

TRUE RMS VOLTMETER  
2610

Code No. 52610-900X

©

1982

MARCONI INSTRUMENTS LIMITED  
ST. ALBANS HERTFORDSHIRE ENGLAND.

# CONTENTS

## PRELIMINARIES

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## CHAPTERS

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## HAZARD WARNING SYMBOLS

The following symbols appear on the equipment.

<i>Symbol</i>	<i>Type of hazard</i>	<i>Reference in manual</i>
△	Static sensitive device	Page (iv)
△	Input voltage limit	Chap. 1, para. 11 and Chap. 3, para. 5.
△	AC supply setting	Chap. 2, para. 8.

### Note...

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

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

## NOTES AND CAUTIONS

### ELECTRICAL SAFETY PRECAUTIONS

This equipment is protected in accordance with IEC Safety Class 1. It has been designed and tested according to IEC Publication 348, 'Safety Requirements for Electronic Measuring Apparatus', and has been supplied in a safe condition. The following precautions must be observed by the user to ensure safe operation and to retain the equipment in a safe condition.

#### Defects and abnormal stresses

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

#### Removal of covers

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

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

#### Mains plug

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

#### Fuses

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


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

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

#### Earth connection

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

**CAUTION : STATIC SENSITIVE COMPONENTS**

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

- (1) If a printed board containing static sensitive components (as indicated by a warning disc or flag) is removed, it must be temporarily stored in a conductive plastic bag.
- (2) If a static sensitive component is to be removed or replaced the following anti-static equipment must be used.

A work bench with an earthed conductive surface.

Metallic tools earthed either permanently or by repeated discharges.

A low-voltage earthed soldering iron.

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

- (3) As a general precaution, avoid touching the leads of a static sensitive component. When handling a new one, leave it in its conducting mount until it is required for use.
- (4) If using a freezer aerosol in fault finding, take care not to spray programmable ICs as this may affect their contents.

**CAUTION : BATTERY SUPPLY TEMPERATURE**

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

**CAUTION : LCD HANDLING**

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

**WARNING : HANDLING HAZARDS**

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

**WARNING : TOXIC HAZARD**

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

Chapter 1

GENERAL INFORMATION

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Fig. 1 True RMS Voltmeter type 2610 ... .. Page 1



Fig. 1 True RMS Voltmeter type 2610

## FEATURES

1. Voltmeter type 2610 is a thermal converter instrument with microprocessor control that indicates the true r.m.s. value of voltages in the frequency range d.c. to 25 MHz. Measurement can be made on any a.c. signal whether simple or complex, symmetrical or asymmetrical, or with superimposed noise or d.c.
2. To assist with measurements on low frequency signals the display rate can be reduced to give a readout of the r.m.s. average of a number of successive readings. There is also an l.f. damping facility which can be selected for measurements on waveforms with a low frequency component.
3. The 4 digit display is scaled in volts or decibels relative to 1 V or 1 mW referenced to any impedance from 1  $\Omega$  to 999.9 k $\Omega$  on the dBm range. Manual or automatic ranging can be employed. An auxiliary analogue meter is also provided to simplify peak or null measurements and there is a d.c. output for use with a pen recorder.
4. For relative measurements an offset function is provided to enable a desired reference level to be entered and subsequent readings displayed in terms of voltage or dB relative to this reference level.
5. The addition of an optional GPIB interface unit allows remote programming by the General Purpose Interface Bus (GPIB)\*. An alternative option available allows 2610 to be powered from internal batteries or an external d.c. supply instead of the normal a.c. mains supply.

## PERFORMANCE DATA

<i>Characteristic</i>	<i>Performance</i>
6. <u>Functions</u>	AC true r.m.s. AC + d.c. r.m.s. with damping.
7. <u>Displays</u>	Panel selectable for volts or dB. 13 mm high, 4 digit, 7 segment l.c.d. with automatic decimal point location and V, dBm, dBV, k $\Omega$ , AC, DC, LF, mV. OFFSET AND BATT LO annunciators. 50 mm analogue peaking/dipping meter for dB only. 0 dB = range full-scale.
8. <u>Voltage ranges</u>	
Full-scale display :	2 mV to 200 V in x 10 steps and 700 V.
Resolution :	2 mV to 200 V : 0.05% of range. 700 V : 0.14% of range.

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\* GPIB - Marconi Instruments General Purpose Interface Bus in accordance with IEEE Standard 488 - 1978 and IEC Publication 625-1.

*Characteristic*

*Performance*

9. Voltage accuracy

Validity of voltage accuracy is for 12 months.

Accuracy specification applies from 10% to 100% full-scale (full-scale = 2000 counts except 700 V). Low frequency damping may be required below 45 Hz.  
2 mV range is a.c. coupling only.  
At specification change points better specification applies.

For 0 to 18°C and 28°C to 50°C multiply 18° to 28°C specification by  
 $1 + \frac{\Delta\text{Temp. with respect to } 20^{\circ}\text{C}}{20}$

AC voltage 18°C to 28°C :

Below 45 Hz specification applies to d.c. coupling only.

2mV range AC coupling only

45Hz -500kHz ±(1.5% +16 counts)  
500kHz-3MHz ±(2% +21 counts)

20mV range

5Hz -10Hz ±(1.5% +16 counts)  
10Hz -500kHz ±(0.7% +8 counts)  
500kHz-5MHz ±(1.5% +16 counts)  
5MHz-10MHz ±(2% +21 counts)

200mV range

5Hz -10Hz ±(0.7% +8 counts)  
10Hz -500kHz ±(0.5% +6 counts)  
500kHz-5MHz ±(1.5% +16 counts)  
5MHz-25MHz ±(2% +21 counts)

2V range

5Hz -10Hz ±(0.7% +8 counts)  
10Hz -500kHz ±(0.5% +6 counts)  
500kHz-5MHz ±(1.5% +16 counts)  
5MHz-20MHz ±(2% +21 counts)  
20MHz-25MHz ±(3% +31 counts)

20V range

5Hz -10Hz ±(0.7% +8 counts)  
10Hz -500kHz ±(0.5% +6 counts)  
500kHz-5MHz ±(1.5% +16 counts)

200V range

5Hz -20kHz ±(0.7% +8 counts)

700V range

5Hz -1kHz ±5%

▶ % = % of reading ◀

DC voltage 18°C to 28°C

Range 20mV : ±(0.7% of reading + 18 counts).

Range 200mV to 700V : ±(0.5% of reading + 6 counts).

10. Crest factor

Maximum accepted to maintain voltage accuracy :

7 at full-scale increasing down scale by  
 $7 \times \frac{\text{voltage range}}{\text{voltage input}}$

11. Input characteristics

Maximum input

Volts ranges : 700 V r.m.s. or 1000 V peak

Millivolt ranges : 50 V r.m.s.

Subject to a Volts x Hertz limitation of  $1 \times 10^8$  on any range.

*Characteristic**Performance*

Input connection : BNC isolated 1 M $\Omega$  shunted by approx. 50 pF.  
 Maximum common mode voltage : 400 mV r.m.s. or 600 mV peak.

12. Display characteristics

Reading rate : User selectable by pressing DISPLAY and a number key giving the following approx. display rates. Number of readings made does not change but greater r.m.s. averaging occurs as number increases.

<i>Number</i>		<i>Display rate</i>	
1	25	readings/second	
2	12.5	"	"
3	6.2	"	"
4	3.1	"	"
5	1.5	"	"
6	.8	"	"
7	.4	"	"
8	.2	"	"

Response time : Within range, worst case to within 1% of final value in typically 2 s max. When low frequency damping selected, worst case to within 1% of final value in typically 10 s max.

Low frequency damping : Fixed value of damping is selected by pressing LFD key. Annunciator shows LFD when circuit is damped.

Linear analogue output : Rear panel BNC output proportional to analogue meter deflection with f.s.d. of approx. 2 V d.c.

Ranging : Autoranging on all ranges when a.c. coupled, and from the 20 mV range upwards when d.c. coupled.

DISPLAY key holds the display at the last reading.

With manual range selection, autoranging limited to above the range selected. Manual ranges up at 2500 counts and down at 180. In manual mode decimal point flashes to indicate measurement is outside autorange limits.

With AUTO mode selected ranges up at 2200 counts and down at 180. (Allow 30 s recovery time after the application of a signal that gives a reading above 2200 counts.)

