♦ PRECISION INSTRUMENTS FOR TEST AND MEASUREMENT ♦

Operation Manual

MODEL LOM-510A
High Accuracy
Micro-Ohmmeter

User and Service Manual

LOM 510A im/June 2004

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WARRANTY

We warrant that this product is free from defects in material and workmanship and, when properly used, will perform in accordance with applicable IET specifications. If within one year after original shipment, it is found not to meet this standard, it will be repaired or, at the option of IET, replaced at no charge when returned to IET. Changes in this product not approved by IET or application of voltages or currents greater than those allowed by the specifications shall void this warranty. IET shall not be liable for any indirect, special, or consequential damages, even if notice has been given to the possibility of such damages.

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Contents

Figures

WARNING

OBSERVE ALL SAFETY RULES
‘WHEN WORKING WITH HIGH VOLTAGES OR LINE VOLTAGES.

ELECTRICAL SHOCK HAZARD. DO NOT OPEN CASE.
REFER SERVICING TO QUALIFIED PERSONNEL.

HIGH VOLTAGE MAY BE PRESENT WITH **HIGH VOLTAGE OPTIONS.**

WHENEVER HAZARDOUS VOLTAGES (> 45 V) ARE USED, TAKE ALL MEASURES TO AVOID ACCIDENTAL CONTACT WITH ANY LIVE COMPONENTS:

- USE MAXIMUM INSULATION AND MINIMIZE THE USE OF BARE CONDUCTORS.

REMOVE POWER WHEN HANDLING UNIT.

POST WARNING SIGNS AND KEEP PERSONNEL SAFELY AWAY.

CAUTION

DO NOT APPLY ANY VOLTAGES OR CURRENTS TO THE TERMINALS OF THIS INSTRUMENT IN EXCESS OF THE MAXIMUM LIMITS INDICATED ON THE FRONT PANEL OR THE OPERATING GUIDE LABEL.

Chapter 1

Introduction

The Model 510A Micro-ohmmeter is a high performance instrument, useful wherever there is a need for measuring very low values of resistance. The highest range of 200 ohms full scale on the Model 510A is close to the lowest range on general purpose 4 1/2 digit multimeters and ohmmeters. Generally, the measurement range of the Model 510A begins where the general purpose instruments end.

The most significant features of the Model 510A are the basic accuracy of .02% (even on the lowest scale) and the three separate component drive modes. It's the combination of good basic accuracy and selectable drive modes which makes the Model 510A such a useful and accurate resistance measuring instrument. The Switched DC Mode totally eliminates the effects of thermal EMF, a very important source of error. The Continuous DC Mode is required when measuring the resistance of highly inductive components such as transformers. The Pulsed Mode is important when measuring heat sensitive components such as thermistors.

In addition, the Model 510A can perform "dry circuit" measurements. This measurement mode is useful when measuring the contact resistance of low level switches. Several MIL specs require "dry circuit" measurements of certain switch types.

The Model 510A has a 25 pin connector mounted to the rear panel which contains a set of parallel BCD lines which are driven with the same digits as the front panel display. This allows the instrument to interface to a companion limits comparator. In addition, the connector contains signal lines to allow the unit to be remotely triggered.

Figure 1.1 LOM 510A

Chapter 2

Specifications

2.1 Drive Specifications

Range (Full Scale)	Drive	POWER DC	POWER SW DC	ENERGY PULSED	RESOLUTION
19.999 mΩ	1 A	20 mW	5.0 mW	.003 mJ	1 µΩ
199.99 mΩ	0.1 A	2.0 mW	0.5 mW	330 µJ	10 µΩ
1.9999 Ω	10 m A	200 µW	50 µW	33 µJ	100 µΩ
19.999 Ω	1 mA	20 µW	5.0 µW	3 µJ	1 mΩ
199.99 Ω	100 µA	2 µW	0.50 µW	0.3 µJ	10 mΩ

2.2 Performance Specifications

Accuracy, Switched DC:
0.02% of reading + 2 counts + 2 µΩ

Accuracy, Continuous DC:
0.04% of reading + 2 counts + 2 µΩ

Accuracy, Pulsed Mode:
0.02% of reading + 4 counts + 2 µΩ

Accuracy vs. Temperature:
Stated accuracy applies over an ambient temperature range of 18ºC to 27ºC. Error doubles over the range of 10 degrees C to 40ºC.

