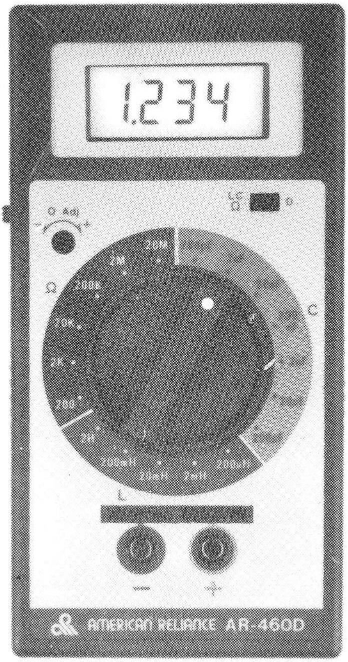
Model: AR-460D

DIGITAL LCR METER OPERATION MANUAL



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I. INTRODUCTION

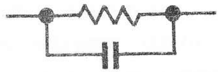
This hand-held test instrument is designed to measure the parameters of an impedance element with high accuracy and speed. It can measure capacitance, inductance, resistance (equivalent series resistance) and dissipation factor over a wide at test frequency of 1KHz. And this LCR meter provides an external zero adjustment for inductance and capacitance measurement. The measured values are displayed on a 3½ digit, 0.5" digit height liquid crystal display with automatic decimal point placement. Battery condition is continuously monitored and a warning "LO BAT" is displayed during the last 5% of battery life. Also a line operation is possible using a 9V AC to DC adaptor.

** IMPORTANT: PLEASE READ THIS MANUAL CAREFULLY TO MAKE YOURSELF THOROUGHLY FAMILIAR WITH THE CAPABILITIES AND LIMITATIONS OF THIS INSTRUMENT BEFORE BEGINNING OPERATION.

II. SPECIFICATIONS

A. General Specification

Power	: DC9V battery or line operation by using a 9V AC to DC adaptor.
Display	: 0.5" digital height, 3½ digits with "–", "LO BAT" and decimal annunciators.
Parameter Measured	: C-D (Capacitance and Dissipation Factor)

	L-D (Inductance and Dissipation Factor)
	R (ESR, Equivalent Series Resistance)
Measurement Circuit Mode	: C: Parallel equivalent circuit mode
	
	L: Series equivalent circuit mode
	
	R: Ratio measurement

Measurement Frequency: 1kHz ±5%

Sampling Time	: 0.4 second
Overrange Warning	: Indication on display shows "1" when input is over the range.
Low Battery Warning	: Display will show "LO BAT" in the last 5% of battery life.
Battery Life	: 100 hours (Alkaline battery)

Operating Temperature: 0°C ~ 40°C

Storage Temperature	: –20°C ~ 70°C	
Standard Accessories	: Test clips (red & black)	1 pair
	Spare Fuse (125mA)	1 piece
	Operation Manual	1 piece
Dimension	: 17.2 x 8.7 x 3.5 cm (LxWxH)	
Weight	: 350 grams	

B. Measurement Range and Accuracy

Capacitance (Test circuit mode in parallel)

Range	Test Condition	Accuracy (% of reading + digits)	Protection Circuit
200pF	1kHz 100mV	±1% + 1	125mA Fuse and transistor protection up to 250VDC/rms
2nF			
20nF			
200nF			
2µF			
20µF		±2% + 1	
200µF	1kHz 10mV		

* The accuracy only applies for D < 2.

Inductance (Test circuit mode in series)

Range	Test Conditon	Accuracy (% of reading + digits)	Protection Circuit
200µH	1kHz 10mA	±2% + 1	125mA Fuse and transistor protection up to 250VDC/rms
2mH	1kHz 1mA	±1% + 1	
20mH	1kHz 100µA		
200mH	1kHz 10µA		
2 H	1kHz 1µA	±2% + 1	

* The accuracy only applies for D < 2.

