# Digital Voltmeter 7075


Part No. 70750011

Issue 3, January 1978

Schlumberger

THE SOLARTRON ELECTRONIC GROUP LIMITED
FARNBOROUGH HAMPSHIRE ENGLAND GU14 7PW
TEL: FARNBOROUGH 44433 (STD 0252)
CABLES: SOLARTRON FARNBOROUGH HANTS
TELEX: 858245 SOLARTRON FARNBOROUGH

**TECHNICAL MANUAL**

# CONTENTS

Solartron pursue a policy of continuous development and product improvement. The specifications in this document thus may be changed without notice.

# SECTION 1 General Description

The 7075, with its simple to use controls and clear, easy-to-read display enables the most inexperienced user to discover that precise digital measurement is now within his grasp.

**Automatic range selection** means that there is, basically, only one operator decision to be made - that of the quantity to be measured : dc volts, ac volts or resistance. The instrument instantaneously evaluates the order of magnitude of the applied input and selects the appropriate range.

| | |
|---|---|
| **Ranging Points:** (5 x 9's) | Range-up > 140 000 digits reading. |
| | Range-down < 12 000 digits reading. |
| | N.B. Excessive series mode signals may cause range-up to occur earlier. |

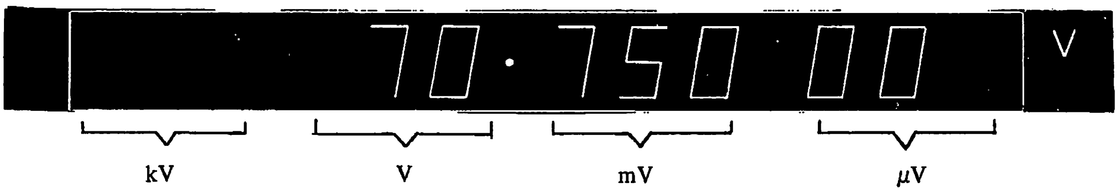
**The facilities available** are those of:-

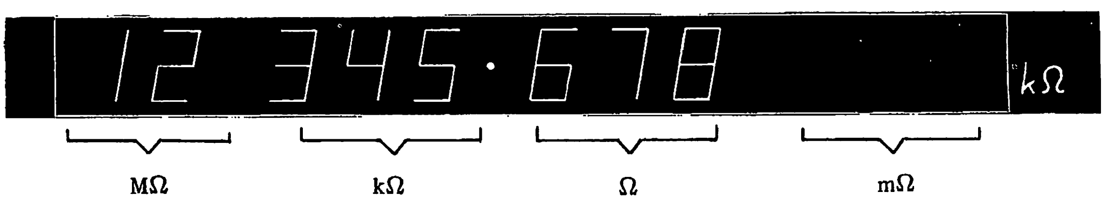
| | |
|---|---|
| DC Voltage | continuous range from 1μV to 1kV |
| AC (RMS) Voltage | continuous range from 1μV to 750V rms (1.1kV Peak). |
| Resistance | continuous range from 1mΩ to 14MΩ |

**True rms measurement**: many instruments in the past presented the mean value of an alternating quantity or if rms value was displayed, it was arrived at by some method of 'doctoring' the mean value actually measured. The disadvantage of that system is that validity of the reading is very much dependent on waveform shape, only a pure sinusoidal input giving acceptable results.

**The 7075 is a true rms measuring instrument**, in which the input is directly converted to its root mean square at the measurement stage. The displayed reading, therefore, is the precisely computed rms value of the alternating quantity being measured.

**A twelve decade display** is used, bright and sharply defined, no extraneous light being permitted to degrade the displayed reading. The **fixed decimal point** and unique grouping of the displayed digits makes possible an instant appreciation of the order of magnitude of the reading thus obviating the need for multiple and submultiple unit annunciators.




**Scale length from 3 x 9's to 7 x 9's** can be selected by the user, the above being typical 7 x 9's displays.

**The display 'moves'** to the right as the applied input reduces in magnitude; leading zeros, except that to the immediate left of the decimal point, are suppressed; and if the quantity is negative the minus sign travels with the display always maintaining its position immediately to the left of the most significant whole digit.

**The new conversion technique** used is capable of obtaining linearities two orders better than those possible using dual ramp and related techniques. An important property of this method is that the applied input is being continuously averaged. Together with the very fast autoranging system, this feature makes conventional filters, with their associated problems, unnecessary. A new exclusive **digital filtering** technique is utilised whereby the difficulty that used to be associated with low frequency ac measurement has, with the 7075, become a thing of the past.

**Operator confidence** is increased by a self check facility. At the touch of a button the instrument can be commanded to carry out a series of tests designed to prove the correct functioning of all its circuits, displaying the result of each check instantaneously.

## SAFETY

Your 7075 has been carefully engineered with ease of use as one of the primary considerations. Attention has also been given to making the instrument immune to most inadvertent overloads and to ensuring operator safety. However it should be appreciated that even the most sophisticated of measuring instruments can be dangerous when connected to high voltages, unless elementary safety precautions are observed.

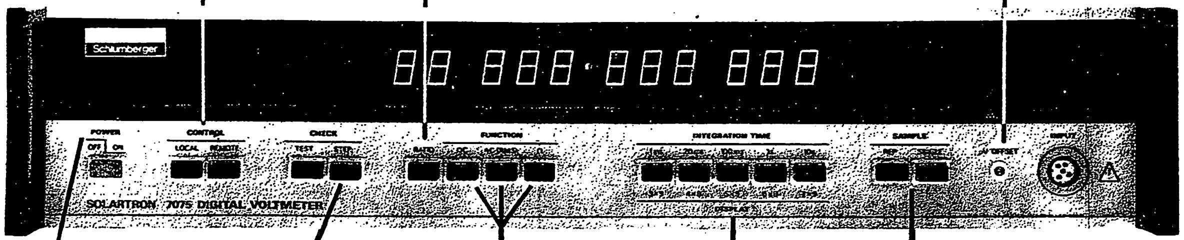
The voltage limit of 1.1kV means that no damage will be caused to the instrument at this level of input. Other than the displayed reading, however, no indication is given to the user that a voltage of such a magnitude is present at the input terminals. Care should therefore be exercised whenever the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

Similarly, when using the instrument on mains operated equipment capable of delivering high voltage outputs, it is strongly recommended that the equipment under test is NOT switched off with the dvm still connected. For example, consider the 7075 connected across the secondary winding of a large mains transformer. The instrument's very high input resistance is such that, in the event of the mains supply being interrupted, the resultant back emf induced in the undamped secondary could be of the order of 100kV. This is obviously hazardous to the user and would certainly harm the voltmeter.

CONTROL: Permits operation by means of front panel switches, when on LOCAL; or under the control of an external system when REMOTE is selected. REMOTE has no effect in the absence of an Interface Unit. (Note 1).

RATIO: Disconnects internal reference and connects external reference applied to the rear input terminals.

$\mu$V OFFSET: Facility for offsetting the effects of externally generated emf's. Applicable on DC and $\Omega$.




REP: Display is repeatedly updated at a rate set by the selected Integration Time.

DC, AC (RMS), $\Omega$ : Used for selection of measurement mode.

SINGLE: Display retains last commanded reading. Update occurs each time button is pressed (Note 2).

TEST: Initiates a series of self-check operations.

STEP: Progresses the test routine step-by-step.

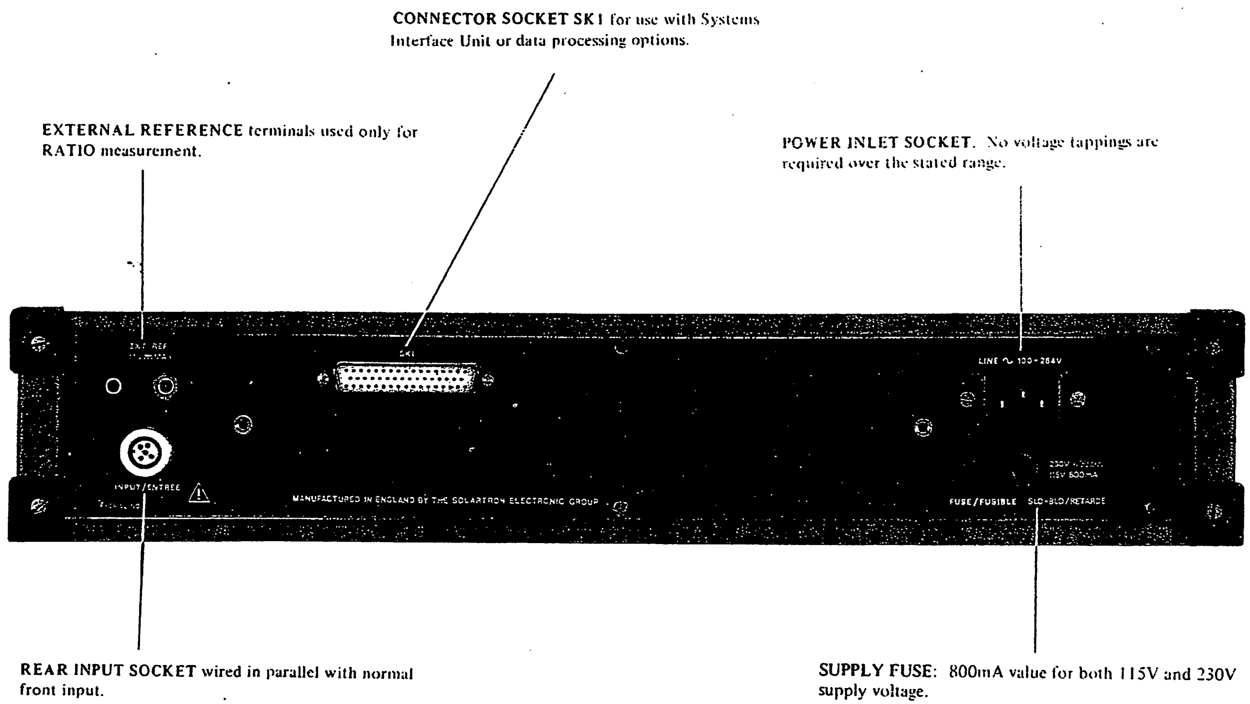
INTEGRATION TIME: Choice of 5 scale lengths by selecting one of 5 integration periods. The longer scale lengths give greater resolution.

