PRECISION COMPONENT ANALYZER
6430B / 6440B

User Manual

Issue A

27th May 2003

Part Nº 9H6430B

USA
Wayne Kerr Electronics Inc.
165L New Boston Street
Woburn MA 01801-1744
Tel: 781 938 8390
Fax: 781 933 9523
email: sales@waynekerr.com
www.waynekerrtest.com

UK
Wayne Kerr Electronics
Vinnetrow Business Park
Vinnetrow Road
Chichester
West Sussex PO20 1QH
Tel: +44 (0)1243 792200
Fax: +44 (0)1243 792201
email: sales@wayne-kerr.co.uk
email: service@wayne-kerr.co.uk
www.waynekerrtest.com

Asia
Microtest
14F-6, No.79, Hsin Tai Wu Road, Sec. 1,
Hsi-chih, Taipei 221, Taiwan, R.O.C.
Tel: +886-2-2698-4104
Fax: +886-2-2698-0716
Email: wksales@microtest.com.tw
www.waynekerrtest.com

CONTENTS

ILLUSTRATIONS

1. SAFETY

1.1 General

This equipment has been designed to meet the requirements of EN61010-1 'Safety requirements for electrical equipment for measurement, control & laboratory use' and has left the factory in a safe condition.

The following definitions in EN61010-1 are applicable:

OPERATOR	Person operating equipment for its intended purpose. **Note: The OPERATOR should have received training appropriate for this purpose.**
RESPONSIBLE BODY	Individual or group responsible for the use and maintenance of equipment and for ensuring that operators are adequately trained.

The RESPONSIBLE BODY must ensure that this equipment is only used in the manner specified. If it is not used in such a manner, the protection provided by the equipment may be impaired.

This product is not intended for use in atmospheres which are explosive, corrosive or adversely polluted (e.g. containing conductive or excessive dust). It is not intended for use in safety critical or medical applications.

The equipment can cause hazards if not used in accordance with these instructions. Read them carefully and follow them in all respects.

Do not use the equipment if it is damaged. In such circumstances the equipment must be made inoperative and secured against any unintentional operation.

Wayne Kerr Electronics and the associated sales organizations accept no responsibility for personal or material damage, nor for any consequential damage that results from irresponsible or unspecified operation or misuse of this equipment.

1.2 AC Power Supply

Power cable and connector requirements vary between countries. Always use a cable that conforms to local regulations, terminated in an IEC320 connector at the instrument end.

If it is necessary to fit a suitable AC power plug to the power cable, the user must observe the following colour codes:

WIRE	EUROPEAN	N. AMERICAN
LIVE	BROWN	BLACK
NEUTRAL	BLUE	WHITE
GROUND	GREEN/YELLOW	GREEN

The user must also ensure that the protective ground lead would be the last to break should the cable be subject to excessive strain.

If the plug is fused, a 3-amp fuse should be fitted.

If the power cable electrical connection to the AC power plug is through screw terminals then, to ensure reliable connections, any solder tinning of the cable wires must be removed before fitting the plug.

Before switching on the equipment, ensure that it is set to the voltage of the local AC power supply.

WARNING!

Any interruption of the protective ground conductor inside or outside the equipment or disconnection of the protective ground terminal is likely to make the equipment dangerous. Intentional interruption is prohibited.

1.3 Adjustment, Maintenance and Repair

WARNING!

The equipment must be disconnected from all voltage sources before it is opened for any adjustment, replacement, maintenance, or repair.

When the equipment is connected to the local AC power supply, internal terminals may be live and the opening of the covers or removal of parts (except those to which access can be gained by hand) is likely to expose live parts.

Capacitors inside the equipment may still be charged even if the equipment has been disconnected from all voltage sources.

Any adjustment, maintenance, or repair of the opened equipment under voltage must be carried out by a skilled person who is aware of the hazards involved.

Service personnel should be trained against unexpected hazards.

Ensure that only fuses with the required rated current and of the specified type are used for replacement. The use of makeshift fuses and short-circuiting of fuse holders is prohibited.

1.4 Static Electricity

The unit supplied uses static-sensitive devices. Service personnel should be alerted to components which require handling precautions to avoid damage by static electrical discharge.

Before handling circuit board assemblies containing these components, personnel should observe the following precautions:

1) The work surface should be a conductive grounded mat.
2) Soldering irons must be grounded and tools must be in contact with a conductive surface to ground when not in use.
3) Any person handling static-sensitive parts must wear a wrist strap which provides a leaky path to ground, impedance not greater than 1MΩ.
4) Components or circuit board assemblies must be stored in or on conductive foam or mat while work is in progress.
5) New components should be kept in the suppliers packaging until required for use

2. INTRODUCTION

Figure 2-1 6430B and 6440B Precision Component Analyzers

The 6430B and 6440B Precision Component Analyzers provide 2-terminal or 4-terminal (Kelvin) measurement of passive components over the frequency range 20Hz to 500kHz (6430B) or 20Hz to 3MHz (6440B). For DC measurements, either 100mV or 1V measurement drive level can be selected; for AC measurements, the measurement drive level can be varied from 1mV to 10V rms. Automatic level control (ALC) can maintain the drive level at the component. DC bias voltage can also be applied during AC measurements: the preset internal level is 2V or the user can input an external supply of up to ±60V via rear panel connectors.

The analyzer's measurement, display and control facilities include:

- spot frequency measurements
- multi-frequency measurements at a number of user-defined frequencies
- display of actual measurement values
- series or parallel resonant frequency of a component or circuit
- display of the difference from a set nominal component value
- display of measurement results in absolute terms or as the percentage difference from a specified nominal value
- bar graph analogue display for easy adjustment of variable components—spot frequency measurements only
- output of measurement results to an Epson-compatible printer
- linear or logarithmic graphical representation of a component or circuit across a user-defined frequency range (6440B or 6430B with the Analysis option fitted)
- output of the graphical display to an Epson-compatible printer
- sorting of components into bins according to their measured value and/or minor term (option)

All the above functions can be selected via manual front panel control or remote control via the GPIB interface for fully-automated high-speed testing.

3. INSTALLATION

3.1 AC Line Connections

The unit is provided with a power cable capable of carrying the input current for both 115V and 230V operation. This cable should be connected via a suitable connector to the local AC power supply. The colour code employed is as follows:

WIRE	EUROPEAN	N. AMERICAN
LIVE	BROWN	BLACK
NEUTRAL	BLUE	WHITE
GROUND	GREEN/YELLOW	GREEN

The supply voltage setting can be checked by looking through the transparent window on the rear panel next to the power inlet socket. This can be changed by first disconnecting the unit from the electrical supply, removing the window and adjusting the switch to read the required voltage. Replace the window and ensure that the fuse rating is correct:

230V 1A–T

115V 2A–T

No adjustment is required for variation of supply frequency.

Before connecting the AC power, read the precautions listed under section 1.2—AC Power Supply.

The instrument is not suitable for battery operation.

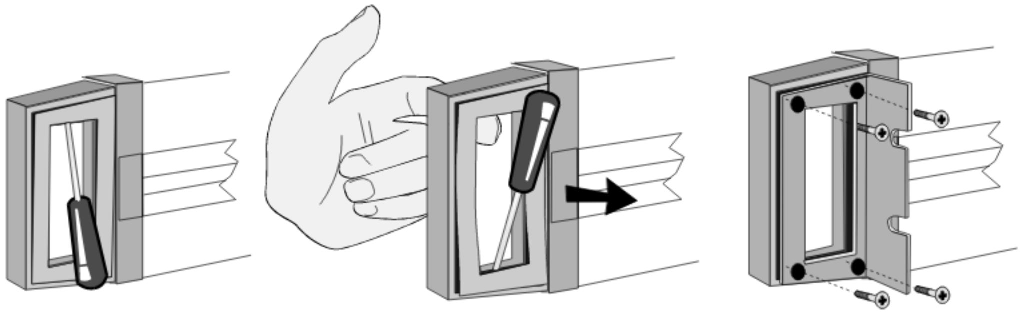
The power switch is located on the left of the front panel.

3.2 Location

The 6430B / 6440B is intended for use either on the bench or in a rack. The power modules are convection cooled and care must be taken not to restrict any of the air paths.

3.2.1 Rack Mounting

There is a rack mounting kit available as an option to fit a standard 19” rack. This kit contains the mounting brackets and screws required for the conversion. To fit these brackets, carefully remove the insert in the outer face of both front handles, see Figure 3-1 below. Fit each bracket into the recess formed by the removal of the insert and secure using the bolts provided (M4 x 10mm CSK). It is important that some provision be made to support the rear of the unit when using the rack mounting brackets.



Insert small screwdriver into the gap between insert and handle body. Prise away one end slightly and hold in position with finger. Note operation of insert with styling cut-out opposite cut-out in handle.

Insert screwdriver into other end and repeat procedure. This will relieve the small tapered pins of the insert from the threaded holes in the handle. Remove insert in the direction of arrow.

Insert rack mounting bracket into recess in handle in attitude shown and secure firmly with 4 M4x10 C'SK HD screws supplied.

Figure 3-1 Procedure for Attachment of Rack Mounting Brackets

3.3 Measurement Connections

The 6430B / 6440B can be used with any of the following Wayne Kerr leads, fixtures or adaptors. In each case ensure that the colour-coded plugs are mated correctly with the corresponding panel sockets.

Kelvin Clip Leads (Fine Jaws), Part No. 1EVA40100

General purpose 4-terminal measuring leads for conventional components giving good accuracy except for measurement of very small capacitances or very small inductances where the use of the 4-terminal component fixture, part number 1EV1006, will give more accurate results.

Kelvin Clip Leads ((large jaws), Part No. 1EVA40180

Similar to part number 1EVA40100 but with larger jaws making them more suitable for connection to terminal posts or larger diameter component leads.

Four-Terminal Lead Set, Part No. 1EV1505

600mm screened cable terminated in four crocodile clips at the component end. Not recommended for use above 30kHz.

SMD Tweezers, Part No. 1EVA40120

2-terminal component tweezers for use with surface-mount or leadless components. A cam is incorporated to set the jaw spacing to the width of the component to be tested so that O/C trim will trim out the residual capacitance of the tweezers.

Four-Terminal Component Fixture, Part No. 1EV1006

Remote fixture with sliding jaws to accommodate both axial and radial leaded components. This fixture will give the greatest accuracy for 4-terminal measurements of conventional components. The jaws can be set to the component width for trimming and component measurements can be performed without moving the measuring leads: stable lead positioning is important when measuring low value inductors.

1100 Protection Unit, Part No. 1J1100

The standard protection built into the 6430B and 6440B prevents damage to the instrument when charged capacitors are connected to the measurement terminals with energy levels up to 0.25J and a maximum voltage of 500V.

The 1100 Protection Unit fits between the measurement terminals and the DUT to raise the maximum energy level to 25J and the voltage to 1000V.

Other Test Leads

Other test leads can be used with the analyzer, provided that they conform to the following connection protocol.

The four front-panel BNC sockets are for screened cable connections to the unknown component or test fixture: use good quality 50Ω screened cable, e.g. RG174A/U; cable length should not exceed 2m. In each case, the outer connection provides the screening and the inner is the active connection. The innermost pair of panel connectors carry the signal source (ORANGE) and the current return (RED) signals. The outer pair serve to monitor the actual voltage at the device under test (DUT), excluding any voltage drops arising in the source and return leads. The common ground point should be connected to component guards and/or screens for in-circuit measurements.

The outers of the four BNC sockets are not directly connected inside the analyzer, but it is important that the GROUNDS are linked OUTSIDE. For accurate high frequency operation, the leads must be screened and the screens connected close to the DUT.

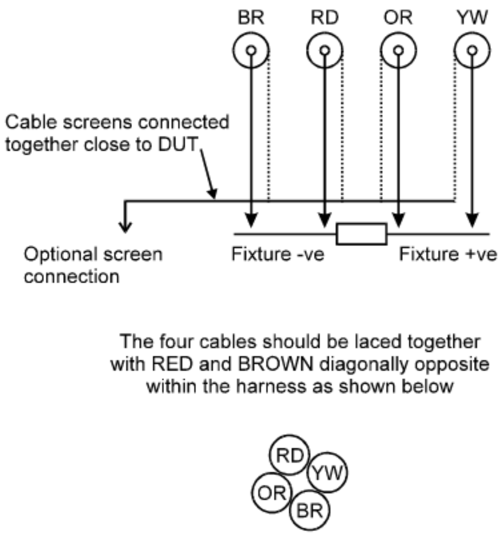


Figure 3-2 4-Terminal Measurement

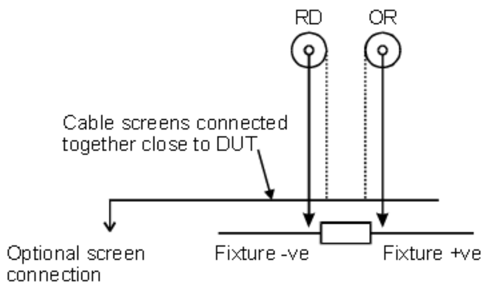


Figure 3-3 2-Terminal Measurement

4. OPERATION

WARNING!

This equipment is intended for use by suitably trained and competent persons.

This product can cause hazards if it is not used in accordance with these instructions. Read them carefully and follow them in all respects. Double check connections to the unit before use.

DO NOT USE THIS EQUIPMENT IF IT IS DAMAGED.

4.1 The Rear Panel

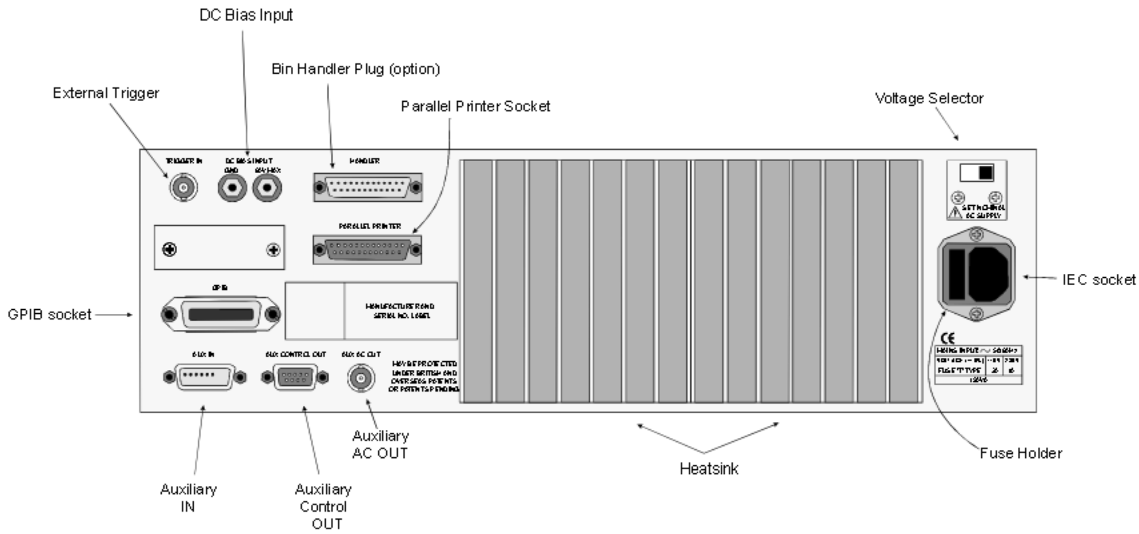


Figure 4-1 The 6430B/6440B Rear Panel

4.1.1 Voltage Selector

The instrument can be operated from an AC power source of either 115V or 230V. Before applying AC power to the IEC socket, ensure that the voltage selector switch is set to the voltage of the local AC power supply.

4.1.2 IEC Socket and Fuse Holder

Please read section 1.2 before connecting the IEC socket to the AC power source.

4.1.3 Rear Panel Control Connections

Label	Type	Use	Reference
DC BIAS INPUT	Two 4mm sockets	To allow an external DC power supply to be connected to the DUT.	Sections 4.1.5 and 4.2.5
GPIB	Standard GPIB	For remote operation.	Sections 4.1.7 and 0
TRIGGER IN	BNC	Duplicates action of front panel trigger key.	Section 4.1.4
AUX IN	15-way D-type (male)	For future expansion	Section 4.1.8
AUX CONTROL OUT	9-way D-type (female)	For future expansion	Section 4.1.9
AUX AC OUT	BNC	For future expansion	Section 4.1.10
PARALLEL PRINTER	25-way D-type (female)	To send results to local printer	Sections 4.2.6.1, 5.11.2 and 6.2.1.
HANDLER	25-way D-type (male)	OPTIONAL - to interface to bin sorting equipment.	Sections 4.1.11 and 5.7

4.1.4 External Trigger

The **TRIGGER IN** BNC socket duplicates the action of the front panel trigger key. The input is TTL compatible and when logic low is equivalent to operating the front panel trigger key. This input is level sensitive and fully debounced, and includes a pull up resistor to enable shorted contacts such as relays or footswitches to be used.

4.1.5 DC Bias Input

The rear panel **DC BIAS INPUT** terminals allow an external DC power supply to be connected to the DUT. See section 4.2.5, paying special attention to the warning in that section.

4.1.6 Parallel Printer Connector

Allows the instrument to be connected to an Epson-compatible printer for printing of measurement results. Graphs can also be printed (6440B or 6430B with Analysis option): see sections 5.11.2 and 6.2.1.

Note:

The printer must be enabled before results can be output to it: enter **Code 30** from the **MAIN MENU** as described in section 4.2.6.1. If printer output is enabled with no printer connected or with the printer power switched off, a message will be displayed and printer output will be disabled. Printer output will also be disabled when the instrument is switched off or goes to remote control. To manually disable the printer output enter **Code 31** from the **MAIN MENU**.

4.1.6.1 Parallel Printer Output

Header

When the printer is enabled, the instrument will print a title, together with the time and date, in the following format:

```
Wayne Kerr 6430B
13:53:17  02 Jan 00
```

Status

Whenever a mode is selected or changed, the status of the selected mode will be printed, for example:

```
2-TERM DEVIATION MODE
```

Test Conditions

A summary of the test conditions will be output whenever the type of test is changed, e.g. from **Rdc Meas** to **AC Meas** in **MEASUREMENT MODE**.

```
AC Meas:
L Q Parallel
1.02Vac  1.0000kHz
Bias OFF Internal
Range Auto
Speed Fast
ALC off
```

If, on selecting a mode, the required test type is already selected, press the highlighted key once to obtain this test condition summary.

Measurement Results

Measurement results will be output to the printer in **MEASUREMENT**, **DEVIATION, BINNING** and **CAPACITOR** modes whenever a single-shot test is performed. The value of the frequency, test level or DC bias will be printed if highlighted in the test set up. For example, printing L and Q variation with frequency.

```
400.00 Hz     13.90mH, 12.55
500.00 Hz     13.85mH, 13.12
600.00 Hz     13.79mH, 13.98
800.00 Hz     13.72mH, 14.52
1.0000kHz     13.61mH, 15.07
```

To obtain a print out of test results without the additional parameter, move the test set-up highlight to **Range** or **Speed**.

Binning

A **PRINT** soft key label will be displayed in **BINNING MODE – COUNT** if a printer is connected and printing is enabled (**Code 30** from the **MAIN MENU**).

In **BINNING MODE – SET, Code 34** will print a list of the current bin set-up (the printer must first be enabled by entering **Code 30** from the **MAIN MENU**).

In **BINNING MODE – SORT** and single-shot mode, measurement results and bin numbers will be printed if printing is enabled.

Capacitor

A **PRINT** soft key label will be displayed in **CAPACITOR MODE – RESULTS** if a printer is connected and printing is enabled (**Code 30** from the **MAIN MENU**). The Bin totals and yield, together with the total number of components tested may be printed.

4.1.6.2 Parallel Printer Connector Pin Assignment

Pin	Description	Pin	Description
1	Strobe	14	Auto Feed
2	Data Line 0	15	Error
3	Data Line 1	16	Initialize Printer
4	Data Line 2	17	Select Input
5	Data Line 3	18	Ground (Data bit 0)
6	Data Line 4	19	Ground (Data bit 1)
7	Data Line 5	20	Ground (Data bit 2)
8	Data Line 6	21	Ground (Data bit 3)
9	Data Line 7	22	Ground (Data bit 4)
10	Acknowledge	23	Ground (Data bit 5)
11	Busy	24	Ground (Data bit 6)
12	Paper End	25	Ground (Data bit 7)
13	Select		

4.1.7 GPIB Connector

The General Purpose Interface Bus (GPIB) is a parallel port which allows communication between the instrument and other devices such as PCs fitted with a suitable interface card. The GPIB port allows remote control of the instrument for measurement of components and the collection of measurement results. For details of GPIB control and commands see section 0.

Devices should be connected to the instrument using a standard GPIB 24-pin connector assembly with a shielded cable. Use of the standard connector consisting of a plug and receptacle is recommended and should be compatible with the Amphenol and Cinch Series 57 or Amp Champ.

4.1.7.1 GPIB Connector Pin Assignment

Pin	Description	Pin	Description
1	Data Line 1	13	Data Line 5
2	Data Line 2	14	Data Line 6
3	Data Line 3	15	Data Line 7
4	Data Line 4	16	Data Line 8
5	EOI (End or Identify)	17	REN (Remote Enable)
6	DAV (Data Valid)	18	Ground
7	NRFD (Not Ready For Data)	19	Ground
8	NDAC (Not Data Accepted)	20	Ground
9	IFC (Interface Clear)	21	Ground
10	SRQ (Service Request)	22	Ground
11	ATN (Attention)	23	Ground
12	Screen	24	Signal Ground

4.1.8 Auxiliary In

For future expansion.

4.1.9 Auxiliary Control Out

For future expansion.

4.1.10 Auxiliary AC Out

For future expansion.

4.1.11 Bin Handler Interface (Option)

For details of how to use the 6430B/6440B **BINNING MODE** – **Set**, – **Sort** and – **Count** modes refer to section 5.7.

An external bin handler may be connected via a 25-way D-type connector at the rear of the instrument (see section 4.1.11.5 for bin handler interface pin assignment details). If the option is fitted the instrument will measure a component, sort it into one of the ten bins according to the measurement results and then provide the signals for external bin handling hardware to physically 'bin' the component. The interface supports up to ten external bins and provision is made for external bin handler hardware to trigger a measurement directly.

On power up, the instrument recognizes if the bin handler option is fitted, the BUSY line is taken low, with the BDA and all BIN lines high. Measurements may be triggered by pressing the **Trigger** key on the front panel or taking the external **TRIGGER IN** line low. If a measurement is in progress when the unit is triggered the current measurement will be aborted and a new measurement started.

If the external trigger is to be used under GPIB control, then the local trigger must be enabled by sending the GPIB command 'LOC-TRIG ON'.

The BUSY line goes low to acknowledge the trigger and also to indicate that the component between its terminals is in the process of being measured and should not be removed until the BUSY line goes high again. The BDA line is the opposite logic level of the BUSY line. The falling edge of the BDA signal indicates that the data on the BIN lines is valid.

In **MEASUREMENT MODE** the Pass/Fail output corresponds to the scale bar PASS, HI and LO. In **MULTI FREQ** – **Run** mode the Pass/Fail output corresponds to the PASS, FAIL, HI and LO results. The Pass/Fail output goes low only when a measurement has passed all set limits, see section 4.1.11.5 for the bin handler interface pin assignment.

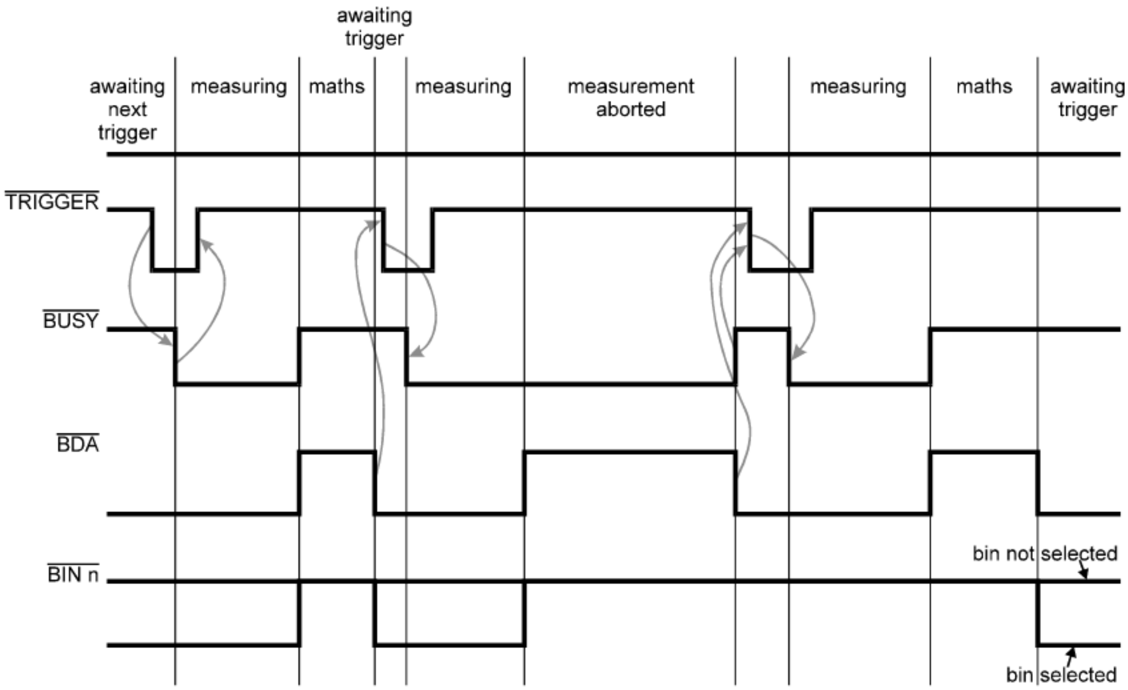


Figure 4-2 Standard Bin Handler Timing

The two output signal lines BUSY and BDA (Bin Data Available) will at any time assume one of four different states:

4.1.11.1 Null State

The null state is defined as BUSY low and BDA high. The instrument enters this state on power-up. When this state is detected by external hardware, it must be assumed that the current signals on the BIN lines are invalid and should be ignored.

4.1.11.2 Ready for Trigger

BUSY is high and BDA is low in this state. All BIN lines will be unchanged. If the previous state was a null then all bin lines will be high, meaning no bin selected, although BDA suggests that valid bin data is present. When the instrument receives a trigger it will respond by entering the next state.

4.1.11.3 Busy

Both BUSY and BDA are low in this state. The BUSY line goes low to acknowledge the trigger and also to indicate that the component between its terminals is in the process of being measured and should not be removed until the BUSY line goes high again, when the instrument enters the next state.

4.1.11.4 Not Busy

Both BUSY and BDA are high and all BIN lines are set to high in this state. The instrument has finished with the component under test, which may be removed and replaced by the next component. However, the instrument has still to sort the component into the relevant bin and, as the current bin is being updated, all the BIN lines are made invalid.

If the process has been completed without interruption, the instrument will re-enter the ‘Ready for Trigger’ state waiting to measure the next component. The bin handler hardware should respond to the falling edges of the BDA line and the relevant BIN line, which will occur only when a component has been successfully measured and sorted.

4.1.11.5 Bin Handler Interface Pin Assignment (B1 Option)

Pin	Description	Pin	Description
1	Bin 0 select (active low)	18	Bin 9 select (active low)
2	Bin 1 select (active low)	19	Unused
3	Bin 2 select (active low)	20	Unused
4	Bin 3 select (active low)	21	Pass/Fail output (low = Pass)
13	Bin 4 select (active low)	8	Trigger input
14	Bin 5 select (active low)	10	Busy output
15	Bin 6 select (active low)	5	BDA output
16	Bin 7 select (active low)	7	+5V Supply (<50mA)
17	Bin 8 select (active low)	24	Ground (0v)

4.1.11.6 Bin Handler Interface Pin Assignment (B2 Option)

Pin	Description	Pin	Description
1	Bin 0 select (active high)	18	Bin 9 select (active high)
2	Bin 1 select (active high)	19	Unused
3	Bin 2 select (active high)	20	Unused
4	Bin 3 select (active high)	21	Pass/Fail output (high = Pass)
13	Bin 4 select (active high)	8	Trigger input +ve
14	Bin 5 select (active high)	9	Trigger input -ve
15	Bin 6 select (active high)	10	BUSY output
16	Bin 7 select (active high)	5	BDA output
17	Bin 8 select (active high)	7	N/C
25	Common (24V input)	24	N/C

4.1.11.7 Signal Levels for B1 Option

Output High:	>4V	Output Low:	<1V
Input High:	>3.5V	Input Low:	<1.5V

Drive capability typically is 10mA sink (low) and 30µA (high).

4.1.11.8 Signal Levels for B2 Option

This option provides an opto-coupled interface.

Output On state current:	up to 10mA at 24V	Output Off state current:	<0.5mA
Output On state voltage:	Input voltage –1.5V at 10mA		
Input High current:	>3mA	Input Low current:	<1.25mA
Input High voltage:	>15.4V	Input Low voltage:	<8V

4.2 The Front Panel

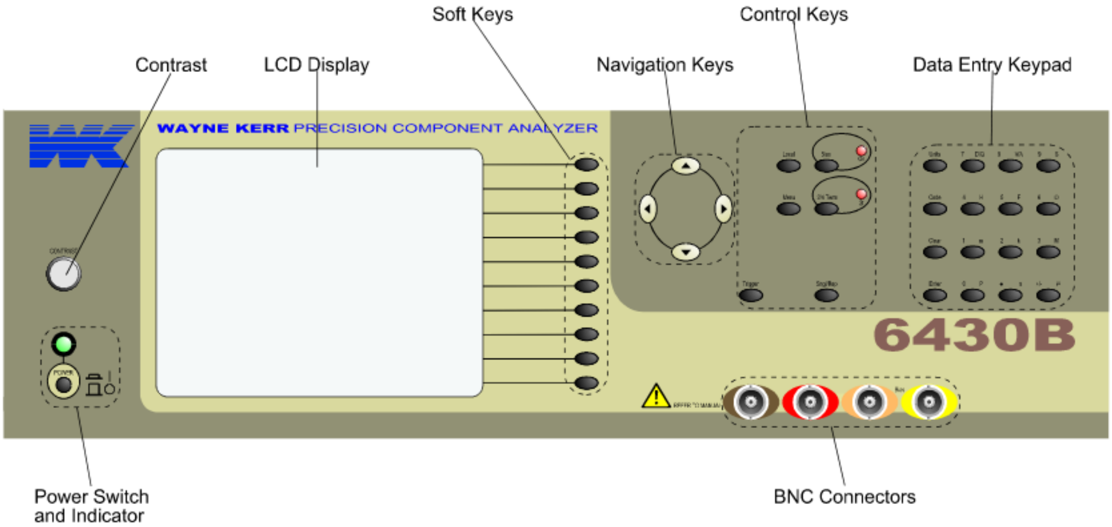


Figure 4-3 The 6430B Front Panel

4.2.1 Switching the Instrument ON

With the instrument connected to the correct AC power supply (see section 3—Installation) press the **POWER** switch. The power indicator will light and the instrument will display the mode and settings selected when the instrument was last switched off (the exception is **Bias** which, for safety reasons, is always OFF when the instrument is powered up).

If the display is too bright or too dark, use the **CONTRAST** control above the power switch to set the contrast level.

If the analyzer had previously been set up for measuring components, testing can recommence after checking the settings and, if applicable, switching the **Bias** back on.

To return to the **MAIN MENU** press the **Menu** control key.

4.2.2 Switching the Instrument OFF

The power can be switched OFF at any time without damage to the instrument, but to avoid losing trim and calibration data, the instrument should be switched OFF when it is in a quiescent state rather than when it is running a routine, e.g. trimming, calibration or data entry.

4.2.3 The Soft Keys

The general protocol is that soft keys labelled with **UPPER CASE** letters select the labelled mode and soft keys labelled with **lower case** letters select settings within the current mode.

The functions of the ten soft keys change according to the mode selected. For example, when the **MAIN MENU** is displayed by pressing the **Menu** key, the soft keys relate to the various modes available, e.g. **MEASURE**, **DEVIATION**, etc. Once a mode has been selected, the soft keys labelled with small letters select settings within the mode, while the soft keys labelled with capital letters select the labelled modes.

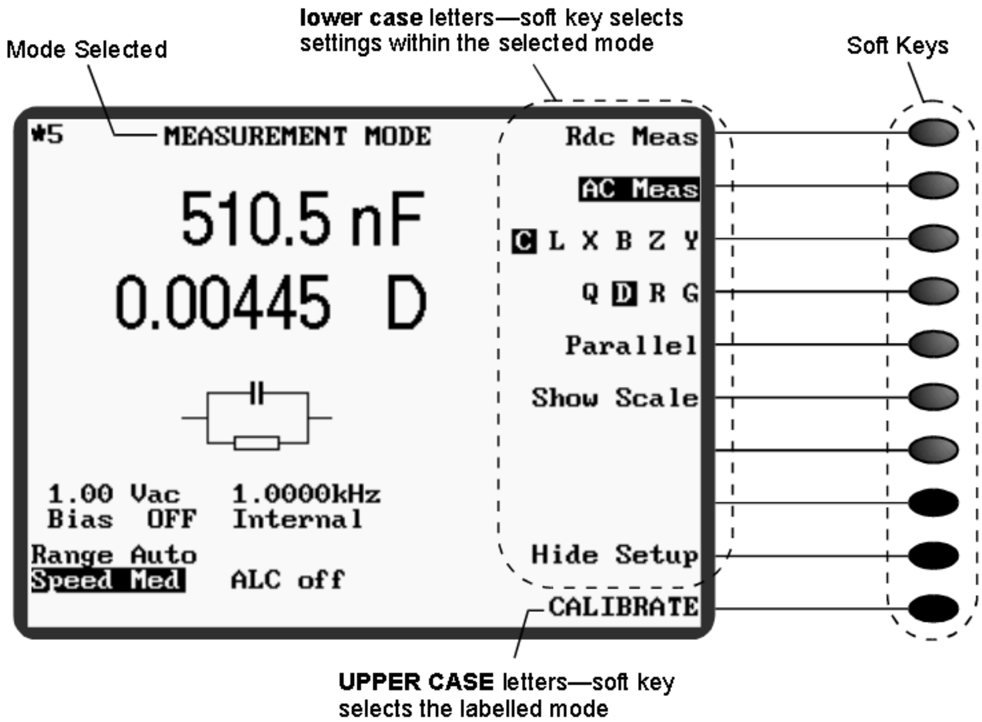


Figure 4-4 The Soft Keys

4.2.4 The Navigation Keys

Figure 4-5 The Navigation Keys

When the set up details are showing on the screen (in some modes, there is a soft key which toggles between **Hide Setup** and **Show Setup:** this soft key can be seen in Figure 4-4), the left and right navigation keys, ◀ and ▶, allow each parameter to be selected in turn. When a parameter is selected, the up and down navigation keys, ▲ and ▼, step the numeric value for AC level and frequency: the steps vary according to the value but are always multiples of 1, 2 or 5. Finer frequency steps can be achieved by using the data entry keypad, see section 4.2.6. For other parameters, the ▲ and ▼ navigation keys change the settings, e.g. Internal/External, Auto Range/[fixed range], Slow/Med/Fast/Max, ALC off/on.

4.2.5 The Control Keys

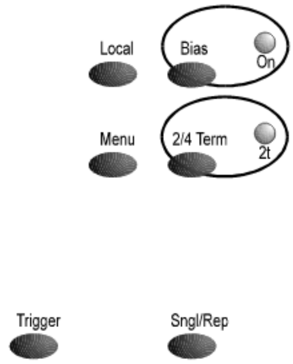


Figure 4-6 The Control Keys

Pressing **Local** restores control to the front panel when the instrument is under GPIB control.

Bias toggles the DC bias ON and OFF. The associated indicator lights when Bias is ON. Bias is selectable between **Internal** and **External**.

WARNING!

Take care to observe the correct polarity when connecting the DUT to the Kelvin clips or fixture when bias voltage is applied:

For internal bias the DUT +ve must be connected to the fixture Bias terminal or the RED Kelvin clip.

For external bias, +ve or –ve bias may be applied. The bias polarity at the fixture Bias terminal or the RED Kelvin clip will correspond to the bias polarity applied to the rear panel Bias terminals.

Internal bias is available for charging capacitors—users wishing to pass DC current through inductors or other components should contact the Wayne Kerr Electronics Applications Department. Internal Bias supplies a preset 2V DC level via a rapid charge circuit. When Bias is switched ON, the indicator flashes, accompanied by a **Charging…** message (Figure 4-7). When the indicator stops flashing and the message disappears, the bias level has stabilized. When Bias is switched OFF, the indicator flashes, accompanied by a **Discharging…** message (Figure 4-8). When the indicator extinguishes and the message disappears, the bias level has stabilized at 0V.

External bias allows an external DC power supply to be connected to the DUT via the Bias terminals on the rear panel. There is a 5% voltage drop between the external bias terminals and the component. The specified maximum of ±60V is the maximum voltage allowed at the component, this equates to ±63V at the external bias terminals. If an accurate bias voltage is required, a DC voltmeter can be connected between the RED Kelvin clip and ground (the crocodile clip). If using a CF1006 fixture, the DC voltmeter can be connected between the Bias terminal and the bar along which the jaws slide. The bias voltage is routed via the ORANGE

BNC connector. Take care that the AC test voltage (Vac) present on the test leads does not affect the DC voltmeter accuracy. If necessary, temporarily set Vac to a low value.

Note that there is a 220Ω resistor across the external bias terminals. This will draw a continuous current from the external power supply in addition to that drawn by the DUT. The continuous current will be equal to:

$$I = \frac{\text{External Power Supply Voltage}}{220}$$

Figure 4-7 Bias Charging

Figure 4-8 Bias Discharging

Pressing the **Menu** key displays the **MAIN MENU**, from where each mode of operation can be selected with the soft keys.

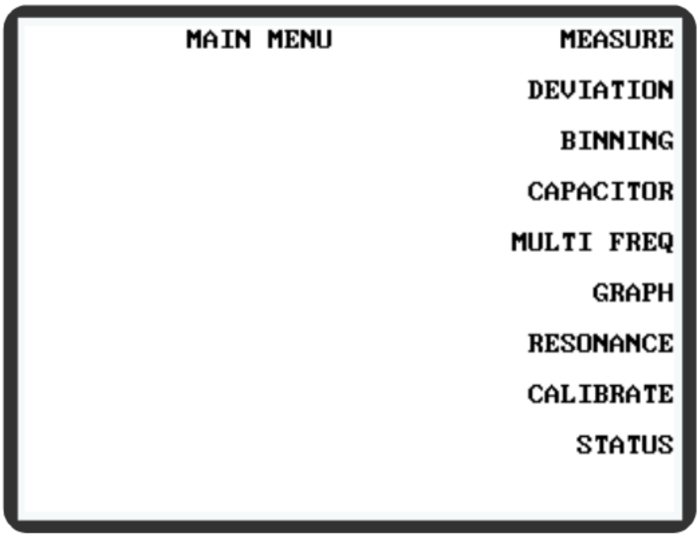


Figure 4-9 The 6440B Main Menu

The **2/4 Term** key selects 2- or 4-terminal measurement. When 2-terminal measurement is selected the associated indicator lights and the display shows **2-TERM MEASUREMENT MODE** at the top of the screen . Switching between 2- and 4-terminal mode will require the analyzer to be retrimmed, see section 4.3. 4-terminal measurements are recommended when measuring low impedance devices. Quoted accuracies assume 4-terminal connection whenever the DUT impedance is below 1kΩ.

Sngl/Rep toggles between **Single shot mode** and **Repetitive mode**. When **Sngl/Rep** is pressed the display briefly indicates the mode selected as shown in Figure 4-10 and Figure 4-11 below. Single shot mode is also indicated by the lack of a continuously flashing asterisk (*) in the top left corner of the screen. Conversely, the presence of a continuously flashing asterisk indicates that the instrument is in repetitive mode. The asterisk flashes once every time the instrument makes a measurement.

Single shot mode

Figure 4-10 Single Shot Mode

Repetitive mode

Figure 4-11 Repetitive Mode

When in single shot mode, the **Trigger** key initiates a single measurement. If it is pressed and held, the analyzer will fall into repetitive measurement mode until the key is released.

4.2.6 The Data Entry Keypad

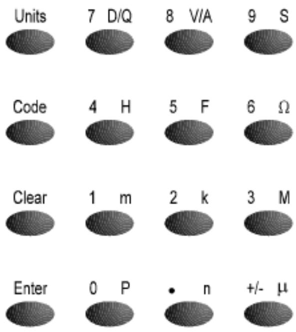


Figure 4-12 The Data Entry Keypad

The data-entry keypad is a multi-function key set permitting manual entry of data values, measurement units and control codes.

The **Units** key must be used prior to keying a unit or multiplier. Where more than one unit is available on a key, e.g. D/Q or V/A, pressing the key will display the first unit, pressing the key again will display the second unit. Terminate the units mode with **Enter** to accept the key sequence. Pressing **Clear** will delete the whole key sequence; pressing ◄ will delete the last key press.

An invalid keypad entry will cause the entry line to be cleared and an error message, such as the one shown in Figure 4-13, to be displayed. The existing settings will be preserved.

Units mismatched

Figure 4-13 Example of an Error Message from an Invalid Keypad Entry

The +/- key may be used before or after a value to change its sign. If the key is pressed more than once, the value will toggle between + and -. For numbers which are positive only, this key is disabled.

