Microprocessor Voltmeters 7055 and 7065

Part No. 70550013

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Schlumberger

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TECHNICAL MANUAL

7055 and 7065, Solartron's new microprocessor controlled digital voltmeters, offer superlative measurement capability plus a choice of processing programs. System flexibility too, the interface options being carefully chosen to cater for the majority of existing or projected instrument interconnection systems.

7055 and 7065 carry out the same functions, but whereas 7065 has a maximum scale length of 6 x 9s (actually 1399999), that of 7055 is limited to 5 x 9s. To simplify the use of this Manual the description will be that for the 7065 (6 x 9s); 7055 (5 x 9s) will be mentioned only in instances where it is not identical.

As basic voltmeters both measure:

dc voltage:	the result being the average value of the input during a selected period.
ac voltage:	the instrument senses the mean value of the ac content of the input and displays the rms equivalent assuming a sine wave.
resistance:	the result being the average value of the unknown during a selected period.

Ranges can be selected individually or automatically, there is a choice of **scale length** and **digital filtering** can be applied. Readings can be taken singly or a succession of readings may be made.

More powerful versions of these two voltmeters, in addition to measuring the unknown inputs, process those measurements to give other useful results. Typical processes are: maximum or minimum of a string of measurements, comparison with preset limits.

Whether the instrument supplied is the basic voltmeter or is the processing version, both carry the identical front panel controls and captions which apply to the full processing voltmeter. This permits a user to change a simple voltmeter into the processing version by adding an internal module.

Finally, both the basic instrument and the processing version can be fitted with a **system interface.** This enables the voltmeter to be controlled by coded electrical commands, and to output data which are the results of simple measurements or of processed measurements.

The operating Manual is arranged in separate parts, covering measurement, processing and system use. Each part contains all the information necessary for operating the instrument in that particular role.

Included in Parts 1 and 2 is the specification applicable to the function being described, the tables showing the expected instrument performance relative to time since calibration. A further section of Parts 1 and 2 is devoted to techniques and applications, offering guidance as to how one can obtain the optimum performance from the dvm and avoid some of the pitfalls.

You are urged to read the Manual carefully. Familiarise yourself with the controls and their functions, with the display and the information it conveys; study the examples given. Thus will you derive maximum advantage from owning and using a completely new type of measuring/processing instrument.

Contents

Microprocessor Voltmeters 7065 and 7055

Part 1

Contents of Part 1

SAFETY

This instrument has been designed and tested in accordance with the recommendations of IEC 348, Class 1. It is primarily intended for indoor use, and for such use it is supplied in a safe condition. However no degradation of its safety will be caused if it is occasionally subjected to temperatures between 0^{o}C and -10^{o}C (see Specification).

This manual contains information and warnings which the user should follow to ensure his own safety and the continued safe operation of the instrument. 7065 (55) has been engineered with ease of use as one of the primary considerations. Attention has also been given to making the instrument immune to most inadvertent overloads. It should be appreciated, however, that even the most sophisticated measuring instrument can be dangerous when connected to high voltages, unless elementary safety precautions are observed.

The voltage limit of 1.1kV means that no damage will be caused to the instrument at this level of input. Other than the displayed reading, however, no indication is given to the user that a voltage of such a magnitude is present at the input terminals. Care should therefore be exercised whenever the dvm input leads are being connected to/removed from live circuits, especially where high voltages are known to exist, or high transients could occur.

Similarly, when using the instrument on mains operated equipment capable of delivering high voltage outputs, it is strongly recommended that the equipment under test is NOT switched off with the dvm still connected. For example, consider the 7065 (55) connected across the secondary winding of a large mains transformer. The instrument's very high input resistance is such that, in the event of the mains supply being interrupted, the resultant back emf induced in the undamped secondary could be of the order of 100kV. This is obviously hazardous to the user and would certainly harm the voltmeter.

Whenever it is likely that the safety of the instrument has been impaired: e.g. if it shows visible signs of damage; if it fails to perform correctly, or if the specifications have been exceeded in any way - it should be made inoperative and referred to a suitable repair organisation.

Any adjustment, maintenance or repair of this instrument shall be carried out only by a skilled person who is aware of the hazards associated with mains operated equipment. Such adjustment, maintenance or repair shall be carried out in accordance with the procedures, and observing the precautions, detailed in the Technical Manual.

Section 1 Introduction

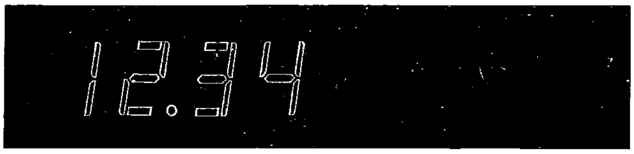
Automatic or Manual range selection plus a choice of scale length and corresponding integration time enables the operator to exploit to the full the versatile 7065 microprocessor controlled digital voltmeter. Simple to operate push button controls with built-in indicators, show at a glance the instrument status. User oriented features include annunciators for negative polarity and invalid readings, overload being indicated by a flashing display.

The measurement facilities are those of:

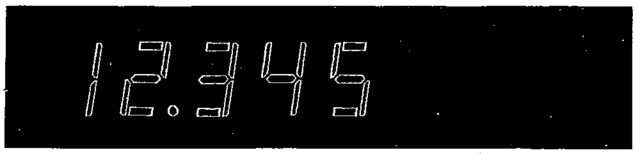
D.C. Voltage from 1μV to 1kV
A.C. Voltage from 1μV to 1kV
Resistance from 1mΩ to 14MΩ (10mΩ to 20MΩ, 7055)
All measurements are continuous range.

When the instrument is switched on, scale length of 5 x 9's is automatically selected, but 3 x 9's to 6 x 9's can be selected by the user, (3 x 9's to 5 x 9's for 7055). Leading zeros, except that to the immediate left of the decimal point, are suppressed and if the quantity is negative, the fixed minus sign is illuminated.

The displayed measurement can be read directly; the units, volts (AC and DC) or kilohms, being indicated by the button annunciator illuminated for the measurement function selected.



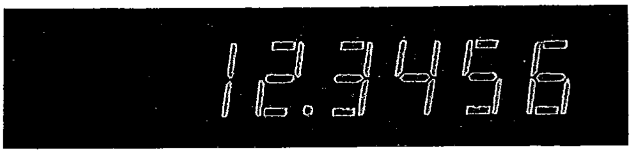
3 x 9's



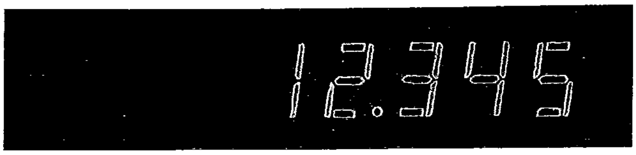
4 x 9's

5 x 9's

The displays above are typical for the given scale lengths assuming automatic range selection, while those overleaf are typical of a 5 x 9's scale length and manually selected range. With 6 x 9's scale length selected the display will show one extra decade; for 4 x 9's, one less.



10V RANGE



100V RANGE

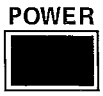
1000V RANGE

The conversion technique used is capable of obtaining linearities two orders better than those possible using dual ramp and related techniques. An important property of this method is that the applied input is being continuously averaged. Together with the very fast autoranging system, this feature makes conventional filters, with their associated problems, unnecessary. A digital filtering technique is utilised whereby the difficulty that used to be associated with low frequency ac measurement has now become a thing of the past. Calibration balance and zero stability are maintained, at all times, by the microprocessor.

CONTROLS

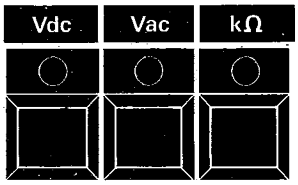
The push button controls are arranged in groups in accordance with the decisions which have to be made for any measurement.

POWER



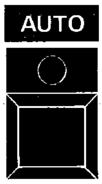
applies mains power to the instrument.

VDC, VAC, kΩ



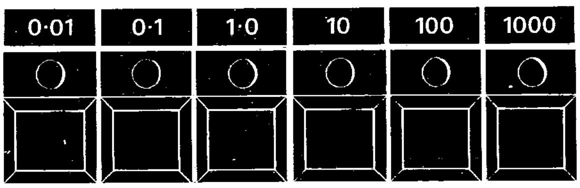
selects the quantity to be measured.

AUTO



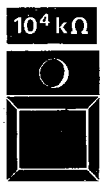
automatic range selection, released for manual range selection.

RANGE



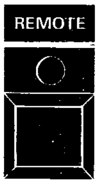
These buttons indicate the measurement ranges, the units being volts or kilohms depending on the measurement function selected. There is no 0.01kΩ range on 7055; selecting this range when using the kΩ (resistance) function selects the next highest range, 0.1kΩ (100Ω).

10^4kΩ



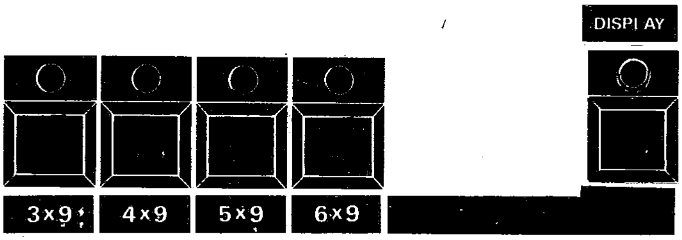
Increases the resistance range by 1 decade to accommodate measurements up to 14MΩ (20MΩ for 7055).

REMOTE



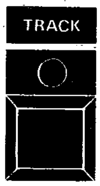
control by Remote Commands, released for local operation.

DISPLAY



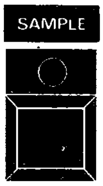
When DISPLAY is selected, four scale lengths (3 x 9's to 6 x 9's) become available for selection, as indicated by the legends (white on blue) below the buttons concerned. (3 x 9's to 5 x 9's for 7055). Each push button also selects one of four corresponding measurement times (3 for 7055).

TRACK



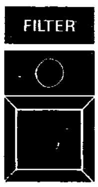
to initiate repeated measurements, each one updating the display.

SAMPLE



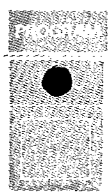
to initiate a single reading and hold it.

FILTER



select to increase integration time.

PROGRAM



with no program board fitted, pressing PROGRAM has no effect

μV OFFSET

The instrument's internal zero is extremely stable and no operator adjustment is necessary. The μV OFFSET is provided to "back-off" any small disturbances where, for example, thermal effects generated in the external circuit are of significance and could degrade the measured result. Use of the μV OFFSET will provide a correction of approximately ±15μV.

FRONT PANEL LOCKOUT

Not apparent from the front panel legends is a facility known as FRONT PANEL LOCKOUT. Under the control of an external electrical command applied via an (optional) Interface Unit, the action of all front panel controls except POWER, can be inhibited. This command signal even disables LOCAL and can be used to prevent unauthorized use of the dvm when it is committed within a system or, with suitable remote programming, enables a test sequence to include both automatic and manual control.

INTEGRATION TIME

The tables in section 2 show the results of varying integration time. For 3 x 9's and 4 x 9's integration rates, there is no rejection of 50Hz (60Hz) series mode ac interference. When the longer integration times are used however, total rejection of series mode ac interference occurs at these frequencies.

Calibration Balance

This is the preferred name for the 7065's automatic drift correction circuits. The instrument has the ability to periodically check it's internal zero and re-balance the positive and negative reference potentials. When operating under Local control this check/balance occurs automatically as follows:

a. Every 10 seconds, controlled by the built-in clock.

b. When range change occurs, either manually or as a result of Autorange.

c. On changing function, i.e. VDC, VAC or kΩ.

d. When a longer integration time is selected.

For details of Calibration Balance when operating within a controlled System the reader is referred to Part 3 of the manual.

INPUT CONNECTORS

The input connectors simply push into their respective terminals.

Two types of connector are available: 2-way, for connection to front panel terminals and 5-way, for rear panel input connection.

2-way connector (supplied as standard)

These leads may be used for all standard measurements. The RED lead is connected to the HI terminal and should be used as Hi, normally at the greatest potential with respect to earth. The BLACK lead is connected to the LO terminal and provides the return path. The GUARD terminal is normally linked to the LO terminal. If this connection is taken to the free end of the black lead however, guard is effectively preserved right up to the signal source. This prevents the measurement being affected in any way by common mode current flowing to the Lo connector and via leakage to earth. The input may be floated above mains earth by up to 500V. The use of higher common mode voltages is not recommended purely to ensure safety for equipment and the user.

Resistance measurement

For resistance measurements the Ω DRIVE terminals should be linked to the V/Ω, HI and LO terminals respectively, thus the same lead can be used for both voltage and resistance measurement.

AC Voltage measurement

To minimise the effects of local pick-up the use of a twisted pair is recommended; it is advisable to keep the connecting leads as short as possible.

REAR INPUT CONNECTOR

The input connector simply pushes into the rear panel socket with a 'snap-in' action. This cannot be released by pulling on the cable, but separation occurs when the skirt of the connector is pulled away from the panel.

When making ac measurements the free ends of the connector should be twisted together, where practicable.

N.B. The symbol which appears in places on the instrument of an exclamation mark enclosed within a triangle ⚠ is an indication to the user that reference should now be made to relevant sections of this book.

DISPLAY

The display area is covered by a red filter to inhibit stray light or reflected light which might otherwise reduce the clarity of the reading.

From left to right the display information is:

a) Fixed minus sign, displayed when the quantity being measured is negative.

b) Two horizontal bars, one above the minus sign and one below. When illuminated these advise the operator that the reading currently being displayed should be regarded as invalid. The legends are extinguished when a valid result is displayed.

c) Numeral indication, 7 bar segment light emitting diodes (LED's) are used to present the result of measurement, or other information.

d) Decimal point, floating point, travels on ranging up and ranging down.

INVALID READINGS

In addition to the two horizontal bars described above, an indication that a reading is invalid is that of a flashing display. Normally this occurs as a result of an overload on the range in use. Notwithstanding this automatic warning the user is reminded that the limits of input specified should never be exceeded.

The limits are:

DC 1100V DC

AC 750V RMS (1100V Peak)
(above 20kHz the limit is 200V RMS)

400V DC when VAC is selected.

N.B. These limits only apply to LOCAL operation. For details of limits applicable when the instrument is under REMOTE control refer to the Technical Specifications and Part 3 of the manual.

BUTTON ILLUMINATION (steady)

VDC, VAC and kΩ function button indicators are illuminated as a result of selecting the required measurement function. Button illumination also verifies the selected overall state of operation. i.e. Autorange, Track, Range etc.

REMOTE

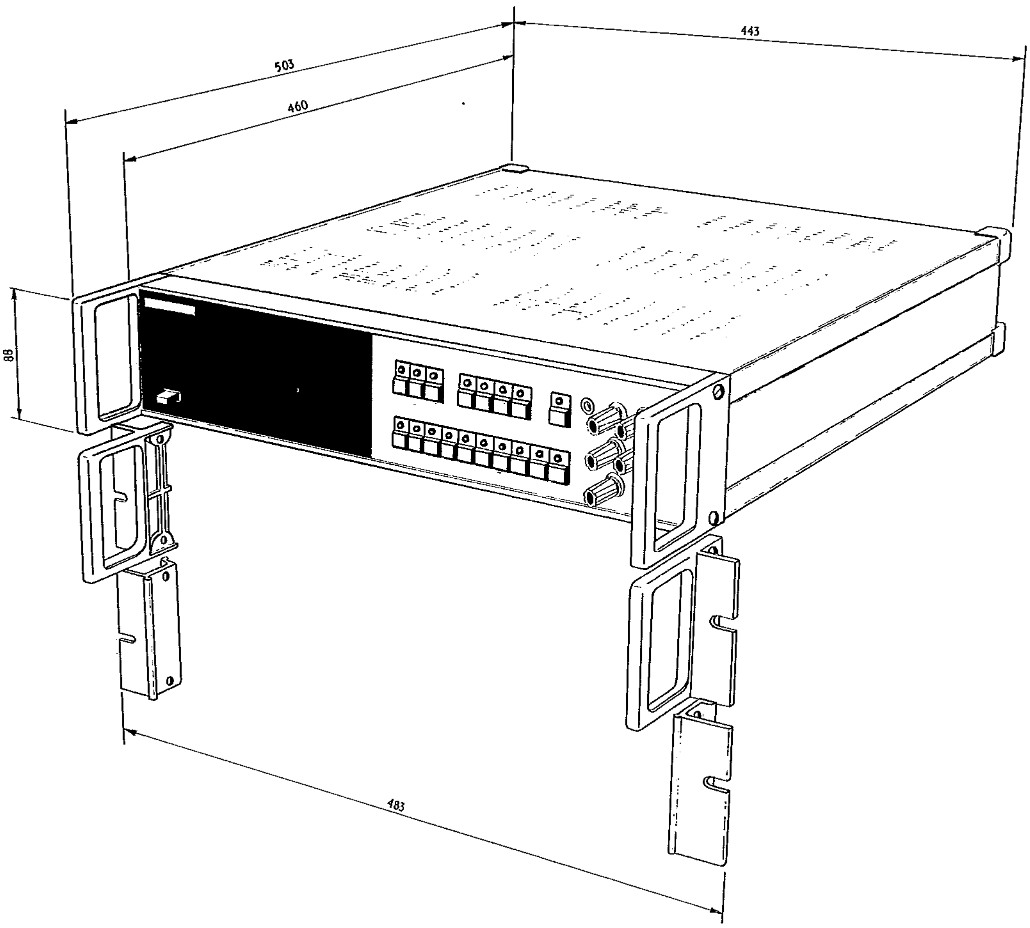
The REMOTE button indicator is illuminated when the instrument is under remote control, this being applicable only when an optional Interface Unit is fitted.

BUTTON ILLUMINATION (flashing)

When DISPLAY is selected, its indicator flashes, reminding the user that there is a choice of scale length available. Subsequently, selection of scale length extinquishes the DISPLAY button indicator.

RACK MOUNTING

The overall dimensions conform to international standards for rack mounting. The instrument can if desired be rack mounted within its case, no additional protection being necessary. User's who so wish can remove the covers which are simply secured by four screws. For rack mounting either the handleless mounting fittings or the combination handle/ears should be substituted for the normal handles. Rack mounting fixtures of both types are supplied as standard – see Accessories list in Section 2.



Drawing illustrates both sets of rack-mounting ears. Dimensions in mm.

Section 2
General Information & Specifications

This section contains, on pages 1.2.2 to 1.2.7, a copy of the performance specification applicable to the voltmeter.

The 7065(55) has been designed and manufactured to the highest specification possible for an instrument of its type. Where typical figures are quoted they are realistic estimates of obtainable performance based on known component tolerances and stability. Guaranteed performance on the other hand is specified from the results of exhaustive tests, stringently controlled, applied to every instrument produced. "Worst-case" figures are quoted in many instances, hence your 7065(55) may be found to exhibit a performance better in some particulars than the tables suggest. However no additional claims are made for the instrument above that published in the current data sheet.

GENERAL INFORMATION 7055 & 7065

Display

Type: 7-bar (red) light emitting diodes.

Scale-length: Six 'nines' display with fixed minus sign and floating decimal point. (Five 'nines' for 7055).

Overload Indication: Flashing display
(i.e. reading > f.s.)

Annunciator: illuminated push buttons

Ranging: Automatic or manual on local operation, as commanded on Remote. Redundant leading zeros, except that immediately preceding the decimal point, are blanked. Trailing zeros not significant for the scale length in use are also blanked.

Ranging Points for 7065:
Range-up > 1400000 digits reading approx.
Range-down < 125000 digits reading approx.
(Over-range 40%)

Ranging Points for 7055:
Range-up > 208000 digits reading approx.
Range-down < 19600 digits reading approx.
(Over-range 100%)

N.B. Excessive series mode signals may cause range-up to occur earlier as the autoranging system accommodates low frequency AC signals.

Environment

Working Temperature Range:	0 to +50°C
Storage Temperature Range:	–30°C to +70°C
Maximum Relative Humidity:	70% at 40°C

Power Supply

Voltage:	100 to 264V (no mains selector)
Frequency:	50, 60 or 400Hz ± 3% selected by links
Consumption:	55VA
Fuse:	800mA Slo Blo

Dimensions

Width:	443mm	(17.4 ins)
Height:	88mm	(3.5 ins)
Depth:	460mm	(18.3 ins)
Weight:	10kg	(22 lbs)

Safety

This instrument conforms to IEC 348 (Class 1) recommendations.

Specification

DC VOLTAGE SPECIFICATION 7055

Manufacturers Calibration temperature 20°C

5 x 9 Scale Length GUARANTEED PERFORMANCE

Digital Filter selected, 160ms integration time.

Nominal Range	Input Sensitivity	Displayed Full Scale	Limits of Error: 24 hrs ± 1°C ±[% rdg. + digits]		6 mnth ± 5°C ±[% rdg. + digits]		1 yr ± 5°C ±[% rdg. + digits]		Input Resistance
10mV	1μV	0.020000V	0.002	2	0.006	3	0.008	3	>100MΩ
100mV	1μV	0.200000V	0.002	2	0.006	2	0.008	2	>1GΩ
1V	10μV	2.00000 V	0.002	1	0.006	1	0.008	1	>10GΩ
10V	100μV	20.0000 V	0.002	1	0.006	1	0.008	1	>10GΩ
100V	1mV	200.000 V	0.002	1	0.006	1	0.008	1	10MΩ
1000V	10mV	2000.00*V	0.002	1	0.006	1	0.008	1	10MΩ

* maximum input 1000V

REDUCED SCALE LENGTH

Digital Filter selected, 160ms integration time.

Scale Length	Limits of Error (all ranges): 24 hrs ± 1°C	6 mnth ± 5°C	1 yr ± 5°C
4 x 9	±[0.008% rdg + 2 digits + 2μV]	±[0.015% rdg + 2 digits + 3μV]	±[0.015% rdg + 2 digits + 3μV]
3 x 9	±2 digits	±2 digits	±2 digits

Input Current: Typically <20pA at 20°C

Overload protection

Autorange: 1.1kV

Command ranges

up to 10V: 350V

100 & 1000V: 1.1kV

Maximum Reading Rate

Scale length	5 x 9	4 x 9	3 x 9
Readings per second	43	182	330

Temperature Coefficient (per °C)

Need be applied only when operating beyond the temperature limits quoted under Limits of Error.

All ranges <±0.001% rdg

Zero offset <±0.2μV

High Speed Operation

Without Digital Filter, at all scale lengths, add ±[25μV + 1 digit] to the quoted Limits of Error.

Specification

DC VOLTAGE SPECIFICATION 7065

Manufacturers Calibration temperature 20°C

6 x 9 Scale Length GUARANTEED PERFORMANCE

Digital Filter selected, 1.28s integration time

Nominal Range	Input Sensitivity	Displayed Full Scale	Limits of Error 24 hrs ± 1°C ±[% rdg + digits]		6 mnth ± 5°C ±[% rdg + digits]		1 yr ± 5°C ±[% rdg + digits]		Input Resistance
10mV	1μV	0.014000V	0.001	4	0.003	4	0.004	4	>100GΩ
100mV	1μV	0.140000V	0.001	4	0.003	4	0.004	4	>100GΩ
1V	1μV	1.400000V	0.0006	4	0.003	4	0.004	4	>100GΩ
10V	10μV	14.00000V	0.0005	4	0.0018	4	0.0025	4	>100GΩ
100V	100μV	140.0000V	0.0008	6	0.003	6	0.004	6	10 MΩ
1000V	1mV	1400.000V*	0.0008	6	0.003	6	0.004	6	10 MΩ

* maximum input 1000V

REDUCED SCALE LENGTH

Digital Filter selected, 160ms integration time.

Scale Length	Limits of Error (all ranges) 24 hrs ± 1°C	6 mnth ± 5°C	1 yr ± 5°C
5 x 9	±[0.002% + 1 digit + 4μV]	±[0.004% rdg + 2 digit + 4μV]	±[0.006% rdg + 2 digit + 4μV]
4 x 9	±[1 digit + 4μV]	±[1 digit + 4μV]	±[1 digit + 4μV]
3 x 9	± 1 digit	± 1 digit	± 1 digit

Input Current: Typically <20pA at 20°C

Overload protection

Autorange: 1.1kV

Command ranges

Up to 10V: 350V

100 & 1000V: 1.1kV

Maximum Reading Rate

Scale length	6 x 9	5 x 9	4 x 9	3 x 9
Readings per second	6	43	182	330

Temperature Coefficient (per °C)

Need be applied only when operating beyond the temperature limits quoted under Limits of Error.

Range	<±% rdg
10mV to 1V	0.0004
10V	0.0003
100 & 1000V	0.0005

Zero offset <±0.2μV

High Speed Operation

Without Digital Filter, at all scale lengths, add ±[25μV + 1 digit] to the quoted Limits of Error.

Specification

AC VOLTAGE SPECIFICATION 7055 — Mean Sensing

Manufacturers Calibration temperature 20°C

5 x 9 Scale Length

Digital Filter selected, 1.28s integration time.
Filter must be used for full accuracy below 400Hz.

Nominal Range	Input Sensitivity	Displayed Full Scale	Limits of Error: 24 hrs at 20°C ± 1°C, 50Hz to 10kHz ±[% rdg + digits]		24 hrs at 20°C ± 1°C, 40Hz to 50kHz ±[% rdg + digits]		6 mnth at 20°C ± 5°C, 50Hz to 10kHz ±[% rdg + digits]		6 mnth at 20°C ± 5°C, 40Hz to 50kHz ±[% rdg + digits]	
100mV	1μV	0.200000V	0.03	20	0.1	20	0.05	20	0.15	20
1V	10μV	2.00000 V	0.03	20	0.1	20	0.05	20	0.15	20
10V	100μV	20.0000 V	0.06	20	0.2	20	0.08	20	0.25	20
100V	1mV	200.000 V	0.06	20	0.2	20	0.08	20	0.25	20
1000V	10mV	2000.00*V	0.06	20	0.2	20	0.08	20	0.25	20

Nominal Range	Limits of Error: 1 year at 20°C ± 5°C, 50Hz to 10kHz ±[% rdg + digits]		1 year at 20°C ± 5°C, 40Hz to 50kHz ±[% rdg + digits]	
100mV	0.07	20	0.2	30
1V	0.07	20	0.2	30
10V	0.1	20	0.3	30
100V	0.1	20	0.3	30
1000V	0.1	20	0.3	30

Limits of Error: apply for inputs above 2% FS.

*** Maximum Input Voltage:**

Below 20kHz:	750V rms
Above 20kHz:	200V rms
DC:	400V

Input Impedance: 1MΩ//<150pF.

Response Time:
First reading will be within 0.2% of step size, with no dc component.

Upper Frequencies:
Useful measurement at frequencies of up to 1MHz can be taken with an error typically <±1dB.

REDUCED SCALE LENGTH

Digital Filter selected, 1.28s integration time.
Filter must be used for full accuracy below 400Hz.

Specification as above except the digits change to those given below, for all ranges:

Scale Length	50Hz to 10kHz digits	40Hz to 50kHz digits
4 x 9	3	3
3 x 9	2	2

Temperature Coefficient (per °C)
Need be applied only when operating beyond the temperature limits quoted under Limits of Error.

Range	<±% rdg
100mV & 1V	0.005
10V and above	0.01

Overload protection

Autorange:	1.2kV peak
Command Ranges:	
100mV, 1V:	350V peak
10V and above:	1.2kV peak

Maximum Reading Rates:

With filter	1 every 2 second
Without filter	1 every second

Specification

AC VOLTAGE SPECIFICATION 7065 — Mean Sensing

Manufacturers Calibration temperature 20°C

5 x 9 Scale Length

Digital Filter selected, 1.28s integration time.
Filter must be used for full accuracy below 400Hz.

			Limits of Error							
			24 hrs at 20°C ± 1°C				6 mnth at 20°C ± 5°C			
Nominal Range	Input Sensitivity	Displayed Full Scale	50Hz to 10kHz ±[% rdg + digits]		40Hz to 50kHz ±[% rdg + digits]		50Hz to 10kHz ±[% rdg + digits]		40Hz to 50kHz ±[% rdg + digits]	
100mV	1μV	0.140000V	0.03	20	0.1	20	0.05	20	0.15	20
1V	10μV	1.40000 V	0.03	20	0.1	20	0.05	20	0.15	20
10V	100μV	14.0000 V	0.06	20	0.2	20	0.08	20	0.25	20
100V	1mV	140.000 V	0.06	20	0.2	20	0.08	20	0.25	20
1000V	10mV	1400.00*V	0.06	20	0.2	20	0.08	20	0.25	20

	Limits of Error			
	1 year at 20°C ± 5°C			
Nominal Range	50Hz to 10kHz ±[% rdg + digits]		40Hz to 50kHz ±[% rdg + digits]	
100mV	0.07	20	0.2	30
1V	0.07	20	0.2	30
10V	0.1	20	0.3	30
100V	0.1	20	0.3	30
1000V	0.1	20	0.3	30

Limits of Error: apply for inputs above 2% FS.

*** Maximum Input Voltage:**

Below 20kHz:	750V rms
Above 20kHz:	200V rms
DC:	400V

Input Impedance: 1MΩ//<150pF.

Response Time:
First reading will be within 0.2% of step size, with no dc component.

Upper Frequencies:
Useful measurement of frequencies of up to 1MHz can be taken with an error typically <±1dB.

REDUCED SCALE LENGTH

Digital Filter selected, 1.28s integration time.
Filter must be used for full accuracy below 400Hz.

Specification as above except the digits change to those given below, for all ranges.

Scale Length	50Hz to 10kHz digits	40Hz to 50kHz digits
4 x 9	3	3
3 x 9	2	2

Temperature Coefficient (per °C)
Need be applied only when operating beyond the temperature limits quoted under Limits of Error.

Range	<±% rdg
100mV & 1V	0.005
10V and above	0.01

Overload protection:

Autorange:	1.2kV peak
Command Ranges:	
100mV, 1V	350V peak
10V and above	1.2kV peak

Maximum Reading Rates:

With filter	1 every 2 second
Without filter	1 every second

Specification

RESISTANCE SPECIFICATION 7055

Manufacturers Calibration temperature 20°C

5 x 9 Scale Length GUARANTEED PERFORMANCE

Digital Filter selected, 160ms integration time.
4 terminal connection.

Nominal Range	Input Sensitivity	Displayed Full Scale	Limits of Error: 24 hrs ± 1°C ±[% rdg + digits]		6 mnths ± 5°C ±[% rdg + digits]		1 year ± 5°C ±[% rdg + digits]		Measuring Current
100Ω	10mΩ	0.20000kΩ	0.01	4	0.02	4	0.03	4	100μA
1kΩ	10mΩ	2.00000kΩ	0.003	4	0.012	4	0.015	4	100μA
10kΩ	100mΩ	20.0000kΩ	0.003	2	0.012	2	0.015	2	100μA
100kΩ	1Ω	200.000kΩ	0.003	2	0.012	2	0.015	2	100μA
1MΩ	10Ω	2000.00kΩ	0.004	4	0.012	4	0.015	4	1μA
10MΩ	100Ω	20000.0kΩ	0.01	4	0.02	4	0.04	4	1μA

REDUCED SCALE LENGTH

Digital Filter selected, 160ms integration time.
4 terminal connection.

Nominal Range	4 x 9 Limits of Error: 24 hrs ± 1°C ±[% rdg + digits]		6 mnths ± 5°C ±[% rdg + digits]		1 year ± 5°C ±[% rdg + digits]		3 x 9 Limits of Error: 1 year ± 5°C ±[% rdg + digits]	
100Ω	0.01	4	0.03	4	0.04	4	0.05	2
1kΩ	0.01	2	0.02	2	0.03	2	0.05	2
10kΩ	0.01	2	0.02	2	0.03	2	0.05	2
100kΩ	0.01	2	0.02	2	0.03	2	0.05	2
1MΩ	0.01	2	0.02	2	0.03	2	0.05	2
10MΩ	0.02	2	0.04	2	0.06	2	0.05	2

Maximum dissipation in unknown: 2.5mW
Maximum Overload: 350V peak

Open circuit conditions:
A source resistance of 1000GΩ ensures full protection to external circuits

Maximum Reading Rate

Scale length	5 x 9	4 x 9	3 x 9
Readings per second	43	182	330

Temperature Coefficient (per °C)
Need be applied only when operating beyond the temperature limits quoted under Limits of Error.

100Ω to 1MΩ	<±0.0020% rdg
10MΩ	<±0.0025% rdg

High Speed Operation
Without Digital Filter, at all scale lengths, add ±[250mΩ + 1 digit] to the quoted Limits of Error.

Specification

RESISTANCE SPECIFICATION 7065

Manufacturers Calibration temperature 20°C

6 x 9 Scale length GUARANTEED PERFORMANCE

Digital Filter selected, 1.28s integration time.
4 terminal connection

Nominal Range	Input Sensitivity	Displayed Full Scale	Limits of Error: 24 hrs ± 1°C ±[%rdg + digits]		6 mnths ± 5°C ±[% rdg + digits]		1 year ± 5°C ±[% rdg + digits]		Measuring Current
10Ω	1mΩ	0.014000kΩ	–	8	0.006	9	0.01	9	1mA
100Ω	1mΩ	0.140000kΩ	0.001	8	0.005	9	0.006	9	1mA
1kΩ	1mΩ	1.400000kΩ	0.001	8	0.005	9	0.006	9	1mA
10kΩ	10mΩ	14.00000kΩ	0.001	8	0.005	9	0.006	9	1mA
100kΩ	100mΩ	140.0000kΩ	0.002	8	0.006	9	0.007	9	10μA
1MΩ	1Ω	1400.000kΩ	0.002	8	0.006	9	0.007	9	10μA
10MΩ	10Ω	14000.00kΩ	0.005	8	0.02	9	0.02	9	1μA

REDUCED SCALE LENGTH

Digital Filter selected, 160ms integration time.
4 terminal connection.

Nominal Range	5 x 9 Limits of Error: 24 hrs ± 1°C ±[% rdg + digits]		6 mnths ± 5°C ±[% rdg + digits]		1 year ± 5°C ±[% rdg + digits]	
10Ω	–	8	0.01	9	0.01	9
100Ω	0.003	8	0.01	9	0.01	9
1kΩ	0.003	2	0.007	3	0.01	3
10kΩ	0.003	2	0.007	3	0.01	3
100kΩ	0.003	2	0.007	3	0.01	3
1MΩ	0.004	2	0.008	3	0.01	3
10MΩ	0.01	2	0.02	3	0.02	3

OTHER SCALE LENGTHS — all ranges

Scale Length	1 year ± 5°C
4 x 9	±[2 digits + 6mΩ]
3 x 9	±2 digits

Maximum dissipation in unknown: 25mW
Maximum overload: 350V peak

Open circuit conditions:
A source resistance of 1000GΩ ensures full protection to external circuits.

Maximum Reading Rate

Scale length	6 x 9	5 x 9	4 x 9	3 x 9
Readings per second	6	43	182	330

Temperature Coefficient (per °C)
Need be applied only when operating beyond the temperature limits quoted under Limits of Error.

Range	<±[% rdg + digits]	
10Ω to 1MΩ	0.001	0.2
10MΩ	0.0025	0.2

High Speed Operation
Without Digital Filter, at all scale lengths, add ±[25mΩ + 1 digit] to the quoted Limits of Error.

Specification

INTERFERENCE REJECTION 7055 & 7065

Ratio of peak interference to 1 digit reading error.

Series Mode

Maximum Series Mode: Autorange: 1.1kV pk
Command Range: 1.1 x V FS

DC Measurement: Rejection of 50 (60) (400) Hz ± 3%

Scale Length	Without Filter Integration Time	Without Filter Rejection	With Filter Integration Time	With Filter Rejection
6 x 9*	160ms	>90dB	1.28ms	>90dB
5 x 9	20ms	>70dB	160ms	>90dB
4 x 9	2.5ms	–	160ms	>90dB
3 x 9	0.3ms	–	160ms	>90dB

* 7065 only

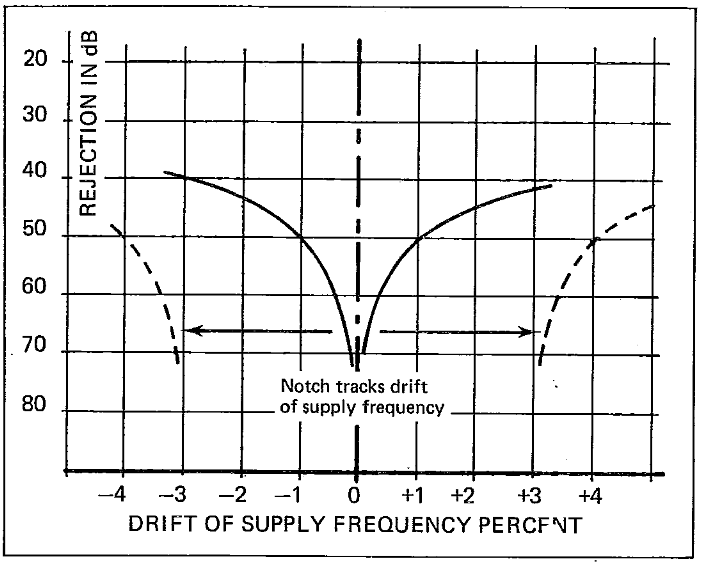
Effective Common Mode

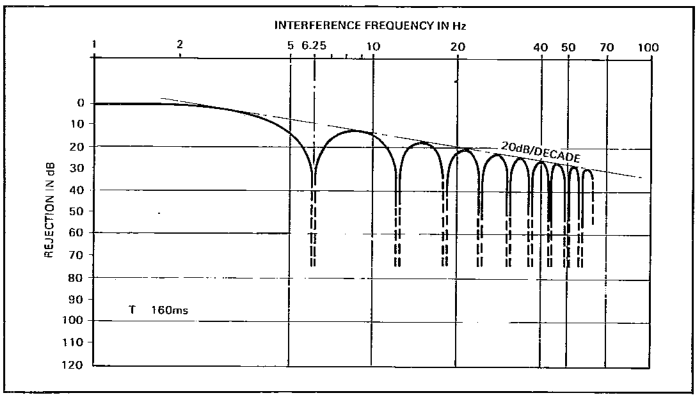
Measured with 1kΩ imbalance in Lo lead.

Maximum Common Mode:
500V dc or peak ac

DC Measurement:
Rejection of dc >150dB
Rejection of 50 (60) Hz ±3% >164dB

AC Measurement:
Rejection of dc >150dB
Rejection of 50 (60) Hz > 50dB

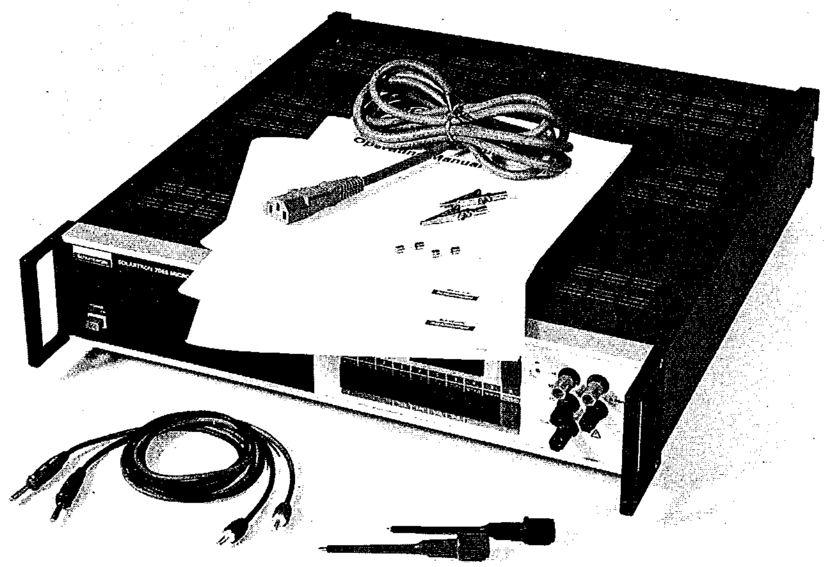




The precise integration time is locked to the period of the mains supply by a digital servo, thus preserving maximum rejection up to a shift of ± 3%.

ACCESSORIES SUPPLIED

	Part Number
Input lead Red	359900090
Input lead Black	359900080
Crocodile Clip (copper) (2 off)	355901030
Test probe Red	351901040
Test probe Black	351901030
Spare fuse 800mA	360106310
Mains cable	480140220
Shorting link	355001660
Rack mounting handles (2 off)	429700101
Rack mounting ears (2 off)	469601201
Operating Manual:	
Part 1 Voltmeter – Measurement	70550010
Part 2 Voltmeter – Processing	70550011
Part 3 Data System Use	70550012
Technical Manual	70550013



OPTIONS

	Unit Type Number
Parallel Binary/BCD Systems Interface	70554
GP-IB/IEEE 488/IEC TR66 System Interface	70555
Processing Functions and RS232C Interface	70556

Optional Accessories	Part Number
Calibration Cover	70559D

Section 3
Operating Instructions

PRELIMINARIES

Check that the correct fuse is fitted as indicated beside the fuse holder.

800mA SLO - BLO for both 115V (nominal) and 230V (nominal) mains voltage.

Only fuses with the rated current, and of the specified type, are to be used for replacement. Makeshift fuses should never be used.

Connect a suitable plug to the mains lead.

BROWN	LIVE
BLUE	NEUTRAL
GREEN/YELLOW	EARTH

This earth connection is essential for stability of reading and user safety.

The mains plug should be inserted in a socket provided with a protective earth - this applies equally to the use of an extension cable. Where 3-contact supply outlets are not available, a suitable protective-earth connection *must* be made *before switching the instrument on.* Any interruption of the protective earth is likely to render the instrument unsafe.

Operation at other than 50Hz supply frequency.

The links for 50Hz, 60Hz and 400Hz operation are positioned on board 3; access to these necessitates partial removal of the cover. For 50Hz, links A C and F are made, for 60Hz link A only is made while for 400Hz links C F and B are made.

The instrument should be disconnected from the mains supply before any attempt is made to remove the cover.

Whenever the instrument is switched on, the DC Voltage measurement function is automatically selected. The VDC button indicator will be illuminated as will the following: AUTO, (automatic range selection is operative), FILTER (increases the integration time) and TRACK (tracks the input quantity). Zero input places the instrument on it's lowest range (0.01 volts) ranged down from 1000V; 5 x 9's scale length is operative and the white on black legends only apply.

DC VOLTAGE MEASUREMENT

1. Switch POWER on

2. Ensure REMOTE button indicator is off (i.e. Local operation), unless REMOTE operation with Optional Interface unit is required. (In that instance refer to the appropriate part of the manual).

3. Select DISPLAY (Ind "flashing"). Select the scale length and corresponding integration time for the resolution, noise rejection and reading rate as required.

4. Connect the input lead to the unknown voltage source – BLACK lead to signal Low, RED lead to signal High (in that order).

5. Press SAMPLE for each single reading required or TRACK for repetitive measurement.

6. Read the displayed value (in volts). The indicated polarity is that of the RED lead with respect to the BLACK (Polarity is positive unless the minus sign is illuminated).

Note: With FILTER selected (Ind. "on") more stable less noisy readings are achieved. For 3 to 5 nines scale lengths the integration time is 160ms. For 6 x 9's the integration time is 1.28s.

AC VOLTAGE MEASUREMENT (mean)

1. Switch POWER on

2. Ensure REMOTE button indicator is off (i.e. Local operation), unless Remote operation with the optional Interface Unit is required (in that instance refer to the appropriate part of the manual).

3. Select VAC (Ind on).

4. Select DISPLAY (Ind "flashing"). Select the scale length and corresponding integration time for the resolution, noise rejection and reading rate required.

5. Connect the input lead to the unknown voltage source.

The 7065 (7055) voltmeter has μV sensitivity on AC to 1MHz. For AC measurement it is recommended that the connecting leads are kept as short as possible; the use of a twisted-pair is strongly advised for connection to the front panel terminals. When using the rear input lead the free ends should also be twisted where practicable. This practice will reduce the effect of local pick-up to an acceptable level.

6. Press SAMPLE for each single reading required or TRACK for repetitive display of measurement.

7. Read the displayed value (in volts).

NOTE: With FILTER selected, more stable less noisy readings are achieved. For 5 x 9's scale length the integration time is 1.28s. This is the maximum scale length for AC measurement.

CURRENT MEASUREMENT

Although not a facility directly provided by the voltmeter, this option is available in the processor. Nevertheless current measurement can be easily effected by measuring the potential difference developed across a known precision resistor, either a resistance standard or a precision wire wound component. For ac measurement a metal film precision resistor is recommended.

RESISTANCE MEASUREMENT

1. Switch POWER on.

2. Ensure REMOTE button indicator is off (i.e. Local operation), unless Remote operation with the optional Interface Unit is required. (In that instance refer to the appropriate part of the manual).

3. Link the Ω DRIVE terminals to the V/Ω Hi and Lo terminals.

4. Select kΩ (Ind on).

5. Select DISPLAY (Ind "flashing"). Select the scale length and corresponding integration time for the resolution, noise rejection and reading rate required.

6. Connect input lead to the unknown resistance.

7. Press SAMPLE for each single reading required or TRACK for repetitive display of measurement.

8. Read the displayed value (kilohms).

FILTER selection as for DC measurement

Section 4
Measurement Techniques

The following notes are written for those users who wish to know more about the techniques of precision measurement. They also provide the user with a guide as to how he can obtain the optimum performance from the dvm in more unusual applications and avoid some of the pitfalls.

INPUT RESISTANCE

In making a measurement of voltage virtually all instruments take a current from the voltage source. The one exception is the true potentiometer in which, at balance, the current drawn falls to zero. The current drawn by the measuring device causes a voltage drop across the internal resistance of the source such that the voltage measured is less than the true emf of the source. (Fig. 4.1).

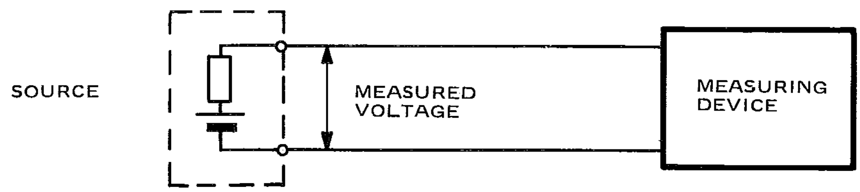


Fig. 4.1 *Current taken by a measuring instrument can cause a voltage drop across source resistance.*

A good moving coil meter will take a current of typically 10μA (100kΩ/V) so that with a source resistance of 1kΩ the voltage drop would be 10mV. This is obviously unacceptable for precision work since an instrument with such a low input resistance would read 1.49V instead of 1.50V.

Fortunately, electronic feedback techniques can give a digital voltmeter such a high input resistance that, for most practical purposes, the effect can be ignored. Thus the 7065(55) when measuring dc voltages less than 14V, (20V, 7055) has an input resistance in excess of 10GΩ. This means that the source resistance has to exceed 10kΩ before an error of 1 part per million is produced. If this sounds somewhat vague, it should be understood that defining the input resistance more closely is impossible since a group of voltmeters will have differing gains in their input amplifier. This will of course have no effect on their accuracy, but will make the input resistance different possibly 20GΩ to 50GΩ. but never as low as 10GΩ.

When measuring voltages greater than 14V (20V, 7055) it is not possible to apply the unknown input directly to the input amplifier; first it must be attenuated. The attenuator must be very accurate and stable, capable of withstanding high input voltages, hence precision wire wound resistors are used. Since the use of high value resistors would make the attenuator more difficult and expensive to produce, a 10MΩ network is used. Hence, for voltages greater than 14V (20V, 7055) the input resistance is 10MΩ ± 0.25%, errors arising from source resistance being calculable with reasonable accuracy. For example, a source resistance of 1kΩ will degrade the reading by 0.01%, which is expressed as 1 digit in 10 000.

INPUT CURRENT

All solid state devices have finite input currents and/or leakage currents. A voltmeter will therefore have a current flowing at the input terminals even with zero input signal. The effects of this current are additional to those of input resistance. (Fig. 4.2).

By careful design this current can be reduced such that its effects are almost negligible and in the 7065(55) it is less than 20pA at room temperature. The input current will flow into or out of the Hi terminal and must therefore, be regarded as lying between +20pA and -20pA.

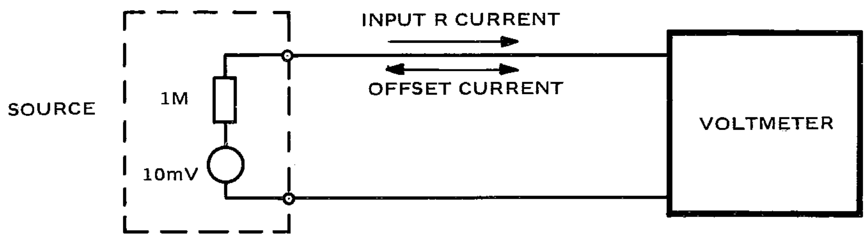


Fig. 4.2 *Current taken by input resistance flows into the voltmeter; offset current may flow either way. Both effects are present together.*

If we take an extreme example of a 10mV source having a resistance of 1MΩ, the input resistance (> 10GΩ) would give a reading that is up to 1μV in error. In addition an input current of 20pA will introduce an error of ± 20μV which will add to or subtract from the input resistance error. The total uncertainty then will be in the range + 19μV to -21μV.

The condition given in the above example is unlikely to be encountered by the average user because low level signals nearly always have a relatively low source resistance, less than 10kΩ, the effects of which are insignificant.

ASSESSING INPUT RESISTANCE AND CURRENT

1. Input Current

Connect a 10MΩ resistor across the input terminals. Select 5 x 9's (55) or 6 x 9's (65) integration time, select FILTER and VDC. (In a "noisy" environment it may be necessary to enclose the resistor in a screening box connected to the Lo terminal). The input current in pA is obtained by dividing the reading in μV by 10.

2. Input Resistance:

Connect the voltmeter to a source of approximately 10V dc. via a 10MΩ resistor and a switch, mounted in a screening box as illustrated in Fig. 4.3.

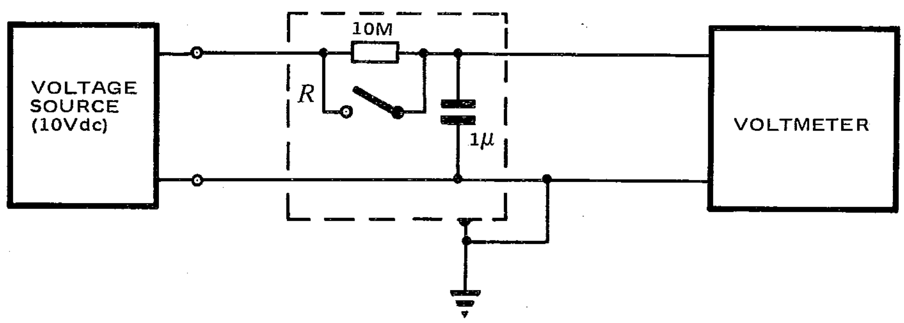


Fig. 4.3 *An assessment of input resistance will include an effect due to offset current.*

Select 5 x 9's (55) or 6 x 9's (65) integration time, select FILTER and VDC.
With switch closed note the reading.
Open the switch and note the fall in reading (ΔV)

The fall is the algebraic sum of the voltage drop across R as a result of the source current and the instrument's input current, I_{in}. Thus:

$$\Delta V = \frac{R}{R_{in}} V_{in} + RI_{in} \quad (\text{assuming } R_{in} \gg R)$$

then:

$$\Delta V - RI_{in} = \frac{R}{R_{in}} V_{in}$$

$$R_{in} = \frac{RV_{in}}{\Delta V - RI_{in}}$$

Substituting the experimental known values:

$$R_{in} = \frac{(10 \times 10^6) \times 10}{\Delta V - (10 \times 10^6) I_{in}} \quad \Omega$$

For convenience this can be simplified and R_{in} expressed in GΩ (1GΩ = 10^9Ω), taking ΔV in μV and I_{in} in pA, thus:

$$R_{in} = \frac{10^5}{\Delta V - 10 I_{in}} \quad \text{G}\Omega$$

It was previously noted that I_{in} may flow into or out of the dvm Hi terminal, assisting or opposing the source current. The magnitude of I_{in} is evaluated as in 1. above; its direction and hence its effect on R_{in} can be readily established by reversing the source terminals in the circuit of Fig. 4.3 and again noting the reading with the switch open. A higher reading is obtained when I_{in} opposes the source current, in which case ΔV will be smaller and I_{in} in the final expression will have a negative value.

SPURIOUS VOLTAGES

Although small emf's occur in the voltmeter input circuit, they are compensated for by careful design. When the instrument has warmed-up for about 30 minutes, they are so stable as to be quite insignificant to the user.

The voltmeter will faithfully measure any input that is applied to its terminals; it is the responsibility of the user to ensure that the input contains only the voltage that he wishes to measure. In low level work – with perhaps a few tens of microvolts – this may require some care and thought in the arrangement of the circuit.

As an example, consider measuring the voltage produced by passing a very small current through a wirewound resistor. On the relevant range the reading is recorded as 126μV. But the resistor is placed – in the sun or near a power transistor – so that one end is a little warmer than the other. Because of the dissimilar materials used in the wire of the resistor and the copper connections, a net thermal emf of possibly 40μV/°C will exist. Thus a differential of 0.5°C across the resistor could mean that the true result should be either 106μV or 146μV. The voltmeter cannot possibly distinguish between the wanted and unwanted parts of the signal that is applied to it. In this example, without altering the conditions of the resistor in any way, a measurement should be made with the small current flowing first in one direction and then in the other. In one case the thermal emf will add and in the other it will subtract. So the mean of the two results will eliminate the error.

Metal oxide resistors and reed relays are two other examples in which thermal emf's bring about similar errors, in the reed relay the heat produced by the operating coil being the contributing factor.

When the unwanted emf can be determined and is steady, it can be 'backed-off' by using the μV OFFSET control. This has a range of ±15μV (typically).

In attempting precision measurement of low level signals, effects other than thermal emf's can cause problems. Leakage across an insulator which is degraded by humidity or an industrial atmosphere may produce an unsuspected voltage across a source resistance. Coaxial cables, when flexing under vibration, can generate quite high transient voltages due to the screen scrubbing the pvc insulant; the use of low noise cables will prevent this effect.

SERIES MODE INTERFERENCE

The examples of thermal and other, spurious emf's given above can be regarded as forms of interference because they interfere with the accurate assessment of the unknown signal. They are in series with the signal and voltmeter input and represent a special case of series mode interference because there is nothing that the voltmeter can do about rejecting dc interference while measuring a dc signal.

Series mode ac interference is a different matter. Because of the basic design principle, this voltmeter will ignore all the usual forms of ac and noise that may be intermingled with the dc signal. Hence in all normal measurement work the user will be unaware of ac interference and it will not cause errors.

Nevertheless, it would be possible to introduce such a degree of interference that the voltmeter would be unable to cope, so the keen user may be interested in the mechanism that brings about rejection.

The most common form of ac interference is simple 'hum' – i.e. 50Hz superimposed on the dc signal. This can be visualised either as pick-up on the connecting leads, as shown in Fig. 4.4(a), or as a generator that is a part of the source, as in Fig. 4.4(b). In both the result is the same and is shown graphically in Fig. 4.5.

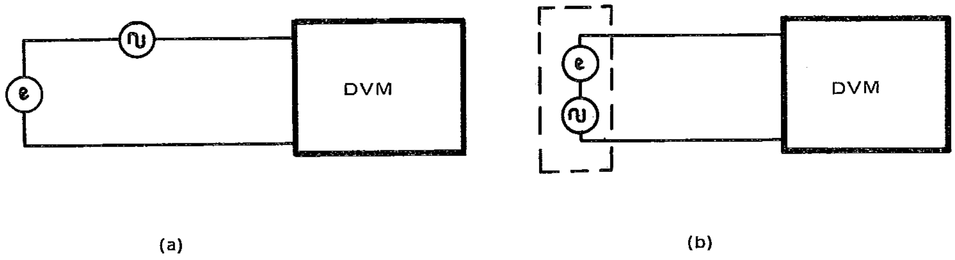


Fig. 4.4 *Interference at 50Hz can arise from pick-up on the leads (a), or may be inherent in the source (b).*

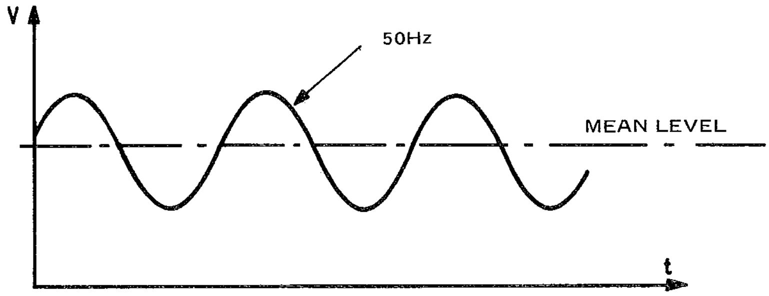


Fig. 4.5 *50Hz superimposed on the dc level that the voltmeter is trying to measure.*

Users of oscilloscopes will be familiar with this sort of picture and will know that the ac component is typically a few milli-volts peak-to-peak. This may be superimposed on a wanted dc signal of a mere 10μV.

The 7065(55) rejects ac signals by averaging the input voltage over the period of time selected, i.e. the integration time. Since the most common form of interference is attributable to the 50Hz (60Hz) mains, the integration times are chosen to be exact multiples of the mains period (20ms at 50Hz). This is achieved by timing the integration periods using a clock synchronised to the mains supply. Thus over the integration period the average 50Hz (60Hz) interference will be zero, the reading being unaffected.

This total rejection occurs at any frequency with a period equal to an exact fraction of the integration time. Harmonics of the mains frequency will also be totally rejected, while at other frequencies the rejection will be less.

Considering, as an example, the 160ms integration time:–

Total rejection will occur at:

6.25Hz, 12.5Hz, 18.75Hz, 25Hz . . . . 43.7Hz, 50Hz . . . . 62.5Hz, 68.75 Hz, 75Hz . . . . 100Hz etc.

For the 1.28s integration time there will be 8 times as many totally rejected frequencies starting at 0.781Hz and spaced 0.781Hz apart. The only practical limitation of frequency rejection is that imposed by clock frequency and in the 7065 rejection of 50Hz (60Hz) is better than 70dB.

Series mode rejection is defined as:–

$$SMR = 20 \log_{10} \frac{\text{Peak reading error}}{\text{Peak of interference}} \text{ dB.}$$

N.B. The 0.3125ms and 2.5ms integration times have of course no rejection at 50Hz.

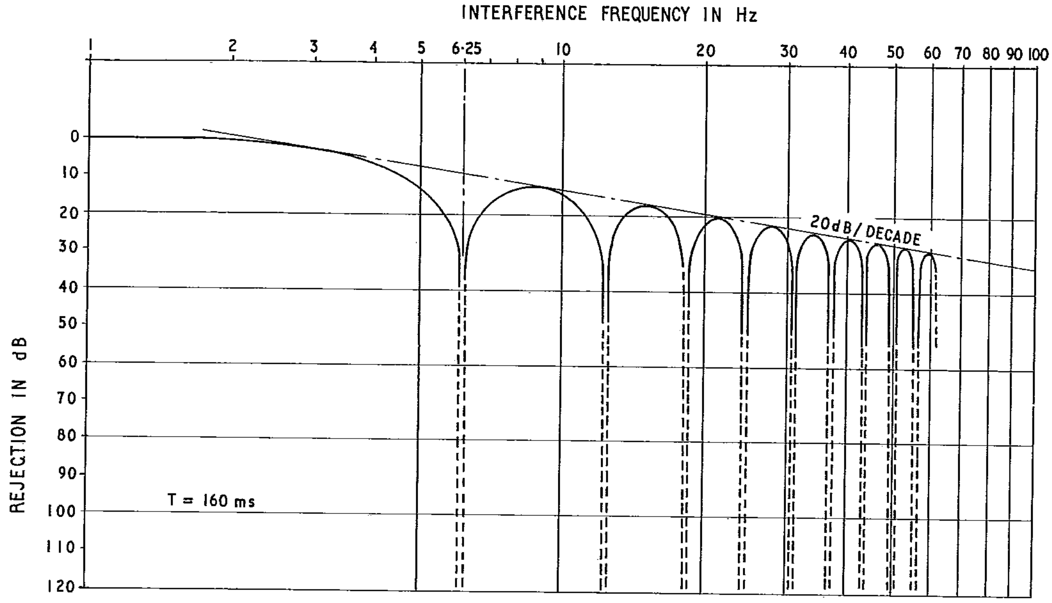


Fig. 4.6 *SERIES MODE REJECTION. These curves show the rejection at the frequencies given whilst measuring dc. The integration time is locked to the mains period so the curves will shift along the frequency axis as the mains supply frequency alters.*

COMMON MODE INTERFERENCE

Interference can also arise from unwanted voltages which are common to both input leads. This is illustrated in Fig. 4.7, where the signal source is earthed locally and the voltmeter input has also been earthed.

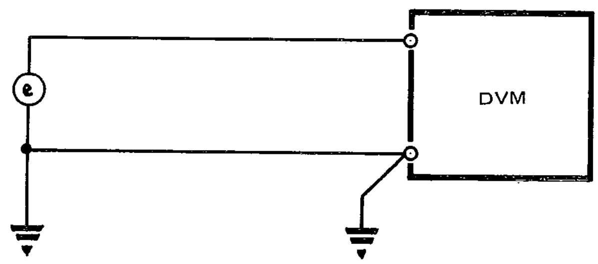


Fig. 4.7 *An 'earth' at both source and voltmeter input may introduce common mode interference. For this reason the voltmeter input is fully isolated.*

There is a distinct possibility that the two 'earths' are not at a common zero potential; in large industrial plants and in some multi-terminal system applications, widely separated earths can have potential differences between them in excess of 10V.

This situation can be represented as in Fig. 4.8, where the source is shown to be at a finite potential with respect to earth.

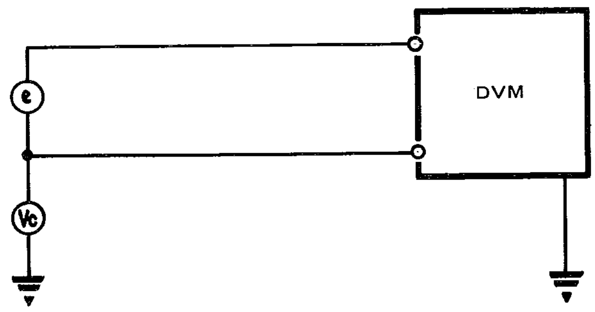


Fig. 4.8 *The source can be at a high potential above earth without causing errors.*

This would happen in practice, for example, where a thermocouple is used to measure the temperature of a furnace element. The signal emf might be millivolts of dc while the element itself is at 240V ac with respect to earth. Obviously earthing the voltmeter input would not be possible, although the case and many of the instrument's circuits are earthed via the mains lead.

The 7065(55) has been engineered so that the input circuits are extremely well isolated from the case, which itself is connected to mains earth. In all normal measurement the small current which does flow as a result of a large common mode voltage, will not cause any error. However, purely for the safety of equipment and operator, this voltage should not exceed 500V.

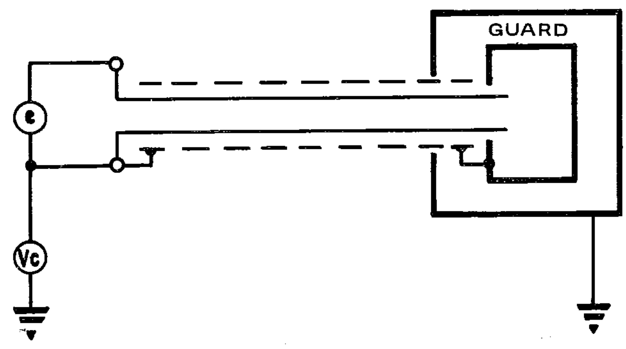


Fig. 4.9 *With this lead the voltmeter Guard is strapped to Lo (BLACK) within the free end of the cable.*

A 2 terminal lead enclosed in a braided screen is shown in Fig. 4.9. Within the instrument the cable screen is connected to the guard "box" (a screening compartment which encloses the input circuits) and at the free end the screen is strapped to signal Lo (Black). Hence the guard is preserved right up to the signal source and measurements cannot be affected by common mode current flowing in the screen and via leakage to earth.

In some measurement situations common mode voltage can have an effect on the reading. Most users will never meet the problem, but those who do can still eliminate errors by using the voltmeter correctly. When there is resistance associated with the source – perhaps inherent in the source, or in the connecting leads – common mode current can flow through this resistance. Examples are: the resistance of strain gauges, long compensating leads from a thermocouple. This is illustrated by Fig. 4.10 where it will be seen that current flowing from V_c to earth through the screen will pass through the resistance. If the guard-earth leakage is assumed to be the specified minimum of $10^{10}\,\Omega$ and $V_c = 100$V dc the common mode current will be 10^{-8}A. Taking a lead resistance of 1kΩ, 10^{-8}A will develop a voltage drop of 10μV. Since the voltmeter cannot reject dc interference the worst error will be 10μV.

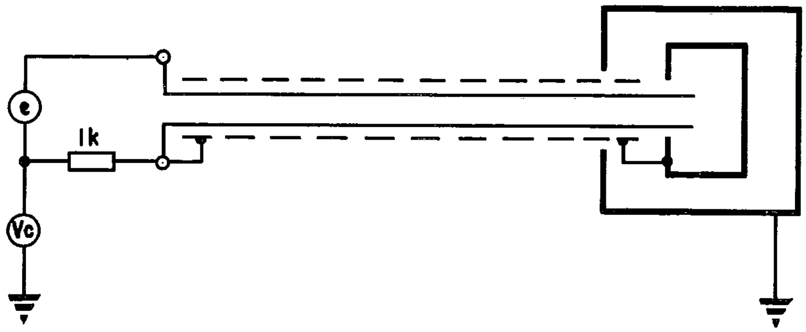


Fig. 4.10 *A rare, but more difficult, situation is where common mode current flows through lead resistance. This is entirely overcome by the arrangement of Fig. 4.11.*

If the source of common mode is ac, the stray capacitance from guard to earth is more important. The figure specified is 500pF which exhibits a reactance of about 6MΩ at 50Hz. With V_C now 100V rms the drop across 1kΩ is approximately 17mV rms or 24mV peak. This appears at the input terminals and the inherent rejection of series mode will be effective in reducing reading error to much less than 24mV. At worst the final reading error will not exceed 1μV.

In these examples a 1kΩ resistance has been assumed in one lead. Obviously the magnitude of the errors is proportional to this resistance and it is accepted practise to specify common mode rejection with 1kΩ unbalance in the leads using the configuration of Fig. 4.10. Even in these exceptionally adverse circumstance the error can be overcome by using a different input arrangement as in Fig. 4.11.

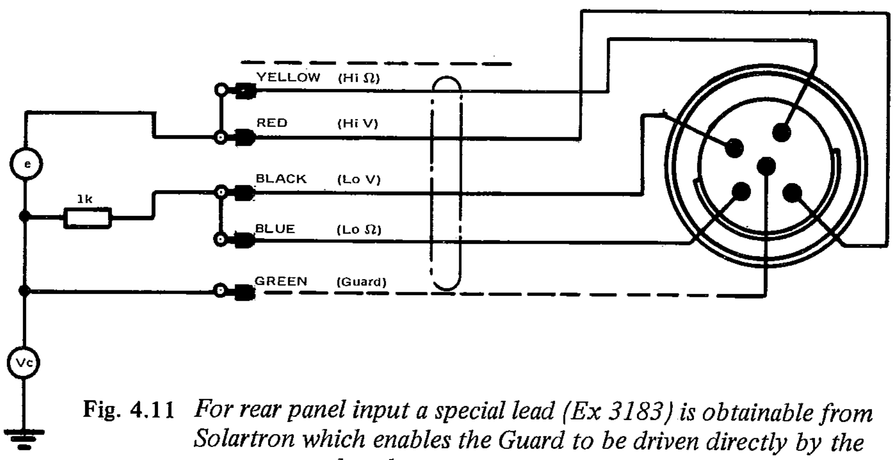


Fig. 4.11 *For rear panel input a special lead (Ex 3183) is obtainable from Solartron which enables the Guard to be driven directly by the common mode voltage.*

Here use has been made of a special 5 way lead from which 4 cores and the screen are brought out at separate terminations.

For voltage measurement with Guard only 3 terminals are required, Signal Hi, Signal Lo and Screen (Guard). For voltage measurement from the front panel terminals the RED and BLACK Ω Drive terminals should be linked to the V/Ω HI and LO terminals respectively. GREEN is connected directly to the source of interference thus isolating common mode current from the input leads.

Using this arrangement even though the interference were the permitted maximum (500V dc or peak ac), it is most unlikely that there would be any discernible error – even on the most sensitive range.

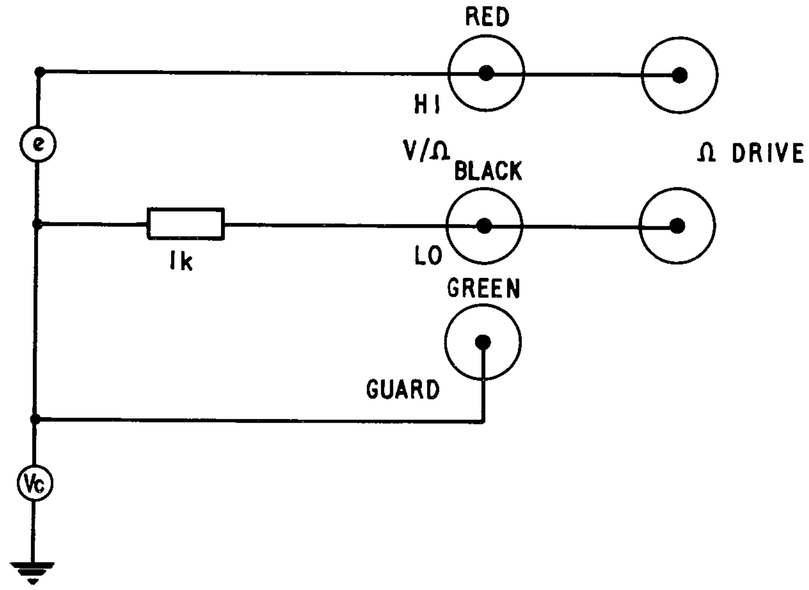


Fig. 4.12. *Front panel input which enables the GUARD to be driven directly by the common mode voltage.*

When considering immunity to series mode interference, reference was made to the integration time. This time, which is capable of selection by the user, is the period over which the instrument takes an *average* measurement of the input level. The conversion technique continuously integrates (i.e. averages) the input signal, results being obtained which, in principle, increase the accuracy of the conversion in direct proportion to the integration time.

Integration time determines the resolution, maximum sensitivity, noise rejection and, of course, the number of readings presented per second.

The maximum displayed sensitivity is limited to 1μV but achieved in the instrument and present in the Interface output data is a sensitivity to 10nV.

All integration times are available in DC AC and Ω but the display on AC is limited to 5 x 9's, full scale 140000 (200000, 7055).

AC MEASUREMENT

In it's simplest form a dvm is able to measure dc voltage only. It can be adapted to measure ac by including an ac-dc converter ahead of the dc input circuits. This has been done in the 7065 and 7055 and includes a converter which may be regarded as a sophisticated full-wave rectifier. By including semi-conductor rectifiers in an operational amplifier loop, non-linearities in the transfer characteristics of the rectifiers are eliminated. The smoothed output of such a rectifier system is a dc level which is proportional to the mean value of the ac; it is this which is passed to the dc voltmeter for measurement. Fig. 4.13 shows this action.

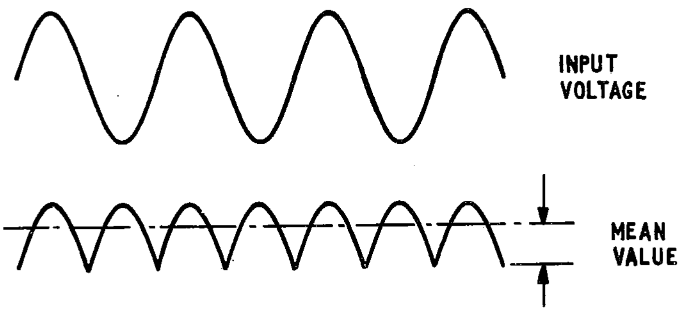


Fig. 4.13 *An ac input voltage is rectified in the ac-dc converter and the smoothed mean value is passed to the dc circuits for measurement. Although the mean value is sensed the rms value is indicated.*

There are three ways of specifying the amplitude of an ac voltage: the mean, the peak or the root-mean-square (rms) value. For any periodic function there is a precise relationship between these which can be calculated. In the case of a sine wave:–

$$\text{Mean} = \frac{2}{\pi}\ \text{peak}$$

$$\text{rms} = \frac{1}{\sqrt{2}}\ \text{peak}$$

When speaking of ac voltage (e.g. 240V) it is accepted convention that the rms value is understood unless mean or peak value is stated. It has therefore become accepted that a measuring instrument will read rms, although the vast majority actually measure the mean. For these reasons 7065(55) are scaled to give a reading of the rms of the input on the assumption that the input is a perfect sine wave.

Distortion is a factor which can occasionally introduce errors as a result of this assumption. The reader will be familiar with the analysis of a complex waveform which breaks down a periodic function into a fundamental sine wave plus a series of harmonics. It is the harmonics which represent the distortion content, the degree of distortion being dependent upon the order, the amplitude and phase of the harmonics. It will be extremely rare that the detailed harmonic content is known, but what may be known is the total distortion which is, in effect, the sum of the total harmonic content.

Measurement errors would be greatest for a mean sensing, rms indicating instrument if the total distortion were all third harmonic. This assumption would enable an estimate of the worst possible errors to be made. In this case:

Max. percentage error = 1/3 total percentage distortion.

Thus a total distortion of 0.3%, if all third harmonic, could give a worst error of 0.1%.

The voltmeter input impedance on ac is either 1MΩ or 10MΩ (depending on range) in parallel with a capacitance. At frequencies above a few tens of Hz the capacitive term will be dominant. The values are given in the formal specification and may be used to calculate the voltage drop across a source impedance at a particular frequency.

Consideration of Fig. 4.13 will show that the lower the signal frequency the more smoothing is required before the mean level can be applied to the dc measuring circuit. Therefore, below about 100Hz a longer time constant filter is required in order to preserve measurement accuracy. AC measurement with a digital voltmeter gives easily the best compromise between speed and accuracy over all other forms of ac measurement. But with low frequencies, using any measurement technique, the reading must have time to settle.

It has been pointed out that when measuring dc voltages the voltmeter cannot reject thermal or other dc interference. In exactly the same way they cannot possibly be rejection of series mode ac interference when measuring ac voltages. Common mode rejection is, however, still preserved, and the input circuits on ac are still fully isolated from chassis and earth.

For those who are interested in pursuing the subject in greater depth, a paper on AC Voltage Measurement, with particular reference to waveform errors, is available free on request to Solartron.

INTEGRATION TIME

In an earlier note reference was made to the limitation of scale length imposed on the ac mode of measurement. Two integration times are available on AC but selection of 6 x 9's is not accompanied by the increased resolution obtained in dc measurement. Selection of FILTER introduces Digital Filtering, enabling more stable, less noisy readings to be achieved with low frequency ac input voltages. It is recommended that, in a noisy environment, users wishing to measure low frequency ac voltages make use of the significant advantages to be gained by selecting the longer integration time, i.e. 1.28s with FILTER, 85ms without FILTER.

N.B. These limits only apply to LOCAL operation. For details of limits applicable when the instrument is under REMOTE control, reference should be made to the appropriate Part of the Manual.

RESISTANCE

The 7065(55) measures the value of a resistor by passing a defined current through it and measuring the resulting potential difference. The current is small so that the power dissipated in the resistor is negligible.

Resistance Value measured	Current used	
$< 14k\Omega$	1mA	
$> 14k\Omega < 1.4M\Omega$	10μA	
$> 1.4M\Omega \leqslant 14M\Omega$	1μA	
$< 200k\Omega$	100μA	7055 only
$> 200k\Omega$	1μA	7055 only

The 1mΩ sensitivity is satisfactory for most low value measurements. Should there be a requirement for increased sensitivity on low values the voltmeter can be used on a dc voltage range to measure the potential difference across the resistor with the current provided from an external source (Fig. 4.14).

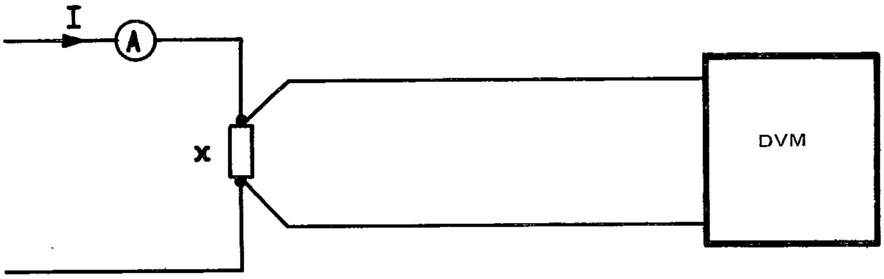


Fig. 4.14 *A very low value resistance may be measured by measuring the voltage developed across it. The voltage leads should be connected close to the ends of the resistor.*

If I is 10mA, a reading of 0.101245V means that X is 10.1245Ω. Obviously other appropriate currents could be used. The first point to observe is that, in this example, the sensitivity is 0.1mΩ per digit. Hence the voltmeter connections must be made right at the ends of the resistor and must not embrace any significant length of the current carrying leads (1cm of 22swg copper wire is approximately 0.4mΩ).

A second point is that the accuracy is affected directly by the precision of the current setting. There would be little point in using a moving coil multimeter to set the current and then record a reading of 12.631Ω.

An improved technique is shown in Fig. 4.15.

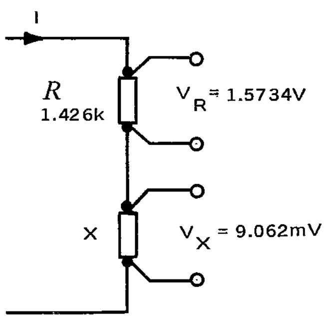


Fig. 4.15 *A ratio measurement avoids having to set a precise value of current.*

Here a resistor R, whose value is known, is connected in series with the low value unknown X. R can be a much higher value than X. If R is not already known it can be measured on one of the ohms ranges.

The voltmeter is connected across R and the current supply adjusted to give a reading. The precise value of V_R is not important; neither is the value of the current I. In this example I could be simply provided by a 1.5V cell. The reading V_R is recorded. The voltmeter is transferred to X and the reading V_X is noted. The value of X is then given by:-

$$X = R \frac{V_X}{V_R} \text{ ohms}$$

Using the values shown in Fig. 4.14:-

$$= \frac{1.426 \times 10^3 \times 9.062 \times 10^{-3}}{1.5734} = 8.213\Omega$$

If X is being set to different values it may be necessary to measure V_R each time because, unless I comes from a constant current supply, changes of X may significantly alter I.

Should it be necessary to measure resistance at a distance from the voltmeter which is beyond the reach of the rear input standard lead, a special lead may be obtained from Solartron. In this the four cores and screen are terminated separately as shown in Fig. 4.16. For front panel input the YELLOW and BLUE connections correspond to the Ω DRIVE RED and BLACK terminals respectively.

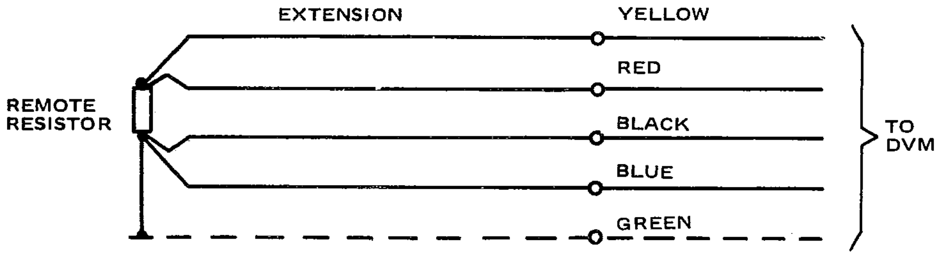


Fig. 4.16 *In measuring a remote resistor, lead compensation can be preserved for rear panel input by using the special input cable (obtainable from Solartron) and extending it by a 4 core screened cable.*

RESISTANCE MEASUREMENT USING THE 4-WIRE TECHNIQUE

When measuring low values of resistance the voltage dropped along the leads can sometimes introduce errors. In the 7065(55) the effect is entirely eliminated by the use of a 4-wire technique. With this technique, two wires supply the current to the resistor while two sense the potential developed across it. The voltage leads must be made right at the ends of the resistor and must not embrace any significant length of the current carrying leads. Hence no current flows in the sensing leads, therefore no voltage drop is developed. Likewise the effects of contact resistance are also eliminated.

Microprocessor Voltmeters 7065 and 7055

Part 2

Contents of Part 2

Section 1
General Information

INTRODUCTION

Part 1 of this manual described the measurement functions of the 7065 (7055) voltmeter. This book is concerned with *processing* those measurements, the use of the instrument's range of programs which Option 70556 makes possible.

The aim of this Part of the manual is to teach the user, who will probably not have used a processing voltmeter before and is possibly not familiar with programming, how to derive maximum benefit from owning and using the Solartron Microprocessor Voltmeter.

In all the descriptions which follow the model is assumed to be the 6 x 9's 7065. Also details of pure measurement are omitted except where absolutely essential to the text. For details of the differences between 7065 and 7055 and of measurement without processing the reader is referred to Part 1 of the manual.

Fitting instructions for the Program pcb, Part No. 70559508, are to be found in Appendix 1 to Part 3 of this manual. (Data Systems Use). It should be noted that this pcb includes interfacing circuitry to RS232C/CCITT V-24 Standard.

The Processing Voltmeter

7065 when fitted with Processing Option 70556 offers on the spot processing of measurements without the need for the user to record intermediate results. The processing voltmeter could be mistaken for a voltmeter plus a calculator – it is more than that. The processing facilities form an integral part of the instrument such that there is no need for the user to obtain measurements and then enter them for processing; they are automatically accessed by the microprocessor as required.

Facilities

The processor facilities available are 8 mathematical programs plus Time. The 8 maths functions offer the user a total of 16 different manipulations of the measured quantity while Time can be used in two different ways. As will be seen later, programs can be used alone or in combination to give even more useful results.

It sounds complicated, and in fact the microprocessor voltmeter is capable of performing quite complicated mathematical manipulations. For the user, however, nothing could be more simple.

Program definitions

Before learning how to use 7065 in its processing role the reader is invited to consider just what the Programs can do for him. The facilities available are:

1. **Multiply** by a constant.
2. **Percentage Deviation** from a nominal value.
3. **Offset** reading by a constant.
4. Derive the **Ratio** to a constant.
5. Obtain **Maximum, Minimum** and **Peak-to-Peak** values.
6. **Off-limit** detection.
7. **Statistical Analysis.**
8. **Thermocouple** temperature measurement.
9. **Time** control.

The programs are here described in some detail. Elsewhere in this book a Summary table is included for the user's quick reference. In the mathematical expressions which accompany many of the descriptions the symbols used are:

R, the result of the calculation
and x, the variable, either the measurement itself or the result from a previous calculation.

MULTIPLY: $R = cx$

The measurement is multiplied by a constant, c, which the user must set in from the keyboard when defining the program. This program has possibly the widest range of applications, permitting the scaling of electrical quantities into engineering units, as just one example. Like most of the mathematical programs it becomes more powerful when used in combination with others. The constant c can be positive or negative, having a modulus within the range 10^{-15} to 10^{+15}.

PERCENTAGE DEVIATION: $R = 100 \dfrac{x - n}{n}$

This program is used to determine the percentage deviation of a measurement from a nominal value. It requires the insertion by the user of n, the nominal value with which all measurements are to be compared. Apart from this the operator merely uses the voltmeter in the conventional way, the difference being that the displayed reading is the required percentage deviation. Checking component tolerances is an immediate application.

OFFSET: $R = x - \Delta$

Another very simple, arithmetic program in which a constant Δ is subtracted from the measured quantity. (A negative value of Δ will result in an effective addition). Again the only operator action necessary is to enter the value of Δ when defining the program.

The three programs considered thus far are very basic, involving simple arithmetic relationships. They are capable of performing just the one calculation; even combined or concatenated the resulting mathematics is uncomplicated. Many of the processes that follow are more complex in that they include a choice of routines or *Options.* When calling up the program the user is faced with a decision – the display reminds him – as to which routine to use. It is necessary to key in an option number before proceeding with the rest of the program parameters. The next program is an example.

RATIO

Ratio is a relationship, of one quantity *relative* to another. Commonly expressed as A:B (A is to B), what it really means, mathematically, is A ÷ B. In ratio measurement one intends that measurement is to be made with respect to a reference source. That is simple ratio. However another use of ratio, familiar to amplifier designers and sound engineers is *logarithmic* ratio, expressed in decibels, (i.e. dB). **Program 4** permits the user to choose how the ratio is to be computed.

Option 0. *LINEAR:* $R = \frac{x}{r}$ Simple ratio is selected by Option 0, in which r is the reference relative to which the measurement is to be made. It can be seen that this program provides simple division. Were the expression to be restated in terms of electrical quantities:

$$Amps = \frac{Volts}{Ohms} \text{ i.e. Ohm's Law}$$

then one sees an immediate application in deriving current measurement from the voltage across a known resistance.

Option 1. *LOGARITHMIC:* $R = 20 \log \frac{x}{r}$. Again the user merely sets in the value of r from the keyboard, the calculation is performed and the displayed value is in decibels. This program has numerous applications, examples being filter and transmission line design as well as those in sound and amplifier research previously mentioned.

Option 2. *POWER:* $R = \frac{x^2}{r}$. A useful variation of Option 0 in which the measurement is squared prior to division by the reference. Included specifically for the purpose it permits power, in Watts, milliWatts etc., to be measured directly. In the expression, x is the voltage measured across a load r, which of course has to be set in as a constant by the user. As an example, the load could be that of a hi-fi amplifier (typically 8Ω) and its power output could thus be measured directly.

MAX/MIN

A multiple option program which conveys to the reader something of the power of the processor. No longer any necessity for recording a long series of measurements in order to determine maximum and minimum values, or peak-to-peak value. One simply calls up **Program 5,** selects one of four Options and the value of interest is presented at the display – being constantly updated while the program is running. Meanwhile other calculations are being carried out and the results stored, for instant recall when required. The chosen option governs what is displayed, not what is calculated:

Option 0 : each measurement as it is taken.
Option 1 : the maximum-to-date.
Option 2 : the minimum-to-date.
Option 3 : the peak-to-peak value, i.e. the algebraic subtraction of the minimum from the maximum.

Each measurement is compared with the stored max. and min. values, these being amended as required; similarly the stored peak-to-peak value is updated each time a new max. or min. value is obtained.

Although this program can be used alone for simple monitoring, it is more likely to be combined with one, or two, others enabling the voltmeter to monitor engineering parameters such as boiler pressure or temperature.

LIMITS

In addition to maxima and minima, many measurement situations call for knowledge of when the measured quantity, not necessarily that of voltage, is outside pre-set *limits.* It may be of interest to the user only that temperature, or pressure, has risen beyond a safe level; that the parameter has gone outside a defined *zone.* **Program 6** permits the user to define High and Low limits, with which each measurement is then compared. The displayed reading is accompanied by one of two warning "flags", horizontal bars to the left of the numerical value. The upper bar informs the user that the reading is High, the lower that the reading is Low. All the time the readings are within the zone the bars are extinguished.

At the end of a run the user can, with the RECALL facility, cause the display to show:

Number of measurements **High**	i.e. above High Limit
Number of measurements **Low**	i.e. below Low Limit
Number of measurements **Go**	i.e. within the zone
Value of High Limit Value of Low Limit	reminding the user what Limits were originally set.

This program is of considerable value when the 7065 is connected to a printer or other recording device, such that a print-out only occurs when the measurement is off-limits (see Part 3 of the manual).

STATISTICS

Probably the most powerful program in the 7065's repertoire, all statistical calculations are carried out by the processor, regardless of the selected Option. The Option governs what result is displayed during the running of the program; the user can recall all results from memory at the end of a run.

What **Program 7** does is calculate trends; mean, variance and standard deviation, all statistical analysis calculations; also root-mean-square value. The display Options are:

Option 0 : each measurement is displayed, unprocessed.

Option 1 : the average-to-date. **Option 2** : the variance. **Option 3** : the standard deviation **Option 4** : the root-mean-square	Subject to continuous updating while the program is running.

The following information is available for recall at the end of a measurement run:

The number of measurements made Their average value The variance The standard deviation The root-mean-square value	the mathematical expressions for these will be found in the Summaries (page 2.3.21)

Numerous applications come to mind in, for example, design and process control, or in Quality Assurance.

THERMOCOUPLE LINEARISATION

Mention has been made in describing other programs, of the use of the processing facilities in converting electrical quantities into other, more meaningful units. One thinks of transducers of various types which are involved in measurement of engineering units but give an output which may be voltage or current. Where the relationship between the engineering units and the electrical analogue is linear a simple arithmetic program can be employed for the conversion. This is not the case with thermocouples – a plot of emf against temperature is very definitely curved, a more complex, algebraic expression governing that curve.

Program 8 offers a solution which *linearises* the curve, using a pair of polynomial expressions, such that the voltmeter can give a reading directly in °C. Constants for the laws of the 4 most widely used thermocouples are built-in to the program ROMs. The user merely has to select the option for the thermocouple he is using; key-in the ambient, or cold junction, temperature; connect up and press the execute push button. The displayed reading is the result of a pair of calculations which convert mV to °C.

Considering this mathematically, the reading R is obtained from the cubic polynomial:

$$R = a + bx_p + cx_p^2 + dx_p^3$$

where x_p is derived from a further equation:

$$x_p = x + a' + b'A + c'A^2$$

In the latter quadratic equation, A is the ambient or cold junction temperature pre-set by the user, in °C. It may be necessary to devise an isothermal chamber for the terminals, in certain instances, to maintain a controlled cold junction temperature.

In practice the polynomial calculation involves the use of two separate cubic expressions, their curves being splined together at approximately the mid-point of the linearisation plot.

The preceding information is obviously of considerable interest to the reader with mathematical inclinations; to the user with a more practical engineering bent it is sufficient to know that the voltmeter does all the work for him – freeing him, perhaps, for more interesting pursuits.

The thermocouple options are:

Option 0 : Type T, Cu/Con
Option 1 : Type R, Pt/PtRh(13%)
Option 2 : Type J, Fe/Con
Option 3 : Type K, NiCr/NiAl

Temperature Measurement Specification

Type	Range °C	Sensitivity °C	Repeatability (one week) °C	Limits of Error (one year) °C
T	−100 to 400	0.3	0.9	± 1.5
R	0 to 100	2	6	± 7
	100 to 350	1.5	4.5	± 5
	350 to 1750	1	3	± 4
J	0 to 750	0.2	0.6	± 1.5
K	−120 to 1370	0.3	0.9	± 1.7

Cold junction temperature range 0 to 50°C

TIME

Program 9 Unlike the other programs this one does not process measurements to give other results. What it can do is bring all measurement and processing under comprehensive time control. The options provide two different ways of applying time control.

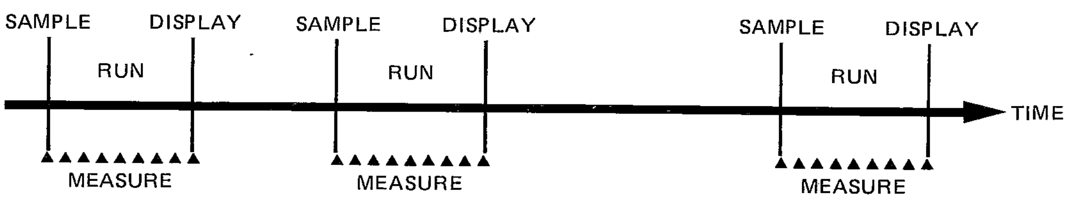
The clock The time clock is derived directly from the voltmeter's internal clock, which is locked to the frequency of the mains supply over a variation of ±3% in order to preserve the best series mode rejection.

The locking is maintained for supplies at 60Hz or 400Hz by changing links within the instrument. Thus should the supply be from a 400Hz motor-generator set, time will keep pace with the generator and not with the supply mains. In normal operation from the local mains supply the time keeping will be as good as the frequency of that supply.

The time clock covers a time span of 96 hours; it does not use days. Thus it will run up to 95h 59m 59s, recycle to zero, and start another span of 96 hours. So it will continue to carry out it duties for any length of time as long as the instrument remains switched on. Successive Run Times (see Option 0) can carry on for weeks on end. If a Start Time of, say, 10.00h is set (see Option 1), the voltmeter will start measurements at 10.00h every 4th day.

Option 0: *RUN TIME* One constant, Run Time, is inserted; the measurement process may then be initiated by pressing either the SAMPLE or TRACK push-buttons.

SAMPLE: a string of measurements is initiated which ceases at the end of the Run Time. The speed is that given by the measurement controls (Filter, Display Length) and by any programs that may have been entered in addition to Program 9.*



* *Program 9, when used with other programs, must be call-up last, i.e. P 3 7 9. Changing the sequence to P 9 3 7 could give incorrect results.*

On pressing SAMPLE, although measurements commence, no result is displayed until the end of the Run Time. If straight measurements are being made this will be the last measurement. With some programs (*MAX/MIN* for example) the result will take into account all measurements made during that Run Time. Thus, during the run the display is invalid, this being indicated by the two bars to the left, viz: .

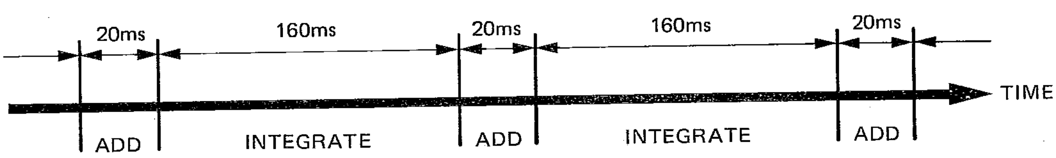
at the end of the run the disappearance of the bars indicates the completion of the run.

After a run, all the results of the program options may be recalled. Successive runs can be initiated by SAMPLE, the results of the previous run being cleared automatically as SAMPLE is pressed. Thus each new run starts from scratch.

TRACK: gives similar operation as at SAMPLE, except that each successive Run Time automatically follows the previous one. Every run starts from scratch, the display updating at the end of each, and invalid bars appear only during the first run. Obviously there is no opportunity to recall results until TRACK is cancelled.

Long-Term Averages

This program, together with statistics (Program 7), gives the ability to average over a pre-set Run Time; any time up to 59h 59m 59s can be used. In calculating the average, the voltmeter dumps each measurement in an accumulator, adding them all together. Finally the number of readings is divided into this total. The addition of each new value to the previous total occupys 20ms, and, at the end, the final division takes a further 20ms. Thus, if the basic measurement is already taking 160ms, as at 5 x 9's with Filter, to measure and add to the accumulator requires 180ms, during the last 20ms of which the voltmeter is not integrating the input signal.

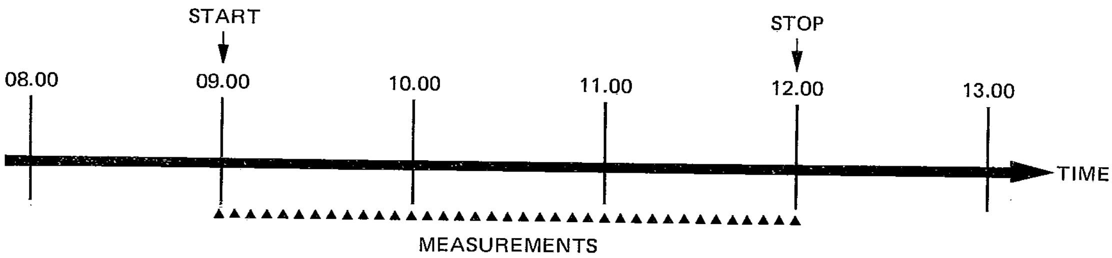


The result at the end of the Run Time is therefore the average of a number of averages (integration times) but with 20ms gaps. The most valid result will be obtained by running the measurements with the longest possible integration time (1.28s with 7065). Fast measurement (say 3 x 9's, no Filter) results in the instrument spending less time looking at the input, hence the final average will be less valid because there will be a greater possibility of the signal doing something peculiar in the 20ms gaps.

On the other hand, standard deviation, variance, maximum values etc, are more valid when obtained from a large number of point measurements; this means that short integration times are necessary. As with may engineering solutions the best choice is often a compromise.

Option 1: *START/INTERVAL/STOP* The intention of this Option is to permit measurements to occur at preset intervals (*tb*) commencing and finishing at nominated start and stop times (*ta* and *tc*). These three times can therefore be entered at the keyboard. Voltmeter time can also be set, usually to correspond to time-of-day, and it is voltmeter time with which the start and stop settings are compared.

Start and Stop in Real Time Voltmeter time is clocked up from the moment of switch on. Thus when Program 9, Option 1, is initially accessed the time indicated will be that elapsed from the moment of switch on. To set time-of-day, key a time slightly in advance of actual time; as actual time reaches the value set, press ENTER. Voltmeter time will now keep time-of-day – even when Program 9 is not in use.



Key and enter in turn, Start Time (*ta*), Measurement Interval (*tb*) and Stop Time (*tc*). Press SAMPLE. Assuming this is before start time is reached, nothing will happen. At start time a measurement will be made, and processed if other programs are included, the result being displayed. The SAMPLE LED will start flashing. Actually it remains 'on' while each measurement is made, but this will not be noticed unless on 1.28s integration (6 nines and Filter). Further measurements are made at the selected interval and cease at the stop time. At this point the SAMPLE LED remains 'on'.

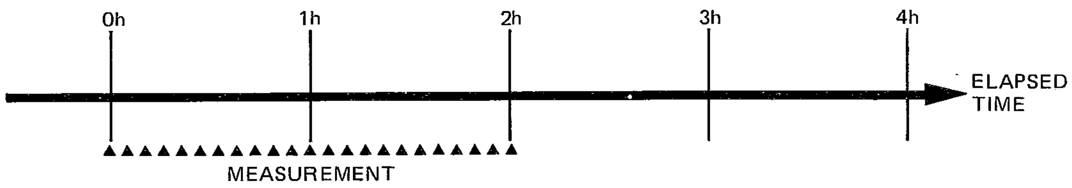
Start and Stop Both can be set at any value up to 95h 59m 59s. Thus a user can leave work on a Friday having set the voltmeter to do 2 hours of measurements before he returns on Monday morning. Because the clock recycles every 96 hours, starts and stops will recur every fourth day. If this is allowed to happen measurements will again take place at the interval (*tb*), but there will be no measurement at start time. To achieve the latter, SAMPLE must be pressed again.

Interval The measurement interval can be set to zero. In this case measurements will be initiated as far as possible, limited by integration time and the processing of any other programs in use.

If 7065 is operated at 6 nines with Filter the integration time is 1.28s. With the interval set at 1s the voltmeter will ignore a sample command while it is busy. However, it will store that command and action as soon as it can; thus readings occur at 1.28s.

It could be that a user wishes to measure at precise intervals (say every 10s) but not use automatic start and stop. This can be done by setting Start and Stop to zero; the voltmeter has been taught to ignore stop when the value is zero. With Interval at 10s, pressing SAMPLE will manually initiate readings every 10s.

Working in Elapsed Time Perhaps a user wishes to manually initiate a run and terminate it after a preset elapsed time.



Set Start to zero, the required Interval (say 5 minutes) and the required Stop (say 2 hours). Now RECALL Program 9. First, Option 1; then voltmeter time. Press CLEAR, thus setting time to zero. When the run is required to start, press ENTER and SAMPLE in rapid succession. Measurements will occur every 5 minutes for the next 2 hours.

The first measurement will occur 1 second after zero (provided ENTER and SAMPLE are operated in under 1 second) and the last measurement, in a 2-hours span of 5 minutes, at 1h 55m 1s. Should the last measurement be required nearer to the stop time the value set could be just in excess of 2 hours, in which case the last one would occur at 2h + 1s.

Track When Option 1 has been set-up, pressing TRACK will over-ride the time program, causing the instrument to measure as in normal use. This gives the ability to check that measurement and processing are operating correctly prior to the instrument starting a time controlled run.

Funny Numbers with some products the insertion of numbers that lie outside the normal range of use is not acceptable. Not so with 7055 and 7065; these voltmeters have been trained to think for themselves. Should the user key a time of 02.84.73 it will be recognised as 03.25.13 and used without comment. On recall the display will also show 03.25.13.

Again, as the clock recycles at 96h, a Stop Time of 97h will be accepted, but will never be reached. So measurements taken at a preset Interval would go on and on for evermore.

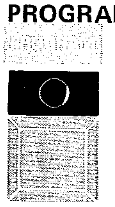
Section 2
Controls

This Section covers the use of the keyboard and the interpretation of the various visual indications which are associated with program definition and execution.

Controls

The basic voltmeter buttons have their normal meaning as described in Part 1 of the manual. Pressing **PROGRAM** however causes the push buttons to assume new meanings, as annotated in white on grey.

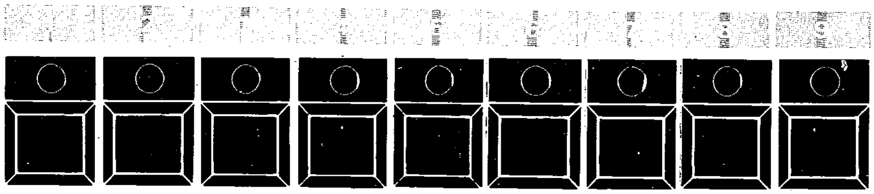
PROGRAM



Selecting **PROGRAM** places the instrument in its program definition role. The indicator LED commences to flash as a reminder to the user that this facility has been selected. The COMPUTE indicator is now illuminated (see page 2.2.2).

