Insulation Tester
MEGGER® Series 1-5000

Operating
Instructions

MEGGER®

SAFETY WARNING

- ★ ***The circuit must be de-energized and isolated BEFORE connections are made for any test.***
- ★ ***Do not touch the circuit during an insulation test.***
- ★ ***After insulation tests, capacitive circuits MUST be discharged by the user BEFORE disconnecting the test leads. See page 30 for the recommended procedure.***
- ★ ***Test leads, including crocodile clips, must be in good order; clean and having no broken or cracked insulation.***
- ★ ***Replacement fuses MUST be of the correct type and rating.***
- ★ ***Never operate the instrument with the terminal box door open.***

Refer also to page 30 for further explanations and other precautions. The warnings and precautions must be read and understood before the instrument is used. They must be observed during use.

NOTE

This instrument is only to be used by a suitably trained and competent person.

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QUICK START

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Operation - Quick Start

QUICK START Guide.

This section is for those who do not need the full information given in the rest of the instruction book.

1. Read the Safety Warning on page 2.
2. Read the First Time Use section below.
3. Read the Brief Operating Instructions below.

With the information from these three sections of the book it will be possible to adequately use the instrument.

To extend the working life of the SERIES 1-5000:-

- Keep the battery charged.
  Avoid charging at temperatures below 0 °C.
- Look after the test leads.
  High voltage test leads with good insulation properties are not as robust as general purpose multimeter test leads. They are also expensive to replace.
- Avoid extremes of temperature for long periods.
  Although the instrument may be stored at up to 60 °C, such high temperatures will reduce the life of the battery significantly.

Useful facts about the instrument:-

- A fully charged battery will power the instrument for about five hours of continuous testing, (slightly longer in the 'standby' mode).
- A 'BATTERY LOW' message appears when there is approximately one hour of life left in the battery.
- The battery is charging if the red light in the power switch on the side of the instrument is glowing.
- It is not possible to over-charge the battery.
- It is not possible to fully discharge the battery while testing. The instrument switches itself off when the battery voltage becomes too low. The battery may be damaged if it is left for too long a period in a discharged state.
- Using mains power for testing will not normally affect the test results; this is irrespective of the test lead polarity.

Operation - Quick Start

FIRST TIME USE

1. Check that the mains supply voltage selector, on the right hand side panel, is set correctly.

2. It is recommended that mains power is connected as soon as possible so that the battery can be fully charged.

3. To set the instrument to individual requirements, press and hold the red button, then switch the instrument on by rotating the left hand knob and so enter the set-up mode.

   The contrast and back-light keys serve special purposes in this mode and can be used as indicated on the screen display to configure the instrument for:-

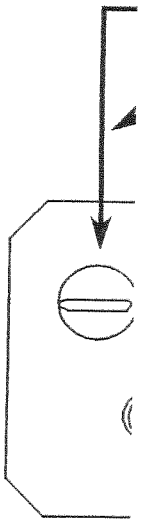
   - Language
   - Time and date setting
   - Simple (single screen) or enhanced (multiple screen) mode
   - Enabled/disabled voltage settings
   - Clearing stored test data
   - Baud rate settings

   To use the instrument at its maximum capability select the enhanced mode for all types of test and have all the voltage ranges turned on. For full details see page 35 etc.

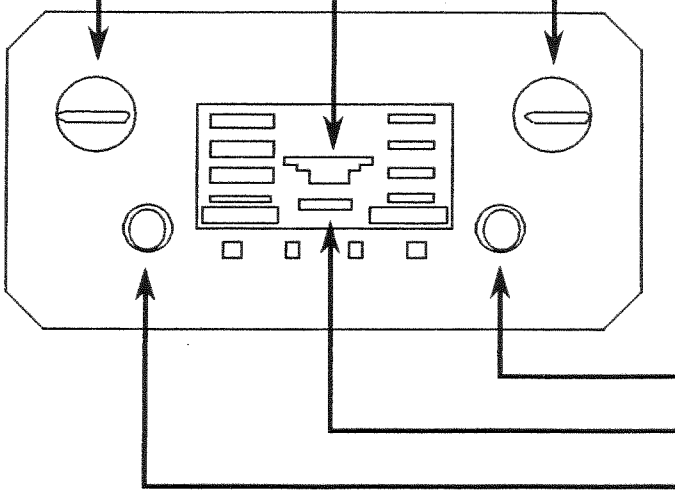
Note:- The minimum leakage which can be measured is 10 nA. This corresponds to 500 GΩ at 5000 V (less at lower voltages).

When the measured leakage current is less than 10 nA the overcurrent condition will be indicated by, for example, > 500 GΩ. When this occurrssome functions of the instrument will be inhibited, e.g. graphs will not plot and access to certain screen displays will not be possible.

BRIEF OP



BRIEF OPERATING INSTRUCTIONS



ROTATE TO TURN ON
(wait a few seconds for automatic calibration)

ROTATE TO SELECT TEST TYPE

ROTATE TO SELECT VOLTAGE

Observe next test number, time and date

Observe battery condition

PRESS START (hold for one second)

TEST IS NOW RUNNING

Depending upon the test selected:-

- After 1 min results storage begins
- After 5 min the SV test will stop
- After 10 min the PI test will stop
- After 30 min the IR test will stop

TO STOP A TEST MANUALLY PRESS STOP

Observe the 'DISCHARGING' message
When the 'QUIT' prompt appears discharging is complete; observe safety procedures before touching the test leads

PRESS QUIT TO CLEAR SCREEN

READY FOR NEXT TEST

General Description

The SERIES 1-5000 is a high voltage, high sensitivity insulation tester. It will undertake insulation resistance tests up to 500 GΩ at 5000 V d.c.; 250 GΩ at 2500 V d.c.; 100 GΩ at 1000 V d.c. and 50 GΩ at 500 V d.c.

DESIGN PHILOSOPHY

The instrument's design takes full advantage of microprocessor technology, as applied to instrumentation, and the benefits provided by a large area dot matrix liquid crystal display. These factors have enabled MEGGER INSTRUMENTS LIMITED to produce a sophisticated insulation tester which is easy to use yet will perform, automatically, recognized standard test techniques which are otherwise complex. They have also enabled the instrument to provide greater detail in the test results obtained than has been possible hitherto; these being available in both alpha-numeric and graphical form. The benefits of storing and then re-displaying results data and transferring it to printers and PCs are an added advantage of the design technology.

Though advanced in what it achieves, the SERIES 1-5000 is quite simple to operate. Most users will find sufficient guidance given in the 'Operation -- Quick Start' section on page 5. This coupled with the information given on the display should be sufficient to allow the instrument's functions to be explored without reference to the full text of this book. (Intuitive operation will probably be a faster learning process than reading). However, if difficulties arise, for detailed information refer to the relevant sections in this book.

TYPES OF TEST AVAILABLE

1. Basic insulation resistance tests at any of the nominal d.c. test voltages, namely 500 V, 1000 V, 2500 V and 5000 V. These tests are carried out largely by the operator.

2. Polarization Index (P.I.) tests at any of the nominal d.c. test voltages. The series of individual tests which form a P.I. test is carried out automatically.

3. Step Voltage (S.V.) tests, in five equal steps either up to 2500 V d.c. or up to 5000 V d.c. The series of tests is carried out automatically.

CASE CONSTRUCTION

The instrument is physically very robust. Its casing is made in a tough material, Noryl plastic, and the body and lid form one portable unit with protective rubber corner buffers and non-slip feet. The instrument is carried either by the handle in the lid or by the woven shoulder strap which is attached by spring clips to the metal loops at each side.

Front panel

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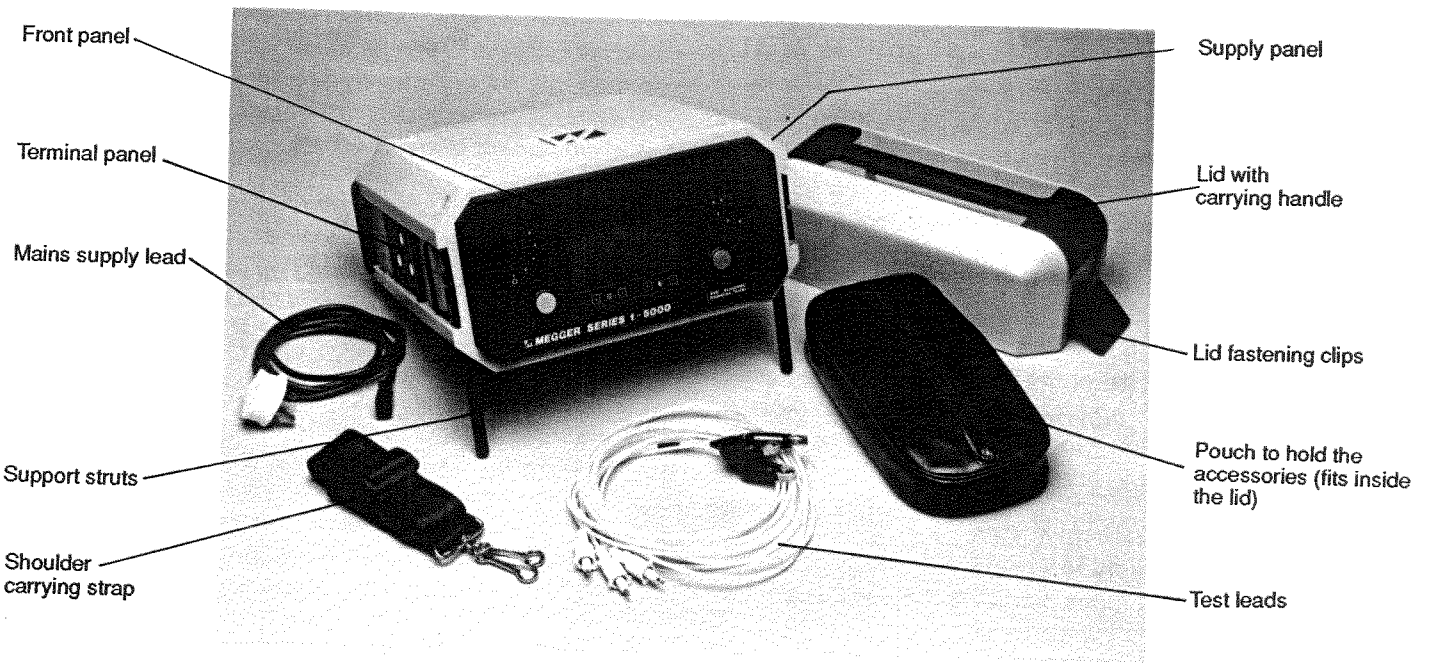

Figure 1 The SERIES 1-5000

General Description

The instrument may be used in either the vertical or horizontal positions. However, it may prove more convenient to prop the instrument at an angle by using the two support struts supplied. They simply screw in at the front case fixing recesses.

Removing the Lid

There are two clips which hold the lid in place, one on either side of the case. To remove the lid stand the instrument vertically and use the thumbs to press downwards and outwards on the top of the clips until they snap open; then pull the bottom of the clips outwards to unfasten them and so release the lid. Lift the lid by the handle.

Attached to the inside of the lid is a zip fastened pouch which stores the three test leads and mains power supply lead. The operating instruction book and support struts may be kept in here as well.

CONTROLS, TERMINALS ETC.

The instrument has three panels which hold all the controls etc. required for operating the instrument; the front panel, the terminal panel and the supply panel.

Front Panel

The large area, dot-matrix, liquid crystal display is mounted on the front panel and has its back-lighting and contrast controls situated below the bottom edge. These controls take the form of membrane key pads and they are also used, with alternative functions, when setting the instrument's test programme.

The front panel also holds the main function selector switch and the test voltage/sub-function selector switch. These are rotary switches whose function labels (highlighted when selected) appear on the display after the instrument is switched on.

A green and a red push-button are located one on either side of the display, their main functions are, respectively, for starting and stopping a test.

The layout of the front panel and display is illustrated in figures 2.

Terminal Panel

The panel on the left hand side of the instrument holds the three terminal sockets, 'H' high, 'L' low and 'G' guard. These are captive recessed sockets for safety and they are mounted in a box arrangement with a cover. The test lead connectors are pushed in and turned clockwise to lock them in place. This ensures that there is no chance of the test leads becoming accidentally disconnected during a test.

The terminal box cover can be opened in order that the socket housings may be cleaned when necessary.

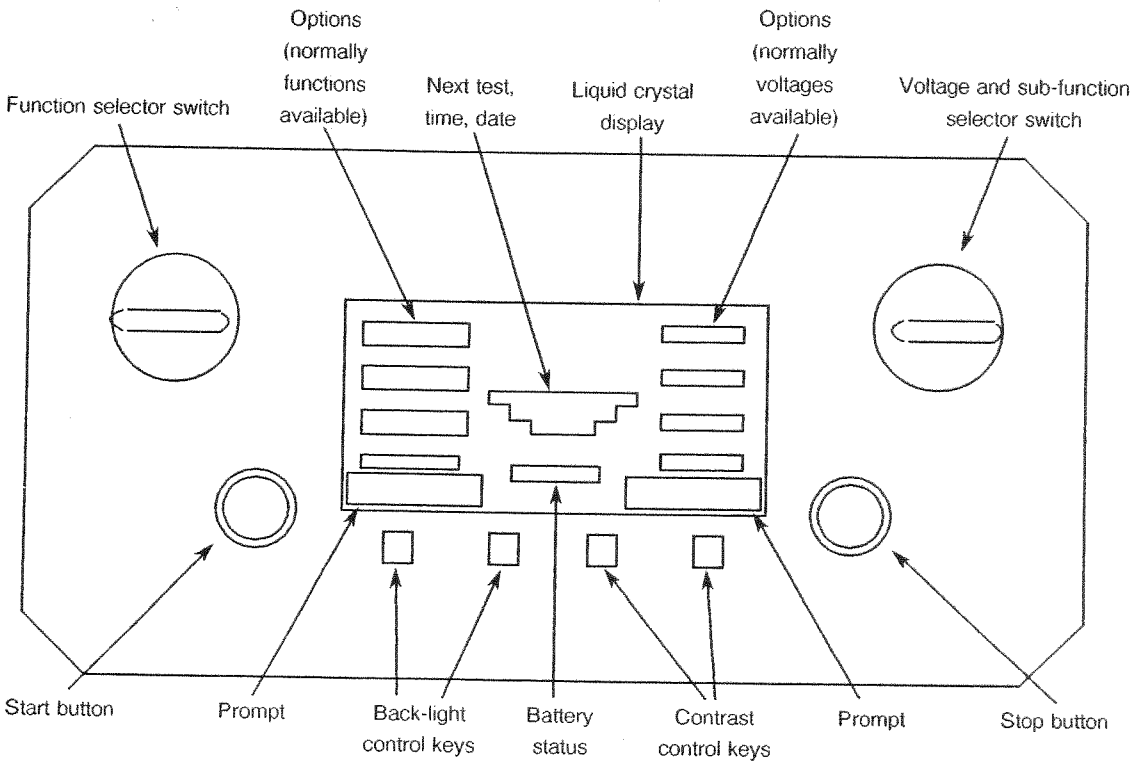

Figure 2 Front panel layout
(display text shown symbolically as it appears before a test)

General Description

Dirt on the terminals can form leakage paths for the test current and result in erroneous readings being taken. The test leads have extremely good electrical properties in order to ensure minimum leakage occurs through them during a test. The leads for the 'H' and 'L' terminals are marked with red and black sleeves respectively.

The low terminal is connected to the Guard, as illustrated in figure 3.

