

Practical Low Resistance Measurements

Bob Nuckolls
Sr. Engineer/SME
Raytheon Aircraft Company
Wichita, Kansas

Modern digital multimeters have two important limitations:

(1) When taking resistance readings on switch or relay contacts, the common multimeter often produces high, almost meaningless resistance readings due to very low test currents generated within the instrument: A sampling of resistance measurement currents for five different digital instruments showed no current exceeding 1.5 milliamperes. Most measurements were made at currents on the order of 250 microamperes.

(2) Typical off-the-shelf multimeters offer a low resistance measurement on the order of 200 ohms full scale with a resolution of 0.1 ohms. For qualitative measurements of components like switches and relay contacts the technician needs to resolve resistance values of 1 ohm or less with resolution in the milliohms. Contact resistance due to film or corrosion build-up requires a substantial current flow to penetrate contact film.

A “4-wire” measurement technique for low resistance is illustrated in Figure 1. A current of known value is caused to run

through the resistor of interest. A voltmeter is used to measure drop across the resistor INSIDE the current connections. Ohms law is used to calculate the resistance value. This technique eliminates effects of test equipment lead and probe resistance.

A practical implementation of the 4-wire measurement technique illustrated in Figure 2. can be assembled in an hour or so with a bill of materials under \$10. The outer housing is a plastic project box from Radio Shack. Dual

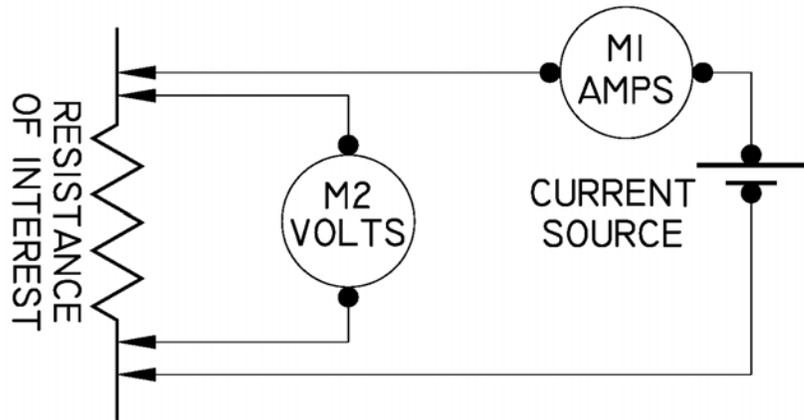


Figure 1. Basic 4-Wire Ohmmeter Technique

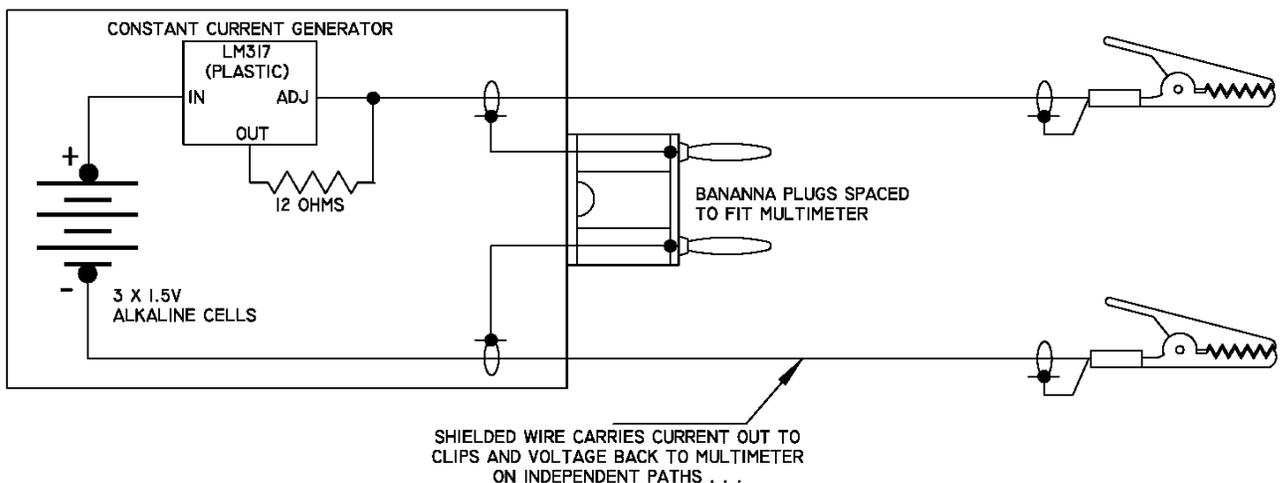


Figure 2. Schematic Diagram - Low Resistance Measurement Adapter

banana plugs to fit most multimeters along with components to implement a constant current source are readily available from suppliers of commercial components such as Radio Shack, Digikey, Hosfelt, Jameco and others

Construction Notes

A constant current generator is fabricated from a popular adjustable voltage regulator combined with a 12-ohm resistor. The LM317 (Figure 4) is readily available in the TO-220 plastic package from most parts suppliers. The LM317 series, 3-terminal regulators come in a variety of packages and environmental ratings. Any version is suited to this application.

