



AVO INTERNATIONAL

Instruction Manual AVTM247701-J

for

Digital Low Resistance Ohmmeter (DLRO®)
Catalog No. 247701

Read the entire manual before operating.

Antes de operar este producto lea este manual enteramente.

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Section 1 Introduction

Receiving Instructions

Check the equipment received against the packing list to ensure that all materials are present. Notify AVO International of any shortage. Telephone (215) 646-9200. Examine the instrument for damage received in transit. If any damage is discovered, file a claim with the carrier at once and notify AVO International or its nearest authorized sales representative, giving a detailed description of the damage.

The instrument has been thoroughly tested and inspected to meet rigid specifications before being shipped. It is ready for use when set up as indicated in this manual. Before attempting to use the DLRO, be sure to read and understand the safety requirements and operating procedures in this manual.

General Information

The Digital Low Resistance Ohmmeter (DLRO®) is a microprocessor-based, general purpose ohmmeter intended for field testing. It is powered by a removable battery pack. A battery charger is supplied with the instrument. A nylon pouch that contains the test leads snaps onto the lid of the instrument.

There are seven ranges for measuring resistance in various applications. Readings are displayed on a four-digit liquid crystal display (LCD). The DLRO stores 250 readings of test data. An RS-232 communications port is provided for transferring stored data to a personal computer.

The instrument has automatic and manual modes of operation. The automatic mode is the default setting requiring no switch selection. After the TEST button is pressed, the instrument checks for lead continuity and overvoltage condition before proceeding with the measurement. The microprocessor computes the average of a forward and reverse reading. The result is displayed and held/stored until the TEST button is pressed again. The manual mode operates with the test current flowing continuously. Manual mode has hold/store functions but no averaging capability.

Section 2 Safety

Safety Precautions

The DLRO and the recommended operating procedures have been designed with careful attention to safety. AVO International has made formal safety reviews of the initial design and any subsequent changes. This procedure is followed for all new products and covers areas in addition to those included in applicable ANSI standards. Regardless of these efforts, it is not possible to eliminate all hazards from electrical test equipment or to foresee every possible hazard which may occur. It is therefore essential that the user, in addition to following the safety rules in this manual, also carefully consider all safety aspects of the test before proceeding.

- Safety is the responsibility of the user.
- The instrument and battery charger have been designed in accordance with the IEC-1010-1 and ANSI/ISA-S82.01 standards. Refer to the Specifications section for details.
- Do not use this instrument in an explosive atmosphere. This includes battery rooms and enclosures.
- Do not use the instrument or any of the accessories on circuits above ground.
- To avoid electric shock, always wear rubber gloves when making connection to energized circuits.
- Do not use this equipment or its accessories for any purpose other than described in this manual.

Refer fuse replacement to qualified service personnel only. To avoid electric shock and fire hazard, use only the fuses specified in this manual that are identical in respect to type, voltage rating and current rating.

The battery charger for this instrument operates from a single-phase power source. It has a three-wire power cord and a two-pole, three-terminal grounding type connector. The voltage to ground from either pole of the power source must not exceed the maximum rated operating voltage of 250 V ac. Before making connection to the power source, determine that the charger voltage rating matches the voltage of the power source and has a suitable two-pole, three-terminal grounding type connector. The power input plug must be inserted only into a mating receptacle with a ground contact. Do not bypass the

grounding connection. Any interruption of the grounding connection can create an electric shock hazard. Determine that the receptacle is correctly wired before inserting the plug.

If the charger is not supplied with a power input plug, determine the color of the individual wires of the supply cord. Depending on whether the test set is supplied with a black, white and green input supply cord or a brown, blue and green/yellow supply cord, the black or brown cord lead must be connected to the live pole and the white or blue cord must be connected to the neutral pole of an approved power input plug. The green or green/yellow ground lead of the input supply cord must be connected to the protective ground (earth) contact of the input plug.

Explanation of Symbols Used on the Instrument

The following symbols are used on the instrument:



Use only in accordance with instruction manual.



Backlight for display

Warnings and Cautions

Warning and caution notices are used in this manual where applicable and should be strictly observed. These notices appear in the format shown below and are defined as follows:

Warning

Warning, as used in this manual, is defined as a condition or practice that could result in personal injury or loss of life.

Caution

Caution, as used in this manual, is defined as a condition or practice that could result in damage to or destruction of the equipment or apparatus under test.

Section 3 Specifications

Electrical

Read and understand the Safety section before operating the instrument.

DLRO

Table 1 delineates the ranges, resolution, and accuracy of the DLRO.

Table 1: Ranges, Resolution, and Accuracy

Range	dc Test Current Regulated $\pm 10\%$	Accuracy of Reading (1 year, 15 to 35°C)*	Resolution
200 Ω	100 μA	$\pm(0.25\% + 1 \text{ LSD})$	0.1 Ω
20 Ω	1.0 mA	$\pm(0.25\% + 1 \text{ LSD})$	0.01 Ω
2 Ω	10.0 mA	$\pm(0.25\% + 1 \text{ LSD})$	0.001 Ω
200 m Ω	100 mA	$\pm(0.25\% + 1 \text{ LSD})$	0.1 m Ω
20 m Ω	1 A	$\pm(0.25\% + 1 \text{ LSD})$	0.010 m Ω
2 m Ω	10 A	$\pm(0.25\% + 1 \text{ LSD})$	0.001 m Ω
200 $\mu\Omega$	10 A	$\pm(0.30\% + 2 \text{ LSD})$	0.1 $\mu\Omega$

* Accuracy of reading (1 year, 0 to 50°C) $\pm(0.5\% + 1 \text{ LSD})$

Allowable test lead resistance: 40 to 160 m Ω total

Power supply: Rechargeable battery pack with integral overload protection for each battery circuit. A 2.4-V circuit supplies the measure circuit and a 6.0-V circuit supplies the electronics.

