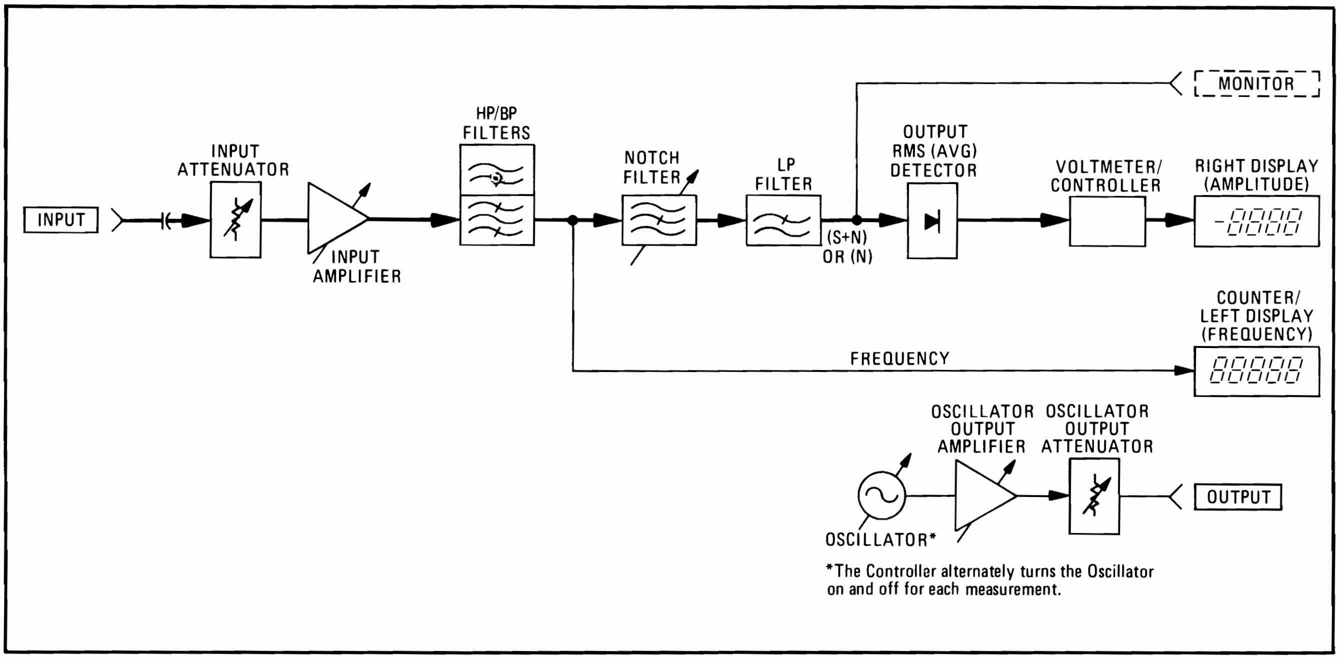
Indications When signal-to-noise is selected, the LEDs in the S (Shift) and the SIG/NOISE keys will light. The appropriate signal-to-noise information is displayed.

Measurement Technique In the signal-to-noise measurement mode, the controller automatically sets the input attenuation and the gain settings of various amplifiers. This control ensures that the signal amplitude is within the proper range for the output rms detector. In addition, the controller alternately turns the oscillator on and off for each measurement. The

Signal-to-Noise (Cont'd)

Measurement Techniques (Cont'd)

output rms detector converts the two ac signals (signal + noise and noise) to dc. The dc voltmeter measures the dc. The controller then corrects for the gain and attenuation, computes the ratio, and displays the results in the appropriate units. The frequency of the input signal is also measured and displayed.



Signal-To-Noise Measurement Block Diagram

Comments

The Audio Analyzer's internal source must be used as the signal stimulus when making signal-to-noise measurements.

Related Sections

Amplitude
Frequency
RATIO and LOG/LIN

SINAD

Description The Audio Analyzer measures SINAD (SIgnal to Noise And Distortion) by first determining the following value:

$$S = \frac{\text{signal, noise, and distortion}}{\text{noise and distortion}}$$

S is then converted into the appropriate measurement units as follows:

$$\%\ \text{units} = S \times 100\%$$

$$\text{dB units} = 20\log S$$

A SINAD measurement can be made on signals from 20 Hz to 100 kHz and from 50 mV to 300V. SINAD measurements are generally made to determine the sensitivity of a receiver. The Audio Analyzer internal notch filter is automatically coarse-tuned to the frequency of the internal oscillator to permit measurements in the presence of large amounts of impurities and to assure that the fundamental frequency is tuned out. The notch filter then fine tunes itself to the signal at the instrument's input. If an external oscillator is used, it must be tuned to within 5% of the internal oscillator frequency. If it is not, the notch filter will not tune to the fundamental frequency of the input signal.

Procedure First, manually set the internal oscillator to the frequency desired. To do this, press FREQ, enter the numeric value for the desired frequency, and then press the appropriate unit key (e.g., kHz). Next press SINAD. If the internal source is being used as a stimulus, also key in the desired amplitude. The SINAD ratio can then be read on the right display or the SINAD meter (if within range). Special Function 7 can be used to change the SINAD meter range.

Example To set the internal source to 1 kHz and select SINAD:

	Function	Data	Unit	Measurement
LOCAL (keystrokes)	FREQ	1	kHz V	SINAD ●
HP-IB (program codes)	FR	1	KZ	M2

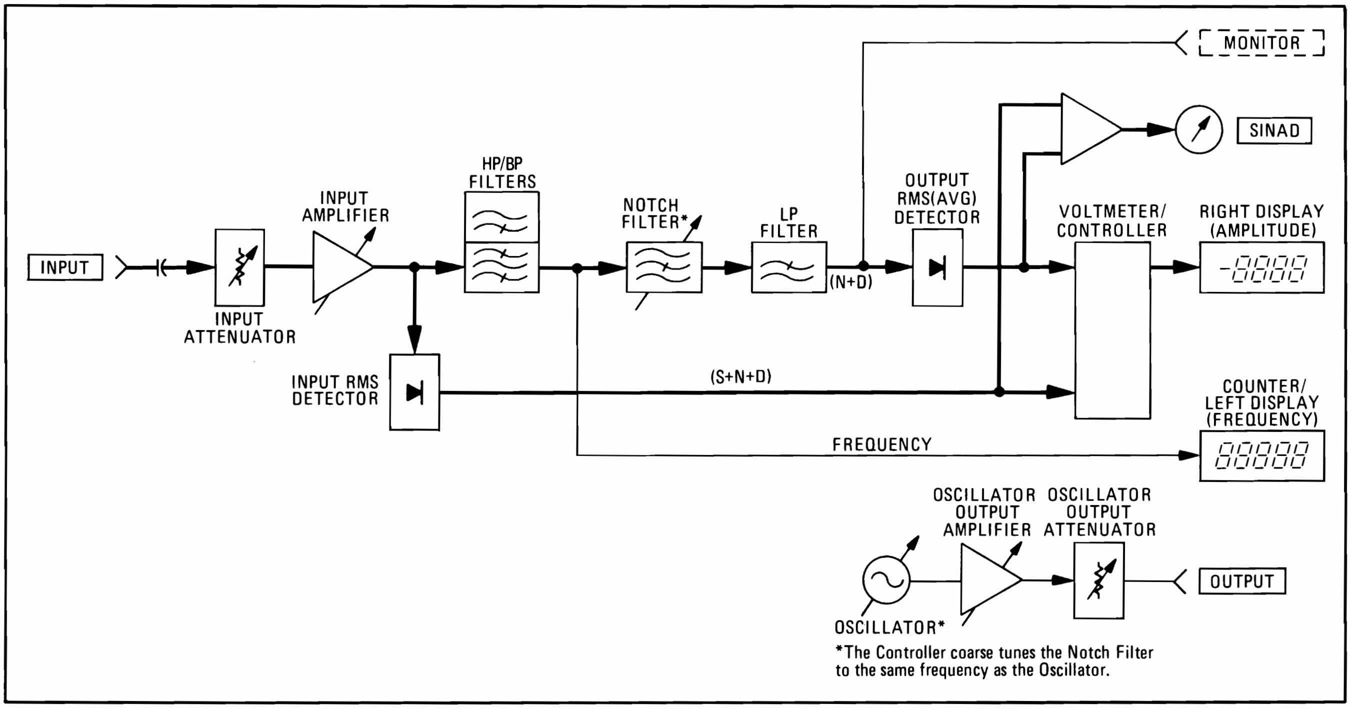
Program Code HP-IB M2 is the HP-IB code for the SINAD measurement.

Indications When either the FREQ or AMPTD key is pressed, the currently programmed values are displayed in the left and right displays respectively. When the numeric data is entered, the numbers appear in the left display. When the unit keys are pressed, both displays blank and four dashes are momentarily displayed in the left display. The displays then return to the normally displayed information for the currently selected measurement mode. When SINAD is pressed, the LED in the SINAD key lights and the appropriate SINAD information for the input signal is displayed.

SINAD (Cont'd)

Measurement Techniques

In the SINAD measurement mode, the controller automatically sets the input attenuation and the gain of various amplifiers. This control ensures that the signal amplitude is within the proper range of the input and output rms detectors. In addition , the controller coarse tunes the notch filter to the programmed frequency of the oscillator to ensure that the Audio Analyzer will not be mistuned. The oscillator is normally used as the source of the test signal. If an external signal source is used, it must be tuned within 5% of the oscillator's programmed frequency. The input rms detector converts the combined signal + noise + distortion ac signal to dc. The notch filter then removes the fundamental signal and the output rms detector converts the noise + distortion ac signal to dc. The dc voltmeter measures both signals. The controller then corrects for the programmed gain and attenuation, computes the ratio, and displays the results in the appropriate units. The frequency of the input signal is also measured and displayed. As a convenience, the SINAD meter displays the SINAD measurement results if within its range. The meter is specially marked for EIA and CEPT sensitivity and selectivity.



*The Controller coarse tunes the Notch Filter to the same frequency as the Oscillator.

SINAD Measurement Block Diagram

Comments

If an external oscillator is used, it must be tuned to within 5% of the internal oscillator frequency.

During a SINAD measurement, the output rms detector uses increased filtering to obtain more consistant readings in the presence of noise.

Special Function 7 can be used to change the SINAD meter range (refer to Special Functions).

For SINAD ratios less than 25 dB, the digital display is automatically rounded to the nearest 0.5 dB to reduce digit flicker.

Related Sections

Amplitude
Frequency
Special Functions

Special Functions

Description

General Information. Special Functions extend user control of the instrument beyond that normally available from dedicated front-panel keys. They are intended for the user who has an understanding of the instrument and the service technician who needs arbitrary control of the instrument functions. Special Functions are accessed via keyboard or HP-IB entry of the appropriate numeric code and terminated by the SPCL key or HP-IB code (refer to Procedures below). The codes comprise a prefix, decimal, and suffix. Special Functions are disabled by a variety of means, depending upon the function. Refer to the comprehensive listings below for actions which clear or disable any Special Function. Special Functions are grouped by their prefixes into three categories as follows:

Prefix 0

This is the Direct Control Special Function and is intended for use in servicing the Audio Analyzer. All instrument error messages and safeguards are inactive. This is discussed in detail in Section VIII. If the Direct Control is entered inadvertently press AUTOMATIC OPERATION.

Prefixes 1 to 39

These are the User Special Functions which are used during normal instrument operation when a special configuration, a special measurement, or special information is required. All error messages and some safeguards remain in effect unless the operator disables them. These Special Functions are described below.

Prefixes 40 to 99

These are the Service Special Functions used to assist in troubleshooting an instrument fault. The functions available are quite diverse — special internal measurements, software control, and special service tests and configurations. Most instrument safeguards are relinquished. These Special Functions are discussed in detail in Section VIII. If a Service Special Function is entered inadvertently, press AUTOMATIC OPERATION.

Viewing Special Function States. In addition to completing the entry of Special Function codes, the SPCL key allows viewing of some Special Function settings. The operator-requested settings of Special Functions prefixed 1 through 8 may be viewed by pressing the SPCL key once (following no numeric entry). This display is called the Special Display. If some of these Special Functions are in automatic modes (generally the 0-suffix setting), the actual instrument settings of these functions may be displayed by pressing the SPCL key a second time while the Special Display is active. This display is called the Special Special Display. If desired, these displays can be cleared by pressing any key except the LCL, numeric, or S (Shift) keys. (While either display is active, pressing the SPCL key will switch to the other display.) A summary of User Special Functions is given on the following pages. Following the summary are procedures for using Special Display. These displays are also illustrated and explained.

Special Function Summary (1 of 4)

Special Function		HP-IB Code	Description	Lights SPCL key	Disable				References and Comments
Name	Code	HP-IB			AUTO. OP. key	Any Meas. key	CLEAR key	All keys*	
Input Level Range (except DC level)	1.0	1.0SP	Automatic selection	N	—	—	—	—	
	1.1	1.1SP	300V range	Y	Y	N	N	N	Input Level Range (except DC Level)
	1.2	1.2SP	189V range	Y	Y	N	N	N	
	1.3	1.3SP	119V range	Y	Y	N	N	N	
	1.4	1.4SP	75.4V range	Y	Y	N	N	N	
	1.5	1.5SP	47.6V range	Y	Y	N	N	N	
	1.6	1.6SP	30.0V range	Y	Y	N	N	N	
	1.7	1.7SP	18.9V range	Y	Y	N	N	N	
	1.8	1.8SP	11.9V range	Y	Y	N	N	N	
	1.9	1.9SP	7.54V range	Y	Y	N	N	N	
	1.10	1.10SP	4.76V range	Y	Y	N	N	N	
	1.11	1.11SP	3.00V range	Y	Y	N	N	N	
	1.12	1.12SP	1.89V range	Y	Y	N	N	N	
	1.13	1.13SP	1.19V range	Y	Y	N	N	N	
	1.14	1.14SP	0.754V range	Y	Y	N	N	N	
	1.15	1.15SP	0.476V range	Y	Y	N	N	N	
	1.16	1.16SP	0.300V range	Y	Y	N	N	N	
	1.17	1.17SP	0.189V range	Y	Y	N	N	N	
	1.18	1.18SP	0.119V range	Y	Y	N	N	N	
	1.19	1.19SP	0.0754V range	Y	Y	N	N	N	
Input Level Range (DC Level only)	2.0	2.0SP	Automatic Selection	N	—	—	—	—	Input Level Range (DC Level only)
	2.1	2.1SP	300V range	Y	Y	N	N	N	
	2.2	2.2SP	64V range	Y	Y	N	N	N	
	2.3	2.3SP	16V range	Y	Y	N	N	N	
	2.4	2.4SP	4V range	Y	Y	N	N	N	
Post-Notch Gain	3.0	3.0SP	Automatic selection	N	—	—	—	—	Post-Notch Gain
	3.1	3.1SP	0 dB gain	Y	Y	N	N	N	
	3.2	3.2SP	20 dB gain	Y	Y	N	N	N	
	3.3	3.3SP	40 dB gain	Y	Y	N	N	N	
	3.4	3.4SP	60 dB gain	Y	Y	N	N	N	
Hold Decimal Point (right display only)	4.0	4.0SP	Automatic Selection	N	—	—	—	—	Hold Decimal Point
	4.1	4.1SP	DDDD. range[1]	Y	Y	N	N	N	
	4.2	4.2SP	DDD.D range	Y	Y	N	N	N	[1]Decimal Point not displayed
	4.3	4.3SP	DD.DD range	Y	Y	N	N	N	
	4.4	4.4SP	D.DDD range	Y	Y	N	N	N	
	4.5	4.5SP	0.DDDD range[2]	Y	Y	N	N	N	[2]Leading zero not displayed. Shown to clarify decimal point position.
	4.6	4.6SP	DD.DD mV range	Y	Y	N	N	N	
	4.7	4.7SP	D.DDD mV range	Y	Y	N	N	N	
	4.8	4.8SP	0.DDDD mV range[2]	Y	Y	N	N	N	

N = No; — = Not Applicable; Y = Yes; *Except the LCL, S (Shift), and Numeric Keys.

Special Function Summary (2 of 4)

Special Function		HP-IB Code HP-IB	Description	Lights SPCL key	Disable				References and Comments
Name	Code				AUTO. OP. key	Any Meas. key	CLEAR key	All keys*	
Post-Notch Detector Response (except in SINAD)	5.0	5.0SP	Fast Detector	N	—	—	—	—	Post-Notch Detector Response
	5.1	5.1SP	Slow Detector	Y	Y	N	N	N	
Notch Tune	6.0	6.0SP	Automatic notch tuning	N	—	—	—	—	Notch Tune
	6.1	6.1SP	Hold notch tuning	Y	Y	N	N	N	
SINAD Meter Range	7.0	7.0SP	0 to ≈18 dB range	N	—	—	—	—	SINAD
	7.1	7.1SP	0 to ≈24 dB range	Y	Y	N	N	N	
Error Disable	8.0	8.0SP	All errors enabled	N	—	—	—	—	Error Disable
	8.1	8.1SP	Disable Analyzer errors (Errors 12-17, 31, and 96)	Y	Y	N	N	N	
	8.2	8.2SP	Disable Source errors (Error 18 and 19)	Y	Y	N	N	N	
	8.3	8.3SP	Disable both Analyzer and Source errors	Y	Y	N	N	N	
Hold Settings	9.0	9.0SP	Hold input level ranges, post-notch gain, decimal point and notch tuning at present settings.	Y	Y	N	N	N	Hold Settings
Display Source Settings	10.0	10.0SP	Display source settings as entered. Frequency in left display/ amplitude in right display.	Y	Y	Y	N	N	Display Source Settings
Re-enter Ratio Mode	11.0	11.0SP	Restore last RATIO reference and enter RATIO mode if allowed.	N	N	Y	N	N	RATIO and LOG/LIN
	11.1	11.1SP	Display RATIO reference	Y	Y	Y	Y	N	
Signal-to-Noise Measurements Delay	12.0	12.0SP	Automatic Selection	N	—	—	—	—	Signal-to-Noise
	12.1	1.21SP	200 ms delay	Y	Y	Y	N	N	
	12.2	12.2SP	400 ms delay	Y	Y	Y	N	N	
(Continued on next page)	12.3	12.3SP	600 ms delay	Y	Y	Y	N	N	
	12.4	12.4SP	800 ms delay	Y	Y	Y	N	N	
	12.5	12.5SP	1.0s delay	Y	Y	Y	N	N	

N = No; — = Not applicable; Y = Yes; *Except the LCL, S (Shift), and Numeric Keys.

Special Function Summary (3 of 4)

Special Function		HP-IB Code HP-IB	Description	Lights SPCL key	Disable				References and Comments
Name	Code				AUTO. OP. key	Any Meas. key	CLEAR key	All keys*	
Signal-to-Noise (Cont'd)	12.6	12.6SP	1.2s delay	Y	Y	Y	N	N	
	12.7	12.7SP	1.4s delay	Y	Y	Y	N	N	
	12.8	12.8SP	1.6s delay	Y	Y	Y	N	N	
	12.9	12.9SP	1.8s delay	Y	Y	Y	N	N	
X-Y Recorder	13.0	13.0SP	Enable plot	N	N	Y	Y	N	X-Y Recording
	13.1	13.1SP	Disable plot	Y	Y	N	N	N	
Time Between Measurements	14.0	14.0SP	Minimum time between measurements	N	—	—	—	—	Time Between Measurement
	14.1	14.1SP	Add 1s between measurements	Y	Y	N	N	N	
SINAD and Signal-to-Noise Display Resolution	16.0	16.0SP	0.01 dB above 25 dB; 0.5 dB below 25 dB	N	—	—	—	—	SINAD and Signal-to-Noise
	16.1	16.1SP	0.01 dB all ranges	Y	Y	N	N	N	
Sweep Resolution (Maximum 255 points/sweep)	17.0	17.0SP	10 points/decade	N	—	—	—	—	Sweep Resolution
	17.1	17.1SP	1 points/decade	Y	Y	N	N	N	
	17.2	17.2SP	2 points/decade	Y	Y	N	N	N	
	17.3	17.3SP	5 points/decade	Y	Y	N	N	N	
	17.4	17.4SP	10 points/decade	Y	Y	N	N	N	
	17.5	17.5SP	20 points/decade	Y	Y	N	N	N	
	17.6	17.6SP	50 points/decade	Y	Y	N	N	N	
	17.7	17.7SP	100 points/decade	Y	Y	N	N	N	
	17.8	17.8SP	200 points/decade	Y	Y	N	N	N	
	17.9	17.9SP	500 points/decade	Y	Y	N	N	N	
Display Level in Watts	19.0	19.0SP	Display level as watts into 8 ohms	Y	Y	Y	Y	Y	Display Level in Watts
	19.NNN	19.NNNSP	Display level as watts into NNN ohms	Y	Y	Y	Y	Y	
Read Display to HP-IB HP-IB	20.0	20.0SP	Read right display	N	N	N	N	N	Read Display to HP-IB
	20.1	20.1SP	Read left display	N	N	N	N	N	

N = No; — = Not Applicable; Y = Yes; *Except the LCL, S (Shift), and Numeric Keys.

Special Function Summary (4 of 4)

Special Function		HP-IB Code	Description		Disable				References and Comments
Name	Code	HP-IB		Lights SPCL key	AUTO. OP. key	Any Meas. key	CLEAR key	All keys*	
HP-IB Address HP-IB	21.0	21.0SP	Displays HP-IB address (in binary) in left display; right display in form TLS where T=1 means talk only; L=1 means listen only; S=1 means SRQ.	Y	Y	Y	Y	Y	HP-IB Address
	21.1	21.1SP	Displays HP-IB address in decimal.						
Service Request HP-IB	22.N	22.NSP	Enable a condition to cause a service request, N is the sum of any combination of the weighted conditions below: 1—Data Ready 2—HP-IB error 4—Instrument error The instrument powers up in the 22.2 state (HP-IB error).	N	N	N	N	N	HP-IB Service Request Condition

N = No; — = Not Applicable; Y = Yes; *Except the LCL, S (Shift), and Numeric Keys.

Special Functions (Cont'd)

Procedure

Entering Special Functions. To use a Special Function, key in the corresponding code, then press the SPCL key.

Special Display. To display the user-requested modes of Special Functions 1 through 8, press the SPCL key alone one time. The digit position (noted beneath the displays) corresponds to the Special Function prefix, and the number displayed in that position corresponds to the Special Function suffix.

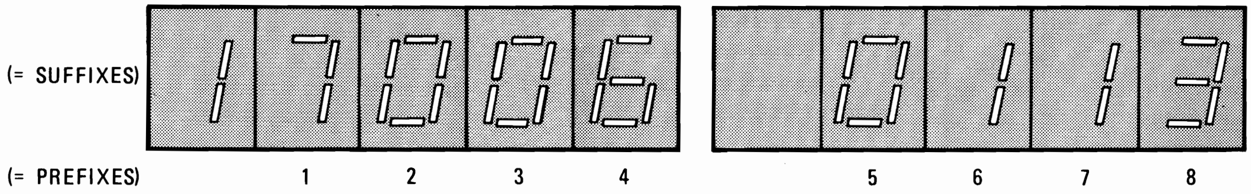
Special Special Display. To determine the actual instrument settings of functions prefixed 1 through 8, press the SPCL key alone once while Special Display is active. (If the Special Display described above is not in effect, press the SPCL key twice to get this display.) The digit position corresponds to the function prefix, and the number displayed in that digit corresponds to the function suffix.

Examples

Entering Special Functions. To display the frequency and the amplitude settings entered for the source (Special Function 10):

LOCAL (keystrokes)	Code: 1 0 . 0 Function: SPCL ●
HP-IB (program codes)	10.0SP Code Function

Special Display. When SPCL is pressed alone once and the following display results,



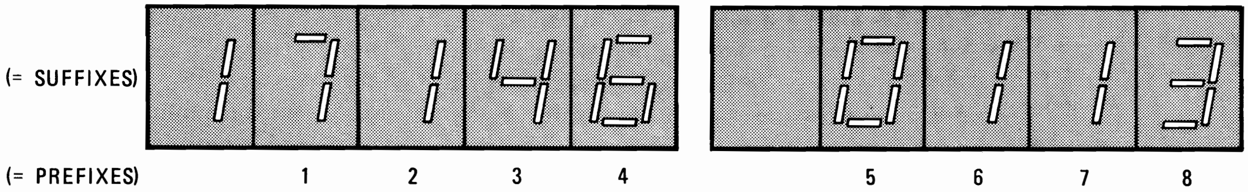
This display indicates that the following Special Functions were selected by the operator:

Special Function		User-Requested Setting
Code	Name	
1.17	Input Level Range (Except DC Level)	0.189V range
2.0	Input Level Range (DC Level only)	Automatic Selection
3.0	Post-Notch Gain	Automatic Selection
4.6	Hold Decimal Point (right display only)	DD.DD mV range
5.0	Post-Notch Detector Response (Except in SINAD)	Fast Detector
6.1	Notch Tune	Hold notch tuning
7.1	SINAD Meter Range	0 to 24 dB range
8.3	Error Disable	Disable both analyzer and source errors

Special Functions (Cont'd)

Examples (Cont'd)

Special Special Display. When SPCL is pressed again while the Special Display is active and the following display results, the actual instrument settings are tablulated below.



Special Function		Actual Instrument Setting
Code	Name	
1.17	Input Level Range (Except DC Level)	0.189V range
2.1	Input Level Range (DC Level only)	300V range
3.4	Post-Notch Gain	60 dB Range
4.6	Hold Decimal Point	DD.DD mV range
5.0	Post-Notch Detector Response (Except in SINAD)	Fast Detector
6.1	Notch Tune	Hold notch tuning
7.1	SINAD Meter Range	0 to 24 dB range
8.3	Error Disable	Disable both analyzer and source errors

Program Codes
HP-IB

HP-IB Codes for the Special Functions are summarized in the Special Function Summary above.

Indications

Entering Special Functions. As the numeric code is entered, both displays will blank, and the entered code will appear in the left display. When the SPCL key is pressed, both displays will again blank and four dashes will momentarily appear in the right display. These dashes are replaced with the appropriate reading for the selected measurement mode.

Comments

If a User Special Function (prefixes 1 to 39) has a suffix of zero, the zero need not be entered. For example, 10.0 SPCL equals 10. SPCL. (However, 1.1 SPCL does not equal 1.10 SPCL.) If when entering a Special Function code, Error 21 (invalid key sequence) is displayed, the Special Function requested has not been executed. Entry of invalid special function suffixes results in display of Error 23. For additional information on Direct Control Special Functions (prefix 0) or Service Special Functions (prefixes 40 to 99) refer to Section VIII.

Related Sections

Automatic Operation
Default Conditions and Power-up Sequence
Special Function Summary table (under Description above)

Sweep

Description

The Audio Analyzer source frequency can be logarithmically swept. The sweep range can be set between any two frequencies in the range of 20 Hz and 100 kHz. The source frequency changes in discrete steps rather than in a continous analog manner. The number of frequency points in a sweep is determined by the sweep width (the ratio of the entered stop and start frequencies) and the sweep resolution selected. The maximum number of points allowable in one sweep is 255. For more information about the number of points in a sweep and sweep resolution refer to Sweep Resolution. Using the sweep feature in conjunction with one of the Audio Analyzer measurement modes provides swept measurement capability. Swept response measurement can be plotted by connecting an X-Y recorder to the Audio Analyzer recorder outputs which are located on the rear panel. Any of the measurement results can be plotted as the source is swept in frequency.

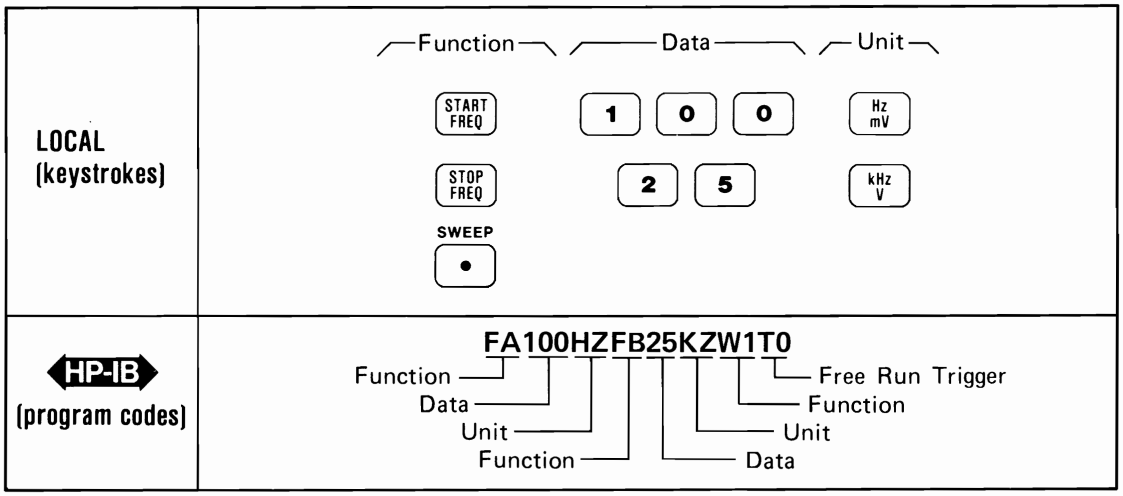
Procedure

Sweep Range Selection. The START FREQ and the STOP FREQ keys are used to set the starting and stopping points of the frequency sweep. To select a start frequency, press the START FREQ key, then the appropriate numeric data and unit keys. To select a stop frequency, press the STOP FREQ key, then the appropriate numeric data and unit keys. To display the currently programmed start or stop frequency, press and hold the respective START FREQ or STOP FREQ key.

Sweep Mode Selection. The SWEEP key puts the instrument in the sweep mode. The source does not start sweeping until a signal is sensed at the INPUT. At the end of the sweep, the sweep circuitry is turned off (no longer in sweep mode). To stop in midsweep, press the CLEAR key. Pressing the SWEEP key again will reset and restart the sweep.

Example

To sweep the source frequency from 100 Hz to 25 kHz:



`FA100HZFB25KZW1T0`

Program Codes

HP-IB

Key	Program Codes
START FREQ	FA
STOP FREQ	FB
SWEEP OFF	W0
SWEEP ON	W1
kHz	KZ
Hz	HZ

NOTE

Free Run triggering (code T0) is the only trigger mode allowed when using the sweep function (code W1). Any other triggering (codes T1, T2, or T3) or use of CLEAR key triggering will cause only the start frequency point to be displayed, plotted, and read to the HP-IB. Both the rear-panel X AXIS and Y AXIS outputs will be inhibited from continuing beyond the start frequency point.

Sweep (Cont'd)

Indications

When the START FREQ or STOP FREQ key is pressed, the left display shows the currently programmed start or stop frequency and the source goes to that frequency. As the new start or stop frequency is entered, it will appear on the left display. When the unit key is pressed, the left display returns to show the input signal frequency. (The source remains at the start or stop frequency.)

When the SWEEP key is pressed, the LED within the SWEEP key will light. The light indicates that the instrument is in the sweep mode. Note, the light does not necessarily mean that the source is sweeping. When the sweep is completed, the light will turn off.

Comments

The Audio Analyzer powers up with start and stop frequencies of 20 Hz and 20 kHz respectively.

Reverse sweep (that is, sweeping from a higher frequency to a lower frequency) is obtained by simply entering a start frequency which is higher than the stop frequency.

During the sweep mode, all the front-panel keys remain active, hence they affect the sweep function. Pressing certain front-panel keys while the instrument is in the sweep mode can cause an undefined state or an error condition. Therefore, it is recommended that only the followings keys be pressed during a sweep: CLEAR, STOP FREQ, START FREQ, AUTOMATIC OPERATION, and SWEEP. The function of these keys during sweep mode is described below.

> CLEAR and AUTOMATIC OPERATION: When pressed the keys stop the sweep. The source remains tuned to the frequency point where the sweep was stopped. However, the sweep cannot be restarted from that point.
>
> START FREQ and STOP FREQ: These keys when pressed, stop the current sweep and tune the source to either the currently programmed start or stop frequency. Which frequency the source is tuned to, depends upon which key was pressed.
>
> SWEEP: The sweep key stops the current sweep, retunes the source frequency back to the start frequency, and restarts the sweep from that point.

Errors which are signified by the two dashes or four dashes on the right display, stop the sweep but do not take the instrument out of sweep mode. As soon as the error-causing condition is removed, the sweep starts again from where it left off.

Nonrecoverable errors, such as Error 10, Error 11, etc., require that the error-causing condition be removed and the error message be cleared before another sweep can be initiated. Note, the sweep cannot continue from the frequency point at which the error first occurred.

The time required to complete a sweep depends on factors such as measurement mode, sweep width, sweep resolution, and input signal level.

Related Sections

Plot Limit
Sweep Resolution
X-Y Recording

Sweep Resolution

(Special Function 17)

Description The Audio Analyzer powers up with a sweep resolution of 10 points/decade. However, the sweep resolution can be manually selected from 1 to 500 points/decade by keyboard entry using the SPCL key.

Procedure To select a different sweep resolution, key in the corresponding Special Function code, then press the SPCL key.

Sweep Resolution	Special Function Code	Program Code HP-IB
10 points/decade	17.0 SPCL	17.0SP
1 point/decade	17.1 SPCL	17.1SP
2 points/decade	17.2 SPCL	17.2SP
5 points/decade	17.3 SPCL	17.3SP
10 points/decade	17.4 SPCL	17.4SP
20 points/decade	17.5 SPCL	17.5SP
50 points/decade	17.6 SPCL	17.6SP
100 points/decade	17.7 SPCL	17.7SP
200 points/decade	17.8 SPCL	17.8SP
500 points/decade	17.9 SPCL	17.9SP

Example To set the sweep resolution to 100 points/decade:

LOCAL (keystrokes)	Code: 1 7 . 7 Function: SPCL •
HP-IB (program codes)	17.7SP Code: 17.7 Function: SP

Program Codes HP-IB For HB-IB codes, refer to Procedure above.

Indications As the numeric code is entered, it will appear on the left display. When the SPCL key is pressed, the left display returns to show the input signal frequency. Unless Special Function code 17.0 was entered, the light within the SPCL key will turn on if not already on. If the light is already on, it will remain on.

Comments The maximum number of points in a sweep is restricted to 255 points. Therefore, if a sweep resolution of 500 points/decade is required the sweep span has to be limited to approximately half a decade.

The frequency points in a sweep can be computed by using the following formulas:

$$\text{Frequency} = \text{START FREQ} \times 10^{n/k}$$

Where: n = the frequency point number and n = 0 is for the start frequency

k = number of points per decade.

Sweep Resolution (Cont'd)

(Special Function 17)

Comments (Cont'd)

For reverse sweep the frequency point formula becomes:

$$\text{Frequency} = \text{START FREQ} \times 10^{-n/k}$$

The following example illustrates how to compute the frequency points for a 50 Hz to 30 kHz sweep with a sweep resolution of 5 points/decade (Special Function code 17.3).

1. Compute the sweep range in decades using the formula:

$$\text{sweep range (in decades)} = \log \frac{\text{STOP FREQ}}{\text{START FREQ}}$$

For this example; sweep range = $\log \frac{30\,000}{50}$

sweep range = 2.78 decades

2. Compute the total number of points in a sweep using the formula:

total number of points = points/decade × sweep range

Since the number of points in a sweep is always an integer, round off the result from the above equation to the nearest integer.

For this example:

total number of points = 5 points/decade × 2.78 decades

total number of points = 13.89 points

Therefore, the total number of points equals 14 points.

3. Compute the frequency points using the frequency point formula. Use the result from step 2 to calculate the point numbers. Start from n=0 (start frequency) and continue to n = last point (stop frequency). Note that the stop frequency always equals the programmed stop frequency which can differ from the computed value.

(Continued on next page)

Sweep Resolution (Cont'd)

(Special Function 17)

Comments (Cont'd)

For this example, the frequency points are computed and listed in the table below.

Point Number (n)	Computed Frequency $f = 50\ Hz \times 10^{n/5}$
0	50.000 Hz
1	79.245 Hz
2	125.59 Hz
3	199.05 Hz
4	315.48 Hz
5	500.00 Hz
6	792.45 Hz
7	1255.9 Hz
8	1990.5 Hz
9	3154.8 Hz
10	5000.0 Hz
11	7924.5 Hz
12	12.559 kHz
13	19.905 kHz
14	31.548 kHz*

*For the last point in the sweep the instrument tunes to the programmed stop frequency (30 kHz) and not the computed value (31.548 kHz).

Related Sections

Special Functions
Sweep
X-Y Recording

Time Between Measurements

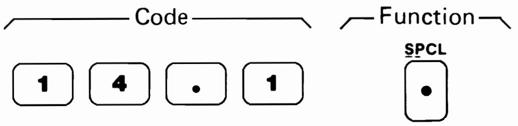
(Special Function 14)

Description A one-second delay between measurements can be added using Special Function 14. This one second delay is normally used when making plots with a relatively slow X-Y recorder. It can also be used to to allow the device under test to settle before making the measurement.

Procedure To add or delete the one second time delay between measurements, key in the corresponding Special Function code; and then press the SPCL key.

Time Delay Between Measurements	Special Function Code	Program Code HP-IB
Minimum Add 1 second	14.0 SPCL 14.1 SPCL	14.0SP 14.1SP

Example To set a one second time delay between measurements:

LOCAL (keystrokes)	
HP-IB (program codes)	14.1SP Code Function

Program Codes HP-IB For HP-IB codes, refer to Procedure above.

Indications As the numeric code is entered, both displays will blank and the entered code will appear in the left display. When the SPCL key is pressed, the SPCL key lights if it is not already on. If it is already on, it will remain on. Both displays then return to the display that is appropriate for the currently selected measurement mode.

Related Sections
Automatic Operation
Special Functions
X-Y Recording

X-Y Recording

Description

When used in conjunction with the sweep mode, any of the measurement results can be plotted as a function of frequency by connecting an X-Y recorder to the Audio Analyzer recorder outputs. The recorder outputs are X AXIS, Y AXIS, and PEN LIFT. These outputs are located on the rear panel of the instrument.

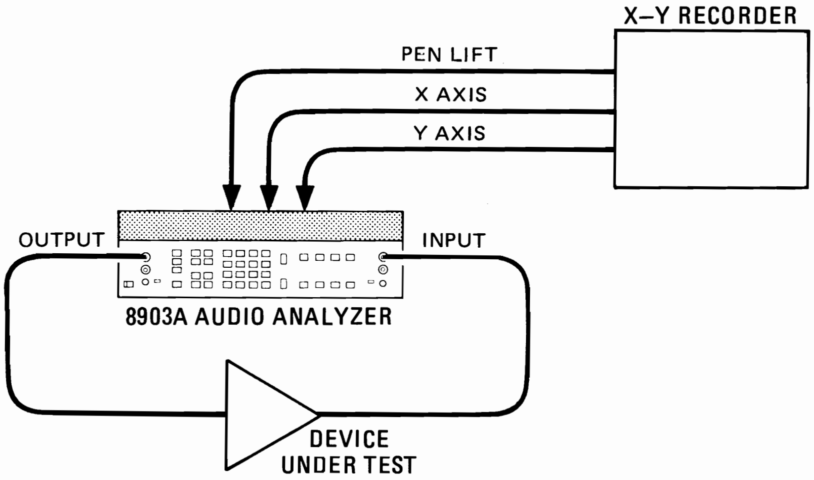
The X AXIS and Y AXIS outputs provide a voltage staircase scaled between 0 and 10 Vdc. The output impedance for both outputs is 1000 ohms. X-axis scaling is determined by the programmed start and stop frequencies. The output voltage is proportional to the logarithmic sweep of the source. The output voltage ranges from 0 Vdc for the start frequency to approximately 10 Vdc for the stop frequency. Y-axis scaling is determined by the measurement unit selected and the programmed upper and lower plot limits. The output voltage is proportional to the displayed reading. The output voltage ranges from 0 Vdc for the lower plot limit value to approximately 10 Vdc for the upper plot limit value.

The PEN LIFT output is a TTL high level for a pen-up condition and a TTL low level for a pen-down condition. During a sweep the PEN LIFT output goes low (pen-down condition) after reaching the first point, then goes high again after plotting the last point.

Procedure

The following procedure describes how to use the Audio Analyzer with an X-Y recorder:

1. The figure below illustrates a typical set-up for X-Y recording. Connect the equipment as shown in the figure and select a measurement.



X-Y Recording Setup

2. The START FREQ and STOP FREQ keys are used to establish the two reference points needed for adjusting the X-Y recorder X and Y axes. These two references determine the plotting area or plot dimension. The START FREQ key sets both the X AXIS and Y AXIS outputs to 0 volts. This reference point corresponds to the lower left corner of the graph. To set the lower left corner point, press the START FREQ key and adjust the zero controls on the X-Y recorder to position the pen to the lower left corner of the graph. The STOP FREQ key sets both the X AXIS and Y AXIS outputs to 10 volts. This reference point corresponds to the upper right

X-Y Recording (Cont'd)

Procedure (Cont'd)

corner of the graph. To set the upper right corner point, press the STOP FREQ key and adjust the vernier controls on the X-Y recorder to position the pen to the upper right corner of the graph.

3. The Y-axis scaling unit is determined by the displayed measurement unit in the right display. Any displayed measurement unit except mV can be used when plotting. To scale the Y axis, key in the desired upper and lower plot limit.

4. The X axis corresponds to the frequency span of the Audio Analyzer source. The frequency scaling of the X axis is in logarithmic units. To scale the X axis, key in the desired start and stop frequencies. The left-most point on the X axis corresponds to the start frequency.

   NOTE

   No readjustment of the X-Y recorder is required if the X and Y scale factors are changed. The Audio Analyzer automatically scales both the X- and Y-axis outputs to fit in the established plot dimension.

5. To execute the plot, press the SWEEP key. The number of frequency points plotted is determined by the sweep size (the ratio of the entered start and frequencies) and the sweep resolution selected. The sweep resolution can be selected from 1 to 500 points per decade using Special Function 17. The maximum number of points allowable in one sweep is 255.

Example

The following example describes how to plot the frequency response (gain vs. frequency) of a RIAA (Record Industry Association of America) phonograph preamplifier. The figure below is a plot of a theoretical RIAA curve. By plotting the frequency response of the amplifier on a copy of this figure, the response of the amplifier can be directly compared with the theoretical response. A table of RIAA response values is also included. (This standard is normally specified over a range 50 Hz to 15 kHz.)

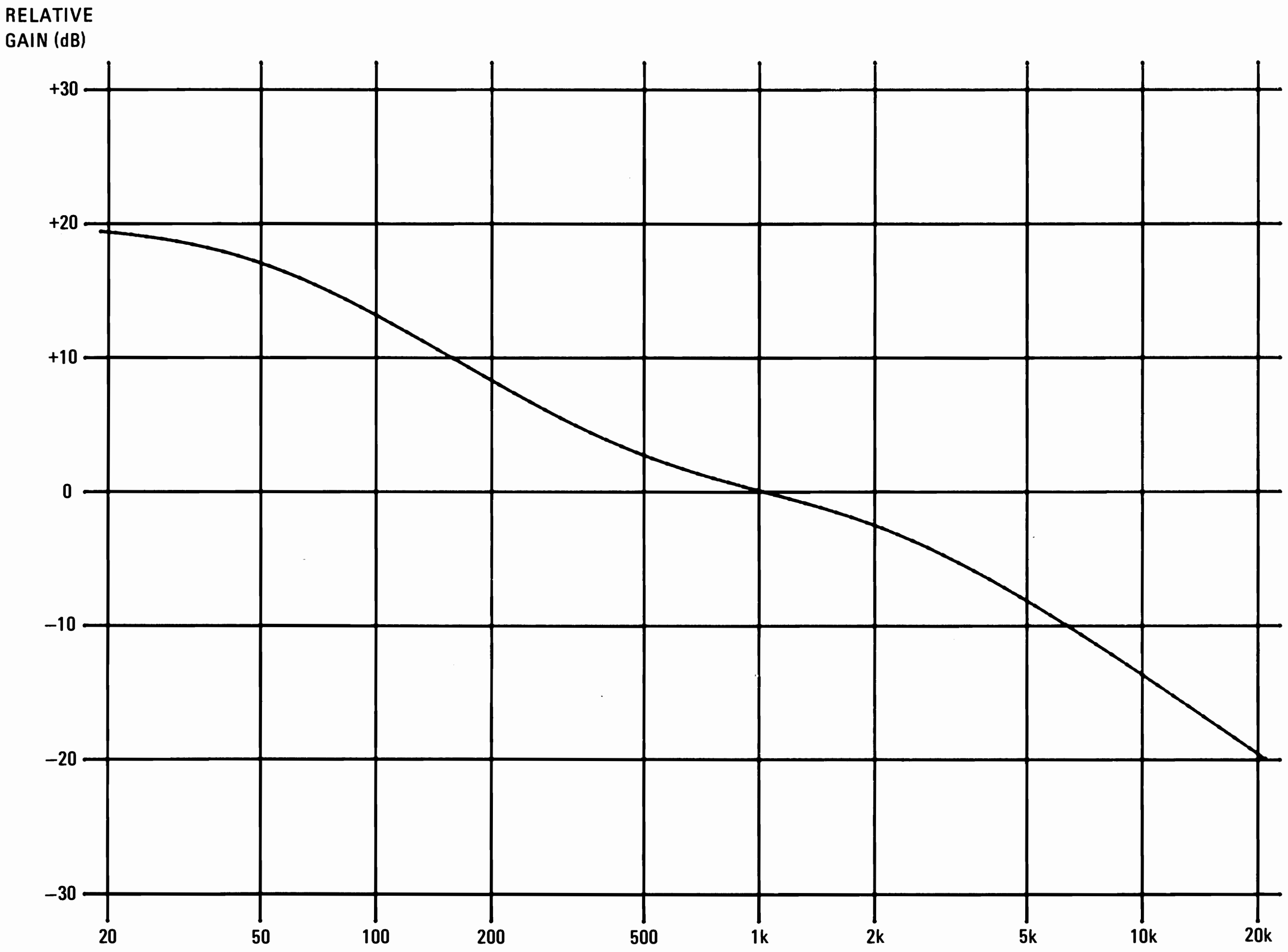
RIAA Standard Response

Frequency (Hz)	Relative Gain (dB)	Frequency (Hz)	Relative Gain (dB)
20	+19.27	800	+0.75
30	+18.59	1 000*	0.00
40	+17.79	1 500	−1.40
50	+16.95	2 000	−2.59
60	+16.10	3 000	−4.74
80	+14.51	4 000	−6.61
100	+13.09	5 000	−8.21
150	+10.27	6 000	−9.60
200	+8.22	8 000	−11.90
300	+5.48	10 000	−13.74
400	+3.78	15 000	−17.16
500	+2.65	20 000	−19.62

* Reference frequency

1. Connect the equipment as shown in the figure on the previous page.

2. Place a graph paper or a copy of the RIAA curve on the X-Y recorder. (This procedure assumes that the measurement result is plotted on a copy of the RIAA



Theoretical RIAA Response Curve

X-Y Recording (Cont'd)

Example (Cont'd)

curve.) Press the START FREQ key and use the zero controls on the X-Y recorder to move the pen to the lower left corner of the graph. The point where the 20 Hz and −30 dB grid lines cross corresponds to the lower left corner. Next, press the STOP FREQ key and use the vernier controls on the X-Y recorder to move the pen to the upper right corner of the graph (the intersection of the +30 dB and 20 kHz grid lines). Press the START FREQ key again to check the lower left corner point and readjust if necessary.

LOCAL (keystrokes)	[START FREQ] [STOP FREQ]

3. Set the Audio Analyzer to measure ac level.

LOCAL (keystrokes)	AC LEVEL [•]

4. Set the Audio Analyzer source to sweep from 20 Hz to 20 kHz. (The Audio Analyzer powers up with start and stop frequencies of 20 Hz and 20 kHz respectively.)

LOCAL (keystrokes)	[START FREQ] [2] [0] [Hz mV] [STOP FREQ] [2] [0] [kHz V]

5. Set the Audio Analyzer upper and lower plot limit to +30 and −30, respectively.

LOCAL (keystrokes)	[PLOT LIMIT] [3] [0] UPPER LIMIT [kHz V] [−] [3] [0] LOWER LIMIT [Hz mV]

6. Select the desired sweep resolution using Special Function 17. (The Audio Analyzer powers up with the sweep resolution set at 10 points per decade.) In this example there are three decades (log 20000/20 = 3) so the maximum sweep resolution allowed is 50 points per decade.

7. Set the Audio Analyzer source frequency to 1 kHz and establish a ratio reference in dB to the displayed value. If the ac level is displayed in volts, press the LOG/LIN key to obtain a display in dB.

LOCAL (keystrokes)	[FREQ] [1] [kHz V] [•] RATIO

X-Y Recording (Cont'd)

Example (Cont'd)

NOTE. Since the RIAA amplifier gain is much higher at 20 Hz, it is recommended that the signal source first be set to 20 Hz and the level be set for less than rated output from the preamplifier.

8. The graph paper is now scaled to measure ac level in dB from 20 Hz to 20 kHz. The upper plot limit is equal to +30 dB and the lower plot limit is equal to –30 dB. The level at 1 kHz is referenced to 0 dB. Press the SWEEP key to start the plot. When the plot is completed the LED within the sweep key will turn off and the PEN LIFT output will go high. (If the plot has been disabled by Special Function 13.1, enable plot by keying in 13.0 SPCL.)

Program Codes HP-IB

The HP-IB codes for the above example are given below:

Key	Program Code HP-IB
START FREQ	FA
STOP FREQ	FB
AC LEVEL	M1
Hz	HZ
kHz	KZ
PLOT LIMIT	PL
UPPER LIMIT	UL
LOWER LIMIT	LL
RATIO Off	R0
RATIO On	R1
LOG	LG
SWEEP	W1

Comments

The X- and Y-axis outputs and the PEN LIFT output can be selectively enabled or disabled by using Special Function 13. This feature allows the user to disable the X-Y recorder during a sweep.

Some delay may be noted when pressing keys during sweep with an X-Y recorder enabled. This delay allows the pen to lift before moving on. Keys pressed during the sweep are recognized, and it is not necessary to hold them down while waiting for the Audio Analyzer to respond.

If the sweep is too fast for the X-Y Recorder, a delay of 1 second can be added between points by using Special Function 14.1.

Related Sections

AC Level
DC Level
SINAD
Signal-to-Noise
Distortion
Distortion Level
Plot Limit
Special Functions
Sweep
Sweep Resolution
Time Between Measurements

SECTION IV
PERFORMANCE TESTS

4-1. INTRODUCTION

The procedures in this section test the instrument's electrical performance using the specifications of Table 1-1 as the performance standards. All tests can be performed without access to the interior of the instrument. A simpler operational test is included in Section III under Basic Functional Checks (paragraph 3-10). The Basic Functional Checks also test the instrument's ability to function in the automatic mode (which is not thoroughly checked by the Performance Tests).

NOTE

Unless otherwise noted, no warm-up period is required for these tests.

Line voltage must be within +5% and −10% of the specified input voltage (100, 120, 220 or 240 Vac) if the performance tests are to be considered valid.

4-2. EQUIPMENT REQUIRED

Equipment required for the performance tests is listed in Table 1-3, Recommended Test Equipment in Section I of this manual. Any equipment that satisfies the critical specifications in the table may be substituted for the recommended model(s).

NOTE

The performance tests are based on the assumption that the recommended test equipment is used. Substituting alternate test equipment may require modification of some procedures.

4-3. TEST RECORD

Results of the performance tests may be tabulated on the Test Record shown in Table 4-1 at the end of the procedures. The Test Record lists all of the tested specifications and their acceptable limits. The results, recorded at incoming inspection, can be used for comparison in periodic maintenance and troubleshooting and after repairs or adjustments.

4-4. CALIBRATION CYCLE

This instrument requires periodic verification of performance. Depending on the use and environmental conditions, the instrument should be checked using the following performance tests at least once every year.

4-5. ABBREVIATED PERFORMANCE TESTING

No abbreviation of performance testing is recommended.

PERFORMANCE TESTS

4-6. AC LEVEL ACCURACY AND OUTPUT LEVEL ACCURACY AND FLATNESS PERFORMANCE TEST

SPECIFICATION:

Characteristic	Performance Limits	Conditions
SOURCE		
OUTPUT LEVEL		
Accuracy	±2% of setting	60 mV to 6V; open circuit; 20 Hz to 50 kHz
	±3% of setting	6 mV to 6V; open circuit; 20 Hz to 100 kHz
	±5% of setting	0.6 mV to 6 mV; open circuit; 20 Hz to 100 kHz
Flatness	±0.7%	20 Hz to 20 kHz; 1 kHz reference
	±2.5%	20 Hz to 100 kHz; 1 kHz reference
MEASUREMENT		
AC LEVEL		
Accuracy	±2%	30V to 300V; 20 Hz to 1 kHz
	±2%	50 mV to 30V; 20 Hz to 20 kHz
	±4%	0.3 mV to 30V; 20 Hz to 100 kHz

DESCRIPTION: For the higher ac ranges, ac level accuracy is determined by measuring the output of an ac calibrator. To improve accuracy for the lowest ac range, the output from a higher, more accurate calibrator range is attenuated. The ac calibrator and Audio Analyzer are used to calibrate out any error in the attenuator.

The output level accuracy and flatness of the Audio Analyzer source are determined by measuring the output of the source directly with the Audio Analyzer's voltmeter which has just been calibrated. To minimize the effects of stray capacitance, the measurements are made using a feedthrough termination at the output. The divider error, caused by the feedthrough, is calibrated out.

EQUIPMENT:

AC Calibrator and High Voltage Amplifier	HP 745A and HP 746A
Attenuator	HP 4437A
Feedthrough Termination, 600Ω	HP 11095A

PERFORMANCE TESTS

4-6. AC LEVEL ACCURACY AND OUTPUT LEVEL ACCURACY AND FLATNESS PERFORMANCE TEST (Cont'd)

PROCEDURE: *High-Level AC Level Accuracy*

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the INPUT and OUTPUT switches both to ground. Set the 80 kHz LOW PASS FILTER off. Connect the ac calibrator to the Audio Analyzer's HIGH INPUT.

2. On the Audio Analyzer, key in the Special Functions indicated in the table below. Set the ac calibrator to the level indicated in the table. (Use the high voltage amplifier for levels >100V.) On the Audio Analyzer, key in the same voltage and press RATIO. Now set the ac calibrator to the frequency indicated in the table. The right display of the Audio Analyzer should read within the limits indicated.

NOTE

Record the readings in the table provided. Many of the readings will be used as calibration factors in later steps.

Special Function	AC Calibrator		Ratio Limits (%)		
	Level (Vrms)	Frequency (Hz)	Minimum	Actual	Maximum
1.1	300	20	98	________	102
		1 000	98	________	102
1.2	150	1 000	98	________	102
		20	98	________	102
1.3	100	1 000	98	________	102
		20	98		102
1.4	70	20	98	________	102
		1 000	98	________	102
1.5	45	1 000	98	________	102
		20	98	________	102
1.6	30	20	98	________	102
		20 000	98	________	102
		100 000	96	________	104
1.7	15	100 000	96	________	104
		20 000	98	________	102
		20	98	________	102

4-6. AC LEVEL ACCURACY AND OUTPUT LEVEL ACCURACY AND FLATNESS PERFORMANCE TEST (Cont'd)

Special Function	AC Calibrator		Ratio Limits (%)		
	Level (Vrms)	Frequency (Hz)	Minimum	Actual	Maximum
1.8	10	20	98	________	102
		20 000	98	________	102
		100 000	96	________	104
1.9	7	100 000	96	________	104
		20 000	98	________	102
		20	98	________	102
1.10	4.5	20	98	________	102
		20 000	98	________	102
		100 000	96	________	104
1.11	3.0	100 000	96	________	104
		50 000	96	________	104
		20 000	98	________	102
		1 000	98	________	102
		20	98	________	102
1.12	1.5	20	98	________	102
		20 000	98	________	102
		100 000	96	________	104
1.13	1.0	100 000	96	________	104
		20 000	98	________	102
		20	98	________	102
1.14	0.7	20	98	________	102
		20 000	98	________	102
		100 000	96	________	104
1.15	0.45	100 000	96	________	104
		20 000	98	________	102
		20	98	________	102
1.16	0.30	20	98	________	102
		1 000	98	________	102
		20 000	98	________	102
		50 000	96	________	104
		100 000	96	________	104
1.17	0.15	100 000	96	________	104
		20 000	98	________	102
		20	98	________	102
1.18	0.10	20	98	________	102
		20 000	98	________	102
		100 000	96	________	104
1.19	0.07	100 000	96	________	104
		20 000	98	________	102
		20	98	________	102

PERFORMANCE TESTS

4-6. AC LEVEL ACCURACY AND OUTPUT LEVEL ACCURACY AND FLATNESS PERFORMANCE TEST (Cont'd)

Low-Level AC Level Accuracy

3. Connect the equipment as shown in Figure 4-1. Set the ac calibrator for 3 Vrms. Set the attenuator to 40 dB.

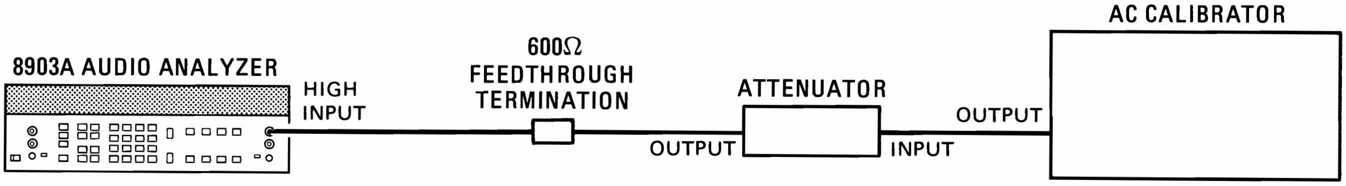


Figure 4-1. Low-Level AC Level Accuracy Test Setup

4. On the Audio Analyzer, set RATIO off. Set the ac calibrator to the frequency indicated in the table below. For each setting, perform the following procedure:

   a. Set the ac calibrator to 3 Vrms. (The right display of the Audio Analyzer should read approximately 30 mVrms.) On the Audio Analyzer, press RATIO.

   b. Set the ac calibrator to 30 mVrms. Set the attenuator to 0 dB. Note the reading of the right display of the Audio Analyzer.

   c. Set the attenuator to 40 dB. On the Audio Analyzer, set RATIO off. Multiply the reading on the right display by the calibration factor of step b above, then divide by 0.300 mV. The corrected reading should be within the limits indicated below. For example, if the reading in step b was 101.5% and the current right display reading is 0.297 mV, the corrected reading is

$$\frac{0.297 \text{ mV} \times 101.5\%}{0.300 \text{ mV}} = 100.49\%.$$

Calibrator Frequency (Hz)	Calibration Factor of Step b (%)	Limits of Corrected Reading (%)		
		Minimum	Actual	Maximum
20	________	96	______	104
1 000	________	96	______	104
20 000	________	96	______	104
50 000	________	96	______	104
100 000	________	96	______	104

Output Level Accuracy and Flatness

5. On the Audio Analyzer, key in 1.9 SPCL to set the input level range to 7V. Set AMPTD to 6V. Connect the the HIGH OUTPUT to the HIGH INPUT. Press RATIO.

6. Insert a 600Ω feedthrough termination in the line connecting HIGH OUTPUT to HIGH INPUT. Note the ratio reading on the right display.

4-6. AC LEVEL ACCURACY AND OUTPUT LEVEL ACCURACY AND FLATNESS PERFORMANCE TEST (Cont'd)

7. Compute:

$$\text{Calibration Factor} = \frac{100\%}{0.994 \times \text{reading of step 6}} = \_\_\_\_\_ .$$

(The factor 0.994 accounts for the voltage divider loss of the 600Ω SOURCE OUTPUT driving the 100 kΩ INPUT.)

8. Set RATIO off. Key in the Special Functions indicated below and set the SOURCE amplitude and frequency as indicated in the table below. For each setting, note the Audio Analyzer's right diplay and calculate the following: (reading of step 8) × (calibration factor of step 7) × 100%/(ratio reading of step 2 or 4 that corresponds to the same frequency and one-half the voltage of step 8). The results should be within the limits indicated.

Special Function	SOURCE		Limits of Results (mVrms)		
	Amplitude (V)	Frequency (Hz)	Minimum	Actual	Maximum
1.11	6	20	5 880	________	6 120
		1 000	5 880	________	6 120
		20 000	5 880	________	6 120
		50 000	5 880	________	6 120
		100 000	5 820	________	6 180
1.16	0.6	1 000	588	________	612
1.19	0.0006	1 000	0.57	________	0.63
		20	0.57	________	0.63
		20 000	0.57	________	0.63
		50 000	0.57	________	0.63
		100 000	0.57	________	0.63

9. For the readings of step 8 for 6V and 0.0006V, subtract the readings for each frequency from the reading for 1000 Hz. Ignoring the sign, the difference should be within the limits given below.

Amplitude (V)	Frequency (Hz)	Difference (mV)	
		Actual	Maximum
6	20	________	42
	20 000	________	42
	50 000	________	150
	100 000	________	150
0.0006	20	________	0.0042
	20 000	________	0.0042
	50 000	________	0.0150
	100 000	________	0.0150

PERFORMANCE TESTS

4-7. DC LEVEL ACCURACY PERFORMANCE TEST

SPECIFICATION:

Characteristic	Performance Limits	Conditions
MEASUREMENT DC LEVEL		
Accuracy	±0.75% of reading	400 mV to 300V
	±3 mV	<400 mV

DESCRIPTION: The output from a dc standard is applied to the input of the Audio Analyzer and the voltage on the display is compared against the output from the standard.

EQUIPMENT: DC Standard .... HP 740B or Fluke 893AR

PROCEDURE:

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the INPUT switch to ground. Set the MEASUREMENT mode to DC LEVEL.
2. Connect the output of the dc standard to the HIGH INPUT of the Audio Analyzer.
3. Set the dc standard to give the output voltage indicated below. For each setting, the right display on the Audio Analyzer should read within the limits indicated.

DC Standard Voltage (Vdc)	DC Voltage Limits (Vdc)		
	Minimum	Actual	Maximum
300	297.75	________	302.25
30	29.775	________	30.225
3	2.9775	________	3.0225
0.4	0.397	________	0.403
0.04	0.037	________	0.043

PERFORMANCE TESTS

4-8. DISTORTION AND NOISE PERFORMANCE TEST

SPECIFICATION:

Characteristic	Performance Limits	Conditions
SOURCE		
OUTPUT LEVEL		
Distortion and Noise	The higher of −80 dB or 30 μV	20 Hz to 20 kHz; 80 kHz bandwidth
	The higher of −70 dB or 95 μV	20 Hz to 50 kHz; 500 kHz bandwidth
	The higher of −65 dB or 169 μV	50 kHz to 100 kHz; 500 kHz bandwidth
MEASUREMENT		
DISTORTION		
Residual Noise and Distortion	The higher of 0.01% (−80 dB) or 30 μV	20 Hz to 20 kHz; 80 kHz bandwidth
	The higher of 0.032% (−70 dB) or 95 μV	20 kHz to 50 kHz; 500 kHz bandwidth
	The higher of 0.056% (−65 dB) or 169 μV	50 kHz to 100 kHz; 500 kHz bandwidth
SIGNAL-TO-NOISE		
Residual Noise	The higher of −80 dB or 30 μV	80 kHz bandwidth
	The higher of −70 dB or 95 μV	500 kHz bandwidth

DESCRIPTION: The output of the Audio Analyzer is connected to the input, and the combination of distortion and noise is measured at various frequencies and levels. The test measures the distortion and noise of the source and analyzer simultaneously. If either the source or the analyzer is out of specification, a known good source or analyzer can be substituted to determine which part of the instrument is not within specification.

EQUIPMENT: Feedthrough Termination, 600Ω............. HP 11095A

PROCEDURE:

1. Key in 41.0 SPCL to initialize the instrument. Set the INPUT and OUTPUT switches both to ground. Connect the HIGH OUTPUT to the HIGH INPUT through the 600Ω feedthrough termination.

2. Set the SOURCE frequency and amplitude and the MEASUREMENT mode and LP FILTER as indicated below. For each setting, the right display should be within the limits indicated.

4-8. DISTORTION AND NOISE PERFORMANCE TEST (Cont'd)

SOURCE		MEASUREMENT		Limits		
FREQ (Hz)	AMPTD (V)	Mode	LP FILTER	Minimum	Actual	Maximum
20	6.0	DISTN	80 kHz		________	0.01%
1 000	6.0	DISTN	80 kHz		________	0.01%
1 000	5.0	DISTN	80 kHz		________	0.01%
1 000	3.8	DISTN	80 kHz		________	0.01%
1 000	0.6	DISTN	80 kHz		________	0.01%
1 000	0.6	SIG/NOISE	80 kHz	+80 dB	________	
20 000	6.0	DISTN	80 kHz		________	0.01%
50 000	6.0	DISTN	Off		________	0.03%
50 000	0.6	DISTN	Off		________	0.03%
50 000	0.6	SIG/NOISE	Off	+70 dB	________	
100 000	6.0	DISTN	Off		________	0.056%
100 000	5.0	DISTN	Off		________	0.056%
100 000	3.8	DISTN	Off		________	0.056%

PERFORMANCE TESTS

4-9. DISTORTION, SINAD, AND SIGNAL-TO-NOISE ACCURACY PERFORMANCE TEST

SPECIFICATION:

Characteristic	Performance Limits	Conditions
MEASUREMENT		
DISTORTION		
Accuracy	±1 dB	20 Hz to 20 kHz
	±2 dB	20 kHz to 100 kHz
SINAD		
Accuracy	±1 dB	20 Hz to 20 kHz
	±2 dB	20 kHz to 100 kHz
SIGNAL-TO-NOISE		
Accuracy	±1 dB	50 Hz to 100 kHz

DESCRIPTION: A signal with a known amount of distortion is created artificially by summing the output from the Audio Analyzer and the output from another source into the input of the Audio Analyzer. The artifical distortion (or noise) is then measured by the Audio Analyzer. An external voltmeter with a very flat frequency response is used to set two signals to an equal level, then the attenuator in the other source is used to obtain a precise ratio.

EQUIPMENT:

Audio Oscillator .... HP 651B
Feedthrough Termination, 600Ω .... HP 11095A
True RMS Voltmeter .... HP 3403C

PROCEDURE:

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the OUTPUT and INPUT switches both to ground. Set AMPTD to 6V, MEASUREMENT to DISTN, and LOG/LIN to LOG.

2. Connect the equipment as shown in Figure 4-2. Set the voltmeter to read ac volts.

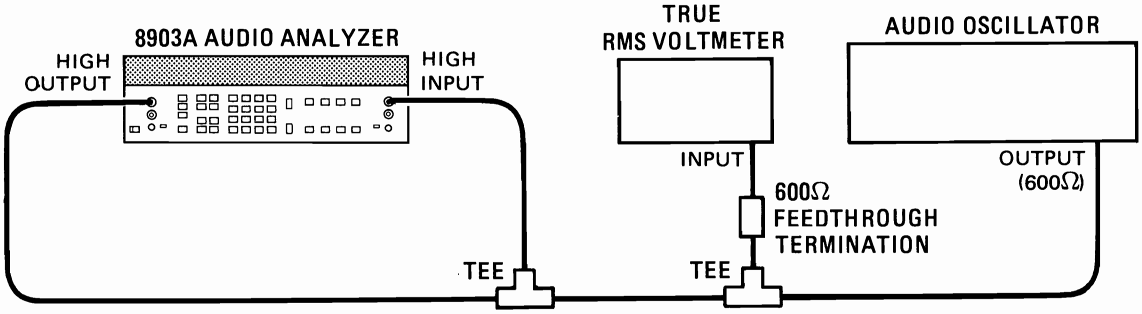


Figure 4-2. Distortion, SINAD, and Signal-to-Noise Accuracy Test Setup

4-9. DISTORTION, SINAD AND SIGNAL-TO-NOISE ACCURACY PERFORMANCE TEST (Cont'd)

3. Set the oscillator frequency and Audio Analyzer frequency as indicated below. For each frequency setting, perform the following procedure:

   a. Set the external audio oscillator level to minimum. Note the level of the Audio Analyzer output on the external voltmeter.

   b. On the Audio Analyzer, set AMPTD to 0V. Adjust the oscillator level (level attenuator and vernier) for the same reading as in step a.

   c. Increase the external oscillator output attenuation as indicated. Do not adjust the amplitude vernier.

   d. On the Audio Analyzer, set AMPTD to 6V. Key in the MEASUREMENT mode indicated in the following table. The display on the Audio Analyzer should read within the limits indicated.

Audio Oscillator		SOURCE FREQ (Hz)	MEASURE-MENT Mode	Limits (dB)		
Freq (Hz)	Atten (dB)			Minimum	Actual	Maximum
50	10	25	DISTN	−11.4		−9.4
50	10	25	SINAD	+9.4		+11.4
50	80	25	SINAD	+79.0		+81.0
50	80	25	DISTN	−81.0		−79.0
100	10	50	SIG/NOISE	+9.4		+11.4
100	80	50	SIG/NOISE	+79.0		+81.0
4 000	10	2 000	DISTN	−11.4		−9.4
4 000	20	2 000	DISTN	−21.0		−19.0
4 000	30	2 000	DISTN	−31.0		−29.0
4 000	40	2 000	DISTN	−41.0		−39.0
4 000	50	2 000	DISTN	−51.0		−49.0
4 000	60	2 000	DISTN	−61.0		−59.0
4 000	70	2 000	DISTN	−71.0		−69.0
4 000	80	2 000	DISTN	−81.0		−79.0
6 000	80	2 000	DISTN	−81.0		−79.0
6 000	10	2 000	DISTN	−11.4		−9.4
8 000	10	2 000	DISTN	−11.4		−9.4
8 000	80	2 000	DISTN	−81.0		−79.0
10 000	80	2 000	DISTN	−81.0		−79.0
10 000	10	2 000	DISTN	−11.4		−9.4
40 000	10	20 000	DISTN	−11.4		−9.4
40 000	10	20 000	SINAD	+9.4		+11.4
40 000	10	20 000	SIG/NOISE	+9.4		+11.4
40 000	80	20 000	SIG/NOISE	+79.0		+81.0
40 000	80	20 000	SINAD	+79.0		+81.0
40 000	80	20 000	DISTN	−81.0		−79.0

PERFORMANCE TESTS

4-9. DISTORTION, SINAD AND SIGNAL-TO-NOISE ACCURACY PERFORMANCE TEST (Cont'd)

4. On the Audio Analyzer, set the 80 kHz LOW PASS FILTER off. Repeat step 3 for the settings indicated below.

Audio Oscillator		SOURCE FREQ (Hz)	MEASURE-MENT Mode	Level (dB)		
Freq (Hz)	Atten (dB)			Minimum	Actual	Maximum
200 000	10	100 000	DISTN	−12.4	________	−8.4
200 000	10	100 000	SINAD	+8.4	________	−12.4
200 000	60	100 000	SINAD	+58.0	________	+62.0
200 000	60	100 000	DISTN	−62.0	________	−58.0
300 000	60	100 000	DISTN	−62.0	________	−58.0
300 000	60	100 000	SINAD	+58.0	________	+62.0
300 000	10	100 000	SINAD	+8.4	________	+12.4
300 000	10	100 000	DISTN	−12.4	________	−8.4

PERFORMANCE TESTS

4-10. FREQUENCY ACCURACY AND SENSITIVITY PERFORMANCE TEST

SPECIFICATION:

Characteristic	Performance Limits	Conditions
SOURCE		
FREQUENCY		
Accuracy	±0.3% of setting	
MEASUREMENT		
FREQUENCY		
Measurement Range	20 Hz to 150 kHz	In ac level mode
	20 Hz to 100 kHz	In distortion, SINAD, and signal-to-noise modes
Accuracy	±0.004% ±1 digit	
Sensitivity	50 mV	Distortion and SINAD modes
	5 mV	AC level and signal-to-noise modes

DESCRIPTION: The frequency of the output of the Audio Analyzer source is measured with both the internal counter and an external counter at high levels. The signal level is then lowered to the minimum specified sensitivity and the frequency is measured again on the internal counter. The accuracy in the ac level mode at 150 kHz is similarly checked, but an external audio oscillator is used as the source.

EQUIPMENT:

Audio Oscillator	HP 651B
Counter	HP 5300B/5307A

NOTE

The counter time base accuracy must be 4 ppm or better.

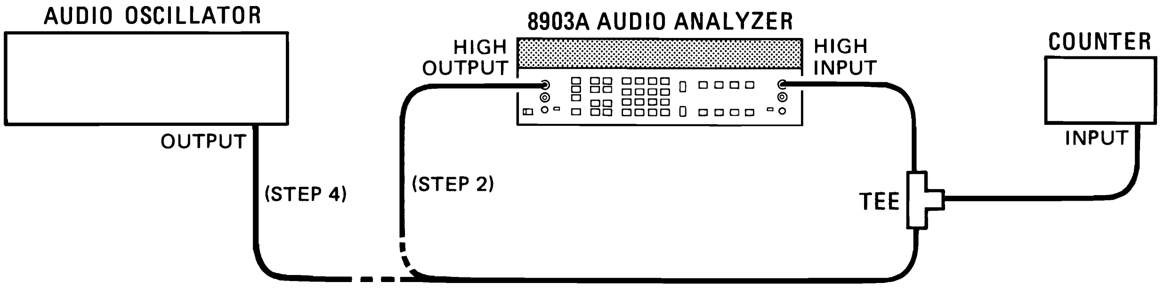


Figure 4-3. Frequency Accuracy and Sensitivity Test Setup

4-10. FREQUENCY ACCURACY AND SENSITIVITY PERFORMANCE TEST (Cont'd)

PROCEDURE:

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the INPUT and OUTPUT switches to ground. Set AMPTD to 1V and set the 80 kHz LOW PASS FILTER off.

2. Connect the equipment as shown in Figure 4-3.

3. Set the Audio Analyzer frequency as indicated below. For each frequency setting, perform the following procedure:

   a. On the Audio Analyzer, set AMPTD to 1V and MEASUREMENT to AC LEVEL. On the counter set the gate time for a resolution that is ten times greater than that of the left display of the Audio Analyzer. The counter display should be within the limits indicated. The Audio Analyzer's left display should agree with the counter display to within the limits indicated.

   b. On the Audio Analyzer, set AMPTD to 50 mV and MEASUREMENT mode to DISTN. The left display on the Audio Analyzer should agree with the counter reading of step a to within the limits indicated.

   c. Set the MEASUREMENT mode to SINAD. The left display on the Audio Analyzer should agree with the counter reading of step a to within the limits indicated.

   d. On the Audio Analyzer, set AMPTD to 5 mV and MEASUREMENT mode to AC LEVEL. The left display on the Audio Analyzer should agree with the counter reading of step a to within the limits indicated.

   e. Set the MEASUREMENT mode to SIG/NOISE. The left display on the Audio Analyzer should agree with the counter reading of step a to within the limits indicated.

SOURCE Frequency (Hz)	Limits of Counter (Hz)			Display Difference (Hz)	
	Minimum	Actual	Maximum	Actual	Maximum
20	19.94	________	20.06	________	0.02
400	398.8	________	401.2	________	0.17
3 000	2 991	________	3 009	________	1.3
100 000	99 700	________	100 300	________	50

4. Connect the audio oscillator output to the Audio Analyzer's HIGH INPUT in place of the line from the HIGH OUTPUT as shown in Figure 4-3.

5. Set the audio oscillator frequency to 150 kHz and set its level to deliver 1V into the Audio Analyzer's 100 kΩ input.

6. On the Audio Analyzer, set the MEASUREMENT mode to AC LEVEL. The left display on the Audio Analyzer should agree with the counter reading to within 70 Hz.

   Left Display Accuracy at 150 kHz and 1V: ________ ±70 Hz

7. Reduce the audio oscillator level to deliver 5 mV. The left display on the Audio Analyzer should agree with the counter reding of step 6 to within 70 Hz.

   Left Display Accuracy at 150 kHz and 5 mV: ________ ±70 Hz

PERFORMANCE TESTS

4-11. AUDIO FILTERS PERFORMANCE TEST

SPECIFICATION:

Characteristic	Performance Limits	Conditions
MEASUREMENT		
AUDIO FILTERS		
400 Hz High-pass Filter 3 dB Cutoff Frequency	400 Hz ±40 Hz	
30 kHz Low-Pass Filter 3 dB Cutoff Frequency	30 kHz ±2 kHz	
80 kHz Low-Pass Filter 3 dB Cutoff Frequency	80 kHz ±4 kHz	
Psophometric Filter Deviation from Ideal Response*	±0.2 dB	800 Hz
	±1 dB	300 Hz to 3 kHz
	±2 dB	50 Hz to 3.5 kHz
	±3 dB	3.5 to 5 kHz

*See the International Telegraph and Telephone Consulative Committee (C.C.I.T.T.), *Fifth Plenary Assembly, 1972, Telephone Transmission Quality,* The International Telecommunication Union (1973, pp. 87-91. (CCITT recommendation P53.)

DESCRIPTION: The output of the Audio Analyzer is connected to the input. At various frequencies the ac level of the output is measured with the audio filters in and out. The ratio of the two levels is the frequency response of the filter at that frequency.

PROCEDURE:

1. Key in 41.0 SPCL to initialize the instrument. Set the INPUT and OUTPUT switches both to ground. Connect the HIGH OUTPUT to the HIGH INPUT. Set AMPTD to 2V and LOG/LIN to LOG.
2. Set the SOURCE frequency as indicated below. For each setting, perform the following procedure:

    a. Set all filters off. Set RATIO off.

    b. Set RATIO on. Set in the filter indicated below.

    c. Note the dB ratio. If it is not between –3.01 and –2.99 dB, increment or decrement the SOURCE frequency slightly until the indicated level is correct. The displayed frequency should be within the limits indicated.

Initial SOURCE Frequency Setting (Hz)	HP or LP Filter	Frequency Limits (Hz)		
		Minimum	Actual	Maximum
400	400 Hz HP	360	________	440
30 000	30 kHz LP	28 000	________	32 000
80 000	80 kHz LP	76 000	________	84 000

4-11. AUDIO FILTERS PERFORMANCE TEST (Cont'd)

3. Key in 48.1 SPCL to enable up-ranging of the gain following the filters. Set the SOURCE frequency as indicated below. For each setting, perform the following procedure:

   a. Set all filters off. Set RATIO off.

   b. Set RATIO on. Set HP/BP FILTER to PSOPH. The displayed ratio should be within the limits indicated.

SOURCE Frequency (Hz)	Ratio Limits (dB)		
	Minimum	Actual	Maximum
50	–65.0	________	–61.0
100	–43.0	________	–39.0
200	–23.0	________	–19.0
300	–11.6	________	–9.6
500	–4.6	________	–2.6
800	–0.2	________	+0.2
1000	0.0	________	+2.0
2000	–4.0	________	–2.0
3000	–6.6	________	–4.6
3500	–10.5	________	–6.5
5000	–39.0	________	–33.0

PERFORMANCE TESTS

4-12. INPUT AND OUTPUT IMPEDANCE PERFORMANCE TEST

SPECIFICATION:

Characteristic	Performance Limits	Conditions
SOURCE		
OUTPUT LEVEL		
Impedance	600Ω ±1%	
MEASUREMENT:		
Input Impedance	100 kΩ ±1%	Except dc level mode; low terminal grounded

DESCRIPTION: The Audio Analyzer's source is connected to its input and a ratio reference set. A known impedance is then added in parallel to or series with the input. The drop in level is a measure of the output or input impedance.

EQUIPMENT:

Feedthrough Termination, 600Ω	HP 11095A
Resistor, 100 kΩ	HP 0698-7497

PROCEDURE:

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Key in 1.11 SPCL to set the input to the 3V level range. Set AMPTD to 3V and FREQ to 100 Hz. Set the INPUT and OUTPUT switches both to ground.

3. Connect the HIGH OUTPUT to the HIGH INPUT. Press RATIO.

4. Insert the 600Ω feedthrough termination between the HIGH OUTPUT and the HIGH INPUT. The right display should read between 49.90 and 50.40%.

49.90 _______ 50.40%

5. Replace the feedthrough termination by a 100 kΩ resistor in series with the HIGH INPUT. The right display should read between 49.90 and 50.40%.

49.90 _______ 50.40%

4-13. COMMON-MODE REJECTION RATIO PERFORMANCE TEST

SPECIFICATION:

Characteristic	Performance Limits	Conditions
GENERAL		
Common Mode Rejection Ratio	<60 dB	Differential input <2V; 60 Hz
	<36 dB	Differential input <48V; 60 Hz
	<30 dB	Differential input >48V; 60 Hz

DESCRIPTION: The output from the internal source, set to 60 Hz, is connected to both the high and low inputs to the Audio Analyzer. The low input is set to float. The ac level of the common-mode input is then measured for three different input ranges.

NOTE

The common-mode rejection can also be optimized for 50 Hz by performing the Common-Mode Rejection Ratio Adjustment (paragraph 5-9). If this has been done, set the internal source to 50 Hz in the following procedure.

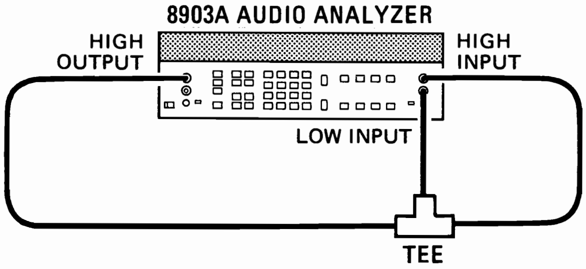


Figure 4-4. Common-Mode Rejection Ratio Test Setup

PROCEDURE:

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the OUTPUT switch to ground. Set the INPUT switch to FLOAT. Set AMPTD to 1V and FREQ to 60 Hz.

2. Connect the Audio Analyzer as shown in Figure 4-4.

3. Key in the Special Function indicated in the table below. For each setting, the right display should read within the limits indicated.

Special Function	AC Level Limits (mV)	
	Actual	Maximum
1.1 SPCL	________	31.6
1.5 SPCL	________	15.6
1.12 SPCL	________	1.0

Table 4-1. Performance Test Record (1 of 6)

Hewlett-Packard Company
Model 8903A
Audio Analyzer
Tested By ______________________

Serial Number ____________________
Date ____________________________

Para. No.	Test Description			Results		
				Min	Actual	Max
4-6.	**AC LEVEL ACCURACY AND OUTPUT LEVEL ACCURACY AND FLATNESS PERFORMANCE TEST** **High-Level AC Level Accuracy**					
	Special Function	AC Calibrator				
		Level	Frequency			
	1.1	300 Vrms	20 Hz	98%	________	102%
			1 000 Hz	98%	________	102%
	1.2	150 Vrms	1 000 Hz	98%	________	102%
			20 Hz	98%	________	102%
	1.3	100 Vrms	1 000 Hz	98%	________	102%
			20 Hz	98%	________	102%
	1.4	70 Vrms	20 Hz	98%	________	102%
			1 000 Hz	98%	________	102%
	1.5	45 Vrms	1 000 Hz	98%	________	102%
			20 Hz	98%	________	102%
	1.6	30 Vrms	20 Hz	98%	________	102%
			20 000 Hz	98%	________	102%
			100 000 Hz	96%	________	104%
	1.7	15 Vrms	100 000 Hz	96%	________	104%
			20 000 Hz	98%	________	102%
			20 Hz	98%	________	102%
	1.8	10 Vrms	20 Hz	98%	________	102%
			20 000 Hz	98%	________	102%
			100 000 Hz	96%	________	104%
	1.9	7 Vrms	100 000 Hz	96%	________	104%
			20 000 Hz	98%	________	102%
			20 Hz	98%	________	102%
	1.10	4.5 Vrms	20 Hz	98%	________	102%
			20 000 Hz	98%	________	102%
			100 000 Hz	96%	________	104%
	1.11	3.0 Vrms	100 000 Hz	96%	________	104%
			50 000 Hz	96%	________	104%
			20 000 Hz	98%	________	102%
			1 000 Hz	98%	________	102%
			20 Hz	98%	________	102%

Table 4-1. Performance Test Record (2 of 6)

Para. No.	Test Description			Results		
				Min	Actual	Max
4-6. (Cont'd)	**AC LEVEL ACCURACY AND OUTPUT LEVEL ACCURACY AND FLATNESS PERFORMANCE TEST (Cont'd)** **High-Level AC Level Accuracy (Cont'd)**					
	Special Function	**AC Calibrator**				
		Level	**Frequency**			
	1.12	1.5 Vrms	20 Hz	98%	________	102%
			20 000 Hz	98%	________	102%
			100 000 Hz	96%	________	104%
	1.13	1.0 Vrms	100 000 Hz	96%	________	104%
			20 000 Hz	98%	________	102%
			20 Hz	98%	________	102%
	1.14	0.7 Vrms	20 Hz	98%	________	102%
			20 000 Hz	98%	________	102%
			100 000 Hz	96%	________	104%
	1.15	0.45 Vrms	100 000 Hz	96%	________	104%
			20 000 Hz	98%	________	102%
			20 Hz	98%	________	102%
	1.16	0.30 Vrms	20 Hz	98%	________	102%
			1 000 Hz	98%	________	102%
			20 000 Hz	98%	________	102%
			50 000 Hz	96%	________	104%
			100 000 Hz	96%	________	104%
	1.17	0.15 Vrms	100 000 Hz	96%	________	104%
			20 000 Hz	98%	________	102%
			20 Hz	98%	________	102%
	1.18	0.10 Vrms	20 Hz	98%	________	102%
			20 000 Hz	98%	________	102%
			100 000	96%	________	104%
	1.19	0.07 Vrms	100 000 Hz	96%	________	104%
			20 000 Hz	98%	________	102%
			20 Hz	98%	________	102%
	Low-Level AC Level Accuracy					
	Calibrator Frequency					
	20 Hz			96%	________	104%
	1 000 Hz			96%	________	104%
	20 000 Hz			96%	________	104%
	50 000 Hz			96%	________	104%
	100 000 Hz			96%	________	104%

Table 4-1. Performance Test Record (3 of 6)

Para. No.	Test Description			Results		
				Min	Actual	Max
4-6. (Cont'd)	**AC LEVEL ACCURACY AND OUTPUT LEVEL ACCURACY AND FLATNESS PERFORMANCE TEST (Cont'd)** **Output Level Accuracy and Flatness** Ratio reading (reading in step 6): ______ Calibration factor (computation in step 7): ______ %					
	Special Function	**SOURCE**				
		Amplitude	**Frequency**			
	1.11	6V	20 Hz	5 880 mVrms	______	6 120 mVrms
			1 000 Hz	5 880 mVrms	______	6 120 mVrms
			20 000 Hz	5 880 mVrms	______	6 120 mVrms
			50 000 Hz	5 880 mVrms	______	6 120 mVrms
			100 000 Hz	5 820 mVrms	______	6 180 mVrms
	1.16	0.6V	1 000 Hz	588 mVrms	______	612 mVrms
	1.19	0.0006V	1 000 Hz	0.57 mVrms	______	0.63 mVrms
			20 Hz	0.57 mVrms	______	0.63 mVrms
			20 000 Hz	0.57 mVrms	______	0.63 mVrms
			50 000 Hz	0.57 mVrms	______	0.63 mVrms
			100 000 Hz	0.57 mVrms	______	0.63 mVrms
		Amplitude	**Frequency**			
		6V	20 Hz		______	42 mV
			20 000 Hz		______	42 mV
			50 000 Hz		______	150 mV
			100 000 Hz		______	150 mV
		0.0006V	20 Hz		______	0.0042 mV
			20 000 Hz		______	0.0042 mV
			50 000 Hz		______	0.0150 mV
			100 000 Hz		______	0.0150 mV

Table 4-1. Performance Test Record (4 of 6)

Para. No.	Test Description	Results		
		Min	Actual	Max
4-7.	**DC LEVEL ACCURACY PERFORMANCE TEST**			
	DC Standard Voltage			
	300 Vdc	297.75 Vdc		302.25 Vdc
	30 Vdc	29.775 Vdc		30.225 Vdc
	3 Vdc	2.9775 Vdc		3.0225 Vdc
	0.4 Vdc	0.397 Vdc		0.403 Vdc
	0.04 Vdc	0.037 Vdc		0.043 Vdc
4-8.	**DISTORTION AND NOISE PERFORMANCE TEST**			
	20 Hz/6.0V/DISTN/80 kHz			0.01%
	1 kHz/6.0V/DISTN/80 kHz			0.01%
	1 kHz/5.0V/DISTN/80 kHz			0.01%
	1 kHz/3.8V/DISTN/80 kHz			0.01%
	1 kHz/0.6V/DISTN/80 kHz			0.01%
	1 kHz/0.6V/SIG/NOISE/80 kHz	+80 dB		
	20 kHz/6.0V/DISTN/80 kHz			0.01%
	50 kHz/6.0V/DISTN/Off			0.03%
	50 kHz/0.6V/DISTN/Off			0.03%
	50 kHz/0.6V/SIG/NOISE/Off	+70 dB		
	100 kHz/6.0V/DIST /Off			0.056%
	100 kHz/5.0V/DIST /Off			0.056%
	100 kHz/3.8V/DIST /Off			0.056%
4-9.	**DISTORTION, SINAD AND SIGNAL-TO-NOISE ACCURACY PERFORMANCE TEST**			
	Readings in step 3:			
	50 Hz/10 dB/25 Hz/DISTN	–11.4 dB		–9.4 dB
	50 Hz/10 dB/25 Hz/SINAD	+9.4 dB		+11.4 dB
	50 Hz/80 dB/25 Hz/SINAD	+79.0 dB		+81.0 dB
	50 Hz/80 dB/25 Hz/DISTN	–81.0 dB		–79.0 dB
	100 Hz/10 dB/50 Hz/SIG/NOISE	+9.4 dB		+11.4 dB
	100 Hz/80 dB/50 Hz/SIG/NOISE	+79.0 dB		+81.0 dB
	4 kHz/10 dB/2 kHz/DISTN	–11.4 dB		–9.4 dB
	4 kHz/20 dB/2 kHz/DISTN	–21.0 dB		–19.0 dB
	4 kHz/30 dB/2 kHz/DISTN	–31.0 dB		–29.0 dB
	4 kHz/40 dB/2 kHz/DISTN	–41.0 dB		–39.0 dB
	4 kHz/50 dB/2 kHz/DISTN	–51.0 dB		–49.0 dB
	4 kHz/60 dB/2 kHz/DISTN	–61.0 dB		–59.0 dB
	4 kHz/70 dB/2 kHz/DISTN	–71.0 dB		–69.0 dB
	4 kHz/80 dB/2 kHz/DISTN	–81.0 dB		–79.0 dB

Table 4-1. Performance Test Record (5 of 6)

Para. No.	Test Description	Results		
		Min	Actual	Max
4-9. (Cont'd)	**DISTORTION, SINAD AND SIGNAL-TO-NOISE ACCURACY PERFORMANCE TEST (Cont'd)**			
	Readings in step 3 (Cont'd):			
	6 kHz/80 dB/ 2 kHz/DISTN	−81.0 dB	________	−79.0 dB
	6 kHz/10 dB/ 2 kHz/DISTN	−11.4 dB	________	−9.4 dB
	8 kHz/10 dB/ 2 kHz/DISTN	−11.4 dB	________	−9.4 dB
	8 kHz/80 dB/ 2 kHz/DISTN	−81.0 dB	________	−79.0 dB
	10 kHz/80 dB/ 2 kHz/DISTN	−81.0 dB	________	−79.0 dB
	10 kHz/10 dB/ 2 kHz/DISTN	−11.4 dB	________	−9.4 dB
	40 kHz/10 dB/20 kHz/DISTN	−11.4 dB	________	−9.4 dB
	40 kHz/10 dB/20 kHz/SINAD	+9.4 dB	________	+11.4 dB
	40 kHz/10 dB/20 kHz/SIG/NOISE	+9.4 dB	________	+11.4 dB
	40 kHz/80 dB/20 kHz/SIG/NOISE	+79.0 dB	________	+81.0 dB
	40 kHz/80 dB/20 kHz/SINAD	+79.0 dB	________	+81.0 dB
	40 kHz/80 dB/20 kHz/DISTN	−81.0 dB	________	−79.0 dB
	Readings in step 4:			
	200 kHz/10 dB/100 kHz/DISTN	−12.4 dB	________	−8.4 dB
	200 kHz/10 dB/100 kHz/SINAD	+8.4 dB	________	−12.4 dB
	200 kHz/60 dB/100 kHz/SINAD	+58.0 dB	________	+62.0 dB
	200 kHz/60 dB/100 kHz/DISTN	−62.0 dB	________	−58.0 dB
	300 kHz/60 dB/100 kHz/DISTN	−62.0 dB	________	−58.0 dB
	300 kHz/60 dB/100 kHz/SINAD	+58.0 dB	________	+62.0 dB
	300 kHz/10 dB/100 kHz/SINAD	+8.4 dB	________	+12.4 dB
	300 kHz/10 dB/100 kHz/DISTN	−12.4 dB	________	−8.4 dB
4-10.	**FREQUENCY ACCURACY AND SENSITIVITY PERFORMANCE TEST**			
	Limits of Counter			
	SOURCE Frequency			
	20 Hz	19.94 Hz	________	20.06 Hz
	400 Hz	398.8 Hz	________	401.2 Hz
	3 000 Hz	2 991 Hz	________	3 009 Hz
	100 000 Hz	99 700 Hz	________	100 300 Hz
	Display Difference			
	SOURCE Frequency			
	20 Hz		________	0.02 Hz
	400 Hz		________	0.17 Hz
	3 000 Hz		________	1.3 Hz
	100 000 Hz		________	50 Hz
	Left Display Accuracy at 150 kHz and 1V (reading in step 6)	−70 Hz	________	+70 Hz
	Left Display Accuracy at 150 kHz and 5 mV (reading in step 7)	−70 Hz	________	+70 Hz

Table 4-1. Performance Test Record (6 of 6)

Para. No.	Test Description	Results		
		Min	Actual	Max
4-11.	**AUDIO FILTERS PERFORMANCE TESTS**			
	Readings in step 2:			
	Initial SOURCE Frequency Setting — Filter			
	400 Hz — 400 Hz HP	360 Hz	______	440 Hz
	30 000 Hz — 30 kHz LP	28 000 Hz	______	32 000 Hz
	80 000 Hz — 80 kHz LP	76 000 Hz	______	84 000 Hz
	Readings in step 3:			
	SOURCE Frequency			
	50 Hz	–65.0 dB	______	–61.0 dB
	100 Hz	–43.0 dB	______	–39.0 dB
	200 Hz	–23.0 dB	______	–19.0 dB
	300 Hz	–11.6 dB	______	–9.6 dB
	500 Hz	–4.6 dB	______	–2.6 dB
	800 Hz	–0.2 dB	______	+0.2 dB
	1000 Hz	0.0 dB	______	+2.0 dB
	2000 Hz	–4.0 dB	______	–2.0 dB
	3000 Hz	–6.6 dB	______	–4.6 dB
	3500 Hz	–10.5 dB	______	–6.5 dB
	5000 Hz	–39.0 dB	______	–33.0 dB
4-12.	**INPUT AND OUTPUT IMPEDANCE PERFORMANCE TEST**			
	Output Impedance (reading in step 4)	49.90%	______	50.40%
	Input Impedance (reading in step 5)	49.90%	______	50.40%
4-13.	**COMMON-MODE REJECTION RATIO PERFORMANCE TEST**			
	Special Function			
	1.1 SPCL		______	31.6 mV
	1.5 SPCL		______	15.6 mV
	1.12 SPCL		______	1.0 mV

SECTION V
ADJUSTMENTS

5-1. INTRODUCTION

This section contains adjustments and checks that assure peak performance of the Audio Analyzer. The instrument should be readjusted after repair or failure to pass a performance test. Allow a 30-minute warm-up prior to performing the adjustments. Removing the instrument top cover and the internal shield cover is the only disassembly required for all adjustments.

To determine which performance tests and adjustments to perform after a repair, refer to paragraph 5-5, Post-Repair Tests, Adjustments and Checks.

5-2. SAFETY CONSIDERATIONS

This section contains information, cautions and warnings which must be followed for your protection and to avoid damage to the equipment.

WARNING

Adjustments described in this section are performed with power supplied to the instrument and with protective covers removed. Maintenance should be performed only by service trained personnel who are aware of the hazard involved (for example, fire and electrical shock). Where maintenance can be performed without power applied, the power should be removed.

5-3. EQUIPMENT REQUIRED

Most adjustment procedures contain a list of required test equipment. The test equipment is also identified by callouts in the test setup diagrams, where included.

If substitutions must be made for the specified test equipment, refer to Table 1-3 in Section I of this manual for the minimum specifications. It is important that the test equipment meet the critical specifications listed in the table if the Audio Analyzer is to meet its performance requirements.

5-4. FACTORY-SELECTED COMPONENTS

Factory-selected components are identified on the schematics and parts list by an asterisk (*) which follows the reference designator. The normal value or range of the components is shown. The Manual Changes supplement will provide updated information pertaining to the selected components. Table 5-1 lists the reference designator, the criterion used for selecting a particular value, the normal value range and the service sheet where the component part is shown.

5-5. POST-REPAIR TESTS, ADJUSTMENTS AND CHECKS

Table 5-2 lists the performance tests, adjustments and checks needed to calibrate or verify calibration of a repaired assembly. The tests, adjustments and checks are classified by assembly repaired.

The table is also useful as a cross reference between performance tests and assemblies when the failure is a specification that is slightly out of limits.

After all repairs, perform the Basic Functional Checks (paragraph 3-10) and the Internal Reference Frequency Adjustment (paragraph 5-7). The Basic Functional Checks utilize automatic tuning and measurements which exercise nearly every circuit in the instrument (except the Remote Inteface Assembly).

5-6. RELATED ADJUSTMENTS

The procedures in this section can be done in any order, but it is advisable to check the time base reference first.

Table 5-1. Factory Selected Components

Reference Designator	Service Sheet	Range of Values	Basis of Selection
A2C4	1	43 to 56 pF	See Input Flatness Adjustment (paragraph 5-8).
A2C9	1	6.2 to 7.5 pF	See Input Flatness Adjustment (paragraph 5-8).
A4R143 and A4R144	6	147 kΩ to infinity	See Voltmeter Adjustment (paragraph 5-13).
A6C33	11	0 to 10 pF	See Oscillator and Output Attenuator Adjustment (paragraph 5-15).
A7R8	13	7.32 to 7.68 kΩ	If the voltage at the Y AXIS output is >10.3 Vdc at full scale, increase the value of A7R8; if the voltage is <9.7 Vdc, reduce the value.
A7R10	13	7.32 to 7.68 kΩ	If the voltage at the X AXIS output is >10.3 Vdc at full scale, increase the value of A7R10; if the voltage is <9.7 Vdc, reduce the value.

Table 5-2. Post-Repair Tests, Adjustments and Checks (1 of 2)

Assembly Repaired	Test, Adjustment or Check	Ref. Para.
A1 Keyboard and Display Assembly	Power-Up Checks Service Special Functions (Use 60.0 SPCL, Key Scan, and exercise all keys).	8-31 8-27
A2 Input Amplifier Assembly	AC Level Accuracy and Output Level Accuracy and Flatness Performance Test (Check ac level accuracy only.) DC Level Accuracy Performance Test Distortion and Noise Performance Test Audio Filters Performance Test Common-Mode Rejection Ratio Performance Test Input Flatness Adjustment Common-Mode Rejection Adjustment Input DC Offset Adjustment 400 Hz High-Pass and Psophometric Filter Adjustment	4-6 4-7 4-8 4-11 4-13 5-8 5-9 5-10 5-11
A3 Notch Filter Assembly	Distortion and Noise Performance Test Distortion, SINAD, and Signal-to-Noise Accuracy Performance Test Notch Filter Tune and Balance Adjustment	4-8 4-9 5-12
A4 Output Amplifier/ Voltmeter Assembly	AC Level Accuracy and Output Level Accuracy and Flatness Performance Test (Check ac level accuracy only.) DC Level Accuracy Performance Test Distortion and Noise Performance Test Distortion, SINAD, and Signal-to-Noise Accuracy Performance Test Voltmeter Adjustment SINAD Meter Adjustment	4-6 4-7 4-8 4-9 5-13 5-14

Table 5-2. Post-Repair Tests, Adjustments and Checks (2 of 2)

Assembly Repaired	Test, Adjustment or Check	Ref. Para.
A5 Oscillator Assembly	AC Level Accuracy and Output Level Accuracy and Flatness Performance Test Distortion and Noise Performance Test Frequency Accuracy and Sensitivity Performance Test Oscillator and Output Attenuator Adjustment	4-6 4-8 4-10 5-15
A6 Output Attenuator Assembly	AC Level Accuracy and Output Level Accuracy and Flatness Performance Test Distortion and Noise Performance Test Input and Output Impedance Performance Test	4-6 4-8 4-12
A7 Latch Assembly	Basic Functional Checks Frequency Accuracy and Sensitivity Performance Test Power-Up Checks	3-10 4-10 8-31
A8 Controller/ Counter Assembly	Basic Functional checks Frequency Accuracy and Sensitivity Performance Test Internal Reference Frequency Adjustment Power-Up Checks	3-10 4-10 5-7 8-31
A9 Remote Interface Asssembly A10 Remote Interface Connector Assembly	HP-IB Functional Checks Power-Up Checks	3-11 8-31
A11 Series Regulator Socket Assembly A12 Connector/Filter Assembly A13 Power Supply and Mother Board Assembly A14 Line Power Module	Basic Functional Checks Power-Up Checks	3-10 8-31

ADJUSTMENTS

5-7. INTERNAL REFERENCE FREQUENCY ADJUSTMENT

REFERENCE: Service Sheet 15.

DESCRIPTION: An oscilloscope, triggered by an external reference, is used to monitor the internal reference frequency while it is adjusted.

EQUIPMENT:

Frequency Standard . . . . House Standard
Oscilloscope . . . . HP 1740A

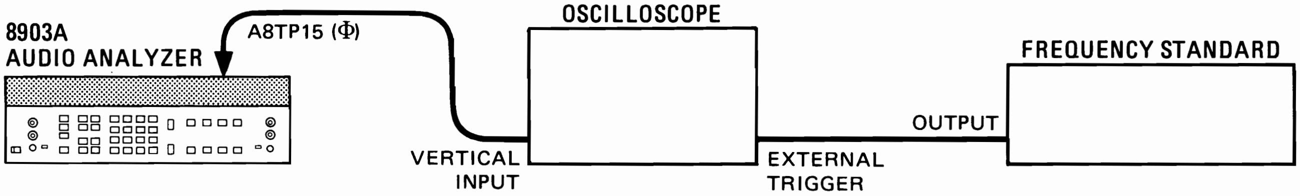
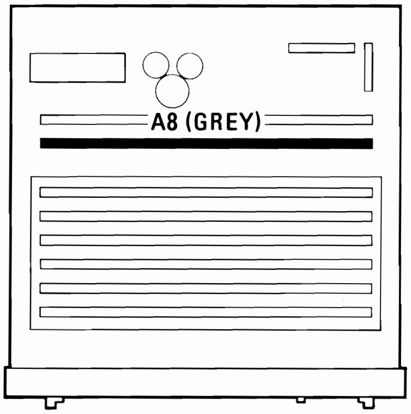


Figure 5-1. Internal Reference Frequency Adjustment Test Setup

PROCEDURE:

1. Allow the equipment to warm up for 15 minutes.
2. Connect the equipment as shown in Figure 5-1. (If the frequency of the frequency standard is 5 or 10 MHz, reverse the vertical input and external trigger connections on the oscilloscope.)
3. Set the oscilloscope's vertical sensitivity to view the Audio Analyzer's time base reference (or the frequency standard output). Set the horizontal scale for 0.1 μs per division. Set the oscilloscope to trigger externally.



4. Adjust A8C27 for a waveform movement of 10 divisions per second or less. A totally non-metalic adjustment tool is recommended.

NOTE

A movement of the waveform to the right (or left if the oscilloscope connections are reversed) at a rate of one division per second means that the Audio Analyzer's time base frequency is low by 0.1 ppm.

ADJUSTMENTS

5-8. INPUT FLATNESS ADJUSTMENT

REFERENCE: Service Sheet 1.

DESCRIPTION: An ac calibrator is connected to the input of the Audio Analyzer. The Audio Analyzer is set to measure ac level. The frequency of the calibrator is varied between 1, 40 and 100 kHz and the flatness adjusted for a constant level at all three frequencies.

EQUIPMENT: AC Calibrator ....HP 745A

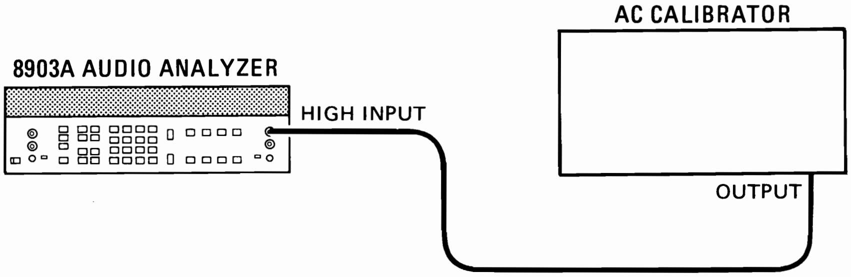
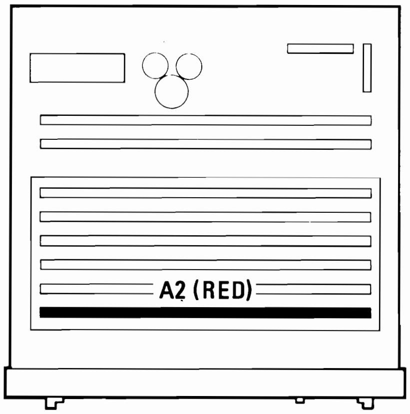


Figure 5-2. Input Flatness Adjustment Test Setup

PROCEDURE:

1. Set the ac calibrator to 1 kHz at 4.5 Vrms.
2. Connect the equipment as shown in Figure 5-2.
3. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the INPUT switch to ground. Set LP FILTER off. Key in 1.10 SPCL to set the input to the 4.76V range.
4. The right display of the Audio Analyzer should read between 4.4 and 4.6V. Press RATIO.
5. Set the ac calibrator frequency to 40 kHz. Adjust A2C3 (FLATNESS 12 dB) for a reading on the right display between 99.70 and 100.3%.



6. Set the ac calibrator frequency to 100 kHz. Adjust A2C3 for a reading between 99.50 and 100.5%. Repeat steps 5 and 6 as often as needed until the flatness at 40 kHz and 100 kHz is within the limits given. (See the following note.)

NOTE

If the flatness cannot be adjusted so that the 40 kHz and 100 kHz readings are both within the given limits, change A2C4 as follows: If the 100 kHz reading is higher than at 40 kHz, decrease A2C4 by approximately 10%. If the 40 kHz reading is higher than that at 100 kHz, increase A2C4 by approximately 10%.

7. On the Audio Analyzer, press RATIO to turn it off. Key in 1.7 SPCL to set the input to the 18.9V range.

5-8. INPUT FLATNESS ADJUSTMENT (Cont'd)

8. Set the ac calibrator frequency to 1 kHz and level to 15 Vrms.

9. The right display of the Audio Analyzer should read between 14.7 and 15.3V. Press RATIO.

10. Set the ac calibrator frequency to 40 kHz. Adjust A2C10 (FLATNESS 24 dB) for a reading on the right display between 99.70 and 100.3%.

11. Set the ac calibrator frequency to 100 kHz. Adjust A2C10 for a reading between 99.50 and 100.5%. Repeat steps 10 and 11 as often as needed until the flatness at 40 kHz and 100 kHz is within the limits given.

NOTE

If the flatness cannot be adjusted so that the 40 kHz and 100 kHz readings are both within the given limits, change A2C9 as follows: If the 100 kHz reading is higher than at 40 kHz, decrease A2C9 by approximately 10%. If the 40 kHz reading is higher than that at 100 kHz, increase A2C9 by approximately 10%.

12. Perform the ac level accuracy portion of the AC Level Accuracy and Output Level Accuracy and Flatness Performance Test (paragraph 4-6).

ADJUSTMENTS

5-9. COMMON-MODE REJECTION ADJUSTMENT

REFERENCE: Service Sheet 1.

DESCRIPTION: The output from the Audio Analyzer's source, set to 60 Hz, is connected to both the high and low inputs to the Audio Analyzer. The low input is set to float. The ac level of the common-mode rejection is then adjusted for minimum response.

NOTE

The common-mode rejection can also be optimized for 50 Hz by setting the Audio Analyzer source frequency to 50 Hz in the procedures below.

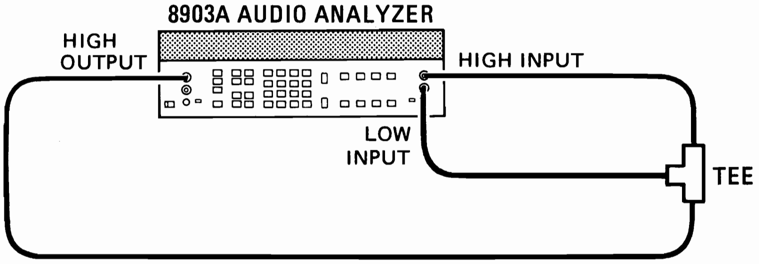
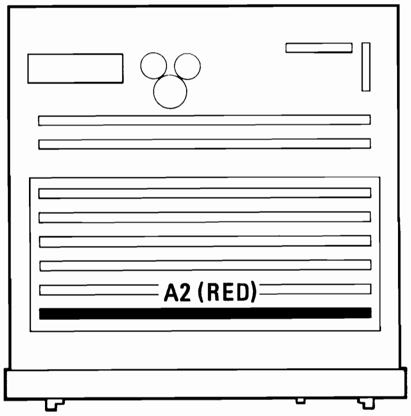


Figure 5-3. Common-Mode Rejection Adjustment Test Setup

PROCEDURE:

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the OUTPUT switch to ground. Set the INPUT switch to FLOAT. Set AMPTD to 1V and FREQ to 60 Hz. Key in 1.1 SPCL to set the input to the highest range.
2. Connect the Audio Analyzer as shown in Figure 5-3.
3. Adjust A2R43 (CM) for the minimum level on the right display but less than 10 mV.
4. Perform the Common-Mode Rejection Ratio Performance Test (paragraph 4-13).



ADJUSTMENTS

5-10. INPUT DC OFFSET ADJUSTMENT

REFERENCE: Service Sheet 1.

DESCRIPTION: With the Audio Analyzer set to measure dc level and the input grounded, the dc offset is adjusted for a display of 0V.

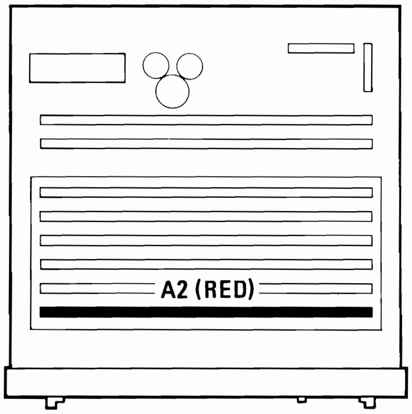
EQUIPMENT: Feedthrough Termination, 600Ω ....HP 11095A

PROCEDURE:

1. Key in 41.0 SPCL to initialize the instrument. Set the INPUT switch to ground. Set MEASUREMENT to DC LEVEL.

2. Connect the 600Ω feedthrough (or a short circuit or a 50Ω load) to the HIGH INPUT.

3. Adjust A2R44 (OFST) for a steady reading of −0.00V on the right display.



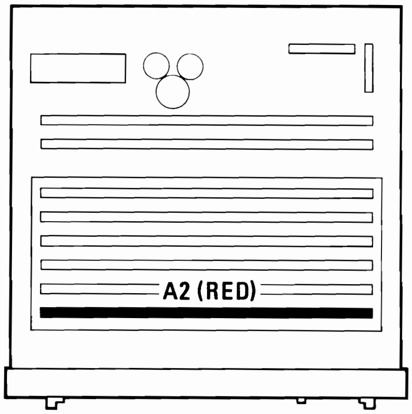
ADJUSTMENTS

5-11. 400 Hz HIGH-PASS AND PSOPHOMETRIC FILTER ADJUSTMENT

REFERENCE: Service Sheet 2.

DESCRIPTION: The source output of the Audio Analyzer is connected to the input. The source is set to a specified frequency and a level reference is set. The filter to be adjusted is then inserted and its gain is adjusted for a level equal to the reference.

PROCEDURE:



1. Key in 41.0 SPCL to initialize the instrument. Set the INPUT and OUTPUT switches both to ground. Set FREQ to 2 kHz then AMPTD to 1V.
2. Connect the HIGH OUTPUT to the HIGH INPUT. Press RATIO.
3. Press HIGH PASS 400 Hz. Adjust A2R70 (400 Hz) for a reading between 99.60 and 99.80% on the right display.
4. Set FREQ to 1 kHz. The right display should read between 99.00 and 101.0%.
5. Key in 800 Hz. Set RATIO off. Set HIGH PASS 400 Hz off. Press RATIO.
6. Press PSOPH. Adjust A2R65 (PSOPH) for a steady reading of 100.0% on the right display.
7. Perform the Audio Filters Performance Test (paragraph 4-11).

ADJUSTMENTS

5-12. NOTCH FILTER TUNE AND BALANCE ADJUSTMENT

REFERENCE: Service Sheet 4.

DESCRIPTION: The Audio Analyzer is set to measure the distortion from its source. The output from the notch filter is observed on an oscilloscope while the tuning and balance are adjusted for a minimum. The measured distortion is also monitored on the amplitude display.

EQUIPMENT: Oscilloscope .... HP 1740A

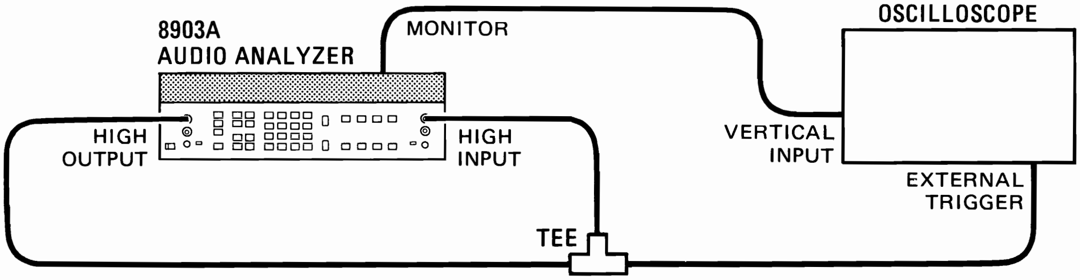


Figure 5-4. Notch Filter Tune and Balance Adjustment Test Setup

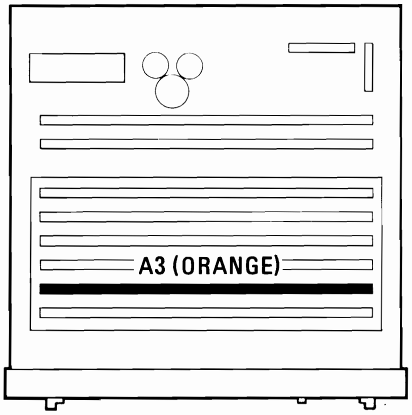
PROCEDURE:

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the INPUT and OUTPUT switches both to ground. Set AMPTD to 3V. Set MEASUREMENT to DISTN. Set LOG/LIN to LOG.

2. Connect the equipment as shown in Figure 5-4.

3. Set the oscilloscope to view the ac signal at the rear-panel MONITOR output. Set the oscilloscope's trigger to external.

4. Adjust A3R62 (TUNE OFST) and A3R63 (BAL OFST) for minimum signal and noise on the oscilloscope display.



5. Observe the right display of the Audio Analyzer. It should read −86 dB or less. Readjust the two adjustments to minimize the reading on the display which must be −86 dB or less.

NOTE

If the reading of step 5 cannot be brought within limit, it may be that the source has excessive distortion.

ADJUSTMENTS

5-13. VOLTMETER ADJUSTMENT

REFERENCE: Service Sheets 6 and 7.

DESCRIPTION: The Audio Analyzer is set to measure the ac level from its source. The internal ac-to-dc converter (as yet uncalibrated) produces a dc voltage that is read by the internal dc voltmeter and monitored by an external dc voltmeter. The sensitivity of the internal dc voltmeter is adjusted so that the amplitude display of the Audio Analyzer agrees with the level measured by the external dc voltmeter.

The ac at the source's output jack is then monitored by an external ac voltmeter. The ac-to-dc converter is adjusted so that the amplitude display of the Audio Analyzer agrees with the level measured by the external ac voltmeter at two different levels.

NOTE

The Ouput RMS (Avg) Detector of the Audio Analyzer can be configured to respond to either true rms or average level of the signal. The configuration from the factory is true rms. Instructions for altering the configuration are given on Service Sheet 6. Since the output of the source is a low-distortion sine wave, the adjustment is valid for the ac-to-dc converter set to either rms or average. Always perform this adjustment after changing the converter configuration.

EQUIPMENT Digital Voltmeter........................HP 3455A

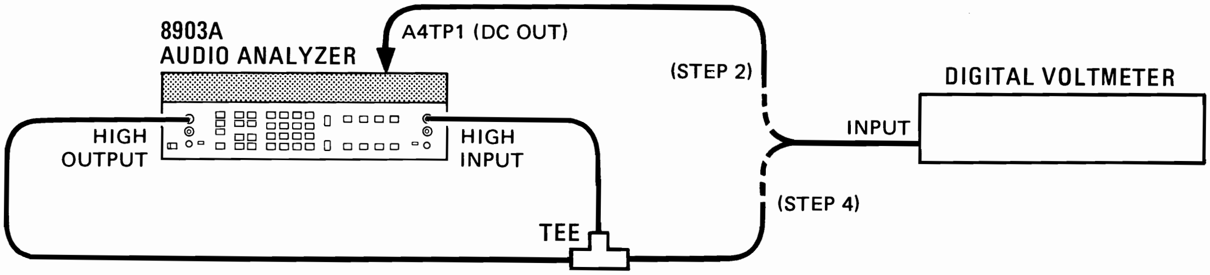
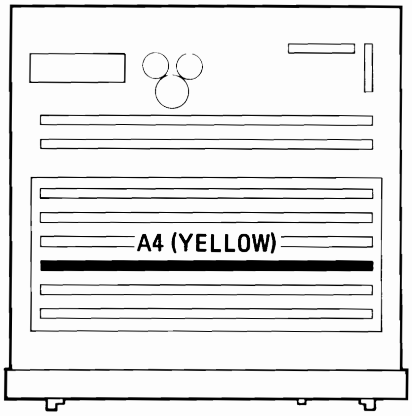


Figure 5-5. Voltmeter Adjustment Test Setup

PROCEDURE:

1. On the Audio Analyzer, key in 41.0 SPCL to intialize the instrument. Key in 1.11 SPCL to set the input range to 3.00V. Key in 3.1 SPCL to set the post-notch amplifier gain to 0 dB. Key in 49.3 SPCL to read the output rms (or average) detector voltage directly. Set the INPUT and OUTPUT switches both to ground. Set AMPTD to 3V.
2. Connect the equipment as shown in Figure 5-5. Connect the voltmeter to A4TP1 (DC OUT).
3. Set the voltmeter to read dc volts. Adjust A4R125 (DC CAL) for a reading on the right display of the Audio Analyzer that is the same as the reading on the voltmeter within ±0.5 mV. (See Service Sheet 7.)



5-13. VOLTMETER ADJUSTMENT (Cont'd)

4. Connect the voltmeter to the HIGH INPUT of the Audio Analyzer. Set the voltmeter to read ac volts. On the Audio Analyzer, set the MEASUREMENT mode to AC LEVEL.

5. Adjust A4R91 (AC SCALE) for a reading on the right display of the of the Audio Analyzer that is the same as the reading on the ac voltmeter within ±1 mV. (See Service Sheet 6.)

6. On the Audio Analyzer, set AMPTD to 150 mV. Adjust A4R85 (AC OFFSET) for a reading on the right display of the Audio Analyzer that is the same as the ac reading on the ac voltmeter within ±0.5 mV. (See Service Sheet 6.) If A4R85 does not have sufficient range, add or alter A4R143 or A4R144 as follows:

   a. Unsolder A4R143 or A4R144 if present.

   b. With a dc voltmeter, measure the voltage at the junction of A4R72 and A4C46.

   c. If the voltage, ignoring polarity, is greater than 2 mV, compute R=1500/V, where V is the voltage measured (in volts).

   d. Select a resistor which has a standard value resistance nearest R. If the measured voltage was negative, solder the resistor in the location for A4R143; if positive, for A4R144.

   e. After a five-minute warm up, measure the voltage again which should be between −2 and +2 mVdc.

   f. Repeat the adjustment of A4R85.

7. On the Audio Analyzer set AMPTD to 3V. Repeat steps 5 through 7 until the right display of the Audio Analyzer and the ac voltmeter readings are the same within the limits stated for both 3V and 150 mV.

ADJUSTMENTS

5-14. SINAD METER ADJUSTMENT

REFERENCE: Service Sheet 6.

DESCRIPTION: The SINAD meter is mechanically zeroed with the measurement mode not set to SINAD. Next a signal with a known amount of distortion is created artificially by summing the output from the Audio Analyzer and the output from another source into the input of the Audio Analyzer. The artifical SINAD is then measured by the Audio Analyzer and the panel meter is adjusted to agree with the digital display.

EQUIPMENT: Audio Oscillator .... HP 651B

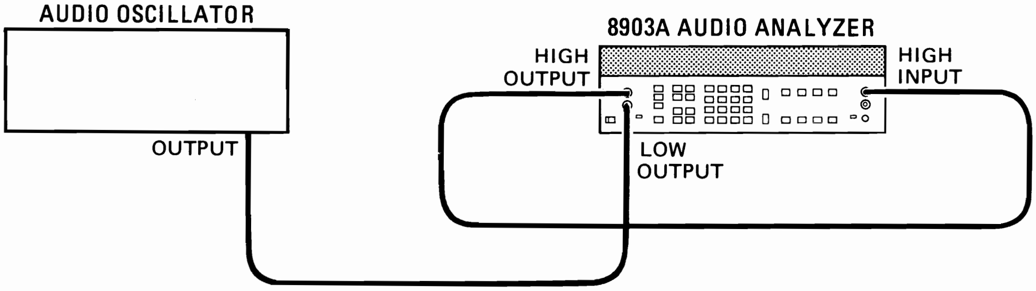


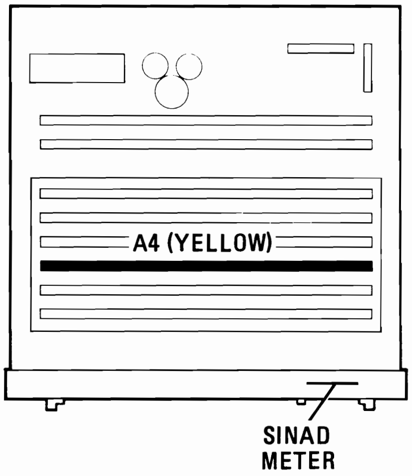
Figure 5-6. SINAD Meter Adjustment Test Setup

PROCEDURE:

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the INPUT switch to ground. Set the OUTPUT switch to FLOAT. Key in 16.1 SPCL to set the SINAD resolution to 0.01 dB. Place the instrument in its normal operating position.

2. Adjust the mechanical zero adjustment screw on the panel meter cw for a zero meter reading, then turn the screw slightly ccw to free the mechanism from the adjusting peg.

3. On the Audio Analyzer, set AMPTD to 3V and MEASUREMENT to SINAD. Key in 7.1 SPCL to enable the 24 dB SINAD meter range.



4. Connect the equipment as shown in Figure 5-6.

5. Set the oscillator frequency to 2.5 kHz and adjust the amplitude until the right display of the Audio Analyzer reads 20.00 dB.

6. Adjust A4R142 (METER CAL) so that the panel meter reads 20 dB SINAD.

ADJUSTMENTS

5-15. OSCILLATOR AND OUTPUT ATTENUATOR ADJUSTMENT

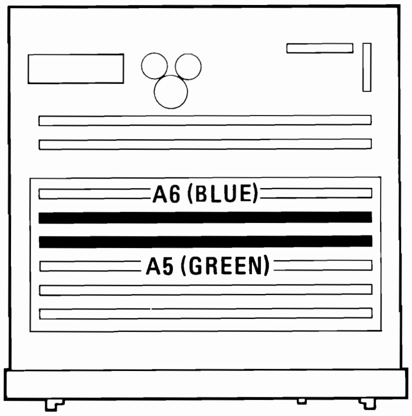
REFERENCE: Service Sheet 9, 10 and 11.

DESCRIPTION: With the oscillator turned off, the offset of two amplifiers is adjusted for 0V. The oscillator is then turned on and adjusted at 1 kHz for 6 Vrms output into an open circuit. Finally, the oscillator is set to 50 mV at 100 kHz, and the high-frequency balance of the output amplifier is adjusted so that the voltage between the source's low output and ground is minimum when measured by the internal ac voltmeter.

EQUIPMENT: Digital Voltmeter .... HP 3455A

PROCEDURE:

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the INPUT and OUTPUT switches both to ground.
2. Connect the dc voltmeter to A6TP5 (AMP 2). (See Service Sheet 10.)
3. Adjust A6R35 (INPUT OFFSET) for 0 ±0.1 mVdc as read on the voltmeter.
4. Connect the dc voltmeter to the OUTPUT jack on the Audio Analyzer.
5. Adjust A6R62 (OUTPUT OFFSET) for 0 ±0.1 mVdc as read on the voltmeter. (See Service Sheet 11.)



6. Set the voltmeter to read ac volts.
7. On the Audio Analyzer, set AMPTD to 6V. Adjust A5R102 (OUTPUT LEVEL) for an output level of 6 Vrms as displayed on the voltmeter. (See Service Sheet 9.)
8. On the Audio Analyzer, set FREQ to 100 kHz, AMPTD to 50 mV and LP FILTER off. Set the OUTPUT switch to FLOAT. Disconnect the ac voltmeter from the HIGH OUTPUT jack. Connect the LOW OUTPUT to the HIGH INPUT.
9. Adjust A6C31 (HF BALANCE) so that the plates go from fully meshed to fully open. The right display on the Audio Analyzer should go through a minimum. Adjust A6C31 for the minimum display. If the adjustment does not go through a minimum, change A6C33 to 10 pF if the lowest reading occurs with the plates of A6C31 fully meshed or remove A6C33 if the lowest reading occurs with the plates fully open; then readjust A6C31. (See Service Sheet 11.)

SECTION VI
REPLACEABLE PARTS

6-1. INTRODUCTION

This section contains information for ordering parts. Table 6-1 lists abbreviations used in the parts list and throughout the manual. Table 6-2 lists all replaceable parts in reference designator order. Table 6-3 contains the names and addresses that correspond to the manufacturer's code numbers.

6-2. ABBREVIATIONS

Table 6-1 lists abbreviations used in the parts list, schematics, and throughout the manual. In some cases, two forms of the abbreviation are used, one all in capitals letters, and one partial or no capitals. This occurs because the abbreviations in the parts list are always all capitals. However, in the schematics and other parts of the manual, other abbreviation forms are used with both lower case and upper case letters.

6-3. REPLACEABLE PARTS LIST

Table 6-2 is the list of replaceable parts and is organized as follows:

a. Electrical assemblies and their components in alphanumeric order by reference designation.

b. Chassis-mounted parts in alphanumeric order by reference designation.

c. Mechanical parts.

The information given for each part consists of the following:

a. The Hewlett-Packard part number.

b. Part number check digit (CD).

c. The total quantity (Qty) for the entire instrument except for option assemblies (given the first time the particular part number appears).

d. The description of the part.

e. A typical manufacturer of the part in a five-digit code.

f. The manufacturer's number for the part.

NOTE

Total quantities for optional assemblies are totaled by assembly and not integrated into the standard list.

6-4. FACTORY SELECTED PARTS (*)

Parts marked with an asterisk (*) are factory selected parts. The value listed in the parts list is the nominal value. Refer to Sections V and VIII of this manual for information on determining what value to use for replacement.

6-5. PARTS LIST BACKDATING (†)

Parts marked with a dagger (†) are different in Audio Analyzers with serial number prefixes lower than the one that this manual applies to directly. Table 7-1 lists the backdating changes by serial number prefix. The backdating changes are contained in Section VII.

6-6. PARTS LIST UPDATING (Manual Changes Supplement)

Production changes to Audio Analyzers made after the publication date of this manual are accompanied by a change in the serial number prefix. Changes to the parts list are recorded by serial number prefix on a MANUAL CHANGES supplement. Also, parts list errors are noted in the ERRATA portion of the MANUAL CHANGES supplement.

6-7. ORDERING INFORMATION

To order a part listed in the replaceable parts table, quote the Hewlett-Packard part number (with the check digit), indicate the quantity required, and address the order to the nearest Hewlett-Packard office. The check digit will ensure accurate and timely processing of your order.

To order a part that is not listed in the replaceable parts table, include the instrument model number, instrument serial number, description and function of the part, and the number of parts required. Address the order to the nearest Hewlett-Packard office.

NOTE

Within the USA, it is better to order directly from the HP Parts Center in Moutain View, California. Ask your nearest HP office for information and forms for the "Direct Mail Order System."

6-8. RECOMMENDED SPARES LIST

Stocking spare parts for an instrument is often done to ensure quick return to service after a malfunction occurs. Hewlett-Packard prepares a "Recommended Spares" list for this instrument. The contents of the list are based on failure reports and repair data. Quantities given are for one year of parts support. A complimentay copy of the "Recommended Spares" list may be requested from your nearest Hewlett-Packard office.

When stocking parts to support more than one instrument or to support a variety of Hewlett-Packard instruments, it may be more economical to work from one consolidated list rather than simply adding together stocking quantities from the individual instrument lists. Hewlett- Packard will prepare consolidated "Recommended Spares" lists for any number or combination of instruments. Contact your nearest Hewlett-Packard office for details.

6-9. SPARE PARTS KIT

A "Spare Parts Kit" is available for the Audio Analyzer. The kit contains the components and assemblies listed in the "Recommended Spares" list. It may be ordered through your nearest Hewlett-Packard office.

Table 6-1. Reference Designations and Abbreviations (1 of 2)

REFERENCE DESIGNATIONS

A	assembly
AT	attenuator; isolator; termination
B	fan; motor
BT	battery
C	capacitor
CP	coupler
CR	diode; diode thyristor; varactor
DC	directional coupler
DL	delay line
DS	annunciator; signaling device (audible or visual); lamp; LED
E	miscellaneous electrical part
F	fuse
FL	filter
H	hardware
HY	circulator
J	electrical connector (stationary portion); jack
K	relay
L	coil; inductor
M	meter
MP	miscellaneous mechanical part
P	electrical connector (movable portion); plug
Q	transistor: SCR; triode thyristor
R	resistor
RT	thermistor
S	switch
T	transformer
TB	terminal board
TC	thermocouple
TP	test point
U	integrated circuit; microcircuit
V	electron tube
VR	voltage regulator; breakdown diode
W	cable; transmission path; wire
X	socket
Y	crystal unit (piezo-electric or quartz)
Z	tuned cavity; tuned circuit

ABBREVIATIONS

A	ampere
ac	alternating current
ACCESS	accessory
ADJ	adjustment
A/D	analog-to-digital
AF	audio frequency
AFC	automatic frequency control
AGC	automatic gain control
AL	aluminum
ALC	automatic level control
AM	amplitude modulation
AMPL	amplifier
APC	automatic phase control
ASSY	assembly
AUX	auxiliary
avg	average
AWG	American wire gauge
BAL	balance
BCD	binary coded decimal
BD	board
BE CU	beryllium copper
BFO	beat frequency oscillator
BH	binder head
BKDN	breakdown
BP	bandpass
BPF	bandpass filter
BRS	brass
BWO	backward-wave oscillator
CAL	calibrate
ccw	counter-clockwise
CER	ceramic
CHAN	channel
cm	centimeter
CMO	cabinet mount only
COAX	coaxial
COEF	coefficient
COM	common
COMP	composition
COMPL	complete
CONN	connector
CP	cadmium plate
CRT	cathode-ray tube
CTL	complementary transistor logic
CW	continuous wave
cw	clockwise
cm	centimeter
D/A	digital-to-analog
dB	decibel
dBm	decibel referred to 1 mW
dc	direct current
deg	degree (temperature interval or difference)
°	degree (plane angle)
°C	degree Celsius (centigrade)
°F	degree Fahrenheit
°K	degree Kelvin
DEPC	deposited carbon
DET	detector
diam	diameter
DIA	diameter (used in parts list)
DIFF AMPL	differential amplifier
div	division
DPDT	double-pole, double-throw
DR	drive
DSB	double sideband
DTL	diode transistor logic
DVM	digital voltmeter
ECL	emitter coupled logic
EMF	electromotive force
EDP	electronic data processing
ELECT	electrolytic
ENCAP	encapsulated
EXT	external
F	farad
FET	field-effect transistor
F/F	flip-flop
FH	flat head
FIL H	fillister head
FM	frequency modulation
FP	front panel
FREQ	frequency
FXD	fixed
g	gram
GE	germanium
GHz	gigahertz
GL	glass
GRD	ground(ed)
H	henry
h	hour
HET	heterodyne
HEX	hexagonal
HD	head
HDW	hardware
HF	high frequency
HG	mercury
HI	high
HP	Hewlett-Packard
HPF	high pass filter
HR	hour (used in parts list)
HV	high voltage
Hz	Hertz
IC	integrated circuit
ID	inside diameter
IF	intermediate frequency
IMPG	impregnated
in	inch
INCD	incandescent
INCL	include(s)
INP	input
INS	insulation
INT	internal
kg	kilogram
kHz	kilohertz
kΩ	kilohm
kV	kilovolt
lb	pound
LC	inductance-capacitance
LED	light-emitting diode
LF	low frequency
LG	long
LH	left hand
LIM	limit
LIN	linear taper (used in parts list)
lin	linear
LK WASH	lock washer
LO	low; local oscillator
LOG	logarithmic taper (used in parts list)
log	logrithm(ic)
LPF	low pass filter
LV	low voltage
m	meter (distance)
mA	milliampere
MAX	maximum
MΩ	megohm
MEG	meg (10^6) (used in parts list)
MET FLM	metal film
MET OX	metallic oxide
MF	medium frequency; microfarad (used in parts list)
MFR	manufacturer
mg	milligram
MHz	megahertz
mH	millihenry
mho	mho
MIN	minimum
min	minute (time)
′	minute (plane angle)
MINAT	miniature
mm	millimeter

NOTE

All abbreviations in the parts list will be in upper-case.

Table 6-1. Reference Designations and Abbreviations (2 of 2)

MOD	modulator
MOM	momentary
MOS	metal-oxide semiconductor
ms	millisecond
MTG	mounting
MTR	meter (indicating device)
mV	millivolt
mVac	millivolt, ac
mVdc	millivolt, dc
mVpk	millivolt, peak
mVp-p	millivolt, peak-to-peak
mVrms	millivolt, rms
mW	milliwatt
MUX	multiplex
MY	mylar
μA	microampere
μF	microfarad
μH	microhenry
μmho	micromho
μs	microsecond
μV	microvolt
μVac	microvolt, ac
μVdc	microvolt, dc
μVpk	microvolt, peak
μVp-p	microvolt, peak-to-peak
μVrms	microvolt, rms
μW	microwatt
nA	nanoampere
NC	no connection
N/C	normally closed
NE	neon
NEG	negative
nF	nanofarad
NI PL	nickel plate
N/O	normally open
NOM	nominal
NORM	normal
NPN	negative-positive-negative
NPO	negative-positive zero (zero temperature coefficient)
NRFR	not recommended for field replacement
NSR	not separately replaceable
ns	nanosecond
nW	nanowatt
OBD	order by description
OD	outside diameter
OH	oval head
OP AMPL	operational amplifier
OPT	option
OSC	oscillator
OX	oxide
oz	ounce
Ω	ohm
P	peak (used in parts list)
PAM	pulse-amplitude modulation
PC	printed circuit
PCM	pulse-code modulation; pulse-count modulation
PDM	pulse-duration modulation
pF	picofarad
PH BRZ	phosphor bronze
PHL	Phillips
PIN	positive-intrinsic-negative
PIV	peak inverse voltage
pk	peak
PL	phase lock
PLO	phase lock oscillator
PM	phase modulation
PNP	positive-negative-positive
P/O	part of
POLY	polystyrene
PORC	porcelain
POS	positive; position(s) (used in parts list)
POSN	position
POT	potentiometer
p-p	peak-to-peak
PP	peak-to-peak (used in parts list)
PPM	pulse-position modulation
PREAMPL	preamplifier
PRF	pulse-repetition frequency
PRR	pulse repetition rate
ps	picosecond
PT	point
PTM	pulse-time modulation
PWM	pulse-width modulation
PWV	peak working voltage
RC	resistance-capacitance
RECT	rectifier
REF	reference
REG	regulated
REPL	replaceable
RF	radio frequency
RFI	radio frequency interference
RH	round head; right hand
RLC	resistance-inductance-capacitance
RMO	rack mount only
rms	root-mean-square
RND	round
ROM	read-only memory
R&P	rack and panel
RWV	reverse working voltage
S	scattering parameter
s	second (time)
..."	second (plane angle)
S-B	slow-blow (fuse) (used in parts list)
SCR	silicon controlled rectifier; screw
SE	selenium
SECT	sections
SEMICON	semiconductor
SHF	superhigh frequency
SI	silicon
SIL	silver
SL	slide
SNR	signal-to-noise ratio
SPDT	single-pole, double-throw
SPG	spring
SR	split ring
SPST	single-pole, single-throw
SSB	single sideband
SST	stainless steel
STL	steel
SQ	square
SWR	standing-wave ratio
SYNC	synchronize
T	timed (slow-blow fuse)
TA	tantalum
TC	temperature compensating
TD	time delay
TERM	terminal
TFT	thin-film transistor
TGL	toggle
THD	thread
THRU	through
TI	titanium
TOL	tolerance
TRIM	trimmer
TSTR	transistor
TTL	transistor-transistor logic
TV	television
TVI	television interference
TWT	traveling wave tube
U	micro (10^{-6}) (used in parts list)
UF	microfarad (used in parts list)
UHF	ultrahigh frequency
UNREG	unregulated
V	volt
VA	voltampere
Vac	volts, ac
VAR	variable
VCO	voltage-controlled oscillator
Vdc	volts, dc
VDCW	volts, dc, working (used in parts list)
V(F)	volts, filtered
VFO	variable-frequency oscillator
VHF	very-high frequency
Vpk	volts, peak
Vp-p	volts, peak-to-peak
Vrms	volts, rms
VSWR	voltage standing wave ratio
VTO	voltage-tuned oscillator
VTVM	vacuum-tube voltmeter
V(X)	volts, switched
W	watt
W/	with
WIV	working inverse voltage
WW	wirewound
W/O	without
YIG	yttrium-iron-garnet
Z_o	characteristic impedance

NOTE

All abbreviations in the parts list will be in upper-case.

MULTIPLIERS

Abbreviation	Prefix	Multiple
T	tera	10^{12}
G	giga	10^{9}
M	mega	10^{6}
k	kilo	10^{3}
da	deka	10
d	deci	10^{-1}
c	centi	10^{-2}
m	milli	10^{-3}
μ	micro	10^{-6}
n	nano	10^{-9}
p	pico	10^{-12}
f	femto	10^{-15}
a	atto	10^{-18}

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A1	08903-60009	9	1	KEYBOARD AND DISPLAY	28480	08903-60009
A1C1	0180-0229	7	7	CAPACITOR-FXD 33UF+-10% 10VDC TA	56289	150D336X9010B2
A1C2	0160-3451	1	44	CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A1C3	0160-2291	5	1	CAPACITOR-FXD .18UF +-10% 80VDC POLYE	28480	0160-2291
A1C4	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A1C5	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A1C6	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A1DS1	1990-0665	3	11	LED-VISIBLE LUM-INT=1MCD IF=20MA-MAX	28480	1990-0665
A1DS2	1990-0665	3		LED-VISIBLE LUM-INT=1MCD IF=20MA-MAX	28480	1990-0665
A1DS3	1990-0665	3		LED-VISIBLE LUM-INT=1MCD IF=20MA-MAX	28480	1990-0665
A1DS4	1990-0665	3		LED-VISIBLE LUM-INT=1MCD IF=20MA-MAX	28480	1990-0665
A1DS5	1990-0665	3		LED-VISIBLE LUM-INT=1MCD IF=20MA-MAX	28480	1990-0665
A1DS6	1990-0665	3		LED-VISIBLE LUM-INT=1MCD IF=20MA-MAX	28480	1990-0665
A1DS7	1990-0665	3		LED-VISIBLE LUM-INT=1MCD IF=20MA-MAX	28480	1990-0665
A1DS8	1990-0665	3		LED-VISIBLE LUM-INT=1MCD IF=20MA-MAX	28480	1990-0665
A1DS9	1990-0486	6	2	LED-VISIBLE LUM-INT=1MCD IF=20MA-MAX	28480	5082-4684
	0380-1231	7	2	L.E.D. MOUNT	00000	ORDER BY DESCRIPTION
A1DS10	1990-0486	6		LED-VISIBLE LUM-INT=1MCD IF=20MA-MAX	28480	5082-4684
	0380-1231	7		L.E.D. MOUNT	00000	ORDER BY DESCRIPTION
A1DS11	1990-0618	6	6	LED-VISIBLE LUM-INT=800UCD IF=20MA-MAX	28480	HLMP-0301
	1400-1025	2	6	L.E.D. MOUNT	28480	1400-1025
A1DS12	1990-0618	6		LED-VISIBLE LUM-INT=800UCD IF=20MA-MAX	28480	HLMP-0301
	1400-1025	2		L.E.D. MOUNT	28480	1400-1025
A1DS13	1990-0618	6		LED-VISIBLE LUM-INT=800UCD IF=20MA-MAX	28480	HLMP-0301
	1400-1025	2		L.E.D. MOUNT	28480	1400-1025
A1DS14	1990-0618	6		LED-VISIBLE LUM-INT=800UCD IF=20MA-MAX	28480	HLMP-0301
	1400-1025	2		L.E.D. MOUNT	28480	1400-1025
A1DS15	1990-0618	6		LED-VISIBLE LUM-INT=800UCD IF=20MA-MAX	28480	HLMP-0301
	1400-1025	2		L.E.D. MOUNT	28480	1400-1025
A1DS16	1990-0618	6		LED-VISIBLE LUM-INT=800UCD IF=20MA-MAX	28480	HLMP-0301
	1400-1025	2		L.E.D. MOUNT	28480	1400-1025
A1DS17	1990-0665	3		LED-VISIBLE LUM-INT=1MCD IF=20MA-MAX	28480	1990-0665
A1DS18	1990-0665	3		LED-VISIBLE LUM-INT=1MCD IF=20MA-MAX	28480	1990-0665
A1DS19	1990-0665	3		LED-VISIBLE LUM-INT=1MCD IF=20MA-MAX	28480	1990-0665
A1J1	1251-4736	1	2	CONNECTOR 26-PIN M RECTANGULAR BLUE RIBBON CABLE	28480	1251-4736
A1MP1	5041-0319	7	6	KEY CAP, HALF, GREY, LED	28480	5041-0319
A1MP2	5041-1832	1	1	KEY CAP, HALF "HZ/MV"	28480	5041-1832
A1MP3	5041-0319	7		KEY CAP, HALF, GREY, LED	28480	5041-0319
A1MP4	5041-0385	7	3	KEY CAP, HALF, SMOKE-GREY	28480	5041-0385
A1MP5	5041-1839	8	1	KEY CAP, HALF "AMPTD"	28480	5041-1839
A1MP6	5041-0817	0	1	KEY CAP, HALF "7"	28480	5041-0817
A1MP7	5041-0813	6	1	KEY CAP, HALF "3"	28480	5041-0813
A1MP8	5041-1665	8	1	KEY CAP-QUARTER "LCL"	28480	5041-1665
A1MP9	5041-1842	3	1	KEY CAP, HALF "PLOT LIMIT"	28480	5041-1842
A1MP10	5041-1831	0	1	KEY CAP, HALF,"KHZ/V"	28480	5041-1831
A1MP11	5041-0319	7		KEY CAP, HALF, GREY, LED	28480	5041-0319
A1MP12	5041-0319	7		KEY CAP, HALF, GREY, LED	28480	5041-0319
A1MP13	5041-1838	7	1	KEY CAP, HALF "FREQ"	28480	5041-1838
A1MP14	5041-0816	9	2	KEY CAP, HALF "6"	28480	5041-0816
A1MP15	5041-0812	5	1	KEY CAP, HALF "2"	28480	5041-0812
A1MP16	5041-0408	5	1	KEY CAP, QUARTER, BLACK	28480	5041-0408
A1MP17	5041-1840	1	1	KEY CAP, HALF "FREQ INCR"	28480	5041-1840
A1MP18	5041-1837	6	1	KEY CAP, HALF "STOP FREQ"	28480	5041-1837
A1MP19	5041-0319	7		KEY CAP, HALF, GREY, LED	28480	5041-0319
A1MP20	5041-0385	7		KEY CAP, HALF, SMOKE-GREY	28480	5041-0385
A1MP21	5041-0816	9		KEY CAP, HALF "6"	28480	5041-0816
A1MP22	5041-0815	8	1	KEY CAP, HALF "5"	28480	5041-0815
A1MP23	5041-0811	4	1	KEY CAP, HALF,"1"	28480	5041-0811
A1MP24	5041-0417	6	1	KEY CAP, QUARTER, BLACK, LED	28480	5041-0417
A1MP25	5041-1641	0	1	KEY CAP, HALF DIVIDE-BY-TEN	28480	5041-1641
A1MP26	5041-1836	5	1	KEY CAP,HALF "START FREQ"	28480	5041-1836
A1MP27	5041-0319	7		KEY CAP, HALF, GREY, LED	28480	5041-0319
A1MP28	5041-0385	7		KEY CAP, HALF, SMOKE-GREY	28480	5041-0385
A1MP29	5041-0818	1	1	KEY CAP, HALF "8"	28480	5041-0818
A1MP30	5041-0814	7	1	KEY CAP, HALF "4"	28480	5041-0814
A1MP31	5041-0819	2	1	KEY CAP, HALF "0"	28480	5041-0819
A1MP32	5041-1640	9	1	KEY CAP, HALF "X10"	28480	5041-1640
A1MP33	5041-0808	9	1	KEY CAP, HALF, DECIMAL	28480	5041-0808
A1MP34	5041-1841	2	1	KEY CAP, HALF "AMPTD INCR"	28480	5041-1841
A1MP35	5041-1834	3	1	KEY CAP, HALF "CLEAR"	28480	5041-1834

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A1MP36	5041-1843	4	2	KEY CAP, HALF, ARROW	28480	5041-1843
A1MP37	5041-1835	4	1	KEY CAP, HALF "-"	28480	5041-1835
A1MP38	5041-0286	7	1	KEY CAP, HALF,LT. GREY, LED	28480	5041-0286
A1MP39	5041-1843	4		KEY CAP, HALF, ARROW	28480	5041-1843
A1MP40	5041-0508	6	1	KEY CAP, HALF, GREEN	28480	5041-0508
A1MP41	5041-1833	2	1	KEY CAP, HALF "DBV/DB"	28480	5041-1833
A1R1	1810-0402	6	11	NETWORK-RES 16-DIP330.0 OHM X 8	01121	316B331
A1R2	1810-0205	7	2	NETWORK-RES 8-SIP4.7K OHM X 7	01121	208A472
A1R3	0698-3155	1	2	RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F
A1R4	0757-0199	3	5	RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A1R5	1810-0207	9	2	NETWORK-RES 8-SIP22.0K OHM X 7	01121	208A223
A1R6	1810-0208	0	3	NETWORK-RES 8-SIP68.0K OHM X 7	01121	208A683
A1R7	0757-0461	2	2	RESISTOR 68.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6812-F
A1R8	0698-0082	7	2	RESISTOR 464 1% .125W F TC=0+-100	24546	C4-1/8-T0-4640-F
A1R9	0698-3453	2	4	RESISTOR 196K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1963-F
A1R10	0757-0461	2		RESISTOR 68.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6812-F
A1R11	0757-0447	4	8	RESISTOR 16.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1622-F
A1R12	0757-0438	3	25	RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A1R13	0698-3445	2	5	RESISTOR 348 1% .125W F TC=0+-100	24546	C4-1/8-T0-348R-F
A1R14	0698-3445	2		RESISTOR 348 1% .125W F TC=0+-100	24546	C4-1/8-T0-348R-F
A1R15	0698-3445	2		RESISTOR 348 1% .125W F TC=0+-100	24546	C4-1/8-T0-348R-F
A1R16	0698-3445	2		RESISTOR 348 1% .125W F TC=0+-100	24546	C4-1/8-T0-348R-F
A1R17	1810-0229	5	1	NETWORK-RES 8-SIP330.0 OHM X 7	01121	208A331
A1R18	1810-0402	6		NETWORK-RES 16-DIP330.0 OHM X 8	01121	316B331
A1R19	1810-0402	6		NETWORK-RES 16-DIP330.0 OHM X 8	01121	316B331
A1R20	1810-0402	6		NETWORK-RES 16-DIP330.0 OHM X 8	01121	316B331
A1R21	1810-0402	6		NETWORK-RES 16-DIP330.0 OHM X 8	01121	316B331
A1R22	1810-0402	6		NETWORK-RES 16-DIP330.0 OHM X 8	01121	316B331
A1R23	1810-0402	6		NETWORK-RES 16-DIP330.0 OHM X 8	01121	316B331
A1R24	1810-0402	6		NETWORK-RES 16-DIP330.0 OHM X 8	01121	316B331
A1R25	1810-0402	6		NETWORK-RES 16-DIP330.0 OHM X 8	01121	316B331
A1R26	1810-0402	6		NETWORK-RES 16-DIP330.0 OHM X 8	01121	316B331
A1R27	1810-0402	6		NETWORK-RES 16-DIP330.0 OHM X 8	01121	316B331
A1R28†	0757-0280	3	45	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A1S1	5060-9436	7	41	PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S2	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S3	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S4	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S5	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S6	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S7	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S8	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S9	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S10	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S11	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S12	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S13	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S14	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S15	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S16	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S17	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S18	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S19	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S20	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S21	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S22	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S23	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S24	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S25	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S26	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S27	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S28	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S29	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S30	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S31	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S32	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S33	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S34	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S35	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S36	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S37	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S38	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S39	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1S40	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436

See introduction to this section for ordering information
*Indicates factory selected value
†For backdating information see Section VII.