Autorange rate: Upward ranging. Max. per range 1 s except during low frequency damping operation when max. per range 3 s.



*Characteristic**Performance*

13. Decibel ranges
- In the decibel modes with a.c. coupling selected the instrument appears as though it has a single range of 130 dB.
- Resolution : 4 digits.
- References :
- dBV : Readings are displayed as dB relative to 1 V r.m.s.
- dBm : Readings are displayed as dB relative to 1 mW into a previously entered load impedance selectable in 1  $\Omega$  steps between 1  $\Omega$  and 999.9 k $\Omega$ .
14. Offset function
- Allows an offset level to be entered into the offset register from the keyboard or display.
15. Impedance function
- Enables a reference value between 1  $\Omega$  and 999.9 k $\Omega$  to be entered into the impedance register allowing dBm readings to be made. On switch-on 50  $\Omega$  is stored in the impedance register.
16. Power requirements
- Voltage ranges : 105 V to 120 V }  $\pm 10\%$   
(switchable) 210 V to 240 V }
- Frequency range : 50 to 400 Hz  $\pm 10\%$ .
- Consumption : 15 VA approx.
- 17.\* Battery option
- Modes of operation :
- Off : Battery supply is disconnected.
- On : Battery operates 2610. If mains supply is present this takes priority.
- Charge : Battery receives a fast charge and voltmeter is inoperative.
- Indication
- Charge : LED at 2610 front panel indicates when charge mode is selected.
- Batt lo : Annunciator on 2610 display indicates when battery volts are low.
- Low volts : LED at rear casing indicates when battery voltage has fallen below 4 V.

*Characteristic**Performance*

External supply voltage : 7 V to 16 V d.c. across rear case terminals.

Battery type : Fully sealed nickel cadmium battery pack.

Capacity : Sufficient for continuous operation at a charging and operating temperature of +20°C for at least 3 hours (typically 5 hours).

Recharging time : Approximately 15 hours to fully charge a discharged battery when in CHARGE mode.

External charge : Rear panel switch and terminals allow battery to be charged from an external source in the range 7 V to 16 V d.c.

18. GPIB option

Capabilities : Complies with the following subsets as defined in IEEE 488 - 1978 and IEC publication 625-1: SH1, AH1, T5, L4, SR1, RL1, PPO, DC1, DT1, CO, E1.

19. Environmental

## 2610 and GPIB option

Rated range of use temperature : 0°C to 50°C.

Limit range of operation temperature : 0°C to 55°C.

Conditions of storage and transport :

Temperature : -40°C to +70°C.

Humidity : Up to 90% relative humidity.

Altitude : Up to 2500 m (pressurized freight at 27 kPa differential i.e. 3.9 lbf/in<sup>2</sup>).

## Battery option

Limit range of operation temperature : 0°C to +45°C.

Conditions of storage and transport :

Temperature : -40°C to +50°C.

Humidity : Up to 90% relative humidity.

Altitude : Up to 2500 m (pressurized freight at 27 kPa differential i.e. 3.9 lbf/in<sup>2</sup>).

<i>Characteristic</i>	<i>Performance</i>
20. <u>Safety</u>	Complies with IEC 348.
21. <u>Radio frequency interference</u>	This equipment conforms to the requirements of EEC directive 76/889.
22. <u>Dimensions and weight</u>	
Height :	108 mm (4.25 in) overall.
Width :	215 mm (8.5 in) +41mm (1.6 in) for handles.
Depth :	338 mm (13.3 in) overall.
Weight	
2610 :	3 kg (6.6 lb) approx.
2610 with battery option fitted :	4 kg (8.8 lb) approx.

## ACCESSORIES

	<u>Code no.</u>
23. <u>Supplied</u>	
AC supply lead	43129-003W
Cover, polythene	37490-435X
Operating Manual H 52610-900X, Vol. 1	46881-427T
24. <u>Optional</u>	
Battery option, comprising:	54462-022S
Battery control unit	44990-414L
Battery unit	44990-413N
GPIB interface unit	54433-002Y
GPIB lead assembly, IEEE connectors	43129-189U
GPIB adapter, IEEE male to IEC female	46883-408K
Coaxial input lead, BNC connectors	43126-012S
Front panel cover (stowage)	54124-022L
Rack mounting kit (single unit)	46883-638P
Rack mounting frame kit, 3 UH. (double unit)	46883-906G
Service Manual H 52610-900X, Vol. 2	46881-428P
The GPIB Manual H 54811-010P	46881-365R



Chapter 2

## INSTALLATION

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## UNPACKING AND REPACKING

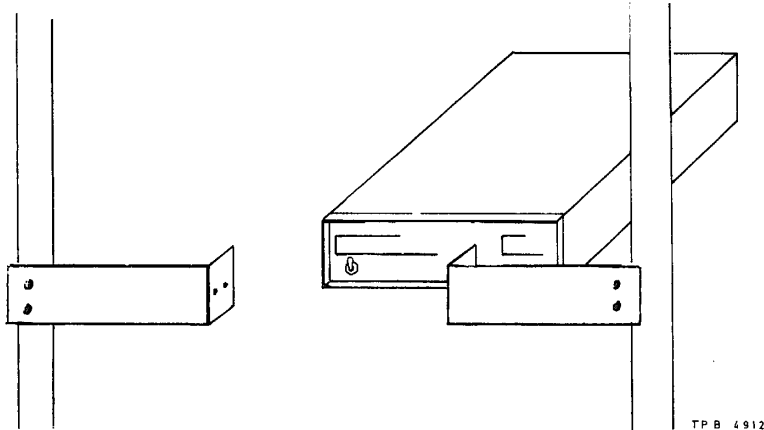
1. Retain the container, packing materials and the packing instruction note (if included) in case it is necessary to reship the instrument.
2. If the instrument is to be returned for servicing attach a label indicating the service required, type or model number (on rear label), serial number and your return address. Pack the instrument in accordance with the general instructions below or with the more detailed information in the packing instruction note.
  - (1) Place a pad in the bottom of the container.
  - (2) Place pads in the front and rear ends of the container with the plywood load spreader(s) facing inwards.
  - (3) Put the polythene cover over the instrument and place it in the container with the front handles and rear projections (where applicable) against the plywood load spreaders.
  - (4) Place pads in the two sides of the container with cushioning facing inwards.
  - (5) Place the top pad in position.
  - (6) Wrap the container in waterproof paper and secure with adhesive tape.
  - (7) Mark the package FRAGILE to encourage careful handling.

## Note...

If the original container or materials are not available, use a strong double-wall carton packed with a 7 to 10 cm layer of shock absorbing material around all sides of the instrument to hold it firmly. Protect the front panel controls with a plywood or cardboard load spreader; if the rear panel has guard plates or other projections a rear load spreader is also advisable.

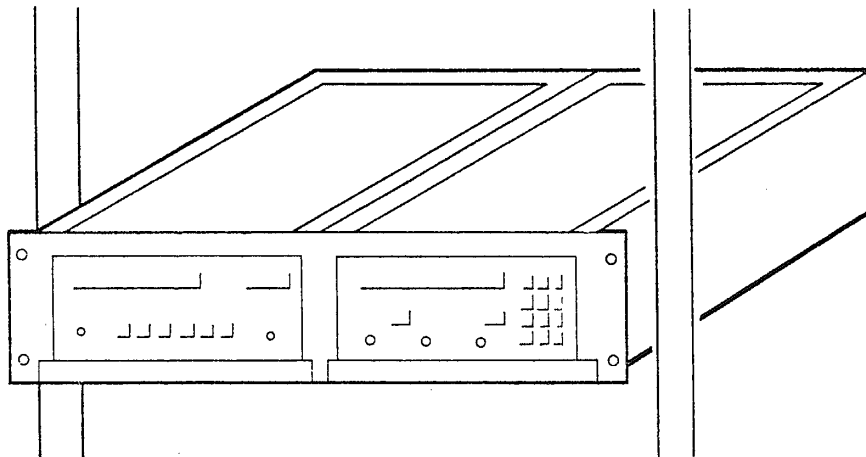
## RACK MOUNTING ARRANGEMENTS

3. For rack mounting the 2610 voltmeter alone, a single unit rack mounting kit 46883-638P is available. This contains a pair of side angle plates wide enough to allow the instrument to sit centrally within the 19 inch rack frame - see sketch Fig. 1.



