LCR Meter
SM5118

User Manual **scientific**

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LCR Meter SM5118

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LCR Meter SM5118

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The **LCR Meter SM5118** measures inductance, capacitance, resistance, impedance, quality factor (Q), dissipation factor (D) & phase angle (θ). **SM5118** can measure above mentioned values up to the basic accuracy of ± 0.25% of reading for values up to 2000 H, 2000 μF, 2 MΩ, 2 MΩ, 99, 0.1 & -180^0 to $+180^0$ respectively & either the series equivalent or parallel equivalent component values can also be displayed. **LCR Meter SM5118** is auto ranging, also it discriminates automatically between inductors & capacitors. Measurement can be made at frequencies of 100 Hz or 1 kHz, as required. An internal DC bias voltage of 2 volts can be selected for use when testing electrolytic capacitors. The operating system of the **SM5118** provides assistance to the user, in selecting measurement mode & frequency to give best accuracy.

Technical Specifications

Measurement Modes	:	Auto/ Manual L, C, R, Z, Q, D, θ
Equivalent Circuit	:	Series or Parallel
Measurement Ranges	:	Auto or Manual
L	:	0.1 μH to 9999 H, Resolution 0.1 μH
C	:	0.1 pF to 9999 μF, Resolution 0.1 pF
R	:	0.001 Ω to 100 MΩ, Resolution 0.001 Ω
Z	:	0.001 Ω to 100 MΩ, Resolution 0.001 Ω
Q	:	0 to 99
D	:	0 to 10
θ	:	-180^{0} to $+180^{0}$
Test Conditions		
Test Frequency	:	100 Hz/ 1 kHz
Test voltage	:	0.3 Vrms
Measurement Speed	:	2 Meas/ sec
Measurement Accuracy	:	± 0.25% ± 1 digit, accuracy varies with range & frequency selected, (after 30 min. warm up period)
Accuracy of Test Frequency	:	0.025%
Condition For Basic Accuracy		
L	:	2 mH to 2000 H, Q > 10, at 100 Hz
	:	200 μH to 200 H, Q > 10, at 1 kHz
C	:	2 nF to 2000 μF, D < 0.1, at 100 Hz
	:	200 pF to 200 μF, D < 0.1, at 1 kHz
R	:	1 Ω to 2 MΩ, Q < 0.1, at 100 Hz
	:	1 Ω to 2 MΩ, Q < 0.1, at 1 kHz
Connection	:	4-wire Kelvin on BNC guarded connector for probes & fixtures connections

Recommended Circuit Mode		
L	:	0.1μH to 9999 H, series mode
C	:	>1μF(elect), series mode
	:	Any non elect (≤ 1 μF elect), Parallel Mode
R	:	≤ 10 kΩ, series mode
	:	≥ 10 kΩ, Parallel Mode

Zero Compensation	:	Auto calibration on both frequencies, **Open or Closed:** limits compensation **Closed:** R < 14 Ω, IZI < 14 Ω **Open:** IZI > 1 MΩ
Low Accuracy Prompt	:	Range indicating LED flashing for value which can be displayed but cannot be measured to basic accuracy
Hold	:	Disable auto range to measure large quantity of components within particular range
DC Bias	:	Internal 2 VDC or external 50 VDC for electrolyte capacitor.
General Information		
Display	:	4 digits 12.5 mm, 7 segment LED display & units' display
Operating Conditions	:	0-45 °C, RH 95%
Supply	:	230 V ± 10%, 50 Hz
Power Consumption	:	≤ 6 VA
Dimensions	:	W 205, H 95, D 292 mm
Weight	:	2.12 kg (approx.)
Accessories		
Standard	:	Operating manual, BNC to Kelvin probe, detachable mains cord, spare fuse

(Subject to change)

Terms & symbols

S. No.	Parameter Symbol	Meaning
1	R	**Resistance (R):** The property of a conductor (resistor) that opposes the flow of current through a closed electrical circuit, is called resistance. Its measuring unit is ohm (Ω). 1. Pure resistance is frequency independent property. 2. Inductive & capacitive resistance are frequency dependent property. 3. R may be either series equivalent (Rs) or parallel equivalent (Rp) resistance as per impedance value.
2	L	**Inductance (L):** The property of a coil, made up of multiple turns of wire over conductor, that opposes any change to the current flowing through it, is called inductance. Its measuring unit is Henry (H). L may be either series equivalent (Ls) or parallel equivalent (Lp) inductance as per impedance
3	C	**Capacitance (C):** The property of a passive element that allows to pass AC & blocks the DC component, is called capacitance. Its measuring unit is Farad (F). 1. It is an energy storing device, which stores the energy in the form of $½CV^2$ 2. C may be either series equivalent (Cs) or parallel equivalent (Cp) capacitance as per impedance value.
4	Z	**Impedance (Z):** When there are two or more than two components out of resistor (R), Inductor (L) & capacitor (C) in a circuit, then an opposing property, is called impedance. Its measuring unit is ohm (Ω).

4	**Z**	It is represented in the complex form as follows, **Z = R + jX** **Reactance (X):** When there is an inductor or capacitor in a circuit, then its opposing property, is called as reactance. Its measuring unit is ohm (Ω). When there is inductor, then it is called inductive reactance & in case of capacitor, it is called the capacitive reactance. Where, the absolute value of $Z = (R^2 + X^2)^{1/2}$ & phase the angle $\phi = \tan^{-1}(X/R)$ Where, for purely inductive circuit: $X = X_L = \omega L = 2\pi f L$ Voltage leads the current by 90º For purely capacitive circuit: $X = X_c = 1/\omega C = 1/(2\pi f C)$ Current leads the voltage by 90º For inductive & capacitive circuit $X = X_L - X_c$
5	**Q**	**Quality Factor (Q):** The ratio of the reactive part (imaginary part) to the resistive part (real part), is called quality factor. Q is a unit less quantity & expressed as follows, **Q= Xs/Rs** 1.The quality factor of a resistor is approx. zero. This is because, the imaginary part of impedance is zero for a purely resistive circuit & hence pure resistance is frequency independent property. 2.For an inductor, the quality factor is high means the quality of inductor is that much better & vice-versa.
6	**D**	**Dissipation Factor (D):** The reciprocal of quality factor, is called Dissipation Factor. D is a unit less quantity & expressed as follows, **D= 1/Q** D qualifies capacitor i.e. the dissipation factor is as low, the capacitor is of that much better quality.

