LCR METER
4255 / 4275

Specification

Issue A

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1. 4255 SPECIFICATION

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

1.1 Measurement Parameters

Any of the following parameters can be measured and displayed.

DC Functions (Option)

Resistance (Rdc).

AC Functions

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

The following display formats are available.

Series or Parallel Equivalent Circuit

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

Series Equivalent Circuit Only

X+R, X+D, X+Q

Parallel Equivalent Circuit Only

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

Polar Form

Z + Phase Angle, Y + Phase Angle

1.2 Test Conditions

1.2.1 AC Drive

1.2.1.1 Frequency Range

20Hz to 500kHz >1000 steps

Accuracy of set frequency ±0.005%

1.2.1.2 Pre-set frequencies

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

1.2.1.3 Drive Level (AC Measurements)

Open Circuit Voltage

50mV to 2V rms

Short Circuit Current

1mA to 40mA rms

Signal source impedance

50Ω nominal

1.2.1.4 Step Size

Voltage Drive		Current Drive	
Step size	**up to drive level**	**Step size**	**up to drive level**
1mV	100mV	50µA	5mA
2mV	200mV	100µA	10mA
5mV	500mV	200µA	20mA
10mV	1V	500µA	40mA
20mV	2V		

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

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

±5% ±1mV or ±5% ±0.1mA at 20Hz

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

1.2.2 DC Bias Voltage

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

DC bias of 2V ±5%.

Peak short circuit current <90mA.

1.2.3 Drive Level Rdc (Option)

Two selectable drive levels:

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

Source resistance: 100Ω nominal.

1.3 Measurement Speeds

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

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

Maximum speed (intended for automatic sorting) ≈ 50ms.

Fast speed (for non-critical measurements) ≈ 100ms.

Medium speed (for improved resolution) ≈ 300ms.

Slow speed (for best resolution and enhanced supply frequency rejection) ≈ 900ms.

1.4 Measurement Ranges

R, Z, X 0.01mΩ to >2GΩ

G, Y, B 0.01nS to >2kS

L 0.1nH to >2kH

C 1fF to >1F

D 0.00001 to >1000

Q 0.00001 to >1000

Rdc 0.1mΩ to >10MΩ

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

1.5 Hardware Ranges

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

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

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

1.6 Modes Of Operation

1.6.1 MEASUREMENT

Selection of any measurement parameter and test condition.

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

Single and repetitive measurements displaying major and minor terms.

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

1.6.2 DEVIATION

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

1.7 Measurement Connections

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

Terminals withstand connection of charged capacitor up to following limits:

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

- a capacitor charged to between 50V and 500V with a stored energy of less than 0.25J, either polarity. For higher voltages and energy levels the instrument may be used with the 1100 protection unit. (See section **Error! Reference source not found.** for further information).

1.8 Measurement Accuracy

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

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

For other frequencies and speeds see section 1.9 - Accuracy Charts.

1.8.1 Resistance / Reactance (R / X)

Frequency	Accuracy % (for Q < 0.1)	Range for specified accuracy
100Hz /120Hz	0.1	1Ω to 1.6MΩ
1kHz	0.1	1Ω to 1.6MΩ
10kHz	0.1	2Ω to 900kΩ
100kHz	0.5	1.1Ω to 100kΩ

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

1.8.2 Conductance / Susceptance (G / B)

Frequency	Accuracy % (for Q < 0.1)	Range for specified accuracy
100Hz /120Hz	0.1	0.63µS to 1S
1kHz	0.1	0.63µS to 1S
10kHz	0.1	1.11µS to 0.5S
100kHz	0.5	10µS to 0.9S

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

1.8.3 Capacitance (C)

Frequency	Accuracy % (for D < 0.1)	Range for specified accuracy
100Hz /120Hz	0.1	1nF to 1mF
1kHz	0.1	100pF to 100μF
10kHz	0.1	60pF to 10μF
100kHz	0.5	10pF to 1μF

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

1.8.4 Inductance (L)

Frequency	Accuracy % (for Q > 10)	Range for specified accuracy
100Hz /120Hz	0.1	1mH to 1000H
1kHz	0.1	100μH to 100H
10kHz	0.1	20μH to 10H
100kHz	0.5	4μH to 200mH

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

1.8.5 Dissipation Factor (D)

Frequency	Accuracy (A_d)	Range for specified accuracy
100Hz /120Hz	0.001	1nF to 1mF
1kHz	0.001	100pF to 400μF
10kHz	0.001	100pF to 10μF
100kHz	0.005	10pF to 3μF

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

1.8.6 Quality Factor (Q)

Frequency	Accuracy % (A_L)	Range for specified accuracy
100Hz /120Hz	0.1	4m to 1000H
1kHz	0.1	100μH to 100H
10kHz	0.1	20μH to 10H
100kHz	0.5	4μH to 200mH

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

1.8.7 DC Resistance Rdc (Optional)

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

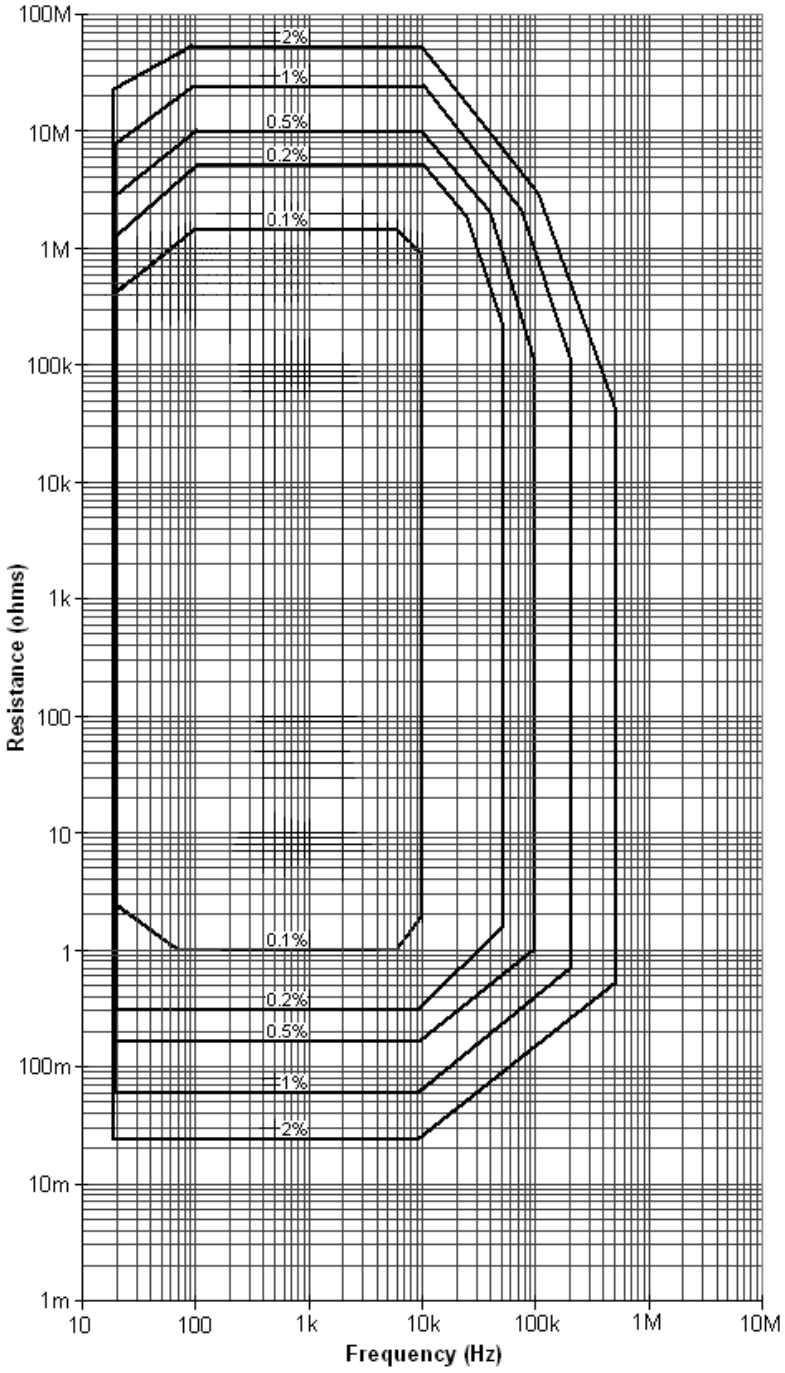
1.9 Accuracy Charts

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

For above and below the ranges indicated in the following charts, the accuracy degrades linearly with increasing/decreasing DUT value. For example, 470MΩ and 2.5mΩ measured at 10kHz are both a factor of 10 beyond the indicated range for 2% and will each have an accuracy of 20%.