*Fig. 1 Single unit rack mounting*

4. For rack mounting the voltmeter side by side with another instrument of the same construction a double unit rack mounting kit 46883-906G is available. This kit comprises a framework which accommodates the fully cased instruments and requires only the removal of the handles. Should only one instrument be fitted, a supplied blanking plate can be positioned to cover the unused aperture at the front.



*Fig. 2 Twinned unit rack mounting*

5. For detailed information on kit parts, assembly etc. refer to the fitting instructions which are supplied with each rack mounting kit, i.e.,

Code no. H 46883-638P for rack mounting kit - single unit,

Code no. H 46883-906G for rack mounting frame kit - double unit.

## CONNECTING TO SUPPLY

6. AC mains or battery or external d.c. operation can be used as detailed below.

### AC mains supply

7. The instrument will operate from a.c. supplies in the ranges 105 to 120 V or 210 to 240 V, at frequencies from 50 to 400 Hz; a tolerance of  $\pm 10\%$  is allowable on both voltage and frequency ranges.

8. Before connecting the instrument to the a.c. supply check the position of the AC SUPPLY selector on the rear panel. This has a locking plate which reveals the selected range and the appropriate fuse value. The instrument is normally despatched with the 210 to 240 V range selected. To change ranges, remove the locking plate, reset the selector and replace the locking plate in its alternative position. Ensure that fuses of the correct rating are fitted as follows:-

315 mA (time lag) for the 105 to 120 V range  
or 160 mA (time lag) for the 210 to 240 V range.

The fuses are 20 mm x 5 mm cartridge type.

9. The free a.c. supply cable is fitted at one end with a female plug which mates with the a.c. connector at the rear of the instrument. When fitting a supply plug ensure that conductors are connected as follows:-

Earth - Green/yellow  
Neutral - Blue  
Live - Brown

When attaching the mains lead to a non-soldered plug it is recommended that the tinned ends of the lead are first cut off owing to the danger of cold flow resulting in intermittent connections.

### Safety testing

10. Where safety tests on the mains input circuit are required, the following procedures can be applied. These comply with BS 4743 and IEC Publication 348. Tests are to be carried out as follows and in the order given, under ambient conditions, to ensure that mains input circuit components and wiring (including earthing) are safe.

(1) Earth lead continuity test from any part of the metal frame to the bared end of the flexible lead for the earth pin of the user's mains plug. Preferably a heavy current (about 25 A) should be applied for not more than 5 seconds.

Test limit : not greater than 0.5  $\Omega$ .

(2) 500 V d.c. insulation test from the mains circuit to earth.

Test limit : not less than 2 M $\Omega$ .

Battery or external d.c. supply

11. The instrument can be powered from an internal 6 V or external 7 V to 16 V d.c. supply. In both cases the optional Battery Control Unit 44990-414L must be fitted. The internal supply is provided by the optional Battery Unit 44990-413N which is powered by five 1.2 V nickel-cadmium cells in series. These allow typically 5 hours use before recharging is necessary.
12. To select d.c. operation move the switch on the Battery Control Unit to ON and switch off the front panel SUPPLY switch (otherwise a.c. operation will get priority if the mains supply is present). For external operation connect a 7 V to 16 V d.c. supply to the DC INPUT terminals; this input is protected against reversed polarity connection.
13. If the internal or external supply is too low the BATT LO annunciator will be displayed and after a period of further use the supply will be automatically disconnected. An l.e.d. at the rear casing lights to indicate this condition has been reached.
14. To charge the internal batteries move the switch on the Battery Control Unit to CHARGE. Charging then takes place when the a.c. supply is connected and the SUPPLY switch is set to ON, causing the CHARGE lamp to light. Alternatively an external d.c. supply connected to the DC INPUT terminals may be used as the charging source. The instrument cannot be operated as a voltmeter while switched to CHARGE. The recharging time to fully charge a discharged battery is approximately 15 hours.

## FITTING BATTERY OPTIONS

15. Before fitting the Battery Control Unit or the Battery Unit the top cover must be removed after slackening the two screws securing the rear feet and rear frame.
16. The Battery Control Unit goes in the rectangular cut-out in the rear panel (which alternatively accepts the GPIB board). Having removed the cut-out plate insert the unit and secure it with the two screws that retained the cover plate.
17. Connect the unit into circuit by engaging its free socket with plug PLA on the mother board in place of the shorting socket already fitted.

Note...

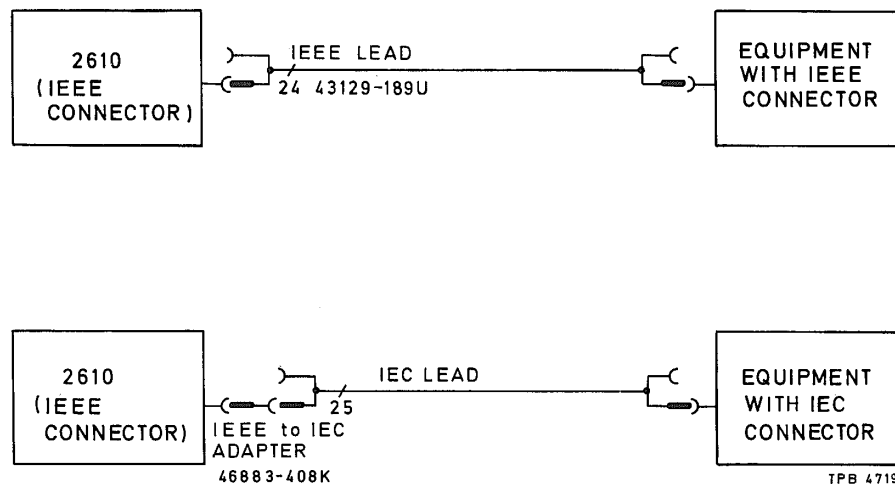
If the Battery Control Unit is removed the shorting socket must be replaced.

18. The Battery Unit mounts transversely between the two side frames, with its leads to the rear. Secure it with its four fixing screws through holes in the side frames.
19. Connect the unit into circuit by engaging its free connector with PLA on the Battery Control Unit. Then replace the top cover with the ventilation holes to the rear.