4.2.6.1 Keypad Codes

A number of special functions are available by pressing **Code** followed by a valid code number and terminated with **Enter**. The codes shown below are only available in the mode or menu indicated; some are for the use of a service engineer.

MAIN MENU	
Code	**Description**
0.1	Display the character set. Press any key to display more characters, when all characters have been shown, the main menu will be displayed and normal operation can be resumed.
0.4	Test the keyboard.
9.1	Load default values of non-volatile RAM variables, measurement conditions and trim values.
9.3	Load default values of self-calibration and HF lead compensation data
30	Enable printer output
31	Disable printer output
32	Print factory calibration data

STATUS MENU	
Code	**Description**
25	Set the real time clock
34	Print the status page. Printer must be enabled first—enter code 30 in MAIN MENU.

MEASURE, DEVIATION, BINSET MODES	
Code	**Description**
10	Select fine frequency steps (6440B or 6430B with Analysis option)
11	Select coarse frequency steps
18	Single-shot mode
19	Repetitive mode

Key Sequence Examples (characters in [ ])

Example 1: Supply the analyzer with a value of 27.39mH

1) Select the following settings in **MEASUREMENT MODE**:

   AC Meas, **L**, **Q**, **Parallel**, **Show Scale**, **%**.

2) Using the ◀ and ▶ keys, highlight the nominal parameter (underneath the left-hand-side of the scale).

3) Key the following sequence:

[.] [0] [2] [7] [3] [9] [Units] [H] check data entry line is correct, then press [Enter]

or

[2] [7] [.] [3] [9] [Units] [m] [H] [Enter]

If a mistake is made in a key sequence, before pressing **Enter**, press ◀ to delete the last key press or **Clear** to delete the whole key sequence.

Example 2: Set the frequency to 100kHz

1) Using the ◀ and ▶ keys, highlight the selected frequency.

2) Key the following sequence:

[1] [0] [0] [0] [0] [0] [Enter]

or

[1] [0] [0] [Units] [k] [Enter]

or

[.] [1] [Units] [M] [Enter

4.3 Trimming

The purpose of trimming is to eliminate the effects of stray capacitance or series impedance in the connecting leads or fixture.

The trim values are held in non-volatile stores and for most measurements no retrimming is necessary. The exceptions are when the lead set or fixture is changed; when the highest possible accuracy is required for measurements of very high or very low impedances; and when the instrument is switched between 4-terminal and 2-terminal operation.

Depending on the trim option selected, the analyzer trims by making measurements at a number of frequencies, including the measurement frequency in use when the trim was initiated, and storing the corrections for each. If the measurement frequency is changed the analyzer automatically applies a new correction value by interpolation of the stored values. Corrections for the Rdc functions are also stored.

For **O/C Trim** the Kelvin clips or fixture jaws should be separated by a distance equivalent to the DUT pin separation.

For **S/C Trim** the connector jaws should be clipped to a piece of wire or a component lead as close together as possible. Do not connect the clips directly together: this does not provide the necessary 4-terminal short circuit and will lead to trim errors.

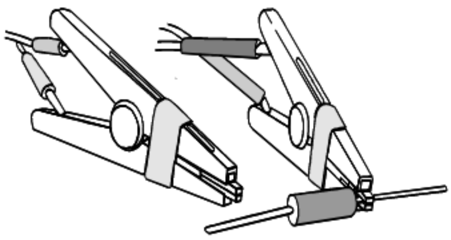


Figure 4-14 Connections for O/C trimming of Kelvin clips

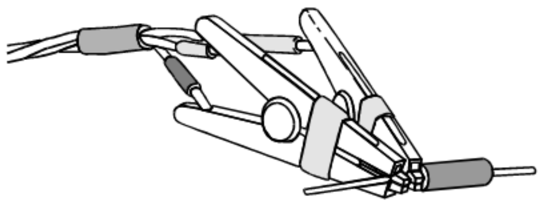


Figure 4-15 Connections for S/C trimming of Kelvin clips

For **HF Lead Compensation** (6440B and 6430B with the Analysis option fitted) the transfer standard capacitor supplied with the analyzer should be placed in the Kelvin clips or fixture jaws. Both O/C and S/C Trims must be performed before performing HF lead compensation.

4.3.1 Performing an O/C Trim or S/C Trim..

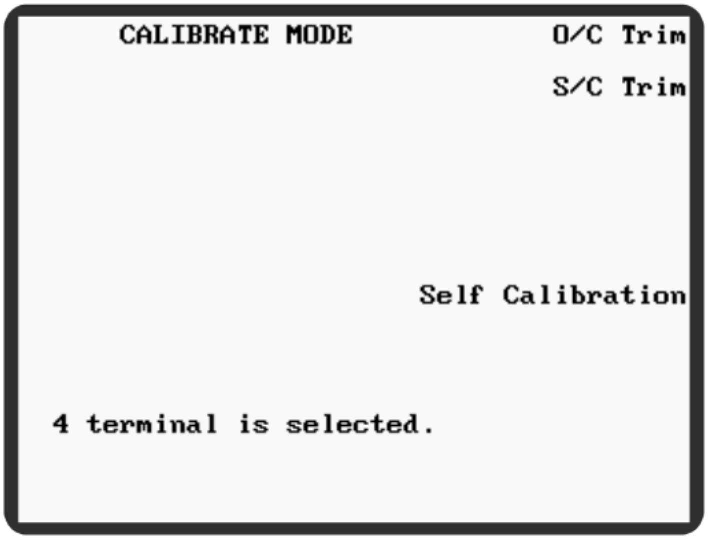


Figure 4-16 6430B Calibrate Mode

1) Select **CALIBRATE**, either from the **MAIN MENU**, or from a mode which has **CALIBRATE** as an option (in which case pressing the **RETURN** soft key will return the analyzer to the original mode). The analyzer will enter **CALIBRATE MODE**.
2) Select **O/C Trim** or **S/C Trim**
3) Open- or short-circuit the Kelvin clips or fixture jaws as appropriate.
4) Select the trim option required and wait until the analyzer has finished trimming. The trim options are described below.

Note:

If the instrument is switched OFF during O/C trim or S/C trim, the message shown in Figure 4-17 will be displayed when the instrument is next switched ON. **MEASUREMENT MODE** will be reset to the default settings and `O/C Trim Error` or `S/C Trim Error` will be displayed at the top of the screen. These messages will only be cleared by performing the appropriate trim. The instrument can be used with the default settings but it is recommended that O/C trim and/or S/C trim is run for full measurement accuracy.

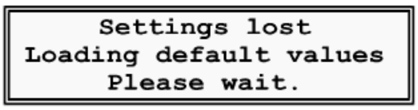


Figure 4-17 Settings Lost

Figure 4-17 will also be displayed when power is removed during other critical routines, such as calibration and data entry.

4.3.1.1 Trim Options.

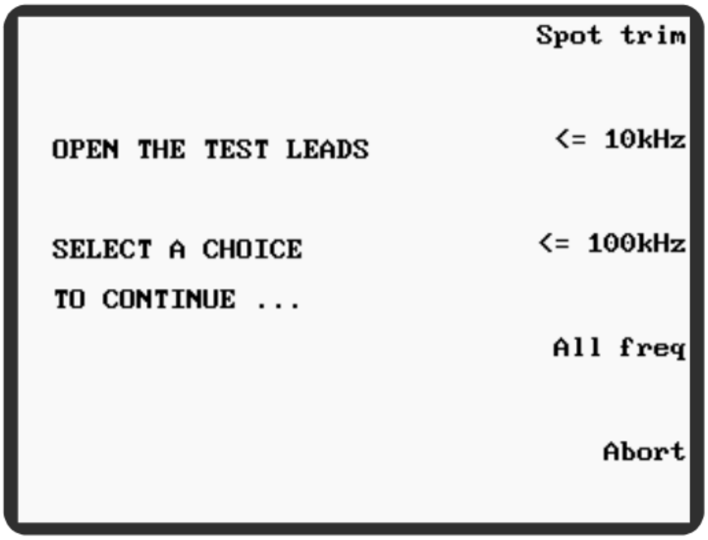


Figure 4-18 Trim Options

All freq trims at a number of frequencies, including the frequency set when the trim was initiated. For most measurements made using standard test leads and fixtures this is the normal trim option to use. The other trim options are normally only used in exceptional circumstances, such as when a special test fixture fails O/C or S/C trim at certain frequencies outside of the component test parameters.

Spot trim trims only at the frequency set in **MEASUREMENT MODE**.

<= **10kHz** trims at a number of frequencies up to and including 10kHz.

<= **100kHz** trims at a number of frequencies up to and including 100kHz.

Abort cancels the trim and displays the **CALIBRATE MODE** main screen.

Note:

If, after trimming with an option other than **All freq**, a measurement frequency is selected which is outside of the trim parameters, `O/C Trim Error` or `S/C Trim Error` will be displayed at the top of the screen and no trim corrections will be applied for the frequency selected. The analyzer can be used without trim correction but full measurement accuracy will not be available until the analyzer is retrimmed using an option which covers the new measurement frequency.

4.3.2 Performing HF Lead Compensation (6440B, 6430B with Analysis option)

The purpose of HF lead compensation is to eliminate scalar errors which are due to the test leads. These vary with test lead length and become significant at frequencies above 200kHz.

Before performing HF lead compensation, both O/C Trim and S/C Trim must be performed using the **All freq** trim option, see section 4.3.1 above.

1) Select **CALIBRATE**, either from the **MAIN MENU**, or from a mode which has **CALIBRATE** as an option (in which case pressing the **RETURN** soft key will return the analyzer to the original mode). The analyzer will enter **CALIBRATE MODE**.

2) Select the **HF Lead Compensation** soft key.

   The following message will be displayed:

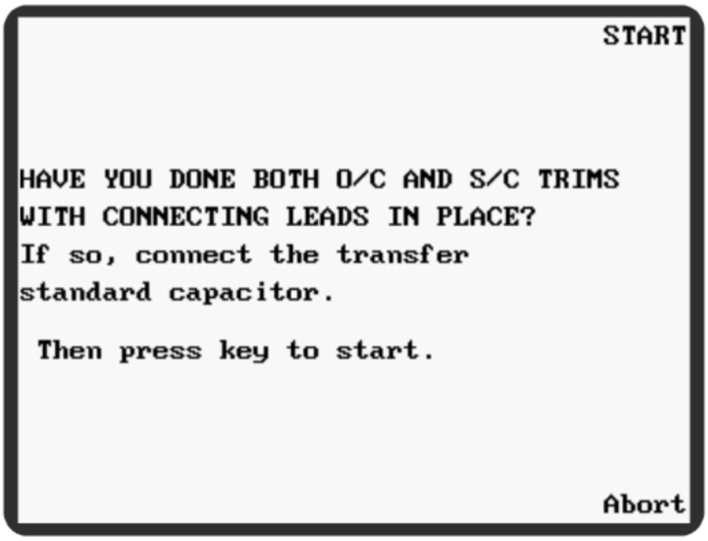


Figure 4-19 HF Lead Compensation

3) Assuming that O/C and S/C trims have already been performed, connect the transfer standard capacitor supplied with the instrument to the Kelvin clips or fixture jaws.

4) Press the **START** soft key: when the **CALIBRATE MODE** main screen is redisplayed, HF lead compensation has finished.

Note:

If the HF lead compensation routine fails for any reason, e.g. a test lead connection error or a power failure during the routine, Figure 4-17 (above) will be displayed when the instrument is next switched ON, followed by Figure 4-20, which will be displayed every time the instrument is switched ON. When **MEASUREMENT MODE** is selected, `Calibrate Error` will be displayed at the top of the screen. These messages will only be cleared by successfully performing the HF lead compensation routine. The instrument can be used with the default settings but it is recommended that HF lead compensation is run for full measurement accuracy.

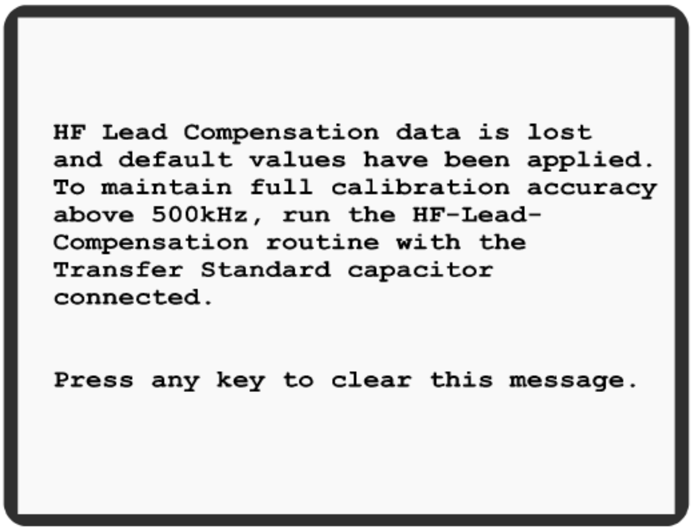


Figure 4-20 HF Lead Compensation Data Lost

4.4 Self Calibration

Self calibration is performed to set calibration constants for signal processing elements in the measurement hardware and signal generation system, and to compensate for components which have drifted with time. To maintain full specified accuracy it should be run at least every three months. If it is not run within this period, a reminder will be displayed at power up. This message is shown in Figure 4-21 below.

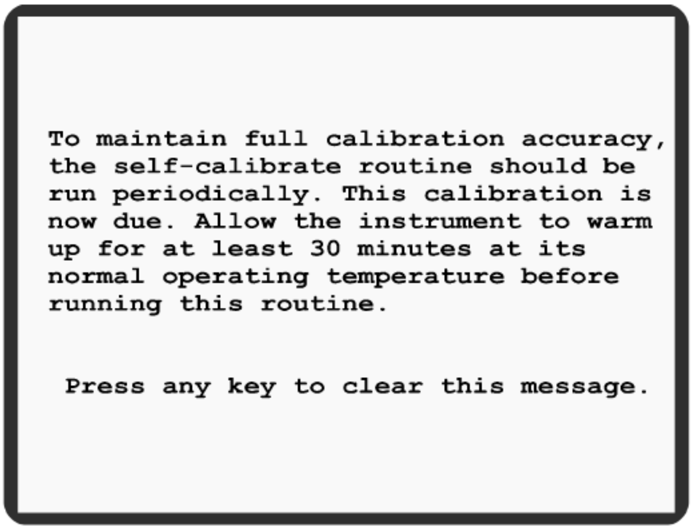


Figure 4-21 Self-Calibration Reminder

4.4.1 Performing a Self Calibration

1) Switch on the instrument and allow it to stabilize for at least 30 minutes at a stable ambient temperature.

2) Select **CALIBRATE**, either from the **MAIN MENU**, or from a mode which has **CALIBRATE** as an option (in which case pressing the **RETURN** soft key will return the

analyzer to the original mode). The analyzer will enter **CALIBRATE MODE** (Figure 4-16).

3) Select **Self Calibration**.
4) Disconnect all BNC leads from the instrument front panel and select the **Start** soft key. Allow at least 1 minute for the self calibrate routine to run

When self calibration is finished, the analyzer will return to **CALIBRATE MODE**.

The **Abort** soft key will return the analyzer to **CALIBRATE MODE**.

Note:

If the self calibration routine fails for any reason, e.g. a test lead connection error or a power failure during the routine, or if the self calibration data becomes corrupted, Figure 4-17 (above) will be displayed when the instrument is next switched ON, followed by Figure 4-22, which will be displayed every time the instrument is switched ON. When **MEASUREMENT MODE** is selected, **`Calibrate Error`** will be displayed at the top of the screen. These messages will only be cleared by performing self calibration. The instrument can be used with the default settings but it is recommended that self calibration is run for full measurement accuracy.

```
Calibration data is lost and
default values have been applied.
To restore full calibration accuracy,
run the self-calibrate routine,
preferably after the instrument has
warmed up for at least 30 minutes at
its normal operating temperature.


Press any key to clear this message.
```

Figure 4-22 Calibration Data Lost

4.5 Measuring a Component

The analyzer should be powered up with the test leads or fixture connected to the front panel BNC connectors. If the test leads or fixture have been changed since the analyzer was last used, they should be trimmed as described in section 4.3. If measurements will be made at 200kHz and above, repeat the HF lead compensation as described in section 4.3.2 (6440B, 6430B with Analysis option only).

The following instructions illustrate the process of measuring a component.

1) Press the front panel **Menu** control key. The **MAIN MENU** (**Error! Reference source not found.**) will be displayed.

2) Press the **MEASURE** soft key. **MEASUREMENT MODE** (Figure 4-23) will be displayed.

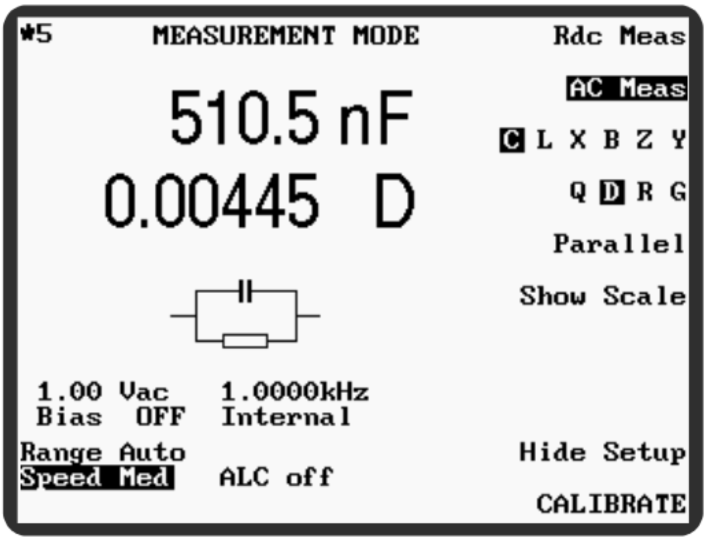


Figure 4-23 Measurement Mode

3) Use the soft keys, shown in Figure 4-3 and Figure 4-4, to set the required measurement parameters: these are described in section 4.5.2 below. Do not exceed the limitations of the component to be measured.

4) Connect the component to be measured to the test leads or fixture.

5) If the analyzer is in **Repetitive mode**, the measured values will be displayed and updated according to the **Speed** setting selected. A continuously flashing asterisk (*) in the top left-hand-corner of the screen indicates that the analyzer is in repetitive mode.

6) If the analyzer is in **Single shot mode**, the front panel **Trigger** key must be pressed to initiate a measurement; alternatively, a suitable trigger pulse may be applied to the **TRIGGER IN** socket on the rear panel, see section 4.1.4. If the **Trigger** key is pressed and held, the analyzer will make repetitive measurements at the **Speed** setting selected until the key is released. When in single shot mode, the asterisk (*) in the top left-hand-corner of the screen only flashes when a measurement is triggered.

4.5.1 Example

This example will take the user through the process of measuring the capacitance and dissipation factor of a 470nF capacitor. The settings used are examples only and the user may substitute other settings, subject to the limitations of the component to be measured.

The analyzer should be powered up with the test leads or fixture connected to the front panel BNC connectors. If the test leads or fixture have been changed since the analyzer was last used, they should be trimmed as described in section 4.3. If measurements will be made at 200kHz and above, repeat the HF lead compensation as described in section 4.3.2 (6440B, 6430B with Analysis Option only).

1) Press the front panel **Menu** control key. The **MAIN MENU** will be displayed.

2) Press the **MEASURE** soft key. **MEASUREMENT MODE** will be displayed.

3) Ensure that the analyzer is in **Repetitive mode** (if there is no continuously flashing asterisk (*) in the top left-hand-corner of the screen press the front panel **Sngl/Rep** control key—the analyzer will briefly indicate which mode it is entering (shown in Figure 4-10 and Figure 4-11)).

4) Use the soft keys to select the following parameters. Pressing the soft keys will either toggle between two options or, where more than two options are available, scroll through the options from left to right, one option at a time.

   AC Meas
   C
   D
   Parallel

5) Using the navigation keys, highlight and set each of the following parameters in turn. Use the ◀ and ▶ navigation keys to highlight a parameter and the ▲ and ▼ navigation keys to alter the highlighted parameter setting. Settings may be altered one step at a time, or continuously by holding the navigation key down.

   500mVac
   1.5000kHz
   Bias ON set with the front panel **Bias** control key (shown in Figure 4-3 and Figure 4-6)
   Internal
   Range Auto
   Speed Med
   ALC on

6) Connect the component to be measured to the test leads or fixture. The screen will display the measured values of C and D. The display should be similar to Figure 4-24 below.

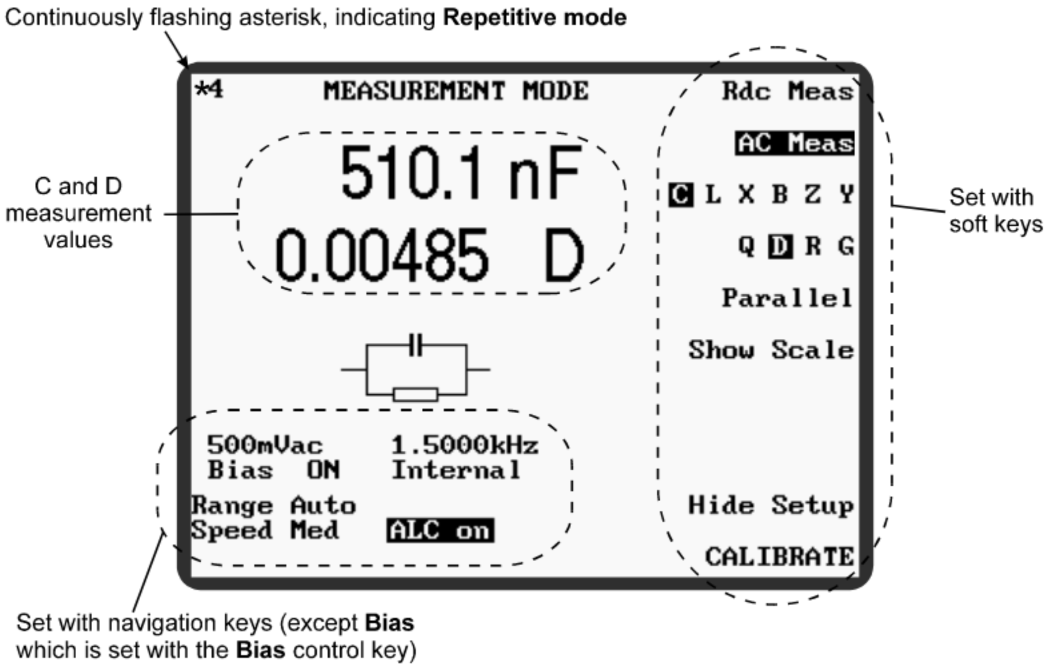


Figure 4-24 Example Capacitance and Dissipation Factor

4.5.2 MEASUREMENT MODE Parameters

The following **MEASUREMENT MODE** parameters are selectable with the ten soft keys to the right of the display.

Rdc Meas DC measurement of resistors. The only measurement options are DC drive level (100mV or 1V), range and speed. For full measurement range use a drive level of 1V which corresponds to 10mA max or 2.5mW max in the DUT.

AC Meas Allows AC measurements to be performed at the selected drive level and frequency. The measurement terms and equivalent circuit are set with the next three soft keys.

C L X B Z Y The first measurement term.

To select **X**, the **Parallel/Series** soft key must first be set to **Series**.

To select **B**, the **Parallel/Series** soft key must first be set to **Parallel**.

When either **Z** or **Y** are selected, the second measurement term is angle (°). The **Q D R G** and **Parallel/Series** soft keys are not appropriate and are therefore not shown.

Q D R G The second measurement term.

To select **G**, the **Parallel/Series** soft key must first be set to **Parallel**.

Parallel/Series **Parallel** or **Series** equivalent circuit. All first and second measurement terms are shown above this soft key but only the appropriate measurement terms can be set depending on whether **Parallel** or **Series** is selected. See the narrative on **C L X B Z Y** and **Q D R G** (above) for details.

Show/Hide Scale Toggles between **Show Scale** and **Hide Scale**. The selection either shows a diagram of the equivalent circuit, i.e. **Parallel** or **Series**, or shows a bar graph representation of either of the measurement terms (selectable by setting the nominal and limits, see **Abs %** below). The bar graph scale can either be used as a quick visual verification that the component is within the limits set, or can be used for adjustment of variable components. When the measurement falls within the centre band the analyzer reports PASS; when the measurement falls above or below the centre band the analyzer reports HI or LO.

Notes:

1) The centre portion of the scale length is proportional to the measured value, but scale compression is used above and below the centre band.
2) If the binning option is fitted, an external output is available to indicate **PASS** or **FAIL**, see sections 4.1.11 and 4.1.11.5 for details.

Abs % Only available when the bar graph scale is displayed. Toggles between **Abs** and **%**. When **Abs** is selected, absolute Hi and Lo limits (i.e. units of the measured parameter) are displayed. When **%** is selected, a nominal value together with Hi and Lo percentage limits are displayed.

The limits and nominal value (if applicable) must be set using the and navigation keys to highlight each parameter and the data entry keypad to set each value (the use of the data entry keypad is described in section 4.2.6). When in **%** mode, the bar graph scale Hi and Lo limits can easily be set equidistant about the nominal by setting either of the limits then highlighting the other limit and pressing the keypad **Enter** key twice. This mimics the setting of the other limit but with the opposite sign

Save Nom Only available when the bar graph scale is displayed and **%** limits is selected. If a standard component exists, it can be connected to the test leads or fixture and measured by the analyzer. Pressing **Save Nom** enters the most recent analyzer measurement of the component as the nominal test value for comparing all subsequent components with.

Notes:

1) To change this function from the first to the second measured parameter (or vice versa), first enter a dummy value with units via the keypad; e.g. to change from L to R, enter [1] [units] [Ω] [Enter] then press the **Save Nom** key.
2) Do not use the **Save Nom** function if the measured value is negative (e.g. an inductor measured above its self resonant frequency).

Show/Hide Setup Once the measurement parameters have been set, **Hide Setup** can be selected to clear them from the screen. The parameter settings are still valid and will be used for component measurements. The bar graph scale and limits will still be displayed. **Hide Setup** is used primarily to unclutter the display, making it more easily readable. Selecting **Show Setup** will redisplay the parameter settings.

CALIBRATE Enters **CALIBRATE MODE** which is used for Trimming (section 4.3) and Self Calibration (section 4.4).

The following **MEASUREMENT MODE** parameters are those displayed in the bottom left-hand-corner of the screen, shown in Figure 4-25. They are only visible when **Hide Setup** is NOT SELECTED.

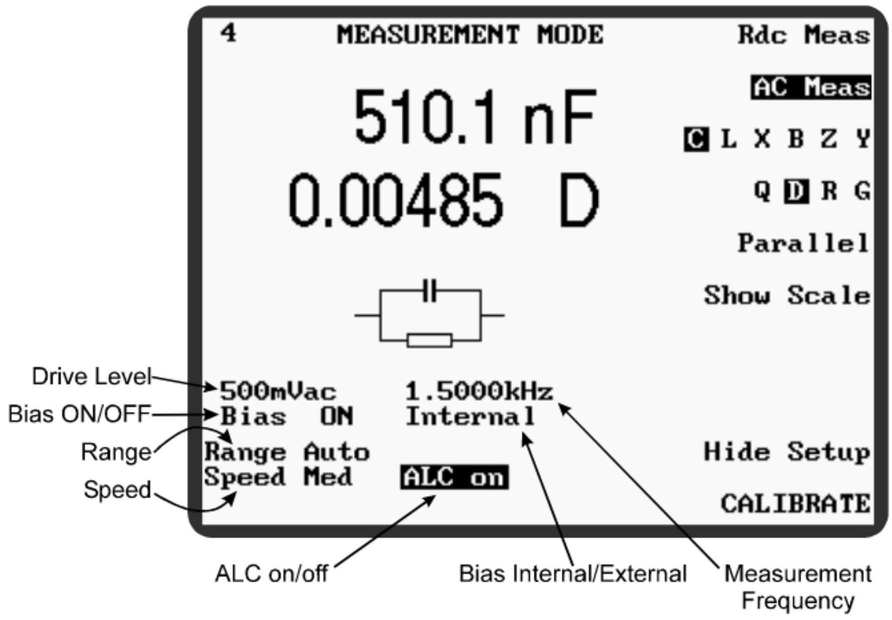


Figure 4-25 Non-Soft Key MEASUREMENT MODE Parameters

Drive Level

Set by highlighting the parameter with the ◄ and ► navigation keys, then altering the setting in pre-determined steps with the ▲ and ▼ navigation keys, or by using the data entry keypad. The range is:

Rdc Meas mode	100mV or 1V
AC Meas mode	Variable between: 1mV–10V or 50µA–200mA (appropriate for low impedance components)
	At frequencies above 300kHz the maximum values are restricted (see specification).

See also **ALC**, below

Measurement Frequency

Set by highlighting the parameter with the ◄ and ► navigation keys, then altering the setting in pre-determined steps with the ▲ and ▼ navigation keys, or by finer increments using the data entry keypad. The range is:

6430B 20Hz to 500kHz
6440B 20Hz to 3MHz

6440B and 6430B with Analysis option: fine or coarse frequency steps are available. Coarse steps vary in increments of between 20% and 33%; fine steps vary in increments of 1% or less. Set fine or coarse steps from the Status page—see section 5.12, or use code 10 (fine steps) or code 11 (coarse steps)—see section 4.2.6

Bias

The **Bias** is turned ON and OFF with the **Bias** control key and is selectable between **Internal** and **External**. For more information see section 4.2.5.

Range

Toggles between auto range and manual range selection, set by highlighting the parameter with the and navigation keys and altering the setting with the and navigation keys. Auto range automatically selects the most accurate range for the measurement. Circumstances where manual ranging may be more appropriate include:

- measuring non-linear components (auto range may hunt)
- to avoid the short auto range delay, for example when using max speed with an auto handler.

The manual range is set using the data entry keypad. Ranges 1 to 8 are valid. When a manual range is selected, the equivalent measurement range is shown on the display: although range boundaries are impedance values they are converted to appropriate L, C, G or B values.

At higher frequencies or reduced levels, availability of the highest or lowest ranges is restricted (see specification). If a previously selected range is changed due to a change in drive conditions, the selection will be remembered by the analyzer and reapplied when drive conditions allow it.

Speed

Four measurement speeds are available: **Slow**, **Med**, **Fast** and **Max**. Selecting slower measurement speeds increases the display resolution and decreases measurement noise by averaging. The measurement speed is set by highlighting the parameter with the and navigation keys and altering the setting with the and navigation keys.

The following measurement periods apply for **Rdc Meas** and **AC Meas** ≥100Hz:

Max speed makes measurements at ≈50ms intervals and is intended for automatic sorting under GPIB control.

Fast speed makes measurements at ≈100ms intervals and is intended for non-critical measurements.

Med speed makes measurements at ≈300ms intervals and gives full measurement accuracy.

Slow speed makes measurements at ≈900ms intervals and gives full measurement accuracy, maximum display resolution and enhanced supply frequency rejection.

ALC

ALC (Automatic Level Control) is only available for AC measurements and works in conjunction with the drive level, which has a 50Ω source impedance. It is set by highlighting the parameter with the and navigation keys and altering the setting with the and navigation keys.

Three ALC options are available: **ALC off**, **ALC on** and **ALC hold**.

When **ALC off** is selected, the analyzer will not try to maintain the drive level at the component. The drive level will therefore be diminished according to the impedance of the component being measured. For example, since the drive level source impedance is 50Ω, measuring a component which has an impedance of 100Ω will reduce the drive level by:

$$\frac{50}{(50+100)} \text{ x } 100\% = 33.3\%$$

The level indicated on the display however, corresponds to the open-circuit voltage or short-circuit current at the test fixture.

When **ALC on** is selected, the analyzer will try to maintain the selected drive level at the component. If, due to the impedance of the component being measured, it is unable to maintain the set drive level, a message such as Figure 4-26 will be displayed at the top of the display. If the drive level is diminished to such an extent that measurement of the component is impossible, Figure 4-27 will be reported instead. This will happen if the measure terminals are short-circuited with voltage drive selected, or alternatively if they are open-circuited with current drive selected.

`Nearest Level = 9.90V`

Figure 4-26 Nearest Drive Level Warning

`Cannot Set Level`

Figure 4-27 Cannot Set Level Warning

ALC hold is intended for the fastest possible repetitive measurement, either manually or under GPIB control, of components which should have the same impedance value. If, when a representative component is measured with **ALC on**, **ALC hold** is then selected, the drive level voltage is maintained at the drive source. Therefore, the drive level at the fixture jaws will rise when a component is removed and will return to the correct level when a new component of the same impedance is inserted (`Range Error` may be reported at the top of the display with no component in the fixture jaws). The range is also maintained at that used for measuring the representative component. When using **ALC hold** therefore, the analyzer does not spend time computing the correct ALC compensation and range, thus making measurements quicker.

5. ADVANCED OPERATION

This section will provide the user with a guide to:

- two-, three- and four-terminal connections
- in-circuit measurements
- measurement of very small capacitors
- measurement of very small inductors
- measurement of iron-cored and ferrite inductors
- using the various modes available from the **MAIN MENU**, with the exception of **CALIBRATE MODE** which is covered in sections 4.3 and 4.4, and **MEASUREMENT MODE** which is covered in section 4.5.

5.1 Two-, Three- and Four-Terminal Connections

The analyzer has four front panel BNC sockets for screened cable connections to the device under test (DUT). In each case the outer connection provides the screening and the inner is the active connection. The innermost pair of panel connectors carry the signal source (ORANGE) and current return (RED) signals, while the outer pair serve to monitor the actual voltage at the DUT, excluding any voltage drops arising in the source and return leads. With Kelvin clip leads or the four-terminal component fixture 1EV1006, screened four-terminal connections are made automatically to the DUT.

In some cases it may prove more convenient to use leads with crocodile clips or other special terminations. See section 3.3 for a description of the measurement lead sets available from Wayne Kerr and for details of the connection protocol for manufacturing special test leads.

If the impedance being measured is greater than 1kΩ, four-terminal connections are not necessary, the S/C trim facility being used to remove the effect of series lead impedance. To maintain accuracy when using two-terminal connections, do not plug anything into the BROWN or YELLOW BNC sockets

For low impedances, the main advantage of four-terminal connections is to reduce the effect of contact resistance *variations* at the DUT.

If the DUT has a large area of metal not connected to either of its measured terminals (e.g. a screen or core), this should be separately connected to ground using the green clip lead; but if there is a relatively large unscreened conducting surface which *is* connected to one of its measured terminals (e.g. an air-spaced tuning capacitor), this should be connected to the ORANGE signal source (bias +ve) lead to minimize noise pick-up.

5.2 In-Circuit Measurements.

A component connected into a circuit can usually be measured even when the impedances of other components connected to it are comparable to or less than that of the DUT. This is possible by connecting one side of all such components to the grounded neutral terminal of the analyzer, as shown in Figure 5-1. The components Zd and Zs are connected to ground via the green clip lead when using Wayne Kerr leads.

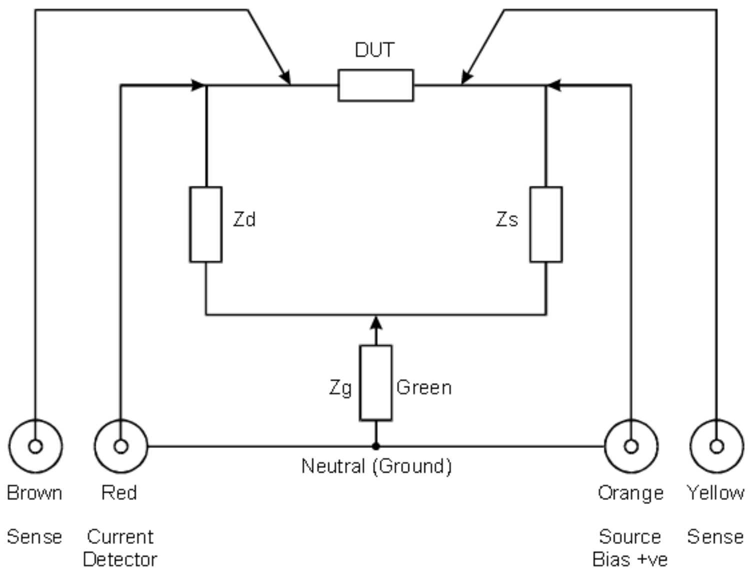
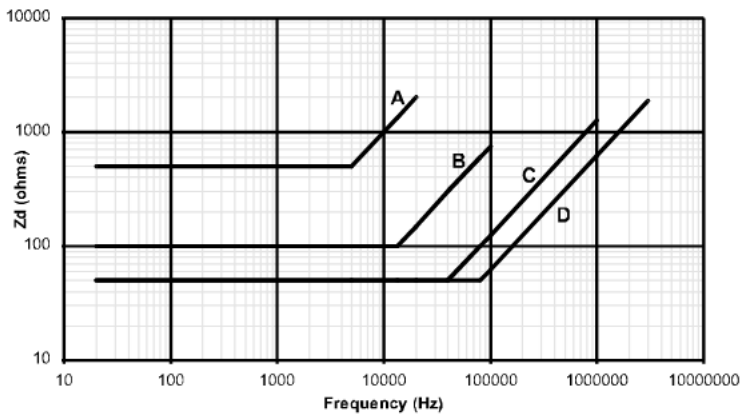


Figure 5-1 In-Circuit Measurements

The presence of Zd introduces a small measurement error, dependant on the frequency and impedance range in use. Figure 5-2 shows the minimum shunt impedance (i.e. R, ωL or ωC) for an additional error (magnitude or phase) not exceeding 1%. Note that when measuring high impedances it may be beneficial to use a drive level greater than 1V or to manually select a lower measurement range (see section 4.5.2).



Range No	Freq Range	Level ≤1V	Level >1V
8	≤10kHz	Curve A	Curve B
7	≤10kHz	Curve A	Curve B
	>10kHz	Curve B	Curve C
6	≤100kHz	Curve B	Curve C
	>100kHz	Curve C	Curve D
5	≤1MHz	Curve C	Curve D
	>1MHz	Curve D	Curve D
1 – 4	All	Curve D	Curve D

Figure 5-2 Effect of shunt loading on current terminal

The main effect of adding Zs alone is to reduce the available drive signal. When measuring high impedances, this effect is dominated by the fixed 50Ω output resistance of the signal source. For example, a shunt resistance of 50Ω may be expected to halve the available output level. When measuring components with an impedance below 50Ω, the degree of reduction will be less. Note that when ALC is turned ON (section 4.5.2) the displayed level will always correspond to the actual level at the measurement terminals.

When Zd and Zs are connected simultaneously, an additional measurement error occurs due to the impedance of the guard lead (Zg). This error may become significant if the DUT is larger than Zd and Zs, and is given by

$$\text{Error}\,\% = 100 \text{ x } \frac{\text{DUT x Zg}}{\text{Zs x Zd}}$$

At low frequencies Zg is up to 40mΩ for lead types A40100, A40180 or 1505. At frequencies above 10kHz the series inductance, which depends to some extent on lead and component positioning, may become significant. For lowest inductance, minimize the area of the loop formed by the Red (current detector lead), via Zd and the Green lead to neutral. In this case the inductance should not exceed 0.25μH.

Note that at low frequencies (<2kHz) the effective guard resistance can be reduced by a factor of 2:1 or more by returning Zs and Zd directly to the outer of the Red BNC connector. However this technique increases the loop inductance and any benefit is lost at frequencies above 5kHz

5.3 Measurement of Very Small Capacitors

For best accuracy when measuring small value capacitors it is necessary to perform an O/C trim (see section 4.3.1) at the frequency to be used for the measurement and to ensure that the measurement leads are not moved between the trimming and the measurement. A level of 1V is an optimum value for minimizing lead errors as this is the level used during the trim operation.

When measuring surface-mount or leadless capacitors with the two-terminal SMD tweezers, part no. 1EVA40120, the cam should be used to set the jaw spacing of the tweezers to the width of the DUT when performing the O/C trim so that the residual capacitance of the tweezers is trimmed out.

5.4 Measurement of Very Small Inductors

The analyzer measures the difference between the inductance of S/C trimming and the inductance of the DUT. Stable measurement lead arrangements are essential for low inductance measurements; the use of the four-terminal component fixture, part no. 1EV1006, is recommended for leaded components. When using this fixture, S/C trim (see section 4.3.1) is achieved by placing a wire across the jaws:

a 5cm length of 1mm diameter wire has an inductance of 50nH
a 5cm length of 2mm diameter wire has an inductance of 40nH

The known inductance of the wire used for the S/C trim should be subtracted from the measured DUT inductance.

A similar, stable fixture arrangement should be used for four-terminal measurements of surface-mount or leadless components: contact the Wayne Kerr Electronics Applications Department if this kind of fixture is required.

The Q is always low, but self-capacitance is not normally a problem at the analyzer's measurement frequencies. For best inductance measurement results, make the measurement at

20kHz (6430B) or 200kHz (6440B) in series configuration. Where possible, make the measurements at an AC level of 20mA which is the level used during trimming.

When an inductor is measured at a frequency much lower than that for which it is designed (e.g. an HF choke tested at AF) it will tend to behave as an inductive resistor. In these circumstances, the inductance measurement accuracy is widened by the factor (1 + 1/Q).

Air-cored coils are particularly susceptible to noise pick up and should be kept well clear of any test equipment that may contain power transformers or display scan circuitry. Also avoid proximity to metal objects which may modify inductor characteristics. Whenever possible, measure at 20kHz (6430B) or 200kHz (6440B). If low frequency measurements are required and trouble persists, use slow measurement speed.