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

1.9.1 R/G Accuracy



Conditions

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

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

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

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

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

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

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

High resistance values

Accuracy = $\pm$ (A + 100Y_T . R_X) %.

Low resistance values

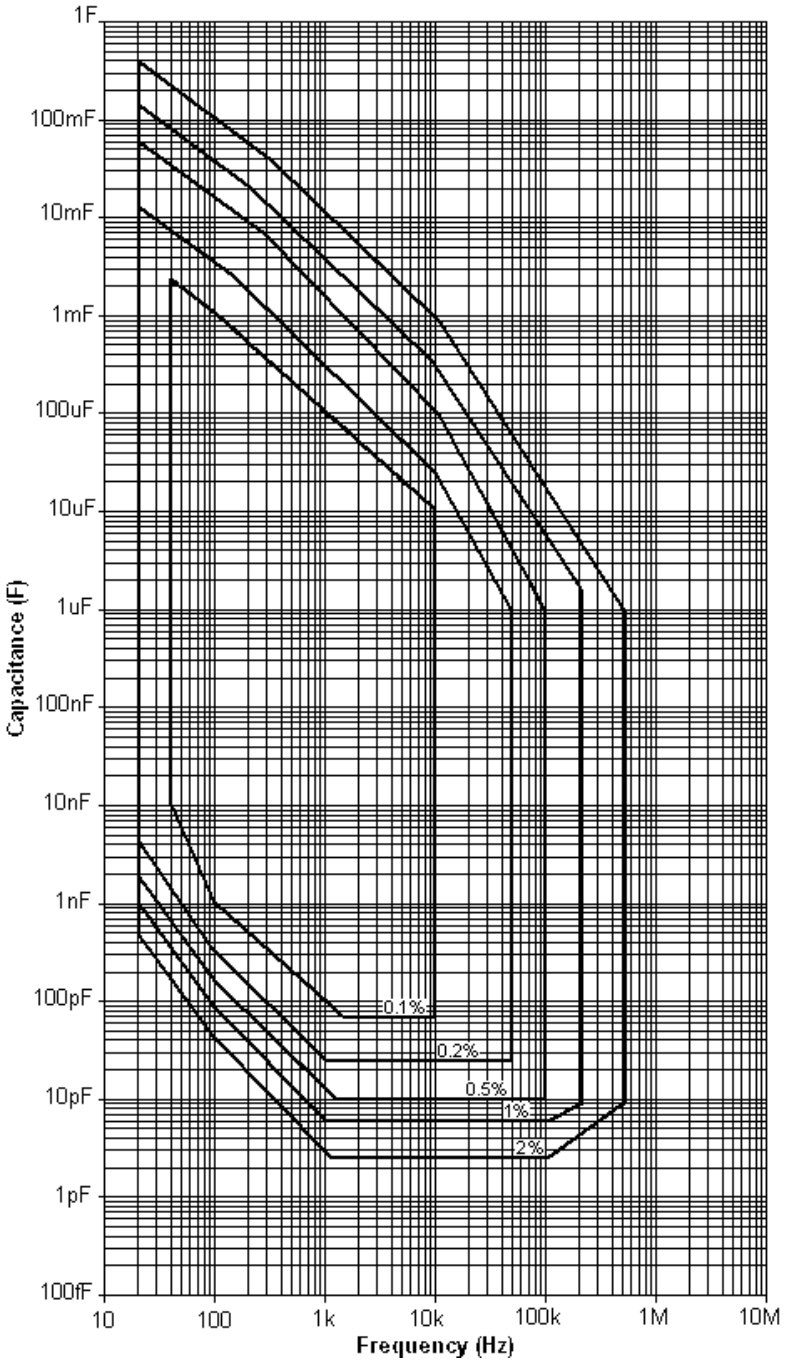
Accuracy = $\pm$ (A + 100R_T / R_X) %

where:
A = accuracy from adjacent chart.
R_X = measured value of unknown component.
R_T = sum of Z_I, Z_L (as appropriate, from section 1.10.2).
Y_T = sum of Y_I, Y_L (as appropriate, from section 1.10.1).

Conductance (G)