Power to bias the test comes from three AA sized alkaline cells in series. Spring loaded battery holders have a potential for poor connection to the cells with age and environmental effects. Soldered connections are easy to make and very reliable



Figure 3. Interior View Component Location

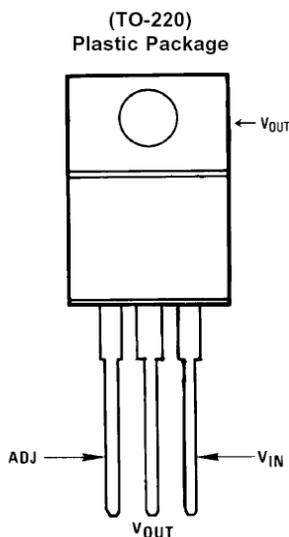


Figure 4. LM317 Connections.

less than two or three seconds total. Eliminating the battery holder allows construction to be contained in a smaller enclosure and eliminates future problems that arise from poor contact with cells.

Brighten an area on the battery to be soldered with a file, knife edge or edge of grinding wheel. The Dremel Moto-Tool with a cut-off wheel attached works really nice. Use a hot iron to get on and off quickly each time the cell is touched. First, tin the area where a wire will attach to the cell. Tin the wire and then tack it into place on the cell.

With a little practice, the two times you touch the cell with the soldering iron should be

Calibration

The finished fixture can be tested for calibration by plugging it into the multimeter while it is set up to measure current. The fixture fabricated for this article produces a constant current of 104 mA. This is expected; the LM317 voltage regulator is a 1.25 volt device. A 12.0 ohm resistor would be expected to produce a current slightly higher than 100 mA. For most purposes, this variability is insignificant.

Using the Fixture

The adapter illustrated herein generates 100 milliamperes of test current. When used in conjunction with a multimeter having readout in tenths of a millivolt, the resolution of a low resistance measurement will be 1 milliohm.

This device will yield useful resistance measurements up to better than 10 ohms (1.000 volts displayed on multimeter) If your multimeter has a 200 or 300 millivolt range, a 100 milliampere test adapter will display 2 or 3 ohms full scale.

The low resistance measurement adapter is useful in diagnosing system malfunctions that could be attributed to increased contact resistance in switches or relays. Switches outside the pressure vessel on turbojet aircraft are particularly good candidates for environmental effects,

especially those under the nacelles or on landing gear struts.

When investigating the condition of a switch or relay, it's useful to exercise the part and observe variations in contact resistance from one measurement to the next. Unless you are offered baseline resistance values as part of a published test procedure, you'll have to make comparative measurements between a suspected bad and a known good component.

Storage

Current flows from these cells only while a measurement is being made. Shelf life of an alkaline cell is 5 years or more. Cells in this fixture should not require frequent replacement. To take advantage of the very long shelf life of alkaline cells, be sure to store the adapter in a way that protects the lead wires and/or exposed banana plugs from becoming shorted together.