Resistance

Range	Accuracy (% of reading + digits)	Protection Circuit
200 Ω	±0.5% + 1	PTC and transistor protection up to 250 VDC/rms
2 kΩ		
20 kΩ		
200 kΩ		
2 MΩ		
20 MΩ	±1% + 1	

Dissipation Factor

$$L{:}D = \frac{R_s}{2\pi f L_s} \qquad C{:}D = \frac{G_p}{2\pi f C_p} = \frac{1}{2\pi f C_p R_p}$$

Range	Accuracy (% of reading + digits)
0-19.99	DL $1\% + (3 + \frac{200}{L_s})$ DC $1\% + (2 + \frac{300}{C_p})$
* Typically 3 to 5 digits of jitter will be observed if C_p or L_s is less than 20% of full scale	

NOTE:

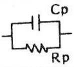
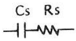
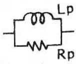
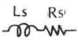
1. The accuracy given assume an operating temperature of 18°C to 28°C, humidity up to 80%, and 1 year calibration cycle.
2. If the "D" factor of a capacitor or a inductor is greater than 2, following accuracy is applied.

   C: 5% of reading + (2 + 1000/Cp) digits
   L: 5% of reading + (3 + 200/Ls) digits

C. Measurement Parameter Conversion

Parameter value for a component measured in parallel equivalent circuit and that measured in series equivalent circuit may be different from each other. For example, the parallel capacitance of a given component is not equal to the series capacitance of that component unless the dissipation factor of that component is zero. The equations in the Table A shows the relationship between parallel and series parameter of a component .

Table A. Dissipation Factor Equations

Circuit Mode		Dissipation Factor	Conversion to other modes
Cp mode		$D=\frac{1}{2\pi fCpRp}(=\frac{1}{Q})$	$Cs=(1+D^2)Cp$, $Rs=\frac{D^2}{1+D^2}\cdot Rp$
Cs mode		$D=2\pi fCsRs\ (=\frac{1}{Q})$	$Cp=\frac{1}{1+D^2}Cs$, $Rp=\frac{1+D^2}{D^2}\cdot Rs$
Lp mode		$D=\frac{2\pi fLp}{Rp}\ (=\frac{1}{Q})$	$Ls=\frac{1}{1+D^2}Lp$, $Rs=\frac{D^2}{1+D^2}\cdot Rp$
Ls mode		$D=\frac{Rs}{2\pi fLs}\ (=\frac{1}{Q})$	$Lp=(1+D^2)Ls$, $Rp=\frac{1+D^2}{D^2}\cdot Rs$

* f: Test signal frequency

Example I. A parallel capacitance Cp of 1000pF with a dissipation factor of 0.5 is equivalent to a series capacitance (Cs) value of 1250 pF at 1kHz.

$Cs = (1 + D^2)\ Cp = [1 + (0.5)^2]\ 1000pF$

$= 1250pF$

Example II. A series inductance of 1000 μH which has a dissipation factor of 0.5 at 1kHz has a series resistance of 3.14 Ω.

$$D = \frac{Rs}{2\pi fLs}$$

$$Rs = 2\pi fL_S \times D = 2\times 3.14\times 1000\times 10^{-3}\times 0.5$$

$$= 3.14\Omega$$

The dissipation factor of a component always has the same dissipation factor at a given frequency for both parallel equivalent and series equivalent circuit.

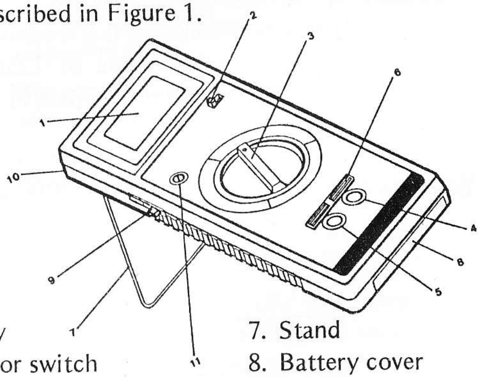
The reciprocal of dissipation factor (D) is quality factor (Q) and D is often represented as tanδ which is the tangent of the dissipation angle (δ).

