Wayne Kerr Electronics

INDUCTANCE ANALYZER
3255B Series

User Manual

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Wayne Kerr Electronics Limited Worldwide

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
service@waynekerr.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
service@wayne-kerr.co.uk

Europe
Wayne Kerr Europe
Märkische Str. 38-40
58675 Hemer
Germany

Tel: +49 (0)2372 557870
Fax: +49 (0)2372 5578790
Email: info@waynekerr.de
service@waynekerr.de

Asia
Wayne Kerr Asia
A604 Pengdu Building,
Guimiao Road,
Nanshan District,
Shenzhen, Guangdong
China
Tel: +86 130 66830676
Fax: +86 755 26523875
Email: sales@waynekerr.com
service@waynekerr.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 3255B Inductance Analyzer

The 3255B Inductance Analyzer series provide 2-terminal or 4-terminal (Kelvin) measurement of inductors and transformers over the frequency range 20Hz to 1MHz. The upper frequency available is dependant on model specified.

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;
- output of measurement results 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.

The drive level for AC measurements can be varied from 1mV to 10V rms while DC resistance measurements are performed at a drive level of 100mV. Automatic level control (ALC) can maintain the drive level at the component.

With the DC Bias option fitted a variable current of between 1mA and 1A may be applied when making AC measurements. The 3255B series is compatible with the external 3265B DC Bias Units which can increase the maximum current to 125A.

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 3255B 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.

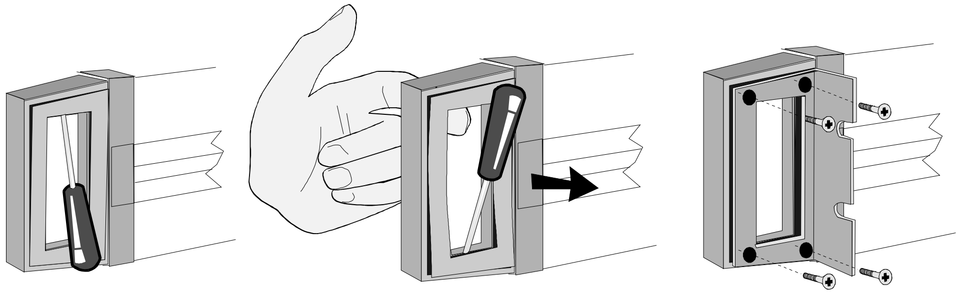


Figure 3-1 Procedure for Attachment of Rack Mounting Brackets

3.3 Wayne Kerr Electronics Measurement Leads

The 3255B can be used with any of the following Wayne Kerr Electronics leads or fixtures. 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.

3.3.1 Other Test Leads

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

The 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 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.

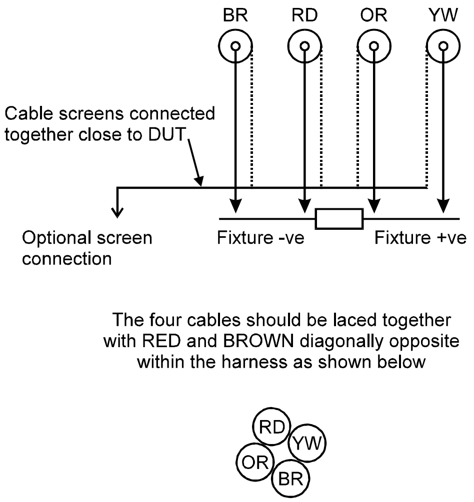


Figure 3-2 4-Terminal Measurement

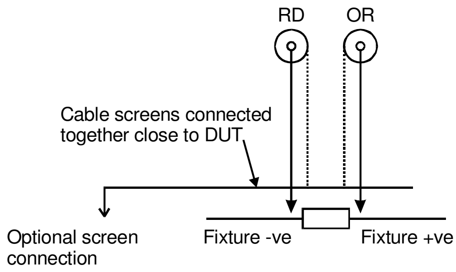


Figure 3-3 2-Terminal Measurement

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

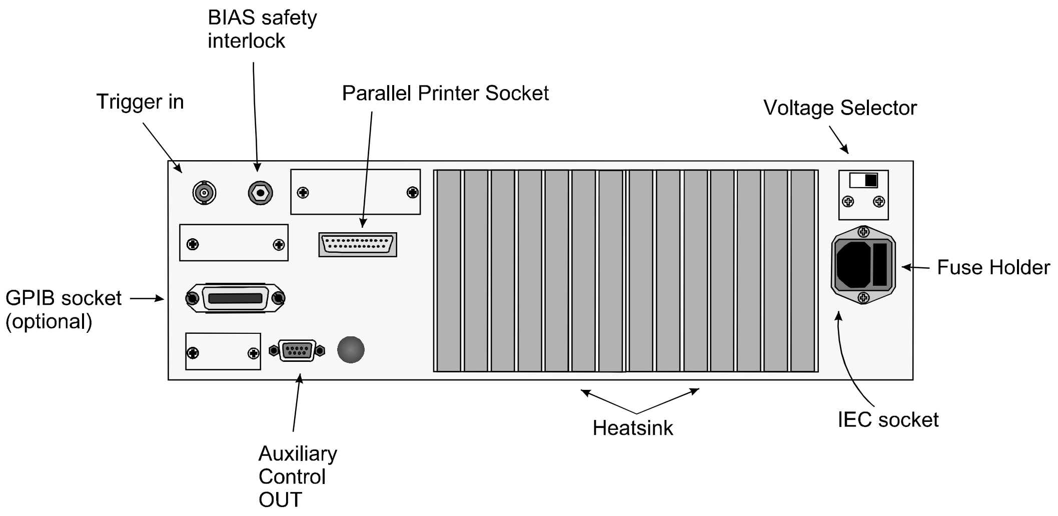


Figure 4-1 The 3255B Rear Panel

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—AC Power Supply, before connecting the IEC socket to the AC power source.

4.1.3 Rear Panel Control Connections

Label	Type	Use	Reference
SAFETY INTERLOCK	3 pole 3.5mm jack plug	To protect user against unintentional back emf.	See section 4.1.4
GPIB (optional)	Standard GPIB	For remote operation.	Sections 4.1.7 and 4.2.5
TRIGGER IN	BNC	Duplicates action of front panel trigger key.	Section 4.1.5
AUX CONTROL OUT	9-way D-type (female)	For control of external options.	Section 4.1.8
PARALLEL PRINTER	25-way D-type (female)	To send results to local printer	Sections 4.1.6, 4.2.6.1 and 6.2.1.

4.1.4 Safety Interlock for DC Bias Option

DC bias current is inhibited until the safety interlock circuit is complete. The terminal fixture for the inductor under test should be placed within a housing with an interlocked door controlled by a circuit such as that shown in Figure 4-2 below.

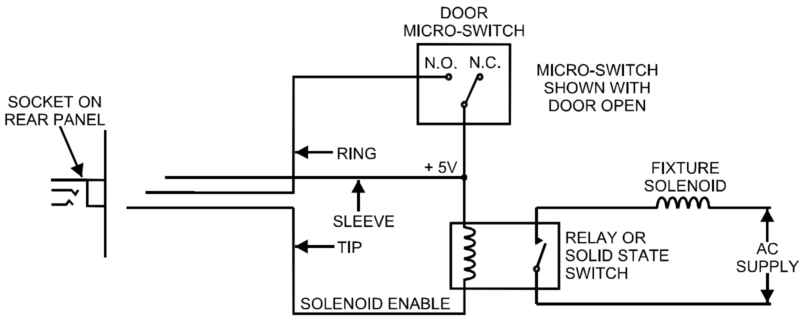


Figure 4-2 Typical Bias Interlock Fixture

Only when the fixture door is closed, and the microswitch therefore made, can DC bias be activated. At this time, the relay is energized, activating an AC supply for a solenoid which can be used to lock the door while bias remains available.

The solenoid drive relay should have a 5V DC coil of resistance not less than 200Ω. Diode coil protection is provided within the bias circuitry.

The door lock is activated when **Bias On** is selected on the instrument. If the door switch or interlock lead is broken, DC bias is inhibited.

IMPORTANT

If the safety interlock is not required, it is necessary to insert the 3.5mm jack plug, with the ring and sleeve connections linked, into the socket on the back panel. Failure to do this will result in bias being inhibited, and the message, ✳ **Bias Interlock** ✳ being displayed.

4.1.5 External Trigger

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

4.1.6 Parallel Printer Connector

Allows the instrument to be connected to an Epson-compatible printer for printing of measurement results.

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 3255B
13:53:17  02 Oct 00
```

Status

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

```
MEASUREMENT 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
DC Bias 0.000 A OFF NORM
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 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.

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 (optional)

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 6.

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 Control Out

For control of external options, e.g. when using external DC bias current from a 3265B DC Bias Unit, the 3255B **AUX CONTROL OUT** connector is connected to the 3265B **AUX IN** connector using the control link cable supplied with the 3265B DC Bias Unit.

4.2 The Front Panel

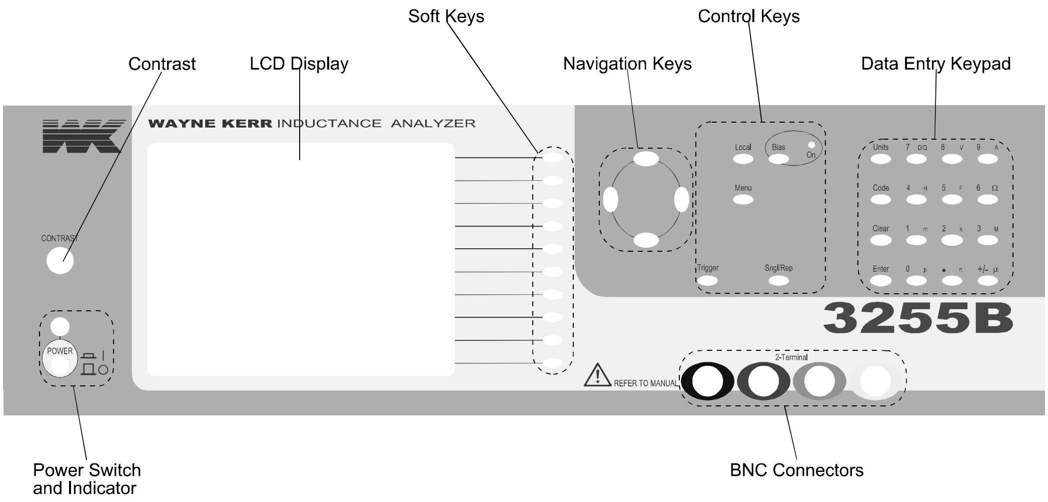


Figure 4-3 The 3255B Front Panel

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. **MEASUREMENT**, **MULTI FREQ**, 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.

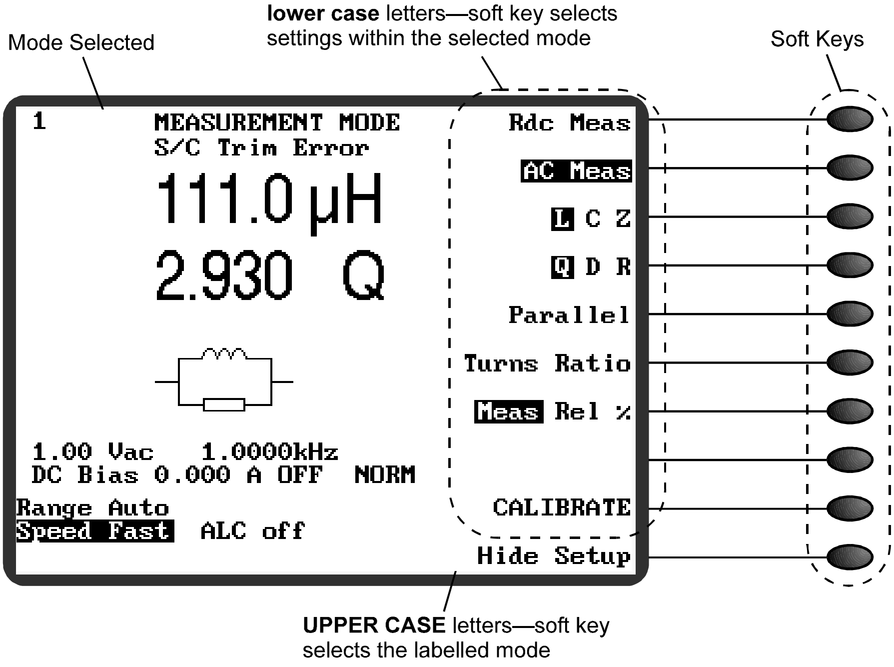


Figure 4-4 The Soft Keys

4.2.4 The Navigation Keys

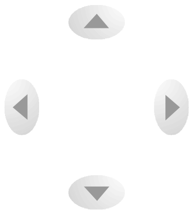


Figure 4-5 The Navigation Keys

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, frequency and DC Bias: the steps vary according to the value but are always multiples of 1, 2 or 5. For other parameters, the ▲ and ▼ navigation keys change the settings, e.g. Auto Range/[fixed range], Slow/Med/Fast/Max, ALC off/on.