Unit of Measure

Multiplier	Scientific	Engineer	Symbol
1000000	10^6	Mega	M
1000	10^3	kilo	k
0.001	10^{-3}	milli	m
0.000001	10^{-6}	Micro	μ
0.000000001	10^{-9}	nano	n
0.000000000001	10^{-12}	pico	p

Glossary

Coil: A coil is made of a multiple turns of wire on conductor / Core. It has the property to oppose / resist changes in current. It is characterized by its Inductance.

Capacity: Characteristics of a Capacitor. The unit is the Farad (F).

Capacitor: Passive element consists of two conductors / plates separated by a dielectric. The capacitor has the property of passing the AC while blocking the DC.

Test Frequency: The frequency with which the measurement of parameters of component is done. The value of a parameter sometime depend on frequency.

Range: Range of resistance that the instrument uses to perform measuring function.

Parameter: The main or primary parameter is the property of most commonly sought component (capacity, inductance, resistance). The second parameter of lesser importance characterized losses in the component (quality factor, dissipation factor).

Accuracy: The difference between the measured value & the true value of

Component. The accuracy is expressed as a percentage for the principal parameter. The accuracy depends on the value of the impedance & the frequency. Typically the accuracy is a secondary parameter & is great importance.

Accuracy Background: The accuracy of LCR bridge depends on a number of parameters such as the frequency & impedance. The accuracy of the standard programmed database is checked with precision instrument in optimum conditions, i.e. at frequency of 1 kHz.

Source Resistance: Resistance in series with the testing signal generator. This resistance relates to the range of impedance.

Resolution: The smallest value that can be shown on the display of the instrument. Do not confuse this with the accuracy.

Test Voltage: This is the rms value of the alternating voltage that generates a current in the test component. Because of resistance & impedance of component under test, test voltage is always less than specified value.

Front Panel Control

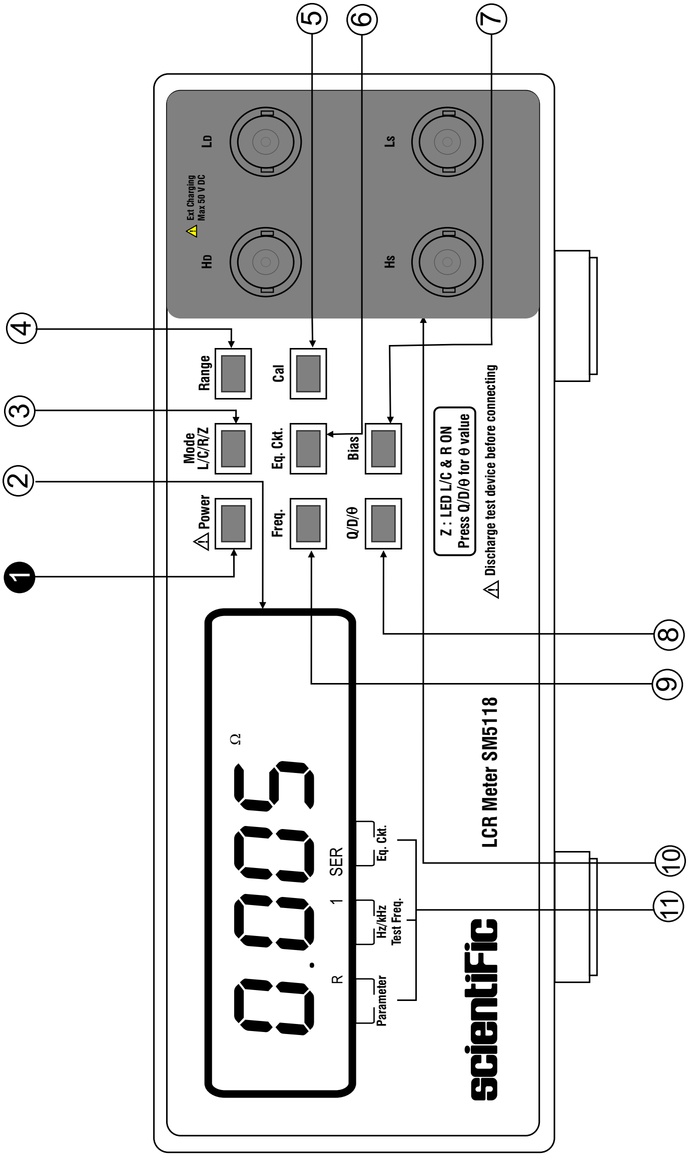


Fig.1

① **Power** : Push button for switching ON/ OFF mains supply to instrument.

② **Digital Display**: The digital display indicates the measured value on a four digit, seven segment, LED display. The decimal point is set automatically. Under certain measurement conditions, the measured value will not be displayed using all four digits. This is because the **LCR Meter SM5118** has determined that the undisplayed digits will be sufficiently unstable as to be unusable, due to the type of measurement which it has been set to perform.

③ **Mode L/C/R/Z:** By this push button, the instrument determines whether the reactive or resistive component of the value measured is being displayed. If the LED under the L/ C legend is lit, then the **LCR Meter SM5118** will measure inductance or capacitance. The **LCR Meter SM5118** determines which is being measured automatically & indicates this on the Range Indication panel.
If the LED under the R legend is lit, then **LCR Meter SM5118** is measuring resistance & one of the LEDs on Ω, KΩ or MΩ on the Range Indicator panel will lit. If both LEDs for L/ C & R will lit, it will indicate that instrument measures impedance (Z) & one of LEDs on Ω, KΩ or MΩ will lit

④ **Range:** Operation of the **Range** Button cause the auto ranging functions of the **LCR Meter SM5118** to be disabled, locking the range setting at whatever it happened to be when the button was operated. This function may be particularly useful when a large number of components of the nominal value have to be measured. The operation of the auto ranging system adds up to half a second to the time before the first valid reading is displayed, after connection of a component to the test points. If the correct measurement range is already known, this auto ranging delay is eliminated, resulting in a worth while time saving over a large number of component measurements.
To use the **Range** facility, first connect a typical component to be measured to the test connectors. Once the reading is displayed operate the **Range** button, noting that the **Range** LED indicator lights. All further measurement will now be made on the same range until the **Range** Button is operated once more, or the **LCR Meter SM5118** is switched OFF & ON again.

