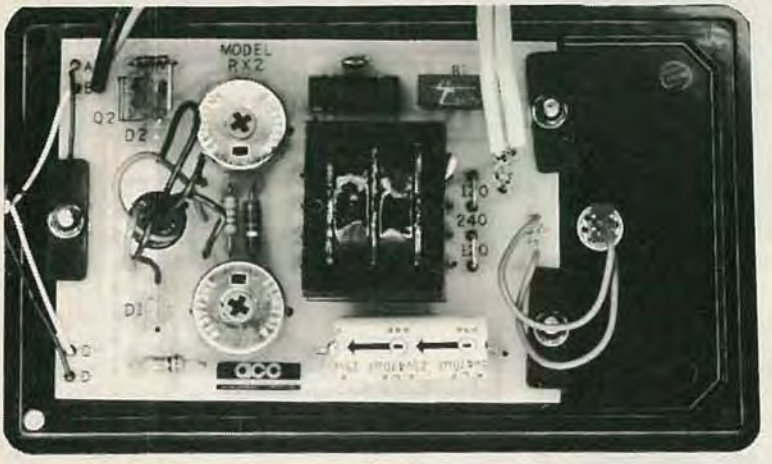
ADD-ON ACCESSORY FOR YOUR DMM



J. T. CATALDO

ACCURATE RESISTANCE MEASUREMENTS of less than one ohm have been a problem for experimenters, servicemen, and production testers who do not have the use of expensive, elaborate equipment. Analog ohmmeters will indicate resistance down to one ohm with reasonable accuracy, but below that value, accuracy is difficult to come by.

With proper measurement procedures, digital ohmmeters will indicate resistance as low as 0.1 ohm. That involves measuring the resistance of the test leads after the unknown resistance has been measured. Subtracting the second reading from the first gives the true value of the unknown resistance. The Lohmeter described in this article is an accessory to your present analog or digital multimeter that makes it possible to measure resistances as low as 0.001 ohm without having to do any subtraction. Readings are linear, thereby eliminating the difficulty of reading exponential scales.

In the laboratory, accurate resistance measurements can be made with a Wheatstone bridge or by the use of the "four-terminal" method. In the latter case, a known current is passed through the unknown resistance and the voltage drop developed across it is measured with a voltmeter (see Fig. 1). A practical example of that is the shunt used with ammeters to measure high currents. In the case of measuring resistance, the shunt is the unknown (a very low) resistance and the meter measures the voltage drop. Both the Wheatstone bridge and the four-terminal method produce accurate results.

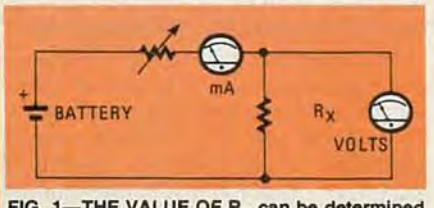


FIG. 1—THE VALUE OF R_X can be determined by passing a known current through it and measuring the voltage drop.

How it works

The Lohmeter is based on the four-terminal method. It contains its own regulated constant-current source. The current will not vary even if the input line-voltage drops as low as 95 volts. One set of leads is provided with clips for connection to the unknown resistance; another set of leads, with banana plugs, is provided for insertion into your meter.

Figure 2 is a block diagram of the circuit. The leads to the unknown resistance are actually 2-conductor cables. One lead in each cable carries the constant current while the other lead (in each cable) returns to the Lohmeter and exits again as the banana-plug leads that connect to your meter to measure voltage.

Two ranges are provided to measure resistances from 0.01 ohm to 100 ohms, with LED's to indicate the range in use. The range is selected via a front-panel range switch. The ×10 range is for resistances of 0.01 to 10 ohms. On the ×100 range, you can measure from 0.1 to 100 ohms. (Resistances smaller than 0.01 ohm may be measured if your meter has a 100 mV scale.)