4.2.5 The Control Keys

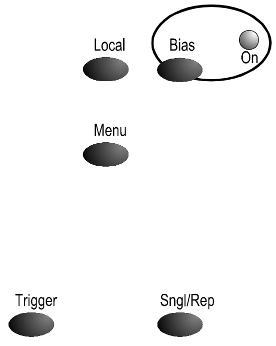


Figure 4-6 The Control Keys

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

Bias toggles the DC bias current ON and OFF. Before bias can be switched ON, the Bias parameter must be selected with the left and right navigation keys, and , and a Bias current value entered, either with the up and down navigation keys, and , or using the data entry keypad: see section 4.2.6. If the DC bias current option is fitted, AC measurements may have a DC bias current applied which is variable between 1mA and 1A (**DC Bias NORM**) and when used with one or more external 3265B DC Bias Units (max 5), up to 125A DC bias current is available (**DC Bias BOOST**). Whenever DC bias is on, the message shown below in Figure 4-7 will be displayed at the top of the screen.

Figure 4-7 Bias Safety Hazard Notice

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

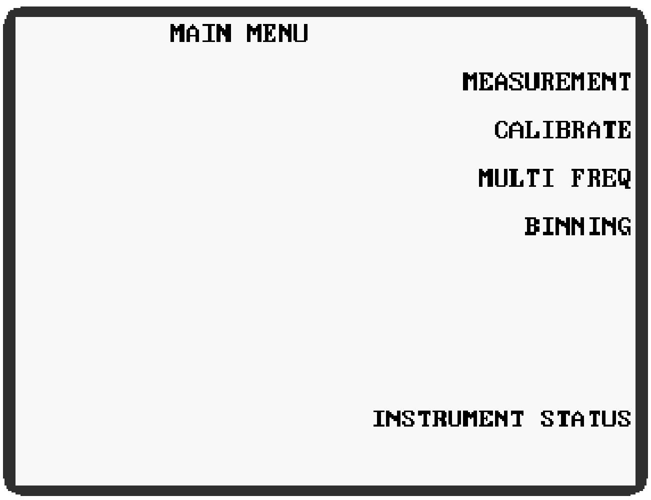


Figure 4-8 The3255B Main Menu

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 4-9 and Figure 4-10 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 4-9 Single Shot Mode

`Repetitive mode`

Figure 4-10 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

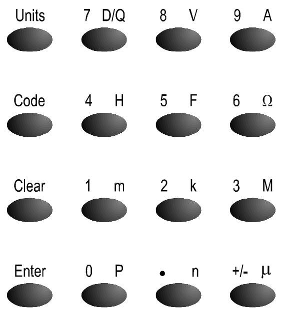


Figure 4-11 The Data Entry Keypad

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, 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 may cause the entry line to be cleared and an error message, such as the one shown in Figure 4-12, to be displayed, in which case the existing settings will be preserved; or the nearest available value may be set, accompanied by the message shown in Figure 4-13.

`Units mismatched`

Figure 4-12 Example of an Error Message from an Invalid Keypad Entry

`Nearest Available`

Figure 4-13 'Nearest Available' Message

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 data
30	Enable printer output
31	Disable printer output
32	Print factory calibration data

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

MEASUREMENT MODE	
Code	**Description**
12	Set global test conditions
13	Set non-global test conditions
18	Single-shot mode
19	Repetitive mode

BIN SET MODE	
Code	**Description**
18	Single shot mode
19	Repetitive mode
34	Print the present bin set-up. Code 30 must be entered first from the MAIN MENU.
40	Store bin set-up at a given location in non-volatile memory.

BIN SET MODE	
Code	**Description**
41	Recall a bin set-up from non-volatile memory.
42	List all the set-up in non-volatile memory.

BIN SORT AND BIN COUNT MODES	
Code	**Description**
18	Single shot mode
19	Repetitive mode

4.2.6.2 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**, **%**.

2) Using the ◄ and ► keys, highlight the **nom:** parameter.

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;
- when maximum accuracy is required when switching between modes, in which case maximum accuracy will be obtained by trimming from the mode which is to be used for component measurement.

If the **All Freq** trim option is 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. Alternatively, a **Spot** trim may be performed which trims only at the frequency set in **MEASUREMENT MODE**.

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.

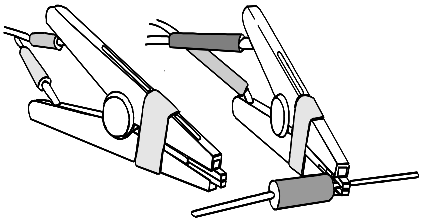


Figure 4-14 Connections for O/C trimming of Kelvin clips

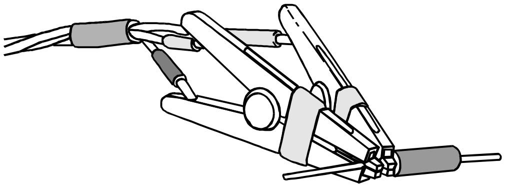


Figure 4-15 Connections for S/C trimming of Kelvin clips

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

1) Select **CALIBRATE**, either from the **MAIN MENU**, or from one of the other modes (in which case pressing the bottommost soft key, which will be labelled with the name of the original mode, e.g. **MEASUREMENT**, **BINNING**, will return the analyzer to that mode). The analyzer will enter **CALIBRATE MODE**.

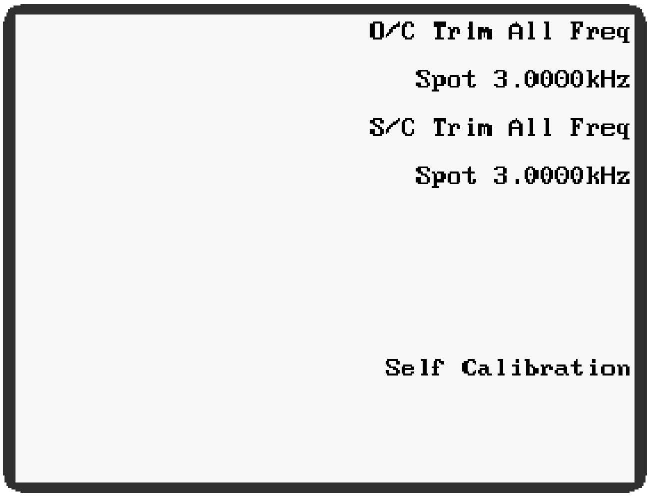


Figure 4-16 3255B Calibrate Mode

2) With the measurement leads connected to the BNC connectors, open- or short-circuit the Kelvin clips or fixture jaws as appropriate.

3) Select **O/C Trim** or **S/C Trim**, choosing the **All Freq** or **Spot** option as required. See section 4.3.1.1 for details of the trim options.

4) Wait until the analyzer has finished trimming.

Note:

If the instrument is switched OFF during the trim, the message shown in Figure 4-17 will be displayed when the instrument is next switched ON. The component measurement modes 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. The messages will only be cleared by performing the appropriate trims. 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.

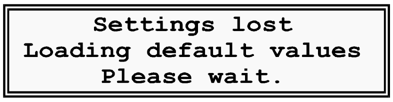


Figure 4-17 Settings Lost

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

4.3.1.1 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 **Spot** 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**.

Note:

If, after performing a **Spot** trim, a measurement frequency other than the trim frequency is selected, **`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 at the new frequency using either a **Spot** or **All Freq** trim.

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 4-18 below.

```
To maintain full calibration accuracy,
the self-calibrate routine should be
run periodically. This calibration is
now due. Allow the instrument to warm
up for at least 30 minutes at its
normal operating temperature before
running this routine.


 Press any key to clear this message.
```

Figure 4-18 Self-Calibration Reminder

4.4.1 Performing 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 one of the other modes (in which case pressing the bottommost soft key, which will be labelled with the name of the original mode, e.g. **MEASUREMENT**, **BINNING**, will return the analyzer to that mode). The analyzer will enter **CALIBRATE MODE**, shown in 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 calibration 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 power failure during the routine, or if the self calibration data becomes corrupted, Figure 4-17 (above) may be displayed when the instrument is next switched ON, followed by Figure 4-19, which will be displayed every time the instrument is switched ON. When component measuring modes are selected, calibration or trim errors will be reported at the top of the screen. These messages will only be cleared by performing self calibration and, if necessary, O/C and S/C trims. The instrument can be used with the default settings but it is recommended that self calibration is run for full measurement accuracy.

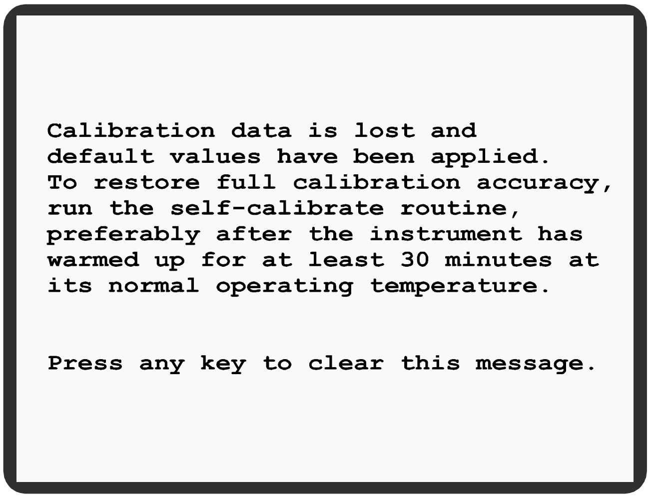


Figure 4-19 Calibration Data Lost

4.5 Measuring a Component in MEASUREMENT MODE

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.

The following instructions illustrate the process of measuring a component in **MEASUREMENT MODE**.

1) Press the front panel **Menu** control key. The **MAIN MENU** (Figure 4-8) will be displayed.

2) Press the **MEASUREMENT** soft key. **MEASUREMENT MODE** (Figure 4-20) will be displayed.

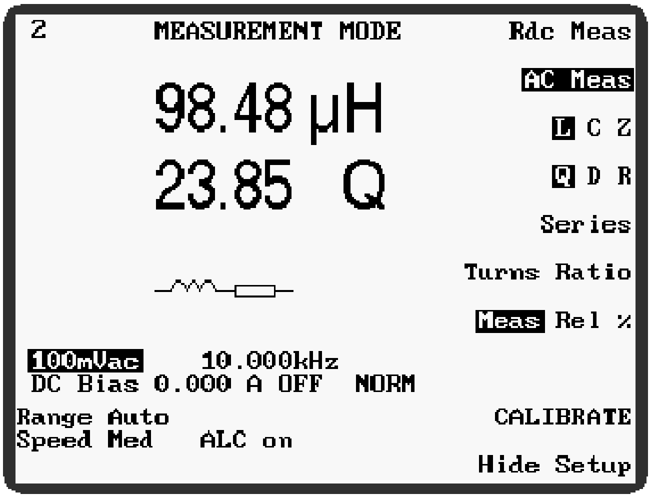


Figure 4-20 MEASUREMENT MODE

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 4.1.5. 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 inductance (L) and quality factor (Q) of a 100µH inductor. 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.

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

2) Press the **MEASUREMENT** 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 4-9 and Figure 4-10)).

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
L
Q
Series
Meas

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.

100mVac
10.000kHz
DC Bias OFF set with the front panel **Bias** control key (shown in Figure 4-3 and Figure 4-6)
NORM can be set to **BOOST** only when a 3265B External Bias Unit is connected
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 L and Q. The display should be similar to Figure 4-21 below.