POWER: Push-on/push-off. Applies mains power to the instrument. No remote control facility.

**NOTES**

1. An external command from the Interface Unit, FRONT PANEL LOCKOUT, can be used to inhibit all front panel controls (except POWER).

2. When in SINGLE operation, changes of FUNCTION or INTEGRATION TIME will not be implemented until the SINGLE button is again pressed.

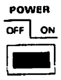


**CONNECTOR SOCKET SK1** for use with Systems Interface Unit or data processing options.
**EXTERNAL REFERENCE** terminals used only for RATIO measurement.
**POWER INLET SOCKET.** No voltage tappings are required over the stated range.
SK1
LINE ∿ 100 - 264V
INPUT/ENTREE
MANUFACTURED IN ENGLAND BY THE SOLARTRON ELECTRONIC GROUP
FUSE/FUSIBLE SLO-BLO/RETARDE
**REAR INPUT SOCKET** wired in parallel with normal front input.
**SUPPLY FUSE:** 800mA value for both 115V and 230V supply voltage.

## CONTROLS

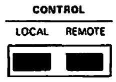
The push button controls are arranged in groups in accordance with the decisions which have to be made for any measurement.

### 1. POWER



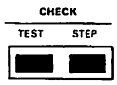

This mains switch operates with a push on - push off action and is clearly marked to indicate whether on or off. The display is always illuminated when the instrument is switched on, thus obviating the need for separate button illumination. The switch cannot be remotely controlled, however remote switch-off can be achieved by interrupting the power supply.

### 2. CONTROL




With the (optional) interface unit fitted, selection of LOCAL inhibits the effect of all remote command inputs except FRONT PANEL LOCKOUT (a command signal from the interface unit) and control is via the front panel push buttons. When REMOTE is selected all functions except SAMPLE are controlled by remote command inputs (see Section 5). the remaining three groups of push-buttons being disabled. With no interface unit fitted selecting REMOTE has no effect.

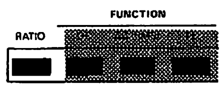
### 3. CHECK




When TEST is selected the Self Test programme is initiated, designed to check the overall function of the instrument. Progression from one test to the next is effected by pressing the STEP button. The 5 tests check the function of:-

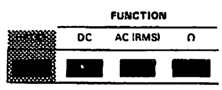
| | |
|---|---|
| 1. The DC Measurement system | Should display 7V DC ± 0.005V |
| 2. The A - D converter internal zero | Should read zero ± 0.0002V |
| 3. The AC converter | Should display 10V AC ± 0.01V |
| 4. The Ohms converter | Should display 10kΩ ± 0.02kΩ |
| 5. The Display | Should display a "full house" of eleven 8's. |

### 4.a. RATIO



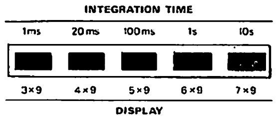

This push on - push off switch, when selected, replaces the internal reference with the user's choice of external reference applied to the terminals on the Rear Panel. A suitable reference voltage between 2 and 11 volts should be used. This function is not available with resistance measurement. N.B. It is important to disconnect any external reference supply when not making Ratio measurements.

### b. FUNCTION




These three push buttons are mechanically linked, mutually exclusive and left-justified electronically. The mechanical linkage ensures that, barring misuse, selection of one switch automatically disengages any other which had previously been selected. Should accident or misuse result in the forcing in of two of these buttons simultaneously, left-justification causes the left hand one of the pair to be the function selected electronically.

## 5. INTEGRATION TIME

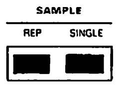



Each push button selects one of five available measurement times and, as can be seen from the legend below the switches, causes the display length to vary between 3 x 9's and 7 x 9's. The switches are of the mutually exclusive mechanically linked type with left justification as described above (4b).

The tables in Section 2 show the results of varying integration time. It should be particularly noted here, however, that when the longer integration times are used, there is a finite delay between successive updatings of the reading. This lengthening of the conversion time is true for both REP and SINGLE operation. During the delay any alteration the operator might make to the front panel controls will not be effective.

For more detailed information on the significance of integration time, the user is referred to Section 4 (Measurement Techniques).

## 6. SAMPLE




When REP is selected (i.e. normal operation) the instrument makes repeated readings at the rate determined by the selected Integration Time, each reading updating the display. When SINGLE is selected the display presents the next complete reading, and holds it. Updating of the displayed information is achieved by a further pressing of the SINGLE button, which initiates one further measurement. As a safety precaution the autorange circuits will still cause range-up while SINGLE is selected and overload protection remains operative. However care must still be exercised to ensure that the specified limits of input for the displayed mode of operation are never exceeded.

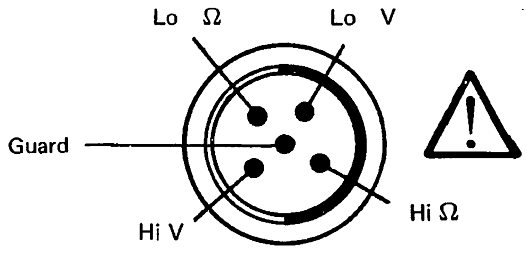
## 7. μV OFFSET

The instrument's internal zero is extremely stable and no operator adjustment is necessary. The μV OFFSET is provided to 'back-off' any small disturbances to the instrument zero which might be generated externally to the dvm. In those applications where, for example, thermal effects generated in the external circuit could be of significance and degrade the measured result, use of the μV offset will provide a correction of approximately ± 10μV.

## FRONT PANEL LOCKOUT

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

## INPUT CONNECTOR




Input connector socket, showing pin identification (front panel view).

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

The skirt of the connector acts as an isothermal chamber thus preventing errors which could otherwise result from temperature differentials across the input terminals.

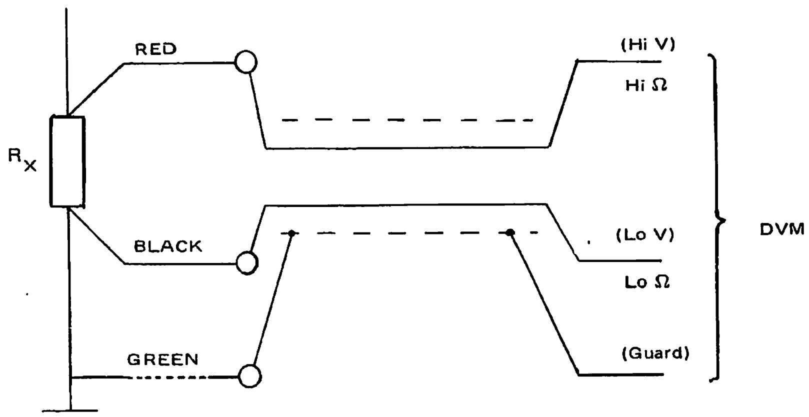
Three types of input lead are available as follows:-

(a) **2 Way Lead** (supplied as standard).

This input lead may be used for all standard measurements. The RED lead is connected to HiV and should be used as Hi, normally at the largest potential with respect to earth. The BLACK lead is connected to LoV and provides the return path. The 2 cores are enclosed in a braided screen which is connected to Guard. At the free-end of the cable, this screen is connected to the black lead thus effectively preserving the guard right up to the signal source. This prevents the measurement being affected in any way by common mode current flowing in the screen and via leakage to earth. The input may be floated above mains' earth by up to 500V, the use of higher common mode voltages is not recommended purely to ensure safety for equipment and the user. The guard is not made available as a separate termination.

(b) **3 Way Lead**

In some rare measurement situations, common mode voltages can have an affect on the readings. Most users will never encounter the problem, but those who do can still eliminate error by using this lead which has 2 cores and a screen which is available to the user. The RED should be used for Hi and the BLACK for Lo as above. The screen is available as Guard and colour-coded GREEN.



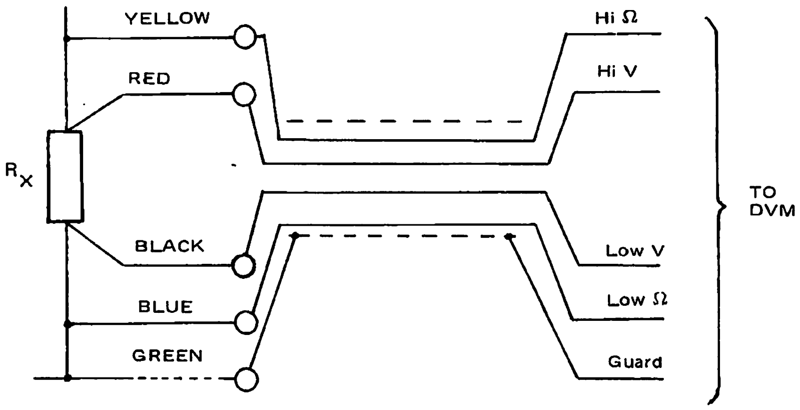

Note. In both (a) and (b) HiΩ and LoΩ are internally connected within the lead to HiV and LoV respectively. The same lead can thus be used for both voltage and resistance measurement.