The test voltage at the 'H' terminal is positive with respect to the 'L' terminal. The 'G' and 'L' terminals are almost at the same potential. The instrument must always be operated with the terminal box cover closed.

Supply Panel

The panel on the right hand side of the instrument holds the mains power supply components, the supply voltage selector, the external battery power supply socket and the RS232 connector to interface with external equipment.This latter connection provides facilities for downloading test results to a printer or personal computer.

The layout of the components is illustrated in figure 4.

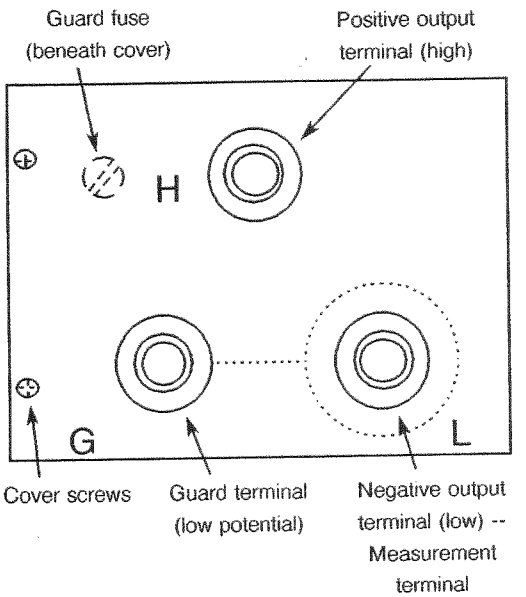

Figure 3 Terminal panel layout

POWER SUPPLY

The instrument is fitted with an internal, rechargeable, sealed lead acid battery. Normally power for the instrument is supplied from this battery, but alternatively the mains supply can be used. Whenever the instrument is connected to the mains supply and the power switch is on, battery charging will take place. A neon in the switch illuminates in the on position.

It is possible to charge the battery from a separate, external 12 V d.c. battery e.g. a vehicle battery. The rate of charge under this system will be very slow and it should only be used in an emergency e.g. if the internal battery loses its charge before the end of a series of tests and there is no mains supply available with which to continue.

Note:- It is not possible to use the instrument when its internal battery is being charged from an external one.

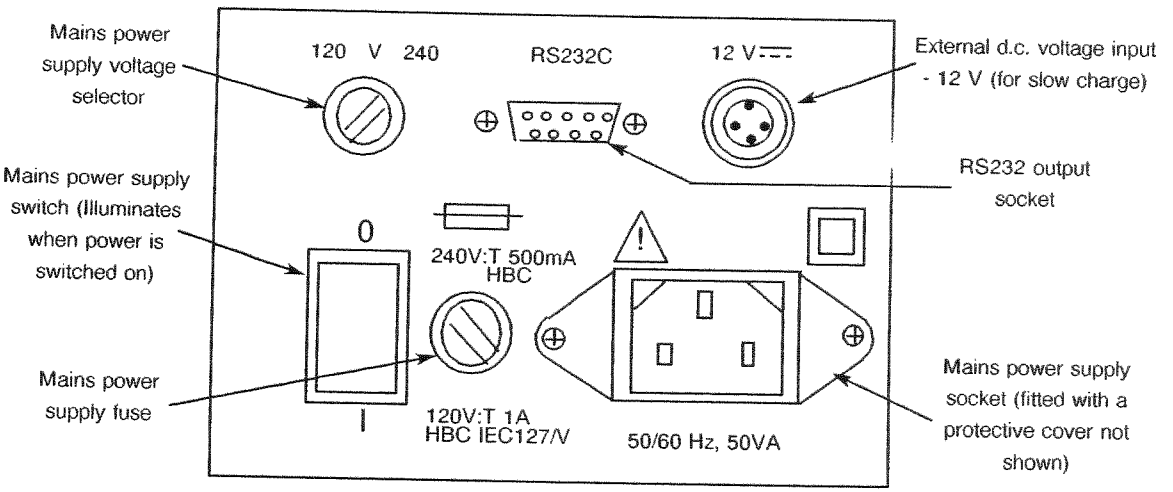

Figure 4 Supply panel layout

General Description

OVERVIEW OF INSTRUMENT USE

The instrument has comprehensive testing facilities but it is not difficult to use. It can be configured to perform a basic insulation test at just one voltage or the whole spectrum of its tests at all its possible voltages. The test results can be given in either a simple or an enhanced form according to the requirement that the operator sets up.

Set-Up

The first step in using the instrument is to select the desired test requirements. This is achieved through the set-up menu whose main display screen is entitled 'SETUP STATUS' and is illustrated in figure 5.

Through the set-up menu the language that the instrument will use on the screen and for data transfer via the RS232 port can be selected from the options available (normally English, French, German and Spanish). The three testing techniques, namely Insulation Resistance testing, Polarization Index testing and Step Voltage testing can be enabled or disabled, and each of these can be set to give the results in the basic or enhanced form (refer to the applications section for details). Likewise, each of the possible d.c. test voltages can be enabled or disabled so that testing can be limited to just one type of test and just one voltage if required.

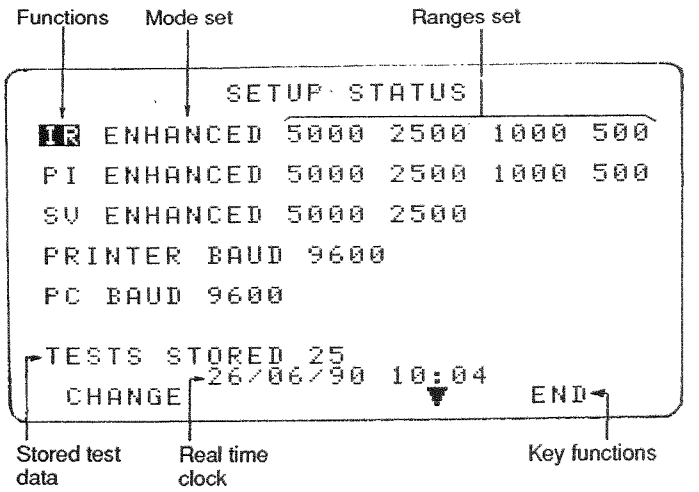

Figure 5 Typical format for the 'SETUP STATUS' display screen

It is through the set-up menu that the instrument's real time clock, giving the date and time, is adjusted. Also the option is given to clear the instrument's memory of all the test results stored. The 'SETUP STATUS' screen will always show exactly what test facilities have been enabled and are therefore available for use.

Testing

The function screen appears when the instrument has been switched on; it follows the initial copyright message (shown briefly). On the screen labels are allocated for the function selector switch and voltage/sub-function selector switch positions, similarly the green button will be labelled and highlighted 'START' and, after a test is commenced, the red button will receive the highlighted label 'STOP'.

The function screen format before a test is commenced is shown in figures 6 and 7. When one of the selector switches is set to a position, that position's label is highlighted. Invalid switch positions are not labelled. Only the options shown on the screen are selectable and can be set in operation.

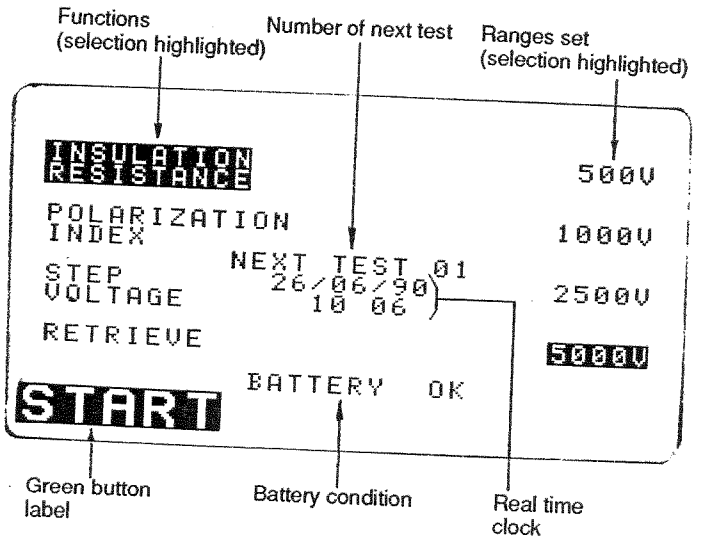

Figure 6 Function screen format 'INSULATION RESISTANCE'

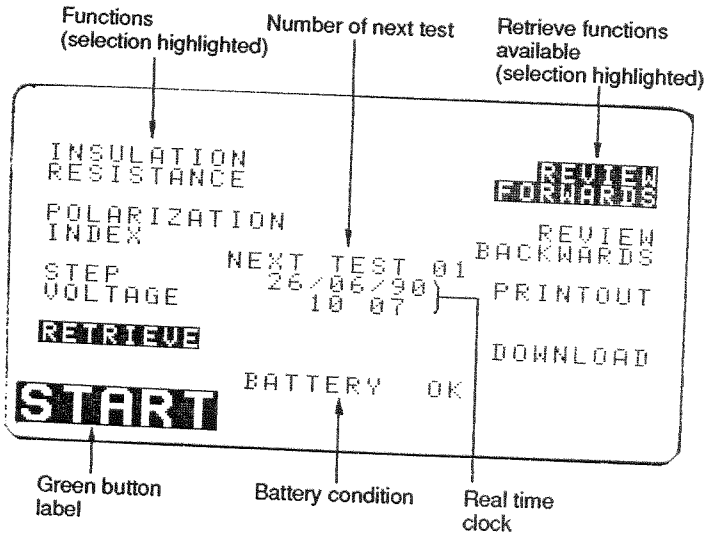

Figure 7 Function screen format 'RETRIEVE'

General Description

A test is commenced when the green 'START' button is pressed and ended when the red 'STOP' button is pressed; however, P.I. and S.V. tests stop automatically.

Automatic discharge follows immediately a test is ended, and then the option to 'QUIT' and return to the function screen ready to perform another test is given.

The test techniques are explained more fully in the Applications section of the book.

Retrieving Stored Results

The instrument's memory is capable of storing the results of up to 25 separate tests; this it does automatically. When the memory is full, the oldest set of results will be over-written by the newest set of results.

The results of all the tests made can be re-displayed in the alpha-numeric form only. Alternatively those results plus additional data can be sent via the RS232 output socket to an external printer or personal computer. The Baud rate making the instrument compatible with the printer etc. is part of the set-up process.

The tests performed on any one day are numbered consecutively starting from number one. The next day, when the real time clock has changed the date, the test numbering starts from number one again. Therefore when reviewing results there may be more than one having the same number but they can be uniquely identified by the date.

INSTRUMENT CIRCUIT SAFETY DESIGN

A basic schematic diagram for the instrument's circuit is shown in figure 35.

There are two main parts to the instrument's circuit. They are separated physically, and electrically to double insulation standards. This factor contributes significantly to the overall safety level of the instrument.

The two parts of the circuit are:-

(i) the high voltage generation and measurements
(ii) the user controls, display and power circuits.

Both parts of the circuit are controlled via microprocessors and communication is through a fibre optic serial link. Power is delivered to the separate parts of the circuit by an inverter with an isolating transformer and this system provides a high degree of isolation between the input supply and the fully floating output voltage from the terminals.

The measurement microprocessor controls the output of the high voltage invertor and the voltage across the terminals is measured via an A to D converter. A two

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range integrator changes the measurement current into a pulse of variable length, while the microprocessor controls the range and measures the pulse. The resistance value is calculated and sent to the display microprocessor ready for passing on to the l.c.d. and, if appropriate, putting into the storage RAM. The date and time information is generated by a real time clock which also interrupts the microprocessor regularly to provide a time base for the whole system.

WARNINGS OF APPLIED VOLTAGE

The operator is always made aware when the test voltage is applied to the terminals and when a dangerous external voltage is present i.e. from the item under test.

At all times the test voltage at the terminals is measured and shown by vertical bars appearing one at each side if the display. Also, while a test is in progress, warning of the high test voltage is given to the operator by flashing arrows on the display and by a flashing red 'STOP' button.

If a dangerous external voltage (> 50 V) is detected at the terminals before a test is started, a warning message is given on the display. If the voltage applied to the terminals is greater than about 1 kV, or the current into the terminals is greater than 2 mA, it will not be possible to start a test and a warning message will be given. If during a test a separate external voltage is applied to the item under test which is high enough to affect the measurement, the test is aborted and a warning appears on the display.

Applications

The SERIES 1-5000 is designed to meet a wide variety of heavy duty insulation testing applications. These include individual items of equipment, such as transformers and rotating machines, as well as distribution networks rated from low voltage to 400 kV. The test techniques available with the instrument cover those most commonly used when insulation testing and, as such, the instrument is eminently suited to applications at electricity substations and plant electrical equipment. The comprehensive test data that the instrument can produce enables engineers to monitor and record the gradual deterioration which occurs during the working life of high voltage insulation.

The test techniques available are:-

1. Insulation Resistance test
2. Polarization Index (P.I.) test
3. Step Voltage (S.V.) test

The paragraphs below briefly describe these techniques and how the SERIES 1-5000 performs them. In each of these test techniques two ways or modes of giving the results are possible, a simple mode and an enhanced mode. The choice as to which the operator uses is made during the set-up process. The text describes these modes and gives an example in each case.

INSULATION RESISTANCE TEST

This is a straightforward insulation resistance test, performed at any of the d.c. voltages set and selected. The test will continue for 30 minutes after which time it is automatically terminated to conserve battery power.

This test technique is totally under the control of the operator and enables him to do short time or spot-resistance tests. The results of such tests cannot be regarded as the true insulation resistance but will give a guide, and can be interpreted to show a trend in insulation condition if similar tests are performed at regular intervals e.g. in scheduled maintenance.

Insulation Resistance Test (Simple)

During the test the screen shows the resistance reading digitally, with a resolution up to 3 digits, and in the form of a logarithmic bar graph. The test voltage is shown and the time for which this has been applied i.e. the test time. An example of how the display screen appears is shown in figure 8 and is referred to as the 'ANALOGUE DISPLAY'.

Insulation Resistance Test (Enhanced)

For the first minute of an enhanced Insulation Resistance test the screen appears as in figure 8 above. Thereafter a graphical plot of the ratio of the present value to the value at one minute is shown, as illustrated in the example of figure 9.

