7061
SYSTEMS VOLTMETER
OPERATING MANUAL

Contents

Chapter 1
General Information

1   INTRODUCTION

The 7061 combines high speed digital electronics with microprocessor control to provide a fast, accurate systems voltmeter. With channel scanning, timer control and measurement processing, the 7061 is ideally suited to automated test requirements using the built-in IEEE 488 interface (GPIB) to give remote control.
The 7061 is equally at home as a bench instrument, with scanning, timing and processing facilities all controllable from the front panel. And, of course, straightforward voltage, current and resistance measurements are easily made with great reliability and accuracy.

Chapter 1 of the manual deals with details relevant to the installation of the voltmeter. Rack mounting is dealt with in Appendix D.

To make simple measurements, refer to Chapter 2, 'Getting Started'.

For more advanced measurements using processing facilities, but still under front panel control, refer to Chapter 3, 'Front Panel Controls'.

To use the 7061 as a remotely controlled instrument via the GPIB, refer to Chapter 5, 'Remote Control'.

For information on making measurements, see Chapter 4.

Chapter 6 contains the full specification and chapter 7 gives calibration information.

2   ACCESSORIES

Supplied:
2-terminal input lead
Power lead
Copper crocodile clip (2)
Rack mounting brackets (2)
Operating manual
2-terminal reference lead
Spare fuses
Calibration key

Optional:
High voltage probe   70757
2-terminal input lead   3187
3-terminal input lead   3193
5-terminal input lead   3183
Kelvin input lead (4-terminal ohms)   70758 E
Low thermal input lead kit   70758 D
2-terminal reference lead   70617 B
4-terminal reference lead   70617 D
Temperature probe, insertion PRT   70617 E
Telescopic rack slides (pair)   70759
Technical manual   70610011

3   THE CONFIGURATION SWITCH

The configuration switch is a dual in-line switch inside the instrument. Its settings are shown in Fig. 1.1, with the example showing 50 Hz line frequency and 8 channel operation selected.

(5) SPARE..................................

(4) SPARE..................................

(3) 16/8 CHANNEL.......................   16 channel

(2) SPARE..................................

(1) LINE FREQUENCY...................

(0) LINE FREQUENCY...................

(Leave these two switches as shown)

8 channel

(Leave as shown)

50 Hz   400 Hz   60 Hz   50 Hz
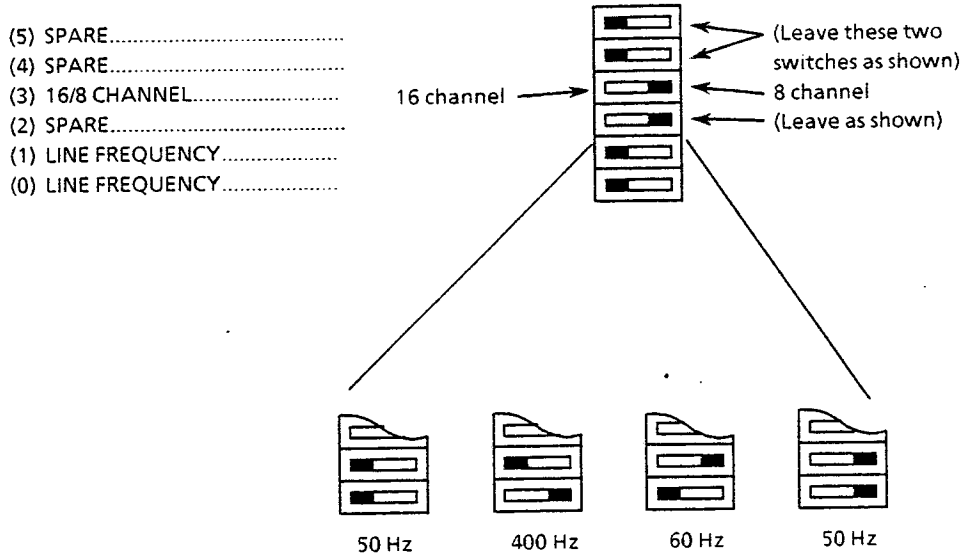
Fig. 1.1 *Configuration switch settings*

To reach the switch, disconnect the instrument from signal inputs and from the mains supply before removing the top panel. This is held in place by four screws. The switch is just behind the front panel, to the left of centre, as shown in Fig. 1.2. If the memory expansion board is fitted, this will have to be removed in order to reach the switch. It is held in place by three screws.

CONFIGURATION SWITCH

FRONT PANEL
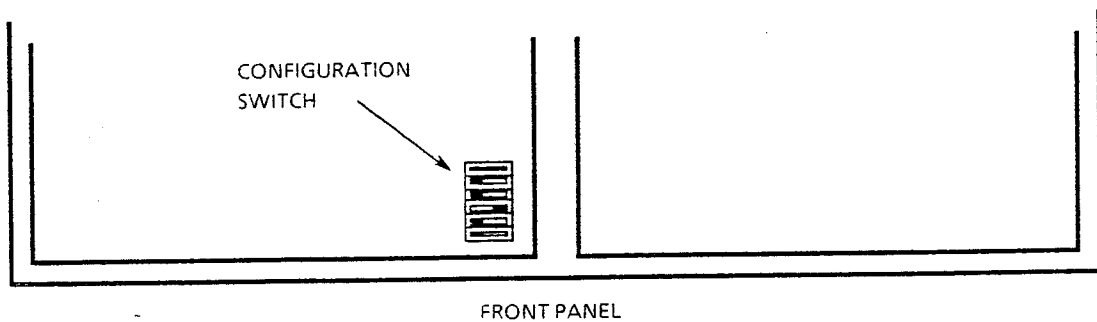
Fig. 1.2 *Plan view showing position of configuration switch*

4 OPTIONS

4.1 70612A SCANNER OPTION

The scanner option increases the number of physical input connectors on the instrument from 2 to 10 (plus current input). There are then 8, 4-pole or 16, 2-pole *extra* channels available, depending on the selection made using the configuration switch.

1) HI ohms source
2) LO
3) LO ohms source
4) HI
5) Not used
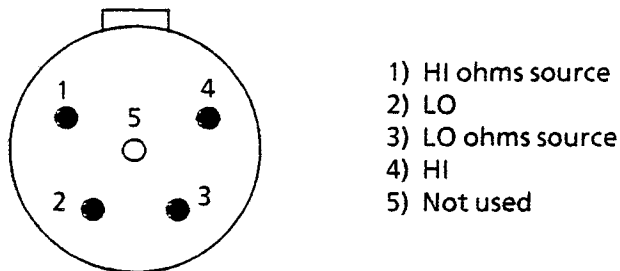
Fig. 1.3 *Rear panel view of connector socket, 8 channels selected*

1) HI (channels 10 → 17)
2) LO (channels 2 → 9)
3) LO (channels 10 → 17)
4) HI (channels 2 → 9)
5) Not used

Fig. 1.4 *Rear panel view of connector socket, 16 channels selected*

Input plug :

Switchcraft TA5FL
(Solartron no. 351505030)

More details are given in the sections on the CHANNEL and SCAN keys and the CHannel and SCan commands.

4.2 70613A MEMORY EXPANSION OPTION

The memory expansion option increases the measurement buffer from 1000 to 8000 memory locations.

5 SAFETY

The 7061 has been designed in accordance with the IEC publication 348 (Class 1), 'Safety Requirement for Electronic Measurement Apparatus', and has been supplied in a safe condition. This operating manual contains information and warnings which must be followed in order to ensure safe operation and to keep the equipment in a safe condition.
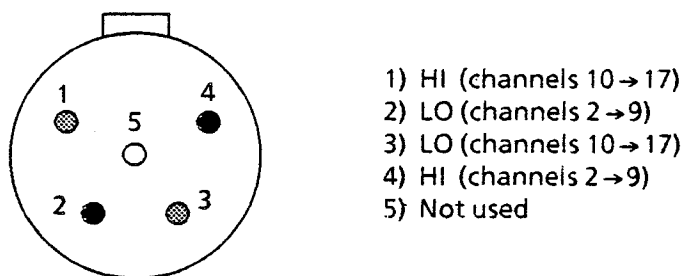
The operating instructions include safety precautions where appropriate, but the principal ones are also listed below.

5.1 GENERAL SAFETY PRECAUTIONS

1. Before switching on, ensure that the mains lead is connected to the ac supply in accordance with the colour code.
2. Ensure that the mains voltage selector is correctly set.
3. Ensure that the mains plug is connected only to a mains outlet which has a protective earth contact. This applies equally if an extension lead is used: the lead must contain an earth conductor.
4. For earthing, the mains plug must be inserted before connections are made to measuring and control circuits. The mains plug or external earth (as appropriate) must remain connected until all measuring and control circuits have been disconnected.
5. Any interruption of the earth connection (inside or outside the 7061) is prohibited.
6. When the 7061 is connected to its supply the opening of covers or removal of parts could expose live conductors. The 7061 should be disconnected from all voltage sources before it is opened for any adjustment, replacement, maintenance or repair. Adjustments, maintenance or repair of the 7061 when it is powered should not be attempted. Consult a Solartron Service Centre if repairs are necessary.
7. Ensure that fuses of the correct rating and of the specified type are fitted. Makeshift fuses, and short-circuiting of fuse holders, is prohibited.
8. Whenever it is likely that the safety of the 7061 has been impaired, it should be switched off and not used again until repaired. Safety could be impaired if the 7061:
   a. shows visible damage
   b. fails to perform intended measurements
   c. has been subjected to prolonged storage under unfavourable conditions
   d. has been subjected to severe transport stress.
9. The 'Δ' and '!' symbols on the 7061 mean 'Refer to Operating Manual' for detailed instructions or safety precautions.

5.2 EARTHING

For safety, an earth connection is essential whenever measurement and control circuits are connected, even if the 7061 is switched off. The instrument is earthed by connecting it to a mains outlet or other suitable earthing point. This earth should be capable of carrying 25A and conform to the regulation in 'British Standard Code of Practice CP1013 1965, Earthing'.

6   CONNECTING THE AC MAINS
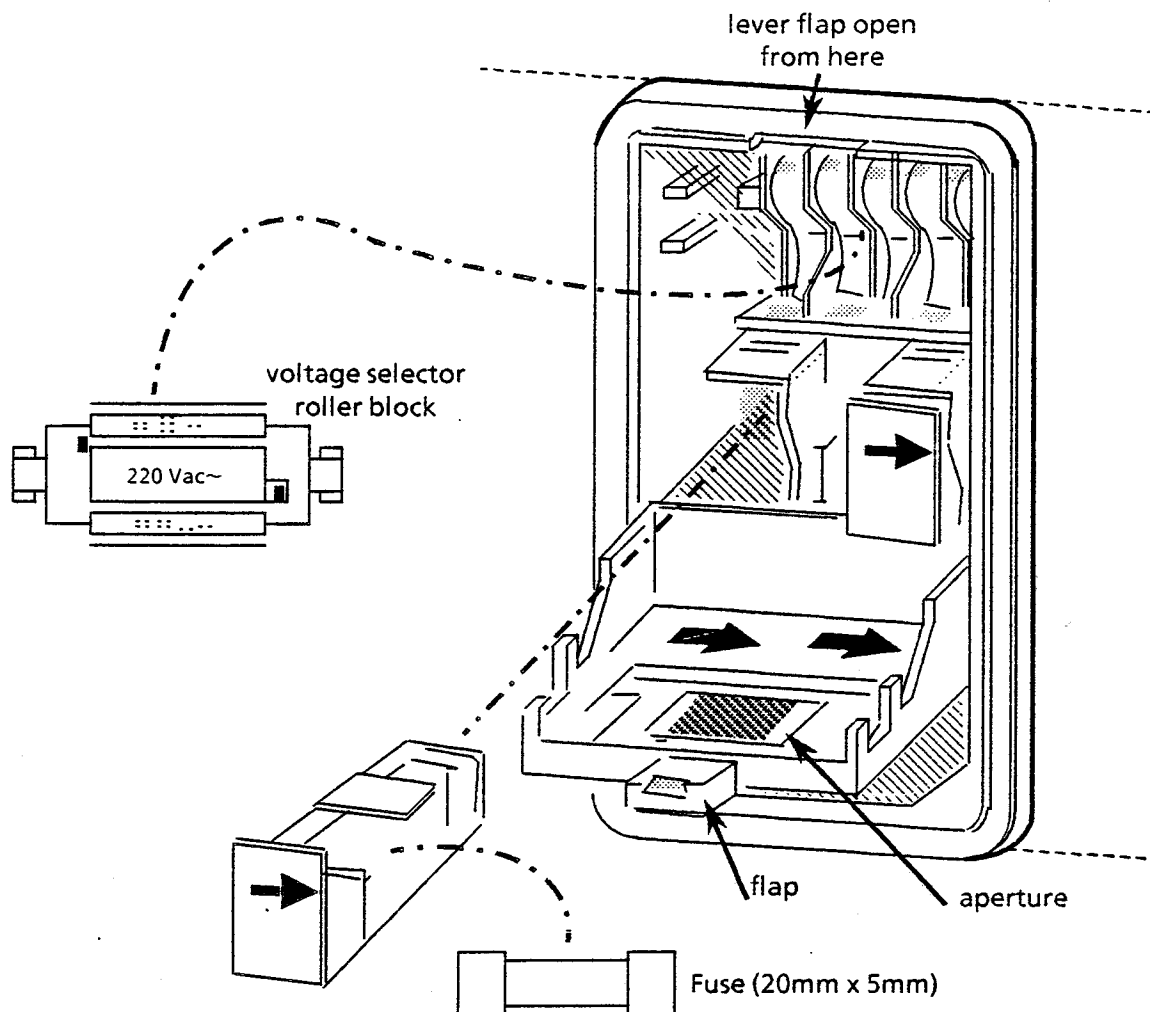
Fig. 1.5 *Mains input unit*

The 7061 is fitted with a mains unit (Fig.1.5) containing two mains fuses, and a voltage selector. These items cannot be accessed until the mains connector has been unplugged from the unit.

6.1   VOLTAGE SELECTOR

The following table gives the correct selector setting for different mains voltage ranges (nominal 50Hz or 60Hz):

Mains Voltage Variation Range	Voltage Selector Setting Required
90 - 110V	100V
108 - 132V	120V
198 - 242V	220V
216 - 264V	240V

In cases of doubt, set the voltage selector to the lower of the two possible values to ensure that all 7061 internal voltage levels are fully attained.

To change the selected voltage:

1.   Unplug the mains connector from the unit.

2.   Lever open the hinged flap with a screwdriver and lift out the voltage selector roller block.

3.   Refit the block with the chosen voltage value facing outwards.

4.   Close the flap securely, checking that the correct value shows through the aperture.

5.   Plug in the mains connector again.

6.2   MAINS FUSES

Live and Neutral are both fused in the 7061. Fig. 1.5 shows how these fuses are accessed, after the mains connector has been unplugged. The arrowheads marked on each fuseholder must align with those on the flap when the fuesholders are refitted.

The fuse values are:

        200 mA, SLO-BLO for 220V or 240V operation
        400 mA, SLO-BLO for 100V to 120V operation

Relacement fuses must be 20mm x 5mm cartridge type.

6.3   MAINS LEAD

An appropriate ac mains connector lead, complete with a mating socket for the IEC plug on the 7061 mains input unit, is supplied according to the destination country.

This lead should be connected to the ac supply according to the following colour code:

BROWN	=	LIVE
BLUE	=	NEUTRAL
GREEN/YELLOW	=	EARTH

An IEC socket and lead other than the one supplied may be used, but it must be correctly wired as shown in Fig 1.6.
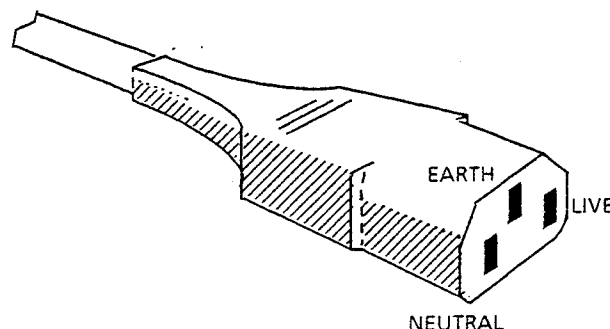
Fig. 1.6 *IEC power socket connections*

6.4   **CONNECTION PROCEDURE**

1.   Before connecting the supply, ensure that the mains voltage selector on the rear panel is correctly set, and that the correct fuses are fitted in the mains input unit. If necessary, the mains power frequency selection can be checked by looking at the configuration switch (see para. 3).

2.   Ensure that the power on/off switch on the rear panel, next to the mains input unit, is 'off'.

3.   Connect the mains lead.

4.   Switch the 7061 'on' at the rear panel.

Chapter 2
Getting Started

GETTING STARTED

At first sight, the front panel may appear to be rather complex, but to make simple measurements of voltage, current and resistance, only a few of the keys are required. These are some of the keys to the right of the display and the two orange keys near the bottom left hand corner of the display.

```
7061 SYSTEMS VOLTMETER
```
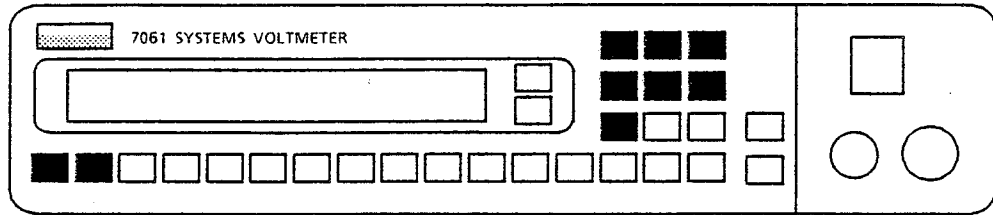
After plugging in to the mains supply, connect a two-terminal test lead to the input socket and switch on the machine (rear panel mains switch).

DC VOLTAGE

To measure dc voltage, connect the test leads to the voltage source and make the following sequence of key pushes, using the keys shaded black on the diagram :

```
7061 SYSTEMS VOLTMETER

1.234567  VDC
```

V → – . – → AUTO RANGE → TRACK

Press if AUTORANGE   Press if TRACK
LED not lit.   LED not lit.
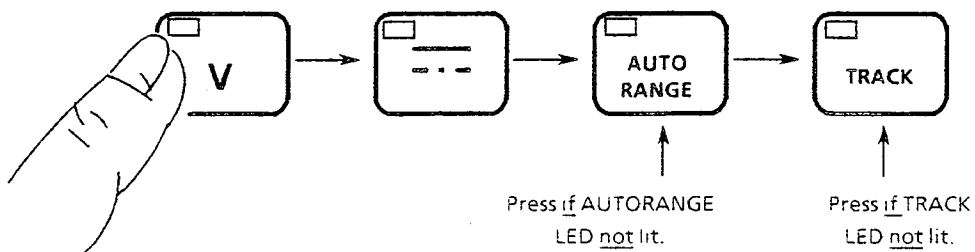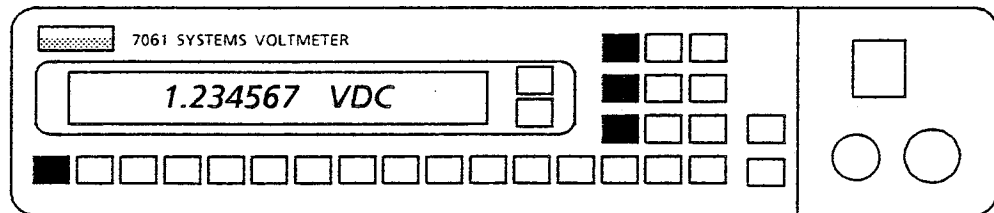
AC VOLTAGE

To measure ac voltage, the keys used and the sequence of key pushes are as follows :
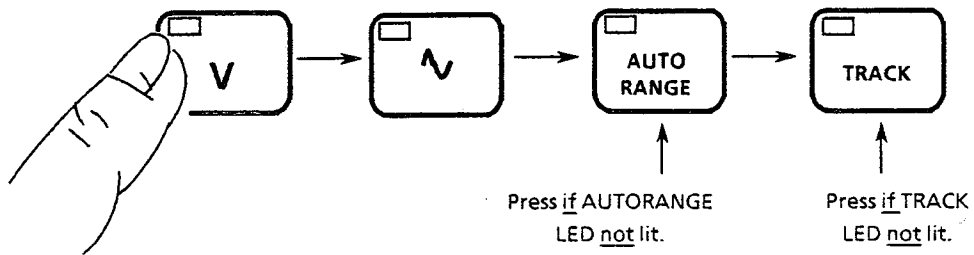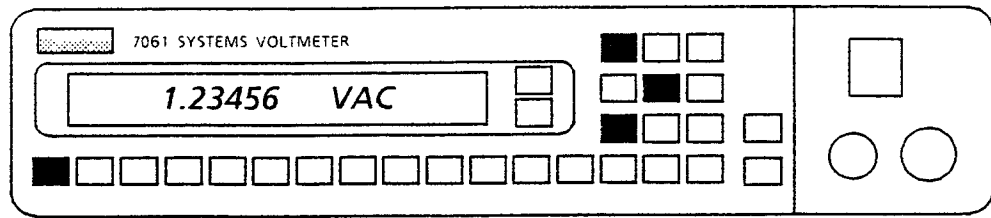
Notice that in both of the above measurements, AUTORANGE and TRACK were used.

Using AUTORANGE means that there is no need to worry about selecting the correct range to match the level of the input signal - this is done automatically.

TRACK gives a continuous sequence of readings, so the display is continually being updated.

To get a single measurement, press TRIG instead of TRACK and the single reading remains in the display until another one is made.

DC CURRENT

To make a single reading of dc current, connect the current source to the two 4mm input sockets on the rear panel and make the following key pushes :
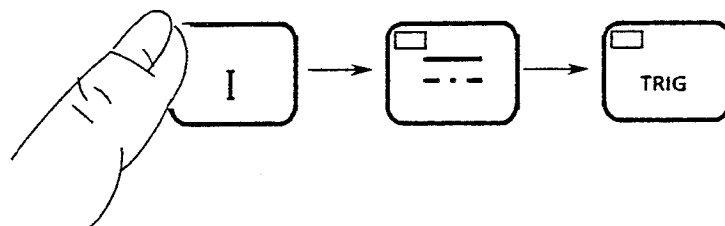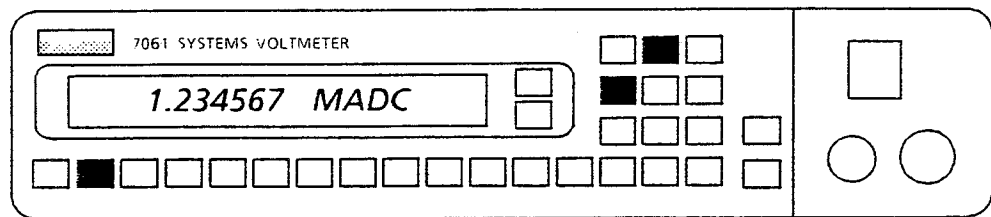
RESISTANCE

Measuring resistance is just as easy. Connect the two terminal test lead across the unknown resistance then :
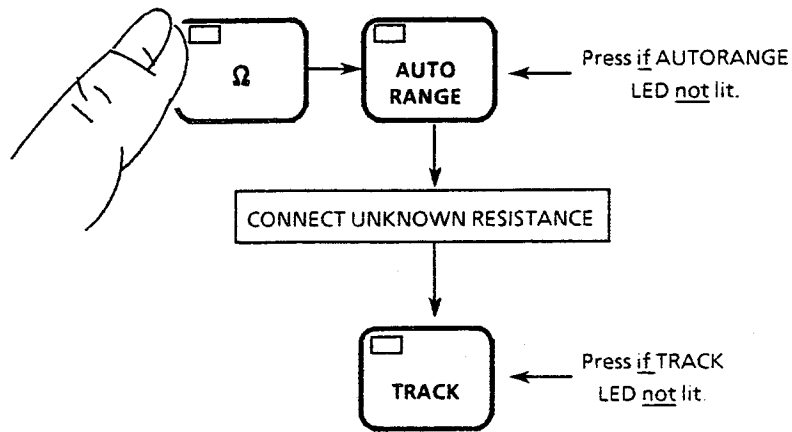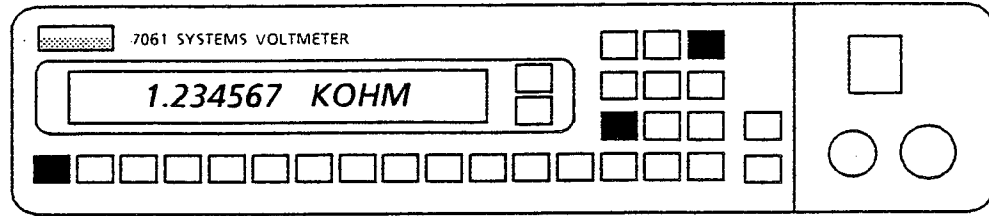
The more straightforward measurements have now been described, but note that there is a key labelled 'True Ω'. This may be used instead of Ω when thermally induced voltages and currents could be a problem, for example, when measuring low resistances in relay circuits.

There are other keys, 'NULL' and 'FILTER', which also allow more accurate measurements under certain circumstances. See the chapter on 'Front Panel Controls' for details of their use. The same chapter describes the functions of all the remaining keys. Use of these allows great flexibility of measurement and processing of results.

Some of the front panel keys call up menus. In other words, on pressing the key, a choice of functions is given. Menu keys are shown shaded in the following diagram:
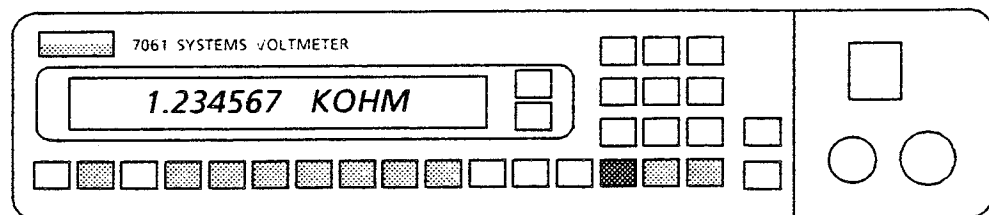
As an example, the darker shaded key, the RATIO key, allows the multiplication or division of the measured value from any channel by the value from any other channel.

RATIO

A possible application for RATIO is the direct measurement of power, for example, dc power:

Connect the current source to the 4mm rear panel input sockets (channel 0 current input). Connect the reference lead (channel 1) so as to measure voltage across the relevant component. Then.....

Select channel 0 :
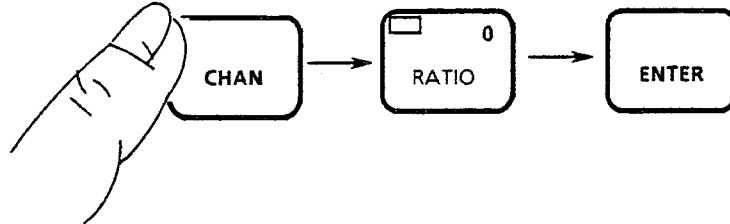
Set up channel 0 to read dc current :
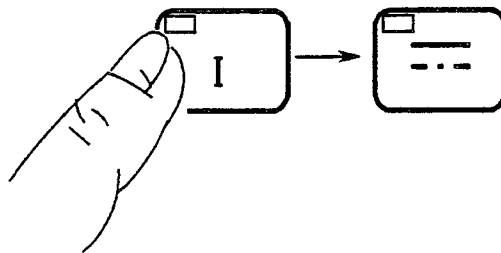
Select ratio channel 1 :
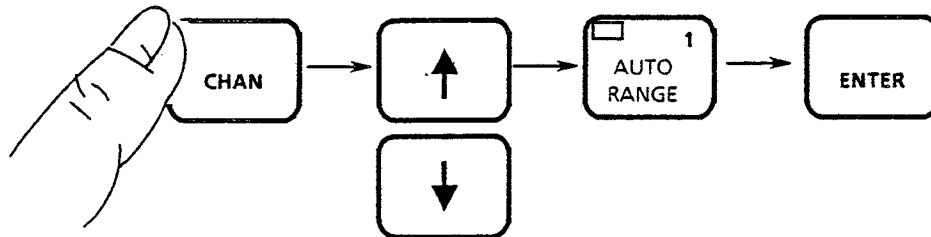
Press either skip key
until **'RATIO CHAN = --'** shows
in the display.

Set channel 1 to read dc voltage, autorange :

Press if AUTORANGE
LED not lit.
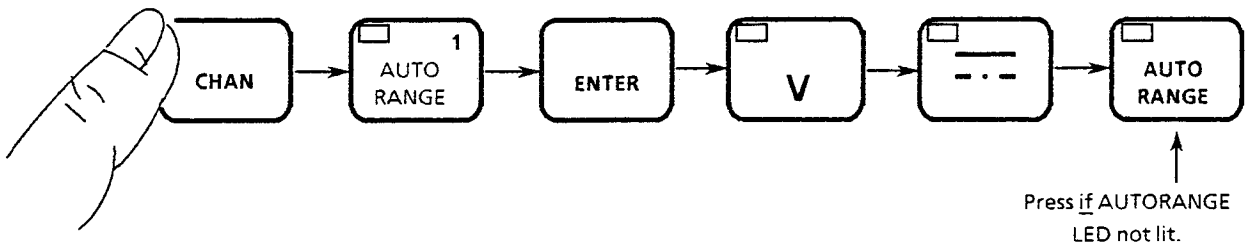
Go back to channel 0:
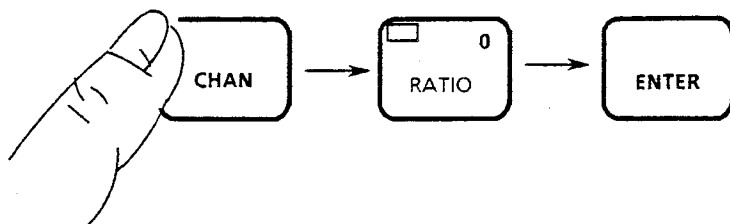
Now set the ratio function to give the product of channel 0 with channel 1 :
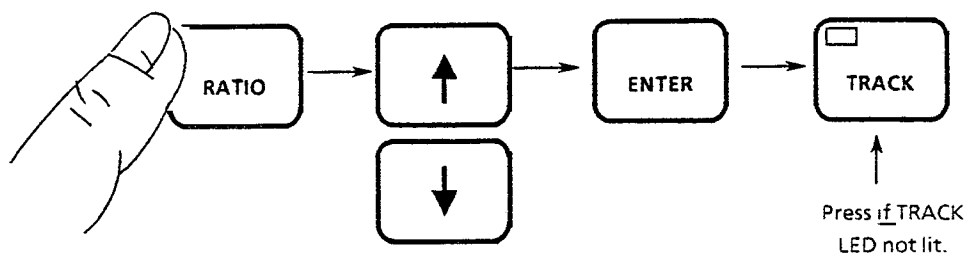
Press either skip key until
'**PRODUCT**' shows in the display.

(Note that the vertical arrows to the right of the display mean that 'SKIP' (↑ ↓) then 'ENTER' are the next keys to be pressed.)

The display now shows the product of the two channels - in this case, a direct reading of power. The **'PRD'** in the display indicates a product reading.
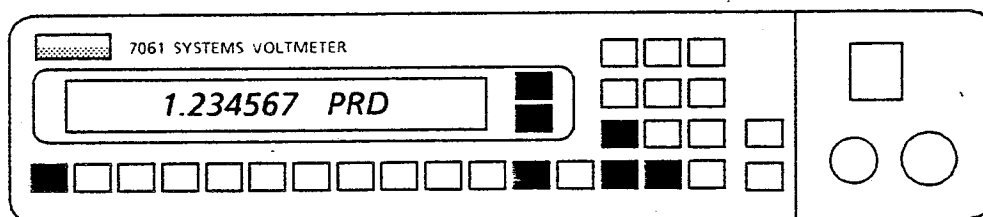
SCANNING

The usefulness of the instrument is increased by its ability to measure more than one channel on receipt of a trigger. This is achieved using the scan key. Details are described later in the manual, but a simple scan sequence using channels 0 and 1 is shown here.

First initialise the instrument, then turn track off :
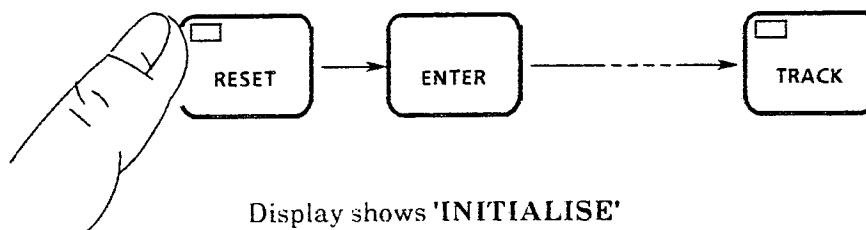
Display shows '**INITIALISE**'
then '**SELF TEST PASSED**'
then '**7061 INITIALISED**'

Ensure that the GPIB is set to OUTPUT OFF using the following key sequence :

MENU → RESET → ↑ ↓ → ENTER

Press either skip key
until **'GPIB'** shows in
the display.

Then :

↑ ↓ → ENTER → ENTER

Press either skip key
until **'OUTPUT OFF'** shows
in the display.
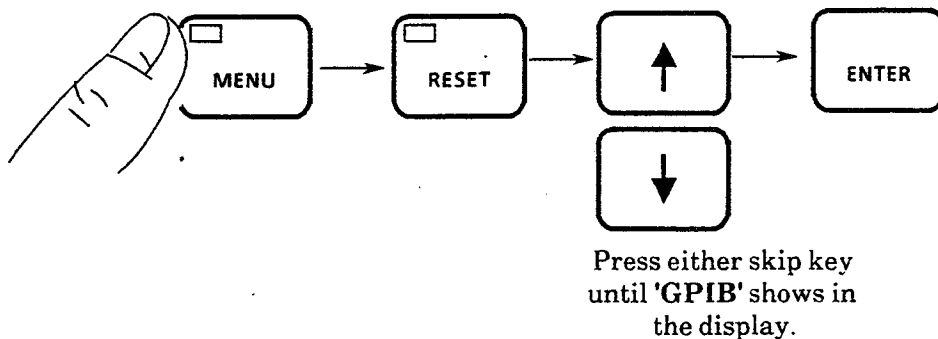
The last part of the menu
is irrelevant to front panel operation
- simply press ENTER again
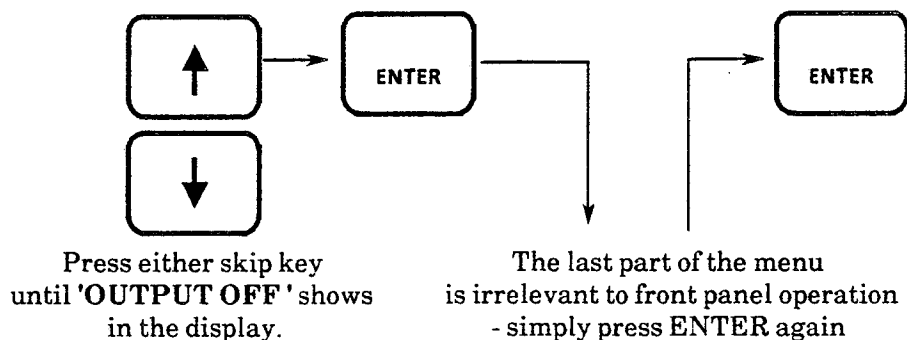
Suppose we want to measure ohms both on the main input (channel 0), and on the reference input (channel 1).

Set up channel 0 to read ohms :

Ω
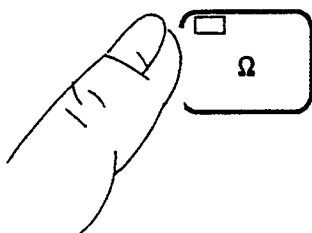
Select channel 1 and set it to read ohms :

CHAN → AUTO RANGE 1 → ENTER → Ω
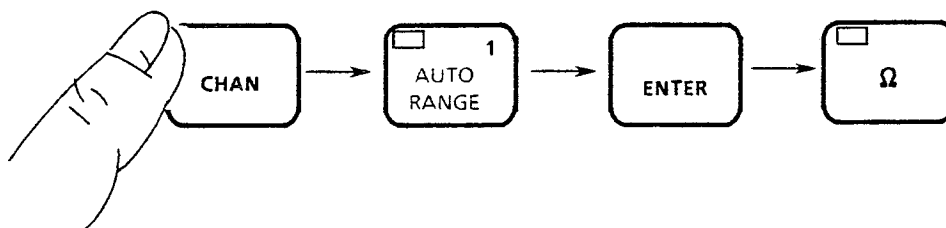
Set up the scan sequence from channel 0 to channel 1 :

MENU → SCAN → ENTER

The display now reads
'SCAN SEQUENCE'
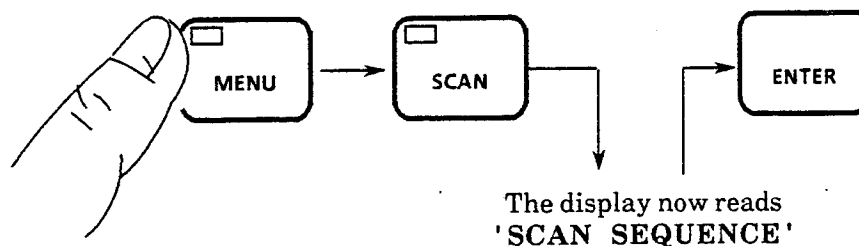
The display now reads ' CHANNEL = 0 '. This is the default setting, which in this case is wanted.

'ENTER' the default setting, then put channel 1 into the scan sequence :

ENTER → AUTO RANGE 1 → ENTER → ENTER

The display now reads
' CHANNEL = END '

The display now reads
' CHANNEL = END '
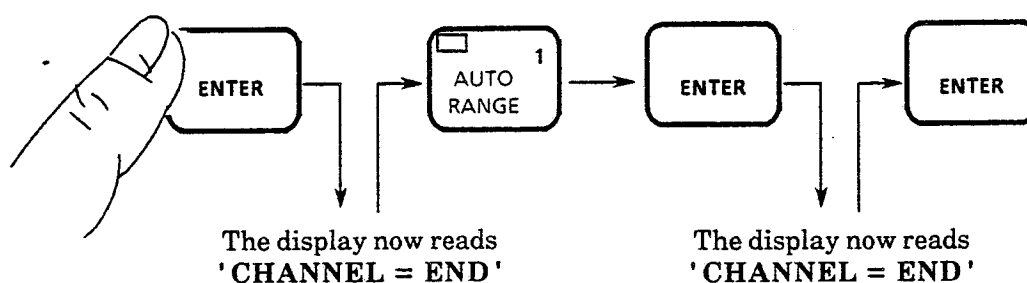
The scan sequence has now been set up, and it starts each time a trigger is sent or runs continuously when TRACK is on. The display shows first the reading from channel 0, then the reading from channel 1.