When the 3-way lead is not being used as illustrated the GREEN wire should be connected to Lo (BLACK).

(c) **5 Way Lead**

This lead has 4 cores and a screen which is available to the user. The RED lead is connected to HiV, the BLACK lead to LoV, the YELLOW to HiΩ, the BLUE to LoΩ and the GREEN to GUARD.

When measuring low values of resistance, the voltage dropped along the leads can sometimes introduce errors. This effect may be eliminated by employing the 4 wire technique in which two wires supply the current to the resistor and two others sense the potential developed across it.




The example shows the correct method of using the lead, the order of connections is important, i.e. the RED and BLACK leads should be as close to the resistor as possible. The GREEN (guard) may be used as previously detailed to reduce common mode interference if this introduces errors.

These and other leads are available to order as Optional Accessories. (see full Accessories List Section 2).

To preserve the integrity of readings obtainable with this instrument it is recommended that only copper connecting clips, as supplied, are used with the input connector.

**Rear Input**

A rear input socket is fitted as standard, wired in parallel with the normal front input. This is provided as an alternative (e.g. in rack mounting use of the instrument) and connections should never be made to both front and rear input sockets.

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

A pull-out instruction card, repeating the basic operating parameters, is mounted below the front panel.

## DISPLAY

The display area is covered by a tinted screen laminated with a circularly polarised membrane to inhibit stray light or reflected light which might otherwise reduce the clarity of the reading. The front surface is lightly frosted to eliminate surface reflection from overhead lights or light coloured garments worn by the user. Very slight de-focussing results from this frosting.

The reading is updated at the selected integration rate or on pressing the SINGLE button as described earlier.

From left to right the displayed information is:-

(a) RATIO Selection of RATIO operation illuminates this legend.

(b) ∿ This sign is displayed when AC (RMS) is selected.

(c) **Numerical Indication.** Plasma discharge tubes are used to present the result of measurement. The numerals are grouped in threes, for ease of reading.

(d) **Decimal Point.** This is a fixed point, floating display instrument, leading zeroes being suppressed.

(e) **Units.** V and kΩ annunciators are illuminated as a result of selecting the required mode of measurement with the FUNCTION buttons.

(f) REMOTE An indication that the instrument is under REMOTE control - only applicable when the (optional) interface unit is fitted.

BUSY Should this legend be illuminated it advises the operator that the reading currently being displayed should be regarded as invalid. The legend is extinguished when the new result is displayed. The BUSY signal has the additional function of inhibiting the front panel push buttons. Thus once a command has initiated a measurement, the instrument will not abort that reading.

## INVALID READINGS

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

The limits are:-

**DC** **1100V DC**

**AC** **750V RMS (1100V Peak)**
**above 20kHz limit is 200V RMS**
**400V dc when on AC**

N.B. These limits only apply to LOCAL operation - for details of limits applicable when instrument is under REMOTE control see Technical Specification and Section 5.

## RACK MOUNTING

The overall dimensions conform to international standards for rack mounting. The instrument can if desired be rack mounted within its case, no additional protection being necessary. Users who so wish can remove the covers which are simply secured by four screws. For rack mounting either the handle-less rack mounting fittings, or the combination handle/ears should be substituted for the normal handles. Rack mounting fixtures of both types are included in the accessory pack supplied with the voltmeter, (See Accessories list in Section 2).

# SECTION 2 Specifications and General Information

This section contains a copy of the technical specification applicable to the voltmeter.

The 7075 has been designed and manufactured to the highest specification possible for an instrument of its type. Where typical figures are quoted, they are realistic estimates of obtainable performance based on known component tolerances and stability. Guaranteed performance, on the other hand, is specified from the results of exhaustive tests, stringently controlled, applied to every instrument produced. "Worst-case" figures are quoted in many instances, hence your 7075 may be found to exhibit a performance better in some particulars than the tables suggest. However no additional claims are made for the instrument above that published in the current data sheet.

# SPECIFICATIONS

Manufacturers calibration temperature 20°C.

## Table 1 GUARANTEED PERFORMANCE 1s Integration

| Nominal Range | Input Sensitivity | Displayed Full Scale | Limits of Error 24 hrs ± 1°C ±[% rdg. | + % f.s.] | 6 mnth ± 5°C ±[% rdg. | + % f.s.] | 1 yr ± 5°C ±[% rdg. | + % f.s.] | Input Resistance |
|---|---|---|---|---|---|---|---|---|---|
| 10mV | 1μV | 0.013 999V | | 0.007 | | 0.007 | | 0.007 | > 10GΩ |
| 100mV | 1μV | 0.139 999V | 0.0014 | 0.0014 | 0.002 | 0.0014 | 0.003 | 0.0014 | > 10GΩ |
| 1V | 1μV | 1.399 999V | 0.0006 | 0.0004 | 0.002 | 0.0008 | 0.003 | 0.001 | > 10GΩ |
| 10V | 10μV | 13.999 99 V | 0.0003 | 0.0002 | 0.0015 | 0.0005 | 0.002 | 0.0008 | > 10GΩ |
| 100V | 100μV | 139.999 9 V | 0.0007 | 0.0005 | 0.003 | 0.0008 | 0.004 | 0.001 | 10MΩ |
| 1000V | 1mV | 1 000.000 V | 0.0007 | 0.0007 | 0.003 | 0.0008 | 0.004 | 0.001 | 10MΩ |

## Table 2 TYPICAL PERFORMANCE 10s Integration

| Nominal Range | Input Sensitivity | Displayed Full Scale | Limits of Error 24 hrs ± 1°C ±[% rdg. | + % f.s.] | 6 mnth ± 5°C ±[% rdg. | + % f.s.] | 1 yr ± 5°C ±[% rdg. | + % f.s.] | Input Resistance |
|---|---|---|---|---|---|---|---|---|---|
| 10mV | 1μV | 0.013 999V | | 0.007 | | 0.007 | | 0.007 | 15GΩ |
| 100mV | 1μV | 0.139 999V | | 0.0007 | 0.001 | 0.0007 | 0.0015 | 0.0007 | 20GΩ |
| 1V | 1μV | 1.399 999V | 0.0004 | 0.00015 | 0.001 | 0.0003 | 0.0015 | 0.0005 | 200GΩ |
| 10V | 1μV | 13.999 999V | 0.00015 | 0.0001 | 0.0005 | 0.00025 | 0.001 | 0.0004 | 1000GΩ |
| 100V | 10μV | 139.999 99 V | 0.0005 | 0.0002 | 0.0015 | 0.0005 | 0.002 | 0.0007 | 10MΩ |
| 1000V | 100μV | 1 000.000 0 V | 0.0005 | 0.0003 | 0.0015 | 0.0005 | 0.002 | 0.0008 | 10MΩ |

## Reduced scale lengths

| Scale Length | Integration Time | Input Sensitivity | Limits of Error [1 year ± 5°C] |
|---|---|---|---|
| 5 x 9 | 100ms | 1μV | ± 0.004% rdg. ± 1 digit ± 1μV |
| 4 x 9 | 20ms | 1μV | ± 1 digit ± 1μV |
| 3 x 9 | 1ms | 10μV | ± 1 digit ± 10μV |

## Temp. coeff.

| Range | <± [% rdg. | + % f.s.] per °C |
|---|---|---|
| 10mV | 0.0004 | 0.0015 |
| 100mV | 0.0004 | 0.0002 |
| 1V | 0.0004 | 0.0001 |
| 10V | 0.0002 | 0.00007 |
| 100V | 0.0005 | 0.0001 |
| 1000V | 0.0005 | 0.0001 |

Zero offset <± 0.2μV per °C

**Input Current**
Typically < 20pA at 20°C

**Overload protection:**
Autorange: 1.1kV
Commanded ranges:
up to 10V: 350V
100V & 1000V: 1.1kV

**Linearity:**
error due to non-linearity is less than 1ppm and is included in the above specification.

**Temperature corrections:**
need be applied only when operating beyond the temperature limits quoted under Limits of Error.

Manufacturers calibration temperature 20°C.

Performance guaranteed above 10% of f.s. (i.e. Range-change point).

## Table 3 24 hrs at 20°C ± 1°C 1s integration

| Nominal Range | Input Sensitivity | Displayed Full Scale | Limits of Error 10Hz to 40Hz | 40Hz to 10kHz | 10kHz to 100kHz |
|---|---|---|---|---|---|
| 100mV | 1μV | 0.139 999V | ± 0.3% rdg. ± 0.05% f.s. | ± 0.05% rdg. ± 0.05% f.s. | ± 0.5% rdg. ± 0.2% f.s. |
| 1V | 10μV | 1.399 99 V | | | |
| 10V | 100μV | 13.999 9 V | | | |
| 100V | 1mV | 139.999 V | | | |
| 1000V | 10mV | 750.00§ V | ± 0.3% rdg. ± 0.1% f.s. | ± 0.05% rdg. ± 0.1% f.s. | ± 0.5% rdg. ± 0.4% f.s. |

§ Above 20kHz: 200V rms max.