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A1S41	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A1U1	1820-1729	3	25	IC LCH TTL LS COM CLEAR 8-BIT	01295	SN74LS259N
A1U2	1990-0540	3	9	DISPLAY-NUM-SEG 1-CHAR .43-H	28480	5082-7650
	1200-0508	0	10	SOCKET-IC 14-CONT DIP-SLDR	28480	1200-0508
A1U3	1990-0540	3		DISPLAY-NUM-SEG 1-CHAR .43-H	28480	5082-7650
	1200-0508	0		SOCKET-IC 14-CONT DIP-SLDR	28480	1200-0508
A1U4	1990-0540	3		DISPLAY-NUM-SEG 1-CHAR .43-H	28480	5082-7650
	1200-0508	0		SOCKET-IC 14-CONT DIP-SLDR	28480	1200-0508
A1U5	1990-0540	3		DISPLAY-NUM-SEG 1-CHAR .43-H	28480	5082-7650
	1200-0508	0		SOCKET-IC 14-CONT DIP-SLDR	28480	1200-0508
A1U6	1990-0540	3		DISPLAY-NUM-SEG 1-CHAR .43-H	28480	5082-7650
	1200-0508	0		SOCKET-IC 14-CONT DIP-SLDR	28480	1200-0508
A1U7	1820-1729	3		IC LCH TTL LS COM CLEAR 8-BIT	01295	SN74LS259N
A1U8	1990-0574	3	1	DISPLAY-NUM-SEG 1-CHAR .43-H	28480	5082-7651
	1200-0508	0		SOCKET-IC 14-CONT DIP-SLDR	28480	1200-0508
A1U9	1990-0540	3		DISPLAY-NUM-SEG 1-CHAR .43-H	28480	5082-7650
	1200-0508	0		SOCKET-IC 14-CONT DIP-SLDR	28480	1200-0508
A1U10	1990-0540	3		DISPLAY-NUM-SEG 1-CHAR .43-H	28480	5082-7650
	1200-0508	0		SOCKET-IC 14-CONT DIP-SLDR	28480	1200-0508
A1U11	1990-0540	3		DISPLAY-NUM-SEG 1-CHAR .43-H	28480	5082-7650
	1200-0508	0		SOCKET-IC 14-CONT DIP-SLDR	28480	1200-0508
A1U12	1990-0540	3		DISPLAY-NUM-SEG 1-CHAR .43-H	28480	5082-7650
	1200-0508	0		SOCKET-IC 14-CONT DIP-SLDR	28480	1200-0508
A1U13	1820-1729	3		IC LCH TTL LS COM CLEAR 8-BIT	01295	SN74LS259N
A1U14	1820-1729	3		IC LCH TTL LS COM CLEAR 8-BIT	01295	SN74LS259N
A1U15	1820-1729	3		IC LCH TTL LS COM CLEAR 8-BIT	01295	SN74LS259N
A1U16	1820-1729	3		IC LCH TTL LS COM CLEAR 8-BIT	01295	SN74LS259N
A1U17	1820-1729	3		IC LCH TTL LS COM CLEAR 8-BIT	01295	SN74LS259N
A1U18	1820-1729	3		IC LCH TTL LS COM CLEAR 8-BIT	01295	SN74LS259N
A1U19	1820-1729	3		IC LCH TTL LS COM CLEAR 8-BIT	01295	SN74LS259N
A1U20	1820-1729	3		IC LCH TTL LS COM CLEAR 8-BIT	01295	SN74LS259N
A1U21	1820-1729	3		IC LCH TTL LS COM CLEAR 8-BIT	01295	SN74LS259N
A1U22	1826-0412	1	2	IC COMPARATOR PRCN DUAL 8-DIP-P PKG	27014	LM393N
A1U23	1820-1144	6	2	IC GATE TTL LS NOR QUAD 2-INP	01295	SN74LS02N
A1U24	1820-1417	6	6	IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS26N
A1U25	1820-1417	6		IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS26N
A1U26	1820-1729	3		IC LCH TTL LS COM CLEAR 8-BIT	01295	SN74LS259N
A1U27	1820-1729	3		IC LCH TTL LS COM CLEAR 8-BIT	01295	SN74LS259N
A1U28	1820-1216	3	6	IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N
A1U29	1820-1216	3		IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N
A1U30	1820-1427	8	1	IC DCDR TTL LS 2-TO-4-LINE DUAL 2-INP	01295	SN74LS156N
A2	08903-60004	4	1	INPUT AMPLIFIER	28480	08903-60004
A2C1	0180-1746	5	7	CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X9020B2
A2C2	0160-2091	3	2	CAPACITOR-FXD 1.5UF +-5% 600VDC	27556	ZA2G1S5J
A2C3	0121-0422	8	2	CAPACITOR-V TRMR-PSTN .8-4.5PF 1250V	18736	TP5G
A2C4*	0160-2023	1	1	CAPACITOR-FXD 50PF +-5% 500VDC MICA	28480	0160-2023
A2C5	0160-3879	7	4	CAPACITOR-FXD .01UF +-20% 100VDC CER	28480	0160-3879
A2C6	0160-2616	8	2	CAPACITOR-FXD 68PF +-10% 1KVDC CER	28480	0160-2616
A2C7	0160-2239	1	1	CAPACITOR-FXD 1.8PF +-.25PF 500VDC CER	28480	0160-2239
A2C8	0160-3533	0	1	CAPACITOR-FXD 470PF +-5% 300VDC MICA	28480	0160-3533
A2C9*	0160-2253	9	1	CAPACITOR-FXD 6.8PF +-.25PF 500VDC CER	28480	0160-2253
A2C10	0121-0422	8		CAPACITOR-V TRMR-PSTN .8-4.5PF 1250V	18736	TP5G
A2C11	0160-2616	8		CAPACITOR-FXD 68PF +-10% 1KVDC CER	28480	0160-2616
A2C12	0160-2237	9	1	CAPACITOR-FXD 1.2PF +-.25PF 500VDC CER	28480	0160-2237
A2C13	0180-0228	6	4	CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X9015B2
A2C14	0160-4084	8	36	CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A2C15	0160-3879	7		CAPACITOR-FXD .01UF +-20% 100VDC CER	28480	0160-3879
A2C16	0160-3879	7		CAPACITOR-FXD .01UF +-20% 100VDC CER	28480	0160-3879
A2C17	0180-1746	5		CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X9020B2
A2C18	0160-0166	9	1	CAPACITOR-FXD .068UF +-10% 200VDC POLYE	28480	0160-0166
A2C19	0160-2091	3		CAPACITOR-FXD 1.5UF +-5% 600VDC	27556	ZA2G1S5J
A2C20	0180-3059	7	2	CAPACITOR-FXD 315UF 16V (HERMETIC)	28480	0180-3059
A2C21	0180-3059	7		CAPACITOR-FXD 315UF 16V (HERMETIC)	28480	0180-3059
A2C22	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A2C23	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A2C24	0160-3324	7	5	CAPACITOR-FXD 1UF +-5% 100VDC MET-POLYC	28480	0160-3324
A2C25	0140-0192	9	1	CAPACITOR-FXD 68PF +-5% 300VDC MICA	72136	DM15E680J0300WV1CR
A2C26	0160-2306	3	3	CAPACITOR-FXD 27PF +-5% 300VDC MICA	28480	0160-2306
A2C27	0160-2306	3		CAPACITOR-FXD 27PF +-5% 300VDC MICA	28480	0160-2306
A2C28	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A2C29	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A2C30	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A2C31	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A2C32	0160-2150	5	2	CAPACITOR-FXD 33PF +-5% 300VDC MICA	28480	0160-2150
A2C33	0160-2257	3	6	CAPACITOR-FXD 10PF +-5% 500VDC CER 0+-60	28480	0160-2257
A2C34	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A2C35	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A2C36	0160-0576	5	2	CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576
A2C37	0180-0229	7		CAPACITOR-FXD 33UF+-10% 10VDC TA	56289	150D336X9010B2
A2C38	0180-0229	7		CAPACITOR-FXD 33UF+-10% 10VDC TA	56289	150D336X9010B2
A2C39	0160-2265	3	5	CAPACITOR-FXD 22PF +-5% 500VDC CER 0+-30	28480	0160-2265
A2C40	0160-2306	3		CAPACITOR-FXD 27PF +-5% 300VDC MICA	28480	0160-2306
A2C41	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A2C42	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A2C43	0160-5045	3	5	CAPACITOR-FXD .022UF 2% 100VDCW	28480	0160-5045
A2C44	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A2C45	0160-5045	3		CAPACITOR-FXD .022UF 2% 100VDCW	28480	0160-5045
A2C46	0160-3471	5	1	CAPACITOR-FXD 1060PF +-1% 300VDC MICA	28480	0160-3471
A2C47	0160-3400	0	1	CAPACITOR-FXD .01UF +-5% 200VDC	28480	0160-3400
A2C48	0160-2265	3		CAPACITOR-FXD 22PF +-5% 500VDC CER 0+-30	28480	0160-2265
A2C49	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A2C50	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A2C51	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A2C52	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A2C53	0160-0577	6	1	CAPACITOR-FXD 1.8UF +-20% 50VDC	28480	0160-0577
A2C54	0160-5045	3		CAPACITOR-FXD .022UF 2% 100VDCW	28480	0160-5045
A2C55	0160-5045	3		CAPACITOR-FXD .022UF 2% 100VDCW	28480	0160-5045
A2C56	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A2C57	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A2C58	0160-2302	9	1	CAPACITOR-FXD 4000PF +-1% 100VDC MICA	28480	0160-2302
A2C59	0160-5045	3		CAPACITOR-FXD .022UF 2% 100VDCW	28480	0160-5045
A2C60	0160-4759	4	1	CAPACITOR-FXD .0068 UF 1%	28480	0160-4759
A2C61	0160-3661	5	1	CAPACITOR-FXD .1UF +-5% 50VDC MET-POLYC	28480	0160-3661
A2C62	0160-2265	3		CAPACITOR-FXD 22PF +-5% 500VDC CER 0+-30	28480	0160-2265
A2C63	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A2C64	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A2C65	0160-4622	0	1	CAPACITOR-FXD .1UF +-1% 160VDC MET-POLYC	28480	0160-4622
A2C66	0160-5046	4	2	CAPACITOR-FXD .039UF 2% 100VDCW	28480	0160-5046
A2C67	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A2C68	0160-5046	4		CAPACITOR-FXD .039UF 2% 100VDCW	28480	0160-5046
A2C69	0160-3843	5	1	CAPACITOR-FXD 560PF +-1% 100VDC MICA	28480	0160-3843
A2C70	0160-0572	1	1	CAPACITOR-FXD 2200PF +-20% 100VDC CER	28480	0160-0572
A2C71	0160-0578	7	2	CAPACITOR-FXD .047UF +-1% 50VDC	28480	0160-0578
A2C72	0160-0578	7		CAPACITOR-FXD .047UF +-1% 50VDC	28480	0160-0578
A2C73	0160-4267	9	4	CAPACITOR-FXD .02UF +-1% 200VDC	28480	0160-4267
A2C74	0160-4267	9		CAPACITOR-FXD .02UF +-1% 200VDC	28480	0160-4267
A2C75	0160-4267	9		CAPACITOR-FXD .02UF +-1% 200VDC	28480	0160-4267
A2C76	0160-4267	9		CAPACITOR-FXD .02UF +-1% 200VDC	28480	0160-4267
A2C77	0160-2265	3		CAPACITOR-FXD 22PF +-5% 500VDC CER 0+-30	28480	0160-2265
A2C78	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A2C79	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A2C80	0160-2257	3		CAPACITOR-FXD 10PF +-5% 500VDC CER 0+-60	28480	0160-2257
A2C81	0160-3879	7		CAPACITOR-FXD .01UF +-20% 100VDC CER	28480	0160-3879
A2CR1	1901-0033	2	20	DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A2CR2	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A2CR3	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A2CR4	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A2CR5	1901-0040	1	14	DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A2CR6	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A2CR7	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A2CR8	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A2CR9	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A2CR10	1901-0376	6	36	DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A2CR11	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A2CR12	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A2CR13	1901-0470	1	2	DIODE-HV RECT 1KV 600MA DO-41	28480	1901-0470
A2CR14	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A2CR15	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A2CR16	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A2CR17	1901-0470	1		DIODE-HV RECT 1KV 600MA DO-41	28480	1901-0470
A2CR18	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A2CR19	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A2CR20	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A2CR21	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A2CR22	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A2CR23	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A2F1	2110-0337	3	1	FUSE .032A 250V TD 1.25X.25 UL	75915	313.031
A2F2	2110-0011	0	1	FUSE .062A 250V NTD 1.25X.25 UL	28480	2110-0011
A2K1	0490-0916	6	5	RELAY-REED 1A 500MA 100VDC 5VDC-COIL	28480	0490-0916
A2K2	0490-0916	6		RELAY-REED 1A 500MA 100VDC 5VDC-COIL	28480	0490-0916
A2K3	0490-0916	6		RELAY-REED 1A 500MA 100VDC 5VDC-COIL	28480	0490-0916
A2K4	0490-1215	0	4	RELAY-REED 1A 500MA 500VDC 5VDC-COIL	28480	0490-1215
A2K5	0490-1215	0		RELAY-REED 1A 500MA 500VDC 5VDC-COIL	28480	0490-1215
A2K6	0490-1215	0		RELAY-REED 1A 500MA 500VDC 5VDC-COIL	28480	0490-1215
A2K7	0490-1215	0		RELAY-REED 1A 500MA 500VDC 5VDC-COIL	28480	0490-1215
A2L1	9140-0114	4	3	INDUCTOR RF-CH-MLD 10UH 10% .166DX.385LG	28480	9140-0114
A2L2	9100-2430	7	2	INDUCTOR RF-CH-MLD 220UH 10%	28480	9100-2430
A2L3	9140-0114	4		INDUCTOR RF-CH-MLD 10UH 10% .166DX.385LG	28480	9140-0114
A2MP1	4040-0748	3	8	EXTR-PC BD BLK POLYC .062-BD-THKNS	28480	4040-0748
	1480-0073	6	16	PIN-ROLL .062-IN-DIA .25-IN-LG BE-CU	28480	1480-0073
A2MP2	4040-0750	7	1	EXTR-PC BD RED POLYC .062-BD-THKNS	28480	4040-0750
	1480-0073	6		PIN-ROLL .062-IN-DIA .25-IN-LG BE-CU	28480	1480-0073
A2MP3	2110-0269	0	10	FUSEHOLDER-CLIP TYPE.25D-FUSE	28480	2110-0269
A2Q1	1854-0477	7	10	TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	04713	2N2222A
A2Q2	1855-0082	2	2	TRANSISTOR J-FET P-CHAN D-MODE SI	28480	1855-0082
A2Q3	1855-0082	2		TRANSISTOR J-FET P-CHAN D-MODE SI	28480	1855-0082
A2R1	0698-6058	9	1	RESISTOR 100K .1% .5W F TC=0+-50	28480	0698-6058
A2R2	0757-0159	5	1	RESISTOR 1K 1% .5W F TC=0+-100	28480	0757-0159
A2R3	0699-0413	0	1	RESISTOR 112.32K .1% 1W F TC=0+-25	28480	0699-0413
A2R4	0699-0526	6	1	RESISTOR-FXD 37.68K .1% .25W	28480	0699-0526
A2R5	0698-3457	6	1	RESISTOR 316K 1% .125W F TC=0+-100	28480	0698-3457
A2R6	0699-0402	7	1	RESISTOR 281.07K .1% .5W F TC=0+-25	28480	0699-0402
A2R7	0699-0405	0	1	RESISTOR 15.93K .1% .25W F TC=0+-25	28480	0699-0405
A2R8	0698-6348	0	1	RESISTOR 3K .1% .125W F TC=0+-25	28480	0698-6348
A2R9	0698-3451	0	1	RESISTOR 133K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1333-F
A2R10	0757-0394	0	5	RESISTOR 51.1 1% .125W F TC=0+-100	24546	C4-1/8-T0-51R1-F
A2R11	0698-3157	3	18	RESISTOR 19.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1962-F
A2R12	0698-3152	8	4	RESISTOR 3.48K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3481-F
A2R13 †	0757-0465	6	13	RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A2R14	0698-3157	3		RESISTOR 19.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1962-F
A2R15 †	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A2R16	0698-3157	3		RESISTOR 19.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1962-F
A2R17	0698-3415	6	1	RESISTOR 19.6K 1% .5W F TC=0+-100	28480	0698-3415
A2R18	0757-0442	9	42	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A2R19	0764-0031	7	4	RESISTOR 47K 5% 2W MO TC=0+-200	28480	0764-0031
A2R20	0757-0447	4		RESISTOR 16.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1622-F
A2R21	0764-0031	7		RESISTOR 47K 5% 2W MO TC=0+-200	28480	0764-0031
A2R22	0757-0288	1	3	RESISTOR 9.09K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-9091-F
A2R23	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A2R24	0764-0031	7		RESISTOR 47K 5% 2W MO TC=0+-200	28480	0764-0031
A2R25	0764-0031	7		RESISTOR 47K 5% 2W MO TC=0+-200	28480	0764-0031
A2R26	0757-0401	0	26	RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A2R27	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A2R28	0698-6447	0	2	RESISTOR 683.8 .1% .125W F TC=0+-25	28480	0698-6447
A2R29	0699-0412	9	2	RESISTOR 493 .1% .25W F TC=0+-25	28480	0699-0412
A2R30	0699-0412	9		RESISTOR 493 .1% .25W F TC=0+-25	28480	0699-0412
A2R31	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A2R32	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A2R33	0699-0407	2	1	RESISTOR 1.749K .1% .25W F TC=0+-25	28480	0699-0407
A2R34	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A2R35	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A2R36	0699-0409	4	2	RESISTOR 1.3224K .1% .25W F TC=0+-25	28480	0699-0409
A2R37	0699-0409	4		RESISTOR 1.3224K .1% .25W F TC=0+-25	28480	0699-0409
A2R38	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A2R39	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A2R40	0698-8835	4	3	RESISTOR 5K .1% .125W F TC=0+-10	28480	0698-8835
A2R41	0698-8835	4		RESISTOR 5K .1% .125W F TC=0+-10	28480	0698-8835
A2R42	0699-0513	1	1	RESISTOR-FXD 4.98K .1% 1W	28480	0699-0513
A2R43	2100-0552	3	1	RESISTOR-TRMR 50 10% C SIDE-ADJ 1-TRN	28480	2100-0552
A2R44	2100-3355	0	3	RESISTOR-TRMR 100K 10% C SIDE-ADJ 1-TRN	28480	2100-3355
A2R45	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A2R46	0698-8835	4		RESISTOR 5K .1% .125W F TC=0+-10	28480	0698-8835
A2R47	0757-0199	3		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A2R48	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A2R49	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A2R50	1810-0207	9		NETWORK-RES 8-SIP22.0K OHM X 7	01121	208A223
A2R51	0698-7268	5	1	RESISTOR 21.5K 1% .05W F TC=0+-100	24546	C3-1/8-T0-2152-G
A2R52	0698-3155	1		RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F
A2R53	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A2R54	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A2R55	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F

See introduction to this section for ordering information
*Indicates factory selected value
†For backdating information see Section VII.

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A2R56	0698-7404	1	1	RESISTOR 1.005K .1% .125W F TC=0+-50	19701	MF4C1/8-T2-1005R-B
A2R57	0699-0411	8	1	RESISTOR 634 .1% .25W F TC=0+-25	28480	0699-0411
A2R58	0698-6355	9	1	RESISTOR 400 .1% .125W F TC=0+-25	28480	0698-6355
A2R59	0698-6447	0		RESISTOR 683.8 .1% .125W F TC=0+-25	28480	0698-6447
A2R60	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A2R61	0757-0448	5	2	RESISTOR 18.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1822-F
A2R62	0757-0448	5		RESISTOR 18.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1822-F
A2R63	0699-0403	8	1	RESISTOR 45.2K .1% .25W F TC=0+-25	28480	0699-0403
A2R64	0698-8586	2	1	RESISTOR 4.71K 1% .125W F TC=0+-100	28480	0698-8586
A2R65	2100-3351	6	2	RESISTOR-TRMR 500 10% C SIDE-ADJ 1-TRN	28480	2100-3351
A2R66	0698-0083	8	6	RESISTOR 1.96K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1961-F
A2R67	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A2R68	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A2R69	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A2R70	2100-3351	6		RESISTOR-TRMR 500 10% C SIDE-ADJ 1-TRN	28480	2100-3351
A2R71	0757-0290	5	9	RESISTOR 6.19K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-6191-F
A2R72	0698-7353	9	1	RESISTOR 19K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-1902-F
A2R73	0698-3157	3		RESISTOR 19.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1962-F
A2R74	0699-0404	9	1	RESISTOR 29.3K .1% .25W F TC=0+-25	28480	0699-0404
A2R75	0698-3157	3		RESISTOR 19.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1962-F
A2R76	0757-0439	4	5	RESISTOR 6.81K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6811-F
A2R77	0699-0408	3	1	RESISTOR 4.28K .1% .25W F TC=0+-25	28480	0699-0408
A2R78	0698-3515	7	2	RESISTOR 5.9K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5901-F
A2R79	0757-0200	7	4	RESISTOR 5.62K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5621-F
A2R80	0757-0439	4		RESISTOR 6.81K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6811-F
A2R81	0757-0441	8	4	RESISTOR 8.25K 1% .125W F TC=0+-100	24546	C4-1/8-T0-8251-F
A2R82	0698-3515	7		RESISTOR 5.9K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5901-F
A2R83	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A2R84	0698-7853	4	1	RESISTOR 101.5K .1% .125W F TC=0+-50	19701	MF4C1/8-T2-10152-B
A2R85	0698-8607	8	1	RESISTOR 4.5K .1% .125W F TC=0+-25	28480	0698-8607
A2R86	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A2R87	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A2R88	0698-3159	5	1	RESISTOR 26.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2612-F
A2R89	0699-0410	7	1	RESISTOR 938 .1% .25W F TC=0+-25	28480	0699-0410
A2R90	0698-4508	0	1	RESISTOR 78.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7872-F
A2R91	0757-0200	7		RESISTOR 5.62K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5621-F
A2R92	0698-4489	6	1	RESISTOR 28K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2802-F
A2R93	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A2R94	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A2R95				NOT ASSIGNED		
A2R96	0698-3152	8		RESISTOR 3.48K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3481-F
A2TP1	1251-0600	0	81	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A2TP2	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A2TP3	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A2TP4	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A2TP5	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A2TP6	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A2TP7	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A2U1	1826-0421	2	1	IC CONV RMS/DC 14-DIP-C PKG	24355	AD536AJ
A2U2	1826-0569	9	12	IC OP AMP LOW-NOISE TO-99 PKG	18324	NE5534AT
A2U3	1826-0569	9		IC OP AMP LOW-NOISE TO-99 PKG	18324	NE5534AT
A2U4	1826-0138	8	16	IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N
A2U5	1826-0569	9		IC OP AMP LOW-NOISE TO-99 PKG	18324	NE5534AT
A2U6	1826-0662	3	7	IC OP AMP LOW-BIAS-H-IMPD TO-99 PKG	28480	1826-0662
A2U7	1826-0662	3		IC OP AMP LOW-BIAS-H-IMPD TO-99 PKG	28480	1826-0662
A2U8	1826-0569	9		IC OP AMP LOW-NOISE TO-99 PKG	18324	NE5534AT
A2U9	1826-0569	9		IC OP AMP LOW-NOISE TO-99 PKG	18324	NE5534AT
A2U10	1826-0582	6	7	IC SWITCH ANLG QUAD 16-DIP-C PKG	27014	LF13201D
A2U11	1826-0582	6		IC SWITCH ANLG QUAD 16-DIP-C PKG	27014	LF13201D
A2U12	1826-0662	3		IC OP AMP LOW-BIAS-H-IMPD TO-99 PKG	28480	1826-0662
A2U13	1826-0522	4	1	IC OP AMP QUAD 14-DIP-P PKG	01295	TL074CN
A2U14	1820-1202	7	2	IC GATE TTL LS NAND TPL 3-INP	01295	SN74LS10N
A2U15	1820-0668	7	1	IC BFR TTL NON-INV HEX 1-INP	01295	SN7407N
A2U16	1826-0138	8		IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N
A3	08903-60005	5	1	NOTCH FILTER	28480	08903-60005
A3C1	0160-0575	4	2	CAPACITOR-FXD .047UF +-20% 50VDC CER	28480	0160-0575
A3C2	0180-0049	9	2	CAPACITOR-FXD 20UF+75-10% 50VDC AL	56289	30D206G050CC2
A3C3	0180-0049	9		CAPACITOR-FXD 20UF+75-10% 50VDC AL	56289	30D206G050CC2
A3C4	0160-0575	4		CAPACITOR-FXD .047UF +-20% 50VDC CER	28480	0160-0575
A3C5	0160-2250	6	4	CAPACITOR-FXD 5.1PF +-.25PF 500VDC CER	28480	0160-2250

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A3C6	0160-2055	9	59	CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A3C7	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A3C8				NOT ASSIGNED		
A3C9	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A3C10	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A3C11	0160-4590	1	4	CAPACITOR-FXD .18UF +-1% 200VDC	28480	0160-4590
A3C12	0160-5032	8	4	CAPACITOR-FXD .0223UF 1% 200VDCW	28480	0160-5032
A3C13	0160-3293	9	4	CAPACITOR-FXD 2470PF +-1% 100VDC MICA	28480	0160-3293
A3C14	0160-3918	5	2	CAPACITOR-FXD 355PF +-1% 100VDC MICA	28480	0160-3918
A3C15	0160-2250	6		CAPACITOR-FXD 5.1PF +-.25PF 500VDC CER	28480	0160-2250
A3C16	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A3C17	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A3C18	0160-2250	6		CAPACITOR-FXD 5.1PF +-.25PF 500VDC CER	28480	0160-2250
A3C19	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A3C20	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A3C21	0160-2257	3		CAPACITOR-FXD 10PF +-5% 500VDC CER 0+-60	28480	0160-2257
A3C22				NOT ASSIGNED		
A3C23	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A3C24	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A3C25	0160-4590	1		CAPACITOR-FXD .18UF +-1% 200VDC	28480	0160-4590
A3C26	0160-5032	8		CAPACITOR-FXD .0223UF 1% 200VDCW	28480	0160-5032
A3C27	0160-3293	9		CAPACITOR-FXD 2470PF +-1% 100VDC MICA	28480	0160-3293
A3C28	0160-3918	5		CAPACITOR-FXD 355PF +-1% 100VDC MICA	28480	0160-3918
A3C29	0180-0374	3	4	CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2
A3C30	0180-0094	4	1	CAPACITOR-FXD 100UF+75-10% 25VDC AL	56289	30D107G025DD2
A3C31	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A3C32	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A3C33	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A3C34	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A3C35	0140-0196	3	5	CAPACITOR-FXD 150PF +-5% 300VDC MICA	72136	DM15F151J0300WV1CR
A3C36	0160-2250	6		CAPACITOR-FXD 5.1PF +-.25PF 500VDC CER	28480	0160-2250
A3C37	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A3C38	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A3C39	0160-2199	2	2	CAPACITOR-FXD 30PF +-5% 300VDC MICA	28480	0160-2199
A3C40	0160-2199	2		CAPACITOR-FXD 30PF +-5% 300VDC MICA	28480	0160-2199
A3C41	0160-2432	6	1	CAPACITOR-FXD .1UF +-5% 100VDC POLYSTY	84411	863T10451W2
A3C42	0160-3179	0	1	CAPACITOR-FXD .033UF +-5% 100VDC POLYSTY	28480	0160-3179
A3C43	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A3C44	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A3C45	0160-3510	3	1	CAPACITOR-FXD 3UF +-10% 50VDC MET-POLYC	28480	0160-3510
A3C46	0160-4233	9	1	CAPACITOR-FXD .47UF +-5% 50VDC MET-POLYC	28480	0160-4233
A3C47	0160-3531	8	1	CAPACITOR-FXD 2UF +-5% 50VDC MET-POLYC	28480	0160-3531
A3C48	0160-3339	4	1	CAPACITOR-FXD .22UF +-5% 100VDC POLYSTY	28480	0160-3339
A3C49	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A3C50	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A3C51				NOT ASSIGNED		
A3C52	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A3C53	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A3CR1	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A3CR2	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A3CR3	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A3CR4	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A3CR5	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A3CR6	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A3CR7-A3CR10				NOT ASSIGNED		
A3CR11	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A3CR12	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A3CR13	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A3CR14	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A3L1	9140-0114	4		INDUCTOR RF-CH-MLD 10UH 10% .166DX.385LG	28480	9140-0114
A3L2†	9100-2430	7		INDUCTOR RF-CH-MLD 220UH 10%	28480	9100-2430
A3MP1	4040-0748	3		EXTR-PC BD BLK POLYC .062-BD-THKNS	28480	4040-0748
	1480-0073	6		PIN-ROLL .062-IN-DIA .25-IN-LG BE-CU	28480	1480-0073
A3MP2	4040-0751	8	1	EXTR-PC BD ORN POLYC .062-BD-THKNS	28480	4040-0751
	1480-0073	6		PIN-ROLL .062-IN-DIA .25-IN-LG BE-CU	28480	1480-0073
A3MP3	0403-0026	6	3	GLIDE NYLON FITS 0.192 HOLD 0.156HI	28480	0403-0026
A3Q1	1855-0414	4	8	TRANSISTOR J-FET 2N4393 N-CHAN D-MODE	04713	2N4393
A3Q2	1855-0414	4		TRANSISTOR J-FET 2N4393 N-CHAN D-MODE	04713	2N4393
A3Q3	1855-0414	4		TRANSISTOR J-FET 2N4393 N-CHAN D-MODE	04713	2N4393
A3Q4	1855-0091	3	74	TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A3Q5	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A3Q6	1855-0414	4		TRANSISTOR J-FET 2N4393 N-CHAN D-MODE	04713	2N4393
A3Q7	1855-0414	4		TRANSISTOR J-FET 2N4393 N-CHAN D-MODE	04713	2N4393
A3Q8	1855-0414	4		TRANSISTOR J-FET 2N4393 N-CHAN D-MODE	04713	2N4393
A3Q9	1855-0414	4		TRANSISTOR J-FET 2N4393 N-CHAN D-MODE	04713	2N4393
A3Q10	1855-0414	4		TRANSISTOR J-FET 2N4393 N-CHAN D-MODE	04713	2N4393

See introduction to this section for ordering information
*Indicates factory selected value
† For backdating information see Section VII.

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A3Q11	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A3Q12	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A3Q13	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A3Q14	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A3Q15	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A3Q16	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A3Q17	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A3Q18	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A3Q19	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A3Q20	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A3Q21	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A3Q22	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A3Q23	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A3Q24	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A3Q25	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A3Q26	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A3Q27	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A3Q28	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A3Q29	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A3Q30	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A3Q31	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A3Q32	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A3Q33	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A3Q34	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A3Q35	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A3R1	0698-3152	8		RESISTOR 3.48K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3481-F
A3R2	1810-0208	0		NETWORK-RES 8-SIP68.0K OHM X 7	01121	208A683
A3R3	1810-0208	0		NETWORK-RES 8-SIP68.0K OHM X 7	01121	208A683
A3R4	0698-3160	8	7	RESISTOR 31.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3162-F
A3R5	0698-3160	8		RESISTOR 31.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3162-F
A3R6	0698-6360	6	16	RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360
A3R7	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360
A3R8	0698-0084	9	6	RESISTOR 2.15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2151-F
A3R9	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360
A3R10	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A3R11	0698-8204	1	7	RESISTOR 7.98K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-7981-B
A3R12	0698-8205	2	6	RESISTOR 15.98K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-15981-B
A3R13	0698-8047	0	6	RESISTOR 32K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-3202-B
A3R14	0698-8049	2	6	RESISTOR 64K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-6402-B
A3R15	0698-8053	8	7	RESISTOR 128K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-1283-B
A3R16	0698-8050	5	7	RESISTOR 256K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-2563-B
A3R17	0698-8958	2	6	RESISTOR 511K 1% .125W F TC=0+-100	28480	0698-8958
A3R18	0698-8827	4	6	RESISTOR 1M 1% .125W F TC=0+-100	28480	0698-8827
A3R19	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A3R20	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360
A3R21	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360
A3R22	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360
A3R23	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360
A3R24	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360
A3R25	0698-8204	1		RESISTOR 7.98K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-7981-B
A3R26	0698-8205	2		RESISTOR 15.98K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-15981-B
A3R27	0698-8047	0		RESISTOR 32K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-3202-B
A3R28	0698-8049	2		RESISTOR 64K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-6402-B
A3R29	0698-8053	8		RESISTOR 128K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-1283-B
A3R30	0698-8050	5		RESISTOR 256K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-2563-B
A3R31	0698-8958	2		RESISTOR 511K 1% .125W F TC=0+-100	28480	0698-8958
A3R32	0698-8827	4		RESISTOR 1M 1% .125W F TC=0+-100	28480	0698-8827
A3R33	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A3R34	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A3R35	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A3R36	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A3R37	0698-3157	3		RESISTOR 19.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1962-F
A3R38	0698-3157	3		RESISTOR 19.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1962-F
A3R39	0698-3157	3		RESISTOR 19.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1962-F
A3R40	0698-3157	3		RESISTOR 19.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1962-F
A3R41	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A3R42	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A3R43	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A3R44	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A3R45	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A3R46	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A3R47	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A3R48	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A3R49	0698-0084	9		RESISTOR 2.15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2151-F
A3R50	0698-0084	9		RESISTOR 2.15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2151-F

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A3R51	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360
A3R52	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360
A3R53	0698-3160	8		RESISTOR 31.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3162-F
A3R54	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A3R55	0698-3200	7	1	RESISTOR 8K 1% .125W F TC=0+-100	24546	C4-1/8-T0-8001-F
A3R56	0757-0279	0	17	RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
A3R57	0757-0458	7	2	RESISTOR 51.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5112-F
A3R58	0698-3245	0	1	RESISTOR 20.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2052-F
A3R59	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A3R60	0698-3454	3	1	RESISTOR 215K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2153-F
A3R61	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A3R62	2100-3355	0		RESISTOR-TRMR 100K 10% C SIDE-ADJ 1-TRN	28480	2100-3355
A3R63	2100-3355	0		RESISTOR-TRMR 100K 10% C SIDE-ADJ 1-TRN	28480	2100-3355
A3R64	0698-3453	2		RESISTOR 196K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1963-F
A3R65	0698-3453	2		RESISTOR 196K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1963-F
A3R66	0757-0416	7	9	RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F
A3R67	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F
A3R68	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F
A3R69	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F
A3R70	0757-0290	5		RESISTOR 6.19K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-6191-F
A3R71	0757-0290	5		RESISTOR 6.19K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-6191-F
A3R72	0757-0279	0		RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
A3R73	0757-0279	0		RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
A3R74				NOT ASSIGNED		
A3R75	0757-0439	4		RESISTOR 6.81K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6811-F
A3R76	0757-0439	4		RESISTOR 6.81K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6811-F
A3R77	0698-3157	3		RESISTOR 19.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1962-F
A3R78	0698-3157	3		RESISTOR 19.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1962-F
A3R79	0757-0956	0	2	RESISTOR 22K 2% .125W F TC=0+-100	24546	C4-1/8-T0-2202-G
A3R80	0757-0956	0		RESISTOR 22K 2% .125W F TC=0+-100	24546	C4-1/8-T0-2202-G
A3R81	0757-1094	9	6	RESISTOR 1.47K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1471-F
A3R82	0757-1094	9		RESISTOR 1.47K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1471-F
A3R83	0757-0278	9	2	RESISTOR 1.78K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1781-F
A3R84	0757-0278	9		RESISTOR 1.78K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1781-F
A3R85	0698-8869	4	2	RESISTOR 2.15K .25% .125W F TC=0+-100	28480	0698-8869
A3R86	0698-8869	4		RESISTOR 2.15K .25% .125W F TC=0+-100	28480	0698-8869
A3R87	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F
A3R88	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F
A3R89	0698-4339	5	2	RESISTOR 11.111K .1% .125W F TC=0+-50	28480	0698-4339
A3R90	0698-4339	5		RESISTOR 11.111K .1% .125W F TC=0+-50	28480	0698-4339
A3R91	0698-8655	6	2	RESISTOR 13.3K .1% .125W F TC=0+-50	28480	0698-8655
A3R92	0698-8655	6		RESISTOR 13.3K .1% .125W F TC=0+-50	28480	0698-8655
A3R93	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360
A3R94	0757-0290	5		RESISTOR 6.19K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-6191-F
A3R95	0757-0279	0		RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
A3TP1	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A3TP2	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A3TP3	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A3TP4	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A3TP5	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A3TP6	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A3TP7	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A3TP8	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A3TP9	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A3TP10	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A3TP11	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A3TP12	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A3TP13	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A3TP14	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A3U1	1826-0059	2	4	IC OP AMP GP TO-99 PKG	01295	LM201AL
A3U2	1826-0025	2	2	IC OP AMP LOW-DRIFT TO-99 PKG	27014	LM208AH
A3U3	1826-0025	2		IC OP AMP LOW-DRIFT TO-99 PKG	27014	LM208AH
A3U4	1826-0014	9	3	IC MULTIPLIER 14-DIP-C PKG	04713	MC1595L
A3U5	1826-0569	9		IC OP AMP LOW-NOISE TO-99 PKG	18324	NE5534AT
A3U6	1826-0662	3		IC OP AMP LOW-BIAS-H-IMPD TO-99 PKG	28480	1826-0662
A3U7	1826-0109	3	4	IC OP AMP WB TO-99 PKG	34371	HA2-2625-B0593
A3U8	1826-0412	1		IC COMPARATOR PRCN DUAL 8-DIP-P PKG	27014	LM393N
A3U9	1826-0014	9		IC MULTIPLIER 14-DIP-C PKG	04713	MC1595L
A3U10	1826-0138	8		IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N
A3U11	1826-0569	9		IC OP AMP LOW-NOISE TO-99 PKG	18324	NE5534AT
A3U12	1826-0569	9		IC OP AMP LOW-NOISE TO-99 PKG	18324	NE5534AT
A3U13	1826-0662	3		IC OP AMP LOW-BIAS-H-IMPD TO-99 PKG	28480	1826-0662
A3U14	1826-0138	8		IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N
A3U15	1826-0138	8		IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A3U16	1826-0138	8		IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N
A4	08903-60001	1	1	OUTPUT AMPLIFIER/VOLTMETER	28480	08903-60001
A4C1	0180-2207	5	3	CAPACITOR-FXD 100UF+-10% 10VDC TA	56289	150D107X9010R2
A4C2	0180-0100	3	2	CAPACITOR-FXD 4.7UF+-10% 35VDC TA	56289	150D475X9035B2
A4C3	0180-0374	3		CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2
A4C4	0180-0100	3		CAPACITOR-FXD 4.7UF+-10% 35VDC TA	56289	150D475X9035B2
A4C5	0180-0291	3	17	CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A4C6	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A4C7	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A4C8	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A4C9	0160-2307	4	11	CAPACITOR-FXD 47PF +-5% 300VDC MICA	28480	0160-2307
A4C10	0160-2236	8	2	CAPACITOR-FXD 1PF +-.25PF 500VDC CER	28480	0160-2236
A4C11	0180-0374	3		CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2
A4C12	0160-0174	9	2	CAPACITOR-FXD .47UF +80-20% 25VDC CER	28480	0160-0174
A4C13	0160-2221	1	1	CAPACITOR-FXD 1300PF +-5% 300VDC MICA	28480	0160-2221
A4C14	0160-2229	9	1	CAPACITOR-FXD 3000PF +-5% 300VDC MICA	28480	0160-2229
A4C15	0160-0336	5	2	CAPACITOR-FXD 100PF +-1% 300VDC MICA	28480	0160-0336
A4C16	0160-4679	7	1	CAPACITOR-FXD 270PF +-1% 300VDC MICA	28480	0160-4679
A4C17	0160-4456	8	2	CAPACITOR-FXD 750PF +-1% 300VDC MICA	28480	0160-4456
A4C18	0160-0336	5		CAPACITOR-FXD 100PF +-1% 300VDC MICA	28480	0160-0336
A4C19	0160-3046	0	1	CAPACITOR-FXD 250PF +-1% 100VDC MICA	28480	0160-3046
A4C20	0160-4456	8		CAPACITOR-FXD 750PF +-1% 300VDC MICA	28480	0160-4456
A4C21	0160-3324	7		CAPACITOR-FXD 1UF +-5% 100VDC MET-POLYC	28480	0160-3324
A4C22	0160-2251	7		CAPACITOR-FXD 5.6PF +-.25PF 500VDC CER	28480	0160-2251
A4C23	0160-3324	7		CAPACITOR-FXD 1UF +-5% 100VDC MET-POLYC	28480	0160-3324
A4C24	0160-2241	5	3	CAPACITOR-FXD 2.2PF +-.25PF 500VDC CER	28480	0160-2241
A4C25	0180-2206	4	3	CAPACITOR-FXD 60UF+-10% 6VDC TA	56289	150D606X9006B2
A4C26	0180-0229	7		CAPACITOR-FXD 33UF+-10% 10VDC TA	56289	150D336X9010B2
A4C27	0160-3324	7		CAPACITOR-FXD 1UF +-5% 100VDC MET-POLYC	28480	0160-3324
A4C28	0160-2307	4		CAPACITOR-FXD 47PF +-5% 300VDC MICA	28480	0160-2307
A4C29	0160-2307	4		CAPACITOR-FXD 47PF +-5% 300VDC MICA	28480	0160-2307
A4C30	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A4C31	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A4C32	0160-2251	7		CAPACITOR-FXD 5.6PF +-.25PF 500VDC CER	28480	0160-2251
A4C33	0160-2241	5		CAPACITOR-FXD 2.2PF +-.25PF 500VDC CER	28480	0160-2241
A4C34	0180-2206	4		CAPACITOR-FXD 60UF+-10% 6VDC TA	56289	150D606X9006B2
A4C35	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A4C36	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A4C37	0160-2236	8		CAPACITOR-FXD 1PF +-.25PF 500VDC CER	28480	0160-2236
A4C38	0180-2207	5		CAPACITOR-FXD 100UF+-10% 10VDC TA	56289	150D107X9010R2
A4C39	0160-2307	4		CAPACITOR-FXD 47PF +-5% 300VDC MICA	28480	0160-2307
A4C40	0160-2251	7		CAPACITOR-FXD 5.6PF +-.25PF 500VDC CER	28480	0160-2251
A4C41	0140-0196	3		CAPACITOR-FXD 150PF +-5% 300VDC MICA	72136	DM15F151J0300WV1CR
A4C42	0160-2208	4	1	CAPACITOR-FXD 330PF +-5% 300VDC MICA	28480	0160-2208
A4C43	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A4C44	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A4C45	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A4C46	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A4C47	0160-2307	4		CAPACITOR-FXD 47PF +-5% 300VDC MICA	28480	0160-2307
A4C48	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A4C49	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A4C50	0160-2241	5		CAPACITOR-FXD 2.2PF +-.25PF 500VDC CER	28480	0160-2241
A4C51	0180-1746	5		CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X9020B2
A4C52	0140-0196	3		CAPACITOR-FXD 150PF +-5% 300VDC MICA	72136	DM15F151J0300WV1CR
A4C53	0160-3324	7		CAPACITOR-FXD 1UF +-5% 100VDC MET-POLYC	28480	0160-3324
A4C54	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A4C55	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A4C56	0160-4653	7	6	CAPACITOR-FXD .1UF +-5% 100VDC MET-POLYP	28480	0160-4653
A4C57	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A4C58	0140-0196	3		CAPACITOR-FXD 150PF +-5% 300VDC MICA	72136	DM15F151J0300WV1CR
A4C59	0160-4653	7		CAPACITOR-FXD .1UF +-5% 100VDC MET-POLYP	28480	0160-4653
A4C60	0160-4653	7		CAPACITOR-FXD .1UF +-5% 100VDC MET-POLYP	28480	0160-4653
A4C61	0160-4653	7		CAPACITOR-FXD .1UF +-5% 100VDC MET-POLYP	28480	0160-4653
A4C62	0160-4653	7		CAPACITOR-FXD .1UF +-5% 100VDC MET-POLYP	28480	0160-4653
A4C63	0160-4653	7		CAPACITOR-FXD .1UF +-5% 100VDC MET-POLYP	28480	0160-4653
A4C64	0160-0174	9		CAPACITOR-FXD .47UF +80-20% 25VDC CER	28480	0160-0174
A4C65	0180-0228	6		CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X9015B2
A4C66	0180-0228	6		CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X9015B2
A4C67	0180-0228	6		CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X9015B2
A4C68	0180-2206	4		CAPACITOR-FXD 60UF+-10% 6VDC TA	56289	150D606X9006B2
A4C69	0160-2150	5		CAPACITOR-FXD 33PF +-5% 300VDC MICA	28480	0160-2150
A4C70	0160-4397	6	1	CAPACITOR-FXD .1UF +-1% 100VDC POLYSTY	28480	0160-4397

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A4C71	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A4CR1	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A4CR2	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A4CR3	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A4CR4	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A4CR5	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A4CR6	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A4CR7	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A4CR8	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A4CR9	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A4CR10	1901-0518	8	3	DIODE-SM SIG SCHOTTKY	28480	1901-0518
A4CR11	1901-0518	8		DIODE-SM SIG SCHOTTKY	28480	1901-0518
A4CR12	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A4CR13	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A4CR14	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A4CR15	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A4CR16	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A4CR17	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A4CR18	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A4CR19	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A4CR20	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A4CR21	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A4CR22	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A4CR23	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A4CR24	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A4CR25	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A4CR26	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A4CR27	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A4CR28	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A4JP1	8159-0005	0	3	WIRE 22AWG W PVC 1X22 80C	28480	8159-0005
A4JP2	8159-0005	0		WIRE 22AWG W PVC 1X22 80C	28480	8159-0005
A4JP3	8159-0005	0		WIRE 22AWG W PVC 1X22 80C	28480	8159-0005
A4K1	0490-1013	6	1	RELAY-REED 1C 250MA 28VDC 5VDC-COIL 3VA	28480	0490-1013
A4L1	9140-0210	1	12	INDUCTOR RF-CH-MLD 100UH 5% .166DX.385LG	28480	9140-0210
A4L2	9140-0210	1		INDUCTOR RF-CH-MLD 100UH 5% .166DX.385LG	28480	9140-0210
A4MP1	4040-0748	3		EXTR-PC BD BLK POLYC .062-BD-THKNS	28480	4040-0748
	1480-0073	6		PIN-ROLL .062-IN-DIA .25-IN-LG BE-CU	28480	1480-0073
A4MP2	4040-0752	9	1	EXTR-PC BD YEL POLYC .062-BD-THKNS	28480	4040-0752
	1480-0073	6		PIN-ROLL .062-IN-DIA .25-IN-LG BE-CU	28480	1480-0073
A4MP3	0403-0026	6		GLIDE NYLON FITS 0.192 HOLD 0.156HI	28480	0403-0026
A4MP4	1205-0202	1	1	THERMAL LINK DUAL TO-18-CS	28480	1205-0202
A4MP5	1251-1998	1	5	CONN-SGL CONT SKT 0.025 IN. BSC-SZ	28480	1251-1998
A4Q1	1854-0753	2	2	TRANSISTOR-DUAL NPN TO-71 PD=500MW	28480	1854-0753
A4Q2	1854-0753	2		TRANSISTOR-DUAL NPN TO-71 PD=500MW	28480	1854-0753
A4Q3	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A4Q4	1854-0830	6	1	TRANSISTOR-DUAL NPN PD=500MW	27014	LM394
A4Q5	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A4Q6	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A4Q7	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A4Q8	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A4Q9	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A4Q10	1854-0071	7	1	TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A4Q11	1853-0281	9	9	TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	04713	2N2907A
A4Q12	1853-0281	9		TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	04713	2N2907A
A4R1	0757-0279	0		RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
A4R2	0757-0441	8		RESISTOR 8.25K 1% .125W F TC=0+-100	24546	C4-1/8-T0-8251-F
A4R3	0698-6343	5	6	RESISTOR 9K .1% .125W F TC=0+-25	28480	0698-6343
A4R4	0698-6362	8	6	RESISTOR 1K .1% .125W F TC=0+-25	28480	0698-6362
A4R5	0757-0441	8		RESISTOR 8.25K 1% .125W F TC=0+-100	24546	C4-1/8-T0-8251-F
A4R6	0757-0422	5	4	RESISTOR 909 1% .125W F TC=0+-100	24546	C4-1/8-T0-909R-F
A4R7	0698-8822	9	12	RESISTOR 6.81 1% .125W F TC=0+-100	28480	0698-8822
A4R8	0698-8822	9		RESISTOR 6.81 1% .125W F TC=0+-100	28480	0698-8822
A4R9	0698-8822	9		RESISTOR 6.81 1% .125W F TC=0+-100	28480	0698-8822
A4R10	0698-8822	9		RESISTOR 6.81 1% .125W F TC=0+-100	28480	0698-8822
A4R11	0757-0441	8		RESISTOR 8.25K 1% .125W F TC=0+-100	24546	C4-1/8-T0-8251-F
A4R12	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360
A4R13	0698-6631	4	5	RESISTOR 2.5K .1% .125W F TC=0+-25	28480	0698-6631
A4R14	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A4R15	0757-0274	5	9	RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F
A4R16	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F
A4R17	0757-0443	0	1	RESISTOR 11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1102-F
A4R18	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F
A4R19	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A4R20	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A4R21	1810-0205	7		NETWORK-RES 8-SIP4.7K OHM X 7	01121	208A472
A4R22	0698-0083	8		RESISTOR 1.96K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1961-F
A4R23	0757-0440	7		RESISTOR 7.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7501-F
A4R24	0757-0440	7		RESISTOR 7.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7501-F
A4R25	0698-3151	7	6	RESISTOR 2.87K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2871-F
A4R26	0757-0447	4		RESISTOR 16.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1622-F
A4R27	0698-3151	7		RESISTOR 2.87K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2871-F
A4R28	0757-0439	4		RESISTOR 6.81K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6811-F
A4R29	0698-6631	4		RESISTOR 2.5K .1% .125W F TC=0+-25	28480	0698-6631
A4R30	0698-6631	4		RESISTOR 2.5K .1% .125W F TC=0+-25	28480	0698-6631
A4R31	0757-0199	3		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A4R32	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A4R33	0757-0422	5		RESISTOR 909 1% .125W F TC=0+-100	24546	C4-1/8-T0-909R-F
A4R34	0698-6343	5		RESISTOR 9K .1% .125W F TC=0+-25	28480	0698-6343
A4R35	0698-6362	8		RESISTOR 1K .1% .125W F TC=0+-25	28480	0698-6362
A4R36	0757-0447	4		RESISTOR 16.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1622-F
A4R37	0757-0447	4		RESISTOR 16.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1622-F
A4R38	0698-3151	7		RESISTOR 2.87K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2871-F
A4R39	0757-0447	4		RESISTOR 16.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1622-F
A4R40	0698-3151	7		RESISTOR 2.87K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2871-F
A4R41	0757-0470	3	4	RESISTOR 162K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1623-F
A4R42	0698-3151	7		RESISTOR 2.87K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2871-F
A4R43	0757-0447	4		RESISTOR 16.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1622-F
A4R44	0698-3151	7		RESISTOR 2.87K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2871-F
A4R45	0698-6343	5		RESISTOR 9K .1% .125W F TC=0+-25	28480	0698-6343
A4R46	0698-6362	8		RESISTOR 1K .1% .125W F TC=0+-25	28480	0698-6362
A4R47	0757-0422	5		RESISTOR 909 1% .125W F TC=0+-100	24546	C4-1/8-T0-909R-F
A4R48	0698-6343	5		RESISTOR 9K .1% .125W F TC=0+-25	28480	0698-6343
A4R49	0698-6343	5		RESISTOR 9K .1% .125W F TC=0+-25	28480	0698-6343
A4R50	0698-6362	8		RESISTOR 1K .1% .125W F TC=0+-25	28480	0698-6362
A4R51	0698-6362	8		RESISTOR 1K .1% .125W F TC=0+-25	28480	0698-6362
A4R52	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A4R53	0699-0550	6	1	RESISTOR-FXD 620 5% .25W	28480	0699-0550
A4R54	0698-0085	0	2	RESISTOR 2.61K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2611-F
A4R55	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360
A4R56	0698-3160	8		RESISTOR 31.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3162-F
A4R57	0698-3160	8		RESISTOR 31.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3162-F
A4R58	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A4R59	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A4R60	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A4R61	0698-3152	8		RESISTOR 3.48K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3481-F
A4R62	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360
A4R63	0698-8822	9		RESISTOR 6.81 1% .125W F TC=0+-100	28480	0698-8822
A4R64	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A4R65	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A4R66	0698-3150	6	3	RESISTOR 2.37K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2371-F
A4R67	0698-3153	9	5	RESISTOR 3.83K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3831-F
A4R68	0757-1108	6	1	RESISTOR 300 1% .125W F TC=0+-100	24546	C4-1/8-T0-301-F
A4R69	0757-0279	0		RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
A4R70	0698-6630	3	3	RESISTOR 20K .1% .125W F TC=0+-25	28480	0698-6630
A4R71	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360
A4R72	0757-1094	9		RESISTOR 1.47K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1471-F
A4R73	0698-3136	8	3	RESISTOR 17.8K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1782-F
A4R74	0757-1094	9		RESISTOR 1.47K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1471-F
A4R75	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A4R76	0698-8822	9		RESISTOR 6.81 1% .125W F TC=0+-100	28480	0698-8822
A4R77	0698-8822	9		RESISTOR 6.81 1% .125W F TC=0+-100	28480	0698-8822
A4R78	0698-0084	9		RESISTOR 2.15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2151-F
A4R79	0757-0440	7		RESISTOR 7.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7501-F
A4R80	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A4R81	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A4R82	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A4R83	0698-3157	3		RESISTOR 19.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1962-F
A4R84	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A4R85	2100-3054	6	1	RESISTOR-TRMR 50K 10% C SIDE-ADJ 17-TRN	02111	43P503
A4R86†	0698-3223	4	1	RESISTOR 1.24K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1241-F
A4R87	0698-8827	4		RESISTOR 1M 1% .125W F TC=0+-100	28480	0698-8827
A4R88	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A4R89	0698-3157	3		RESISTOR 19.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1962-F
A4R90	0699-0150	2	1	RESISTOR 16.2K .1% .1W F TC=0+-15	28480	0699-0150
A4R91	2100-3109	2	1	RESISTOR-TRMR 2K 10% C SIDE-ADJ 17-TRN	02111	43P202
A4R92	0698-6320	8	4	RESISTOR 5K .1% .125W F TC=0+-25	03888	PME55-1/8-T9-5001-B
A4R93	0699-0122	8	1	RESISTOR 4.8K .1% .125W F TC=0+-25	28480	0699-0122
A4R94	0698-3266	5	2	RESISTOR 237K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2373-F
A4R95	0698-6630	3		RESISTOR 20K .1% .125W F TC=0+-25	28480	0698-6630

See introduction to this section for ordering information
*Indicates factory selected value
†For backdating information see Section VII.

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A4R96	0698-3266	5		RESISTOR 237K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2373-F
A4R97	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A4R98	0698-6630	3		RESISTOR 20K .1% .125W F TC=0+-25	28480	0698-6630
A4R99	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A4R100	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A4R101	0698-3160	8		RESISTOR 31.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3162-F
A4R102	0757-0279	0		RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
A4R103	0757-0279	0		RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
A4R104	0757-0470	3		RESISTOR 162K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1623-F
A4R105	0757-0200	7		RESISTOR 5.62K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5621-F
A4R106	0757-0279	0		RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
A4R107	0757-0464	5	1	RESISTOR 90.9K 1% .125W F TC=0+-100	24546	C4-1/8-T0-9092-F
A4R108	0698-3456	5	1	RESISTOR 287K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2873-F
A4R109	0698-3453	2		RESISTOR 196K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1963-F
A4R110	0698-6631	4		RESISTOR 2.5K .1% .125W F TC=0+-25	28480	0698-6631
A4R111	0698-6631	4		RESISTOR 2.5K .1% .125W F TC=0+-25	28480	0698-6631
A4R112	0757-0279	0		RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
A4R113	0757-0470	3		RESISTOR 162K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1623-F
A4R114	0757-0279	0		RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
A4R115	0757-0279	0		RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
A4R116	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A4R117	0757-0279	0		RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
A4R118	0757-0290	5		RESISTOR 6.19K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-6191-F
A4R119	0757-0421	4	1	RESISTOR 825 1% .125W F TC=0+-100	24546	C4-1/8-T0-825R-F
A4R120	0698-3443	0	1	RESISTOR 287 1% .125W F TC=0+-100	24546	C4-1/8-T0-287R-F
A4R121	0757-0290	5		RESISTOR 6.19K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-6191-F
A4R122	0757-0422	5		RESISTOR 909 1% .125W F TC=0+-100	24546	C4-1/8-T0-909R-F
A4R123	0698-3441	8	1	RESISTOR 215 1% .125W F TC=0+-100	24546	C4-1/8-T0-215R-F
A4R124	0698-0082	7		RESISTOR 464 1% .125W F TC=0+-100	24546	C4-1/8-T0-4640-F
A4R125	2100-3103	6	1	RESISTOR-TRMR 10K 10% C SIDE-ADJ 17-TRN	02111	43P103
A4R126	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A4R127	0699-0239	8	1	RESISTOR 59K .1% .1W F TC=0+-15	28480	0699-0239
A4R128	0698-3150	6		RESISTOR 2.37K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2371-F
A4R129	0698-0085	0		RESISTOR 2.61K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2611-F
A4R130	0698-3153	9		RESISTOR 3.83K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3831-F
A4R131	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A4R132	0757-0405	4	2	RESISTOR 162 1% .125W F TC=0+-100	24546	C4-1/8-T0-162R-F
A4R133	0757-0200	7		RESISTOR 5.62K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5621-F
A4R134	0698-8822	9		RESISTOR 6.81 1% .125W F TC=0+-100	28480	0698-8822
A4R135	0757-0405	4		RESISTOR 162 1% .125W F TC=0+-100	24546	C4-1/8-T0-162R-F
A4R136	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A4R137	0757-0279	0		RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
A4R138	0757-0279	0		RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
A4R139	0757-1094	9		RESISTOR 1.47K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1471-F
A4R140	0698-3153	9		RESISTOR 3.83K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3831-F
A4R141	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A4R142	2100-3350	5	1	RESISTOR-TRMR 200 10% C SIDE-ADJ 1-TRN	28480	2100-3350
A4RT1	0837-0180	2	1	THERMISTOR 1K-OHM	01295	TSP102J
A4TP1	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A4TP2	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A4TP3	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A4TP4	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A4TP5	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A4TP6	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A4TP7	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A4TP8	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A4TP9	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A4TP10	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A4U1	1826-0574	6	3	IC OP AMP LOW-DRIFT TO-99 PKG	07263	UA714LHC
A4U2	1826-0574	6		IC OP AMP LOW-DRIFT TO-99 PKG	07263	UA714LHC
A4U3	1826-0059	2		IC OP AMP GP TO-99 PKG	01295	LM201AL
A4U4	1826-0447	2	3	IC OP AMP WB TO-99 PKG	27014	LF257H
A4U5	1826-0059	2		IC OP AMP GP TO-99 PKG	01295	LM201AL
A4U6	1826-0109	3		IC OP AMP WB TO-99 PKG	34371	HA2-2625-B0593
A4U7	1826-0582	6		IC SWITCH ANLG QUAD 16-DIP-C PKG	27014	LF13201D
A4U8	1826-0109	3		IC OP AMP WB TO-99 PKG	34371	HA2-2625-B0593
A4U9	1826-0582	6		IC SWITCH ANLG QUAD 16-DIP-C PKG	27014	LF13201D
A4U10	1826-0600	9	2	IC OP AMP QUAD 14-DIP-P PKG	01295	TL074ACN
A4U11	1820-1197	9	5	IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N
A4U12	1826-0574	6		IC OP AMP LOW-DRIFT TO-99 PKG	07263	UA714LHC
A4U13	1826-0109	3		IC OP AMP WB TO-99 PKG	34371	HA2-2625-B0593
A4U14	1826-0547	3	4	IC OP AMP DUAL 8-DIP-P PKG	01295	TL072ACP
A4U15	1826-0059	2		IC OP AMP GP TO-99 PKG	01295	LM201AL

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A4U16	1826-0447	2		IC OP AMP WB TO-99 PKG	27014	LF257H
A4U17	1826-0600	9		IC OP AMP QUAD 14-DIP-P PKG	01295	TL074ACN
A4U18	1826-0609	8	1	IC MULTIPLXR ANLG 16-DIP-C PKG	06665	MUX08FQ
A4U19	1826-0138	8		IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N
A4U20	1826-0447	2		IC OP AMP WB TO-99 PKG	27014	LF257H
A4U21	1826-0582	6		IC SWITCH ANLG QUAD 16-DIP-C PKG	27014	LF13201D
A4VR1	1902-0943	5	3	DIODE-ZNR 2.4V 5% DO-35 PD=.4W TC=-.037%	28480	1902-0943
A4VR2	1902-0064	1	1	DIODE-ZNR 7.5V 5% DO-35 PD=.4W TC=+.05%	28480	1902-0064
A4VR3	1902-3024	9	1	DIODE-ZNR 2.87V 5% DO-7 PD=.4W TC=-.07%	28480	1902-3024
A4VR4	1902-0680	7	2	DIODE-ZNR 1N827 6.2V 5% DO-7 PD=.4W	24046	1N827
A4VR5	1902-0953	7	1	DIODE-ZNR 6.2V 5% DO-35 PD=.4W TC=+.053%	28480	1902-0953
A5	08903-60006	6	1	OSCILLATOR	28480	08903-60006
A5C1	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A5C2	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A5C3	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A5C4	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A5C5	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A5C6	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A5C7	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A5C8	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A5C9	0160-4590	1		CAPACITOR-FXD .18UF +-1% 200VDC	28480	0160-4590
A5C10	0160-5032	8		CAPACITOR-FXD .0223UF 1% 200VDCW	28480	0160-5032
A5C11	0160-3293	9		CAPACITOR-FXD 2470PF +-1% 100VDC MICA	28480	0160-3293
A5C12	0180-2620	6	2	CAPACITOR-FXD 2.2UF+-10% 50VDC TA	25088	D2R2GS1B50K
A5C13	0180-2620	6		CAPACITOR-FXD 2.2UF+-10% 50VDC TA	25088	D2R2GS1B50K
A5C14	0160-3934	5	2	CAPACITOR-FXD 350PF +-1% 100VDC MICA	28480	0160-3934
A5C15	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A5C16	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A5C17	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A5C18	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A5C19	0160-3934	5		CAPACITOR-FXD 350PF +-1% 100VDC MICA	28480	0160-3934
A5C20	0160-4590	1		CAPACITOR-FXD .18UF +-1% 200VDC	28480	0160-4590
A5C21	0160-5032	8		CAPACITOR-FXD .0223UF 1% 200VDCW	28480	0160-5032
A5C22	0160-3293	9		CAPACITOR-FXD 2470PF +-1% 100VDC MICA	28480	0160-3293
A5C23	0160-3874	2	1	CAPACITOR-FXD 10PF +-.5PF 200VDC CER	28480	0160-3874
A5C24	0160-0194	3	1	CAPACITOR-FXD .015UF +-10% 200VDC POLYE	28480	0160-0194
A5C25	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A5C26	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A5C27	0160-4494	4	1	CAPACITOR-FXD 39PF +-5% 200VDC CER 0+-30	51642	200-200-NP0-390J
A5C28	0180-0197	8	21	CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A5C29	0180-2141	6	4	CAPACITOR-FXD 3.3UF+-10% 50VDC TA	56289	150D335X9050B2
A5C30	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A5C31	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A5C32	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A5C33	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A5C34	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A5C35	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A5C36	0160-2225	5	1	CAPACITOR-FXD 2000PF +-5% 300VDC MICA	28480	0160-2225
A5C37	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A5C38	0160-3454	4	1	CAPACITOR-FXD 220PF +-10% 1KVDC CER	28480	0160-3454
A5C39	0160-4251	1	1	CAPACITOR-FXD 3300PF +.0000000033-3%	84411	863UW
A5C40	0160-3466	8	1	CAPACITOR-FXD 100PF +-10% 1KVDC CER	28480	0160-3466
A5C41	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A5C42	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A5C43	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A5C44	0160-4521	8	2	CAPACITOR-FXD 12PF +-5% 200VDC CER 0+-30	51642	200-200-NP0-120J
A5C45	0160-4402	4	1	CAPACITOR-FXD .1UF +-10% 100VDC POLYP	28480	0160-4402
A5C46	0160-2255	1	1	CAPACITOR-FXD 8.2PF +-.25PF 500VDC CER	28480	0160-2255
A5C47	0160-4084	8		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-4084
A5C48	0160-3456	6	3	CAPACITOR-FXD 1000PF +-10% 1KVDC CER	28480	0160-3456
A5C49	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A5C50	0160-5031	7	1	CAPACITOR-FXD .047UF 2% 100VDCW	28480	0160-5031
A5C51	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A5C52	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A5C53	0160-4521	8		CAPACITOR-FXD 12PF +-5% 200VDC CER 0+-30	51642	200-200-NP0-120J
A5C54	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A5C55	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A5C56	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A5C57	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A5C58	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A5CR1	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A5CR2	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A5CR3	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A5CR4	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A5CR5	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A5CR6	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A5CR7	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A5CR8	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A5CR9	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A5CR10	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A5CR11	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A5CR12	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A5CR13	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A5CR14	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A5CR15	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A5CR16†	1901-0050	3	36	DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A5MP1	4040-0748	3		EXTR-PC BD BLK POLYC .062-BD-THKNS	28480	4040-0748
	1480-0073	6		PIN-ROLL .062-IN-DIA .25-IN-LG BE-CU	28480	1480-0073
A5MP2	4040-0753	0	1	EXTR-PC BD GRN POLYC .062-BD-THKNS	28480	4040-0753
	1480-0073	6		PIN-ROLL .062-IN-DIA .25-IN-LG BE-CU	28480	1480-0073
A5MP3	0403-0026	6		GLIDE NYLON FITS 0.192 HOLD 0.156HI	28480	0403-0026
A5Q1	1853-0281	9		TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	04713	2N2907A
A5Q2	1854-0477	7		TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	04713	2N2222A
A5Q3	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A5Q4	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A5Q5	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A5Q6	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A5Q7	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A5Q8	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A5Q9	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A5Q10	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A5Q11	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A5Q12	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A5Q13	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A5Q14	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A5Q15	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A5Q16	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A5Q17	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A5Q18	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A5Q19	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A5Q20	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A5Q21	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A5Q22	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A5Q23	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A5Q24	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A5Q25	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A5Q26	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A5Q27	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A5Q28	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A5Q29	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A5Q30	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A5Q31	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A5Q32	1854-0477	7		TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	04713	2N2222A
A5Q33	1853-0281	9		TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	04713	2N2907A
A5Q34	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A5R1	0698-3430	5	31	RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A5R2	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A5R3	1810-0206	8	5	NETWORK-RES 8-SIP10.0K OHM X 7	01121	208A103
A5R4	1810-0206	8		NETWORK-RES 8-SIP10.0K OHM X 7	01121	208A103
A5R5	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A5R6	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A5R7	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A5R8	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A5R9	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A5R10	0698-8204	1		RESISTOR 7.98K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-7981-B
A5R11	0698-8205	2		RESISTOR 15.98K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-15981-B
A5R12	0698-8047	0		RESISTOR 32K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-3202-B
A5R13	0698-8049	2		RESISTOR 64K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-6402-B
A5R14	0698-8053	8		RESISTOR 128K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-1283-B
A5R15	0698-8050	5		RESISTOR 256K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-2563-B
A5R16	0698-8958	2		RESISTOR 511K 1% .125W F TC=0+-100	28480	0698-8958
A5R17	0698-8827	4		RESISTOR 1M 1% .125W F TC=0+-100	28480	0698-8827
A5R18	0757-0417	8	2	RESISTOR 562 1% .125W F TC=0+-100	24546	C4-1/8-T0-562R-F
A5R19	0757-0447	4		RESISTOR 16.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1622-F
A5R20	1810-0206	8		NETWORK-RES 8-SIP10.0K OHM X 7	01121	208A103

See introduction to this section for ordering information
*Indicates factory selected value
†For backdating information see Section VII.

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A5R21	0757-0290	5		RESISTOR 6.19K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-6191-F
A5R22	0757-0394	0		RESISTOR 51.1 1% .125W F TC=0+-100	24546	C4-1/8-T0-51R1-F
A5R23	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A5R24	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A5R25	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A5R26	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A5R27	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A5R28	0698-8204	1		RESISTOR 7.98K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-7981-B
A5R29	0698-8205	2		RESISTOR 15.98K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-15981-B
A5R30	0698-8047	0		RESISTOR 32K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-3202-B
A5R31	0698-8049	2		RESISTOR 64K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-6402-B
A5R32	0698-8053	8		RESISTOR 128K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-1283-B
A5R33	0698-8050	5		RESISTOR 256K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-2563-B
A5R34	0698-8958	2		RESISTOR 511K 1% .125W F TC=0+-100	28480	0698-8958
A5R35	0698-8827	4		RESISTOR 1M 1% .125W F TC=0+-100	28480	0698-8827
A5R36	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A5R37	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A5R38	0757-0394	0		RESISTOR 51.1 1% .125W F TC=0+-100	24546	C4-1/8-T0-51R1-F
A5R39	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A5R40	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A5R41	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A5R42	0698-8049	2		RESISTOR 64K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-6402-B
A5R43	0698-8047	0		RESISTOR 32K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-3202-B
A5R44	0698-8205	2		RESISTOR 15.98K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-15981-B
A5R45	0698-8204	1		RESISTOR 7.98K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-7981-B
A5R46	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A5R47	0698-3450	9	2	RESISTOR 42.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4222-F
A5R48	0698-3157	3		RESISTOR 19.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1962-F
A5R49	0698-3157	3		RESISTOR 19.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1962-F
A5R50	0698-8827	4		RESISTOR 1M 1% .125W F TC=0+-100	28480	0698-8827
A5R51	0698-8958	2		RESISTOR 511K 1% .125W F TC=0+-100	28480	0698-8958
A5R52	0698-8050	5		RESISTOR 256K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-2563-B
A5R53	0698-8053	8		RESISTOR 128K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-1283-B
A5R54	0757-0279	0		RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
A5R55	0757-1094	9		RESISTOR 1.47K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1471-F
A5R56	0698-0083	8		RESISTOR 1.96K 1% .125W F TC=0+-100	24546	C4-1/8-TO-1961-F
A5R57	0757-0288	1		RESISTOR 9.09K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-9091-F
A5R58	0698-3160	8		RESISTOR 31.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3162-F
A5R59	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A5R60	0698-3136	8		RESISTOR 17.8K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1782-F
A5R61	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A5R62	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A5R63	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A5R64	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A5R65	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A5R66	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A5R67	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A5R68				NOT ASSIGNED		
A5R69	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A5R70	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A5R71				NOT ASSIGNED		
A5R72	0698-3435	0	7	RESISTOR 38.3 1% .125W F TC=0+-100	24546	C4-1/8-T0-38R3-F
A5R73	0698-3435	0		RESISTOR 38.3 1% .125W F TC=0+-100	24546	C4-1/8-T0-38R3-F
A5R74	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A5R75				NOT ASSIGNED		
A5R76	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A5R77	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A5R78	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A5R79	0757-0417	8		RESISTOR 562 1% .125W F TC=0+-100	24546	C4-1/8-T0-562R-F
A5R80	0698-3450	9		RESISTOR 42.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4222-F
A5R81	0757-0470	3		RESISTOR 162K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1623-F
A5R82	0757-0288	1		RESISTOR 9.09K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-9091-F
A5R83	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A5R84	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A5R85	0757-0290	5		RESISTOR 6.19K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-6191-F
A5R86	0698-3161	9	2	RESISTOR 38.3K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3832-F
A5R87	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A5R88	0757-0317	7	2	RESISTOR 1.33K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1331-F
A5R89	0698-3435	0		RESISTOR 38.3 1% .125W F TC=0+-100	24546	C4-1/8-T0-38R3-F
A5R90	0698-3435	0		RESISTOR 38.3 1% .125W F TC=0+-100	24546	C4-1/8-T0-38R3-F
A5R91	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A5R92	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A5R93	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A5R94	0698-3435	0		RESISTOR 38.3 1% .125W F TC=0+-100	24546	C4-1/8-T0-38R3-F
A5R95	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A5R96	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A5R97	0699-0400	5	1	RESISTOR 3.6K .1% .125W F TC=0+-25	28480	0699-0400
A5R98	0698-8204	1		RESISTOR 7.98K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-7981-B
A5R99	0698-0083	8		RESISTOR 1.96K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1961-F
A5R100	0698-3445	2		RESISTOR 348 1% .125W F TC=0+-100	24546	C4-1/8-T0-348R-F
A5R101	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A5R102	2100-3056	8	1	RESISTOR-TRMR 5K 10% C SIDE-ADJ 17-TRN	02111	43P502
A5R103	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A5R104	0698-6320	8		RESISTOR 5K .1% .125W F TC=0+-25	03888	PME55-1/8-T9-5001-B
A5R105	0698-6320	8		RESISTOR 5K .1% .125W F TC=0+-25	03888	PME55-1/8-T9-5001-B
A5R106	0757-0317	7		RESISTOR 1.33K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1331-F
A5R107	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A5R108	0698-3161	9		RESISTOR 38.3K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3832-F
A5R109	0757-0428	1	1	RESISTOR 1.62K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1621-F
A5R110	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A5R111	0757-0279	0		RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
A5R112	0698-3435	0		RESISTOR 38.3 1% .125W F TC=0+-100	24546	C4-1/8-T0-38R3-F
A5R113	0698-3435	0		RESISTOR 38.3 1% .125W F TC=0+-100	24546	C4-1/8-T0-38R3-F
A5R114	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A5R115	0698-3150	6		RESISTOR 2.37K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2371-F
A5R116	0757-0459	8	1	RESISTOR 56.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5622-F
A5R117	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A5R118	0698-7262	9	1	RESISTOR 12.1K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1212-G
A5R119	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A5R120	0757-0440	7		RESISTOR 7.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7501-F
A5R121	0698-7241	4	1	RESISTOR 1.62K 1% .05W F TC=0+-100	28480	0698-7241
A5R122	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A5R123	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A5R124	0698-0084	9		RESISTOR 2.15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2151-F
A5R125	0698-0084	9		RESISTOR 2.15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2151-F
A5R126	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A5R127	0698-3153	9		RESISTOR 3.83K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3831-F
A5R128	0698-3153	9		RESISTOR 3.83K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3831-F
A5R129	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A5R130	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A5R131	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A5R132	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A5TP1	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A5TP2	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A5TP3	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A5TP4	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A5TP5	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A5TP6	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A5TP7	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A5TP8	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A5TP9	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A5TP10	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A5TP11	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A5U1	1820-1144	6		IC GATE TTL LS NOR QUAD 2-INP	01295	SN74LS02N
A5U2	1826-0026	3	1	IC COMPARATOR PRCN TO-99 PKG	01295	LM311L
A5U3				NOT ASSIGNED		
A5U4	1826-0662	3		IC OP AMP LOW-BIAS-H-IMPD TO-99 PKG	28480	1826-0662
A5U5	1826-0569	9		IC OP AMP LOW-NOISE TO-99 PKG	18324	NE5534AT
A5U6	1826-0014	9		IC MULTIPLIER 14-DIP-C PKG	04713	MC1595L
A5U7	1820-1423	4	1	IC MV TTL LS MONOSTBL RETRIG DUAL	01295	SN74LS123N
A5U8	1826-0138	8		IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N
A5U9	1826-0371	1	3	IC OP AMP LOW-BIAS-H-IMPD TO-99 PKG	27014	LF256H
A5U10	1826-0547	3		IC OP AMP DUAL 8-DIP-P PKG	01295	TL072ACP
A5U11	1826-0662	3		IC OP AMP LOW-BIAS-H-IMPD TO-99 PKG	28480	1826-0662
A5U12	1826-0547	3		IC OP AMP DUAL 8-DIP-P PKG	01295	TL072ACP
A5U13	1826-0371	1		IC OP AMP LOW-BIAS-H-IMPD TO-99 PKG	27014	LF256H
A5U14	1813-0041	5	2	IC OP AMP TO-99 PKG	27014	LH0042CH
A5U15	1813-0041	5		IC OP AMP TO-99 PKG	27014	LH0042CH
A5U16	1826-0138	8		IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N
A5U17	1826-0138	8		IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N
A5U18	1826-0138	8		IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N
A5U19	1826-0582	6		IC SWITCH ANLG QUAD 16-DIP-C PKG	27014	LF13201D
A5U20	1826-0138	8		IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N
A5VR1	1902-0951	5	2	DIODE-ZNR 5.1V 5% DO-35 PD=.4W TC=+.035%	28480	1902-0951
A5VR2	1902-0951	5		DIODE-ZNR 5.1V 5% DO-35 PD=.4W TC=+.035%	28480	1902-0951
A5VR3	1902-0943	5		DIODE-ZNR 2.4V 5% DO-35 PD=.4W TC=-.037%	28480	1902-0943
A5VR4	1902-0954	8	1	DIODE-ZNR 6.8V 5% DO-35 PD=.4W TC=+.057%	28480	1902-0954
A5VR5	1902-0680	7		DIODE-ZNR 1N827 6.2V 5% DO-7 PD=.4W	24046	1N827

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A5VR6	1902-0955	9	1	DIODE-ZNR 7.5V 5% DO-35 PD=.4W TC=+.062%	28480	1902-0955
A6	08903-60008	8	1	OUTPUT ATTENUATOR	28480	08903-60008
A6C1	0180-1746	5		CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X9020B2
A6C2	0180-2141	6		CAPACITOR-FXD 3.3UF+-10% 50VDC TA	56289	150D335X9050B2
A6C3	0180-1746	5		CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X9020B2
A6C4	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A6C5	0180-2141	6		CAPACITOR-FXD 3.3UF+-10% 50VDC TA	56289	150D335X9050B2
A6C6	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A6C7	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A6C8	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A6C9	0180-2141	6		CAPACITOR-FXD 3.3UF+-10% 50VDC TA	56289	150D335X9050B2
A6C10- A6C12				NOT ASSIGNED		
A6C13	0160-2265	3		CAPACITOR-FXD 22PF +-5% 500VDC CER 0+-30	28480	0160-2265
A6C14	0160-2261	9	1	CAPACITOR-FXD 15PF +-5% 500VDC CER 0+-30	28480	0160-2261
A6C15	0140-0191	8	1	CAPACITOR-FXD 56PF +-5% 300VDC MICA	72136	DM15E560J0300WV1CR
A6C16	0160-2257	3		CAPACITOR-FXD 10PF +-5% 500VDC CER 0+-60	28480	0160-2257
A6C17	0180-2207	5		CAPACITOR-FXD 100UF+-10% 10VDC TA	56289	150D107X9010R2
A6C18	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A6C19	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A6C20	0180-1746	5		CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X9020B2
A6C21	0180-1746	5		CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X9020B2
A6C22	0160-4764	1	1	CAPACITOR-FXD 150PF +-5% 100VDC CER	28480	0160-4764
A6C23	0160-2251	7		CAPACITOR-FXD 5.6PF +-.25PF 500VDC CER	28480	0160-2251
A6C24	0160-2307	4		CAPACITOR-FXD 47PF +-5% 300VDC MICA	28480	0160-2307
A6C25	0160-2257	3		CAPACITOR-FXD 10PF +-5% 500VDC CER 0+-60	28480	0160-2257
A6C26	0160-2257	3		CAPACITOR-FXD 10PF +-5% 500VDC CER 0+-60	28480	0160-2257
A6C27	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A6C28	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A6C29	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A6C30	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A6C31	0121-0493	3	1	CAPACITOR-V TRMR-AIR 1.7-11PF 175V	74970	187-0306-125
A6C32	0140-0210	2	2	CAPACITOR-FXD 270PF +-5% 300VDC MICA	72136	DM15F271J0300WV1CR
A6C33*	0160-2251	7	5	CAPACITOR-FXD 5.6PF +-.25PF 500VDC CER	28480	0160-2251
A6CR1	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A6CR2	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A6CR3	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A6CR4	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A6CR5	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A6CR6	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A6CR7	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A6CR8	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A6CR9	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A6CR10	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A6CR11	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A6F1	2110-0513	7	2	FUSE .125A 125V NTD .348X.25	75915	273.125
A6F2	2110-0513	7		FUSE .125A 125V NTD .348X.25	75915	273.125
A6K1	0490-0916	6		RELAY-REED 1A 500MA 100VDC 5VDC-COIL	28480	0490-0916
A6K2	0490-0916	6		RELAY-REED 1A 500MA 100VDC 5VDC-COIL	28480	0490-0916
A6K3	0490-1190	0	2	RELAY 2C 5VDC-COIL .5A 125VAC	28480	0490-1190
A6K4	0490-1190	0		RELAY 2C 5VDC-COIL .5A 125VAC	28480	0490-1190
A6L1	9140-0210	1		INDUCTOR RF-CH-MLD 100UH 5% .166DX.385LG	28480	9140-0210
A6L2	9140-0210	1		INDUCTOR RF-CH-MLD 100UH 5% .166DX.385LG	28480	9140-0210
A6L3	9140-0210	1		INDUCTOR RF-CH-MLD 100UH 5% .166DX.385LG	28480	9140-0210
A6L4	9140-0210	1		INDUCTOR RF-CH-MLD 100UH 5% .166DX.385LG	28480	9140-0210
A6L5	9140-0210	1		INDUCTOR RF-CH-MLD 100UH 5% .166DX.385LG	28480	9140-0210
A6L6	9140-0210	1		INDUCTOR RF-CH-MLD 100UH 5% .166DX.385LG	28480	9140-0210
A6MP1	4040-0748	3		EXTR-PC BD BLK POLYC .062-BD-THKNS	28480	4040-0748
	1480-0073	6		PIN-ROLL .062-IN-DIA .25-IN-LG BE-CU	28480	1480-0073
A6MP2	4040-0754	1	1	EXTR-PC BD BLU POLYC .062-BD-THKNS	28480	4040-0754
	1480-0073	6		PIN-ROLL .062-IN-DIA .25-IN-LG BE-CU	28480	1480-0073
A6MP3	1251-1998	1		CONNECTOR-SGL CONT SKT .025-IN-BSC-SZ	28480	1251-1998
A6Q1	1854-0477	7		TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	04713	2N2222A
A6Q2	1853-0281	9		TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	04713	2N2907A
A6Q3	1853-0281	9		TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	04713	2N2907A
A6Q4	1854-0477	7		TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	04713	2N2222A
A6Q5	1853-0316	1	1	TRANSISTOR-DUAL PNP PD=500MW	28480	1853-0316

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A6Q6	1853-0281	9		TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	04713	2N2907A
A6Q7	1854-0477	7		TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	04713	2N2222A
A6Q8	1854-0477	7		TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	04713	2N2222A
A6Q9	1855-0232	4	1	TRANSISTOR-JFET DUAL 2N5565 N-CHAN	17856	2N5565
A6Q10	1855-0050	4	1	TRANSISTOR-JFET DUAL N-CHAN D-MODE SI	28480	1855-0050
A6Q11	1853-0281	9		TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	04713	2N2907A
A6Q12	1854-0477	7		TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	04713	2N2222A
A6Q13	1854-0477	7		TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	04713	2N2222A
A6Q14	1853-0281	9		TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	04713	2N2907A
A6Q15	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A6Q16	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A6Q17	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A6Q18	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A6Q19	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A6Q20	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A6Q21	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A6Q22	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A6Q23	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A6Q24	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A6Q25	1855-0091	3		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A6R1	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A6R2	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A6R3	0698-8822	9		RESISTOR 6.81 1% .125W F TC=0+-100	28480	0698-8822
A6R4	0698-8822	9		RESISTOR 6.81 1% .125W F TC=0+-100	28480	0698-8822
A6R5	0698-8204	1		RESISTOR 7.98K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-7981-B
A6R6	1810-0280	8	1	NETWORK-RES 10-SIP10.0K OHM X 9	01121	210A103
A6R7	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-TO-1211-F
A6R8	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A6R9	0698-8205	2		RESISTOR 15.98K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-15981-B
A6R10	0698-8047	0		RESISTOR 32K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-3202-B
A6R11	0698-8049	2		RESISTOR 64K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-6402-B
A6R12	0698-8053	8		RESISTOR 128K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-1283-B
A6R13				NOT ASSIGNED		
A6R14	0757-0199	3		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A6R15	0698-8050	5		RESISTOR 256K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-2563-B
A6R16	0757-0199	3		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A6R17	0757-0440	7		RESISTOR 7.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7501-F
A6R18	0698-8053	8		RESISTOR 128K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-1283-B
A6R20	0698-8050	5		RESISTOR 256K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-2563-B
A6R21	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A6R22	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A6R23	0698-8958	2		RESISTOR 511K 1% .125W F TC=0+-100	28480	0698-8958
A6R24				NOT ASSIGNED		
A6R25	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A6R26	0698-3179	9	1	RESISTOR 2.55K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2551
A6R27	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A6R28	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A6R29	0698-3157	3		RESISTOR 19.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1962-F
A6R30	0698-3157	3		RESISTOR 19.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1962-F
A6R31	0698-3439	4	1	RESISTOR 178 1% .125W F TC=0+-100	24546	C4-1/8-T0-178R-F
A6R32	0698-6320	8		RESISTOR 5K .1% .125W F TC=0+-25	03888	PME55-1/8-T9-5001-B
A6R33	0757-0462	3	1	RESISTOR 75K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7502-F
A6R34	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A6R35	2100-3161	6	2	RESISTOR-TRMR 20K 10% C SIDE-ADJ 17-TRN	02111	43P203
A6R36	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A6R37	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A6R38	0757-0418	9	1	RESISTOR 619 1% .125W F TC=0+-100	24546	C4-1/8-T0-619R-F
A6R39	0698-6317	3	3	RESISTOR 500 .1% .125W F TC=0+-25	03888	PME55-1/8-T9-500R-B
A6R40	0698-6317	3		RESISTOR 500 .1% .125W F TC=0+-25	03888	PME55-1/8-T9-500R-B
A6R41	0698-6317	3		RESISTOR 500 .1% .125W F TC=0+-25	03888	PME55-1/8-T9-500R-B
A6R42	0698-6347	9	5	RESISTOR 1.5K .1% .125W F TC=0+-25	28480	0698-6347
A6R43	0698-6625	6	2	RESISTOR 6K .1% .125W F TC=0+-25	28480	0698-6625
A6R44	0698-6625	6		RESISTOR 6K .1% .125W F TC=0+-25	28480	0698-6625
A6R45	0698-6347	9		RESISTOR 1.5K .1% .125W F TC=0+-25	28480	0698-6347
A6R46	0698-6347	9		RESISTOR 1.5K .1% .125W F TC=0+-25	28480	0698-6347
A6R47	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A6R48	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-TO-1211-F
A6R49	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F
A6R50	0698-8822	9		RESISTOR 6.81 1% .125W F TC=0+-100	28480	0698-8822
A6R51	0698-8822	9		RESISTOR 6.81 1% .125W F TC=0+-100	28480	0698-8822
A6R52	0698-6444	7	1	RESISTOR 21.62K .1% .125W F TC=0+-25	28480	0698-6444
A6R53	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360
A6R54	0698-6362	8		RESISTOR 1K .1% .125W F TC=0+-25	28480	0698-6362
A6R55	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-TO-1211-F
A6R56	0698-3154	0	5	RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A6R57	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F
A6R58	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F
A6R59	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A6R60	0757-0440	7		RESISTOR 7.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7501-F
A6R61	0757-0346	2	1	RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F
A6R62	2100-3161	6		RESISTOR-TRMR 20K 10% C SIDE-ADJ 17-TRN	02111	43P203
A6R63	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F
A6R64	0757-0419	0	4	RESISTOR 681 1% .125W F TC=0+-100	24546	C4-1/8-T0-681R-F
A6R65	0698-6343	5		RESISTOR 9K .1% .125W F TC=0+-25	28480	0698-6343
A6R66	0698-3446	3	1	RESISTOR 383 1% .125W F TC=0+-100	24546	C4-1/8-T0-383R-F
A6R67	0757-0419	0		RESISTOR 681 1% .125W F TC=0+-100	24546	C4-1/8-T0-681R-F
A6R68	0757-0382	6	2	RESISTOR 16.2 1% .125W F TC=0+-100	19701	MF4C1/8-T0-16R2-F
A6R69	0757-0382	6		RESISTOR 16.2 1% .125W F TC=0+-100	19701	MF4C1/8-T0-16R2-F
A6R70	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A6R71	0698-6624	5	4	RESISTOR 2K .1% .125W F TC=0+-25	28480	0698-6624
A6R72	0698-6624	5		RESISTOR 2K .1% .125W F TC=0+-25	28480	0698-6624
A6R73	0698-6624	5		RESISTOR 2K .1% .125W F TC=0+-25	28480	0698-6624
A6R74	0698-6624	5		RESISTOR 2K .1% .125W F TC=0+-25	28480	0698-6624
A6R75	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A6R76	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A6R77	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A6R78	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A6R79	0698-6347	9		RESISTOR 1.5K .1% .125W F TC=0+-25	28480	0698-6347
A6R80	0699-0241	2	4	RESISTOR 2.4K .1% .125W F TC=0+-25	28480	0699-0241
A6R81	0699-0241	2		RESISTOR 2.4K .1% .125W F TC=0+-25	28480	0699-0241
A6R82	0699-0241	2		RESISTOR 2.4K .1% .125W F TC=0+-25	28480	0699-0241
A6R83	0699-0241	2		RESISTOR 2.4K .1% .125W F TC=0+-25	28480	0699-0241
A6R84	0698-6347	9		RESISTOR 1.5K .1% .125W F TC=0+-25	28480	0698-6347
A6R85	0698-3154	0		RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F
A6R86	0698-3154	0		RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F
A6R87	0698-3154	0		RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F
A6R88	0698-3154	0		RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F
A6R89	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A6R90	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A6R91	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A6R92	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A6R93	0698-6295	6	2	RESISTOR 300 .1% .125W F TC=0+-50	28480	0698-6295
A6R94	0698-6295	6		RESISTOR 300 .1% .125W F TC=0+-50	28480	0698-6295
A6R95	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F
A6R96	0699-0524	4	1	RESISTOR-FXD 120 .25% .125W	28480	0699-0524
A6R97	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A6R98	0698-3132	4	2	RESISTOR 261 1% .125W F TC=0+-100	24546	C4-1/8-T0-2610-F
A6R99	0699-0394	6	4	RESISTOR 490.9 .1% .125W F TC=0+-50	28480	0699-0394
A6R100	0699-0397	9	2	RESISTOR 121.2 .1% .125W F TC=0+-50	28480	0699-0397
A6R101	0699-0394	6		RESISTOR 490.9 .1% .125W F TC=0+-50	28480	0699-0394
A6R102	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A6R103	0698-3132	4		RESISTOR 261 1% .125W F TC=0+-100	24546	C4-1/8-T0-2610-F
A6R104	0699-0394	6		RESISTOR 490.9 .1% .125W F TC=0+-50	28480	0699-0394
A6R105	0699-0397	9		RESISTOR 121.2 .1% .125W F TC=0+-50	28480	0699-0397
A6R106	0699-0394	6		RESISTOR 490.9 .1% .125W F TC=0+-50	28480	0699-0394
A6R107	0757-0419	0		RESISTOR 681 1% .125W F TC=0+-100	24546	C4-1/8-T0-681R-F
A6R108	0757-0419	0		RESISTOR 681 1% .125W F TC=0+-100	24546	C4-1/8-T0-681R-F
A6R109	0698-3459	8	2	RESISTOR 383K 1% .125W F TC=0+-100	28480	0698-3459
A6R110	0698-3459	8		RESISTOR 383K 1% .125W F TC=0+-100	28480	0698-3459
A6R111	0683-1035	1	1	RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A6TP1	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A6TP2	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A6TP3	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A6TP4	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A6TP5	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A6TP6	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A6U1	1826-0569	9		IC OP AMP LOW-NOISE TO-99 PKG	18324	NE5534AT
A6U2	1826-0569	9		IC OP AMP LOW-NOISE TO-99 PKG	18324	NE5534AT
A6U3†	1826-0109	3		IC OP AMP WB TO-99 PKG	34371	HA2-2625-B0593
A6U4	1826-0569	9		IC OP AMP LOW-NOISE TO-99 PKG	18324	NE5534AT
A6U5	1826-0582	6		IC SWITCH ANLG QUAD 16-DIP-C PKG	27014	LF13201D
A6U6	1820-1418	7	2	IC DCDR TTL LS BCD-TO-DEC 4-TO-10-LINE	01295	SN74LS42N
A6U7	1820-1197	9		IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N
A6U8	1826-0138	8		IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N
A6U9	1826-0138	8		IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N
A6U10	1826-0138	8		IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N
A6VR1	1902-0579	3	4	DIODE-ZNR 5.11V 5% DO-15 PD=1W TC=-.009%	28480	1902-0579
A6VR2	1902-0579	3		DIODE-ZNR 5.11V 5% DO-15 PD=1W TC=-.009%	28480	1902-0579
A6VR3	1902-0579	3		DIODE-ZNR 5.11V 5% DO-15 PD=1W TC=-.009%	28480	1902-0579
A6VR4	1902-0579	3		DIODE-ZNR 5.11V 5% DO-15 PD=1W TC=-.009%	28480	1902-0579

See introduction to this section for ordering information
*Indicates factory selected value
†For backdating information see Section VII.

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A7	08903-60007	7	1	LATCH	28480	08903-60007
A7C1	0180-0116	1	10	CAPACITOR-FXD 6.8UF+-10% 35VDC TA	56289	150D685X9035B2
A7C2	0180-0229	7		CAPACITOR-FXD 33UF+-10% 10VDC TA	56289	150D336X9010B2
A7C3	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A7C4	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A7C5	0180-0116	1		CAPACITOR-FXD 6.8UF+-10% 35VDC TA	56289	150D685X9035B2
A7C6	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A7C7	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A7C8	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A7C9	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A7C10	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A7C11	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A7C12	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A7C13	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A7C14	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A7C15	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A7C16	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A7C17	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A7C18	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A7C19	0180-0376	5	7	CAPACITOR-FXD .47UF+-10% 35VDC TA	56289	150D474X9035A2
A7C20	0180-0376	5		CAPACITOR-FXD .47UF+-10% 35VDC TA	56289	150D474X9035A2
A7C21	0160-3064	2	2	CAPACITOR-FXD 1000PF +-5% 300VDC MICA	28480	0160-3064
A7C22	0160-3064	2		CAPACITOR-FXD 1000PF +-5% 300VDC MICA	28480	0160-3064
A7C23	0180-1704	5	2	CAPACITOR-FXD 47UF+-10% 6VDC TA	56289	150D476X9006B2
A7C24	0180-1704	5		CAPACITOR-FXD 47UF+-10% 6VDC TA	56289	150D476X9006B2
A7C25	0180-0376	5		CAPACITOR-FXD .47UF+-10% 35VDC TA	56289	150D474X9035A2
A7C26	0180-0376	5		CAPACITOR-FXD .47UF+-10% 35VDC TA	56289	150D474X9035A2
A7C27	0180-0376	5		CAPACITOR-FXD .47UF+-10% 35VDC TA	56289	150D474X9035A2
A7C28	0180-0116	1		CAPACITOR-FXD 6.8UF+-10% 35VDC TA	56289	150D685X9035B2
A7C29	0180-0116	1		CAPACITOR-FXD 6.8UF+-10% 35VDC TA	56289	150D685X9035B2
A7C30	0160-4523	0	1	CAPACITOR-FXD 16PF +-5% 200VDC CER 0+-30	51642	200-200-NPO-160J
A7C31	0180-0376	5		CAPACITOR-FXD .47UF+-10% 35VDC TA	56289	150D474X9035A2
A7C32	0180-0376	5		CAPACITOR-FXD .47UF+-10% 35VDC TA	56289	150D474X9035A2
A7CR1	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A7CR2	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A7CR3	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A7CR4	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A7CR5	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A7CR6	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A7CR7	1906-0042	3	1	DIODE-DUAL 70V VF DIFF=10MV	28480	1906-0042
A7CR8	1901-0358	4	1	DIODE-DUAL 50V VF DIFF=3MV	04713	MSD6101
A7CR9	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A7CR10	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A7CR11	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A7CR12	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A7MP1	4040-0748	3		EXTR-PC BD BLK POLYC .062-BD-THKNS	28480	4040-0748
	1480-0073	6		PIN-ROLL .062-IN-DIA .25-IN-LG BE-CU	28480	1480-0073
A7MP2	4040-0755	2	1	EXTR-PC BD VIO POLYC .062-BD-THKNS	28480	4040-0755
	1480-0073	6		PIN-ROLL .062-IN-DIA .25-IN-LG BE-CU	28480	1480-0073
A7R1	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A7R2	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A7R3	1810-0204	6	2	NETWORK-RES 8-SIP1.0K OHM X 7	01121	208A102
A7R4	1810-0204	6		NETWORK-RES 8-SIP1.0K OHM X 7	01121	208A102
A7R5	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A7R6	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A7R7	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A7R8*	0757-0440	7	11	RESISTOR 7.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7501-F
A7R9	0757-0440	7		RESISTOR 7.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7501-F
A7R10*	0757-0440	7		RESISTOR 7.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7501-F
A7R11	0757-0440	7		RESISTOR 7.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7501-F
A7R12	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A7R13	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A7R14	0698-3157	3		RESISTOR 19.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1962-F
A7R15	0675-1021	8	2	RESISTOR 1K 10% .125W CC TC=-330/+800	01121	BB1021
A7R16	0675-1021	8		RESISTOR 1K 10% .125W CC TC=-330/+800	01121	BB1021
A7R17	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A7R18	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A7R19	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A7R20	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A7R21	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A7R22	0699-0070	5	2	RESISTOR 3.16M 1% .125W F TC=0+-100	28480	0699-0070
A7R23	0699-0070	5		RESISTOR 3.16M 1% .125W F TC=0+-100	28480	0699-0070
A7R24	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A7R25	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A7R26	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A7R27	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A7R28	0683-1015	7	1	RESISTOR 100 5% .25W FC TC=-400/+500	01121	CB1015
A7TP1	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A7TP2	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A7TP3	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A7TP4	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A7TP5	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A7TP6	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A7U1	1820-1197	9		IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N
A7U2	1826-0138	8		IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N
A7U3	1826-0323	3	1	IC OP AMP GP QUAD 14-DIP-C PKG	28480	1826-0323
A7U4	1826-0188	8	2	IC CONV 8-B-D/A 16-DIP-C PKG	04713	MC1408L-8
A7U5	1820-1729	3		IC LCH TTL LS COM CLEAR 8-BIT	01295	SN74LS259N
A7U6	1820-1729	3		IC LCH TTL LS COM CLEAR 8-BIT	01295	SN74LS259N
A7U7	1820-1216	3		IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N
A7U8	1820-1211	8	1	IC GATE TTL LS EXCL-OR QUAD 2-INP	01295	SN74LS86N
A7U9	1820-1195	7	3	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS175N
A7U10	1820-1195	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS175N
A7U11	1820-1195	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS175N
A7U12	1820-1112	8	7	IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN
A7U13	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN
A7U14	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN
A7U15	1820-0269	4	1	IC GATE TTL NAND QUAD 2-INP	01295	SN7403N
A7U16	1820-1197	9		IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N
A7U17	1826-0371	1		IC OP AMP LOW-BIAS-H-IMPD TO-99 PKG	27014	LF256H
A7U18	1820-1971	7	1	IC SWITCH ANLG QUAD 16-DIP-P PKG	17856	DG201CJ
A7U19	1826-0188	8		IC CONV 8-B-D/A 16-DIP-C PKG	04713	MC1408L-8
A7U20	1820-1729	3		IC LCH TTL LS COM CLEAR 8-BIT	01295	SN74LS259N
A7U21	1820-1729	3		IC LCH TTL LS COM CLEAR 8-BIT	01295	SN74LS259N
A7U22	1820-1729	3		IC LCH TTL LS COM CLEAR 8-BIT	01295	SN74LS259N
A7U23	1820-1729	3		IC LCH TTL LS COM CLEAR 8-BIT	01295	SN74LS259N
A7U24	1820-1729	3		IC LCH TTL LS COM CLEAR 8-BIT	01295	SN74LS259N
A7U25	1820-1729	3		IC LCH TTL LS COM CLEAR 8-BIT	01295	SN74LS259N
A7U26	1820-1729	3		IC LCH TTL LS COM CLEAR 8-BIT	01295	SN74LS259N
A7U27	1820-1729	3		IC LCH TTL LS COM CLEAR 8-BIT	01295	SN74LS259N
A7U28	1820-1729	3		IC LCH TTL LS COM CLEAR 8-BIT	01295	SN74LS259N
A7U29	1820-1729	3		IC LCH TTL LS COM CLEAR 8-BIT	01295	SN74LS259N
A7U30	1820-1199	1	4	IC INV TTL LS HEX 1-INP	01295	SN74LS04N
A8	08903-60003	3	1	CONTROLLER/COUNTER	28480	08903-60003
A8C1	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A8C2	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A8C3	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A8C4	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A8C5	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A8C6	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A8C7	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A8C8	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A8C9	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A8C10	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A8C11	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A8C12	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A8C13	0160-3456	6		CAPACITOR-FXD 1000PF +-10% 1KVDC CER	28480	0160-3456
A8C14	0160-3456	6		CAPACITOR-FXD 1000PF +-10% 1KVDC CER	28480	0160-3456
A8C15	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A8C16	0180-0229	7		CAPACITOR-FXD 33UF+-10% 10VDC TA	56289	150D336X9010B2
A8C17	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A8C18	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A8C19	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A8C20	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A8C21	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A8C22	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A8C23	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A8C24	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A8C25	0160-2264	2	2	CAPACITOR-FXD 20PF +-5% 500VDC CER 0+-30	28480	0160-2264

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A8C26	0160-2264	2		CAPACITOR-FXD 20PF +-5% 500VDC CER 0+-30	28480	0160-2264
A8C27	0121-0436	4	1	CAPACITOR-V TRMR-AIR 2.6-23.5PF 350V	74970	189-0509-125
A8C28	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A8C29	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A8C30	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A8C31	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A8C32	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A8C33	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A8C34	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A8C35				NOT ASSIGNED		
A8C36	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A8C37	0180-1745	4	1	CAPACITOR-FXD 1.5UF+-10% 20VDC TA	56289	150D155X9020A2
A8CR1	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A8CR2	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A8CR3	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A8CR4	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A8CR5	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A8CR6	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A8CR7	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A8CR8	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A8CR9	1901-0539	3	1	DIODE-SM SIG SCHOTTKY	28480	1901-0539
A8DS1	1990-0524	3	4	LED-VISIBLE LUM-INT=1MCD IF=20MA-MAX	28480	5082-4550
A8DS2	1990-0524	3		LED-VISIBLE LUM-INT=1MCD IF=20MA-MAX	28480	5082-4550
A8DS3	1990-0524	3		LED-VISIBLE LUM-INT=1MCD IF=20MA-MAX	28480	5082-4550
A8DS4	1990-0524	3		LED-VISIBLE LUM-INT=1MCD IF=20MA-MAX	28480	5082-4550
A8J1	1200-0507	9	1	SOCKET-IC 16-CONT DIP-SLDR	28480	1200-0507
A8MP1	4040-0748	3		EXTR-PC BD BLK POLYC .062-BD-THKNS	28480	4040-0748
	1480-0073	6		PIN-ROLL .062-IN-DIA .25-IN-LG BE-CU	28480	1480-0073
A8MP2	4040-0747	2	1	EXTR-PC BD GRA POLYC .062-BD-THKNS	28480	4040-0747
	1480-0073	6		PIN-ROLL .062-IN-DIA .25-IN-LG BE-CU	28480	1480-0073
A8R1	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A8R2	0698-3440	7	1	RESISTOR 196 1% .125W F TC=0+-100	24546	C4-1/8-T0-196R-F
A8R3	1810-0055	5	1	NETWORK-RES 9-SIP10.0K OHM X 8	28480	1810-0055
A8R4	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A8R5	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A8R6	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A8R7	1810-0363	8	1	NETWORK-RES 6-SIP330.0 OHM X 5	01121	206A331
A8R8	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A8R9	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A8R10	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A8R11	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A8R12	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A8R13	0757-0458	7		RESISTOR 51.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5112-F
A8TP1	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A8TP2	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A8TP3	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A8TP4	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A8TP5	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A8TP6	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A8TP7	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A8TP8	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A8TP9	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A8TP10	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A8TP11	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A8TP12	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A8TP13	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A8TP14	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A8TP15	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A8TP16	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A8TP17	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A8TP18	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A8U1	1820-1193	5	4	IC CNTR TTL LS BIN ASYNCHRO	01295	SN74LS197N
A8U2	1820-1193	5		IC CNTR TTL LS BIN ASYNCHRO	01295	SN74LS197N
A8U3	1820-1201	6	1	IC GATE TTL LS AND QUAD 2-INP	01295	SN74LS08N
A8U4	1820-1197	9		IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N
A8U5	1820-1928	4	1	IC MICPROC NMOS	07263	3850PC
	1200-0654	7	3	SOCKET-IC 40-CONT DIP DIP-SLDR	28480	1200-0654
A8U6	1820-2027	6	1	IC MICPROC-ACCESS NMOS	07263	3853PC
	1200-0654	7		SOCKET-IC 40-CONT DIP DIP-SLDR	28480	1200-0654
A8U7	1820-1417	6		IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS26N
	1200-0638	7	2	SOCKET-IC 14-CONT DIP DIP-SLDR	28480	1200-0638
A8U8	1818-1416	0	1	ROM #2	18324	N2616N MASKED
A8U8	1200-0541	1	9	SOCKET-IC 24-CONT DIP DIP-SLDR	28480	1200-0541
A8U8	08903-80002	4	1	ROM #2 (ALTERNATE)	28480	08903-80002

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A8U9	1200-0541	1		SOCKET-IC 24-CONT DIP DIP-SLDR	28480	1200-0541
A8U9	08903-80001	3	1	ROM #1 (ALTERNATE)	28480	08903-80001
A8U10	1818-1417	1	1	ROM #3	18324	N2616N MASKED
A8U10	1200-0541	1		SOCKET-IC 24-CONT DIP DIP-SLDR	28480	1200-0541
A8U10	08903-80003	5	1	ROM #3 (ALTERNATE)	28480	08903-80003
A8U11	1818-1418	2	1	ROM #4	18324	N2616N MASKED
A8U11	1200-0541	1		SOCKET-IC 24-CONT DIP DIP-SLDR	28480	1200-0541
A8U11	08903-80004	6	1	ROM #4 (ALTERNATE)	28480	08903-80004
A8U12	1818-1421	7	1	ROM #7	18324	N2616N MASKED
A8U12	1200-0541	1		SOCKET-IC 24-CONT DIP DIP-SLDR	28480	1200-0541
A8U12	08903-80007	9	1	ROM #7 (ALTERNATE)	28480	08903-80007
A8U13	1818-1420	6	1	ROM #6	18324	N2616N MASKED
A8U13	1200-0541	1		SOCKET-IC 24-CONT DIP DIP-SLDR	28480	1200-0541
A8U13	08903-80006	8	1	ROM #6 (ALTERNATE)	28480	08903-80006
A8U14	1820-1193	5		IC CNTR TTL LS BIN ASYNCHRO	01295	SN74LS197N
A8U15	1820-1193	5		IC CNTR TTL LS BIN ASYNCHRO	01295	SN74LS197N
A8U16	1820-1287	8	1	IC BFR TTL LS NAND QUAD 2-INP	01295	SN74LS37N
A8U17	1820-1417	6		IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS26N
	1200-0638	7		SOCKET-IC 14-CONT DIP DIP-SLDR	28480	1200-0638
A8U18	1820-1199	1		IC INV TTL LS HEX 1-INP	01295	SN74LS04N
A8U19	1820-1202	7		IC GATE TTL LS NAND TPL 3-INP	01295	SN74LS10N
A8U20	1820-1199	1		IC INV TTL LS HEX 1-INP	01295	SN74LS04N
A8U21	1820-1216	3		IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N
A8U22	1820-1216	3		IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N
A8U23	1820-0174	0	1	IC INV TTL HEX	01295	SN7404N
A8U24	1820-1418	7		IC DCDR TTL LS BCD-TO-DEC 4-TO-10-LINE	01295	SN74LS42N
A8U25				NOT ASSIGNED		
A8U26	1818-1423	9	1	ROM #9	18324	N2616N MASKED
A8U26	1200-0541	1		SOCKET-IC 24-CONT DIP DIP-SLDR	28480	1200-0541
A8U26	08903-80009	1	1	ROM #9 (ALTERNATE)	28480	08903-80009
A8U27	1818-1422	8	1	ROM #8	18324	N2616N MASKED
A8U27	1200-0541	1		SOCKET-IC 24-CONT DIP DIP-SLDR	28480	1200-0541
A8U27	08903-80008	0	1	ROM #8 (ALTERNATE)	28480	08903-80008
A8U28	1818-1419	3	1	ROM #5	18324	N2616N MASKED
A8U28	1200-0541	1		SOCKET-IC 24-CONT DIP DIP-SLDR	28480	1200-0541
A8U28	08903-80005	7	1	ROM #5 (ALTERNATE)	28480	08903-80005
A8U29	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN
A8U30	1818-0197	2	1	IC NMOS 1024 (1K) RAM STAT 400-NS 3-S	34335	AM91L11BDC
	1200-0539	7	1	SOCKET-IC 18-CONT DIP DIP-SLDR	28480	1200-0539
A8Y1	0410-0757	5	1	CRYSTAL-QUARTZ 2.000 MHZ HC-6/U-HLDR	28480	0410-0757
	1200-0770	8	1	SOCKET-XTAL 2-CONT HC-6/U DIP-SLDR	28480	1200-0770
A9	08903-60010	2	1	REMOTE INTERFACE	28480	08903-60010
A9C1	0180-0374	3		CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2
A9C2	0180-0229	7		CAPACITOR-FXD 33UF+-10% 10VDC TA	56289	150D336X9010B2
A9C3	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A9C4	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A9C5	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A9C6	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A9C7	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A9C8	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A9C9	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A9C10	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A9C11	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A9C12	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A9C13	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A9C14	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A9C15	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A9C16	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A9C17	0160-0574	3	2	CAPACITOR-FXD .022UF +-20% 100VDC CER	28480	0160-0574
A9C18	0140-0196	3		CAPACITOR-FXD 150PF +-5% 300VDC MICA	72136	DM15F151J0300WV1CR
A9C19	0160-0574	3		CAPACITOR-FXD .022UF +-20% 100VDC CER	28480	0160-0574
A9CR1	1901-0518	8		DIODE-SM SIG SCHOTTKY	28480	1901-0518
A9MP1	4040-0748	3		EXTR-PC BD BLK POLYC .062-BD-THKNS	28480	4040-0748
	1480-0073	6		PIN-ROLL .062-IN-DIA .25-IN-LG BE-CU	28480	1480-0073
A9MP2	4040-0756	3	1	EXTR-PC BD WHT POLYC .062-BD-THKNS	28480	4040-0756
	1480-0073	6		PIN-ROLL .062-IN-DIA .25-IN-LG BE-CU	28480	1480-0073
A9R1	0698-3444	1	2	RESISTOR 316 1% .125W F TC=0+-100	24546	C4-1/8-T0-316R-F
A9R2	1810-0206	8		NETWORK-RES 8-SIP10.0K OHM X 7	01121	208A103
A9R3	1810-0206	8		NETWORK-RES 8-SIP10.0K OHM X 7	01121	208A103
A9R4	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A9R5	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	CD	Qty	Description	Mfr Code	Mfr Part Number
A9R6	1810-0136	3	1	NETWORK-RES 10-SIP MULTI-VALUE	28480	1810-0136
A9R7	0698-0083	8		RESISTOR 1.96K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1961-F
A9R8	0698-3444	1		RESISTOR 316 1% .125W F TC=0+-100	24546	C4-1/8-T0-316R-F
A9S1	3101-1973	7	1	SWITCH-SL 7-1A DIP-SLIDE-ASSY .1A 50VDC	28480	3101-1973
	1200-0485	2	1	SOCKET-IC 14-CONT DIP DIP-SLDR	28480	1200-0485
A9TP1	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A9TP2	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A9TP3	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A9TP4	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A9TP5	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A9TP6	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A9TP7	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A9TP8	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A9TP9	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A9U1	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN
A9U2	08901-80004	4	1	PROM PROGRAMMED	28480	08901-80004
A9U3	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN
A9U4	1820-1417	6		IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS26N
A9U5	1820-0706	4	1	IC COMPTR TTL MAGTD 5-BIT	07263	9324PC
A9U6	1820-1905	7	1	IC GATE TTL LS NOR DUAL 5-INP	07263	74LS260PC
A9U7	1820-1198	0	2	IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS03N
A9U8	1820-1689	4	2	IC UART TTL QUAD	01295	MC3446P
A9U9	1820-1198	0		IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS03N
A9U10	1820-1689	4		IC UART TTL QUAD	01295	MC3446P
A9U11	1820-1200	5	2	IC INV TTL LS HEX	01295	SN74LS05N
A9U12	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN
A9U13	1820-1200	5		IC INV TTL LS HEX	01295	SN74LS05N
A9U14	1820-1199	1		IC INV TTL LS HEX 1-INP	01295	SN74LS04N
A9U15	1820-0054	5	1	IC GATE TTL NAND QUAD 2-INP	01295	SN7400N
A9U16	1820-1216	3		IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N
A9U17	1820-1417	6		IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS26N
A9U18	1820-2100	6	1	IC MICPROC-ACCESS NMOS DUAL 8-BIT	07263	3861EPC
	1200-0654	7		SOCKET-IC 40-CONT DIP DIP-SLDR	28480	1200-0654
A9U19	1820-1416	5	1	IC SCHMITT-TRIG TTL LS INV HEX 1-INP	01295	SN74LS14N
A9U20	1820-0621	2	1	IC BFR TTL NAND QUAD 2-INP	01295	SN7438N
A10	08903-60017	9	1	REMOTE INTERFACE CONNECTOR	28480	08903-60017
A10J1	1251-3283	1	1	CONNECTOR 24-PIN F MICRORIBBON	28480	1251-3283
A10MP1	0380-0643	3	2	STANDOFF-HEX .255-IN-LG 6-32THD	00000	ORDER BY DESCRIPTION
	2190-0017	4	2	WASHER-LK HLCL NO. 8 .168-IN-ID	28480	2190-0017
A10MP2	1530-1098	4	2	CLEVIS 0.070-IN W SLT: 0.454-IN PIN CTR	00000	ORDER BY DESCRIPTION
	2190-0019	6	2	WASHER-LK HLCL NO. 4 .115-IN-ID	28480	2190-0019
	2200-0109	8	2	SCREW-MACH 4-40 .438-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
	2260-0002	6	2	NUT-HEX-DBL-CHAM 4-40-THD .062-IN-THK	00000	ORDER BY DESCRIPTION
A11	08903-60015	7	1	SERIES REGULATOR SOCKET	28480	08903-60015
A11C1	0180-0116	1		CAPACITOR-FXD 6.8UF+-10% 35VDC TA	56289	150D685X9035B2
A11C2	0180-0116	1		CAPACITOR-FXD 6.8UF+-10% 35VDC TA	56289	150D685X9035B2
A11C3	0180-0116	1		CAPACITOR-FXD 6.8UF+-10% 35VDC TA	56289	150D685X9035B2
A11C4	0180-0116	1		CAPACITOR-FXD 6.8UF+-10% 35VDC TA	56289	150D685X9035B2
A11F1	2110-0001	8	2	FUSE 1A 250V NTD 1.25X.25 UL	75915	312001
A11F2	2110-0294	1	1	FUSE 4A 32V NTD 1.25X.25	28480	2110-0294
A11F3	2110-0001	8		FUSE 1A 250V NTD 1.25X.25 UL	75915	312001
A11MP1	2110-0269	0		FUSEHOLDER-CLIP TYPE.25D-FUSE	28480	2110-0269
A11MP2	2110-0269	0		FUSEHOLDER-CLIP TYPE.25D-FUSE	28480	2110-0269
A11MP3	2110-0269	0		FUSEHOLDER-CLIP TYPE.25D-FUSE	28480	2110-0269
A11MP4	2110-0269	0		FUSEHOLDER-CLIP TYPE.25D-FUSE	28480	2110-0269
A11MP5	2110-0269	0		FUSEHOLDER-CLIP TYPE.25D-FUSE	28480	2110-0269
A11MP6	2110-0269	0		FUSEHOLDER-CLIP TYPE.25D-FUSE	28480	2110-0269
A11XQ1	1200-0041	6	3	SOCKET-XSTR 2-CONT TO-3 SLDR-EYE	28480	1200-0041
A11XU1	1200-0041	6		SOCKET-XSTR 2-CONT TO-3 SLDR-EYE	28480	1200-0041
A11XU2	1200-0041	6		SOCKET-XSTR 2-CONT TO-3 SLDR-EYE	28480	1200-0041

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A12	08903-60016	8	1	CONNECTOR/FILTER	28480	08903-60016
A12C1	0160-2307	4		CAPACITOR-FXD 47PF +-5% 300VDC MICA	28480	0160-2307
A12C2	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A12C3	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A12C4	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A12J1	1250-1096	8	4	CONNECTOR-RF BNC FEM SGL-HOLE-RR 50-OHM	28480	1250-1096
A12J2	1250-1096	8		CONNECTOR-RF BNC FEM SGL-HOLE-RR 50-OHM	28480	1250-1096
A12J3	1250-1096	8		CONNECTOR-RF BNC FEM SGL-HOLE-RR 50-OHM	28480	1250-1096
A12J4	1250-1096	8		CONNECTOR-RF BNC FEM SGL-HOLE-RR 50-OHM	28480	1250-1096
A12L1	9140-0210	1		INDUCTOR RF-CH-MLD 100UH 5% .166DX.385LG	28480	9140-0210
A12L2	9140-0210	1		INDUCTOR RF-CH-MLD 100UH 5% .166DX.385LG	28480	9140-0210
A12L3	9140-0210	1		INDUCTOR RF-CH-MLD 100UH 5% .166DX.385LG	28480	9140-0210
A12L4	9140-0210	1		INDUCTOR RF-CH-MLD 100UH 5% .166DX.385LG	28480	9140-0210
A13	08903-60020	4	1	POWER SUPPLY & MOTHER BOARD	28480	08903-60020
A13C1	0180-2317	8	2	CAPACITOR-FXD 3600UF+75-10% 40VDC AL	00853	539-7445-02
	2190-0011	8	6	WASHER-LK INTL T NO. 10 .195-IN-ID	28480	2190-0011
	2680-0129	8	6	SCREW-MACH 10-32 .312-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
A13C2	0180-2317	8		CAPACITOR-FXD 3600UF+75-10% 40VDC AL	00853	539-7445-02
	2190-0011	8		WASHER-LK INTL T NO. 10 .195-IN-ID	28480	2190-0011
	2680-0129	8		SCREW-MACH 10-32 .312-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
A13C3	0180-0452	8	1	CAPACITOR-FXD .013F+75-10% 25VDC AL	28480	0180-0452
	2190-0011	8		WASHER-LK INTL T NO. 10 .195-IN-ID	28480	2190-0011
	2680-0129	8		SCREW-MACH 10-32 .312-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
A13C4	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A13C5	0180-0116	1		CAPACITOR-FXD 6.8UF+-10% 35VDC TA	56289	150D685X9035B2
A13C6	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A13C7	0140-0210	2		CAPACITOR-FXD 270PF +-5% 300VDC MICA	72136	DM15F271J0300WV1CR
A13C8	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A13C9	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A13C10	0180-0116	1		CAPACITOR-FXD 6.8UF+-10% 35VDC TA	56289	150D685X9035B2
A13C11	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A13C12	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576
A13C13	0160-2307	4		CAPACITOR-FXD 47PF +-5% 300VDC MICA	28480	0160-2307
A13C14	0160-2307	4		CAPACITOR-FXD 47PF +-5% 300VDC MICA	28480	0160-2307
A13C15	0160-2307	4		CAPACITOR-FXD 47PF +-5% 300VDC MICA	28480	0160-2307
A13C16	0160-2307	4		CAPACITOR-FXD 47PF +-5% 300VDC MICA	28480	0160-2307
A13CR1	1901-0200	5	4	DIODE-PWR RECT 100V 1.5A	28480	1901-0200
	0340-0669	9	4	INSULATOR-XSTR SLBL-ORG-POLYM	28480	0340-0669
A13CR2	1901-0200	5		DIODE-PWR RECT 100V 1.5A	28480	1901-0200
	0340-0669	9		INSULATOR-XSTR SLBL-ORG-POLYM	28480	0340-0669
A13CR3	1901-0200	5		DIODE-PWR RECT 100V 1.5A	28480	1901-0200
	0340-0669	9		INSULATOR-XSTR SLBL-ORG-POLYM	28480	0340-0669
A13CR4	1901-0200	5		DIODE-PWR RECT 100V 1.5A	28480	1901-0200
	0340-0669	9		INSULATOR-XSTR SLBL-ORG-POLYM	28480	0340-0669
A13CR5†	1906-0231	2	1	DIODE-CT-RECT 200V 15A	28480	1906-0231
	1200-0043†	8	1	INSULATOR-XSTR ALUMINUM	28480	1200-0043
	1205-0021	2	1	HEAT SINK TO-3-CS	28480	1205-0021
	2360-0123	4	2	SCREW-MACH 6-32 .625-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
	2420-0002	6	8	NUT-HEX-DBL-CHAM 6-32-THD .109-IN-THK	28480	2420-0002
	2190-0006	1	8	WASHER-LK HLCL NO. 6 .141-IN-ID	28480	2190-0006
	3050-0227	3	8	WASHER-FL MTLC NO. 6 .149-IN-ID	28480	3050-0227
A13CR6	1901-0159	3	7	DIODE-PWR RECT 400V 750MA DO-41	28480	1901-0159
A13CR7	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A13CR8	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A13CR9	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A13CR10	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A13CR11	1901-0159	3		DIODE-PWR RECT 400V 750MA DO-41	28480	1901-0159
A13CR12	1901-0159	3		DIODE-PWR RECT 400V 750MA DO-41	28480	1901-0159
A13CR13	1901-0159	3		DIODE-PWR RECT 400V 750MA DO-41	28480	1901-0159
A13CR14	1901-0159	3		DIODE-PWR RECT 400V 750MA DO-41	28480	1901-0159
A13CR15	1901-0159	3		DIODE-PWR RECT 400V 750MA DO-41	28480	1901-0159
A13CR16	1901-0159	3		DIODE-PWR RECT 400V 750MA DO-41	28480	1901-0159
A13DS1	1990-0485	5	4	LED-VISIBLE LUM-INT=800UCD IF=30MA-MAX	28480	5082-4984
A13DS2	1990-0485	5		LED-VISIBLE LUM-INT=800UCD IF=30MA-MAX	28480	5082-4984
A13DS3	1990-0485	5		LED-VISIBLE LUM-INT=800UCD IF=30MA-MAX	28480	5082-4984
A13DS4	1990-0485	5		LED-VISIBLE LUM-INT=800UCD IF=30MA-MAX	28480	5082-4984
A13J1	1251-4736	1		CONNECTOR 26-PIN M RECTANGULAR	28480	1251-4736
A13J2	1251-3412	8	1	CONNECTOR 6-PIN M POST TYPE	28480	1251-3412
A13J3	1251-5169	6	2	CONNECTOR 6-PIN M POST TYPE	28480	1251-5169
A13J4	1251-5169	6		CONNECTOR 6-PIN M POST TYPE	28480	1251-5169

See introduction to this section for ordering information
*Indicates factory selected value

† For backdating information see Section VII.

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A13L1	9140-0137	1	1	INDUCTOR RF-CH-MLD 1MH 5% .2DX.45LG Q=60	28480	9140-0137
A13L2	9100-3922	4	2	INDUCTOR-FIXED 120-1300 HZ	28480	9100-3922
A13L3	9100-3922	4		INDUCTOR-FIXED 120-1300 HZ	28480	9100-3922
A13MP1	0403-0115	4	1	BUMPER FOOT-ADH MTG .5-IN-WD .25-IN-THK	28480	0403-0115
A13Q1	1854-0477	7		TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	04713	2N2222A
	1205-0012	1	1	HEAT SINK TO-18-CS	28480	1205-0012
A13Q2	1884-0005	0	1	THYRISTOR-SCR VRRM=50	04713	MCR649P-2
	2190-0006	1		WASHER-LK HLCL NO. 6 .141-IN-ID	28480	2190-0006
	2360-0121	2	6	SCREW-MACH 6-32 .5-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
	2420-0002	6		NUT-HEX-DBL-CHAM 6-32-THD .109-IN-THK	28480	2420-0002
	3050-0227	3		WASHER-FL MTLC NO. 6 .149-IN-ID	28480	3050-0227
A13Q3	1884-0076	5	1	THYRISTOR-TRIAC TO-66	0192B	T2700D
	2190-0006	1		WASHER-LK HLCL NO. 6 .141-IN-ID	28480	2190-0006
	2360-0121	2		SCREW-MACH 6-32 .5-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
	2420-0002	6		NUT-HEX-DBL-CHAM 6-32-THD .109-IN-THK	28480	2420-0002
	3050-0227	3		WASHER-FL MTLC NO. 6 .149-IN-ID	28480	3050-0227
A13Q4	1884-0012	9	3	THYRISTOR-SCR 2N3528 TO-8 VRRM=200	0192B	2N3528
A13Q5	1884-0012	9		THYRISTOR-SCR 2N3528 TO-8 VRRM=200	0192B	2N3528
A13Q6	1884-0012	9		THYRISTOR-SCR 2N3528 TO-8 VRRM=200	0192B	2N3528
A13R1	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A13R2	0698-3429	2	1	RESISTOR 19.6 1% .125W F TC=0+-100	03888	PME55-1/8-T0-19R6-F
A13R3	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A13R4	0757-0440	7		RESISTOR 7.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7501-F
A13R5	8110-0180	0	1	RIBBON-RES .157-OHM/FT .0253X.0625	28480	8110-0180
A13R6	0757-0460	1	1	RESISTOR 61.9K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6192-F
A13R7	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A13R8	0698-0083	8		RESISTOR 1.96K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1961-F
A13R9	0757-0394	0		RESISTOR 51.1 1% .125W F TC=0+-100	24546	C4-1/8-T0-51R1-F
A13R10	0757-0394	0		RESISTOR 51.1 1% .125W F TC=0+-100	24546	C4-1/8-T0-51R1-F
A13R11	0757-0290	5		RESISTOR 6.19K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-6191-F
A13R12	0698-4020	1	1	RESISTOR 9.53K .01% .125W TC=0+-100	28480	0698-4020
A13R13	0698-3136	8		RESISTOR 17.8K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1782-F
A13R14	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A13R15	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A13R16	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A13R17	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A13R18	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A13U1	1826-0547	3		IC OP AMP DUAL 8-DIP-P PKG	01295	TL072ACP
A13U2	1826-0117	3	1	IC 7812 V RGLTR TO-3	07263	7812KC
	2190-0006	1		WASHER-LK HLCL NO. 6 .141-IN-ID	28480	2190-0006
	2360-0121	2		SCREW-MACH 6-32 .5-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
	2420-0002	6		NUT-HEX-DBL-CHAM 6-32-THD .109-IN-THK	28480	2420-0002
	3050-0227	3		WASHER-FL MTLC NO. 6 .149-IN-ID	28480	3050-0227
A13VR1	1902-3381	1	2	DIODE-ZNR 68.1V 5% DO-7 PD=.4W TC=+.079%	28480	1902-3381
A13VR2	1902-3381	1		DIODE-ZNR 68.1V 5% DO-7 PD=.4W TC=+.079%	28480	1902-3381
A13VR3	1902-0960	6	2	DIODE-ZNR 12V 5% DO-35 PD=.4W TC=+.077%	28480	1902-0960
A13VR4	1902-0957	1	1	DIODE-ZNR 9.1V 5% DO-35 PD=.4W TC=+.069%	28480	1902-0957
A13VR5	1902-0943	5		DIODE-ZNR 2.4V 5% DO-35 PD=.4W TC=-.037%	28480	1902-0943
A13VR6	1902-0960	6		DIODE-ZNR 12V 5% DO-35 PD=.4W TC=+.077%	28480	1902-0960
A13VR7	1902-0963	9	2	DIODE-ZNR 16V 5% DO-35 PD=.4W TC=+.088%	28480	1902-0963
A13VR8	1902-0961	7	1	DIODE-ZNR 13V 5% DO-35 PD=.4W TC=+.082%	28480	1902-0961
A13VR9	1902-0952	6	1	DIODE-ZNR 5.6V 5% DO-35 PD=.4W TC=+.046%	28480	1902-0952
A13VR10	1902-0963	9		DIODE-ZNR 16V 5% DO-35 PD=.4W TC=+.088%	28480	1902-0963
A13XA2A	1251-2035	9	7	CONNECTOR-PC EDGE 15-CONT/ROW 2-ROWS	28480	1251-2035
A13XA2B	1251-1365	6	10	CONNECTOR-PC EDGE 22-CONT/ROW 2-ROWS	28480	1251-1365
A13XA3A	1251-2035	9		CONNECTOR-PC EDGE 15-CONT/ROW 2-ROWS	28480	1251-2035
A13XA3B	1251-2035	9		CONNECTOR-PC EDGE 15-CONT/ROW 2-ROWS	28480	1251-2035
A13XA4A	1251-2035	9		CONNECTOR-PC EDGE 15-CONT/ROW 2-ROWS	28480	1251-2035
A13XA4B	1251-2035	9		CONNECTOR-PC EDGE 15-CONT/ROW 2-ROWS	28480	1251-2035
A13XA5A	1251-2035	9		CONNECTOR-PC EDGE 15-CONT/ROW 2-ROWS	28480	1251-2035
A13XA5B	1251-1365	6		CONNECTOR-PC EDGE 22-CONT/ROW 2-ROWS	28480	1251-1365
A13XA6A	1251-2035	9		CONNECTOR-PC EDGE 15-CONT/ROW 2-ROWS	28480	1251-2035
A13XA6B	1251-1365	6		CONNECTOR-PC EDGE 22-CONT/ROW 2-ROWS	28480	1251-1365
A13XA7A	1251-1365	6		CONNECTOR-PC EDGE 22-CONT/ROW 2-ROWS	28480	1251-1365
A13XA7B	1251-1365	6		CONNECTOR-PC EDGE 22-CONT/ROW 2-ROWS	28480	1251-1365
A13XA7C	1251-1365	6		CONNECTOR-PC EDGE 22-CONT/ROW 2-ROWS	28480	1251-1365
A13XA8A	1251-1365	6		CONNECTOR-PC EDGE 22-CONT/ROW 2-ROWS	28480	1251-1365
A13XA8B	1251-1365	6		CONNECTOR-PC EDGE 22-CONT/ROW 2-ROWS	28480	1251-1365
A13XA9A	1251-1365	6		CONNECTOR-PC EDGE 22-CONT/ROW 2-ROWS	28480	1251-1365
A13XA9B	1251-1365	6		CONNECTOR-PC EDGE 22-CONT/ROW 2-ROWS	28480	1251-1365
A13XA10	1251-1626	2	1	CONNECTOR-PC EDGE 12-CONT/ROW 2-ROWS	28480	1251-1626
A13XA11	1251-0472	4	1	CONNECTOR-PC EDGE 6-CONT/ROW 2-ROWS	28480	1251-0472

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A14	0960-0443	1	1	LINE POWER MODULE	28480	0960-0443
A14TB1	5020-8122	2	1	LINE VOLTAGE SELECTOR CARD	28480	5020-8122

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
				CHASSIS PARTS		
F1	2110-0305	5	1	FUSE 1.25A 250V TD 1.25X.25 UL (FOR 115V OPERATION)	75915	3131.25
F1	2110-0202	1	1	FUSE .5A 250V TD 1.25X.25 UL (FOR 230V OPERATION)	75915	313.500
J1				CONNECTOR(INPUT HIGH) NSR, P/O W1 (EXCEPT OPTION 001)		
J2				CONNECTOR (OUTPUT,LOW) NSR, P/O W2 (EXCEPT OPTION 001)		
J3	1510-0038	8	2	BINDING POST ASSY SGL THD-STUD (OUTPUT GROUND) (DOES NOT INCLUDE THE FOLLOWING)	28480	1510-0038
	2190-0027	6	1	WASHER-LK INTL T 1/4 IN .256-IN-ID	28480	2190-0027
	2950-0006	3	2	NUT-HEX-DBL-CHAM 1/4-32-THD .094-IN-THK	00000	ORDER BY DESCRIPTION
J4				CONNECTOR(INPUT, HIGH) NSR, P/O W4 (EXCEPT OPTION 001)		
J5				CONNECTOR(INPUT,LOW) NSR, P/O W5 (EXCEPT OPTION 001)		
J6	1510-0038	8		BINDING POST ASSY SGL THD-STUD (INPUT GROUND) (DOES NOT INCLUDE THE FOLLOWING)	28480	1510-0038
	2190-0007	2	1	WASHER-LK INTL T NO. 6 .141-IN-ID	28480	2190-0007
	2950-0006	3		NUT-HEX-DBL-CHAM 1/4-32-THD .094-IN-THK	00000	ORDER BY DESCRIPTION
J7				CONNECTOR(OUTPUT,HIGH) NSR, P/O W7 (OPTION 001 ONLY)		
J8				CONNECTOR(OUTPUT, LOW) NSR, P/O W8 (OPTION 001 ONLY)		
J9				CONNECTOR(INPUT, HIGH) NSR P/O W9 (OPTION 001 ONLY)		
J10				CONNECTOR(INPUT LOW) NSR, P/O W10 (OPTION 001 ONLY)		
M1	1120-0694	5	1	METER-PANEL, LOG SCALE (DOES NOT INCLUDE THE FOLLOWING)	28480	1120-0694
	0380-0019	7	4	SPACER-RND .188-IN-LG .116-IN-ID	28480	0380-0019
	2260-0009	3	4	NUT-HEX-W/LKWR 4-40-THD .094-IN-THK	00000	ORDER BY DESCRIPTION
	2820-0002	4	2	NUT-HEX-DBL-CHAM 10-32-THD .094-IN-THK	00000	ORDER BY DESCRIPTION
	8150-0479	4	2	WIRE 24AWG W/BR/V 300V PVC 7X32 80C	28480	8150-0479
	8150-0481	8		WIRE 24AWG W/R/O 300V PVC 7X32 80C	28480	8150-0481
MP1				FOR MECHANICAL PARTS SEE PAGE 6-35		
Q1	1854-0669	9	1	TRANSISTOR NPN 2N6057 SI TO-3 PD=150W	04713	2N6057
	1200-0043	8	5	INSULATOR-XSTR ALUMINUM	28480	1200-0043
	2190-0018	5	6	WASHER-LK HLCL NO. 6 .141-IN-ID	28480	2190-0018
	08640-20057	5	6	INSULATOR-TRANSISTOR SCREW	28480	08640-20057
	0624-0459	7	6	SCREW-TPG 6-20 .75-IN-LG PAN-HD-POZI STL	00000	ORDER BY DESCRIPTION
S1	3101-2080	9	1	SWITCH-RKR BASIC DPDT 3A 250VAC SLDR-LUG (LINE SWITCH ONLY-SEE W12)	28480	3101-2080
S2	3101-0415	0	2	SWITCH-SL DPDT MINTR .5A 125VAC/DC (DOES NOT INCL MP31 OR THE FOLLOWING)	28480	3101-0415
	2190-0014	1	2	WASHER-LK INTL T NO. 2 .089-IN-ID	28480	2190-0014
	0520-0128	7	4	SCREW-MACH 2-56 .25-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
S3	3101-0415	0		SWITCH-SL DPDT MINTR .5A 125VAC/DC (DOES NOT INCL MP31 OR THE FOLLOWING)	28480	3101-0415
	2190-0014	1		WASHER-LK INTL T NO. 2 .089-IN-ID	28480	2190-0014
	0520-0128	7		SCREW-MACH 2-56 .25-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
T1	08903-60053	3	1	TRANSFORMER-POWER (INCLUDES THE FOLLOWING)	28480	08903-60053
	1251-3275	1	1	CONNECTOR 6-PIN F POST TYPE	28480	1251-3275
	1251-4283	3	6	CONTACT-CONN U/W-POST-TYPE FEM CRP	28480	1251-4283
	1400-0249	0	6	CABLE TIE .062-.625-DIA .091-WD NYL	06383	PLT1M-8
	2510-0136	8	2	SCREW-MACH 8-32 2.5-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
	2510-0135	7	2	SCREW-MACH 8-32 2.25-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
	3050-0139	6	8	WASHER-FL MTLC NO. 8 .172-IN-ID	28480	3050-0139
	0590-0049	8	4	NUT-HEX-PLSTC LKG 8-32-THD .172-IN-THK	28480	0590-0049
	0890-0983	5		TUBING-HS .125-D/.062-RCVD .02-WALL	28480	0890-0983
U1	1826-0203	8	1	IC 7815 V RGLTR TO-3	07263	7815KC
	1200-0043	8		INSULATOR-XSTR ALUMINUM	28480	1200-0043
	2190-0018	5		WASHER-LK HLCL NO. 6 .141-IN-ID	28480	2190-0018
	08640-20057	5		INSULATOR-TRANSISTOR SCREW	28480	08640-20057
	0624-0459	7		SCREW-TPG 6-20 .75-IN-LG PAN-HD-POZI STL	00000	ORDER BY DESCRIPTION
U2	1826-0169	5	1	IC V RGLTR TO-3	27014	LM320K-15
	1200-0043	8		INSULATOR-XSTR ALUMINUM	28480	1200-0043
	2190-0018	5		WASHER-LK HLCL NO. 6 .141-IN-ID	28480	2190-0018
	08640-20057	5		INSULATOR-TRANSISTOR SCREW	28480	08640-20057
	0624-0459	7		SCREW-TPG 6-20 .75-IN-LG PAN-HD-POZI STL	00000	ORDER BY DESCRIPTION

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
W1	08903-60039	5	1	CABLE-OUTPUT HIGH (EXCEPT OPTION 001)	28480	08903-60039
W2	08903-60040	8	1	CABLE-OUTPUT LOW (EXCEPT OPTION 001)	28480	08903-60040
W3	08903-60036	2	1	CABLE-FLOAT SWITCH S3	28480	08903-60036
W4	08903-60037	3	1	CABLE-INPUT HIGH (EXCEPT OPTION 001)	28480	08903-60037
W5	08903-60038	4	1	CABLE-INPUT LOW (EXCEPT OPTION 001)	28480	08903-60038
W6	08903-60035	1	1	CABLE-FLOAT SWITCH S2	28480	08903-60035
W7	08903-60043	1	1	CABLE-OUTPUT HIGH (OPTION 001 ONLY)	28480	08903-60043
W8	08903-60044	2	1	CABLE-OUTPUT LOW (OPTION 001 ONLY)	28480	08903-60044
W9	08903-60041	9	1	CABLE-INPUT HIGH (OPTION 001 ONLY)	28480	08903-60041
W10	08903-60042	0	1	CABLE-INPUT LOW (OPTION 001 ONLY)	28480	08903-60042
W11	08903-60028	2	1	CABLE-RIBBON (A1J1 TO A13J1)	28480	08903-60028
W12	08903-60029	3	1	CABLE-LINE SWITCH (INCLUDES S1 AND MP32- BUT NOT THE FOLLOWING)	28480	08903-60029
	2200-0164	5	1	SCREW-MACH 4-40 .188-IN-LG UNCT 82 DEG	00000	ORDER BY DESCRIPTION

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
				MECHANICAL PARTS		
MP1	08903-20024	4	1	FRAME-FRONT	28480	08903-20024
	8160-0226	0		RFI ROUND STRIP MNL-MSH .05-IN-OD	28480	8160-0226
MP2	5020-8836	5	4	CORNER STRUTS 15"	28480	5020-8836
	2510-0192	6	16	SCREW-MACH 8-32 .25-IN-LG 100 DEG (MP2 TO MP1, MP16)	28480	2510-0192
MP3	5040-7202	9	1	TRIM, TOP	28480	5040-7202
MP4	5060-9803	2	2	STRAP-HANDLE	28480	5060-9803
MP5	08903-00015	1	1	COVER-TOP	28480	08903-00015
MP6	5060-9992	0	1	COVER-BOTTOM	28480	5060-9992
MP7	5060-9936	2	2	COVER-SIDE	28480	5060-9936
MP8	08903-00022	0	1	TRAY-PULL-OUT CARD	28480	08903-00022
MP9	5040-7219	8	2	STRAP-HANDLE, CAP-FRONT	28480	5040-7219
	2680-0118	5	4	SCREW-MACH 10-32 .5-IN-LG 82 DEG (MP4, 8 TO MP1)	00000	ORDER BY DESCRIPTION
MP10	5040-7220	1	2	STRAP-HANDLE, CAP-REAR	28480	5040-7220
	2680-0118	5		SCREW-MACH 10-32 .5-IN-LG 82 DEG (MP4, 8 TO MP16)	00000	ORDER BY DESCRIPTION
MP11	5040-7201	8	4	FOOT	28480	5040-7201
MP12	5001-0439	8	2	TRIM-SIDE	28480	5001-0439
MP13	1460-1345	5	2	TILT STAND SST	28480	1460-1345
MP14	08903-00001	5	1	PANEL-FRONT DRESS (EXCEPT OPTION 001)	28480	08903-00001
MP14	08903-00020	8	1	PANEL-FRONT DRESS (OPTION 001 ONLY)	28480	08903-00020
MP15	08903-00002	6	1	SUB-PANEL, FRONT	28480	08903-00002
	2200-0107	6	8	SCREW-MACH 4-40 .375-IN-LG PAN-HD-POZI (A1 TO MP15)	00000	ORDER BY DESCRIPTION
	2360-0180	3	6	SCREW-MACH 6-32 .188-IN-LG 82 DEG (MP15 TO MP1 - TOP)	00000	ORDER BY DESCRIPTION
	2190-0047	0	6	WASHER-LK 82 CTSK EXT T NO. 6 .142-IN-ID	28480	2190-0047
	2360-0114	3	3	SCREW-MACH 6-32 .25-IN-LG 82 DEG (MP15 TO MP1 - BOTTOM)	00000	ORDER BY DESCRIPTION
MP16	08903-00014	0	1	PANEL-REAR	28480	08903-00014
	2360-0115	4	48	SCREW-MACH 6-32 .312-IN-LG PAN-HD-POZI (A13 TO MP16)	00000	ORDER BY DESCRIPTION
MP17	08903-00004	8	1	GUSSET-LEFT	28480	08903-00004
	2360-0115	4		SCREW-MACH 6-32 .312-IN-LG PAN-HD-POZI (MP19, MP20, A13 TO MP18)	00000	ORDER BY DESCRIPTION
	2360-0119	8	2	SCREW-MACH 6-32 .438-IN-LG PAN-HD-POZI (MP17 TO MP2)	00000	ORDER BY DESCRIPTION
MP18	08903-00005	9	1	GUSSET-RIGHT	28480	08903-00005
	2360-0115	4		SCREW-MACH 6-32 .312-IN-LG PAN-HD-POZI (MP19, MP20, A13 TO MP18)	00000	ORDER BY DESCRIPTION
	2360-0119	8		SCREW-MACH 6-32 .438-IN-LG PAN-HD-POZI (MP18 TO MP2)	00000	ORDER BY DESCRIPTION
MP19	08903-00006	0	1	GUSSET-FRONT	28480	08903-00006
	2360-0115	4		SCREW-MACH 6-32 .312-IN-LG PAN-HD-POZI (A13 TO MP19)	00000	ORDER BY DESCRIPTION
	2360-0117	6	12	SCREW-MACH 6-32 .375-IN-LG PAN-HD-POZI (MP19 TO MP2)	00000	ORDER BY DESCRIPTION
MP20	08903-00007	1	1	GUSSET-REAR	28480	08903-00007
	2360-0115	4		SCREW-MACH 6-32 .312-IN-LG PAN-HD-POZI (A13 TO MP20)	00000	ORDER BY DESCRIPTION
	2360-0117	6		SCREW-MACH 6-32 .375-IN-LG PAN-HD-POZI (MP20 TO MP2)	00000	ORDER BY DESCRIPTION
MP21	08903-00008	2	1	P.C BOARD SHIELD (BETWEEN A6 AND A7)	28480	08903-00008
	2360-0115	4		SCREW-MACH 6-32 .312-IN-LG PAN-HD-POZI (MP17, MP18, A13, MP23 TO MP21)	00000	ORDER BY DESCRIPTION
MP22	08903-00021	9	1	P.C BOARD SHIELD (BETWEEN A3, A4, A5, AND A6)	28480	08903-00021
	2360-0115	4		SCREW-MACH 6-32 .312-IN-LG PAN-HD-POZI (MP17, MP18 TO MP22)	00000	ORDER BY DESCRIPTION
MP23	08903-00011	7	1	INTERNAL SHIELD COVER (INCLUDES MP47 THROUGH MP51)	28480	08903-00011
MP24	08903-00012	8	1	FRAME SUPPORT-LEFT	28480	08903-00012
	2360-0115	4		SCREW-MACH 6-32 .312-IN-LG PAN-HD-POZI (A13 TO MP24)	00000	ORDER BY DESCRIPTION
	2360-0117	6		SCREW-MACH 6-32 .375-IN-LG PAN-HD-POZI (MP24 TO MP2)	00000	ORDER BY DESCRIPTION
MP25	08903-00013	9	1	FRAME SUPPORT-RIGHT	28480	08903-00013
	2360-0115	4		SCREW-MACH 6-32 .312-IN-LG PAN-HD-POZI (A13 TO MP24)	00000	ORDER BY DESCRIPTION
	2360-0117	6		SCREW-MACH 6-32 .375-IN-LG PAN-HD-POZI (MP25 TO MP2)	00000	ORDER BY DESCRIPTION

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
MP26	08903-20023	3	1	REAR PANEL HEATSINK	28480	08903-20023
	2200-0588	7	6	SCREW-MACH 4-40 .438-IN-LG PAN-HD-POZI (MP26, MP27 TO MP16)	00000	ORDER BY DESCRIPTION
	2190-0019	6	6	WASHER-LK HLCL NO. 4 .115-IN-ID (MP26, MP27 TO MP16)	28480	2190-0019
MP27	08903-00018	4	1	REAR LABEL PLATE (EXCEPT OPTION 001)	28480	08903-00018
MP27	08903-00019	5	1	REAR LABEL PLATE (OPTION 001 ONLY)	28480	08903-00019
MP28	08903-00010	6	1	REAR PANEL HEATSINK COVER	28480	08903-00010
	2460-0001	9	6	SCREW-MACH 6-32 .25-IN-LG PAN-HD-PHL BRS (MP28 TO MP26)	00000	ORDER BY DESCRIPTION
	2190-0018	5	6	WASHER-LK HLCL NO. 6 .141-IN-ID (MP28 TO MP26)	28480	2190-0018
MP29	2950-0035	8	8	NUT-HEX-DBL-CHAM 15/32-32-THD	00000	ORDER BY DESCRIPTION
	2190-0102	8	8	WASHER-LK INTL T 15/32 IN .472-IN-ID (A12J1-4 TO MP16)	28480	2190-0102
MP30	2950-0035	8		NUT-HEX-DBL-CHAM 15/32-32-THD	00000	ORDER BY DESCRIPTION
	2190-0102	8		WASHER-LK INTL T 15/32 IN .472-IN-ID (J7-10 TO MP16 - OPTION 001 ONLY	28480	2190-0102
MP31	08640-40052	2	2	FLOAT SWITCH LEVER (S2, S3)	28480	08640-40052
MP32	5041-1418	9	1	SWITCH-ROCKER (FOR S1)	28480	5041-1418
MP33	0510-1148	2	3	RETAINER-PUSH ON KB-TO-SHFT EXT (HOLDS MP14 TO MP15)	28480	0510-1148
MP34	08903-20022	2	1	WINDOW-LED	28480	08903-20022
MP35	08903-00017	3	1	POWER MODULE-TRANSFORMER COVER	28480	08903-00017
	2580-0003	5	2	NUT-HEX-W/LKWR 8-32-THD .125-IN-THK	00000	ORDER BY DESCRIPTION
MP36	7120-1254	1	1	NAMEPLATE .312-IN-WD .54-IN-LG AL	28480	7120-1254
MP37	7120-8053	2	1	LABEL-WARNING:FOR CONTINUED...	28480	7120-8053
MP38	7120-3528	6	1	LABEL-CAUTION:NO OPERATOR SERV...	28480	7120-3528
MP39	7120-4295	6	1	LABEL-WARNING:HAZARDOUS VOLTAGE...	28480	7120-4295
MP40	7120-5087	6	1	LABEL-WARNING:TO PREVENT ELECTRICAL...	28480	7120-5087
MP41	5040-7221	2	4	STANDOFF-REAR PANEL	28480	5040-7221
	2360-0197	2	4	SCREW-MACH 6-32 .375-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
MP42	1400-0116	0	2	STRAP-CABLE .25-DIA POLYETH (W12 TO A13)	28480	1400-0116
MP43	1400-0611	0	1	CLAMP-FL-CA 1-WD (APPLY TO MP19)	06915	CFCC-8
MP44	1400-1016	1	2	CLAMP MULTIPLE TYPE (APPLY TO MP19)	84971	TA-561 T S03-02
	2360-0115	4		SCREW-MACH 6-32 .312-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
MP45	0400-0164	7		GROMMET-CHAN PLAIN .03-IN-GRV-WD (APPLY TO MP19)	28480	0400-0164
MP46	0363-0146	5		CONTACT-FINGER .34-WD .075-FREE-HGT (APPLY TO MP19)	28480	0363-0146
MP47	08656-00014	0	1	RFI SPRING-REAR (FOR INSIDE SHIELD COVER, MP23)	28480	08656-00014
MP48	08656-00017	3	1	RFI SPRING-FRONT (FOR INSIDE SHIELD COVER, MP23)	28480	08656-00017
MP49	08903-00025	3	2	RFI SPRING-SIDES (FOR INSIDE SHIELD COVER, MP23)	28480	08903-00025
MP50	08903-00023	1	3	CUSHION STRIP-LONG (FOR INSIDE SHIELD COVER, MP23)	28480	08903-00023
MP51	08903-00024	2	3	CUSHION STRIP-SHORT (FOR INSIDE SHIELD COVER, MP23)	28480	08903-00024
MP52	9320-4241	8	1	INFO CARD-OPERATING	28480	9320-4241
MP53	9320-4242	9	1	INFO CARD-ERROR CODE/HP-IB/DISPLAY	28480	9320-4242

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Code List of Manufacturers

Mfr Code	Manufacturer Name	Address	Zip Code
00000	ANY SATISFACTORY SUPPLIER		
00853	SANGAMO ELEC CO S CAROLINA DIV	PICKENS SC	29671
01121	ALLEN-BRADLEY CO	MILWAUKEE WI	53204
01295	TEXAS INSTR INC SEMICOND CMPNT DIV	DALLAS TX	75222
01928	RCA CORP SOLID STATE DIV	SOMERVILLE NJ	08876
02111	SPECTROL ELECTRONICS CORP	CITY OF IND CA	91745
03888	KDI PYROFILM CORP	WHIPPANY NJ	07981
04713	MOTOROLA SEMICONDUCTOR PRODUCTS	PHOENIX AZ	85062
06383	PANDUIT CORP	TINLEY PARK IL	60477
06665	PRECISION MONOLITHICS INC	SANTA CLARA CA	95050
06915	RICHCO PLASTIC CO	CHICAGO IL	60646
07263	FAIRCHILD SEMICONDUCTOR DIV	MOUNTAIN VIEW CA	94042
17856	SILICONIX INC	SANTA CLARA CA	95054
18324	SIGNETICS CORP	SUNNYVALE CA	94086
18736	VOLTRONICS CORP	HANOVER NJ	07936
19701	MEPCO/ELECTRA CORP	MINERAL WELLS TX	76067
24046	TRANSITRON ELECTRONIC CORP	WAKEFIELD MA	01880
24355	ANALOG DEVICES INC	NORWOOD MA	02062
24546	CORNING GLASS WORKS (BRADFORD)	BRADFORD PA	16701
25088	SIEMENS CORP	ISELIN NJ	08830
27014	NATIONAL SEMICONDUCTOR CORP	SANTA CLARA CA	95051
27556	IMB ELECTRONIC PRODUCTS INC	SANTA FE SPGS CA	90670
28480	HEWLETT-PACKARD CO CORPORATE HQ	PALO ALTO CA	94304
34335	ADVANCED MICRO DEVICES INC	SUNNYVALE CA	94086
34371	HARRIS SEMICON DIV HARRIS-INTERTYPE	MELBOURNE FL	32901
51642	CENTRE ENGINEERING INC	STATE COLLEGE PA	16801
56289	SPRAGUE ELECTRIC CO	NORTH ADAMS MA	01247
72136	ELECTRO MOTIVE CORP SUB IEC	WILLIMANTIC CT	06226
74970	JOHNSON E F CO	WASECA MN	56093
75915	LITTELFUSE INC	DES PLAINES IL	60016
84411	TRW CAPACITOR DIV	OGALLALA NE	69153
84971	TA MFG CORP	LOS ANGELES CA	90039

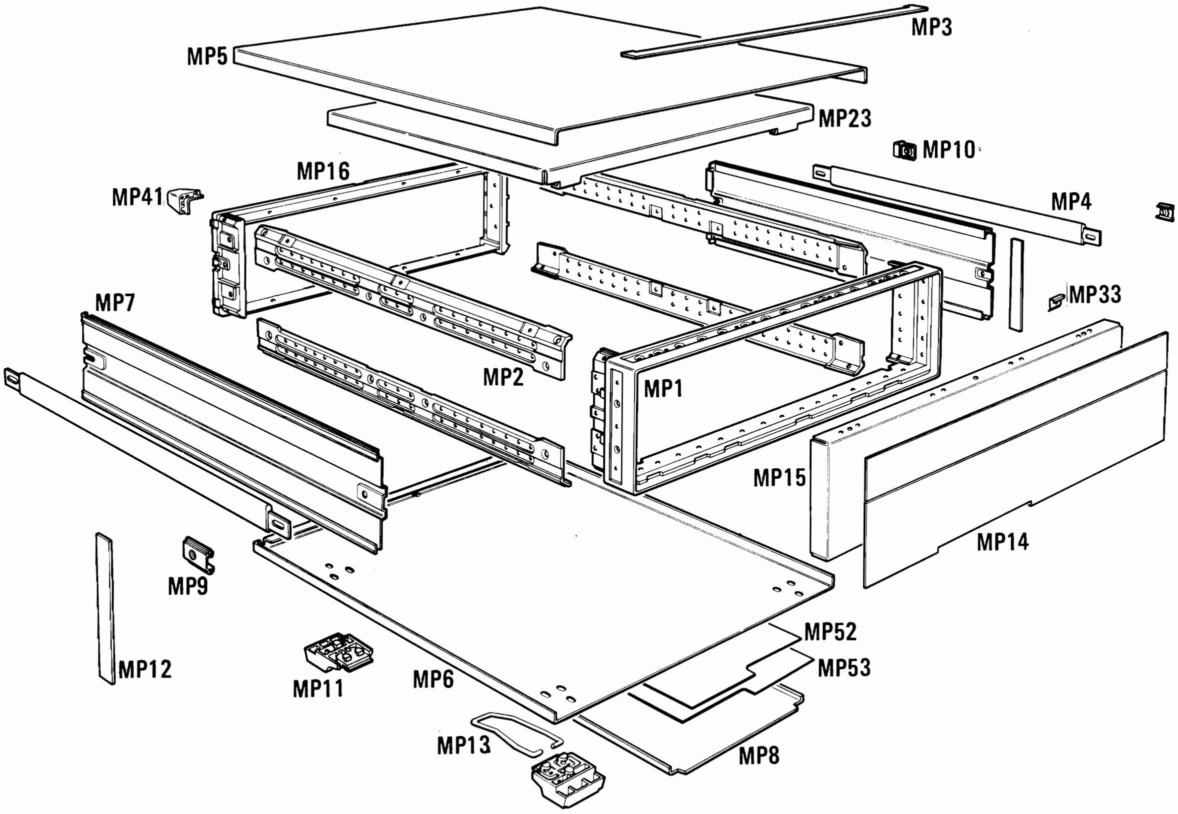


Figure 6-1. Cabinet Parts

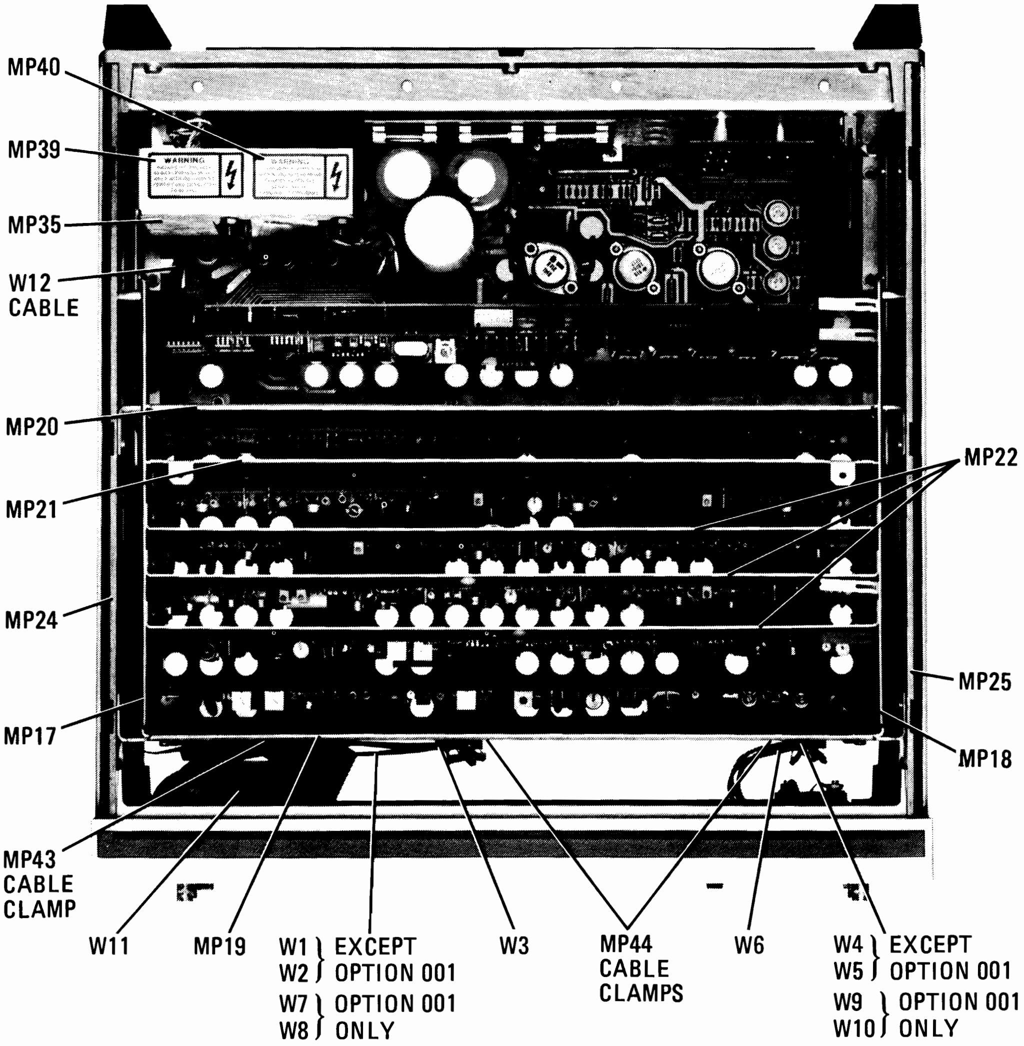


Figure 6-2. Top Chassis Parts, Mechanical Parts, and Cable Identification

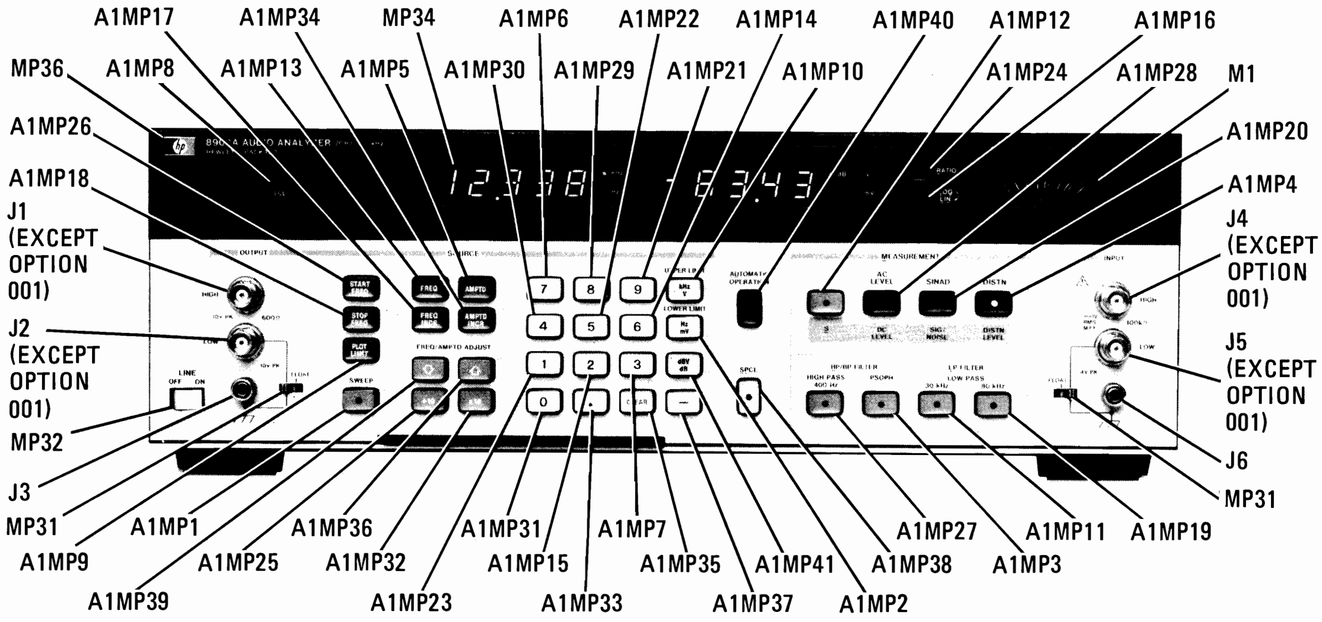


Figure 6-3. Chassis and Mechanical Parts Identification — Front Panel

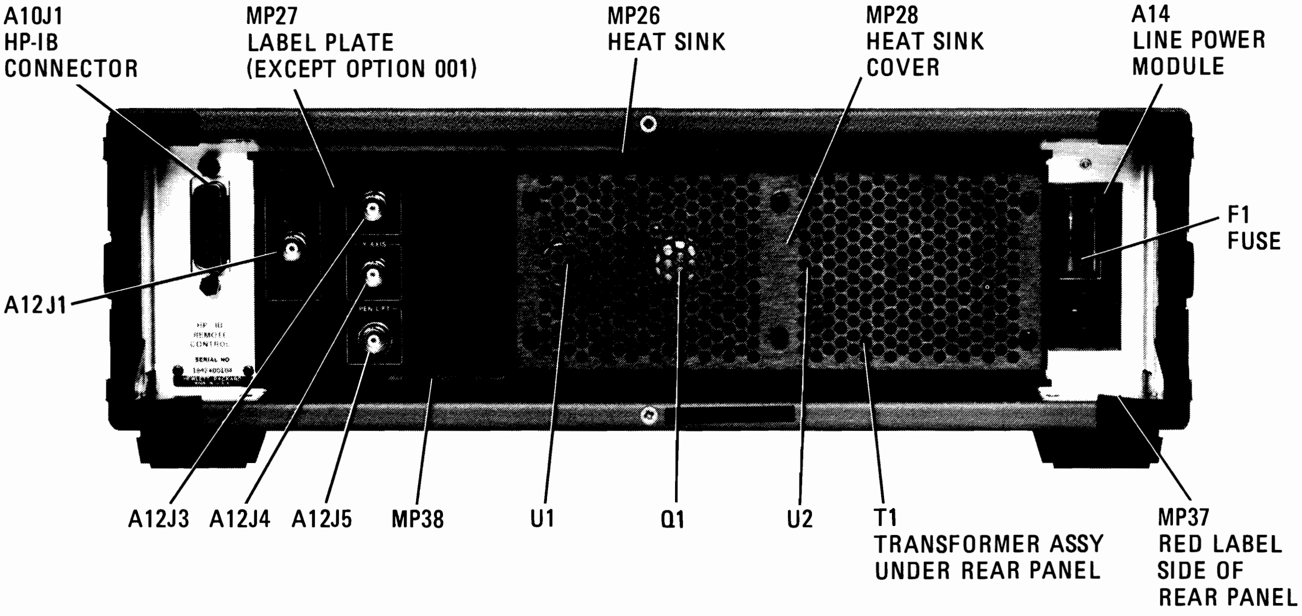


Figure 6-4. Chassis and Mechanical Parts Identification — Rear Panel

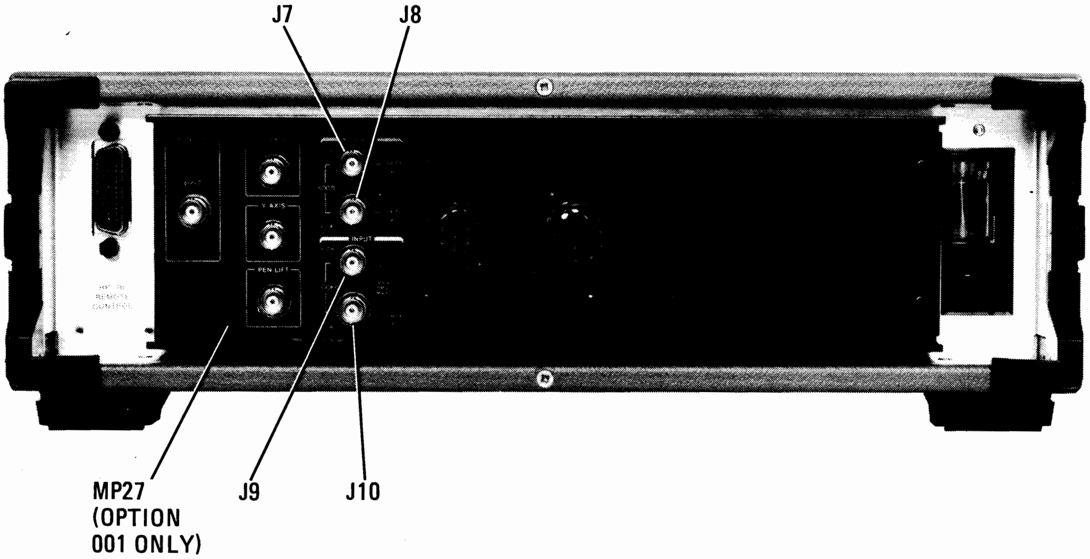


Figure 6-5. Chassis and Mechanical Parts Identification – Rear Panel, Including Option 001

SECTION VII
MANUAL CHANGES

7-1. INTRODUCTION

This section contains manual change instructions for backdating this manual for HP Model 8903A Audio Analyzers that have serial number prefixes that are lower than 2016A.

7-2. MANUAL CHANGES

To adapt this manual to your instrument, refer to Table 7-1 and make all of the manual changes listed opposite your instrument's serial number or prefix.

If your instrument's serial number or prefix is not listed on the title page of this manual or in Table 7-1, it may be documented in a MANUAL CHANGES supplement. For additional important information about serial number coverage, refer to INSTRUMENTS COVERED BY MANUAL in Section I of this manual.