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

1.9.2 C Accuracy



Conditions

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

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

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

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

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

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

High capacitance values

Accuracy = $\pm$ (A + 100 X_T . ω C_X) %

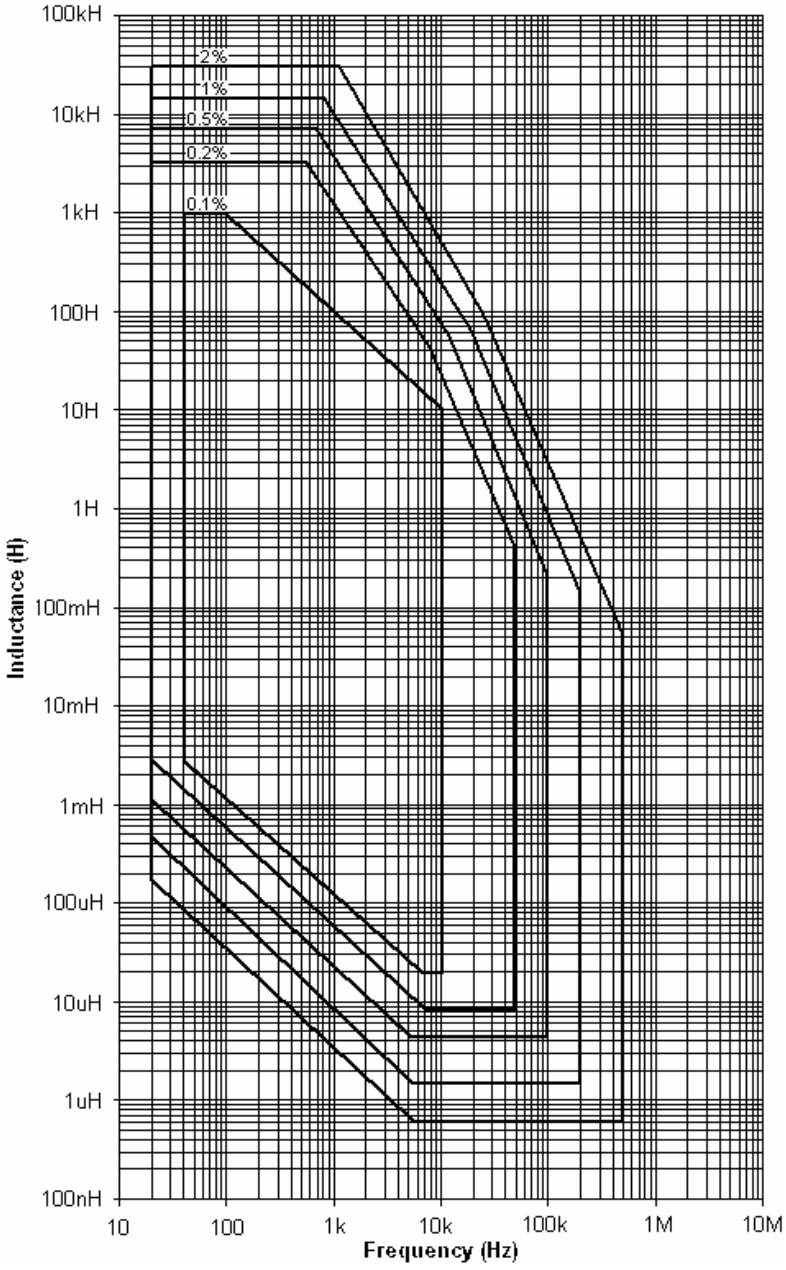
Low capacitance values

Accuracy = $\pm$ (A + 100 C_T / C_X) %

where

A = accuracy from adjacent chart
C_X = measured value of unknown component.
X_T = sum of Z_I, Z_L (as appropriate, from section 1.10.2)
C_T = sum of C_I, C_L (as appropriate, from section 1.10.1)
$\omega = 2\pi$. frequency

1.9.3 L Accuracy



Conditions

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

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

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

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

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

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

High inductance values

Read accuracy direct from chart

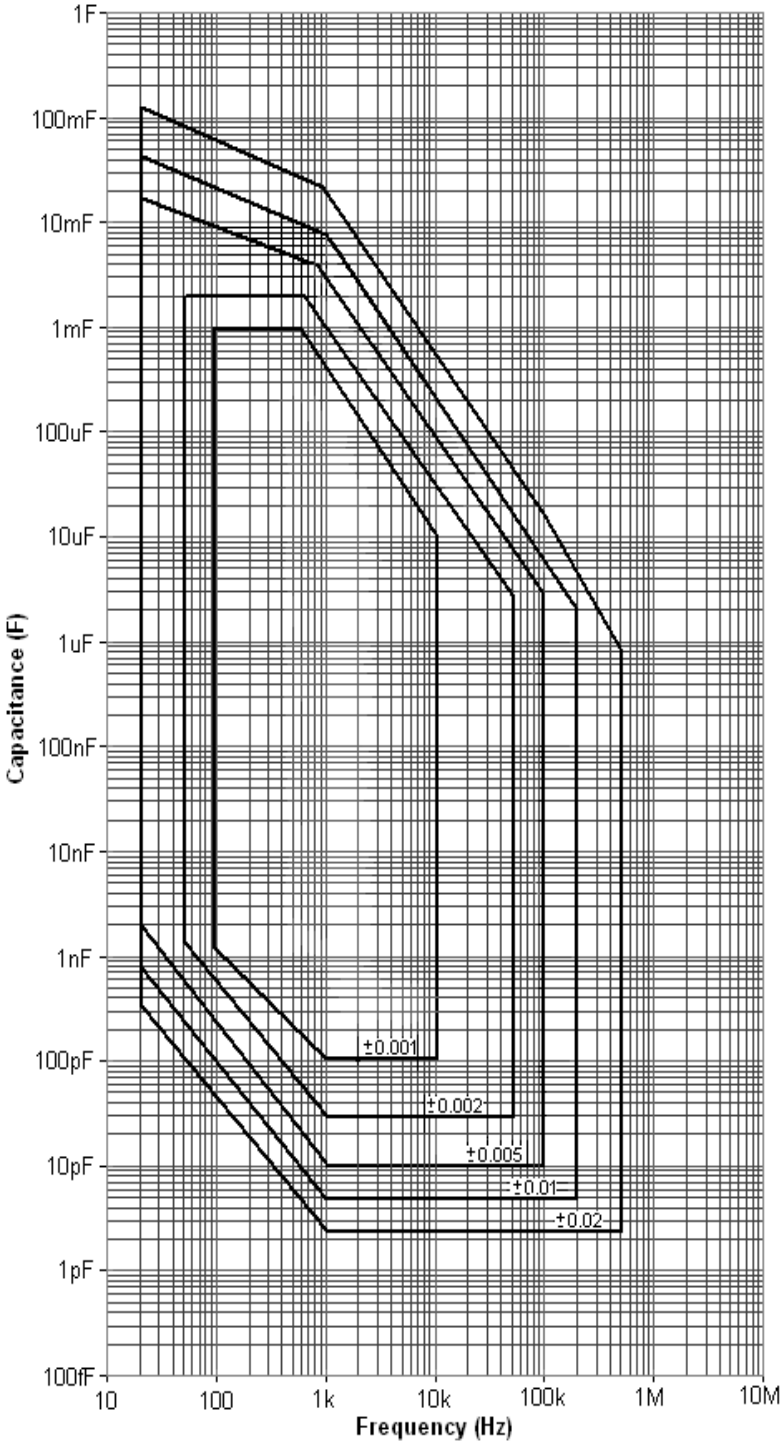
Low inductance values

Accuracy = $\pm$ (A + 100 L_T / L_X) %

where

A = accuracy from adjacent chart
L_X = measured value of unknown component.
L_T = sum of L_I, L_L (as appropriate, from section 1.10.2)

1.9.4 D Accuracy



Conditions

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

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

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

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

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

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

If D >0.1, multiply accuracy by $(1+D^2)$.

High capacitance values

D accuracy = $\pm (A + R_T . \omega C_X)$

Low capacitance values

D accuracy = $\pm (A + Y_T / \omega C_X)$.

Capacitor series loss resistance (esr)

Accuracy = $\pm (A/\omega C_X)\ \Omega$

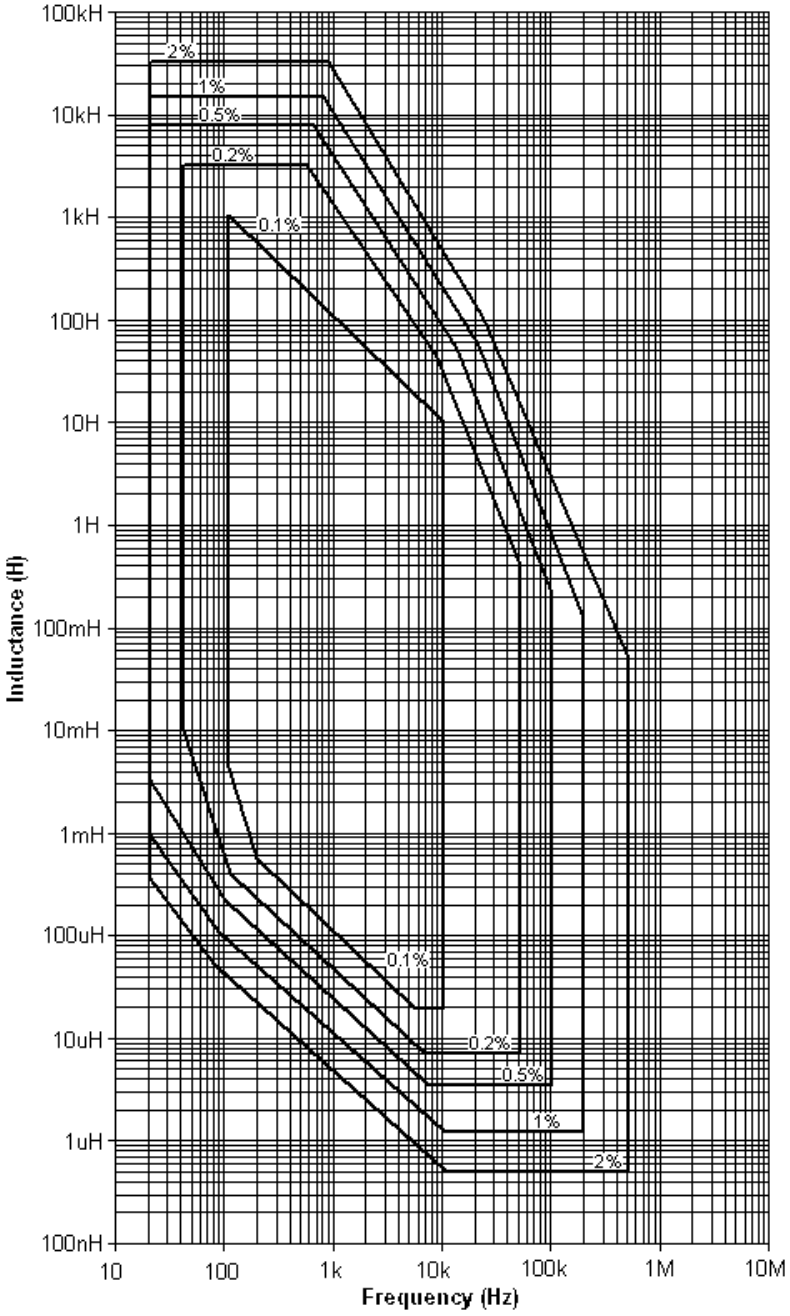
Capacitor parallel loss resistance (epr)