5.5 Measurement of Iron-Cored and Ferrite Inductors

The effective value of iron-cored and ferrite inductors can vary widely with the magnetization, and therefore the level, of the test signal. Ideally, they should be measured at the AC level and frequency of use. When core materials can be damaged by excessive magnetization (for example, some tape heads and microphone transformers), check before connection that the test signal level is acceptable.

The analyzer is not designed to pass DC through inductors: if this facility is required please contact the Wayne Kerr Electronics Applications Department; the Wayne Kerr Precision Magnetics Analyzer PMA3260A is designed specifically for this type of measurement, and when used with one or more 3265A 25A Bias Units, up to 125A DC is available.

5.6 DEVIATION MODE

DEVIATION MODE displays the difference from a set nominal component value. Either measurement term can be used as the nominal and the result can be displayed in either absolute or percentage terms. The actual component measurement is displayed in small characters underneath the deviation measurement. When **DEVIATION MODE** is entered after using **MEASUREMENT MODE** the relevant settings are left as set in **MEASUREMENT MODE**. Settings that are common between the modes (measure parameters, measure settings) may be updated from either mode; they always correspond. A typical **DEVIATION MODE** display is shown in Figure 5-3 below.

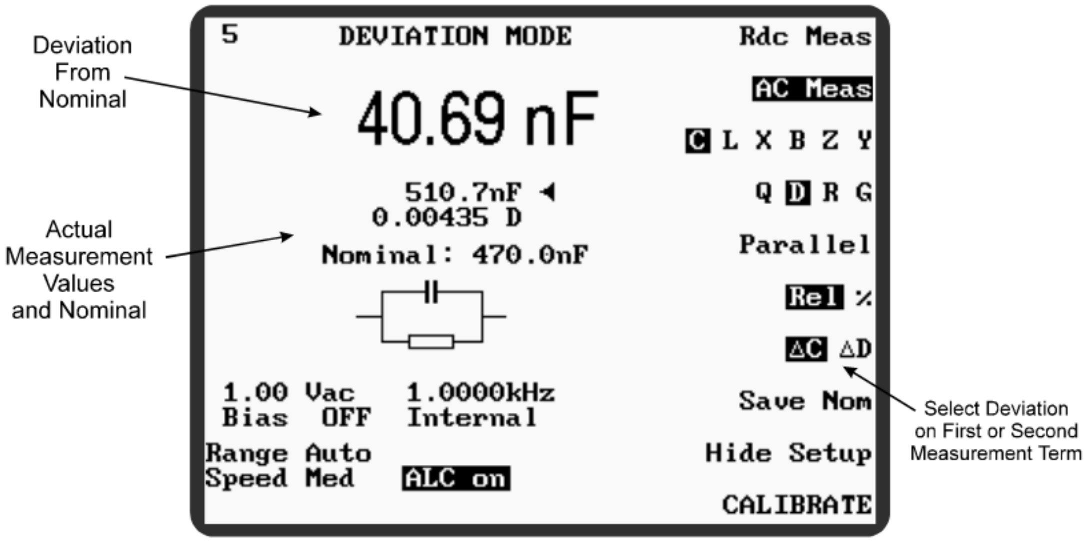


Figure 5-3 Typical DEVIATION MODE Display

5.6.1 DEVIATION MODE Parameters

Parameters which are common to both **DEVIATION MODE** and **MEASUREMENT MODE** are described in section 4.5.2—MEASUREMENT MODE Parameters.

Rel % Toggles between **Rel** and **%**. When **Rel** is selected, absolute deviation units are displayed. When **%** is selected, deviation from the nominal is displayed as a percentage.

The nominal value may be set by highlighting the **Nominal** field with the and navigation keys, then setting the nominal value with the data entry keypad. The use of the data entry keypad is described in section 4.2.6.

Alternatively, pressing **Save Nom** when a valid measurement value is showing will update the nominal to that value.

The **DEVIATION MODE** nominal is NOT common with the **MEASUREMENT MODE** bar graph nominal.

First/Second Measurement Term Selector Toggles between the two measurement terms, e.g. ΔC and ΔD in Figure 5-3. The highlighted term (ΔC in Figure 5-3) sets the deviation measurement unit and is confirmed by the ◄ symbol pointing at the measured value of capacitance rather than at the measured value of dissipation factor.

5.7 MULTI FREQ MODE

This mode allows measurement of components at a number of user-defined frequencies. Limits can be turned off or set in absolute or percentage terms and can be different for each defined frequency. When limits are set in percentage terms, a nominal component value must also be entered. **MULTI FREQ** mode is divided into two areas: **MULTI FREQ – Set** and **MULTI FREQ – Run**.

5.7.1 MULTI FREQ – Set

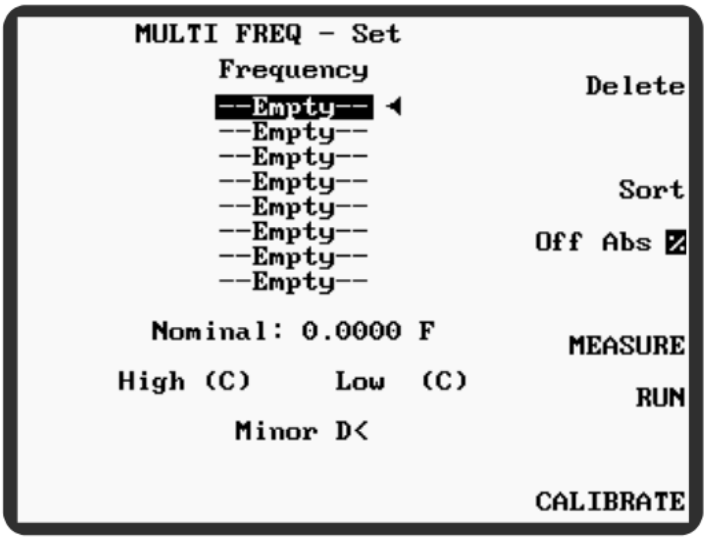


Figure 5-4 MULTI FREQ – Set Display With No Parameters Set up

Up to eight frequencies can be defined by highlighting the frequency, then entering the frequency with the data entry keypad. The and navigation keys scroll through each frequency in turn. Also available, depending upon the setting of the **Off Abs %** soft key, are **High**, **Low** and **Minor** term limits and a **Nominal** parameter. The **High**, **Low**, **Minor** and **Nominal** settings are accessed by pressing either of the or navigation keys when one of the frequency settings is highlighted. The **Nominal** value is common to all frequencies but the **High**, **Low** and **Minor** term limits may be different for each frequency set.

Any limit set to zero is ignored when the multi-frequency test is run. Therefore either the major or minor term test may be omitted by setting the appropriate limits to zero.

5.7.1.1 Example

This example will illustrate the procedure for setting **MULTI FREQ** parameters using different limits for each set frequency. The sequence used in this example is not the only way to set the parameters but is intended to familiarize the user with this mode of operation. For this illustration, percentage limits will be used.

1) Enter **MULTI FREQ – Set** mode by pressing the **MULTI FREQ** soft key from the **MAIN MENU**. If **MULTI FREQ – Run** mode is displayed, press the **SET** soft key. If no parameters have previously been set, the display will look like Figure 5-4 above.

2) Use the **Off Abs %** soft key to highlight **%**. This sets the display ready to accept percentage limits.

3) Press the **MEASURE** soft key. This will return the instrument to **MEASUREMENT MODE** where the appropriate measurement parameters must be set prior to running a **MULTI FREQ** test. Enter the parameters required for the test. For this example they are set to:

   AC Meas
   C
   D
   Parallel
   1.00Vac
   1.0000kHz—this setting will be overridden when running the MULTI FREQ test
   Bias OFF
   Internal
   Range Auto
   Speed Med
   ALC off

   Note: Where a capacitor (or inductor) is to be measured over a wide frequency range, setting **Range** to **Auto** is recommended.

   When the measurement parameters have been set, press the **RETURN** soft key to return the instrument to **MULTI FREQ – Set** mode.

4) Highlight the first frequency, shown highlighted in Figure 5-4 (the ▲ and ▼ navigation keys scroll through each frequency in turn) and enter the required frequency with the data entry keypad.

5) Highlight and enter the next frequency. Continue to highlight and enter up to eight frequencies in this way. This example will enter frequencies of 100Hz, 300Hz, 1kHz, 3kHz, 10kHz, 30kHz and 100kHz.

6) With the first (top) frequency highlighted, press either of the ◄ or ► navigation keys until the **Nominal** parameter is highlighted (if using absolute limits there is no nominal parameter). Enter the **Nominal** value with the data entry keypad; for this example the nominal will be set to 470nF.

7) Still using the ◄ and ► navigation keys, highlight the **High** limit then enter the required limit with the data entry keypad. For this example the limits at 100Hz will be set to ±10%. Highlight the **Low** limit and enter the required limit. Pressing the **Enter** key twice will echo the **High** limit but with the opposite sign.

8) Highlight the **Minor** term with the ◄ and ► navigation keys and enter the required value. Note that the **Minor** term limit is either an upper or lower limit depending on what the parameter is (e.g. <D, >Q). For this example the D term will be set to <0.001 at 100Hz, i.e. anything less than or equal to 0.001D will pass the minor term parameter and anything above 0.001D will fail.

9) Press the ▼ navigation key: the ◄ symbol will move down and point to the second frequency (300Hz in this example). Note that the limits showing at the bottom of the screen change as each frequency is selected in turn. Using the ◄ and ► navigation keys highlight and set the **High**, **Low**, and **Minor** limits for the second frequency. Press the ▼ navigation

key again and the ◄ symbol will point to the third frequency and the limits for the third frequency can be set. Continue in this way until the limits have been set for each frequency. The limits set in this example are as follows:

Frequency	High Limit	Low Limit	Minor Term Limit
100Hz	10%	-10%	<0.001D
300Hz	10%	-10%	<0.002D
1kHz	10%	-10%	<0.005D
3kHz	10%	-10%	<0.01D
10kHz	15%	-15%	<0.02D
30kHz	25%	-25%	<0.05D
100kHz	50%	-50%	<0.1D

These limits can be read back by selecting each frequency in turn.

Figure 5-5 shows the display when set to four of the frequencies used in the example above.

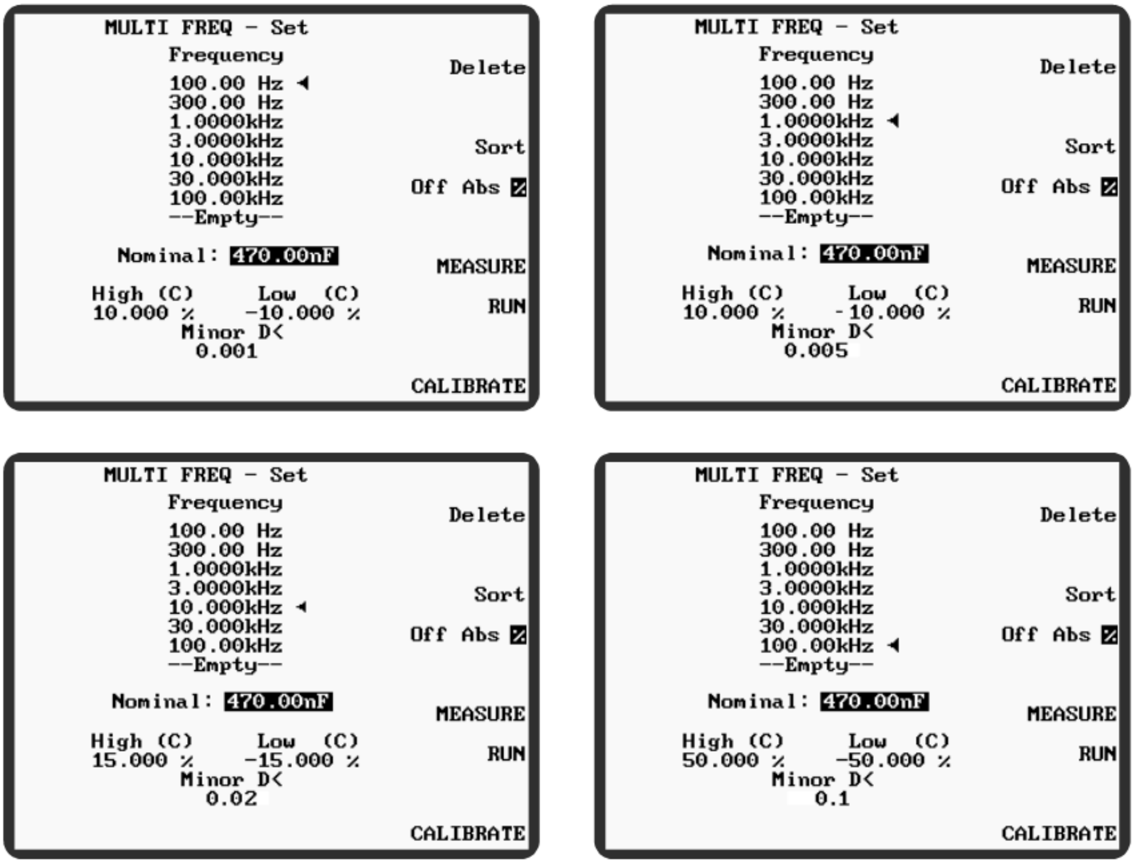


Figure 5-5 MULTI FREQ – Set Display Examples

5.7.1.2 MULTI FREQ – Set Parameters

Parameters which are common to **MEASUREMENT MODE** are described in section 4.5.2—MEASUREMENT MODE Parameters.

Delete — The **Delete** soft key will delete the frequency which the ◄ symbol is pointing to. Before deleting the frequency a message, shown in Figure 5-6 will be displayed and must be acknowledged with either the **Yes** or **No** soft key.

```
Delete frequency
 Are you sure?
```

Figure 5-6 Delete Frequency Message

Sort — If the frequencies entered were not in sequence, pressing the **Sort** soft key will sort them into ascending order. Pressing **Sort** again toggles the frequency sequence, i.e. the top frequency becomes the bottom frequency and vice versa. The limits will stay with the frequency they relate to.

Off Abs % — Switches between no limits, absolute limits or percentage limits. When set to **Off**, no nominal value or limits are displayed, but any previously selected values will be retained in memory.

When **Abs** is selected, **High**, **Low** and **Minor** term limits are displayed.

when **%** is selected the **Nominal** value together with **High**, **Low** and **Minor** term limits are displayed.

The nominal and limits are set as described in the example above. Nominal and limit values for **MULTI FREQ – Set** mode are independent of those set in any other mode.

MEASURE — Enters **MEASUREMENT MODE** so that measurement parameters may be set up or changed. When the correct measurement parameters are set, the **RETURN** soft key returns the instrument to **MULTI FREQ – Set** mode.

RUN — Enters **MULTI FREQ – Run** mode: see section 5.7.2.

5.7.2 MULTI FREQ – Run

Before a multi-frequency test can be run it must be set up as described in section 5.7.1. Pressing the **RUN** soft key from **MULTI FREQ – Set** mode enters **MULTI FREQ – Run** mode. When first entering this mode the screen will look similar to Figure 5-7 which shows **MULTI FREQ – Run** mode entered after setting **MULTI FREQ – Set** mode according to the example in section 5.7.1.1.

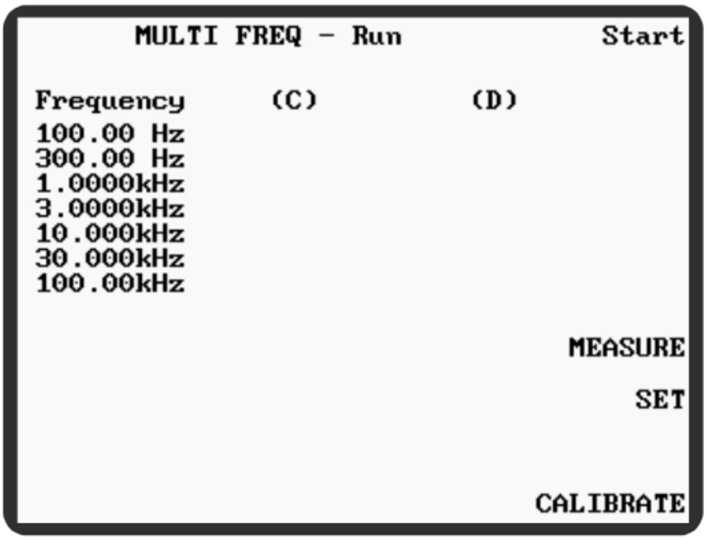


Figure 5-7 Initial MULTI FREQ – Run Display (from example in section 5.7.1.1)

When the **Start** soft key or the **Trigger** key is pressed, the analyzer will measure the component at the frequencies and measurement parameters previously set and the measurement values will be displayed. If either **Abs** or **%** was selected in **MULTI FREQ – Set** mode, the analyzer will report **PASS**, **FAIL, HI** or **LO** according to the table below. Figure 5-8 shows the results of running the multi-frequency test set up in section 5.7.1.1.

PASS	Major *and* minor terms are within the limits set.
FAIL	Major *and* minor terms are outside of the limits set.
HI (X), e.g. HI D, HI C	The parameter indicated is above the upper limit.
LO (X), e.g. LO L, LO Q	The parameter indicated is below the lower limit.

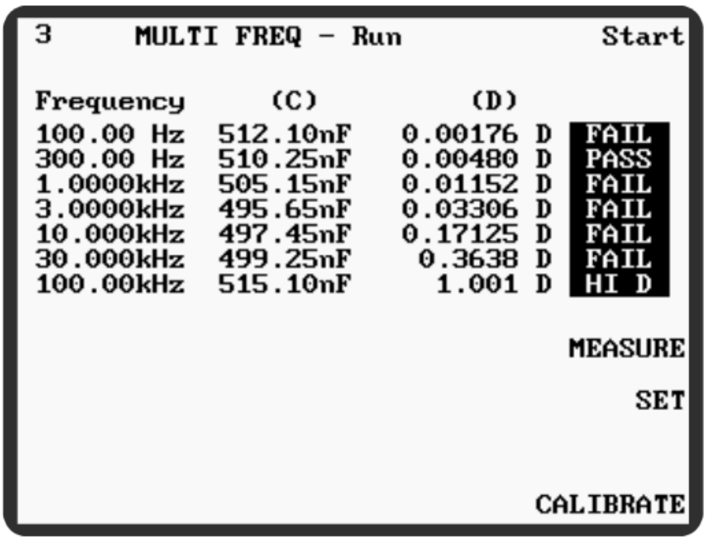


Figure 5-8 MULTI FREQ – Run

When the bin handler option is fitted, the bin handler Pass/Fail output corresponds to the PASS, FAIL, HI and LO results. The Pass/Fail output goes low only when a measurement has passed all set limits, see section 4.1.11.5 for the bin handler interface pin assignment.

5.8 BINNING MODE (Optional)

BINNING MODE allows components to be sorted into bins according to their measured value and/or minor term. Bins 0 to 8 contain the sorted components and bin 9 the rejects. Binning is normally done in **Single shot mode** or under GPIB control. Using **Repetitive mode** will disable the **Count** facility, but can be used if this is not required. The measurement conditions and test parameters will be as selected in **MEASUREMENT MODE**.

BINNING MODE is divided into three sections: **Set**, **Sort** and **Count**.

5.8.1 BINNING MODE – Set

When **BINNING** is selected from the **MAIN MENU** the analyzer will display the last binning mode used. If **BINNING MODE** – **Set** is not displayed at the top of the screen, press the **BIN SET** soft key to select it. Figure 5-9 shows a typical **BINNING MODE** – **Set** main screen with no parameters set up.

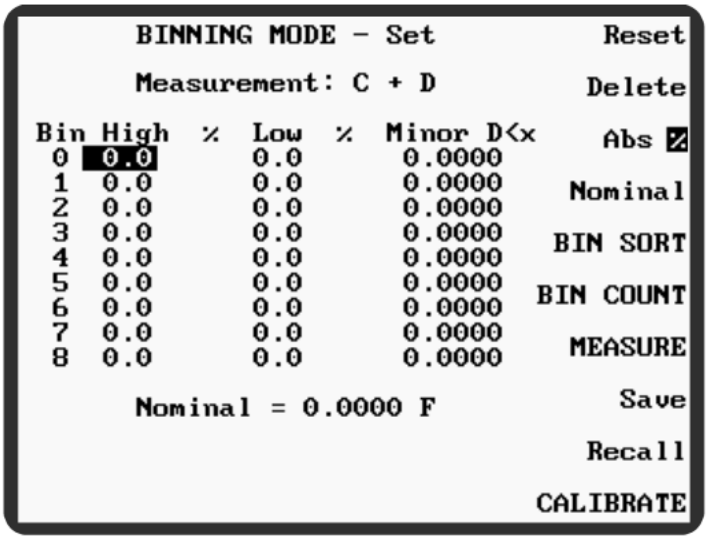


Figure 5-9 BINNING MODE – Set Main Screen With No Parameters Set up

In Figure 5-9 above, the bins are shown ready to receive percentage limits. Absolute limits can be entered by highlighting **Abs** with the **Abs %** soft key. The limits are set by highlighting each field using the navigation keys, then entering the limits with the data entry keypad. The ◄ and ► navigation keys move the cursor left and right one step at a time; the ▲ and ▼ navigation keys move the cursor up and down the column. Either nested or stacked limits can be entered. When entering nested limits, the second limit in a row can be entered by highlighting it and pressing the keypad **Enter** key twice. This mimics the setting of the first limit but with the opposite sign. Since the analyzer will accept one set of percentage limits and another set of absolute limits it is possible to enter a set of nested percentage limits and a set of stacked absolute limits, or vice versa. The only limitation to this is that the minor term is common to both percentage and absolute limits.

When using percentage limits, the nominal component value must also be entered by pressing the **Nominal** soft key, then entering the nominal component value with the data entry keypad.

Nominal, **Abs %** and **limits** for this mode are completely independent of **DEVIATION MODE** settings.

Any limit set to zero is ignored during subsequent sorting. Bins can therefore be set up with no minor term limit.

The minor term limit is a single maximum or minimum value as appropriate, e.g. Q would have a minimum limit, indicated by **Minor Q > x**.

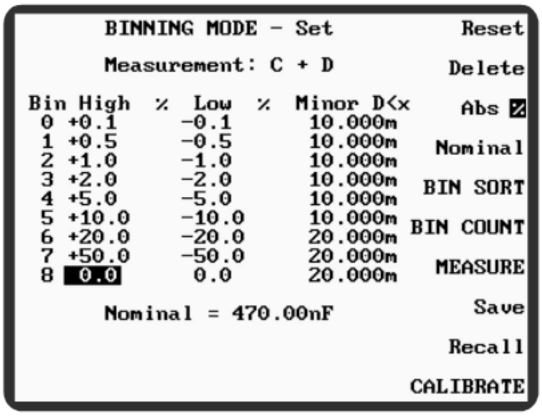


Figure 5-10 BINNING MODE
Nested Percentage Limits

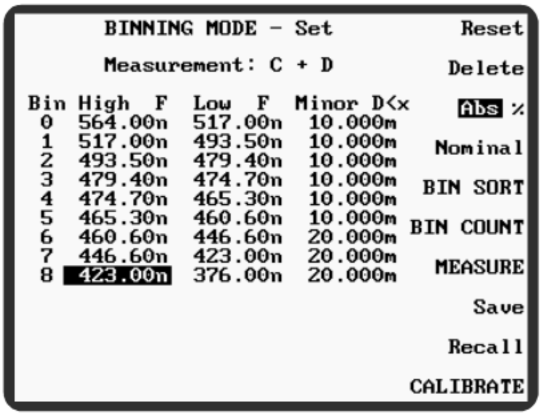


Figure 5-11 BINNING MODE
Stacked Absolute Limits

The example shown in Figure 5-10 above would sort 470nF capacitors on the basis of their % deviation from nominal value, accepting only those devices with a good D factor value. The measurement parameters C + D, together with the frequency and other test parameters are as selected in MEASURE mode. In this case, a capacitor with a value of 470nF +0.8% and a D value not exceeding 0.01 would be sorted into bin 2.

Figure 5-11 is an alternative set-up with stacked limits, sorting the capacitors by absolute value. In this case the same capacitor (=473.76nF) would be sorted into bin 4.

5.8.1.1 BINNING MODE – Set Parameters

Parameters which are common to **MEASUREMENT MODE** are described in section 4.5.2— MEASUREMENT MODE Parameters.

Reset Resets all parameters to 0 after displaying a warning message, shown in Figure 5-12 below. Confirm by pressing the **Yes** soft key. Absolute and percentage limits must be reset separately, but since the minor term is common to both, it is reset from either limits mode.

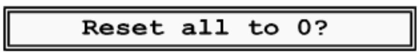


Figure 5-12 BINNING MODE – Set: Reset Warning

Delete Deletes the limits for the bin highlighted by the cursor after a warning message, shown in Figure 5-13, is displayed and confirmed by pressing the **Yes** soft key. Absolute and percentage bin limits must be deleted separately, but since the minor term is common to both, it is deleted from either limits mode.

```
Are you sure that you
 want to delete the
 limits for this bin?
```

Figure 5-13 BINNING MODE – Set: Delete Limits Warning

Abs % Toggles between **Abs** and **%**. When **Abs** is selected, absolute Hi and Lo limits (i.e. units of the measured parameter) are displayed. When **%** is selected, a nominal value together with Hi and Lo percentage limits are displayed.

The limits and nominal value must be set using the navigation keys to highlight each parameter, and the data entry keypad to set each value (the use of the data entry keypad is described in section 4.2.6). When in **%** mode, the Hi and Lo limits can be set equidistant about the nominal by setting either of the limits then highlighting the other limit and pressing the keypad **Enter** key twice. This mimics the setting of the first limit but with the opposite sign.

Nominal This soft key operates only when percentage limits are displayed. The nominal value is displayed below the percentage limits and can be seen, set to 470nF, in Figure 5-10. The nominal is set by pressing the **Nominal** soft key and entering the value using the data entry keypad.

The **BINNING MODE** nominal is NOT common with either the **DEVIATION MODE** nominal or **MEASUREMENT MODE** bar graph nominal.

BIN SORT Enters **BINNING MODE** – **Sort**: see section 5.8.2.

BIN COUNT Enters **BINNING MODE** – **Count**: see section 5.8.3

MEASURE Enters **MEASUREMENT MODE** (see section 4.5) where the component measurement parameters must be set up if not done prior to entering **BINNING MODE**. When the correct measurement parameters are set, the **RETURN** soft key returns the instrument to **BINNING MODE**.

Save Saves the displayed limits (and nominal if percentage limits are displayed). When the **Save** soft key is pressed, the instrument will prompt the user to enter a location number to save the settings under: 99 locations are available (Figure 5-14). If both absolute and percentage limits are set up, they must be saved separately under different location numbers.

```
Save bin setup at
location 1 to 99
```

Figure 5-14 Save Bin Setup Message

If the selected location has already been used, a warning message will be displayed (Figure 5-15); this is confirmed by pressing the **Yes** soft key or cleared by pressing the **No** soft key, in which case Figure 5-16 will be displayed.

```
Overwrite setup
Are you sure?
```

Figure 5-15 Overwrite Setup Warning

```
Setup not saved
```

Figure 5-16 Setup Not Saved Message

Recall

Saved limits can be loaded using the **Recall** soft key. The user will be prompted to enter the location number.

```
Recall bin setup at
location 1 to 99
```

Figure 5-17 Recall Bin Setup Message

If a location is entered which contains no saved bin limits data, Figure 5-18 will be briefly displayed and the user will be returned to the main **BINNING MODE – Set** screen.

```
Invalid bin setup
```

Figure 5-18 Invalid Bin Setup Message

Note: If the **BINNING** soft key is pressed when the binning option is not fitted, the analyzer will report **Unit Not Available** (Figure 5-19).

```
Unit Not Available
```

Figure 5-19 Unit Not Available Message

5.8.2 BINNING MODE – Sort

Before sorting components into their respective bins, the bin limits should be set up as described in section 5.8.1—BINNING MODE – Set. When the limits are correctly set up and the screen is displaying the desired limits mode, i.e. absolute limits (**Abs**) or percentage limits (**%**), the **BIN SORT** soft key can be selected from the **BINNING MODE – Set** display.

BINNING MODE – Sort can be performed in Repetitive mode, Single shot mode or under GPIB control; if performed in Single shot mode the **Count** total will be updated in the background (see section 5.8.3). As each component is inserted into the fixture and the measurement made, the bin designation for the measured component is displayed in large characters and the actual measured value is displayed in smaller characters underneath. The component may now be placed into the appropriate bin and the next component placed in the fixture ready for sorting.

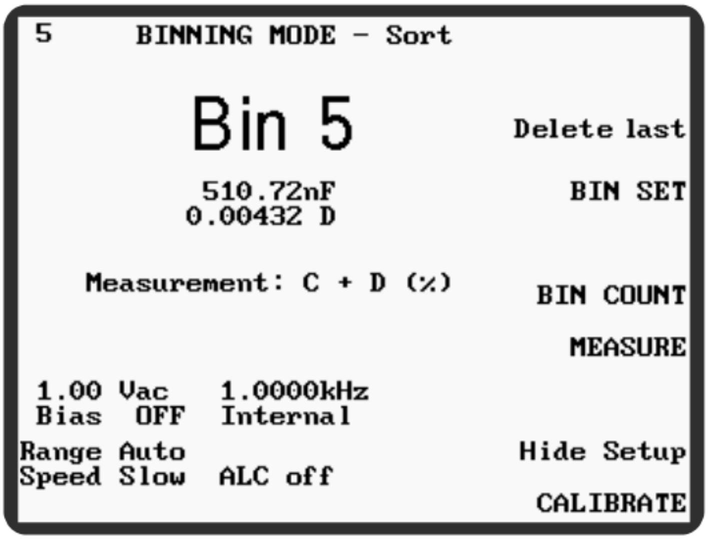


Figure 5-20 BINNING MODE – Sort

5.8.2.1 BINNING MODE – Sort Parameters

Parameters which are common to **MEASUREMENT MODE** are described in section 4.5.2— MEASUREMENT MODE Parameters.

Delete last If a component is wrongly sorted (e.g. a bad connection to the fixture), pressing the **Delete last** soft key will clear this result from the total. It is only possible to step back one reading.

This soft key appears after a measurement is triggered. Selecting it will display Figure 5-21 below.

Figure 5-21 Delete Last Result Message

Selecting the **Yes** soft key will delete the last result.

Selecting the **No** soft key will not delete the last result.

Selecting either the **Yes** or **No** soft key will cause the **Delete last** soft key to disappear until the next measurement is triggered.

BIN SET Enters **BINNING MODE – Set**: see section 5.8.1.

BIN COUNT Enters **BINNING MODE** – **Count**: see section 5.8.3.

MEASURE Enters **MEASUREMENT MODE** so that measurement parameters may be changed if desired. When the correct measurement parameters are set, the **RETURN** soft key returns the instrument to **BINNING MODE**.

5.8.3 BINNING MODE – Count

BINNING MODE – **Count** can be entered at any time during component sorting by selecting the **BIN COUNT** soft key. Figure 5-22 below shows 17 components sorted into their respective bins. Binning measurement can be made while in **Count** mode.

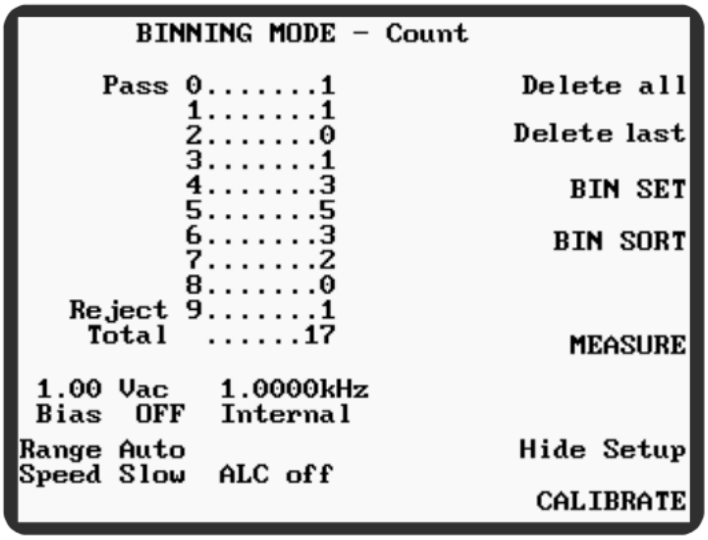


Figure 5-22 BINNING MODE – Count

5.8.3.1 BINNING MODE – Count Parameters

Parameters which are common to **MEASUREMENT MODE** are described in section 4.5.2—MEASUREMENT MODE Parameters.

Delete all Deletes all of the bin counts, resetting them to 0, after a warning message, shown in Figure 5-23 is displayed and is confirmed by pressing the **Yes** soft key.

Figure 5-23 Delete Bin Counts Warning

Delete last If a component is wrongly rejected (e.g. a bad connection to the fixture), pressing the **Delete last** soft key will clear this result from the total. It is only possible to step back one reading.

See also **Delete last** in section 5.8.2.1 above.

BIN SET Enters **BINNING MODE** – **Set**: see section 5.8.1.

BIN SORT Enters **BINNING MODE – Sort**: see section 5.8.2.

MEASURE Enters **MEASUREMENT MODE** so that measurement parameters may be changed if desired. When the correct measurement parameters are set, the **RETURN** soft key returns the instrument to **BINNING MODE**.

5.9 CAPACITOR MODE (Optional)

The capacitor mode combines the Multi Frequency and Binning modes to provide efficient testing of capacitors. Capacitors may be measured at up to eight different frequencies and tests with tolerance levels set for up to 9 bins plus a reject bin.

The optional Bin Handler Interface card provides an interface to external bin handling systems enabling capacitors to be physically sorted depending on measurement test results. See section 4.1.11 for further information.

Bins 0 to 8 may be used to sort results from the first test frequency into multiple tolerance levels with Bin 9 designated for rejected components. Subsequent test frequencies may have a reject bin assigned which is not used by the first frequency or may also use Bin 9. Sorting of test results by tolerance is only available on the first test frequency.

To set test frequencies, measurement types, instrument measurement ranges and bin tolerances use the CAPACITIOR MODE set menu. If the measurement ranges are not known then the CAPACITOR MODE learn screen enables the instrument range to be optimised for each test.

To test a capacitor select the CAPACITOR MODE run menu and use the Trigger key to initiate a measurement.

Tests results are accumulated for each bin together with the yield. To view the statistics use the CAPACITOR MODE – Results menu.

5.9.1 CAPACITOR MODE – Set

To enter CAPACITOR MODE select the CAPACITOR soft key from MAIN MENU.

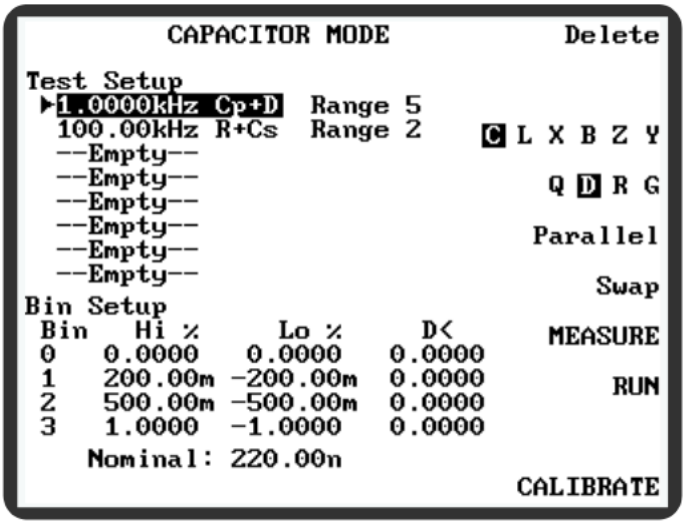


Figure 5-24 CAPACITOR – Set Bin Tolerances

The test frequencies, measurement types and bin tolerances are chosen using the Set menu.

Up to eight frequencies can be defined by highlighting the frequency, then entering the frequency with the data entry keypad. The and navigation keys scroll through each frequency in turn. Use the soft keys to set the required measurement test and equivalent circuit. If a test frequency is no longer required then use the Delete soft key to remove.

Highlight the first test frequency and use the or navigation keys to move to Bin Setup. Use the navigation keys and data entry keypad to enter measurement tolerances for individual bins and the nominal value for the component under test. The major term is tested to a tolerance limit while the minor term is relative. Use the Swap soft key if the minor term requires a tolerance limit with a relative tolerance being acceptable for the major term.

Select each subsequent frequency in turn and use the or navigation keys to move to the Reject Setup area. Continue using the or navigation keys to select the reject bin, tolerance levels and nominal value, using the numeric keypad to assign values for each parameter. The major term is tested to a tolerance limit while the minor term is relative.

Use the Swap soft key if the minor term requires a tolerance limit with a relative tolerance being acceptable for the major term. A typical application of the Swap function is when making ESR measurements.

Note

Any component measurement results that do not fall within any of the bin setup tolerances for the first test frequency will have failed and will be added to accumulated results for the reject bin (Bin 9). For subsequent test frequencies any component tested which measures outside the entered reject tolerances will have failed and will be added to the accumulated results for the specified reject bin.

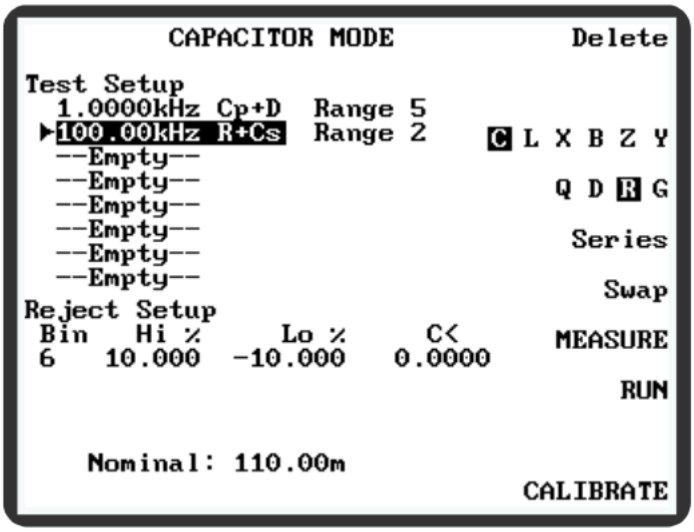


Figure 5-25 CAPACITOR – Set Reject Bin

5.9.2 CAPACITOR MODE – Run

Select the Run soft key from the CAPACITOR MODE set screen.

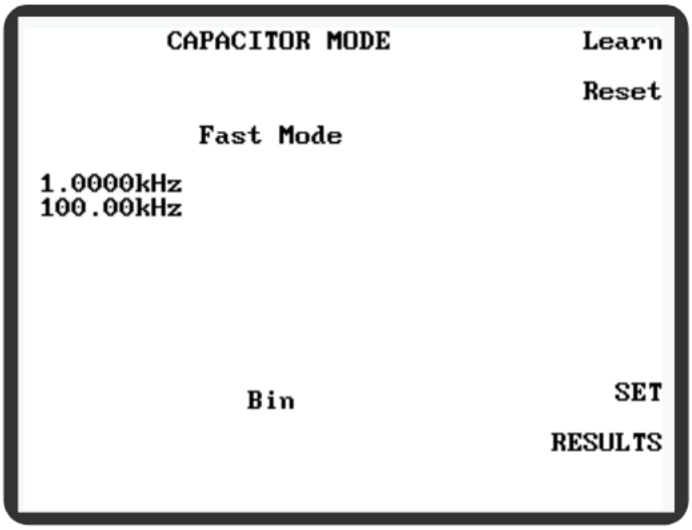


Figure 5-26 CAPACITOR – Component Learnt

Enter the ideal measurement range for each test to speed up the test sequence.

To achieve the highest level of performance, the component should be learnt using a typical capacitor. The learn process selects the ideal measurement range and other instrument settings for each test and then applies the same settings for each subsequent component tested.

Connect a typical component to the instrument and press the Learn soft key. The instrument will run all tests optimising the instrument for each test. Once the component has been successfully learnt the display will change to indicate that the Fast Mode will be used for subsequent components.

The Reset soft key may be used to clear the learnt parameters and return to the standard mode of operation.

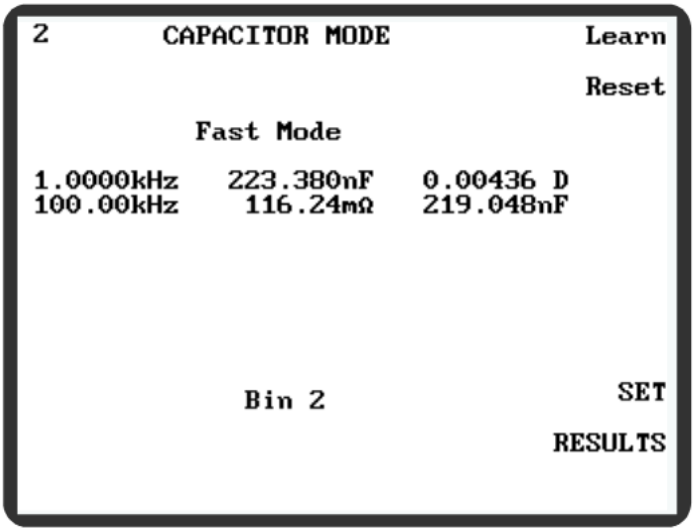


Figure 5-27 CAPACITOR – Component Tested

Start the measurement sequence by pressing the Trigger key. When all measurements have been completed the allocated bin number will be displayed and the accumulated results for the bin and total components tested will be updated. If a bin interface option is fitted then appropriate signal lines will be updated to reflect the test result. See section 4.1.11 for further details.