Table 7-1. Manual Changes by Serial Number Prefix

Serial Number Prefix	Make Manual Changes
1942A	B, A
2006A	B

Table 7-2. Summary of Changes by Component

Change	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13
A	R28	R13, R15	L2	R86	CR16								
B						U3, C16							CR5

MANUAL CHANGES

7-3. MANUAL CHANGE INSTRUCTIONS

CHANGE A

Table 6-2:
Delete A1R28.

Table 6-2:
Change HP part number of A2R13 and A2R15 from 0757-0465 to 0698-8020 (no change in Description).

Table 6-2:
Delete A5CR16.

Service Sheet 6 (schematic):
Delete A1R28 (100 ohms, in series between +5V and the "+" connection of the panel meter).

Service Sheet 8 (schematic):
Delete A5CR16 from −15V (anode) to ground (cathode).

NOTES

On instruments with serial prefix 1942A inductor A3L2 has a value of 10 μH (HP 9140-0114). If A3L2 requires replacement, use 200 μH inductor (HP 9100-2340) which is listed in Section VI.

On instruments with serial prefix 1942A, if 1.21 kΩ resistor A4R86 requires replacement, use 1.24 kΩ resistor (HP 0698-3223), which is listed in Section VI.

CHANGE B

Table 6-2:
Change A6U3 to 1826-0569 CD9 IC OP AMP LOW-NOISE TO-99.

Service Sheet 10 (schematic):
Change the part number for A6U3 to 1826-0569.
Delete the ground connection from the negative side of A6C16.
Connect the negative side of A6C16 to pin 8 of A6U3.

NOTE

On instruments with serial prefix 2006A and below, diode A13CR5 is mounted on its heat sink without an insulator. If A13CR5 requires replacement, use insulator (HP 1200-0043), which is listed under A13CR5 in Section VI, between A13CR5 and the heat sink.

SECTION VIII
SERVICE

8-1. INTRODUCTION

This section contains information for troubleshooting and repairing the Audio Analyzer. Included are troubleshooting tests, schematic and block diagrams, and principles of operation (as outlined below):

- SERVICE SHEETS
  - Block Diagrams
  - Schematics
  - Additional Service Sheets
- SAFETY CONSIDERATIONS
  - Before Applying Power
  - Safety
- RECOMMENDED TEST EQUIPMENT AND ACCESSORIES
- SERVICE TOOLS, AIDS AND INFORMATION
  - Service Accessories
  - Service Tools
  - Assembly Locations
  - Parts and Cable Locations
  - Test Point and Adjustment Locations
  - Service Aids on Printed Circuit Boards
  - Other Service Documents
- TROUBLESHOOTING
  - General
  - Troubleshooting Strategy
  - Levels of Troubleshooting
- SPECIAL FUNCTIONS
  - Direct Control Special Functions
  - Service Special Functions
- ERROR MESSAGES
  - Service Errors
- POWER-UP CHECKS
- SIGNATURE ANALYSIS
- DISASSEMBLY PROCEDURE
- REPAIR
- RETROFITTING OPTIONS
- BASIC LOGIC SYMBOLOGY
- SERVICE SHEETS
  - Block Diagrams
  - Schematics
  - Principles of Operation
  - Troubleshooting Checks
  - Assembly and Disassembly Service Sheets
  - Service Special Functions and Error Message Summary

8-2. SERVICE SHEETS

The foldout pages in the last part of this section are block diagrams (BD1, 2, 3 and 4) and service sheets (1 to 21 and A to C).

8-3. Block Diagrams

Block Diagram 1 (BD1) is an overall block diagram that breaks the instrument into functional sections. It serves as an index to the other block diagrams and as a starting point for troubleshooting (refer to TROUBLESHOOTING, paragraph 8-20). The other block diagrams (BD2, BD3, and BD4) cover the Measurement, Source, and Digital Sections of the instrument, respectively. The power supply is included with the Measurement Section on BD2. These block diagrams break the sections into physical assemblies and serve as an index to the schematic Service Sheets. Included with the block diagrams are troubleshooting checks and discussions of the principles of operation.

8-4. Schematics

Service Sheets 1 through 20 consist of assembly schematic diagrams, principles of operation discussions, component locator photographs, troubleshooting checks and hints, and when necessary, mnemonic tables. Symbols used on the schematic diagrams are defined in paragraph 8-43.

8-5. Additional Service Sheets

Service Sheets A and B contain disassembly procedures and exploded views of the front and rear panel assemblies. Service Sheet C contains a summary of Service Special Functions and Error Messages.

8-6. SAFETY CONSIDERATIONS

8-7. Before Applying Power

Verify that the instrument is set to match the available line voltage and that the correct fuse is installed. An uninterrupted safety earth ground must be provided from the main power source to the instrument input wiring terminals, power cord, or supplied power cord set. In addition, verify that a common ground exists between the Audio Analyzer and all test equipment.

8-8. Safety

Pay attention to WARNINGS and CAUTIONS. They must be followed for your protection and to avoid damage to the equipment.

WARNINGS

Maintenance described herein is performed with power supplied to the instrument and with the protective covers removed. Such maintenance should be performed only by service-trained personnel who are aware of the hazards involved (for example, fire and electrical shock). Where maintenance can be performed without power supplied, the power should be removed.

Any interruption of the protective (grounding) conductor (inside or outside the instrument) or disconnection of the protective earth terminal will create a potential shock hazard that could result in personal injury. Grounding one conductor of a two conductor outlet is not sufficient. Whenever it is likely that the protection has been impaired, the instrument must be made inoperative (i.e., secured against unintended operation).

If this instrument is to be energized via an autotransformer, make sure that the autotransformer's common terminal is connected to the earth terminal of the power source.

Capacitors inside the instrument can still be charged even if the instrument is disconnected from its source of supply.

Make sure that only 250 volt fuses with the required rated current and of the specified type (normal blow, time delay, etc.) are used for replacement. Do not use repaired fuses or short-circuited fuseholders. To do so could create a shock or fire hazard.

CAUTIONS

Do not unplug any boards in the Audio Analyzer unless the instrument is unplugged or switched to OFF. Some boards contain devices which can be damaged if the board is removed when the power is on. Use conductive foam when removing MOS devices from sockets. Use care when unplugging ICs from high-grip sockets.

8-9. RECOMMENDED TEST EQUIPMENT AND ACCESSORIES

Test equipment and test accessories required to maintain the Audio Analyzer are listed in Tables 1-3 through 1-5. Equipment other than that listed may be used if it meets the listed critical specifications.

8-10. SERVICE TOOLS, AIDS AND INFORMATION

8-11. Service Accessories

The accessory items required for servicing the Audio Analyzer are listed in Section I (Table 1-5) of this manual. Three of the 44-contact extender boards (HP 08901-60084) are required for the observation of waveforms and signatures on the A7 assembly. Two of the 30-contact extender boards (HP 08901-60085) are required for the A3 and A4 assemblies. One each of the 44- and 30-contact extender boards are required for use with the A2, A5, and A6 assemblies. The Digital Test/Extender Board (HP 08903-60018) is required for troubleshooting the A8 Controller/Counter Assembly. Refer to Figure 8-1. The conductive polyurethane foam pad (HP 4208-0094) is required for the protection of MOS devices as cautioned in paragraph 8-8 and Service Sheets BD4 and 14.

8-12. Pozidriv Screwdrivers

Many screws in the Audio Analyzer appear to be Phillips type, but are not. To avoid damage to the screw slots, Pozidriv screwdrivers should be used. HP 8710-0899 is the No. 1 Pozidriv. HP 8710-0900 is the No. 2 Pozidriv.

8-13. Tuning Tools

For adjustments requiring non-metallic tuning tools, use the HP 8710-0033 blade tuning tool. For other adjustments an ordinary small screwdriver or suitable tool is sufficient. No matter which tool is used, never force any adjustment control. This is especially critical when adjusting variable inductors or capacitors.

8-14. Heat Staking Tool

The front panel pushbutton switches and the plastic divider on the front sub-panel have small plastic

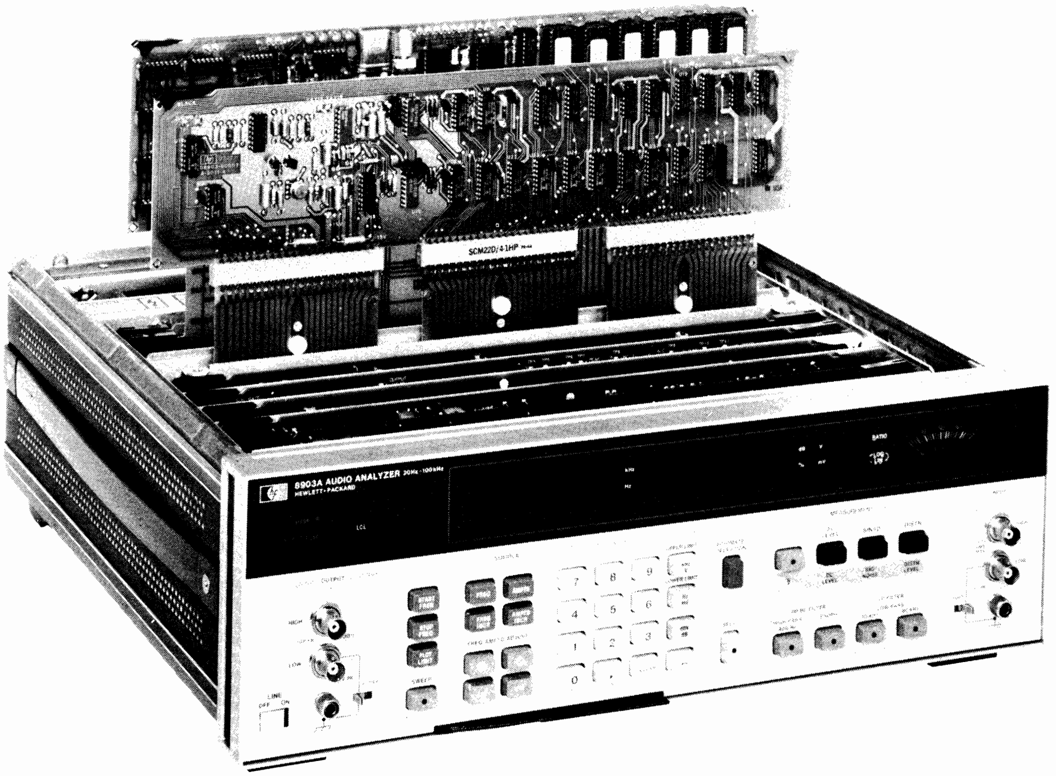


Figure 8-1. Assemblies A7 and A8 Shown on Extender Boards

pins protruding from the back. These tabs fit through holes in the front-panel printed circuit board (A1 assembly) and are melted down to hold the switch in place. This process is known as heat staking. The heat staking tool is a standard soldering iron with a special tip attached (see Figure 8-2).

Refer to Table 8-1 for specifications and recommended equipment. The front panel disassembly procedure given in Service Sheet A at the rear of this manual includes instructions on the heat staking operation.

8-15. Assembly Locations

Assemblies in the Audio Analyzer are numbered sequentially from front to back as shown in Figure 8-3. Assemblies A2 through A9 have color coded board extractors. (For example, assembly A6 has a black left extractor and blue right extractor. Thus, the color code of A6 is 06.) Assembly A1 is part of the front-panel assembly of the instrument.

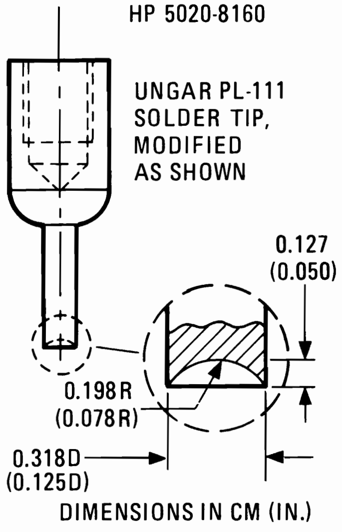


Figure 8-2. Heat Staking Tip

8-16. Parts and Cable Locations

The locations of individual components mounted on printed circuit boards or other assemblies are shown

Table 8-1. Etched Circuit Soldering Equipment

Item	Use	Specification	Item Recommended	HP Part No.
Soldering Tool	Soldering, Heat Staking	Wattage: 35W Tip Temp.: 390-440°C (735-825°F)	Ungar No. 135 Ungar Division Eldon Ind. Corp. Compton, CA 90220	8690-0167
Soldering Tip	Soldering, Unsoldering	*Shape: Chisel	*Ungar PL113	8690-0007
Soldering Tip	Heat Staking	Shape: Cupped	HP 5020-8160 or modified Ungar PL111 (See Figure 8-2).	5020-8160
De-Soldering Aid	To remove molten solder from connection	Suction Device	Soldapullt by Edsyn Co., Van Nuys, CA 91406	8690-0060
Rosin (flux) Solvent	To remove excess flux from soldered area before application of protective coating	Must not dissolve etched circuit base board	Freon	8500-0232
Solder	Component replacement; Circuit Board repair wiring	Rosin (flux) core, high tin content (63/37 tin/lead), 18 gauge (SWG) 0.048 in. diameter preferred.		8090-0607

*For working on circuit boards; for general purpose work, use No. 555 Handle (8690-0261) and No. 4037 Heating Unit 47½ — 56½ W (HP 8690-0006); tip temperature of 850° - 900°F; and Ungar No. PL113 ⅛" chisel tip.

adjacent to the schematic diagram on the appropriate service sheet. The part reference designator is the assembly designator plus the part designator. For example, A6R9 is R9 on the A6 assembly. For specific component descriptions and ordering information, refer to Table 6-2, Replaceable Parts, in Section VI. Chassis and frame parts, as well as mechanical parts and cables, are identified on Figures 6-1 through 6-5. In addition, Service Sheets A and B in this section contain illustrated parts breakdowns that locate many mechanical parts and cables.

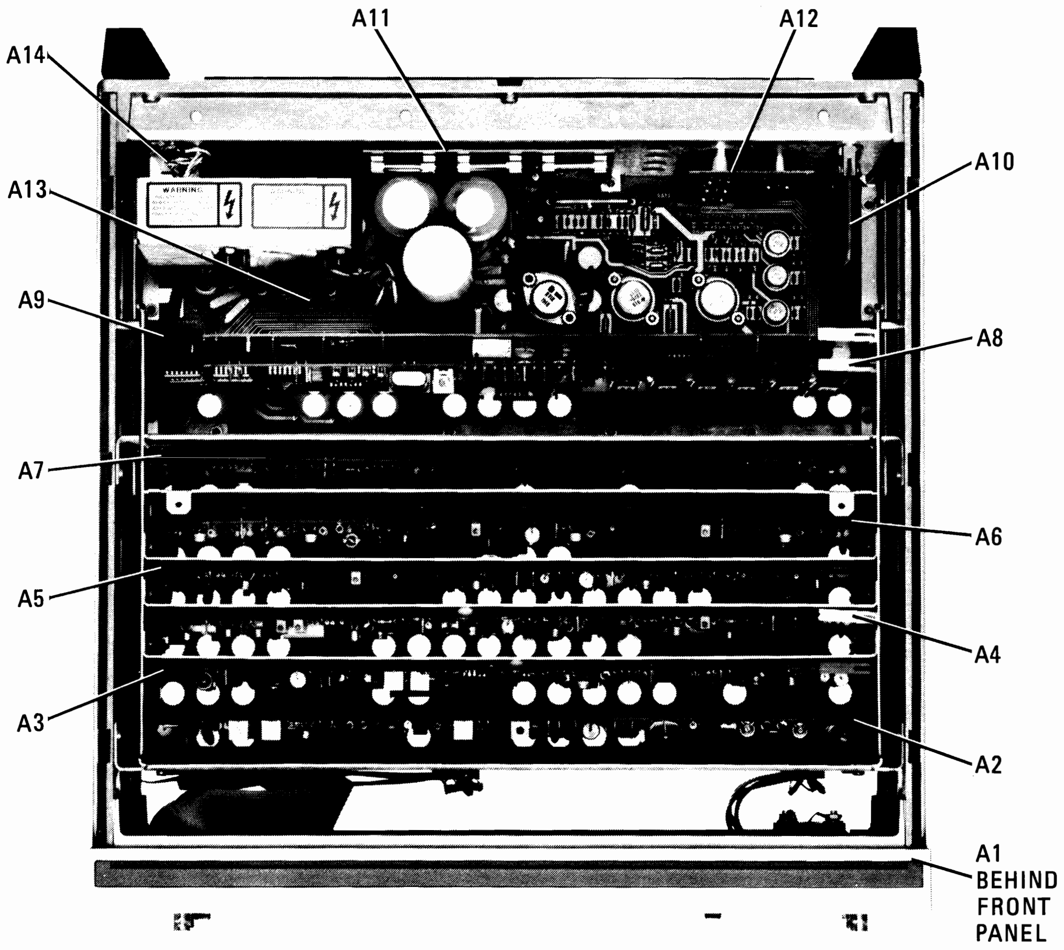
Major mechanical parts have reference designations that begin with the letters MP. Other mechanical parts, such as screws, are listed in the replaceable parts list below the part to which they fasten. To find the part number and description of a mechanical part, find the part in one of the figures in Section VI or Section VIII. The part in the figure will be labeled with its reference designator. Look up that reference designator in the Table of Replaceable Parts. If the part is a fastener, such as a screw, nut, or washer, look to the figure for the part to which it fastens. Then, look up the fastened part in the parts list. Just below it are the part numbers and description of the desired hardware.

8-17. Test Points and Adjustment Locations

Most test points and adjustments are indicated on the component locator photograph(s) on each applicable service sheet.

8-18. Service Aids on Printed Circuit Boards

Service aids on printed circuit boards include test points, indicator lights, transistor and integrated circuit and relay designations, adjustment names, cand assembly part numbers. Of particular importance are the four test LEDs and associated test points on the A8 Controller/Counter Assembly. These are used with the Audio Analyzer's power-up test routine to aid in troubleshooting the Controller.



Reference Designator	Assembly
A1	Keyboard and Display
A2	Input Amplifier
A3	Notch Filter
A4	Output Amplifier/Voltmeter
A5	Oscillator
A6	Output Attenuator
A7	Latch
A8	Controller/Counter
A9	Remote Interface
A10	Remote Interface Connector
A11	Series Regulator Socket
A12	Connector/Filter
A13	Power Supply and Mother Board
A14	Line Power Module

Figure 8-3. Assembly Locations

8-19. Other Service Documents

Service Notes, Manual Change Supplements, and other service literature are available through Hewlett-Packard. For further information, contact your nearest Hewlett-Packard office.

8-20. TROUBLESHOOTING

Instrument problems usually fall into three general categories: operator errors, operation out of specification, and catastrophic failures. The troubleshooting strategy is different for each category.

8-21. Operator Errors

Apparent failures sometimes can result from using the instrument outside of its range. Usually, the instrument can sense the condition and will display an error message. At other times it cannot, such as when it attempts to measure signals with frequencies higher than 100 kHz. Consult the Specifications table (Table 1-1) and the Detailed Operating Instructions in Section III for more detailed information.

8-22. Operation Out of Specification

The specifications are listed in Table 1-1. Performance Tests that can be used to verify the specifications are found in Section IV. If instrument performance is only slightly out of limits, it can sometimes be corrected by an adjustment. The procedures for adjustments are in Section V. References listed for each adjustment indicate which service sheet to consult when the adjustment procedure fails. In general, however, it is also a good practice to perform the troubleshooting checks on Service Sheet BD1, since they take only a few minutes and reveal much information.

8-23. Catastrophic Failures

Begin troubleshooting of catastrophic failures by performing the troubleshooting checks on Service Sheet BD1. The simple procedures there take only a few minutes and will quickly differentiate a control (digital) problem from a hardware (analog) problem. The checks then give cross-references to the detailed block diagrams (Service Sheets BD2 to BD4) or to a schematic.

The troubleshooting information found on all service sheets consists of a series of performance checks. The purpose of the checks is not to identify which circuit or component has failed but rather to verify whether or not the assembly or circuit is operating correctly. Information on the possible cause of failure is given in the form of hints whenever they can be given reliably. The limits given in the troubleshooting checks are rather loose to facilitate the use of general-purpose equipment (usually an oscilloscope). If a slightly-out-of-tolerance condition is suspected, the test can usually be run more rigorously paying greater attention to measurement accuracy.

Troubleshooting on the block diagram level normally utilizes User and Service Special Functions, while that on the schematic level often utilizes Direct Control Special Functions. Direct Control Special Functions will require some study of their operation before using them for the first time.

8-24. SPECIAL FUNCTIONS

8-25. General

Special Functions extend user control of the instrument beyond that normally available from the front panel. They are intended for the user who has an understanding of the instrument and the service technician who needs arbitrary control of the instrument functions. During normal use, the Audio Analyzer safeguards itself against invalid measurements. Safeguards come in the form of automatic tuning and ranging, overvoltage protection, and error messages. When Special Functions are used, some of these safeguards are removed, depending on the Special Function selected, and thus there is a degree of risk that the measurement may be invalid. (However, there is no risk of damage to the instrument.)

To enter a Special Function, enter the Special Function code (usually a prefix, decimal, and suffix), then press the SPCL key. The Special Function code will appear on the display as it is being entered. If a mistake is made during entry of the Special Function code, press the CLEAR key and start over. When a Special Function is entered, the light in the SPCL key will usually go on (if it is not already on). The readout on the display will depend on the Special Function entered — it may be a measured quantity, an instrument setting, or a special code, or in some cases the display is unaltered. Special Functions can be entered from the HP-IB by issuing the Special Function code followed by the code SP.

The Special Functions are grouped by prefix range as follows:

0: Direct Control Special Functions. These functions are used for service. They halt the functioning of the Controller and con-

General (Cont'd)

figure the instrument hardware as dictated by the suffix. All software safeguards are relinquished.

1-39: User Special Functions. These functions are used during normal instrument operation when a special configuration, measurement, or information is required. Many of the instrument safeguards remain implemented. More information on User Special Functions can be found under Special Functions in the Detailed Operating Instructions in Section III and on the Operating Information pull-out cards.

40-99: Service Special Functions. These functions are used to assist in troubleshooting an instrument fault. The functions available are quite diverse and include special internal measurements, software control, and special service tests and configurations. Safeguards are generally relinquished.

8-26. Direct Control Special Functions (Prefix 0)

Communication between the instrument's Controller and its hardware is via the Instrument Bus. During normal instrument operation, the Instrument Bus carries measurement results, status information, and commands (which control hardware). The Direct Control Special Functions halt the bus activity and send out commands as determined by the code suffix. One command is sent for each Special Function entry.

Direct Control Special Function Code Format. The Direct Control Special Function code is in the form 0.esd, where 0 is the prefix (which may be omitted) and esd represents a three-digit hexadecimal number. The significance of esd (which stands for enable, select, and data) is discussed in the Principles of Operation on Service Sheet BD4. Specific Direct Control codes are given in the Troubleshooting section of the individual service sheets.

As the Direct Control code is entered, the code will appear on the left display. Pressing the SPCL key initiates the Special Function. The displays will then be in the form rrrr (left display) and wwww (right display), where each digit represents a binary bit (1 or 0). The rrrr is the d (data) read back from the Instrument Bus. The wwww is the d (data) written to the bus. Thus rrrr and wwww are normally the binary form of the hexadecimal d. Exceptions to this are Special Functions 0.03d through 0.06d and 0.0Bd through 0.0Fd, which control the display itself.

Since the display has a limited set of segments for alphabetic characters, the hexadecimal characters A, B, C, D, E, and F are displayed on entry as —, E, H, L, P, and blank, respectively, and they are entered from the keyboard as Shift 0, Shift 1, Shift 2, etc., or from the HP-IB as X0, X1, X2, etc. Table 8-2 summarizes the hexadecimal entry and readback for Direct Control Special Functions.

Table 8-2. Hexadecimal Information for Direct Control Special Functions

Hexadecimal Character	Decimal Equivalent	Binary Equivalent	Keystroke Entry	HP-IB Code Entry	Display On Entry
0	0	0000	0	0	0
1	1	0001	1	1	1
2	2	0010	2	2	2
3	3	0011	3	3	3
4	4	0100	4	4	4
5	5	0101	5	5	5
6	6	0110	6	6	6
7	7	0111	7	7	7
8	8	1000	8	8	8
9	9	1001	9	9	9
A	10	1010	S (Shift) 0	X0	—
B	11	1011	S (Shift) 1	X1	E
C	12	1100	S (Shift) 2	X2	H
D	13	1101	S (Shift) 3	X3	L
E	14	1110	S (Shift) 4	X4	P
F	15	1111	S (Shift) 5	X5	(blank)

Direct Control Special Functions (Prefix 0) (Cont'd)

Direct Control Special Function Applications. Direct Control Special Functions are used in troubleshooting to provide manual control of various switches or digital-to-analog devices in the hardware where other special functions or front-panel keys prove ineffective. Some examples will illustrate how to use Direct Control Special Functions.

Example #1

In the measurement path of the input signal is a Programmable Gain Amplifier located on the A2 Input Amplifier Assembly. A simplified diagram of the circuit is shown in Figure 8-4. Amplifier gain is selected by analog switches U11A, U11B, U11C, and U11D. Table 8-3 shows the Direct Control Special Functions that can be used to control the switches. (Special Function 1.N is normally used to set the amplifier gain in troubleshooting. This example was chosen to illustrate the concept of Direct Control Special Functions because of its simplicity.)

To set the gain to 8 dB, key in 0.722 SPCL or .722 SPCL. The displays will show 0010 0010, indicating that the Controller received d=2 from the keyboard (or HP-IB), issued it to the Instrument Bus, and read it back. If circuitry on the assembly is working properly, only switch U11C should be closed, and thus the signal is amplified by 8 dB.

Table 8-3. Programmable Gain Amplifier Switching Direct Control Special Functions

Direct Control Special Function	Switch Closed	Gain (dB)
0.720	U11D	0
0.724	U11B	4
0.722	U11C	8
0.721	U11A	12

Notice that the display no longer shows a measurement result. No annunciators are lighted (except REMOTE and ADDRESSED if the Special Function is entered via HP-IB) and only the SPCL key is lighted. If any key other than a number key, the S (Shift) key, or the LCL key is pressed, the instrument hardware will revert back to the measurement mode it was in before the Direct Control Special Function was entered. Thus, in this example, unless 8 dB gain had been previously set, it would be removed from the audio path when any other key is pressed. (However, note that there are some Service Special Functions that will maintain the requested configurations even if another key is pressed.)

As it turns out, 0.72d codes other than those shown in Table 8-3 will affect the gain of the

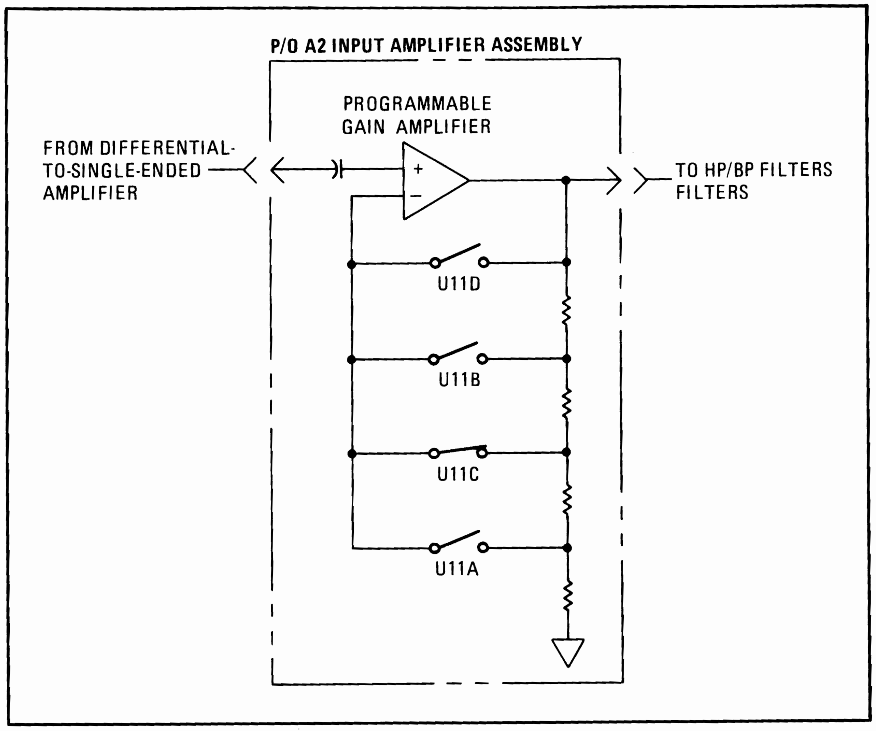


Figure 8-4. Example Showing Programmable Gain Amplifier Switching

Direct Control Special Functions (Prefix 0)(Cont'd)

Programmable Gain Amplifier. For example, 0.723 will close U11C and U11A simultaneously (gain is now 10.6 dB). This fact is ascertained from the service sheet schematics.

Example #2

A second example from the A2 assembly illustrates data readback. One of the means of detecting an overrange of the input circuits is by the Input Overload Detector. The detector connects to both the input (directly) and output (through the Input RMS Detector) of the Programmable Gain Amplifier of Example #1. See Figure 8-5. At the input of the amplifier, the Input Overload Detector senses the dc level and compares it against both a positive and negative reference. At the output of the Input RMS Detector it also compares the dc level (and hence the ac level of the signal) against a reference. If any detected level exceeds a reference, the output of the detector goes low and resets flip-flop A7U14 on the A7 Latch Assembly. A7U14 also sets the gain of all input circuits up to and including the Programmable Gain Amplifier to minimum gain without intervention of the Controller. A7U15B, when enabled, inverts the output of A7U14. The output of A7U14 is across the least significant bit of the readback data line of the Instrument Bus. In the normal measurement cycle, the Controller reads the status of the Input Overload Detector (by enabling A7U15B and reading its output) and takes corrective action if A7U14 has tripped.

At this point in the discussion, a more detailed description of the Instrument Bus data lines is needed. Data (d) is sent out from the I/O port of the Controller to the Instrument Bus through buffers (TTL inverters). However, data is read back to the I/O port directly, bypassing the buffers. An I/O port outputs a low by actively pulling the line to ground. It outputs a high by allowing the output to be passively pulled up by an external pull-up resistor. When a Controller I/O port inputs data from other circuits of the Audio Analyzer, these circuits must operate against the pull-up resistor.

Readback devices that are read out to the data lines, such as A7U15B, are similarly config-

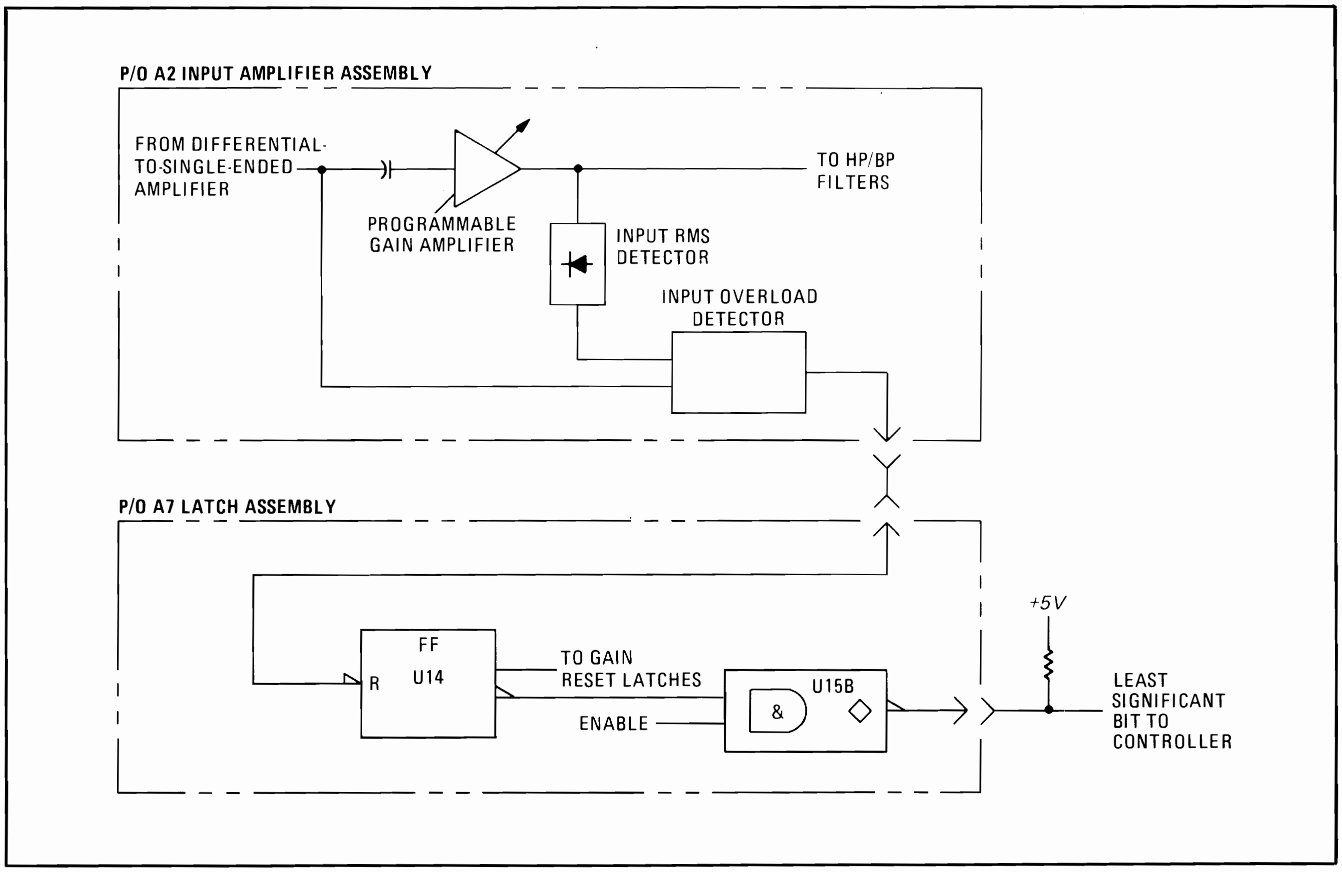


Figure 8-5. Example Showing Input Overload Detector Readback

Direct Control Special Functions (Prefix 0) (Cont'd)

ured. A7U15B has an open-collector TTL output. When it outputs data, a low is produced by switching the output device to ground. A high is produced by switching the device off and allowing the output to be passively pulled up. The readback lines are low true (i.e., r=1 when the line is low).

When A7U15B is disabled (enable is low), the output is high (inactive) and has no effect on the data line. A7U15B is enabled by Direct Control Special Function 0.70d. The value of d is arbitrary to enable A7U15B, but the least-significant bit must be 0 (i.e., d must be even) to switch off the output device of the I/O data port.

To clarify this, suppose that A7U14 has not been reset. If Direct Control Special Function 0.700 is entered, the displays will show 0000 0000. The second four digits are 0000 because d=0 was received by the Controller from the keyboard and issued to the Instrument Bus. The un-reset flip-flop puts a low on the input of A7U15B and an inactive high on the least-significant data line. This is read by the Controller as r=0 and thus is the same as the bit issued. The other three data readback lines are unaffected by the readback command and remain 000. Thus the d read back is 0000.

If A7U14 is reset, A7U15B puts a low on the least-significant data bit (r=1), and the data read back is 0001. The displays are therefore 0001 0000. (Note that rrrr is different from wwww.) If d is keyed in as a hexadecimal F, the displays are 1111 1111 regardless of the state of A7U15B. This is because all output devices on the data I/O port of the Controller are on (logical 1).

One final note, after a Direct Control Special Function is entered, it is periodically re-issued to the Instrument Bus. If a fault causes rrrr to indicate a malfunction, the display will begin to read correctly as soon as the fault is removed. For example, if you key in 0.700 SPCL then increase the input signal level until an overload condition is reached, you will find that the displays show 0000 0000 continuously except for the instant the overload is detected when the displays momentarily blink 0001 0000. An automatic resetting of the input circuits removes the overload as soon as it is detected so the overload is observed only for one period of the Direct Control Special Function cycle.

8-27. Service Special Functions (Prefix 40-99)

The Service Special Functions are used to perform a variety of tasks related to service. The functions are cataloged below. A suffix N indicates that a parameter other than 0 may be required to complete the Special Function Code. See Table 8-2 for entry of hexadecimal suffixes.

40.0 **Controller Reset.** Initializes the Controller to its power-up state. Because this disturbs the HP-IB hardware, it is unavailable from the interface bus (gives Error 24). Power-up sequence is discussed in paragraph 8-31.

41.0 **Controller Clear.** Initializes the Controller to its power-up state but bypasses the operational checks (see paragraph 8-31). Leaves HP-IB hardware unaffected but clears any service request message (SRQ) being issued by the Audio Analyzer, sets the service request condition to its power up state, and clears all bits in the status byte.

42.0 **Display Software Date.** Displays the date of the software in the form <month of year> <day of month> in the left display and (year) in the right display.

43.N **Service Error Display Control.** Service Errors are numbered 65 to 95. Refer to paragraph 8-30.

N=0 Disables display of Service Errors.
N=1 Enables display of Service Errors.
N=65 to N=95 Enables display of only the Service Error specified by N. Operating and Entry Errors remain enabled.

44.N **Notch Filter Mode Select.** Permits manual selection of one of three configurations of the Notch Filter.

N=0 Notch Filter mode selected automatically as required by the measurement mode.
N=1 Notch Filter in notch mode.
N=2 Notch Filter in flat mode.
N=3 Notch Filter in bandpass mode.

45.N **SINAD Meter Enable.** Permits the SINAD meter to be enabled for measurement modes

Service Special Functions (Prefix 40-99) (Cont'd)

other than SINAD and in SINAD for measurements greater than 24 dB. It is most often useful for reading distortion when the displayed reading is very noisy. When this Special Function is invoked, the meter reads the ratio of the level at the Input RMS detector to the Output RMS (Avg) Detector expressed in dB. The reading must, therefore, be interpreted relative to the dB reading in the right display. Usually, this entails ignoring the minus sign and subtracting multiples of 20 dB. For example, a distortion reading of −66.80 dB in the right display may be indicated as 6.8 dB on the SINAD meter or −76.80 dB may be indicated as 16.8 dB. AC level readings will normally be 0 dB.

N=0 SINAD meter enabled normally. See Detailed Operating Information in Section III.
N=1 SINAD meter enabled in all measurement modes except dc level.

46.N Count Internal Signals. The Counter counts the internal signal selected by N and displays the count. The resolution is the same as would normally be displayed.

N=0 Oscillator Frequency. See Service Sheets 9 and 13.
N=1 Input Frequency. See Service Sheets 2 and 13.
N=3 Output Amplifier Frequency. See Service Sheets 5 and 13.

48.N Defeat Output Amplifier Overdrive Protection. In the ac level and signal-to-noise measurement modes, the gain of the Output Amplifier is normally set to 0 dB whenever the signal detected by the Input RMS Detector exceeds 0.6V and a low-pass filter has been selected. This prevents the first amplifier after the Notch Filter from being overdriven by signals in the stopband which would normally be detected by the Output RMS (Avg) Detector. When this Special Function is invoked, the Output RMS (Avg) Detector is used to determine the gain setting of the Output Amplifier. Use of this function permits measurement of filters (such as the internal Psophometric Filter) with extended dynamic range, but care must be taken not to overload the selected low-pass filter (either 30 or 80 kHz).

N=0 Output Amplifier gain determined normally.
N=1 Output Amplifier gain determined by the Output RMS (Avg) Detector.

49.N Display Internal Voltages. The Voltmeter measures and displays the internal voltage selected by N.

N=0 Ground. See Service Sheet 7.
N=1 Input RMS Detector with Ripple Filter. See Service Sheets 2 and 7.
N=2 DC Input Voltage without Filter. See Service Sheet 1.
N=3 Output RMS (Avg) Detector with Ripple Filter. See Service Sheets 6 and 7.
N=4 Output RMS (Avg) Detector. See Service Sheet 6.
N=5 Output RMS (Avg) Detector with SINAD Filter. See Service Sheets 6 and 7.
N=6 Notch Tune Voltage. See Service Sheet 4.
N=7 DC Input Voltage with Filter. See Service Sheet 1.

NOTE

The suffix can also be two digits, XY. The difference (49. X SPCL — 49.Y SPCL) is then displayed. For example, 49.3 SPCL or 49.30 SPCL gives a display of the Output RMS (Avg) Detector with Ripple Filter with respect to ground. 49.34 SPCL gives a display of the difference between the Output RMS (Avg) Detector with Ripple Filter and the same detector without the Ripple Filter.

50.N Display Oscillator Frequency. The frequency of the Oscillator is displayed on the left display in all measurement modes except dc level and where a valid measurement cannot be made. The right display operates as usual. Resolution is the same as it would be if it had been an input signal.

N=0 Display frequency as normal.
N=1 Display Oscillator frequency.

52.N Read Only Memory Verification. The Controller displays the checksum of the read only memory (ROM) specified by N. When specifying a ROM, use N=1 through 10. The Display is in the form <actual checksum> in

Service Special Functions (Prefix 40-99) (Cont'd)

the left display and <expected checksum> in the right display. Both displays should show 0 for ROM 10. See Service Sheet 16.

53.N **Notch Filter Frequency Range.** Permits the frequency range of the Notch Filter to be displayed or manually set. If no suffix is keyed in (i.e., 53. SPCL), the current Notch Filter range is displayed where 0 is the lowest range and 3 is the highest. For N=0 through 3, the Notch Filter is set to the range specified by N. See Service Sheet 9 and Special Function 54.N.

54.N **Notch Filter Coarse Tune.** Permits the coarse tune code of the Notch Filter to be displayed or manually set. If no suffix is keyed in (i.e., 54. SPCL), the current Notch Filter coarse tune code is displayed where 0 is the lowest frequency and 255 is the highest. For N=0 through 255, the Notch Filter coarse tune code is set to the number specified by N. (N is keyed in as a decimal value and not a hexadecimal value.) Fine tuning of the Notch Filter is via the automatic tuning circuitry on the Notch Filter Assembly. See Service Sheet 9 and Special Function 53.N.

55.N **Oscillator Frequency Range.** Permits the frequency range of the Oscillator to be displayed or manually set. If no suffix is keyed in (i.e., 55. SPCL), the current Oscillator range is displayed where 0 is the lowest range and 3 is the highest. For N=0 through 3, the Oscillator is set to the range specified by N. See Service Sheet 8 and Special Functions 56.N and 57.N.

56.N **Oscillator Coarse Tune.** Permits the coarse tune code of the Oscillator to be displayed or manually set. If no suffix is keyed in (i.e., 56. SPCL), the current Oscillator coarse tune code is displayed where 0 is the lowest frequency and 255 is the highest. For N=0 through 255, the Oscillator coarse tune code is set to the number specified by N. (N is keyed in as a decimal value and not hexadecimal value.) See Service Sheet 9 and Special Functions 55.N and 57.N.

57.N **Oscillator Fine Tune.** Same as Special Function 56.N except that it pertains to fine tuning.

58.N **Source Fine Level.** Permits the fine level code of the Source to be displayed or manually set. If no suffix is keyed in (i.e., 58. SPCL), the current Source level code is displayed where 0 is the lowest level and the 255 is the highest. For N=0 through 255, the Source fine level code is set to the number specified by N. (N is keyed in as a decimal value and not a hexadecimal value.) See Service Sheet 10 and Special Function 59.N.

59.N **Source Coarse Level.** Permits the coarse level code of the Source to be displayed or manually set. If no suffix is keyed in (i.e., 59. SPCL), the current Source coarse level code is displayed where 31 is the lowest level, 0 is the highest, and 32 through 63 switch the level off. For N=0 through 63, the Source coarse level code is set to the number specified by N. For N=0 through 31, the level is controlled in 2.5 dB steps where the attenuation is N × 2.5 dB. (N is keyed in as a decimal value and not a hexadecimal value.) See Service Sheet 11 and Special Function 58.N.

60.0 **Key Scan.** The keyboard is scanned and a keycode is displayed and output to the HP-IB. The key codes are shown in Figure 8-6.

To use the Key Scan Special Function, remove the instrument top cover. Key in 60.0 SPCL then jumper A9TP7 (INT) to A9TP1 (GND) on the A9 Remote Interface Assembly. Press the front-panel keys and observe the right display. If two or more keys are pressed simultaneously, the display shows the first one found in its normal scan. See Service Sheet 17.

Two simple programs for displaying the key codes on a computing controller are shown in Table 8-4. Removal of the top cover is unnecessary. The Audio Analyzer is assumed to have HP-IB address 28.

61.N **Display HP-IB Status.** Displays the status of the HP-IB lines selected by N. The display is in binary. See Service Sheet 19 for troubleshooting and a complete list of HP-IB mnemonics.

Service Special Functions (Prefix 40-99) (Cont'd)

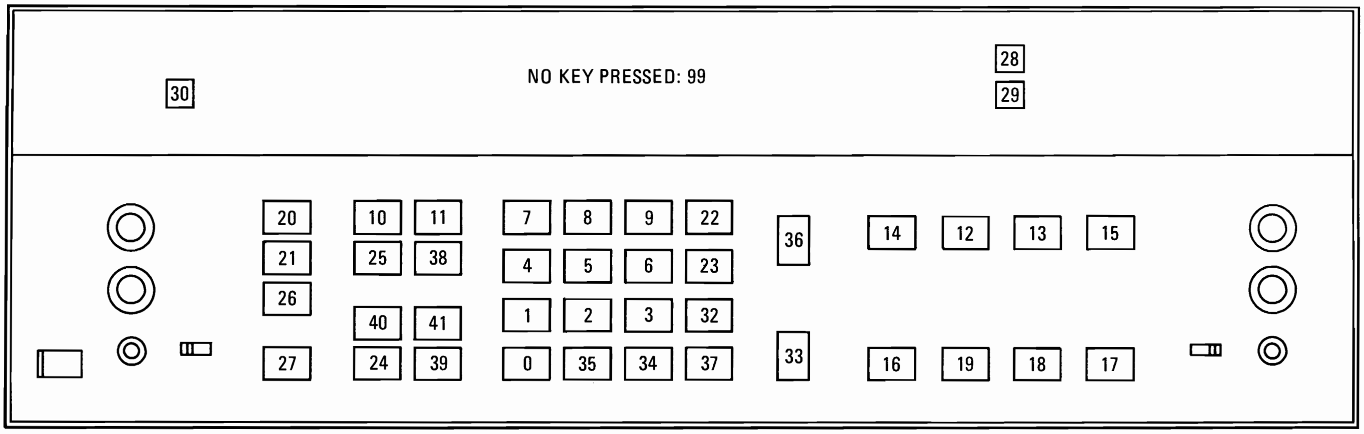


Figure 8-6. Key Codes for Key Scan (Service Special Function 60.0)

Table 8-4. Key Scan Programs

HP 9825A (HPL) Program	HP 9835A and 9845A (BASIC) Program
0: fxd 0 1: rem 728; llo 7 2: wrt 728, "60.SP" 3: red 728,A; 4: dsp A; jmp -1 5: end	10 FIXED 0 20 REMOTE 728 30 LOCAL LOCKOUT 7 40 OUTPUT 728; "60.SP" 50 ENTER 728; A 60 DISP A 70 GOTO 50 80 END

NOTE

Binary representations of the information in pointed brackets appear on the Audio Analyzer's displays.

N=0 Displays <0> in the left display and <Addressed to Talk> . <Addressed to Listen> in the right display. This function reads back and displays the present state of the Talk and Listen Address flip-flops (A9U1A and U1B). For example, if the displays show 1 and 0, the Audio Analyzer is addressed to talk (and is unaddressed to listen). This means the Talk Address flip-flop is set (and the Listen Address flip-flop is reset).

N=1 Displays <0> in the left display and <DAV>.<RFD><DAC> in the right display. This function reads back and displays the present state of the three bus handshake lines. <DAV> reflects the state of the Data Valid bus handshake line as being driven by the Audio Analyzer (1 = being driven; 0 = not being driven). Thus, when in Listen Only, this display will always show 0 for <DAV>. The <RFD> and <DAC> always track the bus lines Ready For Data and Data Accepted. For example, 1 for <RFD> means line Ready For Data is true (high).

N=2 Displays <0> in the left display and <ATN> . <REN> in the right display. This function reads back and displays the present state of the ATN (Attention) bus control line and the state of the Remote Enable Flip-Flop. A 1 for either <ATN> or <REN> indicates ATN is true (low at the bus) or that the Remote Enable Flip-Flop is set.

N=3 Displays <0> in the left display and <SPM> . <SRQ> in the right display. This function reads back and displays the state of the Serial-Poll Flip-Flop and the state of the SRQ bus control line as being driven by the Audio Analyzer. A 1 for either <SPM> or <SRQ> indicates the Audio Analyzer is in serial-poll mode (SPM) or that it is presently driving the SRQ bus control line.

N=4 Displays PIO Port A with the most-significant bits in the left display and the least-significant bits in the right display. This function inputs

Service Special Functions (Prefix 40-99) (Cont'd)

and displays (without modifying) the data at PIO port A (A9U18). Leading zeros in both displays are blanked. The display is interpreted as shown in Table 8-5.

N=5 Displays PIO Port B with the most-significant bits in the left display and the least-significant bits in the right display. This function is similar to Special Function 61.4 except PIO port B is displayed. The display is interpreted as shown in Table 8-6.

N=6 Displays the HP-IB Status Register with <SPM> <STSO> <SRQ> <LLO> in the left display and <REM> <ADRSD> <TRIG> <HOLD/DELAY> in the right display. The status register is contained in RAM.

Table 8-5. PIO Port A

A9U18 Pin No.	2	37	36	31	30	25	24	19
Display Digit	1	2	3	4	5	6	7	8
Mne-monic	IO8	IO7	IO6	IO5	IO4	IO3	IO2	IO1
1 = True								

Table 8-6. PIO Port B

A9U18 Pin No.	1	38	35	32	29	26	23	20
Display Digit	1	2	3	4	5	6	7	8
Mne-monic	ATN	ARD	AAD	SRQ	RNL	ATT	ATL	SDV
1 = True								

8.28. ERROR MESSAGES

8-29. General

The instrument generates error messages to indicate operating problems, incorrect keyboard entries, or service-related problems. The error message is generally cleared when the error condition is removed.

The Error Messages are grouped by error code as follows:

Error 10 through Error 39 and Error 96. These are Operating and Entry Errors which indicate that not all conditions have been met to assure a calibrated measurement or that an invalid key sequence or keyboard entry has been made. Operating Errors can usually be cleared by readjustment of the front-panel controls. The Error Disable Special Function (8.N) can be used to selectively disable certain operating error messages. Entry Errors require that a new keyboard entry or function selection be made. More information on Operating and Entry Errors and error message disabling can be found under Error Message Summary and Error Disable in the Detailed Operating Instructions in Section III and on the Operating Information pull-out cards.

Error 65 through Error 95. These are Service Errors which provide additional service-related information and are discussed below.

8-30. Service Errors (Error 65 through Error 95)

Service Errors are not normally displayed. When a service-related problem is suspected, enable the Service Errors by keying in 43.1 SPCL. Also a specific error message can be enabled by keying in 43.N where N is the number of the desired error message (N=65 through 95). Service Errors can be disabled by keying in 43.0 SPCL or by pressing AUTOMATIC OPERATION. Not all Service Errors are an indication of a problem but may be a normal occurrence under the circumstances. When Service Errors are not enabled, a Service Error will often map into an Operating or Entry Error; when Service Errors are enabled, both Service and Operating or Entry Errors are displayed sequentially.

Error 65 **Decimal Point Fixed Too Far to the Left.** The decimal point has been held by Special Function 4.N and the reading to be displayed is too large to fit the display. This error maps into Error 10.

Error 70 **Cannot Count Oscillator Frequency.** When the Oscillator is being tuned (i.e., when a new frequency is entered or a new measurement mode requiring tuning has been selected), the frequency count is 0. See Service Sheets BD3 and BD4. This error maps into Error 19.

Service Errors (Error 65 through Error 95) (Cont'd)

Error 71 **Oscillator Tune Abort.** The Oscillator failed to tune after three attempts. See Service Sheet BD3. This error is identical to Error 18.

Error 72 **AC Input Overload with Input Range Hold.** For all measurements except dc level, the Input Overload Detector has tripped while the input level range has been held with Special Function 1.N. See Service Sheet BD2. This error maps into Error 30.

Error 73 **Input AC Level Abort.** For all measurements except dc level, the Input Amplifier failed to level after three attempts. This would be normal for an unstable signal. See Service Sheet BD2. This error maps into a display of "— — — —" until Error 31 appears.

Error 74 **Output Amplifier Overload with Output Amplifier at 0 dB Gain.** The Output Overload Detector has tripped with the Output Amplifier gain at 0 dB. See Service Sheet BD2. This error maps into a display of "— — — —" until Error 31 appears.

Error 75 **DC Input Overload with Input Range Hold.** For a dc level measurement only, the Input Overload Detector has been tripped while the input level range has been held with Special Function 2.N. See Service Sheet BD2. This error maps into Error 30.

Error 76 **Too Much AC for DC Level Measurement.** For a dc level measurement, the Input Overload Detector has tripped because of too much ac (as sensed by the Input RMS Detector). This error maps into Error 14 or generates a normal range down.

Error 77 **Output Amplifier Gain Too High after Leveling Once.** The Output RMS (Avg) Detector has sensed too high a level after one attempt to set the Output Amplifier Gain. This would be normal for an unstable signal. See Service Sheet BD3. This error maps into a display of "— — — —" until Error 31 appears.

Error 78 **Output Amplifier Overload after Leveling Once.** The Output Overload Detector has tripped after one attempt to set the Output Amplifier gain. This would be normal for an unstable signal. See Service Sheet BD3. This error maps into a display of "— — — —" until Error 31 appears.

Error 79 **Output Amplifier Overload with No Post-Notch Gain Hold.** The Output Overload Detector remains tripped after three attempts to set the Output Amplifier gain and Special Function 3.N is in automatic selection. See Service Sheet BD3. This error maps into a display of "— — — —" until Error 31 appears.

Error 80 **Cannot Count Oscillator Frequency in SINAD.** When the Oscillator is attempting to tune to the frequency of the Notch Filter, the frequency count is 0. See Service Sheets BD3 and BD4. This error maps into Error 19.

Error 81 **Cannot Count Input Frequency.** The input frequency cannot be counted in ac level, distortion, distortion level, or signal-to-noise measurement modes. See Service Sheet BD2. This error maps into Error 13.

Error 82 **Notch Filter Does Not Null.** The Notch Filter does not null after three attempts. This would be normal for an erratic signal. See Service Sheet BD2. This error maps into Error 13.

Error 83 **Cannot Count Input Frequency.** After sensing the presence of a signal, the count is 0. This would be normal when the input signal is filtered by the HP/BP Filters. See Service Sheet BD2. This error gives rise to a display of 0.00 Hz.

Error 84 **Output Amplifier Overvoltage with No Overload.** The Output RMS (Avg) Detector senses an overvoltage, the Output Amplifier gain is 0 dB, but the Output Overload Detector has not tripped. See Service Sheet BD2. This error maps into a display of "— — — —" until Error 31 appears.

Error 85 **Period of the Voltage-to-Time Converter 0.** The Counter receives no pulses from the Voltage-to-Time Converter. This can occur if the input to the Voltage-to-Time Converter is too negative. See Service Sheet BD2. This error is identical to Error 17.

Error 86 **Frequency Count Greater Than 200 kHz.** This error causes a display of 0.000 kHz.

Service Errors (Error 65 through Error 95) (Cont'd)

Error 87 **Output Amplifier Overload with Post-Notch Gain Hold.** The Output Overload Detector remains tripped after three attempts to set the Output Amplifier gain and Special Function 3.N has been selected. See Service Sheet BD2. This error maps into Error 19.

Error 88 **Attempt to Take Log of Negative Ratio.** This error maps into Error 11.

Error 89 **Attempt to Take Log of Negative Number.** This error maps into Error 11.

Error 90 **Decimal Point Fixed and Exponent Too Large.** One of the mV ranges has been requested by 4.N SPCL for a measurement that does not use those ranges. This error maps into Error 10.

Error 91 **Decimal Point Fixed Too Far to the Left.** The decimal point has been held by Special Function 4.N and the reading to be displayed is too large to fit the display. This error maps into Error 10.

Error 92 **Decimal Point Fixed and Unable to Display.** This error maps into Error 10.

Error 93 **Number to Be Displayed Greater Than 9999.** This error maps into Error 10.

Error 94 **Attempt to Divide by Zero in Ratio.** This error maps into Error 11.

Error 95 **Signal-to-Noise Ratio Too Large to Calculate.** This error maps into Error 10.

8-31. POWER-UP CHECKS

When the Audio Analyzer is first turned on (or if 40.0 SPCL is entered), the instrument goes through a series of operational checks. When a check fails, an error code is output for two seconds on the four internal TEST LEDs on the A8 Controller/Counter Assembly. The sequence then continues on to the next check.

Except for the check of the front-panel LED annunciators, no indication of the power-up sequence or results is given on the front-panel displays. The principle advantages to using the Power-Up Checks are that the keyboard and display need not be operational.

To use the Power-Up Checks, remove the top cover (refer to Top and Bottom Cover Removal, Service Sheet A), remove any signal at the INPUT, and switch the LINE to OFF for five seconds (to discharge the supplies) and back to ON. Observe the four TEST LEDs on the top of the Controller/Counter Assembly as the instrument powers up. The LEDs should light in the following sequence:

	8	4	2	1
1. Indeterminate for about 1/8 second.	☼	●	●	☼
2. ( )( )( )(1) for about 1/2 second.	●	●	●	☼
3. (8)(4)(2)(1) for about 2 seconds.	☼	☼	☼	☼
4. (8)(4)(2)(1), with (1) blinking indefinitely until a key is pressed.	☼	☼	☼	☼

The Power-Up Checks actually begin at step 2 (above) and are carried out in the following order:

1. **Front-Panel Annunciator Check.** All front-panel LEDs and display segments and decimal points are lighted and remain so throughout the tests that follow and for about one second afterwards. Failure of one or more LEDs or segments indicates that the respective components or drive circuits have failed. See Service Sheet 18.

2. **Read Only Memory Check.** The checksum of each of the read only memories (ROMs) is read and compared against a stored reference (stored in ROM 1). (This is similar to entering a series of 52.N SPCL commands — see Service Special Functions, paragraph 8-27.) When a wrong checksum is found, the four TEST LEDs blink for one second with the binary code of the ROM number. For example, if ROM 5 is faulty, the TEST LEDs will blink ( )(4)( )(1) — i.e., 0101, a binary 5. The check then continues on to the next ROM. See Service Sheets BD4 and 16. If no faulty ROM is found, a steady ( )( )( )(1) appears for about 1/2 second.

3. **Random Access Memory Check.** Data is stored into and retrieved from the random access memory (RAM). If the data read back differs from the data entered, error code ( )( )(2)( ) is output to the TEST LEDs for two seconds. See Service Sheet 15.

4. **Instrument Bus Parity Check.** A parity check of the data lines of the Instrument Bus is made. A failure is indicated by ( )( )(2)(1) on the TEST LEDs for two seconds. See Service Sheets BD4, 12, and 16.

5. **Keyboard Checks.** The keyboard is scanned to see if any keys are down. If a key is down, error code

POWER-UP CHECKS (Cont'd)

( )(4)( )( ) is output to the TEST LEDs for two seconds. See Service Sheets BD4 and 17.

8-32. CONTROLLER TEST LEDs AND TEST POINTS

Near the top edge of the A8 Controller/Counter Assembly are located four test points and four associated LED annunciators labeled TEST which are used primarily for troubleshooting the instrument. The LED annunciators are labeled (from left to right) 8, 4, 2, and 1 and are associated with test points A, B, C, and D respectively.

The label on the annunciators is sometimes used to represent a binary weighting. They function in the following way:

1. At instrument power-up the TEST annunciators light in a certain sequence that indicates proper functioning of several vital areas of the instrument. A failure in any of the areas is indicated on the annunciators. For details see Power-Up Checks, paragraph 8-31.
2. After power-up, annunciator 1 toggles once for each measurement cycle.
3. After power-up, annunciator 2 toggles once for each keyboard interrupt (i.e., each time a key is pressed).
4. After power-up, annunciator 4 toggles once for each HP-IB interrupt.

Grounding of certain of the TEST test points alters instrument operation in the following ways:

1. Grounding test point C on power-up initiates the Counter, Latch, and Controller I/O signature analysis troubleshooting routines. See Service Sheet 14.
2. Grounding test point D on power-up initiates the Keyboard signature analysis troubleshooting routine. The signature analyzer's start and stop leads are then connected to test point A and the probe leads are then connected to test point B. See Service Sheet 17.

Whenever a test point is grounded, the associated annunciator is extinguished.

8-33. SIGNATURE ANALYSIS

Signature analysis is a simple method of verifying the operation of digital circuitry. When properly used, signature analysis can detect extremely subtle hardware faults. Signatures must identically match those given in the signature tables. If everything is working correctly, signatures will all match exactly. If they don't match, by even one digit, something is wrong.

The Keyboard and Display, Latch, and Counter/Controller Assemblies (A1, A7, and A8) are designed for troubleshooting with signature analysis. Signature analysis is a method of digital signal tracing using test routines programmed in the Audio Analyzer's ROM. With the Audio Analyzer's Controller executing the signature analysis routine, the signature analysis routine, the signature analyzer's test probe is used to check nodes in the circuit under test. The signature analyzer converts the signals at the node into a four digit "signature", which it displays. This signature is then compared to the signature in the troubleshooting checks adjacent to the appropriate schematic. These two signatures must be identical.

Signature analysis can be speeded up if the following considerations are kept in mind:

1. Make sure that every step is performed as described in the set-up procedure. That is, make sure that the clock, start, and stop connections and triggering are correct.
2. Double-check to ensure that the signatures are being taken at the correct node.
3. Make sure that the signature analyzer probe is making good contact with the pin being checked. Oxidation on pins can cause invalid signatures due to poor contact.
4. When you think that you have found a bad signature, double check to make sure.
5. When checking a node, be sure that the unstable signature indicator is not blinking.

8-34. DISASSEMBLY PROCEDURES

Procedures for removal of the top, bottom, and side covers, and the front and rear panels of the instrument and the illustrated parts breakdowns (IPBs) are contained in Service Sheets A and B.

8-35. REPAIR

8-36. Factory-Selected Components (*)

Some component values are selected at the time of final checkout at the factory (see Table 5-1). These values are selected to provide optimum compatibility with associated components. These components are identified on individual schematics and the parts list by an asterisk (*).

8-37. Manual Backdating (†)

A dagger (†) by an item of service information means that information is different for Audio Analyzers with serial number prefixes lower than the one to which this manual applies directly. Table 7-1 lists the backdating changes by serial number prefix. The backdating changes are contained in Section VII. Recommended modifications are also contined in Section VII.

8-38. Manual Updating (Manual Changes Supplement)

Production changes to Audio Analyzers made after the publication date of this manual are indicated by a change in the serial number prefix. Changes to this manual's information are recorded by a serial number prefix on the Manual Changes supplement. Errors are also noted in the ERRATA portion of the Manual Changes supplement.

Keep this manual up to date by periodically requesting the latest, complimentary supplement from your Hewlett-Packard office.

8-39. Etched Circuits (Printed Circuit Boards)

The etched circuit boards in the Audio Analyzer have plated-through holes which make a solderable path through to both sides of the insulating material. Soldering can be done from either side of the board with equally good results. When soldering to any circuit board, keep in mind the following recommendations.

1. Avoid unnecessary component substitution. Substitution can result in damage to the circuit board and/or adjacent components.
2. Do not use a high-power soldering iron on etched circuit boards. Excessive heat may lift a conductor or damage the board.
3. Use a suction device or wooden toothpick to remove solder from component mounting holes.

CAUTION

Do not use a sharp metal object such as an awl or twist drill for this purpose. Sharp objects may damage the plated-through conductor.

8-40. MOS and CMOS Integrated Circuit Replacement

MOS and CMOS integrated circuits are used in this instrument. They are prone to damage from both static and transients and must be handled carefully. When working on the Audio Analyzer, keep in mind the following recommendations to avoid damaging these sensitive components.

1. Do not remove any board unless the Audio Analyzer has been turned off or unplugged.
2. When removing a socketed MOS or CMOS device from an assembly, be careful not to damage it. High-grip sockets are used throughout the instrument. Avoid removing devices from these sockets with pullers. Instead, use a small screwdriver to pry the device up from one end, slowly pulling it up one pair of pins at a time.
3. Once a MOS or CMOS device has been removed from an assembly, immediately stick it into a pad of conductive foam or other suitable holding medium.
4. When replacing a MOS or CMOS device, ground the foam on which it resides to the instrument before removing it. If a device requires soldering, make sure that the assembly is lying on a pad of conductive foam, and that the foam and soldering iron tip are grounded to the assembly. Apply as little heat as possible.
5. Before turning the instrument off, remove any large ac sources which may be driving MOS switches.

8-41. Front-Panel Switch Replacement

If it becomes necessary to replace a front-panel switch, refer to the switch replacement procedure in Service Sheet A.

8-42. RETROFITTING OPTIONS

Section I of this manual (paragraphs 1-18 and 1-22) lists the optional equipment available for use with the Audio Analyzer.

8-43. SCHEMATIC SYMBOLOGY

The following pages summarize the symbology used in presenting many of the devices found in the Audio Analyzer.

8-44. Logic Symbology

The logic symbols used in this manual are based on the American National Standard Institute (ANSI) Y32.14-1973, "Graphic Symbols for Logic Diagrams (Two State Devices)". A summary of this symbology is provided to aid in interpreting these symbols.

Basic Logic Symbols (Gates) and Qualifiers. This section includes a brief description of the basic logic symbols used on the service sheets (see Figure 8-7), a summary of indicator symbols (see Figure 8-8), a discussion of contiguous blocks, control blocks, and dependency notation, and a summary of symbology for some of the more complex devices.

Qualifiers are that portion of a device symbol that denotes the logic function. For example, "&" denotes the AND function. See Figure 8-7 for a summary of the basic logic symbols and their qualifiers.

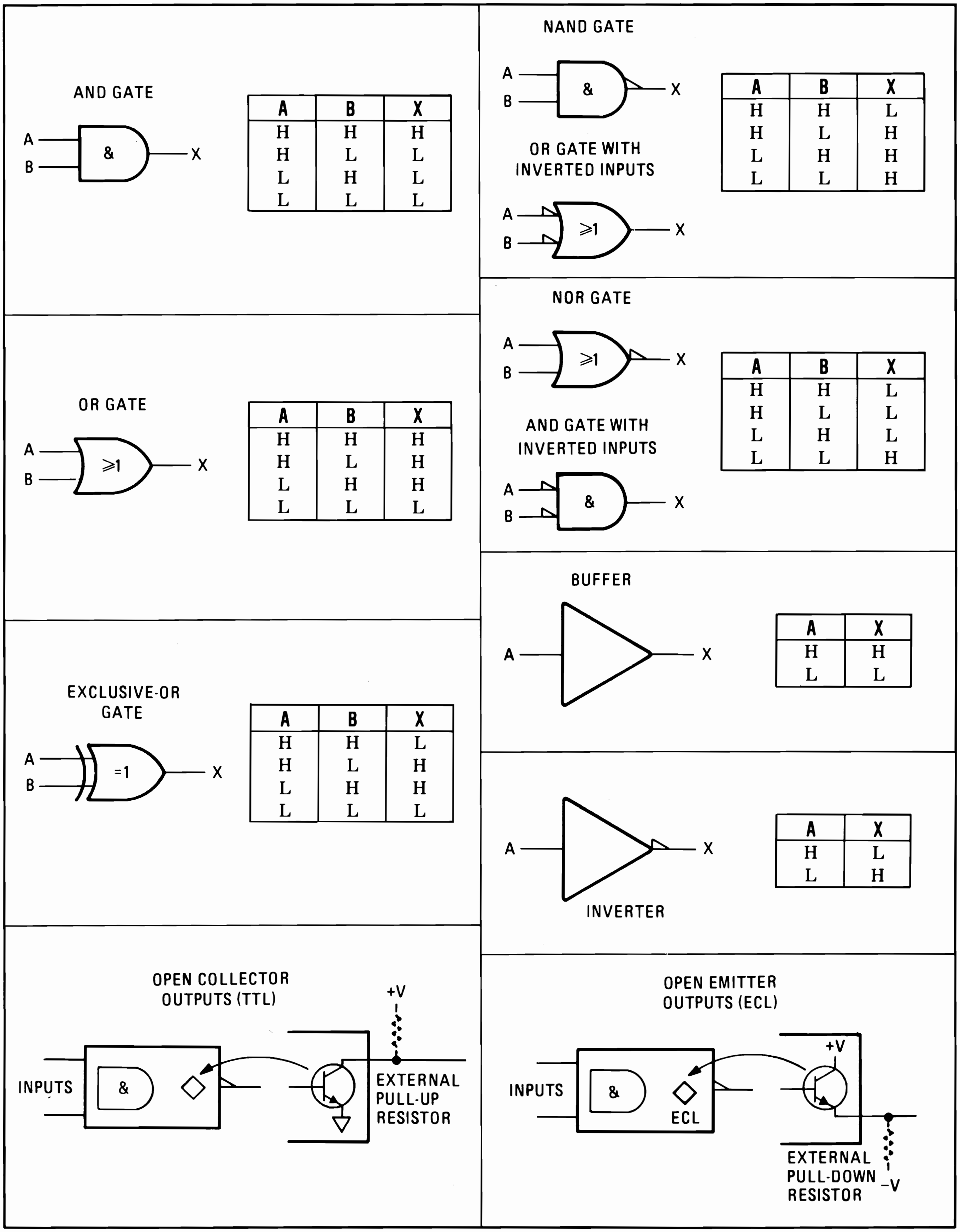
Power supply and ground connections are not shown on the symbols. This information is tabulated on the right margins of the service sheets.

Indicator Symbols. Indicator symbols identify the active state of a device's input or output, as shown in Figure 8-8.

Contiguous Blocks. Two symbols may share a common boundary parallel or perpendicular to the direction of signal flow. Note that in the examples shown in Figure 8-9, there is generally no logic connection across a horizontal line, but there is always an implied logic connection across a vertical line. Notable exceptions to this rule are the horizontal lines beneath control blocks and between sections of shift registers and counters (dividers).

Dependency Notation. Dependency notation simplifies symbols for complex integrated circuit elements by defining the interdependencies of inputs or outputs without actually showing all the elements and interconnections involved (see Figures 8-10 through 8-12). The following examples use the letter A for address, C for control, G for AND, V for OR, and F for free dependencies. The dependent input or output is labeled with a number that is either prefixed (e.g., 1X) or subscripted (e.g., X_1). They both mean the same thing. Note that many times a controlled line may already be labeled with a number that indicates input or output weighting (for example, in a coder). In this case, the controlling or gating input will be labeled with a letter (see Figure 8-11).

(Text continued on page 8-23)



AND GATE

A	B	X
H	H	H
H	L	L
L	H	L
L	L	L

NAND GATE / OR GATE WITH INVERTED INPUTS

A	B	X
H	H	L
H	L	H
L	H	H
L	L	H

OR GATE

A	B	X
H	H	H
H	L	H
L	H	H
L	L	L

NOR GATE / AND GATE WITH INVERTED INPUTS

A	B	X
H	H	L
H	L	L
L	H	L
L	L	H

EXCLUSIVE-OR GATE

A	B	X
H	H	L
H	L	H
L	H	H
L	L	L

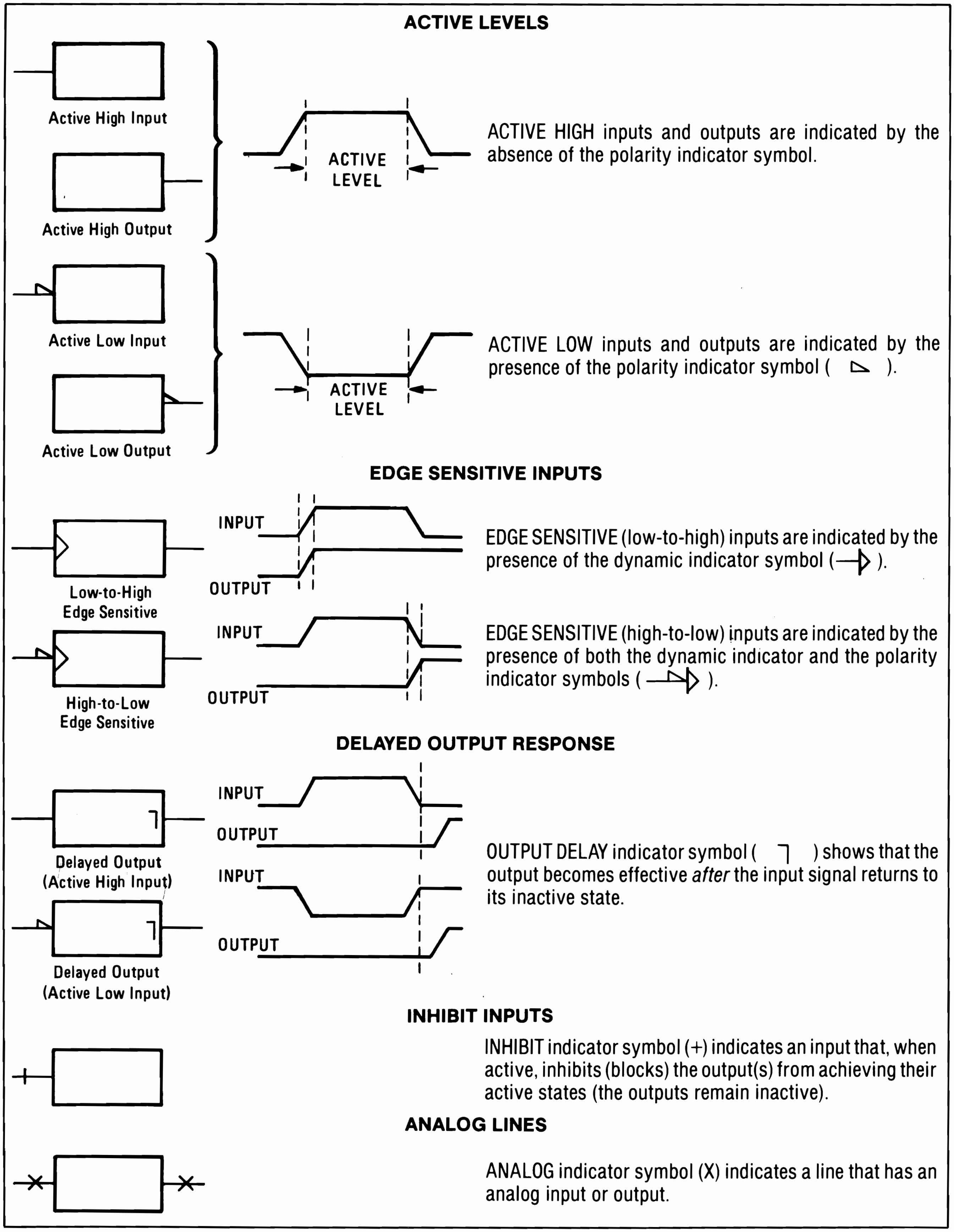
BUFFER

A	X
H	H
L	L

INVERTER

A	X
H	L
L	H

Figure 8-7. Basic Logic Symbols and Qualifiers



ACTIVE LEVELS

ACTIVE HIGH inputs and outputs are indicated by the absence of the polarity indicator symbol.

ACTIVE LOW inputs and outputs are indicated by the presence of the polarity indicator symbol (◺).

EDGE SENSITIVE INPUTS

EDGE SENSITIVE (low-to-high) inputs are indicated by the presence of the dynamic indicator symbol (—▷).

EDGE SENSITIVE (high-to-low) inputs are indicated by the presence of both the dynamic indicator and the polarity indicator symbols (—◺▷).

DELAYED OUTPUT RESPONSE

OUTPUT DELAY indicator symbol (┐) shows that the output becomes effective *after* the input signal returns to its inactive state.

INHIBIT INPUTS

INHIBIT indicator symbol (+) indicates an input that, when active, inhibits (blocks) the output(s) from achieving their active states (the outputs remain inactive).

ANALOG LINES

ANALOG indicator symbol (X) indicates a line that has an analog input or output.

Figure 8-8. Indicator Symbols

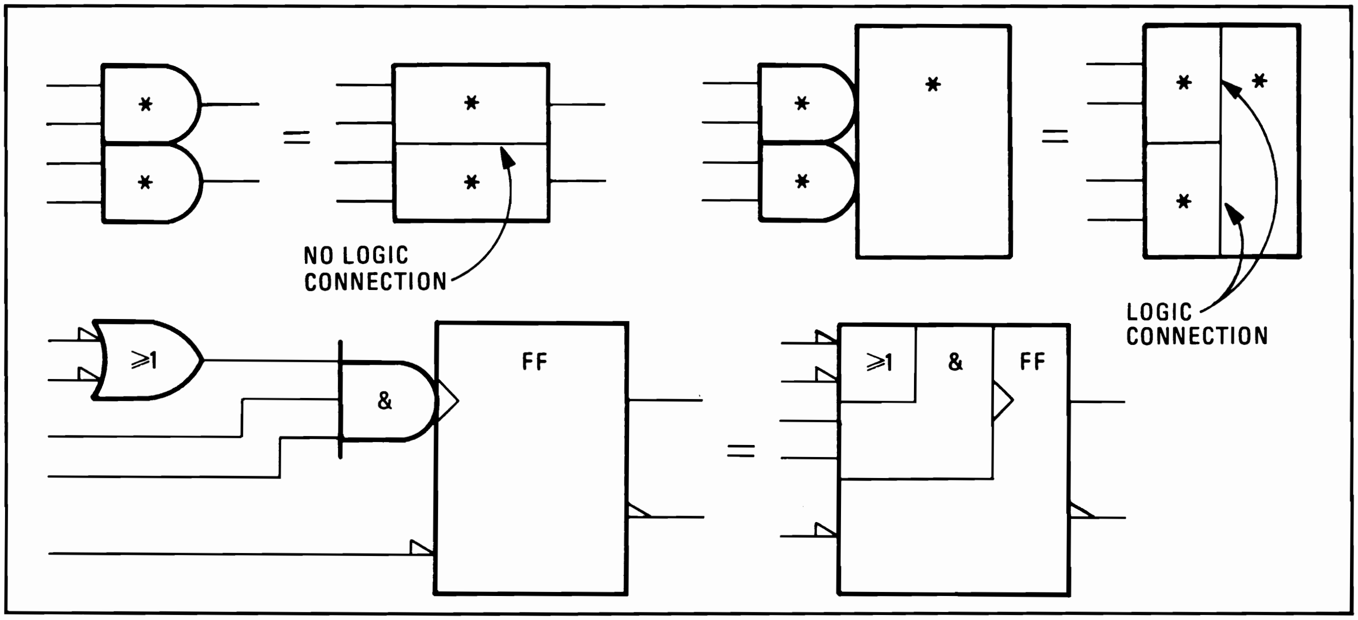
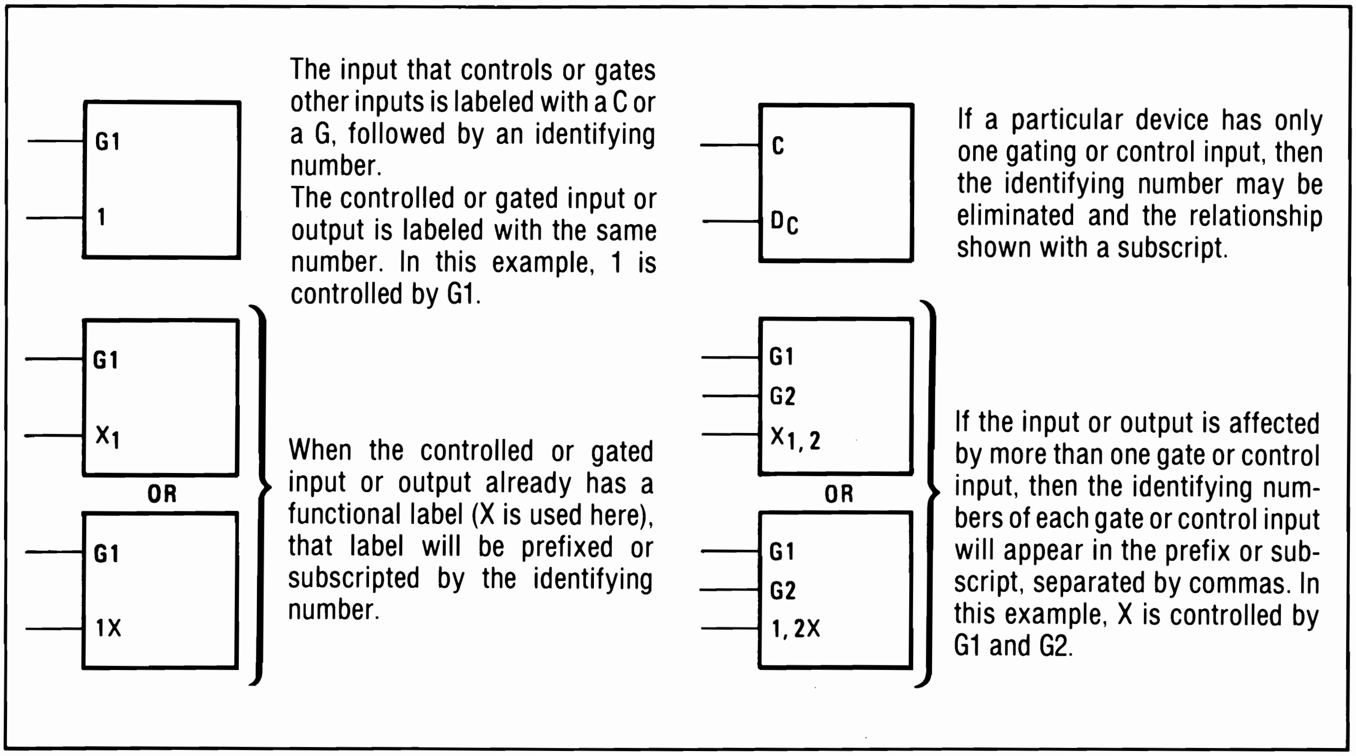


Figure 8-9. Contiguous Blocks



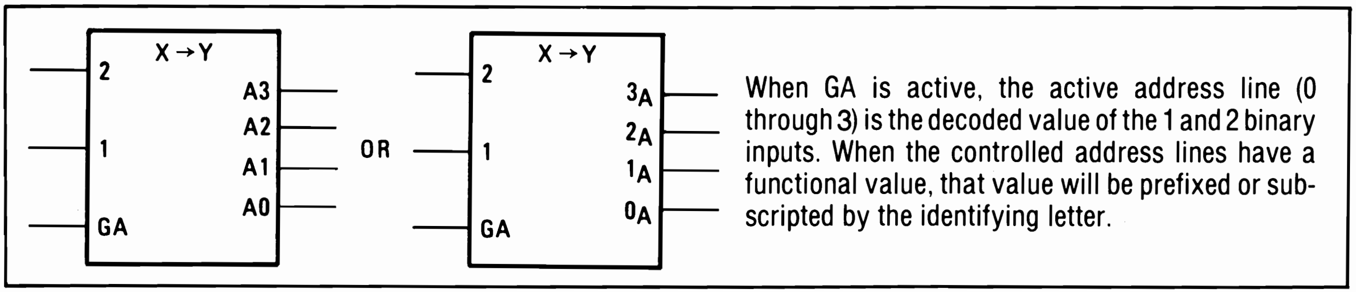
The input that controls or gates other inputs is labeled with a C or a G, followed by an identifying number. The controlled or gated input or output is labeled with the same number. In this example, 1 is controlled by G1.

If a particular device has only one gating or control input, then the identifying number may be eliminated and the relationship shown with a subscript.

When the controlled or gated input or output already has a functional label (X is used here), that label will be prefixed or subscripted by the identifying number.

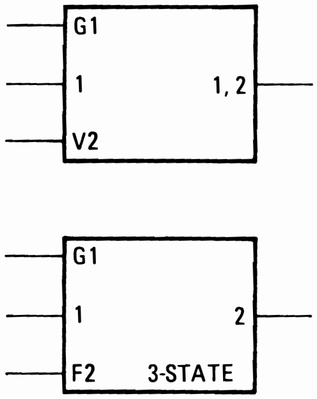
If the input or output is affected by more than one gate or control input, then the identifying numbers of each gate or control input will appear in the prefix or subscript, separated by commas. In this example, X is controlled by G1 and G2.

Figure 8-10. AND Dependency Notation



When GA is active, the active address line (0 through 3) is the decoded value of the 1 and 2 binary inputs. When the controlled address lines have a functional value, that value will be prefixed or subscripted by the identifying letter.

Figure 8-11. Address Dependency Notation: Coder Example Using Alpha Characters (Letters)



When a V input is active, the output will be in its active state. With the V input inactive, the device functions as if the V input doesn't exist.

When a F input is active, the output is enabled to function normally. When an F input is inactive, the output becomes a high impedance, effectively removing that device from the circuit.

The 3-STATE label is sometimes used with the free dependency notation.

Figure 8-12. OR and Free Dependency Notation

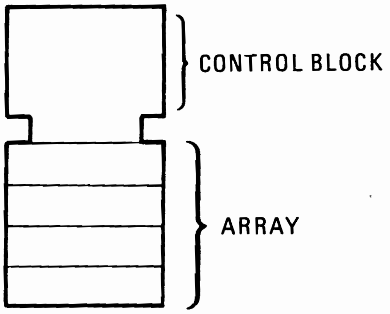


Figure 8-13. Common Control Block

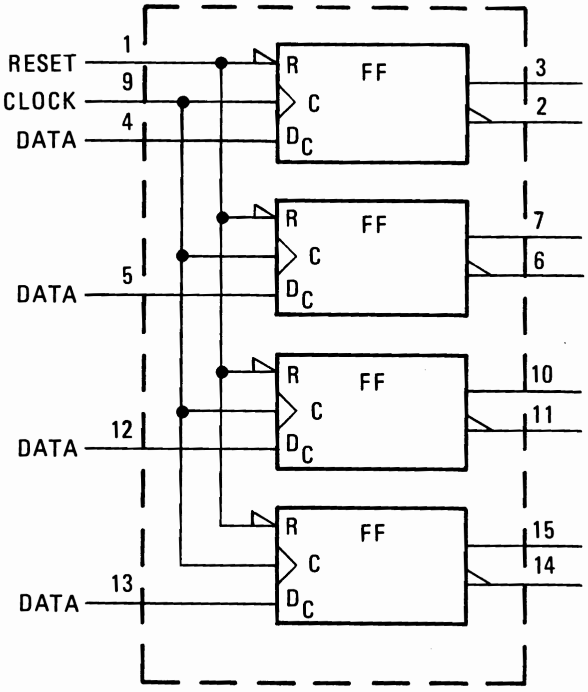


Figure 8-14. Quad D-Type Latch (Individual)

Common Control Block. The Control block is used in conjunction with an array of related symbols in order to group common logic lines. Figure 8-13 shows how the Control block is usually represented. Figure 8-14 shows a quad D-type flip-flop with reset. This can be redrawn as shown in Figure 8-15. Note that the more complex representation shown in Figure 8-14 can be used when the flip-flops are functionally scattered around the schematic (i.e., not used as a quad unit).

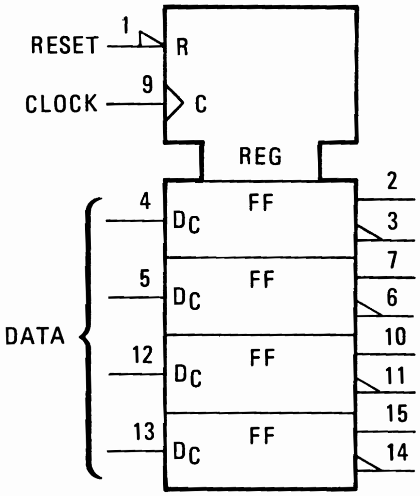


Figure 8-15. Quad D-Type Latch (Combined)

Complex Device Symbology. Figures 8-16 through 8-19 show how the basic symbols can be combined to illustrate behavior of fairly complex devices.

Shift Register. The Shift Register Control Block (Figure 8-16) is used to show common inputs to a bidirectional shift register. Notice that "→ m" means shift the contents to the right or down by "m" units. And "← m" means shift the contents to

Logic Symbology (Cont'd)

the left or up by "m" units. Note: If m = 1, it may be omitted. Inputs "a" and "b" are each single IC pins that have two functions. Input "a" enables one of the inputs to the top D-type flip-flop (1D) and also shifts the register contents down "m" units. Input "b" enables one of the inputs to the bottom flip-flop (2D), and also shifts the register contents up "m" units. Input "c" loads all four flip-flops in parallel (3D). Input "d" is a common reset. The output delay indicator is used because these are master-slave flip-flops.

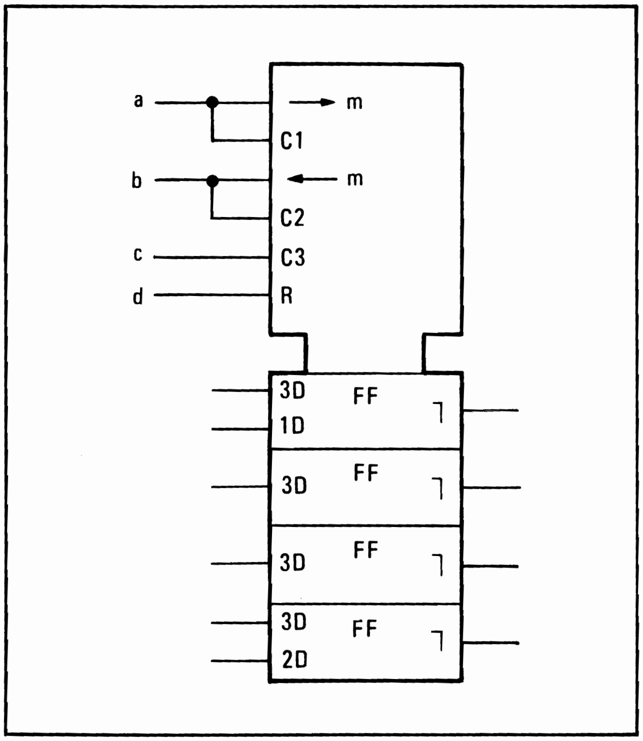


Figure 8-16. Shift Register

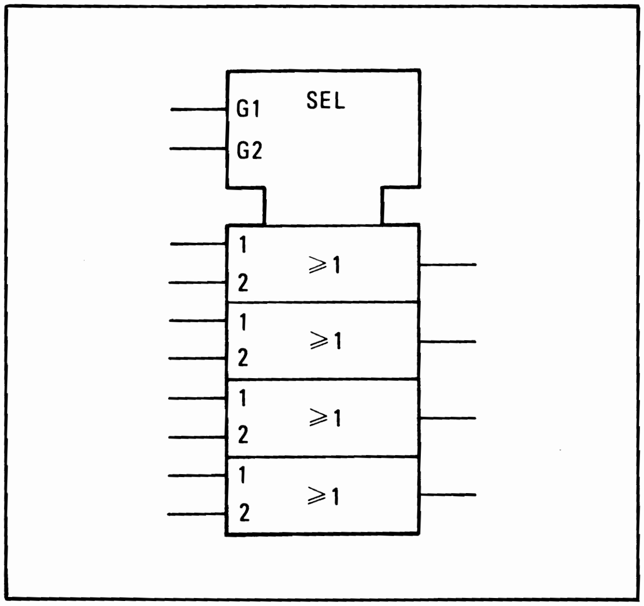


Figure 8-17. AND-OR Selector

AND-OR Selector. The Selector Control Block (Figure 8-17) is used to simplify the AND portion of a quad AND-OR select gate. When G1 is high, the data presented at the "1" inputs will be gated through. When G2 is high, the data presented at the "2" inputs will be gated through.

Up/Down Counter. The Counter Control Block is used to show common inputs to a Presettable Decade Up/Down Counter (Figure 8-18). Notice that "+m" means count up (increment the count) by "m"; "–m" means count down by "m". Note: if m = 1, it may be omitted. Since the D-type flip-flops are master-slave, the output delay indicator is used. The "=9, +1" and "=0, –1" notations define when the carry and borrow outputs are generated. They also define it as a decade counter; a binary counter would have the carry indicated with "=15, +1". Flip-flop weighting is indicated in parenthesis. Input "C1" allows all four "D1" flip-flops to be preset in parallel.

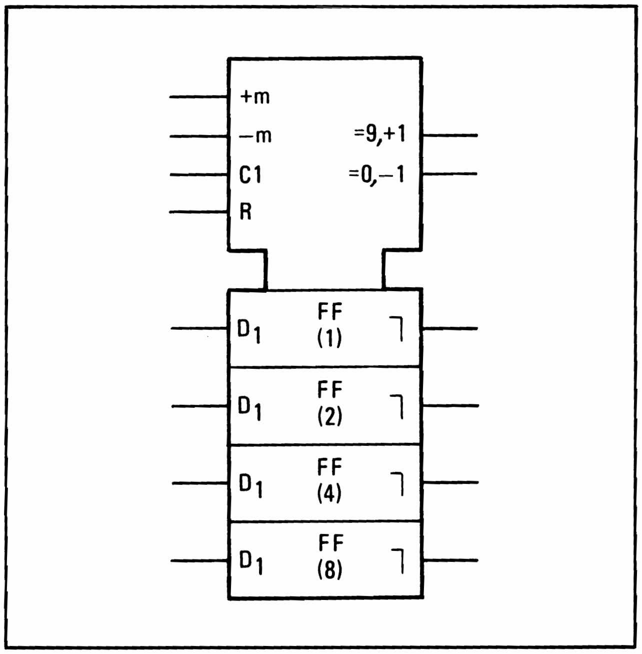


Figure 8-18. Up/Down Counter

Quad D-Type Latch. The Register Control Block is used to illustrate a quad D-type latch (Figure 8-19). There is a common active-low reset (R), and a common edge-triggered control input (C). Since there is only one dependency relationship, the controlling input is not numbered and the controlled functions (D) are subscripted with a C.

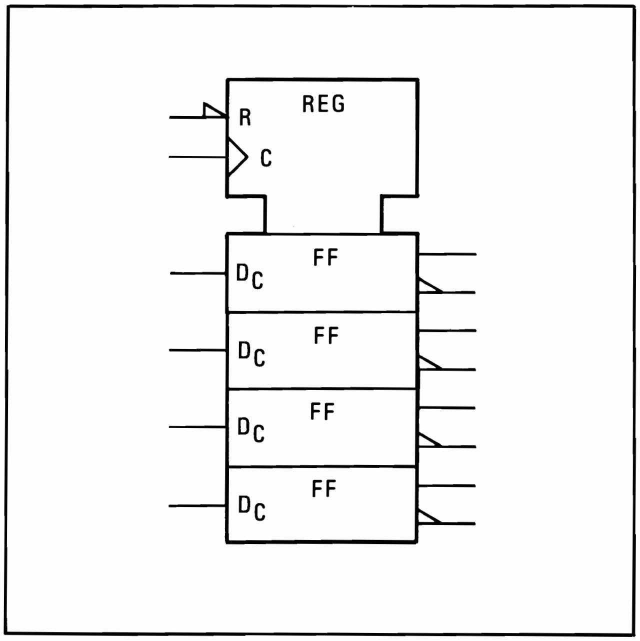


Figure 8-19. Quad D-Type Latch

8-45. LOGIC DEVICE THEORY

8-46. Schmitt Trigger

A typical Schmitt trigger is shown in Figure 8-20. Some Schmitt triggers have complimentary outputs. When the input signal increases in voltage, the device changes state as the input surpasses a voltage reference called the upper trip point. When the input signal is decreasing in voltage, the device changes back to its original state as the input voltage passes a voltage reference called the lower trip point.

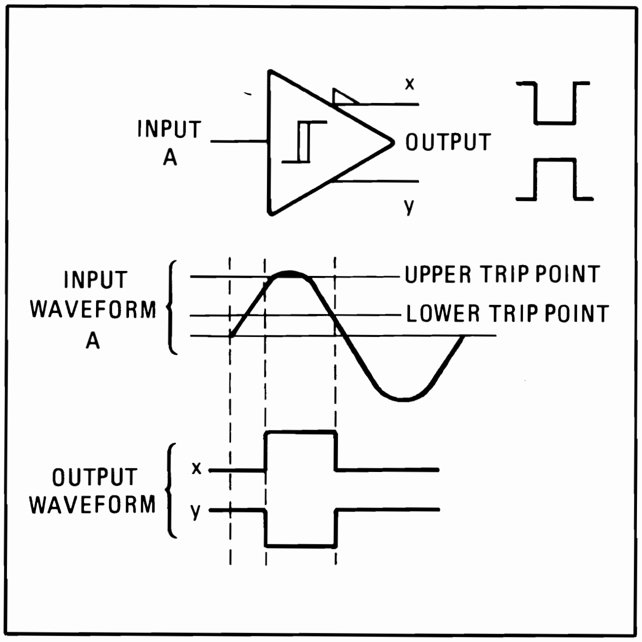


Figure 8-20. Schmitt Trigger

8-47. ECL-to-TTL Translator

This particular level translator is used to interface ECL family logic to TTL family logic. The translator shown in Figure 8-21 is essentially a comparator and a voltage reference. Comparator biasing sets the output level limits, the reference voltage source sets the input point. The ×s on the input and output lines indicate that the signals at those pins are analog in nature.

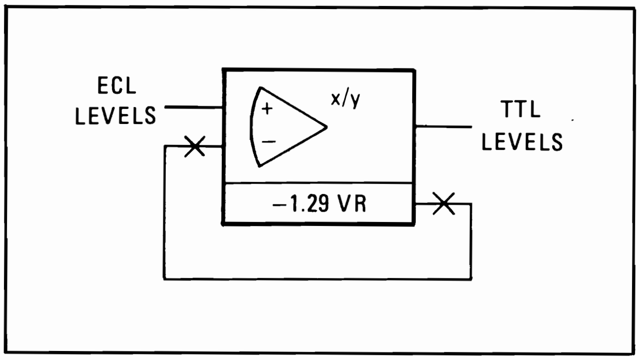


Figure 8-21. ECL-to-TTL Translator

8-48. One-Shot Multivibrator

The one-shot or monostable multivibrator, when triggered, produces a pulse of pre-programmed length. The length of the pulse is determined by the external resistor (R) and capacitor (C). See Figure 8-22.

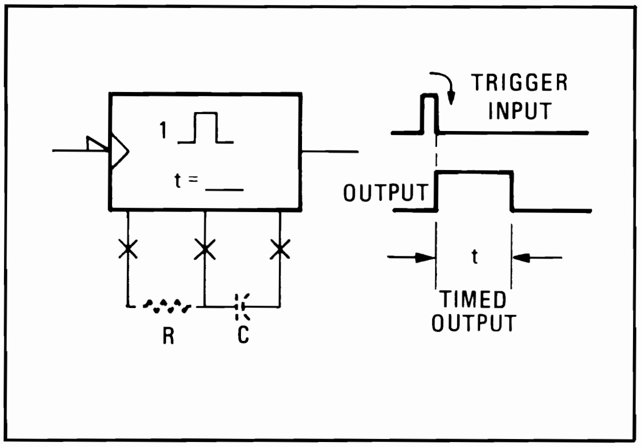


Figure 8-22. One-Shot Multivibrator

8-49. D-Type Flip-Flop (Edge-Triggered)

D-type flip flops are used for temporary storage of one bit of binary data. The D_C input is stored and transferred to the output at x when the control input (C) gives a low-to-high transition. y is the complement of x (i.e., $y=\overline{x}$). The S and R inputs set (S) and reset (R) the outputs independent of the control input status. Only one of these inputs is normally active at

D-Type Flip-Flop (Edge-Triggered) (Cont'd)

a time. If both are active, then x and y are either both high or both low, depending on the particular device used. See Figure 8-23.

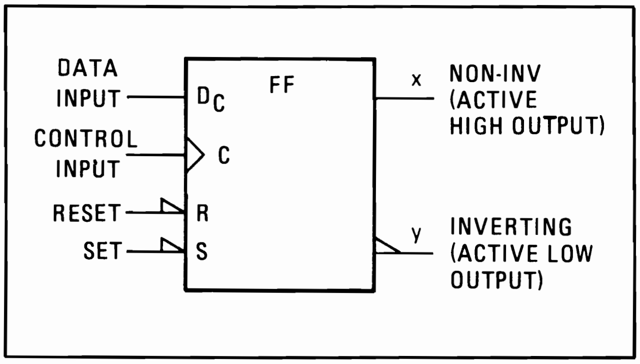


Figure 8-23. D-Type Flip-Flop (Edge-Triggered)

8-50. Presettable Counter

Presettable counters consist of four D flip-flops which are internally connected to provide a divide-by-two and a divide-by-five counter for a BCD counter or a divide-by-two and a divide-by-eight for a hexadecimal counter. The outputs of these devices can be preset to any state by placing a low on the load/count (C) input and applying the desired data to the D inputs. As long as the load/count input is low, the outputs will follow the D inputs. When the load/count input is set high, the outputs are latched to the preset values, and the output will advance one count with each low-to-high transition of the clock. The reset (R) function is asynchronous. See Figure 8-24.

8-51. Three-Bit Binary One-of-Eight Decoder

This device selects an output line (1-of-8) corresponding to the value of the binary input. For example, to make the 5G output go low, a binary 101 must be presented to the select inputs. For the output to reflect the weighted binary input, all three lines to control section must be active. See Figure 8-25.

8-52. Analog Multiplexer

This device is the electronic version of a single-pole-eight-throw (SP8T) switch. The binary code at the select inputs determines which analog input (1-of-8) will be routed to the output. The output is enabled by the F input. See Figure 8-26.

8-53. Digital-to-Analog Converter

The analog output of the digital-to-analog converter is a current which is proportional to the binary-weight of the input multiplied by [$V_{REF}(+)$ – $V_{REF}(-)$]/R. In other words, the output current is proportional to the maximum possible current through R divided by the binary value at the digital input. The analog output is thus attenuated by any value between 0 and 255. See Figure 8-27.

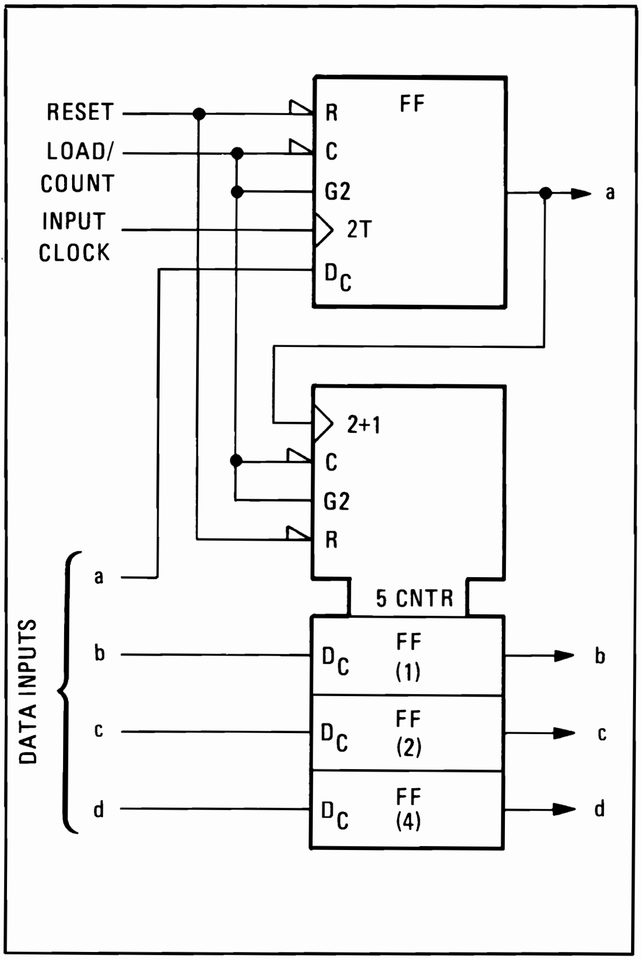


Figure 8-24. Presettable Counter

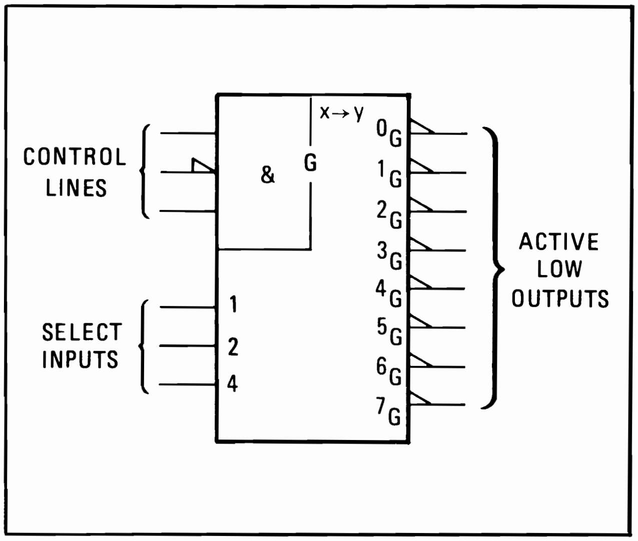


Figure 8-25. Three-Bit Binary One-of-Eight Decoder

Digital-to-Analog Converter (Cont'd)

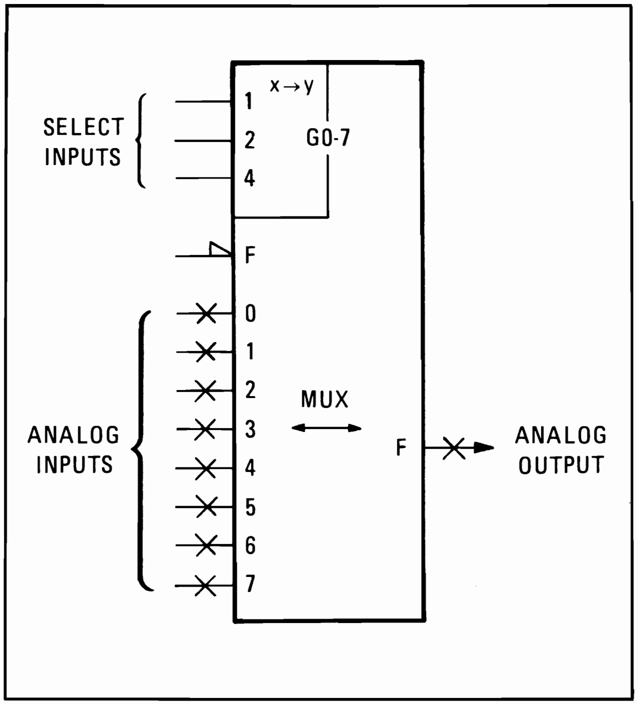


Figure 8-26. Analog Multiplexer

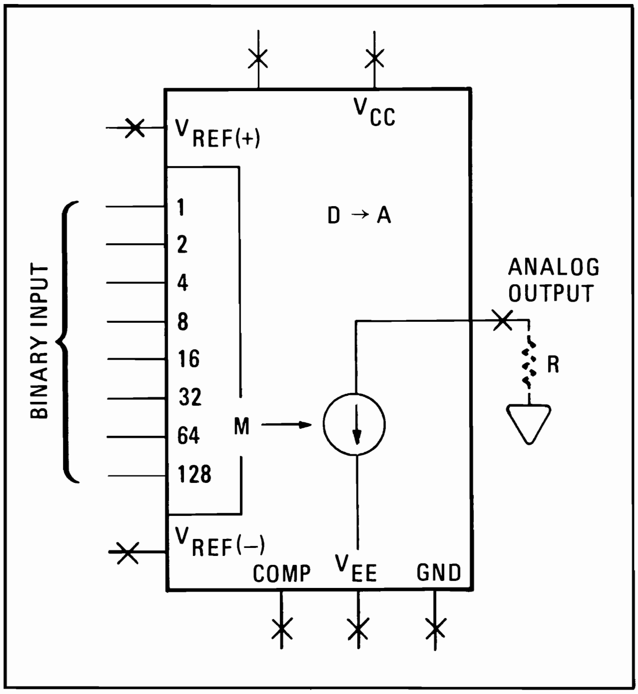


Figure 8-27. Digital-to-Analog Converter

8-54. Eight-Bit Addressable Latch

When the control input (C8) goes low, the device stores the logic level at the data input (8D) in the flip-flop selected by the binary value of the select inputs. The IC has additional modes of operation available but they are not used in this application. Once the output of a flip-flop has been set to a specific level it can only be changed by addressing that flip-flop and loading the opposite level. See Figure 8-28.

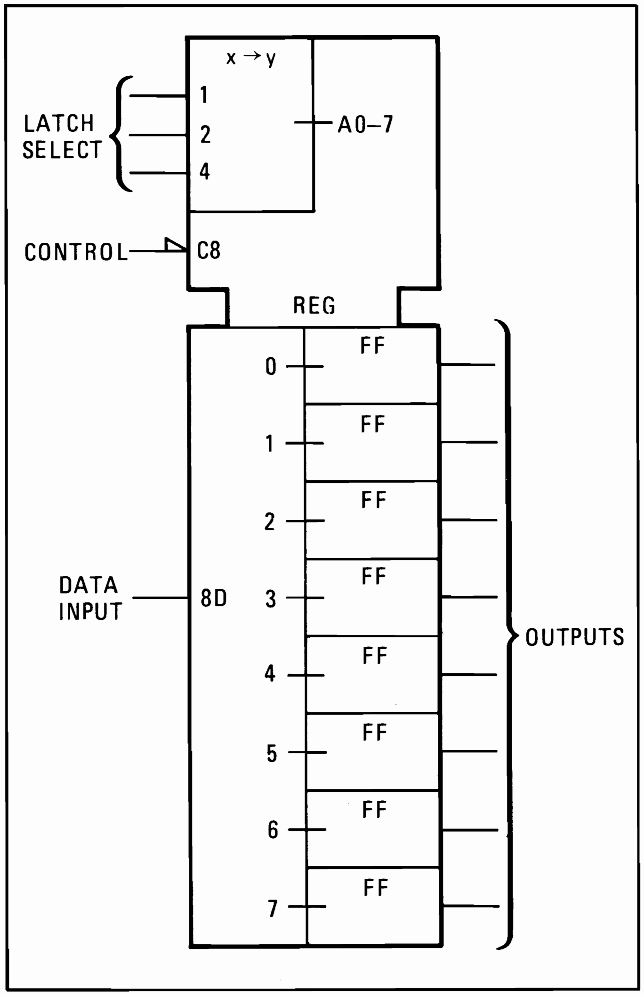


Figure 8-28. Eight-Bit Addressable Latch

8-55. BCD-to-Decimal Converter

The BDC-to-decimal converter is a 4-line-to-10-line decoder. It is composed of eight inverters and 10 four-input NAND gates. The inverters are connected in pairs to make BCD input data available for decoding by the NAND gates. The outputs are low true. The decoding logic ensures that all outputs are held high false for all invalid input conditions. See Figure 8-29.

8-56. Analog Switch

The analog switch is a bi-directional device, as is indicated by the double-ended arrow. The F1 input is the gate. F1 indicates the input and output (labeled with "1"s) are dependent on this input. See Figure 8-30.

Analog Switch (Cont'd)

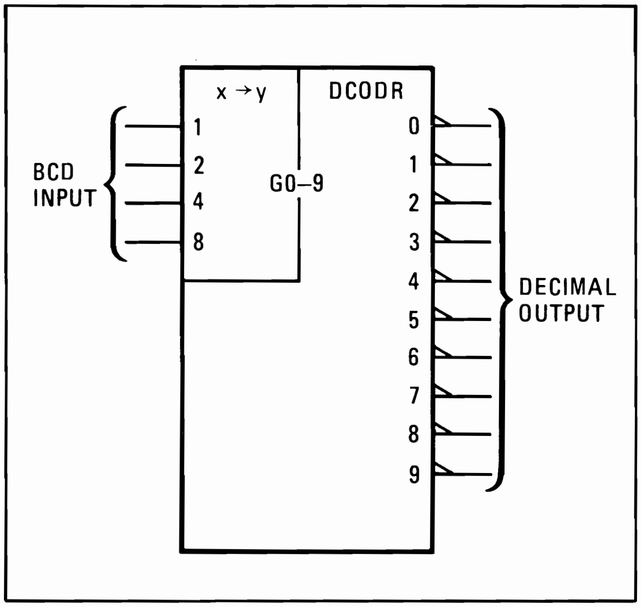


Figure 8-29. BCD-to-Decimal Converter

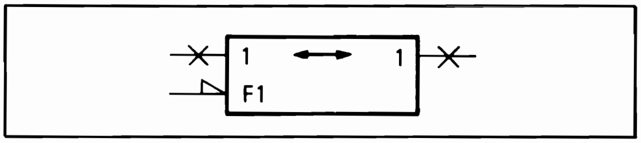


Figure 8-30. Analog Switch

8-57. Read Only Memory (ROM)

This device has an eight-bit word length. Locations in memory (32 total) are addressed by the five-bit binary code at the Address Input. The G input must be low to enable the outputs. The outputs are open-collector. See Figure 8-31.

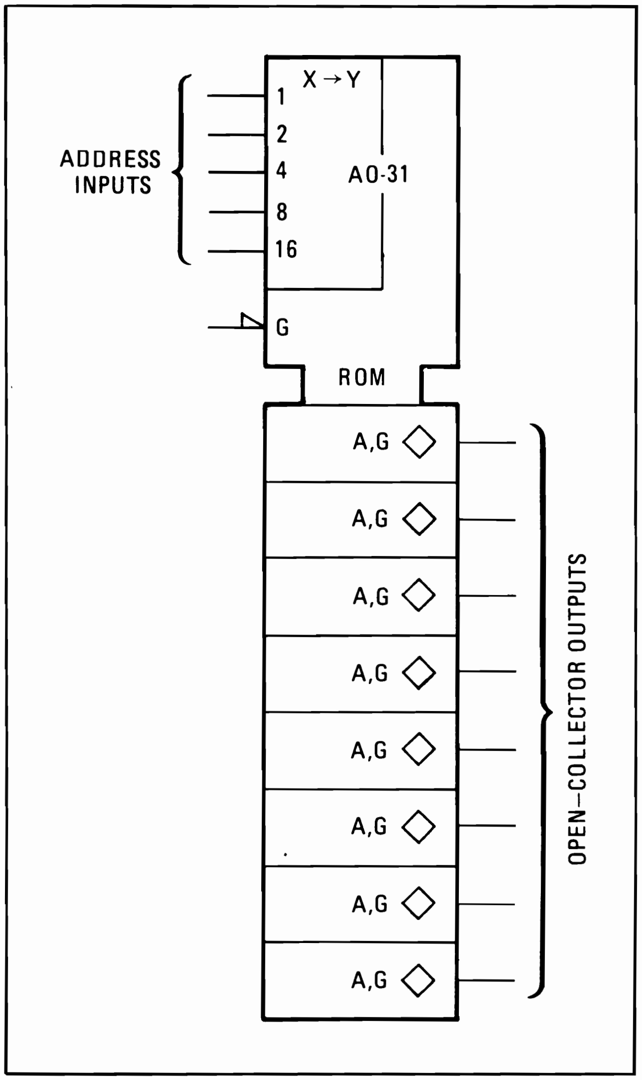


Figure 8-31. Read Only Memory (ROM)

8-58. Static Random Access Memory (RAM)

This device is a 256 word static memory. Each word is four bits in length and is addressed via the address lines. Both of the inputs to G1 must be low to enable the device. The G2 input must be low to write into memory and the G3 input must be high to read from memory. F4, when low, enables the output; F4, when high, disables the output. See Figure 8-32.

8-59. LINEAR DEVICE THEORY

8-60. Operational Amplifiers

The source of gain in an operational amplifier can be characterized as an ideal, differential voltage amplifier having low output impedance, high input impedance, and very high differential gain. The output of an operational amplifier is proportional to the difference in the voltages applied to the two input terminals. In use, the amplifier output drives the input voltage difference close to zero through a feedback path.

When troubleshooting an operational amplifier circuit, measure the voltages at the two inputs; the difference between these voltages should be less than 10 mV. (Note: This troubleshooting procedure will not work for operational amplifiers which are configured as comparators.) A difference voltage much greater than 10 mV indicates trouble in the amplifier or its external circuitry. Usually, this difference will be several volts and one of the inputs will be very close to one of the supply voltages (e.g., +15 or −15V).

Next, check the amplifier's output voltage. It will probably also be close to one of the supply voltages

Operational Amplifiers (Cont'd)

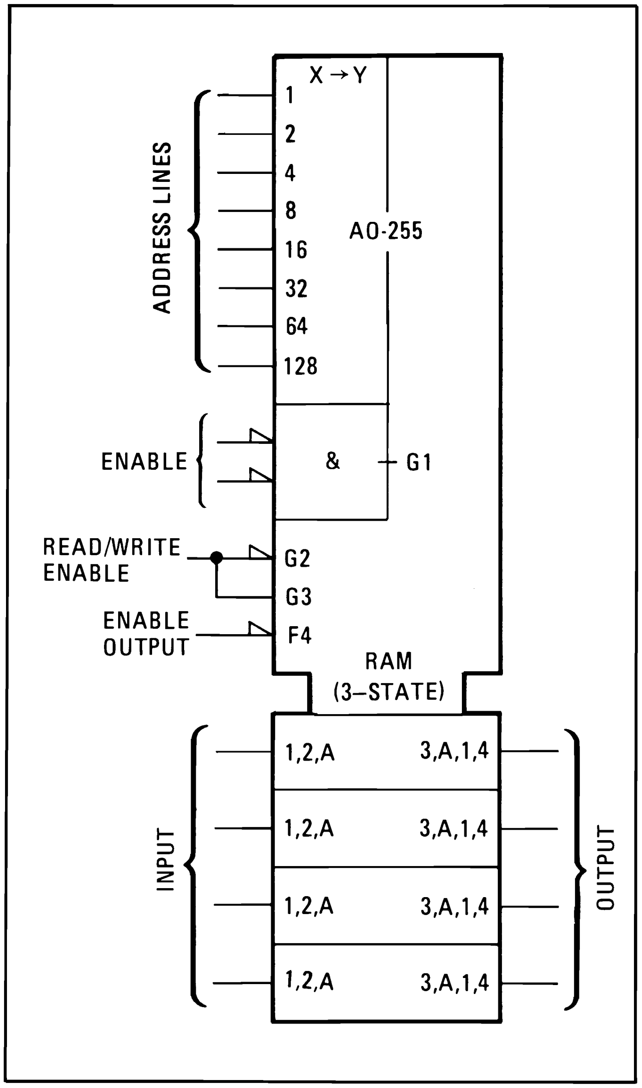


Figure 8-32. Static Random Access Memory (RAM)

(e.g., ground, +15V, or −15V). Check to see that the output conforms to the inputs. For example, if the inverting input is more positive than the non-inverting input, the output should be negative; if the non-inverting input is more positive than the inverting input, the output should be positive. If the output conforms to the inputs, check the amplifier's external circuitry. If the amplifier's output does not conform to its inputs, it is probably defective.

Figures 8-33, 8-34, and 8-35 show typical operational amplifier configurations. Figure 8-33 shows a non-inverting buffer amplifier with a gain of 1. Figure 8-34 is a non-inverting amplifier with gain determined by R1 and R2. Figure 8-35 is an inverting amplifier with a gain determined by R1 and R2.

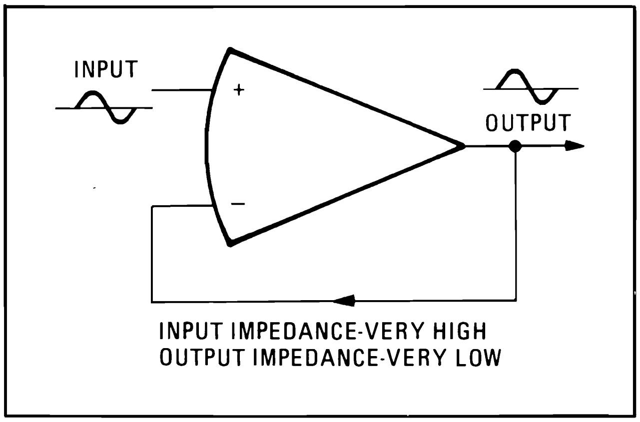


Figure 8-33. Non-Inverting Amplifier (Gain = 1)

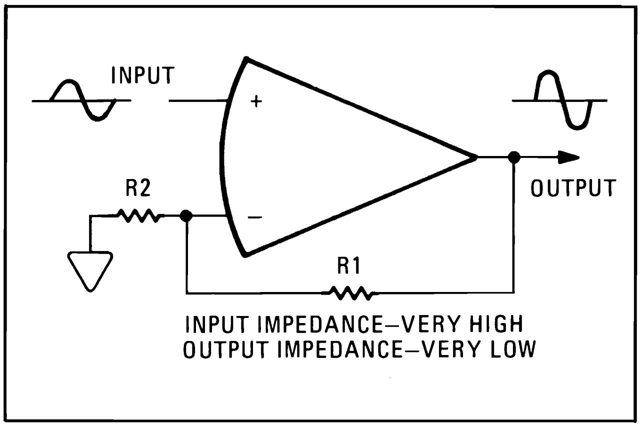


Figure 8-34. Non-Inverting Amplifier (Gain = 1 + R_1/R_2)

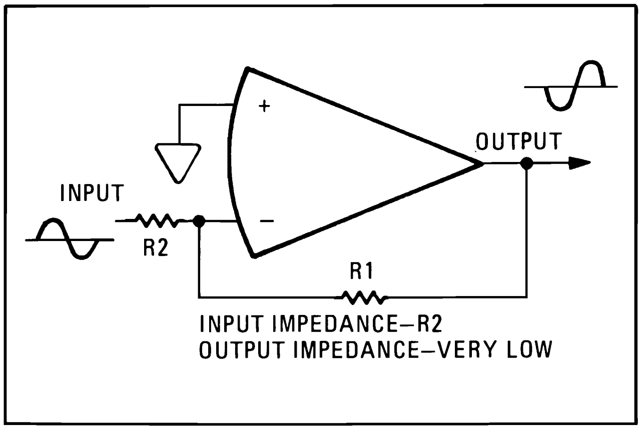


Figure 8-35. Inverting Amplifier (Gain = $-R_1/R_2$)

8-61. Comparators

Comparators are used as level sense amplifiers, switch drivers, pulse height discriminators, and voltage comparators. A voltage reference is connected to one of the amplifier's outputs as shown in Figures 8-36 and 8-37. When the input signal voltage crosses the reference, the output goes positive; the output remains positive until the signal re-crosses the reference.

Comparators (Cont'd)

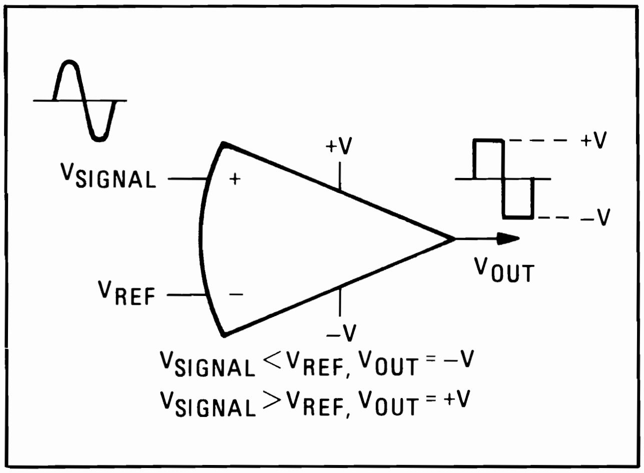


Figure 8-36. Non-Inverting Comparator

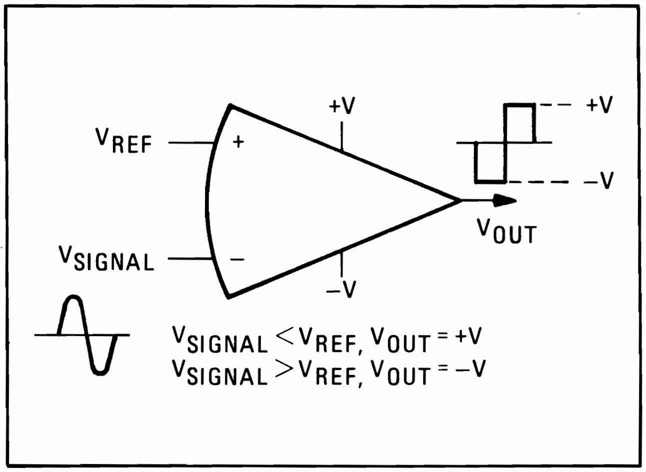


Figure 8-37. Inverting Comparator

8-62. Four-Quadrant Multiplier

The four-quadrant multiplier operates on the principle of variable transconductance. The output current is a linear product of two input voltages. The differential output current of the multiplier is given by

$$\Delta I = \frac{2V_xV_y}{R_xR_yI_x}$$

where V_x and V_y are the x and y voltages at the multiplier input terminals. See Figure 8-38.

8-63. SCHEMATIC DIAGRAM NOTES

Table 8-7 summarizes the symbology used in presenting many of the devices used in the Audio Analyzer.

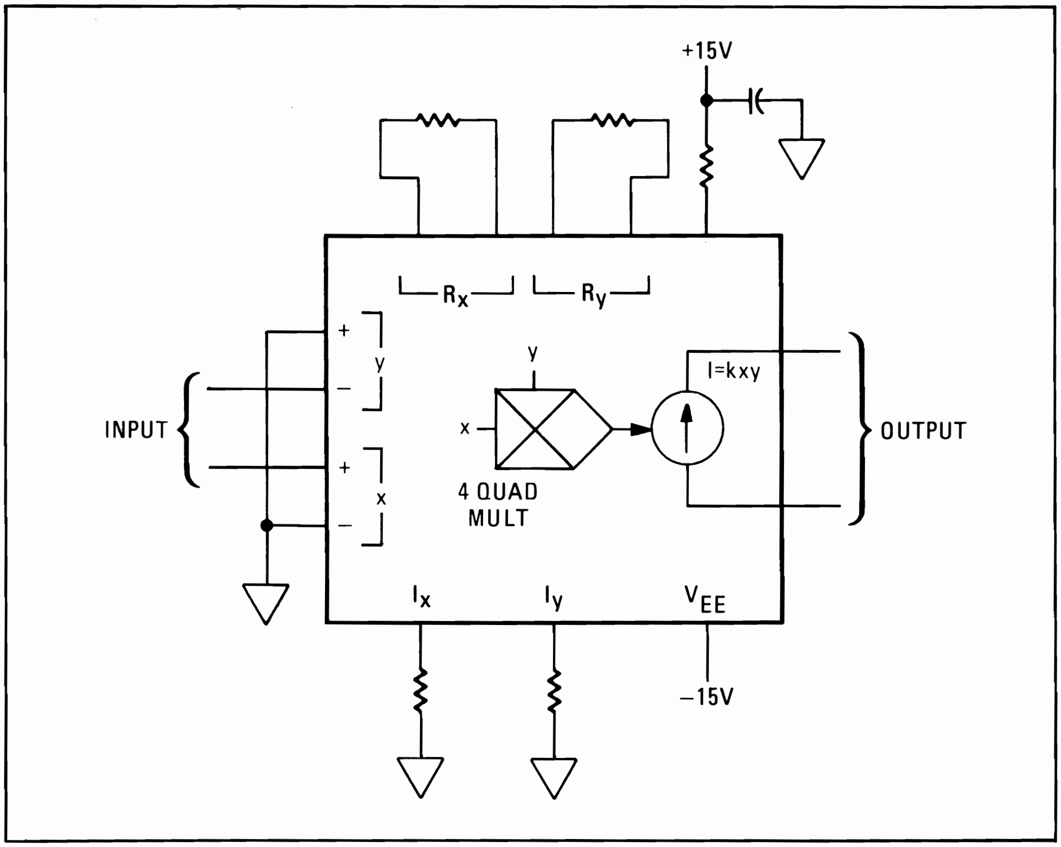


Figure 8-38. Four-Quadrant Multiplier

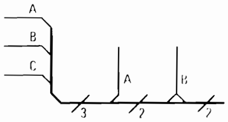
Table 8-7. Schematic Diagram Notes (1 of 6)

SCHEMATIC DIAGRAM NOTES

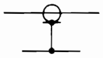
*	Asterisk denotes a factory-selected value. Value shown is typical.
†	Dagger indicates circuit change. See Section VII.
⊘	Tool-aided adjustment.
○	Manual control.
▭	Encloses front-panel designation.
⬚	Encloses rear-panel designation.
—— - - ——	Circuit assembly borderline.
- - - - - -	Other assembly borderline.
━━▶━━	Heavy line with arrows indicates path and direction of main signal.
━ ━▶━ ━	Heavy dashed line with arrows indicates path and direction of main feedback.
CW	Wiper moves toward cw with clockwise rotation of control (as viewed from adjustment slot).
1	Numbered test point, measurement aid provided.
⬭	Encloses wire or cable color code. Code used is the same as the resistor color code. First number identifies the base color, second number identifies the wider stripe, and the third number identifies the narrower stripe, e.g., (947) denotes white base, yellow wide stripe, violet narrow stripe.
⏚	A direct conducting connection to earth, or a conducting connection to a structure that has a similar function (e.g., the frame of an air, sea, or land vehicle).
⊥	A conducting connection to a chassis or frame.
▽	Common connections; all like-designation points are connected.
AK 12	Letters = off-page connection, e.g., AK . Number = Service Sheet number for off-page connection, e.g., **12**.
1 THIS PAGE	Number (only) = on-page connection.

Table 8-7. Schematic Diagram Notes (2 of 6)

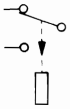
SCHEMATIC DIAGRAM NOTES



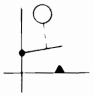
Indicates multiple paths represented by only one line. Letters or names identify individual paths. Numbers indicate number of paths represented by the line.



Coaxial or shielded cable.

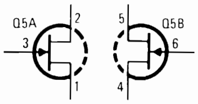


Relay. Contact moves in direction of arrow when energized.

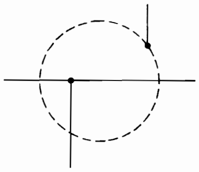


Indicates a pushbutton switch with a momentary (ON) position.

Indicates a Schottky (hot-carrier) diode.



Multiple transistors in a single package—physical location of the pins is shown in package outline on schematic.

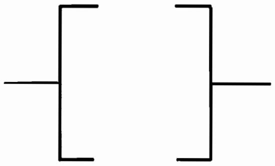


Guard trace. A printed conductor (indicated by phantom line) which prevents the leakage of current into or out of the enclosed area on the printed wiring assembly.

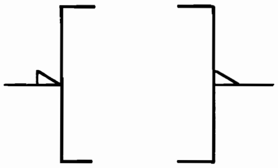
Table 8-7. Schematic Diagram Notes (3 of 6)

DIGITAL SYMBOLOGY REFERENCE INFORMATION

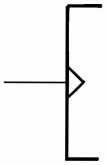
Input and Output Indicators



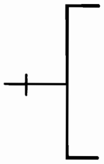
Implied Indicator—Absence of polarity indicator (see below) implies that the active state is a relative high voltage level. Absence of negation indicator (see below) implies that the active state is a relative high voltage level at the input or output.



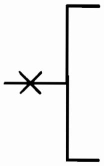
Polarity Indicator—The active state is a relatively low voltage level.



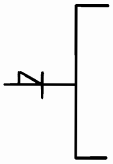
Dynamic Indicator—The active state is a transition from a relative low to a relative high voltage level.



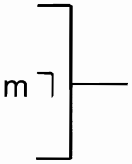
Inhibit Input—Input that, when active, inhibits (blocks) the active state outputs of a digital device.



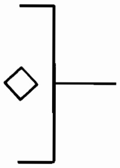
Analog Input—Input that is a continuous signal function (e.g., a sine wave).



Polarity Indicator used with Inhibit Indicator—Indicates that the relatively low level signal inhibits (blocks) the active state outputs of a digital device.



Output Delay—Binary output changes state only after the referenced input (m) returns to its inactive state (m should be replaced by appropriate dependency or function symbols).



Open Collector or Open Emitter Output.

Table 8-7. Schematic Diagram Notes (4 of 6)

DIGITAL SYMBOLOGY REFERENCE INFORMATION

Input and Output Indicators (Cont'd)

3-STATE	Three-state Output—Indicates outputs that can have a high impedance (disconnect) state in addition to the normal binary logic states.

Combinational Logic Symbols and Functions

&	AND—All inputs must be active for the output to be active.
≥1	OR—One or more inputs being active will cause the output to be active.
≥m	Logic Threshold—m or more inputs being active will cause the output to be active (replace m with a number).
=1	EXCLUSIVE OR—Output will be active when one (and only one) input is active.
=m	m and only m—Output will be active when m (and only m) inputs are active (replace m with a number).
=	Logic Identity—Output will be active only when all or none of the inputs are active (i.e., when all inputs are identical, output will be active).
▷	Amplifier—The output will be active only when the input is active (can be used with polarity or logic indicator at input or output to signify inversion).
X/Y	Signal Level Converter—Input level(s) are different than output level(s).
◄──►	Bilateral Switch—Binary controlled switch which acts as an on/off switch to analog or binary signals flowing in both directions. Dependency notation should be used to indicate affecting/affected inputs and outputs. Note: amplifier symbol (with dependency notation) should be read to indicate unilateral switching.
X→Y	Coder—Input code (X) is converted to output code (Y) per weighted values or a table.
(Functional Labels)	The following labels are to be used as necessary to ensure rapid identification of device function.
MUX	Multiplexer—The output is dependent only on the selected input.
DEMUX	Demultiplexer—Only the selected output is a function of the input.
CPU	Central Processing Unit
PIO	Peripheral Input/Output
SMI	Static Memory Interface

Table 8-7. Schematic Diagram Notes (5 of 6)

DIGITAL SYMBOLOGY REFERENCE INFORMATION

Sequential Logic Functions

1 ⎍	Monostable—Single shot multivibrator. Output becomes active when the input becomes active. Output remains active (even if the input becomes inactive) for a period of time that is characteristic of the device and/or circuit.
FF	Flip-Flop—Binary element with two stable states, set and reset. When the flip-flop is set, its outputs will be in their active states. When the flip-flop is reset, its outputs will be in their inactive states.
T	Toggle Input—When active, causes the flip-flop to change states.
S	Set Input—When active, causes the flip-flop to set.
R	Reset Input—When active, causes the flip-flop to reset.
D	Data Input—Always enabled by another input (generally a C input—see Dependency Notation). When the D input is dependency-enabled, a high level at D will set the flip-flop; a low level will reset the flip-flop. Note: strictly speaking, D inputs have no active or inactive states—they are just enabled or disabled.
+m	Count-Up Input—When active, increments the contents (count) of a counter by "m" counts (m is replaced with a number).
−m	Count-Down Input—When active, decrements the contents (count) of a counter by "m" counts (m is replaced with a number).
→m	Shift right (Down) Input—When active, causes the contents of a shift register to shift to the right or down "m" places (m is replaced with a number).
←m	Shift Left (Up) Input—When active, causes the contents of a shift register to shift to the left or up "m" places (m is replaced with a number).

NOTE

If m is one, it is omitted.

(Functional Labels)	The following functional labels are to be used as necessary in symbol build-ups to ensure rapid identification of device function.
mCNTR	Counter—Array of flip-flops connected to form a counter with modules m (m is replaced with a number that indicates the number of states: 5 CNTR, 10 CNTR etc.).
REG	Register—Array of unconnected flip-flops that form a simple register or latch.
ROM	Read Only Memory—Addressable memory with read-out capability only.
RAM	Random Access Memory—Addressable memory with read-in and read-out capability.

Table 8-7. Schematic Diagram Notes (6 of 6)

DIGITAL SYMBOLOGY REFERENCE INFORMATION

Dependency Notation

mAm	Address Dependency—Binary affecting inputs of affected outputs. The m prefix is replaced with a number that differentiates between several address inputs, indicates dependency, or indicates demultiplexing and multiplexing of address inputs and outputs. The m suffix indicates the number of cells that can be addressed.
Gm	Gate (AND) Dependency—Binary affecting input with an AND relationship to those inputs or outputs labeled with the same identifier. The m is replaced with a number or letter (the identifier).
Cm	Control Dependency—Binary affecting input used where more than a simple AND relationship exists between the C input and the affected inputs and outputs (used only with D-type flip-flops).
Vm	OR Dependency—Binary affecting input with an OR relationship to those inputs or outputs labeled with the same identifier. The m is replaced with a number or the letter (the identifier).
Fm	Free Dependency—Binary affecting input acting as a connect switch when active and a disconnect when inactive. Used to control the 3-state behavior of a 3-state device.

NOTE

The identifier (m) is omitted if it is one—that is, when there is only one dependency relationship of that kind in a particular device. When this is done, the dependency indicator itself (G, C, F, or V) is used to prefix or suffix the affected (dependent) input or output.

Miscellaneous

	Schmitt Trigger—Input characterized by hysterisis; one threshold for positive going signals and a second threshold for negative going signals.
Active	Active State—A binary physical or logical state that corresponds to the true state of an input, an output, or a function. The opposite of the inactive state.
Enable	Enabled Condition—A logical state that occurs when dependency conditions are satisfied. Although not explicitly stated in the definitions listed above, functions are assumed to be enabled when their behavior is described. A convenient way to think of it is as follows: A function becomes active when: • it is enabled (dependency conditions—if any—are satisfied) • and its external stimulus (e.g., voltage level) enters the active state.

SERVICE SHEET BD1—OVERALL BLOCK DIAGRAM

TROUBLESHOOTING HELP

- Troubleshooting .... Paragraph 8-20

PRINCIPLES OF OPERATION

General

The Audio Analyzer can be conceptually broken down into three subsections. The subsections are shown in Table 8-8. Service Sheets BD2 through BD4 break the operation of the instrument along similar lines as indicated in the table.

Table 8-8. Instrument Block Diagram and Subsection Breakdown

Service Sheet	Subsection	Circuits
BD2	Measurement	Input, Notch Filter, Output Amplifier, Detectors, DC Voltmeter, Power Supplies
BD3	Source	Oscillator, Output Attenuator
BD4	Digital	Controller, Counter, Keyboard and Display, Remote Interface

Input Circuits

Audio signals at the INPUT jack can range from 20 Hz to 100 kHz and up to 300V. DC levels can also be up to 300V. The input impedance is 100 kΩ (101 kΩ for dc level). For ac measurements, the AC/DC Switch inserts a capacitor into the input path. The HIGH and LOW sides of the INPUT jack can be either floated or grounded. The voltage between the LOW INPUT and ground should not exceed 4 Vpk. Measurements on the input signal are made on the difference between the HIGH and LOW inputs. Both input lines are protected with fuses.

The Input Attenuator is a voltage divider which can be set to 0, 12, 24, or 40 dB. It is set automatically to 0 dB when the input signal is 3V or less.

The Over-Voltage Protection circuit produces an open circuit when the input to it exceeds ±15V. Operation of the Over-Voltage Protection is instantaneous and non-latching (i.e., the open circuit persists only as long as the instantaneous signal level is more positive than +15V or more negative than –15V). Unlike diode limiter-type protection circuits, the current flow is small when limiting occurs. When the Input Attenuator is set to 40 dB, the Over-Voltage Protection is bypassed. The input fuses and the attenuator itself provide sufficient protection.

The Differential-to-Single-Ended Amplifier converts the non-referenced, differential signal to a signal referenced to ground. The gain of the amplifier can be set to 0, 8, 16, or 20 dB. The amplifier is dc coupled. When DC LEVEL is selected, the output of the amplifier is measured by the dc voltmeter. The output is also sensed by the Input Overload Detector. If the level is more positive than +8.7V or more negative than –8.7V, the detector sets the Input Attenuator to the 40 dB range until the proper range has been determined by the Controller.

The Programmable Gain Amplifier can be set for 0, 4, 8, or 12 dB gain and is ac coupled. The gain of the input path (Input Attenuator, Differential-to-Single-Ended Amplifier, and Programmable Gain Amplifer) is set so that the signal is between 1.7 and 3V at the Input RMS Detector. This is the optimum level for the Input RMS Detector and the Notch Filter.

The output of the Input RMS Detector is used to set the gain of the input path and, after processing by the Controller, it is also used as the numerator of the SINAD measurement or the denominator of the distortion measurement.

Either a 400 Hz high-pass filter or a psophopmetric-response filter can be inserted into the input path at this point. Filter selection is via front-panel keys or HP-IB. Both are active filters. The Psophometric Filter is a bandpass type with a standard frequency response that simulates the response of a telecommunications system as perceived by human hearing. It gives predominance to 1 kHz.

Notch Filter

The Notch Filter is inserted into the signal path in the distortion, distortion level, and SINAD measurement modes. It is coarse tuned by the Controller. When measuring distortion, the Controller sets the Notch Filter to the frequency of the signal counted at the input. When measuring SINAD, the Controller sets it to the programmed frequency of the internal oscillator.

SERVICE SHEET BD1 (Cont'd)

A notch filter frequency response is obtained by passing the signal through a unity-gain, inverting, active bandpass filter then summing the filter's output with its input. At the center frequency of the bandpass filter, the two signals into the Sum and Output Amplifier nearly cancel. This results in significant rejection of the signal at that frequency. Since the notch is very narrow, only the fundamental is rejected while noise and harmonic components are passed.

The Balance and Fine Tune Control circuit uses negative feedback to fine tune the bandpass filter to the signal and to fine adjust (balance) its gain to maximize the depth of the notch. The tuning range of the fine tune control is 8% of the nominal center frequency. Feedback for the Balance and Fine Tune Control circuit comes from Amplifier 1 which follows the Notch Filter. The tune error is also measured by the DC Voltmeter which is monitored by the Controller. If a large tune error exists the Controller takes steps to either retune the Notch Filter or display an error message.

In the other measurement modes, the bandpass filter is not switched in and a flat response results.

Output Circuits

The output from the Notch Filter is attenuated, amplified, and filtered to condition the signal for the most accurate measurement by the Voltmeter. The signal level at the input to the Output RMS (Avg) Detector is normally between 0.3 and 3V. Attenuator 1 is set to either 0 or 20 dB. Amplifier 1 has a gain of 14 dB. The Low-Pass Filters are selected from the front panel or HP-IB. The 3 dB frequencies of the filters are 30 kHz, 80 kHz, and 750 kHz. The latter filter is selected when the other two filters are off. The filters are active-types and have 6 dB gain.

Attenuator 2 is set to either 0 or 20 dB. Amplifier 3 has a gain of 20 dB. Attenuator 3 is set to either 0 or 20 dB. The Buffer amplifier has 0 dB gain. The High-Pass Filter is set to 0.3 Hz in the AC LEVEL measurement mode to ensure accuracy down to 20 Hz; otherwise, it is set to 13 Hz to speed up measurement time. Amplifier 4 has 20 dB of gain. The output from Amplifier 4 is the rear-panel MONITOR output signal, an input to the Counter (since this is the point of greatest sensitivity in the ac measurement mode), and the input to the Output RMS (Avg) Detector.

The Output RMS (Avg) Detector is used to set the gain of the output path (Attenuators 1, 2, and 3) and, after processing by the Controller, its output is also used as the numerator of the distortion measurement or the denominator of the SINAD measurement. The detector can also be configured to respond to the absolute average of the signal instead of the true rms value. The Output Overload Detector senses the output of the Output RMS (Avg) Detector. If the output exceeds 3V, the gain of the output path is set to 0 dB. The state of the output can also be read by the Controller which then takes appropriate action.

The SINAD panel meter is normally used only in the SINAD measurement mode when the SINAD is between 0 and 18 dB. On that range, since the gain of the output path is 0 dB, SINAD is equal to the log of the ratio of the output of the Input RMS Detector to the output of the Output RMS (Avg) Detector. The mathematical manipulation takes place in the SINAD Log Ratio Meter Amplifier. The Meter Transconductance Amplifier converts the voltage at its input to a current to drive the SINAD meter. If SINAD is not in the range of 0 to 18 dB or if some other measurement mode has been selected, the Controller either pegs the meter to full scale or switches it off via the Meter Peg/Off Switch.

DC Voltmeter

Various dc voltages are routed to the Voltmeter Input Selector switch. The outputs from the Input RMS Detector and the Output RMS (Avg) Detector are measured through Ripple Filters when measurements are made on noisy ranges. The DC Voltmeter consists of the Counter, the Controller, and the Voltage-to-Time Converter. The output of the Voltage-to-Time Converter controls one of the input gates of the Counter. The voltage measurement cycle begins when the Controller gates the 2 MHz Clock into the Clock Counter. Counting proceeds until the Voltage-to-Time Converter produces a Stop Count pulse which opens the Stop Count Gate. The lapse of time between the gating of the clock and the opening of the Stop Count Gate is proportional to the dc input voltage. The count thus accumulated during the interval is proportional to the input voltage.

Power Supplies

The instrument is run from four regulated supplies: +15V, –15V, +12V, and +5V. All supplies are

SERVICE SHEET BD1 (Cont'd)

independent except the +5V supply which is dependent on the +15V and –15V supplies.

Source

The source consists of a 20 Hz to 100 kHz Oscillator and output level-setting circuits. Oscillator tuning is programmed by the Controller which uses the Counter to check frequency. The Oscillator output is self-leveled to about 3 Vrms via an automatic leveling control (ALC) circuit. The circuit senses the level with a peak Level Detector. The output from the detector is compared against a dc reference voltage by the Level Error Amplifier. The output of the amplifier drives the level-varying circuitry in the Oscillator to eliminate the error condition.

The amplifiers and attenuators in the output path are: Amplifier 1 with a gain of 0 to 6 dB settable in 256 steps; Attenuator A which can be set to 0, 2.5, 5, or 7.5 dB; Amplifier 2 with a gain of 6 dB; the Output Amplifier Driver with a gain of –30, –20, –10, or 0 dB; the Floating Output Amplifier with a gain of about +1 dB; and the Output Attenuator which can be set to 0, 20, or 40 dB. The switch in front of Amplifier 1 (actually part of Amplifier 1) is open when an amplitude of 0V is selected. In the signal-to-noise measurement mode, it is switched on and off by the Controller which reads the Output RMS (Avg) Detector for both conditions and computes their ratio.

The Floating Output Amplifier also converts the output signal to one without a ground reference. Either output terminal (HIGH or LOW) may be grounded or floated up to 10 Vpk. This allows the user to eliminate ground loops, sum signals, and add dc offsets to the output. The Output Attenuator is also floating. The output impedance is 600Ω. The Voltage Clamp circuit and the fuses on the output lines protect the output circuitry from reverse power.

Counter

When the frequency of the input signal or Oscillator is to be counted, two sub-counters (the Cycle and Clock Counters) operate simultaneously. The signal itself is directed into the Cycle Counter. In the case of counting the input signal, the signal is first routed through the Counter Input Schmitt Trigger which converts the analog signal into square wave pulses which are compatible with the Cycle Counter. The 2 MHz Clock signal is directed into the Clock Counter.

To count frequency, the Controller first sets the Clock Counter Gate switch to route the path from the Frequency Gate switch into the Clock Counter. Then, the Controller arms the Cycle Counter Gate and Frequency Gate switches,and the first signal pulse closes the switches. Both counters (which were previously cleared) then begin to accumulate counts. The Cycle Counter is a divide by 32, the Clock Counter is a divide by 2048. The overflow or carry pulses of each counter are counted by the Controller. After a pre-determined minimum number of carries from the Clock Counter and at least one carry from the Cycle Counter, the Frequency Gate and Cycle Counter Gate switches are disabled by the Controller. The first signal pulse opens the switches and counting ceases. The Controller then reads the contents of the Cycle and Clock Counters and computes the signal frequency which is

$$f = \frac{|\text{Count of Cycle Counter} + (32 \times \text{Cycle Counter Carries})| \times 2\ \text{MHz}}{(2048 \times \text{Clock Counter Carries}) + \text{Count of Clock Counter}}$$

The count sequence is also timed out to prevent hang-up of the instrument should there be no input signal or should the signal be interrupted during a count cycle.

During a voltage measurement cycle, only the Clock Counter is used. The Controller first sets the Clock Counter Gate to receive the signal from the Voltmeter Gate and closes the Voltmeter Gate. (The Controller had also previously closed the Stop Count Gate by deactivating the Voltage-to-Time Converter via the Ramp Gate line.) The 2 MHz Clock is now routed into the Clock Counter. After a time interval which is proportional to the dc voltage being measured, the Voltage-to-Time Converter opens the Stop Count Gate. The accumulated count is proportional to the dc voltage at the input of the DC Voltmeter.

Controller and Remote Interface

The Controller plays a key role in governing the instrument operation. The Microprocessor in the Controller outputs information to configure the instrument, reads back and processes measurement results, reads back vital status information to prevent invalid measurements, and services interrupts from the Keyboard or Remote Interface. Information from the Input/Output (I/O) port of the Microprocessor is carried to the rest of the

SERVICE SHEET BD1 (Cont'd)

instrument by the Instrument Bus. Typically, the data on the Instrument Bus are decoded by the Decoders and Latches and distributed to the appropriate circuit. For the Counter, Keyboard and Display, and Remote Interface, decoding of the Instrument Bus is done on the assemblies.

Information within the Controller itself is handled by three main buses: the ROM Control Bus (which coordinates the various devices which make up the Controller), the Address Bus (which addresses the ROM and RAM), and the Data Bus (which carries information to or from the ROM and RAM). Since the Remote Interface contains some Controller devices, these buses are also distributed to it.

The Remote Interface receives inputs from the external interface bus (HP-IB), processes the information, and interrupts the Controller in a manner similar to the Keyboard. It also processes the measurement information and outputs it on the HP-IB if requested. The Remote Interface is designed to make operation from an external computing controller as similar as possible to operation from the front panel.

Instrument Software Supervisor Flowchart

The instrument's software is structured in a form called the supervisor. See Figure 8-39. The supervisor is a loop that is continually traversed with displays made near the end after checks for oscillator tuning, input and output leveling, notch tuning, and measurements. Arithmetic manipulation (e.g., for the ratio function) follows the measurement, and the programs loop back up to the beginning after outputting to the display.

The various level and tune blocks verify that the instrument is adjusted to make an accurate measurement. A measurement is not made until all of the tests are passed in succession. If a test is not passed, corrective action is taken. The decision after that block then forces the program back to the top of the supervisor, bypassing the measurement for that loop if corrective action is unsuccessful. The software interface with the hardware makes use of two concepts called software state and hardware state. The software state is located in the RAM and totally describes the state of the instrument. On power-up, the initialization procedure loads the software state from ROM. Keyboard and HP-IB entry routines modify only the software state and do not effect the hardware immediately. The setup block in the supervisor is where the hardware state is made to conform with the software state. Setup is not the only place where hardware is affected; tune, level, and measurement blocks manipulate the hardware as well.

The Keyboard and HP-IB interrupt the flow around the loop, forcing the Microprocessor to execute a short program and then return to the loop as shown in the diagram. Since the supervisor can be interrupted at any point but always returns to a single location, Keyboard and HP-IB interrupts must abort the current measurement and start a new measurement cycle. The Keyboard and HP-IB can be thought of as a medium through which the user requests a certain setup.

The microprocessor-based Controller interacts closely with the hardware of the instrument. Many circuits are used by the Controller for different functions at different times. Thus, a specific failure in one circuit can show up as a collection of symptoms that superficially seem unrelated. The appearance of several symptoms can often be used to advantage as they provide many avenues to pursue when tracking down a problem.

A clear line is drawn between Service Special Functions and normal instrument operation. When most Service Special Functions are used, normal instrument functions are suspended. When the Service Special Function mode is left to resume normal measurements, all effects of the Service Special Functions on hardware are lost. As an example, a Service Special Function can be used to display the oscillator frequency. But once normal measurements are resumed, the display will revert back to what it was before the Service Special Function was invoked.

TROUBLESHOOTING

General

The troubleshooting checks that follow are a starting place for locating an instrument fault. They are easy to perform and give much key information in a short amount of time. In most instances they can differentiate between an instrument hardware failure and a Controller or software problem. The comments associated with each procedure summarize the information known as a result of passing or failing the check. The

SERVICE SHEET BD1 (Cont'd)

checks should be done in order. For additional information on the troubleshooting philosophy used in these checks, refer to paragraph 8-20.

√1 Line Check

Procedure: Remove instrument top cover (three screws) and switch LINE to ON.

Normal Indication: The four green LEDs on the A13 Power Supply and Mother Board Assembly are lighted indicating that the supplies are nominally operating.

If Indication Abnormal: Check rear-panel line fuse and line voltage selector. Check Mains wiring. See Service Sheet 20. Check individual regulators. See Service Sheet BD2.

√2 Power-Up Checks

Procedure: If there are any jumpers on the TEST test points on the A8 Controller/Counter Assembly, remove them. Switch LINE to OFF for five seconds and back to ON. Note the sequencing of the four TEST LEDs on the top of the Controller/Counter Assembly as the instrument powers up.

Normal Indication: The four TEST LEDs light in the following sequence:

1. Indeterminate for about 1/8 second.
2. ( )( )( )(1) for about 1/2 second. This indicates the start of the power-up routines and the run of the Read Only Memory Check.
3. (8)(4)(2)(1) for about 2 seconds. This indicates that all power-up checks passed and that a visual front-panel check is in progress (see √3 below).
4. (8)(4)(2)(1), with (1) blinking indefinitely until a key is pressed. The behavior of the LED (1) is also affected by the presence of an input signal.

Any other sequence indicates a failure of the check. Passing this check indicates that the Controller is functioning properly and that there is no catastrophic failure in the following circuits:

Read Only Memory
Random Access Memory
Instrument Bus
Keyboard (only that no key is down).

If Indication Abnormal: If the TEST LEDs come on and remain in the indeterminate state of step 1 above, check the Controller Kernel. See Service Sheet BD4. If other indications appear in or after step 2 above, consult Power-Up Checks, paragraph 8-31, which discusses the individual checks, documents the error indications, and cross references to the service sheets.

√3 Front-Panel LED Check

Procedure: Disconnect all connections to INPUT. Switch LINE to OFF and back to ON.

Normal Indication: After less than 1/8 second, all front-panel LEDs and display segments and decimal points should light for about 3 seconds, then the displays blank for one second then after a few seconds settle to readings of 0.000 kHz in the left display and <0.100 mV in the right display. The measurement cycle indicator LED in the upper left-hand corner of the right display should blink rapidly. The kHz and mV annunciators and the AC LEVEL and 80 kHz LOW PASS key lights should be on. This indicates that the Controller is able to output to the front-panel LED and display latches which are all operative.

If Indication Abnormal: If one or more LEDs or display segments fail, check the respective components and drive circuits. See Service Sheet 18. Also check the CPU I/O port. See Service Sheet BD4.

√4 Measurement Error Check

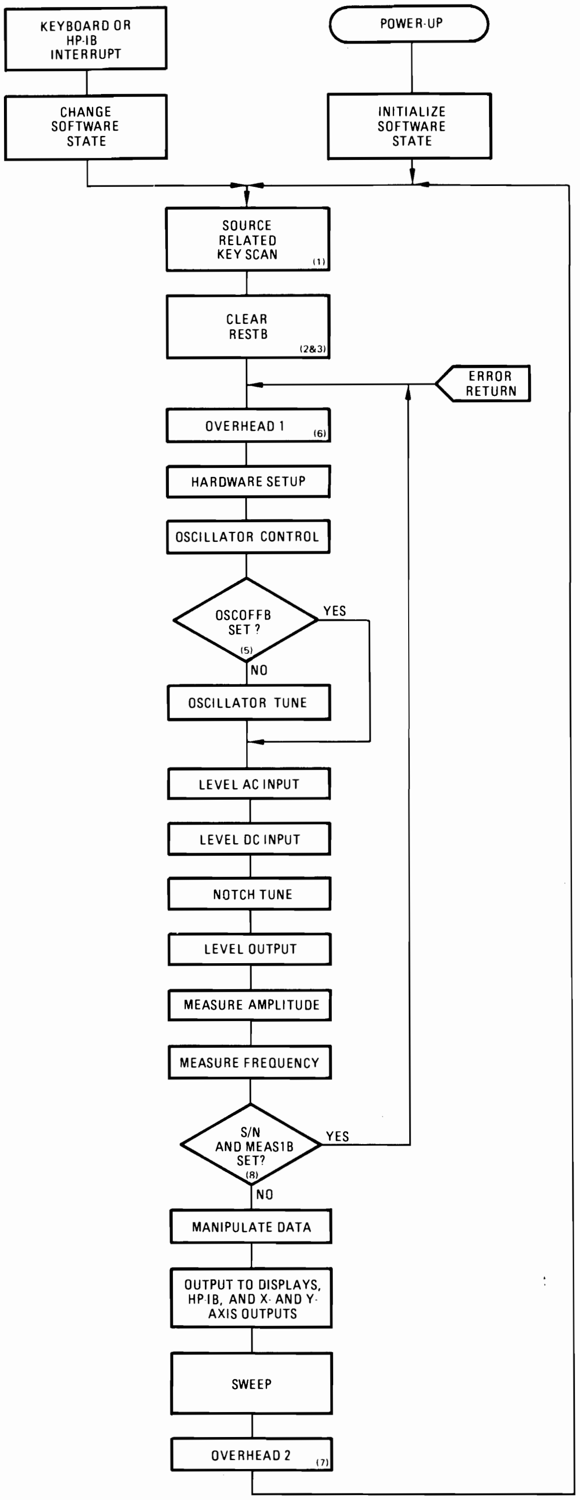
Procedure: Key in 43.1 SPCL. This enables Service Errors. Make the measurement in which the fault appears.

Normal Indications: As the Special Function code is entered, 43.1 should appear in the left display. This indicates that the Controller responds to keyboard interrupts. After pressing the SPCL key, measurements should proceed as normal.

If Indication Abnormal: If the keys have no effect, check the keyboard interrupt. See Service Sheet 17. If the keystrokes produce an erroneous display, check the Keyboard. See Service Sheet BD4. If the measurement is improper or error messages appear in the display, consult the error message tables (see Error Messages in the Detailed Operating Instructions, Section III and Error Messages, paragraph 8-28) or consult the block diagram service sheet that documents the section of the instrument that appears to have the fault (see Service Sheets BD2 through BD4).

NOTE

For problems that are exclusive to the HP-IB, see Service Sheet BD4.