## Table 4 6 months at 20°C ± 5°C 1s integration

| Nominal Range | Limits of Error 10Hz to 40Hz | 40Hz to 10kHz | 10kHz to 100kHz |
|---|---|---|---|
| 100mV, 1V | ± 0.4% rdg. ± 0.08% f.s. | ± 0.1% rdg. ± 0.06% f.s. | ± 0.5% rdg. ± 0.2% f.s. |
| 10V, 100V | ± 0.4% rdg. ± 0.08% f.s. | ± 0.1% rdg. ± 0.06% f.s. | ± 0.7% rdg. ± 0.2% f.s. |
| 1000V | ± 0.4% rdg. ± 0.08% f.s. | ± 0.1% rdg. ± 0.1% f.s. | ± 0.7% rdg. ± 0.4% f.s. |

## Table 5 1 year at 20°C ± 5°C 1s integration

| Nominal Range | Limits of Error 10Hz to 40Hz | 40Hz to 10kHz | 10kHz to 100kHz |
|---|---|---|---|
| 100mV, 1V | ± 0.5% rdg. ± 0.1 f.s. | ± 0.15% rdg. ± 0.1% f.s. | ± 0.6% rdg. ± 0.2% f.s. |
| 10V, 100V | ± 0.5% rdg. ± 0.1% f.s. | ± 0.15% rdg. ± 0.1% f.s. | ± 1.0% rdg. ± 0.2% f.s. |
| 1000V | ± 0.5% rdg. ± 0.2% f.s. | ± 0.15% rdg. ± 0.2% f.s. | ± 1.0% rdg. ± 0.4% f.s. |

## Other integration times

| Time | Sensitivity | Scale Length | Min. Frequency* | Specification |
|---|---|---|---|---|
| 10s | 1μV | 139 999 | as Tables 3 to 5 | as Tables 3 to 5 |
| 100ms | 1μV | 139 999 | 40Hz | as Tables 3 to 5 |
| 20ms | 10μV | 13 999 | 100Hz | add ± 0.01% f.s. |
| 1ms | 100μV | 1 399 | 400Hz | add ± 0.1% f.s. |

* < 40Hz best performance is given by 1s or 10s integration.

## Temp. coeff.

| Range | <± [% rdg. | + % f.s.] per °C |
|---|---|---|
| 100mV | 0.015 | 0.004 |
| 1V | 0.015 | 0.004 |
| 10V | 0.015 | 0.004 |
| 100V | 0.015 | 0.004 |
| 1000V | 0.015 | 0.004 |

**Overload protection:**

| | |
|---|---|
| 100mV & 1V ranges: | 350V peak |
| 10V, 100V, 1000V ranges: | 1.1kV peak |
| All ranges, above 20kHz: | 200V rms |

**Crest factor:** 5 : 1 at f.s.

**Input impedance:**

| | |
|---|---|
| at input socket: | 1MΩ//< 150pF |
| of standard input cable: | < 300pF |

**Very low frequency measurement:**
Useful readings can be made down to 1Hz with <1dB error by employing the 10s integration time.

**Temperature corrections:**
need be applied only when operating beyond the temperature limits quoted under Limits of Error.

Manufacturers calibration temperature 20°C.

## Table 6 GUARANTEED PERFORMANCE 1s integration

| Nominal Range | Input Sensitivity | Displayed Full Scale | Limits of Error 24 hrs ± 1°C ±[% rdg. + % f.s.] | | 6 mnth ± 5°C ±[% rdg. + % f.s.] | | 1 yr ± 5°C ±[% rdg. + % f.s.] | | Measuring Current |
|---|---|---|---|---|---|---|---|---|---|
| 10Ω | 1mΩ | 0.013 999kΩ | | 0.014 | | 0.014 | 0.01 | 0.014 | 1mA |
| 100Ω | 1mΩ | 0.139 999kΩ | 0.001 | 0.002 | 0.003 | 0.002 | 0.005 | 0.002 | 1mA |
| 1kΩ | 1mΩ | 1.399 999kΩ | 0.002 | 0.0005 | 0.003 | 0.001 | 0.005 | 0.0015 | 1mA |
| 10kΩ | 10mΩ | 13.999 99 kΩ | 0.002 | 0.0003 | 0.0025 | 0.0008 | 0.004 | 0.001 | 1mA |
| 100kΩ | 100mΩ | 139.999 9 kΩ | 0.001 | 0.0005 | 0.003 | 0.001 | 0.006 | 0.0015 | 10μA |
| 1MΩ | 1Ω | 1 399.999 kΩ | 0.001 | 0.0003 | 0.003 | 0.001 | 0.006 | 0.0015 | 10μA |
| 10MΩ | 10Ω | 13 999.99 kΩ | 0.002 | 0.001 | 0.006 | 0.0015 | 0.008 | 0.0015 | 1μA |

Maximum dissipation in unknown: 14mW Maximum overload: 250V rms Maximum Voltage, Lo current/Lo sense: 10V peak.

**10s integration time:** specification as above, but having one additional decade displayed on ranges 10kΩ and above.

## Reduced scale lengths

| Scale Length | Integration Time | Input Sensitivity | Limits of Error 1 year ± 5°C |
|---|---|---|---|
| 5 x 9 | 100ms | 1mΩ | ± 0.008% rdg. ± 1 digit ± 1mΩ |
| 4 x 9 | 20ms | 1mΩ | ± 1 digit ± 2mΩ |
| 3 x 9 | 1ms | 10mΩ | ± 1 digit ± 10mΩ |

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

## Temp. coeff.

| Range | <± [% rdg. + % f.s.] per °C | |
|---|---|---|
| 10Ω | 0.0007 | 0.0015 |
| 100Ω | 0.0007 | 0.0002 |
| 1kΩ | 0.0007 | 0.0001 |
| 10kΩ | 0.0005 | 0.00007 |
| 100kΩ | 0.0007 | 0.0001 |
| 1MΩ | 0.0007 | 0.0001 |
| 10MΩ | 0.0012 | 0.0001 |

Zero offset <± 0.2mΩ per °C

**Temperature corrections:**
need be applied only when operating beyond the temperature limits quoted under Limits of Error.

# RATIO FACILITY

| | |
|---|---|
| Reference Voltage: | 2 to 11V |
| Input Resistance: | Ref Hi to Ref Lo: 2 MΩ |
| | Ref Hi to Sig Lo: 1.7MΩ |
| | Ref Lo to Sig Lo: 1.7MΩ |
| Reference Overload: | 100V peak differential |
| | 100V peak either terminal to Sig Lo. |
| **Limits of Error** 1 yr at 20°C ± 5°C: | $\pm$ [Normal % rdg. + 0.005% rdg. + (Normal % f.s. + 0.005% rdg.) $\frac{10}{V_{Ref}}$ ] |
| Temperature Coefficient: | $\pm$ [Normal % rdg. T.C. + 0.001% rdg. + (Normal % f.s. T.C. + 0.001% rdg.) $\frac{10}{V_{Ref}}$ ] |

Ratio of peak interference to 1 digit reading error.

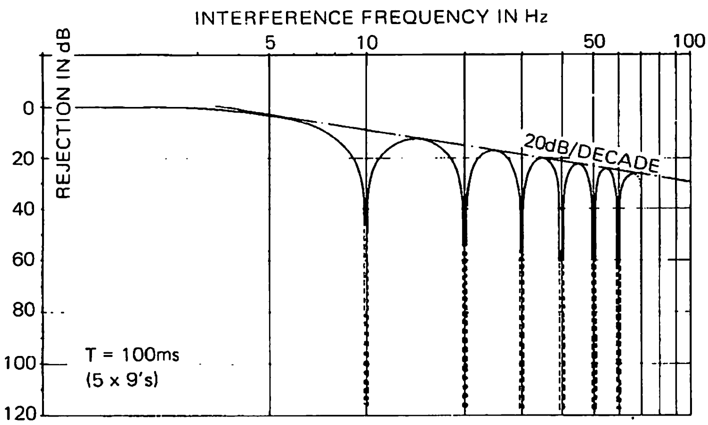
# Series mode

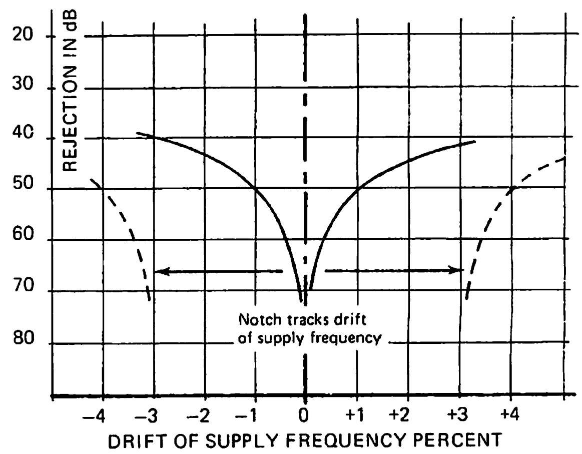
| | | | |
|---|---|---|---|
| Maximum Series Mode: | Autorange: | 1.1kV pk | |
| | Command Range: | 1.5 x $V_{Range}$ | |
| DC Measurement: | Rejection of 50 (60) Hz ± 3% | | > 70dB |
| Ratio Measurement: | Rejection of 50 (60) Hz ± 3% at Ref. | | > 40dB |

# Effective common mode

Measured with 1kΩ imbalance in Lo lead.

| | | |
|---|---|---|
| Maximum Common Mode: | | 500V dc or peak ac. |
| DC Measurement: | Rejection of dc: | > 150dB |
| | Rejection of 50 (60) Hz ± 3%: | > 144dB |
| AC Measurement: | Rejection of dc: | > 150dB |
| | Rejection of 50 (60) Hz ± 3%: | > 74dB |
| Ratio Measurement: | Max. Common Mode Ref. Hi or Lo to Sig Lo: | 30V |
| | Rejection of Common Mode Ref Lo to Sig Lo with up to 80Ω lead imbalance: | > 80dB |




In the measurement of dc voltage 7075 gives the mean (average) value of the input during the chosen integration time. Except for 1ms, the times are multiples of the period of the mains supply. Hence the curves for interference rejection exhibit deep notches at discrete frequencies, those for 100ms shown above having a notch every 10Hz. By using the 10s integration the notches become spaced at only 0.1Hz intervals. Furthermore the tangent to the peaks, while retaining the slope of 20dB/decade, is spaced 20dB lower on 1s integration and 40dB lower on 10s integration.