⑤ **Cal:** Zero Compensation is done by pressing **Cal** push button. Before start the parameter measurement, zero compensation for open & short terminals are done.

⑥ **Eq. Ckt.:** The equivalent circuit of a component under test can be expressed either in terms of its series or its parallel equivalent values at the given frequency. In order to display the parallel equivalent values, the PAR indicator LED should be lit. Note that for inductors & capacitors with a high Q or for resistors with a low Q the equivalent values of the major term (i.e. inductance for inductors, capacitance for capacitors, resistance for resistors) will be virtually identical in the two modes.

⑦ **Bias:** The push button labeled **Bias** may be operated in order to provide the 2 V polarizing voltage for use when measuring electrolytic capacitors. Note that the instrument requires about thirty seconds to settle after application or removal of the bias voltage.

During the settling period, the display will be random, once the display has stabilized, components can be connected & measured at the normal operating speed of the instrument & no further settling delays will occur.

⑧ **Q/ D/ θ:** When **Q/ D /θ** measurement has been selected, the **Q /D / θ** indicator will lit & all the LED's on the range indicator panel will be extinguished. Q is shown for L & R, D for C & **θ** for Z. (D has no meaning for L or R, Q has no meaning for C & θ has no meaning for L/ C or R measurements)

⑨ **Freq.:** With the help of this push button we can select the frequency at which measurement is to be made. The choice of measurement frequency depends on the type of component under test. It is important to note that to obtain full use of the **LCR Meter SM5118** extended measurement frequency must be selected. High values (C >1 μF, L> 1H) should be measured at 100 Hz, low values (C <1 μF, L< 1H) at 1 kHz.

⑩ **BNC connectors (4 nos.):** The **LCR Meter SM5118** is provided with BNC to

Kelvin probes. Any test component under test can be connected the Kelvin crocodile clips for the measurement. Although the **LCR Meter SM5118** is well protected against the connection of precharged capacitors to the measurement points, it is advisable, where there is possibility of a capacitor that has been precharged, to discharge it through a suitable resistor.

(11) **Parameter:** LEDs either L/ C, R or both glow when **L/C/R/Z** push button is pressed, for required parameter to be measured

Hz/ kHz: These are the test frequencies belonging to 100 Hz or 1 kHz respectively. When **Freq.** push button is pressed then LEDs indicating 100 Hz or 1 kHz glows.

Eq. Ckt.: When **Eq. Ckt.** push button is pressed then LEDs indicating 'SER' or 'PAR' equivalent circuit mode, glows.

Operating Instructions

General Information

The logical front panel layout of **SM5118** ensures rapid familiarization with the various functions. However, even experienced operators should not neglect to carefully read the following instructions, to avoid any operational errors & to be fully acquainted with the instrument when later in use.

After unpacking the instrument, check for any mechanical damage or loose parts inside. Should there be any transportation damage, inform the supplier immediately & do not put the instrument into operation.

Safety

The case chassis & all measuring terminals are connected to the protective earth contact. The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. The protective action must not be negated by the use of an extension cord without a protective conductor.

Warning!

Any interruption of the protective conductor inside or outside the instrument or disconnection of the protective earth terminal is likely to make the instrument dangerous. Intentional interruption is prohibited. The mains/ line plug should be inserted before connections are made to measuring circuits.

When removing or replacing the metal case, the instrument must be completely disconnected from the mains supply. If any measurement or calibration procedures are unavoidable on the opened-up instrument, these must only be carried out by qualified personnel acquainted with the danger involved.

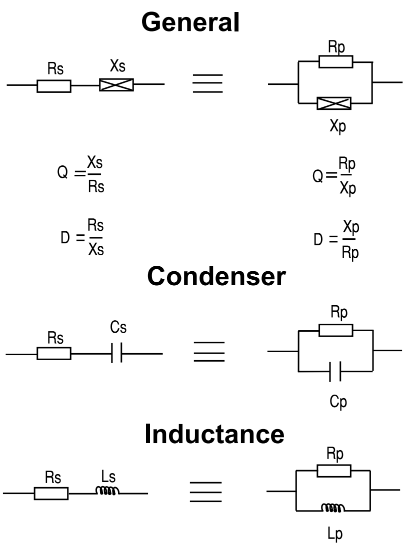
Operating Conditions

The ambient temperature range during operation should be between + 0° to + 40°C RH 90% should not exceed -40°C or +70°C during transport or storage. The operational position is optional, however the ventilation holes on **SM5118** must not be obstructed. Prior to calibration a warmup time of approx. 30 minutes is required.

First Time Operation

Switching ON: Plug the mains cable into the mains socket at the rear of the instrument. Now plug the other end into a suitable mains outlet. To switch ON, press power ON switch. On application of power, the unit & function indicators will lit. The **LCR Meter SM5118** is designed to set itself automatically to capacitance measurement, parallel equivalent circuit, 1 kHz frequency when terminals are opened, as it is switched on. The internal circuitry normally takes a few seconds to stabilize after the instrument is switched ON.