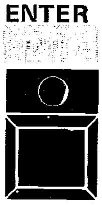
NUMBER

To define the required process the user must select one of the number buttons:



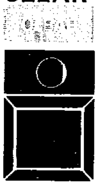
These, in conjunction with the zero button , are also used when entering Option numbers, and constants, for those programs which require them. Constants also employ the and the (decimal point) keys.

ENTER



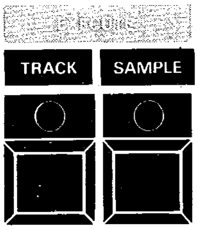
Used for entering programs, Option numbers and constants into memory when defining the program.

CLEAR



Clears previously entered programs; clears the display for re-definition of Option number or constants; clears results for a fresh run; clears display of results, to revert to showing programs in use. (See detail overleaf).

EXECUTE



When processing measurements, TRACK and SAMPLE initiate the implementation of the program either repeatedly, or just once. In this respect their function is similar to that described in Part 1 of the manual. The PROGRAM indicator is extinguished and the functions assume their white-on-black meanings.

The **CLEAR** push button performs several functions, both at program definition time and during processing:

During program definition

1. Having pressed PROGRAM the display shows the programs in use. By pressing CLEAR all programs are removed from the use register, results and constants for these programs being retained for later re-use if required.

2. Should an error be made when entering an Option number, or if the stored Option is no longer required CLEAR will erase it and permit the user to substitute another. Similarly constants can be erased and new constants inserted.

During processing

3. At the end of a process, or during the run, it is possible to recall to the display the program in use. By then pressing CLEAR the user can reset the results memory of that program to zero, for a new run.

4. When results are being displayed pressing CLEAR causes the display to revert to showing the program(s) in use.

During a processing sequence it is possible to interrupt the program, in one of several different ways. The first of these is by using the COMPUTE button.

COMPUTE

Although not a white-on-grey caption this button is very much associated with processing. Its indicator is lit when PROGRAM is selected, and pressing it (i.e. cancelling Processing) will cause the voltmeter to revert to displaying unprocessed measurements.

A further pressing of COMPUTE will cause the run to be resumed.

The second method of interrupting the program is that of pressing the PROGRAM button. The display will indicate which programs are in use. At this stage the ENTER, CLEAR and RECALL buttons can be used, if required, to redefine programming parameters. To resume the run one of the two EXECUTE buttons should be used, while to commence a new run PROGRAM should be pressed again. Note that in the latter case the results of the previous run will be lost.

Finally, had the program been initiated by TRACK the process can be terminated after one more measurement by pressing SAMPLE.

Section 3 of this book contains step-by-step program definition and execution instructions which illustrate the detailed use of the controls.

Indicator Lamps

Each processing push button is equipped with an LED which serves to advise the operator of the instrument status. The information conveyed by the voltmeter lamps was covered in Part 1 and still applies to the non-processing buttons when the programs are in use. Additionally the following indications apply:

PROGRAM	Once selected, its LED will commence flashing, this indication continuing until an EXECUTE button is selected by the operator
COMPUTE	During processing this indicator is illuminated.

A special case is that of SAMPLE when timed processing or measurement is being implemented. Using Option 1 the instrument can be programmed to commence measurement at some future time, preset by the user. The run is initiated by pressing SAMPLE, but at this time its indicator will not be illuminated. At Start time the SAMPLE LED will come on, remaining lit for the brief measurement, process and display (and data output to System) period. The LED then commences to flash, for the duration of the time interval, coming on steady for the next measurement period . . . . and so on. After the last measurement the SAMPLE LED remains lit, even though the run has terminated.

Interpretation of Display

Numeric Content

The results of processing measurements can give a conventional display up to a 'full house' reading of 9 999 999. However it may be desirable for very large or very small quantities to be displayed.

As an example consider a process which involves conversion from voltage to current. The voltage developed across a 2kΩ resistor is 3mV. The current is, of course, 1.5μA but how to display that in terms of the normal instrument scale? The answer is simple, change the reading to exponent form. It would appear as 1.500–06 which is interpreted as 1.5×10^{-6}. The instrument's microprocessor carries out the conversion, automatically, coping with quantities within the range 10^{15} to 10^{-15} – whether the quantity is the result of a process or a constant being entered by the operator.

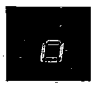
Mnemonics

The user is guided through the programming sequence, and displayed information is identified, by a series of characters. These mnemonics spell-out, within the limitations of the 7-segment format, words and alphabetic symbols meaningful within the programs in which they occur.

Many of the characters are self explanatory and they are all listed in the Summary of Programs which will be found on page 2.3.21. Nevertheless a few examples are included here, together with their meaning.


= c = the constant required by Program 1

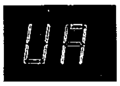

= n = the nominal value in Program 2
the number of readings in Programs 6 and 7


= Δ = the offset for Program 3


= °C

= *r* = reference for use in Program 4

= *AV* = Average value



= *VA* = Variance

} in Program 7

Notice that no attention has been paid to convention in respect of capital and lower case letters, e.g. Option appears as:

and whereas Start time, Time A is:

the next constant, Time B comes up as:

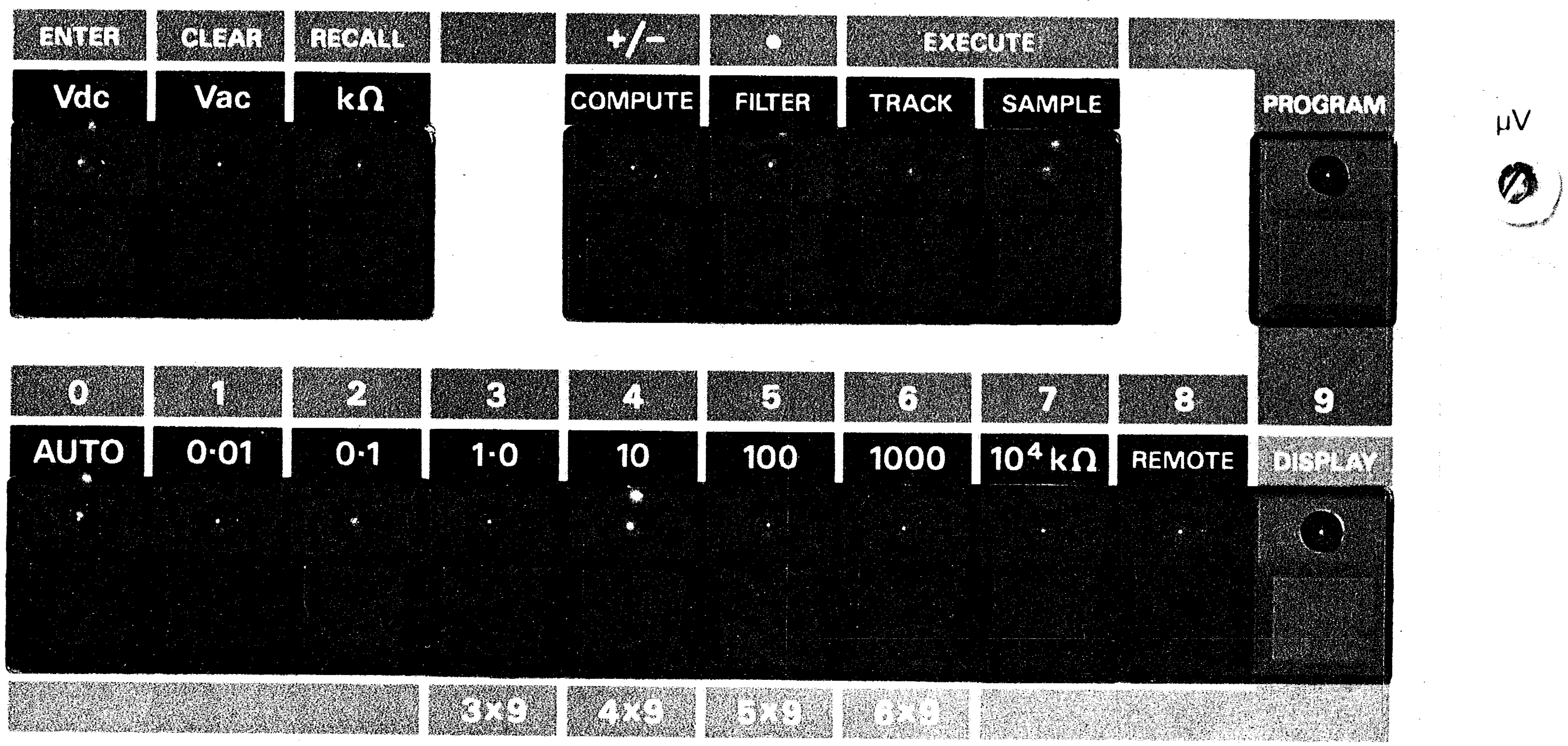


Fig 2.1 The Keyboard

Section 3
Programming Instructions

The user who is only slightly familiar with programming will find the 7065 (55) microprocessor very easy to use. The layout, logical operation of the controls and information presented by the display serve to guide the user through each program, ensuring that even the totally inexperienced can set up and process programs with complete confidence.

Throughout the program sequences which follow, the reader should assume that all constant values, and option numbers, have been reset to zero.

When the voltmeter is first switched on, a constant of zero will be displayed in the normal way as:

0 . 0

At any other time, however, the zero for all constants will be displayed in exponent form, viz:

0 . 0 0 0 - 1 5

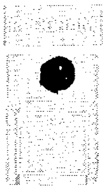
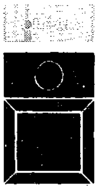
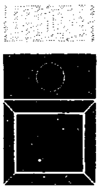
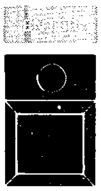
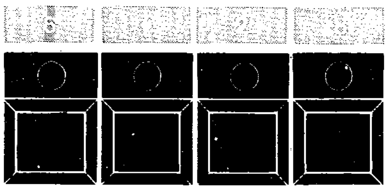
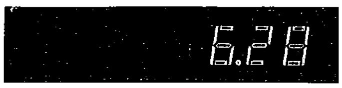
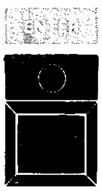
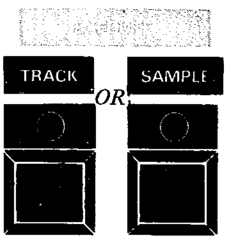
i.e. 0 x 10^{-15}, which is the way 7065 and 7055 express very large or very small quantities (see page 2.2.3).

Scale length

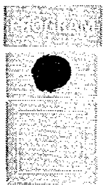
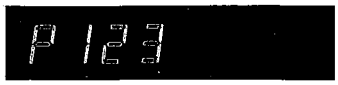
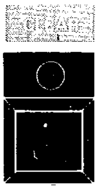
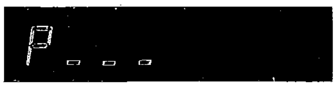
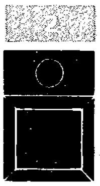
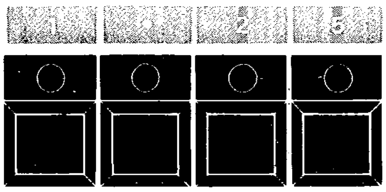
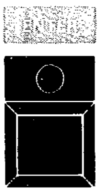
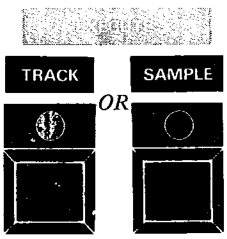
The scale length for the programming sequences has been standardised at 3 x 9. It should be noted that constants recalled to the display will, however, be displayed to 6 decimal places, even though measurement readings, and processed results, are themselves displayed to the resolution appropriate to the selected scale length.

Note: Program 8 should always be used with a 3 x 9's scale length since greater resolution is unnecessary.

PROGRAM 1 MULTIPLY – enables all measurements to be multiplied by a constant C

Key Operation	Display	NOTES
1 		*Display may be P _ _ _ if so proceed to step 3. Otherwise display shows current programs entered.*
2 		*Memory now cleared for new program entry.*
3 		*Program 1 selected.*
4 		*Program 1 entered. Mnemonic c appears as a reminder that a CONSTANT has to be entered next. Display is then reset awaiting number entry.*
5 		*Constant selected can be any number from 10^{-15} to 10^{+15}, either positive or negative (note change to floating point at 9999999)*
6 		*Constant entered. Display confirms Program 1 ready for use, and space is indicated for other programs if required.*
7 		*Measurement of 1.95 volts now processed either for a single measurement or continuously.*

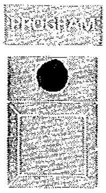
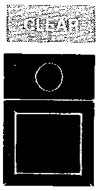
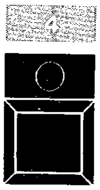
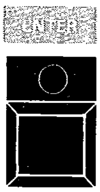
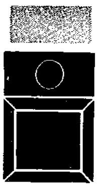
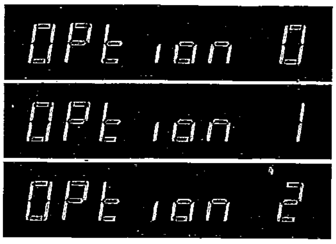
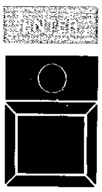
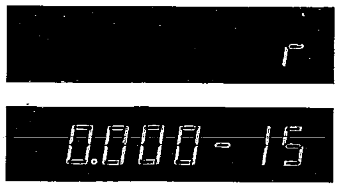
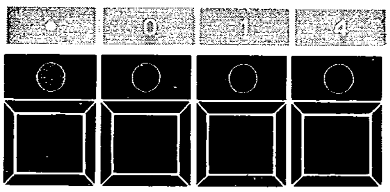
PROGRAM 2 % DEVIATION – enables any measurement to be displayed as a percentage deviation from a nominal value.

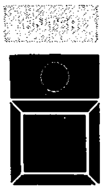
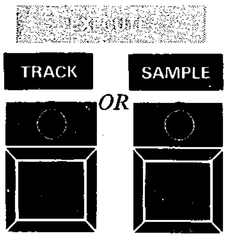
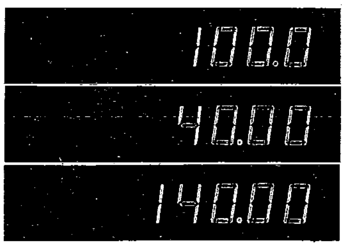
Key Operation	Display	NOTES
1 		*Display may be P . . . if so proceed to step 3. Alternatively display shows current programs entered.*
2 		*Memory now cleared for new program entry.*
3 		*Program 2 selected.*
4 		*Program 2 entered. Mnemonic n appears as a reminder that a nominal value has to be entered next. Display is then reset awaiting number entry.*
5 		*Nominal value selected any number from 10^{-15} to 10^{+15}, either positive or negative. (Note change to floating point at 9999999)*
6 		*Nominal value entered. Display confirms Program 2 ready for use, with space indicated for other programs if required.*
7 		*A measurement of 1.375 is displayed as being 10% above the nominal of 1.25.*

PROGRAM 3 OFFSET – enables all measurements to have a constant subtracted from or added to them.

	Key Operation	Display	NOTES
1		P 123	*Display may be P . . . if so proceed to step 3. Otherwise display shows current programs entered.*
2		P . . .	*Memory now cleared for new program entry.*
3		P 3	*Program 3 selected.*
4		□ 0.000-15	*Program 3 entered. Mnemonic □ appears as a reminder that an offset value has to be entered next. Display is then reset awaiting number entry.*
5		4.25	*Offset value selected any value from 10^{-15} to 10^{+15}, either positive or negative. (Note change to floating point at 9999999).*
6		P 3 . .	*Offset value entered. Display confirms Program 3 ready for use with spaces indicating that other programs can be entered if required.*
7	TRACK *OR* SAMPLE	9.75	*A measurement of 14.00 has been processed by applying an offset of 4.25.*

PROGRAM 4 RATIO – enables division by reference for linear ratio OR process by a logarithmic function to give an answer in dB's OR process by the Power formula to convert Volts to Watts.

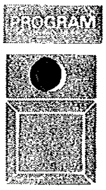
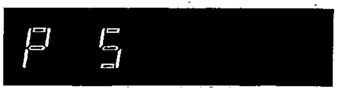
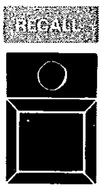
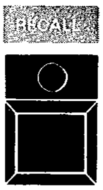
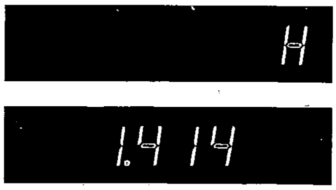
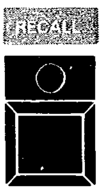
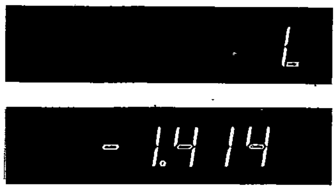
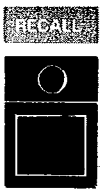
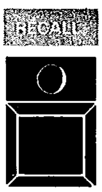
Key Operation		Display	NOTES
1 			*Display may be P . . . if so proceed to step 3. Otherwise display shows current programs entered.*
2 			*Memory now cleared for new program entry.*
3 			*Program 4 selected.*
4 			*Program 4 entered, display shows Option O. Alternatively could display Option 1, or 2 whichever last used with this program.*
5  *0,1 or 2*	*Linear* or *Logarithmic* or *Power* or		*Option selected.*
6 			*Option entered. First r appears as a reminder that a ref value has to be entered next. Display then resets awaiting number entry.*
7 			*Reference value selected any value from 10^{-15} to 10^{+15}, either positive or negative. (Note change to floating point at 9999999).*

Key Operation		Display	NOTES
8 			*Reference value entered display confirms Program 4 ready for use. Blanks indicate that three programs can be entered as required.*
9 	*1* *or 2* *or 3*		*A voltage of 1.4 volts measured at the input has been processed by* *1. linear ratio* *2. logarithmic ratio (dB)* *3. Power*

PROGRAM 5 MAX/MIN – enables the maximum or minimum of a series of measurements to be displayed together with the peak to peak value.

Key Operation		Display	NOTES
1 PROGRAM		P 123	*Display may be P _ _ _ if so proceed to step 3. Otherwise display shows current programs entered.*
2 CLEAR		P _ _ _	*Memory now cleared for new program entry.*
3 5		P 5	*Program 5 selected.*
4 ENTER		OPtion 0	*Program 5 entered, display shows Option O. Alternatively could display Option 1, 2 or 3 depending on last one used with this program.*
5 *0,1,2 or 3*	*Voltmeter readings* or	OPtion 0	*Option selected for display during execution. But all results can be RECALLED after processing complete.*
	Max. value or	OPtion 1	
	Min. value or	OPtion 2	
	Peak to peak or	OPtion 3	
6 ENTER		P5 _ _	*Option entered, display confirms Program 5 ready for use. Other programs can be entered, as shown by dashes.*
7 EXECUTE TRACK *OR* SAMPLE		1.004	*Depending on option chosen display will show either straight DVM readings; max value; min value or peak to peak. (Option 0 assumed). After sufficient processing the recall facility may be used.*

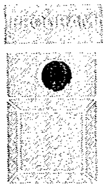
RECALL OPERATIONS:–

Key Operation	Display	NOTES
8 		*Display shows current program entered.*
9 		*Program to be recalled selected.*
10 		*Display shows option in use during measurement time to give answer in display.*
11 		*The mnemonic H is displayed indicating MAX value and then changes to the stored result.*
12 		*Displays mnemonic L indicating MIN value and then changes to the stored result.*
13 		*Firstly displays PP indicating Peak to Peak value and then changes to stored value.*
14 		*Reminder is given of program in use.*

PROGRAM 6 LIMITS – enables a high and low limit to be set and the number of measurements inside or outside limits to be counted.

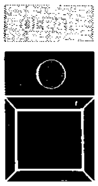
Key Operation | **Display** | **NOTES**

1



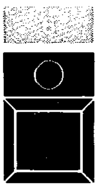
Display may be P . . . if so proceed to step 3. Alternatively display shows current programs entered.

2



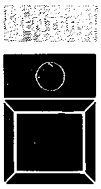
Memory now cleared for new program entry.

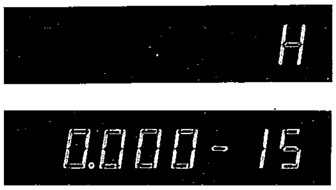
3



Program 6 selected.

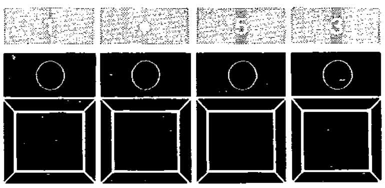
4





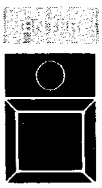
Program 6 entered. The mnemonic H reminds the operator that a HIGH limit has to be entered next, Display then resets awaiting number entry.

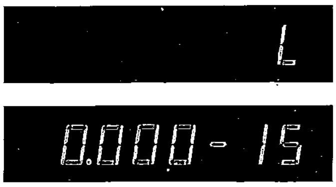
5



Value of high limit selected.

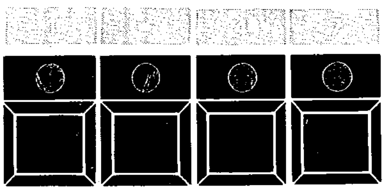
6





High limit entered L appears as a reminder that a LOW limit has to be entered next. Display then clears.

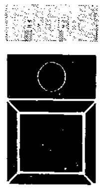
7

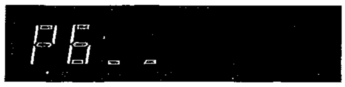


Value of low limit selected.

Key Operation | **Display** | **NOTES**

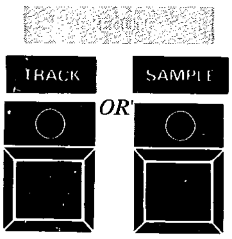
8

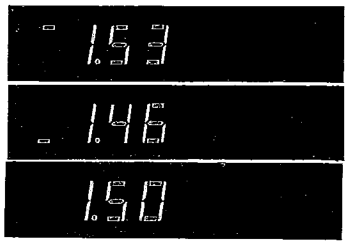




Low limit entered P6 ready for use.

9





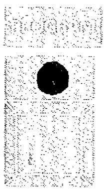
High reading

Low reading

Within zone reading

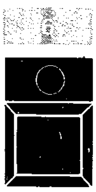
RECALL OPERATIONS

10



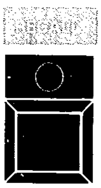
Display shows current program entered.

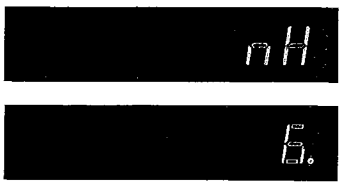
11



Program to be recalled selected.

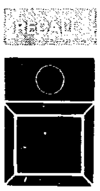
12

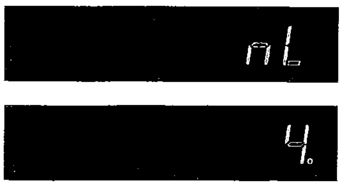




Display shows the number of readings above High limit, preceded by the relevant mnemonic.

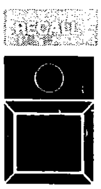
13

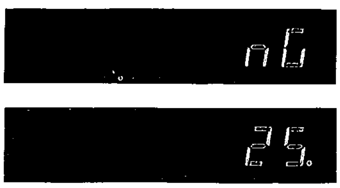




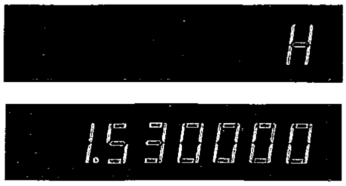
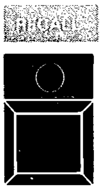
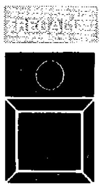
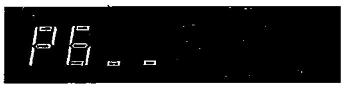
Display initially displays the "number low" mnemonic, followed by the number of readings which were low.

14

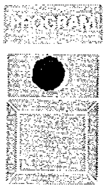
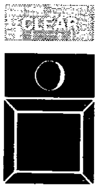
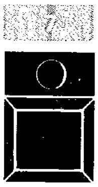
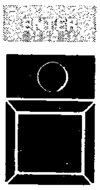
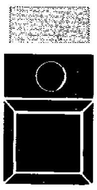
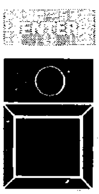


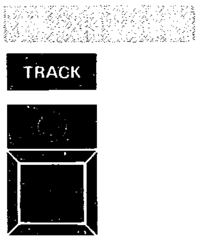


The mnemonic means "number within the zone" (i.e. Go). Display then shows the number of readings which were Go.

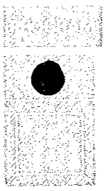
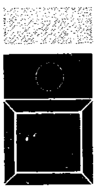
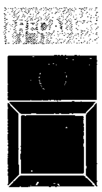
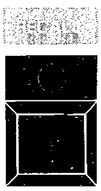
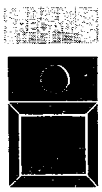
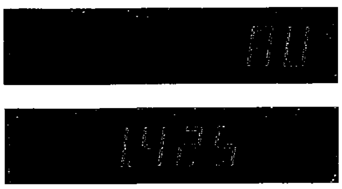
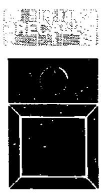
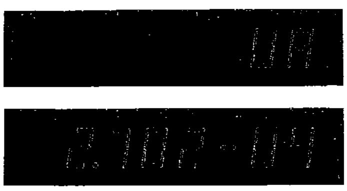
Key Operation		Display	NOTES
15			*Confirmation of high limit set.*
16			*Confirmation of low limit set.*
17			*Confirmation of program set in and ready for use again. If required other programs can be entered.*

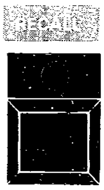
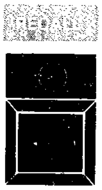
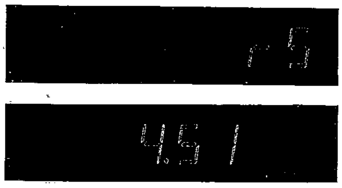
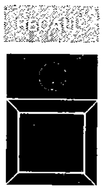
PROGRAM 7 STATISTICS – enables the average value, variance, standard deviation and root-mean-square value of a series of measurements to be computed and displayed.

Key Operation		Display	NOTES
1 		P 123	*Display may be P . . . if so proceed to step 3. Otherwise display shows current programs entered.*
2 		P . . .	*Memory now cleared for new program entry.*
3 		P 7	*Program 7 selected.*
4 		OPtion 0	*Program 7 entered. Display will show Option 0, 1, 2, 3 or 4 depending on last option used with this program.*
5 	*0,1,2,3 or 4* *Voltmeter readings*	OPtion 0	*Option selected for display during execution. But all results can be RECALLED after processing complete.*
	or Average value	OPtion 1	
	or Variance	OPtion 2	
	or Standard/deviation	OPtion 3	
	or RMS	OPtion 4	
6 		P 7 . .	*Option entered. Display confirms Program 7 ready for use.*

Key Operation	Display	NOTES
7 		*Depending on option chosen display will show either straight DVM readings, average value, variance, standard deviation or root-mean-square value. NOTE: Although SAMPLE could be used to EXECUTE program, TRACK is more usual.*

RECALL OPERATIONS:–

8 		*Display shows current program entered.*
9 		*Program to be recalled selected.*
10 		*Display shows option in use during measurement time to give answer in display.*
11 		*Displayed mnemonic means "number of readings recorded". Instrument then displays answer e.g. 10 readings.*
12 		*The mnemonic AV is followed by the average of the measurements made e.g. 1.425 being an average of 10 readings.*
13 		*The variance mnemonic VA is followed by answer e.g. 2.702 x 10^{-4}. Note exponent form.*

Key Operation	Display	NOTES
14 		*Displays the standard deviation mnemonic followed by the result e.g. 0.01643.*
15 		*Initially displays the root-mean-square mnemonic, rS, followed by its value e.g. 4.507.*
16 		*Reminds user of the program in use. The dashes indicate possibility of entering others if required.*

PROGRAM 8 THERMOCOUPLE – enables measurements to be displayed directly in °C, using 4 individual thermocouple laws.

Step	Key Operation	Display	NOTES
1	PROGRAM	P 123	*Display may be P _ _ _ if so proceed to step 3. Alternatively display shows current programs entered.*
2	CLEAR	P _ _ _	*Memory now cleared for new program entry.*
3	8	P 8	*Program 8 selected.*
4	ENTER	OPtion 0.	*Program 8 entered, display shows Option O. Alternatively could display Option 1, 2 or 3 depending on that last used with this program.*
5	*0, 1, 2 or 3* — *Cu/Con (type T)*	OPtion 0	*Option selected for display during execution.*
	Pt/PtRh(13%)(type R)	OPtion 1	
	Fe/Con(type J)	OPtion 2	
	NiCr/NiAl(type K).	OPtion 3	
6	ENTER	A	*Option entered, display shows A as a reminder that the ambient temperature has to be entered next.*
		0.000- 15	
7	2 3	23.0	*Ambient temperature selected.*

Key Operation	Display	NOTES
8 ENTER	P8_ _	*Ambient temperature entered, display confirms Program 8 ready for use.*
9 EXECUTE TRACK *OR* SAMPLE	37.21°C	*A measurement is being linearised and displayed as a temperature.*

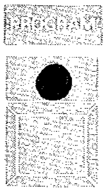
RECALL OPERATIONS:–

Key Operation	Display	NOTES
10 PROGRAM	P8_ _	*Display shows program in use.*
11 8	P 8	*Program to be recalled selected.*
12 RECALL	OPtion 0	*Option in use.*
13 RECALL	A 23.00000	*Firstly displays ambient mnemonic A then changes to the stored ambient temperature.*
14 RECALL	P8_ _	*Reminds user of program in use. and indicates space for further programs if required.*

PROGRAM 9 TIME – enables measurements to be taken for a set time (RUN TIME) OR measurements to be started and stopped at certain times and at set intervals between.

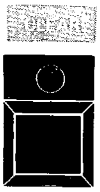
Key Operation | **Display** | **NOTES**

1



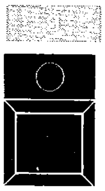
Display may be P _ _ _ if so proceed to step 3. Otherwise display shows current programs entered.

2



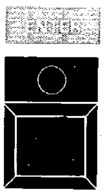
Memory now cleared for new program entry.

3



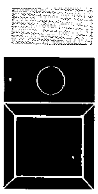
Program 9 selected.

4



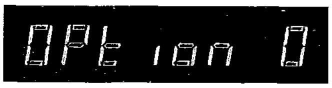
Program 9 entered, display shows either Option 0 or 1 depending on which was last used.

5



0 or 1

Run time

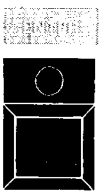


Start/Stop *or*

Option 0 or 1 selected.

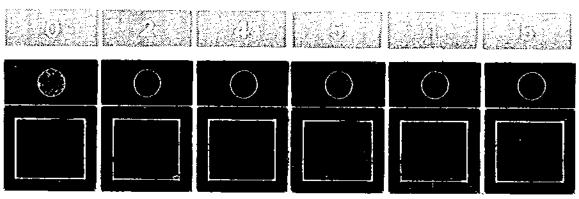
(If Option 1 chosen proceed to step 10).

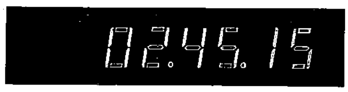
6



Option 0 entered. Firstly display shows tr as a reminder that a value for RUN TIME must be entered next, then resets to zero.

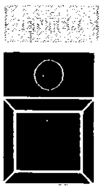
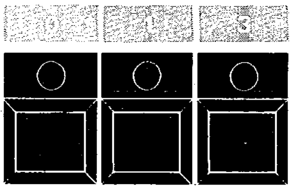
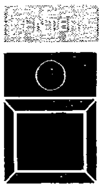
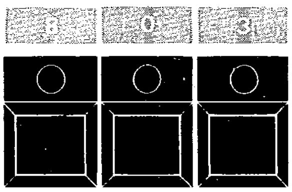
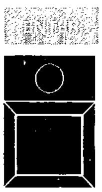
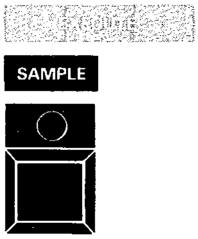
7





RUN TIME selected e.g. 2hrs 45min 15sec.

Key Operation	Display	NOTES
8 ENTER	P9 _ _	*Run time entered. Display confirms Program 9 ready for use. etc.*
9 EXECUTE TRACK OR SAMPLE	-02.45.15 1.429	*The display shows run time accompanied by bars indicating that it should be ignored. After the prescribed run time e.g. 2hrs 24min 15sec a final measurement is taken and brought to the display. In TRACK mode another measurment will be taken after a further RUN TIME period. In SAMPLE no further measurements will be taken unless SAMPLE is pressed again.*
10 ENTER	t 13.45.30	*Option 1 entered. Firstly display shows t (TIME) and then changes to the current TIME. This can be either real or elapsed.*
11 CLEAR	00.00.00	*Clock is now reset to zero awaiting new time entry. This step can be omitted if the clock is already synchronised to real time.*
12 0 8 2 5 3 0	08.25.30	*Actual time selected.*
13 ENTER	tA 00.00.00	*Time entered. Display reminds that start time (tA) has to be entered next. Display then resets to zero.*
14 1 6 3 0	16.30.00	*Start time selected e.g. 16-30 – could be Friday afternoon.*

Key Operation	Display	NOTES
15 		*Start time entered. Display shows tb, reminder that interval is to be defined. Then resets to zero.*
16 		*Interval defined.*
17 		*Interval time entered. Display shows tc, reminder that Stop time needs to be defined; then resets to zero.*
18 		*Stop time defined, in this example 8:30 a.m. the following Monday.*
19 		*Stop time entered. Display confirms program in use.*
20 		*Pressing SAMPLE triggers the program but no action will take place until the designated start time – the SAMPLE LED will not be illuminated and the display is meaningless.* *At Start Time the LED will flash, the display will show the measurement reading.* *At Stop Time the LED will be on permanently.*

From 16:30 onwards the SAMPLE button LED will commence to flash, reverting to a brief steady indication for each measurement. The measurement will be displayed, updating each time the clock control causes a new sample to occur.

At the end of the programmed time sequence measurements will cease and the Sample Indicator will be lit continuously.

As an added feature, if between program definition time and the pre-set Start Time the user were to select TRACK, the timed measurement program would be overridden and the instrument would take a series of readings. This is obviously of considerable benefit in confirming the validity of measurements before the voltmeter is left unattended over, in our example, a weekend. The validity check described can be terminated by pressing SAMPLE*, at which one more measurement will take place and then the instrument reverts to Timed control as previously described.

The foregoing has illustrated the full repertoire of programs available with the 7065. Use of more than one program at a time (up to 3) presents no difficulty since they can be entered at the will of the user in, virtually, any order. The only restriction is a purely mathematical one, namely:

$$2x + y \text{ is not the same as } 2(x + y)$$

so if multiplication is involved in a calculation it must be programmed in the right place. In this respect 7065 is no different from a pocket calculator or a large computer – it will only give the right answers if it is programmed intelligently.

The reader is invited to work through some very simple applications of processed measurement for himself, using the Summary tables overleaf as a guide, before proceeding to the next Section.

* To reset stored results to zero for the timed run the user must press PROGRAM twice before pressing SAMPLE.

Programming Summary

Program	Option	What is displayed	Calculation	Process Time	Enter Data	Recall Sequence
1 MULTIPLY	–	Multiplied measurement	$R = cx$ where c = constant	12ms	c Multiplier	c Multiplier
2 % DEVIATION	–	% deviation from nominal	$R = 100\frac{x-n}{n}$ where n = nominal value	14ms	n Nominal Value	n Nominal Value
3 OFFSET	–	Measurement – offset	$R = x - \Delta$ where Δ = offset	2ms	□ Value of offset	□ Value of offset
4 RATIO	0	$\frac{\text{Measurement}}{\text{Reference}}$	$R = \frac{x}{r}$ where r = reference value	12ms	r Value of reference	(a) Option in use r (b) Value of reference
	1	$20 \log \frac{\text{Measurement}}{\text{Reference}}$ dB	$R = 20 \log_{10} \frac{x}{r}$ where $\frac{x}{r}$ must be positive	135ms	r Value of reference	
	2	Power	$R = \frac{x^2}{r}$ where r = resistor value	20ms	r Value of resistor	
5 MAX/MIN	0	Each measurement	$R = x$	6ms	–	(a) Option in use
	1	Maximum measurement	R = max x found	6ms	–	H (b) Maximum found
	2	Minimum measurement	R = min x found	6ms	–	L (c) Minimum found
	3	Peak-to-Peak measurement	R = max x – min x	9ms	–	PP (d) Peak-to-Peak found
6 LIMITS	–	Each measurement	$x >$ High Limit = Hi	10ms	H Value of High Limit	nH (a) no. of measurements High
			$x <$ Low Limit = Lo	10ms	L Value of Low Limit	nL (b) no. of measurements Low
			High Limit $> x >$ Low Limit = Go	10ms		nG (c) no. of measurements Go
			Comparator fuzz $< \pm 1$ digit Comparisons are algebraic, i.e. negative values are less than positive values.			H (d) value of High Limit L (e) value of Low Limit
7 STATISTICS	0	Each measurement	$R = x$	24ms	–	(a) Option in use n (b) no. of measurements
	1	Updated Average	$R = \frac{1}{i}\sum_{k=1}^{i} x_k = \overline{x}$	40ms	–	AV (c) Average
	2	Updated Variance	$R = \frac{1}{i}\sum_{k=1}^{i} (x_k - \overline{x})^2$	100ms	–	VA (d) Variance Sd (e) Std. Deviation rS (f) RMS
	3	Updated Std. Deviation	$R = \sqrt{\frac{1}{i}\sum_{k=1}^{i} (x_k - \overline{x})^2}$	190ms	–	
	4	Updated RMS	$R = \sqrt{\frac{1}{i}\sum_{k=1}^{i} x_k^2}$	210ms	–	
8 THERMO-COUPLE	0	°C for Cu/Con (T)	$R = a + bx_p + cx_p^2 + dx_p^3$	70ms	A Ambient in °C	(a) Option in use A (b) Ambient in °C
	1	°C for Pt/PtRh(13%) (R)	where $x_p = x_i + a' + b'A + c'A^2$	70ms		
	2	°C for Fe/Con (J)	A = ambient temp. in °C	70ms		
	3	°C for NiCr/NiAl (K)	a, b, c, d, a', b', c' are stored in the voltmeter for all options	70ms		
9 TIME	0	Clock: mains locked. Time span 96 hours Run Time and Interval: 95h 59m 59s in 1s increments			tr Run time t Time	(a) Option tr (b) Run time
	1				t Time tA Start time tb Reading interval tc Stop time	(a) Option t (b) Time tA (c) Start time tb (d) Interval tc (e) Stop time

Capture Times (MAX/MIN):

Scale	Filter Out	Filter In
3 x 9	0.3ms	160ms
4 x 9	2.5ms	160ms
5 x 9	20ms	160ms
6 x 9	160ms	1.6s

In each calculation the variable is x. Up to three programs can be strung together. Thus in the first calculation x will be a voltmeter measurement (V or kΩ). Subsequent calculations in the same string use the previous result for their value of x.

R is the result of a calculation; sometimes it is related to a single value of x (e.g. x x constant); for other calculations R may result from all values of x to date (e.g. average of x).

Where a calculation requires a constant it must be in the unit appropriate to that calculation. Thus the unit of a first program will be V or kΩ, but subsequent programs of a string may be in other units (e.g. mA or °C).

Any value entered, or a result displayed, as an integer can be in the range – 9 999 999 to + 9 999 999. Outside this range the instrument automatically changes to exponent form, the limits being ± 9.999 x $10^{\pm 15}$.

Overflow, or calculation invalid is displayed as 9.9.9.9.1.5.

Remember to call-up program 9 last if used in combination with other programs!.

Section 4
Processing Application

Introduction

Elsewhere in this book step-by-step explanations of programs are given to familiarise the reader with the Processing push-buttons and their use in entering and running programs.

This section takes programming a stage further. The examples given relate to real life processing needs, in industry maybe, or research – having been chosen to illustrate the use of the complete repertoire of programs available with 7065 (7055). Use again is made of actual pictures of the push-buttons, but treated as programming sequences. The text describes the effect of those sequences, together with an explanation of what can be seen on the display.

It is recommended that the user who wishes to gain maximum benefit from his 7065 Voltmeter in its processing role, works through the example programs, adapting them where necessary in keeping with his own needs and facilities. The time spent will, it is suggested, be more than justified by the increased confidence in one's ability to use the instrument.

Example 1

Consider a simple manufacturing problem. A batch of resistors, being mass-produced, are only nominally of the same value. A handful will probably include many within ± 25%, some within ± 10% and a few possibly within ± 5%. The manufacturer needs to sort them for distribution.

Such a problem is no problem at all to a processing 7065 voltmeter. What is required is the Percentage Deviation from a Standard – i.e. Program 2. Using, naturally, the resistance measurement function of the dvm, which is set up as follows:

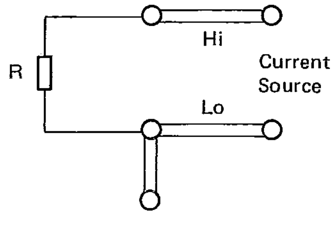
Step

1. kΩ 100 3x9 FILTER

i.e. setting up the 100kΩ range; a scale length of 3 x 9's, since greater resolution is not required; filter ON.

2.

3.



Sequence 2 selects the required program and enters it into the instrument's memory. Note that on pressing PROGRAM the display shows P_ _ _. waiting for the number button*. Sequence 3 is used to load the Standard value into store, in this instance 47kΩ.

The program is now ready to run. All that is required of the operator is for him to connect each resistor from the batch, in turn, across the voltmeter Hi and Lo terminals (see sketch), pressing the SAMPLE button for each measurement. The displayed value will be the % deviation of each resistor from the standard.

*When PROGRAM is pressed, it is possible that the display will show P followed by one or more numbers instead of dashes. This indicates that programs are already called up and stored. If there are three numbers after the P, then the sequence "PROGRAM, 2, ENTER" will cause the display to show FULL and will not be obeyed. It will be necessary to clear the memory of the stored programs before implementing sequence 2.

Clearing the programs from memory and loading program 2 is effected by the sequence:

PROGRAM CLEAR 2 ENTER

The example above is a very simple application of measurement processing, employing only a single program. It is, however, possible to enter and run 2, or even 3, programs in combination. Thus more complex mathematical manipulation of the measurements can be achieved. The next example, though still not complicated, involves the use of 2 programs.

Example 2

Many transducers produce as their output an electrical quantity which is not zero when the stimulus itself is zero. Pressure transducers, for example, produce an output current between, say, 4 and 20mA over their working range of zero to 'x' Newtons.

Other devices will produce a 0V output only as the result of an extremely small stimulus, thermocouples and platinum resistance thermometers for example are related to K, 0°C being 273 K.

An example involving temperature measurement is included later in this section; let's consider the pressure transducer, giving a not very meaningful output in mA. What the engineer requires to know is pressure, in ft. lb. or possibly, in Newtons.

A graph relating stimulus to response would probably look like that in Fig. 4.1.

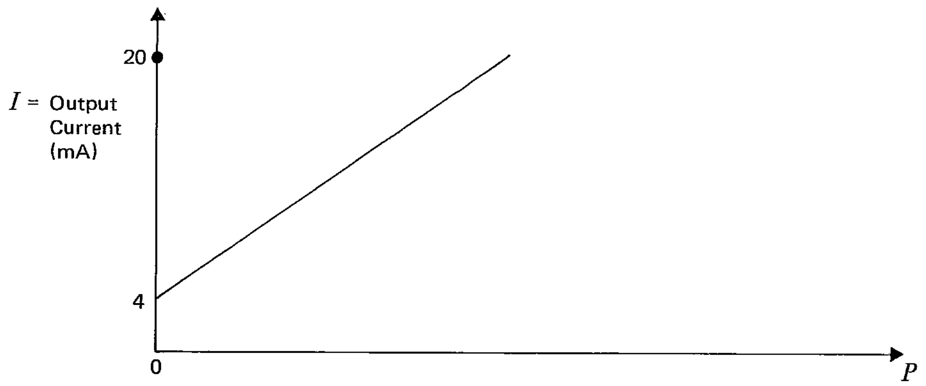


Fig. 4.1 *Graph of current plotted against pressure*

It can be seen that current I is related to pressure P by the equation $I = cP + \Delta$, c defining the slope of the graph and Δ being the constant offset (in this case 4mA).

To use the 7065 for this problem involves no more than a simple scaling exercise, converting the current reading into voltage in such a way that 1V (or 10V, 100V etc) relates to a unit pressure. First of all though, that offset Δ must be eliminated.

Part of the problem is conveniently solved by transducer manufacturers. The Transmitter Unit which follows the Sensor incorporates a resistor, of nominally 250Ω, across which the voltage can readily be measured. With zero pressure applied it is thus possible to obtain a value for Δ, the offset voltage. Let us assume that this is established at 1.047V.

A second voltage reading is then made at an applied pressure of, say, 10kN. This will give the upper extremity of a graph of voltage against pressure. Assuming the graph to be essentially linear, one has defined the slope and thus a value for c.

From here on 7065 has the capacity for doing all the work itself. To remove Δ from the equation one should use Program 3. The value of Δ obtained, at zero pressure, will be 1.047V (4mA x 261.75Ω). With the voltmeter set to measure VDC the programming sequence will be:

Step
1.

2.

The processor will now hold program 3 available for use, with 1.047V stored as an offset. If measurements were now to be made, using program 3 alone, a plot of voltage against pressure would be as shown in Fig. 4.2, above the shaded portion.

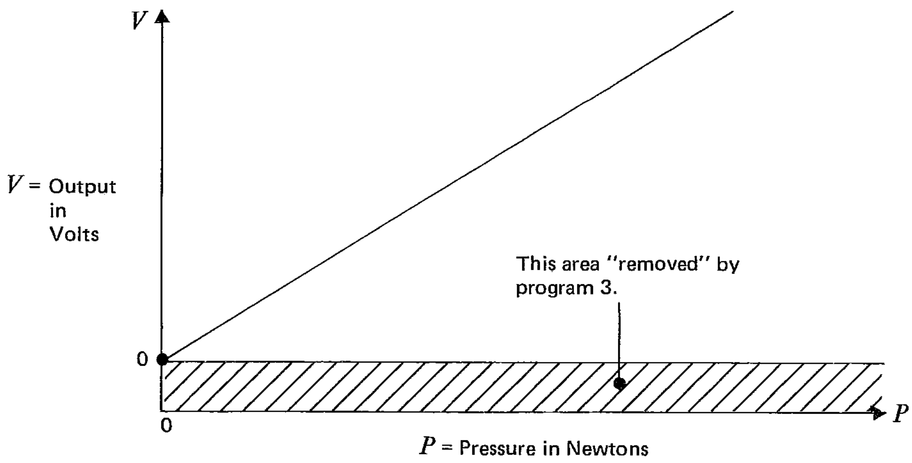


Fig. 4.2 Graph of Voltage plotted against pressure

The application of a suitable multiplier to V will be necessary to obtain a meaningful read-out of the pressure. For example, assume that for 1kN applied pressure the output were to be measured as 5V. If the voltage reading were to be scaled by a factor of 200, 1kN would be displayed directly as 1000, Volts. Alternatively a factor of 0.2 would give a reading of 1V which would need to be mentally read in terms of kN. Whatever the factor chosen, (depending on the range of pressures expected), the processing program would be as follows:

3.

4. c where c = scaling factor

Sequences 3 and 4 enter Program 1 (scaling by a constant) into memory together with the value of the scaling factor.

By connecting the voltmeter input terminals across the transducer output and pressing TRACK, the pressure acting on the transducer will be automatically measured and displayed, the display being updated at the rate related to the chosen Scale Length.

It should be noted that the programs were deliberately called up in the order 3,1. In some instances, where the mathematics is simple, the order of implementing programs is not very important, in many others a totally different result will be obtained by reversing the processing sequence.

e.g. $2a + b \neq 2(a + b)$

Having read, and it is hoped, tried out for himself, two relatively simple applications of the processing voltmeter, the reader is invited to consider the following, rather more complex, examples. The first introduces a combination of programs, including statistical analysis. The second illustrates timed and processed measurement, using the voltmeter's built in clock – which incidentally can be used simply as a digital clock when the voltmeter is not otherwise employed!

Example 3. Statistical Analysis

Consider a manufacturing plant which is producing 'things' on a production line, conveyor belt basis. The products might be chemicals, steel melts, or even cans of beans. For the purpose of this example, however, it is assumed that the merchandise is "packaged" by weight.

It is the responsibility of Quality Assurance and Process Control to monitor the packaged product for, among other things, its weight. However the statistical variations in weight over a period of, say, several months, is of far more interest to Process Control than is the absolute weight of each packet (or can).

Using Programs 1 and 3 as in Example 2, 7065 was demonstrated as an instrument which can display the output from a pressure transducer in the relevant engineering units. The same programs can be used for converting the electrical output from a strain-gauge weighbridge into lbs or kg etc. Thus the weight of the packaged product can be monitored as it reaches the end of the line.

This is where Program 7 comes into the picture, using the results of programs 1 and 3 as the base data. The voltmeter will calculate all the statistical facts concerning a production run of several hours, several weeks, even months – up to 1000 million cans of beans can be 'sampled' without giving 7065 digital indigestion.

The voltmeter is simply programmed, subsequent to Programs 1 and 3, as follows:

Step

1.

2.

Option 1 has been chosen deliberately. It will be remembered that, in Program 7 (and some others), the Option defines what is displayed during the run. *All* calculations are performed while this program is running, permitting the operator to access them at any time he may choose. It is convenient, however, to set the instrument such that it is showing the average weight-to-date – each day during the run an overseer can glance at the display and note this reading without interrupting the program.

3.	TRACK	The voltmeter commences taking measurements at the selected rate.

During the running of this measurement sequence the operator can stop the run to examine the results-to-date. This is achieved by pressing:

Step		Display
1.		Programs in use
2.		Program 7
3.		The Option selected
4.		The number of measurements taken
5.		The average weight (to-date)
6.		The variance (to-date)
7.		The standard deviation (to-date)
8.		The root-mean-square value (possibly of no interest in this example).

To resume the run, as though no interruption had occurred, necessitates the pressing of:

9. TRACK

This sequence of Recalling results-to-date can be called up at any time, possibly once per week for a run of several months.

Example 4. Time controlled temperature analysis.

In carrying out tests which include temperature measurement it is sometimes necessary to extend the measurement period over two or three days rather than just a few hours. The test engineer may only be interested in the extremes of temperature experienced during the test period, or in those values above or below preset limits. This example is concerned with the use of the voltmeter in: its temperature measurement role, Program 8; unattended, time controlled operation, Program 9; monitoring excursions of temperature above and below preset levels, Program 6.

It is assumed that a series of measurements are to be taken at quarter of an hour intervals starting at 6 p.m. on the first day and terminating at 9 a.m. on the fourth day, the only interest being in those temperatures outside a preset zone. The limits are to be set at +50 and +350 degrees Celsius, measurement to be made with a Type K thermocouple.

The voltmeter is programmed as follows:

Step						
1.						
2.						Selects thermocouple type K.
3.						Enters ambient temperature °C

It is assumed that the instrument is in a controlled environment for the duration of the test. As an alternative to referring measurements to ambient (the Cold Junctions at the input terminals) the user could employ an isothermal chamber; Cold Junction Units, either ovens or 'ice point' units are available commercially.

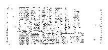
4.	PROGRAM		6	ENTER		
5.	3	5	0	ENTER		High limit value °C
6.	5		0	ENTER		Low limit value °C
7.	PROGRAM		9	ENTER		Time
8.	1		ENTER			Option 1 is the Real Time option
9.	1	4	2	5	ENTER	An arbitrary time-of-day example

Sequence 9 is used to set the clock to real time-of-day (alternatively the clock could be set to time zero immediately before the start of the test run).

10.		Presets test run START (time a)
11.		Time interval, 15 minutes (time b)
12.		Presets test run END (time c)
13.	SAMPLE	

The voltmeter will automatically start the test run and at the pre selected intervals will take measurements, completely unattended for the duration of the run. At his convenience the engineer merely has to recall Program 6 and examine the number of readings outside the programmed limits. Thus:

Total number of measurements
High is displayed



Total number of measurements
Low is displayed

A further pressing of RECALL will cause the display to show the number of measurements which were within the zone, while two more steps will recall what High Limit and Low Limit, respectively, were set.

More useful results would be obtained by connecting 7065 to a printer, only those measurements outside limits being printed (see Part 3, Systems Use).

Conclusion

The reader will no doubt be able to think of many more applications for the 7065 processing facilities. Indeed the examples given may in no way be appropriate to his particular needs. It is hoped, however, that this Section of the manual has achieved it's aim, of demonstrating both the power and the ease of use of the instrument. Solartron will be pleased to advise any user having a specific measurement processing problem.

Microprocessor Voltmeters 7065 and 7055

Part 3

Data Systems Use

7055 and 7065 are readily incorporated into a data logging or other processor controlled system, whether it be simple, involving only one other instrument, or complex such as a full ATE system. All front panel button functions are programmable (except POWER), permitting full remote control of the voltmeter by coded electrical commands. The interface outputs measurement data to, and generates control signals required by, the external system.

Covering a wide range of differing applications, a choice of 3 interfacing options is available:

1. **70556** Conforms to the RS232/CCITT V-24 standard.
2. **70554** A parallel binary BCD (8, 4, 2, 1) interface.
3. **70555** GP-IB Interface, implementing the IEC TC66 specifications.

Each option is treated in a separated section of this Part of the manual, the interfaces being described in terms of how they are used. Included are interconnection tables and, where appropriate, basic programming information.

The Appendices, at the rear of this book, contain fitting instructions for the option pcb's.

Contents of Part 3

Section 1
Interface Unit 70556

The RS232/CCITT V-24 Standard defines a method of interconnecting instruments, i.e. communicating devices, with other devices – teleprinters, VDU's or computers – i.e. terminal equipment. Interface Unit 70556 conforms to that Standard.

The 70556 Serial Interface enables the 7065 (7055) to be connected 'on line' to a teletype or similar keyboard operated device. An operator, possibly remote from the voltmeter, can thus command measurements (with or without processing – see Part 2 of this manual), the results being printed or displayed at the control position. Automatic control is also possible; the controller could be a simple tape reader (magnetic or punched tape) or perhaps a computer with the ability to modify the program depending on the received measurement data – even control a process, or sound an alarm if undesired conditions are found to exist.

The communicating language is ISO-7 code, thus a voltmeter equipped with the Interface is compatible with a wide range of keyboard operated or automatic control devices. 70556 permits a full automatic test system (ATE) to be designed around the 7065.

In the following descriptions it is assumed that the terminal device is a teleprinter, the Texas ASR Silent 700.

The Interface Module

The 70556 Interface is a separate circuit on, but an integral part of, the Processing option – the Program pcb referred to in Part 2 of this manual. To enable it to be used for interfacing, however a suitable cable is required (Part No. 70558), together with an Adaptor Panel (supplied with the Interface) which plugs onto the instrument rear 50-way Cannon socket.

Fitting the Interface

Instructions for fitting the Program/Interface pcb are included in the Appendices at the rear of this book.

Implementation of RS232

Of the 16 lines defined within the Standard, 8 only are used, the Interface thus being categorised as a Type E with an additional Protective Ground (i.e. Supply 0V). Its use is further simplified in that the four handshake wires are joined together internally within the instrument and 'pulled' permanently to an enabled state. Continuous 2-way communication is thus possible between the voltmeter, as Data Communication Equipment (DCE) and the controller (teletype, VDU etc.) as the Data Terminal Equipment (DTE).

The RS232/CCITT V-24 lines used, and their pin numbers, are detailed overleaf. The table shows both the instrument connector pins (rear 50-way Cannon) and those of the Adaptor Panel connector.

Table 1.1

Signal		Instrument SK1 Pin Number	Adaptor Panel SK1 Pin Number
CLEAR TO SEND	Handshake signals commoned internally (see Note)	2	5
DATA SET READY		34	6
DATA TERMINAL READY		36	20
CARRIER DETECT*		4	8
RECEIVED DATA	Input commands from DTE	6	2
TRANSMITTED DATA	Output Data to DTE	8	3
PROTECTIVE GROUND	Supply 0V	37	1
COMMON RETURN	Signal 0V	40	7

* The RS232 term for this line is "RECEIVED LINE SIGNAL DETECTOR"

Note: A pseudo-handshake is provided by the voltmeter echoing back the Command data as it is implemented, informing the DTE that a fresh Command can be accepted. However this facility can be suppressed (see page 3.1.6, and "Pre-programmed Sequences").

Current/Voltage drive

The RS232 Standard specifies voltage drive for communication links between devices whereas teletypes and other similar devices require current drive. Provision is made for the user to set up either current loops or voltage drive to suit his particular system. This is achieved by means of links on the pcb together with a built-in −12V power supply and the use of pint 23 to 25 on SK2 of the Adapter Panel. LK1 when bridged configures the Interface precisely to RS232 (ie Voltage drive), LK2 and 3 being bridged to provide current drive for teletypes etc. The signal lines RECEIVED DATA and TRANSMITTED DATA are parallel to pins SK2/25 and SK2/24 respectively while SK2/23 (−12V) is the common return line.

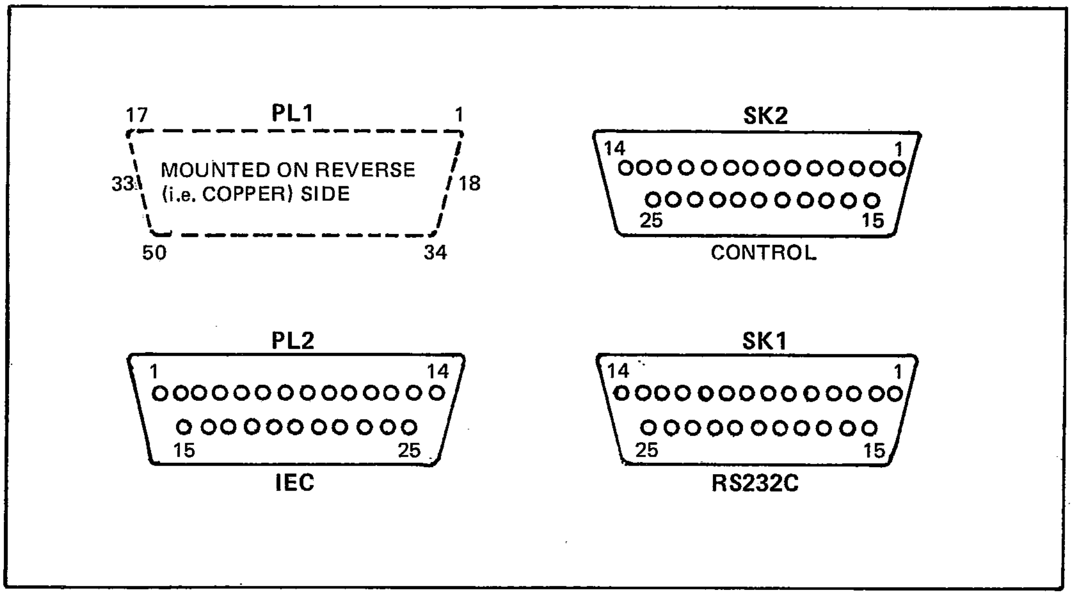


Fig. 1.1 *View of Adapter Panel showing the connectors. The RS232 Interface uses SK1 and some pins of SK2. PL1 mates with the instrument rear connector socket, hence is mounted on the reverse side of the panel. (Not drawn to scale.)*

70556 as an Output Interface

The RS232C facilities built into the 70556 Interface offer the user considerable sophistication. For the dvm owner who wishes merely to obtain a hard-copy print out of the measurements, the interface provides a very simple answer. By connecting the 7065 (or 7055) to a printer and operating the voltmeter from it's front panel, a print out is obtained of the measured value.

For example, consider the following requirement: "to measure, on the 1V range, at a scale length of 5 x 9's; to output the reading obtained to a printer." This would be achieved by:

1. Connect the printer to the voltmeter, using the cable supplied.
2. Connect both printer and voltmeter to the mains supply and switch them on.

Note: The Texas ASR Silent 700, if fitted with Remote Device Control, must have the ADC ON/OFF switch set to "OFF" in this application.

3. Using the voltmeter front panel controls select the following: **Vdc, 1.0, DISPLAY, 5x9.**
4. Since output to a remote device is required, select REMOTE.
5. For a single measurement, press SAMPLE.

On completion of operation 5 the voltmeter will make a measurement and output the reading to the printer. A specimen print-out from a Silent 700, obtained exactly as described (the voltmeter input leads were open circuit and floating) is reproduced below:

```
VDC   +1.0200900E+00
```

For an explanation of the various components of the printed output, see page 3.1.12 **"Output Format"**.

The example assumed the use of a printer, but a VDU can be used if a remote visual display is required; a recording device (punched tape or recording cassette) is another possibility of on-line output peripheral.

Processed measurements can be obtained in a similar manner. Thus any of the example Programs in Part 2 of the manual, provided that REMOTE is selected immediately before the SAMPLE button is pressed, can be run and the results printed.

Remote Control

The foregoing illustrates the use of the voltmeter, equipped with the 70556 Interface, in a conventional way, control being effected by means of the front panel push-buttons. However, as stated in the introduction to this section, interfacing option 70556 offers much more than a data output facility. With it the voltmeter can be remotely controlled, all front panel facilities being commanded *from the terminal*. The entire measurement operation can be going on with the voltmeter located some distance from the terminal, perhaps in an environment hostile to a human operator. Every function described in Parts 1 and 2 of this manual can be commanded by electrical signals; the interface also provides facilities unique to itself. The remainder of this Section describes the 70556 in terms of Remote Control.

INPUT COMMANDS

Note

The information contained in this Section of the manual refers in the main to the signals generated by the Interface in response to commands received from a terminal. It should be appreciated by the reader that many of the special control facilities – DLE and the commands DC1 to DC4, for example – may only be put to use with the more sophisticated, programmable terminal devices. These feature such refinements as cassette recording/playback equipment, one such terminal being the Texas Silent 700. A user wishing to exploit to the full the facilities offered by the 70556 Interface is urged to study the terminal manufacturer's handbook, in order to determine which control commands can be used.

Command Characters

The full list of acceptable Command characters is given in the following table: (but see page 3.1.7).

Keyboard Character	Range of n	Commanded Action	Notes	
D	0 to 3	DISPLAY (SCALE LENGTH)	0 = 3 x 9's to 3 = 6 x 9's (5 x 9's, 7055)	Measurement Commands
E	0,1	ECHO BACK	0 = Normal; 1 = Echo-back inhibited	
F	0,1	FILTER	0 = $\overline{\text{FILTER}}$; 1 = FILTER	
G	–	TRIGGER	"G C_R" initiates a Sample	
H	0,1	SAMPLE	0 = Single Sample; 1 = Repetitive Sample	
K	0,1	KEYBOARD	0 = Keyboard ON; 1 = Keyboard OFF	
L	0,1	LOCAL	0 = Local, 1 = Remote	
M	0 to 2	MEASUREMENT (or MODE)	0 = VDC; 1 = kΩ; 2 = VAC	
R	0 to 7	RANGE	0 = Autorange; 1 = 1000V; 7 = 10mV	
T	0,1	TRACK/SAMPLE	0 = SAMPLE; 1 = TRACK	
Y	0,1	DRIFT CORRECT	0 = not specified; 1 = Drift Correct after first reading	
C_R	–	TERMINATE (CARRIAGE RETURN)	End of Message String	
P	1 to 9	PROGRAM	Remote control of Program facilities	Processing Commands
Z	0,1	COMPUTE	0 = $\overline{\text{COMPUTE}}$; 1 = COMPUTE	
#	–	CLEAR		
!	–	PROGRAM EXIT		
; or] or [	–	ENTER		
?	–	RECALL or QUERY	Processing Command or Interrogate	
A	0,1	ALARM PRINT	Prints only if outside limits (Program 6)	
%	–	DEFINE	Start of pre-program sequence	Pre-programming Commands
$	–	END	End of pre-program sequence	
CNTL,H	–	BACKSPACE	Printer Backspace (Editing Commands)	
CNTL,Z	–	PRINT	Prints next character (Editing Commands)	
ESC	–	ESCAPE	Escape from EDIT (Editing Commands)	
X	0,1	PRE-PROGRAM	0 = $\overline{\text{RUN}}$; 1 = RUN	
C	00 to FF	DEVICE CONTROL	For details see page 3.1.17	

The characters in Column 1 of the table are those appearing on the standard keyboard of, for example, a teletype machine. For the ISO-7 code table, giving the binary equivalent, the reader is referred to page 3.1.19 at the end of this Section.

Commanding Measurements

An operator at a terminal keyboard, or the automatic control device, can command the voltmeter to operate as required by sending Command characters which are in many instances, the initial letter of the commanded function. Other characters are used to initiate program facilities (when the voltmeter is operating in its processor role), to interrogate the instrument, and for defining and editing a pre-programmed sequence (see page 3.1.6). The end of a message is indicated by the terminator $\mathbf{C_R}$, which character also acts as a trigger when accompanied by certain other characters.

Associated with many Command characters is a variable integer, **n**, which further defines the function or facility being commanded. These commands are only complete when the letter (character) is followed by the integer, e.g. **Mn**. Alternatively following a character by **?** (QUERY) is the method whereby the controller can interrogate the voltmeter, to verify programmed settings. For example, if **M2** had been set, then **M?** will elicit the reply **02** (**n** is expressed as a 2-digit code). However it should be noted that **M0** is echoed as **03** and **Z1** as **08**.

Error Correction

Mistakes are easily corrected by simply overwriting the incorrect data. Thus if VDC is required (**M0**) and **M1** is keyed-in by mistake, a further key sequence of **M0** will reset the stored value of n to that required.

Message Format

The Command characters may be sent, in any order, in a serial message string. Unless the string is defined as a pre-programming sequence (see overleaf) Commands are implemented as they are received by the voltmeter. However it is not obligatory for the Sample Command to be sent last since the voltmeter is not "triggered" until it receives the message terminator $\mathbf{C_R}$.

A typical message string might be:

T0L1M0R5D2F0H0Y1G $\mathbf{C_R}$ (See Note below).

This would be implemented as follows:

T0	SAMPLE commanded
L1	places the voltmeter under Remote control
M0	selects VDC
R5	selects 1V Range
D2	selects 5 x 9's scale length
H0	commands a Single Sample, implemented after **G** $\mathbf{C_R}$
Y1	selects Drift Correct after the first reading
$\mathbf{GC_R}$	initiates the measurement sample defined by the **H** Command.

The voltmeter would measure the voltage, output the data to the DTE and then wait. Had **H1** been programmed, a repetitive cycle of measure-output, measure-output, etc. would have been initiated. Unless one uses the special facilities offered by a pre-programmed sequence, or calls up Option 1 of Program 9, *timed* measurement (see Part 2 of the manual) – **the essential conditions for obtaining a series of printed readings from a single Command are:**

L1 T0 (**A0** unless using Program 6) **H1**

Should **T1** be commanded (i.e. TRACK) the voltmeter will make repeated measurements, but *data output will be inhibited.*

Note: Spaces between character groups in the message string will be ignored by the interface, but within a group will cause an error message to be output.
e.g.

M2 R3D2 the spaces are ignored, whereas

M 2R3D2 will be unacceptable.

Echo-back

The Command **En** is used to control the echoing back of Command Data where speed of operation is important. Normally (**E0**) every Command is repeated by the Interface and output at the DTE. However this is very time consuming – merely sending C_R results in an echo-back of C_R L_F **NUL NUL NUL NUL**, i.e. 6 character times. So, by commanding **E1**, the user can very considerably speed-up the measurement function within a System environment.

Pre-programmed sequences

In addition to normal, one at a time, measurement Commands it is possible to pre-program the voltmeter with a series of measurement instructions, terminated by a "go" command. The sequence is not implemented command-by-command but is stored until required to be used. The Command **X1** is the "engage" command – its reception after sequence definition primes the sequence to run on receipt of the next C_R. A pre-programmed sequence, once running, will only stop if:

a. A fresh Command character is received, which will immediately interrupt the sequence. On receipt of C_R the run will be restarted.

b. The pre-programmed sequence includes **X0**C_R**, L0, %**. This tells the instrument to implement the sequence up to these characters and then exit – otherwise it will be repeated indefinitely.(**X0**C_R = disengage, **L0** = wait in local, **%** starts a new definition).

The message string example given earlier (page 3.1.5) might be part of a preprogrammed sequence, as follows:

L1%T0M0R5D2F0H0Y1GC_R
**$X1**$C_R$

The bracketing characters % and **$** enclose the sequence which is engaged by **X1** and run by C_R. Note that L1 precedes the sequence, placing the voltmeter in Remote operation *before* the sequence is implemented.

Assuming that the voltmeter measurement parameters had already been set up,the pre-program sequence: **%M1**C_R
M0C_R
M2C_R
**$H1X1**$C_R$

will cause the voltmeter to make a repeated series of measurements on KOHM, VDC and VAC. **H1X1**C_R commands the voltmeter to obey the **M1** instruction, followed by **M0** and **M2**, and then repeat. The measurements will continue until the Interface receives *any* keyboard character.

The second print out, on page 3.1.13, illustrates the series of measurements obtained from a sequence similar to that given above.

The pre-program sequence definition is initiated by the character %, it can consist of up to 128 ISO-7 characters (sufficient for at least 6 full measurement message-strings), and is ended by the character $. To facilitate editing of the pre-program sequence, three commands are available as shown in the table, viz CNTL H, CNTL Z and ESC. Editing is described on page 3.1.9.
Within a pre-programmed sequence definition, the character C_R terminates control-message strings in the normal way but does not end the overall message.

Notes: 1. Unassigned Control characters are ignored but those from columns 2–7 of the ASCII table will give rise to an error message.

2. Control characters, from column 1 of the ASCII table, included in a pre-programmed sequence are output at that point in the sequence.

3. In the case of **DLE** the next character in the sequence is output in addition to the Control character. This permits control to be exercised over the format of the printed measurement data – for example, tabulation of results, or control of peripherals.

Control Characters

Certain characters applicable to the Interface are neither letters, numerals or symbols. These are Control characters, from columns 0 and 1 of the ISO-7 table, which exercise control over the terminal and any auxiliary devices it may include.

These characters are written either in terms of their ASCII (ISO-7) meaning, (e.g. **EOT**) or as the abbreviation **CNTL** followed by an alpha character. The latter method gives a clue as to how Control characters are keyed-in from the terminal. Figures 1.2 and 1.3 illustrate the points covered in the following explanation, reference should also be made to the ISO-7 Table on page 3.1.19.

The key marked **CNTL** (Control) operates in a similar way to the more familiar SHIFT key. In the case of the latter, the binary code generated by striking one of the alpha-numeric keys is modified if the SHIFT key is held down at the same time. Thus the figure **3** is converted to the symbol #, the letter **K** is converted to **[**. A shift from Column 3 to Column 2 occurs in the ISO-7 Table.

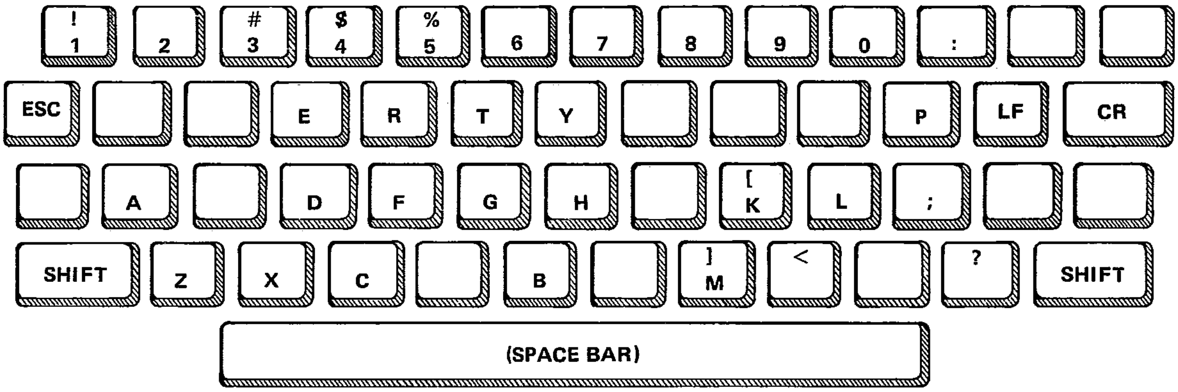


Fig. 1.2 *Teleprinter keyboard illustrating the keys used to generate normal Command characters. (Only capital letters are used.) The upper character printed on many keys is obtained by holding down the* **SHIFT** *key and striking the appropriate key.*

In order to produce a Control character the **CNTL** key is held down and a second, alphabetic key is pressed. In the ISO-7 table the resulting "shift" is 4 Columns to the left, i.e. from Column 4 to Column 0; from Column 5 to Column 1. Thus, for example, the letter **D** is converted to ASCII character **EOT**; the letter **T** to the character **DC4**.

Note that, with very few exceptions, the user is unaware of the instrument's reaction to Control characters since, although they are echoed-back in the same way as other keyboard characters, no printed symbol appears at the terminal as visible evidence of the echo-back. The exceptions are various output formatting characters (such as line feed, tabulate) which will cause a movement of paper/type head in a teleprinter, or of the displayed data in the case of a VDU.

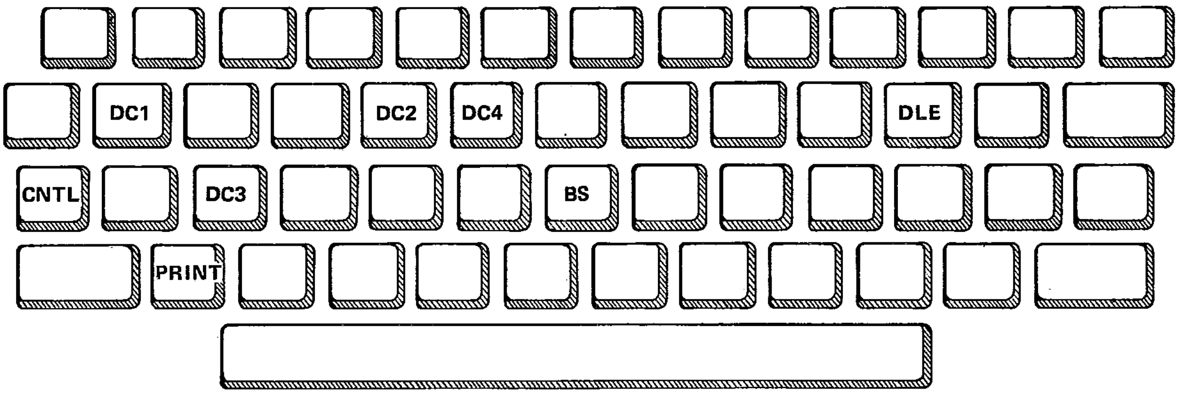


Fig. 1.3 *Teleprinter keyboard illustrating the keys used to generate Control characters. These, ASCII characters, are obtained by holding down the* **CNTL** * *key and striking the appropriate letter key.*

Control Character DLE

The ASCII character **DLE** is an example of a Control character applicable to the 70556 Interface, used in a pre-programmed sequence. In keyboard terms, **DLE** is written as **CNTL P,** since it is obtained by holding down **CNTL** and striking the letter key **P**. In all other explanations within the manual it is referred to as **DLE.**

In the key-sequence examples which follow, any possibility of ambiguity is avoided by offsetting **CNTL P** above the normal line of printing, a vertical line being used to indicate the place(s) within the sequence where the Control character should be inserted. Thus

CNTL P

| S | P | E | C | I | M | E | N

conveys the instruction "type the letters of the word **SPECIMEN** preceding <u>each</u> letter in the sequence with the **DLE** code obtained from **CNTL P**."

Use of Control DLE (1) – *Preamble*

There may be instances where it is desirable to precede a measurement output with a title, the date, or other identifying preamble. This is pre-programmed, as part of a defining sequence. Each character of the title is preceded by the ISO-7 Control character **DLE**, which ensures that the voltmeter does not treat the preamble characters as Command data.

Use of Control DLE (2) – *Auxiliary Device Control*

The alternative use of **DLE** is in the control of such auxiliary devices as cassette reader, or recorder. Start, stop, rewind, etc., can be commanded using code characters preceded by **DLE** – again within a pre-programmed sequence.

*The CONTROL key is labelled **CTRL** on some devices.

Editing (CNTL H, CNTL Z)

Should a pre-programmed sequence contain an error the user could put matters right by simply switching off the voltmeter, thus clearing the memory of all data, and start again or perhaps by overwriting the entire sequence. However this could be time-consuming, hence the provision of the **EDIT** facility. To edit a sequence, first press the % key. Repeated pressings of **CNTL Z** will cause the Interface to recall the stored sequence previously programmed and output it to the printer – in software terms, a *listing* is obtained.

When the incorrect statement is printed backspacing is necessary to permit overwriting. This is achieved by pressing **CNTL H** for each incorrect character. The correct character(s) should then be typed, overwriting the error (extra characters cannot, however, be inserted). If less characters are required, the redundant characters must be overwritten with spaces. The editing complete, the **ESC** key is used to escape from Edit and **X1** $\mathbf{C_R}$ will start a fresh run.

Some otherwise suitable, and fully compatible, terminal devices do not have separate keys for some of the specialised functions described in this manual. Thus ESCAPE is featured on the ASR Silent 700 but does not appear on an ADDS 980 VDU (as just one example). However, an examination of the ISO-7 Table (page 3.1.19) will show that **ESC** can be obtained by holding down the **CNTL** key and pressing **[**. In a similar way any apparent shortcomings of a particular keyboard can be resolved, since whatever means is used to generate an ISO-7 (ASCII) character, it's bit-pattern is always the same.

Device Control (DC1 to DC4)

Not listed in the Table on page 3.1.4, but referred to in the ISO-7 Code Table at the end of this Section of the book, are the special Device Control characters **DC1** to **DC4**. These, in addition to the **DLE** Commands, can have significance in controlling auxiliary devices such as a cassette recorder/playback machine. In the case of the Silent 700 **DC1** to **DC4** are associated with switching the built-in cassette machine between record and playback.

For those readers who wish to interface the voltmeter to the Texas ASR Silent 700, a full list of Device Control characters particular to that terminal is included on page 3.1.20, at the end of this Section.

Commanding Processed Measurement

If the voltmeter is to be used in it's processing role the command **P** should be sent, followed by the identifying number of the program(s) required. As detailed in Part 2 of this manual, up to 3 programs can be entered and run at the same time.

The commands **Z** (COMPUTE), ? (RECALL), # (CLEAR) and a choice of ; *or*] *or* [(all of which mean ENTER) have the same function as the front panel push buttons. The exclamation mark !, however, is the equivalent of pressing the PROGRAM push button a second time, i.e. exiting from the program back to displaying normal measurements, resetting accumulated results. Command **A** is used in conjunction with program 6, limiting print out to only those measurements outside preset limits.

Constants are entered as numbers, from the terminal keyboard, using +/-, decimal point and numerals 0-9.

It is not intended to repeat here the information contained in Part 2 of the manual. Nevertheless it is, perhaps, worthwhile to consider one important aspect of the Remote operation of 7065. That is the ability to command processed measurement sequences which are timed, i.e. under the control of the voltmeter's built-in clock. Using this facility a System Controller can program the voltmeter and then leave it to operate unattended – one line remaining "open" to receive measurement data – the computer thus being freed to attend to other controlled devices.

The following example is chosen to illustrate the programming of timed and processed measurement. It also demonstrates the neat formatting of the message string, possible as a result of imposing the meaning "ENTER" on the three characters ; *and*] *and* [. It is assumed that the instrument is to be used to monitor temperature, using a type J thermocouple; measurements are to be taken every 10 minutes and a print out is only required of those temperatures outside preset limits; the run is to start at 08:10 and end at 16:30.

The string would be:

P#8[2;21] P6[1200; 800] P9[1;;0810; 0010;.1630] A1GC$_R$

Note. **Remember L1 T0 are the essential conditions for a print-out to take place. If in doubt, include them in every message string.**

Considering the individual elements:

P#8[2;21] =

P6[1200; 800] =

These sequences: command the linearisation program for a type J thermocouple, option 2 of program 8; set the ambient to 21°C; call up the Limits program (P6), and define upper and lower limits at 1200°C and 800°C.

P9[1;; =

This commands option 1 of the Time program; the second ENTER after the 1 sets real time from the built in clock – assumed in this example to be running.

0810; 0010; 1630] This sets the three controlling parameters, START time, INTERVAL and END time.

A1 specifies Alarm print, while **GC$_R$** initiates the trigger – the run will then start at 08:10.

It is not necessary to use a pre-programmed sequence to command processed measurement, but a pre-programmed sequence can contain any mix of normal measurement and processed measurement commands. Intermediate results can thus be printed-up, during a lengthy process, for on-the-spot analysis..

The following simple example, which the reader may like to try for himself, employs 3 processing programs and illustrates the use of **DLE** within a pre-program sequence to add title and "sign-off" to the measurement data. (Note that **DLE** is coded from the keyboard by holding down the **CONTROL** key and pressing **P**).

Initially the voltmeter's clock is set to real time, using Option 1 of Program 9 and setting suitable figures for times a, b and c:

(a) **L1 P# 9[1; 161830; 162000; 000001; 164000]**

This is followed with the pre-program definition, commencing with a title (in this example = SPECIMEN).

CNTL P

% **C_R S P E C I M E N C_R**

Note that **DLE** must be coded before *each* character of the title, including the formatting **C_R** characters.

The measurement instructions are coded next:

P9?????D3 F0 H0 M0 R0 T0 Y1 C_R
P5????M1 R5 P5[3] C_R
P7??????M2 R0 P7[4] C_R

These instructions command the voltmeter to make:

1. a timed Volts DC measurement, preceded by a full Program 9 Recall* sequence.
2. a timed Kohm measurement, processed by Program 5 and preceded by a full Program 5 Recall sequence.
3. a timed Volts AC measurement, processed by Program 7 and preceded by a full Program 7 Recall sequence.

The "sign off" is coded in the same way as was the title:

CNTL P

C_R E N D C_R

and the sequence definition is terminated by:

$ X1 C_R

On receipt of **C_R** the sequence will be obeyed by the voltmeter repetitively commencing at 16:20, the measurements being terminated at 1640. However at this time the Recall sequences will continue until the user sends a keyboard character (e.g. **X0**) to exit from the sequence.

A print out obtained as a result of this sequence is illustrated on page 3.1.13

At the end of a run, the reader can obtain a print-out of the pre-program sequence (from **%** to **$**) by keying the following:

% **CNTL Z** (repeated 90 times!) which will terminate at **$**

Should editing be required the use of **CNTL H** will cause the printer to back-space, permitting overwriting of the character which needs to be amended. This procedure is described on page 3.1.9.

*The use of **?** for Recall is described on page 3.1.13.

OUTPUT DATA

Format

Measurement output data is in floating point exponential form, preceded by an Alpha header which gives additional information about the measurement. Thus a typical printed output is:

```
.... VDCSp  Sp  +1.23456E +03 ....
      \__/        \_________/
 1     2      3 4      5        6
```

wherein the various fields are defined as follows:

1. The first 'alpha' character can be either a $\wedge$, indicating an Alram condition (i.e. Calculation overflow) or the character @, indicating an Overload (i.e. an input at some time too large for the measurement Range). If both conditions occur the @ only is displayed.

2. The 4-character header specifies the measurement function and hence the units. (Sp is the ISO-7 character "Space".)

VDC Sp	=	Volts DC
VAC Sp	=	Volts AC (mean sensing)
KOHM	=	kilohms

3. A further **Sp** separates the alpha header from the measurement numeric data.

4. Polarity indication, not applicable to **VAC** or **kΩ**. Either '+' or '–'.

5. Measurement data in floating point format to 6 significant digits. The decimal point can float over 3 digits, E being within the range +15 to –15.

6. Blanks on the print out. Note that this field can contain additional, non-measurement data, as specified below.

Trailing digits insignificant for the Scale Length in use are always output as 0.

Output of Processed Data

When program 6 is in use, field 6 will contain either HI, LO or Blank, depending on whether the measurement is > High Limit, < Low Limit or within the zone defined at program definition time. This field is, of course, blank if program 6 is not in use.

It is necessary for the user to be aware of what programs, if any, are being implemented since an output ostensibly in volts may in fact be a temperature measurement from a thermocouple; the program may have scaled current to voltage or some other engineering units such as $\mu\epsilon$ (microstrain) from a strain gauge. To remind the user of this, the output data when the voltmeter is operating in it's processor role is accompanied by **P** n_1, n_2, n_3, where n_1, n_2, n_3 are the numbers* of the program(s) in use. Thus, the reading:

VDC +21.0000E00 P 8

should not be read as 21V d.c., but as 21°C since **P8** is the temperature measurement program. That is a simple example whereas, were the 8 to be replaced in the above by a 1, interpretation would necessitate knowledge of what significance the programmer had attached to the scaling factor employed in Program 1.

* **P** can have three, two, or one **n** identifiers associated with it, depending on how many programs are called up.

Titles and Preamble — DLE

The following specimen print-out illustrates the inclusion of a title, which was entered into the Interface memory using a pre-programming sequence. In addition to **SPECIMEN** the preamble could well have included the date, or an identifying number. (The Command Message for this example is that on page 3.1.11).

```
SPECIMEN
 OPTION 1
 T  16 39 38
 TA 16 31 00
 TB 00 00 01
 TC 16 40 00
 VDC  +1.2787700E+00      P 9,5,7   TIME 16 39 41
 OPTION 3
  H+2.3265400E+00
  L+000.66300E-03
 PP+2.3258770E+00
@KOHM +1.3323200E+00      P 9,5,7   TIME 16 39 46
 OPTION 4
 N +0.0000270E+06
 AV+1.1284605E+00
 VA+0.5016803E+00
 SD+0.7082905E+00
 RS+1.3323205E+00
 VAC  +1.3801900E+00      P 9,5,7   TIME 16 39 53
END
```

Additional Data

To obtain additional processed data, the ? character is used as a Remote RECALL "button". It is possible thereby to obtain information as to which option of a program is in use; to step through all the computed results, of Program 7, for example. One can, in fact, remotely Command all the push-button facilities available on the front panel.

The remaining data output to the printer, or other DTE, are the word TIME followed by a 6-digit time record. This is the time at which each measurement was taken and only appears if program 9 is called up. The following specimen print-out shows a simple time related measurement.

```
TEST RUN
@KOHM +2.3314900E+00      P 9         TIME 00 05 40
@VDC  +2.3278800E+00      P 9         TIME 00 05 41
 VAC  +0.0238000E+00      P 9         TIME 00 05 43
```

The next example illustrates a print-out from the voltmeter when program 6 is being implemented.

```
TEST RUN
@KOHM +23.265100E+00 HI   P 9,6,4   TIME 11 51 39
@VDC  +22.226700E+00      P 9,6,4   TIME 11 51 41
 VAC  +00.022600E+00 LO   P 9,6,4   TIME 11 51 43
```

Every output message is terminated by:

C_R, L_F, NUL, NUL, NUL, NUL

The latter four characters are "all-zeros" in ISO-7 code and are merely to ensure that the slowest peripheral device will have time to respond to the Carriage Return, Line Feed instruction.

Selector Switches

There are three selector switches mounted on the 70556 circuit board. The user-selectable facilities are:

Baud rate

S1 is an eight-position slider switch to define the data transfer baud rate:

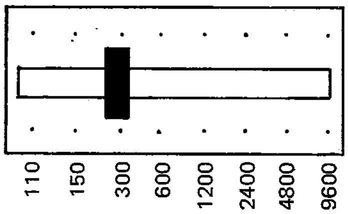


Fig. 1.4

Facility & Protocol Selection

S2 and **S3** are mounted side-by-side to the right of S1, S3 being the left hand one of the pair. The annotations are as shown:

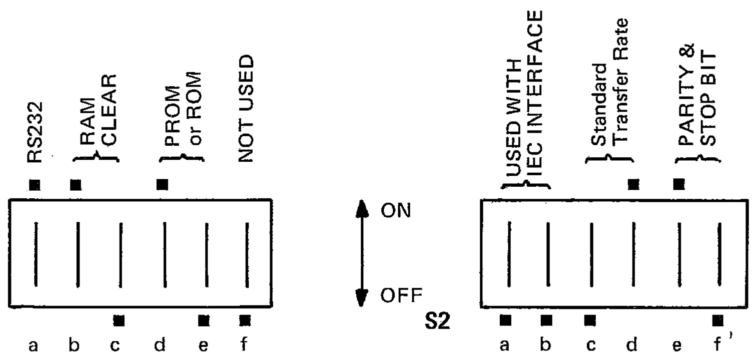


Fig. 1.5

The significance of the switch settings is as follows:

S3a. If the RS232 Interface is to be used this switch should be ON. For normal processing, also when either the 70554 or 70555 Interface is fitted, this switch should be set to OFF. The ON position is marked ■.

S3b & c. These two switches give the option of either clearing the RAM at 'Power-up', or not, as required. Normally these switches will be in the marked position (■), i.e. the RAMs are cleared at Power-up.

S3d & e. In the marked position, ■, the switches permit the use of Programmable ROMs. Later production of the Program Option 70556 will incorporate masked ROMs, requiring the switches to be set to the alternative state.

S3f is a spare.

S2 also carries markings, ■, to show the normal-use position:

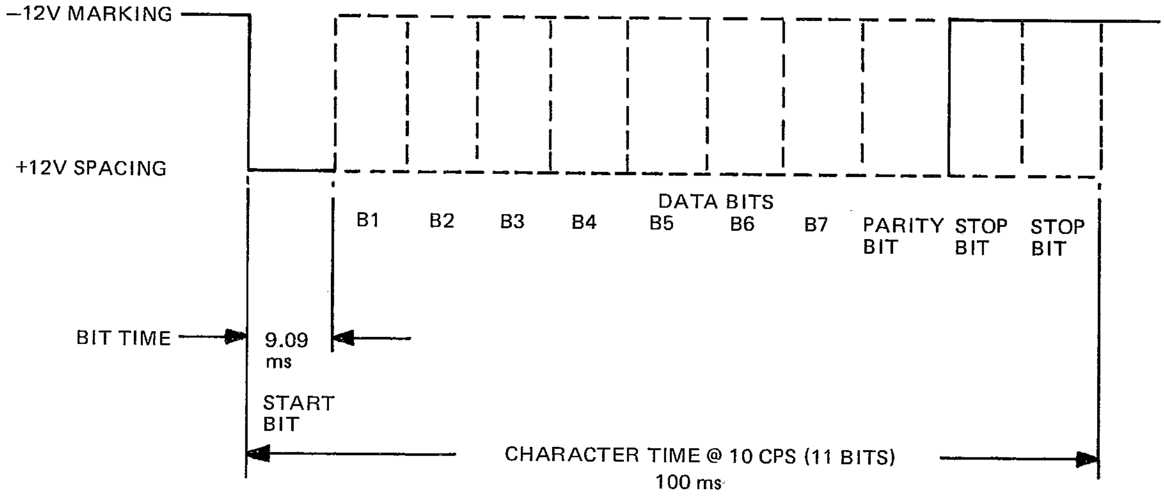
S2a & b. are associated only with the IEC Interface 70555.

S2c & d. The standard transfer speed is as set by these switches in the marked position.

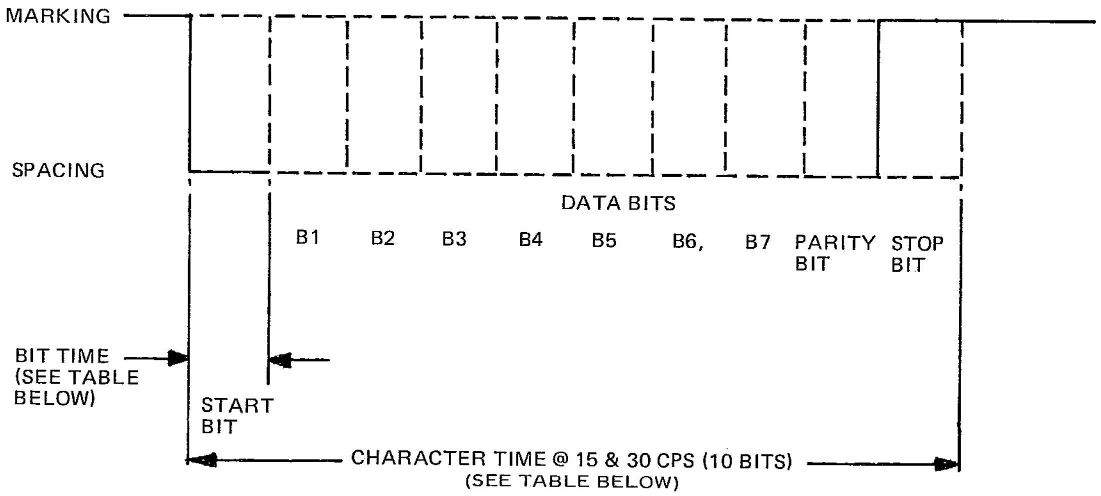
S2e & f. Bit parity and the stop bit are selected by means of these two switches, as follows:

	S2e	S2f	Action
	Off	Off	7 bits, ODD parity, 1 STOP bit
	Off	On	7 bits, ODD parity, 2 STOP bits
■	On	Off	7 bits, EVEN parity, 1 STOP bit ←
*	On	On	7 bits, EVEN parity, 2 STOP bits

The marked position, ■, is that used for the Texas ASR Silent 700, while that marked, *, is suitable for a Teletype. The significance of this is illustrated in Fig. 1.6 (overleaf).



(a) 10 CPS Timing, e.g. Teletype



	15 CPS	30 CPS
BIT TIME (ms)	6.67	3.33
CHARACTER TIME (ms)	66.7	33.3

(b) 15 and 30 CPS Timing, e.g. Silent 700

Note: CPS = CHARACTERS PER SECOND

Fig. 1.6 SERIAL DATA TIMING

Device Control (Command C)

A feature of the voltmeter which is probably unique, is that provided by the Command character **C**, associated with the outputs on SK2 of the Adaptor Panel. This facility enables a System Controller (teletype, computer etc.) to control other devices within the system via the 7065. A measurement system can thus be constructed having much greater flexibility.

The principal use of Device Control, Command **C**, would be with a pre-programmed, or tape controlled, sequence of Command instructions. The Device Control Command would be used to energise relays for auxiliary device control, the relays being connected to SK2 on the rear Adaptor Panel. For example one relay could control a punched tape reader, another a tape punch. Measurement commands stored on punched tape could then control the voltmeter, measurement data being recorded on a second tape.

The Command **C** must, in common with other Command characters, be followed by a two-digit identifier – the numerals **0** to **9** and the letters **A** to **F**. This gives a two digit (hexadecimal) code ranging from **C01** to **CFF**, i.e. 255 different 'values' of **n**. There are, in fact, 256 but **C00** is a no-control, default condition which represents the status of **C** when Device Control has not been selected; **C00** will also be 'true' before and after the two 3ms time periods described overleaf.

Implementation of Command C

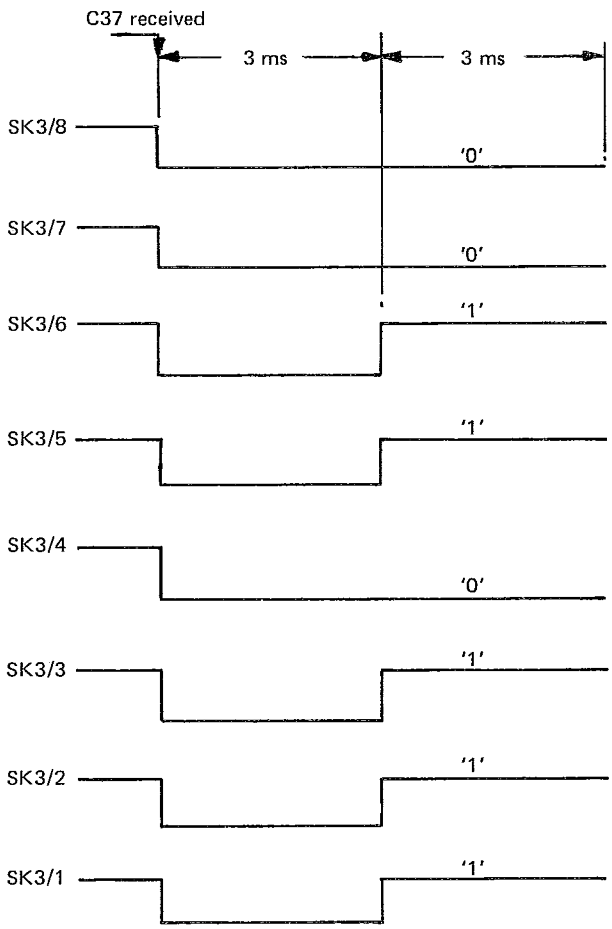
On receipt of a Device Control command the voltmeter initially sets all 8 control lines (see Table 1.2) to logic 0. This state prevails for 3ms and alerts the connected devices. The lines then assume levels corresponding to the BCD value of the identifying digits which follow **C**, again held for 3ms to allow for device settling time.

The pins of the voltmeter rear (50-way) connector socket, SK1, used for Device Control are identified in the following table, together with the corresponding pin numbers on SK2 of the Adaptor Panel.

Table 1.2

SK1 Pin Number			SK2 Pin Number
7	msd	BCD 8	8
5		" 4	7
3		" 2	6
1		" 1	5
35		" 8	4
9		" 4	3
42		" 2	2
41	lsd	" 1	1

As an example, if the command **C37** were received the Interface would set the output control lines as shown in the accompanying diagram(page 3.1.18).



This is recognisable as:

0011 0111

i.e. Decimal 37 in BCD form with SK3/8 as the most significant digit.

Fig. 1.5

Printed/Displayed Formats

A typical message string, excluding measurement commands, might be:

C37 P#1; P2; P9; H1 C_R

which would result in a measurement data output of the form:

```
VDC  -099.69900E+00       P 1,2,9 C37  TIME 16 56 05
```

Notice that, in contrast to earlier examples, all data "fields" are filled*. The example is an actual print out from a teletype thus the spaces etc. are exactly as formatted by the voltmeter.

Interrogation

C? has the expected meaning 'recall Device Control setting' and will elicit the response **37** in the example given.

* The instrument was not, in the example, implementing Program 6 hence the field immediately following the measurement data is blank.

ISO-7 (ASCII) Code Table

	0	1	2	3	4	5	6	7	◂ COLUMN
bit 7	0	0	0	0	1	1	1	1	
bit 6	0	0	1	1	0	0	1	1	
bit 5	0	1	0	1	0	1	0	1	ROW
bit 4 3 2 1									▾
0 0 0 0	**NUL**	**DLE**	SPACE	**0**	@	**P**		p	0
0 0 0 1	SOH	**DC1**	!	**1**	**A**	Q	a	q	1
0 0 1 0	STX	**DC2**	"	**2**	B	**R**	b	r	2
0 0 1 1	ETX	**DC3**	#	**3**	**C**	S	c	s	3
0 1 0 0	EOT	**DC4**	**$**	**4**	**D**	**T**	d	t	4
0 1 0 1	ENQ	NAK	%	**5**	**E**	U	e	u	5
0 1 1 0	ACK	SYN	&	**6**	**F**	V	f	v	6
0 1 1 1	BEL	ETB	'	**7**	**G**	W	g	w	7
1 0 0 0	**BS**	CAN	(	**8**	**H**	X	h	x	8
1 0 0 1	HT	EM	)	**9**	I	**Y**	i	y	9
1 0 1 0	L_F	**SUB**	*	:	J	Z	j	z	10
1 0 1 1	VT	**ESC**	+	;	**K**	[	k	{	11
1 1 0 0	FF	FS	,	<	**L**	\	l	|	12
1 1 0 1	C_R	GS	–	=	**M**	]	m	}	13
1 1 1 0	SO	RS	.	>	N	**^**	n	~	14
1 1 1 1	SI	US	/	?	O	_	o	DEL	15

Command characters, (70556) are shown bold, thus **M**; as are Control characters, in Columns 0 and 1, which have an assigned meaning within the Interface, thus **DLE**.

Notes:
1. Unassigned Control characters will be ignored.
2. Unassigned, or out-of-context, characters in Columns 2–7 will cause the Interface to output an error response.
3. Control characters in Column 1, if included in a pre-programmed sequence are output at that point in the sequence. If preceded by **DLE**, the next character in the sequence is also output.
4. The table is essentially ISO-7 but it conforms to the American Coding in the case of **$**, | and ~, which are ASCII characters.

Abbreviations and Meanings (within the 70556)

BS = Backspace
C_R = Carriage Return
DC(1-4) = Device Control
DLE = Data Link Enable or Data Link Escape
ESC = Escape (from Editing)
L_F = Linefeed
NUL = Null or Blank
SUB = Substitute (**PRINT** in Editing)

Control Characters, ***Silent 700***

The following table is included for the user specifically wishing to interface 7065 (7055) to a Texas ASR Silent 700 terminal. The reader is reminded that other manufacturer's terminal devices may place a different meaning on the Control Characters.