Operating time: Depends on the mode of operation and the range selected. Maximum continuous (manual mode) operating time at 10 A test current is 30 minutes with battery at 100% capacity. At lower test currents, the operating time is 7 to 8 hours with battery capacity at 100%.

Battery life: Up to 500 charge/discharge cycles

Battery Charger

Input: 100 to 240 V, 50/60 Hz, 70 VA maximum

Charger has 8 ft (2.4 m) power cord with 13 in. (33 cm) of cord between the charger and the charger receptacle

Charges battery pack in 3-1/2 hours.

Accessories

Accessories supplied with the DLRO are listed in Table 2. Optional accessories are listed in Table 3.

Table 2: Accessories Supplied

Description	Part No.
10 ft (3 m) Current and potential duplex test lead set	33896
Battery charger, 100/240 V ac, 50/60 Hz with a line cord having a three-pronged, molded plug, identified as "North American" type, designated for 120 V ac, 60 Hz, U.S.A. receptacles. For other voltages, use a suitable grounded plug. Refer to tag on cord.	33650
Snap-on nylon pouch with Velcro closure to contain leads	25613-21
Instruction Manual	AVTM247701-J
Data Transfer Software	34393
Soft pack carrying case	218746

Table 3: Optional Accessories

Description	Cat. No. or Part No.
Spare battery pack for use with existing battery charger	33642
Spare 100/240 V ac, 50/60 Hz battery charger to charge spare battery pack when another battery pack is charging with supplied charger	33650
10 ft (3 m) Current and potential duplex lead set with remote test switch	242703-10
10 ft (3 m) Kelvin clip, light duty, duplex lead set with remote test switch	242705-10
20 ft (6 m) Kelvin clip, heavy duty, duplex lead set with remote test switch	242706-20
10 ft (3 m) and spikes helical spring point lead set with remote test switch	242711-10
Adapter block (for use with existing C/N 2420XX-XX test leads)	247710
Field test shunt, $10 \Omega \pm 0.25\%$, 0.001 A	249000
Field test shunt, $1.0 \Omega \pm 0.25\%$, 0.01 A	249001
Field test shunt, $0.10 \Omega \pm 0.25\%$, 1 A	249002
Field test shunt, $0.010 \Omega \pm 0.25\%$, 10 A	249003
Field test shunt, $0.001 \Omega \pm 0.25\%$, 100 A	249004
Field test shunt, $0.0001 \Omega \pm 0.25\%$, 500 A	249005
Certificate of Calibration, NIST	CERT-NIST

Section 4 Controls, Indicators, and Connectors

Control Panel

Figure 1 shows the control panel of the DLRO and the following controls and indicators.

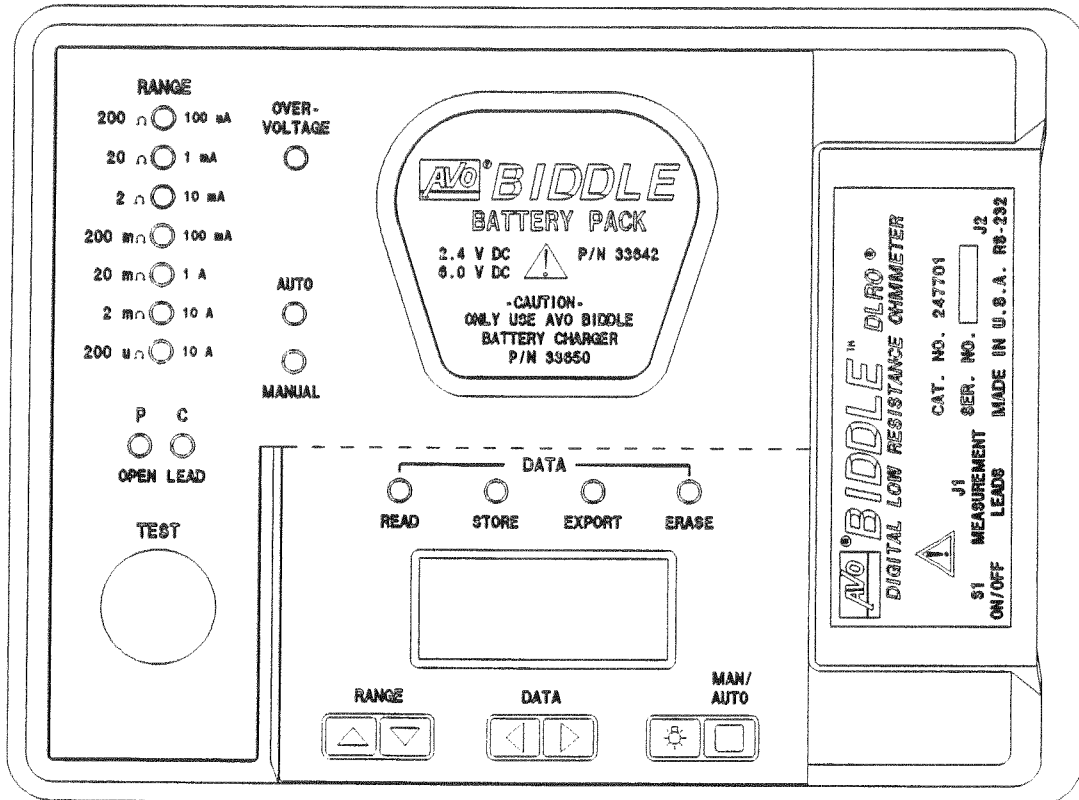


Figure 1: DLRO Control Panel

RANGE

Up and down arrow keys select the following measurement ranges, illuminating the corresponding red LED:

- 200 Ω /100 μ A
- 20 Ω /1 mA
- 2 Ω /10 mA
- 200 m Ω /100 mA
- 20 m Ω /1 A
- 2 m Ω /10 A
- 200 μ Ω /10 A

OPEN LEAD

The red P LED flashes to indicate that one or both potential leads are not connected properly.