Understanding & Measuring Passive Components



$$Rs = \frac{Rp}{1 + Q^2} \qquad Rp = Rs\,(1 + Q^2)$$

$$Cs = Cp\,(1 + D^2) \qquad Cp = \frac{Cs}{(1 + D^2)}$$

$$Ls = \frac{Lp}{(1 + \frac{1}{Q^2})} \qquad Lp = Ls\,(1 + \frac{1}{Q^2})$$

Fig.2

A passive component non- ideal (resistance, capacitor, & inductance) can be represented by its part (resistance) in part serial or parallel with a reactive part (capacitor or inductor).The impedance is a function of frequency. The Eq. Ckt. / model selectable is series & parallel (are mathematically equivalent) & can be switched normally from one to another by equations. Particular Eq. Ckt. is more appropriate than other decided by conditions of measurement data, i.e. the resistance series or parallel decided by physical construction. This also mean that series or parallel resistance represents an actual size. Some of the components are tested in industry standards condition. For example electrolytic capacitors are often measured with the Eq. Ckt. series Rs + Cs, so ESR (Equivalent series resistance) can be measured. This resistance includes parameters such as the absorption &

ohmic losses due to connections.

The high value capacitors should be measured at low frequency while low values capacitors are measured with the high frequency.

Regarding inductors, resistance parallel Eq. Ckt. in general represent losses in the core, while the resistance series Eq. Ckt. represent resistance of coil.

Heavy inductors are preferably measured with the parallel Eq. Ckt. The low values inductors are themselves represented by the series, their reactance being low.

In order to obtain a more accurate result high inductance values are analyzed with the lowest rate, while low inductance values are analyzed in contrast with the highest.

The instrument can automatically determine Eq. Ckt. generally more appropriate (series impedance below 10 kΩ, parallel over 10 kΩ). But the user can always measure the Eq. Ckt.. value of his choice by pressing Eq. Ckt. push button key. We can go back to automatic mode selection by switching OFF & then ON the instrument.

The quality factor Q is the ratio of the imaginary part of the impedance & its real part. For inductors, a high value of Q denotes a term better component purity. A value of Q close to zero on the contrary means that the element is close to its resistive strength. Apart from the dissipation in the ohmic resistance of coil. The value of quality coefficient also depends on the frequency.

The dissipation factor D is commonly used to describe all types of capacitors. It is the opposite of Q i.e. D = 1/ Q & thus represents the relationship between the real Part to imaginary of the capacitor or impedance at a given frequency. A low value of D represents a capacitor with low loss.

Measurement of parameters is carried out with an accuracy of ± 0.25% basis for components whose value exceeds Q >10 (D <0.1).

It is to be noted that the values obtained when measuring ferro magnetic core windings may be significantly different from their values of use. This is the non-linear behavior of the core towards difference in magnetization between the use & measurement. It is possible to find out the current flowing through winding by measuring the parameter serial resistance R, inductance L & calculating the

required value of reactance X & knowing the source resistance. The source resistance depends on the range; it is 100 Ω for the ranges 1 & 2.
For example; The measurement is taken at 1 kHz, then it will be:

$$X = 2\pi f L$$

$$i = Vs/\sqrt{(Rs + R)^2 + X^2}$$

Where Vs = 0.3 Vrms (test voltage)
f = 1000 Hz (test frequency)

Example : When measuring a winding , where R = 2 Ω & L = 6.8 mH
The range as determined by the instrument is the range - 2, which has a 100 Ω source Approx. then

$$X = 2 * 3.14 * 1000 * 0.0068 = 43\ \Omega \text{ approx.}$$

The current flowing through the winding will be

$$i = 0.3/\sqrt{(100+2)^2 + 43^2} = 2.7\ \text{mA}$$

Understanding Displayed Parameters

L : Inductance: The inductance value is displayed on the LED display with L/C indicator ON. Units of the inductance are μH, mH or H.

Q : Quality Factor: Q value is displayed on the LED display with Q/D indicator ON. Q is the ratio the imaginary part to that of real part of the impedance & has no unit. The Q value is the same for both types of equivalent circuits (series or parallel). If Q is a positive component & is likely inductive or capacitive.

C : Capacitance: The capacitance is displayed on the LED display with L/ C indicator ON. The units of capacitance are pF, nF, μF.

D : Dissipation Factor: D value is displayed on the LED display with Q/ D indicator ON. D is the ratio of the real part of the impedance to its imaginary part, or 1 / Q. A good capacitor is with low series equivalent resistance, i.e. with low D. If capacity displayed is negative then the component is inductive.

R : Resistance: The resistance value is displayed on the LED display with R indicator ON. Units of the resistance are Ω, k Ω or MΩ.

Z : Impedance modulus : The impedance modulus value is displayed on the LED display with both L/ C & R indicators ON. Units of the impedance are Ω, kΩ or MΩ.

θ: Phase Angle: θ value is displayed on LED display with Q/ D/ θ indicator LED is on.

Auto / Manual : There is always an automatic parameter selection between L & C in instrument. Also there is an automatic selection for equivalent circuit mode. Manual selection of equivalent circuit mode is done by pressing Eq. Ckt. push button. To go back to automatic equivalent circuit mode by switching OFF & then ON the instrument.

Zero Compensation or OPEN / SHORT Calibration:

Zero compensation or open-short calibration function of the instrument can compensate for the parts of the measuring cable in order to compensate for parasitic elements. The model used is the one represented in the figure below. The instrument determines the value of these elements Rss & Lss at a preliminary measure.

The values of Gpp & Cpp are measured during open circuit measure. The instrument reflects these elements by applying the correction given on the diagram. The calibration should be carried out each time that there is measured at the ends of the measuring range, which means for the weak & high impedance.

