TRUE RMS VOLTMETER
2610

Code No. 52610-900X

AMENDMENT RECORD

The following amendments are incorporated in this manual

Amendment No.	*Date*	*Issued at Ser. No.*
-	Jan. 84	202901/001
Am.1	Apr. 84	202901/001
Am.2	Oct. 84	202910/001
Am.3	Feb. 86	202910/001
Am. 4	Apr. 87	202926/001

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CONTENTS

HAZARD WARNING SYMBOLS

The following symbols appear on the equipment :

Symbol	*Type of hazard*	*Reference in manual*
⚠	Input voltage limit	See operating manual
⚠	Static sensitive device	Prelim page (iv) and Chaps. 5, 6 and 7
⚠	AC supply setting	See operating manual.

Note...

Each page bears the date of the original issue or the code number and date of the latest amendment (Am. 1, Am. 2 etc.). New or amended material of technical importance introduced by the latest amendment is indicated by triangles positioned thus ▶.....◀ to show the extent of the change. When a chapter is reissued the triangles do not appear.

Any changes subsequent to the latest amendment state of the manual are included on inserted sheets coded C1, C2 etc.

NOTES AND CAUTIONS

ELECTRICAL SAFETY PRECAUTIONS

This equipment is protected in accordance with IEC Safety Class I. It has been designed and tested according to IEC Publication 348, 'Safety Requirements for Electronic Measuring Apparatus', and has been supplied in a safe condition. The following precautions must be observed by the user to ensure safe operation and to retain the equipment in a safe condition.

Defects and abnormal stresses

Whenever it is likely that protection has been impaired, for example as a result of damage caused by severe conditions of transport or storage, the equipment shall be made inoperative and be secured against any unintended operation.

Removal of covers

Removal of the covers is likely to expose live parts although reasonable precautions have been taken in the design of the equipment to shield such parts. The equipment shall be disconnected from the supply before carrying out any adjustment, replacement or maintenance and repair during which the equipment shall be opened. If any adjustment, maintenance or repair under voltage is inevitable it shall only be carried out by a skilled person who is aware of the hazard involved.

Note that capacitors inside the equipment may still be charged when the equipment has been disconnected from the supply. Before carrying out any work inside the equipment, capacitors connected to high voltage points should be discharged; to discharge mains filter capacitors, if fitted, short together the L (live) and N (neutral) pins of the mains plug.

Mains plug

The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. The protective action shall not be negated by the use of an extension lead without protective conductor. Any interruption of the protective conductor inside or outside the equipment is likely to make the equipment dangerous.

Fuses

Note that there is a supply fuse in both the live and neutral wires of the supply lead. If only one of these fuses should rupture, certain parts of the equipment could remain at supply potential.

To provide protection against breakdown of the supply lead, its connectors, and filter where fitted, an external supply fuse (e.g. fitted in the connecting plug) should be used in the live lead. The fuse should have a continuous rating not exceeding 6 A.

Make sure that only fuses with the required rated current and of the specified type are used for replacement. The use of mended fuses and the short-circuiting of fuse holders shall be avoided.

Earth connection

Earth connection to the equipment during a.c. mains operation is made via the mains lead and plug. When 2610 is powered from the optional battery supply unit a direct external earth connection must be made.

CAUTION : STATIC SENSITIVE COMPONENTS

Components identified with the symbol  on the circuit diagrams and/or parts lists are static sensitive devices. The presence of such devices is also indicated in the equipment by orange discs, flags or labels bearing the same symbol. Certain handling precautions must be observed to prevent these components being permanently damaged by static charges or fast surges.

(1) If a printed board containing static sensitive components (as indicated by a warning disc or flag) is removed, it must be temporarily stored in a conductive plastic bag.

(2) If a static sensitive component is to be removed or replaced the following anti-static equipment must be used.

A work bench with an earthed conductive surface.

Metallic tools earthed either permanently or by repeated discharges.

A low-voltage earthed soldering iron.

An earthed wrist strap and a conductive earthed seat cover for the operator, whose outer clothing must not be of man-made fibre.

(3) As a general precaution, avoid touching the leads of a static sensitive component. When handling a new one, leave it in its conducting mount until it is required for use.

(4) If using a freezer aerosol in fault finding, take care not to spray programmable ICs as this may affect their contents.

CAUTION : BATTERY SUPPLY TEMPERATURE

When fitted with the battery supply option, 2610 has an upper ambient temperature limit of +50°C and an upper temperature limit for the rated range of use of +45°C. To avoid damage to the instrument, do not permit it to be exposed to a temperature higher than +50°C or to be operated in a temperature higher than +45°C. Also to prolong battery life, avoid charging the unit in an ambient temperature exceeding +30°C.

CAUTION : LCD HANDLING

When operating or servicing this equipment take care not to depress the front or rear faces of the display module as this may damage the liquid crystal display elements.

WARNING : HANDLING HAZARDS

This equipment is formed from metal pressings and although every endeavour has been made to remove sharp points and edges care should be taken, particularly when servicing the equipment, to avoid minor cuts.

WARNING : TOXIC HAZARD

Many of the electronic components used in this equipment employ resins and other chemicals which give off toxic fumes on incineration. Appropriate precautions should therefore be taken in the disposal of these items.

Chapter 4-2

TECHNICAL DESCRIPTION

CONTENTS

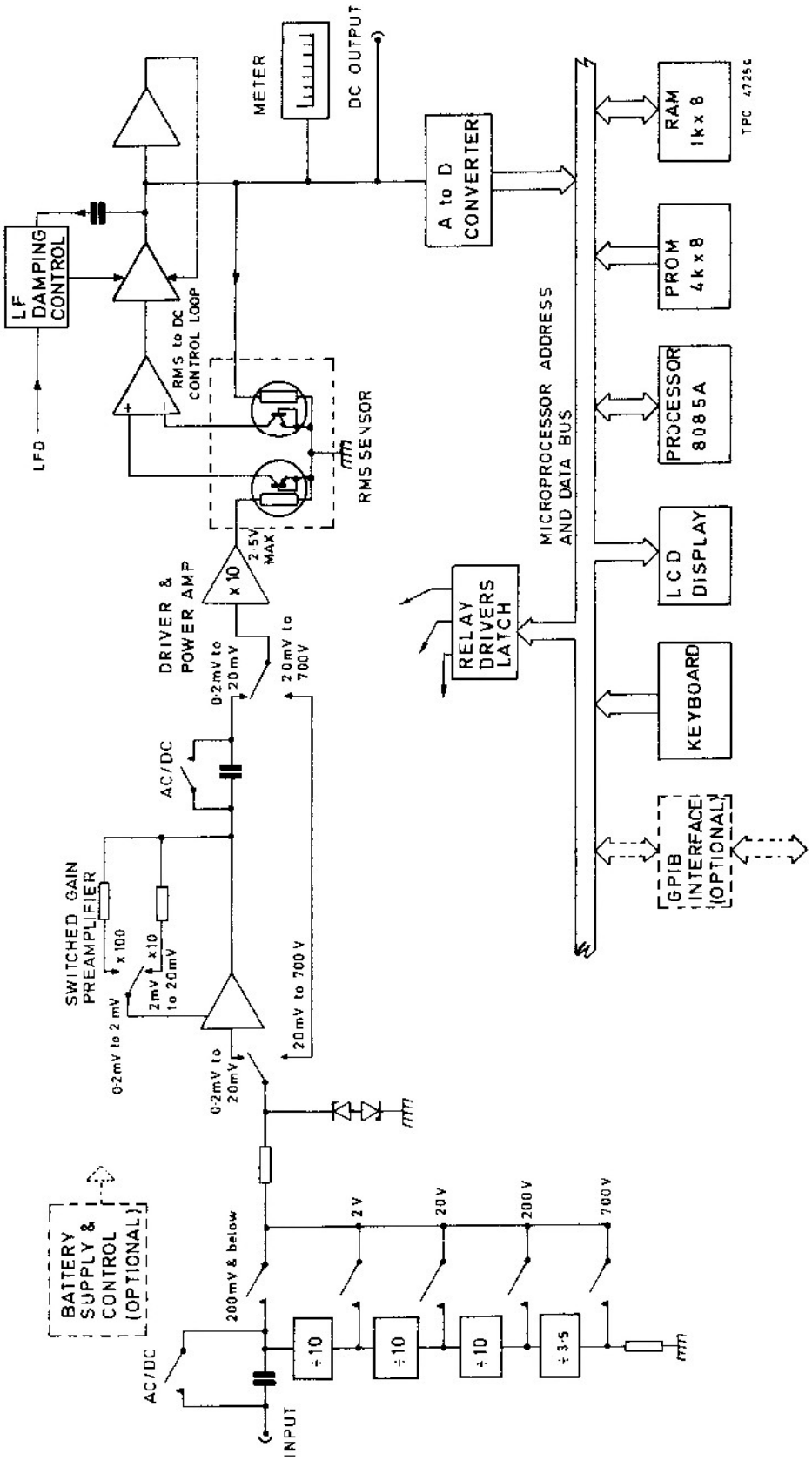


Fig. 1 2610 : simplified block diagram

INTRODUCTION

1. This chapter outlines the overall and circuit functions of 2610 and is intended to be read with reference to the circuit diagrams and illustrations contained within this service manual.

OVERALL CIRCUIT SUMMARY

Block diagram : Fig. 1

2. The voltage to be measured is coupled via switches and attenuators to amplifiers which provide an input signal to an r.m.s. voltage sensing device. DC output from the sensor is fed to a front panel meter, to terminals at the rear panel and to an analogue to digital converter.

3. The converted digital output signal is fed on to the microprocessor data bus. Processor control enables selection of relay switches to perform the required measurement function and output the processed result to a front panel l.c.d. display.

4. For local operation, front panel keys provide instructions to the processor while remote operation is enabled by the optional GPIB interface unit receiving instructions and sending data via the GPIB bus.

5. 2610 is powered normally from an a.c. mains supply but, by adding the optional supply unit can be powered from internal batteries or an external d.c. supply.

6. The input and amplifier circuits, RMS converter, A-D converter, microprocessor system and power supply circuits are all contained on the motherboard AB01. Chap. 7, Fig. 1 shows the connections from the motherboard to the display board AC01 and the keyboard AC02 and also the battery and GPIB option connectors.

INPUT AND AMPLIFIER CIRCUITS

Circuit diagram : Chap. 7, Fig. 3

Input attenuator

7. The input attenuator utilizes high stability resistors and capacitors for each range, relay switch controlled by the processor unit acting on instructions from the keyboard or via the optional GPIB. Variable capacitors C3, C6, C9 and C12 allow frequency correction for each range. Capacitors C117, C118 and C119 provide capacitive loading for the intermediate ranges to balance/match the pre-amplifier input capacity.

8. Transistors TR40 and TR41 are connected as diodes to form a low capacity overload protection circuit. This gives protection against excessive input voltages and also protects the pre-amplifier during auto ranging.

Pre-amplifier

9. Input voltages in the range 0.2 mV to 20 mV are routed through the pre-amplifier by relay switches RLK and RLN. For input voltages from 20 mV to 700 V these same switches bypass the pre-amplifier and couple the attenuator output to the driver amplifier.

10. Fig. 2 shows the key components of the pre-amplifier and their interconnections in block diagram form. Transistor circuits are represented by blocks without the prefix TR, i.e. [5] = TR5. This representation also applies in Figs. 3 to 6.

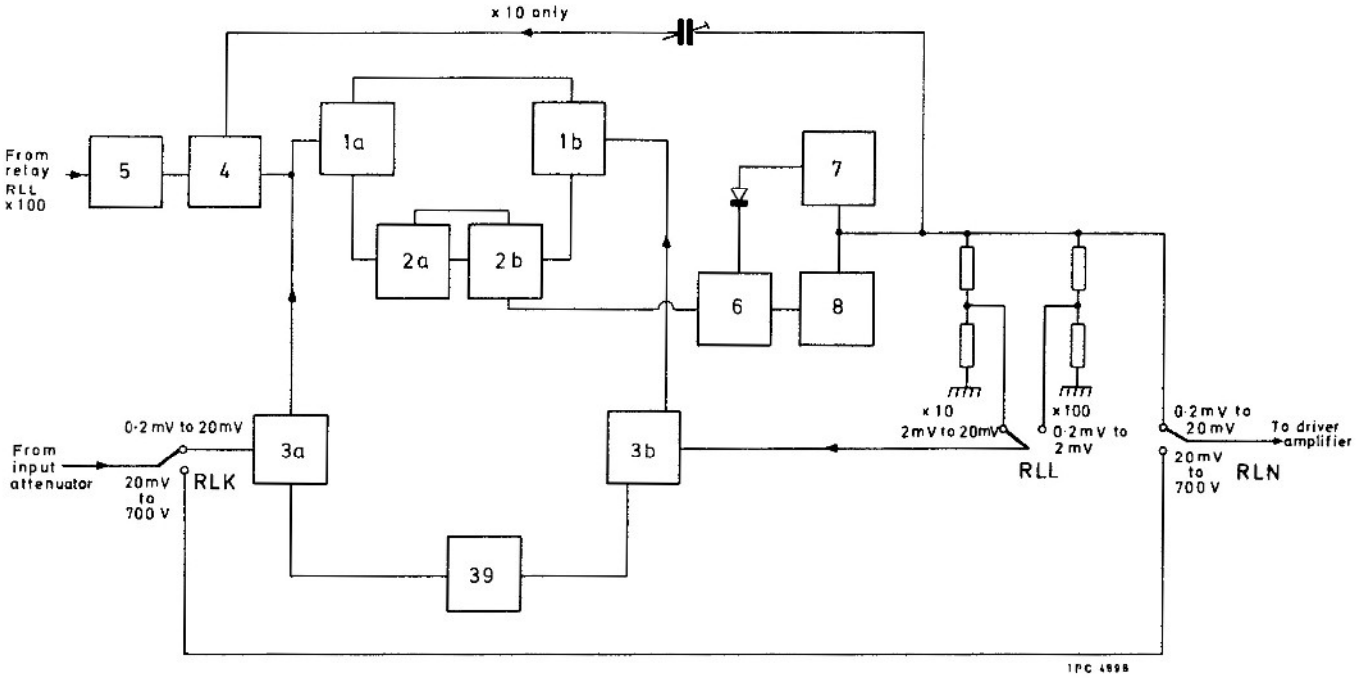


Fig. 2 Pre-amplifier block diagram

11. Dual transistors TR1, 2 and 3 operate as a differential voltage amplifier and form the first stage of the pre-amplifier. TR39 provides a constant current source for TR3 which ensures correct temperature compensation and circuit stability.

12. Output is taken from TR2b collector to a direct coupled push pull power amplifier TR6, 7 and 8. Junction diodes D5 and D6 provide the bias to TR7 and TR8 and because of their temperature characteristics also provide compensation for the temperature variation of TR7 and TR8 emitter base resistances.

13. Pre-amplifier gain of x10 or x100 is determined by selection of resistors which control the feedback to TR3b. These range resistors are switch selected by relay RLL.

14. In the x10 position R31/R32 sets the gain for the 2 mV to 20 mV input range. Frequency compensation is provided by C15 and variable capacitor C21 operating through TR4 which is biased on by TR5. TR5 is controlled by the voltage across relay RLL coil. In the x10 position relay RLL is not energized thus TR5 base is connected through R27 to 0 V which biases TR5 on and in turn TR4 on.

15. In the x100 position feedback from R33/R34 sets the gain for the 0.2 mV to 2 mV input range with frequency compensation provided by variable capacitor C22. The frequency compensation feedback path via TR4 is not operative in the x100 position as TR5 and TR4 are cut off by the voltage across the energized coil of relay RLL.

Driver amplifier

16. Fig. 3 shows the key components of the driver amplifier and their interconnections in block diagram form.

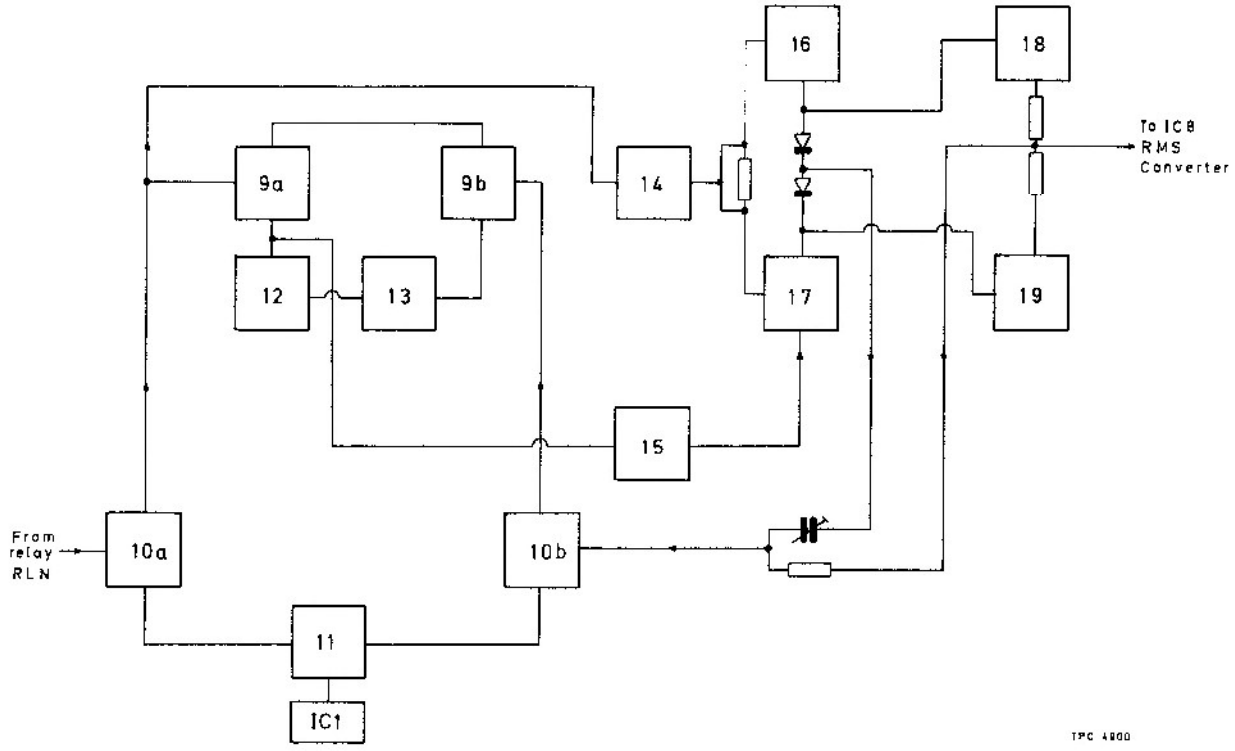


Fig. 3 Driver amplifier block diagram

17. TR9 and TR10 are dual transistors operating as two differential amplifiers Input is from relay RLN contacts to TR10a and power amplifier feedback input to TR10b. TR13 is connected as a diode and maintains the d.c. bias to TR12. Output from TR9/TR12 collectors via emitter follower TR15 to TR17 emitter provides the main current path. The second output is taken from TR10a drain to emitter follower TR14, through a frequency compensating network including variable capacitor C113, to TR16 and TR17. This input complements the input to TR17 emitter and speeds up the action of the amplifier enabling an efficient response to frequencies up to 25 MHz.

18. IC1 and TR11 form a constant current source for TR10a and b. Zener diode D7 provides the reference voltage for differential amplifier IC1 whose output is coupled to TR11 base. Feedback from TR11 emitter load is connected to IC1 negative input. Thus if the current starts to increase through TR11 the reduced voltage feedback to IC1 reduces the forward bias to TR11 and the current returns to the normal steady value. This constant current source for the driver amplifier first stage, provides temperature compensation and maintains circuit stability.

19. Current drive from TR15 is fed to TR17 emitter. TR16 and TR17 form a push pull amplifier with collectors coupled via diodes D9 and D10. These junction diodes provide the bias to push pull power amplifier TR18 and TR19 and also temperature compensation for the temperature variation of the emitter/base resistances of TR18 and TR19. Power amplifier output to the RMS sensor IC8 is taken from the junction of load resistors R63 and R64.

20. Separate feedback paths from the power amplifier for phase and voltage are both taken to the first stage of the driver amplifier TR10b gate. Voltage feedback is taken from the power amplifier output via potential divider R68/R69. Phase feedback from junction of D9/D10 (power amplifier input) is coupled back to TR10b gate via variable capacitor C39.

RMS TO DC CONVERSION

Circuit diagram : Chap. 7, Fig. 3

21. The r.m.s. voltage output from amplifier TR18 and TR19 is converted to d.c. voltage by the r.m.s. to d.c. converter and control loop. This comprises the r.m.s. converter IC8, comparator IC6d and square law amplifier and integrator IC6a,b,c, IC7 and TR28.

RMS converter

22. RMS sensor and converter IC8 is a thin film chip device containing two npn transistors each with a resistive temperature control component. The emitters are connected externally via a variable resistor R118 to form a long tailed pair. Collector output is directly proportional to the temperature generated by the voltage across the resistive control component.

RMS converter and control loop

23. Under no signal input conditions the driver amplifier output is at a steady value with the comparator and integrator control loop also in a steady state. This develops sufficient power in the regulating resistor at pin 5 of IC8 to match that in the input resistor at pin 10. The collector outputs, being directly proportional to the heating effect of the two inputs, are equal and the sensor is balanced. Variable resistor R118 assists in the setting up of this initial balance.

24. When the voltage to be measured is applied to 2610, output from the driver amplifier is fed to the r.m.s. sensor pin 10 and collector output at pin 2 rises. This gives increased output from comparator IC6d and c to the square law amplifier IC6b, a and IC7. TR28 buffers the loop output current while D23 reduces the output voltage to the converter.

25. Square law amplification maintains the correct response for the extra power required to pin 5 to match that at pin 10 and so return the r.m.s. sensor to a balanced state. Negative feedback from IC6a to IC6c via R106 and C72 provides stability for the amplifier and integrator circuit.

DC outputs

26. The d.c. output voltage present on pin 5 of the r.m.s. sensor is fed to the analogue to digital converter, rear panel terminals and the front panel meter.

27. A-D converter. Output to this device (IC16) is taken from pin 5 and pin 4 of the r.m.s. converter to provide the required IN HI and IN LO input lines.

28. Rear panel terminals. The r.m.s. sensor is a power operating device and although it is in a balanced state, the input and output voltages are not equal. Thus the voltage at the rear panel terminals is only an approximate representation of the instrument input voltage.

29. Front panel meter. Meter calibration is enabled by series variable resistor R112. Protection for the meter under transient overload conditions is provided by TR42 which is connected across R112 and the meter. It protects the meter in the following way.

30. Divider R149/R148 across the control loop output line to earth provides the bias to TR42 which under normal conditions is cut off. When a transient overload occurs, e.g. at switch on, the voltage across the divider rises sharply and TR42 is biased on. Current is drawn through R111 away from the meter circuit and the meter pointer is held below full scale. The meter resumes normal operation after the transient has expired.

RMS converter protection circuit

31. The r.m.s. converter sensor operates quickly and efficiently over a reasonable working temperature range. An excessive input voltage would produce a large rise in temperature outside of this normal working range. Even after removal of the overload the time taken for the device temperature to return to normal would be unacceptable. The protection circuit comes into operation during an overload condition to prevent this by cutting off the driver amplifier output to the sensor.

32. Fig. 4 shows in block diagram form the protection circuit with converter and driver amplifier output stage.

33. If the driver amplifier output voltage to IC8 rises above 3 V r.m.s. then the consequent rise in control loop output operates the Schmitt trigger TR43 and TR44. The rise in TR44 collector volts biases off TR45 which turns off FET TR46. With TR46 turned off, TR47 and TR48 are biased on by the rise in base voltage from the +5 V and -5 V supply lines through R157 and R158.

34. TR47 and TR48 collectors are coupled to the base inputs of the power amplifier TR18 and TR19 through D1 and D2. With TR47 and TR48 conducting, the inputs to TR18 and TR19 are effectively held down at earth potential until such time as the sensor overload is removed. Diodes D1 and D2 maintain the driver amplifier bias and temperature compensation.

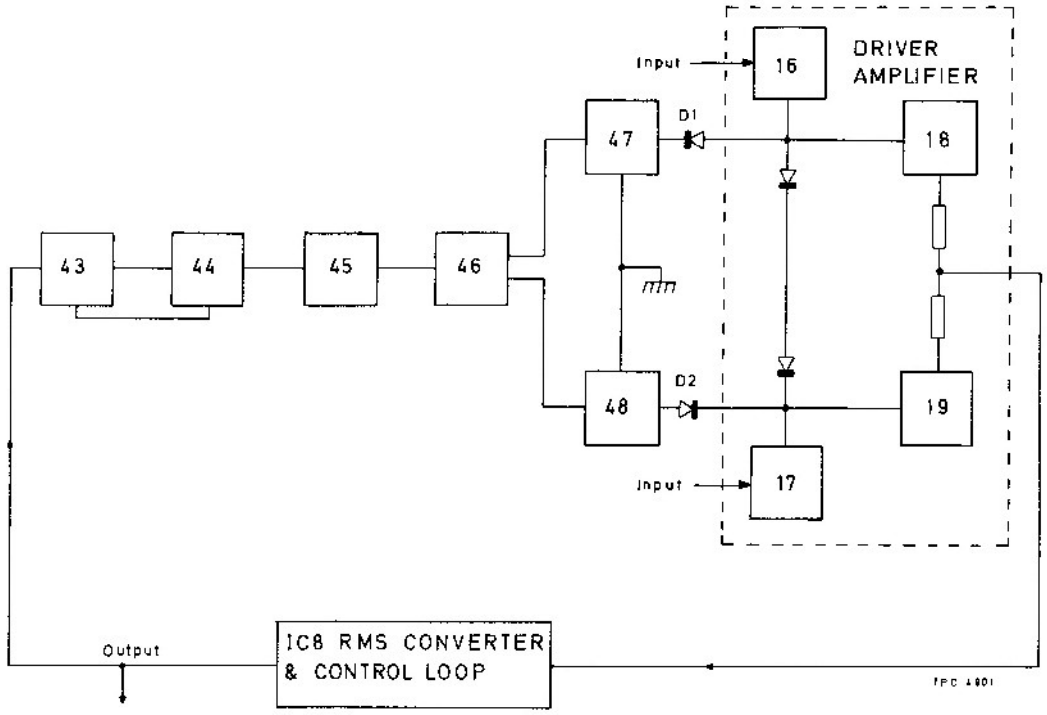


Fig. 4 RMS converter protection circuit : block diagram

LOW FREQUENCY DAMPING (LFD)

Circuit diagram : Chap. 7, Fig. 3

35. Low frequency damping may be selected to overcome the display and dB reading instability commonly experienced when measuring low frequency signals. The LF annunciator at the front panel indicates that LFD function has been selected.