The red C LED flashes to indicate that one or both current leads are not connected properly.

TEST

This green push button initiates testing when in the automatic mode. After the test is over, the push button must be pressed again to obtain a new reading. In the manual mode, the first press of this button initiates a “live” reading and the second press holds the reading. Subsequent depressions toggle between “live” and held readings. The TEST push button performs other functions that are described in detail elsewhere in this manual. If test leads with a remote test switch are used, the remote test switch performs in the same manner as this push button.

OVERVOLTAGE

This yellow LED flashes to indicate an overvoltage condition between C1-C2, P1-P2, or both.

AUTO

This green LED is illuminated when the instrument is set to operate in the automatic mode.

MANUAL

This green LED is illuminated when the instrument is set to operate in the manual mode.

Battery Pack

The battery pack is a molded unit that is removable for recharging. The unit is shipped fully charged.

Caution

Only use AVO Biddle Battery Charger P/N 33650.

DATA

Left and right arrow keys select the following functions and associated red LEDs.

READ	Displays the resistance reading and transmits the reading through the serial port.
STORE	Displays and stores the resistance reading. When flashing, this LED indicates that memory is full. The READ indicator is illuminated to allow testing to continue with no storage.
EXPORT	Transfers stored data to a personal computer.
ERASE	Erases all stored data.

DISPLAY

Illuminated, four-digit LCD displays resistance and messages. At start-up, the display shows the revision of the instrument software followed by the amount of remaining storage. The following messages are displayed when appropriate:

Table 4: Display Messages

Message	Description
Lo b	Low battery condition indicates that there are fewer than 2.5 minutes of operating time available.
OL	Overvoltage condition
Pc Er	Open potential or current leads
Hi r	Leads or sample have too much resistance in the measuring circuit for the instrument to operate properly.
Err3	No calibration information or bad calibration information on file (not fatal, but readings will be inaccurate). This message alternates with any reading being displayed. User calibration needed.
Err4	No data present. May be shown for export or erase when no data are available.
Err5	Calibration input value out of specifications. Probably a setup error. Only shown during calibration.
Err6	Readings did not settle during calibration. Probably a setup or hardware problem; otherwise, may be due to environmental conditions.
Err7	Factory calibration needed. (Press TEST button to continue.)
Err8	User calibration needed. (Press TEST button to continue.)
Err9	Stored test data corrupted—data lost.
Er10	Overflow of error queue. Too many errors.
Er11	The user interrupted the operation.
Er16	Measurement overrange.
l...	Measurement overrange.
ConF	Confirm request to erase data, save calibration data, or restore factory calibration data.

MAN/AUTO

Toggles operating mode between automatic and manual.

Backlight (light symbol)

This key turns the display backlight on and off. This key is the only functional key while the instrument is performing automatic measurements. The backlight will turn off automatically at the first indication of low battery power. To conserve battery charge, use the backlight only when necessary.

Right Side Panel

Figure 2 shows the right side panel of the instrument and the following control and connectors:

- J1
MEASUREMENT LEADS receptacle for connecting measurement leads or for connecting cord from adapter block option.
 - J2
RS-232 connection for transfer of data to a personal computer. This receptacle accepts a nine-pin serial cable (not supplied) for connection to a 25-pin connector on a personal computer.
 - S1
ON/OFF switch turns the instrument on and off.
- Annunciator
Provides audible feedback for instrument operations and conditions.