FACILITY COMMANDED	CONTROL CHARACTER	
Playback ON	**DC1**	Note 1
Playback OFF	**DC3**	Note 1
Record ON	**DC2**	Note 1
Record OFF	**DC4**	Note 1
Rewind Cassette 1	**DLE 1**	Note 2
" " 2	" **2**	
Load Cassette 1	" **3**	
" " 2	" **4**	
Record on Cassette 1	" **5**	
Playback on Cassette 1	" **6**	
Block fwd	" **7**	
Block rev	" **8**	
Printer ON	" **9**	
Printer OFF	" **0**	
ADC ON	" **:**	
ADC OFF	" **;**	
STATUS	" <	
REMOTE CANCEL	" ?	

Notes:
1. **DC1** is keyed as X ON, **DC3** is X OFF, **DC2** is TAPE and **DC4** is $\overline{\text{TAPE}}$, holding down **CONTROL.**
2. **DLE** is keyed by holding down **CONTROL** and pressing **P**.
3. The machine must have the Remote Device Control option fitted, and the "ADC" switch must be ON.

Section 2
Interface Unit 70554

INTRODUCTION

The 70554 Interface is an "add-on" module comprising a single pcb which carries all the logic required for system operation of the voltmeter. Also mounted on the pcb are the code switches which preset many of the available functions to suit the system architecture and protocols.

The interface can, for convenience, be considered as two separate modules. The one is concerned with decoding and implementing Command data received from the external system, while the other is primarily concerned with outputting measurement data. The latter sub-section of the interface is also responsible for the generation of certain timing and control signals necessary for the efficient use, by the system, of the measurement data.

Note: Since the operation of the dvm where it is committed within a system is entirely under the control of the system program, the operating description which follows covers all possible conditions of each voltmeter control. It is not intended that the reader should attach any programming significance to the order in which the Command signals are described; a logical sequence has been adopted, corresponding where possible to that used in Part 1 of the manual.

Logic Levels

All signals, except where shown to the contrary, conform to the following logic levels:

Input

Hi (Logic '1') : $+2.4V < '1' < 5V$ at $100\mu A$.
Lo (Logic '0') : $-0.5V < '0' < +0.5V$ at 5 mA sink.

Output

Hi (Logic '1') : $+2.4V < '1' < +6V$, TTL compatible.
Lo (Logic '0') : $-0.5V < '0' < +0.5V$ at 10mA sink.

INPUT COMMANDS

The following input commands are required from the external system, connection being via a Cannon D-type 50-way connector at the rear of the dvm. Table 2.1 at the end of this Section summarises the pin designations for the connector, each pin being individually treated in the descriptive text.

Control

External commands are effective only when the instrument is under Remote control, either as a result of the user selecting REMOTE at the front panel or as a consequence of the system Command, Front Panel Lockout. The latter is an overriding Command signal which inhibits the effect of all front panel controls (except POWER), thus preventing unauthorised switching of the voltmeter to LOCAL (i.e. manual) control.

Front Panel Lockout is commanded on Pin 38, where:

0 = Front Panel Lockout

1 = $\overline{\text{Front Panel Lockout}}$

Function Command

The measurement functions VDC, VAC, kΩ are commanded by the coded levels on Pins 42 and 43. The state of these two lines has the following significance:

Pin 42	Pin 43	Function
1	1	VDC
1	0	VAC
0	1	kΩ

Programming 0 0 will result in VDC being selected.

Range Command

When operating under Remote control the voltmeter can either be commanded to Autorange or a specific measurement range can be selected for each measurement or series of measurements. For maximum speed it will be found beneficial to group measurements on the same range together, thus avoiding a multiplicity of range change delays.

Pins 48, 49 and 50 carry the Range Command information, as shown in the following table.

Note: In all the code tables within this section, the Pins are arranged in conventional binary order, i.e. the msb is on the left. Thus code 110 is read as decimal 6.

Pin 50	Pin 49	Pin 48	VDC	VAC	kΩ
0	0	0	1000V	1000V	10MΩ
0	0	1	100V	100V	1MΩ
0	1	0	10V	10V	100kΩ
0	1	1	1V	1V	10kΩ
1	0	0	100mV	100mV	1kΩ
1	0	1	10mV	**100mV**	100Ω
1	1	0	**1000V**	**1000V**	10Ω (100Ω, 7055)
1	1	1	AUTORANGE		

The table shows the differences between the 7065 and 7055 in terms of available ranges – see Part 1 of the Manual.

Integration Time

Pins 44 and 45 carry the Command Rate information, specifying the integration time and thus the displayed (or output) scale length. Naturally 6 x 9's cannot be called up if 7055 is the voltmeter being considered.

Pin 44	Pin 45		
0	0	3 x 9's	0.3125ms
0	1	4 x 9's	2.5 ms
1	0	5 x 9's	20 ms
1	1	6 x 9's	(7065 only) 160ms

Note: Code 1, 1 calls up 5 x 9's on model 7055.

Filter

In conjunction with the main integration time selection the user can choose to switch in extra digital filtering, involving a longer integration time. This facility is commanded on Pin 46, where:

0 = FILTER

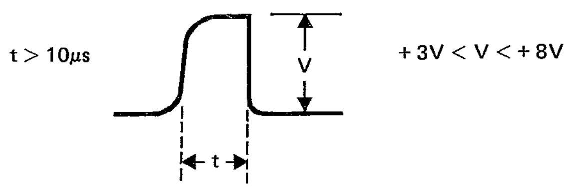
1 = $\overline{\text{FILTER}}$

The reader is referred to Part 1 in the manual for further details of the digital filter and its significance with regard to the readings obtained. It should be noted that this gives a 160ms integration time *regardless of selected scale length* with the exception of 6 x 9's, where integration time = 1.28s.

Sample

A measurement is initiated by means of a Sample Command originating from the external system (but see Note below.) Sample Command is either a positive pulse applied to Pin 40, or a contact closure between Pins 40 and 37 – selected by the user, according to the requirements of the peripheral device, by means of the switches on the Interface board. (See Switch Selectable Options, page 3.2.7).

Pulse Sample should exhibit the following characteristics:



Contact Sample should exhibit < 2ms contact bounce.

Note: If the voltmeter is in Remote operation as a consequence of the REMOTE push button having been selected, the TRACK and SAMPLE push buttons will still be effective. Hence selecting TRACK manually will override any external Sample Command and inhibit PRINT commands. With Front Panel Lockout programmed however, the manual push buttons are disabled.

CDC/IDC Enable

The voltmeter's Calibration Balance (Drift Correct) feature, described in Part 1 of the manual, can be employed in one of three ways when the instrument is under Remote control. To recap the earlier notes, 7065 (and 7055) has a built-in feature which allows it to periodically examine and correct it's input amplifier zero. This Calibration Balance occurs under the following conditions, interrupting the measurement:

a. immediately after a Range Change, an *increase* in Integration Time or a change of Measurement Function.

b. every 10 seconds, controlled by the built-in clock.

For Remote operation the system user can choose to either:

1. leave the Calibration Balance to operate normally, or
2. disable the timed correction (b. above), or
3. force a correction after every reading.

The three options are selectable by means of two switches, Inhibited Drift Correct (IDC) and Continuous Drift Correct (CDC) on the Interface board, the effectiveness of which is controlled by the level applied to Pin 47, where:

Pin 47 = 0 = both switches enabled

Pin 47 = 1 = both switches inhibited

The switch functions are described under the heading "Switch Selectable Options" (page 3.2.7).

OUTPUT DATA

Numerical measurement data, up to 6 (5) decades in BCD form, are available at the output connector. Table 2.1 at the end of this Section shows the pin designations, again each Pin is individually treated in the following descriptions.

Polarity

Voltage, or other, polarity is indicated by the levels on Pins 26 and 27 of the connector, coded as follows:

Pin 26	Pin 27	Meaning
0	0	AC/Ω (Polarity not applicable)
0	1	Negative (–)
1	0	Positive (+)

Range

There are two types of output format applicable to the Range Output, one of which relates directly to the input Range Command as in the following table which defines the coding on Pins 30, 31 and 32. (This is referred to as the *non-preferred* code.)

Pin 30	Pin 31	Pin 32	VDC & VAC	kΩ
0	0	0	1000V	10MΩ
0	0	1	100V	1MΩ
0	1	0	10V	100kΩ
0	1	1	1V	10kΩ
1	0	0	100mV	1kΩ
1	0	1	10mV (100mV ac)	100Ω
1	1	0	×	10Ω (100Ω, 7055)
1	1	1	×	×

× = Code not applicable

The so called *preferred* codes, of which there are two, cause the output to be formatted in such a way that the integer value of the output data is related to the measurement as in the following formula, where N is the output code decimal value:

Measurement = Reading (as an integer) x 10^{-N} V or kΩ

The 6 x 9's* preferred code interpretation of Pins 30, 31 and 32 output is:

Pin 30	Pin 31	Pin 32	Voltage	Resistance	N
0	1	0	–	10MΩ	2
0	1	1	1000V	1MΩ	3
1	0	0	100V	100kΩ	4
1	0	1	10V	10kΩ	5
1	1	0	1V	1kΩ	6
1	1	1	100mV	100Ω	7
0	0	0	10mV (dc)	10Ω	(8)

*Note that 6 x 9's is *not* applicable to 7055, and that in the 5 x 9's table (overleaf) Code 7 has the significance 100Ω in the case of the 7055

For the 5 x 9's preferred code the relationship remains the same, but the value of N is reduced by 1, viz:

Pin 30	Pin 31	Pin 32	Voltage	Resistance	N
0	0	1	–	10MΩ	1
0	1	0	1000V	1MΩ	2
0	1	1	100V	100kΩ	3
1	0	0	10V	10kΩ	4
1	0	1	1V	1kΩ	5
1	1	0	100mV	100Ω	6
1	1	1	10mV (dc)	10Ω*	7

Selection of the three optional Range Output formats is by means of the switches on the Interface pcb – described under the heading "Switch Selectable Options", page 3.2.7.

Function

Also sometimes referred to as Mode, the coding on Pins 28 and 29 defines the measurement function, i.e. the units. Coding is as follows:

Pin 28	Pin 29	Function
1	1	VDC
0	1	VAC
1	0	kΩ

BCD measurement data

Pins 1 to 25 and Pin 41 carry the BCD data, where the value on Pin 41 is the most significant decade, 2 x 10^6, and that on Pin 25 the least significant, 1 x 10^0. The full list is given in Table 2.1 at the end of this Section.

The remaining four outputs are management signals and an Overload indication.

Overload

An indication that the voltmeter input has, at some time in the measurement cycle, been too large for the range in use is given by a logic '1' on Pin 36. This could be used to cause an "alarm" printout, (e.g. an asterisked value or a reading printed in red ink).

Print Command

At the end of a measurement cycle the voltmeter generates a signal to the external system that measurement data is available for print-out (or other use by the system). There are two alternatives:

a. Print Command Pulse, Pin 33 is set High for between 10 and 30μs.

b. Print Command Level, Pin 34 is set High, remaining up until it is reset to '0' by an incoming Sample Command.

Data can change

The logic inverse of Print Command Level is taken out on Pin 35, the logic '0' informing the System that new Command data can be accepted.

Note: When TRACK is selected the PRINT COMMAND signal is disabled, both pins 33 and 34 being held LOW; conversely Data Can Change is held High thus denying the system the opportunity of programming fresh Command Data.

SWITCH SELECTABLE OPTIONS

The 70554 Interface pcb carries two switches which can be preset by the user to suit the requirements of his System. Many of the facilities have already been referred to in the main descriptive text, the intention here being to present the reader with the information in at-a-glance tabular form. Where necessary additional information is given to that within the main text. The information is summarised as part of the silk-screened printing on the upper face of the pcb. (The ON position is "up" when viewing the pcb from the front of the instrument – see sketch, Fig. 2.1).

Switch S1

Section	Function	
a	ON selects the non-preferred Range Output code.	
b & c	ON together selects the 5 x 9's preferred Range Output code.	
c	ON selects the 6 x 9's preferred Range Output code.	
d	ON selects CDC (Continuous Drift Correct)	provided that Pin 47 = '0'
e	ON selects IDC (Inhibit Drift Correct)	
f	ON selects "Not function". This disables the EXECUTE push buttons (applicable when the Program p.c.b. is fitted) hence, while allowing programs to be Entered and Recalled, it prevents the user from actually running a measurement processing program. Selection of "Not function" with this switch also causes the COMPUTE lamp to be extinguished.	

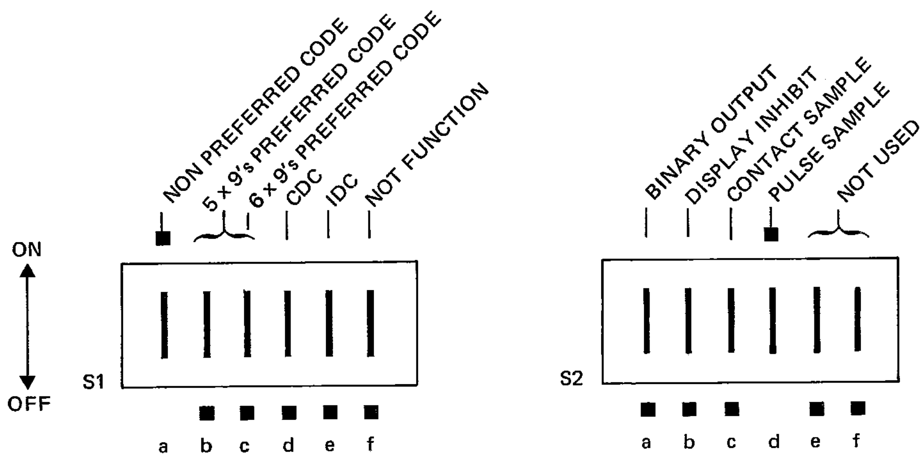


Fig. 2.1 70554 Switch Selectable Options

Notes:
1. On some switches the sections will be labelled 1, 2, 3 etc. as an alternative to a, b, c . . . . . .
2. For detailed explanation of facilities reference should be made to the text.
3. The "blobs" (■) show the position of the switches as set by the manufacturer. If difficulties should be experienced setting a desired configuration the user can "reset" back to these initial conditions before making any further adjustments.

Switch S2

Section	Function
a	The output data is converted from BCD to binary if this switch is set to ON. (Lsd is on Pin 25).
b	ON inhibits display update – this increases measurement speed if the display is not required.
c	ON selects Contact Sample.
d	ON selects Pulse Sample.

The switches are accessible to the user only when the instrument's dust cover is removed, since once set for a particular system it is not envisaged that they will require to be adjusted again.

SK1 Pin Number	Numerical value (BCD) 7065	Numerical value (BCD) 7055	SK1 Pin Number		Description
1	1×10^{6}	1×10^{5}	26		+ve POLARITY
2	8×10^{5}	8×10^{4}	27		–ve POLARITY
3	4×10^{5}	4×10^{4}	28		MODE (FUNCTION) OUTPUT CODE
4	2×10^{5}	2×10^{4}	29		
5	1×10^{5}	1×10^{4}	30	4	RANGE OUTPUT CODE
6	8×10^{4}	8×10^{3}	31	2	
7	4×10^{4}	4×10^{3}	32	1	
8	2×10^{4}	2×10^{3}	33		PRINT COMMAND (PULSE)
9	1×10^{4}	1×10^{3}	34		PRINT COMMAND (LEVEL)
10	8×10^{3}	8×10^{2}	35		DATA CAN CHANGE
11	4×10^{3}	4×10^{2}	36		OVERLOAD
12	2×10^{3}	2×10^{2}	37		EARTH (SIGNAL 0V)
13	1×10^{3}	1×10^{2}	38		FRONT PANEL LOCKOUT
14	8×10^{2}	8×10^{1}	39		– not used –
15	4×10^{2}	4×10^{1}	40		SAMPLE COMMAND
16	2×10^{2}	2×10^{1}	41		(BCD) 2×10^{5} *(7055 only)*
17	1×10^{2}	1×10^{1}	42		FUNCTION (MODE) COMMAND
18	8×10^{1}	8×10^{0}	43		
19	4×10^{1}	4×10^{0}	44		RATE COMMAND
20	2×10^{1}	2×10^{0}	45		
21	1×10^{1}	1×10^{0}	46		FILTER COMMAND
22	8×10^{0}	not used	47		CDC/ICD ENABLE
23	4×10^{0}		48	1	RANGE COMMAND
24	2×10^{0}		49	2	
25	1×10^{0}		50	4	

Table 2.1 Pin Identification, 7065/7055 Rear Connector

	$\times 10^{6}$	$\times 10^{5}$	$\times 10^{4}$	$\times 10^{3}$	$\times 10^{2}$	$\times 10^{1}$	$\times 10^{0}$
7065	1	4	0	0	0	0	0
	Pin 1	Pins 2 to 5	Pins 6 to 9	Pins 10 to 13	Pins 14 to 17	Pins 18 to 21	Pins 22 to 25

	$\times 10^{5}$	$\times 10^{4}$	$\times 10^{3}$	$\times 10^{2}$	$\times 10^{1}$	$\times 10^{0}$
7055	2	0	0	0	0	0
	Pins 1 and 41	Pins 2 to 5	Pins 6 to 9	Pins 10 to 13	Pins 14 to 17	Pins 18 to 21

Relationship between BCD values shown above and displayed reading.

INTERFACE TIMING

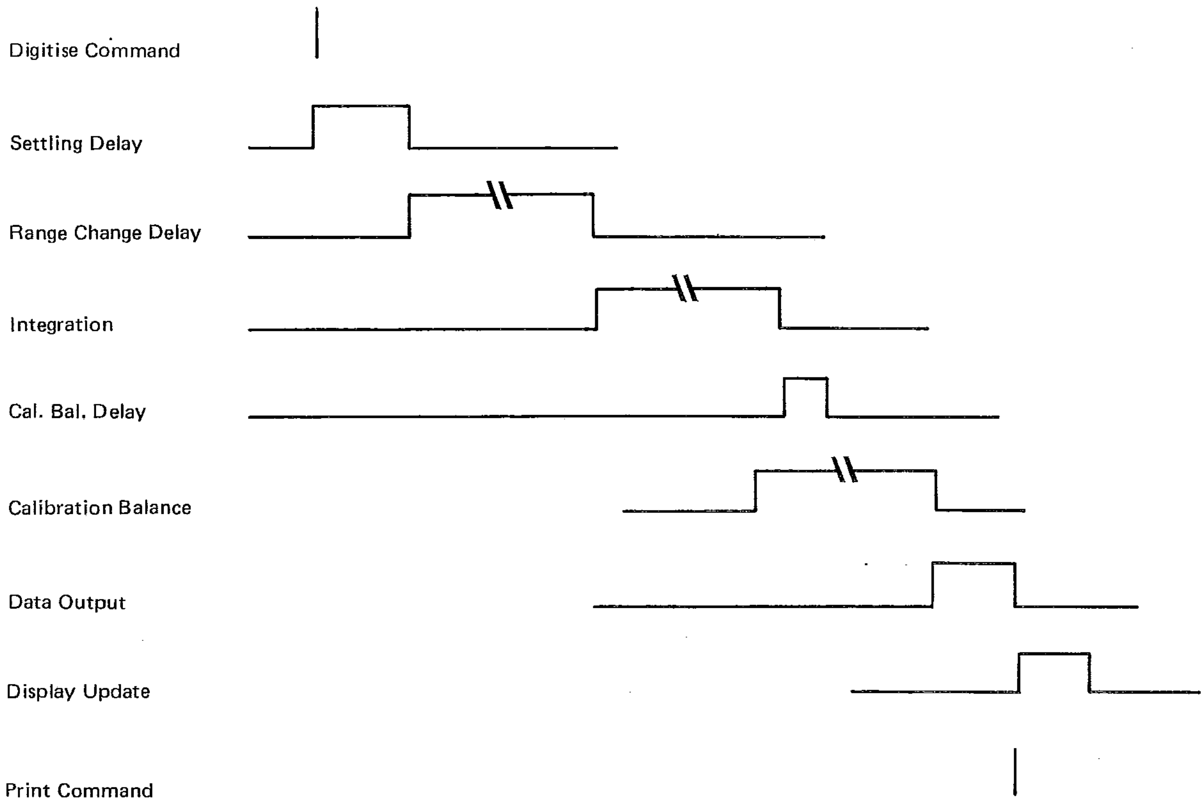


Fig. 2.2 Timing Diagram, 70554 Interface

Integration Times

Nines	Without filter	With digital filter
5	20ms	160ms
4	2.5ms	160ms
3	0.3ms	160ms

Settling Delay

2.7ms

Calibration Balance and Delay

1.6ms + integration time selected
Occurs every 10 seconds; or every scale or range change; or every sample, if more than 10 seconds between samples.

Data Output

0 for binary, 2.5ms for bcd

Display Update

4ms for binary, 1.5ms for bcd

Range Change Delay (0 for no change)

a. Command range change: 1.4ms max. below 100V range
21.4ms max. for 100V & 1000V ranges

b. Autorange change UP: 12.4ms max below 100V range
35.4ms max. for 100V & 1000V ranges

c. Autorange change DOWN:
Below 100V range –
12.4ms max. + (60ms or 3 x Integration time whichever is less)
100V and 1000V ranges –
35.4ms + (100m or 5 x Integration time whichever is less)

Note: All times based on 50Hz operation, unprocessed measurement.

Total Conversion Times

Without filter, range change or calibration balance.

a. BCD output format (incorporating display update)
5 Nines = 2.7 + 20 + 2.5 + 1.5 = 26.7ms
4 Nines = 2.7 + 2.5 + 2.5 + 1.5 = 9.2ms
3 Nines = 2.7 + 0.3 + 2.5 + 1.5 = 7ms

b. BCD output format (no display update)
5 Nines = 2.7 + 20 + 2.5 = 25.2ms
4 Nines = 2.7 + 2.5 + 2.5 = 7.7ms
3 Nines = 2.7 + 0.3 + 2.5 = 5.5ms

c. Binary output format (no display update)
5 Nines = 2.7 + 20 = 22.7ms
4 Nines = 2.7 + 2.5 = 5.2ms
3 Nines = 2.7 + 0.3 = 3ms

Section 3
Interface Unit 70555

The range of interfaces for use with the Microprocessor voltmeter is completed by the 70555 GP-IB Interface, conforming to the IEEE 488-1975* standard.

A byte-serial, bit-parallel interfacing system, the Standard governs the interconnection of programmable measurement instruments and defines cables, connectors and control protocols for unambiguous inter-device communication. Within the constraints of the Standard, a compatible instrument can be configured by the user for the system of his choice. The limitations are:

1. A maximum of 15 devices can be interconnected by a single bus.

2. Total bus length shall not be greater than 20 m, or No. of devices x 2 m (whichever is the shorter).

3. Transmission rate must not exceed 1 Mbaud.

4. Bus data is to be digital.

IEEE BUS

The IEEE Bus is a 16-wire highway system, comprising:

8 data wires, digital input/output (DIO).

5 management wires, for interface control signals.

3 handshake wires, controlling data transfers.

* The Standard is known variously as IEEE 488-1975, IEC TC66 WG3 and ANSI MC1-1 – or more simply as GP-IB (General Purpose Interface Bus). For more information the reader is referred to the introductory work, *Plus Bus, the Solartron GP-IB,* available free on request to Solartron.

70555 INTERFACE

The 70555 Interface is an add-on module comprising a single pcb, which is fitted internally within the voltmeter, and an Adapter Panel which is mounted on the rear of the instrument. The Interface contains all the electrical and mechanical features necessary for operating the 7055, or 7065 within a GP-IB system. Its function is that of a bi-directional data transfer interface capable of both sending and receiving data. Incoming messages can be either data, or electrical commands for remote control of the voltmeter.

An Interface Adapter (70558D) is supplied with the Interface. The Adapter, illustrated in Fig. 1, is equipped with connectors for both IEC TC66 and IEEE 488 standard cables to suit the user's system.

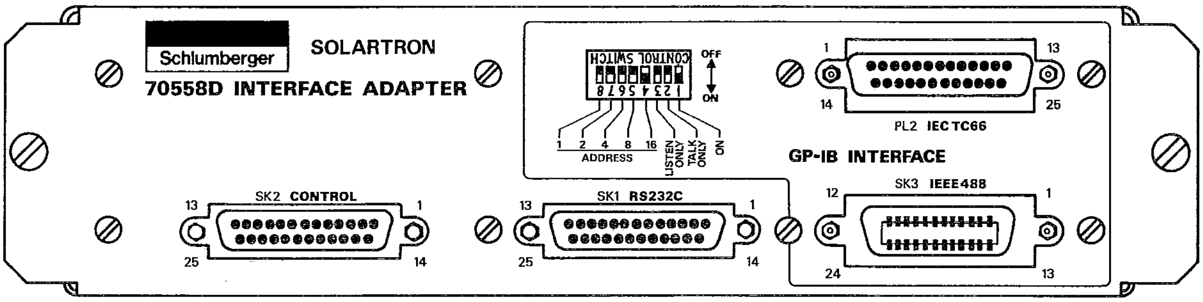


Fig. 1 *Interface Adapter 70558D*

FITTING THE INTERFACE

Full fitting instructions for the 70555 pcb are to be found in the Appendices which follow this section of the manual.

The 70558D Interface Adapter simply mates with SK1 at the rear of the instrument and is secured by two captive pan-head screws.* The annotations on the instrument's rear panel marked thus "✓", indicate which of the other optional pcb's are already fitted.

Interface compatibility is as follows:

> 70556 (Program and RS232 Interface); can be fitted *alone or* with 70555 (IEC Interface) *or* with 70554 (Parallel Interface).
>
> 70555 and 70554 should *not* be fitted together.

When Interfaces 70556 and 70555 are used together, it is essential to also use Adapter 70558D. The Adapter 70558A, is required only for Interface 70556 when used alone.

* Some earlier instruments have a separate panel (screwed onto the rear panel) through which SK1 protrudes. Where applicable, this panel *must* be removed before fitting the adapter panel, to ensure adequate electrical contact between the adapter and the dvm.

Selector Switches

When used with Option 70555, selector switches S2 and S3 on Option 70556 pcb, should be in the positions shown in Fig. 2. Selection of data transfer rate (S1), will depend on the users own requirements.

Additional information regarding the switch functions is given on page 3.1.14 of this manual.

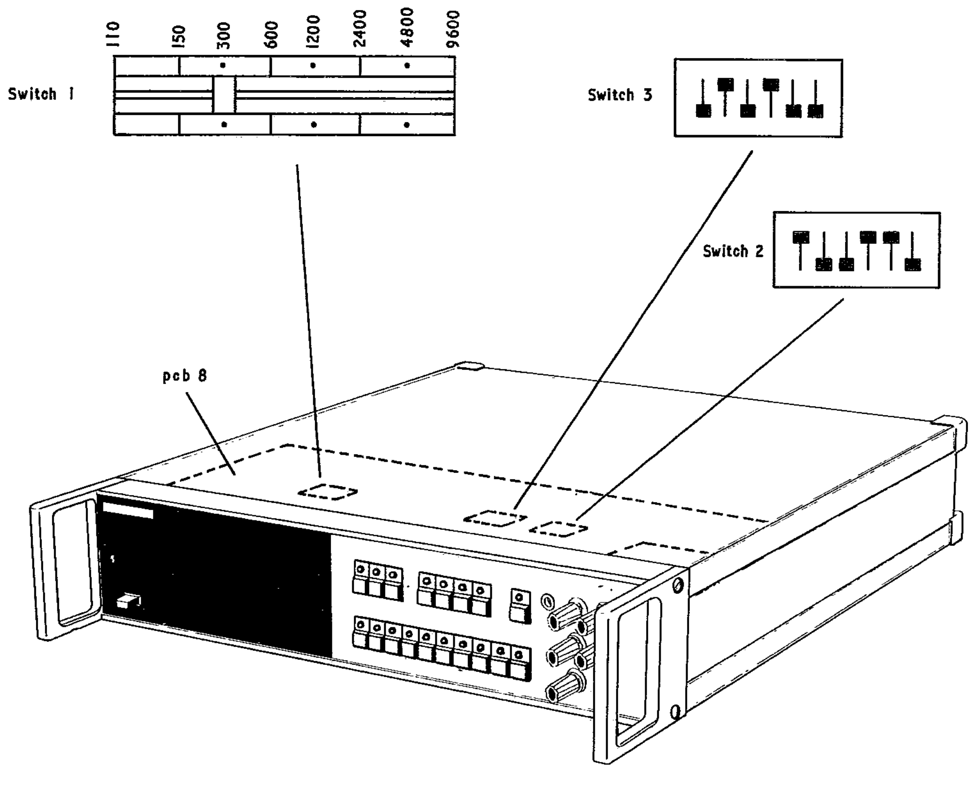


Fig. 2 *DVM Selector Switches*

DEFINITIONS

The following glossary of terms is included to assist the reader to understand concepts with which he may be unfamiliar. The list is not exhaustive, nor is it intended to be verbatim from the IEEE Standard.

Bi-directional Bus: a highway used for two-way communication, both input and output data being conveyed on the same lines.

Bit-parallel: used to describe data which are present simultaneously on a number of wires in a bus. The data bits are usually (but not always) acted upon as a single group or **byte.**

Bus: a data link, which may be a single wire but is more usually a parallel set of wires within a multi-way cable.

Byte: a group of data bits which are treated as a single item of information.

Byte Serial: information, in bit-parallel data bytes, transferred sequentially between devices.

Device Dependent Message: a message containing commands/data, specifically for use by the recipient instrument. Such messages pass through the interface, via the interpreter, to the measurement device.

Handshake: a sequence of conditional signals controlling the transfer of data over the interface bus. The signals are interlocked, in that each condition in turn must be satisfied before the next step in the sequence can occur.

Interface: that part of an instrument, or system, which enables it to be connected to another instrument or system via an interconnecting bus. An interface can be considered as having the two functions of data transfer and information translation (see **Interpreter**).

Interface message: a message intended for interface management, as distinct from device control (cf. **Device Dependent Message**).

Interpreter: that portion of the interface which translates incoming bus data into a form acceptable for use within the instrument, and outgoing data into a form suitable for transmission on the bus.

Local operation: operation of a device by means of its (normally) front panel controls; otherwise known as manual control.

Mnemonic: a shorthand label, designating a signal, which bears an easily recognisable relationship to the function of that signal. As an example, "clr" for the signal CLEAR, used to reset an interface to its initial condition.

Remote operation: operation of a device under the control of external electrical commands.

IMPLEMENTATION OF THE IEEE 488-1975 STANDARD

The 70555 Interface implements the Standard to the maximum degree necessary for the instrument for which it was designed.

The basic facilities are:

LOCAL/REMOTE operation, fully implemented.

Addressable TALK and LISTEN states.

Serial and parallel poll.

Both Selected Device Clear (SDC) and Device Clear (DCL) can be used.

Group Execute Trigger (GET)

25-way Cannon D-type connector (as per IEC TC66 recommendation).

24-way Amphenol connector (as per IEEE 488 recommendation).

In addition the Interface offers:

Full programmability of 7055, or 7065, including all processing options (if 70556 Option fitted).

Full resolution of the measurement data, to 10nV.

Error detection for input message strings; remote settings can be echoed back for verification.

Output parity user selectable.

Talk only/listen only states can be assumed, for use with simple systems.

Flexible output-data format, either fixed or floating point.

User control over output data alpha header.

ISO-7 (ASCII) coded input/output, compatible with most types of controller.

Access to all measurement parameter settings including front panel push-button selections.

User control over handshake rate, to cater for speed of peripheral devices.

Interrupt on sample completion.

Facility for including an RS232 compatible device within the system (but external to the GP-IB) if Option 70556 is fitted.

NB There are computers/calculators on the market which do not wholly comply with IEEE 488 - 1975. The user should therefore, by reference to the manufacturer's handbook, ensure that he understands the implications of any anomalies, and the limitations they may impose on the device's ability to function with the Microprocessor Voltmeter.

INTERFACING WITH 70555

Full programmability of the Microprocessor Voltmeter functions is possible if the instrument is to be used in a complex system. However, a simple system can be constructed, having only one other device additional to the voltmeter. The other device, the Controller, fitted with its own GP-IB Interface, may be as uncomplicated as a teleprinter; equally it could be a computer, a desk calculator, or a VDU.

Simple, output only interfacing

For the user who wishes merely to obtain a hard-copy print-out of measurement data, or readings displayed at a remote terminal, the 70555 can function as a simple output interface. The terminal, which must itself be fitted with a GP-IB Interface, is simply connected via the 70555 Interface to the voltmeter. The latter must have its address switches (see Fig. 1 and "Addressing") set to TALK ONLY; similarly the terminal must be in the LISTEN ONLY state. The voltmeter can then be operated normally, under LOCAL control, and measurement data presented at the terminal.

Simple interfacing with remote control

A refinement of the foregoing would be that of controlling the dvm from the remote terminal. For such an application the terminal would be employed as Controller, able to both send and receive data and capable of commanding the voltmeter to become either Talker or Listener. For this to be possible, the voltmeter and the terminal must be addressable; unique address codes must be set up for both the controller and the voltmeter.

The user should refer to the manufacturers handbook applicable to the chosen terminal for details of the former, to Fig. 1 for the latter.

Addressing The IEEE 488 Standard specifies that a 5-bit address code will be allocated to each bus connected device; the codes are selectable by the user. On the 7055D Interface Adapter (Fig. 1) a bank of rocker switches controls the function of the Interface; rockers 4 to 8 select the instrument address code. The standard setting for these switches, when 70555 is shipped, is binary 10000 (i.e. decimal 16). Examination of the ISO 7 table on page 3.1.19 will show that "My Listen Address" (MLA) for the voltmeter is ASCII character "Ø" (see note) and that its "My Talk Address" (MTA) is ASCII "P".

Should the user wish to select TALK ONLY (UNLISTEN) for output only interfacing, rocker 2 should be switched "ON".

A change of device address, made after the voltmeter has been switched on, will require the Addressed Command "Device Clear" to be sent for the new address to become effective. Thus, if the voltmeter address switches had been set to 10000 (decimal 16) and were subsequently changed to, say, 10001 (decimal 17), the Controller would need to send:

clr 716 i.e. Selected Device Clear

in order to activate the Address Enable line within the Interface, and thus implement the change of address. Subsequent Addressed Commands would then call up Device Address 17, e.g.

trg 717

Note. The symbol "Ø" (meaning zero) is used in those instances where confusion with the letter "O" may arise, e.g., the alpha-numeric string;

"O2MØTØ"

SYSTEM OPERATION WITH 70555

Having connected the 7055 (or 7065) voltmeter, via the Interface Adapter, to the Controller and its Interface, both instrument and controller can be switched on. Initially the voltmeter will be in its LOCAL condition, able to operate independently of the controller. The Control Switch, rocker 1, should be switched 'ON' and the address switches set as required.

DVM Control, LOCAL/REMOTE The GP-IB always has overall LOCAL/REMOTE control of the dvm. The bus signal REN (Remote Enable) when released, i.e. set High, sets all devices on the bus to LOCAL. Asserting REN (to Low) enables any addressed device to assume REMOTE operation. The device can be commanded to revert to LOCAL operation by means of the message GO TO LOCAL (GTL).

Front Panel Selected Local If the instrument has been manually switched to LOCAL, the controller can override the condition by sending the messages REN and LOCAL LOCKOUT (LLO). The effect is to disable all front-panel switches (except POWER) and transfer control to the Controller.

The remainder of this section describes the REMOTE operation of the voltmeter, but includes instances of the Controller commanding LOCAL operation to permit use of front-panel selectors where appropriate.

INSTRUCTION SET – MEASUREMENT COMMANDS

Keyboard Character	Range of n	Commanded Action	Notes
B	**0 – 1**	OUTPUT FORM	0 = Decimal, 1 = Binary.
D	**0 – 3**	SCALE LENGTH	0 = 3 x 9's to 3 = 6 x 9's (5 x 9's 7055).
E	–	ECHOBACK	
F	**0 – 1**	FILTER	0 = Filter out, 1 = Filter in.
H	**0 – 1**	HANDSHAKE	0 = Dvm operates at own rate, 1 = Dvm waits for Listener.
J	**0 – 8**	PARALLEL POLL CONFIGURE	0 = Unconfigure, 1 to 8 = Configure DIO lines.
K	**0 – 3**	PARITY	0 = Parity OFF, 1 = Parity ODD, 2 = Parity EVEN, 3 = Parity ON.
M	**0 – 2**	MEASUREMENT FUNCTION	0 = VDC, 1 = kΩ, 2 = VAC.
N	**0 – 1**	ALPHA HEADER	0 = Normal output formatt 1 = Literals supressed
Q	**0 – 1**	SERVICE REQUEST (Data Available)	0 = Inhibited, 1 = Enabled.
R	**0 – 7**	RANGE	0 = Autorange, 1 = 10 MΩ to 7 = 10 Ω OR, 2 = 1000 V to 7 = 0.01 V.
T	**0 – 1**	SAMPLE/TRACK	0 = Single Sample (on GET). 1 = Track.
U	**0 – 7**	DELIMITERS	0 = CRLF, 1 = ; , 2 = ETX, 3 = CRLFETX, 4 = EOI with last data character, 5 = CRLF plus EOI, 6 = ETX plus EOI, 7 = CRLFETX plus EOI.
Y	**0 – 1**	DRIFT CORRECT	0 = Drift Correct Normal, 1 = Drift Correct each reading.

Commanding Measurements

With the voltmeter under Remote control, provided that LLO has also been sent, front-panel selection of function, range, scale length etc. is not possible. Thus the Controller must command all the settings and instruct the voltmeter to take a measurement. Instructions are sent in the form of a message string, using the appropriate Command characters followed by an integer which clearly defines the setting. For example, to command the voltmeter to operate on Range 2, the 1000 V range, the command is R2; if Autorange is required the command if RØ. In general terms, Range is commanded by Rn where n can be between 0 and 7.

Other parameters are commanded just as simply: measurement function is Mn, n being within the range 0 to 2; displayed scale length is Dn, n = 0 to 3 – where possible, initial letters are used as command characters. Thus:

"MØRØD3"

will command the voltmeter to select VDC, Autorange, 6 x 9's displayed.

Message Protocol

For the voltmeter to accept the controller's message and act upon its instructions, certain conditions must be met:

1. The voltmeter must receive the message i.e., it must be in the Listen state.
2. The message must be recognisable as being Device Dependent.
3. A trigger command must accompany the message (there are exceptions to this rule)

Condition 1 is satisfied by the controller sending MLA i.e. addressing the voltmeter as a listener. The details of precisely how this is achieved are irrelevant to this description, (the method depends upon the chosen controller and its software); sufficient to say that the voltmeter recognises its own unique address code and will therefore accept the message.

The message is identified by the controller as being a Device Dependent Message by means of the management signal ATN (Attention). The ATN signal ensures that the Interface passes the decoded message through to the voltmeter.

The trigger command is Group Execute Trigger (GET). How it is obeyed is determined by a further parameter, Tn, which selects either SAMPLE (TØ) or TRACK (T1).

In the ensuing descriptions of programming the voltmeter via the 70555 Interface, and in all the examples, the system controller is assumed to be the HP9825A Calculator. Hence all instructions are in the operating code and format specific to that controller. The user must substitute the operating code and format appropriate for his chosen controller, by reference to the manufacturers handbook.

Example 1 To use the voltmeter for simple measurement, under LOCAL control, and output the measurements to the controller.

This example introduces the concept of Local messages, i.e. instructions which are local to the controller. Since they are not accompanied by a device address, the voltmeter ignores them. (They are identified in the text by the symbol ■). Italicised notes are given in explanation of the HP operational codes used. For further information the user should refer to the table on page 3.3.36, or to the manufacturers handbook. The controller address is 7, while that for the dvm is 16.

■ 0 : dim X $ [100]	*Defines a string variable, X $, of length 100 characters, within the controller.*
1 : clr 716	*Interface and dvm are cleared to the power-up state. Addressed command SDC (Selected Device Clear) is sent.*
2 : lcl 7	*REN (Remote Enable) is released; voltmeter is operating in LOCAL permitting the use of front panel controls.*
3 : red 716, X $	*The read instruction causes the voltmeter to be addressed as Talker (MTA is sent) with the controller as Listener. Data from the last completed measurement are output via the 70555 Interface to the controller.*
■	*Locally the measurement data is stored in X $.*
■ 4 : dsp X $	*This local message causes the stored measurement data to be displayed at the controller.*
■ 5 : gto 3	*A further local message transfers program control back to instruction line 3 and the loop repeats.*

If the above simple program is loaded into the Controller's memory and run, the voltmeter will make continuous measurements as defined by its front panel settings, and the readings will be displayed at the controller. Manual changes can be made to function, range, scale length etc. at any time during the running of the program.

Trigger Mode

In the foregoing example, line 1 has the effect of clearing the dvm to the power-up state. The trigger (Tn) assumed state is T1, i.e. Track, therefore continuous measurements are made. If the SAMPLE button is pressed while the program is running, T1 will be cancelled and measurements will be updated only by repeated pressings of SAMPLE. The same effect can be obtained if line 1 is followed by a device dependent message which commands TØ (Sample):

2 : wrt 716, "TØ"	*The write instruction causes the voltmeter to be addressed as listener (MLA is sent) with the controller as Talker. The message following the comma is automatically accompanied by the management signal ATN (Attention) in order that the interface shall recognise the data within the quotes (" ") as a device dependent message.*

For the interface to action the device dependent message in the Write statement, it must be followed by GET. (There are exceptions to this rule as will be seen in subsequent examples for Echo-back and for using Program Recall commands.) This is achieved, in HP operating code by the instruction:

3 : trg 716	*The Addressed Command GET is sent to the dvm, to action the Write statement.*

The modified program will be:

```
■ 0 :  dim X $ [100]
  1 :  clr 716
  2 :  wrt 716, "TØ"
  3 :  trg 716
  4 :  lcl 7
  5 :  red 716, X $
■ 6 :  dsp X $
■ 7 :  gto 5
```

When the program is running, a change in any measurement parameter will be effective only after the SAMPLE button is pressed; similarly, repeated pressings of SAMPLE will be necessary if the displayed reading is to be updated.

In example 1, once the program is set running, the controller behaves merely as an output terminal. Changes of measurement function, range etc. have to be carried out using the front panel push-buttons. The next example program illustrates the use of a terminal device as a true controller.

For the terminal to take overall control of the voltmeter, the latter must be switched to Remote operation. This is achieved by the controller commanding Remote operation with a bus message.

REMOTE ENABLE (REN) is asserted by means of the HP code instruction:

rem 7 .... which has the effect of "pulling down" the REN line for all bus connected devices.

For the REN command to be implemented, the voltmeter also requires the trigger message:

trg 716 .... the addressed command GET is sent to the voltmeter.

Alternatively one can achieve the same effect by sending the single *addressed* command : rem 716. Finally, to ensure that the voltmeter settings cannot be changed manually, the controller can send the message LLO (Local Lockout) which inhibits all front panel push-buttons:

Example 2 To use the voltmeter for simple measurement under Remote control, assuming no access to front panel selectors.

■ 0 : dim Y $ [80]	*Defines a string variable Y $ of length 80 characters, within the controller.*
1 : clr 716	*Clr interface and dvm to the power-up state by means of SDC.*
2 : rem 7	*Assert REN, priming the voltmeter (and any other bus device) to assume Remote operation on receipt of the next trigger command.*
3 : llo 7	*The controller sends LLO to all bus connected devices.*
4 : wrt 716, "MØRØD3F1TØ"	*The write instruction causes the voltmeter to be addressed as listener (MLA is sent). The message string within the quotes (" ") is settings data, i.e. a device dependent message.*
5 : trg 716	*The addressed command GET is sent to the voltmeter, enabling it to execute lines 2 to 4.*
6 : red 716, Y $	*The read instruction causes the voltmeter to be addressed as Talker (MTA is sent); measurement data are output to the controller ....and stored in Y $.*
■ 7 : prt Y $	*Here Print is used instead of display – the Controller will print a hard copy version of the measurement data held in Y $.*
■ 8 : stp	*Stop is a local message which terminates the program.*

When this program is stored and run, the voltmeter assumes the following state:

Remote,	VDC,	Autorange,	6 x 9's displayed,	Filter in,	Sample
	MØ	RØ	D3	F1	TØ

E Command

It may be useful to know the voltmeter settings which were used for a measurement, or to confirm that a message string was actioned. One could of course, read off the condition of the instrument push-button indicators for a single measurement. However, in a sequence of different measurements under program control, changes will be occurring very rapidly. A facility is therefore included in the 70555 which will provide the user with a display, or print-out of the settings, automatically. The facility, known as Echoback, is commanded by the letter E, which is sent in a message string in the normal way. (E does not require an accompanying n integer.) Thus:

wrt 716 "E"	*Commands the use of Echoback, causing settings data to be assembled in the output register.*

It should be noted that the E Command must NOT be followed by GET, since the latter has the effect of triggering a measurement – data from which would overwrite the settings data in the output register.

A typical use of Echoback is that of message string verification. The following example illustrates this application.

Example 3 Message string verification for error detection.

0 : dim A $ [50]	
1 : clr 716	
2 : rem 7	
3 : llo 7	
4 : wrt 716, "AØBØCØØD1TØ"	
5 : trg 716	
6 : wrt 716, "E"	
7 : red 716, A $	*Settings data are sent to the store A $.*
8 : if A $ [1,9] # "AØBØCØØD1"; prt "error"; stp	*Checks the first 9 characters of the settings data against those sent in line 4. If they are not the same, the word "error" is printed and the program stops –*
9 : wrt 716, "TØ"	*otherwise the program continues.*
10 : trg 716	
11 : red 716, A $	
12 : dsp A $	
13 : gto 9	

The Echoback steps, 6 through 8, are included to test that the voltmeter has correctly assembled and executed the first 4 settings commanded in step 4.

Step 8 is known as an "if" statement (the example is in HP operating code but similar programming facilities will be found in most other calculator or computer languages). Notice that the statement is in 3 parts, separated by semi-colons (;). The first part is the conditional test which, in English, says: "If the first 9 characters of string variable A $ are not AØBØCØØD1"; the second and third parts of the statement are only obeyed if the first part is true. Otherwise the program ignores the remainder of that statement and continues with the next step.

Command H

The examples thus far have assumed that the Microprocessor Voltmeter is operating solely with a controller, the HP9825A Calculator. However it is possible for other devices to be connected into the system, devices to which the voltmeter can send data under the control of the controller. Such Listener devices may be considerably slower than the voltmeter, resulting in their being unable to accept data as rapidly as they are being made available. To cater for slow peripheral devices, the interface can be commanded to "slow down", and wait for the "ready for data" signal before sending new measurement data. The Hn command provides this facility,

where n = 0, dvm operates at its own rate

n = 1, dvm waits for listener.

Binary output, Command B

Under normal circumstances, the assumed state of output is decimal – measurement data to be displayed or printed is in the familiar format:

VDC + 1.2345E + 03

In fact the characters are in ISO-7 code, which is translated into the displayed format by the user's terminal. Should the terminal require data in pure binary, the 70555 Interface must perform a different conversion on the data (which are actually in BCD within the voltmeter). This is commanded by setting the Bn parameter to B1. Naturally, if one programs B1 when using a controller equipped with an ASCII compatible display/printer, then the data presented will be largely unintelligible.

Alpha header, Command N

The interface outputs measurement data in a precise format comprising literals, i.e. a group of alphabetic characters (alpha header) defining the measurement function, and the measured value in floating point exponent form. In its standard format, the data string may be too long for the chosen output medium; alternatively, there may be a requirement to display other information on the same line as the voltmeter reading, requiring additional space. (See also Processed Measurements, page 3.3.18)

The alpha header can be suppressed by means of command Nn, where;

n = 0, normal output format.

n = 1, literals suppressed.

This facility may be useful in systems where a high data transfer rate is required; an approximate saving in transfer time of 27% is possible by suppressing the six header characters (including spaces).

Example 4 The following program demonstrates the use of many of the facilities previously described:

0 : clr 716	
1 : rem 7	
2 : llo 7	
3 : dim A $ [50] , B $ [50]	*This statement is used to declare 2 string variables, each of length 50 characters.*
4 : wrt 716, "D3FIMØN1R5TØ"	*The message string will be obeyed on receipt of the next GET command which initiates a single sample.*
5 : trg 716	*GET*
6 : red 716, A $	*Measurement data are sent to A $*
7 : wrt 716, "E"	*Commands assembly of settings data for echoback.*
8 : red 716, B $	*Echoback data are sent to B $*
9 : prt A $, B $	*The content of A $, B $ are output consecutively to the printer.*
10 : stp	

Note that line 7 in the program (wrt 716,"E") is not followed by GET, for the reason stated on page 3.3.13.

The program having been loaded and run, a print-out will be obtained similar to that illustrated.

```
+0.0000810E+00
A0B0C00D3F1H0J0K
0M3N1O000R5 T0U0
X0Y0Z0P000
```

(The specimen was in fact obtained from a HP9825A, the page layout will probably differ slightly were another terminal to be used.)

The first line of the print-out is that resulting from the voltmeter measurement; since the settings data includes N1, the reading is purely numeric. Strictly speaking therefore, the need to declare the string variable A$[50] in line 3 of the above example is unecessary; a simple variable would suffice. Thus lines 6 and 9 could be modified: e.g. red 716A and prt A. (The use of simple variables may be preferred if calculations, based on measured data, are to be carried out within a program).

The remainder of the print-out comprises a full echoback, including many command characters, which have not yet been described. These will be covered in subsequent paragraphs – however it is worth examining the echoback here in some detail.

Echoback

The settings are listed in alphabetical order, with the exception of P (which will be defined later). Almost all the letters of the English alphabet are used, those omitted being G, I, L, S, V and W. (The echoback command, E, does not appear in the list since it is cancelled once it has been actioned.) Certain of the missing letters are used for command characters, but without an accompanying integer.

The measurement function, Mn, has apparently been echoed back incorrectly, in that the list shows M3, whereas the program calls for MØ. However, this is merely a peculiarity of the voltmeter coding: there is of course, no function M3. Similarly, Z1 is echoed back in various ways, e.g. Z8, Z6. (See page 3.3.20).

Range is echoed back in two distinct ways, depending upon whether Autorange or a selected range has been commanded. In the case of the former, a two digit value of n is displayed, e.g. RØ5, indicating that, with Autorange commanded, the voltmeter has itself selected range 5. Alternatively, if R5Sp is echoed back, it shows that the commanded range was, in fact, Range 5.

Considering again the first line, that of the voltmeter measurement, one can readily perform the mental convertion to a reading of 1 μV negative potential. Had the reading been:

+ 0.0000010E - 03

then that can be seen as + 1 nV.

The reader is invited to re-work the example program, substituting parameters of his own choosing and measuring actual electrical quantities, in order to familiarise himself with simple programmed measurement. Step 7, and any reference to B $, may be omitted if echoback is not required, and step 9 can be changed to call up a display if preferred.

Drift Correct, Command Yn

The 7065 (7055) drift correction (or calibration balance) feature, as described in Part 1 of the manual, normally operates:

a. every 10 seconds

and b. when a range change occurs

and c. on changing measurement function

and d. when a longer integration time is selected.

When operating within a GP-IB System, with the 70555 Interface, the voltmeter can be commanded to suspend normal drift correct operation and instead apply a drift correction for each reading. The command character is Yn, where;

n = 0, normal drift correct

n = 1, drift correct each reading.

Yn must be sent as part of a device dependent message e.g.;

wrt 716, "Y1"

Assumed Settings

When the voltmeter is first switched on, or after a clear command (clr 716), the settings assumed are, generally speaking, those which would apply for n = 0 for each Command Character. The exceptions are T1 (track), F1 (Filter IN), RØ1 (Range 1 selected in Autorange), and D2 (Scale length 5 x 9's). From that point onwards, unless a Command character is included in the device dependent message, the Interface will accept the setting **as last commanded**. This is of particular importance if the user programs the Controller to send an invalid message (e.g. M4), since the voltmeter will ignore the commanded setting and assume the value of Mn currently stored.

An echoback output, obtained immediately after a clr 716 command, illustrates the initial condition of the Interface settings register.

```
A0B0C00D2F1H0J0K
0M3N0O0Q0R07T1U0
X0Y0Z0P000
```

The facilities described in the preceding pages have been those concerned with commanding simple measurements, using 7055 (or 7065) purely as a systems voltmeter. However, the Microprocessor Voltmeter has more to offer, with the power of its Processing Option 70556. A companion to this manual, Part 2, describes the use of the voltmeter for measurement-plus-processing, opening up a whole range of additional facilities. Processed measurement is commanded via the 70555 Interface in the same way as normal measurement, using input command characters which define the processing function and its execution. The voltmeter must of course be fitted with the processing pcb (70559508) as described in Appendix 1 at the rear of this book.

INSTRUCTION SET – PROCESSING COMMANDS

Keyboard Character	Range of n	Commanded Action	Notes
A	**0 – 1**	ALARM PRINT	0 = Alarm OFF (prints all values). 1 = Alarm ON (prints off limit values only).
P	**1 – 9**	PROGRAM	1 = R x constant, 2 = percentage deviation, 3 = offset, 4 = ratio, 5 = max; min; peak, 6 = off limits, 7 = stat. analysis, 8 = thermocouple, 9 = time.
Z	**0 – 1**	COMPUTE	0 = program(s) exit, 1 = program(s) enter. Retain stored data. (On Echoback, Z0 = Z0; Z1 = Z1 to Z8).
; *or* [*or*]	–	ENTER	
#	–	CLEAR	
!	–	PROGRAM EXIT	Exit program and remove stored data.
?	–	RECALL OR QUERY	Recall program/option in use; recall stored data.

Commanding Processed Measurement

To call up one, or more, of the voltmeter's built-in programs, the Controller message must include the command P, together with the program identifying integer and other details which define the program. As described in Part 2, up to three programs can be entered and used at the same time.

For example, if the voltmeter is to make a measurement of voltage across a resistor of known value, the user wishing to ascertain the current flowing in the circuit, then the instrument itself can be programmed to perform the calculation and output a reading – not in volts but in mA or A. The voltmeter program to use would be Program 1 (Multiply) and the multiplier constant would be the reciprocal of the resistor value. The device dependent message, for a 1 kΩ resistor would be:

wrt 716, "P1 [0.001]"

Examining this message:

P1 defines the program to be used

[is one of the three codes which all mean ENTER, the other two are] and ;

0.001 is the multiplier constant, the reciprocal of 1000 (Ω).

For the program to be executed, the voltmeter must now receive GET, i.e. trg 716. Program 1 having been loaded, all measurements will be automatically multiplied by the stored constant, or to put it another way, division by 1000 will be carried out, **before the reading is displayed.**

It should be noted that the Interface output will still include the alpha-header VDC, and polarity indication – the user must remember that, for this example, he is calculating current and must mentally convert the units to Amps. If the Controller terminal has facilities for adding characters to the displayed value, it is a simple matter of including these extra characters in the control program, thus;

red 716, A $	*A $ having been previously dimensioned.*
dsp A $, "Amps"	*The word Amps will be displayed after the measured value. (To avoid confusion the device dependent message can include N1 to suppress the alpha-header.)*

The complete program would be;

```
0 :  clr 716
1 :  rem 716
2 :  llo 7
3 :  dim A $ [50]
4 :  wrt 716, "TØMØR4D2F1
     P#1 [0.001] N1"
5 :  trg 716
6 :  red 716, A $
7 :  dsp A $, "Amps"
8 :  gto 5
```

Note the use of # (CLEAR) before the program number. (step 4)

In step 4, the voltmeter program part of the device dependent message is that between F1 and N1. In push-button terms it commands;

PROGRAM, CLEAR, 1, ENTER, 0.001, ENTER.

The CLEAR Command, #, is included to ensure that any previously commanded programs are removed from the voltmeter's program-in-use register before P1 is loaded. In the example under consideration, CLEAR is not strictly necessary, since step Ø has the effect of resetting the voltmeter to its initial state. It is however, good programming to use CLEAR, unless previously stored programs are required to be used in the present measurement.

Using other Processing Commands

All of the facilities available via the front panel push-buttons can be remotely commanded within a device dependent message. Voltmeter Program data can be recalled using the ? character; processed mesurement can be interrupted, and subsequently resumed, by commanding Z0 for unprocessed, and Z1 for processed, measurement; while the character ! has the same effect as pressing the voltmeter's PROGRAM button during processing, i.e. the voltmeter exits from the program, erasing stored results and constants.

Command Z

When Z0 is commanded, the voltmeter accepts it as an instruction to exit from the current built-in program(s) and revert to unprocessed measurement. The register which holds the value of Zn is loaded with an integer which is determined by the program-in-use and the chosen option. Hence, when echoed back, Zn will be either Z0, if that was the commanded setting, or Z plus one of several different integers, if Z1 was specified or if processed measurements are being carried out; e.g. Z2, Z6, Z7, Z8 are all possible.

Example 5 Commanding a series of resistance measurements which are to be processed by the voltmeter to obtain details of the maximum and minimum values measured. The voltmeter will use Program 5.

0 : dim A $ [50]	
1 : wrt 716, "M1R5D2P#5 [0] T0"	*Sets up measurement parameters and Program 5, Option 0.*
2 : for I = 0 to 99	*The controller "for, next" loop will command the voltmeter to make 100 readings, and output them for display.*
3 : trg 716	
4 : red 716, A $; dsp A $	
5 : next I	
6 : wrt 716, "P5?"	*The first step in the recall sequence is the option in use. The device dependent message reads "Program 5 Recall".*
7 : red 716, A $; prt A $	
8 : for R = 0 to 3	*This "for, next" loop will command the voltmeter to step through the remaining 4 parts of the recall sequence : Maximum, Minimum, Peak to Peak value and the voltmeter Programs in use will be printed.*
9 : wrt 716, "?"	
10 : red 716, A $; prt A $	
11 : next R	
12 : trg 716	*A further sample will be taken and the program will stop.*
13 : stp	

In lines 4, 7 and 10, use has been made of the HP operating code facility for stringing two instructions together on the same line, the semi-colon being used as a command separator.

The user can interrupt the processing of measurement data, without loss of stored results, at any time by commanding COMPUTE, using ZØ. This could be done at line 12 of the above program, viz:

```
12 :  wrt 716, "ZØ"; trg 716

13 :  stp
```

To consolidate the information on commanding processed measurement, the reader is invited to consider the following examples.

Example 6 This example is taken, with minimal alteration, from Part 2 of the manual, the Applications Program illustrated on pages 2.4.4 to 2.4.7. There it was detailed for Local operation of the voltmeter from its front-panel controls; here it is translated into Interface terms.

0 :	dim A $ [50], Y $ [50], Z $ [50]	*Allocates three 50 character storage areas for voltmeter data.*
1 :	wrt 716, "P#3 [-1.047] 1 [3.8] 7 [1] N1MØRØD2TØ"	
2 :	for I = 1 to 500	*Commands the voltmeter to take 500 individual readings which will be processed by Programs 3, 1 and 7 (in that order as commanded).*
3 :	trg 716; red 716, A $; dsp A $	
4 :	next I	
5 :	wrt 716, "NØZØ" ; trg 716 ; red 716, A $	
6 :	wrt 716, "P7?"	*Commands the first recall step.*
7 :	red 716, Y $; dsp Y $	
8 :	for I = 1 to 5	*Commands the voltmeter to complete the remaining 5 steps of the recall sequence. Locally these are printed by the controller.*
9 :	wrt 716, "?"	
10 :	red 716, Z $; prt Z $	
11 :	next I	
12 :	prt "Next batch"; gto 2	*Causes the voltmeter to repeat the run for the next 500, without erasing previously accumulated P7 data*.*

The built-in Voltmeter programs will offset the measurement by -1.047 (P3 [-1.047]), scale the reading by a factor of 3.8 (P1 [3.8]) and carry out the statistical analysis calculations stored as program 7. The displayed value, as set by Option 1 (P7 [1]), will be that of the running average.

* If the user writes "gto 1" instead of "gto 2" in line 12, the voltmeter's stored results from the first run will be erased before the next 500 samples are taken.

Having taken 500 "samples", the program will cause the voltmeter to enter its recall sequence, of which the Option-in-use will be displayed but not printed; the remaining Recall data are printed out sequentially. At line 12, a data separator message is printed before the Controller resumes the run.

Example 7 To command Program 9 (Time) and set the voltmeter's internal clock to the correct time of day – for subsequent use in time related measurements.

```
0 :  wrt 716, "P#9[1;102530;0;0;0]"     Note that ], [ and ; all have the meaning ENTER.

1 :  trg 716

2 :  wrt 716, "P#"

3 :  wait 1000                          Remainder of users program.

4 :

5 :
```

This example would normally form part of a larger program if time related measurements were required. It very simply calls up the voltmeter's Time program and in doing so, accesses the internal 96 hr clock; line Ø contains the device dependent message which specifies option 1 of Program 9 P#9[1; and sets the clock to 10:25:30 – an arbitrary value – as the next parameter (hours, minutes and seconds). The subsequent parameters, time a, time b and time c are not required in this instance, thus zero is set in.

Line 2 clears out P9, but without affecting the time setting, which will continue to update while the voltmeter is switched on – keeping track of real time.

To obtain a reading of time during a measurement requires the use of a Program 9 Recall command. It will be remembered that the first Recall step calls up a reminder of the option in use, the second is t, i.e. real-time. Hence the necessary command program will be:

```
6 :  dim X $ [50]

7 :  wrt 716, "P9?"

8 :  red 716, X $; dsp X $

9 :  wrt 716, "?"

10:  red 716,X$; prt X$
```

The printed output will be of the form:

```
T   10 25 31
```

The program segment illustrated can be used within a measurement definition program, such that the voltmeter reading, and the time that the reading was taken, are output together and printed. Thus:

wrt 716, "P9?"	*Recall option-in-use.*
red 716, X $; dsp X $	*Recalled option is displayed.*
wrt 716, "?"	*Recall time t.*
red 716, X $	*Output time to the controller, to X $.*
wrt 716, "Z∅"	*Revert to $\overline{\text{COMPUTE}}$ i.e. non-processed measurement.*
trg 716	*Trigger a reading.*
red 716, Y $	*Output to the controller, to Y $.*
prt Y $, X $	*Print reading and time consequtively.*

```
 VDC   -0.2506600
E+00
 T   10 25 31
```

A typical print-out is illustrated.

Protocol Commands

Protocol commands are those commands which define message content in terms of the specific requirements of the user's controller. Command Bn, previously discussed, comes into this category; the other commands are those defined by Kn and Un, which control output parity and message delimiters.

Kn, Parity definition There are four possible parity options, namely:

K∅	Parity always off.
K1	Odd parity.
K2	Even parity.
K3	Parity always on.

The default condition, assumed at switch-on, is K∅.

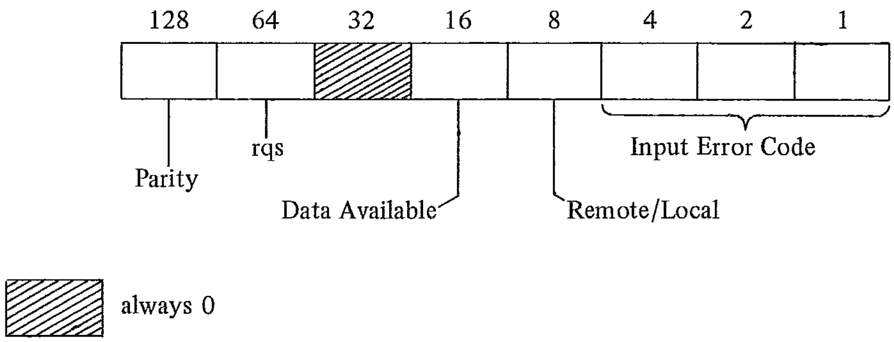
Delimiting Characters, Command Un, The delimiter is the character which is output at the end of a message string. Unless otherwise programmed, the standard delimiter C_R L_F is output by the interface. The options are:

UØ C_R L_F	U4 EOI with last data character.
U1 ;	U5 C_R L_F *plus* EOI
U2 ETX	U6 ETX *plus* EOI
U3 C_R L_F *plus* ETX	U7 C_R L_F *plus* ETX, *plus* EOI

The user should consult the manufacturers handbook for details of the delimiter and message parity requirements of his Controller.

REQUEST FOR SERVICE, POLLING

Status Byte Voltmeter status is coded in an 8-bit register in the Interface; the Status Byte, as it is designated by the IEEE 488 Standard, is made up as follows:



Command Qn The voltmeter requests service by setting rqs true and asserting SRQ. The user's software must, of course, include the means of detecting, and reacting to SRQ; unless the Service Request is satisfied then, depending upon what caused it, the voltmeter will "hang-up" waiting for the controller to respond. In respect of the voltmeter having data available for transmission on the bus, the SRQ (and rqs) facility is controlled by Qn, where n = 0 = SRQ inhibited and n = 1 = SRQ enabled. Qn must be sent as part of the device dependent message in a Write instruction e.g.

wrt 716, "Q1"

From the above, it will be seen that Command Qn determines whether or not the voltmeter will set bit 7 of the status byte when data is available (bit 7 has the value decimal 64). If rqs is set under these conditions, it follows that bit 5 (decimal 16) will also be set. Thus reading the status byte will give an output of 80, displayed as 80.00 in the HP9825A's standard format. Naturally, if the voltmeter is operating in REMOTE, bit 4 (decimal 8) will also be in the '1' state, thus giving an output of 88.00.

Error Indication The rqs bit can also be set, irrespective of the Qn command, as a result of the Interface receiving an invalid message. The message may contain an unrecognisable command character, e.g. "S"; alternatively the value of n may be outside that specified for the preceding letter, e.g.

"M3". Although the voltmeter itself ignores the setting commanded by the invalid message, the error is detected by the Interface and an SRQ is raised. At the same time, the error type is coded in bits 1 to 3 of the status byte and rqs is set true. In the 70555 Interface, the possible error codes are:

0, No error	(000)
4, Out of range value	(100)
5, Unrecognised character	(101)

Serial Poll

Having detected that the SRQ line has been pulled, the controller can interrogate the Interface and read the status byte by means of a Serial Poll; the controller asserts the message SPE, which in HP operating code is achieved by:

dsp rds (716)	*Read the status byte and display the value of the sum of its bits.*

Alternatively one could use:

prt rds (716)	*The value will be printed.*

The Serial Poll instruction can be used at any time, but it is of more value if it forms part of a user program subroutine – to which the program will go if an interrupt, resulting from SRQ, is detected.

Example 8 A program segment incorporating interrupt detection and the serial poll sub-routine.

dim X $ [50], C $ [50]	
0 → F	*F will be used as a "change flag" within the main program (not included in this illustration).*
clr 716	
oni 7, "ser poll"	*This instruction says, "On interrupt detection by the controller, go to the sub-routine whose label is ser poll".*
eir 7	*The interrupt enable instruction, local to the controller.*
wrt 716, "Q1"	*Remainder of user's program.*
⋮	
"ser poll" : prt "SER POLL", rds (716)	*The serial poll sub-routine causes the label SER POLL to be printed, followed by the value of the status byte.*
eir 7	*The interrupt is reactivated, enabling the next rqs to be detected.*
iret	*Program control is returned to the point at which the program was interrupted.*

The following instructions will serve to illustrate the effect of Qn.

wrt 716, "QØ"

trg 716

prt rds (716)

The print-out will be 24.00 when data is available, if the voltmeter is in Remote, indicating that data is available. (If the instrument is in Local, the print-out will be 16.00). The rqs bit is not set, because SRQ is inhibited by QØ. By changing the device dependent message to "Q1":

wrt 716, "Q1"

trg 716

prt rds (716)

.........one obtains a print-out of 88.00 (in Remote) or 80 (in Local); the rqs bit has been enabled by Q1.

Parallel Poll

In a system comprising more than one controlled device it is essential that the controller should be able to identify which instrument is requesting service when the SRQ line is pulled. It obtains this information by conducting a parallel poll.

The 70555 Interface is configured for parallel poll in a somewhat unusual manner. There is no provision made for the normal sub-function – as defined in the Standard – involving the interface commands PPC and PCU. In their place, the instruction set, i.e. the allowable device dependent message commands, includes a "settings" command which is decoded as thought it were an interface command.

The 70555 Interface allows for the voltmeter to be allocated a unique data wire (DIO 1 through 8) as its parallel poll code wire. This is configured by the command Jn (where J0 = unconfigure). Thus Jn forms part of the device dependent message in the normal way i.e. wrt 716 "J2". When the device pulls SRQ it will also set its allocated DIO wire to the 1 state.

In the multi-device system under consideration, if an interrupt occurs as a result of SRQ, the controller must send a parallel poll enable which in HP operating code takes the form:

prt pol (7) — *i.e. Conduct a parallel poll and print (or display) the value of the data wire code.*

or dsp pol (7)

In configuring for parallel poll, the controller has allocated each instrument one of the eight DIO wires as its code wire. These are coded in binary, thus DIO 1 = 0 DIO 2 = 2, DIO 3 = 4 etc. When the PPE message is obeyed, the data sent back to the controller is the **sum** of the codes of those devices responding. Thus 64.00 means it is the device whose allocated wire is DIO 7, while 72 shows that both DIO 7 and DIO 4 are requesting attention.

To complete its response to the SRQ interrupt, the controller must interrogate (Serial Poll) the device requesting service, by sending SPE as described above.

Parallel Poll — Sharing

Clearly, where the number of controlled devices exceeds eight, (the number of DIO lines available) then it is not possible to allocate to each device an individual DIO wire for polling purposes. Thus it may be necessary for two devices to share a common line. The users program should of course take this into account. A parallel poll will establish which DIO line has been set, then serial polling, (which can also be written into the program) will ascertain which of the two devices has requested service, and what service is required.

Example 9 A program incorporating a Serial and Parallel-Poll subroutine, and a change routine, introduced by the Change Flag F.

0 : dim X$ [50] , C$ [50]	
1 : 0 → F	*F is used as a "change flag" within the main program.*
2 : wrt 716, "TØH1Q1F1D2J3" ; trg 716	*Commands settings data to addressed device, followed by GET.*
3 : oni 7, "polling"	*On receipt of an interrupt, program jumps to line 13.*
4 : eir 7	*Enable interrupt.*
5 : wrt 716, "Y1" ; trg 716	*Commands drift correct every reading on receipt of GET.*
6 :	*User's program*
7 :	
8 : if F = 1 ; gsb "change"	*If F = 1 is entered at the controller, program jumps to line 20, otherwise continues to next line.*
9 : wait 400	
10 : gto 4	*Program returns to line 4 and the loop continues.*
11 :	
12 :	
13 : "polling" : prt "P POLL", pol (7) ; prt "SER POLL", rds (716)	*Causes: (a) Label "P POLL" and the value of the data wire code to be printed. (b) Label "SER POLL" and the value of the Interface Status Byte (from addressed device) to be printed.*
14 : eir 7	*The interrupt is re-activated, enabling next rqs bit to be detected.*
15 : iret	*Program control returns to line 4.*
16 :	*User's program*
17 :	

18 : "change" : ent C $	*The characters, C $?, are displayed, to allow settings data to be entered into C $.*
19 : wrt 716, C $; trg 716	*New settings data will be entered on receipt of GET. (An invalid character, e.g. "S8" will be detected as an error and cause an SRQ interrupt. Hence line 3 will be obeyed. . . . .*
20 : red 716, X $; dsp X $	*. . . . . otherwise measurement data is displayed.*
21 : 0 → F ; wait 2000	*Resets flag to zero.*
22 : ret	*The program returns to line 9.*

PRE-PROGRAMMED SEQUENCES

Normal operation of the Microprocessor Voltmeter with the 70555 Interface, as described, involves the controller's sending device dependent messages which are implemented **as they are received.** Apart from the degree of automation offered by the built-in time function of Program 9, the user wishing to set up an automatic measurement sequence has to write a program for his controller – which must, of necessity, be a calculator or computer. An alternative is that offered by a feature of the Processing Option 70556 (the program pcb) which provides the voltmeter with an RS232 interfacing capability. Fully described in Section 1 of this book, the RS232 Interface includes the means whereby a set sequence of measurement instructions can be pre-programmed – stored within the voltmeters memory – and executed on command.

The user who wishes to make use of this facility must ensure that his voltmeter is fitted with Option 70556.

Note: It is NOT necessary for the voltmeter to be connected to an RS232 compatible terminal for this particular feature to be used. (See page 3.3.30)

Commanding Pre-programmed Sequences

A pre-programmed sequence is defined by a message string which is initiated by the "per cent" sign (%) and terminated by the dollar symbol ($); between these two symbols, the sequence message itself can comprise up to 128 characters. The pre-programmed sequence is sent as part of a device dependent message in the normal way, viz:

wrt 716, "% .... $"

A "go" command must normally form part of the pre-programmed sequence, the character G being allocated for this purpose. The G is usually sent as the last character before the $ sign but more than one G can be used if the sequence calls for several samples to be made, on different ranges for example.

The execute command, on receipt of which the pre-programmed sequence is performed, is X1; the complementary command XØ will cause the voltmeter to exit from the sequence.

Example 10 A simple pre-programmed sequence to command the voltmeter to range up and down continuously while measuring VDC.

wrt 716 "MØTØ%R2GR3GR4GR5GR4GR3G$X1" ; trg 716

The command message string, typed in as shown and followed by the GET command (trg 716) will load the voltmeter memory with the set sequence. The X1 will be obeyed and the voltmeter will run the sequence automatically until the user sends XØ to stop it. One can readily check that the dvm is operating totally independent of the controller by either switching the latter off, or erasing its memory. Control can be regained by means of a fresh interface command. The pre-programmed sequence can be erased by Device Clear (clr 716 in HP code) or if the sequence is required to be run again later, the voltmeter can be commanded to exit the sequence, by means of the command XØ.

A practical use of the pre-programmed sequence is to found where results of a statistical analysis run are required when Program 7 is in use. Assuming that the voltmeter has been running a measurement sequence, one could command a Recall sequence as follows:

wrt 716, "H1TØ%P7??????$X1"	*Note the use of the "wait for listener" handshake command, H1.*
trg 716	
red 716, X $	*Repeating these steps 6 times will cause the controller to access and display each of the recalled values*.*
dsp X $	

In the above example, the use of H1TØ ensures that the dvm is halted at each of the Recall sequence steps to permit the controller to read the output buffer. In this instance, the command G is not applicable, since the pre-programmed sequence does not call for measurement samples to be taken.

* Using the full power of an "intelligent" controller, one could set up a "for-next" loop for the Read/Display statement. However, the example is written in its simplest form, for use with any controlling terminal.

Time Control

The facilities afforded by Program 9, Option 1, are of considerable benefit to Systems users of the Microprocessor Voltmeter. Quite independently of the rest of the GP-IB system, the voltmeter operating under the control of its built-in clock, can make regular measurements as frequently as required by the users application. The frequency of repitition is controlled by time b of Program 9 – the measurement interval. This is described in Part 2 of the manual.

Command I, Interval Use can be made of time b, once set up, even where Program 9 is not currently being used. Command I, included as part of a pre-programmed sequence, is actioned as an instruction to delay the next step in the sequence, for the interval stored as time b. This is possible because clearing Program 9 from the program-in-use register does not erase the stored constants.

Taking the previous example, in which the voltmeter is pre-programmed to range up and down continuously, insertion of I between each command group will introduce the required delay, (time b having been previously set up).

Thus:

wrt 716, "P#9 [1;time, time a;000020; time c] "	*The only important constant here is time b.*
trg 716	
wrt 716 "P#"	*Clears out Program 9.*

trg 716

wrt 716, "MØ%R2IR3IR4IR3I$TØX1"

trg 716

There will be an interval of 20 seconds, during which time the Sample button will "flash", between each range change.

Literals and formatting

In Section 1 of this book, reference is made to the means by which output data can be formatted, and titles incorporated in the hard copy, by including the required characters in a pre-programmed sequence. In the case of the 70556 Interface described in that Section, it was necessary to prefix each formatting/literal character with the ASCII character DLE (keyed in as CNTL P). The relevant information is to be found in pages 3.1.8 and 3.1.11.

This facility is a feature of the RS232 interface, in that the required characters have to be pre-programmed into the 128-character register which forms part of Option 70556.

Literals and formatting characters can be similarly generated, provided that the Option 70556 is fitted, under the control of the GP-IB Interface (70555). The difference lies in the method of identifying the message as literals, so that the dvm will not attempt to decode the characters as settings data. In the case of the 70555 Interface this is simply achieved by enclosing the literals/formatting characters in quotes (" "), again within a pre-programmed sequence. Since the 70555 includes provision for using an RS232 terminal as auxiliary controller, the user can choose to use either the GP-IB Controller or the RS232 terminal to command the facility. The reader is invited to compare the two methods of achieving the desired result, in the following example:

Example 11 To output a title, on its own line, before the result of a measurement.

It is assumed that the voltmeter has been commanded to output data to the RS232 terminal, by means of Command 02.

a. Using the RS232 keyboard – with the dvm in LOCAL – one sends:

%"***TITLE Sp EXAMPLE***$C_R L_F$
"XØG$TØX1G

b. Using the GP-IB Controller (the HP9825A) one sends:

wrt 716, "%""***TITLE Sp EXAMPLE***"

wrt 716, " " "XØG$TØX1" ; trg 716

The output, as a result of either a. or b., will be similar to that illustrated.

```
***TITLE EXAMPLE***
 VDC  -0.3269100E+00
```

In example b. there is no printing error in the number of quotes used – the doubling-up derives from the protocols governing the HP9825A. The user should be aware of such protocols as apply, in respect of message delimiters, in his own controller. Taking b. line by line:

1. As previously described, device dependent messages have to be enclosed in quotes – whatever their content.

2. A single quotes-character after the % would be treated as a message delimiter. To prevent the resulting syntax error, the HP-code demands the use of the second set of quotes.

3. Line 2 can be seen as a continuation of line 1, the automatic C_R L_F generated by the HP9825A being exploited to match that keyed-in as part of example a. Line 2 also includes the necessary $, to terminate the pre-program sequence.

4. Finally the GET, conveyed by trg 716, causes the sequence of instructions to be implemented by the voltmeter.

Listing, Command L

The Echoback facility already described (Command E) provides the user with the means of listing the voltmeter settings used for the current measurement sample. However E gives a static condition; the changes that may be occurring as the result of a pre-programmed sequence cannot be detected by the E command. To obtain details of the pre-programmed sequence that the voltmeter is performing, one commands a listing with command L in a normal device dependent message.

wrt 716, "L" — *Note that there is no requirement here for a GET command.*

red 716, X $

prt X $

Auxiliary Terminal

The 70555 IEEE Interface is primarily designed to permit the Microprocessor Voltmeters to be used within a standard GP-IB System. However, with the fitting of the Processing Option 70556, which incorporates the RS232 interfacing capability, one has the means with which the voltmeter can communicate with a second terminal. The RS232 terminal can be a VDU or a teleprinter. As such it is not merely a passive output device; the RS232 terminal can itself command measurements and thus function as an auxiliary Controller.

INSTRUCTION SET – RS232 COMMANDS

Keyboard Character	Range of n	Commanded Action	Notes	
G	–	TRIGGER	(RS232).	
I	–	INTERVAL TIMER	Commands use of time b (P9) for use as interval in pre-programmed sequence.	
L	–	LIST PRE-PROGRAM	Lists settings data entered as part of pre-programmed sequence.	
O	**0 – 2**	OUTPUT CONTROL	0 = Output to GP-IB devices only, 1 = Output to GP-IB and RS232, 2 = Output to RS232 only.	
W	–	WAIT	Inhibits dvm output until operation of any front panel key, or until any RS232 character is entered.	
X	**0 – 1**	PRE-PROGRAM EXECUTE	0 = $\overline{\text{run}}$, 1 = run.	
%	–	DEFINE PRE-PROGRAM	Initial command of device dependent message in pre-programmed sequence message string.	
$	–	TERMINATE PRE-PROGRAM	Final command of device dependent message in pre-programmed sequence message string.	
CNTL/H		BACKSPACE	Printer backspace,	Edit Commands.
CNTL/Z		PRINT	Print (step by step) next character in pps.	Edit Commands.
ESC or CONTL/ SHIFT/K		ESCAPE	Escape from EDIT.	Edit Commands.
C	**00 – FF**	DEVICE CONTROL	Interrogate designated device.	Device Control Commands.
>	**00 > FF**	INTERROGATE DEVICE CONTROL	Interrogate block of devices.	Device Control Commands.

Using the RS232 Terminal

The VDU or teleprinter should be connected to SK1 on the 70555D Adaptor Panel. The links on pcb 8 must be set for either current loop or voltage drive as appropriate to the chosen terminal (see Section 1 of this book).

Note: When being used in this configuration, the RS232 Interface must NOT be switched to the ON state. Any attempt to switch both interface options on together will result in the voltmeter microprocessor's entering a lock-out condition.

The voltmeter can be commanded for choice of output peripheral by means of command On, where;

n = 0, output to GP-IB terminal only.

n = 1, output to both GP-IB and RS232 terminals.

n = 2, output to RS232 terminal only.

Command On is sent as part of a device dependent message in the normal way, viz:

wrt 716, "O2MØTØ"

The voltmeter will output measurement, or other data, to both the auxiliary terminal and the GP-IB controller.

As previously stated, the RS232 terminal, once suitably configured, can itself become Controller and all RS232 functions, as described in Section 1 of this manual, can be commanded from its keyboard. The reader should be aware of the differences in the Instruction Sets applicable to the two Interfaces. Apart from 9 additional command characters, the letters E, H, K and L take on a new meaning with the 70555 GP-IB Interface.

In order for it to accept commands from the auxiliary terminal, the dvm must be set to LOCAL; hence the message string:

wrt 716, "O2TØ" ; trg 716; lcl 716

triggers a sample and simultaneously transfers control to the RS232 terminal. Further samples can be commanded at the auxiliary terminal for execution on receipt of the keyboard character G.* Thus for example typing M1G at the RS232 terminal will cause the voltmeter to select kΩ and take a single resistance measurement, outputting the data to the RS232 terminal.

When using the RS232 terminal in this way, it is of no practical value to command O1 or OØ. The dvm will be unable to output data to the GP-IB Controller because data are only transferred to the bus when the voltmeter interface is addressed as a Talker -- something the RS232 Controller cannot do. In the case of OØ, output to the RS232 terminal is also inhibited.

* The standard RS232 Interface, 70556, requires G C_R as trigger. The C_R character is not required when the RS232 terminal is employed with the 70555 GP-IB Interface.

In keeping with the recommendations of both IEEE 488 and IEC TC66 Standards, the GP-IB Controller must always have overriding control of all devices on the bus. To this end, the receipt of *any* addressed GP-IB message, whether it is an Interface Command or a Device Dependent Message, will cause the dvm to resume GP-IB operation. Any further messages from the RS232 terminal will be ignored. Note that the GP-IB Controller *gives* control to the RS232 terminal, and subsequently *takes* control again. The RS232 terminal can only accept control *when it is offered*; it cannot then transfer control back to the GP-IB, nor can it prevent such a transfer. Logically therefore, in this particular configuration, the RS232 terminal has no control over the Local/Remote operation of the voltmeter.

RS232 Editing Commands

Editing of the pre-programmed sequence is achieved as described in Section 1 of this book, using the special control characters CNTL H, CNTL Z and CNTL [(these are characters from columns 0 and 1 of the ISO-7 table). Unless the GP-IB Controller has the ability to generate the special characters, it will not be possible to use the facility. It is likely, however, than an alternative method of erasing and substituting characters will be provided by the controller keyboard.

Alarm Printing, Command A

A useful feature, for use in conjunction with Program 6 (High/Low limits), is the means by which the voltmeter can be commanded to output only those values which are outside the preset limits. With A1 commanded, the Alarm Print facility is enabled; AØ is the default condition, at switch-on, which allows normal measurement output. "An" is sent as part of a device dependent message.

Wait Instruction, Command W

Command W, without any defining integer, can be used in a pre-programmed sequence to instruct the voltmeter to wait after it has obeyed the preceding step in the sequence. Its function therefore is somewhat similar to that of command I, the difference being that after the W command has been obeyed, the voltmeter is held-up until one of three events occur. These are:

1. The receipt, by the GP-IB Interface of a hardware Remote Sample command.

2. The receipt, by the RS232 Interface, of **any** ISO-7 character.

3. The pressing of **any** front-panel push-button.

These occurrences will cause the pre-programmed sequence to continue from where it was halted. Consider the message string:

wrt 716, "%MØGWM1GWM2G$T1HØX1" ; trg 716

Having reached the first W command, satisfaction of any of the three conditions described will cause the sequence to advance to M1G (measure on kΩ) and then wait again – and so on.

Device Control, Command C

Command C, in combination with a hexadecimal code number n (00 through FF), produces a binary output from SK2 of the 70558D Interface Adapter. The range 00 through FF allows for 256 different combinations of 0's or 1's from pins SK2/1 through SK2/8. This output which is used as a 2-digit BCD number, is derived from the voltmeter's 70556 Interface and provides the means of commanding other devices, connected *via the adapter.* A simple application would be that of switching relays and thus of exercising control over the inputs to the dvm. More details concerning the use of the Command C are given on pages 3.1.17 and 3.1.18 in Section 1 of this manual.

Command C can be used with other command characters within a pre-programmed sequence; interrogation of other devices can thus be combined with changes of range, processed measurement etc, to suit the users requirements. Exclusive to the 70555 Interface is the additional facility of commanding the voltmeter to interrogate a *block* of devices – connected to the 70558D Adapter – using a single message string. This is achieved by using the character >.

Thus:

wrt 716, "C37 > 3B" trg 716

will command the voltmeter to interrogate the 5 devices (37 through 3B in hexadecimal code) in sequence, and carry out a measurement for each one.

Table 1 Summary of IEEE Bus Action.

HP-IB Operating Code		Effect	IEE 488 Bus Messages (A) = Asserted (UA = Unasserted)
lcl	7	Unassert interface command line REN, thus all devices to LOCAL state.	REN (UA)
	716	Sends coded command: Go To Local (GTL) to selected device(s) only.	ATN, (A). Codes sent; MTA; MLA, GTL.
rem	7	Assert REN only. Selected devices will assume remote state on receipt of MLA (My Listen Address)	REN (A)
	716	Assert REN and set addressed device(s) to REMOTE.	REN, ATN(A). Codes sent; UNL, MTA, MLA.
trg	716	Sends coded command: Group Execute Trigger (GET) to all selected device(s) – initiates an action, i.e. a measurement on dvm.	ATN(A). (Codes sent; UNL, MTA, MLA, GET.
llo	7	Sends coded command: Local Lockout (LLO). Places selected device(s) to either their Remote with Local Lockout, or Local with Local Lockout states.	ATN(A). Codes sent; LLO
clr	7	All bus interfaces except controller set to initial state. Coded command: Device Clear (DCL) is sent.	ATN(A). Codes sent; DCL.
	716	Selected device(s) cleared; codes: MTA (My Talk Address), MLA (My Listen Address), followed by SDC (Selected Device Clear) are sent.	ATN(A). Codes sent; UNL. MTA, MLA, SDC.
wrt	716	Output data to selected bus device(s) Device(s) addressed as Listener(s).	ATN(A). Codes sent; UNL, MTA, MLA. ATN(UA). Data sent . . . CRLF
red	716	Inputs data from addressed device(s) and places them in specified variables. Device(s) addressed as Talker(s).	ATN(A). Codes sent; UNL, MLA, MTA. Data received.
rds	716	Serial Poll; requests addressed device to place contents of its interface status register onto the 8 data lines.	ATN(A). Codes sent; UNL, MLA, MTA, SPE. ATN(UA). Read device status, ATN(A). Codes sent; SPD.
pol	7	Conducts Parallel Poll on all devices connected to addressed interface.	ATN, EOI(A). Read status.

70558D INTERFACE ADAPTER – PIN INTERCONNECTIONS

Tables 2a and 2b show the interconnections between PL1 on the reverse side of the Interface Adapter and SK's 1, 2 and 3 and PL2 on the front. PL1 mates with SK1 on the dvm. Those pin no's on PL1 marked with an asterisk are also connected to PL1 pin 40 via the Adapter Control Switches S1/A to F. The alternate wire codes or designations shown in parentheses in column 2 of the tables, apply specifically to the 70555 (IEEE) Interface Unit and can be ignored if this is not fitted.

Legend The following abbreviations are used within the tables:

ATN –	Attention
DAV –	Data Available
DIO 1 to 8 –	Data Input/Output
$D0_o$ to $D7_o$ –	Device Control
$D0_i$ to $D7_i$ –	MPU Data Bus Input
EOI –	End or Interrogate
IFC –	Interface Clear
NDAC –	Not Data Accepted
NRFD –	Not Ready for Data
REN –	Remote Enable
RTS –	Request to Send

Table 2a; pins 1 to 25

PL1 Pin No.	Wire Designation or Code	SK1 (RS232C) Pin No.	SK2 (CONTROL) Pin No.	SK3 (IEEE) Pin No.	PL2 (I.E.C) Pin No.
1	$D4_o$		5		
2	CLEAR TO SEND	5			
3	$D5_o$		6		
4	CARRIER DETECT	8			
5	$D6_o$		7		
6	RECEIVED DATA	2	25		
7	$D7_o$		8		
8	TRANSMITTED DATA	3	24		
9	$D2_o$		3		
10	DIO1			1	1
11	DIO2			2	2
12	DIO3			3	3
13	DIO4			4	4
14	REN			17	5
15	EOI			5	6
16	DAV			6	7
17	NRFD			7	8
18*	$D1_i$ (A1)		14		
19		NOT CONNECTED			
20*	$D1_i$ (A2)		15		
21	ADDRESS 4100		11		
22*	$D2_i$ (A3)		16		
23	$\overline{RTS}$		10		
24*	$D3_i$ (A4)		17		
25		NOT CONNECTED			

* Note: ALSO connected to PL1/40 via S1/A-H on Interface Adapter Control Switch

Table 2b; pins 26 to 50

PL1 Pin No.	Wire Designation or Code	SK1 (RS232C) Pin No.	SK2 (CONTROL) Pin No.	SK3 (IEEE) Pin No.	PL2 (I.E.C.) Pin No.
26*	$D4_i$ (A5)		18		
27		NOT CONNECTED			
28*	$D5_i$ (LISTEN ONLY)		19		
29	−12V		23		
30*	$D6_i$ (TALK ONLY)		20		
31	REM SAMPLE		9		
32*	$D7_i$ (GP-IB ON/OFF)		21		
33	$+5V_a$		18		
34	DATA SET READY	6			
35	$D3_o$		4		
36	DATA TERMINAL READY	20			
37	OV	1	12		
38	+12V		22		
39		NOT CONNECTED			
40	OV SIG	7		18 to 24	18 to 25
41	$D0_o$		1		
42	$D1_o$		2		
43	NDAC			8	9
44	IFC			9	10
45	SRQ			10	11
46	ATN			11	12
47	DIO5			13	14
48	DIO6			14	15
49	DIO7			15	16
50	DIO8			16	17

Appendix 1
Fitting Option 70556

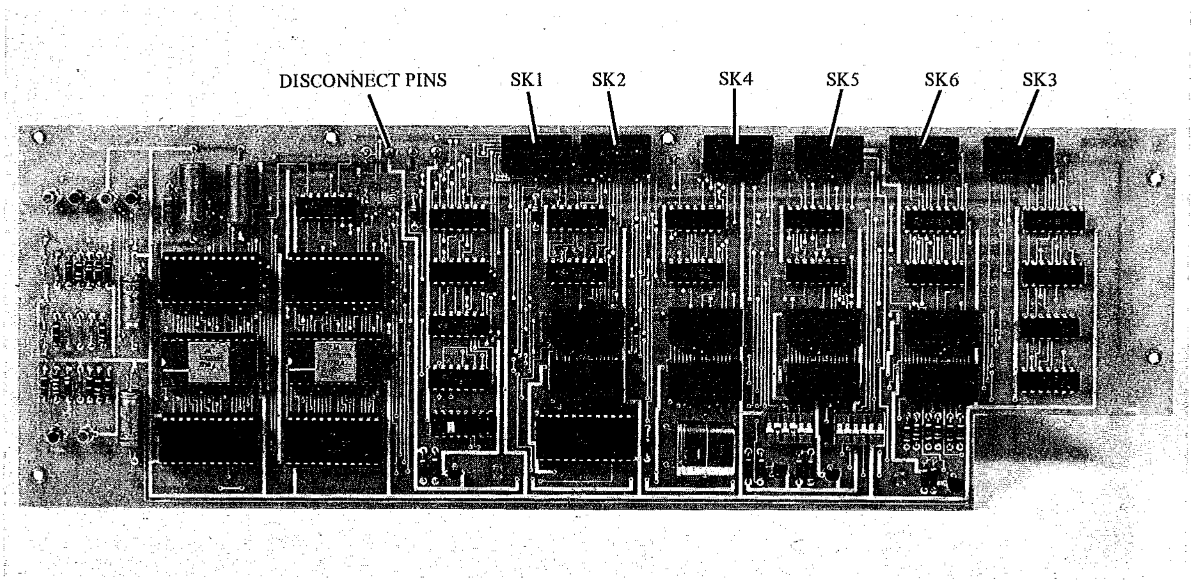


Fig. 1 PCB 70559508 (pcb 8)

The 70556 kit includes pcb 70559508 (Fig. 1), 70558A Connector Assembly, 6 Scotchflex connectors, disconnect leads, cable clamp and mounting screws and pillars. Pcb 70559508, referred to in this procedure as 'pcb 8', is designed to mount inside the instrument near the front. Pcb 8 can be fitted in one of two alternative positions, depending on whether or not the instrument is equipped with the Parallel Interface 70554 (pcb 4). The latter occupies the position immediately above pcb 3 – towards the front of the instrument – and pcb 8 should then be fitted above pcb 4. If option 70554 is not incorporated, pcb 8 will itself occupy the position immediately above pcb 3. In either instance the board is mounted on eight 1" support pillars.

The various interconnections required between pcb 8 and pcb 3 (or 4 if fitted) are similar and therefore only one procedure, giving pcb 3 and 4 alternative connections is described.

1. Disconnect the mains supply from the instrument.
2. Slacken screws in the 4 feet at rear of the instrument and remove the top and bottom covers.
3. Remove the central guard screen (Fig. 2).

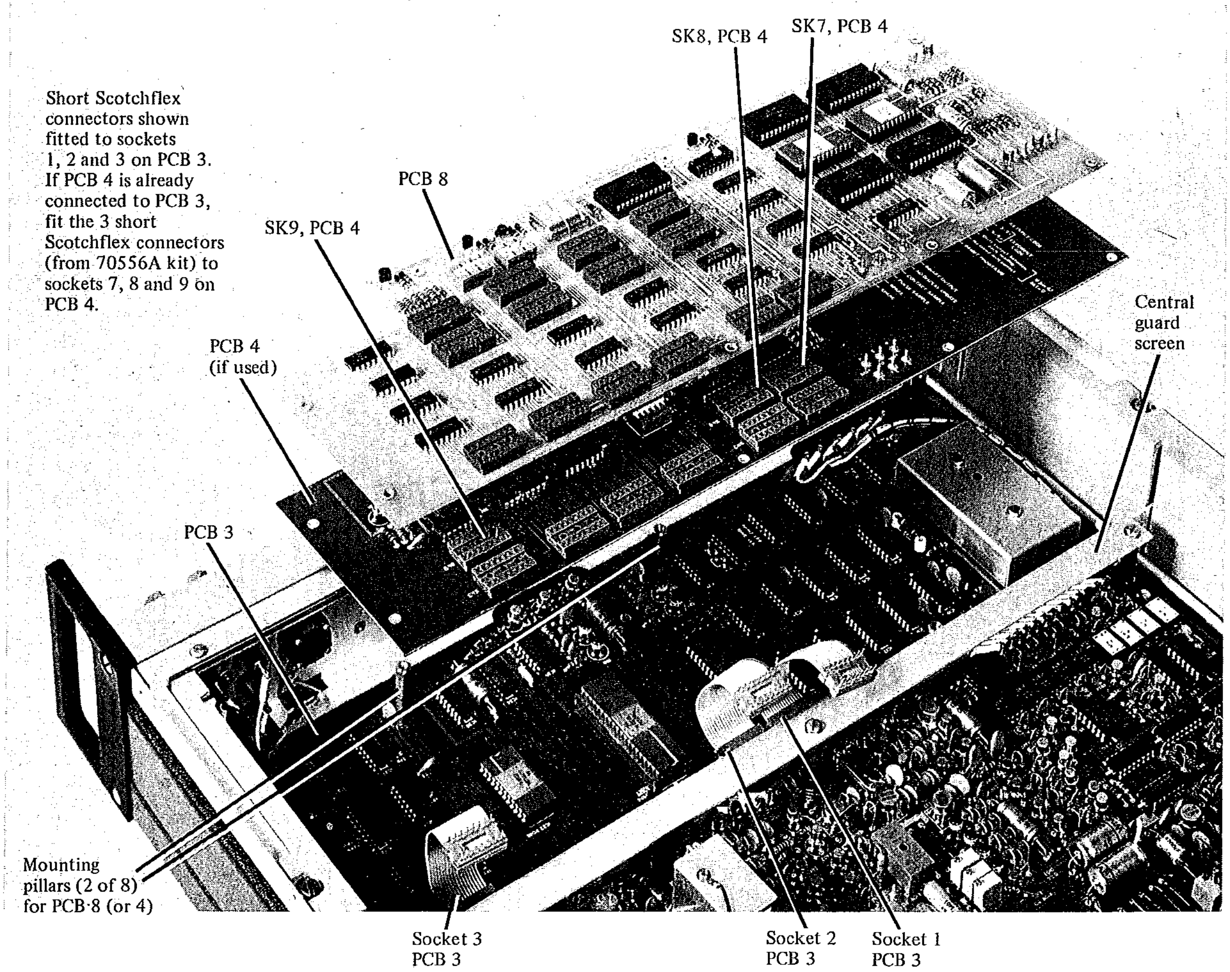


Fig. 2 Fitting PCB 8 (and PCB 4 if required) to the instrument

4. If pcb 4 is fitted replace its eight securing screws with the eight 1 inch pillars from the 70556 kit.
5. Fit the 3 short Scotchflex connectors to either sockets 1, 2 and 3 on pcb 3 (such that the cables point toward the front of the instrument) or, if pcb 4 is fitted, to sockets 7, 8 and 9 on pcb 4. See Figs 2 and 4 (or 5).
6. Fit the 3 long Scotchflex connectors to the 3 sockets in pcb at rear of the instrument (Fig. 3) unless these are already fitted with pcb 4. The connectors should pass underneath the instrument and up through the slot provided in pcb 3.

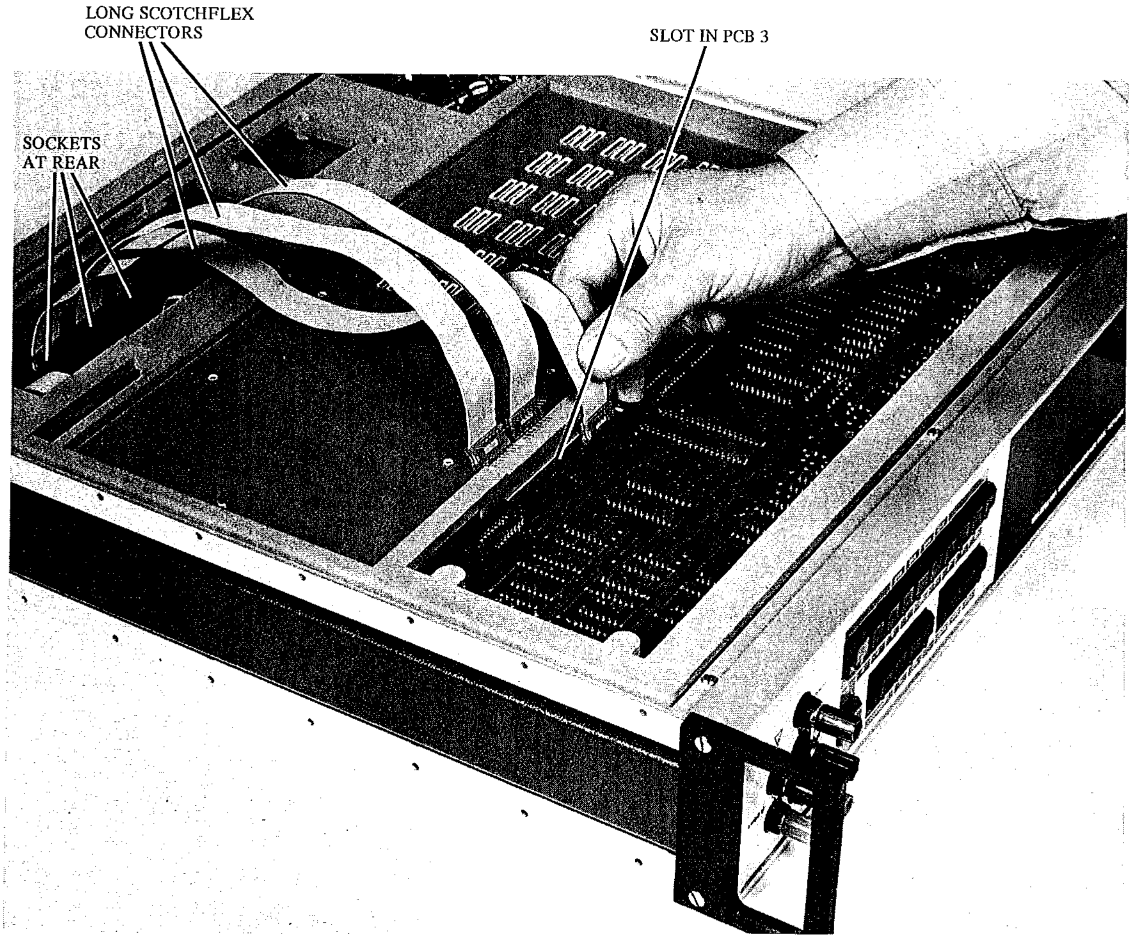


Fig. 3 Fitting the long Scotchflex connectors

7. Fit the 4 disconnect leads – red (RD), white (WH), black (BK) and green (GN) – to the +5VA, 0V, +5VB and 50Hz disconnect pins on pcb 3/4 as appropriate. If pcb 4 is not fitted see Fig. 4, otherwise see Fig. 5.

