

MAN100

# Model LC-4.5

## PART #5203

# Reference Manual



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Instruments and Software for the Corrosion Engineer

## **TYPICAL APPLICATIONS**

- Structure - to - soil potentials
- IR Drops (.01 mV resolution)
- Interference Testing
- Cathodic Protection Tests
- Rectifier Trouble-Shooting
- URD Cable Corrosion Tests
- Bridge Deck Corrosion Surveys (Rebar)
- Surface Potential Surveys
- Side Drain Measurements



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## GENERAL

The model LC-4.5 is a state-of-the-art digital meter specifically designed for corrosion and cathodic protection testing. The M.C. Miller Co. has taken the following steps to insure that your meter will cope with the difficult environmental conditions encountered by corrosion engineers and technicians:

- Switches are Mil. Spec. Type Sealed with Gaskets.
- Both sides of printed circuit board have a baked-on moisture and fungus resistant coating to prevent electrical leakage and damage to components.
- Case is insulated with Neoprene gasket closure.
- Banana jack terminals are insulated and sealed to prevent entrance of moisture.
- The display window is an integral part of the panel and therefore is perfectly sealed.
- Liquid crystal display is a type which is operable over an unusually wide temperature range.
- Input resistance is selectable, 10 mega-ohms through 200 mega-ohms, which enables testing even when soil is unusually dry or frozen.
- Circuitry in the meter provides automatic zeroing, automatic polarity sensing, automatic decimal point location, automatic over-ranging indication and automatic low battery indication. Damage as a result of over-ranging is highly unlikely with potentials normally encountered in corrosion measurements.

## MEASURING DC POTENTIALS

The Model LC-4.5 is specially designed for measuring potentials encountered in corrosion and cathodic protection testing. These include structure-to-soil potentials, structure-to-water potentials, surface potentials surveys, potential of rebars in concrete, voltage gradients in soil or water, structure potentials-to-anode potentials and output voltage of cathodic protection rectifiers and solar cell arrays.

The 20mV range is designed for measuring IR drop on metallic structures such as pipes or cables, and is also used in conjunction with an optional external .001 ohm shunt to measure DC currents up to 20A. The input resistance on the 20mV range is fixed at 1,000 ohms. The input resistance selector switch does not function on this range. However, the input resistance selector switch does function on all other voltage ranges.

## PROCEDURE FOR MEASURING DC POTENTIAL

- A. Turn range switch to 200mV range.
- B. Turn function switch to DC.
- C. Turn power switch to 10 meg position. Display should turn on and within a few seconds indicate "000". If "Lo Bat" appears in the display, then the 9V battery must be replaced as soon as possible.
- D. Connect test leads to common (-) and center (+) terminals.
- E. Turn range switch to a lower range if necessary to obtain a more detailed reading. If polarity at input is opposite to that marked on panel, a "-" sign will appear in the display. When the display shows "1" followed by blanked digits, the input is higher than full scale. Use higher scale if available.



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- F. Use input resistance selector switch as necessary to detect and minimize effects of high resistance in the external circuit. See "Use of Input Resistance Selector Switch".

### **USE OF INPUT RESISTANCE SELECTOR SWITCH**

(Functions only on DC and AC voltage ranges 200mV and up.) This switch is normally left in the 10 mega-ohm position. When the meter is used in conjunction with one or more reference electrodes, we recommend the following procedure for detection and elimination (usually) of errors caused by high electrode contact resistance.

- 1. Take reading with input resistance switch on 10 mega-ohm range.
- 2. Rotate switch to 25M range; take reading. If reading is the same as in 1, record reading. If reading is higher than 1, switch should be rotated until same reading is obtained on two adjacent sensitivity positions. For example, if the following readings were obtained:

Reading	Sensitivity Reading
0.88	10 mega-ohms
0.89	25 mega-ohms
0.90	50 mega-ohms
0.90	100 mega-ohm

then the .90 volt reading would be correct.

- 3. If reading increases when switch is rotated from 100M position to 200M position, then it is not possible to get an accurate reading without obtaining a better contact between the electrode and the soil. This can usually be accomplished by digging the
  - electrode into the soil or by watering the soil at the point of the electrode contact.

**Precaution:** It is essential that insulation on the test lead wire between the meter and the electrode be free of cracks or pinholes, otherwise leakage errors may occur, particularly in those locations where it is necessary to use the higher settings in order to obtain a reading.

**Note:** Use of either the 200 or 10 mega-ohm range in conjunction with the 200mV range is not recommended. Use the 2V or 200V range if input resistances greater than 50 mega-ohms are required.