Component test results may be printed. See section 4.1 for details on connecting compatible printers and enabling printer output.

5.9.3 CAPACITOR MODE - Results

Select the RESULTS soft key from the CAPACITOR Mode run screen.

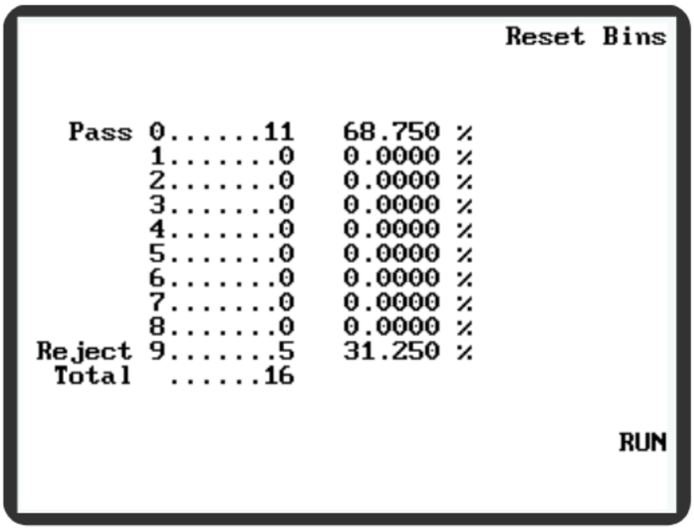


Figure 5-28 CAPACITOR - Results

Accumulated results for each bin will be displayed together with the total number of capacitors tested.

Bin totals and yield together with the total number of components tested may be printed. See section 4.1 for details on connecting compatible printers and enabling printer output.

To clear all bin totals press the Reset Bins soft key. Bin data will only be cleared after the Yes soft key has been pressed when the confirmation prompt appears. To cancel clearing down the bin totals select the No soft key.

5.10 RESONANCE MODE

RESONANCE MODE identifies and analyses either series or parallel resonances in the component under test. These are typically caused by the self-inductance of capacitors or the self-capacitance of inductors respectively. For analysis purposes, the equivalent circuits shown below are assumed.

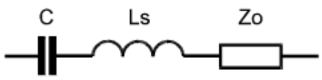


Figure 5-29 Series Equivalent Circuit

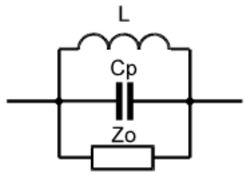


Figure 5-30 Parallel Equivalent Circuit

At the selected resonant frequency, the capacitive and inductive reactances are equal and opposite, giving a measured impedance that is purely resistive. By making measurements above and below this frequency, the exact resonant characteristics are found by interpolation. For resonances with reasonably high Q factors, accurate results are returned for the resonant frequency (fo), self inductance (Ls) or self capacitance (Cp). The Q value and effective resistance at resonance (Zo) are also indicated.

For simple components, where the above models are valid, the series or parallel frequency obtained will also correspond to the minimum or maximum impedance point. The results may not be valid for more complex components, especially those exhibiting more than one resonance.

Enter the **Start** and **Stop** frequencies corresponding to the range in which resonance is expected to occur. The process searches for a pair of frequencies as close to resonance as possible. The impedance is then measured at the final pair of frequencies and the resonance is calculated. Use the **Speed** parameter to specify the measurement speed used for the final pair of frequencies. The standard measurement speeds of SLOW, MED, FAST and MAX are available with the best accuracy being achieved if the SLOW speed is selected.

The **Depth** parameter sets the number of iterations used during the initial search for the pair of frequencies near resonance. Typically set the **Depth** parameter to 10 if a full instrument frequency range search has been specified. Setting the **Depth** parameter to 0 calculates resonance using the entered **Start** and **Stop** frequencies.

The search process will complete more quickly if close search limits are entered and a low value for the depth parameter is specified. The search will be performed at the AC test level specified in **MEASUREMENT MODE**, but other test parameters will be selected automatically and need not be specified.

Setting the **Extrp** parameter to On enables resonance to be extrapolated if it is outside the specified frequency range or outside the range of the instrument. Accuracy of extrapolated results is undefined, as it is not possible to verify the validity of the circuit model.

Start the search by pressing the **Find Series** or **Find Parallel** soft key. If a resonance is found, the results will appear after a few seconds, as shown in Figure 5-32. With the **Find Series** or **Find Parallel** label highlighted, a further search may be initiated by pressing the **Trigger** key. Alternatively, press the soft key again.

If no resonance is detected, the analyzer will report **Resonance not found.**

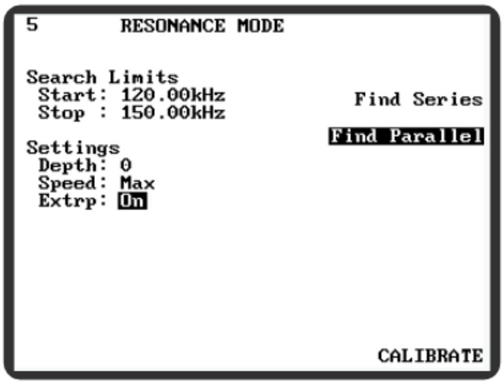


Figure 5-31 RESONANCE MODE

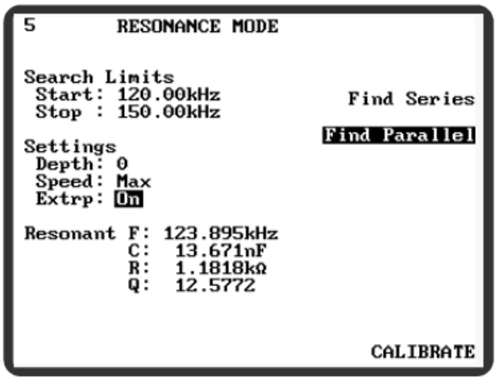


Figure 5-32 RESONANCE MODE Results

Figure 5-32 shows the resonant frequency for a 10µF capacitor with the bandwidth limits set to 120kHz and 150kHz. The search depth is set to 0 so measurements have been taken at 120kHz and 150kHz with the results used to calculate resonance. If the search depth had been set to greater than 0 then a binary search would have been performed for a pair of frequencies closest to resonance with the number of iterations defined by the Depth parameter. Measurements would then have been made using the last two frequencies found during the resonance search and resonance calculated.

Resonance mode accuracy is dependant upon the Start and Stop frequencies, search depth, measurement speed and the resonance characteristics of the component being measured.

5.11 GRAPH MODE (6440B, Optional on 6430B)

GRAPH MODE allows both major and minor term component or circuit characteristics to be viewed in graphical form (linear or logarithmic) across a user-defined frequency range. Only one term can be viewed at a time but it is possible to rapidly toggle between the major and minor term views. The major term graph may be in absolute units, or as a percentage from a nominal value. The vertical axes for both the major and minor term may be pre-defined by the user. After plotting the graph, the **FIT** function may be used to autoscale either vertical axis for the best available resolution. Other functions within **GRAPH MODE** can be used to find resonance and to identify the highest peak and lowest trough across the frequency range. A marker is displayed with the graph and can move along the graph outline and give x and y value readouts. Results can be printed to an Epson-compatible printer if required after entering **Code 30** from the **MAIN MENU**.

When first entering **GRAPH MODE** from the **MAIN MENU**, the **GRAPH MODE – Set** screen is displayed (Figure 5-33) which defines the parameters necessary to draw the graph.

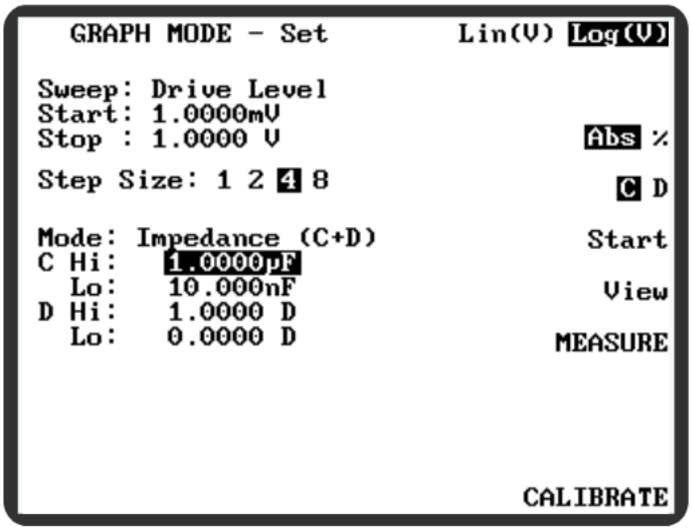


Figure 5-33 GRAPH MODE – Set

Figure 5-33 shows **GRAPH MODE** set up to draw a graph of impedance (C + D) against drive level on a log/log scale between 1.0000mV and 1.0000V with the component limits set in absolute terms.

5.11.1 GRAPH MODE – Set Parameters

Parameters which are common to **MEASUREMENT MODE** are described in section 4.5.2—MEASUREMENT MODE Parameters.

Lin(unit**) Log(**unit**)**	Toggles between **Lin(*unit*)** and **Log(*unit*)** to set either linear or logarithmic horizontal scale, where *unit* is **Sweep** parameter.
Lin(Z) Log(Z) **or** **Lin(Y) Log(Y)**	This soft key is displayed only when **Log(*unit*)** is selected (above) and when **Mode** is set to **(Z+θ)** or **(Y+ θ)**. It allows the selection of Lin or Log vertical scale, allowing log/log graphs to be plotted. Note that negative or zero scale limits cannot be plotted on a log scale. Both limits must be set to positive values before pressing **Start**, or a warning message will be displayed.
Sweep	The **Start** and **Stop** settings for the graph, which are set by highlighting each in turn with the ◀ and ▶ navigation keys, then entering the value with the data entry keypad. When **Sweep** is highlighted the ▲ and ▼ navigation keys are used to set the **Sweep** parameter to **Frequency** or **Drive Level**.
Step Size	The **Step Size** is the number of LCD display pixels used for a single point along the graph. The higher the number selected, the coarser the graph but the more quickly it is drawn. Set by highlighting **Step Size** with the ◀ and ▶ navigation keys, then select from **1 2 4 8** with the ▲ and ▼ navigation keys.

Abs %

This soft key toggles between **Abs** and **%** (major term only). When **Abs** is selected, absolute **High** and **Low** limits (i.e. units of the measured parameter) are displayed. When **%** is selected, a **Nominal** value together with **High** and **Low** percentage limits is displayed.

The limits and nominal value (if applicable) must be set using the ◂ and ▸ navigation keys to highlight each parameter and the data entry keypad to set each value.

Note: The **Abs %** soft key is only available when the vertical scale is linear.

Major/Minor Term Select

This soft key toggles between either of the measurement terms selected in **MEASUREMENT MODE**. The graph will be drawn according to whichever of these terms is highlighted, e.g. in Figure 5-33 C is highlighted, so the graph will be of capacitance against drive level.

Start

When all parameters have been set up, pressing the **Start** soft key will draw the graph.

As the graph is being drawn, a progress marker at the bottom of the screen shows how complete the graph is and the speed of the marker gives an indication of how long the graph will take to draw. If the graph is progressing too slowly, perhaps because too small a **Step Size** has been selected, it can be aborted by pressing and *holding* the **Abort** key.

Notes:

1) If the range is manually selected and the component characteristics take the graph outside the boundaries of the selected range, that portion of the graph will not be drawn.
2) If incorrect y axis settings are selected, no graph will be seen even though the progress marker will indicate that a graph is being drawn: the graph will actually be 'drawn' outside of the display area. The display can be corrected by using the **FIT** autoscale function, or by pressing the **RETURN** soft key and selecting more appropriate limits.
3) An error message shown at the top of the screen indicates that the error occurred somewhere on the sweep.

View

When the graph has been drawn and **GRAPH MODE – Set** has been reselected with the **RETURN** soft key, **View** can be used to redisplay the last graph drawn by the analyzer.

MEASURE

Enters **MEASUREMENT MODE** so that measurement parameters may be set up or changed. When the correct measurement parameters are set, the **RETURN** soft key returns the instrument to **GRAPH MODE – Set**.

5.11.2 Parameters Available when the Graph is Displayed

FUNCTION	Pressing **FUNCTION** temporarily crops the graph to display other soft keys available. These are shown indented below:
VIEW	Pressing **VIEW** hides the available soft keys and displays the whole graph.
FIT	The **FIT** soft key redraws the graph, autoscaling the vertical axis for the best available resolution. This may be done separately for both major and minor terms.
TOGGLE	When a graph is plotted on the major or minor term, the other term is automatically stored in the background and the **TOGGLE** soft key can be used to toggle between the two graphical displays.
RESONANCE	Enters **RESONANCE MODE**. See section 5.10.
PEAK	Aligns the marker (shown in Figure 5-34) with the highest peak in the set frequency range.
DIP	Aligns the marker with the lowest trough in the set frequency range (Figure 5-35).
PRINT	Prints the graph on an Epson-compatible printer after entering **Code 30** from the **MAIN MENU**.
RETURN	Returns the analyzer to **GRAPH MODE – Set**

Note

If the DUT exhibits high Q resonances, the graph function may miss the peak or trough due to quantized frequency steps. For accurate values at resonance, use the **RESONANCE** function.

5.11.3 Example

This example will illustrate the procedure for using **GRAPH MODE** and is intended to familiarize the user with this mode of operation. For this example a log/log scale will be used to draw the impedance characteristics of a 10µF capacitor.

1) Enter **GRAPH MODE – Set** by pressing the **GRAPH** soft key from the **MAIN MENU**.
2) Use the **Lin(Hz) Log(Hz)** soft key to highlight **Log(Hz)**.
3) Press the **MEASURE** soft key. This will return the instrument to **MEASUREMENT MODE** where the appropriate measurement parameters must be set prior to drawing the graph. Enter the parameters required for the test. For this example they are set to:

   AC Meas
   Z
   Angle
   100mAac
   10.000kHz—this setting will be overridden when the graph is drawn
   Bias OFF
   Internal
   Range Auto

Speed Max
ALC off

When the measurement parameters have been set, press the **RETURN** soft key to return the instrument to **GRAPH MODE– Set**.

4) Note that there is now a soft key labelled **Lin(Z) Log(Z)**. This soft key has become available because both **Log(Hz)** and **Z** are selected. Use the soft key to select **Log(Z)**.
5) Using the **Major/Minor Term Select** soft key, highlight **Z**.
6) Highlight the **Start** frequency with the ◀ or ▶ navigation key and enter the required frequency with the data entry keypad. For this example **100Hz** will be entered.
7) Highlight the **Stop** frequency with the ◀ or ▶ navigation key and enter the required frequency with the data entry keypad. For this example **1MHz** will be entered. Note that for **Log(Hz)** the minimum scale length is one decade.
8) Highlight **Step Size** with the ◀ or ▶ navigation key, then use the ▲ and ▼ navigation keys to select **1 2 4** or **8**. For this example **4** is selected.
9) Highlight each of the **Measurement High** and **Low** limits with the ◀ or ▶ navigation key, then set each one with the data entry keypad. For this example they will be set to:

   Z: High: 1kΩ
   Z: Low: 10mΩ
   θ: High: 100 °
   θ: Low: -**100 °**

   The screen should now look like Figure 5-33.
10) Press the **Start** soft key. A graph will be drawn showing the component characteristics using the measurement parameters and frequency range set (Figure 5-34).

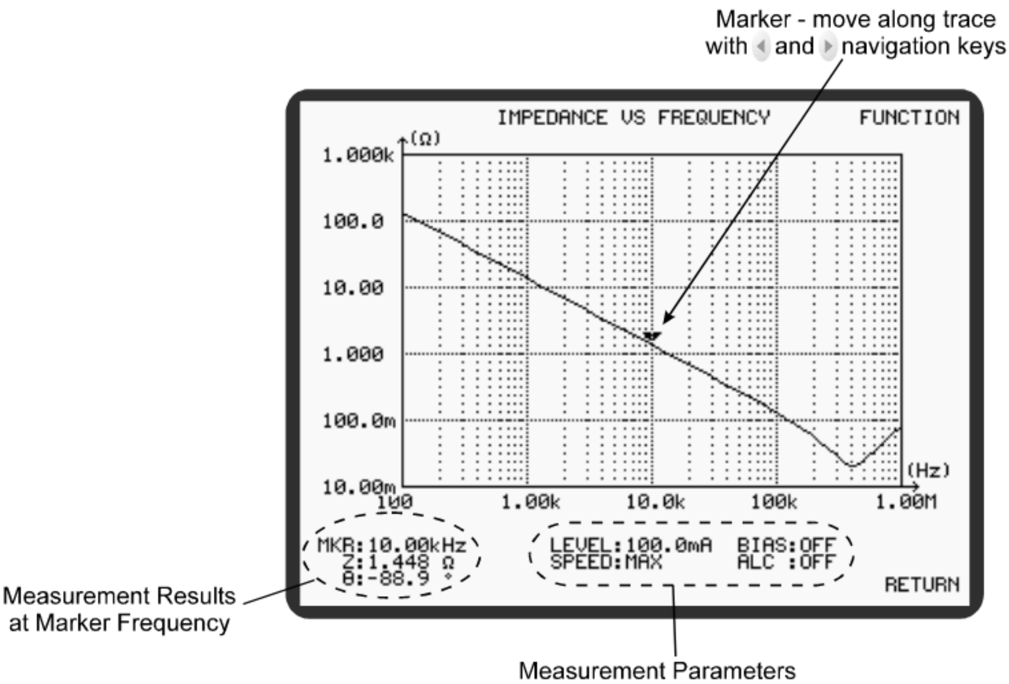


Figure 5-34 Graph Drawn From Example

11) Press the **FUNCTION** soft key to display the other soft keys available, then press the **DIP** soft key: the marker will be positioned at the lowest trough in the set frequency range. The bottom left corner of the display will show the component measurements and frequency (Figure 5-35) at the trough.

Note

The **PEAK** or **DIP** function will find the maximum and minimum of the plot. Due to quantized frequency steps this may not be at the absolute peak or trough of the waveform.

The **DIP** position may be a resonance on an impedance plot. More accurate results will be obtained by using **RESONANCE MODE**, which can be obtained by using the **RESONANCE** soft key. See later text in this example.

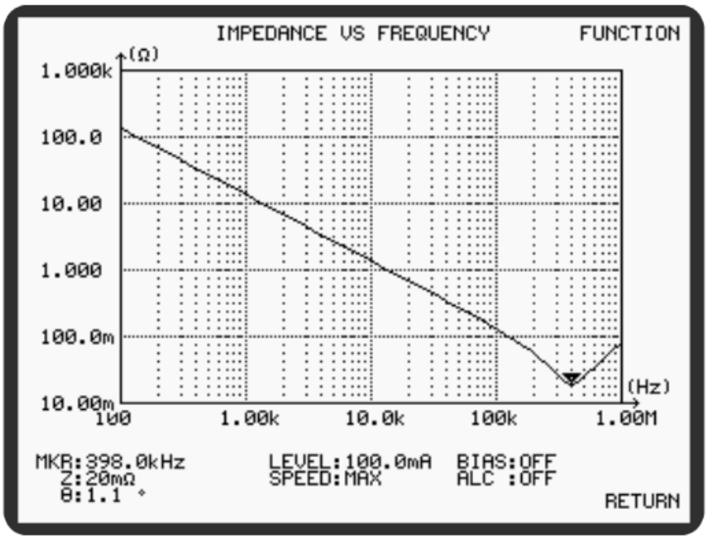


Figure 5-35 Graph Trough (major term)

12) Press the **TOGGLE** soft key to display the graph for the minor term (θ). Note that since the **DIP** function was used on the major term graph, the marker is positioned at the same frequency on the minor term graph (Figure 5-36).

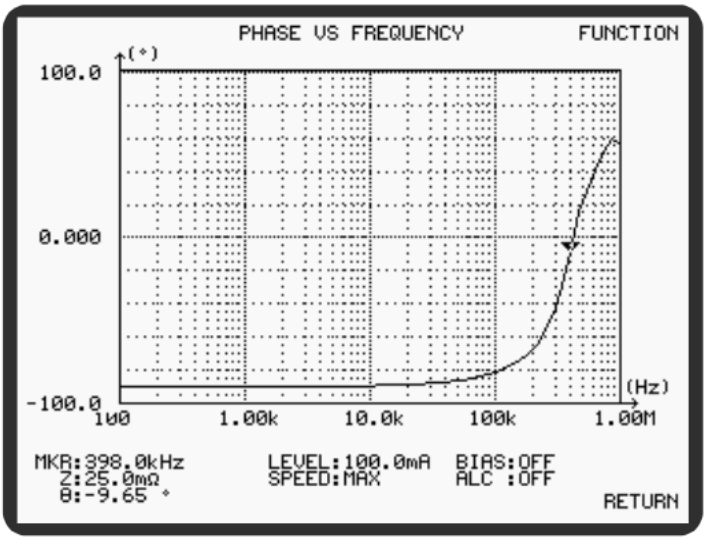


Figure 5-36 Graph Trough (minor term)

13) Having estimated the resonant frequency using the GRAPH MODE **DIP** function, **RESONANCE MODE** will be used for a more accurate result. With the graph displayed, select **FUNCTION** then **RESONANCE**.

RESONANCE MODE will be entered. Set the **Search Limits** either side of the resonant frequency determined in GRAPH MODE and a search depth of 2. In this case the frequency search limits are relatively narrow so the **Depth** parameter has been set to a low value. To ensure measurement accuracy the SLOW **Speed** setting should be used. From GRAPH MODE the resonant frequency was estimated to be 398.0kHz, this example will use **Search Limits** of 390kHz and 410kHz.

Select the **Find Series** soft key: the resonant frequency and component characteristics will be displayed on the screen as shown in Figure 5-37.

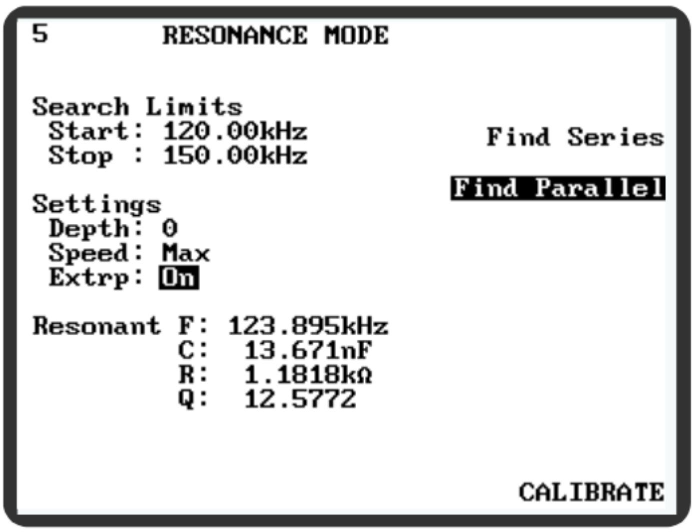


Figure 5-37 RESONANT MODE Search

5.12 The STATUS Page

The status page is displayed by pressing the **STATUS** soft key from the **MAIN MENU**. Figure 5-38**Error! Reference source not found.** shows a typical status page. √ indicates that an option is fitted or the calibration status indicated is valid. x indicates that an option is not fitted or that the calibration status indicated is not valid.

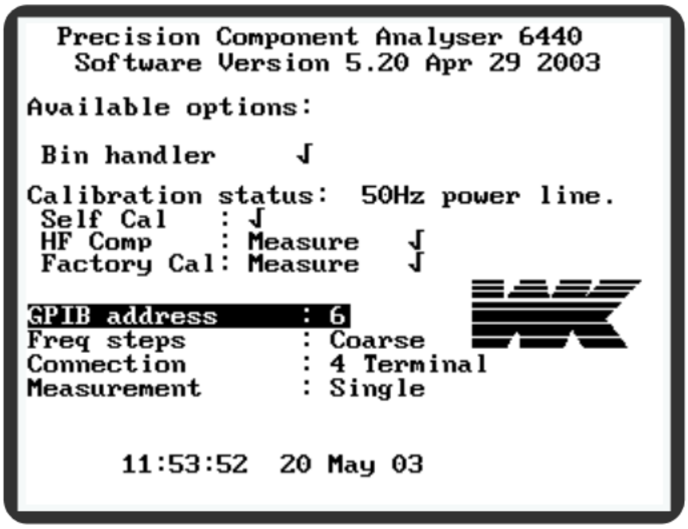


Figure 5-38 The STATUS Page

There are four parameters which may be altered from within the status page: **GPIB address**, **Freq steps**, **Connection** and **Measurement**.

5.12.1 The STATUS Page Parameters

GPIB Address

The analyzer's default GPIB address is 6. This may be changed by highlighting the status page **GPIB address** parameter with the ▲ and ▼ navigation keys, then altering the address with the ◀ or ▶ navigation keys or the data entry keypad. Allowable addresses are 0 to 30 inclusive.

Freq Steps (6440B and 6430B with Analysis option)

This sets the frequency steps used when the measurement frequency is altered using the navigation keys. Two options are available: **Coarse** or **Fine** (6440B or 6430B with Analysis option). Set by highlighting the status page **Freq steps** parameter with the ▲ and ▼ navigation keys, then using the ◀ or ▶ navigation keys to toggle between the two choices. With **Coarse** steps selected, the frequency steps are 33% or less; with **Fine** steps selected, the frequency steps are 1% or less (see specification).

Even with **Coarse** frequency steps selected, the data entry keypad can be used to set the measurement frequency with the maximum possible resolution and accuracy.

Connection

Toggles the analyzer between 2- and 4-terminal operation by highlighting the status page **Connection** parameter with the and navigation keys, then using the or navigation keys to toggle between the two choices.

Alternatively, the **2/4 Term** control key can be used to switch between 2- and 4-terminal operation (see section 4.2.5).

Note:

1) When 2-terminal measurement is selected the **2/4 term** control key indicator will light and the display will show **2-TERM MEASUREMENT MODE** at the top of the screen in **MEASUREMENT MODE.**
2) The leads will require retrimming when switching from 4- to 2-terminal measurement or vice versa..

Measurement

Toggles the analyzer between **Single shot mode** and **Repetitive mode** operation. Set by highlighting the status page **Measurement** parameter with the and navigation keys, then using the or navigation keys to toggle between the two choices.

Alternatively, the **Sngl/Rep** control key can be used to select either single shot or repetitive mode (see section 4.2.5

6. GENERAL PURPOSE INTERFACE BUS (GPIB)

6.1 GPIB Control

6.1.1 Introduction

The GPIB is a parallel port designed to be used for communication between instruments (listeners) and control devices (talkers) such as PCs fitted with a suitable interface card. The interface protocol is defined by the IEEE488.1 standard. Some additional generic capabilities of the listeners and talkers are defined by IEEE488.2. The SCPI standard defines the highest level of command structure including a number of standard commands for all instruments.

6.1.2 Interface Specification

The IEEE 488.1 bus standard and the IEEE 488.2 code standard are fully supported. The command set has also been designed to the SCPI standard.

The IEEE 488.1 functions supported

SH1	Full source handshake
AH1	Full acceptor handshake
T6	Basic talker, serial poll, no talk only, untalk if MLA
TE0	No talker with secondary addressing
L4	Basic listener, no listen only, unlisten if MTA
LE0	No listener with secondary addressing
SR1	Full service request
DC1	Full device clear
RL1	Full remote/local compatibility
PP0	No parallel poll
DT1	Full device trigger compatibility
C0	No controller

6.1.3 Changing GPIB Address

Each instrument on the GPIB requires a unique address, this can be set to any address in the range 0 to 30.

The default address is 6. This may be changed from the **STATUS** page, as follows:

1) From the **MAIN MENU** select **STATUS.**
2) Highlight the status page **GPIB address** parameter with the and navigation keys.
3) Alter the address with the or navigation keys or the data entry keypad.

The GPIB address is stored in non-volatile memory.

6.1.4 Message Syntax

A GPIB message is made up of one or more commands. Commands can be separated into two groups, **common commands** and **subsystem commands**. The available common commands are defined by IEEE488.2 and are primarily concerned with the instrument's GPIB configuration, e.g. reading error registers and identifying the instrument. The subsystem commands are the higher level commands that follow the SCPI guidelines and are concerned with setting up the instrument functions, e.g. changing the frequency and drive level.

6.1.4.1 Message structure

Messages are sent to the instrument as ASCII character strings. The structure of these strings can be seen in Figure 6-1. When interpreting the strings the instrument is not case-sensitive.

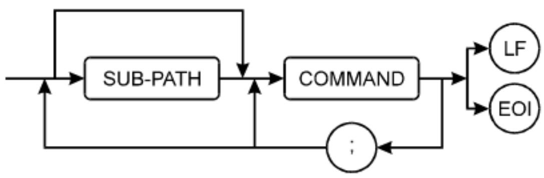


Figure 6-1 GPIB Message Structure

The path command prefix allows access to commands in the SCPI command tree. Using this approach greatly simplifies GPIB programming by allowing related commands to be grouped together. The next part of the string is the command itself which has the structure shown in Figure 6-2. Multiple commands can be sent in one message by separating them with a semicolon (maximum length 256 bytes). The terminator indicates the end of the command string to the instrument: this can be the sending of the line-feed character (ASCII 0Ah) and/or the assertion of the EOI handshake line on the GPIB bus.

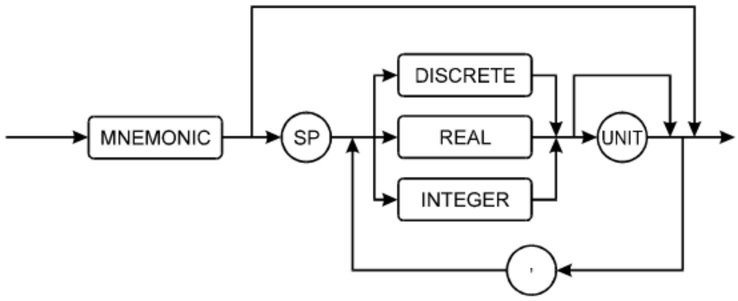


Figure 6-2 GPIB Command Structure

Each instrument command begins with a mnemonic that describes the required action, e.g. `FREQ` for changing the frequency.

If the command requires a parameter, then the next character should be a white space character (ASCII 20h), although any character in the range 00h-20h can be used with the exception of line-feed (ASCII 0Ah).

The parameter itself can take one of three forms depending on the command:

1) Discrete data

   This includes words like `ON`, `OFF` and `ABS`.

2) Real Number

   A floating point number that can be in engineering format or a number with a multiplier suffix K (kilo-), M (mega-) or G (giga-).

   For example:

   ```
   FREQ 1000.0
   FREQ 1E+3
   FREQ 0.1E4
   FREQ 1k
   ```

   are all valid ways of setting a frequency of 1kHz.

3) Integer

   A single integer number. Often used to indicate a Boolean state.

   For example:

   ```
   RANGE 1
   ```

   will select range 1.

   If invalid data is supplied then a command error will be generated. If data is supplied but the instrument is not able to apply the setting, an execution error will be generated. If the instrument is unable to exactly comply with the command and can only apply the nearest available, a device specific error is generated. Details of these error codes can be found in Figure 6-6.

6.1.4.2 Hierarchical Commands

As described in the previous section, SCPI uses a command tree to simplify device programming. This structure is similar to the directory structure used on most computers. To access a specific command in a specific mode the user must supply the 'path' to reach that particular command within the tree.

When the unit is powered up the initial path is 'root' which is the top level from which all paths must start.

Note that common commands (which by convention always start with the '*' character) are not part of the tree and can be accessed regardless of the current path.

So to select the impedance measurement function in deviation mode, the path must describe the command tree as below:

```
ROOT
 └► DEViation
     └► FUNCtion
         └► Z
```

The ':' character is used as the path separator so the command string will be:

```
:DEV:FUNC:Z
```

Note that the string starts with ':'. This tells the instrument to start from the 'root' path. Whenever a terminator is reached (line-feed and/or EOI) the path is reset to the root path, so each new GPIB command string must state the full path in order to work correctly, for example:

To set a measurement frequency of 1kHz at a level of 1.0V, the following string can be used:

```
:MEAS:FREQ 1k;LEV 1.0V <line-feed>
```

Or it can be expressed as two separate commands:

```
:MEAS:FREQ 1k <line-feed>

:MEAS:LEV 1.0 <line-feed>
```

However, the following will not work as the second command will be run from the 'root' path, not the measurement path which was required:

```
:MEAS:FREQ 1k      <line-feed>

LEV 1.0            <line-feed>
```

Summary: The following are the rules for negotiating the command hierarchy

- On power-up or reset, the current path is set to the root.
- Message terminator, line-feed (ASCII 0Ah) or EOI, sets the current path to the root.
- When a colon is the first character of a command, it specifies that the next command mnemonic is a root level command.
- When a colon is placed between two path mnemonics, the current path is moved down one level in the command tree if the path name is valid.
- A semicolon separates two commands in the same message without changing the current path.
- If a command requires more than one parameter, the separate adjacent parameters must be specified using a comma. Commas do not affect the current path.
- Common commands, such as *RST, *RCL, are not part of the tree. An instrument interprets them in the same way, regardless of the current path setting.

Other syntax rules

- Commands will be executed in the order in which they appear in the string.
- A command string can contain any number of 'query commands': the response will contain the replies to each query separated by a semicolon.
- Only commands available in the selected mode will be accepted. Otherwise, an Execution Error will be generated. For example, AC frequency cannot be set if Rdc type of test is selected
- Either full or abbreviated forms of the device specific commands will be accepted. The abbreviated form is indicated by upper case letters in section 6.2.
- Device specific commands have the same effect as pressing the equivalent front panel key and can be expected to interact with any other instrument settings in the same way.

6.1.5 Data Output

6.1.5.1 Output Syntax

For each query which generates an output response, a Response Message Unit (RMU), will be generated. This consists of a string of numbers or alphanumeric characters; if more than one RMU is generated they will be delimited with a semicolon. The terminator, line-feed and EOI asserted indicates the end of data output. All characters will be upper case.

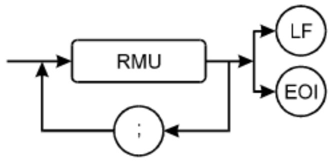


Figure 6-3 GPIB Data Output

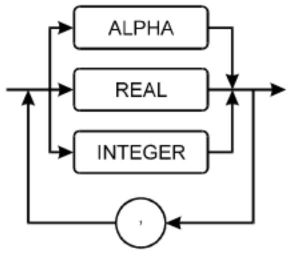


Figure 6-4 GPIB RMU Structure

6.1.5.2 Multiple Items

Some commands will generate an RMU containing more than one item of data (e.g. TRIG will generate a first and second result). In this case, each item of response data will be separated by a comma. Note that the maximum number of characters that can be output is 256, any data beyond this will be lost.

If the command string contained multiple queries then the response will contain multiple RMUs, each of which will be separated by a semicolon.

6.1.5.3 Numeric Format

The format of numeric results will correspond to that used for the instrument display, with the engineering multiplier (if any) replaced by an equivalent 10's exponent. If the FAST-GPIB mode is being used then numbers will be output in a raw engineering format.

6.1.6 Status Reporting

6.1.6.1 Status byte

The status byte is used to summarize information from the other status groups. It is shown in Figure 6-5, which conforms to IEEE 488.2 and SCPI. The status byte can be read by the query command *STB? or by performing a serial poll on the instrument (these two are identical although the point at which the RQS bit can be cleared is slightly different).

BIT	Meaning True = '1'
7	Operation Status Event Register summary bit. This bit is true when measurement or trimming etc., is in progress
6	RQS – ReQuest for Service. When the bit in the Service Request Enable mask is set with the corresponding bit in the status register true, this will trigger a service request to the controller. MSS – Master Summary Status bit. The version of the request for service bit which appears in the Status Byte.
5	ESB – Event Summary Bit. When unmasked by the ESE register, this bit will be set whenever the corresponding bit or bits are set in the Event Status Register.
4	MAV – Message available. The output queue has data to be read.

BIT	Meaning True = ‘1’
3	A summary bit from Questionable Data. This bit is not used, so is always 0.
2	This is a summary bit of error and instrument status messages. True if any new status information is available.
1	Always 0.
0	Always 0.

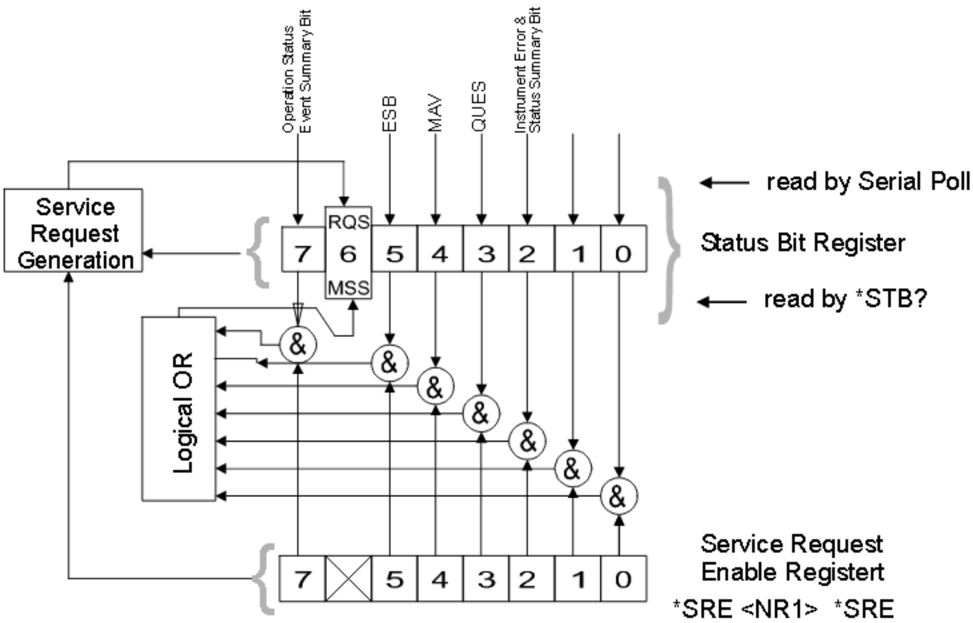


Figure 6-5 Status Byte Register

6.1.6.2 Service Request Enable Register

The service request enable register (SRE) is a mask determining the conditions in which the SBR will generate a service request. It is bit-wise ANDed with the SBR and if the result is not zero then bit 6 of the SBR is set (see Figure 6-5). The SRE is set by the *SRE command and read by the *SRE? command.

6.1.6.3 Standard Event Status Register

The standard event status register (ESR) contains the 8 bits of the operation status report which is defined in IEEE 488.2. If one or more event status bit is set to ‘1’ and their enable bits are also ‘1’, bit 5 (called ESB) of the status register byte is set to ‘1’.

Each bit of the standard event status register is shown below.

BIT	Name	Meaning (True = ‘1’)
7	Power On (PON)	True when the instrument power supply has been turned OFF and then ON since the last time this register was read.
6	User Request (URQ)	Not used. Always 0.
5	Command Error (CME)	True if the following command errors occur: An IEEE 488.2 syntax error occurred. The device received a Group Execute Trigger (GET) inside a program message.
4	Execution Error (EXE)	True when a parameter following a header of a GPIB command was evaluated by the instrument as being outside of its legal input range or is otherwise inconsistent with the instrument’s capabilities.
3	Device Dependent Error (DDE)	True when any bit is set in the Encoded Message Register.
2	Query Error (QYE)	True when attempting to read data from the output buffer in which no data was present, or when the data was lost.
1	Request Control (RQC)	Not used. Always 0.
0	Operation Complete (OPC)	True when the instrument has completed all selected pending operations before sending the *OPC command

Figure 6-6 Standard Event Status Register

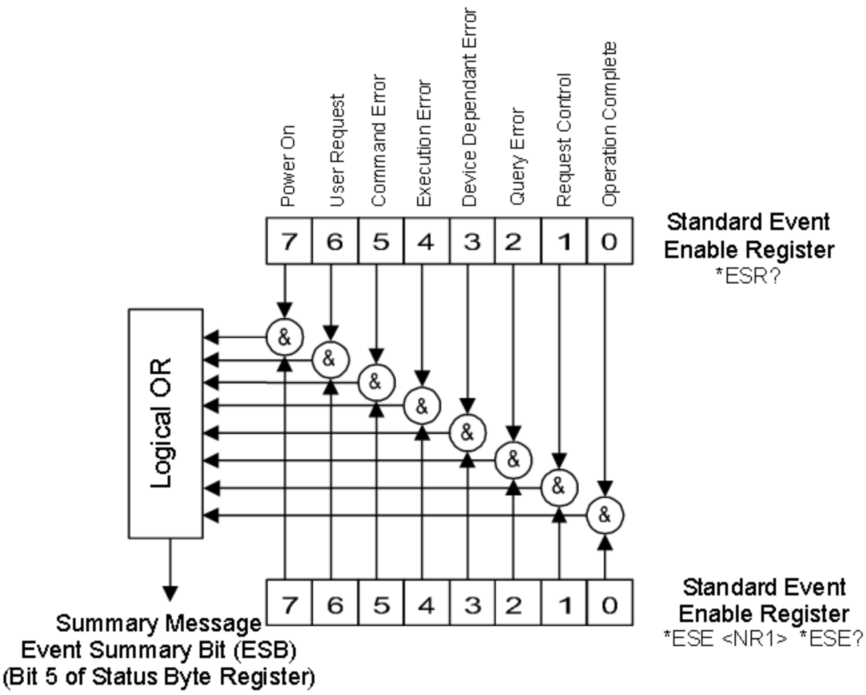


Figure 6-7 Event Status Byte Register

6.1.6.4 Event Status Enable Register

The event status enable register (ESE) is a mask determining the conditions in which the ESR will set bit 5 of the SBR. It is bit-wise ANDed with the ESR and if the result is not zero then ESB (bit 5) of the SBR is set (see Figure 6-7). Thus any event affecting the ESR can be made to generate a Service Request in conjunction with the ERE and the SRE.