Accuracy = $\pm (100A\ R_X . \omega C_X)$ %

where:

A = accuracy from adjacent chart
C_X = measured value of unknown component.
R_X = measured value of unknown component.
R_T = sum of Z_I, Z_L (as appropriate, from section 1.10.2)
Y_T = sum of Y_I, Y_L (as appropriate, from section 1.10.1)
$\omega = 2\pi$. frequency

1.9.5 Q Accuracy



Conditions

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

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

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

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

For all Q values

Q accuracy =A(Q + 1/Q)

High inductance values

Read Q accuracy direct from chart

Low inductance values

Q accuracy = $\pm((A + 100R_T/\omega L_X)(Q+1/Q))$ %

Inductor series loss resistance

Accuracy = $\pm$ $(A.\ \omega L_X/R_X)$ %

Inductor parallel loss resistance

$$\text{Accuracy} = \pm \frac{A.R_X}{\omega L_X}\%$$

where

A = accuracy from adjacent chart
L_X = measured value of unknown component.
R_X = measured value of unknown component.
R_T = sum of Z_I, Z_L (as appropriate, from section 1.10.2).
$\omega = 2\pi$. frequency

1.10 Additional Corrections

The following tables give the additional corrections which need to be applied to measurements when some or all the measurement conditions specified in the Iso_Accuracy charts are not used.

1.10.1 Open Circuit Trim Correction

f = frequency in kHz

Frequency range (Hz)	Interpolation		Level 1.02 - 2V	
	Y_I (nS)	C_I (pF)	Y_L (nS)	C_L (pF)
20-250	1	0.15 / f	1	0.015 / f
300-10k	0.2	0.03 / f	0.2	0.03 / f
12k-100k	0.12 x f	0.02	0.12 x f	0.02
120k - 500k	0.31 x f	0.05	0.31 x f	0.05

f = frequency in kHz, V= drive level in V

Frequency range (Hz)	Level 0.1 - 0.98V		Level < 0.1V	
	Y_L (nS)	C_L (pF)	Y_L (nS)	C_L (pF)
20-250	0.4 / V	0.06 / (f x V)	0.4 / V	0.06 / (f x V)
300-10k	0.1 / V	0.015 / (f x V)	0.1 / V	0.015 / (f x V)
12k-100k	0.12 x f	0.02	0.012 x f / V	0.002 / V
120k - 500k	0.31 x f	0.05	0.031 x f / V	0.005 / V

1.10.2 Short Circuit Trim Correction

f = frequency in kHz

Frequency range (Hz)	Interpolation		Level 2 - 40mA		
	Z_I (μΩ)	L_I (nH)	Z_L (μΩ)	L_L (nH)	
20	1500	240 / f	1500	240 / f	For drive levels below 2mA multiply level corrections in previous column by 2 / (level in mA).
25-80	1000	160 / f	1000	160 / f	
100	500	80 / f	500	80 / f	
120-10k	250	40 / f	250	40 / f	
12k-500k	18 x f	3	18 x f	3	

1.11 General

1.11.1 Power Supply

Input Voltage	115V AC ±10% or 230V AC ±10% (selectable)
Frequency	50/60Hz
VA rating	150VA max
Input fuse rating	115V operation: 2AT
	230V operation: 1AT
	The input fuse is in the fuse holder drawer integral to the IEC input connector.

1.11.2 Display

High contrast black and white LCD module 320 x 240 pixels with CPL back lighting.

Visible area 115 x 86mm.

1.11.3 Remote Control (Optional)

Designed to GPIB IEEE-488.2 and SCPI 1992.0.

1.11.4 Remote Trigger

Rear panel BNC with internal pull-up, operates on logic low or contact closure.

1.11.5 Mechanical

Height	150mm (5.9")
Width	440mm (17.37")
Depth	525mm (20.5")
Weight	11kg (24.25lbs)

1.12 Environmental Conditions

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

1.12.1 Temperature Range

Storage:	-40°C to +70°C.
Operating:	0°C to 40°C.
Normal accuracy:	15°C to 35°C. See section 1.8—Measurement Accuracy for full specification.

1.12.2 Relative Humidity

Up to 80% non-condensing.

1.12.3 Altitude

Up to 2000m.

1.12.4 Installation Category

II in accordance with IEC664.

1.12.5 Pollution Degree

2 (mainly non-conductive)

1.12.6 Safety

Complies with the requirements of EN61010-1.

1.12.7 EMC

Complies with EN61326 for emissions and immunity.

2. 4275 SPECIFICATION

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2.1 Measurement Parameters

Any of the following parameters can be measured and displayed:

DC Functions (Option)

Resistance (Rdc).

AC Functions

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

The following display formats are available:

Series or Parallel Equivalent Circuit

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

Series Equivalent Circuit Only

X+R, X+D, X+Q

Parallel Equivalent Circuit Only

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

Polar Form

Z + Phase Angle, Y + Phase Angle

2.2 Test Conditions

2.2.1 AC Drive

2.2.1.1 Frequency Range

20Hz to 1MHz >1600 steps

Accuracy of set frequency ±0.005%

2.2.1.2 Pre-set frequencies

Coarse step setting

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

Fine step setting

Step size 1% or better throughout range.

2.2.1.3 Drive Level (AC Measurements)

Open Circuit Voltage
50mV to 2V rms

Short Circuit Current
1mA to 40mA rms

Signal source impedance

50Ω nominal

2.2.1.4 Step Size

Voltage Drive		Current Drive	
Step size	up to drive level	Step size	up to drive level
1mV	100mV	50µA	5mA
2mV	200mV	100µA	10mA
5mV	500mV	200µA	20mA
10mV	1V	500µA	40mA
20mV	2V		

Automatic Level Control (ALC) ensures that the drive level at the device under test (DUT) is ±2% ±1mV of set voltage or ±2% ±0.1mA of set current between 100Hz and 500kHz.

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

±5% ±1mV or ±5% ±0.1mA at 20Hz

Drive level accuracy degrades above 500kHz: ±4% ±1mV or ±4% ±0.1mA at 1MHz

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

2.2.2 DC Bias Voltage

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

DC bias of 2V ±5%.

Peak short circuit current <90mA.