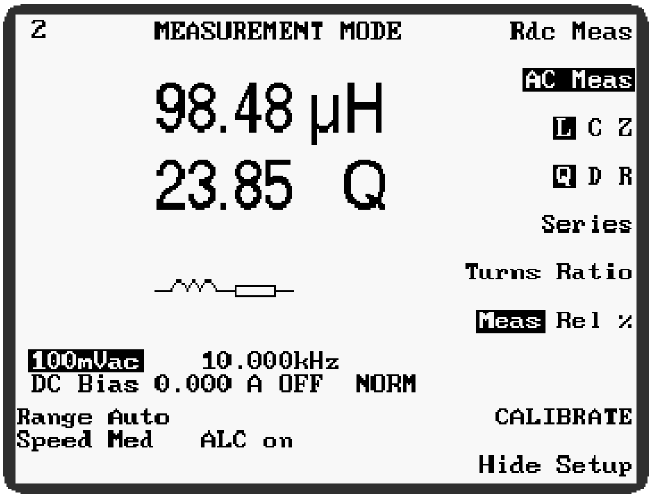


Figure 4-21 Measuring the Inductance and Quality Factor of a 100µH Inductor

4.5.2 MEASUREMENT MODE Parameters

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

Rdc Meas

DC measurement of resistors. The drive level is fixed at 100mV (short circuit current 10mA). The only measurement options are range and speed.

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.

L C Z

The first measurement term.

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

Q D R

The second measurement term.

Parallel/Series

Parallel or **Series** equivalent circuit. This soft key is not available when **Z** is selected: see the narrative on **L C Z** (above).

Turns Ratio

Measures the turns ratio of a transformer. Turns ratio can be displayed as **Np/Ns** or **Ns/Np**. When maximum resolution is required, choose the display which is greater than unity. The value displayed is the ratio of measured voltages, hence non-integer results are likely. Trimming is not required for turns ratio measurements.

A negative reading when measuring turns ratio implies a reverse-connected winding. Check the winding sense convention.

Secondary turns (**Ns**) can be displayed. This requires the primary turns (Np) to be preset via the data entry keypad. Allowable values of Np are between 0.001 and 10000.

For step-up transformers, the measured secondary voltage is limited to 10Vrms.

Constant current drive is not provided for turns ratio measurements.

See also: 5.6—Turns Ratio Measurements.

Meas Rel %

Meas displays the actual component measurement. When **Rel** or **%** is selected, the screen displays **RELATIVE MODE** or **PERCENTAGE MODE** at the top and shows the difference, in relative terms (i.e. units of the measured parameter) or percentage terms, between the measured value of the main parameter and a preset nominal value which must be entered with the **Save nominal** soft key or via the data entry keypad. When **Rel** or **%** is selected, the **Nom** parameter and **Save nominal** soft key become available and the actual measured value of the component is displayed in small characters above the **Nom** parameter. See also **Save nominal** below.

Save Nominal

Only available when the **Meas Rel %** soft key is set to either **Rel** or **%**. If a standard component exists, it can be connected to the test leads or fixture and measured by the analyzer. Pressing **Save Nominal** 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 Nominal** 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).

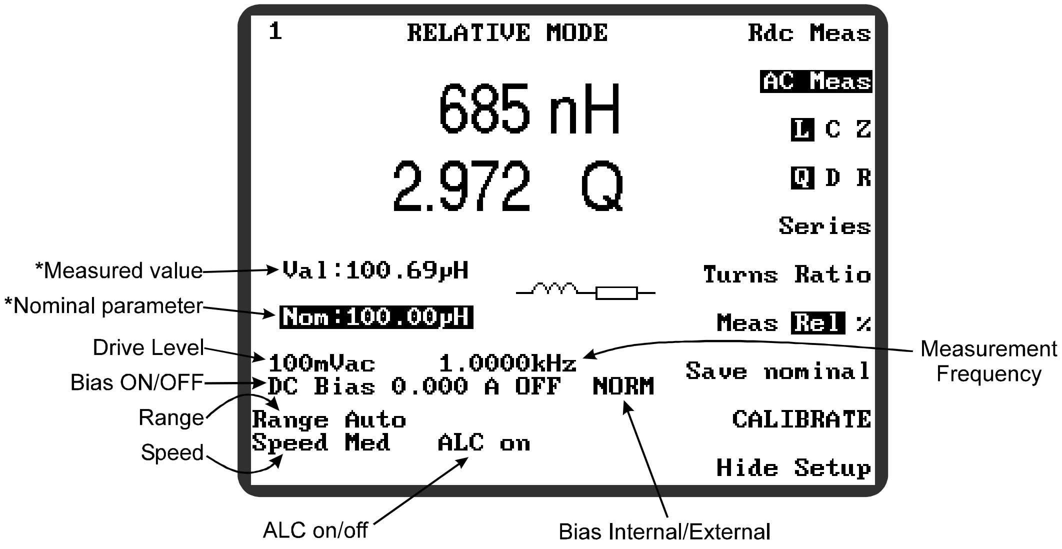
CALIBRATE

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

Show Setup/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. **Hide Setup** is used to unclutter the display, making it more easily readable. Selecting **Show Setup** will redisplay the parameter settings.

The following **MEASUREMENT MODE** parameters are those displayed in the bottom left-hand-corner of the screen, shown in Figure 4-22. They are only visible when **Hide Setup** is NOT SELECTED.



* Only shown when **Meas Rel %** is set to **Rel** (**RELATIVE MODE**) or **%** (**PERCENTAGE MODE**).

Figure 4-22 Non-Soft Key MEASUREMENT MODE Parameters

Measured Value

Only shown when the **Meas Rel %** soft key is set to either **Rel** (**RELATIVE MODE**) or **%** (**PERCENTAGE MODE**). It shows the actual measured value of the component under test, while the main display shows the difference from the preset nominal value in either relative terms (i.e. units of the measured parameter) or percentage terms according to whether **Rel** or **%** is selected. See also: **Nominal Parameter**, below.

Nominal Parameter

Only shown when the **Meas Rel %** soft key is set to either **Rel** (**RELATIVE MODE**) or **%** (**PERCENTAGE MODE**). It shows the nominal component value which is set with the **Save nominal** soft key or entered via the data entry keypad. See also **Save nominal**, above.

Drive Level

Only available when **AC Meas** is selected. 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	Drive Level not displayed—Fixed at 100mV (short circuit current 10mA)
AC Meas mode	Variable between: 1mV–10V or 50µA–200mA (appropriate for low impedance components)

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:

20Hz to 200kHz - 3255BL

20Hz to 500kHz - 3255B

20Hz to 1MHz - 3255BQ

DC Bias (option)

The **DC Bias** is turned ON and OFF with the **Bias** control key. Before bias can be turned ON, the level must be 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. 1mA to 1A is available internally (**NORM** mode). With one or more 3265B External Bias Units connected (max 5), the unit may be toggled between **NORM** (internal bias) and **BOOST** (external bias). Up to 25A per 3265B is available in **BOOST** mode. 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.

The manual range is set using the data entry keypad. Ranges 1 to 7 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 or C values.

At higher frequencies or reduced levels, availability of the highest or lowest ranges is restricted. 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 ≈40ms intervals and is intended for the fastest possible repetitive measurement 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 4-23 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 4-24 will be reported instead. This will happen if the measure terminals are short-circuited with voltage drive selected, or if they are open-circuited with current drive selected.

`Nearest Level = 9.90V`

Figure 4-23 Nearest Drive Level Warning

`Cannot Set Level`

Figure 4-24 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:

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

5.1 Front Panel Connections

5.1.1 Connection Protocol

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.

For turns ratio measurements connect the RED and ORANGE colour-coded clips to the Primary winding, and the BROWN and YELLOW colour-coded clips to the Secondary winding. If the primary and secondary have a common connection (e.g. an auto transformer), connect both the RED and BROWN clips to this point.

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 Electronics and for details of the connection protocol for manufacturing special test leads.

The following tables illustrate the connection protocols to use for measurements.

INSTRUMENT	BNC Connectors			
	Brown	**Red**	**Orange**	**Yellow**
LEADS	Brown Sense Low	Red Drive Low	Orange Drive High	Yellow Sense High

Figure 5-1 Connection Protocol for 4-Terminal Measurements

INSTRUMENT	BNC Connectors			
	Brown	Red	Orange	Yellow
LEADS	* not used	Red Drive Low	Orange Drive High	* not used

* disconnect from front panel for best 2-terminal measurement accuracy

Figure 5-2 Connection Protocol for 2-Terminal Measurements

INSTRUMENT	BNC Connectors			
	Brown	Red	Orange	Yellow
LEADS	Secondary Common	Primary Common	Primary Signal	Secondary Signal

Figure 5-3 Connection Protocol for Turns Ratio Measurements

5.1.2 Two-, Three- and Four-Terminal Connections

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. For 2-terminal measurements, use the RED and ORANGE colour-coded leads only. For optimum measurement accuracy in this case, remove the BROWN and YELLOW BNC connectors completely.

For low impedances, the main advantage of four-terminal connections is to reduce the effect of contact resistance *variations* at the DUT. With Kelvin clip leads or the four-terminal component fixture 1EV1006, screened four-terminal connections are made automatically to the DUT.

If the DUT has a large area of metal not connected to either of its 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 terminals (e.g. an air-spaced tuning capacitor), this should be connected to the ORANGE signal source lead to minimize noise pick-up.

Note

It is not possible to set the analyzer to 2- or 4-terminal connection. This is automatically applied by the analyzer according to the mode and parameters selected, and the test lead/fixture configuration.

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 5-4. The components Zd and Zs are connected to ground via the GREEN clip lead when using Wayne Kerr Electronics leads.

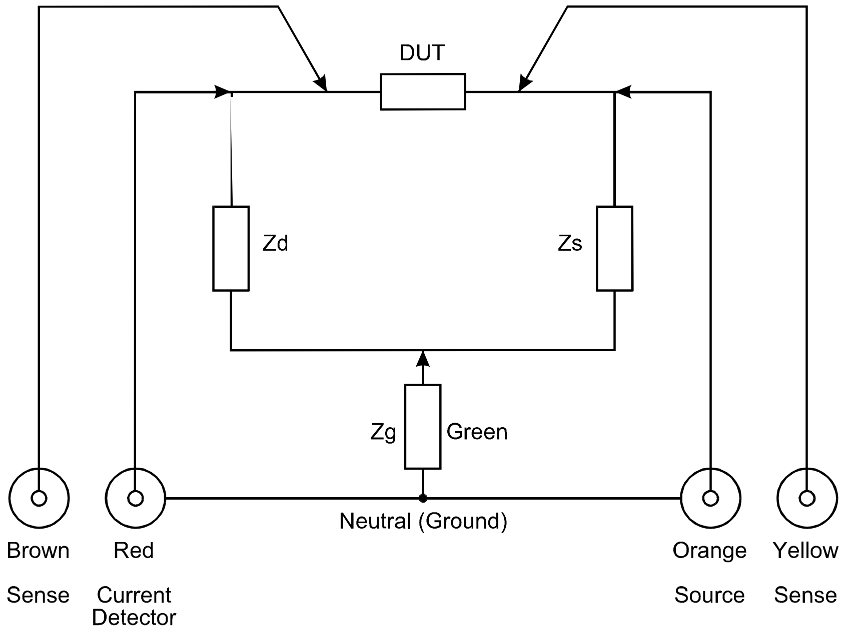
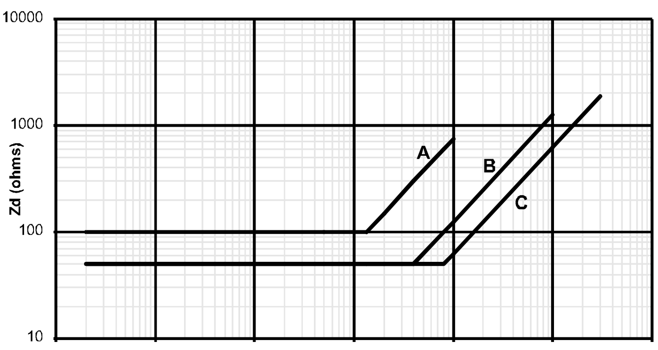


Figure 5-4 In-Circuit Measurements

The presence of Zd introduces a small measurement error, dependant on the frequency and impedance range in use. Figure 5-5 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—MEASUREMENT MODE Parameters).