The event status enable is set by the *ESE command and read by the *ESE? command.

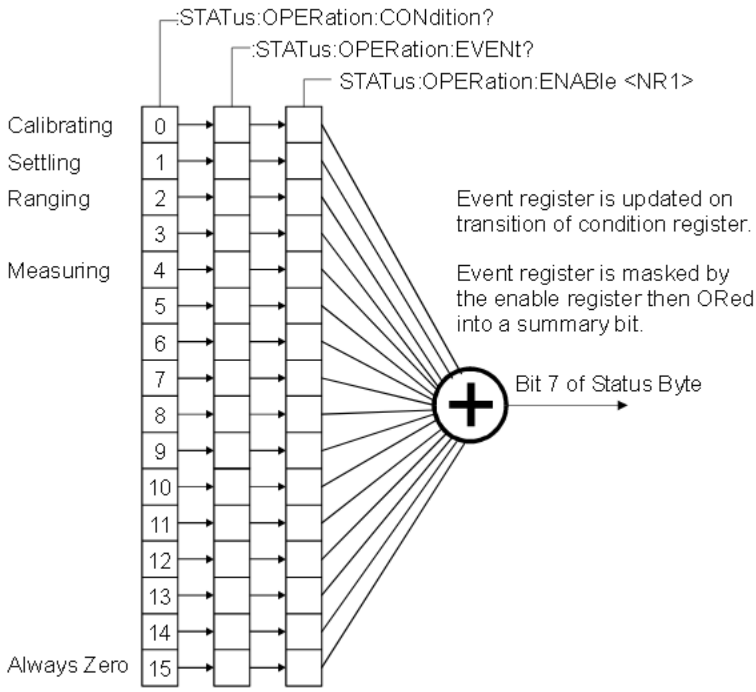


Figure 6-8 Standard Operation Status Group

6.1.6.5 Standard Operation Status Group

The standard operation status group provides information about the state of the measurement systems in the instrument. This status group is accessed through the STATus subsystem. Standard operation status includes a condition register, event register, and an enable register. Figure 6-8 illustrates the structure of standard operation status.

6.1.6.6 Standard Operation Status Condition Register

This is a 16-bit register gathering information about the state of the measurement systems in an instrument. According to SCPI recommendation, we define:

BIT	Meaning (True = ‘1’)
0	Calibrating bit which is true when S/C trimming, O/C trimming, or calibrating is in progress, and otherwise reset.
4	Measuring bit which is true when measurement is in progress, and otherwise reset.

Other bits are unused and are 0.

6.1.6.7 Standard Operation Status Event Register

This is a 16-bit register; each event bit in the event register corresponds to a condition bit in the standard operation status condition register. According to SCPI recommendation, we define:

BIT	Meaning (True = '1')
0	True when S/C trimming, O/C trimming, or calibration measurement is completed.
4	Set true when single shot measurement is completed.

Other bits are uncommitted and are always 0.

6.1.6.8 Encoded Message Register

All front panel warnings and messages can be monitored over the GPIB. There are also several extra flags, otherwise hidden, that are of interest to the bus user.

The encoded message query command returns a string of 8 hexadecimal digits. Each digit represents 4 different errors or their combinations.

The encoded message format is as follows:

D7 D6 D5 D4 D3 D2 D1 D0

D0 indicates range or trim errors

bit0 = Range Error

bit1 = S/C Trim Error

bit2 = O/C Trim Error

bit3 = Calibrate Error

D1 is reserved for future expansion.

D2 indicates errors related to ALC operations.

bit0 = CANNOT SET LEVEL

bit1 = Reserved

bit2 = ALC HELD

bit3 = Reserved

D3 indicates errors related to data entry.

bit0 = Nearest Available

bit1 = Units Mismatched

bit2 = Connection Error

bit3 = Reserved

D4 is reserved.

D5 represents errors related to voltage Bias.

bit0 = Bias overload, Bias Turned Off

bit1 = Reserved

bit2 = Reserved

bit3 = Reserved

D6 is reserved.

D7 is reserved.

Any of the above messages will set bit 2 of the Service Request Register. If ‘Range Error’ or ‘Connection Error’ occurs, pseudo-measurement results ‘999.9E+15, 999.9E+15’ or ‘999.9E+15’ will be produced dependent on the measurement function.

6.1.7 Common Commands

Common commands are listed below. Their detailed description will be given later.

Command	Name	Description
*CLS	Clear Status	Clears the Event Status Register and associated status data structure.
*ESE <NR1>	Event Status Enable	Sets the Event Status Enable Register to the value of the data following the command.
*ESE?	Event Status Enable Query	Returns the current contents of the Standard Event Status Enable Register as an integer in the range 0 to 255.
*ESR?	Event Status Register Query	Returns the current contents of the Standard Event Status Register as an integer in the range 0 to 255. It also clears ESR.
*SRE <NR1>	Service Request Enable	Sets the Service Request Enable Register to the value following the command. The register is set except that bit 6 is ignored.
*SRE?	Service Request Enable Query	Returns the current contents of the Service Request Enable Register as an integer in the range 0 to 63 and 128 to 255.

Command	Name	Description
*STB?	Status Byte Query	Returns the current contents of the Status Byte with the Master Summary bits as an integer in the range 0 to 255. Bit 6 represents Master Summary Status rather than Request Service.
*IDN?	Identification Query	Returns the data identifying the instrument. (e.g. the data output will be: 'Wayne Kerr,6430B,0,1.0' where the first field is the manufacturer, then the model number, then a zero and the software revision number: here represented as Issue 1.0).
*RST	Reset	Resets the instrument to a default setting. This command is equivalent to a power-up reset.
*TRG	Trigger	Triggers a direct measurement, but does not return the results to the controller. This is the same as a GET (Group Execute Trigger) command.
*OPT	Option Identification Query	Returns the hardware options installed in the instrument.
*OPC	Operation Complete Command	Sets the OPC bit of the ESR register.
*OPC?	Operation Complete Query	Always returns 1 as instrument commands are always processed sequentially.
*WAI	Wait-to-continue	Command has no effect as commands are processed sequentially.

6.1.8 Standard Operation Status Commands

Refer to section 6.1.6 for an explanation of the following commands.

Command	Description	Query
	Read Status Operation Condition register.	:STATus:OPERation:CON?
	Read Status Operation Event register	:STATus:OPERation:EVENt?
:STATus:OPERation:ENABle <NR1>	Set Status Operation Enable Register	
	Read Encoded Message Register	:MESSage?

6.2 6430B/6440B Device-Specific Commands

The sub-system commands are grouped in different modes similar to the local operation. The recommended discipline to control the instrument under GPIB is to select the mode and the type of test first, then change the measurement conditions. Trying to change measurement conditions which are not in the present mode and type of test will be rejected and return an error flag.

6.2.1 Command Summary

Command	Summary	Page
:MEAS	Select measurement mode/path.	6–21
:MEAS:TEST	Select test sub-path within measurement mode.	6–21
:MEAS:TEST:AC	Select AC measurement.	6–21
:MEAS:TEST:RDC	Select Rdc measurement.	6–21
:MEAS:TEST?	Measurement test query.	6–22
:MEAS:TRIGger	Trigger an AC or Rdc measurement.	6–22
:MEAS:FREQuency <real>	Set frequency of AC measurement.	6–22
:MEAS:FREQuency?	Frequency query.	6–22
:MEAS:LEVel <real>	Set drive level for currently selected test.	6–23
:MEAS:LEVel?	Drive level query.	6–23
:MEAS:DRIVE?	Test level drive type query.	6–23
:MEAS:BIAS <disc> / <real>	Set the voltage bias condition.	6–24
:MEAS:BIAS-STATus?	Bias status query.	6–24
:MEAS:SPEED <disc>	Select measurement speed.	6–24
:MEAS:SPEED?	Speed query.	6–24
:MEAS:RANGE <disc>	Select auto-ranging or range-hold on range N.	6–25
:MEAS:RANGE?	Range query.	6–25
:MEAS:ALC <disc>	Select the state of Automatic Level Control.	6–25
:MEAS:ALC?	ALC status query.	6–25
:MEAS:EQU-CCT <disc>	Select equivalent circuit.	6–26
:MEAS:EQU-CCT?	Equivalent circuit query.	6–26
:MEAS:FUNC	Select function sub-path within measurement mode.	6–26
:MEAS:FUNC:C, L, X, B, Z, Y, Q, D, R or G	Select first or second AC measurement function.	6–27

Command	Summary	Page
:MEAS:FUNC:MAJOR?	First AC function query.	6–27
:MEAS:FUNC:MINOR?	Second AC function query.	6–28
:MEAS:SCALE <disc>	Show / Hide the scale bar.	6–28
:MEAS:SCALE?	Scale status query.	6–28
:MEAS:NOMinal <real>	Set nominal value for scale.	6–29
:MEAS:NOMinal?	Nominal query.	6–29
:MEAS:LIMIT <disc>	Set percentage or absolute scale limits.	6–29
:MEAS:LIMIT?	Limit type query.	6–29
:MEAS:HIgh-LIMit <real>	Set scale high limit.	6–30
:MEAS:HIgh-LIMit?	High limit query.	6–30
:MEAS:LOw-LIMit <real>	Set scale low limit.	6–30
:MEAS:LOw-LIMit?	Low limit query.	6–30
:DEViation	Select deviation mode/path.	6–31
:DEViation:READout <disc>	Select relative or percentage display readout.	6–31
:DEViation:READout?	Readout type query.	6–31
:DEViation:MEASurement <integer>	Select deviation measurement term.	6–32
:DEViation:MEASurement?	Measurement term query.	6–32
:DEViation:NOMinal <real>	Set deviation nominal.	6–32
:DEViation:NOMinal?	Nominal query.	6–32
:DEViation:TRIGger	Trigger a deviation measurement.	6–33
:BINning	Select binning mode / path.	6–34
:BINning:SET	Select BIN SET mode.	6–34
:BINning:SORT	Select BIN SORT mode.	6–34
:BINning:COUNT	Select BIN COUNT mode.	6–34
:BINning:NOMinal <real>	Set binning mode nominal value.	6–35
:BINning:NOMinal?	Nominal query.	6–35
:BINning:LIMIT <disc>	Select absolute or relative bin limits.	6–35
:BINning:LIMIT?	Limit type query.	6–35
:BINning:BIN <integer>	Select the bin to edit in BIN SET mode.	6–36

Command	Summary	Page
:BINning:BIN?	Query bin for editing.	6–36
:BINning:HIgh-LIMit <real>	Set bin high limit.	6–36
:BINning:HIgh-LIMit?	High limit query.	6–36
:BINning:LOw-LIMit <real>	Set bin low limit.	6–37
:BINning:LOw-LIMit?	Low limit query.	6–37
:BINning:MINOR <real>	Set minor bin limit.	6–37
:BINning:MINOR?	Minor limit query.	6–37
:BINning:DEL-ALL	Reset bin counters.	6–37
:BINning:SAVE <integer>	Save bin limit settings.	6–38
:BINning:LOAD <integer>	Load bin limits settings.	6–38
:BINning:TRIG	Trigger a binning measurement.	6–39
:BINning:DEL-LAST	Remove the last bin result from the bin count tables.	6–39
:BINning:RES?	Return all the current bin counters.	6–39
:MULTI	Select multi-frequency mode / path.	6–40
:MULTI:SET	Switch to the multi-frequency set-up page.	6–40
:MULTI:RUN	Switch to the multi-frequency run page.	6–40
:MULTI:TEST	Select the frequency step to edit.	6–41
:MULTI:TEST?	Return the number of the step that is currently being edited.	6–41
:MULTI:FREQuency <real>	Set the frequency for the currently selected step.	6–41
:MULTI:FREQuency?	Returns the frequency of the currently selected step.	6–41
:MULTI:HIgh-LIMit <real>	Set the higher test limit of the currently selected step.	6–42
:MULTI:HIgh-LIMit?	Returns the high limit value of the currently selected step.	6–42
: MULTI:LOw-LIMit <real>	Set the lower test limit of the currently selected step.	6–42
: MULTI:LOw-LIMit?	Returns the low limit value of the currently selected step.	6–42
: MULTI:MINor <real>	Set the minor test limit of the currently selected step.	6–43
: MULTI:MINor?	Returns the minor limit value of the currently selected step.	6–43
:MULTI:NOMinal <real>	Set the multi-frequency nominal value.	6–43
:MULTI:NOMinal?	Returns the multi-frequency nominal value.	6–43
:MULTI:LIMIT <disc>	Selects absolute or percentage limits checking.	6–44

Command	Summary	Page
:MULTI:LIMIT?	Returns the current limits checking mode.	6–44
:MULTI:DEL	Remove the current frequency.	6–44
:MULTI:SORT <disc>	Sorts the current frequency list into the required order.	6–45
:MULTI:TRIGger	Starts a run of multi-frequency measurements.	6–45
:MULTI:RES? <integer>	Query the result of the selected frequency step.	6–45
:GRAPH	Select graphing mode / path.	6–46
:GRAPH:StarT <real>	Set the start frequency for the sweep.	6–46
:GRAPH:StarT?	Returns the start frequency of the sweep.	6–46
:GRAPH:StoP <real>	Set the stop frequency for the sweep.	6–46
:GRAPH:StoP?	Returns the stop frequency of the sweep.	6–46
:GRAPH:LOGF <disc>	Selects the frequency scale type.	6–47
:GRAPH:LOGF?	Returns the current frequency scale type.	6–47
:GRAPH:LOGY <disc>	Selects the measurement scale type.	6–47
:GRAPH:LOGY?	Returns the current measurement scale type.	6–47
:GRAPH:LIMIT <disc>	Selects absolute or relative plotting.	6–48
:GRAPH:LIMIT?	Returns the current graph plotting mode.	6–48
:GRAPH:MarKer?	Returns the first and second measurement from the current	6–48
:GRAPH:MarKerF <real>	Move the marker to the frequency nearest the supplied value.	6–49
:GRAPH:MarKerF?	Returns the current marker frequency.	6–49
:GRAPH:MAJor-LOw <real>	Set the Y-axis start point for the first measurement type.	6–49
:GRAPH:MAJor-LOw?	Query the current Y-axis start point for the first measurement	6–49
:GRAPH:MAJor-HIgh <real>	Set the Y-axis stop point for the first measurement type.	6–50
:GRAPH:MAJor-High?	Query the current Y-axis stop point for the first measurement type.	6–50
:GRAPH:MINor-LOw <real>	Set the Y-axis start point for the second measurement type.	6–50
:GRAPH:MINor-LOw?	Query the current Y-axis start point for the second	6–50
:GRAPH:MINor-HIgh <real>	Set the Y-axis stop point for the second measurement type.	6–51
:GRAPH:MINor-High?	Query the current Y-axis stop point for the second	6–51
:GRAPH:NOMinal <real>	Set the nominal value for use when graphs are being plotted	6–51
:GRAPH:NOMinal?	Returns the current graph nominal.	6–51

Command	Summary	Page
:GRAPH:TERM <integer>	Set which measurement will be shown/viewed.	6–52
:GRAPH:TERM?	Query the current measurement selection.	6–52
:GRAPH:STEP <integer>	Select the number of pixels between each measured point on	6–52
:GRAPH:STEP?	Query the current step size for the plot.	6–52
:GRAPH:SET	Go to the graph mode set-up page.	6–53
:GRAPH:VIEW	Redraw the graph.	6–53
:GRAPH:FIT	Fit the Y-axis scale to the current measurement data.	6–53
:GRAPH:TRIG	Start plotting a graph with the current settings.	6–53
:GRAPH:PEAK	Move the marker to the highest point on the current graph.	6–54
:GRAPH:DIP	Move the marker to the lowest point on the current graph.	6–54
:GRAPH:PRINT	Print the current graph on an Epson compatible printer.	6–54
:CAP	Select capacitor mode / path.	6–55
:CAP:SET	Switch to the capacitor mode set-up page.	6–55
:CAP:RUN	Switch to the capacitor mode run page.	6–55
:CAP:LEARN	Learn component.	6–55
:CAP:RESET	Clear learnt component data.	6–56
:CAP:DELETE	Delete test.	6–56
:CAP:TEST <integer>	Select the capacitor mode test	6–56
:CAP:TEST?	Return the number of the test that is currently being edited.	6–56
:CAP:FREQuency <real>	Set the frequency for the currently selected step.	6–57
:CAP:FREQuency?	Returns the frequency of the currently selected step.	6–57
:CAP: RANGE <disc>	Select the measurement range.	6–57
:CAP:RANGE?	Range query.	6–57
:CAP:MAJOR	Set Major test	6–58
:CAP:MAJOR?	Query Major test type	6–58
:CAP:MINOR	Set Minor test	6–58
:CAP:MINOR?	Query Minor test type	6–58
:CAP:EQU-CCT <disc>	Select equivalent circuit.	6–59
:CAP:EQU-CCT?	Equivalent circuit query.	6–59

Command	Summary	Page
:CAP:BIN <integer>	Select bin	6–59
:CAP:BIN?	Query selected bin	6–59
:CAP:HI-LIM <real>	Set bin high limit.	6–60
:CAP:HI-LIM?	High limit query.	6–60
:CAP:LO-LIM <real>	Set bin low limit.	6–60
:CAP:LO-LIM?	Low limit query.	6–60
:CAP:MINOR-LIM <real>	Set minor limit.	6–60
:CAP:MINOR-LIM?	Minor limit query.	6–60
:CAP:TOGGLE	Swap major and minor test types	6–61
:CAP:TRIGGER	Starts a run of multi-frequency measurements.	6–61
:CAP:RES? <integer>	Return results for a specified test.	6–62
:CAP:VERBOSE <disc>	Full or just bin results returned.	6–62
:RESOnance	Enter resonance mode / path.	6–63
:RESOnance:StarT <real>	Set the start frequency for the search.	6–63
:RESOnance:StarT?	Returns the start frequency of the search.	6–63
:RESOnance:StoP <real>	Set the stop frequency for the search.	6–63
:RESOnance:StoP?	Returns the stop frequency of the search.	6–63
:RESOnance:EQU-CCT <disc>	Select the equivalent circuit type for resonance search.	6–64
:RESOnance:EQU-CCT?	Returns the currently selected equivalent circuit.	6–64
:RESOnance:TRIG	Begin a resonance search.	6–64
:RESOnance:EXTRP <disc>	Extrapolate resonance if outside set frequencies	6–65
:RESOnance:EXTRP?	Indicates whether readings may be extrapolated or not.	6–65
:RESOnance:DEPTH <integer>	Set resonance search depth.	6–65
:RESOnance:DEPTH?	Returns the currently set resonance search depth.	6–65
:RESOnance:SPEED <disc>	Measurement speed for final resonance measurements.	6–66
:RESOnance:SPEED?	Measurement speed for final resonance measurements.	6–66
:CAL	Select calibrate mode / path.	6–67
:CAL:OC-TRIM <integer>	Perform open circuit trimming.	6–67
:CAL:SC-TRIM <integer>	Perform short circuit trimming.	6–68

Command	Summary	Page
:CAL:HF-CAL	Perform HF lead compensation.	6–68
:CAL:SELF-CAL	Perform self-calibration.	6–68
:CAL:RES?	Returns the result of the calibration performed.	6–69
:TRIGger	Trigger a measurement in the current mode.	6–70
:LOC-TRIG <disc>	Select local trigger condition.	6–70
:LOC-TRIG?	Query the local trigger condition.	6–70
:REPeat <disc>	Enable repetitive measurements when unit is returned to local	6–71
:REPeat?	Query trigger status.	6–71
:TERMinal <integer>	Select 2 or 4 terminal measurements.	6–71
:TERMinal?	Query the current terminal setting.	6–71
:SETUP <disc>	Select set-up view ON and OFF.	6–72
:SETUP?	Query the current set-up mode.	6–72
:FAST-GPIB <disc>	Select fast GPIB mode.	6–72
:FAST-GPIB?	Query fast GPIB mode.	6–72
:MODE?	Query the currently selected operating mode.	6–73
:DUMP-BMP	Returns the display as a windows compatible bitmap.	6–73

MEASUREMENT MODE

:MEAS

Select measurement mode.

Parameters:

None.

Response:

None.

:MEAS:TEST

Select test sub-path within measurement mode.

Parameters:

None.

Response:

None.

:MEAS:TEST:AC

Select AC measurement.

Parameters:

None.

Response:

None.

:MEAS:TEST:RDC

Select Rdc measurement.

Parameters:

None.

Response:

None.

MEASUREMENT MODE

:MEAS:TEST?

Measurement test query.

Parameters:

None.

Response:

0 AC measurement type.

1 Rdc measurement type.

:MEAS:TRIGger

Trigger a measurement using the current settings.

Parameters:

None.

Response:

For AC measurements the response will be the first and second measurements separated by a comma.
Example: `68.860E-9 , 13.0E+6`

For Rdc measurements the response will be a single measurement result.
Example: `6.2295E+3`

:MEAS:FREQuency <real>

Set frequency of AC measurement.

Parameters:

The required frequency in Hertz. The unit suffix ‘Hz’ is optional.

Example: MEAS:FREQ 1k

MEAS:FREQ 1000 Hz

MEAS:FREQ 1E3

are all equivalent commands and set the test frequency to 1kHz.

Response:

None.

:MEAS:FREQuency?

Returns the current AC test frequency.

Parameters:

None.

Response:

Returns the current test frequency in engineering format.

Example: +.10000000E+04

for a test frequency of 1kHz.

MEASUREMENT MODE

:MEAS:LEVel <real>

Set drive level for currently selected test.

Parameters:

For AC tests supply the required drive level in either Volts or Amps.

Example: MEAS:LEV 1.2V

MEAS:LEV 1E-2A

will select drive levels of 1.2V and 10mA respectively.

For Rdc tests the only valid drive levels are 1V and 100mV.

Example: MEAS:LEV 1V

MEAS:LEV 0.2V

The latter will select a level of 100mV, as that is the nearest available test level. Note that the unit defines what type of drive will be used, if none is supplied then the drive type will remain unchanged.

Response:

None.

:MEAS:LEVel?

Drive level query.

Parameters:

None.

Response:

Returns the current test level in engineering format.

Example: +.20000000E-01

for a test level of 20mV.

:MEAS:DRIVE?

Test level drive type query.

Parameters:

None:

Response:

0 Current drive.

255 Voltage drive.

MEASUREMENT MODE

:MEAS:BIAS <disc> / <real>

Set the voltage bias condition.

Parameters:

`ON`	Turn on voltage bias.
`OFF`	Turn off voltage bias.
`VINT`	Select internal voltage bias drive.
`VEXT`	Select external voltage bias drive.

Example: `MEAS:BIAS VINT`

`MEAS:BIAS ON`

will select internal voltage bias and turn it on.

Response:

None.

:MEAS:BIAS-STATus?

Returns the current voltage bias status.

Parameters:

None.

Response:

Returns bias status in two integers delimited by a comma:

First integer:	0 Voltage bias OFF.
	1 Voltage bias ON.
Second integer:	0 Internal bias.
	1 External bias.

Example: `1,0`

would indicate that internal voltage bias is turned on.

:MEAS:SPEED <disc>

Select the required measurement speed.

Parameters:

`MAX`	Maximum speed.
`FAST`	Fast speed.
`MED`	Medium speed.
`SLOW`	Slow speed.

Example: `:MEAS:SPEED SLOW`

will select slow speed for measurements.

Response:

None.

:MEAS:SPEED?

Returns the current test speed.

Parameters:

None.

Response:

Returns the test speed as an integer according to the table:

`0`	Maximum
`1`	Fast
`2`	Medium
`3`	Slow

Example: `1`

indicates that Fast measurements are selected.

MEASUREMENT MODE

:MEAS:RANGE <disc>

Select the required measurement range condition for AC and RDC tests.

Parameters:

The following parameters are valid:

`AUTO`	Auto-ranging.
`HOLD`	Hold current range.
`1 to 8`	Range 1 to 8 for AC
`1 to 5`	Range 1 to 5 for Rdc

Example: `MEAS:RANGE 1`

`MEAS:RANGE AUTO`

will select range 1 and auto-ranging respectively.

Response:

None.

:MEAS:RANGE?

Returns the current measurement range.

Parameters:

None.

Response:

Returns the measurement range as an integer according to this table:

`0`	Auto-ranging.
`1-8`	Current measurement range.

Example: `0`

indicates that auto ranging is selected.

:MEAS:ALC <disc>

Select the state of Automatic Level Control for AC tests.

Parameters:

The following parameters are valid:

`ON`	ALC on.
`OFF`	ALC off.
`HOLD`	Hold current ALC level.

Example: `MEAS:ALC OFF`

will turn off ALC.

Response:

None.

:MEAS:ALC?

Returns the Automatic Level Control condition.

Parameters:

None.

Response:

Returns the ALC state according to this table:

`0`	OFF.
`1`	ON.
`2`	HELD.

Example: `2`

indicates that ALC is currently held.

MEASUREMENT MODE

:MEAS:EQU-CCT <disc>

Select the equivalent circuit type for AC tests.

Parameters:

The following parameters are valid:

`SER`	Series equivalent circuit.
`PAR`	Parallel equivalent circuit.

Example: `:MEAS:EQU-CCT SER`

will select the series equivalent circuit.

Response:

None.

:MEAS:EQU-CCT?

Returns the currently selected equivalent circuit.

Parameters:

None.

Response:

Returns the equivalent circuit flag according to this table:

`0`	Parallel.
`1`	Series.

Example: `0`

indicates the parallel equivalent circuit is selected.

:MEAS:FUNC

Select function sub-path within measurement mode.

Parameters:

None.

Response:

None.

MEASUREMENT MODE

:MEAS:FUNC:C, L, X, B, Z, Y, Q, D, R, G

Select first or second AC measurement function.

Selecting first measurement:

`:MEAS:FUNC:C`	Capacitance.
`:MEAS:FUNC:L`	Inductance.
`:MEAS:FUNC:X`	Reactance.
`:MEAS:FUNC:B`	Susceptance.
`:MEAS:FUNC:Z`	Impedance.
`:MEAS:FUNC:Y`	Admittance.

Selecting second measurement:

`:MEAS:FUNC:Q`	Quality factor.
`:MEAS:FUNC:D`	Dissipation factor.
`:MEAS:FUNC:R`	Resistance.
`:MEAS:FUNC:G`	Conductance.

Note that selecting Z or Y as the first measurement will force the second measurement to be Angle. This does not change the equivalent circuit flag setting.

Example: `:MEAS:FUNC:C;D`

will select C+D measurements.

:MEAS:FUNC:MAJOR?

First AC function query.

Parameters:

None.

Response:

Returns the measurement type according to this table:

`0`	Capacitance
`1`	Inductance.
`2`	Reactance.
`3`	Susceptance.
`4`	Impedance.
`5`	Admittance.

Example: `4`

indicates that the first measurement is impedance (Z).

MEASUREMENT MODE

:MEAS:FUNC:MINOR?

Second AC function query.

Parameters:

None.

Response:

Returns the measurement type according to this table:

`0` Q-Factor.

`1` D-Factor.

`2` Resistance.

`3` Conductance.

Example: `1`

indicates that the second measurement is dissipation factor (D). Note that if the first measurement is polar (Z or Y), this query will return the last non-polar setting.

:MEAS:SCALE <disc>

Show / Hide the scale bar.

Parameters:

The following parameters are valid:

`ON` Show scale.

`OFF` Hide scale.

Example: `:MEAS:SCALE OFF`

will turn off the scale.

Response:

None.

:MEAS:SCALE?

Returns the current status of the scale bar.

Parameters:

None.

Response:

Returns scale setting according to this table:

`0` Scale hidden.

`1` Scale visible.

Example: `0`

indicates that the scale is currently hidden.

MEASUREMENT MODE

:MEAS:NOMinal <real>

Set nominal value for scale.

Parameters:

The required nominal value. If a unit is supplied it must that of either the first or second measurement otherwise the unit mismatch error will be set. If no unit is supplied the current nominal unit will be used.

Examples:

`:MEAS:NOMINAL 1e-6F`
will set a nominal of 1µF.

`:MEAS:NOMINAL 0.47e-5`
will set a nominal of 4.7µF

Response:

None.

:MEAS:NOMinal?

Returns the scale bar graph nominal value.

Parameters:

None.

Response:

Returns the nominal in engineering format.

Example: `+.10000000E-01`

would indicate a nominal of 10mH if the first nominal unit is Henrys.

:MEAS:LIMIT <disc>

Set percentage or absolute scale limits.

Parameters:

The following discrete parameters are valid:

`ABS`	Absolute limits.
`PERC`	Percentage limits.

Example: `:MEAS:LIMIT PERC`

will select percentage limits.

Response:

None.

:MEAS:LIMIT?

Limit type query.

Parameters:

None.

Response:

Returns the scale bar limits according to this table:

`0`	Absolute scale.
`1`	Percentage scale.

Example: `0`

indicates that the scale bar currently has absolute limits.

MEASUREMENT MODE

:MEAS:HIgh-LIMit <real>

Set scale high limit.

Parameters:

The required high limit. No unit should be supplied: the nominal unit is used.

Example: `:MEAS:HI-LIM 5.0`

will set a high limit of +5.0% of nominal.

Response:

None.

:MEAS:HIgh-LIMit?

Returns the current scale bar percentage high limit.

Parameters:

None.

Response:

The current high limit in engineering format.

Example: `+.25000000E+01`

indicating a high limit of +2.5% of nominal.

:MEAS:Low-LIMit <real>

Set scale low limit.

Parameters:

The required low limit. No unit should be supplied: the nominal unit is used.

Example: `:MEAS:LO-LIM -5.0`

will set a low limit of -5.0% of nominal.

Response:

None.

:MEAS:LOw-LIMit?

Returns the current scale bar percentage low limit.

Parameters:

None.

Response:

The current low limit in engineering format.

Example: `-.20000000E+01`

indicating a high limit of -2.0% of nominal.

DEVIATION MODE

:DEViation

Select deviation mode. All commands available in measurement mode, except for those that control the scale bar, are available in deviation mode, and have exactly the same effect.

Example: :DEV:FREQ 1000

Will select a test frequency of 1kHz in deviation mode.

Parameters:

None.

Response:

None.

:DEViation:READout <disc>

Selects relative or percentage display readout.

Parameters:

The following discrete parameters are valid:

`REL` Absolute display relative to nominal.

`PERC` Percentage display.

Example: :DEV:READ PERC

Will set the display to read out as a percentage deviation from nominal.

Response:

None.

:DEViation:READout?

Readout type query.

Parameters:

None.

Response:

`1` Absolute display relative to nominal.

`2` Percentage display.

Example: `1`

indicates that the display is set to read out as an absolute deviation from a nominal.

DEVIATION MODE

:DEViation:MEASurement <integer>

Selects the deviation measurement term.

Parameters:

The following discrete parameters are valid:

`1` Deviate on the first measurement.

`2` Deviate on the second measurement.

Example: `:DEV:FUNC:C;D;:DEV:MEAS 1`

will select C+D measurements with the deviation term set to C.

Response:

None.

:DEViation:MEASurement?

Measurement term query.

Parameters:

None.

Response:

The following discrete parameters are valid:

`1` Absolute display relative to nominal.

`2` Percentage display.

Example: 2

Indicates that the second measurement is being used for deviation.

:DEViation:NOMinal <real>

Set deviation nominal.

Parameters:

The required nominal value only. No unit should be supplied: the unit of the selected deviation measurement is used.

Example: `:MEAS:NOMINAL 1e3`

will select a nominal of 1kΩ if for example Z+Angle measurements are selected.

Response:

None.

:DEViation:NOMinal?

Nominal query.

Parameters:

None.

Response:

Returns the nominal in engineering format.

Example: `+.10000000E-01`

will indicate a nominal of 10mH if the deviation measurement is inductance.

DEVIATION MODE

:DEViation:TRIGger

Trigger a measurement in deviation mode.

Parameters

None.

Response:

Returns the currently selected deviation measurement as a deviation and the other measurement as an absolute reading, separated by a comma.

Example: `2.3, 0.20`

indicates a 2.3Ω deviation from nominal for a 1kΩ nominal resistor. Likewise if the second measurement is the deviation term:

`68.210E-9, 5.10`

would indicate a 5.1Ω deviation from nominal on the resistance of a 68nF capacitor.

BINNING MODE

:BINning

Select binning mode / path. As with the manual use of binning mode the test set-up is defined by the current settings in measurement mode.

Parameters:

None.

Response:

None.

:BINning:SET

Select BIN SET mode, this mode is used to set-up the test limits.

Parameters:

None.

Response:

None.

:BINning:SORT

Select BIN SORT mode, in this mode the test result and allocated bin number are displayed.

Parameters:

None.

Response:

None.

:BINning:COUNT

Select BIN COUNT mode, in this mode the total number of components sorted into each bin are displayed.

Parameters:

None.

Response:

None.

BIN SET MODE

:BINning:NOMinal <real>

Set binning mode nominal value.

Parameters:

The required bin nominal value. No unit is required: the measurement mode unit is used.

Example `:BIN:NOM 68e-9`

will set a nominal value of 68nF.

Response:

None.

:BINning:NOMinal?

Nominal query.

Parameters:

None.

Response:

Returns the nominal in engineering format.

Example: `+.68000002E-07`

would indicate a nominal of 68nF if the measurement is capacitance

:BINning:LIMIT <disc>

Selects absolute or percentage limits checking.

Parameters:

The following discrete parameters are valid:

`ABS`	Absolute limits.
`PERC`	Limits as a percentage of nominal.

Example: `:BIN:LIMIT PERC`

will set the test limits to a percentage of the nominal value.

Response:

None.

:BINning:LIMIT?

Limit type query.

Parameters:

None.

Response:

`1`	Absolute limits.
`2`	Percentage limits.

Example: `1`

indicates that components will be tested against limits that are a percentage of the nominal value.

BIN SET MODE

:BINning:BIN <integer>

Select the bin to edit in BIN SET mode.

Parameters:

The bin number in the range 0 to 8.

Example: `:BIN:BIN 3`

will select bin 3 for editing.

Response:

None.

:BINning:BIN?

Query bin for editing.. In BIN SET mode this returns the number of the bin currently being edited.

Parameters:

None.

Response:

The bin number in the range 0 to 8.

Example: `5`

indicates that the settings for bin number 5 are those currently being edited.

:BINning:HIgh-LIMit <real>

Set bin high limit.

Parameters:

The required high limit.

Example: `:BIN:HI-LIM 10.0`

will set a high limit of 10% when percentage limits are selected.

Response:

None.

:BINning:HIgh-LIMit?

High limit query.

Parameters:

None.

Response:

The high limit value in engineering format.

Example: `+.50000000E+01`

indicates a high limit of +5% when percentage limits are selected.

BIN SET MODE

:BINning:LOw-LIMit <real>

Set bin low limit.

Parameters:

The required lower limit.

Example: `:BIN:LO-LIM -10.0`

will set a low limit of -10% when percentage limits are selected.

Response:

None.

:BINning:LOw-LIMit?

Low limit query.

Parameters:

None.

Response:

The low limit value in engineering format.

Example: `-.50000000E+01`

indicates a high limit of -5% when percentage limits are selected.

:BINning:MINOR <real>

Set minor bin limit.

Parameters:

The required limit.

Example: `:BIN:MINOR 1.0`

will set a low limit of 1.0 for the minor test.

Response:

None.

:BINning:MINOR?

Minor limit query.

Parameters:

None.

Response:

The minor limit value in engineering format.

Example: `.10000000E+01`

indicates a minor limit of 1.0.

:BINning:DEL-ALL

Reset bin counters.

Parameters:

None.

Response:

None.

BIN SET MODE

:BINning:SAVE <integer>

Save bin limit settings.

Parameters:

The memory store to use in the range 0 to 99.

Example: `:BIN:SAVE 2`

will save the current bin limits to memory store number 2.

Response:

None.

:BINning:LOAD <integer>

Load bin limits settings.

Parameters:

The memory store to use in the range 0 to 99.

Example: `:BIN:LOAD 1`

will load the set-up currently stored in memory number 1.

Response:

None.

BIN SORT AND BIN COUNT MODES

:BINning:TRIG

Trigger a measurement in BIN SORT or BIN COUNT mode.

Parameters:

None.

Response:

In BIN SORT mode the measurement result and bin number are returned.

Example: `69.36E-9 , 0.0001, 3`

where the first two fields are the measurement result and the trailing integer is the allocated bin store.

In BIN COUNT mode only the result bin is returned.

Example: `3`

indicating that the component met the characteristics of bin 3.

:BINning:DEL-LAST

Remove the last bin result from the count tables in BIN count mode.

Parameters:

None.

Response:

None.

:BINning:RES?

Return all the current bin counters.

Parameters:

None.

Response:

The cumulative counts of all the bins 0 to 8, the reject bin and the total number of components tested are returned in comma delimited form.

Example: `4, 3, 2, 6, 3, 7, 8, 2, 5, 1, 34`

indicating a total of 34 components tested with 1 reject and bins 0 through 8 containing 4, 3, 2, 6, 3, 7, 8, 2, 5 components respectively.

MULTI-FREQUENCY MODE

:MULTI

Select multi-frequency mode / path.

Parameters:

None.

Response:

None.

:MULTI:SET

Switch to the multi-frequency set-up page.

Parameters:

None.

Response:

None.

:MULTI:RUN

Switch to the multi-frequency run page.

Parameters:

None.

Response:

None.

MULTI-FREQUENCY MODE

:MULTI:TEST

Select the frequency step to edit.

Parameters:

The frequency number in the range 0 to 7.

Example: `:MULTI:TEST 0`

will select the top frequency for editing

Response:

None.

:MULTI:TEST?

Return the number of the step that is currently being edited.

Parameters:

None.

Response:

The frequency number in the range 0 to 7.

Example: `7`

would indicate the last frequency is selected for editing.

:MULTI:FREQuency <real>

Set the frequency for the currently selected step.

Parameters:

The required frequency in Hertz. The unit suffix 'Hz' is optional.

Example: `MEAS:FREQ 1k`

will set the selected frequency to 1kHz

Response:

None.

:MULTI:FREQuency?

Returns the frequency of the currently selected step.

Parameters:

None.

Response:

Returns the current test frequency in engineering format.

Example: `+.10000000E+04`

for a test frequency of 1kHz.

MULTI-FREQUENCY MODE

:MULTI:HIgh-LIMit <real>

Set the higher test limit of the currently selected step.

Parameters:

The required higher limit.

example: `:BIN:HI-LIM 10.0`

will set a high limit of 10% when percentage limits are selected.

Response:

None.

:MULTI:HIgh-LIMit?

Returns the high limit value of the currently selected step.

Parameters:

None.

Response:

The high limit value in engineering format.

Example: `+.50000000E+01`

indicates a high limit of +5% when percentage limits are selected.

: MULTI:LOw-LIMit <real>

Set the lower test limit of the currently selected step.

Parameters:

The required lower limit.

Example: `:BIN:LO-LIM -10.0`

will set a low limit of -10% when percentage limits are selected.

Response:

None.

: MULTI:LOw-LIMit?

Returns the low limit value of the currently selected step.

Parameters:

None.

Response:

The low limit value in engineering format.

Example: `-.50000000E+01`

indicates a high limit of -5% when percentage limits are selected.

MULTI-FREQUENCY MODE

: MULTI:MINor <real>

Set the minor test limit of the currently selected step.

Parameters:

The required limit.

Example: `:BIN:MINOR 1.0`

will set a low limit of 1.0 for the minor test.

Response:

None.

: MULTI:MINor?

Returns the minor limit value of the currently selected step.

Parameters:

None.

Response:

The minor limit value in engineering format.

Example: `.10000000E+01`

indicates a minor limit of 1.0.

:MULTI:NOMinal <real>

Set the multi-frequency nominal value.

Parameters:

The required nominal value, no unit is required: the measurement mode unit is used.

Example `:MULTI:NOM 33e-9`

will set a nominal value of 33nF.

Response:

None.

:MULTI:NOMinal?

Returns the multi-frequency nominal value.

Parameters:

None.

Response:

Returns the nominal in engineering format.

Example: `+.68000002E-07`

would indicate a nominal of 68nF if the measurement is capacitance.

MULTI-FREQUENCY MODE

:MULTI:LIMIT <disc>

Selects absolute or percentage limits checking.

Parameters:

The following discrete parameters are valid:

`OFF`	No limits.
`ABS`	Absolute limits.
`PERC`	Limits as a percentage of nominal.

Example: `:MULTI:LIMIT PERC`

will set the test limits to a percentage of the nominal value.

Response:

None.

:MULTI:LIMIT?

Returns the current limits checking mode.

Parameters:

None.

Response:

`0`	No limits.
`1`	Absolute limits.
`2`	Percentage limits.

Example: `1`

indicates that components will be tested against limits that are a percentage of the nominal value.

:MULTI:DEL

Remove the current frequency.

Parameters:

The frequency number in the range 0 to 7

Example: `MULTI:DEL 0`

will delete the top frequency.