### **DETAILED POTENTIAL SURVEYS**

Many firms are making potential surveys at close intervals of all their underground piping. When spacing between adjacent readings is 20 ft or less, it is often referred to as a detailed survey. If the spacing is 5 ft or less it is called a continuous potential survey. Because it is small and light, the LC-4.5 works well for this type of survey.

Suggested accessories to make the survey faster and easier include the LC adapter plate (5701), an intermediate electrode extension (16203), a copper sulfate electrode such as the RE-5 or RE-5C, and a slip-ring type test lead reel with #18 test lead wire.

Suggested crew would include at least three people: one to locate the pipe, one to take the reading, and one to write down the reading. An additional person is sometimes used to carry stakes and install them to flag the problem areas.



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## **SURFACE POTENTIAL READINGS**

This type of survey employs two copper sulfate electrodes and is applicable to bare pipelines. No connection to the pipe is required. The survey is conducted with both electrodes directly over the line at a fixed spacing of 10 or 20 feet. Readings are taken of potential between electrodes at intervals matching the electrode spacing. The same electrode is always kept in front as the survey progresses. The front electrode is connected to the positive terminal. The readings will change polarity from + to – as an anode area is passed. Supplementary side drain readings (one electrode over the pipe, the other electrode 5 ft to one side) are taken at suspected anode points. The reading is often repeated on the opposite side of the pipe as a double check.

The use of the LC Adapter Plate and Intermediate electrode extension along with an electrode extension for the rear electrode will make the job simpler. It is important that the survey be conducted directly over the pipeline. For this reason, a pipe locator is usually employed.

## **USE OF THE PUSH-TO-HOLD BUTTON**

The push-button, located on the right side of the panel below the display, functions to freeze whatever is being displayed. The holding or freezing action continues until the button is released.

This feature is especially useful in areas varying stray currents are encountered, since it is difficult to interpret a digital read-out which is continually changing.

Some of the companies take coordinated readings at a number of locations at the same instant, using a network of two way radios. The push-to-hold button provides an excellent way to insure simultaneous readings. The group leader instructs each person to read this meter when he says “mark”, at which time each person depresses his push-to-hold button until he has had time to enter the reading on a data sheet.

Another increasingly important use for the push-to-hold button is for obtaining so-called “instant off readings of polarized potentials on a structure. (See “Instant Off Potential Measurements).

**INSTANT-OFF DC POTENTIAL MEASUREMENT** The criterion for adequate cathodic protection involves the measurement of structure-to-soil potential immediately after cathodic protection is turned off. This potential measurement is called an “instant off”, or polarized potential, since the structure has not yet had time to lose its polarization.

The push-to-hold button enables instant measurements to be made quite easily. Just depress and hold down the button as soon as it is perceived that the cathodic protection has been turned off. With a little practice, you can freeze within approximately .5 seconds after cathodic protection is de-energized.

When there are several sources of cathodic protection current for a structure, all should be turned off at the same instant if meaningful “instant-off” readings are to be obtained. This normally means that a crystal controlled current interrupter must be installed at each cathodic installation. These should be synchronized within a fraction of a second.

## **IR DROP MEASUREMENTS**

Because the 20mV DC range of the LC-4.5 has a resolution of .01mv, it is ideally suited for measuring IR drops on metallic structures such as pipes, cables, guide wires, or structural members.

Before taking an IR drop reading, the circuit should be tested for continuity by use of the 200 ohm resistance range. For accurate results on the 20mv range, the external circuit resistance should be less than 100 ohms. This should rarely present a problem since test station wiring normally measures less than 1 ohm. The positive test lead must be on the center terminal for the resistance test and must be moved over to the 20mV terminal for the actual IR drop measurement. In order to avoid thermally produced errors, both of your test leads should be at the same temperature.

Do not attempt to measure IR drops in the soil using the 20mV range. Use the 200mV or 2mV range instead.



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## **DC CURRENT MEASUREMENTS USING EXTERNAL SHUNT**

An external shunt (not supplied) is required. MCM's .001 ohm LC shunt (5803) used in conjunction with the 20mV range yields a range of 0-20A DC. This compact shunt has convenient banana plug potential terminals which plug into the common (-) and (+) 20mV terminals. Other external shunts can also be used. However they would require a pair of test leads to be connected between the common (-) and center (+) meter terminals and the potential of the shunt. Depending on the particular shunt, the 20mv or 200mv range would be employed.

## **RESISTANCE MEASUREMENTS**

Any resistance less than 200 ohms can be measured. The only precaution is to make sure that there is no pre-existing voltage in the circuit being measured. If there is a pre-existing voltage, a noticeable error will be produced. If the voltage is high enough, damage to the meter is likely. Always check for existing voltage before measuring resistance.