Range No	Freq Range	Level ≤1V	Level >1V
7	≤10kHz	Curve A	Curve A
	>10kHz	Curve A	Curve B
6	≤100kHz	Curve A	Curve B
	>100kHz	Curve B	Curve C
5	≤500kHz	Curve B	Curve C
1 – 4	All	Curve C	Curve C

Figure 5-5 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 impedance 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 (see 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

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

At low frequencies Zg is up to 40mΩ for lead types 1EVA40100, 1EVA40180 or 1EV1505. 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 200kHz in series configuration. Where possible, make the measurements at an AC level of 100mA 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 10kHz. 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.

Iron-cored inductors, including transformers, are susceptible to disaccommodation arising from electrical, magnetic, mechanical and thermal shock; any of which can produce transient or permanent change in inductance. The effect is worst in un-gapped iron-cored inductors at low drive levels. Since the shocks can be caused by large changes in level of the driving signal, it is advisable to change the drive level in small increments. The transient changes have long recovery time-constants, so successive measurements (at the same conditions) on a shocked inductor, will show unidirectional changing values. The time taken for the overall change of level, will depend on the component itself and the accuracy required..

5.6 Turns Ratio Measurements

2-terminal turns ratio measurements are performed in **MEASUREMENT MODE**. See Figure 5-3 for the connection protocol. The general procedure when making turns ratio measurements is as follows.

1) Select the **Menu** control key, followed by the **MEASUREMENT** soft key.
2) From **MEASUREMENT MODE** select the **Turns Ratio** soft key.
3) Select **Meas**, **Rel** or **%** as required: see **Meas Rel %** in section 4.5.2—MEASUREMENT MODE Parameters.
4) If the setup parameters are hidden, press **Show Setup.**
5) Change the setup parameters, e.g. **drive level**, **frequency**, as necessary for the test, being careful not to exceed the limitations of the component to be measured.
6) Connect the measurement leads to the transformer to be tested: see Figure 5-3 for the connection protocol.
7) If the instrument is set to make repetitive measurements, the measurement will be displayed on the screen, otherwise press the **Trigger** control key to initiate a measurement.

5.6.1 Example

This example will take the user through the process of making a turns ratio measurement. 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.

1) Press the front panel **Menu** control key. The **MAIN MENU** will be displayed.
2) Press the **MEASUREMENT** 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 4-9 and Figure 4-10).

4) Press the **Turns Ratio** soft key.

5) Set the **Meas Rel %** soft key to **Meas**.

6) 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 data entry keypad or 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.

   100mVac
   50.000kHz
   Ratio: Np/Ns
   Range Auto
   Speed Fast
   ALC off

7) Connect the component to be measured to the test leads or fixture according to the connection protocol for turns ratio measurements (see Figure 5-3).. The screen will display the measured value of turns ratio.

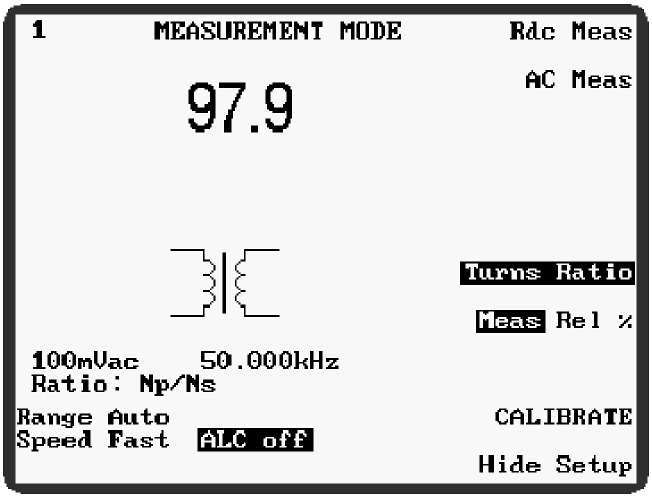


Figure 5-6 Example of Measuring Turns Ratio

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

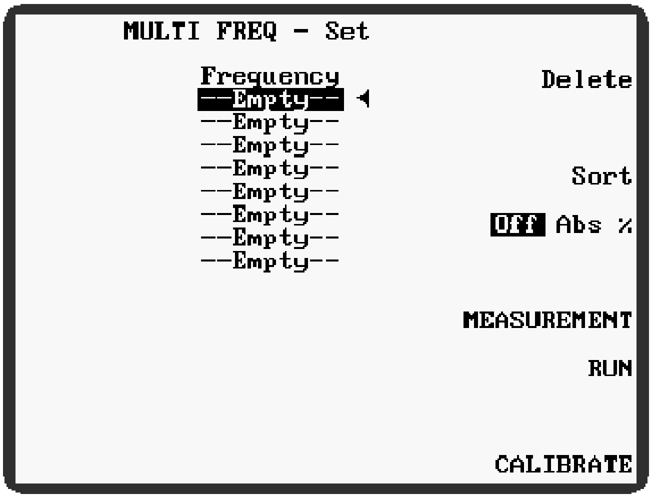


Figure 5-7 MULTI FREQ – Set Display With No Parameters Set up

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. 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 5-7 above.

2) If the test leads or fixture have been changed since the last time the analyzer was used, press the **CALIBRATE** soft key and perform the following trims with reference to section 4.3. When finished, press the **MULTI FREQ** soft key to return to **MULTI FREQ – Set** mode.

   O/C Trim All Freq
   S/C Trim All Freq

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

4) Press the **MEASUREMENT** 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
L
Q
Parallel
1.00Vac
1.0000kHz—this will be the first set frequency in **MULTI FREQ – Set** mode
DC Bias 0.000 A OFF
NORM
Range Auto
Speed Med
ALC off

Note: Where a component 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.

5) Highlight the first frequency, shown highlighted in Figure 5-7 (the and navigation keys scroll through each frequency in turn) and enter the required frequency with the data entry keypad.

6) Highlight and enter the next frequency. Continue to highlight and enter up to eight frequencies in this way. This example will enter frequencies of 1kHz, 2.5kHz, 5kHz, 10kHz, 25kHz, 50kHz, 100kHz and 250kHz.

7) 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 100µH.

8) Still using the and navigation keys, highlight the **High** limit then enter the required limit with the data entry keypad. For this example all the limits will be set to ±10%, though they could be set to different values for each frequency. Highlight the **Low** limit and enter the required limit. Pressing the **Enter** key twice will echo the **High** limit but with the opposite sign.

9) Highlight the **Minor** term with the and navigation keys and enter the required value with the data entry keypad. 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 Q term will be set to >2 at 1kHz, i.e. anything more than or equal to 2Q will pass the minor term parameter and anything below 2Q will fail.

10) Press the navigation key: the ◄ symbol will move down and point to the second frequency (2.5kHz in this example). Note that the limits shown 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
1kHz	10%	-10%	>2Q
2.5kHz	10%	-10%	>5Q
5kHz	10%	-10%	>20Q
10kHz	10%	-10%	>30Q
25kHz	10%	-10%	>40Q
50kHz	10%	-10%	>50Q
100kHz	10%	-10%	>50Q
250kHz	10%	-10%	>50Q

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

Figure 5-8 shows the display when set to 25kHz in the example above.

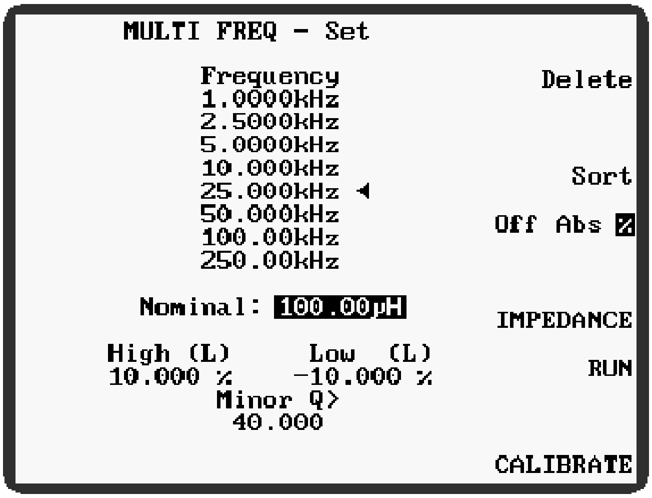


Figure 5-8 MULTI FREQ – Set Display Example

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 5-9, will be displayed and must be acknowledged with either the **Yes** or **No** soft key.

Figure 5-9 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.

MEASUREMENT

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 5-10 which shows **MULTI FREQ – Run** mode entered after setting **MULTI FREQ – Set** mode according to the example in section 5.7.1.1.

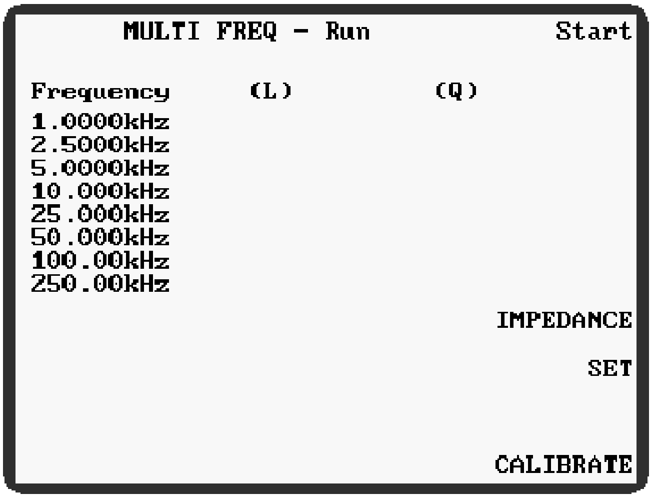


Figure 5-10 Initial MULTI FREQ – Run Display (from example in section 5.7.1.1)

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 5-11 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.

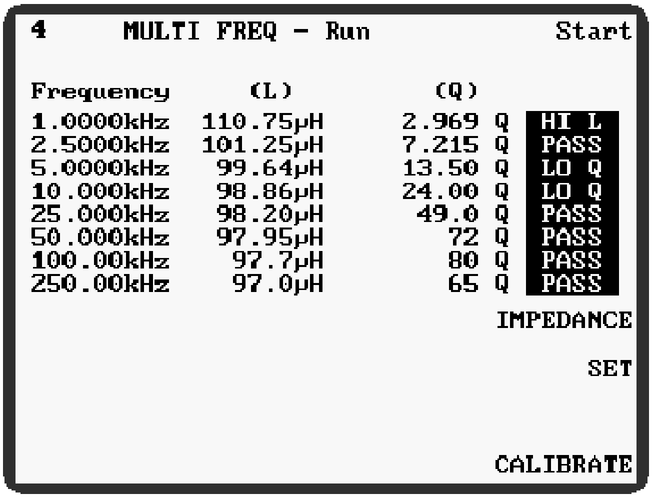


Figure 5-11 MULTI FREQ – Run

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 are independent of other modes when the instrument is set to non-global test conditions (see section 5.9—The INSTRUMENT STATUS Page).

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

Note

If the **BINNING** soft key is pressed when the binning option is not fitted, the analyzer will report **Unit Not Available** (Figure 5-12).

Figure 5-12 Unit Not Available Message

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 5-13 shows the **BINNING MODE – Set** main screen set to measure inductance (L) and quality factor (Q).

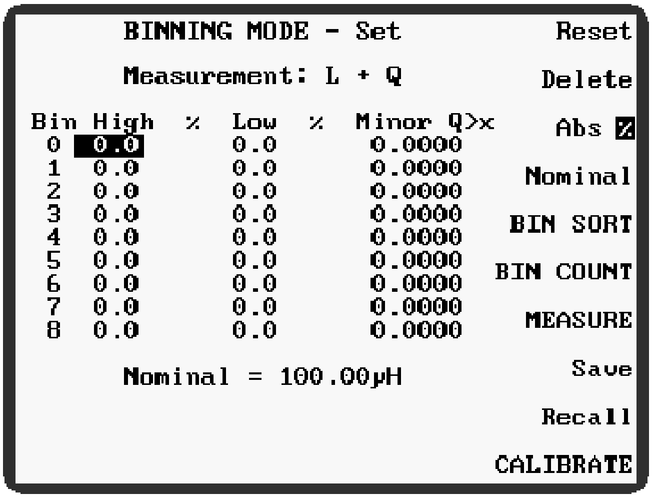


Figure 5-13 BINNING MODE – Set Main Screen

In Figure 5-13 above, the bins are shown ready to receive percentage limits. Absolute limits can be entered by highlighting **Abs** with the **Abs %** soft key. 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, when displayed, 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.