8. Locate pcb 8 in position (above pcb 3 or 4, on the eight pillars) and use the screws and washers in 70556 kit to secure the pcb to the pillars.

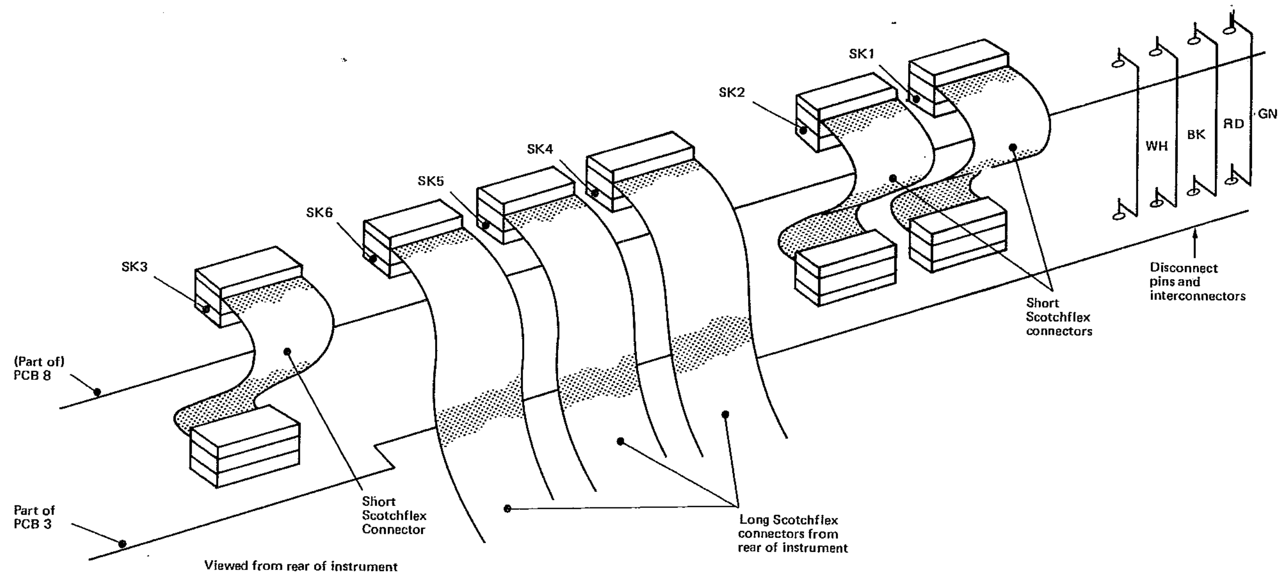


Fig. 4 Interconnections to PCB 8 (if PCB 4 not fitted)

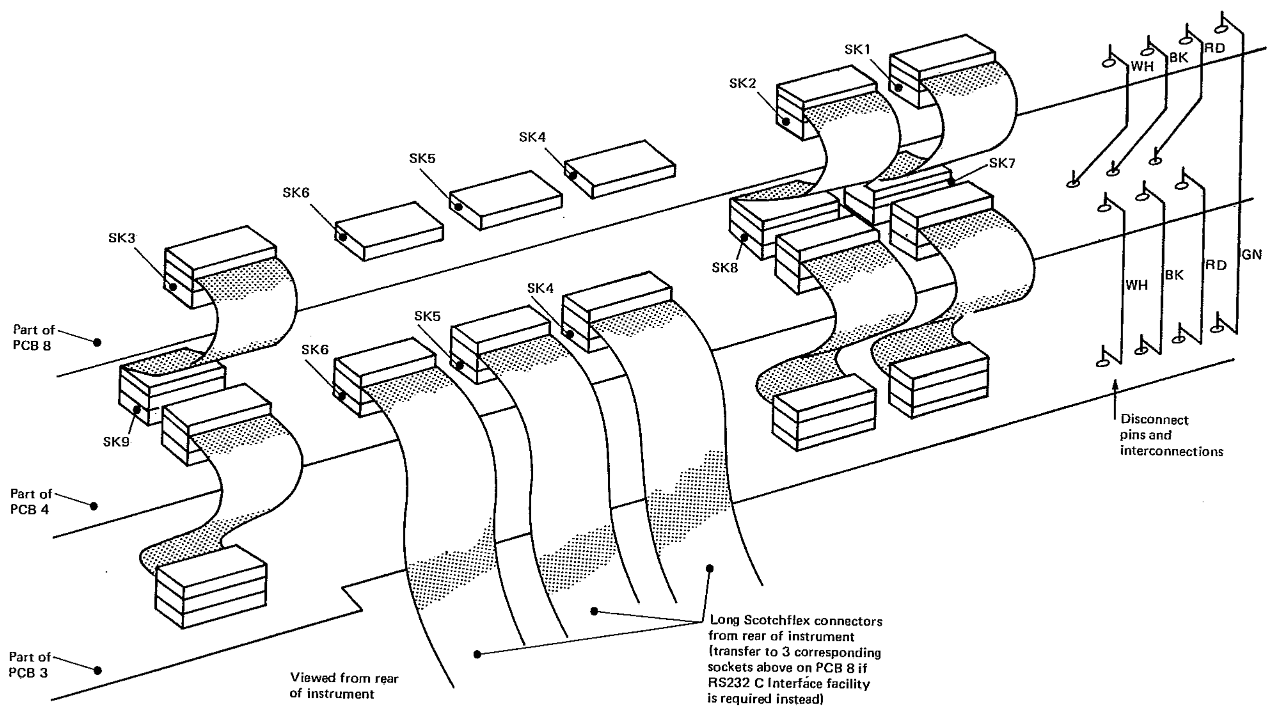


Fig. 5 Interconnections to PCB 8 (if PCB 4 fitted)

9. Connect the short Scotchflex connectors to the sockets on pcb 8 which are immediately in line with each connector (Figs. 4 and 5). Similarly connect the long Scotchflex connectors, see note below.

Note If option 70554 has been incorporated the long Scotchflex connectors are already connected to sockets 4, 5 and 6 on pcb 4, effecting the Parallel Interface capability. Pcb 8 provides both Programming and RS232 C Interfacing capabilities; the latter may be selected instead of the Parallel Interface by connecting the long Scotchflex connectors to sockets 4, 5 and 6 on pcb 8. This configuration will, of course, cause pcb 4 to become redundant.

10. Connect the disconnect leads to pcb 8 as shown in Fig. 4 or 5.

11. See Fig. 6 to verify that pcb 8 has been correctly connected.

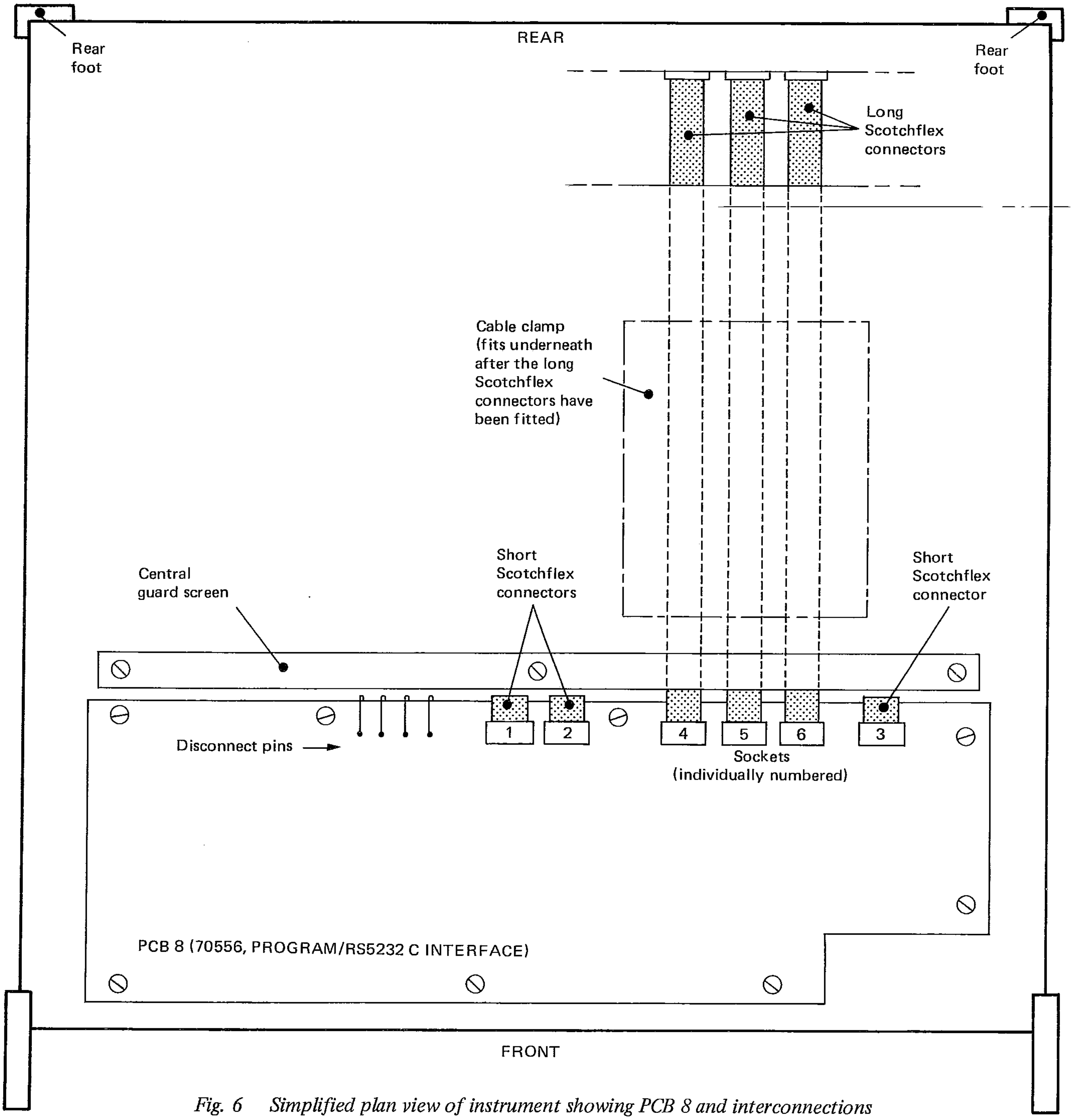


Fig. 6 Simplified plan view of instrument showing PCB 8 and interconnections

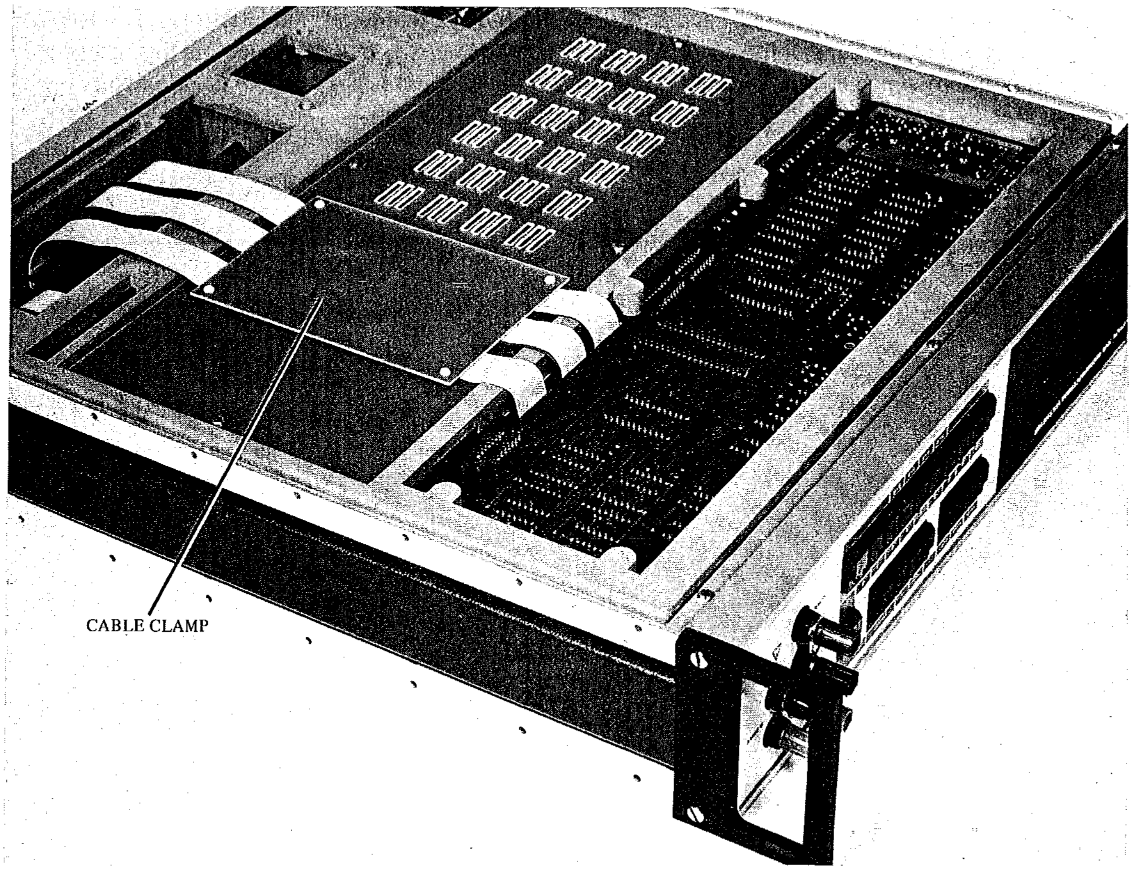


Fig. 7 Fitting the Cable Clamp

12. Fit the cable clamp to underside of instrument using the push-in securing buttons (Fig. 7).
13. Refit central guard screen.
14. Refit top and bottom covers. Tighten screws in the feet at rear of instrument.

Note If both 70554 and 70556 options are fitted to an instrument there will be 3 redundant long Scotchflex connectors.

15. Fit the 70558A assembly to rear of instrument by plugging into the socket, and fitting the securing screws in the hank bushes on rear panel.

Appendix 2
Fitting Option 70554

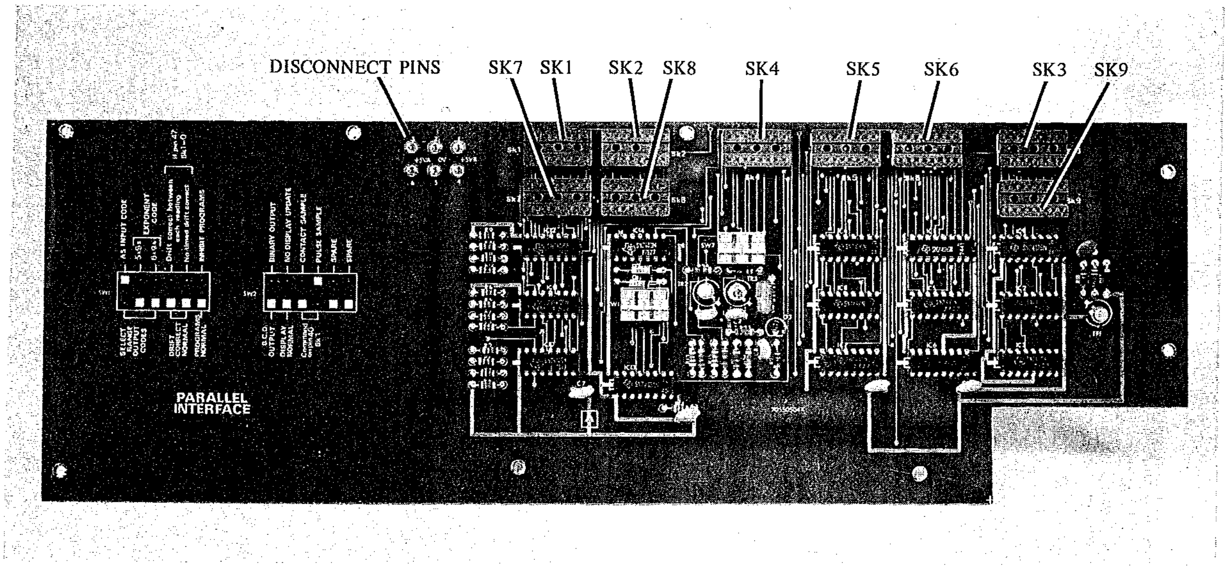


Fig. 1 PCB 70559504 (pcb 4)

The 70554 kit includes pcb 70559504 (Fig. 1), 6 Scotchflex connectors, disconnect leads, cable clamp, and mounting screws and pillars. Pcb 70559504, referred to in this procedure as 'pcb 4', is designed to mount inside the instrument near the front. Pcb 4 actually mounts directly above pcb 70559503 ('pcb 3') on the eight 1 inch pillars already present.

If pcb 70559508 (pcb 8) – one of the other optional pcb's – is already fitted, it must be removed and subsequently replaced directly above pcb 4. on eight 1 inch pillars. Removal and refitting instructions for pcb 8 are incorporated in this procedure.

1. Disconnect the mains supply from the instrument.
2. Slacken screws in the 4 feet at rear of the instrument and remove the top and bottom covers.
3. Remove the central guard screen (Fig. 2).

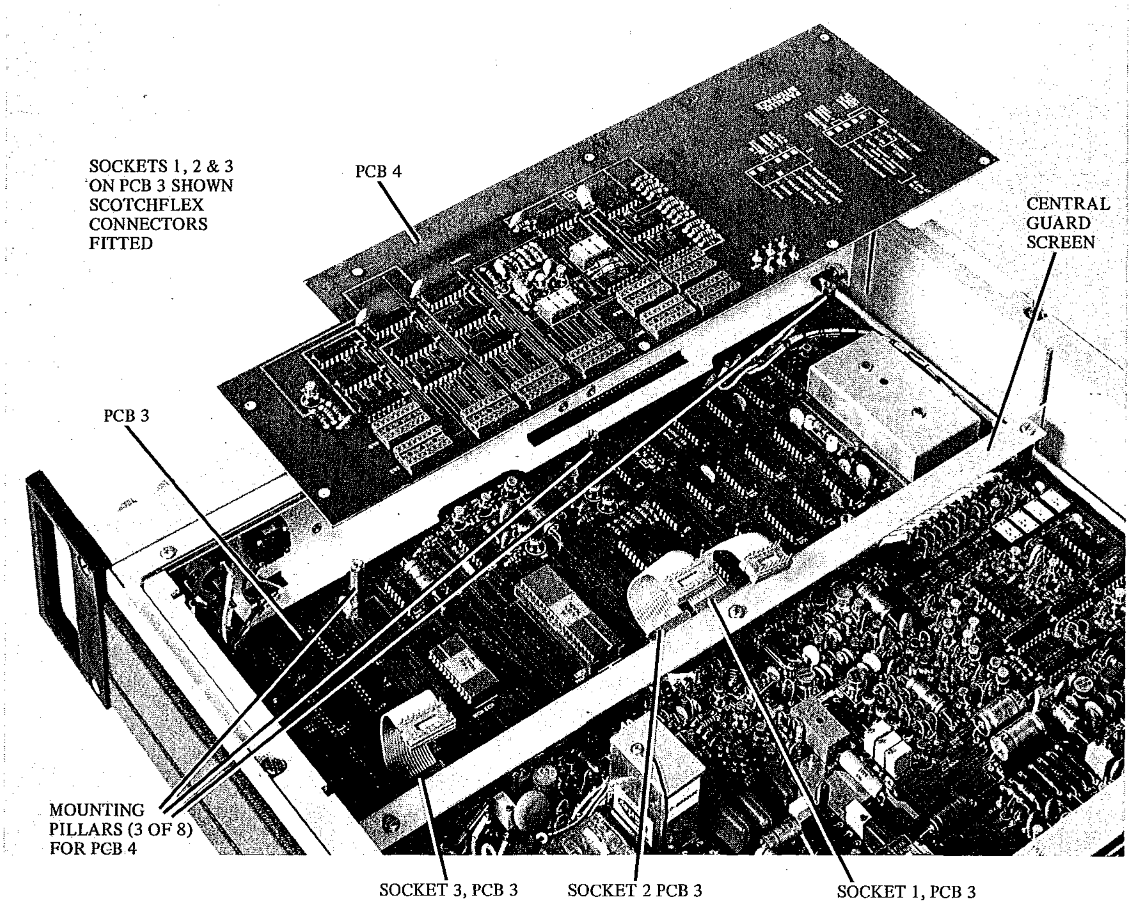


Fig. 2 Fitting PCB 4 to the instrument

4. Disconnect and remove pcb 8 (70556 Program/RS 232 Interface) if fitted. Leave the eight 1 inch pillars in position.
5. Fit the 3 short Scotchflex connectors to sockets 1, 2 and 3 on pcb 3 (Fig. 2) unless already fitted for pcb 8, such that the cables point toward the front of the instrument.
6. Fit the 3 long Scotchflex connectors to the 3 sockets in pcb at rear of the instrument (Fig. 3), unless already fitted for pcb 8. Feed these cables underneath the instrument and up through the slot provided in pcb 3.

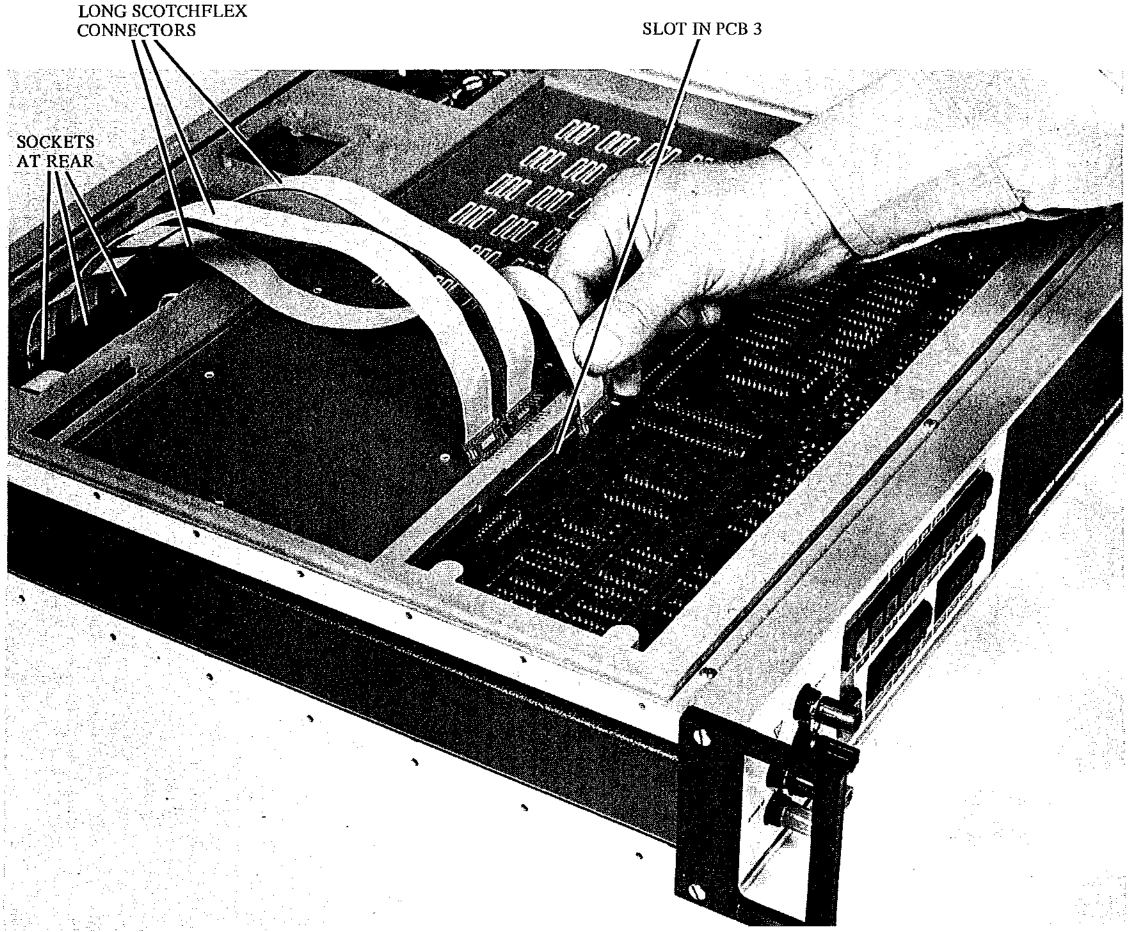


Fig. 3 Fitting the long Scotchflex connectors

7. Fit the 3 disconnect leads – red (RD), black (BK) and white (WH) – to the + 5VA, 0V and 5VB disconnect pins on pcb 3 (Fig. 4). The 50Hz pin on pcb 3 is not used.
8. Locate pcb 4 in position (above pcb 3 on the eight pillars) and use the screws and washers in 70554 kit to secure the pcb to the pillars.
9. Connect all short and long Scotchflex connectors to the sockets on pcb 4 which are immediately in line with each connector (Fig. 4).
10. Connect the 3 disconnect leads to the appropriate disconnect pins on pcb 4 (Fig. 4).

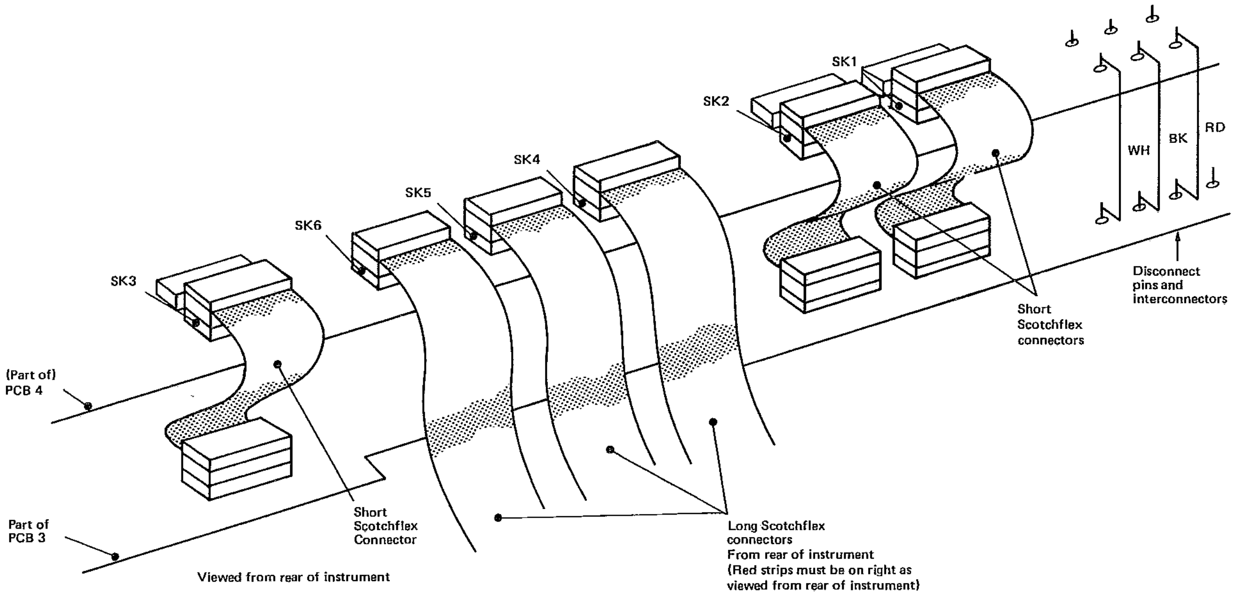


Fig. 4 PCB 4 Interconnecting leads

Pcb 4 is now fully fitted to the instrument (see Fig. 5 to verify correct interconnections). However if it is required to fit/replace pcb 8 instructions 11–17 should now be carried out. If pcb 8 is not to be fitted proceed directly to instruction 18.

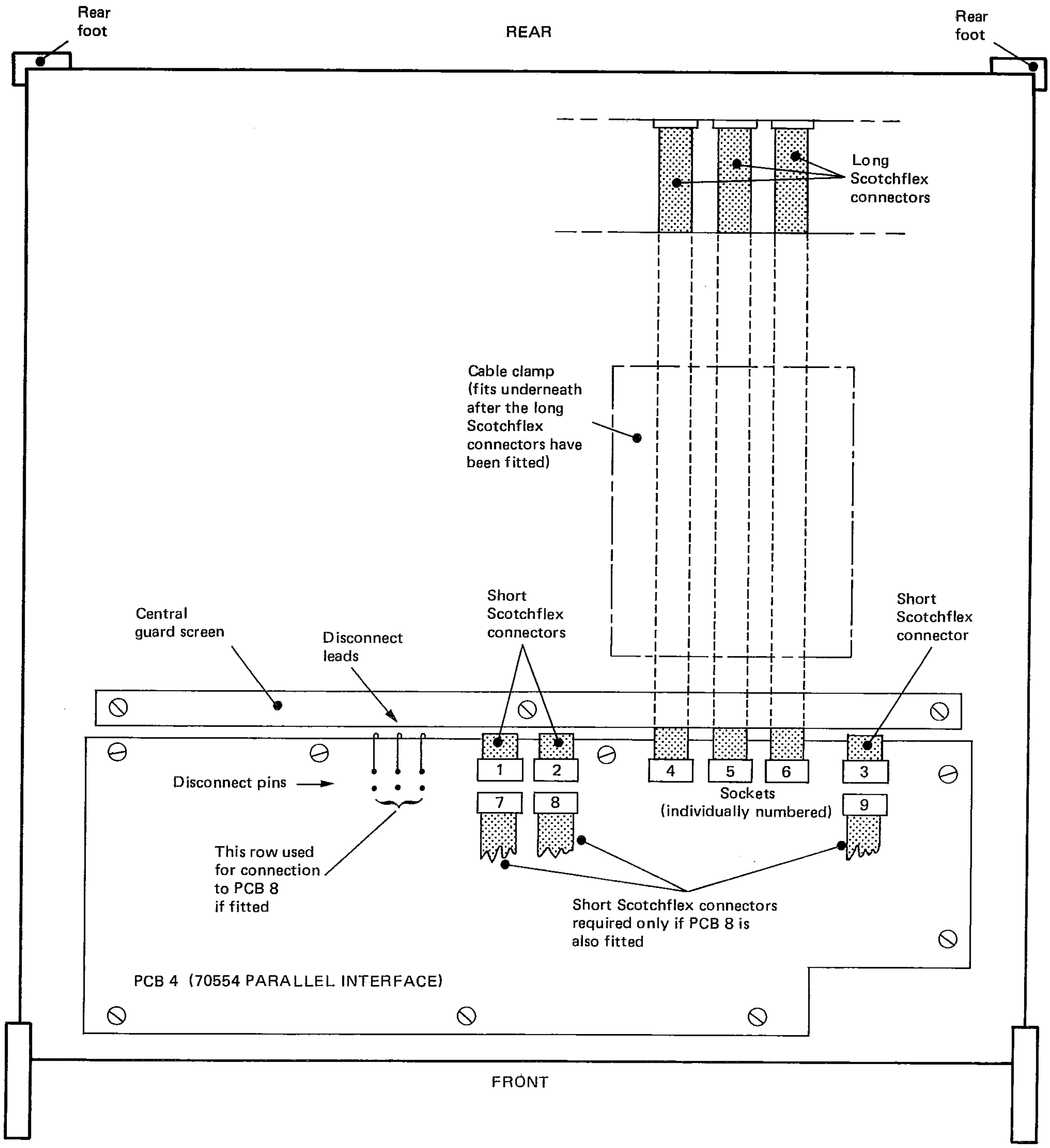


Fig. 5 Simplified plan view of the instrument showing PCB 4 and interconnections

11. Pcb 8, when fitted with pcb 4, mounts above pcb 4 on eight 1 inch pillars. The interconnecting leads and screws, pillars etc. supplied in the 70556 kit should be used for fitting pcb 8.

12. Replace the 8 screws securing pcb 4 with the eight 1 inch pillars.

13. Fit the 3 short Scotchflex connectors to sockets 7, 8 and 9 on pcb 4. (Figs. 5 and 6) such that the cables point toward the front of the instrument.

14. Fit the 4 disconnect leads to pcb 3 and 4 (Fig. 6); red (RD), black (BK) and white (WH) leads to the (inner) + 5VA, 0V and + 5VB disconnect pins on pcb 4 and the green (GN) lead to the 50Hz disconnect pin on pcb 3.

15. Locate pcb 8 in position (above pcb 4, on the eight pillars) and use the screws and washers to secure the pcb to the pillars.

16. Fit the 3 short Scotchflex connectors (from pcb 4) to sockets 1, 2 and 3 on pcb 8 (Fig. 6).

17. Connect all disconnect leads as shown in Fig. 6.

Note The earlier connection of the 3 long Scotchflex connectors to pcb 4 (instruction 9) provides the Parallel Interface capability. If it is desired to effect the RS232C Interface capability instead, then the 3 long Scotchflex connectors should be transferred to the corresponding sockets on pcb 8 (Fig. 6). This configuration however, causes pcb 4 to become redundant.

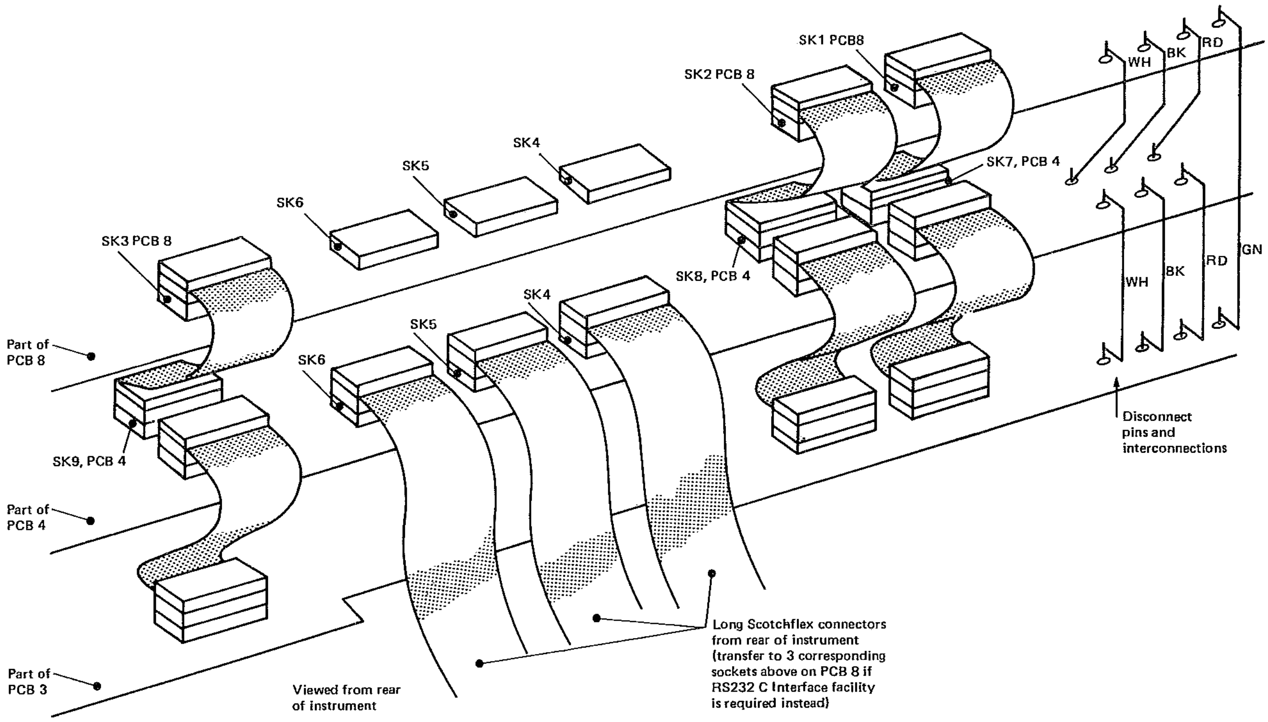


Fig. 6 Connecting PCB 8

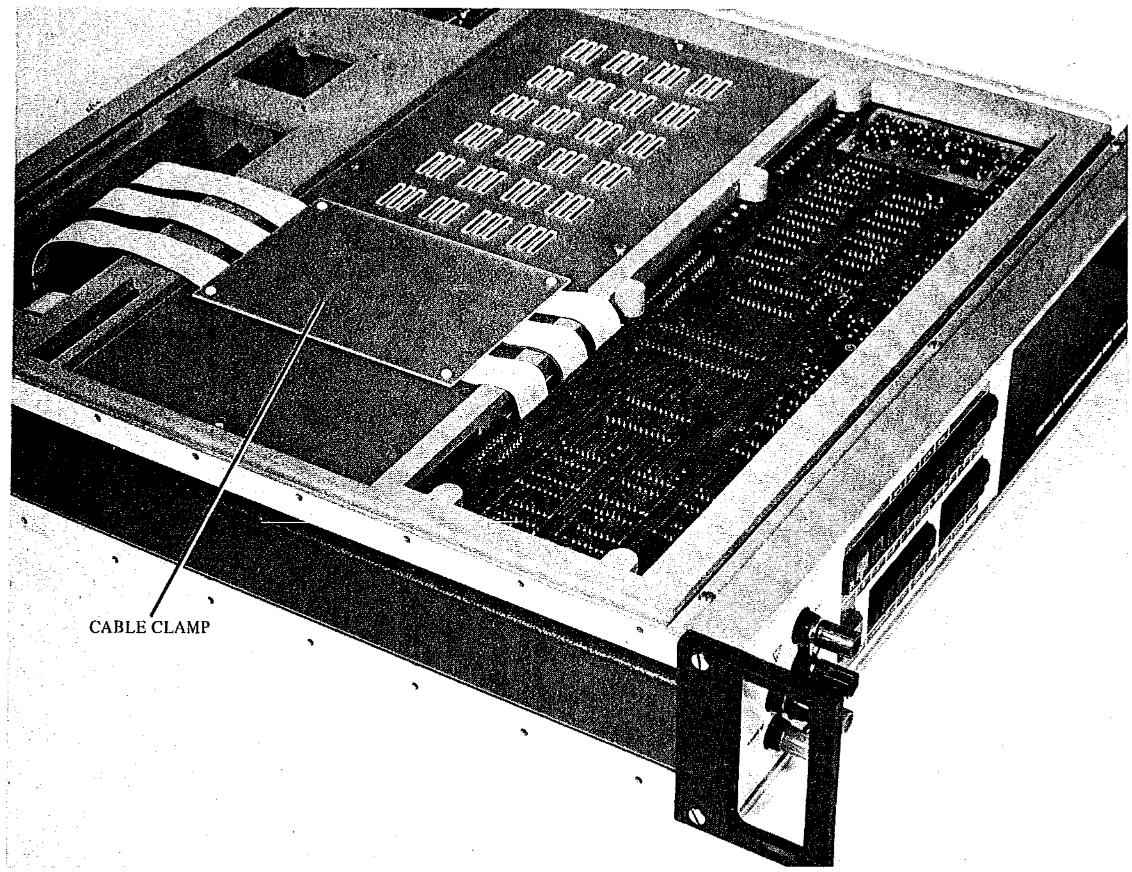


Fig. 7 Fitting the Cable Clamp

18. Fit the cable clamp to underside of the instrument using the push-in securing buttons (Fig. 7).
19. Refit central guard screen.
20. Refit top and bottom covers. Tighten screws in rear feet.

Note If both 70554 and 70556 options are fitted to an instrument there will be 3 redundant long Scotchflex connectors.

Appendix 3
Fitting Option 70555

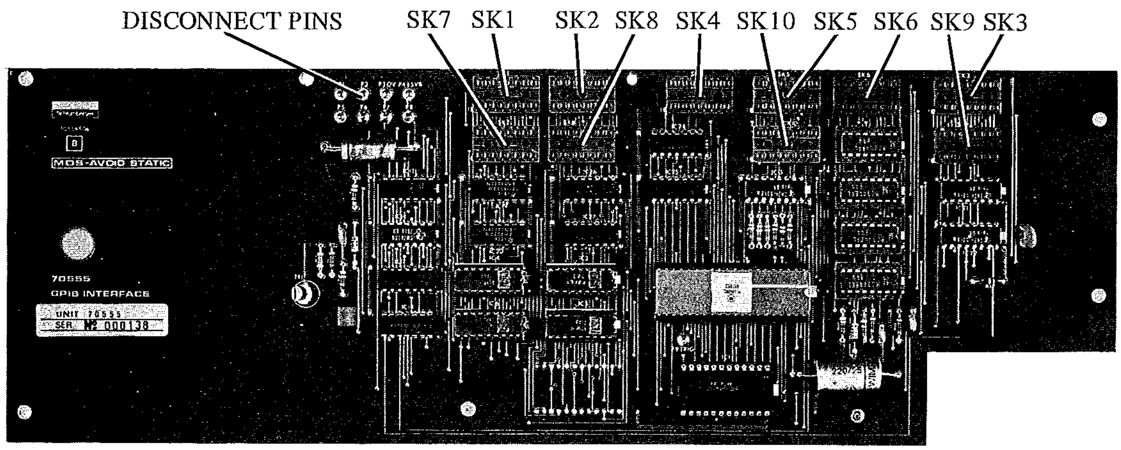


Fig. 1   PCB 70559506 (pcb 6)

Throughout the following description, the following pcb's; 70559503, 70559504, 70559506 and 70559508 are referred to as pcb's 3, 4, 6 and 8 respectively.

The 70555 kit includes pcb 6 (Fig. 1), the Interface Adapter (70558D), 7 Scotchflex connectors, disconnect leads, cable clamp, mounting screws and pillars.

The instrument may already be fitted with additional pcb's 4, or 4 and 8 – associated with the other two options. These should first be removed prior to fitting pcb 6; pcb 8 can then be re-fitted. It may not be necessary to use all of the Scotchflex connectors supplied with the kit – this will depend on the options already in use.

In the following procedure it is assumed that pcb 8 (Programming Option 70556) is to be included with the fitting of pcb 6; Fig. 4 shows the relevant electrical interconnections. The procedure is similar if pcb 8 is not fitted, although in this case, the electrical connections are different and reference should be made to Fig. 5 rather than Fig. 4.

1. Disconnect mains supply from the instrument.

2. Slacken the screws in the four feet at the rear of the instrument and remove top and bottom covers.

3. Remove central guard screen. (Fig. 2.)

4. After disconnecting the Scotchflex connectors and disconnect leads, remove pcb 8.

Note: pcb 4 if fitted, can be taken out in a similar manner once the eight support pillars are removed.

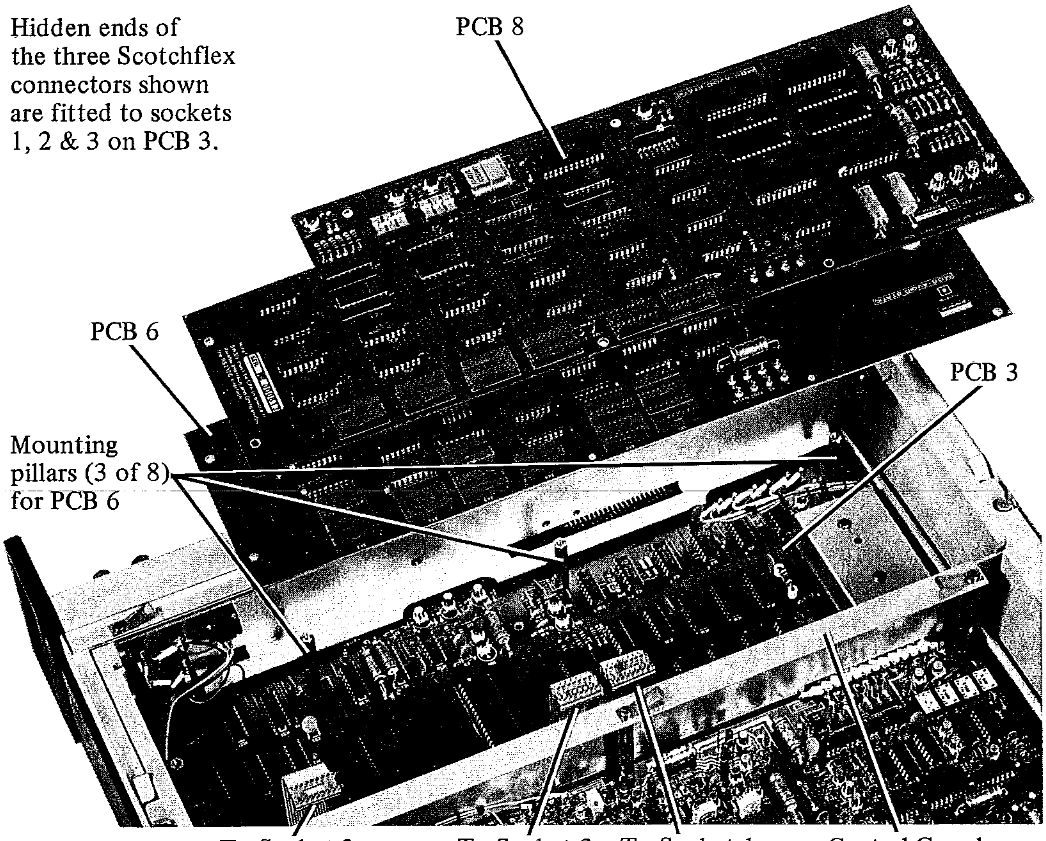


Fig. 2 Fitting PCB 6 (and PCB 8) to the instrument

5. Before locating pcb 6 above pcb 3, make the electrical connections to pcb 3 as shown in Fig. 4. (Note that the short Scotchflex connectors point towards the front of the instrument).

6. Secure pcb 6 using the 8 support pillars and complete the interconnections between pcb's 3 and 6.

7. Make the remaining electrical connections to pcb 6 (Fig. 4) before locating pcb 8.

8. Locate pcb 8 over the 8 support pillars and secure using the screws and washers supplied.

9. Make the electrical connections to pcb 8 as indicated (Fig. 4).

10. Connect the other ends of the long Scotchflex connectors to the sockets inside the instrument at the rear. (These pass through the recess in pcb 3, underneath the instrument, and are correctly aligned with their respective sockets – see Fig. 3.)

11. Fit the cable clamp to the underside of the instrument using the push-in buttons (Fig. 6).

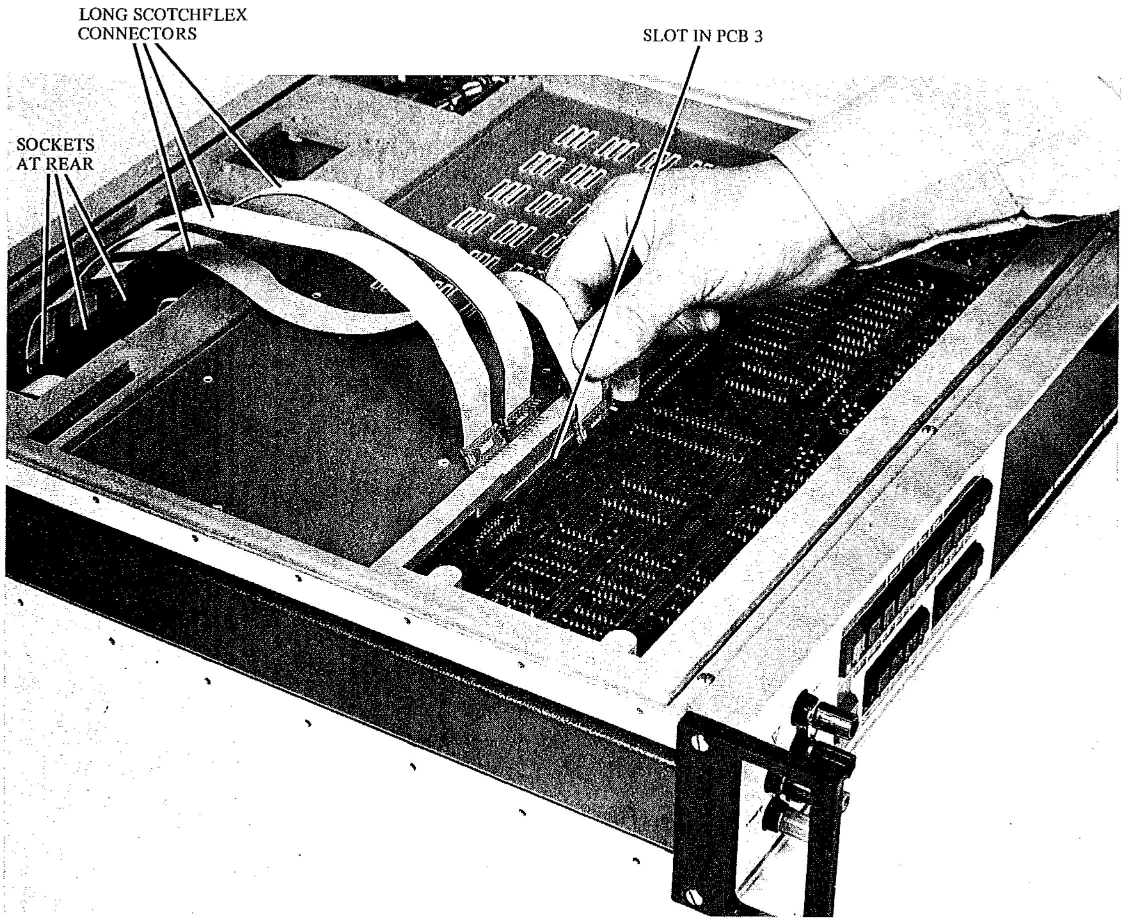


Fig. 3 Fitting the long Scotchflex connectors

12. Refit central guard screen.

13. See Fig. 6 to verify that the pcb has been connected correctly.

14. Refit top and bottom covers.

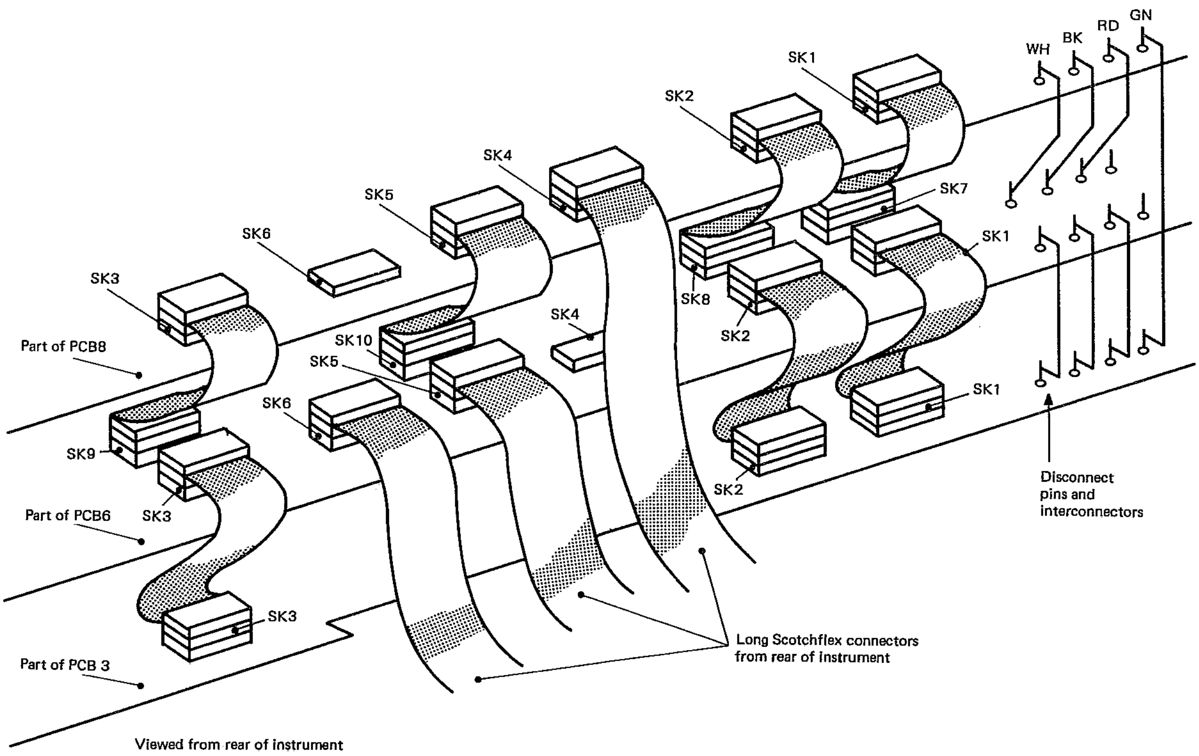


Fig. 4 Interconnections to PCB 6 and PCB 8

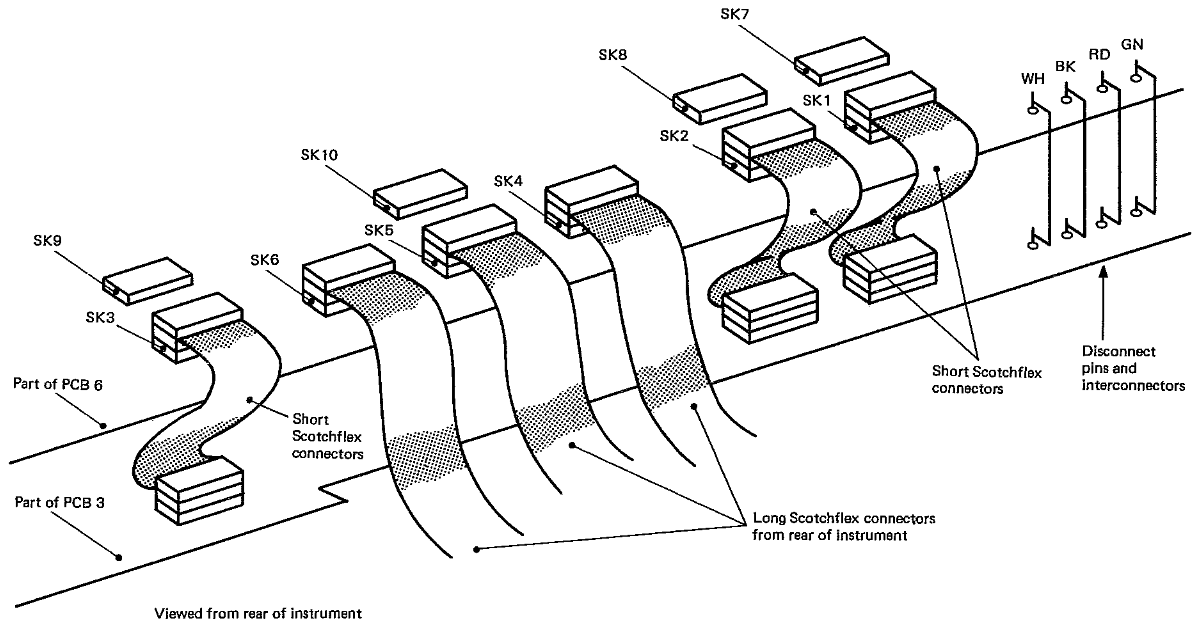


Fig. 5 Interconnections to PCB 6 if PCB 8 not fitted

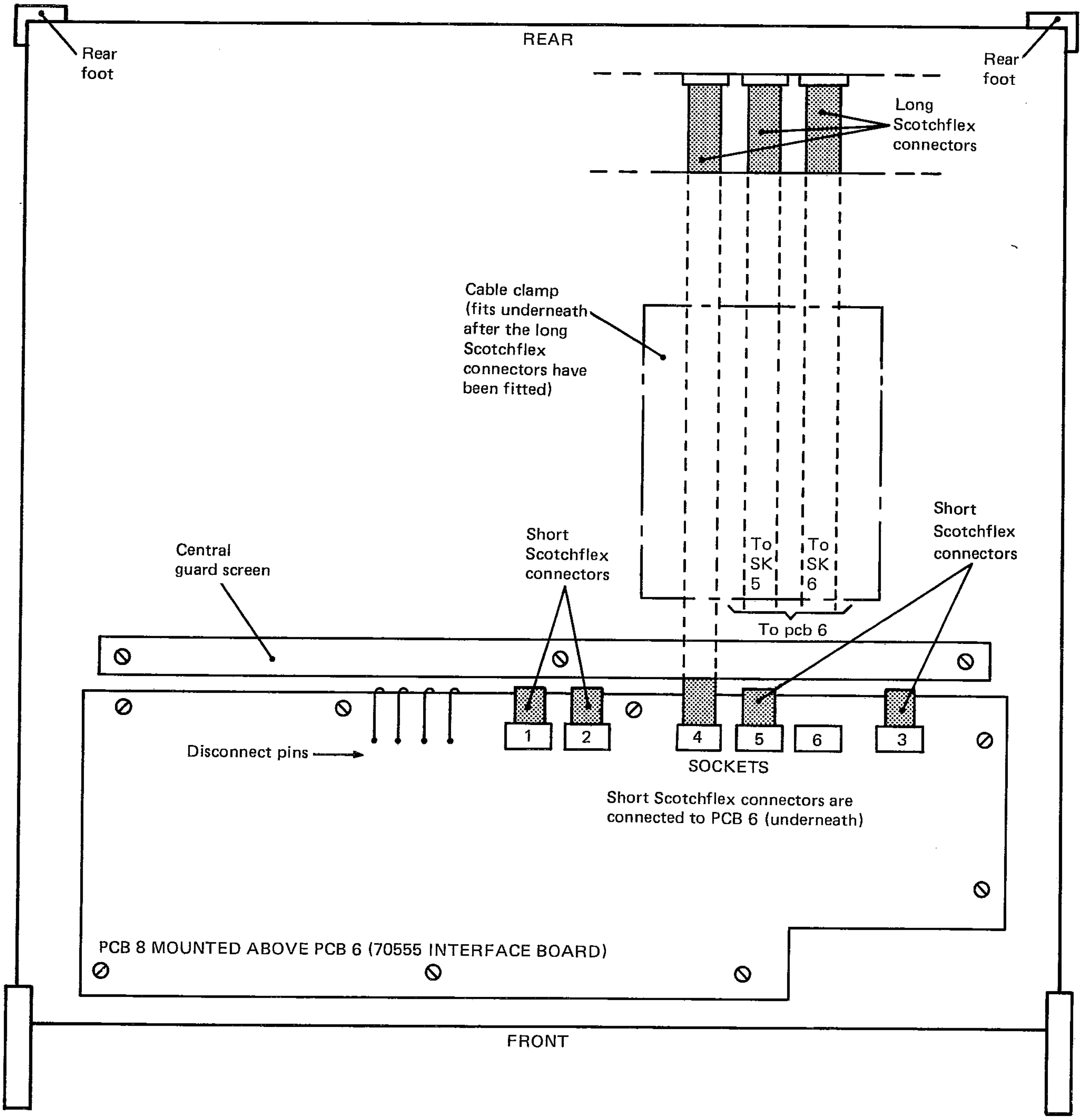


Fig. 6 Simplified plan view of instrument showing interconnections to PCB's 6 and 8

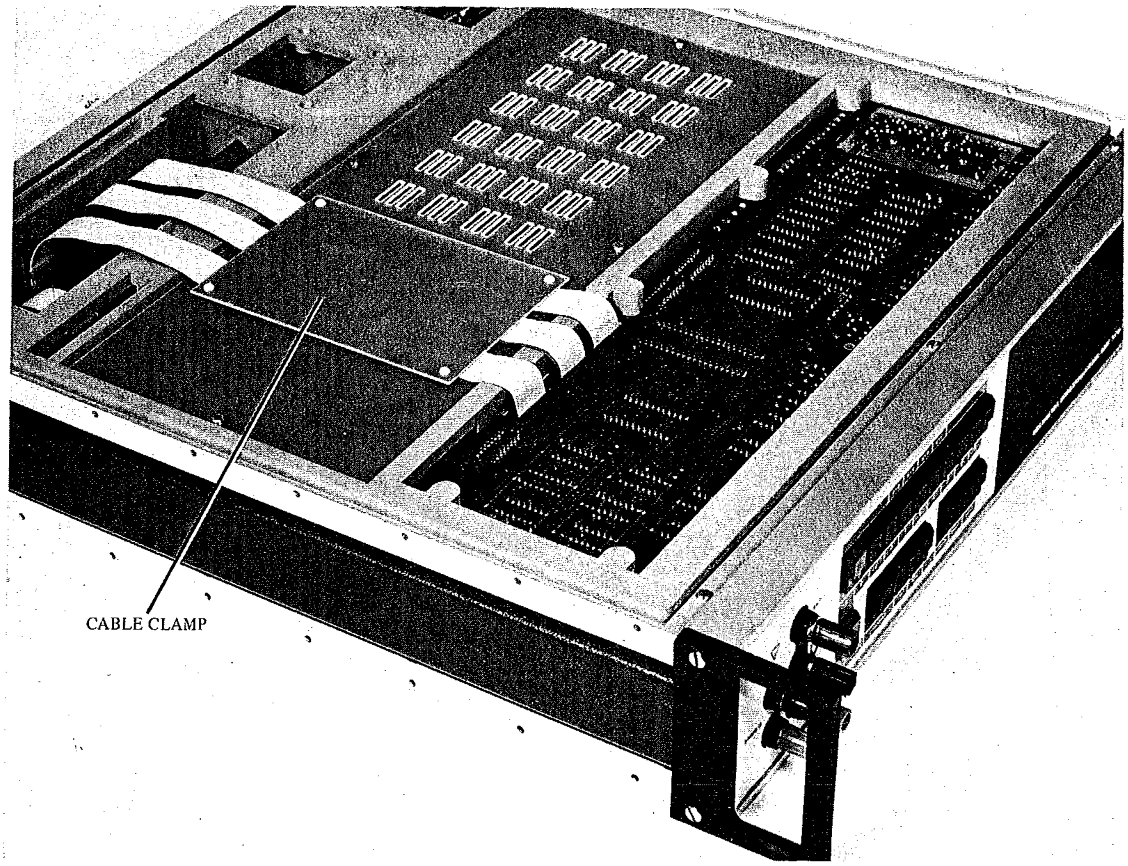


Fig. 7 Fitting the Cable Clamp

Microprocessor Voltmeters 7065 and 7055

Part 4

Contents of Part 4

Section 1
Introduction

This part of the manual contains Technical Information and is written primarily to meet the needs of the Service engineer. A detailed treatment of the principles of operation is not included but the descriptive text accompanying each circuit diagram is sufficient to enable the reader to understand the purpose of the circuit and its effect on its input(s). To facilitate fault diagnosis attention is drawn to peculiarities of circuits, together with any precautions necessary when carrying out checks.

PRESENTATION OF INFORMATION

The circuit diagrams are arranged to fold out clear to the right, the functional description appearing on the facing left hand page. Similarly the pcb layout and notation diagrams will fold out clear to the left, where possible arranged to immediately precede the relevant text. Hence immediate cross reference can be made between the circuit and the component layout diagram.

Signal paths are indicated by bold lines, arrows being used where necessary to indicate the direction of functional flow. In general this is from left to right, feedback paths flowing from right to left. To prevent ambiguity however and where space is limited, this convention has not been followed rigidly.

COMPONENT IDENTIFICATION

In addition to the pcb layout diagrams, line drawings and/or clear photographs are reproduced in the manual to facilitate rapid identification of components during diagnostic checks.

The component numbers on each diagram are particular to that pcb only – thus each board will have, for example, an R1. Identification is by reference to the Parts List which accompanies each circuit diagram.

On two major circuit boards the component numbering has been coded, a prefix digit being used to differentiate between components of the several functions carried on those boards. Thus R201 indicates R1 in the circuit coded '2'. (This is explained in greater detail in the circuit descriptions which follow this Section).

POWER RAILS

These are represented by short, detached bars annotated to show the nominal voltage. Several separate bars, annotated with the same voltage, may appear on a diagram. These of course are electrically connected to a common rail derived from the Power Supply circuits.

Zero volts may be either Supply OV or one of six separate Signal OV lines. Signal 'earth' rails are annotated Sig OV1 to Sig OV6, these being commoned at a star point. They should not be joined at any time during servicing.

Note that voltages specified on the circuit diagrams are in all cases nominal values, the actual value being dependent upon the load offered to the supply by the specific circuit. Inconsistencies between actual measured values and those quoted should not, therefore, be regarded with suspicion without considering other symptoms of possible unserviceability.

ELECTRICAL CONNECTIONS

Scotchflex ribbon connectors are generally used for pcb interconnections, though in some instances Berg-type pins/sockets have been used where pcb's are mounted in the same vertical plane. The latter are marked 'B'' followed by a number.

It is important to ensure correct mating of all inter-board connections after any servicing operation.

SPLIT PADS

These are used to provide a means of isolating various parts of the circuit for fault diagnosis and, in some instances, to permit alteration of circuit parameters for a particular operating need. They are simply bridged with solder, open circuit being effected by removing the solder. It should be noted that excessive heat applied during this operation could damage the solder track – a small, low wattage iron should be used.

TEST POINTS

A further aid to rapid circuit check-out is the provision of test pins. These are indicated on the circuit diagrams and clearly marked on the pcb's

CAUTION FLOATING CIRCUITS

As much of the instrument's electronic circuitry is floating with respect to Supply Earth, it is recommended that an isolating transformer is used for all servicing work within this voltmeter.

PRINCIPLES OF OPERATION

The 7065 employs an A/D Converter which converts the input voltage to a time analogue, which in turn is split into discrete, equal length time units. These are counted and the result displayed as a numerical indication of the measured quantity.

The V to t converter produces a pulse train, the pulse width being variable and proportional to the magnitude of the input signal. The pulses gate the output of a fixed frequency clock into a counter, over a time period which can be selected by the user. At the end of the time period the total accumulated in the counter is a measure of the input during that time. An averaging (integrating) technique is used whereby the total count is divided by the number of gating pulses used. The average thus obtained is displayed as a direct reading of the measured quantity.

Statistically, the larger the sample the truer will be the average. This reasoning has been applied to the 7065, in that the integration time (the measurement period) can be varied by the user. At a fast reading rate the measurement period is very short and the average obtained is correct to, say 3 significant figures. Increasing the measurement period provides a much truer average, the resolution being increased to much smaller divisions.

Since the total count is much larger when operating at the longer integration times, the counter requires more capacity. This results in an increase in scale length and it follows that the display sensitivity is improved hand-in-hand with the increased measurement resolution. Counting is divided between the three reversible hardware counters and a software (or perhaps "firmware") counting routine. The hardware counters measure the length of one pair of pulses from the A/D converter.

FUNCTIONAL DESCRIPTION

7065 can conveniently be regarded as consisting of four major functional sub-divisions. Reference to the Block Diagram (DIAG. 1.0) will identify these as:

1. The SIGNAL CONDITIONING section.
2. The A/D CONVERTER
3. The DIGITAL section.
4. The POWER SUPPLY.

Considering the overall functioning of the instrument, an input is processed by the Signal Conditioning circuits which convert all measured quantities into a dc voltage, scaled to a level suitable for further processing. Input protection, reference and guard circuits are included in this sub-section.

The correctly scaled dc signal is converted to a train of digital pulses by the A/D Converter, these pulses being used to gate the output of a Clock circuit.

Control of the measurement conversion and timing of the control sequences by the microprocessor set are two important functions of the Digital section. It also contains the reversible counters which accumulate the gated clock pulses, and the tri-state latches which shift the counter content to the data bus under the influence of an address bus decode.

Decoded output includes analogue command signals for control of the floating circuits, transferred via optical couplers and drive currents to light the appropriate display elements and keyboard annunciators.

All necessary operating power for the analogue circuits, and logic levels for the digital circuits, are provided by the Power Supply. Also derived from this section of circuitry is the synchronising waveform for the mains locked clock.

SIGNAL CONDITIONING

Regardless of what measurement is being made the A–D Converter is only capable of handling dc volts, hence all other quantities require to be converted into a dc level. Once converted, the input signal is applied to an amplifier, the gain of which is determined by the range on which the instrument is operating. It is the output of this amplifier which is compared with the instrument's reference, both being applied to the A/D Converter.

A/D CONVERTER

The analogue input, changed to a dc voltage level and correctly scaled, is converted to digital form by a circuit which produces a pulse train; the width of the pulses is proportional to the magnitude of the input. This conversion technique is known as Voltage-to-time conversion, the method employed being a variant in which "time" is in fact the difference between two distinct time periods. It is this time differential which is used to control the number of clock pulses finally accumulated in an up/down counter in the Digital circuits.

DIGITAL SECTION

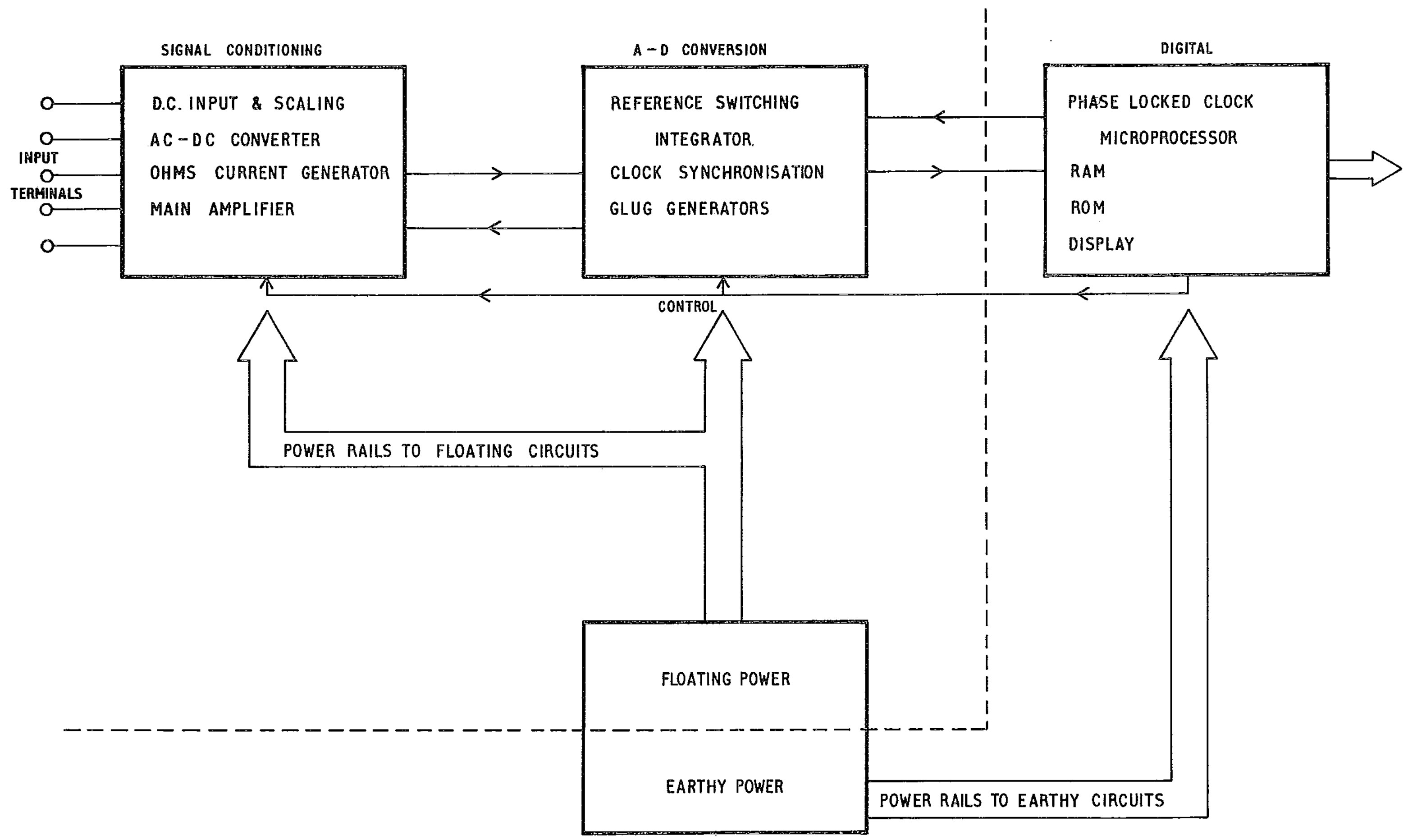
These circuits comprise the phase locked clock which produces the pulses that will be counted to digitally measure the applied input; the microprocessor clock which supplies timing and synchronising signals for the digital circuits and a microprocessor set for controlling and shifting data.

The microprocessor set consists of a Central Processor Unit (CPU), a Read Only Memory (ROM) and a Random Access Memory (RAM). The function of the CPU is to provide an interface to the ROM and RAM via the address bus and to carry out, by means of instructions held in the ROM, transfer of data to and from the RAM. The output data provides drives for the display bars, the keyboard annunciators and the analogue circuits.

POWER SUPPLY

The power supply features a switching regulator driving a 25kHz inverter to provide the main supply rails. Thus no mains transformer is used and voltage tappings are not required. A small transformer is included to provide the reference frequency for the mains locked clock.

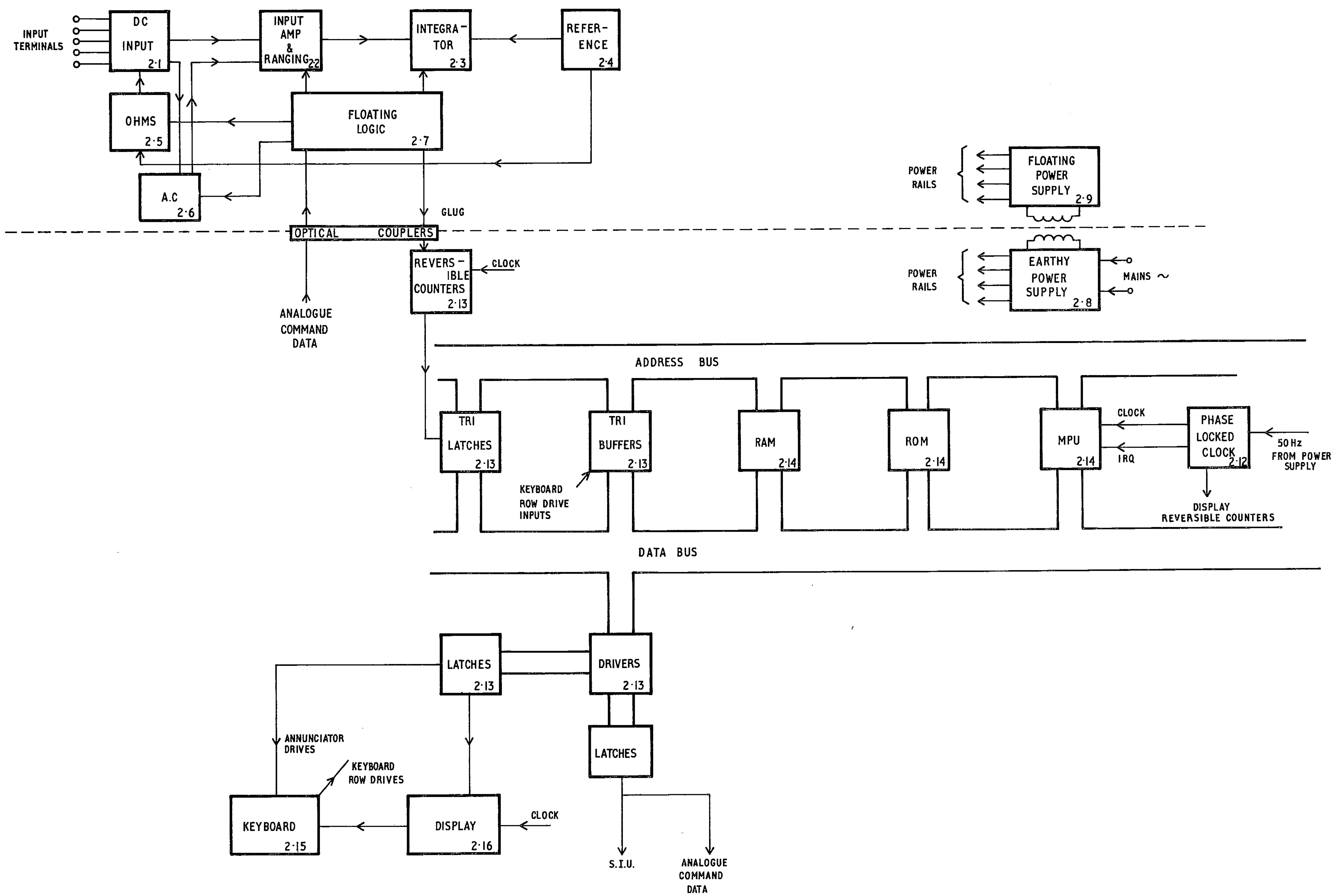
It should be noted that parts of the power supply are floating with respect to supply earth. The use of an isolating transformer is essential when carrying out checks on the floating circuits.



DIAG. 1.0 SIMPLIFIED BLOCK DIAGRAM

BLOCK SCHEMATIC DIAGRAM

The Block Schematic Diagram (Diag. 1.1) illustrates the functional layout of the instrument, the number in each block referring to the appropriate circuit diagram. The diagram can be seen to be an expansion of that in diagram 1.0 and while it's primary function is that of affording an overall appreciation of the instrument, it also provides the reader with a pictorial index to the ensuing circuit descriptions.



DIAG. 1.1 BLOCK SCHEMATIC

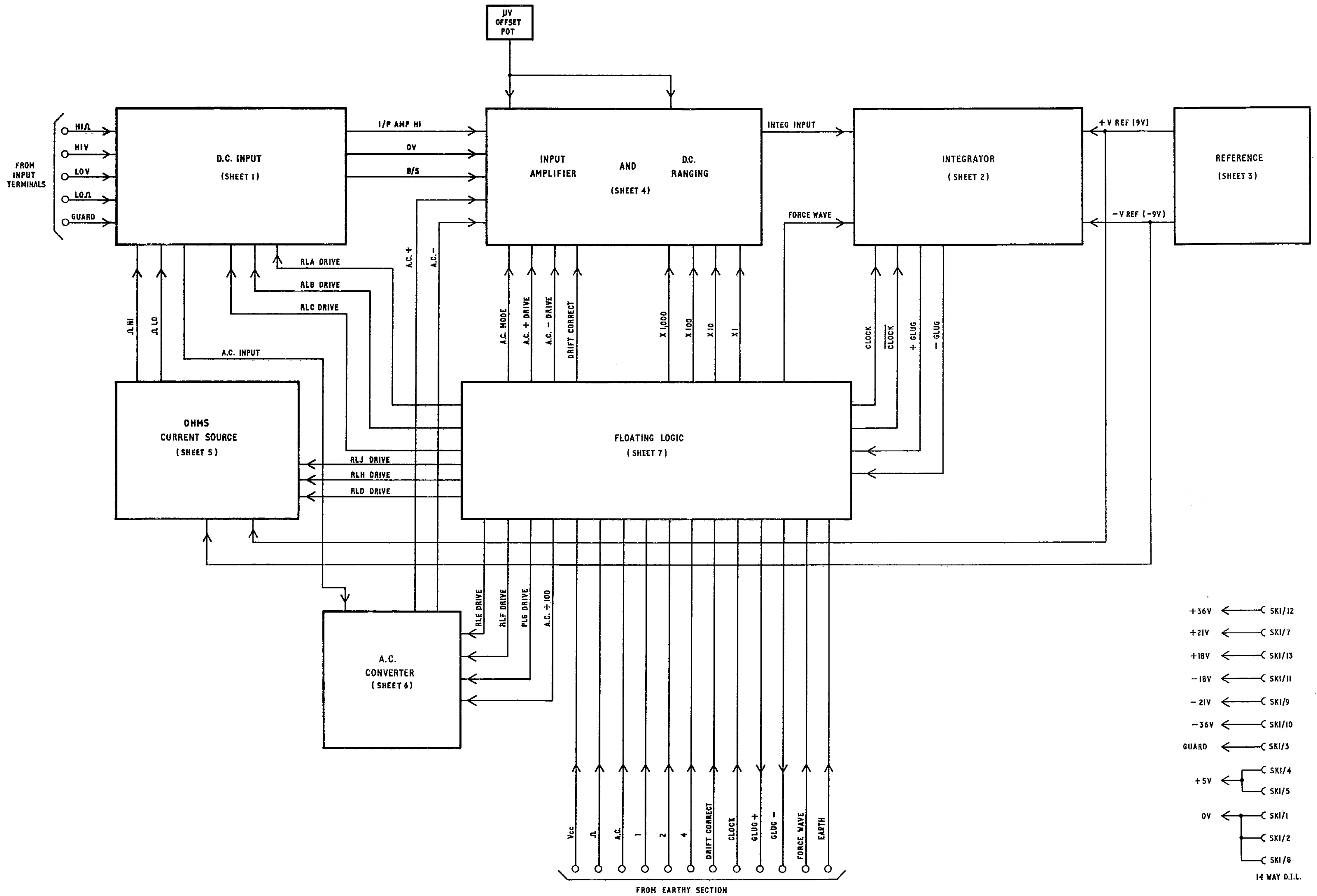
Section 2
Circuit Descriptions
Analogue & Digital

INTRODUCTION

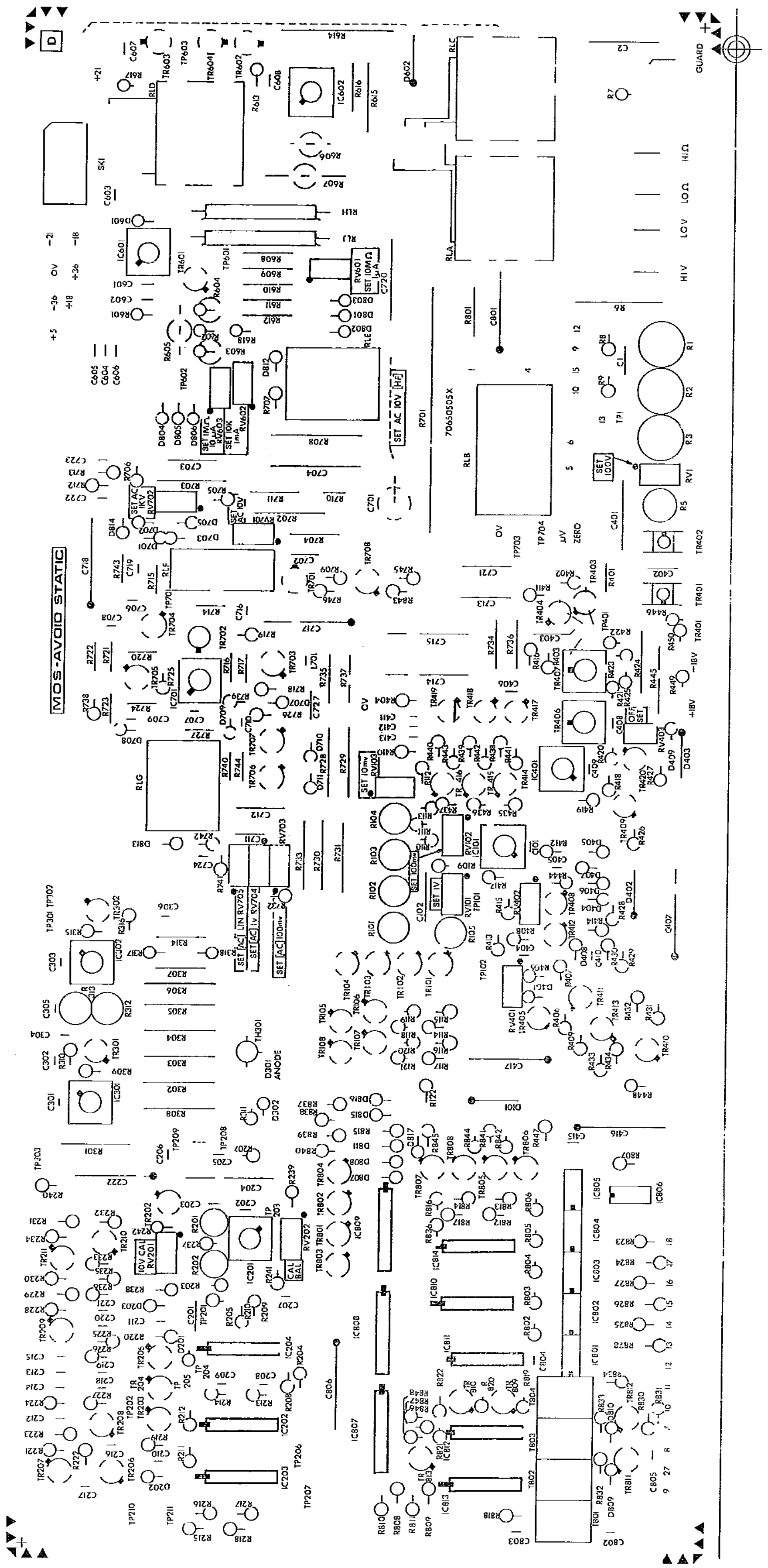
This section provides the servicing Engineer with information concerning the function of the instruments' circuits, the treatment being one of defining the effect of each circuit on the input(s) applied to it. In the main, the descriptions follow a signal path through the circuit board, diversions from the flow being examined as they become relevant to the signal. When considering the digital circuits, however, the descriptive text is concerned more with sequences and parallel logic activities. In these instances a flow treatment is inappropriate.

Diagram 2.0 illustrates in Block Schematic form 7065 board 5. The diagram also shows the circuit's interconnections, it's inputs and outputs, intercircuit signal functions and their direction of flow.

For information particular to the 7055 version of pcb 5 the user is referred to Section 3. (page 4.3.1).



DIAG. 2.0 PCB 5 INTERCONNECTIONS



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PCB 5 NOTATIONS

DC INPUT (DIAG. 2.1)

The circuits shown in diagram 2.1 contain the input attenuator and input protection for DC measurements, together with signal switching for AC and Resistance measurement.

INPUT ATTENUATOR

Resistors R1, R2, R3 and R5 form the DC Input Attenuator which is switched out of circuit by energising RLB from the output of IC808/IC811 (DIAG. 2.7).

When RLB is energised the input signal passes, without attenuation, to the "INPUT AMPLIFIER HIGH" via R6 and contacts 12 and 13 of the relay. The instrument is capable of measuring inputs of up to 14V in this condition.

When RLB is de-energised the signal path via R6 is open circuit (contacts 12 and 13 open) and R5 is connected to OV (Contacts 5 and 6 closed).

The input signal must now pass through R1, R2 and R3 which, together with R5, attenuates the signal by 100:1, adjusted by RV1 "SET 100V DC", before it is applied to the input of the amplifier. The instrument is capable of measuring inputs of up to 1000V in this condition.

C1, R4 and R5 form a spark suppression circuit for the contacts of RLB.

AC MEASUREMENT

The input signal is switched to the AC CONVERTER (DIAG. 2.6) by energising RLA via the output of IC811 (DIAG. 2.7).

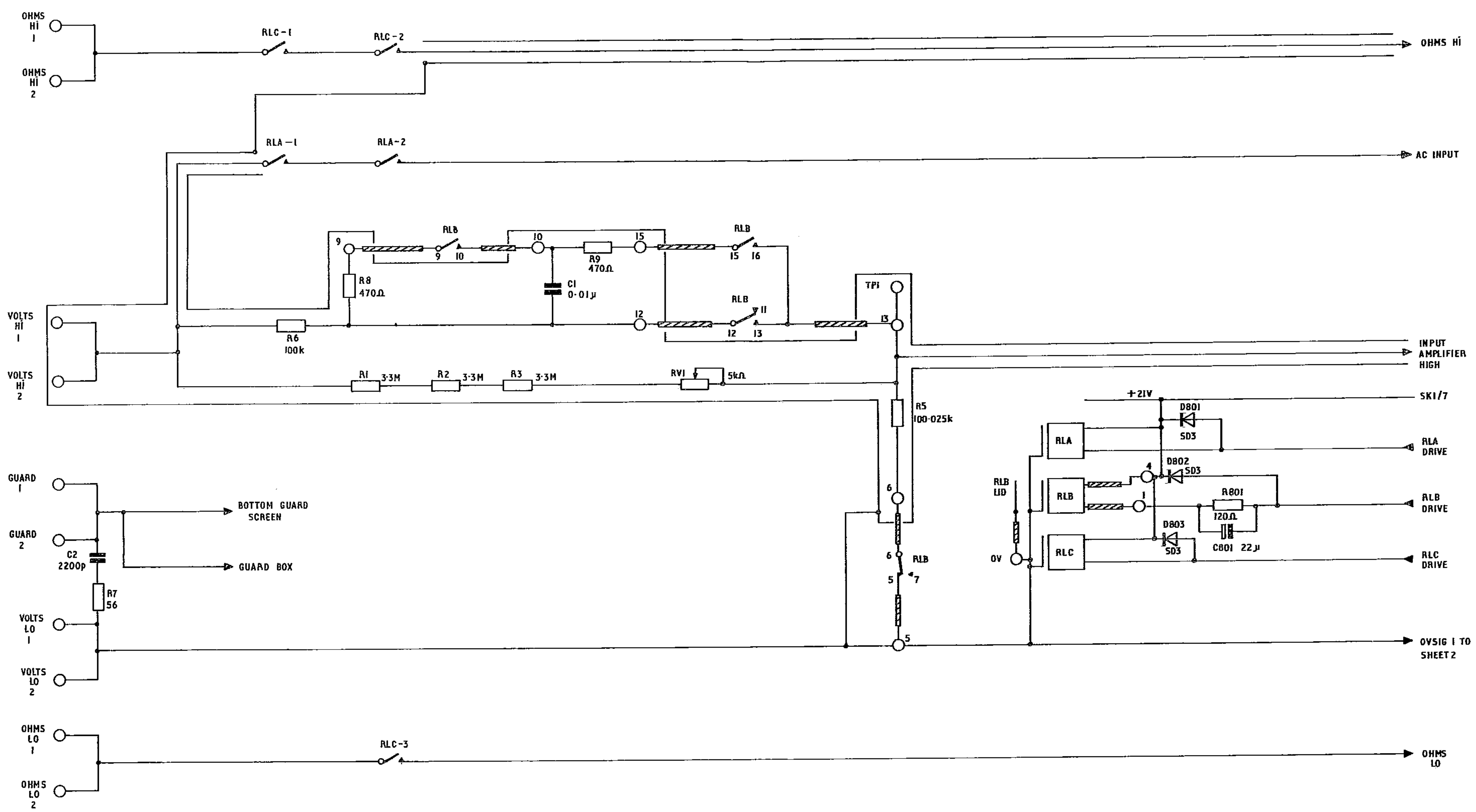
As the DC INPUT circuit is always connected to the "VOLTS Hi" input, RLB is de-energised to ensure that high AC voltages are attenuated before being applied to the "INPUT AMPLIFIER HIGH" line.

RESISTANCE MEASUREMENT

To measure resistance, a known current, generated by the "OHMS CURRENT SOURCE" (DIAG. 2.5), is switched to the HiΩ and LoΩ terminals by RLC. By making suitable external connections, the current is passed through the unknown resistor to produce a voltage between the HiV and LoV terminals which is measured by the DC circuits in the same manner as for DC measurements.

RLB is energised for all resistance ranges to ensure that the DC ATTENUATOR does not shunt the unknown resistance.

◀ *PCB 5 NOTATIONS*



DIAG. 2.1 DC INPUT

INPUT AMPLIFIER AND RANGING (DIAG. 2.2)

All input signals, after suitable conditioning, are applied to the input amplifier which, in conjunction with the DC RANGING circuit, "area" coded 1, scales the signal to a level suitable for processing by the Analogue to Digital converter. The INPUT AMPLIFIER is "area" coded 4.

INPUT PROTECTION

The voltage applied to the amplifier via the DC AMPLIFIER INPUT line is limited to approx ±20V by TR401 and TR402 thereby protecting the circuit from accidental overload. The excess voltage is dropped across the attenuator resistors if RLB is de-energised or R6 if RLB is energised.

MAIN AMPLIFIER

The main amplifier comprises a differential input stage (TR407 and TR406) followed by an operational amplifier (IC401) and a transistor output stage (TR410). TR409 and TR420 provide a current source for the differential input.

The gain of the amplifier is defined by the range resistors R101 to R104 and the operation of this circuit is explained in the DC RANGING section to follow.

Offsets in the input amplifier are initially taken out by inserting a suitable value resistor for R424, shorting out R425 (LKR) if necessary. The remaining offset is taken out by adjusting RV401 (SET OFFSET). With the amplifier offset reduced to an acceptable level, "Calibration Balance" will compensate for any further offsets.

CALIBRATION BALANCE

Calibration Balance (or Drift Correct) corrects for drifts, such as those caused by temperature variations or component aging, in the input amplifier or integrator. A Drift Correct cycle will be initiated under the following conditions:-

a) Immediately after a change of range

b) After a change of integration time

c) After a change of measurement function

d) 10 secs after the previous drift correct, controlled by a built in clock.

In DC or OHMS mode drift correct is obtained by taking a measurement with the DC and AC inputs isolated from the amplifier input (TR403, TR417 and TR418 switched off) which is then connected to OV (TR404 and TR419 switched on). This permits the system to correct for error voltages in the circuits that follow.

In AC mode the amplifier is held in drift correct (TR403 switched off and TR404 switched on), the amplifier input being isolated from OV by switching off TR419. The outputs of the AC CONVERTER (AC+ AND AC–) are alternately applied to the amplifier input, for half the measurement cycle, via TR418, TR417 and TR404. Combining a positive and negative measurement in this way achieves calibration balance for AC measurements.

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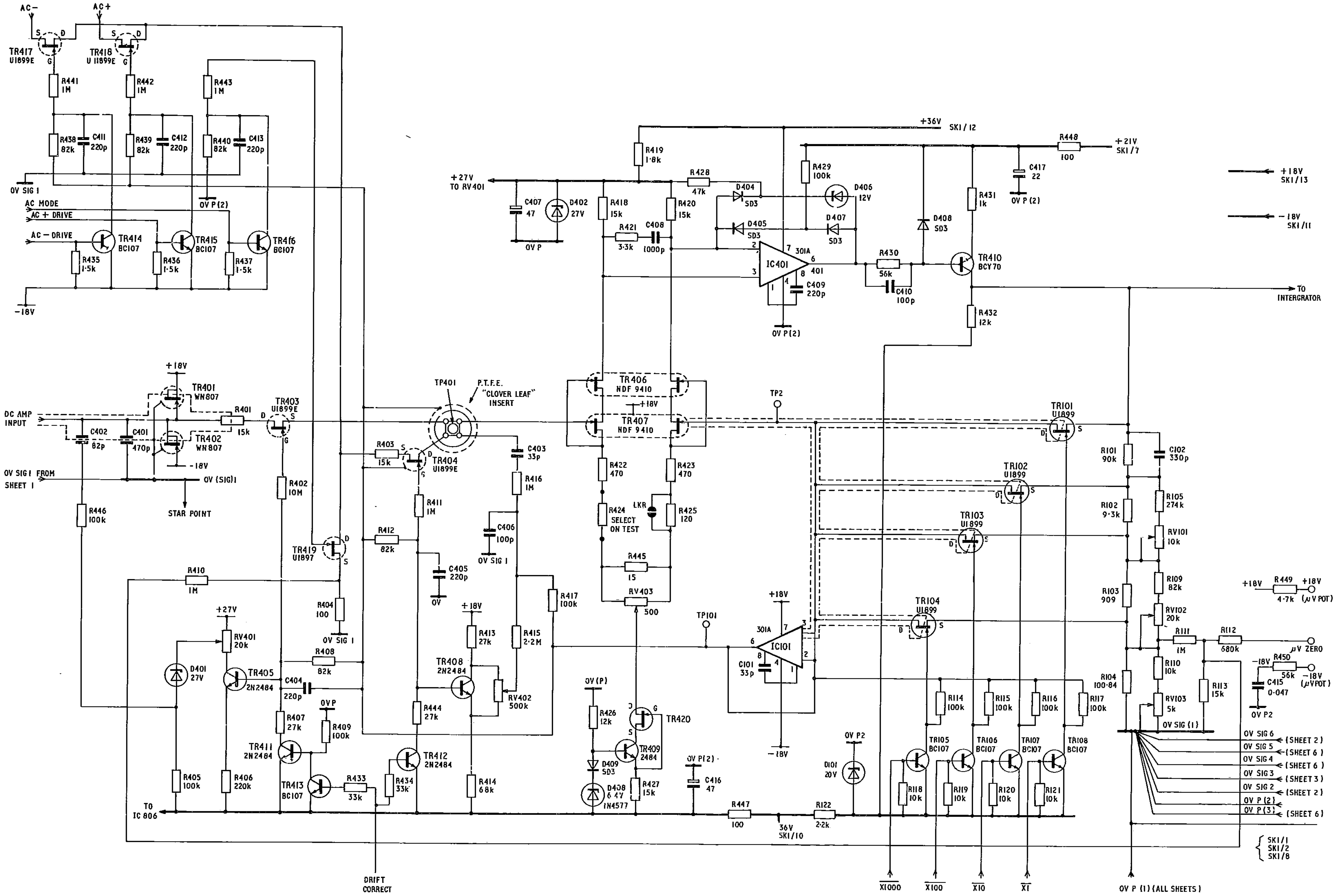


DIAG. 2.2 INPUT AMPLIFIER AND RANGING

DC RANGING

The gain of the input amplifier is controlled by a matched set of precision resistors, R101 to R104, which form the feedback network. The feedback connection, and hence the gain, is selected by one of the F.E.T. switches TR103 to TR106 which are driven from IC807 (DIAG. 2.7) via transistor level shifters (TR801 to TR804 and TR105 to TR108). The gain of the amplifier may be set to x1, x10, x100 or x1000 and is adjusted by means of RV101 to RV103.

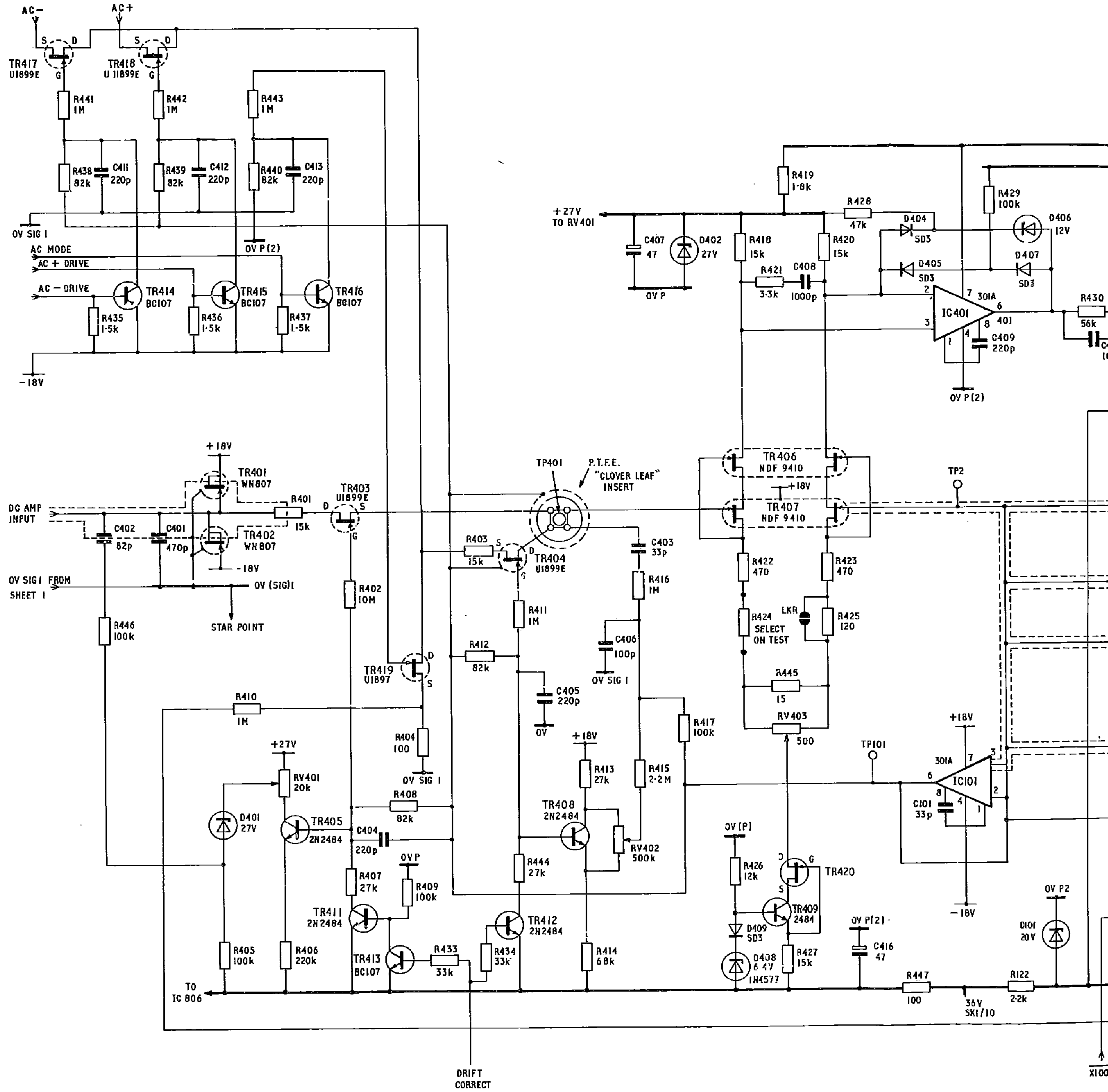
μV OFFSET

This adjustment is provided to compensate for small offsets such as thermal e.m.f's which might be generated in the circuit external to the voltmeter.