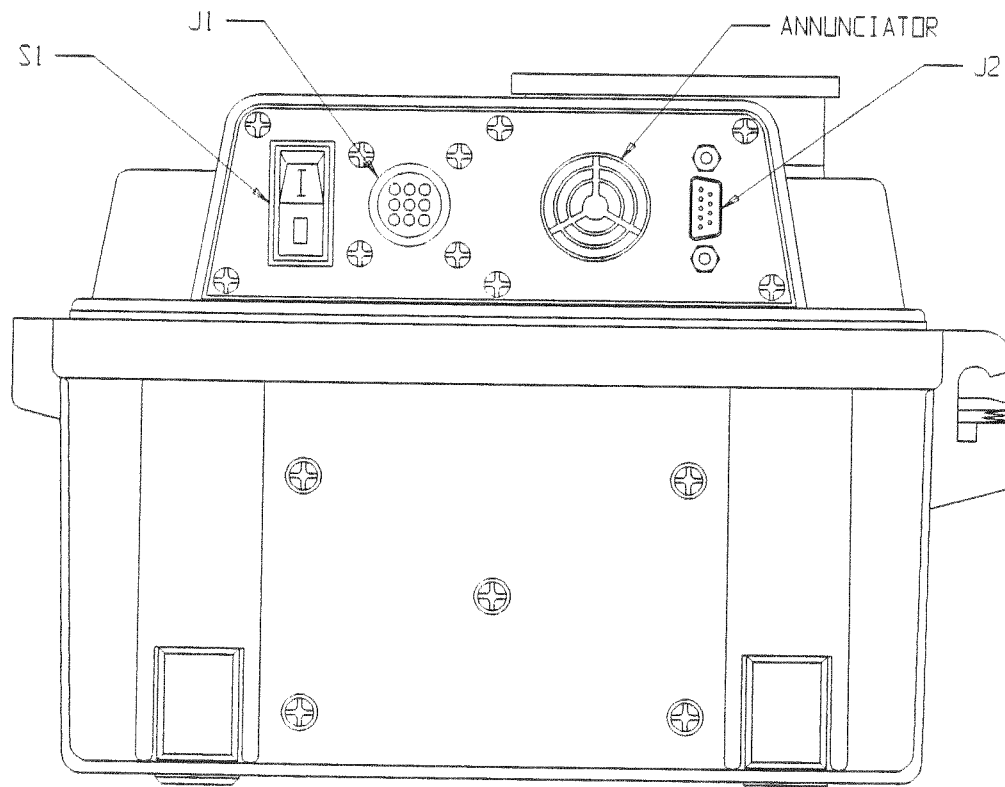


Figure 2: Side View Showing Connections

Section 5 Operation

Preparation for Use

Ensure that the battery pack is fully charged before testing. The easiest way to do this is to plug the battery pack into the battery charger and observe the LED. If you anticipate many long, continuous tests, AVO International recommends that you have a spare battery pack on hand.

Connections

Warning

Do not use the DLRO or any of the accessories on circuits in excess of 300 V above ground. To avoid electric shock, always wear rubber gloves when making connection to energized circuits. Do not use this instrument in an explosive atmosphere.

1. Attach plastic circular connector end of test leads to output connector J1 on side of DLRO or use the connector from the optional adapter block.
2. Connect test leads to the test specimen. The intended application determines the type and length of lead required. Refer to the Applications Section of this manual for information and typical test lead connections.

Automatic Measurements

Automatic mode frees the user from making calculations (averaging forward and reverse readings) and performs several pretest checks before the test current is applied to the specimen. Users less experienced in making DLRO measurements should select automatic mode to reduce errors. All users will benefit from the time savings that the automatic mode affords. Special measurement applications such as those requiring continuous test current should be performed in manual mode.

To operate the DLRO in the automatic mode, perform the following procedure:

1. Turn on the instrument by setting the ON/OFF switch S1 on the side of the instrument to | (on). The LCD/LED self-check is activated and applicable error messages may be displayed. The automatic mode is automatically selected. Observe that the green AUTO LED is illuminated.
2. Correct any problems indicated by displayed error messages or blinking LEDs (OPEN LEAD or OVERVOLTAGE) before proceeding with the test.

3. Press the RANGE up/down arrow keys to select the range. Corresponding RANGE LED will illuminate.
4. Press the DATA arrow keys to select READ (hold and serial port transmit, no store) or STORE (hold and store), as desired. A red LED illuminates to indicate the selection.
5. Press the TEST button to begin the test. All keys except the backlight are now disabled. The progress indicator will be displayed until the resistance has been calculated at which time the value is displayed and the annunciator beeps.

If the P and C leads are not properly connected before the test or become disconnected during the test, the display will show "Pc Er" and the annunciator will beep three times. P and C OPEN LEAD indicators will blink. Check connections and try again.

6. To start a new test, press the TEST push button.
7. Turn off the instrument by setting the ON/OFF switch S1 on the side of the instrument to O (off).

Warning

Due to the possibility of spark generation, do not remove the test probes from the specimen terminals or from the connector J1 (refer to Section 4, Controls, Indicators, and Connectors) unless the DLRO is turned off.

8. Disconnect test leads.

Manual Measurements

Manual mode allows the user to apply continuous current to the test specimen. The current will always be in the forward direction (C1 positive). Pretest checks will be performed. When the TEST push button is pressed, a continually updated reading is displayed. The reading can only be held when the TEST push button is pressed a second time. If the DATA function is set to STORE, the reading will also be saved.

Note: Test current will still flow as long as the leads are connected even when the reading is held. To leave manual mode, press the MAN/AUTO key.

1. Turn on the instrument by setting the ON/OFF switch S1 on the side of the instrument to I (on). The LCD/LED self-check is activated and applicable error messages may be displayed. Press the MAN/AUTO key until the green MANUAL LED is illuminated.

2. Correct any problems indicated by displayed error messages or blinking LEDs (OPEN LEAD, OVERVOLTAGE) before proceeding with the test.
3. Press the RANGE up/down arrow keys to select the range. The corresponding RANGE LED will illuminate.
4. Press the DATA left/right arrow keys to select READ (hold only) or STORE (hold and store), as desired. A red LED indicates the selection.
5. Press the TEST button. The display shows the resistance reading continuously.

Note: All keys are functional in manual mode. Any DATA function change after the start of testing will stop testing. Press the TEST push button again to start testing.

6. Press the TEST button again to hold the displayed reading. Subsequent depressions of the TEST push button will toggle the display between a “live” reading and a held reading.
7. Turn off the instrument by setting the ON/OFF switch S1 on the side of the instrument to O (off).

Warning

Due to the possibility of spark generation, do not remove the test probes from the specimen terminals or from the connector J1 (refer to Section 4, Controls, Indicators, and Connectors) unless the DLRO is turned off.