AC Hz Noise Rejection:
80 dB for Switched DC and Pulsed Modes; 60 dB for continuous DC Mode.

Zero Adjust:
Front panel screwdriver adjustment, active only in continuous DC Mode.
Adjustment range is +/- 150 counts (150 µV) minimum.

Switched DC Mode:
Current switched on for 167 milliseconds, then off for 500 milliseconds.
(duty cycle = 1/4)

Pulsed Mode:
One cycle of Switched DC Mode. Enabled by shorting two contacts on rear panel connector.

Dry Circuit:
Open circuit voltage limited to 50 millivolts max. (A Model 510A/20MV is available which limits the open circuit voltage to 20 millivolts max.)

Speed:
667 milliseconds per reading.

Warm-up Time:
1 minute to rated accuracy

Connections to Unknown:
4 terminal plus shield

Rear panel connector:
25 pin “D” type connector; 5 BCD digits for value, polarity indication, Pulse Mode control lines, Power Supply lines.

Display:
4 1/2 digit, .5 inch high, red LED display.

Display Overrange Indication:
Flashes for Switched DC and Continuous DC Modes, blanks in Pulsed Mode.

Power Requirements:
105 - 135 VAC, 60 Hz, 30 Watts max.
Other voltages and frequencies available.

Dimensions:
9" wide x 2.25" high x 11.5" deep.

Weight:
6 lbs.

Chapter 3

Operation

3.1 General Operating Instructions.

1. Plug the power cord into the rear panel AC connector and the test leads into the connector provided on the front panel.
2. Push the power switch in to turn the Model 510A on and wait 30 minutes to allow the instrument to stabilize. If the test leads are left open circuited or the resistance of the unknown exceeds maximum value for the selected range, the display will flash. This does no harm to the instrument.
3. Select the proper measurement drive mode. The Continuous and Switched DC drive modes are selected by the front panel mode select switch. The Pulsed Mode is selected through the rear panel I/O connector. Refer to the next section to determine which mode is beat for a particular measurement task.

If the Continuous DC Mode is selected then the front panel zero control should be adjusted periodically to assure that a true zero is maintained. Zeroing the meter is beat done on the highest (200 ohms full scale) range since a true short circuit can be difficult to attain with Kelvin type clips on the more sensitive ranges. (Almost any chunk of metal has at least a micro-ohm of resistance.). Connect the test clips to a heavy, short piece of wire and carefully zero the display.

Push the “DRY CKT” button in if the open circuit voltage is to be clamped to 50 millivolts maximum. (20 millivolts maximum on the Model 510A/20MV)

4. Select the proper resistance range by pushing in the appropriate range button. Very often the correct range can’t be determined in advance. In such cases start with the highest range, working down to the lower ranges. This keeps the stress on the unknown to a minimum.

3.2 Continuous DC Mode

The Continuous DC Mode is the traditional method of measuring the value of’ a resistor. A constant current is forced through the unknown and the voltage developed across the device is measured. This voltage is directly proportional to the resistance of the device. Unfortunately, this method doesn’t cancel one important source of error, small voltage sources in series with the measured resistance. These voltage sources are mainly due to thermocouple effects and unless they are carefully nulled out with the front panel zero control they can seriously degrade the accuracy of the measurement. When attaching the test leads to the unknown try not to warm the contact area with your fingers.

The Continuous DC Mode is the proper mode only when measuring highly inductive components such as transformers, chokes and motor windings. Wire wound resistors are not inductive enough to require measurement in this mode.