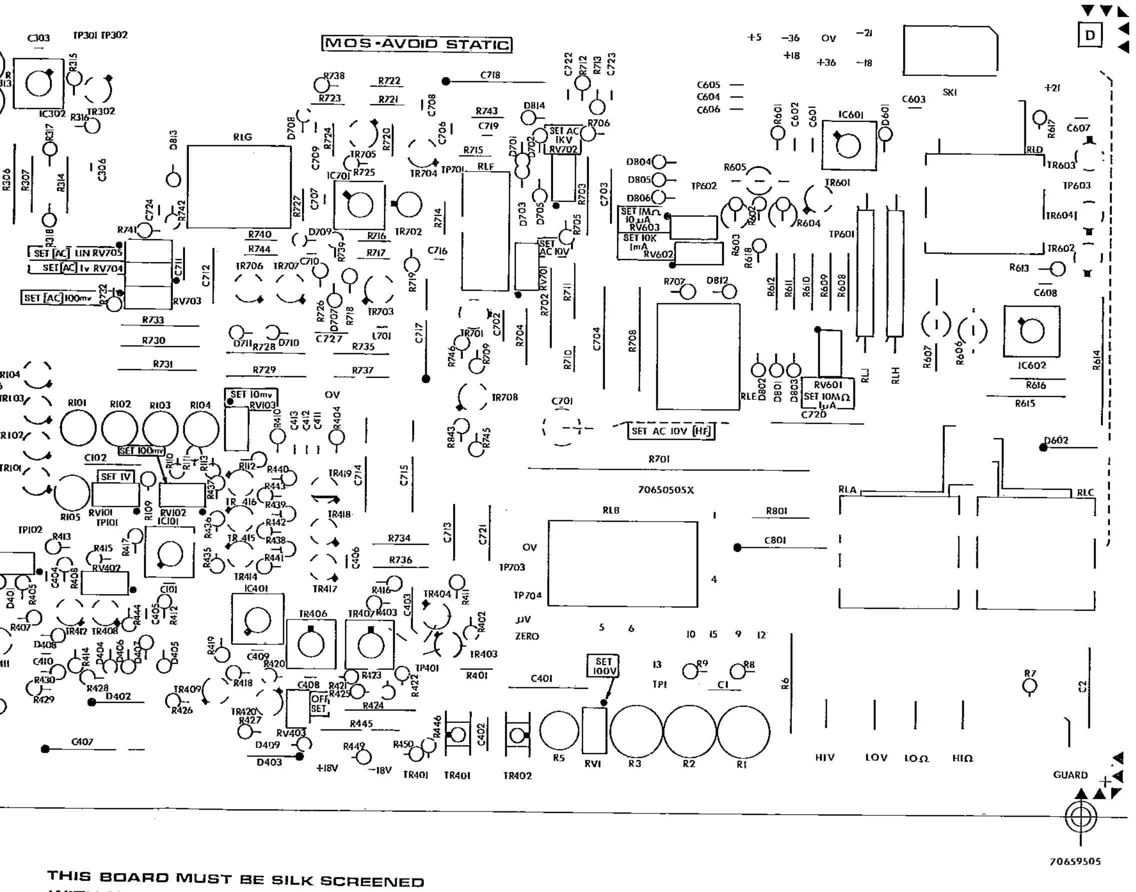
BOOTSTRAP AMPLIFIER

Amplifier IC101 is a low output impedance, unity gain, voltage follower producing an output voltage level close to that of the input to the amplifier. This output is used to provide a suitable gate voltage to switch on the gain defining FETs (TR103 to TR106) and the input switching FETs (TR403, TR404 and TR417 to TR419) in addition to guarding sensitive lines such as the feedback connection.

DIAG. 2.2 INPUT AMPLIFIER AND RANGING ▶



DIAG. 2.2 INPUT AMPLIFIER AND RANGING



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WITH YELLOW PAINT.

PCB 5 NOTATIONS

ANALOGUE TO DIGITAL CONVERTER (DIAG. 2.3)

This circuit, containing an integrator, level detectors, clock synchronising bistables, reference switching FETs and their drivers, converts the voltage provided by the input amplifier into pulses. These, when used to gate clock into a counter, provide a count proportional to the input voltage. This section of pcb 5 is "area" coded 2.

INTEGRATOR

The integrator (IC201) has the following three inputs connected to its summing point:

1. The input to be measured (TP209) via R201
2. The FORCING WAVEFORM (TP201) is AC coupled via C201 and R203
3. +REFERENCE, –REFERENCE or OV via R202

With the input voltage (TP209) at 0V and a 3.2kHz forcing square wave applied continuously to the integrator the output is driven alternately positive and negative through the thresholds of the detectors (IC204 pins 2 and 4). The state of the detectors is followed by IC202 and IC203 which thus synchronise the transitions to clock. The outputs of IC203 are then used to drive the FET switches which connect the appropriate reference voltage to the integrator input (TP202) such that the integrator output is dynamically balanced about zero. The voltage at TP202 consists of positive and negative reference pulses (GLUG), running at 3.2kHz, the width of which will be adjusted by the detectors so as to maintain the balance at the integrator output. This feedback ensures that the width of the reference pulses is proportional to the input voltage applied to TP209.

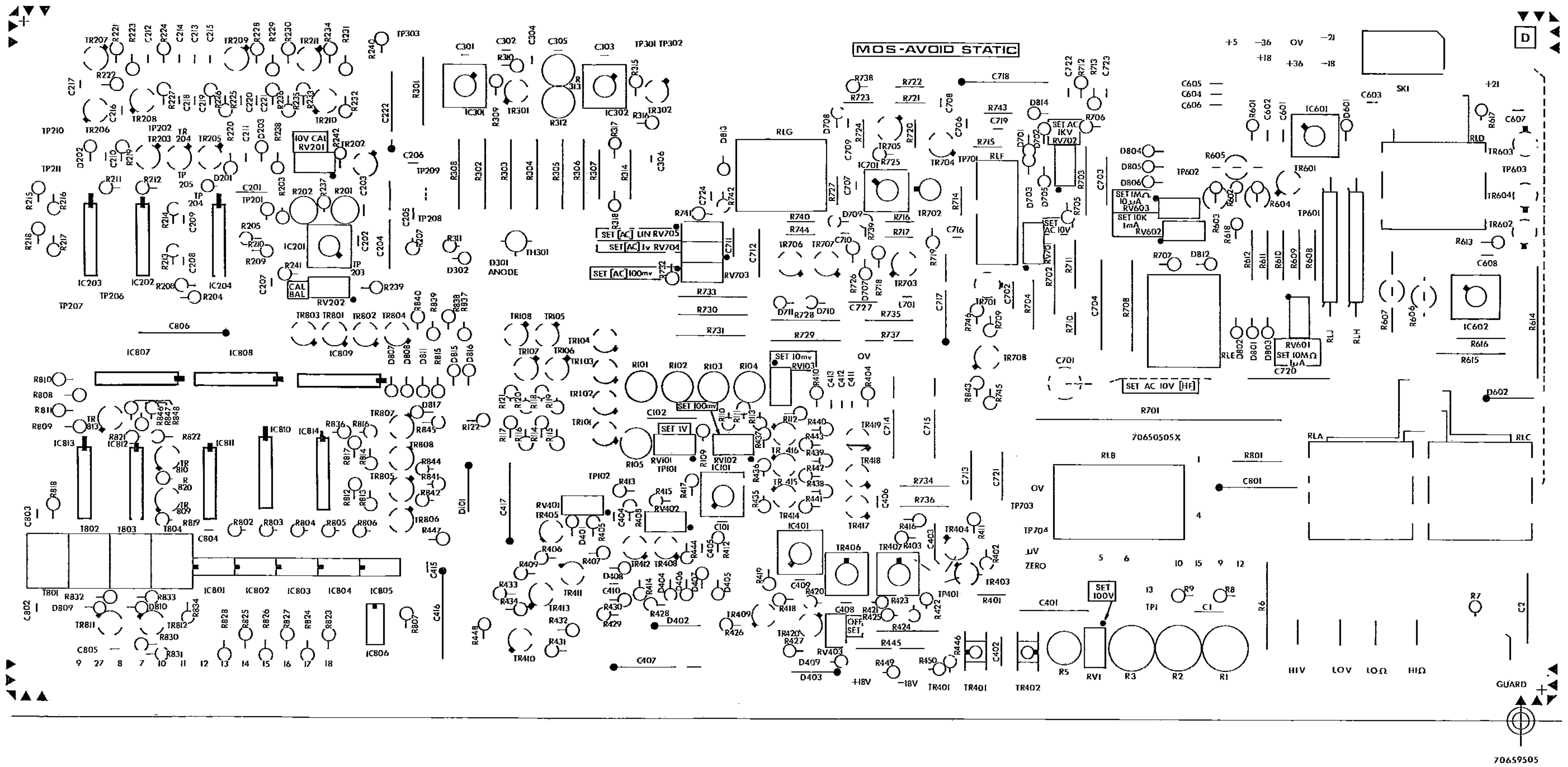
GLUG

Within this manual the reader will find many signal annotations which include the word "GLUG". The term is used as a convenient alternative to the cumbersome title "Quantum of Charge" (i.e. V x t) and should be treated merely as an identifier label facilitating circuit tracing.

CALIBRATION BALANCE ADJUSTMENT (RV202)

RV202 is adjusted, when calibrating the instrument, in order to compensate for any asymmetry in the Analogue to Digital converter which might otherwise cause the positive and negative readings to be unequal. Once adjusted, the calibration balance sequence, described earlier, automatically corrects for any drifts and keeps positive and negative readings in agreement.

◄ *PCB 5 NOTATIONS*



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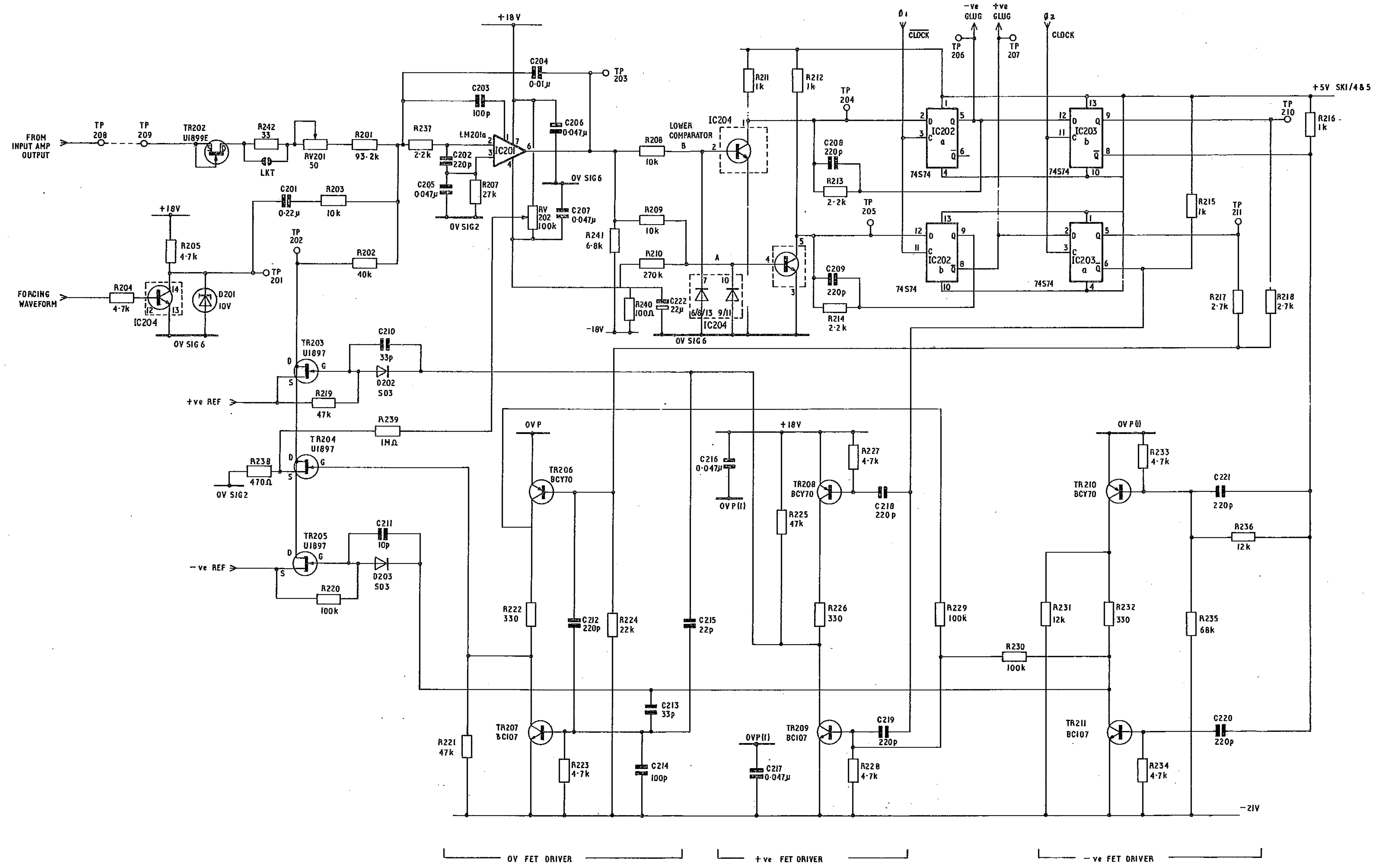
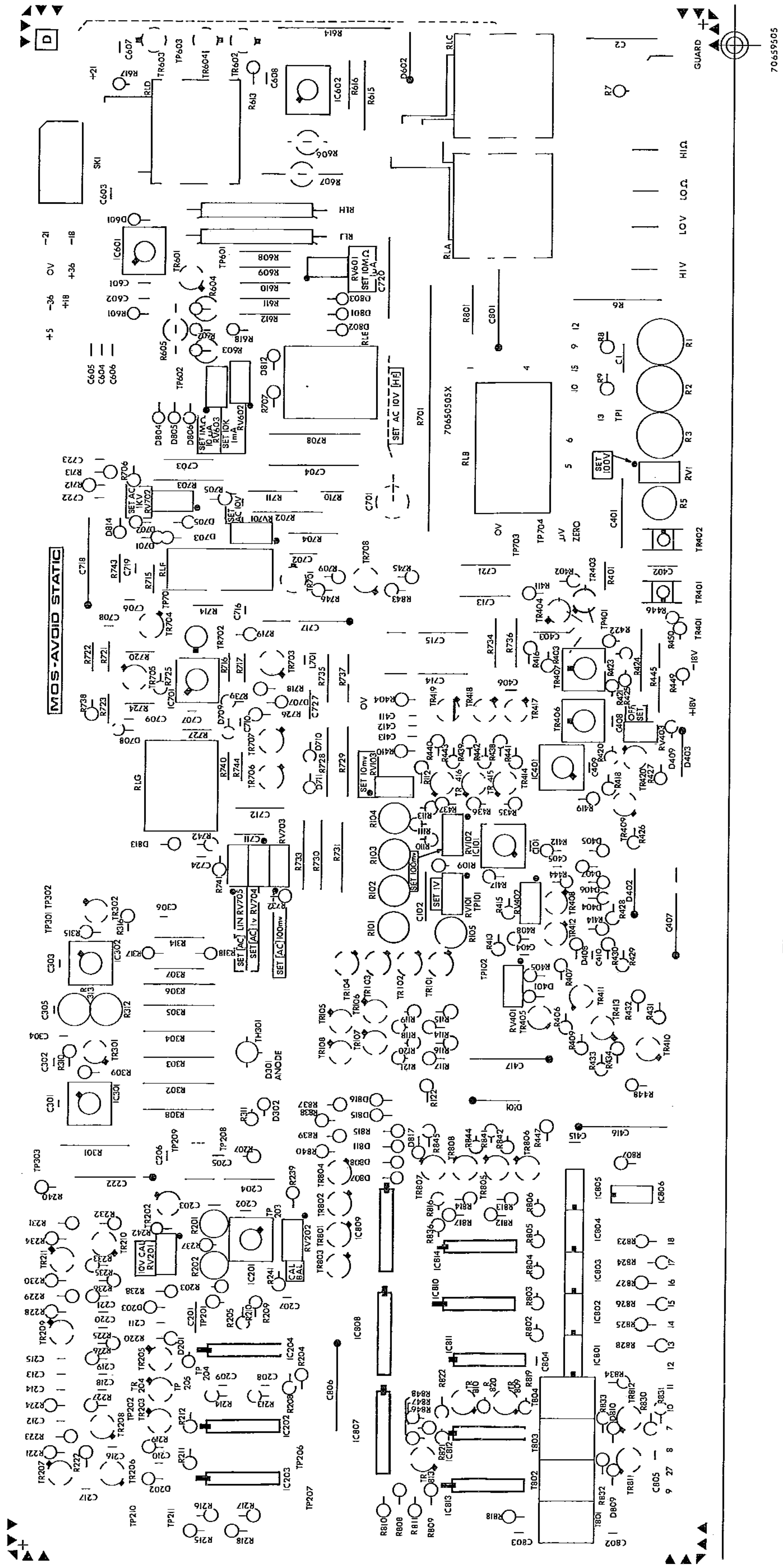
PCB 5 NOTATIONS

◀ *PC*



DIAG. 2.3 INTEGRATOR



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PCB 5 NOTATIONS

REFERENCE (DIAG. 2.4)

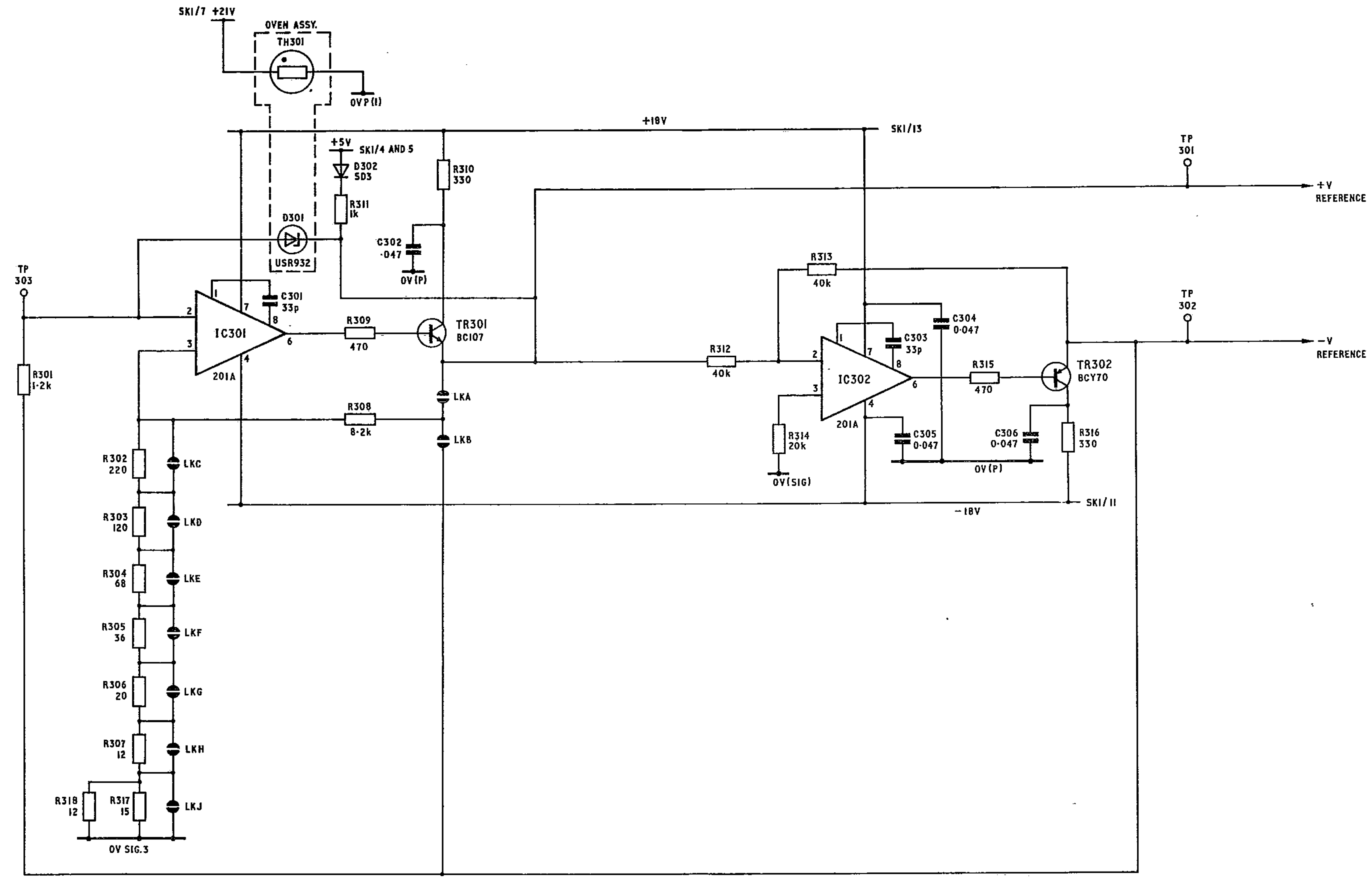
The reference voltages are generated by the circuits illustrated in diagram 2.4 which are "area" coded 3 on pcb 5.

In this circuit there are two amplifiers consisting of IC301, TR301 and IC302, TR302. The first amplifier (IC301) has a precision reference zener (D301) as its feedback element which defines its output at +9 volts which provides the +REFERENCE. The zener is mounted in an oven to maintain a stable temperature environment and so improve stability of the reference.

The +Reference is fed to the second amplifier (IC302) via R312 which, together with R313, defines a gain of –1. The output voltage of this amplifier is therefore –9 volts which is used as –REFERENCE and also provides the constant current for the reference zener via R301.

Links A and B, the resistor network R302 to R308 and R317, R318, together with the associated links C to J, are used during calibration to compensate for zener tolerances.

◀ *PCB 5 NOTATIONS*



DIAG. 2.4 REFERENCE

RESISTANCE (DIAG. 2.5)

Resistance measurement with the 7065 is accomplished by measuring the voltage developed across the unknown resistance when passing a known current through it. This section of board 5 is "area" coded 6.

CURRENT GENERATORS

The +REFERENCE and –REFERENCE are used by IC601 to define a current through R605 which is passed through R604 via TR601. The voltage generated across R604 is used by IC602 as a reference voltage to define the current through TR602 (ΩHi current).

Resistance ranges up to 1MΩ use two currents, 10μA and 1mA, which are controlled by RLD as follows:-

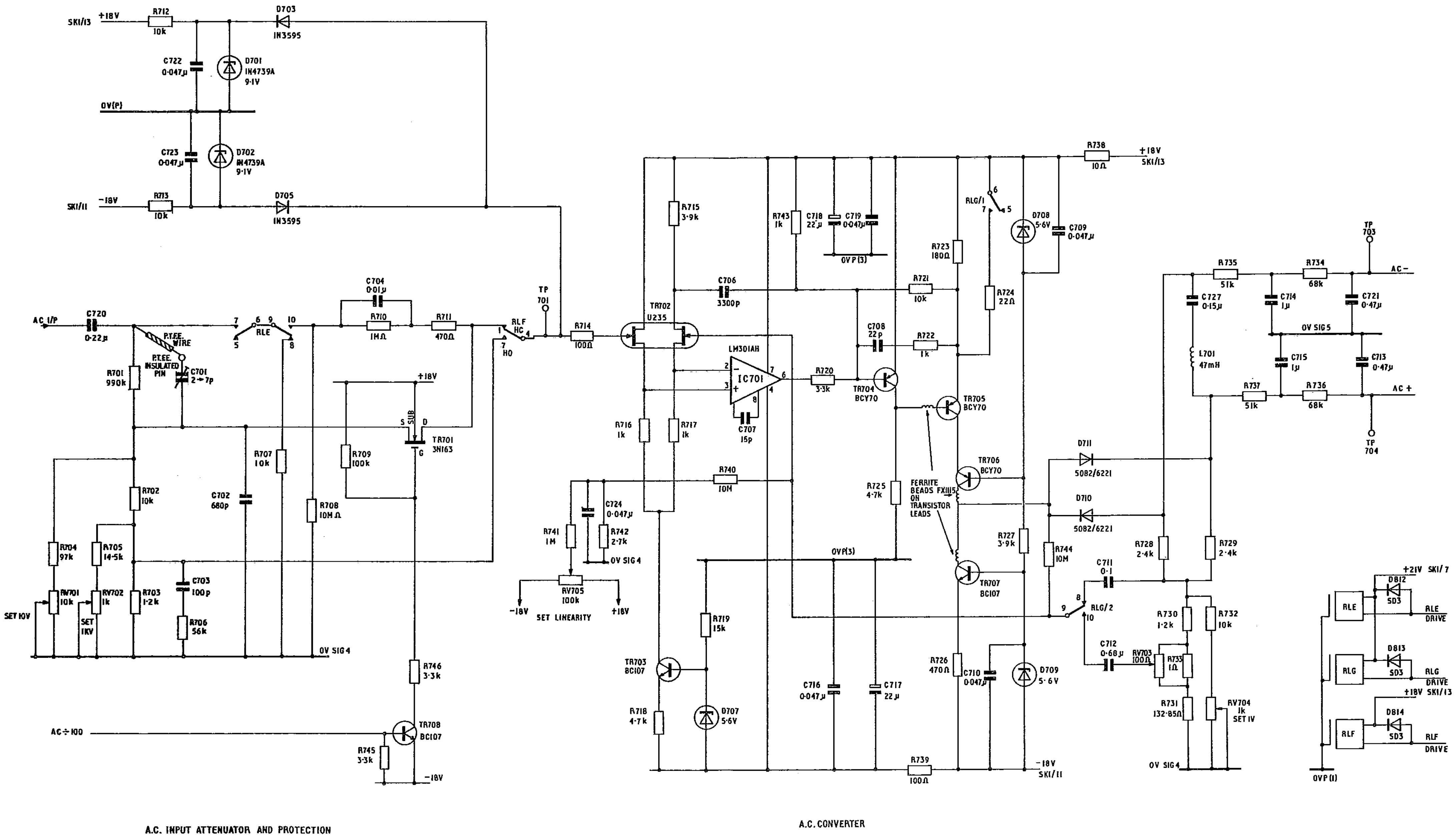
RLD–1	closed	1mA	10Ω,	100Ω,	1kΩ	ranges
RLD–1	open	10μA	10kΩ,	100kΩ,	1MΩ	ranges

The current for the 10MΩ range is controlled by RLJ which, when closed, reduces the reference voltage supplied to IC602 to 10% of its original value. With RLD–1 open, the HiΩ current then becomes the 1μA required by the 10MΩ range.

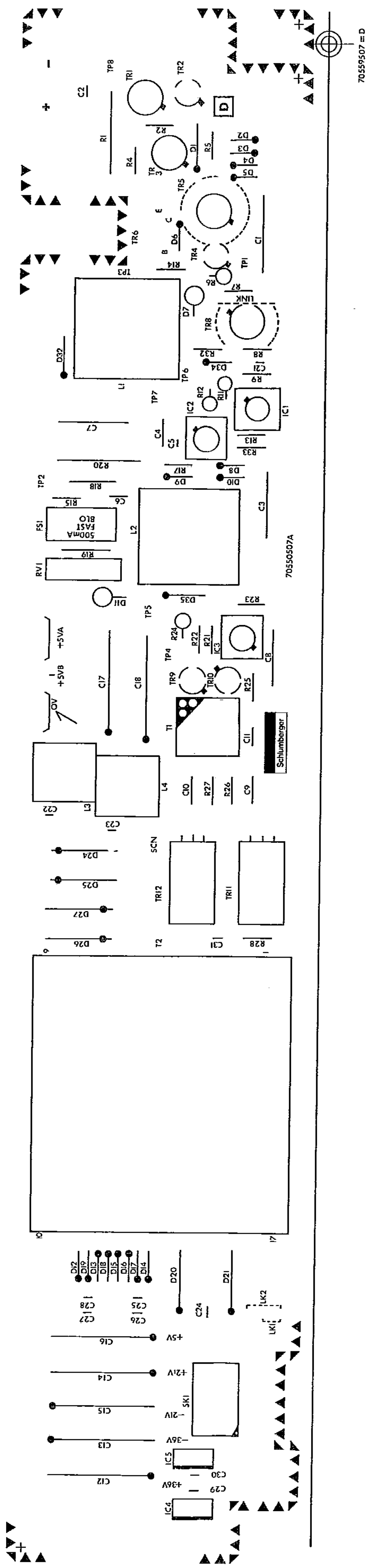
Relay contacts RLH and RLD–3 connect resistors from –REFERENCE to the ΩLo terminal, which provide the 10μA and 1mA current sink necessary to provide effective 4-terminal resistance measurement by minimising the current flowing down the Volts Lo lead. The two contacts are open on the 10MΩ range since the current of 1μA is sufficiently low to make it unnecessary to sink the current at the unknown resistance.

Links K to P and RV602 (SET 10kΩ 1mA), RV603 (SET 1MΩ 10μA) and link S, RV601 (SET 10^4kΩ 1μA) are adjusted during factory calibration to give the required ΩHi currents.

The current generator is protected from accidental overload inputs by D602, R614, TR603 and TR604. The two FET's connected in diode configuration, TR603 and TR604, limit the voltage at the drain of TR602 (TP603) to approx +22V and –1V respectively with R614 and D602 limiting the current.



DIAG. 2.6 AC CONVERSION



PCB 7 NOTATIONS

FLOATING LOGIC (DIAG. 2.7)

The three main functions of this circuit, which is "area" coded 8, are:-

1. Decoding range and mode (function) information to give the appropriate relay and F.E.T. drives.

2. Providing a gated clock which is counted to compute the reading.

3. Interfacing, by means of opto-couplers and pulse transformers, the floating measurement circuits with those connected to mains earth referenced supplies.

RANGE AND MODE DECODERS

Data is sent out at the beginning of each reading via the latches of IC22 on pcb 3. The data which determines the range and mode is transferred to the floating circuits by opto-couplers IC801 to IC805 and then, via buffers IC810 to the decoding circuits. The DRIFT CORRECT command is transferred by opto-coupler IC806 to the switching circuits shown in diagram 2.2.

The gain of the input amplifier (DIAG. 2.2) is decoded by IC807, a BCD to DECIMAL decoder and TR813 which controls, via level shifting circuits, the FET's described in the DC RANGING section.

The AC+ and AC– FET's are driven from signals decoded by IC814 a, b, and c.

The drives for the relays which control the OHMS CURRENT GENERATOR, RLJ, RLH and RLD are decoded by IC808, a BCD to DECIMAL decoder, whilst the OHMS MODE relay drive (RLC) is decoded by IC814d.

Diodes D815 and D816 ensure that the DC attenuator relay, RLB, is energised whenever RLC or RLD is energised.

IC809 provides the necessary decoding and current drive for the control of the AC range switching (DIAG. 2.6).

MEASUREMENT WAVEFORMS

The FORCING WAVEFORM is sent from the earthy logic via a pulse transformer (T804). As the output from this transformer is only a short pulse when the forcing waveform changes state, it is necessary to reform the square wave in the floating circuits. TR809, TR810 and inverters IC811b and c form a SET/RESET bistable which regenerates the 3.2kHz square wave. This is then passed to the integrator via a buffer transistor (Part of IC204, DIAG. 2.3).

The system clock is also transmitted to the "floating" circuits via a pulse transformer (T801). IC812a and b buffer the output of the transformer and produce the two phases of clock required.

IC813 is used to gate the GLUG outputs of IC202 (DIAG. 2.3) with the appropriate phase of clock and drive pulse transformers T802 and T803 which transmit the gated clock to the earthy circuits. TR811 and 812 buffer the outputs of these transformers and drive the circuits on pcb 3.

◄ *PCB 7 NOTATIONS*

RANGE DECODE TABLE

MODE	RANGE	DISCONNECT PINS					see note 1	INPUT AMP	RELAY DRIVES								see note 2
		17	18	13	16	15	14	GAIN	A	B	C	D	E	F	G	H	J
DC	1000V	1	1	see note 3	0	1	0	x1	0	0	0						
	100V	1	1		0	1	1	x10	0	0	0						
	10V	1	1		1	0	0	x1	0	1	0						
	1V	1	1		1	0	1	x10	0	1	0						
	0.1V	1	1		1	1	0	x100	0	1	0						
	0.01V	1	1		1	1	1	x1000	0	1	0						
AC	1000V	0	see note 4	0	0	1	0	x10	1	0	0		0	1	0		
	100V	0		0	0	1	1	x10	1	0	0		0	1	0		
	10V	0		0	1	0	0	x10	1	0	0		0	0	1		
	1V	0		0	1	0	1	x10	1	0	0		1	0	0		
	0.1V	0		0	1	1	0	x10	1	0	0		1	0	1		
KΩ	10^4k	1	0	see note 3	0	0	1	x1	0	1	1	0				0	1
	1000k	1	0		0	1	0	x1	0	1	1	0				1	0
	100k	1	0		0	1	1	x10	0	1	1	0				1	0
	10k	1	0		1	0	0	x1	0	1	1	1				0	0
	1k	1	0		1	0	1	x10	0	1	1	1				0	0
	0.1k	1	0		1	1	0	x100	0	1	1	1				0	0
	0.01k	1	0		1	1	1	x1000	0	1	1	1				0	0

NOTES

1. The Disconnect Pins code '1' and '0' refer to normal T.T.L. levels.

2. The Relay Drive code is as follows:-

   '1' = Relay energised

   '0' = Relay de-energised

   The state of the relay does not matter where no codes are shown.

3. Disconnect Pin 13 is coded '1' = normal measurement

   '0' = DRIFT CORRECT

4. Disconnect Pin 18 changes between '1' and '0' during the measurement.

POWER SUPPLY (DIAG. 2.8, 2.9)

The instruments power rails are derived from the circuits on the facing page and. that shown overleaf.

Applied directly, without the use of a mains transformer, the supply voltage is roughly rectified by the circuit on pcb 13 (DIAG. 2.8) before being converted to a regulated dc by a switched regulator circuit. The dc thus obtained is again converted to a stable ac by means of an Inverter stage, the output of which feeds the primary of a transformer.

The transformer secondary winding and its associated conventional circuits are shown on diagram 2.9.

START UP

When the instrument is switched ON, this circuit produces an initial supply for the remaining circuits. The current through the emitter followers TR1, TR3 is controlled by that through TR2. The base level for D4, D5 is also controlled by TR2 which conducts reducing TR1 and TR3 conduction when the potential across the zeners exceeds their combined nominal limit. The circuit thus operates in a closed current loop maintaining the junction D1, D5 at +36V derived from the mains input.

VOLTAGE REGULATOR

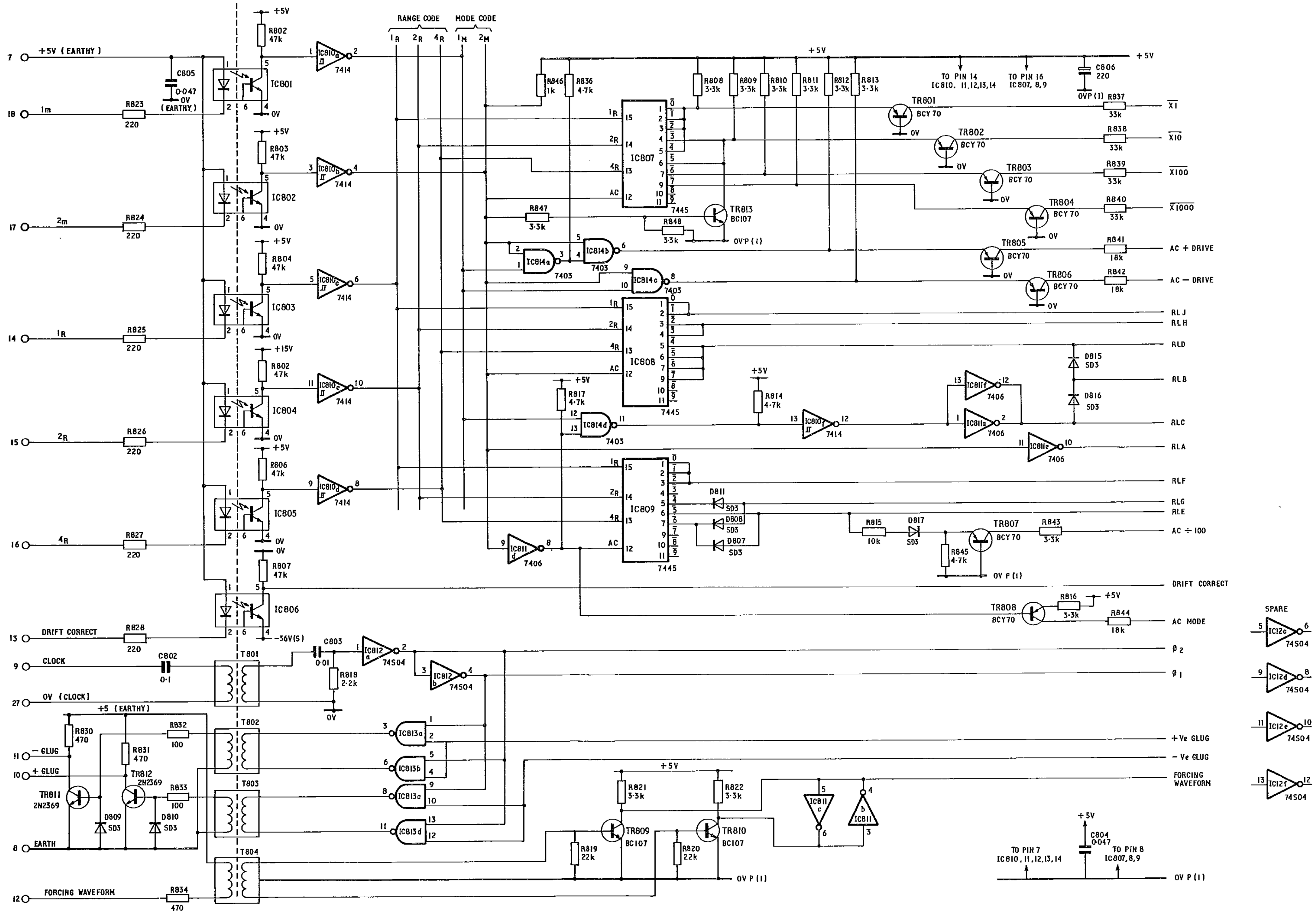
After the initial current surge the circuit described above settles very rapidly. The Voltage Regulator then takes control to redefine the +36V rail and switch off the Start Up circuit. A series transistor TR6, is switched on/off at 30kHz by the output of oscillator IC1 via TR8, TR5. The mains supply is therefore pulsed by TR6 before being smoothed by choke L1. The mark/space ratio of the switching 30kHz is controlled by the output of comparator IC2, and thus the regulated voltage levels. RV1 adjusts the comparator 'sample' to set the output of the regulator to +70V. The current through R20 now defines the +36V rail and via D5, D4 it causes the now redundant Start Up circuit to be turned off.

Note that mains ripple is eliminated by the high switching speed of IC's 1 and 2.

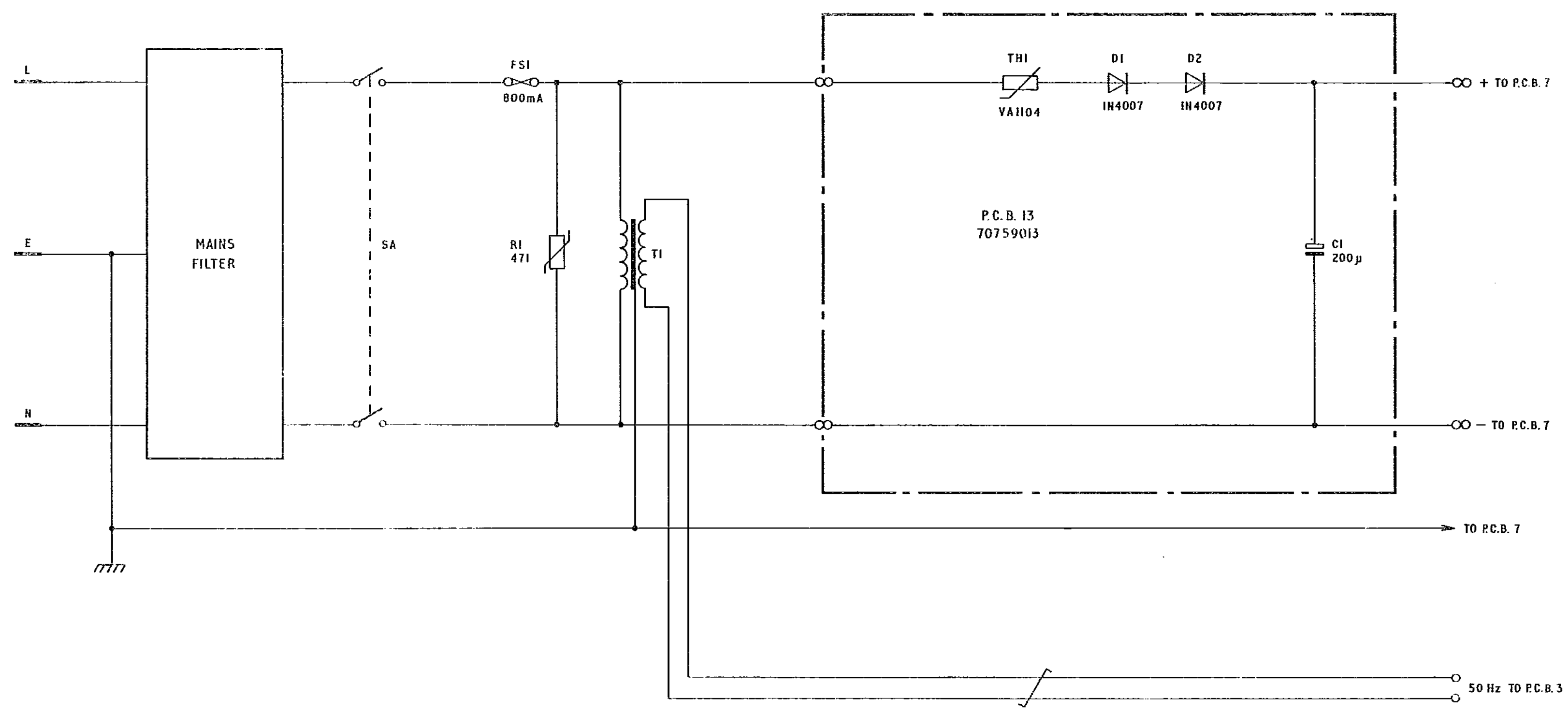
INVERTER

IC3 is connected as an oscillator, switching the common emitter of TR9, TR10 between +36V and the neutral rail, at approximately 20kHz. The square switching waveform, stepped down by transformer T1, causes TR11, TR12 to alternately turn on and off. Thus the primary winding of T2, centre fed by the regulated +70V rail, produces an alternating current which is independent of mains supply voltage and frequency. This "supply" is used in the rectifier circuits which follow.

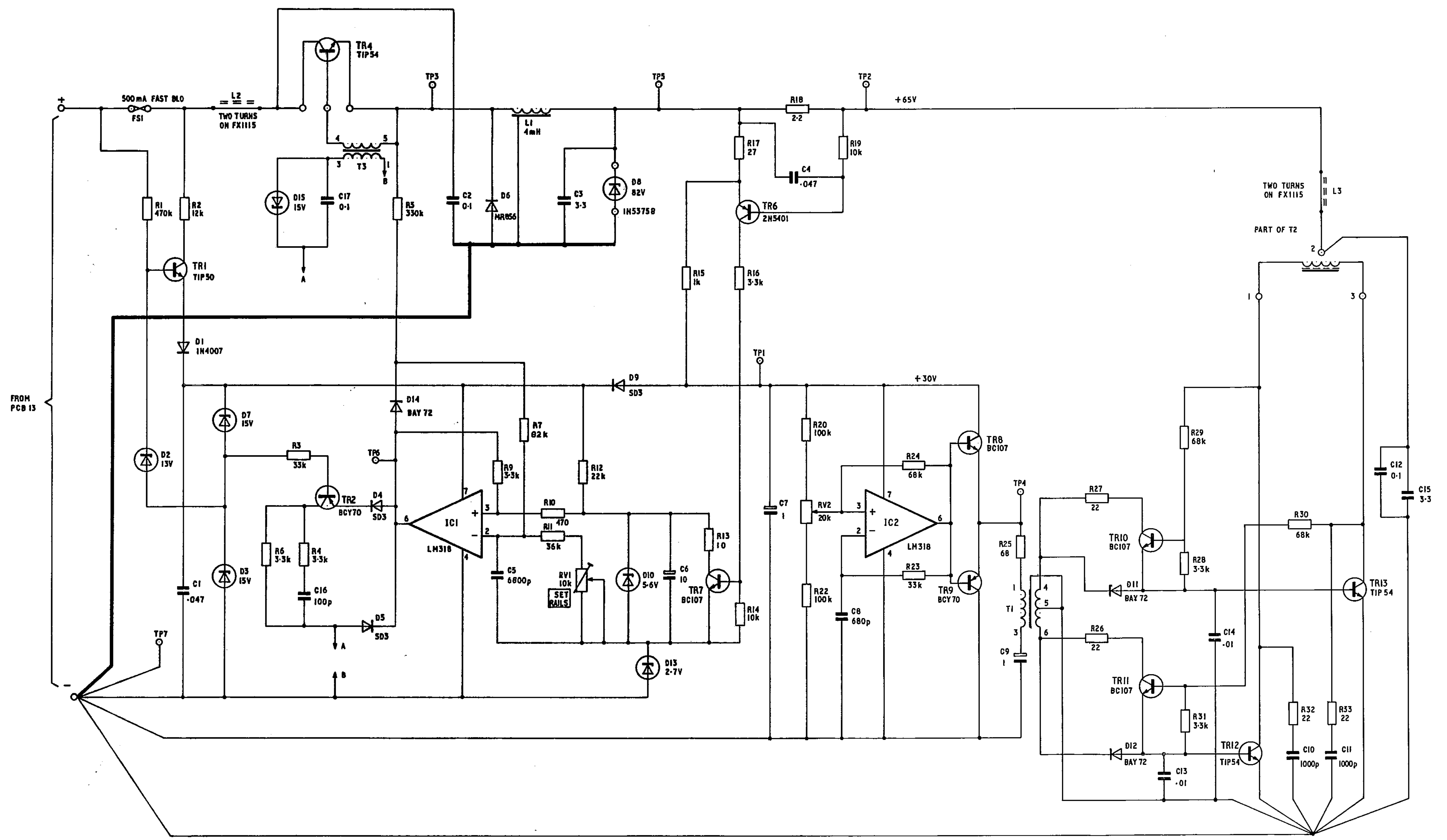
◄ *DIAG. 2.8 MAINFRAME (PCB 13)*



DIAG. 2.7 FLOATING LOGIC



DIAG. 2.8 MAINFRAME (PCB 13)



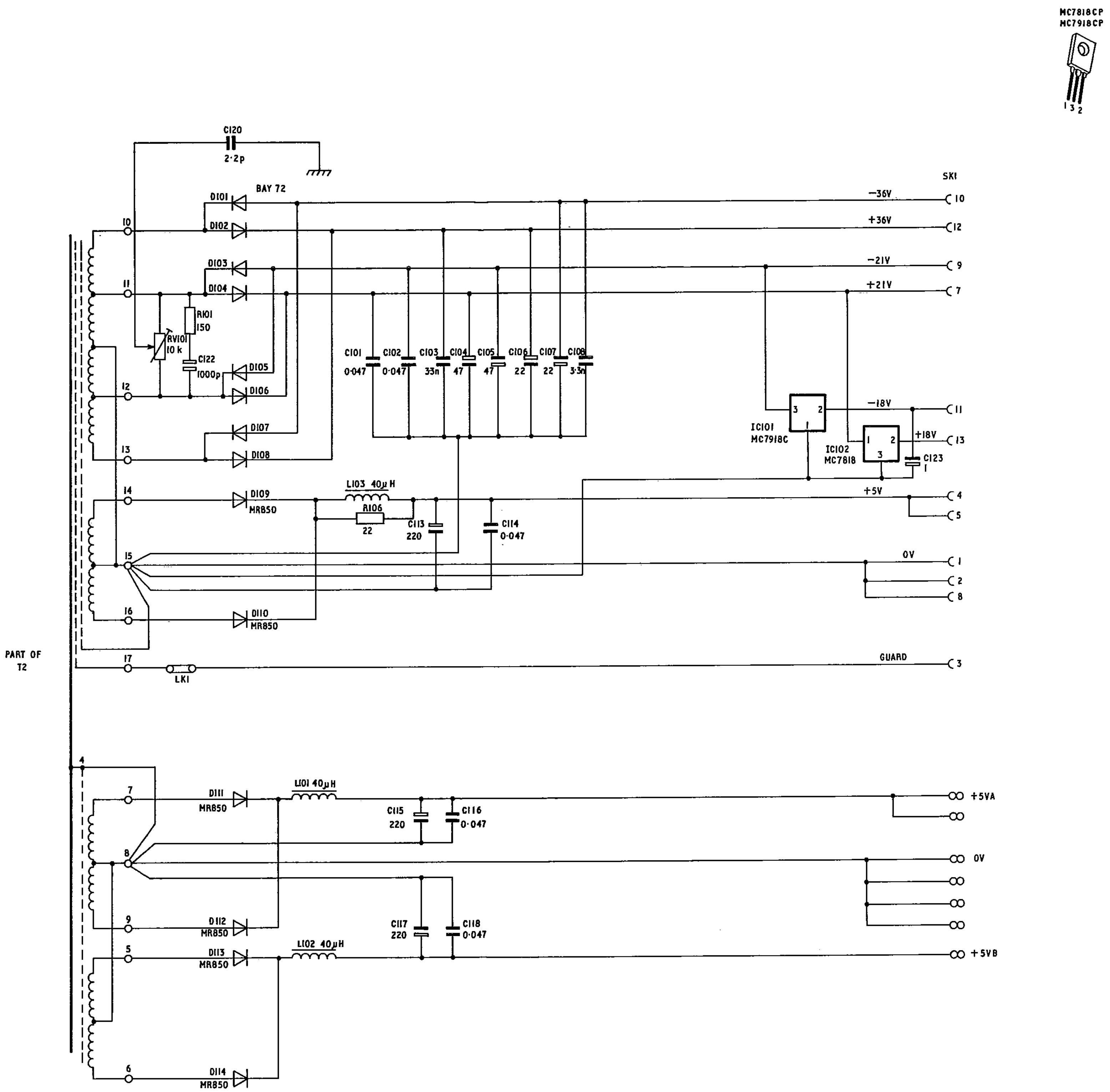
DIAG. 2.9 POWER SUPPLY (PCB 7)

RECTIFICATION (DIAG. 2.10)

T2 secondary windings provide the rectifier current required to power the various dc rails used within the voltmeter.

IC4, IC5 are used to regulate the floating positive/negative 18V rails.

D24 to D27 provide earthy power for board 3.



DIAG. 2.10 RECTIFICATION (PCB 7)

DIGITAL SECTION

INTRODUCTION

This part of the manual covers those circuits which convert the pulses generated in the A/D Converter into a digital count which, after further processing, is used to drive the display.

The Block Schematic Diagram (DIAG. 2.11) illustrates the functional layout of the digital section which, for convenience, can be considered as having 4 sub-sections.

1. The Phase Locked Clock, Clock Oscillator and Clock Divider (DIAG. 2.12).
2. The Microprocessor Set, address and data buses, the Reversible counters, tri-state buffers and latches (DIAG. 2.13, 2.14).
3. The Keyboard (DIAG. 2.15).
4. The Display (DIAG. 2.16)

GLUG

Within this manual the reader will find many signal annotations which include the word "GLUG". The term is used as a convenient alternative to the cumbersome title "Quantum of Charge" (i.e. v x t) and should be treated merely as an identifier label facilitating circuit tracing.

PHASE LOCKED CLOCK, CLOCK OSCILLATOR AND CLOCK DIVIDER

Illustrated on diagram 2.12, this circuit provides the clock pulses for both the floating and earthy circuits. Signals generated for the floating circuits consist of a 3.2kHz forcing waveform for the Integrator and 13.1MHz clock for synchronising GLUG to clock. Those signals generated for the earthy circuits include anode and keyboard scan, MPU interrupt, display blank and MPU clock input.

THE MICROPROCESSOR SET, REVERSIBLE COUNTERS, TRI-STATE BUFFERS AND LATCHES AND ADDRESS BUS DECODERS

This sub-section is illustrated on two sheets (DIAG. 2.13 and 2.14).

Diagram 2.13 shows the Reversible Counters; Tri-state latches and buffers; address decoders and data bus, with bus drivers and shift registers.

The Microprocessor clock drive, the Microprocessor Unit (MPU), Read Only Memory (ROM) and Random Access Memory (RAM) are illustrated on diagram 2.14.

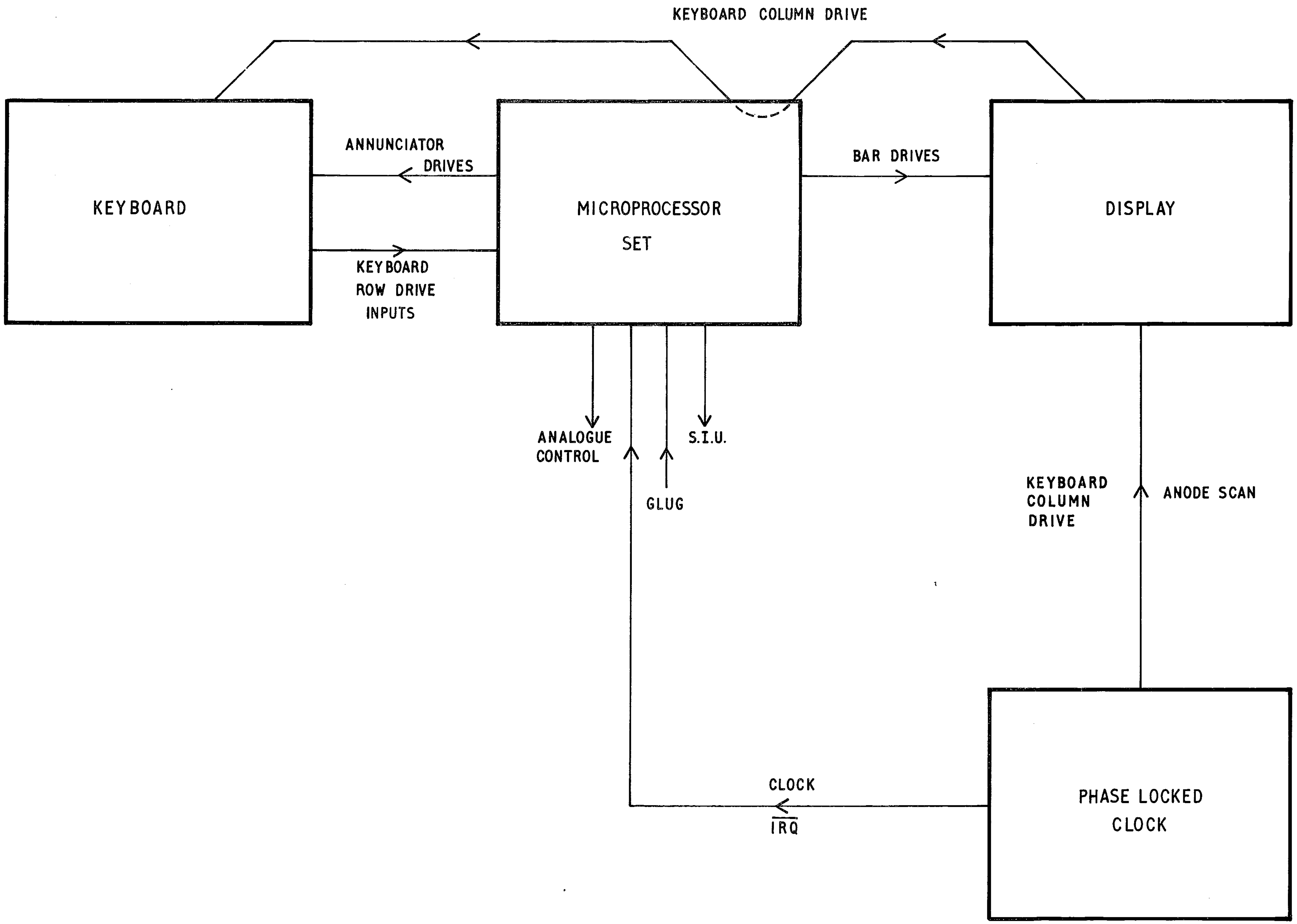
This board controls the other logic boards and the floating circuits.

KEYBOARD

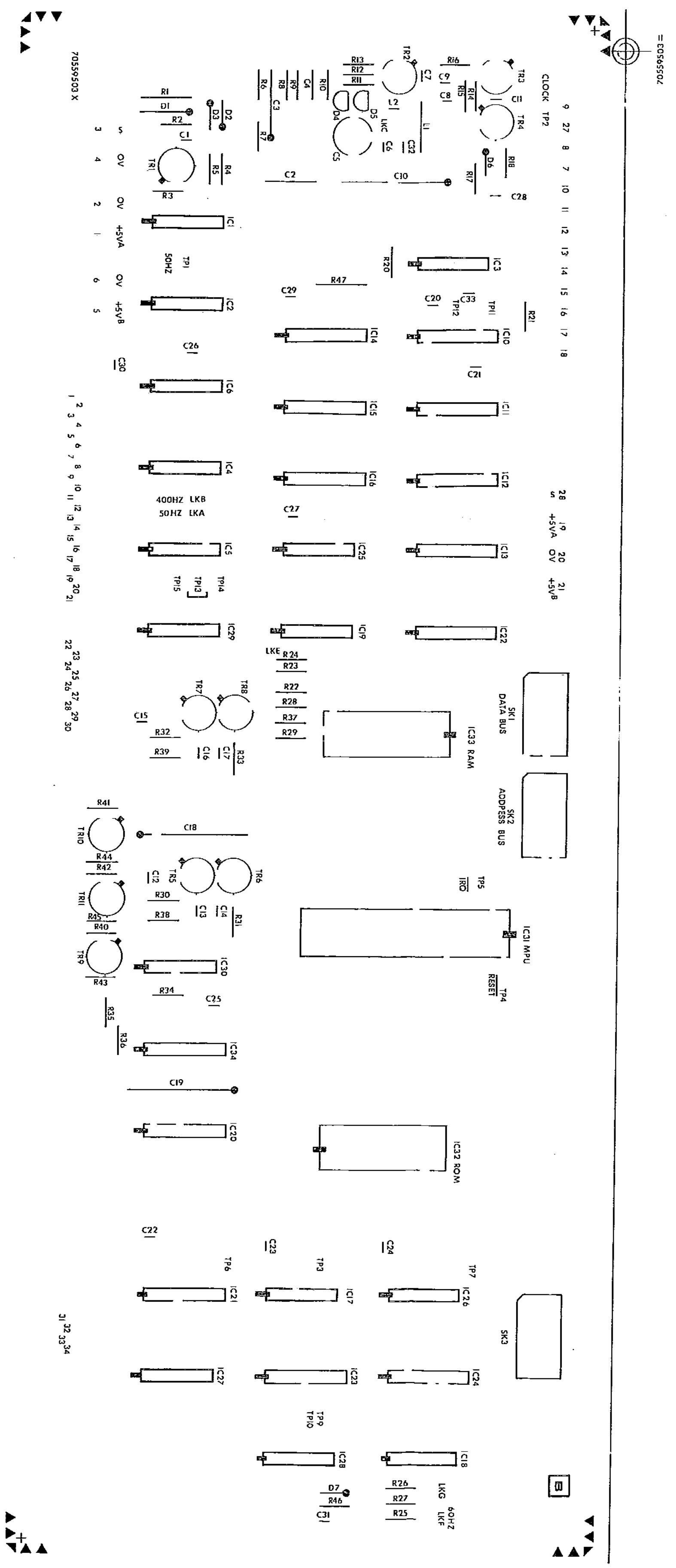
The keyboard is illustrated on diagram 2.15. The keyswitches and annunciators are configured electrically in three rows of six in a time shared arrangement. Column strobing drives are input from the display board. Synchronised row drives for the annunciators are input from Board 3 while keyboard row outputs return to Board 3.

DISPLAY

Again in a time shared fashion, the decoded information is presented to the display (DIAG. 2.16) synchronously with the coded display anode address from the clock circuitry. 8 decade windows are used to display the visual information which features a floating decimal point, fixed minus sign and invalid reading bar-annunciators.



DIAG. 2.11 SIMPLIFIED BLOCK DIAGRAM



PCB 3 NOTATIONS

PHASE LOCKED CLOCK (DIAG. 2.12)

A mains derived 50Hz synchronising signal is shaped by R_1 C_1 D_1 and buffered by TR1 before being applied to IC1a. The inverted output of this gate is then fed to IC2b, one half of a D-type bistable. The other half, IC2a, also has a 50Hz signal input, in this instance derived from the clock divider chain.

The phase difference between the two inputs is compared by IC1b and converted to a positive driving or negative driving train of pulses which charge C2.

The mean dc level on C2 controls the varactor diodes D4 and D5, the capacitance of which determines the frequency of the LC oscillator (TR2 L1 etc.). The output from the clock oscillator is applied via TR3 and TR4 to IC3a and b, a divide by four bistable in the clock divider chain. A phase locked loop is thus formed, stabilizing the clock oscillator at 13.1MHz. This output is transferred to the Integrator on pcb 5 to synchronise GLUG with clock.

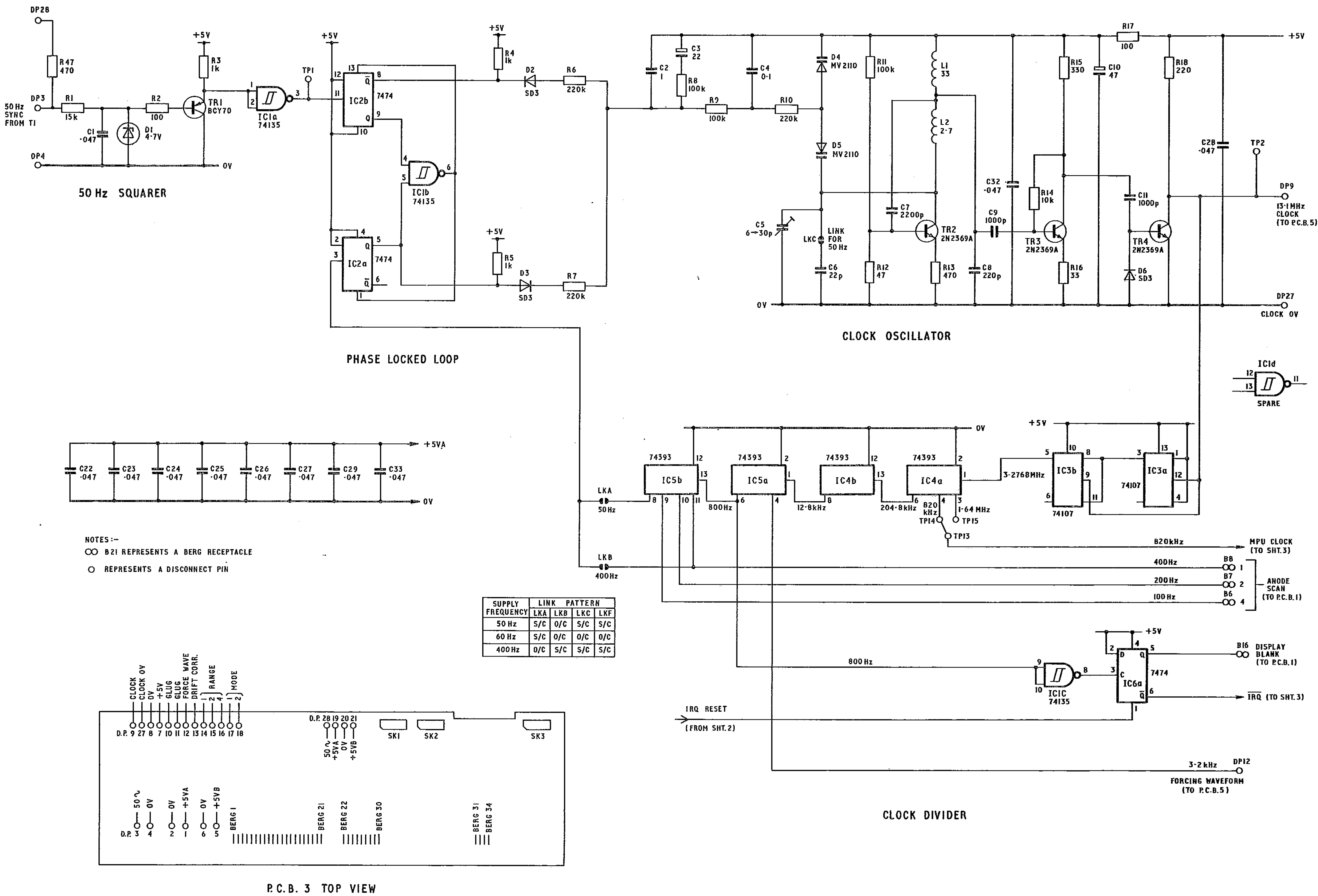
IC4a provides the input for the Microprocessor clock (MPU). TP13 can be linked to either TP14 or TP15. Linking TP13 to TP15 doubles the clock frequency. (See Microprocessor Set page 4.2.28).

Outputs from IC5b in the clock divider chain are used for anode scan signals at 400Hz, 200Hz and 100Hz and passed to the display via pins B8, B7 and B6 respectively.

The other half of this 4-bit binary counter (IC5a), provides two outputs; on pin 4 a 3.2kHz forcing waveform is output to drive the Integrator on pcb 5; the output on pin 6, applied to and inverted by IC1c provides 800kHz clock for IC6a. Every 1.25ms the states of the display anode scan lines change (IC5b pin 13, DIAG. 2.12) allowing a new display digit, annunciator column and keyboard column to be driven. New data is required for the display digit and annunciator LEDs.

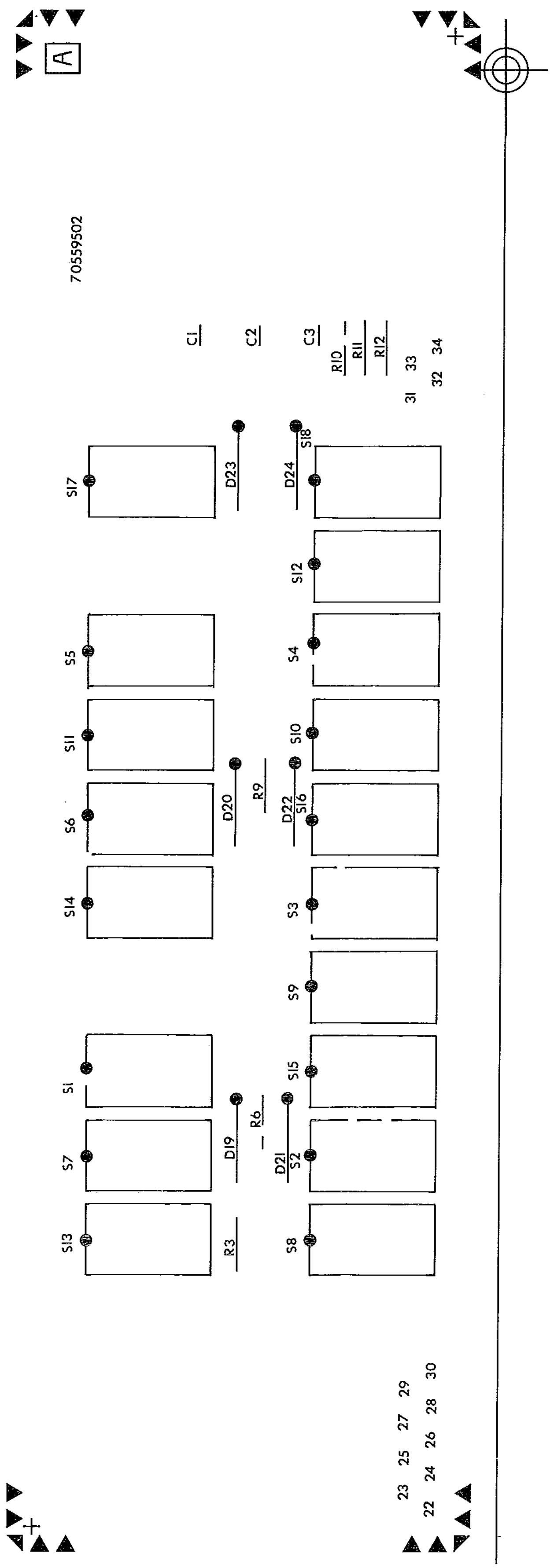
IC6a is triggered every 1.25ms (800Hz input on pin 3) generating an Interrupt Request signal (IRQ) for the MPU. This causes the MPU to suspend its present activity. It now outputs display and annunciator data, reads keyboard data and performs various other 'housekeeping' tasks. When these tasks are completed, the MPU resets IC6a (IRQ RESET input on pin 1). During this time the display is blanked by IC6a.

◀ *PCB 3 NOTATIONS*



SUPPLY FREQUENCY	LINK PATTERN			
	LKA	LKB	LKC	LKF
50 Hz	S/C	O/C	S/C	S/C
60 Hz	S/C	O/C	O/C	O/C
400 Hz	O/C	S/C	S/C	S/C

DIAG. 2.12 PHASE LOCKED CLOCK (PCB 3)



PCB 2 NOTATIONS

DATA CONTROL (DIAG. 2.13)

This part of the circuit controls the transfer of data between the input/output ports and the MPU. Each input port, enabled by a particular address bus decode, passes its data to the data bus. Decodes applied to the output ports shift data from the bus and store them in the output latches, to drive keyboard annunciators, display bars, and analogue circuits. Also driven are interface boards (if fitted) used in conjunction with devices remote from the instrument.

REVERSIBLE COUNTERS (DIAG. 2.13)

GLUG gated with clock arrives from board 5 and is fed to pins 4 and 5 of the reversible counter IC11. ICs 11, 12, 13 and IC25 (an overflow counter) form a 17-bit reversible binary counter chain.

The first monostable (IC11) is continuously retriggered during the –ve glug. At the end of this glug and after a further 0.5μs it relaxes to its untriggered state. This loads the tri-state latch buffers with the counter data and triggers the second monostable (IC12) to give a 0.5μs pulse. The pulse resets the counter chain, ready for the next pair of glugs, and triggers a latch (IC25a and b) informing the MPU that a new count has been made. As the MPU reads the data from the tri-state latch buffers this signal is automatically reset.

ADDRESS BUS DECODERS

Enabled by IC28a when Valid Memory Address (VMA) is present, IC23 and 24, address bus decoders, provide decodes which are used to determine the status of the rest of the circuitry on this board.

INPUT DATA TO MPU

ICs 17 and 18, tri-state buffers, are enabled by address bus decode 7000 and determine:

a) The measurement function and range (keyboard row drives sequentially scanned, input on pins 2 and 3 of IC17 and pin 12 of IC18 provide this data).

b) Whether or not the measurement function selected is AC. If so, is it Mean ac or RMS (Link G)

c) The mains input frequency i.e. 50Hz or 60Hz (Link F).

d) If IRQ SYNC is present, (IC17 pin 12). This keeps the display and keyboard software scan synchronised to hardware.

e) When the glug is present in the reversible counters (IC18 pin 2).

f) If the parallel Interface board is fitted (IC18 pin 9)

◄ *PCB 2 NOTATIONS*

TRI-STATE LATCHING BUFFERS

Address bus decode 6800 enables ICs 15, 16 and 25 to determine the value of the 8 most significant bits (MSB) of the counter chain.

Similarly address bus decode 6000 checks IC14 and IC19 to determine the value of the 5 least significant bits (LSB); whether front panel lockout is commanded from the parallel interface board (IC19 pin 5) and also if either the IEC or the RS232 Interface boards are fitted (IC19 pin 9). IC19 pin 12 input determines the identity of the instrument – Link E being made for 7055, open circuit for 7065.

OUTPUT DATA FROM MPU

Output data from the MPU is passed to drivers IC26 and 27, latched by IC20, 21 and 22. The data is thus interfaced to the display, keyboard and analogue board. The address bus decode for IC20 is 4700 while that for IC21 and 22 is 4400.

Address decodes 4500, 4200, 4800 and 7800 input and output to the parallel Interface board.

Finally address bus decode 4600 resets IC6a (DIAG. 2.12) during the interrupt cycle.

MICROPROCESSOR SET (DIAG. 2.14)

This circuit controls the other logic boards and contains the Microprocessor clock generator and the Microprocessor Set (MPU Set). The MPU Set consists of an 8-bit word single chip microprocessor IC31, a 2k x 8 bit read only memory (ROM) IC32, and a 128 x 8 bit random access memory (RAM) IC33.

IC31 contains all the functions required for multi-instruction processing; an arithmetic and logic unit; instruction decode and address registers; an instruction register; all of the clock and logic circuits required for timing and a full complement of data bus lines to output matrices and address bus drivers.

The microprocessor can modify its sequence of addresses on the basis of the results of previous operations. It can also store its own state when interrupted (IRQ) and continue, from where it left off, when the interrupt cycle is satisfied.

MPU CLOCK GENERATOR

820kHz from the Phase Locked Clock (DIAG. 2.12) is applied via buffers IC29a, b, c and IC30a, b, c to the MPU clock generator input which in turn provides two non-overlapping clock inputs Ø1 and Ø2 for the microprocessor IC31. Control and movement of data is synchronised with clock on address bus-line A15 via IC30d and passed to IC28a (on diagram 2.14).

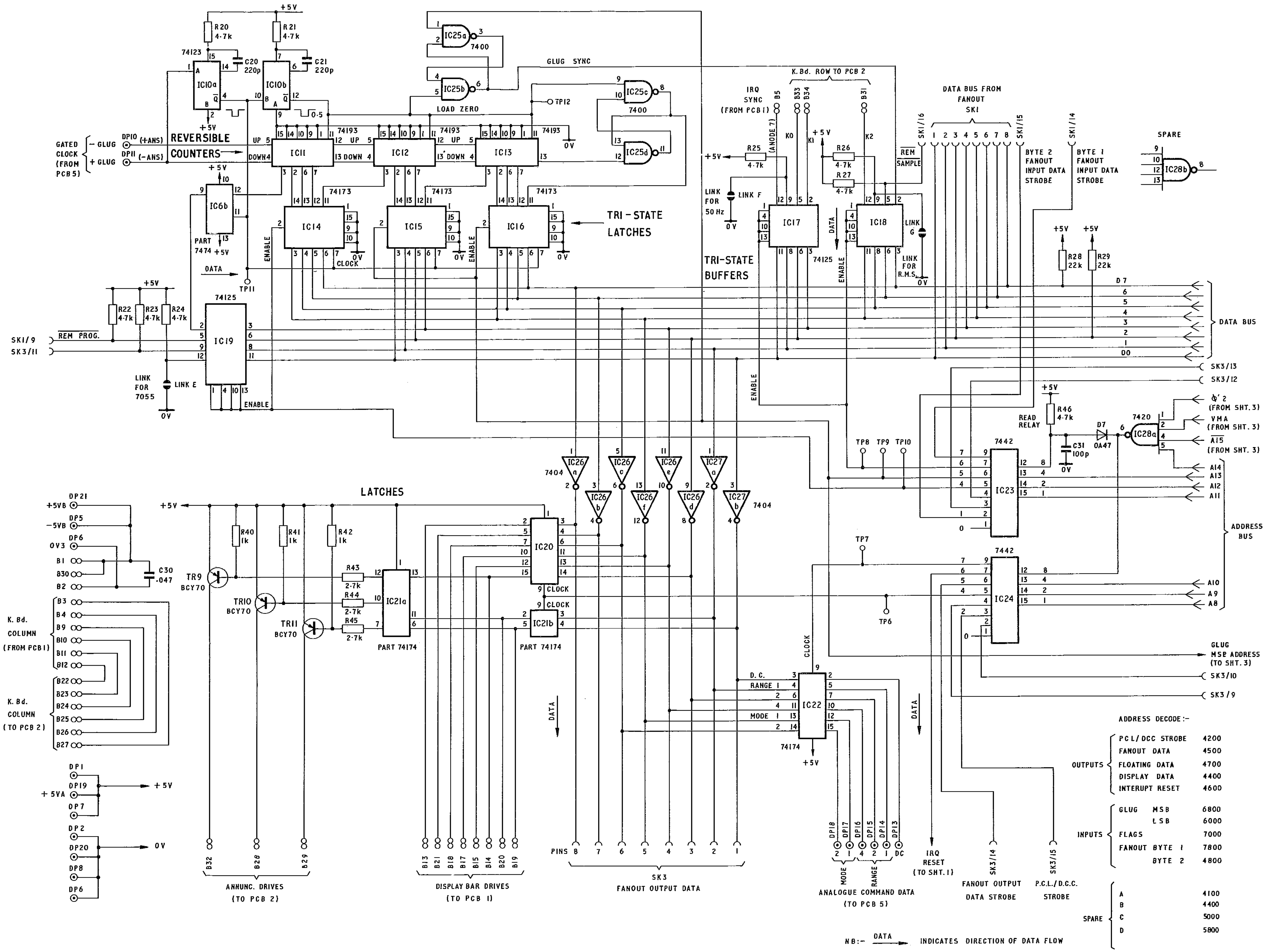
READ/WRITE (R/W)

Determines the direction of data flow between the MPU and IC33 (RAM), and the Serial Interface board (if fitted) for read/write operations. When logic level 1 is present Read is selected; when 0, Write is operative (Write = MPU → RAM etc.)

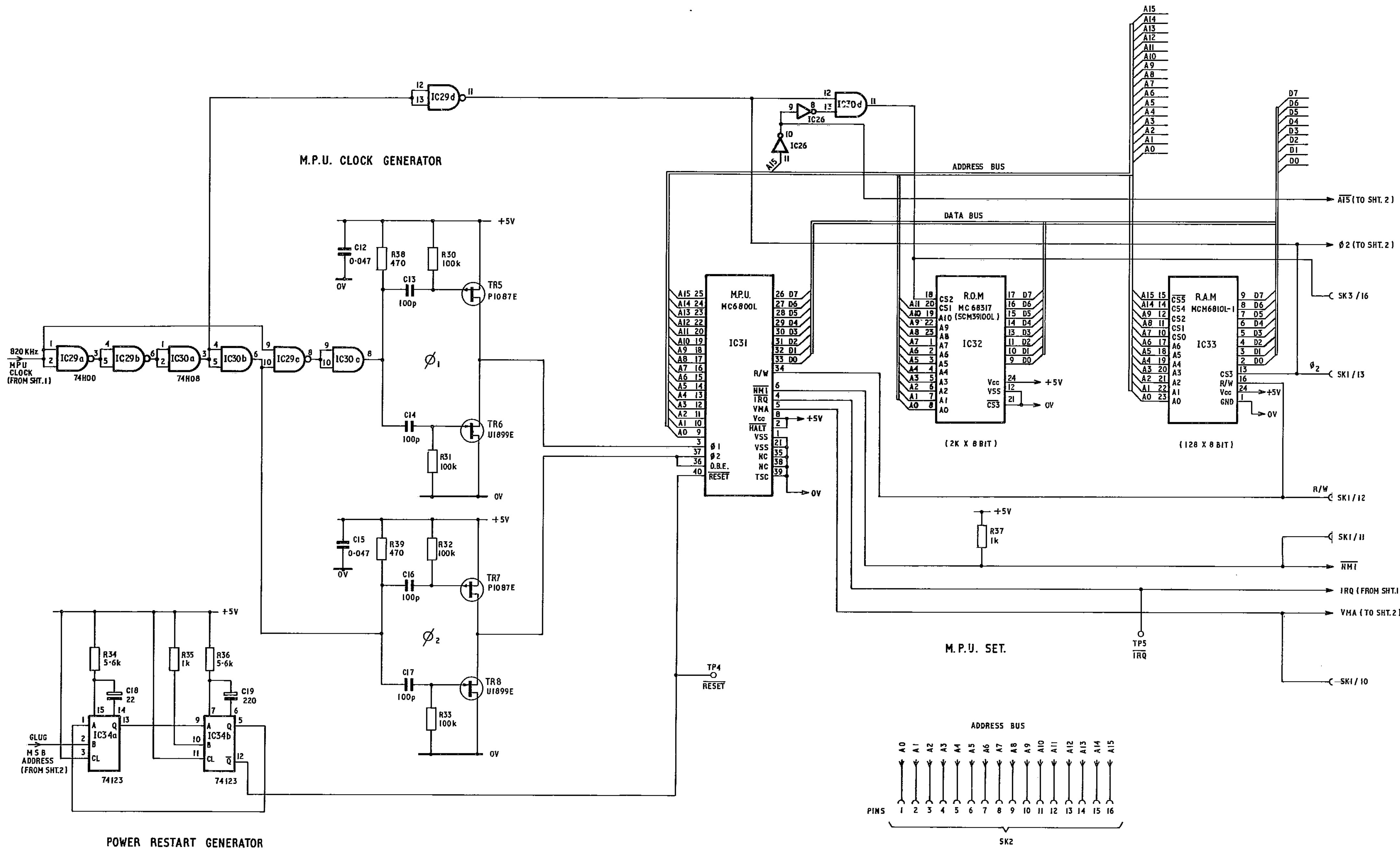
INTERRUPT REQUEST (IRQ)

Interrupt request (IRQ), initiated by the 800Hz clock signal, is applied to IC31 via IC6a (DIAG. 2 12). IRQ occurs every 1.25ms (800Hz input to IC6a pin 3), interrupting the measurements and blanking the display. It requests the MPU set to carry out a prescribed set of instructions. The MPU immediately stores its current state and carries out the operations detailed on page 4.[illegible]. When the cycle is completed, display blank is inhibited, the stored state is accessed allowing the MPU to carry on from where it stopped.

◀ *DIAG. 2.14 MICROPROCESSOR SET (PCB 3)*



DIAG. 2.13 DATA CONTROL (PCB 3)



DIAG. 2.14 MICROPROCESSOR SET (PCB 3)

NON MASKABLE INTERRUPT (NMI)

Control by remote operation only, has priority over IRQ.

VALID MEMORY ADDRESS (VMA)

When the address lines are correct, a VMA signal is fed to IC28a (DIAG. 2.14). This in turn enables the address bus decoders IC28, 24.

ADDRESS BUS AND DATA BUS

The address bus of 16 lines (A0 to A15), controls tri-state data transfer between the MPU set, input/ output ports and external memories or peripheral devices. This can take place over part of, or the whole of the 8 data lines of the data bus (D0 to D7).

POWER RESTART GENERATOR

Whenever the instrument is switched on IC34a and b (a retriggerable monostable) clears the contents of the MPU registers in order that program execution will start from a defined start location in memory. Also, during program execution, regular pulses are applied to the first monostable (IC34a pin 2) to keep it in the retriggered state. Should program flow be corrupted by noise spikes, these pulses will cease and the monostable will relax, initiating a new power restart pulse.

KEYBOARD (DIAG. 2.15)

This circuit contains the keyboard, its 18 keys arranged electrically in 6 columns of 3 rows. Each key is at an intersection of one row and one column to simplify key addressing (by the MPU).

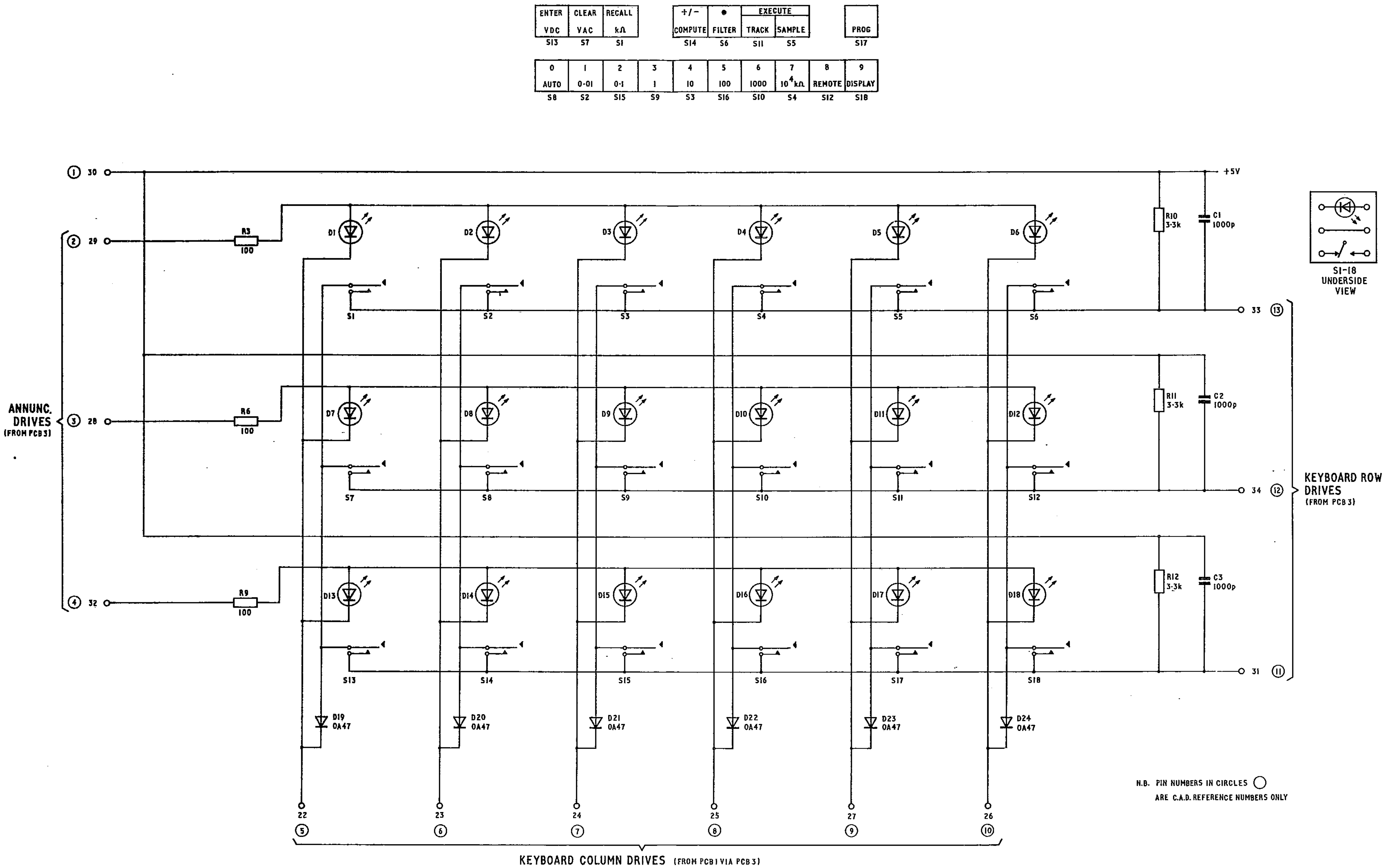
KEYBOARD DRIVES

An address decode continually scans the keyboard columns and sequentially places a single binary 0 on each column drive input. If any key in that column has been depressed a binary 0 will appear on the appropriate row output. In the same period, decoded data fed from the MPU and interfaced via TR9, 10 and 11 are used to illuminate key LEDs as required. The MPU set "knows" the column being strobed and this knowledge, in combination with the particular row output energised at a logic 0, establishes the identity of any key depressed.

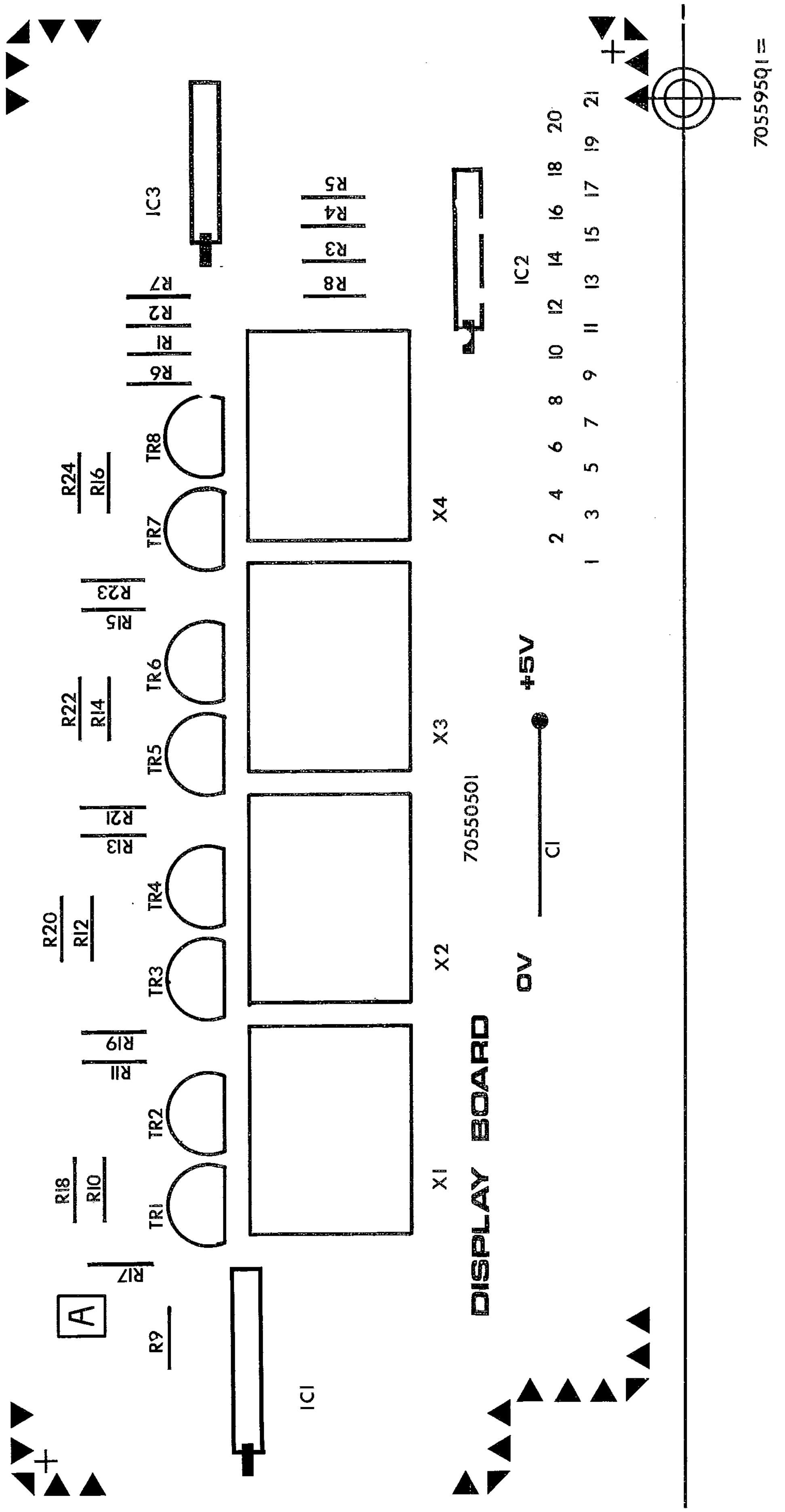
Key de-bouncing, multiple keying and key roll-over are eliminated by functions implemented in software and executed by the CPU.

D1 to D18 are keyswitch LEDs.

D19 to D24 are isolation diodes to prevent interaction between keys during selection.



DIAG. 2.15 KEYBOARD (PCB 2)



PCB 1 NOTATIONS

DISPLAY (DIAG. 2.16)

This circuit is driven from an output port which enables input data to the instrument once processed to be digitally displayed. A synchronisation signal for the keyboard and display scan is derived from this board.

DISPLAY FORMAT

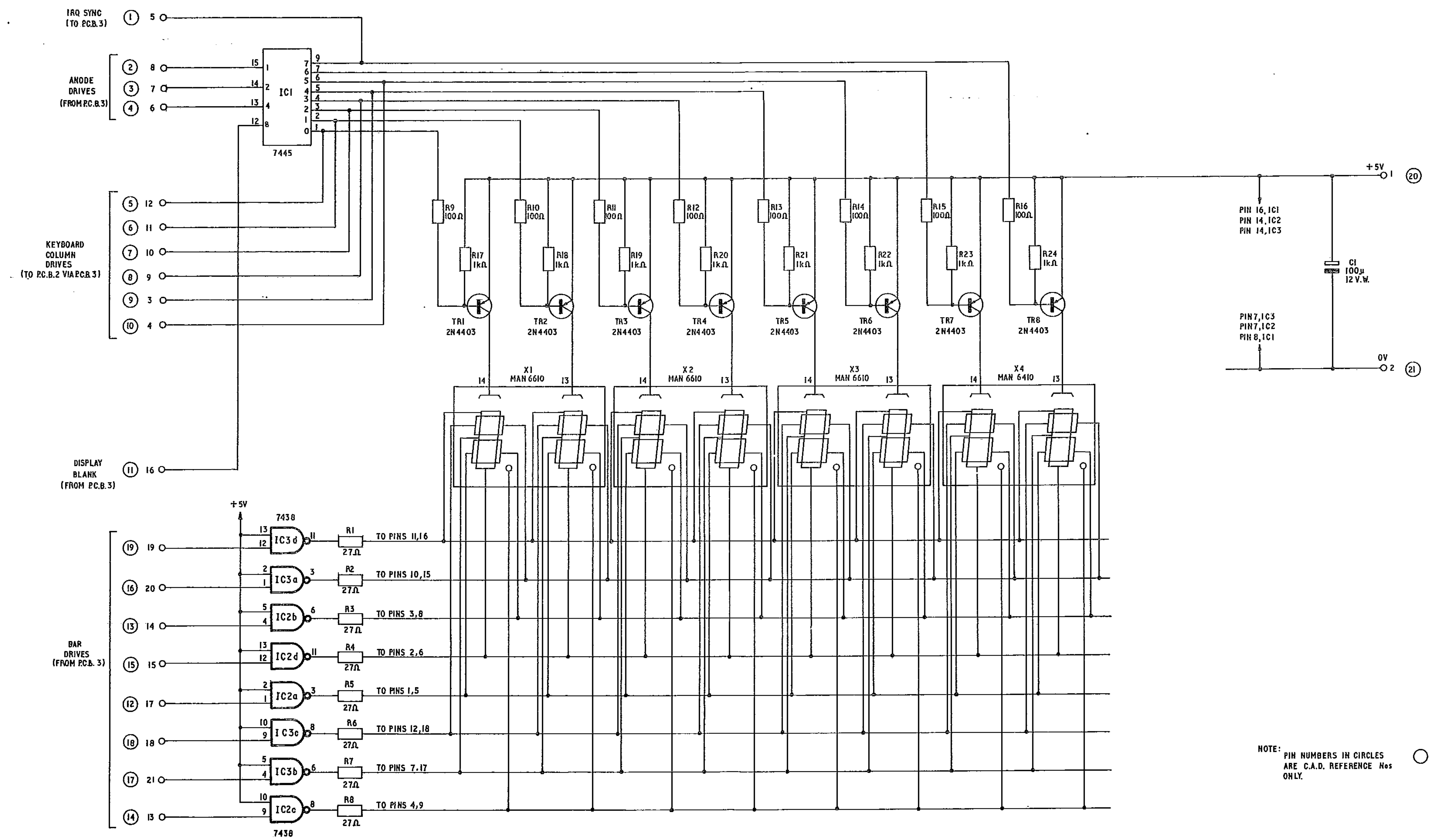
Eight decade windows are required to display the necessary information which includes a floating decimal point, a fixed minus sign (extreme left window) to indicate quantities that are negative, and two horizontal bars, one above and one below the minus sign, which illuminate when displayed information is invalid. (These 'bars' are also used as High, Low indicators in Program 6) Overload signals cause the display to flash.

Drives fed to pins 13, 14, 15 and 17 to 21, are buffered and interfaced by IC2a, b, c, d and IC3a, b, c, d to drive the 7 bar segments and floating decimal point. Rl to R8 limit current drive.

Anode drives from the phase locked clock (DIAG. 2.12) arriving on pins 13, 14 and 15 of IC1a, a one-in-n decoder, provide anode scan for the display. Display blank on pin 8 completes the inputs.

IC1 outputs, sequentially scanned, provide keyboard column drives while IRQ SYNC is output to the tri-state buffers on pcb 3 to synchronise keyboard and display scans (software) to hardware drives.

◀ *PCB 1 NOTATIONS*



DIAG. 2.16 DISPLAY (PCB 1)

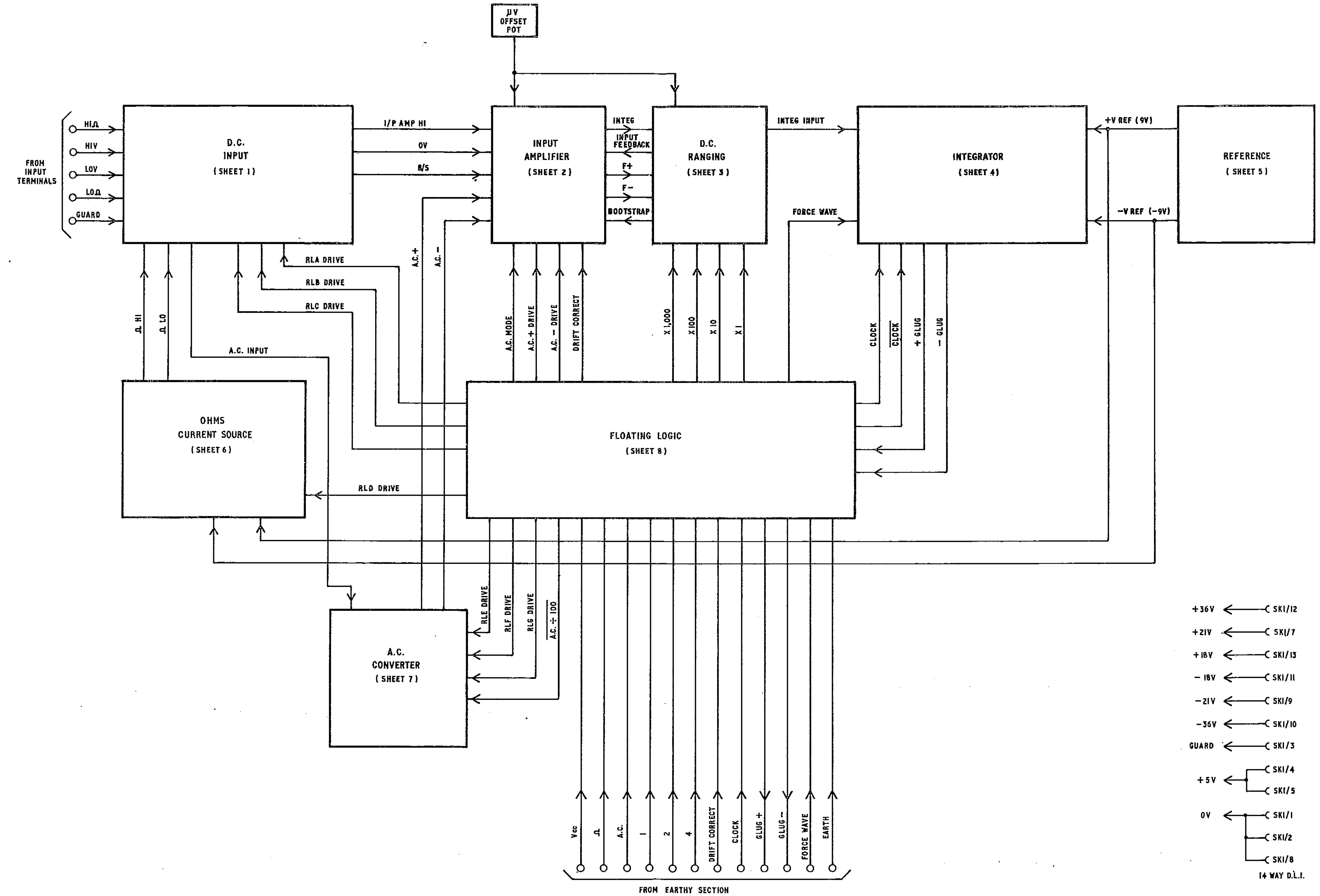
Section 3
Circuit Description
PCB 5 (Analogue) 7055 only

This section contains circuit diagrams and functional description of 7055 Board 5 to cover the major differences between the 7055 and 7065 – the remaining circuits for the other boards being common to both instruments.

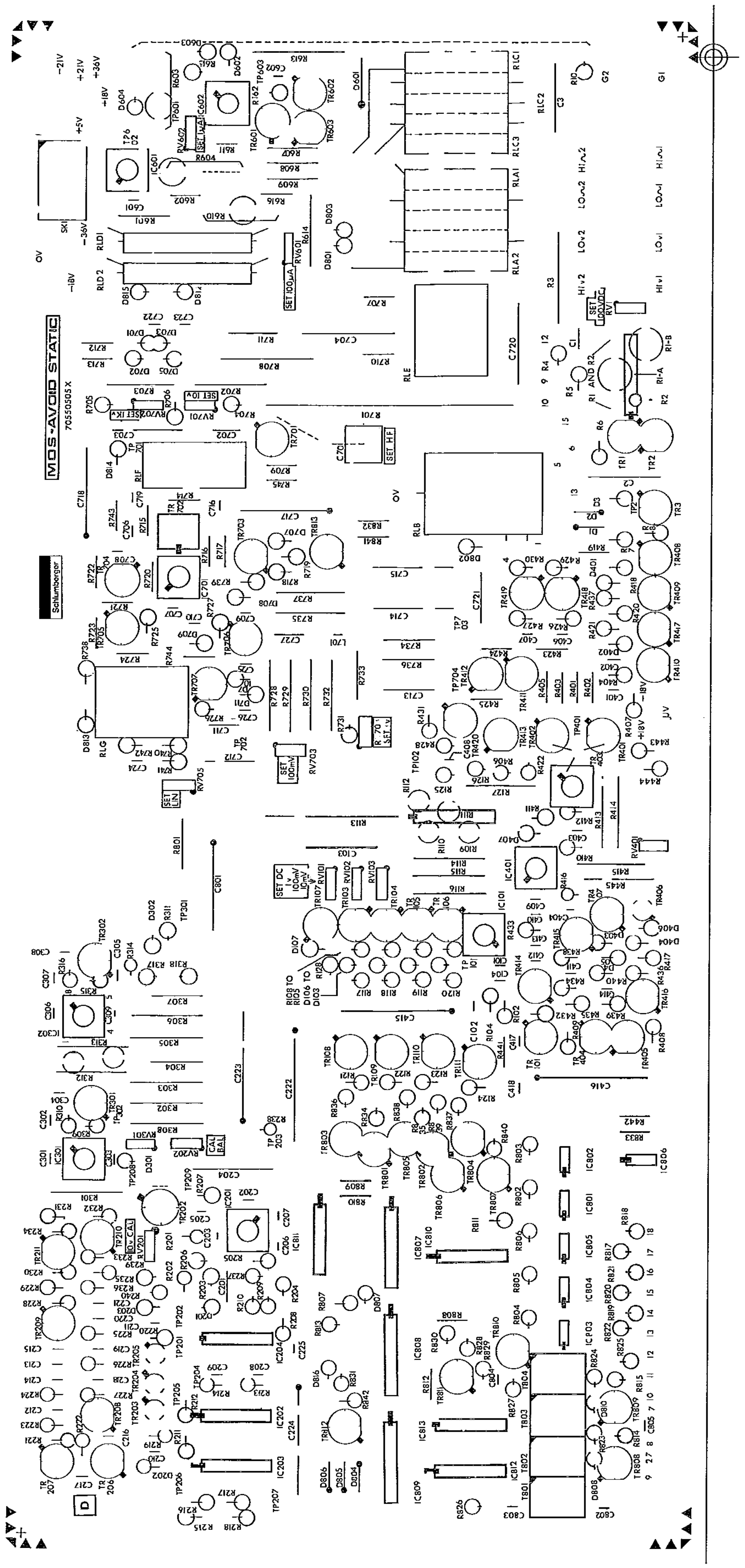
7055 BOARD 5

Diag. 3.0 illustrates in Block Schematic form 7055 board 5. The diagram also shows the circuits inter-connections, it's inputs and outputs, inter-circuit signal functions and their direction of flow.