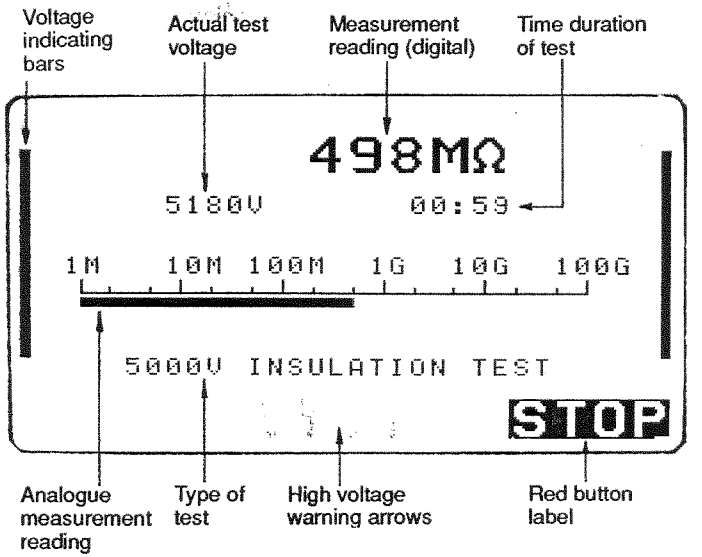

Figure 8 Typical display screen for a simple Insulation Resistance test showing the 'ANALOGUE DISPLAY'

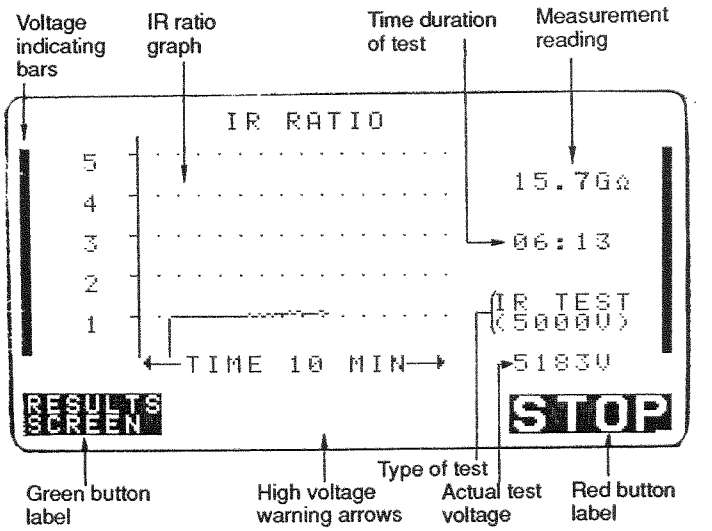

Figure 9 Typical display screen for an enhanced Insulation Resistance test showing the 'GRAPHIC DISPLAY'

This graph is in effect a continuous plot of the Dielectric Absorption Ratio. Dielectric Absorption Ratio is the ratio of two Time-Resistance insulation tests, e.g. the resistance value taken at say 2 minutes divided by the resistance value taken at 1 minute and is a standard technique used in recording and documenting insulation test results.

This screen display is useful in the fact that the operator can see at a glance what has happened to the insulation resistance over the last 10 minutes (the max.

of the time axis of the graph) without being on hand while the test is in progress.

Pressing the green button changes the screen to show the 'RESULTS SCREEN'. This gives the test results in a tabular form similar to that shown in the example of figure 10.

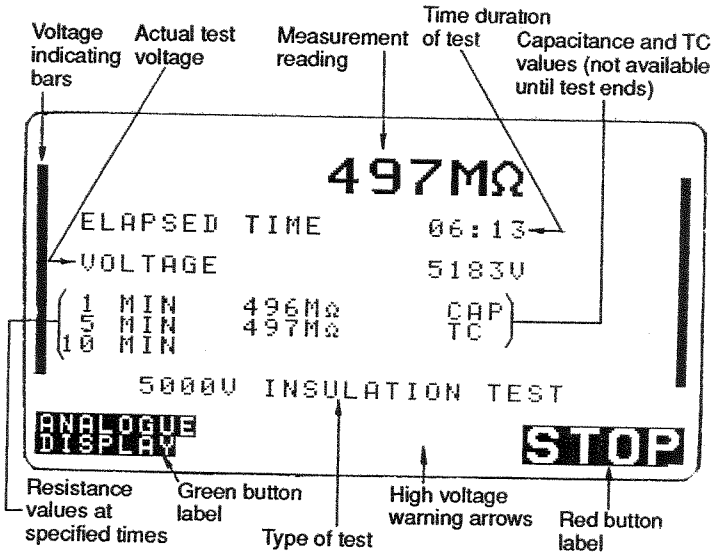

Figure 10 Typical display screen for an enhanced Insulation Resistance test showing the 'RESULTS SCREEN'

Pressing the green button again changes the screen to show the 'ANALOGUE DISPLAY' showing the bar graph as in figure 8.

Repeated pressing of the green button will cycle between the three display screen forms i.e. 'ANALOGUE DISPLAY', 'GRAPHIC DISPLAY' and 'RESULTS SCREEN'.

Two factors which appear on the results screen display are the capacitance value and the time constant (TC). Both of these are useful additional items of information about the insulation under test. The capacitance of the item under test is given in µF and the time constant, the product of the insulation resistance after 1 minute and the final capacitance, has the units of seconds. The TC is sometimes referred to as the Figure of Merit for the insulation and is used for comparing insulation quality over periods of time.

Note:- The capacitance value and time constant are only measured at the end of a test. hence, on the results screen these factors will have no value shown until a test is concluded.

POLARIZATION INDEX TEST

A Polarization Index test is basically a special case of a Time-Resistance insulation test. Polarization Index is the term applied to the Dielectric Absorption Ratio when

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the resistance values are taken after 1 minute and after 10 minutes. Polarization Index is therefore the resistance value after 10 minutes divided by the resistance value after 1 minute. Again this is a standardtechnique used in recording and documenting insulation test results.

As far as the instrument is concerned the P.I. test is similar to the Insulation Resistance test but terminates automatically after 10 minutes and displays the P.I. value.

Polarization Index Test (Simple)
This test is identical to the simple Insulation Resistance test and the display screen appears as in figure 8 except that the test is named a Polarization Index test. It will terminate automatically after 10 minutes and at the end of the test the Polarization Index value is given.

Polarization Index Test (Enhanced)
Again this test is identical to the enhanced Insulation Resistance test and the display screens appear as in figures 8, 9 and 10 except that they are named Polarization Index test. The green button can be used to cycle between the three forms of screen display as is possible with the Insulation Resistance test in the enhanced mode.

The test will terminate automatically after 10 minutes and, at the end, the Polarization Index value is given.

STEP VOLTAGE TEST
This is a test in which the voltage is applied for five minutes in total and then the test is terminated automatically. The test voltage is increased in equal steps and is applied for one minute at each step. There are two ranges of steps, the lower one with voltage steps of 500 V, 1000 V, 1500 V, 2000 V and 2500 V, and the higher one with voltage steps of 1000 V, 2000 V, 3000 V, 4000 V and 5000 V. The voltage is held constant for one minute at each step and then increased to the next.

Step Voltage testing is another standard technique used in recording and documenting insulation resistance. Faults in insulation may have a greater effect on the overall resistance when subjected to a higher test voltage. Therefore the principle of a Step Voltage test is to show whether the overall insulation resistance is maintained or falls as the voltage is increased. If the resistance falls then there is incipient weakness in the insulation which is a potential cause of problems.

Step Voltage Test (Simple)
In the simple Step Voltage test the screen shows the present resistance reading digitally, with a resolution up to 3 digits, also after one minute at each voltage step the resistance reading for that step voltage is given.

Applications

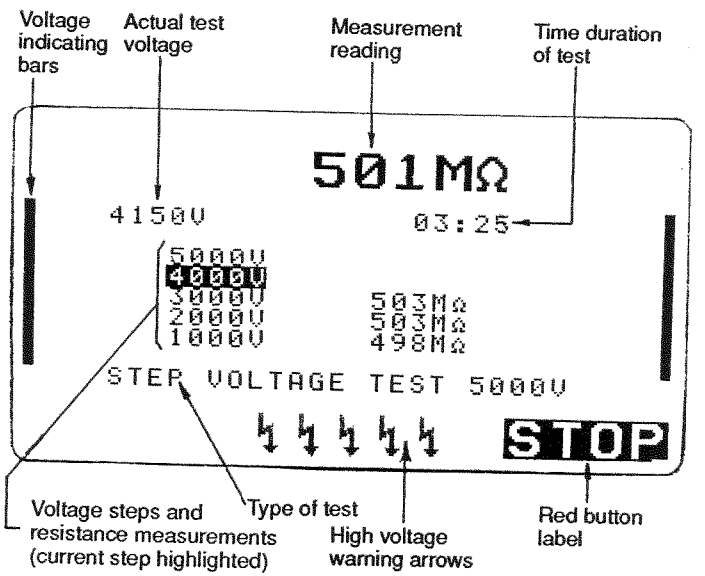


Figure 11 Typical display screen for a simple Step Voltage test

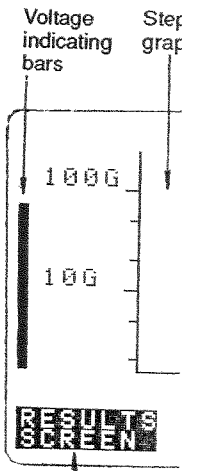
The test voltage is shown and the time for which this has been applied i.e. the test time. An example of how the display screen appears is shown in figure 11. Note that the voltage warning bars at the sides of the screen increase in length as the voltage steps increase in value.

Step Voltage Test (Enhanced)

For the first minute of an enhanced Step Voltage test the screen appears very similar to that for a simple Insulation Resistance test as shown in figure 8, i.e. the 'ANALOGUE DISPLAY', and the test is named a Step Voltage test. Thereafter a graphical plot of the resistance against the step voltage is shown, as illustrated in the example of figure 12. The graph of log R against log V is plotted at the five cardinal points i.e. the resistance value at the end of each one minute voltage step. It is not a continuous voltage against resistance graph. (R is the insulation resistance and V is the voltage at the terminals). From this display screen the operator may easily see whether the insulation under test has any weaknesses shown by a reducing resistance reading as the voltage increases.

Pressing the green button changes the screen to show the 'RESULTS SCREEN'. This gives the test results in a tabular form similar to that shown in the example of figure 13.

Pressing the green button again changes the screen to show the 'ANALOGUE DISPLAY' giving the bar graph as at the start of the test.



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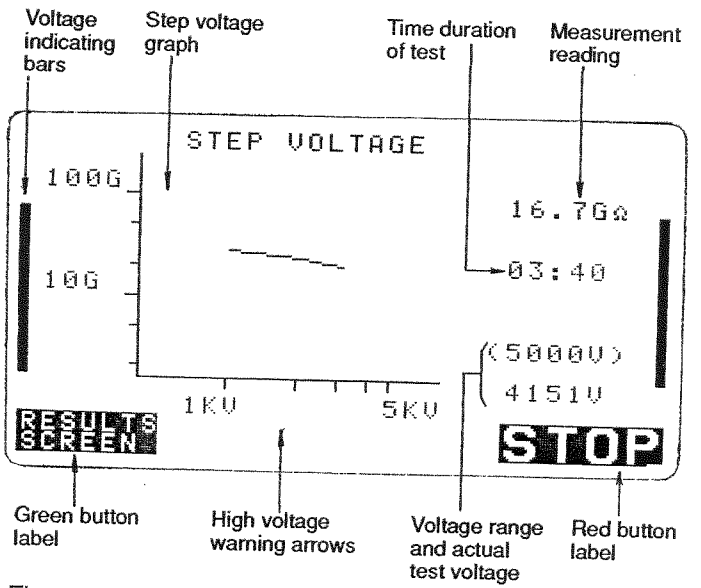

Figure 12 Typical display screen for an enhanced Step Voltage test showing the 'GRAPHIC DISPLAY'

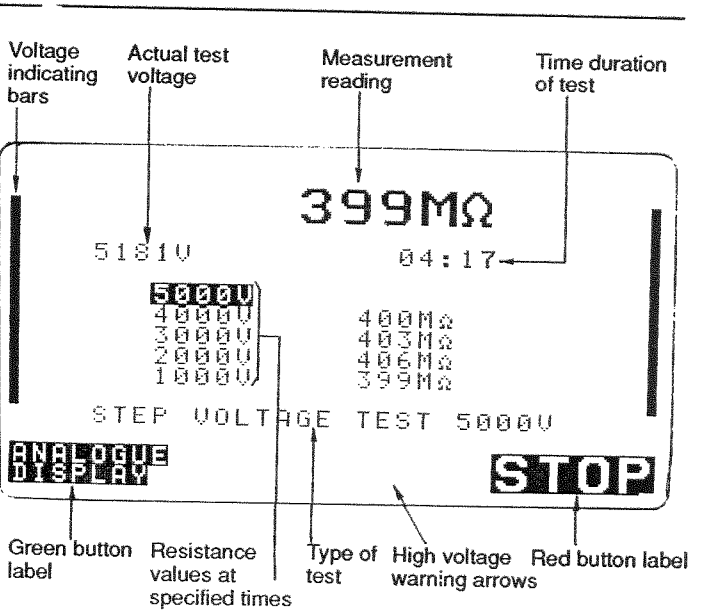

Figure 13 Typical display screen for an enhanced Step Voltage test showing the 'RESULTS SCREEN'

Repeated pressing of the green button will cycle between the three display screen forms i.e. 'ANALOGUE DISPLAY', 'GRAPHIC DISPLAY' and 'RESULTS SCREEN'.

More information about Polarization Index testing and Step Voltage testing is given in separate publications available from MEGGER INSTRUMENTS LIMITED. The titles are (i) 'A Simple Guide to Insulation Testing' and (ii) 'The Lowdown on High-Voltage DC Testing'.

Specification

Insulation Resistance Testing
(Ranges and Test Voltages)

Resistance Range	Test Voltage (d.c.)
0 - 50 GΩ	500 V
0 - 100 GΩ	1000 V
0 - 250 GΩ	2500 V
0 - 500 GΩ	5000 V

Polarization Index (P.I.) Testing
Resistance ranges and test voltages are as above.

Step Voltage Testing
With 2500 V d.c. selected, tests are performed at the following voltages:-
500 V
1000 V
1500 V
2000 V
2500 V
With 5000 V d.c. selected, tests are performed at the following voltages:-
1000 V
2000 V
3000 V
4000 V
5000 V

Short Circuit Terminal Current
2 mA nominal, 2,5 mA max.

Accuracy (20 °C to 23 °C)
Basic accuracy of resistance measurement, ± 5% of reading.
Test voltage accuracy, ± 5% of nominal at 1 GΩ.

Test Voltage Stability
± 0,1% over a 10 minute period

wing voltages:-

wing voltages:-

ling.

Voltage Measurement	Voltage at the terminals is measured to an accuracy of ± 2% of reading ± 1 V. Voltage range during testing, 50 V - 5000 V d.c. Voltage range at other times, 50 V - 2500 V d.c. or 50 V - 2500 V a.c. 45 Hz to 65 Hz
Capacitance Measurement/Merit Figure	Capacitance at the terminals is measured over the range 0 - 10,00 µF. Accuracy will normally be within ± 15% of reading ± 0,03 µF but is dependent on the configuration of the system under test. The time constant (TC) or 'Figure of Merit' is given, (i.e. the capacitance value x resistance value) over the range 0 - 9999 s.
Timing	Real-time clock shows day, month, year, hour and minute (in 24 hour form), with automatic length of month and leap year correction. Elapsed time counter used during a test shows minutes and seconds since start of test. Timing accuracy ± 20 ppm.
Display	Graphics l.c.d. giving a digital reading with resolution up to 3 digits, plus information regarding the set-up and test conditions. Graphical presentation in the enhanced functions.
Capacitor Discharging	Automatic when test is ended. Will discharge at rate of 3 s/µF. Capacitance limit 10 µF. (Discharge resistor is 574 kΩ).
Interference Rejection	Will measure, to full specification, with up to 2 mA (45 Hz to 65 Hz) interference current.

Specification

Guard Terminal*	Will guard both measuring terminals with 250 kΩ parallel resistance applied singularly or together. Error produced is less than ± 5% at 100 MΩ.
Temperature Coefficient	For temperatures, - 10 °C to + 20 °C and + 23 °C to + 50 °C Insulation resistance measurement:- 0,75%/°C for test currents 10 nA to 100 nA. 0,15%/°C for a test current > 100 nA Test voltage:- 0,05%/°C
Temperature Range	
Operating	- 10 °C to + 50 °C (0 °C to + 40 °C for battery charging)
Storage	- 20 °C to + 60 °C
Humidity Range	
Operating	Up to 95% RH at 40 °C
Overload Ratings	Terminal 'H' to terminals 'L' or 'G', 5 kV peak continuous during testing, 2,5 kV r.m.s. continuous at other times. Terminal 'L' to terminal 'G', 250 V a.c. r.m.s. fuse protected.
Environmental Protection	The instrument has been designed to the requirements of IP 54 in BS 5490 (1977) and IEC 529 (1976), (specifications for classification of degrees of protection provided by enclosures).