Calibration open/closed is also essential if we are to the reduce margin of error losses in a measured value of component. Such as the resistance of a series capacitor. Precautions should be taken during the calibration. The position of cables should not change between the calibration & measurement of the component. During the shorted calibration it should be a small piece wire that connects the four jaws of clip, or both clamps. For very low impedance values place component in clips at 90º to minimize coupling between wires as shown in the figure. The same Provision should be used when measuring a component. The calibration can be performed for a frequency of test data or for all the frequencies. Indeed, the parts are not necessarily consistent with all the frequencies & the instrument retains in memory parasites elements for all four fixtures for each frequency. Calibration is performed pressing CAL. The limits of correction are:

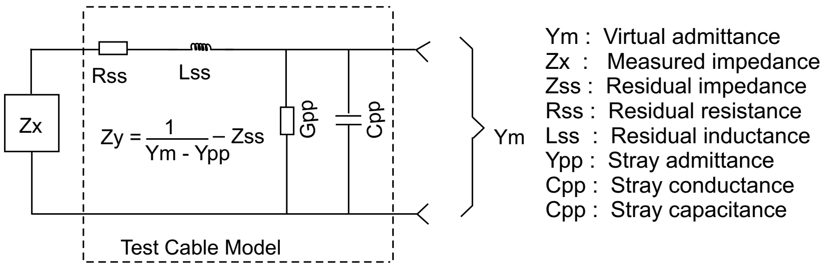


Fig.3 Normal measurement mode

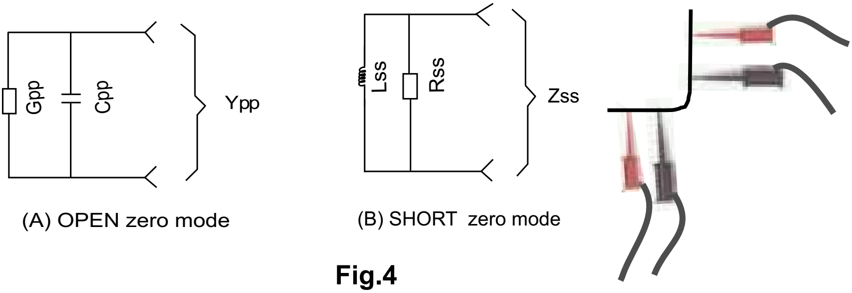


Fig.4

- **Calibration short :** Maximum series resistance of the cables must be less than 14 Ω while the total impedance should be less than 14 Ω .
- **Calibration open:** Parallel impedance of the cable must be more than 1 MΩ.

The instrument displays the zero readings or near zero value after zero compensation, except for small negligible value (to be ignored , part of value too small in comparison to the range) if the calibration went well, “Failed” in the opposite case.

Calibration must be preformed at each change of measuring cord or for sensitive measures (see above). Calibration in open circuit is more delicate because the spacing of contacts varies.

Frequency of Test

There are 2 possible test frequencies ; 100 Hz & 1 kHz. The Frequency accuracy is 0.025%. The frequency of current test can be changed by pressing Freq. push button. The frequency is indicated below the display by glowing indicators 100 for 100 Hz & 1 for 1 kHz. The frequency of the test 1 kHz is used mostly. It is the frequency for which accuracy of the instrument is optimal. The capacitors & coils higher values are tested with the lowest frequency, while the low capacity & Low inductors are measured with a higher frequency.

Impedance Range :

The Instrument has 6 impedance ranges (R1-R6). The range of impedance can be selected manually or can be set to automatic, which is the normal or default mode. Range in use can be seen on display by pressing Range push button. When Range push button is pressed then Range indicator is lit, that indicates the manual range selection & if Range indicator is off, that indicates auto range selection. Successive press of Range push button allows choosing the desired range (R1 -R6). The table below shows the limits of impedance for each of the ranges. The ranges R1& R6 ranged are extended, they use resistors respectively reference ranges R2 & R5.

Note: The ranges are impedance ranges & not capacitors or inductor. The choice of a manual range implies on knowing the impedance of the component under testing. The manual mode will be restricted when measuring similar components whose impedance is known & does not vary too much. Otherwise the instrument should be configured for automatic mode. The choice of range not suitable impedance will result in an unstable or by displaying the message “Or” (Over range) or “Fail” error.

Range	R source	Resistance	Inductance(H)	Capacitance
R1	100 Ω	1 m Ω -10 Ω	0.01 μH-2.4/f	99.9mF-10.6/f mF
R2	100 Ω	10 m Ω -330Ω	2.4/f-52.5/f	10.6/f mF-482/f μF
R3	1.1 kΩ	330Ω -3.3 kΩ	52.5/f-525/f	482/2f μF-48.2/f μF
R4	11.1 kΩ	3.3 kΩ 33 kΩ	525/f-5252/f	482/2f μF-4.82/f μF
R5	111 kΩ	33 kΩ 800 k Ω	5252/f-52520/f	4.82/2f μF-0.48/f μF
R6	111 kΩ	800kΩ -100MΩ	52520/f-99990	48/f μF-0.001/f pF

Here f is frequency in Hz

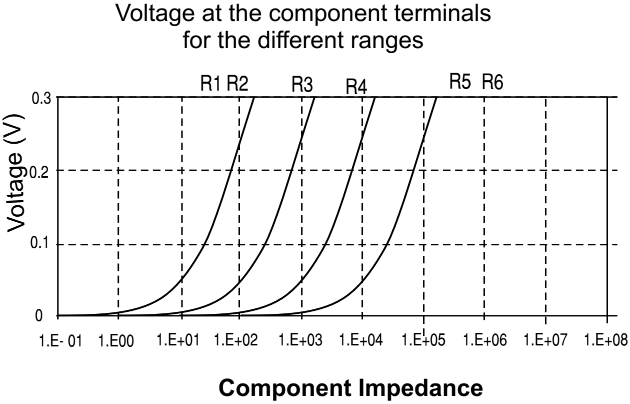


Fig.5

The source resistance of the signal generator test is linked to the range as shown in Table (R SOURCE column). The real test voltage within the leads of Component depend on the range & its impedance as shown in the chart above.

Precision & Accuracy

The accuracy of measurements depends on the basic accuracy which depends on the value of the impedance & frequency. This value is increased by a factor corresponding to additional impedance that can be found at the ends of measuring clips. The values of accuracy are valid with the use of a Kelvin probes. where calibration open/closed is carried out before the measurement & when the instrument is in automatic mode.