Circuit descriptions of each "block" are contained in this section of the manual.



DIAG. 3.0 7055 PCB 5 INTERCONNECTIONS



PCB 5 NOTATIONS

DC INPUT (DIAG. 3.1)

The circuits shown in diagram 3.1 contain the input attenuator and input protection for DC measurements together with signal switching for AC and Resistance measurements.

INPUT ATTENUATOR

Resistors R1 and R2 form the DC Input Attenuator The attenuator is switched in and out of circuit by RLB which is controlled by a drive from IC808 (DIAG. 3.8).

When RLB is energised the input signal can pass without attenuation to 'I/P AMP HIGH' via R3 and contacts 12 and 13 of the relay. The instrument can accept up to 21V in this condition.

When RLB is de-energised the signal path via R3 is broken and contacts 5 and 6 are closed connecting R2 to OV. The input signal must now pass through R1 which, together with R2, provides an attenuation of 100:1 which may be adjusted by RV1 (SET 100V DC). C1, R4 and R5 are RLB contact spark suppression components.

INPUT PROTECTION

Despite the use of an Input Attenuator, large input swings could still occur, sufficient to over-drive the Input Amplifier (DIAG. 3.3). The Input Protection circuit provides an extra safeguard limiting excursions of the 'I/P AMP HIGH' line to approximately ±22V. Thus the circuitry (in DIAG. 3.3) connected to this line is protected from accidental overload. If higher voltages are applied to the 7055 input terminals, with the input attenuator set to x1, the excess voltage is dropped across R3.

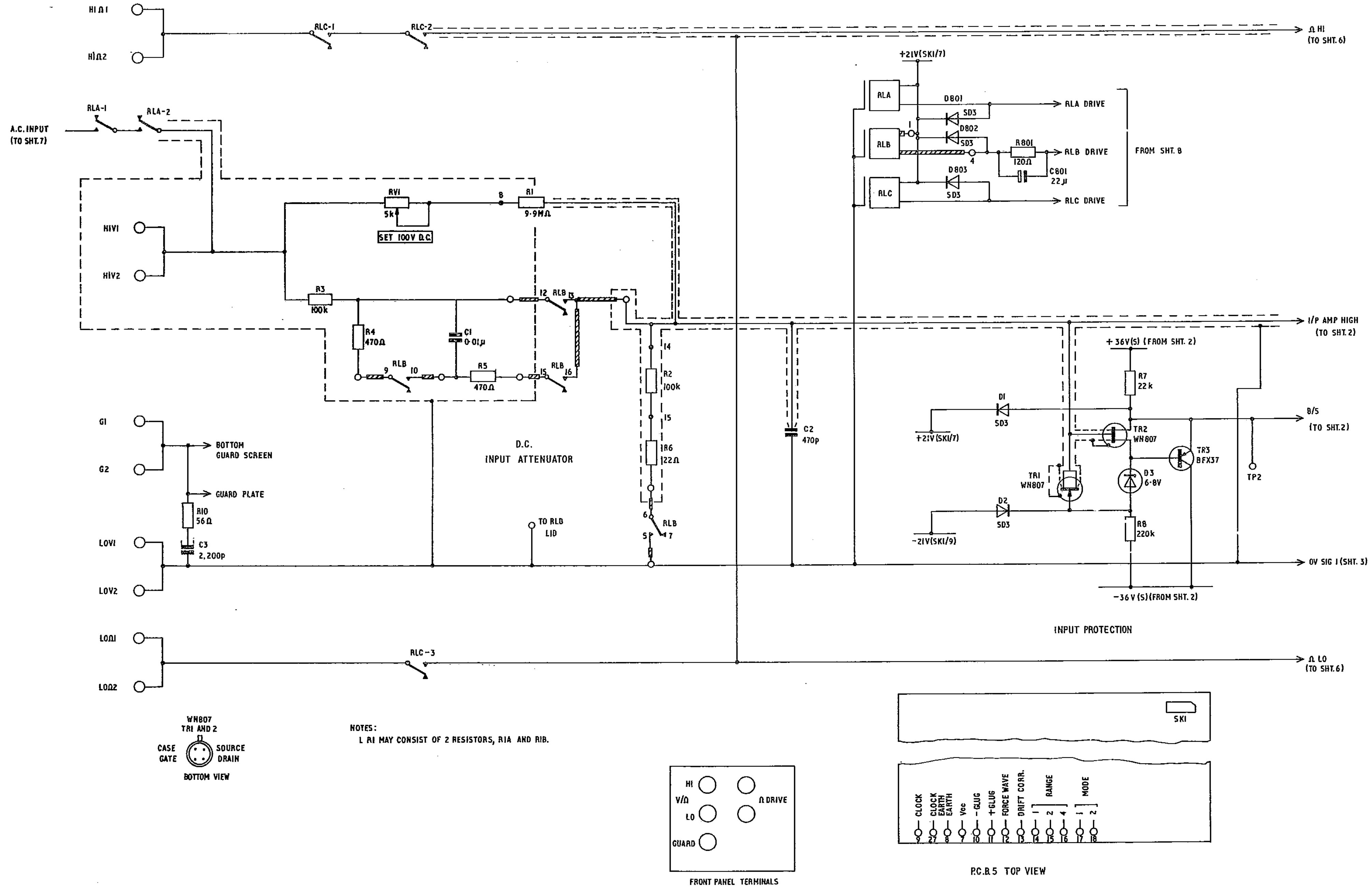
AC MEASUREMENTS

For AC Measurements RLA is energised to switch the input signal to the AC CONVERTER (DIAG. 3.7) via contacts RLA–1 and RLA–2. As there is no switch to break the connection to the 'I/P AMP HIGH' line, RLB is de-energised selecting the 100:1 attenuation to protect the DC circuits from high AC voltages. Overload protection for the AC Converter is shown in diagram 3.7.

RESISTANCE MEASUREMENTS

To measure resistance, a known current from the OHMS CURRENT SOURCE (DIAG. 3.6) is switched to the HIΩ and LOΩ input terminals by RLC. By suitable external connections, when this current is passed through the unknown resistor it produces a voltage between the HIV and LOV terminals which is measured by the DC circuitry in the normal way. To avoid loading the unknown resistance, the x1 setting of the input attenuator is selected for all resistance ranges. The protection for the Ohms Current Source is shown in diagram 3.6.

◀ *PCB 5 NOTATIONS*



DIAG. 3.1 DC INPUT

INPUT AMPLIFIER (DIAG. 3.2)

All input signals, however derived, are applied to this circuit, the last in the signal conditioning chain. In conjunction with the DC RANGING circuit (DIAG. 3.3) the amplifier scales the signals to a level suitable for processing by the A–to–D converter. The circuit is "area" coded 4.

MAIN AMPLIFIER

The main amplifier is composed of a differential amplifier (TR403) followed by an operational amplifier (IC401) and two common emitter amplifiers TR415 and TR414. Of the remaining transistors TR406 provides a current source for the input long-tail pair and TR's 404, 405, 407 and 416 provide the rails F+ and F– for the early stages of the amplifier. These rails follow the input signal and enable the amplifier to achieve a large input common mode range. The gain of the complete amplifier is determined by the range resistors on diagram 3.3.

Offsets in the Input Amplifier are initially taken out by choosing a suitable value for R415, soldering across link N if necessary and by adjusting RV401 (SET OFFSET). Such adjustments form part of the calibration procedure described later. Calibration Balance thereafter corrects for any further voltage errors.

CALIBRATION BALANCE

Calibration Balance also known as Drift Correction corrects for drift caused by temperature variations and component aging in the input amplifier and integrator. It also interrupts the measurement and occurs under the following conditions:

a) Immediately after a Range Change

b) After a change in Integration Time

c) After a change of Measurement Function

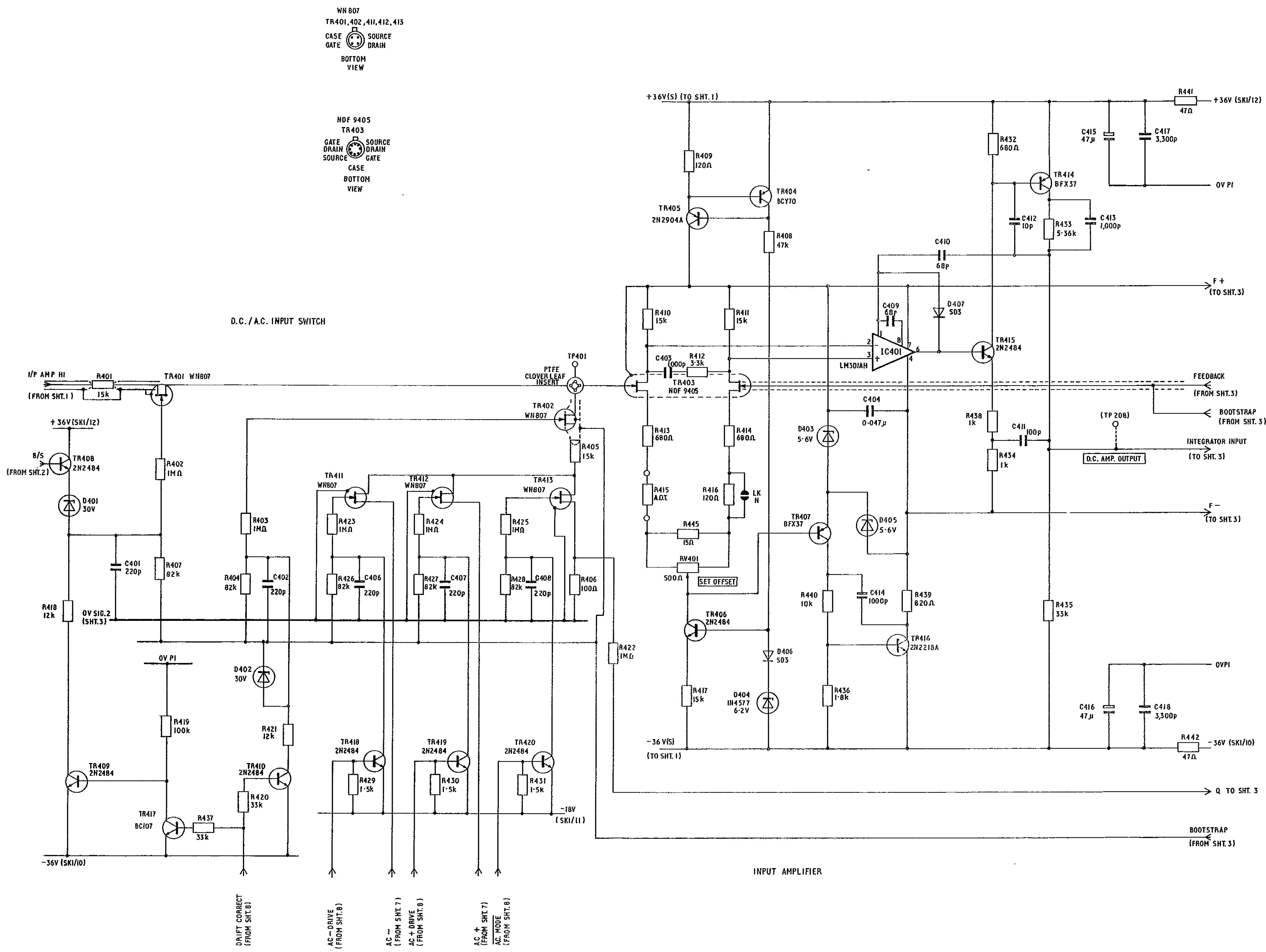
d) Every 10 seconds, controlled by a built-in clock.

DC AND OHMS MODE

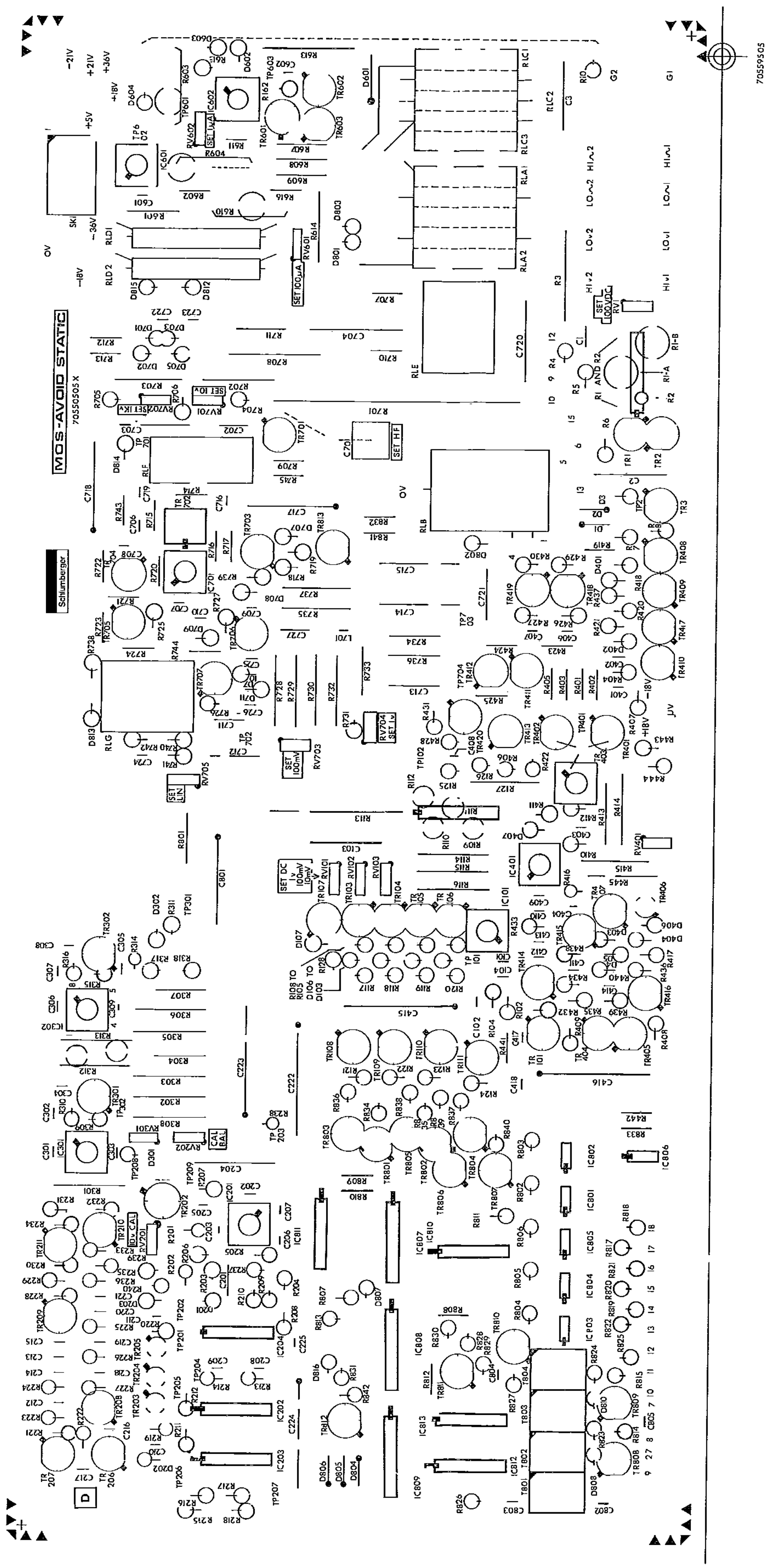
During drift correction, TR401 is switched off isolating the input signal from the Input Amplifier. TR402 and TR413 are switched on to connect the Input Amplifier input to OV thus allowing the system to correct for error voltages in the circuits that follow.

AC MODE

In this mode TR401 and TR413 are switched off. TR412 and TR411 are switched on alternately for half of each measurement to select first the positive and then the negative output of the AC Converter. The output thus selected drives the input amplifier via TR402, which is switched on for the whole measurement. Combining a positive and a negative measurement in this way achieves calibration balance for AC measurements.



DIAG. 3.2 INPUT AMPLIFIER



PCB 5 NOTATIONS

DC RANGING (DIAG. 3.3)

The gain of the main Input Amplifier (DIAG. 3.2) is controlled by the scaling resistor network in this circuit, which is "area" coded 1.

DC RANGING

R109 to R112 are a matched set forming the feedback network for the input amplifier. The feedback connection is selected by one of the FET switches TR's 103 to 106 which, in turn, are switched on by drives obtained from the DC Decoder (DIAG. 3.8). Thus the amplifier gain may be set to x1, x10, x100 or x1000. Resistors R113 to R116 together with RV101, RV102 and RV103 permit the gain to be accurately adjusted.

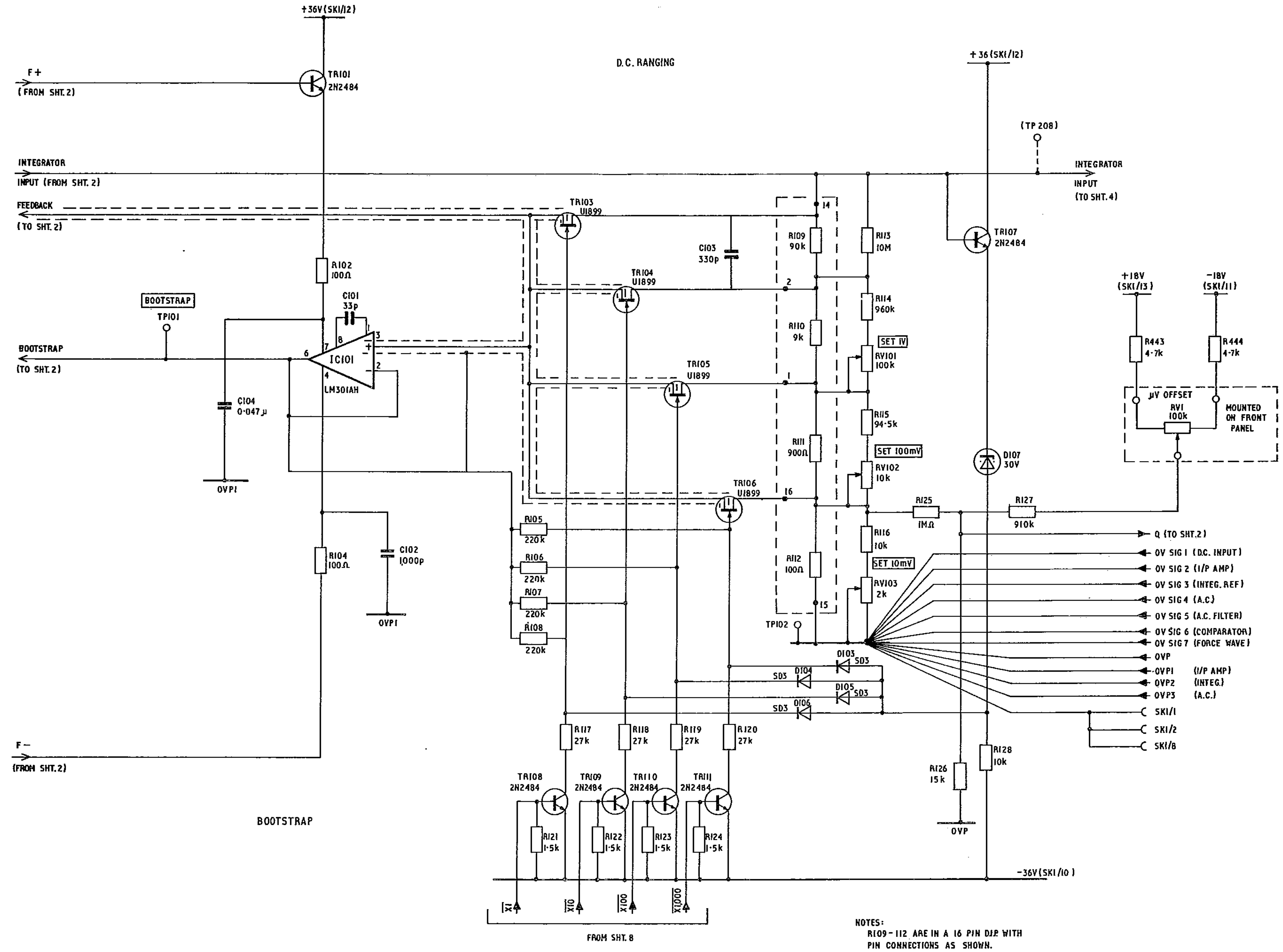
μV OFFSET

This is provided to permit the backing-off of any small zero errors which might be generated externally to the voltmeter.

BOOTSTRAP AMPLIFIER

Amplifier, IC101, is a low output impedance, unity gain, voltage follower producing an output voltage level close to that of the input to the input amplifier. This output is used to provide a suitable gate voltage to switch on the gain-defining FETs, TR103 to TR106, and the input switching FETs, TR401, 402, 411 and 412 (see diagram 3.2). BOOTSTRAP also affords additional guarding throughout the feedback circuits.

◀ *PCB 5 NOTATIONS*



DIAG. 3.3 DC RANGING

ANALOGUE TO DIGITAL CONVERTER (DIAG. 3.4)

This circuit – comprising an integrator; level detectors; clock synchronising bistables; reference switching FETs and their associated drivers - converts the voltage provided by the input amplifier into pulses. These, when used to gate Clock into a counter, provide a count proportional to the input voltage. This section of pcb 5 is "area" coded 2.

INTEGRATOR

The integrator (IC201) has the following three inputs connected to its summing point:

1. The input to be measured at TP208.

2. The Forcing Waveform which is ac coupled at TP201.

3. +REFERENCE, –REFERENCE or OV at TP202.

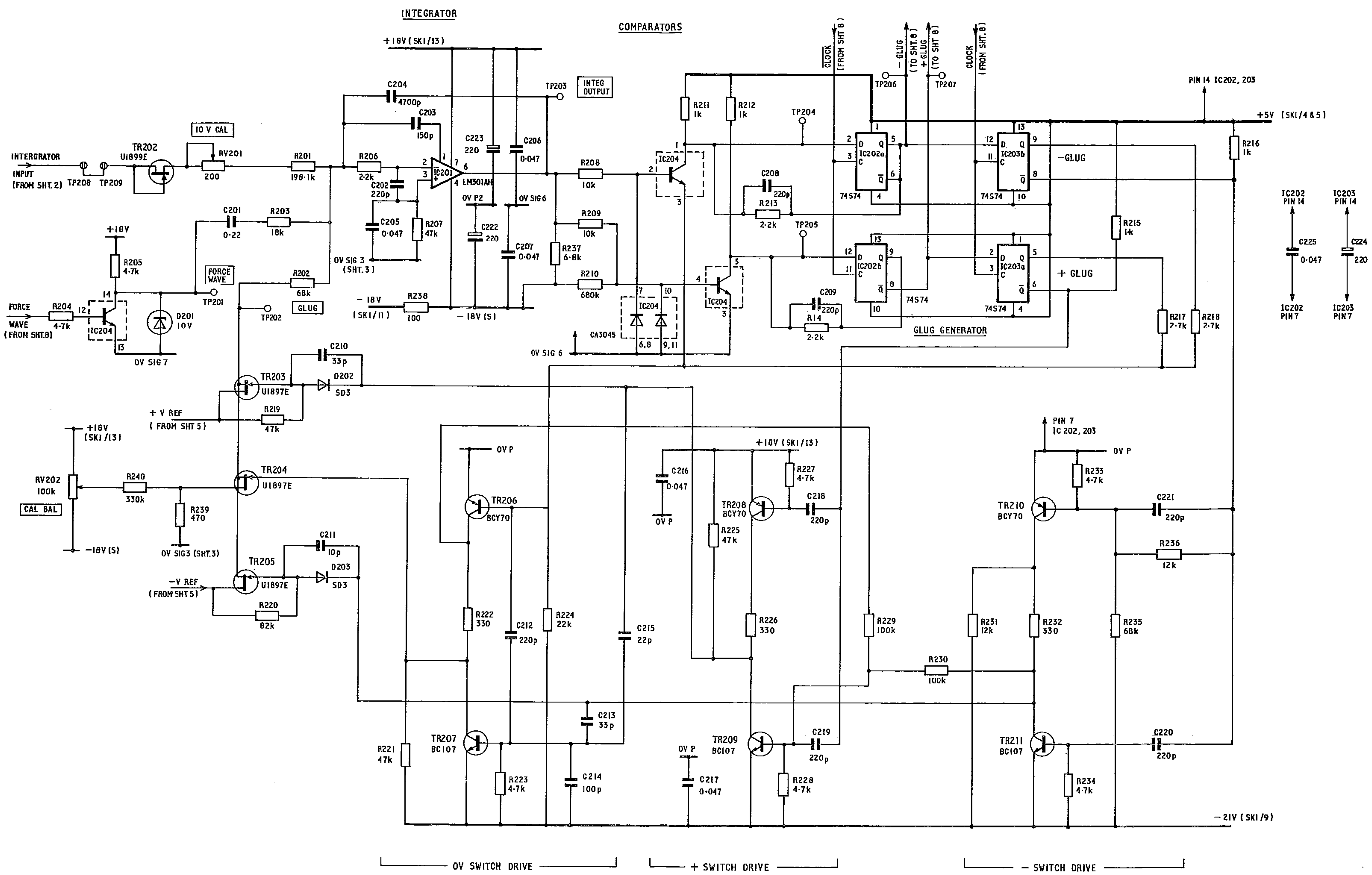
With the input voltage (TP208) at OV and a 3.2kHz forcing square wave applied continuously to the integrator, the output is driven alternately positive and negative through the thresholds of the detectors (IC204 pins 2 and 4). The state of the detectors is followed by IC202 and IC203 which thus synchronise the transitions of clock. The outputs of IC203 are then used to drive the FET switches, which connect the appropriate voltage to the integrator input (TP202). The integrator output is thereby dynamically balanced about zero. The voltage at TP202 consists of positive and negative reference pulses (GLUGS) running at 3.2kHz, the width of which will be adjusted by the detectors so as to maintain the balance at the integrator output. This feedback ensures that the width of the reference pulses is proportional to the input voltage applied to TP208.

GLUG

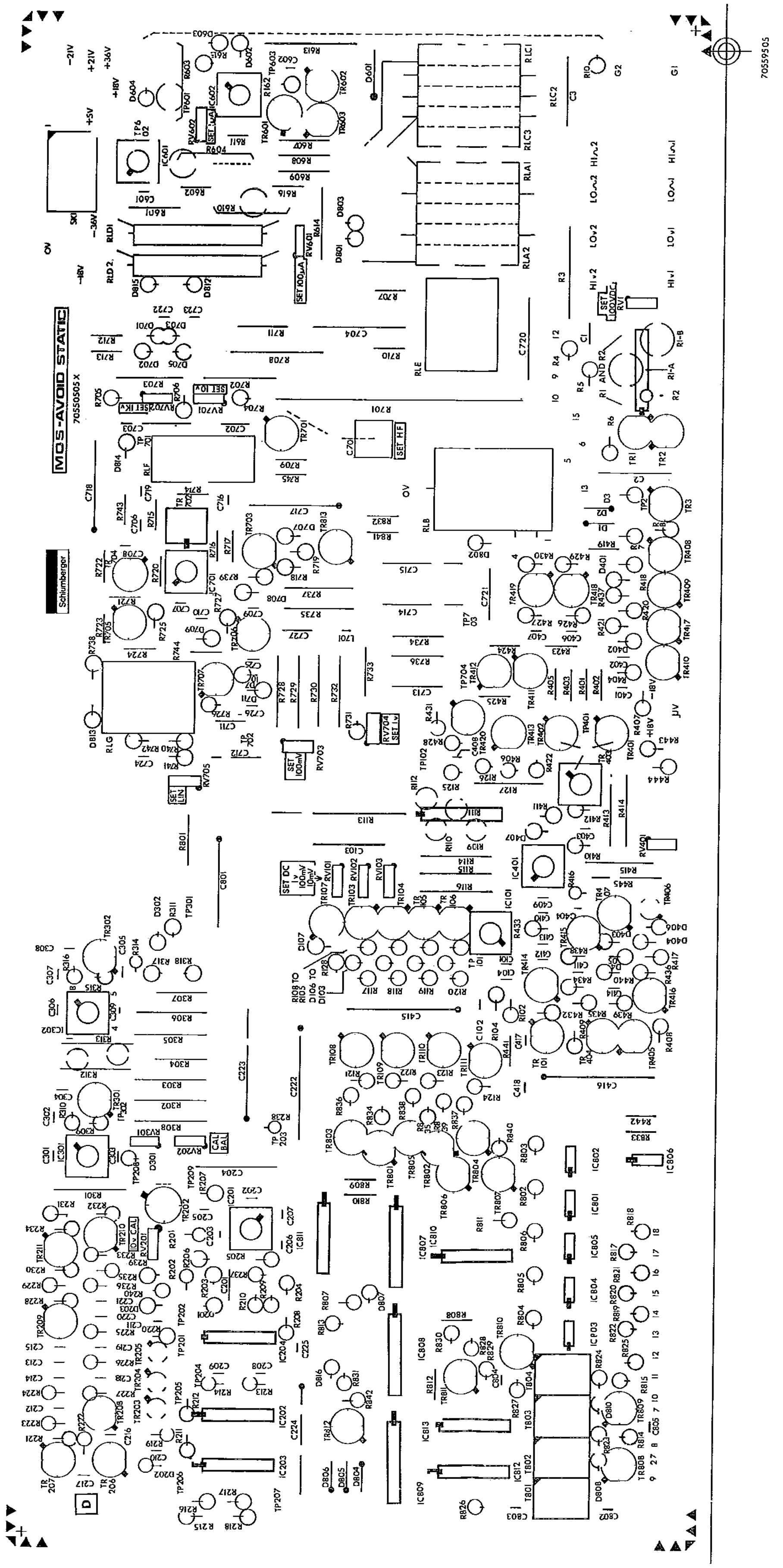
Within this manual the reader will find many signal annotations which include the word "GLUG". The term is used as a convenient alternative to the cumbersome title "Quantum of Charge" (i.e. v x t) and should be treated merely as an identifier label facilitating circuit tracing.

CALIBRATION BALANCE ADJUSTMENT (RV202)

RV202 is adjusted during calibration in order to compensate for any asymmetry in the Analogue to Digital Converter which would otherwise cause the positive and negative readings to be unequal. Once adjusted, the calibration balance sequence, described earlier, automatically corrects for any drifts and keeps positive and negative readings in agreement.



DIAG. 3.4 INTEGRATOR



PCB 5 NOTATIONS

REFERENCE (DIAG. 3.5)

The reference voltages are generated in the circuits illustrated in diagram 3.5 which are "area" coded 3 on board 5.

INTERNAL REFERENCE

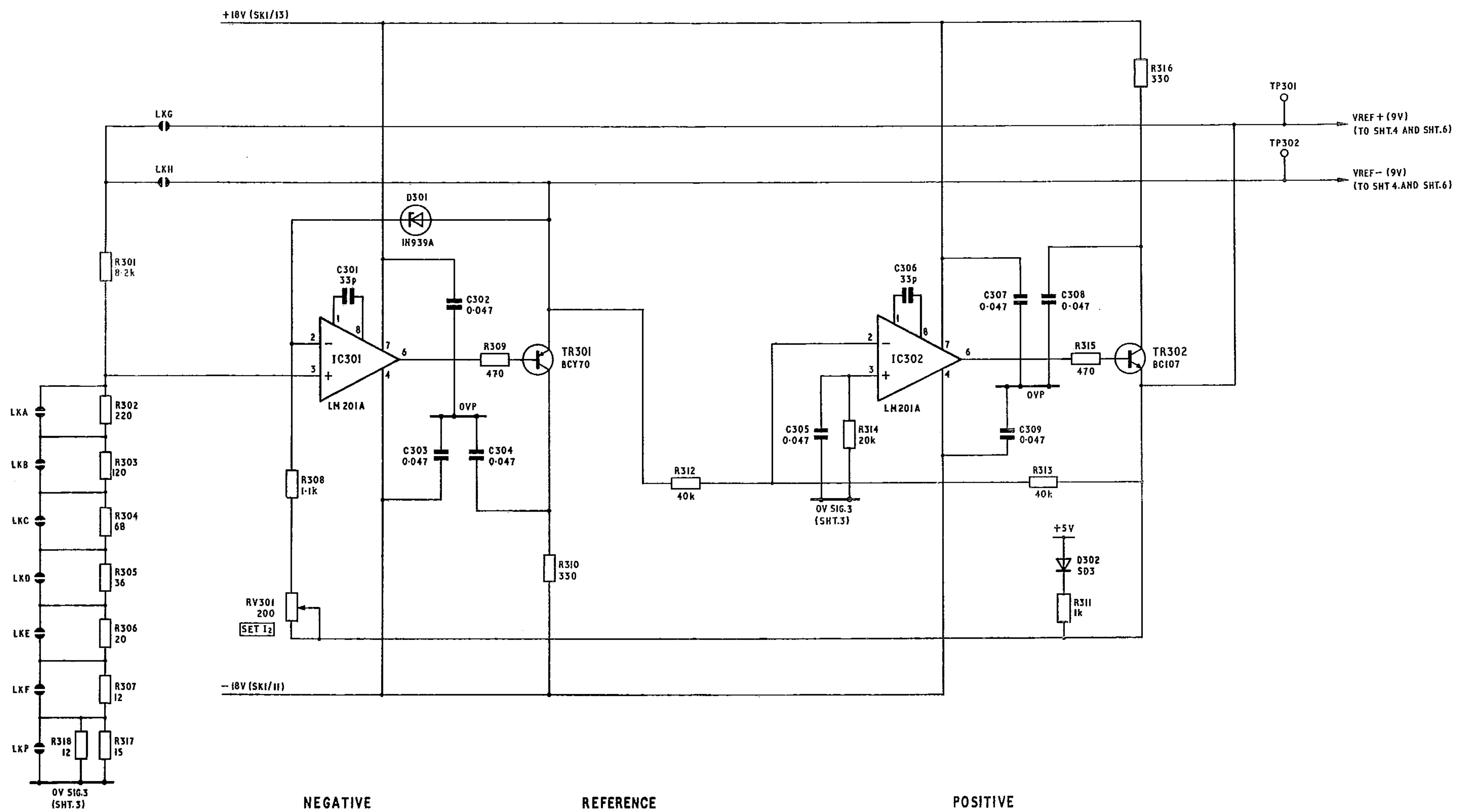
In this circuit there are two amplifiers, the first consisting of IC301 and TR301, the second, IC302 and TR302.

The first amplifier has a reference zener diode D301 as its feedback element and this defines its output at –9 volts. This output is the negative Reference voltage.

R312 and R313 define the gain of the second amplifier (IC302, TR302) to be –1. The output voltage of this amplifier is therefore +9 volts and this is used as the positive Reference. This reference applied to R308 provides a constant current through D301, thus keeping the Reference voltages very stable.

Links G and H, the resistor network R302 to R307 and the associated links A to E, together with RV301, are used during calibration to take out zener tolerances in order to accurately define the positive and negative 9 volt references.

◀ *PCB 5 NOTATIONS*



DIAG. 3.5 REFERENCE

RESISTANCE (DIAG. 3.6)

Resistance measurement with the 7055 is accomplished by measuring the voltage developed across the unknown resistor produced by a known current passing through it. This section of board 5 (which is "area" coded 6) generates the necessary current.

CURRENT GENERATORS

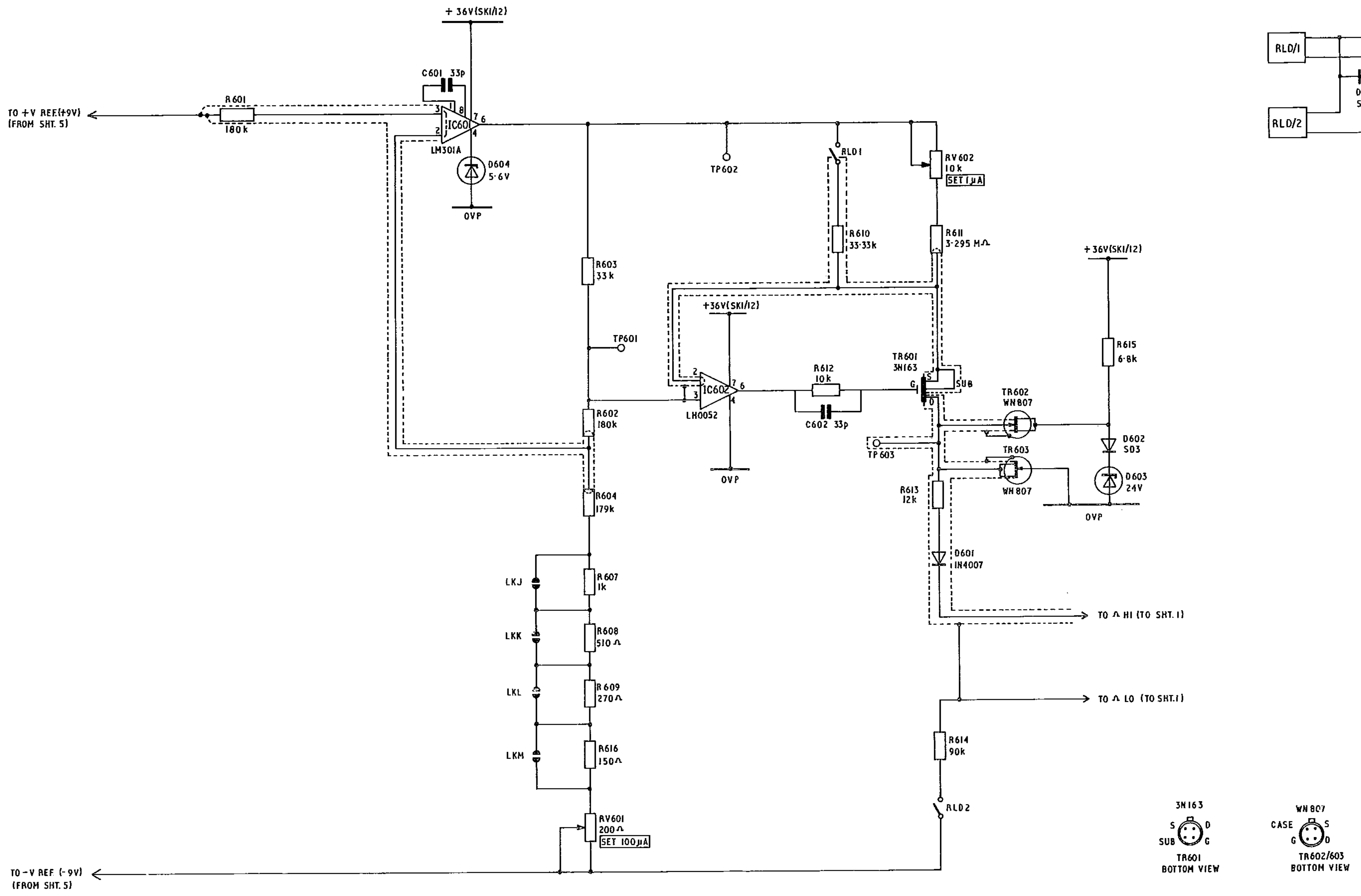
The positive and negative references applied to IC601 determine the current through R604 which, in its turn, produces a reference potential across R603. (R603, R604 are a matched set). IC602 uses this potential to define the current through TR601 which is the ΩHI current. Relay RLD, driven by IC811f,. selects the value of the ΩHI current as follows:

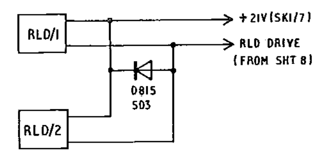
RLD1	closed	100μA	0.1kΩ, 1.0kΩ, 10kΩ and 100kΩ ranges
RLD1	open	1μA	1000kΩ and 10^4 kΩ ranges

The second pair of contacts of RLD provides connection to the ΩLO terminal for the necessary current sink necessary to give effective 4–terminal measurement on all but the 1000kΩ and 10^4 kΩ ranges.

Links J to M, RV601 and RV602 are used to adjust the HIΩ current and are set as required during factory calibration.

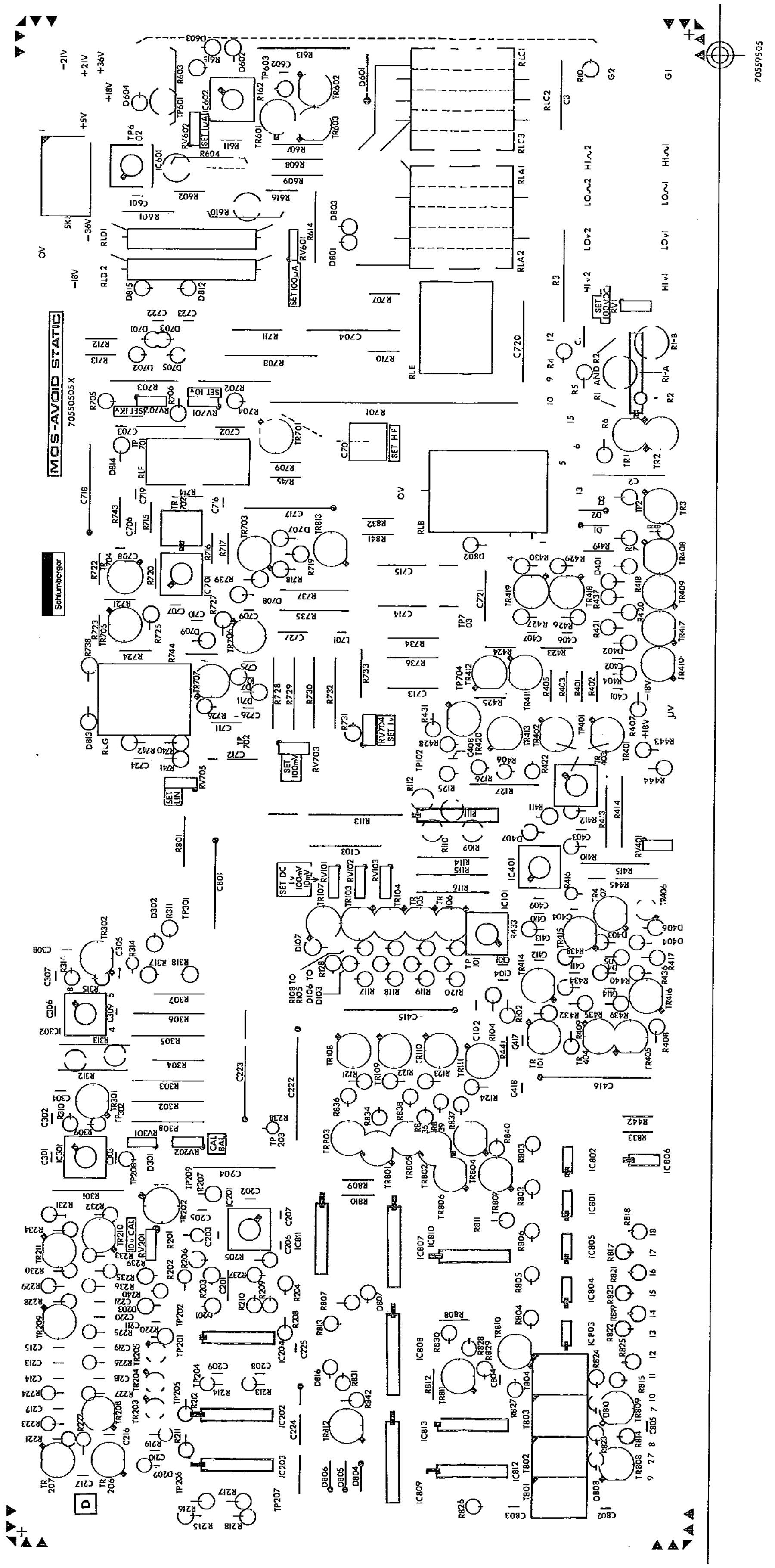
R613, D601, TR602 and TR603 are for protection against accidental overload. TRs 602 and 603 catch the drain of TR601 at +25 volts and –0.6 volts respectively and thereby prevent damage to TR601 and IC602, with R613 and D601 limiting the current into the catching transistors.





Ω CURRENT SOURCE

DIAG. 3.6 RESISTANCE



PCB 5 NOTATIONS

AC CONVERSION (DIAG. 3.7)

Diagram 3.7 illustrates the circuits concerned with processing an alternating input to produce an equivalent dc level. The dc signal thus obtained is fed to the input amplifier as described earlier in this part of the manual under "DC". This circuit is "area" coded 7 on pcb 5.

AC ATTENUATOR

Three alternative signal paths provide attenuation as follows:

on the 1000V range	1:1000 via R701, R702, RLF
on the 10V, 100V ranges	1:100 via R701, TR701
other ranges	no attenuation via RLE

The output from this stage is thereby scaled to a maximum of 2 volts. Relay drives for RLE and RLF, and the gate drive for TR701, are derived from the AC DECODER circuit (DIAG. 3.8). Potentiometers RV701 and RV702 provide attenuator adjustment for the 10V and 1000V ranges while C701 is adjusted to balance the attenuator for high input frequencies.

PROTECTION

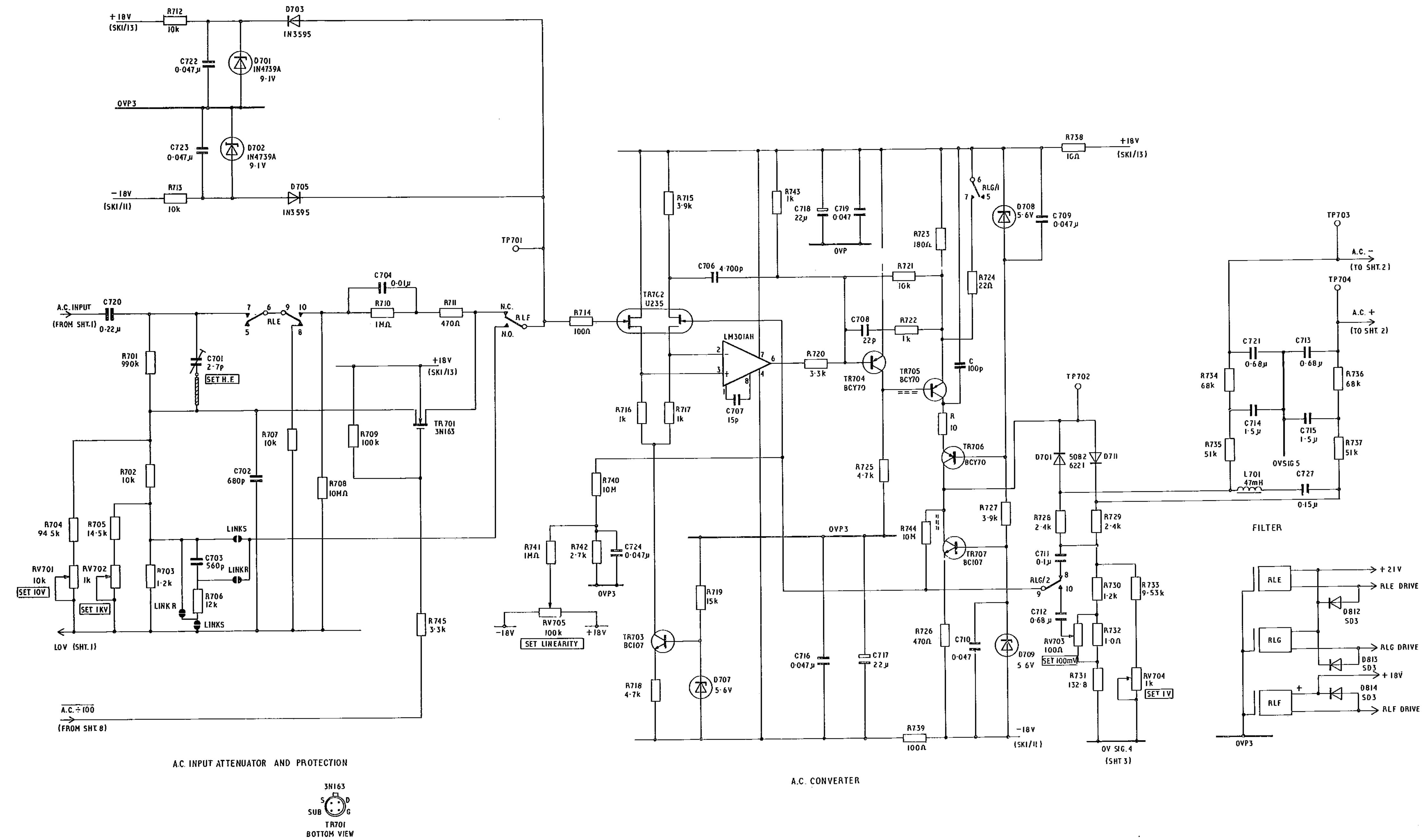
Diodes D701, 702, 705 and 706 prevent the voltage at TP701 from exceeding ±10 volts, with respect to 0 volts, thereby protecting the AC Converter circuits. C704, R710 and R711 limit the current into this catching circuit when the attenuator is set to x1.

AC CONVERTER

The AC Converter combines the two functions of converter and buffer amplifier, as it presents a high input impedance which does not significantly load the attenuator. Rectification is achieved having two feedback paths selected, one path for positive signals and one for negative signals. Outputs from the two paths are smoothed independently by the FILTER circuit to give positive and negative dc outputs which are fed to the DC amplifier (DIAG. 3.2) via TR412 and TR411.

The AC Converter can operate with a gain of x1 or x10 switched by RLG, whose drive is derived from IC809 in diagram 3.8. RLG, in addition to switching the feedback components which define the overall gain, also switches the forward gain of the converter amplifier to maintain the same accuracy on both ranges. As all the necessary AC range switching is included in these circuits (DIAG. 3.7), the DC input amplifier is set to x10 for all AC ranges.

◄ *PCB 5 NOTATIONS*



DIAG. 3.7 AC CONVERSION

FLOATING LOGIC (DIAG.3.8)

The three main functions of this circuit ("area" coded 8) are:

1. Decoding range and mode (function) information to give the appropriate relay and FET drives.

2. To provide a gated clock which is counted to compute the reading.

3. To provide an interface, by means of opto-couplers and pulse transformers, between the floating measurement circuits and circuits which are connected to earthy supplies on pcb 3.

RANGE AND MODE DECODERS

Data is sent out at the beginning of each reading via the latches of IC22 on pcb 3. The data which determines the range and mode switching is transferred to the floating circuitry by the opto-couplers of ICs 801 to 805 and then via the buffers of IC810 to the decode circuitry. When required, Drift Correct (DC) is commanded in the same way and transferred by opto-coupler IC806 via the Floating Logic circuit (DIAG. 3.8) to the Input Amplifier (DIAG. 3.2).

DC DECODER

IC807, a bcd to decimal decoder, decodes the range and mode data to generate the control signals for the DC Ranging circuits (DIAG. 3.3).

AC DECODER

IC809 provides the necessary decoding and current drive for the control of the AC range switching (DIAG. 3.7).

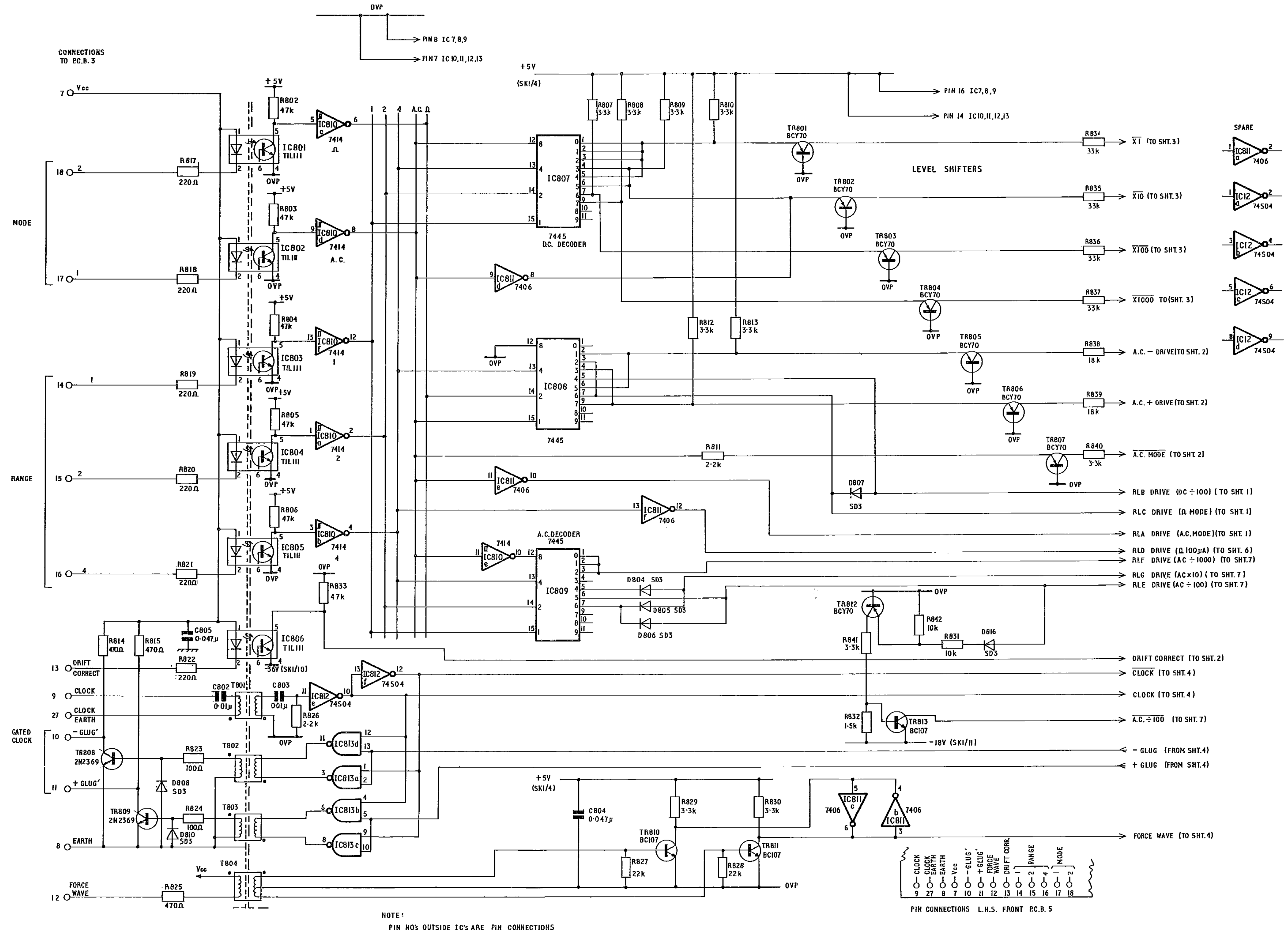
IC808 together with inverters IC811e and f, decodes the relay/switch drives for control of the Ohms current source (DIAG. 3.6) and the remaining ac and dc switching.

MEASUREMENT WAVEFORMS

The Forcing Waveform is sent from the earthy logic via a pulse transformer. As the output from this transformer is only a short pulse when the forcing waveform changes state, it is necessary to reform the square wave in the floating circuits. TR810 and 811 and inverters IC811b and c form a set/reset bistable which regenerates the 3.2kHz square wave. This is then passed to the integrator via a buffer mode from a transistor IC204.

The system clock frequency is also transmitted to the floating logic by a pulse transformer (T801). The inverters of IC812 buffer the output of this transformer and produce the two phases (CLOCK and $\overline{\text{CLOCK}}$) required by the gates of IC813 and ICs 202 and 204 (DIAG. 3.4).

The GLUG outputs of IC202 are gated with the clock frequency by IC813 to produce bursts of clock pulses. These are transmitted to a reversible counter on pcb 3 via pulse transformers T802 and T803.



DIAG. 3.8 FLOATING LOGIC

RANGE DECODE TABLE

MODE	RANGE	DISCONNECT PINS (see note 1) 17	18	13	16	15	14	INPUT AMP GAIN	RELAY DRIVES (see note 2) A	B	C	D	E	F	G
DC	1000V	1	1	see note 3	1	0	1	x1	0	0	0				
	100V	1	1		1	0	0	x10	0	0	0				
	10V	1	1		0	1	1	x1	0	1	0				
	1V	1	1		0	1	0	x10	0	1	0				
	0.1V	1	1		0	0	1	x100	0	1	0				
	0.01V	1	1		0	0	0	x1000	0	1	0				
AC	1000V	0	see note 4	0	1	0	1	x10	1	0	0		0	1	0
	100V	0		0	1	0	0	x10	1	0	0		0	0	0
	10V	0		0	0	1	1	x10	1	0	0		0	0	1
	1V	0		0	0	1	0	x10	1	0	0		1	0	0
	0.1V	0		0	0	0	1	x10	1	0	0		1	0	1
kΩ	10^4 kΩ	1	0	see note 3	1	0	1	x1	0	1	1	0			
	1000kΩ	1	0		1	0	0	x10	0	1	1	0			
	100kΩ	1	0		0	1	1	x1	0	1	1	1			
	10kΩ	1	0		0	1	0	x10	0	1	1	1			
	1kΩ	1	0		0	0	1	x100	0	1	1	1			
	0.1kΩ	1	0		0	0	0	x1000	0	1	1	1			

NOTES

1. The disconnect pins code "1" and "0" refer to normal T.T.L. levels.

2. The relay drive code is as follows:

   '1' = Relay energised

   '0' = Relay de-energised

   The state of the relay does not matter where there are no codes shown

3. Disconnect pin is coded '1' for normal measurement

   and '0' for Drift Correct.

4. Disconnect pin 18 switches between 1 and 0 during the measurement to select positive and negative outputs from the filter.

Section 4
Component Parts Lists

This section contains detailed Parts Lists for each of the printed circuit boards fitted in the instrument. When ordering spare parts, it is essential to quote the instrument serial number, located on the rear panel, as well as the full description shown in the appropriate parts list.

COMPONENT PARTS LIST ABBREVIATIONS

CIRCUIT REFERENCES

AE	Aerial	R	Resistor (Ω)
B	Battery	RE	Recording Instrument
C	Capacitor (μF)	RL	Relay
CSR	Thyristor	S	Switch
D	Diode	SK	Socket
FS	Fuse	T	Transformer
IC	Integrated Circuit	TP	Terminal Post (or Test Point)
L	Inductor	TR	Transistor
LP	Lamp (including Neon)	V	Valve
LK	Link	X	Other Components
M	Motor		
ME	Meter		
MSP	Mains Selector Panel		
PL	Plug		

Also Used:-

RNL	Non Linear Resistor (Ω)
RV	Variable Resistor (Ω)

COMPONENT TYPES

Fixed Resistors

Carbon Composition	CACP
Carbon Film	CAFM
Cracked Carbon	CKCA
Metal Film	MEFM
Metal Oxide	MEOX
Power Wirewound	POWW
Precision Wirewound	PRWW
Temperature Sensitive	TEMP
Thick Film	TKFM
Thin Film	TNFM
Voltage Sensitive	VOLT

Variable Resistors

Carbon Front Panel Multiturn	CAFM
Carbon Front Panel Single Turn	CAFS
Carbon Preset Multiturn	CAPM
Carbon Preset Single Turn	CAPS
Cermet Front Panel Multiturn	CMFM
Cermet Front Panel Single Turn	CMFS
Cermet Preset Multiturn	CMPM
Cermet Preset Single Turn	CMPS
Wirewound Front Panel Multiturn	WWFM
Wirewound Front Panel Single Turn	WWFS
Wirewound Preset Multiturn	WWPM
Wirewound Preset Single Turn	WWPS

Capacitors

Air	AIR
Aluminium Electrolytic	ALME
Aluminium Solid	ALMS
Polycarbonate	CARB
Ceramic	CERM
Polyester Foil	ESTF
Polyester Metallised	ESTM
Glass	GLAS
Mica	MICA
Metallised Lacquer	MLAC
Paper Foil	PAPF
Paper Metallised	PAPM
PTFE	PTFE
Polypropylene Film	PYLN
Polystyrene	STYR
Tantalum Dry	TAND
Tantalum Foil	TANF
Tantalum Wet	TANW

PCB 1

Cct Ref	General Description				Solartron Part No.
R1 to R8	CACP	27	1/4W	10%	172012700
R9 to R16	CACP	100	1/4W	10%	172021000
R17 to R24	CACP	1k	1/4W	10%	172031000
C1	ALME	220μ	10V	+100% -20%	273182200
IC1	7445				510000900
IC2	7438				510002110
IC3	7438				510002110
X1 to X4	MAN 6610				300730320
TR1 to TR8	2N 4403				300555570

PCB 2

Cct Ref	General Description				Solartron Part No.
R3	CACP	100	1/4W	10%	172021000
R6	CACP	100	1/4W	10%	172021000
R9	CACP	100	1/4W	10%	172023300
R10	CACP	3.3k	1/4W	10%	172033300
R11	CACP	3.3k	1/4W	10%	172033300
R12	CACP	3.3k	1/4W	10%	172033300
C1 to C3	CERM	1,000p	500V	20%	241331000
D19 to D24	OA47				300520850
S1/D1 to S16/D16	Switch/L.E.D. Assy Type SRL with Red L.E.D. and Black button (Schadow/I.T.T.)				377500320
S17/D17	SRL/Red L.E.D. Grey button				377500350
S18/D18	SRL/Red L.E.D. Blue button				377500340

PCB 3

Cct Ref	General Description				Solartron Part No.
R1	CACP	15k	1/2W		172341500
R2	CACP	100	1/4W	10%	172021000
R3 to R5	CACP	1000	1/4W	10%	172031000
R6	CACP	220k	1/4W	10%	172052200
R7	CACP	220k	1/4W	10%	172052200
R8	CACP	100k	1/4W	10%	172051000
R9	CACP	100k	1/4W	10%	172051000
R10	CACP	220k	1/4W	10%	172052200
R11	CACP	100k	1/4W	10%	172051000
R12	CACP	47k	1/4W	10%	172044700
R13	CACP	470	1/4W	10%	172024700

PCB 3 (cont)

Cct Ref	General Description				Solartron Part No.
R14	CACP	10k	1/4W	10%	172041000
R15	CACP	330	1/4W	10%	172023300
R16	CACP	33	1/4W	10%	172013300
R17	CACP	100	1/4W	10%	172021000
R18	CACP	220	1/4W	10%	172022200
R20 to R27	CACP	4.7k	1/4W	10%	172034700
R28	CACP	22k	1/4W	10%	172042200
R29	CACP	22k	1/4W	10%	172042200
R30 to R33	CACP	100k	1/4W	10%	172051000
R34	CACP	5.6k	1/4W	10%	172035600
R35	CACP	1k	1/4W	10%	172031000
R36	CACP	5.6k	1/4W	10%	172035600
R37	CACP	1k	1/4W	10%	172031000
R38	CACP	470	1/4W	10%	172024700
R39	CACP	470	1/4W	10%	172024700
R40 to R42	CACP	1k	1/4W	10%	172031000
R43 to R45	CACP	2.7k	1/4W	10%	172032700
R46	CACP	4.7k	1/4W	10%	172034700
R47	CACP	470	1/2W	10%	172324700
C1	CERM	0.047μ	25V	+50% -20%	241944700
C2	ESTM	1μ	100V	10%	225461000
C3	TAND	22μ	10V	20%	265672200
C4	ESTM	0.1μ	100V	10%	225451000
C5	Variable	7-35p	160V		290020440
C6	CERM	15p	500V	20%	241311500
C7	CERM	2200p	500V	20%	241332200
C8	CERM	220p	500V	20%	241322200
C9	CERM	1,000p	500V	20%	241331000
C10	TAND	47μ	25V		265874700
C11	CERM	1,000p	500V	20%	241331000
C12	CERM	0.047μ	25V	+50% -25%	241944700
C13	CERM	100p	500V	20%	241321000
C14	CERM	100p	500V	20%	241321000
C15	CERM	0.047μ	25V	+50% -20%	241944700
C16	CERM	22p	500V	20%	241312200
C17	CERM	100p	500V	20%	241321000
C18	ALME	22μ	25V	+100%	273772200
C19	ALME	220μ	10V	-10%	273182200
C20	CERM	220p	500V	20%	241322200
C21	CERM	220p	500V	20%	241322200
C22 to C30	CERM	0.047μ	25V	+50% -20%	241944700
C31	CERM	100p	500V	20%	241321000
C32	CERM	0.047μ	25V	+50% -20%	241944700

PCB 3 (cont)

Cct Ref	General Description		Solartron Part No.
L1	R.F. Choke 33μH	5%	305020440
L2	R.F. Choke 2.7μH	10%	305020730
D1	ZENER 4.7V		300521470
D2	SD3		300522160
D3	SD3		300522160
D4	MV2110 33p		300525320
D5	MV2110 33p		300525320
D6	SD3		300522160
D7	OA47		300520850
TR1	BCY70		300553590
TR2	2N2369A		300552390
TR3	2N2369A		300552390
TR4	2N2369A		300552390
TR5	P1087E		300555550
TR6	U1899		300554320
TR7	P1087E		300555550
TR8	U1899		300554320
TR9	BCY70		300553590
TR10	BCY70		300553590
TR11	BCY70		300553590
IC1	74135		510001430
IC2	7474		510000490
IC3	74107		510000810
IC4	74393		510002150
IC5	74393		510002150
IC6	7474		510000490
IC10	74123		510000980
IC11	74193		510001000
IC12	74193		510001000
IC13	74193		510001000
IC14	74173		510002770
IC15	74173		510002770
IC16	74173		510002770
IC17	74125		510001490
IC18	74125		510001490
IC19	74125		510001490
IC20	74174		510002780
IC21	74174		510002780
IC22	74174		510002780
IC23	7442		510000330
IC24	7442		510000330
IC25	7400		510000340
IC26	7404		510000410
IC27	7404		510000410
IC28	7420		510000380
IC29	74H00		510000720
IC30	7408		510000830
IC31	MC6800L		510002750
IC32	MCM68317		5196032
IC33	MCM6810L-1		510002760
IC34	74123		510000980
	40 pin D.I.L. socket		300584880
SK1-3	16 pin D.I.L. sockets		300584860
	Disconnect pins		355900550
	Horizontal P.V. sockets		352501700
	24 pin D.I.L. socket		300584910
	Ceramic beads		470120060

PCB 5

Cct Ref	General Description				Solartron Part No.
R1	PRWW	3.3M			1696091
R2	PRWW	3.3M	Matched		
R3	PRWW	3.3M	set		
R5	PRWW	100.025K			
R6	CACP	100k	1W	10%	172551000
R7	CACP	56	1/4W	10%	172015600
R8	CACP	470	1/4W	10%	172024700
R9	CACP	470	1/4W	10%	172024700
R101	PRWW	90k			16960900
R102	PRWW	9300			
R103	PRWW	909	Matched		
R104	PRWW	100.84	set		
R105	PRWW	274k			
R109	MEFM	82k	1/8W	0.5%	192748202
R110	MEFM	10k	1/8W	0.5%	192741001
R111	MEFM	1M	1/8W	0.5%	192761002
R112	MEFM	680k	1/8W	0.5%	192756802
R113	MEFM	15k	1/8W	0.5%	192741502
R114 to R117	CACP	100k	1/4W	10%	172051000
R118 to R121	CACP	10k	1/4W	10%	172041000
R122	CACP	2200	1/4W	10%	172032200
R201	PRWW	93.2k	Matched		169610801
R202	PRWW	40k	set		
R203	PRWW	10k	1/8W	0.5%	192741001
R204	CACP	4700	1/4W	10%	172034700
R205	CACP	4700	1/4W	10%	172034700
R207	MEFM	27k	1/8W	0.5%	192742702
R208	MEFM	10k	1/8W	0.5%	192741001
R209	MEFM	10k	1/8W	0.5%	192741001
R210	MEFM	270k	1/8W	0.5%	192752701
R211	MEFM	1000	1/8W	0.5%	192731001
R212	MEFM	1000	1/8W	0.5%	192731001
R213	CACP	2200	1/4W	10%	172032200
R214	CACP	2200	1/4W	10%	172032200
R215	CACP	1000	1/4W	10%	172031000
R216	CACP	1000	1/4W	10%	172031000
R217	CACP	2700	1/4W	10%	172032700
R218	CACP	2700	1/4W	10%	172032700
R219	CACP	47k	1/4W	10%	172044700
R220	CACP	100k	1/4W	10%	172051000
R221	CACP	47k	1/4W	10%	172044700
R222	CACP	330	1/4W	10%	172023300
R223	CACP	4700	1/4W	10%	172034700
R224	CACP	22k	1/4W	10%	172042200
R225	CACP	47k	1/4W	10%	172044700
R226	CACP	330	1/4W	10%	172023300
R227	CACP	4700	1/4W	10%	172034700
R228	CACP	4700	1/4W	10%	172034700
R229	CACP	100k	1/4W	10%	172051000
R230	CACP	100k	1/4W	10%	172051000
R231	CACP	12k	1/4W	10%	172041200
R232	CACP	330	1/4W	10%	172023300
R233	CACP	4700	1/4W	10%	172034700

PCB 5 (cont)

Cct Ref	General Description				Solartron Part No.
R234	CACP	4700	1/4W	10%	172034700
R235	CACP	68k	1/4W	10%	172046800
R236	CACP	12k	1/4W	10%	172041200
R237	CACP	2200	1/4W	10%	172032200
R238	MEFM	470	1/8W	0.5%	192724702
R239	MEFM	1M	1/8W	0.5%	192761002
R240	CACP	100	1/4W	10%	172021000
R241	CACP	6800	1/4W	10%	172036800
R242	MEFM	33	1/8W	0.5%	192713302
R301	MEMF	1200	1/4W	0.5%	198231201
R302	MEMF	220	1/4W	0.5%	198222201
R303	MEMF	120	1/4W	0.5%	198221201
R304	MEMF	68	1/8W	0.5%	192716802
R305	MEMF	36	1/4W	0.5%	198213601
R306	MEFM	20	1/8W	0.5%	198212001
R307	MEFM	12	1/8W	0.5%	192711202
R308	MEMF	8200	1/4W	0.5%	198238201
R309	CACP	470	1/4W	10%	172024700
R310	CACP	330	1/4W	10%	172023300
R311	CACP	1000	1/4W	10%	172031000
R312	PRWW	40k	Matched		1696070
R313	PRWW	40k	set		
R314	MEFM	20k	1/8W	0.5%	192742001
R315	CACP	470	1/4W	10%	172024700
R316	CACP	330	1/4W	10%	172023300
R317	MEFM	15	1/8W	0.5%	192711502
R318	MEFM	12	1/8W	0.5%	192711202
R401	CACP	15k	1/4W	10%	172041500
R402	CACP	10M	1/4W	10%	172071000
R403	CACP	15k	1/4W	±10%	172041500
R404	MEFM	100	1/8W	0.5%	192721002
R405	CACP	100k	1/4W	10%	172051000
R406	CACP	220k	1/4W	10%	172052200
R407	CACP	27k	1/4W	10%	172042700
R408	CACP	82k	1/4W	10%	172048200
R409	CACP	100k	1/4W	10%	172051000
R410	MEFM	1M	1/8W	0.5%	192761002
R411	CACP	1M	1/4W	10%	172061000
R412	CACP	82k	1/4W	10%	172048200
R413	CACP	27k	1/4W	10%	172042700
R414	CACP	68k	1/4W	10%	172046800
R415	CACP	2.2M	1/4W	10%	172062200
R416	CACP	1M	1/4W	10%	172061000
R417	CACP	100k	1/4W	10%	172051000
R418	MEFM	15k	1/8W	0.5%	192741501
R419	CACP	1800	1/4W	10%	172031800
R420	MEFM	15k	1/8W	0.5%	192741501
R421	CACP	3300	1/4W	10%	172033300
R422	MEFM	470	1/8W	0.5%	192724701
R423	MEFM	470	1/8W	0.5%	192724701
R424	MEFM	Select on test	1/8W	0.5%	1927
R425	MEFM	120	1/8W	0.5%	192721202
R426	CACP	12k	1/2W	10%	172341200
R427	MEFM	15k	1/8W	0.5%	192741501
R428	CACP	47k	1/4W	10%	172044700
R429	CACP	100k	1/4W	10%	172051000
R430	CACP	56k	1/4W	10%	172045600
R431	MEFM	1000	1/4W	0.5%	198231001
R432	MEFM	12k	1/4W	0.5%	198241201

PCB 5 (cont)

Cct Ref	General Description				Solartron Part No.
R433	CACP	33k	1/4W	10%	172043300
R434	CACP	33k	1/4W	10%	172043300
R435	CACP	1500	1/4W	10%	172031500
R436	CACP	1500	1/4W	10%	172031500
R437	CACP	1500	1/4W	10%	172031500
R438	CACP	82k	1/4W	10%	172048200
R439	CACP	82k	1/4W	10%	172048200
R440	CACP	82k	1/4W	10%	172048200
R441	CACP	1M	1/4W	10%	172061000
R442	CACP	1M	1/4W	10%	172061000
R443	CACP	1M	1/4W	10%	172061000
R444	CACP	27k	1/4W	10%	172042700
R445	CACP	15	1/4W	0.5%	198211501
R446	CACP	100k	1/4W	10%	172051000
R447	CACP	100	1/4W	10%	172021000
R448	CACP	100	1/4W	10%	172021000
R449	CACP	4700	1/4W	10%	172034700
R450	CACP	56k	1/8W	0.5%	192745601
R601	MEFM	180k	1/8W	0.5%	192751802
R602	MEFM	100k	1/8W	0.5%	192751002
R603	PRWW	11.07k	1/4W	±0.1%	160300424
R604	PRWW	90k	Matched set		169612001
R605	PRWW	179k			
R606	PRWW	9.09k	1/4W	±0.1%	160300423
R607	PRWW	899k	1/4W	±0.1%	160300425
R608	MEFM	1000	1/8W	0.5%	192731001
R609	MEFM	510	1/8W	0.5%	192725102
R610	MEFM	270	1/8W	0.5%	192722702
R611	MEFM	150	1/8W	0.5%	192721502
R612	MEFM	82	1/8W	0.5%	192718202
R613	CACP	10k	1/4W	10%	172041000
R614	PRWW	5.6k	6W	5%	173735600
R615	MEFM	900k	1/4W	1%	198359001
R616	MEFM	9k	1/8W	0.5%	192739001
R617	CACP	47k	1/4W	10%	172044700
R618	MEFM	3.9k	1/8W	0.5%	192733901
R701	MEFM	990k	2W	±0.1%	169600500
R702	MEFM	10k	1/4W	±0.1%	198141004
R703	MEFM	1.2k	1/4W	±0.1%	198131204
R704	MEFM	94.5k	1/2W	±0.2%	160400041
R705	MEFM	14.5k	1/4W	±0.5%	198241454
R706	CACP	56k	1/8W	±0.5%	192745601
R707	CACP	10k	1/4W	±10%	172041000
R708	CACP	10M	1/2W	±5%	170871000
R709	CACP	100k	1/4W	±10%	172051000
R710	CACP	1M	1/4W	±10%	172061000
R711	CACP	470	1/2W	±10%	172324700
R712	CACP	10k	1/4W	±10%	172041000
R713	CACP	10k	1/4W	±10%	172041000
R714	CACP	100	1/4W	±10%	172021000
R715	CACP	3.9k	1/4W	±10%	172033900
R716	MEOX	1k	1/4W	±5%	195631000
R717	MEOX	1k	1/4W	±5%	195631000
R718	CACP	4.7k	1/4W	±10%	172034700
R719	CACP	15k	1/4W	±10%	172041500
R720	CACP	3.3k	1/4W	±10%	172033300

PCB 5 (cont)

Cct Ref	General Description				Solartron Part No.
R721	CACP	10k	1/4W	10%	172041000
R722	CACP	2.2k	1/4W	10%	172032000
R723	CACP	180	1/4W	10%	172021800
R724	CACP	22	1/4W	10%	172012200
R725	CACP	4700	1/4W	10%	172034700
R726	CACP	470	1/4W	10%	172024700
R727	CACP	3900	1/2W	±10%	172033900
R728	MEFM	2400			169610701
R729	MEFM	2400	Matched		
R730	MEFM	1200	set		
R731	MEFM	132.8			
R732	MEFM	10k	1/8W	0.5%	192741002
R733	PRWW	1	2.6W	10%	173501000
R734	MEFM	68k	1/8W	0.5%	192746802
R735	MEFM	51k	1/8W	0.5%	198245101
R736	MEFM	68k	1/8W	0.5%	192746802
R737	MEFM	51k	1/8W	0.5%	198245101
R738	CACP	10	1/4W	10%	172011000
R739	CACP	100	1/4W	10%	172021000
R740	CACP	10M	1/4W	10%	172071000
R741	CACP	1M	1/4W	10%	172061000
R742	CACP	2700	1/4W	10%	172032700
R743	CACP	1000	1/4W	10%	172031000
R744	CACP	10M	1/4W	10%	172071000
R745	CACP	3300	1/4W	10%	172033300
R746	CACP	3300	1/4W	10%	172033300
R801	CACP	120	1/4W	10%	172321200
R802 to R807	CACP	47k	1/4W	10%	172044700
R808 to R812	CACP	3300	1/4W	10%	172033300
R813	CACP	3300	1/4W	10%	172033000
R814	CACP	4700	1/4W	10%	172034700
R815	CACP	10k	1/4W	10%	172041000
R816	CACP	3300	1/4W	10%	172033300
R817	CACP	4700	1/4W	10%	172034700
R818	CACP	2200	1/4W	10%	172032200
R819	CACP	22k	1/4W	10%	172042200
R820	CACP	22k	1/4W	10%	172042200
R821	CACP	3300	1/4W	10%	172033300
R822	CACP	3300	1/4W	10%	172033300
R823 to R828	CACP	220	1/4W	10%	172022200
R830	CACP	470	1/4W	10%	172024700
R831	CACP	470	1/4W	10%	172024700
R832	CACP	100	1/4W	10%	172021000
R833	CACP	100	1/4W	10%	172021000
R834	CACP	470	1/4W	10%	172024700
R836	CACP	4700	1/4W	10%	172034700
R837 to R840	CACP	33k	1/4W	10%	172043300
R841	CACP	18k	1/4W	10%	172041800
R842	CACP	18k	1/4W	10%	172041800
R843	CACP	3300	1/4W	10%	172033300
R844	CACP	18k	1/4W	10%	172041800

PCB 5 (cont)

Cct Ref	General Description				Solartron Part No.
R845	CACP	4700	1/4W	10%	172034700
R846	CACP	1000	1/4W	10%	172031000
R847	CACP	3300	1/4W	10%	172033300
R848	CACP	3300	1/4W	10%	172033300
RV1	CMPS	5000		10%	130935000
RV101	CMPS	10k		10%	130941000
RV102	CMPS	20k		10%	130942000
RV103	CMPS	5000		10%	130935000
RV201	CMPS	50		10%	130915000
RV202	CMPS	100k		10%	130951000
RV401	CMPS	20k		10%	130942000
RV402	CMPS	500k		10%	130955000
RV403	CMPS	500		10%	130925000
RV601	CMPS	5k		10%	130935000
RV602	CMPS	100		10%	130921000
RV603	CMPS	2000		10%	130932000
RV701	CMPS	10k		10%	130941000
RV702	CMPS	1000		10%	130931000
RV703	CMPS	100		10%	130921000
RV704	CMPS	1000		10%	130931000
RV705	CMPS	100k		10%	130951000
C1	CERM	0.01μ	3kV	20%	208450085
C2	ESTF	2200p	400V	10%	222332200
C101	CERM	33p	500V	20%	241313300
C102	STYR	330p	125V	10%	210223300
C201	ESTF	0.22μ	100V	10%	225452200
C202	CERM	220p	500V	20%	241322200
C203	CERM	100p	500V	20%	241321000
C204	STYR	0.01μ	125V	10%	210241000
C205	CERM	0.047μ	25V	+50% -20%	241944700
C206	CERM	0.047μ	25V	+50%	241944700
C207	CERM	0.047μ	25V	+50% -20%	241944700
C208	CERM	220p	500V	20%	241322200
C209	CERM	220p	500V	20%	241322200
C210	CERM	33p	500V	20%	241313300
C211	CERM	10p	500V	20%	241311000
C212	CERM	220p	500V	20%	241322200
C213	CERM	33p	500V	20%	241313300
C214	CERM	100p	500V	20%	241321000
C215	CERM	22p	500V	20%	241312200
C216	CERM	0.047μ	25V	+50% -20%	241944700
C217	CERM	0.047μ	25V	+50% -20%	241944700
C218 to C221	CERM	220p	500V	20%	241322200
C222	ALME	22μ	40V		273772200
C301	CERM	33p	500V	20%	241313300
C302	CERM	0.047μ	25V	+50% -25%	241944700
C303	CERM	33p	500V	20%	241313300
C304	CERM	0.047μ	25V	+50% -25%	241944700

PCB 5 (cont)

Cct Ref	General Description				Solartron Part No.
C305	CERM	0.047µ	25V	+50% -25%	241944700
C306	CERM	0.047µ	25V	+50% -25%	241944700
C401	STYR	470p	125V	10%	210224700
C402	STYR	33p	125V	10%	210213300
C403	STYR	15p	125V	10%	210211500
C404	CERM	220p	500V	20%	241322200
C405	CERM	220p	500V	20%	241322200
C406	CERM	100p	500V	20%	241321000
C407	ALME	47µ	40V		273774700
C408	CERM	1000p	500V	20%	241331000
C409	CERM	220p	500V	20%	241322200
C410	CERM	100p	500V	20%	241321000
C411	CERM	220pF	500V	20%	241322200
C412	CERM	220pF	500V	20%	241322200
C413	CERM	220pF	500V	20%	241322200
C415	CERM	0.047µ	25V	+50% -20%	241944700
C416	ALME	47µ	40		273774700
C417	ALME	22µ	40		273772200
C601	CERM	100p	500V	20%	241321000
C602	CERM	100p	500V	20%	241321000
C603 to C607	CERM	0.047µ	25V	+50% -25%	241944700
C608	CERM	33p	500V	20%	241313300
C701	PTFE	2-7p	3kV		290060080
C702	MICA	680p	350	±5%	250326800
C703	STYR	100p	125V	±2.5%	210121000
C704	ESTF	0.01µ	1000V	±10%	222841000
C706	CERM	3300p	500V	20%	241333300
C707	CERM	15p	500V	±20%	241311500
C708	CERM	22p	500V	±20%	241312200
C709	CERM	0.047µ	25V	+50% -20%	241944700
C710	CERM	0.047µ	25V	+50% -20%	241944700
C711	ESTF	0.1µ	100V	10%	225451000
C712	ESTF	0.68µ	100V	10%	225456800
C713	ESTF	0.47µ	100V	±10%	225454700
C714	ESTF	1µ	100V	±10%	225461000
C715	ESTF	1µ	100V	±10%	225461000
C716	CERM	0.047µ	25V	+50% -20%	241944700
C717	ALME	22µ	40V		273772200
C718	ALME	22µ	40V		273772200
C719	CERM	0.047µ	25V	+50% -20%	241944700
C720	ESTE	0.22µ	400V	±10%	226152200
C721	ESTE	0.47µ	100V	10%	225454700
C722	CERM	0.047µ	25V	+50% -25%	241944700
C723	CERM	0.047µ	25V	+50% -25%	241944700
C724	CERM	0.047µ	25V	+50% -25%	241944700
C727	ESTF	0.15µ	160V	±10%	225451500
C801	ALME	22µF	40V		273772200

PCB 5 (cont)

Cct Ref	General Description				Solartron Part No.
C802	CERM	0.01µ	25V	+50% -25%	241941000
C803	CERM	0.01µ	25V	+50% -25%	241941000
C804	CERM	0.047µ	25V	+50% -25%	241944700
C805	CERM	0.047µ	25V	+50% -25%	241944700
C806	ALME	220µ	10V		270182000
D101	Zener BZY88 20V				300523790
D201	Zener BZY88 10V				300522760
D202	SD3				300522160
D203	SD3				300522160
D301	Zener USR932				300525610
D302	SD3				300522160
D401	Zener BZY88 27V				300522970
D402	Zener BZY88 27V				300522970
D403	Zener IN4577 6.4V				300525050
D404	SD3				300522160
D405	SD3				300522160
D406	Zener BZY88 12V				300521480
D407	SD3				300522160
D408	SD3				300522160
D409	SD3				300522160
D601	SD3				300522160
D602	IN4007				300524990
D701	Zener IN4739A 9.1V				300525410
D702	Zener IN4739A 9.1V				300525410
D703	IN3595				300523590
D705	IN3595				300523590
D707	Zener BZY88 5.6V				300521460
D708	Zener BZY88 5.6V				300521460
D709	Zener BZY88 5.6V				300521460
D710	5082-6221				300525380
D711	5082-6221				300525380
D801 to D817	SD3				300522160
TR101 to TR104	U1899				300554320
TR105 to TR108	BC107				300553320
TR202	U1899				300554320
TR203	U1897				300553800
TR204	U1897				300553800
TR205	U1897				300553800
TR206	BCY70				300553590
TR207	BC107				300553320
TR208	BCY70				300553590
TR209	BC107				300553320
TR210	BCY70				300553590
TR211	BC107				300553320
TR301	BC107				300553320
TR302	BCY70				300553590
TR401 to TR404	WN807				300555380

PCB 5 (cont)

Cct Ref	General Description	Solartron Part No.
TR405	2N2484	300552860
TR406	NDF9405	300555580
TR407	NDF9405	300555580
TR408	2N2484	300552860
TR409	2N2484	300552860
TR410	BCY70	300553590
TR411	2N2484	300552860
TR412	2N2484	300552860
TR413 to TR416	BC107	300553320
TR417	WN807	300555380
TR418	WN807	300555380
TR419	U1897	300553800
TR420	U1899	300554320
TR601	U1899	300554320
TR602	3N163	300554530
TR603	WN807	300555380
TR604	WN807	300555380
TR701	3N163	300554530
TR702	U235	300553810
TR703	BC107	300553320
TR704	BCY70	300553590
TR705	BCY70	300553590
TR706	BCY70	300553590
TR707	BC107	300553320
TR708	BC107	300553320
TR801 to TR808	BCY70	300553590
TR809	BC107	300553320
TR810	BC107	300553320
TR811	2N2369	300552390
TR812	2N2369	300552390
TR813	BC107	300553320
IC101	LM301AH	510000620
IC201	LM201AH	510090300
IC202	74S74	510002020
IC203	74S74	510002020
IC204	CA3045	300554090
IC301	LM201AH	510090300
IC302	LM201AH	510090300
IC401	LM301AH	510000620
IC601	LM201AH	510090300
IC602	LM0052CH	510090260
IC701	LM301AH	510000620
IC801 to IC806	TIL111	300540140
IC807	SN7445	510000900
IC808	SN7445	510000900
IC809	SN7445	510000900
IC810	SN7414	510001990
IC811	SN7406	510000760
IC812	SN74S04	510002660
IC813	SN7400	510000340
IC814	SN7403	510001200
L701	47mH	305020710

PCB 5 (cont)

Cct Ref	General Description	Solartron Part No.
RLA-1	MRA500	300670120
RLA-2	MRA500	300670120
RLB	2Pc/o 2Pn/o	301200806
RLC-1	MRA500	300670120
RLC-2	MRA500	300670120
RLC-3	MRA500	300670120
RLD-1	MR308	379615501
RLD-2	MR308	379615501
RLD-3	MR308	379615501
RLE	2Pc/o	301200203
RLF	1P c/o	300651980
RLG	2P c/o	301200203
RLH	Relay ALMA	301202201
RLJ	Relay ALMA	301202201
SK1	14 pin dual inline socket	300584680
	Ceramic beads	470120060
	Disconnect pins	355900550
T801	Newport 76601/5	303050020
T802	Newport 76601/5	303050020
T803	Newport 76601/5	303050020
T804	Newport 76614/4	303050010
RH301	DO7 type diode	300584370
	Insert P.T.F.E. "Cloverleaf"	355400250
	Ferrite Beads FX1115	309010060

PCB 7

Cct Ref	General Description				Solartron Part No.
R1	CACP	470k	1/2W	10%	172354700
R2	CACP	12k	1/2W	10%	172341200
R3	CACP	33k	1/4W	10%	172043300
R4	CACP	3.3k	1/4W	10%	172033300
R5	MEOX	330K	1/2W	1%	195453300
R6	CACP	3.3k	1/4W	10%	172033300
R7	MEOX	82k	1/4W	5%	195648200
R9	MEOX	33k	1/4W	5%	195653300
R10	MEOX	470	1/4W	5%	195624700
R11	MEFM	36k	1/8W	0.5%	192743602
R12	CACP	22k	1/4W	10%	172042200
R13	CACP	10	1/4W	10%	172011000
R14	CACP	10k	1/4W	10%	172041000
R15	POWW	1k	6W	5%	173731000
R16	CACP	3.3k	1/4W	10%	172033300
R17	CACP	27	1/4W	10%	172012700
R18	POWW	2.2k	2.5W	5%	173402200
R19	CACP	10k	1/4W	10%	172041000
R20	MEOX	100k	1/4W	5%	195651000
R22	MEOX	100k	1/4W	5%	195651000
R23	MEOX	33k	1/4W	5%	195643300
R24	MEOX	68k	1/4W	5%	195646800
R25	CACP	68	1/4W	10%	172016800
R26	CACP	22	1/4W	10%	172012200
R27	CACP	22	1/4W	10%	172012200
R28	CACP	3.3k	1/4W	10%	172033300
R29	CACP	68k	1/4W	10%	172046800
R30	CACP	68k	1/4W	10%	172046800

PCB 7

Cct Ref	General Description				Solartron Part No.
R31	CACP	3.3k	1/4W	10%	172033300
R32	CACP	22	1/4W	10%	172012200
R33	CACP	22	1/4W	10%	172012200
R101	CACP	150	1/4W	10%	172021500
R106	CACP	22	1/4W	10%	172012200
RV1	CMPR	10k	1/2W	10%	130641000
RV2	CMPR	20k	1/2W	10%	130642000
RV101	CAPS	10k	1/2W	20%	137341000
C1	ESTM	0.047μ	100V	± 10%	225444700
C2	ESTM	0.1μ	400V	± 20%	226151000
C3	ESTM	3.3μ	100V	± 10%	225463300
C4	CERM	0.047μ		+ 50% − 25%	241944700
C5	ESTF	6800p	100V	± 10%	227036800
C6	TAND	10μ	20V	20%	265871000
C7	TAND	1μ	40V	20%	266061000
C8	ESTF	680p	150V	10%	221326800
C9	TAND	1μ	40V	20%	266061000
C10	CERM	1000p	500V	20%	241331000
C11	CERM	1000p	500V	20%	241331000
C12	ESTM	0.1μ	160V	10%	220351000
C13	CERM	0.01μ		+ 50% − 25%	241941000
C14	CERM	0.01μ		+ 50% − 25%	241941000
C15	ESTM	3.3μ	100V	± 10%	225463300
C16	CERM	100p	500V	20%	241321000
C17	CERM	0.1μ	30V	+ 50% − 20%	242051000
C101	CERM	0.047μ	30V	+ 50% − 25%	241944700
C102	CERM	0.047μ	30V	+ 50% − 25%	241944700
C103	CERM	3300p	500V	25%	241333300
C104	ALME	47μ	40V		273774700
C105	ALME	47μ	40V		273774700
C106	ALME	22μ	40V		273772200
C107	ALME	22μ	40V		273772200
C108	CERM	3300p	500V	25%	241333300
C113	ALME	220μ	10V		273182200
C114	CERM	0.047μ	30V	+ 50% − 25%	241944700
C115	ALME	220μ	10V		273182200
C116	CERM	0.047μ	30V	+ 50% − 25%	241944700
C117	ALME	220μ	10V		273182200
C118	CERM	0.047μ	30V	+ 50% − 25%	241944700
C120	CERM	2.2p	500V	± 0.5pf	208450094
C122	CERM	1000p	500V	20%	241331000
C123	TAND	1μ	40V	20%	266061000
D1	Diode	IN4007			300524990
D2	Zener	BZY88	13V		300523920
D3	Zener	BZX61	15V		300524820
D4	Diode	SD3			300522160

PCB 7

Cct Ref	General Description			Solartron Part No.
D5	Diode	SD3		300522160
D6		MR856		300525550
D7	Zener	BZX61	15V	300524820
D8	Zener	IN5375B		300525530
D9	Diode	SD3		300522160
D10	Zener	BZY88	5.6V	300521450
D11	Diode	BAY72		300524530
D12	Diode	BAY72		300524530
D13	Zener	BZY88	2.7V	300523870
D14	Diode	BAY72		300524530
D15	Zener	BZY88	15V	300521390
D101	Diode	BAY72		300524530
D102	Diode	BAY72		300524530
D103	Diode	BAY72		300524530
D104	Diode	BAY72		300524530
D105	Diode	BAY72		300524530
D106	Diode	BAY72		300524530
D107	Diode	BAY72		300524530
D108	Diode	BAY72		300524530
D109	Diode	MR850		300525560
D110	Diode	MR850		300525560
D111	Diode	MR850		300525560
D112	Diode	MR850		300525560
D113	Diode	MR850		300525560
D114	Diode	MR850		300525560
TR1		TIP50		300555450
TR2		BCY70		300553590
TR4		TIP54		300555350
TR6		2N5401		300555470
TR7		BC107		300553320
TR8		BC107		300553320
TR9		BCY70		300553590
TR10		BC107		300553320
TR11		BC107		300553320
TR12		TIP54		300555350
TR13		TIP54		300555350
IC1		LM318		510090210
IC2		LM318		510090210
IC101		Regulator −18V		510090350
IC102		Regulator +18V		510090340
L1		Choke RM10 4mH		309508601
L2		Bead FX1115		309010060
L3		Bead FX1115		309010060
L101		Choke RM6		309507001
L102		Choke RM6		309507001
L103		Choke RM6		309507001
T1		Transformer RM6		309608702
T2		Transformer		309611003
T3		Transformer RM6		309613201
SK1		14 pin DIL		300584680
FS		Fuse Fast Blo 500mm		360106090

PCB 13

Cct Ref	General Description				Solartron Part No.
TH1	YA1104				161000024
C1	ALME	190µ	400V	+50% −25%	274882200
D1	IN4007				300524990
D2	IN4007				300524990

MAINFRAME

µV Offset Pot 100K	10%	110024080
Bush		419600101
Transformer		309610501
Zenamic Z10L471		160800005
Mains socket/filter		550000990
Mains fuse assy. 20mm		360206010
Fuse Link 20mm 800mA		360106310
Mains on/off switch		377000290

ACCESSORIES

Shorting link	355001660
Test probe red	351901040
Test probe black	351901030
Crocodile clip (2 off)	355901030
Input lead red	359900090
Input lead black	359900080
Fuse link 800mA	360106310
Mains cable	480140220

7055 Board 5 Component Parts List

This part of the section contains a detailed Parts List for 7055 board 5 to cover the major differences between 7055 and 7065 – the remaining boards being common to both instruments.