* Refer to page 42 for a further explanation of the effect of the guard terminal.

Safety	The instrument will, in general, meet the requirements of BS 4743 (1979) and IEC 348 (1978). Safety Class II
Fuses	Mains supply fuse: 500 mA(T)/250 V ceramic HBC, 20 mm x 5 mm, for 220 V/ 240 V supply 1 A(T)/120 V ceramic HBC, 20 mm x 5 mm IEC 127/V, for 110 V/ 120 V supply Guard circuit fuse: 1 A/250 V ceramic HBC, 20 mm x 5 mm IEC 127 /
Power Supply	(i) Internal, rechargeable, sealed lead acid battery (12 V nominal, 6,5 Ah). (ii) Mains power supply, nominally, 110 V to 120 V 50 Hz/60 Hz or 220 V to 240 V 50 Hz/60 Hz (< 50 VA). 12 V external battery e.g. a vehicle battery (for emergency charging of the internal cells).
Dimensions	480 mm x 365 mm x 180 mm (18 $^{7}/_{8}$ in x 14 $^{1}/_{2}$ in x 7 in) approx.
Weight	12$^{1}/_{4}$ kg (27 lb approx.)

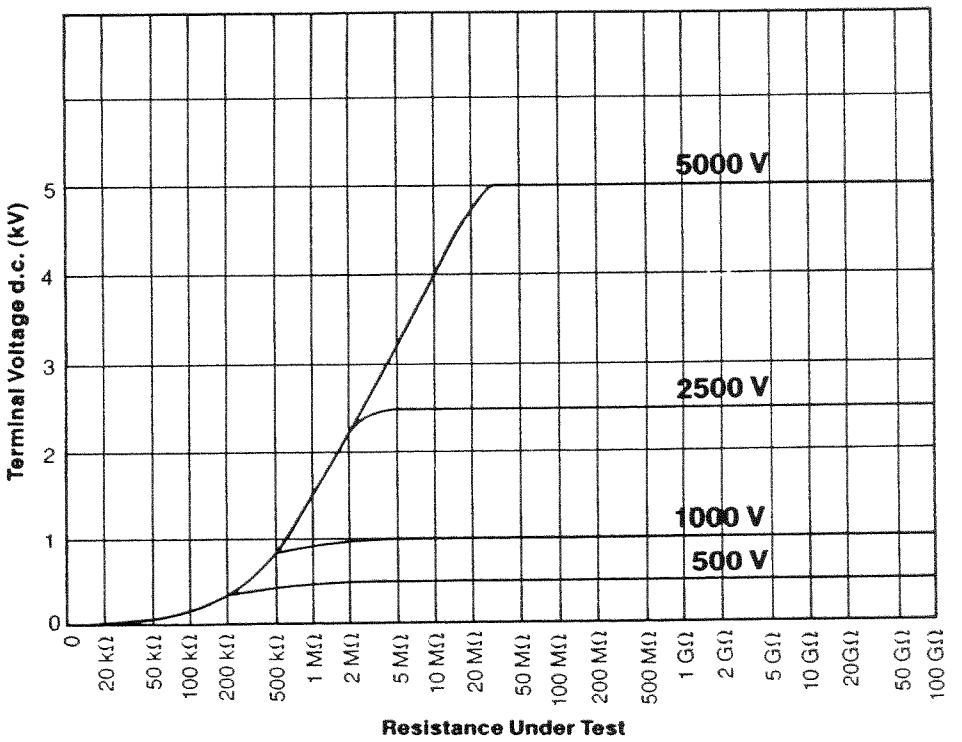

Figure 14 Typical terminal voltage characteristics

Acces

Supplied v

Available

Accessories

Supplied with the instrument	High voltage test leads, 3 m long:-	
	High terminal lead	part no. 6220-464
	Low terminal lead	part no. 6220-465
	Guard terminal lead	part no. 6220-466
	Mains supply lead	part no. 25424-860
	Support strut (2 off)	part no. 6131-871
	Operating instruction book	part no. 6171-453
Available as an optional extra	High voltage test leads, 10 m long:-	
	High terminal lead	part no. 6220-467
	Low terminal lead	part no. 6220-468
	Guard terminal lead	part no. 6220-469
	Download software on $5\frac{1}{4}$ inch disc	part no. 206139-044
	Download software on $3\frac{1}{2}$ inch disc	part no. 206139-045

Operation - Detailed

WARNINGS

1. The equipment to be tested must be completely de-energized. Before making insulation tests, disconnect and isolate the equipment that is to be the subject of the test.

2. In connecting the instrument to the item to be tested care must be taken to ensure that there is no hazard to the user due to the voltage produced at the instrument terminals. This voltage can be 5 kV.

3. The instrument generates very high voltages which, when applied to capacitive loads such as long lengths of cable, will usually produce a potentially lethal charge within one second of the green 'Test' button being pressed. Care must be taken to avoid the capacitive load becoming disconnected during a test, otherwise the load will be left in a charged state. It is for this reason that the instrument's test leads are captive so that they cannot be accidentally pulled out of the terminals.

   When testing items having significant capacitance (e.g. long cables) be aware of the dangers involved.

   Caution:- The voltmeter and automatic discharge facilities of the SERIES 1-5000 should be regarded as additional safety features and not substitutes for the safe working practice of connecting a link across capacitances after discharge and before touching the connections.

   On its own the SERIES 1-5000 can give an electric shock, however a 1 µF capacitance, for example, charged to several kV will probably give a fatal shock.

   Therefore after testing capacitive items:-
   (i) Wait for the 'DISCHARGING' message to disappear (indicating voltage is < 50 V).
   (ii) Press the red button (labelled 'QUIT').
   (iii) Connect an external discharge link to earth the item under test.
   (iv) Disconnect the test leads.

4. When carrying out prolonged tests, care should be taken that no harm or damage can be caused if the instrument is left unattended, since it may be producing a dangerously high voltage.

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5. Care should be taken that excessive voltages are not applied to the instrument's terminals. The maximum continuous voltage that may be applied (from an external source) between the 'H' and 'L' terminals is 2500 V a.c. r.m.s. and between the 'L' and 'G' terminals is 250 V a.c. r.m.s.

   The maximum permissible current injected into the terminals from a high impedance source is 2 mA during testing, 4,5 mA at other times.

6. The cleanliness and freedom from damage of the test leads is most important from the safety point of view, and in order to avoid unwanted leakage currents which would cause a false reading.

   The terminal box cover should always be properly closed after cleaning the terminals. Never operate the instrument with the terminal box cover open or loose.

7. It is important that fuse replacements are made with the correct type and rating of fuse. Refer to the specification section for details of the correct fuse to use.

8. Before connecting the instrument to the mains power supply ensure that the voltage selector is set correctly, and the correct fuse is fitted.

9. The instrument must not be connected to an external power supply when its casing is opened since "live" parts will be exposed. Furthermore, capacitors within the instrument may still retain charge for a considerable period even after the supply has been disconnected, particularly if the instrument exhibits a fault. Since the instrument has its own internal power source these dangers are always present.

10. Any repair or adjustments to the instrument must be carried out by a suitably trained and skilled instrument technician who is aware of the hazards involved in working with high voltage equipment.
    Note:- Opening the casing will automatically invalidate any warranty covering the instrument unless carried out by the manufacturer or one of his approved agents.

11. Whenever it is likely that the instrument's protection has been impaired, it should not be used but returned to the manufacturer or one of his agents for repair. The protection is likely to be impaired if, for example, the instrument shows visible damage, fails to perform the intended measurements, has been subjected to prolonged

storage under unfavourable conditions or has been subjected to severe transport stresses.

12. **The Battery**
The sealed lead acid battery used in this instrument has been designed and constructed, so far as is reasonably practicable, by its manufacturer, to be safe and without risk to health when correctly used. Appropriate health and safety precautions for the battery must nevertheless be observed. The recommendations of the battery manufacturer in this respect are available from MEGGER INSTRUMENTS LIMITED.

Battery charging must be carried out in a ventilated area.

After six months of non-use, the instrument's battery **must** be fully re-charged to avoid causing it permanent damage. Do not delay recharging for more than six months.

PRECAUTIONS

1. Observe the working temperature limits as given in the specification to maximise the life of the battery cells and the liquid crystal display. Prolonged exposure to high temperatures above 50 °C may result in the battery becoming discharged and permanent damage may result.

2. The instrument circuit contains many static sensitive devices. If the casing is opened for any reason, care must be exercised in handling the printed circuit boards. This should be done in accordance with DEF STAN 59-98 and BS 5783, specifications for handling electrostatic sensitive devices.
Note:- Opening the casing will automatically invalidate any warranty covering the instrument unless carried out by the manufacturer or one of his approved agents.

POWER SUPPLIES

The instrument has three methods of obtaining the power necessary for its operation:-

1. internal rechargeable lead acid battery
2. mains power supply
3. external 12 V battery e.g. a vehicle battery

The internal lead acid battery is expected to be the main power source used since it is the most convenient. When the mains power is connected the battery will charge automatically and the instrument may be used for testing at the same time.

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The external battery supply is only for use as an emergency measure. It will, very slowly, charge the internal battery sufficiently to complete a sequence of tests but will not provide a full charge. The instrument cannot be used for testing while an external battery is connected.

Internal Battery Supply
It is advisable to fully charge the battery before the instrument is put into service. The battery should be kept in a fully charged state whenever possible; if it is left in a discharged state for some time damage may result. Battery charging is automatic when the mains supply is connected. For further details of how to charge the battery refer to the section on Mains Power Supply/Battery Charging.

A message concerning the condition of the battery is given when the instrument's main function menu is displayed on the screen. The message may say 'BATTERY OK' or it may be 'BATTERY LOW'.

If, during a test, the battery voltage falls too low for an accurate result to be obtained, the test will be stopped automatically and a message to that effect given. When the battery nears the complete discharge state the whole instrument will be switched off automatically to avoid damage to the battery. Charging from the mains supply is then imperative. In the absence of a mains supply use a 12 V external battery.

Mains Power Supply/Battery Charging
Connect the mains supply lead from the input connector in the supply panel at the right hand side of the instrument to a mains supply socket outlet. Switch the supply on at the outlet socket and at the instrument's supply panel; the red switch on this panel illuminates when pressed to show that the mains power is connected. The internal battery will automatically commence to charge and, if the instrument is switched on, a message 'BATTERY ON CHARGE' will be shown on the main function menu screen. When charged the message changes to 'BATTERY CHARGED'.

The battery will take at least eight hours to fully charge from the first indication of 'BATTERY LOW', but it will not over charge if the mains supply is left on for long periods.

The instrument can be used while being supplied from the mains voltage since power can be drawn to simultaneously supply the instrument and charge the battery. The time for charging the battery will not be extended if the instrument is in use while charging is in progress.

Caution:- Be aware that the temperature range over which battery charging can take place is 0 °C to 40 °C.

External Battery Supply

If the internal battery voltage becomes too low during a test and a mains supply is not available, a 12 V d.c. vehicle battery may be used to charge the internal battery sufficiently for the test to be completed after 2 to 3 hours (if the charging battery is isolated). However, in order to charge as quickly as possible by this means, it is recommended that the instrument's function switch is set to off and that the vehicle, whose battery is being used as the charging source, has its engine running.

Charging by this method should be regarded only as an emergency measure. The battery cannot be fully charged by this means nor can testing be carried out while an external vehicle battery is connected.

Connect an external battery supply lead to the three pin DIN socket in the supply panel and to the vehicle battery (be careful to observe the correct polarity). The interconnecting lead will have to be made up and the connections for the DIN socket are as shown in figure 15.

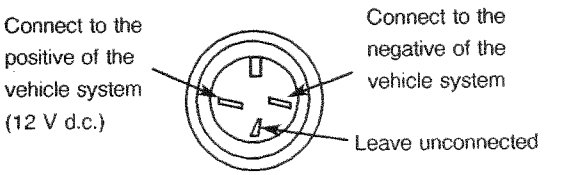

Figure 15 Connections for the external battery supply DIN socket (As viewed on the supply panel)

Connecting lead details:-

Connecting lead

Twin core cable rated at 3 A minimum, preferable sheathed for protection and mechanical strength

Instrument connector

Standard 3-pin DIN plug

Vehicle connector

Suitable connector for vehicle system i.e. cigarette lighter plug.

When the external d.c. charging voltage is applied a message appears on the display to this effect and testing cannot continue.

Disconnect the external battery after charging and before recommencing the test.

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DISPLAY LIGHTING

When the instrument is switched on the contrast and back-lighting of the display can be adjusted to suit the operator. The four membrane keys below the display screen are used for this purpose. The left hand pair adjust the back-lighting and the right hand pair the contrast; the ' + ' keys increase the lighting and contrast, the '-' keys decrease them. These keys, which are single-step (one press) or auto-repeat (continued press), can be used to alter the display screen readability at any time except in the set-up programme menu; then they adopt other software defined functions.

The lighting level set by these keys is remembered by the instrument when it is switched off, and therefore automatically restored when it is switched on again. The backlight consumes about 10% of the total power from the battery.

SET-UP PROGRAMME

Setting the Functions etc. (Set-up Mode)

All the user configuration facilities, together with the operating language and the date and time, are accessed through the set-up programme. To enter the set-up mode press and hold the red button while switching the instrument on by turning the function selector switch (left hand switch) away from the 'O' position. The back-light and contrast keys now have other functions allocated to them by the software programmes as shown immediately above them on the display screen.

All the functions, test voltages etc. that are chosen in the set-up mode are stored in battery backed memory. Therefore the instrument does not have to be set up every time it is used.

Setting the Display and Printer Language

On entering set-up mode, the display screen shows the language options available for the display and printer. Press the 3rd key from the left (labelled with an arrow head on the display screen) to select the desired language, then press the extreme right hand key (labelled 'YES') to confirm the choice and move into the 'SETUP STATUS' display.

Operation - Detailed

Note:- For all screen displays where there are choices to be made the feature highlighted is the one chosen.

Main Set-up Screen Display

The 'SETUP STATUS' screen display is the main display through which the functions of the instrument are set up. This display is obtained automatically after selecting the language and is shown diagrammatically in figure 16.

The text which follows details the procedure for setting up every function. Since the procedure is simple and straight forward this section of the book may not need to be read. The selections that are made appear on the 'SETUP STATUS' display screen adjacent to the function reference; so that the operator can check what functions are enables and set.

Important Note:-

At any time during the setting up process pressing the 'END' key when the 'SETUP STATUS' display screen is in view will return the instrument to the test measuring mode and the normal function screen display. There is no need to go through the whole set-up programme if this is not necessary; only those features which are of interest need be set.

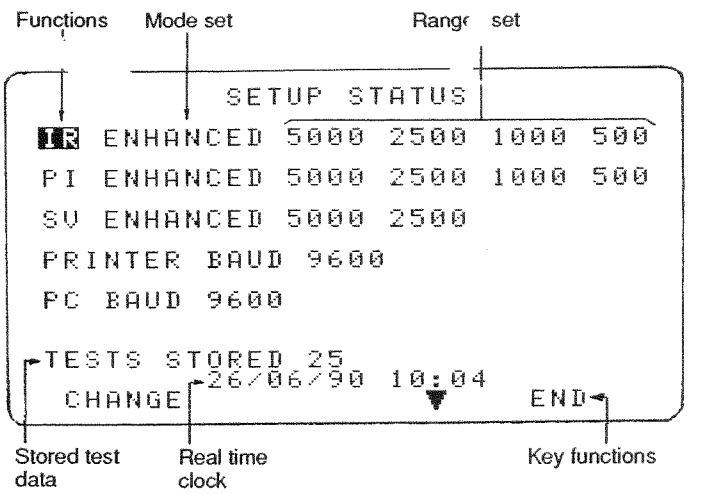

Figure 16 Typical format for the 'SETUP STATUS' display screen

Setting the Date and Time

1. From the 'SETUP STATUS' display screen press the 'arrow head' key (the key is auto-repeat) until the date and time information is highlighted.