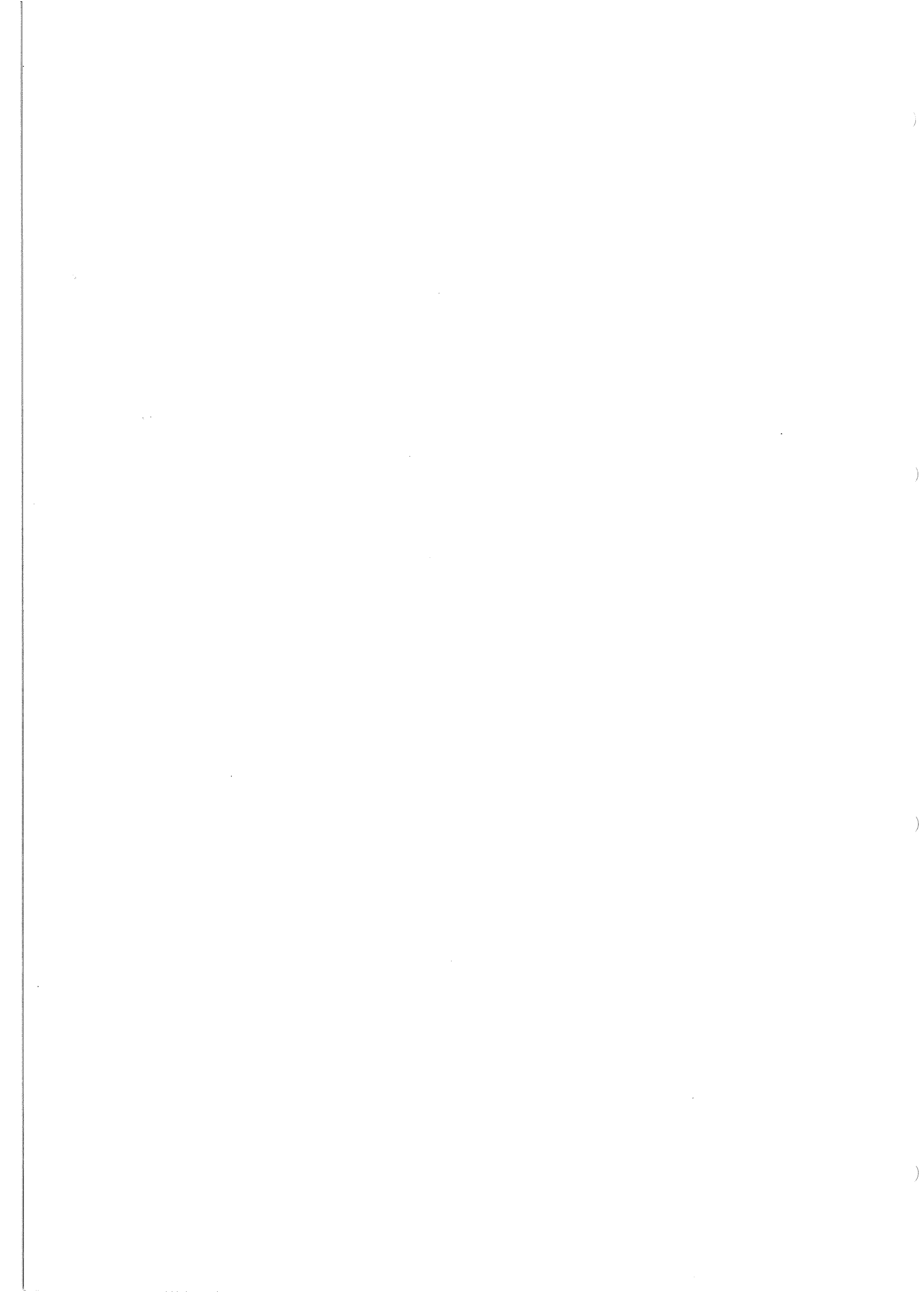


## FITTING THE GPIB OPTION

20. Before fitting this unit the top cover must be removed as described in para. 15.
21. The GPIB Interface Unit goes in the rectangular cut-out in the rear panel (which alternatively accepts the Battery Control Unit). Having removed the cut-out cover plate insert the unit and secure it with the two screws that retained the cover plate.
22. Connect the unit into circuit by engaging its free socket with plug PLF on the mother board and refit the top cover.
23. External connections are made via the 24-way connector mounted directly on the module and accessible at the rear panel. The GPIB address switch is mounted alongside this connector.
24. Connection to other equipment which has a 24-way bus connector to IEEE Standard 488 can be made with the GPIB lead assembly 43129-189U, available as an optional accessory. An IEEE-to-IEC adapter 46883-408K is also available for interfacing with systems using a 25-way bus connector to IEC Recommendation 625 - see Fig. 3.



*Fig. 3 GPIB interconnections*



Chapter 3

## OPERATION

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## PREPARATION FOR USE

Turn-on procedure

1. The instrument is primarily intended for a.c. mains operation but may also be powered from an external or internal battery supply when fitted with the optional Battery Control Unit - see Chap. 2 for details.
2. For a.c. operation make sure the AC SUPPLY selector is correctly set and the appropriate fuses fitted before connecting the supply lead. Then set the  $\sim$  supply switch to ON.

3. For battery or external d.c. supply operation set the Battery Control Unit switch to ON.

Note...

Battery operation is not affected by the setting of the front panel SUPPLY switch unless an a.c. supply is present. If so, then switching to  $\sim$  SUPPLY ON will cause the instrument to select a.c. operation and inhibit the battery supply.

#### Operational check

4. The following procedure may be used as a first-time operating sequence to make you familiar with the voltmeter's capabilities. Alternatively, since the procedure exercises all the local control functions it is also useful as a routine performance check.

(1) With no signal input connected, switch the SUPPLY on and check that an all-eights display appears for a few seconds, with minus sign, decimal markers and all annunciators as in Fig. 1. The SRQ and REM lamps also come on during this period.

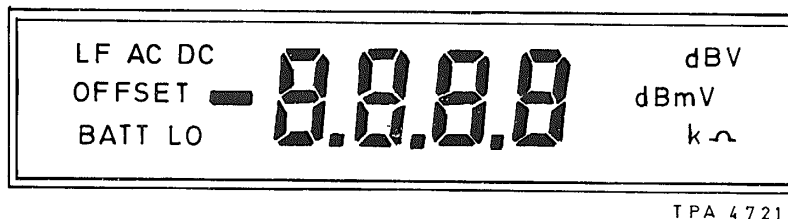


Fig. 1 Self-check display

After this the display should indicate DC 0.000 V with the decimal point flashing approx.  $1\frac{1}{2}$  times a second.

(2) Press 200 mV range key. Connect a sine wave signal of say 150 mV r.m.s. at 1 kHz to the INPUT socket. The instrument will display DC 150.0 mV (DC = DC coupling) and the dB meter will indicate about -2.5 dB.

(3) Reduce the input frequency to about 10 Hz. Then check the effect of different display times by pressing the DISPLAY key followed by 8 to give the slowest rate, with the reading changing every 5 seconds, and then DISPLAY again followed by 1 to give 25 readings a second. Check also that the AC and DC annunciators can be toggled by means of the AC/DC key. Finally restore the original conditions by pressing the RESET key and the 200 mV range key and return the input frequency to 1 kHz.

(4) Press AUTO key. Check the autoranging by increasing the input through 200 mV. When the display reaches 220.0 mV (+1 dB) it should change to 0.220 V as the instrument ranges up to the 2 V range. Then decrease the input through 200 mV and at 0.180 V the display should change to 180.0 mV (-1 dB) as the instrument reverts to the 200 mV range.

(5) Restore the input to 150 mV, press dBV and check for a display of nominally -16.48 dBV.

(6) Press the IMP key and note that the display shows the default impedance value of 0.050 k $\Omega$ . Press the ENTER (IMP) key to re-enter this value. Then press the dBm key and check for a display of nominally -3.47 dBm.

(7) Press the AUTO key to restore the 150.0 mV reading. Then press the OFFSET key and note that the OFFSET annunciator appears. Press the ENTER (OFFSET) key to enter this value, which will zero the display reading. Vary the input level a few millivolts in each direction and note that the display indicates a reading equal to the input level minus 150 mV.

Note...

If the input level goes above 220 mV absolute the instrument will range up and the offset function will be cancelled.

Clear the OFFSET function by pressing AUTO or any other function or range key.

(8) To observe the effect of measuring low frequency signals reduce the input frequency to about 4 Hz and note the degree of fluctuation in both the display and the dB reading. Press the LFD key and note that the LF annunciator appears. After a few seconds both the display and the dB reading should stabilize.

## PRINCIPLES OF MEASUREMENT

### RMS reading

5. The instrument measures voltage by comparing the heating effect of the applied signal with that of a calibrated internal d.c. voltage. It therefore measures the true r.m.s. value of any waveform (with certain crest factor limitations) and, if switched to d.c. coupling, will correctly include any d.c. component in the signal.

### $\triangle$ CAUTION

The input a.c. + d.c. voltage must not exceed :

700 V r.m.s. or 1000 V peak on the volts ranges.

50 V r.m.s. on the millivolt ranges.

The V x Hz product must not exceed  $10^8$  on any range.

### Automatic ranging

7. The instrument under microprocessor control selects the correct voltage range to measure the incoming voltage. If the input voltage subsequently changes such that it is outside the selected range limits then the voltmeter will switch to the more appropriate range. Manual control of voltage range selection is enabled by pressing the appropriate front panel key but the voltmeter still retains the ability to automatically change range if necessary. In order to protect the voltmeter from overload the voltage ranging function has certain restrictions imposed and operates in the following manner.

- ▶ 8. On power up 2610 goes to 700 V range and then AUTO ranges down (input voltage permitting) to 2 V range. AUTO range limits of 180 counts and 2200 counts apply (2000 counts = full-scale except 700 V range). Selecting a range manually, limits the automatic ranging to above the range selected and the ranging limits are then 180 counts and 2500 counts.
9. If the input falls below 150 counts on the manually selected range the display is zeroed. This avoids any erroneous readings that might occur for example residual noise counts on the lowest a.c. (2 mV) or d.c. (20 mV) range. ◀ Pressing the AUTO key sets 2 mV a.c. or 20 mV d.c. as the lower range limit with AUTO ranging limits as before. Pressing the RESET key or resetting the power on condition will restore 2 V as the lower range limit.

#### Data averaging

10. The measured analogue voltage is converted into digital form at intervals of about 40 ms; in other words the conversion rate is 25/second. The rate at which these converted readings are displayed can be varied from the same rate, so as to give a readout after each conversion, down to 0.2 readings/s (= 5 s/reading) which gives a readout after 128 conversions.