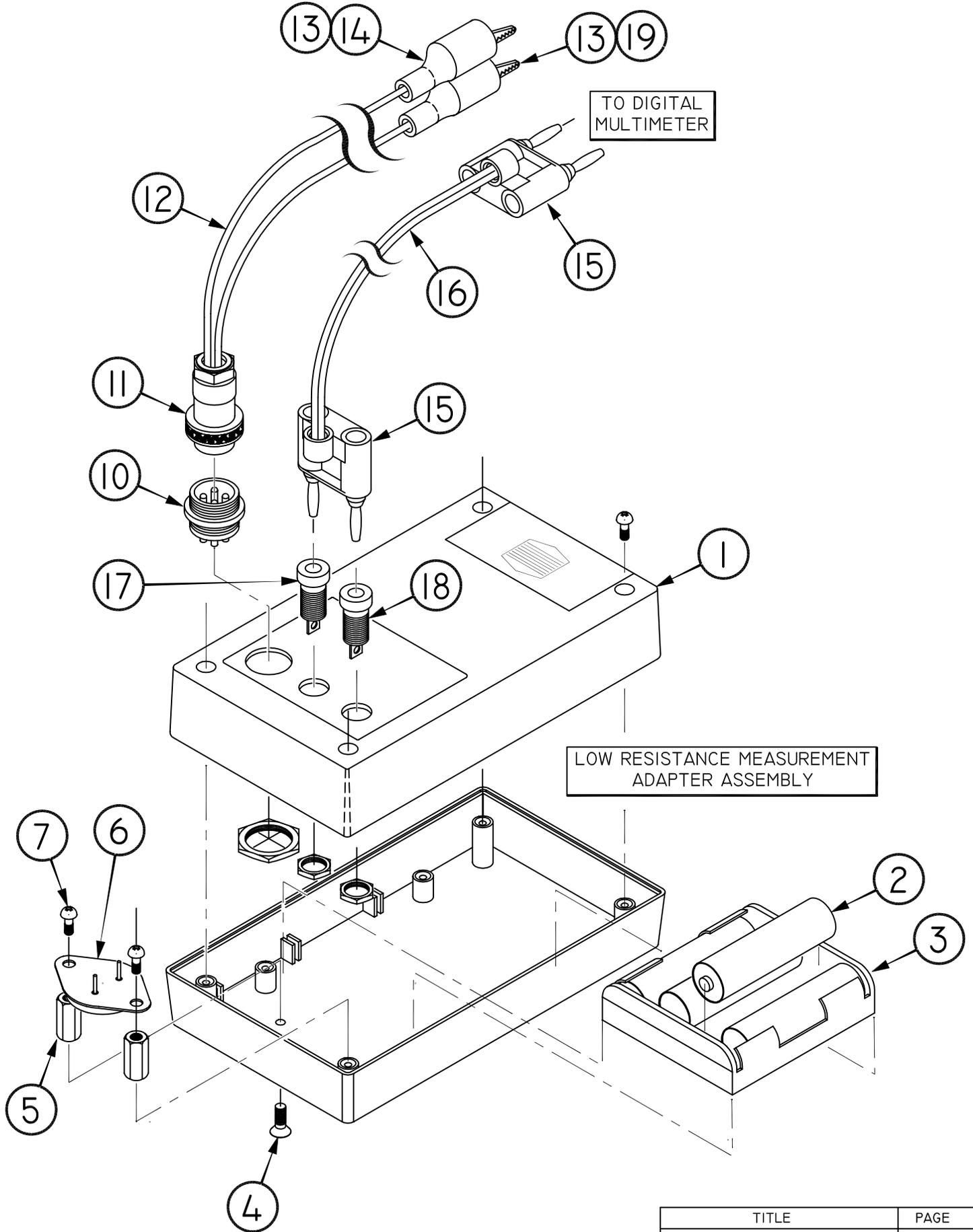


Figure 6. Adapter Shows 2 Milliohms Parasitic Resistance.