2. To alter any of these settings press the 'CHANGE' key to mov to the 'SET CLOCK' screen as shown in fi re 17.

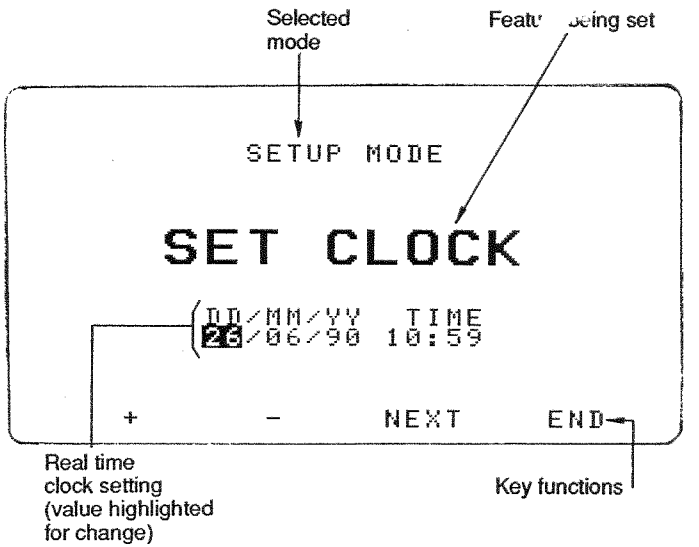

Figure 17 'SET CLOCK' screen from the 'SETUP MODE'

3. Press the ' + ' and '-' keys followed by the 'NEXT' key to alter, first the day, then the month, year, hour and finally minute settings.

Note:- The ' + ' and '-' keys auto-repeat therefore hold them pressed for rapid changing.

4. When the correct information has been inserted press the 'END' key to return to the 'SETUP STATUS' screen display.

Selecting the Insulation Resistance Test Options

1. From the 'SETUP STATUS' screen press the 'arrow head' key to select the 'IR' function option. Press the 'CHANGE' key to move to the 'IR TEST' screen as shown in figure 18.

2. The choice between the simple and the enhanced mode is now presented, together with the option to disable (and therefore not have available for use) this type of test. Press the appropriate key, 'SIMPLE', 'ENHANCED' or 'DISABLE', for the option required. If the choice is made to disable the test then, unless changed later, the instrument will ignore this test type completely and this option will be deleted from the normal function screen display. Pressing 'DISABLE' returns the programme automatically to the 'SETUP STATUS' screen.

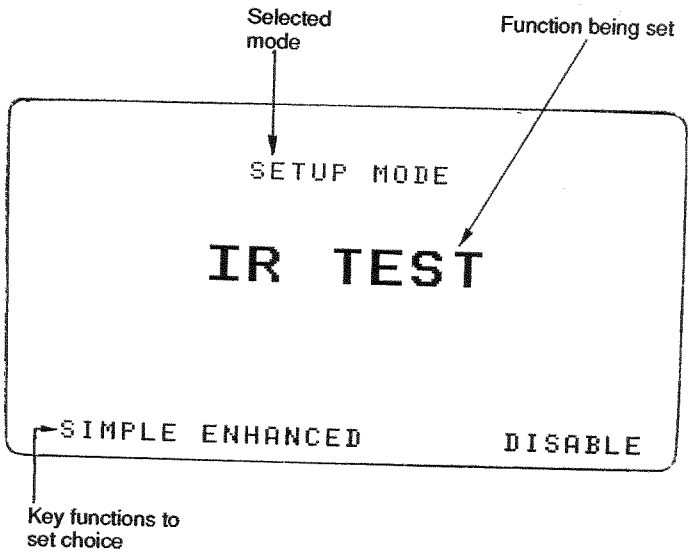

Figure 18 'IR TEST' screen from the 'SETUP MODE'

3. Having chosen the simple or enhanced option the programme automatically moves to the 'IR TEST RANGES' screen as shown in figure 19. Four possible d.c. test voltage are given and each voltage can be switched on or off by the appropriately labelled keys; the 'NEXT' key selects the voltage options in turn.

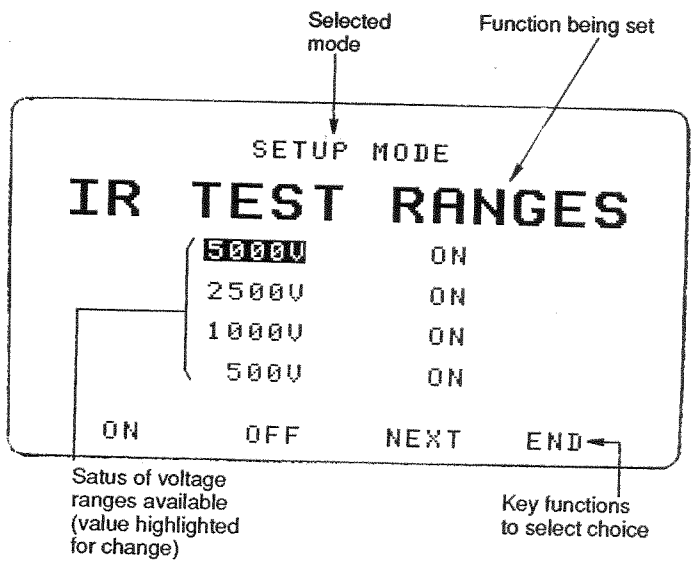

Figure 19 'IR TEST RANGES' screen from the 'SETUP MODE'

4. When the choices have been made press the 'END' key to move back to the 'SETUP STATUS' screen display.

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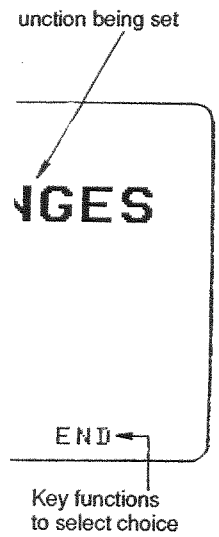

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Selecting the Polarization Index Test Options

1. From the 'SETUP STATUS' screen press the 'arrow head' key to select the 'PI' function option. Press the 'CHANGE' key to move to the 'PI TEST' screen as when setting up the insulation resistance test. The screen display is similar to that shown in figure 18.

2. As when setting up the insulation test the choice between the simple and the enhanced mode is now presented, together with the option to disable and therefore not be able to use this type of test. Press the appropriate key, 'SIMPLE', 'ENHANCED' or 'DISABLE', for the option required. If the choice is made to disable the test then, unless changed later, the instrument will ignore this test type completely and this option will be deleted from the normal function screen display. Pressing 'DISABLE' returns the programme automatically to the 'SETUP STATUS' screen.

3. Having chosen the simple or enhanced option the programme automatically moves to the 'PI TEST RANGES' screen which is similar to that shown in figure 18. The four possible d.c. test voltage are given as they were for insulation tests and each voltage can be switched on or off by the appropriately labelled keys; the 'NEXT' key selects the voltage options in turn.

4. When the choices have been made press the 'END' key to move back to the 'SETUP STATUS' screen display.

Selecting the Step Voltage Test Options

1. As before, from the 'SETUP STATUS' screen press the 'arrow head' key to select the 'SV' function option. Press the 'CHANGE' key to move to the 'SV TEST' screen as when setting up the insulation resistance test. Again the screen display is similar to that shown in figure 17.

2. Select the 'SIMPLE', 'ENHANCED' or 'DISABLE' option as before and from the 'SV TEST RANGES' screen display (similar to that shown in figure 18) which follows select the desired ranges. There are only two choices of ranges 5000 V and 2500 V. These are the maximum values of the series of five step voltage tests that the instrument will carry out; the voltage steps are automatically set.

3. When the choices have been made press the 'END' key to move back to the 'SETUP STATUS' screen display.

Operation - Detailed

Selecting the Baud Rate for Output to a Printer

1. From the 'SETUP STATUS' screen press the 'arrow head' key to select the 'PRINTER BAUD' option. Press the 'CHANGE' key to move to the 'PRINTER BAUD' screen as shown in figure 20.

2. A choice of Baud rates from 9600 to 300 is available, the desired one is selected by pressing the 'NEXT' key until the correct value is highlighted. Pressing 'END' will accept the value selected and return to the 'SETUP STATUS' display.

Selecting the Baud Rate for a P.C.

1. The procedure for setting this option is exactly the same as for setting the Baud rate for a printer. From the 'SETUP STATUS' screen press the 'arrow head' key to select the 'PC BAUD' option. Press the 'CHANGE' key to move to the 'PC BAUD' screen (the screen appears similar to that shown in figure 20) and make a choice from the Baud rates, 9600 to 300, available using the 'NEXT' key.

2. Pressing 'END' will accept the value selected and return to the 'SETUP STATUS' screen display.

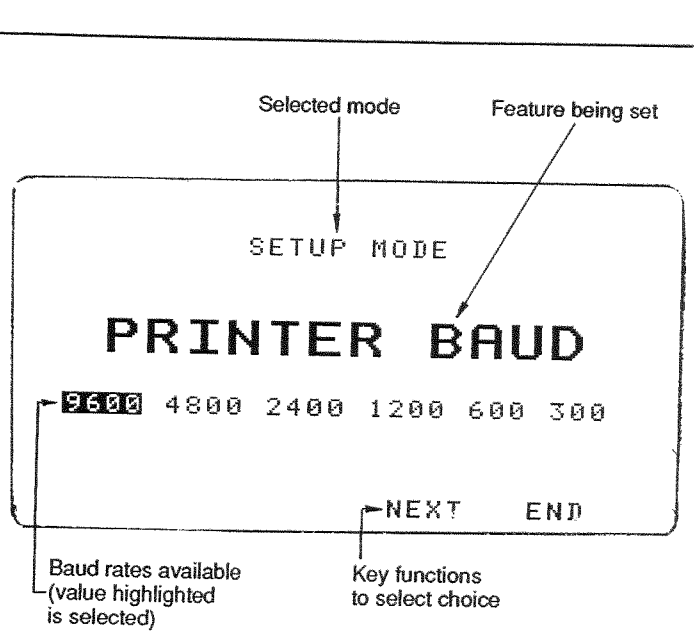


Figure 20 'PRINTER BAUD' screen from the 'SETUP MODE'

Keeping/Deleting Stored Test Data

1. From the 'SETUP STATUS' display screen press the 'arrow head' key until the 'TESTS STORED XX' is highlighted.

2. Press the 'CHANGE' key to move into the 'DELETE TESTS CONFIRM' screen display as shown in figure 21. Press 'YES' to delete all the test results; press 'NO' to escape.

3. After either key has been pressed the appropriate action is automatically taken and the programme returns to the 'SETUP STATUS' screen, which now shows 'TESTS STORED 00' if the tests were deleted.

Returning to the Function Screen

After the set-up programme has been completed press the 'END' key from the 'SETUP STATUS' screen to exit from the set-up menu and return to the main function screen.

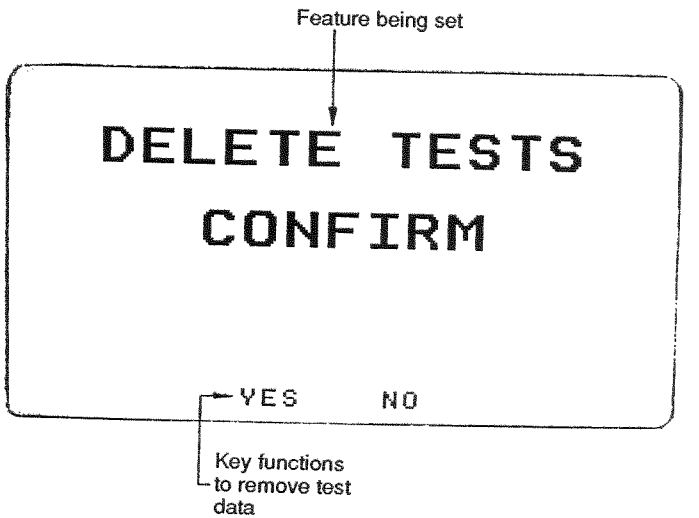


Figure 21 'DELETE TESTS CONFIRM' screen from the 'SETUP STATUS' display

Operation - Detailed

USING THE GUARD TERMINAL

For straightforward insulation tests the guard terminal 'G' will not be used. Insulation tests are performed by connecting the item to be tested between the 'H' and 'L' terminals . Tests performed like this will reveal any deficiencies in the insulation, whether they are caused by leakage through the insulator body or across its surface.

Where there is no possibility of leakage affecting the measurement, i.e. if the test sample is clean and there are no adverse current paths, using the guard terminal is unnecessary. Where leakage currents may be unavoidable the guard system will prove a valuable means of separating the measurement from unwanted and unstable surface leakage.

Purpose of the Guard

To distinguish between current flowing through the body insulation and any surface leakage currents the guard terminal 'G' is used. By use of this terminal, the surface leakage current is removed before it enters the measuring circuit.

When testing a cable, for example, there may be a path for leakage current across the insulation between the bared cable and the external sheathing, due perhaps to the presence of moisture or dirt. It would be necessary to remove the effect of this leakage current, particularly at high testing voltages. A bare wire should be bound tightly around the insulation and connected via the third test lead to the guard terminal 'G'. The 'G' terminal is near in potential to the 'L' terminal and it is best to locate the guard connection near to the low connection. Figure 22 illustrates the use of the guard system.

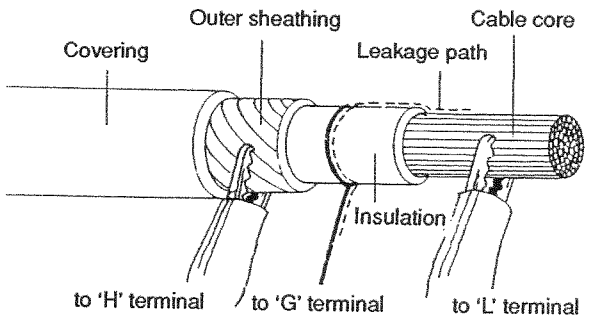
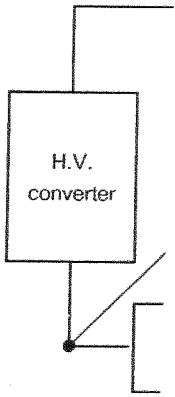


Figure 22 Use of the guard terminal

Since the leakage resistance is effectively in parallel with the resistance to be measured, the use of the guard causes the current flowing through the surface leakage to be diverted from the measuring circuit. The instrument therefore gives more nearly the true insulation resistance. The diagram of figure 23 illustrates this principle.