TRIG OR TRACK
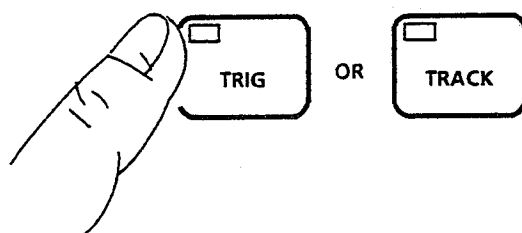
Before preceding to the next example, turn off the scan sequence by pressing SCAN:

SCAN
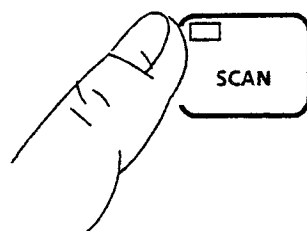
PROGRAMS
The 7061 contains seven programs for processing data. They are described in detail in chapter 3 (Front panel controls) and chapter 5 (Remote control). For example, the OFFSET program adds a pre-defined constant to the measured value. For instance, add 10 to each measurement :

Select the OFFSET program:
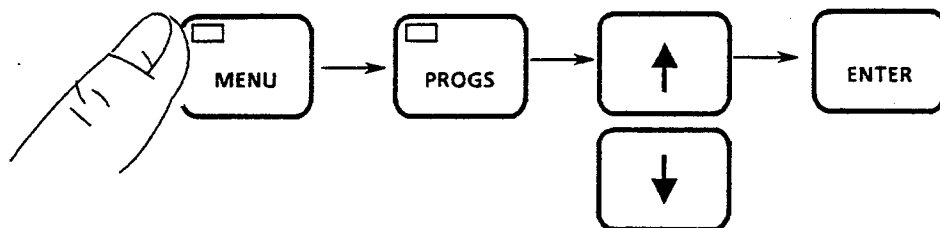
Press either skip key
until **'SELECT'** shows in
the display.

[Note: The skip keys will appear when programs have been selected previously.]

Then:
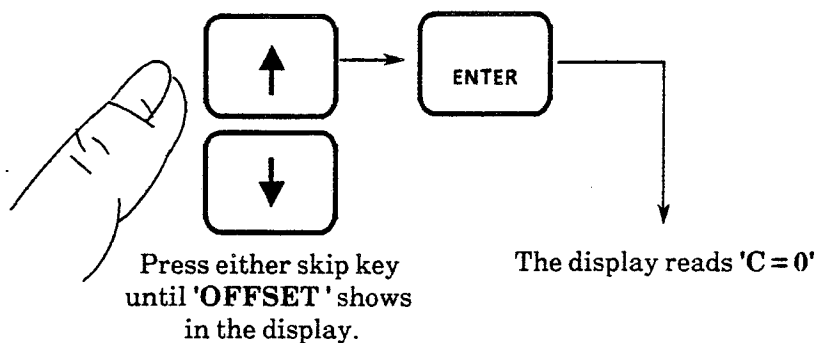
Press either skip key
until **'OFFSET '** shows
in the display.

The display reads **'C = 0'**

Set the offset constant to 10:
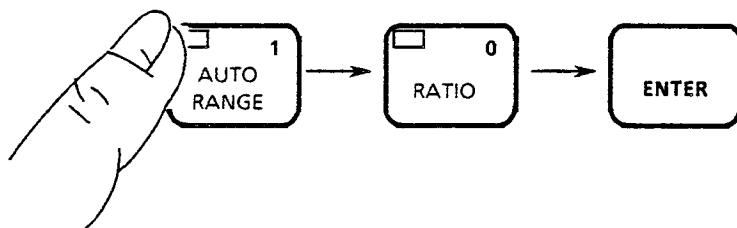
The display briefly reads **'READY'** and then **'SELECT'**. This allows the option of selecting more programs. If no further programs are required, simply **press the MENU key:**
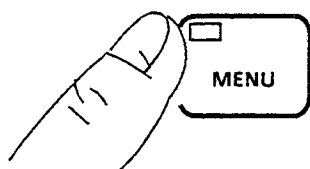
The program is now 'on' so that any readings made
have the value 10 added to them. (To turn programs
off, press the PROGS key, and the LED goes out.)

PREPARATION FOR REMOTE CONTROL

Many of the simpler front panel measurements have now been described. Another important function of the front panel controls is to set up the GPIB output to prepare the instrument for remote control. For example, to set the output 'on' and the GPIB address to '12', use the following key sequence :

MENU → RESET → ↑ ↓ → ENTER
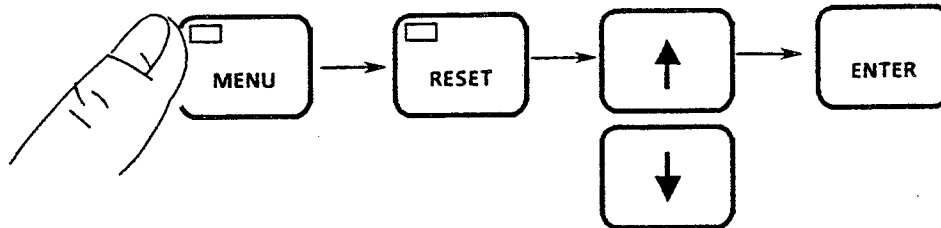
Press either skip key
until 'GPIB' shows in
the display.

Set GPIB output to 'on'

↑ ↓ → ENTER
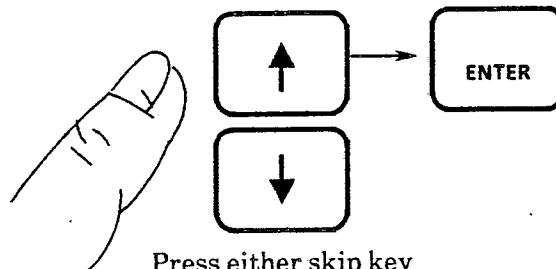
Press either skip key
until 'OUTPUT ON ' shows
in the display.

Set GPIB address to 12 (for example)

↑ ↓ → AUTO RANGE 1 → FILTER 2 → ENTER
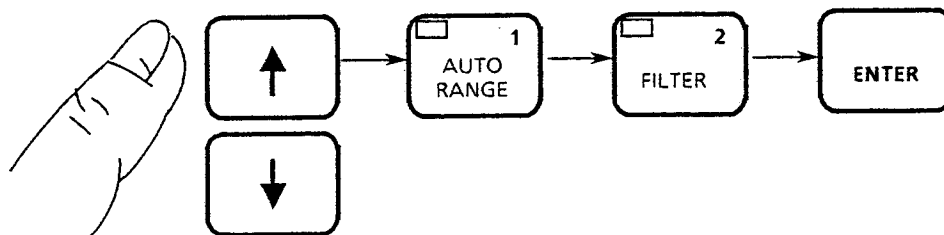
Press either skip key
until 'ADDRESS = -- ' shows
in the display.

The instrument is now ready for remote control. See chapter 5 for details.

Chapter 3
Front Panel Controls

Alphabetical list of keys   *Page*

1   INTRODUCTION

This chapter describes the functions of the front panel keys in some detail. Some keys call up menus to give choices in the use of functions. To make straightforward measurements of voltage, current and resistance, much of this information is not needed. Chapter 2 provides a simple introduction to such measurements.

When an LED in a key is lit, it indicates that the associated function is operating. When an LED is flashing, it indicates that the associated menu has been called up.

The instrument may be 'Initialised' either to clear existing settings or to get out of any problem, or uncertain condition.   The instrument then has the settings shown in Appendix A. **Initialise by pressing the RESET key then the ENTER key.**

1.1   MENUS

Menu items are shown on the display and read through with the aid of the skip (↑ or ↓) keys. Then selected items are implemented using 'ENTER'. When numbers have to be entered in menus, the second level numeric keypad is used.

In the descriptions of keys which invoke menus, diagrams are used. Dotted boxes show information that can be displayed. Solid boxes and arrows show examples of typical routes through the menus. The sequences of key-pushes are numbered. Fig. 3.1 shows the delay key as a simple example of a menu.

When all the selections for a menu function have been done, and the final ENTER key-push has been made, the MENU LED goes out but the function LED stays on, indicating that the function is now operative.

The setting up of a menu function can be abandoned at any time by pressing either the MENU or the function key. Anything keyed in since the previous pressing of the ENTER key is then ignored.
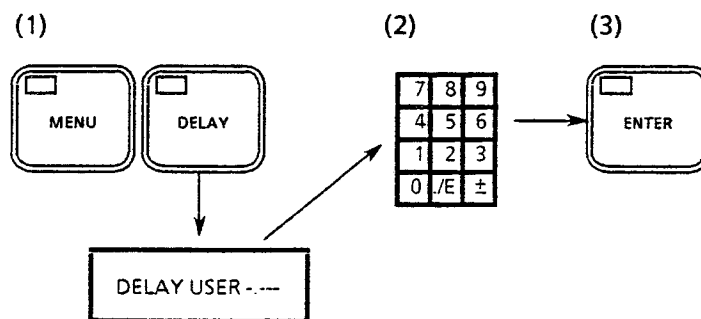
Fig. 3.1 *Example menu*

1.2   MEASUREMENT HANDLING

The 7061 can measure voltage, current and resistance as well as 'True ohms', the latter being a resistance measurement which compensates for thermally induced voltages. The power of the instrument is greatly enhanced by the use of signal processing using data storage, probe processing and programs. Extra input channels may be added by fitting the scanner option (70612) or more complex processing may be achieved by using 'virtual' channels. These are described in the sections on the CHANNEL key and the CHannel command.

Figures 3.2 and 3.3 are block diagrams showing possible paths of a measured value through the instrument. 'History File access' is the output, or processing *then* output, of results stored in the measurement buffer. This is done remotely using the DUmp command or from the front panel using the History key.

Probe and program processing may be switched in or out of any channel and the kind of processing may be set up independently for each channel or virtual channel.

Input → Analogue to digital converter → Measure-ment buffer → Output switch → Display / GPIB

Probe and program processing OFF

Input → Analogue to digital converter → Processing → Measure-ment buffer → Output switch → Display / GPIB

Probe and/or program processing ON

Fig.3.2 *MEASUREMENT*

Measure-ment buffer → Output switch → Display / GPIB

Post-processing disabled or
Post-processing enabled and Probe and Program processing OFF.

Measure-ment buffer → Processing → Output switch → Display / GPIB

Post-processing enabled and Probe and/or Program processing ON
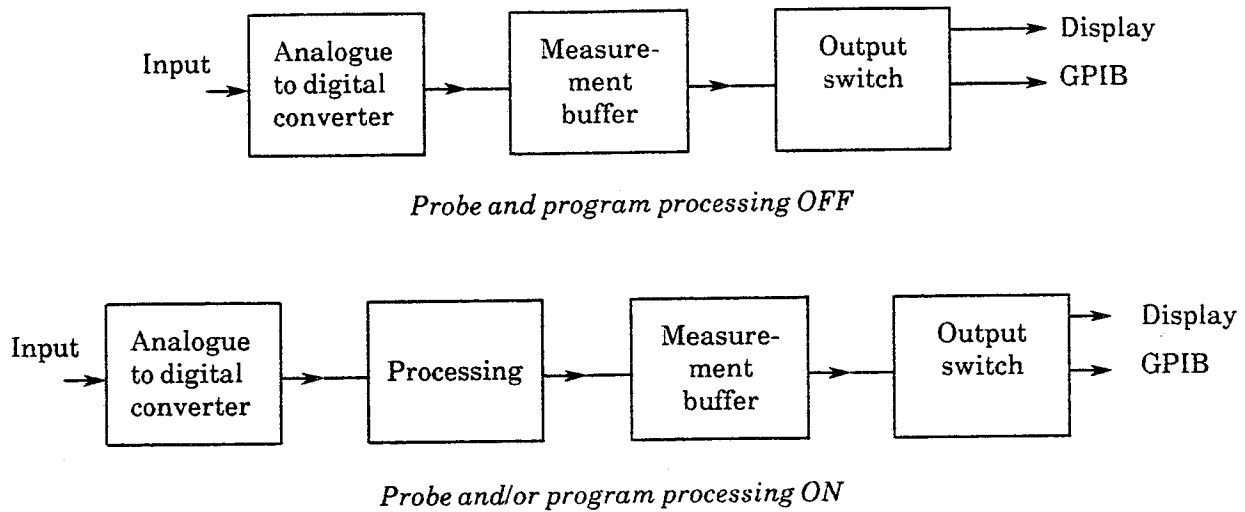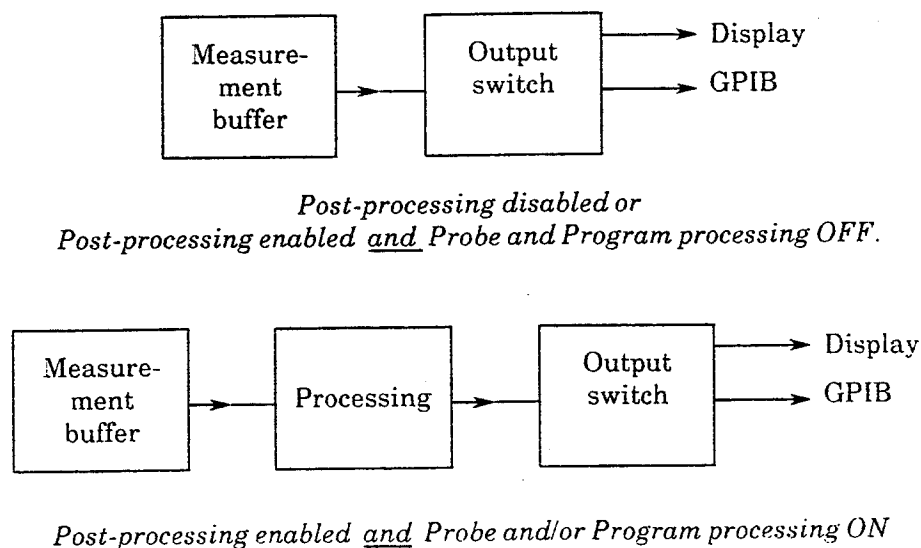
Fig.3.3 *HISTORY FILE ACCESS*

Caution for History File accessing:
If the original measurement was made with programs on, the memory buffer contains *processed* results. History file accessing with programs on would then give *twice-processed* results.
(Probe processing can only be done *either* during measurement *or* during History File accessing. The instrument prevents double probe processing.)

An advantage of post-processing is that measurements may be taken at the fastest possible rate, then processed later using History file accessing. This allows the combination of rapid measurement with data processing.

1.3   OVERLOAD INDICATION

If an input is applied to the instrument and it is too high for the selected range, the display flashes on and off as a warning. Appendix C shows the levels at which this occurs.

The high input resistance (see specification) is maintained even during overload on the 0.1, 1, and 10 volt ranges.

2 FRONT-REAR SWITCHING

Input terminals are provided on both front and rear panels except for current measurement which is done from the rear panel only. This allows for both rack mounted or free standing use. Front or rear inputs may be selected by the front panel switch.

INPUT :-

▮ FRONT Push button out: front inputs selected.

▟ REAR Push button in: rear inputs selected.
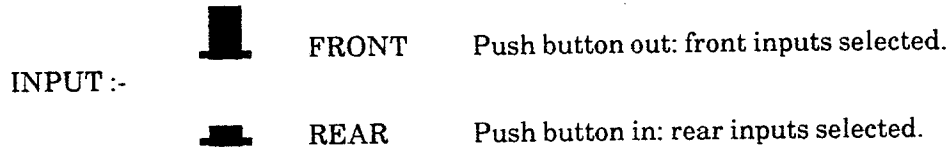
Selection between front and rear inputs cannot be done by remote control. A remote controller can interrogate the instrument (using the OPtion command) to determine which inputs are selected.
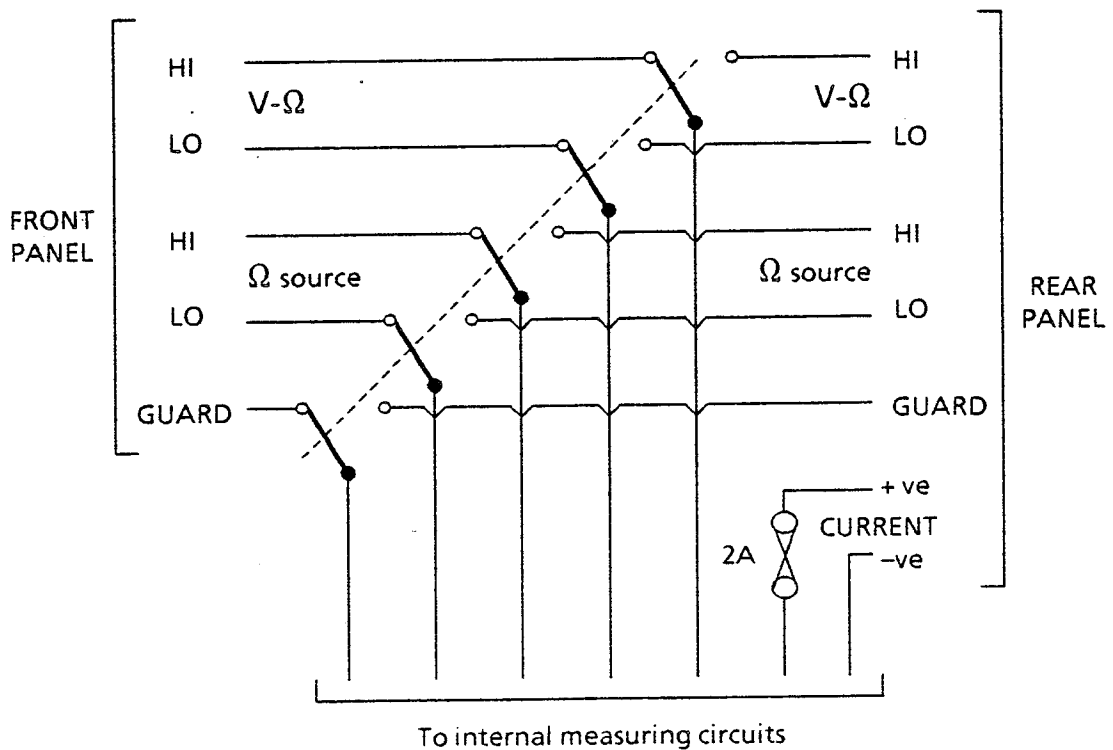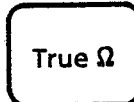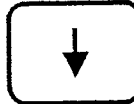
Fig 3.4 *Switching of front-rear inputs*

3   MEASUREMENT KEYS

V	---	Voltage, dc, 0.1V to 1000V in 5 ranges.

V ∿   Voltage, ac, 0.1V to 1000V in 5 ranges.

I ---   Current, dc, 1A in 1 range. (Rear panel only)

I ∿   Current, ac, 1A in 1 range. (Rear panel only)

Ω   Resistance, 0.1Ω to 1000kΩ and 10MΩ, in 6 ranges. (10MΩ range does 2-terminal measurement only. See chapter 4 for further measurement information.)

True Ω   Resistance, 0.1Ω to 1000kΩ in 5 ranges. *

*Note, True ohm measurements are used to compensate for thermally induced voltages other than those produced by the measurement current, (which are removable by nulling). The instrument measures resistance with its source current off then on. Subtraction then removes contributions from thermal voltages and external currents. Settling times are 2-3 times greater than for ohms.

4   RANGE KEYS

AUTO RANGE   Selects or de-selects auto-ranging of the chosen measurement function. De-selection leaves the instrument fixed in the existing range.

↑   Selects less sensitive fixed range.

↓   Selects more sensitive fixed range.

The 'up' and 'down' skip keys also de-select autorange. (When menus are in use, the skip keys are used to read through menu lists.)

5 FILTER KEY

FILTER

Selects or de-selects filtering.
For ac measurements, FILTER improves low frequency response and hence accuracy. Use FILTER for all ac measurements of 400 Hz or below.
For dc measurements, FILTER improves noise rejection by increasing measurement integration times fourfold.
The use of the filter increases both ac and dc measurement integration and settling times.

6 NULL KEY

NULL

Null compensates for small dc offsets (max. 2% of Vdc, 1% of Idc, Ohms and TrueOhms ranges) at the point of measurement. Null is not applicable on V_{ac} and I_{ac} ranges.
NULL on AUTORANGE nulls all ranges. The same command on a fixed range nulls that range only.
To null volts and ohms, short input leads; to null current, open circuit input leads. Then press NULL. The voltmeter meaures the offset ('NULLING') and stores the result ('NULL COMPLETE'). The stored offset is then subtracted automatically from all subsequent dc measurement values in that mode and range.
Channels 0 and 1 can hold null values for all nullable modes and ranges.
Channels 2 to 9 or 2 to 17 can hold nulls for one mode only, e.g. for all the ranges of the Vdc mode.
When null is operating, pressing NULL switches null off for all modes and ranges. These settings can then only be recovered via the interface 'NUll - ON' command.
Null may be retained after switching-off, depending on the setting of RESUME which is done via MENU RESET.

7 RATIO KEY

RATIO

Selects (or de-selects) either division or multiplication of the presently selected channel by the value from the ratio channel, as selected under the CHANNEL key menu :
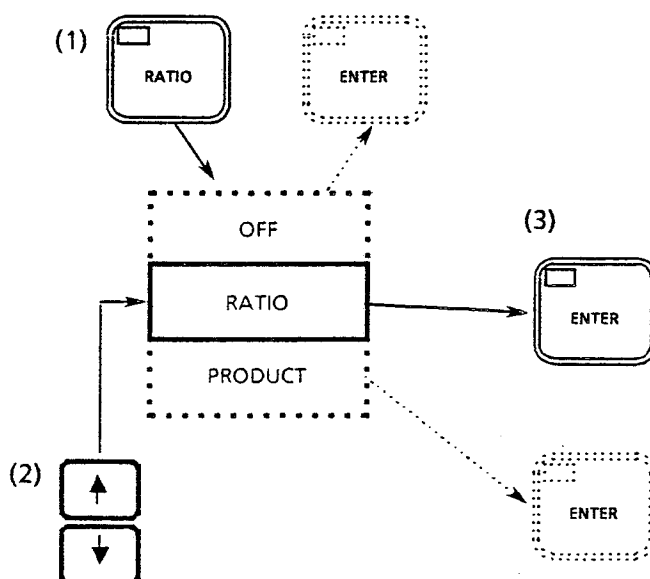
8   CHANNEL KEY

CHANNEL   Gives a two-option menu to select both the channel through which readings are to be made, and the channel to be used for ratio measurements.
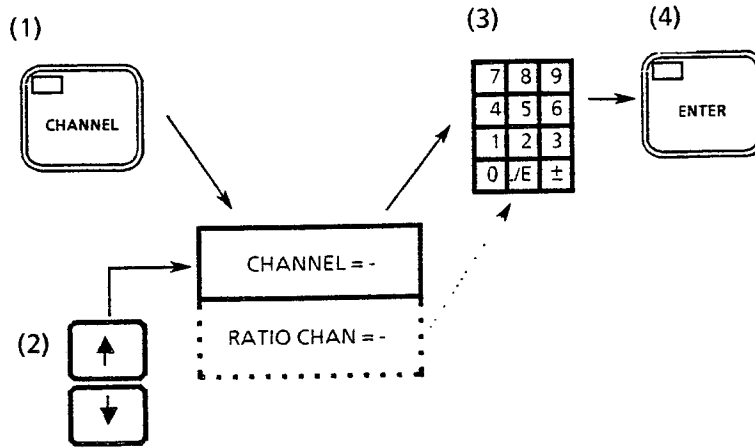
Channel 0 is the normal input; channel 1 is the reference input (rear panel connector).

Channel numbers may be 0-9 or 0-17 depending on the setting of the configuration switch (See chapter 1). Alternatives are shown in the tables below. The selected channel number is shown on the right hand end of the display (except channel 0:-blank).

To de-select the channel function, press the channel key. The LED then goes out.

'Virtual' channels are available when the scanner option is not fitted. Signals then pass along the same physical route as for channel 0, but may be processed in different ways. Processing for virtual channels is set up in the same manner as for 'normal' channels. Virtual channels may be scanned in the same way as normal channels (see SCAN key description).

The position of the configuration switch is read by the instrument on power-up only.

Without scanner option:

		Selected Channel		
		0,1	2→9	10→17
Configuration switch setting	8	five-pole	virtual	✕
	16	five-pole	virtual	virtual

With scanner option:

		Selected Channel		
		0,1	2→9	10→17
Configuration switch setting	8	five-pole	four-pole	✕
	16	five-pole	two-pole	two-pole

9   DIGITS KEY

DIGITS Gives a two-option menu whereby either the number of digits displayed (i.e. significant figures plus leading digit of 0 or 1 or 2) or the measurement integration time may be specified. Thus the resolution or accuracy respectively of a measurement may be chosen.
The higher the number of digits specified, the longer is the integration time and of course the shorter the integration time chosen, the lower the precision of the reading.

(1)   (3)   (4)

(Default settings)

ITIME	DIGITS
2.0s ≤ ITime	7
0.2s ≤ ITime ≤ 1.9s	6
ITime = 0.1s	5
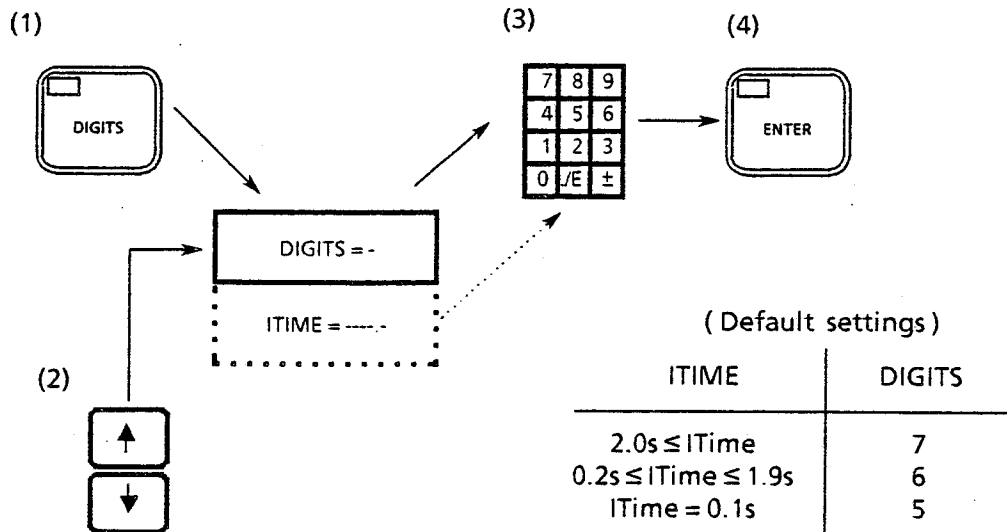
When ITIME is selected, the number of digits displayed is still determined by the DIGITS selection. If, however, the setting of DIGITS is greater than is valid for the selected ITIME, then the setting is overruled (but not altered). If the setting of DIGITS is less than is valid, then only the number of digits set is displayed.
The number of digits may be 4, 5, 6 or 7 and integration times may be from 0000.1s to 9999.9s.

To de-select DIGITS or ITIME, press the DIGITS key. The LED then goes out.

10   TRACK AND TRIGGER KEYS

The voltmeter can either measure continuously or make one or more measurements at precisely defined times. Two keys, TRACK and TRIGGER, offer the choice.

10.1   TRACK KEY

TRACK TRACK is an on/off key. When in TRACK, the voltmeter self-triggers and thereby measures the input signal continuously, at an input rate dependent on the measurement time and the pre-measurement DELAY. The measurement time depends on:

1)   The integration time (selected in accordance with the number of DIGITS or the user-defined ITIME).
2)   FILTER selection, on or off.

See specification for details of measurement times.

10.2   TRIGGER KEY

TRIGGER — Starts measurements according to the conditions set up using MENU TRIGGER. It is a 'single-shot' key whose LED remains lit until the trigger is complete. See specification for details of measurement times.

MENU **TRIGGER** — The trigger menu offers a choice of SAMPLE, CAPTURE, GATED, or BURST measurements. These measurements start on receipt of a trigger signal, which can come from:

1) The TRIGGER key (MENU not selected).
2) An external source (applied to the EXT TRIG input on the voltmeter rear panel).
3) The voltmeter TIMER.
4) The GPIB (Group Execute Trigger (GET) or 'TRIg').
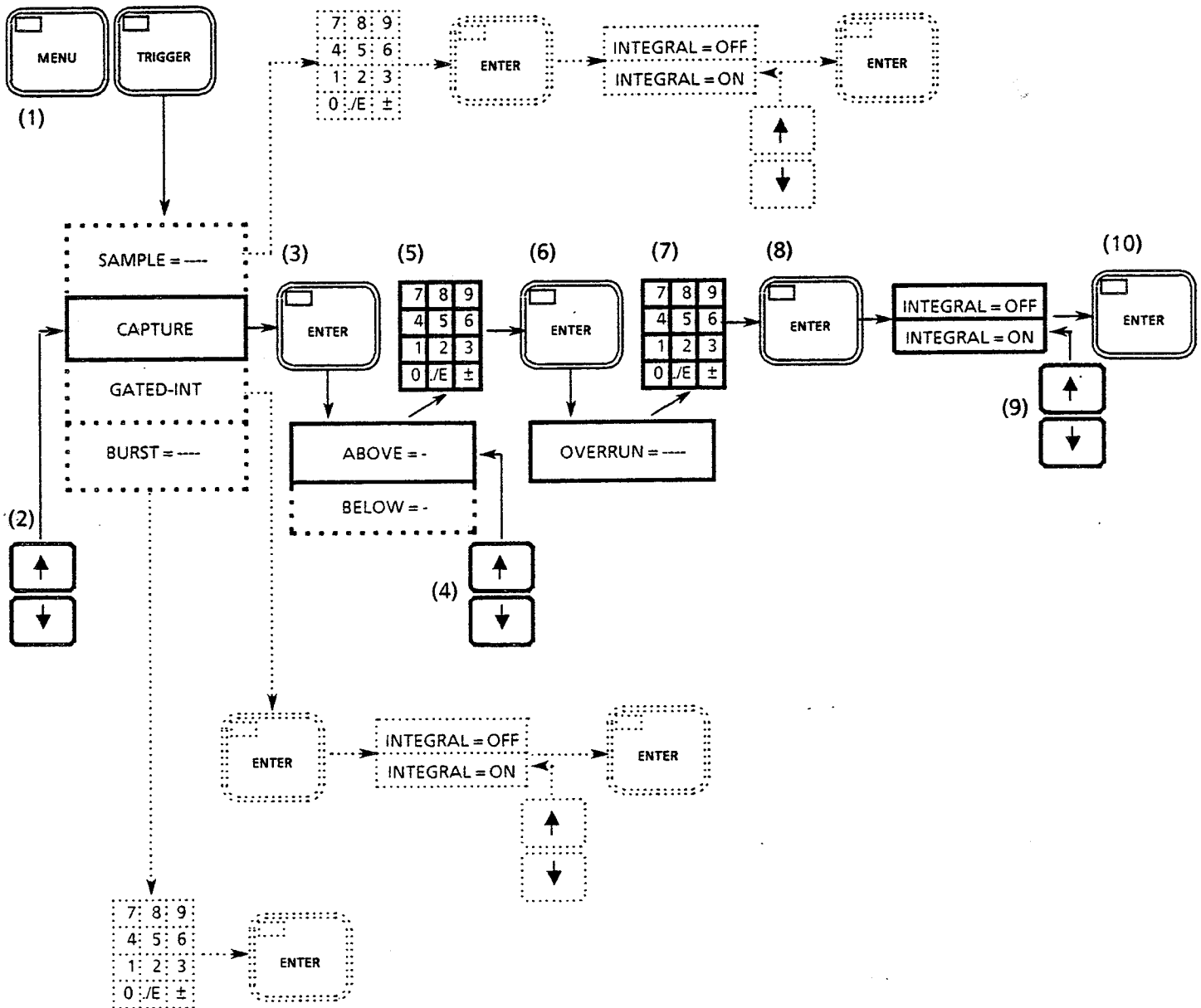
Note: In order to make multiple measurements from the front panel, e.g. SAMPLE or CAPTURE etc., the GPIB must be set to OUTPUT-OFF.

Details of trigger operation are shown overleaf.

10.3   TRIGGER OPERATION

Sampled Measurements

Sampled measurement starts on receipt of a trigger and continues for 1 to 1000 measurements (or 1 to 8000, with the memory expansion option), as defined by the user. Maximum speed with 4 digits set is 1000 readings per second.

Gated measurements

A gated measurement starts within 1ms of one trigger and finishes within 1ms of the next. Although controllable from the front panel this way of making measurements is better suited to remote control, where the integration time can be more precisely defined.

Gated measurements may be made in all measurement modes except True ohms, and RATIO must be off. Also, fixed range should be selected and SCAN must be off, although any channel may be used.

Captured Measurements

To 'capture' measurements the voltmeter starts measuring continuously (as in TRACK) on receipt of a trigger. When a measurement result reaches a pre-defined value between -10^{18} to $+10^{18}$ (ABOVE = , or BELOW =) the voltmeter continues until a pre-defined number of up to 1000 (or 8000) OVERRUN measurements have been made, and then stops. By varying the OVERRUN value, the first captured measurement may be positioned at any convenient point in the HISTORY file. This gives a choice of the number of results available for examination before and after an event.

Captured measurements may be made in any measurement mode and RATIO may still be used. Capture can be made on any channel, but its selection turns off SCAN. Maximum speed with 4 digits set is 1000 readings per second.

The TRIGGER LED is lit during capture and overrun.

(See chapter 5, paragraph 4.33 for an example of a capture measurement.
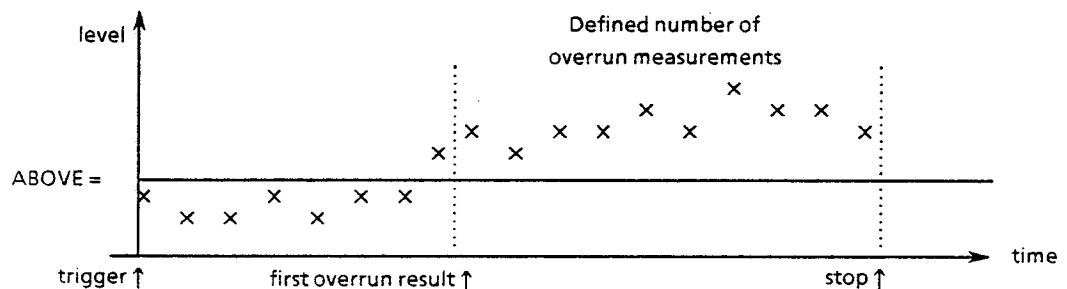
Integral Function

When the integral option is selected (see trigger operations on the previous page) the voltmeter automatically performs a time integration, multiplying the value of measured quantity by the time (in seconds). The 'INTG' in the display indicates that an integration has been taken. If the voltmeter is used to measure voltage, or current, or resistance, the units for these respective intergrations will be mA-seconds, V-seconds, or kΩ-seconds.

For **sampled or captured measurements** the integral function uses either the standard integration time (defined by the number of digits selected), or the user-defined ITIME. (Refer to Digits Key, section 9 of this chapter.)

For **gated measurements** the integral function takes the time between the starting trigger and the terminating trigger.

Burst Measurements

Makes a series of up to 1000 (or 8000) measurements at a speed of 1500 readings per second. 'Burst' forces the following conditions : Digits 4, Filter Off, Ratio Off, Scan Off, Track Off, Output Normal.

When using Burst, the instrument must be in one of the following measurement modes: Vdc, Idc, K ohms:-0.1→1000KΩ ranges, with autorange OFF. Attempted use in any other mode will generate an error. Also, the receipt of any command other than a trigger will change the setting from Burst to Sample.

Note: If a TRIGGER is sent before the previous measurement has finished, readings cease to be output from the first measurement but may still be available in the History file unless overwritten by the second measurement.

External Triggering.
When external triggering is used, the voltmeter should be told what sort of trigger to expect, i.e. positive or negative edge, de-bounce off or on. (Debounce is for mechanical switch inputs.) This can be done through the EXTTRIG menu, which appears under the MENU RESET key. 'ExtTrig' is a BNC input connector on the rear panel, using TTL signal levels. On receipt of an 'ExtTrig' trigger signal, there is the same effect as if the front panel TRIGGER key had been pressed.

TrigComplete signal
The 'TrigComplete' socket is a rear panel BNC output which is normally high but which pulses low for typically 4µs, after the completion of a measurement. This pulse may be used, for example, to advance external circuitry such as a scanner.
During captured measurements, the pulse is output on the first occurence of a measured value outside the capture limit. The output is high again throughout overrun.
When using the LIMITS program, if 'ALARM ON' is selected, a pulse is output each time an out-of-limits measurement is made.
CAUTION. Sending a new Trigger, from any source, before the previous one has been completed, stops the present action and starts a new one.
For timing details, see Appendix B.

11 GENERAL OPERATING KEYS

MENU Used in conjunction with 'grey-barred' keys to call up the associated menu.

↑ When a menu has been called-up, the skip keys are used to read through the lists of menu items.

↓

ENTER The ENTER key is used for entering numeric data into the instrument and to select menu items. It is also used with the RESET key (see below). Changes to instrument settings can occur only after an ENTER.

MEM Gives access to a single memory location.
When the number pad is inoperative (ie. when not in a menu),pressing MEM causes the last displayed reading to be stored.
When the number pad is operative (ie. when in a menu), pressing MEM recalls the number stored in the user-memory for use as a numeric entry.

CLEAR Pressing CLEAR erases numeric entries only.

12 INTERFACE KEYS
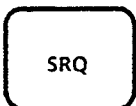
SRQ Generates a user SRQ (service request) to the GPIB, with an LED indication in the key.

LOCAL Returns the instrument to local control from the GPIB remote condition, provided that the remote command 'LOckout ON' hasn't been sent or that the GPIB 'LLO' hasn't been done.
If already in local when the key is pressed, the GPIB address is displayed.
An led indication of local/remote condition is given in the key.