The complete schematic diagram is shown in Fig. 3. The LM723D (IC1) is a voltage regulator connected as a constant-current source. The LED's (LED1 and LED2) are turned on by RANGE switch S2. Potentiometers R2 and R4 are used to adjust the constant-current source to 100 and 10 mA, respectively. A high-quality potentiometer was selected because of the need to maintain accurate calibration. Pass transistor Q1 is used to limit the current through IC1. Since the transformer used has dual primary and secondary windings, the Lohmeter can be used with 117- or 230-volt lines by

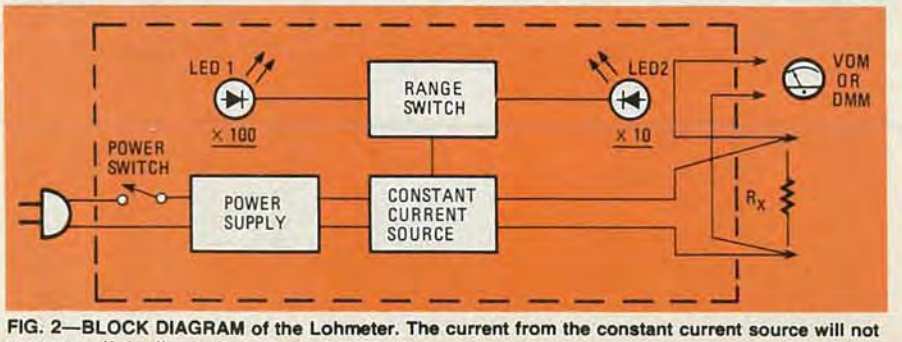


FIG. 2—BLOCK DIAGRAM of the Lohmeter. The current from the constant current source will not vary even if the line-voltage drops to 95 volts.

MEASURES ULTRA-LOW RESISTANCE

Measure resistances as small as 0.001 ohm. You can do it with this easy-to-build Lohmeter and your DMM.

PARTS LIST

All resistors ½ watt, 10% unless otherwise specified
R1—560 ohms
R2, R4—250 ohms, 2 watts, trimmer potentiometer (CTS style 115 or equivalent)
R3—120 ohms
R5, R6—1000 ohms
Capacitors, 20% or better
C1—470 μF, 15 volt electrolytic
C2—.001 μF, 15 volt, ceramic disc
Semiconductors
IC1—LM723D
Q1—2N5496
BR1—50 volt, 1 amp bridge rectifier
LED1, LED2—jumbo red LED
T1—24 volt, 100 mA, center-tapped, PC-mount, dual-primary (Signal DST 3-24 or equivalent)
S1—SPST toggle switch
S2—DPDT toggle switch
Miscellaneous: PC board or perforated construction board, case and front panel, line cord, two-conductor cable, hardware, etc.

The following are available from Alpha Components Corp., P.O. Box 306, El Segundo, CA 90245:
No. RC-2PC—PC board only, etched, drilled and tinned, $6.95 postpaid in USA.
No. RX-2K—Complete kit, including cabinet, front panel, wire, quick disconnects, etc., $39.50 plus $2.50 shipping & handling.
No. RX-2—Factory wired, tested and calibrated unit, $49.50 plus $2.50 shipping & handling.
California residents please add applicable sales tax. Sorry, no credit cards.