11. Each readout represents the r.m.s. average of the preceding conversions. For example, in the default display rate setting of 3 readings/s, 8 conversions (C<sub>1</sub>, C<sub>2</sub>, C<sub>3</sub> .... C<sub>8</sub>) are averaged to give a display (D) of

$$D = \sqrt{\frac{C_1^2 + C_2^2 + C_3^2 + \dots + C_8^2}{8}}$$

12. When measuring the voltage of low frequency waveforms, or signals with a low frequency ripple, this averaging technique at the slower display rates gives a readout of greater stability and accuracy than that obtainable with a high display rate. It is particularly effective with waveforms having large random fluctuations.

#### Low frequency damping

13. This offers an alternative method of reducing display instability when measuring low frequency signals and also enables the use of a higher display rate than would be possible with the averaging technique. It operates by smoothing out ripple in the thermal converter control loop.

Note...

Damping is disabled during range changing. This permits faster ranging and affords protection to the sensor.

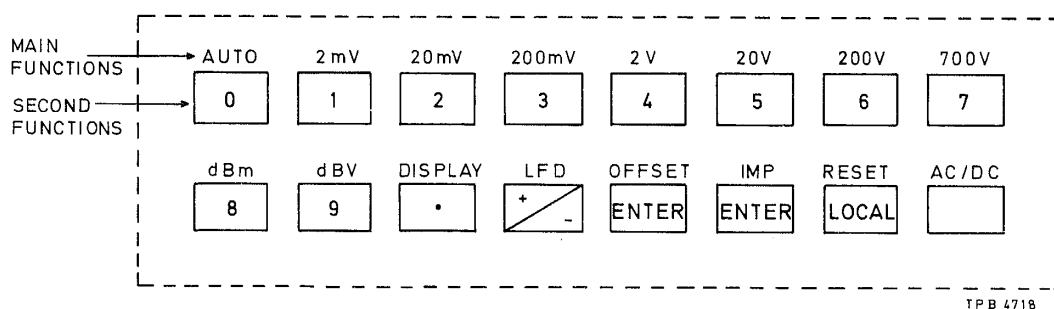
Offset measurements

14. In this measurement mode an entered value, or 'offset' is subtracted from the readout. This enables you to make measurements relative to a datum level as in the following examples.

15. Measuring frequency response characteristic. Having made a measurement in dBV at the reference frequency, say 1 kHz, the reading obtained is entered as the offset value (by pressing the OFFSET button twice) which reduces the 1 kHz reading to 0 dB. Measurements at other frequencies are then displayed in dB relative to the value at 1 kHz.

16. Setting to a predetermined value. To simplify setting up procedures and reduce the possibility of errors the required reading can first be entered as an offset. Setting up is then simply a matter of adjusting the input for zero reading.

MEASUREMENT KEY FUNCTIONS



*Fig. 2 Key-pad layout*

17. The main function of each key is labelled above the key. Certain keys also have a second function which is labelled on the face of the key. The second function (except for the RESET/LOCAL key) applies only in the 'number entry' mode.

18. The 'number entry' mode is enabled by first pressing the OFFSET or IMP key. The limited second function display range 1 to 8 is enabled by first pressing the DISPLAY key. Key functions are summarized in Table 1.

TABLE 1 KEY FUNCTIONS

MAIN FUNCTION	KEY	SECOND FUNCTION (in number entry mode)
Selects autoranging mode for measurements in V or mV.	AUTO 0	0
Selects 2 mV range and a.c. coupling.	2 mV 1	1
Selects range full-scale from 20 mV to 700 V.	20 mV 2 200 mV 3 2 V 4 20 V 5 200 V 6 700 V 7	2 3 4 5 6 7
Instrument goes into autoranging mode and displays dB relative to 1 mW referenced to the impedance value entered by IMP; default value is 50 $\Omega$ . The dBm indication refers to the power that would be developed in an external impedance equal to the entered value.	dBm 8	8
Instrument goes into autoranging mode and displays dB relative to 1 V.	dBV 9	9



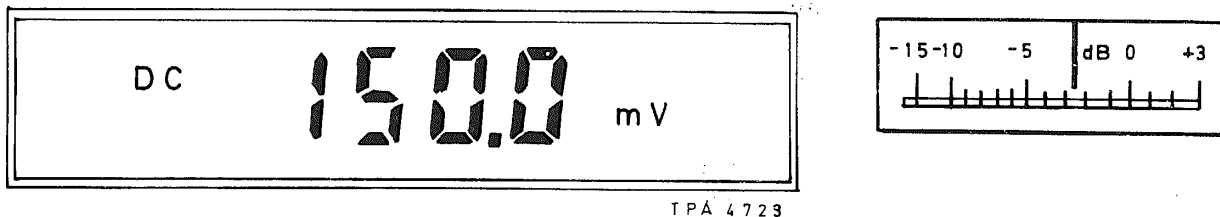
TABLE 1 KEY FUNCTIONS (continued)

MAIN FUNCTION	KEY	SECOND FUNCTION (in number entry mode)																											
<p>Holds the display reading. If a number key from 1 to 8 is then pressed the display rate changes as follows:</p> <table border="1" data-bbox="311 533 917 1019"> <thead> <tr> <th>Number</th> <th>Display rate (approx)</th> <th>Readings averaged</th> </tr> </thead> <tbody> <tr> <td><input type="checkbox"/> 1</td> <td>25</td> <td>1</td> </tr> <tr> <td><input type="checkbox"/> 2</td> <td>12.5</td> <td>2</td> </tr> <tr> <td><input type="checkbox"/> 3</td> <td>6</td> <td>4</td> </tr> <tr> <td><input type="checkbox"/> 4</td> <td>3</td> <td>8</td> </tr> <tr> <td><input type="checkbox"/> 5</td> <td>1.5</td> <td>16</td> </tr> <tr> <td><input type="checkbox"/> 6</td> <td>1.25</td> <td>32</td> </tr> <tr> <td><input type="checkbox"/> 7</td> <td>2.5</td> <td>64</td> </tr> <tr> <td><input type="checkbox"/> 8</td> <td>5</td> <td>128</td> </tr> </tbody> </table> <p>Default setting is <input type="checkbox"/> 4, i.e. 3 readings/s. Readings are averaged using r.m.s. technique - see para. 10.</p>	Number	Display rate (approx)	Readings averaged	<input type="checkbox"/> 1	25	1	<input type="checkbox"/> 2	12.5	2	<input type="checkbox"/> 3	6	4	<input type="checkbox"/> 4	3	8	<input type="checkbox"/> 5	1.5	16	<input type="checkbox"/> 6	1.25	32	<input type="checkbox"/> 7	2.5	64	<input type="checkbox"/> 8	5	128	<p>DISPLAY</p> <p><input type="checkbox"/></p>	<p>Decimal point</p>
Number	Display rate (approx)	Readings averaged																											
<input type="checkbox"/> 1	25	1																											
<input type="checkbox"/> 2	12.5	2																											
<input type="checkbox"/> 3	6	4																											
<input type="checkbox"/> 4	3	8																											
<input type="checkbox"/> 5	1.5	16																											
<input type="checkbox"/> 6	1.25	32																											
<input type="checkbox"/> 7	2.5	64																											
<input type="checkbox"/> 8	5	128																											
<p>Toggles the low frequency damping function - see para. 13.</p>	<p>LFD</p> <p><input type="checkbox"/> +/-</p>	<p>Toggles +ve &amp; -ve numbers.</p>																											
<p>Initiates the offset function - see para. 14 - and goes into number entry mode. The number currently displayed is available for entering as the offset value or a new value can be keyed in. Pressing any other range key after entering the offset clears the offset function.</p>	<p>OFFSET</p> <p><input type="checkbox"/> ENTER</p>	<p>Enters the offset value, enables the function and exits from number entry mode.</p>																											
<p>Displays the current value of the dBm reference impedance (equal to 50 Ω following switch-on or reset), and goes into number entry mode. To change the impedance, key in a new value in kΩ.</p>	<p>IMP</p> <p><input type="checkbox"/> ENTER</p>	<p>Enters impedance value, enables the function and exits from number entry mode.</p>																											

TABLE 1 KEY FUNCTIONS (continued)

MAIN FUNCTION	KEY	SECOND FUNCTION (in number entry mode)
<p>If under local control, the instrument reverts to all default conditions :</p> <p>DC coupling Autoranging on V ranges 3 readings/second display 50 reference impedance for dBm.</p> <p>If under GPIB control, the instrument reverts to local control unless Local Lockout (LLO) program code is enabled. By holding the key down the GPIB address is displayed in the form AdNN, or TONN if set for talk only.</p>	<p>RESET</p> <p>LOCAL</p>	<p>Display is cleared or, if already clear, the instrument exits from number entry mode.</p>
<p>Toggles a.c. and d.c. coupling. Use d.c. coupling for measuring asymmetric waveforms or signals with a d.c. component. (DC coupling is not available on the 2 mV range.)</p>	<p>AC/DC</p>	<p>-</p>

## DISPLAY



TPA 4723

Fig. 3 Digital and analogue display

19. The numeric display comprises 4 digits with 3 decimal point locations and is preceded by a minus sign for negative values. Numbers are always displayed with leading zero suppression.