13   RESET + ENTER & MENU + RESET KEYS

RESET **ENTER**   By pressing RESET then ENTER, the instrument is 'Initialised' and settings revert to the pre-determined conditions shown in Appendix A.
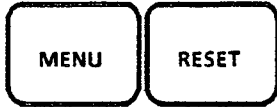
MENU **RESET**   'MENU RESET' offers a choice of reset states, external trigger and interface conditions.
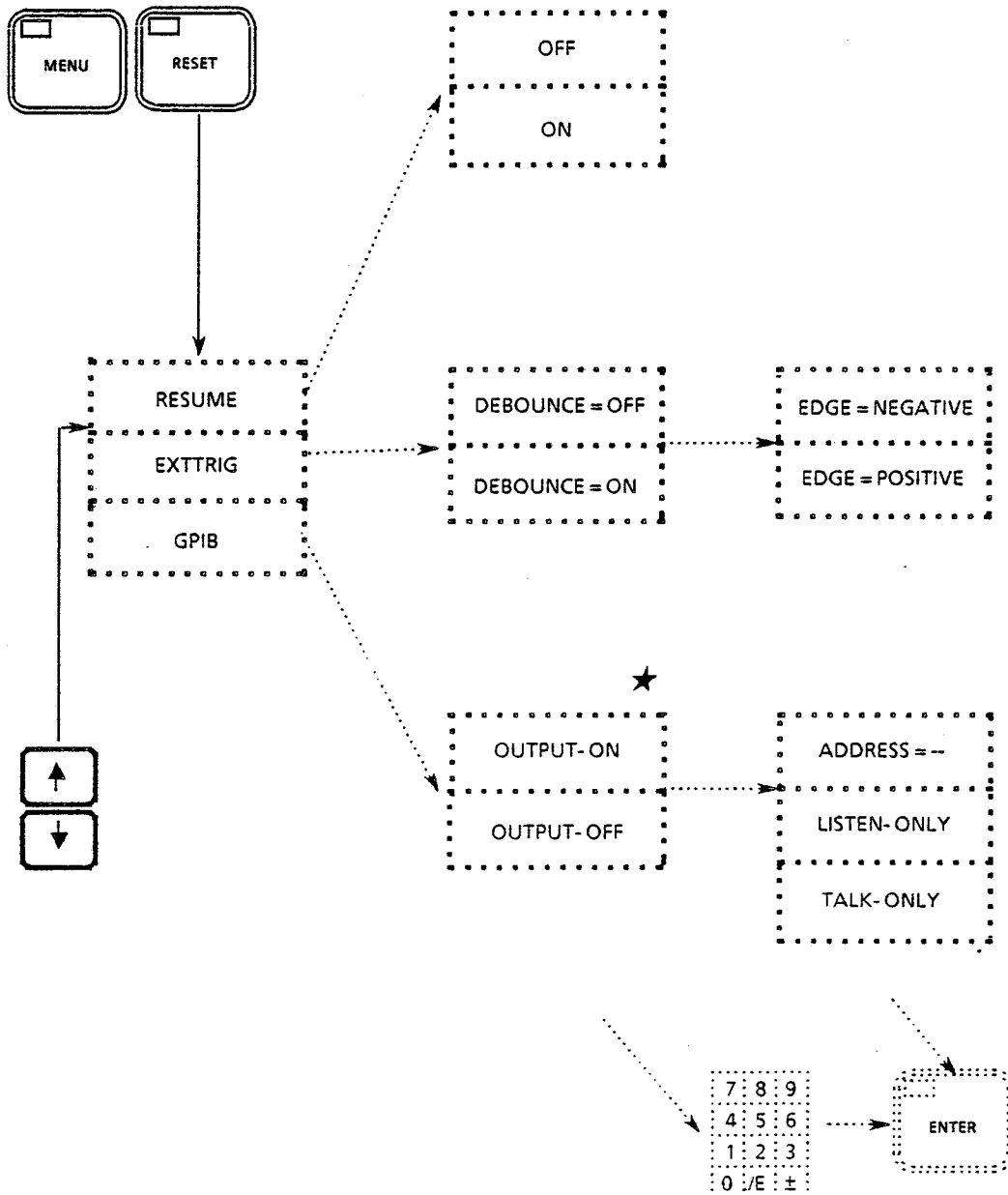
Note: When the calibration switch is in the 'CAL' position, the menus are changed when MENU RESET is selected. (Refer to Chapter 8 for details of calibration.)

★ The GPIB should be set to OUTPUT-OFF for front panel operation.

14   TIMER KEY

TIMER — Enables/disables timer control of triggering. The LED is lit when the timer is enabled.

MENU TIMER — Gives a menu to allow setting of the timer.

To check or re-set the clock, select REAL and skip to CLOCK. If the time displayed is correct, simply press ENTER, if not, make the appropriate setting using the key pad and press ENTER to start the clock.

For making settings in either real or elapsed times, skip through the menu, make settings with the key pad and ENTER selections.

The maximum time setting is 23h 59m 59s and the maximum day setting is 7.

Once set and enabled, the timer will supply trigger pulses from BEGIN time until END time, at intervals corresponding to the INTERVAL selected.

The timer may be set to operate in either real or elapsed time :

'TIMER REAL'

After enabling, the display shows 'TIMER ACTIVE' and timer trigger signals begin *at* the BEGIN time. For each DAYBEGIN specified, the start is delayed by 24 hours. INTERVAL and DAYINTERVAL specify the time between triggers. Timer signals cease *at* the END time. For each DAYEND specified, the cessation is delayed by 24 hours. (When DAYBEGIN is to be specified, the day on which the timer is enabled is regarded as DAY 0. The next day is DAY 1, and so on up to DAY 7.)

'TIMER ELAPSED'

Following enabling, the display shows 'TIMER ARMED'. Then the instrument must be triggered, the display shows 'TIMER ACTIVE' and timer signals begin *after* a delay equal to the BEGIN time. For each DAYBEGIN specified, the delay is increased by 24 hours. INTERVAL and DAYINTERVAL specify the time between triggers. Trigger signals cease with a delay equal to END time after the timer was enabled. For each DAYEND specified, the delay is increased by 24 hours.

See following page for diagram of timer menu.

MENU   TIMER

ENTER → CLOCK = -- --.-- →
7	8	9
4	5	6
1	2	3
0	./E	±
→ ENTER

REAL

ELAPSED

ENTER → BEGIN = --.--.-- →
7	8	9
4	5	6
1	2	3
0	./E	±
→ ENTER

DAYBEGIN = - →
7	8	9
4	5	6
1	2	3
0	./E	±
→ ENTER

INTERVAL = --.--.- →
7	8	9
4	5	6
1	2	3
0	./E	±
→ ENTER

DAYINTERVAL = - →
7	8	9
4	5	6
1	2	3
0	./E	±
→ ENTER

END = --.--.-- →
7	8	9
4	5	6
1	2	3
0	./E	±
→ ENTER

DAYEND = - →
7	8	9
4	5	6
1	2	3
0	./E	±
→ ENTER
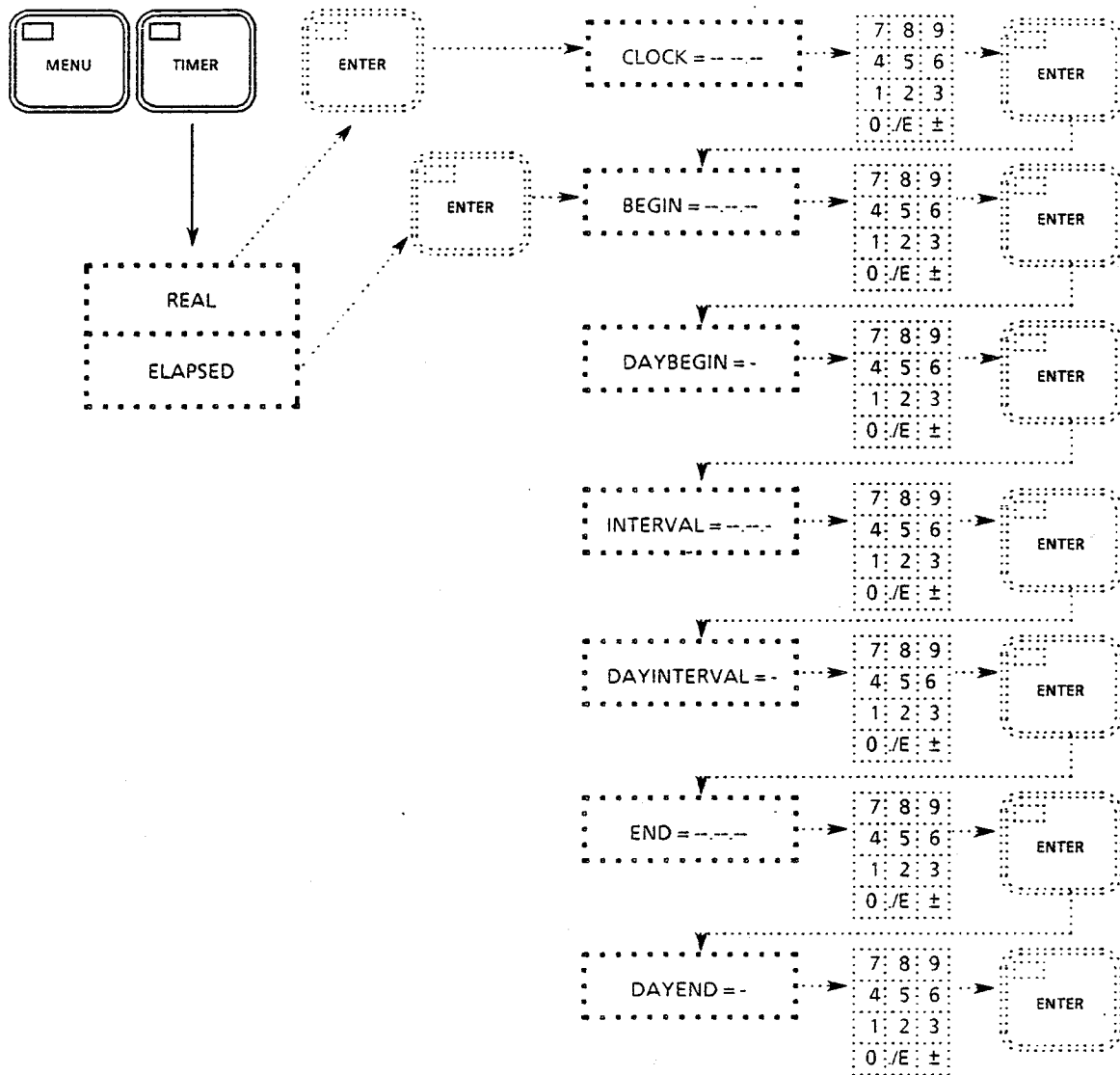
The timer is automatically enabled after the final pressing of the ENTER key, but when using 'TIMER ELAPSED', the instrument must then be triggered.

15   SCAN KEY

SCAN   Enables/disables scanning of channels. The LED indicates scanning on/off. When scan is enabled, one scan is started by each trigger.

MENU   **SCAN**   Gives a menu to allow specification of a scan sequence of up to 18 channels. Channel numbers (i.e. $0 \to 9$ or $0 \to 17$) are entered using the numeric keypad and a setting up sequence may be terminated by pressing CLEAR then ENTER. Any selectable channel may be scanned in any order and the same channel may be scanned more than once.

All channels or just one selected channel may be monitored. See 'MENU HISTORY' keys for details.

For important timing information concerning scanning, see Appendix B.
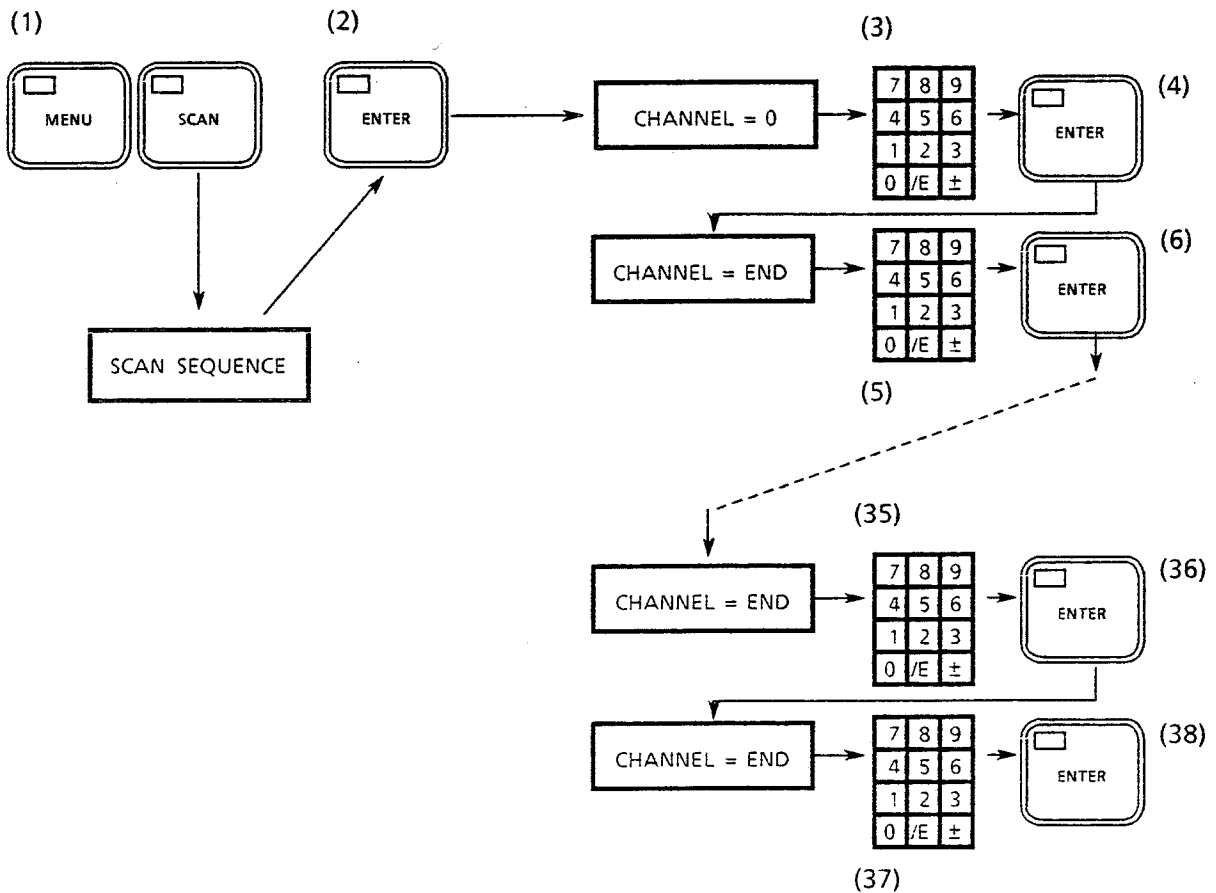
To terminate the setting up of a scan sequence, simply ENTER 'END' (the default condition) instead of a number.

If the power fails during a scan sequence, when power is restored the next scan sequence starts at the beginning again, not at the point where the power failed. See Appendix A for details of track and trigger after a power failure.

16   DELAY KEY

DELAY	Selects user-defined pre-integration delay, with LED indication of selection.
MENU **DELAY**	Sets up user-defined pre-integration delay. The delay may be from 0.000s to 9.999s.
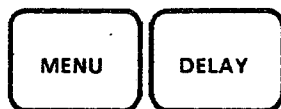
See Appendix B for detailed information on delay timing.

(1)   (2)   (3)

| MENU | DELAY | → | 7 8 9 / 4 5 6 / 1 2 3 / 0 ./E ± | → | ENTER |

USER = -.—
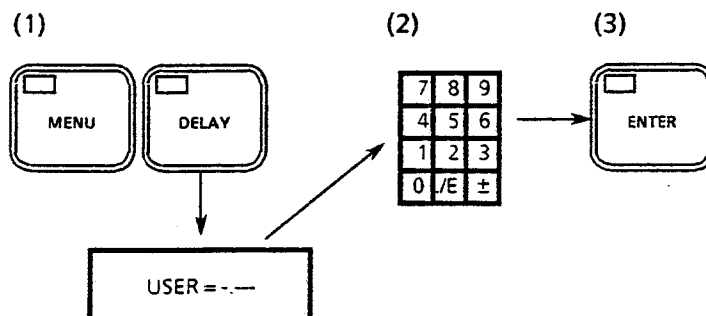
17   PROBE KEY.

PROBE	Allows use of accessory probes, with LED indication of selection.
MENU **PROBE**	Gives a menu to specify the kind of probes to be used.
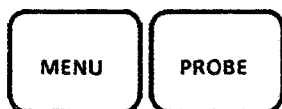
Three kinds of probe may be used:

High Voltage (HV)
Permits the use of high voltage probe, to extend the range of dc voltage measurement on Channel 0. To obtain the correct division ratio of 100:1 the probe must have a series resistance of 990MΩ. This corresponds with the 10MΩ input impedance of Channel 0.

Current Shunt (SHUNT)
Permits the use of a current shunt, to extend the range of current measurement, ac or dc, on any channel. If the value of the shunt resistance R is not specified, the default value is 1Ω.

Temperature (PRT)
Permits the use of platinum resistance thermometer, on any channel. Linearisation conforming to IEC 751 is performed to present a result in degrees Celcius (°C), Fahrenheit (°F) or Kelvin (K), with a resolution of 0.001 degrees. A probe resistance of 100Ω for 0°C is assumed. Where this is not suitable for the PRT in use the correct value can be entered by the user. There is a choice of NORMAL or TRUEOHM measurements.
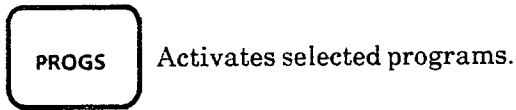
PROBE KEY (continued)

If probes are switched on during measurements, processed results are stored in the memory buffer. Results which are stored in the memory buffer may be post processed (see under History Key, section 19 of this chapter).

(1)

| MENU | PROBES | ENTER | ENTER | ENTER | 7 8 9 / 4 5 6 / 1 2 3 / 0 /E ± | ENTER |

HV

SHUNT

PRT

OFF

MODE = IDC

MODE = IAC

R(OHM) = -*

MEM   ENTER

(3)   (5)   (6)   (7)

(2)

ENTER   ENTER   ENTER

OUTPUT = DEGC

OUTPUT = DEGF

OUTPUT = K

R0(OHM) = -*

| 7 8 9 / 4 5 6 / 1 2 3 / 0 /E ± | ENTER

MEM   ENTER

(4)

MODE = NORMAL   ENTER

MODE = TRUEOHM

(9)

(8)

* R and R0 must be specified in ohms.

18   PROGS KEY

PROGS   Activates selected programs.

MENU PROGS   Selects and sets up programs.

There are seven programs in the instrument:

%Deviation   Divide   Limits   Maxmin

Offset   Scale   Statistics

Each of the programs may be in one of two states:- Active or Idle. Programs selected are held in the Active list whilst unused programs remain in the Idle list. Selecting and setting up a program transfers it from the Idle list to the Active list; cancelling a program has the reverse effect.

SELECT

IDLE list	→	ACTIVE list

(unused programs)   CANCEL   (programs in use)

Programs may be used individually, or linked together to perform more complex computations, in which case they are executed in their order of selection. Note that a program can only appear once in a sequence of programs.

Following the selection of MENU PROGS, one of five program actions can be ordered using skip then ENTER:
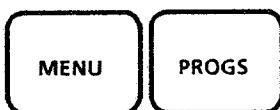
MENU PROGS

SELECT	→ Causes programs in the Idle list to be selected. The display prompts the setting up of program options and variables.
RECALL	→ Allows details of an Active program to be examined. Options, constants, results, can be displayed by repeatedly pressing ENTER.
MODIFY	→ Permits new options or constants to be put into Active programs by overwriting the old ones.
RESET	→ Erases the results of Active programs either one program at a time or all at once.
CANCEL	→ Returns programs from the Active to the Idle list. Constants are not altered but results are automatically reset.

Measurement rates are slowed by pre-processing. The extra delay per measurement is from 1ms to 30ms depending on the processing applied.

18.1 THE PROGRAMS

In the following diagrams, x = program input and y = program output. When more than one program is selected, the output, y, of one program becomes the input, x, of the next.

Program variables may be entered either from the keyboard, or from the memory by pressing MEM then ENTER. In either case, the variables can be in the range from -10^{18} to $+10^{18}$.

18.1.1 %deviation

Computes the percentage deviation of an input from a user-defined value N.

$-10^{18} \leq N \leq +10^{18}$

Thus $y = 100 \, (x-N) \, / \, N$.
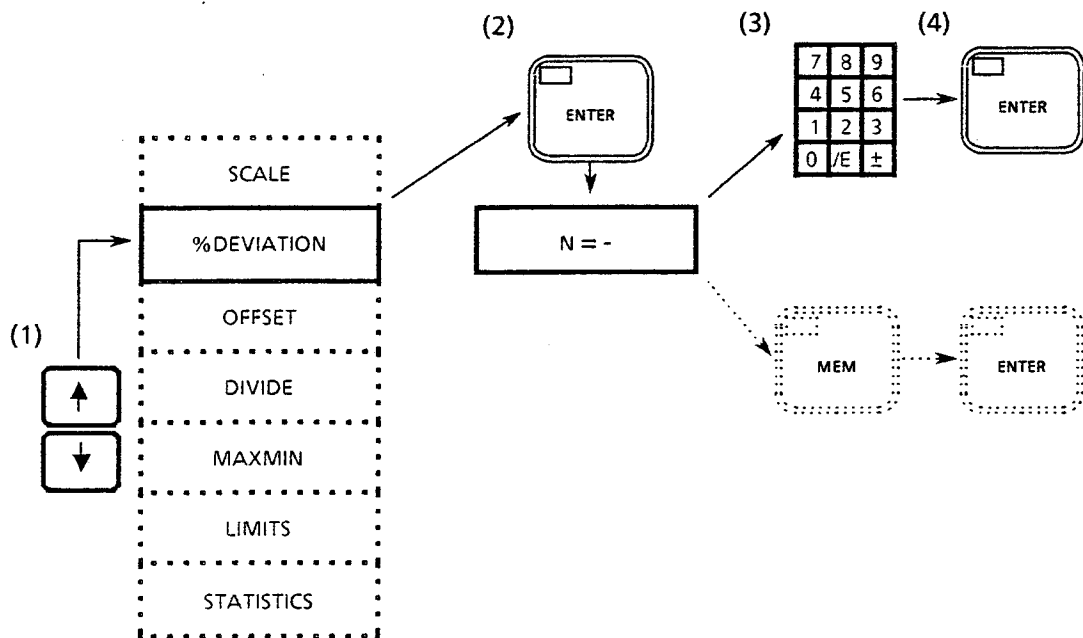
18.1.2   Divide

Takes the measured input, x, and acts on it in one of six ways with a user-defined constant N, giving an output y.

$$-10^{18} \leq N \leq +10^{18}$$

Thus:

1)	X/N	$y = x \div N$
2)	N/X	$y = N \div x$
3)	XX/N	$y = x^2 \div N$
4)	DBX/N	$y = 20\log_{10}(x \div N)$
5)	DBN/X	$y = 20\log_{10}(N \div x)$
6)	DBXX/N	$y = 20\log_{10}(x^2 \div N)$

Outputs 4, 5 and 6 are the decibel (dB) equivalents of outputs 1, 2 and 3 respectively.
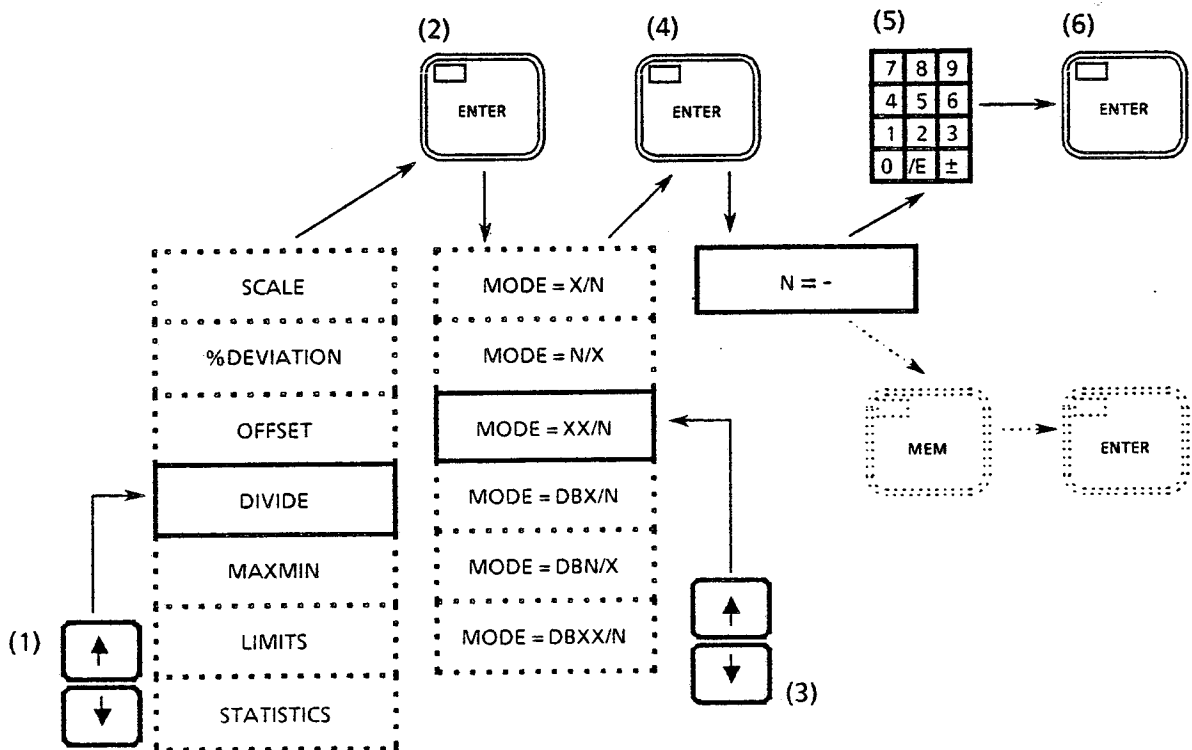
18.1.3 Limits

Compares each input value x with two user-defined limits H and L, or the Memory value.

$-10^{18} \leq H \leq +10^{18}$, $-10^{18} \leq L \leq +10^{18}$

Each input value x is put into one or more of four categories:

1) Hi $\quad$ $x > H$
2) Lo $\quad$ $x < L$
3) Go $\quad$ $L \leq x \leq H$
4) Nogo $\quad$ $x > H$ or $x < L$

Outputs are available either from individual categories or from all.
Whilst the program is running, the number of results in each category is recorded and is available for RECALL.
If ALARM ON is selected, a low, approximately 4μs pulse is output to the 'Trig Complete' (LINE 0) socket each time an out-of-limits measurement is made.
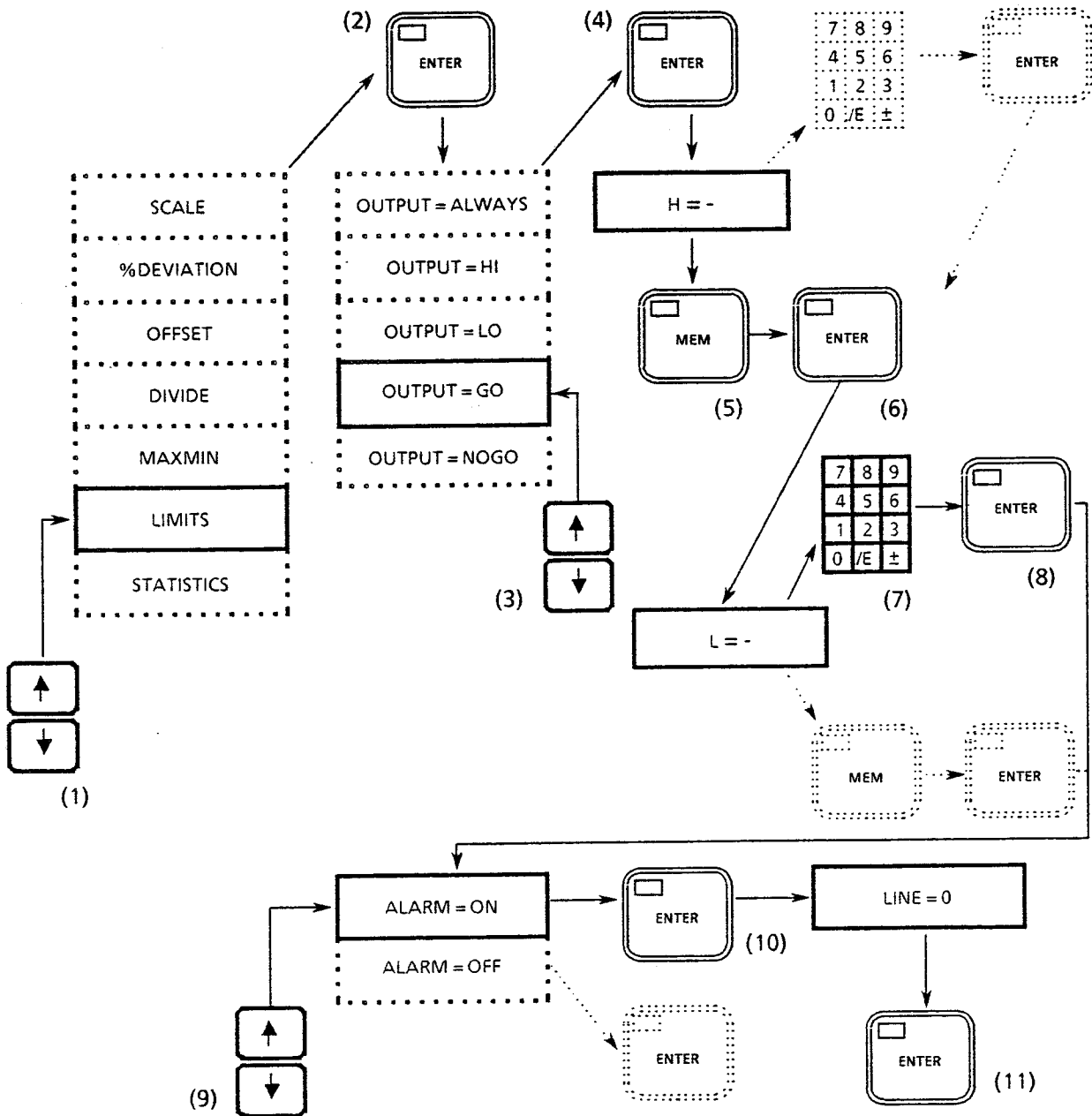
18.1.4   Maxmin

Records the minimum and maximum values of inputs, x, and the difference between them.

Output, y, may be selected from:

INPUT	$y = x$
MAX	$y =$ present maximum value of x
MIN	$y =$ present minimum value of x
PP	$y =$ present peak-to-peak (difference) value between max. and min. x.

MAX, MIN and PP are available for RECALL, together with the total number of input values.
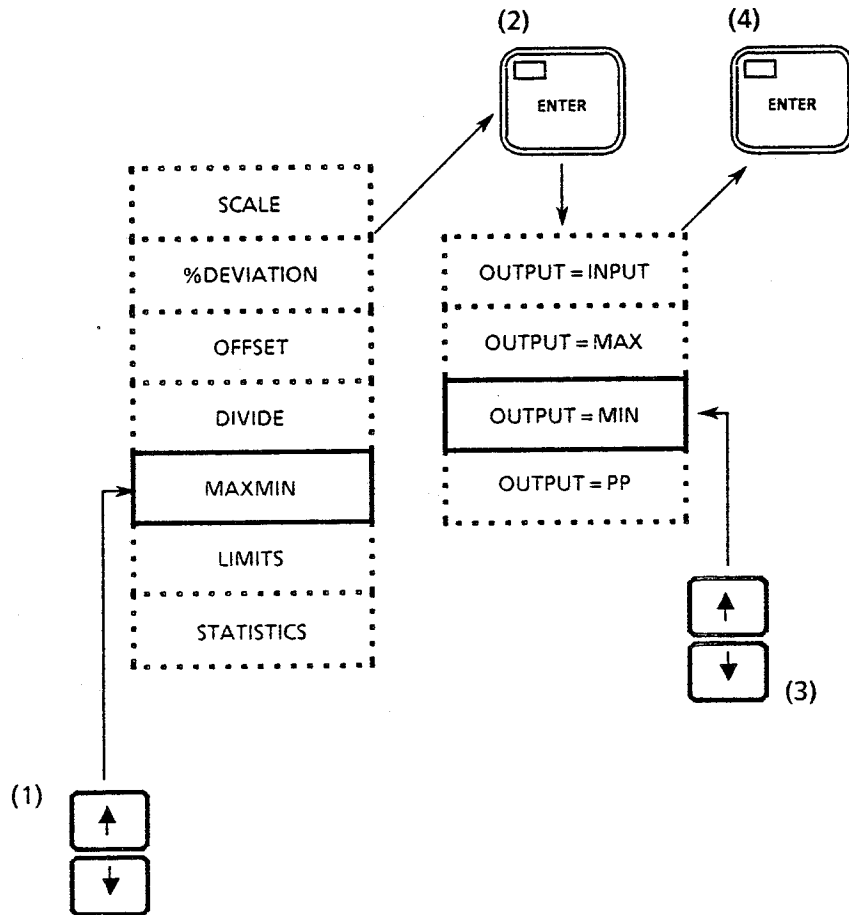
18.1.5 Offset

Adds a user-defined constant, C, to the measured value.

$$y = x + C \qquad -10^{18} \leq C \leq +10^{18}$$
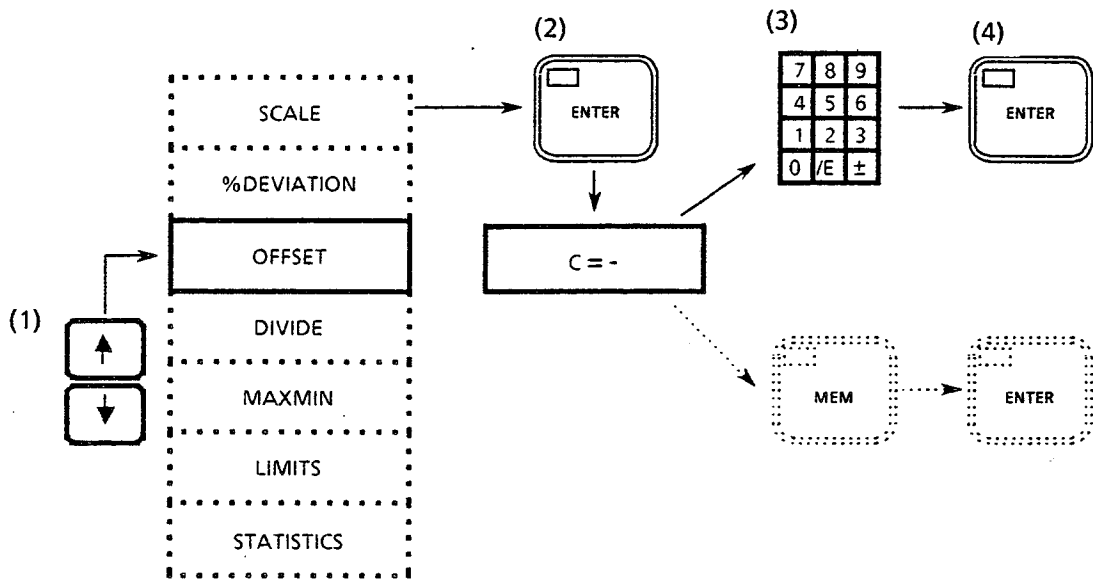
18.1.6 Scale

Multiplies measured value by a user-defined constant, M.

$$y = Mx \qquad -10^{18} \leq M \leq +10^{18}$$
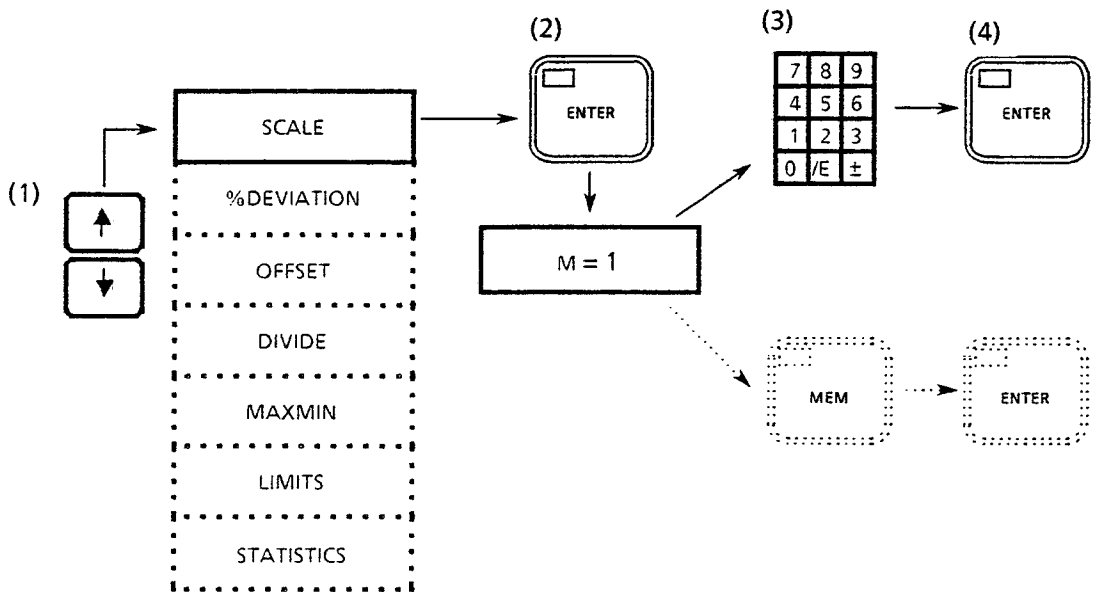
18.1.7   Statistics

Computes statistics from a series of inputs, x, to give outputs, y.

$$INPUT \qquad y = x$$

$$MEAN \qquad y = \sum_{i=1....n} x_i/n = \bar{x}$$

$$SD \qquad y = \sqrt{(\sum_{i=1....n} (x_i - \bar{x})^2/n)}$$

$$VAR \qquad y = \sum_{i=1....n} (x_i - \bar{x})^2/n$$

$$RMS \qquad y = \sqrt{(\sum_{i=1....n} x_i^2/n)}$$
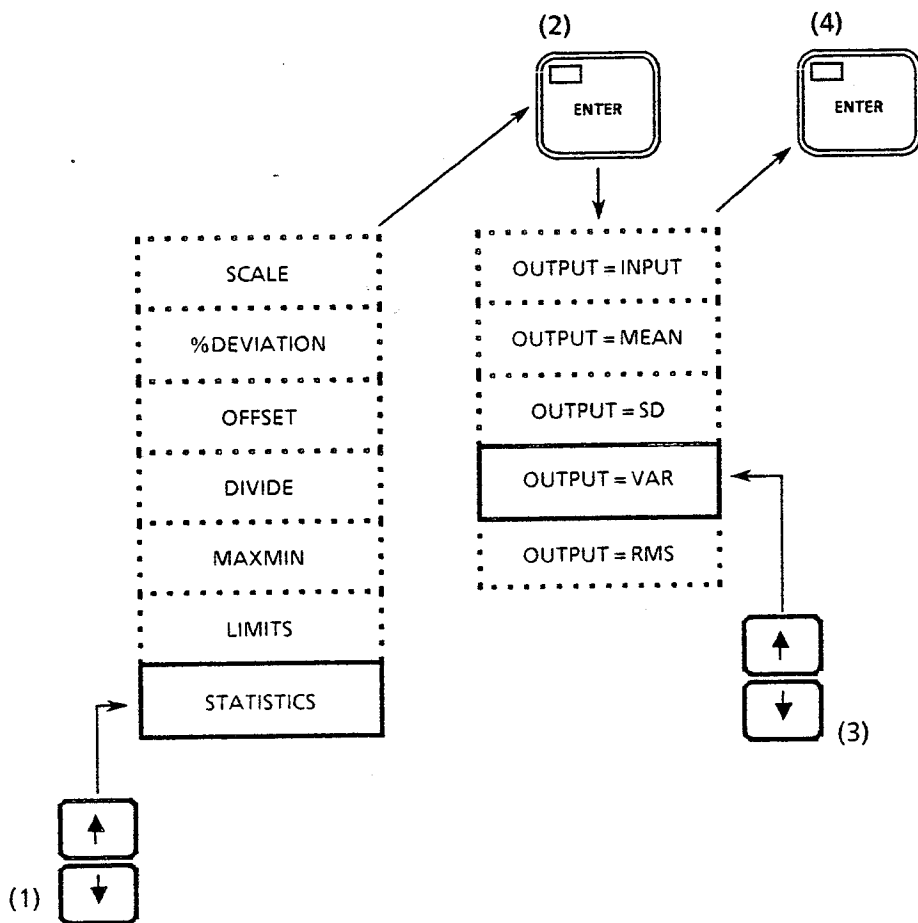
18.2   **PROGRAM EXAMPLES**

Example 1
To take a series of measurements and divides each result by a factor of, say, 20.