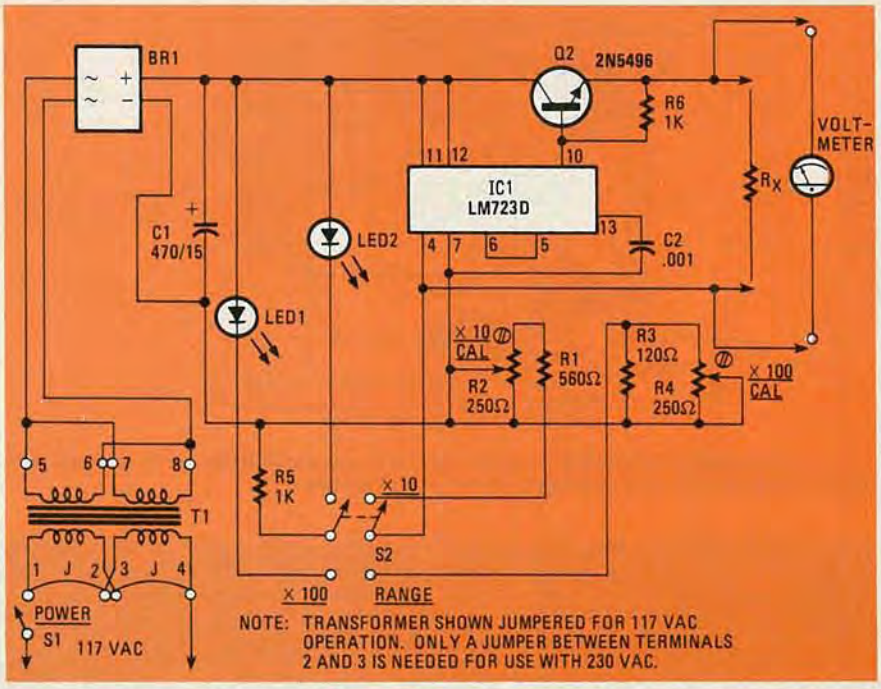


FIG. 3—A SCHEMATIC DIAGRAM of the Lohmeter. The test leads to R_X are two-conductor cables. The two resistance ranges are switch selectable and the LED's indicate which range is in use.

changing the jumpers on the primary windings.

Construction

Although a printed-circuit board makes it easier to assemble, other assembly methods such as a perforated board with solder-type terminals or point-to-point wiring may be used. Don't forget a 14-pin socket for IC1.

The foil pattern for the printed-circuit board is shown in Fig. 4 and the component placement guide is shown in Fig. 5. The switches are mounted on the front panel of the unit and the LED's are soldered to the *foil side* of the board. Since none of the values are critical—except for the calibrating pots—10% resistors and 20% capacitors may be used.

In designing the accessory, considerable thought was given to simplifying assembly. Miniature quick-disconnect terminals are used on the board for connection of the switches. The transformer is mounted on the

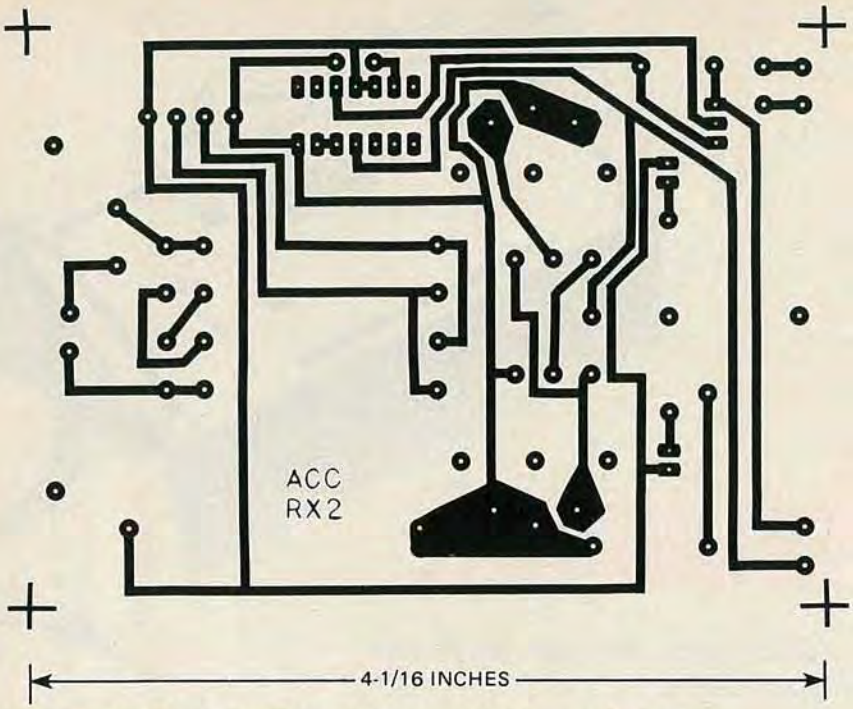


FIG. 4—FOIL PATTERN for the PC board. Point-to-point wiring may also be used.