The resistance range is very useful for checking resistance and continuity of test leads, test station wiring, bond connections, etc. if the circuit is open (non-continuous), or if resistance exceeds 200 ohms, the display will show "1" followed by blank digits. To measure resistance, place range switch in "200 ohms" position, connect test leads to common (-) and (+) center banana jack terminals, turn function switch to "ohms" position.

## **AC POTENTIAL MEASUREMENTS**

The use of the 600V AC range will enable you to check line voltage of AC power source, to check AC output Voltage of rectifier transformers, to check for hazardous induced voltages on structures near power lines, and to measure structure-to-soil AC potentials which may have an effect on corrosion behavior of concentric copper neutrals of buried cable.

To measure AC voltage, turn the range switch to "600V AC", turn function switch to AC position, then connect the test leads to the (-) left and (+) center input terminals of the meter.

The input resistance selector switch is functional on the 600V AC range and can be used to detect and eliminate errors caused by high resistance in the external circuit (see "use of Input Resistance Selector Switch").

The voltage source, if over 500V, should not be energized at the time test leads are being connected. Do not touch bare parts of the banana plugs or test clips when measuring line voltages. Make sure that the test leads have an adequate insulation rated 600V or more.

The banana jack terminals on your meter are insulated from the panel, which in turn is an insulating material.

When measuring structure-to-soil AC voltages, contact to the soil may be with any metal rod or a copper sulfate reference electrode can be employed.

If the soil is very dry, frozen, or consists of mostly gravel, it may be necessary to use the input resistance selector switch (right side) to check for and eliminate contact resistance errors. (See "Use of Input Sensitivity Switch")

**Caution:** Always disconnect test leads from AC voltage source before turning either the range switch or function switch to another position. Failure to do so may result in damage to the meter.



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## **USING THE LC-4.5 IN STRAY CURRENT AREAS**

Stray DC currents are of two general types: steady or varying. Steady stray currents, such as those produced by cathodic protection interference, pose no testing problem since they can be measured with almost any corrosion meter.

Varying DC currents, such as those produced by traction systems and mining operations, are most difficult to measure, particularly with an ordinary digital meter. The push-to-hold button on your meter offers a way to obtain representative readings under even the widest variations.

The technique which we recommend is to take and record a series of readings at intervals of perhaps 10 seconds, using the hold button each time. From this data, you will be able to obtain approximate maximum, minimum, and average values.

Another technique is to use a high sensitivity analog voltmeter connected in parallel with your LC-4.5. The Analog meter indicates trends, and therefore suggests when to push the hold button to obtain the readings you desire.

Regardless of which of these methods you employ, the digital meter has the advantage of requiring no interpretation of scales.

## **URD CABLE TESTS**

Underground Residential Distribution cable (URD) typically has bare copper concentric neutral wires. There have been a large number of corrosion failures of these neutrals. In most cases, the attack is quite localized.

In order to prevent possible voltage hazards resulting from failure of the neutral, many power companies are surveying their URD cable.

At the present time, not all engineers are in agreement as to test procedures. However, a number of engineers suggest measurements of cable-to-soil DC potentials at intervals of as little as 2.5 feet. Since the presence of AC potentials may be a factor, it is suggested that AC potential to soil should also be measured. IR drop test from transformers will indicate magnitude and direction of DC currents along the neutral.

Cathodic protection is considered to be the most effective and most economical method of preventing further corrosion damage to existing URD cable systems.



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## **BRIDGE DECK CORROSION SURVEYS**

In areas where de-icing salts are used on highways in the winter, accelerated corrosion of the steel reinforcement (rebar) often occurs.

A potential survey (on 4 ft centers) of the rebar will provide useful data as to the presence or absence of active corrosion on rebar.

For more details on this type of survey, see ASTM Spec. C-876 or write to the M.C. Miller Co. for information.

## **USE OF LC ADAPTER PLATE**

There is an optional LC Adapter Plate (5701) which mounts by means of Velcro pads, without use of tools, to the bottom of the meter case. The adapter plate provides a ¼-20 female electrical and mechanical connection into which an intermediate electrode extension (16203) is screwed. Any of MCM's copper sulfate reference electrodes can be screwed into the female end of the intermediate extension to obtain a rigid, watertight connection.

With this test set-up in place, the electrode is now mechanically and electrically connected to the meter which is at a convenient waist height.

Additional intermediate electrode extensions (16302 (each 30" long) can be added to provide a greater distance between electrode and the meter. The added length is desirable when measuring into manholes from the surface of the ground, when measuring potentials in elevated water storage tanks, when measuring potential around and under the hull of a ship, or when measuring underground storage tank potentials.