3.3 Switched DC Mode

The Switched DC Mode first measures the voltage across the unknown with the drive current off. It stores this voltage and then measures the voltage with a calibrated current source flowing through the unknown. The displayed reading is the difference between the two measurements.

The Switched DC Mode is the appropriate drive mode for most measurements. No zeroing is required, in fact the front panel offset control has no effect. All sources of zero offset are cancelled by the auto zero circuitry. In addition the instrument is less sensitive to AC pickup in this mode, although the instrument is quite insensitive to AC pickup in all modes. Power dissipation of the unknown is 1/4 that of an equivalent measurement in the Continuous DC Mode.

3.4. Pulsed Mode

The Pulsed Mode drives the unknown with a single 167 millisecond pulse of current each time a short is removed between pins 18 and 19 of the rear panel I/O connector. The short must be removed for at least 1 microsecond but less than 667 milliseconds. If the open circuit lasts for longer than 667 milliseconds then the instrument will take an additional measurement. The front panel mode switch must be in the Switched DC Mode for proper operation.

A normally closed, momentary pushbutton switch can be wired to the rear panel connector to manually trigger the Pulsed Mode. If remote electronic control of the Pulsed Mode is desired an analog switch such as a Motorola MC14066 or Siliconix DG200 can be used. A small relay also works well.

The Pulsed Mode should be used when the component to be measured is extremely temperature sensitive, such as in the case of small bead thermistors. The Pulsed Mode is the only way to externally trigger the Model 510A.

If the Model 510A is pulsed into an open circuit, the first measurement after the open circuit measurement will read about 4 counts higher than the actual value. All subsequent readings will be within specifications.

3.5 Dry Circuit Measurements

Switch contacts can oxidize, causing a high resistance contact when closed. This oxide layer will usually break down when the voltage drop across the contacts approaches a volt or so. The “DRY CKT” button, when depressed will limit the voltage to 50 millivolts maximum (20 millivolts maximum on the Model 510A/20MV). If the switch is being used in a low level signal application then the dry circuit measurement will give a better indication of how the switch will perform. Several MIL specifications dealing with contact resistance measurements in switches and relays require dry circuit measurements.

All Cambridge Technology, Inc. test clips, probes and fixtures include 100 kW resistors between drive(+) and sense(+) and between drive(-) and sense(-). The resistors assure that the output voltage is monitored (and limited to 50 millivolts) even if the sense leads fail to make contact with the sample. If custom made test fixtures are used with the Model 510A and the dry circuit feature is desired, make sure the resistors are installed.

Chapter 4

Circuit Descriptions

4.1 Power Supply

The power supply produces 3 regulated DC voltages, namely +5 V DC, +8 V DC and -SVDC. The 120 VAC, 60 Hz enters the unit via the rear panel three pronged connector and the high side immediately pas-sea through F1, a 1/2 amp slow blow fuse. The AC high then runs up one edge of the pc board to the front panel power switch and back down to one side of the power transformer primary. The other side of the primary connects directly to the AC low terminal of the AC connector, providing a return path for the 120VAC input.

The transformer secondary contains two center-tapped windings. The first set of windings (transformer pins 10-12) feed CR11 and CR12 which in turn charge C11 and C12 to about 9 VDC. This raw voltage is then regulated to +5 VDC by U16.

The second set of windings (transformer pins 7-9) feed RA1, a full wave bridge, which generates positive and negative unregulated DC voltages of about 13 VDC. The three terminal regulators, U17 and U18 reduce and regulate these voltages to the required +8VDC and -SVDC.

4.2 Timing Circuitry

NOTE: The digital signals in the timing circuitry switch from -8V to +av.

All measurements are synchronized with the AC line to reduce the effects of line related noise. This is especially important in the Model 510A since the least significant digit in the display is only 1 microvolt DC. The test leads can easily pick up line related noise orders of magnitude greater than this.