20. The meter gives an analogue equivalent of the digital display. It is scaled -15 to +3 dB where 0 dB represents the full-scale value of the selected range. This facility is intended to assist in measurement of changing values, in particular in peaking or dipping adjustments of tuned circuits, for example. It is not recommended for absolute measurement on account of its limited accuracy.

21. Annunciators on the digital display panel indicate the units of measurement of the reading, the status of certain operating modes and the state of battery charge. These are summarized in Table 2.

TABLE 2 ANNUNCIATORS

<i>Symbol</i>	<i>Interpretation</i>
LF	Low frequency damping function enabled.
AC	Input is a.c. coupled.
DC	Input is d.c. coupled.
OFFSET	Readout shows value relative to that of the entered offset.
BATT LO	Battery is discharged to less than 5.7 V.
dBV dBm V mV k $\Omega$	Units of measurement of the displayed value.

## GPIB CONTROL

22. When fitted with the GPIB option the instrument may be remotely controlled via the standard IEEE 488 (or IEC 625) bus to the extent defined by the interface functions :

SH1 AH1 T5 L4 SR1 RL1 DC1 DT1 CO PPO EI

These are briefly described below. For detailed information on this subject see 'The GPIB Manual' which is available as an optional accessory.

SH1 : Source handshake (complete capability)

The source handshake sequences the transmission of each data byte from the instrument over the bus data lines. The sequence is initiated when the function becomes active, and the purpose of the function is to synchronize the rate at which bytes become available to the rate at which accepting devices on the bus can receive the data.

AH1 : Acceptor handshake (complete capability)

The acceptor handshake sequences the reading of the data byte from the bus data lines.

T5 : Talker function

The talker function provides the 2610 with the ability to send device dependent messages over the bus to other devices. The ability of any device to talk exists only when it has been addressed as a talker.

L4 : Listener function (no listen only function)

The listener function provides a device with the ability to receive device dependent messages over the bus. The capability only exists where the device is addressed to listen via the bus by the controller.

SR1 : Service request function (complete capability)

The service request function gives the 2610 the capability to inform the controller when it requires attention.

RL1 : Remote/local function (complete capability)

The remote/local function allows the 2610 to be controlled either by the local front panel keys or by device dependent messages over the bus.

DC1 : Device clear function (complete capability)

Device clear is a general reset and may be given to all devices in the system simultaneously (DCL).

DT1 : Device trigger function (complete capability)

Device trigger function allows the synchronization of the start of two or more devices tasks irrespective of their particular programming codes.

C0 : Controller function (no capability)PPO : Parallel poll function (no capability)E1 : Open collector drivers

The GPIB drivers fitted to 2610 have open collector, rather than tri-state, outputs.

23. The instrument may be addressed in one of three modes :

Talk and listen,  
Talk only,  
Talk only in upper case characters.

When addressed to listen it will respond to Data, Trigger (GET), Clear (SDC) and Go to Local (GTL) messages.

When addressed to talk it will send Data and Status Byte messages.

Whether addressed or not it will respond to the Clear (DCL), Local Lockout (LLO), Go to Local (GTL) and Interface Clear (IFC) messages and will send Service Request (SRQ) messages.

Setting the GPIB address

24. The instruments talk and listen addresses can be selected by the address switch, illustrated in Fig. 4. This is positioned on the GPIB unit alongside the connector and accessible at the rear panel.

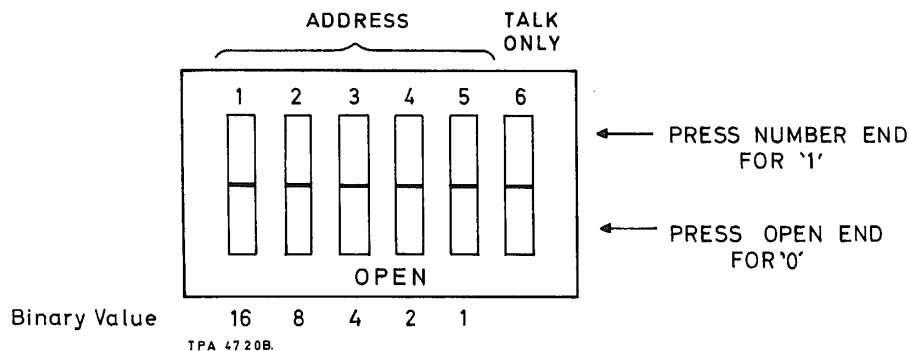


Fig. 4 GPIB address rocker switch

For talk and listen mode press open end of talk only switch and select any address from binary 00000 to 11111 ( 0 to 31 decimal ).

For talk only mode press number end of talk only switch and select any address from binary 00000 to 11110 ( 0 to 30 decimal ).

For talk only with upper case characters press number end of talk only switch and set address - binary 11111 ( 31 decimal ).

Remote operation

25. On receipt of the Remote Enable (REN) message from the GPIB the instrument switches to remote operation and the REM lamp on the front panel comes on. No instrument settings are changed but all front panel keys except LOCAL are disabled and their functions come under GPIB control.

26. Unless inhibited by the Local Lockout (LLO) message the instrumentation can be returned to local control by pressing the LOCAL key or by receipt of a Go to Local (GTL), Interface Clear (IFC) or Not Remote Enable (REN L) message.

GPIB program codes

27. All valid GPIB program codes are listed in Table 3. These include equivalents for all front panel keys (except LOCAL) with additional codes for special operating modes.

TABLE 3 GPIB PROGRAM CODES

<i>Function</i>	<i>Program code</i>	<i>Description</i>
AUTO ranging	R0	Range select
2 mV range	R1	
20 mV range	R2	
200 mV range	R3	
2 V range	R4	
20 V range	R5	
200 V range	R6	
700 V range	R7	
dBm range	R8	
dBV range	R9	
DISPLAY rate	Dn	Changes reading rate (n = 1 to 8 as shown in Table 1)
LFD	Ln	Sets low frequency damping (n = 0 for OFF, 1 for ON).
OFFSET	Onnnn <sup>†</sup>	Number entered is subtracted from reading. To clear function reselect any range.
IMP	Innnn <sup>†</sup>	Changes reference impedance (nnnn is in k $\Omega$ ).
AC/DC	An	Sets coupling (n = 0 for DC, 1 for AC).
TRIG	T	Sets single shot mode and executes one measurement cycle. On completion a service request (SRQ) message is normally sent to indicate that data is ready.
SINGLE SHOT	S	Sets single shot and waits for trigger.
CONTINUOUS	C	Sets free-running mode.
SEND IMP	Z	Displays the value of the dBm reference impedance.
SRQ INHIBIT	Qn	Enables instrument to free-run without raising service requests, whenever data becomes available (n = 0 for OFF, 1 for ON).
UPPERCASE	U	Causes upper case characters only to be sent (for printers without lower case characters).

<sup>†</sup> Delimiter required if further commands are to follow.

Typical program string

28. When the instrument has been addressed to listen as part of the routine GPIB protocol, it can be set to the required operating conditions by a string of program codes terminated by a line feed (LF) (usually accompanied by End or Identify EOI) as shown in Fig. 5. In this and subsequent examples the symbol '^' indicates a space.