## **BATTERY POWER SUPPLY**

All of the power required to operate this meter is obtained from one 9V battery. Replacement is required when the "Lo Bat" indication shows up in the display. The "Lo Bat" indication shows up only when the battery voltage drops below 6.8V. If the battery is not replaced within a few hours, the meter will start to read high.

We suggest carrying a spare 9V battery so that you will not have to interrupt a survey.

Although any 9V battery will operate the LC4.5, we recommend the heavy-duty type, such as the Eveready #1222. In cold weather, or when the resistance range is used often, an alkaline 9V battery, such as Eveready #522 or Mallory # MN1604 will have a longer life.

Access to the battery is obtained by removing the four screws.



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## **LC-4.5 TROUBLE-SHOOTING**

- No display reading?
  - Battery dead or disconnected
  - Replace battery
- Display partially or complete blackened?
  - Meter subjected to excessive temperature
  - Replace display
- No reading on AC range?
  - Function switch in wrong position
  - Turn function switch to AC position
- Ohms range reads differently when leads reversed?
  - Circuit under test has voltage
  - Remove voltage supply from circuit
- No reading on 20mv range?
  - Test lead on wrong terminal
  - Shift test lead from Volts/Ohms to +20mV
- All readings are high?
  - Operator neglected to heed "Lo Bat" display
  - Replace battery without delay
- Display changes very slowly?
  - Meter too cold
  - Keep meter in warm place, except when actually taking a reading
- Display jumps erratically and is not correct?
  - Excessive RF from radio or TV transmitter



## **MAINTENANCE**

The Model LC-4.5 should require very little maintenance other than to replace the 9V battery when "Lo Bat" indication appears in the display. Several hours of normal operation remain after "LO Bat" flashes on.

If operator remembers to turn off the meter at night, service life of a 9V battery should be about 3 months.

The panel should be kept clean and as dry as possible for the best results. A slightly moistened cloth can be used to remove mud, after which the panel can be dried under a lamp or in the sun for a few minutes.

Avoid abrasive cleaning compounds or strong chemical solutions which may harm the panel.

## **TEMPERATURE LIMITATIONS**

The liquid crystal display used in the LC-4.5 has temperature limitations as listed below:

Operating range: -4 to 158° F (-20 to 80°C). Will tend to be sluggish at low end of temperature range

Storage Temperature: -37 to 158° F (-35 to 80°C) Storage outside these temperatures limits may damage the display.

## **SERVICING**

Should any trouble be encountered with the LC-4.5 contact M.C. Miller Co. for a RMA (Return Material Authorization) number and a note explaining the problem and a copy of a repair order, if available. If the meter is still within the one year warranty period, and the trouble is the result of faulty material or workmanship, then the unit will be repaired and returned without charge, other than shipping.

## **SPECIFICATIONS**

Logic:	CMOS; crystal controlled timing
Display:	Liquid-crystal; 3-1/2 digits, 1/2" high
DC Volt Ranges:	0-20mV (.01mV resolution) 0-200mV (.1mV resolution) 0-2V (1mV resolution) 0-200V (.1V resolution)
AC Volt Range:	0-600V (1V resolution)
Resistance Range:	0-200 ohms (.1 ohm resolution)
DC Current Range:	Using optional LC shunt 0-20A (.01 A resolution)
Accuracy:	DCV - 1% of reading ± 1 digit ACV - 3% of reading ± 1 digit Ohms - 2% of reading ± 1 digit
AC Rejection:	20mV range - 200mV @50/60/400Hz 200mV range - 5V @50/60/400Hz 2V range - 120v @50/60/400Hz 200V range - 600V @50/60/400Hz



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DC Rejection: 600VAC range: 600VDC

Zero: Automatic

Decimal Point: Automatic - set by range switch

Polarity: Automatic - negative symbol displayed, positive assumed

Overload Protection: Will safely withstand overloads on all voltage ranges well in excess of any normally encountered

Warm-Up: Negligible

Over-range: Indicated by symbol "1" on left side of display; no other digits  
A negative symbol will be displayed if a negative over-range occurs.

Input Resistance: 20mv range: 1000 ohms. All other DC ranges are switch selectable (10,25,50,100 ,& 200 mega-ohms).  
600 VAC range: 6.67 mega-ohms minimum to 18 mega-ohms maximum, depending on input resistance switch position.

Operating Range: -4 to 158° F (-20 to 80°C)

Battery: Qty-1 9V Alkaline recommended  
Battery Life Approx. 3 months  
Before "Lo Bat" is displayed.

Case: Plastic, weatherproof

Size 6-1/8" x 3-5/8" x1-3/4" (15 x 8 x4.5 cm)

Weight: 11 Oz. Approx. (.312 Kg)