III. OPERATION

This section of the manual will provide you with information on measurement techniques that will help you to fully utilize the measurement capabilities of this instrument.

A. Physical Features

All of the external features of this LCR meter are shown and described in Figure 1.



1. Display
2. D Factor switch
3. Rotary switch
4. Input terminal "+"
5. Input terminal "–"
6. Input socket
7. Stand
8. Battery cover
9. Power switch
10. Socket for 9V AC to DC adaptor.
11. Zero adjustment switch for L/C

B. Input Power

1. Power supplied by 9V battery: Open the battery cover by pressing the " ⩡ " mark on the battery cover and push it from the case. Pull the battery snap from battery compartment. Connect it to the battery and return both to battery compartment, then slide on the battery cover.

2. Power supplied by 9V AC to DC adaptor: Connect the plug of the adaptor to the socket on the top of this instrument. The other side of adapter is connected to AC power line (AC110V or 220V depending on the specifications of converter). When adaptor is plugged into this instrument, the battery is automatically disconnected to conserve battery life.

C. Capacitance C-D Meaurement

1. Set the rotary switch to the desired range at "C" section.
2. Set the slide switch to the position of "LC" Ω.
3. Insert the component to be tested into the test socket.(If the leads of component are too short to be inserted into the socket,the test clips can be used to connect the leads to input terminals).
4. Turn the power on and read the displayed value for capacitance of the tested component.
5. Set the slide switch to the position of "D". Read the displayed value for dissipation factor D of that component.

NOTE: 1. To avoid a hazard, discharge the capacitor to be tested before measurement.

2. If a voltage is applied to the input terminals, it may blow the 125mA fuse to protect the circuits.

D. Inductance L-D Measurement

1. Set the rotary switch to the desired range at "L" section.

2. Set the slide switch to the position of "LC" Ω.

3. Insert the component to be tested into test socket (If the leads of component are too short to be inserted into the socket, the test clips can be used to connect the leads to input terminals.)

4. Turn the power on and read the displayed value for inductance of the tested component.

5. Set the slide switch to the position of "D", read the displayed value for dissipation factor D of the component.

E. Resistance Measurement

1. Set the rotary switch to the desired range at "Ω" section.

2. Set the slide switch to the position of "LC" Ω.

3. Inset the component to be tested into test socket or connect the test clip to the measuring point.

4. Turn the power on and read the displayed value for resistance.

NOTE: The circuit to be tested must be in power-off status during the resistance measurement. Any voltage drop across the circuit to be tested will cause mistaken reading of resistance measurement.

MAINTENANCE

A. Replacement of Battery

If reading of display becomes unstable and dim, battery must be replaced.

1. Remove the input signal from this instrument. Set power switch of this instrument to OFF.
2. Open the battery compartment by pressing the "⩢" mark on the battery cover and push it from the case.
3. Get the battery out of the compartment and take the battery snap off the battery terminal carefully.
4. Plug the battery snap onto the replacement battery and return both to the battery compartment.
5. Slide on the battery cover back to case.

B. Replacement of Fuse

In the event the fuse is blown, follow the procedure below to replace the fuse.

1. Remove the input signal.
2. Set power switch of this instrument to OFF.
3. Open the battery compartment by pressing the "⩢" mark and push it from the case.
4. Carefully remove the defective fuse and put in the replacement.
5. Slide on the battery cover back to case.

NOTE: A spares fuse is enclosed in battery compartment when the instrument is shipped out from factory.

The manual for the AR-460D is currently being revised. Please use the sections of the manual below instead of the indicated portions of the manual. We apologize for any inconvienence this may cause. Please contact us after April 1, 1988, and we will be happy to send you the updated manual.

Page 7, Section III:

C. Capacitance and "D" Factor Measurements

1. Select the appropriate capacitance range with the range switch for the capacitor under test. If the capacitance value is unknown, select the 200pF range.