The AC voltage at the transformer secondary is converted into a square wave by U7 and its associated circuitry. R34 feeds CR8 and CR9 with the AC voltage. The diodes clip the AC voltage, reducing it to about 1.2 volts peak to peak. This reduced voltage is then amplified by U7 to produce a 60Hz square wave. R33 and C10 provide some hysterisis to insure clean switching. The 60Hz signal is then reduced to 6Hz by the decade counter US. U9 then takes this 6Hz signal and produces 4 equally spaced time slots. Each time slot lasts for a period of 1/6 seconds, giving a total measurement cycle time of 4/6 seconds. Normally U9 would reset after 10 pulses but is instead reset after every 4 pulses via the RS latch formed by two gates in U9. This latch is set every time the first time slot goes high, forcing the reset line of U9 low. When the forth time slot has been completed the latch is reset, causing the reset line of U9 to go high. This resets U9, starting a new measurement cycle.

System timing in the Switched DC Mode is as follows; During time slot one (U9, pin 3 is high) current to the unknown is switched off allowing the measurement circuit to auto zero itself. During time slot 2 (U9, pin 2 is high) test current is applied to the unknown and the resultant voltage appearing across the unknown is amplified. During time slot 3 (U9, pin 2 is high) and time slot 4 the measurement circuitry converts the analog voltage proportional to the unknown's resistance to a digital number to drive the display.

Timing in the Pulsed Mode is identical to the Switched DC Mode except that the cycle is not automatically repeated. The RS latch formed by U28 is inhibited, holding the timing circuitry in reset. In the Continuous DC Mode switch S2 inhibits the auto zero, forcing a constant current to flow continuously through the unknown. The AC to DC conversion timing however is the same as in the other modes so that the 60Hz noise rejection remains.

4.3 Component Drive Circuitry

The drive circuitry drives the unknown with one of 5 constant current levels, depending upon the range selected. In measuring resistors a constant current is very convenient since the voltage appearing across the unknown will be directly proportional to its resistance.

The network formed by CR1, R1 and Cl produces a stable voltage source of about 1.23VDC. This voltage is used as a reference by both the drive circuitry and measurement circuitry. In the Switched DC Mode, during time slot 1 U1 pins 9 and 8 are shorted driving the input of U2 to 0 VDC. During time slot 2 U1, pins 10 and 11 are shorted driving the input of U2 to about 1VDC. When the input of U2 is driven positive the output also goes positive. This turns Q1 on. Q1 in turn drives a network of precision current sensing resistors (SIP-1,R10-R19 and R21). The current sensing resistors then drive the unknown.

The value of the current sensing resistance is determined by the range selected and is either 1,10,100,1000 or 10000 ohms. Trims are provided for each of the five ranges. U3 feeds the voltage appearing across the current sensing resistor back to the negative input of U2 where it is compared to the reference voltage such that the current flowing through the current sensing resistor and the unknown is held constant.

R9 provides short circuit current limiting during switching.
R8/C32 and R7/C3 add stability to the constant current loop. The function of R2-R4 is to null out any small offset voltages which might produce a difference in reading between the Continuous and Switched DC Modes.

When the “DRY CKT” button is (S8) depressed the voltage at the output of U4 is sensed. When this voltage exceeds approximately 3 volts U29 becomes positive. As this voltage becomes more positive CR15 forward biases, closing a loop which clamps the output voltage to less than 50 millivolts (20 millivolts on the Model 510A/20MV).

4.4 Measurement Circuitry

U4 is a differential amplifier wired to have a voltage gain of 100. The inputs of this amplifier are the sense terminals connecting to the unknown. Since on any given range the voltage appearing across the unknown will vary from 0 to 20 mV then the output of U4 can go from 0 to 2V. For the Switched DC Mode, during time slot one the current through the unknown is 0. However there can be a small voltage appearing across the unknown due to thermal EMF’S. There is also an offset associated with U4. These offsets are multiplied by 100 and used to charge the sample and hold circuit formed by U1, pins 3-5 and C4. During time slot 2 U1, pins 4 and 5 are opened and U1, pins 1 and 2 are closed, causing C5 to be charged. The difference between the voltages appearing across C4 and C5 is proportional to the resistance of the unknown.