36. LFD operation provides negative feedback of the low frequency component in the r.m.s. converter control loop. This slows the response time of the loop and smooths out the ripple. To maintain fast ranging LFD is disabled during range changing.

LFD selected (see Fig. 5)

37. When LFD is selected, keyboard input data is decoded by the processor IC9 and SOD output is set high. This cuts off TR26 which then turns off TR29 and IC7e. With IC7e cut off, TR27 is biased on and provides the path for negative feedback from D23 via feedback capacitor C71 to IC6c inverting input.

LFD not selected (see Fig. 6)

38. During normal operation with LFD not selected, SOD output from the processor is set low with TR26 turned on. The voltage drop across R104 turns on TR29 and IC7e. Conduction of IC7e biases off TR27 which opens the feedback loop to IC6c leaving C71 coupled to earth via TR29.

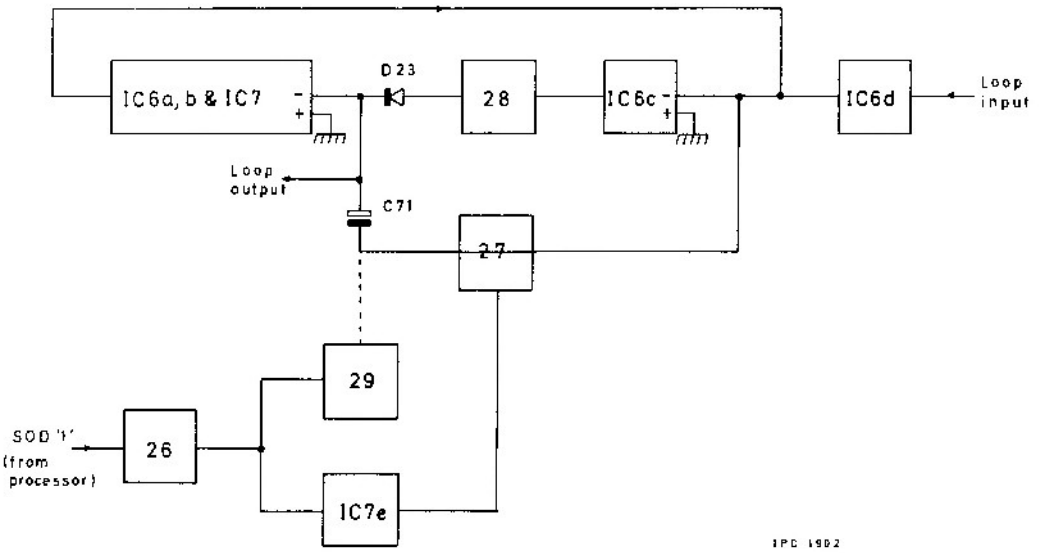


Fig. 5 LFD selected : block diagram

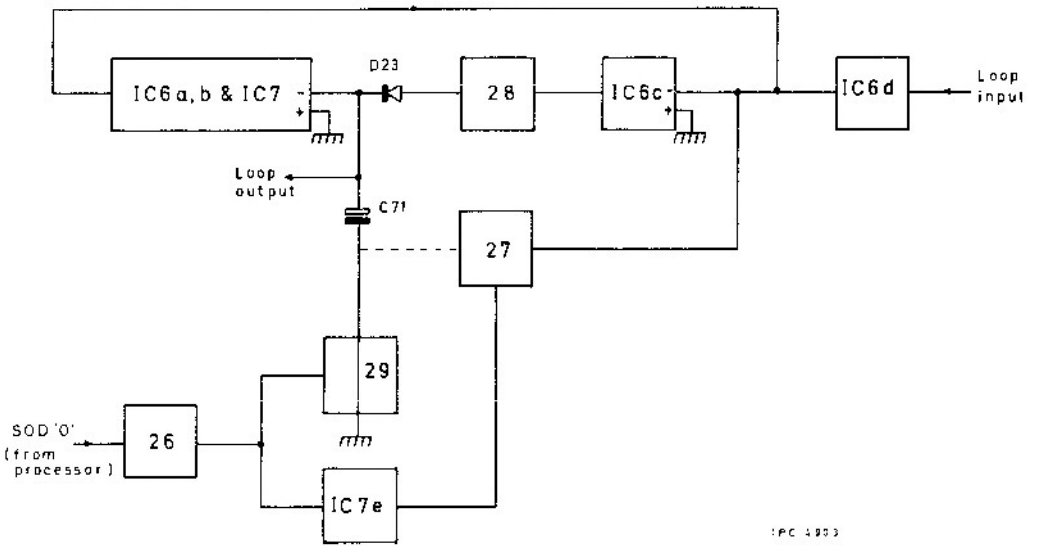


Fig. 6 LFD not selected : block diagram

ANALOGUE TO DIGITAL CONVERSION

Circuit diagram : Chap. 7, Fig. 5

39. The a-d converter IC16 converts the analogue d.c. voltage from the r.m.s. converter IC8 into a digital format which is fed on to the data bus lines. This information is processed under software control and then fed via the data bus lines to the liquid crystal display units.

A-D converter

40. Analogue input to IC16, connected to pins 35 and 34 (HI and LO), is integrated to form a voltage ramp. A reference voltage is set up by variable R135 operating in a resistor network voltage, stabilized by Zener diode D25 and supplied from the +12 V line. The voltage ramp is returned to 0 V by the reference voltage in a time represented by the number of clock pulses counted. Counter output is latched and presented for output in 12 bit format.

41. When the converter has data available the STATUS output goes high and the positive edge provides an interrupt request to the processor on the RST 7.5 input. This is the highest priority interrupt and when serviced initiates a multi function routine.

42. Digital output data from the converter is accessed by the processor in two bytes. The low order byte, bits B1 to B8 is accessed by the chip select line CS3 asserted low. High order byte bits B9 to B12 with overrange and polarity bits is accessed by CS4 asserted low.

43. The service routine tests the data to determine overflow or underflow and range and then stores the data for later processing outside the interrupt service routine. A flag is set to indicate that new data is available.

44. On testing the flag, the processor jumps to an r.m.s. averaging routine to process the data and feeds the encoded results on to the data bus lines for the l.c.d. display. If the GPIB option is fitted then the results are also encoded in ASCII format ready for output to the GPIB.

MICROPROCESSOR SYSTEM

Circuit diagram : Chap. 7, Fig. 5

45. The microprocessor system comprising the processor, ROM, RAM, decoders, latches and transceivers which drive the address and data bus lines to control the instrument is contained entirely on the motherboard.

Processor functions

46. Processor functions can be summarized very briefly as follows. On power up or after a reset command, a routine is initiated which performs tests to check on then set up the hardware and to initialize the GPIB option if found to be present.

47. The processor then waits in a loop testing data availability flags which are set by the interrupt service routines. These are initiated by the re-start inputs 7.5, 6.5 and 5.5. Three types of data are available - analogue to digital converter data, GPIB command data and keyboard data. Descriptions of the circuits providing this data are contained in their individual sections.

48. Responding to the flag, the processor jumps to the appropriate routine programmed in the ROM and feeds the required information out on to the data bus lines for display or for transmission over the GPIB bus.

System operation

49. The 8 bit microprocessor IC9 is a type 8085A with on chip clock generation, 4 vectored interrupts and a data bus that is multiplexed with the 8 low order address lines. Demultiplexing is carried out by octal latch IC11 which latches the lower 8 bits of the address bus AD0 to AD7 when ALE (address latch enable) is asserted high. Data bus lines are latched by transceiver IC12 with direction of data controlled by the RD line.

50. IC10 decoder is enabled by the RDL or WRL signals and decodes the address lines A12, A13, A14 to provide chip select signals. 1 of 8 chip select lines is asserted low to enable the selected device. The decoder is disabled through NAND gates IC18a and IC18b when the RD and WR lines are set high.

51. IC13 is a 4k x 8 bits EPROM which is ultra violet eraseable and electrically programmed to include all the control routines including a power up routine. It is enabled by CS1 asserted low.

52. Chip select line CS5 asserted low enables the two static RAM devices IC14 and IC15. These each contain 1k x 4 bits and are together organized as 1024 words by 8 bits. Each device has 8 address inputs (A0 to A7) and 4 data IO lines (D0 to D3 and D4 to D7). Write/Read operation is controlled by the Write enable input, asserted low for Write and set high for Read.

53. Octal latch IC17 operates the range switch relays RLB to RLN by turning on the appropriate transistor driver TR30 to TR38. IC17 is enabled by CS6 asserted low and latches the output to the driver high when the data input line is set high. This turns on the driver transistor whose collector current energizes the relay coil.

54. Chip select lines CS3 and CS4 asserted low enable the low byte and high byte of the A/D converter IC16 output data. CS7 Low enables the display/keyboard buffer IC3 and CS8 Low enables the keyboard return buffer IC4, both of which are contained on the display board AC01.

55. The optional GPIB unit when fitted is enabled by CS2 line asserted low. All microprocessor system connections to the unit are made via the interface connector PLF.

KEYBOARD AND DISPLAY

Circuit diagram : Chap. 7, Figs. 7 and 9

56. The keyboard comprises all the front panel key switches and the l.e.d. indicators for remote operation and SRQ/Charge function. It is coupled to the display board by a 12 way flexible link.

57. The display board contains the liquid crystal display, display drivers and the control logic circuitry required to interface the key switch lines and the display driver lines to the internal data bus.

58. Keyboard operation is converted by the circuits on the display board into uniquely identified signals to the processor. The processor responds by performing the measurement function and indicating the result on the display unit.

Keyboard operation

59. Key switches are organized in an array of 4 columns and 4 rows. Latch IC3, with no input and not clocked, has all outputs to the key switches set low. Input lines from the open switches to the buffer IC4 and NAND gate IC5b are held high by the pull up resistors R1 to R4. With all inputs set high, IC5b output is held low. Diodes D42 to D45 in the output lines of IC3 prevent the output levels being connected in parallel if more than one key in a row is pressed at the same time.

60. When a key is pressed, the low state is transferred through the closed switch and the line to IC4 and IC5b is pulled low. With one input low IC5b output goes high, so raising an interrupt request (RST 5.5) to the processor for keyboard service. On responding to the interrupt the processor enables the input latch IC3 (CS7 asserted low) and the output buffer IC4 (CS8 asserted low) and initiates a scanning program to determine which key is pressed.

61. This sets high all but the right-hand column (connected to IC3 pin 6). If the key pressed is in this column then the row line of that key is forced low. If not the row lines will remain high. The next column is then set low with the others held high and the process repeated until all the columns have been scanned. In this way the column and row information uniquely identifies the key pressed. This is converted into a key image which the processor interprets and then actions the appropriate function.

REM indicator

62. With GPIB unit fitted and 2610 under remote operation, inputs to NAND gate IC5a are set high (fast switching high states) which sets output low to TR2. This turns on TR2 which lights l.e.d. D40 the REMote operation indicator at the front panel.

SRQ/CHARGE indicator

63. This indicator has a dual role being used as the SRQ indicator when 2610 is under GPIB control or as the CHARGE indicator when the battery control unit is in the charging mode.

SRQ indication

64. When 2610 is under remote operation and a service request (SRQ) is raised, latch IC3 pin 12 output is asserted low. This turns on TR1 which through diode D1 lights l.e.d. D41, the SRQ indicator at the front panel. When SRQ has been serviced the light is extinguished.

CHARGE indication

65. When 2610 is fitted with a battery supply unit and switched for the charging operation, l.e.d. D41 lights to indicate this condition. Drive for the l.e.d. originates at the battery control board pin 13 and is linked, via the motherboard pin 15 to the display board pin 15. Diode D1 isolates transistor TR1 (SRQ driver) from the CHARGE driver line.

Display operation

66. The displays on the liquid crystal display unit X1 are driven using two CMOS LSI circuits IC1 and IC2 connected in cascade. These integrated circuits each contain a shift register, latches, segment drivers and an oscillator. Fig. 7 shows the display driver in block diagram form.

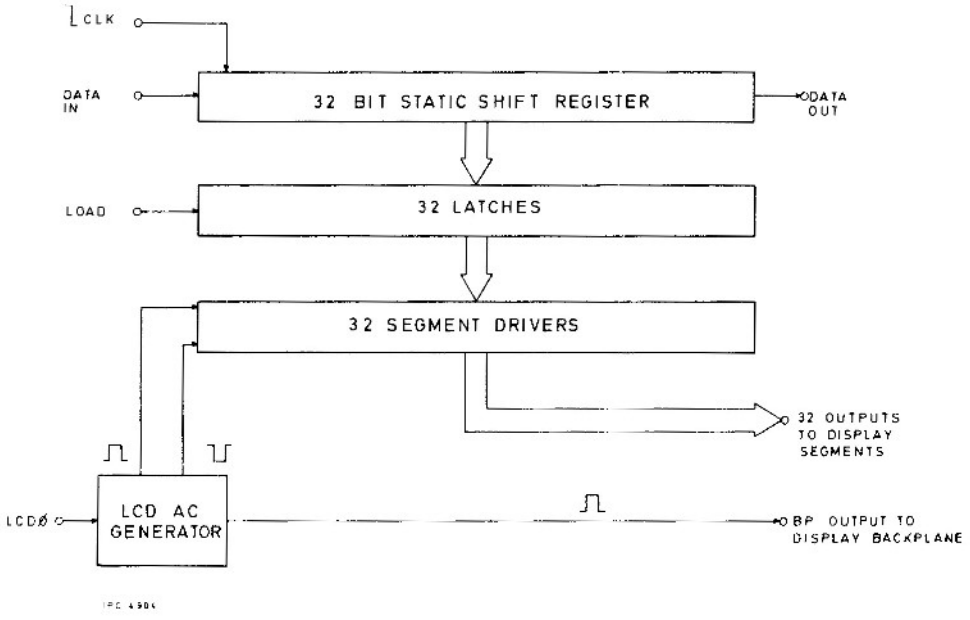


Fig. 7 Display driver : block diagram

67. Display data on D7 line is fed to display latch IC3 which is enabled by CS7 low to high transition. Data is in the form of 48 bits serial input with IC2 input shift register overflowing into IC1 shift register via the data out/ in connections. CLOCK and LOAD control signals for the display drivers on D5 and D6 lines are also latched by IC3.

68. Data information latched by IC3 is loaded into IC2 shift register with every clock pulse. The contents are shifted along with each data input until the register is full. The LOAD line is then asserted high which causes a parallel load of the data in the register into the latches that control the segment drivers. Driver output is an a.c. voltage generated by the on chip oscillator.

69. The oscillator in IC1 generates a 50 Hz square wave voltage (frequency determined by C1) which is applied via the drivers to the individual display segments. The 50 Hz square wave voltage from IC1 is coupled to IC2 LCD 0 input pin 31 and used as the source for IC2's drive to the display segments. This same square wave voltage is fed from IC2 pin 30 to the liquid crystal display unit backplane which forms the common electrode connection to the crystal displays.

70. With no data in to IC1 and IC2 the square wave drive to the display segments is in phase with that applied to the display backplane. As there is no potential difference across them, the crystals are not excited and the segments remain non-visible.

71. When the DATA IN line is asserted high and clocked and loaded, the driver latch output changes to an out of phase square wave voltage to the display segment electrode. The crystals for the selected segment are excited (scattered) and the segment becomes visible.

GPIB INTERFACE UNIT

Circuit diagram : Chap. 7, Fig. 11

72. This unit is an optional item and only fitted to 2610 when remote facilities are required. The unit when coupled via the GPIB lead assembly allows direct connection to a GPIB talker/listener device and implements the full IEEE 488 specifications (no control function).

73. IC3 (8291A) is a microprocessor controlled device designed to interface the microprocessor to the GPIB. Its capabilities include data transfer, handshake protocol, talker/listener addressing procedures, device clearing and triggering, service request, and serial polling. Details of the GPIB control are given in Chap. 3 of the Operating Manual.

74. The 8291A has 16 registers. 8 of these registers may be written in to by the microprocessor. The other 8 may be read by the microprocessor. One each of these read and write registers is for direct data transfers. The rest of the write registers control the device, while the rest of the read registers provide the microprocessor with a monitor of the GPIB states, bus conditions and device conditions.

75. Address lines A0, A1 and A2 select 1 of 8 internal read/write registers in conjunction with RDL or WRL. IC1a and IC1b decode the CS2 asserted low input and the A3 address line asserted high input. This forces the CS input to IC3 low which enables reading from or writing to the selected register. The interrupt output from IC3 is connected to the RST 6.5 input of the processor and is asserted high for request.

76. T/R1 and T/R2 are external transceiver control lines. T/R1 asserted high indicates output data/signals on DIO1 to DIO8 and DAV lines and input signals on NRFD and NDAC lines. Asserted low indicates the opposite on these lines. T/R2 asserted high indicates output signals on the EOI line. Asserted low indicates expected input on EOI line.

77. IC4 to IC7 transceivers translate the negative true logic on the 16 bus lines and act as drivers. IC1c provides the low level logic for the receive instruction TR/1 to IC6. IC1d fed from IC1c provides the talker high level logic for IC4 and IC5.

78. Switch SA is the GPIB address switch and allows the personalized 2610 GPIB address to be programmed. SA1 to SA5 set the address in binary format 1, 2, 4, 8, 16 for talk and listen modes. SA6 is set for talk only mode. Pull up resistors (R1 to R6) on each of the address switch lines, latch the input to IC2. This is a tri-state gated driver which when enabled by CS2 and A3 asserted low places the information on the data bus lines D0 to D5.

▶ 79. Fig. 8 shows the General Purpose Interface Bus structure with the 16 lines sub-divided into data, interface management and transfer. Bus and line functions are described below.

General purpose interface bus structure

Data bus

80. Comprises 8 data input/output lines DIO 1 to 8 and is used to transfer the data (commands, addresses and instructions) in bit parallel, byte serial form.

Interface management bus

81. Manages the orderly flow of data across the interface and consists of 5 wires carrying the following signals:

Interface clear (IFC); sent by the station controller to clear all device interfaces so that they set to an initial condition.

Remote enable (REN); sent by the controller to enable instruments to be placed under remote control.

Attention (ATN); sent by the controller to indicate that an address or command is on the data lines.

End or identify (EOI); an instrument or controller signal sent to indicate the end of a message.

Service request (SRQ); sent to the controller by an instrument to indicate that it needs service. ◀

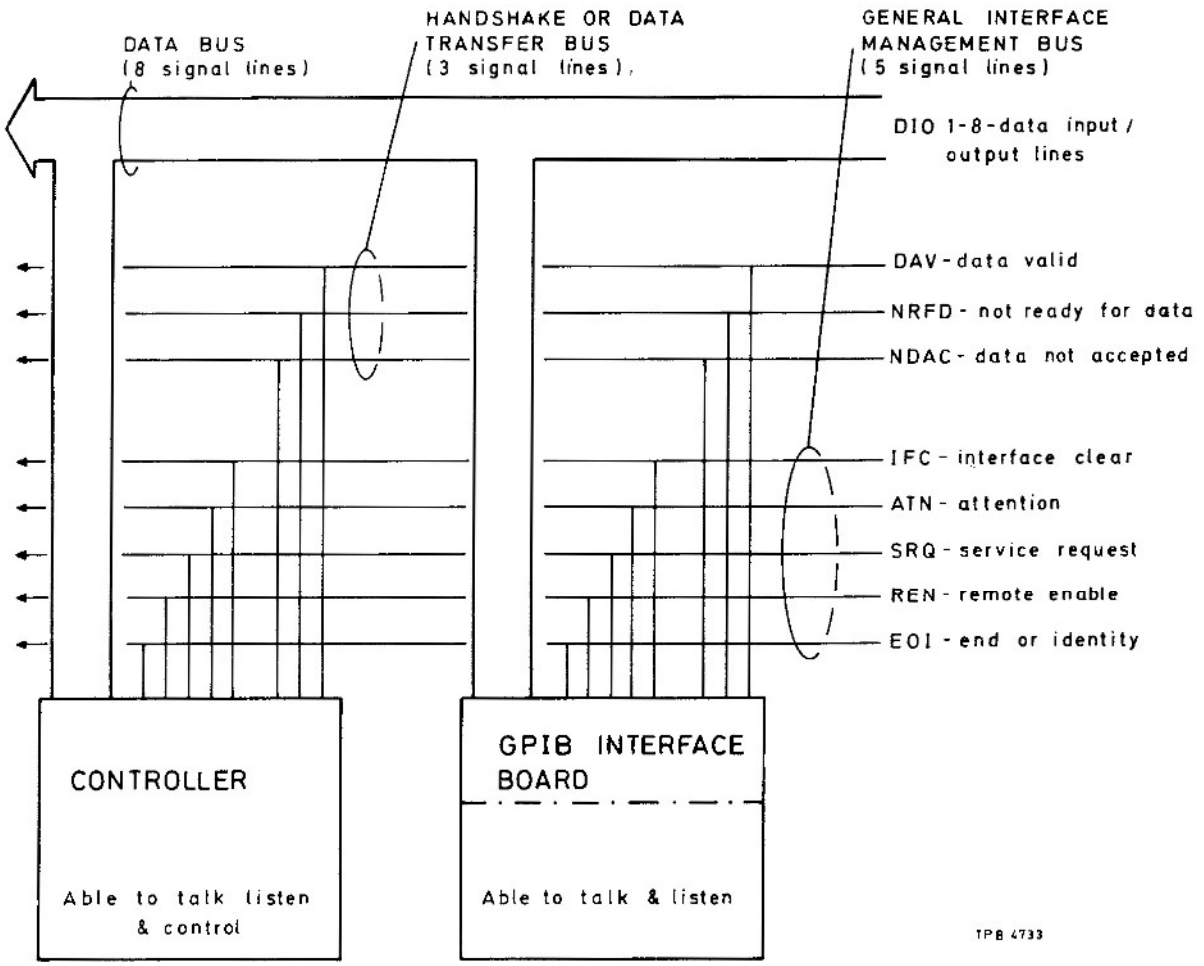


Fig. 8 General Purpose Interface Bus structure

Handshake or data transfer bus

82. Co-ordinates the flow of data and comprises 3 lines which are used for the handshaking process, by which a talker or controller synchronizes its readiness to send data with a listener's readiness to receive data. The handshake signals are :

Not ready for data (NRFD); asserted (low) by a listener when it is active and not yet ready to receive data. Set high to signal its readiness to receive data, DAV can then be signalled if further data is to be processed.

Data valid (DAV); asserted by a talker to indicate that the data it has placed on the data bus has settled and may be accepted.

Not data accepted (NDAC); asserted by a listener when receiving information from the data lines. Release of the NDAC line tells the data source that new data can be submitted.

Bus operation

83. (i) A sequence of messages may be commenced by the controller asserting IFC on the management bus to set the interface to its initial condition.

(ii) The controller then sets up which instruments are to be listeners by asserting ATN and handshaking the personalized listen address of these instruments over the bus. Similarly the controller designates the talker (only one instrument may talk at a time) by sending its talk address, again with ATN asserted.

(iii) On release of the ATN command (ATN low) the talker is then able to place data on the data lines DIO 1 to 8, the transfer of this is controlled by the handshake process and is received by all addressed listeners. The talker typically concludes the sequence by asserting EOI and the controller then resumes control.

(iv) Both the talker and the listeners may be switched by the controller into an inactive state by asserting IFC and UNL (unlisten) on the data bus.

Handshake procedure

84. The handshake is used whenever data is transferred on the bus. When a signal is asserted the function indicated by the line is carried out, e.g. NRFD is asserted to signify the listener's unreadiness to receive data, and unasserted or removed when ready to receive data. A typical handshake is as follows :

(i) Talker (controller) places a byte on the data bus with DAV initially unasserted to show data is not yet valid.

(ii) When all listeners are ready to receive data NRFD is removed with NDAC at this time asserted.

(iii) After a delay to allow the data bus to settle, talker asserts DAV to show data is valid and may be accepted.

(iv) Data byte is transferred, then listeners assert NRFD. When all the listeners have accepted the byte NDAC is removed to signify receipt.

(v) Talker removes DAV, listeners assert NDAC, and the bus reverts to its initial condition ready for the next data byte, a typical cycle is shown below in Fig. 9.