2. Set the function switch to the L-C position.

3. Set the power switch to the "on" position.

4. Using a small, flat-blade screwdriver, calibrate the display for a zero reading using the "0 Adj" control. If test leads are to be used in the measurement, have them plugged in, but not connected to the capacitor to be tested.

5. Insert the capacitor under test into the component test socket at the front of the meter. If the leads are too short, use the test leads provided to connect to the capacitor. Be sure to observe the proper polarity if the capacitor is a polarized type.

6. Read the capacitance value in the display. If 1--- (a one with the following 3 digits blanked) is shown in the display, set the range switch to the next higher capacitance range, until the value is displayed.

7. To measure the Dissipation Factor of the capacitor, set the function switch to the "D" position, and read the value shown in the display.

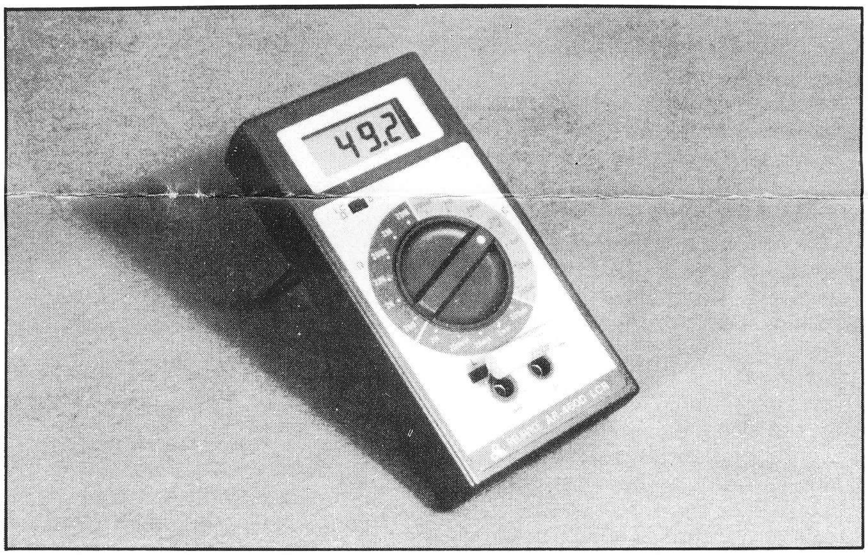
NOTE: To avoid possible damage to the instrument, discharge all capacitors before attempting to measure their value or dissipation factor. Connecting a charged capacitor or applying a voltage to the input connectors may cause the 125mA fuse to open.

Report from the test lab

The dissipation factor... an explanation

In the last "Report from the Test Lab" (April 1987) the author evaluated the American Reliance AR-460-D LCR meter and asked the question, "What is a dissipation factor?" He pointed out that the meter being tested measures dissipation factor, but this parameter was not thoroughly discussed in the material provided with the meter.

D. Joseph Frazier, strategic marketing manager for American Reliance, provides the following explanation.



An ideal capacitor or inductor would store but not dissipate energy – energy out would be equal to energy in. However, in the real world capacitors and inductors do have losses.

The first type of loss in a capacitor is associated with the dielectric material. The dielectric losses may be represented by a *parallel model* expressed as a perfect, lossless capacitor (C_p) in parallel with a resistor (R_p) that represents the dielectric resistance. (See Figure 1.)

In this model, the dissipation factor may be expressed as:

$$D = 1 / (F \times C_p \times R_p)$$

where F represents the frequency of the applied voltage, and C_p and R_p represent the values of capacitance and resistance measured at frequency F.

The second type of loss is associated with the resistance of the conductors and plates. The resistance losses may be represented by the *series model*, which is represented as a perfect, lossless capacitor (C_s) in series with a resistor (R_s) that represents the resistance in the plates and conductors. (See Figure 2.)

In this model, the dissipation factor may be expressed as:

$$D = F \times C_s \times R_s$$

where F again represents the frequency of the applied voltage, and C_s and R_s represent the values of capacitance and resistance measured at frequency F.