Press 'MENU' then 'PROGS'. Using CANCEL, clear any SELECTED programs from the Active to the Idle list.
Select the Scale program and set the constant to 0.05.

With the Scale program implemented, i.e. with the 'PROGS' key pressed, all readings are then divided by 20.

Example 2
To examine the tolerances of a batch of resistors.

To find the standard deviation and the worst case variation of resistance values requires the use of the MAXMIN and STATISTICS programs. Remember that programs act in the order of their selection and the output of the final program is the one displayed.

Select the MAXMIN program. Select OUTPUT = INPUT.
Select the STATISTICS program. Select OUTPUT = SD.

Now with the PROGS key pressed (LED on), individually triggered resistance measurements are stored by the MAXMIN program, and each displayed reading shows the standard deviation of the measured resistance compared with the previously-measured values.

When the whole batch has been measured, by using RECALL, the MAXMIN and STATISTICS results may be seen.

19 HISTORY KEY

HISTORY
Pressing the HISTORY key causes readings in the memory buffer to be displayed, together with their record numbers and the channels through which they were read. (A blank indicates channel 0.)
Pressing the skip key ↑ then allows the display of earlier readings, each press accessing the previous reading. Pressing skip key ↓ gives access to later readings until the latest is reached once more. Trying to skip to a non-existent record causes a 'beep'.

HISTORY
7	8	9
4	5	6
1	2	3
0	/E	±
ENTER
Specific readings may be displayed by pressing HISTORY, entering the record number of the reading, then pressing ENTER.
Lower record numbers refer to later results, so the last reading taken is always in position 1.

Example of a displayed reading:

$$2.5239 \quad 703 \quad 5$$

VALUE   RECORD   CHANNEL
             NUMBER   NUMBER
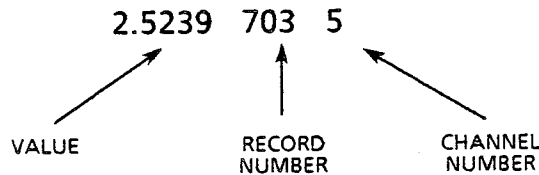
MENU HISTORY   Gives access to the following facilities:

CLEAR	Clears the memory buffer.
DUMP	Allows the specification of a range of readings to be taken from the memory buffer, and the results displayed. By specifying 'POST-PROCESS', results may be probe or program processed, before display. If 'SINGLE STEP' is chosen, results are displayed one at a time, on repeated pressing of the ENTER key. 'FAST' gives the results in a rapid succession.
MONITOR	Gives a choice of displaying all channels or one selected channel when making scanning measurements or when using HISTORY either alone or with DUMP.
DISPLAY-FIELD	Gives a choice of displaying measurement units as applicable, or record numbers, when using HISTORY.

MENU   HISTORY   ENTER   (1)

(4)

CLEAR

DUMP

MONITOR

DISPLAY-FIELD

ENTER   (3)

FROM = 1

7	8	9
4	5	6
1	2	3
0	/E	±

ENTER   (5)

TO = n^t

7	8	9
4	5	6
1	2	3
0	/E	±

(6)   ENTER   (7)

ENTER

POST-PROCESS

NO-POST-PROCESS

ENTER   (9)

(8)

ALL

CHANNEL = 0

7	8	9
4	5	6
1	2	3
0	/E	±

ENTER

ENTER

SINGLE-STEP

FAST

(11)

ENTER

(10)

(2)

RECORD-NUMBER

ENTER

UNIT

n^t = highest record number
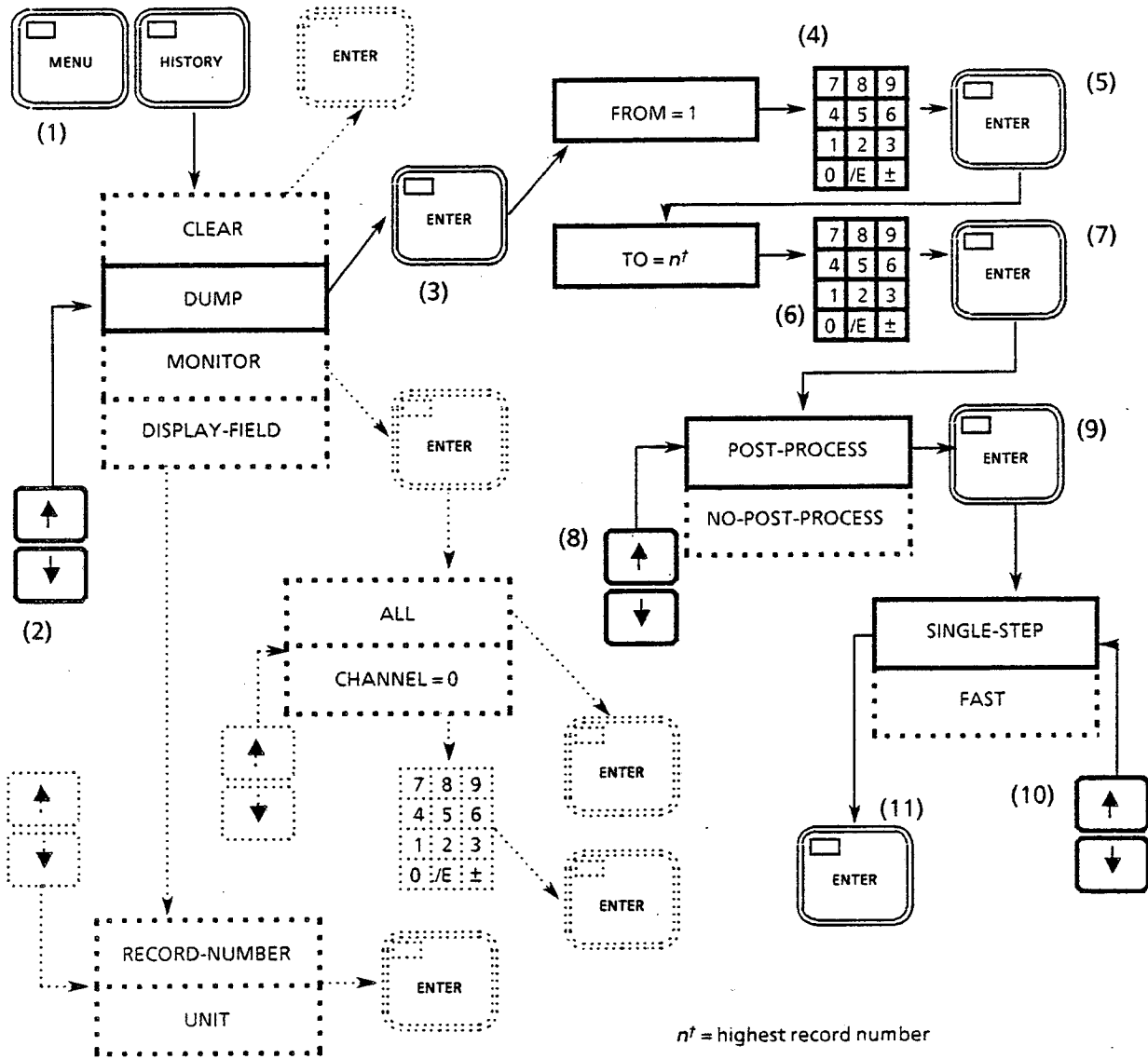
If 'MONITOR CHANNEL=n' is specified and no readings from 'n' are taken, no readings will be displayed or output. Whenever a single channel is monitored (i.e. not MONITOR ALL), the History LED remains lit as a warning that not all readings may be displayed and output. The monitor facility is only applicable when scanning, or when the monitor dump is invoked, or when accessing the memory buffer.

Examples of DUMP :
To DUMP a single result (e.g. record 35), enter DUMP FROM 35 TO 35
To DUMP all results in the memory buffer, enter DUMP FROM 1 TO 1000 (8000)*
To DUMP a range e.g. from 100 to 51, enter DUMP FROM 100 TO 51

Note that lower record numbers hold later results, so dumping '100 to 51' displays and outputs results in the order in which measurements were made.

The choice between individual accessing of readings (SINGLE STEP) or accessing in blocks of readings (FAST) is best determined by considering the kind of program processing required. If a set of readings is to be 'scaled' or 'offset' for example, each result will need to be read from the display, so the former method should be used. If the readings are to be processed by 'maxmin' or 'statistics', only the final result from perhaps hundreds of readings is required, in which case the latter method is more suitable.
*Memory expansion option.

Chapter 4
Connections & Measurements

1   GENERAL

For many applications it is sufficient just to connect the unknown quantity (volts, ohms etc.) to the instrument using the 2-terminal test lead. Measurements can then be taken. Sometimes, however, interference is superimposed on the input signal to the instrument and, if it is large enough, the displayed result may be affected, i.e. unstable, or worse still, steady but incorrect. As it is sometimes difficult to assess whether or not results will be affected by interference, it is advisable to null the dc ranges prior to their use. (See chapter 2)

It is not normally too important which way round the connecting leads are arranged as the instrument can measure +ve or –ve signals. If –ve, a minus sign will precede the displayed result.

Details of main (channel 0) and reference (channel 1) input sockets are given in figures 4.1 and 4.2. The sockets are shown viewed from the outside of the instrument.

1) Not used
2) LO
3) LO ohms source
4) HI
5) HI ohms source

Input plug :

Selectro-Fischer S104A053
(Solartron no. 351005010)
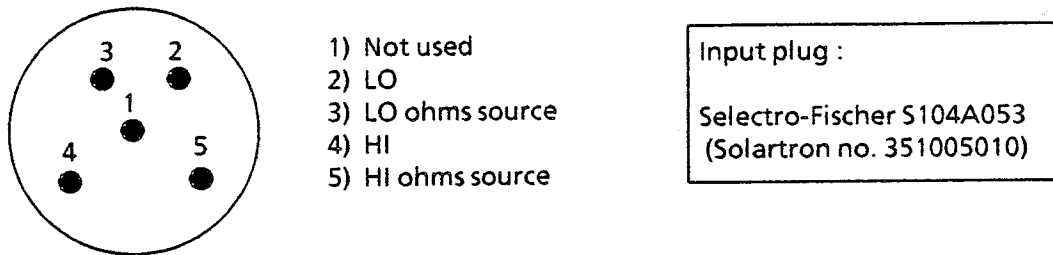
Fig. 4.1 *Main Input (front or rear panel)*

1) HI ohms source
2) LO
3) LO ohms source
4) HI
5) Not used

Input plug :

Switchcraft TA5FL
(Solartron no. 351505030)
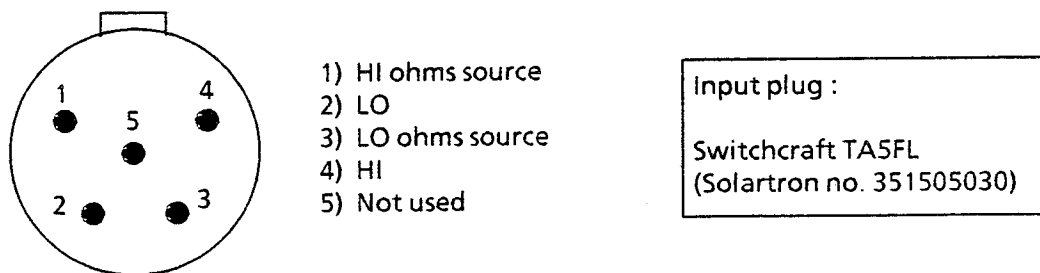
Fig. 4.2 *Reference Input (rear panel)*

See chapter 1, section 4.1 for details of scanner connections.

2   VOLTAGE (via front or rear panel, 2 terminal lead)

Connect the test leads to the instrument and select V, dc or V, ac. Select AUTO ranging and connect the test leads across the unknown voltage. Fig 4.3 shows the 2-terminal test lead in use. Measurements can be taken by pressing TRACK or TRIGGER.
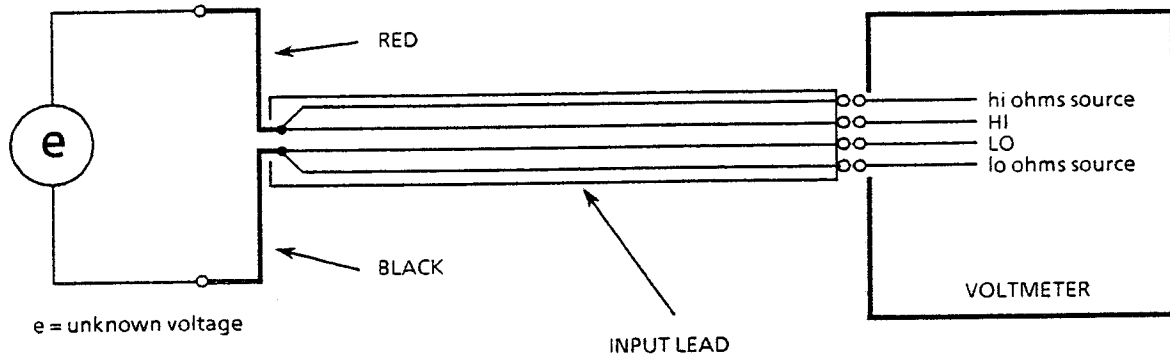
Fig. 4.3 *Connections for voltage measurements (2-terminal)*

Note: Protection against overload voltages is given by a spark gap between HI and LO.

3   CURRENT (via rear panel only)

Connect two test leads to the sockets at the rear of the instrument and select I, dc or I, ac. Connect the test leads to the unknown current. Measurements can be taken by pressing TRACK or TRIGGER.

Note: Protection against currents in excess of 2A is provided by a 2A fast blow fuse mounted on the rear panel.

4   RESISTANCE (2 or 4 terminal lead)

Resistances can be measured by using the 2-terminal method. For most applications this method is satisfactory. However, as the value of unknown resistance becomes smaller, the effects of the instrument being remote from the resistance becomes more noticeable. In particular, the connecting leads always have some resistance, typically 0.25Ω. Therefore the ratio of unwanted resistances to the wanted one may become significant.

In order to ascertain which method should be used, it is sufficient to measure the resistance of the test leads (if not already known), and then calculate their value as a percentage of the resistor under test. If this figure is unacceptable, the 4-terminal method should be used.

A test current for resistance measurement is provided by a constant current generator whose output varies with the selected resistance range.

For low resistance measurements involving thermally induced voltages (e.g. relay contacts), use the True ohm mode to eliminate these junction errors.

The $10M\Omega$ range uses 2-terminal measurements only. Settling times are longer than for other ohms ranges, and depend on the value of resistance being measured.

4.1 **2-TERMINAL (VIA FRONT OR REAR PANEL)**

Connect the test lead to the instrument and select Ω, auto-range. Short the leads together and perform a null. Connect the test leads across the unknown resistance. Measurements can be taken by pressing TRACK or TRIGGER.
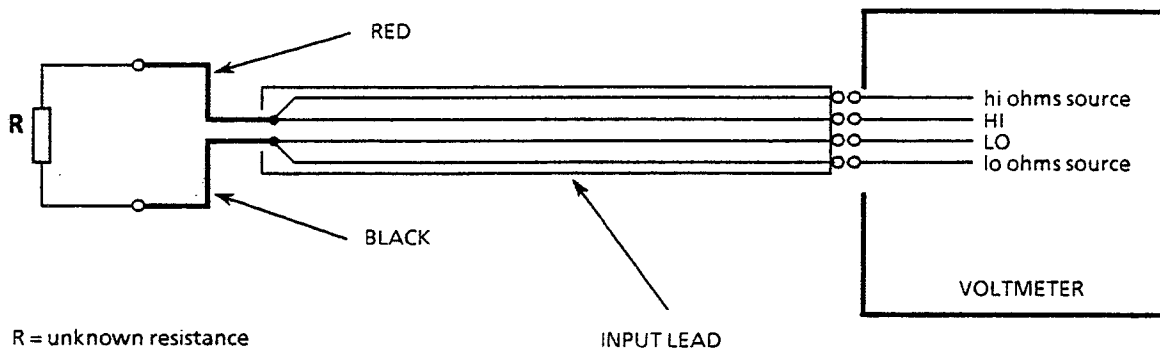
Fig. 4.4 *2-terminal connections for resistance measurements*

4.2 **4-TERMINAL (VIA FRONT OR REAR PANEL)**

Connect the test lead to the instrument and select Ω, auto-range. Short the leads together and perform a null. Connect the test leads across the unknown resistance as close as possible to the body of the resistance. Measurements can be taken by pressing TRACK or TRIGGER.
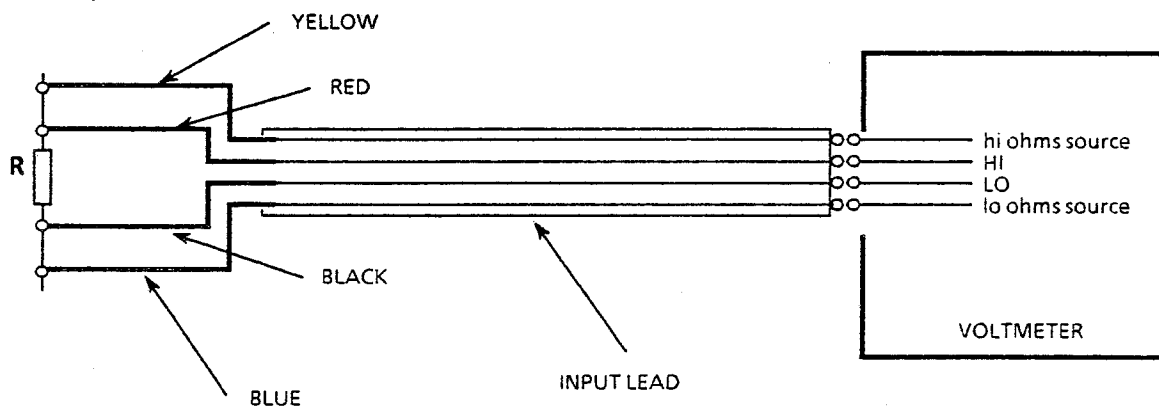
Fig. 4.5 *4-terminal connections for resistance measurements*

5   DRIFT CORRECTION

The instrument automatically compensates for internal drift every 15 minutes but does not interrupt a GPIB input or a keyboard trigger. Under remote control, drift correction may be turned on and off. For example, in tracking measurements lasting longer than 15 minutes, drift should be turned off for continuity of results.

Chapter 5
Remote Control

1   INTRODUCTION

Full control of all the 7061 facilities can be achieved via the GPIB using a suitable controller. These facilities consist of all those offered at the front panel, plus some additional ones. See chapter 3, para. 1.2 for details of measurement handling.

The 7061 will accept commands from the controller, initiate measurements, and send results back to the controller when requested. In addition the 7061 can be programmed to interrupt the controller when a measurement or an error occurs (see SRq command), thereby allowing the controller to conduct other tasks until interrupted, and so increase instrument efficiency.

Connection to the GPIB is made using the 'IEEE488/GPIB INTERFACE' socket on the rear panel. The 7061 address number and talk/listen status are selected using the front panel 'MENU RESET' key sequence.

1.1   SENDING COMMANDS TO THE 7061

The 7061 is controlled by messages sent from the controller. This is normally achieved by using statements of the form :

<Controller-specific command> <7061 Command string>

1.1.1   Controller -specific command

The 'controller-specific command' is an instruction to the controller, such as 'output', 'display', 'read' or 'print' which is expressed in the language appropriate for the controller being used. Because one of many types of controller could be used, and since each has its own language, the precise statements cannot be defined in this handbook.

1.1.2   7061 command string

The '7061 command string' is a message which controls the 7061. The string consists of one or more commands from the 7061 Command Set which is shown in the following section. The commands are also listed in alphabetical order on the contents page, 5.1, and additional information is given where appropriate.

Most commands consist of a command word and a number (the argument), e.g. ITime = 1.5. This command would result in an integration time of 1.5 seconds.

In most cases, the complete command word need not be used, the essential part of each being shown in block capitals. For some frequently-used commands an even shorter 'cryptic' form is available.

1.2   OUTPUT DATA FORMATS

Results are presented in different formats depending upon the settings of the FOrmat and LIterals commands. See Appendix C for details. For example :

FOrmat DVM, LIterals ON, the output is of the form :
                    "+1.234567   VDC   CHAN 3"

FOrmat DVM, LIterals OFf, the output is of the form :
                    "+1.234567"

1.3   ADDRESS AND TALK/LISTEN SELECTION

For operation on the GPIB using a controller, set the front panel 'MENU RESET' selections to :
                    "OUTPUT ON"
                    "ADDRESS = (as required)"

For operation without a controller, select appropriately, e.g. if a printer only is connected:
                    "OUTPUT ON"
                    "TALK ONLY"

2 REMOTE COMMANDS AND PROGRAM NAMES

2.1 COMMAND LIST

Calibration	CALibrate	Allows instrument calibration.
Clock	BEGin	Selects start time for the timer.
	CLock	Allows clock to be read or re-set.
	ENd	Sets end time for the timer.
	INTerval	Defines interval between timer signals.
	ONTImer	Defines action taken when timer signal occurs.
	TImer	Provides control of the timer.
Measurement	CHannel	Selects channel to be measured.
	DElay	Selects pre-measurement delay time.
	DIGits	Sets number of digits in display.
	DRift	Controls drift correction.
	EXTtrig	Prepares instrument for external trigger.
	FIlter	Switches filter on/off.
	ITime	Selects measurement integration time.
	MODE	Selects measurement mode.
	NInes	Alternative command for digits.
	NUll	Controls nulling.
	OUtput	Selects measurement rate.
	PROBes	Permits use of accessory probes.
	RANge	Selects measurement range or autorange.
	RATio	Provides ratio or product facility.
	SCan	Controls channel scanning.
	TRAck	Enables/disables repetitive measurements.
	TRIgger	Starts a measurement sequence.
Program	CANcel	Deselects programs.
	MODIfy	Enables changes to be made to an active program.
	PROGrams	Switches all selected programs on or off.
	RECall	Permits examination of a selected program.
	RESEt	Clears results of active programs.
	SELect	Selects programs for use.
System	BEEp	Produces a short tone.
	DCl	Puts instrument in Device Clear state.
	DISplay	Controls front panel display.
	DUmp	Commands output of data from history file.
	EXEcute	Executes a user-defined command string.
	FOrmat	Selects output format.
	GPib	Configures the GPIB.
	History	Clears measurement buffer.
	INItialise	Resets instrument to default setting.
	LIterals	Suppresses non-numerics in the output string.
	LOckout	Enables/disables front panel keys.
	MONitor	Selects channels to be displayed.
	MEmory	Controls storage of a number in the memory location.
	ONTRigger	Defines measurement sequence when trigger received.
	OPtion	Shows settings of configuration switches.
	RESUme	Determines condition of instrument at switch-on.
	SRq	Controls generation of the service request.
	STAtus	Allows last error detected to be examined.
	STRing	Allows definition of user command strings.

2.2 PROGRAM NAMES

%deviation
Divide
Limits
Maxmin
Offset
SCale
STatistics

Program names can be used in conjunction with the program commands CANcel, MODify, RECall, RESEt, and SELect only.

3   INTERFACE COMMAND LANGUAGE

The interface command language for the GPIB consists mainly of English language words (verbose commands).

     For example,   MODE VDC
                              RANGE AUTO
                              DIGITS 5

All facilities can be controlled with commands of this type.

Some of the commands are also available in the shorter 'cryptic' form.

     For example,   M0
                              R0
                              D1

These are the cryptic forms of the three verbose commands above.

The two forms may be mixed if desired.

4   COMMAND SET -- VERBOSE

On the following pages the flow diagrams indicate the necessary syntax for each command structure. The general flow is from left to right (starting with the command word) unless an arrowed line indicates otherwise. Optional items are indicated with by-pass lines.
A brief description of the symbols used is given below.

 Indicates a command word.

 Indicates that a user-specified value/text should be entered e.g. program constants.
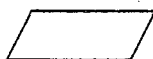
 Indicates that one of a set of pre-defined values/texts should be entered e.g. program options.
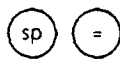
 These are interchangeable as far as the interface is concerned, but in the diagrams, the more natural character is used to separate adjacent items. (Commas may also be used as separators here.)

 Indicates the valid end of a command. This may be either a colon ':' if another command follows within the same command string, or the end of string terminator 'LF' or 'EOI' using the GPIB.

 Where a question mark appears in a diagram, it indicates that the status of the particular command may be queried. For example, sending MODE ? causes the instrument to return a message such as 'MODE VDC REAR'.

Commands may be entered in full, but only those parts of commands printed in upper case letters are essential. For example, the command "ontrigger sample = 10 " may be shortened to "ontr s = 10 ".

4.1 BEEp

Produces a short tone to draw attention to the display.

```
( BEEp )─────────────────────────⊗
```

4.2 BEGin

Selects the start time for the TImer.

```
( BEGin )──────────( ? )───────────────────⊗
            └─(sp)─[ hh.mm.ss ]─────────┐
                          └─(sp)─( Day )─(=)─[ d ]─┘
```

0 ≤ hh ≤ 23   0 ≤ d ≤ 7
0 ≤ mm ≤ 59
0 ≤ ss ≤ 59
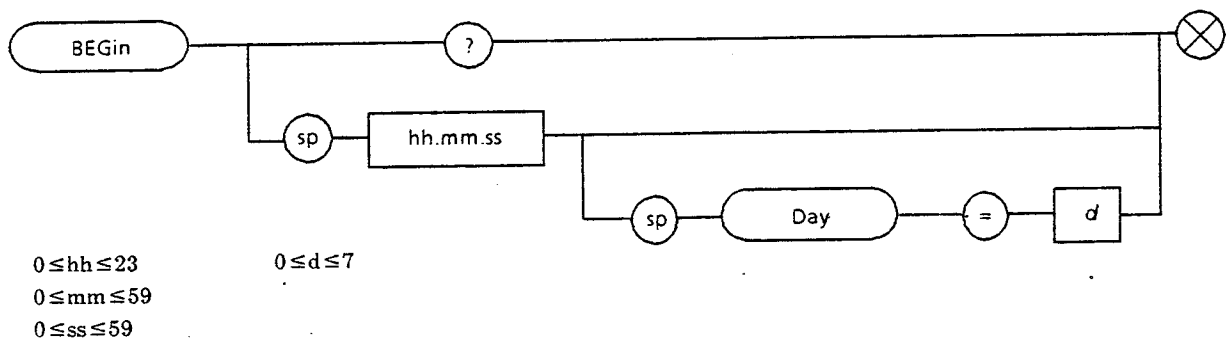
If the timer is set to operate in elapsed time, then following enabling, time signals begin *after* a delay equal to the BEGin time. For each Day specified, the delay is increased by 24 hours.

If the timer is set to operate in real time, then following enabling, time signals begin *at* the BEGin time.
When the Day is to be specified, the day on which 'TImer = Real' is set is regarded as DAY 0. The next day is Day 1 and so on up to Day 7.

4.3 CALibrate

Allows the instrument to be calibrated. It is available only with the front panel switch turned to the CAL position.

See chapter 8 for details of calibration.

4.4 CANcel

De-selects active programs.
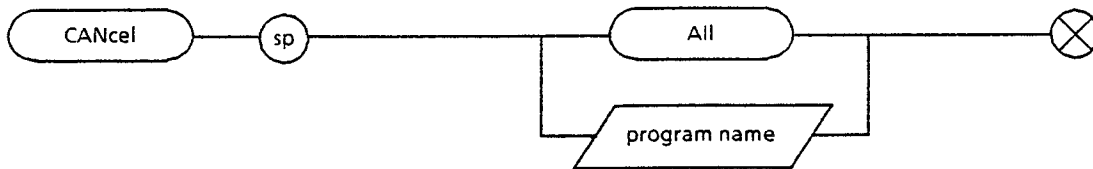
If no programs remain selected after using CANcel, the 7061 reverts to the PROGram OFf condition.
Cancelling a program resets its results. User-specified parameters, however, are not altered.

4.5 CHannel

Selects channel to be measured.
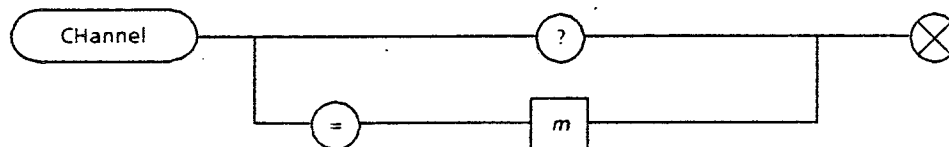
$0 \leq m \leq 9$.......config. switch '8'
$0 \leq m \leq 17$.....config. switch '16'

Channel 0 is the normal input, channel 1 is the reference input.

Channel numbers may be 0-9 or 0-17 depending on the setting of the configuration switch (See chapter 1) and on whether or not the scanner option is fitted. Alternatives are shown in the tables below.

Probe and program processing may be switched in or out of any channel and the kind of processing may be set up independently for each channel or virtual channel.

Note that 'virtual' channels are physically connected through channel 0. Thus all virtual channel inputs pass through the same connector and wiring, but may be processed differently. Processing for virtual channels is set up in the same manner as for 'normal' channels.

The position of the configuration switch is read on power-up only.

Without scanner option:

		Selected Channel		
		0,1	2→9	10→17
Configuration switch setting	8	five-pole	virtual	✕
	16	five-pole	virtual	virtual

With scanner option:

		Selected Channel		
		0,1	2→9	10→17
Configuration switch setting	8	five-pole	four-pole	✕
	16	five-pole	two-pole	two-pole

4.6   CLock

Allows the setting of the clock to be read or re-set.

$$0 \leq hh \leq 23$$
$$0 \leq mm \leq 59$$
$$0 \leq ss \leq 59$$
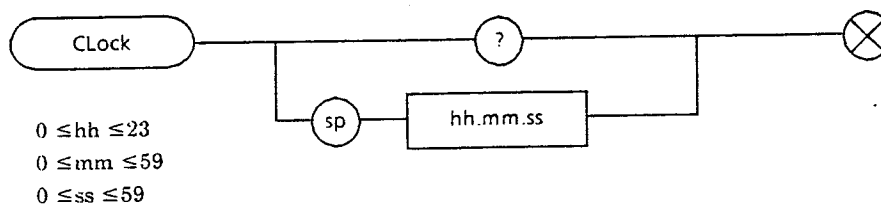
The query command gives the present time.

4.8   DCl

Causes the 7061 to go to the (Device Clear) state shown in Appendix A.
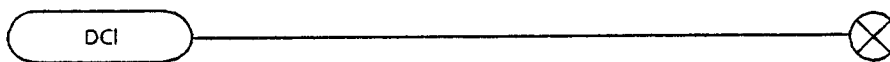
All 7061 command settings revert to the pre-determined condition, although History File results are unaffected. The interface will behave as defined in the appendix on Adopted Settings.
DCl is a duplication of the GPIB interface command 'Device Clear'.

4.9   DElay

Selects a 'normal' pre-measurement delay or a user-defined one.

$0.000s \leq m \leq 9.999s$
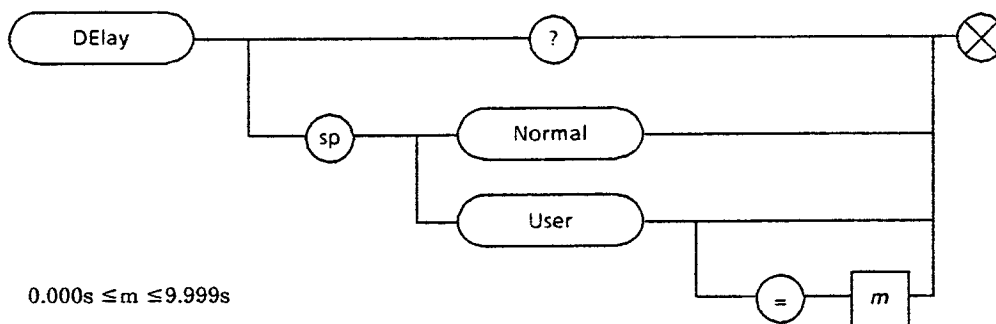
| DElay Normal | The pre-measurement delay is set automatically according to the mode, range and number of digits selected. |
| DElay User | Defines a fixed pre-measurement delay in the range shown. |

See Appendix B for details.

4.10   DIGits

Defines the number of digits ('nines') that are to appear in each measurement result, together with a leading digit of 0,1 or 2.
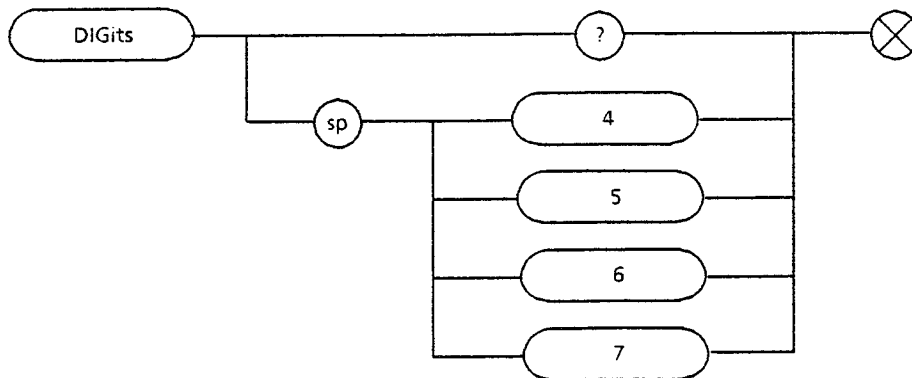
A measurement integration time suited to the measurement mode and the number of digits selected is automatically set (ITime Normal). The DIGits command overrides the user-defined integration time (ITime User).

For compatibility with earlier instruments, NInes may be used instead of DIGits.

4.11   DISplay

Enables/disables the writing of measurement values to the display, or allows user-messages to be displayed.
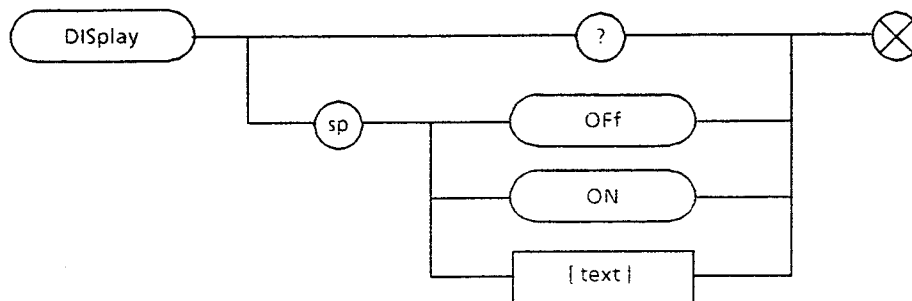
e.g. 'DISplay [TESTING]' causes the word 'TESTING' to be displayed.

The command 'DISplay [text]' is unaffected by the OFf/ON state.

4.12   DRift

Controls drift correction.
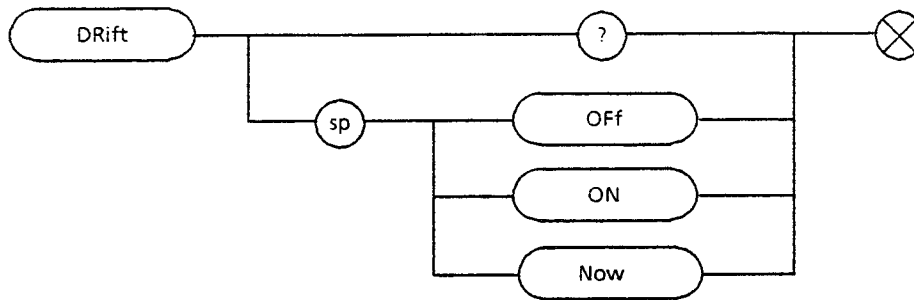
When ON, drift correction is done every 15 minutes for 5, 6, and 7 digits.

'DRift OFf'	Turns drift correction off.
'DRift ON'	Turns correction on and does the first correction immediately.
'DRift Now'	Does one correction immediately and resets the 15 minute clock. The OFf/ON state is unaffected.

4.13   DUmp

Commands the 7061 to output data from its history file.
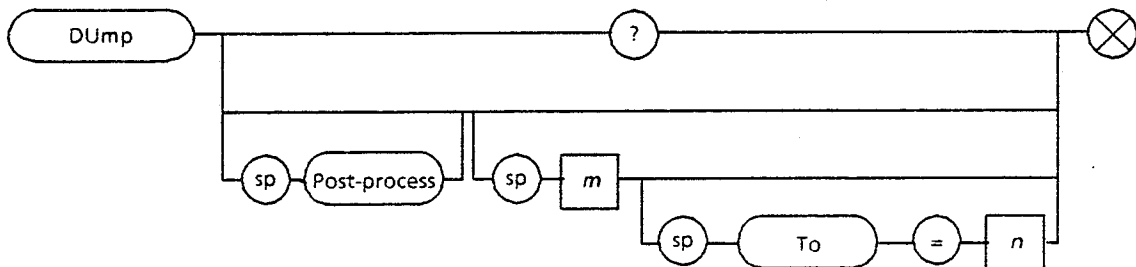
$1 \le m \le 1000 \,(8000)$ $1 \le n \le 1000 \,(8000)$

The latest file entry is held in location 1, the earliest in location 1000

History File Access:

DUmp ?	Gives the number of readings in the history file.
DUmp	The complete contents of the file are output, beginning with location 1.
DUmp 'm'	The content of location 'm' is output.
DUmp 'm' To 'n'	The contents of file locations 'm' through 'n' are output, starting with 'm' and ending with 'n'. For example, 'DUmp 200 To 101' will dump 100 readings in the order taken.
DUmp Process.......	Applies probe and/or program processing if these are selected.

With 'LIterals OFf' and no post-processing, readings are dumped at faster than 200 p/s.
If the memory expansion option is fitted, the size of the history file is increased to 8000 locations.
See 'MONitor' for the effect of that command on the DUmp command.

4.14   ENd

Sets the end time for the timer.