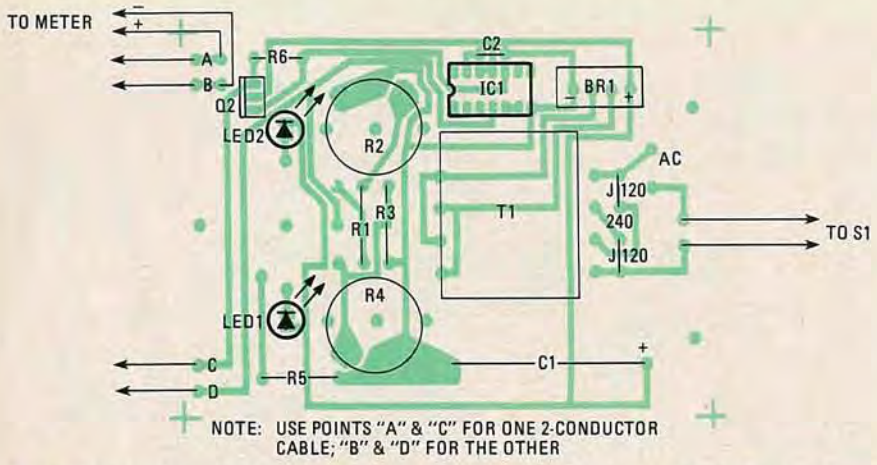


FIG. 5—COMPONENT PLACEMENT guide for the PC board. Switches S1 and S2 are front-panel mounted and the LED's are soldered to the foil side of the board.

TABLE 1

Unknown Resistance (ohms)	Range	Voltmeter Reading (volts)	Example
100 to 0.1	×100	1.0 to 0.001	1.0 volt × 100 = 100 ohms 0.001 volt × 100 = 0.1 ohm
10 to 0.01	× 10	1.0 to 0.001	1.0 volt × 10 = 10 ohms 0.001 volt × 10 = 0.01 ohm
1 to 0.001	× 10	0.1 to 0.0001	100 mV × 10 = 1.0 ohm *or* 0.1 volt × 10 = 1.0 ohm 0.1 mV × 10 = 0.001 ohm *or* 0.0001 volt × 10 = 0.001 ohm

PC board and its terminals are soldered to pads on it. By using jumpers, conversion from 117 to 230 volts can be made where necessary. Certain solder pads are marked with a dot to help orient polarized components: the emitter of Q2, the anodes of the LED's, pin-one of IC1, the "+"-side of the bridge rectifier, and the positive end of the electrolytic capacitor. The PC board is firmly secured to the front panel by three sturdy, rectangular, phenolic mounts.

Calibration

The calibration procedure is easy. Calibration potentiometers, R2 and R4, are accessible through two holes in the top panel. Simply connect a precision resistor to the clip leads, with the Lohmeter connected to your meter. If you are using your own components, select a value of about 10 ohms—for example, 9.6 ohms. Throw the range switch to ×10. Adjust R2 until you read 0.96 volts (0.96 × 10 = 9.6 ohms). Change the range to ×100 and adjust R4 to read 0.096 volts (0.96 × 100 = 9.6 ohms). The instrument is now calibrated and ready to use.

Operation

To use the Lohmeter, simply plug in the line cord and set the ON-OFF switch, to the ON position. Insert the cables' banana plugs into your voltmeter, maintaining the correct polarity. Set your voltmeter to the 1.0 VDC scale. Select a suitable Lohmeter range and connect the clips across the unknown resistance to obtain a reading.

If, for example, the ×10 range has been selected and the reading is 0.002 volt, then the resistance is 0.02 ohm (10×0.002). For higher resistances, set the range switch to ×100. A reading of 0.002 volt would indicate a resistance of 0.2 ohm; a reading of 0.005 volt would be 0.5 ohm. Any scale can be used since the voltage reading multiplied by the appropriate multiplier gives the value of the resistance. For greatest accuracy, always choose the range that will result in the highest voltage reading. The greatest resistance that can be read, regardless of the voltage-scale used, is about 500 ohms, due to internal voltage limit of the accessory.

That voltage limit does not, however, interfere with *lower* value resistances. If a 100 mV scale is available on your meter, readings as low as 0.001 ohm may be made. For values of that order of magnitude, use the ×10 range. Then the 0.001-ohm resistance will be indicated on the meter as 0.1 mV (.0001 volt). When that reading is multiplied by 10, the resistance is 0.001 ohm (see Table 1).

The Lohmeter is a very versatile accessory. Besides being of value in the laboratory or on the service bench, it can also be used as a production tool for grading and matching resistors, coils, transformers and motor windings, or whenever it is necessary to measure or match low resistance value components. **R-E**