Any limit set to zero is ignored during subsequent sorting.

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**.

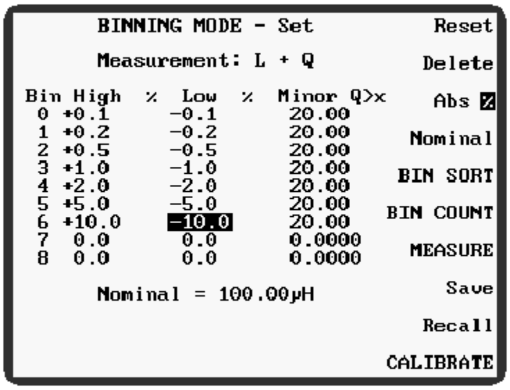


Figure 5-14 BINNING MODE: Nested Percentage Limits

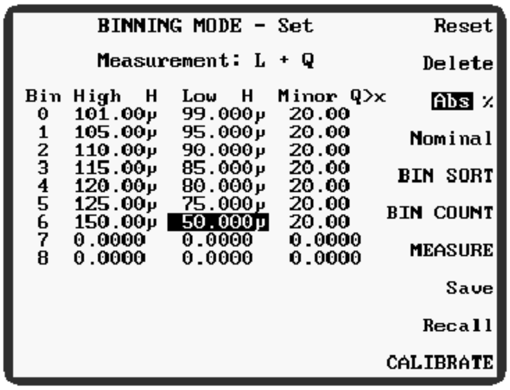


Figure 5-15 BINNING MODE: Stacked Absolute Limits

The example shown in Figure 5-14 above would sort inductors on the basis of their % deviation from the preset nominal inductance and Q factor. In this case, an inductor with an inductance of 100µH ±0.5% and a Q factor greater than 20 would be sorted into bin 2.

Figure 5-15 is an alternative set-up with stacked limits, sorting the inductors by absolute value. In this case, an inductor with an inductance of 112µH and a Q factor greater than 20 would be sorted into bin 3.

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 bin limits to 0 after displaying a warning message, shown in Figure 5-16 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 5-16 BINNING MODE – Set: Reset Warning

Delete

Deletes the limits for the bin highlighted by the cursor after a warning message, shown in Figure 5-17 below. Confirm by pressing the **Yes** soft key. Absolute and percentage limits must be deleted separately, but since the minor term is common to both, it is deleted from either limits mode.

Figure 5-17 BINNING MODE – Set: Delete Bin Limits Warning

Abs %

Toggles between **Abs** and **%**. 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 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 High and Low 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 bin limits and can be seen, set to 100µH, in Figure 5-14. The nominal is set by pressing the **Nominal** soft key and entering the value using the data entry keypad.

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** so that the measurement parameters may be set-up for the **BINNING MODE** test. See section 4.5 for details of setting the test parameters in **MEASUREMENT MODE**.

Save

Saves the bin limits in one of 99 locations which the user is prompted to enter when this soft key is pressed. If a location is entered which already contains bin limits, a warning message is displayed (Figure 5-18) asking for confirmation to overwrite the location with the new bin limits. Press **Enter** to confirm, or any other key to abort. Absolute and percentage bin limits are saved under separate location numbers.

```
  Overwrite setup
Confirm press ENTER
```

Figure 5-18 BINNING MODE: Overwrite setup message

Recall

Recalls previously saved bin limits. After pressing the **Recall** soft key the user is prompted to enter the location number of the bin limits required. This must be followed by the keypad **Enter** key. If a location is entered which contains no bin limits, the message shown below in Figure 5-19 is displayed.

Figure 5-19 BINNING MODE – Set: Invalid bin setup

CALIBRATE See section 4.3.

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 together with the measured value(s). The component may now be placed into the appropriate bin and the next component placed in the fixture ready for sorting.

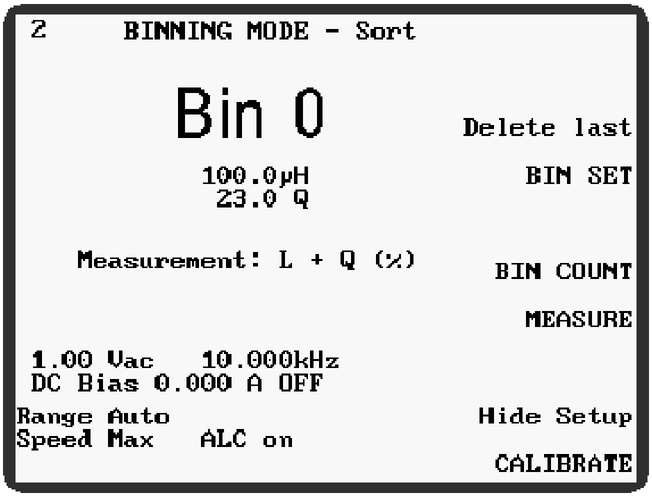


Figure 5-20 BINNING MODE – Sort

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. because of 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.

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 the measurement parameters may be changed, if required, for the **BINNING MODE** test. See section 4.5 for details of setting the test parameters in **MEASUREMENT MODE**.

Show Setup/Hide Setup **Hide Setup** can be selected to clear the measurement parameters from the screen. The parameter settings are still valid and will be used for component measurements. **Hide Setup** is used to unclutter the display, making it more easily readable. Selecting **Show Setup** will redisplay the parameter settings.

CALIBRATE See section 4.3.

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 9 components sorted into their respective bins.

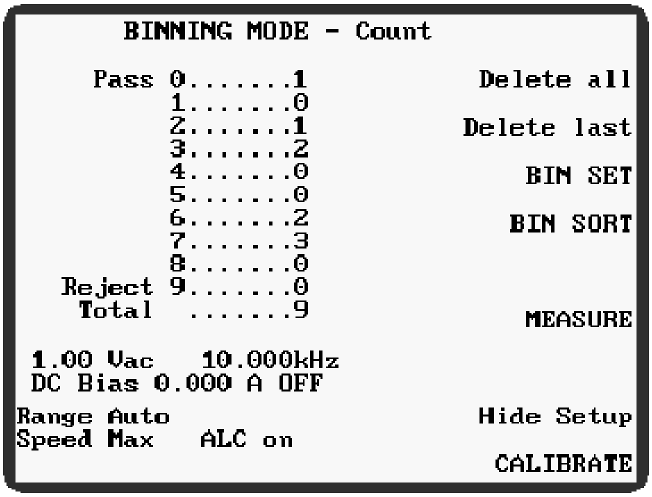


Figure 5-22 BINNING MODE – Count

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.

```
Delete bin counts.
  Are you sure?
```

Figure 5-23 Delete Bin Counts Warning

Delete last

If a component is wrongly rejected (e.g. because of 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 the measurement parameters may be changed, if required, for the **BINNING MODE** test. See section 4.5 for details of setting the test parameters in **MEASUREMENT MODE**.

Show Setup/Hide Setup

Hide Setup can be selected to clear the measurement parameters from the screen. **Hide Setup** is used to unclutter the display, making it more easily readable. Selecting **Show Setup** will redisplay the parameter settings.

CALIBRATE

See section 4.3.

5.9 The INSTRUMENT STATUS Page

The **INSTRUMENT STATUS** page, shown in Figure 5-24, is displayed by pressing the **INSTRUMENT STATUS** soft key from the **MAIN MENU**. **√** indicates that an option is fitted or a calibration is valid.

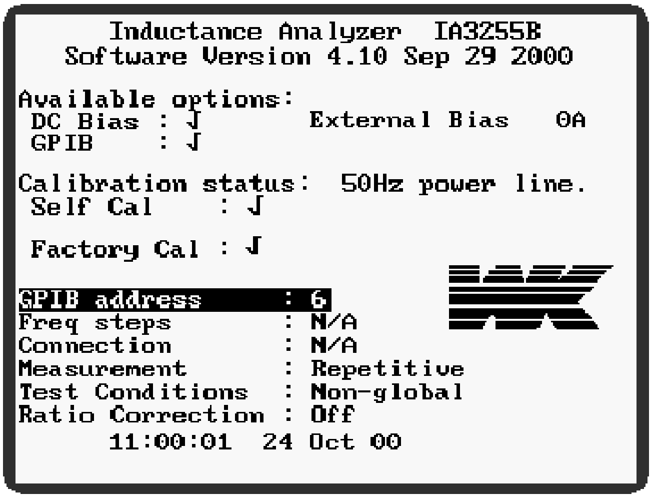


Figure 5-24 The SETTINGS Page

There are three parameters which may be altered from within the instrument status page: **GPIB address**, **Measurement**, **Test Conditions**. It is not possible to change the **Freq steps**, **Connection** and **Ratio Correction** parameters.

5.9.1 The INSTRUMENT STATUS Page Parameters

GPIB Address

The analyzer's default GPIB address is 6. This may be changed by highlighting the **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

It is not possible to change the **Freq steps** parameter.

Connection

It is not possible to change the **Connection** parameter. 2- or 4-terminal connection is automatically applied by the analyzer, according to the mode and parameters selected, and the test lead/fixture configuration.

Measurement

Toggles the analyzer between **Single shot mode** and **Repetitive mode** operation. Set by highlighting the **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 when in normal use (see section 4.2.5).

Test Conditions

Toggles the analyzer between **Global** and **Non-global** test conditions. With **Global** set, any parameter, e.g. drive level, frequency, set in one mode of operation, is automatically reflected in other modes. With **Non-global** set, the parameters in each mode may be set independently of the parameters in other modes. Set by highlighting the **Test Conditions** parameter with the and navigation keys, then using the or navigation keys to toggle between the two choices.

Ratio Correction

It is not possible to change the **Ratio Correction** parameter. The 3255B does not use ratio correction.

6. GENERAL PURPOSE INTERFACE BUS (GPIB) OPTION

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 IEEE488.1 bus standard and the IEEE488.2 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 **INSTRUMENT STATUS** page, as follows:

1) From the **MAIN MENU** select **INSTRUMENT STATUS**.
2) Highlight the settings 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.

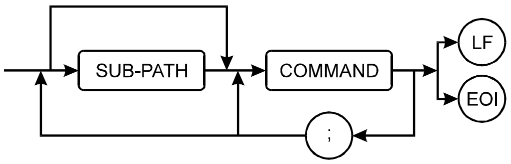


Figure 6-1 GPIB Message Structure

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.

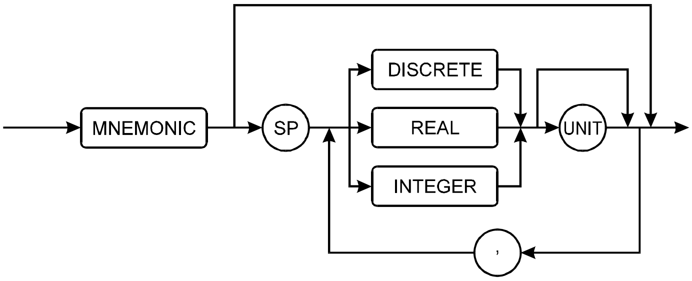


Figure 6-2 GPIB Command Structure

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.

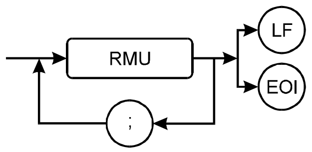


Figure 6-3 GPIB Data Output

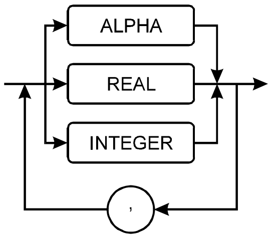


Figure 6-4 GPIB RMU Structure

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 IEEE488.2 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.
3	A summary bit from Questionable Data. This bit is not used, so is always 0.

BIT	Meaning True = ‘1’
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.