Service request and status byte

85. When the attention of the controller is required i.e. when faulty information is received or at the end of a measurement, the processor causes the interface to send SRQ (service request). Having received SRQ the controller uses serial polling to find out the source of the request (necessary since all devices use the same SRQ line). SPE (serial poll enable) is sent, all devices are unlistened and then sequentially addressed to talk. When the interface receives SPE the processor prepares the status byte.

▶ 86. When addressed as a talker, the interface removes SRQ and the processor sends the status byte with bit 6 indicating that the test set was the instrument requesting service. The contents of the remainder of the byte indicate the reason for requesting service. SPD (serial poll disable) ends the sequence.

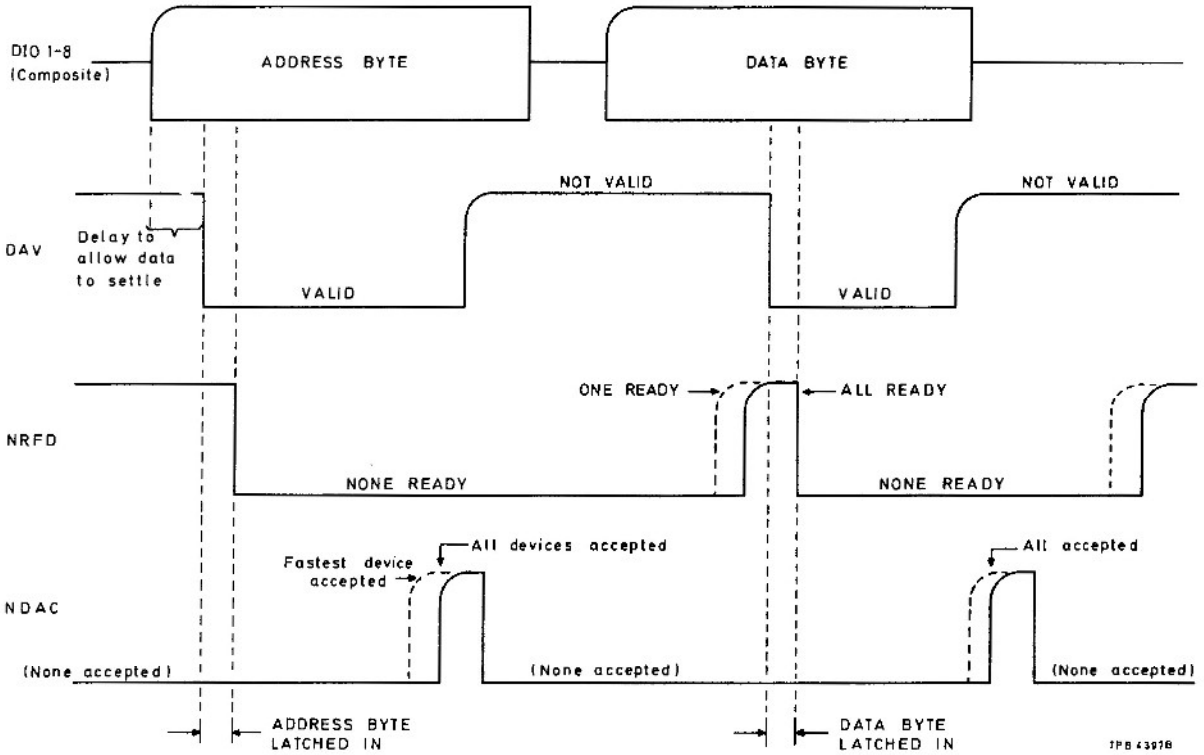


Fig. 9 Handshake procedure ◀

AC MAINS POWER SUPPLY

Circuit diagram : Chap. 7, Figs. 1 and 3

87. The power supply input circuit comprises an a.c. mains input filter, two time lag fuses, double pole on/off switch and mains transformer with two primary windings linked in series or parallel by a single switch. This switch provides a choice of two input voltage ranges allowing operation from any voltage between 95 V a.c. to 132 V a.c. and 190 V a.c. to 264 V a.c.

88. Two transformer secondary windings supply 9 V a.c. to each of two bridge rectifiers which provide the positive and negative unregulated d.c. voltages to the regulator circuits. These regulators provide the following d.c. supplies, -5 V, +5 V, -20 V and -12 V, +20 V and +12 V.

89. To avoid earth current loops which would affect the accuracy of the voltmeter, the measuring circuits are not returned to earth but to a nominal 0 V chassis line. This is protected against a possible rise in voltage by the cross-coupled bridge rectifier D2 which is connected between the chassis and earth.

90. Fig. 10 is a simplified block diagram showing the key components of the a.c. mains power supply.

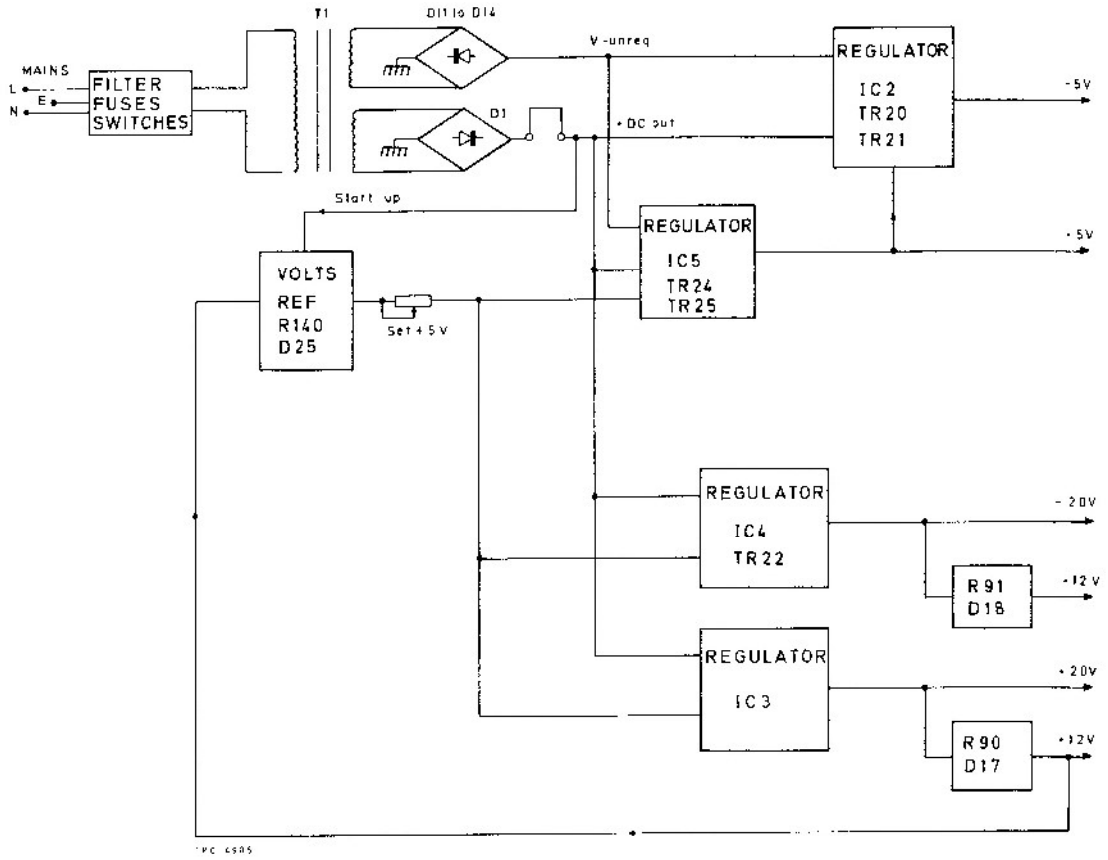


Fig. 10 AC mains power supply : block diagram

+5 V supply

Circuit diagram : Chap. 7, Fig. 3

91. The +5 V regulated supply is a conventional circuit using a series regulating element TR24. This is controlled by driver TR25 and operational amplifier IC5.

92. The negative (inverting) input of IC5 is connected to the +5 V regulated line and the positive input is connected to the +5 V reference line. This is a Zener diode controlled voltage (D25) taken from the +12 V line and set by variable resistor R96.

93. Increasing the reference voltage to IC5 produces a greater input to TR25 which provides more drive to TR24. This effectively decreases the resistance across TR24, due to the extra current drawn, and results in the supply line voltage rising. Thus R96 is used to accurately set the +5 V supply voltage.

94. Because input voltage levels are not established instantaneously at switch on IC5 output could possibly swing negative. This would result in excessive voltage across TR25 base/emitter junction. D20 connected across this junction, ensures that any transient voltages of this nature are conducted away from TR25.

95. With the reference input voltage fixed by R96, IC5 gain is controlled by the inverting input and provides voltage regulation under normal operating conditions in the following way.

96. If the +5 V line voltage decreases (due to increased current consumption) then IC5 responds by amplifying the difference voltage. This causes TR25 to drive TR24 harder and as the voltage across the series element falls, the +5 V line voltage rises to the previously set value. Should the +5 V line voltage increase above the set value, then the control circuit will operate in a reverse manner to restore the line voltage.

97. The controlled reference voltage from R96 also serves as the reference voltage for the +20 V and -20 V switching regulators. This voltage is derived from the +12 V supply which in turn is derived from the +20 V supply.

98. At switch on, the slight delay on the build up of this reference voltage might prevent the switching regulators from operating. To avoid this possibility a back up starting voltage to the reference line is taken from the unregulated +d.c. line by R80.

-5 V supply

Circuit diagram : Chap. 7, Fig. 3

99. The -5 V line regulating circuit operates in the same way as that for the +5 V line. However, the operational amplifier IC2 is controlled by the inverting input only. The non-inverting input is earthed.

100. The -5 V line voltage is initially set up by employing the +5 V supply as the reference voltage fed through R79 to IC2. Voltage variations on the -5 V line are sensed by IC2 across R78 and the regulating circuit responds in the same way as that described for the +5 V supply.

-20 V and -12 V supplies

Circuit diagram : Chap. 7, Fig. 3

101. The -20 V regulated supply is provided by the switching regulator IC4 and power amplifier inverter TR22.

102. IC4 is an integrated circuit containing a duty cycle controllable oscillator, voltage comparator, high current/high voltage output switch and operational amplifier. Circuit diagram Chap. 7, Fig. 3 shows the internal IC circuit as well as the external connections for the regulator supply.

103. Duty cycle of the oscillator is set by timing capacitor C57 with output to the AND gate. The reference voltage from R96, reduced by R89 is fed to the positive input of the voltage comparator. Negative input is fed from the regulator output feedback loop via the operational amplifier.

104. Comparator output to the AND gate determines the frequency of bursts of oscillator pulses from the AND gate to the set input of the set/reset bistable. Oscillator output connected directly to the rest pin provides a fast reset signal after every set condition.

105. The train of positive pulses from the Q output of the bistable is fed to the driver transistor whose collector output is controlled by the switching transistor. The switched negative-going pulses are inverted and power amplified by PNP transistor TR22 across collector load L3.

106. At the end of every pulse, when TR22 is momentarily switched off, L3 regenerates a very fast large negative voltage spike. These are rectified by D19 and the resultant negative voltage is smoothed by L4, C60 and C61 to provide the -20 V supply.

107. R91 reduces the -20 V to -12 V with voltage regulation provided by Zener diode D18 and smoothing by C63.

+20 V and +12 V supplies

Circuit diagram : Chap. 7, Fig. 3

108. The +20 V supply circuit operates in a very similar way to the -20 V circuit except that the operational amplifier is not used and the power amplifier inverter is not required.

109. Driver output is switched through the series load L1 and rectified by D16. Smoothing is provided by C53, 54, 55 and L2 to produce the +20 V supply.

110. R90 reduces the +20 V to +12 V with voltage regulation provided by Zener diode D17 and smoothing by C62.

BATTERY SUPPLY AND EXTERNAL DC SUPPLY

Circuit diagram : Chap. 7, Figs. 12 & 14

111. The battery unit and battery control unit are optional items and are only fitted when it is required to power 2610 from a d.c. supply.

112. Battery supply for 2610 is enabled by fitting the battery control unit and battery unit. External d.c. supply for 2610 is enabled by fitting the battery control unit and connecting to it a 7 V to 16 V external d.c. supply.

113. In both cases the battery control unit is connected by cable assembly to the 2610 motherboard. It provides a +5 V and -5 V supply to the 2610 voltage regulating circuits. When in the charging mode it utilizes 2610 power supply or the external d.c. supply to provide a charging current to the battery.

114. Fig. 11 shows in block diagram form the battery and external d.c. supply connections.

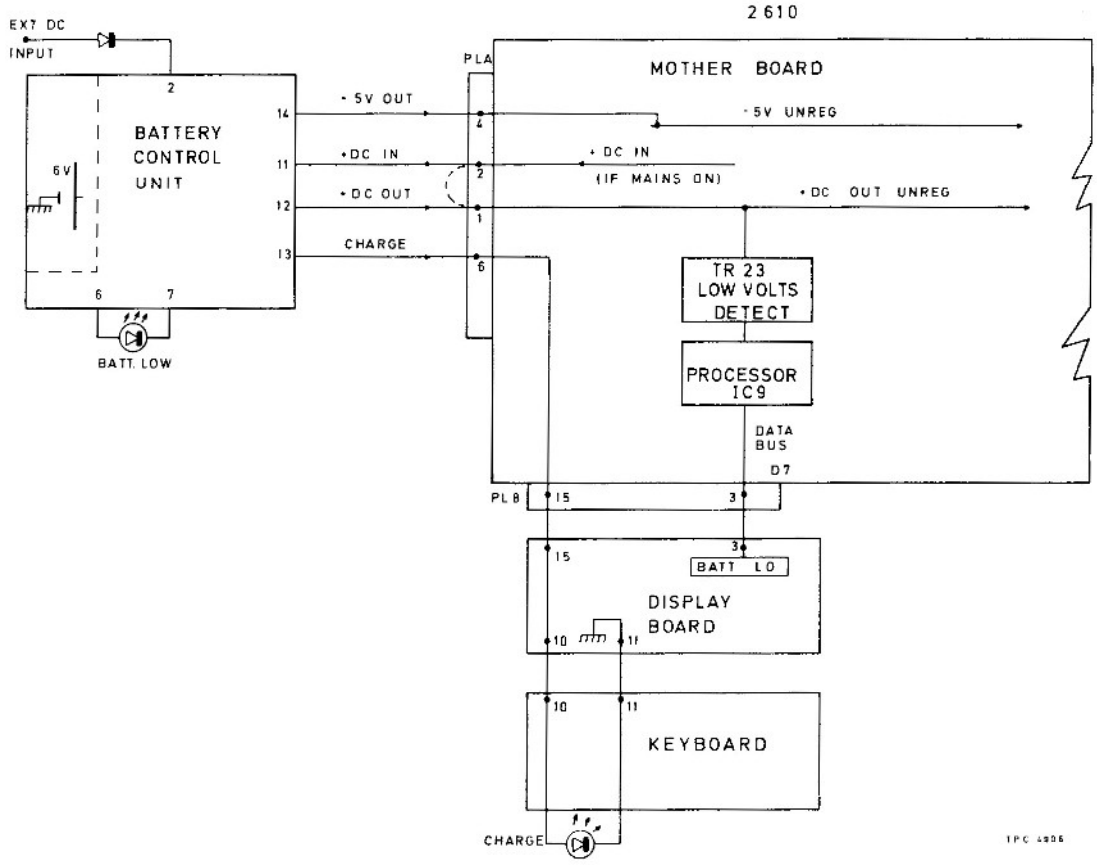


Fig. 11 Battery and external d.c. supply connections : block diagram

Battery unit

115. The battery unit incorporates a nickel cadmium type battery pack (5 x 1.2 V cells) which when fully charged allows typically 5 hours normal use from the instrument before recharging is necessary. Recharging time to fully charge a discharged battery is approximately 15 hours in the CHARGE mode.

Battery control unit

116. Block diagram Fig. 12 shows the key components of the battery control unit. A 3 position switch selects the control unit functions which are as follows:-

ON - 2610 is powered from the battery supply. If an external d.c. supply is connected this will take priority as will 2610 power supply if the a.c. mains is switched on.

OFF - Battery supply to 2610 is disconnected. Batteries are trickle charged from 2610 power supply (if switched on) or if connected, from the external d.c. supply.

CHARGE - Battery is charged from a constant current charging circuit fed from 2610 power supply or from the external d.c. supply. A drive is supplied to 2610 for the front panel CHARGE indicator.

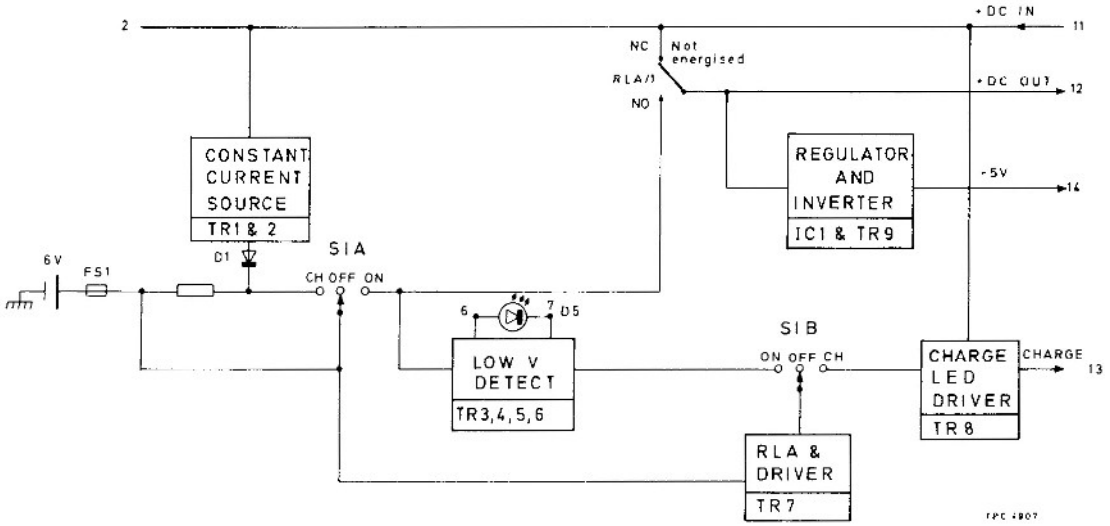


Fig. 12 Battery control unit : block diagram

117. Circuit descriptions of the battery control unit operations are listed under the ON - OFF - CHARGE switch position titles and include alternative conditions e.g. battery supply ON with a.c. mains supply on.

ON

118. Battery unit fitted - a.c. mains supply off. +6 V battery supply is fed via fuse FS1 to switch SA1 and to relay coil RLA. Rectifier D1 blocks the path through to the unused +DC IN line. With no current flow through D5 and no voltage on the +DC IN line, TR6 is cut off. Collector voltage connected

via SA2 ON position turns on TR7. Current drawn through TR7 energizes relay RLA which connects the battery voltage to the +DC OUT line via SA1 ON position.

119. Smoothing circuit L1, C3, C4 fed from the +DC OUT line, supplies the operating voltage to the -5 V switching regulator and inverter IC1 and TR9. This circuit functions in the same way as that described for the -20 V regulator/inverter. See section on -20 V supply for full description.

120. TR8 is the driver transistor for the charging line indicator. With SA2 in the ON position the junction of resistors R15/R16 is isolated. This produces a positive bias which cuts off TR8 resulting in no drive to the indicator.

121. When the battery working voltage is above 5.7 V, Zener diode D3 maintains 4.3 V bias to TR3 which is conducting. Voltage developed across R7 biases off TR5 which holds the low volts indicator l.e.d. D5 in the off state. C1 and C2 slightly reduce sensitivity and prevent noise interference.

122. After a period of use the battery working voltage will begin to fall. An early warning of this condition is given by the BATT LO annunciator at the 2610 front panel display. The sensing device is TR23 on the motherboard. A fall in voltage on the +DC OUT line, monitored by potential divider R93/R94 turns on TR23. This forces the SID line to the processor high which when tested, results in output on the data bus to drive the BATT LO annunciator l.c.d. segments on the display board.

123. When, after a period of further use, the battery working voltage falls below 4 V, current drawn through TR3 falls and so does the voltage across R7. TR5 now conducts and the collector load voltage at R9/R10 is amplified by TR4. This causes TR5 base voltage to fall even further so ensuring TR5 is held in the biased on condition. With forward bias applied by TR5 collector volts l.e.d. D5 on the battery control unit rear casing lights. This indicates that the supply voltage has fallen <u>below</u> the minimum required for normal operation.

124. Current through D5, R11, R13 turns on TR6. The fall in collector volts passed through switch SA2 ON position, cuts off TR7 and relay RLA is de-energized, disconnecting the +DC OUT and -5 V lines.

125. To overcome this latched low voltage condition the battery control unit must be switched off and the battery recharged before further use can be made of the battery supply.

126. <u>Battery unit fitted - a.c. mains supply on.</u> In this condition the a.c. mains operated 2610 power supply takes priority over the battery supply. The +DC IN line provides a trickle charge to the batteries via the constant current circuit TR1, TR2 and R4.

127. TR6 is turned on by positive bias derived from the +DC IN line and stabilized by Zener diode D6. With TR6 turned on, TR7 is cut off and relay RLA de-energized. This connects the +DC IN line directly to the +DC OUT line feeding back to 2610 power supply.

128. Battery unit fitted - external d.c. supply connected. The external d.c. supply will override the battery supply in the same manner as that described for the a.c. mains supply on operation. Diode D2 provides protection against reversed polarity connection and feeds the supply voltage on to the +DC IN line.

129. Batteries are trickle charged from the external d.c. supply and the low volts detector circuit will become active should this supply voltage fall below the acceptable level.

OFF

130. This is the off position for the battery supply when the battery unit is fitted. It does not disconnect supplies to 2610 if the external d.c. supply is connected or the a.c. mains supply is switched on. Relay RLA is not energized (no voltage on TR7 base) so + DC IN line is connected directly to +DC OUT line.

131. The batteries are trickle charged from the +DC IN line voltage fed from the external d.c. or 2610 supply.

CHARGE

132. Battery unit fitted - a.c. mains supply on. With battery control unit switched to the CHARGE position +DC and -5 V supplies to 2610 are disconnected. Thus 2610 cannot be operated as a voltmeter but only as a source of charging current.

133. The battery is charged from the constant current charging circuit TR1 and TR2 which is fed from the +DC IN line voltage. Switch SA1 in the CHARGE position bypasses the trickle charge resistor R4 to supply maximum charge. Current overload protection is provided by a 5 A fuse FS1, which is fitted in series with the battery.

134. TR1, biased by load resistors R2, R3 and TR2, biased by R1 supply a charging current of 700 mA. Variations in battery loading which would normally affect the charging current are compensated by TR1 and TR2 in the following way.

135. If current consumption starts to rise above 700 mA, the voltage drop across R2, R3 will increase, reducing the bias to TR1. This will cause TR1 to draw more current through R1 so increasing the bias to TR2. Current through TR2 will be reduced, returning to 700 mA. If the current consumption starts to fall below 700 mA then the circuit will operate in a reverse manner to restore the current.

136. The +DC IN line voltage is also fed to TR8 and via SA2 CHARGE position to TR7 base. Voltage from the battery charging line is fed through relay RLA to TR7 collector. TR7 now conducts, energizing relay RLA which changes over to the disconnected voltage line from TR6/SA1 ON position. With no voltage on the +DC OUT line there is also no voltage on the -5 V OUT line.

137. TR8 is now turned on by completion of the circuit from bias resistors R15/R16 through SA2 CHARGE position and TR7 to chassis. Diode D8 is forward biased with R24 delivering the operating voltage to the CHARGE l.e.d. indicator at the front panel keyboard. The CHARGE indicator line combines with the SRQ

indicator line on the display board. Diode D8 isolates the CHARGE driver line from the SRQ driver line.

138. Battery unit fitted - external d.c. supply connected. Charging conditions and circuit operations using an external d.c. supply are the same as those described for charging from an a.c. mains power supply.

Chapter 5

MAINTENANCE

CONTENTS

INTRODUCTION

1. This chapter contains information for maintaining the equipment in good working order, checking its overall performance and details adjustment procedures that may be necessary after replacement of components. Before attempting any maintenance, the information given should be read with reference to the preceding Technical Description chapter.

2. Integrated circuits and semiconductor devices are used throughout this instrument, and although these have inherent long term reliability and mechanical ruggedness, they are susceptible to damage by overloading, reversed polarity and excessive heat or radiation. Avoid hazards such as prolonged soldering, strong r.f. fields or other forms of radiation, the use of insulation testers or accidentally applied short circuits.

3. Static sensitive components ⚠ . The c.m.o.s. integrated circuits used in this instrument have extremely high input resistance and can be damaged by accumulation of static charges (see preliminary pages, Notes and Cautions).

ACCESS AND LAYOUT

Fuses

4. The voltmeter is protected by fuses in both the live and neutral conductors of the mains supply. Access is by means of screw caps on the rear panel.

Removing external covers

5. The top and bottom covers are retained by the rear frame which is held in position by two screws through the rear feet. To remove the covers, withdraw these screws approximately 12 mm and pull the rear frame back away from the cover edges. Lift up the revealed cover edge and then lift the cover away from the chassis. Tighten the feet securing screws to maintain protection for the rear panel and frame.

6. If the rear feet and frame are removed from the chassis ensure that the feet spigots are correctly aligned when re-assembling.

CAUTION.

> 2610 fitted with battery option. After removing external covers for fault finding, whenever possible disconnect the battery unit connector to avoid accidental short circuit and possible damage to components.