8. Disconnect test leads.

Using DATA Functions

The functions controlled by the use of the DATA left/right arrow keys are READ, STORE, EXPORT, and ERASE. Select the desired function in accordance with the following descriptions and instructions.

READ

Use READ when it is not necessary to save the readings. READ is automatically selected when the memory is full (250 readings).

1. Press the DATA left/right arrow keys until the red READ LED is illuminated.
2. Press the TEST push button.

Automatic mode: When the annunciator beeps, the reading will hold. The resistance reading will not be stored. The reading is transmitted to the serial port.

Manual mode: When the TEST push button is pressed (second time), the reading will hold. The resistance reading will not be stored.

STORE

Use STORE to save readings. Once the memory is full, it is necessary to erase the data before more readings can be saved. At turn-on, the number of remaining memory locations is displayed. The user can then decide if the data must be transferred to a personal computer or if there is enough space for the anticipated work load.

1. Press the DATA left/right arrow keys until the red STORE LED is illuminated.
2. Press the TEST push button.

Automatic mode: When the annunciator beeps, the reading will hold. The resistance reading will be stored.

Manual mode: When the TEST push button is pressed (second time), the reading will hold. The resistance reading will be stored. The reading is transmitted to the serial port.

EXPORT

Use EXPORT to transfer data to a personal computer.

Note: The user is responsible for providing an RS-232 interface cable. The DLRO Data Transfer software can be used to transfer data from the DLRO to a personal computer. The data can be formatted for Microsoft Excel™, Word™, or Notepad™.

1. Connect the interface cable to the RS-232 connection J2 on the side of the instrument and then to the serial port of the computer.
2. Press the DATA left/right arrow keys until the red EXPORT LED is illuminated. The number of stored readings is displayed.

Note: While the EXPORT LED is illuminated, but no active transfer is taking place, the only controls that will function are the DATA arrow keys, backlight key, MAN/AUTO key, and the TEST push button.

3. Press the TEST push button to transfer data. The display shows the transfer activity by counting down the number of stored readings to 0000. The time it takes for the transfer varies with the number of stored readings

Note: After the TEST push button has been pressed to start the transfer, only the backlight and MAN/AUTO keys will function. If for some reason the transfer must be canceled, press the MAN/AUTO key. The count will reset back to the original number of readings to be transferred. The MAN/AUTO key functions as a reset/cancel key when using EXPORT.

4. Press the MAN/AUTO key to reset the count and enable another transfer when the TEST push button is pressed again.
5. Press the DATA left/right arrow keys to leave EXPORT.

ERASE

Use ERASE to clear all stored resistance readings.

1. Press the DATA left/right arrow keys until the red ERASE LED is illuminated. The number of stored readings is displayed.

Note: While the ERASE LED is illuminated, the only controls that will function are the DATA arrow keys, backlight key, MAN/AUTO key, and the TEST push button.

2. Press the TEST push button. The display will show “ConF” to confirm the request to erase data.

Note: At this point, you may cancel ERASE by pressing either DATA arrow key or the MAN/AUTO key.

3. Press the TEST push button again to permanently erase all stored data.

Conserving Battery Charge

To conserve battery charge, turn off the DLRO when not in use. Use the automatic mode whenever possible. Switch off the display backlight when not needed. If “Lo b” is displayed while testing with high currents, switching to the next lower test current may extend test time.

Charging the Battery Pack

Use the line-operated battery charger supplied with the DLRO to charge the battery pack when necessary (as indicated by a “Lo b” display). Charging takes approximately 3-1/2 hours for fully discharged battery packs, less for partially discharged packs. Perform the following procedure:

Warning

Do not use the battery charger to try to charge batteries other than the battery pack supplied with the DLRO. An explosive/fire hazard may result. Also, do not use the battery charger in wet environment because of the risk of electrical shock.

1. Remove the battery pack from the DLRO and connect to charger receptacle.
2. Plug the battery charger power cord into a wall socket.
3. Observe that the red LED on the charger illuminates after approximately 3 seconds to indicate that charging is in progress. Charging is complete when the LED flashes. A fault condition is indicated if the LED is extinguished.
4. Unplug the charger from the wall and reinstall the battery pack in the instrument.

Section 6 Applications

Bonds in Parallel with Mechanical Connections

Pipelines

Pipeline specifications require that straps be secured between each section of pipe to ensure electrical continuity. This is accomplished by welding a copper jumper from one pipe to another to protect against corrosion due to ground currents.

Special power circuits may be connected to the bond circuit to introduce a current to oppose ground currents and prevent rusting of the metal pipes. To compensate for the ground current affecting the measurement, use the automatic mode to measure the correct resistance of the bond. However, if excessive ground current exists, switch to the manual mode to make the measurement. Make two measurements — one forward, one reverse by exchanging the positions of the probes and averaging the readings. Helical spring point leads (available as an option) are recommended for this application. Figure 3 shows the connections.