$00 \leq hh \leq 23$ $0 \leq d \leq 7$
$00 \leq mm \leq 59$
$00 \leq ss \leq 59$
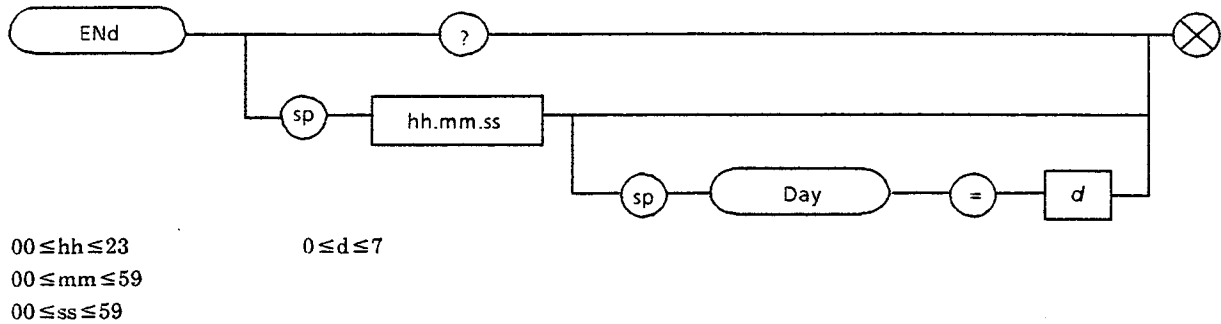
If the timer signal is set to operate in elapsed time, then timer trigger signals cease, with a delay equal to ENd time, after the timer was enabled. For each Day specified, the delay is increased by 24 hours.

If the timer is set to operate in real time, then time signals cease *at* the ENd time. When the Day is to be specified, the day on which the timer is enabled is regarded as DAY 0. The next day is Day 1, and so on up to Day 7.

4.15   EXEcute

Executes the stored string (see STRing command) of the specified number.

$0 \leq n \leq 9$
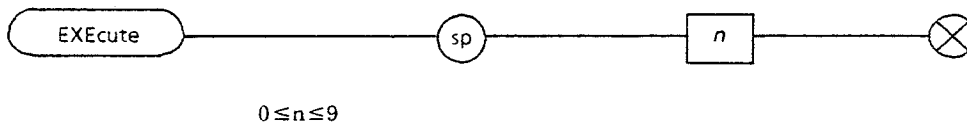
The 'EXEcute n' command should be last on its line as following commands are discarded.

4.16   EXTtrig

Defines the external trigger signal recognised by the voltmeter.
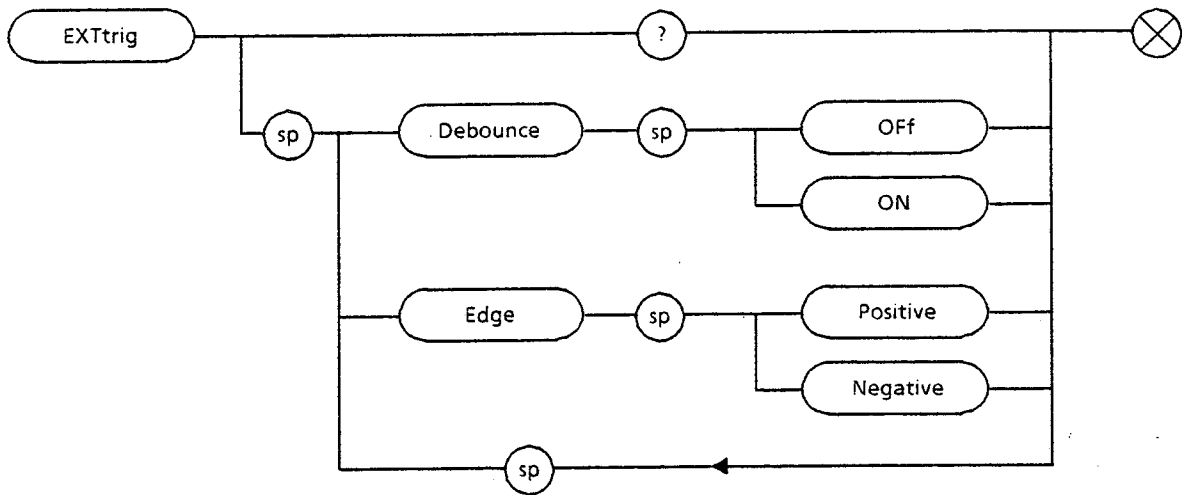
'Debounce ON' is for mechanical switch inputs.

The query command generates a single output string.

4.17   FIlter

Switches the filter on or off.
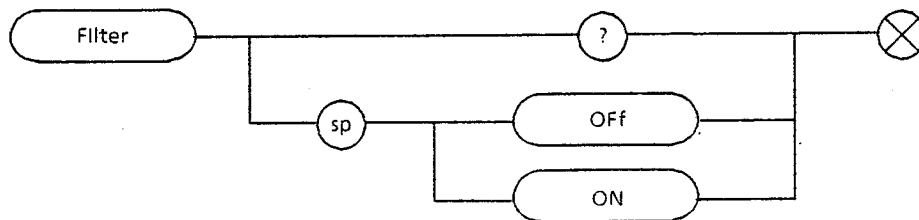
For ac measurements, FIlter improves low frequency response and hence accuracy. Use 'FIlter ON' for all ac measurements of 400Hz or below.

For dc measurements, FIlter improves noise rejection by increasing measurement integration time fourfold.

The use of the filter increases measurement integration and settling times.

4.18   FOrmat

Selects interface and display format.
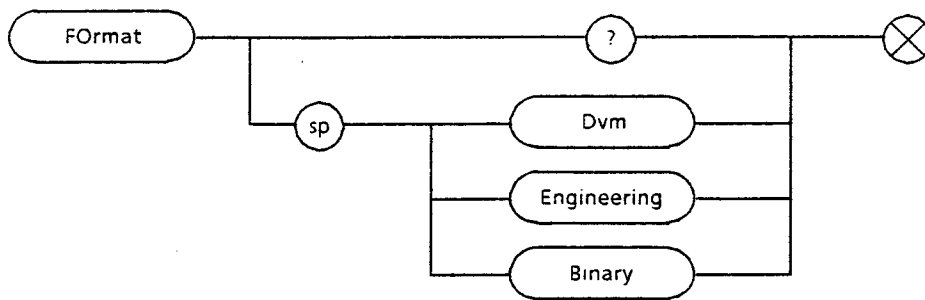
The diagram of formats in Appendix C shows the effect of the different FOrmat selections on the output.

Binary format

'Binary' affects only the interface. The display remains in 'Dvm'.

The binary output format used conforms to IEEE 754 'Standard for Binary Floating-point Arithmetic'. Only single format is used, giving four byte representation.
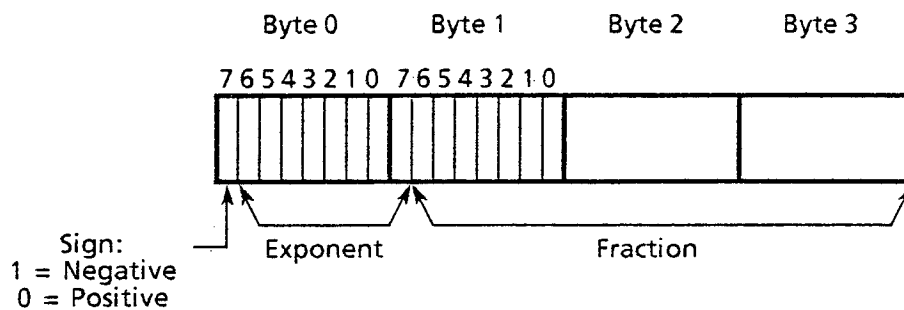
Bit 7 of byte 1 is implied as bit 23 of the fraction, and is equal to 1.

The exponent bias is 127, therefore :-

$$\text{number represented} = (-1)^S.2^{\text{exponent}-127}.(1.f)$$

where   s = sign bit
                f = fraction
and $0 < \text{exponent} < 255$

If exponent = 0 then number = 0
If exponent = 255 then number = $(-1)^S.\infty$

When using binary format, it is recommended that the controller uses EOI as a delimiter and that the voltmeter be configured to send EOI. See 'GPib Delimit' command.

4.19   GPib

Configures the GPIB.

$0 \leq m \leq 127$
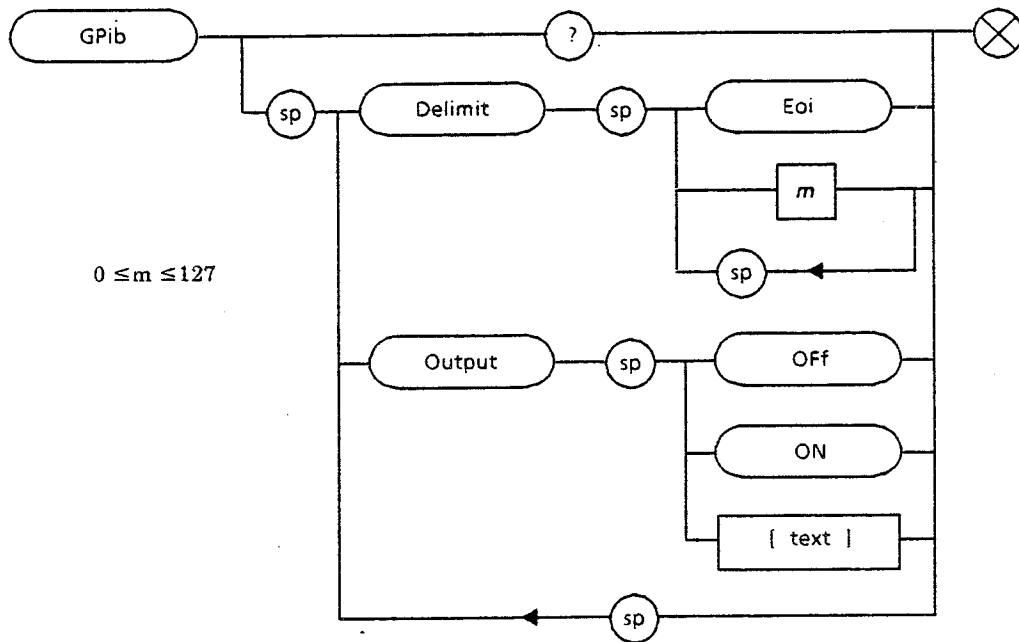
The maximum number of delimiter characters that may be used in a string is six. Eoi may be specified as one of the delimiters together with the decimal equivalents (m) of ASCII characters. For example, the command 'GP DEL EOI' sets the output delimiters on the GPIB to Eoi.

'Output OFf/ON' affects only measurement results, not text. 'Output [text]' allows the output of characters for use, for example, as messages or prompts. The total length of the command cannot exceed 80 characters.

The query command produces 1 output string.

GPIB talk/listen and GPIB output on/off are unaffected by Reset/Initialise/Resume. See Appendix A for further details.

4.20　History
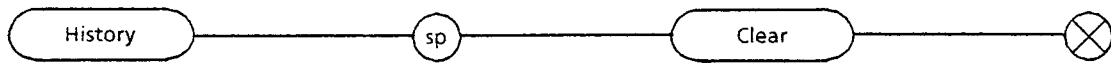
Allows clearance of the measurement buffer.

4.21　INItialise

Initialises the instrument to the settings shown in appendix A on adopted settings.

All variables are reset to the default values.

4.22　INTerval

Defines the interval which is to occur between successive TImer signals.

$00 \leq hh \leq 23$　　　$0 \leq d \leq 7$
$00 \leq mm \leq 59$
$00 \leq ss \leq 59$
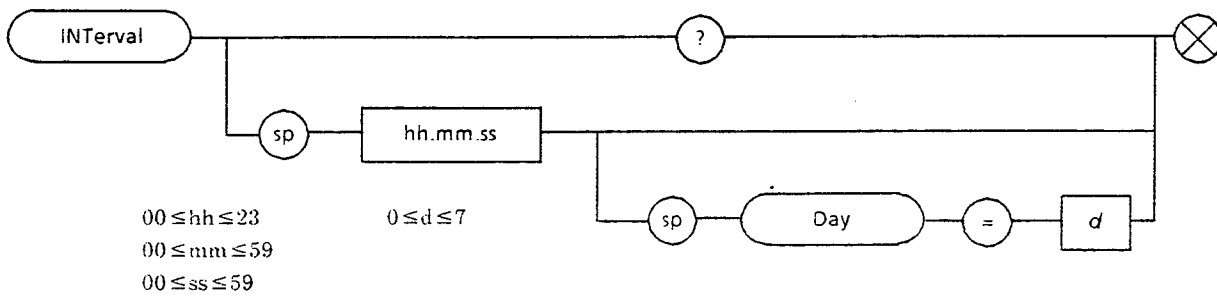
The same interval is applied for both elapsed and real time.

For each Day selected, 24 hours are added to the interval.

4.23   ITime

Selects either the 'normal' or the user-defined time for measurement integration.

0000.1s ≤ m ≤ 9999.9s
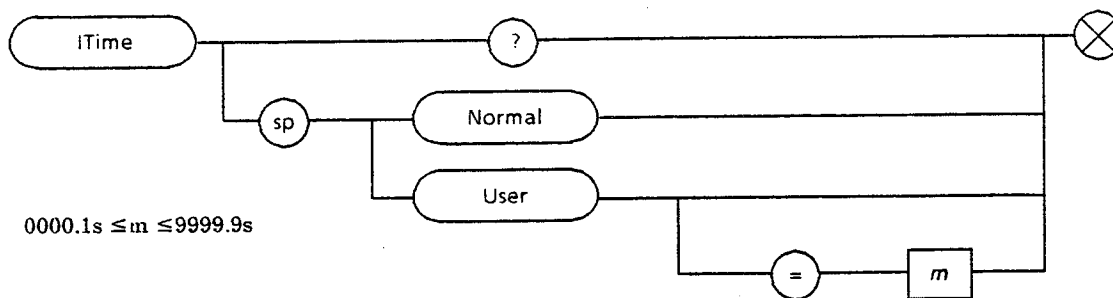
With 'ITime Normal', integration times are the default values, which are predetermined by the number of digits, measurement mode and filter settings.

These integration times may be overridden by a user-defined integration time (m), with a resolution of 0.1s.

In general, the previous setting of DIGits is used to control the number of digits displayed.

When 'ITime User' is selected, the number of digits produced by each result is still determined by the DIGits command. If, however, the setting of DIGits is greater than is valid for the selected ITime, then the setting is overruled (but not altered). If the setting of DIGits is less than is valid, only the number of digits set is displayed.

The breakpoints are:

User-ITime	Number of digits
2.0s ≤ ITime	7
0.2s ≤ ITime ≤ 1.9s	6
ITime = 0.1s	5

Note. Using the DIGits command automatically sets ITime to Normal.

4.24   LIterals

Suppresses the non-numeric portion of a result output string.

```
   ┌─────────┐                    ┌───┐
──(  LIterals  )────┬──────────────( ? )────────┬──────⊗
   └─────────┘      │              └───┘         │
                    │   ┌──┐    ┌────────┐        │
                    └───( sp )──┬─(  OFf   )──────┤
                        └──┘    │ └────────┘      │
                                │ ┌────────┐      │
                                └─(  ON    )──────┘
                                  └────────┘
```
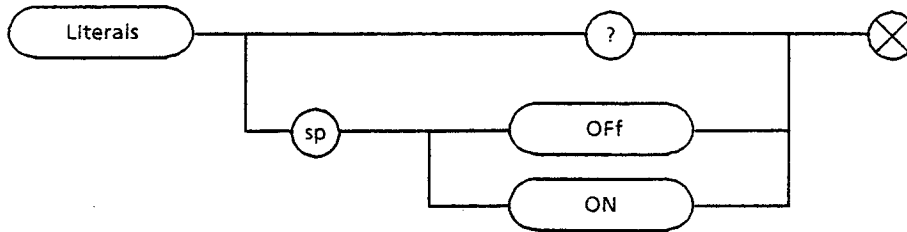
With 'Literals ON', a typical measurement result output string may be :

'+2.798450   VDC   CHAN 4'

With 'Literals OFf', the same output string would be :

'+2.798450'

4.25   LOckout

Enables/disables the action of the voltmeter front panel keys.

```
   ┌─────────┐                    ┌───┐
──(  LOckout   )────┬──────────────( ? )────────┬──────⊗
   └─────────┘      │              └───┘         │
                    │   ┌──┐    ┌────────┐        │
                    └───( sp )──┬─(  OFf   )──────┤
                        └──┘    │ └────────┘      │
                                │ ┌────────┐      │
                                └─(  ON    )──────┘
                                  └────────┘
```
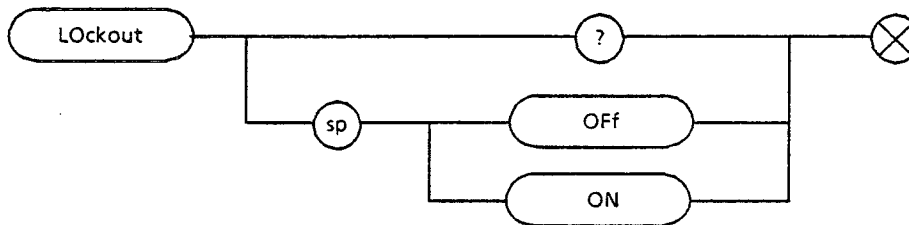
When in remote mode, all keys on the front panel of the voltmeter are disabled except for the LOCAL key.
'LOckout' enables a GPIB controller incapable of issuing a 'local lockout' (LLO) command to enable/disable the action of the LOCAL key on the front panel. Thus the front panel may be completely disabled.

With lockout on the following applies:

LOckout ON   The LOCAL key is disabled regardless of whether LLO has been sent.

The GPIB 'go to local' (GTL) command, or disabling the GPIB remote enable line REN, will return the voltmeter to local without local lockout.

With lockout off the voltmeter conforms to the IEEE488 STD.

LOckout OFf   Enables the LOCAL key and leaves the voltmeter in remote.

4.26   MEmory

Stores the last displayed result, or a user-defined number in the memory location.

$$-10^{18} \leq m \leq +10^{18}$$
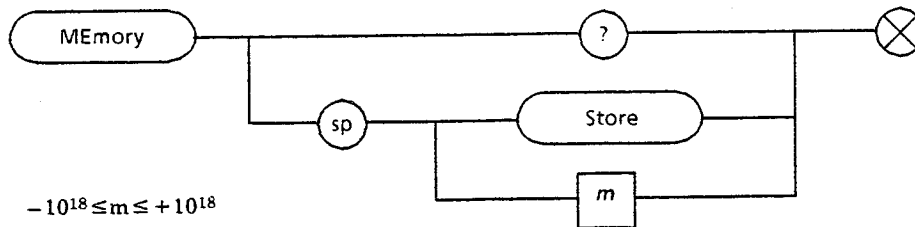
This value may be used when setting up programs and when specifying capture values, as shown on the relevant syntax diagrams.

4.27   MODE

Selects the required measurement mode.
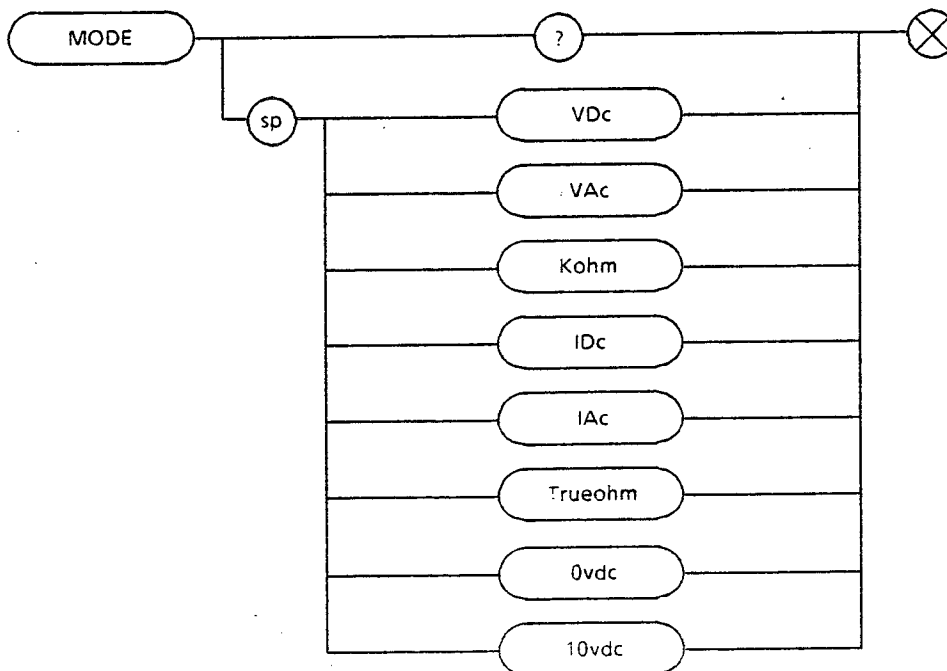
0vdc and 10vdc are reference voltages, used for maintenance, and selectable via the interface only.

The query command gives both MODE setting and front/rear switch setting, for example, 'MODE VDC REAR'. The entire string can be sent back to the voltmeter, but the front/rear word is ignored.

4.28   MODIfy

Enables changes to be made to an active program.
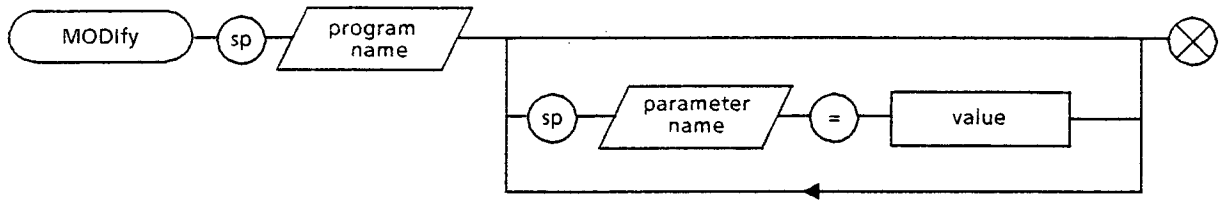
Only parameters requiring change need be specified. Refer to the section on Programs.

4.29   MONitor

Displays and outputs readings from selected channels.
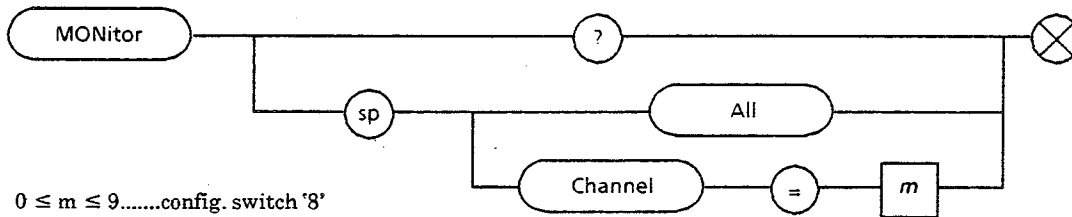
$0 \leq m \leq 9$.......config. switch '8'
$0 \leq m \leq 17$.....config. switch '16'

Effect on display:

	Monitor All	Monitor Channel 'm'
SCan OFf	Display at normal rate.	Display of channel 'm' at normal rate. (Other channels not displayed.)
SCan ON	Display at slow rate according to scan sequence.	Display of channel 'm' at normal rate.

Notes: If 'Monitor Channel m' is specified and no readings from 'm' are taken, no readings will be displayed.

4.30   NInes

An alternative to the DIGits command for compatibility with earlier instruments. Refer to 'DIGits'.

4.31   NUll

Allows cancellation of small dc offsets up to 2% of Vdc, Idc, Ohms and TrueOhms ranges.
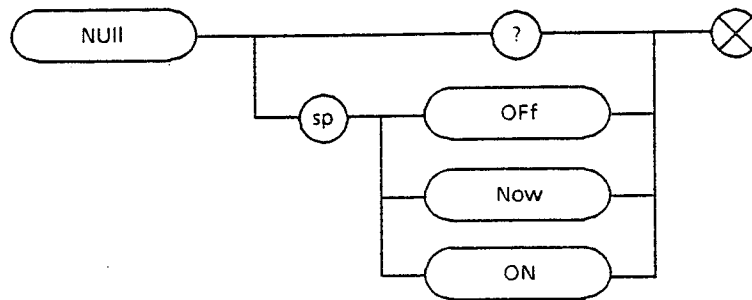
'NUll Now' measures the input, stores it as the null value and enables nulling.
Nulling on auto-range causes all the ranges of the selected mode to be nulled.
Nulling on a fixed range nulls only that range.

'NUll OFf'; Disables nulling on the selected channel but retains values.

'NUll ON'; Enables nulling on the selected channel using previously stored values.

Each channel has its own independent set of nulls. The null command applies to the selected channel.

On channels 0 and 1, nulls can be held for all nullable measurement modes and ranges simultaneously.
On channels 2...17, nulls can only be held for the ranges of any *one* nullable measurement mode, e.g. for all ranges of Vdc only.

4.32   ONTImer

Defines the action that the voltmeter takes when a time signal occurs.
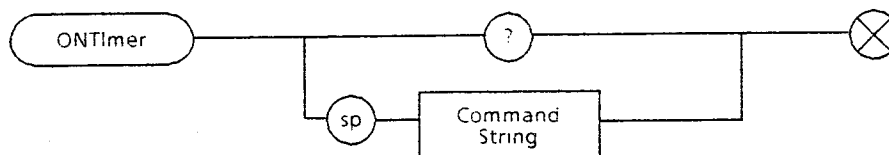
The default command string is TRIgger. The command string is delimited by a line feed. Any character except LF (line feed) may appear within the command. The ONTImer command must be the last on any one line.
As an example, 'ONTImer TRIgger : CLock? ' produces time-recorded measurements.
The query command gives two strings, in this example - 'ontimer' 'trigger : clock?'.

4.33 ONTRigger

Defines the kind of measurement made when the voltmeter receives a trigger.

ONTRigger — ? — ⊗

sp — Sample — = — m — sp — Integral — sp — ON / OFf

Burst — = — n

Gated — sp — Integral — sp — ON / OFf

Capture — sp — Above — = — p / Mem — sp — Integral — sp — ON / OFf
Below
Overrun — = — q
sp

$1 \leq m \leq 1000/8000*$
$1 \leq n \leq 1000/8000*$
$-10^{18} \leq p \leq +10^{18}$
$1 \leq q \leq 1000/8000*$

*memory expansion
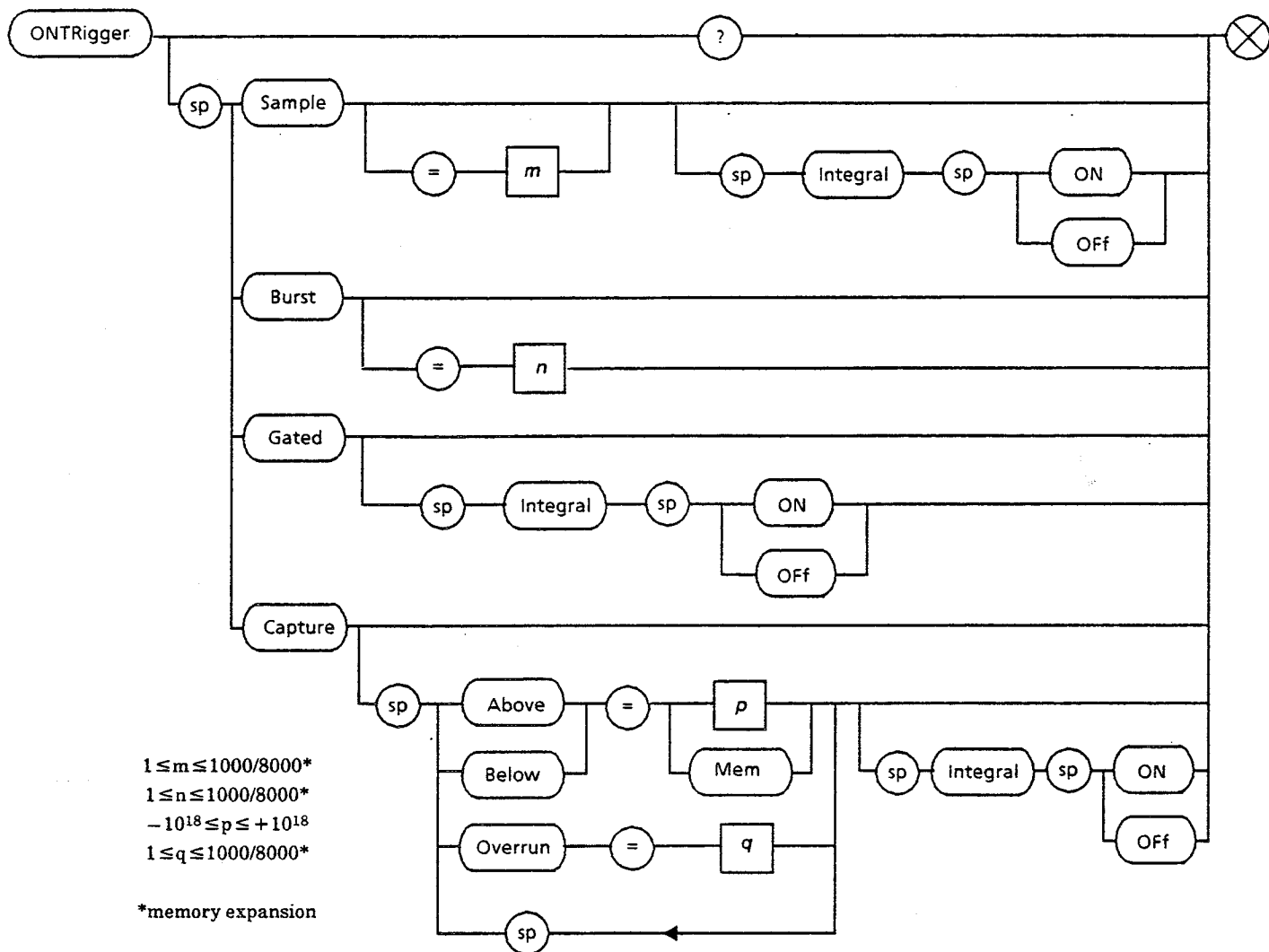
'ONTRigger Sample'   TRIgger starts a series of 'm' measurements. The default value is $m = 1$. If SCan is on, 'm' scan sequences are made.

'ONTRigger Burst'   Makes a series of 'n' readings at the rate of 1500 per second.

'ONTRigger Gated'   A measurement starts within 1ms of one TRIgger and finishes within 1ms of the next.

'ONTRigger Capture'   TRIgger starts repetitive measurement. When a measured result is Above or Below a user-defined value 'p' (or memory value), a series of 'q' Overrun measurements is made.

'ONTRigger Burst' forces the following conditions:
        Digits 4, Filter Off, Ratio Off, Scan Off, Track Off, Output Normal.

When using Burst, the instrument must be in one of the following measurement modes:
        Vdc, Idc, K ohms:-0.1→1000KΩ ranges, with RANge **not** set to Auto.
Attempted use in any other mode will generate an error. Also, the receipt of any command other than TRIgger will change the setting to 'ONTRigger Sample'.

4.33.1   TRIGGER OPERATION

Sampled Measurements
Sampled measurement starts on receipt of a trigger and continues for 1 to 1000 measurements (or 1 to 8000, with the memory expansion option), as defined by the user. Maximum speed with 4 digits set is 1000 readings per second.

Gated measurements
A gated measurement starts within 1ms of one trigger and finishes within 1ms of the next. Gated measurements may be made in all measurement modes except True ohms, and RATIO must be off. Also, fixed range should be selected and SCAN must be off, although any channel may be used.

Captured Measurements
To 'capture' measurements the voltmeter starts measuring continuously (as in TRACK) on receipt of a trigger. When a measurement result reaches the pre-defined value (Above = , or Below =), the voltmeter continues until a pre-defined number Overrun measurements has been made, and then stops. By varying the Overrun value, the first captured measurement may be positioned at any convenient point in the History file. This gives a choice of the number of results available for examination before and after an event.
The front panel trigger LED is lit during capture and overrun. Captured measurements may be made in any measurement mode and RATIO may still be used. Capture can be made on any channel, but its selection turns off SCAN. Maximum speed with 4 digits set is 1000 readings per second.
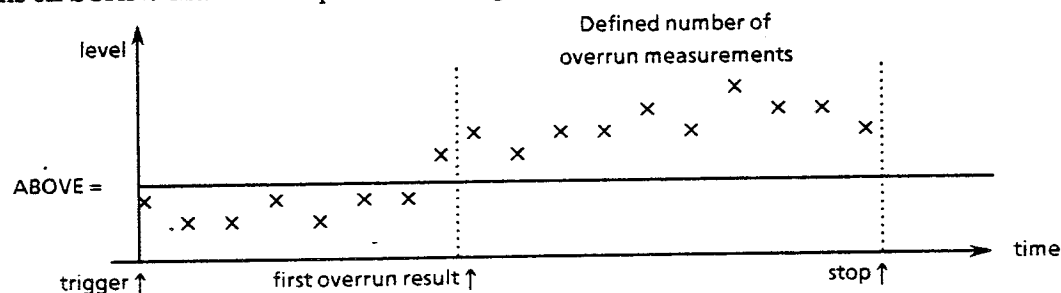
Integral Function
When the integral option is selected (see trigger operations on the previous page) the voltmeter automatically performs a time integration, multiplying the value of measured quantity by the time (in seconds). The 'INTG' in the display or 'INTEG' across the interface indicates that an integration has been taken. If the voltmeter is used to measure voltage, or current, or resistance, the units for these respective intergrations will be mA-seconds, V-seconds, or kΩ-seconds.
For **sampled or captured measurements** the integral function uses either the standard integration time (defined by the number of digits selected), or the user-defined ITIME. (Refer to Digits key, Chapter 3, section 9.)
For **gated measurements** the integral function takes the time between the starting trigger and the terminating trigger.

Burst Measurements
The fastest way of making readings (1500 p/s), in a series of pre-defined length.

Notes.   If a TRIgger is sent before the previous measurement has finished, readings cease to be output from the first measurement but may still be available in the History file unless overwritten by the second measurement.
If more than one TRIgger command is used in a single line of instruction, and data from a later TRIgger command 'runs into' data from the first, in the History file, then the error message 'HISTORY OVERFLOW' is output. The total number of measurements generated in one line of instruction cannot exceed the number of memory locations.

Example of a 'CAPTURE' measurement
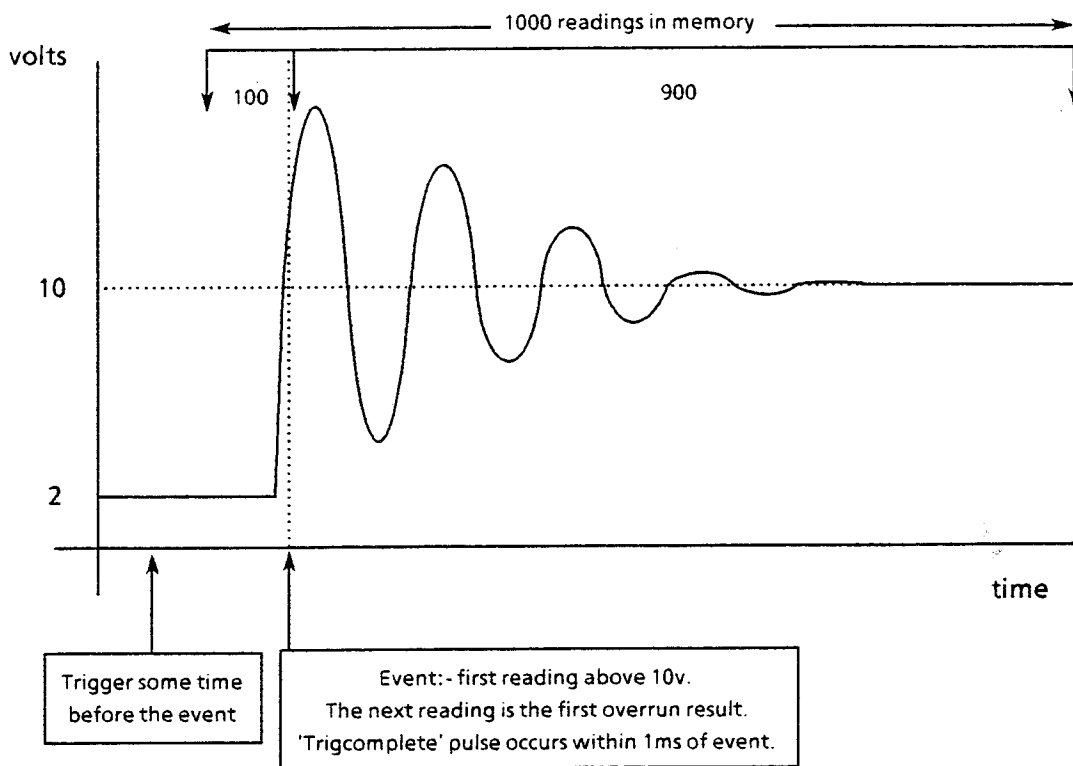
To set up the voltmeter to 'capture' a waveform knowing that the final output is 10 volts:-

Use : " ONTRIGGER CAPTURE ABOVE = 10.0 OVERRUN = 900 "

Then : " TRIGGER "

After the triggered measurement, there are 1000 readings in the History file consisting of 100 readings made up to and including the event and 900 overrun readings made after the event. Thus the complete waveform may be recorded.

External Triggering.
When external triggering is used, the voltmeter should be told what sort of trigger to expect, i.e. positive or negative edge, de-bounce off or on. (Debounce is for mechanical switch inputs.) This can be done through the EXTTRIG command.
'ExtTrig' is a BNC input connector on the rear panel, using TTL signal levels. On receipt of an 'ExtTrig' trigger signal, there is the same effect as if the front panel TRIGGER key had been pressed.

TrigComplete signal
The 'TrigComplete' socket is a rear panel BNC output which is normally high but which pulses low for typically 4µs, after the completion of the measurement sequence. This pulse may be used, for example, to advance external circuitry such as a scanner.
During captured measurements, the pulse is output on the first occurence of a measured value outside the capture limit. The output is high again throughout overrun.
When using the LIMITS program, if 'ALARM ON' is selected, a pulse is output each time an out-of-limits measurement is made.

CAUTION. Sending a new Trigger from any source, or sending any other command, before the previous measurement has been completed, stops the present action and starts a new one.