Internal layout (Fig. 1)

7. All the large power supply components are mounted on the rear panel. The motherboard is secured to the bottom chassis rails and electrically connected to the display board by a ribbon cable plug and socket. A metal screen wall separates the input preamplifier and driver amplifier circuits from each other and the remainder of the motherboard circuits. A top screen cover is not necessary and is not provided.

8. The keyboard is fixed to the display board, sandwich style and the whole assembly mounted on the front panel. A wired ribbon cable at the input socket side provides the electrical connection between the two boards.

9. Fig. 1 shows the internal layout with the preset controls identified for easy location. Also shown are the test point locations for measuring the supply voltages.

10. To gain access to the display board or keyboard remove the front panel and board assemblies as follows:-

(1) Unplug the ribbon cable from the motherboard PLB.

(2) Disconnect the meter leads from the motherboard terminals 9 and 10.

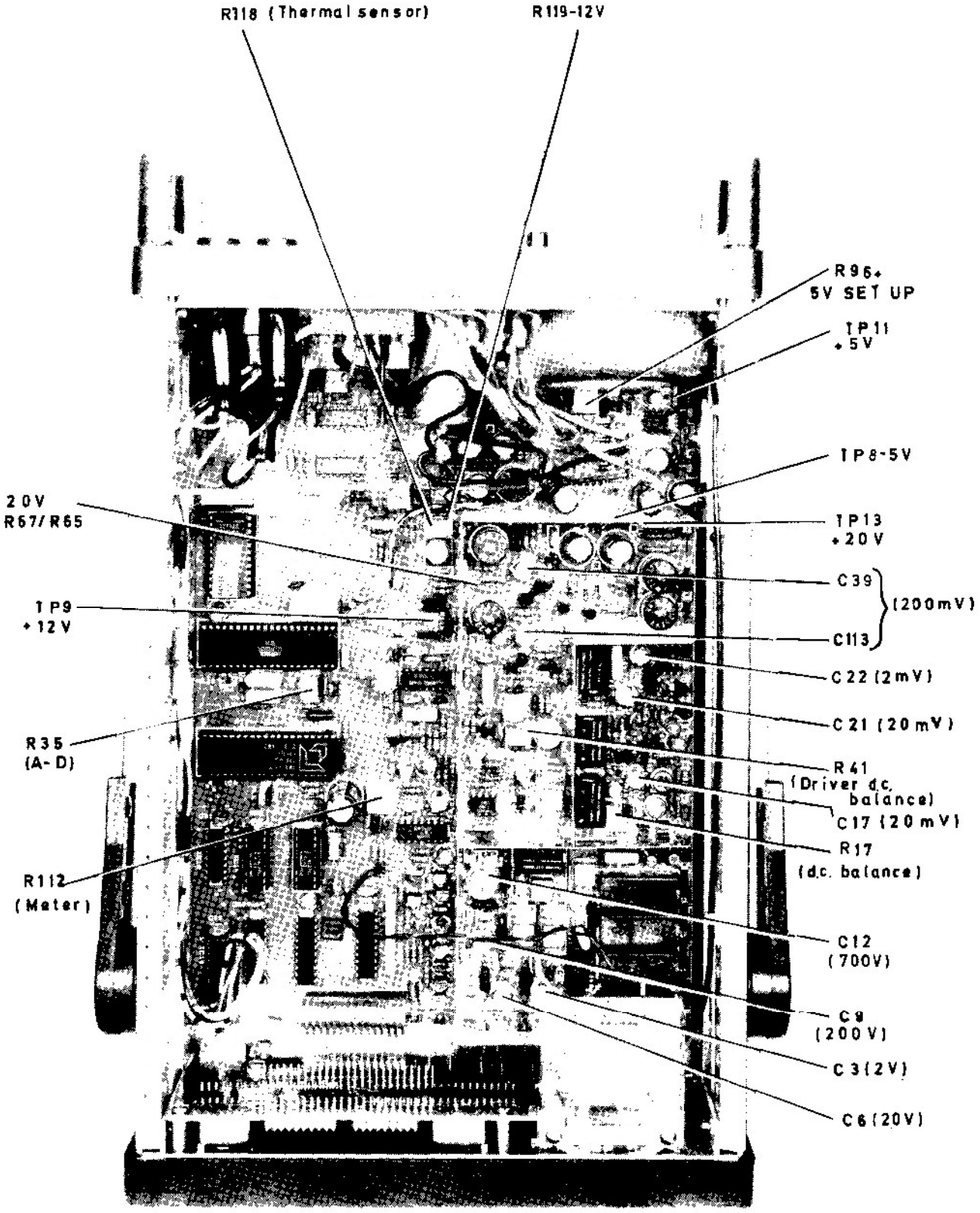


Fig. 1 2610 Preset controls and test point locations

(3) Unscrew and remove the locking nuts from the BNC input socket and the on/off switch.

(4) Remove the two front panel securing screws fitted to each side just behind the front frame.

(5) Carefully pull forward the whole front panel assembly which includes the keyboard, display board and meter.

(6) Remove the board securing screws and using the ribbon cable as a hinge, carefully hinge back the display board to reveal the keyboard.

PERFORMANCE TESTS

11. The tests in this section provide a performance check procedure for use during routine maintenance, to determine whether adjustment or repair is necessary.

12. The performance limits quoted are for guidance and should not be taken as guaranteed performance specifications unless they are also quoted in the Performance Data in Chap. 1 (Vol. 1).

13. When making tests to verify that the instrument meets the stated performance limits, allowance must always be made for the uncertainty of the test equipment used.

14. In case of difficulties which cannot be resolved with the aid of this manual, please contact our Service Division at the address given on the rear cover, or your nearest Marconi Instruments representative. Always quote the type or model number and serial number found on the label at the rear of the instrument.

15. The following tests are carried out to ensure correct performance :

DC voltage accuracy,
AC voltage accuracy at low frequency,
Frequency response,
Analogue output.

16. It should be noted that due to the 50 pF input capacitance of the 2610 the high frequency tests must be carried out using thermal voltage converters and micropotentiometers. Using a matched 50 Ω system will produce errors of several percent at the high frequency end of the instrument's bandwidth. Test equipment items with descriptions are listed in Table 1.

TABLE 1 TEST EQUIPMENT

Item	*Description*	*Minimum performance requirements*	*Examples*
a	AC/DC Calibrator	DC : 0 to 700 V, accuracy ±0.01%. AC : 0 to 700 V, 10 Hz - 50 kHz, accuracy ±0.1%.	Fluke 5100B or Rotek 610.
b	DC Digital Voltmeter	0 - 25 V, 1 μV resolution.	Datron 1065.
c	Set of Micro-potentiometers covering the range 2 mV to 200 mV output.	DC to 25 MHz.	Ballantine 440 series.
d	Set of thermal converters 5 V and 10 V.	DC to 25 MHz.	Fluke A55 series.
e	Inductive Divider	0.01% at 1 kHz.	Gertsch RT-60.
f	Signal Generator	2 V max. output 50 kHz to 25 MHz.	Marconi Instruments 2018.
g	RF Amplifier	50 kHz to 25 MHz >10 V output.	Marconi Instruments TF 2167 or RF Power Labs 30-12LC.
h	Low Frequency Oscillator	10 Hz - 50 Hz 1 V max. output.	Marconi Instruments 2104 or Hewlett Packard HP 3325A.

DC voltage accuracy

Test equipment : item (a)

17. Connect the calibrator output to the 2610 input and set the 2610 to d.c. coupling. Apply the voltages shown below and check the results obtained are within the specified limits.

2610 range	*Applied d.c. voltage*	*Limits*
20 mV	+10 mV	9.85 mV to 10.15 mV
	+20 mV	19.78 mV to 20.22 mV
	-10 mV	9.85 mV to 10.15 mV
	-20 mV	19.78 mV to 20.22 mV
200 mV	+100 mV	98.9 mV to 101.1 mV
	+200 mV	198.4 mV to 201.6 mV
	-100 mV	98.9 mV to 101.1 mV
	-200 mV	198.4 mV to 201.6 mV
2 V	+2 V	1.984 V to 2.016 V
	-2 V	1.984 V to 2.016 V
20 V	+20 V	19.84 V to 20.16 V
	-20 V	19.84 V to 20.16 V
200 V	+200 V	198.4 V to 201.6 V
	-200 V	198.4 V to 201.6 V
700 V	+700 V	690 V to 710 V
	-700 V	690 V to 710 V

AC voltage accuracy (LF)

Test equipment : items (a),(e)

18. Connect the calibrator output to the 2610 input and set the 2610 to a.c. coupling. When testing the 2 mV range the inductive divider should be interposed between the calibrator and the 2610. The inductive divider should be set to a ratio of 0.01 and the calibrator set to 100 times the required voltage. Apply the voltages shown in the table below and check the results obtained are within the specified limits.

2610 range	*Applied voltage/frequency*		*Limits*
2 mV	2 mV	1 kHz	1.954 mV to 2.046 mV*
20 mV	10 mV	1 kHz	9.85 mV to 10.15 mV
	20 mV	1 kHz	19.78 mV to 20.22 mV*
200 mV	100 mV	1 kHz	98.9 mV to 101.1 mV
	200 mV	1 kHz	198.4 mV to 201.6 mV*
2 V	2 V	1 kHz	1.984 V to 2.016 mV*
20 V	10 V	1 kHz	9.89 V to 10.11 V*
	20 V	1 kHz	19.84 V to 20.16 V
200 V	200 V	1 kHz	197.8 V to 202.2 V
700 V	700 V	100 Hz	687 V to 713 V

*Record 2610 reading for later use as reference for frequency response tests.

Frequency response

Test equipment : items (a),(b),(c),(d),(f),(g),(h)

2 mV range (see Fig. 2)

19. Connect the 2 mV micropotentiometer directly to the 2610 input and set the 2610 to a.c. coupling. Monitor the d.c. output of the micropotentiometer using the digital voltmeter. Reduce the calibrator output to minimum and apply a signal at 1 kHz to the input of the micropotentiometer. Increase the level until the same 2610 reading is obtained as noted for the 2 mV range accuracy. Note the d.c. voltage reading on the digital voltmeter. Set the voltage source to the frequencies shown in the table below and adjust the level for the same d.c. voltage reading on the digital voltmeter. Items (a), (f) and (h) are used to provide the test voltages. Check that all readings on 2610 are within the specified limits.

Frequency	*Limits*
45 Hz	1.954 mV to 2.046 mV
60 Hz	1.954 mV to 2.046 mV
100 Hz	1.954 mV to 2.046 mV
1 kHz	(reference)
10 kHz	1.954 mV to 2.046 mV
100 kHz	1.954 mV to 2.046 mV
500 kHz	1.954 mV to 2.046 mV
1 MHz	1.939 mV to 2.061 mV
3 MHz	1.949 mV to 2.061 mV

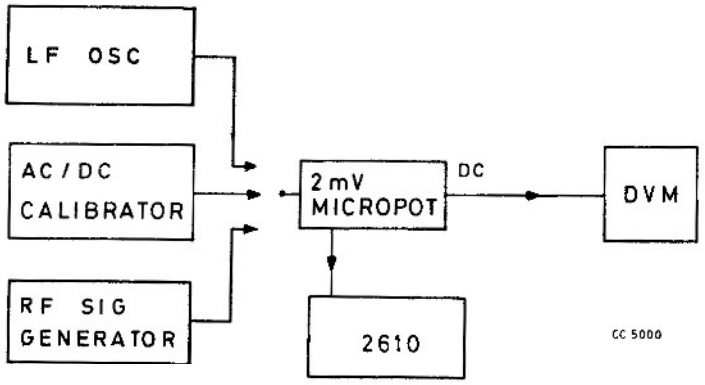


Fig. 2 Test set-up : 2 mV range

20 mV range

20. Using the 20 mV micropotentiometer and the method described for the 2 mV tests, check the 2610 at the following frequencies:-

Frequency	*Limits*
10 Hz (use d.c. coupling)	19.78 mV to 20.22 mV
60 Hz	19.78 mV to 20.22 mV
1 kHz	(reference)
10 kHz	19.78 mV to 20.22 mV
100 kHz	19.78 mV to 20.22 mV
500 kHz	19.78 mV to 20.22 mV
1 MHz	19.54 mV to 20.46 mV
5 MHz	19.54 mV to 20.46 mV
10 MHz	19.39 mV to 20.61 mV

200 mV range

21. Using the 200 mV micropotentiometer and the method described for the 2 mV tests, check the 2610 at the following frequencies:-

Frequency	*Limits*
10 Hz (use d.c. coupling)	198.4 mV to 201.6 mV
60 Hz	198.4 mV to 201.6 mV
1 kHz	(reference)
10 kHz	198.4 mV to 201.6 mV
100 kHz	198.4 mV to 201.6 mV
500 kHz	198.4 mV to 201.6 mV
1 MHz	195.4 mV to 204.6 mV
5 MHz	195.4 mV to 204.6 mV
10 MHz	193.9 mV to 206.1 mV
15 MHz	193.9 mV to 206.1 mV
20 MHz	193.9 mV to 206.1 mV
25 MHz	193.9 mV to 206.1 mV

2 V range (see Fig. 3)

22. Connect the 5 V thermal converter directly to the 2610 input via a tee-connector and set the 2610 to a.c. coupling. Apply a 1 kHz test signal from the calibrator to the other port of the tee-connector. Connect the d.c. output of the thermal converter to the digital voltmeter. Increase the level of the test signal until the same 2610 reading is obtained as noted for the 2 V range accuracy. Note the d.c. voltage reading on the digital voltmeter. Set the voltage source to the frequencies shown in the table below and adjust the level for the same d.c. voltage reading on the digital voltmeter. Items (a),(f) and (g) are used to provide the test voltages. Check that all 2610 readings are within the specified limits.

Frequency	*Limits*
60 Hz	1.984 V to 2.016 V
1 kHz	(reference)
10 kHz	1.984 V to 2.016 V
100 kHz	1.984 V to 2.016 V
500 kHz	1.984 V to 2.016 V
1 MHz	1.954 V to 2.046 V
5 MHz	1.954 V to 2.046 V
10 MHz	1.939 V to 2.061 V
15 MHz	1.939 V to 2.061 V
20 MHz	1.939 V to 2.061 V
25 MHz	1.909 V to 2.091 V

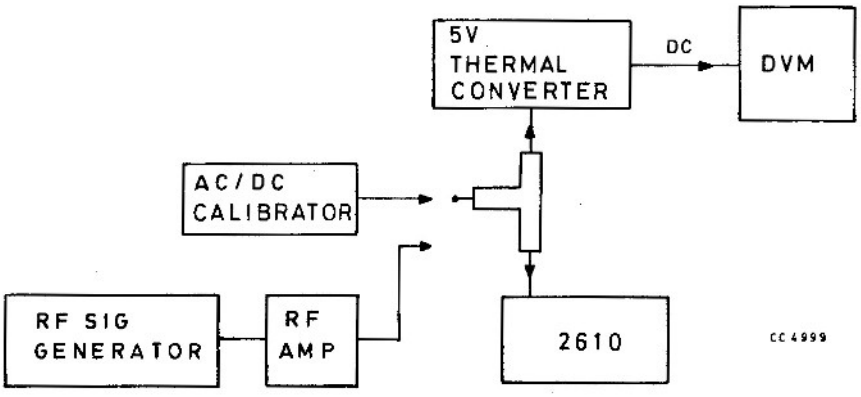


Fig. 3 Test set-up : 2 V range

20 V range

23. Using the 10 V thermal converter and the method described for the 2 V tests, check the 2610 at the following frequencies:-

Frequency	*Limits*
60 Hz	9.89 V to 10.11 V
1 kHz	(reference)
10 kHz	9.89 V to 10.11 V
100 kHz	9.89 V to 10.11 V
500 kHz	9.89 V to 10.11 V
1 MHz	9.69 V to 10.31 V
5 MHz	9.69 V to 10.31 V

200 V range

24. Using item (a) apply 200 V to the 2610 input socket at the frequencies shown below and check that all readings are within the specified limits.

Frequency	*Limits*
60 Hz	197.8 V to 202.2 V
100 Hz	197.8 V to 202.2 V
1 kHz	197.8 V to 202.2 V
5 kHz	197.8 V to 202.2 V
10 kHz	197.8 V to 202.2 V
20 kHz	197.8 V to 202.2 V

700 V range

25. Using item (a) apply 700 V to the 2610 input socket at the frequencies shown below and check that all readings are within the specified limits.

Frequency	*Limits*
60 Hz	687 V to 713 V
100 Hz	687 V to 713 V
1 kHz	687 V to 713 V

Analogue output

Test equipment : items (a),(b)

26. Apply 20 V at 1 kHz from the calibrator to the 2610 input socket. Connect the digital voltmeter to the 2610 rear panel d.c. output socket. Adjust the level from the calibrator to obtain a reading on the 2610 of 20.00 V. Check that the d.c. output indicated on the digital voltmeter is 2.0 V ±0.1 V.

ADJUSTMENT AND RECALIBRATION

27. This section contains realignment instructions for 2610 and these should be carried out if components have been replaced or if the instrument performance is found to be below the performance specification quoted in Chap. 1.

28. Preset components and test point locations are shown in Fig. 1 of this chapter and their circuit connections in the servicing diagrams in Chap. 7. Pin connections for the integrated circuits and transistors are shown in Table 2.

29. Test equipment items with descriptions are listed in Table 1.

Power supply

Test equipment : item (b)

30. Connect the digital voltmeter between test point 11 and board ground. Adjust R96 until the d.v.m. displays +5.1 V ±0.1 V. Check that the following voltages with respect to board ground are within the specified limits.

Voltage line	*Test point*	*Limits*
+20 V	TP13	+19 V to +22 V
-20 V	-ve side R67/R65	-19 V to -22 V
+12 V	TP9	+11.5 V to +13 V
-12 V	-ve side R119	-11.5 V to -13 V
-5 V	TP8	-5.0 V to -5.2 V

Driver amplifier d.c. balance

Test equipment : item (a)

31. Set the 2610 to d.c. coupling and select the 200 mV range. Apply 200 mV d.c. from the calibrator. Adjust potentiometer R41 until the 2610 displays the same reading (±3 counts) for a positive or negative input.

Analogue to digital converter

Test equipment : item (a)

32. Set the 2610 to d.c. coupling and select the 200 mV range. Apply +200 mV d.c. from the calibrator. Adjust potentiometer R135 for a displayed reading of 200.0 mV.

Thermal sensor balance

Test equipment : item (a)

33. With the 2610 set to d.c. coupling and the 200 mV range selected, apply +20 mV d.c. from the calibrator. Adjust potentiometer R118 for a displayed reading of 19.8 mV ±0.2 mV.

A-D converter recheck

Test equipment : item (a)

34. Set the 2610 to d.c. coupling and select the 200 mV range. Apply +200 mV d.c. from the calibrator. Adjust potentiometer R135 for a display reading of 200.0 mV.

20 mV amplifier preliminary d.c. balance

Test equipment : item (a)

35. This test must be carried out in a temperature controlled environment at 23°C ±1°C.

36. Select the 20 mV range on the 2610 and apply 20 mV d.c. from the calibrator. Adjust potentiometer R17 until the 2610 displays the same voltage (±3 counts) for a positive or negative input.

Analogue meter

Test equipment : item (a)

37. Select the 2 V range and apply +2 V d.c. from the calibrator to the 2610 input. Adjust potentiometer R112 for a reading of 0 dB on the analogue meter.

Frequency response

Test equipment : items (a),(c),(d),(f),(g)

38. Frequency response tests on the 2 mV to 200 mV ranges are carried out using micropotentiometers to establish signals of known flat frequency response at the 2610 input socket. Refer to the Frequency Response section of the Performance Tests for details of using these devices. The 2 V to 700 V ranges are tested directly against the a.c./d.c. calibrator (item (a)).

Driver amplifier frequency response

39. Select the 2610 200 mV range and apply 200 mV via the 200 mV micropotentiometer. Adjust trimmer C39 to set the high frequency response and trimmer C113 to set the mid-band frequency response. If necessary select value of C34 to obtain adequate coverage on C113. Repeat adjustments of C39 and C113 until the optimum response is obtained. If frequency response at 500 kHz is too high, change C33 to a lower value and repeat adjustments for C39 and C113.

20 mV amplifier frequency response

40. Select the 2610 20 mV range and apply 20 mV via the 20 mV micropotentiometer. Adjust trimmer C21 to set the high frequency response and trimmer C17 to set the mid-band frequency response. Repeat these adjustments until the optimum response is obtained.

2 mV amplifier frequency response

41. Apply 2 mV via the 2 mV micropotentiometer and adjust trimmer C22 to set the high frequency response.

2 V attenuator frequency response

42. Connect the calibrator (item (a)) to the 2610 input; select the 2 V range and apply 2 V. Adjust trimmer C3 to set the attenuator flatness at 50 kHz. On some instruments the value of R143 has been selected to improve the high frequency response.

20 V attenuator frequency response

43. Repeat the 2 V test with the 2610 set to the 20 V range and with 20 V applied to the 2610 input. Adjust trimmer C6 to set the attenuator flatness at 50 kHz.

200 V attenuator frequency response

44. Repeat the 2 V test with the 200 V range selected and with 200 V applied. Adjust trimmer C9 to set the flatness of the attenuator at 20 kHz.

700 V attenuator frequency response

45. Apply 700 V from the calibrator and adjust trimmer C12 for optimum response at 1 kHz.

Frequency response recheck

46. Repeat adjustments in paras. 39 to 45 until no further improvement is obtained.

20 mV amplifier d.c. balance

Test equipment : item (a)

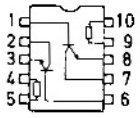
47. This test must be carried out in a temperature controlled environment at 23°C ±1°C.

48. Loosely fit the top cover; switch on the 2610 and allow at least 2 hours to stabilize. Select the 20 mV range, d.c. coupling and apply 20 mV d.c. from the calibrator. Adjust potentiometer R17 until the 2610 displays the same voltage to within ±3 counts for a positive or negative input. Refit the case, allow the 2610 to restabilize and check that the polarity reversal error is still within ±3 counts.

TABLE 2 INTEGRATED CIRCUIT CONNECTIONS

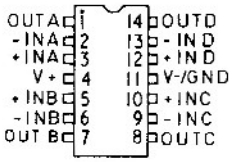
TFA 004
THIN FILM
ASSEMBLY

RMS SENSOR



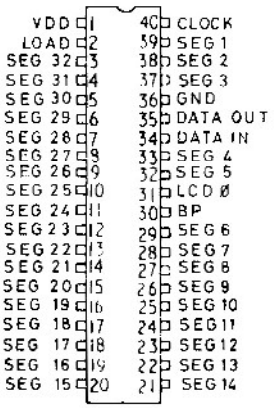
TL 074 CN
QUAD J FET

INPUT
OPERATIONAL
AMPLIFIER

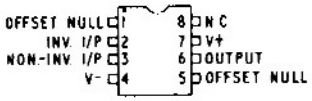


HLCD 0438

SERIAL INPUT
LCD DRIVER

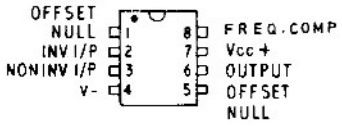


μA741CN
OPERATIONAL
AMPLIFIER.



μA 748 CN

OPERATIONAL
AMPLIFIER



2114 AL
1K x 4 BIT
STATIC RAM

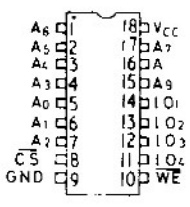
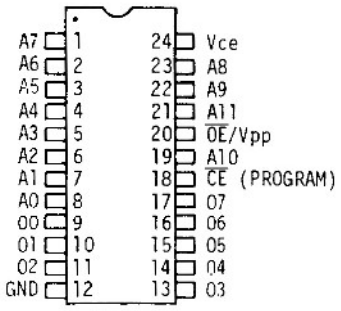
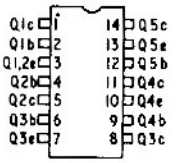


TABLE 2 INTEGRATED CIRCUIT CONNECTIONS (contd.)

B 2732 A
4K x 8 BIT UV
EPROM

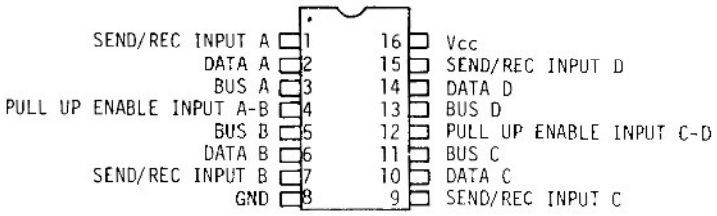


CA3046
5 TRANSISTOR
ARRAY



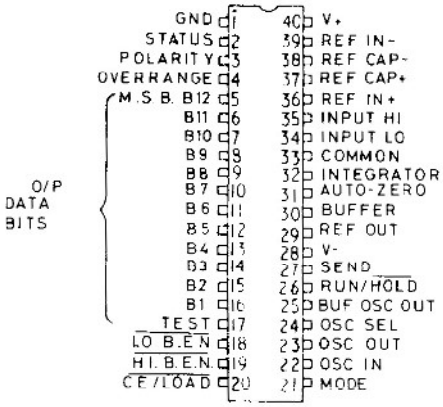
Q1 Q2
ONE DIFFERENTIALLY CONNECTED PAIR

3448
QUAD 3 STATE BUS TRANSCEIVER

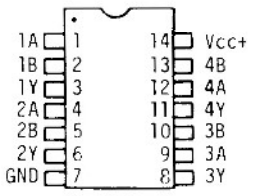


SEND/REL	ENABLE	INFO. FLOW
0	X	BUS → DATA
1	1	DATA → BUS
1	0	DATA → BUS

7109
A-D
CONVERTER
12 BIT



74 LS 00
QUAD 2 I/P
+ve NAND
GATES

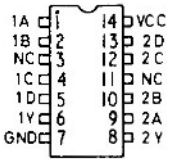


A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

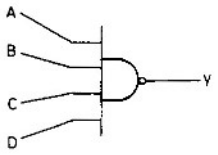
TABLE 2 INTEGRATED CIRCUIT CONNECTIONS (contd.)