Measurement Conditions

While the **LCR Meter SM5118** is capable of providing both series & parallel equivalent values of components, at frequencies of 100 Hz & 1 kHz, we recommended that certain types or values of components are measured in specified ways. This is to achieve measurements which have the most relevance either to the physical form of the component or to a manner in which it is most commonly used. For example, large value electrolytic capacitors are often used for power supply smoothing application. It will also be found that the capacitance value at 1 kHz is significantly lower than that at 100 Hz . This is for a number of reasons associated with the physical construction of this type of component. Their value at 100 Hz is the most useful, therefore . The loss term of such capacitor is usually expressed at Equivalent Series Resistance (ESR) & therefore the series capacitance & resistance values should be measured.

A table of recommended measurement condition is given on next page:

Component	Test Freq.	Ser or Par
Capacitor < 1 µF	1 KHz	PAR
Capacitor ≥ 1 µF(non Electrolytic)	100 Hz	PAR
Capacitor > 1 µF(Electrolytic)	100 Hz	SER
Inductor < 1 H	1 KHz	SER
Inductor ≥ 1 H	100 Hz	SER
Resistor < 10 kΩ	100 Hz	SER
Resistor ≥ 10 kΩ	100 Hz	PAR

DC Bias :

Electrolytic capacitors are normally biased to a suitable dc voltage. A 2 volts internal bias is available for this purpose & the use of the bias control is explained in section front panel controls.

A bias voltage of 2 V should be suitable for all such measurements. If, however, a different bias voltage of up to 50 V is required. It is possible to connect an external DC supply to achieve this. A full floating mains power supply or a battery may be used as external dc bias sources. Mains power supplies should have a ripple voltage of less than 2 mV peak to peak.

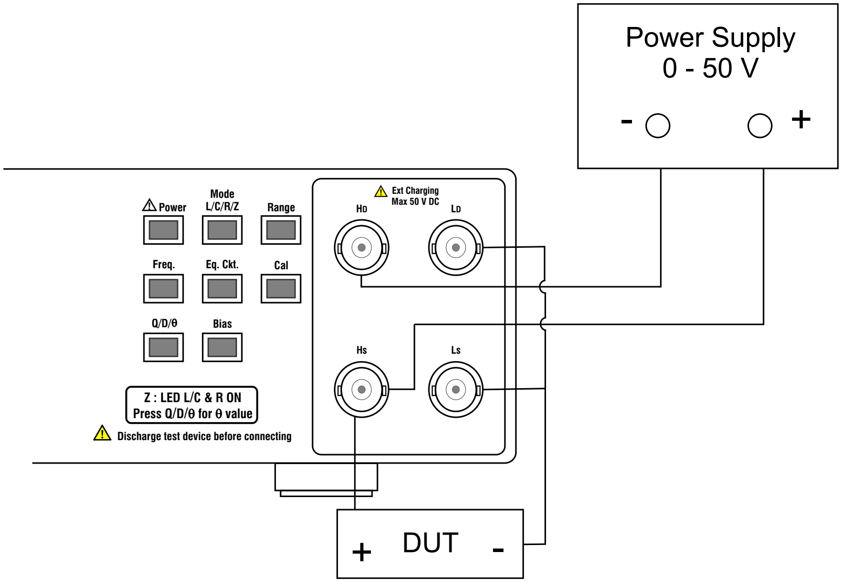


Fig.6

To connect an external DC bias supply, it is necessary to achieve a separate electrical connection between the two BNC terminals of the +ve (on the left hand side) of the **LCR Meter SM5118** Test terminals. The connection may be made either by using the separate test leads. The -ve power supply connection goes to the **HD** BNC terminal. The +ve power supply connection goes to **Hs** BNC terminal. The capacitor under test is then connected between the -ve (on right hand side) terminal & the +ve terminal of the external connected power supply. Note that the

+ve side of the capacitor should go to the +ve connection to the external power supply.

The **LCR Meter SM5118's** internal circuitry may require at least 30 seconds to settle, after connection of the externals supply & no stable readings will be obtained during this process.

Calibration Check Internal

It is recommended that the **LCR Meter SM5118** calibration is checked every six months. We will carry out a full functional & calibration check for a standard fee, if the instrument is returned, carriage paid to our works.

Basic Accuracy

The accuracy of a LCR meter is quite complex. The basic accuracy depends on the actual test frequency & absolute impedance, from which the final accuracy is calculated. This figure is given by a two-dimensional graph. The actual accuracy is always less that the basic accuracy; it is equal for medium impedances & decreases when the impedance is getting low or high. The test fixture causes this effect, which is never perfect. Parasitic series impedance & parallel impedance are not constant, so for extreme impedances there are more errors. This is the same for all LCR meter. When one says that the basic accuracy is 0.2 % it is valid for a maximum frequency (always 1 kHz) & for given range of impedance (generally from 1 Ω to 1 MΩ). The better basic accuracy is limited by the accuracy of calibration resistors & the drift of reference resistors inside the instrument.

Low Accuracy Prompt :

When ever the **LCR Meter SM5118** is set to display a value which it can not measure to the basic accuracy, it will make the measurement but will indicate low accuracy by flashing the Range Indication LED in use, per second. In addition if there is some change which the operator can make to the controls to improve the accuracy, this is indicated by flashing the appropriate control indication LED.

The internal system, which determine that an accurate reading is or is not possible operates by inspecting the relative & absolute magnitudes of the actual currents &

voltages in the components under test. The published specification is a general one covering the minimum operating performance over a wide range of measurement ranges & modes. However with particular component value, the instrument may continue to measure within its basic accuracy even for example, under adverse Q conditions. As the out of basic accuracy even for example, under adverse Q conditions. As within its basic accuracy even, for example, under adverse Q conditions. As the out of basic accuracy is determined by the real measurement conditions, it does indicate whether the displayed reading is actually within the basic accuracy of the instrument or not. This may often far surpass the published specification.

Graphs showing the typically variation of measurement accuracy with frequency, Q & the value of the component measured are shown in Fig.7 & Fig.8.