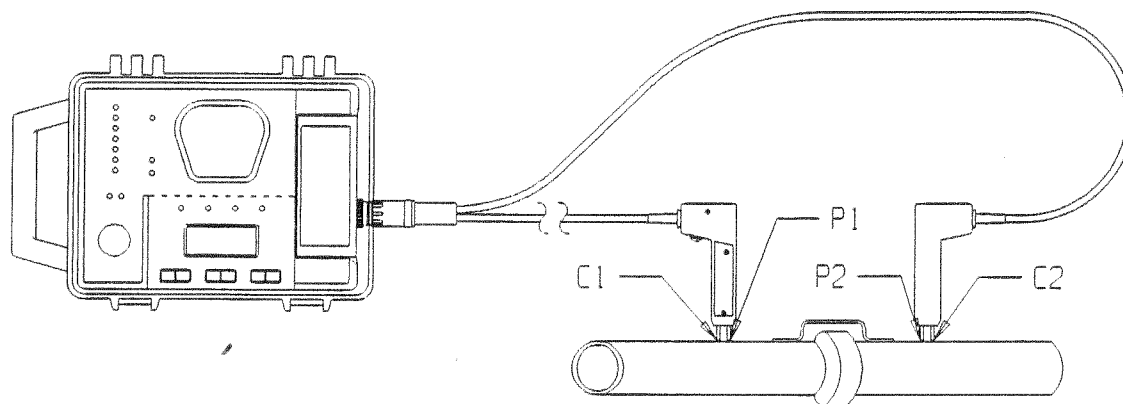


Figure 3: Testing Pipeline Bonds

Bus Bars

High current circuits use copper bus bars to conduct current within a plant. The quality of the lap joint connections in a bus bar system must be of high quality to prevent power losses due to excessive heating.

The mechanical connections must be clean and tightened to the correct torque level; if not, power losses will occur resulting in failure of the connection. Excessive torque may cause problems due to buckling of the parallel bars with a resulting increase in the resistance of the bond. A test of the circuit bond will measure the resistance across the connection.

Use the leads supplied with the DLRO to measure the resistance across copper bus bar bonds. Position the current leads upstream and downstream from the bond site. Then, position the potential leads at the bond site to measure the resistance. See Figure 4 for the connections.

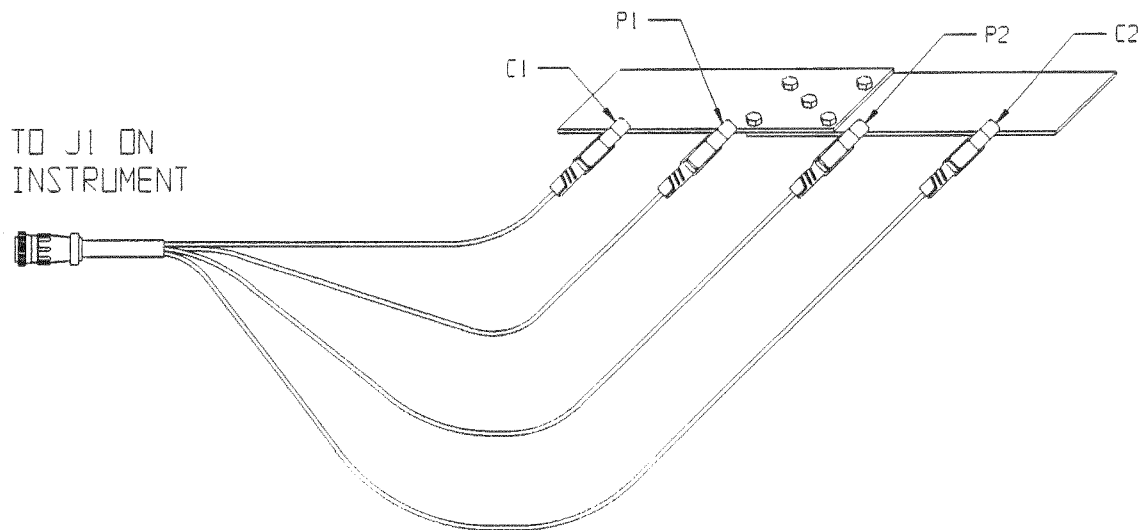


Figure 4: Testing Bus Bar Bonds

Battery Straps

Warning

To avoid electric shock, always wear rubber gloves when making connection to battery systems. Do not use on batteries with terminal voltage in excess of 300 V above ground.

Warning

Due to the possibility of spark generation at battery terminals, do not remove the test probes from the battery terminals or from the connector J1 (refer to Section 4, Controls, Indicators, and Connectors) unless the DLRO is turned off.

The resistance of intercell connections is critical to the successful operation of a battery-operated, power back-up system. In the smaller ampere-hour battery systems, the typical resistance of these connections will be measured in the 50 to 100 $\mu\Omega$ range. In the larger ampere-hour systems, the intercell connections will typically be in the 20 to 50 $\mu\Omega$ range. In either case, the DLRO can perform an on-line test using the 200 $\mu\Omega$ range.

Warning

Do not use in an explosive atmosphere. Battery rooms and other enclosures must be properly ventilated.

Caution

Do not attempt to measure across the positive (+) and negative (-) posts of a battery or cell.

The injection of the test current across the positive and negative terminals of the adjacent cells allows the operator to measure the characteristic resistance of the conductive path between terminals. The effects of float current on the measurement is taken into consideration by interchanging the positions of the test probes and averaging the two readings. The DLRO will automatically perform this averaging operation when set to the automatic mode.

Helical spring point leads are recommended for this application. See Figure 5 for the test setup.

Warning

When using the helical spring point leads, operate the DLRO only in the automatic mode. Wait for the DLRO to display a reading before removing the test probes from the battery strap. Use of the helical spring point leads with the DLRO in the manual mode does not facilitate safe operation because of the requirement to switch off the DLRO before removing the test probes.