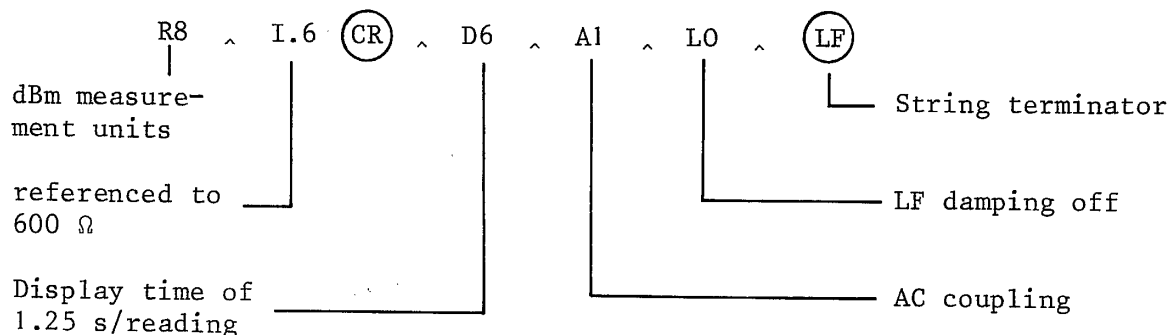


Fig. 5 Typical program string

29. In this example spaces are inserted between each program code for clarity but are not essential.

L0 is a default condition and therefore not essential.

For subsequent program strings, only the altered codes need be sent followed by (LF).

Output data format

30. The output data to the GPIB is in a 12-byte format followed by a carriage return, (CR), and a line feed, (LF) as in Fig. 6.

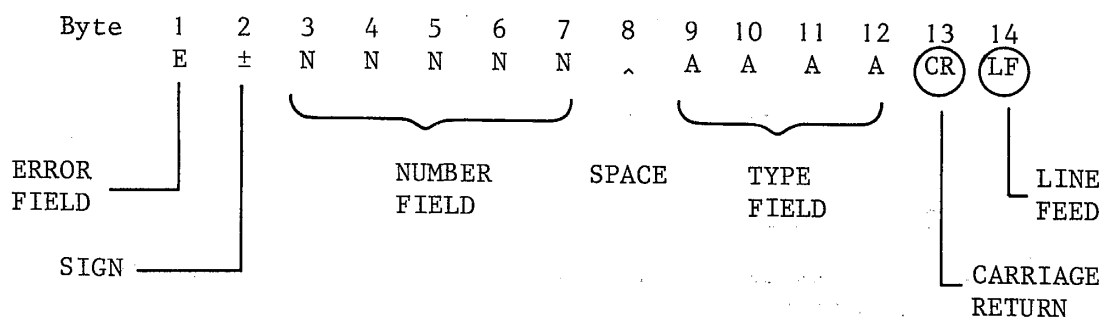


Fig. 6 Output data string

TABLE 4 OUTPUT DATA PARAMETERS

Byte No.	Name	Purpose
1	Error field E	Indicates to user or controller the validity of the data transmitted. * = outside normal operating range. ^ = no error.
2	Sign field ±	Indicates the sign of the number field. - = negative ^ = positive
3 to 7	Number field NNNNN	Contains the numerical information with 1 byte reserved for the decimal point. Valid characters are 0 to 9 and ^. Any leading zero is suppressed and replaced by ^.
8	Compulsory space ^	To assist intelligibility and act as a delimiter between the number and the type fields.
9 to 12	Type field AAAA	Identifies the units of measurement (padded out where necessary with trailing spaces).  e.g. kohm dBm^ V^^^
13	Carriage return ⓄCR	For correct formatting of printed copy.
14	Line feed ⓄLF	For correct formatting of printed copy. Also used as a terminator and usually followed by End or Identify (EOI) to indicate the end of a multibyte message.

Service request (SRQ) message

31. A service request message is raised when output data is ready or when an invalid GPIB program code is received, (unless the SRQ INHIBIT command is active). The SRQ lamp on the front panel comes on and is extinguished when SRQ is serviced.



Status byte

32. A status byte is prepared following receipt of Serial Poll Enable (SPE) or when 2610 raises SRQ. This consists of 8 bits, each of which is set true under the conditions shown in Fig. 7 and is sent to the controller when 2610 is addressed as a talker.

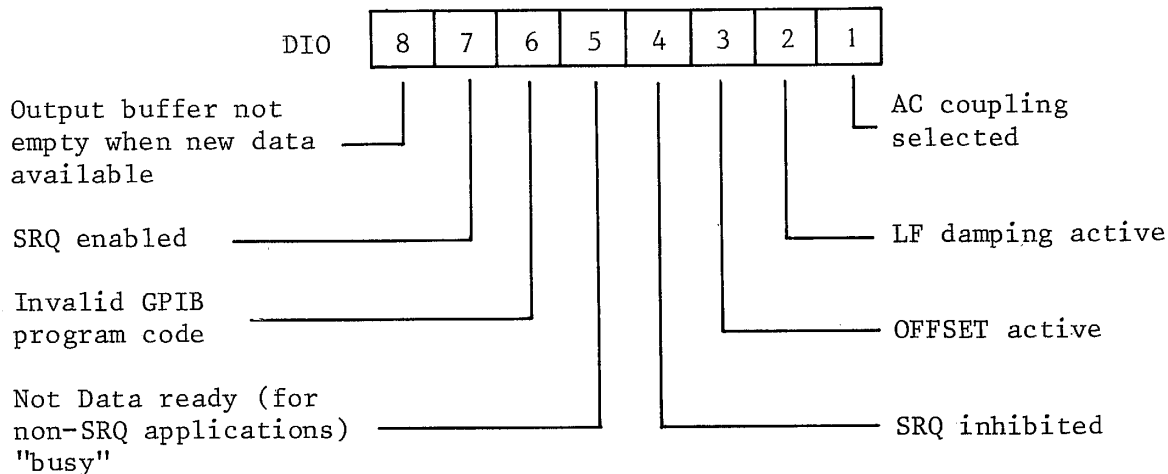


Fig. 7 Status byte

GPIB connector contact assignment

33. The contact assignment of the GPIB cable connector and the device connector is as shown in Fig. 8 below.

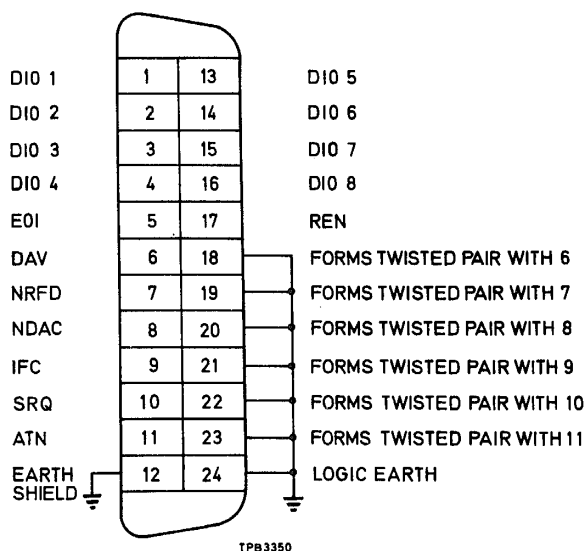
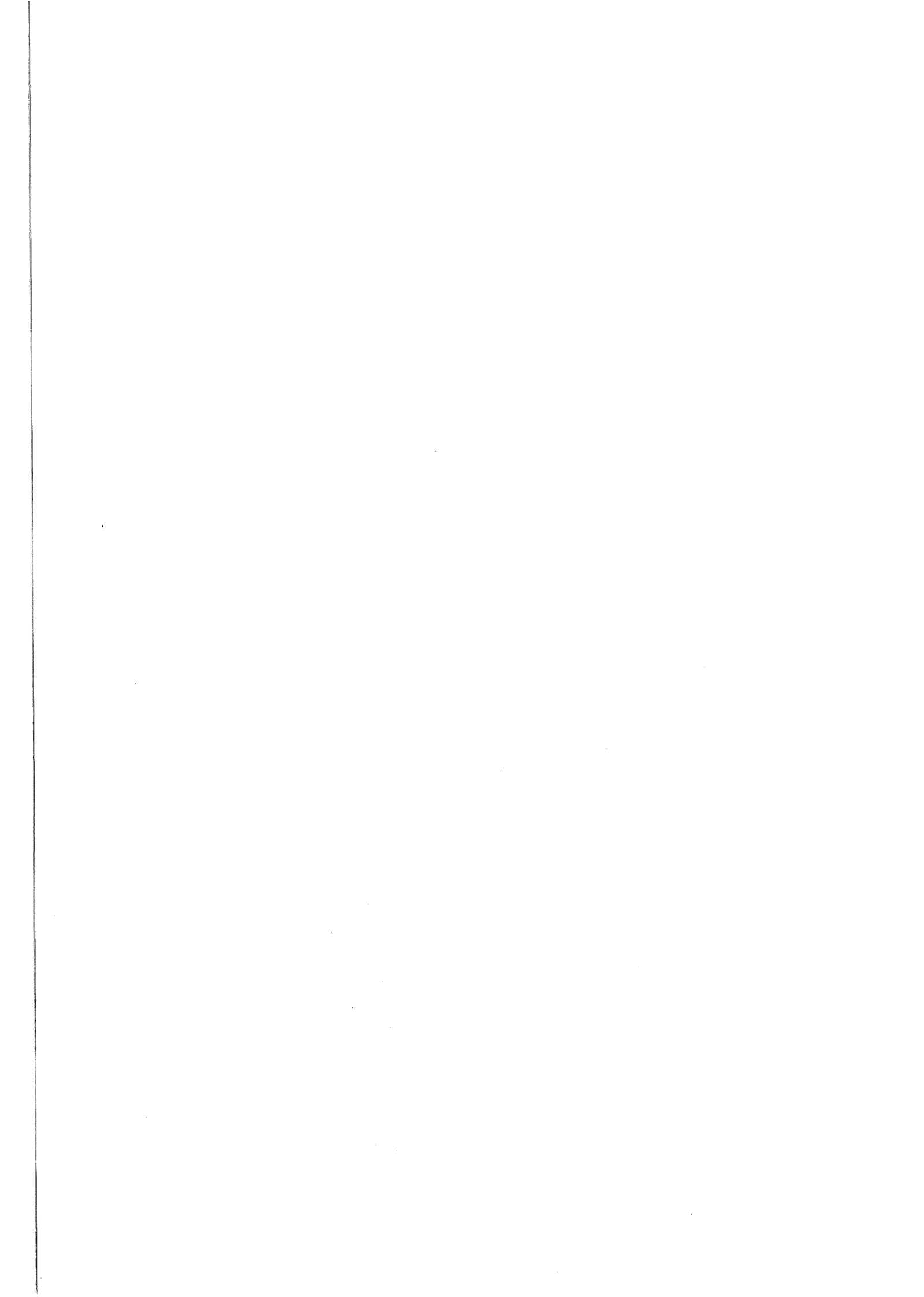