PCB 5

Cat Ref	General Description				Solartron Part No.
R1	TNFM	9.9M			169611102
R2	TNFM	100k			
R3	CACP	100k	1W	10%	172551000
R4	CACP	470	1/4W	10%	172024700
R5	CACP	470	1/4W	10%	172024700
R6	MEFM	22	1/8W	0.5%	192712202
R7	CACP	22k	1/4W	10%	172042200
R8	CACP	220k	1/4W	10%	172052200
R10	CACP	56	1/4W	10%	172015600
R102	CACP	100	1/4W	10%	172021000
R104	CACP	100	1/4W	10%	172021000
R105 to R108	CACP	220k	1/4W	10%	172052200
R109	TNFM	90k			169612501
R110	TNFM	9k			1696110
R111	TNFM	900			
R112	TNFM	100			
R113	MEFM	10M	1W	1%	198971002
R114	MEFM	960k	1/4W	0.5%	160400070
R115	MEFM	94.5k	1/2W	0.2%	160400041
R116	MEFM	10k	1/4W	0.5%	198241001
R117 to R120	CACP	27k	1/4W	10%	172042700
R121 to R124	CACP	1.5k	1/4W	10%	172031500
R125	MEFM	1M	1/8W	0.5%	192761002
R126	MEFM	15k	1/8W	0.5%	192741502
R127	MEFM	910k	1/8W	0.5%	192759101
R128	CACP	10k	1/4W	10%	172041000
R201	MEFM	198.1k			169612701
&	matched pair				
R202		68k			
R203	MEFM	18k	1/8W	0.5%	192741802
R204	CACP	4.7k	1/4W	10%	172034700
R205	CACP	4.7k	1/4W	10%	172034700
R206	CACP	2.2k	1/4W	10%	172032200
R207	CACP	47k	1/4W	10%	172044700
R208	MEFM	10k	1/8W	0.5%	192741001
R209	MEFM	10k	1/8W	0.5%	192741001
R210	MEFM	680k	1/8W	0.5%	192756802
R211	MEFM	1k	1/8W	0.5%	192731001
R212	MEFM	1k	1/8W	0.5%	192731001
R213	CACP	2.2k	1/4W	10%	172032200
R214	CACP	2.2k	1/4W	10%	172032200
R215	CACP	1k	1/4W	10%	172031000
R216	CACP	1k	1/4W	10%	172031000
R217	CACP	2.7k	1/4W	10%	172032700
R218	CACP	2.7k	1/4W	10%	172052700
R219	CACP	47k	1/4W	10%	172044700
R220	CACP	82k	1/4W	10%	172048200
R221	CACP	47k	1/4W	10%	172044700
R222	CACP	330	1/4W	10%	172023300
R223	CACP	4.7k	1/4W	10%	172034700
R224	CACP	22k	1/4W	10%	172042200
R225	CACP	47k	1/4W	10%	172044700
R226	CACP	330	1/4W	10%	172023300

PCB 5 (cont)

Cct Ref	General Description				Solartron Part No.
R227	CACP	4.7k	1/4W	10%	172034700
R228	CACP	4.7k	1/4W	10%	172034700
R229	CACP	100k	1/4W	10%	172051000
R230	CACP	100k	1/4W	10%	172051000
R231	CACP	12k	1/4W	10%	172041200
R232	CACP	330	1/4W	10%	172023300
R233	CACP	4.7k	1/4W	10%	172034700
R234	CACP	4.7k	1/4W	10%	172034700
R235	CACP	68k	1/4W	10%	172046800
R236	CACP	12k	1/4W	10%	172041200
R237	CACP	6.8k	1/4W	10%	172036800
R238	CACP	100	1/4W	10%	172021000
R239	MEFM	470	1/8W	0.5%	192724702
R240	MEFM	330k	1/8W	0.5%	192753302
R301	MEFM	8.2k	1/4W	0.5%	198238201
R302	MEFM	220	1/4W	0.5%	198222201
R303	MEFM	120	1/4W	0.5%	198221201
R304	MEFM	68	1/8W	0.5%	192716802
R305	MEFM	36	1/4W	0.5%	198213601
R306	MEFM	20	1/8W	0.5%	198212001
R307	MEFM	12	1/8W	0.5%	192711202
R308	MEFM	1.1k	1/4W	0.5%	198231101
R309	CACP	470	1/4W	10%	172024700
R310	CACP	330	1/4W	10%	172023300
R311	CACP	1k	1/4W	10%	172031000
R312	MEFM	40k	Matched set		169607001
R313	MEFM	40k			
R314	MEFM	20k	1/8W	0.5%	192742001
R315	CACP	470	1/4W	10%	172024700
R316	CACP	330	1/4W	10%	172023300
R317	MEFM	15	1/4W	0.5%	192711502
R318	MEFM	12	1/4W	0.5%	192711202
R401	CACP	47k	1/4W	10%	172044700
R402	CACP	1M	1/4W	10%	172061000
R403	CACP	1M	1/4W	10%	172061000
R404	CACP	82k	1/4W	10%	172048200
R405	CACP	15k	1/4W	10%	172041500
R406	CACP	100	1/8W	0.5%	192721002
R407	CACP	82k	1/4W	10%	172048200
R408	CACP	47k	1/4W	10%	172044700
R409	CACP	120	1/4W	10%	172021200
R410	MEFM	15k	1/8W	0.5%	192741501
R411	MEFM	15k	1/8W	0.5%	192741501
R412	CACP	3.3k	1/4W	10%	172033300
R413	MEFM	680	1/4W	0.5%	198226801
R414	MEFM	680	1/4W	0.5%	198226801
R415	Adjust on test		1/4W		1927
R416	MEFM	120	1/8W	0.5%	192721202
R417	MEFM	15k	1/8W	0.5%	192741501
R418	CACP	12k	1/4W	10%	172041200
R419	CACP	100k	1/4W	10%	172051000
R420	CACP	33k	1/4W	10%	172043300
R421	CACP	12k	1/4W	10%	172041200
R422	MEFM	1M	1/8W	0.5%	192761002
R423	CACP	1M	1/4W	10%	172061000
R424	CACP	1M	1/4W	10%	172061000
R425	CACP	1M	1/4W	10%	172061000
R426	CACP	82k	1/4W	10%	172048200
R427	CACP	82k	1/4W	10%	172048200
R428	CACP	82k	1/4W	10%	172048200

PCB 5 (cont)

Cct Ref	General Description				Solartron Part No.
R429	CACP	1.5k	1/4W	10%	172031500
R430	CACP	1.5k	1/4W	10%	172031500
R431	CACP	1.5k	1/4W	10%	172031500
R432	CACP	680	1/4W	10%	172026800
R433	MEFM	5.36k	1/8W	0.5%	192735362
R434	CACP	1k	1/4W	10%	172031000
R435	MEFM	33k	1/8W	0.5%	192743301
R436	CACP	1.8k	1/4W	10%	172031800
R437	CACP	33k	1/4W	10%	172043300
R438	CACP	1k	1/4W	10%	172031000
R439	CACP	820	1/4W	10%	172028200
R440	CACP	10k	1/4W	10%	172041000
R441	CACP	47	1/4W	10%	172014700
R442	CACP	47	1/4W	10%	172014700
R443	CACP	4.7k	1/4W	10%	172034700
R444	CACP	4.7k	1/4W	10%	172034700
R445	MEFM	15	1/4W	0.5%	198211501
R601	MEFM	180k	1/8W	0.5%	192751802
R602	CACP	180k	1/8W	0.5%	192751802
R603	MEFM	33k			169612601
R604	Matched pair 179k				169612601
R607	MEFM	1k	1/8W	0.5%	192731001
R608	MEFM	510	1/8W	0.5%	192725102
R609	MEFM	270	1/8W	0.5%	192722702
R610	PRWW	33.33k	1/5W	0.1%	160300427
R611	PRWW	3.29M	1/2W	0.1%	160300414
R612	CACP	10k	1/4W	10%	172041000
R613	CACP	12k	1/2W	10%	172541200
R614	MEFM	90k	1/4W	0.5%	198249001
R615	CACP	6.8k	1/4W	10%	172036800
R616	MEOX	150	1/4W	5%	195621500
R701	MEFM	990k	2W	0.1%	1696005
R702	MEFM	10k	1/4W	0.1%	198141004
R703	MEFM	1.2k	1/4W	0.1%	198131204
R704	MEFM	94.5k	1/4W	0.5%	160400041
R705	MEFM	14.5k	1/4W	0.5%	198241454
R706	CACP	12k	1/8W	0.5%	192741202
R707	CACP	10k	1/4W	10%	172041000
R708	CACP	10M	1/2W	5%	170871000
R709	CACP	100k	1/4W	10%	172051000
R710	CACP	1M	1/4W	10%	172061000
R711	CACP	470	1/2W	10%	172324700
R712	CACP	10k	1/4W	10%	172041000
R713	CACP	10k	1/4W	10%	172041000
R714	CACP	100	1/4W	10%	172021000
R715	CACP	3.9k	1/4W	10%	172033900
R716	MEOX	1k	1/4W	5%	195631000
R717	MEOX	1k	1/4W	5%	195631000
R718	CACP	4.7k	1/4W	10%	172034700
R719	CACP	15k	1/4W	10%	172041500
R720	CACP	3.3k	1/4W	10%	172033300
R721	CACP	10k	1/4W	10%	172041000
R722	CACP	1k	1/4W	10%	172031000
R723	CACP	180	1/4W	10%	172021800

PCB 5 (cont)

Cct Ref	General Description				Solartron Part No.
R724	CACP	22	1/4W	10%	172012200
R725	CACP	4.7k	1/4W	10%	172034700
R726	CACP	470	1/4W	10%	172024700
R727	CACP	3.9k	1/2W	10%	172333900
R728	Set of four	2.4k			
R729	(KM2)	2.4k			1696107
R730		1.2k			
R731		132.8			
R732	MEFM	1.0	1/4W	1%	173501000
R733	MEFM	9.53k	1/8W	0.5%	192739532
R734	MEFM	68k	1/8W	0.5%	192746802
R735	MEFM	51k	1/8W	0.5%	198245101
R736	MEFM	68k	1/8W	0.5%	192746802
R737	MEFM	51k	1/8W	0.5%	198245101
R738	CACP	10	1/4W	10%	172011000
R739	CACP	100	1/4W	10%	172021000
R740	CACP	10M	1/4W	10%	172071000
R741	CACP	1M	1/4W	10%	172061000
R742	CACP	2.7k	1/4W	10%	172032700
R743	CACP	1k	1/4W	10%	172031000
R744	CACP	10M	1/4W	10%	172071000
R745	CACP	3.3k	1/4W	10%	172033300
R746	CACP	10	1/4W	10%	172011000
R801	CACP	120	1/2W	10%	172321200
R802 to R806	CACP	47k	1/4W	10%	172044700
R807 to R810	CACP	3.3k	1/4W	10%	172033300
R811	CACP	2.2k	1/4W	10%	172032200
R812	CACP	3.3k	1/4W	10%	172033300
R813	CACP	3.3k	1/4W	10%	172033300
R814	CACP	470	1/4W	10%	172024700
R815	CACP	470	1/4W	10%	172024700
R817 to R822	CACP	220	1/4W	10%	172022200
R823	CACP	100	1/4W	10%	172021000
R824	CACP	100	1/4W	10%	172021000
R825	CACP	470	1/4W	10%	172024700
R826	CACP	2.2k	1/4W	10%	172032200
R827	CACP	22k	1/4W	10%	172042200
R828	CACP	22k	1/4W	10%	172042200
R829	CACP	3.3k	1/4W	10%	172033300
R830	CACP	3.3k	1/4W	10%	172033300
R831	CACP	10k	1/4W	10%	172041000
R832	CACP	1.5k	1/4W	10%	172031500
R833	CACP	47k	1/4W	10%	172044700
R834 to R837	CACP	33k	1/4W	10%	172043300

PCB 5 (cont)

Cct Ref	General Description				Solartron Part No.
R838	CACP	18k	1/4W	10%	172041800
R839	CACP	18k	1/4W	10%	172041800
R840	CACP	3.3k	1/4W	10%	172033300
R841	CACP	3.3k	1/4W	10%	172033300
R842	CACP	10k	1/4W	10%	172041000
RV1	CMPS	5k	1/2W	10%	130935000
RV101	CMPS	100k	1/2W	10%	120951000
RV102	CMPS	10k	1/2W	10%	130941000
RV103	CMPS	2k	1/2W	10%	120932000
RV201	CMPS	200	1/2W	10%	130922000
RV202	CMPS	100k	1/2W	10%	130951000
RV301	CMPS	200	1/2W	10%	130922000
RV401	CMPS	500	1/2W	10%	130925000
RV601	CMPS	200	1/2W	10%	130922000
RV602	CMPS	10k	1/2W	10%	130941000
RV701	CMPS	10k	1/2W	10%	130941000
RV702	CMPS	1k	1/2W	10%	130931000
RV703	CMPS1	100	1/2W	10%	130921000
RV704	CMPS	1k	1/2W	10%	130931000
RV705	CMPS	100k	1/2W	10%	130951000
C1	CERM	0.01µ	3kV	20%	208450085
C2	STYR	470p	125V	10%	210224700
C3	ESTF	2,200p		10%	222332200
C101	CERM	33p	500V	20%	241313300
C102	CERM	1,000p	500V	20%	241331000
C103	STYR	330p	125V	10%	210223300
C104	CERM	0.047µ	25V	+50% -10%	241944700
C201	ESTF	0.22µ	100V	10%	225452200
C202	ESTF	220p	500V	20%	241322200
C203	CERM	150p	500V	20%	241321500
C204	STYR	4,700p	125V	2.5%	210134700
C205 to C207	CERM	0.047µ	25V	+50% -20%	241944700
C208	CERM	220p	500V	20%	241322200
C209	CERM	220p	500V	20%	241322200
C210	CERM	33p	500V	20%	241313300
C211	CERM	10p	500V	20%	241311000
C212	CERM	220p	500V	20%	241322200
C213	CERM	33p	500V	20%	241313300
C214	CERM	100p	500V	20%	241321000
C215	CERM	22p	500V	20%	241312200
C216	CERM	0.047µ	25V	+50% -20%	241944700
C217	CERM	0.047µ	25V	+50% -20%	241944700
C218	CERM	220p	500V	20%	241322200
C219	CERM	220p	500V	20%	241322200
C220	CERM	220p	500V	20%	241322200
C221	CERM	220p	500V	20%	241322200
C222	ALME	220µF	25V		273582200
C223	ALME	220µF	25V		273582200
C224	TANF	220µF	25V		265482200
C225	CERM	0.047µ	25V	+50% -20%	241944700
C301	CERM	33p	500V	20%	241313300
C302 to C305	CERM	0.047µ	25V	+50% -20%	241944700
C306	CERM	33p	500V	20%	241313300

PCB 5 (cont)

Cct Ref	General Description				Solartron Part No.
C307	CERM	0.047µ	25V	+50% -20%	241944700
C308	CERM	0.047µ	25V	+50% -20%	241944700
C309	CERM	0.047µ	25V	+50% -20%	241944700
C401	CERM	220p	500V	20%	241322200
C402	CERM	220p	500V	20%	241322200
C403	CERM	1,000p	500V	20%	241331000
C404	CERM	0.047µ	25V	+50% -20%	241944700
C406 to C408	CERM	220p	500V	20%	241322200
C409	CERM	68p	500V	20%	241316800
C410	CERM	68p	500V	20%	241316800
C411	CERM	100p	500V	20%	241321000
C412	CERM	10p	500V	20%	241311000
C413	CERM	1,000p	500V	20%	241331000
C414	CERM	1,000p	500V	20%	241331000
C415	ALME	47µF	50V		273774700
C416	ALME	47µF	50V		273774700
C417	CERM	3.300p	500V	20%	241333300
C418	CERM	3,300p	500V	20%	241333300
C601	CERM	33p		20%	241313300
C602	CERM	33p	500V	20%	241313300
C701	Var. PTFE	2-7p	3kV		290060080
C702	MICA	680p	350	5%	250326800
C703	STYR	560p	125V	2.5%	210125600
C704	ESTF	0.01µ	1,000V	10%	222841000
C706	CERM	3,300p	500V	20%	241333300
C707	CERM	15p	500V	20%	241311500
C708	CERM	22p	500V	20%	241312200
C709	CERM	0.047µ	25V	+50% -20%	241944700
C710	CERM	0.047µ	25V	+50% -20%	241944700
C711	ESTF	0.1µ	100V	10%	225451000
C712	ESTF	0.68µ	100V	10%	225456800
C713	ESTF	0.68µ	100V	10%	225456800
C714	ESTF	1.5µ	100V	10%	225461500
C715	ESTF	1.5µ	100V	10%	225461500
C716	CERM	0.047µ	25V	+50% -20%	241944700
C717	ALME	22µ	40V		273772200
C718	ALME	22µ	40V		273772200
C719	CERM	0.047µ	25V	+50% -20%	241944700
C720	ESTE	0.22µ	400V	10%	226152200
C721	ESTE	0.68µ	100V	10%	225456800
C722 to C724	CERM	0.047µ	25V	+50% -20%	241944700
C727	ESTF	150n		10%	225451500
C728	CERM	100p		20%	241321000

PCB 5 (cont)

Cct Ref	General Description				Solartron Part No.
C801	ALME	22μ	40V		273772200
C802	CERM	0.01μ	500V	20%	241341000
C803	CERM	0.01μ	500V	20%	241341000
C804	CERM	0.047μ	25V	+50% -20%	241944700
C805	CERM	0.047μ	25V	+50% -20%	241944700
D1	SD3				300522160
D2	SD3				300522160
D3	Zener BZY88 6.8V				300522540
D103 to D106	SD3				300522160
D107	Zener BZY88 30V				300521430
D201	Zener BZY88 10V				300522760
D202	SD3				300522160
D203	SD3				300522160
D301	Zener IN939A 9V				300525520
D302	SD3				300522160
D401	Zener BZY88 30V				300521430
D402	Zener BZY88 30V				300521430
D403	Zener BZY88 5.6V				300521450
D404	Zener IN4577				300525050
D405	Zener BZY88 5.6V				300521450
D406	SD3				300522160
D407	SD3				300522160
D601	IN4007				300524990
D602	SD3				300522160
D603	Zener BZY88 24V				300523930
D604	Zener BZY88 5.6V				300521450
D701	Zener IN4739A 9.1V				300525410
D702	Zener IN4739 9.1V				300525410
D703	IN3595				300523590
D705	IN3595				300523590
D707	Zener BZY88 5.6V				300521450
D708	Zener BZY88 5.6V				300521450
D709	Zener BZY88 5.6V				300521450
D710	5082-6221				300525380
D711	5082-6221				300525380
D801 to D808	SD3				300522160
D810	SD3				300522160
D812 to D816	SD3				300522160
TR1	WN807				300555380
TR2	WN807				300555380
TR3	BFX 37				300553030
TR101	2N2484				300552860
TR103 to TR106	U1899				300554320
TR107 to TR111	2N2484				300552860

PCB 5 (cont)

Cct Ref	General Description	Solartron Part No.
TR202	U1899	300554320
TR203	U1897	300553800
TR204	U1897	300553800
TR205	U1897	300553800
TR206	BCY70	300553590
TR207	BC107	300553320
TR208	BCY70	300553590
TR209	BC107	300553320
TR210	BCY70	300553590
TR211	BC107	300553320
TR301	BCY70	300553590
TR302	BC107	300553320
TR401	WN807	300555380
TR402	WN807	300555380
TR403	WD401	300555370
TR404	BCY70	300553590
TR405	2N2904A	300551670
TR406	2N2484	300552860
TR407	BFX 37	300553030
TR408	2N2484	300552860
TR409	2N2484	300552860
TR410	2N2484	300552860
TR411	WN807	300555380
TR412	WN807	300555380
TR413	WN807	300555380
TR414	BFX37	300553030
TR415	2N2484	300552860
TR416	A1778/2	300551430
TR417	BC107	300553320
TR418	2N2484	300552860
TR419	2N2484	300552860
TR420	2N2484	300552860
TR601	3N163	300554530
TR602	WN807	300555380
TR603	WN807	300555380
TR701	3N163	300554530
TR702	U235	300553810
TR703	BC107	300553320
TR704	BCY70	NAF
TR705	BCY70	NAF
TR706	BCY70	NAF
TR707	BC107	300553320
TR801 to TR807	BCY70	300553590
TR808	2N2369	300552390
TR809	2N2369	300552390
TR810	BC107	300553320
TR811	BC107	300553320
TR812	BCY70	300553590
TR813	BC107	300553320
IC101	LM301 AH	510000620
IC201	LM301 AH	510000620
IC202	SN 74S74	510002020
IC203	SN 74S74	510002020
L701	Inductor 4mH	305020710

PCB 5 (cont)

Cct Ref	General Description	Solartron Part No.
IC204	NPN array CA3045	300554090
IC301	LM201A	510090300
IC302	LM201A	510090300
IC401	LM301 AH	510000620
IC601	LM301 AH	510000620
IC602	LH0052	510090260
IC701	LM301 AH	510000620
IC801 to IC806	TIL 111	300540140
IC807	7445	510000900
IC808	7445	510000900
IC809	7445	510000900
IC810	7414	510001990
IC811	7406	510000760
IC812	74S04	510002660
IC813	7400	510000340
RLA-1	MRA 500	300670120
RLA-2	MRA 500	300670120
RLB	2P C/O 2P N/O	301200807
RLC-1	MRA 500	300670120
RLC-2	MRA 500	300670120
RLC-3	MRA 500	300670120
RLD-1	Relay	301202201
RLD-2	Relay	301202201
RLE	2P C/O	301200203
RLF	1P C/O RS-24	300651980
RLG	2P C/O	301200203
	Coil 1.4k	309506702
T801	Newport 76601/5	303050020
T802	Newport 76601/5	303050020
T803	Newport 76601/5	303050020
T804	Newport 76614/4	303050010
SK1	14 pin dual inline socket	300584680

Section 5
Setting-up & Calibration

INTRODUCTION

This section provides a comprehensive setting-up and calibration procedure which may be necessary after rectification and/or a component replacement on the voltmeter.

It is divided into two sub-sections as follows:

A Setting-Up Procedures

These involve partial strip down of the instrument in order to effect initial adjustments of the circuit parameters.

B Calibration Procedures

The final adjustments provide an instrument performance which conforms with the specification published in Part 1, Section 2 of this manual. For normal calibration only Sub-section B of this section should be followed. Where an instrument fails a calibration, or has undergone rectification and/or a component replacement, it is advisable to carry out the full procedure detailed in this section.

NOTE: It is essential when carrying out setting-up or final calibration procedures that they be completed and carried out in the order given. The information on pages 4.5.2 to 4.5.7 is common to both 7055 and 7065. Thereafter, until page 4.5.34 refers to the 7065; setting-up and calibration specific to the 7055 continues on page 4.5.35.

A. Setting up

TEST EQUIPMENT

The test equipment used must have an accuracy/uncertainty equal to or better than that shown in the calibration tables.

The test equipment listed below should be available to carry out the setting-up procedures correctly.

a) Mains Isolation Transformer

b) Variac.

c) Digital Voltmeter (e.g. Type 7040).

d) Oscilloscope plus x10 probe (e.g. A100).

e) DC Voltage Standard.

f) AC Voltage Standard (e.g. Hewlett Packard 745A).

g) Resistance Standard 100Ω to 10MΩ (e.g. ESI DB62 or ESI RS624 and separate 10MΩ Standard).

h) Voltage Divider (e.g. ESI RV722).

Additional items required:

100Ω and 10Ω Standard resistors, known to an accuracy of 50ppm.

5-terminal lead.

PRELIMINARY

1. Prepare the instrument as follows:

SAFETY

THE INSTRUMENT SHOULD BE DISCONNECTED FROM THE MAINS SUPPLY BEFORE ANY ATTEMPT IS MADE TO REMOVE THE TOP COVER.

BEWARE OF GUARD POTENTIAL ON THE GUARD PLATE AND MAINS POTENTIAL ON THE POWER SUPPLY WHEN THE TOP COVER IS REMOVED.

   a) At the top corners, on the rear of the instrument, remove the screw securing each buffer.

   b) Remove the two buffers.

   c) Remove the top cover by sliding it away from the front panel.

2. Check that the fuse fitted is 800mA–SLO–BLO as indicated beside the fuse holder.

POWER SUPPLY SWITCHING WAVEFORM

1. Connect the 7065(55) to the mains transformer as shown in Fig. 5.1.

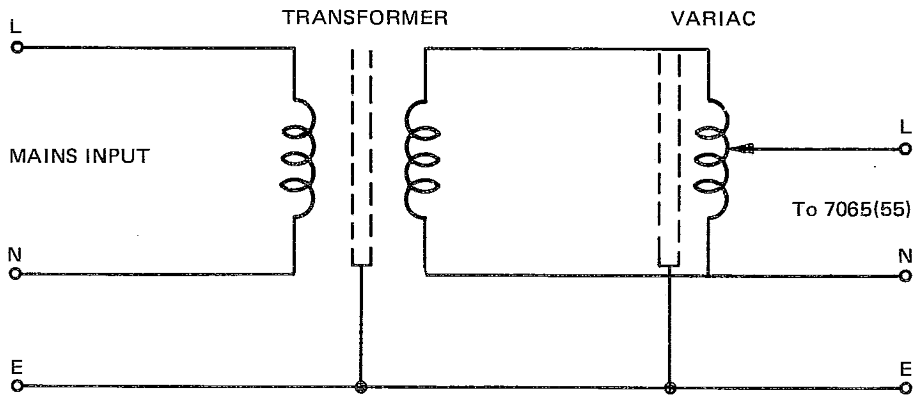


Fig. 5.1

2. Set the variac for minimum output.
3. Connect a voltmeter, set to dc, between the +36V rail and 0V pin adjacent to SK1 on pcb 5.
4. Connect an oscilloscope, via a x10 probe, to TP3 on pcb 7 and input negative.
5. Switch on the instrument.
6. Adjust the variac for 60V input and observe the following:
   a) A display should begin to appear on the instrument under test.
   b) A reading of approximately +36V on the voltmeter.
   c) A 60V p/p amplitude waveform on the oscilloscope.
7. Adjust the variac to 120V input.
8. Check that the voltmeter reading is 36V ± 10V.
9. Increase the input to 240V.
10. Check that the switching waveform is within the limits shown. Fig. 5.2.

Fig. 5.2 Switching Waveform

11. Disconnect the oscilloscope from TP3 and connect to TP4.

12. Check that the displayed waveform is 30V p/p ± 3V and 35μs ± 5μs duration.

13. Disconnect the oscilloscope from TP4 and input negative on pcb 7.

RAIL CHECKS

1. Adjust RV1 on pcb 7 for a voltmeter reading of +36V ± 0.1V.

2. Vary the mains input between 120V and 260V.

3. Ensure that the reading does not change by more than ± 0.5V from that in operation 1.

4. Adjust the mains input to 230V.

5. Switch off the instrument under test.

6. Disconnect the voltmeter from the +36V rail and the 0V pin adjacent to SK1 on pcb 5.

Table 5.1 below summarises the voltage rails in the instrument. These need not be checked unless a fault is suspected.

Table 5.1

AREA	RAIL	READING	
		Value	Limits ± V
EARTHY RAILS PCB 3 (measure with respect to 0V)	+5VA +5VB	+5V	0.5V
FLOATING RAILS PCB 5 (measure with respect to 0V floating)	+36V	+36V	0.1V
	+21V	+21V	1V
	+18V	+18V	1V
	+5V	+5V	0.5V
	–18V	–18V	1V
	–21V	–21V	1V
	–36V	–36V	1V

EARTHY LOGIC CHECKS

1. Check that the "split pad" links on pcb 3 are set as follows:

Open circuit	Short circuit
LK B	LK A
LK G	LK C
	LK F
7065 only LK E	7055 only LK E

2. Check that TP13 is linked to TP14.

3. Switch on the instrument and check that:

   a) The display reads HELLO, then ......

   b) .... the VDC, FILTER, TRACK, AUTO and '000V keyswitch indicators illuminate.

   c) The instrument is in 'Local operation'. i.e. REMOTE keyswitch indicator is "off".

4. Short circuit the input terminals.

Note: As the instrument is in autorange and with zero input, the range indicator LED illumination should step quickly, one range at a time, to the lowest range (0.01V).

5. The display should then read ± 0.000000V.

KEYSWITCH ILLUMINATION

1. Carry out in order the checks as per Table 5.2.

TABLE 5.2

TEST	PRESS	CHECK
1	VAC	Range change from 0.01 to 0.1 VAC led illuminated.
2	10^4kΩ	Range change to 1000. AUTO led extinguished.
3	AUTO	Range led's should step down one range at a time, illuminating for approximately 1s per range until the 0.1 range is reached.
4	kΩ	Range change to 0.01. (7065 only). kΩ led illuminated.
5	10^4kΩ	Range change to 10^4kΩ. AUTO led extinguished.
6	AUTO	Range led's should step down, one range at a time (quickly) until the 0.01 range is reached.
7	FILTER	Filter led extinguished. Check that the led is alternately illuminated or extinguished with successive depressions of the keyswitch. Select FILTER (led "on")
8	COMPUTE	No change in led's. With no program board fitted pressing COMPUTE has no effect.
9	PROGRAM	All led's are extinguished, and "*noP*" is displayed for approximately 2s. The instrument then reverts to its previously selected condition.
10	DISPLAY	DISPLAY led "flashing", all other led's extinguished. The instrument displays *d5*.
11	DISPLAY	DISPLAY led extinguished. The instrument then returns to its previously selected condition.

2. Open circuit the Input terminals.

SCALE LENGTH CHECK

1. Select: VDC, 1.0V range.

2. Carry out checks as per Table 5.3.

TABLE 5.3

TEST	PRESS 1	PRESS 2	DISPLAY	
1	DISPLAY	6x9's	7055 7065	No change 0.0000XX*
2	DISPLAY	5x9's		0.0000X*
3	DISPLAY	4x9's		0.0000
4	DISPLAY	3x9's		0.000

* Where X equals any digit from 0 to 9.

CLOCK OSCILLATOR ADJUSTMENTS pcb 3

1. Connect a voltmeter between the junction of (R6, R7 and C2, R8, R9) (+ve) and oscillator 0V (–ve).

2. Check that LK C and LK F split pads are short circuit.

3. Adjust C5 on pcb 3 for a reading of 1.9V ± 200mV on the voltmeter.

4. Disconnect the voltmeter from pcb 3.

CONVERSION TO 60Hz OPERATION (operate instrument from a 60Hz supply)

1. Remove the short circuits on LK C and LK F split pads on pcb 3.

2. Connect a voltmeter between the junction of R6, R7 and C2, R8, R9 (+ve) and oscillator 0V (–ve).

3. Adjust C5 on pcb 3 for a reading of 1.9V ± 200mV on the voltmeter.

4. Disconnect the voltmeter from pcb 3.

INTEGRATOR

1. Select: 10V range, DISPLAY and 5x9's scale length.
2. Short circuit V/Ω Hi, V/Ω Lo and the GUARD front panel input terminals with wire links.
3. Check that the displayed reading is 0.0000V ± 1 bit.
4. Remove the links connecting the V/Ω Hi and Lo terminals.
5. Connect an oscilloscope between TP202 (+ve) and 0V (–ve) on pcb 5.
6. Check that the Integrator switching waveform is within the limits shown (Fig. 5.3)

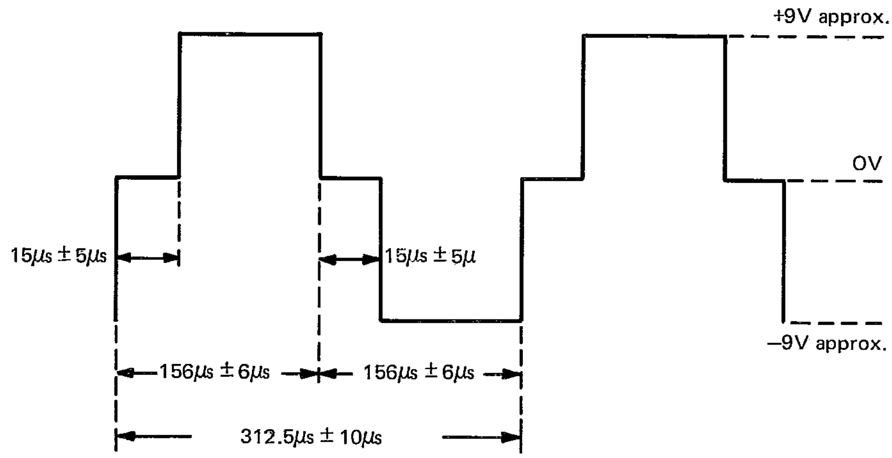


Fig. 5.3

7. Disconnect the oscilloscope from TP202 and 0V on pcb 5.

INPUT AMPLIFIER

OFFSET ADJUSTMENT

1. Connect a voltmeter between TP208 (+ve) and 0V (–ve) on pcb 5.

2. Select the ranges in turn and check that the displayed reading and TP208 voltages are within limits as per Table 5.4.

TABLE 5.4

TEST	RANGE	TP208	READING	
			Value	± bits
1	10V	–0.3 to +0.3mV	0.0000	1
2	1V	–0.3 to 25mV	0.0000	4
3	0.1V	–30 to 55mV	0.000000	30
4	0.01V	–300 to 325mV	0.000000	30

Note: If the voltmeter reading at TP208 is outside the limits specified, the reader is referred to Table 5.5.

3. Insert a suitable value resistor for R424, shorting out R425 (LK R) if necessary.

TABLE 5.5

TP208 VOLTAGE (mV)			R424 (OHMS)
0	to	3	TCW link
2.5		5.5	12
4.7		7.7	22
7.0		10.0	33
10.0		13.0	47
11.9		14.9	56
14.5		17.5	68
17.5		20.5	82
19.4		22.4	91
21.4		24.3	100
23.4		26.4	110
25.6		28.6	120
27.7		30.7	130

4. Remove the voltmeter from TP208 and 0V.

OVERLOAD TEST

1. Connect the RED and BLACK leads to the V/Ω Hi and Lo front panel input terminals.
2. Select the 10V range.
3. Connect a voltmeter to TP1 (+ve) on pcb 5 and the V/Ω Lo front panel input terminal.
4. Apply +30V to the V/Ω front panel input.
5. Check that the voltmeter reading is +18V ±1V and that the 7065 display is flashing.
6. Select: AUTO.
7. Check that the instrument does not display HELLO prior to autoranging up to the 100V range.
8. Check that the displayed reading on the 100V range is approximately +30V.
9. Select the 1000V range, check that the displayed reading is still approximately +30V.
10. Repeat operations 1 to 8 for negative values using the same voltage source.
11. Remove the DC source.
12. Disconnect the voltmeter from TP1 on pcb 5 and from the V/Ω Lo front panel input terminal.

INPUT CURRENT AND μV ZERO CHECK

1. Select the 100mV range (0.1V)
2. Short circuit the input leads.
3. Check that the display reads zero, ± 20μV.
4. Check that the μV OFFSET control on the front panel can be adjusted to obtain a reading within the limits ±8μV.
5. Finally adjust the μV OFFSET for a reading of zero, or as near zero as possible.
6. Remove the short circuit.
7. Connect a 1MΩ resistor across the input terminals.
8. The display should settle to between ± 25μV.
9. Disconnect the 1MΩ resistor from the input terminals

INPUT IMPEDANCE CHECK

1. Press: Display, 6x9's scale length and 10V range.
2. Apply +10V to the instrument input and note the displayed reading.
3. Connect a 1MΩ resistor in series with the Hi input and the DC source.
4. Check that the displayed reading does not differ from that in operation 2 by more than ± 10 bits.
5. Repeat for a negative value (–10V) using the same voltage source.
6. Remove the DC source.

NOISE CHECK

1. Short circuit the input leads and ensure that the displayed reading does not exceed ± 2 bits for 10 seconds.
2. De-select FILTER, (ind "off"); the noise should not exceed 3 bits for 10 seconds.
3. Press: DISPLAY and 5x9's scale length; the noise should not exceed ± 3 bits for 10 seconds.
4. Remove the short circuit.

REFERENCE ADJUSTMENTS

1. Press: FILTER, DISPLAY and 6x9's scale length.
2. Using a DC VOLTAGE STANDARD, apply –10V to the input.
3. Adjust RV201 (10V CAL) on pcb 5 for a reading of –10.00000V ± 10 bits.

The total scatter of readings, with ± 10V input to the instrument, should not exceed 4 bits.

N.B. If RV201 does not provide sufficient adjustment, links A to J will require re-adjustment and the reader is referred to the Reference Linkage table (see page 4.5.27).

NB The reader must wait for a Drift Correct cycle (up to 10 seconds) after each adjustment as the CAL BAL will be in error until this has occurred.

DC RANGE CALIBRATION

10V RANGE

1. Apply +10V to the input. Note the displayed reading.

2. Apply –10V to the input. Note the displayed reading.

3. Adjust RV202 (CAL BAL) on pcb 5 for equal +ve and –ve readings ± 2 bits.

4. Apply +10V to the input and adjust RV201 (10V CAL) for a reading of +10.00000V ± 5 bits.

Repeat operations 1 to 4 as necessary.

NB. The reader must wait for a Drift Correct cycle (up to 10 seconds) after each adjustment as the CAL BAL will be in error until this has occurred.

5. Remove the DC source.

6. Remove the front panel input connectors.

SPIKE CORRECTION

RV401 and RV402 are adjusted during calibration at the factory and should not require further adjustment.

AC CHECKS

1. Select: VAC, 1.0V range, DISPLAY and 5x9's scale length.

2. Link the V/Ω Hi and Lo front panel inputs. Ensure GUARD is also linked to the V/Ω Lo terminal.

3. Check that the displayed reading is less than 5 bits.

4. Select the 0.1V range. Check that the displayed reading is less than 60 bits.

5. Remove the link connecting the V/Ω Hi and Lo inputs.

6. Connect the RED and BLACK leads to the V/Ω Hi and V/Ω Lo front panel terminals respectively.

7. Connect the AC standard to the input.

8. Select the 1.0V range on the voltmeter.

9. Apply 1V rms at 1kHz to the input. Check that the displayed reading is approximately 1V.

10. Apply 100mV at 1kHz to the input.

11. Select the 0.1V range. Check that the displayed reading is approximately 100mV.

12. Select the 10V range.

13. Apply a voltage of between 5V and 10V to the input. Check that the displayed reading is approximately correct.

14. Select the 100V and 1000V ranges in turn, check that the displayed reading on both ranges is approximately correct.

15. Remove the AC source and input connectors.

OHMS CURRENT CHECK

1. Select: kΩ and the 10kΩ range.

2. Connect a voltmeter (with current measuring facility) between the HiΩ DRIVE (+ve) terminal and the Lo V/Ω (–ve) input terminal.

3. Refer to Table 5.6 and check that the current is within limits for each range.

TABLE 5.6

RANGE	READING
10kΩ	1mA ± 10μA
100kΩ	10μA ± 0.1μA
10^4kΩ	1μA ± 0.02μA

4 Remove the voltmeter lead from the HiΩ DRIVE terminal and connect it to the LoΩ DRIVE input.

5. Refer to Table 5.7, check that the current is within limits for each range.

TABLE 5.7

RANGE	READING
10kΩ	1mA ± 20μA
100kΩ	10μA ± 200nA
10^4kΩ	0 ± 10nA

6. Disconnect the voltmeter from the Lo V/Ω and LoΩ DRIVE input terminals.

OVERLOAD PROTECTION CHECK

1. Link Ω DRIVE HI to the V/Ω HI terminal and Ω DRIVE LO to the V/Ω LO terminal.
2. Ensure GUARD is also linked to the V/Ω Lo terminal.
3. Select the 10kΩ range.
4. Connect the AC Standard to the input.
5. Apply 240V at 50/60Hz for 10s.
6. Remove the AC source.
7. Connect a voltmeter (with current measuring facility) between the Hi (+ve) and Lo (–ve) input terminals, checking that the reading is still 1mA ± 10μA.
8. Remove the voltmeter connected in operation 7.

COMMON MODE

DC REJECTION

1. Connect the instrument as shown in Fig. 5.4.

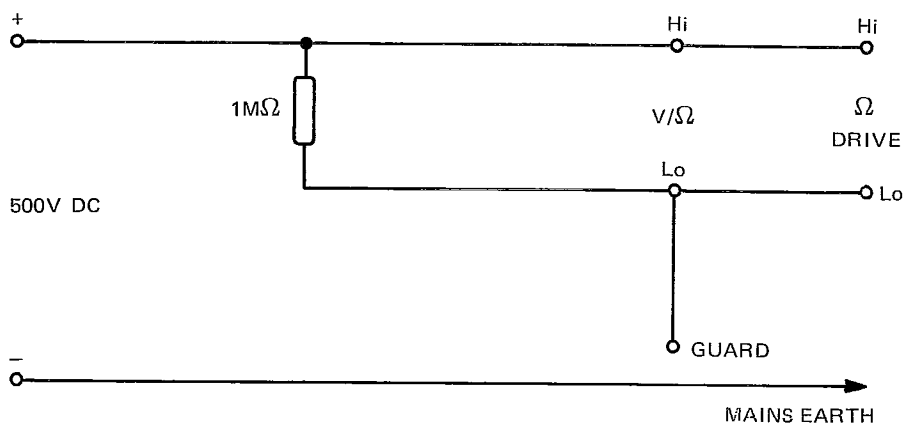


Fig. 5.4

2. Select: VDC and AUTO.
3. Apply 500V to the instrument input.

4. The reading on the display should not exceed 10mV.

5. Remove the DC source.

6. Disconnect the 1MΩ resistor.

7. Disconnect the links and connectors from the front panel terminals.

LINEARITY

1. Select: 10V range, DISPLAY and 6 x 9's scale length.

2. Fit the 5-terminal lead to the rear panel input.

3. Connect the DC Standard and Dekavider to the rear input.

4. Check the linearity in accordance with Table 5.8.

TABLE 5.8

TEST	INPUT VOLTAGE (Volts)	READING	
		Value	Limits ± bits
1	10	10.00000	3
2	9	9.000000	3
3	8	8.000000	3
4	7	7.000000	3
5	6	6.000000	3
6	5	5.000000	3
7	4	4.000000	3
8	3	3.000000	3
9	2	2.000000	3
10	1	1.000000	3
11	100mV	0.100000	2
12	10mV	0.010000	2
13	1mV	0.001000	2
14	Zero input	0.000000	2

5. Repeat for negative values using the same voltage source.

6. Increase the DC source to the Dekavider for a displayed reading of 10.00000V ± 1 bit on the instrument under test.

7. Change the Dekavider output to 13.90000V.

8. Ensure that the 7065 reads 13.90000 ± 10 bits.

9. Increase the Dekavider output and check that the 7065 display does not begin to flash until a reading greater than 14.00000 is obtained.

10. Remove the DC source and Dekavider.

10mV, 100mV AND 1V RANGE CALIBRATION

1. Select: AUTO.

2. Short circuit the input leads.

3. Adjust the μV zero control for a zero reading on the display.

4. Remove the short circuit.

5. Connect the DC source and Dekavider to the rear input socket and apply the voltages as per Table 5.9.

TABLE 5.9

TEST	INPUT	OPERATION	READING	
			Value	Limits ± bits
1	-10mV	RV103 (10mV DC)	–0.010000	1
2	-100mV	RV102 (100mV DC)	–0.100000	2
3	–1V	RV101 (1V DC)	–1.000000	5

6. Repeat for positive values using the same voltage source.

7. Check that the readings obtained for the two polarities do not differ by more than:-

   a) 3μV on the 10mV range.

   b) 4μV on the 100mV range

   c) 5μV on the 1V range.

100V AND 1000V RANGE CALIBRATION

1. Disconnect the Dekavider from the DC source.
2. Apply –100V to the 7065 input direct from the DC source.
3. Adjust RV1 (100V DC) on pcb 5 for a reading of –100.0000V ± 10 bits.
4. Increase the input to –1000V. The display should settle to –1000.000V ± 25 bits.
5. The drift after 1 minute should be less than ± 5 bits.
6. Reduce the input to zero. Remove the DC source.

AC CALIBRATION

100mV AND 1V RANGE CALIBRATION

1. Connect the AC STANDARD to the rear input.
2. Select: VAC, DISPLAY and 5x9's scale length.
3. Ensure FILTER is selected.
4. Apply the voltages given in Table 5.10.

TABLE 5.10

TEST	RANGE	INPUT	FREQUENCY	OPERATION	READING	
					Value	Limits ± bits
1	1V	1V	1kHz	RV704(1V LF)	1.00000	10
2	"	0.1V	"	RV705(AC Lin)	0.100000	2
3	Repeat tests 1 and 2 as necessary					
4	0.1V	0.1V	1kHz	RV703(100mV LF)	0.100000	10
5	"	0.01V	"		0.010000	15
6	"	0.1V	50kHz		0.100000	40
7	"	"	10kHz		0.100000	40
8	"	"	50kHz		0.100000	100
9	1V	1V	"		1.00000	40
10	"	"	10kHz		1.00000	40
11	"	"	50kHz		1.00000	100

10V, 100V and 1000V RANGE CALIBRATION

1. Apply the voltages as per Table 5.11.

TABLE 5.11

TEST	RANGE	INPUT	FREQUENCY	OPERATION	READING	
					Value	Limits ± bits
1	10V	10V	1kHz	RV701(10V LF)	10.0000	30
2	1000V	800V	"	RV702(1000V LF)	800.00	10
3	10V	10V	"	RV701(10V LF)	10.0000	30
4	10V	10V	50kHz	C701(10V HF)	10.0000	200
5	Repeat tests 3 and 4 as necessary.					
6	10V	10V	10kHz		10.0000	60
7	100V	100V	50kHz		100.000	70
8	100V	100V	1kHz		100.000	50
9	100V	100V	10kHz		100.000	60
10	100V	100V	50kHz		100.000	200
11	1000V	800V	1kHz	RV702(1000V LF)	800.00	10
12	1000V	800V	10kHz		800.00	60
13	1000V	200V	50kHz		200.00	50

2. Disconnect the AC source.

OHMS RANGE CALIBRATION

1. Select kΩ, 10kΩ range, DISPLAY and 6 X 9's scale length.

2. Connect the Resistance Standard set to 10kΩ, to the rear input.

3. Adjust RV602 for a displayed reading of 10.00000 kΩ ± 10 bits.

4. Select the other ranges in turn and carry out the checks as per Table 5.12.

TABLE 5.12

TEST	RANGE	INPUT	OPERATION	READING	
				Value	Limits ± bits
1	10kΩ	10kΩ	RV602(10kΩ)	10.00000	10
2	1000kΩ	1MΩ	RV603(1MΩ)	1000.000	10
3	10^4kΩ	10MΩ	RV601(10MΩ)	10000.00	20
4	Repeat tests 1 to 3 as necessary.				
5	1kΩ	1kΩ		1.000000	20
6	10kΩ	13.9kΩ		13.90000	25
7	100kΩ	100kΩ		100.0000	20

3. Disconnect the resistance standard from the instrument.

4. Disconnect the rear input connector.

4. Switch off the instrument.

NB. If RV602 does not provide sufficient adjustment, links LK K to LK P will need to be adjusted; the reader is referred to the Resistance linkage Table (see page 4.5.31).

This concludes the setting up of the 7065. A full calibration should now be carried out, B overleaf.

B. Calibration

INTRODUCTION

The following calibration is basically that to which all instruments are subjected prior to despatch from the factory.

For the greatest accuracy the instrument's top cover should be removed and its calibration cover, Part No. 70559D, fitted. Failing this, allowances must be made for variations in the working temperatures.

See page 4.5.61 for details of calibration cover.

PRELIMINARY

For the following checks the microprocessor voltmeter will have its top cover removed and be fitted with its calibration cover (if available).

SAFETY

THE INSTRUMENT SHOULD BE DISCONNECTED FROM THE MAINS SUPPLY BEFORE ANY ATTEMPT IS MADE TO REMOVE THE TOP COVER

BEWARE OF GUARD POTENTIAL ON THE GUARD PLATE AND MAINS POTENTIAL ON THE POWER SUPPLY WHEN THE TOP COVER IS REMOVED

1. Prepare the instrument as follows:

   a) At the top corners on the rear of the instrument, remove the screw securing each buffer.

   b) Remove the two buffers.

   c) Remove the top cover by sliding it away from the front panel.

2. Check that the fuse fitted is 800mA–SLO–BLO, as indicated beside the fuse holder. For calibration procedures to be carried out at 20°C, it is essential that the following test equipment or its equivalent is available.

TEST EQUIPMENT

a) Mains Isolation Transformer.

b) Variac.

c) Digital Voltmeter (e.g. Type 7050).

d) Oscilloscope plus x10 probe (e.g. Type A100).

e) DC Voltage Standard.

f) AC Voltage Standard.

g) Resistance Standard, 100Ω to 20MΩ.

h) Voltage Divider.

Additional item required:

5-terminal input lead (EX3183).

It should be noted that if the calibration equipment used does not meet the uncertainty specification of the items listed, the Limits of Error specified in Part 1 section 2 of this Manual will not be achieved. Measurements made with the dvm after such recalibration therefore, while exhibiting errors no worse than those specified, will be related to the calibration equipment rather than to the internationally agreed volt.

CALIBRATION

The calibration sequence must be carried out in the order given. Calibration should be carried out at an ambient temperature 20°C ± 1°C after a warm-up period of at least two hours with the calibration cover fitted.

CALIBRATION AT 20°C

1. Fit the 7065 with it's calibration cover.
2. Switch on the instrument at least two hours before commencing calibration.
3. Select: the 10V range, DISPLAY and 6x9's scale length.
4. Check that there are no front panel inter-connecting links fitted between terminals.
5. Fit the 5-terminal connector to the rear panel input and short circuit the leads.
6. Check that the displayed reading is zero ± 1 bit.
7. Remove the short circuit.
8. Apply +10V to the input. Note the displayed reading.
9. Apply –10V to the input. Note the displayed reading.
10. Adjust RV202 (CAL BAL) on pcb 5 for equal +ve and –ve readings ± 2 bits.

NB The reader must wait for a Drift Correct cycle (up to 10 seconds) after each adjustment as the CAL BAL will be in error until this has occurred.

11. Apply +10V and adjust RV201 for a reading of +10.00000V ± 3 bits.
12. Apply –10V and check that the reading is –10.00000V ± 3 bits.
13. Repeat operations 11 and 12 as necessary until the readings meet the limits specified.
14. Remove the DC source.

DC RANGE CALIBRATION

1. Short circuit the input leads.

2. Adjust the μV OFFSET control on the front panel for a reading of zero.

3. Remove the short circuit.

4. Apply the voltages as per Table 5.13.

TABLE 5.13

TEST	RANGE	INPUT	OPERATION	READING Value	READING Limits ± bits
1	0.01	+10.0mV	RV103(10mV DC)	+0.010000	2
2	0.01	–10.0mV		–0.010000	2
3	0.1	+100mV	RV102(100mV DC)	+0.100000	3
4	0.1	–100mV		–0.100000	3
5	1	+1.0V	RV101(1V DC)	+1.000000	4
6	1	–1.0V		–1.000000	4
Repeat tests 1 to 6 as necessary					
7	1000V	+1000V	RV1(100V DC)	+1000.000	5
8	1000	–1000V		–1000.000	5
9	100	+100V		+100.0000	8
10	100	–100V		–100.0000	8

Note: Adjust for equal readings. Share any deviations equally between readings.

5. Reduce the input to zero. Remove the DC source.

OHMS RANGE CALIBRATION

1. Select: kΩ

2. Connect the ohms standard to the input.

3. Apply the resistance values as per Table 5.14.

TABLE 5.14

TEST	RANGE	INPUT	OPERATION	READING	
				Value	Limits ± bits
1	10kΩ	10kΩ	RV602(SET 10kΩ)	10.00000	5
2	1000kΩ	1MΩ	RV603(SET 1MΩ)	1000.000	5
Repeat tests 1 and 2 as necessary					
3	10^4kΩ	10MΩ	RV601(SET 10MΩ)	10000.00	20
4	100kΩ	100kΩ		100.0000	20
5	1kΩ	1kΩ		1.000000	20
6	0.1kΩ	0.1kΩ		0.100000	20
7	0.01kΩ	0.01kΩ		0.010000	20

4. Remove the Ohms Standard.

AC RANGE CALIBRATION

1. Select: VAC, DISPLAY and 5x9's scale length.

2. Connect the AC standard to the rear input.

3. Apply the voltages as per Table 5.15.

TABLE 5.15

TEST	RANGE	INPUT	FREQUENCY	OPERATION	READING	
					Value	Limits ± bits
1	1V	1V	1kHz	RV704(1V LF)	1.00000	10
2	1V	100mV	”	RV705(AC Lin)	0.10000	2
	Repeat tests 1 and 2 as necessary					
3	1V	1V	10kHz		1.00000	40
4	”	1V	50kHz		1.00000	100
5	”	100mV	”		0.10000	20
6	0.1V	”	1kHz	RV703(100mV LF)	0.100000	10
7	”	”	50kHz		0.100000	40
8	”	”	10kHz		0.100000	40
9	”	”	50kHz		0.100000	100
10	”	10mV	1kHz		0.010000	15
11	”	”	50kHz		0.010000	20
12	10V	10V	1kHz	RV701(10V LF)	10.0000	30
13	”	”	50kHz	C701(10V HF) (Note 1)	10.0000	200
14	”	”	10kHz		10.0000	60
15	100V	100V	1kHz		100.000	50
16	”	”	10kHz		100.000	60
17	”	”	50kHz		100.000	70
18	”	”	”		100.000	200
19	1000V	750V	1kHz	RV702 (1000V LF) (Note 2)	750.00	10
20	”	”	10kHz		750.00	60
21	”	200V	50kHz		200.00	50
22	10V	10V	”		10.0000	200

Notes:

1. Test 13, adjust C701 as necessary for best overall frequency response.
2. Test 19, allow time for reading to settle.
3. Remove the AC standard.
4. Disconnect the 5-terminal lead from the rear input.
5. Switch off the instrument.

This concludes the calibration of the 7065.

7065 Reference Set-Up Table

Notes: 1. For voltages in column A, link A should be soldered, for those in column B, link B.

2. In the link pattern, "S" indicates that the link is to be soldered.

VOLTAGE RANGE				LINK PATTERN						
A		B		C	D	E	F	G	H	J
9.9957	10.0043	9.9937	10.0043	S	S	S	S	S	S	S
9.9877	9.9963	10.0037	10.0124	S	S	S	S	S	S	
9.9811	9.9897	10.0103	10.0189	S	S	S	S	S		S
9.9731	9.9817	10.0184	10.0270	S	S	S	S	S		
9.9714	9.9800	10.0201	10.0287	S	S	S	S		S	S
9.9635	9.9721	10.0281	10.0368	S	S	S	S		S	
9.9570	9.9656	10.0347	10.0433	S	S	S	S			S
9.9491	9.9576	10.0428	10.0514	S	S	S	S			
9.9522	9.9608	10.0396	10.0482	S	S	S		S	S	S
9.9443	9.9529	10.0476	10.0563	S	S	S		S	S	
9.9379	9.9464	10.0542	10.0629	S	S	S		S		S
9.9300	9.9386	10.0623	10.0709	S	S	S		S		
9.9284	9.9369	10.0640	10.0726	S	S	S			S	S
9.9205	9.9291	10.0720	10.0807	S	S	S			S	
9.9142	9.9227	10.0786	10.0873	S	S	S				S
9.9064	9.9149	10.0866	10.0953	S	S	S				
9.9142	9.9227	10.0786	10.0873	S	S		S	S	S	S
9.9064	9.9149	10.0866	10.0953	S	S		S	S	S	
9.9000	9.9086	10.0932	10.1019	S	S		S	S		S
9.8923	9.9008	10.1013	10.1100	S	S		S	S		
9.8907	9.8992	10.1030	10.1117	S	S		S		S	S
9.8833	9.8915	10.1110	10.1197	S	S		S		S	
9.8767	9.8852	10.1176	10.1263	S	S		S			S
9.8690	9.8775	10.1256	10.1344	S	S		S			
9.8721	9.8806	10.1225	10.1312	S	S			S	S	S
9.8644	9.8729	10.1305	10.1392	S	S			S	S	
9.8582	9.8667	10.1371	10.1458	S	S			S		S
9.8506	9.8591	10.1451	10.1538	S	S			S		
9.8490	9.8575	10.1469	10.1556	S	S				S	S
9.8414	9.8499	10.1549	10.1636	S	S				S	
9.8352	9.8437	10.1615	10.1702	S	S					S
9.8277	9.8362	10.1695	10.1783	S	S					

VOLTAGE RANGE				LINK PATTERN						
A		B		C	D	E	F	G	H	J
9.8536	9.8621	10.1420	10.1507	S		S	S	S	S	S
9.8460	9.8545	10.1500	10.1588	S		S	S	S	S	
9.8398	9.8483	10.1566	10.1653	S		S	S	S		S
9.8323	9.8407	10.1647	10.1734	S		S	S	S		
9.8307	9.8391	10.1664	10.1751	S		S	S		S	S
9.8232	9.8316	10.1744	10.1832	S		S	S		S	
9.8170	9.8255	10.1810	10.1897	S		S	S			S
9.8096	9.8180	10.1890	10.1978	S		S	S			
9.8125	9.8210	10.1859	10.1946	S		S		S	S	S
9.8051	9.8135	10.1939	10.2027	S		S		S	S	
9.7990	9.8074	10.2005	10.2093	S		S		S		S
9.7916	9.8000	10.2085	10.2173	S		S		S		
9.7900	9.7984	10.2102	10.2190	S		S			S	S
9.7826	9.7910	10.2183	10.2271	S		S			S	
9.7766	9.7850	10.2249	10.2337	S		S				S
9.7692	9.7776	10.2329	10.2417	S		S				
9.7766	9.7850	10.2249	10.2337	S			S	S	S	S
9.7692	9.7776	10.2329	10.2417	S			S	S	S	
9.7632	9.7716	10.2395	10.2483	S			S	S		S
9.7559	9.7643	10.2475	10.2564	S			S	S		
9.7544	9.7628	10.2492	10.2581	S			S		S	S
9.7471	9.7555	10.2573	10.2661	S			S		S	
9.7412	9.7496	10.2639	10.2727	S			S			S
9.7339	9.7423	10.2719	10.2808	S			S			
9.7368	9.7452	10.2688	10.2776	S				S	S	S
9.7296	9.7379	10.2768	10.2856	S				S	S	
9.7237	9.7320	10.2834	10.2922	S				S		S
9.7165	9.7249	10.2914	10.3003	S				S		
9.7150	9.7233	10.2931	10.3020	S					S	S
9.7078	9.7162	10.3012	10.3100	S					S	
9.7020	9.7103	10.3078	10.3166	S						S
9.6949	9.7032	10.3158	10.3247	S						

VOLTAGE RANGE				LINK PATTERN						
A		B		C	D	E	F	G	H	J
9.7412	9.7496	10.2639	10.2727		S	S	S	S	S	S
9.7339	9.7423	10.2719	10.2808		S	S	S	S	S	
9.7280	9.7364	10.2785	10.2873		S	S	S	S		S
9.7208	9.7292	10.2866	10.2954		S	S	S	S		
9.7193	9.7277	10.2883	10.2971		S	S	S		S	S
9.7122	9.7205	10.2963	10.3052		S	S	S		S	
9.7063	9.7147	10.3029	10.3117		S	S	S			S
9.6992	9.7075	10.3109	10.3198		S	S	S			
9.7020	9.7103	10.3078	10.3166		S	S		S	S	S
9.6949	9.7032	10.3158	10.3247		S	S		S	S	
9.6891	9.6974	10.3224	10.3313		S	S		S		S
9.6820	9.6903	10.3304	10.3393		S	S		S		
9.6805	9.6888	10.3321	10.3410		S	S			S	S
9.6734	9.6818	10.3402	10.3491		S	S			S	
9.6677	9.6760	10.3468	10.3557		S	S				S
9.6617	9.6690	10.3548	10.3637		S	S				
9.6677	9.6760	10.3468	10.3557		S		S	S	S	S
9.6607	9.6690	10.3548	10.3637		S		S	S	S	
9.6549	9.6632	10.3614	10.3703		S		S	S		S
9.6480	9.6563	10.3694	10.3784		S		S	S		
9.6465	9.6548	10.3711	10.3801		S		S		S	S
9.6395	9.6478	10.3792	10.3881		S		S		S	
9.6339	9.6422	10.3858	10.3947		S		S			S
9.6270	9.6352	10.3938	10.4028		S		S			
9.6297	9.6380	10.3907	10.3996		S			S	S	S
9.6228	9.6311	10.3987	10.4076		S			S	S	
9.6171	9.6254	10.4053	10.4142		S			S		S
9.6103	9.6185	10.4133	10.4223		S			S		
9.6088	9.6171	10.4150	10.4240		S				S	S
9.6020	9.6103	10.4231	10.4320		S				S	
9.5964	9.6047	10.4297	10.4386		S					S
9.5896	9.5979	10.4377	10.4467		S					

VOLTAGE RANGE				LINK PATTERN						
A		B		C	D	E	F	G	H	J
9.6130	9.6213	10.4102	10.4191			S	S	S	S	S
9.6061	9.6144	10.4182	10.4272			S	S	S	S	
9.6005	9.6088	10.4248	10.4338			S	S	S		S
9.5937	9.6020	10.4328	10.4418			S	S	S		
9.5923	9.6005	10.4345	10.4435			S	S		S	S
9.5855	9.5937	10.4426	10.4516			S	S		S	
9.5800	9.5882	10.4492	10.4582			S	S			S
9.5732	9.5814	10.4572	10.4662			S	S			
9.5759	9.5841	10.4540	10.4630			S		S	S	S
9.5691	9.5774	10.4621	10.4711			S		S	S	
9.5636	9.5719	10.4687	10.4777			S		S		S
9.5569	9.5651	10.4767	10.4857			S		S		
9.5555	9.5637	10.4784	10.4874			S			S	S
9.5488	9.5570	10.4865	10.4955			S			S	
9.5434	9.5516	10.4930	10.5021			S				S
9.5367	9.5449	10.5011	10.5101			S				
9.5434	9.5516	10.4930	10.5021				S	S	S	S
9.5367	9.5449	10.5011	10.5101				S	S	S	
9.5313	9.5395	10.5077	10.5167				S	S		S
9.5247	9.5329	10.5157	10.5248				S	S		
9.5233	9.5315	10.5174	10.5265				S		S	S
9.5167	9.5249	10.5255	10.5345				S		S	
9.5113	9.5195	10.5321	10.5411				S			S
9.5048	9.5130	10.5401	10.5492				S			
9.5074	9.5155	10.5369	10.5360					S	S	S
9.5008	9.5090	10.5450	10.5540					S	S	
9.4955	9.5036	10.5516	10.5606					S		S
9.4890	9.4971	10.5596	10.5687					S		
9.4876	9.4958	10.5613	10.5704						S	S
9.4811	9.4893	10.5694	10.5784						S	
9.4758	9.4840	10.5759	10.5850							S
9.4694	9.4775	10.5840	10.5931							

7065 Resistance Set Up Table

In the link pattern, 'S' indicates that the link is to be soldered.

Resistance Range (kΩ)		Link Pattern				
From	To	K	L	M	N	P
9.8888	9.8943	S	S	S	S	S
9.8933	9.8989	S	S	S	S	
9.8971	9.9026	S	S	S		S
9.9016	9.9071	S	S	S		
9.9037	9.9092	S	S		S	S
9.9082	9.9138	S	S		S	
9.9120	9.9175	S	S			S
9.9165	9.9221	S	S			
9.9170	9.9225	S		S	S	S
9.9215	9.9270	S		S	S	
9.9253	9.9308	S		S		S
9.9298	9.9353	S		S		
9.9319	9.9374	S			S	S
9.9364	9.9419	S			S	
9.9402	9.9457	S				S
9.9447	9.9502	S				
9.9440	9.9496		S	S	S	S
9.9486	9.9541		S	S	S	
9.9523	9.9579		S	S		S
9.9569	9.9624		S	S		
9.9590	9.9645		S		S	S
9.9635	9.9690		S		S	
9.9672	9.9728		S			S
9.9718	9.9773		S			
9.9722	9.9777			S	S	S
9.9767	9.9823			S	S	
9.9805	9.9860			S		S
9.9850	9.9906			S		
9.9871	9.9927				S	S
9.9917	9.9972				S	
9.9954	10.0009					S
10.0000	10.0055					

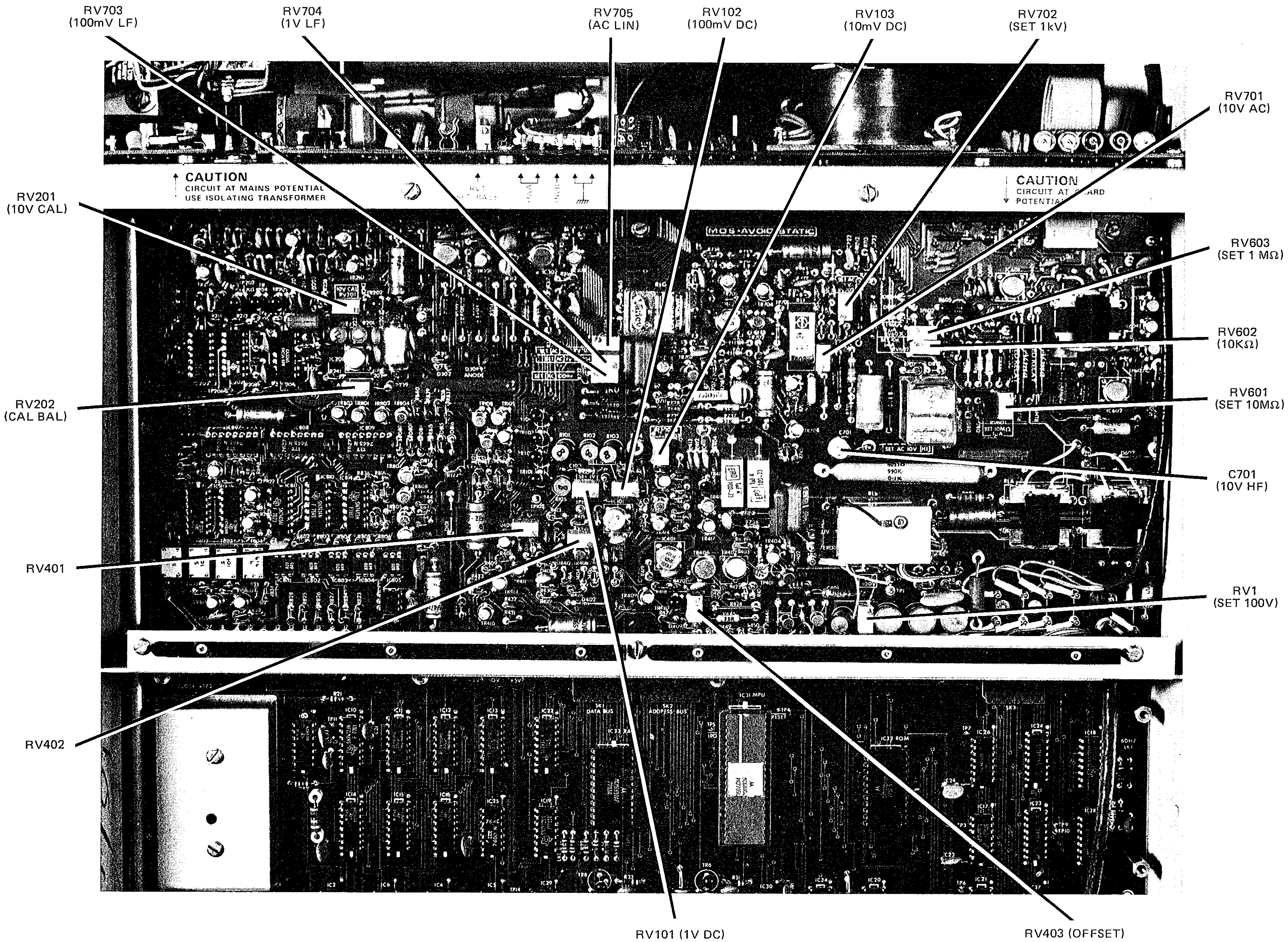


Fig. 5.5. View of PCB Assembly identifying potentiometers and their functions.

7055 Board 5
Setting up and Calibration

This part of the manual contains the setting-up and calibration procedures for 7055 board 5. The remaining boards are common to both variants.

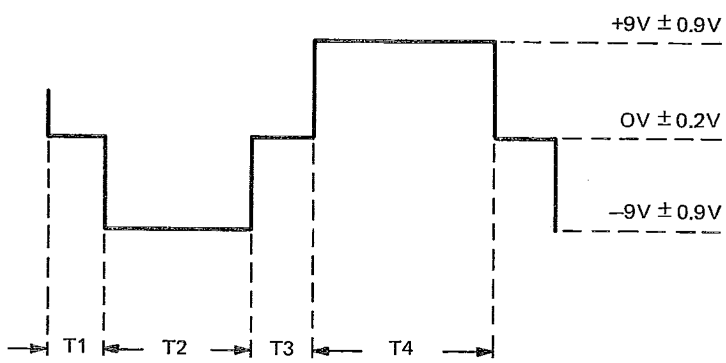
A. Setting up

7055 BOARD 5

SETTING UP PROCEDURE

INTEGRATOR

1. Select: 10V range.
2. Short circuit V/Ω Hi, V/Ω Lo and GUARD front panel input terminals with wire links.
3. Check that the displayed reading is 0.0000 ± 1 bit.
4. Remove the short circuit from V/Ω Hi and Lo terminals.
5. Connect an oscilloscope between TP202 (+ve) and 0V (–ve) on pcb 5.
6. Check that the Integrator switching waveform is within the limits shown (Fig. 5.6)



T1 and T3 = 5± 3μs
T2 and T4 = 150± 15μs
T1+T2+T3+T4 = 313± 30μs

Fig. 5.6

7. Disconnect the oscilloscope from TP202 and 0V on pcb 5.

INPUT AMPLIFIER

OFFSET ADJUSTMENT

1. Connect a voltmeter between TP208 (+ve) and 0V (–ve) on pcb 5.

2. Select the ranges in turn and check that the displayed reading and TP208 voltage are within limits as per Table 5.16

TABLE 5.16

TEST	RANGE	TP208	READING	
			Value	Limits ± bits
1	10V	–0.3 to 0.3mV	0.0000	1
2	1V	–0.3 to 25mV	0.0000	4
3	0.1V	–30 to 55mV	0.000000	30
4	0.01V	–300 to 325mV	0.000000	30

Note: If the voltmeter reading at TP208 is outside the limits specified, the reader is referred to Table 5.17

3. Insert a suitable value resistor for R415, shorting out R416 (LK N) if necessary.

TABLE 5.17

TP208 VOLTAGE (mV)	R415 VALUE (ohms)
0 to 3	TCW link
2.5 5.5	12
4.7 7.7	22
7.0 10.0	33
10.0 13.0	47
11.9 14.9	56
14.5 17.5	68
17.5 20.5	82
19.4 22.4	91
21.3 24.3	100
23.4 26.4	110
25.6 28.6	120
27.7 30.7	130

4. Remove the voltmeter from TP208 and 0V.

OVERLOAD TEST

1. Connect the RED and BLACK leads to V/Ω Hi and Lo front panel input terminals respectively.
2. Select: 10V range.
3. Connect a voltmeter between pin 13 of RLB on pcb 5 and the V/Ω Lo front panel input terminal.
4. Apply +30V to the front panel input.
5. Check that the voltmeter reading is 22V ± 1V and that the display is flashing.
6. Select: AUTO.
7. Check that the instrument does not display HELLO prior to autoranging up to the 100V range.
8. Check that the displayed reading on the 100V range is approximately +30V.
9. Select the 1000V range, check that the displayed reading is still approximately +30V.
10. Repeat operations 2 to 9 for negative values using the same voltage source.
11. Remove the DC source.
12. Disconnect the voltmeter from TPl (pin 13 of RLB) on pcb 5 and the V/Ω Lo front panel input terminal.

INPUT CURRENT AND μV ZERO CHECK

1. Select: AUTO.
2. Short circuit the input leads.
3. Check that the display reads zero ± 20μV
4. Check that the μV OFFSET control can be adjusted to obtain a reading within the limits ± 8μV.
5. Finally adjust the μV OFFSET control for a reading of zero or as near zero as possible.
6. Remove the short circuit.
7. Connect a 1MΩ resistor across the input leads.
8. The display should settle to between ± 25μV.
9. Disconnect the 1MΩ resistor from the input.

INPUT IMPEDANCE CHECK

1. Select: 10V range.
2. Apply +20V to the instrument input and note the displayed reading.
3. Connect a 1MΩ resistor in series with the Hi input and the DC source.
4. Check that the reading does not differ from that in operation 2 by more than ± 10 bits.
5. Repeat for a negative value using the same voltage source.
6. Remove the voltage source and resistor.

NOISE CHECKS

1. De-select FILTER (ind "off").
2. Short circuit the input leads.
3. Check that the displayed reading does not exceed ± 3 bits for 10 seconds.
4. Remove the short circuit.

REFERENCE ADJUSTMENTS

1. Select: FILTER.
2. Using a DC VOLTAGE STANDARD, apply +20V to the input.
3. Adjust RV201 (if fitted) on pcb 5 for a reading of +20.0000V ± 20 bits.

The total scatter of readings with ± 20V input to the instrument should not exceed 4 bits.

NB. If RV201 does not provide sufficient adjustment, Links LK A to LK H and LK P will require to be adjusted; the reader is referred to the Reference linkage table (see page 4.5.52).

NB The reader must wait for a Drift Correct cycle (up to 10 seconds) after each adjustment as the CAL BAL will be in error until this has occurred.

AC CHECKS

1. Connect the AC Standard to the instrument input.
2. Select: VAC and the 1V range.
3. Apply 1V rms at 1kHz, check that the displayed reading is approximately 1V.
4. Apply 100mV at 1kHz, check that the reading on the 1V range is approximately 100mV.

5. Select the 0.1V range, check that the reading is approximately 100mV.

6. Select the 10V range.

7. Apply a voltage of between 5V and 10V to the input. Check that the displayed reading is approximately the voltage applied.

8. Select the 100V and 1000V range in turn, check that the displayed reading is approximately the voltage applied.

9. Remove the AC source.

OHMS CURRENT CHECK

1. Select: kΩ, 100kΩ range and FILTER.

2. Connect a voltmeter (with current measuring facility) between the HiΩ DRIVE (+ve) terminal and the LoV/Ω (–ve) input terminal.

3. Check that the voltmeter reading is 100μA ± 1μA.

4. Select the 10^4kΩ range and check that the current falls to 1μA ± 20nA.

5. Remove the voltmeter (+ve) lead from the HiΩ DRIVE terminal and connect to the LoΩ DRIVE input.

6. Select the 100kΩ range, check that the voltmeter reading is 100μA ± 5μA.

7. Select 10^4kΩ, check that the voltmeter reading is 0 ± 10nA.

8. Disconnect the voltmeter from the Lo V/Ω and LoΩ DRIVE input terminals.

OVERLOAD PROTECTION CHECK

1. Link Ω DRIVE HI to the V/Ω HI terminal and Ω DRIVE LO to the V/Ω LO terminal.

2. Ensure GUARD is linked to the V/Ω Lo terminal.

3. Select: 100kΩ range.

4. Connect the AC Standard to the input.

5. Apply 240V at 50/60Hz for 10 seconds.

6. Remove the AC source.

7. Connect a voltmeter (with current measuring facility) between the Hi (+ve) and Lo (−ve) input terminals, check that the reading is still 100μA ± 5μA.

8. Disconnect the voltmeter from the input.

9. Remove the input leads and all front panel terminal interconnecting links.

COMMON MODE

DC REJECTION

1. Connect the instrument as shown in Fig. 5.7.

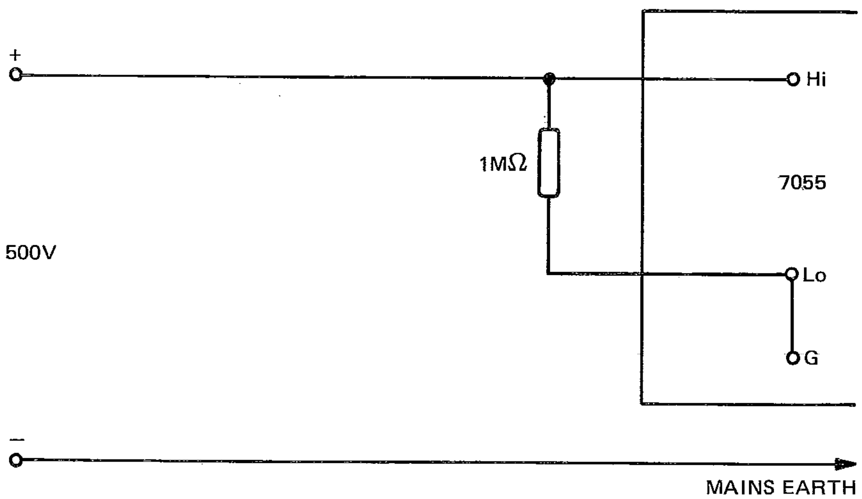


Fig. 5.7

2. Select: VDC and AUTO.

3. Apply 500V to the instrument.

4. The displayed reading should not exceed 10mV.

5. Remove the DC source.

6. Disconnect the 1MΩ resistor and connectors fitted in operation 1.

DC RANGE CALIBRATION

10V RANGE

1. Ensure all front panel interconnecting terminal links are removed.
2. Connect the 5 terminal connector to the rear panel input.
3. Select the 10V range.
4. Connect the DC standard to the rear input.
5. Apply +20V. Note the display.
6. Apply –20V. Note the reading.
7. Adjust RV202 (CAL BAL) on pcb 5 for equal +ve and –ve readings ± 2 bits.
8. Apply +20V and adjust RV201 (10V CAL) for a reading of +20.0000V ± 2 bits.
9. Repeat operations 5 to 8 as necessary.

NB. The reader must wait for a Drift Correct cycle (up to 10 seconds) after each adjustment as the CAL BAL will be in error until this has occurred.

10. Remove the DC source.

LINEARITY

1. Connect the DC source to the Dekavider and connect the Dekavider to the rear input.
2. Select: AUTO.
3. Check the linearity in accordance with Table 5.18

TABLE 5.18

TEST	INPUT (volts)	READING Value	READING Limits ± bits
1	20	20.0000	1
2	10	10.0000	2
3	1	1.00000	2
4	100mV	0.10000	2
5	10mV	0.01000	2
6	1mV	0.00100	2
7	100μV	0.00010	2

4. Repeat for negative values using the same voltage source.

5. Remove the DC source and Dekavider.

10mV, 100mV AND 1V RANGE CALIBRATION

1. Short circuit the input leads.

2. Adjust the μV OFFSET control on the front panel for a zero reading on the display. (or as near zero as possible).

3. Remove the short circuit.

4. Connect the DC source and Dekavider to the input terminals and apply the voltages as per Table 5.19.

TABLE 5.19

TEST	RANGE	INPUT	OPERATION	READING	
				Value	Limits ± bits
1	0.01V	20mV	RV103(10mV DC)	0.020000	2
2	0.1V	200mV	RV102(100mV DC)	0.200000	2
3	1.0V	2V	RV101(1V DC)	2.00000	2

5. Repeat for negative values using the same voltage source.

6. Check that the readings obtained for the two polarities do not differ by more than:

   a) 3μV on the 10mV range.

   b) 3μV on the 100mV range.

   c) 4μV on the 1V range.

7. Disconnect the Dekavider from the DC source and the instrument input.

100V and 1000V RANGE CALIBRATION

1. Apply +100V to the 7055 input direct from the DC source.

2. Adjust RV1 (100V DC) on pcb 5 for a reading of +100.000V ± 2 bits.

3. Increase the input to +1000V.

4. Check that the displayed reading settles to +1000.00V ± 5 bits.

5. Check that the drift after 1 minute is less than ± 2 bits.

6. Reduce the input to zero. Remove the DC source.

AC CALIBRATION

100mV AND 1V RANGE CALIBRATION

1. Connect the AC standard to the instrument rear panel.

2. Select: VAC, FILTER.

3. Apply the voltages in Table 5.20

TABLE 5.20

TEST	RANGE	INPUT	FREQUENCY	OPERATION	READING	
					Value	Limits ± bits
1	1V	1V	1kHz	RV704(SET 1V)	1.00000	10
2	1V	100mV	"	RV705(SET Lin)	0.10000	2
3	Repeat tests 1 and 2 as necessary					
4	1V	2V	1kHz	RV703(SET 100mV)	2.00000	70
5	0.1V	100mV	"		0.100000	10
6	0.1V	10mV	"		0.010000	15
7	0.1V	100mV	50kHz		0.100000	40
8	0.1V	100mV	10kHz		0.100000	40
9	0.1V	100mV	50kHz		0.100000	100
10	1V	1V	"		1.00000	40
11	1V	1V	10kHz		1.00000	40
12	1V	1V	50kHz		1.00000	100

10V, 100V AND 1000V RANGE CALIBRATION

1. Apply the voltages as per Table 5.21.

TABLE 5.21

TEST	RANGE	INPUT	FREQUENCY	OPERATION	READING	
					Value	Limits ± bits
1	10V	10V	50kHz	C701(SET H F)	10.0000	200
2	10V	10V	1kHz	RV701(SET 10V)	10.0000	30
3	Repeat tests 1 and 2 as necessary.					
4.	10V	10V	10kHz		10.0000	60
5	100V	100V	50kHz		100.000	70
6	100V	100V	1kHz		100.000	50
7	100V	100V	10kHz		100.000	60
8	100V	100V	50kHz		100.000	200
9	1000V	800V	1kHz	RV702(SET 1kV)	800.00	10
10	1000V	800V	10kHz		800.00	60
11	1000V	200V	50kHz		200.00	50

2. Reduce the input to zero. Remove the AC source.

OHMS RANGE CALIBRATION

1. Select kΩ and 100kΩ ranges.
2. Connect the resistance standard to the rear input and set to 200kΩ.
3. Adjust RV601 for a displayed reading of 200.000 kΩ ± 2 bits.
4. Select the other ranges and carry out checks as per Table 5.22.

TABLE 5.22

TEST	RANGE	INPUT	OPERATION	READING	
				Value	Limits ± bits
1	100kΩ	200kΩ	RV601(SET 100μA)	200.000	2
2	1000kΩ	2MΩ	RV602(SET 1μA)	2000.00	5
3	Repeat tests 1 and 2 as necessary.				
4	10^4kΩ	20MΩ		20000.0	30
5	10kΩ	20kΩ		20.0000	7
6	1kΩ	2kΩ		2.00000	12

5. Disconnect the resistance standard from the instrument.
6. Disconnect the rear input connector.
7. Switch off the instrument.

NB. If RV601 does not have enough adjustment, links LK J to LK M will need to be adjusted;

The reader is referred to the Resistance linkage table (see page 4.5.57).

This concludes the setting up of the 7055. A full calibration should now be carried out, B overleaf.

B. Calibration

INTRODUCTION

The following calibration is basically that to which all instruments are subjected prior to despatch from the factory.

For the greatest accuracy the instrument's top cover should be removed and its calibration cover, Part No. 70559D, fitted. Failing this, allowances must be made for variations in the working temperatures.

See page 4.5.61 for details of calibration cover.

PRELIMINARY

For the following checks the microprocessor voltmeter will have its top cover removed and be fitted with its calibration cover (if available).

SAFETY

THE INSTRUMENT SHOULD BE DISCONNECTED FROM THE MAINS SUPPLY BEFORE ANY ATTEMPT IS MADE TO REMOVE THE TOP COVER.

BEWARE OF GUARD POTENTIAL ON THE GUARD PLATE AND MAINS POTENTIAL ON THE POWER SUPPLY WHEN THE TOP COVER IS REMOVED.

1. Prepare the instrument as follows:

   a) At the top corners on the rear of the instrument, remove the screw securing each buffer.

   b) Remove the two buffers.

   c) Remove the top cover by sliding it away from the front panel.

2. Check that the fuse fitted is 800mA–SLO–BLO, as indicated beside the fuse holder. For calibration procedures to be carried out at 20°C, it is essential that the following test equipment or its equivalent is available.

TEST EQUIPMENT

a) Mains Isolation Transformer.

b) Variac.

c) Digital Voltmeter (e.g. Type 7050).

d) Oscilloscope plus x10 probe (e.g. Type A100)

e) DC Voltage Standard.

f) AC Voltage Standard.

g) Resistance Standard, 100Ω to 20MΩ.

h) Voltage Divider.

Additional item required:

5-terminal input lead. (EX3183)

It should be noted that if the calibration equipment used does not meet the uncertainty specification of the items listed, the Limits of Error specified in Part 1 section 2 of this Manual will not be achieved. Measurements made with the dvm after such recalibration therefore, while exhibiting errors no worse than those specified, will be related to the calibration equipment rather than to the internationally agreed volt.

CALIBRATION

The calibration sequence must be carried out in the order given. Calibration should be carried out at an ambient temperature 20°C ± 1°C after a warm-up period of at least two hours with the calibration cover fitted.

CALIBRATION AT 20°C

1. Fit the 7055 with its calibration cover.
2. Switch on the instrument at least two hours before commencing calibration.
3. Select the 10V range.
4. Check that there are no front panel terminal interconnecting links fitted.
5. Fit the 5-terminal connector to the rear panel input and short circuit the leads.
6. Check that the displayed reading is zero ± 1 bit.
7. Remove the short circuit.
8. Apply +20V to the input. Note the displayed reading.
9. Apply –20V to the input. Note the displayed reading.
10. Adjust RV202 (CAL BAL) on pcb 5 for equal +ve and –ve readings ± 2 bits.

NB. The reader must wait for a Drift Correct cycle (up to 10 seconds) after each adjustment as the CAL BAL will be in error until this has occurred.

11. Apply +20V and adjust RV201 (10V CAL) for a reading of +20.0000V ± 1 bit.

12 Apply –20V and check that the reading is –20.0000V ± 1 bit.

13 Repeat operations 11 and 12 as necessary until the readings meet the limits specified.

14 Remove the DC source.

DC RANGE CALIBRATION

1. Select the 10mV range (0.01V).

2. Short circuit the input leads.

3. Adjust the µV OFFSET for a display reading of zero.

4. Remove the short circuit.

5. Apply the voltages as per Table 5.23

TABLE 5.23

TEST	RANGE	INPUT	OPERATION	READING Value	READING Limits ± bits
1	0.01V	+20mV	RV103	0.020000	2
2	0.01V	–20mV		–0.020000	2
3	0.1V	+200mV	RV102	0.200000	2
4	0.1V	–200mV		0.200000	2
5	1.0V	+2V	RV101	2.00000	2
6	1.0V	–2V		–2.00000	2
7	Repeat tests 1 to 6 as necessary				
8	100V	+200V	RV1	200.000	2
9	100V	–200V		–200.000	2
10	1000V	+1000V		1000.00	
11	1000V	–1000V		–1000.00	3

Note: Adjust for equal readings. Share any deviations equally between readings.

6. Remove the DC source.

OHMS RANGE CALIBRATION

1. Select kΩ.

2. Connect the Ohms standard to the rear input.

3. Apply the resistance values as per Table 5.24

TABLE 5.24

TEST	RANGE	INPUT	OPERATION	READING	
				Value	Limits ± bits
1	100kΩ	200kΩ	RV601(SET 100μA)	200.00	2
2	1000kΩ	2MΩ	RV602(SET 1μA)	2000.00	5
3	Repeat tests 1 and 2 as necessary.				
4	10^4 kΩ	20MΩ		20000.0	20
5	10kΩ	20kΩ		20.0000	5
6	1kΩ	2kΩ		2.00000	10

4. Remove the Ohms standard.

AC RANGE CALIBRATION

1. Select: VAC, and FILTER.

2. Connect the AC standard to the rear input.

3. Apply the voltages as per Table 5.25

TABLE 5.25

TEST	RANGE	INPUT	FREQUENCY	OPERATION	READING	
					Value	Limits ± bits
1	1V	1V	1kHz	RV704(SET 1V)	1.00000	10
2	1V	100mV	”	RV705(SET Lin)	0.10000	2
3	Repeat tests 1 and 2 as necessary.					

TABLE 5.25 (cont'd)

4	1V	2V	1kHz		2.00000	70
5	0.1V	100mV	"	RV703(SET 100mV)	0.100000	10
6	0.1V	"	50kHz		0.100000	40
7	0.1V	"	10kHz		0.100000	40
8	0.1V	"	50kHz		0.100000	100
9	0.1V	10mV	1kHz		0.010000	15
10	0.1V	10mV	50kHz		0.010000	20
11	1V	1V	10kHz		1.00000	40
12	1V	1V	50kHz		1.00000	100
13	1V	100mV	"		0.10000	20
14*	10V	10V	"	C701(SET H F)	10.0000	200
15	10V	10V	1kHz	RV701(SET 10V)	10.0000	30
16	Repeat tests 13 and 14 as necessary.					
17	10V	10V	50kHz		10.0000	70
18	10V	10V	10kHz		10.0000	60
19	100V	100V	1kHz		100.000	50
20	100V	100V	10kHz		100.000	60
21	100V	100V	50kHz		100.000	200
22	1000V	750V	1kHz	RV702(SET 1kV)	750.00	10
23	1000V	750V	10kHz		750.00	60
24	1000V	200V	50kHz		200.00	50
25	10V	10V	"		10.0000	200

* Note: TEST 14, adjust C701 as necessary for best overall frequency response.

4. Remove the AC standard.
5. Remove the connector from the rear input.
6. Switch off the instrument.

This concludes the calibration of the 7055.

7055 Reference Set-Up Table

Notes:

1. For voltages in column G, link G should be soldered, for those in column H, link H should be connected.

2. In the link pattern, 'S' indicates that the link is to be soldered.

Voltage Range				Link Pattern						
G		H		A	B	C	D	E	F	P
19.9900	20.0100	19.9900	20.0100	S	S	S	S	S	S	S
19.9734	19.9934	20.0065	20.0265	S	S	S	S	S	S	
19.9608	19.9808	20.0192	20.0392	S	S	S	S	S		S
19.9443	19.9643	20.0358	20.0558	S	S	S	S	S		
19.9414	19.9614	20.0387	20.0588	S	S	S	S		S	S
19.9250	19.9450	20.0553	20.0753	S	S	S	S		S	
19.9125	19.9325	20.0680	20.0880	S	S	S	S			S
19.8962	19.9162	20.0845	20.1046	S	S	S	S			
19.9030	19.9229	20.0777	20.0978	S	S	S		S	S	S
19.8867	19.9066	20.0943	20.1144	S	S	S		S	S	
19.8743	19.8942	20.1070	20.1271	S	S	S		S		S
19.8581	19.8780	20.1235	20.1437	S	S	S		S		
19.8553	19.8751	20.1265	20.1466	S	S	S			S	S
19.8392	19.8590	20.1430	20.1632	S	S	S			S	
19.8269	19.8467	20.1557	20.1759	S	S	S				S
19.8109	19.8307	20.1723	20.1925	S	S	S				
19.8269	19.8467	20.1557	20.1759	S	S		S	S	S	S
19.8109	19.8307	20.1723	20.1925	S	S		S	S	S	
19.7987	19.8185	20.1850	20.2052	S	S		S	S		S
19.7827	19.8025	20.2016	20.2218	S	S		S	S		
19.7799	19.7997	20.2045	20.2247	S	S		S		S	S
19.7641	19.7838	20.2211	20.2413	S	S		S		S	
19.7520	19.7717	20.2337	20.2540	S	S		S			S
19.7362	19.7559	20.2503	20.2706	S	S		S			

Voltage Range				Link Pattern						
G		H		A	B	C	D	E	F	P
19.7427	19.7624	20.2435	20.2637	S	S			S	S	S
19.7269	19.7467	20.2601	20.2803	S	S			S	S	
19.7149	19.7347	20.2727	20.2930	S	S			S		S
19.6993	19.7190	20.2893	20.3096	S	S			S		
19.6965	19.7162	20.2922	20.3125	S	S				S	S
19.6809	19.7006	20.3088	20.3291	S	S				S	
19.6691	19.6887	20.3215	20.3418	S	S					S
19.6535	19.6732	20.3381	20.3584	S	S					
19.7057	19.7254	20.2825	20.3028	S		S	S	S	S	S
19.6901	19.7098	20.2991	20.3194	S		S	S	S	S	
19.6782	19.6979	20.3117	20.3321	S		S	S	S		S
19.6627	19.6823	20.3283	20.3487	S		S	S	S		
19.6599	19.6796	20.3312	20.3516	S		S	S		S	S
19.6445	19.6641	20.3478	20.3682	S		S	S		S	
19.6326	19.6523	20.3605	20.3809	S		S	S			S
19.6173	19.6369	20.3771	20.3975	S		S	S			
19.6236	19.6432	20.3702	20.3906	S		S		S	S	S
19.6082	19.6279	20.3868	20.4072	S		S		S	S	
19.5965	19.6161	20.3995	20.4199	S		S		S		S
19.5812	19.6008	20.4161	20.4365	S		S		S		
19.5786	19.5981	20.4190	20.4394	S		S			S	S
19.5633	19.5829	20.4356	20.4560	S		S			S	
19.5517	19.5713	20.4483	20.4687	S		S				S
19.5366	19.5562	20.4648	20.4853	S		S				
19.5517	19.5713	20.4483	20.4687	S			S	S	S	S
19.5366	19.5562	20.4648	20.4853	S			S	S	S	
19.5251	19.5446	20.4775	20.4980	S			S	S		S
19.5100	19.5295	20.4941	20.5146	S			S	S		
19.5074	19.5269	20.4970	20.5175	S			S		S	S
19.4924	19.5119	20.5136	20.5341	S			S		S	
19.4809	19.5004	20.5263	20.5468	S			S			S
19.4660	19.4855	20.5428	20.5634	S			S			

Voltage Range				Link Pattern						
G		H		A	B	C	D	E	F	P
19.4722	19.4917	20.5360	20.5566	S				S	S	S
19.4573	19.4768	20.5526	20.5732	S				S	S	
19.4459	19.4654	20.5653	20.5858	S				S		S
19.4311	19.4506	20.5818	20.6024	S				S		
19.4285	19.4480	20.5848	20.6054	S					S	S
19.4138	19.4332	20.6014	20.6220	S					S	
19.4025	19.4220	20.6140	20.6347	S						S
19.3879	19.4073	20.6306	20.6512	S						
19.4809	19.5004	20.5263	20.5468		S	S	S	S	S	S
19.4660	19.4855	20.5428	20.5634		S	S	S	S	S	
19.4547	19.4741	20.5555	20.5761		S	S	S	S		S
19.4398	19.4593	20.5721	20.5927		S	S	S	S		
19.4372	19.4567	20.5750	20.5956		S	S	S		S	S
19.4225	19.4419	20.5916	20.6122		S	S	S		S	
19.4112	19.4306	20.6043	20.6249		S	S	S			S
19.3965	19.4159	20.6209	20.6415		S	S	S			
19.4025	19.4220	20.6140	20.6347		S	S		S	S	S
19.3879	19.4073	20.6306	20.6512		S	S		S	S	
19.3767	19.3961	20.6433	20.6639		S	S		S		S
19.3621	19.3815	20.6599	20.6805		S	S		S		
19.3596	19.3789	20.6628	20.6835		S	S			S	S
19.3450	19.3644	20.6794	20.7001		S	S			S	
19.3339	19.3533	20.6920	20.7127		S	S				S
19.3195	19.3388	20.7086	20.7293		S	S				
19.3339	19.3533	20.6920	20.7127		S		S	S	S	S
19.3195	19.3388	20.7086	20.7293		S		S	S	S	
19.3085	19.3278	20.7213	20.7420		S		S	S		S
19.2941	19.3134	20.7379	20.7586		S		S	S		
19.2916	19.3109	20.7408	20.7615		S		S		S	S
19.2773	19.2965	20.7574	20.7781		S		S		S	
19.2663	19.2856	20.7700	20.7908		S		S			S
19.2521	19.2714	20.7866	20.8074		S		S			

Voltage Range				Link Pattern						
G		H		A	B	C	D	E	F	P
19.2579	19.2772	20.7798	20.8006		S			S	S	S
19.2437	19.2630	20.7964	20.8172		S			S	S	
19.2329	19.2521	20.8091	20.8299		S			S		S
19.2188	19.2380	20.8256	20.8465		S			S		
19.2163	19.2355	20.8286	20.8494		S				S	S
19.2022	19.2214	20.8451	20.8660		S				S	
19.1914	19.2106	20.8578	20.8787		S					S
19.1774	19.1966	20.8744	20.8953		S					
19.2246	19.2438	20.8188	20.8396			S	S	S	S	S
19.2105	19.2297	20.8354	20.8562			S	S	S	S	
19.1997	19.2189	20.8481	20.8689			S	S	S		S
19.1857	19.2048	20.8646	20.8855			S	S	S		
19.1832	19.2024	20.8676	20.8884			S	S		S	S
19.1692	19.1884	20.8841	20.9050			S	S		S	
19.1585	19.1777	20.8968	20.9177			S	S			S
19.1446	19.1638	20.9134	20.9343			S	S			
19.1503	19.1695	20.9066	20.9275			S		S	S	S
19.1364	19.1556	20.9231	20.9441			S		S	S	
19.1259	19.1450	20.9358	20.9568			S		S		S
19.1120	19.1312	20.9524	20.9734			S		S		
19.1096	19.1287	20.9552	20.9763			S			S	S
19.0958	19.1149	20.9719	20.9929			S			S	
19.0853	19.1044	20.9846	21.0056			S				S
19.0717	19.0907	21.0012	21.0222			S				
19.0853	19.1044	20.9846	21.0056				S	S	S	S
19.0717	19.0907	21.0012	21.0222				S	S	S	
19.0612	19.0803	21.0138	21.0349				S	S		S
19.0476	19.0666	21.0304	21.0514				S	S		
19.0452	19.0642	21.0333	21.0544				S		S	S
19.0316	19.0507	21.0499	21.0710				S		S	
19.0213	19.0403	21.0626	21.0837				S			S
19.0078	19.0268	21.0792	21.1003				S			

Voltage Range				Link Pattern						
G		H		A	B	C	D	E	F	P
19.0133	19.0323	21.0723	21.0934					S	S	S
18.9999	19.0189	21.0889	21.1100					S	S	
18.9896	19.0086	21.1016	21.1227					S		S
18.9762	18.9952	21.1182	21.1383					S		
18.9738	18.9928	21.1211	21.1422						S	S
18.9604	18.9794	21.1377	21.1588						S	
18.9503	18.9692	21.1503	21.1715							S
18.9370	18.9559	21.1669	21.1881							

7055 Resistance Set Up Table

In the link pattern, 'S' indicates that the link is to be soldered.

Resistance Range (1kΩ)		Link Pattern			
From	To	J	K	L	M
197.757	197.978	S	S	S	S
197.922	198.143	S	S	S	
198.055	198.276	S	S		S
198.221	198.442	S	S		
198.320	198.541	S		S	S
198.486	198.707	S		S	
198.619	198.839	S			S
198.784	199.005	S			
198.862	199.083		S	S	S
199.027	199.248		S	S	
199.160	199.381		S		S
199.326	199.547		S		
199.425	199.646			S	S
199.591	199.812			S	
199.723	199.944				S
199.889	200.110				

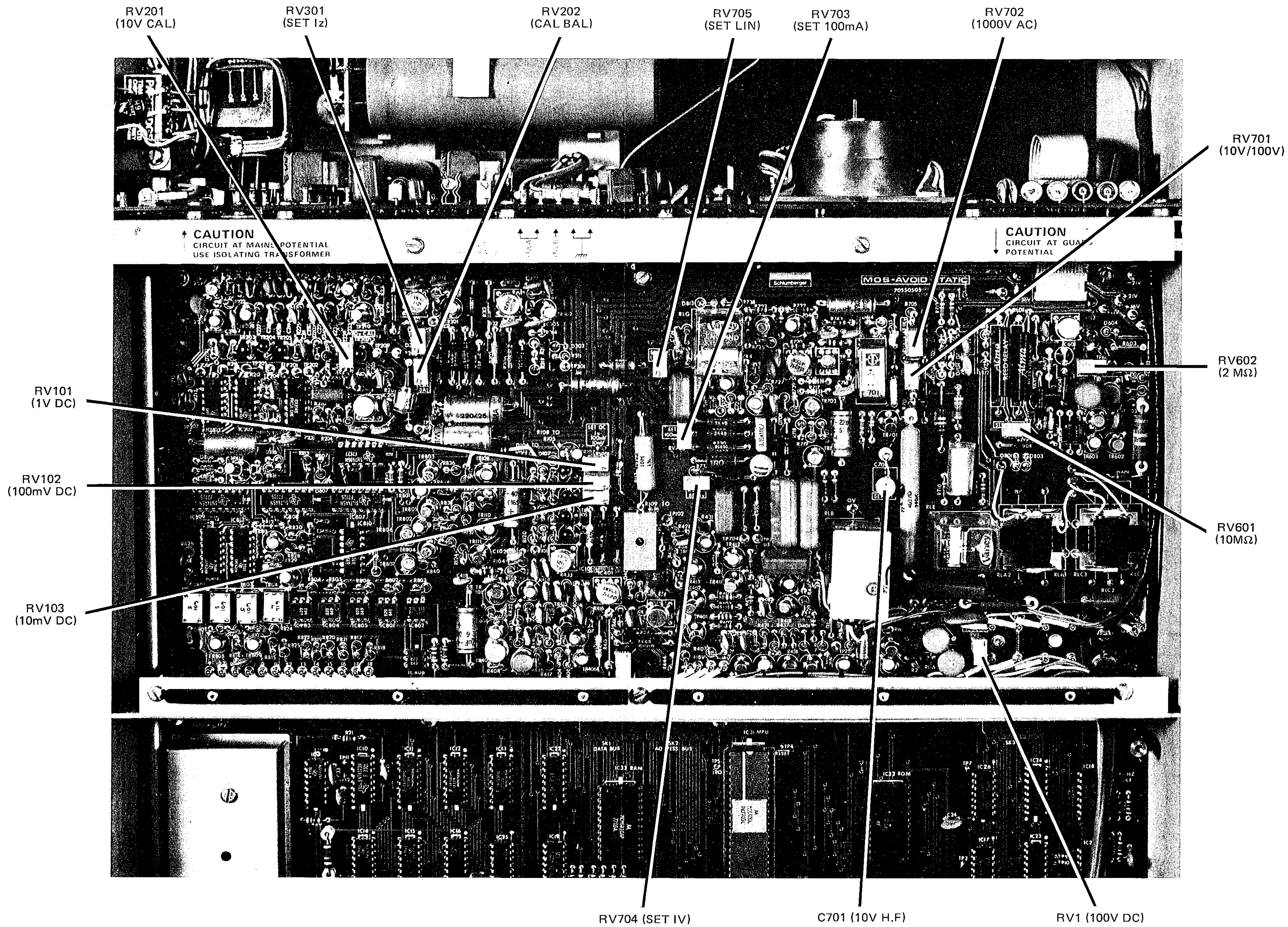


Fig. 5.8. View of PCB Assembly identifying potentiometers and their functions.

CALIBRATION COVER TYPE 70559D

Introduction

This part of the section contains details of specialised selection procedures and/or test equipment to facilitate servicing.

In order to achieve the greatest accuracy during calibration it is essential that the operating temperatures affecting circuit components are as near as possible to those experienced within the instrument case during normal operation.

The calibration cover 70559D enhances the calibration accuracy by allowing access for adjustments whilst the instrument is functioning under normal working conditions.

General Description

The Calibration cover is basically a normal instrument top cover with holes drilled in convenient positions allowing access to the potentiometers. Fig. 5.9 illustrates the calibration cover, showing the access holes and the relevant potentiometers. This cover may be used for either 7055 or 7065.

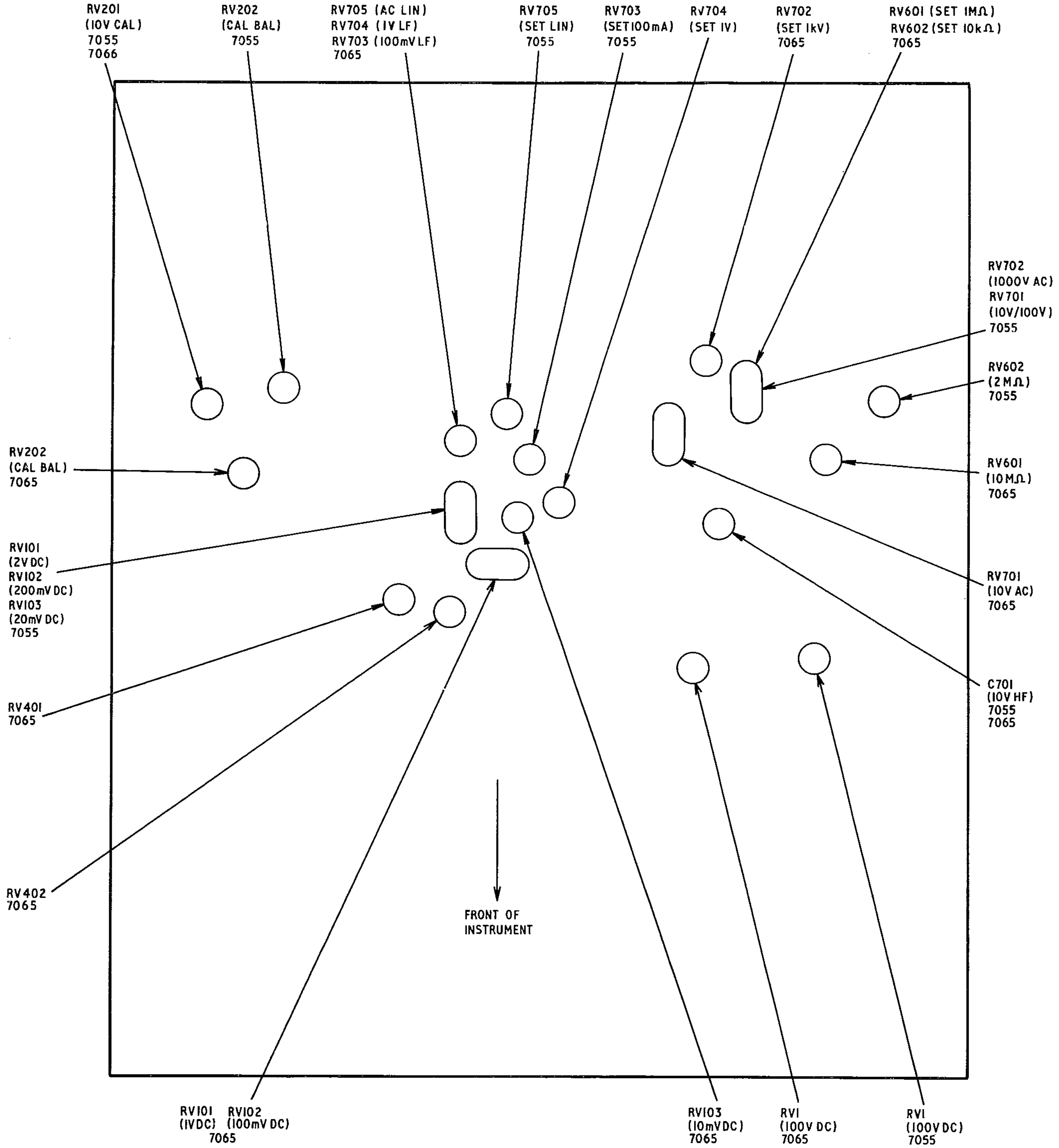


Fig. 5.9 View of Calibration Cover showing potentiometer access holes

Section 6
Option Pcb's

INTRODUCTION

This part of the manual contains circuit descriptions of the Options available for use with 7065. These options include the Program board which, when fitted to the basic instrument, permits measurements to be processed.