4.34 OPtion

Allows the settings of configuration switches to be examined over the interface.
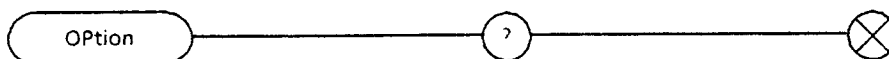
Configuration can be changed only by alteration of mechanical switches followed by a RESET.
"OPTION?" returns a number in the range 0 to 32767. This corresponds to a 16-bit binary number. The binary values have the meanings shown below. The controller must have a BIT or AND command to decode the decimal number.

decimal value	bit	
1	0	} line frequency selection*
2	1	
4	2	ALWAYS SET TO ONE
8	3	70612 option†, 1 = 8 channel
16	4	
32	5	
64	6	
128	7	
256	8	
512	9	
1024	10	70613 option, 1 = fitted
2048	11	Normal/Cal, 1 = normal
4096	12	Front/Rear, 1 = front
8192	13	
16384	14	7061/7062 1 = 7062
32768	15	ALWAYS SET TO ZERO

```
* Line frequency 0 = 50Hz        † 70612    0 = 16, 2-pole channels
                 1 = 400Hz                  1 = 8, 4-pole channels
                 2 = 60Hz
                 3 = 50Hz
```

Options list:

```
70612   Scanner
70613   Memory expansion, 8000 locations
```

Example: Transmit 'OPtion?' to instrument

Returns with '2054'

This corresponds to:

	2054
7061	0
rear input	0
Normal (not Cal)	2048
	6
no memory expansion	0
16 channel scanner	0
bit two always set to one	4
	2
60 Hz line frequency	2
	0

4.35   OUtput

Selects output rate on the GPIB.
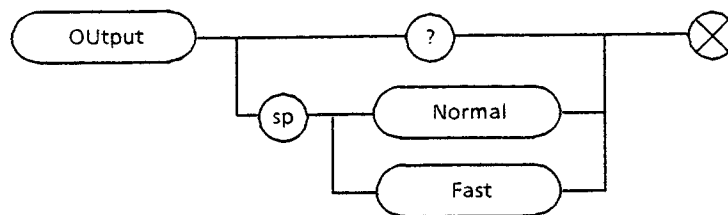
'OUtput Normal'   Gives results at 10 per second and allows fast input at 1000 readings per second. This is the default condition of the voltmeter.

'OUtput Fast'   Gives a continuous output rate of up to 500 per second with track on. A new reading starts when the previous one has been output. An individually triggered reading may be output to the bus within 3ms (4 digits).

'OUtput Fast' forces the following conditions:

Digits 4
Filter Off
Ratio Off
Scan Off
Format:- Eng is changed to Dvm
Ontrigger Sample

Also, all the front panel keys are disabled, with all the LEDs out.

The following settings are assumed, although present settings are not altered:

Display Off
Probes Off
Programs Off

(The display reads 'DISPLAY OFF')

When using 'OUtput Fast', the instrument must be in one of the following measurement modes:

Vdc, Idc, K ohms:- $0.1 \rightarrow 1000$ KΩ ranges.

Attempted use in any other mode will generate an error.

See Appendix B for details of measurement timings.

4.36   PROBes

Permits use of accessory probes. Probe processing may be switched in or out of any channel and the kind of processing may be set up independently for each channel.

*m and n must be specified in ohms
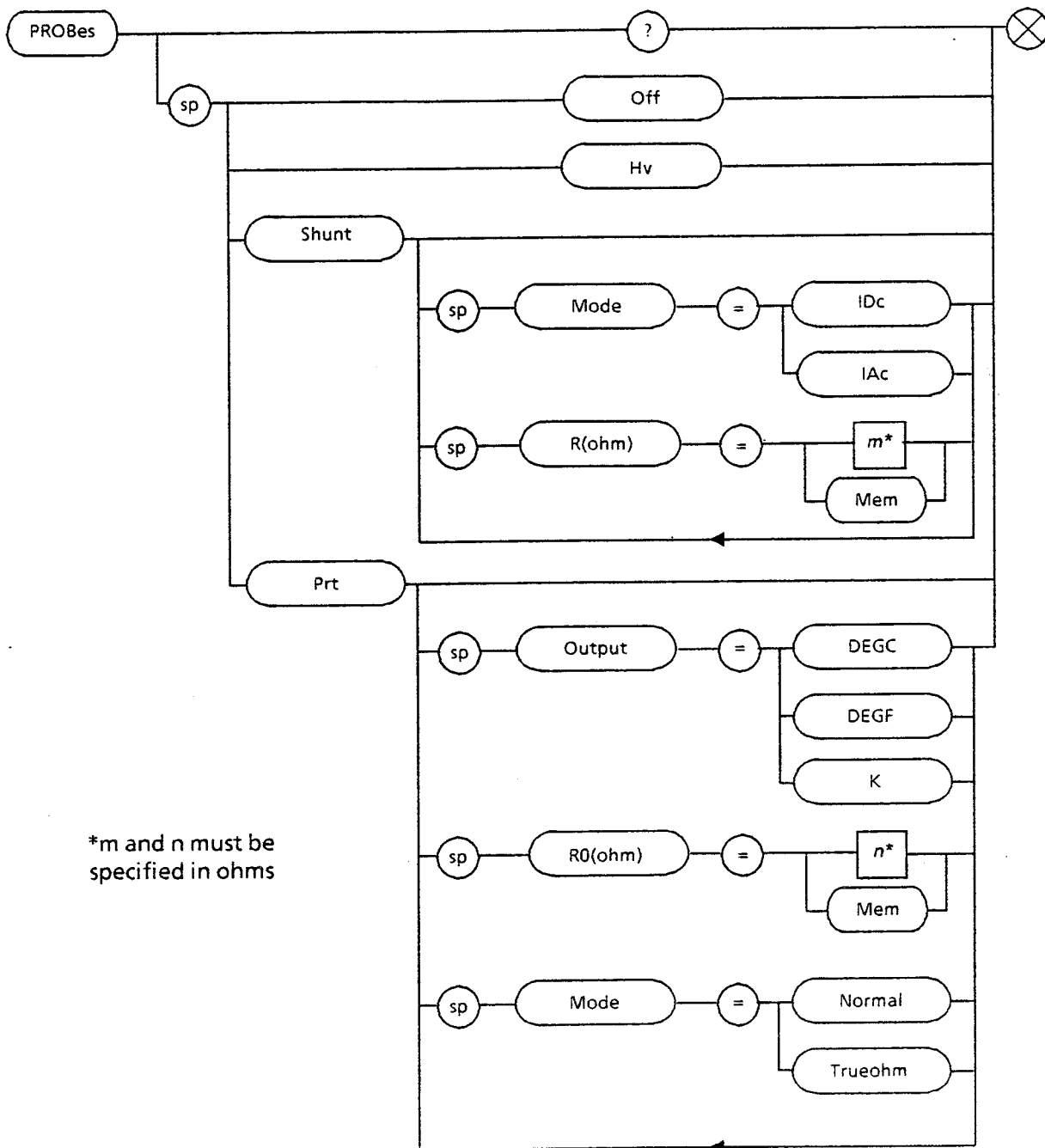
'PROBe Off'   Deselects any probe already in use.

'PROBe Hv'   Enables a high voltage probe to be used on channel 0, and sets the voltmeter to VDC Autorange. All results are multiplied by 100 to give displayed results in volts.

'PROBe Shunt' Enables a current shunt to be used, and sets the voltmeter to the appropriate function (Idc or Iac), autorange and divides all the results by the user-defined shunt resistance, R. Results are displayed in milliamps.

'PROBe Prt'   Enables a platinum resistance thermometer (prt) to be used, sets the voltmeter to Kohm, Autorange and linearises all measurements to give the required units. The user specifies prt resistance R0 (resistance at 0°C), normal or trueohm measurement, and the required display, either Celcius, Fahrenheit or Kelvin. Results are displayed as temperatures.

'PROBe Off is selected automatically when a mode command is received.

4.37   PROGrams

Switches all SELected programs on or off for the present channel selection.
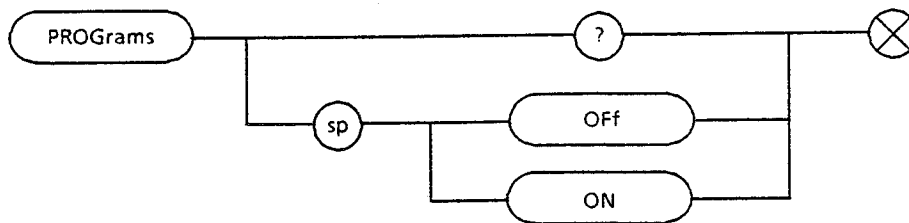
When a program is SELected, 'PROGrams' is automatically set 'ON'. If all programs are cancelled, 'PROGrams' is set 'OFf'.

4.38   RANge

Selects either a fixed measurement range, or autorange.
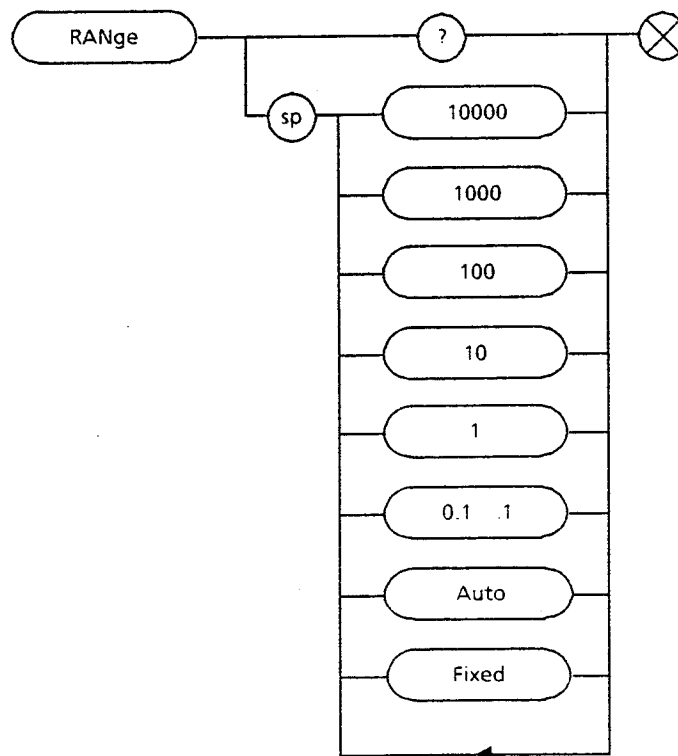
'RANge Auto' enables range changing to suit the input signal. Not all ranges are available for all measurement modes, but no error is produced if an illegal range is selected.

4.39 RATio

Divides or multiplies the present measured value by the value from a specified channel.
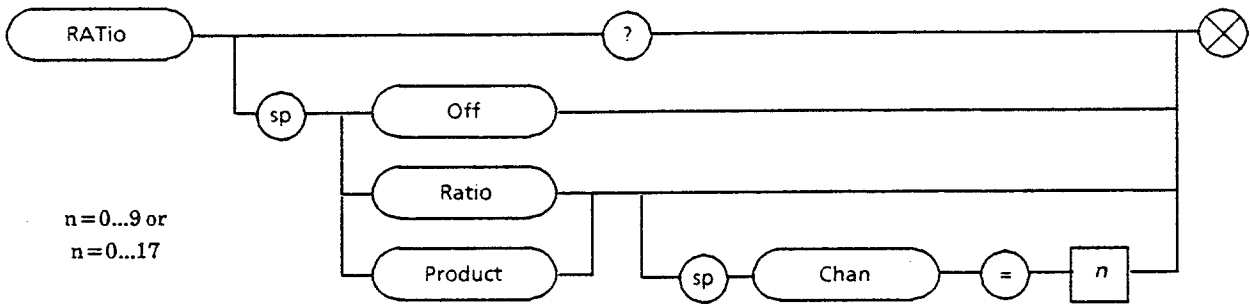
The default value is n = 1, ie. the reference channel.

4.40 RECall

Permits examination of settings and results of active programs.
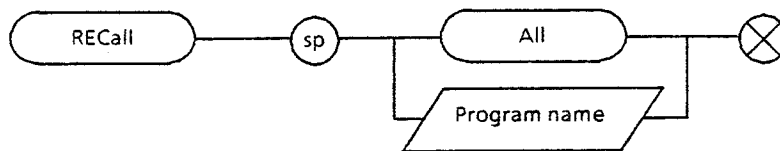
'RECall All' causes output of the number of active programs, followed by the names of the programs in their order of selection.

'RECall "Program name"' causes output of all settings and results of the specified active program.

4.41 RESEt

Clears the results, (if any),of an active program. Its settings are unaffected.
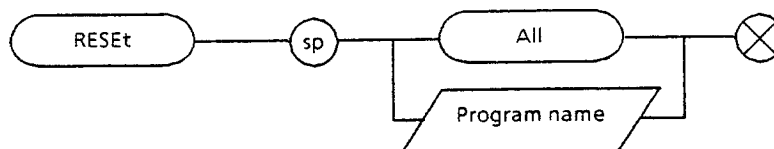
4.42 RESUme

Determines the condition of the instrument at switch-on.
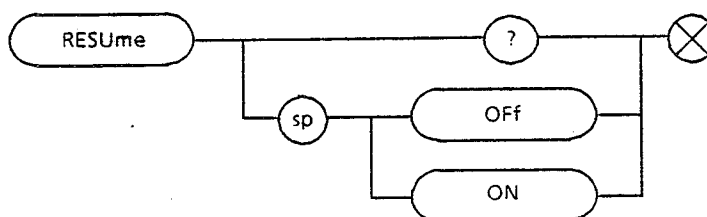
'RESUme OFf' causes the instrument to "INITIALISE" when next switched on, ie. a full reset occurs.

'RESUme ON' causes the instrument to "RESUME" its previous settings, i.e. measurement set-up and probe and program parameters, when next switched on. This is provided to allow continued operation after a power failure.

See appendix A on Adopted Settings.

4.43 SCan

Switches channel scan on or off and enables selection of channels to be scanned.

$0 \leq n \leq 9$
or
$0 \leq n \leq 17$
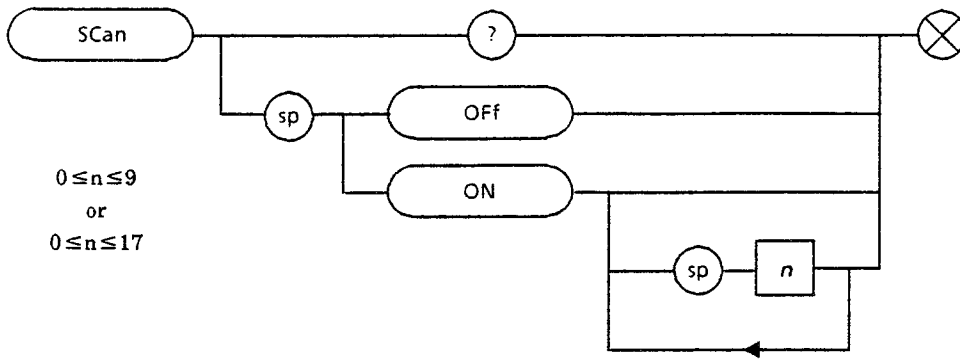
Up to 18 channels may be included in a scan sequence.
Channels may be set in any order in a scan command.
Channels are scanned in the order in which they were set in the command.
The same channel may appear more than once.
Virtual channels may also be scanned.
See 'CHannel' command section for channel details.
For important timing information concerning scanning, see Appendix B.

If the power fails during a scan sequence, when power is restored the next scan sequence starts at the beginning again, not at the point where the power failed. See Appendix A for details of track and trigger after a power failure.

4.44 SELect

Calls-up programs for use, and allows setting of parameters.

4.45   SRq

Controls generation of the service request.

SRq Error ON   Srq generated when,   a) Command cannot be interpreted.
                                        b) Command cannot be executed.
                                        c) Calibration fault occurs.
                                        d) Input message too long (>80 characters).

SRq Output ON   Srq when output is available. Output may be measurement data, user messages etc..

SRq Ready ON   Srq when a measurement operation is completed and the voltmeter goes to the 'not busy' state.

SRq User ON   Srq when the front panel Srq key is pressed.

Alternatively, an Srq may be specified by its serial poll status number, i.e. :
         SRq 32   Srq on error.
         SRq 8   Srq when output available.
         SRq 16   Srq when voltmeter ready.
         SRq 4   Srq from front panel key.

Serial poll numbers may be combined, e.g. :
         SRq 40   Srq on 'error' and 'output available'.

The query command provides a string in the form 'SRQ nn'.

4.46   STAtus

Allows the last error detected (if any) to be examined.

An output string generated in response to this command contains an error number followed by a brief descriptive phrase. The position of the error number in the string is fixed.
Once reported, the error status reverts to the no error condition. A typical response to the command might be:

'ERROR 13 PROGRAM NOT SELECTED'

Note :
The error message can be read once only. It is replaced by the message 'ERROR 00 OK'.

4.47   STRing

Allows user-definition of 10 strings.

$0 \leq n \leq 9$
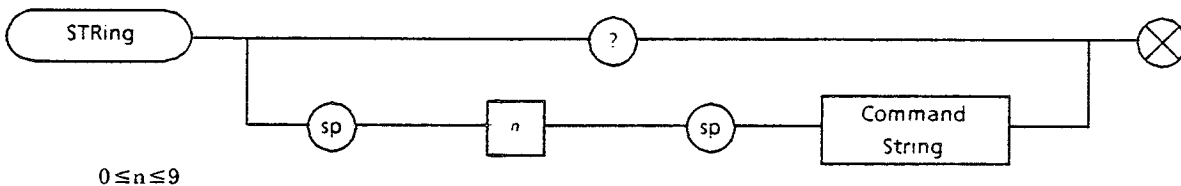
Up to 10 command sequences may be stored, then executed at any time by specifying the required number, using the EXEcute command.

The commands must be delimited by a line feed, and colons are allowed between characters (as with the ONTimer command). The query command gives eleven lines, 'S' plus the ten command strings.

4.48   TImer

Provides control of the timer.
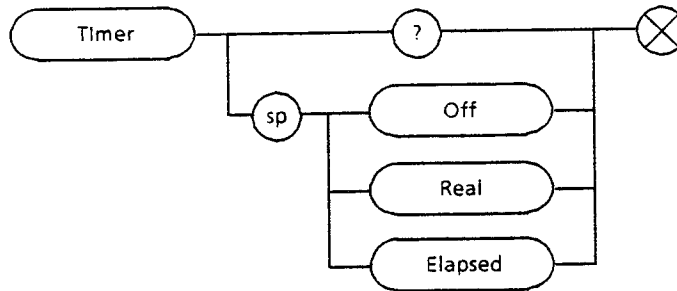
When the timer is enabled, trigger signals begin according to the 'BEGin' command setting and end according to the 'ENd' command setting. The period between successive triggers is set by the 'INTerval' command.

'TImer OFf'   De-selects the timer (without affecting the setting of the clock).

'TImer Real'   After enabling, timer trigger signals begin *at* the BEGin time. Timer signals cease *at* the ENd time. When the Day is to be specified, the day on which the timer is enabled is regarded as DAY 0. The next day is Day 1, and so on up to Day 7.

'TImer Elapsed'   Following enabling, a trigger must be sent, then time signals begin *after* a delay equal to the BEGin time. For each Day specified, the delay is increased by 24 hours. Trigger signals cease with a delay equal to ENd time after the timer was enabled. For each Day specified, the delay is increased by 24 hours.

See Appendix A for details of resume conditions in the event of a power failure when the timer is on.

4.49   TRAck

Enables/disables repetitive measurement.
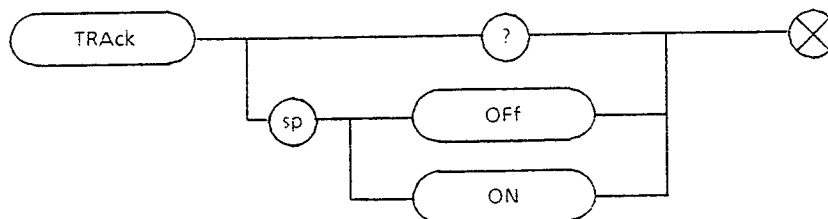
'TRAck ON' Causes self triggering and repetitive measurement.

'TRAck OFf' Inhibits the facility. This condition is forced when a TRIgger is received.

4.50   TRIgger

Starts a measurement sequence.

```
  ( TRIgger )————————————————⊗
```
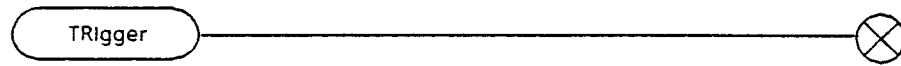
The measurement sequence that occurs is defined by the set-up of the 'ONTRigger' command. TRIgger turns TRAck off.

5 COMMAND SET --- CRYPTIC

Cryptic commands are available for Mode, Range, Digits, Trigger, String and Execute.

In general, the command syntax is is that of a single character followed by an integer argument or a command string. Separators are not required between commands and spaces are ignored. The optional use of colons is explained at the end of the section.

5.1 MODE Selects measurement mode.

	Response
M ?	← RECALL
0	← VDC
1	← VAC
2	← KOHM
3	← IDC
4	← IAC
5	← TRUEOHM
6	← Future use.
7	← Future use.
8	← 0VDC
9	← 10VDC

5.2 RANGE Selects measurement range.
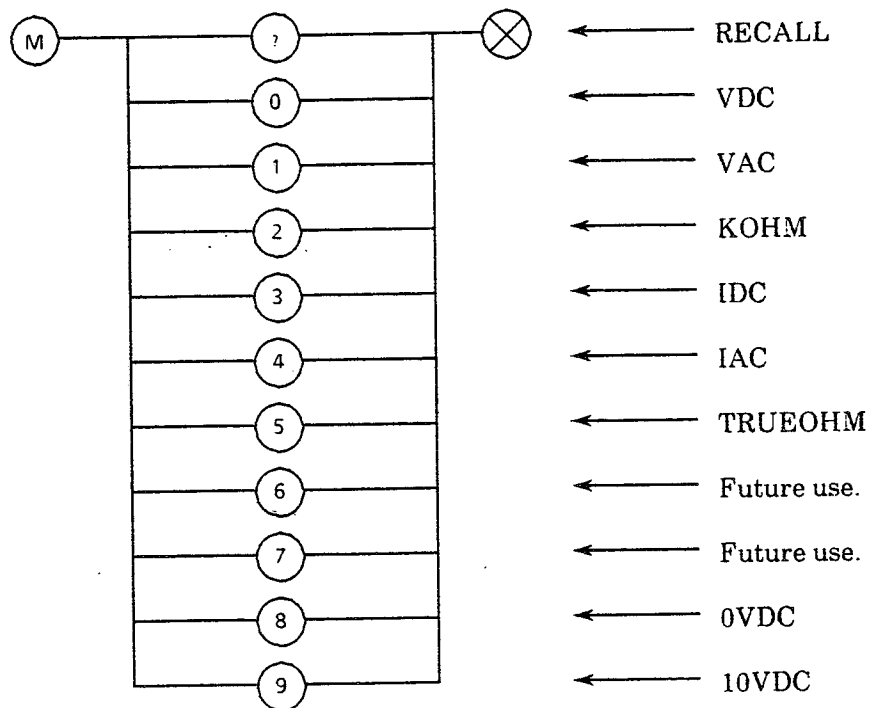
	Response
R ?	← RECALL
0	← AUTO
1	← 0.1
2	← 1
3	← 10
4	← 100
5	← 1000
6	← 10000
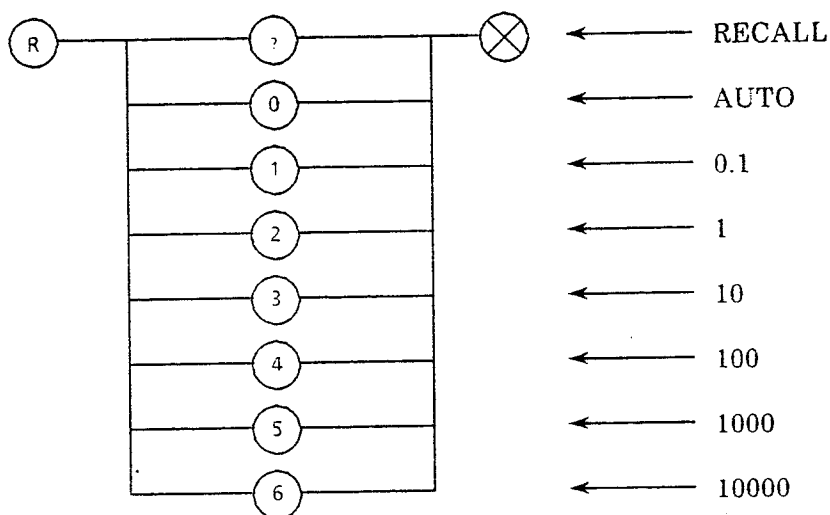
The query command, R?, produces a response in the form $R\alpha\beta$, where $\alpha = 0$ for fixed range or 1 for autorange, and $\beta = 1 \rightarrow 6$ according to range, as above.

5.3   DIGITS   Selects number of digits.
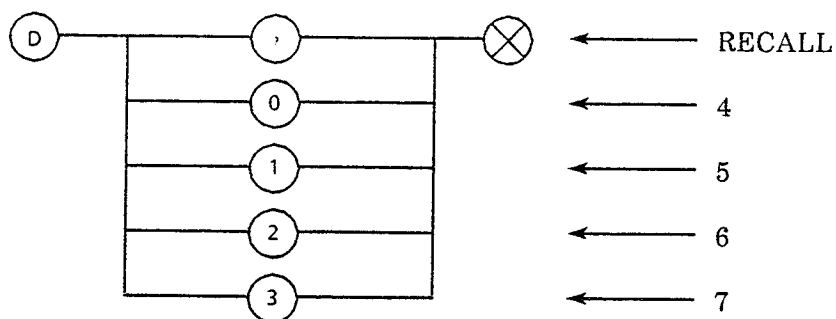
5.4   TRIGGER   Generates a trigger.
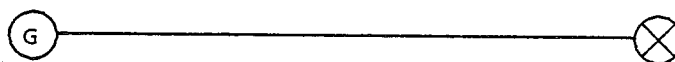
5.5   STRING   Sets up command strings.

$0 \leq n \leq 9$
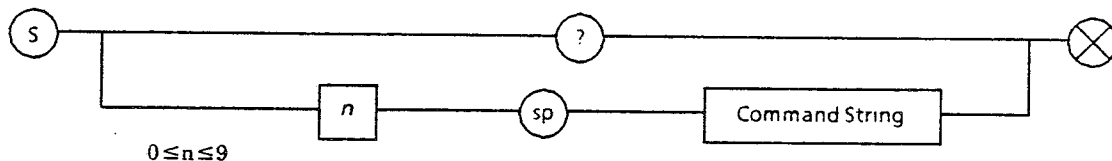
The command string can contain a mixture of cryptic and verbose commands provided that the 'colon rule' is observed (see below).

Strings are blank until programmed and the query command outputs 11 lines, 'S' then one line for each command string.

For example, use string 3 to program 'Reset, 10kΩ range, make 2 measurements', and then execute the sequence using 'X3'.

S3[DC1:M2R3GG]X3

5.6   EXECUTE   Executes command strings.

$$0 \leq n \leq 9$$
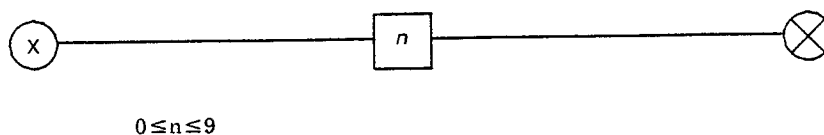
The string of the specified number will be executed. If the selected string is not programmed, it will have no effect.
Any commands following an 'EXEcute' will be ignored, as control passes to the specified string.

5.7   THE COLON RULE FOR CRYPTIC COMMANDS

Colons are optional within totally cryptic commands.
If a verbose form is used as part of a command however, a colon must follow it.

For example:		
M1R3D2GG	O.K.
M1:R3:G	O.K.
M2RANGE 2GG	ERROR
M2:RANGE 2GG	ERROR
M2RANGE 2:GG	O.K.

6 PROGRAMS

These are not commands and can be used in conjunction with the program commands **SELect, RECall, MODify, RESEt,** or **CANcel** only. There are seven programs in the instrument:

<div align="center">

%deviation Divide   Limits   Maxmin

Offset   Scale   Statistics

</div>

Each of the programs may be in one of two states:- Active or Idle. Programs SELECTed are held in the Active list whilst unused programs remain in the Idle list. Selecting and setting up a program transfers it from the Idle list to the Active list; cancelling a program has the reverse effect.

<div align="center">

SELECT

</div>

<div align="center">

(unused programs)   CANCEL   (programs in use)

</div>

Programs may be used individually, or linked together to perform more complex computations, in which case they are executed in their order of selection. Note that a program can appear once only in a sequence of programs.

Program processing may be switched in or out of any channel and the kind of processing may be set up independently for each channel or virtual channel.

Action of program commands on programs:

Command	Description
SELECT	Causes programs in the Idle list to be selected. The display prompts the setting up of program options and variables.
RECALL	Allows details of an Active program to be examined. Options, constants, and results can be displayed by repeatedly pressing 'skip'.
MODIFY	Permits new options or constants to be put into Active programs by overwriting the old ones.
RESET	Erases the results of Active programs either one program at a time or all at once.
CANCEL	Returns programs from the Active to the Idle list. Constants are not altered but results are automatically reset.

Measurement rates are slowed by pre-processing. The extra delay per measurement is from 1ms to 30ms depending on the processing applied.

6.1 %deviation

Computes the percentage deviation of an input from a user-defined nominal value N.
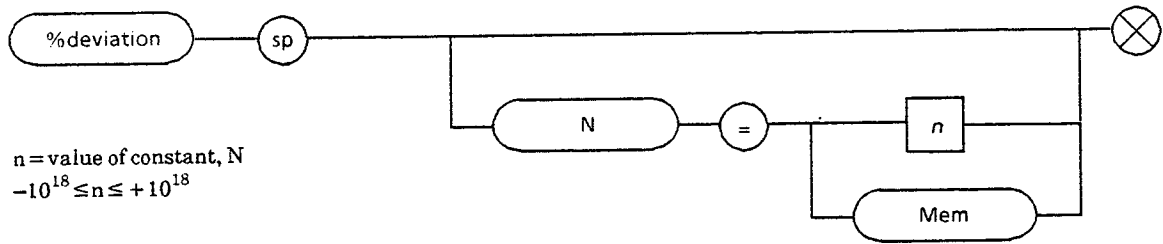
$n =$ value of constant, N
$-10^{18} \leq n \leq +10^{18}$

Calling the measured value x, then the % deviation is given by:

$$y = 100\,(x{-}N)/N$$

6.2 Divide

Takes the measured input x and acts on it in one of six ways with a user-defined constant N, giving an output y.
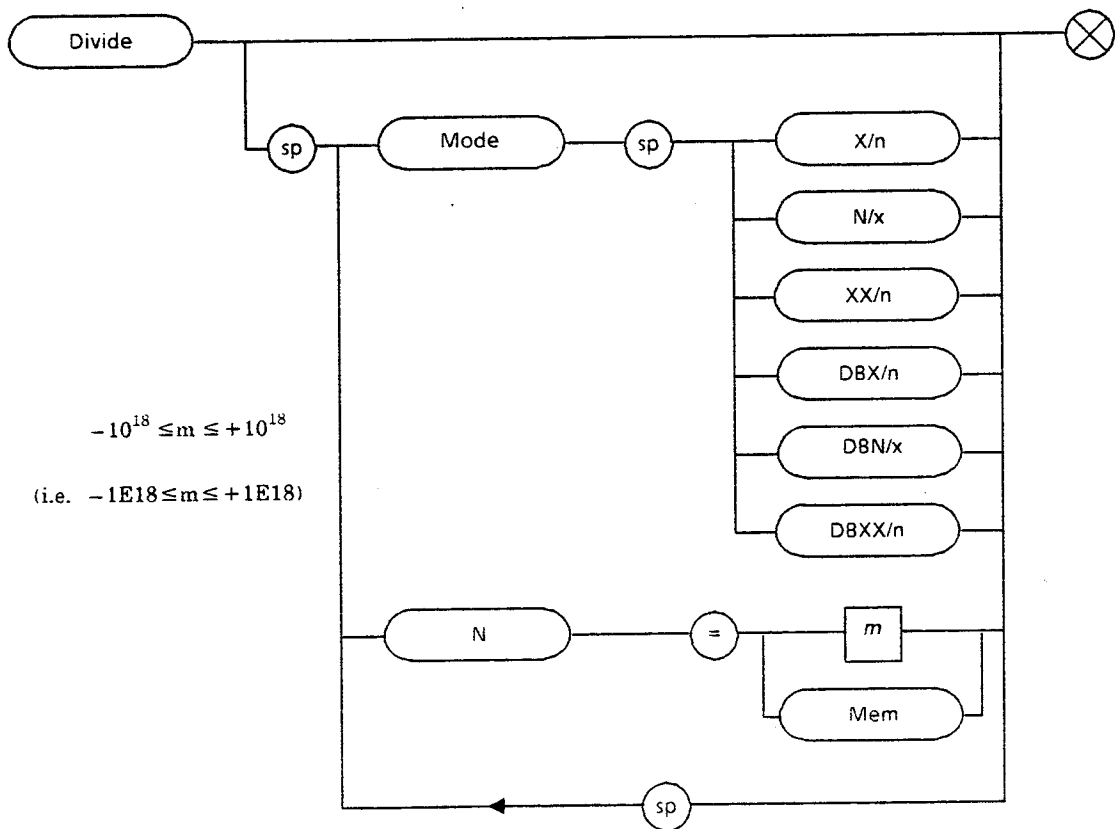
$-10^{18} \leq m \leq +10^{18}$

(i.e. $-1E18 \leq m \leq +1E18$)

1)	X/N	$y = x \div N$
2)	N/X	$y = N \div x$
3)	XX/N	$y = x^2 \div N$
4)	DBX/N	$y = 20\log_{10}(x \div N)$
5)	DBN/X	$y = 20\log_{10}(N \div x)$
6)	DBXX/N	$y = 20\log_{10}(x^2 \div N)$

Outputs 4, 5 and 6 are the decibel (dB) equivalents of outputs 1, 2 and 3 respectively.

6.3 Limits

Compares each input value x with two user-defined limits H and L.
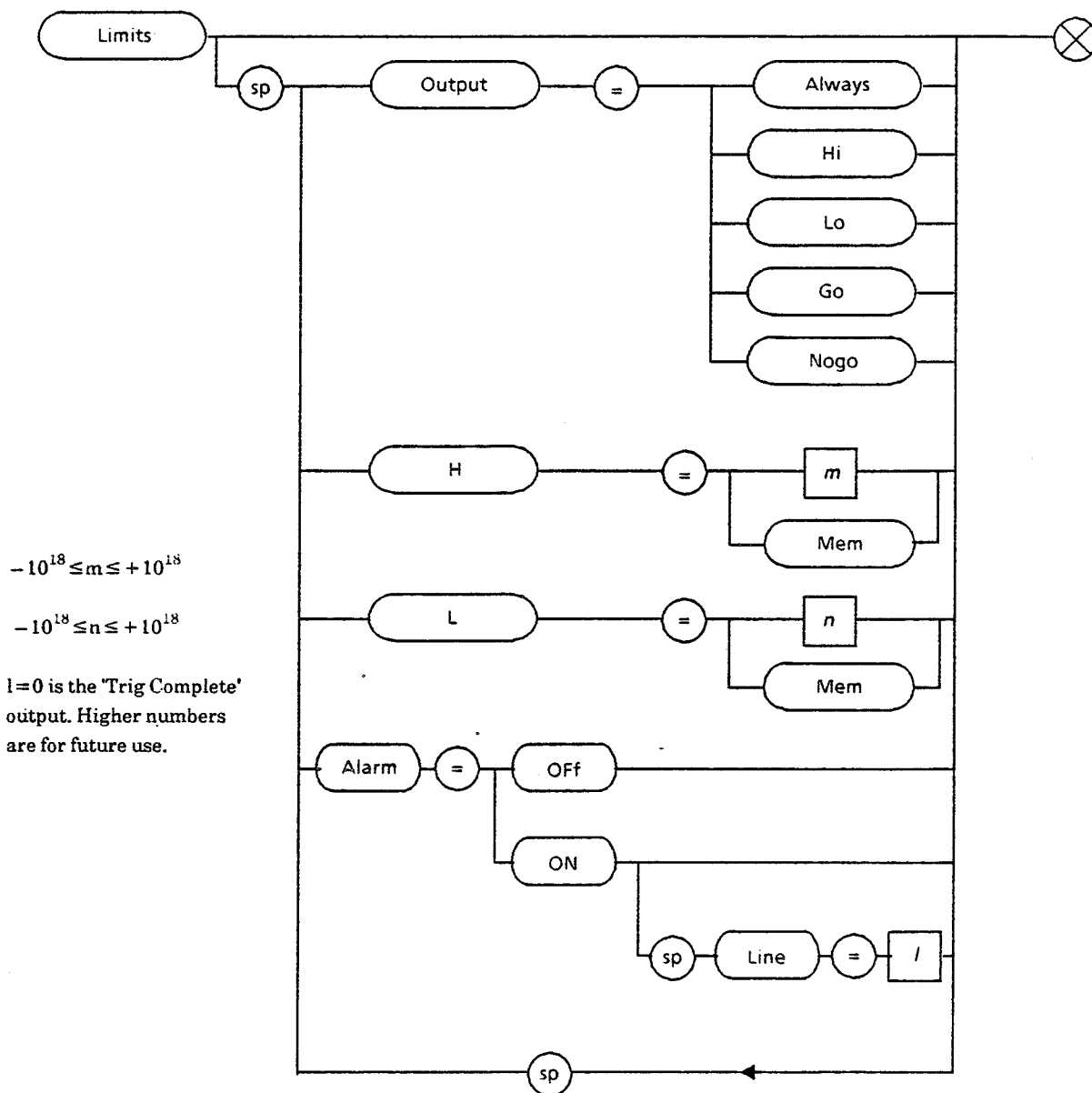
$-10^{18} \leq m \leq +10^{18}$

$-10^{18} \leq n \leq +10^{18}$

$l = 0$ is the 'Trig Complete' output. Higher numbers are for future use.

Each input value x is put into one or more of four categories:

1) Hi $x > H$
2) Lo $x < L$
3) Go $L \leq x \leq H$
4) Nogo $x > H$ or $x < L$

Outputs are available either from individual categories or from all.

If Alarm ON is selected, a low, approximately 4μs pulse is output to the 'Trig Complete' (LINE0) socket each time an out-of-limits measurement is made.

The number of results in each category is stored and 'RECall Limits' generates 5 strings giving both set-up information and the categorised results.

6.4 Maxmin

Records the minimum and maximum values of inputs, x, and the difference between them.
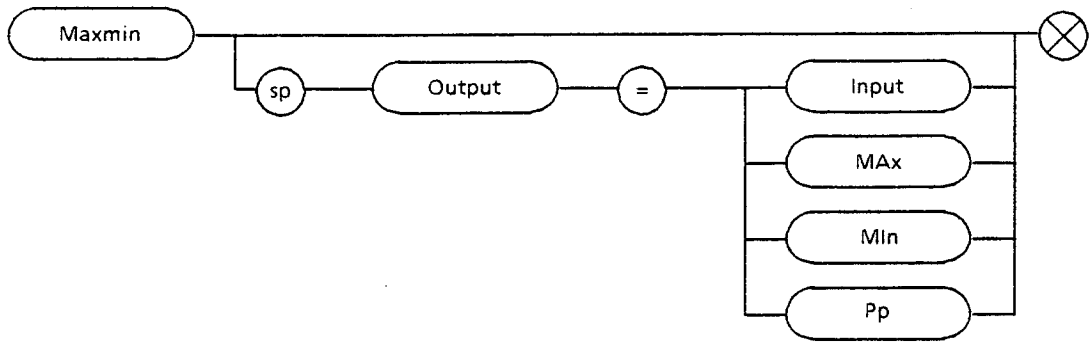
Output, y, may be selected from:

Input	$y = x$
MAx	$y =$ present maximum value of x
MIn	$y =$ present minimum value of x
Pp	$y =$ present peak-to-peak (difference) value between max. and min. x.