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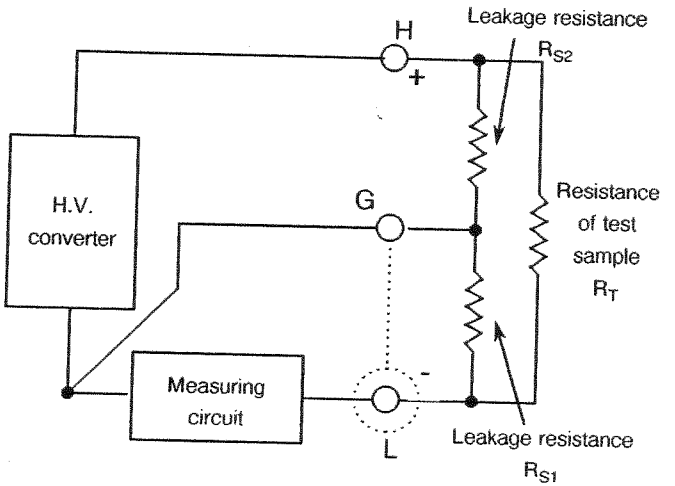

Figure 23 Principle of the Guard system

Effect of the Guard System on the Test Voltage
Referring to figure 23 the advantages and limitations of the Guard system can be explained. The true insulation resistance of the test sample being measured is R_T, but the true measurement may be masked by surface leakage resistances R_{S1} and R_{S2}. The true value will be measured provided R_{S1} and R_{S2} are not too low.

Although the guard system will always reduce the effect of surface leakage it may also introduce other errors:-

(i) If R_{S2} is low (less than 1 MΩ per kV of test voltage) it will have a loading effect on the high test voltage supply and cause the test to be performed at a lower voltage than that selected.

(ii) Resistances in the 'G' and 'L' terminal circuits within the instrument will cause voltage to appear across R_{S1} and therefore generate extra measured leakage current.

(iii) Offset voltage in the measuring circuit also causes measured leakage currents to flow through R_{S1}.

The SERIES 1-5000 suffers from error (i) in a predictable manner (refer to the typical terminal voltage characteristics given in the Specification section) and the actual test voltage always appears on the display. The very low resistances in the 'G' and 'L' terminal circuits (approximately 1 Ω each) together with an offset voltage of typically 1 mV makes the effect of errors (ii) and (iii) extremely small. For example, if $R_{S1} = R_{S2} =$ 250 kΩ the error produced will be equivalent to a 50 GΩ resistor in parallel with the item under test.

These are theoretical figures, but a carefully connected guard could achieve similar results; much in excess of the conservative specification of the instrument.

The minimum test current that the instrument will measure is 10 nA, therefore the maximum resistance that can be measured is given by:-

$$\frac{\text{the open circuit voltage}}{10\ \text{nA}}$$

That is, the maximum resistance is 50 GΩ at 500 V d.c. or 500 GΩ at 5000 V d.c.

When the Guard system is in use the loading effect of the surface leakage resistance R_{S2} may reduce the available output voltage and consequently reduce the upper limit of the resistance measurement. When the Guard system is not being used and the limit of resistance measurement is reached the display shows, for example, '> 50 GΩ' on the 500 V d.c. range. When the leakage resistance R_{S2} is affecting the output voltage the limit of resistance measurement will occur at a lower value and the display will indicate this fact. The actual test voltage is always shown on the display.

Guard Terminal Fuse

The Guard circuit is protected by a 1 A fuse, located inside the terminal box. This fuse protects the Guard should an external voltage be applied accidentally, e.g. wrongly connecting the instrument to an energized test sample or a voltage appearing on the Guard during a test. If this fuse ruptures the Guard system is rendered ineffective. A message to the effect that the Guard fuse has blown will appear on the display.

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PERFORMING TESTS

Connecting the Test Leads

1. Connect the test leads to the instrument by pushing the lead plugs into the terminal sockets on the left hand side of the instrument's case. Having pushed them in fully, turn them clockwise through 90 ° so that they are locked in place and cannot easily be pulled out.

   Note:- There are identification sleeves on the test leads to assist in making connections correctly. The 'H' terminal should have the red sleeved lead and the 'L' terminal should have the black sleeved lead. The lead for the Guard terminal is unmarked.

2. The 'H' terminal is ' + ' with respect to the 'L' terminal. For an insulation test to earth the convention is to connect the lead from the 'L' terminal to the item to be tested and to connect the lead from the 'H' terminal to the earth point of that item.

   Note:- This is the conventional way of making connections, although for most insulating materials it makes no difference which way the connections are made; there will be no loss of accuracy in the measurement. It might, therefore, be preferred or established practice to connect 'H' to the point of test and 'L' to the earth point. However, for certain insulating materials e.g. some ceramics, a lower resistance value is obtained by following the convention.

3. For an insulation test between conductors e.g. two conductors in a cable, connect one test lead to each conductor.

4. The 'G' (Guard) terminal may be connected so as to remove the effect of leakage currents on the measurement being made. Refer to the previous section for use of the Guard system and be aware of the loading of the test voltage that can occur.

Testing Environment

The maximum resistance for each test voltage range is:-

500 V d.c.	50 GΩ
1000 V d.c.	100 GΩ
2500 V d.c.	250 GΩ
5000 V d.c.	500 GΩ

These values may be reduced when the Guard is used as explained in the section 'Using the Guard Terminal'.

Operation - Detailed

Be aware of the environment and conditions under which measurements are being made. For example, when measuring very high resistances take care to avoid stray leakage paths by keeping the test leads well separated and dry. Don't allow the connectors to rest on anything that would create a possible stray leakage path. The test leads themselves have extremely good insulation properties but, if measuring a resistance approaching 500 GΩ, allowing the leads to be tangled together or to lie across a wet surface will create conditions in which stray leakage paths can occur. Such a situation may cause incorrect test results to be obtained.

The instrument is designed to measure resistance in the presence of up to 2 mA a.c. interference current (45 Hz to 65 Hz). If higher currents are encountered a warning message will be displayed.

Over-range

Over-range is normally indicated by the '>' symbol, i.e. for each voltage range over-range is nominally:-

500V d.c. >50 GΩ
1000 V d.c. >100 GΩ
2500 V d.c. >250 GΩ
5000 V d.c. >500 GΩ

This assumes that there is no loading effect through the guard system (refer to the previous section). If there is then the value at which over-range occurs is reduced.

When over-range is indicated and the enhanced mode is in operation the screen will remain in the analogue display and not move to the graphic display or results screen.

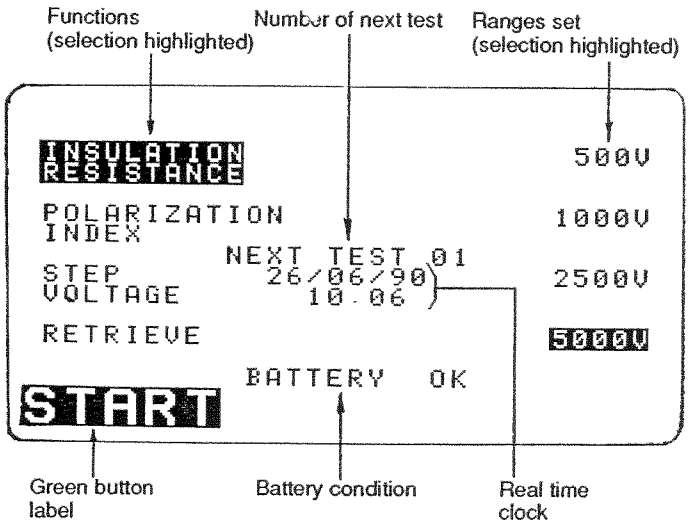

Figure 24 Main function display screen

Insulation Resistance Testing

1. Turn the left hand selector switch fully anticlockwise to the '2 o'clock' position. This switches the instrument on and selects the

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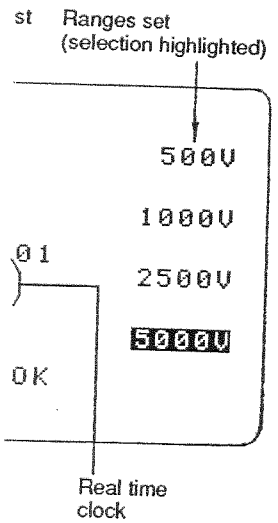

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Insulation Resistance function (observe the display). Initially a copyright message appears on the display, after a few seconds this will be replaced by the function screen display as shown in figure 24.

All the test functions which have been set-up appear on the left hand side of the screen display adjacent to their respective switch position markers. The top left hand one reading 'INSULATION RESISTANCE' is highlighted showing that this function has been selected.

2. On the right hand side of the display, adjacent to the positions of the right hand selector switch, the test voltages that have been set-up are shown. Turn selector switch to the test voltage required; the value will become highlighted when selected.
   Note:- The number of the next test is shown together with the date, time and condition of the battery.

(a) Simple IR test

3. To start the test press the green button (labelled 'START') for > 1 second. (This delay helps avoid accidental operation). The following now happens:-
   (i) The test voltage is applied.
   (ii) The red button will be labelled 'STOP' and will illuminate and flash to warn that high voltage is being applied to the terminals.
   (iii) High voltage warning arrows will appear and flash at the bottom of the display.
   (iv) The display will be similar to that shown in figure 25.

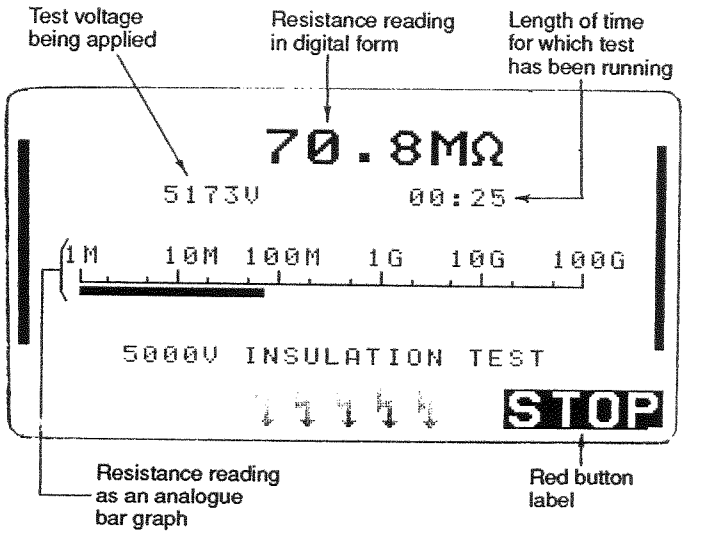

Figure 25 Typical screen display for a simple IR test (equivalent to the 'ANALOGUE DISPLAY' of an enhanced test)

The value being measured is plotted as a logarithmic bar graph on the display and it is shown numerically in large characters to three significant figures at the top of the display.

Note:- Once a test has been started the rotary switches are ineffective, apart from switching the instrument off with the left hand one. Switching the instrument off in this manner may result in the loss of stored data for the test.

4. Press the red 'STOP' button to end the test. The sample under test will automatically discharge and the screen display will have the word 'DISCHARGING' shown highlighted in place of the high voltage warning arrows. When the test voltage has decayed to a safe level the red button will be given the label 'QUIT' and 'TEST COMPLETED' is shown. Apply normal safety practices and link the terminals of capacitive items before removing the test leads.

   Note:- The test will automatically end after 30 minutes to conserve battery power.

5. Pressing the red button returns the screen display to the original function menu.

(b) Enhanced IR test

6. If an enhanced IR test is being conducted the action required is the same as that for a simple test. For the first minute the screen display is the same as for the simple test, but then it automatically changes to show graphically an 'IR RATIO' plot i.e. the ratio of the present value to the value at one minute.

7. In the enhanced test three screen displays are available. Pressing the green button cycles between the three displays. This button has the label of the next screen display available i.e. the 'RESULTS SCREEN', followed by 'ANALOGUE DISPLAY', followed by 'GRAPHIC DISPLAY'. Typical examples of the 'RESULTS SCREEN' and the 'GRAPHIC DISPLAY' and what they show are illustrated in figures 26 and 27.

8. After the test has stopped and the red button is labelled 'QUIT', the three screen displays can still be selected with the green button. They are very similar to the displays visible while the test was in progress but 'TEST COMPLETED' is shown and a figure for the capacitance of the test sample is given.

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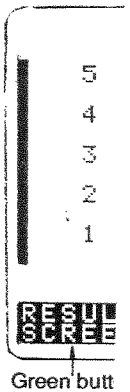

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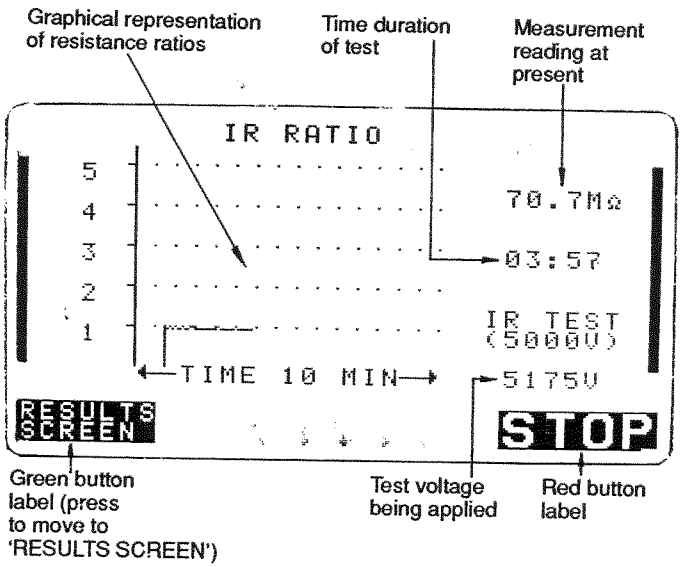


Figure 26 Typical 'GRAPHIC DISPLAY' screen for an enhanced IR test

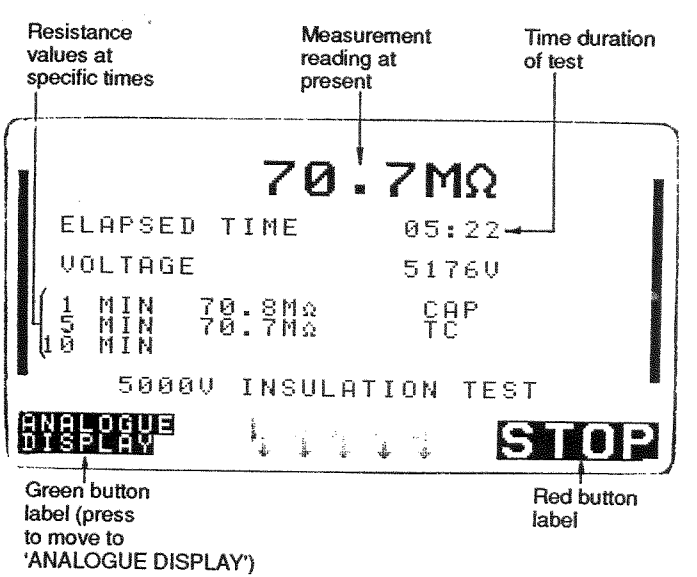


Figure 27 Typical 'RESULTS SCREEN' display for an enhanced IR test

9. Pressing the red button when it is labelled 'QUIT' returns the screen display to the original function menu.

Polarization Index Testing

The procedure for Polarization Index testing is exactly the same as for Insulation Resistance testing except that the test is automatically ended after 10 minutes. (although is may be stopped beforehand by pressing the red button).

Operation - Detailed

To select the 'POLARIZATION INDEX' test turn the left hand selector switch anticlockwise away from the 'O' position to the '3 o'clock' position. Initially a copyright message appears on the display, after a few seconds this will be replaced by the function display screen as before.

The screen displays for the simple test and the enhanced test are the same as those for the IR test except that they are labelled 'POLARIZATION INDEX'.

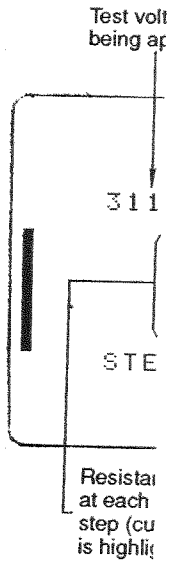
When a test is completed, the test sample discharged and the red button labelled 'QUIT', the screen displays will be as for the IR tests but the P.I. value will be given.