Because the capacitor's dielectric material is not a perfect insulator, a current will flow between the two plates. This current is referred to as the *leakage current* and causes some of the stored energy to be lost as heat. Also, because the conductors are not perfect, they possess a certain resistance, which also causes heat (IR) losses during charge and discharge cycles. Both these losses considered together are the capacitor's *dissipation factor*.

It is important to note here that excessive leakage currents will cause errors in capacitance measurements. Therefore, it is good practice to test a capacitor for excessive leakage *before* attempting a capacitance measurement.

It may be clearly seen in the dissipation factor formula that the dissipation factor is inversely related to the leakage current.

The inductor's energy loss that we are concerned with is caused by the resistance inherent in the wire forming the inductor. This may be shown as the inductance L_s in series with the resistance R_s. (See Figure 3.)

However, the resistance of an inductor is rarely specified. Instead, a quality factor, Q, is commonly used:

$$Q = (F \times L) / R$$

where F represents the frequency of the applied voltage, L is the inductive reactance at frequency F and R is the resistance. Obviously, Q is therefore frequency dependent.

During periods of current flow, the resistance develops heat due to IR losses. This is the loss defined by the quality factor, Q.

Q is related to the dissipation factor by:

$$D = 1 / Q$$

It is easily seen, then, that the higher the Q (or lower the dissipation factor) the better an inductor's quality is.

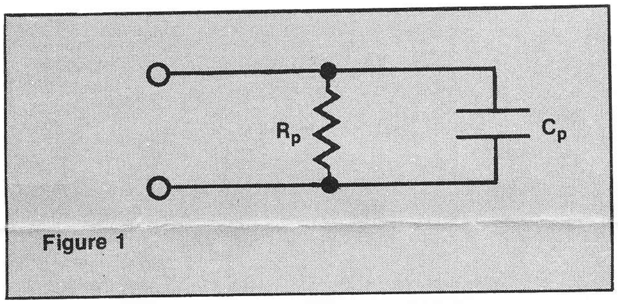


Figure 1. One energy loss that occurs in capacitors is associated with the dielectric material. The dielectric losses may be represented by a parallel model expressed as a perfect, lossless capacitor (C_p) in parallel with a resistor (R_p) representing the dielectric resistance. Leakage current caused by the imperfect dielectric material will cause heat loss and errors in capacitance measurements. A leakage resistance of 100MΩ or more is considered large, and 1MΩ or less will cause excessive leakage current.

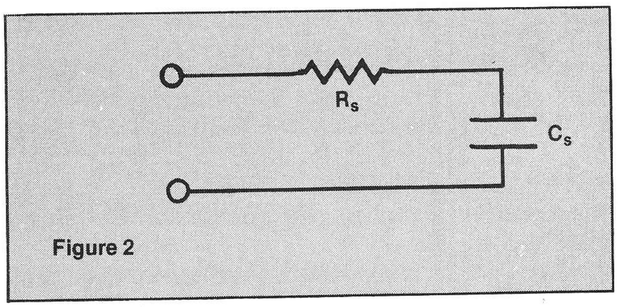


Figure 2. Capacitor energy loss is also caused by the capacitor's conductors and plates. These losses may be represented by a series model, with a perfect, lossless capacitor (C_s) in series with a resistor (R_s) representing this resistance.

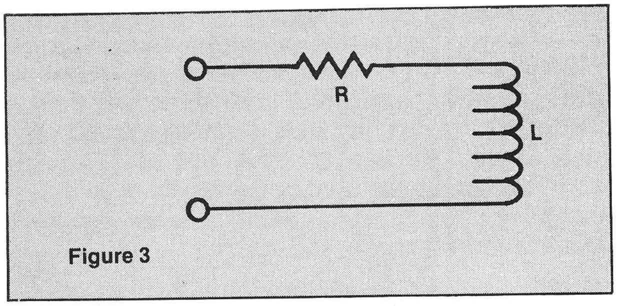


Figure 3. Energy loss in an inductor is primarily caused by the resistance inherent in the wire forming the inductor. This loss may be shown as the inductance L_s in series with the resistance R_s.