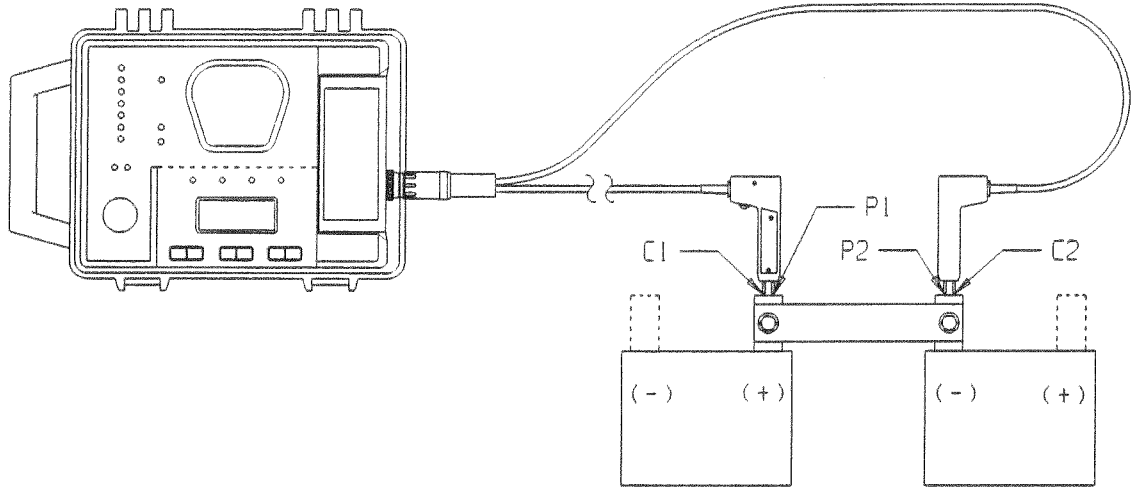


Figure 5: Testing Battery Straps

Circuit Breakers

The resistance of the closed contacts is measured to determine the quality of a circuit breaker. On three-phase circuit breakers, the resistance of each phase resistance is compared to the other phases. The resistance should be in balance for proper operation. When troubleshooting a circuit breaker, it is not only the mating contacts that are tested, but it is also important to locate internal linkage losses.

Heavy-duty Kelvin clamp leads (Cat. No. 242706-20, 6 m) are recommended for testing the overall performance of circuit breakers. Helical spring point leads (Cat. No. 242711-10, 3 m) are used to test components within the circuit breaker. These leads and others are available through the AVO International catalog. Figure 6 shows the setup for testing circuit breakers without current transformers using heavy-duty Kelvin clamp leads.

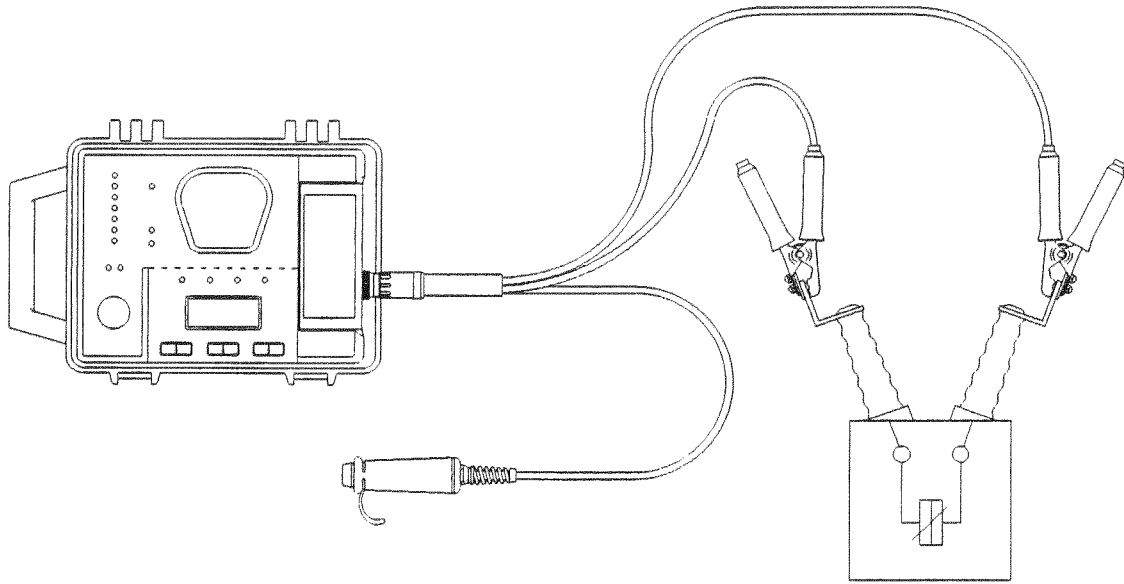


Figure 6: Testing Circuit Breakers

Wire Testing

The DLRO can be used to measure the resistance in ohms per foot or ohms per meter of a sample length of wire. Using this information, the amount of wire remaining on the spool or reel can be calculated. Kelvin clip leads are recommended for testing wire on spools or reels; the leads supplied with the DLRO are recommended for testing lengths of wire. See Figure 7.