2.2.3 Drive Level Rdc (Option)

Two selectable drive levels:

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

Source resistance: 100Ω nominal.

2.3 Measurement Speeds

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

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

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

2.4 Measurement Ranges

R, Z , X 0.01mΩ to >2GΩ

G, Y, B 0.01nS to >2kS

L 0.05nH to >2kH

C 0.5fF to >1F

D 0.00001 to >1000

Q 0.00001 to >1000

Rdc 0.1mΩ to >10MΩ

For L and C, the lower range is available at 10kHz, 100kHz and 1MHz; the upper range is available at 100Hz and below.

2.5 Hardware Ranges

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

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

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

2.6 Modes Of Operation

2.6.1 MEASUREMENT

Selection of any measurement parameter and test condition.

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

Single and repetitive measurements displaying major and minor terms.

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

2.6.2 DEVIATION

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

2.7 Measurement Connections

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

Terminals withstand connection of charged capacitor up to following limits:

- any value capacitor charged up to 50V, either polarity;
- a capacitor charged to between 50V and 500V with a stored energy of less than 0.25J, either polarity. For higher voltages and energy levels the instrument may be used with the 1100 protection unit. (See section **Error! Reference source not found.** for further information).

2.8 Measurement Accuracy

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

1V (DUT >50Ω) or 20mA (DUT <50Ω), slow speed, 4-terminal measurement. The instrument must have warmed up for at least 30 minutes at a steady ambient temperature of between 15°C and 35°C. The instrument must have been trimmed with its measuring leads and fixture at the measurement frequency. For frequencies above 20kHz, HF lead compensation must have been performed.

For other frequencies and speeds see section 2.9—Accuracy Charts.

2.8.1 Resistance / Reactance (R / X)

Frequency	Accuracy % (for Q < 0.1)	Range for specified accuracy
100Hz /120Hz	0.1	1Ω to 1.6MΩ
1kHz	0.1	1Ω to 1.6MΩ
10kHz	0.1	1Ω to 1.6MΩ
100kHz	0.1	25Ω to 100kΩ
1MHz	0.2	30Ω to 10kΩ

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

2.8.2 Conductance / Susceptance (G / B)

Frequency	Accuracy % (for Q < 0.1)	Range for specified accuracy
100Hz /120Hz	0.1	0.63μS to 1S
1kHz	0.1	0.63μS to 1S
10kHz	0.1	0.63μS to 1S
100kHz	0.05	10μS to 0.04S
1MHz	0.2	100μS to 33mS

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

2.8.3 Capacitance (C)

Frequency	Accuracy % (for D <0.1)	Range for specified accuracy
100Hz /120Hz	0.1	1nF to 1mF
1kHz	0.1	100pF to 100μF
10kHz	0.1	50pF to 10μF
100kHz	0.1	50pF to 100nF
1MHz	0.2	60pF to 2.5nF

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

2.8.4 Inductance (L)

Frequency	Accuracy % (for Q >10)	Range for specified accuracy
100Hz /120Hz	0.1	1mH to 1000H
1kHz	0.1	100μH to 100H
10kHz	0.1	20μH to 10H
100kHz	0.2	8μH to 160mH
1MHz	0.5	2μH to 4mH

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

2.8.5 Dissipation Factor (D)

Frequency	Accuracy (A_d)	Range for specified accuracy
100Hz /120Hz	0.001	1nF to 1mF
1kHz	0.001	100pF to 400μF
10kHz	0.001	100pF to 10μF
100kHz	0.001	100pF to 60nF
1MHz	0.002	25pF to 6nF

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

2.8.6 Quality Factor (Q)

Frequency	Accuracy % (A_L)	Range for specified accuracy
100Hz /120Hz	0.1	4mH to 1000H
1kHz	0.1	100μH to 100H
10kHz	0.1	20μH to 10H
100kHz	0.2	7μH to 160mH
1MHz	0.5	3.5μH to 4mH

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

2.8.7 DC Resistance Rdc (Optional)

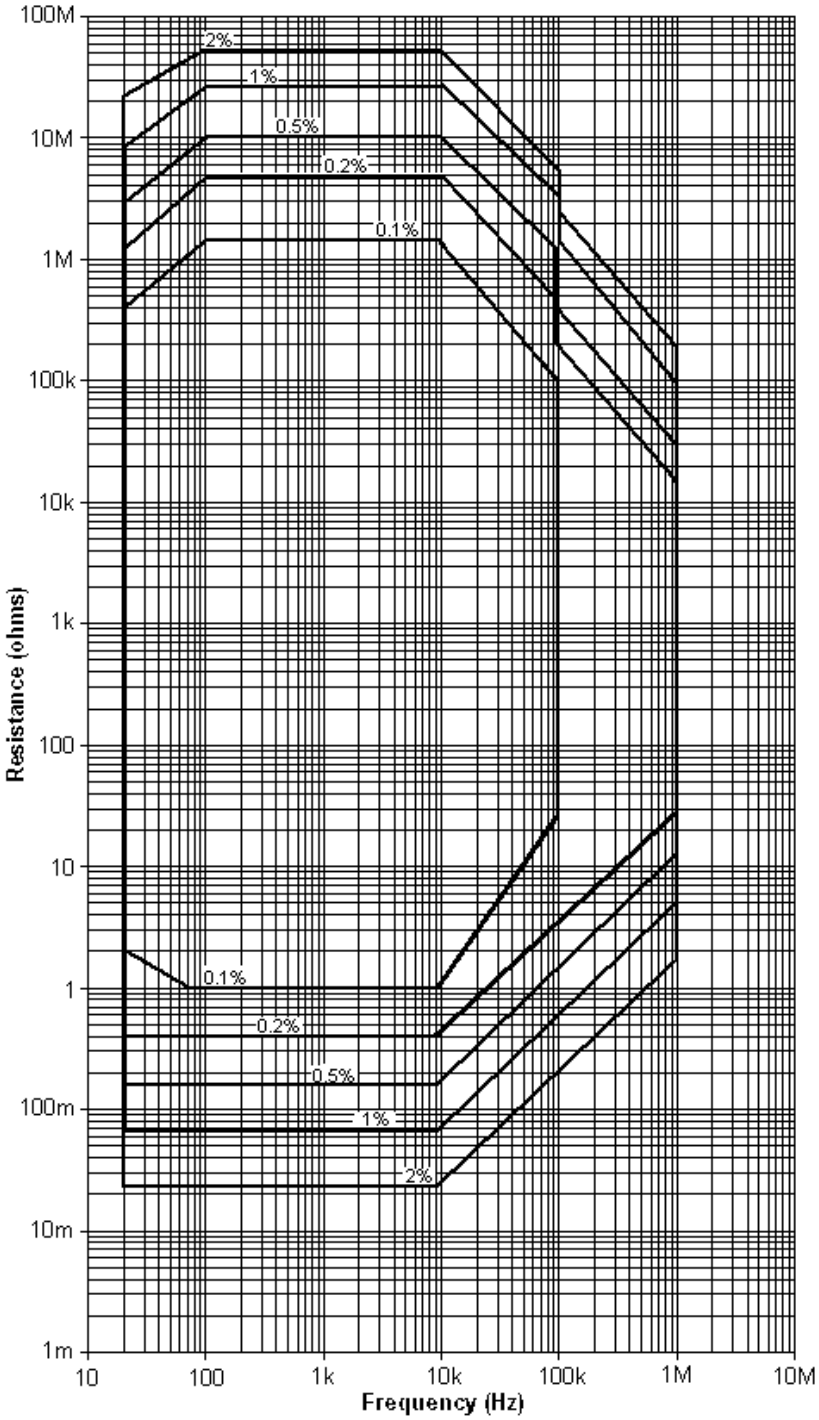
Drive Level	Accuracy %	Range for specified accuracy
100mV	0.25	10Ω to 10kΩ
1V	0.1	1Ω to 100kΩ

2.9 Accuracy Charts

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

For above and below the ranges indicated in the following charts, the accuracy degrades linearly with increasing/decreasing DUT value. For example, 470MΩ and 2.5mΩ measured at 10kHz are both a factor of 10 beyond the indicated range for 2% and will each have an accuracy of 20%.