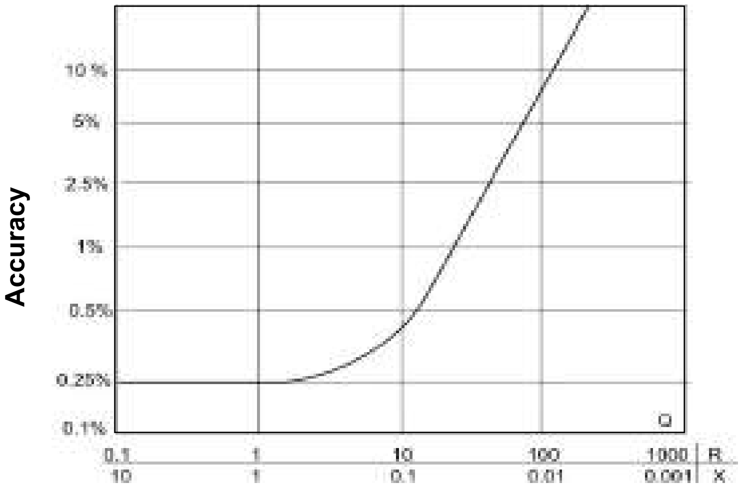


Fig.7 Graph showing typical variation of measurement accuracy as Q varies (Note: The scale for reactors (X) is the inverse of the Q scale for resistor ®))

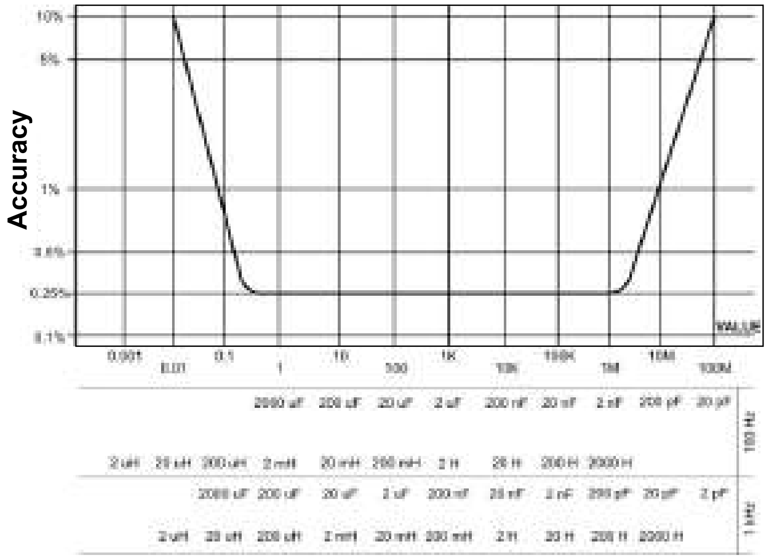


Fig .8 Graph showing variation of accuracy with reading for 100 Hz & 1 KHz Q > 10 for L& C , Q <0.1 for R

Measurement Accuracy

As with all instrument designed to measured passive components, the accuracy of measurement, which can be achieved, depends on a number of factors, which may change from one measurement to the next. The features are :

(i) The measurement type- reactance or resistance

(ii) The frequency at which the measurement is made

iii) The magnitude of the measured values

(iv) The Q of the component being measure

The written specification of the **SM5118** states that, within certain boundaries determined by these factors, the accuracy achieved is ±0.25% of reading ± 1 digit. However to make full use of the extended range capability of the instrument, it is important to be able to estimate the accuracy of measurement beyond these boundaries. This variation is described in the following sections.

Accuracy Variation With Q

Fig 9 shows, a graph indicating the typical variation of measurement accuracy as Q varies. Note that, although the basic accuracy of the instrument is guaranteed for Qs greater than10 (reactance measurement) & less than 0.1 (resistance measurements), the **LCR Meter SM5118's** typical performance is considerably better than this & full accuracy is generally achieved for Q greater than 1 (reactance measurement) & less than 1 (resistance measurement). The user is able to confirm this as the **LCR Meter SM5118's** signals a loss of basic accuracy by flashing the range indication LED.

Graph showing typical variation of measurement accuracy as Q varies (The Q scale for reactors (X) is the inverse of the Q scale for resistors).

Accuracy of Q Measurement

The **SM5118** measures Q to a basic accuracy of ±0.25% ± 1 digit for Q values from 0.25 to 4. Outside of this range, the accuracy is degraded so that at both extremes of the measurement range (i.e. Qs of 0.01 or 100) the accuracy is ±3.5 ± 1 digit. A graph, showing the variation of Q accuracy with the value of Q measured, is shown in Fig 9.

Accuracy Variation With Range Extension & Frequency

Fig8 on page 29 shows the variation of accuracy with the magnitude of the value measured, both at 100 Hz & 1 kHz measurement frequencies, where the Q of the component under test is respectively greater than or less than 0.1 for reactance & resistance measurement

Dealing With Two Error Terms

In some measurement, outside the conditions in which the **SM5118** achieves its basic a accuracy, the effects of both the Range Extension & the Low Q error terms may apply. In order to estimate the likely magnitude of the combined error, it is possible to sum the two error terms to provide a worst case error figure. However as the error sources are not usually co-related, it is highly unlikely that this worst case figure would be ever obtained in practice. A realistic & practical methods of computing the errors terms is to take the square root of the sum of the squares of the contributing error terms. An example will illustrated this.

An inductor has to be measured at 1 kHz. The measured value is 20 μH & the Q is measured to be only 0.04.