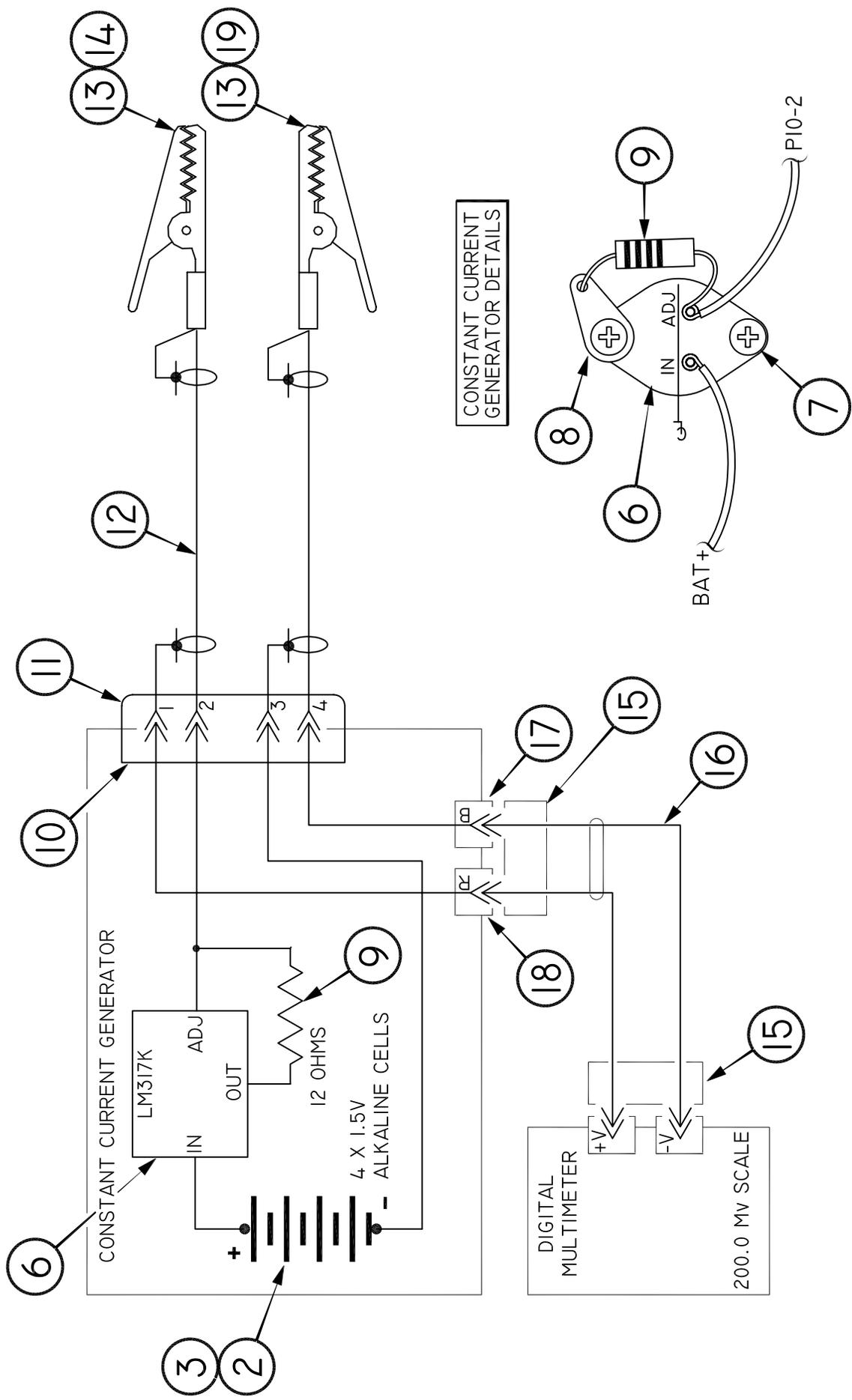
LOW RESISTANCE
UNDER TEST

TO DIGITAL
MULTIMETER

LOW RESISTANCE MEASUREMENT
ADAPTER ASSEMBLY



TITLE	PAGE
COMPONENT LAYOUT	I.0



TITLE	PAGE
SCHEMATIC	2..0

SUGGESTED PARTS LIST:
 CCS = COMMON COMMERCIAL STOCK

19	1	BU-60-2	INSULATOR BOOT - RED	MUELLER
18	1	J151	BANANA JACK - RED	LMB
17	1	J152	BANANA JACK - BLACK	LMB
16	1	CCS	18AWG 2-COND LAMP CORD	CCS
15	2	274-717	DUAL IN-LINE BANANA PLUG	RADIO SHACK
14	1	BU-60-0	INSULATOR BOOT - BLACK	MUELLER
13	2	BU-60CS	ALIGATOR CLIP	MUELLER
12	1	350-223	22AWG SHIELDED WIRE	LMB
11	1	274-001	4-PIN PLUG	RADIO SHACK
10	1	274-002	4-PIN SOCKET	RADIO SHACK
9	1	12.4XBK	12.4-OHM, 1%, 1/4W RESISTOR	DIGIKEY
8	1	CCS	SOLDER LUG	CCS
7	1	CCS	6-32 x .24 RH MACHINE SCREW	CCS
6	1	LM317K-STEEL	3-TERMINAL VOLTAGE REGULATOR	DIGIKEY
5	1	CCS	6-32 x .25 x .50 LONG SPACER	CCS
4	1	CCS	6-32 X .38 FH MACHINE SCREW	CCS
3	1	274-411	4XAA BATTERY HOLDER	RADIO SHACK
2	1	CCS	AA ALKALINE CELL	CCS
1	1	503	PLSTC PRJCT BX 3.3 x 1.5 x 5.6	LMB
ITEM	QTY	P/N	DESCRIPTION	MFGR

INSTRUCTIONS FOR USE

THE LOW RESISTANCE MEASUREMENT ADAPTER GENERATES A 100 MILLIAMPER CONSTANT CURRENT BETWEEN THE MEASUREMENT CLIPS. AN INDEPENDENT PAIR OF WIRES CONNECTS THE DISPLAY MULTIMETER TO THE CLIPS.

SET MULTIMETER TO ITS MOST SENSITIVE SCALE. MOST DIGITAL MULTIMETERS WILL READ 100 MILLIVOLTS WITH 0.1 MILLIVOLT RESOLUTION. THE 100 MILLIAMPER CURRENT SOURCE PRODUCES 0.1 MILLIVOLT OF DROP FOR EVERY MILLIOHM OF RESISTANCE. EXAMPLE: A VOLTAGE READING OF 12.2 MILLIVOLTS WILL BE OBSERVED WHEN 122 MILLIOHMS RESISTANCE PATH EXISTS BETWEEN THE TEST CLIPS.

DISCONNECT TEST LEADS WHEN THE INSTRUMENT IS NOT IN USE TO AVOID ACCIDENTAL DISCHARGE OF THE BATTERY.