This differential voltage is applied to the 7135 DVM integrated circuit. The analog to digital conversion takes place when pin 25 of U6 goes high at the beginning of time slot 3. The conversion time takes all of time slot 3 and most of time slot 4.

A l50 kHz clock is required by the DVM chip to make the conversion. This oscillator is formed by U5 and its associated passive components. The output of the DVM circuit is multiplexed BCD and is used to drive the display circuitry and I/O circuitry. The DVM circuit also requires a number of passive components (C7-C9 and R30) for proper operation. R31 and R32 function as a voltage divider, reducing the reference voltage to 1.0VDC.

CR13 and CR14 assure that the common mode range of the DVM circuit is not exceeded when the test clips are open circuited. R42 and R43 provide current limiting to the DVM circuit during open circuit. S2-C and R24 discharge C4 in the Continuous DC Mode.

R22 in conjunction with R40 is used to zero the meter when in the Continuous DC Mode. Although this offset control is still active in the Switched DC Mode it has no effect on the reading because offsets from any source are cancelled by the auto zero circuitry.

4.5 Display Circuitry

The 20,000 count (4 1/2 digit) display is multiplexed to reduce power consumption and the number of display drivers. The DVM circuit supplies both digit select and BCD outputs. All five digits (UlO-Ul4) have their segments wired in common. The common anodes for each digit each have their own drivers.

U15 converts the 4 BCD lines to the proper 7 segment code and pulls those particular segments low. Which digit is selected is determined by which of the digit select lines (DI-D5) is high. When a digit select line goes high it turns on the associated transistor which in turn pulls the common anode of that digit on.

RN-1 provides the proper current level to the segments.

The correct decimal point location for a particular range is selected by a single pole in each of the range buttons (S3-C through S7-C). R39 provides the current limiting for the decimal point.

To facilitate zeroing the meter when in the Continuous DC Mode segment “g” (the center horizontal segment) is driven when the polarity to the DVM circuit reverses.

4.6 I/O Circuitry

The multiplexed BCD information produced by the DVM circuitry is latched and presented to the I/O connector in a parallel format. U21 through U25 are 4 bit latches. The multiplexed BCD lines are wired in common with each 4 bit latch. This BCD information is transferred to the appropriate latch when a given digit line goes high and the strobe line from the DVM chip is pulsed. The latch will present the BCD information to the I/O connector until the next measurement cycle.

If pine 18 and 19 are shorted together the meter will finish the current measurement cycle and then go into a hold mode until the short is temporarily removed (1 microsecond or greater). Each time the short is opened the meter will take a single measurement and display the results. When the two lines are shorted, U28, pin 13 is pulled low. This prevents the associated latch from changing state, which in turn holds the reset line of U9 high, forcing U9 into a reset condition.

Chapter 5

Calibration

Danger !!!
The calibration procedure requires that the top cover of the instrument be removed. This exposes the operator to hazardous voltages within the instrument. In particular several points around power on/off switch and fuse assembly are at AC high (120 VAC).