Response:

None.

MULTI-FREQUENCY MODE

:MULTI:SORT <disc>

Sorts the current frequency list into the required order.

Parameters:

The required sort order.

`UP` Ascending frequency.

`DOWN` Descending frequency.

Example: `MULTI:SORT UP`

will sort the frequencies in ascending order.

Response:

None.

:MULTI:TRIGger

Starts a run of multi-frequency measurements.

Parameters:

None.

Response:

None.

:MULTI:RES? <integer>

Query the result of the selected frequency step.

Parameters:

The frequency number in the range 0 to 7

Response:

The first and second result separated by a comma, if the result is being checked against limits (absolute or percentage) the PASS/FAIL flag will prefix the result.

Examples: `1, +.68898363E-07, +.72168059E-04`
would indicate a pass result on a 68nF capacitor.

`+.68898363E-07, +.72168059E-04`
would be the result if limits were not being checked.

GRAPH MODE (6440 only)

:GRAPH

Select graphing mode / path.

Parameters:

None.

Response:

None.

:GRAPH:StarT <real>

Set the start frequency for the sweep.

Parameters:

The required frequency in Hertz. The unit suffix ‘Hz’ is optional.

Example: `:GRAPH:ST 1k`

will set the start frequency to 1kHz.

Response:

None.

:GRAPH:StarT?

Returns the start frequency of the sweep.

Parameters:

None.

Response:

Returns the start frequency in engineering format.

Example: `+.10000000E+05`

for a start frequency of 10kHz.

:GRAPH:StoP <real>

Set the stop frequency for the sweep.

Parameters:

The required frequency in Hertz. The unit suffix ‘Hz’ is optional.

Example: `:GRAPH:SP 100k`

will set the stop frequency to 100kHz.

Response:

None.

:GRAPH:StoP?

Returns the stop frequency of the sweep.

Parameters:

None.

Response:

Returns the stop frequency in engineering format.

Example: `+.125000000E+06`

for a start frequency of 125kHz.

GRAPH MODE (6440 only)

:GRAPH:LOGF <disc>

Selects the frequency scale type.

Parameters:

The required scale type:

`ON` Logarithmic scale.

`OFF` Linear scale.

Example: `GRAPH:LOGF ON`

will select the logarithmic frequency scale.

Response:

None.

:GRAPH:LOGF?

Returns the current frequency scale type.

Parameters:

None.

Response:

The current scale type:

`1` Logarithmic scale.

`0` Linear scale.

Example: `0`

would indicate that the linear frequency scale is selected.

:GRAPH:LOGY <disc>

Selects the flag for the measurement scale type.

Parameters:

The required scale type:

`ON` Logarithmic scale.

`OFF` Linear scale.

Example: `GRAPH:LOGY ON`

will select the logarithmic scaling of the Y-axis (available for Z, Y only).

Response:

None.

:GRAPH:LOGY?

Returns the flag for the measurement scale type.

Parameters:

None.

Response:

The current scale type:

`1` Logarithmic scale.

`0` Linear scale.

Example: `1`

would indicate that logarithmic scaling of the Y-axis will be used if Z or Y is selected.

GRAPH MODE (6440 only)

:GRAPH:LIMIT <disc>

Selects absolute or relative plotting.

Parameters:

The following discrete parameters are valid:

`ABS` Absolute plot.

`PERC` Plot as a percentage of nominal.

Example: `:GRAPH:LIMIT ABS`

will select plotting of the absolute measurement result.

Response:

None.

:GRAPH:LIMIT?

Returns the current graph plotting mode.

Parameters:

None.

Response:

`0` Absolute plotting.

`1` Percentage plotting.

Example: `1`

indicates that the graph will be plotted with the results calculated as a percentage of the nominal value.

:GRAPH:MarKer?

Returns the first and second measurement from the current marker position.

Parameters:

None.

Response:

The results in engineering format, separated by a comma.

Example: +.10666955E-06, +.11760951E+01

GRAPH MODE (6440 only)

:GRAPH:MarKerF <real>

Move the marker to the frequency nearest to the supplied value.

Parameters:

The required frequency in Hertz. The unit suffix ‘Hz’ is optional.

Example: `GRAPH:MKF 10k`

will move the marker to the point nearest to 10kHz.

Response:

None.

:GRAPH:MarKerF?

Returns the current marker frequency.

Parameters:

None.

Response:

Returns the marker frequency in engineering format.

Example: `+.100000000E+04`

for a marker frequency of 1kHz.

:GRAPH:MAJor-LOw <real>

Set the Y-axis minimum for the first measurement type.

Parameters:

The required start value.

Example: `:GRAPH:MAJ-LO 10.0`

will set the minimum to 10.

Response:

None.

:GRAPH:MAJor-LOw?

Query the current Y-axis minimum for the first measurement type.

Parameters:

None.

Response:

The current minimum in engineering format.

Example: `+.95000006E-04`

would indicate that the Y-axis will start at 95µF for example.

GRAPH MODE (6440 only)

:GRAPH:MAJor-HIgh <real>

Set the Y-axis maximum for the first measurement type.

Parameters:

The required maximum value.

Example: `:GRAPH:MAJ-HI 1000.0`

will set the end point to 1k.

Response:

None.

:GRAPH:MAJor-High?

Query the current Y-axis maximum for the first measurement type.

Parameters:

None.

Response:

The current maximum in engineering format.

Example: `+.105000006E-03`

would indicate that the Y-axis will stop at 105µF for example.

:GRAPH:MINor-LOw <real>

Set the Y-axis minimum for the second measurement type.

Parameters:

The required minimum value.

Example: `:GRAPH:MIN-LO 0.0`

will set the minimum to zero.

Response:

None.

:GRAPH:MINor-LOw?

Query the current Y-axis minimum for the second measurement type.

Parameters:

None.

Response:

The current minimum in engineering format.

Example: `+.100000000E-01`

would indicate that the Y-axis will start at 1Ω for example.

GRAPH MODE (6440 only)

:GRAPH:MINor-HIgh <real>

Set the Y-axis maximum for the second measurement type.

Parameters:

The required maximum.

Example: `:GRAPH:MAJ-HI 100.0`

will set the end point to 100Ω for example.

Response:

None.

:GRAPH:MINor-High?

Query the current Y-axis maximum for the second measurement type.

Parameters:

None.

Response:

The current maximum in engineering format.

Example: `+.100000000E+02`

would indicate that the Y-axis will stop at 10Ω for example.

:GRAPH:NOMinal <real>

Set the nominal value for use when graphs are being plotted in percentage mode.

Parameters:

The required nominal value, no unit is required: the unit of the first measurement type is used.

Example `:GRAPH:NOM 150e-12`

will set a nominal value of 150pF.

Response:

None.

:GRAPH:NOMinal?

Returns the current graph nominal.

Parameters:

None.

Response:

Returns the nominal in engineering format.

Example: `+.15000000E-09`

would indicate a nominal of 150pF for example.

GRAPH MODE (6440 only)

:GRAPH:TERM <integer>

Set which measurement will be shown/viewed.

Parameters:

The following values are valid:

1 Plot 1^{st} measurement.

2 Plot 2^{nd} measurement.

Response:

None.

:GRAPH:TERM?

Query the current measurement selection.

Parameters:

None.

Response:

`1` 1^{st} measurement.

`2` 2^{nd} measurement.

Example: `2`

would, for example, indicate that the Angle measurement would be displayed if the selected measurements were Z+Angle.

:GRAPH:STEP <integer>

Select the number of pixels between each measured point on the graph.

Parameters:

The following values are valid:

Value	Step Size	
`1`	1	(Slowest, Most accurate)
`2`	2	
`3`	4	
`4`	8	(Fastest, Most interpolated)

Example: `GRAPH:STEP 3`

would set the plot to take a measurement at every 4 pixels on the graph and interpolate between them.

Response:

None.

:GRAPH:STEP?

Query the current step size for the plot.

Parameters:

None.

Response:

The step size in pixels.

Example: `4`

would indicate that a measurement will be taken every 4 pixels when the graph is plotted.

GRAPH MODE (6440 only)

:GRAPH:SET

Go to the graph mode set-up page.

Parameters:

None.

Response:

None.

:GRAPH:VIEW

Redraw the graph.

Parameters:

None.

Response:

None.

:GRAPH:FIT

Fit the Y-axis scale to the current measurement data.

Parameters:

None.

Response:

None.

:GRAPH:TRIG

Start plotting a graph with the current settings.

Parameters:

None.

Response:

None.

GRAPH MODE (6440 only)

:GRAPH:PEAK

Move the marker to the highest point on the current graph.

Parameters:

None.

Response:

None.

:GRAPH:DIP

Move the marker to the lowest point on the current graph.

Parameters:

None.

Response:

None.

:GRAPH:PRINT

Print the current graph on an Epson compatible printer.

Parameters:

None.

Response:

None.

CAPACITOR MODE

:CAP

Enter capacitor mode / path.

Parameters:

None.

Response:

None.

:CAP:SET

Switch to the capacitor mode set-up page.

Parameters:

None.

Response:

None.

:CAP:RUN

Switch to the capacitor mode run page.

Parameters:

None.

Response:

None.

:CAP:LEARN

Learn component and set the range for each test.

Parameters:

None.

Response:

`1` Capacitor learnt.

`0` Error while learning the capacitor.

CAPACITOR MODE

:CAP:RESET

Clears the learnt component data.

Parameters:

None.

Response:

None.

:CAP:DELETE

Deletes the currently selected test.

Parameters:

Nine.

Response:

None.

:CAP:TEST <integer>

Select the capacitor mode test.

Parameters:

The test number in the range 0 to 7.

Example: `:CAP:TEST 0`

will select the first test for editing

Response:

None.

:CAP:TEST?

Return the currently select test.

Parameters:

None.

Response:

The frequency number in the range 0 to 7.

Example: `7`

would indicate the last test is selected for editing.

CAPACITOR MODE

:CAP:FREQuency <real>

Set the frequency for the currently selected step.

Parameters:

The required frequency in Hertz. The unit suffix 'Hz' is optional.

Example: `:CAP:FREQ 1k`

will set the selected frequency to 1kHz

Response:

None.

:CAP:FREQuency?

Returns the frequency of the currently selected step.

Parameters:

None.

Response:

Returns the current test frequency in engineering format.

Example: `+.10000000E+04`

for a test frequency of 1kHz.

:CAP:RANGE <disc>

Selects the required measurement range for the current test.

Parameters:

The following parameters are valid:

`1 to 8` Range 1 to 8.

Example: `:CAP:RANGE 1`

will select range 1.

Response:

None.

:CAP:RANGE?

Returns the measurement range for the current test.

Parameters:

None.

Response:

Returns the measurement range as an integer.

`1-8` Current measurement range.

Example: `5`

indicates that range 5 is selected.

CAPACITOR MODE

:CAP:MAJOR <integer>

Sets the Major term for the current test.

Parameters:

The following parameters are valid:

- `0` Capacitance (C).
- `1` Inductance (L).
- `2` Reactance (X).
- `3` Susceptance (B).
- `4` Impedance (Z).
- `5` Admittance (Y).

Example: `:CAP:MAJOR 1`

will select Inductance.

Response:

None.

:CAP:MAJOR?

Returns the test type for the Major term of the currently selected test.

Parameters:

None.

Response:

- `0` Capacitance (C).
- `1` Inductance (L).
- `2` Reactance (X).
- `3` Susceptance (B).
- `4` Impedance (Z).
- `5` Admittance (Y).

Example: `4`

The Major term is set to Impedance.

:CAP:MINOR <integer>

Sets the Minor term for the current test.

Parameters:

The following parameters are valid:

- `0` Quality factor (Q).
- `1` Dissipation factor (D).
- `2` Resistance (R).
- `3` Conductance (G).

Example: `:CAP:MINOR 2`

will select Resistance

Response:

None.

:CAP:MINOR?

Returns the test type for the Minor term of the currently selected test.

Parameters:

None.

Response:

- `0` Quality factor (Q).
- `1` Dissipation factor (D).
- `2` Resistance (R).
- `3` Conductance (G).

Example: 3

The Minor term is set to Conductance.

CAPACITOR MODE

:CAP:EQU-CCT <disc>

Select the equivalent circuit type for current test.

Parameters:

The following parameters are valid:

`SER` Series equivalent circuit.

`PAR` Parallel equivalent circuit.

Example: `:CAP:EQU-CCT SER`

will select the series equivalent circuit.

Response:

None.

:CAP:EQU-CCT?

Returns the currently selected equivalent circuit.

Parameters:

None.

Response:

Returns the equivalent circuit flag according to this table:

`0` Parallel.

`1` Series.

Example: `0`

indicates the parallel equivalent circuit is selected.

:CAP:BIN <integer>

Select the bin to edit.

Parameters:

The bin number in the range 0 to 8.

Example: `:CAP:BIN 3`

will select bin 3 for editing.

Response:

None.

:CAP:BIN?

Query bin for editing.

Parameters:

None.

Response:

The bin number in the range 0 to 8.

Example: `5`

indicates that the settings for bin number 5 are those currently being edited.

CAPACITOR MODE

:CAP:HI-LIM <real>

Set bin high limit.

Parameters:

The required high limit.

Example: `:CAP:HI-LIM 10.0`

will set a high limit of 10% when percentage limits are selected.

Response:

None.

:CAP:HI-LIM?

High limit query.

Parameters:

None.

Response:

The high limit value in engineering format.

Example: `+.50000000E+01`

indicates a high limit of +5% when percentage limits are selected.

:CAP:LO-LIM <real>

Set bin low limit.

Parameters:

The required lower limit.

Example: `:CAP:LO-LIM -10.0`

will set a low limit of -10% when percentage limits are selected.

Response:

None.

:CAP:LO-LIM?

Low limit query.

Parameters:

None.

Response:

The low limit value in engineering format.

Example: `-.50000000E+01`

indicates a high limit of -5% when percentage limits are selected.

:CAP:MINOR <real>

Set minor bin limit.

Parameters:

The required limit.

Example: `:CAP:MINOR 1.0`

will set a low limit of 1.0 for the minor test.

Response:

None.

:CAP:MINOR?

Minor limit query.

Parameters:

None.

Response:

The minor limit value in engineering format.

Example: `+.10000000E+01`

indicates a minor limit of 1.0.

CAPACITOR MODE

:CAP:TOGGLE

Swap Major and Minor test types.

Parameters:

None.

Response:

None.

:CAP:TRIGGER

Start a multi-frequency measurement sequence and return the results for all test frequencies or just the bin number if :CAP:VERBOSE is set to Off.

Parameters:

None.

Response:

Verbose is set On:

Major and Minor terms returned for all tested frequencies. The first pair of results returned are for the first test frequency followed by the second etc. The Major terms are returned first for each test.

Example: `+.124700E-02,+.247000E-01,+.23700E-03,+.42800E-02`

Only two test frequencies have been set in the above example.

Verbose is set Off:

Bin number only returned.

Example: `2`

CAPACITOR MODE

:CAP:RES? <integer>

Returns Major and Minor measurement results for the specified test.

Parameters:

The test number in the range 0 to 7.

Example: `:CAP:RES 0`

returns the measurement results for the first test.

Response:

The Major and Minor terms for the first test.

Example: `+.200000E-04,+.100000E-02`

:CAP:VERBOSE <disc>

Defines the data returned from a multi-frequency measurement sequence.

Parameters:

`On` Major and Minor measurement results returned for all test frequencies.

`Off` Bin number only.

Response:

None.

RESONANCE MODE

:RESOnance

Enter resonance mode / path.

Parameters:

None.

Response:

None.

:RESOnance:StarT <real>

Set the start frequency for the search.

Parameters:

The required frequency in Hertz. The unit suffix ‘Hz’ is optional.

Example: `:RESO:ST 1k`

Would set the search to start at 1kHz.

Response:

None.

:RESOnance:StarT?

Returns the start frequency of the search.

Parameters:

None.

Response:

Returns the start frequency in engineering format.

Example: `+.10000000E+05`

For a start frequency of 10kHz.

:RESOnance:StoP <real>

Set the stop frequency for the search.

Parameters:

The required frequency in Hertz. The unit suffix ‘Hz’ is optional.

Example: `:RESO:SP 1k`

Would set the search to stop at 1kHz.

Response:

None.

:RESOnance:StoP?

Returns the stop frequency of the search.

Parameters:

None.

Response:

Returns the stop frequency in engineering format.

Example: `+.10000000E+05`

For a stop frequency of 10kHz.

RESONANCE MODE

:RESOnance:EQU-CCT <disc>

Select the equivalent circuit type for resonance search.

Parameters:

The following parameters are valid:

`SER` Series resonance.

`PAR` Parallel resonance.

Example: `:RESO:EQU-CCT SER`

will select the series resonance search.

Response:

None.

:RESOnance:EQU-CCT?

Returns the currently selected equivalent circuit.

Parameters:

None.

Response:

Returns the equivalent circuit state according to this table:

`0` Parallel.

`1` Series.

Example: `0`

indicates the parallel resonance search circuit is selected.

:RESOnance:TRIG

Begin a resonance search.

Parameters:

None.

Response:

Returns the resonant frequency, capacitance, inductance, resistance and Q all separated by commas.

Example: +.77534195E+06, +.47321000E-05, +.89043000E-08,
+.19562000E-02, +.221748E+02

indicating a resonant frequency of 775.342kHz with equivalent series values at resonance of 4.7321µF, 8.904nH, 1.956mΩ and a Q value of 22.175.

RESONANCE MODE

:RESOnance:EXTRP

Resonance may be extrapolated if not found within the entered test frequency limits. Accuracy of extrapolated results is undefined, as it is not possible to verify the validity of the circuit model.

Parameters:

`On`

Resonance is determined within the entered test frequency limits. If not found then it is extrapolated.

`Off`

Resonance is determined only within the entered test frequency limits.

Response:

None.

:RESOnance:EXTRP?

Queries whether resonance may be extrapolated if not found within the entered test frequency limits.

Parameters:

None.

Response:

`0` Resonance is not extrapolated.

`1` Resonance may be extrapolated.

:RESOnance:DEPTH

Set resonance search depth.

Parameters:

The following parameters are valid:

`0 to 12`

Example: `:CAP:DEPTH 2`

The instrument will conduct a binary search to a depth of two iterations then use the final pair of frequencies found to calculate resonance.

Response:

None.

:RESOnance:DEPTH?

Returns the resonance search depth.

Parameters:

None.

Response:

The search depth.

Example: `0`

Indicates that resonance is calculated using the entered frequency limits. No resonance search is carried out prior to calculation.

RESONANCE MODE

:RESOnance:SPEED

Select the required measurement speed for the pair of test frequencies used to calculate resonance.

Parameters:

`MAX`	Maximum speed.
`FAST`	Fast speed.
`MED`	Medium speed.
`SLOW`	Slow speed.

Example: `:RESO:SPEED SLOW`

will select slow speed for the resonance measurements.

Response:

None.

:RESOnance:SPEED?

Returns the current measurement speed for the pair of frequencies used to calculate resonance.

Parameters:

None.

Response:

Returns the test speed as an integer according to the table:

`0`	Maximum
`1`	Fast
`2`	Medium
`3`	Slow

Example: `1`

indicates that Fast measurements are selected.

CALIBRATE MODE

:CAL

Select calibrate mode / path.

Parameters:

None.

Response:

None.

:CAL:OC-TRIM <integer>

Perform open circuit trimming.

Parameters:

The required trim type.

`1` Spot trim.

`2` Up to 10kHz.

`3` Up to 100kHz.

`4` All frequency.

Example: `:CAL:OC-TRIM 4`

would perform an open circuit trim across the whole frequency range of the unit.

Response:

None.

CALIBRATE MODE

:CAL:SC-TRIM <integer>

Perform short circuit trimming.

Parameters:

The required trim type.

`1` Spot trim.

`2` Up to 10kHz.

`3` Up to 100kHz.

`4` All frequency.

Example: `:CAL:SC-TRIM 1`

would perform a short circuit trim at the current frequency.

Response:

None.

:CAL:HF-CAL

Perform HF lead compensation.

Parameters:

None.

Response:

None.

:CAL:SELF-CAL

Perform self-calibration; disconnect all BNCs from the instrument terminals before using this command.

Parameters:

None.

Response:

None.

CALIBRATE MODE

:CAL:RES?

Returns the result of the most recent trim or calibration performed.

Parameters:

None.

Response:

The trim flag:

`1` Calibration passed.

`0` Calibration failed.

Example: `1`

would indicate that the last trim or calibration was successful.

ROOT COMMANDS

:TRIGger

Trigger a measurement in the current mode.

Parameters:

None.

Response:

The measurement result depending on the mode.

:LOC-TRIG <disc>

Select local trigger condition. When local trigger is ON the trigger button on the front panel can be used to take a measurement, all other functions being under remote control.

Parameters:

`ON` Enable local trigger.

`OFF` Disable local trigger.

Example: `:LOC-TRIG ON`

will allow triggering from the front panel.

Response:

None.

:LOC-TRIG?

Query the local trigger condition.

Parameters:

None.

Response:

The local trigger flag:

`1` Local trigger enabled.

`0` Local trigger disabled.

ROOT COMMANDS

:REPeat <disc>

Enable repetitive measurements when unit is returned to local control.

Parameters:

The required state:

`ON` Repetitive

`OFF` Single shot

Example: `:REP ON`

will set the unit to repetitive mode when it is returned to local control.

Response:

None.

:REPeat?

Query trigger status.

Parameters:

None.

Response:

The selected trigger mode.

`0` Single shot

`1` Repetitive

Example: 1

would indicate that the instrument will begin repetitive measurements when returned to local control.

:TERMinal <integer>

Select 2 or 4 terminal measurements.

Parameters:

The required mode:

`2` 2-Terminal.

`4` 4-Terminal.

Example: `:TERM 4`

will select 4 terminal measurement.

Response:

None.

:TERMinal?

Query the current terminal setting.

Parameters:

None.

Response:

The current setting:

`2` 2-Terminal.

`4` 4-Terminal.

Example: `:TERM 4`

will select 4 terminal measurement.

ROOT COMMANDS

:SETUP <disc>

Select set-up view ON and OFF. GPIB commands that change the test settings will be slightly faster with the set-up display off.

Parameters:

The required mode:

`ON` Show set-up.

`OFF` Hide set-up.

Example: `:SETUP OFF`

will turn off the set-up display.

Response:

None.

:SETUP?

Query the current set-up mode.

Parameters:

None.

Response:

The set-up condition:

`1` Set-up displayed.

`0` Set-up hidden.

Example: `1`

would indicate that the set-up is visible.

:FAST-GPIB <disc>

Select fast GPIB mode, in this mode all measurement results are returned in a raw unformatted format and without displaying the result. Measurement time is reduced when using this mode.

Parameters:

The required mode:

`ON` Enable fast GPIB.

`OFF` Disable fast GPIB.

Example: `:FAST-GPIB ON`

will turn on fast GPIB operation.

Response:

None.

:FAST-GPIB?

Query fast GPIB mode.

Parameters:

None.

Response:

The current fast GPIB setting:

`1` Fast GPIB operation.

`0` Normal GPIB operation.

Example: `1`

would indicate that fast GPIB is selected.

ROOT COMMANDS

:MODE?

Query the currently selected operating mode.

Parameters:

None.

Response:

The current mode:

`0` Main menu.

`1` Measurement.

`2` Deviation.

`3` Binning.

`4` Multi-frequency.

`5` Graph.

`6` Resonance.

`7` Calibrate.

`8` Status.

Example: `1`

would indicate that Measurement Mode is selected.

:DUMP-BMP

Returns the display as a windows compatible bitmap. The data conforms to IEEE 488.2 or SCPI 'Indefinite Length Arbitrary Block Response Data'.

Parameters:

None.

Response:

None.

6.3 Example Programs

The following examples are written for Microsoft QuickBasic 4.5 running on a PC with a National Instruments GPIB controller. The programs are short and can be readily converted to another language/platform as their function is primarily to illustrate the use of the instrument GPIB commands.

Example 1:

Simple identification query, use this program to establish that the GPIB configuration is correct.

Example 2:

Simple measurement program. This program triggers a single AC measurement and displays the result.

Example 3:

Simple querying example. This program interrogates the instrument and display the current values for a number of AC measurement settings.

Example 4:

Multi-frequency example for AC tests. This program sets up a 4-measurement multi-frequency test and displays the results from a single trigger.

Example 5:

Performs a graphical sweep of impedance from 20-400kHz and finds the lowest impedance value. It also takes a screenshot of the graph to a file.

6.3.1 Example 1

```
' **************************************************************
'
' Program 1 : Simple GPIB operation check Version 1.0
'
' Platform : QuickBasic 4.5
'
' Description :
'
' This program will ask the instrument to identify itself.
' It assumes the instrument is called 'WK' in the National
' Instruments configuration.
'
' **************************************************************

' $INCLUDE: 'QBDECL.BAS' ' National Instruments include file.

buf$ = SPACE$(200) ' Buffer for GPIB response.

CLS ' Clear the screen

CALL IBFIND("WK", wk%) ' Look for 'WK'

IF wk% < 0 THEN ' Check that the id was found.
 PRINT "Identifier 'WK' not found"
 PRINT "Please check your configuration."
 END
END IF

CALL IBCLR(wk%) ' Clear the device.
IF IBSTA% < 0 THEN ' Check for a problem.
 PRINT "Error clearing instrument"
 PRINT "Please check you configuration."
 END
END IF

CALL IBWRT(wk%, "*IDN?") ' Request identification.
IF IBSTA% < 0 THEN ' Check for a problem.
 PRINT "Error writing to instrument"
 PRINT "Please check that the instrument"
 PRINT "is powered, set to the correct"
 PRINT "GPIB address and the cable is"
 PRINT "securely connected."
 END
END IF

CALL IBRD(wk%, BUF$) ' Read the response.
IF IBSTA% < 0 THEN ' Check for a problem.
 PRINT "Error reading from instrument"
 PRINT "Please check the device configuration"
 END
END IF

PRINT buf$ ' Display the response.

END           ' The end.
```

6.3.2 Example 2

```
' ****************************************************************
'
' Program 2 : Simple Measurement Version 1.0
'
' Platform : QuickBasic 4.5
'
' Description :
'
' This program will set-up and run a single Z+Angle measurement
' on a component.
' This program assumes that the GPIB configuration is correct
' enough to be able to run example program 1 correctly.
'
' ****************************************************************
' $INCLUDE: 'QBDECL.BAS' ' National Instruments include file.
CLS ' Clear the screen.

' Initialise the GPIB
CALL IBFIND("WK", wk%) ' Look for 'WK'.
CALL IBCLR(wk%) ' Clear the device.

' Select the required operating mode
CALL IBWRT(wk%, ":MEAS") ' Go to measurement mode.
CALL IBWRT(wk%, ":MEAS:TEST:AC")
CALL IBWRT(wk%, ":MEAS:FUNC:Z") ' Select Z+Angle.

' Set-up measurement conditions.
' Level = 100mV Freq = 10kHz
' Alc = Off Speed = Medium
' Range = AUTO Bias = Off
CALL IBWRT(wk%, ":MEAS:LEVEL 0.1; FREQ 1E4; ALC OFF; SPEED MED")
CALL IBWRT(wk%, ":MEAS:RANGE AUTO; BIAS OFF")

' Perform the measurement.
buf$ = SPACE$(200) ' Prepare buffer for GPIB response.
CALL IBWRT(wk%, "TRIG") ' Trigger a measurement.
CALL IBRD(wk%, buf$) ' Read in the response.
buf$ = LEFT$(buf$, ibcnt% - 1) ' Remove trailing characters.

' The next piece of code extracts the numbers from
' the response so that they can be manipulated.
first = VAL(LEFT$(buf$, INSTR(buf$, ",") - 1))
second = VAL(RIGHT$(buf$, LEN(buf$) - INSTR(buf$, ",") - 1))

' Display the final result.
PRINT " Z = "; first
PRINT "Angle = "; second

END ' The end.
```

6.3.3 Example 3

```
DECLARE FUNCTION GPIBQuery$ (id%, Query$)
' ***************************************************************
'
' Program 3 : Querying the instrument state Version 1.0
'
' Platform : QuickBasic 4.5
'
' Description :
'
' This program will use queries to find out the current settings
' of the unit.
' This program assumes that the GPIB configuration is correct
' enough to be able to run example program 1 correctly.
'
' ***************************************************************
' $INCLUDE: 'QBDECL.BAS' ' National Instruments include file.
CLS ' Clear the screen.

' Initialise the GPIB
CALL IBFIND("WK", wk%) ' Look for 'WK'.
CALL IBCLR(wk%) ' Clear the device.

' Select the required operating mode
CALL IBWRT(wk%, ":MEAS") ' Go to measurement mode.
CALL IBWRT(wk%, ":MEAS:TEST:AC") ' Select AC measurements.

' Start querying
alc = VAL(GPIBQuery$(wk%, ":MEAS:ALC?")) ' Query the ALC setting.
freq = VAL(GPIBQuery$(wk%, ":MEAS:FREQ?")) ' Query the AC frequency.
level = VAL(GPIBQuery$(wk%, ":MEAS:LEV?")) ' Query the AC level.
range = VAL(GPIBQuery$(wk%, ":MEAS:RANGE?")) ' Query the range.
speed = VAL(GPIBQuery$(wk%, ":MEAS:SPEED?")) ' Query the speed.

' Print the status of the major settings.
PRINT "AC Frequency ="; freq; "Hz" ' Print the AC frequency.

PRINT "AC Drive level ="; level; "V" ' Print the AC level.

PRINT "AC Range ="; ' Print the AC range.
IF range = 0 THEN
 PRINT " AUTO"
ELSE
 PRINT range
END IF

PRINT "ALC = "; ' Print the ALC condition.
IF alc = 0 THEN
 PRINT "OFF"
ELSE
 PRINT "ON"
END IF

PRINT "SPEED = "; ' Print the test speed.
SELECT CASE speed
 CASE 3
       PRINT "SLOW"
 CASE 2
       PRINT "MEDIUM"
 CASE 1
```

```
        PRINT "FAST"
  CASE 0
        PRINT "MAX"
END SELECT

END ' The end.

' This function sends the supplied query to the instrument
' and reads back the reply and strips the trailing characters
FUNCTION GPIBQuery$ (id%, Query$)
 buf$ = SPACE$(80) ' Initialise the buffer.
 CALL IBWRT(id%, Query$) ' Query the level
 CALL IBRD(id%, buf$) ' Read in the response.
 GPIBQuery$ = LEFT$(buf$, ibcnt% - 1) ' Remove trailing characters.
END FUNCTION
```

6.3.4 Example 4

```
DECLARE FUNCTION GPIBQuery$ (id%, Query$)
' ***************************************************************
'
' Program 4 : Multi-frequency mode Version 1.0
'
' Platform : QuickBasic 4.5
'
' Description :
'
' This program sets up and runs a simple 4 frequency measurement
' in Multi-frequency mode
'
' ***************************************************************
' $INCLUDE: 'QBDECL.BAS' ' National Instruments include file.
CLS ' Clear the screen.

' Initialise the GPIB
CALL IBFIND("WK", wk%) ' Look for 'WK'.
CALL IBCLR(wk%) ' Clear the device.

' Set-up the AC test parameters
CALL IBWRT(wk%, ":MEAS") ' Measurement mode
CALL IBWRT(wk%, ":MEAS:TEST:AC") ' Select AC measurements.
CALL IBWRT(wk%, ":MEAS:FUNC:C;D") ' Select C+D measurements.

' Go to multi-frequency mode
CALL IBWRT(wk%, ":MULTI") ' Multi-frequency mode
CALL IBWRT(wk%, ":MULTI:SET") ' Multi-frequency set-up

' Set-up frequency steps
CALL IBWRT(wk%, ":MULTI:TEST 0; FREQ 1k") ' Step 1
CALL IBWRT(wk%, ":MULTI:TEST 1; FREQ 2k") ' Step 2
CALL IBWRT(wk%, ":MULTI:TEST 2; FREQ 5k") ' Step 3
CALL IBWRT(wk%, ":MULTI:TEST 3; FREQ 10k") ' Step 4

CALL IBWRT(wk%, ":MULTI:LIMIT OFF") ' No limit checking
CALL IBWRT(wk%, ":MULTI:RUN; TRIG") ' Go to RUN mode and start

PRINT GPIBQuery(wk%, ":MULTI:RES? 0") ' Get result 1
PRINT GPIBQuery(wk%, ":MULTI:RES? 1") ' Get result 2
PRINT GPIBQuery(wk%, ":MULTI:RES? 2") ' Get result 3
PRINT GPIBQuery(wk%, ":MULTI:RES? 3") ' Get result 4

END ' The end!

' This function sends the supplied query to the instrument
' and reads back the reply and strips the trailing characters
FUNCTION GPIBQuery$ (id%, Query$)
 buf$ = SPACE$(80) ' Initialise the buffer.
 CALL IBWRT(id%, Query$) ' Query the level
 CALL IBRD(id%, buf$) ' Read in the response.
 GPIBQuery$ = LEFT$(buf$, ibcnt% - 1) ' Remove trailing characters.
END FUNCTION
```

6.3.5 Example 5

```
DECLARE FUNCTION GPIBQuery$ (id%, Query$)
' *****************************************************************
'
' Program 5 : Graph mode Version 1.0
'
' Platform : QuickBasic 4.5
'
' Description :
'
' This program sets up and plots a graph of the characteristic
' of a 4.7uF capacitor.
' At the end it takes a screenshot which is in windows bitmap
' format (.BMP) and can be viewed in MS Paint (Win 9X).
'
' *****************************************************************
' $INCLUDE: 'QBDECL.BAS' ' National Instruments include file.
CLS ' Clear the screen.

' Initialise the GPIB
CALL IBFIND("WK", wk%) ' Look for 'WK'.
CALL IBCLR(wk%) ' Clear the device.
CALL IBTMO(14) ' 30 Second timeout for graph drawing.

' Set-up the AC test parameters
CALL IBWRT(wk%, ":MEAS") ' Measurement mode.
CALL IBWRT(wk%, ":MEAS:TEST:AC") ' Select AC measurements.
CALL IBWRT(wk%, ":MEAS:FUNC:Z") ' Plot impedance.
CALL IBWRT(wk%, ":MEAS:SPEED MAX") ' As fast as possible.

CALL IBWRT(wk%, ":GRAPH") ' Enter GRAPH mode.
CALL IBWRT(wk%, ":GRAPH:ST 20;SP 400k") ' Sweep 20Hz-500kHz.
CALL IBWRT(wk%, ":GRAPH:LOGY ON; LOGF ON") ' Log-Log plot.
CALL IBWRT(wk%, ":GRAPH:TERM 1") ' Plot Z.
CALL IBWRT(wk%, ":GRAPH:STEP 2") ' Step size 4.
CALL IBWRT(wk%, ":GRAPH:MAJ-LO 1e-3") ' Y start 1mOhm.
CALL IBWRT(wk%, ":GRAPH:MAJ-HI 1k") ' Y stop 1kOhm.
CALL IBWRT(wk%, ":GRAPH:TRIG;FIT") ' Plot the graph and fit scale.
CALL IBWRT(wk%, ":GRAPH:DIP") ' Find the low point.

' Take a screenshot.
PRINT "Taking screenshot."
CALL IBWRT(wk%, "DUMP-BMP") ' Request data.
CALL IBRDF(wk%, "GRAPH.BMP") ' Read to file.
PRINT "Done!"

END ' The end!

' This function sends the supplied query to the instrument
' and reads back the reply and strips the trailing characters
FUNCTION GPIBQuery$ (id%, Query$)
 buf$ = SPACE$(80) ' Initialise the buffer.
 CALL IBWRT(id%, Query$) ' Query the level
 CALL IBRD(id%, buf$) ' Read in the response.
 GPIBQuery$ = LEFT$(buf$, ibcnt% - 1) ' Remove trailing characters.
END FUNCTION
```

7. 6430 SPECIFICATION

Wayne Kerr Electronics Limited reserves the right to change specification without notice

7.1 Measurement Parameters

Any of the following parameters can be measured and displayed.

DC Functions

Resistance (Rdc).

AC Functions

Capacitance (C), Inductance (L), Resistance (R), Conductance (G), Susceptance (B), Reactance (X), Dissipation Factor (D), Quality Factor (Q), Impedance (Z), Admittance (Y) and Phase Angle (θ).

The following display formats are available.

Series or Parallel Equivalent Circuit

C+R, C+D, C+Q, L+R, L+Q

Series Equivalent Circuit Only

X+R, X+D, X+Q

Parallel Equivalent Circuit Only

C+G, B+G, B+D, B+Q

Polar Form

Z + Phase Angle, Y + Phase Angle

7.2 Test Conditions

7.2.1 AC Drive

7.2.1.1 Frequency Range

20Hz to 500kHz >1000 steps

Accuracy of set frequency ±0.005%

7.2.1.2 Pre-set frequencies

20, 25, 30, 40, 50, 60, 80, 100, 120, 150; repeats for each decade.

Step size is 1% or better through the frequency range when the 6430B Analysis option is fitted.

7.2.1.3 Drive Level (AC Measurements)

Open Circuit Voltage	Short Circuit Current	Frequency Range
1mV to 10V rms	50µA to 200mA rms	up to 300kHz
1mV to 5V rms	50µA to 100mA rms	up to 500kHz

Signal source impedance: 50Ω nominal

7.2.1.4 Step Size

Voltage Drive		Current Drive	
Step size	up to drive level	Step size	up to drive level
1mV	100mV	50µA	5mA
2mV	200mV	100µA	10mA
5mV	500mV	200µA	20mA
10mV	1V	500µA	50mA
20mV	2V	1mA	100mA
50mV	5V	2mA	200mA *
100mV	10V *		

* Drive levels are reduced to 9V and 180mA at 40Hz or below.

User-selectable Automatic Level Control (ALC) ensures that the drive level at the device under test (DUT) is ±2% ±1mV of set voltage or ±2% ±0.1mA of set current at or above 100Hz.

Drive level accuracy degrades below 100Hz: ±3% ±1mV or ±3% ±0.1mA at 50Hz

±5% ±1mV or ±5% ±0.1mA at 20Hz

With DC bias applied the maximum drive voltages indicated above are halved.

7.2.2 DC Bias Voltage

A DC bias voltage derived from an internal or external source can be applied to capacitors during AC measurements.

7.2.2.1 Internal

DC bias of 2V ±5%.

Peak short circuit current <90mA.

7.2.2.2 External

External bias of up to ±60V is provided by connecting an external power supply to the rear panel bias terminals. The voltage required at the rear terminals is 5% higher than the voltage at the DUT.

A bias load of 220Ω is permanently connected across the rear panel bias terminals.

Steady state short circuit load: 70Ω.

A resettable trip protects the bias circuit against a continuous short circuit.

7.2.3 Drive Level (Rdc)

Two selectable drive levels:

Open circuit voltage	Short circuit current
100mV ±7%	1mA
1V ±7%	10mA

Source resistance: 100Ω nominal.

7.3 Measurement Speeds

Four selectable speeds for all measurement functions. Selecting slower measurement speed increases reading resolution and reduces measurement noise by averaging.

The following measurement periods apply for Rdc or for AC measurements ≥100Hz.

Maximum speed (intended for automatic sorting) ≈ 50ms.
Fast speed (for non-critical measurements) ≈ 100ms.
Medium speed (for improved resolution) ≈ 300ms.
Slow speed (for best resolution and enhanced supply frequency rejection) ≈ 900ms.

7.3.1 Capacitor Mode

Two frequency measurement ≈ 180ms.

7.4 Measurement Ranges

R, Z, X	0.01mΩ to >2GΩ
G, Y, B	0.01nS to >2kS
L	0.1nH to >2kH
C	1fF to >1F
D	0.00001 to >1000
Q	0.00001 to >1000
Rdc	0.1mΩ to >10MΩ

For L and C, the lower range is available at 10kHz and 100kHz; the upper range is available at 100Hz and below.

7.5 Hardware Ranges

The hardware range used is determined by the impedance being measured, the frequency and the level. The table below lists the boundaries of operation for AC measurement functions. The hardware range being used is indicated in the top-left-hand-corner of the instrument display.

Range number	Impedance coverage	Frequency coverage up to
1	<1Ω	100kHz
2	<10Ω	500kHz
3	<50Ω	500kHz
4	>50Ω	500kHz
5	>250Ω	500kHz
6	>2.5kΩ	500kHz
7	>25kΩ	100kHz
8	>250kΩ	10kHz

For drive levels below 100mV, the highest range at each frequency is not available.
For drive levels below 20mA, range 1 is not available.
For drive levels below 0.5mA, range 2 is not available.

7.6 Modes Of Operation

7.6.1 MEASUREMENT

Selection of any measurement parameter and test condition.

Single-level function-menu controlled by keypad and soft keys.

Single and repetitive measurements displaying major and minor terms.

Analogue scale with configurable Hi/Lo limits giving PASS/FAIL indication (connected to logic output on binning option).

7.6.2 DEVIATION

Similar to MEASUREMENT MODE but relative or percentage deviation from nominal value displayed for major or minor term. There is no analogue scale in DEVIATION MODE.

7.6.3 MULTI FREQUENCY

Measurement parameters and test conditions set using MEASUREMENT MODE.

Up to 8 frequencies with configurable major and minor term limits.

PASS/FAIL indication (connected to logic output on binning option).

7.6.4 BINNING (Optional)

Measurement parameters and test conditions set using MEASUREMENT MODE.

8 PASS bins with absolute or percentage limits and 1 FAIL bin. Up to 99 sets of limits may be saved.

Bin count function logs the number of components in each bin.