74 LS 20

DUAL 4 I/P +VE NAND GATES

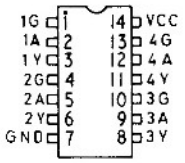


$Y = \overline{ABCD}$



74 LS 125

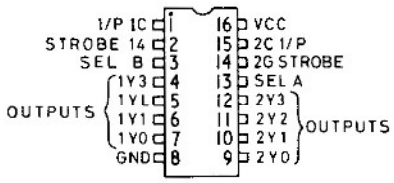
QUAD 3 STATE OUTPUT BUFFER



ENABLE	INPUT	OUTPUT
G	A	Y
0	1	1
0	0	0
1	X	Z

74 LS 155

3 to 8 LINE DECODER

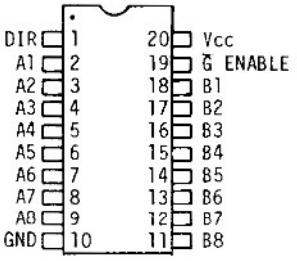


INPUTS				OUTPUTS							
SELECT			STROBE	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
C+	B	A	G=	2Y0	2Y1	2Y2	2Y3	1Y0	1Y1	1Y2	1Y3
X	X	X	1	1	1	1	1	1	1	1	1
0	0	0	0	0	1	1	1	1	1	1	1
0	0	1	0	1	0	1	1	1	1	1	1
0	1	0	0	1	1	0	1	1	1	1	1
0	1	1	0	1	1	1	0	1	1	1	1
1	0	0	0	1	1	1	1	0	1	1	1
1	0	1	0	1	1	1	1	1	0	1	1
1	1	0	0	1	1	1	1	1	1	0	1
1	1	1	0	1	1	1	1	1	1	1	0

+C = inputs 1C and 2C connected together
+G = inputs 1G and 2G connected together

74 LS 245

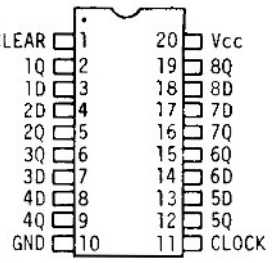
OCTAL BUS TRANSCEIVER WITH 3 STATE NON INVERTED OUTPUT



ENABLE	DIRECTION CONTROL	OPERATION
$\overline{G}$	DIR	
0	0	B DATA TO A BUS
0	1	A DATA TO B BUS
1	X	ISOLATION

74 LS 273

OCTAL EDGE TRIGGERED FLIP FLOP



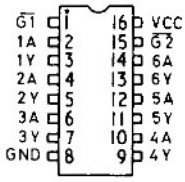
INPUTS			OUTPUT
CLEAR	CLOCK	D	Q
0	X	X	0
1	0	X	NC
1	1	X	NC
1	+	1	1
1	+	0	0

NC = NO CHANGE

TABLE 2 INTEGRATED CIRCUIT CONNECTIONS (contd.)

74 LS 365

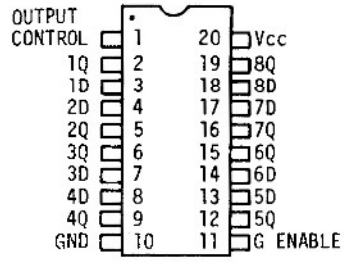
HEX DRIVERS
NON INVERTED
3 STATE
GATED ENABLE
INPUT



ENABLE G1	ENABLE G2	INPUT A	OUTPUT Y
0	0	1	1
0	0	0	0
0	1	X	Z
1	0	X	Z
1	1	X	Z

74 LS 373

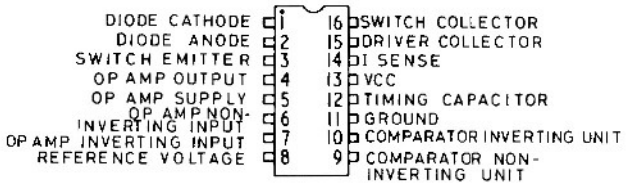
OCTAL
D TYPE
3 STATE
TRANSPARENT
LATCH



OUTPUT CONTROL	ENABLE G	ENABLE D	OUTPUT
0	1	1	1
0	1	0	0
1	X	X	Z
0	0	X	NC

NC = NO CHANGE
Z = OFF (HIGH IMPEDANCE) STATE

μA 78 S 40
REGULATOR
SUB SYSTEM



P8085A

8 BIT
N CHANNEL
MICROPROCESSOR

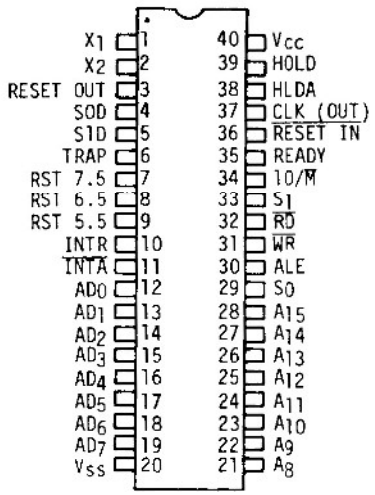


TABLE 2 INTEGRATED CIRCUIT CONNECTIONS (contd.)

8291A

GPIB TALKER/
LISTENER

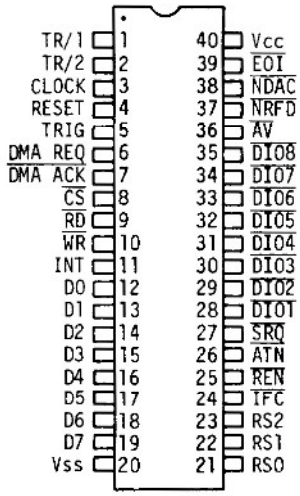
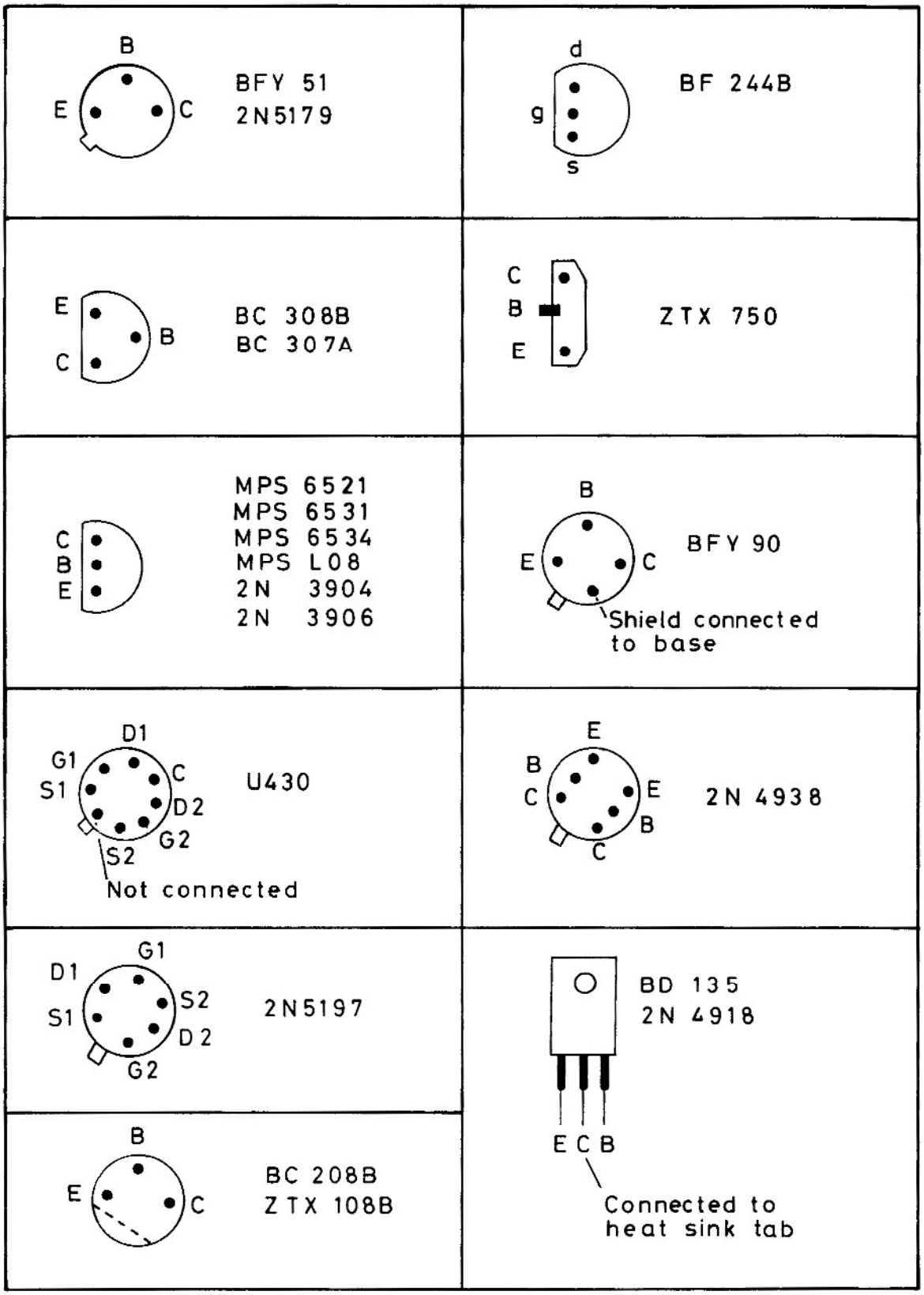


TABLE 3 TRANSISTOR CONNECTIONS



Chapter 6

REPLACEABLE PARTS

CONTENTS

INTRODUCTION

1. Each sub-assembly or printed circuit board in this equipment has been allocated a reference designator code, e.g. AA00,AB01,AC02.

2. The complete component reference includes its reference designator as a prefix e.g. AA00C1(capacitor C1 on sub-assembly AA00) but for convenience in the text and diagrams the prefix is omitted unless it is needed to avoid confusion. However when ordering replacements or in correspondence the complete component reference must be quoted.

ABBREVIATIONS

3. Electrical components are listed in alpha-numerical order of their complete circuit reference and the following standard abbreviations are used:

ADC	analogue-digital converter
CAP	capacitor
CARR	carrier
CARB	carbon
CC	carbon composition
CDE CNV	code converter
CER	ceramic
CERM	cermet

CF	carbon film
COAX	coaxial
CON	connector
CTR	counter
DAC	digital-analogue converter
DEC/DMX	decoder/demultiplexer
DECOD	decoder
DIL	dual in-line
DIV	divider
DRIV	driver
ELEC	electrolytic
ENCOD	encoder
FEM	female
FF	flip-flop (bistable)
FILTERCON	filtering capacitor
GER	germanium
GP	general purpose
ICA	integrated circuit, analogue
ICD	integrated circuit, digital
IND	inductor
INV	inverter
LD/T	lead through
MF	metal film
MG	metal glaze
MISC	miscellaneous
MO	metal oxide
MP	microprocessor
MP SUPP	microprocessor support
MUX	multiplexer
NET	network
PLAS	plastic
PLL	phase-locked loop
Q/ACT	quick acting
RECT	rectifier
RES	resistor
RV	resistor, variable
RX	receiver
SAPPH	sapphire
SEC	secondary
SH REG	shift register
SIL	silicon
SW	switch
T/LAG	time lag
TANT	tantalum
TOG	toggle

TRANS	transistor
TX	transmitter
VAR	variable
VREG	voltage regulator
WW	wirewound
!	static sensitive component

COMPONENT VALUES

4. One or more of the components fitted in the equipment may differ from those listed in this chapter for any of the following reasons:

(a) Components indicated by a * have their values selected during test to achieve particular performance limits.

(b) Owing to supply difficulties, components of different value or type may be substituted provided the overall performance of the equipment is maintained.

(c) As part of a policy of continuous development, components may be changed in value or type to obtain detail improvements in performance.

5. When there is a difference between the component fitted and the one listed, always use as a replacement the same type and value as found in the equipment.

ORDERING

6. When ordering replacements, address the order to our Service Division (address on rear cover) or nearest agent and specify the following for each component required:-

(1) Type# and serial number of equipment.

(2) Complete circuit reference.

(3) Description.

(4) Part number.

#As given on the serial number label at the rear of the equipment; if this is superseded by a model number label, quote the model number instead of the type number.

Circuit Ref	Description	Part Number
Unit AA00	- CHASSIS ASSEMBLY	
	7. When ordering, prefix circuit reference with AA00	
C1	CAP ELEC 4700UF 16V 10%+ TAGS	26426-091P
D1	DIODE BRIDGE BY260 200V 12A	28359-190S
D2	DIODE BRIDGE BY260 200V 12A	28359-190S
FS1	FUSE T/LAG 0.16A 20X5MM	23411-054T
	FUSE T/LAG 0.31A 20X5MM	23411-049W
	FUSEHOLDER PANEL 20X5MM	23416-192R
	COVER FOR FUSEHOLDER	23416-198E
FS2	FUSE T/LAG 0.16A 20X5MM	23411-054T
	FUSE T/LAG 0.31A 20X5MM	23411-049W
	FUSEHOLDER PANEL 20X5MM	23416-192R
	COVER FOR FUSEHOLDER	23416-198E
M1	METER EDGEWISE 1MA	44579-013Y
SK1	TERM SCREW 2MM SKT BLACK - DC OUTPUT	23235-205Y
SK2	CON RF BNC FEM 50 BKHD INS - RF INPUT	23443-449Y
S1	SW TOG 2P2W LEVER MAINS - ON/OFF	23462-249Z
	COVER (MAINS SW)	37590-298U
S2	SW SLIDE DPCO PANEL MTG - VOLTS ADJUST	23467-161W
	COVER (VOLTS ADJUST SW)	37590-211G
T1	TRANSFMR PRI 2X120V SEC 2X9V	23622-001H
	CON PWR MALE 3 FXD RF FILTER	23423-150L
	COVER FOR PWR CON INS PVC BLK	23423-999Y

Circuit Ref	Description	Part Number
Unit AB01	- MOTHER BOARD	
	8. When ordering, prefix circuit reference with AB01	
	Complete unit	44828-676B
C1	CAP PETP .047UF 1000V 10%	26582-227V
C2	CAP MICA 39PF 400V	26272-484Z
C3	CAP VAR PLAS 10PF 2PF TRIM	26876-001F
C4	CAP MICA 180PF 350V 2%	26272-068K
C5	CAP MICA 15PF 400V	26272-483A
C6	CAP VAR PLAS 10PF 2PF TRIM	26876-001F
C7	CAP CER 100PF 63V 2% PLATE	26343-477V
C8	CAP CER 33PF 63V 5% PLATE	26343-471Y
C9	CAP VAR PLAS 10PF 2PF TRIM	26876-001F
C10	CAP CER 150PF 63V 2% PLATE	26343-479W
C11	CAP CER 56PF 63V 2% PLATE	26343-474J
C12	CAP VAR PLAS 65PF 5.5PF TRIM	26878-408Y
C13	CAP CER 68PF 63V 2% PLATE	26343-475F
C14	CAP CER 10NF 50V 20% x7R MON AX	26346-120Y
C15	CAP CER 4.7PF 63V 0.5% PLATE	26343-461B
C16	CAP TANT 10UF 35V 20% BEAD	26486-225C
C17	CAP VAR CER 20PF 4.5PF TRIM	26847-114Z
C18	CAP TANT 10UF 35V 20% BEAD	26486-225C
C19	CAP CER 100N 100V 20% M/LAYER	26383-532E
C20	CAP CER 0.022UF 18V 20% DISC	26383-007R
C21	CAP VAR PLAS 10PF 2PF TRIM	26876-001F
C22	CAP VAR PLAS 10PF 2PF TRIM	26876-001F
C23	CAP CER .001UF 63V 10% PLATE	26383-585M
C24	CAP PETP 0.47UF 63V 10% RAD	26582-410P
C25	CAP CER 56PF 63V 2% PLATE	26343-474J
C26	CAP CER 0.022UF 18V 20% DISC	26383-007R
C27	CAP CER 56PF 63V 2% PLATE	26343-474J
C28	CAP CER .0047UF 63V 10% PLATE	26383-591B
C29	CAP CER 0.047UF 25V 20% DISC	26383-017U
C30	CAP CER .0047UF 63V 10% PLATE	26383-591B
C31	CAP CER .001UF 63V 10% PLATE	26383-585M
C32	CAP ELEC 10UF 35V 20%	26421-112Z
C33	CAP PETP 33NF 250V 10% RAD	26582-205M
C34 *	CAP CER 39PF 63V 5% PLATE	26343-472N
C35	CAP CER .0047UF 63V 10% PLATE	26383-591B
C36	CAP CER .0047UF 63V 10% PLATE	26383-591B
C37	CAP CER 100N 100V 20% M/LAYER	26383-532E
C38	CAP CER .0047UF 63V 10% PLATE	26383-591B
C39	CAP VAR PLAS 10PF 2PF TRIM	26876-001F
C40	CAP CER .0047UF 63V 10% PLATE	26383-591B

Circuit Ref	Description	Part Number
Unit AB01	- MOTHER BOARD (Contd.)	
C41	CAP CER .0047UF 63V 10% PLATE	26383-591B
C42	CAP ELEC 220UF 25V 20%+ PCB	26423-254E
C43	CAP ELEC 220UF 25V 20%+ PCB	26423-254E
C44	CAP ELEC 470UF 6.3V 20%+ PCB	26423-261L
C45	CAP ELEC 470UF 6.3V 20%+ PCB	26423-261L
C46	CAP ELEC 220UF 25V 20%+ PCB	26423-254E
C47	CAP ELEC 220UF 25V 20%+ PCB	26423-254E
C48	CAP CER .0047UF 63V 10% PLATE	26383-591B
C49	CAP TANT 2.2UF 20V 20% TUB	26486-540K
C50	CAP TANT 10UF 20V 20% TUB	26488-212N
C51	CAP CER .0018UF 63V 10% PLATE	26383-586C
C52	CAP ELEC 470UF 16V 20%+ PCB	26423-262J
C53	CAP ELEC 22UF 25V 20%+ TUB	26415-805K
C54	CAP ELEC 220UF 25V 20%+ PCB	26423-254E
C55	CAP ELEC 22UF 63V 20%+ PCB	26423-223U
C56	CAP TANT 2.2UF 20V 20% TUB	26486-540K
C57	CAP CER .001UF 63V 10% PLATE	26383-585M
C58	CAP ELEC 220UF 16V 20%	26421-124G
C59	CAP CER 0.047UF 25V 20% DISC	26383-017U
C60	CAP ELEC 220UF 25V 20%+ PCB	26423-254E
C61	CAP ELEC 22UF 63V 20%+ PCB	26423-223U
C62	CAP ELEC 22UF 63V 20%+ PCB	26423-223U
C63	CAP ELEC 22UF 63V 20%+ PCB	26423-223U
C64	CAP ELEC 22UF 63V 20%+ PCB	26423-223U
C65	CAP ELEC 2.2UF 50V 20% L/LEAK	26421-009E
C66	CAP ELEC 22UF 63V 20%+ PCB	26423-223U
C67	CAP CER 0.01UF 25V 20% DISC	26383-006C
C68	CAP CER 0.047UF 25V 20% DISC	26383-017U
C69	CAP CER 0.047UF 25V 20% DISC	26383-017U
C70	CAP CER 470PF 63V 10% PLATE	26383-582T
C71	CAP ELEC 10UF 50V 20% L/LEAK	26421-013U
C72	CAP PETP 0.1UF 100V 10% RAD	26582-211B
C73	CAP CER 330PF 63V 2% PLATE	26343-483D
C74	CAP CER 180PF 63V 2% PLATE	26343-480V
C75	CAP CER 180PF 63V 2% PLATE	26343-480V
C76	CAP CER 180PF 63V 2% PLATE	26343-480V
C77	CAP CER 33PF 63V 5% PLATE	26343-471Y
C78	CAP ELEC 4.7UF 63V 20%+	26415-801M
C79	CAP ELEC 1000UF 6.3V 20%+ PCB	26423-268D
C80	CAP CER 0.047UF 25V 20% DISC	26383-017U
C81	CAP CER 0.047UF 25V 20% DISC	26383-017U
C82	CAP CER 0.047UF 25V 20% DISC	26383-017U
C83	CAP TANT 10UF 35V 20% BEAD	26486-225C

Circuit Ref	Description	Part Number
Unit AB01	- MOTHER BOARD (Contd.)	
C84	CAP TANT 10UF 35V 20% BEAD	26486-225C
C85	CAP CER 0.047UF 12V 20% DISC	26383-016E
C86	CAP CER 0.047UF 25V 20% DISC	26383-017U
C87	CAP CER 0.047UF 25V 20% DISC	26383-017U
C88	CAP CER 0.047UF 25V 20% DISC	26383-017U
C89	CAP CER 0.047UF 25V 20% DISC	26383-017U
C90	CAP CER 0.047UF 25V 20% DISC	26383-017U
C91	CAP PETP 1.0UF 100V 10% RAD	26582-217U
C92	CAP PETP 0.047UF 250V 10% RAD	26582-206C
C93	CAP PETP 0.047UF 250V 10% RAD	26582-206C
C94	CAP CER 18PF 63V 5% PLATE	26343-468Y
C95	CAP PETP 100N 63V 10% RAD	26582-429F
C96	CAP CER .0047UF 63V 10% PLATE	26383-591B
C97	CAP TANT 10UF 35V 20% BEAD	26486-225C
C98	CAP CER .0047UF 63V 10% PLATE	26383-591B
C99	CAP CER .0047UF 63V 10% PLATE	26383-591B
C100	CAP CER .0047UF 63V 10% PLATE	26383-591B
C101	CAP CER .0047UF 63V 10% PLATE	26383-591B
C102	CAP CER 0.47UF 63V 10% PLATE	26383-531H
C103	CAP CER .0047UF 63V 10% PLATE	26383-591B
C104	CAP CER .0047UF 63V 10% PLATE	26383-591B
C105	CAP CER .001UF 63V 10% PLATE	26383-585M
C106	CAP CER .022UF 18V 20% DISC	26383-007R
C107	CAP ELEC 33UF 25V 20% SUBMIN	26421-115U
C108	CAP TANT 10UF 35V 20% BEAD	26486-225C
C109	CAP CER .001UF 63V 10% PLATE	26383-585M
C110	CAP CER 0.1UF 30V 20% DISC	26383-031S
C111	CAP TANT 10UF 35V 20% BEAD	26486-225C
C112	CAP CER 0.047UF 25V 20% DISC	26383-017U
C113	CAP VAR CER 10PF 2PF TRIM	26876-001F
C115	CAP CER 0.047UF 25V 20% DISC	26383-017U
C116	CAP CER 0.047UF 25V 20% DISC	26383-017U
C117	CAP CER 22PF 500V 5% DISC	26343-061N
C118	CAP CER 47PF 63V 5% PLATE	26343-473L
C119	CAP CER 33PF 63V 5% PLATE	26383-471Y
C120	CAP TANT 10UF 35V 20% BEAD	26486-225C
C121	CAP CER .0018UF 63V 10% PLATE	26383-586C
C122	CAP CER .0018UF 63V 10% PLATE	26383-586C
C123	CAP PETP 6.8NF 63V 1% RAD	26538-922Z
C125	CAP CER .001UF 63V .5P PLATE	26345-502Z
C127	CAP CER 82PF 63V 5% PLATE	26343-476G
C128	CAP CER 100PF 63V 2% PLATE	26343-477V
C130	CAP MICA 39PF 400V	26272-484Z