Step Voltage Testing

The basic procedure for carrying out Step Voltage tests is the same as that for the other two types of test, but the screen displays are different.

(a) Simple SV test

1. To select the 'STEP VOLTAGE' test turn the left hand selector switch anticlockwise away from the 'O' position to the '4 o'clock' position. Initially a copyright message appears on the display, after a few seconds this will be replaced by the function display screen as before.
2. Turn the right hand selector switch to the test voltage required. Only two values are shown (provided they have been set-up), they are the maximum voltages for the two Step Voltage Test ranges.
3. Press the green button to start the test. The screen display will be as shown in figure 28; having the same basic features as before but showing the test result for each step of the test digitally. The test will commence with an applied voltage one fifth of the maximum set i.e. 500 V or 1000 V, and will remain at that level for one minute. It will then automatically increase by another fifth i.e. to 1000 V or 2000 V respectively for the two ranges, and remain stable at that figure for another minute.
4. The test will be automatically ended when the last of the five steps of voltage has been applied for one minute. Therefore the total test time is five minutes. The test circuit discharges and 'TEST COMPLETED' is displayed along with the 'QUIT' label for the red button. The display shows the time for which the test has lasted, the final resistance value, terminal voltage, the nominal voltage of each step and the resistance value at each step.



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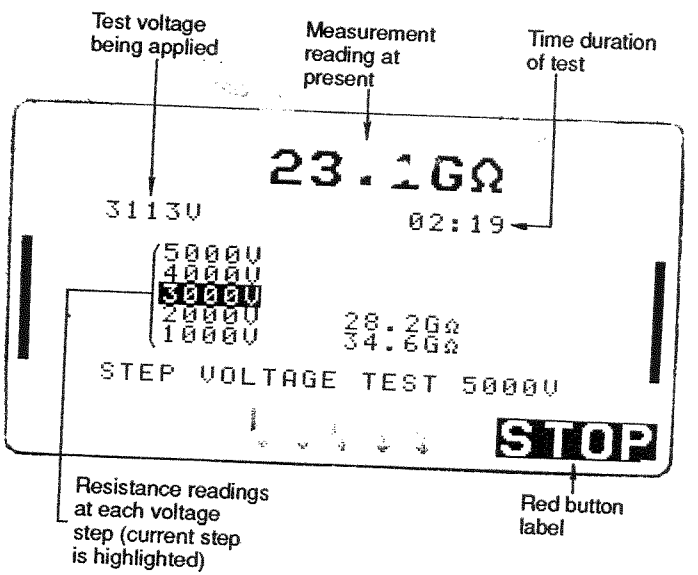


Figure 28 Typical screen display for a simple Step Voltage test

5. Pressing the red button returns the screen display to the original function menu.

(b) Enhanced SV test

6. If an enhanced SV test is being conducted the action required is the same as that for a simple test. For the first minute the screen display is the same as for the simple test, but then it automatically changes to show a 'STEP VOLTAGE' graph in which the scales for voltage and resistance are logarithmic. The resistance value at the end of each one minute voltage step is plotted rather than it being a continuous voltage against resistance graph.

7. In the enhanced test three screen displays are available. Pressing the green button cycles between the three displays. This button has the label of the next screen display available i.e. the 'RESULTS SCREEN', followed by 'ANALOGUE DISPLAY', followed by 'GRAPHIC DISPLAY'. Typical examples of the 'RESULTS SCREEN' and the 'GRAPHIC DISPLAY' and what they show are illustrated in figures 29 and 30.

8. After the test has stopped and the red button is labelled 'QUIT', the three screen displays can still be selected with the green button. They are very similar to the displays visible while the test was in progress but 'TEST COMPLETED' is shown and a figure for the capacitance of the test sample is given.

9. Pressing the red button when it is labelled 'QUIT' returns the screen display to the original function menu.

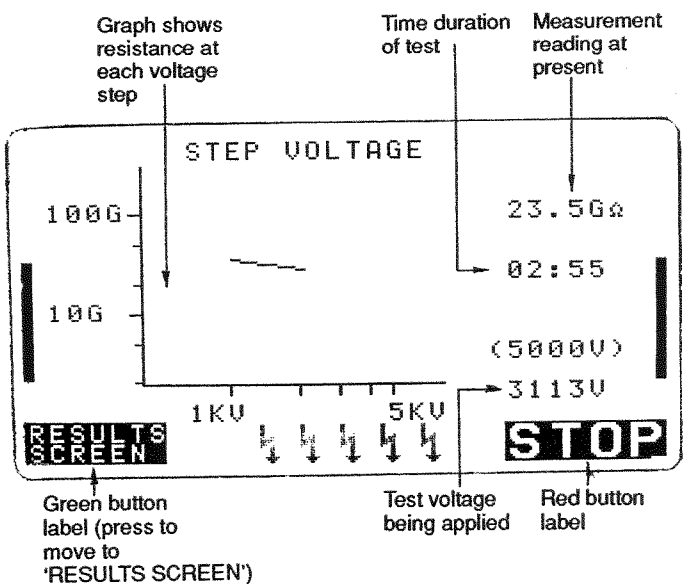


Figure 29 Typical 'GRAPHIC DISPLAY' screen in an enhanced SV test

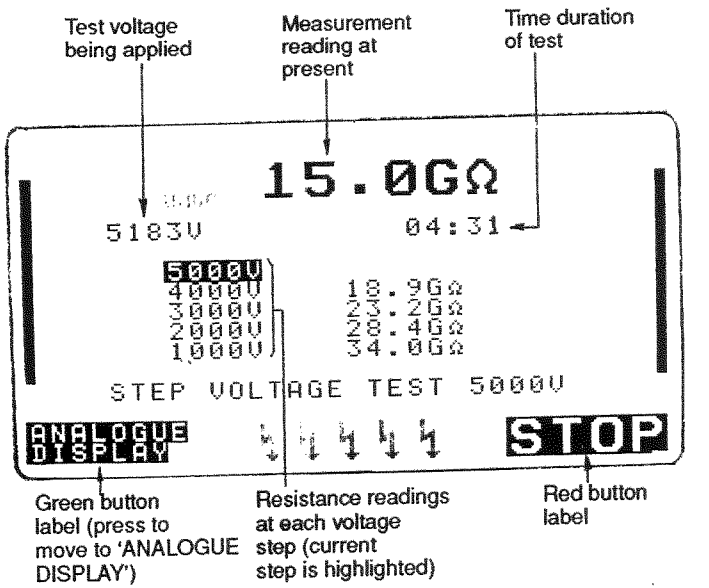
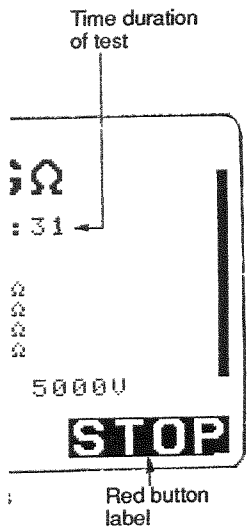


Figure 30 Typical 'RESULTS SCREEN' display in an enhanced SV test

Test Sample Breakdown and Burn Facility

If, during any test there is a complete breakdown in the insulation of the test sample, the applied voltage will be immediately switched off, the sample will be discharged and the 'QUIT' label given to the red button. The screen display will "freeze" in whatever state is was in at the time of the breakdown and the message 'TESTING STOPPED BREAKDOWN' will be shown. Pressing the red button returns the screen display to the original function menu.

To maintain the test voltage and cause burning at the point of breakdown the 'BURN' mode must be engaged. To do this have the function menu in view on



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In this condition the test voltage will continue and remain even though the breakdown may reoccur. The instrument will continue to measure and show its display screens in the normal way and the 'BURN' mode is ended by pressing the red button as before.

The advantage of the 'BURN' facility is that it enables a fault in the insulation to be established so that subsequent visual inspection may be able to pin-point its locality. Arcing may even be visible while the 'BURN' test is in progress.

Note:- When the 'BURN' mode is in use the test results will not record the fact that a breakdown has occurred.

Operation - Detailed

REVIEWING TEST RESULTS

1. Turn the left hand selector switch to the '5 o'clock' position. The function screen display appears with the 'RETRIEVE' function highlighted.

2. The right hand selector switch positions are now labelled:-
   'REVIEW FORWARDS'
   'REVIEW BACKWARDS'
   'PRINTOUT'
   'DOWNLOAD'
   For retrieving the stored results and showing them on the screen select either the 'REVIEW FORWARDS' or 'REVIEW BACKWARDS' positions. The first one shows each result in chronological order the second one shows them in reverse order.

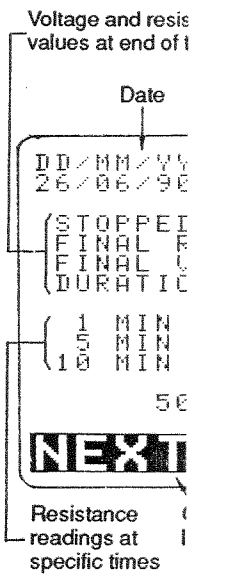
3. Press the green 'START' button and the first result screen display appears. All results screen displays are in an alpha-numeric format and are are labelled 'REVIEW'. The green button is labelled 'NEXT' or 'LAST' and the red button 'QUIT'.

4. Press the green button to move to the next results screen and the red button to return to the main function menu screen.

   Note:- At any time during the review process the right hand switch can be changed to the 'REVIEW FORWARDS' or 'REVIEW BACKWARDS' position to alter the direction of the review without returning to the main function menu screen.

5. A typical results screen for an Insulation Resistance test is shown in the illustration of figure 31.

   Note:- The capacitance value given is the capacitance that the sample under test has at the end of the test. For some items this will be a very low value perhaps even zero, but for a cable, for example, the value might be several microfarads. The 'TC' value shown is the time constant with units of seconds i.e. the final capacitance of the test sample multiplied by its resistance at one minute. This is sometimes referred to as the "merit figure" of the item tested. The 'PI' value is given if the test lasted for 10 minutes.



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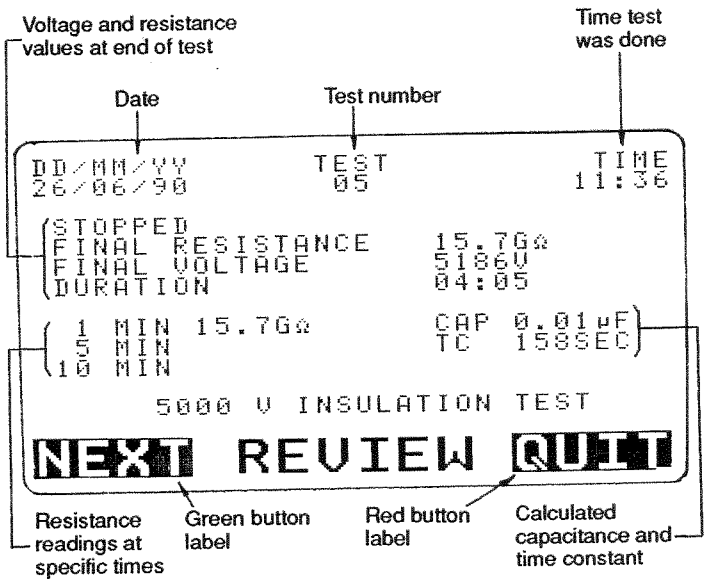

Figure 31 A typical results screen for an Insulation Resistance test

6. A typical results screen for a Polarization Index test is shown in the illustration of figure 32; it is the same as that for an Insulation Resistance test except that it is referred to as a 'PI TEST' and the 'PI' value is also given.

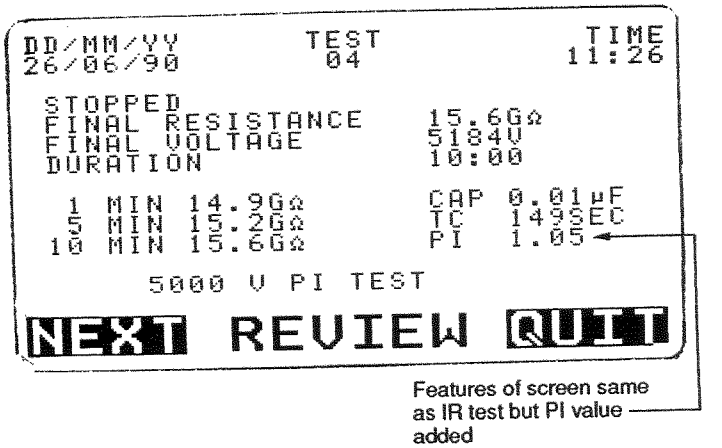

Figure 32 A typical results screen for a Polarization Index test

7. A typical results screen for a Step Voltage test is shown in the illustration of figure 33.

Operation - Detailed

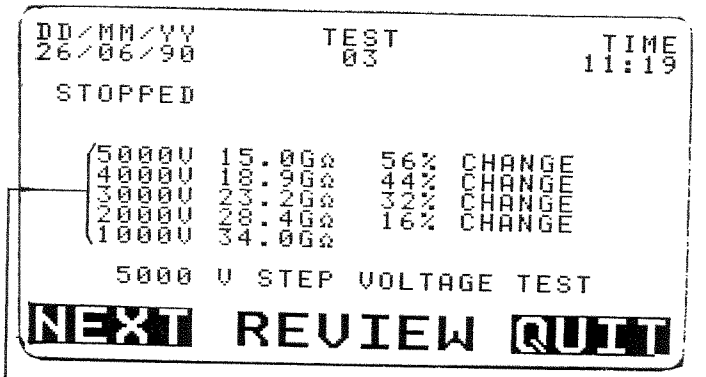

Figure 33 A typical results screen for a Step Voltage test

Note:- The '% CHANGE' values given for each voltage step are:-

$$\frac{\text{1 min IR value - new IR value}}{\text{1 min value}} \times 100\%$$

These figures may be useful in the assessment of the insulation condition.

OBTAINING A PRINT-OUT OF THE RESULTS

1. Connect a printer to the RS232 output plug mounted on the supply panel on the right hand side of the case. An interconnecting cable will be required whose connections for the instrument's RS232 plug are as shown in figure 34. Consult the printer's own instruction book to ascertain the correct connections for its RS232 port. In most cases a standard serial cable should be suitable (9-way 'D' socket to 25-way 'D' plug).

   Note:- It is assumed that the Baud rate of the instrument has been set to that of the printer. The instrument will interface with a standard RS232 serial interface printer and has the following data format: 1 start bit, 8 data bits, 1 stop bit, no parity.

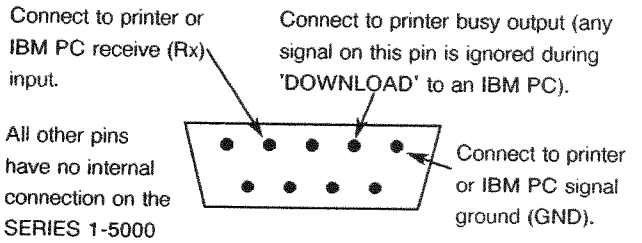

Figure 34 Connections for the RS232 plug (As viewed on the supply panel)

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' to an IBM PC).

Connect to printer or IBM PC signal ground (GND).

ə RS232 plug
y panel)

2. Select the 'RETRIEVE' function on the left hand switch and 'REVIEW FORWARDS' or 'REVIEW BACKWARDS' on the right hand switch.

3. Using the green button labelled 'NEXT' (or 'LAST') scroll through the test results screens until the one for which a print out is required is in view. Press the red 'QUIT' button.