The precise integration time is locked to the period of the mains supply by a digital servo. The notches move to right or left as supply frequency changes thus preserving maximum rejection up to a shift of ± 3%. This is beyond the limit of frequency deviation specified for the national grid.

# Environment

| | |
|---|---|
| Working Temperature Range: | 0 to + 50°C. |
| Storage Temperature Range: | −30 to + 70°C. |
| Maximum Relative Humidity: | 70% at + 40°C. |

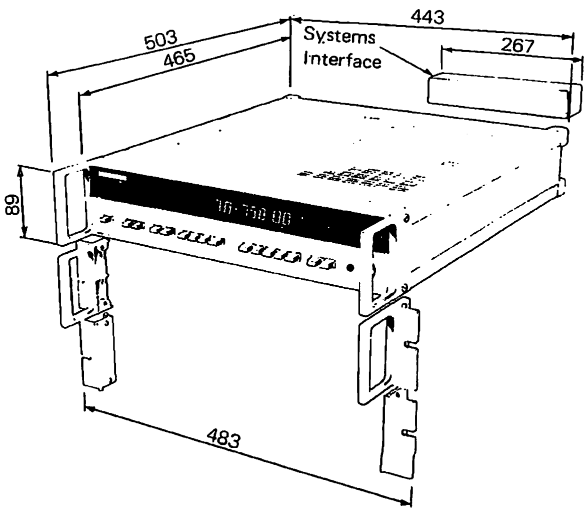
Other specifications to Solartron spec. 50/01/102.

# Power supply

| | |
|---|---|
| Voltage: | 100 to 264V (no mains tap). |
| Frequency: | 50(60)Hz ± 3%. Internal switch provides optional 400Hz operation. The instrument is capable of operating up to 2400Hz supply frequency. |
| Consumption: | Approx. 65VA (35W) |
| Fuse | 800mA Slo Blo |

# Dimensions

| | | | |
|---|---|---|---|
| Width: | 443mm | (17.4ins) | Rack mounting depth, |
| Height: | 89mm | (3.5ins) | over interface + cable: |
| Depth: | 465mm | (18.3ins) | 533mm (21ins). |
| Weight: | 9.1kg | (20lbs) | |




# Safety

This instrument conforms to IEC 348 recommendations.

# Accessories

| Included Accessories | | Part No. | Optional Accessories | Part No. |
|---|---|---|---|---|
| Input Cable | | A2000168 | Systems Interface (Parallel BCD) | 70754A |
| Crocodile Clip (copper) | | 355901030 | Systems Interface (IEC TC66/IEEE 488) | 70755A |
| Test Probe | Red | 351901020 | High Voltage Probe | 70757A |
| Test Probe | Black | 351901010 | 3-Terminal input lead | 3193 |
| Spare fuse | 800mA | 360106310 | 5-Terminal input lead | 3183 |
| Mains cable | | 480140220 | Telescopic Rack Slides (pair) | 70759A |
| Rack mounting handles | (2 off) | 429700101 | ESI Kelvin clip leads (pair) | 70758E |
| Rack mounting ears | (2 off) | 469601201 | Low thermal lead kit | 70758D |
| Operating Manual | | 70750010 | Master Series adaptor lead | 70758G |
| Technical Manual | | 70750011 | Service kit | 70759C |
| | | | Calibration cover | 70759D |

# SECTION 3 Operating Instructions

**PRELIMINARIES**

Check that the correct fuse is fitted, 800mA SLO-BLO

Connect a suitable plug to the mains lead:-

| | |
|---|---|
| BROWN | LINE |
| BLUE | NEUTRAL |
| GREEN/YELLOW | EARTH |

*N.B. It is important that this Earth connection is made.*

**Operation at other than 50Hz supply frequency**

The link for 60Hz operation and the switch for 400Hz operation are positioned on board 2, on the right hand side of the instrument. Access to these necessitates partial removal of the cover.

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

## DC VOLTAGE MEASUREMENT

1. Switch POWER on.

2. Select LOCAL, unless Remote operation with optional interface unit is required. (In that instance refer to Section 5).

3. Ensure TEST and RATIO push buttons are released.

4. Select DC.

5. Select INTEGRATION TIME for the resolution, noise rejection and reading rate that are required.

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

7. Select REP for repetitive display of measurement or press SINGLE for each single reading required. 'V' will now be illuminated.

8. Read the displayed value. The indicated polarity is that of the red lead with respect to the black. (Polarity is positive unless the minus sign is illuminated).

   The user is referred to Section 4 for further information on measurement technique, and the significance of varying Integration Time.

## AC VOLTAGE MEASUREMENT (True RMS)

1. Switch POWER on.

2. Select LOCAL, unless Remote operation with interface unit is required. (In that instance refer to Section 5).

3. Ensure TEST and RATIO push buttons are released.

4. Select AC (RMS).

5. Select INTEGRATION TIME for the resolution, noise rejection and reading rate that are required.

Note. A maximum of 5 × 9's reading can be obtained, selection of 1s or 10s resulting in a quieter display at low frequencies, by a process of Digital Filtering (the user is referred to Section 4 for more detailed information on the significance of Integration Time when measuring AC).

6. Connect input lead to the unknown Voltage source.

7. Select REP for repetitive display of measurement or press SINGLE for each single reading required. The ∿ sign will be illuminated.

8. Read the displayed value.

## CURRENT MEASUREMENT

Although not a facility directly provided by this instrument, current measurement can be easily effected by measuring the potential difference developed across a known precision resistor, either a resistance Standard or a precision wire wound component. For ac measurement a metal film precision resistor is recommended. Alternatively the Solartron Current Adaptor may be used to convert your voltmeter into an ac/dc digital ammeter capable of measuring currents in the range 100pA to 1.2A. Full details and operating instructions are contained in the Adaptor handbook.

## RATIO MEASUREMENT DC/DC and AC/DC (True RMS)

Without RATIO selected, all instrument measurements are made with reference to an internal reference supply.

With RATIO selected an external reference supply (between 2V and 11V dc) must be connected to the rear terminals and all instrument measurements are then referenced to this supply. The relationship between input and the display becomes:-

$$V_{out} = \frac{10V_{in}}{2 < V_{ref} < 11}$$

where $V_{out}$ is the displayed reading, $V_{in}$ is the applied voltage and $V_{ref}$ is the chosen value of external reference.

After the external reference supply is connected, RATIO measurement operation is as for normal operation. The ratio is,

$$\frac{\text{displayed reading}}{10}$$

## RESISTANCE MEASUREMENT

1. Switch POWER on.

2. Select LOCAL, unless remote operation with interface unit is required. (In that instance refer to Section 5).

3. Ensure TEST and RATIO push buttons are released.

4. Select Ω.

5. Select INTEGRATION TIME for the resolution, noise rejection and reading rate that are required.

6. Connect input lead to the unknown resistance.

7. Select REP for repetitive display of measurement or press SINGLE for each single reading required. The kΩ annunciator will be illuminated.

8. Read the displayed value.

   For details of 4 terminal measurement and other refinements of technique the user is referred to Section 4 of this manual.

# SECTION 4 Measurement Techniques

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

## INPUT RESISTANCE

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

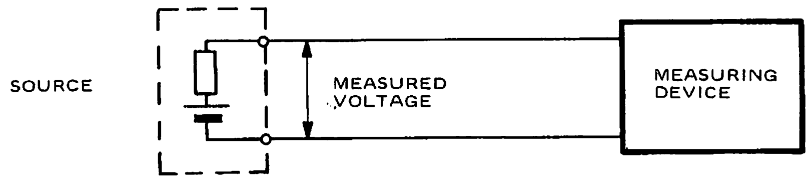



Fig. 4.1 *Current taken by a measuring instrument can cause a voltage drop across source resistance.*

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

Fortunately, electronic feedback techniques can give a digital voltmeter such a high input resistance that, for most practical purposes, the effect can be ignored. Thus the 7075 when measuring dc voltages less than 14V, has an input resistance in excess of 10GΩ. This means that the source resistance has to exceed 10kΩ before an error of 1 part per million is produced. If this sounds somewhat vague, it should be understood that defining the input resistance more closely is impossible since a group of voltmeters will have differing gains in their input amplifier. This will of course have no effect on their accuracy, but will make the input resistance different - possibly 20GΩ to 50GΩ, but never as low as 10GΩ.

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

## INPUT CURRENT

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

By careful design this current can be reduced such that its effects are almost negligible and in the 7075 it is less than 20pA at room temperature. The input current will flow into or out of the Hi terminal and must therefore, be regarded as lying between + 20pA and − 20pA.