NOTES

1. *The SOURCE RELATED KEY SCAN block monitors the FREQ, FREQ INCR, AMPTD, AMPTD INCR, ↑ (step up), and ↓ (step down) keys.*

2. *On errors, the instrument exits the current block, jumps to the error return point, and sets the GUARB (guarantee bit), RESTB (reset bit), and FIRSTB (first bit).*

3. *If RESTB is set, the OSCILLATOR CONTROL block will not execute and RESTB will be cleared.*

4. *Certain blocks may or may not execute during different measurement modes depending upon relevancy bits and other conditions.*

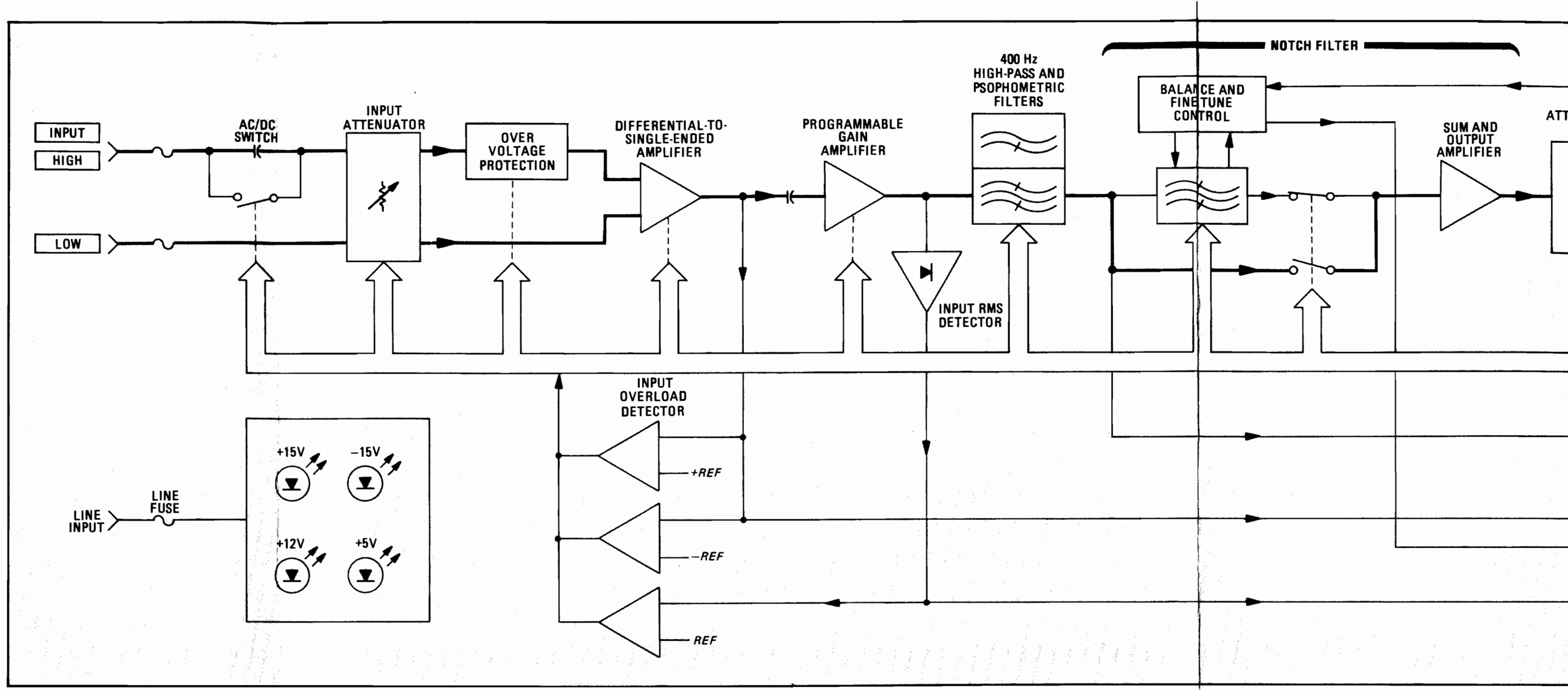
5. *The OSCOFFB (oscillator off bit) is set on alternate Signal-to-Noise (S/N) measurement cycles.*

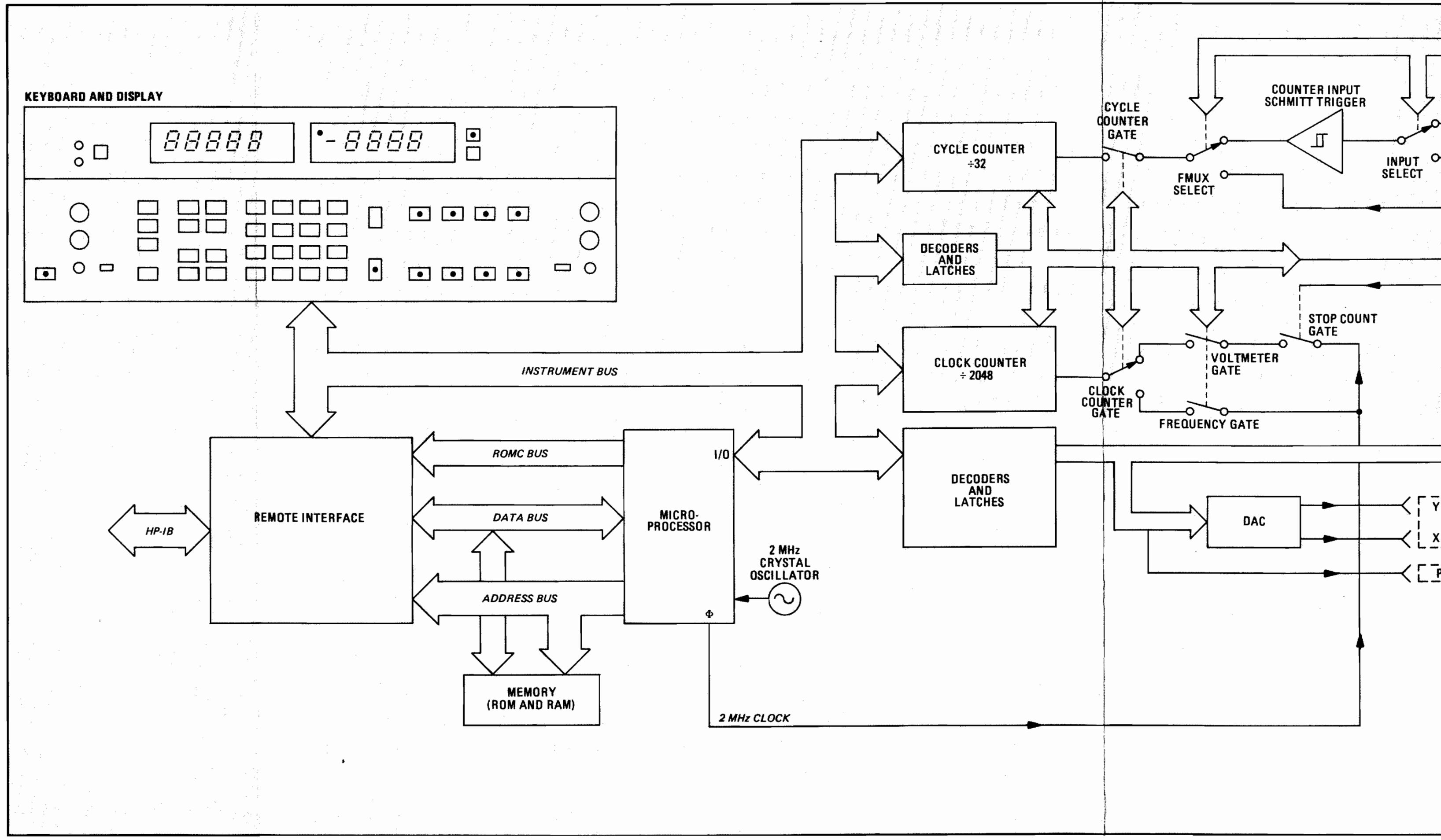
6. *The GUARB indicates a valid measurement is guaranteed. It is set by most interrupts, errors, trigger mode, and under some conditions in the OVERHEAD 1 block (e.g., it is always set in Signal-to-Noise measurement mode). It is also cleared by some conditions in OVERHEAD 1 block.*

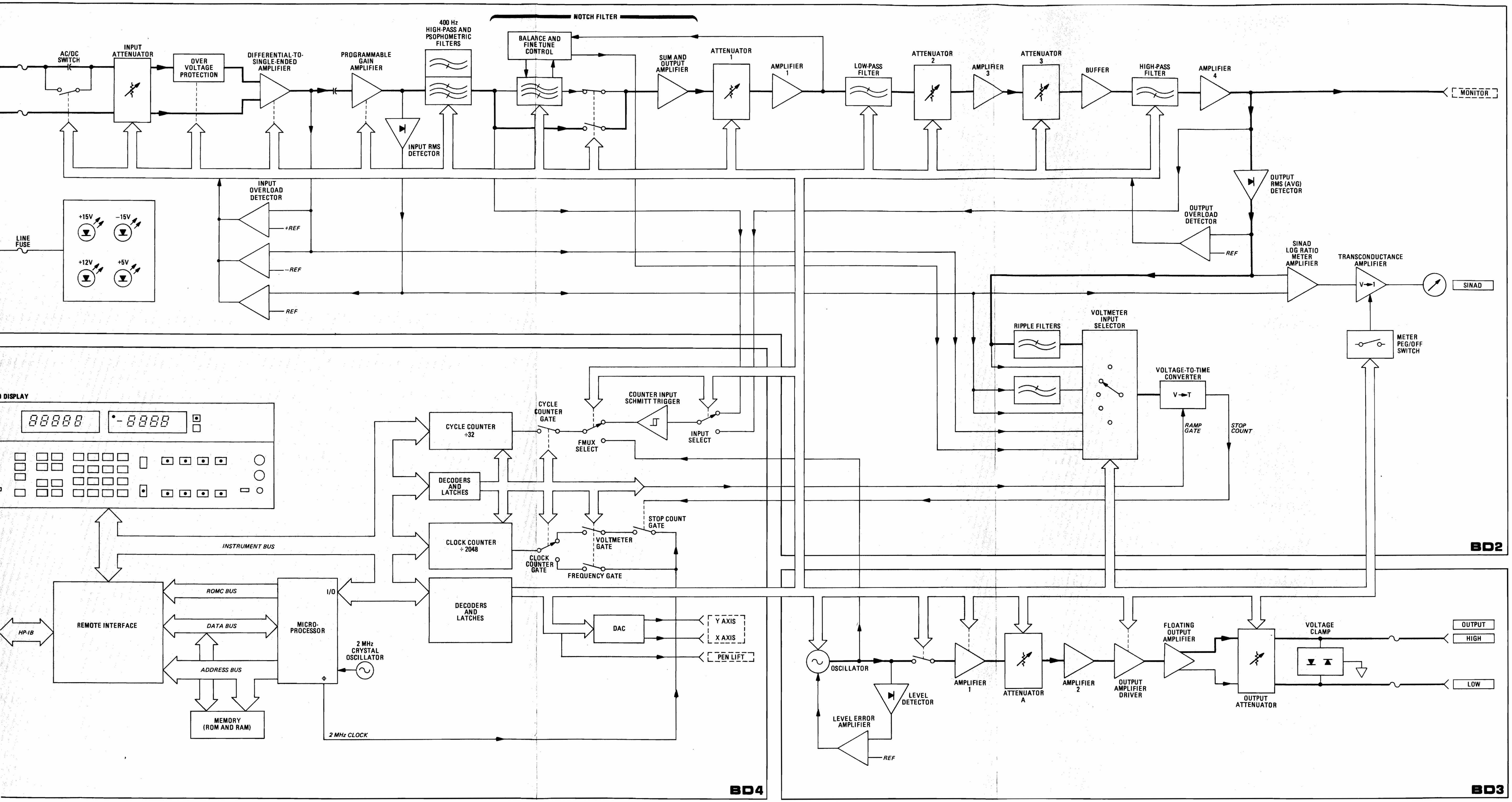
7. *The FIRSTB indicates the first cycle after an interrupt or error. It is cleared in the OVERHEAD 2 block.*

8. *MEAS1B is set if the instrument is in the Signal-to-Noise measurement mode and it is the first pass after an interrupt. It takes two passes to measure Signal-to-Noise. Therefore, the instrument must restart without a display output and clear MEAS1B at the end of the first pass.*

Figure 8-39. Supervisor Flowchart


NOTCH FILTER
INPUT
HIGH
LOW
AC/DC SWITCH
INPUT ATTENUATOR
OVER VOLTAGE PROTECTION
DIFFERENTIAL-TO-SINGLE-ENDED AMPLIFIER
PROGRAMMABLE GAIN AMPLIFIER
400 Hz HIGH-PASS AND PSOPHOMETRIC FILTERS
BALANCE AND FINE TUNE CONTROL
SUM AND OUTPUT AMPLIFIER
ATT
INPUT RMS DETECTOR
INPUT OVERLOAD DETECTOR
+REF
−REF
REF
+15V
−15V
+12V
+5V
LINE INPUT
LINE FUSE


KEYBOARD AND DISPLAY
INSTRUMENT BUS
REMOTE INTERFACE
HP-IB
ROMC BUS
DATA BUS
ADDRESS BUS
MICRO-PROCESSOR
I/O
Φ
MEMORY (ROM AND RAM)
2 MHz CRYSTAL OSCILLATOR
2 MHz CLOCK
CYCLE COUNTER ÷32
DECODERS AND LATCHES
CLOCK COUNTER ÷2048
DECODERS AND LATCHES
CYCLE COUNTER GATE
COUNTER INPUT SCHMITT TRIGGER
FMUX SELECT
INPUT SELECT
STOP COUNT GATE
VOLTMETER GATE
CLOCK COUNTER GATE
FREQUENCY GATE
DAC
Y
X



BD1

Figure 8-40. Overall Instrument Block Diagram

SERVICE SHEET BD2—MEASUREMENT CIRCUITS

TROUBLESHOOTING HELP

- Overall Block Diagram .... Service Sheet BD1

PRINCIPLES OF OPERATION

General

Service Sheet BD2 covers the input circuits, notch filter, output circuits, and part of the voltmeter; i.e., it covers most of the measurement (analyzer) circuits of the instrument.

Input Amplifier (A2)

The Input Amplifier circuits amplify or attenuate the input signal so that its output is within 1.9 to 3V at the input to the Notch Filter. The overall input gain can be controlled by Special Function 1 for ac measurements and Special Function 2 for dc. Other circuits provide ac or dc coupling, over-voltage protection, differential-to-single-ended conversion, filtering, and level sensing.

The HIGH and LOW INPUT jacks are the differential inputs. A front-panel switch permits convenient grounding of the LOW INPUT. Both inputs are protected by fuses. The LOW INPUT is also protected by the Limiter. For ac measurements, the AC/DC Switch is set to ac couple the input.

Two voltage dividers form the Input Attenuator. The first divider is 12 dB; the second divider has taps at 24 and 40 dB. The input level range and the associated attenuation are summarized in Table 8-9 for dc measurements and Table 8-10 for ac measurements.

The Over-Voltage Protection circuit opens the path to the Differential-to-Single-Ended Amplifier when the signal level exceeds ±15V. It is active only for ac measurements and is bypassed when the Input Attenuator is set to 40 dB. The diodes of the protection circuit are in series with the signal path and are normally biased on. The amplifier allows the signal voltage to develop at the output but prevents signal current from flowing through the diodes and creating distortion. At high levels the diode circuit is biased off.

Table 8-9. Input Attenuation for DC Measurements

DC Input Level Range		Input Attenuation (dB)
Range (Vdc)	Special Function	
4	2.4	0
16	2.3	12
64	2.2	24
300	2.1	40

The signals on the high and low paths are each amplified by programmable-gain amplifiers. The outputs from the two amplifiers are subtracted to create a single-ended signal (i.e., one that is referenced with respect to ground). The gain of the Differential-to-Single-Ended Amplifier is 0, 8, 16, or 20 dB. The gain is 0 dB when measuring dc. The gain for ac is summarized in Table 8-10.

DC measurements are made at the output of the Differential-to-Single-Ended Amplifier by the DC Voltmeter.

Table 8-10. Gain Summary for AC Measurements

Range (Vrms)	Special Function	Gain (dB)		
		Input Attenuator	Differential-to-Single-Ended Amplifier	Programmable Gain Amplifier
300	1.1	−40	0	0
189	1.2	−40	0	4
119	1.3	−40	0	8
75.4	1.4	−40	0	12
47.6	1.5	−24	0	0
30.0	1.6	−24	0	4
18.9	1.7	−24	0	8
11.9	1.8	−12	0	0
7.54	1.9	−12	0	4
4.76	1.10	−12	0	8
3.00	1.11	0	0	0
1.89	1.12	0	0	4
1.19	1.13	0	0	8
0.754	1.14	0	0	12
0.476	1.15	0	8	8
0.300	1.16	0	8	12
0.189	1.17	0	16	8
0.119	1.18	0	16	12
0.0754	1.19	0	20	12

The Programmable Gain Amplifier has a gain of 0, 4, 8, or 12 dB. The gain is summarized in Table 8-10. The amplifier is ac coupled at its input.

The rms level at the output of the Programmable Gain Amplifier is converted to dc by the Input RMS Detector. The output is measured by the DC Voltmeter and is used to set the input gain. It is also the numerator in the SINAD measurement or denominator in the distortion measurement.

The output of the Input RMS Detector and the dc at the input of the Programmable Gain Amplifier are compared to positive and negative references by the Input Overload Detector. This is to determine if the signal levels are too large for the input gain settings.

The output of the Programmable Gain Amplifier can be filtered with either the 400 Hz High-Pass Filter or the Psophometric Filter. Both are active filters. The 400 Hz High-Pass Filter is a 7-pole filter. The Psophometric Filter is a bandpass design with a response that closely approximates a C.C.I.T.T. psophometric filter standard (Recommendation P.53).

Notch Filter (A3)

The Notch Filter is a state-variable filter, i.e., a filter which is formed by combining various circuit blocks which perform simple mathematical functions (amplification, inversion, summation, and integration). A simplified diagram of the basic filter is shown in Figure 8-41. The transfer functions at various points in the diagram are also given. Band reject, bandpass, high-pass, and low-pass responses are all generated by the circuit. The output of the circuit diagram is V_2 (the notch filter output).

In actual use, the circuit is configured to obtain three types of responses: band reject or notch (in the SINAD, distortion, and distortion level measurement modes), bandpass (in Special Function 44.3), and flat (in the other ac measurement modes). Referring now to Block Diagram 2, the transfer function has a notch filter response when both switches at the input to the Sum and Output Amplifier are closed. The transfer function has a bandpass response when the path from the input to the Sum and Output Amplifier is open. The transfer function has a flat response when the path from Integrator 1 to the Sum and Output Amplifier is broken.

In the notch filter configuration, the notch frequency is coarse tuned by adjusting ω_0 in the simplified diagram (Rs and Cs in Integrators 1 and 2). This is done by the Controller. Coarse tuning accuracy is about 8%. Special Functions 53 and 54 can be used to manually set the tuning of the Notch Filter. The damping factor α is fixed and is approximately equal to 0.15. (Thus the low- and high-pass filters are underdamped.) To improve the depth of the notch, the phase and level of the output of the Notch Filter are sensed. The phase and level error voltages then correct the tuning and balance by controlling the amount of signal of the appropriate magnitude and phase injected into Sum Amplifier 2. (The amplifier is not depicted in Figure 8-41. It is a summing amplifier inserted before Integrator 2.) Operation of the fine tune and balance circuit is independent of the Controller.

Figure 8-42 shows the essential parts of the phase and level sensing circuits and the associated waveforms. The input to the circuit (V_{NOTCH}) comes from the output of the Notch Filter after being amplified by the combination of Attenuator 1 and Amplifier 1 of the Output Amplifier/ Voltmeter Assembly (A4) and the Notch Amplifier. The total gain is either 5.5 or 55 depending on the setting of Attenuator 1. The input (V_{NOTCH}) can be considered as having components in phase with the input to the Notch Filter and in quadrature (i.e., 90° out-of-phase) with it. The waveform for V_{NOTCH} in Figure 8-42 is shown as being totally in phase with the input.

The in-phase component represents a balance error in the Notch Filter, i.e., the notch does not completely null out the signal. The quadrature component represents a tuning error. When perfectly tuned, any output from an imperfectly balanced Notch Filter will be in phase with the input.

To sense the in-phase component, a current, produced by the input signal (V_{NOTCH}), is chopped in phase with the input to the Notch Filter. Chopper S_i is driven by the bandpass output of the Notch Filter which is in phase with the fundamental component of the

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output is
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Output
The sigr
detected
The sign
(gain=2)
maximu
have a s
the Con
Detector
by Speci

C Measurements

Gain (dB)	
fferential-to-ingle-Ended Amplifier	Programmable Gain Amplifier
0	0
0	4
0	8
0	12
0	0
0	4
0	8
0	0
0	4
0	8
0	0
0	4
0	8
0	12
8	8
8	12
16	8
16	12
20	12

gain of 0, 4, 8, or 12 dB. The
amplifier is ac coupled at

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nplifier can be filtered with
Psophometric Filter. Both
Filter is a 7-pole filter. The
ign with a response that
phometric filter standard

ter, i.e., a filter which is
cks which perform simple

SERVICE SHEET BD2 (Cont'd)

mathematical functions (amplification, inversion, summation, and integration). A simplified diagram of the basic filter is shown in Figure 8-41. The transfer functions at various points in the diagram are also given. Band reject, bandpass, high-pass, and low-pass responses are all generated by the circuit. The output of the circuit diagram is V_2 (the notch filter output).

In actual use, the circuit is configured to obtain three types of responses: band reject or notch (in the SINAD, distortion, and distortion level measurement modes), bandpass (in Special Function 44.3), and flat (in the other ac measurement modes). Referring now to Block Diagram 2, the transfer function has a notch filter response when both switches at the input to the Sum and Output Amplifier are closed. The transfer function has a bandpass response when the path from the input to the Sum and Output Amplifier is open. The transfer function has a flat response when the path from Integrator 1 to the Sum and Output Amplifier is broken.

In the notch filter configuration, the notch frequency is coarse tuned by adjusting ω_o in the simplified diagram (Rs and Cs in Integrators 1 and 2). This is done by the Controller. Coarse tuning accuracy is about 8%. Special Functions 53 and 54 can be used to manually set the tuning of the Notch Filter. The damping factor α is fixed and is approximately equal to 0.15. (Thus the low- and high-pass filters are underdamped.) To improve the depth of the notch, the phase and level of the output of the Notch Filter are sensed. The phase and level error voltages then correct the tuning and balance by controlling the amount of signal of the appropriate magnitude and phase injected into Sum Amplifier 2. (The amplifier is not depicted in Figure 8-41. It is a summing amplifier inserted before Integrator 2.) Operation of the fine tune and balance circuit is independent of the Controller.

Figure 8-42 shows the essential parts of the phase and level sensing circuits and the associated waveforms. The input to the circuit (V_{NOTCH}) comes from the output of the Notch Filter after being amplified by the combination of Attenuator 1 and Amplifier 1 of the Output Amplifier/ Voltmeter Assembly (A4) and the Notch Amplifier. The total gain is either 5.5 or 55 depending on the setting of Attenuator 1. The input (V_{NOTCH}) can be considered as having components in phase with the input to the Notch Filter and in quadrature (i.e., 90° out-of-phase) with it. The waveform for V_{NOTCH} in Figure 8-42 is shown as being totally in phase with the input.

The in-phase component represents a balance error in the Notch Filter, i.e., the notch does not completely null out the signal. The quadrature component represents a tuning error. When perfectly tuned, any output from an imperfectly balanced Notch Filter will be in phase with the input.

To sense the in-phase component, a current, produced by the input signal (V_{NOTCH}), is chopped in phase with the input to the Notch Filter. Chopper S_i is driven by the bandpass output of the Notch Filter which is in phase with the fundamental component of the input to the Notch Filter. If V_{NOTCH} is in phase with S_i (as in this example), the chopped current (I_{1i}) will be a half-wave rectified signal. Current I_2 is proportional to the input voltage but half the level of the chopped current. I_{1i} and I_2 are summed together to produce a current (I_{3i}) whose average (dc) level represents the level error of the in-phase component of the signal. For this example, the result is a full-wave rectified signal (I_{3i}). I_{3i} is integrated (i.e., amplified and filtered). The integrated current controls the gain of the Balance Multiplier which balances the Notch Filter.

Sensing of the quadrature component is similar. A current, produced by the input signal (V_{NOTCH}), is chopped in quadrature with the input to the Notch Filter. Chopper S_q is driven by the low-pass output of the Notch Filter which is 90° out of phase with the fundamental of the input to the Notch Filter. If V_{NOTCH} is in quadrature with S_q (as in this example), the chopped current (I_{1q}) will consist only of the half cycles going from the positive to the negative peak. (The dc component of this signal is zero). Current I_2 is as before. I_{1q} and I_2 are summed together to produce a current (I_{3q}) whose average (dc) level represents the level error of the quadrature component of the signal. For this example, the result has a dc value of zero. I_{3q} is integrated and controls the gain of the Tune Multiplier which tunes the Notch Filter.

More commonly, V_{NOTCH} will have both quadrature and in-phase components. The tune and balance detectors isolate the respective components and drive the respective multiplier with the error signal. The resistors through which I_{1i}, I_{1q}, and I_2 flow can be switched to change the magnitude of the current by a factor of ten. This compensates for the gain change in Attenuator 1 of assembly A4.

The Tune and Balance Multipliers can be visualized as variable-gain amplifiers with ac inputs from the bandpass and high-pass outputs of the Notch Filter respectively. (The bandpass output is in phase with the fundamental of the input to the Notch Filter; the high-pass output is in quadrature.) The dc control inputs (from the Tune and Balance Integrators) control the gain of the multipliers, including the sense of the gain (i.e., inverting or non-inverting). The output currents of the multipliers are summed together (their outputs are in parallel) and the composite signal is summed with the output from Integrator 1 in Sum Amplifier 2 to create a feedback loop that fine adjusts the tuning and balance of the Notch Filter.

Output Amplifier/Voltmeter (A4)

The signal from the Notch Filter is further processed before being detected by the voltmeter or sent to the rear-panel MONITOR output. The signal is amplified by Amplifier 1 (gain=5), the Low-Pass Filters (gain=2), Amplifier 3 (gain=10), and Amplifier 4 (gain=10). The maximum gain is thus 1000 (or 60 dB). Attenuators 1, 2, and 3 each have a selectable attenuation of 0 or 20 dB. The overall gain is set by the Controller so that the level sensed by the Output RMS (Avg) Detector is 3V or less. Switching of the attenuators can be controlled by Special Function 3 and is summarized in Table 8-11.

Selection of the active low-pass filters is from the front panel or HP-IB. When no filtering is selected, the 750 kHz filter is active. The other two filters are 80 and 30 kHz.

The Buffer amplifier has 0 dB of gain. The High-Pass Filters following the Buffer are either 0.3 Hz in AC LEVEL or 13 Hz in the other measurement modes. The 13 Hz filter is an active filter. Amplifier 4 drives the MONITOR output, the Output RMS (Avg) Detector, and the Counter Input Schmitt Trigger (see Service Sheet BD4).

The Output RMS (Avg) Detector converts its input into a dc voltage corresponding to the rms level of the signal. The detector can also be reconfigured to produce the absolute average level. The output is measured by the DC Voltmeter for computing measurement results and setting the gain of the Output Amplifier. In the rms configuration the circuit is an analog computer consisting of a full-wave rectifier, log amplifier, and anti-log amplifier and filter.

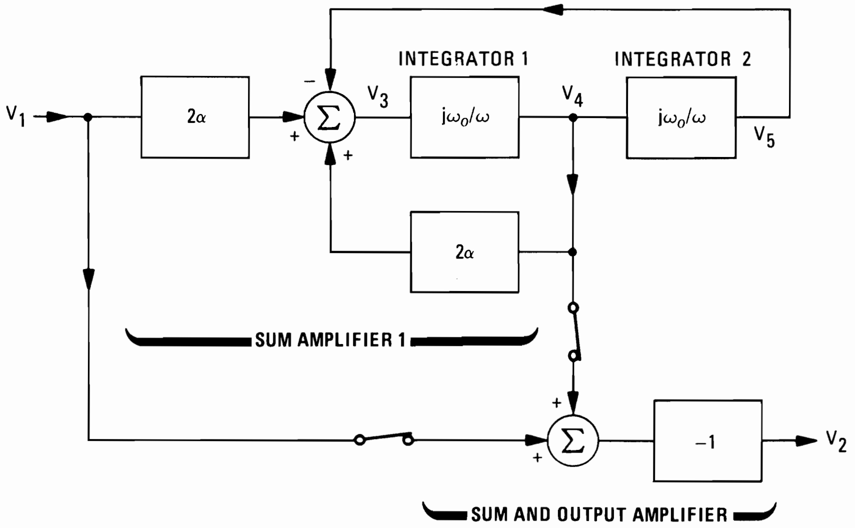
Table 8-11. Summary of Attenuator Switching

Post-Notch Amplifier		Attenuation (dB)		
Gain (dB)	Special Function	Attenuator 1	Attenuator 2	Attenuator 3
0	3.1	20	20	20
20	3.2	20	20	0
40	3.3	0	0	20
60	3.4	0	0	0

The Output Overload Detector compares the output of the Output RMS (Avg) Detector with a reference and sets the Output Amplifier gain to 0 dB if an overload is sensed (unless defeated by Special Function 3).

The SINAD Log Ratio Meter Amplifier produces an output voltage which is the log of the ratio of the outputs of the Input and Output RMS Detectors. The amplifier drives a Meter Transconductance Amplifier which converts the log-ratio voltage to a current which drives the front-panel SINAD meter.

The state of the Meter Peg/Off Switch is set by the Controller. If the SINAD reading exceeds 18 dB (or 24 dB when Special Function 7.1 is invoked), the switch is set to peg (force off scale) the meter. If the SINAD measurement mode has not been selected, the meter is switched off. Special Function 45 enables the meter for all ac measurement modes.



Transfer Function	Type of Response	Transfer Function at		
		$\omega = 0$	$\omega = \omega_0$	$\omega = \infty$
$\frac{V_2}{V_1} = - \frac{\omega^2 - \omega^2_0}{\omega^2 - j2\alpha\,\omega_0\omega - \omega^2_0}$	Notch Filter	−1	0	−1
$\frac{V_3}{V_1} = \frac{2\alpha\omega^2}{\omega^2 - j2\alpha\omega_0\omega - \omega^2_0}$	High-Pass Filter	0	j	2α
$\frac{V_4}{V_1} = \frac{j2\alpha\omega_0\omega}{\omega^2 - j2\alpha\omega_0\omega - \omega^2_0}$	Bandpass Filter	0	−1	0
$\frac{V_5}{V_1} = - \frac{2\alpha\omega^2_0}{\omega^2 - j2\alpha\omega_0\omega - \omega^2_0}$	Low-Pass Filter	2α	−j	0

Figure 8-41. Simplified Diagram of Notch Filter with Transfer Functions Given for Various Points

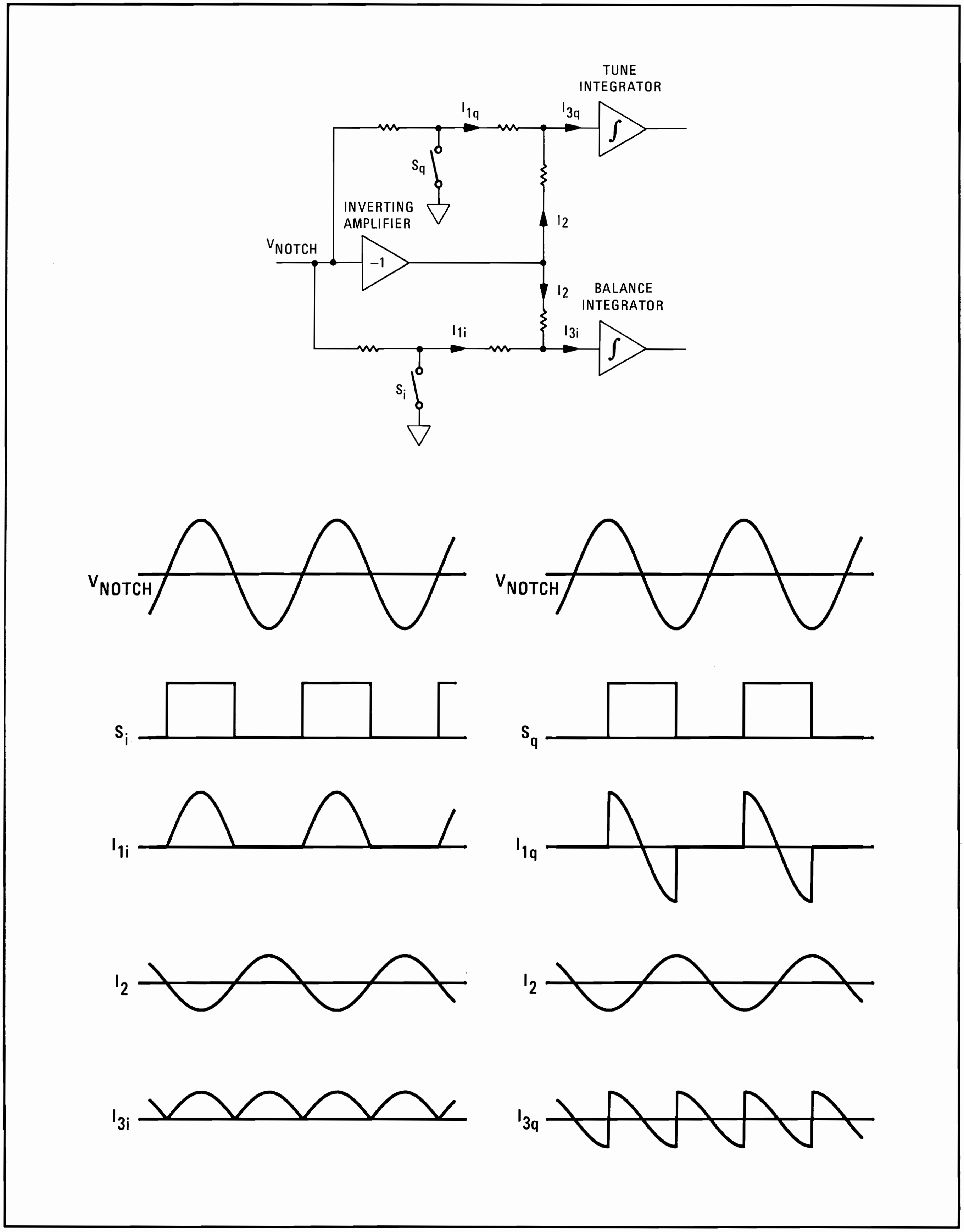


Figure 8-42. Notch Filter Tune and Balance Detectors

SERVICE SHEET BD2 (Cont'd)

The Voltmeter Input Selector selects one of the dc inputs into the Voltage-to-Time Converter. The Ripple Filters on lines from the Input and Output RMS Detectors add low-pass filtering to reduce display fluctuation on noisy measurements. The output from the Output RMS (Avg) Detector is also heavily filtered by the SINAD Filter in the SINAD measurement mode.

The output of the selector is the reference input for a Comparator. The Comparator's other input is a constant slope ramp. The ramp is initiated by the Controller. As the ramp rises, the Counter counts the time base reference (2 MHz). When the ramp voltage equals the level of the reference input, the Comparator signals the Counter to stop counting. The accumulated count is proportional to the dc voltage. Ground is measured before each reading and subtracted from the DC Voltmeter measurement to eliminate the effect of offsets. The ramp begins at approximately −6V which permits measurement of negative voltages.

Power Supplies (A11 and A13)

The four regulated supplies are: +15V, −15V, +12V, and +5V. The +15V and −15V supplies are used primarily to power the analog circuits. The +5V supply is used to power most of the relays and digital circuits. The +12V supply powers the main Controller ICs. The inputs for the +15V, −15V, and +12V supplies are obtained from one secondary winding of the power transformer, and the +5V supply (the supply drawing the most current) is obtained from another. The supplies are independently referenced except the +5V supply, which is reference from the +15V supply and also requires the −15V supply to operate properly. Each supply has an indicator LED.

TROUBLESHOOTING

General

Procedures for checking the measurement circuits of the instrument are given below. The blocks or points to check are marked on the block diagram by a hexagon with a check mark and a number inside, e.g., ⟨√3⟩. The procedures assume that the source is working properly. A second audio source is needed only if distortion is out of specification and it cannot be determined whether the instrument's source or distortion measurement is at fault. Before performing any check, perform all the checks on Service Sheet BD1.

Equipment

Audio Analyzer	HP 8903A or HP 339A
Oscilloscope	HP 1740A

⟨√1⟩ Input Amplifier Check

NOTE

This check does not test the Over-voltage Protection. If the Over-voltage Protection is suspected to be faulty, see Service Sheet 1.

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the INPUT and OUTPUT switches to ground. Key in AMPTD 3 V. Connect the HIGH OUTPUT to the HIGH INPUT through a tee adapter.

2. Connect a high-impedance, ac coupled oscilloscope to the tee at the HIGH INPUT. Use the oscilloscope's vertical gain controls to adjust the display amplitude for 5 divisions peak-to-peak deflection of the sinusoidal signal. (The period of the signal should be 1 ms.)

3. Connect the oscilloscope to A2TP5 (SING END). Key in the Special Functions listed in Table 8-12. For each setting, increase the oscilloscope's vertical gain by the amount indicated. The peak-to-peak amplitude, displayed on the oscilloscope, should be within the limits indicated. If faulty, see Service Sheet 1 and check the Input Attenuator.

Table 8-12. Amplitude Limits at A2TP5, Special Functions 1.11, 1.8, 1.5 and 1.1

Special Function	Total Change in Oscilloscope Vertical Gain	Amplitude Limits (divisions pk-pk)	
		Minimum	Maximum
1.11	×1	4.9	5.1
1.8	×1	1.2	1.3
1.5	×10	3.0	3.3
1.1	×100	4.8	5.2

4. On the Audio Analyzer, key in 1.11 SPCL. Key in AMPTD .1 V. Readjust the oscilloscope's vertical gain for a display of 5 divisions peak-to-peak.

5. Reduce the oscilloscope's gain by a factor of 10. Key in the Special Functions listed in Table 8-13. The peak-to-peak amplitude displayed on the oscilloscope should be within the limits indicated.

SERVICE SHEET BD2 (Cont'd)

If faulty, see Service Sheet 1 and check the Differential-to-Single-Ended Amplifier.

Table 8-13. Amplitude Limits at A2TP5, Special Functions 1.15, 1.17 and 1.19

Special Function	Amplitude Limits (divisions pk-pk)	
	Minimum	Maximum
1.15	1.2	1.3
1.17	3.0	3.3
1.19	4.8	5.2

6. On the Audio Analyzer, key in 1.11 SPCL. On the oscilloscope, set the gain back to ×1. (Check that the waveform is still 5 divisions peak-to-peak.)

7. Connect the oscilloscope to A2TP4 (PGM AMP). On the Audio Analyzer, key in the Special Functions listed in Table 8-14. For each setting, decrease the oscilloscope's gain by the amount indicated. The peak-to-peak amplitude, displayed on the oscilloscope, should be within the limits indicated. If faulty, see Service Sheet 2 and check the Programmable Gain Amplifier.

Table 8-14. Amplitude Limits at A2TP4, Special Functions 1.11, 1.12, 1.13 and 1.14

Special Function	Total Change in Oscilloscope Vertical Gain	Amplitude Limits (divisions pk-pk)	
		Minimum	Maximum
1.11	×1	4.8	5.2
1.12	×1	7.7	8.2
1.13	÷10	1.2	1.3
1.14	÷10	1.9	2.1

8. On the Audio Analyzer, key in 1.11 SPCL. On the oscilloscope, set the gain back to ×1. (Check that the waveform is still 5 divisions peak-to-peak.)

9. Connect the oscilloscope to A2TP3 (OUT). The oscilloscope display should be between 4.9 and 5.1 divisions peak-to-peak. If faulty, see Service Sheet 2 and check the 400 Hz High-Pass and Psophometric Filters.

10. On the Audio Analyzer, key in the frequencies and HP/BP FILTER indicated in Table 8-15. For each setting, the peak-to-peak amplitude, displayed on the oscilloscope, should be within the limits indicated. If faulty, see Service Sheet 2 and check 400 Hz High-Pass and Psophometric Filters.

Table 8-15. Amplitude Limits at A2TP3 with Various SOURCE Frequencies and Filters

Source Frequency (Hz)	HP/BP FILTER	Amplitude Limits (divisions pk-pk)	
		Minimum	Maximum
1 000	400 Hz	4.9	5.1
1 000	PSOPH	5.2	6.0
400	PSOPH	2.0	2.8
400	400 Hz	2.5	4.5
3 000	PSOPH	2.2	3.0

11. On the Audio Analyzer, key in AMPTD 1 V. Connect the oscilloscope to A2TP4 (PGM AMP). Adjust the oscilloscope's vertical gain for 7.1 divisions peak-to-peak amplitude.

12. DC couple the oscilloscope and connect it to A2TP2 (RMS). The waveform should be a dc voltage between 2.4 and 2.6 divisions (with respect to ground). If faulty, see Service Sheet 2 and check the Input RMS Detector.

13. Set the oscilloscope for 1 V/division. On the Audio Analyzer, key in 1.12 SPCL. Key in AMPTD 5.2 V. The voltage, displayed on the oscilloscope, should be approximately 8.2 Vdc. (Ignore the right display.) If faulty, see Service Sheet 2 and check the Input RMS Detector and Input Overload Detector.

14. On the Audio Analyzer, key in AMPTD 5.5 V. The voltage should drop to approximately 0 Vdc. The displays should show Error 30. If faulty, see Service Sheet 2 and check the Input RMS Detector and Input Overload Detector.

15. On the Audio Analyzer, key in 1.11 SPCL. Key in AMPTD 1 V. Connect the oscilloscope to A2TP4 (PGM AMP). Adjust the oscilloscope's vertical gain for 5 divisions peak-to-peak amplitude.

16. Set the INPUT switch to FLOAT. Connect the HIGH OUTPUT to the LOW INPUT. Short the HIGH INPUT to ground. The waveform on the oscilloscope should be between 4.9 and 5.1 divisions peak-to-peak.

SERVICE SHEET BD2 (Cont'd)

17. On the Audio Analyzer, press AUTOMATIC OPERATION. Press S (Shift) DC LEVEL. Key in 2.3 SPCL to set the dc level range to 16V. Connect the oscilloscope to A2TP5 (SING END).

18. Remove the short from the HIGH INPUT. Remove the connection from the LOW INPUT. Set the INPUT switch to ground. Connect A13TP3 (+5V) to the HIGH INPUT. The oscilloscope should show a dc voltage of approximately −1.25 Vdc. If faulty, see Service Sheet 1 and check the AC/DC Switch.

19. Press AC LEVEL. The oscilloscope should show a dc voltage of approximately 0 Vdc. If faulty, see Service Sheet 1 and check the AC/DC Switch.

⟨√2⟩ Notch Filter Check

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the INPUT and OUTPUT switches to ground. Set the 80 kHz LOW PASS filter off. Key in AMPTD 3 V and FREQ 98.7 Hz. Key in 1.11 SPCL to set the input level to the 3V range. Key in 53.0 SPCL to set the Notch Filter to its lowest frequency range. Key in 54.115 SPCL to set the Notch Filter Coarse Tune near the middle of its range (approximately 98.7 Hz). Connect the HIGH OUTPUT to the HIGH INPUT.

2. Connect a high-impedance, ac coupled oscilloscope to A2TP3 (OUT). The waveform on the oscilloscope should be a sine wave with an amplitude between 8 and 9 Vpp and a period of approximately 10 ms. If faulty, see ⟨√1⟩ Input Amplifier Check.

3. Use the oscilloscope's vertical gain controls to adjust the display amplitude for 5 divisions peak-to-peak deflection of the signal.

4. On the Audio Analyzer, connect A3TP3 (TUNE) and A3TP4 (BAL) to A3TP1 (GND) to defeat the fine tune and balance control. Connect the oscilloscope to A3TP5 (BP OUT). The peak-to-peak amplitude, displayed on the oscilloscope, should be between 4.7 and 5.3 divisions. If faulty, see Service Sheet 3 and check Sum Amplifiers 1 and 2 and Integrators 1 and 2.

5. Connect the oscilloscope to A3TP7 (OUT). The peak-to-peak amplitude, displayed on the oscilloscope, should be between 4.9 and 5.1 divisions. If faulty, see Service Sheet 3 and check the Sum and Output Amplifier.

6. On the Audio Analyzer, key in 44.3 SPCL to set the Notch Filter to the bandpass mode. The peak-to-peak amplitude, displayed on the oscilloscope, should be between 4.7 and 5.3 divisions. The amplitude display on the Audio Analyzer should read between 2.8 and 3.2V. If the oscilloscope waveform is faulty, see Service Sheet 3 and check the Sum and Output Amplifier. If the amplitude display is faulty, see ⟨√3⟩ Output Amplifier Check and ⟨√4⟩ Voltmeter Check.

7. On the Audio Analyzer, key in the Special Functions listed in Table 8-16. For each setting, key in the first frequency, set RATIO off (if on), and, after settling, note the amplitude. Then press RATIO to establish a ratio reference. Key in the other two frequencies, and after settling, note the relative amplitude. The levels should be within the limits indicated. If faulty, see Service Sheet 3 and check Sum Amplifiers 1 and 2 and Integrators 1 and 2.

Table 8-16. Amplitude Limits at A3TP7, Special Functions 53.N

Special Function	Source Frequency (Hz)	Amplitude Limits	
		Minimum	Maximum
53.0	98.7	2.8V	3.2V
	49.4	15%	25%
	197	15%	25%
53.1	781	2.8V	3.2V
	390	15%	25%
	1 560	15%	25%
53.2	6 250	2.8V	3.2V
	3 130	15%	25%
	12 500	15%	25%
53.3	50 000	2.8V	3.2V
	25 000	15%	25%
	100 000	15%	25%

8. On the Audio Analyzer, key in 53.2 SPCL. Key in the frequencies listed in Table 8-17. For each setting, key in the pair of Special Functions indicated. After keying in the first member of the pair of Special Functions, press RATIO twice to establish a new ratio reference. After keying in the second Special Function, the amplitude read on the Audio Analyzer's display should be within the

SERVICE SHEET BD2 (Cont'd)

limits shown. If faulty, see Service Sheet 3 and check Sum Amplifiers 1 and 2 and Integrators 1 and 2.

Table 8-17. Amplitude Limits (%) at A3TP7, Special Functions 54.N

SOURCE Frequency (Hz)	Special Functions	Amplitude Limits (%)	
		Minimum	Maximum
9120	54.128, 54.127	97	99
4560	54.64, 54.63	94	97
2280	54.32, 54.31	90	94
1140	54.16, 54.15	82	88
570	54.8, 54.7	68	76
285	54.4, 54.3	46	58
142.5	54.2, 54.1	20	40

9. On the Audio Analyzer, key in FREQ 1 kHz, 53.1 SPCL, and 54.147 SPCL. Connect the oscilloscope to A3TP2 (NOTCH AMP) and set it for absolute vertical calibration. The waveform should be a heavily clipped sine wave with an amplitude between 20 and 25 Vpp. If faulty, see Service Sheet 4 and check the Notch Amplifier.

10. Press RATIO twice to establish a new ratio reference. Key in 44.1 SPCL to set the Notch Filter to the notch mode. The amplitude display should be less than 25%. If faulty, see Service Sheet 3 and check the Sum and Output Amplifier.

11. Remove the ground from A3TP3 and connect the oscilloscope (dc coupled) to it instead. On the Audio Analyzer, key in 800 Hz. The waveform should be a dc voltage between 4.0 and 4.6 Vdc. If faulty, see Service Sheet 4 and check the tune control circuits.

12. On the Audio Analyzer, key in 1.2 kHz. The waveform should be between −4.6 and −4.0 Vdc. If faulty, see Service Sheet 4 and check the tune control circuits.

13. On the Audio Analyzer, key in FREQ 1 kHz. The waveform should be between −1 and +1 Vdc. If faulty, see Service Sheet 3 and check the Sum Amplifier 2 and Service Sheet 4 and check the Tune Multiplier.

14. Remove the ground from A3TP4. The amplitude display should read 1% or less. If faulty, see Service Sheet 3 and check the Sum Amplifier and Service Sheet 4 and check the balance control circuits.

15. On the Audio Analyzer, key in 41.0 SPCL. Key in AMPTD 3V. Press DISTN. The amplitude display should read 0.01% or less. If the level is slightly out of limit, perform the Notch Filter Tune and Balance Adjustment, paragraph 5-12. Otherwise, the Notch Filter is functioning, but the automatic tuning sequence is faulty. Check the Counter and Output Amplifier/ Voltmeter.

√3 Output Amplifier Check

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the INPUT and OUTPUT switches to ground. Set the 80 kHz LOW PASS filter off. Key in AMPTD 300 mV. Key in 1.11 SPCL to set the input level to the 3V range. Key in 3.1 SPCL to set the output level to the least sensitive range. Connect the HIGH OUTPUT to the HIGH INPUT.

2. Connect a high-impedance, ac coupled oscilloscope to A3TP7 (OUT). The waveform on the oscilloscope should be a sine wave with an amplitude between 800 and 900 mVpp and a period of approximately 1 ms. If faulty, see √2 Notch Filter Check.

3. Use the oscilloscope's vertical gain controls to adjust the display amplitude for 5 divisions peak-to-peak deflection.

4. Connect the oscilloscope to A4TP8 (AMP 1). The peak-to-peak amplitude, displayed on the oscilloscope, should be between 2.4 and 2.6 divisions. If faulty, see Service Sheet 5 and check Attenuator 1 and Amplifier 1.

5. On the Audio Analyzer, key in AMPTD 30 mV. Key in 3.3 SPCL. The peak-to-peak amplitude, displayed on the oscilloscope, should be between 2.4 and 2.6 divisions. If faulty, see Service Sheet 5 and check Attenuator 1.

6. Connect the oscilloscope to A4TP6 (AMP 2). The peak-to-peak amplitude, displayed on the oscilloscope, should be between 4.8 and 5.2 divisions. If faulty, see Service Sheet 5 and check the Low-Pass Filters.

7. Connect the oscilloscope to A4TP5 (AMP 3). Decrease the vertical gain of the oscilloscope by a factor of 10. The peak-to-peak amplitude, displayed

SERVICE SHEET BD2 (Cont'd)

on the oscilloscope, should be between 4.8 and 5.2 divisions. If faulty, see Service Sheet 5 and check Attenuator 2 and Amplifier 3.

8. On the Audio Analyzer, key in AMPTD 300 mV. Key in 3.2 SPCL. Increase the vertical gain of the oscilloscope by a factor of 10. The peak-to-peak amplitude, displayed on the oscilloscope, should be between 4.8 and 5.2 divisions. If faulty, see Service Sheet 5 and check Attenuator 2.

9. Connect the oscilloscope to A4TP4 (AMP 4). Decrease the vertical gain of the oscilloscope by a factor of 10. The peak-to-peak amplitude, displayed on the oscilloscope, should be between 4.8 and 5.2 divisions. If faulty, see Service Sheet 5 and check Attenuator 3, the Buffer, the High-Pass Filter, and Amplifier 4.

10. On the Audio Analyzer, key in 3.1 SPCL. Increase the vertical gain of the oscilloscope by a factor of 10. The peak-to-peak amplitude, displayed on the oscilloscope, should be between 4.8 and 5.2 divisions. If faulty, see Service Sheet 5 and check Attenuator 3.

11. On the Audio Analyzer, key in FREQ 80 kHz. Set the 80 kHz LOW PASS filter on. The peak-to-peak amplitude, displayed on the oscilloscope, should be between 3 and 4 divisions. If faulty, see Service Sheet 5 and check the 80 kHz Low-Pass Filter.

12. On the Audio Analyzer, key in FREQ 30 kHz. Set the 30 kHz LOW PASS filter on. The peak-to-peak amplitude, displayed on the oscilloscope, should be between 3 and 4 divisions. If faulty, see Service Sheet 5 and check the 30 kHz Low-Pass Filter.

13. On the Audio Analyzer, key in 55.0 SPCL, 56.15 SPCL, and 57.140 SPCL to set the internal source to 13 Hz. The peak-to-peak amplitude, displayed on the oscilloscope, should be between 4.6 and 5.4 divisions. If faulty, see Service Sheet 5 and check the High-Pass Filter.

14. On the Audio Analyzer, key in 0.435 SPCL to insert the 13 Hz High-Pass Filter. (Ignore the displays.) The peak-to-peak amplitude, displayed on the oscilloscope, should be between 3 and 4 divisions. If faulty, see Service Sheet 5 and check the High-Pass Filter.

〈√4〉 Voltmeter Check

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Key in AMPTD 300 mV. Key in 1.11 SPCL to set the input level to the 3V range. Key in 3.2 SPCL to set the output level to the 20 dB range. Connect the HIGH OUTPUT to the HIGH INPUT.

2. Connect a high-impedance, ac coupled oscilloscope to A4TP4 (AMP 4). The waveform on the oscilloscope should be a sine wave with an amplitude between 8 and 9 Vpp and a period of approximately 1 ms. If faulty, see 〈√3〉Output Amplifier Check.

3. DC couple the oscilloscope and connect it to A4TP1 (DC OUT). The waveform should be a dc voltage between 2.8 and 3.2 Vdc. If faulty, see Service Sheet 6 and check the Output RMS (Avg) Detector.

4. On the Audio Analyzer, key in AMPTD 400 mV. Key in 0.76 SPCL to enable readback of the Output Overload Detector. The displays should read 0000 0000. If faulty, see Service Sheet 6 and check the Output Overload Detector.

5. On the Audio Analyzer, key in AMPTD 420 mV. Key in 0.76 SPCL. The displays should read 0001 0000. If faulty, see Service Sheet 6 and check the Output Overload Detector.

Hint: Because of hysteresis in the Output Overload Detector, it will be necessary to key in AMPTD 300 mV first if it is desired to repeat steps 4 and 5.

6. On the Audio Analyzer, key in AMPTD 300 mV. Connect the oscilloscope to A4TP9 (MUX). The waveform should be a square wave switching between 0 Vdc and 1.7 to 1.9 Vdc. If faulty, see Service Sheet 7 and check the Voltmeter Input Selector.

Hint: The test point is below and to the left of A4TP2. If it can only be reached by extending the board or by unplugging the assembly, turn the instrument off first. After power up, key in AMPTD 300 mV, 1.11 SPCL, and 3.2 SPCL.

7. The right display should read between 0.29 and 0.31V. If faulty, see Service Sheet 7 and begin troubleshooting with the Voltage-to-Time Converter.

SERVICE SHEET BD2 (Cont'd)

Hint: If the other inputs to the Voltmeter Input Selector are suspected to be faulty, see Service Sheet 7 and check the Voltmeter Input Selector.

8. On the Audio Analyzer, press SINAD. Key in AMPTD 3 V. Key in 3.0 SPCL. Key in 45.1 SPCL to enable the SINAD meter. The amplitude display should read greater than 80 dB. The SINAD meter should read beyond full scale. If the amplitude display is faulty, see ⟨√2⟩ Notch Filter Check. If the SINAD meter is faulty, see Service Sheet 6 and check the SINAD meter circuits.

9. On the Audio Analyzer, key in 6.1 SPCL to hold the Notch Filter at its present setting. Key in FREQ 900 Hz. The amplitude display should read between 15 and 20 dB, but more importantly, the SINAD meter should agree with this reading to within 1 dB. If the SINAD meter is faulty, see Service Sheet 6 and check the SINAD meter circuits.

10. On the Audio Analyzer, key in 0.524 SPCL. The SINAD meter should read beyond full scale. If faulty, see Service Sheet 6 and check the Meter Peg/Off Switch.

11. On the Audio Analyzer, key in 0.528 SPCL. The SINAD meter should read between 0 and +0.5 dB. If faulty, see Service Sheet 6 and check the Meter Peg/Off Switch.

⟨√5⟩ Power Supply Check

1. Key in 41.0 SPCL to initialize the instrument. Key in S (Shift) DC LEVEL. Set the INPUT switch to ground. Observe the four green power supply LEDS on the A13 Power Supply and Mother Board Assembly. The LEDs should be on. If faulty, see Service Sheet 20.

CAUTION

MOS and CMOS ICs can be damaged by static charges and circuit transients. Do not remove the A8 Controller/Counter Assembly or the A9 Remote Control Interface Assembly while power is applied to the instrument.

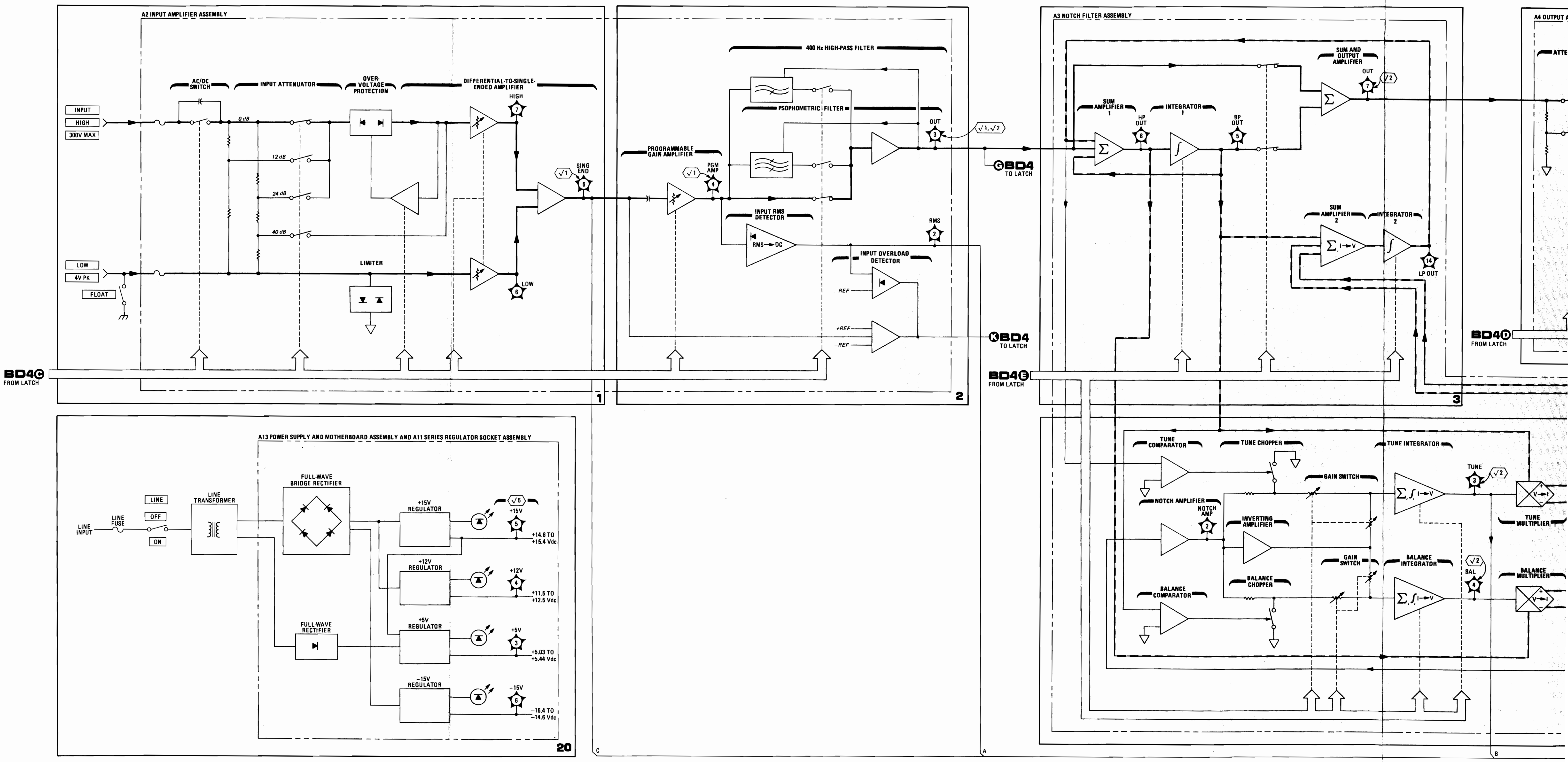
NOTE

When removing assemblies to check for shorts, switch the instrument off before removing the assembly and back on when testing the supply. This will unlatch any crowbar SCRs that may have fired.

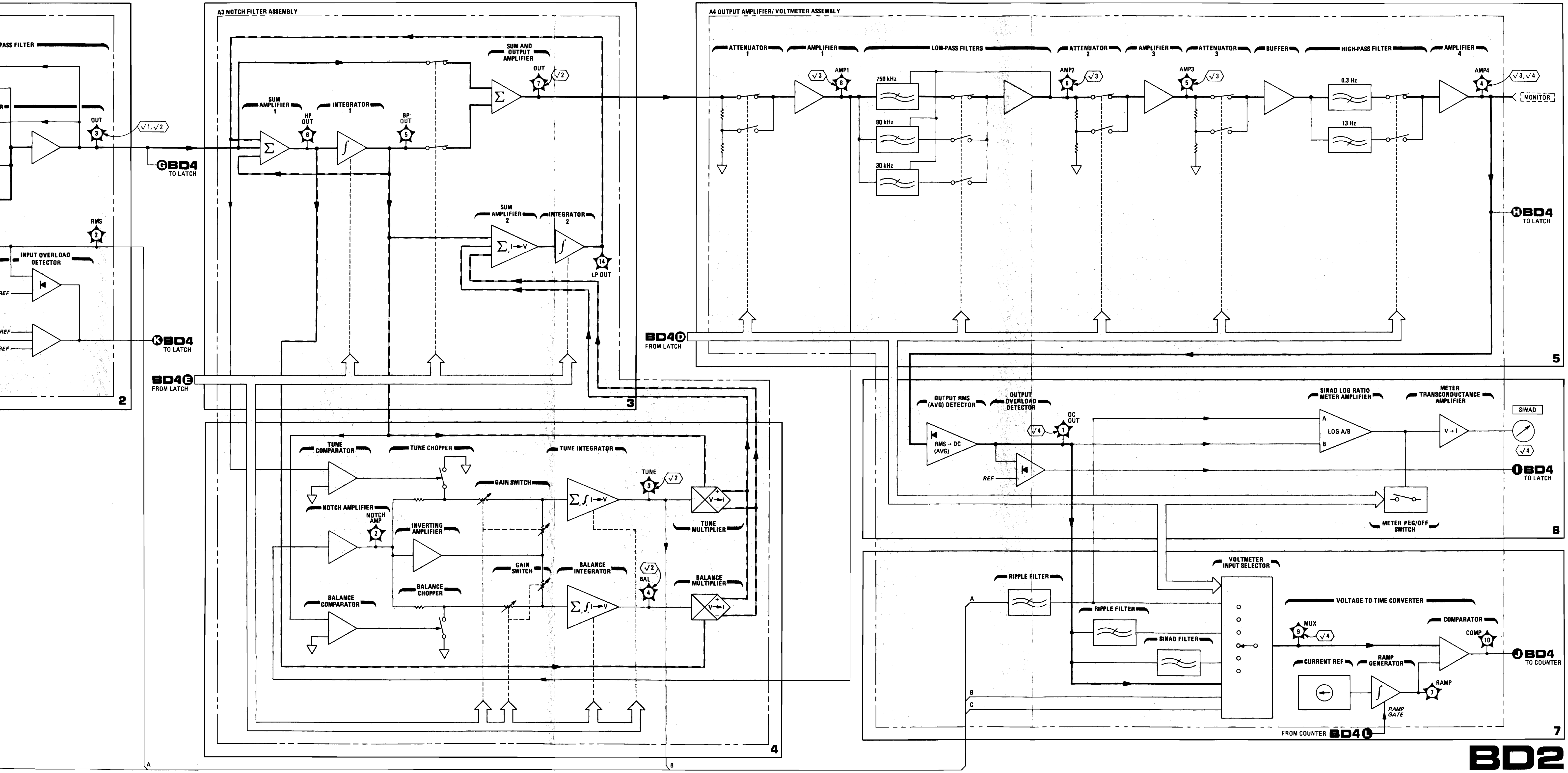
Hint: If a short is suspected, remove assemblies one at a time and observe the four power supply LEDs. An extinguished LED will light when the short is removed from the supply. The A1 Keyboard and Display Assembly can be disconnected by unplugging the wide ribbon cable plugged into it.

Hint: The +5V supply is referenced from the +15V supply and also depends on the −15V supply. The +15V supply and the +12V supply share a common transformer secondary and fuse.

2. Connect the HIGH INPUT to A13TP3 through TP6. The amplitude display for each test point should be within the limits shown in Figure 8-43. If faulty, see Service Sheet 20.



A2 INPUT AMPLIFIER ASSEMBLY
AC/DC SWITCH
INPUT ATTENUATOR
OVER-VOLTAGE PROTECTION
DIFFERENTIAL-TO-SINGLE-ENDED AMPLIFIER
INPUT
HIGH
300V MAX
0 dB
12 dB
24 dB
40 dB
HIGH
7
LOW
6
LIMITER
LOW
4V PK
FLOAT
√1
SING END
5
BD4C
FROM LATCH
1
400 Hz HIGH-PASS FILTER
PSOPHOMETRIC FILTER
PROGRAMMABLE GAIN AMPLIFIER
√1
PGM AMP
4
OUT
3
√1, √2
INPUT RMS DETECTOR
RMS→DC
RMS
2
INPUT OVERLOAD DETECTOR
REF
+REF
−REF
GBD4
TO LATCH
KBD4
TO LATCH
2
A3 NOTCH FILTER ASSEMBLY
SUM AND OUTPUT AMPLIFIER
OUT
7
√2
SUM AMPLIFIER 1
HP OUT
6
INTEGRATOR 1
BP OUT
5
SUM AMPLIFIER 2
INTEGRATOR 2
Σ, I→V
14
LP OUT
BD4E
FROM LATCH
3
BD4D
FROM LATCH
A4 OUTPUT A
ATTE
TUNE COMPARATOR
TUNE CHOPPER
TUNE INTEGRATOR
GAIN SWITCH
TUNE
3
√2
NOTCH AMPLIFIER
NOTCH AMP
2
INVERTING AMPLIFIER
TUNE MULTIPLIER
V→I
GAIN SWITCH
BALANCE INTEGRATOR
√2
BAL
4
BALANCE CHOPPER
BALANCE COMPARATOR
BALANCE MULTIPLIER
Σ, ∫, I→V
A13 POWER SUPPLY AND MOTHERBOARD ASSEMBLY AND A11 SERIES REGULATOR SOCKET ASSEMBLY
LINE INPUT
LINE FUSE
LINE
OFF
ON
LINE TRANSFORMER
FULL-WAVE BRIDGE RECTIFIER
FULL-WAVE RECTIFIER
+15V REGULATOR
√5
+15V
5
+14.6 TO +15.4 Vdc
+12V REGULATOR
+12V
4
+11.5 TO +12.5 Vdc
+5V REGULATOR
+5V
3
+5.03 TO +5.44 Vdc
−15V REGULATOR
−15V
6
−15.4 TO −14.6 Vdc
20
C
A
B



BD2

Figure 8-43. Measurement Circuits Block Diagram

SERVICE SHEET BD3—SOURCE CIRCUITS BLOCK DIAGRAM

TROUBLESHOOTING HELP

- Overall Block Diagram .... Service Sheet BD1

PRINCIPLES OF OPERATION

General

Service Sheet BD3 covers the source circuits which consist of the oscillator and its output circuits.

Oscillator (A5)

The Oscillator is conceptually similar to the Notch Filter in that it is a state-variable design; i.e., it is formed by combining various circuit blocks which perform simple mathematical functions (amplification, inversion, summation, and integration). A simplified diagram of the basic oscillator is shown in Figure 8-44. Each integrator causes 270° of phase shift (i.e., 90° plus an inversion) and the Sum Amplifier and Fine Tune circuits cause an inversion. Thus, there are 720° of total phase shift around the loop which gives rise to positive feedback—a necessary condition for oscillation. The output of the circuit (not shown on the simplified diagram) is taken from Integrator 1.

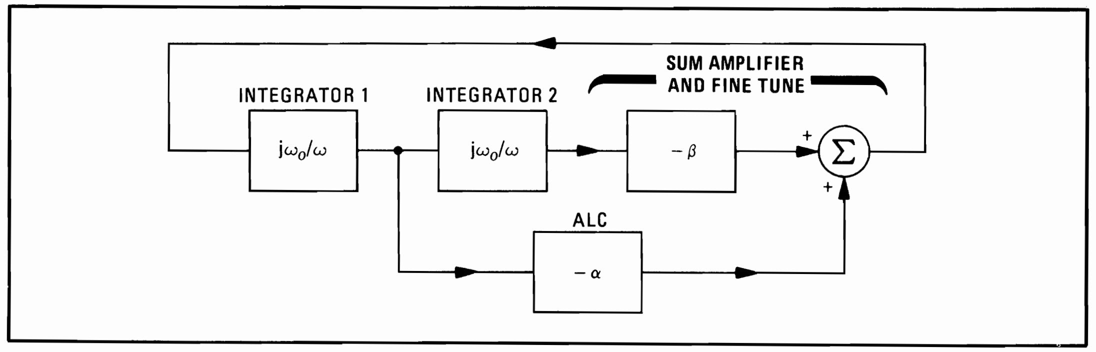


Figure 8-44. Simplified Diagram of the Basic Oscillator

The equation governing the frequency of oscillation for the circuit is

$$s = 1/2\ \omega_0\,(\,\alpha \pm \sqrt{\alpha^2 - 4\beta}),$$

where s is the complex frequency.

Assume for a moment that α=0. The radian frequency of oscillation consists only of the imaginary term and is

$$s = j\omega = j\omega_0\,\sqrt{\beta} = j2\pi\ f_0\,\sqrt{\beta}.$$

The frequency is coarse tuned by adjusting ω_0 in the simplified diagram (Rs and Cs in Integrators 1 and 2). Fine tuning is accomplished by adjustment of β. Tuning is done by the Controller which uses the Counter to check frequency. Special Functions 55, 56, and 57 can be used to manually set the tuning of the Oscillator.

To obtain stable, low distortion oscillation at the prescribed frequency and level (3 Vrms) requires exact adjustment of the gain α to obtain a purely imaginary term for s. If s contains a positive real term, the amplitude of oscillation grows; if it contains a negative real term, oscillation decays. Adjustment of α is done through the use of negative feedback in an automatic leveling control (ALC) circuit. The ALC circuit must correct for an amplitude disturbance (such as during a frequency change) within a few cycles of oscillation and yet introduce no distortion.

Refer now to Figure 8-47. The leveling circuit consists of two Sample and Hold amplifiers, two error amplifiers, and a Level Setting Multiplier. Some of the important waveforms in the circuit are shown in Figure 8-45. The figure shows the situation that occurs when the level suddenly decreases.

The signal from Integrator 1 (at TP6) is buffered then sampled by Sample and Hold 1. The sampling switch is driven by a signal which is in phase with the output from Integrator 2 (at TP8) which lags the output of Integrator 1 by 90°. The sample switch drive voltage appears at TP2. When sampling begins (TP2 goes high), the output of Integrator 1 is at its negative peak. Sampling continues until the positive peak is reached (the negative-going zero crossing of Integrator 2) then the sampling switch opens and the peak voltage is held on a storage capacitor. (The circuit is thus a track-and-hold circuit.) The sampled signal, which has been buffered, appears at TP3. (In actuality, the buffer clips the negative peaks, but this is of little consequence.)

The negative-going edge of the sample switch drive signal also triggers a 35 μs monostable multivibrator which closes the sample switch of Sample and Hold 2. The voltage from Sample and Hold 1 is then transferred to the storage capacitor of Sample and Hold 2 and then held. This signal, after being buffered, appears at TP7 and is a dc voltage equal to the peak of the signal from Integrator 1. (At high frequencies, the OR gate that drives the sampler switch holds the duty cycle at 50% even though the pulse width is less than 35 μs.)

This peak signal is compared against a very stable dc reference by the Proportional Error Amplifier. The amplified level error drives one input to the Level Setting Multiplier. The multiplier can be visualized as a variable-gain amplifier with an ac input from Integrator 1. The dc control input from the Proportional Error Amplifier controls the gain and polarity of this "amplifier". The output of the multiplier drives an input to the sum amplifier which injects a signal of the proper magnitude and phase to bring the output of Integrator 1 to the correct level.

The Proportional Error Amplifier provides coarse, fast-responding ALC action. The amplifier's output is also applied to the Error Integrator through a switch which is also driven by the 35 μs monostable multivibrator. The Error Integrator drives a second dc control input of the Level Setting Multiplier and provides exact ALC correction.

The complete loss of oscillation is sensed by the 200 ms Oscillator Restart monostable multivibrator. It is always retriggered by the signal from Integrator 2 unless the signal ceases. At that time a switch is momentarily closed to force a large restart error in the Proportional Error Amplifier. Normally, the oscillator will restart by the normal action of the ALC circuit; this circuit, however, provides a backup.

The ALC Loop Gain Adjust keeps the loop gain relatively constant regardless of signal level by adjusting the sensitivity of the multiplier to its control voltages. Thus the ALC loop reacts equally well for large or small signals which are produced momentarily during tuning.

Output Attenuator (A6)

The Oscillator is always on and produces a constant level. The Output Attenuator circuits provide a controllable level to the OUTPUT jacks and also allow the signal to be effectively turned off.

Amplifier 1 is used for fine setting of the output level. Its gain can be programmed from approximately –4.6 to +1.4 dB or the amplifier can be switched off. The equation that governs the gain of Amplifier 1 is

$$\text{gain} = 1.17\,\left(\frac{N + 256}{511}\right)$$

where N is an integer between 0 and 255. In practice N is usually kept between 100 and 255 for a range of approximately 3 dB. The on/off switch provides a large amount of signal isolation. The gain of the amplifier can be manually programmed by Special Function 58. Special Functions 59.32 to 59.63 switch the amplifier off.

Attenuator A is a 0 to 7.5 dB voltage divider with steps of 2.5 dB. Amplifier 2 has a gain of 2. The Output Amplifier Driver is also programmable and has a gain of –30, –20, –10, or 0 dB.

The Floating Output Amplifier has a gain of about 1.12 and differential outputs. The LOW OUTPUT jack can be conveniently grounded or floated by a front-panel switch. The output impedance is 600Ω. Attenuator B is a floating 600Ω attenuator which can be programmed to 0, 20, or 40 dB. Attenuator A, the Output Amplifier Driver, and Attenuator B can be manually programmed by Special Function 59. A Voltage Clamp and two fuses protect the output against the accidental application of a large reverse signal to the output.

TROUBLESHOOTING

General

Procedures for checking the source circuits of the instrument are given below. The blocks or points to check are marked on the block diagram by a hexagon with a check mark and a number inside, e.g., ⟨√3⟩. The procedures assume that the measurement circuits of the instrument (e.g., AC Level and Frequency) are working properly. A second Audio Analyzer is needed only if distortion is out of

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check, pe

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Oscillosc

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3. Key i
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Table 8-1

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switch drive signal also
which closes the sample
rom Sample and Hold 1 is
of Sample and Hold 2 and
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rom Integrator 1. (At high
sampler switch holds the
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s coarse, fast-responding
lso applied to the Error
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lways retriggered by the
al ceases. At that time a

switch is momentarily closed to force a large restart error in the Proportional Error Amplifier. Normally, the oscillator will restart by the normal action of the ALC circuit; this circuit, however, provides a backup.

The ALC Loop Gain Adjust keeps the loop gain relatively constant regardless of signal level by adjusting the sensitivity of the multiplier to its control voltages. Thus the ALC loop reacts equally well for large or small signals which are produced momentarily during tuning.

Output Attenuator (A6)

The Oscillator is always on and produces a constant level. The Output Attenuator circuits provide a controllable level to the OUTPUT jacks and also allow the signal to be effectively turned off.

Amplifier 1 is used for fine setting of the output level. Its gain can be programmed from approximately −4.6 to +1.4 dB or the amplifier can be switched off. The equation that governs the gain of Amplifier 1 is

$$\text{gain} = 1.17 \left(\frac{N + 256}{511} \right)$$

where N is an integer between 0 and 255. In practice N is usually kept between 100 and 255 for a range of approximately 3 dB. The on/off switch provides a large amount of signal isolation. The gain of the amplifier can be manually programmed by Special Function 58. Special Functions 59.32 to 59.63 switch the amplifier off.

Attenuator A is a 0 to 7.5 dB voltage divider with steps of 2.5 dB. Amplifier 2 has a gain of 2. The Output Amplifier Driver is also programmable and has a gain of −30, −20, −10, or 0 dB.

The Floating Output Amplifier has a gain of about 1.12 and differential outputs. The LOW OUTPUT jack can be conveniently grounded or floated by a front-panel switch. The output impedance is 600Ω. Attenuator B is a floating 600Ω attenuator which can be programmed to 0, 20, or 40 dB. Attenuator A, the Output Amplifier Driver, and Attenuator B can be manually programmed by Special Function 59. A Voltage Clamp and two fuses protect the output against the accidental application of a large reverse signal to the output.

TROUBLESHOOTING

General

Procedures for checking the source circuits of the instrument are given below. The blocks or points to check are marked on the block diagram by a hexagon with a check mark and a number inside, e.g., √3. The procedures assume that the measurement circuits of the instrument (e.g., AC Level and Frequency) are working properly. A second Audio Analyzer is needed only if distortion is out of specification and it cannot be determined whether the instrument's source or distortion measurement is at fault. Before performing any check, perform all the checks on Service Sheet BD1.

Equipment

Audio Analyzer .... HP 8903A or HP 339A
Oscilloscope .... HP 1740A

√1 Oscillator Tuning Check

NOTE

This check assumes that the internal reference frequency is properly adjusted; see paragraph 5-7.

1. Key in 41.0 SPCL to initialize the instrument. Set the INPUT switch to ground. Set the 80 kHz LOW PASS filter off. Connect A5TP6 (OSC 1) to the HIGH INPUT.

2. Key in 55.3 SPCL, 56.128 SPCL, and 57.128 SPCL to set the Oscillator frequency to its highest range, middle coarse tune, and middle fine tune settings. The frequency should be between 55.3 and 57.3 kHz. The amplitude should be between 2.65 and 3.35 Vrms.

Hint: If there is no signal, short A5TP9 (ALC) to A5TP6 (OSC 1). If a signal now appears with the frequency approximately correct but the amplitude about 2 Vrms, perform √2 Oscillator Leveling Check. If there still is no signal, the fault probably lies with the frequency range and coarse tune circuits; continue on with the following steps to determine which tuning circuits are not responding properly.

Hint: If the signal is present at approximately the correct frequency but the level is incorrect, perform √2 Oscillator Leveling Check or if only slightly out of limits perform the Oscillator and Output Attenuator Adjustment (paragraph 5-15).

Hint: If the signal level is correct but the frequency is incorrect, continue with the following steps to determine which tuning circuits are not responding properly.

3. Key in the following Special Functions and observe the frequency. The frequency should be within the limits shown in Table 8-18.

Table 8-18. Frequency Limits (Hz), Special Functions 55.N

Special Function	Frequency Limits (Hz)	
	Minimum	Maximum
55.2	6930	7810
55.1	856	887
55.0	108.7	112.7

Hint: If the frequencies for Special Functions 55.0 to 55.3 are all out of limits, continue with the following steps to determine which tuning circuits are not responding properly. If at least one frequency, but not all frequencies, for Special Functions 55.0 to 55.3 are correct, see Service Sheet 8 and check the range switching circuits.

4. Key in 55.2 SPCL. Key in the pairs of Special Functions shown in Table 8-19 and observe the frequency for each Special Function. Calculate the percent change in frequency between the first and second Special Function. For example, if the frequency for 56.128 SPCL is 7040.5 Hz and for 56.127 SPCL is 6994.3 Hz the percent change in frequency is

$$\text{Frequency Change} = \left(\frac{6994.3 - 7040.5}{7040.5} \right) \times 100\% = -0.66\%.$$

The frequency change should be within the limits shown. If faulty, see Service Sheet 8 and check the coarse tune switching circuits.

Table 8-19. Limits of Frequency Change (%), Special Functions 56.N

Special Functions	Limits of Frequency Change (%)	
	Minimum	Maximum
56.128, 56.127	−0.14	−1.37
56.64, 56.63	−0.88	−2.13
56.32, 56.31	−2.38	−3.67
56.16, 56.15	−5.38	−6.77
56.8, 56.7	−11.3	−12.9
56.4, 56.3	−22.7	−25.8
56.2, 56.1	−47.9	−49.9

5. Key in 56.128 SPCL. Key in 57.255 SPCL and note the frequency, then key in 57.0 SPCL and note the frequency. Calculate the ratio (frequency for 57.255 SPCL)/(frequency for 57.0 SPCL). The ratio should be between 1.105 and 1.113. If faulty, see Service Sheet 8 and check the fine tune switching circuits.

6. Key in the following pairs of Special Functions and check that the frequency for the second entry is higher than the frequency for the first entry. If faulty, see Service Sheet 8 and check the fine tune switching circuits.

Special Functions	Special Functions
57.254, 57.255	57.239, 57.240
57.253, 57.254	57.223, 57.224
57.251, 57.252	57.191, 57.192
57.247, 57.248	57.127, 57.128

Measurement Circuits
Block Diagram
SERVICE SHEET BD2

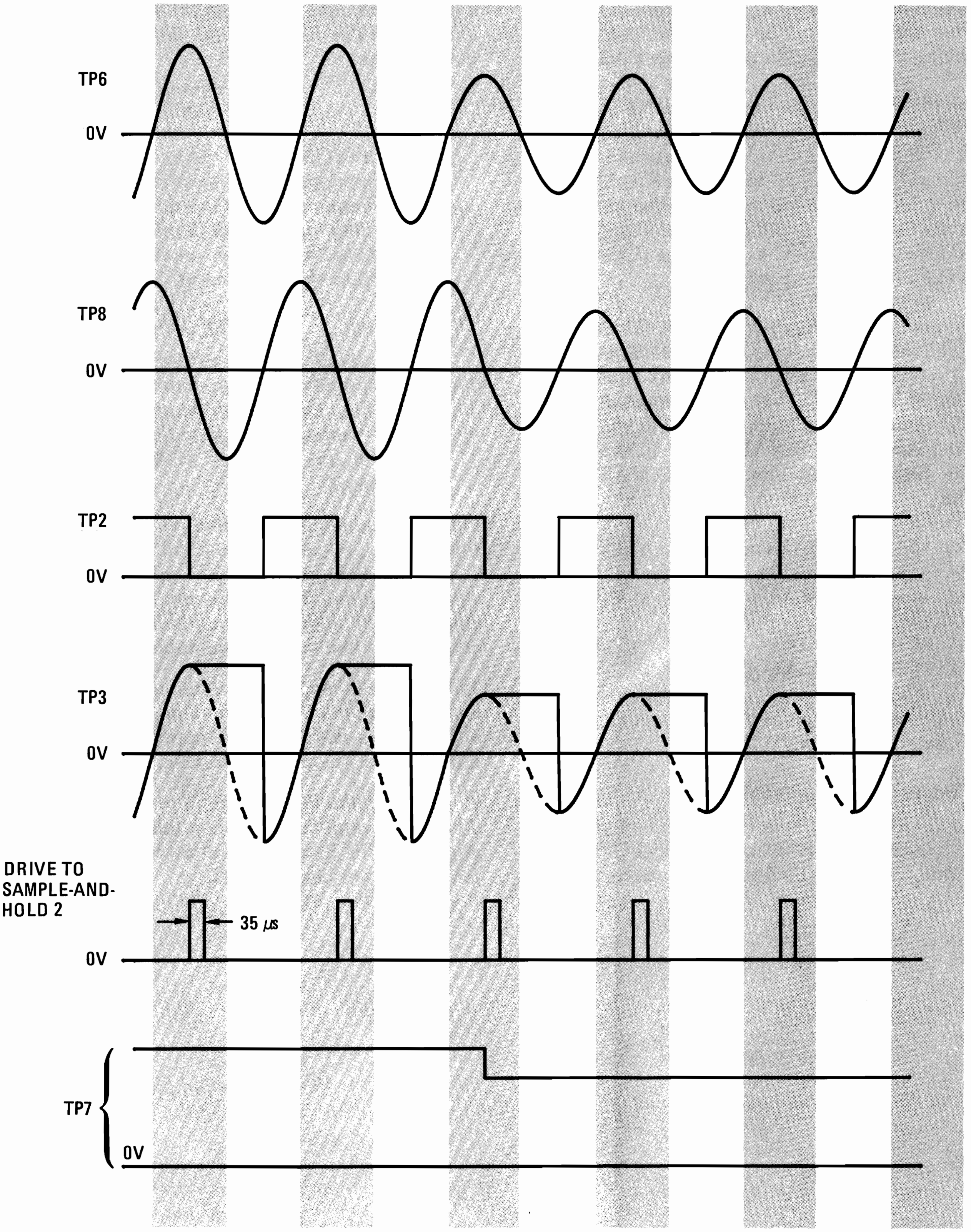


Figure 8-45. Oscillator ALC Waveforms

SERVICE SHEET BD3 (Cont'd)

7. Key in FREQ 20 Hz. The frequency should read between 19.94 and 20.06 Hz. If faulty, see Service Sheet 8.

8. Key in FREQ 100 kHz. The frequency should read between 99.7 and 100.3 kHz. If faulty, see Service Sheet 8.

⟨√2⟩ Oscillator Leveling Check

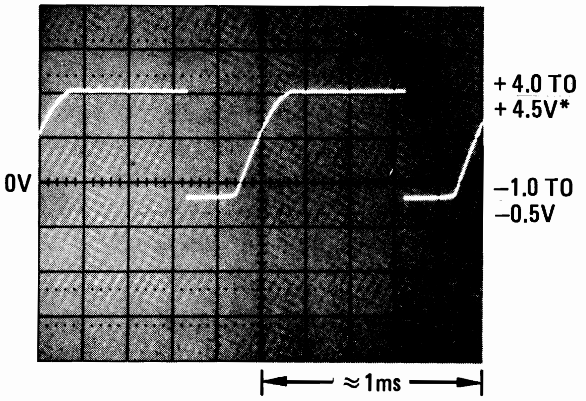
1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Connect a high-impedance, dc coupled oscilloscope to A5TP6 (OSC 1). The waveform should be an undistorted sine wave with an amplitude between 7.5 and 9.5 Vpp and a period of approximately 1 ms.

Hint: If no signal is present, short A5TP9 (ALC) to A5TP6. The waveform should be a distorted sine wave with an amplitude between 6 and 8 Vpp and a period of approximately 1 ms. If there is now a signal, continue on with step 2. If there still is no signal, see Service Sheet 8 and check the analog ICs.

Hint: If the signal is proper, continue on with step 9.

2. Connect the oscilloscope to A5TP2 (S/H GATE). The waveform should be a TTL square wave with a period of approximately 1 ms. If faulty, see Service Sheet 9 and check the Zero Crossing Detector.

3. Connect the oscilloscope to A5TP3 (S/H). The waveform should be as shown in Figure 8-46. If faulty, see Service Sheet 9 and check Sample and Hold 1.



* IF A5TP6 NOT JUMPED TO A5TP9, THE LIMITS ARE +5.5 TO +6.5V

Figure 8-46. Oscillator Leveling Check Waveform

4. Connect the oscilloscope to A5TP7 (V PEAK). The waveform should be a dc level equal to the peak voltage noted in step 1. If faulty, see Service Sheet 9 and check Sample and Hold 2.

5. Short A5TP9 (ALC) to A5TP6 if not already shorted. Connect the oscilloscope to A5TP5 (PROP ERROR). The waveform should be a dc level greater than +2 Vdc. If faulty, see Service Sheet 9 and check the Proportional Error Amplifier.

6. Short A5TP9 (ALC) to ground. The waveform should be a dc level less than −2 Vdc. If faulty, see Service Sheet 9 and check the Proportional Error Amplifier.

7. Connect the oscilloscope to A5TP11 (INT ERROR). The waveform should be a dc voltage less than −1 Vdc. If faulty, see Service Sheet 9 and check the Error Integrator.

Hint: If the signal in step 6 is correct, but the signal of step 1 was either at an incorrect level or required the jumper between A5TP6 and A5TP9, see Service Sheet 9 and check the Level Setting Multiplier and Reference.

8. Remove the short on A5TP9. Jumper A5TP6 to A5TP9. The waveform should be greater than 1 Vdc (and will have some 1 kHz ripple). If faulty, see Service Sheet 9 and check the Error Integrator. (See also the hint under step 7.)

9. Remove the jumper between A5TP6 and A5TP9, if present. Connect the oscilloscope to A5TP6. Key in FREQ 20 Hz. The waveform should be an undistorted sine wave with an amplitude of 7.5 to 9.5 Vpp and a period of approximately 50 ms. If faulty, see Service Sheet 9.

10. Key in FREQ 100 kHz. The waveform should be an undistorted sine wave with an amplitude of 7.5 to 9.5 Vpp and a period of approximately 10 μs. If faulty, see Service Sheet 9.

⟨√3⟩ Output Attenuator Check

1. Key in 41.0 SPCL to initialize the instrument. Set the INPUT and OUTPUT switches to ground.

NOTE

In the following checks the limits of the levels measured assume a source loading of 100 kΩ (the impedance of the HIGH

SERVICE SHEET BD3 (Cont'd)

INPUT). Use of a high-impedance ac voltmeter may give erroneous readings.

2. Connect A5TP6 (OSC 1) to the HIGH INPUT. The amplitude should be between 2.65 and 3.35 Vrms and the frequency should be approximately 1 kHz. If the frequency is faulty, see ⟨√1⟩. Oscillator Tuning Check. If the amplitude is faulty, see ⟨√2⟩ Oscillator Leveling Check.

3. Press RATIO. Connect A6TP6 (AMP 1) to the HIGH INPUT. Key in 59.0 SPCL and 58.255 to switch on Amplifier 1 and set its gain to maximum. The relative amplitude should be between 117.6 and 118.8%. If faulty, see Service Sheet 10 and check Amplifier 1 and the FET switches that switch the output off.

4. Press RATIO twice to establish a new reference. Key in the Special Functions listed in Table 8-20 and observe the amplitude display. The relative amplitude should be within the limits shown. If faulty, see Service Sheet 10 and check Amplifier 1.

Table 8-20. Amplitude Ratio Limits (%) at A6TP6, Special Functions 58.N

Special Function	Amplitude Ratio Limits (%)	
	Minimum	Maximum
58.128	74.90	75.30
58.64	62.50	62.90
58.32	56.25	56.55
58.16	53.20	53.40
58.8	51.60	51.80
58.4	50.85	51.05
58.2	50.47	50.66
58.1	50.27	50.47
58.0	50.07	50.27

5. Key in 58.255 SPCL. Connect A6TP5 (AMP 2) to the HIGH INPUT. The relative amplitude should be between 151.2 and 154.2%. If faulty, see Service Sheet 10 and check Attenuator A and Amplifier 2.

6. Press RATIO twice to establish a new reference. Set LOG/LIN to LOG. Key in the Special Functions listed in Table 8-21 and observe the amplitude display. The relative amplitude should be within the limits shown. If faulty, see Service Sheet 10 and check Attenuator A.

Table 8-21. Amplitude Ratio Limits (dB) at A6TP5, Special Functions 59.N

Special Function	Amplitude Ratio Limits (dB)	
	Minimum	Maximum
59.1	−2.6	−2.4
59.2	−5.1	−4.9
59.3	−7.6	−7.4

7. Key in 59.0 SPCL. Connect A6TP4 (AMP 3) to the HIGH INPUT. The relative amplitude should be between −0.05 and +0.05 dB. If faulty, see Service Sheet 11 and check the Output Amplifier Driver.

8. Press RATIO twice to establish a new reference. Key in the Special Functions listed in Table 8-22 and observe the amplitude display. The relative amplitude should be within the limits shown. If faulty, see Service Sheet 11 and check the Output Amplifier Driver.

Table 8-22. Amplitude Ratio Limits (dB) at A6TP4, Special Functions 59.N

Special Function	Amplitude Ratio Limits (dB)	
	Minimum	Maximum
59.4	−10.06	−9.94
59.24	−20.06	−19.94
59.28	−30.06	−29.94

9. Key in 59.0 SPCL. Connect the HIGH OUTPUT to the HIGH INPUT. The relative amplitude should be between 0.93 and 1.02 dB. If faulty, see Service Sheet 11 and check the Floating Output Amplifier and Attenuator B.

10. Press RATIO twice to establish a new reference. Key in the Special Functions listed in Table 8-23 and observe the amplitude display. The relative amplitude should be within the limits shown. If faulty, see Service Sheet 11 and check Attenuator B.

11. Key in 59.0 SPCL. Connect the LOW OUTPUT to the HIGH INPUT. Set the FLOAT switch to FLOAT. Short the center conductor of the HIGH OUTPUT jack to ground. The relative amplitude should read between − 0.53 and −0.48 dB. If faulty, see Service Sheet 11 and check the Floating Output Amplifier.

SERVICE SHEET BD3 (Cont'd)

Table 8-23. Amplitude Ratio Limits (dB) at HIGH OUTPUT, Special Functions 59.N

Special Function	Amplitude Ratio Limits (dB)	
	Minimum	Maximum
59.8	−20.1	−19.9
59.16	−40.1	−39.9

√4 Source Distortion Check

NOTE

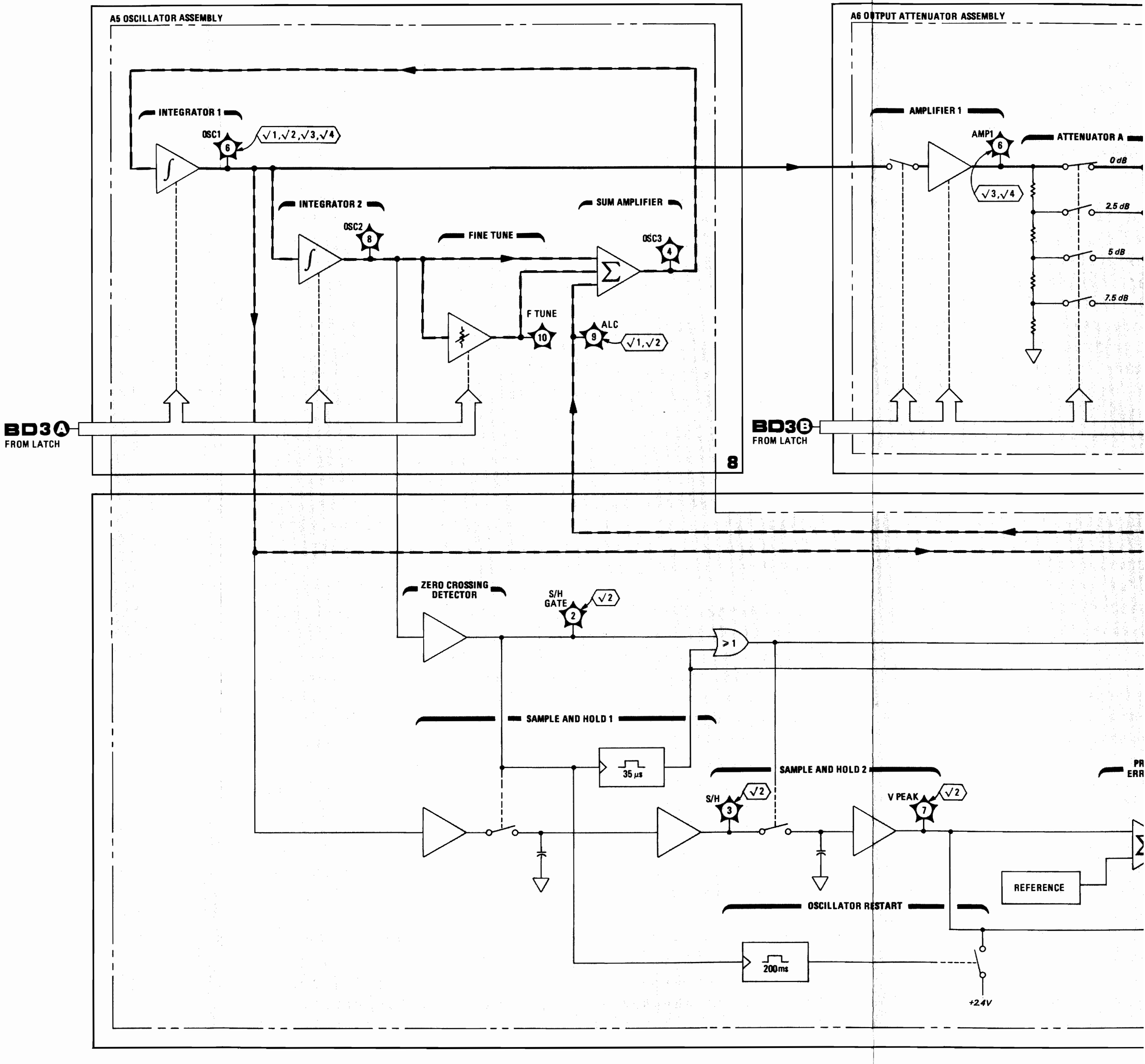
This check is used to pinpoint the source of distortion when it is slightly out of specification. Use an external distortion analyzer unless it is known that the internal distortion analyzer is operating properly.

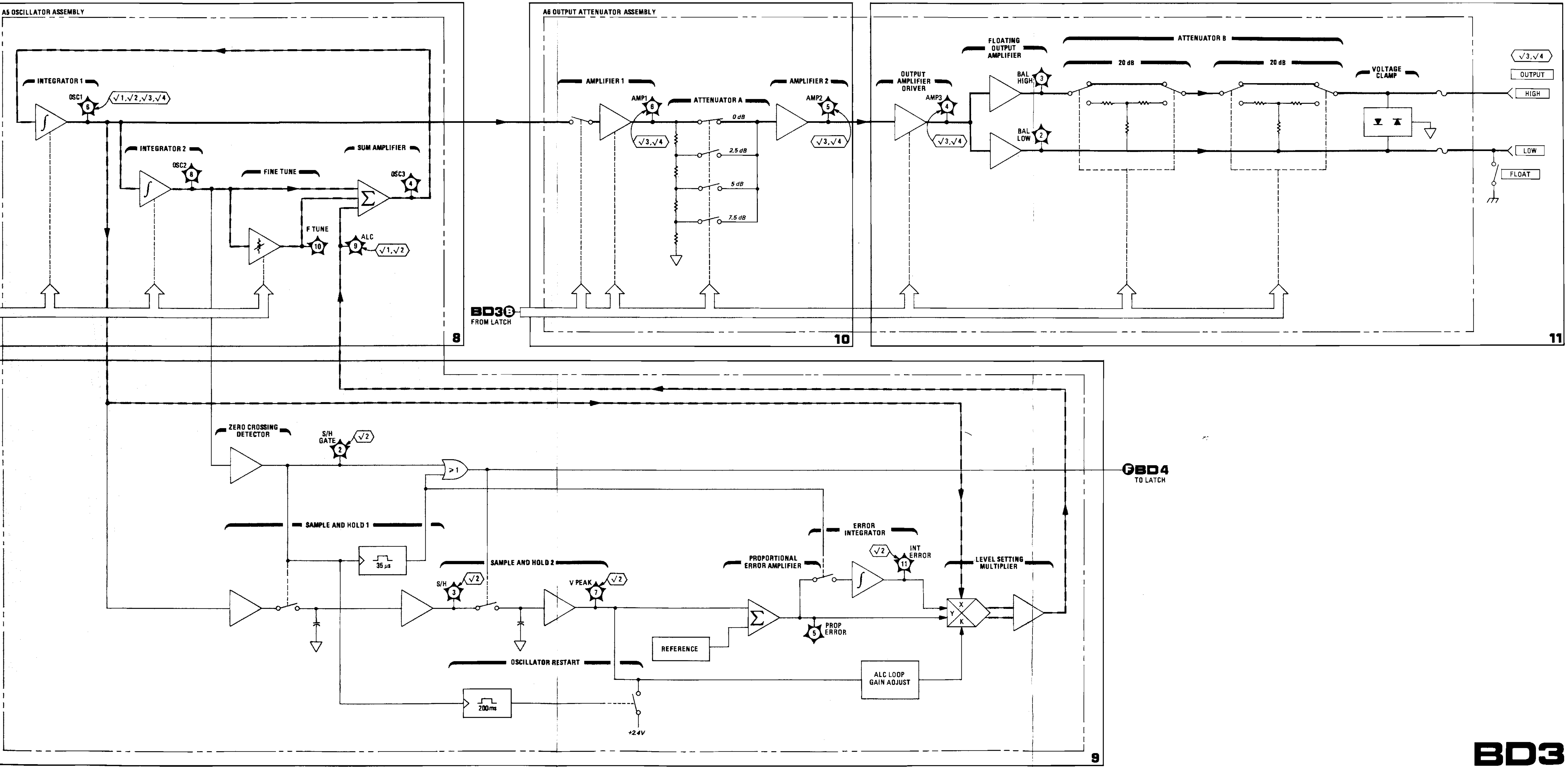
1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the INPUT and OUPUT switches to ground. Key in AMPTD 6 V.

2. Connect a distortion analyzer to the test points listed in Table 8-24 and measure the distortion. Set the low-pass filter of the distortion analyzer to 30 kHz. The distortion should be less than 0.01% in each case. If faulty, see the service sheet and check the circuits listed in Table 8-24.

Table 8-24. Source Distortion Troubleshooting

Test Point	Service Sheet	Most Probable Circuit
A5TP6 (OSC 1)	9	Oscillator Leveling
A6TP6 (AMP 1)	10	Amplifier 1
A6TP5 (AMP 2)	10	Amplifier 2
A6TP4 (AMP 3)	11	Output Amplifier Driver
HIGH OUTPUT	11	Floating Output Amplifier


A5 OSCILLATOR ASSEMBLY
INTEGRATOR 1
OSC1
6
√1,√2,√3,√4
INTEGRATOR 2
OSC2
8
FINE TUNE
SUM AMPLIFIER
OSC3
4
F TUNE
10
ALC
9
√1,√2
BD3A
FROM LATCH
8
A6 OUTPUT ATTENUATOR ASSEMBLY
AMPLIFIER 1
AMP1
6
√3,√4
ATTENUATOR A
0 dB
2.5 dB
5 dB
7.5 dB
BD3B
FROM LATCH
ZERO CROSSING DETECTOR
S/H GATE
2
√2
>1
SAMPLE AND HOLD 1
35 µs
SAMPLE AND HOLD 2
S/H
3
√2
V PEAK
7
√2
PR
ERR
REFERENCE
OSCILLATOR RESTART
200ms
+2.4V



BD3

Figure 8-47. Source Circuits Block Diagram

SERVICE SHEET BD4—DIGITAL CIRCUITS BLOCK DIAGRAM

TROUBLESHOOTING HELP

- Overall Block Diagram .... Service Sheet BD1
- Signature Analysis .... Paragraph 8-33

PRINCIPLES OF OPERATION

General

Service Sheet BD4 covers the Counter, Keyboard and Display, Latches, Controller, and Remote Interface; i.e., it covers most of the digital circuits of the instrument.

Counter (P/O A8)

The Counter consists of the input switching, Clock Counter, Cycle Counter, and counter control circuits. The Counter is used in two modes: (1) to measure frequency (from either the input circuits, the output circuits, or the oscillator) or (2) to measure the duration of the dc voltmeter STOP COUNT pulse. The Clock and Cycle Counters are both utilized for the frequency measurement; however, only the Clock Counter is used for the voltage measurement. The Cycle Counter counts the number of cycles of the input frequency (FMUX) and has two stages giving a total division ratio of 32. The Clock Counter counts the 2 MHz CLOCK OUT (Φ) signal which originates at the Crystal Oscillator of the CPU. The Clock Counter has three stages giving a total division ratio of 2048.

To select the frequency count mode, the Voltmeter Gate switch is opened and the Clock Counter Gate set to route the path from the Frequency Gate into the Clock Counter. The Controller then clears (resets) the counters and at the same time arms the Mode Select. At the beginning of the next cycle of the input signal (FMUX), the Mode Select closes both the Frequency Gate and Cycle Counter Gate switches. After a short period of time, carries are generated at the outputs of both the Clock and Cycle Counters. The Controller counts the carries via the Carry Gating circuit which is now enabled. When a predetermined number of carries from the Clock Counter has been counted, the Controller disarms the Mode Select. At the beginning of the next cycle of the input signal, the Mode Select opens both the Frequency Gate and Cycle Counter Gates switches. This guarantees that at least one cycle of the input signal is counted.

The Count Transfer Logic then transfers the count of the individual stages of both counters in parallel to the Controller via the Counter Output Gating. First, the output from Stage 1 of the Cycle Counter is transferred. Then the output from Stage 2 of the Cycle Counter and Stage 3 of the Clock Counter is loaded into Stage 1 of the Cycle Counter and the output is again transferred. This process is again repeated with Stage 2 of the Clock Counter loading into Stage 1 of the Cycle Counter via Stage 3 of the Clock counter and Stage 2 of the Cycle Counter and transferring. Finally, Stage 1 of the Clock Counter is loaded into Stage 1 of the Cycle Counter via the intermediate stages and transferred.

To make a voltage measurement, the Controller first sets the Clock Counter Gate to receive the signal from the Voltmeter Gate. The Stop Count Gate was closed after completing the previous measurement. The Controller then arms the Voltmeter Gate and initiates the ramp in the Voltage-to-Time Converter (via the Ramp Gate line). The first pulse on the Clock Out (Φ) line closes the Voltmeter Gate. The Clock Counter now begins counting the 2 MHz clock pulses. After an interval determined by the dc level being measured, the Voltage-to-Time Converter generates a Stop Count pulse which opens the Stop Count Gate. The Count accumulated in the Clock Counter is thus proportional to the input voltage. (Note that the Cycle Counter is not used in this measurement.) The count is transferred to the Controller in the same manner as for a frequency measurement.

SERVICE SHEET BD4 (Cont'd)

Controller (P/O A8)

The Controller consists of a Microprocessor, Read-Only Memory (ROM), Random-Access Memory (RAM), a Memory Select Decoder, and input/output interface circuitry. The Microprocessor is divided into two devices: the Central Processing Unit (CPU) and a Static Memory Interface (SMI). A third device, a Peripheral Input/Output (PIO on A9), is also included when the Microprocessor interfaces with the Remote Interface Assembly.

The Controller's program is stored in ROM. To retrieve information from ROM, the SMI, under control of the CPU, outputs the appropriate address on the Address Bus. Four of the sixteen address bits are decoded by the Memory Select Decoder to enable one of the ROM devices. Eleven address bits address the individual ROMs. The enabled ROM then outputs eight bits of data onto the Data Bus from the location corresponding to the input address. Information in ROM may be either a program instruction or data. In a similar manner temporary information is written to or read from the RAM. The RAM, however, is addressed by only eight of the eleven address bits, and inputs or outputs only four data bits. The RAM is enabled by Address 15 (A15).

The CPU interprets bytes from the ROM as data or instructions depending on the context of the program. If the byte is an instruction, the outcome depends on the nature of the instruction. A simple instruction (such as add or shift) is executed immediately and the instruction in the next address fetched. More complex instructions fetch additional data or instructions from following addresses and, in the case of jumps and subroutine calls, cause program execution to move to another location in memory.

When a front-panel key is pressed, an interrupt is generated. The interrupt causes program execution to jump to a specified address location where the interrupt service subroutine is located. The subroutine interrogates the Keyboard to determine which key was pressed and then takes the appropriate action. HP-IB codes and commands interrupt the Microprocessor in a similar way.

The CPU communicates with the SMI and PIO through the ROM Control (ROMC) lines and the Data Bus. The CPU does data manipulation (arithmetic and logic computations) and contains the clocking and control circuitry. The 2 MHz clock comes from the Crystal Oscillator and is also used as the Counter time base reference. The SMI interfaces with the ROMs and RAM.

The CPU also contains bidirectional input/output (I/O) ports for communicating with the instrument hardware. This is done via the Instrument Bus discussed in the next paragraph. Four of the I/O bits, however, are reserved for servicing of the Controller. Four LEDs driven from the port indicate errors encountered during power-up verification tests, measurement cycles, and Keyboard and HP-IB interrupts. Four test points on the port can be used to initiate troubleshooting routines which use signature analysis. Refer to Controller LEDs and Test Points, paragraph 8-32.

SERVICE SHEET BD4 (Cont'd)

Latches (A7) and Instrument Bus

Figure 8-48 shows a typical hookup on the Instrument Bus. The Instrument Bus lines are broken down into three groups: enable (e), select (s), and data (d). The enable code (e0 to e3) comes from I/O lines 10 through 13 of the CPU (A8U5). Three of the lines are decoded by the Enable Code Decoder (A8U22) to activate one of eight unique enable lines (e=0 to e=7). The fourth line enables the decoder itself. The enable lines run to the Keyboard, Remote Interface, and Latch Assemblies and to the Counter on the Controller/Counter Assembly. Typically, each line is dedicated to a specific operational function; e.g., enable line e=6 controls Oscillator tuning.

The select (s0 to s3) and data codes (d0 to d3) come from I/O lines 00 to 07. The eight lines also run to the Keyboard, Remote Interface, and Latch Assemblies and to the Counter where they are decoded. The Latch Assembly decodes the Instrument Bus for all of the measurement and source assemblies. Up to 16 data codes for each of the 16 select codes are possible for each active enable line. The select code typically selects a functional category and the data code selects the specific function or configuration. For a given function the select codes are decoded only while the corresponding enable line is active. The data codes are in turn decoded and latched only when triggered by the decoded select line. The latched data drive the digital-to-analog devices which control the instrument hardware.

On the schematic diagrams, the lines leaving the I/O ports of the CPU are labeled with a mnemonic such as s2(L) for I/O line 02. The "s" indicates a select code, "2" indicates that it is the third least significant bit of the un-decoded select code, and "(L)" indicates that the line is true (1) when the logic level is low. All bit position numbering begins with 0. The select codes go out on the Instrument Bus through Select Buffers which are simple inverters. Thus s2(L) goes out on the bus as s2(H). Decoded codes are labeled as e=1(L) for example. The "e" indicates an enable code, "=" indicates decoding, "1" indicates a decoded hexadecimal 1 (binary 0001), and "(L)" indicates the logic level corresponding to a true. The mnemonic e=1 corresponds to e3e2e1e0=0001. Data codes are also buffered. However, unbuffered data lines are also connected to the Instrument Bus for reading data back to the I/O ports.

The example of Figure 8-48 will be used to illustrate how the 8 dB gain setting is selected for the Programmable Gain Amplifier on the Input Amplifier Assembly. The amplifier (not shown) is set for 8 dB gain when the output line labeled 8 dB(L) of Data Latch A7U11 goes low. A7U11 is on the Latch Assembly. Register U11 is simply a latch; it does not decode the data. To set the amplifier gain to 8 dB, the CPU sends out the binary enable code 0111 (hexadecimal 7), select code 0010 (hexadecimal 2), and data code 0010 (hexadecimal

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?eripheral Input/ Output
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to enable one of the ROM
e individual ROMs. The
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ight of the eleven address
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OMs and RAM.

ut/output (I/O) ports for
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verification tests, measurement cycles, and Keyboard and HP-IB interrupts. Four test points on the port can be used to initiate troubleshooting routines which use signature analysis. Refer to Controller LEDs and Test Points, paragraph 8-32.

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There is a direct relationship between the codes output on the Instrument Bus and the Direct Control Special Functions discussed in paragraph 8-26. If the enable, select, and data codes are combined into a hexadecimal number "esd", this becomes the Direct Control suffix. In the example here it is 722, corresponding to Direct Control code 0.722 discussed in the example there. Instrument control can be visualized as a series of Direct Control Special Functions issued under program control.

The example above decoded only three of the four select code bits and used the data bits directly (or inverted them). Notice that if the code esd=727 were issued, the 4 dB, 8 dB, and 12 dB lines would all be activated. On some assemblies the data codes may be decoded and select codes above 7 may be used. On other assemblies certain select codes are used to enable readback devices which read back status or measurement data onto the unbuffered data lines. This is discussed in more detail in connection with Direct Control Special Functions, paragraph 8-26.

In addition to the Instrument Control Latches which interface the communication between the Controller and the measurement and source circuits, the Latch Assembly also contains the Counter input conditioning circuits and plotter control circuits.

The Parity Check latch is used on power-up to check the integrity of the data lines of the Instrument Bus. Overload conditions from either the Input Overload Detector or the Overload Detector on the output amplifier circuit (see Service Sheet BD2) are read back to the Instrument Bus through the Overload Readback latch.

The Counter Input Switch selects whether the input to the Counter Schmitt Trigger is from the Input Amplifier or Output Amplifier. The Counter Input Schmitt Trigger conditions the analog input signal to make it compatible with the TTL logic of the Counter. It has self-setting upper and lower references. Input peak detectors set the two references at one-half the level of the negative peak of the input and one-half the level of the positive peak. This gives excellent noise immunity over a wide range of input levels. The FMUX Select switch selects the input to the Counter from either the Counter Input Schmitt Trigger or the Oscillator.

The X Axis and Y Axis DACs provide X and Y outputs to the rear panel for plotting during a frequency sweep. The DACs themselves output current which is converted to a voltage by transresistance amplifiers at their outputs. (The amplifiers also filter the signal.) Each DAC amplifier can output 0 to +10V in 255 steps. They are programmed by the Controller via the Plotter Control and Input Latches which also control the Pen Lift line.

Keyboard and Display (A1)

The Keyboard and Display Assembly is both an input peripheral and an output peripheral to the Controller. The pressing of a key is sensed by the Keystroke Detector. The detector interrupts the Microprocessor which then enters an interrupt service routine. The routine causes the key rows and columns to be scanned sequentially via the Key Row and Column Scanner to ascertain which key is down. This is accomplished by driving the rows in sequence with the select decoder and reading the state of the columns with the data readback lines (unbuffered data lines). If no key closure is found (due, perhaps, to key bounce), the scan repeats. If no key closure is found after 50 ms, the Microprocesser leaves this routine and begins making a new measurement.

Lighting of the key and annunciator lights and display digits and decimal points is by a straight-forward decoding of the Instrument Bus. The segments of the displays are lighted (and latched) one segment at a time. Note that the lights in the keys do not light as a direct result of a key closure. This is done by the Microprocessor, having recognized a key closure, sending the command out on the Instrument Bus to light the key light.

Remote Interface (A9)

The Remote Interface Assembly interfaces the Controller with the Hewlett-Packard Interface Bus (HP-IB). It performs necessary handshake operations, interprets the HP-IB control lines, and is both an input and output peripheral to the Controller.

As an input peripheral, it accepts a byte from the HP-IB data lines under control of the bus handshake lines. It then interprets the data byte and the bus control lines to see if the byte is an address (talk or listen), a command, or a data byte. When a byte is processed, one of three things happens: (1) the byte is ignored, (2) the byte is processed in hardware (e.g., some bus commands), or (3) the byte causes a Microprocessor interrupt (e.g., codes received while addressed to listen). The Microprocessor treats an HP-IB interrupt as it would an interrupt from the Keyboard. However, the HP-IB interrupt service routine first checks whether or not the byte is a command (e.g., Device Clear), address, or data (e.g., "M1"). If it is an address or command, the byte is processed. If it is data, the routine first checks whether or not the instrument is in remote. If it is, the incoming byte is processed as program code. If not, the byte is ignored. After processing a byte, the Microprocessor tells the Remote Interface what to do next (e.g., input another byte, set a status latch, or prepare to output a byte).

SERVICE SHEET BD4 (Cont'd)

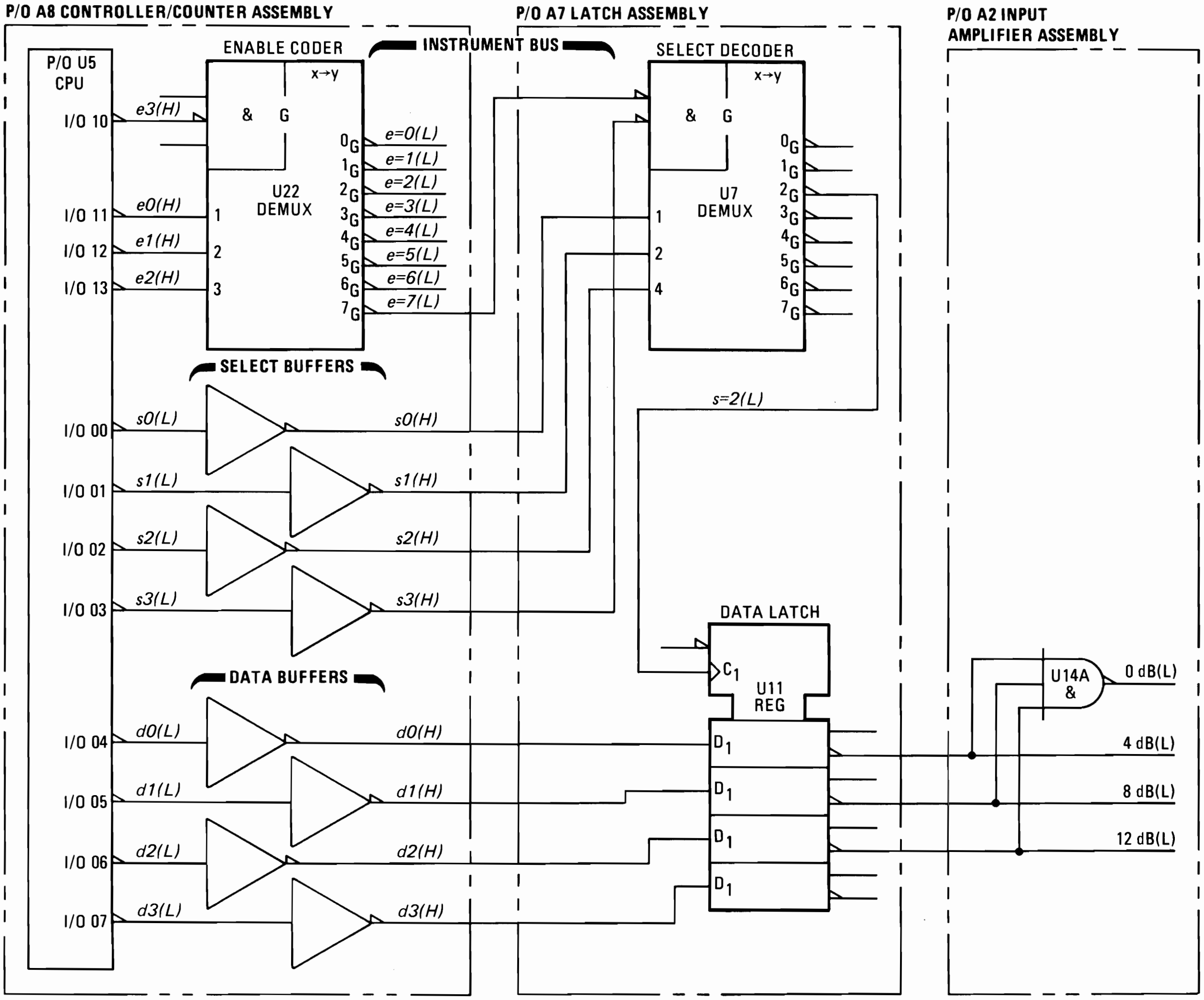


Figure 8-48. Example Showing Instrument Bus Hookup

As an output peripheral, the Remote Interface takes a byte of status or measurement data from the Microprocessor and processes it over the HP-IB. It does this only after determining that the Audio Analyzer has been addressed to talk. The Require Service message (SRQ) is also output via the Remote Interface.

The Remote Interface Assembly consists of Handshake Logic, HP-IB Input/Output Transceivers, Interface Control Logic, Address Decoder, part of the Microprocessor, and Instrument Bus interface circuits. The Handshake Logic controls the asynchronous transfer of bytes over the HP-IB. It does this without interruption of the Microprocessor whenever the byte is data but the Audio Analyzer is not addressed to listen or whenever the byte is not an interrupting bus command. It also provides the means for the Microprocessor to complete the handshake if the byte is an interrupting type.

When the Audio Analyzer is accepting bytes, the Handshake Logic monitors the Microprocessor and HP-IB and signals the HP-IB talker or bus controller when the Audio Analyzer is ready to receive, tells the Microprocessor when valid data is on the HP-IB, and tells the HP-IB talker when the Microprocessor has accepted the data. When the Audio Analyzer is outputting data or status bytes, the Handshake Logic tells the Microprocessor when the HP-IB listener is ready to receive, provides the Microprocessor with logic to tell the listener when data is valid, and tells the Microprocessor when the listener has accepted data.

The HP-IB Input/Output transceivers act as HP-IB

SERVICE SHEET BD4 (Cont'd)

buffers and send/receive switches. They are controlled by the Interface Control Logic.

The Interface Control Logic together with the Address Decoder determines the talk or listen status of the interface and whether or not the Microprocessor should be interrupted. The ROM in the Handshake Control Logic is addressed by two of the HP-IB data lines, the Address Decoder, and one of the HP-IB control lines (Attention, ATN). The ROM contains the control information for the Interface Control Logic and the Microprocessor.

If the Audio Analyzer's listen address is recognized by the Address Decoder, the Microprocessor attempts to set the Remote Enable Flip-Flop. If the HP-IB Remote Enable (REN) control line is true, the flip-flop is set (if not already set), and the Microprocessor sets a status bit in memory. Each time the Microprocessor performs any remote-dependent operation, it checks both the status bit and the flip-flop output (Remote Enable Latch, RNL). Both must be set for the instrument to remain in remote. If REN goes false at any time, the Remote Enable Flip-Flop is cleared, and the instrument is no longer in remote.

The Address Decoder compares the address set by the Address Switches with the five least significant input bits to determine if the instrument is being addressed. The Interface Control Logic looks at the output of the Address Decoder and the next two input bits to determine if it is a talk or listen address and if the instrument should respond to it. The result of this determination modifies the address to the ROM in the Interface Control Logic.

The Address Readback Gates output the address from the Address Switches onto the Instrument Bus data lines when Special Function 21 (HP-IB Address) is selected. This is how the Controller reads the HP-IB address. (See HP-IB Address in the Detailed Operating Instructions, Section III.)

The portion of the Microprocessor that directly handles the HP-IB input/output resides on the Remote Interface Assembly. This is the Peripheral Input/Output (PIO). The PIO is a device that routes the HP-IB data to and from the CPU and the HP-IB, provides a communication link between the CPU and the Remote Interface hardware, and provides the means for interrupting the CPU. One of the two, eight-bit PIO output ports connects to the HP-IB data lines and the other to the handshake and control logic.

Although the Remote Interface Assembly receives data and operating information from the PIO, it is primarily through the Instrument Bus that it is controlled. (Commands such as SRQ that need rapid processing come from the PIO.) A Select Decoder decodes the select lines when enabled by code e=3. The decoded select lines enable or disable parts of the Remote Interface Assembly.

TROUBLESHOOTING

General

Procedures for checking the digital circuits of the instrument are given below. The blocks or points to check are marked on the block diagram by a hexagon with a check mark and a number inside, e.g., ⟨√3⟩. Before performing any check, perform all the checks on Service Sheet BD1.

Equipment

Digital Test/ Extender Board	HP 08903-60018
Oscilloscope	HP 1740A
Signature Analyzer	HP 5004A
Voltmeter	HP 3455A

⟨√1⟩ Counter (Including Counter Input) Check

NOTE

For this check, the Audio Analyzer's Source is assumed to be working properly.

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the INPUT and OUTPUT switches to ground. Set the 80 kHz LOW PASS filter off. Set FREQ to 100 kHz and AMPTD to 1V. Connect the HIGH OUTPUT to the HIGH INPUT.

2. Connect a high-impedance, dc coupled oscilloscope to A7TP2 (FMUX).

3. On the Audio Analyzer, key in 46.0 SPCL to set the Counter to measure the Oscillator frequency. The waveform on the oscilloscope should be a TTL square wave with a period of approximately 10 μs. If faulty, see Service Sheet BD3 and check the oscillator tuning and see Service Sheet 13 and check the FMUX Select.

4. Disconnect the cable to the Audio Analyzer's INPUT. The waveform on the oscilloscope should

SERVICE SHEET BD4 (Cont'd)

remain unchanged. If faulty, see Service Sheet 13 and check the FMUX Select.

5. Reconnect the cable to the Audio Analyzer's INPUT. Key in 46.1 SPCL to set the Counter to measure the input frequency. The waveform on the oscilloscope should remain unchanged. If faulty, see Service Sheet 13 and check the Input Select, Counter Input Schmitt Trigger, and FMUX Select.

6. Disconnect the cable to the Audio Analyzer's INPUT. The waveform on the oscilloscope should become intermittent (it is being triggered by noise). If faulty, see Service Sheet 13 and check the Input Select and Counter Input Schmitt Trigger.

7. Reconnect the cable to the Audio Analyzer's INPUT. Key in 46.3 SPCL to set the Counter to measure the frequency at the output amplifier. The waveform on the oscilloscope should again be a TTL square wave with a period of approximately 10 μs. If faulty, see Service Sheet 13 and check the Input Select.

8. Disconnect the cable to the Audio Analyzer's INPUT. The waveform on the oscilloscope should become intermittent or a steady TTL high. If faulty, see Service Sheet 13 and check the Input Select.

9. Connect the oscilloscope to A8TP5 (CYC). The waveform on the oscilloscope should be bursts of TTL square waves where the period of the pulses in the bursts is approximately 10 μs and the bursts, although difficult to measure, are approximately 170 ms apart. If faulty, see Service Sheet 14 and check the Mode Select and Cycle Counter Gate.

10. Connect the oscilloscope to A8TP6 (CLK). The waveform on the oscilloscope should be bursts of TTL square waves where the period of the pulses in the bursts is 500 ns and the bursts, although difficult to measure, are approximately 170 ms apart. If faulty, see Service Sheet 14 and check the Mode Select and Frequency Gate.

11. Connect the oscilloscope to A8TP2 (CLK CRY). The waveform on the oscilloscope should be bursts of TTL square waves where the period of the pulses in the bursts is 1 ms and the bursts, although difficult to measure, are approximately 170 ms apart. If faulty, see Service Sheet 14 and check the Clock Counter.

12. Connect the oscilloscope to A8TP1 (CYC CRY). The waveform on the oscilloscope should be bursts of TTL square waves where the period of the pulses in the bursts is 500 ns and the bursts, although difficult to measure, are approximately 170 ms apart. If faulty, see Service Sheet 14 and check the Cycle Counter.

Hint: If all steps above give positive results but the Counter is still suspected as being faulty, see Service Sheet 14 and check the Carry Gating and Counter Output Gating.

⟨√2⟩ Controller Kernel Check

CAUTIONS

MOS and CMOS ICs can be damaged by static charges and circuit transients. Do not remove the A8 Controller/Counter Assembly from the instrument while power is applied. Discharge the board and replacement IC to the same potential. (Use a conductive foam pad such as HP 4208-0094.) When unplugging ICs, place the board on a conductive pad. When the IC is unplugged, insert it into the pad also.

Several ICs on these assemblies are held in high-grip sockets. Both the socket and the device can be damaged if an attempt is made to remove the device with an IC extraction tool. The recommended procedure is to first ground the tip of a small blade-type screwdriver, then slide the tip between the IC and the socket and slowly pry up the IC one pin at a time.

1. Switch LINE to OFF. Extend A8 the Controller/Counter Assembly with the Digital Test/Extender Board. Connect the ribbon cable on the extender board to A8J1. Switch LINE to ON.

2. Check A8TP14 (+12V) with dc voltmeter. The voltage should be between +11.4 and +12.6 Vdc. If faulty, see Service Sheet 20 and check the +12V Regulator.

3. Short A8TP4 (RES) to A8TP3 (GND). This resets the Controller and forces a short write (instruction) cycle. Connect a high-impedance, dc coupled oscilloscope to A8TP13 (WRT). The waveform should be TTL pulses with a period of 2 μs. If faulty, see Service Sheet 15 and check the clock circuit and Φ line.

SERVICE SHEET BD4 (Cont'd)

4. Set switches labeled ROMC on extender board to CLOSED. This forces the SMI to step through its addresses. Connect the signature ana9er clock to A8TP13 (WRT) and ground to A8TP3 (GND). Connect start and stop to ADDRESS 15 on the extender board. Set the signature analyzer's start and stop to trigger on a falling edge and set clock to trigger on a rising edge. Check the test points listed in Table 8-25 on the extender board or on A8 with the signature analyzer probe.

Table 8-25. Controller/Counter A8 Test Point Signatures

Test Point	Signature	Test Point	Signature
A8TP16 (+5V)	0001	ADDRESS 8	HC89
A8TP3 (GND)	0000	ADDRESS 7	52F8
ADDRESS 15	755U	ADDRESS 6	UPFH
ADDRESS 14	3827	ADDRESS 5	0AFA
ADDRESS 13	3C96	ADDRESS 4	5H21
ADDRESS 12	HAP7	ADDRESS 3	7F7F
ADDRESS 11	1293	ADDRESS 2	CCCC
ADDRESS 10	HPP0	ADDRESS 1	5555
ADDRESS 9	2H70	ADDRESS 0	UUUU

If all signatures are bad except GND, see Service Sheet 15 and replace the SMI. If only one ADDRESS line is faulty, see Service Sheets 15 and 16 and check the SMI and the address line.

5. Check A8TP17 (RAM WR) and A8TP18 (CPU RD) with a dc coupled oscilloscope. RAM WR should be a TTL high, CPU RD should be a TTL square wave with a period of 2 μs. If faulty, see Service Sheet 15 and check the SMI and the load on the two lines.

6. Switch LINE to OFF. Remove A8U30 (CPU External Register—RAM) from its socket.

NOTE

The signatures listed in Table 8-26 are valid only for the software with the specified date (or ROM part numbers) listed in Table 8-27. Consult the Manual Changes Supplement for signatures corresponding to other software dates.

7. Switch LINE to ON. Check the CONTROL BUS test points listed in Table 8-26 on the extender board with the signature analyzer probe.

Table 8-26. Control Bus Test Point Signatures

Test Point	Signature	Test Point	Signature
DATA 0	88A5	DATA 4	8CP4
DATA 1	U8PF	DATA 5	F723
DATA 2	0PPU	DATA 6	733P
DATA 3	P775	DATA 7	32FA

Table 8-27. Valid ROM Part Numbers*

ROM Number	Part Number
1	08903-80001
2	1818-1416 or 08903-80002
3	1818-1417 or 08903-80003
4	1818-1418 or 08903-80004
5	1818-1419 or 08903-80005
6	1818-1420 or 08903-80006
7	1818-1421 or 08903-80007
8	1818-1422 or 08903-80008
9	1818-1423 or 08903-80009

*Valid software date 3.31 1980

If signatures are faulty, see Service Sheet 15 and check the Memory Select Decoders and ROMs.

√3 CPU I/O Port Check

1. Switch LINE to OFF. Extend the A8 Controller/Counter Assembly with the Digital Test/Extender Board. Switch LINE to ON.

NOTE

Check that the switches labeled ROMC on the extender board are set to OPEN.

2. Key in 0.0 SPCL. Check the INSTRUMENT BUS test points listed in Table 8-28 on the extender board with a dc coupled oscilloscope.

Table 8-28. TTL Levels on Instrument Bus Test Points

Test Point	Measured Signal
ENABLE 0	Low-going TTL Pulses, Period ≈30 ms
SELECT 0 to 3	TTL Low
DATA (H) 0 to 3	TTL Low
DATA (L) 0 to 3	TTL High

If faulty, see Service Sheet 15 and check the CPU and I/O port decoders and buffers.

SERVICE SHEET BD4 (Cont'd)

3. Key in 0.0 S (Shift) 5 S (Shift) 5 SPCL. Recheck the test points listed in Table 8-29.

Table 8-29. Instrument Bus Test Point Recheck

Test Point	Measured Signal
SELECT 0 to 3	TTL High
DATA (H) 0 to 3	TTL High
DATA (L) 0 to 3	TTL Low

If faulty, see Service Sheet 15 and check the CPU and I/O port decoders and buffers.

4. Key in the Special Functions listed listed in Table 8-30. For each entry, the indicated ENABLE test point on the extender board should show low-going TTL pulses with a period of approximately 30 ms. All other ENABLE test points should be TTL highs.

Table 8-30. TTL Pulses on Enable Test Points

Special Function	Test Point	Special Function	Test Point
0.1	ENABLE 1	0.5	ENABLE 5
0.2	ENABLE 2	0.6	ENABLE 6
0.3	ENABLE 3	0.7	ENABLE 7
0.4	ENABLE 4		

If faulty, see Service Sheet 15 and check the Enable Decoder and CPU.

√4 Keyboard Key Check

1. Key in 60.0 SPCL. As the Special Function code is entered, 60.0 should appear in the display. This indicates that the Controller responds to keyboard interrupts. If faulty, see √7 Front-Panel LED Check. While pressing the SPCL key, 33 should appear in the display. After the SPCL key is released, 99 should appear. If other numbers appear, continue on.

2. Jumper pin 7 of A8U6 (EXT INT) to A8TP3 (GND). This defeats the keyboard interrupt.

3. Press the keys one at a time and compare the display with the key codes shown in Figure 8-49. If a code other than 99 appears in the display with no key pressed, the key corresponding to the displayed key code is probably stuck down; see Service Sheet 17. If a wrong code appears for one or more keys, check the corresponding key and decoder; see Service Sheet 20.

√5 Keyboard Interrupt Check

1. Connect high impedance, dc coupled oscilloscope to pin 7 of U6 (EXT INT). The voltage should read a TTL high. Pressing any key should result in a TTL low which should remain low for 40 to 60 ms after the key is released. If faulty, see Service Sheet 17 and check the Keystroke Detector.

√6 Front-Panel LED Check

1. Perform √3 Front-Panel LED Check on Service Sheet BD1.

√7 HP-IB Check

1. See Service Sheet 19.

√8 Instrument Control Latches and Parity Check and Overload Readback Check

1. See Service Sheet 12.

√9 Plotter Control Circuits Check

NOTE

The following procedure assumes that the instrument is capable of making a swept ac level measurement.

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the OUTPUT and INPUT switches to ground. Set AMPTD to 1V. Connect the HIGH OUTPUT to the HIGH INPUT.

2. Connect a dc voltmeter to the rear-panel X AXIS, Y AXIS, and PEN LIFT outputs and observe the voltage as the keys indicated in Table 8-31 are pressed.

Table 8-31. Plotter Control Circuits Check

Key Pressed	Observed Voltage at		
	X AXIS	Y AXIS	PEN LIFT
START FREQ	−10 to +10 mVdc	−10 to +10 mVdc	TTL high
STOP FREQ	+9.7 to +10.3 Vdc	+9.7 to +10.3 Vdc	TTL high
SWEEP	Slow increase from≈0 to ≈+10V	Steady at ≈+5 Vdc	TTL low

SERVICE SHEET BD4 (Cont'd)

Hint: If the upper limits of the X AXIS or Y AXIS outputs are only slightly out of limits, consult Table 5-1, Factory Selected Components, for A7R8 and A7R10.

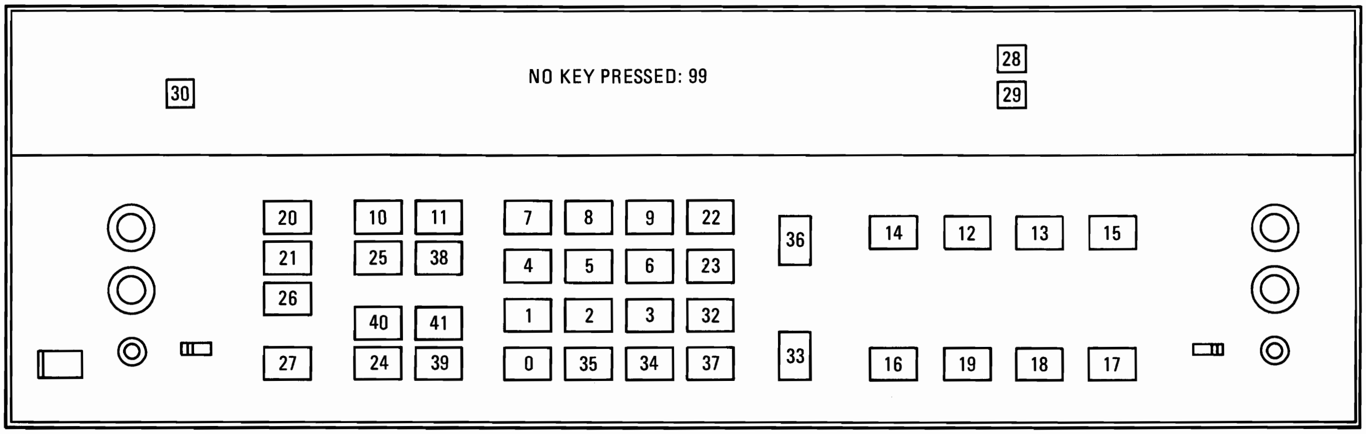
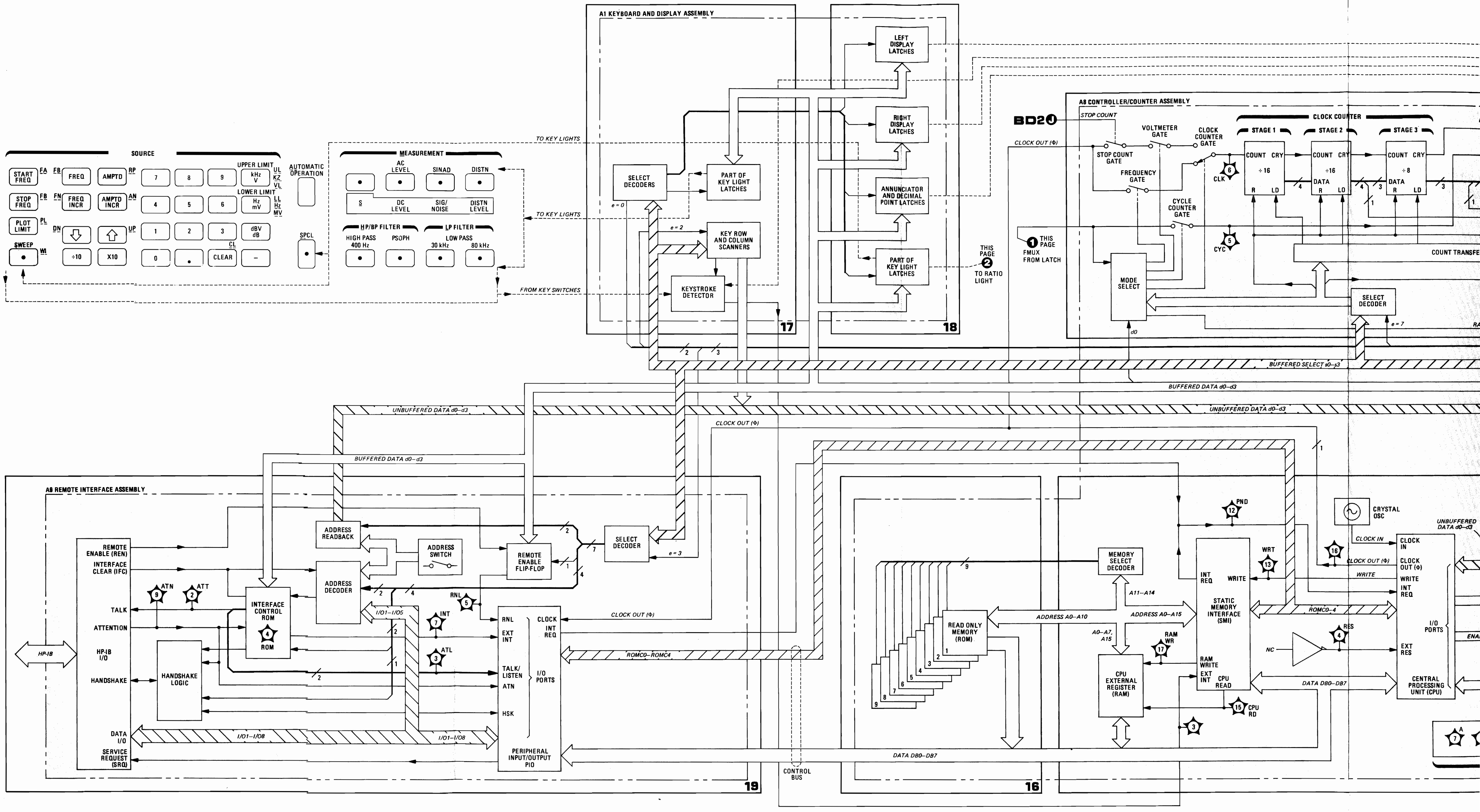


Figure 8-49. Key Codes for Special Function 60.0


SOURCE
START FREQ
FA
FB
FREQ
AMPTD
RP
STOP FREQ
FN
FREQ INCR
AMPTD INCR
AN
PLOT LIMIT
PL
DN
UP
SWEEP
WI
÷10
X10
7
8
9
4
5
6
1
2
3
0
.
CLEAR
CL
−
UPPER LIMIT
kHz V
UL
KZ
VL
LOWER LIMIT
Hz mV
LL
HZ
MV
dBV dB
AUTOMATIC OPERATION
SPCL
MEASUREMENT
AC LEVEL
SINAD
DISTN
S
DC LEVEL
SIG/NOISE
DISTN LEVEL
HP/BP FILTER
HIGH PASS 400 Hz
PSOPH
LP FILTER
LOW PASS
30 kHz
80 kHz
TO KEY LIGHTS
TO KEY LIGHTS
FROM KEY SWITCHES
A1 KEYBOARD AND DISPLAY ASSEMBLY
SELECT DECODERS
PART OF KEY LIGHT LATCHES
KEY ROW AND COLUMN SCANNERS
KEYSTROKE DETECTOR
e = 0
e = 2
17
LEFT DISPLAY LATCHES
RIGHT DISPLAY LATCHES
ANNUNCIATOR AND DECIMAL POINT LATCHES
PART OF KEY LIGHT LATCHES
18
THIS PAGE 2 TO RATIO LIGHT
BD2 1
1 THIS PAGE FMUX FROM LATCH
A8 CONTROLLER/COUNTER ASSEMBLY
STOP COUNT
CLOCK OUT (Φ)
STOP COUNT GATE
VOLTMETER GATE
FREQUENCY GATE
CLOCK COUNTER GATE
CYCLE COUNTER GATE
CLK 6
CYC 5
MODE SELECT
d0
CLOCK COUNTER
STAGE 1
STAGE 2
STAGE 3
COUNT CRY
÷16
R LD
DATA
÷8
4
3
1
COUNT TRANSFE
SELECT DECODER
e = 7
RA
2
3
BUFFERED SELECT s0–s3
BUFFERED DATA d0–d3
UNBUFFERED DATA d0–d3
UNBUFFERED DATA d0–d3
CLOCK OUT (Φ)
BUFFERED DATA d0–d3
A9 REMOTE INTERFACE ASSEMBLY
HP-IB
REMOTE ENABLE (REN)
INTERFACE CLEAR (IFC)
TALK
ATTENTION
HP-IB I/O
HANDSHAKE
DATA I/O
SERVICE REQUEST (SRQ)
HANDSHAKE LOGIC
9 ATN
2 ATT
INTERFACE CONTROL ROM
4 ROM
ADDRESS READBACK
ADDRESS DECODER
ADDRESS SWITCH
REMOTE ENABLE FLIP-FLOP
SELECT DECODER
e = 3
RNL 5
7 INT
3 ATL
I/O1–I/O5
I/O1–I/O8
I/O1–I/O8
RNL
EXT INT
TALK/LISTEN
ATN
HSK
CLOCK
INT REQ
I/O PORTS
PERIPHERAL INPUT/OUTPUT PIO
CLOCK OUT (Φ)
ROMC0–ROMC4
19
CONTROL BUS
READ ONLY MEMORY (ROM)
1 2 3 4 5 6 7 8 9
16
MEMORY SELECT DECODER
A11–A14
ADDRESS A0–A10
ADDRESS A0–A15
A0–A7, A15
CPU EXTERNAL REGISTER (RAM)
17 RAM WR
12 PND
13 WRT
STATIC MEMORY INTERFACE (SMI)
INT REQ
WRITE
RAM WRITE
EXT INT
CPU READ
15 CPU RD
3
ROMC0–4
DATA DB0–DB7
DATA DB0–DB7
CRYSTAL OSC
CLOCK IN
16
CLOCK OUT (Φ)
WRITE
NC
4 RES
UNBUFFERED DATA d0–d3
CLOCK IN
CLOCK OUT (Φ)
WRITE
INT REQ
I/O PORTS
EXT RES
CENTRAL PROCESSING UNIT (CPU)
ENA
7 A

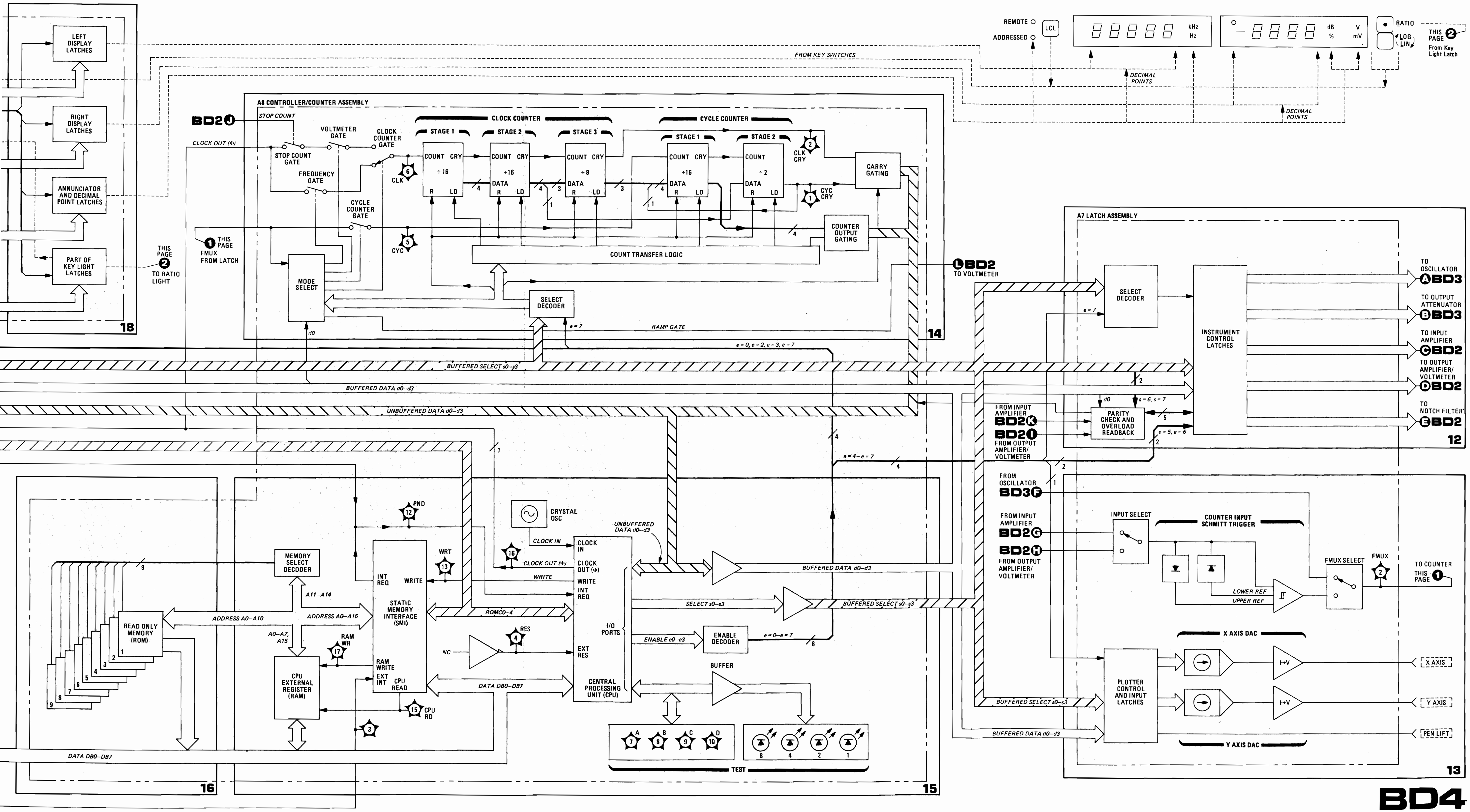


Figure 8-50. Digital Circuits Block Diagram

SERVICE SHEET 1 — INPUT AMPLIFIER — INPUT CIRCUITS (P/O A2)

TROUBLESHOOTING HELP

- Block Diagram .... Service Sheet BD2
- Input Flatness Adjustment .... Paragraph 5-8
- Common-Mode Rejection Adjustment .... Paragraph 5-9

PRINCIPLES OF OPERATION

General

This portion of the Input Amplifier Assembly (A2) contains the AC/DC Switch, Input Attenuator, Over-Voltage Protection, and Differential-to-Single-Ended Amplifier. These and the other circuits on the Input Amplifier Assembly condition the signal to make it suitable to drive the Notch Filter and Output Amplifier that follows.

Input Circuits and Input Attenuator

The signals at the HIGH and LOW INPUT jacks are filtered by RFI filters A13L2 and A13C16 and A13L3 and A13C15. The INPUT jacks are both floating. The LOW INPUT can be switched to ground by chassis part S1. Each input is protected by a fuse (F1 or F2). The input is ac coupled by C2 except in the DC LEVEL measurement mode when C2 is effectively shorted out by R2 which is switched in by K7.

The Input Attenuator is a set of two divider legs with four outputs which are selected by relays K4, K5, and K6 and FET Q2. The two dividers present a combined input impedance of 100 kΩ. (R2 adds another 1 kΩ for dc measurements.) R3 and R4 form a 12 dB divider. C3, C4, C6, C7, and R5 provide compensation for stray capacitance to obtain a flat frequency response. R6, R7, and R8 form a 24 and 40 dB divider. The 24 dB tap is at the junction of R6 and R7; the 40 dB tap is at the junction of R7 and R8. C9, C10, C11, C12, and R9 frequency compensate the 24 dB divider. In addition, C8 and R96 are switched in by Q3 to frequency compensate the 40 dB divider. For input levels below 3V, the attenuation is set to 0 dB.

Over-Voltage Protection

The Over-Voltage Protection circuit opens the path to the Differential-to-Single-Ended Amplifier (U6) and presents a high impedance to the input path when the magnitude of the input signal exceeds 15V. The circuit is bypassed when the Input Attenuator is set to 40 dB and has no effect in the DC LEVEL measurement mode.

Except when measuring dc, K3 is energized (its contacts closed). Diodes CR13 and CR17 are biased on by the dc current which flows from the +15V supply through R20, R21 and R24, CR13 or CR17, R19 or R25, R22, and into the −15V supply. In addition, the ac voltage at the output of the protection circuit is buffered by U7 and fed back to the junction of R20, R21, and R24 through C21 and to the junction of R19 and R22 through C20. This prevents the input signal from altering the current through CR13 and CR17. The effect of this common mode signal is to keep the impedance across the protection circuit constant and prevent distortion from being generated by CR13 and CR17. R17 and R23 provide a dc path around the protection circuit in the DC LEVEL measurement mode while CR10 and CR14 provide over-voltage protection.

SERVICE SHEET 1 (Cont'd)

When a short-term positive transient occurs, the anode of CR13 rises quickly until clamped to the +15V supply by CR11. CR13 then reverse biases and opens the signal path. When a negative transient occurs, the cathode of CR17 falls quickly until clamped to the −15V supply by CR9. CR17 then reverse biases and opens the signal path. For steady-state, over-voltage conditions, the Input Overload Detector resets the Input Overload Flip-Flop which sets the Input Attenuator to 40 dB (see Service Sheets 2 and 12). For this case, the Input Over-Voltage Protection circuit protects against the initial onslaught.

Differential-to-Single-Ended Amplifier

U6, U12, and U5 convert the differential signal from the Input Attenuator to a single-ended signal (i.e., one that is referenced to ground). The differential gain of U6 and U12 is programmed by K1 and K2 as cataloged in Table 8-32. In the DC LEVEL measurement mode, only 0 dB gain is used.

Table 8-32. Gain of the Differential-to-Single-Ended Amplifier

State of K1	State of K2	Gain (dB)
Open	Open	0
Open	Closed	8
Closed	Open	16
Closed	Closed	20

U5 subtracts the output of U6 from U12. Its gain with respect to the output of U6 is −1; its gain with respect to U12 is +1 if the divide-by-two voltage divider (R41, R42, and R43) is taken into account. R43 is adjusted to equalize the two gains and thus reject the common mode signal. C25, C26, C27, and C32 flatten the frequency response of the amplifiers.

Relay Drivers

U15 is a TTL hex peripheral driver capable of driving relays K1, K2, K4, K5, K6, and K7. The relays energize when the driver outputs go low. K3 is driven by Q1. The diodes across the relay coils suppress the inductive transient generated by the coils when the current is interrupted.

TROUBLESHOOTING

General

Procedures for checking the Input Amplifier Assembly are given below. The circuits or points to check are marked on the schematic diagram by a hexagon with a check mark and a number inside, e.g., ⟨√3⟩. In addition, any points outside the labeled circuit area that must be checked are also identified. Fixed signals are shown on the schematic also inside a hexagon, e.g., ⟨+1.9 to +2.1 Vdc⟩. Extend the board assembly where necessary to make measurements. These procedures assume that the source is working properly.

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IER — INPUT

.......Service Sheet BD2
...........Paragraph 5-8
ɜnt ....Paragraph 5-9

sembly (A2) contains the
r-Voltage Protection, and
'hese and the other circuits
tion the signal to make it
put Amplifier that follows.

T jacks are filtered by RFI
ɪnd A13C15. The INPUT
can be switched to ground
ɜd by a fuse (F1 or F2). The
DC LEVEL measurement
ɔy R2 which is switched in

.der legs with four outputs
l K6 and FET Q2. The two
dance of 100 kΩ. (R2 adds
ɪd R4 form a 12 dB divider.
ɪtion for stray capacitance
7, and R8 form a 24 and 40
on of R6 and R7; the 40 dB
9, C10, C11, C12, and R9
In addition, C8 and R96 are
ɪate the 40 dB divider. For
set to 0 dB.

opens the path to the
(U6) and presents a high
gnitude of the input signal
en the Input Attenuator is
EVEL measurement mode.

gized (its contacts closed).
the dc current which flows
nd R24, CR13 or CR17, R19
addition, the ac voltage at
ered by U7 and fed back to
ı C21 and to the junction of
nts the input signal from
CR17. The effect of this
lance across the protection
from being generated by

SERVICE SHEET 1 (Cont'd)

CR13 and CR17. R17 and R23 provide a dc path around the protection circuit in the DC LEVEL measurement mode while CR10 and CR14 provide over-voltage protection.

When a short-term positive transient occurs, the anode of CR13 rises quickly until clamped to the +15V supply by CR11. CR13 then reverse biases and opens the signal path. When a negative transient occurs, the cathode of CR17 falls quickly until clamped to the −15V supply by CR9. CR17 then reverse biases and opens the signal path. For steady-state, over-voltage conditions, the Input Overload Detector resets the Input Overload Flip-Flop which sets the Input Attenuator to 40 dB (see Service Sheets 2 and 12). For this case, the Input Over-Voltage Protection circuit protects against the initial onslaught.

Differential-to-Single-Ended Amplifier

U6, U12, and U5 convert the differential signal from the Input Attenuator to a single-ended signal (i.e., one that is referenced to ground). The differential gain of U6 and U12 is programmed by K1 and K2 as cataloged in Table 8-32. In the DC LEVEL measurement mode, only 0 dB gain is used.

Table 8-32. Gain of the Differential-to-Single-Ended Amplifier

State of K1	State of K2	Gain (dB)
Open	Open	0
Open	Closed	8
Closed	Open	16
Closed	Closed	20

U5 subtracts the output of U6 from U12. Its gain with respect to the output of U6 is −1; its gain with respect to U12 is +1 if the divide-by-two voltage divider (R41, R42, and R43) is taken into account. R43 is adjusted to equalize the two gains and thus reject the common mode signal. C25, C26, C27, and C32 flatten the frequency response of the amplifiers.

Relay Drivers

U15 is a TTL hex peripheral driver capable of driving relays K1, K2, K4, K5, K6, and K7. The relays energize when the driver outputs go low. K3 is driven by Q1. The diodes across the relay coils suppress the inductive transient generated by the coils when the current is interrupted.

TROUBLESHOOTING

General

Procedures for checking the Input Amplifier Assembly are given below. The circuits or points to check are marked on the schematic diagram by a hexagon with a check mark and a number inside, e.g., ⟨√3⟩. In addition, any points outside the labeled circuit area that must be checked are also identified. Fixed signals are shown on the schematic also inside a hexagon, e.g., ⟨+1.9 to +2.1 Vdc⟩. Extend the board assembly where necessary to make measurements. These procedures assume that the source is working properly.

SERVICE SHEET 1 (Cont'd)

Equipment

Oscilloscope	HP 1740A
Test Oscillator	HP 3310A

⟨√1⟩ Input Attenuator and AC/DC Switch Check

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the INPUT switch to FLOAT and the OUTPUT switch to ground. Key in AMPTD 3 V. Connect the HIGH OUTPUT to the LOW INPUT.

2. Connect a high-impedance, ac coupled oscilloscope to pin 2 of U12. The waveform should be 8.3 to 8.7 Vpp. (The period of the signal should be approximately 1 ms.)

3. On the Audio Analyzer, connect the HIGH OUTPUT to the HIGH INPUT. Set the INPUT switch to ground. The waveform at pin 2 of U12 should be 0V.

4. Connect the oscilloscope to the end of C19 that connects to pin 4 of K6, K5, and K4. On the Audio Analyzer, key in the Special Functions listed in Table 8-33. For each setting, the peak-to-peak amplitude, displayed on the oscilloscope, should be within the limits indicated. If the signal level is incorrect, also check the control signals indicated.

Table 8-33. Input Attenuator Check

Check	Special Function	Oscilloscope Display (mVpp)	Level (TTL) at U15 pins		
			11, 10	5, 6	9, 8
0 dB	1.11	8100 to 8900	L	H	H
−12 dB	1.8	2000 to 2200	H	L	H
−24 dB	1.5	500 to 560	H	H	L

5. Connect the oscilloscope to pin 3 of U6. On the Audio Analyzer, key in 1.1 SPCL to switch in the 40 dB attenuator section. The waveform should have an amplitude between 81 and 89 mVpp.

Hint: If the signal level is incorrect, also check that pins 5, 6, 8, 9, 10, and 11 of U15 are TTL high, that pin 8 of U14C is a TTL low, and n 1 of U16A is approximately −15 Vdc. FETs Q2 and Q3 should be on.

6. On the Audio Analyzer, key in 1.11 SPCL. Connect A13TP3 (+5V) to the HIGH INPUT. The oscilloscope (dc coupled), connected to pin 3 of U6, should read 0 Vdc.

Hint: Pins 3 and 4 of U15B should be a TTL high.

7. On the Audio Analyzer, key in 2.4 SPCL to set the input attenuation to 0 dB (in the dc mode). Press S (Shift) DC LEVEL. The oscilloscope should read approximately +5.2 Vdc.

Hint: Pins 3 and 4 of U15B should be a TTL low.

SERVICE SHEET 1 (Cont'd)

⟨√2⟩ Over-Voltage Protection Check

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the INPUT switch to ground. Key in 1.11 SPCL to set the input amplifier gain to 0 dB.

2. Set the test oscillator to 1 kHz and level to appoximately 1 Vrms. Connect the output to the Audio Analyzer's HIGH INPUT.

3. Connect a high-impedance, dc coupled oscilloscope to pin 3 of U6.

4. Connect a short across R46 to drop the gain of U5 to 0.

5. Increase the test oscillator level to approximately 30 Vpp. The waveform on the oscilloscope should appear as shown in Figure 8-51.