Circuit Ref		Description	Part Number
Unit AB01		- MOTHER BOARD (Contd.)	
D1	!	DIODE H/CARR BAT42 30V FAST	28349-013N
D2	!	DIODE H/CARR BAT42 30V FAST	28349-013N
D5		DIODE SIL 1N4148 100V JUNC	28336-676J
D6		DIODE SIL 1N4148 100V JUNC	28336-676J
D7		DIODE ZENER 1N825/A 6.2V 5%	28371-494Z
D9		DIODE SIL 1N4148 100V JUNC	28336-676J
D10		DIODE SIL 1N4148 100V JUNC	28336-676J
D11		DIODE RECT 1N4004 400V	28357-028K
D12		DIODE RECT 1N4004 400V	28357-028K
D13		DIODE RECT 1N4004 400V	28357-028K
D14		DIODE RECT 1N4004 400V	28357-028K
D15		DIODE SIL 1N4148 100V JUNC	28336-676J
D16		DIODE RECT 1N4004 400V	28357-028K
D17		DIODE ZENER BZY88C12 12V 5%	28372-143U
D18		DIODE ZENER BZY88C12 12V 5%	28372-143U
D19		DIODE RECT 11DQ04 40V	28355-170U
D20		DIODE SIL 1N4148 100V JUNC	28336-676J
D21		DIODE SIL 1N4148 100V JUNC	28336-676J
D22		DIODE SIL 1N4148 100V JUNC	28336-676J
D23		DIODE SIL 1N4148 100V JUNC	28336-676J
D24		DIODE SIL 1N4148 100V JUNC	28336-676J
D25		DIODE ZENER 1N825/A 6.2V 5%	28371-494Z
IC1		ICA AMP UA748CN GP DIL8	28461-310M
IC2		ICA AMP UA741CN GP DIL8	28461-304T
IC3		ICA VREG UA78S40 SMPS CTRL DIL16	28461-729E
IC4		ICA VREG UA78S40 SMPS CTRL DIL16	28461-729E
IC5		ICA AMP UA741CN GP DIL8	28461-304T
IC6		ICA AMP TL074CN QUAD FET I/P	28461-349H
IC7		ICA ARRAY CA3046 5 NPN TRAN	28461-901A
IC8		THIN FILM ASSY RMS SENSOR	44389-004F
IC9	!	ICM MP P8085A 8BIT NMOS	28469-396K
IC10		ICD DEC/DMX 74LS155 3-8	28465-026J
IC11		ICD LATCH 74LS373 OCT 3ST	28462-410E
IC12		ICD BUFF 74LS245 OCT TXRX	28469-188B
IC13	!	ICM PROM 2732A 4KX8BIT UV1(PROGRAMMED)	44533-050S
IC14	!	ICM RAM 2114AL-4 1KX4BIT 200NS	28469-306Y
IC15	!	ICM RAM 2114AL-4 1KX4BIT 200NS	28469-306Y
IC16	!	ICA ADC 7109 12BIT MOS DIL40	28469-412N
IC17		ICD FF D 74LS273 OCT +EDGTR	28462-615U
IC18		ICD NAND 74LS00 QUAD 2INP	28466-345H

Circuit Ref	Description	Part Number
Unit AB01	- MOTHERBOARD (Contd.)	
L1	IND CHOKE S.M.P.S.	44190-043H
L2	IND CHOKE 22UH 10% LAQ	23642-557S
L3	IND CHOKE S.M.P.S.	44190-043H
L4	IND CHOKE 22UH 10% LAQ	23642-557S
L5	IND CHOKE 22UH 10% LAQ	23642-557S
PLA	1 STRIP OF 6 X TERM C/PIN 0.64SQx6MM	23435-188V
PLB	1 STRIP OF 15 X TERM C/PIN 0.64SQx6MM	23435-188V
PLC	CON JUMP FEM 1 ROW 2P	23435-990X
PLD	CON JUMP FEM 1 ROW 2P	23435-990X
PLE	CON JUMP FEM 1 ROW 2P	23435-990X
PLF	2 STRIPS OF 10 X TERM C/PIN 0.64SQx6MM	23435-188V
R1	RES MF 470R 1/4W 2% 100PPM	24773-265M
R2	RES MF 111K1 1/2W 0.1% 15PPM	24723-849D
R3	RES MF 450K 1/4W 0.1% 15PPM	24723-853T
R4	RES MF 111K1 1/2W 0.1% 15PPM	24723-849D
R5	RES MF 900K 1/2W 0.1% 15PPM	24723-850S
R6	RES MF 111K1 1/2W 0.1% 15PPM	24723-849D
R7	RES MF 900K 1/2W 0.1% 15PPM	24723-850S
R8	RES MF 285K7 1/2W 0.1% 15PPM	24723-851W
R9	RES MF 714K3 1/2W 0.1% 15PPM	24723-852D
R10	RES MF 100K 1/4W 2% 100PPM	24773-321L
R11	RES MG 100M 0.4W @ 70C	24681-999E
R12	RES MF 3K3 1/4W 0.5% 50PPM	24773-478K
R13	RES MF 270R 1/4W 2%	24773-259T
R14	RES MF 560R 1/8W 5%	24331-965B
R15	RES MF 3K3 1/4W 0.5% 50PPM	24773-478K
R16	RES CC 10R 1/8W 5%	24331-974U
R17	RV CERM 50R LIN 1/2W 10%	25748-561L
R18	RES MF 2K7 1/4W 2%	24773-283L
R19	RES MF 1K3 1/4W 2% 100PPM	24773-276E
R20	RES MF 2K7 1/8W 5%	24331-969H
R21	RES MF 1K3 1/4W 2% 100PPM	24773-276E
R22	RES MF 2K7 1/4W 2%	24773-283L
R23	RES CC 1MO	24331-935A
R24	RES MF 10K 1/4W 2% 100PPM	24773-297M
R25	RES MF 1MO 1/4W 2% 100PPM	24773-346E
R26	RES MF 1MO 1/4W 2% 100PPM	24773-346E
R27	RES MF 10K 1/4W 2% 100PPM	24773-297M
R28	RES MF 510R 1/4W 2% 100PPM	24773-266C
R29	RES MF 4R7 1/4W 2% 100PPM	24773-217J
R30	RES MF 4R7 1/4W 2% 100PPM	24773-217J
R31	RES MF 900R 1/4W 0.1% 15PPM	24723-392N
R32	RES MF 100R 1/4W 0.1% 15PPM	24723-391Y
R33	RES MF 9K9 1/4W 0.1% 15PPM	24723-393L

Circuit Ref	Description	Part Number
Unit AB01	- MOTHERBOARD (Contd.)	
R34	RES MF 100R 1/4W 0.1% 15PPM	24723-391Y
R35	RES MF 1MO 1/4W 2% 100PPM	24773-346E
R36	RES MF 450K 1/4W 0.1% 15PPM	24723-853T
R37	RES MF 750R 1/4W 2% 100PPM	24773-270R
R38	RES MF 43K 1/4W 2% 100PPM	24773-312Z
R39	RES MF 20K 1/4W 2% 100PPM	24773-304C
R40	RES MF 390R 1/4W 2% 100PPM	24773-263P
R41	RV CERM 50R LIN 1/2W 10%	25748-561L
R42	RES MF 22R 1/4W 2% 100PPM	24773-233M
R43	RES MF 270R 1/4W 2% 100PPM	24773-259T
R44	RES MF 22R 1/4W 2% 100PPM	24773-233M
R45	RES MF 68R 1/4W 2% 100PPM	24773-245U
R46	RES MF 22R 1/4W 2% 100PPM	24773-233M
R47	RES MF 100R 1/4W 2% 100PPM	24773-249J
R48	RES MF 75R 1/4W 2% 100PPM	24773-246Y
R49	RES MF 33R 1/4W 2% 100PPM	24773-237K
R50	RES MF 33R 1/4W 2% 100PPM	24773-237K
R51	RES MF 390R 1/4W 2% 100PPM	24773-263P
R52	RES MF 68R 1/4W 2% 100PPM	24773-245U
R53	RES MF 220R 1/4W 2% 100PPM	24773-257W
R54	RES MF 1MO 1/4W 2% 100PPM	24773-346E
R55	RES MF 1K2 1/4W 2% 100PPM	24773-275H
R56	RES MF 18K 1/4W 2% 100PPM	24773-303M
R57	RES MF 1K2 1/4W 2% 100PPM	24773-275H
R58	RES MF 130R 1/4W 2% 100PPM	24773-252J
R59	RES MF 47R 1/4W 2% 100PPM	24773-241A
R60	RES MF 10R 1/4W 2% 100PPM	24773-225W
R61	RES MF 10R 1/4W 2% 100PPM	24773-225W
R62	RES MO 270R 1/2W 2% 250PPM	24573-059Y
R63	RES MF 6R8 1/4W 2% 100PPM	24773-221F
R64	RES MF 6R8 1/4W 2% 100PPM	24773-221F
R65	RES MO 270R 1/2W 2% 250PPM	24573-059Y
R66	RES MO 270R 1/2W 2% 250PPM	24573-059Y
R67	RES MO 270R 1/2W 2% 250PPM	24573-059Y
R68	RES MF 900R 1/4W 0.1% 15PPM	24723-392N
R69	RES MF 100R 1/4W 0.1% 15PPM	24723-391Y
R70	RES MF 5K6 1/4W 2% 100PPM	24773-291S
R71	RES MF 10K 1/4W 2% 100PPM	24773-297M
R72	RES MF 1R0 1/4W 2% 100PPM	24773-201M
R73	RES MF 1R0 1/4W 2% 100PPM	24773-201M
R74	RES MF 1R0 1/4W 2% 100PPM	24773-201M
R75	RES MF 180R 1/4W 2% 100PPM	24773-255V
R76	RES MF 150K 1/4W 2% 100PPM	24773-325V

Circuit Ref	Description	Part Number
Unit AB01	-MOTHER BOARD (Contd.)	
R77	RES MF 100R 1/4W 2% 100PPM	24773-249J
R78	RES MF 10K 1/4W 2% 100PPM	24773-297M
R79	RES MF 10K 1/4W 2% 100PPM	24773-297M
R80	RES MF 4K7 1/4W 2% 100PPM	24773-289W
R81	RES MF 10K 1/4W 2% 100PPM	24773-297M
R82	RES MF 4.7K 1/4W 2% 100PPM	24773-289W
R83	RES MF 4.7K 1/4W 2% 100PPM	24773-289W
R85	RES MF 100R 1/4W 2% 100PPM	24773-249J
R86	RES MF 330R 1/4W 2% 100PPM	24773-261D
R87	RES MF 10K 1/4W 2% 100PPM	24773-297M
R88	RES MF 150K 1/4W 2% 100PPM	24773-325V
R89	RES MF 16K 1/4W 2% 100PPM	24773-302X
R90	RES MF 330R 1/4W 2% 100PPM	24773-261D
R91	RES MF 330R 1/4W 2% 100PPM	24773-261D
R92	RES MF 10K 1/4W 2% 100PPM	24773-297M
R93	RES MF 10K 1/4W 2% 100PPM	24773-297M
R94	RES MF 2K0 1/4W 2% 100PPM	24773-280U
R95	RES MO 680R 1/2W 2% 250PPM	24573-069S
R96	RV CERM 10K LIN .5W 10% HORZ	25711-641G
R97	RES MF 120R 1/4W 2% 100PPM	24773-251L
R98	RES MF 10K 1/4W 2% 100PPM	24773-297M
R99	RES MF 100K 1/4W 2% 100PPM	24773-321L
R100	RES MF 22K 1/4W 2% 100PPM	24773-305R
R101	RES MF 100K 1/4W 2% 100PPM	24773-321L
R102	RES MF 10K 1/4W 2% 100PPM	24773-297M
R103	RES MF 100K 1/4W 2% 100PPM	24773-321L
R104	RES MG 10M 1/4W 5%	24321-885W
R105	RES MF 10K 1/4W 2% 100PPM	24773-297M
R106	RES MF 1M0 1/4W 2% 100PPM	24773-346E
R107	RES MF 10K 1/4W 2% 100PPM	24773-297M
R108	RES MG 10M 1/4W 5%	24321-885W
R109	RES MF 22K 1/4W 2% 100PPM	24773-305R
R110	RES MF 1K0 1/4W 2% 100PPM	24773-273A
R111	RES MF 2K4 1/4W 2% 100PPM	24773-282N
R112	RV CERM 1K0 LIN .5W 10% HORZ	25711-638G
R113	RES MF 220K 1/4W 2% 100PPM	24773-329T
R114	RES MF 270K 1/4W 1% 15PPM	24763-351U
R115	RES MF 270K 1/4W 1% 15PPM	24763-351U
R116	RES MF 270K 1/4W 1% 15PPM	24763-351U
R117	RES MF 270K 1/4W 1% 15PPM	24763-351U
R118	RV CERM 50R LIN 1/2W 10%	25748-561L

Circuit Ref	Description	Part Number
Unit AB01	- MOTHER BOARD (Contd.)	
R119	RES MF 200K 1/4W 2% 100PPM	24773-328D
R120	RES MF 100K 1/4W 2% 100PPM	24773-321L
R121	RES MF 4K7 1/4W 2% 100PPM	24773-289W
R122	RES MF 4K7 1/4W 2% 100PPM	24773-289W
R123	RES MF 4K7 1/4W 2% 100PPM	24773-289W
R124	RES MF 4K7 1/4W 2% 100PPM	24773-289W
R125	RES MF 4K7 1/4W 2% 100PPM	24773-289W
R126	RES MF 4K7 1/4W 2% 100PPM	24773-289W
R127	RES MF 4K7 1/4W 2% 100PPM	24773-289W
R128	RES MF 4K7 1/4W 2% 100PPM	24773-289W
R129	RES MF 4K7 1/4W 2% 100PPM	24773-289W
R130	RES MF 4K7 1/4W 2% 100PPM	24773-289W
R131	RES MF 4K7 1/4W 2% 100PPM	24773-289W
R132	RES MF 4K7 1/4W 2% 100PPM	24773-289W
R133	RES MF 47K 1/4W 2% 100PPM	24773-313H
R134	RES MF 1K5 1/4W 2% 100PPM	24773-277U
R135	RV CERM 500R LIN 1/2W 10%	25748-564G
R136	RES MF 3K0 1/4W 2% 100PPM	24773-284J
R137	RES MF 200K 1/4W 2% 100PPM	24773-328D
R138	RES MF 100K 1/4W 2% 100PPM	24773-321L
R139	RES MF 1M0 1/4W 2% 100PPM	24773-346E
R140	RES MF 750R 1/4W 2% 100PPM	24773-270R
R141	RES CC 10K 1/8W 5%	24331-972H
R142	RES CC 33K 1/8W 5%	24331-973E
R143 *	RES MF 56R 1/4W 2% 100PPM	24773-243H
R144	RES MF 100K 1/4W 2% 100PPM	24773-321L
R145	RES MF 2R2 1/4W 2% 100PPM	24773-209E
R146	RES MF 2R2 1/4W 2% 100PPM	24773-209E
R147	RES MF 150R 1/4W 2% 100PPM	24773-253F
R148	RES MF 4K7 1/4W 2% 100PPM	24773-289W
R149	RES MF 24K 1/4W 2% 100PPM	24773-306B
R150	RES MF 1K0 1/4W 2% 100PPM	24773-273A
R151	RES MF 2K0 1/4W 2% 100PPM	24773-280U
R152	RES MF 2K4 1/4W 2% 100PPM	24773-282N
R153	RES MF 1K2 1/4W 2% 100PPM	24773-275H
R154	RES MF 10K 1/4W 2% 100PPM	24773-297M
R155	RES MF 1M0 1/4W 2% 100PPM	24773-346E
R156	RES 100K 1/4W 2% 100PPM	24773-321L
R159	RES 1M 1/4W 2% 100PPM	24773-346E
R160	RES CC 10R 1/8W 5%	24331-974U
R180	RES NET 2K7 5% 9SIP	24681-607W

Circuit Ref	Description	Part Number
Unit AB01	- MOTHER BOARD (Contd.)	
RLA	RELAY REED 1NO 5V 1KV SWITCH	23486-517D
RLB	RELAY REED 1NO 5V 1KV SWITCH	23486-517D
RLC	RELAY REED 1NO 5V 1KV SWITCH	23486-517D
RLD	RELAY MAG 2CO 5V 62R	23486-101F
RLE	RELAY MAG 2CO 5V 62R	23486-101F
RLF	RELAY MAG 2CO 5V 62R	23486-101F
RLH	RELAY MAG 2CO 5V 62R	23486-101F
RLJ	RELAY REED 1NO 5V 500R DIL	23486-436N
RLK	RELAY REED 1CO 5V 200R DIL	23486-518T
RLL	RELAY REED 1CO 5V 200R DIL	23486-518T
RLM	RELAY REED 1NO 5V 500R DIL	23486-436N
RLN	RELAY MAG 2CO 5V 62R	23486-101F
SKA	S/C ACC SKT DIL40 LOW PROFILE (IC9)	28488-046J
SKB	S/C ACC SKT DIL24 LOW PROFILE (IC13)	28488-044N
SKC	S/C ACC SKT DIL18 LOW PROFILE (IC14)	28488-042U
SKD	S/C ACC SKT DIL18 LOW PROFILE (IC15)	28488-042U
SKE	S/C ACC SKT DIL40 LOW PROFILE (IC16)	28488-046J
TR1	TR PSI DUA 2N4938 40V 300M	28434-826H
TR2	TR PSI DUA 2N4938 40V 300M	28434-826H
TR3	TR NJF DUA 2N5197 50V 50M	28459-044W
TR4	TR NJF AMP BF244B 30V 200M	28459-011S
TR5	TR PSI GEN BC308B 20V 130M	28433-455R
TR6	TR PSI SW MPSL08 12V 700M	28431-767E
TR7	TR NSI AMP MPS6521 25V 400M	28453-536L
TR8	TR PSI SW MPSL08 12V 700M	28431-767E
TR9	TR PSI DUA 2N4938 40V 300M	28434-826H
TR10	TR NJF DUA U430 25V 450M	28459-039V
TR11	TR NSI AMP BFY90 15V 1G	28452-157R
TR12	TR NSI AMP MPS6521 25V 400M	28453-536L
TR13	TR NSI AMP MPS6521 25V 400M	28453-536L
TR14	TR PSI SW MPSL08 12V 700M	28431-767E
TR15	TR NSI AMP MPS6521 25V 400M	28453-536L
TR16	TR PSI GEN 2N3906 40V 250M	28434-856A
TR17	TR NSI GEN 2N3904 40V 250M	28454-786H
TR18	TR NSI AMP MPS6531 40V 390M	28454-749A
TR19	TR PSI AMP MPS6534 40V 260M	28434-827E
TR20	TR NSI PWR BD135 45V 50M 8W	28455-438J

Circuit Ref	Description	Part Number
Unit AB01	- MOTHER BOARD (Contd.)	
TR21	TR PSI GEN BC308B 20V 130M	28433-455R
TR22	TR PSI PWR ZTX750 45V 100M	28435-226Z
TR23	TR PSI GEN BC308B 20V 130M	28433-455R
TR24	TR PSI PWR 2N4918 40V 3M 30W	28434-896Y
TR25	TR NSI GEN BC208B 20V 150M	28452-781A
TR26	TR PSI GEN BC308B 20V 130M	28433-455R
TR27	TR NJF AMP BF244B 30V 200M	28459-011S
TR28	TR NSI GEN BC208B 20V 150M	28452-781A
TR29	TR NJF AMP BF244B 30V 200M	28459-011S
TR30	TR PSI GEN BC308B 20V 130M	28433-455R
TR31	TR PSI GEN BC308B 20V 130M	28433-455R
TR32	TR PSI GEN BC308B 20V 130M	28433-455R
TR33	TR PSI GEN BC308B 20V 130M	28433-455R
TR34	TR PSI GEN BC308B 20V 130M	28433-455R
TR35	TR PSI GEN BC308B 20V 130M	28433-455R
TR36	TR PSI GEN BC308B 20V 130M	28433-455R
TR37	TR PSI GEN BC308B 20V 130M	28433-455R
TR38	TR PSI GEN BC308B 20V 130M	28433-455R
TR39	TR NSI AMP MPS6521 25V 400M	28453-536L
TR40	TR NSI AMP BFY90 15V 1G	28452-157R
TR41	TR NSI AMP BFY90 15V 1G	28452-157R
TR42	TR NSI GEN BC208B 20V 150M	28452-781A
TR43	TR NSI GEN BC208B 20V 150M	28452-781A
TR44	TR NSI GEN BC208B 20V 150M	28452-781A
TR45	TR PSI GEN BC307A 45V 130M	28435-227H
TR46	TR NJF AMP BF244B 30V 200M	28459-011S
TR47	TR NSI GEN BC208B 20V 150M	28452-781A
TR48	TR PSI AMP BC308B 20V 130M	28433-455R
	CON PCB 5 FXD FLEX SKT } connects	23436-197U
	CON PCB 5 FXD FLEX SKT } to	23436-197U
	CON PCB 5 FXD FLEX SKT } PLB	23436-197U
	COVER RF	35903-726C
	LEAD ASSEMBLY (RF I/P SK2 fitted with coax coupling cable)	43129-928D

Circuit Ref		Description	Part Number
Unit AC01		- DISPLAY BOARD	
9. When ordering, prefix circuit reference with AC01			
		Complete unit	44828-677K
C1		CAP CER 0.047UF 25V 20% DISC	26383-017U
C2		CAP CER 0.047UF 25V 20% DISC	26383-017U
C3		CAP CER 0.047UF 25V 20% DISC	26383-017U
C4		CAP CER 56PF 63V 2% PLATE	26343-474J
C5		CAP CER 0.047UF 25V 20% DISC	26383-017U
D1		DIODE SIL 1N4148 100V JUNC	28336-676J
IC1	!	ICD DRIV HLCD-0438 LCD SER IN	28467-016B
IC2	!	ICD DRIV HLCD-0438 LCD SER IN	28467-016B
IC3		ICD FF D 74LS273 OCT +EDG TR	28462-615U
IC4		ICD BUFF 74LS125A QUAD 3ST	28469-184X
IC5		ICD NAND 74LS20 DUAL 4INP	28466-347U
R1		RES MF 10K 1/4W 2% 100PPM	24773-297M
R2		RES MF 10K 1/4W 2% 100PPM	24773-297M
R3		RES MF 10K 1/4W 2% 100PPM	24773-297M
R4		RES MF 10K 1/4W 2% 100PPM	24773-297M
R5		RES MF 330R 1/4W 2% 100PPM	24773-261D
R6		RES MF 330R 1/4W 2% 100PPM	24773-261D
R7		RES MF 10K 1/4W 2% 100PPM	24773-297M
R8		RES MF 10K 1/4W 2% 100PPM	24773-297M
R9		RES MF 2.2K 1/4W 2% 100PPM	24773-281Y
R10		RES MF 2.2K 1/4W 2% 100PPM	24773-281Y
TR1		TR PSI GEN BC308B 20V 130M	28433-455R
TR2		TR PSI GEN BC308B 20V 130M	28433-455R
		DISPLAY UNIT LCD	44990-388P
		CON JUMP MALE 15 FLEX 2"LG (to Motherbd)	23436-103N
		CON JUMP MALE 12 FLEX 1"LG (to Keybd)	23436-106F

Circuit Ref	Description	Part Number
Unit AC02	- KEYBOARD	
10. When ordering, prefix circuit reference with AC02		
	Complete unit	44828-678A
D40	DIODE LED YL4484 3V YELLOW	28624-116K
D41	DIODE LED YL4484 3V YELLOW	28624-116K
D42	DIODE SIL IN4148 100V JUNC	28336-676J
D43	DIODE SIL IN4148 100V JUNC	28336-676J
D44	DIODE SIL IN4148 100V JUNC	28336-676J
D45	DIODE SIL IN4148 100V JUNC	28336-676J
SA	SW PUSH 1P1W MOM LIPA D6	23465-301P
SB	SW PUSH 1P1W MOM LIPA D6	23465-301P
SC	SW PUSH 1P1W MOM LIPA D6	23465-301P
SD	SW PUSH 1P1W MOM LIPA D6	23465-301P
SE	SW PUSH 1P1W MOM LIPA D6	23465-301P
SF	SW PUSH 1P1W MOM LIPA D6	23465-301P
SH	SW PUSH 1P1W MOM LIPA D6	23465-301P
SJ	SW PUSH 1P1W MOM LIPA D6	23465-301P
SK	SW PUSH 1P1W MOM LIPA D6	23465-301P
SL	SW PUSH 1P1W MOM LIPA D6	23465-301P
SM	SW PUSH 1P1W MOM LIPA D6	23465-301P
SN	SW PUSH 1P1W MOM LIPA D6	23465-301P
SP	SW PUSH 1P1W MOM LIPA D6	23465-301P
SR	SW PUSH 1P1W MOM LIPA D6	23465-301P
SS	SW PUSH 1P1W MOM LIPA D6	23465-301P
ST	SW PUSH 1P1W MOM LIPA D6	23465-301P
	D6 KEYCAP BLANK	37590-723F
	D6 KEYCAP "0"	37590-602C
	D6 KEYCAP "1"	37590-603R
	D6 KEYCAP "2"	37590-604B
	D6 KEYCAP "3"	37590-605K
	D6 KEYCAP "4"	37590-606A
	D6 KEYCAP "5"	37590-607Z
	D6 KEYCAP "6"	37590-608H
	D6 KEYCAP "7"	37590-609E
	D6 KEYCAP "8"	37590-610Z
	D6 KEYCAP "9"	37590-611H
	D6 KEYCAP "."	37590-612E
	D6 KEYCAP "+/-"	37590-613U
	D6 KEYCAP "ENTER"(OFFSET)	37590-614Y
	D6 KEYCAP "ENTER"(IMP)	37590-614Y
	D6 KEYCAP "LOCAL"	37590-615N

Description	Part Number
11. SUPPLIED ACCESSORIES	
AC SUPPLY LEAD	43129-003W
COVER POLYTHENE	37490-435X
OPERATING MANUAL H52610-900X Vol.1	46881-427T
12. OPTIONAL ACCESSORIES	
BATTERY OPTION (See Unit BA00) comprising	54462-022S
BATTERY CONTROL UNIT (See Unit BA01)	44990-414L
BATTERY UNIT (See Unit BA02)	44990-413N
GPIB INTERFACE UNIT (See Unit AD00)	54433-002Y
GPIB LEAD, 1M, IEEE CONNECTORS	43129-189U
GPIB ADAPTER, IEEE MALE TO IEC FEMALE	46883-408K
RF COAXIAL INPUT LEAD, BNC CONNECTORS	43126-012S
FRONT PANEL COVER (STOWAGE)	54124-022L
RACK MOUNTING KIT (single unit)	46883-638P
RACK MOUNTING KIT (double unit)	46883-906G
SERVICE MANUAL H52610-900X VOL.2	46881-428P
THE GPIB MANUAL H54811-010P	46881-365R