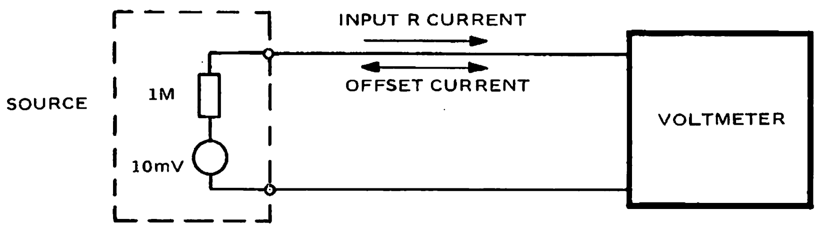



Fig. 4.2 *Current taken by input resistance flows into the voltmeter: offset current may flow either way. Both effects are present together.*

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

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

## ASSESSING INPUT RESISTANCE AND CURRENT

1. **Input Current:-**

Connect a 10MΩ resistor across the input terminals. Select 1s or 10s integration time and DC. (In a "noisy" environment it may be necessary to enclose the resistor in a screening box connected to the Lo terminal). The input current in pA is obtained by dividing the reading in μV by 10.

2. **Input Resistance:-**

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

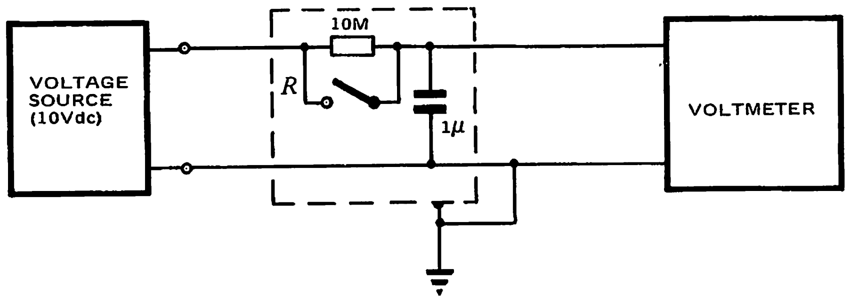



**Fig. 4.3** *An assessment of input resistance will include an effect due to offset current.*

Select 1s or 10s integration time and DC.
With switch closed note the reading.
Open the switch and note the fall in reading (ΔV)

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

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

then:

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

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

Substituting the experimental known values:

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

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

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

It was previously noted that $I_{in}$ may flow into or out of the dvm Hi terminal, assisting or opposing the source current. The magnitude of $I_{in}$ is evaluated as in 1. above (Fig. 4.2); its direction and hence its effect on $R_{in}$ can be readily established by reversing the source terminals in the circuit of Fig. 4.3 and again noting the reading with the switch open. A higher reading is obtained when $I_{in}$ opposes the source current, in which case $\Delta V$ will be smaller and $I_{in}$ in the final expression will have a negative value.

## SPURIOUS VOLTAGES

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

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

As an example, consider measuring the voltage produced by passing a very small current through a wirewound resistor. On the 100mV range the reading is recorded as 126μV. But the resistor is placed - in the sun or near a power transistor - so that one end is a little warmer than the other. Because of the dissimilar materials used in the wire of the resistor and the copper connections, a net thermal emf of possibly 40μV/°C will exist. Thus a differential of 0.5°C across the resistor could mean that the true result should be either 106μV or 146μV. The voltmeter cannot possibly distinguish between the wanted and unwanted parts of the signal that is applied to it. In this example, without altering the conditions of the resistor in any way, a measurement should be made with the small current flowing first in one direction and then in the other. In one case the thermal emf will add and in the other it will subtract. So the mean of the two results will eliminate the error

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

When the unwanted emf can be determined and is steady, it can be 'backed-off' by using the μV OFFSET control. This has a range of ± 10μV. (typically)

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

## SERIES MODE INTERFERENCE

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

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

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

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

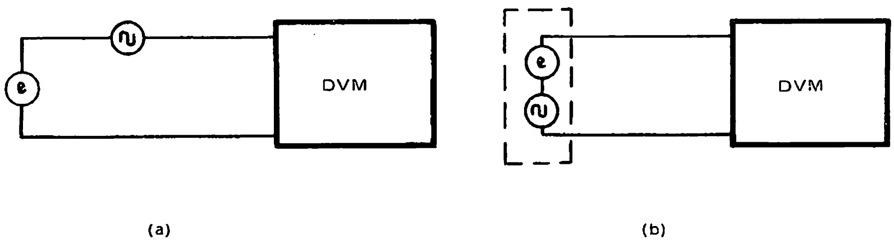



Fig. 4.4 *Interference at 50Hz can arise from pick-up on the leads (a), or may be inherent in the source (b).*

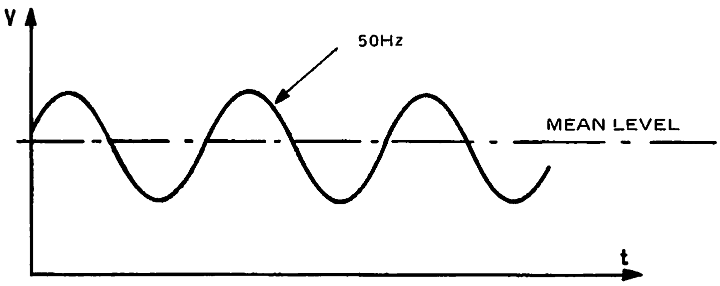



Fig. 4.5 *50Hz superimposed on the dc level that the voltmeter is trying to measure.*

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

The 7075 rejects ac signals by averaging the input voltage over the period of time selected, i.e. the integration time. Since the most common form of interference is attributable to the 50Hz (60Hz) mains, the integration times are chosen to be exact multiples of the mains period (20ms at 50Hz). This is achieved by timing the integration periods using a clock synchronised to the mains supply. Thus over the integration period the average 50Hz (60Hz) interference will be zero, the reading being unaffected.

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

Considering, as an example, the 1s integration time:-

1Hz, 2Hz, 3Hz, 4Hz, 5Hz. . . . . . . . 57Hz, 58Hz. . . . . . 83Hz, 84Hz. . . . . . . . . . . . . . . 126Hz etc., being whole numbers of Hz their periods are exact fractions of 1s and hence total rejection will occur.

For the 10s integration time there will be 10 times as many totally rejected frequencies, starting at 0.1Hz and spaced 0.1Hz apart. The only practical limitation of frequency rejection is that imposed by clock accuracy and in the 7075 rejection of 50Hz (60Hz) is better than 70dB.

Series mode rejection is defined as:-

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

N.B. The 1ms integration time has of course no rejection at 50Hz.

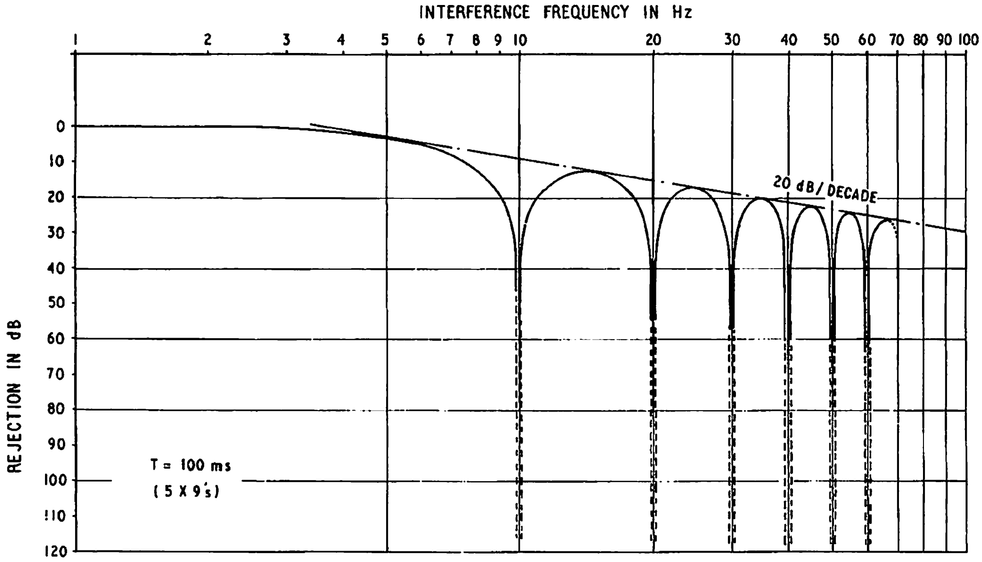



Fig. 4.6 *SERIES MODE REJECTION: These curves show the rejection at the frequencies given whilst measuring dc. The integration time is locked to the mains period so the curves will shift along the frequency axis as the mains supply frequency alters.*

## COMMON MODE INTERFERENCE

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

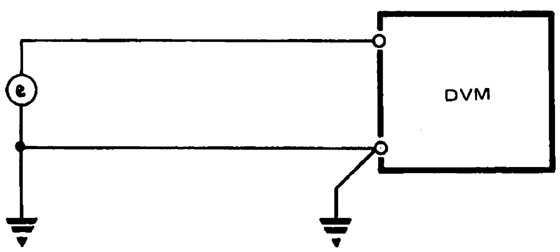



Fig. 4.7 *An 'earth' at both source and voltmeter input may introduce common mode interference. For this reason the voltmeter input is fully isolated.*

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

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

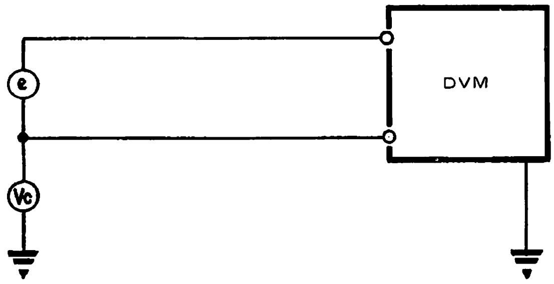



Fig. 4.8 *The source can be at a high potential above earth without causing errors.*

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

The 7075 has been engineered so that the input circuits are extremely well isolated from the case, which itself is connected to mains earth. In all normal measurement the small current which does flow as a result of a large common mode voltage, will not cause any error. However, purely for the safety of equipment and operator, this voltage should not exceed 500V.