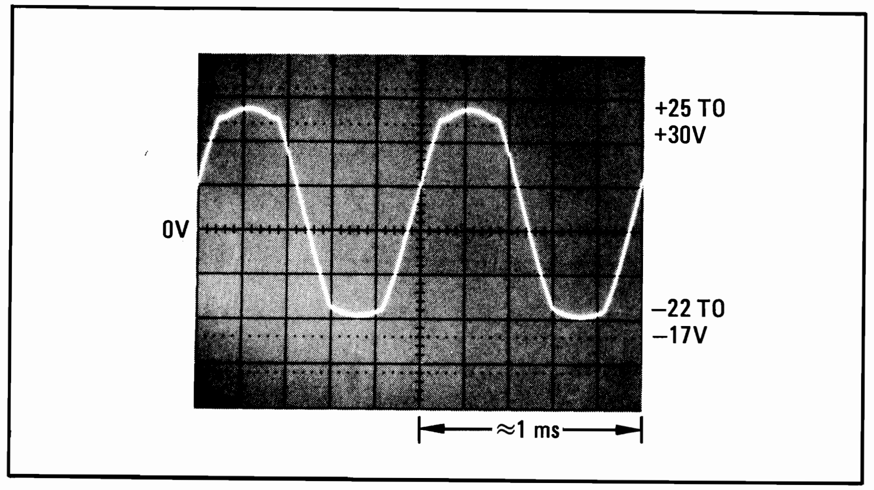


Figure 8-51. Over-Voltage Protection Check Waveform A

Hint: Pins 3 and 4 of U15B should be a TTL high. Pin 14 of U16B should be between 0.6 and 0.8 Vdc. The collector should be between 0 and 0.2 Vdc. If the waveform looks like Figure 8-52, K3 is not closing properly.

6. On the Audio Analyzer, key in 2.4 SPCL to set the input attenuation to 0 dB (in the dc mode). Press S (Shift) DC LEVEL. The waveform on the oscilloscope should appear as shown in Figure 8-52.

Hint: Pins 3 and 4 of U15B should be a TTL low. Pin 14 of U16B should be approximately −15 Vdc. The collector of Q1 should be approximately +5 Vdc.

⟨√3⟩ Differential-to-Single-Ended Amplifier Check

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the INPUT and OUTPUT switches to ground. Key in AMPTD 80 mV. Connect the HIGH OUTPUT to the HIGH INPUT.

Digital Circuits
Block Diagram
SERVICE SHEET BD4

SERVICE SHEET 1 (Cont'd)

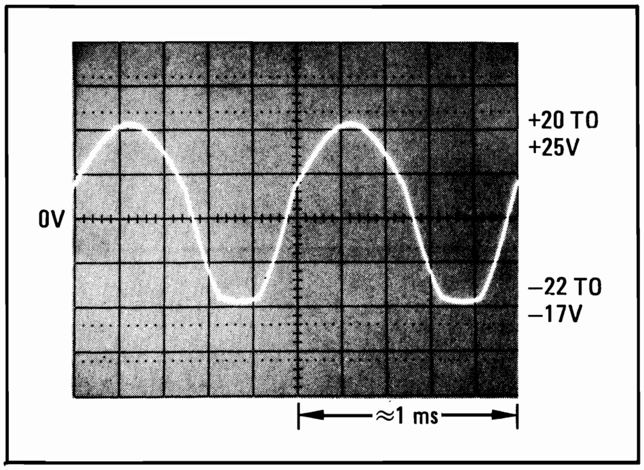


Figure 8-52. Over-Voltage Protection Check Waveform B

2. Connect a high-impedance, ac coupled oscilloscope to pin 3 of U6. The waveform on the oscilloscope should be between 216 and 236 mVpp. (The period of the signal should be 1 ms.)

3. Use the oscilloscope's vertical gain controls to adjust the display amplitude for 2 divisions peak-to-peak deflection of the signal.

4. Connect the oscilloscope to A2TP5 (SING END). Key in the Special Function listed in Table 8-34. For each setting, increase the oscilloscope's vertical gain by the amount indicated. The peak-to-peak amplitude, displayed on the oscilloscope, should be within the limits indicated. If the signal level is incorrect, also check the control signal indicated.

Table 8-34. Differential-to-Single-Ended Amplifier Check

Special Function	Increase in Oscilloscope Vertical Gain	Amplitude Limits (div pp)	Level (TTL) at U15 Pin			
			1	2	12	13
1.11	×1	1.9 to 2.1	H	H	H	H
1.15	×1	4.7 to 5.3	H	H	L	L
1.17	×10	1.2 to 1.3	L	L	H	H
1.19	×10	1.9 to 2.1	L	L	L	L

5. Disconnect the HIGH INPUT, set the oscilloscope to measure dc voltage. The voltage should be between −5 and +5 mVdc.

Hint: If the dc voltage is only slightly out of limits, perform the Input DC Offset Adjustment, paragraph 5-10.

6. On the Audio Analyzer, set the INPUT switch to FLOAT. Using a tee adapter, connect the HIGH OUTPUT to the LOW and HIGH INPUTs in parallel. Key in AMPTD 1 V and FREQ 60 Hz (or 50 Hz if the line frequency is 50 Hz). The waveform on the oscilloscope should have an amplitude less than 50 mVpp. (The waveform may be non-sinusoidal.)

Hint: If the signal is only slightly out of limits, perform the Common-Mode Rejection Adjustment, paragraph 5-9.

A2 ASSEMBLY

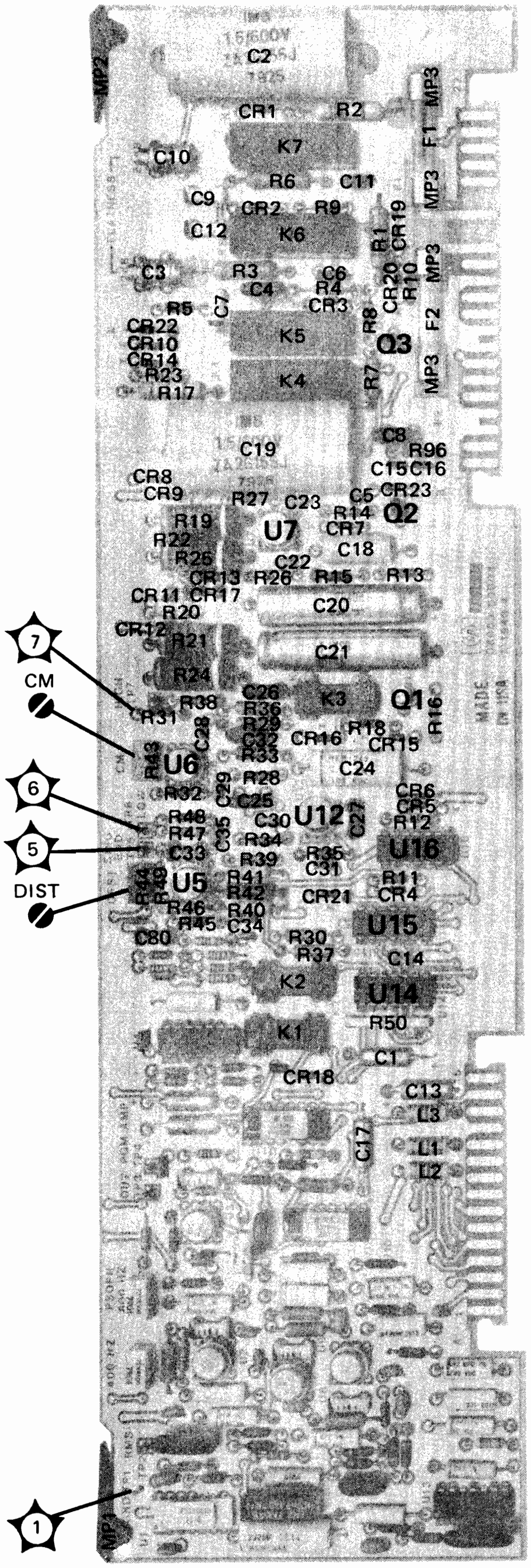
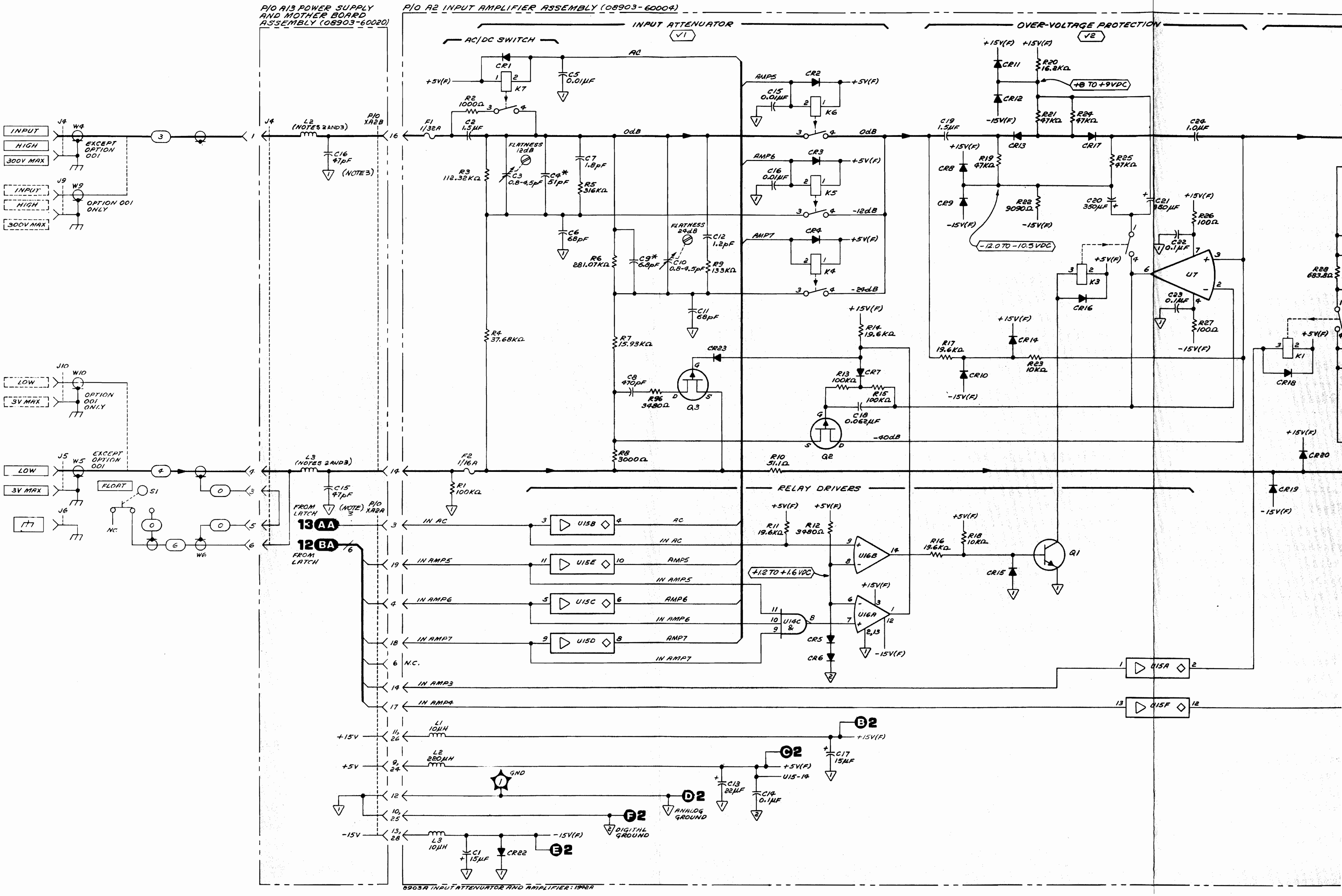
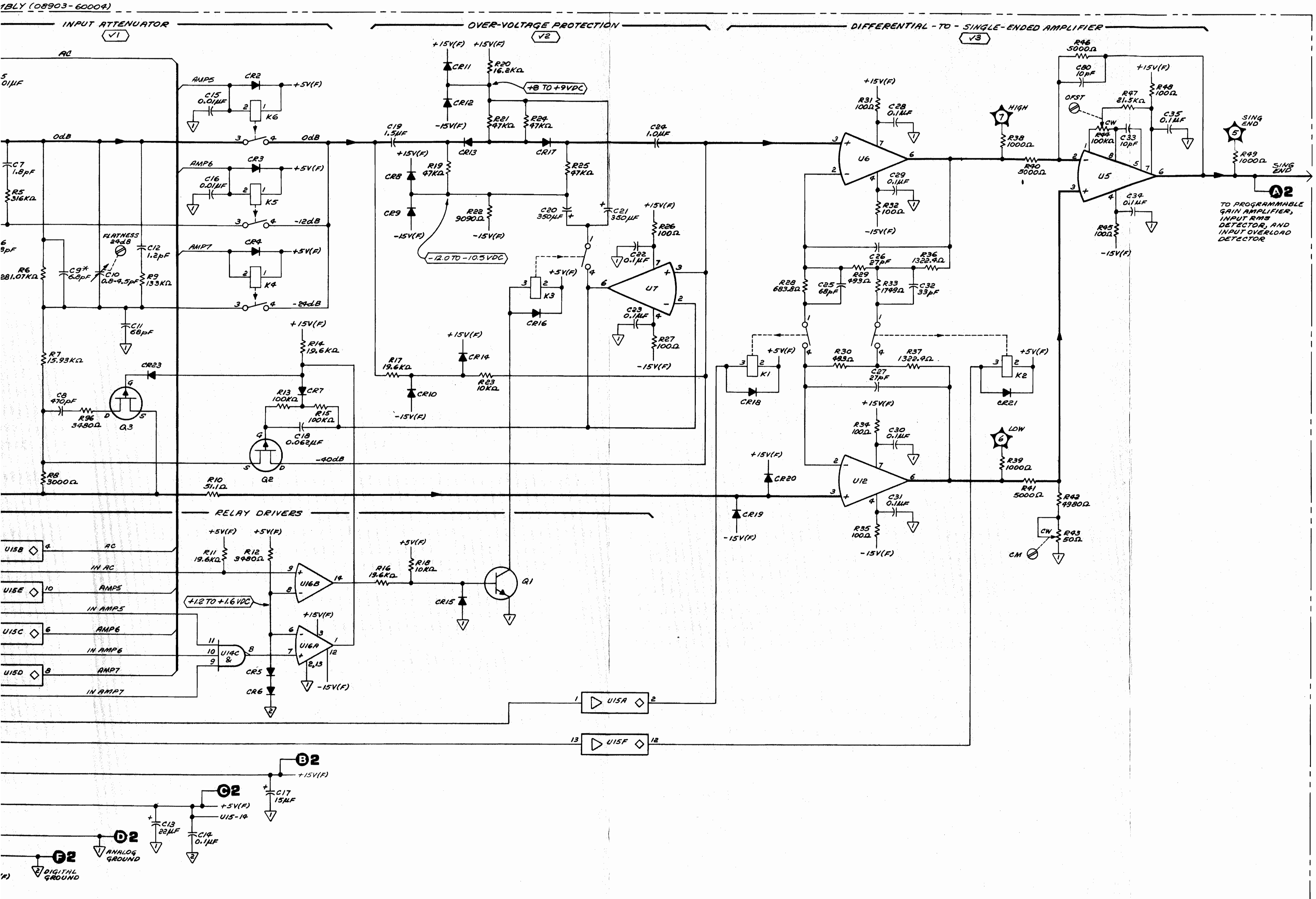


Figure 8-53. P/O A2 Input Amplifier Assembly Component Locations (Input Circuits)



8903A INPUT ATTENUATOR AND AMPLIFIER: 1992A



Reference designations within outline (— — ——) assemblies are abbreviated. Full designation includes Assembly Number; e.g., R1 of Assembly A1 is A1R1. Designations of other components are complete as shown.

NOTES

1. SEE TABLE 8-7 SCHEMATIC DIAGRAM NOTES.
2. RF CHOKE INDUCTANCE IS 2.5 TO 6µH AT 1MHz.
3. POWER SUPPLY AND MOTHER BOARD COMPONENT LOCATIONS ARE SHOWN IN FIGURE 8-119.
4. ✱ ASTERISK MEANS FACTORY SELECTED VALUES.

REFERENCE DESIGNATIONS

NO PREFIX	A2 CONT.
J4-6,9,10 S1 W4-6,9,10	R1-49,96 TP1,5-7 U5-7,12, 14-16
A2	A13
C1-35,80 CR1-23 F1,2 K1-7 L1-3 Q1-3	C15,16 J4 L2,3 XA2A,B

LOGIC LEVELS

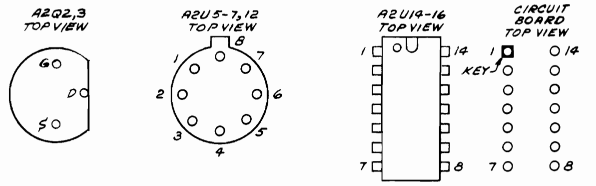
	TTL
HIGH	>2V
LOW	<0.8V
< IS MORE NEG. THAN > IS MORE POS. THAN	
OPEN	HIGH
GROUND	LOW

TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATIONS	PART NUMBERS
Q1	1854-0477
Q2,3	1855-0082
U5	1826-0569
U6,7,12	1826-0662
U14	1820-1202
U15	1820-0668
U16	1820-0138

INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

REFERENCE DESIGNATIONS	PIN NUMBERS
U14,15	+5V(F) - 14 2 - 7



1
P/O A2

Figure 8-54. Input Amplifier—Input Circuits Schematic Diagram

SERVICE SHEET 2 — INPUT AMPLIFIER — OUTPUT CIRCUITS (P/O A2)

TROUBLESHOOTING HELP

- Block Diagram .... Service Sheet BD2
- 400 Hz High-Pass and Psophometric Filter Adjustment .... Paragraph 5-11

PRINCIPLES OF OPERATION

General

This portion of the Input Amplifier Assembly (A2) contains a stage of programmable amplification, the 400 Hz High-Pass Filter, the Psophometric Filter, the Input RMS Detector, and the Input Overload Detector. The output of the assembly drives the Notch Filter.

Programmable Gain Amplifier

The input of the Programmable Gain Amplifier is ac coupled by C37 and C38. The amplifier itself is non-inverting and has a gain as cataloged in Table 8-35. (Only one switch is closed at a time.)

Table 8-35. Gain of the Programmable Gain Amplifier

Switched Closed	Gain (dB)
U11D	0
U11B	4
U11C	8
U11A	12

400 Hz High-Pass and Psophometric Filters

The 400 Hz High-Pass Filter is an active, seven-pole filter with a low-ripple Chebychev response and unity passband gain. A complex pole pair is produced by U2, R63, R64, C43, and C45. U8, U9, and the corresponding resistors and capacitors produce two other complex pole pairs. C54, R70, and R71 produce a real pole that can be adjusted for best flatness of the response. The 400 Hz High-Pass Filter is switched in by U10A.

The Psophometric Filter is an active, bandpass filter with a frequency response that is designed to match the commercial telephone circuit psophometer weighting coefficients gived by the C.C.I.T.T.[1]. Table 8-36 lists the gain at the frequencies which define the filter.

The Psophometric Filter is a complex collection of poles and zeros. U13A, U13B, U13D and their associated resistors and capacitors have low-pass responses. U13C and its associated resistors and capacitors have a bandpass response. U9 and its associated resistors and capacitors have a high-pass response. The filter is switched in by U10C. The through path is switched in by U10D.

SERVICE SHEET 2 (Cont'd)

Table 8-36. Ideal Frequency Response of the Psophometric Filter

Frequency (Hz)	Gain (dB)	Frequency (Hz)	Gain (dB)
50	-63.0	1000	+1.0
100	-41.0	1200	0.0
150	-29.0	1500	-1.3
200	-21.0	2000	-3.0
300	-10.6	2500	-4.2
400	-6.3	3000	-5.6
500	-3.6	3500	-8.5
600	-2.0	4000	-15.0
800	0.0	5000	-36.0

Input RMS Detector

The Input RMS Detector converts the ac input signal into a dc voltage equal to the rms level of the input. The conversion is accomplished by U1. U1 converts the ac signal to its rms dc equivalent by a method called implicit conversion. The implicit equation for rms value is

$$V\text{rms} = \text{avg of } \frac{\text{square of input voltage}}{V\text{rms}}$$

The Absolute Value Detector of U1 converts the input to a full-wave rectified current. The rectified current is squared and divided by the current at the Squarer/Divider's other input which comes from the Current Mirror (a device that produces two output currents equal to the input current). The current into the Current Mirror is filtered (i.e., averaged) by C53. The current I from the Squarer/Divider is

$$I = \frac{\text{square of current from Absolute Value Detector}}{\text{current from Current Mirror}}$$

$$I = \frac{\text{square of current from Absolute Value Detector}}{\text{avg of } I}$$

I_{OUT} from the Current Mirror also equals the average value of I, so

$$I_{OUT} = \text{avg of } I$$

$$I_{OUT} = \text{avg of } \frac{\text{square of current from Absolute Value Detector}}{\text{avg of } I}$$

$$I_{OUT} = \text{avg of } \frac{\text{square of current from Absolute Value Detector}}{I_{OUT}}$$

This is the implicit definition of the rms value of the input current. I_{OUT} flows through U1RL and produces a voltage which is buffered. U1RL is of a value such that the buffered voltage is equal to the rms value of the input voltage.

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[1] The International Telegraph and Telephone Consultative Committee (C.C.I.T.T.), *Fifth Plenary Assembly, 1972, Telephone Transmission Quality*, Recommendation P. 51. The International Telecommunication Union (1973), pp. 89-90.

IER — OUTPUT

.......Service Sheet BD2
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.... Paragraph 5-11

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ble Gain Amplifier

Gain (dB)
0
4
8
12

Filters

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passband gain. A complex
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n by U10D.

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e Committee (C.C.I.T.T.), *Fifth Plenary*
mmendation P. 51. The International

SERVICE SHEET 2 (Cont'd)

Table 8-36. Ideal Frequency Response of the Psophometric Filter

Frequency (Hz)	Gain (dB)	Frequency (Hz)	Gain (dB)
50	-63.0	1000	+1.0
100	-41.0	1200	0.0
150	-29.0	1500	-1.3
200	-21.0	2000	-3.0
300	-10.6	2500	-4.2
400	-6.3	3000	-5.6
500	-3.6	3500	-8.5
600	-2.0	4000	-15.0
800	0.0	5000	-36.0

Input RMS Detector

The Input RMS Detector converts the ac input signal into a dc voltage equal to the rms level of the input. The conversion is accomplished by U1. U1 converts the ac signal to its rms dc equivalent by a method called implicit conversion. The implicit equation for rms value is

$$\text{Vrms} = \text{avg of } \frac{\text{square of input voltage}}{\text{Vrms}}$$

The Absolute Value Detector of U1 converts the input to a full-wave rectified current. The rectified current is squared and divided by the current at the Squarer/Divider's other input which comes from the Current Mirror (a device that produces two output currents equal to the input current). The current into the Current Mirror is filtered (i.e., averaged) by C53. The current I from the Squarer/Divider is

$$I = \frac{\text{square of current from Absolute Value Detector}}{\text{current from Current Mirror}}$$

$$I = \frac{\text{square of current from Absolute Value Detector}}{\text{avg of I}}$$

I_{OUT} from the Current Mirror also equals the average value of I, so

$$I_{OUT} = \text{avg of I}$$

$$I_{OUT} = \text{avg of } \frac{\text{square of current from Absolute Value Detector}}{\text{avg of I}}$$

$$I_{OUT} = \text{avg of } \frac{\text{square of current from Absolute Value Detector}}{I_{OUT}}$$

This is the implicit definition of the rms value of the input current. I_{OUT} flows through U1RL and produces a voltage which is buffered. U1RL is of a value such that the buffered voltage is equal to the rms value of the input voltage.

SERVICE SHEET 2 (Cont'd)

Input Overload Detector

The Input Overload Detector produces a low output that resets the Input Overload Flip-Flop on the Latch Assembly and sets the Input Attenuator to 40 dB (see Service Sheets 1 and 12). The low is produced if the output of the Input RMS Detector exceeds 8 Vdc or if the output from the Differential-to-Single-Ended Amplifier (see Service Sheet 1) goes more positive than +7.5V or more negative than -7.5V. The outputs of U4A and U4D and the outputs of U4C and U4B are wire-ORed such that if any one output goes low, the INPUT OVLD line goes low. R76 and C61 add delay to the circuit that prevents the recognition of short-duration overloads. R87 and C70 form a high-frequency interference filter.

TROUBLESHOOTING

General

Procedures for checking the Input Amplifier Assembly are given below. The circuits or points to check are marked on the schematic diagram by a hexagon with a check mark and a number inside, e.g., √3. In addition, any points outside the labeled circuit area that must be checked are also identified. Fixed signals are shown on the schematic also inside a hexagon, e.g., +1.9 to +2.1 Vdc. Extend the board assembly where necessary to make measurements. These procedures assume that the source is working properly.

Equipment

Oscilloscope ....HP 1740A

√1 Programmable Gain Amplifier Check

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the INPUT and OUTPUT switches to ground. Key in AMPTD 1 V. Key in 1.11 SPCL to set the input gain to 0 dB. Connect the HIGH OUTPUT to the HIGH INPUT.

2. Connect a high-impedance, ac coupled oscilloscope to A2TP5 (SING END). The waveform should be 2.7 to 2.9 Vpp. (The period of the signal should be approximately 1 ms.)

Hint: If the signal is faulty, see Service Sheet 1 and check the Differential-to-Single-Ended Amplifier.

3. Use the oscilloscope's vertical gain controls to adjust the display amplitude for 2 divisions peak-to-peak deflection of the signal.

4. Connect the oscilloscope to A2TP4 (PGM AMP). On the Audio Analyzer, key in the Special Functions listed in Table 8-37. For each setting, the peak-to-peak amplitude, displayed on the oscilloscope, should be within the limits indicated. If the signal level is incorrect, also check the control signals indicated.

√2 400 Hz High-Pass and Psophometric Filters Check

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the INPUT and OUTPUT switches to ground. Key in FREQ 400 Hz and AMPTD 1 V. Key in 1.11 SPCL to set the input gain to 0 dB. Connect the HIGH OUTPUT to the HIGH INPUT.

SERVICE SHEET 2 (Cont'd)

Table 8-37. Programmable Gain Amplifier Check

Gain (dB)	Special Function	Amplitude Limits (div pp)	Level (TTL) at U14A pins			
			1	2	13	12
0	1.11	1.9 to 2.1	H	H	H	L
4	1.12	3.0 to 3.3	L	H	H	H
8	1.13	4.7 to 5.3	H	L	H	H
12	1.14	7.6 to 8.4	H	H	L	H

2. Connect a high-impedance, ac coupled oscilloscope to A2TP4 (PGM AMP). The waveform should be 2.7 to 2.9 Vpp. (The period of the signal should be approximately 1 ms.)

Hint: If the signal is faulty, check the Programmable Gain Amplifier.

3. Use the oscilloscope's vertical gain controls to adjust the display amplitude for 4 divisions peak-to-peak deflection of the signal.

4. Connect the oscilloscope to A2TP3 (OUT). The waveform should be between 3.9 and 4.1 divisions peak-to-peak.

Hint: Pin 16 of U10 should be a TTL low; pins 1 and 9 should be a TTL high.

5. On the Audio Analyzer, press HIGH PASS 400 Hz. The waveform should be between 2.2 and 3.4 divisions peak-to-peak.

Hint: The waveform at pin 6 of U2 should be between 3.8 and 4.8 divisions peak-to-peak and at pin 6 of U3 should be between 3.4 and 4.6 divisions peak-to-peak. Pin 1 of U10 should be a TTL low; pins 9 and 16 should be a TTL high.

6. On the Audio Analyzer, press PSOPH. Key in FREQ 800 Hz. The waveform (at A2TP3) should be between 3.9 and 4.1 divisions peak-to-peak.

Hint: If the signal amplitude is only slightly out of limits, perform the 400 Hz High-Pass and Psophometric Filter Adjustment, paragraph 5-11.

7. On the Audio Analyzer, key in FREQ 2 kHz. The waveform should be between 2.5 and 3.2 divisions peak-to-peak.

Hint: The waveforms on U13 should be as indicated in Table 8-38. Pin 9 of U10 should be a TTL low; pins 1 and 16 should be a TTL high.

◀ Input Amplifiers—Input Circuits
P/O A2
SERVICE SHEET 1

SERVICE SHEET 2 (Cont'd)

Table 8-38. Waveforms at A2U13, 2 kHz Frequency

Pin on U13	Level (div pp)
1	5.0 to 7.0
7	1.4 to 2.2
14	2.0 to 3.0
8	2.0 to 3.0

8. On the Audio Analyzer, key in FREQ 500 Hz. The waveform should be between 2.3 and 3.0 divisions peak-to-peak.

Hint: The waveforms on U13 should be as indicated in Table 8-39.

Table 8-39. Waveforms at A2U13, 500 Hz Frequency

Pin on U13	Level (div pp)
1	3.0 to 5.0
7	2.0 to 3.0
14	2.0 to 3.0
8	6.0 to 9.0

⟨√3⟩ Input RMS Detector and Input Overload Detector Check

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the INPUT and OUTPUT switches to ground. Key in AMPTD 1 V. Key in 1.11 SPCL to set the input gain to 0 dB. Connect the HIGH OUTPUT to the HIGH INPUT.

2. Connect a high-impedance, ac coupled oscilloscope to A2TP4 (PGM AMP). The waveform should be 2.7 to 2.9 Vpp. (The period of the signal should be approximately 1 ms.)

Hint: If the signal is faulty, check the Programmable Gain Amplifier.

3. Use the oscilloscope's vertical gain controls to adjust the display amplitude for 5.7 divisions peak-to-peak of the signal.

4. DC couple the oscilloscope and connect it to A2TP2 (RMS). The dc level should be between 1.9 and 2.1 divisions.

5. Connect the oscilloscope to pin 5 of A13XA2A. Set the vertical gain of the oscilloscope for absolute level calibration. The dc level should be a TTL high.

Hint: Pin 2 of U4 should be approximately +15 Vdc.

6. Short pin 7 of U4B to ground. The dc level at pin 1 of U4B should be a TTL low.

7. Remove the short from pin 7 of U4B. Short pin 5 of U4A to ground. The dc level should be a TTL high except when the CLEAR key is pressed it should go to a TTL low for approximately 1 ms.

8. Remove the short from pin 5 of U4A. Short pin 10 of U4D to ground. The dc level should be a TTL low.

9. Measure the dc voltage at pins 5, 7, and 10 of U4. The level should be as indicated on the schematic diagram.

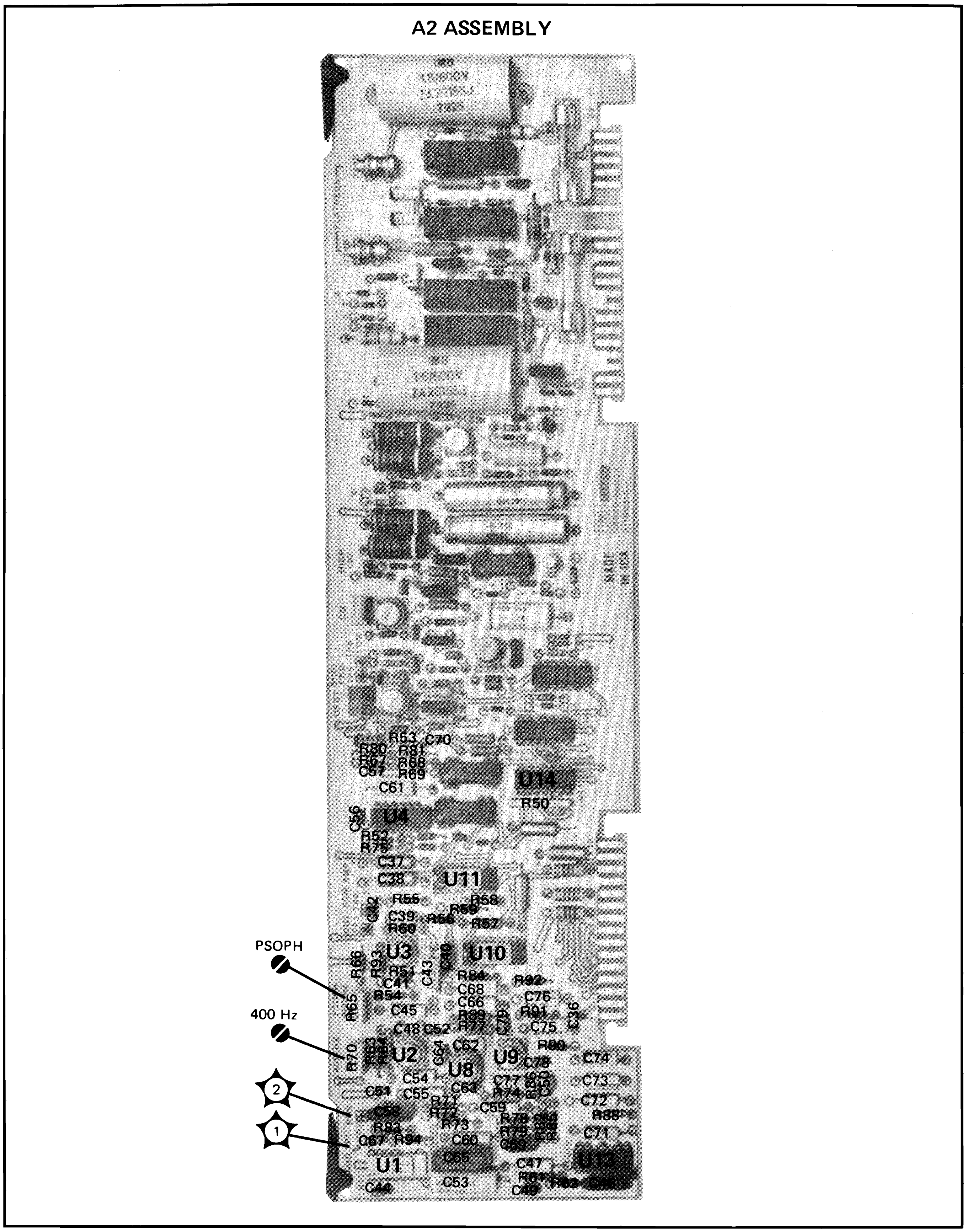
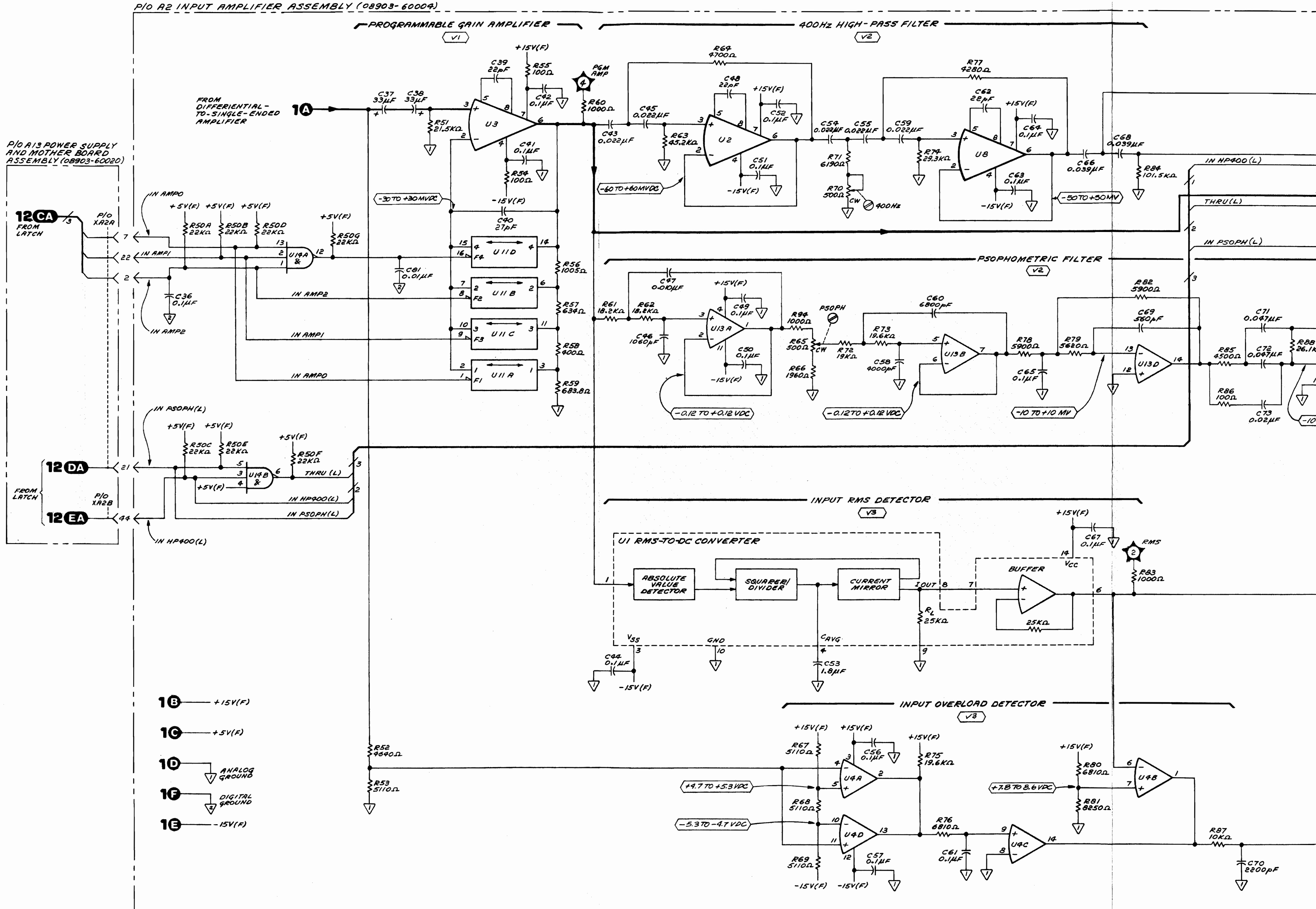
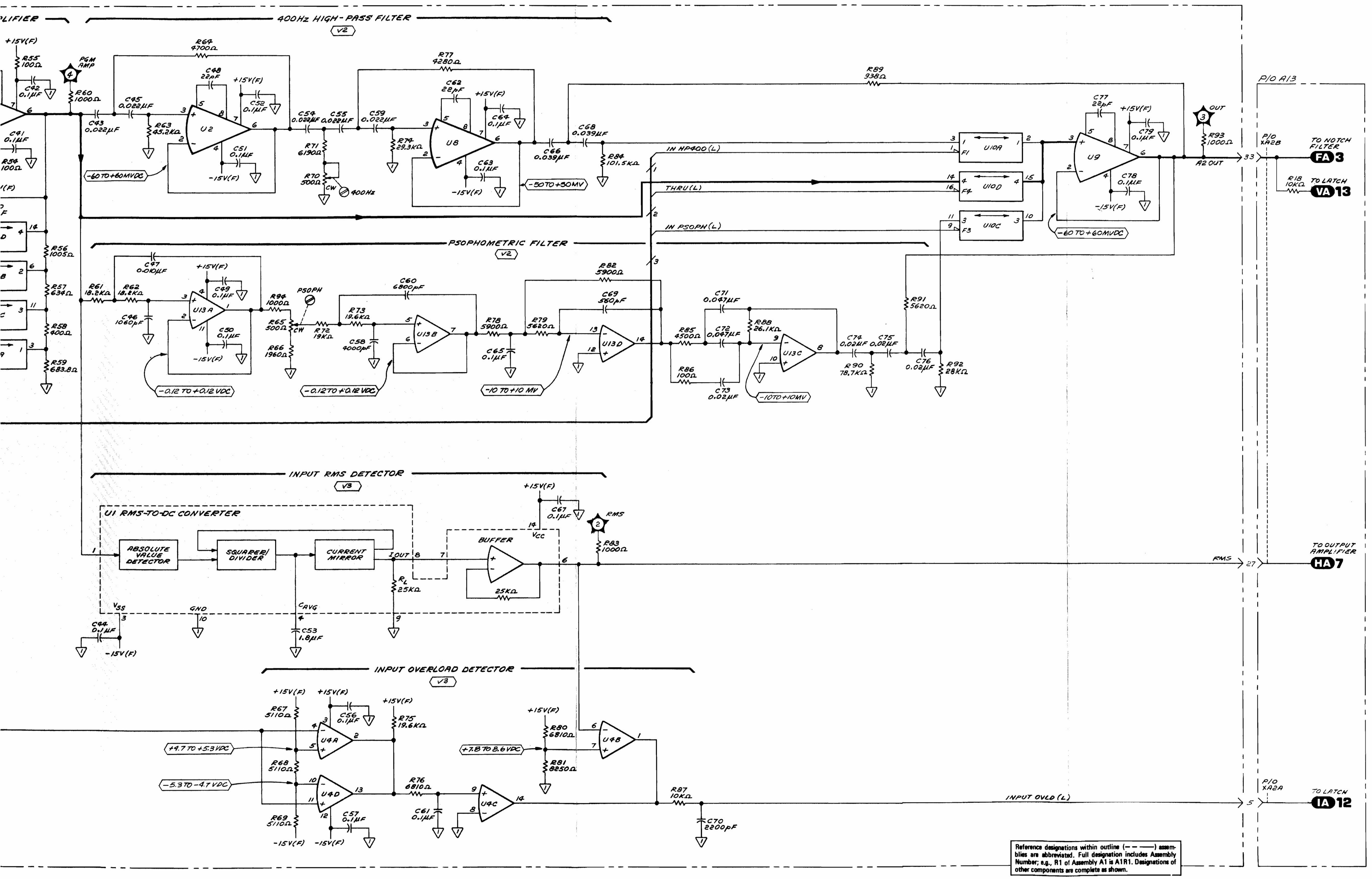


Figure 8-55. P/O A2 Input Amplifier Assembly Component Locations (Output Circuits)



8903A 400Hz AND PSOPHOMETRIC FILTERS AND INPUT RMS DETECTOR: 1942A



Reference designations within outline (— — —) assemblies are abbreviated. Full designation includes Assembly Number; e.g., R1 of Assembly A1 is A1R1. Designations of other components are complete as shown.

NOTES

1. SEE TABLE 8-7 SCHEMATIC DIAGRAM NOTES.

REFERENCE DESIGNATIONS

A2	A13
C36 - 79,81 R50 - 94 TP2 - 4 U1 - 4,8 - 11, 13,14	R18 XA2A,B

NOT ASSIGNED: A2R95

LOGIC LEVELS

	TTL
HIGH	> 2V
LOW	< 0.8V
< IS MORE NEG. THAN > IS MORE POS. THAN	
OPEN	HIGH
GROUND	LOW

INTEGRATED CIRCUIT PART NUMBERS

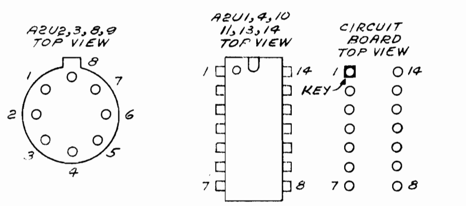
REFERENCE DESIGNATIONS	PART NUMBERS
U1	1826-0431
U2,3,8,9	1826-0569
U4	1826-0138
U10,11	1826-0582
U13	1826-0522
U14	1820-1202

INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

REFERENCE DESIGNATIONS	PIN NUMBERS
U10	+15V(F) - 13 -15V(F) - 4 ▽1 - 5-8
U11	+15V(F) - 13 -15V(F) - 4 ▽1 - 5
U14	+5V(F) - 14 ▽2 - 7

A2R50
TOP VIEW

PIN NO.	1	2	3	4	5	6	7	8
COMMON	A	B	C	D	E	F	G	



2
P/O A2

Figure 8-56. Input Amplifier—Output Circuits Schematic Diagram

SERVICE SHEET 3 — NOTCH FILTER — NOTCH GENERATING CIRCUITS (P/O A3)

TROUBLESHOOTING HELP

- Block Diagram .... Service Sheet BD2

PRINCIPLES OF OPERATION

General

This portion of the Notch Filter Assembly (A3) contains the basic notch generating circuitry which includes two integrators, two sum amplifiers, and their control circuitry.

Integrators

The two integrators are nearly identical. A simplified diagram of an integrator is shown in Figure 8-57. For Integrator 1, FETs Q30 through Q32 switch the feedback capacitors to change ranges. FETs Q14 through Q21 switch the input resistors to coarse tune the filter. The FETs are driven by the Notch Control Drivers whose control inputs come from the Controller via the Latch Assembly (see Service Sheets 12 and 13).

Sum Amplifiers

Sum Amplifiers 1 and 2 and the Sum and Output Amplifier sum various signals in the proportion and phase relationship required by the state-variable design. (See the discussion of the Notch Filter on Service Sheet BD2.) The Sum and Output Amplifier has inputs which are switched by FETs Q11 and Q12 to control the type of filter response, namely, notch, bandpass, or flat. Q13 is a resistive match for the resistance of Q11 or Q12. Sum Amplifier 2 injects the error signal from the notch Balance and Tune Multipliers to automatically fine balance and tune the Notch Filter (see Service Sheet 4). The FETs are driven by the Notch Control Drivers.

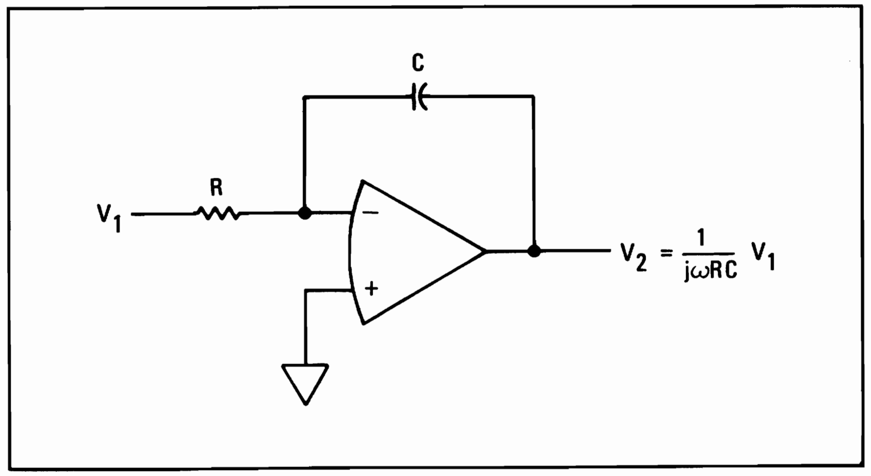


Figure 8-57. Integrator Circuit

TROUBLESHOOTING

General

Procedures for checking the Notch Filter Assembly are given below. The circuits or points to check are marked on the schematic diagram by a hexagon with a check mark and a number inside, e.g., ⟨√3⟩. In addition, any points outside the labeled circuit area that must be checked are also identified. Fixed signals are shown on the schematic also inside a hexagon, e.g., ⟨+1.9 to +2.1 Vdc⟩. Extend the board assembly where necessary to make measurements. These procedures assume that the source is working properly.

Equipment

Oscilloscope .... HP 1740A

⟨√1⟩ Notch Filter Check

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Press DISTN. Short pin 3 of U5 to A3TP1 (GND).

2. Connect a high-impedance, dc coupled oscilloscope to A3TP5 (BP OUT), A3TP6 (HP OUT), A3TP7 (OUT), and A3TP14 (LP OUT) one at a time. The dc level for each should be between −200 and +200 mVdc.

3. On the Audio Analyzer, remove the short at pin 3 of U5. Short A3TP3 (TUNE) and A3TP4 (BAL) both to A3TP1 (GND).

4. On the Audio Analyzer, set the OUTPUT switch to ground. Key in AMPTD 2 V. Key in 1.11 SPCL to set the input gain to 0 dB. Connect the HIGH OUTPUT to the HIGH INPUT.

5. AC couple the oscilloscope and connect it to A2TP3 (OUT). Increment the Audio Analyzer's SOURCE amplitude to obtain exactly 6 Vpp on the oscilloscope.

Hint: The amplitude at A2TP3 should be approximatley between 5 and 6 Vpp before adjustment. (The period should be approximately 1 ms.)

6. On the Audio Analyzer, key in the SOURCE frequency and Special Functions listed in Table 8-40. For each setting, measure the waveforms at the test point indicated. The peak-to-peak amplitude should be within the limits indicated.

Hint: If the waveforms at A3TP14 only are faulty, check the Sum and Output Amplifier. See step 8 below.

Hint: If all waveforms are incorrect, check the Sum Amplifier which should have a gain of 1 (from A3TP5 to pin 6 of U11) and Sum Amplifier 1.

Hint: If most of the waveforms are incorrect, check the control voltages listed in Table 8-41. If the control signals are correct, measure the ac signal at the drains of FETs Q30 through Q35 at the corresponding SOURCE frequency (choose 1 kHz for 53.1 SPCL). The drain voltage should be 0 Vrms when the FET is on. If these signals are all correct, continue on with step 7.

Table 8-40. Voltage Limits (Vpp) at A3TP5, 6, 7 and 14

Special Functions	SOURCE Frequency (Hz)	Voltage Limits (Vpp) at			
		A3TP5	A3TP6	A3TP7	A3TP14
53.1 and 54.147	1 000	4.8 to 7.2	4.8 to 7.2	<1.2	4.8 to 7.2
	5 000	0.3 to 0.5	1.6 to 2.4	4.8 to 7.2	<0.1
	200	0.3 to 0.5	<0.1	4.8 to 7.2	1.6 to 2.4
53.0	125	4.8 to 7.2	4.8 to 7.2	<1.2	4.8 to 7.2
53.2	8 000	4.8 to 7.2	4.8 to 7.2	<1.2	4.8 to 7.2
53.3 and 54.108	47 000	4.8 to 7.2	4.8 to 7.2	<1.2	4.8 to 7.2

Table 8-41. Voltage Levels (Vdc) at A3U16

Special Function	Level (Vdc) at U16 Pin			FETs On
	1	2	13	
53.0	0	−15	−15	Q31, Q34
53.1	−15	0	−15	Q30, Q33
53.2	−15	−15	0	Q32, Q35
53.3	−15	−15	−15	None

7. On the Audio Analyzer, key in 53.1 SPCL. Key in the Special Functions and SOURCE frequencies listed in Table 8-42. For each setting, measure the ac signal on the sources of FETs Q14 through Q29. A signal should appear on the source unless the FET is off; 0 Vrms should appear if the FET is on. If a signal is faulty, also check the control voltage listed in Table 8-42.

Table 8-42. Troubleshooting A3Q14 through A3Q29

Special Function	SOURCE Frequency (Hz)	FETs On	Level (Vdc) at U14 Pin				Level (Vdc) at U15 Pin			
			13	14	2	1	2	1	13	14
54.1	20	Q21, Q29	−15	−15	−15	−15	-15	-15	-15	0
54.2	20	Q20, Q28	−15	−15	−15	−15	-15	-15	0	-15
54.4	20	Q19, Q27	−15	−15	−15	−15	-15	0	-15	-15
54.8	50	Q18, Q26	−15	−15	−15	−15	0	-15	-15	-15
54.16	100	Q17, Q25	−15	−15	−15	0	-15	-15	-15	-15
54.32	200	Q16, Q24	−15	−15	0	−15	-15	-15	-15	-15
54.64	500	Q15, Q23	−15	0	−15	−15	-15	-15	-15	-15
54.128	1000	Q14, Q22	0	−15	−15	−15	-15	-15	-15	-15
54.255	2000	All	0	0	0	0	0	0	0	0

Input Amplifiers—Output Circuits
P/O A2
SERVICE SHEET 2

SERVICE SHEET 3 (Cont'd)

Hint: If an attempt is made to switch on an FET which has failed to an open state, signals will usually appear on the sources of Q14 through Q21 but not Q22 through Q29.

8. On the Audio Analyzer, key in FREQ 1 kHz, 53.1 SPCL, and 54.147 SPCL. Connect the oscilloscope to A3TP7 (OUT).

9. On the Audio Analyzer, key in the Special Functions listed in Table 8-43. For each setting, the peak-to-peak amplitude, observed on the oscilloscope, should be within the limits indicated. If the signal is faulty, also check the control signals indicated.

Table 8-43. Voltage Limits (Vpp) at A3TP7, Special Functions 44.N

Notch Filter Mode	Special Function	Level at A3TP7 (Vpp)	Level (Vdc) at U10 Pin	
			1	2
Notch	44.1	<1.2	0	0
Flat	44.2	5.4 to 6.6	0	–15
Bandpass	44.3	4.8 to 7.2	–15	0

10. See Service Sheet 4 and check the Notch Filter tune and balance.

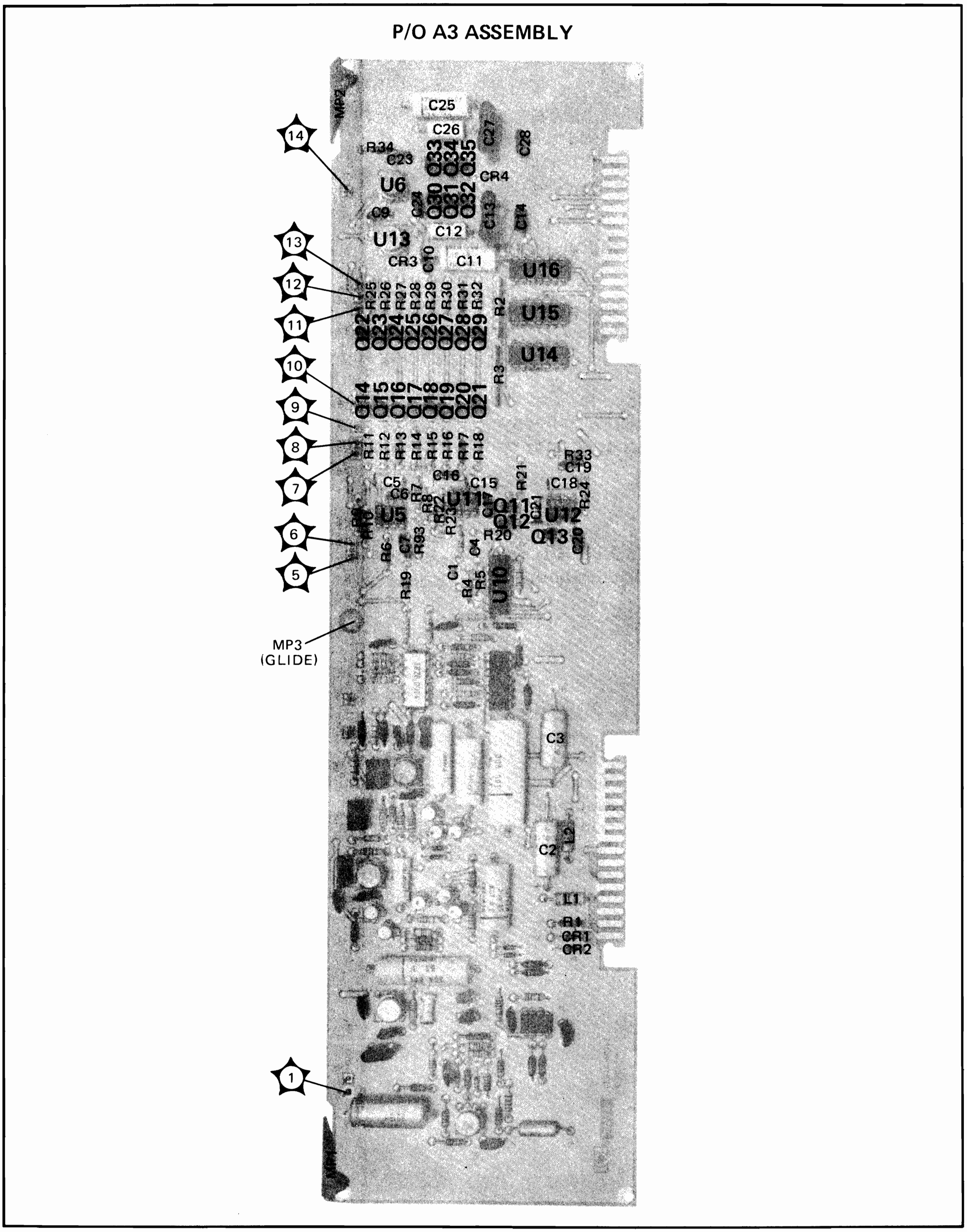
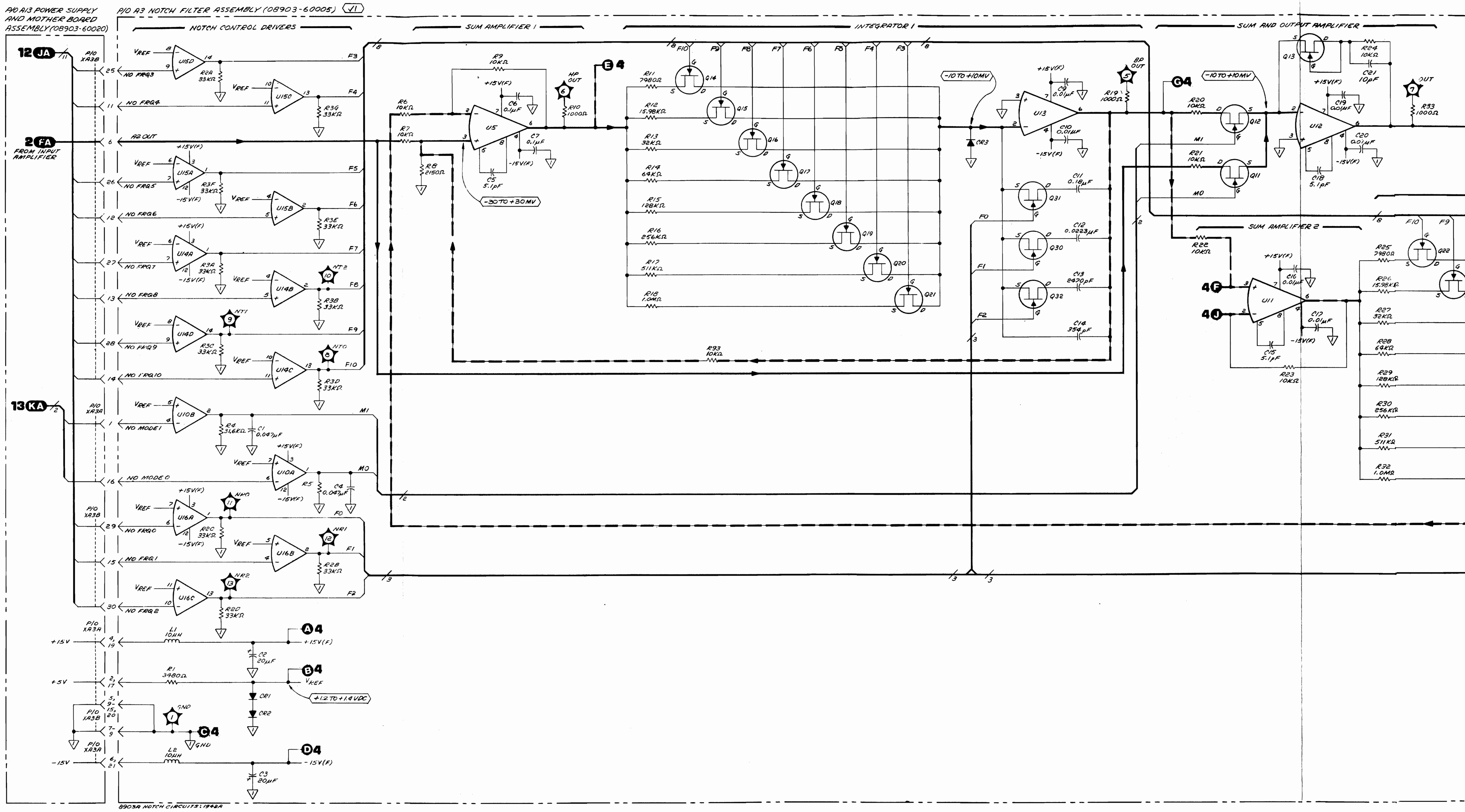
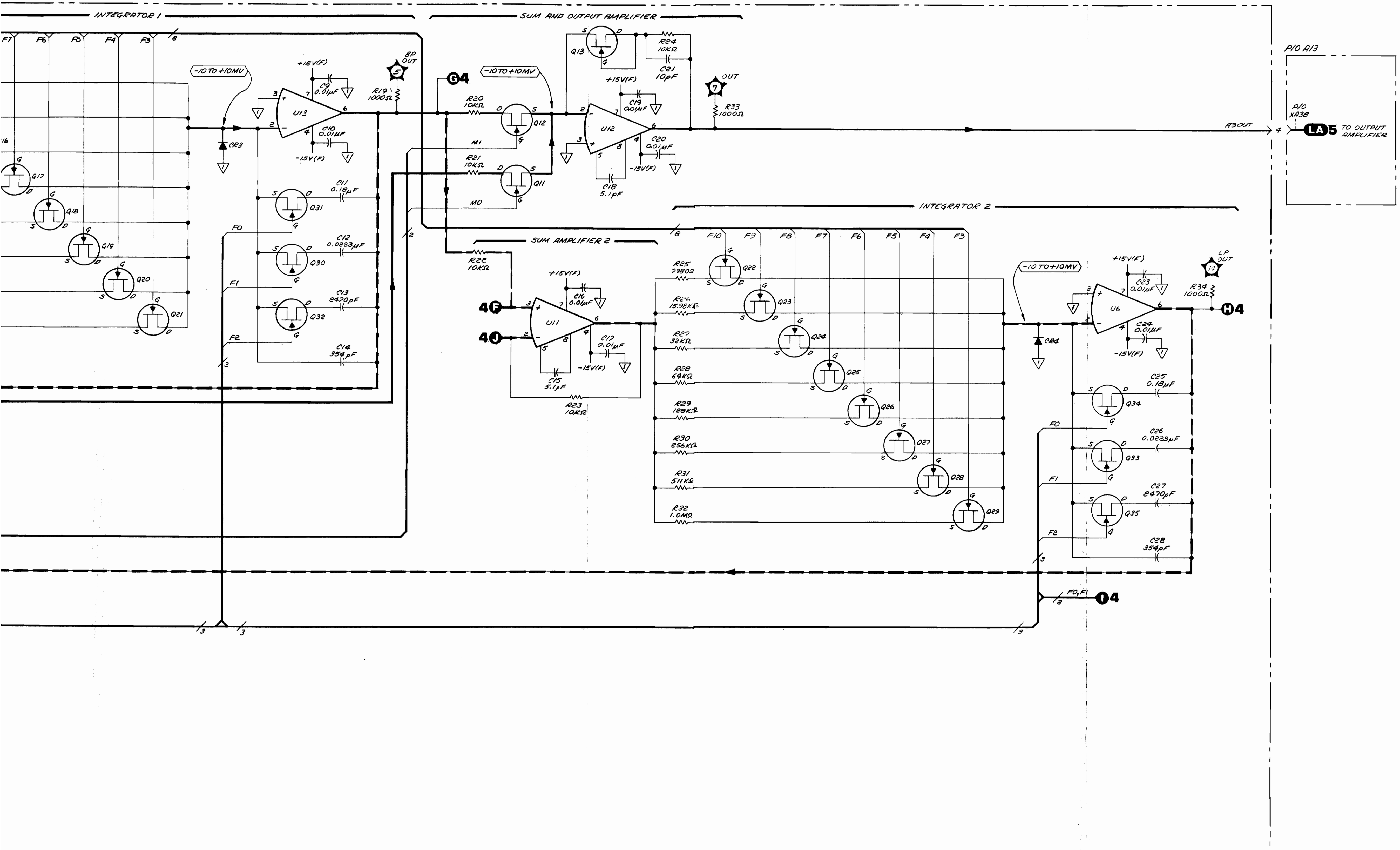


Figure 8-58. P/O A3 Notch Filter Assembly Component Locations (Notch Generating Circuits)


P/O A13 POWER SUPPLY AND MOTHER BOARD ASSEMBLY (08903-60020)
P/O A3 NOTCH FILTER ASSEMBLY (08903-60005) V1
NOTCH CONTROL DRIVERS
SUM AMPLIFIER 1
INTEGRATOR 1
SUM AND OUTPUT AMPLIFIER
SUM AMPLIFIER 2
12 JA
2 FA
FROM INPUT AMPLIFIER
13 KA
P/O XA3B
P/O XA3A
NO FRQ3
NO FRQ4
A2 OUT
NO FRQ5
NO FRQ6
NO FRQ7
NO FRQ8
NO FRQ9
NO FRQ10
NO MODE1
NO MODE 0
NO FRQ0
NO FRQ1
NO FRQ2
VREF
U15D
U15C
U15A
U15B
U14A
U14B
U14D
U14C
U10B
U10A
U16A
U16B
U16C
R2A 33KΩ
R3G 33KΩ
R3F 33KΩ
R3E 33KΩ
R3A 33KΩ
R3B 33KΩ
R3C 33KΩ
R3D 33KΩ
R4 31.6KΩ
C1 0.047μF
R5
C4 0.047μF
R2C 33KΩ
R2B 33KΩ
R2D 33KΩ
+15V(F)
-15V(F)
F0
F1
F2
F3
F4
F5
F6
F7
F8
F9
F10
M1
M0
NT2
NT1
NT0
NR0
NR1
NR2
+15V
L1 10μH
C2 20μF
A4
+15V(F)
+5V
R1 3480Ω
B4
VREF
+1.2 TO +1.4 VDC
CR1
CR2
GND
C4
D4
-15V
L2 10μH
C3 20μF
-15V(F)
R9 10KΩ
R6 10KΩ
R7 10KΩ
R8 2150Ω
C6 0.1μF
C7 0.1μF
C5 5.1pF
U5
HP OUT
6
R10 1000Ω
E4
-30 TO +30 MV
R93 10KΩ
R11 7980Ω
R12 15.98KΩ
R13 32KΩ
R14 64KΩ
R15 128KΩ
R16 256KΩ
R17 511KΩ
R18 1.0MΩ
Q14
Q15
Q16
Q17
Q18
Q19
Q20
Q21
-10 TO +10MV
CR3
U13
C9 0.01μF
C10 0.01μF
BP OUT
5
R19 1000Ω
C11 0.18μF
C12 0.0223μF
C13 2470pF
C14 354pF
Q31
Q30
Q32
G4
-10 TO +10MV
R20 10KΩ
R21 10KΩ
Q12
Q11
Q13
R24 10KΩ
C21 10pF
C19 0.01μF
C20 0.01μF
C18 5.1pF
U12
OUT
7
R33 1000Ω
R22 10KΩ
4F
4J
U11
C16 0.01μF
C17 0.01μF
C15 5.1pF
R23 10KΩ
R25 7980Ω
R26 15.98KΩ
R27 32KΩ
R28 64KΩ
R29 128KΩ
R30 256KΩ
R31 511KΩ
R32 1.0MΩ
Q22
8903A NOTCH CIRCUITS: 1942A



Reference designations within outline (— — ——) assemblies are abbreviated. Full designation includes Assembly Number; e.g., R1 of Assembly A1 is A1R1. Designations of other components are complete as shown.

NOTES

1. SEE TABLE 8-7 SCHEMATIC DIAGRAM NOTES.

REFERENCE DESIGNATIONS

A3	A13
C1-7, 9-21, 23-28 CR1-4 L1, 2 Q11-35 R1-34, 93 TP1, 5-14 U5, 6, 10-16	XA3A, B

NOT ASSIGNED: A3C8, 22

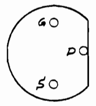
TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATIONS	PART NUMBERS
Q11-35	1855 - 0091
U5, 11, 12	1826 - 0569
U6, 13	1826 - 0662
U10, 14-16	1826 - 0138

A3R2,3
TOP VIEW

PIN NO.	1	2	3	4	5	6	7	8
	GND	A	B	C	D	E	F	G

A3Q11-35
TOP VIEW



3
P/O A3

Figure 8-59. Notch Filter—Notch Generating Circuits Schematic Diagram

SERVICE SHEET 4 — NOTCH FILTER — TUNE AND BALANCE CIRCUITS (P/O A3)

TROUBLESHOOTING HELP

- Block Diagram .... Service Sheet BD2
- Notch Filter Tune and Balance Adjustment .... Paragraph 5-12

PRINCIPLES OF OPERATION

General

This portion of the Notch Filter Assembly (A3) contains the notch balance and tune circuitry that improves the depth and tuning accuracy of the notch.

Chopper Circuits

The Tune Comparator and Chopper are driven by the signal from Integrator 2 (see Service Sheet 3). This signal is in quadrature with the fundamental of the input to the Notch Filter. The Balance Comparator and Chopper are driven by the signal from Integrator 1. This signal is in phase with the fundamental of the input to the Notch Filter. The Tune and Balance Comparators drive the chopper FETs (Q4 and Q5) so that they switch at the zero crossings of the comparator inputs. When the outputs of the comparators go high (i.e., when their open-collector outputs shut off), the FETs switch on (short circuit) because the gates are grounded through R46 or R48. When the comparators go low, putting a large negative voltage at the FET gates, the FETs switch off.

The current from the Tune (or Balance) Chopper and the Inverting Amplifier are summed together at the inverting (−) input of the Tune (or Balance) Integrator. The chopper current is weighted by a factor of 2 because the path resistance from the chopper is about half of the path resistance from the Inverting Amplifier. When Gain Switch Q2 is off, the Tune Chopper's path resistance is R49 in series with R54; the Inverting Amplifier's path resistance is R60. When Q2 is switched on, the current in both paths increases by about a factor of 10. R55 is now in parallel with R54, and R58 with R60. This increases the Tune Integrator gain by a factor of 10 and compensates for a 20 dB reduction in attenuation when Attenuator 1 is switched out (see Service Sheet 5). The action of the Balance Chopper is similar to the Tune Chopper.

Integrators and Multipliers

The sum current from the Tune Chopper and Inverting Amplifier is integrated by the Tune Integrator. The dc value of the sum current represents the tuning error of the Notch Filter. The integrator amplifies and filters the error current and drives the Tune Multiplier. The integration capacitors are switched for different frequency ranges to compensate for the resultant gain change with frequency. When the Notch Filter range is changed, FET Q1 is momentarily switched on to discharge the integration capacitor and speed up the tuning correction. Operation of the Balance Integrator is similar to the Tune Integrator. The Tune and Balance offset adjustments (R62 and R63) compensate for dc offsets in the filter to maximize the depth of the notch.

The Tune Multiplier receives a dc control input (the Y input) from the Tune Integrator and an ac input (the X input) from Integrator 1 (see Service Sheet 3). The sensitivity of the X input is set by R77, the Y input by R81, and the overall multiplier by R75 and R79. The output of the Tune Multiplier is a current which is summed directly with the current from the Balance Multiplier and applied to Sum Amplifier 2 (see Service Sheet 3). The dc level into the Tune Multiplier is also measured by the DC Voltmeter to give the Controller an indication of whether or not the Notch Filter is properly tuned.

TROUBLESHOOTING

General

Procedures for checking the Notch Filter Assembly are given below. The circuits or points to check are marked on the schematic diagram by a hexagon with a check mark and a number inside, e.g., ⟨√3⟩. In addition, any points outside the labeled circuit area that must be checked are also identified. Fixed signals are shown on the schematic also inside a hexagon, e.g., ⟨+1.9 to +2.1 Vdc⟩. Extend the board assembly where necessary to make measurements. These procedures assume that the source is working properly.

Equipment

Oscilloscope .... HP 1740A

⟨√1⟩ Notch Filter Tune and Balance Check

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the INPUT and OUTPUT switches to ground. Key in AMPTD 1 V. Key in 1.11 SPCL to set the input gain to 0 dB. Key in 3.1 SPCL to set the output gain to 0 dB. Key in 53.1 SPCL and 54.147 SPCL to tune the Notch Filter to 1 kHz. Connect the HIGH OUTPUT to the HIGH INPUT.

2. Connect a high-impedance, ac coupled oscilloscope to A4TP8 (AMP 1). The waveform should be between 1.1 and 1.7 Vpp. (The period of the signal should be approximately 1 ms.)

Hint: If the signal is faulty, see Service Sheet 3 and check the Notch Filter and Service Sheet 5 and check Attenuator 1 and Amplifier 1.

3. Connect the oscilloscope to A3TP2 (NOTCH AMP). The waveform should be between 12 and 19 Vpp.

4. DC couple the oscilloscope and connect it to A3TP4 (BAL). The dc level should be between −5 and −4 Vdc.

Hint: Pin 7 of U8B should be a 0 to −15V square wave with a period of 1 ms. The source of Q4 should be a positive, half-wave rectified sine wave. Pin 6 of U1 should be a sine wave with an amplitude of 12 to 19 Vpp. Pin 14 of U16D should be −15V; Q8 should be off.

5. On the Audio Analyzer, key in 44.3 SPCL to set the Notch Filter to the bandpass mode. The dc level should be between +4 and +5 Vdc.

Hint: A3TP2 should be a sine wave with an amplitude of 10 to 21 Vpp. If faulty, see Service Sheet 3 and check the Notch Filter.

Hint: Pin 7 of U8B should be a 0 to −15V square wave with a period of 1 ms. The source of Q4 should be a negative, half-wave rectified sine wave.

6. Connect the oscilloscope to A3TP3 (TUNE). On the Audio Analyzer, key in 44.2 SPCL to set the Notch Filter to the flat mode. Key in FREQ 500 Hz. The dc level should be between +4 and +5 Vdc.

Hint: Pin 1 of U8A should be a 0 to −15V square wave with a period of 2 ms. The source of Q5 should be a negative, half-wave rectified sine wave. Q1 should be off.

7. On the Audio Analyzer, key in FREQ 2 kHz. The dc level should be between −5 and −4 Vdc.

Hint: Pin 1 of U8A should be a 0 to −15V square wave with a period of 0.5 ms. The source of Q5 should be a positive, half-wave rectified sine wave.

8. On the Audio Analyzer, key in 0.56 S (Shift) 3 SPCL to discharge the Tune and Balance Integrators. The dc level should be between −50 and +50 mVdc.

Hint: Pin 14 of U16D should be 0 Vdc; Q1 should be on.

9. Connect the oscilloscope to A3TP4. The dc level should be between− 50 and +50 mVdc.

Hint: Q8 should be on.

10. On the Audio Analyzer, key in 0.565 SPCL to disable the discharge of the Tune and Balance Integrators. Connect one channel of the oscilloscope (ac coupled) to A3TP5 and the other channel to pin 2 of U9. Trigger the oscilloscope from the signal on A3TP5 (BP OUT). The two signals should be in phase. (The signal at pin 2 of U9 should have an amplitude of approximately 100 mVpp.)

11. On the Audio Analyzer, key in FREQ 500 Hz. The two signals should be approximately 180° out of phase.

12. On the Audio Analyzer, key in FREQ 1 kHz. Move the oscilloscope from A3TP5 to A3TP6 (HP OUT) and from pin 2 of U9 to pin 2 of U4. The two signals should be in phase.

13. On the Audio Analyzer, key in 44.3 SPCL. The two signals should be approximately 180° out of phase.

14. On the Audio Analyzer, key in 44.2 SPCL. Connect the oscilloscope to the source of Q2. The waveform should have an amplitude of less than 200 mVpp.

◀ Notch Filter—Notch Generating Circuits
P/O A3
SERVICE SHEET 3

SERVICE SHEET 4 (Cont'd)

Hint: Pin 14 of U10D should be 0V. Q2 should be on.

15. On the Audio Analyzer, key in AMPTD 100 mV. Key in 3.2 SPCL to set the Gain Switch off. The waveform should be a sine wave with a phase reversal at each peak and have an amplitude of approximately 5 Vpp.

Hint: Pin 14 of U10D should be -15V. Q2 should be off.

Hint: The signal at A3TP2 should be a sine wave with an amplitude of 16 Vpp. If faulty, see Service Sheet 5 and check Attenuator 1.

16. Connect the oscilloscope to the source of Q3. The waveform should be a positive, full-wave rectified sine wave with an amplitude of approximately 2 Vpp.

Hint: Q3 should be off.

17. On the Audio Analyzer, key in 3.1 SPCL. Key in AMPTD 1 V. The signal amplitude should be less than 500 mVpp.

Hint: Q3 should be on.

NOTE

The following steps check the overall performance of the Notch Filter at various frequencies. The notch circuitry of Service Sheet 3 is assumed to be operating properly and the Source is assumed to have less than 0.01% distortion and noise. If distortion is high on all ranges, perform the Notch Filter Tune and Balance Adjustment, paragraph 5-12, and also check the distortion of the Output Amplifier 1, see Service Sheet 5.

18. On the Audio Analyzer, press DISTN. Key in AMPTD 2.5 V. Key in 44.1 SPCL to set the Notch Filter to the notch mode. Key in 3.0 SPCL to set the output amplifier gain to automatic. The amplitude display should read 0.01% or less.

Hint: The gates of Q7 and Q9 should be 0V and the FETs should be on. The gates of Q6 and Q10 should be –15V and the FETs should be off. The signal at A3TP7 (OUT) should be less than 100 mVpp.

19. On the Audio Analyzer, key in 54.139 SPCL. Note the amplitude display. Key in 54.155 SPCL. Note the amplitude display. In both cases the display should be 0.01% or less.

20. On the Audio Analyzer, key in FREQ 20 Hz. Key in 53.0 SPCL and 54.23 SPCL to tune the Notch Filter to 20 Hz. The amplitude display should be 0.01% or less.

Hint: The gates of Q6 and Q10 should be 0V and the FETs should be on. The gates of Q7 and Q9 should be –15V and the FETs should be off. The signal at A3TP7 should be less than 100 mVpp.

21. On the Audio Analyzer, key in FREQ 10 kHz. Key in 53.2 SPCL and 54.184 SPCL to tune the Notch Filter to 10 kHz. The amplitude display should be 0.01% or less.

Hint: The gates of Q6, Q7, Q9, and Q10 should be –15V and the FETs should be off. The signal at A3TP7 should be less than 100 mVpp.

22. On the Audio Analyzer, key in FREQ 20 kHz. Key in 53.3 SPCL and 54.46 SPCL to tune the Notch Filter to 20 kHz. The amplitude display should be 0.01% or less.

Hint: See the hint for step 21.

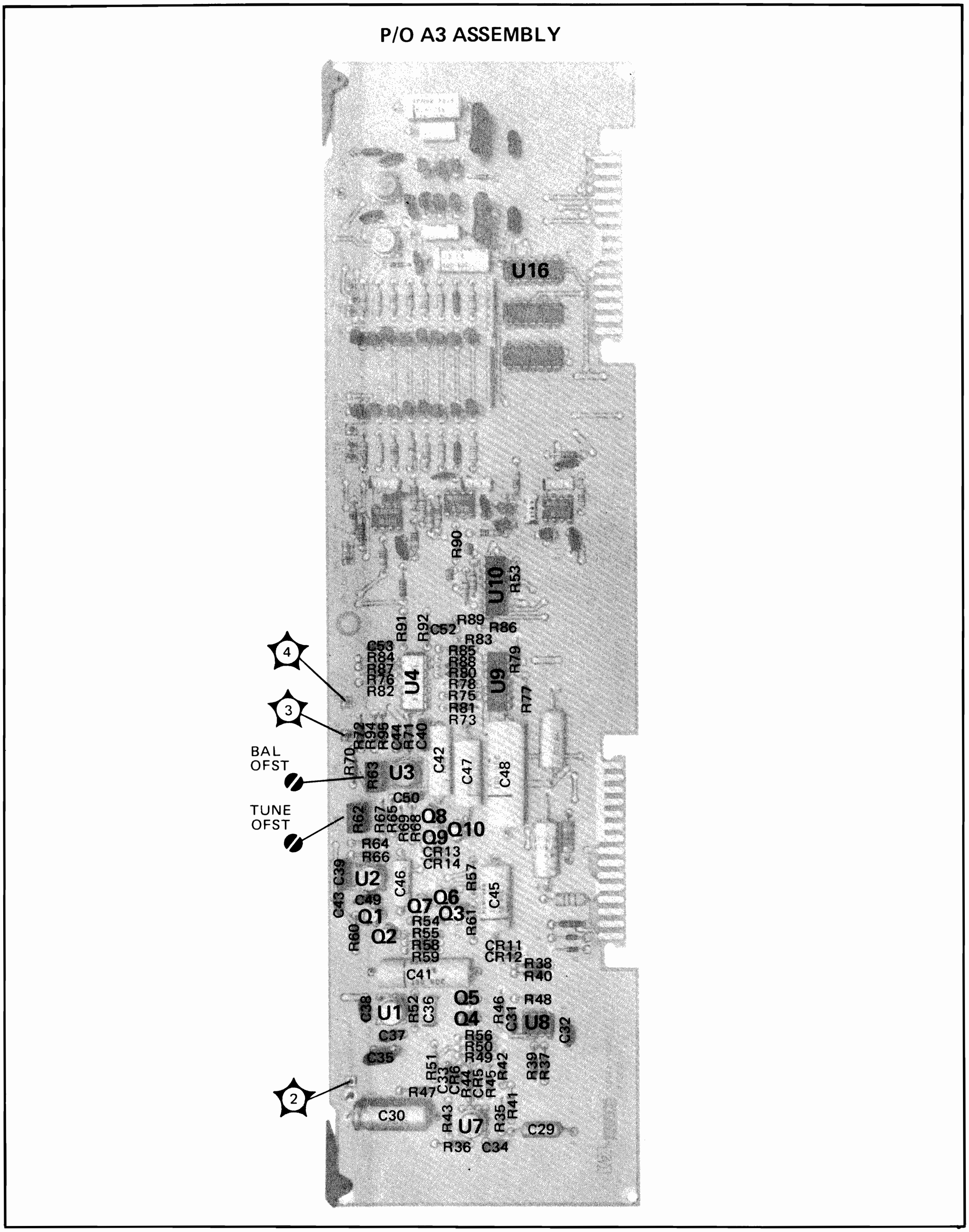
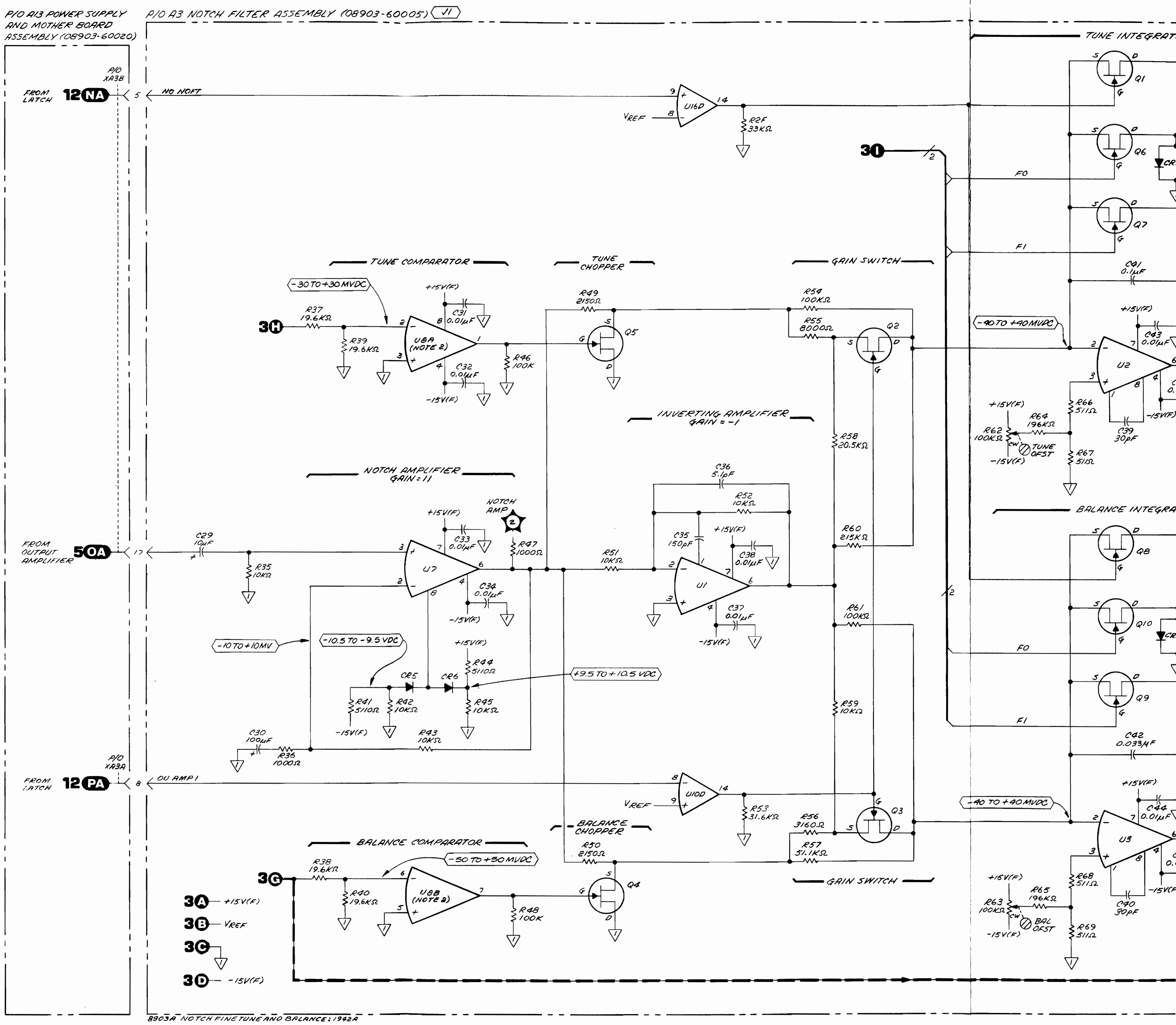
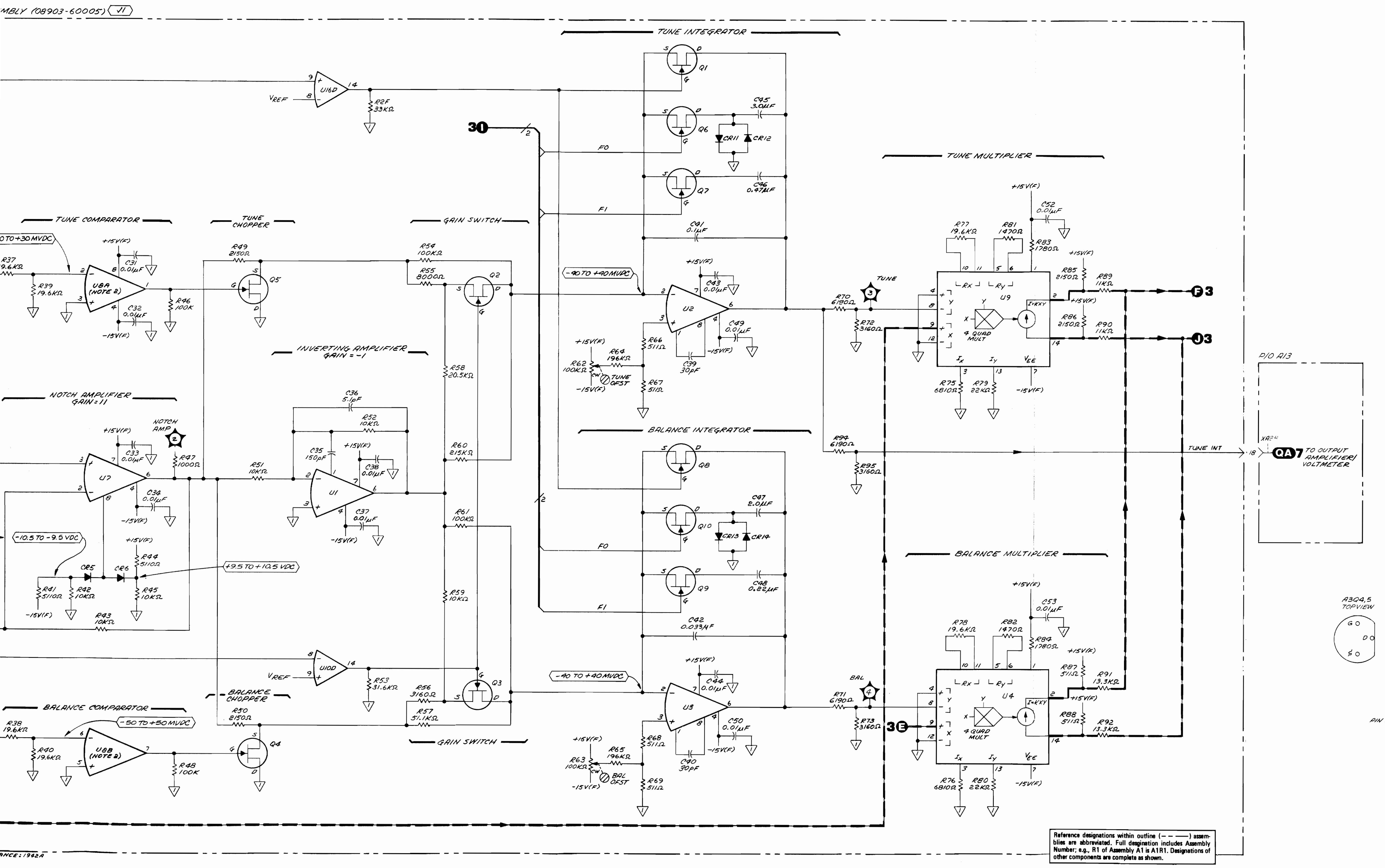


Figure 8-60. P/O A3 Notch Filter Assembly Component Locations (Tune and Balance Circuits)



P/O A13 POWER SUPPLY AND MOTHER BOARD ASSEMBLY (08903-60020)
P/O A3 NOTCH FILTER ASSEMBLY (08903-60005) J1
FROM LATCH 12 NA
P/O XA3B
5 NO NOFT
U16D
VREF
R2F 33KΩ
3I
F0
F1
TUNE INTEGRAT
Q1 Q6 Q7 Q8 Q10 Q9
C41 0.1μF
C42 0.033μF
TUNE COMPARATOR
-30 TO +30 MVDC
3H
R37 19.6KΩ
R39 19.6KΩ
U8A (NOTE 2)
+15V(F)
C31 0.01μF
C32 0.01μF
-15V(F)
R46 100K
TUNE CHOPPER
R49 2150Ω
Q5
GAIN SWITCH
R54 100KΩ
R55 8000Ω
Q2
-40 TO +40 MVDC
U2
C43 0.01μF
R66 511Ω
R67 511Ω
R62 100KΩ
R64 196KΩ
TUNE OFST
C39 30pF
INVERTING AMPLIFIER GAIN = -1
R58 20.5KΩ
C36 5.1pF
R52 10KΩ
C35 150pF
C38 0.01μF
U1
C37 0.01μF
R60 215KΩ
R61 100KΩ
R59 10KΩ
NOTCH AMPLIFIER GAIN = 11
NOTCH AMP 2
R47 1000Ω
R51 10KΩ
FROM OUTPUT AMPLIFIER 5 OA
17
C29 10μF
R35 10KΩ
U7
C33 0.01μF
C34 0.01μF
-10 TO +10MV
-10.5 TO -9.5 VDC
+9.5 TO +10.5 VDC
CR5 CR6
R41 5110Ω
R42 10KΩ
R44 5110Ω
R45 10KΩ
R43 10KΩ
C30 100μF
R36 1000Ω
BALANCE INTEGRA
FROM LATCH 12 PA
P/O XA3A
8 OU AMP1
U10D
R53 31.6KΩ
R56 3160Ω
R57 51.1KΩ
Q3
BALANCE CHOPPER
R50 2150Ω
Q4
BALANCE COMPARATOR
-50 TO +50 MVDC
3G
R38 19.6KΩ
R40 19.6KΩ
U8B (NOTE 2)
R48 100K
U3
C44 0.01μF
R68 511Ω
R69 511Ω
R63 100KΩ
R65 196KΩ
BAL OFST
C40 30pF
3A +15V(F)
3B VREF
3C
3D -15V(F)
8903A NOTCH FINE TUNE AND BALANCE : 1942A



Reference designations within outline (— — —) assemblies are abbreviated. Full designation includes Assembly Number; e.g., R1 of Assembly A1 is A1R1. Designations of other components are complete as shown.

4
P/O A3

NOTES
1. SEE TABLE 8-7 SCHEMATIC DIAGRAM NOTES.
2. OPEN COLLECTOR OUTPUT.

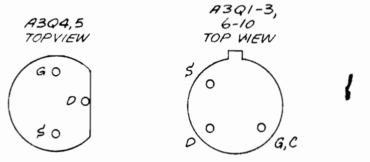
REFERENCE DESIGNATIONS

A3	A13
C29-53 CR5,6,11-14 Q1-10 R35-92,94,95 TP2-4 U1-4,7-10,16	XA3A,B

NOT ASSIGNED: A3C51, R74

TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATIONS	PART NUMBERS
Q1-3,6-10	1855-0414
Q4,5	1855-0091
U1	1826-0059
U2,3	1826-0025
U4,9	1826-0014
U7	1826-0109
U8	1826-0412
U10,16	1826-0138



A3R2 TOP VIEW

PIN NO.	1	2	3	4	5	6	7	8
	GND	A	B	C	D	E	F	G

Figure 8-61. Notch Filter—Tune and Balance Circuits Schematic Diagram

SERVICE SHEET 5 — OUTPUT AMPLIFIER/VOLTMETER — OUTPUT AMPLIFIER (P/O A4, A12)

TROUBLESHOOTING HELP

- Block Diagram ....Service Sheet BD2

PRINCIPLES OF OPERATION

General

This portion of the Output Amplifier/Voltmeter (A4) contains the output amplifier circuitry. The output from the Notch Filter is amplified, attenuated, and filtered as necessary to obtain a proper output reading by the Output RMS (Avg) Detector (see Service Sheet 6). The ac output of the amplifier is available at the rear-panel MONITOR output jack.

Attenuators and Amplifiers

Attenuators 1 and 2 can each be set for an attenuation of 0 or 20 dB. They are switched together. The attenuator control line, OU AMP1, switches in the 0 dB path of Attenuators 1 and 2 indirectly through U21D, which acts as an isolating switch and a logic inverter. When the control input (F4) to U21D is high, U21D is off; F1 of U21A and F3 of U7C are pulled to ground via R11, and the respective switches are enabled. When F4 of U21D is low, U21D is on; resistors R2, R5, and R11 form a voltage divider that applies a logical high to F1 of U21A and F3 of U7C, and the respective switches are disabled.

Amplifier 1 has a fixed gain of 5. Amplifiers 3 and 4 each have a fixed gain of 10. The Output Clamp in Amplifiers 3 and 4 accesses the driver stage of the respective IC and prevents the output from exceeding +12 or −12V. The output from Amplifier 1 drives the Low-Pass Filters and the Notch Filter tune and balance circuitry (see Service Sheet 4). Amplifier 4 drives the MONITOR output jack and is protected against the application of reverse voltage by R53 (which acts as a fuse), CR8, and CR9. A12L1 and C1 form an RFI filter.

Filters

The three Low-Pass Filters are 30, 80, and 750 kHz, three-pole, active Butterworth filters. Passband gain of each filter is 2. The active element of the filter, U8, has an Output Clamp similar to U6 and U13. The filters are switched via U9.

The two High-Pass Filters are respectively a 0.3 Hz, single-pole, passive filter and a 13 Hz, three-pole, active filter. Switching is via K1. CR3 suppresses the inductive transient created by the coil of K1 when the current is interrupted.

TROUBLESHOOTING

General

Procedures for checking the Output Amplifier/Voltmeter Assembly are given below. The circuits or points to check are marked on the schematic diagram by a hexagon with a check mark and a number inside, e.g., ⟨√3⟩. In addition, any points outside the labeled circuit area that must be checked are also identified. Fixed signals are shown on the schematic also inside a hexagon, e.g., ⟨+1.9 to +2.1 Vdc⟩. Extend the board assembly where necessary to make measurements. These procedures assume that the source is working properly.

Equipment

Oscilloscope ....HP 1740A

⟨√1⟩ Attenuators, Amplifiers, and Low-Pass Filters Check

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the INPUT and OUTPUT switches to ground. Key in AMPTD 100 mV. Key in 1.11 SPCL to set the input gain to 0 dB. Connect the HIGH OUTPUT to the HIGH INPUT.

2. Connect an high-impedance, ac coupled oscilloscope to A3TP7 (OUT). Increment the Audio Analyzer's SOURCE amplitude for exactly 300 mVpp on the oscilloscope.

Hint: The amplitude at A3TP7 before adjustment should be between 260 and 300 mVpp. (The period should be approximately 1 ms.) If the signal is faulty, see Service Sheet 3 and check the Notch Filter.

3. Connect the oscilloscope to A4TP8 (AMP 1). On the Audio Analyzer, key in the Special Functions listed in Table 8-44. For each setting, the amplitude of the signal observed on the oscilloscope should be within the limits indicated. If the signal is faulty, also check the control signals indicated.

Table 8-44. Voltage Level (mVpp) at A4TP8, Special Functions 3.N

Special Function	Level at A4TP8 (mVpp)	Level (TTL) at U21 Pin		
		1	8	16
3.1	140 to 160	H	L	L
3.3	1400 to 1600	L	H	H

Hint: Amplifier 1 should have a gain of 5.

4. Connect the oscilloscope to A4TP6 (AMP 2). On the Audio Analyzer, set the LOW PASS FILTER to 80 kHz, 30 kHz, and all off. For each setting the waveform should have an amplitude between 2.7 and 3.3 Vpp.

Hint: The control signals are as shown in Table 8-45.

Table 8-45. TTL Levels at A4U9

LOW PASS FILTER On	Level (TTL) at U9 Pin		
	1	8	9
80 kHz	H	L	H
30 kHz	H	H	L
None	L	H	H

5. On th
LOW PAS
should be

Hint: See

6. On th
80 kHz. R
of 1.2 Vpp

7. Conne
should be

Hint: Pin
high. Am

8. On th
be betwee

Hint: Pin
low.

9. Conne
should be

Hint: Pin
low. The
gain of 1.

10. On t
be betwee

Hint: Pin
high.

11. On t
57.140 SP
should be

Hint: Pin
shorted.

LIFIER/VOLTMETER —

.......Service Sheet BD2

Voltmeter (A4) contains
ut from the Notch Filter
cessary to obtain a proper
vg) Detector (see Service
available at the rear-panel

attenuation of 0 or 20 dB.
or control line, OU AMP1,
1 and 2 indirectly through
and a logic inverter. When
21D is off; F1 of U21A and
nd the respective switches
1D is on; resistors R2, R5,
ies a logical high to F1 of
switches are disabled.

fiers 3 and 4 each have a
mplifiers 3 and 4 accesses
prevents the output from
n Amplifier 1 drives the
une and balance circuitry
he MONITOR output jack
of reverse voltage by R53
12L1 and C1 form an RFI

750 kHz, three-pole, active
ach filter is 2. The active
Clamp similar to U6 and

ely a 0.3 Hz, single-pole,
ive filter. Switching is via
nt created by the coil of K1

ifier/Voltmeter Assembly
check are marked on the
check mark and a number
outside the labeled circuit
ntified. Fixed signals are

shown on the schematic also inside a hexagon, e.g., ⟨+1.9 to +2.1 Vdc⟩. Extend the board assembly where necessary to make measurements. These procedures assume that the source is working properly.

Equipment

Oscilloscope ....HP 1740A

⟨√1⟩ Attenuators, Amplifiers, and Low-Pass Filters Check

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the INPUT and OUTPUT switches to ground. Key in AMPTD 100 mV. Key in 1.11 SPCL to set the input gain to 0 dB. Connect the HIGH OUTPUT to the HIGH INPUT.

2. Connect an high-impedance, ac coupled oscilloscope to A3TP7 (OUT). Increment the Audio Analyzer's SOURCE amplitude for exactly 300 mVpp on the oscilloscope.

Hint: The amplitude at A3TP7 before adjustment should be between 260 and 300 mVpp. (The period should be approximately 1 ms.) If the signal is faulty, see Service Sheet 3 and check the Notch Filter.

3. Connect the oscilloscope to A4TP8 (AMP 1). On the Audio Analyzer, key in the Special Functions listed in Table 8-44. For each setting, the amplitude of the signal observed on the oscilloscope should be within the limits indicated. If the signal is faulty, also check the control signals indicated.

Table 8-44. Voltage Level (mVpp) at A4TP8, Special Functions 3.N

Special Function	Level at A4TP8 (mVpp)	Level (TTL) at U21 Pin		
		1	8	16
3.1	140 to 160	H	L	L
3.3	1400 to 1600	L	H	H

Hint: Amplifier 1 should have a gain of 5.

4. Connect the oscilloscope to A4TP6 (AMP 2). On the Audio Analyzer, set the LOW PASS FILTER to 80 kHz, 30 kHz, and all off. For each setting the waveform should have an amplitude between 2.7 and 3.3 Vpp.

Hint: The control signals are as shown in Table 8-45.

Table 8-45. TTL Levels at A4U9

LOW PASS FILTER On	Level (TTL) at U9 Pin		
	1	8	9
80 kHz	H	L	H
30 kHz	H	H	L
None	L	H	H

5. On the Audio Analyzer, key in the SOURCE frequency and LOW PASS FILTER listed below. For each setting, the waveform should be within the limits indicated in Table 8-46.

Table 8-46. Voltage Limits (Vpp) at A4TP6

SOURCE Frequency (kHz)	LOW PASS FILTER On	Level at A4TP6 (Vpp)
100	None	2.5 to 3.3
80	80 kHz	1.7 to 2.6
30	30 kHz	1.7 to 2.6

Hint: See the hint for step 4.

6. On the Audio Analyzer, key in FREQ 1 kHz. Set LP FILTER to 80 kHz. Reduce the SOURCE amplitude for a waveform amplitude of 1.2 Vpp.

7. Connect the oscilloscope to A4TP5 (AMP 3). The waveform should be between 11.5 and 12.5 Vpp.

Hint: Pin 9 of U7 should be a TTL low. Pin 1 of U7 should be a TTL high. Amplifier 3 should have a gain of 10.

8. On the Audio Analyzer, key in 3.1 SPCL. The waveform should be between 110 and 130 mVpp.

Hint: Pin 9 of U7 should be a TTL high. Pin 1 of U7 should be a TTL low.

9. Connect the oscilloscope to A4TP4 (AMP 4). The waveform should be between 110 and 130 mVpp.

Hint: Pin 8 of U7 should be a TTL high. Pin 16 of U7 should be a TTL low. The Buffer (U14B) and High-Pass Filters should each have a gain of 1. Amplifier 4 should have a gain of 10.

10. On the Audio Analyzer, key in 3.2 SPCL. The waveform should be between 1.1 and 1.3 Vpp.

Hint: Pin 8 of U7 should be a TTL low. Pin 16 of U7 should be a TTL high.

11. On the Audio Analyzer, key in 55.0 SPCL, 56.15 SPCL, and 57.140 SPCL to set the SOURCE frequency to 13 Hz. The waveform should be between 1.1 and 1.3 Vpp.

Hint: Pin 1 of K1 should be a TTL low. Pins 3 and 4 of K1 should be shorted.

12. On the Audio Analyzer, key in 0.435 SPCL to insert the 13 Hz High-Pass Filter (U14A and associated components). The waveform should be between 0.7 and 1.0 Vpp.

Hint: Pin 1 of K1 should be a TTL high. Pins 3 and 5 of K1 should be shorted. The waveform at pin 1 of U14A should be between 80 and 130 mVpp.

P/O A12 ASSEMBLY

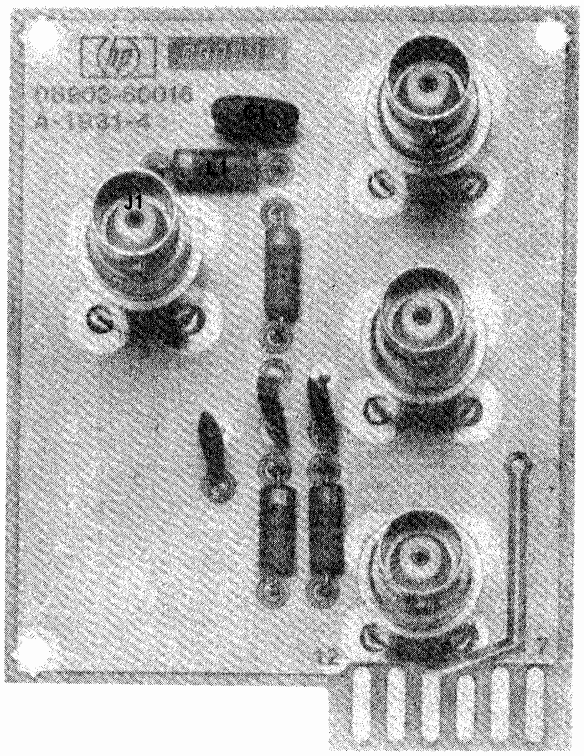


Figure 8-62. P/O A12 Connector/Filter Assembly Component Locations (Output Amplifier)

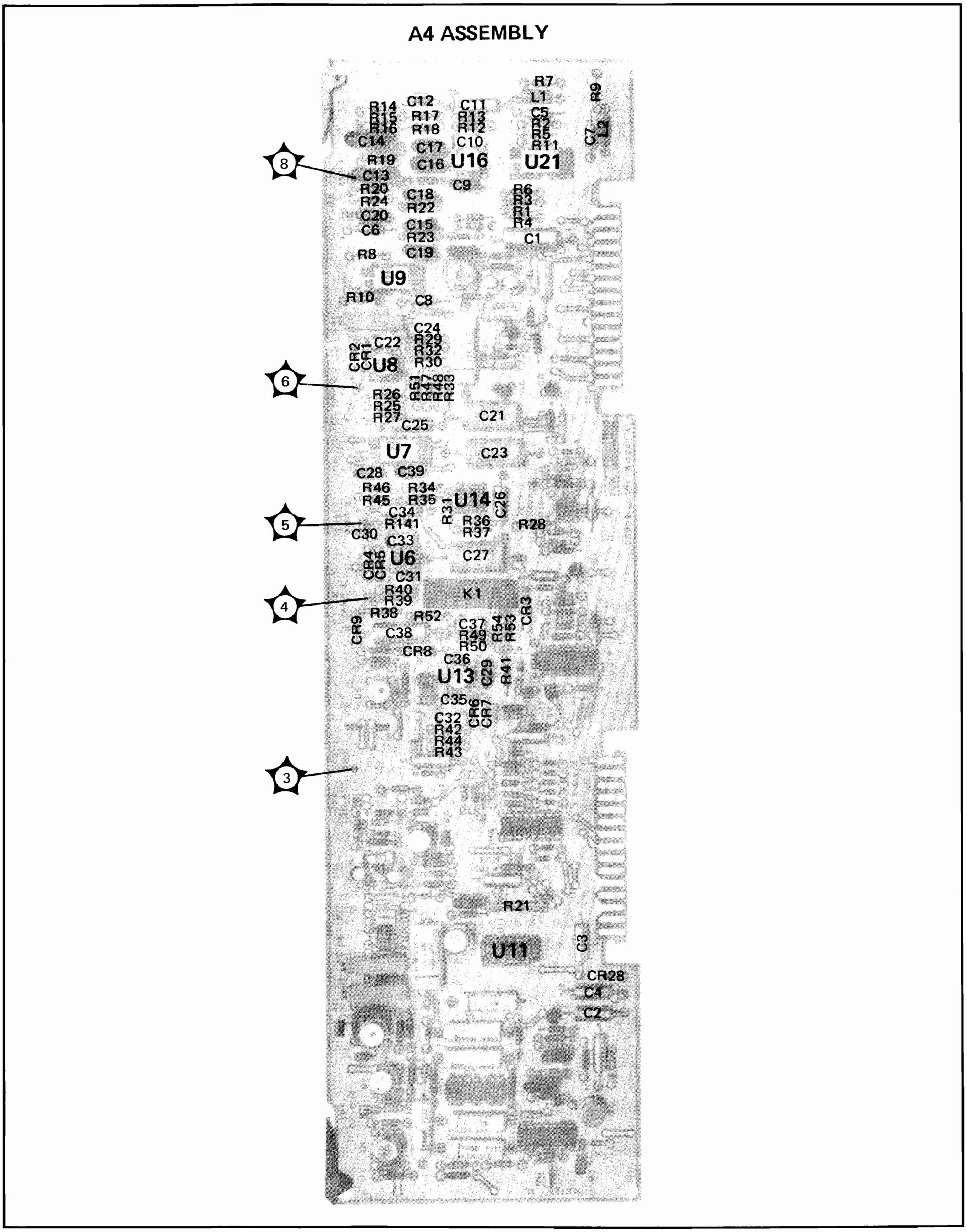
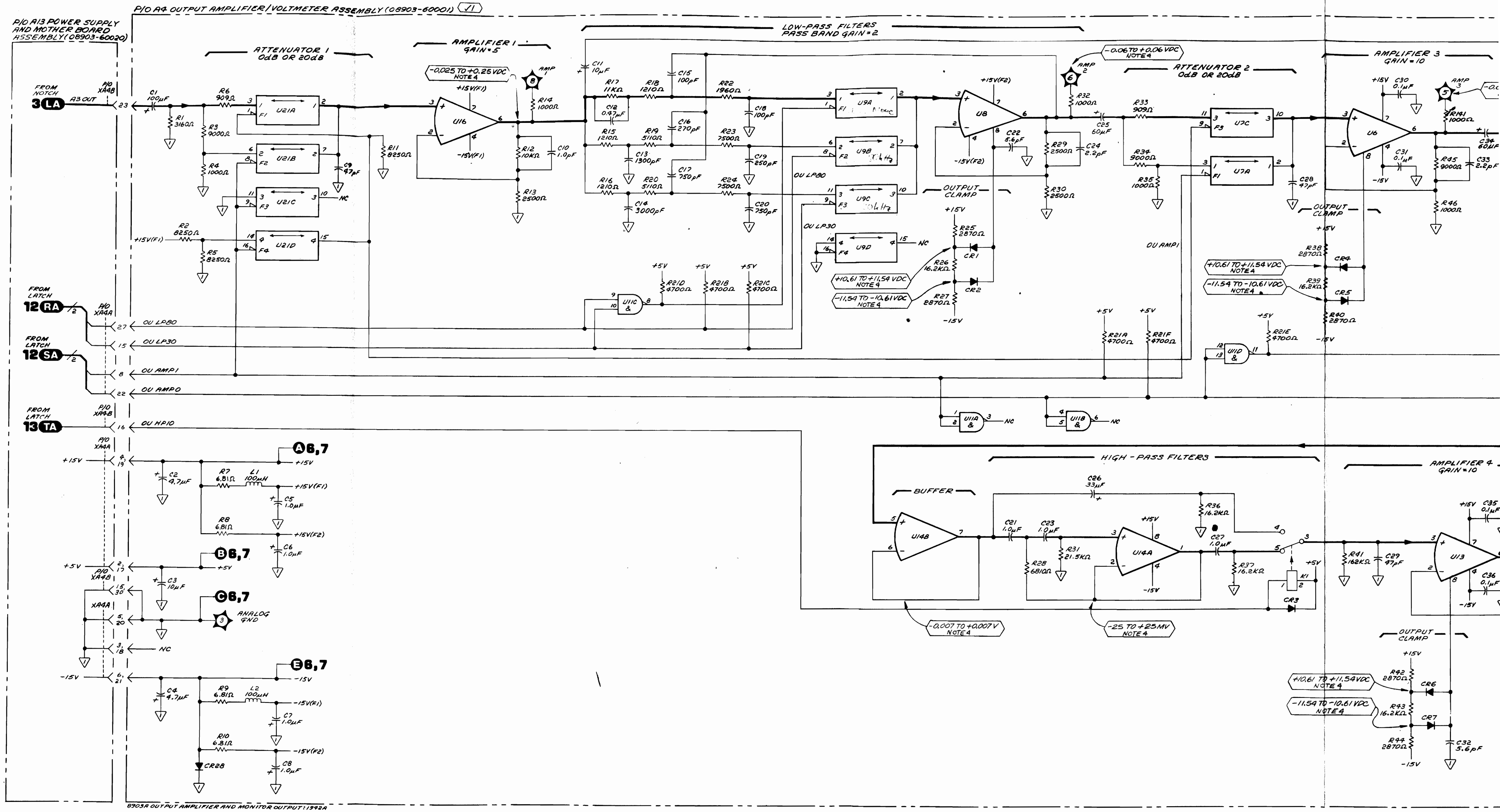
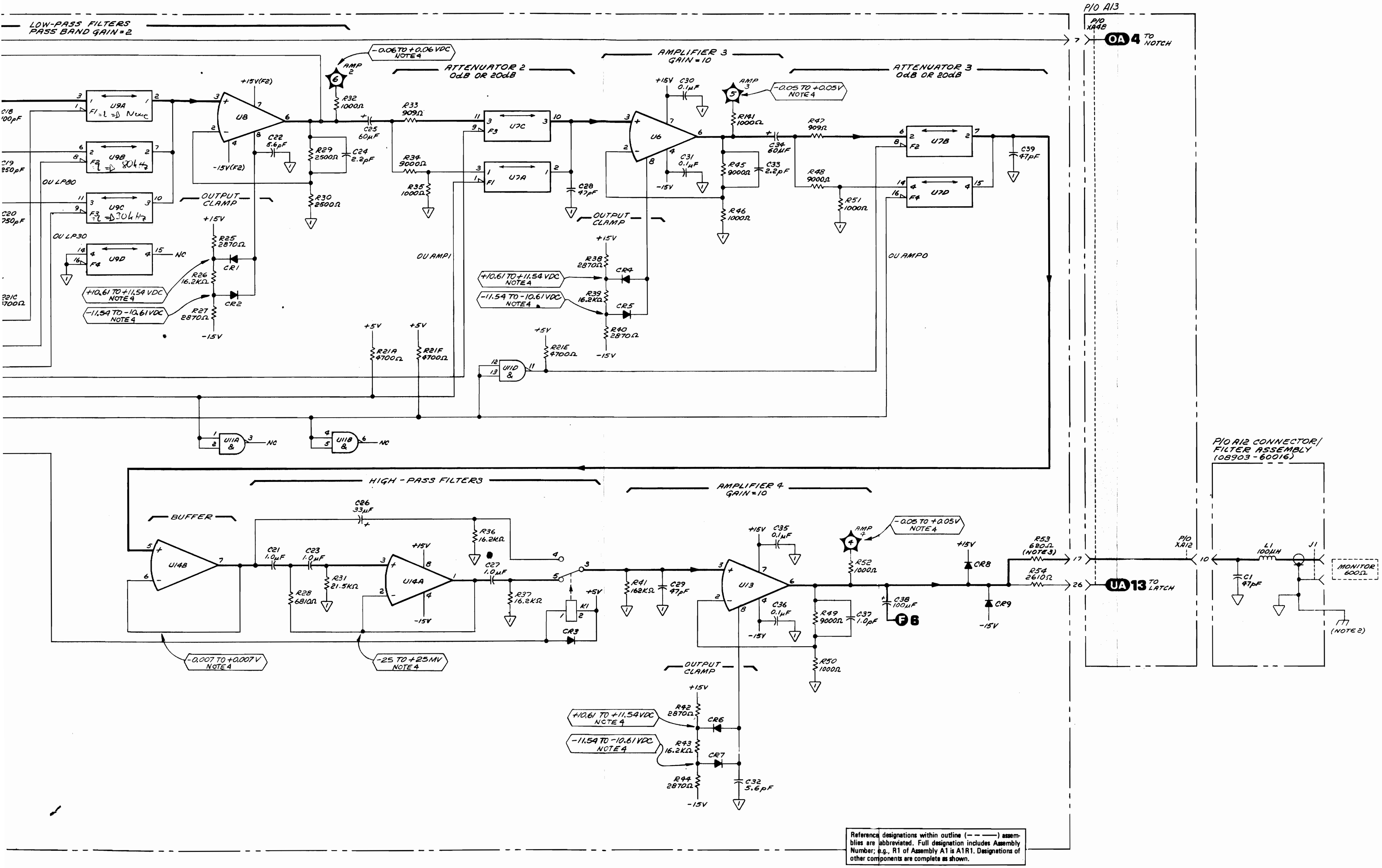


Figure 8-63. P/O A4 Output Amplifier/Voltmeter Assembly Component Locations (Output Amplifier)


P/O A4 OUTPUT AMPLIFIER/VOLTMETER ASSEMBLY (08903-60001)
P/O A13 POWER SUPPLY AND MOTHER BOARD ASSEMBLY (08903-60020)
ATTENUATOR 1 0dB OR 20dB
AMPLIFIER 1 GAIN = 5
LOW-PASS FILTERS PASS BAND GAIN = 2
ATTENUATOR 2 0dB OR 20dB
AMPLIFIER 3 GAIN = 10
HIGH-PASS FILTERS
BUFFER
AMPLIFIER 4 GAIN = 10
OUTPUT CLAMP
FROM NOTCH
3 LA
A3 OUT
P/O XA4B
23
C1 100μF
R1 3160Ω
R6 909Ω
R3 9000Ω
R4 1000Ω
R2 8250Ω
R5 8250Ω
+15V(F1)
U21A
U21B
U21C
U21D
F1
F2
F3
F4
NC
C9 47pF
R11 8250Ω
-0.025 TO +0.25 VDC NOTE 4
+15V(F1)
-15V(F1)
U16
8
AMP 1
R14 1000Ω
R12 10kΩ
C10 1.0pF
R13 2500Ω
C11 10μF
R17 11kΩ
R18 1210Ω
C12 0.47μF
C15 100pF
R22 1960Ω
C16 270pF
C18 100pF
R15 1210Ω
R19 5110Ω
R23 7500Ω
C13 1300pF
C19 250pF
C17 750pF
R16 1210Ω
R20 5110Ω
R24 7500Ω
C14 3000pF
C20 750pF
U9A
U9B
U9C
U9D
OU LP80
OU LP30
+15V(F2)
-15V(F2)
U8
C22 5.6pF
R29 2500Ω
C24 2.2pF
R30 2500Ω
6
AMP 2
R32 1000Ω
-0.06 TO +0.06 VDC NOTE 4
C25 60μF
R33 909Ω
R34 9000Ω
R35 1000Ω
U7C
U7A
C28 47pF
+15V
R25 2870Ω
CR1
R26 16.2kΩ
CR2
R27 2870Ω
-15V
+10.61 TO +11.54 VDC NOTE 4
-11.54 TO -10.61 VDC NOTE 4
+5V
R21D 4700Ω
R21B 4700Ω
R21C 4700Ω
U11C &
OU AMP1
R21A 4700Ω
R21F 4700Ω
R21E 4700Ω
U11D &
U11A &
U11B &
R38 2870Ω
CR4
R39 16.2kΩ
CR5
R40 2870Ω
C30 0.1μF
5
AMP 3
R141 1000Ω
U6
C31 0.1μF
C34 60μF
R45 9000Ω
C33 2.2pF
R46 1000Ω
FROM LATCH
12 RA
P/O XA4A
27
15
OU LP80
OU LP30
FROM LATCH
12 SA
8
22
OU AMP1
OU AMP0
FROM LATCH
13 TA
P/O XA4B
16
OU HP10
P/O XA4A
4, 19
+15V
C2 4.7μF
R7 6.81Ω
L1 100μH
A 6,7
+15V
+15V(F1)
C5 1.0μF
R8 6.81Ω
+15V(F2)
C6 1.0μF
+5V
P/O XA4B
2, 17
B 6,7
C3 10μF
XA4A
15, 30
5, 20
C 6,7
3
ANALOG GND
3, 18
NC
-15V
6, 21
E 6,7
C4 4.7μF
R9 6.81Ω
L2 100μH
-15V(F1)
C7 1.0μF
R10 6.81Ω
-15V(F2)
CR28
C8 1.0μF
U14B
C26 33μF
R36 16.2kΩ
C21 1.0μF
C23 1.0μF
R28 6810Ω
R31 21.5kΩ
U14A
C27 1.0μF
R37 16.2kΩ
K1
CR3
R41 162kΩ
C29 47pF
U13
C35 0.1μF
C36 0.1μF
-0.007 TO +0.007V NOTE 4
-25 TO +25MV NOTE 4
R42 2870Ω
CR6
R43 16.2kΩ
CR7
R44 2870Ω
C32 5.6pF
8903A OUTPUT AMPLIFIER AND MONITOR OUTPUT:1942A



Reference designations within outline (— — —) assemblies are abbreviated. Full designation includes Assembly Number; e.g., R1 of Assembly A1 is A1R1. Designations of other components are complete as shown.

NOTES

1. SEE TABLE 8-7 SCHEMATIC DIAGRAM NOTES.
2. CHASSIS GROUND IS MADE BY MECHANICAL CONTACT OF CONNECTOR TO REAR PANEL.
3. A4R53 MOUNTED ~ 1/8 INCH OFF OF BOARD.
4. ALL VOLTAGES SHOWN ARE FOR NO INPUT, 1.11 SPCL AND 3.1 SPCL.

REFERENCE DESIGNATIONS

A4	A13
C1-39 CR1-9, 28 K1 L1, 2 R1-54, 141 TP3-6, 8 U6-9, 11, 13, 14, 16, 21	XA4A, B, 12
A12	
C1 J1 L1	

LOGIC LEVELS

	TTL
HIGH	>2V
LOW	<0.8V
< IS MORE NEG. THAN > IS MORE POS. THAN	
OPEN	HIGH
GROUND	LOW

INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATIONS	PART NUMBERS
U6, 8, 13	1826 - 0109
U7, 9, 21	1826 - 0582
U11	1820 - 1197
U14	1826 - 0547
U16	1826 - 0447

INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

REFERENCE DESIGNATIONS	PIN NUMBERS
U7	+15V - 13 -15V - 4 ▽ - 5
U9	+15V(F2) - 13 -15V(F2) - 4 ▽ - 5
U11	+5V - 14 ▽ 7
U21	+15V(F1) - 13 -15V(F1) - 4 ▽ - 5

A4R21
TOP VIEW

PIN NO.	1	2	3	4	5	6	7	8
	+5V	A	B	C	D	E	F	G

5
P/O A4,A12

Figure 8-64. Output Amplifier/Voltmeter—Output Amplifier Schematic Diagram

SERVICE SHEET 6 — OUTPUT AMPLIFIER/VOLTMETER — DETECTORS AND METER CIRCUITS (P/O A1, A4)

TROUBLESHOOTING HELP

- Block Diagram .... Service Sheet BD2
- Voltmeter Adjustment .... Paragraph 5-13
- SINAD Meter Adjustment .... Paragraph 5-14

PRINCIPLES OF OPERATION

General

This portion of the Output Amplifier/Voltmeter (A4) contains the Output RMS (Avg) Detector, Output Overload Detector, and SINAD meter circuitry.

Output RMS (Avg) Detector

The Output RMS (Avg) Detector converts the ac input signal into a dc voltage equal to the rms level of the input. The circuits convert the ac signal to its rms equivalent by a method called implicit conversion. This method is also used by the Input RMS Detector (A2U1) which is discussed on Service Sheet 2. The Output RMS (Avg) Detector performs the squaring and dividing by means of a log-antilog circuit.

Refer to Figure 8-65 which is a simplified diagram of the circuit. Since the log-antilog circuit cannot operate on a bi-directional signal, the input is full-wave rectified. Full-wave rectification is accomplished by half-wave rectifying (and inverting) the input then summing the rectified current with a current proportional to the input voltage but weighted by one half. U5, R55, R62, and CR11 perform the half-wave rectification. The rectified signal produces a current (I_1) in R71 which is summed with the current (I_2) in R70 at the inverting (–) input to U4. R70 is twice the resistance of R71.

U4, Q2A, and Q1A form the Log Amplifier. The full-wave rectified current ($I_3=I_1+I_2$) flows through transistors Q2A and Q1A and into the output of U4. (Q2A is a common-base stage; Q1A is configured as a diode.) The current (I_3) through Q2A and Q1A produces a voltage across each base-emitter junction proportional to the log of the current. The sum of the two voltages (V_1) is the sum of two nearly identical logarithms and is proportional to the log of the square of the current ($\log I_3^2$) and hence the log of the square of the input voltage ($\log V_{IN}^2$). (The identity used here is: $\log I + \log I = \log (I \times I) = \log I^2$.)

Now consider the operation of the Antilog Amplifier/Filter. The collector current (I_4) of Q1B is filtered by U3 and the associated resistors and capacitors (R90, R91, R92, R94, C53, and C56). The dc component of this current flows through R90, R91 and R92 and produces a voltage which, when buffered by U2, is the output (V_{OUT}) of the circuit. (The effects of R93 and R95 in the schematic are being momentarily ignored.) U3 also holds the collector of Q1B at ground potential to establish the offset of the output at 0V. The collector current (I_5) of Q2B is generated by the output voltage (V_{OUT}) which appears across R98. U12 holds the collector of Q2B and one end of R98 at ground potential.

The voltage across the base-emitter junctions of Q1B and Q2B is proportional to the log of their respective collector currents. The sum of the two voltages (V_1) is proportional to the log of the product of the two collector currents ($I_4 \times I_5$). Since the sum of the base-emitter voltages of Q1B and Q2B equals the sum of Q1A and Q2A, the products of the respective collector currents are equal ($I_3^2 = I_4 \times I_5$). Recalling that the dc component of I_4 produced the output voltage (V_{OUT}) and that the output voltage produced I_5, it is evident that the output voltage is proportional to the square root of

the product of I_4 and I_5 and thus is proportional to the input voltage (V_{IN}), which has been squared, filtered (to obtain the mean level), and the square root obtained.

Refer now to the schematic diagram, Figure 8-69. R143 and R144 are installed whenever the offset adjustment R85 has insufficient range. CR13 and CR16 protect the log and antilog transistors should voltages of opposite polarity be applied to them. CR14 provides an offset voltage in the collector of Q1B that matches the offset created by the base-emitter junction of Q2A in the collector of Q1A. R93 and R95 improve the response characteristics of the circuit to low frequency inputs while at the same time allow the circuit to respond rapidly to changes in input level. R91 permits fine adjustment of the gain of the circuit. R94 and C56 also form the first real pole in the Ripple Filter (see Service Sheet 7).

The jumpers (JP1, JP2, and JP3) permit the circuit to function as either a true rms detector (jumpers in position R) or as an average-responding detector (jumper in position A). The average-responding circuit bypasses the log and antilog processes and simply full-wave rectifies and filters the input. When the circuit is configured as an average-responding detector, diodes CR10 and CR11 should be reversed.

SINAD Meter Circuits

The SINAD meter displays the log of the Input RMS Detector minus the log of the Output RMS (Avg) Detector. The Input RMS Detector produces a current which flows through R57 and log transistor Q4A. The voltage developed across the base-emitter junction of Q4A is

proportional to the log of its collector current. Similarly, the Output RMS (Avg) Detector produces a current which flows through R56 and log transistor Q4B and develops a base-emitter voltage proportional to the log of its collector current. The voltage at the base of Q4A (with respect to ground) is equal to the difference between the base-emitter voltages of Q4A and Q4B. The feedback amplifier, U17C, amplifies this difference and produces the output. Note that the collectors and bases of both Q4A and Q4B are all biased near ground potential. Thermistor RT1 thermally compensates for the drift of the two log transistors.

The voltage from the SINAD Log Ratio Meter Amplifier is converted to a current by the Meter Transconductance Amplifier which drives the meter. CR15 protects the meter against reverse current. R83 and C51 add heavy filtering to the often noisy SINAD measurement signal.

The Meter Peg/Off Switch receives commands from the Controller via the Latch Assembly which enable, gently peg, or switch off the meter via the Meter Transconductance Amplifier, depending on the measurement being made and the SINAD measurement range. A low at the inverting (–) input of U19A or U19B switches the respective output FET (Q6 or Q5) on pulling the output connection to either ground or +2.4V.

Output Overload Detector

The Output Overload Detector compares the level from the Output RMS (Avg) Detector to a reference set by R60 and R61. If the level exceeds the reference, U19D switches FET Q7 on which resets the

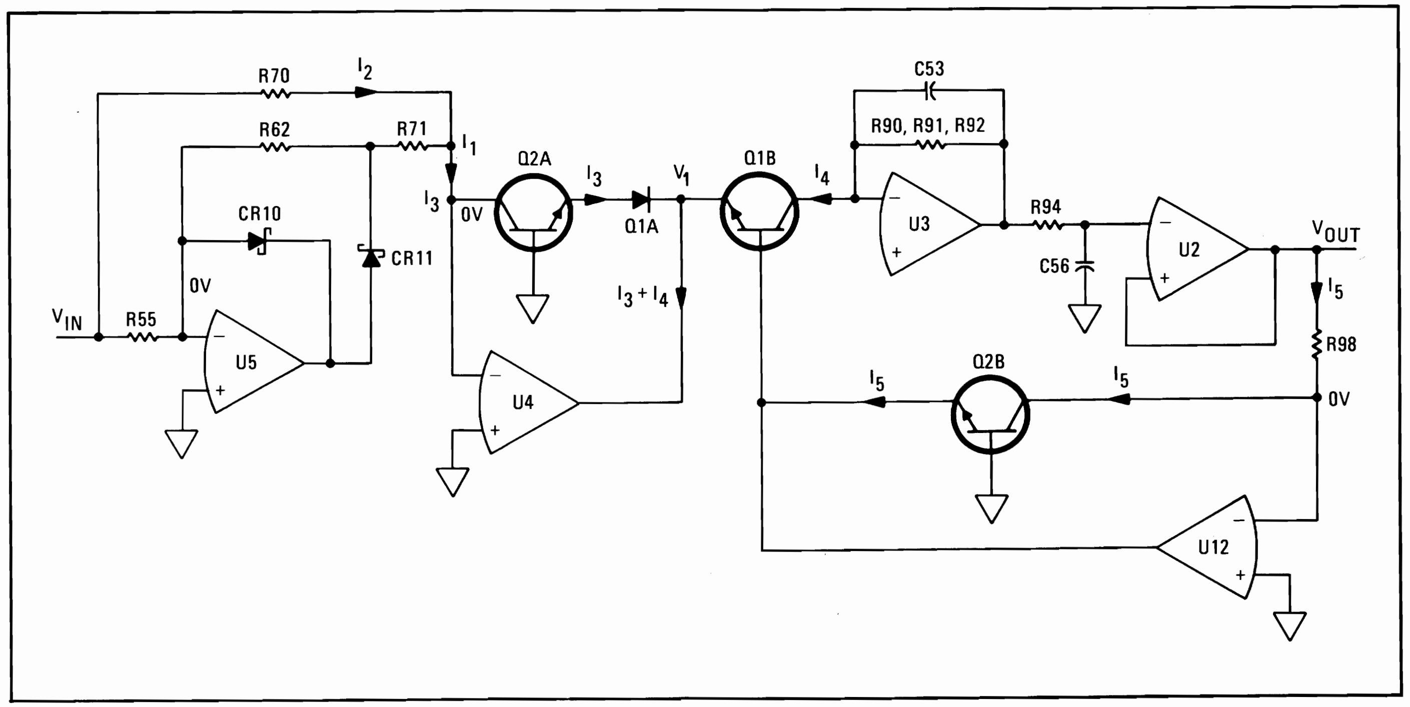


Figure 8-65. Simplified Diagram of Output RMS (Avg) Detector (in RMS Mode)

Overload
Output Ar

OUTPUT

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circuit is configured as an
R10 and CR11 should be

Input RMS Detector minus
r. The Input RMS Detector
57 and log transistor Q4A.
emitter junction of Q4A is

SERVICE SHEET 6 (Cont'd)

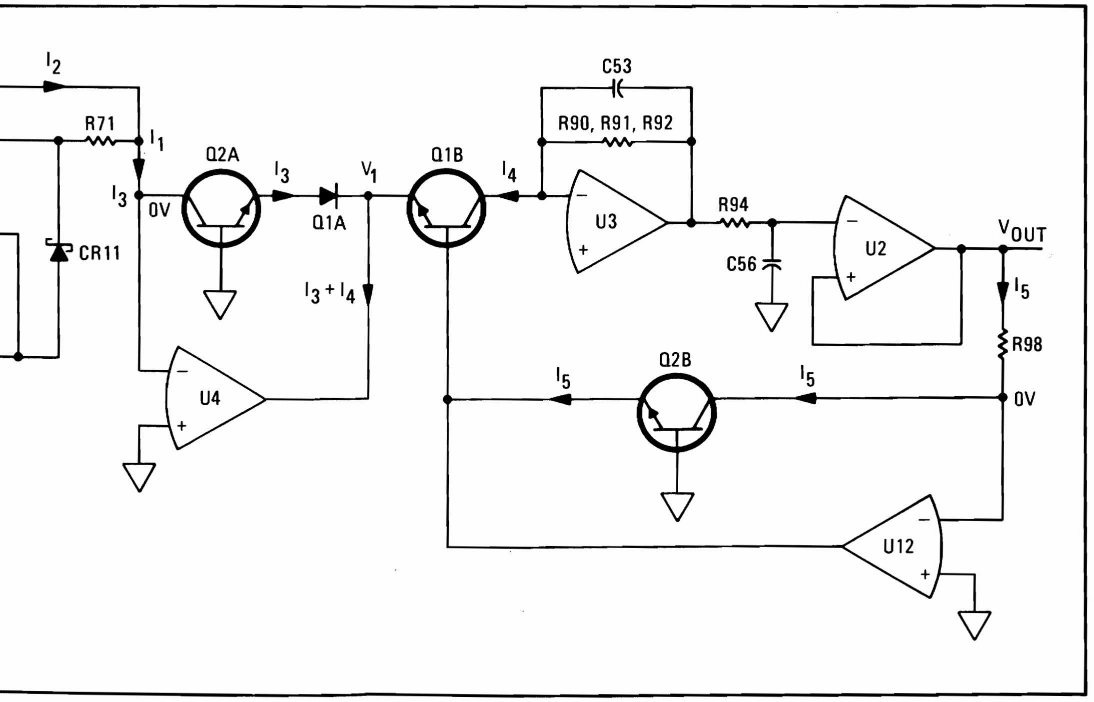
proportional to the log of its collector current. Similarly, the Output RMS (Avg) Detector produces a current which flows through R56 and log transistor Q4B and develops a base-emitter voltage proportional to the log of its collector current. The voltage at the base of Q4A (with respect to ground) is equal to the difference between the base-emitter voltages of Q4A and Q4B. The feedback amplifier, U17C, amplifies this difference and produces the output. Note that the collectors and bases of both Q4A and Q4B are all biased near ground potential. Thermistor RT1 thermally compensates for the drift of the two log transistors.

The voltage from the SINAD Log Ratio Meter Amplifier is converted to a current by the Meter Transconductance Amplifier which drives the meter. CR15 protects the meter against reverse current. R83 and C51 add heavy filtering to the often noisy SINAD measurement signal.

The Meter Peg/Off Switch receives commands from the Controller via the Latch Assembly which enable, gently peg, or switch off the meter via the Meter Transconductance Amplifier, depending on the measurement being made and the SINAD measurement range. A low at the inverting (−) input of U19A or U19B switches the respective output FET (Q6 or Q5) on pulling the output connection to either ground or +2.4V.

Output Overload Detector

The Output Overload Detector compares the level from the Output RMS (Avg) Detector to a reference set by R60 and R61. If the level exceeds the reference, U19D switches FET Q7 on which resets the Overload Flip-Flop (see Service Sheet 12) and reduces the gain of the Output Amplifier to 0 dB.



gure 8-65. Simplified Diagram of Output RMS (Avg) Detector (in RMS Mode)

SERVICE SHEET 6 (Cont'd)

OUTPUT DETECTOR ALTERATION (True RMS or Average)

The Output RMS (Avg) Detector of the Audio Analyzer can be configured to respond to either true rms or average level of the signal. In the average responding configuration, the voltmeter is rms calibrated for sinusoidal signals. The configuration from the factory is true rms. By altering three jumpers and reversing the polarity of two diodes, the detector can be converted from one configuration to the other. The procedure is as follows:

1. Remove JP1 and JP3 for average detection or add them for true rms detection. Common hookup wire will suffice for jumpers.

2. Move JP2 to position A for average detection or position R for true rms detection.

3. Reverse the polarity of diodes CR10 and CR11. (The diode polarity agrees with the schematic and indicator on the circuit board for true rms detection only.) Avoid the use of excessive heat when soldering or unsoldering the diodes.

4. Perform the Voltmeter Adjustment, paragraph 5-13.

TROUBLESHOOTING

General

Procedures for checking the Output Amplifier/Voltmeter Assembly are given below. The circuits or points to check are marked on the schematic diagram by a hexagon with a check mark and a number inside, e.g., ⟨√3⟩. In addition, any points outside the labeled circuit area that must be checked are also identified. Fixed signals are shown on the schematic also inside a hexagon, e.g., ⟨+1.9 to +2.1 Vdc⟩. Extend the board assembly where necessary to make measurements. These procedures assume that the source is working properly.

Equipment

Digital Voltmeter	HP 3455A
Oscilloscope	HP 1740A

⟨√1⟩ Output RMS (Avg) Detector General Check

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the INPUT and OUTPUT switches to ground. Key in AMPTD 3V. Key in 1.11 SPCL to set the input gain to 0 dB. Key in 3.1 SPCL to set the output gain to 0 dB. Connect the HIGH OUTPUT to the HIGH INPUT.

2. Connect a voltmeter to A4TP4 (AMP 4). Set the voltmeter to measure ac. Fine adjust the Audio Analyzer's SOURCE amplitude for 2.99 to 3.01 Vrms on the voltmeter.

Hint: The amplitude at A4TP4 before adjustment should be between 2.85 and 3.15 Vrms. If the signal is faulty, see Service Sheet 5 and check the Output Amplifier circuitry.

3. Connect the voltmeter to A4TP1 (DC OUT). Set the voltmeter to measure dc. The level on the voltmeter should be between +2.94 and +3.06 Vdc.

Hint: If the signal amplitude is only slightly out of limits, perform the Voltmeter Adjustment, paragraph 5-13; if greatly out of limits, perform ⟨√2⟩ Full-Wave Rectifier Check and ⟨√3⟩ Log Amplifier and Antilog Amplifier/Filter Check (True RMS Only) or ⟨√4⟩) Antilog Amplifier/ Filter Check (Average Only).

4. Reconnect the voltmeter to A4TP4. Set the voltmeter to measure ac. On the Audio Analyzer, reduce the SOURCE amplitude for a reading between 299 and 301 mVrms on the voltmeter.

5. Reconnect the voltmeter to A4TP1. Set the voltmeter to measure dc. The level on the voltmeter should be between +294 and +306 mVdc.

Hint: If the signal is only slightly out of limits, perform the Voltmeter Adjustment, paragraph 5-13; if within limits, the detector is functioning properly under the current test conditions.

⟨√2⟩ Full-Wave Rectifier Check

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the INPUT and OUTPUT switches to ground. Key in AMPTD 3V. Key in 1.11 SPCL to set the input gain to 0 dB. Key in 3.1 SPCL to set the output gain to 0 dB. Connect the HIGH OUTPUT to the HIGH INPUT.

2. Connect a high-impedance, dc coupled oscilloscope to A4TP4 (AMP 4). On the Audio Analyzer, fine adjust the SOURCE amplitude for 8.5 Vpp on the oscilloscope.

Hint: The amplitude at A4TP4 before adjustment should be approximately 8.5 Vpp. If the signal is faulty, see Service Sheet 5 and check the Output Amplifier circuitry.

3. Connect the oscilloscope to pin 6 of U5. The waveform should be as shown in Figure 8-66. (Note: Excessive input capacitance of the oscilloscope may cause oscillation. Use a divide-by-ten probe.)

⟨√3⟩ Log Amplifier and Antilog Amplifier/ Filter Check (True RMS Only)

1. On the Audio Analyzer, switch LINE to OFF. Remove JP1. Connect a 100 kΩ resistor between pin 7 of U5 (+15V) and pin 2 of U4. This simulates the average current into the Log Amplifier that would be generated by a 3 Vrms signal.

SERVICE SHEET 6 (Cont'd)

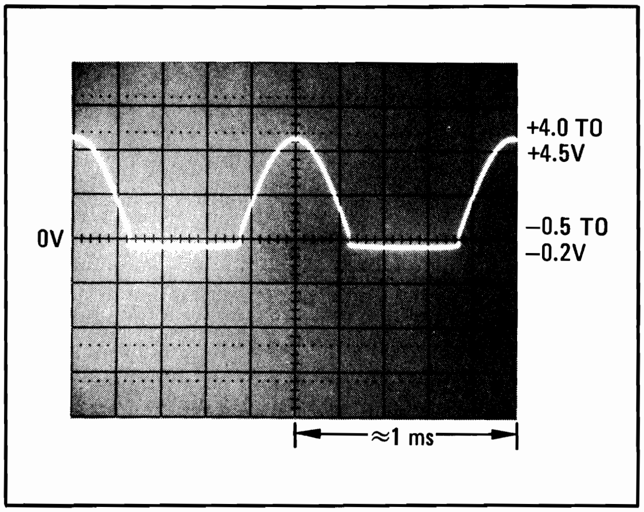


Figure 8-66. Full-Wave Rectifier Check Waveform

2. On the Audio Analyzer, switch LINE to ON. Connect the voltmeter to A4TP2 (LOG AMP). Set the voltmeter to measure dc. The voltmeter should read between −1.26 and −1.21 Vdc. (This voltage is valid only at room temperature.)

3. Connect the voltmeter to pin 6 of U4. The voltage should be approximately −2.4 Vdc.

Hint: If the voltage is closer to −2.0 Vdc, the Log Amplifier is operating properly but no current is flowing in the emitter of Q1B; the fault is in the Antilog Amplifier/Filter. If the voltage is closer to −3.0 Vdc, the Log Amplifier is operating properly but no current is flowing in the collector of Q1B; the fault is in the Antilog Amplifier/ Filter. (The base and emitter current of Q1B is being supplied by U12 which is clamped to +0.5 Vdc.)

4. On the Audio Analyzer, switch LINE to OFF. Remove the resistor added in step 1. Remove JP2. Connect a 196 kΩ resistor between pin 4 of U5 (−15V) and pin 2 of U3. This simulates the average current into the Antilog Amplifier/Filter that would be generated by a 3 Vrms signal.

5. On the Audio Analyzer, switch LINE to ON. Connect the voltmeter to A4TP1 (DC OUT). The voltmeter should read between +2.9 and +3.3 Vdc.

Hint: Pin 6 of U3 should also be between +2.9 and +3.3 Vdc and read the same as A4TP1.

6. Connect the voltmeter to pin 6 of U12. The voltmeter should read between −2.5 to −2.0 Vdc.

Hint: The emitter of Q2B should be approximately −640 mVdc.

Hint: To this point, operation of the Antilog Amplifier/ Filter has been verified except for Q1B, CR14, and the filtering capability of the circuit.

7. On the Audio Analyzer, switch LINE to OFF. Remove the resistor of step 4 and reinstall JP1 and JP2 into their appropriate positions.

8. On the Audio Analyzer, switch LINE to ON. Key in AMPTD 3V and FREQ 20 Hz. Set the INPUT and OUTPUT switches to ground. Key in 1.11 SPCL to set the input gain to 0 dB. Key in 3.1 SPCL to set the output gain to 0 dB. Connect the HIGH OUTPUT to the HIGH INPUT.

9. Connect the voltmeter to A4TP4 (AMP 4). Set the voltmeter to measure ac. The voltmeter should read between 2.9 and 3.1 Vrms.

Hint: If the signal is faulty, see Service Sheet 5 and check the Output Amplifier circuitry.

10. Connect a high-impedance, ac coupled oscilloscope to pin 6 of U3. The waveform should be approximately 600 mVpp.

Hint: The dc level should be approximately +3 Vdc. If the signal is faulty (either ac or dc), perform the ⟨√2⟩ Full-Wave Rectifier Check.

11. Connect the oscilloscope to A4TP1 (DC OUT). The waveform should be approximately 90 mVpp.

⟨√4⟩ Antilog Amplifier/Filter Check (Average Only)

1. On the Audio Analyzer, switch LINE to OFF. Remove JP2. Connect a 100 kΩ resistor between pin 4 of U5 (−15V) and pin 2 of U3. This simulates the average current into the Antilog Amplifier/ Filter that would be generated by a signal of approximately 3.4 Vrms.

2. On the Audio Analyzer, switch LINE to ON. Connect a voltmeter to A4TP1 (DC OUT). Set the voltmeter to measure dc. The voltmeter should read between +3.1 and +3.6 Vdc.

Hint: Pin 6 of U3 should also read between +3.1 and +3.6 Vdc and read the same as A4TP1.

3. On the Audio Analyzer, switch LINE to OFF. Remove the resistor of step 1 and reinstall JP2 to its appropriate position.

SERVICE SHEET 6 (Cont'd)

4. On the Audio Analyzer, switch LINE to ON. Key in AMPTD 3V and FREQ 20 Hz. Set the INPUT and OUTPUT switches to ground. Key in 1.11 SPCL to set the input gain to 0 dB. Key in 3.1 SPCL to set the output gain to 0 dB. Connect the HIGH OUTPUT to the HIGH INPUT.

5. Connect the voltmeter to A4TP4 (AMP 4). Set the voltmeter to measure ac. The voltmeter should read between 2.9 and 3.1 Vrms.

Hint: If the signal is faulty, see Service Sheet 5 and check the Output Amplifier circuitry.

6. Connect a high-impedance, ac coupled oscilloscope to pin 6 of U3. The waveform should be approximately 700 mVpp.

Hint: The dc level should be approximately +3 Vdc. If the signal is faulty (either ac or dc), perform ⟨√2⟩ Full-Wave Rectifier Check.

7. Connect the oscilloscope to A4TP1 (DC OUT). The waveform should be approximately 110 mVpp.

⟨√5⟩ SINAD Meter Circuits Check

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the INPUT and OUTPUT switches to ground. Key in AMPTD 1V. Key in 1.11 SPCL to set the input gain to 0 dB. Key in 3.1 SPCL to set the output gain to 0 dB. Key in 45.1 SPCL to enable the SINAD meter. Press the PSOPH filter. Connect the HIGH OUTPUT to the HIGH INPUT.

2. Connect a dc voltmeter to A2TP2 (RMS). On the Audio Analyzer, fine adjust the SOURCE amplitude for a reading of +1.00 Vdc on the voltmeter.

Hint: The voltage at A2TP2 should read approximately 1 Vdc before adjustment. If it does not, see Service Sheet 2 and check the Input RMS Detector.

3. Connect the voltmeter to A4TP1 (DC OUT). On the Audio Analyzer, reduce the SOURCE frequency until the voltmeter reads between +245 and +255 mVdc.

Hint: The voltage at A4TP1 should read approximately +1 Vdc before adjustment. If it does not, perform ⟨√1⟩ Output RMS (Avg) Detector Check. If the voltage does not decrease when the frequency is tuned below 600 Hz, see Service Sheet 2 and check the Psophometric Filter.

4. Connect the voltmeter to pin 8 of U17C. The voltage should be between +650 and +700 mVdc.

Hint: The voltage at pins 3 and 5 of Q4 should be between −480 and −440 mVdc.

5. Connect the voltmeter to pin 5 of U17B. The voltage should be the same as in step 4 except that the loading of a 10 MΩ oscilloscope probe will cause the signal level to be 0.3% low. The SINAD meter should read between 11.5 and 12.5 dB.

Hint: The drains of Q5 and Q6 should read the same as pin 5 of U17B. Q5 and Q6 should be off. Pins 4 and 6 of U19 should be a TTL high.

Hint: If the meter reads only slightly out of limits, perform the SINAD Meter Adjustment, paragraph 5-14.

6. On the Audio Analyzer, key in 0.528 SPCL to switch the SINAD meter off. The voltage at pin 5 of U17B should read 0 to +10 mVdc. The SINAD meter should read 0.

Hint: Q6 should be on. Pin 4 of U19A should be a TTL low. Pin 6 of U19B should be a TTL high.

7. On the Audio Analyzer, key in 0.524 to peg the meter. The voltage at pin 5 of U17B should read between +1.5 and +2.5 Vdc. The SINAD meter should read slightly off full scale.

Hint: Q5 should be on. Pin 6 of U19B should be a TTL low. Pin 4 of U19A should be a TTL high.

⟨√6⟩ Overload Detector Check

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the INPUT and OUTPUT switches to ground. Key in AMPTD 4V. Key in 1.11 SPCL to set the input gain to 0 dB. Key in 3.1 SPCL to set the output gain to 0 dB. Connect the HIGH OUTPUT to the HIGH INPUT.

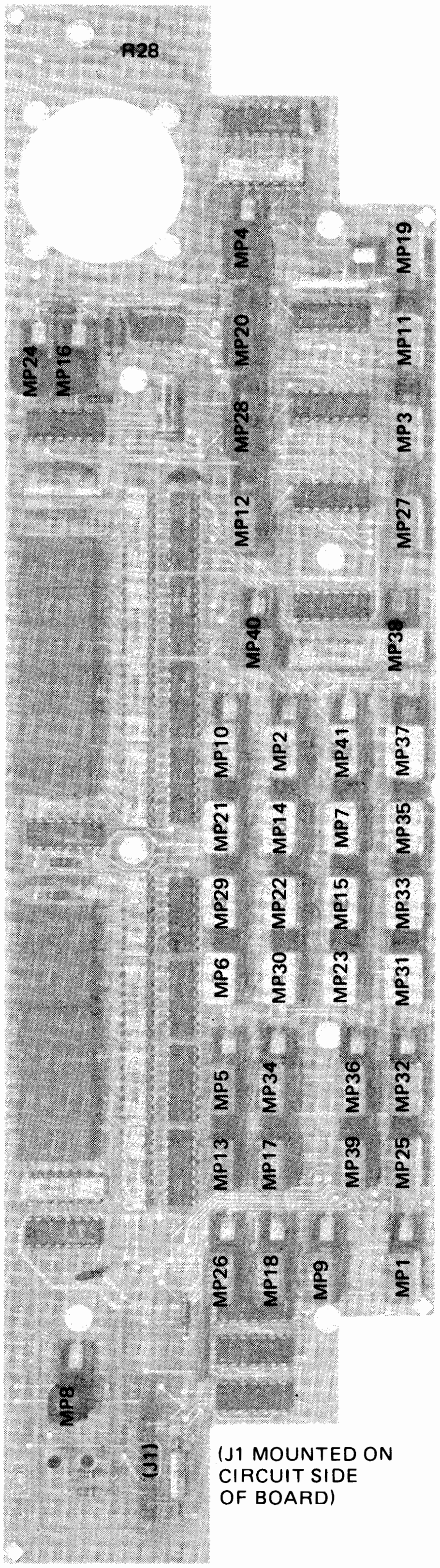
2. Connect a high-impedance, dc coupled oscilloscope to the drain of Q7. The level should be a TTL high.

Hint: Pin 13 of U19D should be between −15.2 and −14.7 Vdc.

3. On the Audio Analyzer, key in AMPTD 4.2 V. The level should be a TTL low.

Hint: Pin 13 of U19D should be between 0 and +200 mVdc

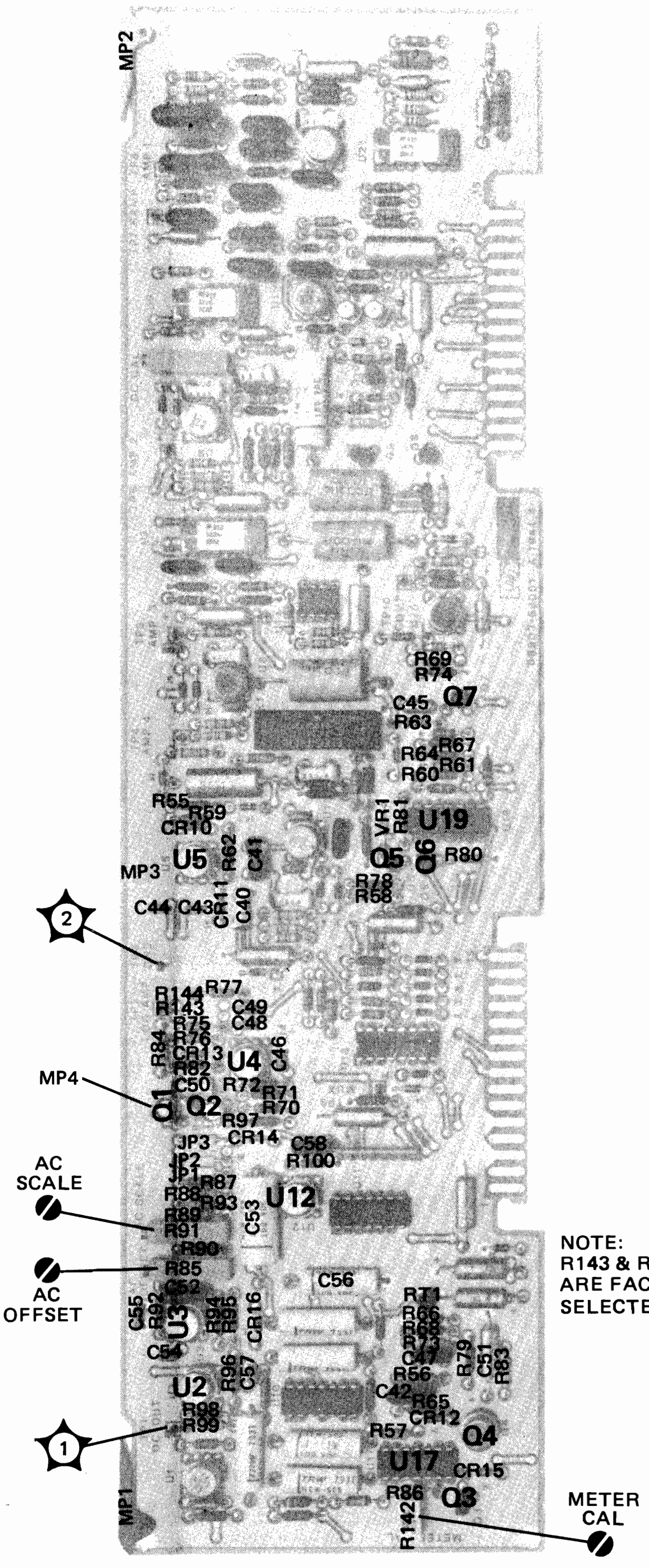
P/O A1 ASSEMBLY



(J1 MOUNTED ON
CIRCUIT SIDE
OF BOARD)

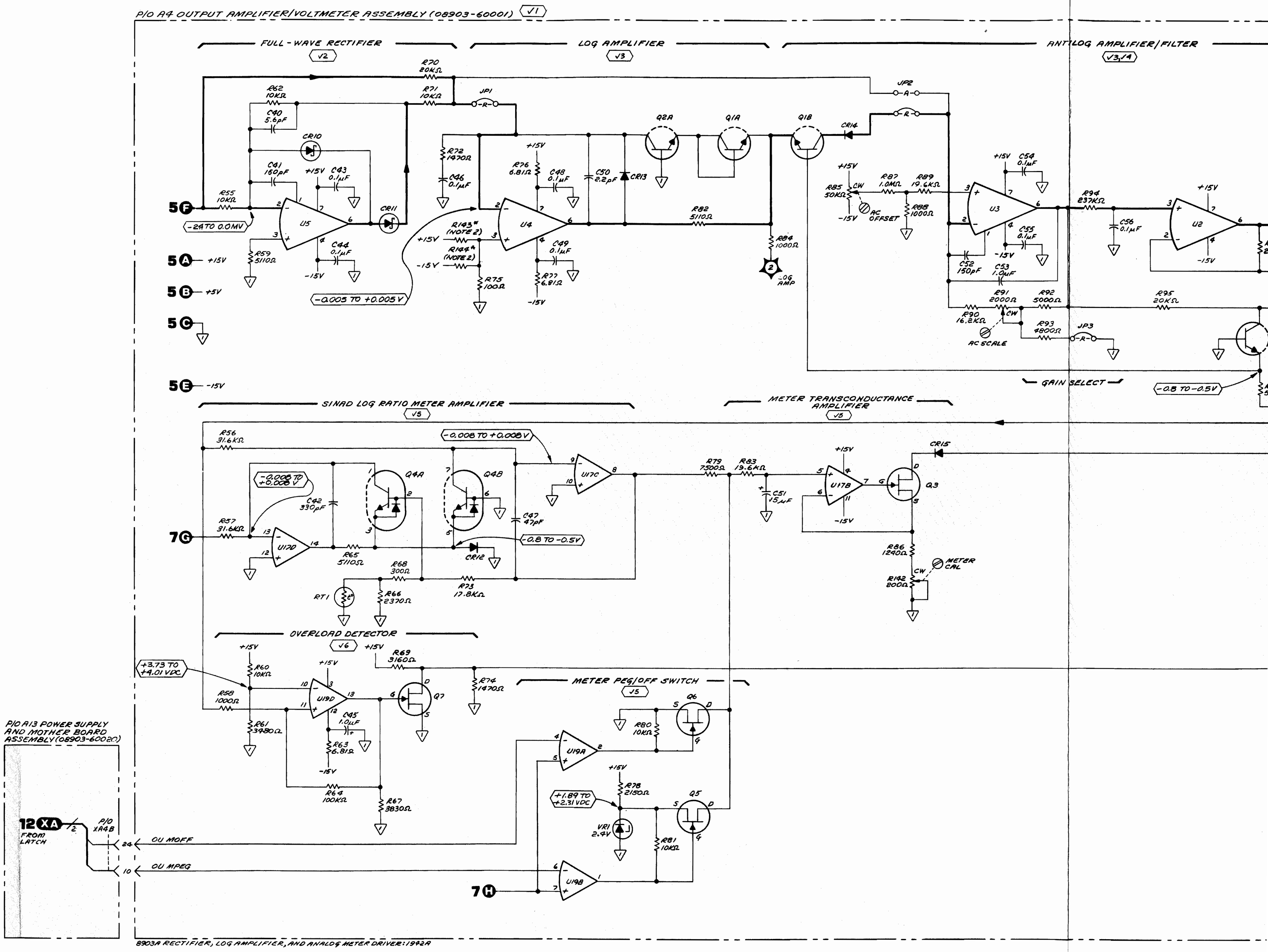
Figure 8-67. P/O A1 Keyboard and Display Assembly Component Locations (Detectors and Meter Circuits)

A4 ASSEMBLY

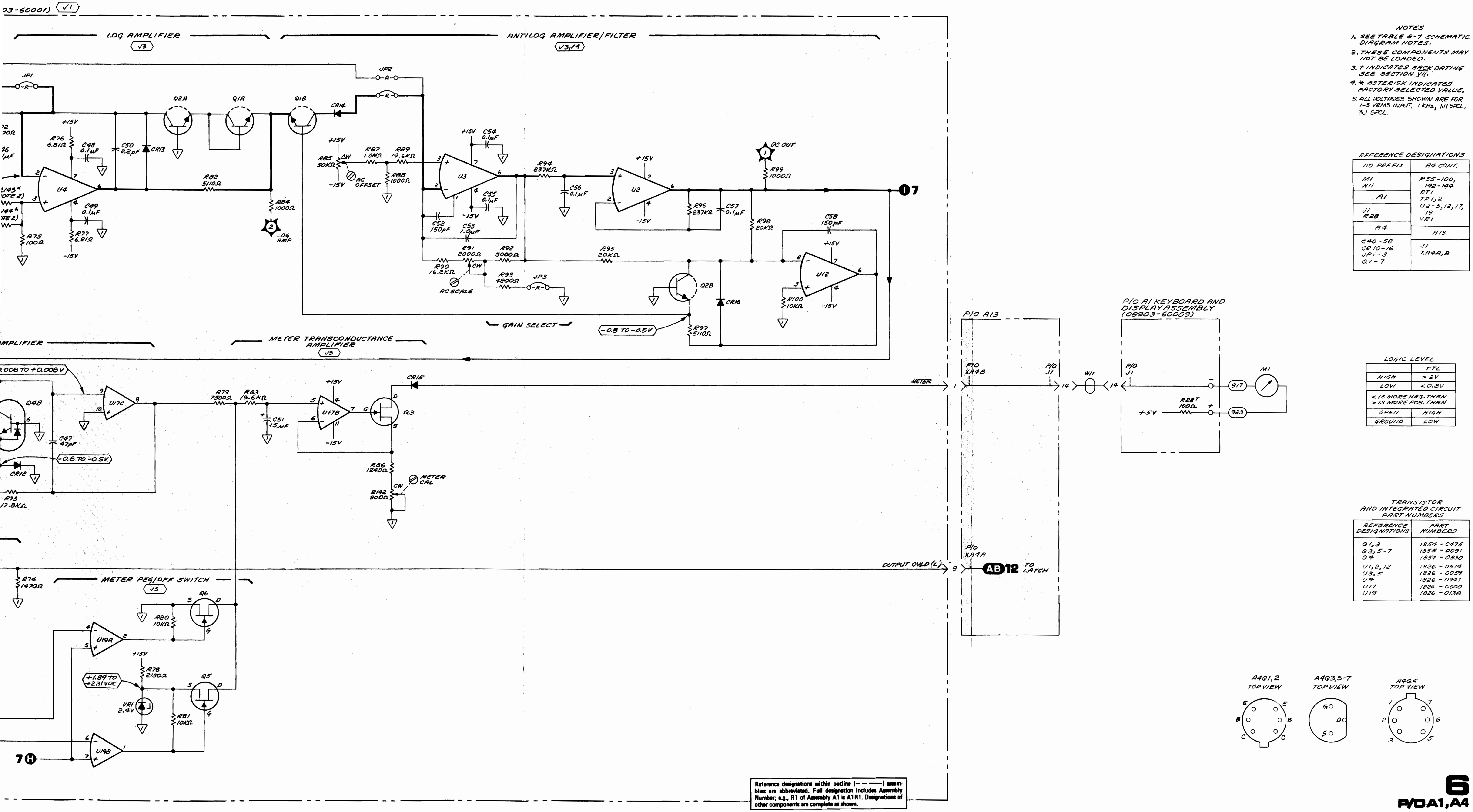


NOTE:
R143 & R144
ARE FACTORY
SELECTED PARTS

Figure 8-68. P/O A4 Output Amplifier/Voltmeter Assembly Component Locations (Detectors and Meter Circuits)



8903A RECTIFIER, LOG AMPLIFIER, AND ANALOG METER DRIVER: 1942A



Reference designations within outline (– – ——) assemblies are abbreviated. Full designation includes Assembly Number; e.g., R1 of Assembly A1 is A1R1. Designations of other components are complete as shown.