Circuit Ref		Description	Part Number
Unit AD00		- GPIB UNIT	
13. When ordering, prefix circuit reference with AD00			
		Complete unit	54433-002Y
		GPIB INTERFACE PCB AD01	44828-639C
SKB		CON 57 FEM 24 FXD PCB EDG - GPIB	23435-133X
		BOX	37136-497H
Unit AD01		- GPIB INTERFACE BOARD	
14. When ordering, prefix circuit reference with AD01			
		Complete unit	44828-639C
C1		CAP TANT 4.7UF 35V 20% BEAD	26486-219P
C2		CAP CER 0.047UF 25V 20% DISC	26383-017U
IC1		ICD NAND 74LS00 QUAD 2INP	28466-345H
IC2		ICD BUFF 74LS365	28469-194Z
IC3	!	ICM 8291A/7210	28467-027N
IC4		ICD BUFF 3448 QUAD GPIBTXRX 3S	28469-190R
IC5		ICD BUFF 3448 QUAD GPIBTXRX 3S	28469-190R
IC6		ICD BUFF 3448 QUAD GPIBTXRX 3S	28469-190R
IC7		ICD BUFF 3448 QUAD GPIBTXRX 3S	28469-190R
R1		RES MF 47K 1/4W 2% 100PPM	24773-313H
R2		RES MF 47K 1/4W 2% 100PPM	24773-313H
R3		RES MF 47K 1/4W 2% 100PPM	24773-313H
R4		RES MF 47K 1/4W 2% 100PPM	24773-313H
R5		RES MF 47K 1/4W 2% 100PPM	24773-313H
R6		RES MF 47K 1/4W 2% 100PPM	24773-313H
SA		SW DIL 6SW - GPIB ADDRESS	23465-897N
		CABLE ASSEMBLY (connects to Motherbd PLF)	43129-825W

Circuit Ref	Description	Part Number
Unit BA00	- BATTERY PACK	
15.	When ordering, prefix description with reference BA00.	
	Complete unit	54462-022S
	Comprising	
	BATTERY CONTROL UNIT (SEE Unit BA01)	44990-413N
	BATTERY UNIT (See Unit BA02)	44990-414L
Unit BA01	- BATTERY CONTROL UNIT	
16.	When ordering, prefix circuit reference with BA01	
	Complete unit	44990-414L
D2	DIODE RECT 1N5401 100V	28355-723N
D5	DIODE LED TIL209 3V RED	28624-110P
SA	SW TOG 2P2W MIN - ON-OFF-CHARGE	23462-257N
SK2	TERM SCREW 2MM SKT RED - EXT I/P +VE	23235-204U
SK3	TERM SCREW 2MM SKT BLACK - EXT I/P -VE	23235-205Y
TR2	TR PSI PWR 2N4918 40V 3M 30W	28434-896Y
	WASHER INSULATING SOT32/TO126	28488-125D
	CABLE ASSEMBLY (connects to Motherbd PLA)	43129-839Z
	BATTERY CONTROL BOARD (See Unit BB01)	44828-680K
Unit BA02	- BATTERY UNIT	
17.	When ordering, prefix description with BA02.	
	Complete unit	44990-413N
	BATTERY PACK 6V 7AH	43113-006Z
	CON MIN MALE/FEM 2 FXD 250V (Battery o/p)	23423-108E
	BOX ASSEMBLY	35903-638L
	LID	35903-639J

Circuit Ref	Description	Part Number
Unit BB01	- BATTERY CONTROL BOARD	
18. When ordering, prefix circuit reference with BB01		
	Complete unit	44828-680K
C1	CAP ELEC 0.1UF 50V 20% SUBMIN	26421-100T
C2	CAP ELEC 0.1UF 50V 20% SUBMIN	26421-100T
C3	CAP ELEC 33UF 25V 20% SUBMIN	26421-115U
C4	CAP ELEC 33UF 25V 20% SUBMIN	26421-115U
C5	CAP ELEC 33UF 25V 20% SUBMIN	26421-115U
C6	CAP CER .0018UF 63V 10% PLATE	26383-586C
C7	CAP ELEC 220UF 10V 20%+	26415-817J
D1	DIODE RECT 1N4004 400V	28357-028K
D3	DIODE ZENER BZY88C4V7 4.7V 5%	28371-373V
D4	DIODE SIL 1N4148 100V JUNC	28336-676J
D6	DIODE ZENER BZY88C4V3 4.3V 5%	28371-313T
D7	DIODE RECT 1N4004 400V	28357-028K
D8	DIODE SIL 1N4148 100V JUNC	28336-676J
FS1	FUSE Q/ACT 5.0A 20X5MM	23411-009J
	FUSE CARRIER OPEN 20X5MM	23416-151D
	FUSE COVER	37590-097L
IC1	ICA VREG UA78S40 SMPS CTRL DIL16	28461-729E
L1	IND CHOKE 100UH 10% LAQ	23642-561W
L2	INDUCTOR ASSEMBLY	44290-868S
R1	RES MF 220R 1/4W 2% 100PPM	24773-257W
R2	RES MF 1R5 1/4W 2% 100PPM	24773-205K
R3	RES MF 1R5 1/4W 2% 100PPM	24773-205K
R4	RES MF 56R 1/4W 2% 100PPM	24773-243H
R5	RES MF 470R 1/4W 2% 100PPM	24773-265M
R6	RES MF 82R 1/4W 2% 100PPM	24773-247N
R7	RES MF 47K 1/4W 2% 100PPM	24773-313H
R8	RES MF 47K 1/4W 2% 100PPM	24773-313H
R9	RES MF 10K 1/4W 2% 100PPM	24773-297M
R10	RES MF 47K 1/4W 2% 100PPM	24773-313H
R11	RES MF 270R 1/4W 2% 100PPM	24773-259T
R12	RES MF 1KO 1/4W 2% 100PPM	24773-273A
R13	RES MF 1KO 1/4W 2% 100PPM	24773-273A
R14	RES MF 1KO 1/4W 2% 100PPM	24773-273A
R15	RES MF 2K2 1/4W 2% 100PPM	24773-281Y
R16	RES MF 10K 1/4W 2% 100PPM	24773-297M

Circuit Ref	Description	Part Number
Unit BB01	- BATTERY CONTROL BOARD (Contd.)	
R17	RES MF 10K 1/4W 2% 100PPM	24773-297M
R18	RES MF 1R0 1/4W 2% 100PPM	24773-201M
R19	RES MF 1R0 1/4W 2% 100PPM	24773-201M
R20	RES MF 10K 1/4W 2% 100PPM	24773-297M
R21	RES MF 120R 1/4W 2% 100PPM	24773-251L
R22	RES MF 100R 1/4W 2% 100PPM	24773-249J
R23	RES MF 56K 1/4W 2% 100PPM	24773-315U
R24	RES MF 220R 1/4W 2% 100PPM	24773-257W
RLA	RELAY MAG 2CO 6V 50R	23486-120K
TR1	TR PSI GEN BC308B 20V 130M	28433-455R
TR3	TR PSI GEN BC308B 20V 130M	28433-455R
TR4	TR NSI GEN BC208B 20V 150M	28452-781A
TR5	TR PSI GEN BC308B 20V 130M	28433-455R
TR6	TR NSI GEN BC208B 20V 150M	28452-781A
TR7	TR NSI GEN BFY51 30V 50M	28455-827T
TR8	TR PSI GEN BC308B 20V 130M	28433-455R
TR9	TR PSI PWR ZTX750 45V 100M	28435-226Z

Item	Description	Part Number
	MISCELLANEOUS MECHANICAL PARTS	
	19. Item numbers refer to Fig. 1. Order without prefix.	
1	FRONT PANEL (MARKED)	35903-612G
	PANEL, SUPPORT	35903-620T
2	TOP COVER	35903-667U
3	SIDE RAIL	34900-747N
4	FLANGE	37590-221X
5	SPRING WASHER	31119-045W
6	ARM	37590-222M
7	REAR FOOT	37590-505Z
8	CAP	37590-219M
9	BOSS	37590-220P
10	HANDLE ASSEMBLY	41700-239W
11	REAR FRAME	35890-072W
12	REAR PANEL	35903-613V
	BLANKING PLATE	35903-666E
	VOLTS ADJ SW LOCKING PLATE	35901-630H
13	BOTTOM COVER	35903-668Y
14	FRONT FRAME	35890-083B
15	STUD	37590-223C
16	BOTTOM FOOT	37590-224R

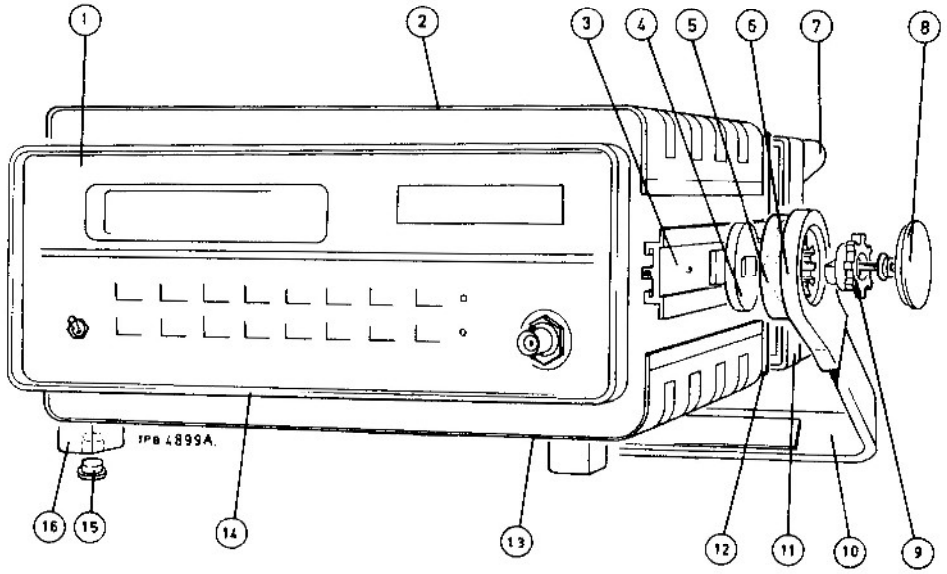


Fig. 1 Miscellaneous mechanical parts

Chapter 7

SERVICING DIAGRAMS

CONTENTS

CIRCUIT NOTES

1. Component values

Resistors : Code letter R = ohms, k = kilohms (10^3), M = megohms (10^6).

Capacitors : Code letter m = millifarads (10^{-3}), μ = microfarads (10^{-6}), n = nanofarads (10^{-9}), p = picofarads (10^{-12}).

Inductors : Code letter H = henrys, m = millihenrys (10^{-3}), μ = microhenrys (10^{-6}), n = nanohenrys (10^{-9}).

† SIC : value selected during test, nominal value shown.

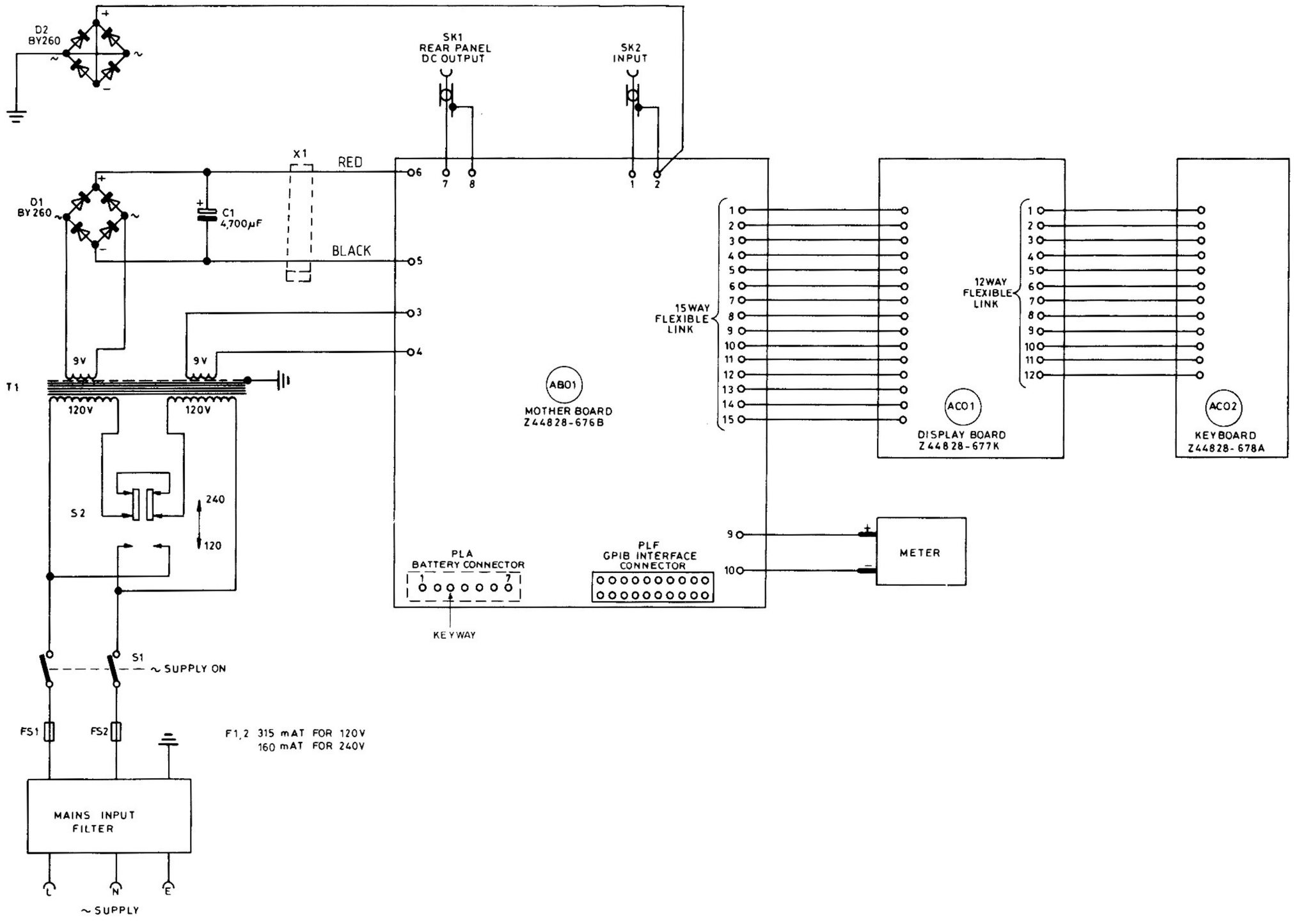
2. Components are marked normally with two, three or four figures according to the accuracy limit ±10%, ±1% or ±0.1%. The code letter used indicates the multiplier and replaces the decimal point. Because a marking 4m7 could be interpreted as milliohms, millifarads or millihenrys all values are placed near to its related symbol.

3. Symbols

Symbols are based on the provisions of BS 3939 with the following additions :

⚠ warning, see page (iv), Notes and Cautions.

unit identification number.

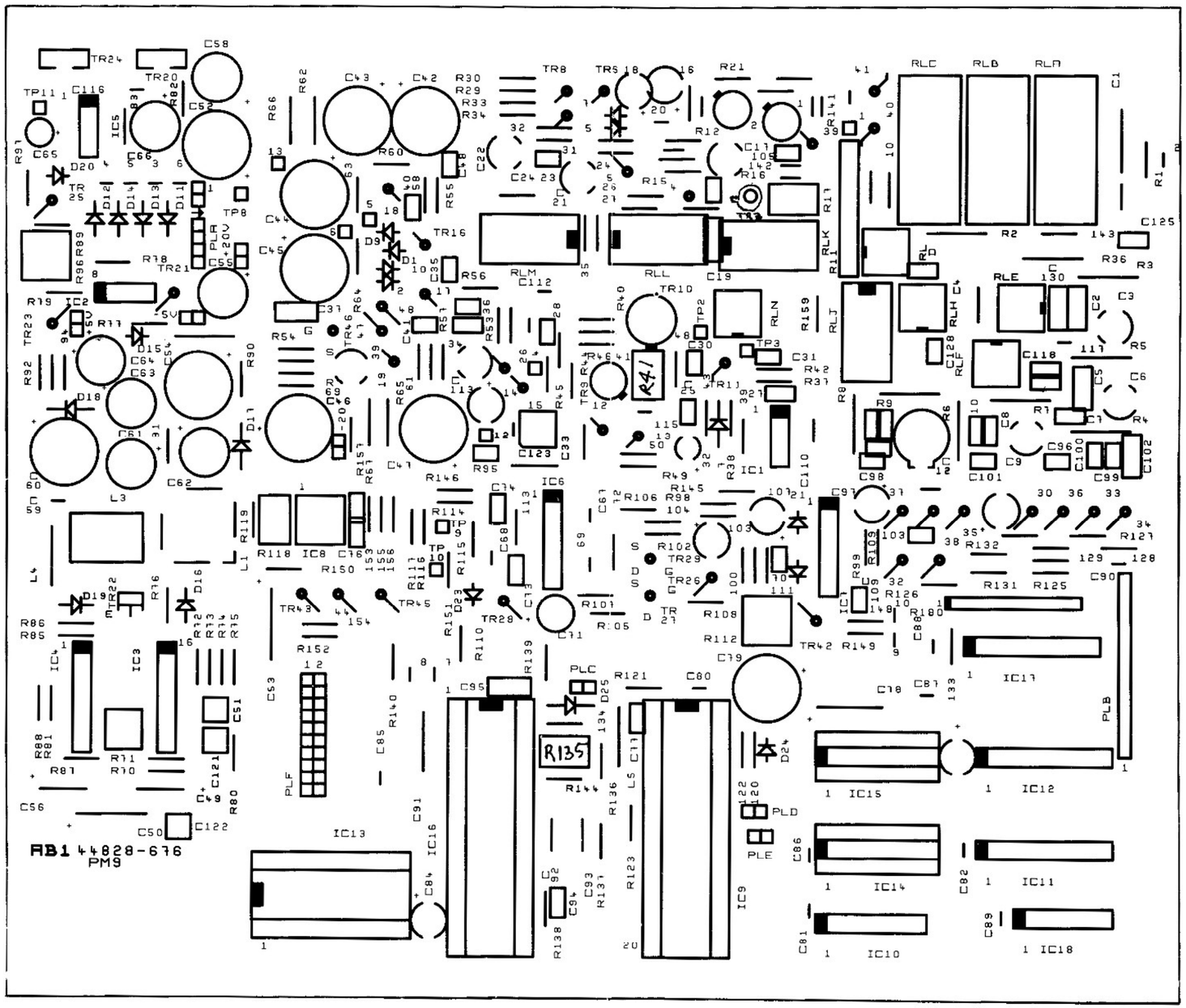


Z44828-900N ISS. 2A

2610 Interconnection diagram AA00

Fig. 1

Apr. 87 (Am. 4)



Motherboard AB01, component layout

Fig. 2

Fig. 2

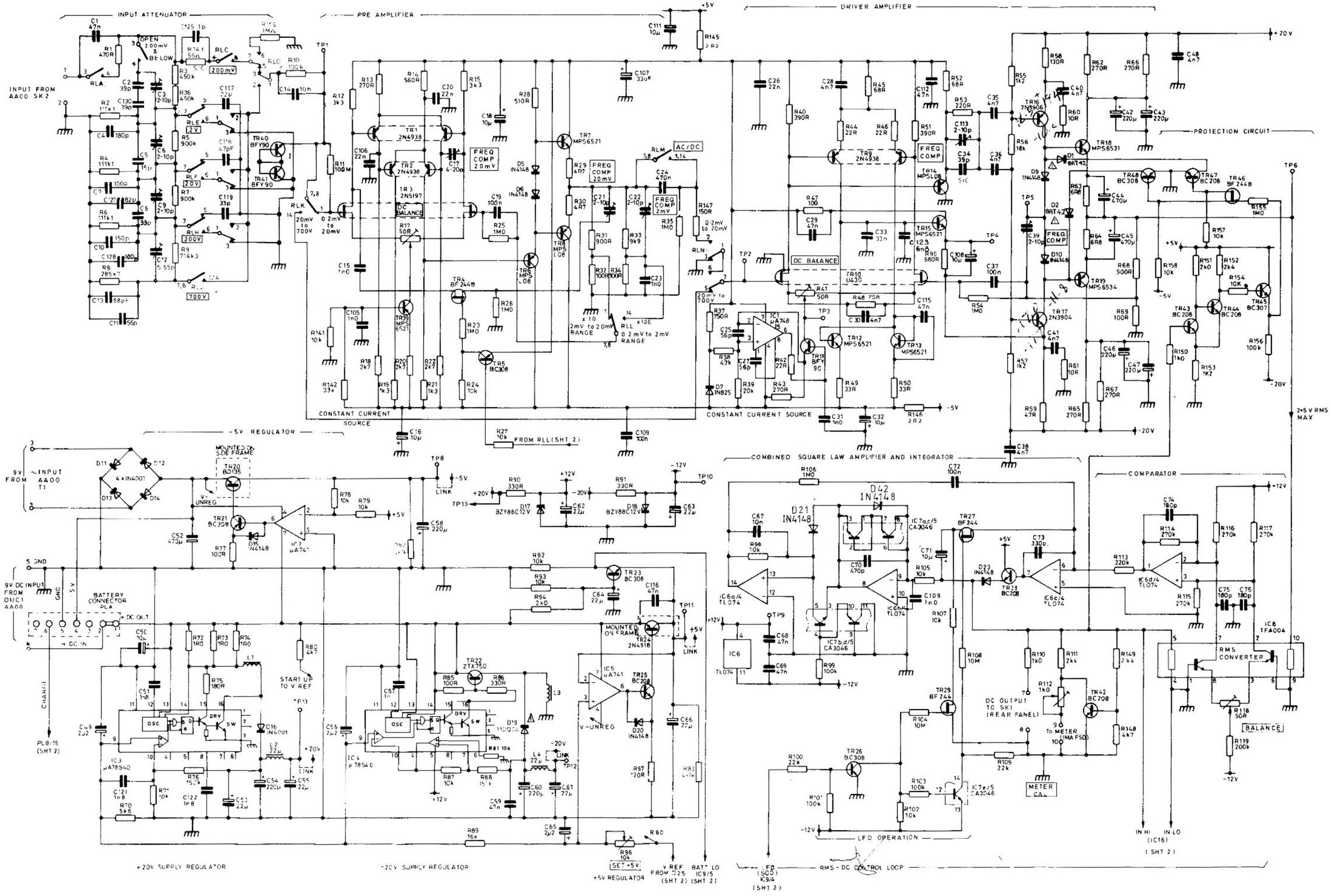
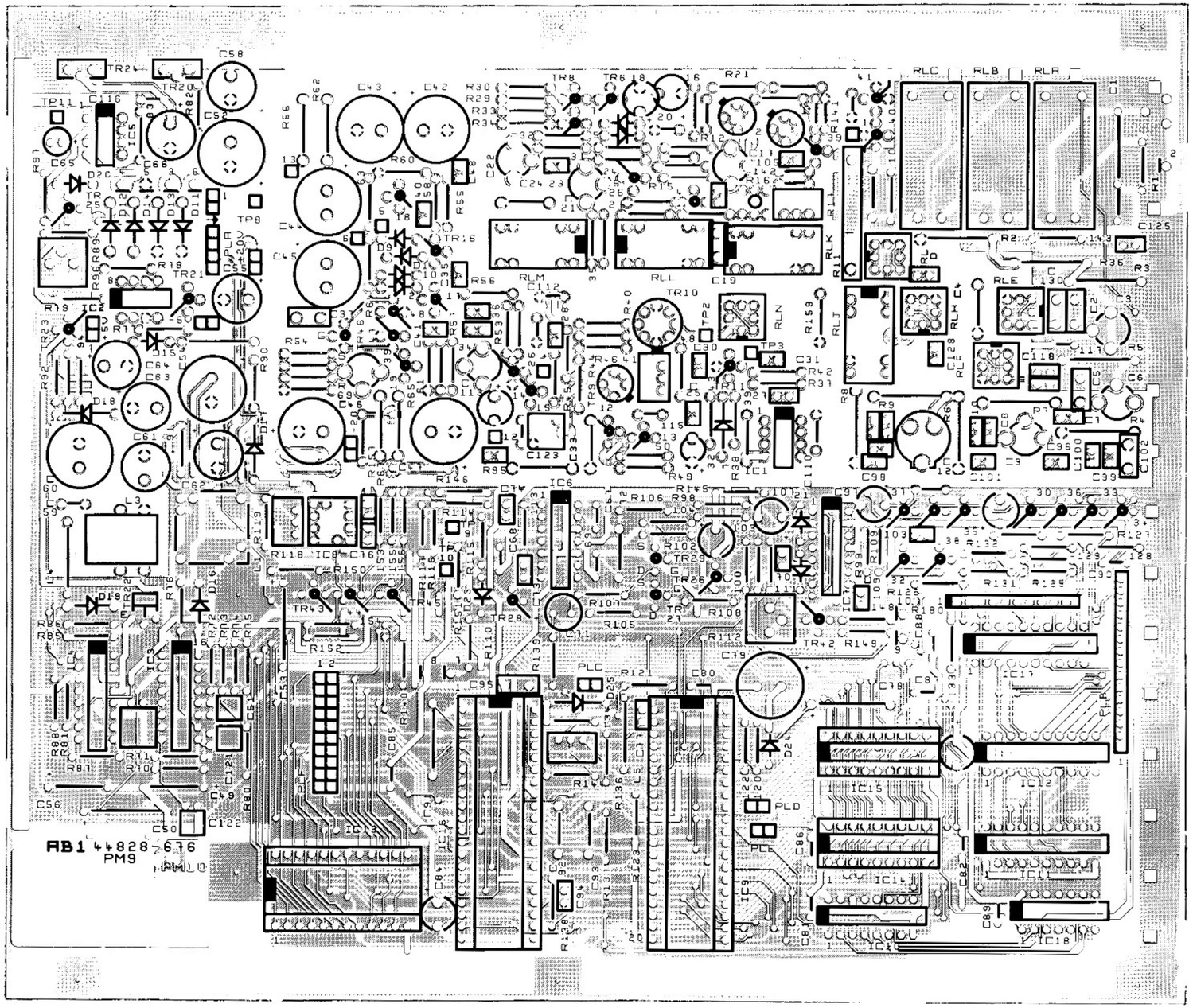


Fig. 3 Z44828-676B SHT.1 ISS. 11 Motherboard AB01, sheet 1, circuit diagram

Apr. 87 (Am. 4)



Motherboard AB01, p.c.b. layout

Fig. 4

Fig. 4

NOTES

1. TP1 TO TP6 ARE LINKED IN PAIRS AS INDICATED BY MINI-JUMP SHORTING SOCKETS.
2. TP1-2 ARE LEFT OPEN IN NORMAL USE, & LINKED ONLY IN TEST MODE
3. COMPONENTS MARKED ⚠ ARE STATIC SENSITIVE.