2.9.1 R/G Accuracy



Conditions

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

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

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

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

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

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

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

High resistance values

Accuracy = $\pm$ (A + A_F + 100Y_T . R_X) %

Low resistance values

Accuracy = $\pm$ (A + 100R_T / R_X) %

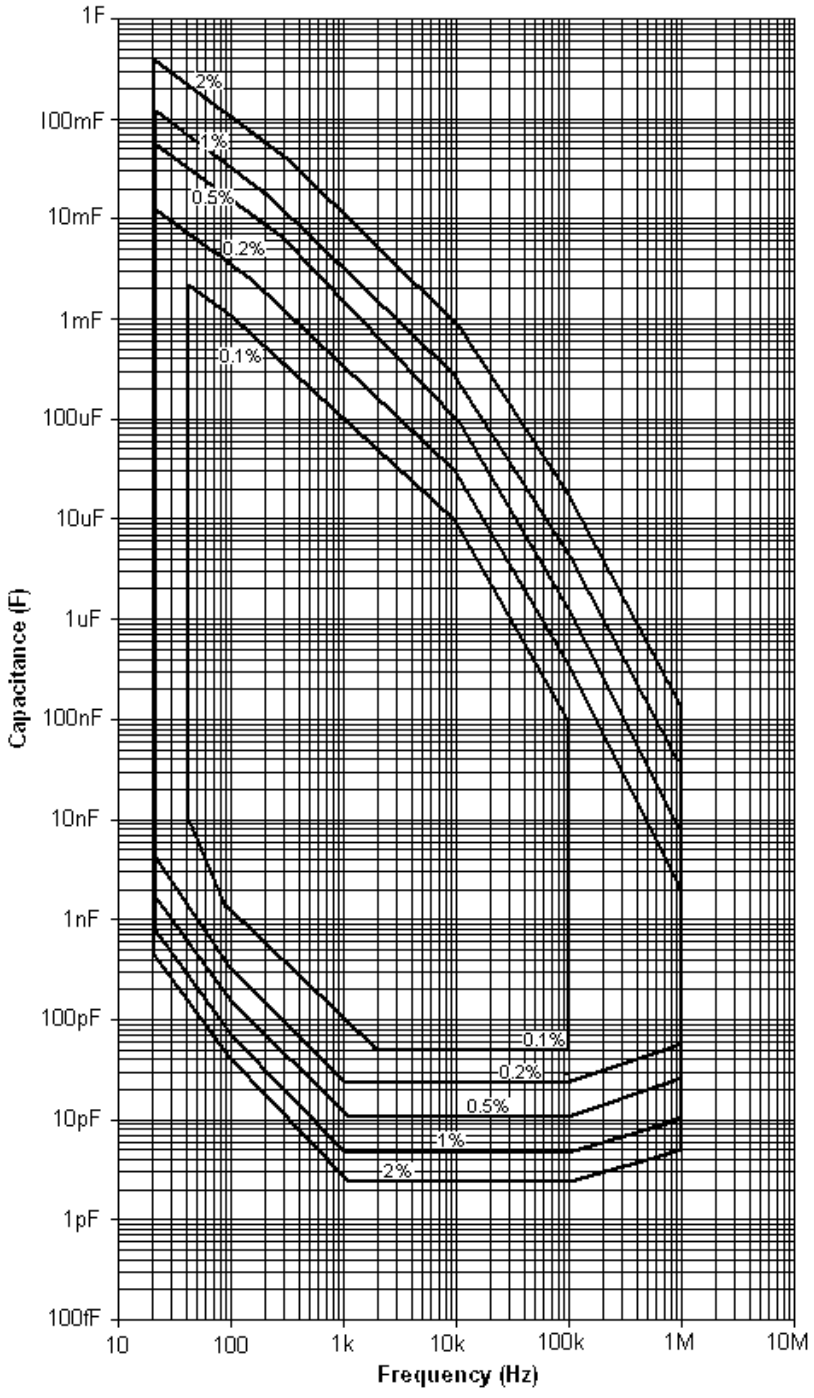
where

A = accuracy from adjacent chart
A_F = fine frequency setting correction (as appropriate from section 2.10.3).
R_X = measured value of unknown component.
R_T = sum of Z_I, Z_L (as appropriate, from section 2.10.2)
Y_T = sum of Y_I, Y_L, G_F (as appropriate, from sections 2.10.1 and 2.10.3)

Conductance (G)