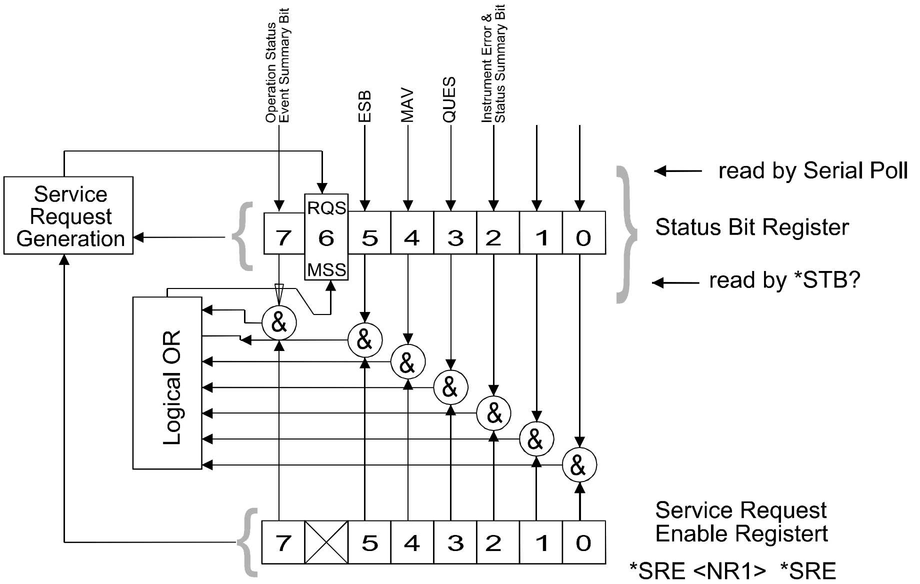


Figure 6-5 Status Byte Register

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 IEEE488.2. 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 IEEE488.2 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

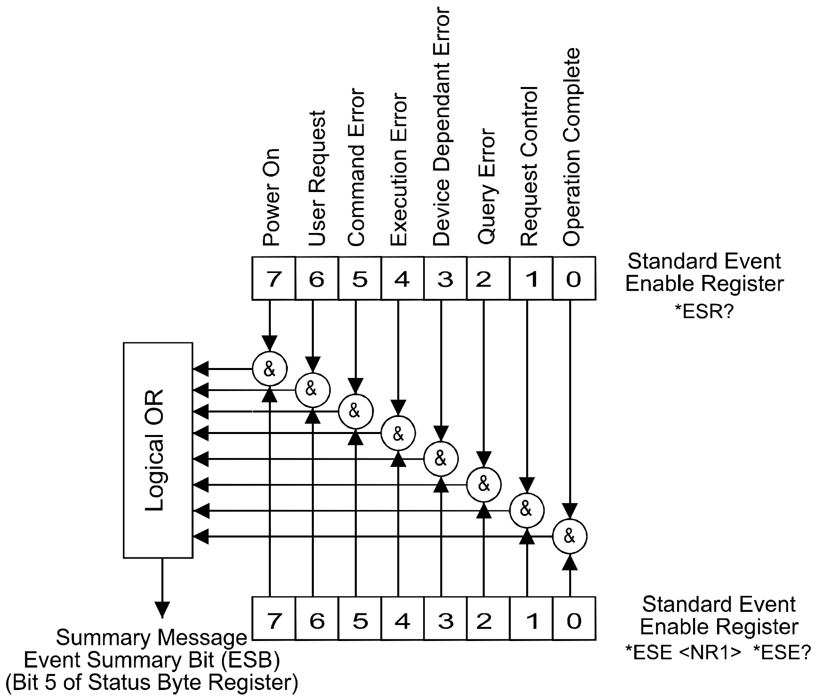


Figure 6-7 Event Status Byte Register

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.

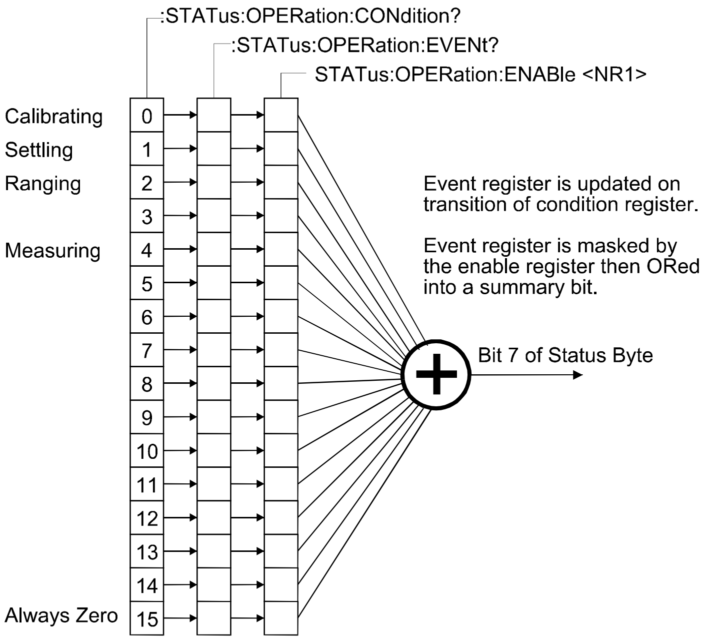


Figure 6-8 Standard Operation Status Group

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.

Command	Name	Description
*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.
*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,3255B,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	

6.2 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.	6–18
:MEAS:TEST	Select test sub-path within measurement mode.	6–18
:MEAS:TEST:AC	Select AC measurement.	6–18
:MEAS:TEST:RDC	Select Rdc measurement.	6–18
:MEAS:TEST:RATIO	Select turns ratio	6–19
:MEAS:TEST?	Measurement test query.	6–19
:MEAS:TRIGger	Trigger an AC or Rdc measurement.	6–19
:MEAS:FREQuency <real>	Set frequency of AC measurement.	6–20
:MEAS:FREQuency?	Frequency query.	6–20
:MEAS:LEVel <real>	Set drive level for currently selected test.	6–20
:MEAS:LEVel?	AC level query.	6–20
:MEAS:DRIVE?	Test level drive type query.	6–21
:MEAS:BIAS <disc>	Control internal and external bias drive.	6–21
:MEAS:BIAS-STATus?	Bias status query.	6–21
:MEAS:SPEED <disc>	Select measurement speed.	6–22
:MEAS:SPEED?	Speed query.	6–22
:MEAS:RANGE <disc>	Select auto-ranging or range-hold on range N.	6–22
:MEAS:RANGE?	Range query.	6–22
:MEAS:ALC <disc>	Select the state of Automatic Level Control.	6–23
:MEAS:ALC?	ALC status query.	6–23
:MEAS:FUNC:NS/NP	Select the display of Turns Ratio Ns/Np measurement.	6–23
:MEAS:FUNC:NP/NS	Select the display of Turns Ratio Np/Ns measurement.	6–23
:MEAS:FUNC:NS <real>	Select the display of Turns Ratio Ns measurement with Np = x.	6–23
:MEAS:FUNC:NP?	Np query	6–23
:MEAS:DEViation	Select deviation type.	6–24
:MEAS:DEViation?	Returns the currently selected deviation type.	6–24

Command	Summary	Page
:MEAS:EQU-CCT <disc>	Select equivalent circuit.	6–24
:MEAS:EQU-CCT?	Equivalent circuit query.	6–24
:MEAS:FUNC:C, L, Z, Q, D, or R	Select first or second AC measurement function.	6–25
:MEAS:FUNC:MAJOR?	First AC function query.	6–25
:MEAS:FUNC:MINOR?	Second AC function query.	6–26
:MEAS:NOMinal <val>	Set the deviation nominal.	6–26
:MEAS:NOMinal?	Returns the deviation mode nominal value.	6–26
:BINning	Select binning mode / path.	6–27
:BINning:SET	Select BIN SET mode.	6–27
:BINning:SORT	Select BIN SORT mode.	6–27
:BINning:COUNT	Select BIN COUNT mode.	6–27
:BINning:NOMinal <real>	Set binning mode nominal value.	6–28
:BINning:NOMinal?	Return the binning mode nominal value.	6–28
:BINning:LIMIT <disc>	Select absolute or relative bin limits.	6–28
:BINning:LIMIT?	Return the current limit type.	6–28
:BINning:BIN <num>	Select the bin to manipulate in BIN SET mode.	6–29
:BINning:BIN?	Return the number of the bin that is currently being edited.	6–29
:BINning:HIgh-LIMit <real>	Set bin high limit.	6–29
:BINning:HIgh-LIMit?	Return the higher test limit of the currently selected bin.	6–29
:BINning:LOw-LIMit <real>	Set bin low limit.	6–30
:BINning:LOw-LIMit?	Return the lower test limit of the currently selected bin.	6–30
:BINning:MINOR <real>	Set minor bin limit.	6–30
:BINning:MINOR?	Return the minor test limit of the currently selected bin.	6–30
:BINning:DEL-ALL	Reset all the bin counters to zero.	6–30
:BINning:SAVE <integer>	Save bin limit settings.	6–31
:BINning:LOAD <integer>	Load bin limit settings.	6–31
:BINning:TRIG	Trigger a binning measurement.	6–32
:BINning:DEL-LAST	Remove the last bin result from the bin count tables.	6–32
:BINning:RES?	Return all the current bin counters.	6–32
:MULTI	Select multi-frequency mode.	6–33
:MULTI:SET	Switch to the multi-frequency set-up page.	6–33
:MULTI:RUN	Switch to the multi-frequency run page.	6–33

Command	Summary	Page
:MULTI:TEST	Select the frequency step to edit.	6–33
:MULTI:TEST?	Return the number of the step that is currently being edited.	6–33
:MULTI:FREQuency <real>	Set the frequency for the currently selected step.	6–34
:MULTI:FREQuency?	Returns the frequency of the currently selected step.	6–34
:MULTI:HIgh-LIMit <real>	Set the higher test limit of the currently selected step.	6–34
:MULTI:HIgh-LIMit?	Returns the high limit value of the currently selected step.	6–34
: MULTI:LOw-LIMit <real>	Set the lower test limit of the currently selected step.	6–34
: MULTI:LOw-LIMit?	Returns the low limit value of the currently selected step.	6–34
: MULTI:MINor <real>	Set the minor test limit of the currently selected step.	6–35
: MULTI:MINor?	Returns the minor limit value of the currently selected step.	6–35
:MULTI:NOMinal <real>	Set the multi-frequency nominal value.	6–35
:MULTI:NOMinal?	Returns the multi-frequency nominal value.	6–35
:MULTI:LIMIT <disc>	Selects absolute or percentage limits checking.	6–36
:MULTI:LIMIT?	Returns the current limits checking mode.	6–36
:MULTI:DEL	Removes the current frequency.	6–36
:MULTI:SORT <disc>	Sorts the current frequency list into the required order.	6–37
:MULTI:TRIGger	Starts a run of multi-frequency measurements.	6–37
:MULTI:RES? <integer>	Query the result of the selected frequency step.	6–37
:CAL	Select calibrate mode / path.	6–38
:CAL:OC-TRIM <integer>	Perform open circuit trimming.	6–38
:CAL:SC-TRIM <integer>	Perform short circuit trimming.	6–38
:CAL:SELF-CAL	Perform self-calibration; disconnect all BNCs from the instrument terminals before using this command.	6–39
:CAL:RES?	Returns the result of the calibration performed.	6–39
:TRIGger	Trigger a measurement in the current mode.	6–40
:LOC-TRIG <disc>	Select local trigger condition.	6–40
:LOC-TRIG?	Query the local trigger condition.	6–40
:REPeat <disc>	Enable repetitive measurements when unit is returned to local control.	6–41
:Repeat?	Query trigger status.	6–41
:SETUP <disc>	Select set-up view ON and OFF.	6–41
:SETUP?	Query the current set-up mode.	6–41
:FAST-GPIB <disc>	Select fast GPIB mode.	6–42

Command	Summary	Page
:FAST-GPIB?	Query fast GPIB mode.	6–42
:MODE?	Query the currently selected operating mode.	6–42
:DUMP-BMP	Returns the display as a windows compatible bitmap.	6–43

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:RATIO

Select turns ratio.

Parameters:

None.

Response:

None.

:MEAS:TEST?

Measurement test query.

Parameters:

None.

Response:

0 AC measurement type.

1 Rdc measurement type.

2 Ratio 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`

MEASUREMENT MODE

: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.

: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 level is 100mV.