4. Turn the right hand selector switch to the 'PRINTOUT' position and press the green 'START' button. The display screen, now titled 'PRINTOUT', shows the results of the selected test which will be printed out.

5. Press the red 'QUIT' button to return to the main function menu screen.

SENDING THE RESULTS TO A PC

1. Connect a PC to the RS232C output socket mounted on the supply panel on the right hand side of the case. An interconnecting cable will be required whose connections for the instrument's RS232 socket are as shown in figure 34. Consult the IBM PC's own instruction book to ascertain the correct connections for its serial port. In most cases a standard serial cable should be suitable (9-way 'D' socket to 25-way 'D' plug).

   Note:- It is assumed that the Baud rate of the instrument has been set to that off the PC.

2. Select the 'RETRIEVE' function on the left hand switch and 'DOWNLOAD' on the right hand switch.

3. Press the green 'START' button to commence the operation; the screen display will show 'DOWNLOAD IN PROGRESS' and then 'DOWNLOAD COMPLETED' at the end.

4. Press the red 'QUIT' button to return to the main function menu screen.

All the stored test results information held in the instrument's memory will be sent to the PC in the form of numeric data only. (All information blocks will be sent even if they contain no data). To interpret and manipulate this data a software package for IBM PCs is needed; this is available from MEGGER INSTRUMENTS LIMITED.

Alternatively, for a user who wishes to write his own software, the output format is given in Appendix A.

Operation - Detailed

SYSTEM ERRORS

When the instrument is being operated a message such as 'STORE OVERFLOW' may appear on the display.This implies that there is a system error which will be cleared if the instrument is switched off and then on again. If the message persists it will be necessary to return the instrument to the manufacturer or one of his approved agents for them to investigate the fault.

Any serious malfunction in the instrument operation will cause all testing to stop and the test sample to be discharged.

CLEANING THE TERMINAL BOX

The terminal box has internal electrical guarding so that the entry of dust will not normally degrade measurement accuracy. However, if required, it can be opened for cleaning purposes as follows:-

First make sure that the instrument is switched off and disconnected from any external source. Disconnect the test leads from the terminals. To open the terminal box remove the two cross head screws in the left hand edge of its cover and swing the cover outwards. After cleaning close the cover and secure it with the two screws before the test leads are connected or the instrument switched on.

REPLACING FUSES

The mains supply fuse holder is fitted into the supply panel at the right hand side of the instrument. Remove the cap of the fuse holder to gain access to the fuse. The guard terminal also has a protecting fuse and this is mounted in a fuse holder inside the terminal box. To gain access to this fuse it is necessary to open the terminal box cover (see the preceding section); the fuse holder is located in the top left hand corner.

Both fuses must only be replaced with ones of the same rating, see the Specification section. Ensure that the fuses are correctly fitted before the instrument is used again.

REPLACING THE RED BUTTON INDICATOR LAMP

This lamp will normally last for many years. If the lamp bulb does need replacing it can be reached by prising off the red cap. (The lamp bulb has part no. 25975-073 and is available from MEGGER INSTRUMENTS LIMITED).

Preventive

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INSTRUMENTS

Preventive Maintenance

It is good practice to make regular tests of the insulation resistance of all larger machinery and thus detect any incipient faults. When the tests are entered in a log book a considerable variation between test results may be noted. It is therefore important to test under similar conditions each time and to note the current weather status.

Damp weather -- or damp conditions of storage -- can cause large reductions in insulation resistance. Drying out by heat or by operation for a period, should give a more consistent and appropriate insulation resistance value.

A counter effect to that above occurs because the insulation resistance of the varnishes used in conjunction with the machine winding becomes lower when hot than when cold. Thus for constant comparisons the temperature of the machine under test should be noted.

The best plan is top make regular insulation checks as soon as possible after the machine has been shut down. The insulation resistance is then likely to be at its lowest operational value, this then would become the figure which would show any continuing mechanical depreciation or potential insulation breakdown.

If the machine stands idle in humid conditions a worse picture might well apply but this would normally be assumed to be safe during the running up to temperature, provided that the resistance at working temperature remained unchanged.

Testing Motors and Generators

1. Disconnect the equipment from the line by opening the main switch and removing the main fuses.

2. Join together BOTH terminals on the motor side of the double pole main switch.

3. With a contactor operated starter where all the lines to the motor are disconnected at off it is necessary to make tests to earth on both the incoming and outgoing terminals of the starter.

4. Connect the 'H' terminal of the SERIES 1-5000 to earth using the frame of the motor or switch.

5. Using the 'L' terminal measure the resistance of each part of the circuit in the usual way. If the value is unsatisfactory then separate tests in starter, motor and cables must be carried out to locate the defect.

6. If the motor itself is suspect, disconnect the supply cables and, with one lead connected to the frame, carry out the following tests.
   a) Test with the armature and field windings connected together.
   b) Test with the brushes lifted from contact with the commutator.
   c) Test the armature only, section by section.

7. If all resistances are low the fault can usually be remedied by complete and careful cleaning of the machine. Equipment that has been in service for a long period can accumulate metallic, or other conducting, dust especially when mixed with oil from bearings etc. The leakage paths from such deposits are eliminated by thorough cleaning.

Circuit Des

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Figure 35 shows a s
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PRIMARY SECTION

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Circuit Description

GENERAL

Figure 35 shows a schematic block diagram of the instrument's circuit. As shown in this diagram the circuit is divided into two parts which are electrically isolated from one another. Each section is controlled by its own 8-bit micro-processor The two parts of the circuit are connected by a specially designed isolating transformer (for transfer of power) and by two optical fibres which allow the exchange of data in the form of pulsed infra-red signals.

PRIMARY SECTION

This is illustrated on the left hand side of the diagram and contains the user interfaces and the power supplies.

The primary microprocessor with its associated RAM and programme ROM interprets the settings of the rotary switches and push-buttons and sends the appropriate instructions to the secondary half of the instrument via the infra-red link. Returning measurement data is then interpreted and sent to the dot-matrix display via a graphics controller system; which has its own associated RAM and character generator ROM.

Serial data can be diverted away from the optical link and sent from the microprocessor to the RS232 port through level shifting circuits. Also included is a real-time clock (RTC) together with an emergency lithium back-up battery and associated circuits to ensure that data is preserved if the main 12 V lead acid battery becomes fully discharged or disconnected. The RTC not only gives time and date information, but also produces regular interrupts which provide a time base for the instrument's operation.

Several separate power supply rails are required. The mains input unit has the usual elements of transformer, rectifier, smoothing capacitor etc. to provide power for the instrument. The charger unit makes use of a special purpose integrated circuit to provide a dual level floating charge system. The positive supply rails are derived, more or less, directly from the battery or mains supply circuit. There is also a switching regulator to produce negative rails required by the display contrast control and other sundry circuits. The display backlight requires a separate a.c. supply which is produced by a self oscillating transformer circuit.

The primary of the isolating transformer is driven from the output of a square wave oscillator which is gated and can be shut down under microprocessor control. The secondary belongs to the other half of the instrument where its output is rectified and smoothed to provide all the operating power for that section.

Circuit Description

SECONDARY SECTION

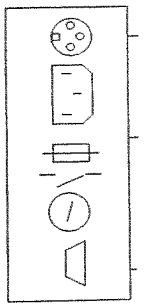
This part consists of the high test voltag pply and measuring circuits.

A specially designed transformer is used to produce the test voltage. The primary is driven by a square wave of variable mark-space ratio and the secondary is rectified and smoothed to provide the d.c. output. A control system stabilizes the level by comparing a fraction of the output to a low-noise reference voltage. The setting can be changes under microprocessor control by means of semiconductor switches in the feedback loop. A high voltage changeover relay connects the 'H' output either to the high voltage supply circuit or to a chain of discharge resistors.

The capacitance of the load is determined at the end of a test by transferring a fixed fraction of its charge onto an internal reference capacitor. To achieve this a modified version of the discharge current is directed to an integrator, whose output voltage is subsequently measured by an A-D converter. The micro-processor then performs the necessary calculations.

The current measurement circuit is associated with 'L' terminal. The unknown current is converted into a square pulse of inverse proportional width, whose deviation is then timed by the microprocessor. The conversion is carried out by using a modified version of the input to drive an integrator between two fixed voltage levels. A system of comparators and digital logic then produces the desired pulse.

The voltage between the 'H' and 'L' terminals is attenuated and modified in a dual purpose measurement circuit which can be set top respond to both a.c. and d.c. voltages, or to d.c. only. The A - D converte nterfaces between this and the microprocessor, which then calculates the insulation resistance using the voltage and current data.



Mains RS232 panel

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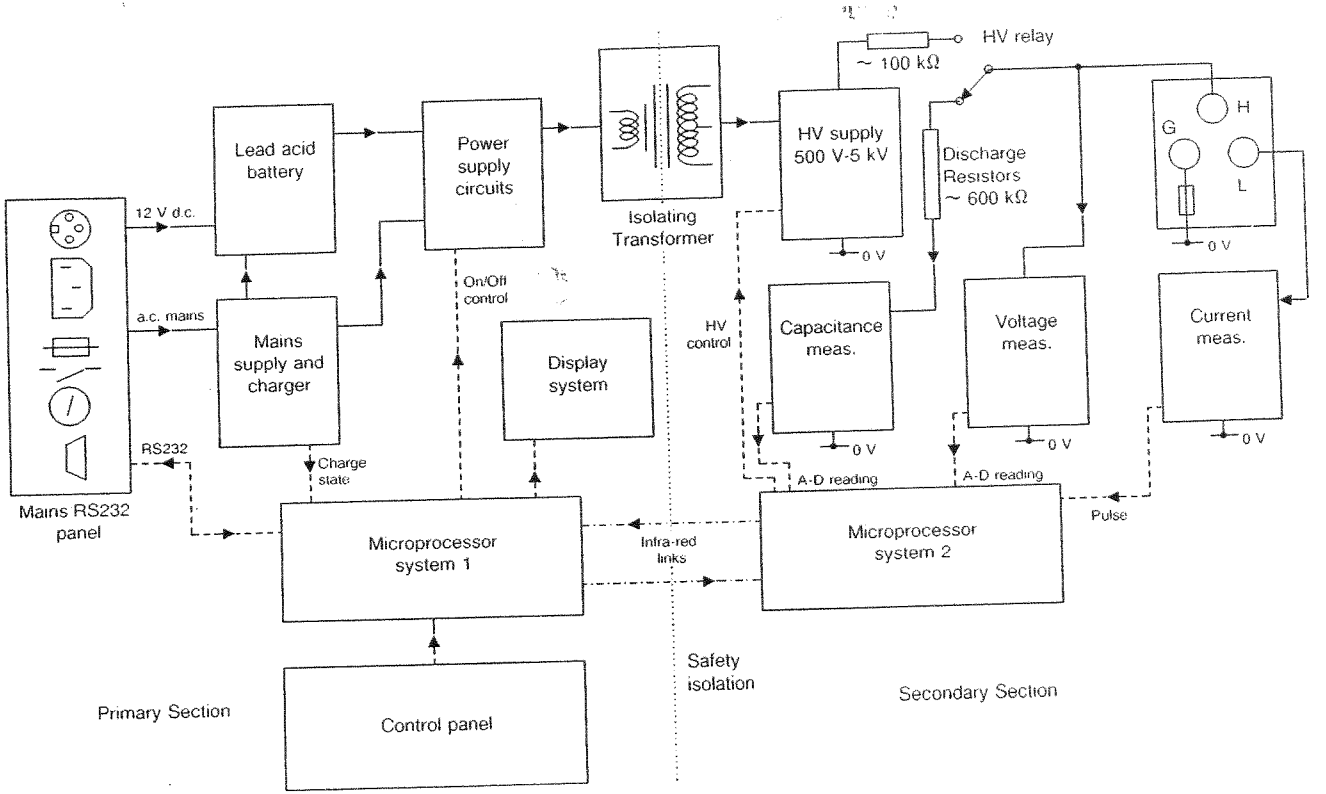

Figure 35 SERIES 1-5000 circuit block diagram

Instrument Repairs and Spare Parts

The manufacturer's service and spare parts organisation for MEGGER® instruments:-

AVO MEGGER INSTRUMENTS LIMITED
Archcliffe Road,
Dover,
Kent CT17 9EN,
England.
Tel: 0304 202620
Fax: 0304 207342

Approved Repair Companies
A number of independent instrument repair companies in the U.K. have been approved for repair work on most MEGGER® instruments, using genuine MEGGER® spare parts. Their names and addresses are listed in the Warranty Card supplied with each new instrument.

Overseas
Instrument owners outside the U.K. should consult the appointed Distributor/Agent for their country regarding spare parts and repair facilities. The Distributor/Agent will advise on the best course of action to take.

If returning an instrument to Britain for repair, it should be sent, freight pre-paid, to the address shown opposite. A copy of the Invoice and of the Packing Note should be sent simultaneously by airmail to expedite clearance through the U. K. Customs.

A repair estimate showing return freight and other charges will be submitted to the sender, if required, before work on the instrument commences.

NEW INSTRUMENTS ARE GUARANTEED FOR 12 MONTHS FROM THE DATE OF PURCHASE BY THE USER.

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Appendix A

RS232 SERIAL OUTPUT FORMAT

Before sending the results data to a PC the Set-up Programme must be used to select the required output baud rate. (Enter the Set-up Programme by Switching the instrument on with the red button pressed).

Each data byte is of the form: 1 Start, 8 Data, 1 Stop, No parity. In the following information the 8 data bits form an ASCII character in all cases except (6) when they form a binary number. Leading zeros are sent as spaces. Blocks which contain no data will be sent as 'ASCII Null' and 'cr lf' characters.

The data output includes all 25 tests, starting with the oldest test. Data is sent, as per the following list, 25 times.

1. **Test Type**
   IR cr lf (Insulation Resistance)
   PI cr lf (Polarization Index)
   SV cr lf (Step Voltage) [4 bytes]
   These characters are in upper case letters and always the same, irrespective of the language selected.

2. **Date of Test**
   DD/MM/YY cr lf [10 bytes]
   This is in the English date format (the American date format will be available later).

3. **Start Time of Test**
   XX:XX cr lf [7 bytes]

4. **Selected Voltage**
   XXXXV cr lf [8 bytes]

5. **Resistance Values**
   A series of resistance values at specific points in time. Each value takes the form:-
   XXXXXM cr lf (Megohms)
   or XXXXXG cr lf (Gigohms) [8 bytes]
   where XXXXX is a four digit number containing a decimal point. Leading zeros appear as spaces. In the case of over-range a '>' will appear before the number.

   IR and PI tests give values at:-
   $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, 20, 25, 30, minutes.
   [17 x 8 bytes total]

   SV test will give values at:-
   $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, 1, minute for each of 5 voltage ranges. [20 x 8 bytes total]

   Unfilled blocks will contain ASCII Null or cr lf.

Appendix A

6. Test Ended By

This is a single byte number (not ASCII) follo
by cr lf:-

AF (HEX) = TIMEOUT
AE (HEX) = MANUAL STOP
4B (HEX) = BATTERY TOO LOW
4A (HEX) = GUARD FUSE BLOWN
4D (HEX) = BREAKDOWN
4C (HEX) = INTERFERENCE [3 bytes]

7. Final Resistance

XXXXXM cr lf
or XXXXXG cr lf [8 bytes]

8. Final Voltage

XXXXXV cr lf [7 bytes]

9. Elapsed Time

MM:SS cr lf [7 bytes]

10. Capacitance Value

X.XX cr lf (Microfarads - fixed point)
**** cr lf (if not available) [6 bytes]

11. Test Number

XX cr lf [4 bytes]

An ASCII EOT is included at the end.

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