MAx, MIn and Pp are available for RECall, together with the total number of input values, giving 5 output strings.

6.5 Offset

Adds a user-defined constant, C, to the measured value.

$-10^{18} \leq n \leq +10^{13}$
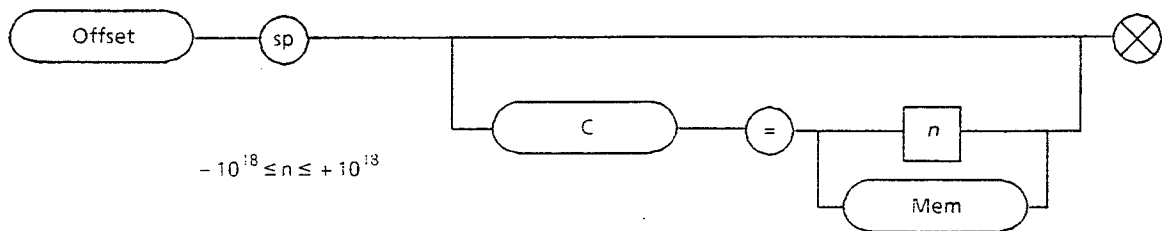
6.6   SCale

Multiplies input by a user-defined constant M.

$$-10^{18} \le n \le +10^{18}$$
Default value, n = 1
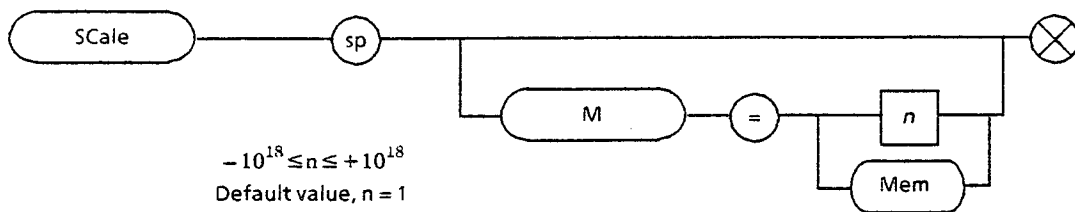
6.7   STatistics

Computes statistics from a series of n inputs, x, to give outputs, y.
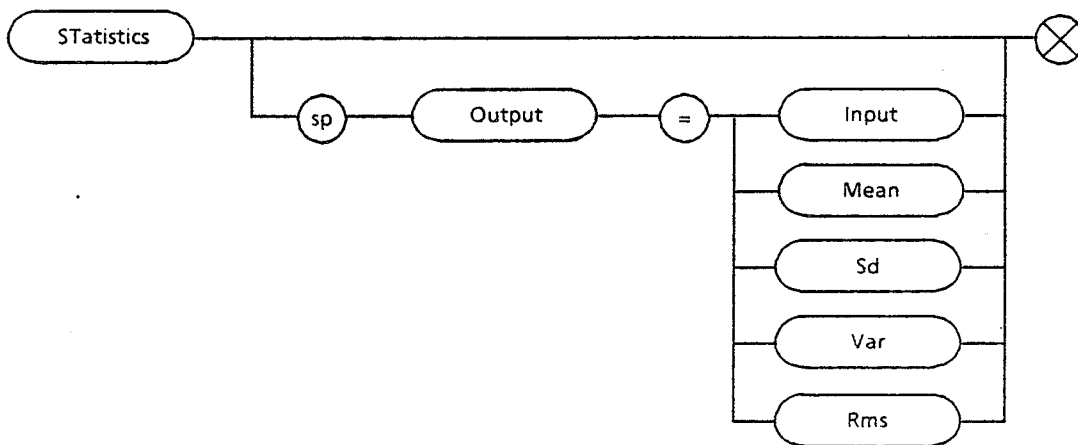
$Input$ $y = x$

$Mean$ $y = \sum_{i=1....n} x_i/n = \bar{x}$

Sd $y = \sqrt{(\sum_{i=1....n} (x_i - \bar{x})^2/n)}$

Var $y = \sum_{i=1....n} (x_i - \bar{x})^2/n$

Rms $y = \sqrt{(\sum_{i=1....n} x_i^2/n)}$

'RECall STatistics' generates 6 strings.

7   ERROR MESSAGES

ERROR MESSAGES	NOTES
"ERROR 00 OK"	
"ERROR 01 BAD COMMAND IN LINE n"	Check command.
"ERROR 02 BAD SEPARATOR IN LINE n"	Check separator.
"ERROR 03 BAD ARGUMENT IN LINE n"	Check number.
"ERROR 04 HIGH NULL"	Reduce offset value directly or using OFFSET program.
"ERROR 05 NULL - ILLEGAL MODE"	Cannot null ac ranges.
"ERROR 06 ILLEGAL ON THIS CHANNEL"	
"ERROR 07 OUTPUT FAST ILLEGAL"	Cannot use 'output fast' in ac or MΩ.
"ERROR 08 CAL INHIBITED"	CAL key in normal position.
"ERROR 09 CAL ZERO TOO LARGE"	'Zero' to be between $0 \rightarrow 0.05$ of range.
"ERROR 10 CAL OUTSIDE LIMITS"	Input not within specified range
"ERROR 11 CAL INCOMPLETE"	Instrument requires calibration.
"ERROR 12 INVALID PROGRAM NAME"	Check name in manual.
"ERROR 13 PROGRAM NOT SELECTED"	Select program required.
"ERROR 14 PROGRAM ALREADY USED"	Program usable once only in sequence
"ERROR 15 NO PROGRAMS SELECTED"	
"ERROR 16 RECORD NOT PRESENT"	No result at this History file location.
"ERROR 17 HISTORY OVERFLOW"	See section 4.33.1, 'Trig. Operation'.
"ERROR 18 TIMER ALREADY ON"	
"ERROR 19 ONTRIG SETUP ILLEGAL"	Cannot use this triggering set-up.
"ERROR 20 STRINGS LOOPING IN LINE n"	A string cannot call itself.
"ERROR 21 I/P BUFFER OVERFLOW"	Break command string into smaller parts.
"ERROR 22 TOO MANY PARAMETERS"	
"ERROR 23 OPTION NOT FITTED"	
"ERROR 24 FAIL 0V"	
"ERROR 25 FAIL 10V"	Errors 24 to 31 indicate that the
"ERROR 26 FAIL AC"	instrument probably requires
"ERROR 27 NVM FAIL"	servicing, with the exception of
"ERROR 28 RAM FAILED"	Error 27 which may possibly be
"ERROR 29 ROM FAILED"	cleared by re-calibration.
"ERROR 30 RAM AND ROM FAILED"	
"ERROR 31 GLUG DEATH"	
ERROR 32 Spare	

8   USING THE 7061 FROM THE GPIB

The following procedures and programs are given primarily to enable users with only elementary programming knowledge to operate the 7061 from a GPIB controller. For each of the following program examples, only the bare essentials have been given, in order to make them easily understood. Much program detail often serves purely to tabulate results or to format them in a particular way; such content can intially be regarded as cosmetic, and is mostly excluded.

Beginning in this way the user can experiment with the programs by inserting his own formatting, or other instructions, tailoring the programs to suit his requirements.

The programs are given initially in the Hewlett-Packard HP85 controller language for which they are fully explained, and modifications suggested. The programs are also listed in the languages of the HP9825, Commodore PET 4032 & 8032 controllers.

8.1   HEWLETT-PACKARD HP85

Preliminaries
Ensure that any necessary modules are fitted to the controller. In general, set the 7061's GPIB address to a number (in the range 0 to 30) currently unused by any other instrument connected to the same GPIB. Address no. 26 is used in the example programs, so set GPIB OUTPUT=ON and ADDRESS=26 using the MENU RESET keys.

Connect the instruments using a GPIB connector cable plugged into the appropriate sockets (24 way connector on the 7061 rear panel).

Switch on the equipment.

Before entering any example programs, erase any existing programs in the HP85 by simultaneously depressing the SHIFT and SCRATCH keys, followed by ENDLINE.

Press the ENDLINE key after entering each program line. Once the program has been fully entered, press RUN to start the program, press RESET to stop the program.

8.1.1   Example 1

This program causes measurements to be taken by the 7061, and the results output via the GPIB to the controller where they are displayed on its screen. The 7061 is to be set up as follows, with the commands taken from the Verbose Command set:

	Command
Measurement mode, Vdc	MODE VDC
Range 10V	RANGE 10
5½ digit readings	DIGITS 5
Track ON	TRACK ON
Results with literals	LITERALS ON

The output delimiter is chosen to match the requirements of the controller. The default setting of the 7061, CRLF, suits the HP85.

Program Listing
```
10    REMOTE 726
20    DIM A$[100]
30    OUTPUT 726;"INITIALISE"
40    FOR I = 1 TO 2000
50    NEXT I
60    OUTPUT 726;"MODE VDC"
70    OUTPUT 726;"RANGE 10"
80    OUTPUT 726;"DIGITS 5"
90    OUTPUT 726;"LITERALS ON"
100   OUTPUT 726;"TRACK ON"
110   ENTER 726;A$
120   DISP A$
130   GOTO 110
140   END
```

Press RUN to start the program.
Press RESET to stop the program.

Listing Description

line 10   Sets the 7061 into remote control (only the Local key operative)

line 20   Defines the string variable (storage area) called A$ and its length
(100 characters) into which measurement results from the 7061 are placed.

line 30   Resets the 7061 to the default state.

lines 40&50   Allow a delay for initialisation of the voltmeter.

line 60
|
| Outputs the required commands to the 7061 (MODE VDC etc.)
line 100

line 110   Causes a measurement result to be taken from the 7061 and placed in the location A$

line 120   Causes the contents of A$ to be displayed.

line 130   Sets up a program loop.

Useful Modifications

1.   Any of the 7061's programs can be selected by inserting the appropriate command into the listing. For example, to display results subject to a multiplication factor of 6.5, insert this program line between lines
90 & 100: OUTPUT 726;"SELECT SCALE M = 6.5"
Renumber the other program lines to suit.

2.   If a printer is to be connected via the GPIB, the results from the 7061 could easily be directed to it. Say the printer's address is set to 24, then replace the existing line 120 with:
OUTPUT 724;A$

8.1.2   **Example 2**
This program causes single shot measurements to be produced when required by pressing one of the special function keys, say K1. To exit from the program, another special function key is pressed, say K2. The measurement results are to be displayed on the screen; the 7061 is to be set up as follows:

	Command
Measurement mode Vac	MODE VAC
Range 10V	RANGE 10
4½ digit readings	DIGITS 4
Track OFF	TRACK OFF
Single sample	TRIGGER
Results with literals	(Default State)

Program Listing
```
10    REMOTE 726
20    DIM A$[100]
30    OUTPUT 726;"INITIALISE"
40    FOR I = 1 TO 2000
50    NEXT I
60    OUTPUT 726;"MODE VAC"
70    OUTPUT 726;"RANGE 10"
80    OUTPUT 726;"DIGITS 5"
90    OUTPUT 726;"TRACK OFF"
100   ON KEY# 1 GOTO 130
110   ON KEY# 2 GOTO 170
120   GOTO 120
130   OUTPUT 726;"TRIGGER"
140   ENTER 726;A$
150   DISP A$
160   GOTO 100
170   CLEAR
180   DISP "PROGRAM TERMINATED"
190   END
```

Press RUN to start the program.
Press RESET to stop the program.

Listing Description
line 10   Sets the 7061 into remote control (only the Local key operative).
line 20   Defines the string variable called A$, and its length.
line 30   Resets the 7061 to the default state.
lines 40&50   Allow a delay for initialisation of the voltmeter.
line 60
| Outputs the required commands to the 7061 (MODE VAC etc.)
line 90
line 100   When K1 is pressed, program execution passes to line 130
line 110   When K2 is pressed, program execution passes to line 170
line 120   Waits for a key - press.
line 130   Outputs to the 7061 the single sample command, "TRIGGER"
line 140   Reads a result from the 7061 and stores it in A$
line 150   Displays the contents of A$
line 160   Sets up a program loop ready for the next key - press
line 170   Clears the screen.
line 180   The legend "PROGRAM TERMINATED" is displayed.

Useful Modifications

Say it is required to take some statistics of the above measurement results. The updated stats. results are to be displayed on request. The means of resetting the stats. is also to be provided, enabling new batches of results to be obtained.

The details to be added to the program are:

(a) Inclusion of the STATISTICS. program
(b) Inclusion of commands to RECALL and RESET the STATISTICS program.
(c) Definition of two more special function keys, say K3 to recall and display the updated statistics, and K4 to reset the stats. results prior to taking a new batch of measurements.

Revised listing

```
10   REMOTE 726
20   DIM A$[100]
30   OUTPUT 726; "INITIALISE"
40   FOR I = 1 TO 2000
50   NEXT I
60   CLEAR
70   OUTPUT 726;"MODE VAC"
80   OUTPUT 726;"RANGE 10"
90   OUTPUT 726;"DIGITS 5"
100  OUTPUT 726;"TRACK OFF"
110  OUTPUT 726;"SELECT STATISTICS OUTPUT=INPUT"
120  OUTPUT 726;"PROG ON"
130  ON KEY# 1 GOTO 180
140  ON KEY# 2 GOTO 320
150  ON KEY# 3 GOTO 220
160  ON KEY# 4 GOTO 290
170  GOTO 170
180  OUTPUT 726;"TRIGGER"
190  ENTER 726;A$
200  DISP A$
210  GOTO 170
220  OUTPUT 726;"RECALL STATISTICS"
230  DISP "★ STATS RESULTS SO FAR★"
240  FOR I = 1 TO 6
250  ENTER 726;A$
260  DISP A$
270  NEXT I
280  GOTO 170
290  OUTPUT 726;"RESET STATISTICS"
300  DISP "★ STATS RESULTS RESET ★"
310  GOTO 170
320  CLEAR
330  DISP "★ PROGRAM TERMINATED ★"
340  END
```

line 240　　When STATISTICS is recalled there are 6 strings of data to be read (OUTPUT
|　　　　　 = INPUT, N = - - -, RMS. = - - - - - etc.).
|　　　　　 The statement "FOR I = 1 TO 6" causes lines 240 and 250 to be repeated 6
line 270　　times. "I" is incremented for each loop, and when 'I = 6', program execution
　　　　　　 continues at line 280.

8.2   HEWLETT-PACKARD HP9825

General
Output Delimiter recognised by HP9825 : CR, LF.

Preliminaries
Ensure that the HPIB interface 98034A is fitted to one of the rear slots on the HP9825.
The interface 'select code', which is switchable by means of the rotary switch on the
interface, should be set to 7 (normal factory setting).

Ensure that a 98214A ROM cartridge is fitted to one of the 4 front slots in the HP9825
(up to 4 ROM cartridges can be fitted).

Set the 7061 GPIB address to 26, as this is used in the following programs. If required,
any other address in the range 0 to 30, with the exception of address 21, can be selected,
provided that the appropriate program lines are amended accordingly. Address 21 is
factory set for the HP9825.

Connect the lead from HPIB interface to the 7061 GPIB socket.

Switch on the equipment.

Before entering any programs, erase any existing programs by pressing the ERASE and
EXECUTE keys.

Remember to press the STORE key after entering each program line.

8.2.1   **Example 1 (per HP85 Ex. 1)**

Program Listing
```
0    dim A$[100]
1    clr 726
2    rem 726
3    wrt 726, "mode vdc"
4    wrt 726, "range 10"
5    wrt 726 "digits 5"
6    wrt 726 "literals on"
7    wrt 726, "track on"
8    red 726, A$
9    dsp A$
10   gto 8
```

Press RUN to start the program.
Press STOP to stop the program.

8.2.2 **Example 2 (per HP85 Ex. 2)**

Prior to running the program the f0 and f1 (special function) keys must be defined as follows:

f0:★1→A i.e. when 'f0' is pressed (to take a measurement) A becomes equal to 1

f1:★2→A when 'f1' is pressed (to exit the program) A becomes equal to 2

The procedure for programming the special function keys is as follows:

1. Press FETCH
2. Press f0
3. Enter the definition, i.e. ★1→A (★ means Immediate Execute)
4. Press STORE
5. Press FETCH
6. Press f1
7. Enter the definition, i.e. ★2→A
8. Press STORE

Program Listing

```
0    dim A$[100]
1    clr 726
2    rem 726
3    wrt 726, "mode vdc"
4    wrt 726, "range 10"
5    wrt 726 "digits 5"
6    wrt 726 "track off"
7    "loop"
8    if A = 1;0→A; gto "trigger"
9    if A = 2;0→A; gto "end"
10   gto "loop":
11   "trigger":trg 726
12   red 726, A$
13   dsp A$
14   gto "loop"
15   "end":dsp "program terminated"
16   end
```

Press RUN to start the program.
Press STOP to stop the program.

8.3   **COMMODORE PET 4032 & 8032**

General
Polling - The PET 4032 & 8032 do not have the normal polling facility. However, the 7061 command, STATUS, may be used as a substitute. Incorporated into a program, the STATUS command causes the 7061 to output an error message which can then be examined to ascertain if an error has occured. If an error is indicated, the user may take appropriate action. During a long program, the STATUS command could be sent periodically to detect any error that may have arisen in the 7061.

Lockout - As the PET 4032 & 8032 do not have a 'local lockout' (LLO), or 'Go to Local' (GTL) command, the 7061 command, LOCKOUT ON/OFF, must be used to disable/enable the Local key on the front panel.

Output Delimiter - The output delimiter *must* be CR, i.e. use 'GPIB DELIMIT 13'. Other delimiters such as LF must not be used.

Bus Transfers - In practice, the PET may attempt to read data from the 7061 before a measurement result is ready and thus a zero reading would be produced. To avoid this, the IF statement is included with the bus transfer statement. This will cause the program to keep repeating the INPUT instruction until a reading is available. At this point the status of the PET will change from 2 to 0 and the program will continue. Status = 2 means no output is available, Status = 0 means an output is available.

Cursor Control Characters - These special characters, used within the programs, are echoed on the VDU and printed on the hardcopy listing. For example, the CLR character echoes a heart-shaped symbol in reverse video.

Addressing - Only the addresses, 5, 6, 7 and 9 to 30 inclusive, can be used for the 7061 when a PET is used as the controller. The remaining addresses are allocated to the PET as follows:

0	Keyboard	3	VDU
1	Cassette 1	4	IEEE Device 4 (Printer)
2	Cassette 2	8	Disk Drives

Preliminaries
Set the 7061 address to 26, as this is the address used in the programs.

Connect the lead from the GPIB port on the 4032/8032 (port nearest the mains switch) to the 7061 GPIB socket.

Switch on the equipment.

8.3.1 Example 1 (per HP85 Ex. 1)

Program Listing
```
10   OPEN 1,26
20   PRINT #1,"DCL":FOR I = 1 TO 2000:NEXT I
30   PRINT #1,"MODE VDC"
40   PRINT #1,"GPIB DELIMIT 13"
50   PRINT #1,"RANGE 10"
60   PRINT #1,"DIGITS 5"
70   PRINT #1,"LITERALS ON"
80   PRINT #1,"TRACK ON"
90   INPUT #1, A$: IF ST < >0 THEN 90
100  PRINT A$
110  GOTO 90
120  END
```

Type RUN to start the program.
Press STOP to stop the program.

Listing Description
line 10   Opens file 1 and assigns it to the instrument at address 26.
line 20   Clears the 7061 and gives a delay (count 2000) before line 30.
line 30

              sets up the 7061 with the necessary commands.

line 70
line 80   Looks to the 7061, takes a result and places it in A$. If no result is ready, this
          line is repeated until a result is received.
line 90   The contents of A$ are printed.
line 100   Sets up a program loop.

8.3.2 Example 2 (per HP85 Ex. 2)

Program Listing
```
10   OPEN 1,26
20   PRINT #1,"DCL"
30   FOR I = 1 TO 2000:NEXT I
40   PRINT #1,"MODE VAC"
50   PRINT #1,"RANGE 10"
60   PRINT #1,"DIGITS 5"
70   PRINT #1,"TRACK OFF"
80   PRINT #1,"GPIB DELIMIT 13"
90   GET B$
100  IF B$ = "A" THEN 130
110  IF B$ = "B" THEN 180
120  GOTO 90
130  PRINT #1, "TRIG"
140  INPUT #1, A$: IF ST < >0 THEN 140
150  PRINT A$
160  GOTO 90
170  CLOSE 1
180  PRINT "PROGRAM TERMINATED"
190  END
```

9   GPIB FUNCTIONS

One command, SRQ (service request), is actioned within the GPIB only. It enables the 7061 to request service from the GPIB controller by means of the SRQ line. Configuration of the voltmeter DIO lines for parallel poll by a controller can be done using GPIB-specific commands. Thus on receiving an SRQ, the controller can then initiate a parallel poll to determine which device is requesting service, followed by a serial poll to read the serial poll byte of the requesting device.

9.1   Parallel Poll

In a system containing more than one controlled device it is essential that the controller should be able to identify which instrument is requesting service when SRQ is asserted. It obtains this information by conducting a Parallel Poll.

The systems interface is configured for parallel poll in accordance with sub-set PP1 of the IEEE 488/1978 standard.

The 7061 interface allows for the voltmeter to be allocated a unique data wire (DIO 1 through 8) as its parallel poll code wire.

In the multi-device system under consideration, if an interrupt occurs as a result of an SRQ, the controller must initiate a parallel poll using the GPIB IDENTIFY (IDY) command.

In configuring for parallel poll, the controller allocates each instrument one of the eight DIO wires as its code wire. When the IDY command is obeyed, the data sent back to the controller is a representation of the eight lines, indicating which devices are responding, i.e.

$$0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 1$$

indicates that the device allocated DIO 1 is requesting attention.

The 7061 is configured for parallel poll using interface-dependent commands issued by the controller. After sending a PPC (Parallel Poll Configure), the PPE (Parallel Poll Enable) is issued.

PPE has the form :-

$$X \ X \ X \ X \ S \ P_1 \ P_2 \ P_3$$

where $P_1 \ P_2 \ P_3 = 0 \rightarrow 7$,

defining the line on which the instrument responds to a parallel poll.

and $S = 0$ or 1

defining the condition under which the instrument responds actively to a parallel poll.

If $S = 1$,   the instrument asserts the line defined by $P_1 \ P_2 \ P_3$ when parallel polled, if it is requesting service. If the instrument is not requesting service, no line is active.

If $S = 0$,   the instrument does not assert any line when parallel polled and when requesting service. The instrument responds actively to a parallel poll if service is *not* required.

If several instruments are assigned to a line with S = 0, an active response is received by the controller if any one of the instruments is not requesting service. The line is inactive after a parallel poll when all the instruments require service.

To complete its response to the SRQ interrupt, the controller must interrogate (Serial Poll) the device requesting service, by sending SPE as described below.

9.2 Parallel Poll Sharing

Where the number of controlled devices exceeds eight (the number of DIO lines available), it is not possible to allocate each device an individual DIO wire for polling purposes. Thus, it may be necessary for two devices to share a common line. A parallel poll will establish which DIO line has been set, then serial polling will ascertain which of the two devices has requested service, and what service is required.

9.3 Serial Poll

When the controller conducts a Serial Poll, it sends SPE (Serial Poll Enable) together with a talk address to the 7061, which responds by outputting the value of its serial poll byte.

It is recommended that for maximum value in a computer-controlled system, the Serial Poll instruction is used as part of a user-program subroutine.

9.4 Serial Poll Byte

Voltmeter status is coded in an 8-bit register in the interface as the Serial Poll Byte, which is made up as follows :

	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
GPIB bit	8	7	6	5	4	3	2	1
Dec. value	128	64	32	16	8	4	2	1

(a)   -
(b)   request for service, 1 = 7061 generating SRQ
(c)   1 = error (see abnormality codes)
(d)   1 = ready
(e)   1 = output available
(f)   1 = user (manual)
(g) & (h)   Abnormality Code :
        00 = command interpretation error
        01 = command execution error
        10 = calibration fault
        11 = input message too long (> 76 characters)

The 7061 requests service by setting the rqs bit true and asserting the SRQ line. The user's software must include the means of detecting, and reacting to an SRQ. The SRQ (and rqs) facility is controlled by the SRQ command, where SRq = 0 inhibits SRQ. Error, Output, User, and Ready define what will cause an SRQ.

Output is an 'enable' for SRQ when data, control information, and error messages are available at the GPIB interface; bit 4 of the serial poll byte is set, the 7061 asserts SRQ and sets bit 7 true.

User enables the front panel SRQ key; bit 3 of the serial poll byte is set, the 7061 asserts SRQ and sets bit 7 true.

Ready enables SRQ when the unit is not busy; bit 5 of the serial poll byte is set to 1, the 7061 asserts SRQ and sets bit 7 true. SRQ will only be asserted when the instrument has finished all triggered measurements and is awaiting a command. The voltmeter *can* be 'ready' and 'output available' at the same time, as measurements are stored in the internal buffer.

9.5   Error Indication

The value of the serial poll byte will be modified if the SRQ is generated as a result of the interface receiving an invalid message. Although the 7061 ignores the setting commanded by the invalid message, the error is detected by the interface and SRQ is asserted. At the same time, the error type is coded in bits 1 and 2 of the serial poll byte and rqs is set true. In the 7061 interface, the possible codes are :

> 00 = command interpretation error
> 01 = command execution error
> 10 = calibration fault
> 11 = input message too long (>76 characters)

Chapter 6
Interference - some causes & cures

1   INTRODUCTION

Consider a voltmeter measuring a signal applied to its input terminals. The signal presented to the input comprises two components; the required input signal and an unwanted signal (no matter how small). If the unwanted signal is sufficiently large, it invariably causes a change in the voltmeter reading.

This unwanted signal, or interference, may be ac or dc. Sometimes, the presence of interference is simply indicated by a result that differs from the expected value, or perhaps the last one or two digits are unstable, due to some additional, spurious signal. Very often however, the displayed result gives no indication that the measurement has been affected by interference, and so precautions against it must be taken.

2   SERIES MODE INTERFERENCE

The term series mode (or normal mode) arises because the interference is effectively in series with the signal source and voltmeter input. It may arise (a) as part of the source where the signal and interference are inextricably mixed; or (b) as a separately identifiable generator.

e = wanted signal
e_i = interference signal
In both cases, the instrument sees an input = $e + e_i$
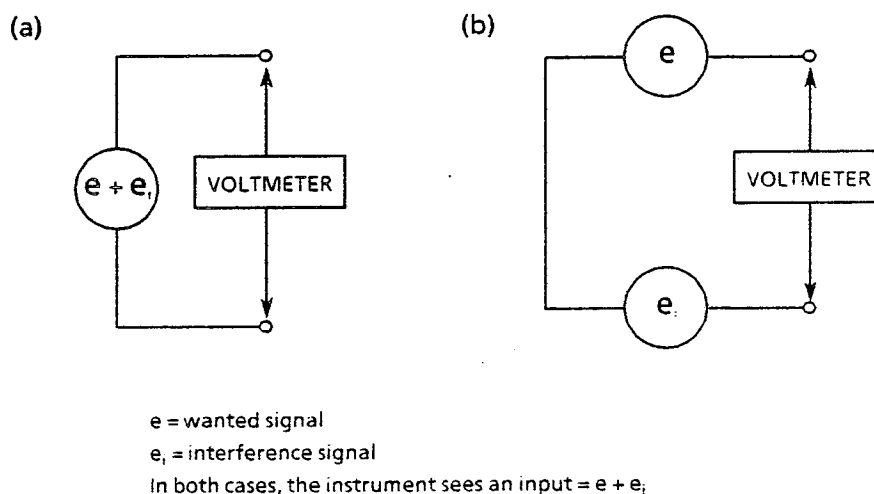
Fig 6.1 *Series mode interference*

2.1   SERIES MODE DC

When the interference is dc there is no way of designing the voltmeter to ignore it. If the interference is only of the order of microvolts then a zero, or null control may be able to compensate. For example, on Volts, dc the 7061 can null out offsets of up to 2%.
If the offset is excessive and cannot be nulled, the user can only take precautions, knowing that the problems may exist. Alternatively, the user could measure the offset, and apply it in the OFFSET program as a correction factor.

If the source of the offset is simply resistance in the test leads then the solution is to make the leads shorter/thicker. Often though, the offset is caused by thermal effects upon connectors, clips, and relays in the measuring path. For example, a simple reed relay with nickel-iron contacts usually has copper connections, i.e. a pair of thermocouples. Any temperature gradient across the relay then results in an emf of approximately 40μV/°C. The 'Trueohm' facility of the 7061 overcomes this problem when making resistance measurements.

Other sources of dc interference can result from leakage across nominally good conductors, especially under conditions of high humidity; moisture on exposed terminals may cause galvanic emf's to be generated; screened cables connected to vibrating equipment may generate electrostatic potentials; and so on.

2.2 SERIES MODE AC

The most serious form of ac interference is usually derived from the mains supply, i.e. 50Hz, 60Hz, etc.

This problem can be overcome by designing the voltmeter so that its measurement times are multiples of the mains frequency period. For example, for 50Hz operation, measurement times of 20ms, 40ms, 60ms --- etc. would be suitable. Thus the 50Hz induced interference components are averaged out. This is done automatically by the 7061 when using default measurement integration times. (See appendix B).

However, if the interference is other than mains induced, the most successful way of dealing with it is to use the longest practicable measurement time in order to average out the interference components. When relying on this process however, the voltmeter's dynamic range becomes important. Consider a voltmeter with a nominal range of 2.00V having an applied input of 1.700V. A series mode rejection ratio of 40dB (100:1) implies that the voltmeter can withstand 100mV of ac before 1mV error is displayed. But conversely, it is not true to say that a displayed error of say, 10mV is allowable in addition to the 1.7V input. This is because with a 40dB (100:1) ratio, to display 10mV error implies an error input of 1.0V, in addition to the wanted signal of 1.7V. Consequently, at times the total input to the voltmeter exceeds the range maximum (2.000V). This problem can easily be avoided by ensuring that plenty of headroom is always given in the selected measurement range, i.e. range up if in doubt.

4 REMEDIAL ACTION

Here is a summary of the suggested methods for dealing with interference. In addition, keep the lengths of any connecting leads approximately equal, and to a minimum.

Series mode, dc   Use the null facility to remove small offsets. If the offset is excessive, measure it and use it as a correction factor in the OFFSET program.

Alternatively, attempt to eliminate the offset source from the measuring path.

When measuring low resistances, use 'TrueΩ' ranges.

Series mode, ac   Use the FILTER key.
Select a measurement time that is a multiple of the mains or interference period, or refer to default times in Appendix B. For example, for 50Hz operation, use 100ms etc. For other forms of interference (e.g. noise), use the longest practicable measurement time to average out the effects, 400ms or 1.6s etc. In practice, the higher ohms ranges may be found more susceptible to series mode ac. The real cure here is to use a screened lead where the V-Ω HI, and Ω SOURCE HI & LO leads are screened by an outer braid connected to V-Ω LO.

FULL SPECIFICATION FOR THE
7061 and 7062
HIGH SPEED SYSTEMS VOLTMETERS

RANGES

The operating manual (including the RANge command) refers to ranges 0.1, 1, 10...etc. In fact, 'full scale' readings are 0.2, 2, 20,...etc. and this specification refers to these.

ACCURACY

The following applies to the Accuracy sections.

Limits of Error:
Applicable after 3 hours warm up with relative humidity up to 70%.
DC and resistance measurement with null in use.
The accuracy specification gives the uncertainty in measurement for the stated time and temperature range and is expressed in two parts- as a fraction of the reading,(in parts per million or percentage), plus a number of counts in the least significant digit displayed. Drift will significantly reduce with increasing age of the instrument.

Temperature Coefficient:

Expressed as ± [ppm reading + counts] /°C. Valid from 15 to 35°C.
Temperature coefficient need only be applied outside the temperature span quoted with T_e.

Calibration Temperature

Calibration Temperature (Te) is the temperature of the calibration room environment. Calibration occurs at 20°C (23°C for USA) and is directly traceable to International Standards via the National Physical Laboratory or the National Bureau of Standards. Recalibration is valid at Te from 18°C to 25°C.

DC Input Resistance

High input resistance is maintained on 0.2, 2, 20V ranges, even if 0.2 and 2V ranges are overloaded with up to 21 volt input level.

Filtering

Digital filtering is used in dc and resistance measurement.It increases the integration time by a factor of four.The filter also improves low frequency performance in ac measurement.

DC VOLTAGE

Accuracy : ± [ppm rdg + counts]
Filter in, 6½ digits

Nominal Range	Input Sensitivity	Input Resistance	Stability 24hrs $T_e\pm$ 1°C	Limits of Error $T_e \pm$ 5°C 90 Day	1 Year	Temperature Coefficients
0.2V	100nV	>10GΩ	7 + 5	20 + 5	30 + 5	2.0 + 1.0
2.0V	1µV	>10GΩ	7 + 3	20 + 3	30 + 3	2.0 + 0.2
20V	10µV	>10GΩ	5 + 2	15 + 2	25 + 2	1.5 + 0.2
200V	100µV	10MΩ	8 + 2	25 + 2	35 + 2	3.5 + 0.2
1000V	1mV	10MΩ	8 + 2	25 + 2	35 + 2	3.5 + 0.2

For 7½ digits add 4 to counts error.
5½ and 4½ digit accuracy, as above.
Above half range on 4½ digits add 1 digit.

Maximum Readings Per Second

Digits	Full Scale	Integration	Into Memory	Onto Bus Track	Trigger
4½	21000	0.67ms	1500	500	>300
5½	210000	16.6ms	60	53	50
5½	210000	20ms	50	44	40
6½	2100000	200ms	5	5	5
7½	21000000	2s	0.5	0.5	0.5

Input Current: 7½, 6½, 5½ digits < 50pA
                          4½ digits < 2nA

Range Of Null: ±1% of full scale
                         (Typical zero stability for 24hrs <1µV)

Overload Protection   Autorange : 1.2kV peak
                         Fixed Ranges: 0.2, 2, 20V   350V peak
                                       200, 1000V   1.2kV peak

Speed of Autorange
Measurements are checked for upranging 1500 times per second. An uprange
is completed within 2ms of full scale being passed. Downranging occurs
when the measurement is below the downrange threshold for a full
integration period or 20ms, whichever is the smaller.

RESISTANCE

Accuracy : ± [ppm rdg + counts]
Filter in, 6½ digits

Nominal Range	Input Sensitivity	Measuring Current	Stability 24hrs, T_e ±1°C	Limits of Error T_e ± 5° C		Temperature Coefficients
				90 Day	1 Year	
0.2kΩ	100µΩ	1mA	7 + 6	25 + 6	30 + 6	2.5 + 2.5
2.0kΩ	1mΩ	1mA	7 + 4	20 + 4	30 + 4	2.5 + 0.25
20kΩ	10mΩ	100µA	7 + 3	20 + 3	30 + 3	2.5 + 0.25
200kΩ	100mΩ	10µA	7 + 3	20 + 3	30 + 3	2.5 + 0.25
2.0MΩ	1Ω	10µA	12 + 3	40 + 3	60 + 3	6.0 + 0.25
20MΩ	10Ω	<2µA	40 + 3	120 + 3	200 + 3	3ppm/MΩ + 0.25
1000MΩ	1ppm	<2µA	10ppm/MΩ	15ppm/MΩ	20ppm/MΩ	3ppm/MΩ + 0.25

7½ digits : add 4 to counts error.
5½ and 4½ digit accuracy as above.

Measurement Configuration :
4 wire measurements up to the 2MΩ range.The 20MΩ range extends
measurement through a 2-wire conductance method to 1000MΩ.

True Ohms : This compensates 4 wire resistance measurements up to the
2MΩ range for thermal voltage offsets.It is especially effective in
improving low resistance measurement.

Maximum Readings Per Second

Normal 2/4-wire:	up to 2MΩ	– as dc voltage
Conductance Range:	up to 1000MΩ (2 wire)	– 46 rdgs/sec into memory
		– 41 rdgs/sec onto GPIB

True Ohms:Additional delays for thermal error correction means the
maximum speed is 20 readings/second.

Maximum overload:	350V peak
Maximum Open Terminal Voltage:	0.2, 2, 20, 200kΩ 15V 2MΩ 26V 20M–1000MΩ 11V
Null	±1% of full scale (Typical zero stability for 24hrs <1mΩ)

AC VOLTAGE

True rms of ac component

Accuracy : ± [% rdg + counts]

Filter in below 400Hz, 5½ digits
Applies to inputs > 1% of range.

Stability, 24 hrs, $T_e \pm 1°C$

Nominal Range	Input Sensitivity		40 to 10kHz	10k to 30kHz	30k to 100kHz
0.2V	1µV	)			
2.0V	10µV	)			
20V	100µV	)	0.05 + 20	0.05 + 50	0.4 + 300
200V	1mV	)			
750V	10mV	)			

For 4½ digit accuracy divide count error by 10, for 6½ digit accuracy multiply count error by 10.

Limits of Error, 1 year, $T_e \pm 5°C$

Add 0.04% rdg to 24hr figures.

Extended Frequency Error:
10	to	20Hz	0.75% rdg + 50 counts
20	to	40Hz	0.25% rdg + 50 counts
100k	to	300kHz	<1dB
300k	to	500kHz	<3dB
	5Hz (typical)		3% rdg
	3Hz (typical)		7% rdg

Input Impedance   1MΩ, 150pf

Crest factor 10:1   add 1% rdg.

Maximum Readings Per Second

Digits	Integration	Into Memory	Onto Bus Track	Trigger
4½	16.7ms	60	53	50
4½	20ms	50	44	40
5½	200ms	5	5	5
6½	2s	0.5	0.5	0.5

Maximum Ratings

Autorange: <1kHz   750V rms or 1.2kV peak
                                        >1kHz   200V rms

Fixed Range: 0.2, 2V   <1kHz   500V rms
                                        >1kHz   120V rms
                 20, 200, 750V   <30kHz   750V rms or 1.2kV peak
                                        >30kHz   2 x 10^7 VHz
 Peak Input   maximum 5 times full scale value

DC Content: 400V max

Temperature Coefficient   0.008% rdg /°C

DC CURRENT

Accuracy: ± [% rdg + counts]
Filter in, 6½ digits, through isolated current terminals.

Nominal Range	Input Sensitivity	Stability 24hrs,T_e ±1°C	Limits of Error 1yr,T_e ±5°C
2000mA	1μA	0.02 + 10	0.04 + 10

7½ digits : multiply counts by 10. 5½ and 4½ digits as above.

Maximum Scale: 2100.0000mA

Shunt Resistor: 100 milliohm

Temperature Coefficient: <0.005% rdg/°C

Burden: <0.5V

Overload Protection: 2A fuse

Null: ± 1% range

The null value will vary for a few minutes after the measurement of high
currents due to thermal offset variation caused by self-heating effects.