Example:
```
:MEAS:LEV 0.1V
: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?

Returns the test level of the currently selected test type AC or Rdc.

Parameters:

None.

Response:

Returns the current test level in engineering format.

Example: +.20000000E-01

for a test level of 20mV.

MEASUREMENT MODE

:MEAS:DRIVE?

Test level drive type query.

Parameters:

None:

Response:

0	Current drive.
255	Voltage drive.

:MEAS:BIAS <state>

Set the bias condition.

Parameters:

`ON`	Turn on bias.
`OFF`	Turn off bias.
`INT`	Select internal bias.
`EEXT`	Select external bias.

Example: `:MEAS:BIAS INT`

`:MEAS:BIAS ON`

will select internal bias and turn it on.

Response:

None.

:MEAS:BIAS-STATus?

Returns the bias status.

Parameters:

None.

Response:

Returns bias status in two integers delimited by a comma:

First integer:	0 Bias OFF.
	1 Bias ON.
Second integer:	0 Internal bias.
	1 External bias.
Example:	`1,0`

would indicate that internal voltage bias is turned on.

MEASUREMENT MODE

: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.

:MEAS:RANGE <integer>

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 7	Range 1 to 7

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.
1-7	Current measurement range.

Example: `0`

indicates that auto ranging is selected.

MEASUREMENT MODE

: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.

:MEAS:FUNC:NS/NP

Select the display of Turns Ratio Ns/Np measurement.

Parameters

None.

Response

None

:MEAS:FUNC:NP/NS

Select the display of Turns Ratio Np/Ns measurement.

Parameters

None.

Response

None

:MEAS:FUNC:NP?

Np query.

Parameters

None.

Response

Returns the value of Np as floating point number.

:MEAS:FUNC:NS <real>

Select the display of Turns Ratio Ns measurement.

Parameters

<real> is decimal numeric data to specify the number of turns of Np.

Example: `:MEAS:FUNC:NS 1`

will set Np to 1 turn.

Response

None

MEASUREMENT MODE

:MEAS:DEViation

Select deviation type.

Parameters:

MEAS	No deviation
PERC	Percentage deviation
REL	Relative deviation

Response:

None.

:MEAS:Deviation?

Returns the currently selected deviation type.

Parameters:

None.

Response:

0	Measurement
1	Relative
2	Percentage

: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.

MEASUREMENT MODE

:MEAS:FUNC:C, L, Z, Q, D, R

Select first or second AC measurement function.

Selecting first measurement:

`:MEAS:FUNC:C`	Capacitance.
`:MEAS:FUNC:L`	Inductance.
`:MEAS:FUNC:Z`	Impedance.

Selecting second measurement:

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

Note that selecting Z 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`	Inductance.
`1`	Capacitance
`2`	Impedance.

Example: `2`

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.

Example: `1`

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

:MEAS:NOMinal <val>

Set the deviation nominal.

Parameters:

The required nominal value. If no unit is supplied, the first measurement unit is used.

Example: `:MEAS:NOM 10e-6H`

will set the nominal to 10µH.

Response:

None.

:MEAS:NOMinal?

Returns the deviation mode nominal value.

Parameters:

None.

Response:

Returns the nominal in engineering format.

Example: `+.10000000E-5`

would indicate a 1µF nominal value.

BINNING MODE

:BINning

Enter binning mode. 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?

Returns the binning mode 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

: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?

Returns the current limits checking mode.

Parameters:

None.

Response:

`0` Absolute limits.

`1` 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 <num>

In BIN SET mode this command selects the bin to be edited.

Parameters:

The bin number in the range 0 to 8.

Example: `:BIN:BIN 3`

will select bin 3 for editing.

Response:

None.

:BINning:BIN?

In BIN SET mode this mode 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?

Returns the high limit value of the currently selected bin.

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?

Returns the low limit value of the currently selected bin.

Parameters:

None.

Response:

The low limit value in engineering format.

Example: `-.50000000E+01`

indicates a low 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?

Returns the minor limit value of the currently selected bin.

Parameters:

None.

Response:

The minor limit value in engineering format.

Example: `.10000000E+01`

indicates a minor limit of 1.0.

:BINning:DEL-ALL

Reset the bin counters in BIN COUNT mode to zero.

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 limit 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.

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: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 MODE

: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: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 <val>

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 low 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: `2`

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

:MULTI:DEL

Removes 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.

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 All frequencies plus spot trim

Example: `:CAL:OC-TRIM 1`

would perform an open circuit trim at the current frequency.

Response:

None.

:CAL:SC-TRIM <integer>

Perform short circuit trimming.

Parameters:

The required trim type.

1 Spot trim.

2 All frequencies plus spot trim

Example: `:CAL:SC-TRIM 1`

would perform a short circuit trim at the current frequency.

Response:

None.

CALIBRATE MODE

:CAL:SELF-CAL

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

Parameters:

None.

Response:

None.

: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.

: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.

ROOT COMMANDS

: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.

:MODE?

Query the currently selected operating mode.

Parameters:

None.

Response:

The current mode:

`0` Main menu

`1` Measurement

`2` Calibrate

`3` Multi Freq

`4` Binning

`5` Instrument Status

Example: `1`

would indicate that Measurement Mode is selected.

ROOT COMMANDS

:DUMP-BMP

Returns the display as a windows compatible bitmap. The data conforms to IEEE488.2 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 displays 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.

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 your 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: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:FUNC: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:FUNC: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
```

7. SPECIFICATION

7.1 Measurement Parameters

Any of the following parameters can be measured and displayed:

DC Resistance	(Rdc)
AC Functions	series or parallel equivalent circuit: Inductance (L), Capacitance (C) with loss terms Quality Factor (Q), Dissipation Factor (D), AC Resistance (R)
	polar form: Impedance (Z) with Phase angle (θ), Turns Ratio

7.2 Test Conditions

7.2.1 AC Drive

7.2.1.1 Drive Level

1mV to 10V rms into open-circuit.

50µA to 200mA rms into short-circuit.

Automatic level control (ALC) ensures 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

7.2.1.2 Source Impedance

50Ω ±7%

7.2.1.3 Frequency 3255B series

3255BL	20Hz to 200kHz
3255B	20Hz to 500kHz
3255BQ	20Hz to 1MHz

At least 800 frequencies may be selected via keyboard or GPIB.

Accuracy of selected frequency ±0.01%.

Standard frequency steps: 20, 25, 30, 40, 50, 60, 80, 100, 120, 150, 200
repeats each decade up to 200kHz

7.2.2 DC Bias Current (option)

1mA to 1A DC is available from internal, fast settling bias supply over full frequency range.

Voltage Compliance	14V minimum.
Bias Current Accuracy	±2.5% ±0.25mA into short-circuit
Bias Current Loading Effect	-0.03%/Ω of winding resistance

Safety Interlock.

7.2.3 DC Resistance

Test Level	100mV ±10%
Short-Circuit Current	10mA ±10%

7.3 Measurement Speeds

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

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

Max speed (intended for automatic sorting) ≈50ms
Fast speed (for non-critical measurements) ≈100ms
Medium speed (for full measurement accuracy) ≈300ms
Slow speed (for best resolution and enhanced supply frequency rejection) ≈900ms

7.4 Measurement Range

All impedance functions operate continuously from short-circuit to open-circuit values.

Usable measurements are available over the following ranges. For C and L measurements the larger values apply at 100Hz and below, the smaller values at 10kHz and above. For D and Q functions the DUT value must lie within the range quoted for full C or L accuracy.

R, Z	0.05mΩ - > 2MΩ
L	1nH - > 1000H
C	10fF - > 250mF
D	0.00005 - >1000
Q	0.00005 - >1000
Rdc	0.1mΩ - > 50kΩ
Turns Ratio	100:1 to 1:100

7.5 Basic Accuracy

The following applies for medium or slow speeds, drive level 200mV or 20mA.

Accuracy reduces for lower drive levels, or frequencies outside the quoted range.

7.5.1 DC Resistance

1Ω - 5kΩ	0.5% ± 1mΩ

resolution 0.1mΩ

7.5.2 Inductance (Q>10)

100Hz	200µH - 100H	0.1%
1kHz	12µH - 50H	0.1%
10kHz	12µH - 4H	0.1%
100kHz	0.6µH - 300mH	0.5%

resolution = 0.1nH at 50kHz

See Figure 7-1 for accuracies at other frequencies.

7.5.3 Capacitance (D<0.1)

100Hz	25nF - 10mF	0.1%
1kHz	500pF - 2mF	0.1%
10kHz	60pF – 20µF	0.1%
100kHz	25pF - 2.5µF	0.5%

resolution = 5fF at 50kHz

7.5.4 AC Resistance (Q<0.1)

100Hz	130mΩ - 60kΩ	0.1%
1kHz	75mΩ - 300kΩ	0.1%
10kHz	750mΩ - 250kΩ	0.1%
100kHz	400mΩ - 180kΩ	0.5%

resolution 0.01mΩ up to 50kHz

7.5.5 Turns Ratio ($0.01 < \frac{Ns}{Np} < 100$)

<20kHz	0.1%
20kHz - 50kHz	0.2%
50kHz - 100kHz	0.5%
100kHz - 200kHz	1%
200kHz – 500kHz	2%*

* 3255B and 3255BQ

7.5.6 Dissipation Factor

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

where A_d = (% accuracy)/100, e.g. when C accuracy = 0.1%, A_d = 0.0025.

7.5.7 Quality Factor

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

where A_L = inductance measurement accuracy.