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

2.9.2 C Accuracy



Conditions

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

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

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

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

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

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

High capacitance values

Accuracy = $\pm$ (A + A_F + 100 X_T . ω C_X) %

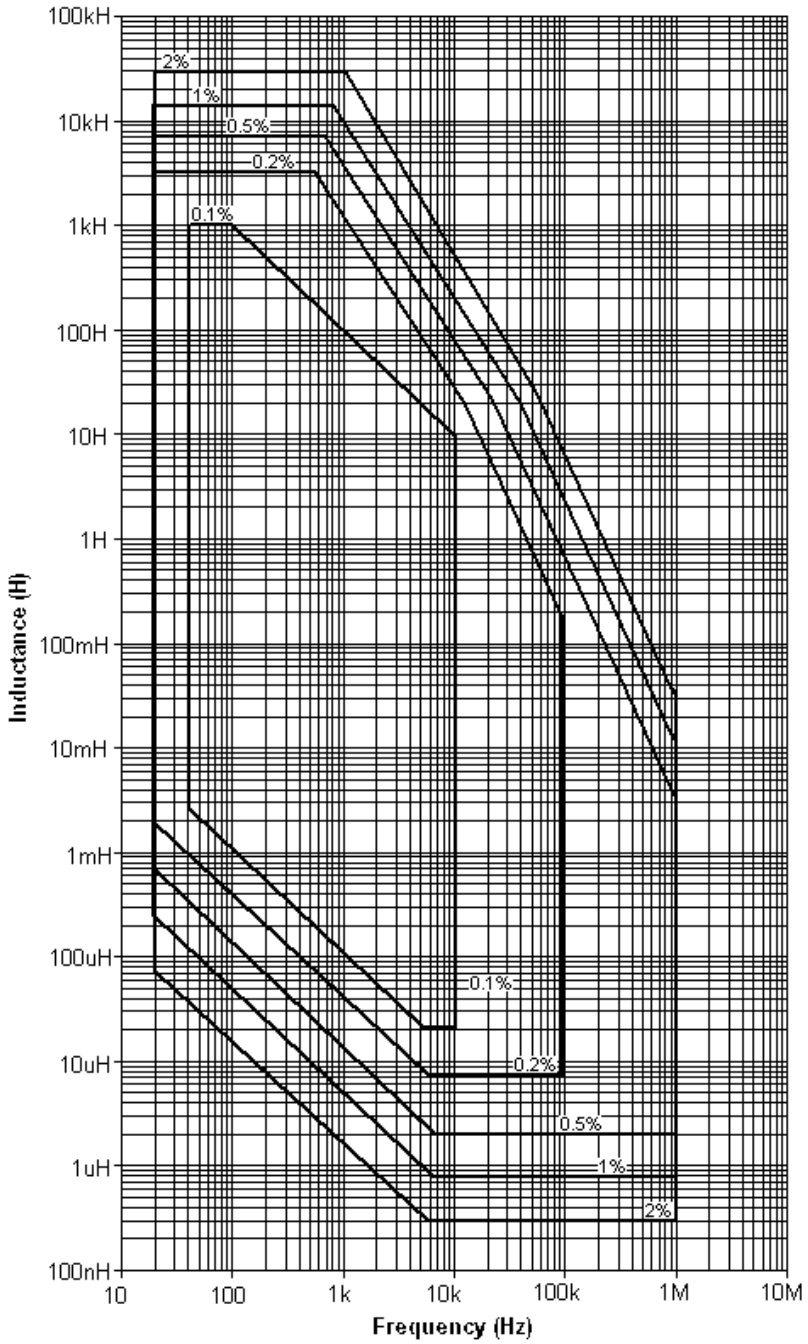
Low capacitance values

Accuracy = $\pm$ (A + 100 C_T / C_X) %

where

A = accuracy from adjacent chart
A_F = fine frequency setting correction (as appropriate from section 2.10.3).
C_X = measured value of unknown component.
X_T = sum of Z_I, Z_L (as appropriate, from section 2.10.2)
C_T = sum of C_I, C_F, C_L (as appropriate, from sections 2.10.1 and 2.10.3)
$\omega = 2\pi$. frequency

2.9.3 L Accuracy



Conditions

AC Drive Level: 1V/20mA
Slow Speed. 4-Terminal Mode.
Coarse Step frequencies.
Analyzer trimmed at measurement frequency.
Q =10

Temperature range 25 ±10ºC.

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

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

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

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

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

High inductance values

Read accuracy direct from chart

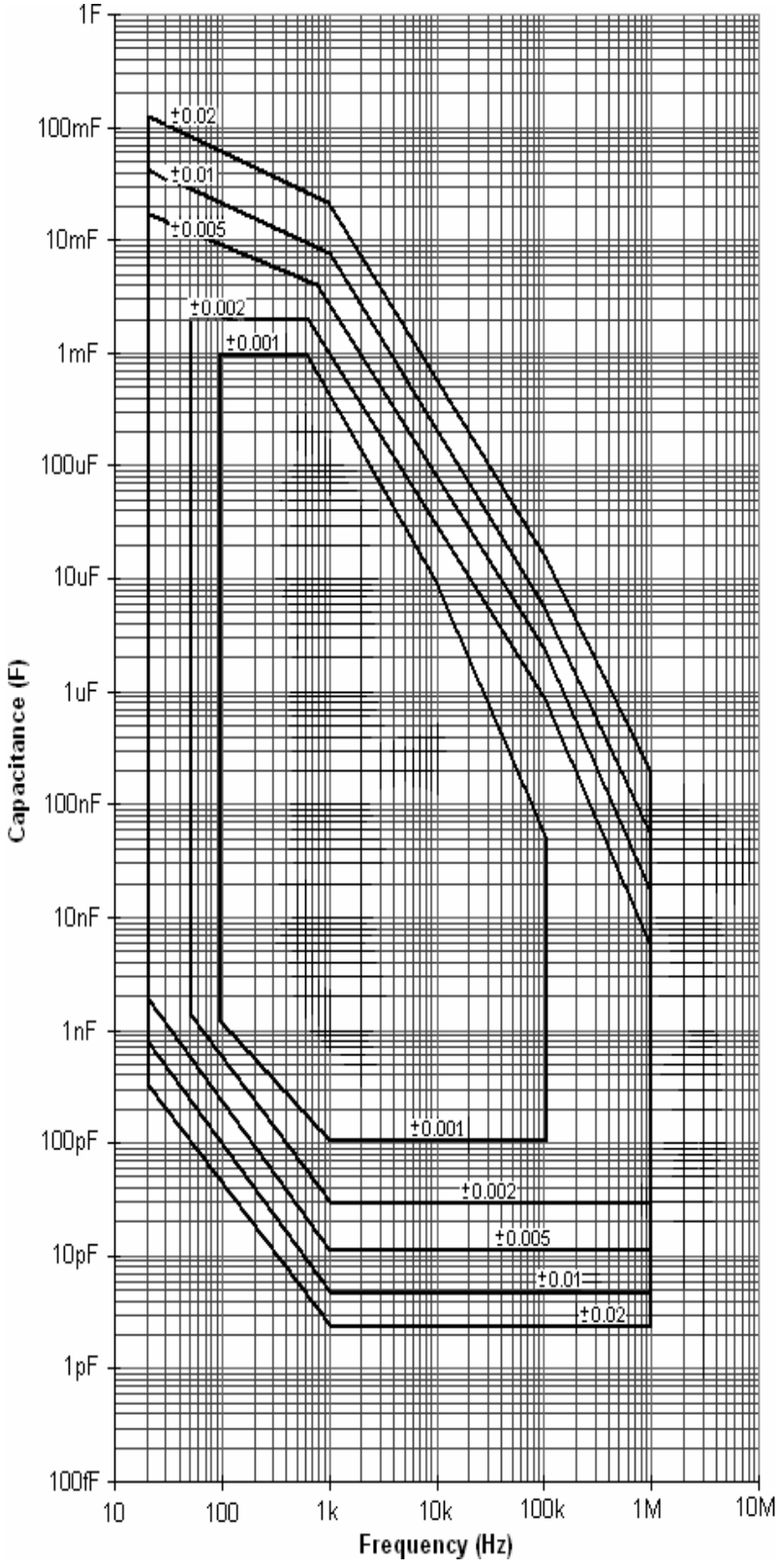
Low inductance values

Accuracy = $\pm$ (A + 100 L_T / L_X) %

where

A = accuracy from adjacent chart
L_X = measured value of unknown component.
L_T = sum of L_I, L_L (as appropriate, from section 2.10.2)

2.9.4 D Accuracy



Conditions

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

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

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

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

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

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

If D > 0.1, multiply D accuracy by $(1+D^2)$.

High capacitance values

D accuracy = $\pm (A + R_T . \omega C_X)$

Low capacitance values

D accuracy = $\pm (A + Y_T / \omega C_X)$

Capacitor series loss resistance (esr)