NOTES

1. SEE TABLE 8-7 SCHEMATIC DIAGRAM NOTES.
2. THESE COMPONENTS MAY NOT BE LOADED.
3. † INDICATES BACK DATING SEE SECTION VII.
4. * ASTERISK INDICATES FACTORY SELECTED VALUE.
5. ALL VOLTAGES SHOWN ARE FOR 1-3 VRMS INPUT, 1 KHz, 1.11 SPCL, 3.1 SPCL.

REFERENCE DESIGNATIONS

NO PREFIX	A4 CONT.
M1 W11	R55-100, 142-144 RT1 TP1,2 U2-5,12,17, 19 VR1
A1	
J1 R28	
A4	A13
C40-58 CR10-16 JP1-3 Q1-7	J1 XA4A,B

LOGIC LEVEL

	TTL
HIGH	> 2V
LOW	< 0.8V
< IS MORE NEG. THAN > IS MORE POS. THAN	
OPEN	HIGH
GROUND	LOW

TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATIONS	PART NUMBERS
Q1,2	1854-0475
Q3,5-7	1855-0091
Q4	1854-0830
U1,2,12	1826-0574
U3,5	1826-0059
U4	1826-0447
U17	1826-0600
U19	1826-0138

6
P/O A1,A4

Figure 8-69. Output Amplifier/Voltmeter-Detectors and Meter Circuits Schematic Diagram

SERVICE SHEET 7 — OUTPUT AMPLIFIER/VOLTMETER — RIPPLE FILTERS, VOLTMETER INPUT SELECTOR AND VOLTAGE-TO-TIME CONVERTER (P/O A4)

TROUBLESHOOTING HELP

- Block Diagram .... Service Sheet BD2
- Voltmeter Adjustment .... Paragraph 5-13
- Direct Control Special Functions .... Paragraph 8-26

PRINCIPLES OF OPERATION

General

This portion of the Output Amplifier/Voltmeter (A4) contains the Voltmeter Input Selector, the Voltage-to-Time Converter, and several input ripple filters.

Ripple Filters

Several of the dc inputs to the Voltage-to-Time Converter are filtered to remove ripple and noise. This gives a smoother-reading display. The line from the Input Amplifier (see Service Sheet 1), from which dc level is read in the dc level measurement mode, is filtered by the passive filter consisting of R118, C65, and C66. CR23 and CR24 are needed to prevent reverse voltages from damaging the electrolytic capacitors, C65 and C66, since the input voltage can be of either polarity. Passive filter R116 and C67 heavily filters the line from the Output RMS (Avg) Detector in the SINAD measurement mode.

The Ripple Filter, consisting of U10C and associated components, provides a complex impedance across the line from the Output RMS (Avg) Detector and gives two poles of high-frequency rolloff. The output is buffered by U1. A similar Ripple Filter (U10A and associated components) filters the line from the Input RMS Detector. It is a more complex filter, having an extra real pole. The output is buffered by U10D.

Diodes CR17 through CR22 protect the inputs to the Voltmeter Input Selector against high or reverse voltages.

Voltmeter Input Selector

Multiplexer U18 forms an 8-pole, single-throw switch. The multiplexer is always enabled by the high on the F input. To change a switch setting, the Controller issues the appropriate code to the Instrument Bus. The code is decoded and latched by the Latch Assembly (see Service Sheet 12) which puts the appropriate logic level on lines VO SEL0, 1, and 2. For a discussion of Instrument Bus control, see Service Sheet BD4.

Voltage-to-Time Converter

The dc voltage at the DC Voltmeter input is converted to a pulse, with a duration linearly related to the magnitude of the voltage, by the Voltage-to-Time Converter. The pulse length is then measured by the Counter (see Service Sheet 14). The converter consists of the Comparator, Ramp Generator, and Reference.

SERVICE SHEET 7 (Cont'd)

The Reference supplies a voltage of controlled temperature coefficient to the input to the Ramp Generator. The basic reference is the temperature-stable reference diode VR4. The reference is fed from current source Q10, which itself is temperature stable because its base-emitter junction and its reference, VR3, have similar thermal behavior. The negative reference supplies current to the inverting (−) input of U15 through R125 and R127. CR25, R123, and R124 add a slight temperature coefficient to the current to cancel the effect of the temperature coefficient of C70. The DC Voltmeter sensitivity is adjusted by means of R125.

U15 (with C60) integrates the negative input current to produce an increasing ramp. The ramp is generated only when Q9 is off (i.e., when Ramp Gate(L) is low). This is initiated by the Controller. When Q9 is on, the voltage across VR5 appears across C70. This clamps the output of U15 at approximately −6.2V. The current for Q9 is supplied by current source Q12. When Q9 goes off, the ramp begins, starting at −6.2V.

The ramp begins when the Ramp Gate(L) line goes low. The output of comparator U20 at this time is high because the voltage at its non-inverting (+) input is higher than the inverting (−) input. The output of U20 is inverted by FET Q8. The Counter now begins clocking the duration of the ramp. When the ramp reaches the voltage at the non-inverting input, the output of U20 goes low and (via Q8) inhibits the clocking of the Counter. R131 and R136 add a small amount of hysteresis to the Comparator to assure a complete and rapid transition of the output once it begins to change.

Since the ramp begins at a negative offset, each voltage measurement consists of clocking the duration of a pair of ramps. The first ramp is generated with the Voltmeter Input Selector set to the grounded input (input 0). The duration of this ramp is proportional to the offset. The second ramp is generated with the selector set to the input to be measured. The duration of this ramp is proportional to the input plus the offset. The difference in duration is computed by the Controller and is proportional to the input voltage.

The large negative offset voltage permits the DC Voltmeter to measure both negative and positive voltages.

TROUBLESHOOTING

General

Procedures for checking the Output Amplifier/Voltmeter Assembly are given below. The circuits or points to check are marked on the schematic diagram by a hexagon with a check mark and a number inside, e.g., ⟨√3⟩. In addition, any points outside the labeled circuit area that must be checked are also identified. Fixed signals are shown on the schematic also inside a hexagon, e.g., ⟨+1.9 to +2.1 Vdc⟩. Extend the board assembly where necessary to make measurements. These procedures assume that the source is working properly.

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.IFIER/VOLTMETER — T SELECTOR AND /O A4)

........Service Sheet BD2
.... Paragraph 5-13
.... Paragraph 8-26

oltmeter (A4) contains the
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Time Converter are filtered
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SERVICE SHEET 7 (Cont'd)

The Reference supplies a voltage of controlled temperature coefficient to the input to the Ramp Generator. The basic reference is the temperature-stable reference diode VR4. The reference is fed from current source Q10, which itself is temperature stable because its base-emitter junction and its reference, VR3, have similar thermal behavior. The negative reference supplies current to the inverting (–) input of U15 through R125 and R127. CR25, R123, and R124 add a slight temperature coefficient to the current to cancel the effect of the temperature coefficient of C70. The DC Voltmeter sensitivity is adjusted by means of R125.

U15 (with C60) integrates the negative input current to produce an increasing ramp. The ramp is generated only when Q9 is off (i.e., when Ramp Gate(L) is low). This is initiated by the Controller. When Q9 is on, the voltage across VR5 appears across C70. This clamps the output of U15 at approximately –6.2V. The current for Q9 is supplied by current source Q12. When Q9 goes off, the ramp begins, starting at –6.2V.

The ramp begins when the Ramp Gate(L) line goes low. The output of comparator U20 at this time is high because the voltage at its non-inverting (+) input is higher than the inverting (–) input. The output of U20 is inverted by FET Q8. The Counter now begins clocking the duration of the ramp. When the ramp reaches the voltage at the non-inverting input, the output of U20 goes low and (via Q8) inhibits the clocking of the Counter. R131 and R136 add a small amount of hysteresis to the Comparator to assure a complete and rapid transition of the output once it begins to change.

Since the ramp begins at a negative offset, each voltage measurement consists of clocking the duration of a pair of ramps. The first ramp is generated with the Voltmeter Input Selector set to the grounded input (input 0). The duration of this ramp is proportional to the offset. The second ramp is generated with the selector set to the input to be measured. The duration of this ramp is proportional to the input plus the offset. The difference in duration is computed by the Controller and is proportional to the input voltage.

The large negative offset voltage permits the DC Voltmeter to measure both negative and positive voltages.

TROUBLESHOOTING

General

Procedures for checking the Output Amplifier/Voltmeter Assembly are given below. The circuits or points to check are marked on the schematic diagram by a hexagon with a check mark and a number inside, e.g., ⟨√3⟩. In addition, any points outside the labeled circuit area that must be checked are also identified. Fixed signals are shown on the schematic also inside a hexagon, e.g., ⟨+1.9 to +2.1 Vdc⟩. Extend the board assembly where necessary to make measurements. These procedures assume that the source is working properly.

SERVICE SHEET 7 (Cont'd)

Equipment

Digital Voltmeter ....HP 3455A
Oscilloscope ....HP 1740A

⟨√1⟩ Ripple Filters Check

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the INPUT and OUTPUT switches to ground. Key in AMPTD 3V. Key in 1.11 SPCL to set the input gain to 0 dB. Key in 3.1 SPCL to set the output gain to 0 dB. Connect the HIGH OUTPUT to the HIGH INPUT.

2. Connect one channel of a high-impedance, dc coupled oscilloscope to A2TP2 (RMS). Connect the other channel to pin 14 of U10D. Both channels should read between +2.9 and +3.1 Vdc and both should read the same.

Hint: If the signal at A2TP2 is faulty, see Service Sheet 2 and check the Input RMS Detector.

3. On the Audio Analyzer, connect and disconnect the HIGH INPUT several times and observe the two traces on the oscilloscope. The signal at pin 14 of U10D should lag in time slightly behind the signal at A2TP2 when the input is connected and disconnected.

4. On the Audio Analyzer, reconnect the HIGH INPUT. Connect one channel of the oscilloscope to A4TP1 (DC OUT). Connect the other channel to pin 7 of U18. Both channels should read between +2.9 and +3.1 Vdc and both should read the same.

Hint: If the signal at A4TP1 is faulty, see Service Sheet 6 and check the Output RMS (Avg) Detector.

5. On the Audio Analyzer, connect and disconnect the HIGH INPUT several times and observe the two traces on the oscilloscope. The signal at pin 7 of U18 should lag slightly behind the signal at A4TP1 when the input is connected and disconnected.

6. On the Audio Analyzer, reconnect the HIGH INPUT. Move the oscilloscope connection from pin 7 of U18 to pin 11. Both channels should read the same.

7. On the Audio Analyzer, connect and disconnect the HIGH INPUT several times and observe the two traces on the oscilloscope. The signal at pin 11 of U18 should lag behind the signal at A4TP1 when the input is connected and disconnected. (The lag will be longer than for the previous steps.)

⟨√2⟩ Voltmeter Input Selector Check

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the INPUT and OUTPUT switches to ground. Key in AMPTD 3V. Key in 1.11 SPCL to set the input gain to 0 dB. Key in 3.1 SPCL to set the output gain to 0 dB. Connect the HIGH OUTPUT to the HIGH INPUT.

SERVICE SHEET 7 (Cont'd)

2. Key in the Direct Control Special Functions listed in Table 8-47. For each setting, compare the dc voltage at A4TP9 (MUX) to the pin on U18 indicated. The two voltages should be the same to within the repeatability of the voltmeter. If faulty, also check the logic level of the pins indicated.

Hint: If the selector has a failure in which one input is always connected to the output, pulses will usually appear on the faulty input when another line is selected. Use Special Function 49.N to select the lines.

Table 8-47. Voltmeter Input Selector Check

Direct Control Special Function	Check Voltage at U18 Pin	Level (TTL) at U18 Pin		
		1	16	15
0.530	4	L	L	L
0.531	5	H	L	L
0.532	6*	L	H	L
0.533	7	H	H	L
0.534	12	L	L	H
0.535	11	H	L	H
0.536	10	L	H	H
0.537	9**	H	H	H

* A 3 Vrms ac signal should appear here also.
** A 1.2 to 1.5 Vrms signal should appear here also if the SOURCE frequency is set to 20 Hz.

⟨√3⟩ Voltage-to-Time Converter Check

1. Measure the anode of VR4 with a dc voltmeter. The voltage should be between –6.51 and –5.89 Vdc.

2. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the INPUT and OUTPUT switches to ground. Key in AMPTD 3V. Key in 1.11 SPCL to set the input gain to 0 dB. Key in 49.1 SPCL to set the voltmeter to measure the Input RMS Detector. Connect the HIGH OUTPUT to the HIGH INPUT.

3. Connect a high-impedance, dc coupled oscilloscope to A4TP7 (RAMP). The waveform should be as shown in Figure 8-70.

Hint: The slope of the triangles in the waveform should be approximately 1V/ms.

Hint: Pin 14 of U19C should be as shown in Figure 8-71. If it appears as a simple square wave, check that pin 5 of U18 is between +1.4 and +1.5 Vdc.

4. Connect the oscilloscope to A4TP10 (COMP). The waveform should be as shown in Figure 8-72.

SERVICE SHEET 7 (Cont'd)

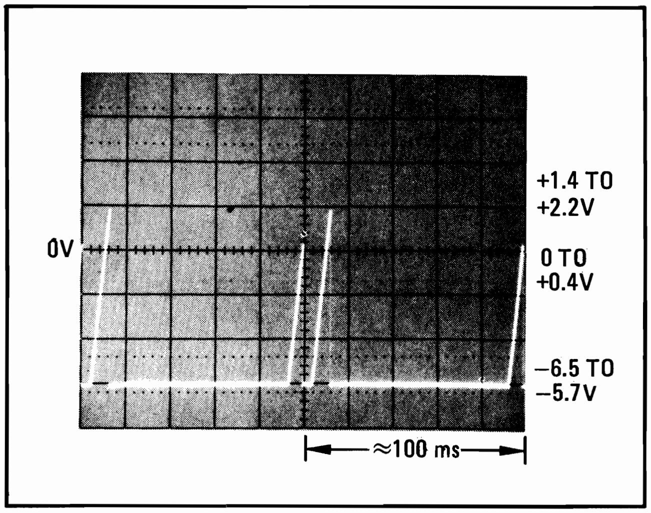


Figure 8-70. Voltage-to-Time Converter Check Waveform A

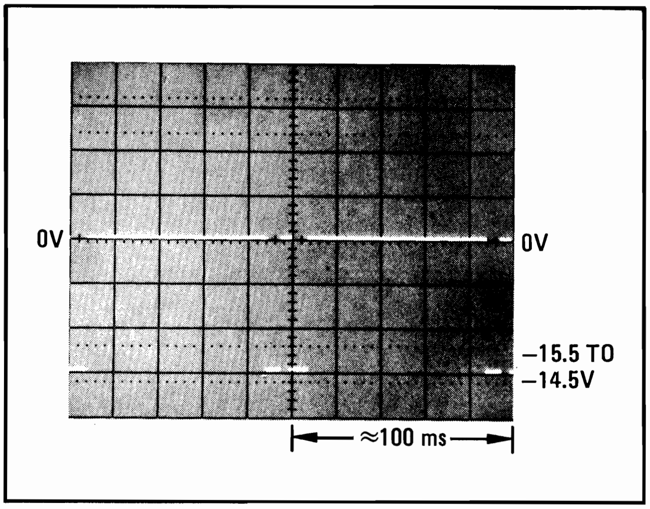


Figure 8-71. Voltage-to-Time Converter Check Waveform B

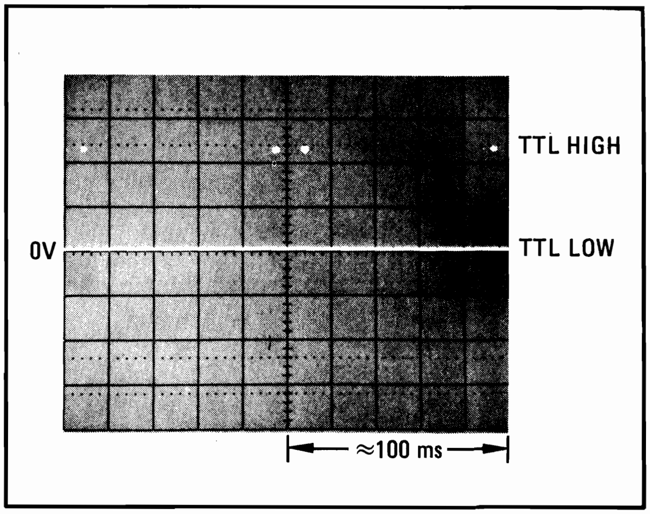


Figure 8-72. Voltage-to-Time Converter Check Waveform C

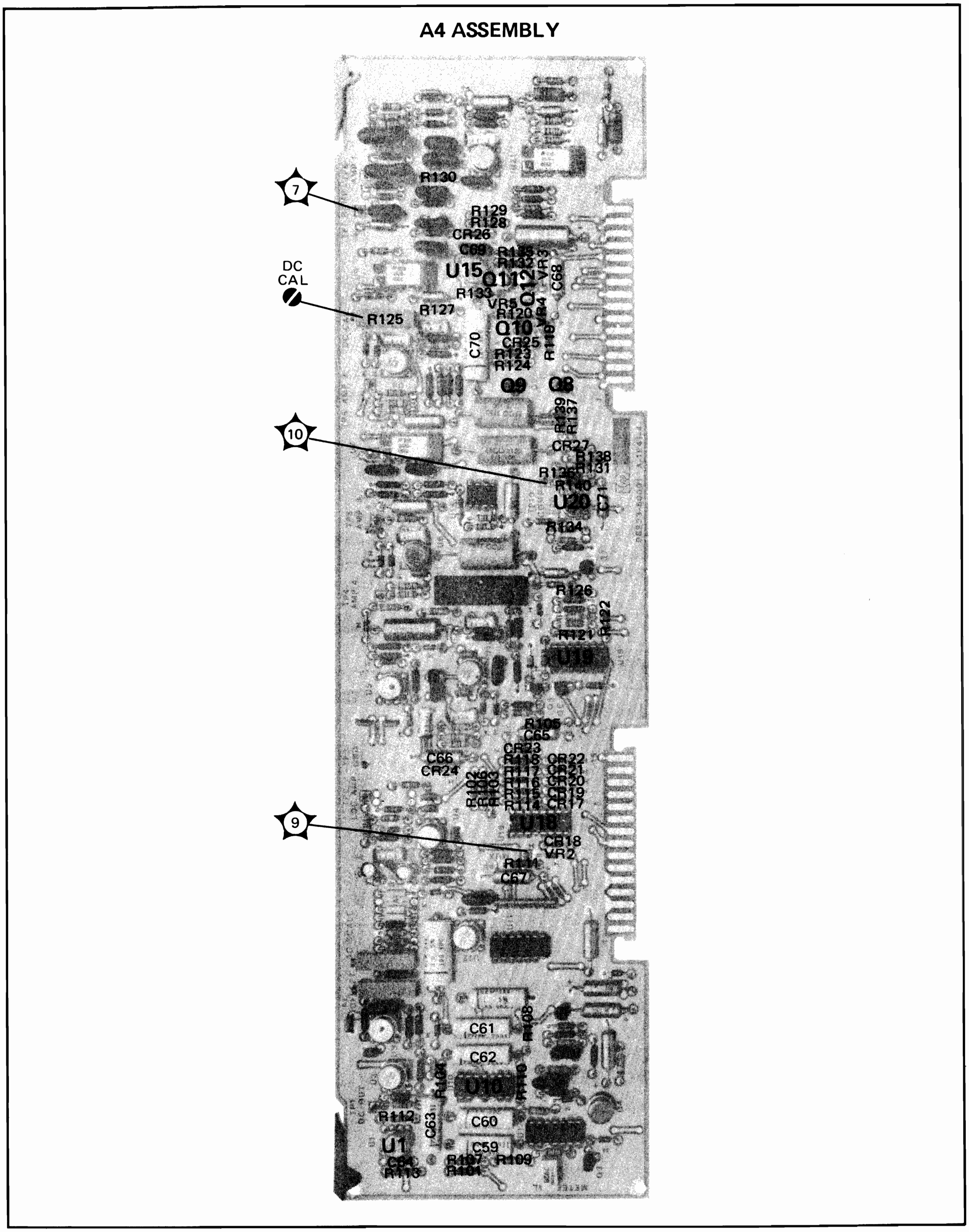
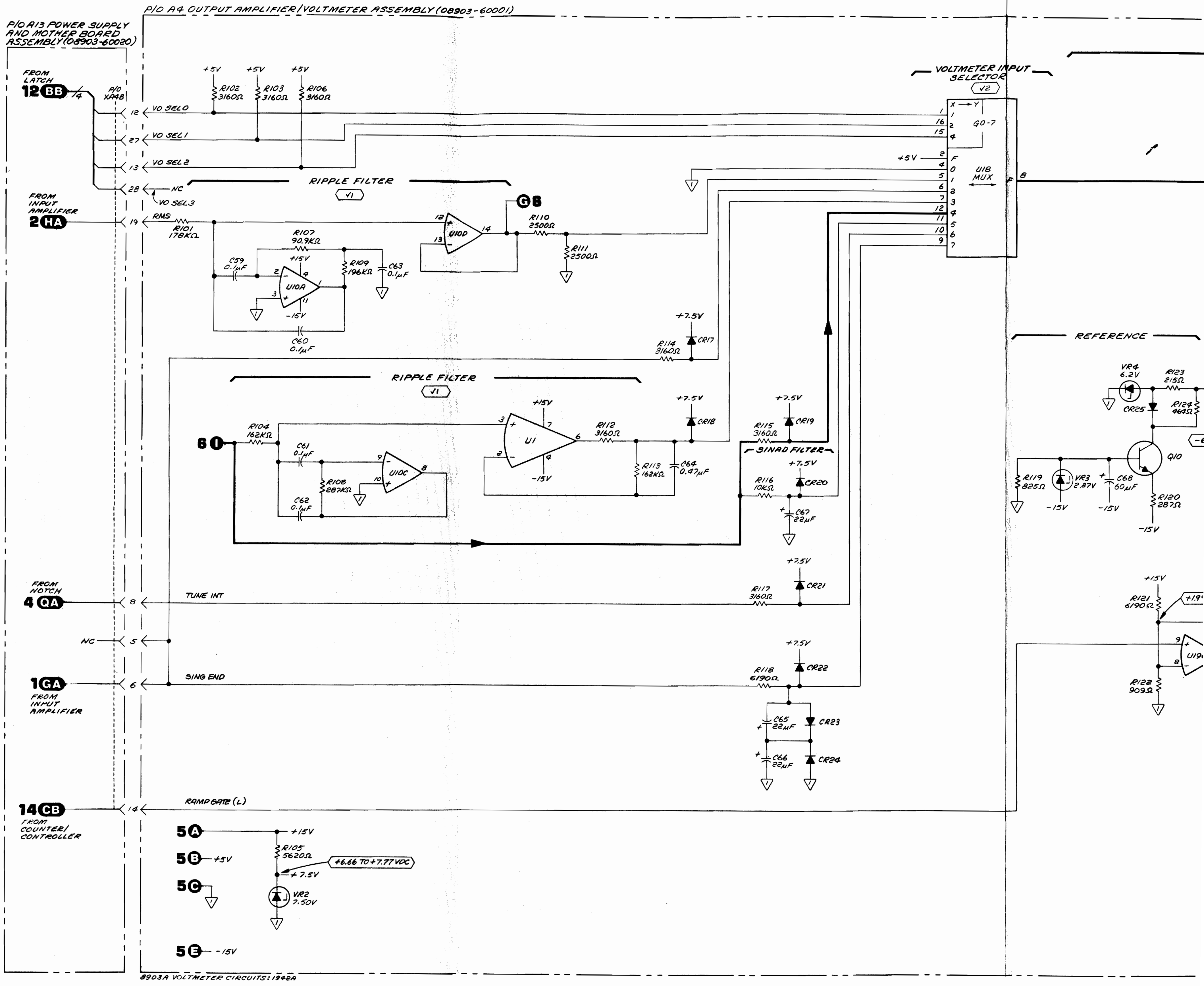
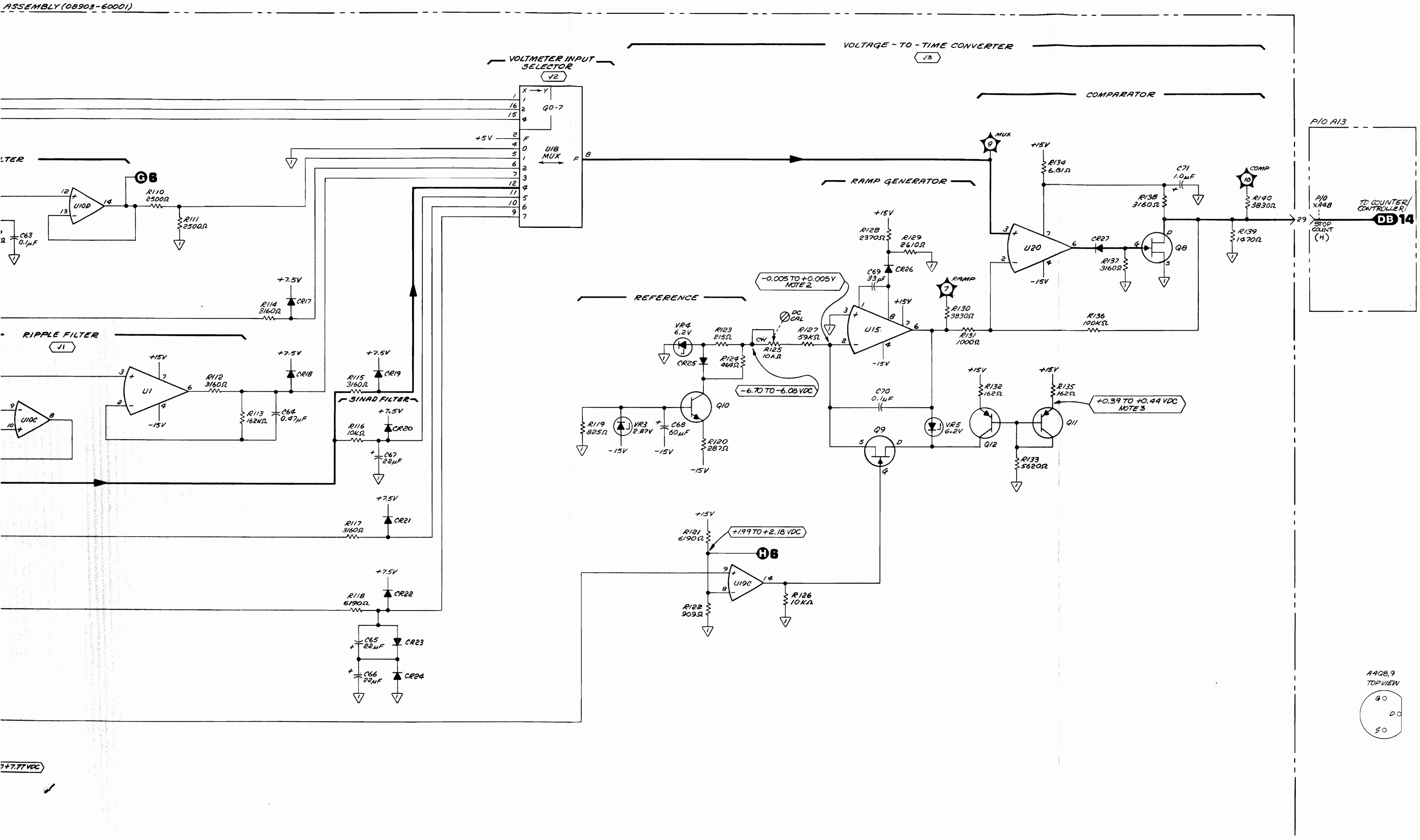


Figure 8-73. P/O A4 Output Amplifier/Voltmeter Assembly Component Locations (Ripple Filters, Voltmeter Input Selector, and Voltage-to-Time Converter


P/O A13 POWER SUPPLY AND MOTHER BOARD ASSEMBLY (08903-60020)
P/O A4 OUTPUT AMPLIFIER/VOLTMETER ASSEMBLY (08903-60001)
FROM LATCH
12 BB
4
P/O XA4B
12
27
13
28
VO SEL0
VO SEL1
VO SEL2
NC
VO SEL3
FROM INPUT AMPLIFIER
2 HA
19
RMS
R101 178KΩ
+5V
R102 3160Ω
R103 3160Ω
R106 3160Ω
RIPPLE FILTER
√1
G B
U10D
12
13
14
R110 2500Ω
R111 2500Ω
R107 90.9KΩ
C59 0.1μF
+15V
U10A
-15V
R109 196KΩ
C63 0.1μF
C60 0.1μF
VOLTMETER INPUT SELECTOR
√2
X → Y
G0-7
U18 MUX
+5V
F
8
+7.5V
R114 3160Ω
CR17
RIPPLE FILTER
√1
6 I
R104 162KΩ
C61 0.1μF
R108 287KΩ
C62 0.1μF
U10C
+15V
U1
-15V
R112 3160Ω
R113 162KΩ
C64 0.47μF
CR18
R115 3160Ω
CR19
SINAD FILTER
R116 10KΩ
CR20
C67 22μF
FROM NOTCH
4 QA
8
TUNE INT
R117 3160Ω
CR21
NC
5
1 GA
FROM INPUT AMPLIFIER
6
SING END
R118 6190Ω
CR22
C65 22μF
CR23
C66 22μF
CR24
14 CB
FROM COUNTER/CONTROLLER
14
RAMP GATE (L)
5 A
+15V
5 B
+5V
5 C
5 E
-15V
R105 5620Ω
+6.66 TO +7.77 VDC
+7.5V
VR2 7.50V
REFERENCE
VR4 6.2V
R123 215Ω
CR25
R124 464Ω
Q10
R119 825Ω
VR3 2.87V
C68 60μF
R120 287Ω
-15V
+15V
R121 6190Ω
+1.9
R122 909Ω
U19
8903A VOLTMETER CIRCUITS: 1942A



Reference designations within outline (— — ——) assemblies are abbreviated. Full designation includes Assembly Number; e.g., R1 of Assembly A1 is A1R1. Designations of other components are complete as shown.

NOTES

1. SEE TABLE 8-7 SCHEMATIC DIAGRAM NOTES.
2. DECOUPLE PROBE WITH 10KΩ RESISTOR WHEN MEASURING THIS VOLTAGE.
3. MEASURED WITH RESPECT TO THE +15 VDC SUPPLY.

REFERENCE DESIGNATIONS

A4	A13
C59-71 CR17-27 Q8-12 R101-140 TP7,9,10 U1,10,15,18-20 VR2-5	XA4B

LOGIC LEVELS

	TTL
HIGH	>2V
LOW	<0.8V
< IS MORE NEG. THAN > IS MORE POS. THAN	
OPEN	HIGH
GROUND	LOW

TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATIONS	PART NUMBERS
Q8,9	1855-0091
Q10	1854-0071
Q11,12	1853-0281
U1	1826-0574
U10	1826-0600
U15	1826-0059
U18	1826-0609
U19	1826-0138
U20	1826-0447

A4Q8,9
TOP VIEW

INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

REFERENCE DESIGNATIONS	PIN NUMBERS
U18	+15V - 13 -15V - 3 ▽ - 14

7
P/O A4

Figure 8-74. Output Amplifer/Voltmeter—Ripple Filters, Voltmeter Input Selector, and Voltge-to-Time Converter Schematic Diagram

SERVICE SHEET 8 — OSCILLATOR — STATE-VARIABLE CIRCUITS (P/O A5)

TROUBLESHOOTING HELP

- Block Diagram .... Service Sheet BD3

PRINCIPLES OF OPERATION

General

This portion of the Oscillator Assembly (A5) contains the basic state-variable circuitry which generates a signal at a specific frequency. (See the discussion of the Oscillator on Service Sheet BD3.) It includes two integrators, a fine tune circuit, a sum amplifier, and their control circuitry.

Integrators

The two integrators are nearly identical. A simplified diagram of an integrator is shown in Figure 8-57 (in the discussion of the Notch Filter). For Integrator 1, FETs Q12 through Q14 switch the feedback capacitors to change ranges. FETs Q4 through Q11 switch the input resistors to coarse tune the oscillator. The FETs are driven by the Oscillator Control Drivers whose control inputs come from the Controller via the Latch Assembly (see Service Sheet 12).

Fine Tune

Fine tuning is accomplished by varying the total amount of input current from Integrator 2 into the Sum Amplifier U5. The Fine Tune circuit inverts the output from Integrator 2. Its gain is determined by the closing of FETs Q28 to Q31 and the switches of U19. The output of U12B produces a current in R60 of opposite polarity to the current in R57.

Sum Amplifier

The Sum Amplifier sums the currents from Integrator 2 and the Fine Tune via R57 and R60 and the current from the ALC circuit (see Service Sheet 9). The currents from Integrator 2 affect the Oscillator frequency, and the current from the ALC circuit affects the level.

TROUBLESHOOTING

General

Procedures for checking the Oscillator Assembly are given below. The circuits or points to check are marked on the schematic diagram by a hexagon with a check mark and a number inside, e.g., ⟨√3⟩. In addition, any points outside the labeled circuit area that must be checked are also identified. Fixed signals are shown on the schematic also inside a hexagon, e.g., ⟨1.9 to +2.1 Vdc⟩. Extend the board assembly where necessary to make measurements. These procedures assume that the measurement circuits of the instrument (e.g., AC LEVEL and frequency) are working properly.

Equipment

Oscilloscope .... HP 1740A

SERVICE SHEET 8 (Cont'd)

⟨√1⟩ Tuning Check

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the INPUT and OUTPUT switches to ground. Key in AMPTD 3V. Key in 55.3 SPCL, 56.255 SPCL, and 57.255 SPCL to set the Oscillator frequency to its highest range, coarse tune, and fine tune settings. Connect the HIGH OUTPUT to the HIGH INPUT.

2. Connect a high-impedance, dc coupled oscilloscope to A5TP6 (OSC 1), A5TP8 (OSC 2), then A5TP4 (OSC 3). Use a low-capacitance 10:1 divider probe. The dc level should be between −50 and +50 mVdc at A5TP6 and A5TP4 and between −250 and +250 mVdc at A5TP8. The ac level at A5TP6 and A5TP8 should be between 8.3 and 8.7 Vpp. The frequency should be between 110 and 130 kHz.

Hint: If the dc level is out of limits, check U4, U5, and U11. The amplifiers are connected in a negative dc feedback loop; a failure in one amplifier will upset the bias of the others. Check that the output voltages have the proper sense. (For example, a positive offset at pin 2 of U4 should result in a negative output at pin 6. It should approach −15V.)

Hint: If the dc level is correct but there is no ac signal, short A5TP9 (ALC) to A5TP6. If a signal now appears with the frequency approximately correct but an amplitude of about 5.5 Vpp, see Service Sheet 9 and check the Oscillator leveling circuits. The signal will be distorted.

Hint: If the dc and ac levels are correct but the frequency is incorrect, continue with the following steps to determine which tuning circuits are not responding properly.

3. On the Audio Analyzer, key in the Special Functions listed in Table 8-48. For each setting, connect the oscilloscope to the drains of the FETs indicated. (Use a probe.) A signal of several volts should be present when 55.3 SPCL is keyed in, but not when the Special Function listed is keyed in. If the signal is faulty, also check the control line indicated. (All control lines should be −15V for 55.3 SPCL.)

Table 8-48. Voltage Levels at A5U18

Special Function	Drains to Check	Level (Vdc) at U18 Pin		
		1	2	14
55.2	Q12, Q25	0	−15	−15
55.1	Q13, Q26	−15	0	−15
55.0	Q14, Q27	−15	−15	0

4. On the Audio Analyzer, key in 55.2 SPCL. Key in the Special Functions listed in Table 8-49. For each setting, connect the oscilloscope to the drains of the FETs indicated. A signal of several volts should be present when the Special Function is keyed in, but not when 56.255 is keyed in. If the signal is faulty, also check the control lines indicated. (All control lines should be 0 Vdc for 56.255 SPCL.)

Table 8-49. Voltage Levels at A5U17 and A5U16

Special Function	Drains to Check	Level (Vdc) at U17 Pin				Level (Vdc) at U16 Pin			
		2	14	13	1	2	1	13	14
56.254	Q6, Q19	0	0	0	0	0	0	0	−15
56.253	Q7, Q20	0	0	0	0	0	0	−15	0
56.251	Q4, Q17	0	0	0	0	0	−15	0	0
56.247	Q5, Q18	0	0	0	0	−15	0	0	0
56.239	Q8, Q21	0	0	0	−15	0	0	0	0
56.223	Q11, Q24	0	0	−15	0	0	0	0	0
56.191	Q10, Q23	0	−15	0	0	0	0	0	0
56.127	Q9, Q22	−15	0	0	0	0	0	0	0

5. On the Audio Analyzer, key in 56.255 SPCL. Key in the Special Functions listed in Table 8-50. For each setting, connect the oscilloscope to the drain of the FET indicated. A signal of several volts should be present when the Special Function is keyed in, but not when 57.0 is keyed in. If the signal is faulty, also check the control lines indicated. (All control lines should be 0 Vdc for 57.0 SPCL.)

Table 8-50. Voltage Levels at A5U20

Special Function	FET to Check	Level (Vdc) at U20 Pin			
		2	1	14	13
57.128	Q31	0	0	0	−15
57.64	Q30	0	0	−15	0
57.32	Q29	0	−15	0	0
57.16	Q28	−15	0	0	0

6. On the Audio Analyzer, key in the Special Functions listed in Table 8-51. For each setting, connect the oscilloscope to the pin of U19 indicated. A signal of several volts should be present when the Special Function is keyed in, but not when 57.15 is keyed in. If the signal is faulty, also check the control lines indicated. (All control lines should be a TTL high for 57.15 SPCL.)

Output Amplifier/Voltmeter —
Ripple Filters, Voltmeter Input Selector,
and Voltage-to-Time Converter
P/O A4
SERVICE SHEET 7

SERVICE SHEET 8 (Cont'd)

Table 8-51. TTL Levels at A5U19

Special Function	Pin On U19 to Check	Level (TTL) at U19 Pin			
		1	8	9	16
57.7	15	H	H	H	L
57.11	10	H	H	L	H
57.13	7	H	L	H	H
57.14	2	L	H	H	H

Hint: This step concludes a check of the functioning of the tuning circuits. If the fault is excessive distortion (particularly at low frequencies), the cause may be a leaky FET switch. The particular FET can be ascertained by observing which switch is on when the distortion goes away. If the fault is a frequency error as observed in the Oscillator Tuning Check of Service Sheet BD3, the faulty resistor or FET switch can be ascertained by noting which Special Functions give correct readings and which do not. Table 8-52 should assist in correlating the Special Functions and range switches.

Table 8-52. Special Function 55.N Vs. Range Switches Closed

Special Function	Switches Closed
55.3	None
55.2	Q12, Q25
55.1	Q13, Q26
55.0	Q14, Q27

Table 8-53 should assist in correlating the Special Functions and the coarse tune switches.

NOTE

For Special Function 56.N, let N=N8+N7+N6+N5+N4+N3+N2+N1. The value of N determines which switches are closed (For example, 56.18 SPCL will close Q8, Q21, Q7, and Q20. N5+N2=16+2=18.)

Table 8-53. Special Function 56.N Vs. Coarse Tune Switches Closed

Component of N	Value	Switches Closed
N8	128	Q9, Q22
N7	64	Q10, Q23
N6	32	Q11, Q24
N5	16	Q8, Q21
N4	8	Q5, Q18
N3	4	Q4, Q17
N2	2	Q7, Q20
N1	1	Q6, Q19

Table 8-54 should assist in correlating the Special Functions and the fine tune switches.

NOTE

For Special Function 57.N, let N=255 -(N8+N7+N6+N5+N4+N3+N2+N1). The value of N determines which switches are closed as follows. (For example, 57.237 SPCL closes switches U19D and U19B. 255-N5-N2=255-16-2=237.)

Table 8-54. Special Function 57.N Vs. Fine Tune Switches Closed

Component of N	Value	Switch Closed
N8	128	Q31
N7	64	Q30
N6	32	Q29
N5	16	Q28
N4	8	U19D
N3	4	U19C
N2	2	U19B
N1	1	U19A

7. On the Audio Analyzer, ground A5TP9 (ALC). Key in 55.3 SPCL, 56.1 SPCL, and 57.0 SPCL. Connect the oscilloscope to A5TP6. The waveform should be less than 2 mVpp and between −50 and +50 mVdc.

Hint: If the signal is too large, an FET switch is leaking. A leaking FET will cause excessive distortion at 20 Hz.

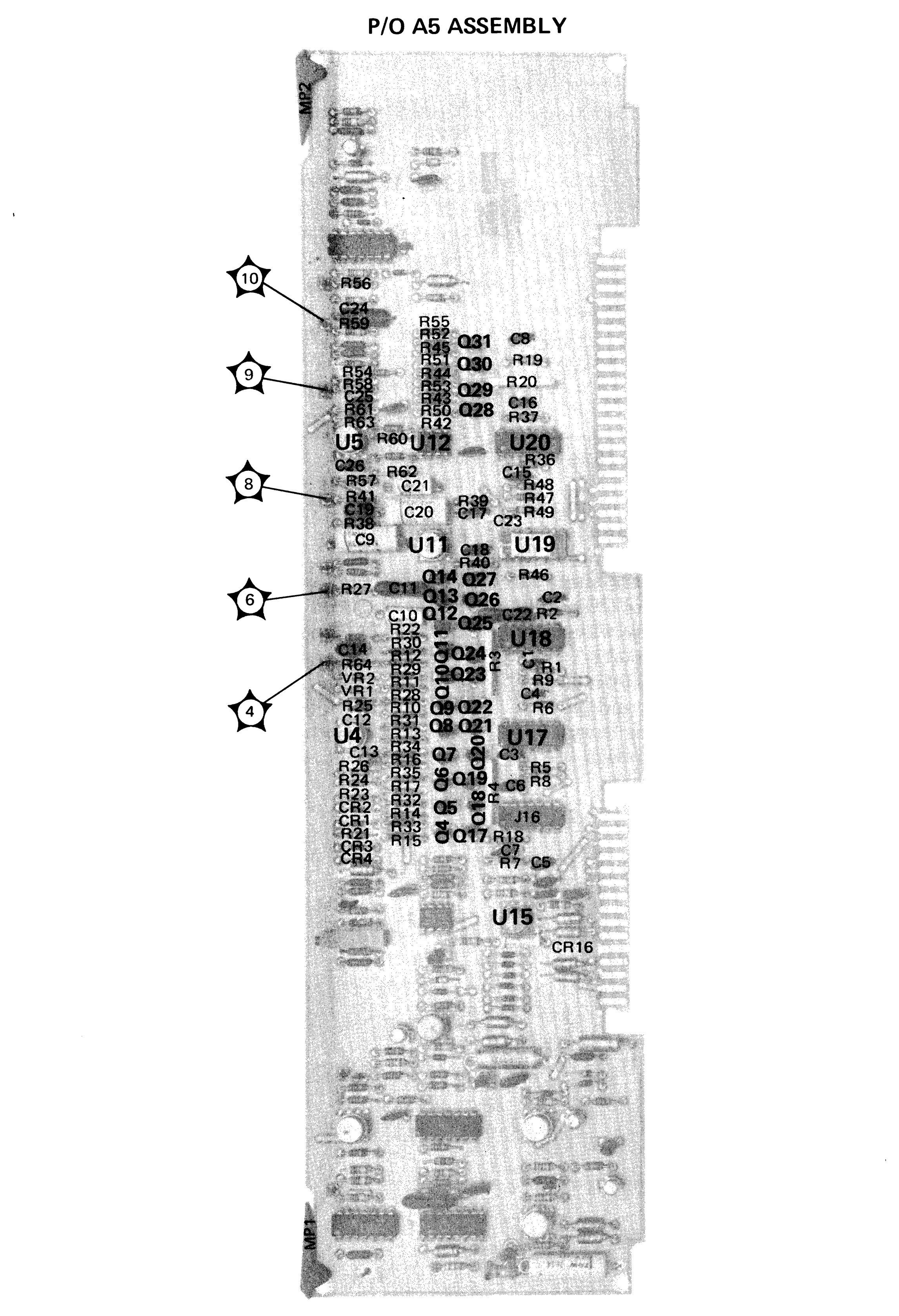
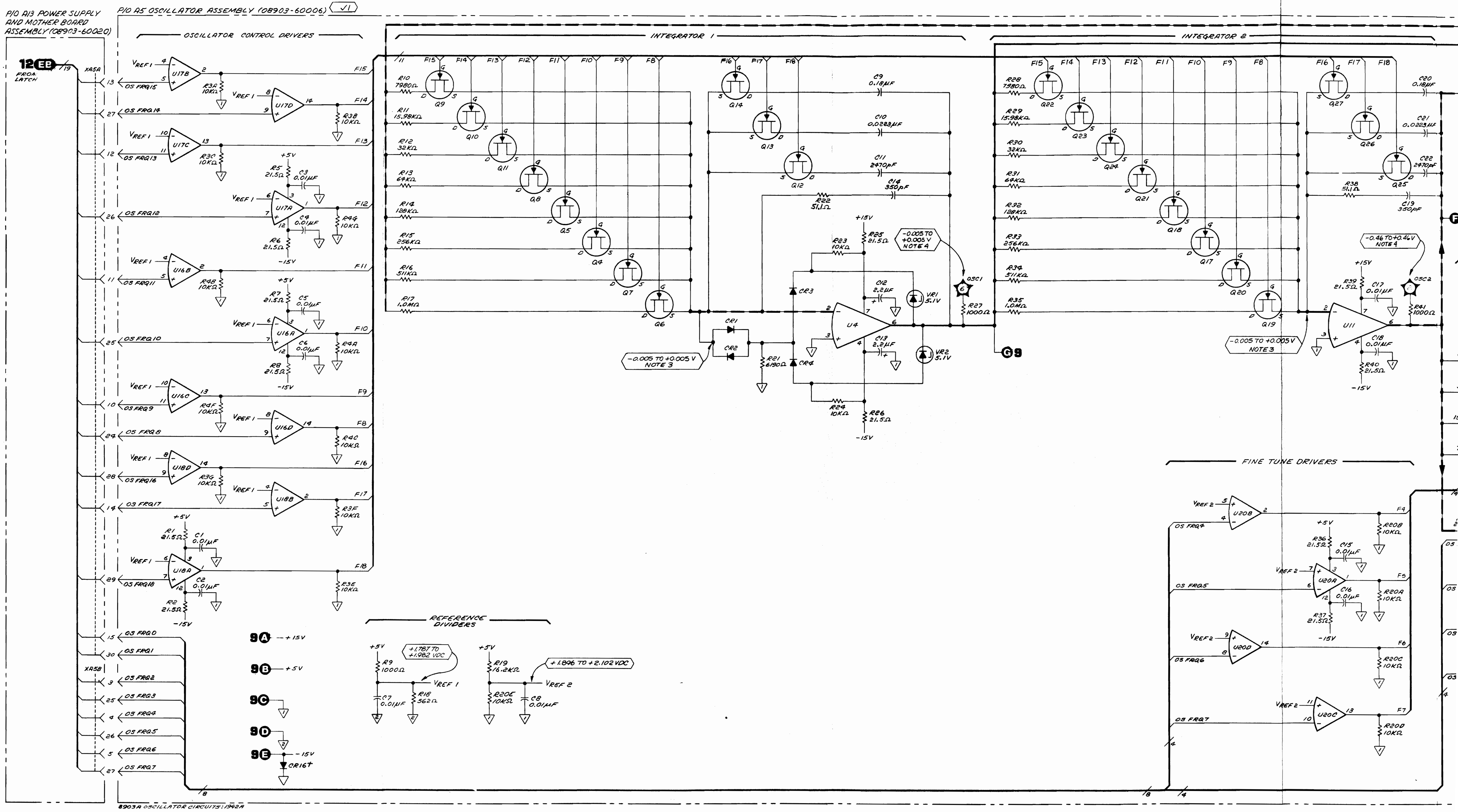
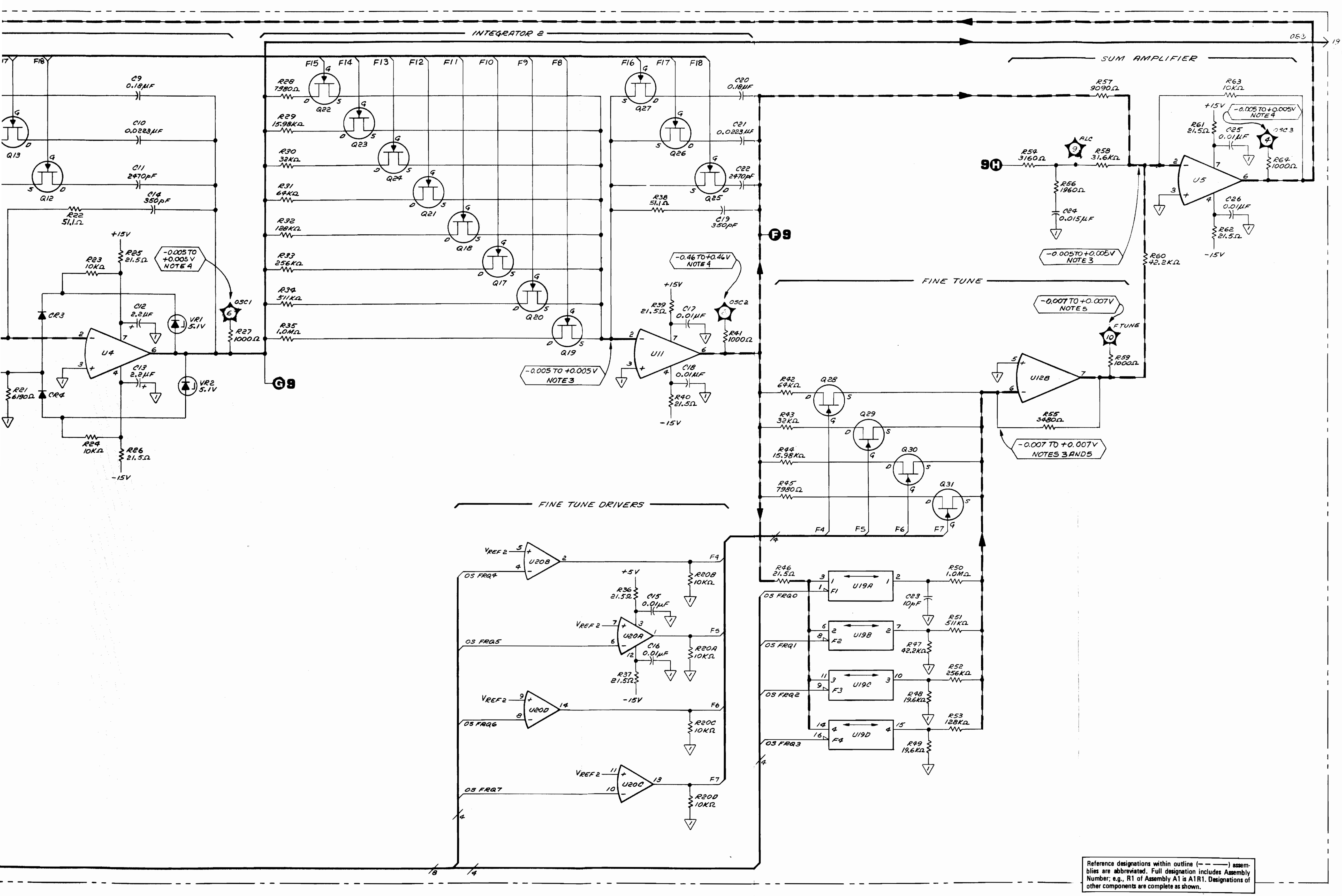
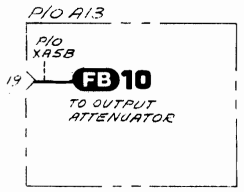


Figure 8-75. P/O A5 Oscillator Assembly Component Locations (State-Variable Circuits)


P/O A13 POWER SUPPLY AND MOTHER BOARD ASSEMBLY (08903-60020)
P/O A5 OSCILLATOR ASSEMBLY (08903-60006)
V1
OSCILLATOR CONTROL DRIVERS
INTEGRATOR 1
INTEGRATOR 2
12EB
FROM LATCH
19
XA5A
XA5B
OS FRQ15
OS FRQ14
OS FRQ13
OS FRQ12
OS FRQ11
OS FRQ10
OS FRQ9
OS FRQ8
OS FRQ16
OS FRQ17
OS FRQ18
OS FRQ0
OS FRQ1
OS FRQ2
OS FRQ3
OS FRQ4
OS FRQ5
OS FRQ6
OS FRQ7
VREF 1
U17B
U17D
U17C
U17A
U16B
U16A
U16C
U16D
U18D
U18B
U18A
R3A 10KΩ
R3B 10KΩ
R3C 10KΩ
R4G 10KΩ
R4B 10KΩ
R4A 10KΩ
R4F 10KΩ
R4C 10KΩ
R3G 10KΩ
R3F 10KΩ
R3E 10KΩ
R5 21.5Ω
R6 21.5Ω
R7 21.5Ω
R8 21.5Ω
R1 21.5Ω
R2 21.5Ω
C3 0.01μF
C4 0.01μF
C5 0.01μF
C6 0.01μF
C1 0.01μF
C2 0.01μF
+5V
-15V
F15
F14
F13
F12
F11
F10
F9
F8
F16
F17
F18
R10 7980Ω
R11 15.98KΩ
R12 32KΩ
R13 64KΩ
R14 128KΩ
R15 256KΩ
R16 511KΩ
R17 1.0MΩ
Q9
Q10
Q11
Q8
Q5
Q4
Q7
Q6
Q14
Q13
Q12
C9 0.18μF
C10 0.0223μF
C11 2470pF
C14 350pF
R22 51.1Ω
+15V
R23 10KΩ
R25 21.5Ω
-0.005 TO +0.005 V NOTE 4
OSC1
CR3
CR4
C12 2.2μF
VR1 5.1V
U4
R27 1000Ω
CR1
CR2
-0.005 TO +0.005 V NOTE 3
R21 6190Ω
C13 2.2μF
VR2 5.1V
R24 10KΩ
R26 21.5Ω
-15V
G9
R28 7980Ω
R29 15.98KΩ
R30 32KΩ
R31 64KΩ
R32 128KΩ
R33 256KΩ
R34 511KΩ
R35 1.0MΩ
Q22
Q23
Q24
Q21
Q18
Q17
Q20
Q19
Q27
Q26
Q25
C20 0.18μF
C21 0.0223μF
C22 2470pF
R38 51.1Ω
C19 350pF
-0.46 TO +0.46V NOTE 4
OSC2
+15V
R39 21.5Ω
C17 0.01μF
R41 1000Ω
U11
C18 0.01μF
R40 21.5Ω
-15V
-0.005 TO +0.005V NOTE 3
FINE TUNE DRIVERS
VREF 2
U20B
U20A
U20D
U20C
OS FRQ4
OS FRQ5
OS FRQ6
OS FRQ7
F4
F5
F6
F7
R20B 10KΩ
R20A 10KΩ
R20C 10KΩ
R20D 10KΩ
R36 21.5Ω
R37 21.5Ω
C15 0.01μF
C16 0.01μF
REFERENCE DIVIDERS
+5V
R9 1000Ω
+1.787 TO +1.982 VDC
C7 0.01μF
R18 562Ω
VREF 1
R19 16.2KΩ
+1.896 TO +2.102 VDC
R20E 10KΩ
C8 0.01μF
VREF 2
9A +15V
9B +5V
9C
9D
9E -15V
CR16
8
4
8903A OSCILLATOR CIRCUITS:1942A



Reference designations within outline (— — —) assemblies are abbreviated. Full designation includes Assembly Number; e.g., R1 of Assembly A1 is A1R1. Designations of other components are complete as shown.



NOTES

1. SEE TABLE 8-7 SCHEMATIC DIAGRAM NOTES.
2. † INDICATES BACKDATING SEE SECTION VII.
3. DECOUPLE PROBE WITH 10KΩ RESISTOR WHEN MEASURING THIS VOLTAGE.
4. GROUND TP9 TO STOP OSCILLATOR WHEN MEASURING THIS VOLTAGE.
5. MEASURE WITH 57.255 SPCL.

REFERENCE DESIGNATIONS

A5	A13
C1-26 CR1-4,16 Q4-14,17-31 R1-64 TP4,6,8-10 U4,5,11,12, 16-20 VR1,2	XA5A,B

LOGIC LEVELS

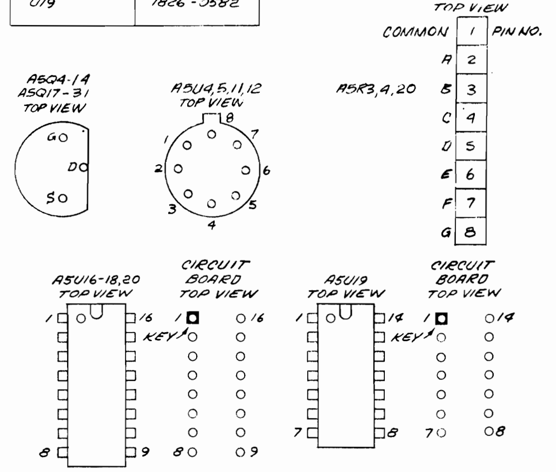
	TTL
HIGH	>2V
LOW	<0.8V
< IS MORE NEG. THAN > IS MORE POS. THAN	
OPEN	HIGH
GROUND	LOW

TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATIONS	PART NUMBERS
Q4-14, 17-31	1855-0091
U4,5,11	1826-0662
U12	1826-0547
U16-18,20	1826-0138
U19	1826-0582

DIGITAL INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

REFERENCE DESIGNATIONS	PIN NUMBERS
U19	+15V - 13 -15V - 4 ⏚ - 5



8
P/O A5

Figure 8-76. Oscillator—State-Variable Circuits Schematic Diagram

SERVICE SHEET 9 — OSCILLATOR — AUTOMATIC LEVELING CONTROL (ALC) CIRCUITS (P/O A5)

TROUBLESHOOTING HELP

- Block Diagram..Service Sheet BD3
- Oscillator and Output Attenuator Adjustment.............. Paragraph 5-15

PRINCIPLES OF OPERATION

General

This portion of the Oscillator Assembly (A5) contains the ALC circuitry which senses the level of the output and injects into the oscillator circuitry a signal of proper phase and amplitude to correct for any error in the Oscillator output level.

Sample-and-Hold Circuits

The output of the sample-and-hold circuits is a dc voltage equal to the positive peak of the Oscillator output. The sample switch, FET Q16, of Sample-and-Hold 1 is driven in quadrature with the signal which is to be sampled. The quadrature drive comes from Integrator 2 of the Oscillator (see Service Sheet 8) via the Zero-Crossing Detector. The Zero-Crossing Detector produces a low output whenever its input is less than 0V. R67 and R70 provide a small amount of hysteresis to assure a rapid and complete output transition once it begins. The output is inverted by NOR gate U1B and translated to a level compatible with Q16 by U8D. A low on the output of U8D (−15V) turns Q16 off; a high (output off) permits Q16 to be turned on by the low gate-to-source resistance of R84.

The signal to be sampled comes from Integrator 1 of the Oscillator. It is buffered by a unity-gain amplifier, U9 and Q2. Q2 boosts the current-drive capability of the amplifier since it must drive a capacitor, C39, when Q16 is on. Sampling begins at the negative peak of the input signal and continues to the positive peak when Q16 shuts off—holding the signal peak on C39. (CR5 actually clamps the negative level to −0.6V.) The circuit thus performs a track-and-hold function. The peak dc voltage is buffered by a high-impedance, unity-gain amplifier, U13.

The sampled peak is further sampled by Sample-and-Hold 2. The sample-and-hold switch, FET Q15, is also driven by the quadrature signal, but the length of the drive pulse is shortened to 35 μs or less by U1C. Monostable multivibrator U7A is triggered by the quadrature signal. Its duration is 35 μs. Its low-true output is combined with the quadrature signal in NOR gate U1C. Should the half-period of the quadrature signal be less than 35 μs, U7A is retriggered before its timing is completed. The output pulses of U1C, then, have a duration less than 35 μs.

The output from U1C is translated to a level compatible with Q15 by U8C (similar to U8D). A signal out of phase with the output to the gate of Q15 is fed through C46 to cancel the turn-on spikes created by the junction capacitances of Q15. The guard traces surrounding the ungrounded nodes of C39 and C45 hold the surrounding printed circuit board area at a potential that is approximately equal to the level being held on the capacitors. Leakage currents, caused by potential differences near the capacitors, thus flow to the guard trace and to the output of U13 or U14 rather than to the capacitor. The sampled output is buffered by U14.

Level Error Amplifiers and Level Setting Multiplier

The ac signal from the Oscillator is fed into one input (−X) of the Level Setting Multiplier (U6, U12A, and associated components). The multiplier, U6, acts as a variable-gain amplifier. The gain of the multiplier is proportional to the difference in voltage between the two Y inputs. The sense of the gain (i.e., inverting or non-inverting) is determined by the sign of the difference in the two voltages.

SERVICE SHEET 9 (Cont'd)

The dc output of the sampler, which is equal to the peak of the ac signal from the Oscillator, is compared to a Reference. The difference between the dc level and the Reference is amplified by the Proportional Error Amplifier, U10B, and is fed into the −Y input of the multiplier. U10B has a gain of 2. (The ALC circuit is designed to react to a change in level in less than one cycle of the input signal.)

The level error voltage from U10B is also integrated and inverted by the Error Integrator, U15, and fed into the +Y input of the multiplier. This integrator gives the ALC loop high gain for long-term level accuracy. It, however, reacts slowly to level errors. The input to the Error Integrator is applied only briefly (for 35 μs or less) each cycle by FET Q3. This provides an integral function over most of the frequency range of the Oscillator.

The overall gain of the multiplier is further controlled by the current into the K input. This current is produced by common-base stage Q1. The current is proportional to the voltage at the output of U14. The additional control holds the gain of the ALC loop more nearly constant as a function of level. This is particularly important when large amplitude perturbations occur such as when the Oscillator range is changed.

The output of the multiplier is a current. U12A forms a transresistance amplifier which converts the differential current to a single-ended voltage. The output drives the Sum Amplifier of the Oscillator (see Service Sheet 8).

Reference

The Reference produces a temperature-stable voltage which the Proportional Error Amplifier compares with the dc voltage from Sample-and-Hold 2. The voltage is derived from voltage reference diode VR5. The voltage across R98 and R102 is the same as across VR5. The current produced in these resistors flows into R97 and produces a constant voltage. The voltage at the output of U10A is equal to the voltage across R97, R98, and R102 and is set (by adjustment of R102) to equal twice the desired peak voltage of the Oscillator.

Oscillator Restart

Monostable multivibrator U7B is normally retriggered by the signal from the Oscillator (via the Zero-Crossing Detector). If the input frequency drops below 5 Hz (corresponding to a period of 200 ms), U7B times out and switches on FET Q34 (via Q33 and Q32). This pulls the non-inverting (+) input of U10B down to approximately 2.4V–the voltage across VR3. The abnormally low voltage at U10B creates a large error which, by the action of the ALC loop, restarts the Oscillator. (The Oscillator is assumed to be stopped if the frequency is below 5 Hz.)

SERVICE SHEET 9 (Cont'd)

TROUBLESHOOTING

General

Procedures for checking the Oscillator Assembly are given below. The circuits or points to check are marked on the schematic diagram by a hexagon with a check mark and a number inside, e.g., ⟨√3⟩. In addition, any points outside the labeled circuit area that must be checked are also identified. Fixed signals are shown on the schematic also inside a hexagon, e.g., ⟨+1.9 to +2.1 Vdc⟩. Extend the board assembly where necessary to make measurements. These procedures assume that the measurement circuits of the instrument (e.g., AC LEVEL and frequency) are working properly.

Equipment

Oscilloscope ....HP 1740A

⟨√1⟩ Oscillator Leveling Check

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Short A5TP9 (ALC) to A5TP6 (OSC 1).

2. Connect a high-impedance, dc coupled oscilloscope to A5TP2 (S/H GATE). The waveform should be a TTL square wave with a period of approximately 1 ms.

Hint: If no signal is present, check A5TP8 (OSC 2). The waveform should be a sine wave with an amplitude between 12 and 13 Vpp. If no signal is present, see Service Sheet 8 and check Oscillator tuning. If signal is present at A5TP8 but at the wrong level, continue on with the following steps.

Hint: If signal is present but at the wrong frequency, see Service Sheet 8 and check Oscillator tuning.

3. Connect the oscilloscope to pin 2 of U9. The waveform should be as shown in Figure 8-77.

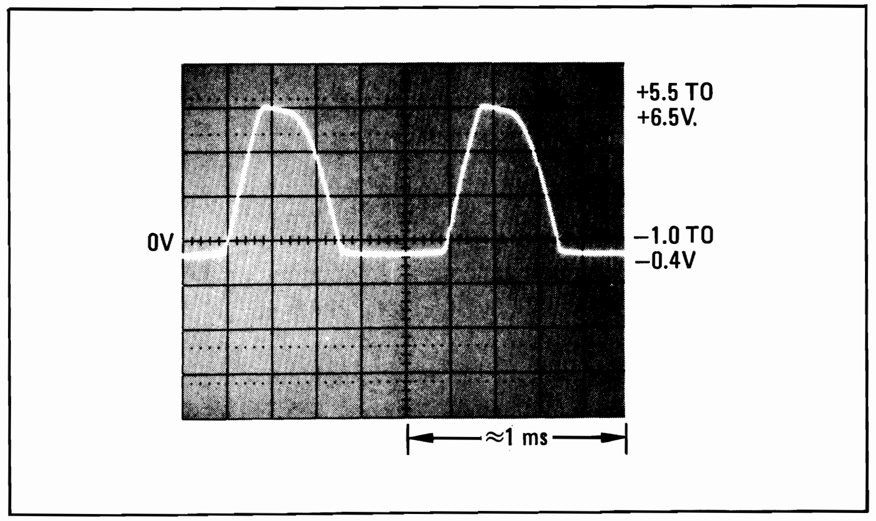


Figure 8-77. Oscillator Leveling Check Waveform A

SERVICE

4. Conne
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5. Conn
be as sho

6. Conn
be as sho

7. Conn
should be
at A5TP

8. Conn
between

Hint: If t
and Outp

sense of the gain (i.e.,
d by the sign of the dif-

qual to the peak of the ac
to a Reference. The dif-
rence is amplified by the
is fed into the –Y input of
ALC circuit is designed to
cycle of the input signal.)

ntegrated and inverted by
+Y input of the multiplier.
gain for long-term level
el errors. The input to the
r 35 μs or less) each cycle
unction over most of the

r controlled by the current
y common-base stage Q1.
at the output of U14. The
e ALC loop more nearly
ticularly important when
h as when the Oscillator

nt. U12A forms a trans-
differential current to a
the Sum Amplifier of the

stable voltage which the
with the dc voltage from
ed from voltage reference
102 is the same as across
stors flows into R97 and
e at the output of U10A is
and R102 and is set (by
esired peak voltage of the

y retriggered by the signal
ng Detector). If the input
ng to a period of 200 ms),
(via Q33 and Q32). This
B down to approximately
nally low voltage at U10B
of the ALC loop, restarts
ned to be stopped if the

TROUBLESHOOTING

General

Procedures for checking the Oscillator Assembly are given below. The circuits or points to check are marked on the schematic diagram by a hexagon with a check mark and a number inside, e.g., ⟨√3⟩. In addition, any points outside the labeled circuit area that must be checked are also identified. Fixed signals are shown on the schematic also inside a hexagon, e.g., ⟨+1.9 to +2.1 Vdc⟩. Extend the board assembly where necessary to make measurements. These procedures assume that the measurement circuits of the instrument (e.g., AC LEVEL and frequency) are working properly.

Equipment

Oscilloscope ....HP 1740A

⟨√1⟩ Oscillator Leveling Check

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Short A5TP9 (ALC) to A5TP6 (OSC 1).

2. Connect a high-impedance, dc coupled oscilloscope to A5TP2 (S/H GATE). The waveform should be a TTL square wave with a period of approximately 1 ms.

Hint: If no signal is present, check A5TP8 (OSC 2). The waveform should be a sine wave with an amplitude between 12 and 13 Vpp. If no signal is present, see Service Sheet 8 and check Oscillator tuning. If signal is present at A5TP8 but at the wrong level, continue on with the following steps.

Hint: If signal is present but at the wrong frequency, see Service Sheet 8 and check Oscillator tuning.

3. Connect the oscilloscope to pin 2 of U9. The waveform should be as shown in Figure 8-77.

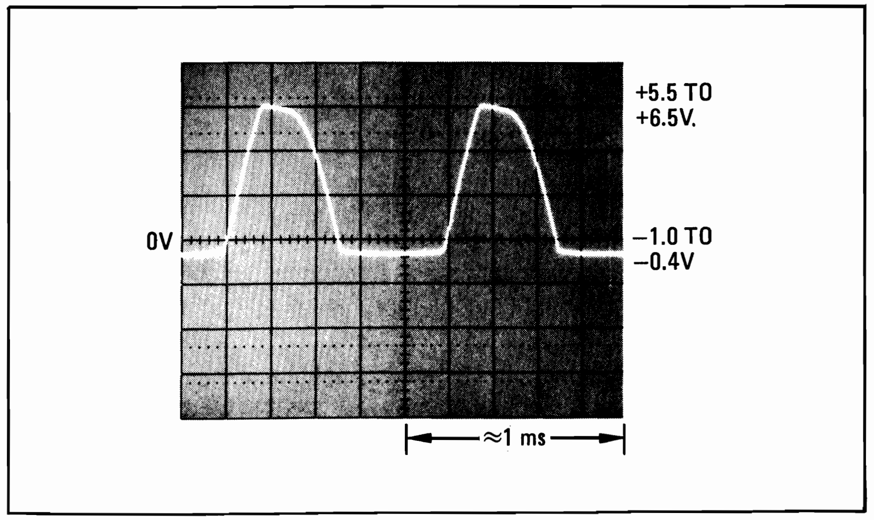


Figure 8-77. Oscillator Leveling Check Waveform A

4. Connect the oscilloscope to pin 14 of U8D. The waveform should be as shown in Figure 8-78.

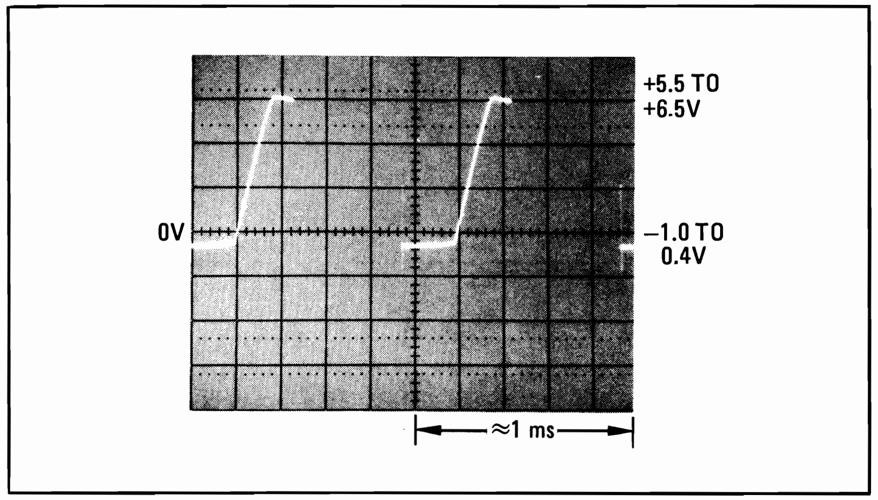


Figure 8-78. Oscillator Leveling Check Waveform B

5. Connect the oscilloscope to A5TP3 (S/H). The waveform should be as shown in Figure 8-79.

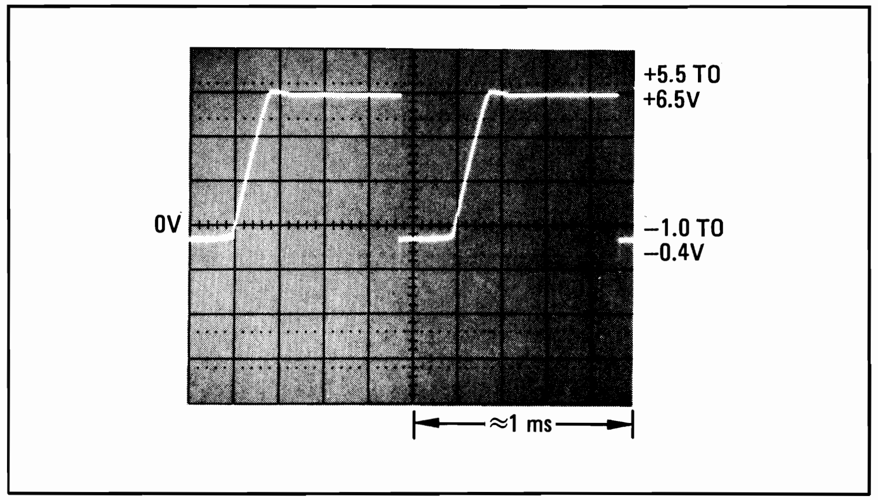


Figure 8-79. Oscillator Leveling Check Waveform C

6. Connect the oscilloscope to pin 13 of U8C. The waveform should be as shown in Figure 8-80.

7. Connect the oscilloscope to A5TP7 (V PEAK). The waveform should be a dc signal with a level equal to the peak level of the signal at A5TP3 (see step 5).

8. Connect the oscilloscope to pin 1 of U10A. The dc level should be between +8.2 and +8.6 Vdc.

Hint: If the level is only slightly out of limits, perform the Oscillator and Output Attenuator Adjustment, paragraph 5-15.

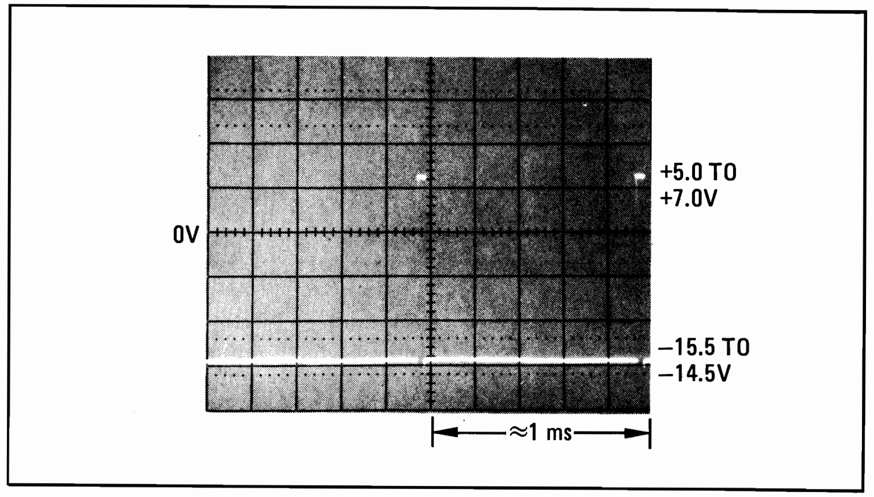


Figure 8-80. Oscillator Leveling Check Waveform D

9. Connect the oscilloscope to A5TP5 (PROP ERROR). The dc level should be between +3.2 and +3.7 Vdc.

Hint: If the level is faulty, measure the voltage at pin 5 of U10B. It should be the same as that observed in step 8. If it is not, also check pin 5 of U7B; it should be a TTL high; Q32 and Q33 should be on; and Q34 should be off. (If Q34 is on, pin 5 of U10B will be approximately +2.3 Vdc and the output of U10B, if working properly, will be approximately -3.7 Vdc.)

10. Connect the oscilloscope to A5TP11 (INT ERROR). The waveform should be as shown in Figure 8-81.

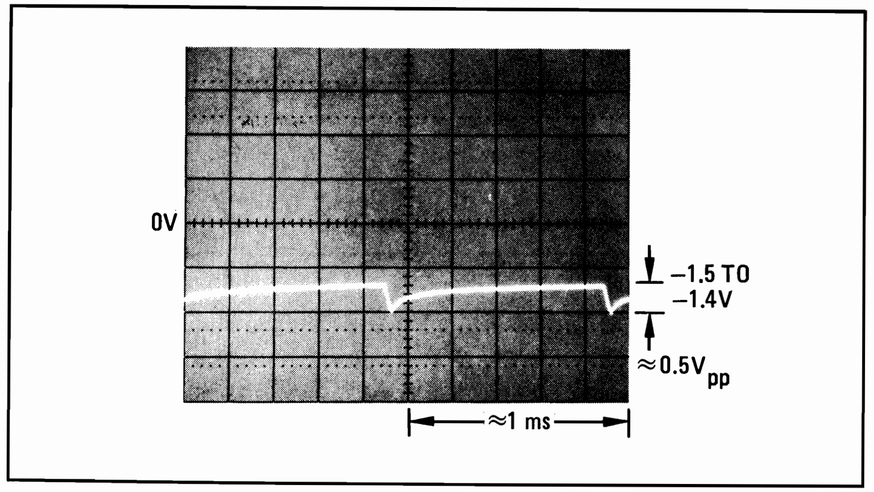


Figure 8-81. Oscillator Leveling Check Waveform E

Hint: The waveform at pin 2 of U8B should be pulses with a 1 ms period, width approximately 35 μs, upper peak approximately +3V, and lower peak approximately –15V.

SERVICE SHEET 9 (Cont'd)

11. Connect the oscilloscope to pin 1 of U12A. The waveform should be as shown in Figure 8-82.

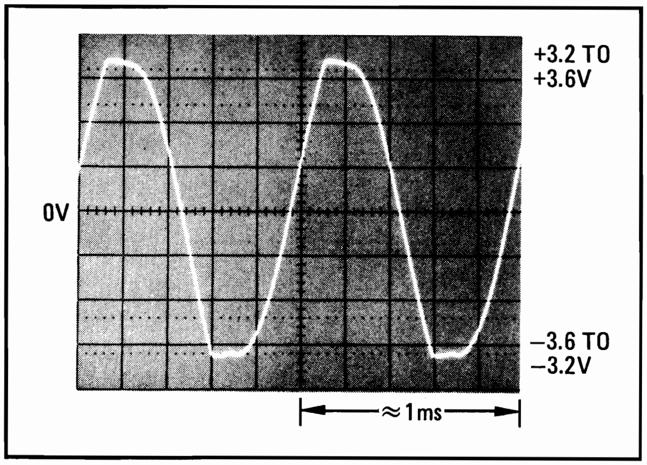


Figure 8-82. Oscillator Leveling Check Waveform F

Hint: The voltage at pin 2 of U6 should be approximately +10 Vdc with an ac waveform superimposed having an amplitude of 0.8 Vpp. (The shape of the waveform should be the same as shown above.) The voltage at pin 14 of U6 should be approximately +10 Vdc with an ac waveform superimposed having an amplitude of 1.7 Vpp. The output of U12A should equal 2.6 times the difference in voltage between pin 14 and pin 2 of U6. (Note that the ac waveform at pins 14 and 2 of U6 are out of phase with each other; thus the ac output of U12A is 2.6 times the sum of the peak-to-peak voltages at pin 14 and pin 2 of U6.)

Hint: The voltage drop across R119 should be 2.9 Vdc.

Hint: This step concludes a check of the function of the leveling circuits with the leveling loop open. The following steps check the closed-loop performance.

12. Remove the short between A5TP9 and A5TP6. Connect the oscilloscope to A5TP6. The waveform should be an undistorted sine wave with an amplitude between 8.3 and 8.7 Vpp.

Hint: If the steps up to 11 give positive results, but step 12 is out of limits, the problem may lie with the loop dynamics. Look for RF oscillations in the amplifiers of the loop. If distortion is excesive, check U6.

13. Set the oscilloscope to a slow sweep rate. Short pin 3 of U10A to ground rapidly several times in succession and observe the oscilloscope. When the pin is grounded, the amplitude should drop to about 6 Vpp. When the waveform changes level (either higher or lower), the change should appear to be instantaneous and have less than 0.5V overshoot or undershoot.

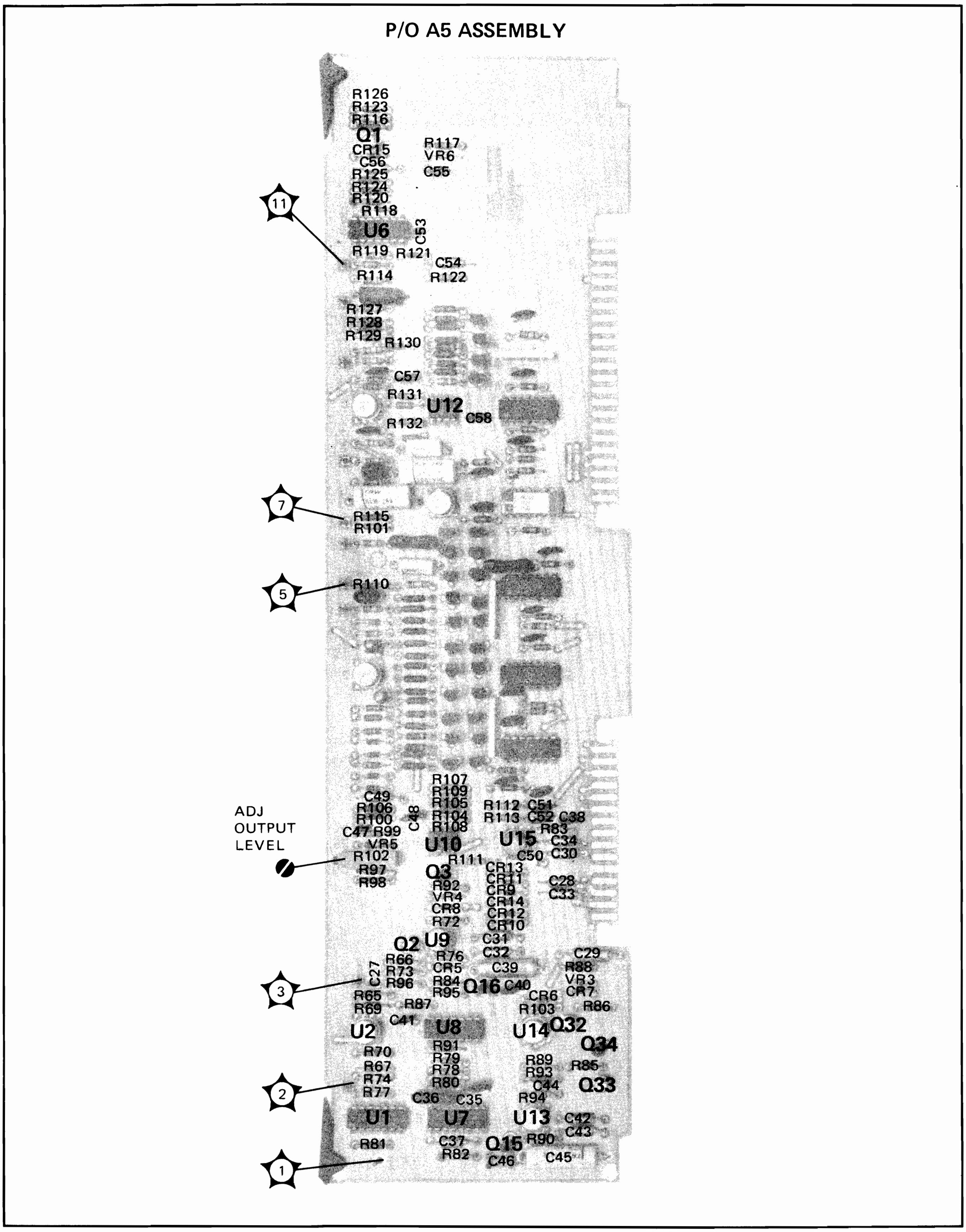
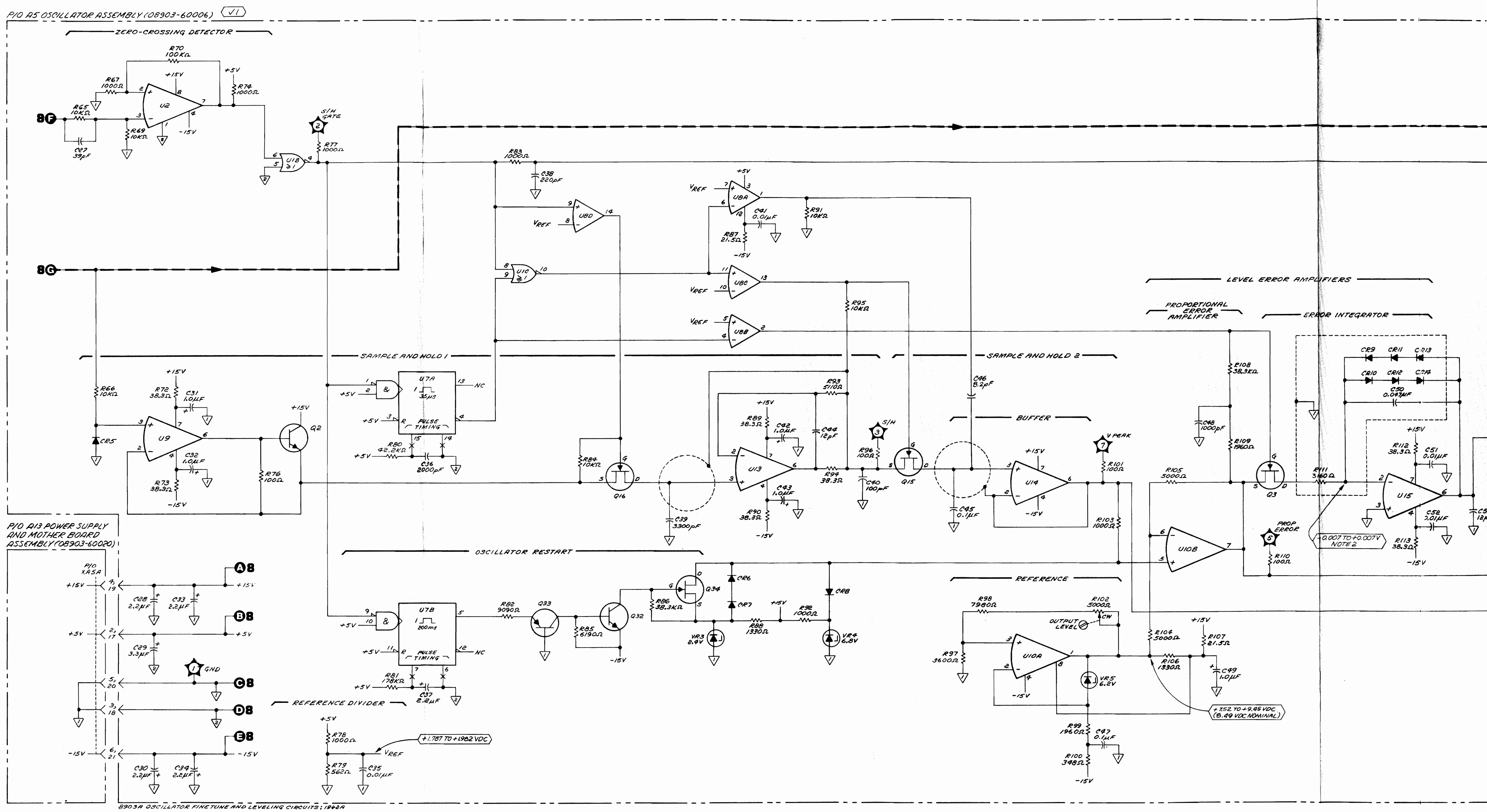
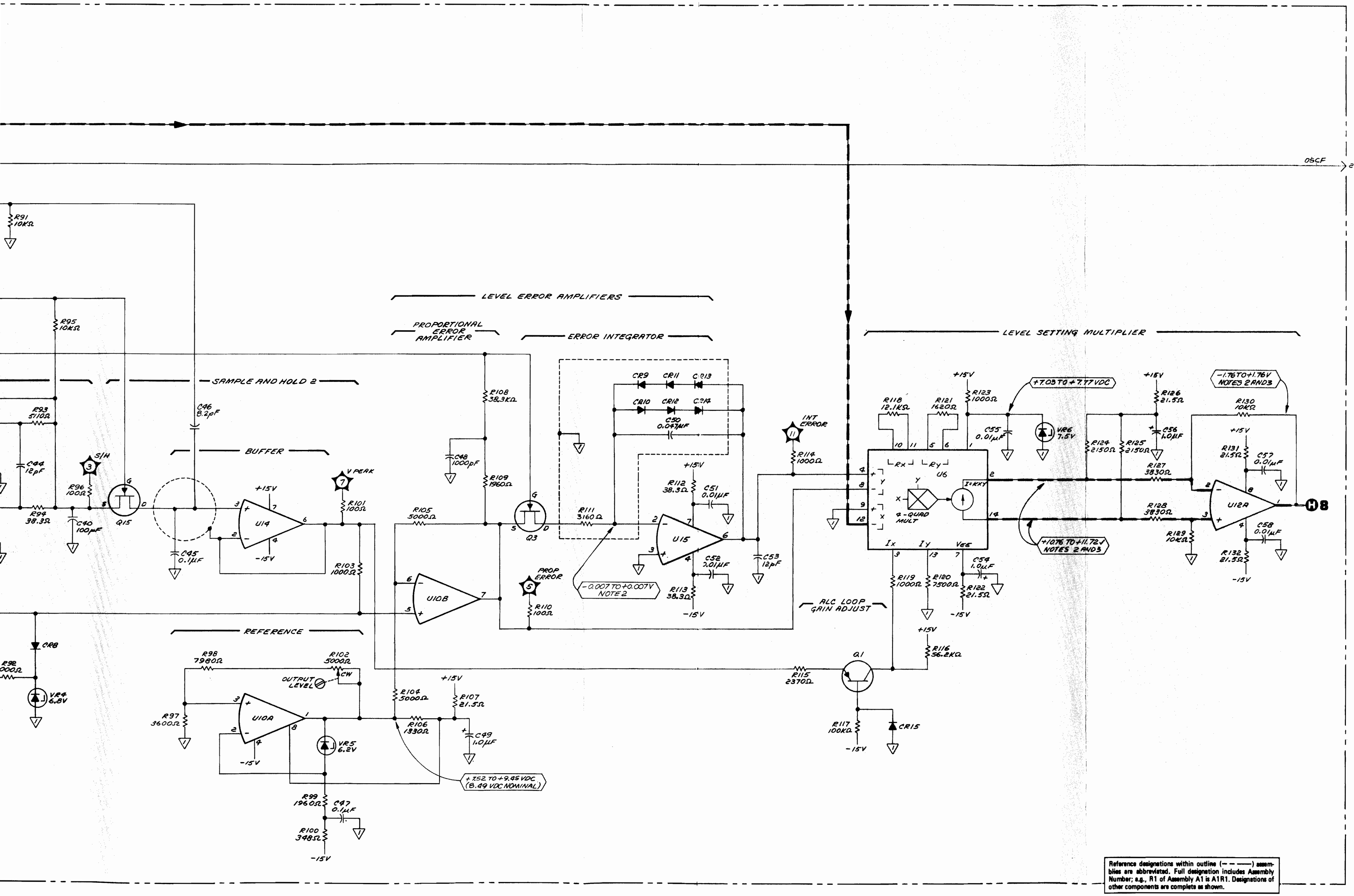


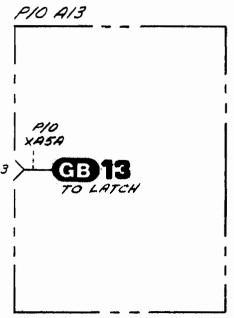
Figure 8-83. P/O A5 Oscillator Assembly Component Locations (ALC Circuits)



8903A OSCILLATOR FINE TUNE AND LEVELING CIRCUITS: 1942A



Reference designations within outline (— — ——) assemblies are abbreviated. Full designation includes Assembly Number; e.g., R1 of Assembly A1 is A1R1. Designations of other components are complete as shown.



NOTES

1. SEE TABLE 8-7 SCHEMATIC DIAGRAM NOTES.
2. DECOUPLE PROBE WITH 10K Ω RESISTOR WHEN MEASURING THIS VOLTAGE.
3. GROUND TP9 TO STOP OSCILLATOR WHEN MEASURING THIS VOLTAGE.

REFERENCE DESIGNATIONS

A5	A13
C27-58 CR5-15 Q1-3,15,16,32-34 R65-67,69,70,72-74,76-132 TP1-3,5,7,11 U1,2,6-10,12-15 VR3-6	XA5A

NOT ASSIGNED: A5R68, 71, 75, U3

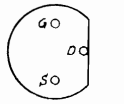
LOGIC LEVELS

	TTL
HIGH	>2V
LOW	<0.8V
< IS MORE NEG. THAN > IS MORE POS. THAN	
OPEN	HIGH
GROUND	LOW

TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATIONS	PART NUMBERS
Q1,33	1853-0281
Q2,32	1854-0477
Q3,15,16,34	1855-0091
U1	1820-1144
U2	1826-0026
U6	1826-0014
U7	1820-1423
U8	1826-0138
U9,13	1826-0371
U10,12	1826-0547
U14,15	1813-0041

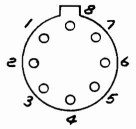
A5Q3,15,16,34 TOP VIEW



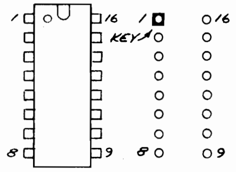
DIGITAL INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

REFERENCE DESIGNATIONS	PIN NUMBERS
U1	+5V - 14 2 - 7
U7	+5V - 16 2 - 8

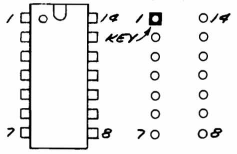
A5U2,3,9,10 12-15 TOP VIEW



A5U7 TOP VIEW — CIRCUIT BOARD TOP VIEW



A5U1,6,8 TOP VIEW — CIRCUIT BOARD TOP VIEW



9
P/O A5

Figure 8-84. Oscillator—ALC Circuits Schematic Diagram

SERVICE SHEET 10 — OUTPUT ATTENUATOR — INPUT CIRCUITS (P/O A6)

TROUBLESHOOTING HELP

- Block Diagram ....Service Sheet BD3
- Oscillator and Output Attenuator Adjustment .... Paragraph 5-15

PRINCIPLES OF OPERATION

General

This portion of the Output Attenuator Assembly (A6) contains a programmable-gain amplifier, a programmable attenuator, and a fixed-gain amplifier. The circuits are used to set the Source level in relatively fine steps (2.5 dB or less). The input to the circuit comes from the output of the Oscillator.

Amplifier 1

Amplifier 1 provides gain which is programmable in fine steps. It also can be switched off when an amplitude of 0V is selected or during the noise measurement in the signal-to-noise measurement mode.

When the amplifier is on, FET Q24 is on and Q23 and Q25 are off. Also, one or more of FETs Q15 to Q22 are on and determine the gain of the amplifier. When the amplifier is off, FET Q24 is off and Q23 and Q25 are on. This configuration minimizes the effects of stray capacitance and non-zero on-resistance of the FETs. Figure 8-85 shows simplified diagrams of the two configurations.

The gain stage of the amplifier consists of a high-impedance differential FET pair, Q10A and Q10B, and U4.

Attenuator A and Amplifier 2

Attenuator A is a voltage divider which can be programmed in 2.5 dB steps from 0 to 7.5 dB. The dividers are switched by the bi-directional switches of U5. Amplifier 2 has a fixed gain of +2.

TROUBLESHOOTING

General

Procedures for checking the Output Attenuator Assembly are given below. The circuits or points to check are marked on the schematic diagram by a hexagon with a check mark and a number inside, e.g., ⟨√3⟩. In addition, any points outside the labeled circuit area that must be checked are also identified. Fixed signals are shown on the schematic also inside a hexagon, e.g., ⟨+1.9 to +2.1 Vdc⟩. Extend the board assembly where necessary to make measurements. These procedures assume that the measurement circuits of the instrument (e.g., AC LEVEL and frequency) are working properly.

Equipment

Oscilloscope ....HP 1740A

⟨√1⟩ Amplifier and Attenuator Check

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Connect a high-impedance, ac coupled oscilloscope to A5TP6 (OSC 1). The waveform should be sinusoidal with a period of approximately 1 ms and an amplitude between 8.3 and 8.7 Vpp.

Hint: If the signal is faulty, see Service Sheet 8 and check the Oscillator tuning.

2. Connect the oscilloscope to A6TP6 (AMP 1). On the Audio Analyzer, key in 59.0 SPCL to switch Amplifier 1 on. Key in 58.255 SPCL to set the gain of Amplifier 1 to maximum. The waveform should be between 9.8 and 10.2 Vpp.

Hint: If the level is incorrect but is between 4.9 and 10.2 Vpp, continue with the following step to determine which FET switch is not being switched in.

Hint: The gates of FETs Q15 through Q22 and Q24 should be 0 Vdc and the FETs should be on. The gates of FETs Q23 and Q25 should be −15 Vdc and the FETs should be off.

3. On the Audio Analyzer, key in the Special Functions listed in Table 8-55. For each setting, connect the oscilloscope to the drain of the FET indicated. A signal of several volts peak-to-peak should be present when the Special Function is keyed in, but not when 58.255 SPCL is keyed in. If the signal is faulty, also check the control lines indicated. (All control lines should be 0 Vdc for 58.255 SPCL.)

Table 8-55. Voltage Levels at A6U8 and A6U9

Special Function	FET to Check	Level (Vdc) at							
		U9-13	U9-1	U9-14	U8-13	U9-2	U8-1	U8-14	U8-2
58.127	Q21	−15	0	0	0	0	0	0	0
58.191	Q20	0	−15	0	0	0	0	0	0
58.223	Q22	0	0	−15	0	0	0	0	0
58.239	Q18	0	0	0	−15	0	0	0	0
58.247	Q19	0	0	0	0	−15	0	0	0
58.251	Q16	0	0	0	0	0	−15	0	0
58.253	Q17	0	0	0	0	0	0	−15	0
58.254	Q15	0	0	0	0	0	0	0	−15

Hint: This step concludes a check of the functioning of the fine level setting circuits. If the fault is a slight level error as observed in the Output Attenuator Check of Service Sheet BD3, the faulty resistor or FET switch can be ascertained by noting which Special Functions give correct readings and which do not. Table 8-56 should assist in correlating the Special Functions and switches.

4. On the Audio Analyzer, key in FREQ 100 kHz. Key in 59.63 SPCL to switch Amplifier 1 off. Connect the oscilloscope to A6TP6. (No divider probe should be used for this step in order to obtain maximum sensitivity.) None of the 100 kHz signal should be observable on the oscilloscope.

SERVICE SHEET 10 (Cont'd)

Hint: The gates of FETs Q23 and Q25 should be 0 Vdc and the FETs should be on. The gate of FET Q24 should be −15 Vdc and the FET should be off.

Table 8-56. Special Function 58.N Vs. Switch Closed

Special Function	Switch Closed
58.128	Q21
58.64	Q20
58.32	Q22
58.16	Q18
58.8	Q19
58.4	Q16
58.2	Q17
58.1	Q15

5. On the Audio Analyzer, set the HIGH INPUT switch to ground. Key in FREQ 1 kHz. Key in 59.0 SPCL. Key in 58.255 SPCL. Connect the HIGH INPUT to A6TP6.

6. On the Audio Analyzer, press RATIO. Connect the HIGH INPUT to A6TP5 (AMP 2). The relative amplitude should be between 151.2 and 154.2%.

Hint: Pin 3 of U3 should read between 75.5 and 77.2% on the Audio Analyzer. Pin 16 of U5D should be a TTL low; pins 1, 9, and 8 of U5 should be a TTL high.

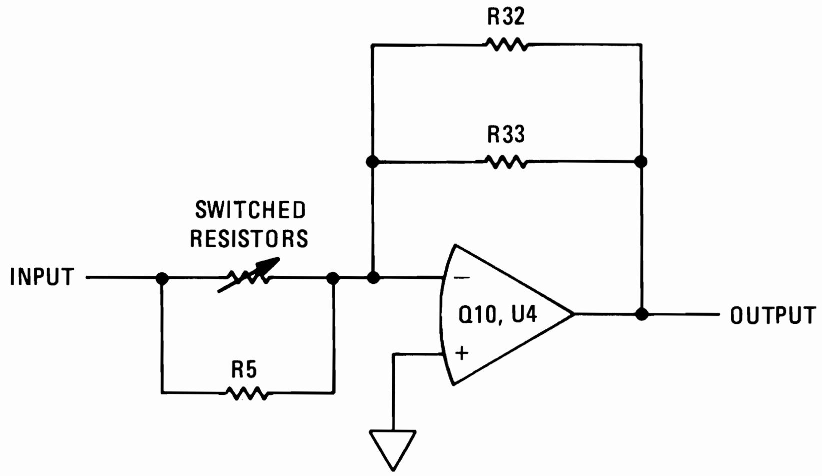
7. On the Audio Analyzer, press RATIO twice to establish a new ratio reference. Press LOG/LIN. Key in the Special Functions listed in Table 8-57. For each setting, the relative amplitude should read within the limits indicated. If the signal is faulty, also check the control lines indicated.

Table 8-57. TTL Levels at A6U5

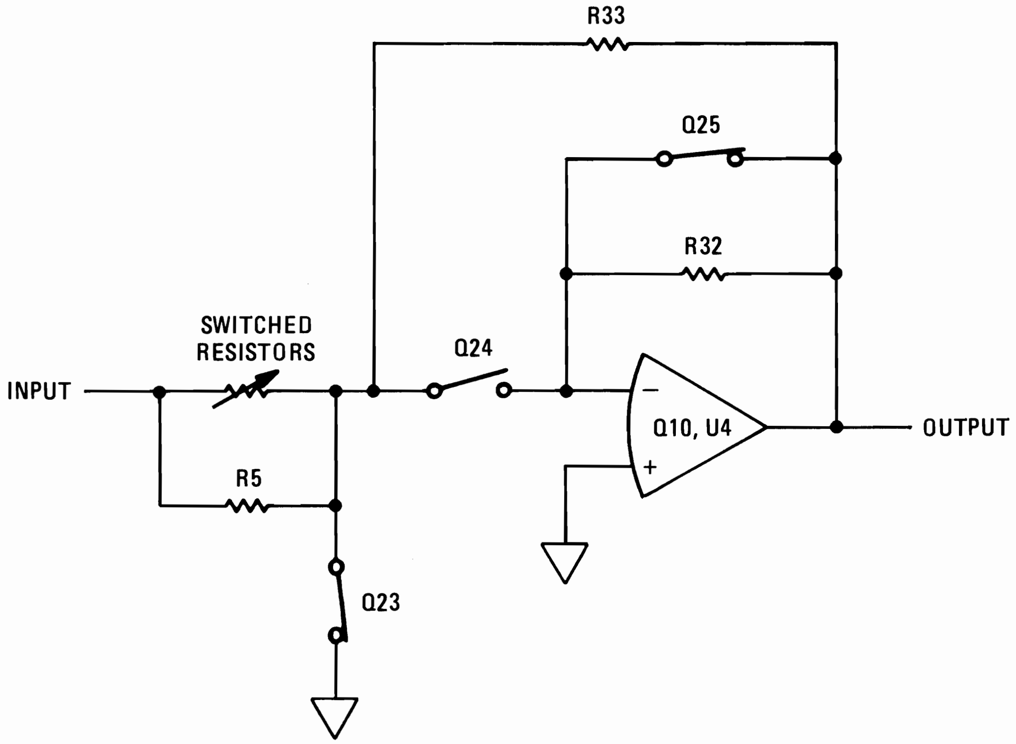
Special Function	Relative Amplitude (dB)	Level (TTL) at U5 Pin			
		16	1	9	8
59.1	−2.6 to −2.4	H	L	H	H
59.2	−5.1 to −4.9	H	H	L	H
59.3	−7.6 to −7.4	H	H	H	L

Hint: If the control lines are incorrect, also check the decoding of U6.

Oscillator — ALC Circuits
P/O A5
SERVICE SHEET 9



AMPLIFIER ON



AMPLIFIER OFF

Figure 8-85. Simplified Diagram of Amplifier 1

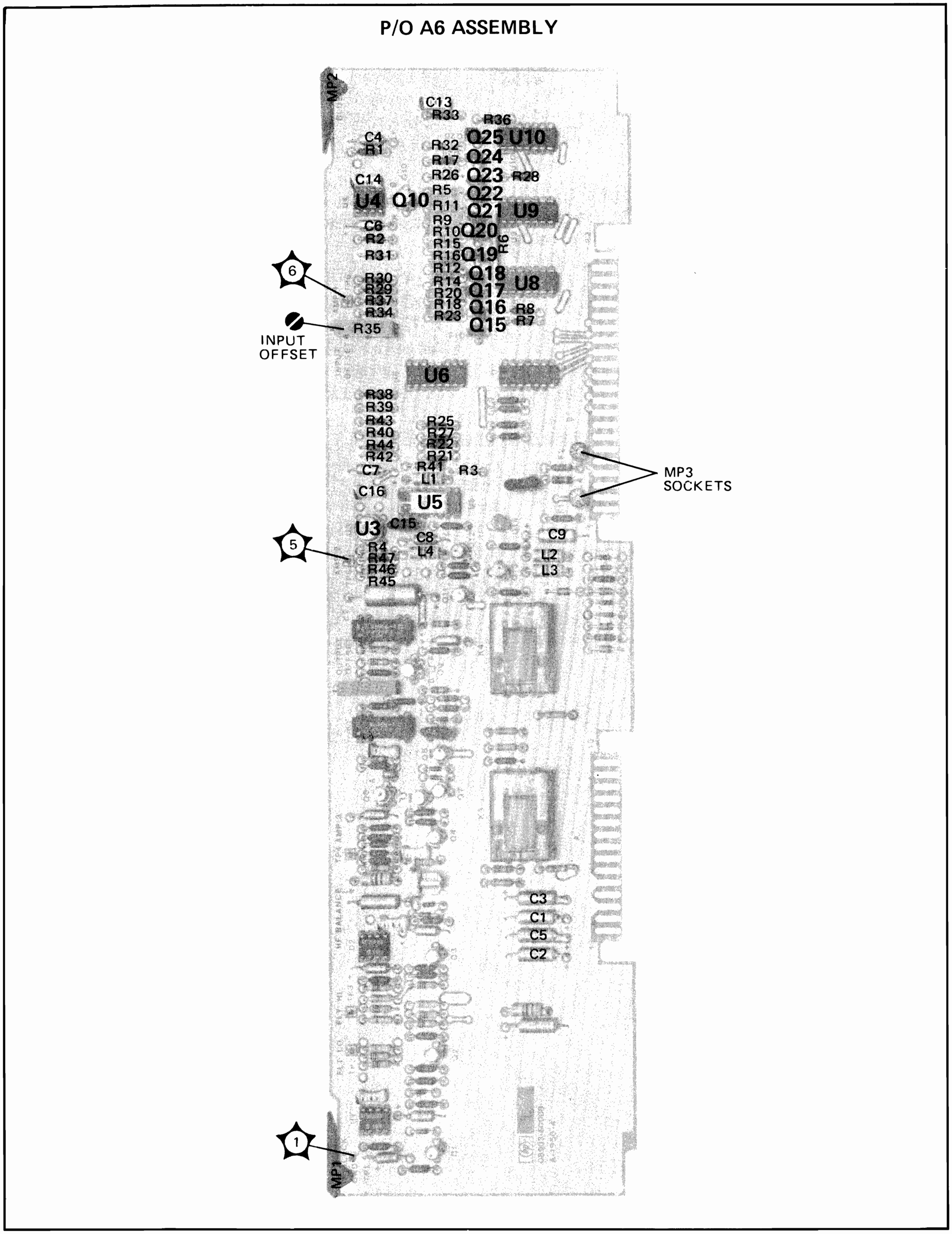
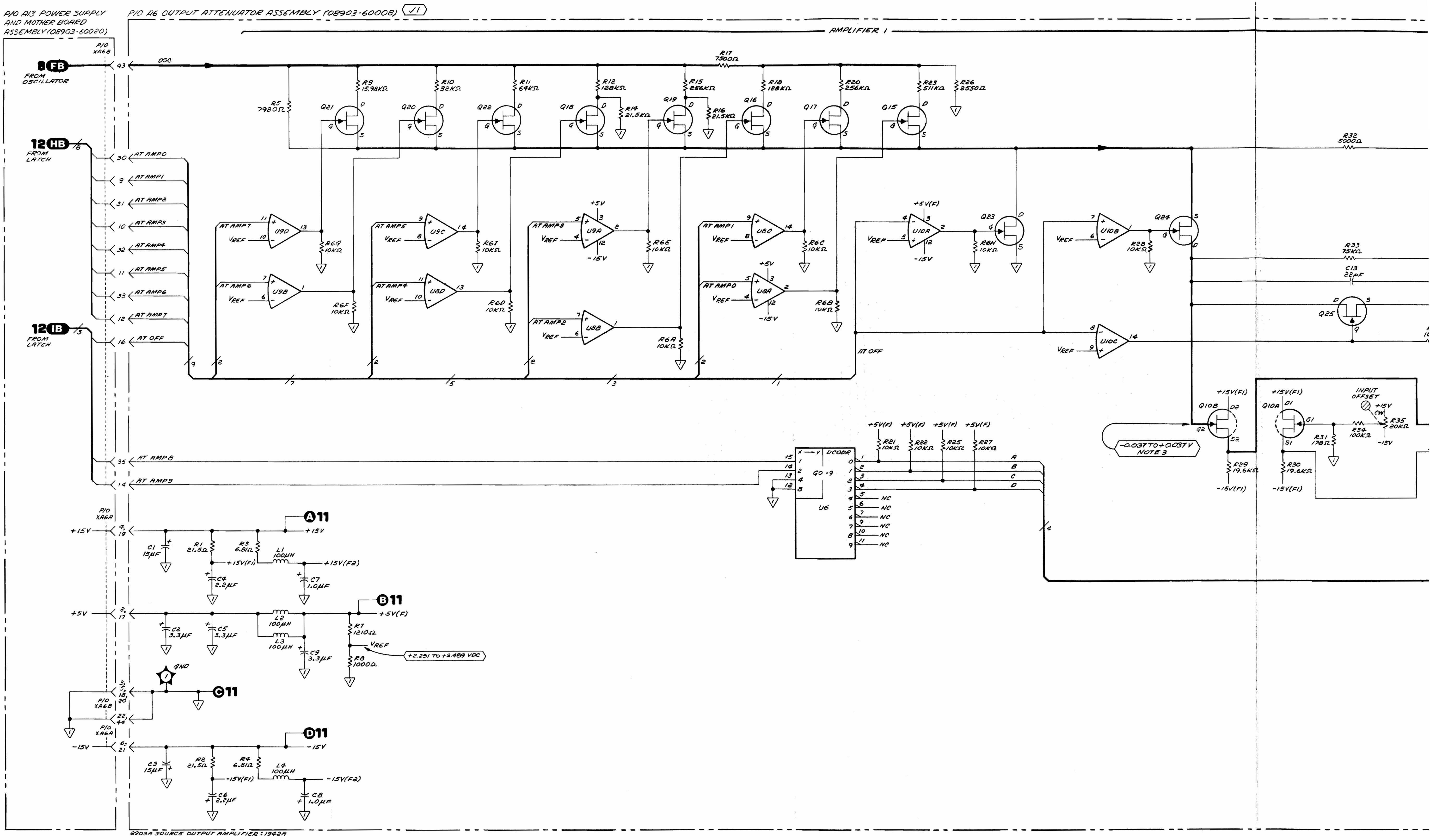
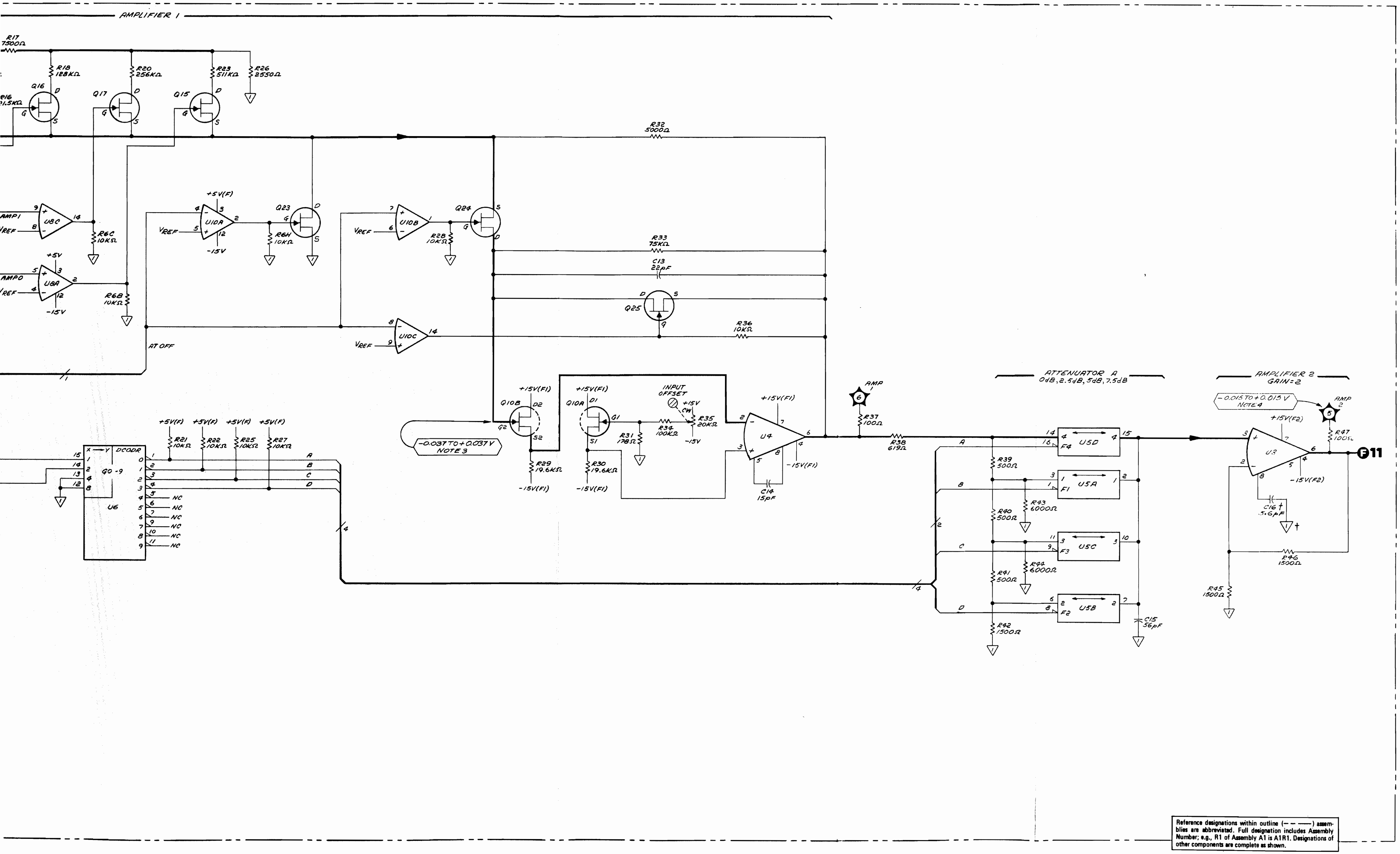


Figure 8-86. P/O A6 Output Attenuator Assembly Component Locations (Input Circuits)



8903A SOURCE OUTPUT AMPLIFIER : 1942A



Reference designations within outline (— — ——) assemblies are abbreviated. Full designation includes Assembly Number; e.g., R1 of Assembly A1 is A1R1. Designations of other components are complete as shown.

NOTES

1. SEE TABLE 8-7 SCHEMATIC DIAGRAM NOTES.
2. † INDICATES BACKDATING SEE SECTION VIII.
3. DECOUPLE PROBE WITH 10KΩ RESISTOR WHEN MEASURING THIS VOLTAGE.
4. MEASURED AT AMPLITUDE 0 VOLTS.

REFERENCE DESIGNATIONS

A6	A13
C1-9, 13-16 L1-4 Q10, 15-25 R1-12, 14-18, 20-23, 25-47 TP1, 5, 6 U3-6, 8-10	XA6A, B

NOT ASSIGNED: A6C10-12, R13, 19, 24

LOGIC LEVELS

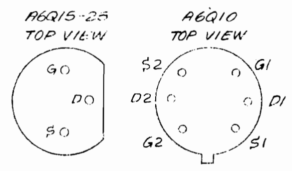
	TTL
HIGH	>2V
LOW	<0.8V
< IS MORE NEG. THAN > IS MORE POS. THAN	
OPEN	HIGH
GROUND	LOW

TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATIONS	PART NUMBERS
Q10	1855-0050
Q15-25	1855-0091
U3	1826-0109 †
U4	1826-0569
U5	1826-0582
U6	1820-1418
U8-10	1826-0138

INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

REFERENCE DESIGNATIONS	PIN NUMBERS
U5	+15V(F2) - 13 -15V(F2) - 4 ▽ - 5
U6	+5V(F) - 16 ▽ - 8



A6R6
TOP VIEW

PIN NO.	1	2	3	4	5	6	7	8	9	10
	COMMON	A	B	C	D	E	F	G	H	I

10
P/O A6

Figure 8-87. Output Attenuator—Input Circuits Schematic Diagram

SERVICE SHEET 11 — OUTPUT ATTENUATOR — OUTPUT CIRCUITS (P/O A6)

TROUBLESHOOTING HELP

- Block Diagram ....Service Sheet BD3
- Oscillator and Output Attenuator Adjustment .... Paragraph 5-15

PRINCIPLES OF OPERATION

General

This portion of the Output Attenuator Assembly (A6) contains the Output Amplifier Driver, Floating Output Amplifier, and output attenuator. The circuits are used to set the Source level in coarse (10 dB) steps. The output is floating (i.e., not referenced to ground) unless chassis switch S2 is closed.

Output Amplifier Driver

The Output Amplifier Driver is an active attenuator with a programmable gain of 0 to -30 dB in 10 dB steps. The amplifier also inverts the input. The gain of the amplifier is summarized in Table 8-58, which also shows how the gain is determined.

Table 8-58. Gain of the Output Amplifier Driver

State of K1	State of K2	Gain (dB)	Gain Equation (Linear)
Open	Closed	0	-(R65+R54)/R53
Open	Open	-10	-(R65+R54)/(R52+R53)
Closed	Closed	-20	-R54/R53
Closed	Open	-30	-R54/(R52+R53)

The gain block consists of a discrete, high-gain inverting amplifier. FET pair Q9 is the differential input amplifier which drives an intermediate differential pair, Q5. Q7 gives the intermediate stage a push-pull, complementary output. The output stage, Q6 and Q8, is also complementary and push-pull. Diodes CR2 and CR3 set the quiescent current in R68 and R69 and thermally compensate the base-emitter junctions of Q6 and Q8. R62 can be adjusted to set the dc output voltage of the amplifier to 0V.

Floating Output Amplifier

The Floating Output Amplifier is a single-ended-to-differential converter. Conversion is accomplished by a precise combination of negative feedback, positive feedback, and cross-coupling which yields a symmetrical differential output with high common-mode rejection and a well-defined output impedance. The complexity of the circuit makes detailed analysis difficult. (For a more detailed discussion see *Hewlett-Packard Journal*, Aug.1980, pp. 12,13.)

Current booster stages, Q1 to Q4, are added to the differential amplifiers (U1 and U2) to provide sufficient output drive. C31 is adjusted for optimum common-mode rejection at 100 kHz where the RFI rejection components (C32, A13C13, and A13C14) and stray circuit capacitance upset the circuit balance. R96 adds enough resistance to the amplifier's output to bring the total impedance to 600Ω. R111 references the amplifier at ground potential when the output jacks are floating.

Output Circuits

Output Attenuator B has two 20 dB, floating-pi sections. The sections are switched by relays K3 and K4. The Voltage Clamp consists of two sections which clamp the level at approximately +11 or -11V. F1 and F2 further protect the output.

TROUBLESHOOTING

General

Procedures for checking the Output Attenuator Assembly are given below. The circuits or points to check are marked on the schematic diagram by a hexagon with a check mark and a number inside, e.g., √3. In addition, any points outside the labeled circuit area that must be checked are also identified. Fixed signals are shown on the schematic also inside a hexagon, e.g., +1.9 to +2.1 Vdc. Extend the board assembly where necessary to make measurements. These procedures assume that the measurement circuits of the instrument (e.g., AC LEVEL and frequency) are working properly.

Equipment

Oscilloscope ....HP 1740A

√1 Output Amplifier Driver Check

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the HIGH INPUT switch to ground. Key in 58.255 SPCL and 59.0 SPCL to preset the SOURCE amplitude. Connect the HIGH INPUT to A6TP5 (AMP 2). The amplitiude display should read between 5.3 and 5.4 Vrms.

Hint: If the signal is faulty, see Service Sheet 10 and check the output circuits.

2. On the Audio Analyzer, press RATIO. Press LOG/LIN. Connect the HIGH INPUT to A6TP4 (AMP 3). Key in the Special Functions listed in Table 8-59. For each setting, the relative amplitude should read within the limits indicated. If the signal is faulty, also check the relay drivers indicated.

Table 8-59. Output Amplifier Driver Check

Special Function	Relative Amplitude (dB)	Level (Vdc) at	
		Q12-c	Q11-c
59.0	-0.05 to +0.05	0	0
59.4	-10.06 to -9.94	0	+4.5 to +5.2
59.24	-20.06 to -19.94	+4 to +5	0
59.28	-30.06 to -29.94	+4 to +5	+4.5 to +5.2

√2 Floating Output Amplifier Check

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the HIGH INPUT and HIGH OUTPUT switches to ground. Key in FREQ 100 Hz. Key in 58.255 SPCL and 59.0 SPCL to preset the SOURCE amplitude. Connect the HIGH INPUT to A6TP4 (AMP 3). The amplitude display should read between 5.3 and 5.4 Vrms.

Hint: If the signal is faulty, see √1. Output Amplifier Driver Check.

2. On the Audio Analyzer, press RATIO. Connect the HIGH INPUT to A6TP3 (FLT HI). The relative amplitude display should read between 111 and 113%.

Hint: If no signal is present, check U1, U2, and Q1 through Q4. If signal is present but at the wrong level, continue with the following steps. If the signal is correct, continue on at step 10.

3. On the Audio Analyzer, ground the junction of R96 and R93. Connect the HIGH INPUT to the junction of R91 and R92. The relative amplitude should read between 74.7 and 75.3%.

Hint: If the signal is faulty, check R73 and R84. (The amplitude is the ratio R84/R73 expressed in %.)

4. Connect the HIGH INPUT to pin 3 of U1. The relative amplitude should read between 37.1 and 37.4%.

Hint: If the signal is faulty, check R72, R80, and R81. (The amplitude is the ratio R/(R+R72) expressed in % and R is the parallel combination of R80, R81, and the 100 kΩ input resistance.)

5. Connect the HIGH INPUT to the junction of R89 and R90. The relative amplitude should read between 64.7 and 65.7%.

Hint: If the signal is faulty, check R71 and R79. (The amplitude is the ratio of step 4 times 1+R79/R71 expressed in %.)

6. Remove the ground from the junction of R96 and R93. Short R93. Connect the HIGH INPUT to the short of R93. On the Audio Analyzer, press RATIO twice to establish a new reference.

7. Connect the HIGH INPUT to pin 3 of U2. The relative amplitude should read between 30.9 and 31.1%.

Hint: If the signal if faulty, check R74, R82, and R83. (The amplitude is R/(R+R82) expressed in % and R is the parallel combination of R74, R83, and the 100 kΩ input resistance.)

8. Remove the short from R93. Connect the HIGH INPUT to A6TP4. On the Audio Analyzer, press RATIO twice to establish a new reference.

SERVICE SHEET 11 (Cont'd)

9. Connect the HIGH INPUT to A6TP3. The relative amplitude should read between 111 and 112%.

Hint: If the signal is faulty, check R93, R96, R109, and R110.

10. On the Audio Analyzer, set the OUTPUT switch to FLOAT. Ground A6TP3. Connect the HIGH INPUT to the LOW OUTPUT. The relative amplitude should read between 105 and 106%.

Hint: If the signal is faulty, check R94.

⟨√3⟩ Attenuator B Check

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the INPUT and OUTPUT switches to ground. Key in 58.255 SPCL and 59.0 SPCL to preset the SOURCE amplitude. Connect the HIGH INPUT to A6TP3 (FLT HI). The amplitude display should read between 5.9 and 6.0 Vrms.

Hint: If the signal is faulty, see ⟨√2⟩. Floating Output Amplifier Check.

2. On the Audio Analyzer, press RATIO. Press LOG/LIN. Connect the HIGH INPUT to the HIGH OUTPUT. Key in the Special Functions listed in Table 8-60. The relative amplitude should read within the limits indicated. If the signal is faulty, also check the control lines indicated.

Table 8-60. Attenuator B Check

Special Function	Attenuator In	Relative Amplitude (dB)	Level (Vdc) at	
			Q13-c	Q14-c
59.0	None	-0.01 to +0.01	+4 to +5	0
59.8	No. 2	-20.1 to -19.9	0	0
59.16	No. 1 & No. 2	-40.1 to -39.9	0	+4.5 to +5.2

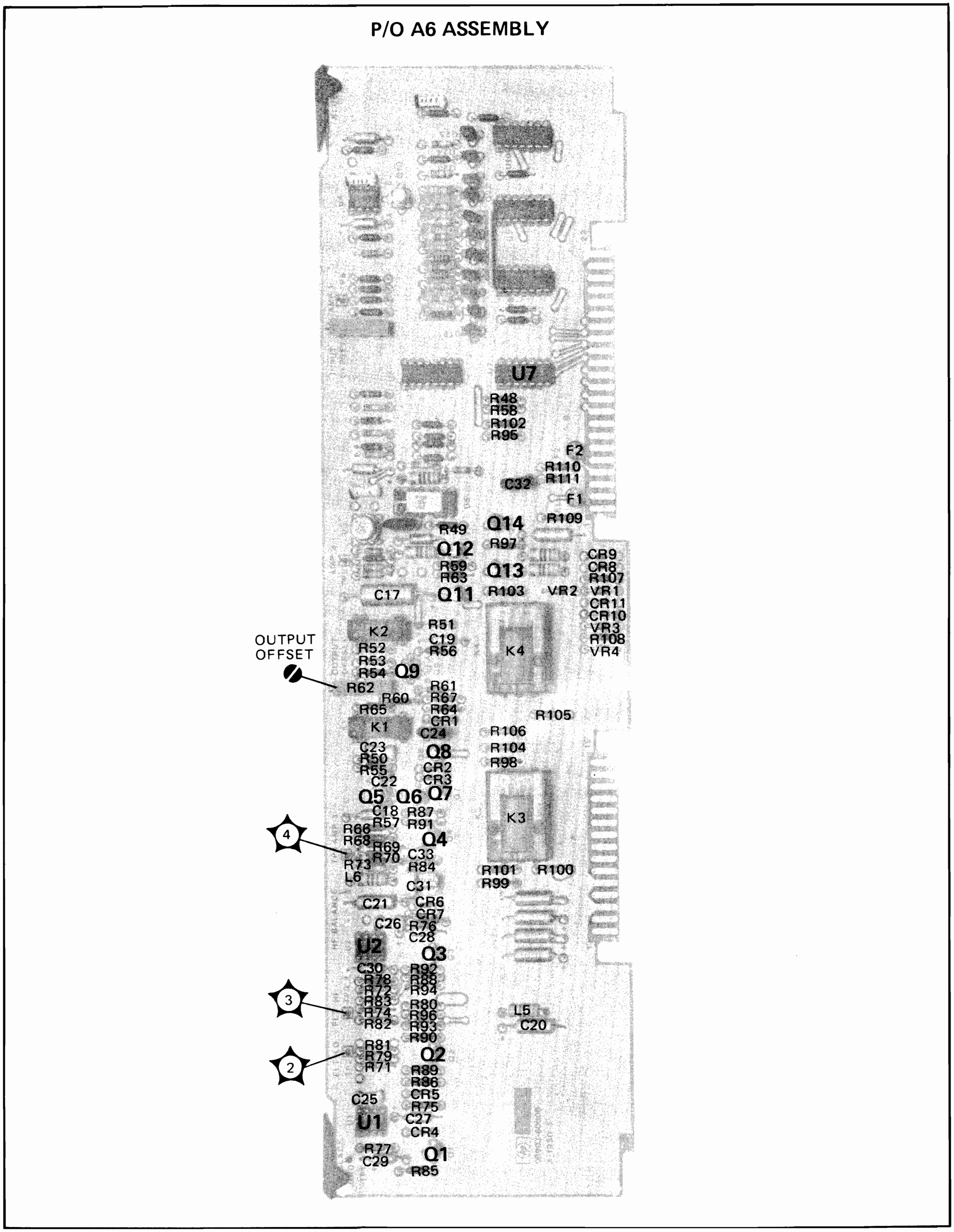
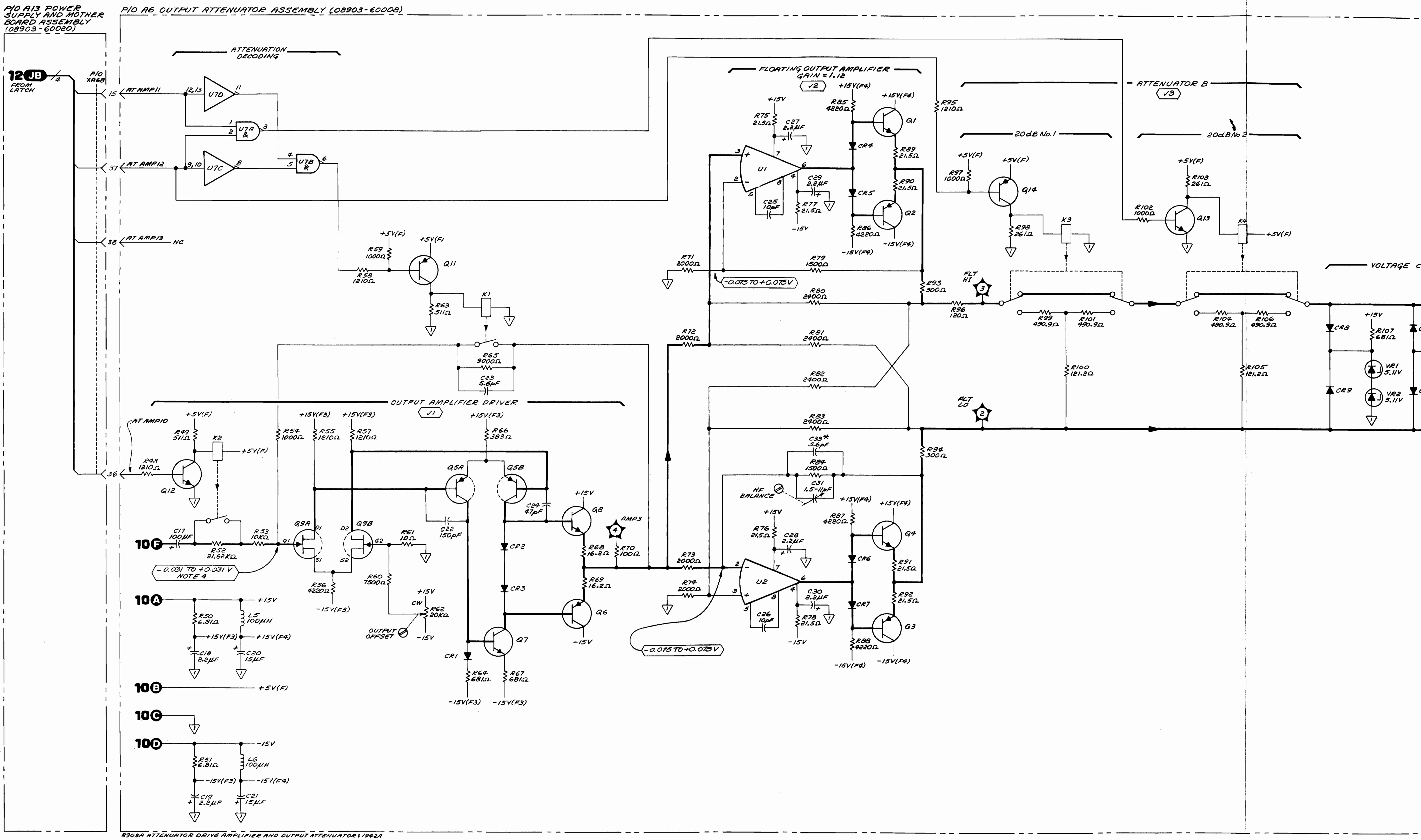
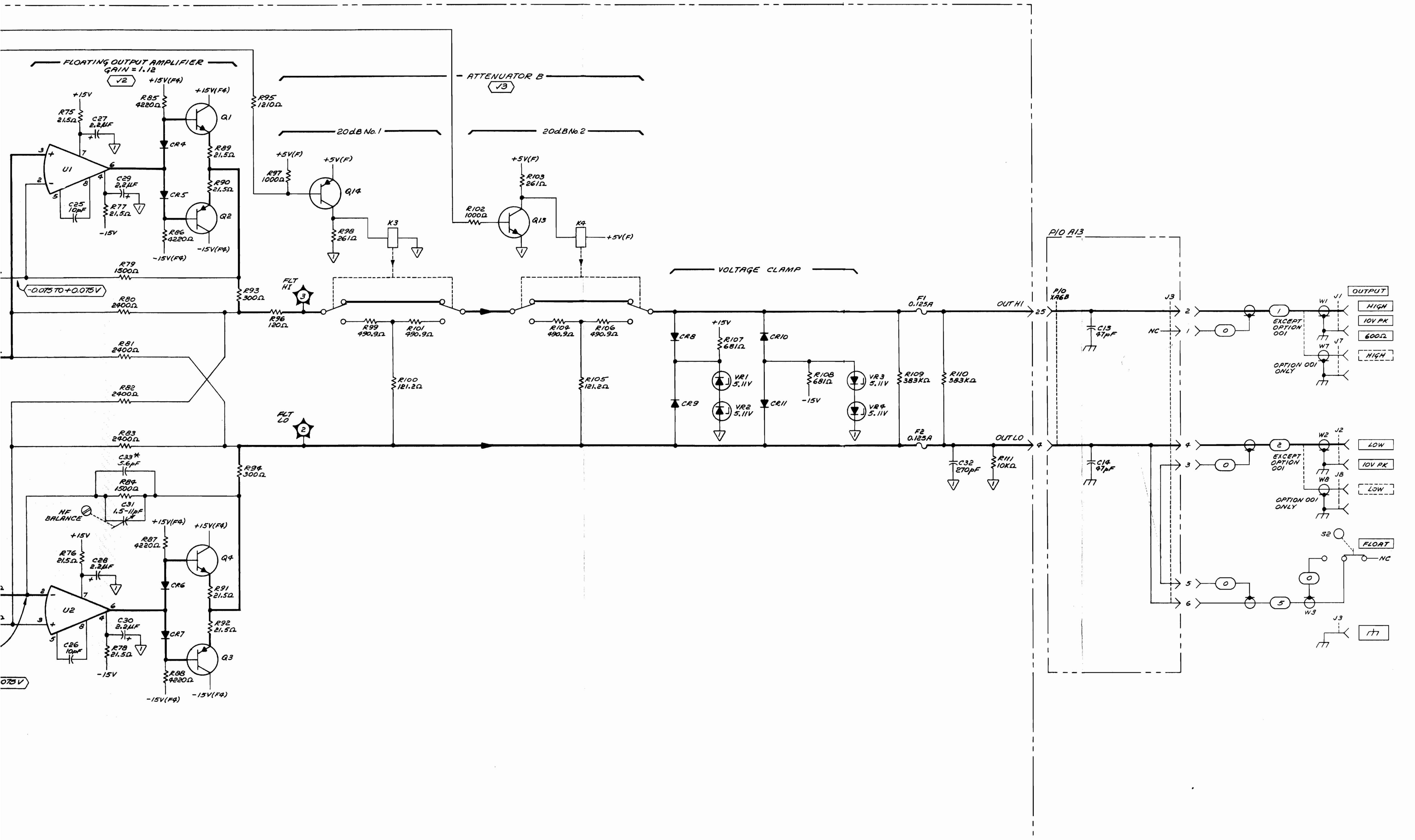


Figure 8-88. P/O A6 Output Attenuator Assembly Component Locations (Output Circuits)



8903A ATTENUATOR DRIVE AMPLIFIER AND OUTPUT ATTENUATOR 1942A



Reference designations within outline (— — ——) assemblies are abbreviated. Full designation includes Assembly Number; e.g., R1 of Assembly A1 is A1R1. Designations of other components are complete as shown.

NOTES

1. SEE TABLE 8-7 SCHEMATIC DIAGRAM NOTES.
2. RF CHOKE INDUCTANCE IS 2.5 TO 6µH AT 1MHz.
3. * ASTERISK MEANS FACTORY SELECTED VALUES.
4. DECOUPLE PROBE WITH 10KΩ RESISTOR WHEN MEASURING THIS VOLTAGE.

REFERENCE DESIGNATIONS

NO PREFIX	A13
J1-3, 7, 8 S2 W1-3, 7, 8	C13, 14 J3 XA6B
A6	
C17 - 33 CR1 - 11 F1, 2 K1-4 L5, 6 Q1-9, 11-14 R48 - 111 TP2-4 U1, 2, 7 VR1-4	

LOGIC LEVELS

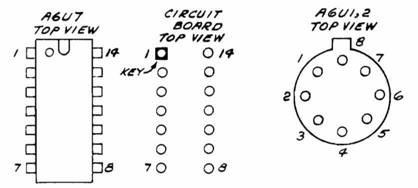
	TTL
HIGH	> 2V
LOW	< 0.8V
< IS MORE NEG. THAN > IS MORE POS. THAN	
OPEN	HIGH
GROUND	LOW

TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATIONS	PART NUMBERS
Q1, 4, 7, 8, 12, 13	1854 - 0477
Q2, 3, 6, 11, 14	1853 - 0281
Q5	1853 - 0316
Q9	1855 - 0232
U1, 2	1826 - 0569
U7	1820 - 1197

INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

REFERENCE DESIGNATIONS	PIN NUMBERS
U7	+5V(F) - 14 ▽ - 7



11
P/O A6

Figure 8-89. Output Attenuator—Output Circuits Schematic Diagram

SERVICE SHEET 12 — LATCH — DATA LATCHES (P/O A7)

TROUBLESHOOTING HELP

- Block Diagram .... Service Sheet BD4
- Direct Control Special Functions .... Paragraph 8-26
- Signature Analysis .... Paragraph 8-33

PRINCIPLES OF OPERATION

NOTE

The following discussions require an understanding of the operation of the Instrument Bus (see Instrument Bus, Service Sheet BD4) and of the Instrument Bus readback (see Direct Control Special Functions, paragraph 8-26).

General

This portion of the Latch Assembly (A7) contains many of the select decoders and data latches which decode the Instrument Bus and drive the digital-to-analog devices in the instrument hardware. The circuit also includes two overload flip-flops and a Parity Check.

Data Latches and Select Decoder

The Data Latches are of two types. One type (e.g., U9) decodes and latches all four data lines of the Instrument Bus when enabled by a unique select code — e.g., s=3(L) — from Select Decoder U7. U7 is enabled by e=7 and s3(H)=0 (i.e., false or low). Thus, U9 responds to esd=73d.

The other type (e.g., U22) is enabled by a unique enable code — e.g., e=6(L). The three least significant bits of the select code (s0, s1 and s2) are then decoded, and the input — eg., d0(H) — is loaded and latched into the output enabled by the decoding of the select inputs. Thus for example, if esd=631, a high is loaded into OS FRQ4. Note that d0(H) is high since d=1, which is a binary 0001. The other outputs of the data latch are unaffected. Also note that more than one data latch can be activated with a single direct control special function (e.g., if esd=633, a high logic level is loaded into both OS FRQ5 of U23 and OS FRQ4 of U22).

Overload Flip-Flops

When an input overload is detected (see Service Sheet 2), Input Overload Flip-Flop U14 is reset. Pin 5 of U14A resets Data Latches U9, U11, and U12 which sets the gain of the input circuits to minimum. The state of U14A is read by the Controller via U15B. To read U14A, the Controller issues esd=700 to the Instrument Bus. If d0(L) is low, the Input Overload Flip-Flop is known to be reset. To set U14A, the Controller issues esd=772 to the Instrument Bus. Since d1(H) is high, pin 8 of U14B is low, which sets U14A.

The Output Overload Flip-Flop, U13, operates in a manner similar to U14. When an overload is detected (see Service Sheet 6), U10 is reset which sets the gain of the Output Amplifier to minimum. The state of U10 is read when the Controller issues esd=740 to the Instrument Bus. The code esd=760 sets the flip-flop.

Parity Check

The Parity Check circuit allows the Controller to test the integrity of the data lines of the Instrument Bus. To check parity, the Controller sends out the sixteen codes esd=740 to esd=74F. For each code, the output of exclusive-OR gate U8C is read back by the Controller. The output of U8C is low when d0+d1+d2+d3 is even, or high when it is odd. Parity is checked only during instrument power up (see Power-Up Checks, paragraph 8-31).

TROUBLESHOOTING

General

Procedures for checking the Latch Assembly are given below. The circuits or points to check are marked on the schematic diagram by a hexagon with a check mark and a number inside, e.g., ⟨√3⟩. Two techniques for troubleshooting the data latches are presented. If ⟨√1⟩ is used, the A8 Controller/Counter Assembly must be extended using the digital test/extender board (HP 08903-60018), and the A7 Latch Assembly must be extended using three 44 pin extender boards. If ⟨√2⟩ is used, extend only the A7 Latch Assembly.

Equipment

Digital Test/Extender Board	HP 08903-60018
Oscilloscope	HP 1740A
Signature Analyzer	HP 5004A
44 Pin Extender Boards (3)	HP 08901-60084

⟨√1⟩ Latches Check—Using Signature Analysis

1. Switch LINE to OFF.

NOTE

Set up the Controller/Counter Assembly connections to the digital/test extender board prior to extending the Latch Assembly.

2. Interconnect the Controller/Counter Assembly, the Latch Assembly, the extender boards, and the signature analyzer as shown in Figure 8-90. Set the switches on the digital test/extender board to the open position.

3. Unplug assemblies A2 through A6. (They do not need to be completely removed.)

4. Set the signature analyzer's start and stop to trigger on a falling edge, and the clock to trigger on a rising edge.

5. Connect A8TP9 (TEST C) to A8TP3 (GND).

NOTE

Disregard the front-panel indications when performing signature analysis.

6. Set LINE switch to ON. Verify that Test LEDs A, B, and D light and remain lit.

7. Remove the ground from A8TP9. Verify that Test LED C lights and remains lit.

8. Press the reset pushbutton on the signature analyzer probe. Verify that the signature analyzer display is 4824. This reading indicates that the signature analysis routine is running correctly.

9. Check the pins on the ICs indicated in Table 8-61 with the signature analyzer.

NOTE

In addition to the signatures shown in Table 8-61, Service Sheet 13 contains signatures that can be checked using the current test setup.

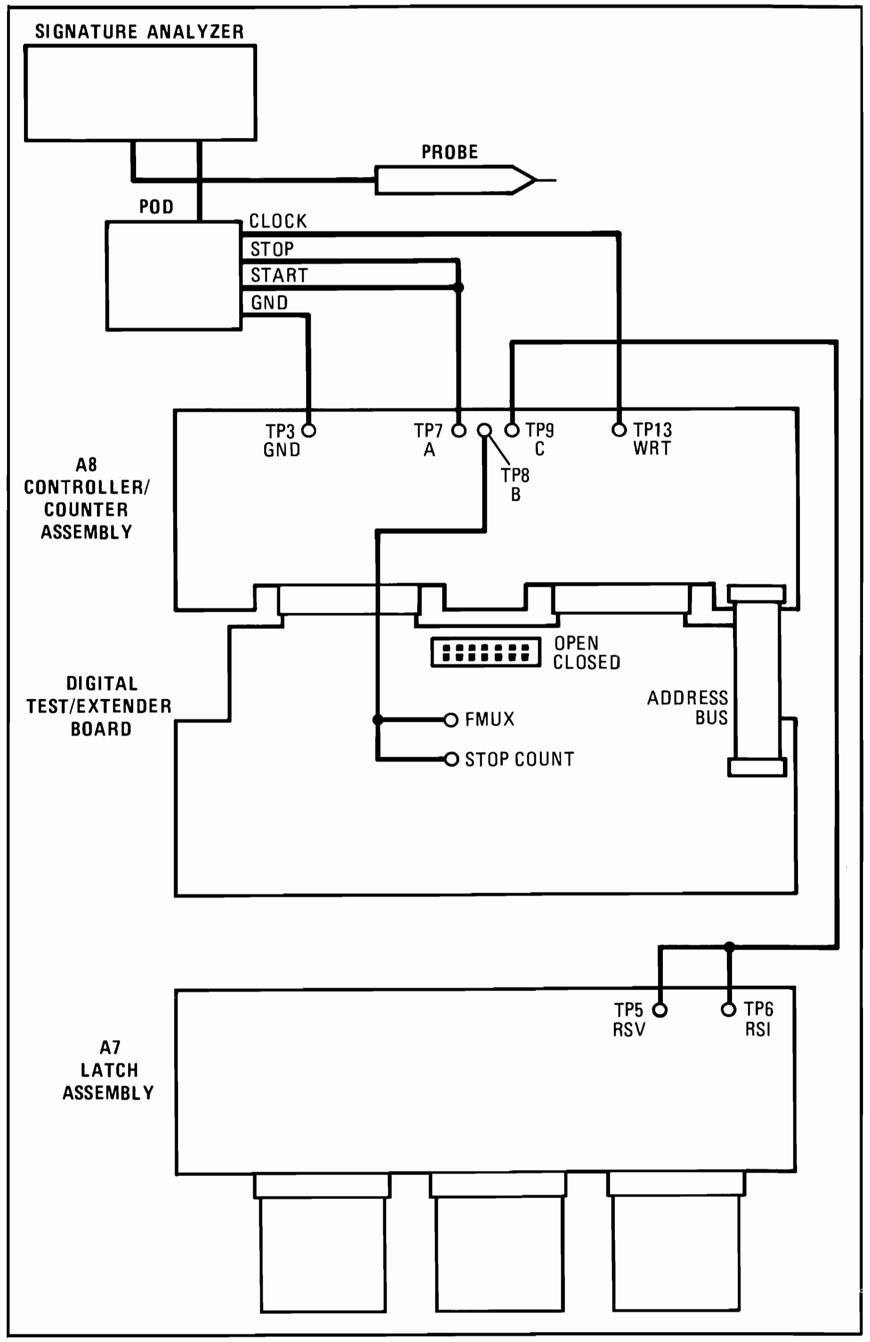


Figure 8-90. Latch Assembly Troubleshooting Setup

Pin	U7
1	600A
2	9CU
3	7PA
4	PH3
5	35F
6	4824
7	0A0
8	0000
9	P1A
10	2308
11	3AH
12	H4A
13	A5A
14	A34
15	HP9
16	4824
Pin	**U15**
1	0000
2	72U
3	1UU
4	96C
5	F839
6	1UU
7	0000
8	1UU
9	P2C
10	A98
11	–
12	–
13	–
14	4824
15	
16	
Pin	**U29**
1	600A
2	9CU
3	7PA
4	54U
5	P322
6	H3C
7	68U
8	0000
9	U12
10	404
11	F798
12	6A4
13	7FC
14	F9P
15	4824
16	4824

ıtput of exclusive-OR gate
ɔutput of U8C is low when
ɔdd. Parity is checked only
ɛr-Up Checks, paragraph

nbly are given below. The
he schematic diagram by a
ɔer inside, e.g., ⟨√3⟩. Two
ı latches are presented. If
ıssembly must be extended
? 08903-60018), and the A7
ng three 44 pin extender
ı7 Latch Assembly.

.HP 08903-60018
.HP 1740A
.HP 5004A
.HP 08901-60084

'e Analysis

ɛmbly connections to
ior to extending the

ıssembly, the Latch Assem-
ture analyzer as shown in
tal test/extender board to

(They do not need to be

l stop to trigger on a falling
edge.

(GND).

ɔns when performing

'est LEDs A, B, and D light

ify that Test LED C lights

SERVICE SHEET 12 (Cont'd)

8. Press the reset pushbutton on the signature analyzer probe. Verify that the signature analyzer display is 4824. This reading indicates that the signature analysis routine is running correctly.

9. Check the pins on the ICs indicated in Table 8-61 with the signature analyzer.

NOTE

In addition to the signatures shown in Table 8-61, Service Sheet 13 contains signatures that can be checked using the current test setup.

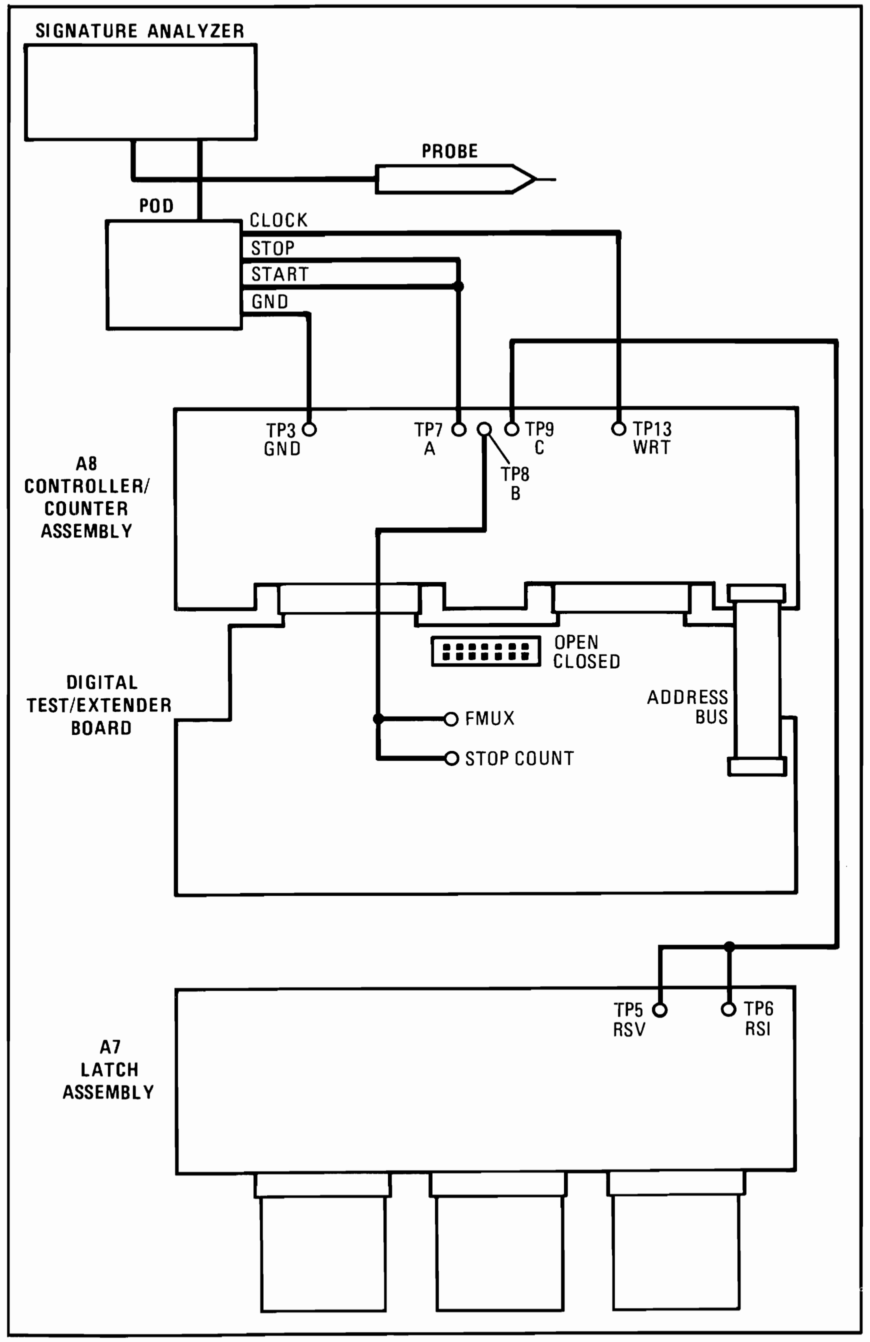


Figure 8-90. Latch Assembly Troubleshooting Setup

SERVICE SHEET 12 (Cont'd)

Table 8-61. Latch Assembly Data Latches Signatures

Pin	U7	U8	U9	U10	U11	U12	U13	U14	Pin
1	600A	2941	801H	AA99	801H	801H	4824	40AA	1
2	9CU7	2941	78A1	C393	8U6U	57H5	57H5	4824	2
3	7PAA	0000	3085	UCC7	F74C	A345	0A07	HP9P	3
4	PH3H	2941	57H5	57H5	57H5	4824	4824	8160	4
5	35F6	2941	F4F9	F4F9	F4F9	8P2C	F944	801H	5
6	4824	0000	3085	UCC7	F74C	F60U	8160	F839	6
7	0A07	0000	78A1	C393	8U6U	0000	0000	0000	7
8	0000	0000	0000	0000	0000	F60U	P2CH	8160	8
9	P1A9	0000	H4AA	2308	A5AP	8P2C	AA99	F944	9
10	2308	0000	78A1	C393	8U6U	4824	8160	–	10
11	3AHU	0000	3085	UCC7	F74C	A345	P1A9	0A07	11
12	H4AA	–	5C95	5C95	5C95	F4F9	4824	F4F9	12
13	A5AP	–	7FC0	7FC0	7FC0	801H	40AA	–	13
14	A345	4824	3085	UCC7	F74C	4824	4824	4824	14
15	HP9P		78A1	C393	8U6U				15
16	4824		4824	4824	4824				16

Pin	U15	U22	U23	U24	U25	U26	U27	U28	Pin
1	0000	600A	600A	600A	600A	600A	600A	600A	1
2	72UC	9CU7	9CU7	9CU7	9CU7	9CU7	9CU7	9CU7	2
3	1UU1	7PAA	7PAA	7PAA	7PAA	7PAA	7PAA	7PAA	3
4	96CA	26U7	26U7	26U7	26U7	54UP	54UP	54UP	4
5	F839	H3HU	H3HU	H3HU	H3HU	P322	P322	P322	5
6	1UU1	7355	7355	7355	7355	H3CF	H3CF	H3CF	6
7	0000	9C3C	9C3C	9C3C	9C3C	68U6	68U6	68U6	7
8	1UU1	0000	0000	0000	0000	0000	0000	0000	8
9	P2CH	3F58	3F58	3F58	3F58	U12F	U12F	U12F	9
10	A98H	HA3H	HA3H	HA3H	HA3H	404F	404F	404F	10
11	–	10U4	10U4	10U4	10U4	F798	F798	F798	11
12	–	2941	2941	2941	2941	6A46	6A46	6A46	12
13	–	57H5	F4F9	5C95	7FC0	57H5	F4F9	5C95	13
14	4824	77F6	77F6	77F6	77F6	F9P1	F9P1	F9P1	14
15		4824	4824	4824	4824	4824	4824	4824	15
16		4824	4824	4824	4824	4824	4824	4824	16

Pin	U29	U30	Pin
1	600A	HP9P	1
2	9CU7	96CA	2
3	7PAA	3AHU	3
4	54UP	72UC	4
5	P322	–	5
6	H3CF	–	6
7	68U6	0000	7
8	0000	–	8
9	U12F	–	9
10	404F	–	10
11	F798	–	11
12	6A46	A98H	12
13	7FC0	P1A9	13
14	F9P1	4824	14
15	4824		15
16	4824		16

Note: The signature for a high or +5V is 4824. The signature for a low or ground is 0000. The "–" indicates that there is no valid signature for the pin. A blank indicates no pin on the IC.

SERVICE SHEET 12 (Cont'd)

Hint: If nearly all signatures are faulty, see Service Sheet BD4 and check the CPU I/O port.

⟨√2⟩ Latches Check — Using Direct Control Special Functions

NOTE

If the keyboard is operating properly, the latches can be checked using Direct Control Special Functions and a logic probe. A signature analyzer is not needed. Extend only the Latch Assembly when performing this check.

Select Decoder

1. Key in the Direct Control Special Functions in Table 8-62. For each setting, check the pins on U7 indicated.

Table 8-62. Select Decoder Check

Direct Control Special Function	Level (TTL) at U7 Pin							
	15	14	13	12	11	10	9	7
0.700	*	H	H	H	H	H	H	H
0.710	H	*	H	H	H	H	H	H
0.720	H	H	*	H	H	H	H	H
0.730	H	H	H	*	H	H	H	H
0.740	H	H	H	H	*	H	H	H
0.750	H	H	H	H	H	*	H	H
0.760	H	H	H	H	H	H	*	H
0.770	H	H	H	H	H	H	H	*

* Low-going TTL pulses, ≈30 ms period.