Separate dedicated output for PASS/FAIL indication driven by analogue scale limits in MEASUREMENT MODE or by test limits in MULTI FREQUENCY MODE.

Trigger input with pull-up, operates on logic low or contact closure.

Handshake outputs indicating measure busy and data valid status.

25-way D-type interface connector.

7.6.4.1 Output Levels (B1 Option)

Output High:	>4V	Output Low:	<1V
Input High:	>3.5V	Input Low:	<1.5V

Drive capability typically is 10mA sink (low) and 30µA (high).

7.6.4.2 Output Levels (B2 Option)

This option provides an opto-coupled interface.

Output On state current:	up to 10mA at 24V	Output Off state current:	<0.5mA
Output On state voltage:	Input voltage –1.5V at 10mA		
Input High current:	>3mA	Input Low current:	<1.25mA
Input High voltage:	>15.4V	Input Low voltage:	<8V

7.6.5 CAPACITOR (Optional)

Combines the Multi Frequency and Binning modes for efficient testing of capacitors.

Measurement parameters and test conditions set using MEASUREMENT MODE.

Up to 8 frequencies with configurable major and minor term limits. The first frequency may be tested against up to 9 bins. The Major term is tested to a tolerance limit while the Minor term is compared to a relative limit. Measurements at subsequent frequencies may be compared to a single reject limit. A measurement term swap function is available if the minor term is required to be tested against a tolerance limit.

7.7 Measurement Connections

4 front panel BNC connectors permit 2-, 3- and 4-terminal connections with the screens at ground potential.

Terminals withstand connection of charged capacitor up to following limits:

- any value capacitor charged up to 50V, either polarity;

- a capacitor charged to between 50V and 500V with a stored energy of less than 0.25J, either polarity.

7.8 Measurement Accuracy

The accuracy statements given apply when the instrument is used under the following measurement conditions.

1V (DUT >50Ω) or 20mA (DUT <50Ω), slow speed, 4-terminal measurement. The instrument must have warmed up for at least 30 minutes at a steady ambient temperature of between 15°C and 35°C. The instrument must have been trimmed with Wayne Kerr Kelvin leads or a Wayne Kerr 1006 fixture at the measurement frequency.

For frequencies above 20kHz with the Analysis option fitted , HF lead compensation must have been performed.

For other frequencies and speeds see section 7.9—Accuracy Charts.

7.8.1 Resistance / Reactance (R / X)

Frequency	Accuracy % (for Q < 0.1)	Range for specified accuracy
100Hz /120Hz	0.05	1Ω to 1.6MΩ
1kHz (Notes 1, 2)	0.02	10Ω to 100kΩ
1kHz	0.05	1Ω to 1.6MΩ
10kHz	0.05	2Ω to 700kΩ
10kHz	0.1	0.3Ω to 4.7MΩ
100kHz	0.2	1.1Ω to 100kΩ

For Q ≥0.1 multiply accuracy figures by (1+Q).

7.8.2 Conductance / Susceptance (G / B)

Frequency	Accuracy % (for Q < 0.1)	Range for specified accuracy
100Hz /120Hz	0.05	0.63µS to 1S
1kHz (Notes 1, 3)	0.02	10µS to 0.1S
1kHz	0.05	0.63µS to 1S
10kHz	0.05	1.4µS to 0.5S
10kHz	0.1	0.22µS to 3.3S
100kHz	0.2	10µS to 0.9S

For Q ≥0.1 multiply accuracy figures by (1+Q).

7.8.3 Capacitance (C)

Frequency	Accuracy % (for D < 0.1)	Range for specified accuracy
100Hz /120Hz	0.05	1nF to 1mF
1kHz	0.05	100pF to 100µF
10kHz	0.05	60pF to 10µF
100kHz	0.2	10pF to 1µF

For D ≥0.1 multiply accuracy figures by (1+D).

7.8.4 Inductance (L)

Frequency	Accuracy % (for Q > 10)	Range for specified accuracy
100Hz /120Hz	0.05	1mH to 1000H
1kHz	0.05	100µH to 100H
10kHz	0.05	20µH to 10H
100kHz	0.2	4µH to 200mH

For Q ≤10, multiply the accuracy figure by (1+1/Q).

7.8.5 Dissipation Factor (D)

Frequency	Accuracy (A_d)	Range for specified accuracy
100Hz /120Hz	0.0005	1nF to 1mF
1kHz (Note 1)	0.0002	1nF to 100µF
1kHz	0.0005	100pF to 1mF
10kHz	0.0005	100pF to 10µF
100kHz	0.002	10pF to 3µF

For capacitors within the ranges shown above , D accuracy = $\pm A_d (1+D^2)$.

7.8.6 Quality Factor (Q)

Frequency	Accuracy % (A_L)	Range for specified accuracy
100Hz /120Hz	0.05	4mH to 1000H
1kHz	0.05	100µH to 100H
10kHz	0.05	20µH to 10H
100kHz	0.2	4µH to 200mH

For inductors within the ranges shown above , Q accuracy = $\pm A_L (Q+1/Q)$.

7.8.7 DC Resistance (Rdc)

Drive Level	Accuracy %	Range for specified accuracy
100mV	0.25	10Ω to 10kΩ
1V	0.1	1Ω to 100kΩ

Notes:

1) Accuracy is typical for 15°C to 35°C, guaranteed for 20°C to 30°C.
2) Accuracy applies to resistance only.
3) Accuracy applies to conductance only.

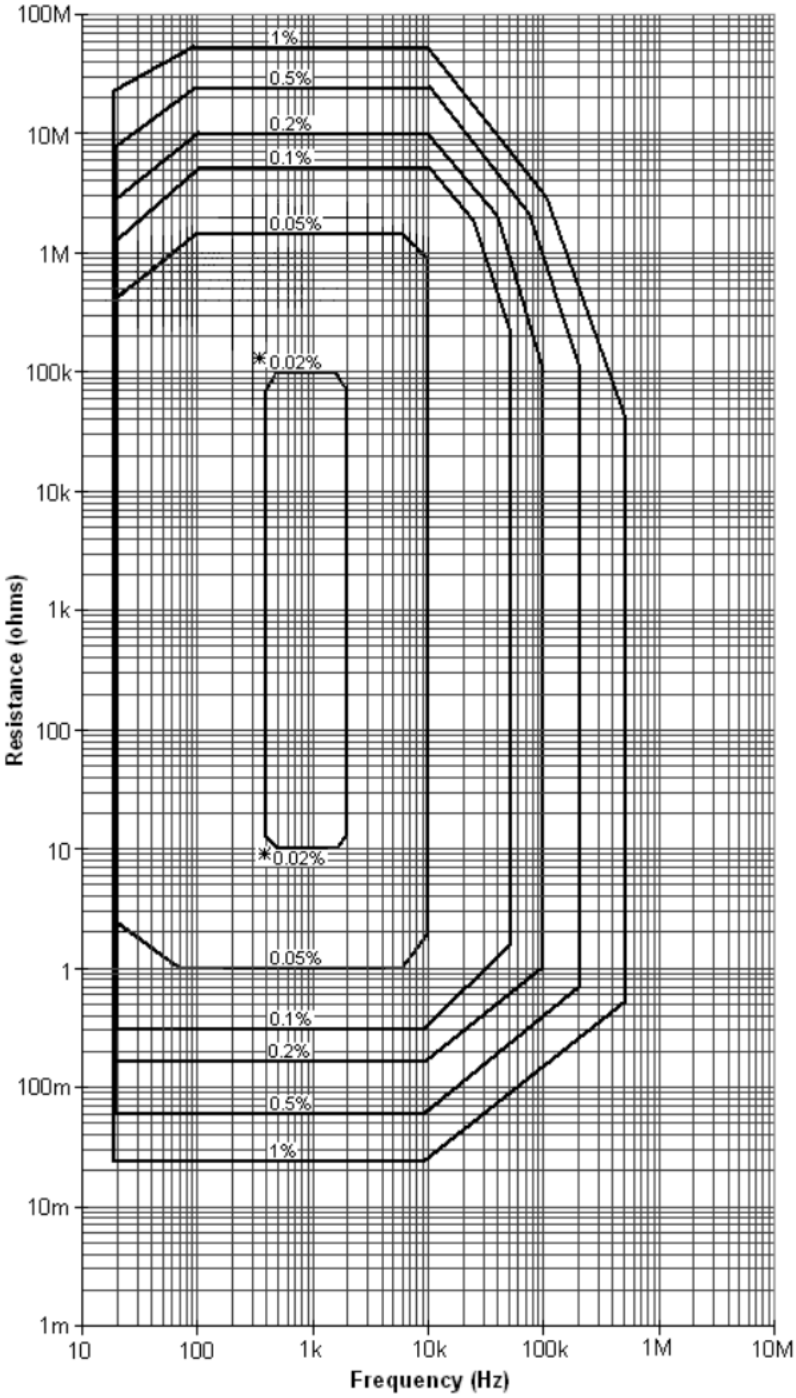
7.9 Accuracy Charts

Iso-accuracy charts define the measurement ranges available, at specified accuracies, over the available frequency band. All curves assume that Slow measurement speed is used, that the analyzer has been trimmed at the frequency used for measurements, that both factory calibration and self calibration are valid and that the component under test is pure. Beside each chart is a summary of these conditions and the information on the accuracy applicable when some or all of the conditions change.

For above and below the ranges indicated in the following charts, the accuracy degrades linearly with increasing/decreasing DUT value. For example, 470MΩ and 2.5mΩ measured at 10kHz are both a factor of 10 beyond the indicated range for 1% and will each have an accuracy of 10%.

Measurement accuracy for the optional Capacitor mode conforms to the maximum speed setting.

7.9.1 R/G Accuracy



Conditions

AC Drive Level: 1V/20mA
Slow Speed. 4-Terminal Mode.
Analyzer trimmed at measurement frequency.
Q ≤0.1
Temperature range 25 ±10ºC.

Except on the highest and lowest hardware measurement ranges, the adjacent iso-accuracy chart also applies to Medium measurement speed.

For Fast speed, on all ranges, the Medium speed figures must be doubled. Supply frequency rejection is also reduced causing additional unquantifiable errors dependent on lead layout, particularly at frequencies below 600Hz and at lower AC drive levels.

* typical figure for 25 ±10ºC, guaranteed for 25 ±5ºC.

O/C and S/C trim corrections under various conditions of interpolation, speed and level are given in the table following these iso-accuracy charts.

For impure components, and for measurements of the highest and lowest available ranges, full accuracy expressions, shown below, apply.

If 1 > Q > 0.1, multiply R accuracy by (1+Q).
For Q > 1 (loss resistance of inductor) see Q accuracy chart.
For D < 1 (loss resistance of capacitor) see D accuracy chart.

High resistance values

Accuracy = ± (A + 100Y_T . R_X) %.

Low resistance values

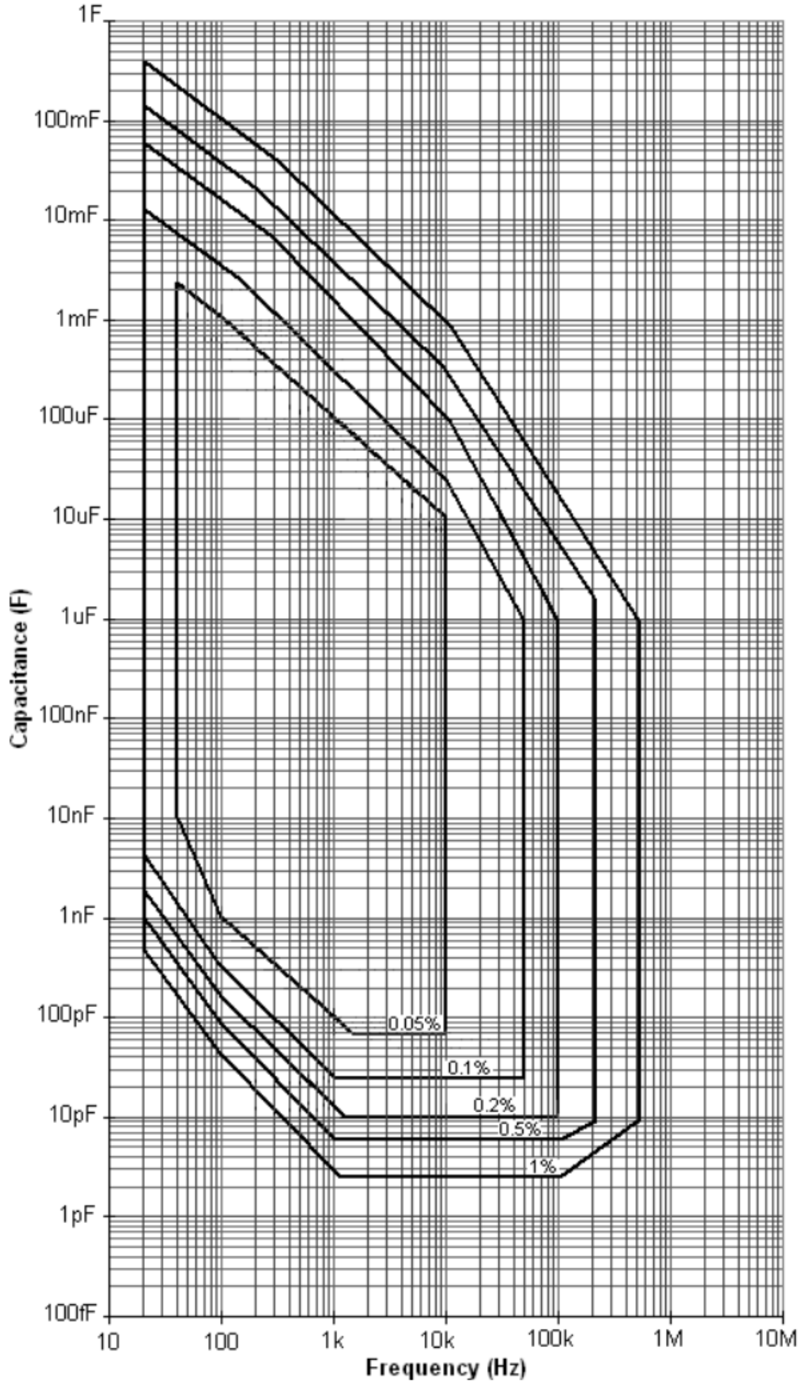
Accuracy = ± (A + 100R_T / R_X) %

where:
A = accuracy from adjacent chart.
R_X = measured value of unknown component.
R_T = sum of Z_I, Z_L (as appropriate, from section 7.10.2).
Y_T = sum of Y_I, Y_L (as appropriate, from section 7.10.1).

Conductance (G)

Find accuracy for equivalent R value from R = 1/G.

7.9.2 C Accuracy



Conditions

AC Drive Level: 1V/20mA
Slow Speed. 4-Terminal Mode.
Analyzer trimmed at measurement frequency.
D ≤0.1
Temperature range 25 ±10ºC.

Except on the highest and lowest hardware measurement ranges, the adjacent iso-accuracy chart also applies to Medium measurement speed.

For Fast speed, on all ranges, the Medium speed figures must be doubled. Supply frequency rejection is also reduced causing additional unquantifiable errors dependent on lead layout, particularly at frequencies below 600Hz and at lower AC drive levels.

O/C and S/C trim corrections under various conditions of interpolation, speed and level are given in the table following these iso-accuracy charts.

For impure components, and for measurements of the highest and lowest available ranges, full accuracy expressions, shown below, apply.

If D >0.1, multiply C accuracy by (1+D).

High capacitance values

Accuracy = ± (A + 100 X_T . ω C_X) %

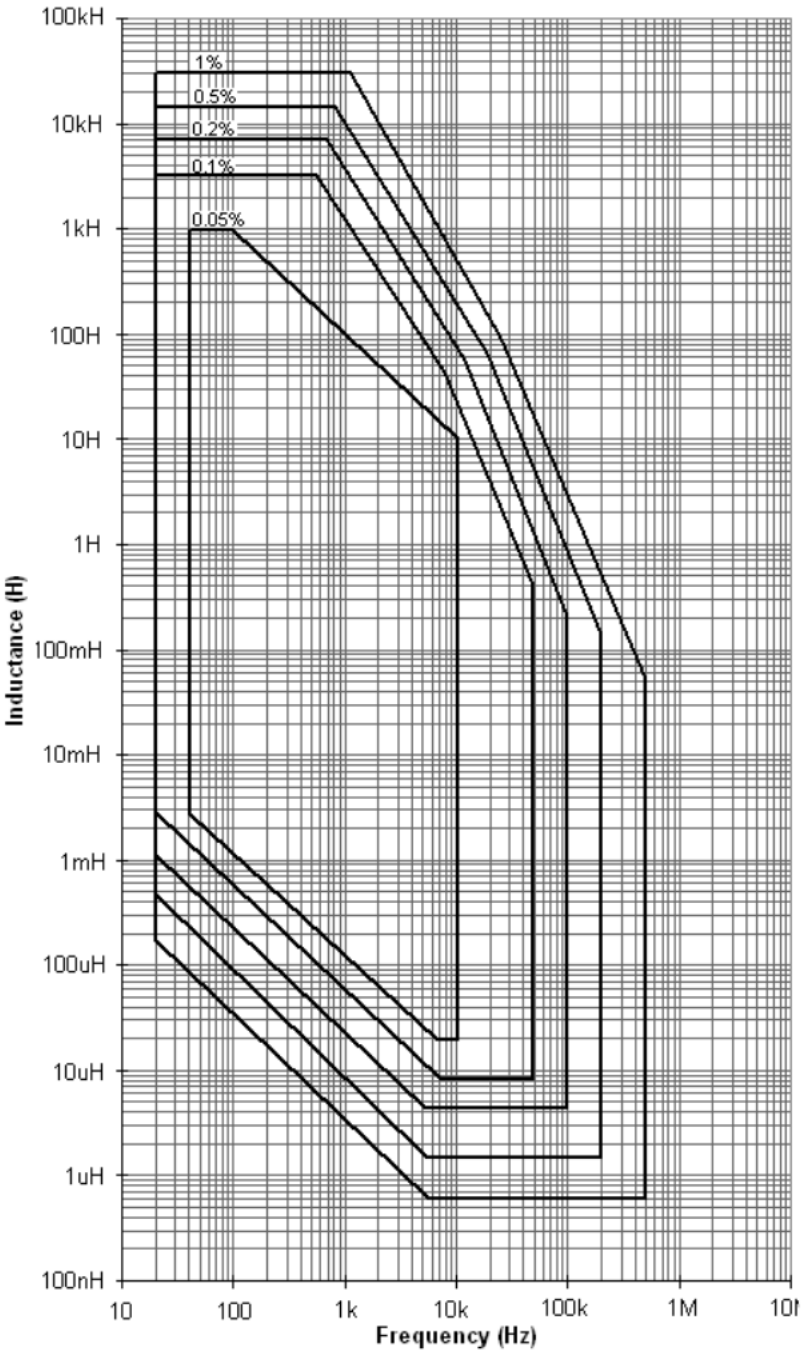
Low capacitance values

Accuracy = ± (A + 100 C_T / C_X) %

where

A = accuracy from adjacent chart
C_X = measured value of unknown component.
X_T = sum of Z_I, Z_L (as appropriate, from section 7.10.2)
C_T = sum of C_I, C_L (as appropriate, from section 7.10.1)
ω = 2π . frequency

7.9.3 L Accuracy



Conditions

AC Drive Level: 1V/20mA
Slow Speed. 4-Terminal Mode.
Analyzer trimmed at measurement frequency.
Q ≥10
Temperature range 25 ±10ºC.

Except on the highest and lowest hardware measurement ranges, the adjacent iso-accuracy chart also applies to Medium measurement speed.

For Fast speed, on all ranges, the Medium speed figures must be doubled. Supply frequency rejection is also reduced causing additional unquantifiable errors dependent on lead layout, particularly at frequencies below 600Hz and at lower AC drive levels.

O/C and S/C trim corrections under various conditions of interpolation, speed and level are given in the table following these iso-accuracy charts.

For impure components, and for measurements of the highest and lowest available ranges, full accuracy expressions, shown below, apply.

If Q <10, multiply L accuracy by (1+1/Q).

High inductance values

Read accuracy direct from chart

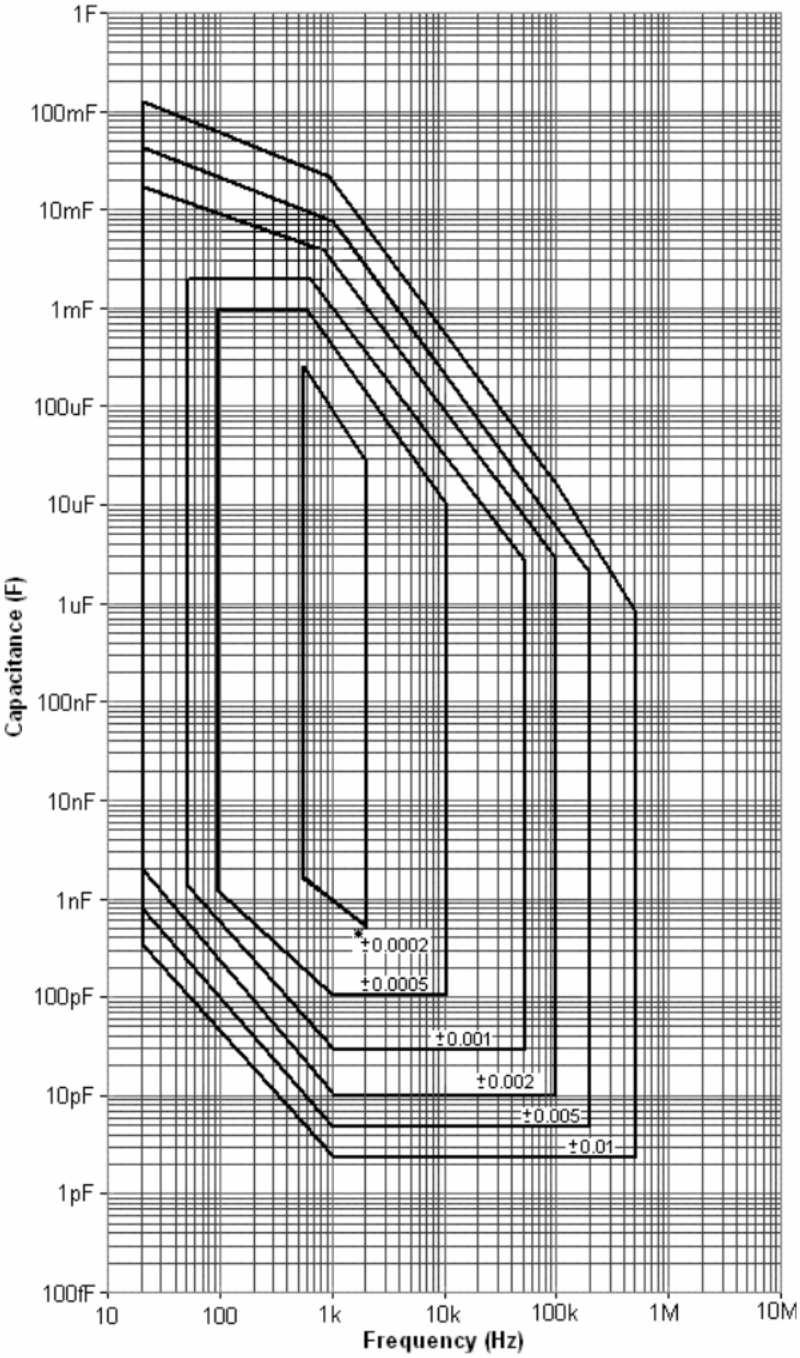
Low inductance values

Accuracy = ± (A + 100 L_T / L_X) %

where

A = accuracy from adjacent chart
L_X = measured value of unknown component.
L_T = sum of L_I, L_L (as appropriate, from section 7.10.2)

7.9.4 D Accuracy



Conditions

AC Drive Level: 1V/20mA
Slow Speed. 4-Terminal Mode.
Analyzer trimmed at measurement frequency.
D ≤0.1
Temperature range 25 ±10ºC.

Except on the highest and lowest hardware measurement ranges, the adjacent iso-accuracy chart also applies to Medium measurement speed.

For Fast speed, on all ranges, the Medium speed figures must be doubled. Supply frequency rejection is also reduced causing additional unquantifiable errors dependent on lead layout, particularly at frequencies below 600Hz and at lower AC drive levels.

* typical figure for 25 ±10ºC, guaranteed for 25 ±5ºC.

O/C and S/C trim corrections under various conditions of interpolation, speed and level are as given in the table following these iso-accuracy charts.

For impure components, and for measurements of the highest and lowest available ranges, full accuracy expressions, shown below, apply.

If D >0.1, multiply accuracy by $(1+D^2)$.

High capacitance values

D accuracy = $\pm (A + R_T \cdot \omega C_X)$

Low capacitance values

D accuracy = $\pm (A + Y_T / \omega C_X)$.

Capacitor series loss resistance (esr)

Accuracy = $\pm (A/\omega C_X)\ \Omega$

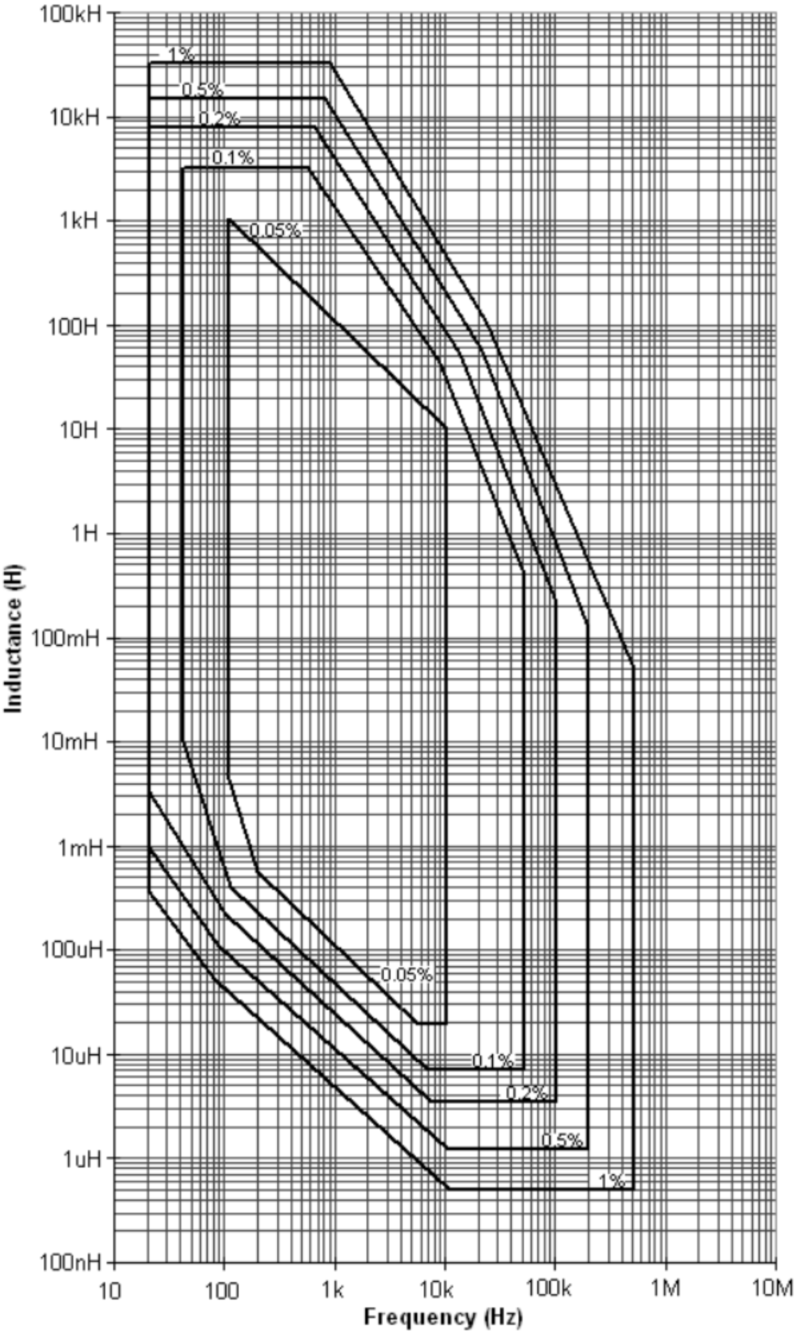
Capacitor parallel loss resistance (epr)

Accuracy = $\pm (100A R_X \cdot \omega C_X)$ %

where:

A = accuracy from adjacent chart
C_X = measured value of unknown component.
R_X = measured value of unknown component.
R_T = sum of Z_I, Z_L (as appropriate, from section 7.10.2)
Y_T = sum of Y_I, Y_L (as appropriate, from section 7.10.1)
$\omega = 2\pi$. frequency

7.9.5 Q Accuracy



Conditions

AC Drive Level: 1V/20mA
Slow Speed. 4-Terminal Mode.
Analyzer trimmed at measurement frequency.
Temperature range 25 ±10ºC.

Except on the highest and lowest hardware measurement ranges, the adjacent iso-accuracy chart also applies to Medium measurement speed.

For Fast speed, on all ranges, the Medium speed figures must be doubled. Supply frequency rejection is also reduced causing additional unquantifiable errors dependent on lead layout, particularly at frequencies below 600Hz and at lower AC drive levels.

O/C and S/C trim corrections under various conditions of interpolation, speed and level are given in the table following these iso-accuracy charts.

For all Q values

Q accuracy =A(Q + 1/Q)

High inductance values

Read Q accuracy direct from chart

Low inductance values

Q accuracy = $\pm((A + 100R_T/\omega L_X)(Q+1/Q))$ %

Inductor series loss resistance

Accuracy = $\pm (A.\ \omega L_X / R_X)$ %

Inductor parallel loss resistance

$$\text{Accuracy} = \pm \frac{A.R_X}{\omega L_X} \%$$

where

A = accuracy from adjacent chart
L_X = measured value of unknown component.
R_X = measured value of unknown component.
R_T = sum of Z_I, Z_L (as appropriate, from section 7.10.2).
$\omega = 2\pi$. frequency

7.10 Additional Corrections

The following tables give the additional corrections which need to be applied to measurements when some or all the measurement conditions specified in the Iso_Accuracy charts are not used.

7.10.1 Open Circuit Trim Correction

f = frequency in kHz

Frequency range (Hz)	Interpolation		Level 1.02 - 10V	
	Y_I (nS)	C_I (pF)	Y_L (nS)	C_L (pF)
20-250	1	0.15 / f	1	0.015 / f
300-10k	0.2	0.03 / f	0.2	0.03 / f
12k-100k	0.12 x f	0.02	0.12 x f	0.02
120k - 300k	0.31 x f	0.05	0.31 x f	0.05
302k-500k (1)	0.31 x f	0.05	0.31 x f	0.05

f = frequency in kHz, V= drive level in V

Frequency range (Hz)	Level 0.1 - 0.98V		Level < 0.1V	
	Y_L (nS)	C_L (pF)	Y_L (nS)	C_L (pF)
20-250	0.4 / V	0.06 / (f x V)	0.4 / V	0.06 / (f x V)
300-10k	0.1 / V	0.015 / (f x V)	0.1 / V	0.015 / (f x V)
12k-100k	0.12 x f	0.02	0.012 x f / V	0.002 / V
120k - 300k	0.31 x f	0.05	0.031 x f / V	0.005 / V
302k-500k (1)	0.31 x f	0.05	0.031 x f / V	0.005 / V

7.10.2 Short Circuit Trim Correction

f = frequency in kHz

Frequency range (Hz)	Interpolation		Level 2 - 200mA		
	Z_I ($\mu\Omega$)	L_I (nH)	Z_L ($\mu\Omega$)	L_L (nH)	
20	1500	240 / f	1500	240 / f	For drive levels below 2mA multiply level corrections in previous column by 2 / (level in mA).
25-80	1000	160 / f	1000	160 / f	
100	500	80 / f	500	80 / f	
120-10k	250	40 / f	250	40 / f	
12k-300k	18 x f	3	18 x f	3	
302k-500k (1)	18 x f	3	18 x f	3	

(1) Level restricted to 5V/100mA

7.11 General

7.11.1 Power Supply

Input Voltage	115V AC ±10% or 230V AC ±10% (selectable)
Frequency	50/60Hz
VA rating	150VA max
Input fuse rating	115V operation: 2AT
	230V operation: 1AT
	The input fuse is in the fuse holder drawer integral to the IEC input connector.

7.11.2 Display

High contrast black and white LCD module 320 x 240 pixels with CPL back lighting.

Visible area 115 x 86mm.

7.11.3 Printer Output

Centronics/parallel printer port for print-out of measurement results or bin count data.

7.11.4 Remote Control

Designed to GPIB IEEE-488.2 and SCPI 1992.0.

7.11.5 Remote Trigger

Rear panel BNC with internal pull-up, operates on logic low or contact closure.

7.11.6 Mechanical

Height	150mm (5.9")
Width	440mm (17.37")
Depth	525mm (20.5")
Weight	11kg (24.25lbs)

7.12 Environmental Conditions

This equipment is intended for indoor use only in a non-explosive and non-corrosive atmosphere.

7.12.1 Temperature Range

Storage:	-40°C to +70°C.
Operating:	0°C to 40°C.
Normal accuracy:	15°C to 35°C. See section 7.8—Measurement Accuracy for full specification.

7.12.2 Relative Humidity

Up to 80% non-condensing.

7.12.3 Altitude

Up to 2000m.

7.12.4 Installation Category

II in accordance with IEC664.

7.12.5 Pollution Degree

2 (mainly non-conductive)

7.12.6 Safety

Complies with the requirements of EN61010-1.

7.12.7 EMC

Complies with EN61326 for emissions and immunity.

8. 6440 SPECIFICATION

Wayne Kerr Electronics Limited reserves the right to change specification without notice

8.1 Measurement Parameters

Any of the following parameters can be measured and displayed:

DC Functions

Resistance (Rdc).

AC Functions

Capacitance (C), Inductance (L), Resistance (R), Conductance (G), Susceptance (B), Reactance (X), Dissipation Factor (D), Quality Factor (Q), Impedance (Z), Admittance (Y) and Phase Angle (θ).

The following display formats are available:

Series or Parallel Equivalent Circuit

C+R, C+D, C+Q, L+R, L+Q

Series Equivalent Circuit Only

X+R, X+D, X+Q

Parallel Equivalent Circuit Only

C+G, B+G, B+D, B+Q

Polar Form

Z + Phase Angle, Y + Phase Angle

8.2 Test Conditions

8.2.1 AC Drive

8.2.1.1 Frequency Range

20Hz to 3MHz >1800 steps

Accuracy of set frequency ±0.005%

8.2.1.2 Pre-set frequencies

Coarse step setting

20, 25, 30, 40, 50, 60, 80, 100, 120, 150; repeats for each decade.

Fine step setting

Step size 1% or better throughout range.

8.2.1.3 Drive Level (AC Measurements)

Open Circuit Voltage	Short Circuit Current	Frequency Range
1mV to 10V rms	50µA to 200mA rms	up to 300kHz
1mV to 5V rms	50µA to 100mA rms	up to 500kHz
1mV to 2.5V rms	50µA to 50mA rms	up to 3MHz

Signal source impedance: 50Ω nominal

8.2.1.4 Step Size

Voltage Drive		Current Drive	
Step size	up to drive level	Step size	up to drive level
1mV	100mV	50µA	5mA
2mV	200mV	100µA	10mA
5mV	500mV	200µA	20mA
10mV	1V	500µA	50mA
20mV	2V	1mA	100mA
50mV	5V	2mA	200mA *
100mV	10V *		

* Drive levels are reduced to 9V and 180mA at 40Hz or below.

Automatic Level Control (ALC) ensures that the drive level at the device under test (DUT) is ±2% ±1mV of set voltage or ±2% ±0.1mA of set current between 100Hz and 500kHz.

Drive level accuracy degrades below 100Hz: ±3% ±1mV or ±3% ±0.1mA at 50Hz

±5% ±1mV or ±5% ±0.1mA at 20Hz

Drive level accuracy degrades above 500kHz: ±4% ±1mV or ±4% ±0.1mA at 1MHz

±8% ±1mV or ±8% ±0.1mA at 3MHz

With DC bias applied the maximum drive voltages indicated above are halved.

8.2.2 DC Bias Voltage

A DC bias voltage derived from an internal or external source can be applied to capacitors during AC measurements.

8.2.2.1 Internal

DC bias of 2V ±5%.

Peak short circuit current <90mA.

8.2.2.2 External

External bias of up to ±60V is provided by connecting an external power supply to the rear panel bias terminals. The voltage required at the rear terminals is 5% higher than the voltage at the DUT.

A bias load of 220Ω is permanently connected across the rear panel bias terminals.

Steady state short circuit load: 70Ω.

A resettable trip protects the bias circuit against a continuous short circuit.

8.2.3 Drive Level (Rdc)

Two selectable drive levels:

Open circuit voltage	Short circuit current
100mV ±7%	1mA
1V ±7%	10mA

Source resistance: 100Ω nominal.

8.3 Measurement Speeds

Four selectable speeds for all measurement functions. Selecting slower measurement speed increases reading resolution and reduces measurement noise by averaging.

The following measurement periods apply for Rdc or for AC measurements ≥100Hz.

Maximum speed (intended for automatic sorting) ≈ 50ms.
Fast speed (for non-critical measurements) ≈ 100ms.
Medium speed (for improved resolution) ≈ 300ms.
Slow speed (for best resolution and enhanced supply frequency rejection) ≈ 900ms.

8.3.1 Capacitor Mode

Two frequency measurement ≈ 180ms.

8.4 Measurement Ranges

R, Z , X	0.01mΩ to >2GΩ
G, Y, B	0.01nS to >2kS
L	0.05nH to >2kH
C	0.5fF to >1F
D	0.00001 to >1000
Q	0.00001 to >1000
Rdc	0.1mΩ to >10MΩ

For L and C, the lower range is available at 10kHz, 100kHz and 1MHz; the upper range is available at 100Hz and below.

8.5 Hardware Ranges

The hardware range used is determined by the impedance being measured, the frequency and the level. The table below lists the boundaries of operation for AC measurement functions. The hardware range being used is indicated in the top-left-hand-corner of the instrument display.

Range Number	Impedance coverage	Frequency coverage up to
1	<1Ω	100kHz
2	<10Ω	1MHz
3	<50Ω	3MHz
4	>50Ω	3MHz
5	>250Ω	3MHz
6	>2.5kΩ	1MHz
7	>25kΩ	100kHz
8	>250kΩ	10kHz

For drive levels below 100mV, the highest range at each frequency is not available.
For drive levels below 20mA, range 1 is not available.
For drive levels below 0.5mA, range 2 is not available.

8.6 Modes Of Operation

8.6.1 MEASUREMENT

Selection of any measurement parameter and test condition.

Single-level function-menu controlled by keypad and soft keys.

Single and repetitive measurements displaying major and minor terms.

Analogue scale with configurable Hi/Lo limits giving PASS/FAIL indication (connected to logic output on binning option).

8.6.2 DEVIATION

Similar to MEASUREMENT MODE but relative or percentage deviation from nominal value displayed for major or minor term. There is no analogue scale in DEVIATION MODE.

8.6.3 MULTI FREQUENCY

Measurement parameters and test conditions set using MEASUREMENT MODE.

Up to 8 frequencies with configurable major and minor term limits.

PASS/FAIL indication (connected to logic output on binning option).

8.6.4 GRAPH

Measurement parameters and test conditions set using MEASUREMENT MODE.

Graphical sweep vs. frequency with selection of start frequency, stop frequency and step size. Linear/linear and linear/log scaling available on all measurement parameters. Log/log scaling available on Z/Y parameters.

Graph may be directly plotted on a printer or saved to a file over GPIB.

8.6.5 BINNING (Optional)

Measurement parameters and test conditions set using MEASUREMENT MODE.

8 PASS bins with absolute or percentage limits and 1 FAIL bin. Up to 99 sets of limits may be saved.

Bin count function logs the number of components in each bin.

Dedicated output for PASS/FAIL indication. Driven by analogue scale limits in MEASUREMENT MODE or by test limits in MULTI FREQUENCY MODE.

Trigger input with pull-up, operates on logic low or contact closure.

Handshake outputs indicating measure busy and data valid status.

25-way D-type interface connector.

8.6.5.1 Output Levels (B1 Option)

Output High:	>4V	Output Low:	<1V
Input High:	>3.5V	Input Low:	<1.5V

Drive capability typically is 10mA sink (low) and 30µA (high).

8.6.5.2 Output Levels (B2 Option)

This option provides an opto-coupled interface.

Output On state current:	up to 10mA at 24V	Output Off state current:	<0.5mA
Output On state voltage:	Input voltage –1.5V at 10mA		
Input High current:	>3mA	Input Low current:	<1.25mA
Input High voltage:	>15.4V	Input Low voltage:	<8V

8.6.6 CAPACITOR (Optional)

Combines the Multi Frequency and Binning modes for efficient testing of capacitors.

Measurement parameters and test conditions set using MEASUREMENT MODE.

Up to 8 frequencies with configurable major and minor term limits. The first frequency may be tested against up to 9 bins. The Major term is tested to a tolerance limit while the Minor term is compared to a relative limit. Measurements at subsequent frequencies may be compared to a single reject limit. A measurement term swap function is available if the minor term is required to be tested against a tolerance limit.