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

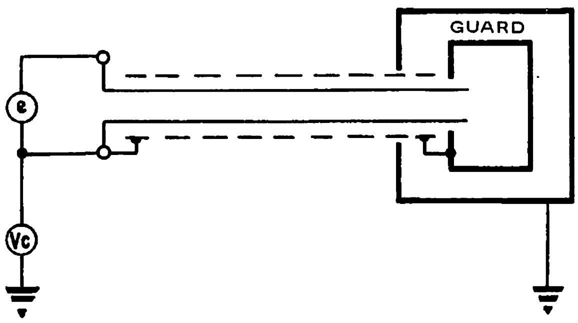



Fig. 4.9 *In the lead provided with the voltmeter Guard is strapped to Lo (BLACK) within the free end of the cable.*

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

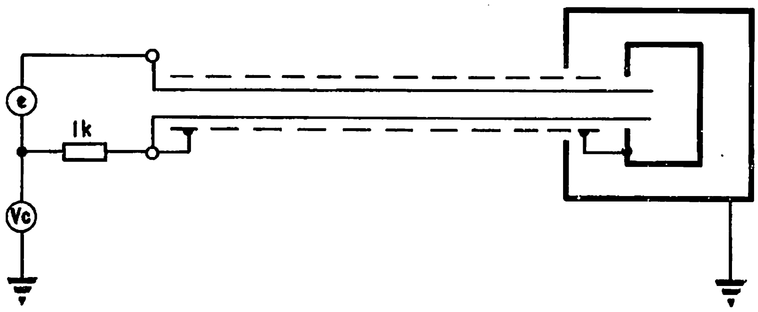



Fig. 4.10 *A rare, but more difficult, situation is where common mode current flows through lead resistance. This is entirely overcome by the arrangement of Fig. 4.11.*

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

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

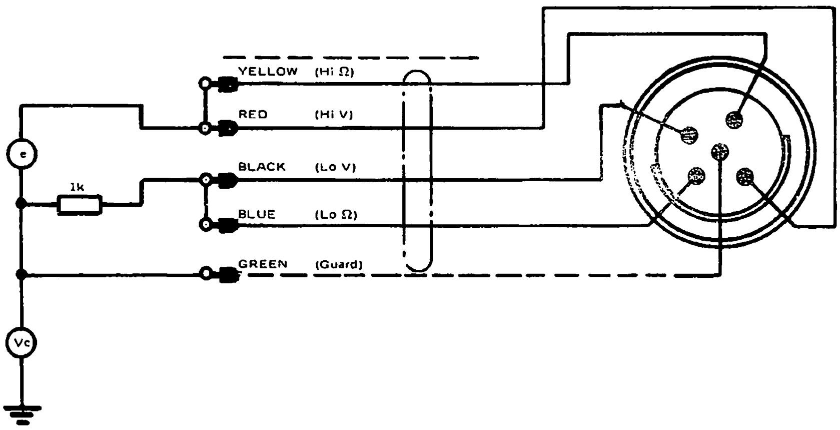



Fig. 4.11 *A special lead (EX 3183) is obtainable from Solartron which enables the Guard to be driven directly by the common mode voltage.*

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

The four cores are required for 4-terminal resistance measurement as described later. For voltage measurement with guard, however, only 3-terminals are required - signal Hi, signal Lo and screen (guard). When measuring voltage the YELLOW and BLUE cores are internally linked to RED and BLACK by the selection circuits. To prevent inadvertent contact of these plugs with earth, other terminals or each other. the user should plug YELLOW into RED and BLUE into BLACK. GREEN is connected directly to the source of interference thus isolating common mode current from the input leads.

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

For a more complete treatment of interference in digital voltmeter measurement the reader is referred to the following monographs:-

(1) Digital Voltmeters and Interference.

(2) Principles of Interference Rejection.

both of which are available free on request to Solartron.

## NOISE

The foregoing explanation of interference dealt specifically with 50Hz because by far the most common source of interference is the mains supply or fields radiating from mains wiring and mains energised equipment. It has been shown in earlier pages of this Section that, at harmonics of 50Hz, rejection is improved so that 100Hz ripple from power supplies or 400Hz/1600Hz aircraft and ship supplies are unlikely to cause difficulty. When considering noise of no specific frequency (e.g. white noise) the integration process still applies and the resultant noise component over the integration period will tend to zero.

## INTEGRATION TIME

When considering immunity to series mode interference, reference was made to the integration time. This time, which is capable of selection by the user, is the period over which the instrument takes an *average* measurement of the input level. The conversion technique continuously integrates (i.e. averages) the input signal, results being obtained which in principle, increase the accuracy of the conversion in direct proportion to the integration time. Averages over periods greater than 10s may be achieved in practice by recording successive 10s measurements and calculating the average over the time required. The result would be a true average of the input signal. For example an input of 10.00001V measured with an integration time of 100ms (full scale 14.0000) will be displayed as 10.0000 with the least significant digit changing to a 1 once every ten readings. This indicates that the true reading (the average over a large number of readings) is in fact 10.00001.

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

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

All integration times are available in DC AC and Ω but the display on AC is limited to 5 × 9's (full scale 140000). This is discussed more fully in the following paragraphs.

## AC MEASUREMENT

In its simplest form a dvm is able to measure dc voltage only. It can be adapted to measure ac by including an ac - dc converter before the dc input circuits. This is the case in the 7075, which employs a sophisticated circuit which converts the input into a dc proportional to its true rms value. This is an obvious advantage over previous, mean sensing, instruments, since alternating voltages are conventionally specified by rms value. In order to appreciate the difference between rms and mean, the reader is reminded of the precise relationship between the three ways of specifying the magnitude of a sinusoidal waveform:-

$$\text{Mean} = \frac{2}{\pi}\,\text{peak} \qquad \text{i.e.} \quad 0.637\ V_p$$

RMS (i.e. the *root* of the *mean* of the *square* of the input).

$$= \frac{1}{\sqrt{2}}\,\text{peak} \qquad \text{i.e.} \quad 0.707\ V_p$$

Two other relationships are important when evaluating alternating quantities. They are *form factor* and *crest factor*, derived as follows:-

$$\text{Form factor} = \frac{\text{rms}}{\text{mean}} = 1.1 \quad \text{for a sine wave.}$$

$$\text{Crest factor} = \frac{\text{Peak}}{\text{rms}} = 1.414 \text{ for a sine wave.}$$

Maximum crest factor for the 7075 is specified as 5:1.

## COMPUTING TECHNIQUE FOR DERIVING RMS

A circuit for deriving true rms value of an alternating quantity is, in its simplest form, a circuit which:

a. squares the input $V^2$

b. obtains a mean $\overline{V^2}$

c. takes the square root $\sqrt{\overline{V^2}}$

That used in the 7075 is one of many configurations based on the simplified illustration in Fig. 4.12. It has the advantage of being, to a large extent, unaffected by waveform shape.

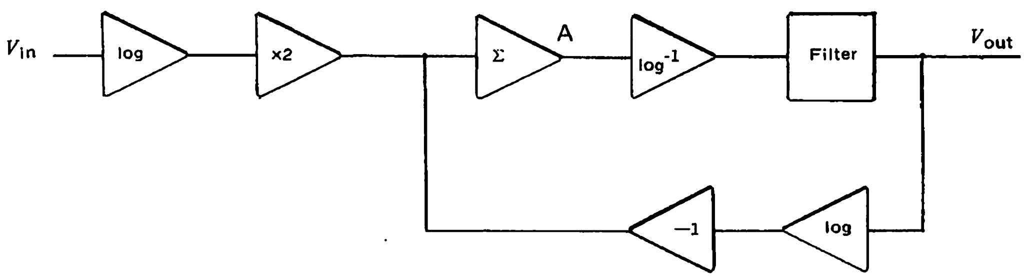



Fig. 4.12 *Typical computing technique for deriving true rms value.*

Expressed mathematically, the output of the summation amplifier, Point A, is

$$2 \log V_{in} - \log V_{out}$$

while the circuit output, $V_{out}$, is:

$$V_{out} = \overline{\text{Antilog}\,(2 \log V_{in} - \log V_{out})}$$

$$\therefore \quad V_{out} = \frac{\overline{V_{in}^2}}{V_{out}}$$

$$\therefore \quad V_{out}^2 = \overline{V_{in}^2}$$

$$\therefore \quad V_{out} = \sqrt{\overline{V_{in}^2}}$$

It has been said that with a circuit of this type the possibility of errors due to waveform distortion are virtually eliminated. However, when the 7075 is used on pulse waveforms, care may be necessary to ensure that it is operating within the specified limits. An approximate Crest Factor value for a pulsed waveform can be calculated from the formula:

$$\text{C.F.} = \sqrt{\text{Mark/space ratio}}$$

Elsewhere in this Section it was noted that when measuring dc voltages the dvm cannot reject thermal or other dc interference. Similarly there cannot possibly be rejection of series mode ac interference when measuring ac voltages. Common mode rejection is, however, still preserved and the input circuits on ac are still fully isolated from the instrument case and from earth.