Data Latches U9, U10, and U11

2. Key in the Direct Control Special Functions in Table 8-63. For each setting, check the pins on the IC indicated.

Table 8-63. Data Latches U9, U10 and U11 Check

Direct Control Special Function	IC to Check	Pin to Check							
		2	3	7	6	10	11	15	14
0.720	U11	L	H	L	H	L	H	L	H
0.72F	U11	H	L	H	L	H	L	H	L
0.730	U9	L	H	L	H	L	H	L	H
0.73F	U9	H	L	H	L	H	L	H	L
0.750	U10	L	H	L	H	L	H	L	H
0.75F	U10	H	L	H	L	H	L	H	L

Hint: Pin 1 on the ICs should be high.

Output Attenuator—Output Circuits
P/O A6
SERVICE SHEET 11

SERVICE SHEET 12 (Cont'd)

Data Latch U12

3. Key in 0.710 SPCL. Pins 6 and 8 of U12 should be high.

4. Key in 0.71F SPCL. Pins 6 and 8 of U12 should be low.

Overload Flip-Flops

5. Momentarily ground A7TP6 (RSI). Pin 5 of U14 should be low; pin 6 should be high.

6. Key in 0.700 SPCL. Pin 5 of U14 should be high; pin 6 should be low.

7. Key in 0.770 SPCL. Momentarily ground A7TP6 again. Key in 0.772 SPCL. Pin 5 of U14 should be high; pin 6 should be low.

8. Momentarily ground A7TP5 (RSV). Pin 9 of U13 should be low; pin 8 should be high.

9. Key in 0.760 SPCL. Pin 9 of U13 should be high; pin 8 should be low.

10. Key in 0.770 SPCL. Momentarily ground A7TP5 again. Key in 0.771 SPCL. Pin 9 of U13 should be high; pin 8 should be low.

Data Latches U22 through U29

11. Key in the Direct Control Special Functions in Table 8-64. For each setting, check the pin on the ICs indicated. For the special function code 0.6s0, the pin should be low, for 0.6sF it should be high.

Table 8-64. Data Latches U22 Through U25 Check

Direct Control Special Function	Pin to Check on U22, U23, U24, and U25
0.600, 0.60F	4
0.610, 0.61F	5
0.620, 0.62F	6
0.630, 0.63F	7
0.640, 0.64F	9
0.650, 0.65F	10
0.660, 0.66F	11
0.670, 0.67F	12

12. Key in the Direct Control Special Functions in Table 8-65. For each setting, check the pin on the ICs indicated. For the special function code 0.5s0, the pin should be low, for 0.5sF it should be high.

Table 8-65. Data Latches U26 Through U29 Check

Direct Control Special Function	Pin to Check on U26, U27, U28, and U29
0.500, 0.50F	4
0.510, 0.51F	5
0.520, 0.52F	6
0.530, 0.53F	7
0.540, 0.54F	9
0.550, 0.55F	10
0.560, 0.56F	11
0.570, 0.57F	12

Parity Check

13. Key in the Direct Control Special Functions in Table 8-66. For each setting, check the pins of U8 indicated.

Table 8-66. Parity Check

Direct Control Special Function	Level (TTL) at U8 pin		
	3	6	8
0.670	L	L	L
0.671	H	L	H
0.674	L	H	H
0.675	H	H	L

Readback Check

14. Key in 0.670 SPCL then 0.740 SPCL. The displays should read 0000 0000.

15. Key in 0.671 SPCL then 0.740 SPCL. The displays should read 0001 0000.

16. Key in 0.770 SPCL then 0.700 SPCL. Note the displays as A7TP6 (RSI) is momentarily grounded. The displays should read 0000 0000 when A7TP6 is ungrounded and 0001 0000 when grounded.

17. Key in 0.760 SPCL. Note the displays as A7TP5 (RSV) is momentarily grounded. The displays should read 0000 0000 when A7TP5 is ungrounded and 0001 0000 when grounded.

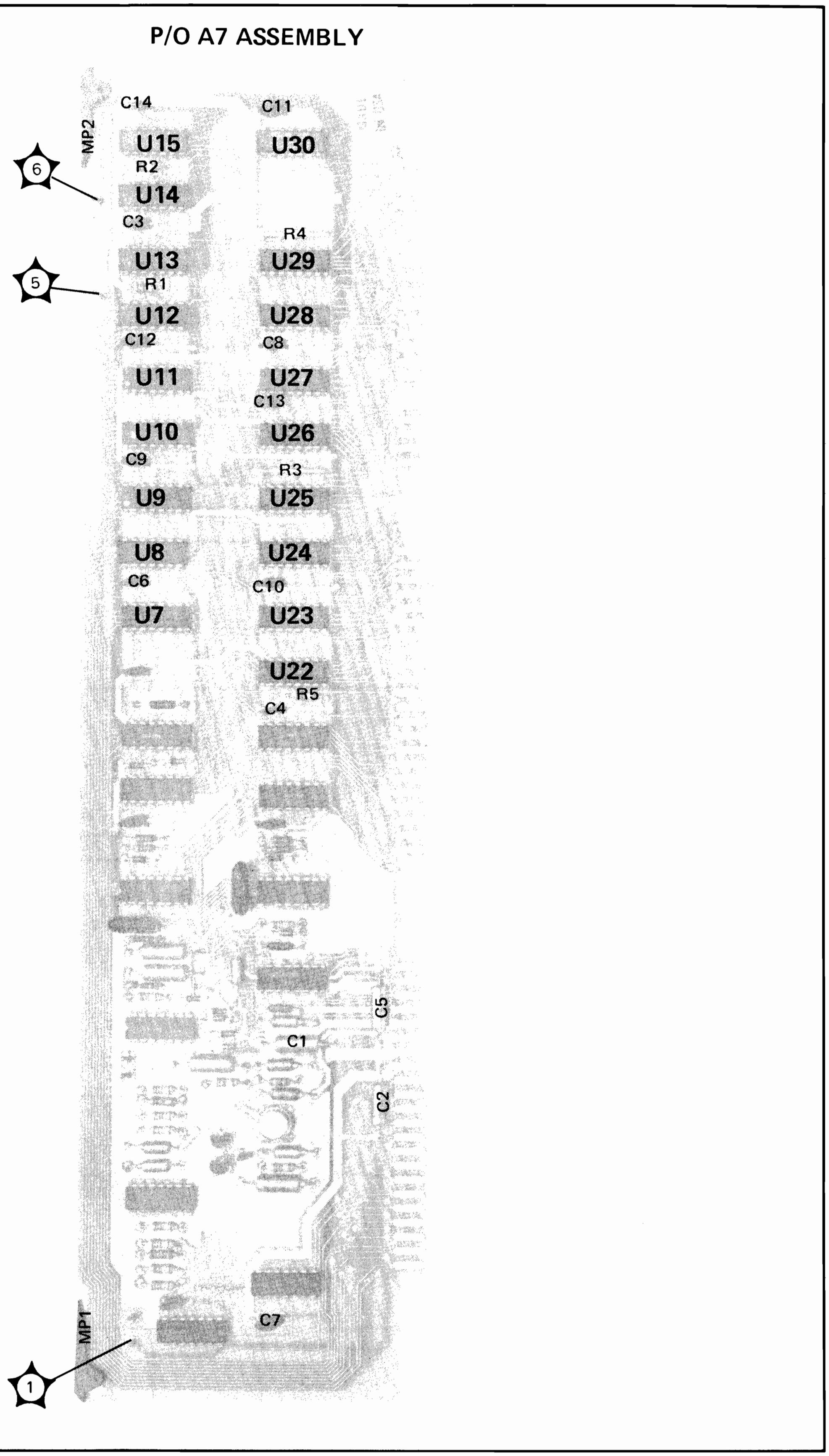
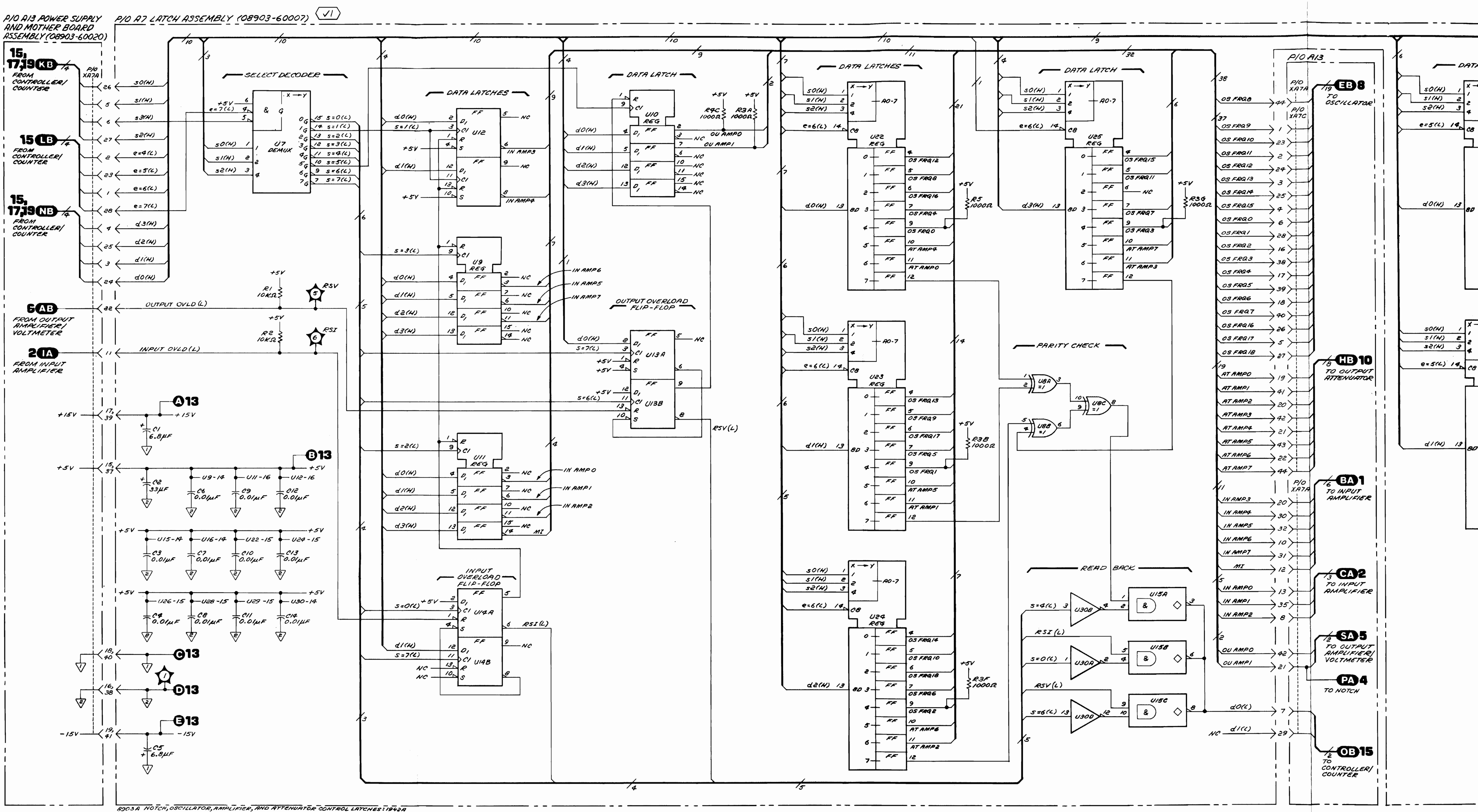
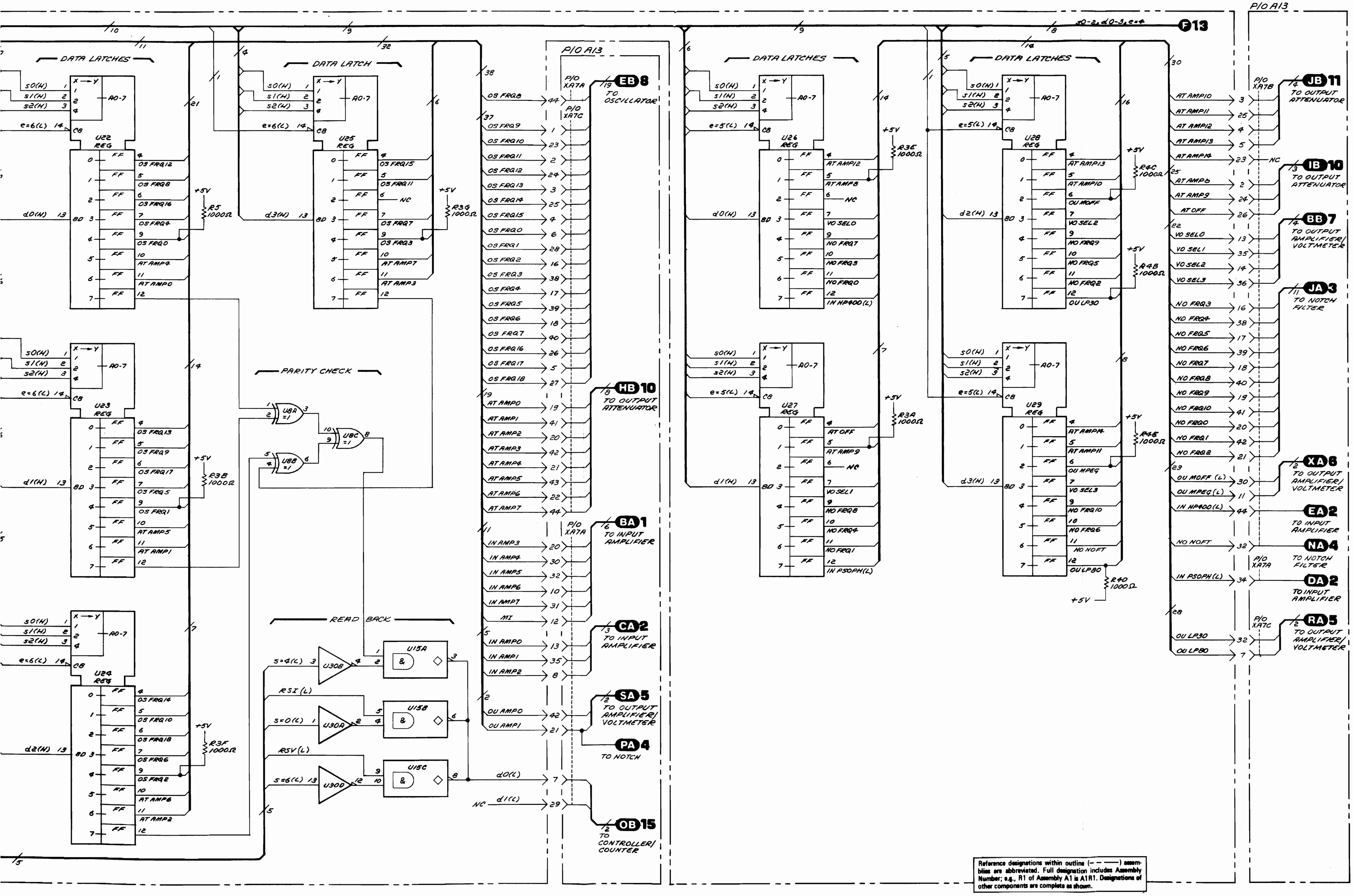


Figure 8-91. P/O A7 Latch Assembly Component Locations (Data Latches)



8903A NOTCH, OSCILLATOR, AMPLIFIER, AND ATTENUATOR CONTROL LATCHES: 1942A



Reference designations within outline (– – ——) assemblies are abbreviated. Full designation includes Assembly Number; e.g., R1 of Assembly A1 is A1R1. Designations of other components are complete as shown.

NOTES

1. SEE TABLE 8-7 SCHEMATIC DIAGRAM NOTES.

REFERENCE DESIGNATIONS

A7	A13
C1-14 R1-5,40 TP1,5,6 U7-15, 22-29,30	XA7A,B,C

LOGIC LEVELS

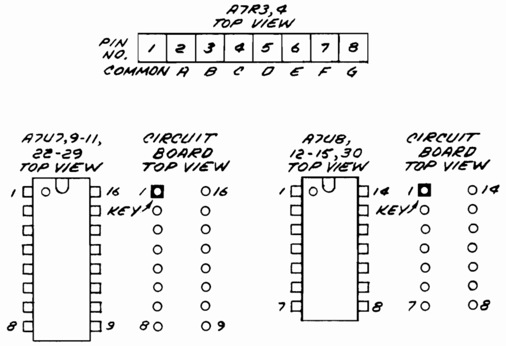
	TTL
HIGH	>2V
LOW	<0.8V
< IS MORE NEG. THAN > IS MORE POS. THAN	
OPEN	HIGH
GROUND	LOW

INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATIONS	PART NUMBERS
U7	1820 - 1216
U8	1820 - 1211
U9-11	1820 - 1195
U12 -14	1820 - 1112
U15	1820 - 0269
U22-29	1820 - 1729
U30	1820 - 1199

DIGITAL INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

REFERENCE DESIGNATIONS	PIN NUMBERS
U7,9-11	+5V - 16 ▽2 - 8
U8,12-15, 30	+5V - 14 ▽2 - 7
U22-29	+5V - 15 ▽2 - 8



12
P/O A7

Figure 8-92. Latch—Data Latches Schematic Diagram

SERVICE SHEET 13—LATCH—DAC AND COUNTER TRIGGER CIRCUITS (P/O A7)

TROUBLESHOOTING HELP

- Block Diagram ....Service Sheet BD4
- Direct Control Special Functions .... Paragraph 8-26
- Signature Analysis .... Paragraph 8-33

PRINCIPLES OF OPERATION

General

This portion of the Latch Assembly (A7) contains some of the data latches, the Counter Input Schmitt Trigger, and the X- and Y-Axis DACs.

Data Latches

The data latches are discussed in the principles of operation for Service Sheet 12.

Counter Input Schmitt Trigger

The Counter Input Schmitt Trigger converts the analog signal from the Input Amplifier (see Service Sheet 2) or the Output Amplifier (see Service Sheet 5) into a TTL-compatible signal which drives the Counter. Switching of the two signals is via the Input Switch, U18. The switch also grounds the unused input to minimize cross-talk.

U17 is a buffer amplifier which drives two peak detector diodes, CR7B and CR8B. CR7A and CR8A cancel the error in the peak detectors caused by the drop across the diodes. R17 to R20 divide the detected voltages by two. U2C and U2D are comparators that are referenced by the peak detectors. U2C trips at one-half the level of the positive peak of the input, U2D trips at one-half the negative peak. R22 and R23 add a small amount of hysteresis to the comparators. The outputs of U2C and U2D are applied to two inputs of set-reset flip-flop U1C and U1B. The output of U2D, however, is first inverted by U1D. The output of U1C drives NAND gate U16B, which acts as a switch.

Consider the action of the Schmitt trigger on an input signal. Assume that the signal is periodic but at the moment is at 0V and increasing. Also assume that the flip-flop is reset (U1C low). The output of U2C is high because the signal has not yet reached half the level of the positive peak. U2D is low because the signal is more positive than half the negative peak. U1D is high. When the signal reaches one-half the positive peak, U2C goes low and the flip-flop sets (U1C high), but when the signal returns below one-half the positive peak and U2C goes high again, the flip-flop remains set. When the signal goes below one-half the negative peak, U2D goes high and resets the flip-flop, but when the signal returns to above one-half the negative peak and U2D returns low again, the flip-flop remains reset. The action of the Schmitt trigger is depicted in Figure 8-93.

The Counter Input Schmitt Trigger thus self-biases its upper and lower references to one-half the respective positive and negative peaks. The result is excellent immunity to noisy signals whether large or small. U16 forms an output switch to route the signal from either the Counter Input Schmitt Trigger or the Oscillator to the Counter.

X- and Y-Axis DACs

The X- and Y-Axis DACs are programmed by the Controller via the Instrument Bus and Latch Assembly. The DACs output a current proportional to the binary weighting of the inputs. The current is converted to a voltage by transconductance amplifiers

SERVICE SHEET 13 (Cont'd)

U3C and U3D. C23 and C24 provide heavy filtering. The outputs are applied to the rear-panel X AXIS and Y AXIS output jacks. The pen lift function is controlled by the Controller via the Instrument Bus and U6. (A high is issued to lift the pen.)

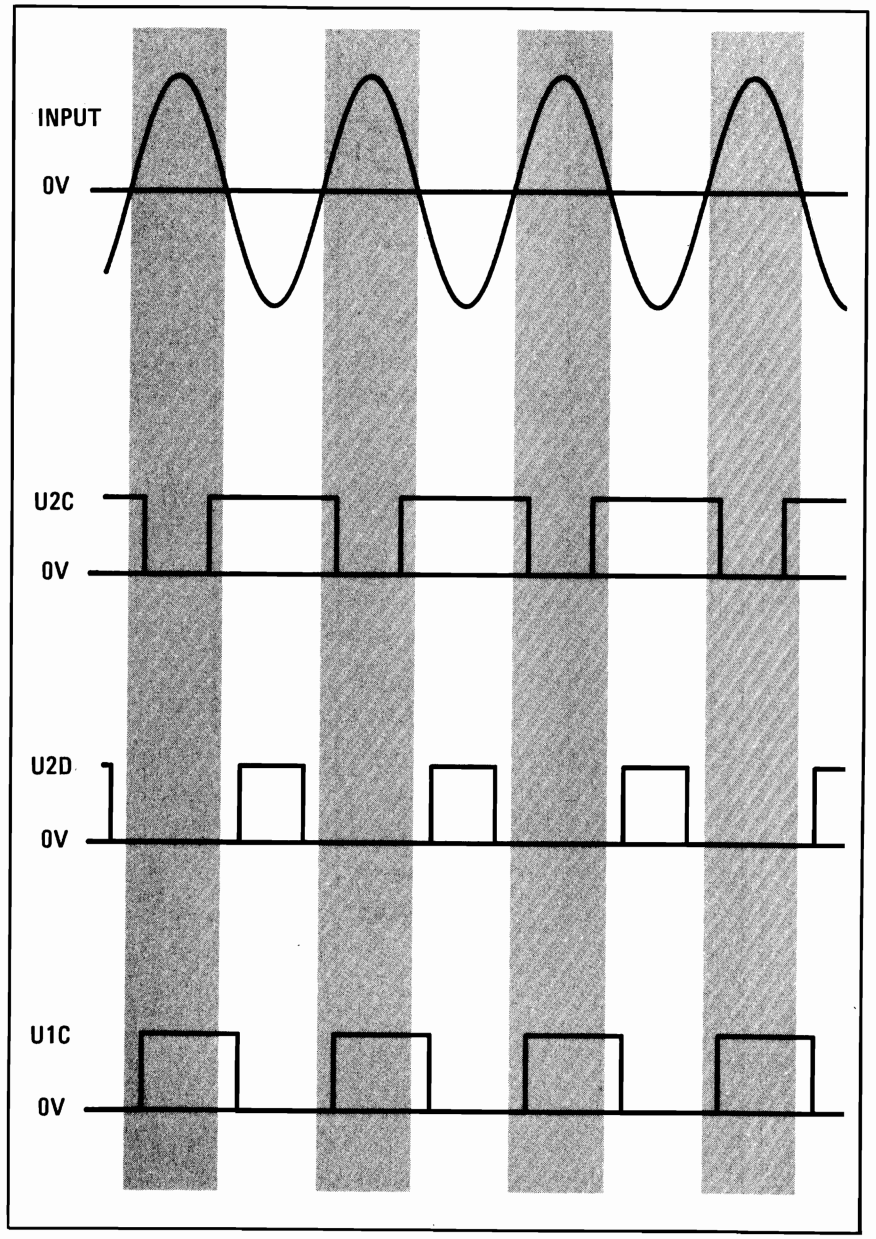


Figure 8-93. Action of the Counter Input Schmitt Trigger for a Sine Wave Input

TROUBLESHOOTING

General

Procedures for checking the Latch Assembly are given below. The circuits or points to check are marked on the schematic diagram by a hexagon with a check mark and a number inside, e.g., ⟨√3⟩. Two techniques for troubleshooting the data latches are presented. If ⟨√1⟩ is used, the A8 Controller/Counter Assembly must be extended using the digital test/extender board (HP 08903-60018) and the A7 Latch Assembly must be extended using three 44 pin extender boards. If ⟨√2⟩ is used, extend only the A7 Latch Assembly.

Equipment

Digital Test/Extender Board	HP 08903-60018
Digital Voltmeter	HP 3455A
Oscilloscope	HP 1740A
Signature Analyzer	HP 5004A
44 Pin Extender Boards (3)	HP 08901-60084

⟨√1⟩ Latches Check—Using Signature Analysis

1. Switch LINE to OFF.

NOTE

Set up the Controller/Counter Assembly connections to the digital test/extender board prior to extending the Latch Assembly.

2. Interconnect the Controller/Counter Assembly, the Latch Assembly, the extender boards, and the signature analyzer as shown in Figure 8-94. Set the switches on the digital test/extender board to the open position.

3. Unplug assemblies A2 through A6. (They do not need to be completely removed.)

4. Set the signature analyzer's start and stop to trigger on a falling edge, and the clock to trigger on a rising edge.

5. Connect A8TP9 (TEST C) to A8TP3 (GND).

NOTE

Disregard the front-panel indications when performing signature analysis.

6. Set LINE switch to ON. Verify that Test LEDs A, B, and D light and remain lit.

7. Remove the ground from A8TP9. Verify that Test LED C lights and remains lit.

8. Press the reset pushbutton on the signature analyzer probe. Verify that the signature analyzer display is 4824. This reading indicates that the signature analysis routine is running correctly.

9. Check the pins on the ICs indicated in Table 8-67 with the signature analyzer.

NOTE

In addition to the signatures shown in Table 8-67, Service Sheet 12 contains signatures that can be checked using the current test setup.

SERVIC

Table 8

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8-68. For
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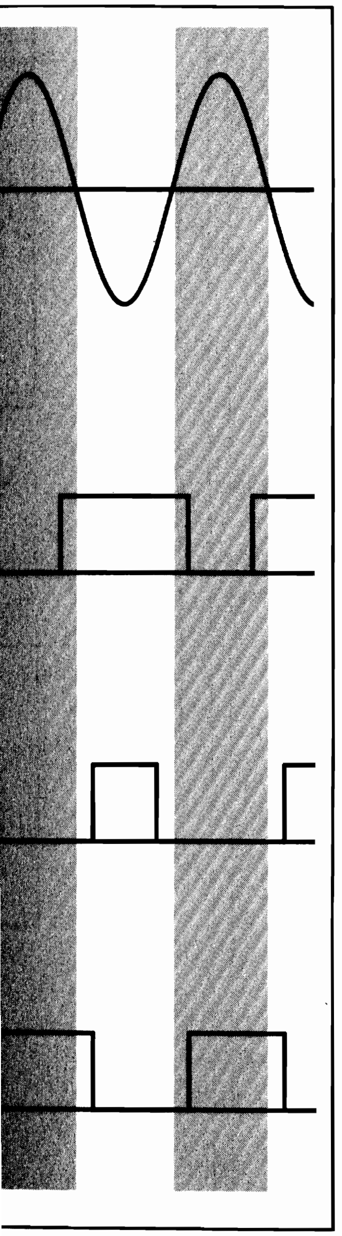

t Trigger for a Sine Wave Input

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ber inside, e.g., ⟨√3⟩. Two
latches are presented. If
ssembly must be extended
P 08903-60018) and the A7

Latch Assembly must be extended using three 44 pin extender boards. If ⟨√2⟩ is used, extend only the A7 Latch Assembly.

Equipment

Digital Test/Extender Board	HP 08903-60018
Digital Voltmeter	HP 3455A
Oscilloscope	HP 1740A
Signature Analyzer	HP 5004A
44 Pin Extender Boards (3)	HP 08901-60084

⟨√1⟩ Latches Check—Using Signature Analysis

1. Switch LINE to OFF.

NOTE

Set up the Controller/Counter Assembly connections to the digital test/extender board prior to extending the Latch Assembly.

2. Interconnect the Controller/Counter Assembly, the Latch Assembly, the extender boards, and the signature analyzer as shown in Figure 8-94. Set the switches on the digital test/extender board to the open position.

3. Unplug assemblies A2 through A6. (They do not need to be completely removed.)

4. Set the signature analyzer's start and stop to trigger on a falling edge, and the clock to trigger on a rising edge.

5. Connect A8TP9 (TEST C) to A8TP3 (GND).

NOTE

Disregard the front-panel indications when performing signature analysis.

6. Set LINE switch to ON. Verify that Test LEDs A, B, and D light and remain lit.

7. Remove the ground from A8TP9. Verify that Test LED C lights and remains lit.

8. Press the reset pushbutton on the signature analyzer probe. Verify that the signature analyzer display is 4824. This reading indicates that the signature analysis routine is running correctly.

9. Check the pins on the ICs indicated in Table 8-67 with the signature analyzer.

NOTE

In addition to the signatures shown in Table 8-67, Service Sheet 12 contains signatures that can be checked using the current test setup.

Table 8-67. Latch Assembly Data Latches Signatures (U5, U6, U20 and U21)

Pin	U5	U6	U20	U21	Pin
1	600A	600A	600A	600A	1
2	9CU7	9CU7	9CU7	9CU7	2
3	7PAA	7PAA	7PAA	7PAA	3
4	2199	2199	2199	2199	4
5	C551	C551	C551	C551	5
6	6380	6380	6380	6380	6
7	44P4	44P4	44P4	44P4	7
8	0000	0000	0000	0000	8
9	F043	F043	F043	F043	9
10	6PA2	6PA2	6PA2	6PA2	10
11	9C44	9C44	9C44	9C44	11
12	1P0U	1P0U	1P0U	1P0U	12
13	F4F9	57H5	7FC0	5C95	13
14	6420	6420	6420	6420	14
15	4824	4824	4824	4824	15
16	4824	4824	4824	4824	16

Note: The signature for a high or +5V is 4824. The signature for a low or ground is 0000.

Hint: If nearly all signatures are faulty, see Service Sheet BD4 and check the CPU I/O port.

⟨√2⟩ Latches Check—Using Direct Control Special Functions

NOTE

If the keyboard is operating properly, the latches can be checked using Direct Control Special Functions and a logic probe. A signature analyzer is not needed. Extend only the Latch Assembly when performing this check.

1. Key in the Direct Control Special Functions indicated in Table 8-68. For each setting, check the pin on the ICs indicated. For special function code 0.4s0, the pin should be low, for 0.4sF it should be high.

Table 8-68. Data Latches Check

Direct Control Special Function	Pin to Check on U5, U6, U20, and U21
0.400, 0.40F	4
0.410, 0.41F	5
0.420, 0.42F	6
0.430, 0.43F	7
0.440, 0.44F	9
0.450, 0.45F	10
0.460, 0.46F	11
0.470, 0.47F	12

⟨√3⟩ X- and Y-Axis DACs and Pen Lift Check

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the INPUT switch to ground. Connect the rear-panel X AXIS output to the INPUT or to the input of a dc voltmeter.

NOTE

If the Audio Analyzer is used to monitor the dc level, S (Shift) DC LEVEL must be pressed for each setting.

2. Key in the Special Functions listed in Table 8-69. For each setting, key in S (Shift) DC LEVEL or note the level on the external voltmeter. The dc level should be as indicated. If the level is faulty, also check the pins on U4 indicated.

Table 8-69. X AXIS Output Level Check

Direct Control Special Function	Level (Vdc) at X AXIS Output	Level (TTL) at U4 pin							
		5	6	7	8	9	10	11	12
0.450, 0.440	–0.002 to 0.002	L	L	L	L	L	L	L	L
0.448	0.03 to 0.05	H	L	L	L	L	L	L	L
0.444	0.07 to 0.09	L	H	L	L	L	L	L	L
0.442	0.14 to 0.17	L	L	H	L	L	L	L	L
0.441	0.29 to 0.33	L	L	L	H	L	L	L	L
0.440, 0.458	0.59 to 0.66	L	L	L	L	H	L	L	L
0.454	1.2 to 1.3	L	L	L	L	L	H	L	L
0.452	2.4 to 2.6	L	L	L	L	L	L	H	L
0.451	4.8 to 5.2	L	L	L	L	L	L	L	H

Hint: If the dc levels are all uniformly high or low, replace A7R10 with a value selected on the basis described in Table 5-1.

3. Connect the rear-panel Y AXIS output to the INPUT or to the input of a dc voltmeter. Key in the Special Functions listed in Table 8-70. For each setting, key in S (shift) DC LEVEL or note the level on the external voltmeter. The dc level should be as indicated. If the level is faulty, also check the pins on U5, U6, U20, and U21 indicated.

Table 8-70. Y AXIS Output Level Check

Direct Control Special Function	Level (Vdc) at Y AXIS Output	Level (TTL) at U19 pin							
		5	6	7	8	9	10	11	12
0.470, 0.460	–0.002 to 0.002	L	L	L	L	L	L	L	L
0.468	0.03 to 0.05	H	L	L	L	L	L	L	L
0.464	0.07 to 0.09	L	H	L	L	L	L	L	L
0.462	0.14 to 0.17	L	L	H	L	L	L	L	L
0.461	0.29 to 0.33	L	L	L	H	L	L	L	L
0.460, 0.478	0.59 to 0.66	L	L	L	L	H	L	L	L
0.474	1.2 to 1.3	L	L	L	L	L	H	L	L
0.472	2.4 to 2.6	L	L	L	L	L	L	H	L
0.471	4.8 to 5.2	L	L	L	L	L	L	L	H

Hint: If the dc levels are all uniformly high or low, replace A7R8 with a value selected on the basis described in Table 5-1.

SERVICE SHEET 13 (Cont'd)

4. Press the SWEEP key. The voltage level will momentarily show a TTL high level, then drop to a TTL low level, and remain there until the sweep is complete. The voltage level will then show a TTL high.

⟨√4⟩ Counter Input Check

1. On the Audio Analyzer, key in 41.0 SPCL to initialize the instrument. Set the INPUT and OUTPUT switches both to ground. Set AMPTD to 1V. Key in 46.3 SPCL to set the counter to read the output amplifier signal. Connect the HIGH INPUT to the HIGH OUTPUT.

2. Connect a high-impedance, dc coupled oscilloscope to pin 3 of U18. The signal should be approximately 6 Vpp.

Hint: Pin 8 of U18 should be a TTL low, pin 1 a high. The signal at pin 10 of U18 should also be 6 Vpp; if it is not, see Service Sheet 5 and check Amplifier 4.

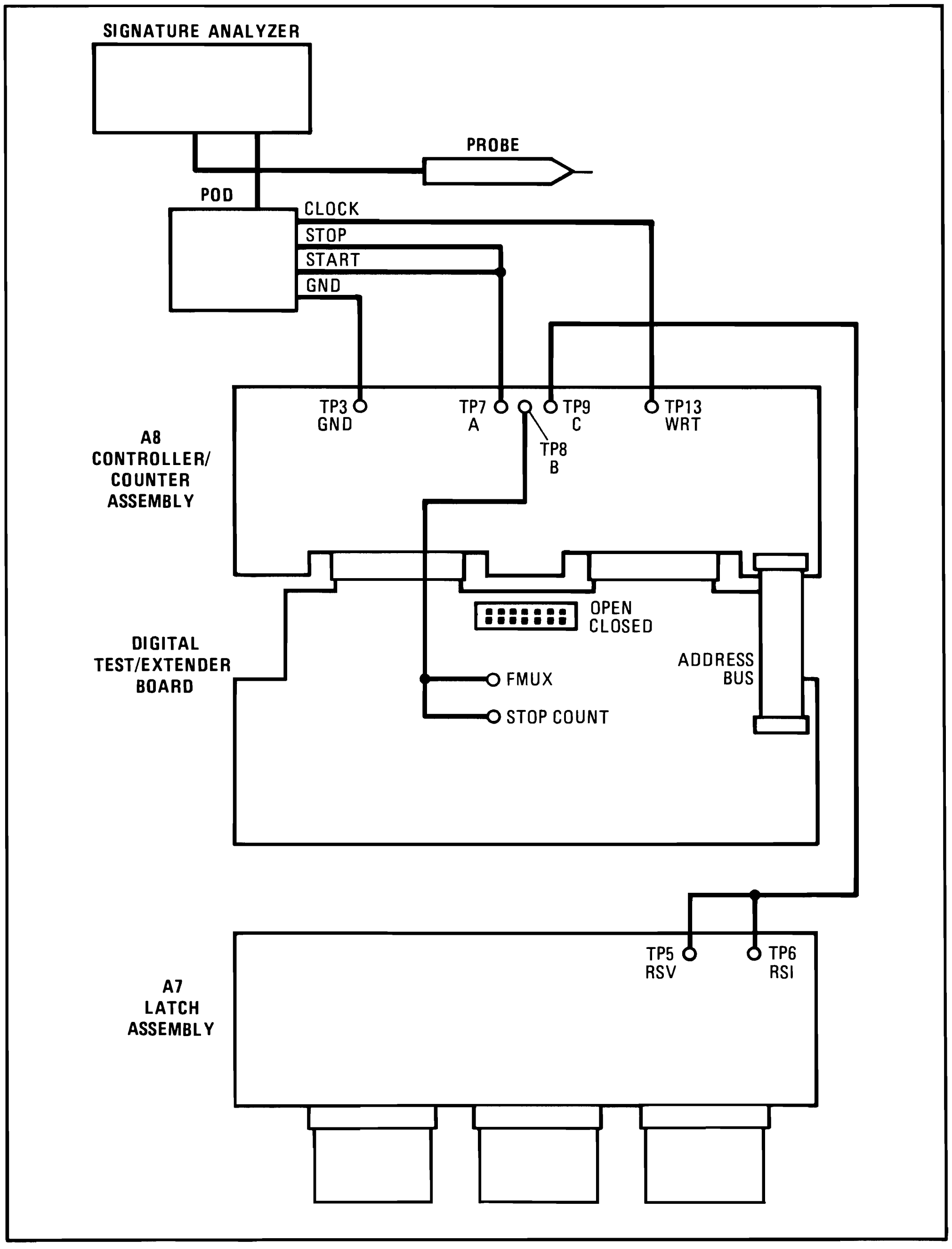


Figure 8-94. Latch Assembly Troubleshooting Setup

SERVICE SHEET 13 (Cont'd)

3. Key in 46.1 SPCL to set the counter to read the input frequency. The signal at pin 3 of U18 should be approximately 4 Vpp.

Hint: Pin 1 of U18 should be a TTL low, pin 8 a high. The signal at pin 2 of U18 should also be 4 Vpp; if it is not, see Service Sheet 2 and check the 400 Hz High-Pass and Psophometric Filters.

4. Connect the oscilloscope to pin 2 of U2 then to pin 13 of U2. The waveforms should be pulses with a period of 1 ms. The pulses at pin 2 of U2 should be +5V for 0.65 ms and −15V for 0.35 ms. The pulses at pin 13 should be the complement of those at pin 2.

Hint: The level at pin 5 of U2 should be approximately one half the level of the positive peak of the signal at pin 3 of U17. The level at pin 11 of U2 should be approximately one half the level of the negative peak of the signal at pin 3 of U17.

5. Connect the oscilloscope to pin 8 of U1. The waveform should be a TTL square wave.

6. Connect the oscilloscope to A7TP2 (FMUX). The waveform should be a TTL square wave which should become intermittent if the HIGH OUTPUT is disconnected.

Hint: Pins 4 and 9 of U16 should be a TTL high.

7. Key in 46.0 SPCL to set the counter to read the oscillator signal. The waveform should be a TTL square wave which should persist if the HIGH OUTPUT is disconnected.

Hint: Pin 4 of U16 should be a TTL low. Pin 10 of U16 should be a TTL high.

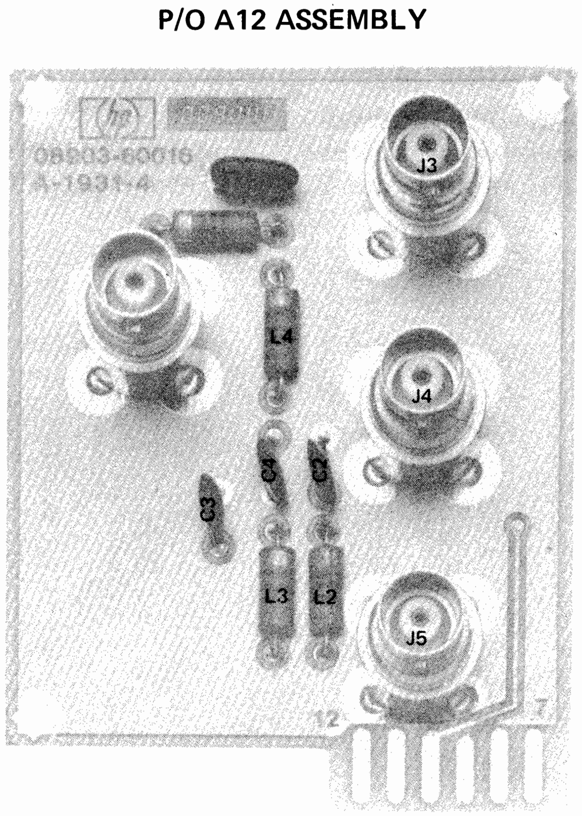


Figure 8-95. P/O A12 Connector/Filter Assembly Component Locations (DAC and Counter Trigger Circuits)

P/O A7 ASSEMBLY

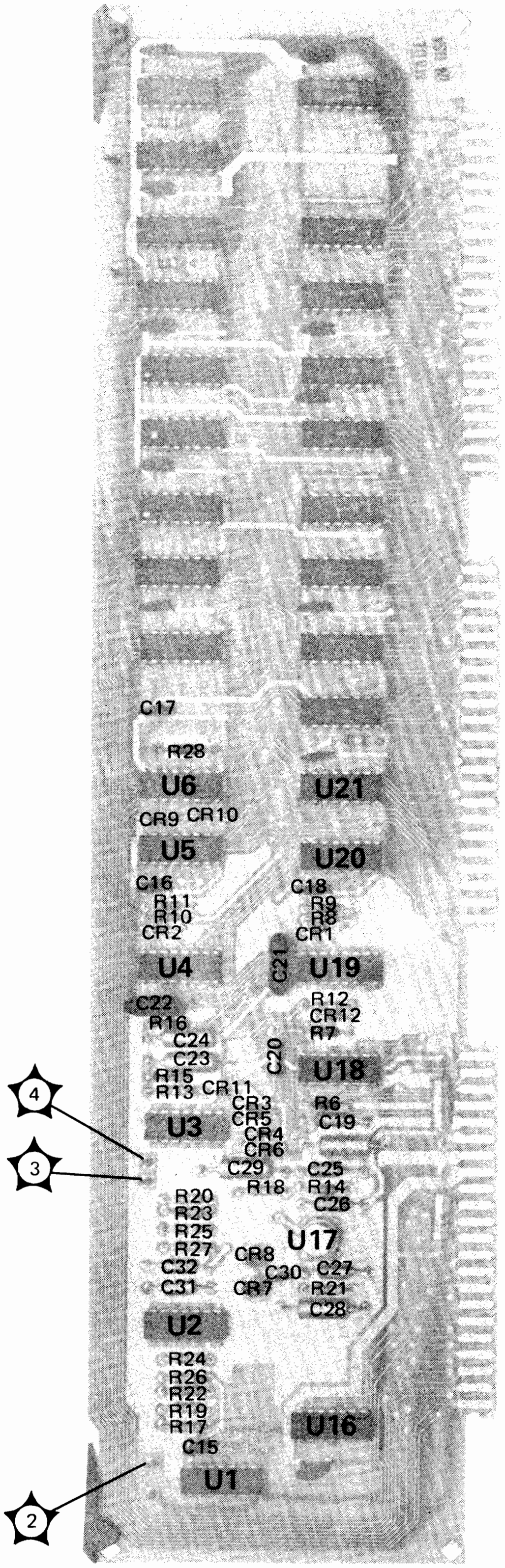
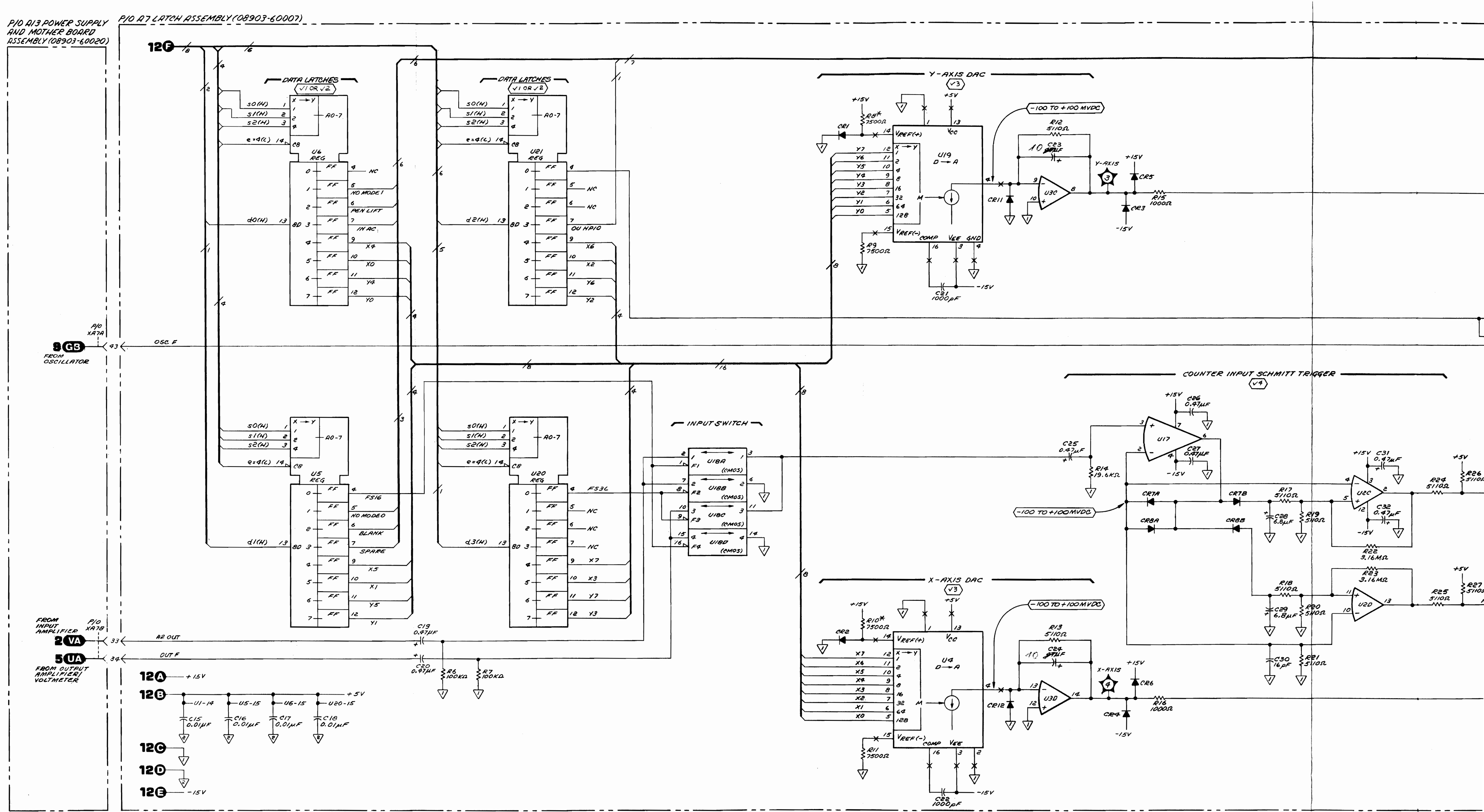
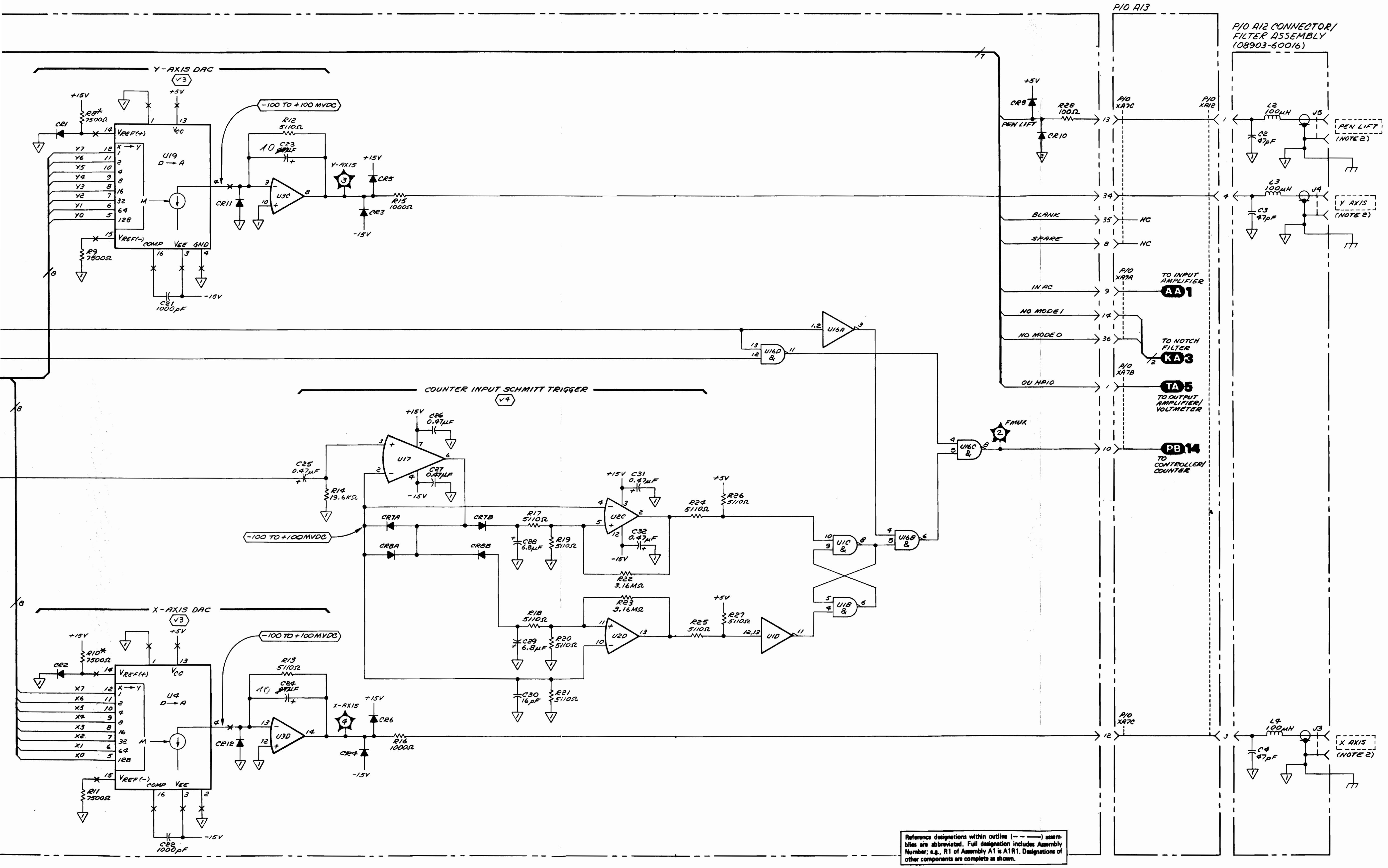


Figure 8-96. P/O A7 Latch Assembly Component Locations (DAC and Counter Trigger Circuits)



8903A X-Y AXES DACS AND COUNTER SCHMITT TRIGGER: 1948A



Reference designations within outline (— — ——) assemblies are abbreviated. Full designation includes Assembly Number; e.g., R1 of Assembly A1 is A1R1. Designations of other components are complete as shown.

NOTES

1. SEE TABLE 8-7 SCHEMATIC DIAGRAM NOTES.
2. CHASSIS GROUND IS MADE BY MECHANICAL CONTACT OF CONNECTOR WITH REAR PANEL.
3. *ASTERISK MEANS FACTORY SELECTED VALUES.

REFERENCE DESIGNATIONS

A7	A12
C15-32 CR1-12 R6-28 TP2-4 U1-6,16-21	C2-4 L2-4
	A13
	XA7A,B,C, 12

LOGIC LEVELS

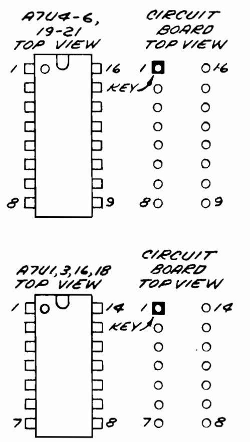
	TTL
HIGH	>2V
LOW	<0.8V
< IS MORE NEG. THAN > IS MORE POS. THAN	
OPEN	HIGH
GROUND	LOW

INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATIONS	PART NUMBERS
U1,16	1820 - 1197
U2	1826 - 0138
U3	1826 - 0323
U4,19	1826 - 0188
U5,6,20,21	1820 - 1729
U17	1826 - 0371
U18	1820 - 1971

DIGITAL INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

REFERENCE DESIGNATIONS	PIN NUMBERS
U1,16	+5V - 14 ▽2 - 7
U3	+15V - 4 -15V - 11
U5,6,20,21	+5V - 15 ▽2 - 8
U18	+15 - 13 -15 - 4 VREF - 12 ▽1 - 5



13
P/O A7, P/O A12

Figure 8-97. Latch—DAC and Counter Trigger Circuits Schematic Diagram

SERVICE SHEET 14—CONTROLLER/COUNTER—COUNTER CIRCUITS (P/O A8)

TROUBLESHOOTING HELP

- Block Diagram .... Service Sheet BD4
- Direct Control Special Functions .... Paragraph 8-26
- Signature Analysis .... Paragraph 8-33

PRINCIPLES OF OPERATION

NOTE

The following discussions require an understanding of the operation of the Instrument Bus (see Instrument Bus, Service Sheet BD4) and of the Instrument Bus readback (see Direct Control Special Functions, paragraph 8-26).

General

The Counter consists of the Clock Counter, the Cycle Counter, gating circuits, and the Count Transfer Logic. The final stages of the Clock and Cycle Counters are in the Controller itself. The Clock Counter counts the 2 MHz clock (Φ) signal. The Cycle Counter counts the input or Oscillator signal (FMUX) and is not used when measuring voltage.

Clock Counter

The Clock Counter has three stages (U1, U2, and U14A) which form a divide-by-2048. The input to the counter, when enabled, is 2 MHz, and the output is 976.5625 Hz.

When the Counter is making a frequency measurement, the Frequency Gate (U19B) is armed by the Controller and gated by the input signal (FMUX). To arm the Frequency Gate, the Controller sends esd=7F0 out on the Instrument Bus which sets U29A (and also clears the Clock Counter). NAND gate U19B is thus high. Next, the Controller issues esd=7E0. This puts a high on the output of U4B, a high on U20C, and thus a low on U4A and the D1 input to U29A. The next falling edge of FMUX clocks the low into U29A and gates U19B, which routes the 2 MHz (Φ) signal into the Clock Counter. (U29B had previously been reset, putting a high on pin 5 of U19B and causing U19C to go high.)

As the count progresses, carries from flip-flop 4 of U14A are output to Instrument Bus line d2(L) via U17D and are counted by the Controller. U17D was enabled by the same signal from the Controller that armed U4A.

After a predetermined number of clock carries have been counted by the Controller, the Controller issues esd=7E1 to the Instrument Bus. U20C now goes low which puts a high on the D1 input of U29A. The next falling edge of FMUX clocks the high into U29A and inhibits U19B. If FMUX should be interrupted during the count, the Controller program terminates the count sequence after 16 more clock carries.

When voltage is being measured, the Voltmeter Gate performs functions similar to the Frequency Gate. To make a voltage measurement, the Controller issues esd=7E0 to the Instrument Bus. This puts a high on both inputs of NAND gate U4A. The low at the output of U4A enables the Voltmeter Gate U19C. (Mode Select flip-flop U29B had previously been set.) At this point the Stop Count(H) line from the Voltage-to-Time Converter is low. Thus the 2 MHz clock (Φ) signal is gated into the counter via the Stop Count and Voltmeter Gates. After an interval determined by the dc voltage at the input to the Voltage-to-Time Converter, Stop Count(H) goes high which disables the clock signal. The accumulated count is, then, a function of the dc voltage.

Cycle Counter

The Cycle Counter has two stages (U15 and U14B) which form a divide-by-32. The input to the counter, when enabled, is FMUX, the signal from the input or Oscillator. The counter is enabled and disabled by the same signal that enables and disables the Frequency Gate; it is cleared at the same time as the Clock Counter. Carries from the Cycle Counter are output to Instrument Bus line d3(L) via U17B and are counted by the Controller. U17B is enabled at the same time as U17D.

Counter Output Gating

To read back the outputs of the Clock and Cycle Counters after completion of a count sequence, the Controller issues esd=7D0 to the Instrument Bus. The output of U4D (which had been low) goes high and enables Counter Output Gates U7B, U7D, U17C, and U17A. The outputs of U15 are inverted and placed on the readback data lines of the Instrument Bus. Next, the Controller issues esd=7C0 to the Instrument Bus. U3C goes low. This causes U15 to be loaded with the output of U14 and also enables the Counter Output Gates since the output of U4D is high. The output of U15 is thus placed on the Instrument Bus through U14. In a similar manner the Controller issues esd=7B0 and esd=7A0 to copy the outputs of U1 and U2 into the subsequent stages and onto the Instrument Bus.

Select Decoder

For a general discussion of operation and decoding of the Instrument Bus, see Instrument Bus, Service Sheet BD4. For a discussion of the readback operation, see Direct Control Special Functions, paragraph 8-26.

TROUBLESHOOTING

General

Procedures for checking the Controller/Counter Assembly are given below. The circuits or points to check are marked on the schematic diagram by a hexagon with a check mark and a number inside, e.g., ⟨√3⟩. The A8 Controller/Counter Assembly must be extended using the digital test/extender board (HP 08903-60018).

CAUTIONS

MOS and CMOS ICs can be damaged by static charges and circuit transients. Do not remove this assembly from the instrument while power is applied. Discharge the board and replacement IC to the same potential. (Use a conductive foam pad such as HP 4208-0094.) When unplugging ICs, place the board on a conductive pad. When the IC is unplugged, insert it into the pad also.

CAUTIONS (Cont'd)

Several ICs on this assembly are held in high-grip sockets. Both the socket and the device can be damaged if an attempt is made to remove the device with an IC extraction tool. The recommended procedure is to first ground the tip of a small blade-type screw driver, then slide the tip between the IC and slowly pry up the IC one pair of pins at a time.

Equipment

Digital Test/Extender Board ..HP 08903-60018
Signature Analyzer...........HP 5004A

⟨√1⟩ Counter Check

1. Set LINE to OFF. Extend the A8 Controller/Counter Assembly using the digital test/extender board (HP 08903-60018).

NOTE

It is not necessary to place the A7 Latch Assembly on extender boards for this procedure.

2. Interconnect the Controller/Counter Assembly, the Latch Assembly, the extender board, and the signature analyzer as shown in Figure 8-98. Set the switches on the digital test/extender board to the open position.

3. Unplug assemblies A2 through A6. (They do not need to be completely removed.)

4. Set the signature analyzer's start and stop to trigger on a falling edge, and the clock to trigger on a rising edge.

5. Connect A8TP9 (TEST C) to A8TP3 (GND).

NOTE

Disregard the front-panel indications when performing signature analysis.

6. Set LINE switch to ON. Verify that Test LEDs A, B, and D light and remain lit.

7. Remove the ground from A8TP9. Verify that Test LED C lights and remains lit.

8. Press the reset pushbutton on the signature analyzer probe. Verify that the signature analyzer display is 4824. This reading indicates that the signature analysis routine is running correctly.

NOTE

If the counter has the signatures shown in Table 8-71, the counter circuits shown in this service sheet are operating correctly.

9. Check the points in Table 8-71 with the signature analyzer probe.

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ime as the Clock Counter.
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and Cycle Counters after
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ch had been low) goes high
, U7D, U17C, and U17A.
aced on the readback data
ntroller issues esd=7C0 to
s causes U15 to be loaded
the Counter Output Gates
ut of U15 is thus placed on
similar manner the Con-
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Instrument Bus.

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CAUTIONS (Cont'd)

Several ICs on this assembly are held in high-grip sockets. Both the socket and the device can be damaged if an attempt is made to remove the device with an IC extraction tool. The recommended procedure is to first ground the tip of a small blade-type screw driver, then slide the tip between the IC and slowly pry up the IC one pair of pins at a time.

Equipment

Digital Test/Extender Board ..	HP 08903-60018
Signature Analyzer............	HP 5004A

√1 Counter Check

1. Set LINE to OFF. Extend the A8 Controller/Counter Assembly using the digital test/extender board (HP 08903-60018).

NOTE

It is not necessary to place the A7 Latch Assembly on extender boards for this procedure.

2. Interconnect the Controller/Counter Assembly, the Latch Assembly, the extender board, and the signature analyzer as shown in Figure 8-98. Set the switches on the digital test/extender board to the open position.

3. Unplug assemblies A2 through A6. (They do not need to be completely removed.)

4. Set the signature analyzer's start and stop to trigger on a falling edge, and the clock to trigger on a rising edge.

5. Connect A8TP9 (TEST C) to A8TP3 (GND).

NOTE

Disregard the front-panel indications when performing signature analysis.

6. Set LINE switch to ON. Verify that Test LEDs A, B, and D light and remain lit.

7. Remove the ground from A8TP9. Verify that Test LED C lights and remains lit.

8. Press the reset pushbutton on the signature analyzer probe. Verify that the signature analyzer display is 4824. This reading indicates that the signature analysis routine is running correctly.

NOTE

If the counter has the signatures shown in Table 8-71, the counter circuits shown in this service sheet are operating correctly.

9. Check the points in Table 8-71 with the signature analyzer probe.

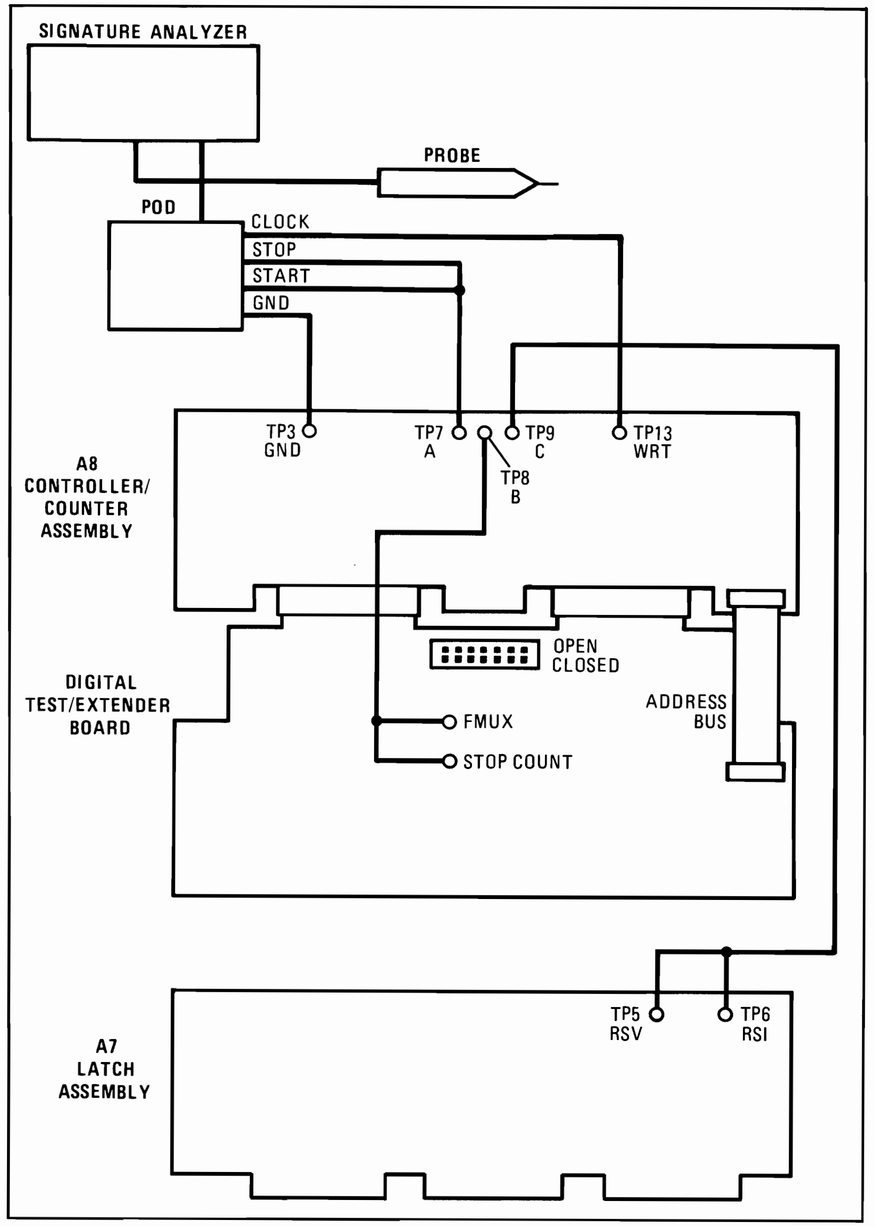


Figure 8-98. Controller/Counter Assembly Troubleshooting Setup

Table 8-71. Counter Summation Check

Description	Location	Signature
+5V	A8TP16 (+5V)	4824
d0(L)	A8U7 pin 6	1UU1
d1(L)	A8U7 pin 11	8FPH
d2(L)	A8U17 pin 8	13C1
d3(L)	A8U17 pin 3	3494

Hint: If a data line is suspected (e.g., if the signature for d2(L) only is faulty), the line itself may be faulty; see √3 CPU I/O Port Check on Service Sheet BD4. Otherwise, continue with step 9. If no signatures are faulty, perform √3 Counter Input Check on Service Sheet 13.

CAUTION

The IC sockets are a high-grip type. Their lifetime is limited to only a few insertions. Use caution when removing or inserting ICs to avoid damage to the socket or IC.

10. Remove A8U7 and A8U17 from their sockets.

11. Check the points in Table 8-72 with the signature analyzer probe (the pin numbers for A8U7 and A8U17 are the socket pin numbers).

Table 8-72. Data Lines Check

Description	Location	Signature
+5V	A8TP16 (+5V)	4824
d0(L)	A8U7 pin 6	104H
d1(L)	A8U7 pin 11	581P
d2(L)	A8U17 pin 8	UA92
d3(L)	A8U17 pin 3	581P

Hint: If faulty, the problem is with the data line itself; see √3 CPU I/O Port Check on Service Sheet BD4.

12. Check the points in Table 8-73 with the signature analyzer probe.

Table 8-73. Counter Circuit Signatures (1 of 2)

Pin	U1	U2	U3	U4	U14	U15	U19	U20	Pin
1	U282	4824	5543	104H	8PU6	PF02	4824*	1H67	1
2	A885	A25C	0000*	5A9U	FFC1	1247	4824*	5543	2
3	A25C	–	0000*	P522	A1F9	4HF1	0000*	5543	3
4	F119	–	U282	12CC	6412	2PCA	U93H	1H67	4
5	U5U1	F119	3450	12CC	5A7H	HA42	C7A5	5869	5
6	U5U1	F119	8PU6	5A9U	6412	HA42	4824*	104H	6
7	0000	0000	0000	0000	0000	0000	0000	0000	7
8	42C1	0000*	PF02	–	A8P9	PF85	4824*	5543	8
9	A1F9	PUP6	8PU6	–	2PCA	4CPU	0000*	1H67	9
10	PUP6	–	2AH0	–	U5U1	FFC1	UU81	5543	10
11	42C1	–	PF85	07P1	A885	5A7H	AH06	1H67	11
12	6412	42C1	U93H	PF02	4HF1	A8P9	0000*	AH06	12
13	5AF7	5AF7	5543	PCP3	5AF7	5AF7	4824*	P522	13
14	4824	4824	4824	4824	4824	4824	4824	4824	14

Note: An * indicates that the light on the probe must be flashing. The signature for a high or +5V is 4824. The signature for a low or ground is 0000. The "–" indicates that there is no valid signature for the pin. A blank indicates no pin on the IC.

(Table 8-73 continued)

SERVICE SHEET 14 (Cont'd)

Table 8-73. Counter Circuit Signatures (2 of 2)

Pin	U21	U29	Pin
1	600A	4824	1
2	9CU7	P522	2
3	7PAA	5543	3
4	PH3H	5AF7	4
5	0000	C119	5
6	35F6	U93H	6
7	5AF7	0000	7
8	0000	C7A5	8
9	12CC	UU81	9
10	PCP3	2F7H	10
11	2AH0	0000	11
12	3450	–	12
13	U282	385U	13
14	2F7H	4824	14
15	385U		15
16	4824		16

13. Plug in A8U17. Check the pins in Table 8-74 with the signature analyzer probe.

Table 8-74. A8U17 Signatures

Pin	U17
1	07P1
2	A8P9
3	3494
4	5A9U
5	5A7H
6	3494
7	0000
8	13C1
9	07P1
10	1247
11	13C1
12	4HF1
13	5A9U
14	4824

Hint: A faulty signature indicates that A8U17 is faulty. No faulty signatures for A8U17 indicate a fault in A8U7.

NOTE

If the counter is operating correctly, only three signatures are different with A8U7 and A8U17 installed. The signatures that differ from Table 8-73 are:

1. *U4, pin 1 is 1UU1 instead of 104H.*
2. *U20, pin 5 is 57H5 instead of 5869.*
3. *U20, pin 6 is 1UU1 instead of 104H.*

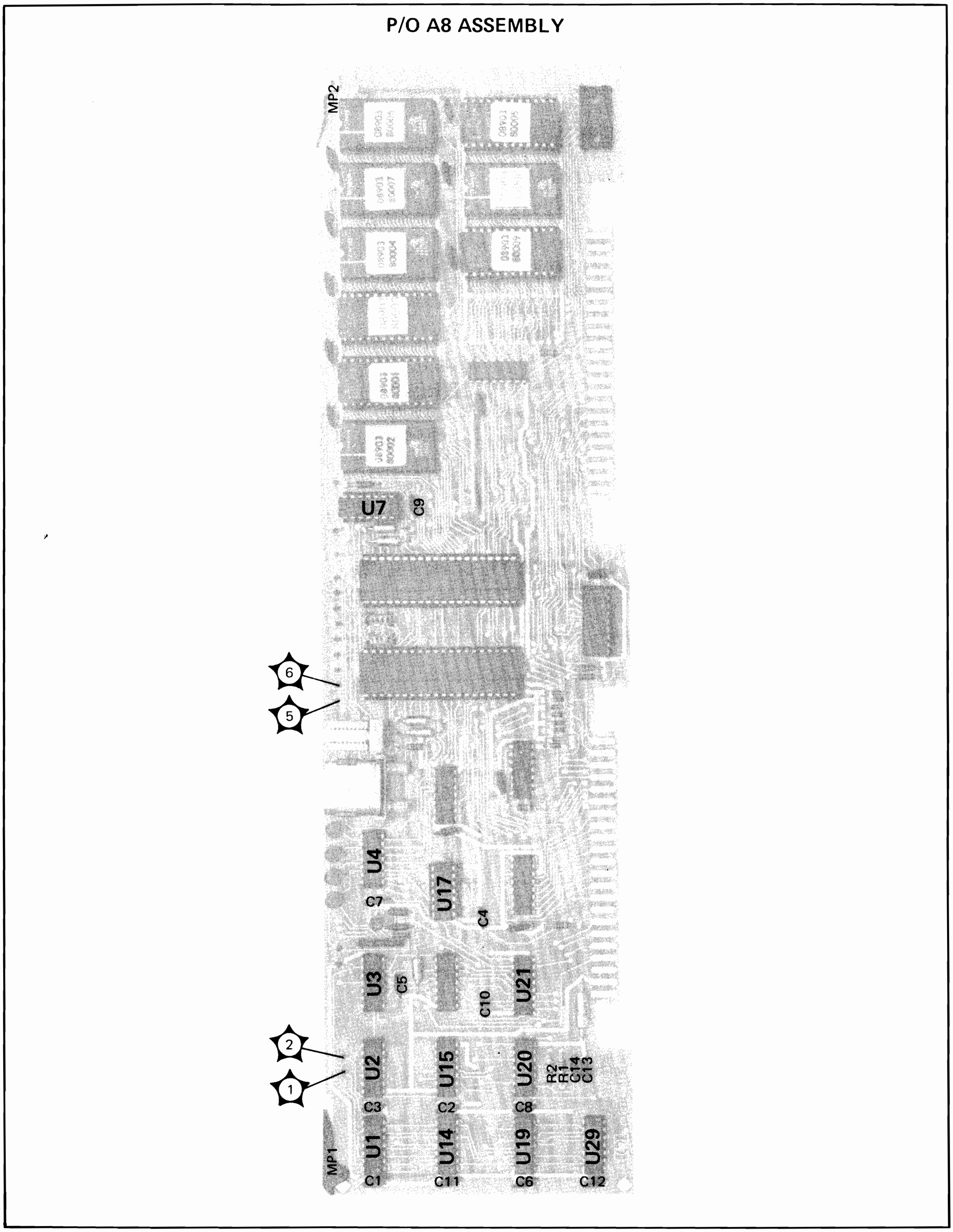
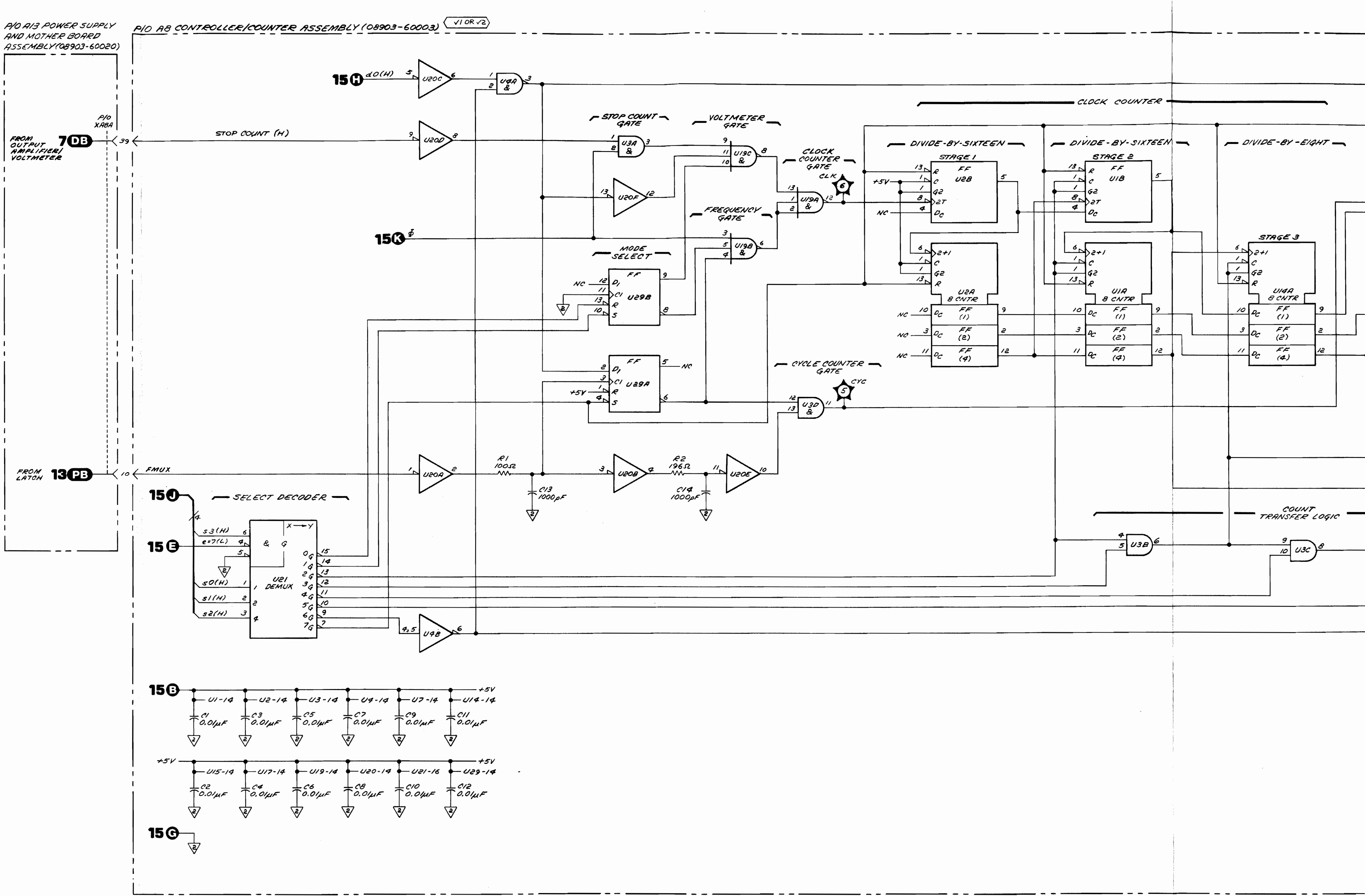
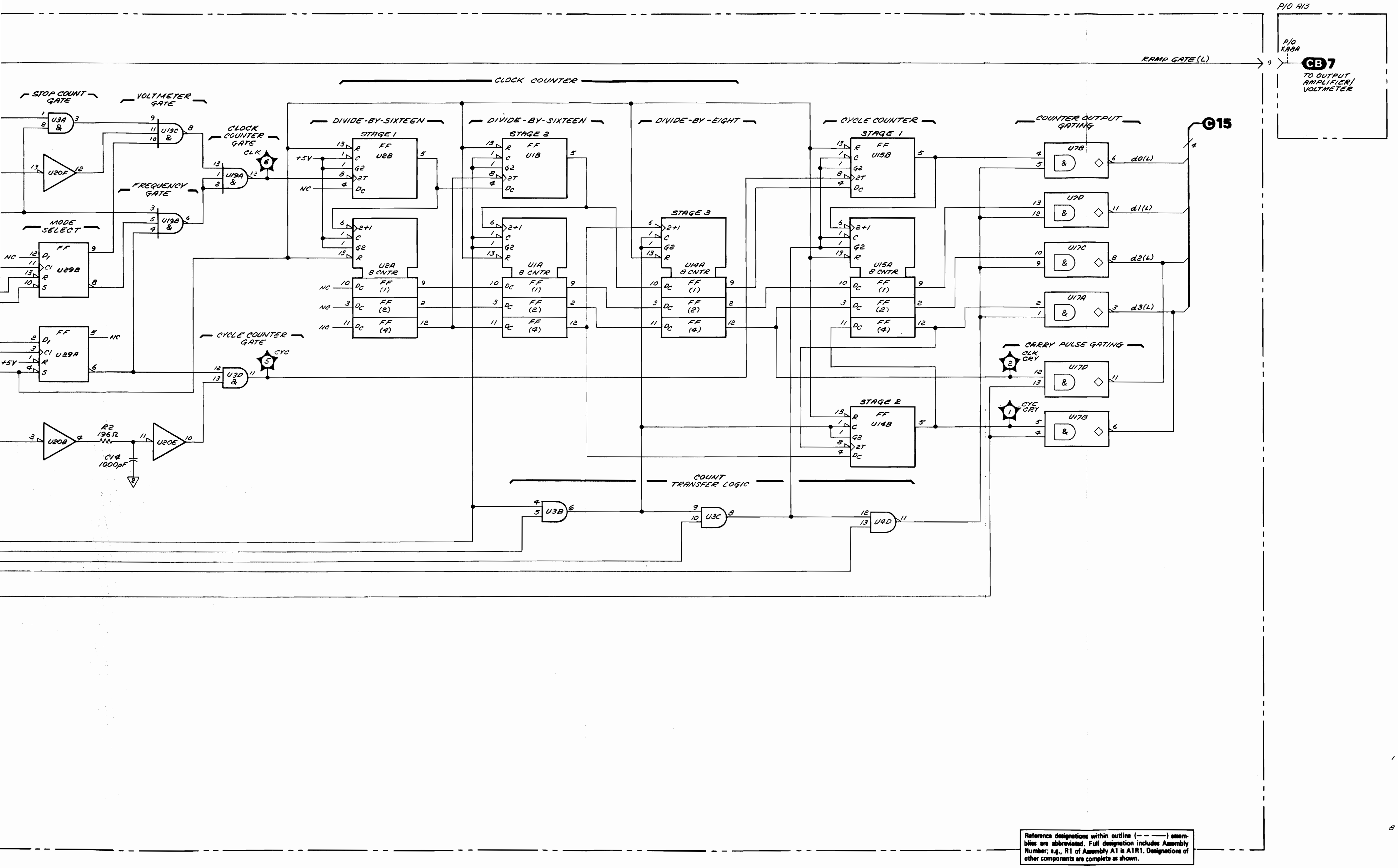


Figure 8-99. P/O A8 Controller/Counter Assembly Component Locations (Counter Circuits)



8903A COUNTER CIRCUITS: 1942A



Reference designations within outline (– – ——) assemblies are abbreviated. Full designation includes Assembly Number; e.g., R1 of Assembly A1 is A1R1. Designations of other components are complete as shown.

NOTES

1. SEE TABLE 8-7 SCHEMATIC DIAGRAM NOTES.

REFERENCE DESIGNATIONS

A8	A13
C1-14 R1,2 TP1,2,5,6 U1-4,7,14, 15,17, 19-21,29	XA8A

LOGIC LEVELS

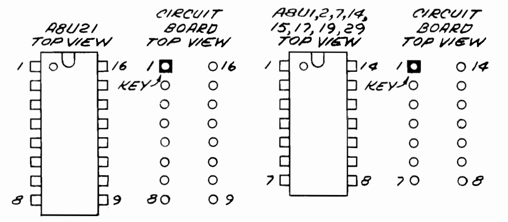
	TTL
HIGH	>2V
LOW	<0.8V
< IS MORE NEG. THAN > IS MORE POS. THAN	
OPEN	HIGH
GROUND	LOW

INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATIONS	PART NUMBERS
U1,2,14,15	1820 - 1193
U3	1820 - 1201
U4	1820 - 1197
U7,17	1820 - 1198
U19	1820 - 1202
U20	1820 - 1199
U21	1820 - 1216
U29	1820 - 1112

INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

REFERENCE DESIGNATIONS	PIN NUMBERS
U1-4,7,14,15, 17,19,20,29	+5V - 14 ▽2 - 7
U21	+5V - 16 ▽2 - 8



14
P/O A8

Figure 8-100. Controller/Counter—Counter Circuits Schematic Diagram

SERVICE SHEET 15—CONTROLLER/COUNTER—CONTROLLER (P/O A8)

TROUBLESHOOTING HELP

- Block Diagram .... Service Sheet BD2
- Direct Control Special Functions .... Paragraph 8-26
- Signature Analysis .... Paragraph 8-33

PRINCIPLES OF OPERATION

General

The Controller/Counter Assembly (A8) controls the entire automated portion of the operation of the instrument. The Controller consists of a Microprocessor, ROMs, a RAM, and input/output circuits. The Microprocessor, RAM, and I/O circuits are shown on Service Sheet 15, the ROMs on Service Sheet 16. For a general discussion of how the Controller and the Instrument Bus control the operations of the instrument, see paragraph 8-26.

Microprocessor

The Microprocessor is divided into two ICs, the Central Processing Unit (CPU) and the Static Memory Interface (SMI). In addition a third IC, the Peripheral Input/Output (PIO) located on the Remote Interface Assembly (Service Sheet 19), is considered a part of the Microprocessor. The PIO is used when it is necessary to interface the CPU with the HP-IB. The CPU (U5) is an eight-bit parallel processor. Crystal Y1 and capacitors C25, C26, and C27 determine the frequency (2 MHz) of the CPU's internal clock. This clock also serves as the time base reference for the Counter. The CPU inputs and outputs are described in Table 8-75.

Table 8-75. Inputs and Outputs of the CPU (U5)

Pin Name	Description	Type
I/O00 thru I/O07	I/O Port Zero	Input/Output
I/O10 thru I/O17	I/O Port One	Input/Output
DB0 thru DB7	Data Bus Lines	Bi-directional (3-state)
ROMC0 thru ROMC4	Control Lines	Output
Φ, WRITE	Clock Lines	Output
EXT RES	External Reset	Input
INT REQ	Interrupt Request	Input
ICB	Interrupt Control Bit	Output
RC	RC Network	Input
XTLX	Crystal Clock Line	Output
XTLY	External Clock Line	Input

The SMI provides most of the interface logic needed to address up to 65 536 bytes of memory in the microprocessor system. In response to control signals from the CPU, the SMI generates the address and control signals needed by the memory devices. The SMI inputs and outputs are described in Table 8-76.

The PIO provides most of the interface logic needed to interface the CPU with the HP-IB. The PIO is described in Service Sheet 19.

Memory

The instrument's memory consists of nine 2048-bit ROMs, a RAM, and some small memory capability within the CPU itself. The RAM is the CPU External Register (U30) and is a 256-address, 4-bit scratch pad memory used to read and write 4 bits (DB0-DB3) to and from the CPU. The Memory Select Decoder (U24) controls which memory IC on the Controller Assembly is enabled. Address line 15 enables the RAM.

Table 8-76. Inputs and Outputs of the SMI (U6)

Pin Name	Description	Type
DB0 thru DB7	Data Bus Lines	Bi-Directional (3-state)
ADDR0 thru ADDR15	Address Lines	Output
ROMC0 thru ROMC4	Control Lines	Input
Φ, WRITE	Clock Lines	Input
INT REQ	Interrupt Request	Output
PRI IN	Priority In Line	Input
RAM WRITE	Write Line	Output
EXT INT	External Interrupt Line	Input
REGDR	Register Drive Line	Input/Output
CPU READ	CPU Read Line	Output

To illustrate how a ROM address is accessed for data, assume that the CPU wants to read information from address 255 of ROM 3 (U10). First, the CPU places the necessary information on the ROM Control (ROMC) and the data lines of the Control Bus. The SMI decodes this information from the CPU and outputs the required address information on lines A0(H) through A15(H) and then sets CPU READ(H) high. CPU READ(H) is inverted by U23E and pulls one of the enable inputs low on each ROM and the RAM.

Note that this is a read operation and the RAM WRITE(L) line from the SMI is high. Of address lines A11(H) through A15(H), only A12(H) will be high. Memory Select Decoder U24 decodes lines A11(H) through A14(H). Since only line A12(H) is high, output 2 — ROM3(L) — of U24 goes low. Since A15(H) is low, the RAM (U30) is not enabled (A15(H) is inverted by U23F). Since CPU READ(L) and ROM3(L) are both low, ROM3 (U10) is enabled.

Since A0(H) through A7(H) are high and A8(H) through A10(H) are low, the data at address 255 is read out of the ROM. The 8 bits of information are placed on lines DB0(H) through DB7(H). This information is then read into the CPU (U5).

The RAM read and write functions are similar to the ROM function. The CPU READ(H) and RAM WRITE(L) lines are used to determine which function of the CPU External Register (U30) is activated. Address line A15(H) is used to enable U30.

TEST LEDs and Test Points

The TEST LEDs DS1 through DS4 are controlled by the CPU as described in paragraph 8-32. The test points (TP7 through TP10) are used to modify the power-up routine and are also used when performing signature analysis.

SERVICE SHEET 15 (Cont'd)

Select and Data Buffers

The Select and Data Buffers (U16 and U23) invert and buffer the I/O 00 through I/O 07 input/output lines from the CPU to the Instrument Bus. For a general discussion of the Instrument Bus, see Service Sheet BD4. In addition, data lines d0(L) through d3(L) are input to the CPU from the Instrument Bus.

Enable Decoder

The Enable Decoder (U22) decodes the e0(H) through e3(H) lines from the CPU into the eight individual enable lines e=0(L) through e=7(L). These are distributed throughout the instrument to enable the desired select decoder.

Power On Reset

The Power On Reset circuit (Q1 and associated components) applies a momentary low on the EXT RES line of the CPU when power is applied to the instrument. When EXT RES is pulled low and then released, a program originating at memory address 0 is executed.

TROUBLESHOOTING

General

Procedures for checking the Controller/Counter Assembly are given below. The circuits to check are marked on the schematic diagram by a hexagon with a check mark and a number inside, e.g., ⟨√3⟩. In addition, any points outside the labeled circuit area that must be checked are also identified. Extend the board assembly where necessary to make measurements.

CAUTIONS

MOS and CMOS ICs can be damaged by static charges and circuit transients. Do not remove this assembly from the instrument while power is applied. Discharge the board and replacement IC to the same potential. (Use a conductive foam pad such as HP 4208-0094.) When unplugging ICs, place the board on a conductive pad. When the IC is unplugged, insert it into the pad also.

Several ICs on this assembly are held in high-grip sockets. Both the socket and the device can be damaged if an attempt is made to remove the device with an IC extraction tool. The recommended procedure is to first ground the tip of a small blade-type screwdriver, then slide the tip between the IC and the socket and slowly pry up the IC one pair of pins at a time.

If the Audio Analyzer powers up correctly, it is a strong indication that the Controller circuits are operating properly. In most cases, the two most common indications of a Controller fault are that the instrument fails to complete even the first phase of the power-up routine or that it behaves very erratically. However, be very careful

pad memory used to read
e CPU. The Memory Select
; on the Controller Assem-
ıe RAM.

ıf the SMI (U6)

	Type
	Bi-Directional (3-state)
	Output
	Input
	Input
	Output
	Input
	Output
	Input
	Input/Output
	Output

ssed for data, assume that
m address 255 of ROM 3
y information on the ROM
he Control Bus. The SMI
and outputs the required
ugh A15(H) and then sets
ıverted by U23E and pulls
M and the RAM.

RAM WRITE(L) line from
H) through A15(H), only
ecoder U24 decodes lines
A12(H) is high, output 2
5(H) is low, the RAM (U30)
3F). Since CPU READ(L)
is enabled.

A8(H) through A10(H) are
of the ROM. The 8 bits of
I) through DB7(H). This
J5).

nilar to the ROM function.
lines are used to determine
egister (U30) is activated.
0.

controlled by the CPU as
ıts (TP7 through TP10) are
d are also used when per-

Select and Data Buffers

The Select and Data Buffers (U16 and U23) invert and buffer the I/O 00 through I/O 07 input/output lines from the CPU to the Instrument Bus. For a general discussion of the Instrument Bus, see Service Sheet BD4. In addition, data lines d0(L) through d3(L) are input to the CPU from the Instrument Bus.

Enable Decoder

The Enable Decoder (U22) decodes the e0(H) through e3(H) lines from the CPU into the eight individual enable lines e=0(L) through e=7(L). These are distributed throughout the instrument to enable the desired select decoder.

Power On Reset

The Power On Reset circuit (Q1 and associated components) applies a momentary low on the EXT RES line of the CPU when power is applied to the instrument. When EXT RES is pulled low and then released, a program originating at memory address 0 is executed.

TROUBLESHOOTING

General

Procedures for checking the Controller/Counter Assembly are given below. The circuits to check are marked on the schematic diagram by a hexagon with a check mark and a number inside, e.g., ⟨√3⟩. In addition, any points outside the labeled circuit area that must be checked are also identified. Extend the board assembly where necessary to make measurements.

CAUTIONS

MOS and CMOS ICs can be damaged by static charges and circuit transients. Do not remove this assembly from the instrument while power is applied. Discharge the board and replacement IC to the same potential. (Use a conductive foam pad such as HP 4208-0094.) When unplugging ICs, place the board on a conductive pad. When the IC is unplugged, insert it into the pad also.

Several ICs on this assembly are held in high-grip sockets. Both the socket and the device can be damaged if an attempt is made to remove the device with an IC extraction tool. The recommended procedure is to first ground the tip of a small blade-type screwdriver, then slide the tip between the IC and the socket and slowly pry up the IC one pair of pins at a time.

If the Audio Analyzer powers up correctly, it is a strong indication that the Controller circuits are operating properly. In most cases, the two most common indications of a Controller fault are that the instrument fails to complete even the first phase of the power-up routine or that it behaves very erratically. However, be very careful about assuming a Controller failure when the instrument behaves erratically. Because of the close interrelationship of the circuit components, the data feedback loops, and the software, a failure that is occuring in one section of the instrument can affect other areas. For example, many types of malfunctions will prevent the Audio Analyzer from tuning properly.

In addition, keep the following points in mind when troubleshooting the Controller:

1. It is important to understand the structure of the Controller's buses. Data on these buses is often unstable or meaningless because of multiplexing, switching transients, and open collector circuits. These conditions cause no problems for the Controller itself since it is synchronous and knows when the bus lines contain stable signals. (This is also true for the signature analyzer.) However, this is not true of other instruments testing the Controller such as a logic probe or oscilloscope. These test instruments, though, can still be used to examine qualitative factors such as general activity, logic levels, waveform timing, and bus conflicts.

2. Since bus structures also make it possible for many devices to be connected together on a single node, finding the one bad device on such a node can be difficult. A current tracer is useful for this purpose.

3. The Controller is a sequential processor. Program flow depends on a long sequence of instructions and events. If even a single bit of information is incorrect, the entire sequence can be changed. Bad memory bits are the most common source of single-bit errors.

4. The proper operation of the clock circuits is critical.

5. An improper reset can cause the Controller to appear to be running, but it may be incorrectly initialized or running the wrong sequence of software.

6. Interrupts are edge triggered. A stuck interrupt will interrupt once and then never again. An intermittent interrupt will keep interrupting. When the Controller is interrupted, the measurement is aborted, and the complete measurement cycle restarts at the beginning. Therefore, if the intermittent interrupt occurs frequently, it will completely prevent the instrument from operating.

Equipment

Digital Test/Extender Board ....HP 08903-60018
Signature Analyzer........................HP 5004A

⟨√1⟩ Memory Select Decoders and ROM Check

NOTE

This check is a continuation of the Controller Kernel Check of Service Sheet BD4.

1. Switch LINE to OFF. Remove A8U30 (CPU External Register –RAM) from its socket. Extend the A8 Controller/Counter Assembly with the digital test/extender board. Connect the ribbon cable on the extender board to A8J1. Switch LINE to ON.

2. Short A8TP4 (RES) to A8TP3 (GND). Switch the ROMC switches on the extender board to CLOSED. Connect the signature analyzer clock to A8TP13 (WRT) and ground to A8TP3 (GND). Connect start and stop to ADDRESS 15 on the extender board. Set the signature analyzer's start to trigger on a falling edge and stop and clock to trigger on a rising edge. Check the pins listed in Table 8-77 with the signature analyzer probe.

Table 8-77. A8U24 Signatures

Selected ROM	Pin on U24	Signature	Selected ROM	Pin on U24	Signature
1	1	4CP2	6	6	2F25
2	2	U1U2	7	7	F615
3	3	P352	8	9	6F7P
4	4	340A	9	10	048A
5	5	8UH9			

Hint: If faulty, check U24 and its output lines.

3. Connect the signature analyzer start and stop to the pin on U24 listed in Table 8-78. Then check the indicated CONTROL BUS test points on the extender board with the signature analyzer probe.

NOTE

The signatures in Table 8-78 are valid only for the ROMs with the part number listed in Table 8-79. Consult Section VII BACKDATING or the Manual Changes Supplement for signatures corresponding to ROMs with other part numbers.

Table 8-78. Control Bus Data Test Point Signatures

ROM	Start/Stop to Pin on U24	Signature on CONTROL BUS DATA Test Point							
		0	1	2	3	4	5	6	7
1	1	H741	2F30	56H3	P199	7HPH	2528	796H	1H12
2	2	8H2A	3186	H197	34PF	0CPF	2H65	8A43	7AP9
3	3	8U1C	8420	0U8H	A1P3	A3F0	65C1	FH1F	12P8
4	4	AF14	64P1	59FA	4FP3	63P7	9HA3	H218	4C88
5	5	2H61	U4CA	61A4	3FFH	29UF	4145	P2UC	73AF
6	6	4F36	FP85	9H4F	815F	9A82	U9AA	19CF	2067
7	7	U6A7	AUPP	8F61	730F	5PA1	458A	223C	U2F3
8	9	63U6	0596	6367	7377	601F	2AP8	U23C	3098
9	10	9AA3	PHH0	6C2F	09U0	6HFF	5C2A	0068	6932

Table 8-79. Valid ROM Part Numbers

ROM Number	Part Number
1	08903-80001
2	1818-1416 or 08903-80002
3	1818-1417 or 08903-80003
4	1818-1418 or 08903-80004
5	1818-1419 or 08903-80005
6	1818-1420 or 08903-80006
7	1818-1421 or 08903-80007
8	1818-1422 or 08903-80008
9	1818-1423 or 08903-80009

Hint: A faulty signature indicates a faulty ROM.

√2 Enable Decoder Check

1. Key in the Direct Control Special Functions indicated in Table 8-80. For each setting, check the pins on U22 indicated.

√3 Select and Data Buffers Check

1. Key in the Direct Control Special Functions indicated in Tables 8-81 and 8-82. For each setting, check the pins indicated.

Table 8-81. TTL Levels at A8U23

Direct Control Special Function	Level (TTL) at U23 Pin							
	9	8	5	6	3	4	1	2
0.000	H	L	H	L	H	L	H	L
0.0FF	L	H	L	H	L	H	L	H

Table 8-82. TTL Levels at A8U16

Direct Control Special Function	Level (TTL) at U16 Pin							
	12	11	9	8	1	3	5	6
0.000	H	L	H	L	H	L	H	L
0.0FF	L	H	L	H	L	H	L	H

Table 8-80. TTL Levels at A8U22

Direct Control Special Function	Level (TTL) at U22 Pin											
	1	2	3	4	7	9	10	11	12	13	14	15
0.000	L	L	L	*	H	H	H	H	H	H	H	*
0.100	H	L	L	*	H	H	H	H	H	H	*	H
0.200	L	H	L	*	H	H	H	H	H	*	H	H
0.300	H	H	L	*	H	H	H	H	*	H	H	H
0.400	L	L	H	*	H	H	H	*	H	H	H	H
0.500	H	L	H	*	H	H	*	H	H	H	H	H
0.600	L	H	H	*	H	*	H	H	H	H	H	H
0.700	H	H	H	*	*	H	H	H	H	H	H	H

* Low-going TTL pulses, ≈30 ms period.

Hint: If "enable=2" is bad, these special functions cannot be keyed into the instrument (perform the Front-Panel Keys and Scanners Check—Using Signature Analysis on Service Sheet 17).

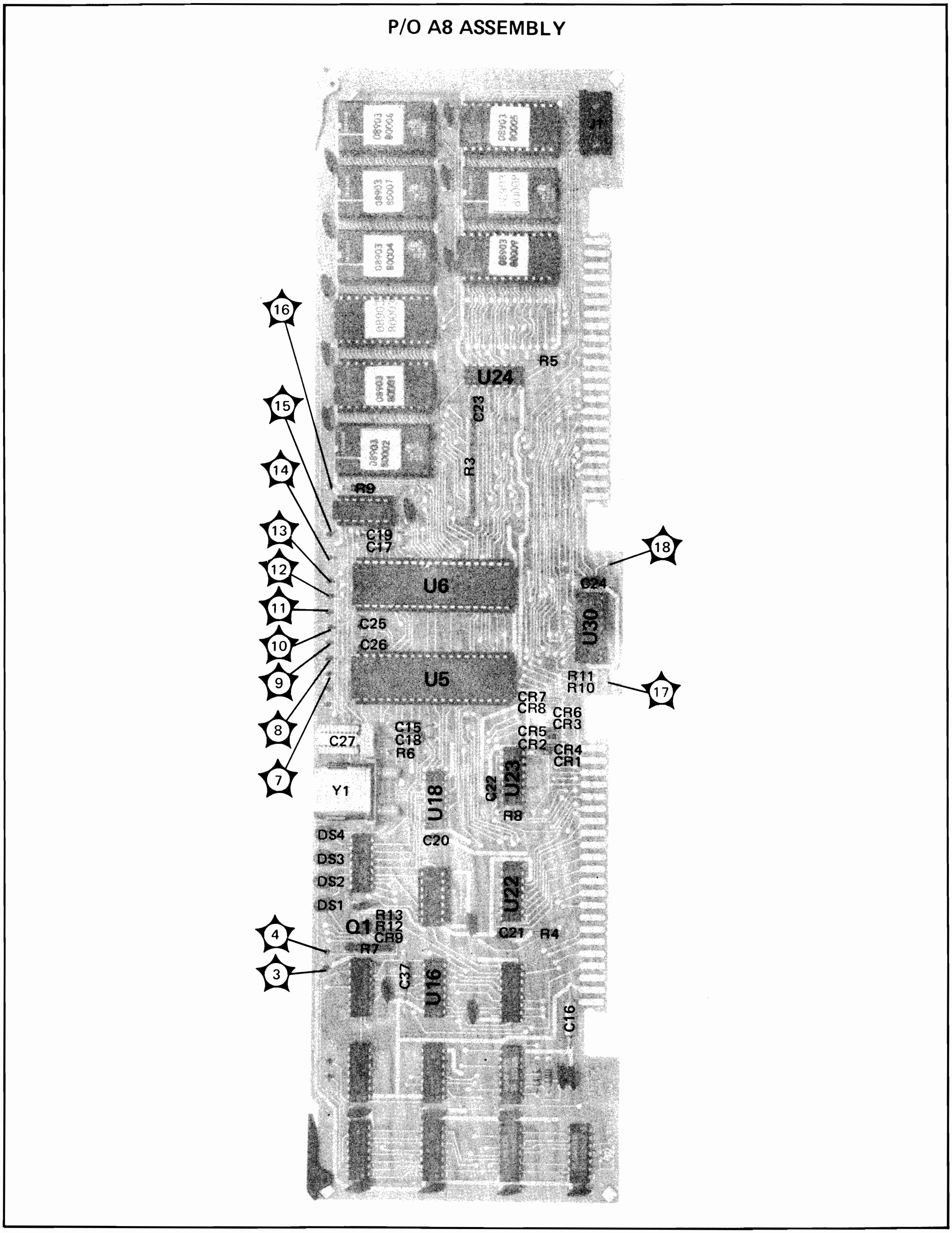
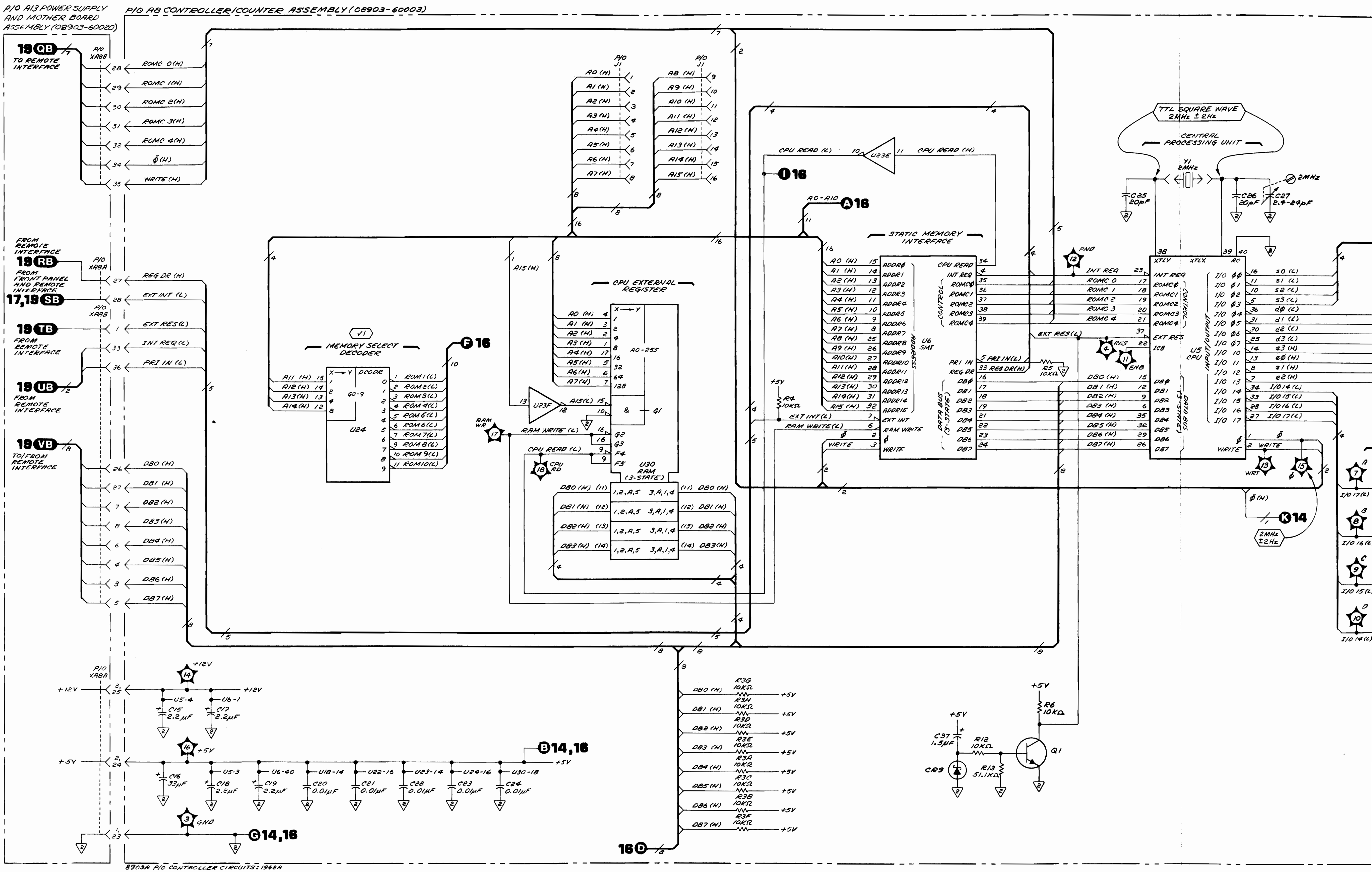
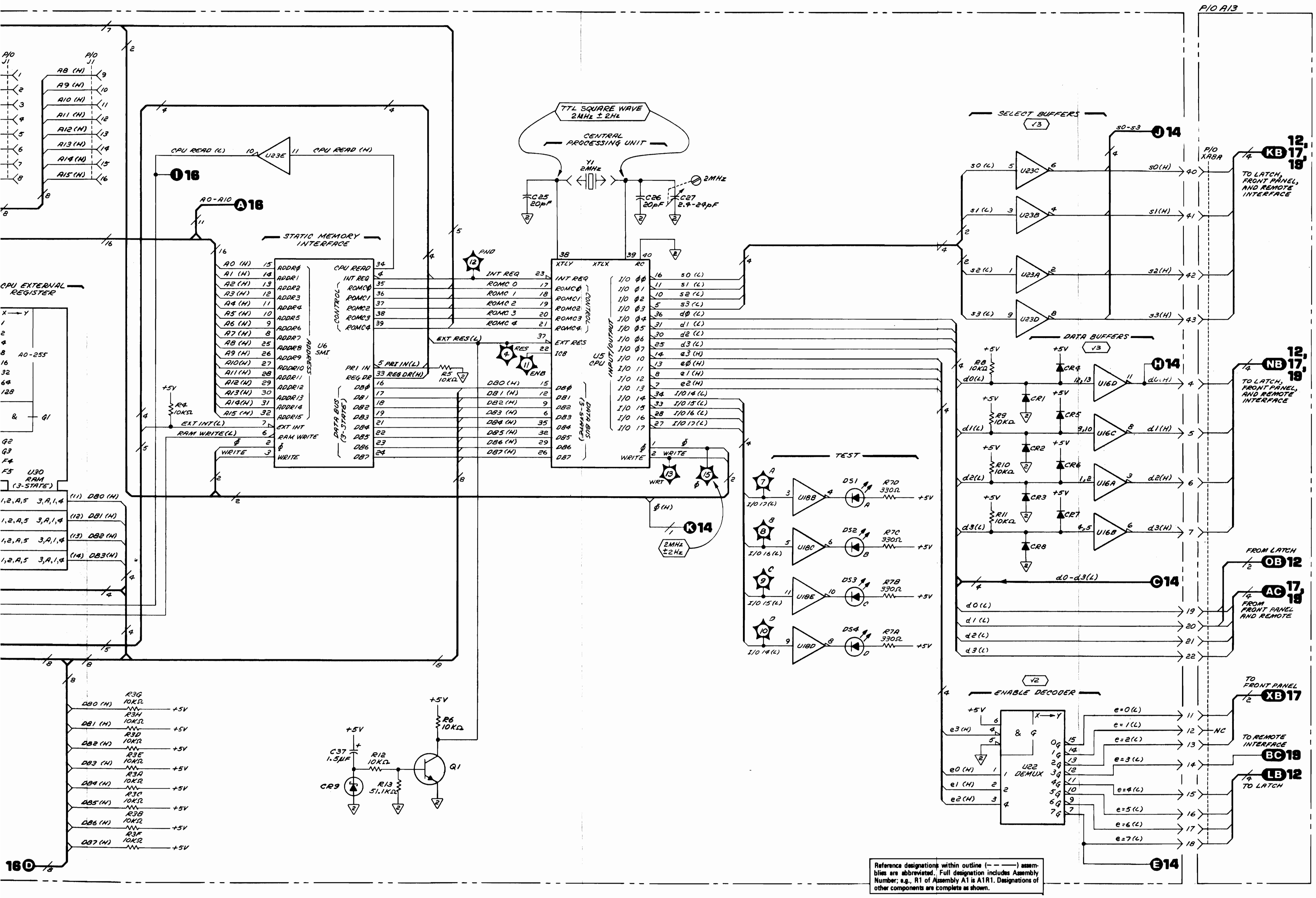


Figure 8-101. P/O A8 Controller/Counter Assembly Component Locations (Controller)


P/O A13 POWER SUPPLY AND MOTHER BOARD ASSEMBLY (08903-60020)
P/O A8 CONTROLLER/COUNTER ASSEMBLY (08903-60003)
19 QB TO REMOTE INTERFACE
P/O XA8B
ROMC 0(H)
ROMC 1(H)
ROMC 2(H)
ROMC 3(H)
ROMC 4(H)
ɸ(H)
WRITE (H)
FROM REMOTE INTERFACE 19 RB
P/O XA8A
REG DR (H)
FROM FRONT PANEL AND REMOTE INTERFACE 17,19 SB
EXT INT (L)
19 TB FROM REMOTE INTERFACE
EXT RES (L)
INT REQ (L)
19 UB FROM REMOTE INTERFACE
PRI IN (L)
19 VB TO/FROM REMOTE INTERFACE
DB0 (H)
DB1 (H)
DB2 (H)
DB3 (H)
DB4 (H)
DB5 (H)
DB6 (H)
DB7 (H)
P/O J1
A0 (H) … A15 (H)
MEMORY SELECT DECODER
U24
DCODE
ROM1(L) … ROM10(L)
F 16
CPU EXTERNAL REGISTER
A15 (H)
U23F
A0-255
U30 RAM (3-STATE)
RAM WR 17
RAM WRITE (L)
CPU READ (L)
CPU RD 18
U23E
CPU READ (H)
I 16
A0-A10 A 16
STATIC MEMORY INTERFACE
U6 SMI
ADDRESS
CONTROL
DATA BUS (3-STATE)
CPU READ
INT REQ
ROMC0 … ROMC4
PRI IN
REG DR
EXT INT
RAM WRITE
WRITE
+5V R4 10kΩ
EXT INT (L)
RAM WRITE (L)
5 PRI IN (L)
33 REG DR (H)
R5 10kΩ
EXT RES (L)
PND 12
RES 4
ENB 11
TTL SQUARE WAVE 2MHz ± 2Hz
CENTRAL PROCESSING UNIT
Y1 2MHz
C25 20pF
C26 20pF
C27 2.9-29pF
2MHz
XTLY
XTLX
RC
U5 CPU
INT REQ
ROMC0 … ROMC4
EXT RES
ICB
DB0 … DB7
INPUT/OUTPUT
I/O ɸ0 … I/O 17
s0 (L) s1 (L) s2 (L) s3 (L)
d0 (L) d1 (L) d2 (L) d3 (L)
e0 (H) e1 (H) e2 (H)
I/O 14 (L) I/O 15 (L) I/O 16 (L) I/O 17 (L)
WRITE
WRT 13
ɸ 15
ɸ(H)
K14
2MHz ±2Hz
I/O 17(L) I/O 16(L) I/O 15(L) I/O 14(L)
P/O XA8A
+12V
14 +12V
U5-4
U6-1
C15 2.2µF
C17 2.2µF
+5V
16 +5V
B 14,16
U5-3 U6-40 U18-14 U22-16 U23-14 U24-16 U30-18
C16 33µF
C18 2.2µF
C19 2.2µF
C20 0.01µF
C21 0.01µF
C22 0.01µF
C23 0.01µF
C24 0.01µF
3 GND
G 14,16
R3G R3H R3D R3E R3A R3C R3B R3F 10kΩ
16 D
+5V R6 10kΩ
C37 1.5µF
CR9
R12 10kΩ
R13 51.1kΩ
Q1
8903A P/O CONTROLLER CIRCUITS: 1942A



Reference designations within outline (– – ——) assemblies are abbreviated. Full designation includes Assembly Number; e.g., R1 of Assembly A1 is A1R1. Designations of other components are complete as shown.

NOTES

1. SEE TABLE 8-7 SCHEMATIC DIAGRAM NOTES.

REFERENCE DESIGNATIONS

A8	A8 CONT.
C15-27,37 CR1-9 DS1-4 J1 Q1 R3-13 TP3,4,7-18	U5,6,16,18, 22-24,30 Y1
	A13
	XA8A,B

LOGIC LEVELS

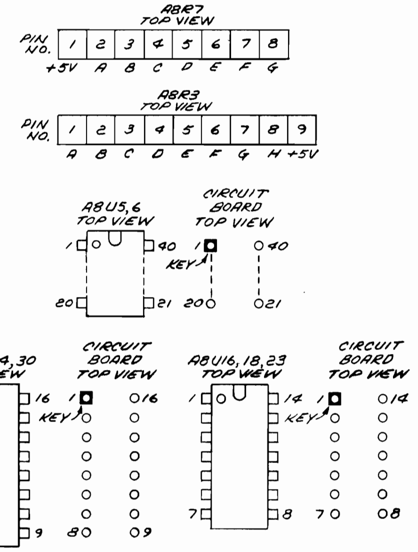
	TTL
HIGH	>2V
LOW	<0.8V
< IS MORE NEG. THAN > IS MORE POS. THAN	
OPEN	HIGH
GROUND	LOW

INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATIONS	PART NUMBERS
U5	1820 - 1928
U6	1820 - 2027
U16	1820 - 1287
U18	1820 - 1199
U22	1820 - 1216
U23	1820 - 0174
U24	1820 - 1418
U30	1818 - 0197
Q1	1854 - 0810

INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

REFERENCE DESIGNATIONS	PIN NUMBERS
U5	+12V - 4 +5V - 3 ▽2 - 24
U6	+12V - 1 +5V - 40 ▽2 - 20
U16,18,23	+5V - 14 ▽2 - 7
U22,24	+5V - 16 ▽2 - 8
U30	+5V - 18 ▽2 - 8



15
P/O A8

Figure 8-102. Controller/Counter—Controller Schematic Diagrasm

Controller/Counter—Controller
P/O A8
SERVICE SHEET 15

SERVICE SHEET 16—CONTROLLER/COUNTER—READ-ONLY MEMORY (P/O A8)

TROUBLESHOOTING HELP

- Block Diagram .... Service Sheet BD4
- Direct Control Special Functions .... Paragraph 8-26
- Signature Analysis .... Paragraph 8-33

PRINCIPLES OF OPERATION

The read-only memory (ROM) circuits are included in the principles of operation discussion on Service Sheet 15.

TROUBLESHOOTING

Procedures for checking the ROMs are given in the Memory Select Decoders and ROM Check on Service Sheet 15.

P/O A8 ASSEMBLY

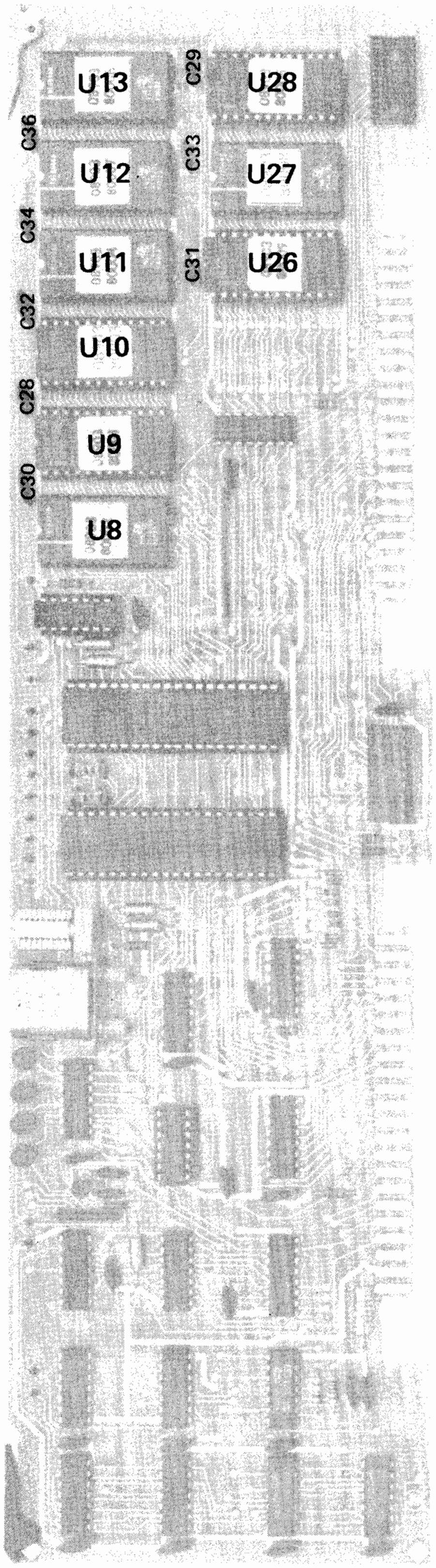
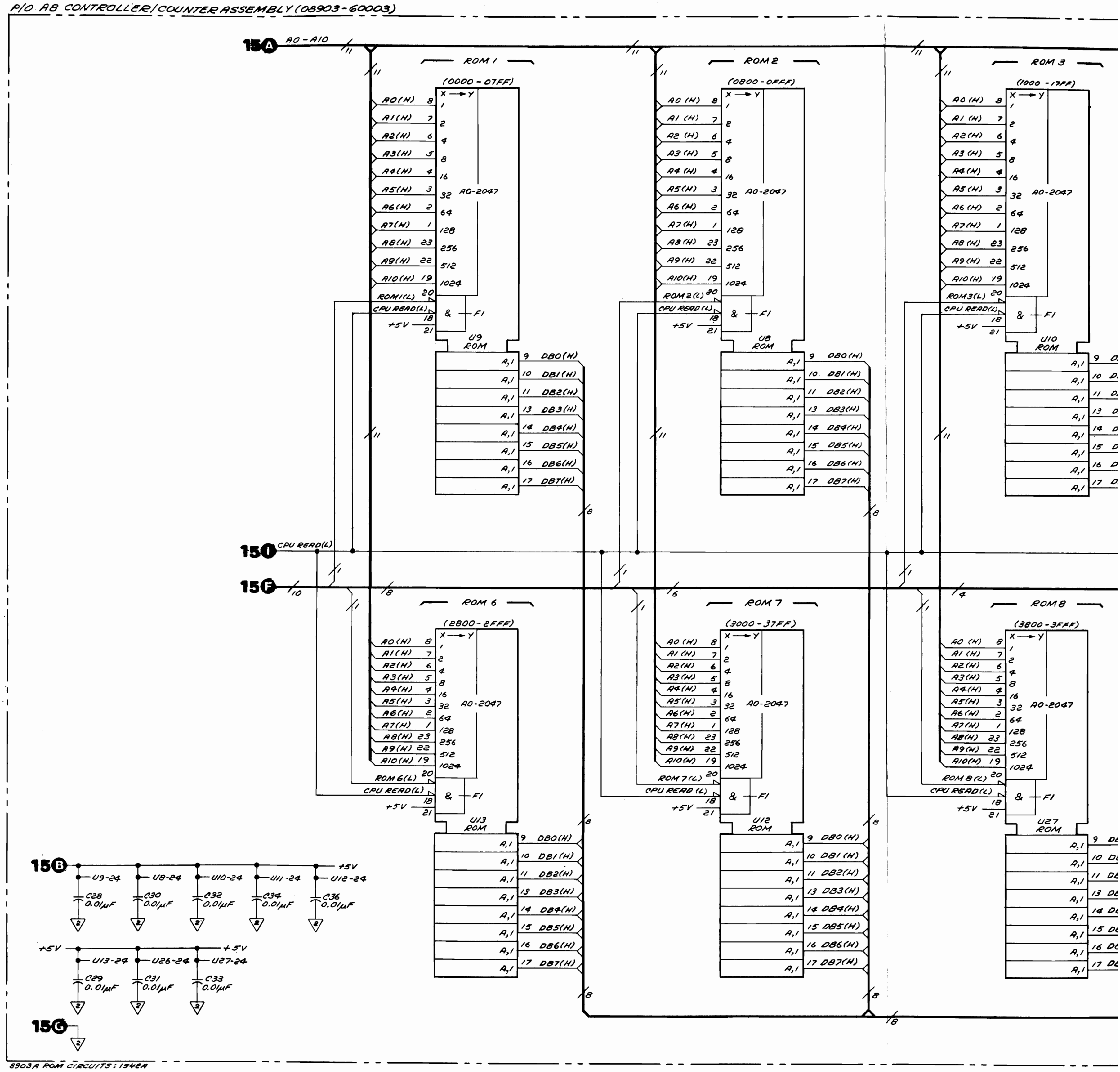
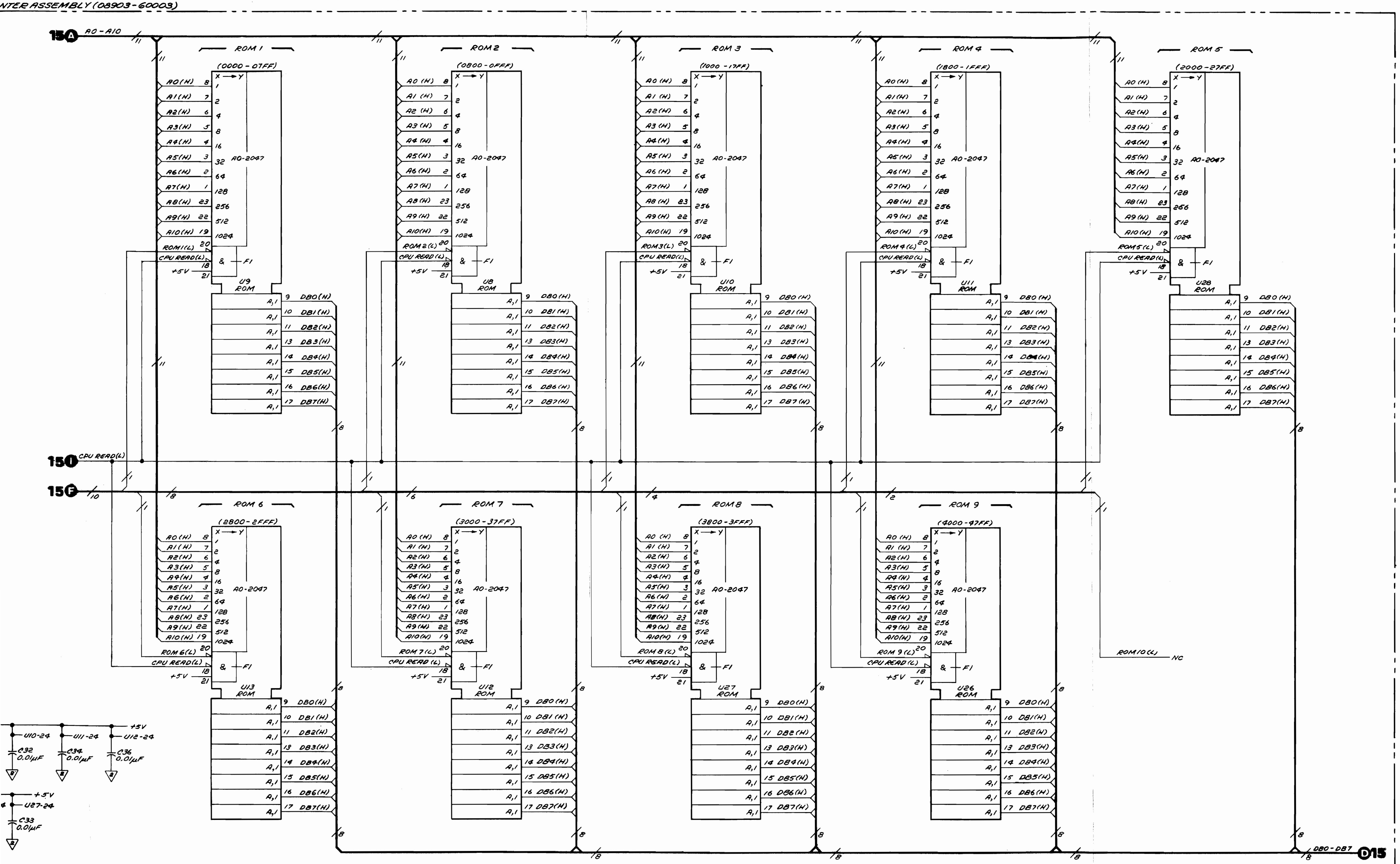


Figure 8-103. P/O A8 Controller/Counter Assembly Component Locations (Read-Only Memory)



P/O A8 CONTROLLER/COUNTER ASSEMBLY (08903-60003)
15A A0-A10
11
ROM 1
(0000-07FF)
ROM 2
(0800-0FFF)
ROM 3
(1000-17FF)
X→Y
A0(H) 8
A1(H) 7
A2(H) 6
A3(H) 5
A4(H) 4
A5(H) 3
A6(H) 2
A7(H) 1
A8(H) 23
A9(H) 22
A10(H) 19
1
2
4
8
16
32
64
128
256
512
1024
A0-2047
ROM1(L) 20
ROM2(L) 20
ROM3(L) 20
CPU READ(L) 18
+5V 21
&
F1
U9 ROM
U8 ROM
U10 ROM
A,1
9 DB0(H)
10 DB1(H)
11 DB2(H)
13 DB3(H)
14 DB4(H)
15 DB5(H)
16 DB6(H)
17 DB7(H)
8
15I CPU READ(L)
15F 10
1
8
6
4
ROM 6
(2800-2FFF)
ROM 7
(3000-37FF)
ROM 8
(3800-3FFF)
ROM 6(L) 20
ROM 7(L) 20
ROM 8(L) 20
U13 ROM
U12 ROM
U27 ROM
15B
+5V
U9-24
U8-24
U10-24
U11-24
U12-24
C28 0.01μF
C30 0.01μF
C32 0.01μF
C34 0.01μF
C36 0.01μF
+5V
U13-24
U26-24
U27-24
C29 0.01μF
C31 0.01μF
C33 0.01μF
15G
8903A ROM CIRCUITS: 1942A



Reference designations within outline (— — ——) assemblies are abbreviated. Full designation includes Assembly Number; e.g., R1 of Assembly A1 is A1R1. Designations of other components are complete as shown.

NOTES

1. SEE TABLE 8-7 SCHEMATIC DIAGRAM NOTES.

REFERENCE DESIGNATIONS

A8
C28-34,36 U8-13, 26-28

NOT ASSIGNED: A8 C35, U25

LOGIC LEVELS

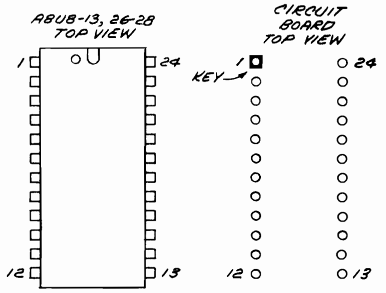
	TTL
HIGH	> 2V
LOW	< 0.8V
< IS MORE NEG. THAN > IS MORE POS. THAN	
OPEN	HIGH
GROUND	LOW

INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATIONS	PART NUMBERS
U8	1818-1416
U9	08903-80001
U10	1818-1417
U11	1818-1418
U12	1818-1421
U13	1818-1420
U26	1818-1423
U27	1818-1422
U28	1818-1419

DIGITAL INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

REFERENCE DESIGNATIONS	PIN NUMBERS
U8-13, 26-28	+5V - 24 ⚠2 - 12



16
P/O A8

Figure 8-104. Controller/Counter—Read-Only Memory Schematic Diagram

SERVICE SHEET 17—KEYBOARD AND DISPLAY—KEYBOARD CIRCUITS (P/O A1)

TROUBLESHOOTING HELP

- Block Diagram .... Service Sheet BD4
- Direct Control Special Functions .... Paragraph 8-26
- Signature Analysis .... Paragraph 8-33

PRINCIPLES OF OPERATION

NOTE

The following discussion requires an understanding of the operation of the Instrument Bus (see Instrument Bus, Service Sheet BD4) and of the Instrument Bus readback (see Direct Control Special Functions, paragraph 8-26).

General

The Keyboard and Display Assembly interrupts the Controller when a key has been pressed and provides the circuitry that enables the Controller to determine which key was pressed.

Keystroke Detector

The Keystroke Detector pulses the External Interrupt line low when a key is pressed. When no key is down (i.e., key switches S1 through S41 open), the inverting (—) input to U22B is pulled low by R6C and R6D. The outputs of the Key Row Scanner U30 are normally in the high or off state (the outputs are open-collector). The non-inverting (+) input of U22B is biased at approximately +1.4V. Thus for the condition when no key is pressed, the output of U22B is high, the output of U22A is low, and the output of U23A is high (i.e., no interrupt, see Service Sheet 15).

Pressing any key (e.g., the SINAD key S20) pulls the inverting input of U22B above +1.4V (via R5G and R2E for the SINAD key). This causes U23A to go low and creates a Controller interrupt. U22B has an open-collector output. When U22B goes low, C3 is rapidly discharged to produce a low on the input to U22A. However, when U22B goes high, C3 can only charge via R9. This action holds the input to U22A low for at least 50 ms regardless of key bounce. R11 adds hysteresis to U22A to improve noise immunity and shorten the transition time of the input to U23A.

Key Scanner and Front-Panel Keys

When the Controller receives an interrupt, it immediately initiates a key scan routine. The scan must identify the pressed key before the key has been released even in the presence of key bounce. Consider the example of pressing the SINAD key (S20). The scan begins by the Controller issuing esd=2F0 to the Instrument Bus. This puts an active low on pin 4 of demultiplexer U30. More specifically, e=2 and s=F. Both 1 and 2 inputs are high since s0=1 and s1=1. A 3 is demultiplexed. The 4 input is enabled since s2=1; the 5 input is disabled. e=2(L) is low and enables input G4. (Input G5 is not enabled because input 5 is not enabled.) Thus only the 3 output of the lower half of the demultiplexer (U38), enabled by input 4, is low.

The same Instrument Bus code enables the readback gates U24A, U25A, U24B, and U25B but not U24D, U25D, U24C, and U25C. More specifically, s3=1. Thus, the input to U23C is high. The two inputs to U23D are low. The NAND gates U24A, U25A, U24B, and U25B are enabled and function as inverters. U23B is low and the outputs of the NAND gates U24D, U25D, U24C, and U25C are high, i.e., off. The Controller reads back the data (d) lines and scans the data giving priority to the highest number decoded. Since all columns are held high by pull-up resistors, the Controller reads d=F. The SINAD key has no effect because the output at pin 7 of U30 is off at this time.

The Controller next issues esd=2E0. Pin 5 of U30 is now low. U24A, U25A, U24B, and U25B are still enabled and U24D, U25D, U24C, and U25C are still disabled. d=F is read back. The sequence then continues with the issuance of esd=2D0 and 2C0 with the result that d=F is read back each time until esd=2C0 when d=B will be read back; i.e., d2=0 (d2(L) is high). The Controller has now learned that the SINAD key was pressed.

If no key had been found in the first four columns, the sequence continues until the issuance of esd=270. With this code, the s3(H) input to U23B and U23C goes low. Now U24A, U25A, U24B, and U25B are disabled, and U24D, U25D, U24C, and U25C are enabled. The Controller now starts reading the data lines from U24D, U25D, U24C, and U25C to determine if one of the keys in the second four columns is closed.

If no key was found (i.e., d=F always) due to key bounce, the scan repeats until 50 ms have elapsed and then the instrument reverts back to its previous mode of operation. Whether the key was found or not, the measurement cycle that was interrupted is aborted and a new software cycle is initiated.

Key Light Circuits

The key light circuits are discussed on Service Sheet 18.

TROUBLESHOOTING

General

Procedures for checking the Keyboard and Display Assembly are given below. The circuits or points to check are marked on the schematic diagram by a hexagon with a check mark and a number inside, e.g., ⟨√3⟩. In addition, any points outside the labeled circuit **area that must be checked are identified. Fixed signals are shown on the schematic also inside a hexagon, e.g., ⟨+1.9 to +2.1 Vdc⟩. Remove the front-panel assembly to gain access to the circuit side of the keyboard. Note that the troubleshooting for the Enable Code e=0 Select Decoders (U28 and U29) shown on this Service Sheet is covered on Service Sheet 18.**

Equipment

Digital Test/ Extender Board	HP 08903-60018
Oscilloscope	HP 1740A
Signature Analyzer	HP 5004A
Voltmeter	HP 3455A

⟨√1⟩ Keystroke Detector Check

1. Press any key and observe Test LED C on the A8 Controller/Counter Assembly. Each time the key is pressed the LED should toggle, i.e., change state. If it does, the Controller is being properly interrupted.

2. Remove the ribbon cable W11.

3. Check the voltages in Table 8-83.

Table 8-83. Keystroke Detector Check

Keys Down	Voltage Limits (Vdc) on A1U22				Level (TTL) at U23 Pin 1
	Pin 2	Pin 5	Pin 6	Pin 7	
None	−0.01 to +0.01	0.6 to 1.1	4.5 to 5.5	0 to 0.5	H
One	2.5 to 4.5	3.0 to 4.3	0 to 0.3	4.0 to 5.5	L

Hint: Any key should give the same voltage readings. The voltage at U22 pin 2 will be higher for the condition of one key down if more than one key is down.

4. Connect a high-impedance, dc coupled oscilloscope to U23 pin 1. Connect the oscilloscope's dc coupled external horizontal input to U22 pin 2. Press then release any key. The dot on the oscilloscope should move as follows:

final position after release o (3)

position momentarily after release o ——— o position

(2) (1) when pressed

Hint: The dot should dwell at the intermediate position (2) momentarily after release of the key for 40 to 60 ms.

⟨√2⟩ Front-Panel Keys and Scanners Check—from Keyboard

NOTE

This check assumes proper operation of the following keys: Shift, SPCL, decimal, and all numeric. Otherwise, use ⟨√3⟩ below which requires a signature analyzer. It also assumes that the Keystroke Detector works properly (see ⟨√1⟩ above).

1. From Table 8-84, determine the row of the key to be checked and enter the Direct Control Special Function for that row. (The display should now show 1111.0000.)

2. Disable keyboard interrupts by shorting A8TP3 (GND) to A8U6 pin 7 (EXT INT) on the A8 Controller/Counter Assembly. Extend the A8 Controller/Counter Assembly to make this connection.

3. Pres
give the
Pressing

To
jum

Direct Cont Special Function
0.250
0.260
0.270
0.280
0.290
0.2A0
0.2B0
0.2C0
0.2D0
0.2E0
0.2F0

⟨√3⟩ Fr Us

1. Grou
Assembl

2. Conr
Set start

3. Conr
trigger o

4. Set
Disregar

5. Conr

6. Pres
are docu

Hint: Pr
meaning

7. Conr
in Table

n as inverters. U23B is low
D, U25D, U24C, and U25C
ıack the data (d) lines and
.est number decoded. Since
stors, the Controller reads
;e the output at pin 7 of U30

5 of U30 is now low. U24A,
1 and U24D, U25D, U24C,
1 back. The sequence then
.nd 2C0 with the result that
C0 when d=B will be read
·oller has now learned that

ɔur columns, the sequence
. With this code, the s3(H)
, U24A, U25A, U24B, and
4C, and U25C are enabled.
.ta lines from U24D, U25D,
:he keys in the second four

ue to key bounce, the scan
ıen the instrument reverts
hether the key was found or
terrupted is aborted and a

ervice Sheet 18.

and Display Assembly are
check are marked on the
. check mark and a number
s outside the labeled circuit
Fixed signals are shown on
, ⟨+1.9 to +2.1 Vdc⟩. Remove
s to the circuit side of the
g for the Enable Code e=0
ı on this Service Sheet is

3-60018
A
A
A

⟨√1⟩ Keystroke Detector Check

1. Press any key and observe Test LED C on the A8 Controller/Counter Assembly. Each time the key is pressed the LED should toggle, i.e., change state. If it does, the Controller is being properly interrupted.

2. Remove the ribbon cable W11.

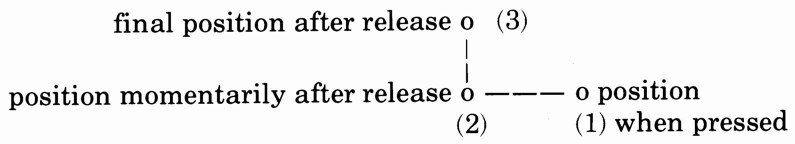
3. Check the voltages in Table 8-83.

Table 8-83. Keystroke Detector Check

Keys Down	Voltage Limits (Vdc) on A1U22				Level (TTL) at U23 Pin 1
	Pin 2	Pin 5	Pin 6	Pin 7	
None	–0.01 to +0.01	0.6 to 1.1	4.5 to 5.5	0 to 0.5	H
One	2.5 to 4.5	3.0 to 4.3	0 to 0.3	4.0 to 5.5	L

Hint: Any key should give the same voltage readings. The voltage at U22 pin 2 will be higher for the condition of one key down if more than one key is down.

4. Connect a high-impedance, dc coupled oscilloscope to U23 pin 1. Connect the oscilloscope's dc coupled external horizontal input to U22 pin 2. Press then release any key. The dot on the oscilloscope should move as follows:



Hint: The dot should dwell at the intermediate position (2) momentarily after release of the key for 40 to 60 ms.

⟨√2⟩ Front-Panel Keys and Scanners Check—from Keyboard

NOTE

This check assumes proper operation of the following keys: Shift, SPCL, decimal, and all numeric. Otherwise, use ⟨√3⟩ below which requires a signature analyzer. It also assumes that the Keystroke Detector works properly (see ⟨√1⟩ above).

1. From Table 8-84, determine the row of the key to be checked and enter the Direct Control Special Function for that row. (The display should now show 1111.0000.)

2. Disable keyboard interrupts by shorting A8TP3 (GND) to A8U6 pin 7 (EXT INT) on the A8 Controller/Counter Assembly. Extend the A8 Controller/Counter Assembly to make this connection.

3. Pressing any key in the appropriate row of Table 8-84 should give the display shown. (No key down gives the display 1111.0000. Pressing a key not in the given row gives this display also.)

NOTE

To repeat step 1 above, it is first necessary to remove the jumper from A8TP3.

Table 8-84. Front-Panel Keys and Scanners Check (Keyboard)

Direct Control Special Function	Display vs. Key Pressed			
	0111.0000	1011.0000	1101.0000	1110.0000
0.250	(N/A)	(N/A)	↑	↓
0.260	×10	AMPTD INCR	—	AUTO OPER
0.270		CLEAR	SPCL	dBV/dB
0.280	(N/A)	LCL	LIN/LOG	RATIO
0.290	SWEEP	PLOT LIMIT	FREQ INCR	÷10
0.2A0	Hz/mV	kHz/V	STOP FREQ	START FREQ
0.2B0	PSOPH	30 kHz	80 kHz	400 Hz
0.2C0	DISTN	S(Shift)	SINAD	AC LEVEL
0.2D0	AMPTD	FREQ	9	8
0.2E0	7	6	5	4
0.2F0	3	2	1	0

⟨√3⟩ Front-Panel Keys and Scanners Check—Using Signature Analysis

1. Ground A8TP10 (TEST D) on the A8 Controller/Counter Assembly.

2. Connect signature analyzer start and stop to A8TP7 (TEST A). Set start and stop to trigger on a falling edge.

3. Connect signature analyzer clock to A8TP13 (WRT). Set clock to trigger on a rising edge.

4. Set Audio Analyzer's LINE switch to OFF and back to ON. Disregard the front-panel display readouts.

5. Connect the signature analyzer's probe to A8TP8 (TEST B).

6. Press the front-panel keys and note the signature. The signatures are documented in Figure 8-105.

Hint: Pressing keys simultaneously alters the signatures. If no meaningful results can be obtained, continue on with step 7.

7. Connect the signature analyzer's probe to the points indicated in Table 8-85 and check the signatures. (No keys should be pressed.)

Table 8-85. Front-Panel Keys and Scanners Check (Signatures)

Pin	U23	U24	U25	U30	Pin
1	938F	938F	938F	62AU	1
2	0000	U005	U005	7008	2
3	0000	7008	7008	1999	3
4	1381	938F	938F	0000	4
5	7008	U005	U005	0000	5
6	AA4P	7008	7008	0000	6
7	0000	0000	0000	0000	7
8	AA4P	7008	7008	0000	8
9	AA4P	1381	1381	0000	9
10	39F2	938F	938F	0000	10
11	39F2	7008	7008	0000	11
12	7008	1381	1381	0000	12
13	U005	938F	938F	7FC5	13
14	938F	938F	938F	7008	14
15				62AU	15
16				938F	16

Note: The signature for a high or +5V is 938F. The signature for a low or ground is 0000.

⟨√4⟩ Key Light Check

1. Key in the Direct Control Special Functions listed in Table 8-86 to turn on the desired key light.

Table 8-86. Key Light Check

Direct Control Special Function	Title
0.010	400 Hz
0.011	PSOPH
0.012	30 kHz
0.013	80 kHz
0.014	AC LEVEL
0.015	SINAD
0.016	DISTN
0.017	S(Shift)

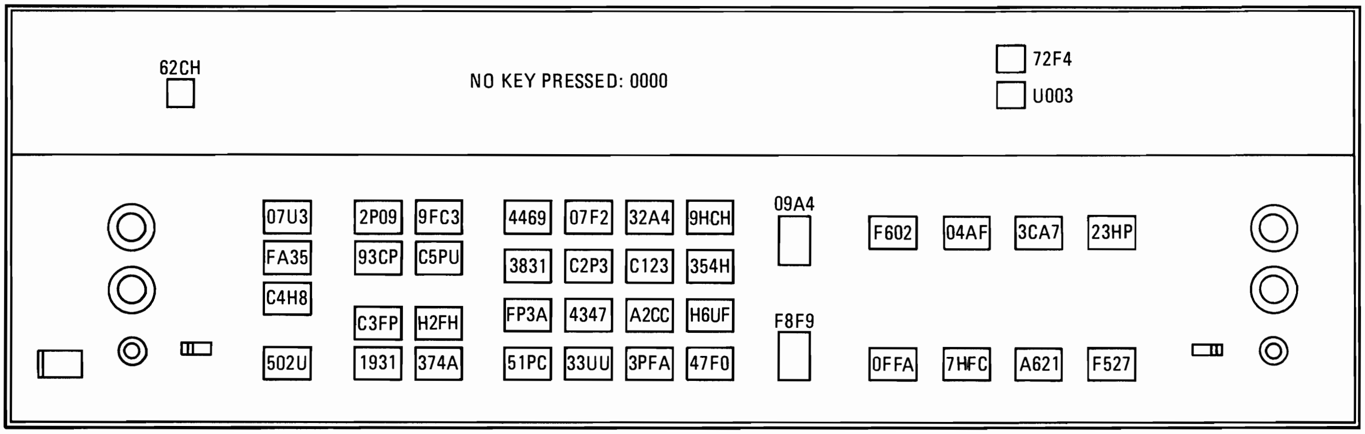


Figure 8-105. Signatures for the Front-Panel Keys and Scanners Check

P/O A1 ASSEMBLY

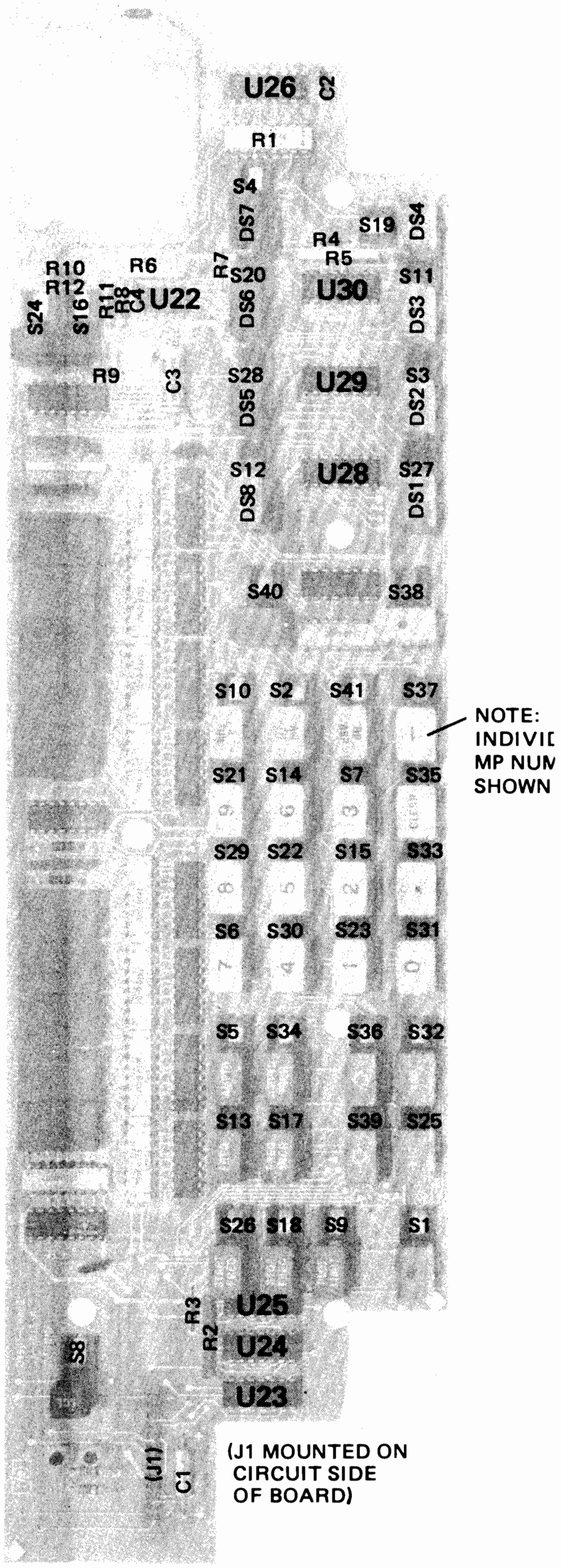
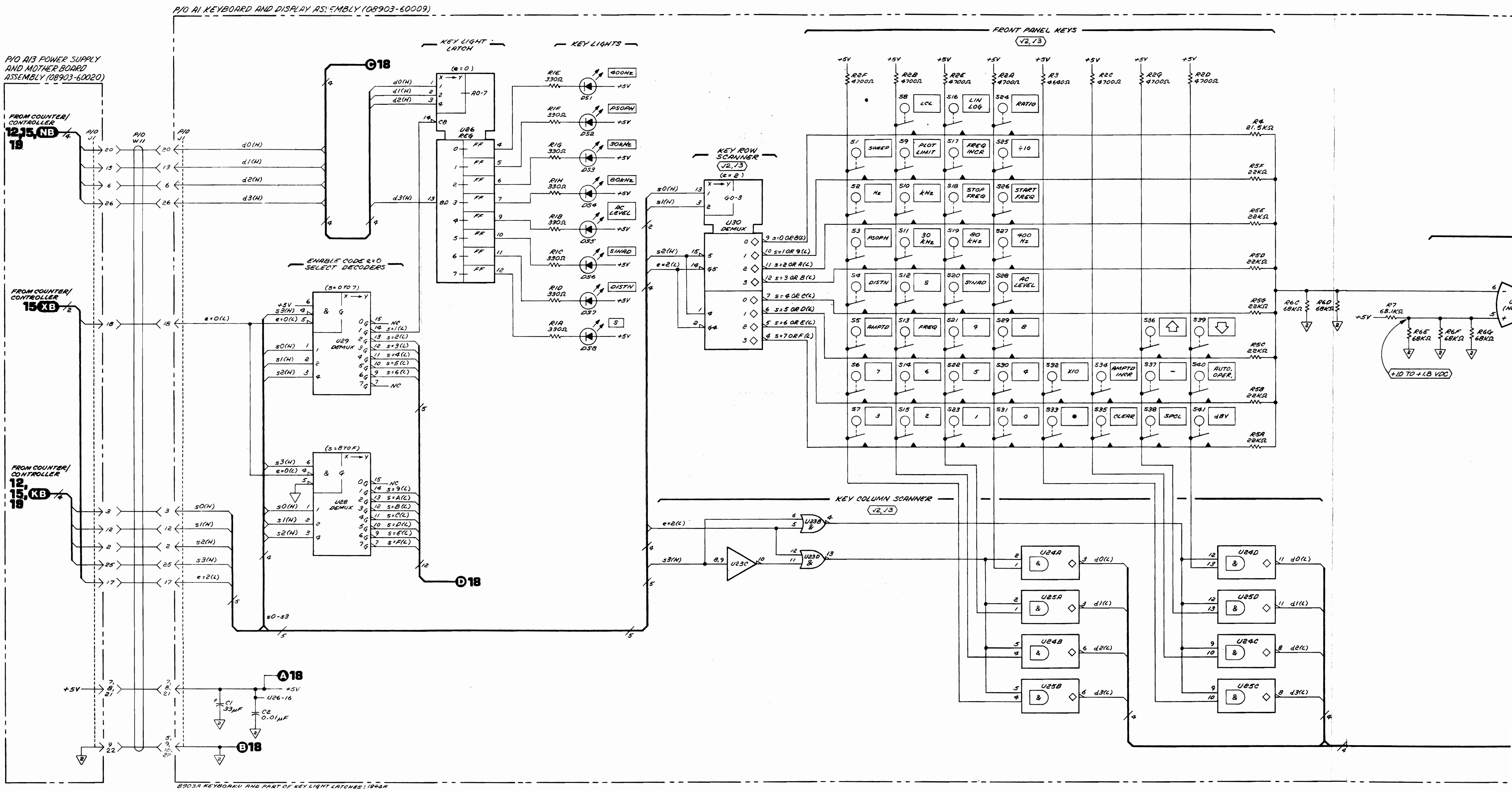
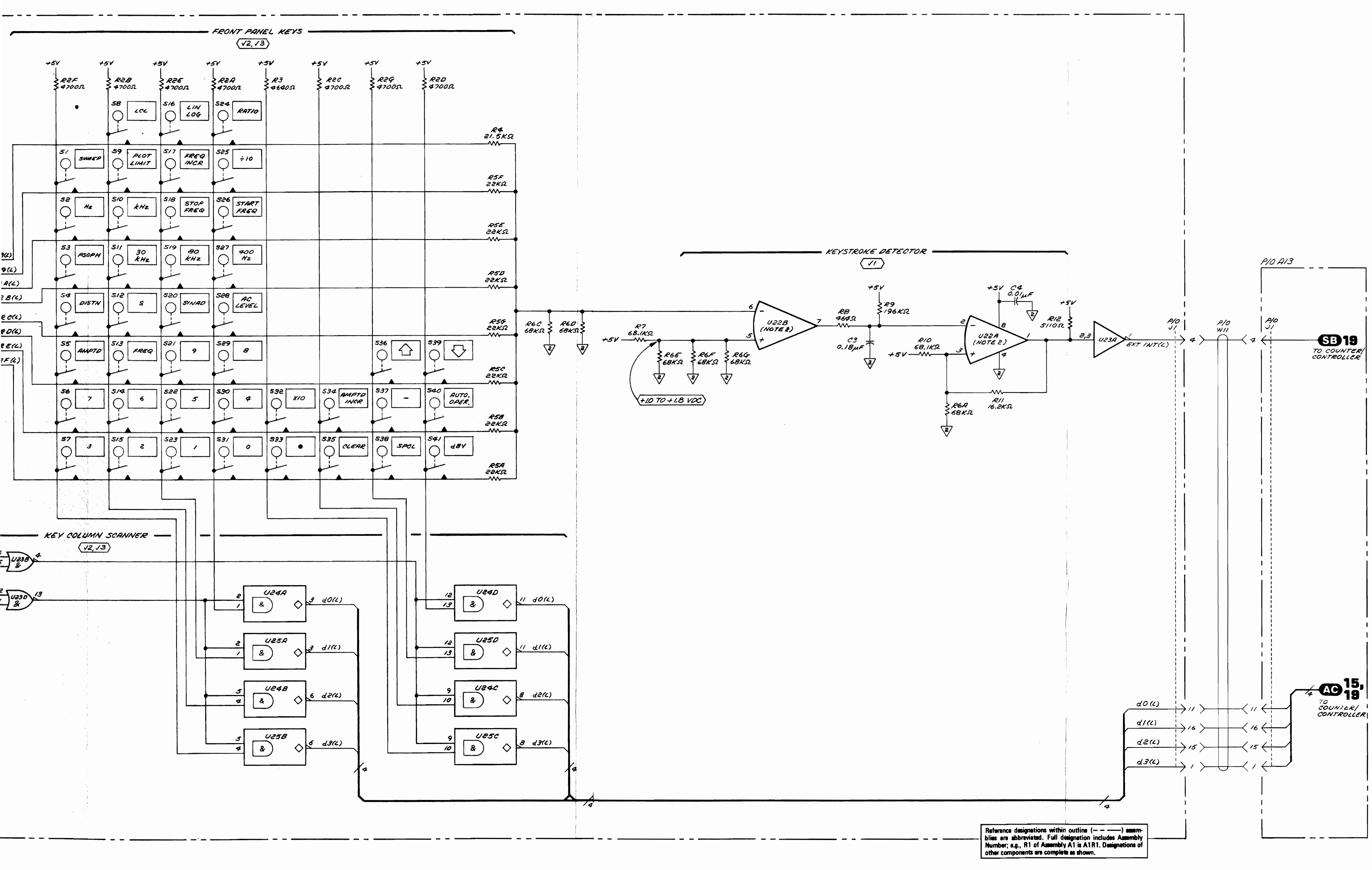


Figure 8-106. P/O A1 Keyboard and Display Assembly Component Locations (Keyboard Circuits)



8903A KEYBOARD AND PART OF KEY LIGHT LATCHES: 1964A



Reference designations within outline (– – ——) assemblies are abbreviated. Full designation includes Assembly Number; e.g., R1 of Assembly A1 is A1R1. Designations of other components are complete as shown.

NOTES

1. SEE TABLE 8-7 SCHEMATIC DIAGRAM NOTES.
2. OPEN COLLECTOR OUTPUT.

REFERENCE DESIGNATIONS

NO PREFIX	A13
W11	J1
A1	
C1-4 DS1-8 J1 R1-12 S1-41 U22-26,28-30	

LOGIC LEVELS

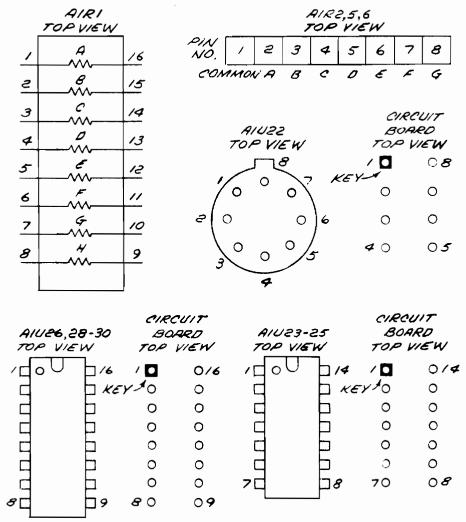
	TTL
HIGH	>2V
LOW	<0.8V
< IS MORE NEG. THAN > IS MORE POS. THAN	
OPEN	HIGH
GROUND	LOW

INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATIONS	PART NUMBERS
U22	1826 - 0412
U23	1820 - 1144
U24, 25	1820 - 1417
U26	1820 - 1729
U28, 29	1820 - 1216
U30	1820 - 1427

DIGITAL INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

REFERENCE DESIGNATIONS	PIN NUMBERS
U23-25	+5V -14 2 - 7
U26,28-30	+5V -16 2 - 8



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P/O A1

Figure 8-107. Keyboard and Display—Keyboard Circuits Schematic Diagram

SERVICE SHEET 18—KEYBOARD AND DISPLAY—DISPLAY CIRCUITS (P/O A1)

TROUBLESHOOTING HELP

- Block Diagram ....Service Sheet BD4
- Direct Control Special Functions ....Paragraph 8-26

PRINCIPLES OF OPERATION

The Keyboard and Display Assembly (A1) contains the front-panel displays, decimal points, annunciators, and key lights and the decoders and latches that control them. Lighting of a display is accomplished by straightforward decoding of the Instrument Bus with one code sent out for each of the seven segments of the display. For example, to display the digit 3 in display U9, the Controller issues esd=031, 032, 033, 034, 03D, 03E, and 037 in succession. Register U18 decodes the Instrument Bus code and successively outputs and latches the data present on the 8D input (i.e., d3(H), the most significant bit of the d code) to its internal flip-flops. A low on an output of U18 turns on a segment, a high turns it off. Thus, a low appears on the output of flip-flops 1, 2, 3, 4, and 7 (corresponding to esd=031, 032, 033, 034, and 037) and turns on the LEDs in segments a, b, c, d, and g respectively in U9. A high appears on the output of flip-flops 5 and 6 (corresponding to esd=03D and 03E) and turns off segments e and f. This results in a 3 being displayed.

Lighting of the minus sign (segment g of U8), decimal points, annunciators, and key lights is similar. For example, to light the % annunciator, the Controller issues esd=0A3 to the Instrument Bus. This is decoded by register U13 which latches a low into its internal flip-flop 3. The low turns on DS16.

The select decoders and the circuits for lighting the key lights are shown in Figure 8-109. For a discussion of the Instrument Bus, see Service Sheet BD4.

TROUBLESHOOTING

General

The procedure for checking the Keyboard and Display Assembly is given below. The circuits are set to a desired (static) state using Direct Control Special Functions, and then the logic levels are checked.

Equipment

Voltmeter ....HP 3455A

√1 Annunciator and Key Light Check

1. Key in the Direct Control Special Functions listed in Table 8-87 to turn on the desired annunciator or key light.

Keyboard and Display—Keyboard Circuits
P/O A1
SERVICE SHEET 17

SERVICE SHEET 18 (Cont'd)

Table 8-87. Annunciator and Key Light Check

Direct Control Special Function	Title	Light Type
0.024	ADDRESSED	Annunciator
0.025	REMOTE	Annunciator
0.026	kHz	Annunciator
0.027	Hz	Annunciator
0.0A0	mV	Annunciator
0.0A1	V	Annunciator
0.0A2	dB	Annunciator
0.0A3	%	Annunciator
0.090	SPCL	Key Light
0.091	RATIO	Key Light
0.095	SWEEP	Key Light

Hint: With the exception of the ADDRESSED and REMOTE lights, the lights go off when a new Direct Control Special Function is entered. To turn off the ADDRESSED light enter 0.02C and to turn off the REMOTE light enter 0.02D.

Table 8-88. Decimal Point Check

Direct Control Special Function	Number of Following Digit
Left Display	
0.023	1
0.022	2
0.021	3
0.020	4
Right Display	
0.093	Upper Left Corner
0.0A7	5
0.0A6	6
0.0A5	7
0.0A4	8

√2 Decimal Point Check

1. Key in the Direct Control Special Functions listed in Table 8-88 to turn on the desired decimal point. The digit number is the number on the display window directly below the digit.