Fig. 8 GPIB connector contact assignment



Chapter 4-1

## BRIEF TECHNICAL DESCRIPTION

## CONTENTS

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2	Input and amplifier circuits								
5	RMS sensor and analogue to digital converter								
7	Microprocessor control								
9	Power supply								
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## INTRODUCTION

1. The following summary is an outline circuit description of 2610 and is intended to be read in conjunction with the block diagram Fig. 1. Detailed circuit descriptions and diagrams are given in Chap. 4-2 of the Service Manual.

## CIRCUIT SUMMARY

Input and amplifier circuits

2. The voltage to be measured is routed through the input and amplifier circuits according to the range selected at the keyboard or automatically under microprocessor control.
3. Routing of the input voltage in the range 0.2 mV to 700 V is as shown in Fig. 1. Protection against application of voltages in excess of the maximum permitted is provided by a diode network before the first amplifier.
4. Selection of attenuators and amplifiers is arranged such that the input to the r.m.s. sensor is not greater than 2.5 V.

RMS sensor and analogue to digital converter

5. The r.m.s. sensor measures voltage by comparing the heating effect of the applied voltage with that of a calibrated internal d.c. voltage. The d.c. voltage is varied by a control loop such that the temperatures are equal. The loop may be damped to extend the low frequency performance.
6. DC analogue output voltage from the sensor is fed to the analogue to digital converter whose output, via the microprocessor data bus, is displayed on the four digit l.c.d. display panel. Sensor output is also displayed on an auxiliary analogue meter and fed to an output terminal for use with a pen recorder.

Microprocessor control

7. An 8085A microprocessor based controller, allows convenient keyboard control, enables selection of switches to perform the required measurement function and control the automatic voltage ranging.

8. With the optional GPIB unit fitted the microprocessor controller also allows remote operation via the GPIB bus.

Power supply

9. +5 V and -5 V d.c. supplies are provided by transformer fed conventional full wave rectifier circuits each with series regulator stabilization. Further supplies of +20 V, +12 V and -20 V, -12 V are provided by two switching regulator circuits.

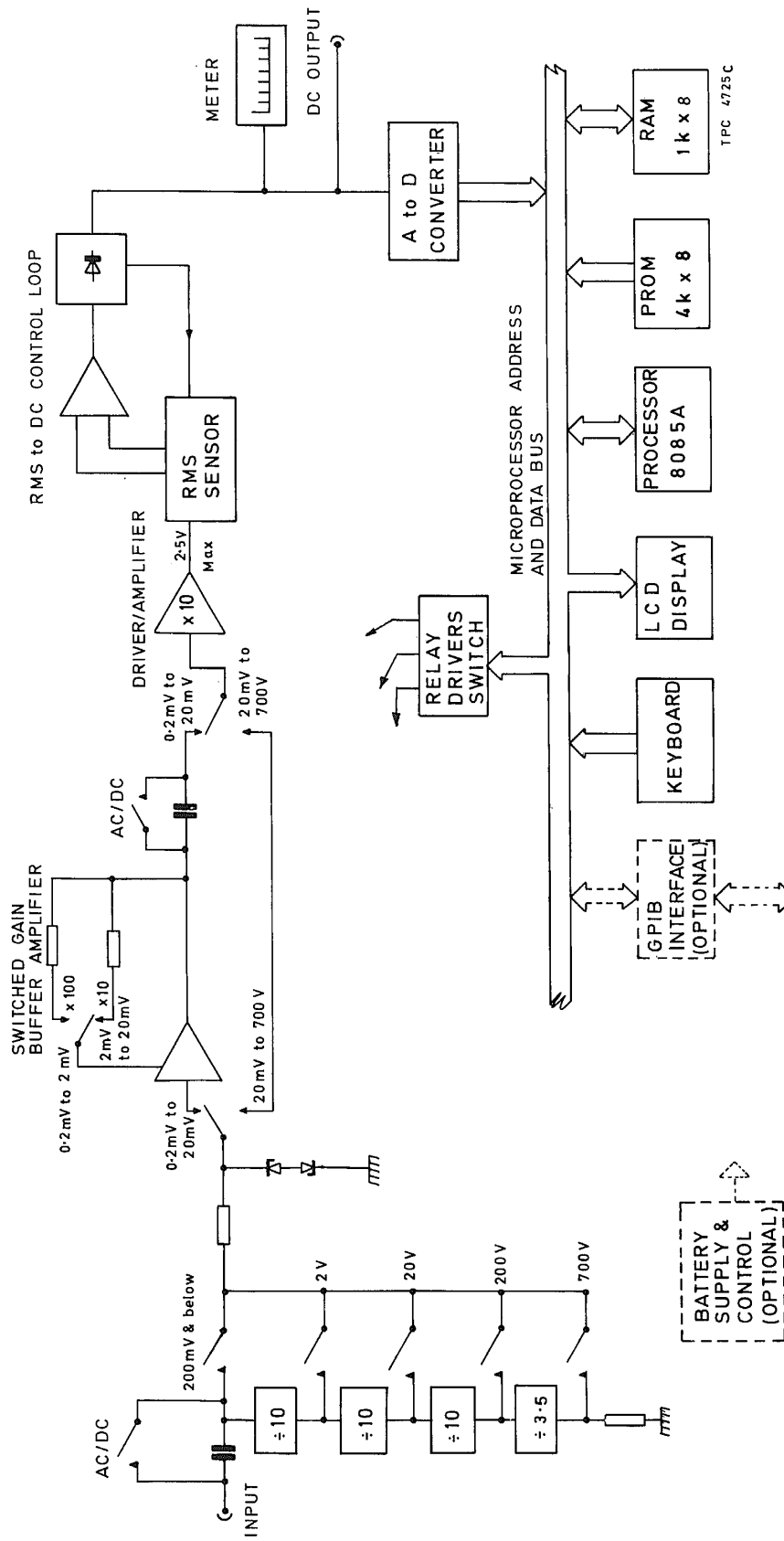


Fig. 1 2610 : simplified block diagram