7.6 Accuracy Charts

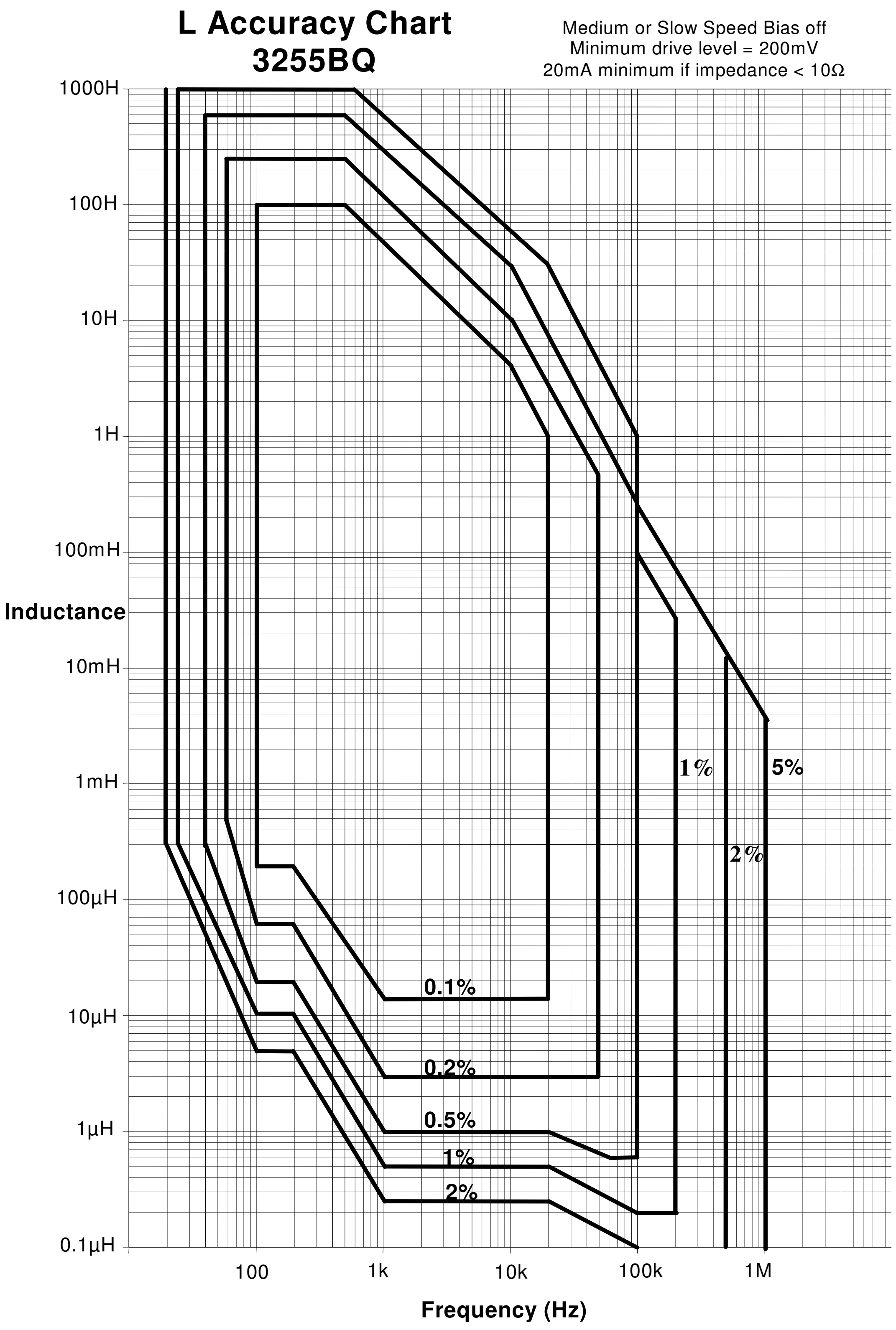


Figure 7-1 3255BQ Inductance Accuracy Chart

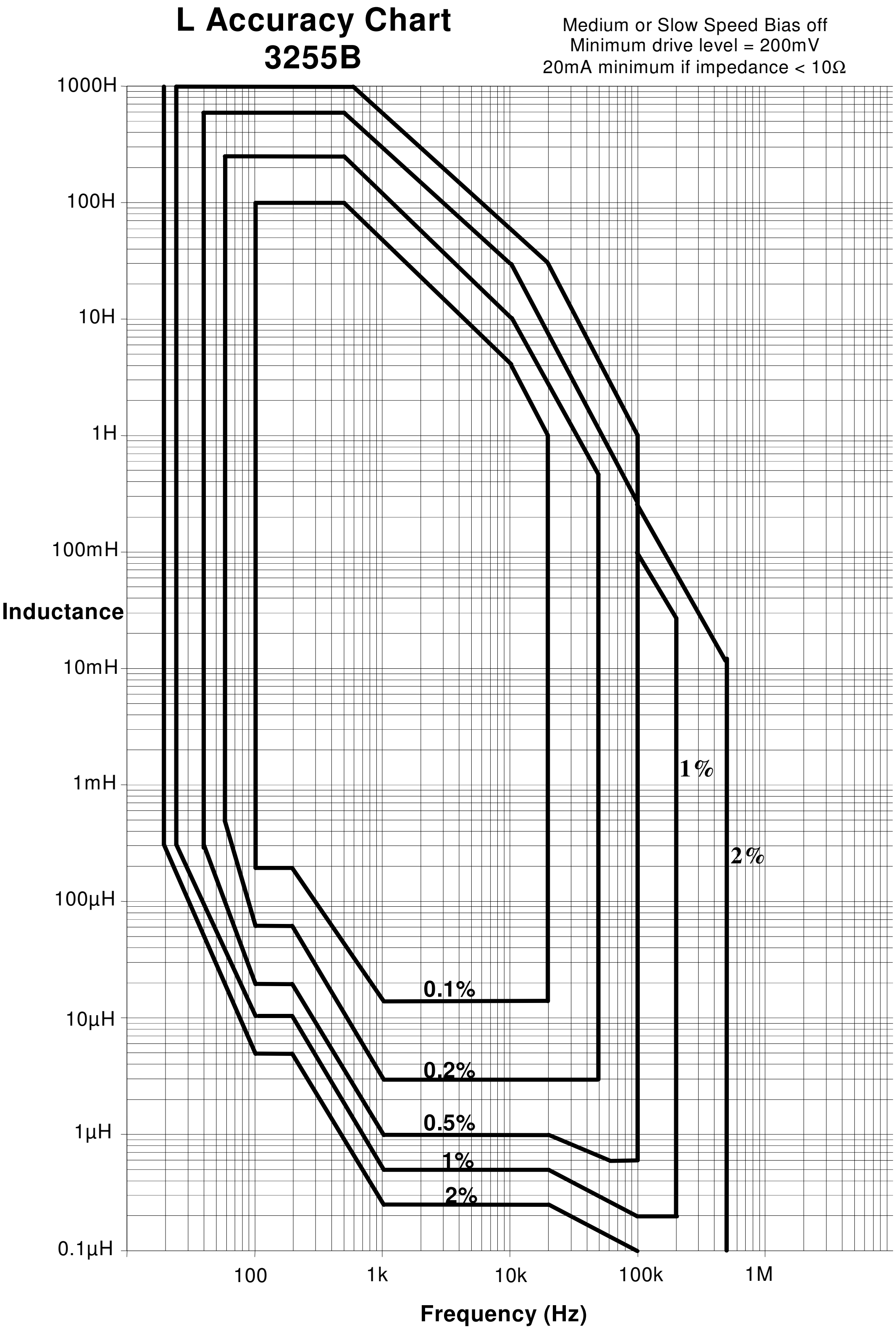


Figure 7-2 3255B Inductance Accuracy Chart

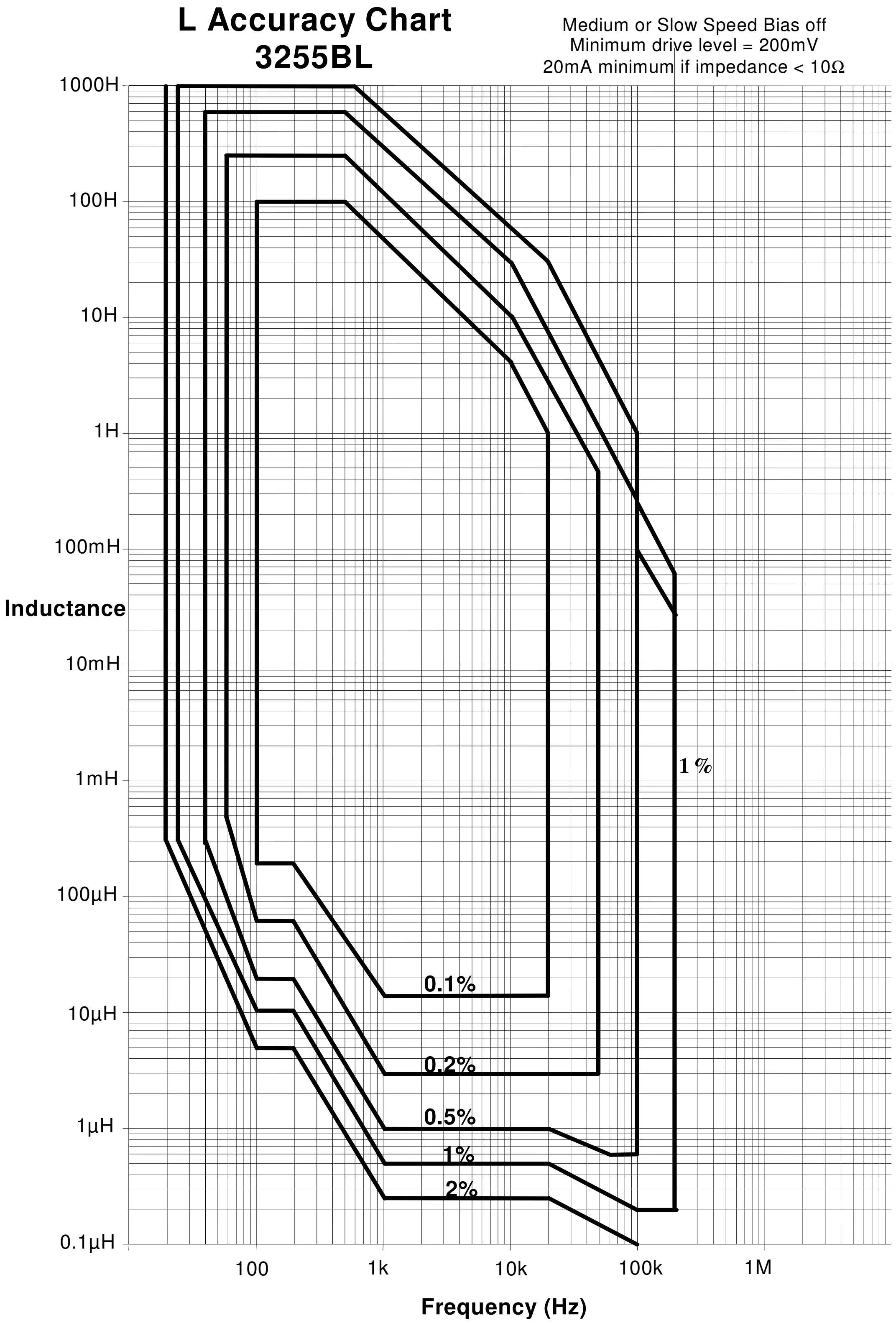


Figure 7-3 3255BL Inductance Accuracy Chart

7.7 General Data

7.7.1 Input Specification

Input Voltage	115V AC ±10% or 230V AC ±10% (selectable on rear panel)
Frequency	50/60Hz
VA Rating	150VA
Input Fuse Rating	115V operation: 2A–T
	230V operation: 1A–T

The input fuse is in the fuse holder drawer integral with the IEC input connector.

7.7.2 Display

High contrast black and white LCD module 320 x 240 dot with CFL back lighting. Visible area 115 x 86mm. Viewing angle 45°.

7.7.3 Measurement Connections

4 front panel BNC sockets.

4-wire (Kelvin) measurements with screen at ground potential.

Equivalent circuit symbols on screen.

7.7.4 Printer Output

Parallel printer port

7.7.5 Remote Control (option)

Designed to GPIB (IEEE488.2) and SCPI 1992.0.

7.7.6 Environmental Conditions

Temperature Range

Storage	-40°C to +70°C
Operating	0°C to 40°C
Full Accuracy	15°C to 35°C

Altitude	up to 2000m
Relative Humidity	up to 80% non-condensing
Installation Category	II (in accordance with IEC664)
Pollution Degree	2 (mainly non-conductive)

This equipment is intended for indoor use only in non-explosive, non-corrosive atmosphere.

7.7.7 Safety

Complies with the requirements of EN61010-1.

7.7.8 EMC

Complies with EN50081-1, EN50082-1 generic emissions and immunity standards by meeting with the requirements of EN55022, IEC801.2, EN801.3 & IEC801.4

7.7.9 Mechanical

Height	150mm (6”)
Width	440mm (17$^{3}/_{8}$”)
Depth	520mm (20$^{1}/_{2}$”)
Weight	11kg (24lb 4oz.)

7.7.10 Options

1A Internal DC Bias Current.

Remote Control (GPIB).

Test Leads and Fixtures

7.7.11 Panel Symbols Used

	Refer to Manual.
	Alternating Current
	CAUTION - Risk of Electric Shock.
	On
	Off

8. THEORY REFERENCE

8.1 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	

8.2 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 $X_L = \omega L \quad X_C = \frac{1}{\omega C} \quad B_C = \omega C \quad B_L = \frac{1}{\omega L}$

$$Q = \frac{\omega L_S}{R_S} = \frac{1}{\omega C_S R_S} \quad \text{(series R, L, C values)}$$

$$Q = \frac{R_P}{\omega L_P} = \omega C_P R_P \quad \text{(parallel R, L, C values}$$

$$D = \frac{G_P}{\omega C_P} = \omega L_P G_P \quad \text{(parallel G, L, C values)}$$

$$D = \frac{R_S}{\omega L_S} = \omega C_S R_S \qquad \text{(series R, L, C values)}$$

Note : The value $Q = \frac{1}{D}$ is constant regardless of series/parallel convention

8.3 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.

8.4 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.

9. MAINTENANCE, SUPPORT AND SERVICES

9.1 Guarantee

The equipment supplied by Wayne Kerr Electronics 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.

9.2 Maintenance

9.2.1 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.

9.2.2 Safety Checks

Each year the equipment should be given a simple safety check.

9.2.2.1 Equipment required

25A ground bond tester (e.g. Megger PAT 2)

Insulation tester @ 500V DC (e.g. Megger BM 7)

9.2.2.2 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.

9.3 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. The Wayne Kerr Electronics global website www.waynekerrtest.com includes the very latest support information.

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
service@waynekerr.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
service@wayne-kerr.co.uk

Europe

Wayne Kerr Europe
Märkische Str. 38-40
58675 Hemer
Germany

Tel: +49 (0)2372 557870
Fax: +49 (0)2372 5578790
Email: info@waynekerr.de
service@waynekerr.de

Asia

Wayne Kerr Asia
A604 Pengdu Building,
Guimiao Road,
Nanshan District,
Shenzhen, Guangdong
China
Tel: +86 130 66830676
Fax: +86 755 26523875
Email: sales@waynekerr.com
service@waynekerr.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.

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