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

## INTEGRATION TIME

In an earlier note reference was made to the limitation of scale length imposed on the ac mode of measurement. All integration times are available on AC but selection of the two longer periods is not accompanied by the increased resolution obtained in dc measurement. Selection of 1s or 10s integration time introduces Digital Filtering, enabling more stable, less noisy readings to be achieved with low frequency ac inputs. It is recommended that, in a noisy environment, users wishing to measure low frequency ac voltages make use of the significant advantages to be gained, by selecting one of the two longer integration times.

## RESISTANCE

The 7075 measures the value of a resistor by passing a defined current through it and measuring the resulting potential difference. The current is small so that the power dissipated in the resistor is negligible.

| Resistance Value measured | Current used |
|---|---|
| $< 14k\Omega$ | 1mA |
| $> 14k\Omega < 1.4M\Omega$ | 10$\mu$A |
| $> 1.4M\Omega \leqslant 14M\Omega$ | 1$\mu$A |

The 1m$\Omega$ sensitivity is satisfactory for most low value measurements. Should there be a requirement for increased sensitivity on low values the voltmeter can be used on a dc voltage range to measure the potential difference across the resistor with the current provided from an external source (Fig. 4.13).

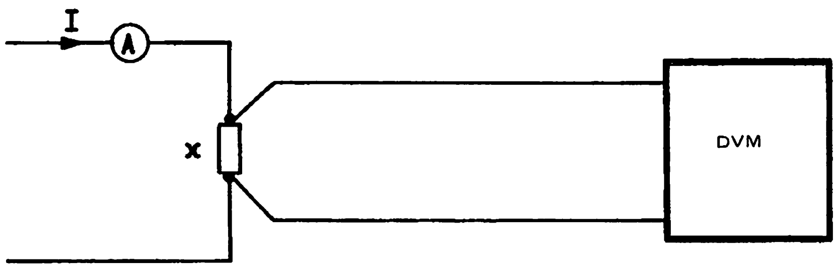



Fig. 4.13 *A very low value resistance may be measured by measuring the voltage developed across it. The voltage leads should be connected close to the ends of the resistor.*

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

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

An improved technique is shown in Fig. 4.14.

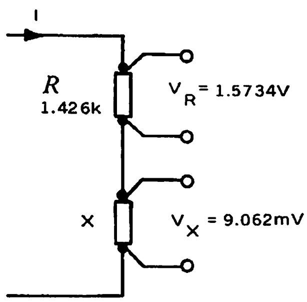



Fig. 4.14 *A ratio measurement avoids having to set a precise value of current.*

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

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

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

Using the values shown in Fig. 4.14:-

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

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

Should it be necessary to measure resistance at a distance from the voltmeter which is beyond the reach of the standard lead, a special lead may be obtained from Solartron. In this the four cores and screen are terminated separately as shown in Fig. 4.15.

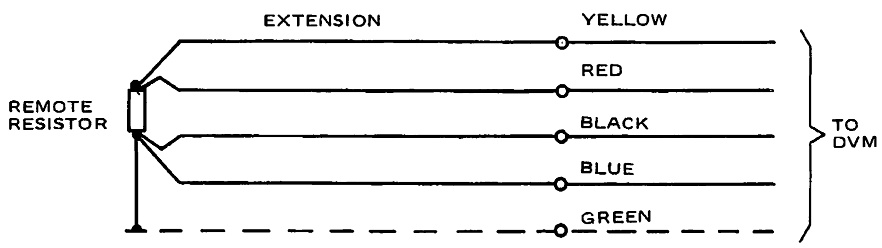



Fig. 4.15 *In measuring a remote resistor, lead compensation can be preserved by using the special input cable (obtainable from Solartron) and extending it by a 4 core screened cable.*

This cable should be extended to reach the point of measurement by means of a similar 4 core screened cable and connected to the remote resistor as shown.

This arrangement will preserve the compensation for lead resistance up to a maximum of 1Ω per wire, on any ohms range. Using an extension of 7/.0076 wires a length of 100m can be safely used. (The Yellow and Red leads may have resistances as high as 1kΩ).

The user is reminded that, should separate extension wires be used for this purpose, the connector run should be identical for each lead - preferably by employing twisted pairs. In this way the effects of interference emf's, induced in the leads as a result of local electromagnetic fields, will be minimised.

## RATIO MEASUREMENT

Ratio is a relationship, of one quantity relative to another. When considering ratio measurement one intends that measurement is to be made relative to a reference source. It is essential, therefore, when making precision ratio measurements with the 7075, that the integrity of the reference matches the stability and accuracy of the dvm. If that cannot be guaranteed, it is suggested that reference and signal inputs are derived from the same voltage source. Thus any variation in the source, providing it is within both input limits, will not affect the readings.

## DC/DC RATIO

Example 1. Comparing the performance of one device against another, standard, device.

Two transducers, A and B are in the same environmental enclosure and fed from a common power source. to ensure that variations in the supply and of temperature, vibration etc., affect both devices equally (Fig. 4.16).

The output of A, the standard, is taken to the dvm reference terminals while that of B - the transducer under test - is taken to the dvm signal input.

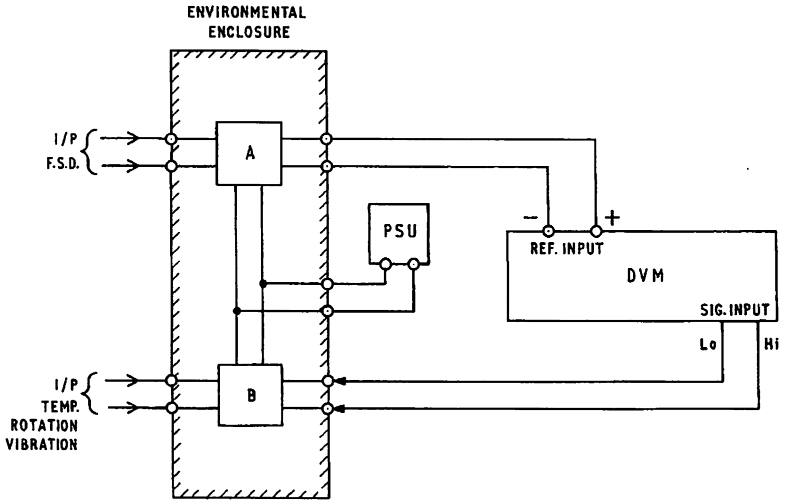



Fig. 4.16.

As was stated in Section 3 of this manual, the relationship between the dvm reading ($V_{out}$) and its input ($V_{in}$) when RATIO is selected is:-

$$V_{out} = \frac{10V_{in}}{V_{ref}}$$

Thus the ratio $V_{in} : V_{ref} = \frac{\text{displayed reading}}{10}$

which in the example is the ration of the output of transducer B to that of A. Thus a true comparison can be made.

Example 2. Determining the actual value of a number of 0.1Ω precision resistors, given a standard resistor of known value 10.0002Ω (± 0.005%) rated at 1A.

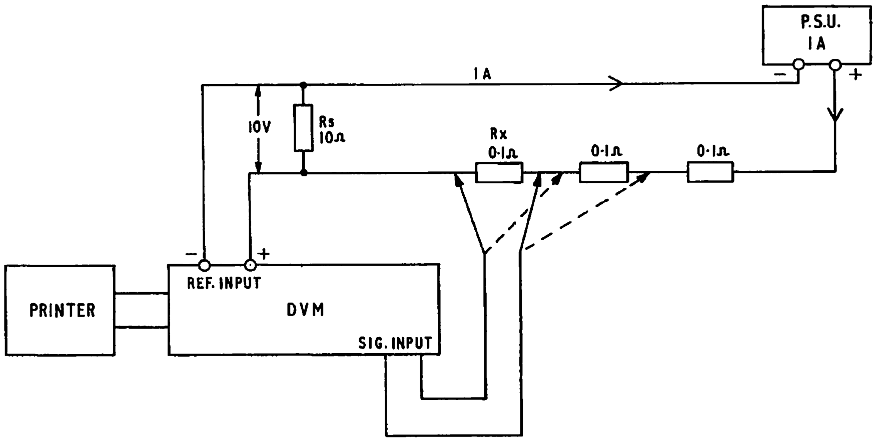



Fig. 4.17.

The constant current psu delivers 10V nominal at 1A. With the dvm operating on the 100mV range:

$$\frac{R_x}{R_s} = \text{Ratio} = \frac{\text{displayed reading}}{10 \times 10^3}$$

$$R_x = \frac{\text{displayed reading}}{10^4} \times R_s$$

If the dvm reading is 100.050mV

$$\text{then } R_x = \frac{100.050}{10^4} \times 10.0002$$

$$= 0.100053\Omega$$

Note that the resolution of the result is 1μΩ and the total uncertainty is the sum of the limits of error of the dvm on the selected range and the tolerance of the standard resistor.

This technique should be compared with that shown in Fig. 4.14 and the two important differences noted:

(i) the actual voltage across $R_s$ does not have to be measured

(ii) provided $V_{ref}$ does not fall below 10V (for minimum uncertainty) the source current need not be stable.

## CONCLUSION

Use of the Ratio facility is not intended to, nor does it, give more accurate measurements than those possible using the instrument's internal reference. It does, however, simplify many otherwise time consuming measurement tasks. The reader will no doubt discover many more applications than the examples given.