Both 7055 and 7065 may also be fitted with Interface boards, permitting the dvm to be used within a system or, perhaps, under the remote control of a single terminal device.

PROGRAM BOARD AND RS 232 INTERFACE (DIAG. 6.1)

The circuits on this board, illustrated in diagram 6.1, contain Read-only and Random Access Memory stores (ROMs and RAMs) and an Interface to permit the serial transfer of data between 7065 and a suitable terminal. Both Programmable Read Only Memory (PROMs) and MASKED ROMs are shown on this diagram, the Masked ROMs being an alternative fit to the PROM set.

ADDRESS BUS BUFFERS

IC's 1 to 4, positive And-gates with totem pole outputs, buffer and interface the address bus outputs from board 3 to the circuits on this board.

ADDRESS BUS DECODER

Four address bus lines, A11 to A14, feed IC28, a 1-in-10 bcd-to-decimal decoder. Its outputs provide address decodes for the PROM set or Masked ROMs (whichever are fitted), while the decodes A008 and A009 are addresses for the Serial Interface via IC26. (Decodes are also provided for an IEC Interface. Those passed via switch S2, contacts A and B, can inhibit the program board data bus buffers, IC's 7 and 8, when the IEC Interface is in use.)

PROM SET

The PROM Set comprises IC's 14 to 21. As implied by their description,these are programmable devices, the programming being carried out at the factory prior to fitment. Each PROM contains 1k x 4 bits, is paired with one other. The pair being addressed by common decodes to obtain 1k x 8 bits of binary storage in keeping with the bus organisation. The PROM pairs and address decodes are as follows:

PROM PAIRS	ADDRESS DECODES
IC14, 15	E000 to E3FF
IC16, 17	D000 to D3FF
IC18, 19	C000 to C3FF
IC20, 21	B000 to B3FF
	OR 8000 to 83FF

Power from TR's 7, 8, 9 and 10 is switched simultaneously as each pair is addressed thereby conserving energy.

MASKED ROMs

IC22 and IC23, programmed during manufacture and each containing 2k x 8 bits, form the MASKED ROM set. The ROMs are individually addressed, IC22 by decodes E000 to E7FF and IC23 by decodes D000 to D3FF or 8000 to 83FF.

The read only Memory (PROMs and ROMs) contain machine code instructions and data necessary for the execution of programs 1 to 9 and for the control of the RS232 Serial Interface.

RANDOM ACCESS MEMORY (RAM)

IC's 11, 12 and 13 make up the Random Access Memory section, each RAM providing 128 x 8 bits of storage, i.e. a total of 384 x 8 bit words. Under the control of the microprocessor, the RAMs hold for further manipulation, data which may originate: from within the dvm; from a single terminal or from the controlling System.

Commands from the Central Processor Unit on board 3, passed via the Read/Write line (R/W), cause the transfer of data to occur between the RAM and the data bus. When logic level 0 is present, Write is operative and data are passed to the RAMs. When logic level 1 is present, Read is operative and data are passed from the RAMs to the data bus.

DATA BUS BUFFERS

IC7 and IC8, gates having 3-state outputs, are enabled by the Read/Write (R/W) line when set to Read, together with the appropriate addresses via IC27. Data are thus gated from the program data bus to the voltmeter bus.

BYTE BUS DRIVERS

IC29 and IC30, 4-bit Byte Drivers, when enabled by Write and the relevant address commands from the CPU, pass 4-bits each to the RAMs, using the whole of the 8-line data bus. When address decode 5000 is present, IC's 29 and 30 buffer a further 2-bits each, from socket SK5, pins 5, 6, 7 and 8. The remaining 4 bits, necessary to make up the 8-bit data byte, are buffered by IC9 from SK5 pins 1 to 4.

Switch S2 sliders c to f select the parity, the number of stop bits and the transfer speed to suit the user's system when the RS232 Interface is in use.

OUTPUT PORTS

Data from the dvm are stored by IC10 and IC24, general purpose 8-bit output ports. Their contents are transferred to an output device under the command of address bus decode 4100.

RS 232 INTERFACE

Provides a method of Interfacing and transferring serial data between 7065 and a suitable terminal device. To enable the Interface, switch SW3 slider "a" should be set to ON.

BAUD GENERATOR

IC25, a crystal controlled oscillator provides eight baud-rate outputs. S1, an eight position slider switch permits the selection of the baud rate compatible with the system in use.

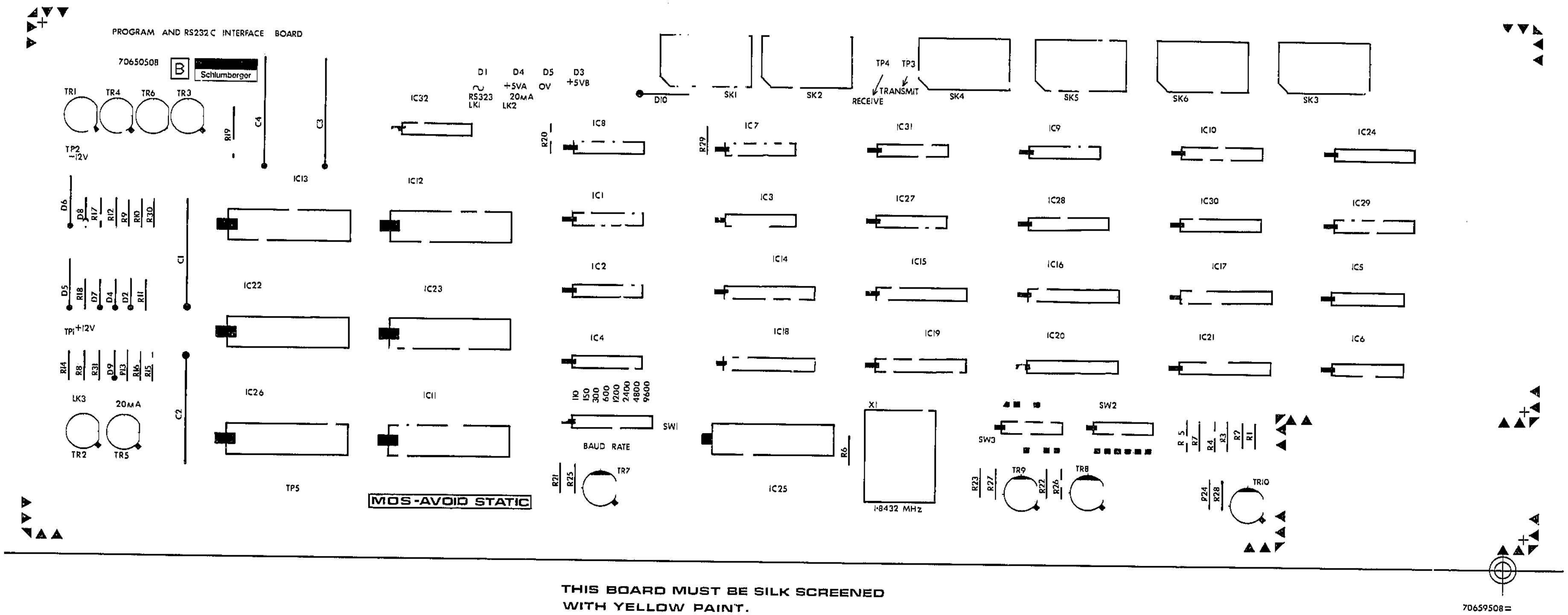
ASYNCHRONOUS CONVERTER

Parrallel data bus inputs to IC26, an asynchronous converter, are serially output, under the control of address bus decodes in conjunction with address line A0 and A3 inputs, which themselves define the addresses A008, A009.

The remaining circuits on this part of the board are used to buffer the output from 5V to 12V. Split pads SP2 and SP3, when bridged, provide a 20mA current drive for those terminals which require current, rather than voltage, drive.

The reader is referred to Part 3 of this manual for 70556 Interface fitting instructions.

PCB 8 NOTATIONS ▶



THIS BOARD MUST BE SILK SCREENED
WITH YELLOW PAINT.

PCB 8 NOTATIONS

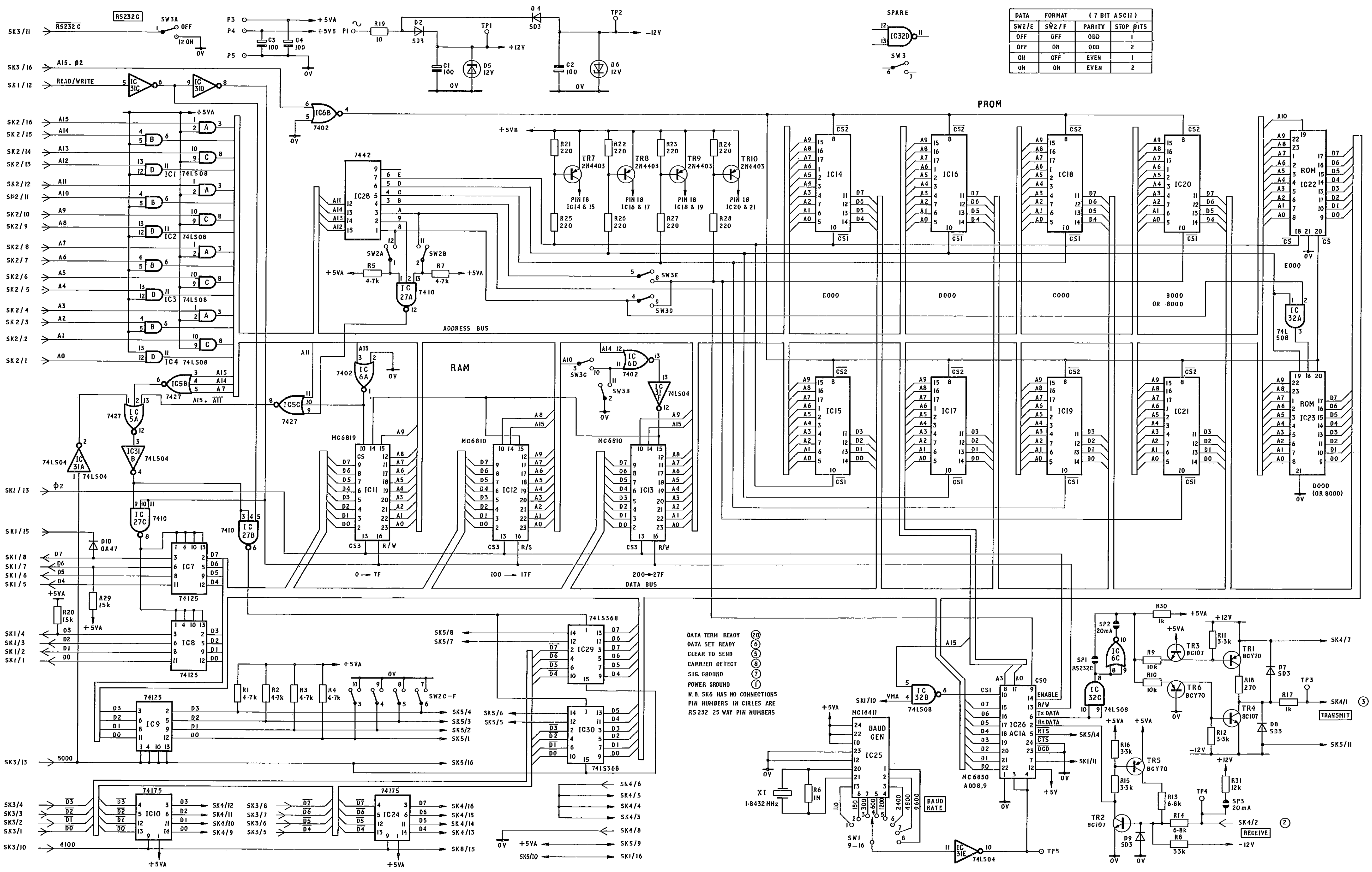
ADAPTER PANEL (DIAG 6.2)

The Adapter Panel 70558A (pcb 9), permits the dvm when fitted with 70556 Interface, to be connected to a suitable terminal.

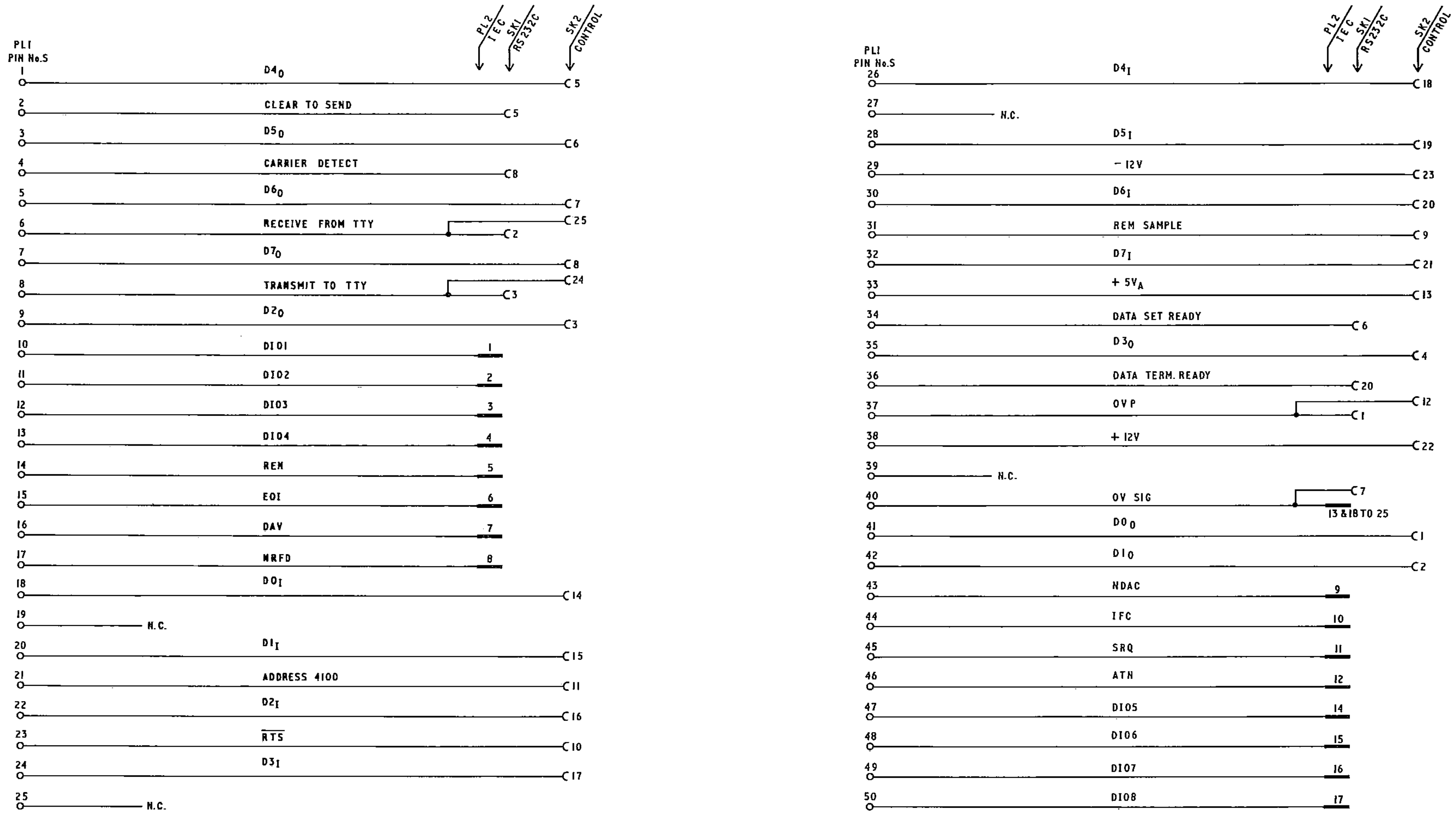
Diagram 6.2 illustrates the Adapter interconnections and pin-to-pin terminations. Plug PL1 on the reverse side of the Adapter mates directly with SK1 on the rear panel of the dvm. Using a standard connector, the Serial Interface board may be connected to the terminal via socket SK1 on the Adapter.

Note. For practical purposes, the pin numbers annotated IEC (PL2) on the diagram can be ignored. It was intended that Adapter 70558A be used also when configuring a dvm (fitted with Option 70555) within a GP-IB system. The introduction of a later type of Adapter (see pages 3.3.2 and 3.3.3 of this manual) associated with 70555, and subsequent circuit changes, means that this facility is no longer possible with adapter 70558A.

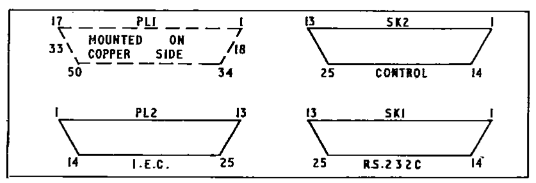
◀ *DIAG. 6.2*



DIAG. 6.1 PROGRAM BOARD AND RS232 INTERFACE



NOTE :– N.C. INDICATES NO CONNECTION



COMPONENT SIDE VIEW

DIAG. 6.2 ADAPTER PANEL

PARALLEL INTERFACE BOARD (DIAG. 6.3)

The purpose of the circuits illustrated on diagram 6.3 is twofold:

1. To Interface measurement data to other devices.

2. To decode and implement commands from those devices.

A choice of range output codes can be selected to suit a particular terminal or system.

1. PARALLEL OUTPUT INFORMATION

IC's 1 to 8, serial-to-parallel 5-bit binary converters, interface and shift the mode, range, measurement and polarity data from the dvm to the outputs. Serial data is input on pin 9 of each IC and transfer of informatoon to the outputs occurs on the positive going edge of the Output Strobe pulse (pin 1), enabled by address bus decode 4500.

IC13, a 4-bit binary adder, performs the addition of two 4-bit binary numbers. Switch contacts S1/11 and S1/10 select the 5 x 9's or 6 x 9's preferred range output code required. Contact S1/2 is linked for non-preferred codes.

DATA CAN CHANGE AND PRINT COMMAND LEVEL OUTPUTS

Enabled by address bus decode 4200, IC9 provides three additional outputs. Two of these outputs are the signals DATA CAN CHANGE (DCC) and PRINT COMMAND LEVEL (PCL); the other output is used to reset IC14b after a SAMPLE (Single) command has been acknowledged.

2. COMMAND INPUTS

SAMPLE

IC14a and b are set by a SAMPLE command (pulse or contact) via switch S2 (contact 9 or 10) and addressed by bus decode 7000, causing a single measurement to be taken. IC14 is reset by a signal from IC9 pin 2 as previously mentioned.

COMMAND DATA

IC's 10, 11 and 12, gates, having 3-state totem pole outputs, interface and transfer command data to the dvm, and to switches S1, S2, from the rear panel connector. Enabled by decode 4800, IC10 places data onto the tri-state data bus. Similarly, IC's 11 and 12 transfer their inputs onto the data bus under the influence of address bus decode 7800.

Switches S1 and S2 permit the following options to be selected as required:

DIAG. 6.3 ▶

Switch S1 contact 9 – Continuous Drift Correct (CDC)

S1 contact 8 – Inhibited Drift Correct (IDC)

S2 contact 12 – BCD to Binary conversion (BIN)

S2 contact 11 – Inhibit Display Update (NODSP)

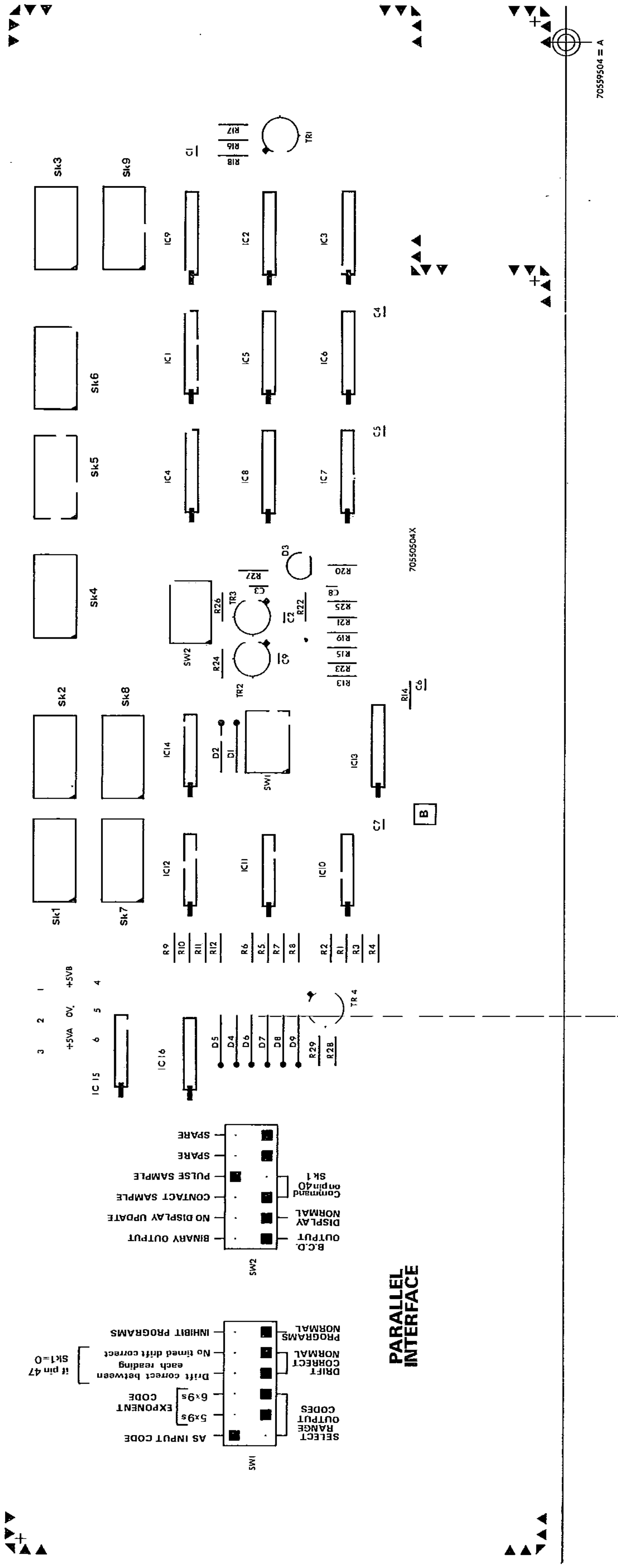
S1 contact 6 – Linked for no functions i.e. no processed measurement

The address bus inputs on socket SK2, (pins 2 to 10 and pins 15, 16) switched by TR4, place data on the data bus lines D2 to D7 when the appropriate bus decode is present. This performs an internal control function.

Diagram 6.5 illustrates, in tabular form, codes and commands applicable when Parallel Interface (70554) is fitted.

The reader is referred to Part 3 of this manual for 70554 fitting instructions.

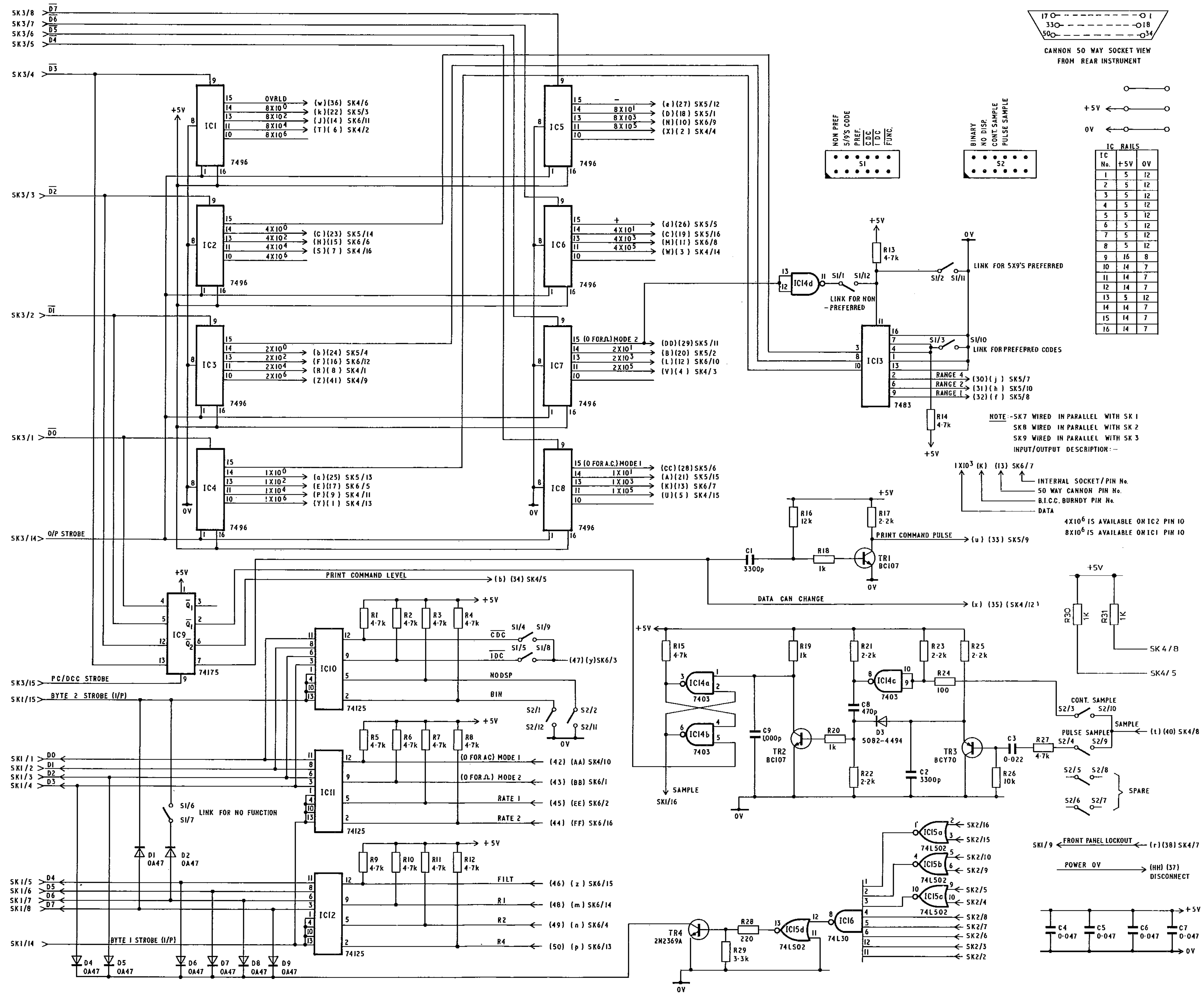
PCB 4 NOTATIONS ▶


PARALLEL INTERFACE
70559504 = A
7055504X
Sk1
Sk2
Sk3
Sk4
Sk5
Sk6
Sk7
Sk8
Sk9
IC1
IC2
IC3
IC4
IC5
IC6
IC7
IC8
IC9
IC10
IC11
IC12
IC13
IC14
IC 15
IC16
SW1
SW2
TR1
TR2
TR3
TR 4
B
+5VA
0V
+5VB
SPARE
SPARE
PULSE SAMPLE
CONTACT SAMPLE
NO DISPLAY UPDATE
BINARY OUTPUT
Command on pin 40 SK1
NORMAL DISPLAY
B.C.D. OUTPUT
INHIBIT PROGRAMS
No timed drift correct
Drift correct between each reading
if pin 47 SK1=0
EXPONENT CODE
AS INPUT CODE
NORMAL PROGRAMS
NORMAL DRIFT CORRECT
SELECT RANGE OUTPUT CODES

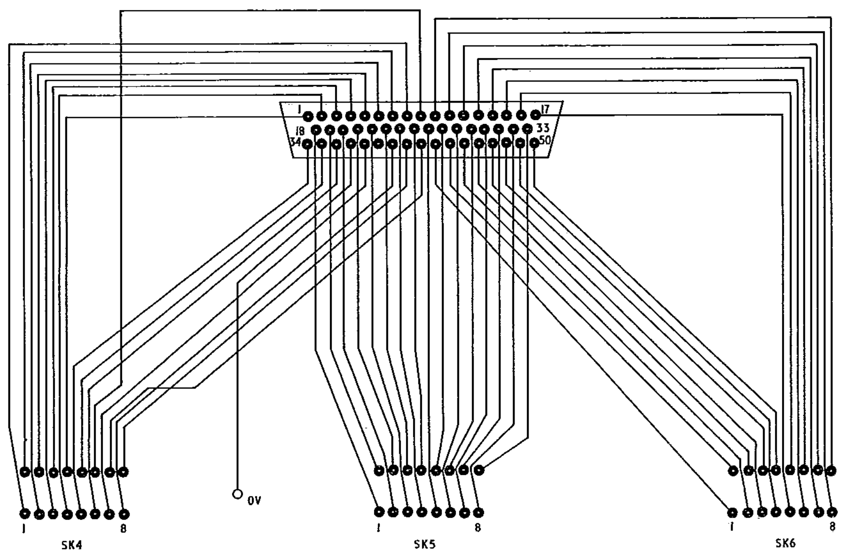
◀ PARALLEL INTERFACE CONNECTOR PCB (DIAG. 6.4)

The Parallel Interface Connector pcb permits the dvm (when fitted with a 70554 Interface) to be used with a terminal, or system, that can accept data in parallel, BCD or binary, form.

Three connectors are required to link the Parallel Interface with the pcb at the rear of the instrument. Diagram 6.4 illustrates the pin-to-pin terminations and interconnections, sockets SK4, SK5 and SK6 being connected to the 70554 Interface.



DIAG. 6.3 PARALLEL INTERFACE BOARD



CANNON			
1			13
2			4
3			14
4			3
5		SK4	15
6			2
7			16
8			1
9			11
10			9
11			8
12			10
13		SK6	7
14			11
15			6
16			12
17			5
18			1
19			16
20			2
21			15
22			3
23			14
24			4
25			13
26		SK5	5
27			12
28			6
29			11
30			7
31			10
32			8
33			9
34			5
35			12
36			6
37	— DISCONNECT PIN		–
38		SK4	7
39	SPARE		–
40			8
41			9
42			10
43			1
44			16
45			2
46		SK6	15
47			3
48			14
49			4
50			13

DIAG. 6.4 PARALLEL INTERFACE CONNECTOR

70555 (GP-IB) INTERFACE

This part of the manual includes circuit diagrams and descriptions of those items comprising or associated with the 70555 Interface.

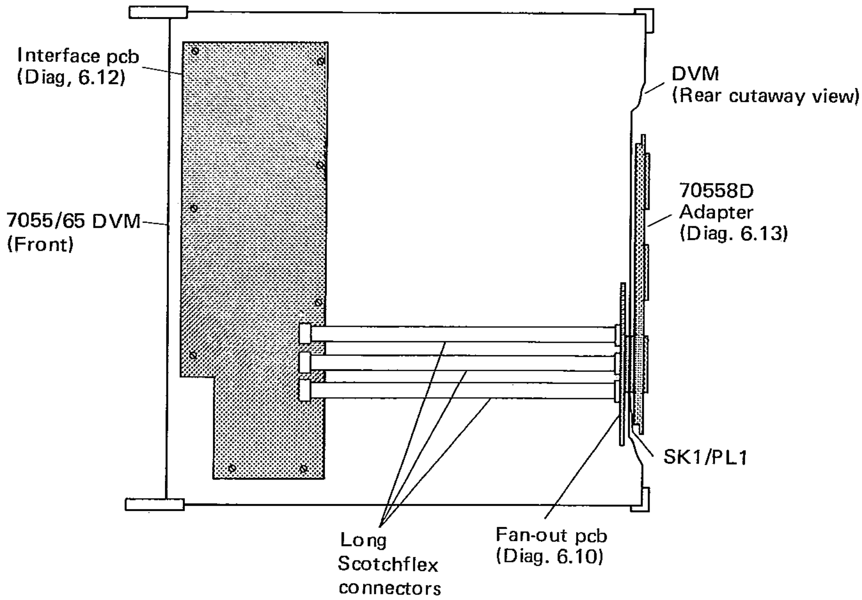
The 70555 Interface permits data exchange between the 7055/65 Microprocessor Voltmeter and any suitable device conforming to IEEE 488 – 1975. (Standard digital interface for programmable instrumentation).

Interface 70555 comprises a single pcb which fits inside the voltmeter, an interface adapter (70558D) which plugs into a socket at the rear of the instrument, and interconnect cables to both IEC TC66 and IEEE 488 standards.

Fitting instructions for the interface pcb are given in Appendix 3 of this manual.

COMPONENT LAYOUT

Diag. 6.5 is a simplified view of the 7055/65 dvm giving the locations of the interface pcb and the adapter panel. Additionally, the drawing shows the fan-out pcb. This item, a standard fit within the dvm, is included since it links the outputs from the interface pcb with the 70558D Adapter. Where applicable, circuit diagram references are included alongside the diagram annotations.



Diag. 6.5 – Component Layout

INTERFACE Pcb (DIAG. 6.12)

The circuit diagram shows the various components fitted to the 70555 Interface board, for complete identification, reference should be made to the Options Parts List in Section 7 of this manual.

The following are descriptions of the main components shown on the diagram.

Random Access Memory (RAM)

IC1 is an eight-bit byte orientated static RAM, used for storing program variables. The chip has seven addressed inputs, A0 to A6, allowing any one of the 128 byte (1k bits) to be addressed, and eight data input/output lines. Address lines A7 to A9 are arranged as three of the six chip-select inputs while the input to pin 16 ($R/\overline{W}$) controls the RAM's read/write functions. When the line is made low, the RAM is able to receive data from the bus, when high the RAM may drive data onto the bus.

Programmable Read Only Memory (PROM)

The PROM-set comprising IC's 2 to 6, are used to store the fixed program of instructions and data constants. Individual PROMS are 1024 x 4 bits and are connected as two pairs i.e. address line A10 high = IC's 3 and 5 selected, A10 low = IC's 4 and 6 selected. (Chip select pins 8 and 10 are both active low). Overall power consumption is reduced by making the supply to the PROMS available only when pin 8 is active, this is due to the drive arrangement of TR1.

Read Only Memory (ROM)

An alternate fit to the PROM-set, currently not used.

Bus Transceivers

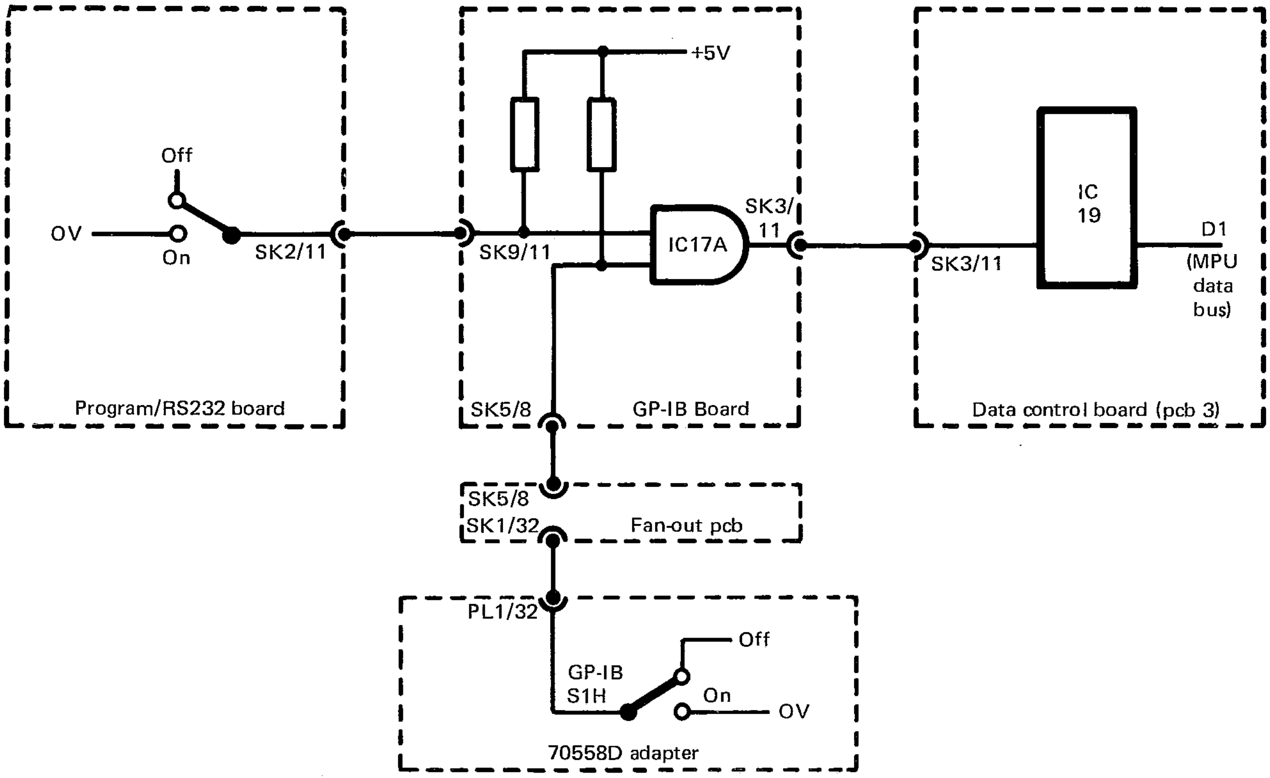
Interconnection between the IEEE instrument and the GPIA data bus is via the four bus transceiver's IC's 7 to 10. These bi-directional devices are placed in either the transmit or the receive mode depending upon the state of control lines $T/\overline{R}1$ or $T/\overline{R}2$.

IC17 Quad Two-input Positive AND Gate

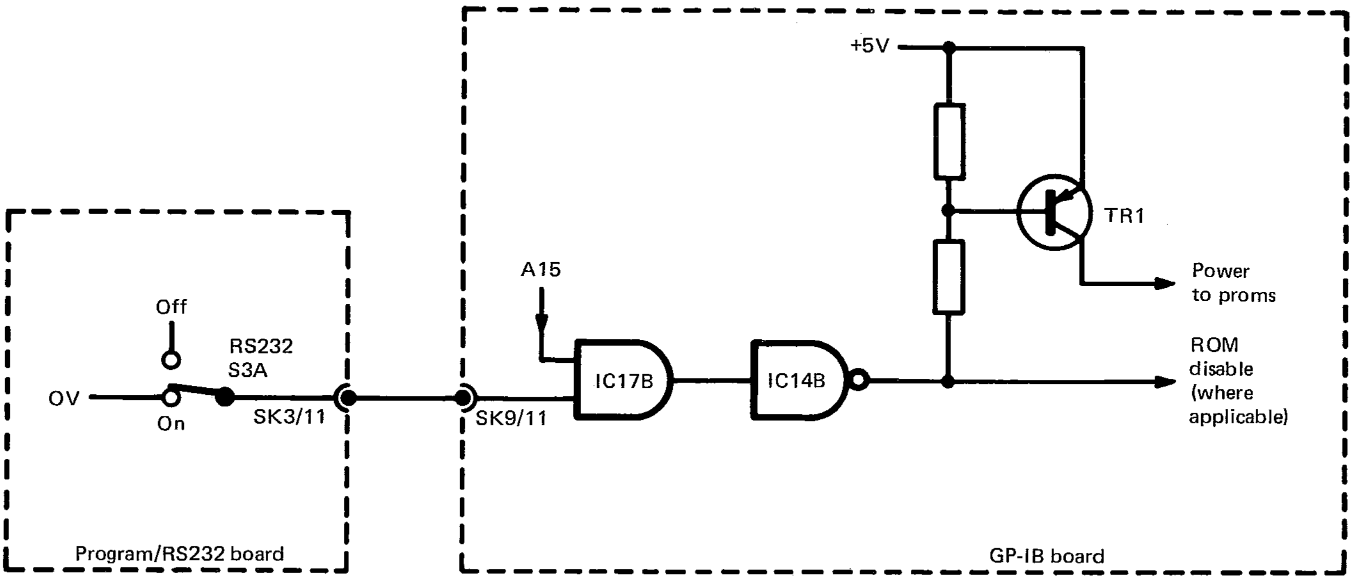
IC17A As shown (Fig. 6.6), the inputs to this IC are derived from both the RS232 selector switch on the Program/RS232 board and the GP-IB selector switch on the 70558D Adapter. When *either* switch is selected ON, the effect is to pull line D1 on the MPU data bus low, the MPU can thus determine if either of the two options are in use.

IC17B Referring to Fig. 6.7, it can be seen that with the RS232 switch on the Program/RS232 Board selected ON, the output from this IC (low) will result in the removal of the PROM power supply. Although it is possible to use the RS232 facility via the GP-IB (see pages 3.3.32-3.3.34 in Section 3 of this manual), **in no event should both RS232 and GP-IB switches be selected ON together.**

IC17C Not used. The input to pin 10 (A15) is also fed (SK8/16) to the Program/RS232 board (SK2/16) when fitted.



Diag. 6.6 – GP-IB and RS232 Selector Switches



Diag. 6.7 – PROM Disabling

Data Bus Buffers and Drivers

IC's 19 and 20 – Quad Bus Buffer Gates, and IC's 21 and 22 – Hex Bus Drivers, are interposed between the interface and MPU data-bus lines D0 to D7. The Bus Buffers are enabled when the control line to pins 1, 4, 10 and 13 goes low i.e. when MPU reads data on the bus (during this period, the Bus Drivers are disabled via Hex Inverter IC18D and are placed in their high impedance states).

Voltmeter Address. The voltmeter's unique address can be read onto the data bus when Hex Bus Driver IC15 is enabled i.e. pins 1 and 15 set high. Interface Adapter Panel switch settings are routed onto the data bus via IC's 15 and 22 as follows:

SK5/1 to 5	–	Address	IC15
SK5/6	–	Listen only	IC15
SK5/7	–	Talk only	IC22

Address Bus Buffers

IC's 24 to 27 are Quad Two-input Positive AND Gates which buffer interface address lines A0-A15 and MPU address bus.

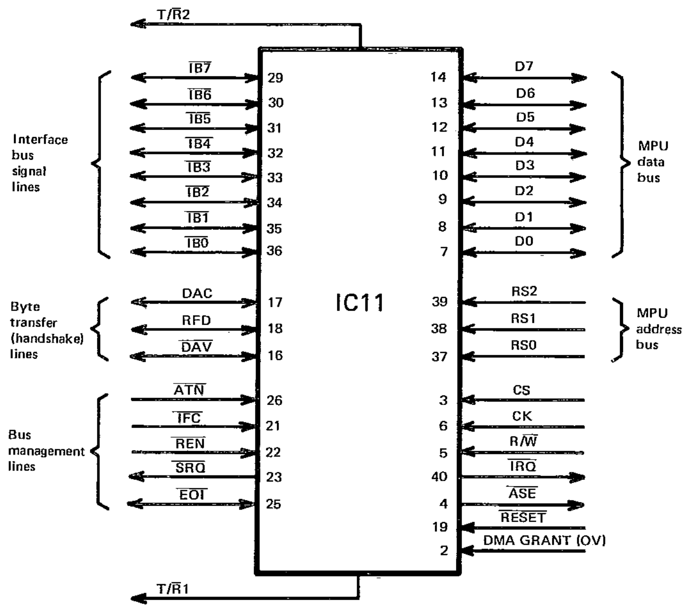
General Purpose Interface Adapter (GPIA)

The GPIA, with associated bus-drivers, provides a means of connecting the voltmeter's MPU with external devices connected to the IEEE Standard bus. The handshake lines $\overline{DAV}$, RFD, DAC are handled automatically by the GPIA.

Essentially the GPIA comprises fifteen registers, (one, the Address Switch Register, is external to the chip). Seven of the registers may be written into by the MPU and eight may be read by the MPU depending on the state of control lines R/$\overline{W}$ and RS0 – RS2. A summary of the GPIA control signal is given on page 4.6.15.

GPIA SIGNAL LINES

The MPU/GPIA and GPIA/IEEE bus signal lines shown in Fig. 6.8 are summarised below.



Diag. 6.8 – GPIA Signal Lines

Bidirectional Data (D0-D7) These lines allow data transfer between MPU and GPIA. The data bus output drives are three-state devices that remain in the high impedance (off) state except when the MPU performs a GPIA read operation. The R/$\overline{W}$ line is inactive (high) when the GPIA is selected for a read operation.

Chip Select (CS) Addresses 4300-4307 when present, select the GPIA by pulling the line low (see Table 6.1).

Read/Write Line (R/$\overline{W}$) This signal is generated by the MPU to control register access and the direction of data transfer on the data-bus. In conjunction with control lines RS0-RS2 (see below), the R/$\overline{W}$ line when low, selects one of seven *write only* registers; when high selects one of eight *read only* registers.

Register Select (RS0, RS1, RS2) Used in combination with R/$\overline{W}$ for register selection.

Interrupt Request ($\overline{IRQ}$) The $\overline{IRQ}$ output goes to the common interrupt bus for the MPU. The $\overline{IRQ}$ line is set active (low) when an interrupt occurs, and remains so until the MPU reads from the interrupt status register.

$\overline{Reset}$ The active low $\overline{Reset}$ line is used to initialize the chip during power-on start-up. $\overline{Reset}$ is driven by an external power-up reset circuit.

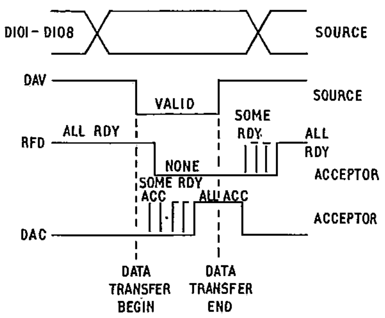
Direct Memory Access (DMA) Not used. The DMA GRANT line, pin 2 is grounded.

Address Switch Enable ($\overline{ASE}$) The $\overline{ASE}$ is used to enable the three-state buffer IC15, thus allowing the instrument address switch settings to be read on the MPU bus. $\overline{ASE}$ occurs only when Device Clear (DCL) or Selected Device Clear (SDC) commands are placed on the instrument bus.

Clock Input (CK) Derived from the MPU clock generator this input is used to synchronise control and data transfer throughout the interface.

Signal Lines $\overline{IB0}$-$\overline{IB7}$ These bi-directional lines allow for the flow of seven-bit ASCII interface messages and device dependent messages.

Byte Transfer Lines (DAC, RFD, $\overline{DAV}$) These lines allow for the proper transfer of each data byte on the bus between sources and acceptors, RFD goes passively true indicating that all acceptors are "ready for data". A source will indicate that "data is valid" by pulling $\overline{DAV}$ low. Upon the reception of valid data by all acceptors, DAC will go passively true – indicating that the "data has been accepted" by all acceptors.



Diag. 6.9 – Handshake Timing Routine

Bus Management Lines ($\overline{ATN}$, $\overline{IFC}$, $\overline{SRQ}$, $\overline{EOI}$, $\overline{REN}$)
These lines are used to manage an orderly flow of information across the Interface lines.

Attention ($\overline{ATN}$) Is sent true over the interface to disable current talker and listeners, freeing the signal lines ($\overline{IB0}$-$\overline{IB7}$). During the $\overline{ATN}$ active state, devices monitor the data lines (D0-D7) for addressing or an interface command. Data are available on the data lines when $\overline{ATN}$ is enabled (high).

Interface Clear ($\overline{IFC}$) This signal is used to put the interface system into a known quiescent state.

Service Request ($\overline{SRQ}$) When active, this signal indicates the need for attention in addition to requesting an interrupt in the current sequence of events. This indicates to the controller that a device on the bus is in need of service.

Remote Enable ($\overline{REN}$) Used to select one of two alternate sources of device programming data, local or remote control.

End or Identify ($\overline{EOI}$) Signals the end of a multiple byte transfer signal and in conjunction with $\overline{ATN}$, executes a parallel polling sequence.

Transmit/Receive Control Signals $T\overline{R}/1$ and $T/\overline{R}2$
These two signals control the Quad Transcievers IC's 7-10 which drive the interface bus. The transmit/receive inputs of $\overline{REN}$, $\overline{IFC}$, and $\overline{ATN}$ are hardwired low to receive, while $\overline{SRQ}$ is hardwired high to transmit. $\overline{EOI}$ (transmit or receive) is controlled by $T\overline{R}/1$.

ADDRESS CODES

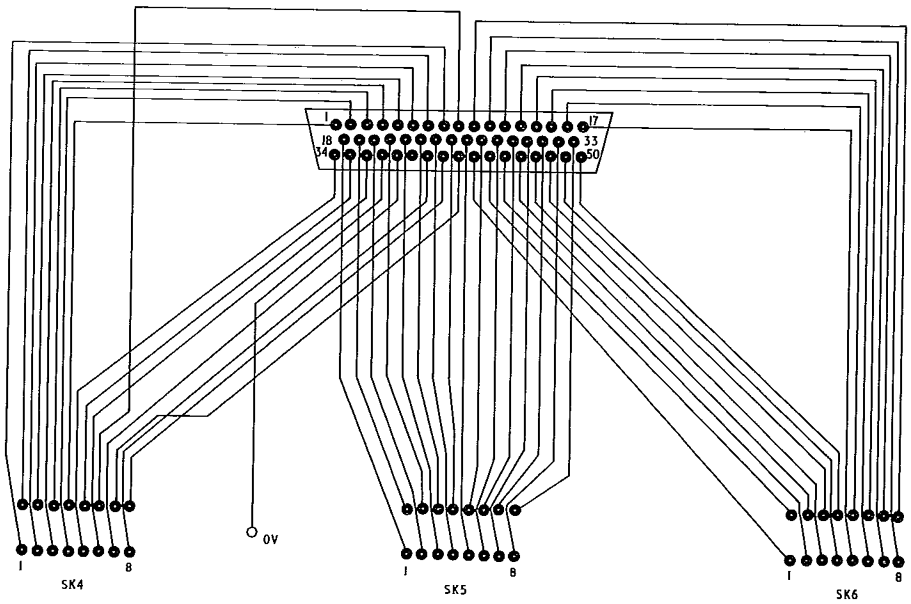
The MPU addresses the various locations of the interface in accordance with the codes shown in Table 6.1.

Table 6.1 – Address Codes

LOCATION	ADDRESS																ADDRESS RANGE (HEX)
	A15	A14	A13	A12	A11	A10	A9	A8	A7	A6	A1	A4	A3	A2	A1	A0	
GPIA	0	1	0	0	0	0	1	●	●	●	●	●	●	X	X	X	4300-4307
PROMS (IC4 & 6)	1	0	0	0	0	0	X	X	X	X	X	X	X	X	X	X	8000-83FF
PROMS (IC3 & 5)	1	0	0	0	0	1	X	X	X	X	X	X	X	X	X	X	8400-87FF
RAM	0	1	0	1	1	0	0	0	0	X	X	X	X	X	X	X	5800-587F
ROM*	1	0	0	0	0	X	X	X	X	X	X	X	X	X	X	X	8000-87FF

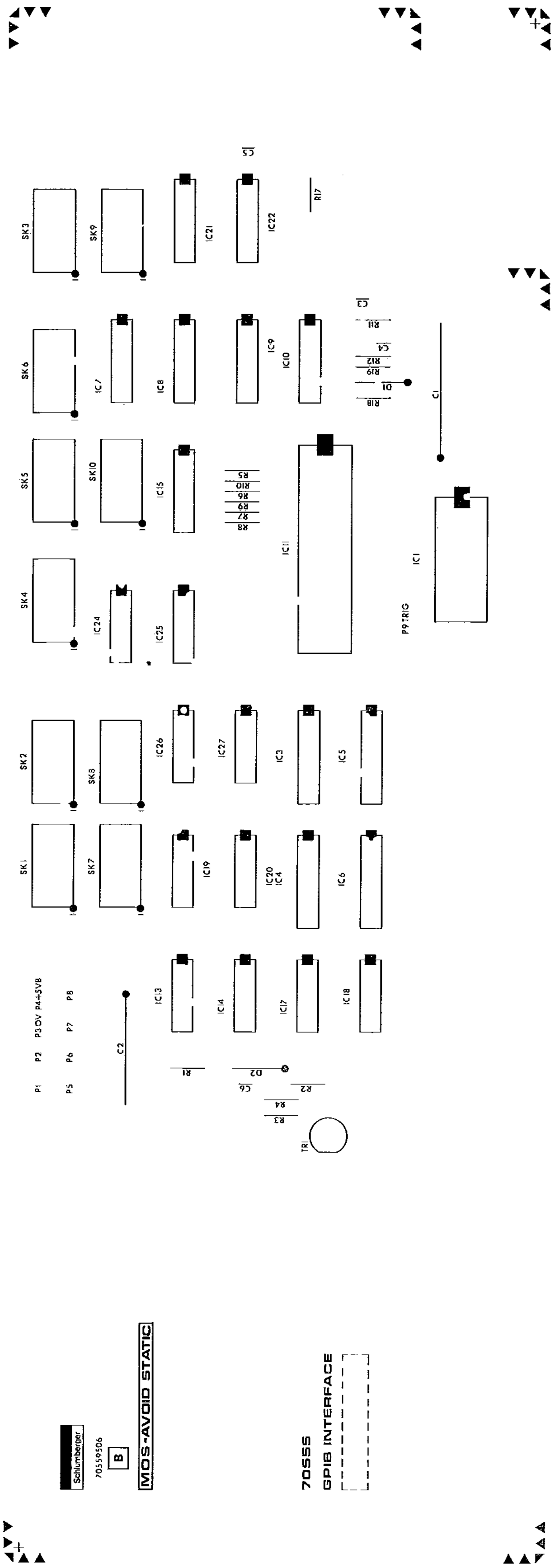
X = 1 or 0
● = not coded
* when used in lieu of **ROMS**

Note: Address codes for the PROMS may be changed to the alternate codes 9000 to 97FF by reversing the bridging arrangement on the two split-pads (Diag. 6.12 refers).



CANNON			
1			13
2			4
3			14
4			3
5		SK4	15
6			2
7			16
8			1
9			11
10			9
11			8
12			10
13		SK6	7
14			11
15			6
16			12
17			5
18			1
19			16
20			2
21			15
22			3
23			14
24			4
25			13
26		SK5	5
27			12
28			6
29			11
30			7
31			10
32			8
33			9
34			5
35			12
36			6
37	– DISCONNECT PIN		–
38		SK4	7
39	SPARE		–
40			8
41			9
42			10
43			1
44			16
45			2
46		SK6	15
47			3
48			14
49			4
50			13

Diag. 6.10 – Fan-out Pcb : circuit



Diag. 6.11 – 70555 Interface Pcb: notations

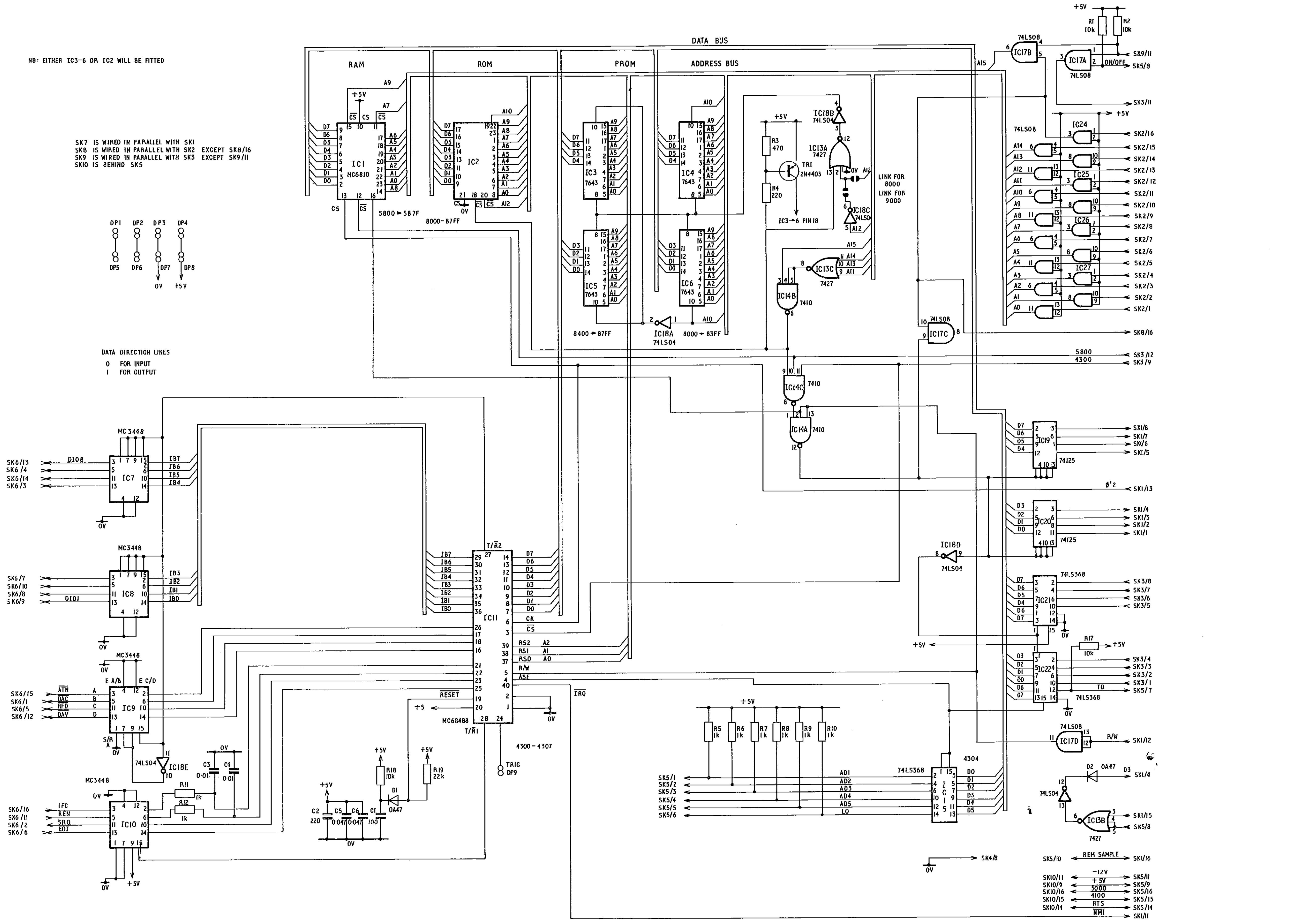
SYSTEM COMPATIBILITY CHART (DIAG. 6.14)

Diagram 6.14 shows, in tabular form, the compatibility of other Solartron instruments for use within a system or with a single terminal device. The table permits a quick-reference comparison to be made between 7065 (7055) and earlier dvm's.

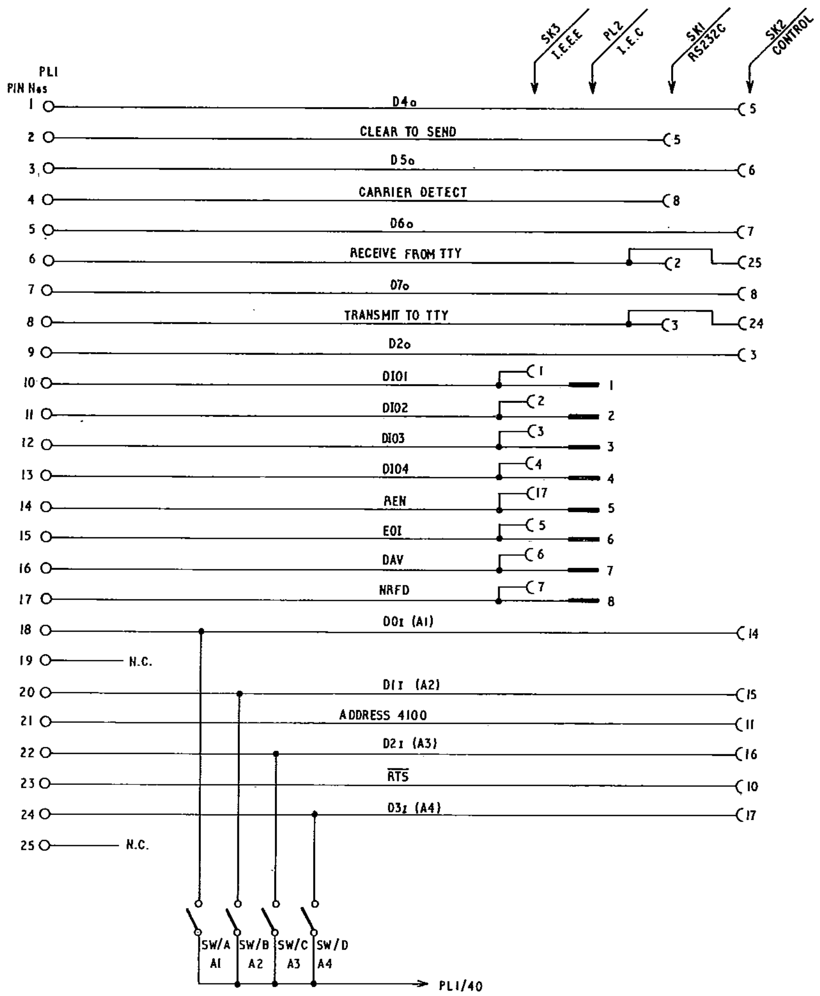
The instrument must be fitted with the appropriate Interface board, meeting the requirements of the chosen system/device. In the case of 7065 (7055) this is Option 70554.

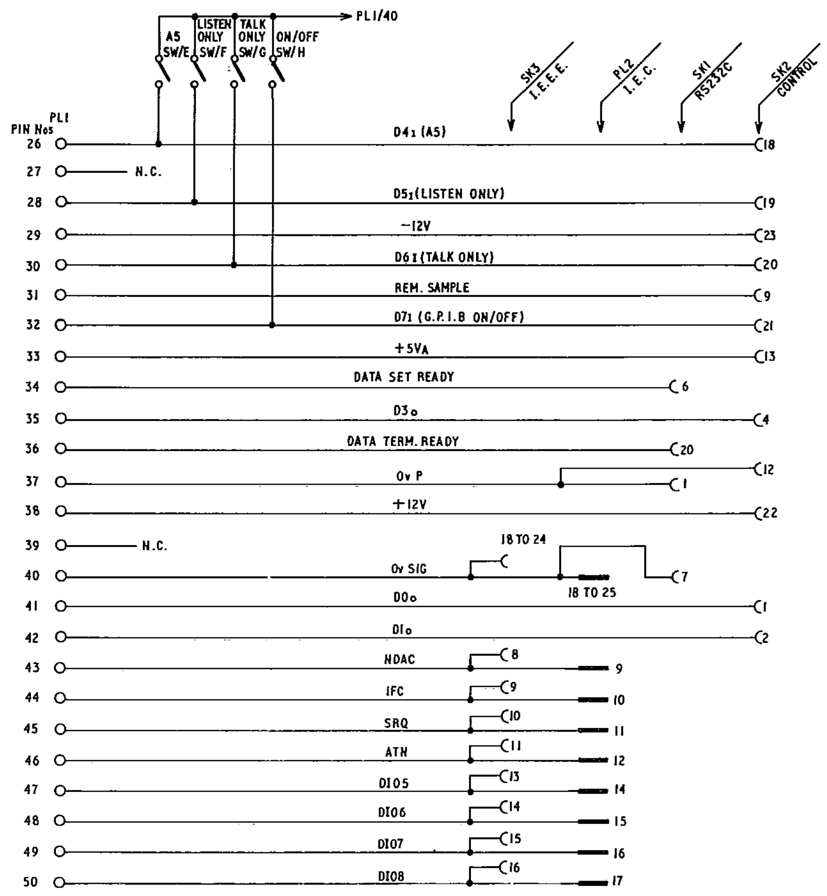
Also shown in the diagram are the codes required, their function and pin designation.

◀ *Diag. 6.13*

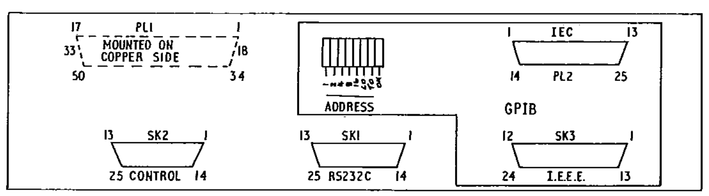


Diag. 6.12 – 70555 Interface Pcb: circuit





NOTE: N.C. INDICATES NO CONNECTION



COMPONENT SIDE VIEW

A213/7055/7065/7075 SYSTEMS CHART

7055/65/75 CANNON PIN No.	A213 BJCC BURNDY	DESCRIPTION (7075)	DESCRIPTION (7055/65)
1	Y	1E6	1E6
2	X	8E5	8E5
3	W	4E5	4E5
4	V	2E5	2E5
5	U	1E5	1E5
6	T	8E4	8E4
7	S	4E4	4E4
8	R	2E4	2E4
9	P	1E4	1E4
10	N	8E3	8E3
11	M	4E3	4E3
12	L	2E3	2E3
13	K	1E3	1E3
14	J	8E2	8E2
15	H	4E2	4E2
16	F	2E2	2E2
17	E	1E2	1E2
18	D	8E1	8E1
19	C	4E1	4E1
20	B	2E1	2E1
21	A	1E1	1E1
22	N.C.	8E0	8E0
23	N.C.	4E0	4E0
24	N.C.	2E0	2E0
25	N.C.	1E0	1E0
26	d	+ POLARITY	+ POLARITY
27	e	− POLARITY	− POLARITY
28	CC	MODE OUTPUTS	MODE OUTPUTS
29	DD		
30	j	4 RANGE OUTPUTS	4 RANGE OUTPUTS
31	h	2	2
32	f	1	1
33	u	PRINT COMMAND PULSE	PRINT COMMAND PULSE
34	v	PRINT COMMAND LEVEL	PRINT COMMAND LEVEL
35	x	DATA CAN CHANGE	DATA CAN CHANGE
36	N.C	OVERLOAD	OVERLOAD
37	HH	EARTH	EARTH
38	r	FRONT PANEL LOCKOUT	FRONT PANEL LOCKOUT
39	s	CONTACT SAMPLE	N.C.
40	t	PULSE SAMPLE	SAMPLE
41	c	COMMAND RATIO	2 E6
42	AA	COMMAND MODE	COMMAND MODE
43	BB		
44	N.C.	4 COMMAND RATE	COMMAND RATE
45	FF	2	
46	EE	1	COMMAND FILTER
47	y	COMMAND AUTO RANGE	COMMAND CDC OR IDC
48	m	1 COMMAND RANGE	1 COMMAND RANGE
49	n	2	2
50	p	4	4

N.B. THIS INFORMATION ASSUMES :-
A214 FITTED TO A213
70754 FITTED TO 7075
70554 FITTED TO 7055/65

RATE COMMANDS

RATE	A213 EE	A213 FF	7075 44	7075 45	7075 46	7055/65 44	7055/65 45
3x9	1	0	0	1	1	0	0
4x9	0	1	1	0	0	0	1
5x9	1	1	1	0	1	1	0
6x9	−	−	1	1	0	1	1
7x9	−	−	1	1	1	−	−

MODE COMMANDS

MODE	A213 AA	A213 BB	7075 42	7075 43	7055/65 42	7055/65 43
D.C	1/0	1/0	1	1	1	1
A.C	0	1	0	1	0	1
Ω	1	0	1	0	1	0
SELF CHECK	−	−	0	0	−	−

MODE OUTPUT CODES

MODE	A213 CC	A213 DD	7075 28	7075 29	7055/65 28	7055/65 29
D.C	0	0	1	1	1	1
A.C	1	0	0	1	0	1
Ω	0	1	1	0	1	0
SELF CHECK	−	−	0	0	−	−

RANGE COMMANDS

RANGE VOLTS	RANGE Ω	A213 P	A213 n	A213 m	7075 50	7075 49	7075 48	7055/65 50	7055/65 49	7055/65 48
AUTO		−	−	−	1	1	1	1	1	1
1,000	10M	0	0	0	0	0	0	0	0	0
100	1M	0	0	1	0	0	1	0	0	1
10	100K	0	1	0	0	1	0	0	1	0
1	10K	0	1	1	0	1	1	0	1	1
0.1	1K	1	0	0	1	0	0	1	0	0
0.01	100Ω	1	0	1	1	0	1	1	0	1
−	10Ω	−	−	−	1	1	0	1	1	0

RANGE OUTPUT CODES (CODE IN = CODE OUT)

RANGE VOLTS	RANGE Ω	A213 j	A213 h	A213 b	7075 30	7075 31	7075 32	7055/65 30	7055/65 31	7055/65 32
1,000	10M	0	0	0	0	0	0	0	0	0
100	1M	0	0	1	0	0	1	0	0	1
10	100K	0	1	0	0	1	0	0	1	0
1	10K	0	1	1	0	1	1	0	1	1
0.1	1K	1	0	0	1	0	0	1	0	0
0.01	100Ω	1	0	1	1	0	1	1	0	1
−	10Ω	−	−	−	1	1	0	1	1	0

NOTES :-

1. 100Ω RANGE NOT AVAILABLE ON A213
2. 10Ω RANGE ONLY AVAILABLE ON 7065 AND 7075
3. 7055/65 OUTPUT INFORMATION ONLY UPDATED IN SAMPLE
4. DATA IS CHANGED IS AUTOMATIC ON 7055/65/75
5. ON 7055/65 PULSE SAMPLE OR CONTACT SAMPLE ARE A SWITCHED OPTION, INPUT MUST BE ON PIN 40
6. PREFERRED RANGE CODES ARE AVAILABLE ON ALL INSTRUMENTS AS DETAILED IN HANDBOOKS
7. '8E2' etc MEANS 8×10^2
8. A203 IS THE SAME AS A213 EXCEPT :-
   a. ONLY 4 x 9s OUTPUT DATA
   b. ONLY 1 RATE
   c. PIN CC AND DD ARE TRANSPOSED ON MODE OUTPUT LINES
   d. PIN C IS AN 'OVERLOAD' LINE

DIAG. 6.14 SYSTEM COMPATIBILITY CHART

Section 7
Parts Lists (Options)

This section contains detailed Parts Lists for each of the Optional circuit boards that can be fitted in the instrument. When ordering spare parts, it is essential to quote the full description shown in the appropriate parts list.

COMPONENT PARTS LIST ABBREVIATIONS

CIRCUIT REFERENCES

AE	Aerial	R	Resistor (Ω)
B	Battery	RE	Recording Instrument
C	Capacitor (μF)	RL	Relay
CSR	Thyristor	S	Switch
D	Diode	SK	Socket
FS	Fuse	T	Transformer
IC	Integrated Circuit	TP	Terminal Post (or Test Point)
L	Inductor	TR	Transistor
LP	Lamp (including Neon)	V	Valve
LK	Link	X	Other Components
M	Motor		
ME	Meter	Also Used:-	
MSP	Mains Selector Panel	RNL	Non Linear Resistor (Ω)
PL	Plug	RV	Variable Resistor (Ω)

COMPONENT TYPES

Fixed Resistors

Carbon Composition	CACP
Carbon Film	CAFM
Cracked Carbon	CKCA
Metal Film	MEFM
Metal Oxide	MEOX
Power Wirewound	POWW
Precision Wirewound	PRWW
Temperature Sensitive	TEMP
Thick Film	TKFM
Thin Film	TNFM
Voltage Sensitive	VOLT

Variable Resistors

Carbon Front Panel Multiturn	CAFM
Carbon Front Panel Single Turn	CAFS
Carbon Preset Multiturn	CAPM
Carbon Preset Single Turn	CAPS
Cermet Front Panel Multiturn	CMFM
Cermet Front Panel Single Turn	CMFS
Cermet Preset Multiturn	CMPM
Cermet Preset Single Turn	CMPS
Wirewound Front Panel Multiturn	WWFM
Wirewound Front Panel Single Turn	WWFS
Wirewound Preset Multiturn	WWPM
Wirewound Preset Single Turn	WWPS

Capacitors

Air	AIR
Aluminium Electrolytic	ALME
Aluminium Solid	ALMS
Polycarbonate	CARB
Ceramic	CERM
Polyester Foil	ESTF
Polyester Metallised	ESTM
Glass	GLAS
Mica	MICA
Metallised Lacquer	MLAC
Paper Foil	PAPF
Paper Metallised	PAPM
PTFE	PTFE
Polypropylene Film	PYLN
Polystyrene	STYR
Tantalum Dry	TAND
Tantalum Foil	TANF
Tantalum Wet	TANW

PCB 4

Cct Ref	General Description				Solartron Part No.
R1 to R15	CACP	4.7k	1/4W	10%	172034700
R16	CACP	12k	1/4W	10%	172041200
R17	CACP	2.2k	1/4W	10%	172032200
R18	CACP	1k	1/4W	10%	172031000
R19	CACP	1k	1/4W	10%	172031000
R20	CACP	1k	1/4W	10%	172031000
R21	CACP	2.2k	1/4W	10%	172032200
R22	CACP	2.2k	1/4W	10%	172032200
R23	CACP	2.2k	1/4W	10%	172032200
R24	CACP	100	1/4W	10%	172021000
R25	CACP	2.2k	1/4W	10%	172032200
R26	CACP	10k	1/4W	10%	172041000
R27	CACP	4.7k	1/4W	10%	172034700
R28	CACP	220	1/4W	10%	172022200
R29	CACP	3.3k	1/4W	10%	172033300
R30	CACP	1k	1/4W	10%	172031000
R31	CACP	1k	1/4W	10%	172031000
C1	CERM	3,300p	500V	20%	241333300
C2	CERM	3,300p	500V	20%	241333300
C3	ESTF	0.022μ	100V	10%	225442200
C4 to C7	CERM	0.047μ	25V	+50% −20%	241944700
C8	CERM	470p	500V	20%	241324700
C9	CERM	1,000p	500V	20%	241331000
D1	OA47				300520850
D2	OA47				300520850
D3	LED 5082-4494				300750080
D4 to D9	OA47				300520850
TR1	BC107				300553320
TR2	BC107				300553320
TR3	BCY70				300553590
TR4	2N2369A				300552390
IC1 to IC8	7496				510000640
IC9	74175				510001310
IC10	74125				510001490
IC11	74125				510001490
IC12	74125				510001490
IC13	7483				510000840
IC14	7403				510001200
IC15	74LS02				510002230
IC16	74L30				510001380
SK1-9	16 pin dual inline socket				300584860
S1-S6	6 way dual inline switch				375000570
S7-S12	6 way dual inline switch				375000570

PCB 6

Cct Ref	General Description				Solartron Part No.
R1	CACP	10k	0.25	10%	172041000
R2	CACP	10k	0.25	10%	172041000
R3	CACP	470	0.25	10%	172024700
R4	CACP	220	0.25	10%	172022200
R5	CACP	10k	0.25	10%	172041000
R6 to R10	CACP	10k	0.25	10%	172041000
R11	CACP	1k	0.25	10%	172031000
R12	CACP	1k	0.25	10%	172031000
R17	CACP	10k	0.25	10%	172041000
R18	CACP	22k	0.25	10%	172042200
R19	CACP	10k	0.25	10%	172041000
C1	ALME	220	25V	+100 −20	273582200
C2	ALME	100	25V	+100 −10	273581000
C3	CERM	0.01	25V	+50 −25	241941000
C4	CERM	0.01	25V	+50 −25	241941000
C5	CERM	0.047	25V	+50 −25	241944700
C6	CERM	0.047	25V	+50 −25	241944700
D1	OA47				300520850
D2	OA47				300520850
TR1	2N4403				300555570
IC1	MC6810				510002760
IC3 to IC6	PROM 7643-5				510002830
IC7 to IC10	MC3448AL				510004300
IC11	MC68488L				510004290
IC13	SN 7427				510001590
IC14	SN 7410				510000420
IC15	SN 74LS368				510003040
IC17	SN 74LS08				510002910
IC18	SN 74LS04				510002690
IC19	SN 74125				510001490
IC20	SN 74125				510001490
IC21	SN 74LS368				510003040
IC22	SN 74LS368				510003040
IC24 to IC27	SN 74LS08				510002910
SK1-10	16-Pin dual inline socket				300584860
	18-Pin dual inline socket				300584850
	24-Pin dual inline socket				300584910
	40-Pin dual inline socket				300584880

PCB 8

Cct Ref	General Description				Solartron Part No.
R1 to R5	CACP	4.7k	1/4W	10%	172034700
R6	CACP	1M	1/4W	10%	172061000
R7	CACP	4.7k	1/4W	10%	172034700
R8	CACP	33k	1/4W	10%	172043300
R9	CACP	10k	1/4W	10%	172041000
R10	CACP	10k	1/4W	10%	172041000
R11	CACP	3.3k	1/4W	10%	172033300
R12	CACP	3.3k	1/4W	10%	172033300
R13	CACP	6.8k	1/4W	10%	172036800
R14	CACP	6.8k	1/4W	10%	172036800
R15	CACP	3.3k	1/4W	10%	172033300
R16	CACP	3.3k	1/4W	10%	172033300
R17	CACP	1k	1/4W	10%	172031000
R18	CACP	270	1/4W	10%	172022700
R19	CACP	10	1/2W	10%	172311000
R20	CACP	15k	1/4W		172041500
R21 to R28	CACP	220	1/4W	10%	172022200
R29	CACP	15k	1/4W	10%	172041500
R30	CACP	1k	1/4W	10%	172031000
R31	CACP	12k	1/4W	10%	172041200
C1	ALME	100μF	25V		273581000
C2	ALME	100μF	25V		273581000
C3	TAND	100μF	20V		265881000
C4	TAND	100μF	20V		265881000
D2	SD3				300522160
D4	SD3				300522160
D5	Zener	12V			300521480
D6	Zener	12V			300521480
D7	SD3				300522160
D8	SD3				300522160
D9	SD3				300522160
D10	OA47				300520850
TR1	BCY70				300553590
TR2	BC107				300553320
TR3	BC107				300553320
TR4	BC107				300553320
TR5	BCY70				300553590
TR6	BCY70				300553590
TR7 to TR10	2N4403				300555570
IC1 to IC4	74LS08				510002910
IC5	7427				510001590
IC6	7402				510000270
IC7	74125				510001490
IC8	74125				510001490
IC9	74125				510001490
IC10	74175				510001310
IC11	MC6810				510002760
IC12	MC6810				510002760
IC13	MC6810				510002760
IC14 to IC21	HM7643				

PCB 8 (cont)

Cct Ref	General Description	Solartron Part No.
IC22	MC68	
IC23	MC68	
IC24	74175	510001310
IC25	MC14411	510003000
IC26	M66850	510003010
IC27	7410	510000420
IC28	7442	510000320
IC29	74LS368	510003040
IC30	74LS368	510003040
IC31	74LS04	510002690
IC32	74LS08	510002910
	N.B. Early batches will contain IC14-21 These will eventually be replaced by IC22 and 23	
SK1-6	16 pin dual inline socket	300584860
	18 pin dual inline socket	300584850
	24 pin dual inline socket	300584910
TP1-5	Test hooks	359600101
SW1	Switch 1 pole 8 way	
SW2	Switch 6 pole 1 way	375000570
SW3	Switch 6 pole 1 way	375000570
	Crystal 1.8432mH_2 Cathodeon AO	N.A.F.

PCB 9

Cct Ref	General Description	Solartron Part No.
PL1	50- Way Cannon	352350070
PL2	DB-25P-OL1	352325030
SK1-2	DB-25S-OL1	352525080

ACCESSORIES

Cct Ref	General Description	Solartron Part No.
	25- Way Cannon plug	351325010
	Cover (side entry)	354003630
	Slide lock	354003640

PCB 11

Cct Ref	General Description	Solartron Part No.
SK1	DD-503-OLI	352550110
SK4-6	16 way dual inline socket	300584860
	Disconnect pin	355900550

Section 8
70556A Setting Up

SETTING UP PROCEDURES

VOLTMETER CHECKS

1. Switch on the instrument under test.

2. Refer to Pt 4, section 5 of this manual and carry out the tests as per Table 5.2
   NB. If the instrument fails the tests in operation 2 above, the reader is referred to fault finding procedure 1 on page 4.8.11

PRELIMINARY CHECKS

1. Refer to Pt 3, section 1 of this manual, ensure switches S1, S2 and S3 are set correctly.

2. Press the PROGRAM key and check that the display reads P – – –.
   NB. If the display responds with *noP* , the reader is referred to fault finding procedure 2 on page 4.8.12

3. Press key 9, check that the display reads *P9.*

4. Press the CLEAR key, check that the display reads P – – –.
   NB. 1. If the display responds with *noP9* in operation 3 or does not clear as in operation 4 then fault finding procedure 3 on page 4.8.13 should be carried out.
   NB. 2. If the display fails (e.g. presents all the decimal points and/or random bars); fails to respond to programming key selections or returns to normal voltmeter operation, fault finding procedure 4 on page 4.8.13 should be carried out.

BASIC FUNCTION OPERATION

1. Press numeral key 1, check that the display reads *P1.*

2. Press the ENTER key, check that the display reads; *C* for approximately 1s followed by *0.0.*

3. Press key 2, check that the display reads 2.

4. Press the decimal point key, check that the display reads 2.

5. Press key 5, check that the display reads 2.5.

6. Press the ENTER key, check that the display reads P1 – –.

7. Press the TRACK key.

8. Connect a known voltage source to the dvm inputs.

9. Check that: a) The COMPUTE key annunciator is illuminated
and b) That the display presents the correct information. i.e. the known voltage input multiplied by the constant 2.5.

10. Press the PROGRAM key, check that the display reads P1 – –.

11. Press key 1, check that the display changes to P1.

12. Press the RECALL key, check that the display reads: *C* for approximately 1s, followed by 2.500000.

13. Press the TRACK key, check that the displayed information is as per operation 9b.
NB. If the instrument fails any of the programming tests, the reader is referred to fault finding procedure 4 on page 4.8.13

14. Remove the dc source connected in operation 8.

SERIAL INTERFACE CHECKS

1. On the program board switch SW3A (pins 1 and 12) to the ON position.
NB. If the display fails (e.g. presents all the decimal points and/or random bars), or fails to respond to programming key selections then fault finding procedure 5 on page 4.8.14 should be carried out.

2. Ensure that there is no I/O terminal connected to the instrument under test.

3. Apply a +3.5V dc voltage between TP4 (+ve) and disconnect pin D5 (OV).

4. Connect a voltmeter between IC26 pin 2 (+ve) and OV (–ve).

5. Check that the voltmeter reading is less than 0.3V (i.e. a logic low).

6. Reduce the DC source to OV, check that the voltmeter reading is still less than 0.3V.

7. Ensure that the connection to D5 is made first to avoid common mode spikes, apply –3.5V dc between TP4 (–ve) and D5 (+ve).

8. Check that the voltmeter reading is greater than +4V (i.e. a logic high).

9. Reduce the dc source to OV, check that the voltmeter reading is still greater than +4V.

10. Apply +3.5V dc as per operation 3 above, again ensuring that the connection to D5 is made first.

11. Check that the voltmeter reading is less than 0.3V (i.e. a logic low).

12. Connect an oscilloscope to IC26 pin 3 (TP5), and OV. Check that a square wave is present.

13. With a counter, measure the frequency of the square wave and ensure that it is within the limits 4.8kHz ± 0.1%.

14. Remove the counter, the oscilloscope and the dc source connected in operation 3.

15. Plug adapter board 9 into the 50 way cannon socket SK1 on the rear panel of the instrument under test.

16. Connect a RS232 compatible "Terminal" to SK2 on adapter board 9. (e.g. SILENT 700).

17. Set SW1 on the RS232 board to the appropriate BAUD rate applicable to the Terminal.

18. On the Terminal check that all the relevant switches are set to give the correct parity of characters and stop bits outputted.

19. On the program board (pcb 8) check that LK1 is short circuit and that LK2 and LK3 are open circuit.

20 Set up the terminal print speed as required (e.g. The fastest print speed for the SILENT 700 is 30 characters/second). Check that FULL DUPLEX is available and that keyboard, print, record switches are set to line.

21. Connect an oscilloscope set to 5V/cm and 5ms/cm to TP3 (+ve) and OV (–ve) on board 8.

22. Switch the dvm off and then on.

23. Send the character P from the Terminal.

24. Check that:
   a) the dvm display reads P – – –
   b) the Terminal prints the character P
   c) a trace appears on the oscilloscope (Fig. 1)

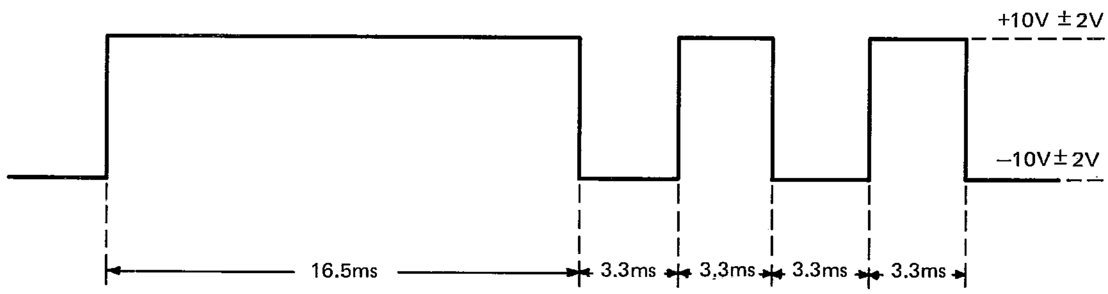


Fig. 8.1

NB.1. If the dvm display does not respond as per operation 24a, check that SW2, SW3, IC26, PROM set IC14 to IC21, IC11 and IC12 are working satisfactorily.
NB.2. If the oscilloscope trace does not respond as in operation 24c, check that the output buffer circuits are satisfactory.

25. Send a Carriage Return (CR) character from the Terminal.

26. Check that the dvm returns to its measurement mode.

27. Send device control characters CA5 and C5A from the Terminal.

28. Check as per Table 8.1 that the following logic levels are present at SK3 on adapter board 9.

TABLE 8.1

SK1 pin No.	7	5	3	1	35	9	42	41
SK3 pin No.	8	7	6	5	4	3	2	1
Logic levels prior to CA5	0	0	0	0	0	0	0	0
CA5 sent	1	0	1	0	0	1	0	1
C5A sent	0	1	0	1	1	0	1	0

PROGRAM and INTERFACE SOFTWARE CHECKS

The test Command strings contained in Table 8.2 are designed to exercise the software of Option 70556A. For these tests the voltmeter input leads should be shorted together. A specimen print-out of correct instrument responses is given in the corresponding table on each facing page.

Note:

Should any response to a test item fail to agree with the specimen given, assuming that it was correctly keyed-in, and in the correct sequence, the reader is referred to Table 8.4 in Fault Finding Procedure 5.

Procedure

1. Refer to Table 8.2 and key-in item 1 at the terminal keyboard. The instrument should immediately respond with an output, which must correspond with that shown in the response table.

(It should be noted that the terminal will echo-back each character of the input message string as it is sent, with the exception of the code DLE. The response specimen omits the echo-back print out for the sake of clarity, but a check should be made, during the test, that echo-back is occurring – except in item 11, when it is deliberately inhibited.)

2. Proceed to item 2, and on through all 11 tests, taking care to key-in only the characters specified; all Wait periods must be observed. Check the terminal equipment's response against the specimen given for each item, carrying out any additional tests called for in the notes.

3. On completion of the test program the instrument should resume local operation.

IMPORTANT

THE TEST PROGRAM SEQUENCE MUST BE FOLLOWED EXACTLY, ITEM BY ITEM, STARTING AT ITEM 1, TO OBTAIN CORRECT RESULTS. SINCE EACH STEP IS DEPENDENT UPON THE PREVIOUS ONE, REPETITION OF AN ITEM OR MISSING ONE OUT WILL INVALIDATE THE TEST. IF IN DOUBT, SWITCH THE DVM 'OFF' AND 'ON' AGAIN, AND START THE TEST AGAIN AT ITEM 1.

TABLE 8.2 7065 (7055) Test Program for use with 70556A Interface

Item Message string

1.
```
M0R0C00T0L1D2F1H0P#GC_R
```

2.
```
C01P3[-9.65]1[2.34567]2[9.8765]GC_R
```

3.
```
%P1?P2?P3? L0$X1C_R
```

4.
```
C02P#3[-1.999]4[0;3.998]6[0.7;-1]% GC_R
P4?1;GC_R
P4?2;GC_R
P4?X0C_R
$L1C_R
```

5.
```
C03P#3[-22.00]4[0;1000]8[0;45] %GC_R
P8?1;GC_R
P8?2;GC_R
P8?3;GC_R
P8?X0C_R
$X1C_R
```

6.
```
P4??10000;P8?0;X1C_R
```

7.
```
P#3[-100]7[1] %P9[1;1630;163030;000010;1631]GC_R
P3?-99;C_R
P3?-97;C_R
P3?C_R
C_R
C_R
C_R
C_R
P7???????P9?????X0C_R
$X1C_R
```

(Wait for approximately 1 minute)

Item Instrument response

```
1.   VDC  -00.003100E-03

2.   VDC  +0.1291800E+03        P 3,1,2 C01

3.   C+2.3456700E+00
     M+9.8765000E+00
     O-9.6500000E+05

4.   VDC  +0.4999900E+00        P 3,4,6 C02
     OPTION 0
     VDC  -06.020600E+00 LO     P 3,4,6 C02
     OPTION 1
     VDC  +0.9994700E+00 HI     P 3,4,6 C02
     OPTION 2

5.   VDC  +448.38400E+00        P 3,4,8 C03
     OPTION 0
     VDC  +1.8561500E+03        P 3,4,8 C03
     OPTION 1
     VDC  +445.03100E+00        P 3,4,8 C03
     OPTION 2
     VDC  +574.63800E+00        P 3,4,8 C03
     OPTION 3

6.        OPTION 0
       R+1.0000000E+03
                 OPTION 3
```

(Echoed-back portion of print out has been deleted).

```
7.   VDC  +099.99900E+00        P 3,7,9 C03   TIME 16 30 30
      O-100.00000E+00
     VDC  +099.49900E+00        P 3,7,9 C03   TIME 16 30 40
      O-99.000000E+00
     VDC  +098.66600E+00        P 3,7,9 C03   TIME 16 30 50
      O-97.000000E+00
     VDC  +098.24900E+00        P 3,7,9 C03   TIME 16 31 00
     OPTION 1
     N +0.0000040E+06
     AV+098.24900E+00
     VA+1.6874904E+00
     SD+1.2990304E+00
     RS+098.25806E+00
    3,7,9 OPTION 1
     T  16 31 07
     TA 16 30 30
     TB 00 00 10
     TC 16 31 00
```

Item	Message string

8. P#3[–90]5[3] %C21GC_R
P3?98;CA5GC_R
P3?97;CFFGC_R
P3?P5????X0C_R
$X1$C_R$

9. %C01M1R1P#3[1047000000]GC_R
P3?C_R
C02M2R6P4[0;0.000000000123]GC_R
P4?C_R
C03M0D0P#3[–1234567]7[1]9[0.000005]GC_R

(Wait approximately 20 seconds)

10. % CNTL P S CNTL P T CNTL P A CNTL P T CNTL P U CNTL P S (Note 1)
CNTL P Sp (Note 2) A?C?D?E?F?H?K?L?M?P?R?T?
X?Y?Z?X0C_R
$X1$C_R$

11. K1L0C_R *(Check that the dvm front panel is locked out)*
E1PPPPC_R *(Check that echo back is inhibited)*
E0K0
% CNTL Z *(repeat 11 more times)* CNTL H CNTL Z ESC (Note 3) T1L0P# C_R

(Voltmeter should now resume LOCAL *operation)*

Notes

1. **CNTL P** is obtained by holding down the **CONTROL** key while pressing the **P** key. The **CONTROL** key must, of course, be released for the letters of the word STATUS. (Item 10)

2. **Sp** is the "space" character, using the keyboard's space-bar. As before, the **CONTROL** key must be released after the **P** has been pressed.

3. **CNTL H, CNTL Z** are keyed in a similar manner to **CNTL P**, i.e. the **CONTROL** key is held down while **H**, or **Z** is pressed (Item 11). **ESC** is the ESCAPE key.

Item	Instrument response		
8.	VDC +00.000000E+00	P 3,5	C21
	O-90.000000E+00		
	VDC +187.99900E+00	P 3,5	CA5
	O+98.000000E+00		
	VDC +187.99900E+00	P 3,5	CFF
	O+97.000000E+00		
	OPTION 3		
	H+89.999990E+00		
	L-98.000000E+00		
	PP+187.99999E+00		
9.	KOHM -1.0470000E+09	P 3	C01
	O+1.0470000E+09		
	^VAC -0.8512100E+15	P 3,4	C02
	OPTION 0		
	R+123.00000E-12		
	VDC +1.2340000E+06	P 3,7,9	C03
10.	STATUS 010300000010000001033,7,90600012501 (Note 4)		
11.	%STATUST1L0P#		

(Voltmeter should now resume LOCAL *operation)*

Note

4. For interpretation of the response in item 10, the output string should mentally be grouped into 9 digit pairs (from the left), a group of 3 single digits separated by commas, and a further 5 digit pairs. The response indicates the status of the 15 addresses interrogated.

FAULT FINDING PROCEDURES

PROCEDURE 1

1. If the instrument fails to run with the PROGRAM board fitted, proceed as follows:

   a) Connect a voltmeter between D4 (+ve) and D5 (OV). Check that the rail voltage is +5V ± .25V.

   b) Disconnect the positive lead from D4 and connect it to D3. Check that the rail voltage is +5V ±.25V.

   c) Disconnect the positive lead from D3 and connect it to TP1.

   d) Check that the rail voltage is +12V ±1V.

   e) Disconnect the positive lead from TP1 and connect it to TP2. Check that the voltage is −12V ±1V.

2. Unplug the 3 inter-board connectors from SK1, 2 and 3 on board 8.
   NB. If the dvm still fails to run, suspect the connectors. If the connectors are satisfactory, proceed as follows:

3. Reconnect Scotchflex ribbon connector to SK2.

   a) Check IC1 to IC4 for a track short on the input lines, or a fault in the ICs.

   b) Using a double beam oscilloscope, set both beams to 2V/cm, the Time base to 200μs/cm and the two inputs subtracted. Check IC1 to IC4 buffered address output against the input address bus on SK2 pins 1 to 16.
   NB. The trace should be a straight line with very narrow spikes (20ns) for each of the 16 address lines.

4. Reconnect the ribbon connector to SK3.

   a) If the display fails (e.g. displays all the decimal points etc.) check for a track short on input data bus ICs 10, 24, 29 and 30 or a fault in those devices.

   b) Check IC6 pin 6 for good logic levels and activity (A15 ∅ 2) i.e. Address bus line A15 gated with MPU clock phase ∅ 2.

5. Reconnect the ribbon connector to SK1. If the dvm now fails check for the following:

   a) A short on SK1 pins 1 to 8.

   b) IC7 or IC8 failure.

   c) Incorrect operation of the address decoding gates IC5, IC31b and IC27c.

   d) Check that there is a 810kHz square wave at IC11 pin 13.

e) Check IC31 pin 5 for good logic levels and activity.

f) Check for parity between IC31 pin 5 and IC31 pin 8.

PROCEDURE 2

1. If the display responds with noP (i.e. as if no programs are available), proceed as follows.

2. Disconnect the 3 scotchflex inter-board connectors from SK1, 2 and 3 on board 8.

3. Apply logic levels to SK2 as per tests 1 and 2 of Table 8.3, check that the data bus response on SK1 is correct.

TABLE 8.3

If PROM set IC14 to IC21 is fitted, tests 1 to 6 only apply.

TEST	ADDRESS BUS ON SK2							DATA BUS RESPONSE ON SK1								IC's ENABLED
	16	15	14	13	12 to 2	1	Pin No.	8	7	6	5	4	3	2	1	
1	1	1	1	0	0	0	LOGIC LEVEL	1	0	1	0	0	1	0	1	14, 15
2	1	1	1	0	0	1	"	0	0	0	0	0	1	0	0	14, 15
3	1	1	0	1	0	0	"	1	0	1	0	0	1	0	1	16, 17
4	1	1	0	1	0	1	"	0	0	0	0	0	0	1	1	16, 17
5	1	1	0	0	0	0	"	1	0	1	0	0	1	0	1	18, 19
6	1	1	0	0	0	1	"	0	0	0	0	0	0	1	0	18, 19

If MASK ROMS IC22 and IC23 are fitted, tests 7 to 12 only apply.

TEST	ADDRESS BUS ON SK2									DATA BUS RESPONSE ON SK1								IC's ENABLED
	16	15	14	13	12	11	10 to 2	1	Pin No.	8	7	6	5	4	3	2	1	
7	1	1	1	0	0	0	0	0	LOGIC LEVEL	1	0	1	0	0	1	0	1	22
8	1	1	1	0	0	0	0	1	"	0	0	0	0	0	1	0	0	22
9	1	1	1	0	0	1	0	0	"	1	0	1	0	0	1	0	1	
10	1	1	1	0	0	1	0	1	"	0	0	0	0	0	0	1	1	
11	1	1	0	1	0	0	0	0	"	1	0	1	0	0	1	0	1	
12	1	1	0	1	0	0	0	1	"	0	0	0	0	0	0	1	0	

NB. For tests 1 and 2, IC14 and 15 are enabled, pins 8 and 10 low, pin 18 at +5V.

For tests 7 and 8, IC22 is enabled, pins 18 and 20 are low.

4. If data is incorrect with PROM set IC14 to IC21 fitted, check from:

    a) SK1 to IC7 and IC8.

    b) IC8 to IC14 and IC15.

    c) IC15 to IC28.

    d) IC28 to ICs 1 to 4.

5. If data is incorrect with MASK Rom's ICs 22 and 23 fitted, check from:

    a) SK1 to IC7 and IC8.

    b) IC8 to IC22.

    c) IC22 to IC28.

    d) IC28 to ICs 1 to 4.

6. If data is correct carry out tests 3 and 4 as per Table 8.3. (PROM set fitted) and tests 9 and 10 (MASK Rom's fitted).

PROCEDURE 3

1. If the display responds with *noP9* (i.e. as if there are less than 9 programs available), proceed as follows:

    a) Carry out Fault Finding Procedure 2.

    b) Carry out tests as per Table 8.3 including tests 5 and 6 (or 11 and 12, dependent on IC's fitted).

PROCEDURE 4

1. If the display fails (e.g. presents all decimal points and/or random bars), fails to respond to programming key selections or returns incorrect data during programming, the following checks should be carried out:

    a) Check for track shorts and shorts on the data bus lines and address bus lines. (Track shorts are by far the most common fault if the board has not been automatically tested).

    b) Remove ICs 13 and 26.

    NB. It is assumed that the setting up and fault finding procedures have been carried out in order, if so, action 1b above may reveal the fault.

2. If the instrument is fitted with PROM set IC14 to IC21 proceed as follows:

    a) Remove IC20 and IC21.

    b) Change IC11 to IC19 with known serviceable devices.

c) Check for logic levels (2 state TTL levels) and random activity on address pins to ICs 11 to 19.

d) Carry out checks as per 3b of Fault Finding Procedure 1.

e) Check for logic levels and random activity on data lines to IC11. (All data lines should have 3 distinct levels when in use and be similar).

3. If the instrument is fitted with MASK Rom's IC22 abd 23, proceed as follows:

a) Change IC22 and IC23 with known serviceable devices.

b) Check for logic levels (2 state TTL levels) and random activity on address pins to IC23.

c) Carry out checks as per operation 3b of Fault Finding Procedure 1.

d) Check for logic levels and random activity on data lines to IC22.(All data lines should have 3 distinct levels when in use and be similar).

NB. When checking continuity of data or address lines to actual IC pins, use a 4.7kΩ resistor connected between the probe and +5V rail.

When checking the nature of the data lines to detect shorts to other TTL outputs (e.g. address lines), first check with no pull-up resistor fitted that all lines have tri-state periods, then with the pull-up resistor fitted check that the tri-state periods become logic 1 levels.

PROCEDURE 5

1. Switch SW3A pin 1 and 12 to ON.

2. If the instrument fails (e.g. displays all the decimal points and random bars), proceed as follows:

a) With SW3A engaged as per operation 1 above, switch the instrument OFF/ON.

3. If the instrument still fails and is fitted with PROM set IC14 to IC21, proceed as follows:

a) Change ICs 20, 21, 26, 11 and 12 with known serviceable devices.

b) Check for logic levels and activity on address lines to ICs 20, 21 and 26.

4. If the instrument is fitted with MASK Roms IC22 and 23 proceed as follows:

a) Change IC23 with a known serviceable device.

b) Check for logic levels and activity on address lines to IC23.

c) Refer to Table 8.4 overleaf for Program ROM and RAM allocations.

TABLE 8.4

PROGRAM FAILURE	POSSIBLE FAULT LOCATION ROMs	RAMs
1, 2, 3	IC14, 15 (22)	IC11
4 (0, 2)	IC14, 15 (22)	IC11
4 (1)	IC16, 17, 18, 19 (22, 23)	IC11
5, 6, 7	IC16, 17 (22)	IC12
8	IC18, 19 (23)	IC11, 12
9	IC18, 19 (23)	IC11, 12
RS232	IC20, 21, 16, 17	IC11, 12, 13

Notes

1. Those program numbers enclosed in brackets are allocated in the Mask Rom set, IC22, IC23.
2. The Option routine is allocated in IC16, 17.
3. Part of the constant entry routine is in IC18, 19.
4. Most programs use subroutines used in earlier programs. If programs are tested in order (1 to 9) then the above table indicates the most likely fault locations.

This concludes the setting up and fault finding procedures for board 8.