Accuracy = $\pm (A/\omega C_X)$ Ω

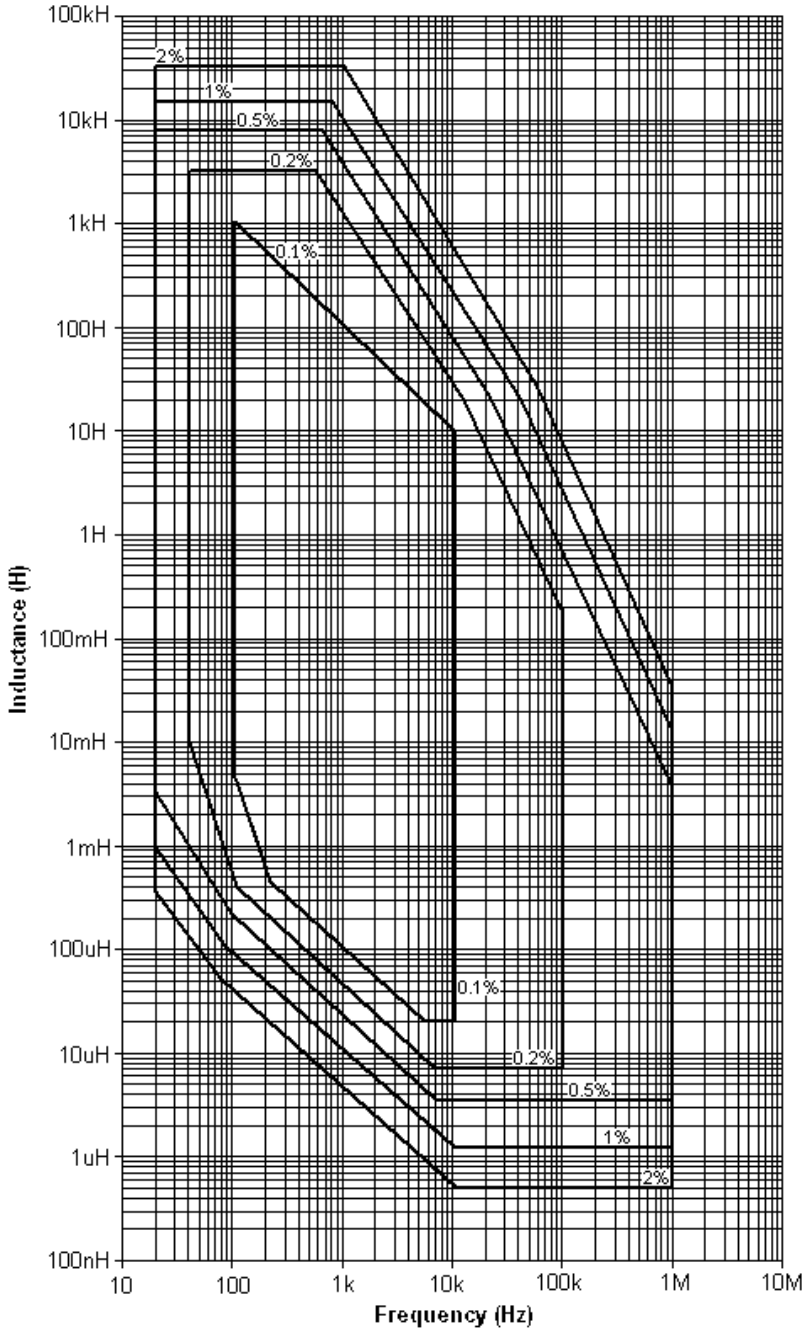
Capacitor parallel loss resistance (epr)

Accuracy = $\pm (100A R_X . \omega C_X)$ %

where

A = accuracy from adjacent chart
C_X = measured value of unknown component
R_X = measured value of unknown component
R_T = sum of Z_I, Z_L, $1/G_F$ (as appropriate, from sections 2.10.2 and 2.10.3)
Y_T = sum of Y_I, Y_L (as appropriate, from section 2.10.1)
$\omega = 2\pi$. frequency

2.9.5 Q Accuracy



Conditions

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

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

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

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

For all Q values

Q accuracy =A (Q + 1/Q)

High inductance values

Read Q accuracy direct from chart

Low inductance values

Q accuracy = $\pm$ (($A + 100R_T / \omega L_X$) (Q+1/Q)) %

Inductor series loss resistance

Accuracy = $\pm$ ($A. \omega L_X / R_X$) %

Inductor parallel loss resistance

$$\text{Accuracy} = \pm \frac{A \,.\, R_X}{\omega L_X} \%$$

where

A = accuracy from adjacent chart
L_X = measured value of unknown component
R_X = measured value of unknown component
R_T = sum of Z_I, Z_L (as appropriate, from section 2.10.2)
$\omega = 2\pi$. frequency

2.10 Additional Corrections

The following tables give the additional corrections which need to be applied to measurements when some or all the measurement conditions specified in the Iso_Accuracy charts are not used.

2.10.1 Open Circuit Trim Correction

f = frequency in kHz

Frequency range (Hz)	Interpolation		Level 1.02 - 2V	
	Y_I (nS)	C_I (pF)	Y_L (nS)	C_L (pF)
20 - 250	1	0.15 / f	1	0.015 / f
300 - 10k	0.2	0.03 / f	0.2	0.03 / f
12k - 100k	0.12 x f	0.02	0.12 x f	0.02
120k - 300k	0.31 x f	0.05	0.31 x f	0.05
302k - 1M	0.31 x f	0.05	0.31 x f	0.05

f = frequency in kHz, V= drive level in V

Frequency range (Hz)	Level 0.1 - 0.98V		Level < 0.1V	
	Y_L (nS)	C_L (pF)	Y_L (nS)	C_L (pF)
20 - 250	0.4 / V	0.06 / (f x V)	0.4 / V	0.06 / (f x V)
300 - 10k	0.1 / V	0.015 / (f x V)	0.1 / V	0.015 / (f x V)
12k - 100k	0.12 x f	0.02	0.012 x f / V	0.002 / V
120k - 300k	0.31 x f	0.05	0.031 x f / V	0.005 / V
302k - 640k	0.31 x f	0.05	0.031 x f / V	0.005 / V
645k - 1M	0.31 x f	0.05	0.31 x f / V	0.05 / V

2.10.2 Short Circuit Trim Correction

f = frequency in kHz

Frequency range (Hz)	Interpolation		Level 2 - 40mA		
	Z_I (μΩ)	L_I (nH)	Z_L (μΩ)	L_L (nH)	
20	1500	240 / f	1500	240 / f	For drive levels below 2mA multiply level corrections in previous column by 2 / (level in mA).
25-80	1000	160 / f	1000	160 / f	
100	500	80 / f	500	80 / f	
120-10k	250	40 / f	250	40 / f	
12k-1M	18 x f	3	18 x f	3	

2.10.3 Fine Frequency Setting Corrections

Drive level = 1V

Frequency range (Hz)	C_F (fF)	A_F (%)	G_F (nS)	A_F (%)
20k - 100k	10	0.02	0.063 x f	0.02
101k - 1M	20	0.035	0.126 x f	0.035

Drive level <1V

Frequency range (Hz)	C_F (fF)	A_F (%)	G_F (nS)	A_F (%)
20k - 100k	10 / level in V	0.02 / level in V	0.063 x f / level in V	0.02 / level in V
101k - 1M	20 / level in V	0.035 / level in V	0.126 x f / level in V	0.035 / level in V

Drive level >1V

Frequency range (Hz)	C_F (fF)	A_F (%)	G_F (nS)	A_F (%)
20k - 100k	30	0.03	0.19 x f	0.03
101k - 1M	100	0.04	0.63 x f	0.04

2.11 General

2.11.1 Power Supply

Input Voltage	115V AC ±10% or 230V AC ±10% (selectable)
Frequency	50/60Hz
VA rating	150VA max
Input fuse rating	115V operation: 2AT
	230V operation: 1AT
	The input fuse is in the fuse holder drawer integral to the IEC input connector.

2.11.2 Display

High contrast black and white LCD module 320 x 240 pixels with CPL back lighting.

Visible area 115 x 86mm.

2.11.3 Remote Control (Optional)

Designed to GPIB IEEE-488.2 and SCPI 1992.0.

2.11.4 Remote Trigger

Rear panel BNC with internal pull-up, operates on logic low or contact closure.

2.11.5 Mechanical

Height	150mm (5.9")
Width	440mm (17.37")
Depth	525mm (20.5")
Weight	11kg (24.25lbs)

2.12 Environmental Conditions

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

2.12.1 Temperature Range

Storage: -40°C to +70°C.
Operating: 0°C to 40°C.
Normal accuracy: 15°C to 35°C. See section 2.8—Measurement Accuracy for full specification.

2.12.2 Relative Humidity

Up to 80% non-condensing.

2.12.3 Altitude

Up to 2000m.

2.12.4 Installation Category

II in accordance with IEC664.

2.12.5 Pollution Degree

2 (mainly non-conductive).

2.12.6 Safety

Complies with the requirements of EN61010-1.

2.12.7 EMC

Complies with EN61326 for emissions and immunity.