Speeds and Integration Times: As dc voltage

AC CURRENT
True rms of ac component

Accuracy : ± [% rdg + counts]

Filter in, 5½ digits , 40 to 440Hz

Nominal Range	Input Sensitivity	Stability 24hrs,T_e ±1°C	Limits of Error 1yr,T_e ±5°C
2000mA	10μA	0.05 + 20	0.2 + 20

6½ digits : multiply count error by 10. 4½ digits as above.

Full Scale   :   2100.000mA (max resolution)

Speeds and Integration Times : as ac voltage

Temperature Coefficient: <0.01% rdg/°C

TEMPERATURE

Using Platinum Resistance Thermometer linearised to IEC751.

Temperature range	:	-200.000°C to +600.000°C
Resolution	:	0.001°C or °F
Conformance to IEC751	:	0.1°C
Measurement Current	:	1mA
Resistance at 0°C	:	25, 75, and 100 ohms (variable to any value)
True Ohms	:	selectable for thermal offset compensation.

Other Probe Functions   High voltage probe
                                         AC or DC Current shunt

REFERENCE INPUT	provided on all instruments -fully floating
DC Voltage	: 0.2, 2, 20V ranges Accuracy as main input
AC Voltage	: 0.2, 2, 20, 200V ranges Accuracy as main input
Resistance	: 0.2kΩ, 2kΩ, 20kΩ, 200kΩ,and 2MΩ ranges Accuracy as main input
Temperature	: as main input
Overload protection :	210 V peak

RATIO/PRODUCT FUNCTIONS

Voltage (dc and ac), current dc and ac), ohms and temperature.All combinations possible using the main and reference channels.Scanner channels may also be used.

PRECISION REED SCANNER OPTION:

70612A

Selectable to : 8 channels of 4 poles
or 16 channels of 2 poles
- channels 2 - 9
- channels 10 - 17

1µV or 1mΩ integrity

1µV or 1mΩ integrity
10µV or 10mΩ integrity
(switching)

Functions and Ranges On Scanner Channels:

DC Voltage	: 0.2, 2, 20,200 V ranges Accuracy as main input
AC voltage	: 0.2, 2, 20, 200V ranges Accuracy as main input
Resistance	: 0.2, 2, 20 ,200 , 2000kΩ, 20MΩ and1000MΩ ranges Accuracy as main input
Temperature	: as main input
Overload Protection:	210V peak
Maximum Speed	300 channels per second
Switching Life:	$>10^8$ operations

| Channel Input Capacitance: | 100 pF | dc voltage |
| | 150 pF | ac voltage |

Crosstalk Immunity:

| at dc | 120dB |
| at 100kHz | 70dB |
(terminated 50 Ohms)

Insulation Resistance >10 Gohms
(between open contacts)   25°C, 40% relative humidity

MEMORY EXPANSION OPTION   70613A

Number of additional readings =   7000

Nicad battery back-up. Typical charge time 50 hours

INTERFERENCE REJECTION

Normal Mode Rejection

DC measurements, 7½ to 5½ digits
Integration time frequency
locked to power line frequency
         50/60/400Hz ±3%   >70dB

Effective Common Mode Rejection
With 1kΩ imbalance

DC measurement, 7½ to 5½ digits
Frequency locked 50/60Hz ±3%   >140dB
         400Hz   ±3%   >120dB

AC measurement, 6½ to 4½ digits
         50/60Hz ±3%   > 60dB

Maximum Common Mode Voltage: 500V, dc or peak

SYSTEMS USE

Interface, provided as standard IEEE488 (1978)

Provides full talker/listener,talk only and listen only facilities and remote control of all functions.Serial and parallel poll.Front panel SRQ.

Subset : SH1, AH1, T5, TEO, L3, LEO, SR1, RL1, DC1, CO, DT1, E1, PP1.

Additional inputs and outputs :

    External trigger input (BNC) : TTL level
    Sample complete output (BNC)
    Reference input (channel 1)
    Main rear input (channel 0)

PROGRAMS

Divide	X/N, N/X, X^2/N, $dB(X)/N$, $dB(N)/X$, $dB(X^2)/N$.
Scale	$Y=MX$
Offset	$Y=X+C$
Statistics	mean,standard deviation, variance,root mean square.
Limits	Hi, Lo, Go, Nogo.
Maximum	Maximum, Minimum, Peak to peak
Percentage Deviation	$Y=100(X-N)/N$

Each input channel is independently configurable for all program and probe functions. A program may be used once on a channel , and chained with other programs in any desired sequence.

GENERAL DATA

Power Supply

Voltage	:	100/120/220/240Vac ±10%
Frequency	:	50/60/400Hz ± 3%
Consumption	:	<40VA

Protection

Power Supply	:	fused line and neutral
Current Measurement	:	fused 2A
Voltage Measurement	:	spark gap at 1.4kV

Safety

Designed in accordance with IEC348, BS4743, and UL 1244.

Environment

Operating	:	0° to 50°C
Storage	:	-30°C to +70°C

DIMENSIONS

Height	:	88mm (3.5ins)
Width	:	432mm (17 ins)
Depth	:	419mm (16.5 ins)
Weight	:	8.62kg (19lbs)

Chapter 8
Calibration

1   CALIBRATION

The 7061 may be calibrated either from the front panel or via the interface. Depending on the measurement mode being calibrated, short/open circuits and known low/high voltage or current inputs must be supplied. For this purpose, 'low' means $0.075 \rightarrow 0.21 \times$ range and 'high' means $0.75 \rightarrow 2.1 \times$ range, where 'range' means $0.1, 1, 10, \ldots\ldots$etc.

The 'Date' facility in the calibrate menu allows the storage of, for example, date of calibration. However, any combination of up to twelve digits and decimal points (from the front panel) or up to twenty characters (via the interface) may be used instead.

1.1   FRONT PANEL CALIBRATION

Pressing MENU then RESET with the calibration switch in the 'CAL' position gives a menu for calibrating the existing measurement mode and range.

The display prompts all necessary inputs according to the measurement mode selected. The instrument checks that 'LOW' and 'HIGH' inputs are within $(0.075 \rightarrow 0.21) \times$ range and $(0.75 \rightarrow 2.1) \times$ range respectively and that the input is correctly specified. Thus supplying an input that differs from the the value specified on the keypad will cause an error message.
'DATE' is a user-defined string of up to 12 digits and decimal points.
If the state of calibration of the instrument is judged to be satisfactory, simply re-write existing calibration constants by sending the 'REFRESH' command.
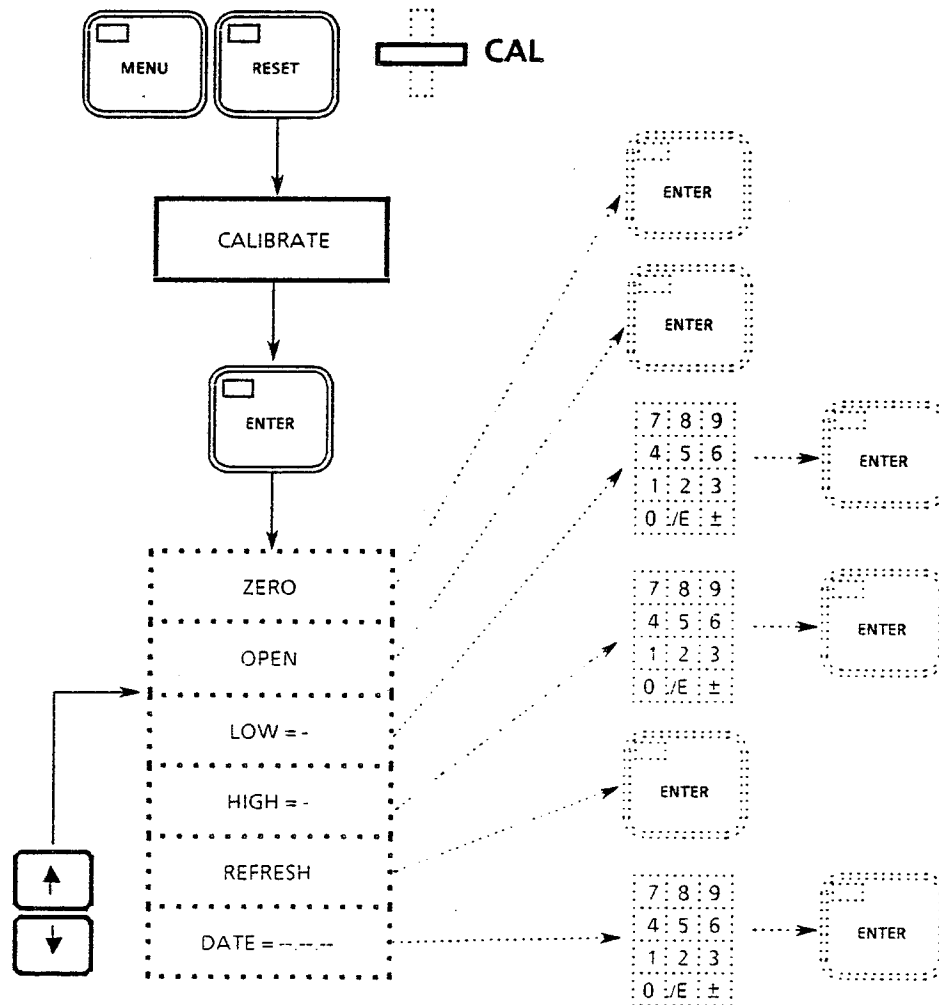
Example :- Calibration of 10V dc range.

1) Move Front/Rear switch to the Front position.
2) Short circuit both the front panel main input, and the rear panel Reference input.
3) Select channel 0, volts, dc, 10V range, and TRACK.
4) Ensure that the display is showing approximately zero.
5) Turn the front panel keyswitch to the CAL position.
6) Press MENU then RESET keys. The diplay now reads 'CALIBRATE'.
7) Press the ENTER key.
8) Use the skip keys (↑ ↓) if necessary until the display reads 'ZERO'.
9) Press ENTER. Display reads 'CAL IN PROGRESS', 'READY', then 0.00000 VDC.
10) Remove short circuit from the front input, and apply an accurately-known dc voltage of between 7.5V and 21V.
11) Press MENU then RESET keys. The diplay now reads 'CALIBRATE'.
12) Press the ENTER key.
13) Use the skip keys (↑ ↓) until the display reads 'HIGH = -'.
14) Key in the value of the voltage. Press ENTER. The display reads 'CAL IN PROGRESS' then 'READY', then the value of the calibration voltage.

The 10V dc range is now calibrated. The other ranges are calibrated in a similar manner, but using the inputs shown in the following table :-

Inputs must be supplied in the order reading from left to right in the table, e.g. for VAC, LOW then HIGH. Notice that 'REFRESH' calibrates all calibration constants, and that similarly, 'DATE' applies to all calibration constants.

	ZERO	OPEN	LOW	HIGH	REFRESH (OPTIONAL)	DATE (OPTIONAL)
VDC	*			*	*	*
VAC			*	*	*	*
IDC				*	*	*
IAC			*	*	*	*
KOHM				*	*	*
MOHM		*		*	*	*

NOTE

1) When calibrating Vdc zeroes, it is essential to have short circuit plugs in both front panel main input and rear panel reference input, because channel 1 (Reference) zeroes are also calibrated at this time.

2) If, for any reason, a new non-volatile memory is fitted, a CALIBRATE LOW command wil not produce the correct reading in the display. This will be corrected, however, after a CALIBRATE HIGH command.

1.2 **REMOTE CALIBRATION**

To calibrate via the interface, turn the CAL switch to the ON position, then use the CALibrate command after selecting the mode and range to be calibrated. The procedure is the same as when using front panel keys, except that remote commands are used instead of key pushes. Measurement mode and range are selected using MODE and RANge commands. Details of the CALibrate command are as follows :

CALibrate command :-

Allows the instrument to be calibrated. It is available only with the front panel switch turned to the CAL position. (Except 'CALibrate DUmp' - available at any time.)

CALibrate — sp — ? — ⊗

- Zero
- Open
- Low — = — m
- High — = — n
- DUmp
- DAte — = — [text]
- Refresh

m = Low input
n = High input
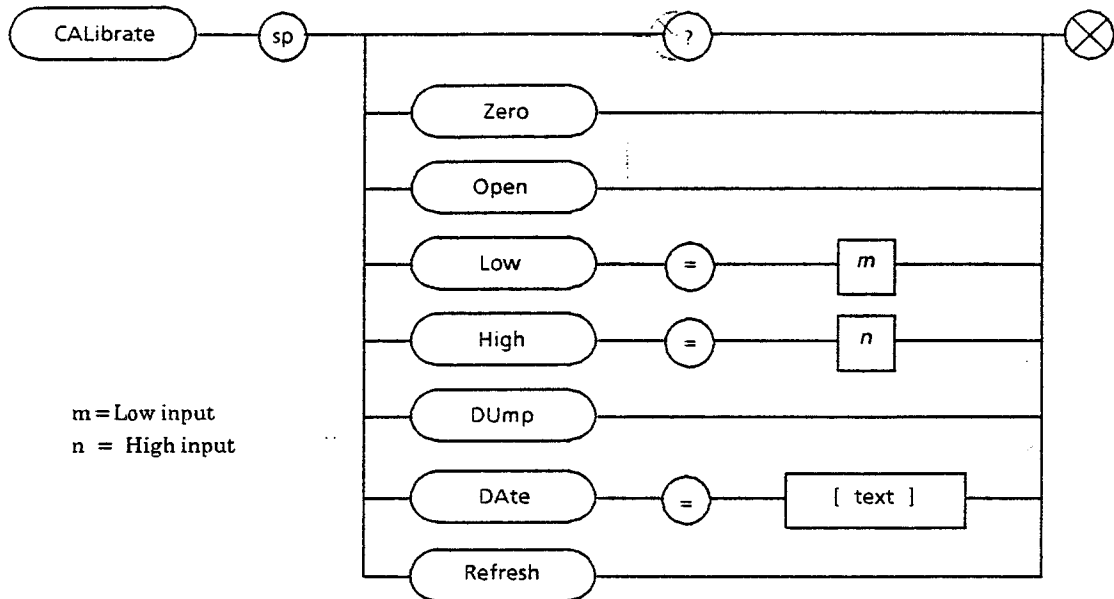
Date is a user-defined string of up to 20 characters delimited with [].
Dump outputs all the calibration constants.
If the instrument is due for re-calibration and the existing state of calibration is satisfactory, sending the Refresh command re-writes the constants with their existing values. Otherwise, the table below shows the inputs for each measurement mode. The TST 0V and TST 10V selections are maintenance aids only.
The query command outputs the Date string.

	ZERO	OPEN	LOW	HIGH	REFRESH (OPTIONAL)	DATE (OPTIONAL)
VDC	*			*	*	*
VAC			*	*	*	*
IDC				*	*	*
IAC			*	*	*	*
KOHM				*	*	*
MOHM		*		*	*	*
TST 0V	*				*	*
TST 10V				*	*	*

Calibrate from left to right in the table.

APPENDIX A

ADOPTED SETTINGS ON POWER-UP AND RESET

When the instrument is switched on, settings are determined by the previously set condition of RESUME. This may be set OFF or ON using the front panel MENU RESET, or the interface RESUme command.

If RESUME is OFF, switching on causes the display to read '7061 INITIALISED'. If RESUME is ON, switching on causes the display to read '7061 RESUMED'.

'INITIALISED' implies clearance of all variables.
'RESUMED' leaves variables unchanged.

An intermediate state may be achieved during use by sending DC1 (device clear) over the interface.
'INItialise' sent over the interface has a similar effect to switching on with RESUME OFF.

Displayed Message	'7061 INITIALISED'	'7061 RESET'	'7061 RESUMED'
Item	(Power on RESUME OFF or front panel RESET)	(DC1 [Interface])	(Power on RESUME ON)
A-to-D			
range	autorange	autorange	no change
mode	vdc	vdc	no change
filter	on	on	no change
null	off	off	no change
ratio	off	off	no change
ratio chan	chan 1	chan 1	no change
channel	chan 0	chan 0	no change
digit	6	6	no change
itime	norm (user = 1 sec)	norm (user = 1 sec)	no change
delay	norm (user = 0 sec)	norm (user = 0 sec)	no change
A-to-D Control			
track	on*	on* _OFF !'_	no change
ontrigger cond	sample 1	sample 1	no change
capture cond	above 0	above 0	no change
output	norm	norm	no change
exttrig	fast neg	fast neg	no change
scanner	off	off	no change
monitor	all	all	no change
user-defined strings	blank	blank	no change
resume	off	on	on
Clock			
clock	zero	zero	zero
timer mode	real	real	no change
begin	zero	zero	no change
interval	zero	zero	no change
end	zero	zero	no change
ontimer	single trigger	single trigger	no change

* Unless instrument has not been calibrated.

continued:

Displayed Message

Item	'INITIALISE' Power on RESUME OFF	'RESET' DCl (Interface)	'RESUME' Power on RESUME ON
Processing			
probes	off	off	no change
probe set up	Prt, DEGC, R0 = 100, Normal	Prt, DEGC, R0 = 100, Normal	no change
programs	off	off	no change
program set up	zero	zero	no change
program 'constants'	zero†	zero†	no change
program results	zero	zero	no change

†Exceptions to these are:

1) limit high $= 10^{18}$ 3) scale, $m = 1$
2) limit low $= -10^{18}$

Item	'INITIALISE'	'RESET'	'RESUME'
History file			
contents	cleared	no change	no change
GPIB input/output			
queued input	deleted	deleted	deleted
queued output	deleted	deleted	deleted
output state	no change	no change	no change
SRQ enables	off	no change	no change
output delims	CR LF	no change	no change
Display			
output state	on	no change	no change
Keyboard			
local	local	no change*	local
lock	off	no change	no change

*(unless REN unasserted, then →local)

GPIB talk/listen and GPIB output on/off are unaffected by Reset/Initialise/Resume. They have the following default values:

GPIB address →16, output →on.

APPENDIX B

MEASUREMENT, DELAY & INTEGRATION TIMES

Measurement timing

The 7061 has a very flexible measurement system which allows the pre-measurement delays and integration periods to be optimised for particular applications.

The default delays and default integration periods are set for general use to still give highly accurate results after sudden changes of input level.

In many applications, e.g. scanning between similar voltage levels, the pre-measurement delays can be reduced by the user in order to give faster scanning rates whilst maintaining high accuracy.

When making measurements with $6\frac{1}{2}$ or $7\frac{1}{2}$ digit resolution, the integration time usually dominates. For faster measurements with $4\frac{1}{2}$ or $5\frac{1}{2}$ digit resolution, the default delay times may be a significant part of the whole measurement.

See the end of this appendix for examples of measurement timings.

Trigger recognition period	Pre-measurement settling delay	Integration period	Calibration	Measurement processing & store to History file	Formatting & output to interface bus
1	2	3	4	5	6
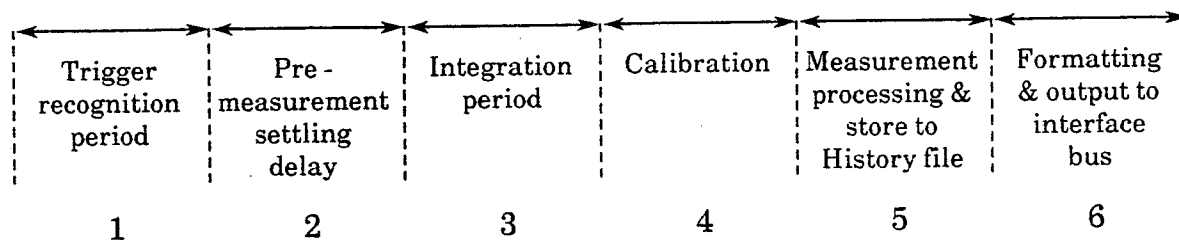
Measurement timing structure.

1   Present when triggering (not when tracking) a measurement. (For first measurement only, when 'BURST' or 'SAMPLE' are selected.)

[1]	External hardware trigger.	450 - 800 µs
[2]	'Group Execute Trigger' (GPIB command)	0.5 - 1.0 ms
[3]	Bus command 'TRIgger'	1.5 - 3.0 ms
[4]	Front panel trigger	approx. 2.0 ms

2   Pre-measurement settling delay occurs before each measurement.
        See tables B1, B2, B3.
    When a scan sequence is selected, additional delays are invoked to allow for relay pull-in and drop-out.
        Scanning delay between channels
                2.33 ms, 4 digits, Vdc, Idc, Ω: 0.1k-1000k
                3.00 ms, 5, 6, 7 digits, Vdc, Idc, Ω: 0.1k-1000k
                3.00 ms, 4 digits, Vac, Iac, Ω: 10000k

3   Integration period during which analogue to digital conversion occurs.
        See tables B4, B5, B6.

4   All measurements require calibration, but it is only done at the time of measurement if 'Processing' or 'Ratio' are selected. In other cases, calibration is done after the reading has been stored in the history file, but before processing or output to the display or interface bus. In this way, measurements can be made at fast rates into the History file using only periods 1, 2, and 3 with delays of 0.75 - 3.5 ms.

5   Minimum when no measurement processing has been selected - increases when Probes and/or Programs are active.
        Delay up to 35 ms with PRT probe and all seven programs selected.
        Minimum delay 0.7 ms for History file update only.

6   Time required to convert internal measurement format into output string :
          Dependent upon :-   Format (DVM, Engineering or Binary)
                              Literals (On or Off)
                              Output (Normal or Fast)
                              Digits (4, 5, 6 or 7)
Formatting and output can take up to 15 ms, but some of this time may coincide with the
settling delay and integration period of a following measurement.
               Minimum delay 0.7 ms in 'Output Fast'

Dump

Measurements can be taken from the History file and sent to the display or the interface
using the dump commands. In this case, only periods 4, 5 and 6 apply and if processing
took place when the measurement was stored in the History file, then calibration will
already have been done.

Multiple-reading measurements

Often in response to a TRIGGER, more than one reading is performed by the voltmeter.
In this case, the delay and integration periods (periods 2 and 3) are repeated several
times. Here are some examples :

Ontrig sample n   Delay and integration periods (periods 2 and 3) are repeated n
                    times. The readings are taken from the History file, calibrated,
                    formatted and output to the bus, at a rate dependent on the
                    interface bus.

10MΩ range   A single reading is made (periods 2 and 3) followed by a 2-5ms
                    calibration time. The result is then processed and written to the
                    History file.

Trueohm; ratio   A pair of readings is made followed by a 2-5ms calibration time. A
                    single result is then processed and written to the History file. Thus
                    in this case, periods 2 and 3 are repeated, then there is calibration
                    followed by periods 5 and 6.

Autoranging   Measurements are checked for up-ranging 1500 times per second
                    during the integration period. An up-range occurs within 2ms of a
                    full scale reading being exceeded. Down-ranging occurs when the
                    measurement is below the down-range threshhold for a full
                    integration period or for 20 ms, whichever is the smaller.

Track   Delay and integration periods (periods 2 and 3) are repeated
                    continually. With a user-delay of 0.000s, continuous integration
                    takes place, however with 4 digit measurements, in Vdc, Idc, 0.1k-
                    1000kΩ, the delay is 0.33 ms. Continuous integration is available
                    using 'burst' - see ONTRigger command in chapter 5.
                    During complex measurements, the sequences described above are
                    performed repeatedly. Periods 4, 5 and 6 take place 'in parallel'
                    with the measurement and the most recent reading is taken,
                    calibrated, processed and sent to the output.

Delay times

These are the default pre-measurement settling delay times that are used by the instrument unless a different delay has been specified by the user via the front panel DELAY key or the remote DElay command. (They are applicable at all mains frequencies.)

Under certain circumstances, the delays shown in the tables below are reduced to 0.33ms (4 digits), and 2.67ms (5,6,7 digits). These times apply when the instrument is reading a single input (ie. not trueohm or ratio), is in 'track' or when the following reading is an 'ontrig sample n'.

'User-delays' are available, with lengths of between 0.000s and 9.999s, i.e. with 1ms resolution. There is one exception to this; when the user delay is set to 0.000 ms with 4 digits, on the Vdc, Idc, or 0.1k-1000kΩ ranges, the delay is actually set to 0.33 ms.

	Digits	Vdc	Vac		Digits	Vdc	Vac
	4	1	150		4	1	600
Filter Off	5	5	100	Filter On	5	5	300
	6	50	100		6	50	200
	7	10	---		7	10	---

Fig. B.1 *Vdc and Vac, times in milliseconds.*

	Digits	0.1k	1k	10k	100k	1M	10M
	4	1	1	1	5	20	800
Filter Off/On	5	10	10	30	30	120	800
	6	10	10	30	40	500	800
	7	10	10	15	20	800	2000

Fig. B.2 *Ohms, times in milliseconds.*

	Digits	0.1k	1k	10k	100k	1M
	4	2	2	10	20	100
Filter Off/On	5	10	10	30	30	700
	6	10	10	30	300	2500
	7	10	10	15	20	5000

Fig. B.3 *Trueohms, times in milliseconds*

Note : Scanner delay times with ac measurements.
When the scanner is being used to measure ac signals, the default settling delays have been optimised for inputs of between approximately 10% and 100% of range, *with no dc content*. If the signal is suspected of including a dc component, or of being less than 10% of range, then a user-delay of 1 second should be set for the appropriate channel/s. See chapter 3, section 16 or chapter 5, section 4.9 for front panel, or remote setting respectively.

Integration times

The default condition, 'Itime Normal', gives measurement integration times dependent on:

      1) Filter off /on

      2) Measurement mode

      3) Mains frequency 50/400 or 60 Hz

      4) Number of digits set...4,5,6, or 7

A feature of the instrument is that it can compensate for mains frequency variations of up to 3% to give best interference rejection. Thus tables B.4 and B.5 below show *nominal* times which are subject to the same percentage variation as the mains frequency.

Filter	Digits	Vdc,Idc,Ω:0.1-1000,	Vac, Iac Ω:10000	True Ohms
Off	4	0.67	20	20
	5	20	200	20
	6	200	2000	200
	7	2000	2000	2000
On	4	20	80	80
	5	80	800	80
	6	800	8000	800
	7	8000	8000	8000

Fig. B.4   *Integration times (milliseconds), mains frequency 50 or 400 Hz*

See following page for 60 Hz times

Filter	Digits	Vdc,Idc,Ω:0.1-1000,	Vac, Iac Ω:10000	True Ohms
Off	4	0.67	16.67	16.67
	5	16.67	200	16.67
	6	200	2000	200
	7	2000	2000	2000
On	4	16.67	66.67	66.67
	5	66.67	800	66.67
	6	800	8000	800
	7	8000	8000	8000

Fig. B.5   *Integration times (milliseconds), mains frequency 60 Hz*

To express the above times as power line cycles, the following conversion table may be used:

Power Frequency	Time in milliseconds								
	0.67	16.67	20	66.67	80	200	800	2000	8000
50 Hz	1/30	–	1	–	4	10	40	100	400
60 Hz	1/25	1	–	4	–	12	48	120	480
400 Hz	4/15	–	8	–	32	80	320	800	3200

Fig. B.6   *Time in Power Line Cycles (PLC)*

Examples :

Measurement timing for continuous output to GPIB (4-digits)
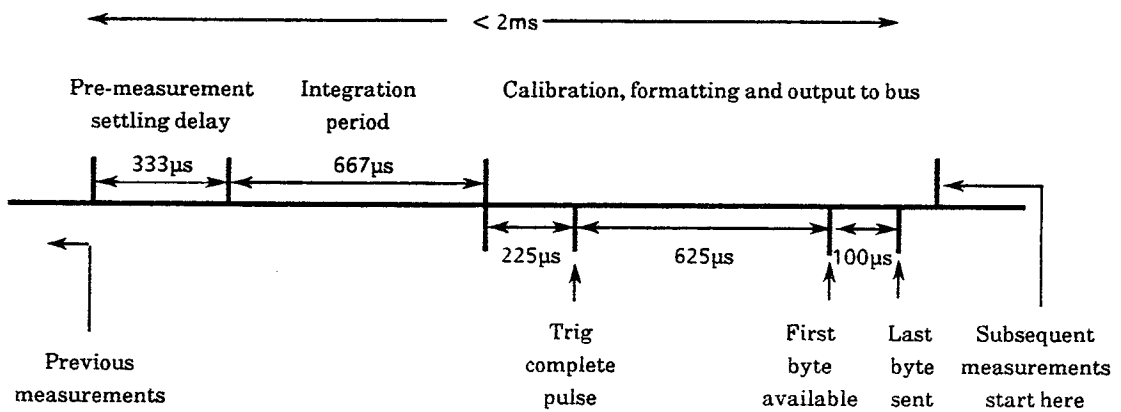
Fig. B.7   GPib Delimit Eoi : FOrmat Dvm : Output Fast : TRAck ON
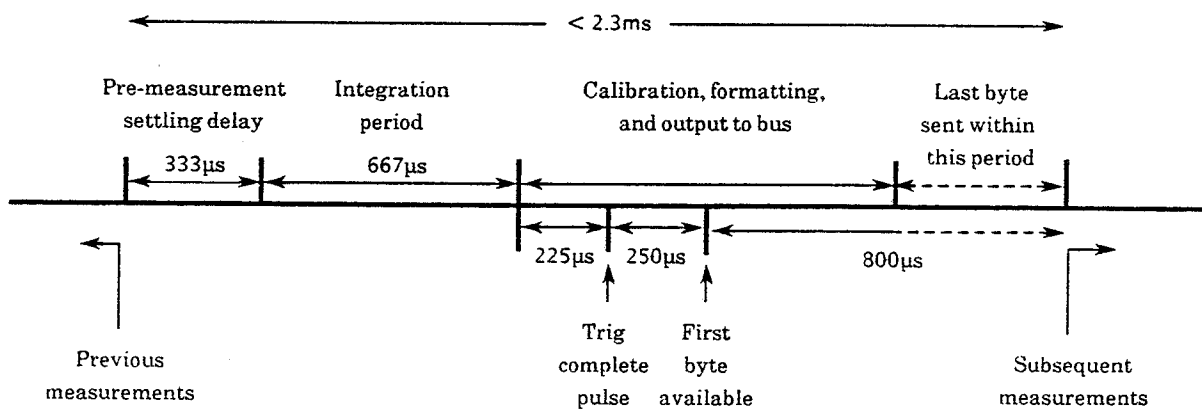
Fig. B.8   GPib Delimit 10 : FOrmat Dvm : Output Fast : TRAck ON

Measurement timing for single sample output to GPIB (4-digits)
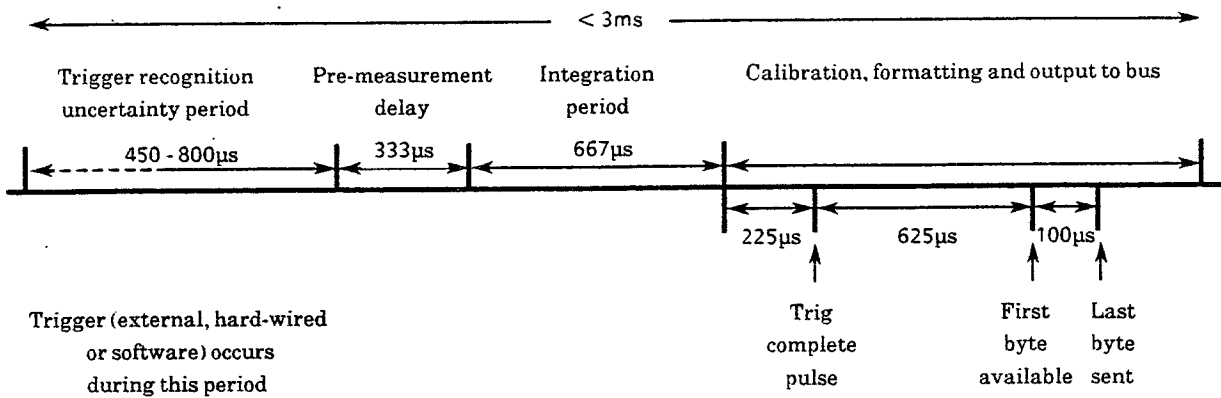
Fig. B.9   *GPib Delimit Eoi : FOrmat Binary : Output Fast : TRAck OFf*

Measurement timing during scanning

Example 1 Scanning Vdc or Ω as fast as possible - $4\frac{1}{2}$ digits, user delay = 0.000s

scanning delay between channels	2.33ms
pre-measurement delay	0.33ms
integration time	0.67ms
	3.33ms

Example 2 Scanning Vac - filter off, $4\frac{1}{2}$ digits, default delay

scanning delay between channels	3ms
pre-measurement delay	150ms
integration time	20ms
	173ms

- filter off, $4\frac{1}{2}$ digits, user delay = 0.000s

scanning delay between channels	3ms
integration time	20ms
	23ms

Example 3 Scanning 10MΩ range - filter off, $6\frac{1}{2}$ digits, default delay

scanning delay between channels	3ms
pre-measurement delay	800ms
integration time	2000ms
	2803ms

Measurement timing during autoranging

Example 1 Volts dc

	6 digits	4 digits
1000V applied to 0.1V range		
pre-measurement delay uncertainty, 0s to -	2.67ms	0.33ms
overload sensed	1ms	1ms
range change to 1V range	2ms	2ms
pre-measurement delay	50ms	1ms
overload sensed	1ms	1ms
range change to 10V range	2ms	2ms
pre-measurement delay	50ms	1ms
overload sensed	1ms	1ms
range change to 100V range	2ms	2ms
pre-measurement delay	50ms	1ms
overload sensed	1ms	1ms
range change to 1000V range	2ms	2ms
pre-measurement delay	50ms	1ms
	214.67ms	16.33ms
first in-range measurement	200ms	0.67ms
total time for first reading	414.67ms	17ms

Example 2 Volts ac, filter off

	5 digits
110V applied to 1V range	
pre-measurement delay uncertainty, 0s to -	2.67ms
overload sensed (nominal response of r.m.s. converter)	10ms
range change to 10V range	2ms
pre-measurement delay	100ms
overload sensed	1ms
range change to 100V range	2ms
pre-measurement delay	100ms
	217.67ms
first in-range measurement	200ms
total time for first reading	417.67ms

APPENDIX C

OVERLOAD INDICATION; DISPLAY & OUTPUT FORMATS

OVERLOAD

On Display:
If an input is applied to the instrument and it is too high for the selected range, the display flashes on and off as a warning.

On Bus:
    Literals ON : Position 15 of output string = !
    Literals OFf : Value = +1.01 E+30

The table below shows the levels at which overload occurs.

	MODE	RANGE	OVERLOAD POINT
Main Input (& Rear Input)	Vdc & Vac	From 0.1 to 100 volts	Range×2.1
		1000 volts	1100 volts
	K ohms	From 0.1 to 1000 KΩ	Range×2.1
		10000 KΩ	No overload
	Idc & Iac	1000 mA	2100 mA
Channel 1 - Ref. Input	Vdc	From 0.1 to 10 volts	Range×2.1
	Vac	From 0.1 to 100 volts	Range×2.1
	K ohms	From 0.1 to 1000 KΩ	Range×2.1
Channel 2-17 (Scanner)	Vdc & Vac	From 0.1 to 100 volts	Range×2.1
		1000 volts	260 volts
	K ohms	From 0.1 to 1000 KΩ	Range×2.1

OVERFLOW

On Display:
Numeric overflow or underflow causes "OVERFLOW" to be displayed.

On Bus:
    Literals ON : Position 15 of output string = >
    Literals OFf : Value = +1.02 E+30

Display Formats

Char. position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
DVM format	1	1	0	0	0	.	0	0	0	0					V	D	C	,		1	7 digits
		1	1	2	3	.	4	5	3						V	D	C			2	5 digits
					0	.	1	2	4	4	5	6			K	O	H	M	,		5/6/7 digits
				-	1	.	2	3	4	5	6				M	A	D	C			6/7 digits
	1	8	4	2	1	.	2	3	4,	5	6				M	O	H	M			conductance, 6 digits
	2	0	4	2	0	.	0	3							K	O	H	M			conductance, 6 digits
	1	2	3	5	6	.	0	0	0						M	O	H	M			conductance, 7 digits
	2	1	0	5	6	0	0	.	0						M	O	H	M			conductance, 7 digits
		1	7	4	0	0	.	0	0						M	O	H	M			Decimal point moves right when integ. field > 5 digits. Displayed digits reduced as number increases - zeroes inserted before decimal point
			3	3	2	.	2	.	3,	4	5	6,	7	,	V	A	C	,	1	2	4/5 digits
	2	1	0	0	0	.	1	2	3,	4	5	6,	7		1	2	3	4,	1	0	history file, 6/7 digits
Eng. format	1	1	2	3	.	1	2	3	4	E	-	0	3	1 5	V	D	C	,	1	4	6/7 digits
			-	2	.	1	2	3	4	E	+	0	3	1 5	V	D	C	,	1		4/5/6/7 digits
			2	1	.	2	3	4	5	E	+	0	6	0 5	K	O	H	M,	0	3	5/6/7 digits
		1	1	2	.	1	2	3	4	E	+	0	3	1 5	,	6	7	M	,	1	history file, 5/6/7 digits
Exp. format	-	2	.	1	2	3	4	5	6	7	E	+	0	1 5		R	A	T	,	5	ratio on, 7 digits
with programs	-	2	.	1	2	3	4	5	6	7	E	-	1	1 5		P	R	G	1		programs on, 7 digits
or ratio (not	-	2	.	1	2	3	4	5	6	7	E	+	0	0 5		R	A	T			ratio on, 7 digits
eng. format)	-	2	.	1	2	3	4	5	6	7	E	+	1	1 5		P	R	G,	1		programs on, 7 digits
	-	1	.	2	3	4	5	6	7	E	+	0	3	, 3	3	0	0	0,		3	programs on, 6 digits, history file
	-	1	.	0	0	0	0	0	0	1	E	-	0	0 7,	8	0	0	0,	1	3	programs on, 7 digits OR ratio on, history file

Character position: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50

Format	Sign (col 1)	Numeric – Field	Units	Channel No.	Hist. Rec. No.
DVM Format	+	732.2	VAC	CHAN 2	HIST 7654
	–	2506.3	LOW	CHAN 10	
	+	20456.	KOHM	CHAN 0	HIST 234
	+	1.2345678E-19	RATIO	CHAN 1	
	+	2300.000	MADC	CHAN 0	HIST 12
Eng. Format	–	210.01E-03	VDC	CHAN 5	
	+	99.999999E+00	HIGH	CHAN 7	
	+	98.000000E+19	PROGS	CHAN 14	
	+	21.234567E+03	KOHM	CHAN 3	
DVM Format (Literals Off)	+	0.1234567			
	–	1.2345678			
	–	12.345678			
	+	987.65431			
	+	1000.0001			
Num. Overflow →	+	1.02E+30			
Overload →	+	1.01E+30			

Output Formats

Column 1   Sign field
Column 15   Abnormality field :   ! = overload,   > = numeric overflow

BRS/7061/2

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