8.7 Measurement Connections

4 front panel BNC connectors permit 2-, 3- and 4-terminal connections with the screens at ground potential.

Terminals withstand connection of charged capacitor up to following limits:

- any value capacitor charged up to 50V, either polarity;
- a capacitor charged to between 50V and 500V with a stored energy of less than 0.25J, either polarity.

8.8 Measurement Accuracy

The accuracy statements given apply when the instrument is used under the following measurement conditions.

1V (DUT >50Ω) or 20mA (DUT <50Ω), slow speed, 4-terminal measurement. The instrument must have warmed up for at least 30 minutes at a steady ambient temperature of between 15°C and 35°C. The instrument must have been trimmed with its measuring leads and fixture at the measurement frequency. For frequencies above 20kHz, HF lead compensation must have been performed.

For other frequencies and speeds see section 8.9—Accuracy Charts.

8.8.1 Resistance / Reactance (R / X)

Frequency	Accuracy % (for Q < 0.1)	Range for specified accuracy
100Hz /120Hz	0.05	1Ω to 1.6MΩ
1kHz (Notes 1, 2)	0.02	10Ω to 100kΩ
1kHz	0.05	1Ω to 1.6MΩ
10kHz	0.05	1Ω to 1.6MΩ
10kHz	0.1	0.3Ω to 4.7MΩ
100kHz	0.05	25Ω to 100kΩ
100kHz	0.1	2.5Ω to 500kΩ
1MHz	0.1	30Ω to 16kΩ
1MHz	0.2	12Ω to 30kΩ

For Q ≥0.1 multiply accuracy figures by (1+Q).

8.8.2 Conductance / Susceptance (G / B)

Frequency	Accuracy % (for Q < 0.1)	Range for specified accuracy
100Hz /120Hz	0.05	0.63μS to 1S
1kHz (Notes 1, 3)	0.02	10μS to 0.1S
1kHz	0.05	0.63μS to 1S
10kHz	0.05	0.63μS to 1S
10kHz	0.1	0.22μS to 3.3S
100kHz	0.05	10μS to 0.04S
100kHz	0.1	2μS to 0.4S
1MHz	0.1	62.5μS to 67mS
1MHz	0.2	33μS to 83mS

For Q ≥0.1 multiply accuracy figures by (1+Q).

8.8.3 Capacitance (C)

Frequency	Accuracy % (for D <0.1)	Range for specified accuracy
100Hz /120Hz	0.05	1nF to 1mF
1kHz	0.05	100pF to 100μF
10kHz	0.05	50pF to 10μF
100kHz	0.05	50pF to 100nF
100kHz	0.1	25pF to 350nF
1MHz	0.1	60pF to 2.5nF
1MHz	0.2	30pF to 10nF

For D ≥0.1 multiply accuracy figures by (1+D).

8.8.4 Inductance (L)

Frequency	Accuracy % (for Q >10)	Range for specified accuracy
100Hz /120Hz	0.05	1mH to 1000H
1kHz	0.05	100µH to 100H
10kHz	0.05	20µH to 10H
100kHz	0.1	8µH to 160mH
1MHz	0.2	2µH to 4mH

For Q ≤10, multiply the accuracy figure by (1+1/Q).

8.8.5 Dissipation Factor (D)

Frequency	Accuracy (A_d)	Range for specified accuracy
100Hz /120Hz	0.0005	1nF to 1mF
1kHz (Note 1)	0.0002	1nF to 100µF
1kHz	0.0005	100pF to 400µF
10kHz	0.0005	100pF to 10µF
100kHz	0.0005	100pF to 60nF
100kHz	0.001	25pF to 600nF
1MHz	0.001	25pF to 2.5nF
1MHz	0.002	10pF to 10nF

For capacitors within the ranges shown above , D accuracy = ± A_d $(1+D^2)$.

8.8.6 Quality Factor (Q)

Frequency	Accuracy % (A_L)	Range for specified accuracy
100Hz /120Hz	0.05	4mH to 1000H
1kHz	0.05	100µH to 100H
10kHz	0.05	20µH to 10H
100kHz	0.1	7µH to 160mH
1MHz	0.2	3.5µH to 4mH

For inductors within the ranges shown above , Q accuracy = $\pm A_L$ (Q+1/Q)

8.8.7 DC Resistance (Rdc)

Drive Level	Accuracy %	Range for specified accuracy
100mV	0.25	10Ω to 10kΩ
1V	0.1	1Ω to 100kΩ

Notes

1) Accuracy is typical for 15°C to 35°C, guaranteed for 20°C to 30°C.
2) Accuracy applies to resistance only.
3) Accuracy applies to conductance only.

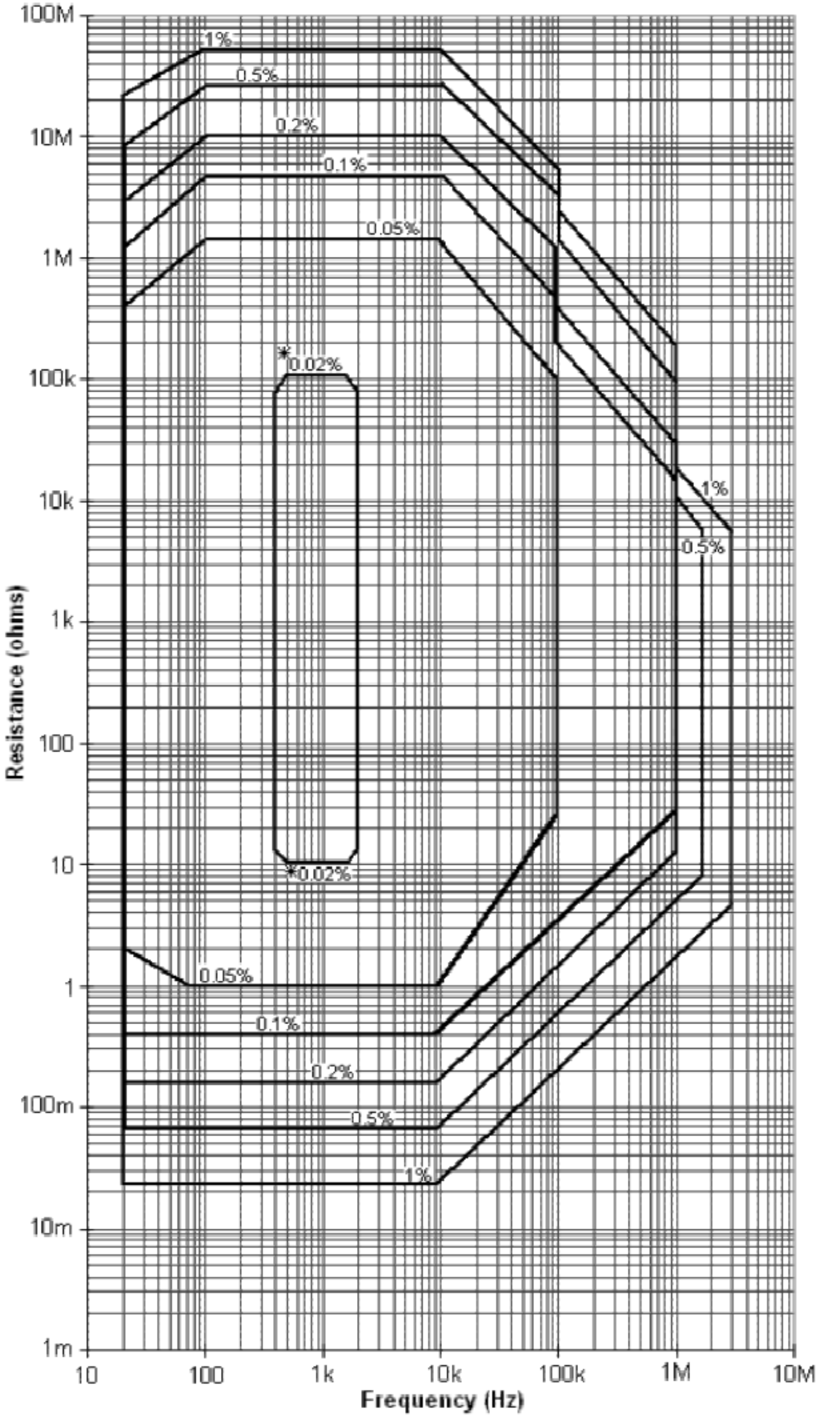
8.9 Accuracy Charts

Iso-accuracy charts define the measurement ranges available, at specified accuracies, over the available frequency band. All curves assume that Slow measurement speed is used, that the analyzer has been trimmed at the frequency used for measurements, that both factory calibration and self calibration are valid, that HF compensation has been performed on the fixture configuration being used and that the component under test is pure. Beside each chart is a summary of these conditions and the information on the accuracy applicable when some or all of the conditions change.

For above and below the ranges indicated in the following charts, the accuracy degrades linearly with increasing/decreasing DUT value. For example, 470MΩ and 2.5mΩ measured at 10kHz are both a factor of 10 beyond the indicated range for 1% and will each have an accuracy of 10%.

Measurement accuracy for the optional Multi Frequency capacitor mode conforms to the maximum speed setting.

8.9.1 R/G Accuracy



Conditions

AC Drive Level: 1V/20mA
Slow Speed. 4-Terminal Mode.
Coarse Step frequencies.
Analyzer trimmed at measurement frequency.
Q ≤0.1
Temperature range 25 ±10ºC.

Except on the highest and lowest hardware measurement ranges, the adjacent iso-accuracy chart also applies to Medium measurement speed.

For Fast speed, on all ranges, the Medium speed figures must be doubled. Supply frequency rejection is also reduced causing additional unquantifiable errors dependent on lead layout, particularly at frequencies below 600Hz and at lower AC drive levels.

* typical figure for 25 ±10ºC, guaranteed for 25 ±5ºC.

O/C and S/C trim corrections under various conditions of interpolation, speed and level, and corrections for fine frequency settings are as given in the table following these iso-accuracy charts.

For impure components, and for measurements of the highest and lowest available ranges, full accuracy expressions, shown below, apply.

If 1 > Q > 0.1, multiply R accuracy by (1+Q).
For Q > 1 (loss resistance of inductor) see Q accuracy chart.
For D < 1 (loss resistance of capacitor) see D accuracy chart

High resistance values

Accuracy = ± $(A + A_F + 100Y_T \cdot R_X)$ %

Low resistance values

Accuracy = ± $(A + 100R_T / R_X)$ %

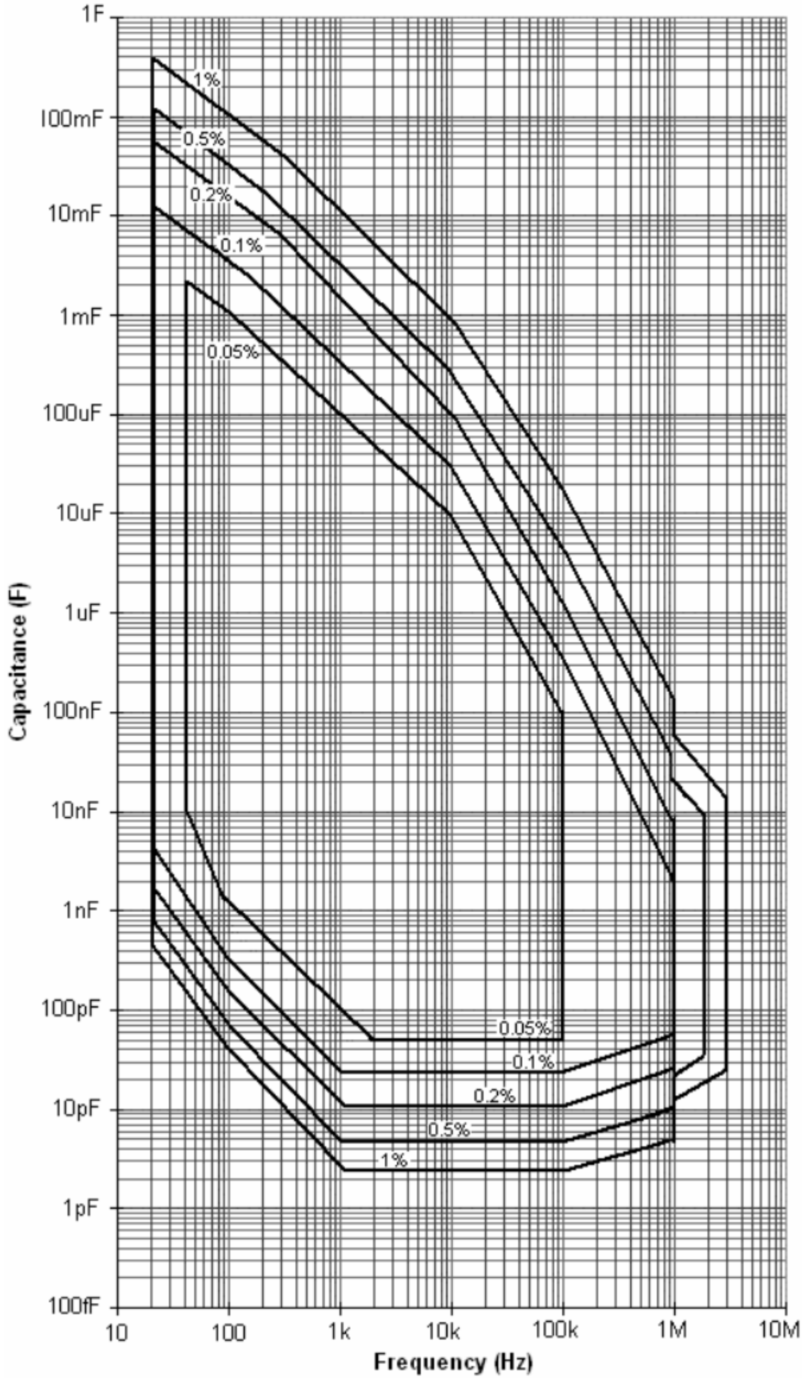
where

A = accuracy from adjacent chart
A_F = fine frequency setting correction (as appropriate from section 8.10.3).
R_X = measured value of unknown component.
R_T = sum of Z_I, Z_L (as appropriate, from section 8.10.2)
Y_T = sum of Y_I, Y_L, G_F (as appropriate, from sections 8.10.1 and 8.10.3)

Conductance (G)

Find accuracy for equivalent R value from R = 1/G

8.9.2 C Accuracy



Conditions

AC Drive Level: 1V/20mA
Slow Speed. 4-Terminal Mode.
Coarse Step frequencies.
Analyzer trimmed at measurement frequency.
D ≤0.1
Temperature range 25 ±10ºC.

Except on the highest and lowest hardware measurement ranges, the adjacent iso-accuracy chart also applies to Medium measurement speed.

For Fast speed, on all ranges, the Medium speed figures must be doubled. Supply frequency rejection is also reduced causing additional unquantifiable errors dependent on lead layout, particularly at frequencies below 600Hz and at lower AC drive levels.

O/C and S/C trim corrections under various conditions of interpolation, speed and level, and corrections for fine frequency settings are as given in the table following these iso-accuracy charts.

For impure components, and for measurements of the highest and lowest available ranges, full accuracy expressions, shown below, apply.

If D > 0.1, multiply C accuracy by (1+D).

High capacitance values

Accuracy = ± (A + A_F + 100 X_T . ω C_X) %

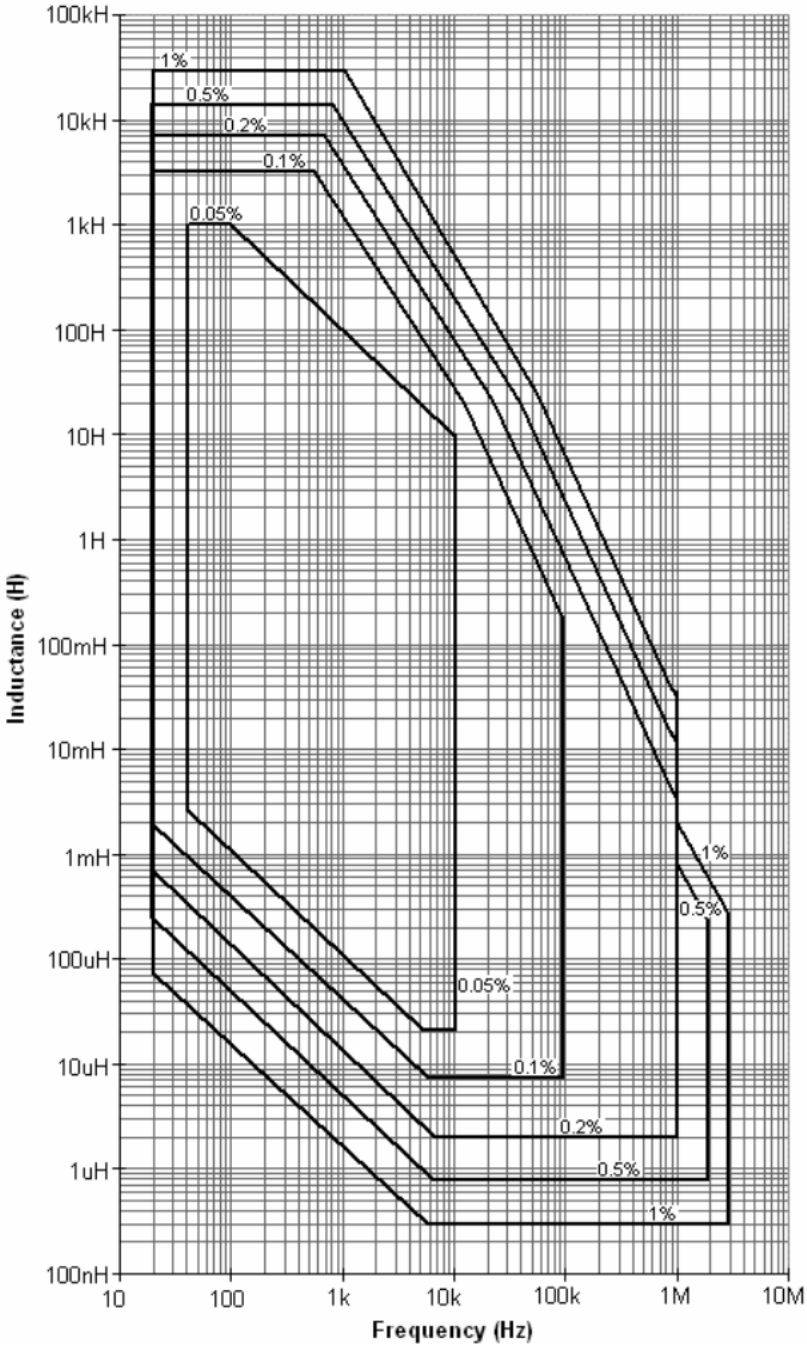
Low capacitance values

Accuracy = ± (A + 100 C_T / C_X) %

where

A = accuracy from adjacent chart
A_F = fine frequency setting correction (as appropriate from section 8.10.3).
C_X = measured value of unknown component.
X_T = sum of Z_I, Z_L (as appropriate, from section 8.10.2)
C_T = sum of C_I, C_F, C_L (as appropriate, from sections 8.10.1 and 8.10.3)
ω = 2π . frequency

8.9.3 L Accuracy



Conditions

AC Drive Level: 1V/20mA
Slow Speed. 4-Terminal Mode.
Coarse Step frequencies.
Analyzer trimmed at measurement frequency.
Q ≥10
Temperature range 25 ±10ºC.

Except on the highest and lowest hardware measurement ranges, the adjacent iso-accuracy chart also applies to Medium measurement speed.

For Fast speed, on all ranges, the Medium speed figures must be doubled. Supply frequency rejection is also reduced causing additional unquantifiable errors dependent on lead layout, particularly at frequencies below 600Hz and at lower AC drive levels.

O/C and S/C trim corrections under various conditions of interpolation, speed and level, and corrections for fine frequency settings are as given in the table following these iso-accuracy charts.

For impure components, and for measurements of the highest and lowest available ranges, full accuracy expressions, shown below, apply.

If Q < 10, multiply L accuracy by (1+1/Q).

High inductance values

Read accuracy direct from chart

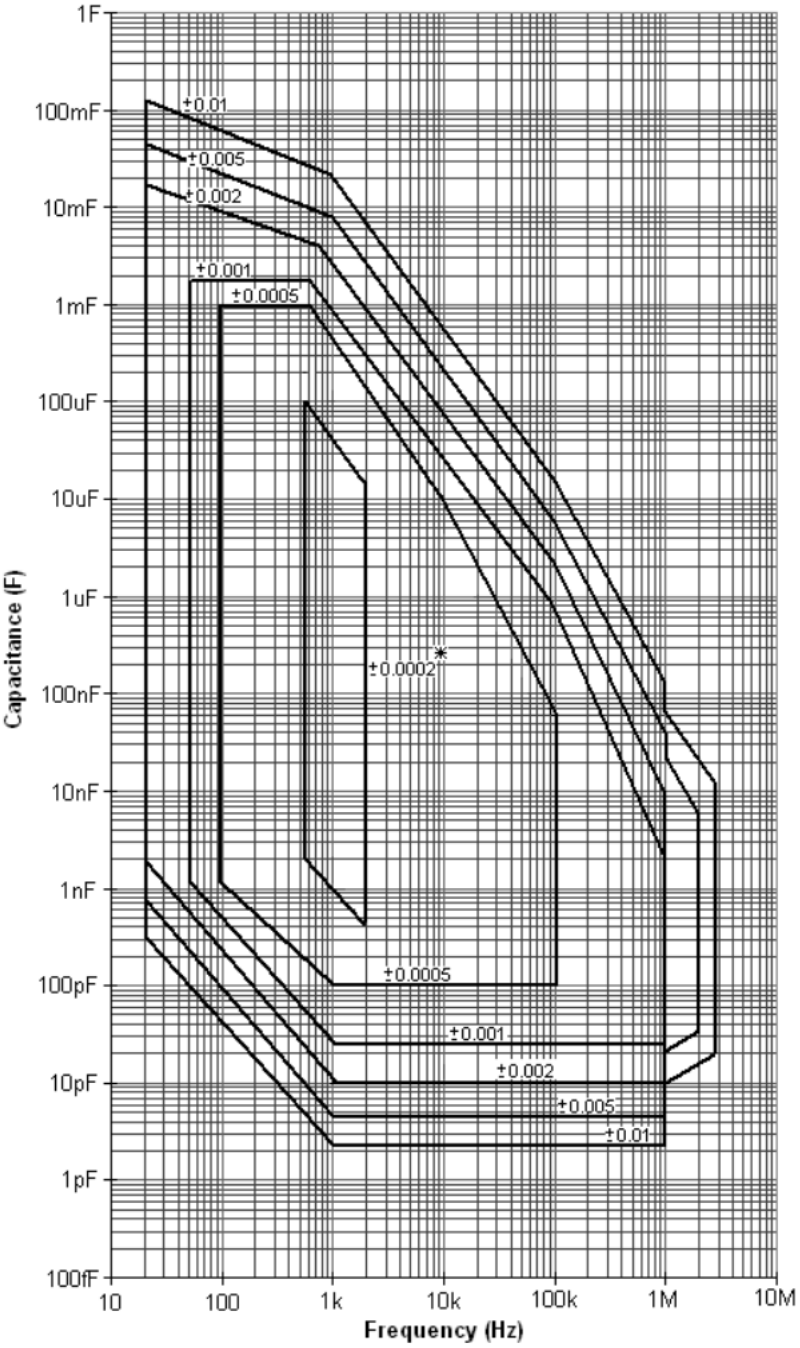
Low inductance values

Accuracy = ± (A + 100 L_T / L_X) %

where

A = accuracy from adjacent chart
L_X = measured value of unknown component.
L_T = sum of L_I, L_L (as appropriate, from section 8.10.2)

8.9.4 D Accuracy



Conditions

AC Drive Level: 1V/20mA
Slow Speed. 4-Terminal Mode.
Coarse Step frequencies.
Analyzer trimmed at measurement frequency.
D ≤0.1
Temperature range 25 ±10ºC.

Except on the highest and lowest hardware measurement ranges, the adjacent iso-accuracy chart also applies to Medium measurement speed.

For Fast speed, on all ranges, the Medium speed figures must be doubled. Supply frequency rejection is also reduced causing additional unquantifiable errors dependent on lead layout, particularly at frequencies below 600Hz and at lower AC drive levels.

* typical figure for 25 ±10ºC, guaranteed for 25 ±5ºC.

O/C and S/C trim corrections under various conditions of interpolation, speed and level, and corrections for fine frequency settings are as given in the table following these iso-accuracy charts.

For impure components, and for measurements of the highest and lowest available ranges, full accuracy expressions, shown below, apply.

If D > 0.1, multiply D accuracy by $(1+D^2)$.

High capacitance values

D accuracy = $\pm (A + R_T \cdot \omega C_X)$

Low capacitance values

D accuracy = $\pm (A + Y_T / \omega C_X)$

Capacitor series loss resistance (esr)

Accuracy = $\pm (A/\omega C_X)\ \Omega$

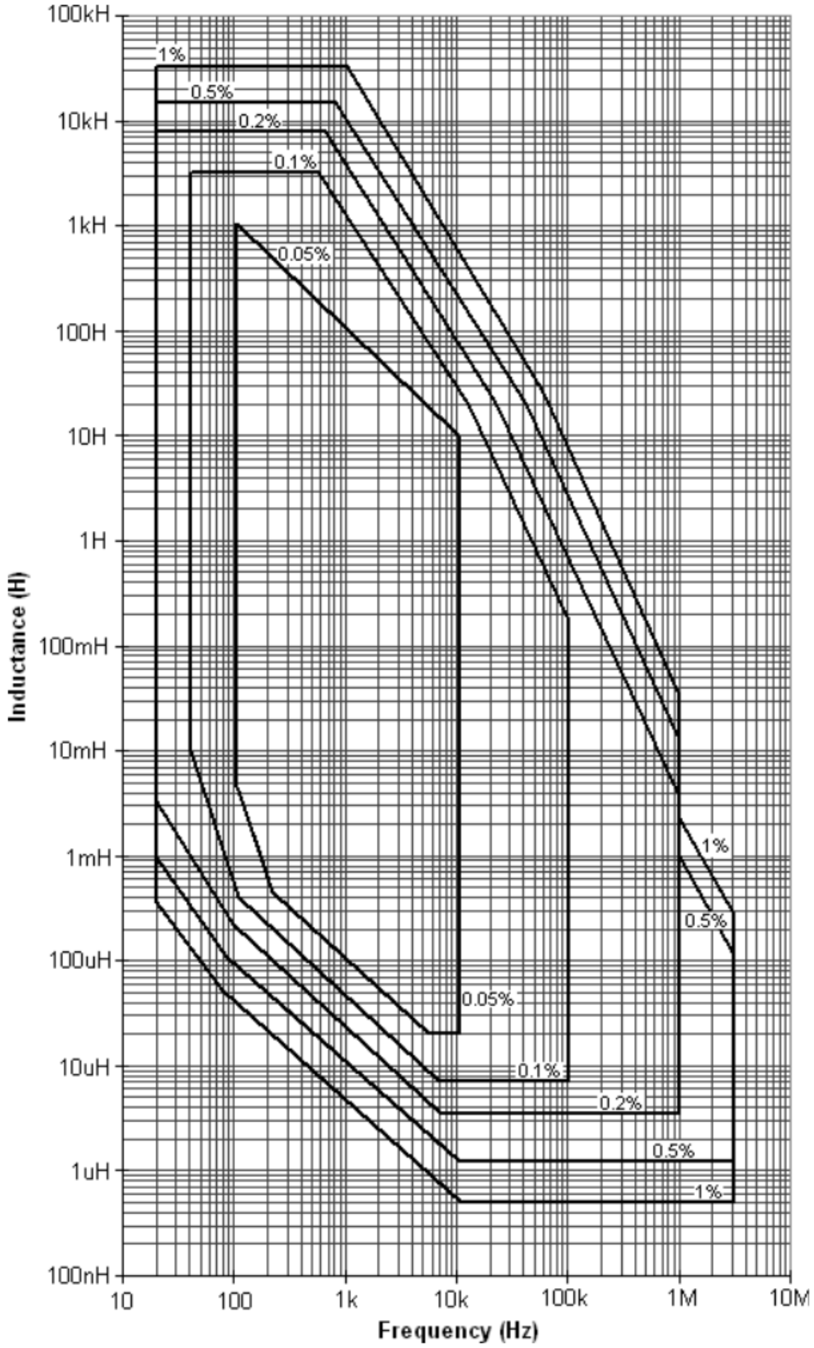
Capacitor parallel loss resistance (epr)

Accuracy = $\pm (100A\ R_X \cdot \omega C_X)$ %

where

A = accuracy from adjacent chart
C_X = measured value of unknown component
R_X = measured value of unknown component
R_T = sum of Z_I, Z_L, $1/G_F$ (as appropriate, from sections 8.10.2 and 8.10.3)
Y_T = sum of Y_I, Y_L (as appropriate, from section 8.10.1)
$\omega = 2\pi \cdot$ frequency

8.9.5 Q Accuracy



Conditions

AC Drive Level: 1V/20mA
Slow Speed. 4-Terminal Mode.
Coarse Step frequencies.
Analyzer trimmed at measurement frequency.
Temperature range 25 ±10ºC.

Except on the highest and lowest hardware measurement ranges, the adjacent iso-accuracy chart also applies to Medium measurement speed.

For Fast speed, on all ranges, the Medium speed figures must be doubled. Supply frequency rejection is also reduced causing additional unquantifiable errors dependent on lead layout, particularly at frequencies below 600Hz and at lower AC drive levels.

O/C and S/C trim corrections under various conditions of interpolation, speed and level, and corrections for fine frequency settings are as given in the table following these iso-accuracy charts.

For all Q values

Q accuracy =A (Q + 1/Q)

High inductance values

Read Q accuracy direct from chart

Low inductance values

Q accuracy = ± ((A + 100R_T / ωL_X) (Q+1/Q)) %

Inductor series loss resistance

Accuracy = ± (A. ωL_X /R_X) %

Inductor parallel loss resistance

$$\text{Accuracy} = \pm \frac{A \cdot R_X}{\omega L_X} \%$$

where

A = accuracy from adjacent chart
L_X = measured value of unknown component
R_X = measured value of unknown component
R_T = sum of Z_I, Z_L (as appropriate, from section 8.10.2)
ω = 2π . frequency

8.10 Additional Corrections

The following tables give the additional corrections which need to be applied to measurements when some or all the measurement conditions specified in the Iso_Accuracy charts are not used.

8.10.1 Open Circuit Trim Correction

f = frequency in kHz

Frequency range (Hz)	Interpolation		Level 1.02 - 10V	
	Y_I (nS)	C_I (pF)	Y_L (nS)	C_L (pF)
20 - 250	1	0.15 / f	1	0.015 / f
300 - 10k	0.2	0.03 / f	0.2	0.03 / f
12k - 100k	0.12 x f	0.02	0.12 x f	0.02
120k - 300k	0.31 x f	0.05	0.31 x f	0.05
302k - 1M (1)	0.31 x f	0.05	0.31 x f	0.05
1.01M - 3M (2)	3.1 x f	0.5	3.1 x f	0.5

f = frequency in kHz, V= drive level in V

Frequency range (Hz)	Level 0.1 - 0.98V		Level < 0.1V	
	Y_L (nS)	C_L (pF)	Y_L (nS)	C_L (pF)
20 - 250	0.4 / V	0.06 / (f x V)	0.4 / V	0.06 / (f x V)
300 - 10k	0.1 / V	0.015 / (f x V)	0.1 / V	0.015 / (f x V)
12k - 100k	0.12 x f	0.02	0.012 x f / V	0.002 / V
120k - 300k	0.31 x f	0.05	0.031 x f / V	0.005 / V
302k - 640k (1)	0.31 x f	0.05	0.031 x f / V	0.005 / V
645k - 1M (1)	0.31 x f	0.05	0.31 x f / V	0.05 / V
1.01M - 3M (2)	3.1 x f	0.5	0.31 x f / V	0.05 / V

8.10.2 Short Circuit Trim Correction

f = frequency in kHz

Frequency range (Hz)	Interpolation		Level 2 - 200mA		
	Z_I (μΩ)	L_I (nH)	Z_L (μΩ)	L_L (nH)	
20	1500	240 / f	1500	240 / f	For drive levels below 2mA multiply level corrections in previous column by 2 / (level in mA).
25-80	1000	160 / f	1000	160 / f	
100	500	80 / f	500	80 / f	
120 -10k	250	40 / f	250	40 / f	
12k - 300k	18 x f	3	18 x f	3	
302k -1M (1)	18 x f	3	18 x f	3	
1.01M - 3M (2)	36 x f	6	36 x f	6	

(1) Level restricted to 5V/100mA
(2) Level restricted to 2.5V/50mA

8.10.3 Fine Frequency Setting Corrections

Drive level = 1V

Frequency range (Hz)	C_F (fF)	A_F (%)	G_F (nS)	A_F (%)
20k - 100k	10	0.02	0.063 x f	0.02
101k - 1M	20	0.035	0.126 x f	0.035
1.01M - 3M	100	0.065	0.630 x f	0.065

Drive level <1V

Frequency range (Hz)	C_F (fF)	A_F (%)	G_F (nS)	A_F (%)
20k - 100k	10 / level in V	0.02 / level in V	0.063 x f / level in V	0.02 / level in V
101k - 1M	20 / level in V	0.035 / level in V	0.126 x f / level in V	0.035 / level in V
1.01M - 3M	100 / level in V	0.065 / level in V	0.630 x f / level in V	0.065 / level in V

Drive level >1V

Frequency range (Hz)	C_F (fF)	A_F (%)	G_F (nS)	A_F (%)
20k - 100k	30	0.03	0.19 x f	0.03
101k - 1M	100	0.04	0.63 x f	0.04
1.01M - 3M	900	0.175	5.65 x f	0.175

8.11 General

8.11.1 Power Supply

Input Voltage	115V AC ±10% or 230V AC ±10% (selectable)
Frequency	50/60Hz
VA rating	150VA max
Input fuse rating	115V operation: 2AT
	230V operation: 1AT
	The input fuse is in the fuse holder drawer integral to the IEC input connector.

8.11.2 Display

High contrast black and white LCD module 320 x 240 pixels with CPL back lighting.

Visible area 115 x 86mm.

8.11.3 Printer Output

Centronics/parallel printer port for print out of measurement results, bin count data and graphical display.

8.11.4 Remote Control

Designed to GPIB IEEE-488.2 and SCPI 1992.0.

8.11.5 Remote Trigger

Rear panel BNC with internal pull-up, operates on logic low or contact closure.

8.11.6 Mechanical

Height	150mm (5.9")
Width	440mm (17.37")
Depth	525mm (20.5")
Weight	11kg (24.25lbs)

8.12 Environmental Conditions

This equipment is intended for indoor use only in a non-explosive and non-corrosive atmosphere.

8.12.1 Temperature Range

Storage: -40°C to +70°C.
Operating: 0°C to 40°C.
Normal accuracy: 15°C to 35°C. See section 8.8—Measurement Accuracy for full specification.

8.12.2 Relative Humidity

Up to 80% non-condensing.

8.12.3 Altitude

Up to 2000m.

8.12.4 Installation Category

II in accordance with IEC664.

8.12.5 Pollution Degree

2 (mainly non-conductive).

8.12.6 Safety

Complies with the requirements of EN61010-1.

8.12.7 EMC

Complies with EN61326 for emissions and immunity.

9. THEORY REFERENCE

9.1 Abbreviations

B	Susceptance (= 1/X)	R	Resistance
C	Capacitance	X	Reactance
D	Dissipation factor (tan δ)	Y	Admittance (= 1/Z)
E	Voltage	Z	Impedance
G	Conductance (= 1/R)	ω	2π x frequency
I	Current		
L	Inductance		Subscript s ($_s$) = series
Q	Quality (magnification) factor		Subscript p ($_p$) = parallel

9.2 Formulae

$$Z = \frac{E}{I} \quad \text{(all terms complex)}$$

$$Y = \frac{I}{E} = \frac{1}{Z}$$

$$Z_s = R + jX = R + j\omega L = R - \frac{j}{\omega C}$$

$$|Z_s| = \sqrt{(R^2 + X^2)}$$

$$|Z_p| = \frac{RX}{\sqrt{(R^2 + X^2)}}$$

$$Y_p = G + jB = G + j\omega C = G - \frac{j}{\omega L}$$

$$|Y_p| = \sqrt{(G^2 + B^2)}$$

$$|Y_s| = \frac{GB}{\sqrt{(G^2 + B^2)}}$$

where $\quad X_L = \omega L \quad X_C = \frac{1}{\omega C} \quad B_C = \omega C \quad B_L = \frac{1}{\omega L}$

$$Q = \frac{\omega L_S}{R_S} = \frac{1}{\omega C_S R_S} \quad \text{(series R, L, C values)}$$

$$Q = \frac{R_P}{\omega L_P} = \omega C_P R_P \quad \text{(parallel R, L, C values}$$

$$D = \frac{G_P}{\omega C_P} = \omega L_P G_P \quad \text{(parallel G, L, C values)}$$

$$D = \frac{R_S}{\omega L_S} = \omega C_S R_S \qquad \text{(series R, L, C values)}$$

Note : The value $Q = \frac{1}{D}$ is constant regardless of series/parallel convention

9.3 Series/Parallel Conversions

$$R_S = \frac{R_P}{\left(1 + Q^2\right)} \qquad R_P = R_S\left(1 + Q^2\right)$$

$$C_S = C_P\left(1 + D^2\right) \qquad C_P = \frac{C_S}{\left(1 + D^2\right)}$$

$$L_S = \frac{L_P}{\left(1 + \frac{1}{Q^2}\right)} \qquad L_P = L_S\left(1 + \frac{1}{Q^2}\right)$$

Conversions using the above formulae will be valid only at the test frequency.

9.4 Polar Derivations

$$R_S = |Z|\cos\theta \qquad G_P = |Y|\cos\theta$$

$$X_S = |Z|\sin\theta \qquad B_P = |Y|\sin\theta$$

Note that, by convention, +ve angle indicates an inductive impedance or capacitive admittance.

If capacitance is measured as inductance, the L value will be –ve.

If inductance is measured as capacitance, the C value will be –ve.

$D = \tan\delta$ where $\delta = (90 - \theta)^\circ$ admittance measurement.

$Q = \frac{1}{\tan\delta}$ where $\delta = (90 - \theta)^\circ$ impedance measurement.

10. MAINTENANCE, SUPPORT AND SERVICES

10.1 Guarantee

The equipment supplied by is guaranteed against defective material and faulty manufacture for a period of twelve months from the date of dispatch. In the case of materials or components employed in the equipment but not manufactured by us, we allow the customer the period of any guarantee extended to us.

The equipment has been carefully inspected and submitted to comprehensive tests at the factory prior to dispatch. If, within the guarantee period, any defect is discovered in the equipment in respect of material or workmanship and reasonably within our control, we undertake to make good the defect at our own expense subject to our standard conditions of sale. In exceptional circumstances and at the discretion of the service manager, a charge for labour and carriage costs incurred may be made.

Our responsibility is in all cases limited to the cost of making good the defect in the equipment itself. The guarantee does not extend to third parties, nor does it apply to defects caused by abnormal conditions of working, accident, misuse, neglect or wear and tear.

10.2 Maintenance

10.2.1 Cleaning

The body of the equipment can be cleaned with a damp lint-free cloth. Should it be required, weak detergents can be used. No water must enter the equipment. Do not attempt to wash down internal parts.

10.2.2 Safety Checks

Each year the equipment should be given a simple safety check.

10.2.2.1 Equipment required

25A ground bond tester (e.g. Megger PAT 2)

Insulation tester @ 500V DC (e.g. Megger BM 7)

10.2.2.2 Tests

1) **DISCONNECT THE INSTRUMENT FROM THE AC POWER SUPPLY!**
2) Inspect the unit and associated wiring for damage e.g. dents or missing parts which might impair the safety or function of the equipment. Look for any signs of overheating or evidence that objects might have entered the unit.
3) **Ground Bond:** Ensure that 25A DC can flow from exposed metal parts of the unit (not BNC connector outers) to ground with an impedance of less than 100mΩ.
4) **Insulation Test:** Connect the Live and Neutral of the power cable together and test the insulation between this point and the ground at 500V DC. Readings greater than 1MΩ are acceptable.

10.3 Support and Service

In the event of difficulty, or apparent circuit malfunction, it is advisable to contact the service department or your local sales engineer or agent (if overseas) for advice before attempting repairs.

For repairs and recalibration it is recommended that the complete instrument be returned to one of the following:

USA

Wayne Kerr Electronics Inc.

165L New Boston Street

Woburn MA 01801-1744

Tel: 781 938 8390

Fax: 781 933 9523

email: sales@waynekerr.com

www.waynekerrtest.com

UK

Wayne Kerr Electronics

Vinnetrow Business Park

Vinnetrow Road

Chichester

West Sussex PO20 1QH

Tel: +44 (0)1243 792200

Fax: +44 (0)1243 792201

email: sales@wayne-kerr.co.uk

email: service@wayne-kerr.co.uk

www.waynekerrtest.com

Asia

Microtest

14F-6, No.79, Hsin Tai Wu Road, Sec. 1,

Hsi-chih, Taipei 221, Taiwan, R.O.C.

Tel: +886-2-2698-4104

Fax: +886-2-2698-0716

Email: wksales@microtest.com.tw

www.waynekerrtest.com

When returning the instrument please ensure adequate care is taken with packing and arrange insurance cover against transit damage or loss. If possible re-use the original packing box.

INDEX

T