√3 Display Check

1. Key in the Direct Control Special Functions listed in Table 8-89 to turn on the desired digit segment in the desired position. The digit number is the number on the display window directly below the digit.

Table 8-89. Display Check

Digit Number	Direct Control Special Function	Digit Number	Direct Control Special Function
Left Display		Right Display	
Digit Before 1	0.0Bd	Digit Before 5	0.092*
1	0.0Cd	5	0.03d
2	0.0Dd	6	0.04d
3	0.0Ed	7	0.05d
4	0.0Fd	8	0.06d
Segment Displayed**			d
(N/A)			0
a			1
b			2
c			3
d			4
e			5
f			6
g			7

* d=2 only (g is the only segment controlled with this special function)

** See Figure 1-109 for identification of segments a through g.

P/O A1 ASSEMBLY

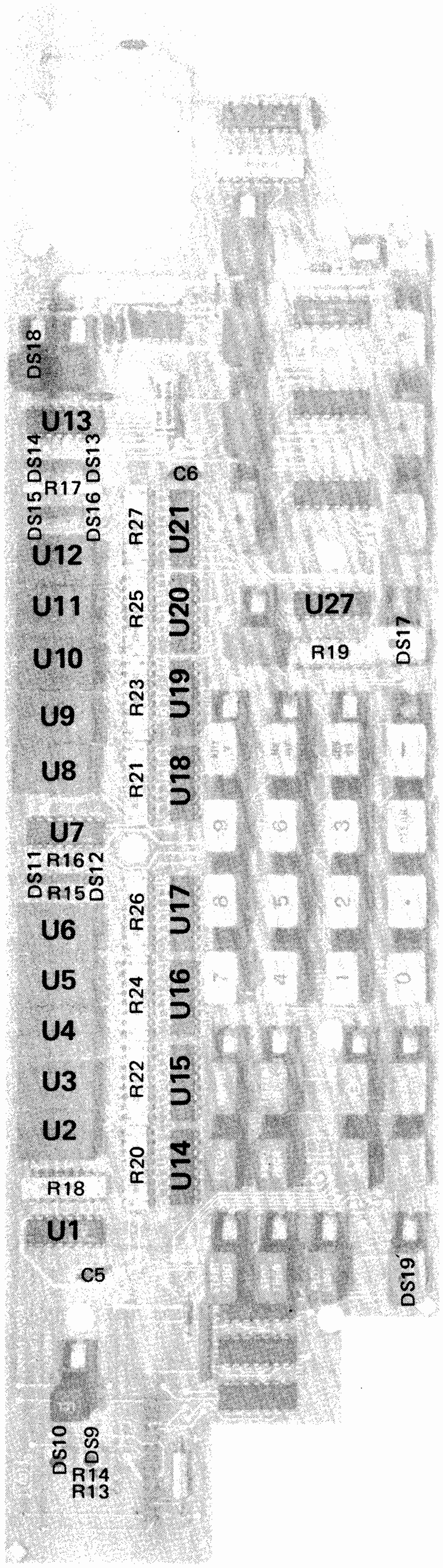
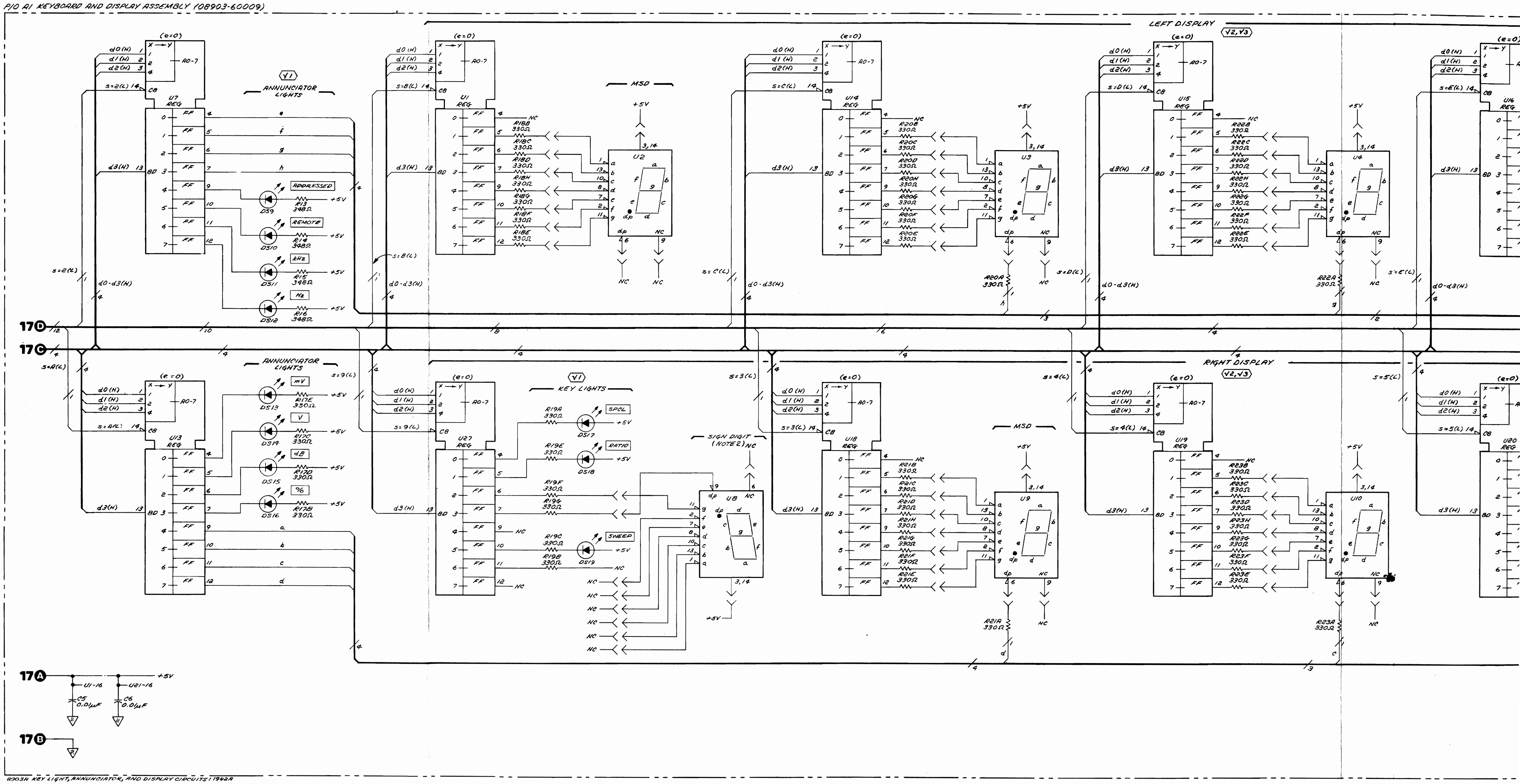
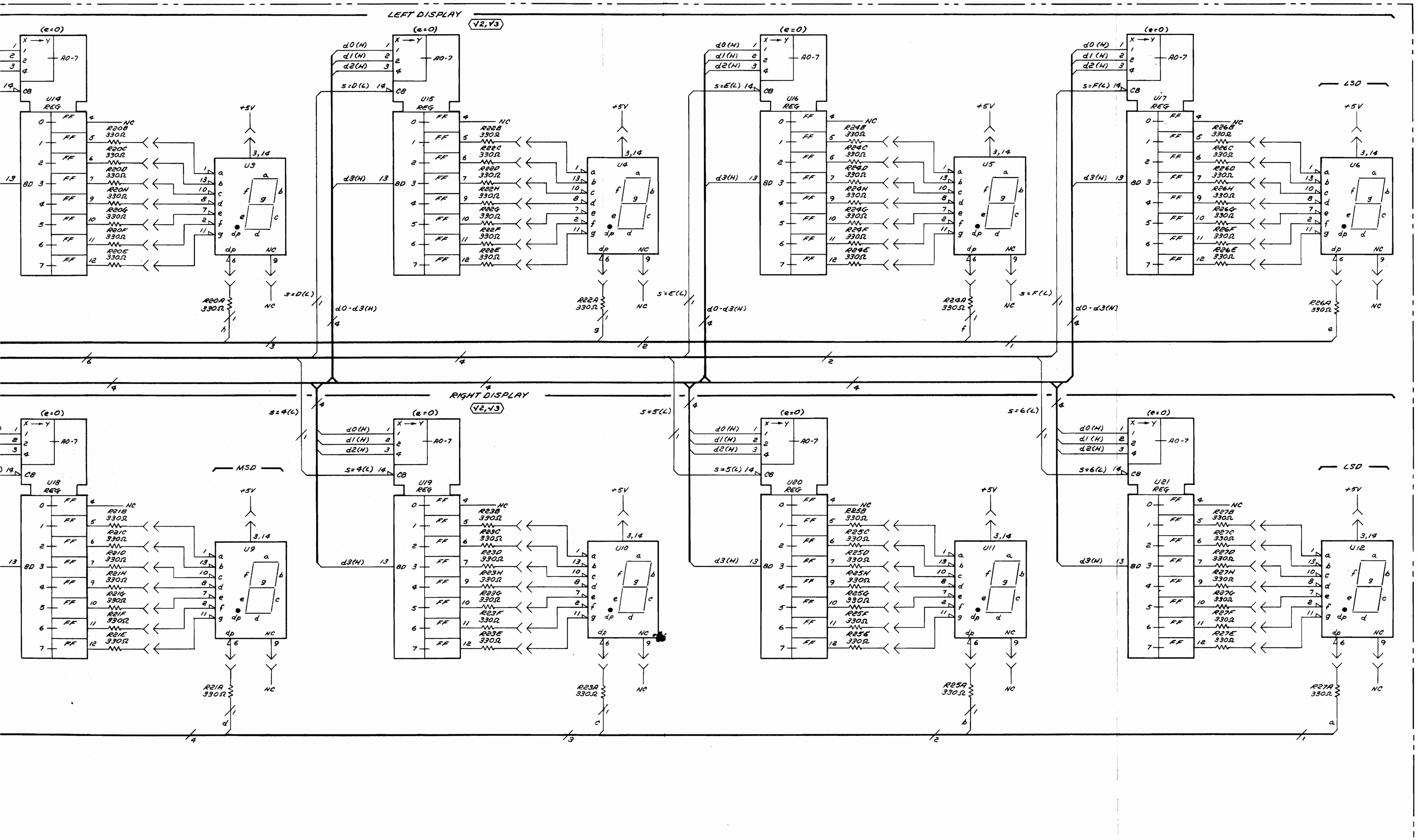


Figure 8-108. P/O A1 Keyboard and Display Assembly Component Locations (Display Circuits)



8903A KEY LIGHT, ANNUNCIATOR, AND DISPLAY CIRCUITS: 1942A



Reference designations within outline (— — ——) assemblies are abbreviated. Full designation includes Assembly Number; e.g., R1 of Assembly A1 is A1R1. Designations of other components are complete as shown.

NOTES

1. SEE TABLE 8-7 SCHEMATIC DIAGRAM NOTES.
2. SOCKET FOR U8 IS UPSIDE DOWN.

REFERENCE DESIGNATIONS

A1
C5,6 DS9-19 R13-27 U1-21,27

LOGIC LEVELS

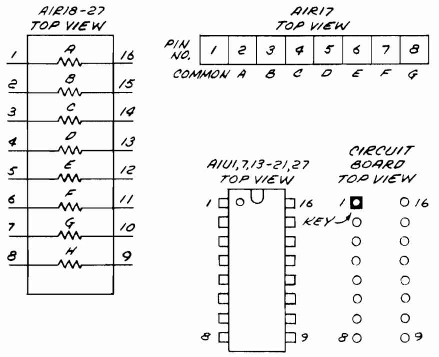
·	TTL
HIGH	> 2V
LOW	< 0.8V
< IS MORE NEG. THAN > IS MORE POS. THAN	
OPEN	HIGH
GROUND	LOW

INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATIONS	PART NUMBERS
U1,7,13-21, 27	1820-1729
U2-6, 9-12	1990-0540
U8	1990-0574

DIGITAL INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

REFERENCE DESIGNATIONS	PIN NUMBERS
U1,7,13-21, 27	+5V - 16 ▽ - 8



18
P/O A1

Figure 8-109. Keyboard and Display—Display Circuits Schematic Diagram

SERVICE SHEET 19—REMOTE INTERFACE (A9)

TROUBLESHOOTING HELP

Block Diagram	Service Sheet BD4
Direct Control Special Functions	Paragraph 8-26
Service Special Functions	Paragraph 8-27

PRINCIPLES OF OPERATION

General

The Remote Interface Assembly (A9) interfaces the Controller with the HP-IB. It performs the necessary handshake operation, interprets the HP-IB control lines, and is both an input and output peripheral to the Controller. The Remote Interface Assembly consists of three basic elements: the HP-IB I/O, the Handshake Logic, and the Interface Control circuits. In addition, other miscellaneous circuits are used on the assembly. The operation of the three basic elements is explained first. Then, a detailed explanation of how the bus controller (e.g., a computing controller) addresses the instrument to talk or to listen is presented. The miscellaneous circuits are then briefly discussed. Table 8-90 lists and identifies the mnemonics used in the Remote Interface and should be referred to while reading the principles of operation.

HP-IB I/O Circuits

The HP-IB I/O circuits provide bidirectional interface between the Remote Interface assembly and the HP-IB. The circuit consists of U7, U8, U9, and U10. When the TALK(L) line is low, the interface is configured to send data to the HP-IB. In this state, U7 and U9 are disabled, and since they are open collector devices, they are essentially out of the circuit. U8 and U10 provide a direct path from the Peripheral Input/Output (U18) to the HP-IB. When the TALK(L) line is high, the Remote Interface is configured to receive data from the HP-IB. In this mode, U7 and U9 are enabled, and the path through U8 and U10 is reversed. This allows data from the HP-IB to be applied to the Peripheral Input/Output (U18), the Address Decoder (U5), and the Interface Control ROM (U2). Depending upon the function being performed, this data is either sent to the Controller or used to decode the talk or listen address.

Handshake Logic Circuits

Information is communicated over the HP-IB by means of handshakes between instruments. It is assumed in this discussion that the reader is familiar with the use of the DAV, NDAC, and NRFD signals as they are used on the HP-IB. (Figure 8-110 illustrates the HP-IB handshake.) The instrument can operate as either a talker or a listener when so directed by the bus controller. The primary control circuits in the Handshake Logic are the DAC Flip-Flop (U3B) and gates U20A, U20B, and U15B.

When the instrument is a listener, the ATL(L) line is low, and the high output from U15B enables U20A and U20B. This condition is also true when ATN(L) goes low and is discussed in detail later. In either case, the DAC Flip-Flop (U3B) controls the handshake. If U3B is set, the RTR(L) line from the reset output is low, and the NRFD(L) line from U20B is high indicating that the instrument is ready to receive data. The ACD(L) line from the active-high output of U3B is high, and (since the other input to U20A is also high) the NDAC(L) line is low. When the bus controller sees all of the required NRFD(L) lines high (more than one instrument can be addressed to listen), it sets DAV(L) low. When DAV(L) goes low (indicating the data on the HP-IB is valid), the Interface Control ROM either sets ICP(L) low or resets U3B by setting SDA(L) low, depending on whether or not the CPU must be interrupted. (See Table 8-91 for a complete list of the Interface Control ROM input and output signals.) If the CPU is interrupted, it will reset U3B using the DFC(L) line. In either case, ACD(L) goes low and the NDAC(L) line from U20A goes high. When the bus controller sees all of NDAC(L) lines go high, it sets DAV(L) high. The DAV(L) signal is applied through gates U19B, U14B, and U13B to set the DAC Flip-Flop (U3B). Gates U14B and U13B are used to slow down the handshake and prevent a possible race condition. When the DAC Flip-Flop is set, the instrument is returned to a ready-for-data condition.

Table 8-90. Mnemonics for Remote Interface

Mnemonic	Signal Name
AAD	Acceptor Accepted Data
ACD	Accepted Data
ADS	Addressed
AFC	Address Flip-Flop Clock
ARD	Accepted Received Data
ATL	Addressed to Listen
ATN	Attention
ATT	Addressed to Talk
AVD	Accept Valid Data
CLF	Clear Listen Flip-Flop
CTF	Clear Talk Flip-Flop
DAR	Disable ROM
DAV	Data Valid
DIO1	Data Input/Output 1
DIO8	Data Input/Output 8
DFC	Data Accepted Flip-Flop Clock
EAH	Enable Acceptor Handshake
EIC	Enable Interface Control
ENR	Enable ROM
EOI	End Or Identify
ICP	Interrupt CPU
IFC	Interface Clear
LAD	Listener Accepted Data
LRD	Listener Ready for Data
NDAC	Not Data Accepted
NRFD	Not Ready for Data
RAS	Read Address Selector
RAT	Read Addressing Type
RDR	Reset DAC/RFD
REN	Remote Enable
RFC	REN Flip-Flop Clock
RNL	REN Flip-Flop Latched
RSL	Read Switch Lower
RSU	Read Switch Upper
RTR	Ready to Receive
RVD	Receive Valid Data
SDA	Set Data Accepted
SDV	Set Data Valid
SLF	Set Listen Flip-Flop
SRQ	Service Request
STF	Set Talk Flip-Flop

When the instrument is a talker, the output from U15B is low because both the ATL(L) and the ATN(L) lines are high. The low output from U15B disables U20A and U20B. This prevents the DAC Flip-Flop from driving the NDAC(L) and NRFD(L) HP-IB lines. The Controller (A8) now reads the NDAC(L) line through U19C and U13C and the NRFD(L) line through U19D and U13D. Both of these signals are routed to the Controller through the Peripheral Input/Output (U18). The DAV(L) signal is driven by the Controller through U18 and U20C by the SDV(H) line. U20C is enabled by U14A when the TALK(L) line is low. In the talker mode, the handshaking is entirely controlled by the instrument's firmware and Controller.

Interface Control Circuits

The primary control element in the Interface Control circuits is the Interface Control ROM (U2). U2 is enabled when all the following conditions are satisfied:

1. RTR(L) is low. This indicates the instrument is ready to receive data or commands.

2. EAH(L) is low. This enables an acceptor handshake. It is decoded from the ATL and ATN lines by U14D. Therefore, if the instrument is addressed to listen or if ATN is true, the gate is enabled.

3. U15C pin 8 is low. This indicates that the Controller (A8) has enabled the interface to receive data. This state is latched by the flip-flop consisting of U15C and U15D. This flip-flop is also used to disable the Interface Control ROM (U2) when the Remote Interface is preparing to talk. U2 is disabled so that its control circuits do not respond to the data that the instrument itself is sending.

4. AVD(L) is low. This indicates that the bus controller is asserting that the data on the HP-IB is valid by pulling DAV(L) low.

When all of these conditions are true, U2 is enabled by setting the EIC(L) line from U14C low. The outputs of U2 are then dependent upon the decoded address line inputs. Depending upon the selected output, the Interface Control ROM will set or clear the appropriate flip-flops, complete a handshake, or interrupt the Controller. The 32 possible states of the output lines are listed and defined in Table 8-91.

Table 8-91. Inputs and Outputs of Interface Control ROM (U2)

Address						Data								Remarks**
Binary Bit Value					Hex	Bit								
16	8	4	2	1		7	6	5	4	3	2	1	0	
Pin Number						Pin Number								
14	13	12	11	10		9	7	6	5	4	3	2	1	
L	L	L	L	L	00	H	*	H	H	H	H	*	L	SCG so AHS only.
L	L	L	L	H	01	H	*	L	H	H	H	*	L	OTA so CTF & AHS.
L	L	L	H	L	02	H	*	H	H	H	H	*	L	OLA so AHS only.

gh. When the bus controller
DAV(L) high. The DAV(L)
J14B, and U13B to set the
J13B are used to slow down
e condition. When the DAC
urned to a ready-for-data

mote Interface

lame

ted Data

op Clock
ved Data
sten

lk
ta
p-Flop
Flop

put 1
put 8
Flip-Flop Clock
r Handshake
e Control

ed Data
for Data
ted
ata
elector
g Type
)

Clock
Latched
wer
per
e
ata
ed

Flop

op

When the instrument is a talker, the output from U15B is low because both the ATL(L) and the ATN(L) lines are high. The low output from U15B disables U20A and U20B. This prevents the DAC Flip-Flop from driving the NDAC(L) and NRFD(L) HP-IB lines. The Controller (A8) now reads the NDAC(L) line through U19C and U13C and the NRFD(L) line through U19D and U13D. Both of these signals are routed to the Controller through the Peripheral Input/Output (U18). The DAV(L) signal is driven by the Controller through U18 and U20C by the SDV(H) line. U20C is enabled by U14A when the TALK(L) line is low. In the talker mode, the handshaking is entirely controlled by the instrument's firmware and Controller.

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1. RTR(L) is low. This indicates the instrument is ready to receive data or commands.

2. EAH(L) is low. This enables an acceptor handshake. It is decoded from the ATL and ATN lines by U14D. Therefore, if the instrument is addressed to listen or if ATN is true, the gate is enabled.

3. U15C pin 8 is low. This indicates that the Controller (A8) has enabled the interface to receive data. This state is latched by the flip-flop consisting of U15C and U15D. This flip-flop is also used to disable the Interface Control ROM (U2) when the Remote Interface is preparing to talk. U2 is disabled so that its control circuits do not respond to the data that the instrument itself is sending.

4. AVD(L) is low. This indicates that the bus controller is asserting that the data on the HP-IB is valid by pulling DAV(L) low.

When all of these conditions are true, U2 is enabled by setting the EIC(L) line from U14C low. The outputs of U2 are then dependent upon the decoded address line inputs. Depending upon the selected output, the Interface Control ROM will set or clear the appropriate flip-flops, complete a handshake, or interrupt the Controller. The 32 possible states of the output lines are listed and defined in Table 8-91.

Table 8-91. Inputs and Outputs of Interface Control ROM (U2)

Table 8-91. Inputs and Outputs of Interface Control ROM (U2) (Cont'd)

Address					Hex	Data								Remarks**
Binary Bit Value						Bit								
16	8	4	2	1		7	6	5	4	3	2	1	0	
Pin Number						Pin Number								
14	13	12	11	10		9	7	6	5	4	3	2	1	
L	L	L	L	L	00	H	*	H	H	H	H	*	L	SCG so AHS only.
L	L	L	L	H	01	H	*	L	H	H	H	*	L	OTA so CTF & AHS.
L	L	L	H	L	02	H	*	H	H	H	H	*	L	OLA so AHS only.
L	L	L	H	H	03	L	*	H	H	H	H	*	H	UBC so INT only.
L	L	H	L	L	04	H	*	H	H	H	H	*	L	SCG so AHS only.
L	L	H	L	H	05	H	*	L	H	H	H	*	L	UNT so CTF and AHS.
L	L	H	H	L	06	H	*	H	H	L	H	*	L	UNL so CLF and AHS.
L	L	H	H	H	07	H	*	H	H	H	H	*	L	NRC so AHS only.
L	H	L	L	L	08	H	*	H	H	H	H	*	L	SCG so AHS only.
L	H	L	L	H	09	H	*	H	L	L	H	*	L	MTA so STF, CLF, and AHS.
L	H	L	H	L	0A	L	*	L	H	H	L	*	H	MLA so SLF, CTF, and INT.
L	H	L	H	H	0B	L	*	H	H	H	H	*	H	UBC so INT only.
L	H	H	L	L	0C	H	*	H	H	H	H	*	L	SCG so AHS only.
L	H	H	L	H	0D	H	*	L	H	H	H	*	L	UNT so CTF and AHS.
L	H	H	H	L	0E	H	*	H	H	L	H	*	L	UNL so CLF and AHS.
L	H	H	H	H	0F	H	*	H	H	H	H	*	L	NRC so AHS only.
H	L	L	L	L	10	L	*	H	H	H	H	*	H	DATA so INT only.
H	L	L	L	H	11	L	*	H	H	H	H	*	H	DATA so INT only.
H	L	L	H	L	12	L	*	H	H	H	H	*	H	DATA so INT only.
H	L	L	H	H	13	H	*	H	H	H	H	*	L	CDATA so AHS only.
H	L	H	L	L	14	L	*	H	H	H	H	*	H	DATA so INT only.
H	L	H	L	H	15	L	*	H	H	H	H	*	H	DATA so INT only.
H	L	H	H	L	16	L	*	H	H	H	H	*	H	DATA so INT only
H	L	H	H	H	17	H	*	H	H	H	H	*	L	CDATA so AHS only.
H	H	L	L	L	18	L	*	H	H	H	H	*	H	DATA so INT only.
H	H	L	L	H	19	L	*	H	H	H	H	*	H	DATA so INT only.
H	H	L	H	L	1A	L	*	H	H	H	H	*	H	DATA so INT only.
H	H	L	H	H	1B	H	*	H	H	H	H	*	L	CDATA so AHS only.
H	H	H	L	L	1C	L	*	H	H	H	H	*	H	DATA so INT only.
H	H	H	L	H	1D	L	*	H	H	H	H	*	H	DATA so INT only.
H	H	H	H	L	1E	L	*	H	H	H	H	*	H	DATA so INT only.
H	H	H	H	H	1F	H	*	H	H	H	H	*	L	CDATA so AHS only.

* Don't care condition.

** The outputs are active low. The functions of each output are:

Bit 7: INT, interrupts CPU.	Bit 3: CLF, clear Listen Flip-Flop.
Bit 6: Don't Care (NC).	Bit 2: SLF, set Listen Flip-Flop.
Bit 5: CTF, clear Talk Flip-Flop.	Bit 1: Don't care (NC).
Bit 4: STF, set Talk Flip-Flop.	Bit 0: AHS, automatic handshake.

Mnemonics used:

CDATA: DATA from Control group	OTA: Other Talk Address
DATA: DATA (interface responds)	SCG: Secondary Group Command
MLA: My Listen Address	
MTA: My Talk Address	UBC: Universal Bus Command
NRC: Non-Recognized Command	UNL: Un-Listen
OLA: Other Listen Address	UNT: Un-Talk

How the Remote Interface Handshakes with the HP-IB

The Remote Interface circuits control the asynchronous transfer of bytes over the HP-IB. The following three conditions require that the instrument complete the handshake requirements:

1. When it is a bystander.

2. When the ATN(L) line is low (true). For example, when the bus controller is addressing the instrument to set it to the talk or listen modes. There are also universal commands that can be sent when ATN(L) is low.

3. When it is already addressed to talk or listen.

The instrument handshakes as a bystander whenever ATN(L) is high and it is not addressed to listen. Actually, this handshake is not an interchange of information because under these conditions the instrument never pulls the NRFD(L) and NDAC(L) output lines low. These lines are held high because ATL(L) and the ATN(L) inputs to U15B remain high. ATL(L) remains high because the instrument is not currently addressed to listen. ATN(L) remains high because it is high at the HP-IB and the signal is applied through two inverters (U19E and U13A) to the input of U15B. The resulting low output is applied to U20A and U20B and the NRFD(L) and NDAC(L) lines are always high. In this mode, the Audio Analyzer is essentially "off the bus". Note that the DAC Flip-Flop (U3B) is also applied to these gates and depending upon its output state would also hold one of the gate outputs high if ATN were true or ATL were true.

When the bus controller wants to address the instrument to talk, ATN(L) is set low. The output of U15B goes high and the status of the NRFD(L) line (U20B) and the status of the NDAC(L) line are controlled by the DAC Flip-Flop (U3B). (The DAC Flip-Flop is already set by DAV(L) being high through U19B, U14B, and U13B). This causes the RTR(L) line from the DAC Flip-Flop to set NRFD(L) high. The bus controller has already placed the instrument's talk address on the bus and it now pulls DAV(L) low indicating that it is valid data.

Since the instrument is not yet addressed to talk, the TALK(L) input to the HP-IB I/O circuits (U7, U8, U9, and U10) is high. The talk address on lines DIO1(L) through DIO5(L) is applied through U7 and U9 to the Address Decoder comparator U5. U5 compares the incoming address with the setting of the first five address switches (S1). If they are the instrument's correct address, the M=N output of U5 goes high. The data on DIO7(L) and DIO6(L) is applied to the Interface Control ROM (U2) to determine whether the instrument is being addressed to talk or to listen. If it is being addressed to talk DIO7(L) is low and DIO6(L) is high (i.e., 10). If it is being addressed to listen, DIO7(L) is high and DIO6(L) is low (i.e., 01). These two bits are the only difference between the DIO inputs from the bus controller to the instrument when it is being set to talk or listen.

SERVICE SHEET 19 (Cont'd)

The EIC(L) input from U14C is low to enable U2. The other inputs to the address lines of U2 select the memory location that will set output pin 5 to low. The STF(L) line sets the Talk flip-flop U1A. At the same time, the SDA(L) output at pin 1 of U2 is low and resets the DAC Flip-Flop (U3B). The low output from pin 9 of U3B is applied to U20A and the NDAC(L) line goes high indicating the handshake is complete. Note that the CPU did not need to be interrupted.

Remote Enable Flip-Flop

When the instrument is addressed to listen, the CPU is interrupted and must determine whether or not it has been enabled to the remote mode (or whether it is already in the remote mode). The Controller does this by attempting to set the Remote Enable Flip-Flop (U3A). If the REN(L) line on the HP-IB is low (true), it is inverted by U19F and the reset input to U3A pin 1 is high. In this case U3A can be set by the Controller. Conversely, if REN(L) is high, the reset input is low and U3A is held reset. The Controller checks the set output of U3A RNL(H) through inverter U11A and the Peripheral Input/Output (U18). If the instrument receives its listen address and if the output of U3A is high, it enters remote mode and lights the REMOTE annunciator on the front panel.

Serial Poll Enable Flip-Flop

When the Controller recognizes the SPE (Serial Poll Enable) bus command, the CPU is interrupted and attempts to set the Serial Poll Flip-Flop (U12B). IFC(L) from the HP-IB is applied through U19A and U11D to the reset input of U12B. If IFC(L) is high the Serial Poll Flip-Flop can be set; if it is low, U12B is held reset. If U12B is set, the instrument enters the serial poll mode, and this information is read back via the Instrument Bus to the Controller through U4D. When the instrument is subsequently addressed to talk, it again reads back the output of U12B to determine what information to output to the HP-IB: measurement results or the status byte. If it is still in the serial poll mode, the status byte is output. When the SPD (Serial Poll Disable) bus command is received, the Controller resets U12B.

Other Control Lines

The remaining HP-IB control lines to the instrument are EOI(L), SRQ(L), and IFC(L). EOI(L) is not used by the instrument and is terminated in R6N and R6P. SRQ(L) is output to the HP-IB under Controller direction through U18. IFC(L) is used to clear all talkers and listeners off the HP-IB. IFC(L) is buffered into four lines. At the output of U19A, after CR1, one line is applied to the Address Comparator (U5) to disable it. This keeps the Interface Control ROM (U2) from affecting either the Talk or Listen Flip-Flop while IFC is true. Two additional lines (from U12E and U13F) clear the Talk and Listen Flip-Flops (U1A and U1B). The fourth line (from U11D) clears the Serial Poll Flip-Flop.

Address Readback Circuit

When so directed by the operator, the Controller sequentially reads back the status of the Address Switches (S1A through S1E) and the talk-only and listen-only switches (S1G and S1F). This information is processed through gates U4 and U17 under control of the RSU(L) and RSL(L) lines from the Select Decoder (U16). The Controller's internal RAM is also read for service request (SRQ) status. The front-panel display shows not only the HP-IB address and the talk-only or listen-only status but also whether or not it is issuing a Service Request (SRQ). (See Special Function 21.0 and 21.1 in the Detailed Operating Information in Section III.)

Peripheral Input/Output

The Peripheral Input/Output (U18) provides the required I/O interface between the Controller and the HP-IB. Refer to the Table 8-92 for a description of inputs and outputs of U18.

Table 8-92. Inputs and Outputs of the PIO (U18)

Pin Name	Description	Type
I/O A0 thru I/O A7	I/O Port A	Input/Output
I/O B0 thru I/O B7	I/O Port B	Input/Output
DB0 thru DB7	Data Bus Lines	Bi-directional (3-state)
ROMC0 thru ROMC4	Control Lines	Input
Φ, WRITE	Clock Lines	Input
EXT INT	External Interrupt	Input
PRI IN	Priority In	Input
PRI OUT	Priority Out	Output
INT REQ	Interrupt Request	Output
DBDR	Data Bus Drive	Output

SERVICE SHEET 19 (Cont'd)

Select Decoder

For a general discussion of instrument control, see Instrument Bus, Service Sheet BD4.

TROUBLESHOOTING

General

Procedures for checking the Remote Interface Assembly are given below. The circuits to check are marked on the schematic diagram by a hexagon with a check mark and a number inside, e.g., ⟨√3⟩. In addition, any points outside the labeled circuit area that must be checked are also identified. Fixed **signals are also shown on the schematic inside a hexagon, e.g., ⟨+1.9 to +2.1 Vdc⟩. Extend the board assembly where necessary to make measurements.**

CAUTIONS

> *MOS and CMOS ICs can be damaged by static charges and circuit transients. Do not remove this assembly from the instrument while power is applied. Discharge the board and replacement IC to the same potential. (Use a conductive foam pad such as HP 4208-0094.) When unplugging ICs, place the board on a conductive pad. When the IC is unplugged, insert it into the pad also.*
>
> *Several ICs on this assembly are held in high-grip sockets. Both the socket and the device can be damaged if an attempt is made to remove the device with an IC extraction tool. The recommended procedure is to first ground the tip of a small blade-type screwdriver, then slide the tip between the IC and the socket and slowly pry up the IC one pair of pins at a time.*

The following checks use the HP-IB Functional Checks in the Operating Section (refer to paragraph 3-11) as a basis for troubleshooting the Remote Interface Assembly. It is assumed in the following procedures that the failure was detected during the functional checks. Therefore, it is only necessary to perform the troubleshooting procedures starting with the equivalent functional check in which the failure occured. During the procedures, the 61.N Service Special Functions are also used to help locate the failure.

When using the troubleshooting flowcharts, it is important that the associated notes be read. These notes help clarify the steps that are flagged. The troubleshooting procedures assume that the bus controller and the bus controller's HP-IB interface are operating properly. Therefore, it is assumed that the required inputs are present at the interface to the Audio Analyzer. Always perform all of the HP-IB Functional Checks after any repair to the Remote Interface Assembly.

When using the flowcharts, refer to the principles of operation to clarify the sequence of troubleshooting. Refer to Figure 8-110 for an explanation of the HP-IB handshake. If replacement of a probably defective part does not correct the Remote Interface problem, check any related circuits that are connected to the faulty area. For example, some bus controllers simultaneously function as both talker and listener. As a result, they may mask a failure of the Remote Interface handshaking capabilities. This can happen when either the NRFD or NDAC output driver on the bus fails in a high state. This type of failure is a very subtle problem. The quickest way to determine what is happening is to monitor the driver outputs while activating both output levels of the individual drivers.

Equipment

Digital Test/ Extender Board	HP 08903-60018
Logic Probe	HP 5004A
Oscilloscope	HP 1740A

⟨√1⟩ Address Recognition Check

1. Perform the steps shown in the Address Recognition Troubleshooting Flowchart, Figure 8-111.

⟨√2⟩ Remote and Local Messages and the LCL Key Check

1. Perform the steps shown in the Remote and Local Messages and the LCL Key Troubleshooting Flowchart, Figure 8-112.

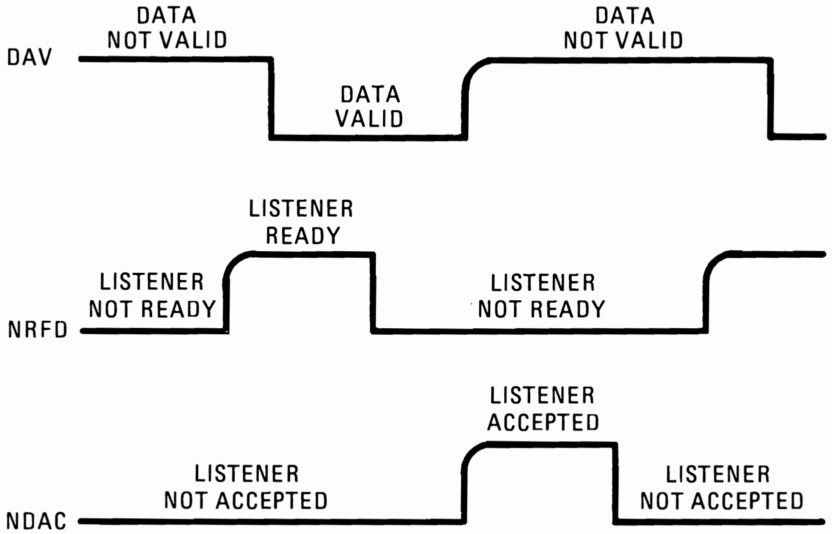
⟨√3⟩ Sending the Data Message Check

1. Perform the steps shown in the Sending the Data Message Troubleshooting Flowchart, Figure 8-113.

⟨√4⟩ Receiving the Data Message Check

1. Perform the Receiving the Data Message portion of the HP-IB Functional Checks.

SERVICE SHEET 19 (Cont'd)



Start with the talker waiting for the listener to release NRFD (not ready for data) indicating it is ready.

When the listener is ready, NRFD goes high (false). The talker then places valid data on DIO1 through DIO8 and sets DAV (data valid) low (true).

NRFD then goes low (true) and the talker waits for the listener to indicate it has accepted the data (or ignored it) by releasing the NDAC (not data accepted) to a high (false, i.e., data is accepted).

The talker sets DAV high (false) and again waits for the listener to release NRFD.

(NOTE that if ATN is true, all instruments on the bus must handshake regardless of whether they are talkers, listeners, or bystanders. Being in remote or local has nothing to do with handshaking.) If ATN is false, they only handshake if addressed.

Figure 8-110. Simplified HP-IB Handshake

Hint: Most of the circuits that are used in this check were used in previous checks. Check the inputs and outputs of gates U8 and U10. If they are good, the problem could be U18(PIO), the Controller (see Service Sheet 15), or the annunciators (see Service Sheet 18).

√5 Local Lockout and Clear Lockout/Set Local Messages Check

1. Perform the Local Lockout and Clear Lockout/Set Local Messages portion of the HP-IB Functional Checks.

Hint: Most of the circuits that are used in this check were used in previous checks. If the instrument fails this check, the problem is probably in the Controller (see Service Sheet 15) or the front panel keyboard circuits (see Service Sheet 17).

√6 Clear Message Check

1. Perform the Clear Message portion of the HP-IB Functional Checks.

Hint: The circuits that are used in this check were used in previous checks. If a problem occurs during the Clear Message Check, repeat the previous checks starting at √1 Address Recognition Check.

√7 Abort Message Check

1. Perform the Abort Message portion of the HP-IB Functional Checks.

Hint: Most of the circuits that are used in this check were used in previous checks. The flowchart (Figure 8-114) is primarily used to check the IFC and serial-poll circuits.

SERVICE SHEET 19 (Cont'd)

√8 Status Byte Message Check

1. Perform the Status Byte Message portion of the HP-IB Functional Checks.

Hint: Most of the circuits that are used in this check were used in previous checks. The most important difference is that the Controller must recognize that the Serial Poll Flip-Flop is set and send the status byte when addressed to talk.

√9 Require Service Message Check

1. Perform the Require Service Message portion of the HP-IB Functional Checks.

Hint: Most of the circuits that are used in this check were used in previous checks. The most important difference is that the Controller must drive the SRQ(L) line low. It does this through gate U20D and the PIO (U18). Repeat the check and monitor the input and output of U20D.

√10 Trigger Message and Clear Key Triggering

1. Perform the Trigger Message and Clear Key Triggering portion of the HP-IB Functional Checks.

Hint: Most of the circuits that are used in this check were used in previous checks. The most important difference is that the Controller must recognize that the CLEAR key can be used to trigger the instrument. The problem is probably in the Controller (see Service Sheet 15) or the CLEAR key circuit (see Service Sheet 17).

√11 Select Decoder and Address Switches Check

1. Key in the Direct Control Special Functions indicated in Table 8-93. For each setting, check the pins on U16 indicated.

Table 8-93. Select Decoder Outputs

Direct Control Special Function	Level (TTL) at U16 Pin							
	15	14	13	12	11	10	9	7
0.300	*	H	H	H	H	H	H	H
0.310	H	*	H	H	H	H	H	H
0.320	H	H	*	H	H	H	H	H
0.330	H	H	H	*	H	H	H	H
0.340	H	H	H	H	*	H	H	H
0.350	H	H	H	H	H	*	H	H
0.360	H	H	H	H	H	H	*	H
0.370	H	H	H	H	H	H	H	*

*Low-going TTL pulses ≈ 30 ms period.

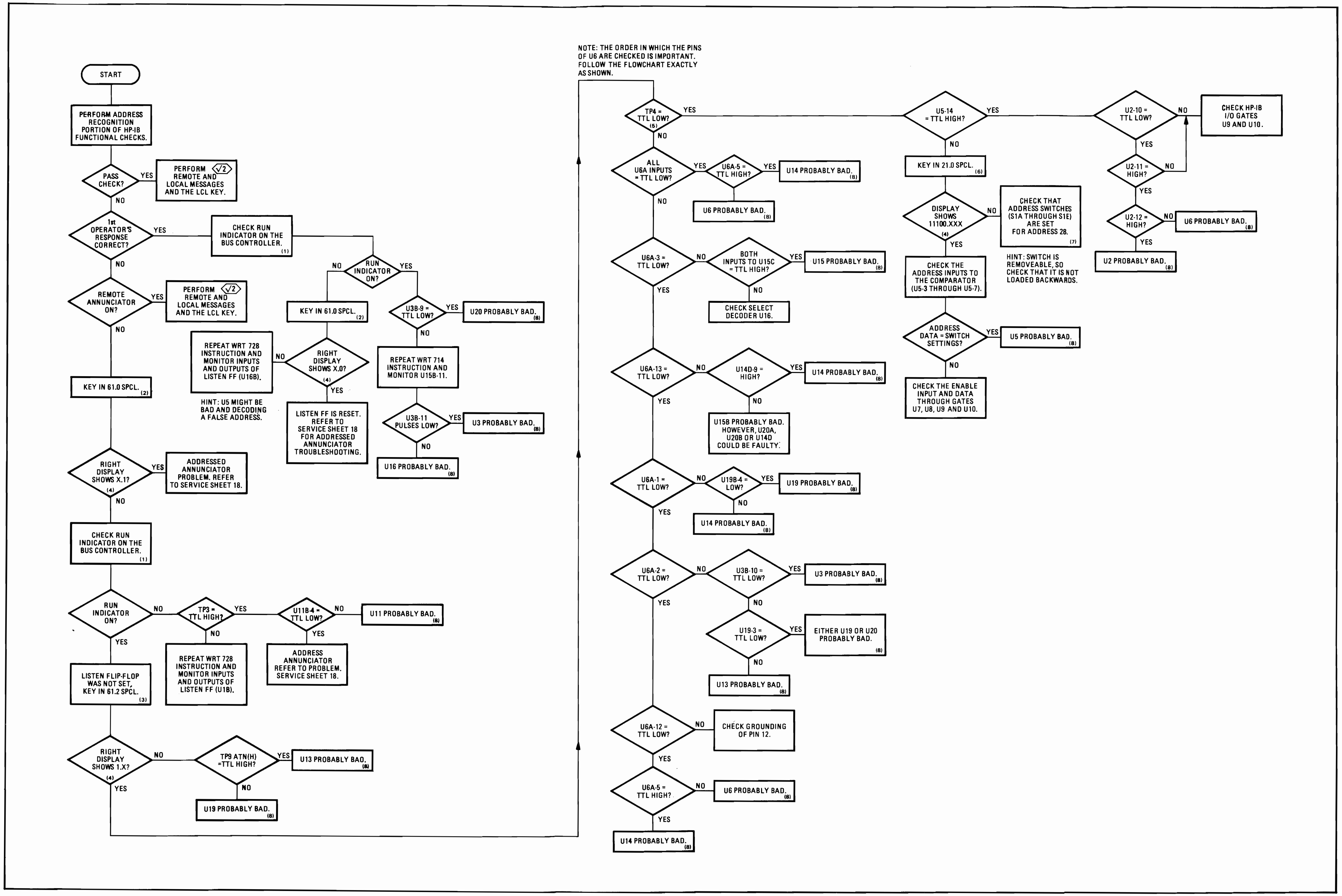
2. Key in 0.350 SPCL to readback part of S1. The left display should be of the form abcd where

a=1 if S1D is open;
b=1 if S1C is open;
c=1 if S1B is open;
d=1 if S1A is open.

3. Key in 0.360 SPCL to read back the rest of S1 and U12B. The left display should be of the form abcd where

a=1 if U12B is set;
b=1 if S1G is open;
c=1 if S1F is open;
d=1 if S1E is open.

(Service Sheet 19 is continued on next page)



NOTE: THE ORDER IN WHICH THE PINS OF U6 ARE CHECKED IS IMPORTANT. FOLLOW THE FLOWCHART EXACTLY AS SHOWN.

Figure 8-111. √1 Address Recognition Check Troubleshooting Flowchart

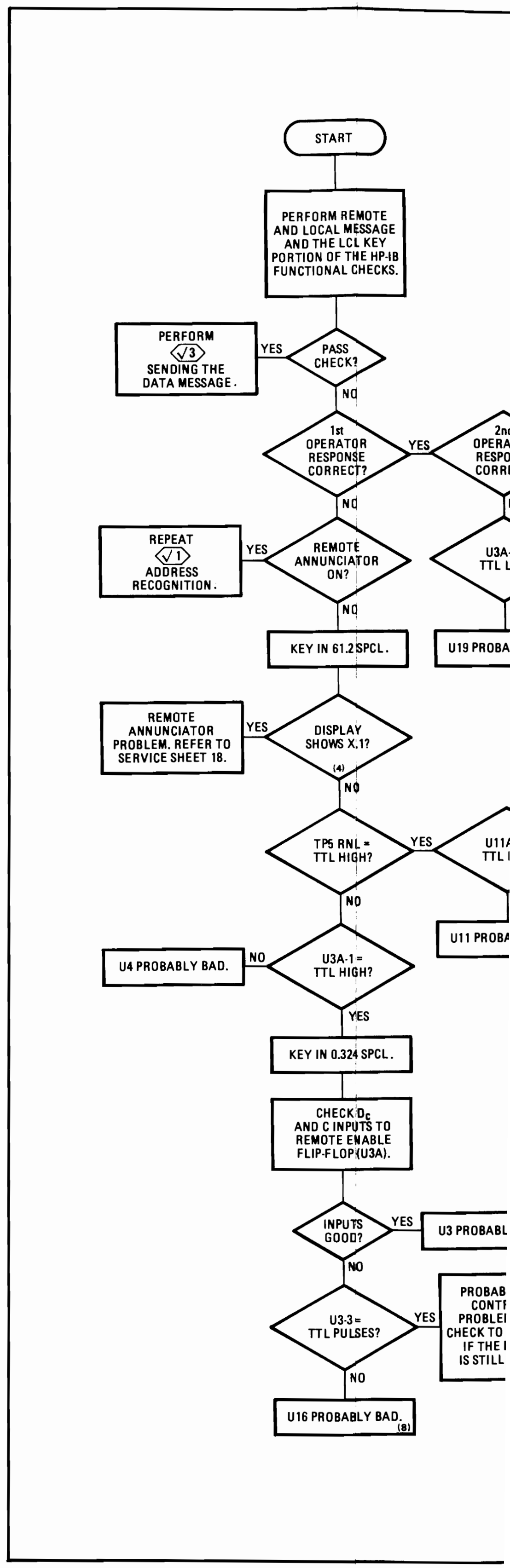
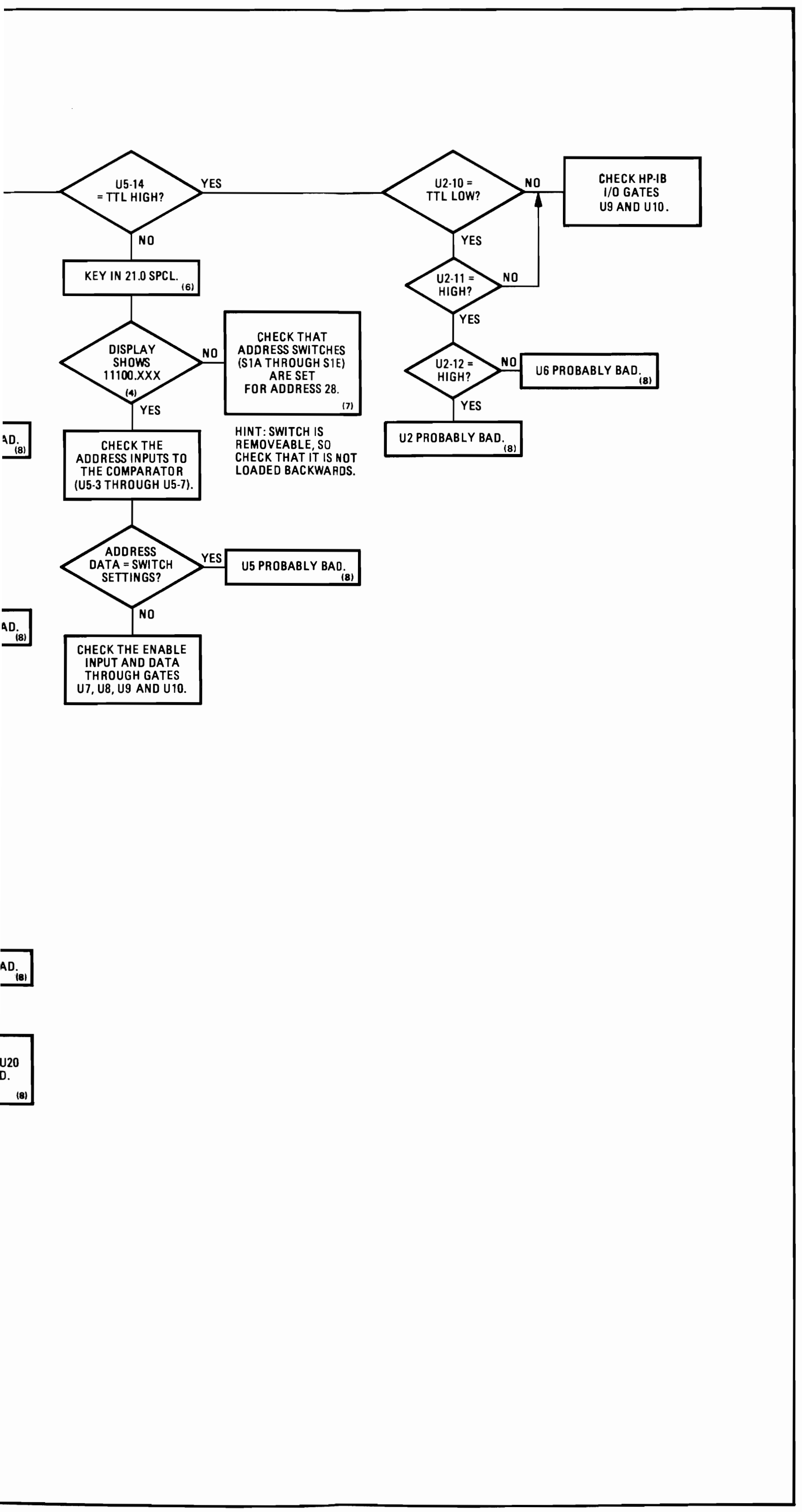


Figure 8-112. √2 Remote and Local Messa
Troubleshooting Flow



rt

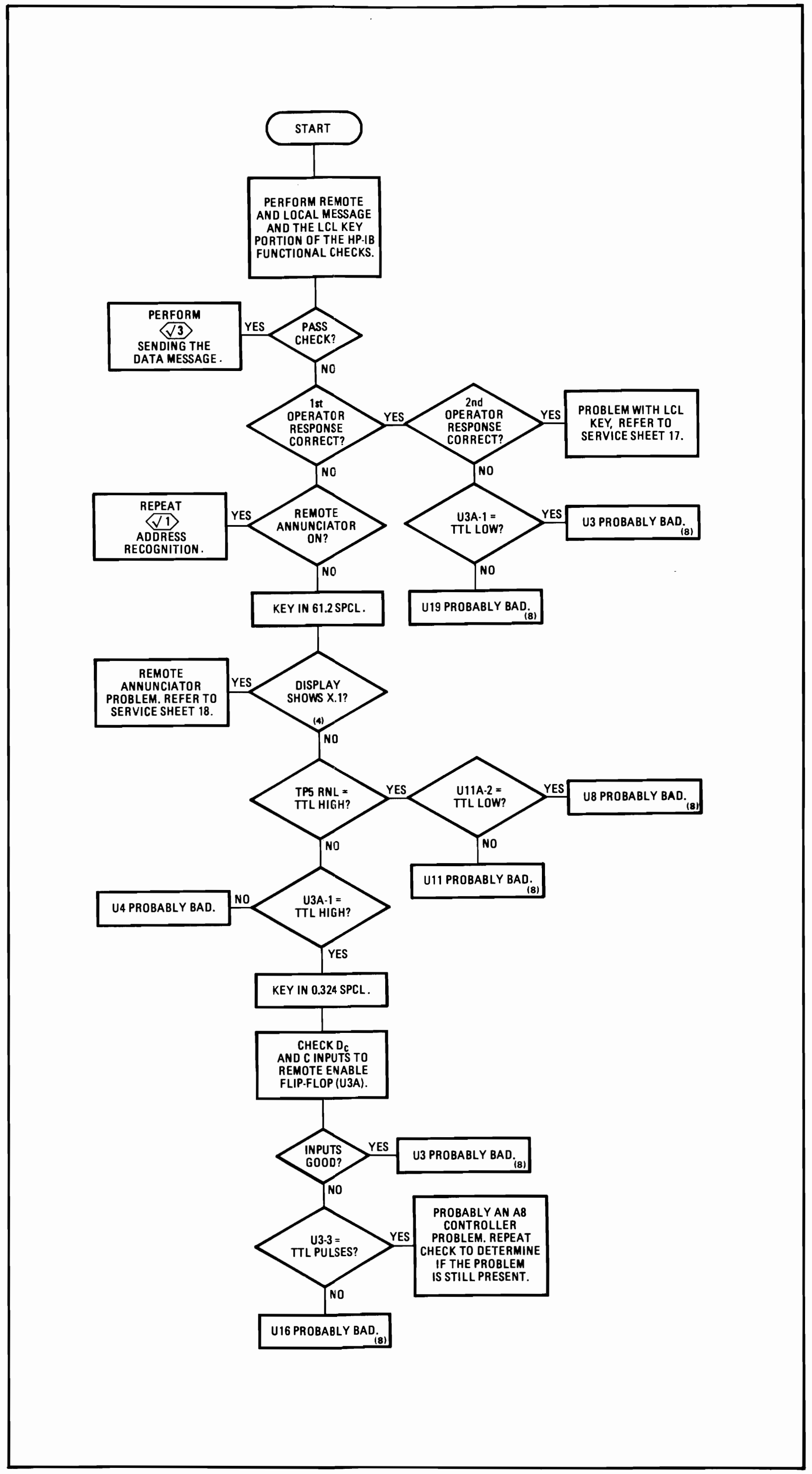


Figure 8-112. √2 Remote and Local Messages and the LCL Key Check Troubleshooting Flowchart

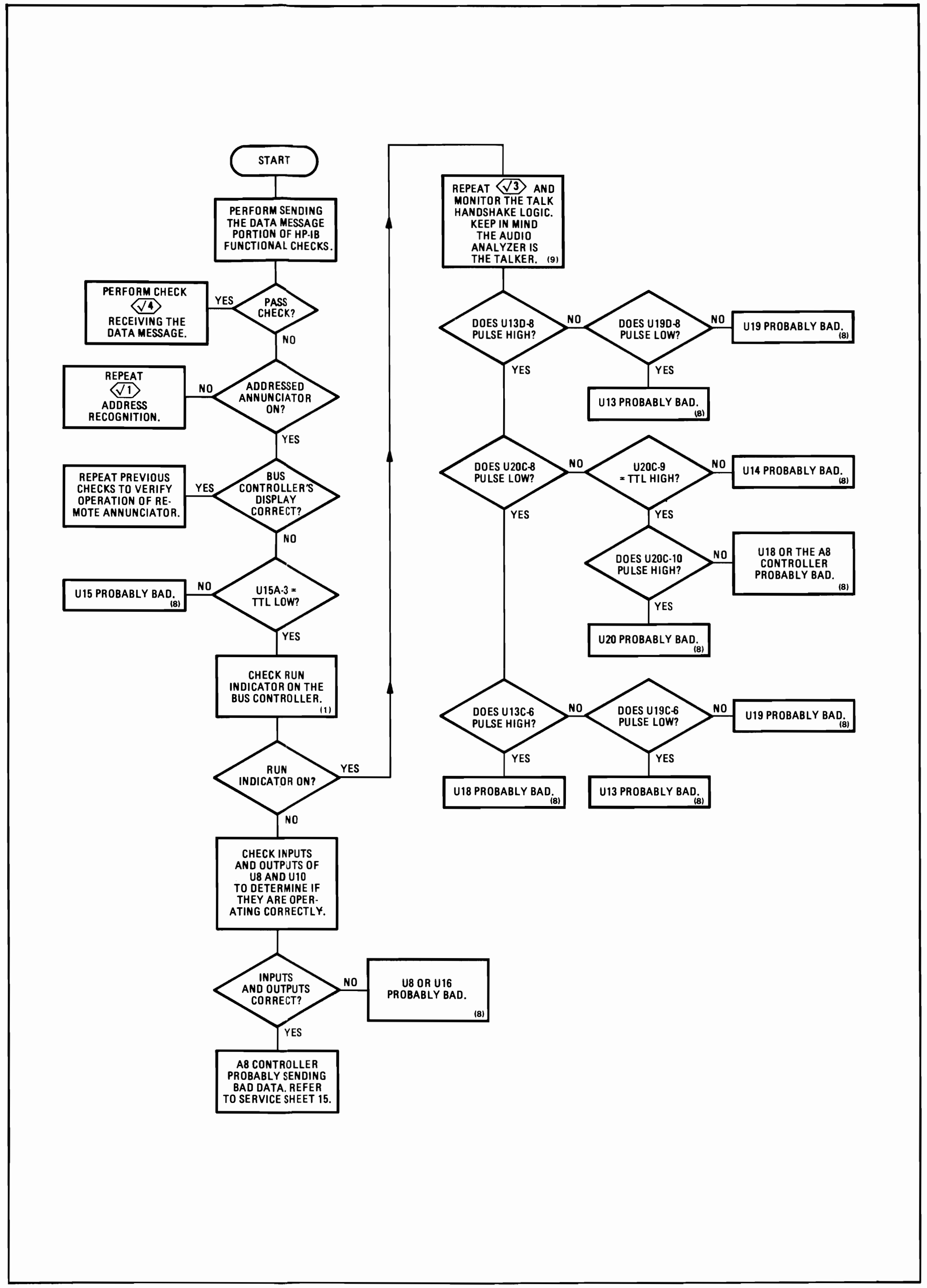


Figure 8-113. √3 Sending the Data Message Troubleshooting Flowchart

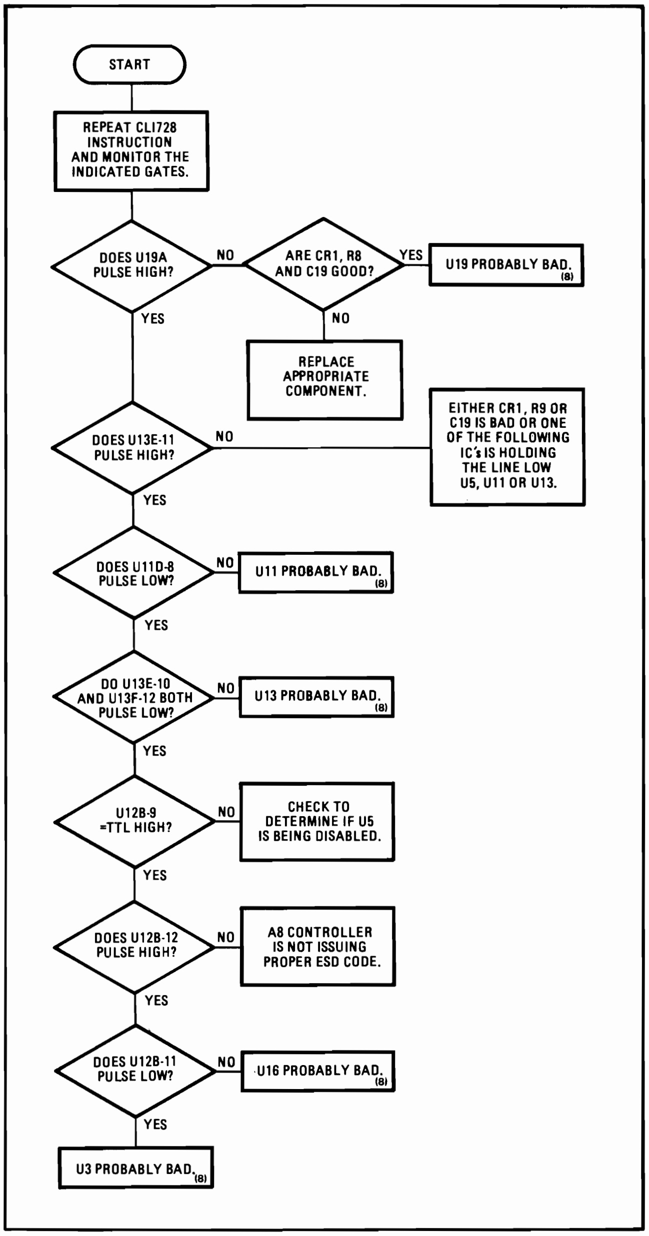


Figure 8-114. ⟨√7⟩ **Abort Message Check Troubleshooting Flowchart**

NOTES

1. *The Run indicator shows the status of the handshake between the bus controller and the Audio Analyzer. If it is still on, the handshake was not completed.*

2. *This special function reads back and displays the present state of the Talk and Listen flip-flops (see 61.N Display HP-IB status in paragraph 8-27.*

3. *This special function reads back and displays the present state of the ATN bus control line and the state of the Remote Enable Flip-Flop.*

4. *X equals "don't care".*

5. *If TP4 is low, the handshake logic has satisfied the initial requirements to input address data to the Interface Control ROM. If TP4 is high, this requirement is not complete.*

6. *Displays HP-IB address set on the Address Switches.*

7. *Remember that the checkout procedure assumes that the Audio Analyzer is set to address 28. If the instrument has been set for a different address, modify the HP-IB Functional Checks procedure and the troubleshooting information to match the new address.*

8. *Indicated IC is the most likely malfunction. However, if replacement does not fix the problem, check the circuits that drive or are driven by the specified IC and all wiring and components that are connected to the same signals.*

9. *See Figure 8-110 for a simplified explanation of the HP-IB Handshake.*

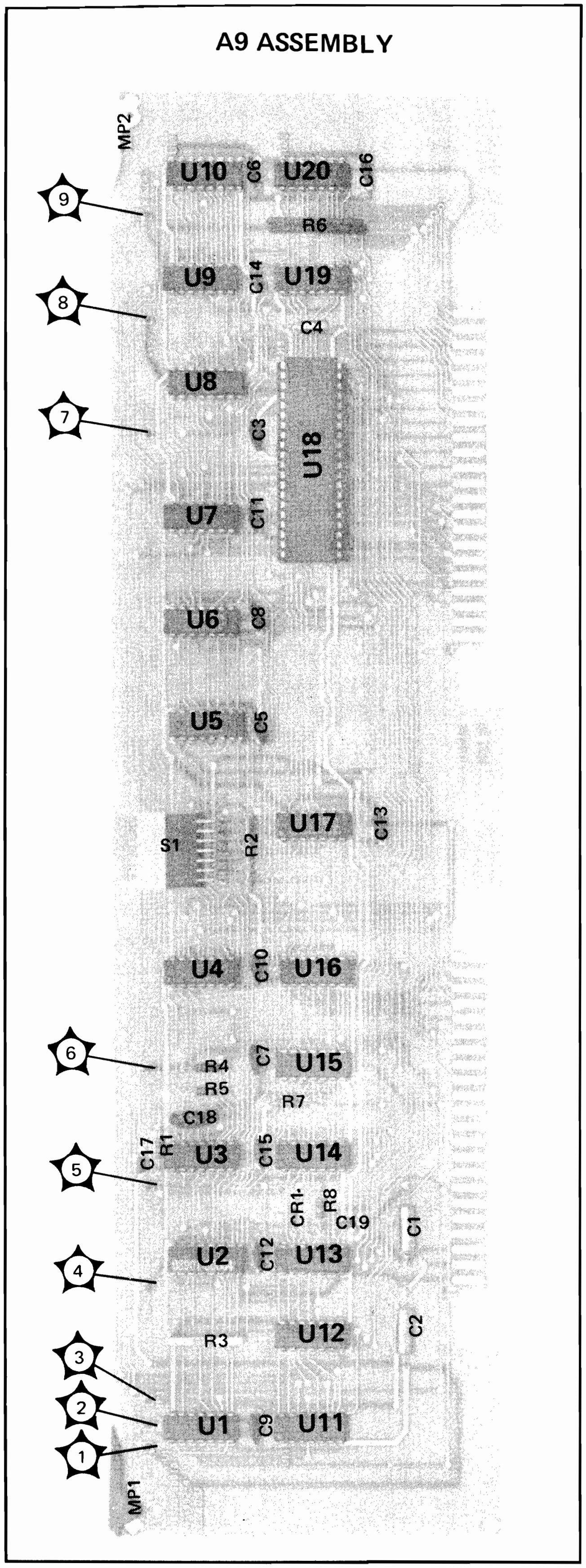


Figure 8-115. A9 Remote Interface Assembly Component Locations

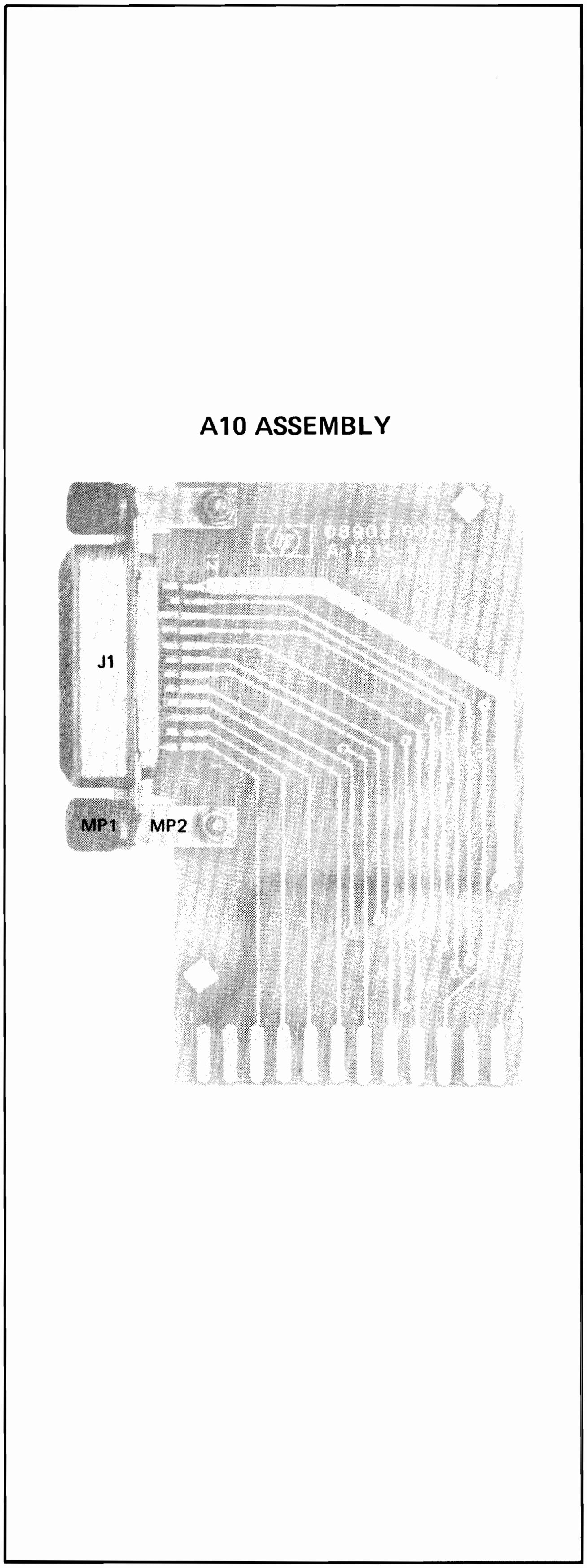
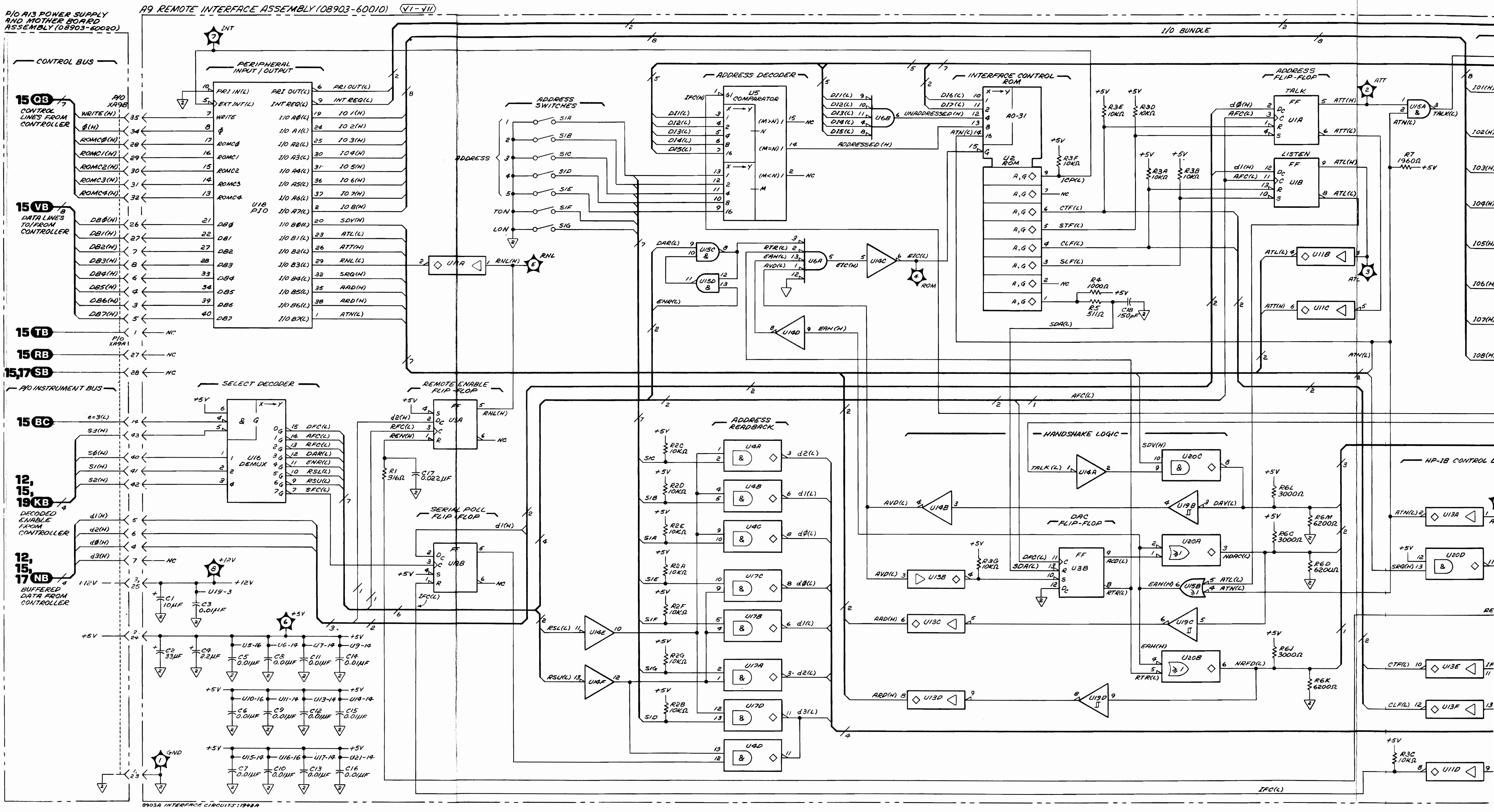
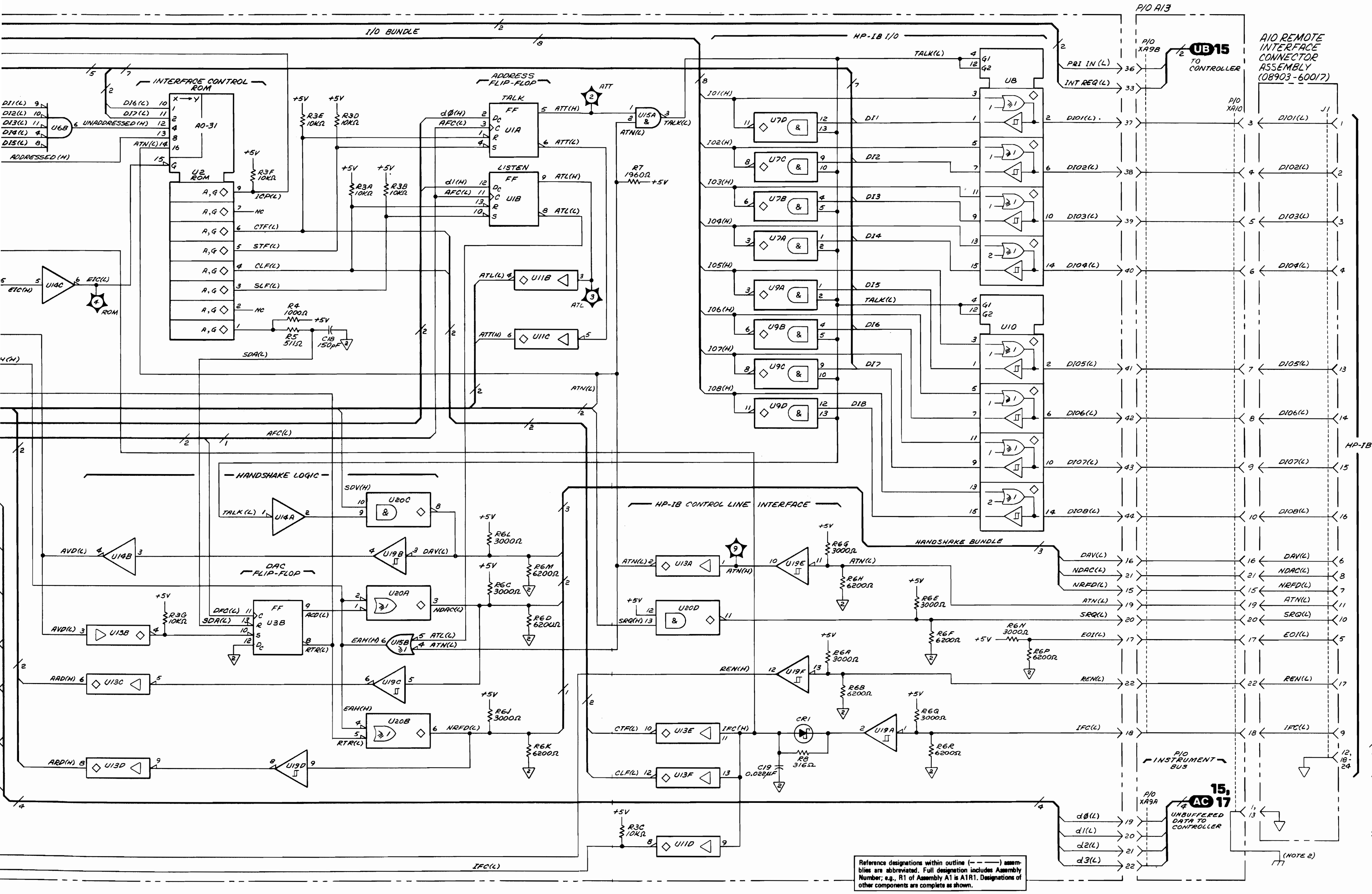


Figure 8-116. A10 Remote Interface Connector Assembly Component Locations


P/O A13 POWER SUPPLY AND MOTHER BOARD ASSEMBLY (08903-60020)
A9 REMOTE INTERFACE ASSEMBLY (08903-60010) (VI-VII)
CONTROL BUS
15 QB CONTROL LINES FROM CONTROLLER
15 VB DATA LINES TO/FROM CONTROLLER
15 TB
15 RB
15,17 SB
P/O INSTRUMENT BUS
15 BC
12, 15, 19 KB DECODED ENABLE FROM CONTROLLER
12, 15, 17 NB BUFFERED DATA FROM CONTROLLER
P/O XA9B
P/O XA9A
WRITE(H)
ROMC0(H)
ROMC1(H)
ROMC2(H)
ROMC3(H)
ROMC4(H)
DB0(H)
DB1(H)
DB2(H)
DB3(H)
DB4(H)
DB5(H)
DB6(H)
DB7(H)
NC
INT
PERIPHERAL INPUT/OUTPUT
U18 PIO
PRI IN(L)
EXT INT(L)
PRI OUT(L)
INT REQ(L)
IO 1(H)
IO 2(H)
IO 3(H)
IO 4(H)
IO 5(H)
IO 6(H)
IO 7(H)
IO 8(H)
SDV(H)
ATL(L)
ATT(H)
RNL(L)
SRQ(H)
AAD(H)
ARD(H)
ATN(L)
U11A
RNL(H)
RNL
ADDRESS SWITCHES
S1A
S1B
S1C
S1D
S1E
S1F
S1G
ADDRESS
TON
LON
ADDRESS DECODER
U5 COMPARATOR
IFC(H)
DI1(L)
DI2(L)
DI3(L)
DI4(L)
DI5(L)
(M>N)
(M=N)
(M<N)
U6B
UNADDRESSED(H)
ADDRESSED(H)
INTERFACE CONTROL ROM
A0-31
U2 ROM
ICP(L)
CTF(L)
STF(L)
CLF(L)
SLF(L)
R4 1000Ω
R5 511Ω
C18 150pF
SDA(L)
R3E 10kΩ
R3D 10kΩ
R3F 10kΩ
R3A 10kΩ
R3B 10kΩ
ADDRESS FLIP-FLOP
TALK
LISTEN
U1A
U1B
ATT(H)
ATT(L)
ATL(H)
ATL(L)
U15A
TALK(L)
R7 1960Ω
ATT
ATL
I/O BUNDLE
DAR(L)
U15C
U15D
ENR(L)
RTR(L)
EAN(L)
AVD(L)
U6A
EIC(H)
U14C
EIC(L)
ROM
U14D
EAH(H)
U11B
U11C
SELECT DECODER
U16 DEMUX
DFC(L)
AFC(L)
RFC(L)
DAR(L)
ENR(L)
RSL(L)
RSU(L)
SFC(L)
e=3(L)
S3(H)
S0(H)
S1(H)
S2(H)
d1(H)
d2(H)
d0(H)
d3(H)
REMOTE ENABLE FLIP-FLOP
U3A
REN(H)
R1 316Ω
C17 0.022µF
SERIAL POLL FLIP-FLOP
U3B
IFC(L)
+12V
C1 10µF
C3 0.01µF
U19-3
C2 33µF
C4 2.2µF
C5 0.01µF
C8 0.01µF
C11 0.01µF
C14 0.01µF
C6 0.01µF
C9 0.01µF
C12 0.01µF
C15 0.01µF
C7 0.01µF
C10 0.01µF
C13 0.01µF
C16 0.01µF
U5-16
U6-14
U7-14
U9-14
U10-16
U11-14
U13-14
U14-14
U15-14
U16-16
U17-14
U21-14
GND
ADDRESS READBACK
U4A
U4B
U4C
U17C
U17B
U17A
U17D
U4D
R2C 10kΩ
R2D 10kΩ
R2E 10kΩ
R2A 10kΩ
R2F 10kΩ
R2G 10kΩ
R2B 10kΩ
U14E
U14F
AFC(L)
HANDSHAKE LOGIC
U14A
U20C
SDV(H)
U19B
DAV(L)
U14B
DAC FLIP-FLOP
U20A
NDAC(L)
U13B
DFC(L)
U3B
ACD(L)
RTR(L)
U15B
U13C
AAD(H)
U19C
U20B
NRFD(L)
U13D
ARD(H)
U19D
R6L 3000Ω
R6M 6200Ω
R6C 3000Ω
R6D 6200Ω
R6J 3000Ω
R6K 6200Ω
R3G 10kΩ
HP-IB CONTROL
U13A
U20D
SRQ(H)
U13E
U13F
CTF(L)
CLF(L)
R3C 10kΩ
U11D
IFC(L)
DI01(H)
DI02(H)
DI03(H)
DI04(H)
DI05(H)
DI06(H)
DI07(H)
DI08(H)
8903A INTERFACE CIRCUITS: 1948A



Reference designations within outline (– – ——) assemblies are abbreviated. Full designation includes Assembly Number; e.g., R1 of Assembly A1 is A1R1. Designations of other components are complete as shown.

NOTES

1. SEE TABLE 8-7 SCHEMATIC DIAGRAM NOTES.
2. CHASSIS GROUND IS ACHIEVED BY MECHANICAL CONTACT THRU SCREWS HOLDING P.C. BOARD.

REFERENCE DESIGNATIONS

A9	A10
C1-19 CR1 R1-8 S1 TP1-9 U1-20	J1
	A13
	XA9A, B, 10

LOGIC LEVELS

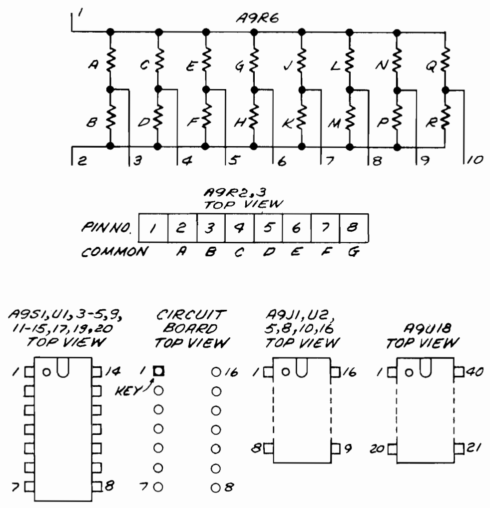
	TTL
HIGH	>2V
LOW	<0.8V
< IS MORE NEG. THAN > IS MORE POS. THAN	
OPEN	HIGH
GROUND	LOW

INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATIONS	PART NUMBERS
U1,3,12	1820-1112
U2	08901-80004
U4,17	1820-1417
U5	1820-0706
U6	1820-1905
U7,9	1820-1198
U8,10	1820-1689
U11,13	1820-1200
U14	1820-1199
U15	1820-0054
U16	1820-1216
U18	1820-2100
U19	1820-1416
U20	1820-0621

DIGITAL INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

REFERENCE DESIGNATIONS	PIN NUMBERS
U1,3,4,6,7,9,11-15,17,19,20	+5V 14 ⏚2 7
U2,5,8,10,16	+5V 16 ⏚2 8
U18	+12V 3 +5V 4 ⏚2 18



19

A9, A10, P/O A13

Figure 8-117. Remote Interface Schematic

SERVICE SHEET 20—POWER SUPPLY AND MOTHER BOARD—POWER SUPPLY (P/O A13)

TROUBLESHOOTING HELP

- Block Diagram .... Service Sheet BD2

PRINCIPLES OF OPERATION

General

The Power Supply has four outputs: +15V, –15V, +12V, and +5V. The +15V and –15V supplies are used to run all operational amplifiers and most other analog circuits. The +12V supply is used by the three microprocessor ICs (A8U5, A8U6, and A9U18). The +5V supply powers most of the digital circuits, all of the relays, and some of the analog circuits.

Transformer Primary Circuits

The input to the primary of the power transformer (chassis part T1) is through the four-voltage, filtered Line Power Assembly (A14) which permits operation from nominal line voltages of 100, 120, 200, and 240V at 48 to 66 Hz. (400 Hz is also permitted for 100 and 120V.) Matching of the primary winding to the input line voltage is accomplished by positioning of the printed circuit card A14TB1.

Regulators and Protection Circuits

A single, center-tapped secondary of the power transformer supplies the +15V, –15V, and +12V Regulators. The secondary is full-wave rectified and filtered by CR1, CR2, and C1 for the +15V and +12V Regulators and by CR3, CR4, and C2 for the –15V Regulator.

The Input Over-Voltage Protection circuit, consisting primarily of VR1, VR2, and Q3, protects the Power Supply and, indeed, the rest of the instrument when the power line is connected to 200 or 220V and the power line printed circuit board is set for 100 or 120V. In that case VR1 and VR2 conduct, triac Q3 fires, and the primary fuse (chassis part F1) blows. C12 prevents Q3 from firing on short-duration line transients.

An independent, center-tapped secondary of the transformer supplies the +5V Regulator. The secondary is full-wave rectified and filtered by CR5A, CR5B, and C3.

All regulators are series-pass types. The +15V, –15V, and +12V Regulators (U2 and chassis parts U1 and U2) are three-terminal ICs with internal short-circuit, over-voltage, and reverse-voltage protection. All regulators, however, are further protected with input fuses. Capacitors at the inputs and outputs of the regulators (C4, C5, A11C1, A11C2, A11C3, and A11C4) prevent spurious oscillations.

The +5V Regulator is a discrete regulator. Chassis part Q1 is a Darlington, series-pass transistor pair driven by Q1. The output of the regulator is sensed by U1B and compared to a 5.2V reference

derived from the +15V supply through voltage divider R12 and R13. Hence, operation of the +5V supply depends on the +15V supply. U1B drives Q1 which drives the series-pass transistor to maintain a constant 5.2V at the regulator's output.

U1A senses both the output current (through R5) and voltage for the +5V supply and folds back the supply during a fault. Foldback begins at about 4A. Short-circuit current is about 1A. C6 and R8 frequency compensate the regulator during foldback, and C7 and R11 during normal operation.

At the output of each supply is a reverse-voltage protection diode (CR11 through CR14), a supply status indicator, and an over-voltage protection circuit. The supply status indicators (DS1 through DS4) light when the voltage on the supply is high enough to cause the series reference diodes (VR3 through VR6) to conduct. Excessive output voltage will cause a reference diode (VR7 through VR10) to conduct and fire its respective SCR (Q2, Q4, Q5, or Q6). The SCR shorts the supply and initiates current foldback.

TROUBLESHOOTING

General

Procedures for checking the Power Supply and Mother Board Assembly are given below. The circuits or points to check are marked on the schematic diagram by a hexagon with a check mark and a number inside, e.g., √3. In addition, any points outside the labeled circuit area that must be checked are also identified. Fixed signals are shown on the schematic also inside a hexagon, e.g., +1.9 to +2.1 Vdc. These procedures assume that the measurement circuits of the instrument (e.g., AC LEVEL and frequency) are working properly.

Equipment

Digital Multimeter	HP 3455A
Oscilloscope	HP 1740A

√1 Power Supply Check—Blown Line Fuse

1. Check that the line voltage selection card (A14TB1) and line fuse (F1) are matched to the power source.

2. With LINE set to OFF, unplug the plug on the secondary of T1 which plugs into A13J2. Replace the blown fuse. Set LINE to ON. If the fuse blows, check the A14 Line Power Assembly, S1, and T1.

3. Switch LINE to OFF. Measure the resistance between pins 4 and 5 of A13J2. The resistance should be greater than 100 kΩ.

4. Measure the resistance between pins 2 and 3 of A13J2. The resistance should be greater than 100 kΩ.

5. Measure the resistance across A13C1, C2, and C3. After allowing the capacitors to be charged by the ohmmeter, the resistance should be greater than 2 kΩ in each case.

Hint: If the resistance is correct but the F1 still blows when the instrument is powered up, the fault is probably in the Input Over-Voltage Protection circuit. Check A13VR1, VR2, and Q3.

√2 Power Supply Check—Blown Regulator Fuses

1. With LINE set to OFF, unplug all board assemblies (including the Keyboard and Display Assembly). Replace the blown fuse. Switch LINE to ON. If the fuse (A11F1, F2, or F3) blows, the problem lies with the power supply itself.

Hint: A short on the output of the +5V, +15V, or –15V supply will blow a fuse.

Hint: If the +15V and –15V supplies work but A11F2 blows, the problem is likely cause by a fault in the Over-Current Protection circuit or shorted transistors.

2. Switch LINE to OFF. Measure the resistance from A13TP3 (+5V), A13TP4 (+12V), A13TP5 (+15V), and A13TP6 (–15V) to A13TP2 (GND A). The resistance should be greater than 3 kΩ.

√3 Power Supply Check—General Integrity

1. With the LINE switch ON, check the dc voltage on A13TP3 (+5V), A13TP4 (+12V), A13TP5 (+15V), and A13TP6 (–15V). The voltage should be within the limits shown on the schematic diagram.

Hint: If the +5V supply is out of limits, check pin 5 of U1B. Check that pin 1 of U1A is between +12 and +15 Vdc (over-current protection unactivated).

2. With an oscilloscope, measure the ripple at the outputs of the Full-Wave Rectifier. (Fuses A11F1, F2, and F3 provide convenient test points.) Ripple should be less than 1.5 V and should be at double the line frequency.

Hint: For reference, typical dc level and ripple is as shown in Table 8-94.

Table 8-94. Typical DC Level and Ripple

Unregulated Input	Typical Level (Vdc)	Typical Ripple (Vpp)
+15V	+23	0.6
+5V	+8	0.8
–15V	–23	0.6

3. Measure the ripple at the supply outputs. Ripple should be less than 2 mVpp.

Remote Interface
A9, A10
SERVICE SHEET 19

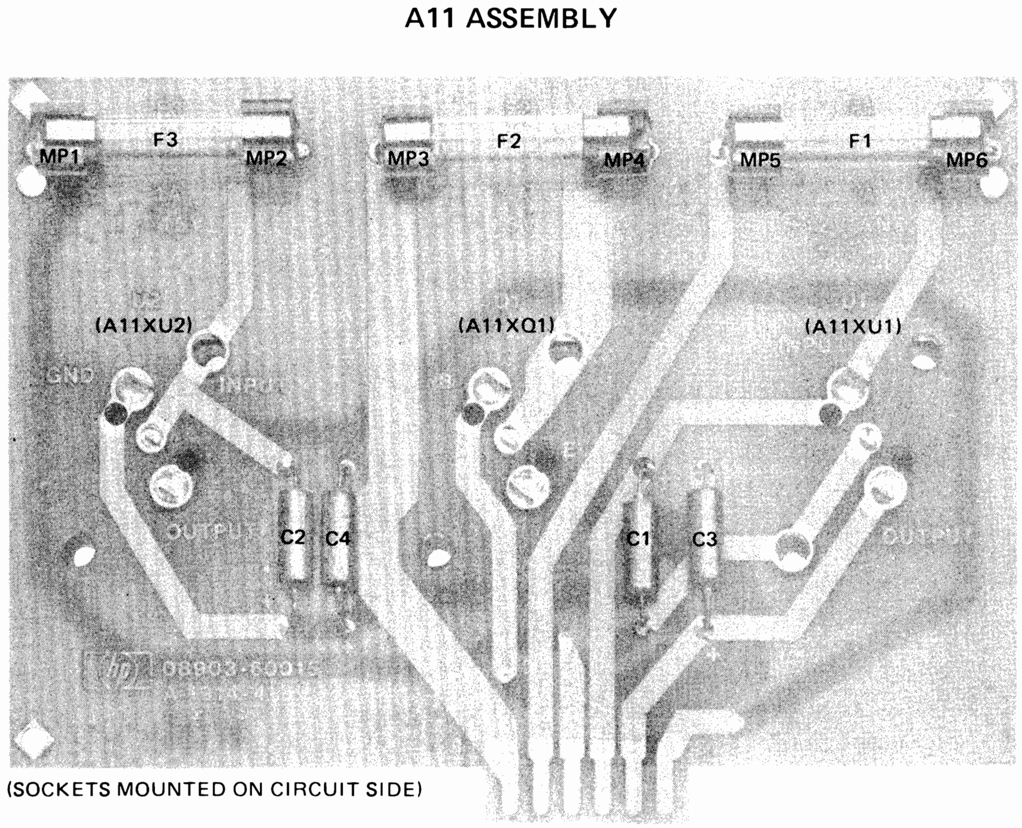


Figure 8-118. A11 Series Regulator Socket Assembly Component Locations

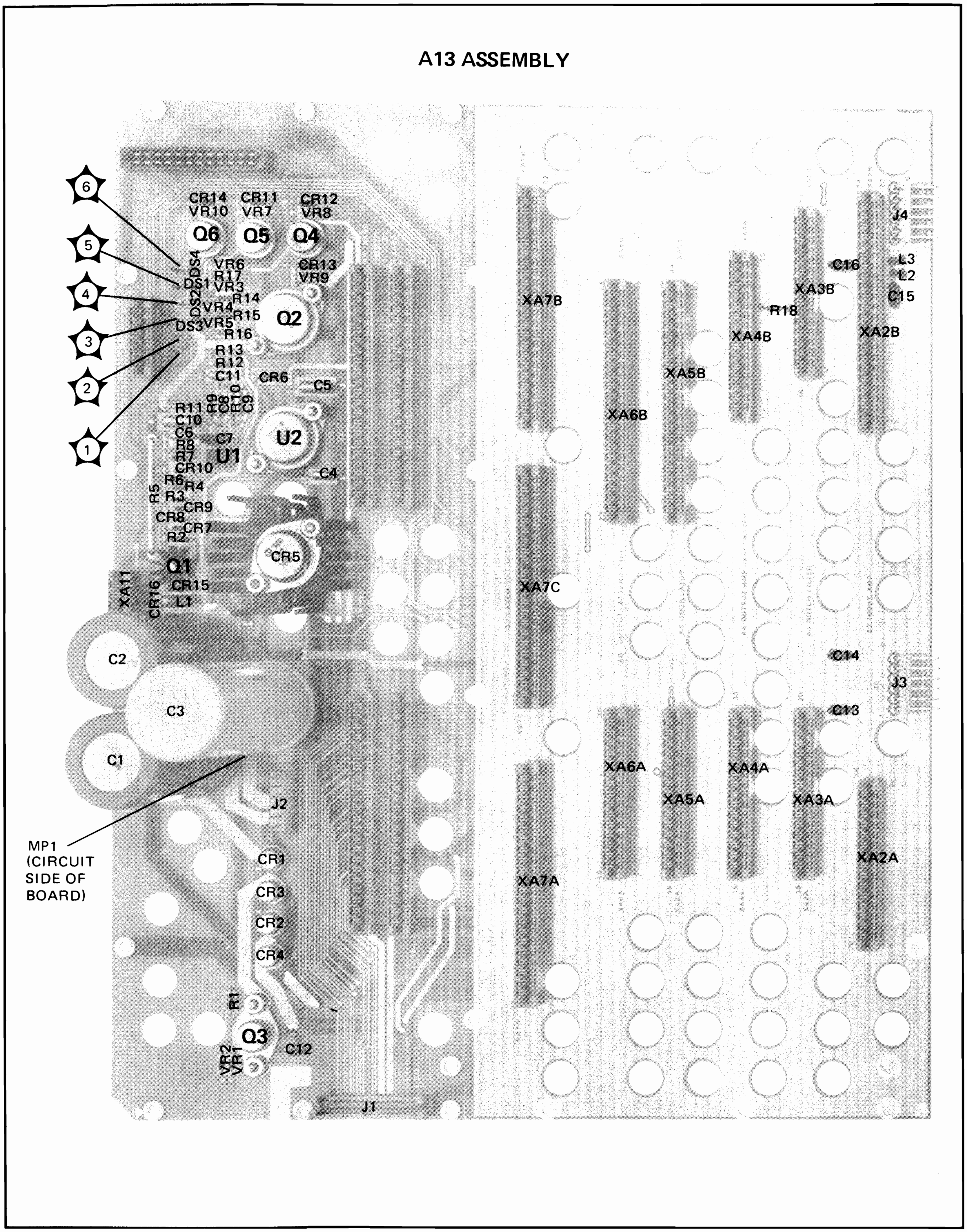
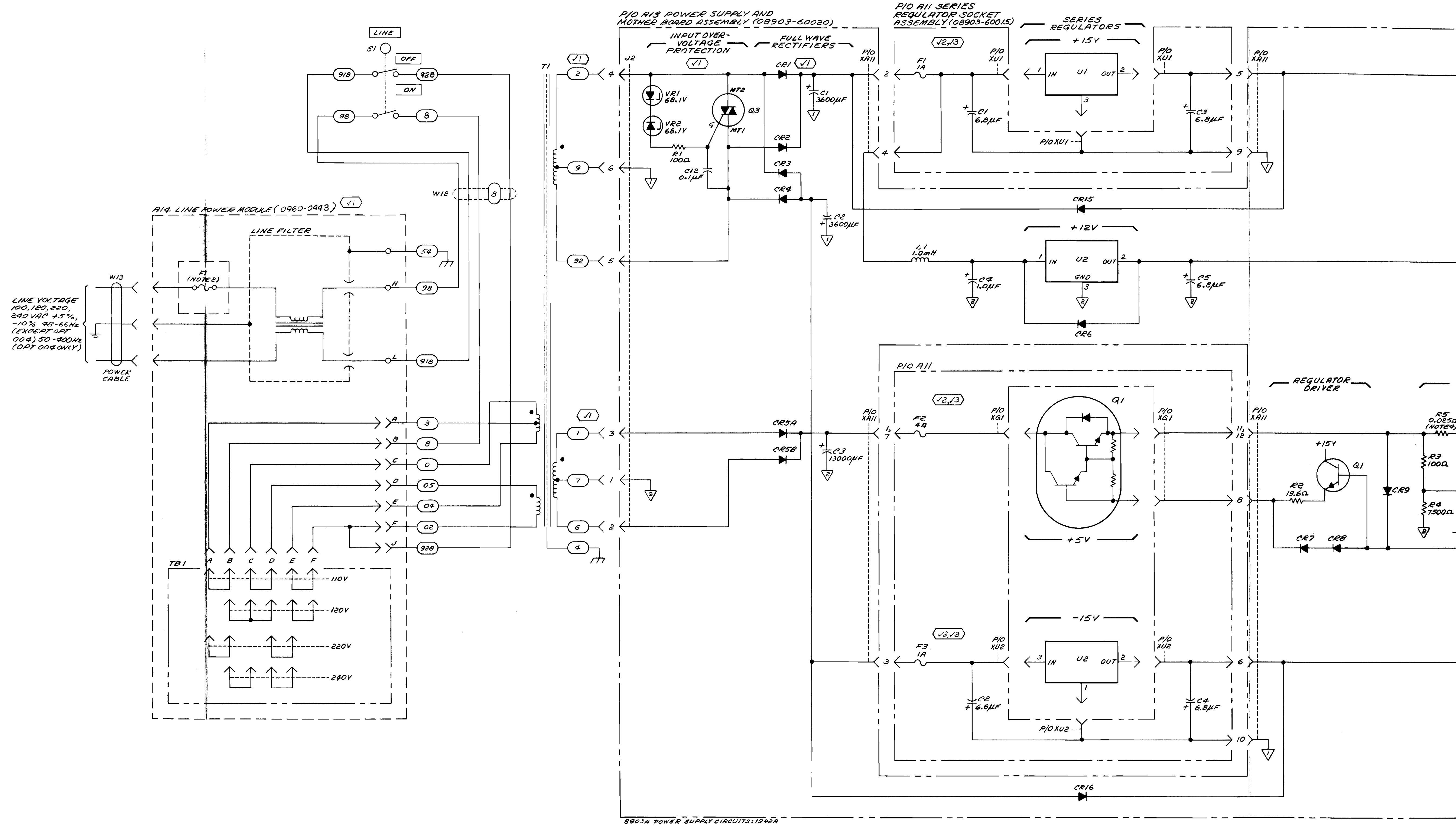
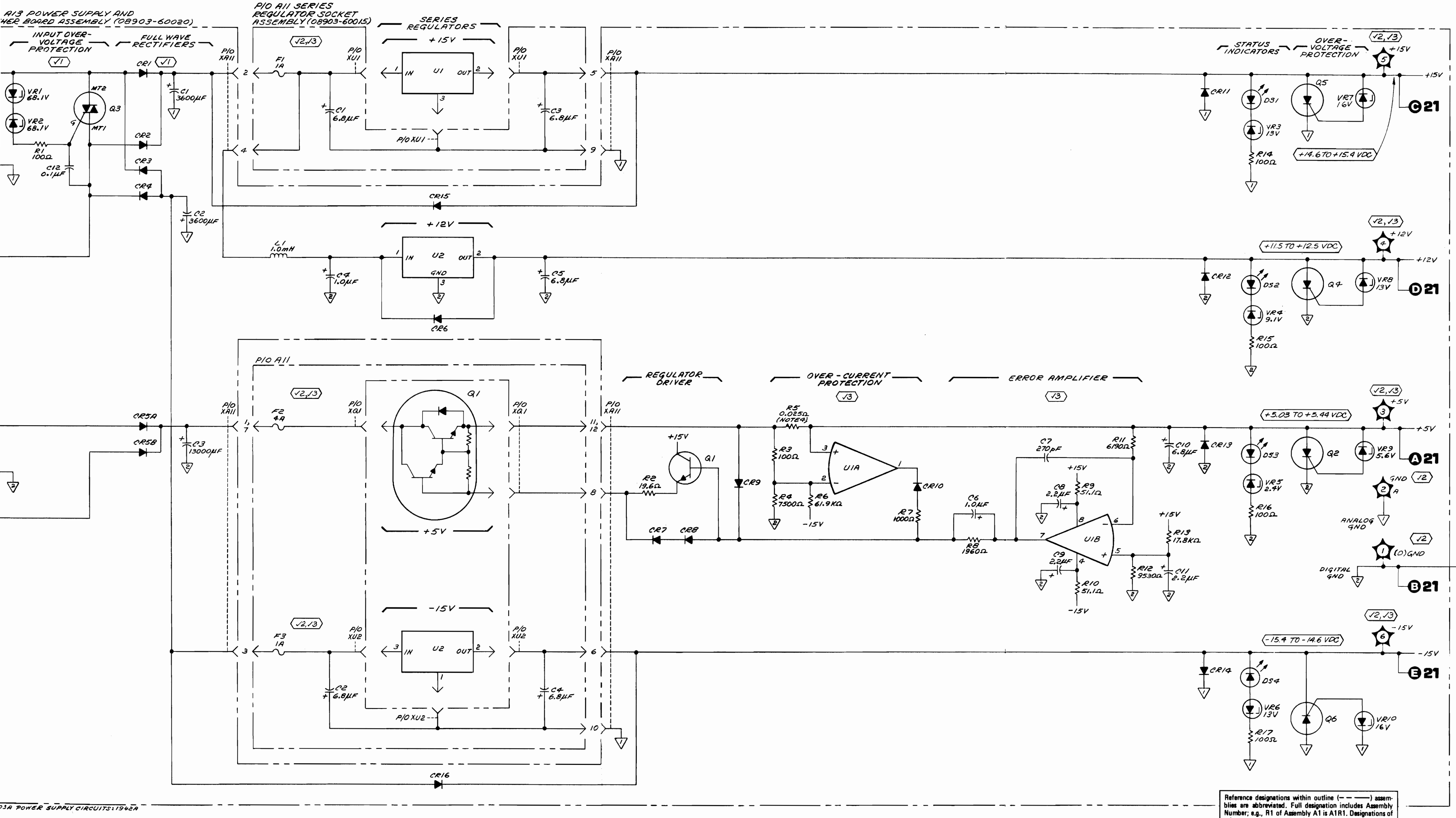


Figure 8-119. A13 Power Supply and Mother Board Assembly Component Locations



8903A POWER SUPPLY CIRCUITS:1942A



Reference designations within outline (— — ——) assemblies are abbreviated. Full designation includes Assembly Number; e.g., R1 of Assembly A1 is A1R1. Designations of other components are complete as shown.

NOTES

1. SEE TABLE 8-7 SCHEMATIC DIAGRAM NOTES.
2. VALUE OF F1 IS 1.25AMP FOR 110/120V AND 0.5AMP FOR 220/240V.
3. CHASSIS GROUND IS ACHIEVED BY MECHANICAL CONTACT THROUGH SCREWS HOLDING PC BOARD TO FRAME.
4. A13R5 IS A 4.8cm (1.9in.) STRIP OF NICKEL COPPER.

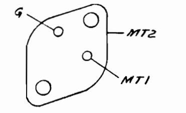
REFERENCE DESIGNATIONS

NO PREFIX	A13
F1 Q1 S1 T1 U1,2 W12,13	C1-12 CR1-16 DS1-4 L1 Q1-6 R1-17 TP1-6 U1,2 VR1-10 XA11
A11	A14
C1-4 F1-3 XQ1 XU1,2	TB1

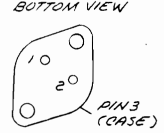
TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATIONS	PART NUMBERS
NO PREFIX	
Q1	1854-0669
U1	1826-0203
U2	1826-0169
A13	
Q1	1854-0477
Q2	1884-0005
Q3	1884-0076
Q4-6	1884-0012
U1	1826-0547
U2	1826-0117

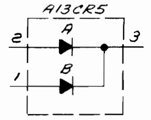
A13Q3

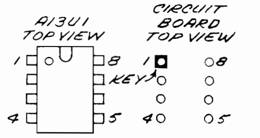


U1,2,A13CR5,U2 BOTTOM VIEW



A13CR5

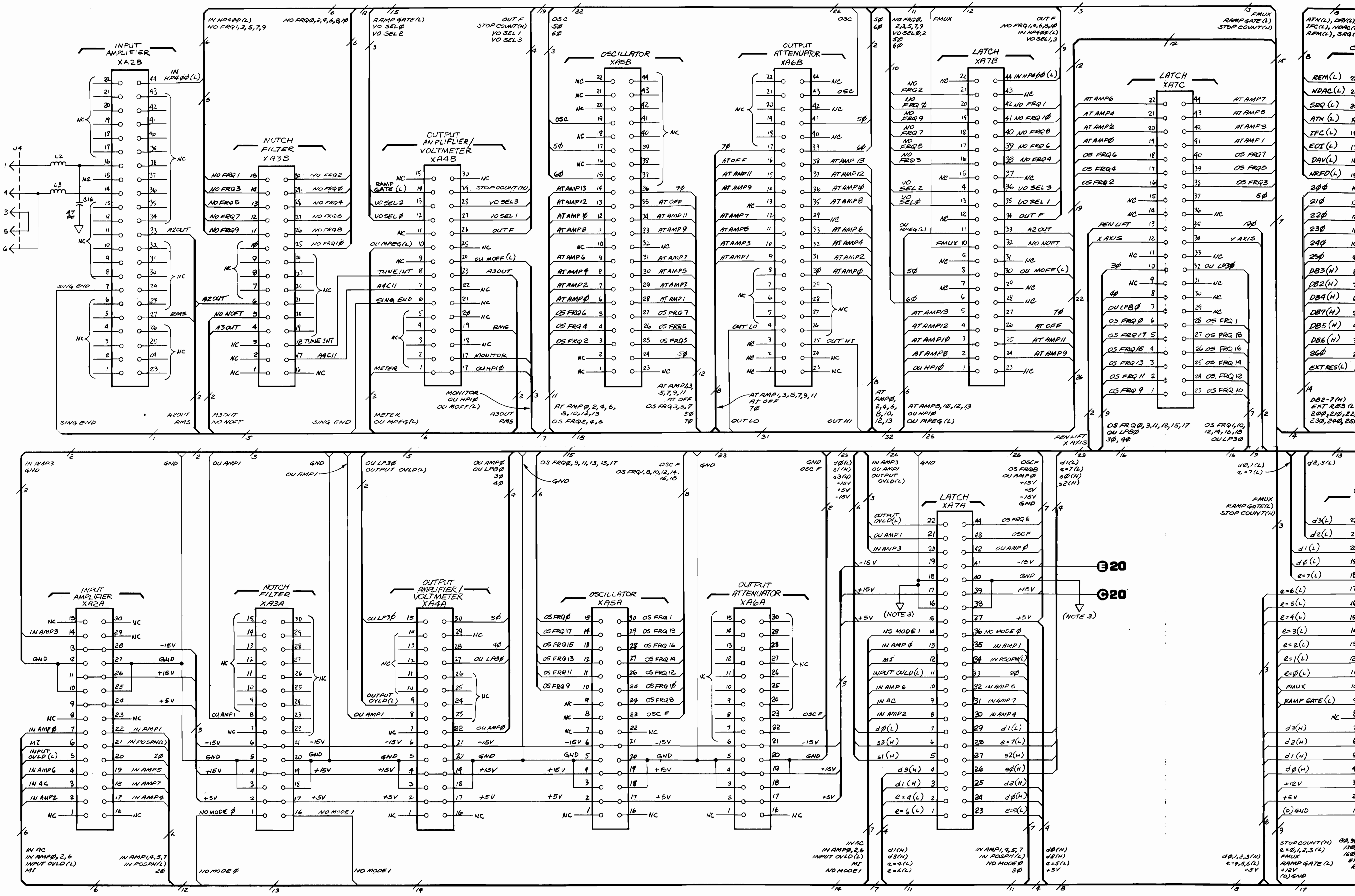


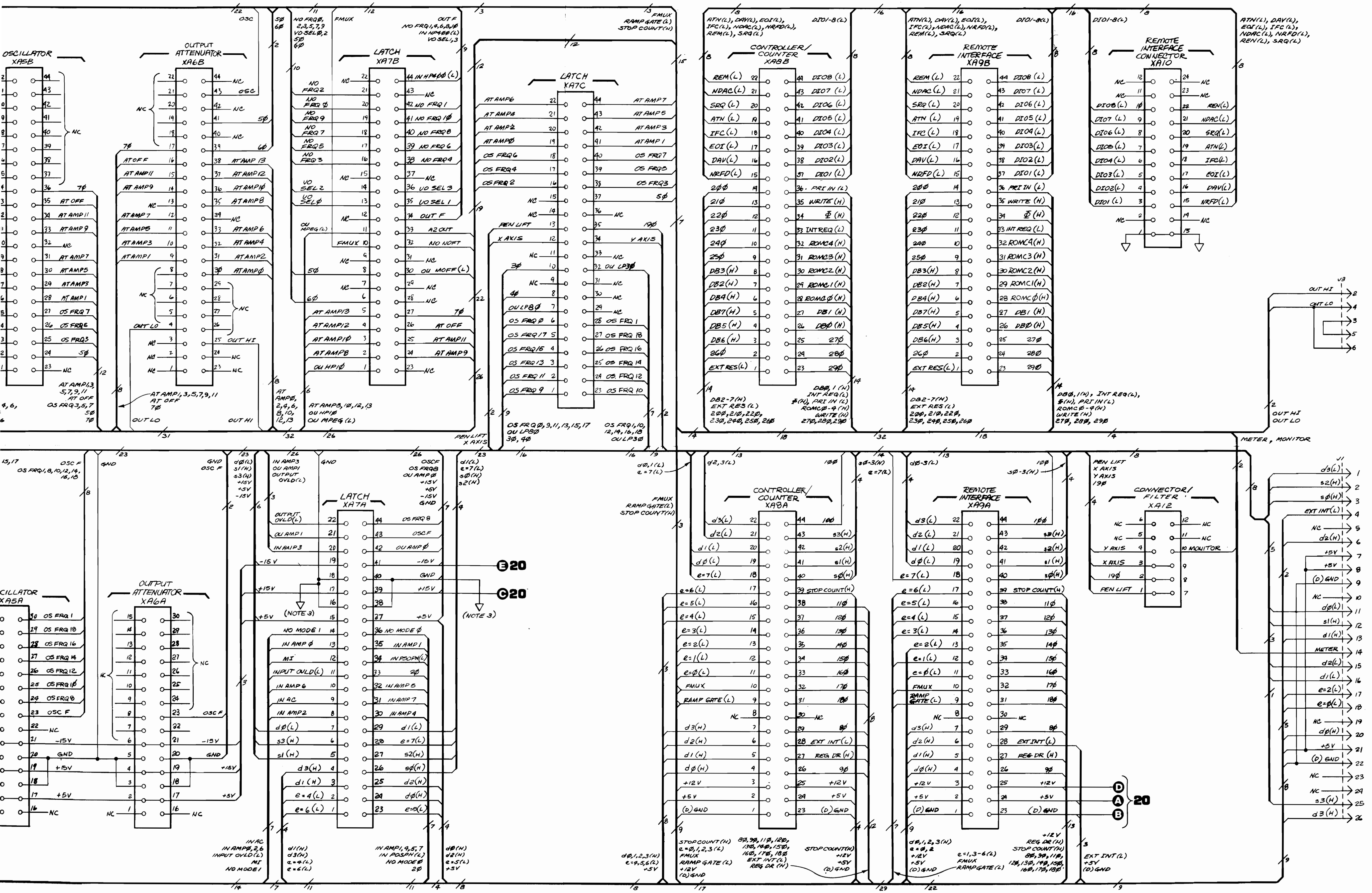


20

P/O A11, P/O A13, A14

Figure 8-120. Power Supply and Mother Board—Power Supply Schematic Diagram


INPUT AMPLIFIER XA2B
NOTCH FILTER XA3B
OUTPUT AMPLIFIER/ VOLTMETER XA4B
OSCILLATOR XA5B
OUTPUT ATTENUATOR XA6B
LATCH XA7B
LATCH XA7C
J4
L2
L3
C16
47 PF
INPUT AMPLIFIER XA2A
NOTCH FILTER XA3A
OUTPUT AMPLIFIER/ VOLTMETER XA4A
OSCILLATOR XA5A
OUTPUT ATTENUATOR XA6A
LATCH XA7A
E20
C20
(NOTE 3)
(NOTE 3)



NOTES

1. THIS WIRING DIAGRAM IS FOR P/O A13 POWER SUPPLY AND MOTHER BOARD ASSEMBLY (08903-60020).
2. PATHS NUMBERED FROM 20 THROUGH 290 IN INCREMENTS OF 10 ARE PRESENT IN THE MOTHER BOARD WIRING BUT ARE NOT USED IN THE AUDIO ANALYZER CIRCUITRY.
3. ANALOG AND DIGITAL GROUND ARE COMMONED TO CHASSIS GROUND BETWEEN XA2A AND XA7A.

Figure 8-121. Power Supply and Mother Board—Mother Board Schematic Diagram

SERVICE SHEET A

GENERAL REMOVAL PROCEDURES

Top Cover Removal

1. Remove the two top plastic standoffs on the rear-panel by removing the Pozidriv screws from each standoff.

2. Unscrew the Pozidriv screw at the middle of the rear edge of the top cover. This is a captive screw and will cause the top cover to push away from the frame.

3. Lift the top cover off the instrument.

Bottom Cover Removal

1. Turn the instrument upside down.

2. Remove the two top plastic standoffs on the rear-panel by removing the Pozidriv screws from each standoff.

3. Unscrew the Pozidriv screw at the middle of the rear edge of the bottom cover. This is a captive screw and will cause the bottom cover to push away from the frame.

4. Lift the bottom cover off the instrument.

Side-Panel Removal

1. Remove the two screws holding each side-panel strap handle in place (there is one screw at either end of each strap handle).

2. Remove the strap handle caps and the strap handles.

3. Slide the side-panel toward the rear of the instrument and then pull it off.

Information Card Removal

1. Turn the instrument upside down.

2. Remove bottom cover. (Refer to Bottom Cover Removal procedure above.)

3. Grasp the information cards firmly with thumb and index finger and withdraw the information cards from the information card tray.

FRONT-PANEL DISASSEMBLY PROCEDURE

Refer to Figure 8-125.

Front-Panel Assembly Removal

1. Remove the top and bottom covers and the side-panels of the instrument (refer to General Removal Procedures above).

2. Pry up the trim strip on the top of the instrument just above the front-panel with a small screwdriver.

3. Remove the three screws in the channel covered by the trim strip.

4. Remove the three screws from the bottom channel.

5. Pull the front-panel assembly outward.

6. Disconnect ribbon cable W11 (17) from connector A1J1 on the Keyboard and Display Assembly (16).

NOTE

Steps 7, 8 and 9 do not apply to instruments which include Option 001.

7. Remove two screws with lock washers which secure two cable clamps MP44 to the front gusset MP19 (not shown).

8. Disconnect the connector for cables W1 and W2 (13) from connector A13J3 on the mother board.

9. Disconnect the connector for cables W4 and W5 (24) from connector A13J4 on the mother board.

NOTE

Parts called out in steps 10, 11 and 12 are shown in Figure 8-126, Service Sheet B.

10. Remove two hex nuts with lock washers (21) and separate cover (22) from the transformer (18).

11. Detach two crimp-on wire connectors (part of W12 — not shown) to the line switch S1 at the Line Power Module (29) as follows:

Wire	Contact
Gray	B
White/Red/Gray	J

12. Unsolder two wires from the Line Power Module (29) (line filter output — not shown) as follows:

Wire	Terminal
White/Gray	H
White/Brn/Gray	L

13. Separate the front-panel assembly from the instrument by pulling the loose end of cable assembly W12 through the cut-out in the mother board and the two polyethylene cable straps which secure W12 to the mother board.

Separation of the A1 Keyboard and Display Assembly from the Front-Dress Panel and Sub-Panel

1. Perform steps 1 through 6 of the Front-Panel Assembly Removal procedure.

2. Remove eight screws with lock washers (18), and separate the Keyboard and Display Assembly (16) from the sub-panel (6).

Meter M1 Removal

1. Perform steps 1 through 6 of the Front-Panel Assembly Removal procedure.

2. Remove eight screws with lock washers (18), and separate the Keyboard and Display Assembly (16) from the sub-panel (6).

3. Remove two hex nuts on the terminals of the meter (21), and separate the white/red/orange wire and the white/brown/violet wire from the meter terminals.

4. Remove four nuts (19), and separate the meter (21) and four spacers (20) from the Keyboard and Display Assembly (16).

Separation of the Front-Dress Panel and Display Window from the Sub-Panel

1. Remove the front-panel assembly from the instrument (refer to Front-Panel Assembly Removal procedure).

2. Remove eight screws with lock washers (18), and separate the Keyboard and Display Assembly (16) from the sub-panel (6).

3. Remove three retainers (7) from the studs on the front-dress panel (3).

NOTE

Step 4 does not apply to instruments which include Option 001.

4. Remove four knurled nuts (2), (29), and separate the four connectors on cables W1, W2, W4 and W5 (15), (14), (22), (23) and 12 lock washers (12) from the sub-panel (6).

5. Separate the front-dress panel (3) from the sub-panel (6) by removing two hex nuts and lock washers (10), (9), and separating two binding post terminals (1), (30) from the sub-panel (6).

REPLACEMENT OF PUSHBUTTON SWITCHES AND ANNUNCIATOR LEDS

Key Cap Replacement

To replace a front-panel pushbutton key cap, pull it off and snap on a new one. You will have to either remove the Keyboard from the Front Panel Assembly (refer to Front-Panel Assembly Removal procedure) or carefully use a pair of pliers to remove the key cap.

Watch the angular position of the key cap as you snap it in place, since eight different positions for installation are possible.

Key Cap LED Replacement

Many of the front-panel pushbutton key caps have molded-in clear lenses which are illuminated by miniature LEDs located in the center portion of the switch at the circuit board. During production of the instrument, the LEDs are first soldered in place and then the switch is slid down around them and heat staked in place. If replacement of the LED becomes necessary (due to burnout), it can

be replac
cap LED,

1. Place
so that it
Assembly
cuit side
through t

2. Remo
Procedure

3. Clear

4. Insert
right. Pul

5. Clip c
keyboard

6. Put t
instrumer
LED wor

Switch R

The front-
becomes
lined belo

1. Lower
Assembly

2. Remo
your free

3. Remo
the circuit
Figure 8-1

4. To as
cuit board
should be
contact pa
not tilted

5. For re
the switch
heat stak
6881) can

The
latea
vapo
non-

·d.

›m connector A1J1 on the

ıments which include

rs which secure two cable
ıot shown).

W1 and W2 (13) from con-

W4 and W5 (24) from con-

2 are shown in Figure

ers (21) and separate cover

(part of W12 — not shown)
/lodule (29) as follows:

›wer Module (29) (line filter

:om the instrument by pull-
! through the cut-out in the
cable straps which secure

isplay Assembly from the

t-Panel Assembly Removal

hers (18), and separate the
om the sub-panel (6).

Meter M1 Removal

1. Perform steps 1 through 6 of the Front-Panel Assembly Removal procedure.

2. Remove eight screws with lock washers (18), and separate the Keyboard and Display Assembly (16) from the sub-panel (6).

3. Remove two hex nuts on the terminals of the meter (21), and separate the white/red/orange wire and the white/brown/violet wire from the meter terminals.

4. Remove four nuts (19), and separate the meter (21) and four spacers (20) from the Keyboard and Display Assembly (16).

Separation of the Front-Dress Panel and Display Window from the Sub-Panel

1. Remove the front-panel assembly from the instrument (refer to Front-Panel Assembly Removal procedure).

2. Remove eight screws with lock washers (18), and separate the Keyboard and Display Assembly (16) from the sub-panel (6).

3. Remove three retainers (7) from the studs on the front-dress panel (3).

NOTE

Step 4 does not apply to instruments which include Option 001.

4. Remove four knurled nuts (2), (29), and separate the four connectors on cables W1, W2, W4 and W5 (15), (14), (22), (23) and 12 lock washers (12) from the sub-panel (6).

5. Separate the front-dress panel (3) from the sub-panel (6) by removing two hex nuts and lock washers (10), (9), and separating two binding post terminals (1), (30) from the sub-panel (6).

REPLACEMENT OF PUSHBUTTON SWITCHES AND ANNUNCIATOR LEDS

Key Cap Replacement

To replace a front-panel pushbutton key cap, pull it off and snap on a new one. You will have to either remove the Keyboard from the Front Panel Assembly (refer to Front-Panel Assembly Removal procedure) or carefully use a pair of pliers to remove the key cap.

Watch the angular position of the key cap as you snap it in place, since eight different positions for installation are possible.

Key Cap LED Replacement

Many of the front-panel pushbutton key caps have molded-in clear lenses which are illuminated by miniature LEDs located in the center portion of the switch at the circuit board. During production of the instrument, the LEDs are first soldered in place and then the switch is slid down around them and heat staked in place. If replacement of the LED becomes necessary (due to burnout), it can be replaced without having to tear out the switch. To replace a key cap LED, use the following procedure:

1. Place the Audio Analyzer on a table top. Lower the front-panel so that it is facing downward (steps 1 through 6 of the Front-Panel Assembly Removal procedure). Unsolder the LED leads on the circuit side of the printed circuit board as you pull the LED down through the middle of the switch stem with a pair of small tweezers.

2. Remove the pushbutton key cap (refer to Key Cap Replacement Procedure).

3. Clear solder from the LED mounting holes.

4. Insert a new LED (one with long leads). Make sure the polarity is right. Pull the leads through the circuit board and solder.

5. Clip off the excess LED lead length on the circuit side of the keyboard.

6. Put the front-panel in place. Snap on the key cap. With the instrument power on, test the switch function to make sure that the LED works.

Switch Replacement

The front-panel switches have a very high cycle life. However, if one becomes faulty and needs replacement, follow the procedure outlined below:

1. Lower the front-panel (steps 1 through 6 of the Front-Panel Assembly Removal procedure).

2. Remove the pushbutton key cap. You will have to pull hard. Use your free hand to hold the board down as you pull.

3. Remove the switch by chipping away the melted plastic tabs at the circuit of the keyboard which hold the switch in place. Refer to Figure 8-122.

4. To assure long life and reliable electrical performance, the circuit board contact traces (which are found underneath the switch) should be clean and free of surface imperfections. Clean the switch contact pads before installing a new switch. Make sure the LEDs are not tilted and that there is no excess solder around the leads.

5. For reliable operation, any method of assembly must assure that the switch is mounted tightly against the pc board. To facilitate the heat staking operation, specially molded support anvils (HP 5040-6881) can be ordered. Refer to Figure 8-123.

NOTE

The following operation should be done in a well ventilated area. If the heat staking tip is too hot, the plastic will vaporize and emit fumes. These fumes, however, are non-toxic.

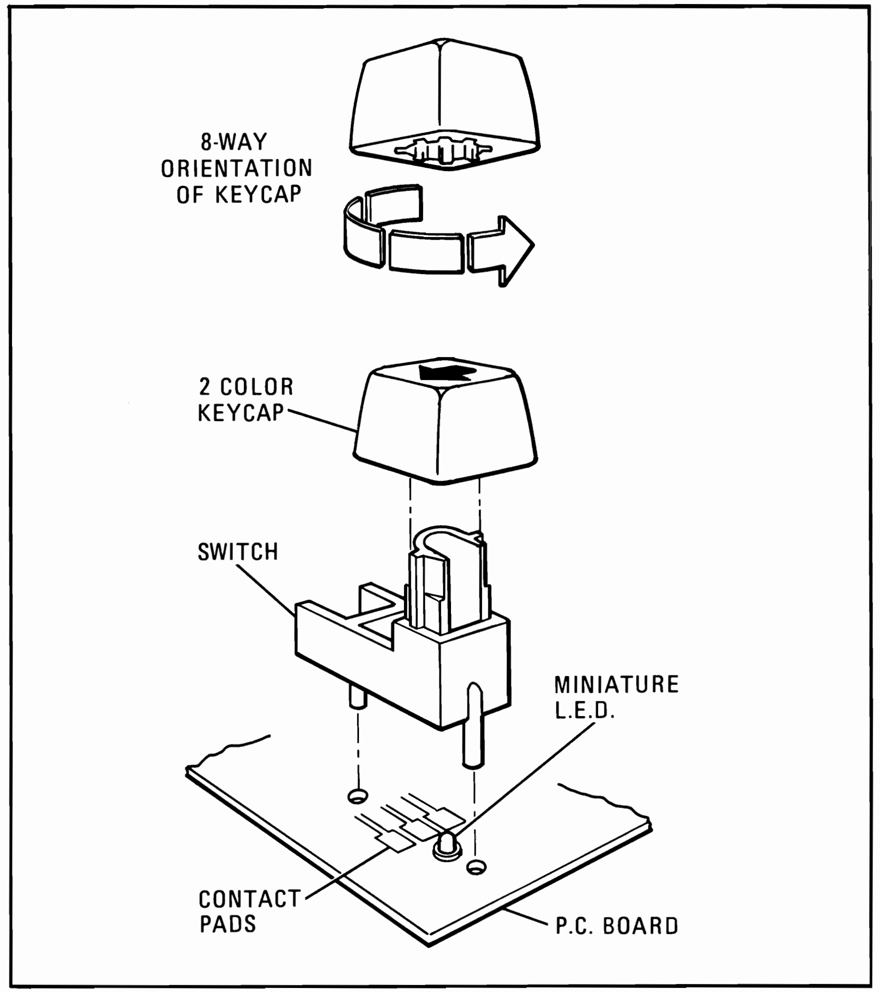


Figure 8-122. Front-Panel Pushbutton Switch Assembly

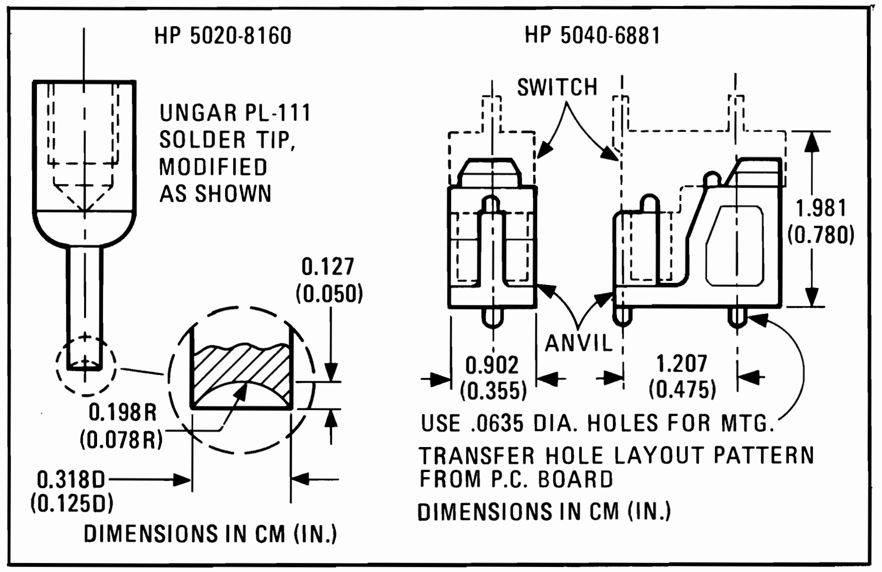


Figure 8-123. Heat Staking Tip and Assembly Anvil

SERVICE SHEET A (Cont'd)

CAUTIONS

Do not disturb the assembly for at least 10 seconds after heat staking.

If not enough heat is applied, the plastic will tend to stick to the tip of the iron.

If too much heat is applied, the plastic will fume profusely, the "rivet" will be irregularly shaped, and the plastic will be permanently discolored.

If the staking tool is worn or flaked, it will cause a misshaped rivet and/or a contamination deposit on the surface.

6. To assure proper switch assembly, verify that the switch is pushed firmly against the circuit board and, with the hot (440°C or 825°F) staking tip, push down on each of the posts (2) of the switch. Each post should take about one second to stake. With the proper cycle, the post should turn a darker color and, in about ten seconds, return to its original bright red color. The correctly staked post should have a smooth round "rivet" like top, as shown in Figure 8-124.

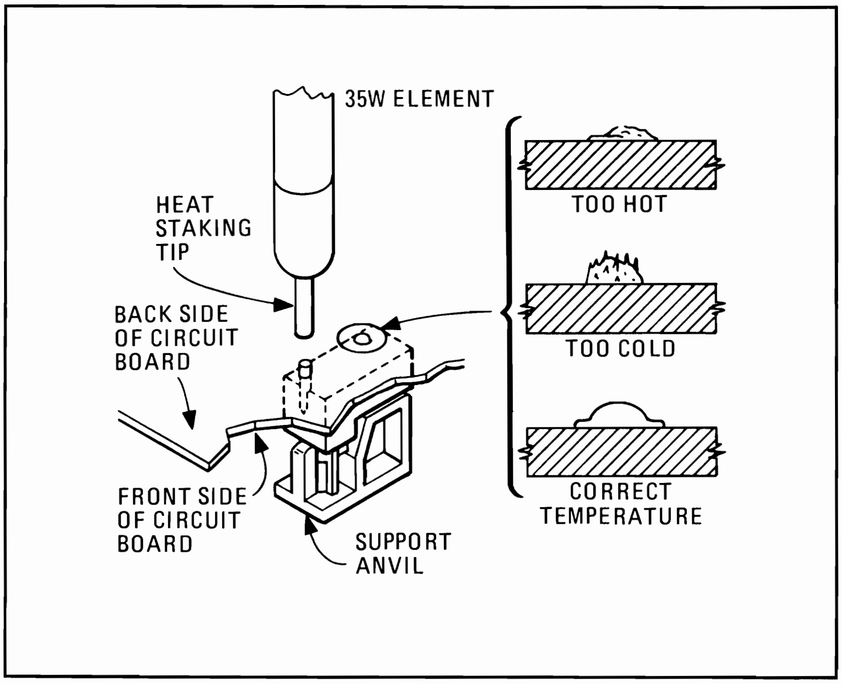


Figure 8-124. Typical Assembly for Heat Staking Operation

Item Number	Reference Designator	Description
1	J3	Binding Post
2	P/O W1, W2, W4 and W5	Knurled Nut
3	MP14	Front-Dress Panel
4	MP34	Window
5	See W12	Screw (4-40 × 4.6 mm)
6	MP15	Front Sub-Panel
7	MP33	Retainer, Push-on
8	W12	Line Switch Cable
9	See J3 and J6	Lock Washer
10	See J3 and J6	Hex Nut
11	S2	Output Float Switch
12	P/O W1, W2, W4 and W5	Lock Washer
13	P/O W1 and W2	Connector
14	W2	Output Low Cable (except Option 001)
15	W1	Output High Cable (except Option 001)
16	A1	Keyboard and Display Assembly
17	W11	Ribbon Cable
18	See MP15	Screw (4-40 × 9.5 mm)
19	See M1	Hex Nut with Lock Washer
20	See M1	Spacer
21	M1	Meter
22	W4	Input High Cable (except Option 001)
23	W5	Input Low Cable (except Option 001)
24	P/O W4 and W5	Connector
25	See S2 and S3	Screw
26	See S2 and S3	Lock Washer
27	S3	Input Float Switch
28	MP31	Float Switch Lever
29	P/O W1, W2, W4 and W5	Knurled Nut
30	J6	Binding Post

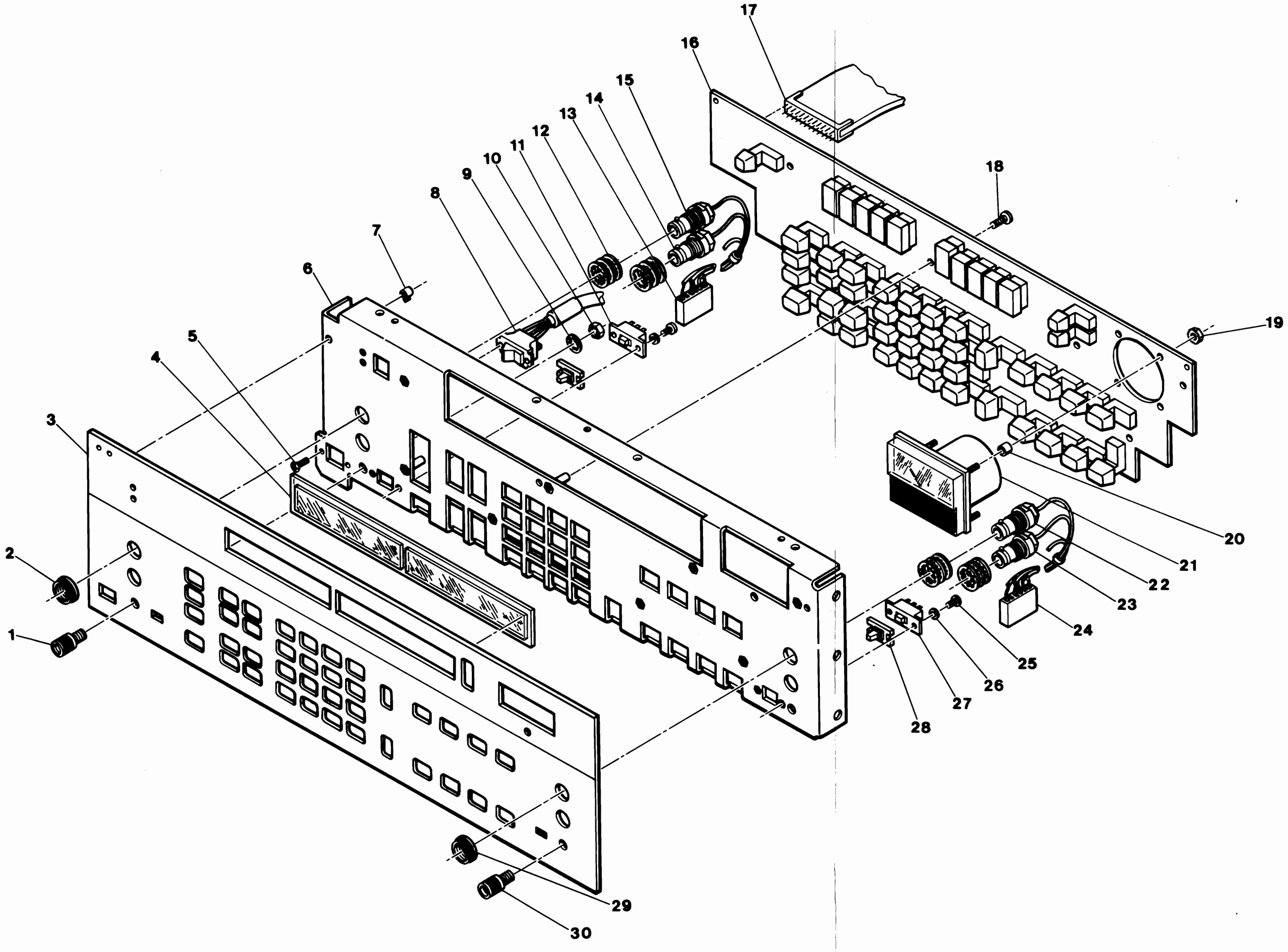


Figure 8-125. Front-Panel Illustrated Parts Breakdown

SERVICE SHEET B

REAR-PANEL DISASSEMBLY PROCEDURES

In order to remove the Power Transformer Assembly (T1) or the Connector/Filter Assembly (A12), the heatsink panel must be separated from the instrument. Refer to Figure 8-126.

Heatsink Panel Removal

1. Remove the top cover of the instrument (refer to General Removal Procedures, Service Sheet A).

2. Remove six screws and lock washers (36), (35), and separate heatsink cover (34) from the heatsink panel (8).

3. Remove six screws and lock washers (1), (2), and separate two voltage regulators (3), (5), transistor (4), and three transistor insulators (6) from the heatsink panel (8).

4. Remove two screws and lock washers (39), (38), and separate rear label plate (37), or (40) if Option 001 is included.

5. Remove four screws and lock washers (33), (32), and separate heatsink panel (8) from rear-panel (13).

6. Separate six insulators (7) from heatsink panel (8).

Power Transformer Assembly (T1) Removal

1. Remove the top cover and side-panels of the instrument (refer to General Removal Procedures, Service Sheet A).

2. Remove the instrument heatsink panel (refer to Heatsink Panel Removal Procedure).

3. Remove two hex nuts with lock washers (21), and separate cover (22) from the transformer (18).

4. Detach transformer output connector (17) from connector A13J2 (not shown) in the mother board.

5. Detach five crimp-on wire connectors (23) from the primary side of the transformer at the Line Power Module (29) as follows:

Wire	Contact
Orange	A
Black	C
Blk/Grn	D
Blk/Yel	E
Blk/Red	F

6. Unsolder yellow wire (24) from ground lug on the rear-panel (13).

7. Remove four screws (27), (28), four washers (19), and four lock nuts (20), and separate transformer (18) and four washers (26) from the rear-panel (13).

SERVICE SHEET B (Cont'd)

Remote Interface Connector Assembly (A10) Removal

1. Remove the top and bottom covers of the instrument (refer to General Removal Procedures, Service Sheet A).

2. Remove two metric hex head standoffs and lock washers (11), (12) from the rear panel (13).

3. Remove seven screws (6-32 × .312) and lock washers which secure the mother board to the chassis at the right-hand rear corner of the instrument: three from the rear edge of the mother board, and four from the right-hand edge of the mother board.

4. Carefully move the right-hand rear corner of the mother board no more than 0.187 inches away from instrument chassis, and remove the Remote Interface Connector Assembly (14) from its connector (A13XA10) in the mother board.

Series Regulator Socket Assembly (A11) Removal

1. Remove the top cover of the instrument (refer to General Removal Procedures, Service Sheet A).

2. Remove six screws and lock washers (36), (35), and separate heatsink cover (34) from the heatsink panel (8).

3. Remove six screws and lock washers (1), (2), and separate two voltage regulators (3), (5) and transistor (4) from the heatsink panel (8).

4. Detach Series Regulator Socket Assembly (16) from connector A13XA11 in the mother board.

Connector/Filter Assembly (A12) Removal

1. Remove the top and bottom covers and the side-panels of the instrument (refer to General Removal Procedures, Service Sheet A).

2. Remove the instrument heatsink panel (refer to Heatsink Panel Removal Procedure).

3. Remove two hex head standoffs and lock washers (11), (12) from the rear panel (13).

4. Remove two flat head screws from the rear end of each of the four corner struts (MP2, shown in Figure 6-1).

5. Remove four screws and lock washers which secure the mother board to the rear-panel (13).

NOTE

Step 6 applies only to instruments which include Option 001.

◀ **General Removal and Front-Panel Disassembly Procedures SERVICE SHEET A**

SERVICE SHEET B (Cont'd)

6. Remove four hex nuts and lock washers (9), (10) which secure connectors J7, J8, J9, and J10 (41), (42), (43), (44) to the rear-panel (13).

7. Remove four hex nuts and lock washers (9), (10) which secure the Connector/Filter Assembly (15) to the rear-panel (13).

8. Carefully move the rear-panel away from the mother board and the corner struts until the four connectors on the Connector/Filter Assembly (15) clear the rear panel.

9. Disengage the Connector/Filter Assembly (15) from connector A13XA12 in the mother board.

Line Power Module (A14) Removal

1. Remove the top and bottom covers and the left-hand side-panel of the instrument (refer to General Removal Procedures, Service Sheet A).

2. Remove two hex nuts with lock washers (21), and separate cover (22) from the transformer (18).

3. Remove four flat head screws and four screws and lock washers and separate lower left-hand corner strut (MP2, shown in Figure 6-1) from the instrument.

4. Remove three screws and lock washers, and separate the left frame support MP24 (not shown) from the mother board.

5. Detach five crimp-on wire connectors (23) from the primary side of the transformer at the Line Power Module (29) as follows:

Wire	Contact
Orange	A
Black	C
Blk/Grn	D
Blk/Yel	E
Blk/Red	F

6. Detach two crimp-on wire connectors (part of W12 — not shown) to the line switch S1 at the Line Power Module (29) as follows:

Wire	Contact
Gray	B
White/Red/Gray	J

7. Unsolder two wires from the Line Power Module (29) (line filter output — not shown) as follows:

Wire	Terminal
White/Gray	H
White/Brn/Gray	L

8. Unsolder green/yellow ground wire (25) from the Line Power Module (29).

9. Depress the tabs on the top and bottom of the Line Power Module (29), and push it out through the rear-panel (13).

Item Number	Reference Designator	Description
1	See Q1, U1, U2	Tapping Screw (6-20 × .75)
2	See Q1, U1, U2	Lock Washer
3	U1	Voltage Regulator 7815KC
4	Q1	Power Transistor 2N6057
5	U2	Voltage Regulator LM320K-15
6	See Q1, U1, U2	Insulator, Transistor
7	See Q1, U1, U2	Insulator, Mounting Screw
8	MP26	Heatsink Panel
9	See A12, J7, J8, J9 and J10	Hex Nut
10	See A12, J7, J8, J9 and J10	Lock Washer
11	See A10	Hex Standoff
12	See A10	Lock Washer
13	MP16	Rear Panel
14	A10	Remote Interface Connector
15	A12	Connector/Filter
16	A11	Series Regulator Socket
17	P/O T1	6-Pin Connector
18	T1	Power Transformer Assembly
19	See T1	Washer
20	See T1	Lock Nut
21	See MP35	Hex Nut with Lock Washer
22	MP35	Cover
23	P/O T1	Primary Input Connections (5)
24	P/O T1	Primary Ground Connection
25	P/O A14	Ground Connection
26	See T1	Washer
27	See T1	Machine Screw (8-32 × 63.5 mm)
28	See T1	Machine Screw (8-32 × 57.2 mm)
29	A14	Line Power Module
30	F1	1.25 Amp Fuse (120 Vac) 0.5 Amp Fuse (220 Vac)
31	A14TB1	Line Voltage Selection Card
32	See MP26	Lock Washer
33	See MP26	Machine Screw (4-40 × .438)
34	MP28	Heatsink Cover
35	See MP28	Lock Washer
36	See MP28	Machine Screw (6031 × .25)
37	MP27	Rear Label Plate (Except Option 001)
38	See MP27	Lock Washer
39	See MP27	Machine Screw (4-40 × .438)
40	MP27	Rear Label Plate (Option 001 Only)
41	J7	Connector (Output, High) (Option 001 Only)
42	J8	Connector (Output, Low) (Option 001 Only)
43	J9	Connector (Input, High) (Option 001 Only)
44	J10	Connector (Input, Low) (Option 001 Only)

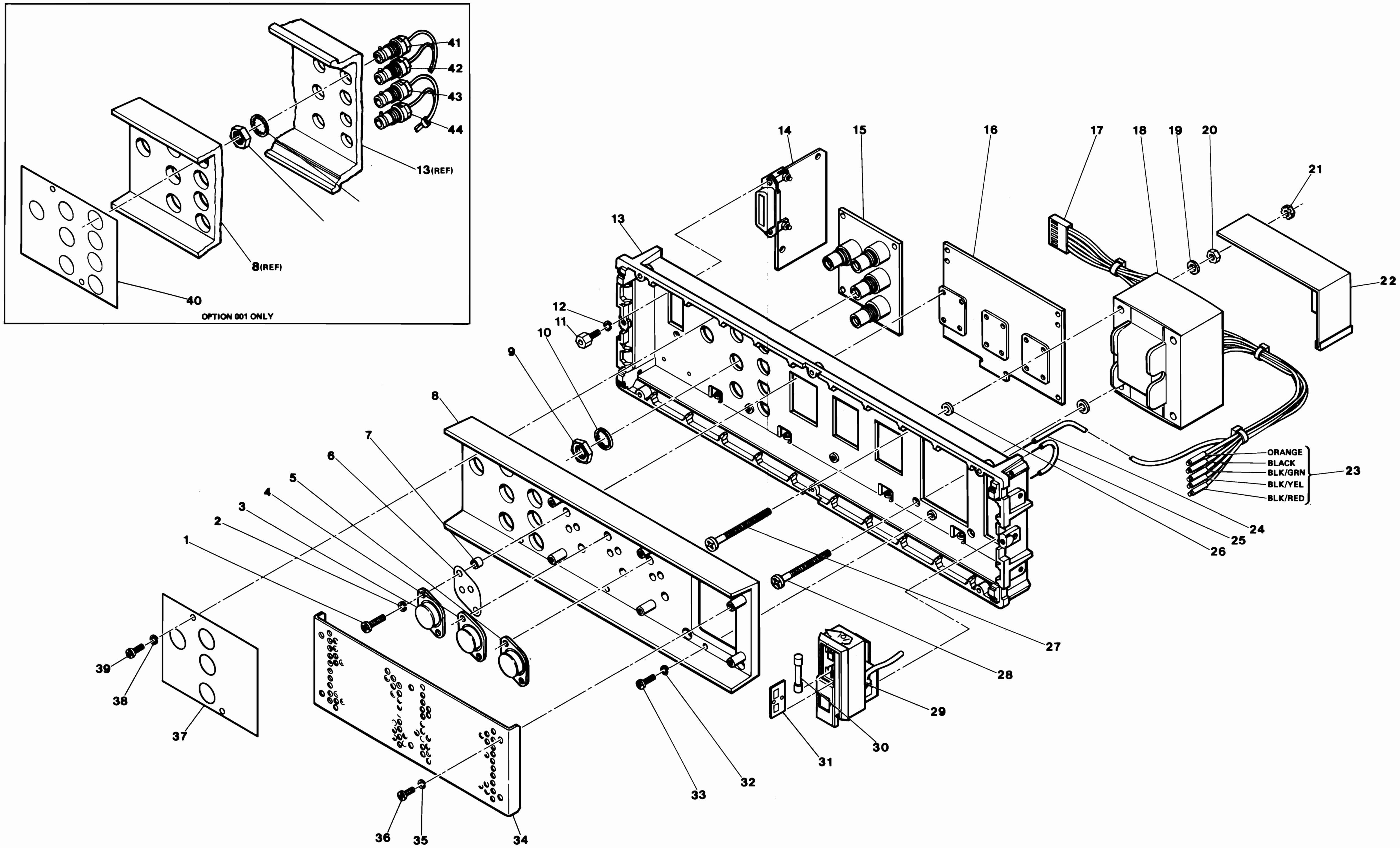


Figure 8-126. Rear-Panel Illustrated Parts Breakdown

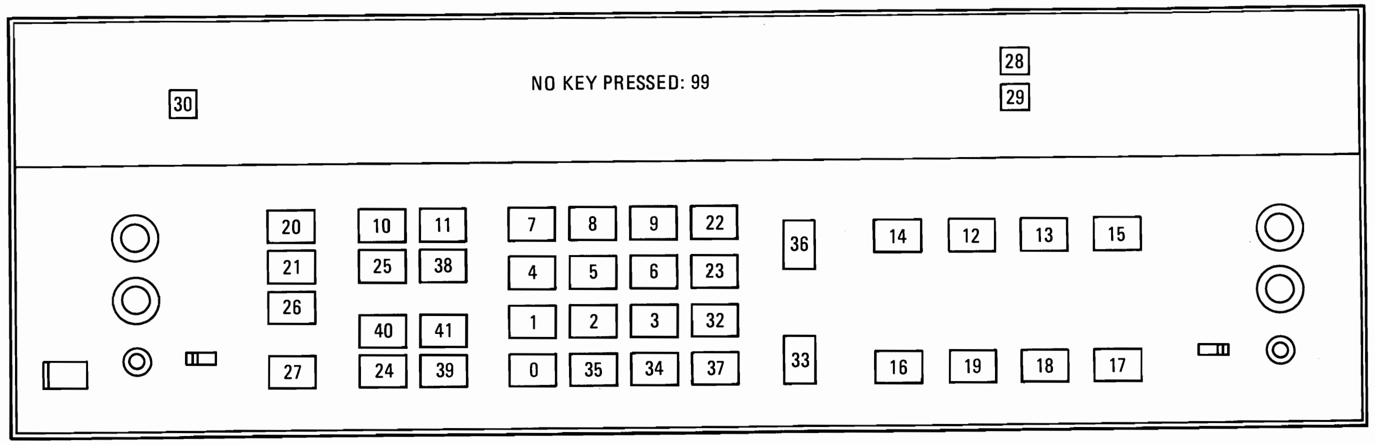


Figure 8-127. Key Scan Codes

SERVICE SHEET C
SERVICE SPECIAL FUNCTIONS

40.0 Controller Reset

41.0 Controller Clear

42.0 Display Software Date

43.N Service Error Display Control
N=0 Disable Display of Service Errors
N=1 Enable Display of Service Errors
N=65 to N=95: Enables display of only the Service Error specified by N

44.N Notch Filter Mode Select
N=0 Notch Filter mode selected automatically as required by the measurement mode
N=1 Notch Filter in notch mode
N=2 Notch Filter in flat mode
N=3 Notch Filter in bandpass mode

45.N SINAD Meter Enable
N=0 SINAD meter enabled normally
N=1 SINAD meter enabled in all measurement modes except DC level

46.N Count Internal Signals
N=0 Oscillator Frequency
N=1 Input Frequency
N=3 Output Amplifier Frequency

48.N Defeat Output Amplifier Overdrive Protection
N=0 Output Amplifier gain determined normally
N=1 Output Amplifier gain determined by the Output RMS (Avg) Detector

49.N Display Internal Voltages
N=0 Ground
N=1 Input RMS Detector with Ripple Filter
N=2 DC Input Voltage without Filter
N=3 Output RMS (Avg) Detector with Ripple Filter
N=4 Output RMS (Avg) Detector
N=5 Output RMS (Avg) Detector with SINAD Filter
N=6 Notch Tune Voltage
N=7 DC Input Voltage with Filter

50.N Display Oscillator Frequency
N=0 Display frequency as normal
N=1 Display Oscillator frequency

52.N Read Only Memory Verification (N=ROM Number)
<Actual Checksum> . <Expected Checksum>

53.N Notch Filter Frequency Range

54.N Notch Filter Coarse Tune

55.N Oscillator Frequency Range

56.N Oscillator Coarse Tune

57.N Oscillator Fine Tune

58.N Source Fine Level

59.N Source Coarse Level

60.N Key Scan (Jumper A9TP7 to A9TP1)
(See Figure 8-127 for key scan codes.)

SERVICE SHEET C (Cont'd)

61.N Display HP-IB Status
N=0 <Addressed to Talk> . <Add
N=1 <DAV> . <RFD> <DAC> (T
N=2 <ATN> . <REN> (True=1)
N=3 <SPM> . <SRQ> (True=1)
N=4 PIO Port A (True=1)

Display Digit	1	2	3
Mnemonic	IO8	IO7	IO6

N=5 PIO Port B (True=1)

Display Digit	1	2	3
Mnemonic	ATN	ARD	AAD

ERROR MESSAGE SUMMARY

The error messages are grouped by

a. Error 10 through Error 39 and
Operating and Entry errors.

b. Error 65 through Error 89: thes

Refer to the Error Message Summar
tion.

N

Not all of the available error

Operating Errors

Error 10 — Reading too large for dis
Error 11 — Calculated value out of
Error 13 — Notch cannot tune to out
Error 14 — Input level exceeds instr

N

Although error codes 17, 18
Errors, they should be con
indications.

Error 17 — Internal voltmeter cann
Error 18 — Source cannot tune as re
Error 19 — Cannot confirm source f

Error 25 — Top and bottom plotter l
Error 26 — RATIO not allowed in pr
Error 30 — Input overload detector
Error 31 — Cannot make measurem
Error 32 — More than 255 points tot
Error 96 — (HP-IB only) No signal s

ICE SHEET C
ICE SPECIAL FUNCTIONS

Controller Reset

Controller Clear

Display Software Date

Service Error Display Control
0 Disable Display of Service Errors
1 Enable Display of Service Errors
65 to N=95: Enables display of only the Service Error specified by N

Notch Filter Mode Select
0 Notch Filter mode selected automatically as required by the measurement mode
1 Notch Filter in notch mode
2 Notch Filter in flat mode
3 Notch Filter in bandpass mode

SINAD Meter Enable
0 SINAD meter enabled normally
1 SINAD meter enabled in all measurement modes except DC level

Count Internal Signals
0 Oscillator Frequency
1 Input Frequency
3 Output Amplifier Frequency

Defeat Output Amplifier Overdrive Protection
0 Output Amplifier gain determined normally
1 Output Amplifier gain determined by the Output RMS (Avg) Detector

Display Internal Voltages
0 Ground
1 Input RMS Detector with Ripple Filter
2 DC Input Voltage without Filter
3 Output RMS (Avg) Detector with Ripple Filter
4 Output RMS (Avg) Detector
5 Output RMS (Avg) Detector with SINAD Filter
6 Notch Tune Voltage
7 DC Input Voltage with Filter

Display Oscillator Frequency
0 Display frequency as normal
1 Display Oscillator frequency

Read Only Memory Verification (N=ROM Number)
<Actual Checksum> . <Expected Checksum>

Notch Filter Frequency Range

Notch Filter Coarse Tune

Oscillator Frequency Range

Oscillator Coarse Tune

Oscillator Fine Tune

Source Fine Level

Source Coarse Level

Key Scan (Jumper A9TP7 to A9TP1)
(See Figure 8-127 for key scan codes.)

SERVICE SHEET C (Cont'd)

61.N Display HP-IB Status
N=0 <Addressed to Talk> . <Addressed to Listen> (True=1)
N=1 <DAV> . <RFD> <DAC> (True=1)
N=2 <ATN> . <REN> (True=1)
N=3 <SPM> . <SRQ> (True=1)
N=4 PIO Port A (True=1)

Display Digit	1	2	3	4	5	6	7	8
Mnemonic	IO8	IO7	IO6	IO5	IO4	IO3	IO2	IO1

N=5 PIO Port B (True=1)

Display Digit	1	2	3	4	5	6	7	8
Mnemonic	ATN	ARD	AAD	SRQ	RNL	ATT	ATL	SDV

ERROR MESSAGE SUMMARY

The error messages are grouped by error code as follows:

a. Error 10 through Error 39 and Error 90 through Error 99: these are Operating and Entry errors.

b. Error 65 through Error 89: these are Service errors.

Refer to the Error Message Summary in Section III for additional information.

NOTE

Not all of the available error message numbers are used.

Operating Errors

Error 10 — Reading too large for display.
Error 11 — Calculated value out of range.
Error 13 — Notch cannot tune to output.
Error 14 — Input level exceeds instrument specifications.

NOTE

Although error codes 17, 18 and 19 are listed as Operating Errors, they should be considered rather as diagnostic indications.

Error 17 — Internal voltmeter cannot make measurement.
Error 18 — Source cannot tune as requested.
Error 19 — Cannot confirm source frequency.

Error 25 — Top and bottom plotter limits are identical.
Error 26 — RATIO not allowed in present mode.
Error 30 — Input overload detector tripped in range hold.
Error 31 — Cannot make measurement.
Error 32 — More than 255 points total in a sweep.
Error 96 — (HP-IB only) No signal sensed at input.

SERVICE SHEET C (Cont'd)

Entry Errors

Error 20 — Entered value out of range.
Error 21 — Invalid key sequence.
Error 22 — Invalid Special Function prefix.
Error 23 — Invalid Special Function suffix.
Error 24 — Invalid HP-IB code.

Service Errors

Error 65 — Decimal point fixed too far to the left.
Error 70 — Cannot count oscillator frequency.
Error 71 — Oscillator tune abort.
Error 72 — AC input overload with input range hold.
Error 73 — Input ac level abort.
Error 74 — Output amplifier overload with output amplifier at 0 dB gain.
Error 75 — DC input overload with input range hold.
Error 76 — Too much ac for dc level measurement.
Error 77 — Output amplifier gain too high after leveling once.
Error 78 — Output amplifier overload after leveling once.
Error 79 — Output amplifier overload with no post-notch gain hold.
Error 80 — Cannot count oscillator frequency in SINAD.
Error 81 — Cannot count input frequency.
Error 82 — Notch filter does not null.
Error 83 — Cannot count input frequency (count=0).
Error 84 — Output amplifier overvoltage with no overload.
Error 85 — Period of the voltage-to-time converter 0.
Error 86 — Frequency count greater than 200 kHz.
Error 87 — Output amplifier overload with post-notch gain hold.
Error 88 — Attempt to take log of negative ratio.
Error 89 — Attempt to take log of negative number.
Error 90 — Decimal point fixed and exponent too large.
Error 91 — Decimal point fixed too far to the left (same as Error 65).
Error 92 — Decimal point fixed and unable to display.
Error 93 — Number to be displayed greater than 9999.
Error 94 — Attempt to divide by zero in ratio.
Error 95 — Signal-to-noise ratio too large to calculate.

Service Special Functions
and Error Message Summary
SERVICE SHEET
C

SALES OFFICES

Arranged alphabetically by country

ANGOLA
Telectra
Empresa Técnica de
Equipamentos
Eléctricos, S.A.R.L.
R. Barbosa Rodrigues,
41-I°DT.°
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Should one of your HP instruments need repair, the HP service organization is ready to serve you. However, you can help us serve you more effectively. When sending an instrument to HP for repair, please fill out this card and attach it to the product. Increased repair efficiency and reduced turn-around time should result.

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MODEL NO. SERIAL NO.

MODEL NO. SERIAL NO.

P.O. NO. DATE

Accessories returned with unit

☐ NONE ☐ CABLE(S)

☐ POWER CABLE ☐ ADAPTER(S)

OTHER

over

Service needed

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☐ REPAIR ☐ REPAIR & CAL

OTHER ____________________

Observed symtoms/problems

FAILURE MODE IS:

☐ CONSTANT ☐ INTERMITTENT

SENSITIVE TO:

☐ COLD ☐ HEAT ☐ VIBRATION

FAILURE SYMPTOMS/SPECIAL CONTROL SETTINGS ____________________

If unit is part of system list model number(s) of other interconnected instruments. ____________________

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Observed symtoms/problems

FAILURE MODE IS:

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SENSITIVE TO:

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