RANGE SELECTION RELAYS

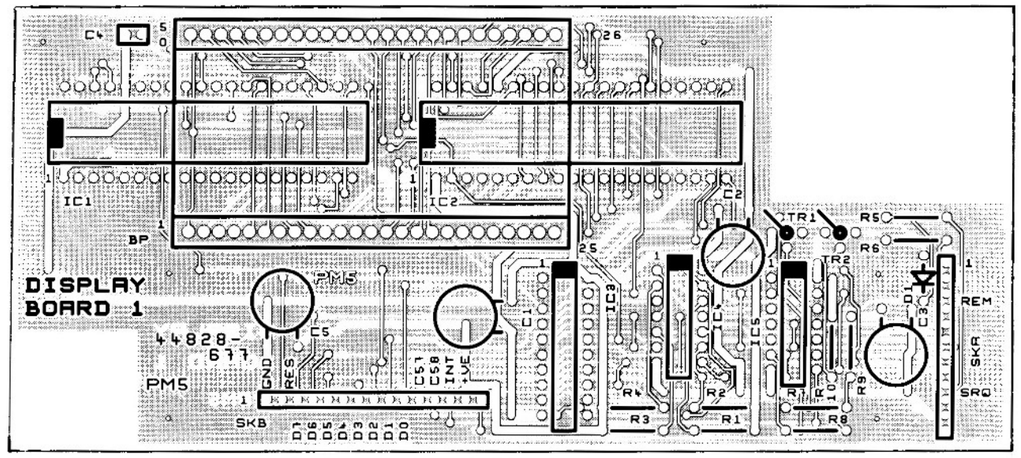
15 WAY FLEXIBLE LINK TO KEYPAD/DISPLAY BOARD ACO 1

Z44828-676B SHT.2 ISS. 5

Motherboard AB01, sheet 2, circuit diagram

Fig. 5

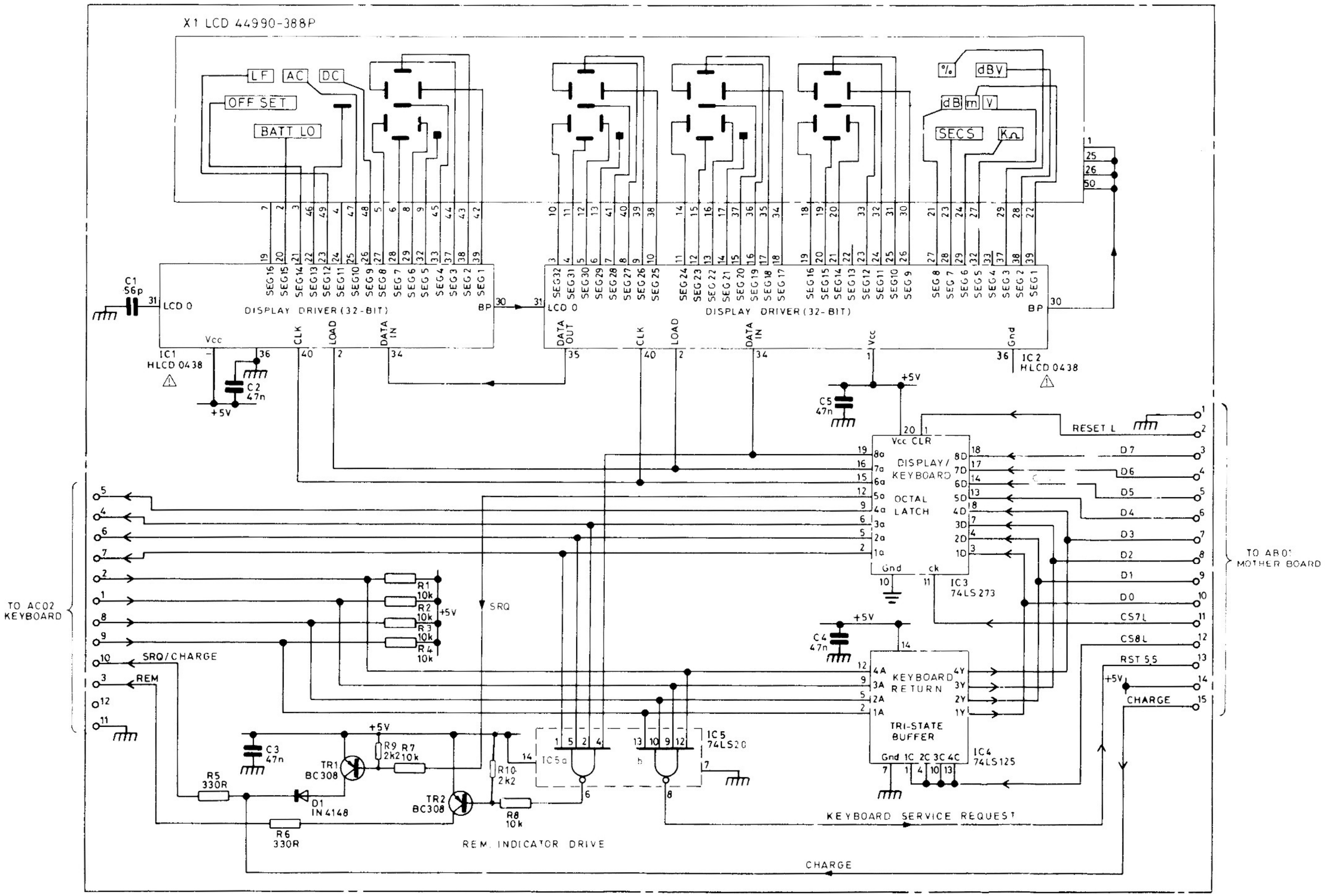
Apr. 87 (Am. 4)



Display board AC01, p.c.b. layout

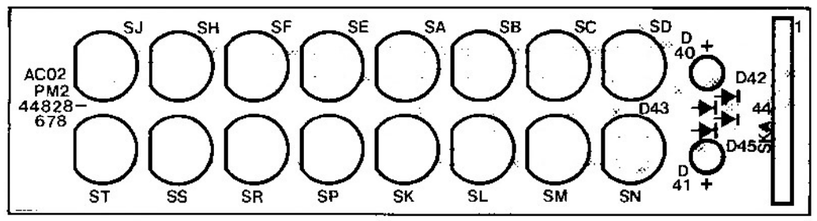
Fig. 6

Fig. 6



z 44828 - 677 K ISS.3

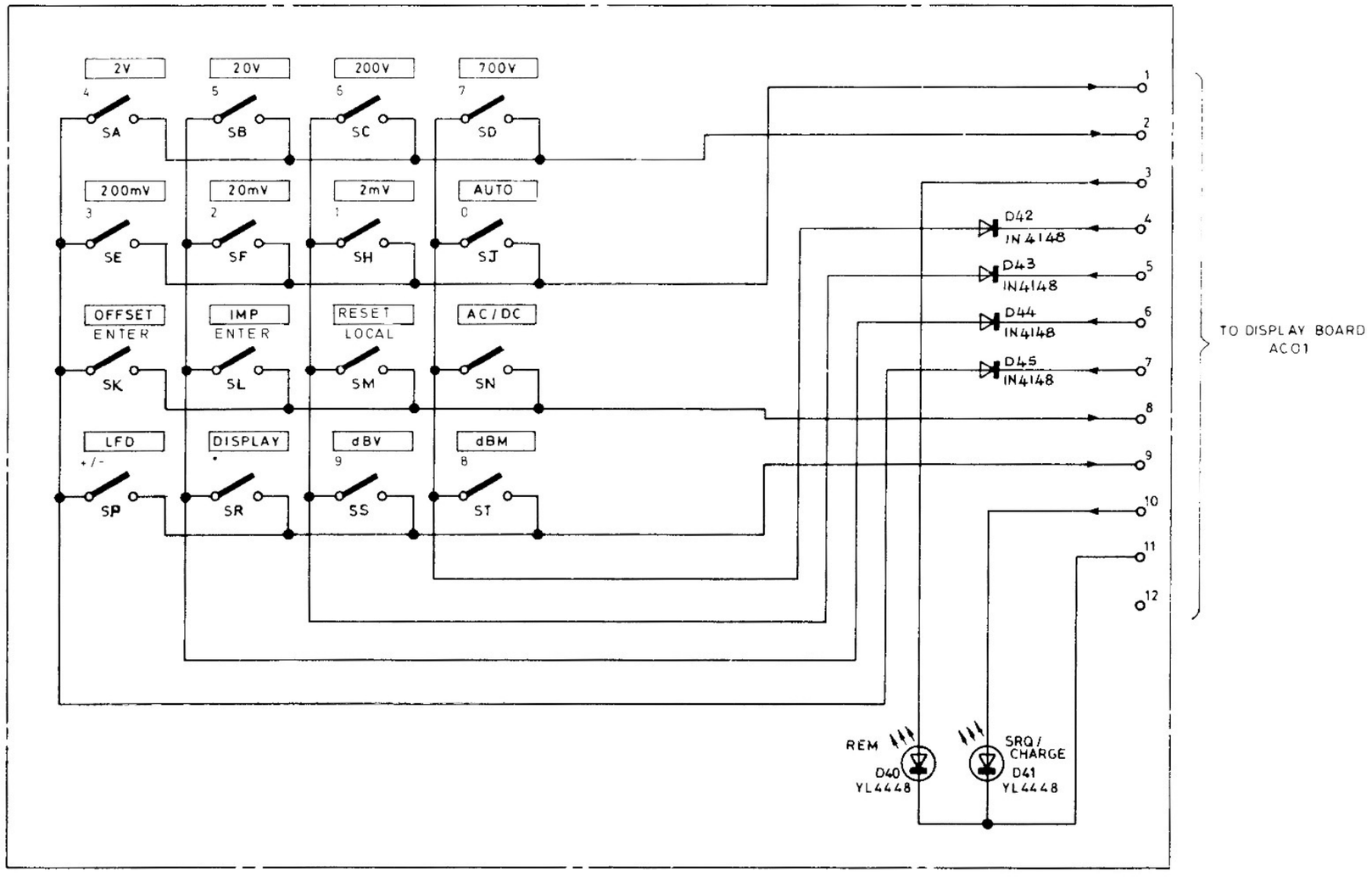
Fig. 7 Display board AC01, circuit diagram



Keyboard AC02, p.c.b. layout

Fig. 8

Fig. 8



Z 44828 - 678 A ISS. 3

Keyboard AC02, circuit diagram

Fig. 9

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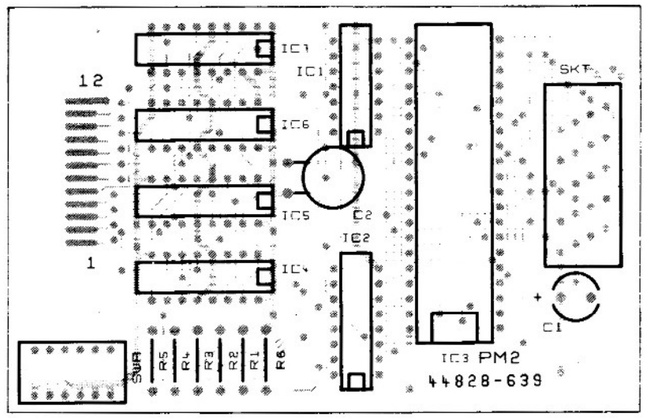
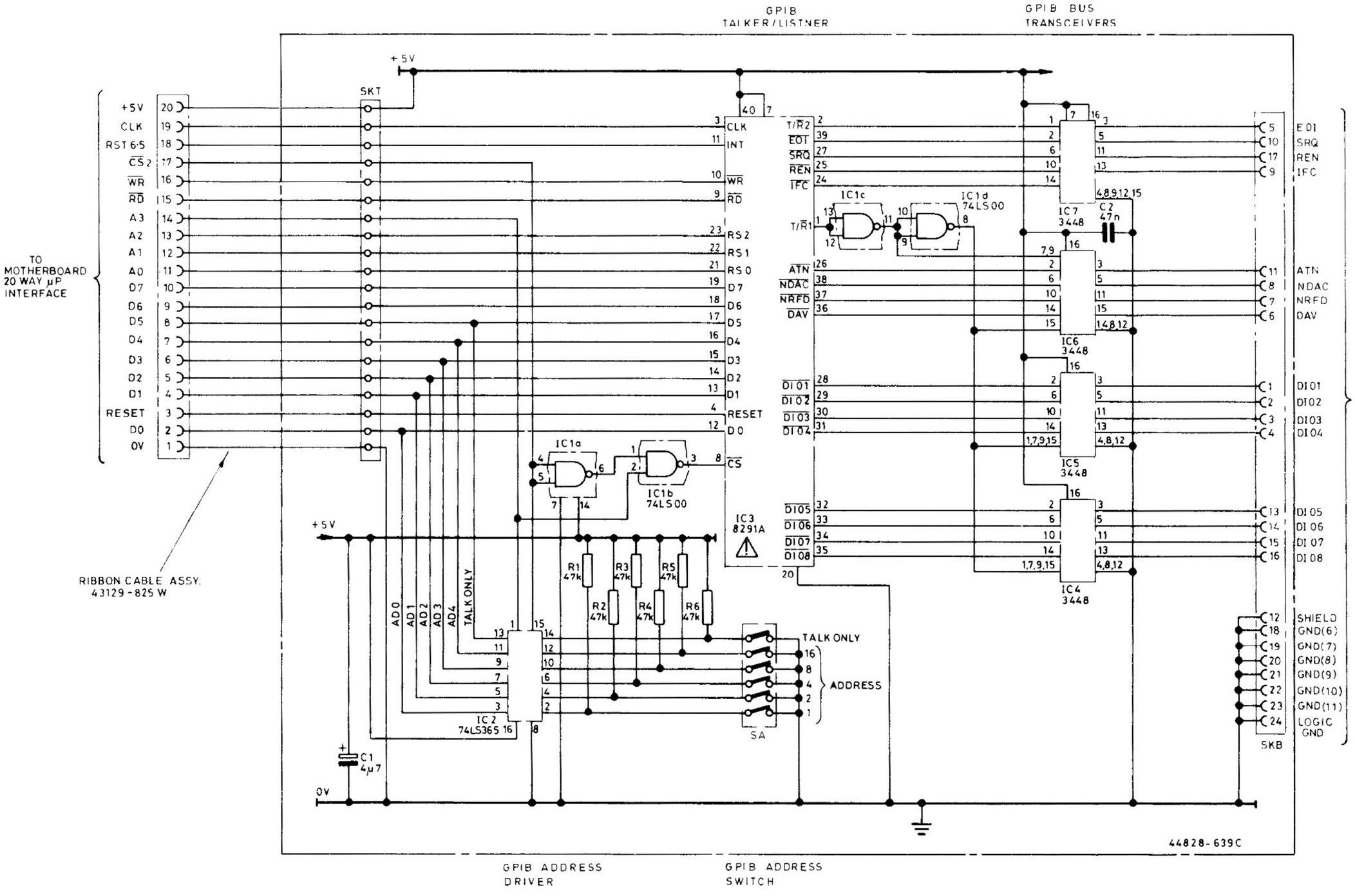


GPIB unit, p.c.b. layout

Fig 10

Fig. 10

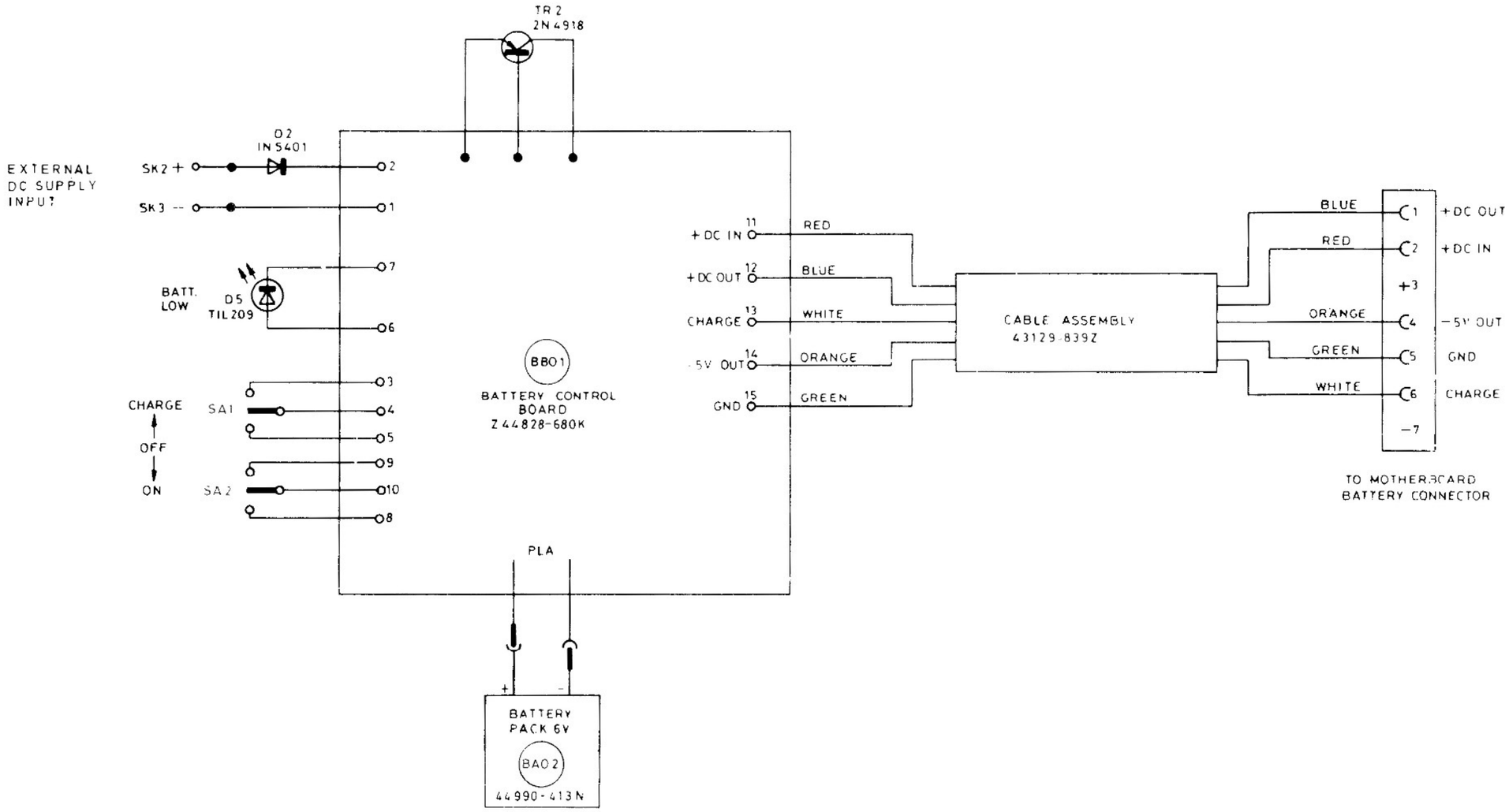


Z 54433-002 Y ISS. 1

GPIB unit, circuit diagram

Fig. 11

Jan. 84



Z 44990 - 414 L ISS. 1

Battery supply unit BA01, interconnection diagram

Fig. 12

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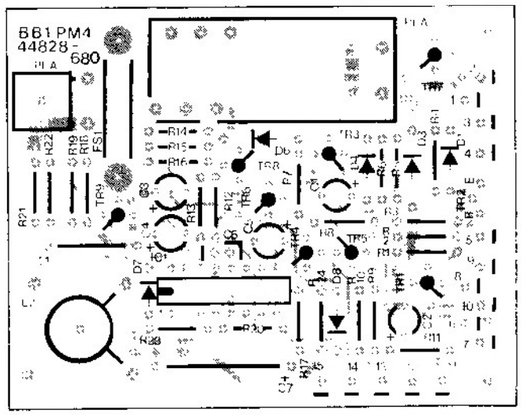
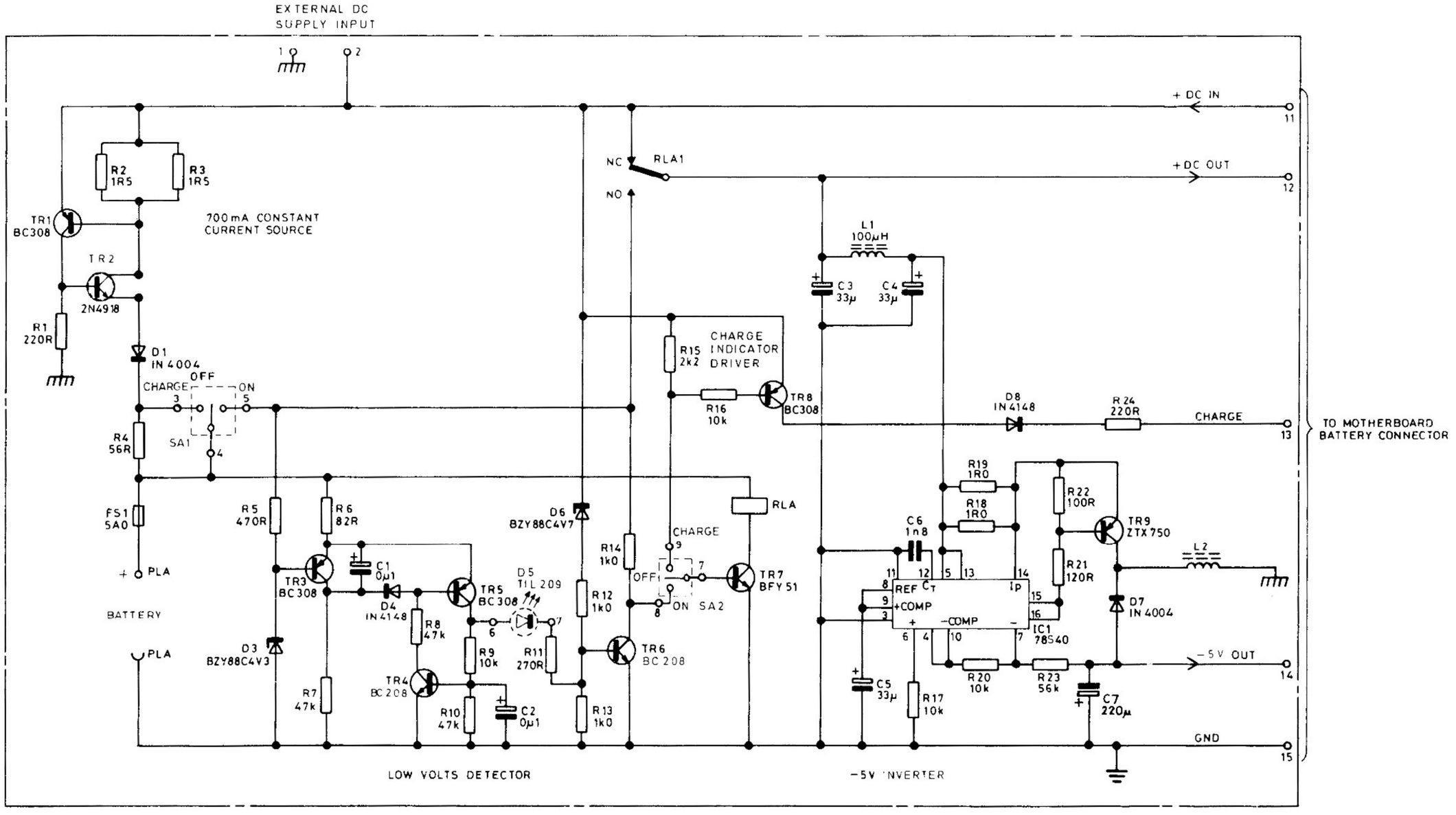


Battery control board BB1, p.c.b. layout

Fig. 13



NOTE - COMPONENTS INSIDE DOTTED LINES ARE MOUNTED OFF P.C.B

Z 44828 -680K ISS. 2

Battery control board BB01, circuit diagram

Fig. 14

Jan. 84