The error due to the value (Fig 8) is 1%. The error due to low Q (Fig 9) is approximately 0.5%. The worst case error is thus 1% + 0.8%. However, the practical working error figure is obtain thus :

$$\sqrt{(1\%)^2 + (0.8\%)^2} = 1.3\%$$

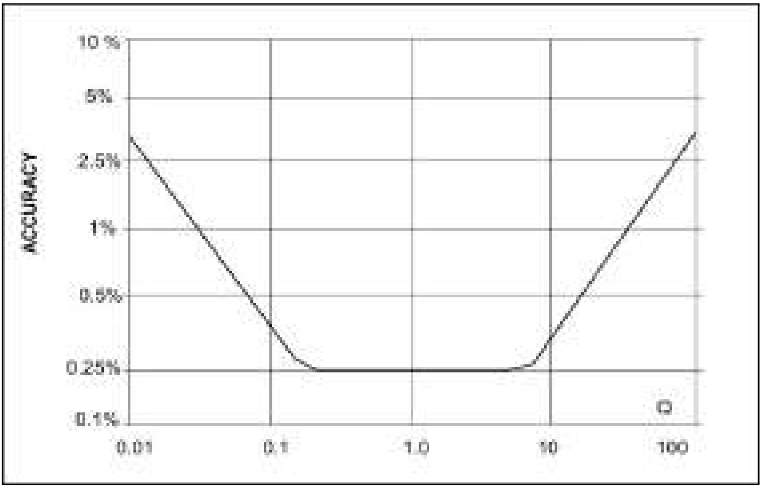


Fig.9 Graph showing the variation of Q accuracy with the value of Q

Maintenance

There are no user serviceable part inside **SM5118**.Your **SM5118 LCR Meter** is thoughtfully engineered for ease of use, accuracy & reliability. The instrument is carefully tested & calibrated using standards traceable to National Laboratories. Take care of your instrument by cleaning the exterior of the instrument regularly with a dusting brush. Dirt which is difficult to remove on the casing & plastic parts, can be removed with a moist cloth (99% water, 1% mild detergent) spirit or washing benzene (petroleum ether) can be used to remove greasy dirt. The display may be cleaned with water or washing benzene (but not with spirit-alcohol solvents), it must then be wiped with a dry clean lint-free cloth. Under no circumstances the cleaning fluid should get into the instrument. The use of cleaning agents can attack the plastic & paint surfaces.

Power Line Fuse Replacement

The power line fuse is located on rear panel on lower right side. In case, the instrument does not show any sign of working, no LED is lit or there is no display immediately switch OFF the mains power switch of the instrument & unplug the mains cord from the mains socket. With the help of small flat blade screwdriver remove the fuse cap of the fuse holder, located just below the socket. There is one spare fuse kept in the fuse cap, replace it for the defective one. Press the cap so that it locks in place . The rating of the fuse is 150 mA, 250 V, slow blow, 5x20 mm glass fuse. Do not use a fuse with a higher value other wise it may damage the instrument in case, the mains voltage goes much higher than the rating of the mains fluctuation of $\pm$ 10%.

Dispatch Procedure For Service

No user serviceable parts are inside the instrument , should it become necessary to send back the instrument to factory for service, please observe the following procedure.

Before dispatching the instrument please write to us giving full details of the fault noticed.

1. After receipt of your communication, our service department. will advise you whether it is necessary to send the instrument back to us for repairs or the adjustment is possible in your premises.
2. Dispatch the instrument (only on the receipt of our advise) securely packed in original packing duly insured & freight paid along with accessories & a copy of the faults details noticed at our Service Center listed on last page of this manual, nearest to you.

Warranty Conditions

1. Scientific warrants all its Instruments to be free from defects in material & workmanship when used under normal operating conditions in accordance with the instructions given in the manual for a period of 12 (Twelve) months from date of purchase from Scientific or its authorised dealers. The service during the warranty period will be rendered on return to factory /service center basis.
2. Its obligation under this warranty is limited to repairing or replacing at its own discretion. This warranty shall not apply to any defect, failure or damage caused by accident, negligence, mis-application, alteration or attempt to repair, service or modify in any way.
3. This warranty does not include LEDs, fuses, batteries or accessories. This warranty is only valid with the original purchaser who must have properly registered the product within 15 days from date of purchase. No other warranty is expressed or implied.
4. When it becomes necessary to return the instrument to our Factory facility, kindly pack it carefully in the original carton or equivalent & ship it duly insured, transportation charges prepaid.
5. Your Scientific instrument is a complex electronic device & deserves the best service available by technicians thoroughly familiar with its service & calibration procedures.

	Major Service Centers	Phone / Fax / Email
1.	Scientific Mes-Technik Pvt. Ltd., 29/3/E, Snehlata Ganj , Indore (M. P.) 452 003	Ph : (0731) 2309741,2422330-31 Fax :(0731)2422334, 2561641 info@scientificindia.com
2.	Scientific Mes-Technik Pvt. Ltd., NO. 46, 4th Main Cross , MLA Layout, R. T. Nagar, Bangaluru 560 032	Ph : (080) 23437635 Fax:(080)23331478 bangalore@scientificindia.com
3.	Scientific Mes-Technik Pvt. Ltd., No. 25 , 2 nd floor, 29 th Cross Street Indira Nagar, Adyar, Chennai 600 020	Ph : (044) 24424598 Fax :(044) 24420421 chennai@scientificindia.com
4.	Scientific Mes-technik Pvt. Ltd., 2, Chowringhee Road, Kolkata- 700 013	Ph: (033)22282223-6 kolkata@scientificindia.com
5.	Scientific Mes-Technik Pvt. Ltd., Room No. 308, Building No.2, 3rd Floor, Sundar Nagar Co-op. Hsg Society Ltd. Senapati Bapat Marg, Dadar (W) Mumbai 400 028	Ph. :(022) 24211171 Fax :(022)24333654 mumbai@scientificindia.com
6.	Scientific Mes-Technik Pvt. Ltd., B-13, D.S.I.D.C Packging Complex Kirti Nagar, New Delhil 110 015	Ph : (011) 65638100, 65638101 Fax:(011)26536298 ndelhi@scientificindia.com
7.	Scientific Mes-Technik Pvt. Ltd., 209, Lloyd's Chamber III 409, Mangalwar Peth, Maldhakka Chowk, Pune 411 011	Ph. : (020)26114688 Fax : (020)26132882 pune@scientificindia.com
8.	Scientific Mes-Technik Pvt. Ltd., "Krupa Ashirwad Complex", 2nd Floor, Door No.5-2-394 81/A, R.P. Road, Hyderbasti Secunderabad 500 026	PH : (040)27534995 Fax : (040)27534996 hyderabad@scietificindia.com

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