In order to calibrate the Model 510A Micro-ohmmeter 5 resistor values are required. The value of each calibration resistor should be known to better than .005% (50 PPM). The actual value of a particular calibration resistor is important only to the extent that it produces a display reading of 10,000 counts (half of full scale) or greater (but less than full scale). Nominal values are as follows;

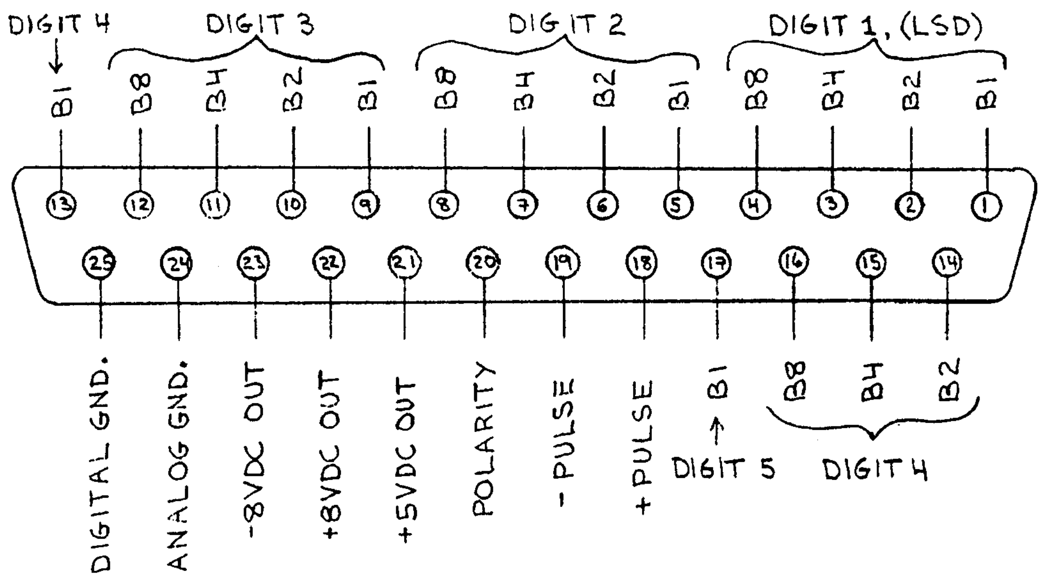
15 mΩ (10 to 19.999 mΩ)
150 mΩ (100 to 199.99 mΩ)
1.5 Ω (1.0 to 1.9999 Ω)
15 Ω (10 to 19.999 Ω)
150 Ω (100 to 199.99 Ω)

Ideally, all 5 resistors should be four terminal to eliminate any error due to component lead resistance. However this is only an absolute requirement for the three lowest ranges and is quite unimportant on the highest range (199.99 ohms full scale).

1. The top cover must first be removed to gain access to the trimming potentiometers. Remove the line cord and turn the instrument upside down. Remove the two screws closest to the rear panel, then remove two screws holding the tilt stand to the instrument that are closest to the front panel. Then, while holding the two clamshell halves together turn the instrument right side up and remove the top clamshell.
2. Reattach the line cord and turn the instrument on. Allow the instrument to stabilize for 5 minutes before proceeding.
3. Place the instrument in the Continuous DC Mode (mode switch is in the out position). Push the 200 ohm range button in. Attach the test clips to the 15 milliohm standard and carefully adjust the front panel zero control such that the display reads +00.01 to +00.02.
4. Push the 20 milliohm range button in and adjust R19 for a reading of 15.000 milliohms.
5. Place the instrument in the switched DC mode and adjust R2 for a reading of 15.000 milliohms.
6. Repeat steps 3 through 5 until no further adjustment is required. Normally, once through steps 3 - 5 is all that's required but sometimes small thermal EMF'A cause drifts of several counts between readings.

The switched DC mode must be used for steps 8 through 11

7. Push the 200 milli-ohm range button in and attach the test clips to the 150 milli-ohm standard. Adjust R17 such that the display reads the correct value.
8. Push the 2 ohm range button in and attach the test clips to the 1.5 ohm standard. Adjust R15 such that the display reads the correct value.
9. Push the 20 ohm range button in and attach the test clips to the 15 ohm standard. Adjust R13 such that the display reads the correct value.
10. Push the 200 ohm range button in and attach the test clips to the 150 standard. Adjust R11 such that the display reads the correct value.



REAR PANEL CONNECTOR

FRONT PANEL CONNECTOR