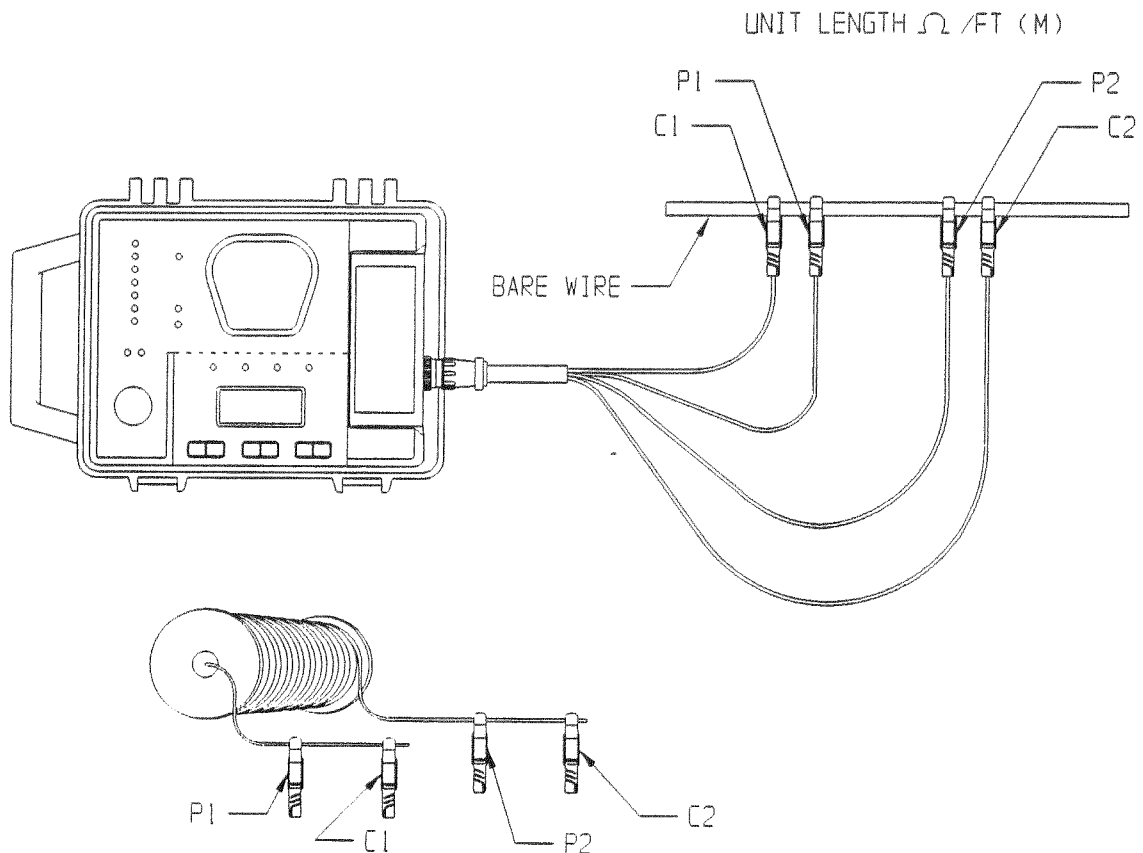


Figure 7: Wire Testing

Other Applications

Other applications include resistance measurements of welded bus bar joints, power fuse testing, welded seams, and rail joints in traction systems. The particular application will determine the type of leads and connections needed. Call (215) 646-9200 for information and applications assistance.

Interference

Alternating current interference in the sample under test can cause several digits fluctuation in a displayed reading. Interference can also be due to pickup in long test leads, especially in the vicinity of strong electric or magnetic fields. In these cases, fluctuation of the reading can sometimes be reduced by twisting the pairs of leads together. If interference is causing fluctuation in the display, the correct reading is the average of the highest and lowest readings.

A dc voltage in the item under test, however small, will produce an error in the reading. Such a voltage can be caused by ground currents in grounded items such as rails, pipes, etc., or by chemical or thermoelectric electromotive force (emf) in items made of dissimilar materials. If dc voltage interference is reasonably steady, this effect can be eliminated by taking a second reading with leads interchanged (C1 with C2 and P1 with P2) and averaging the first and second readings. When making a measurement of a totally new kind, interchange the C leads to determine whether there is any dc interference.

Section 7 Maintenance

Caution

Before performing maintenance on the DLRO, read, understand, and observe all safety precautions as indicated in Section 2, Safety. Maintenance should be performed only by qualified personnel who are familiar with the hazards involved.

Cleaning

Always turn off and disconnect the DLRO before cleaning. The instrument may be cleaned using a mild detergent and soft cloth. Do not immerse the DLRO in water or allow moisture to enter the case. Inspect leads for corrosion and wear.

Battery Pack

Warning

Do not intentionally short-circuit the battery terminals.

Individual cell replacement is not possible. The entire battery pack must be replaced when it will no longer accept a recharge.

Note: Dispose of the battery pack in an environmentally safe way.

The battery pack supplies the power for the DLRO. It contains two individual battery circuits: a 2.4-V battery supplies the test current and a 6.0-V battery supplies the electronics.

Depending on the type of testing, the batteries may discharge unevenly. For example, if the test current is set to 10 A and set to operate continuously in the manual mode, the 2.4-V battery will discharge in 30 minutes. This is not detrimental unless the instrument is consistently used only this way. The battery charger is a “smart” type charger, and when the pack is charged, the 6.0-V circuit will not be charged for as long as the 2.4-V battery.

However, repeated shallow charge/discharge cycles tend to lower the capacity of nickel-cadmium batteries (the so-called “memory effect”). Therefore, we recommend that the user occasionally balance the capacities by performing the following procedure.

Determine the typical use. Is the instrument used mostly on high-current or low-current settings?

If the instrument is used primarily on high-current settings, the 6.0-V battery may not be receiving adequate discharge. In this case, charge the battery pack. Then replace the

battery pack in the instrument and turn on the instrument. Do not connect leads. Let the battery pack run down. This should take approximately 8 hours.

If the instrument is used primarily on low test current settings, after charging, insert the battery pack into the instrument. Connect the test leads and short the C1 and C2 leads together and the P1 and P2 leads together. Turn on the instrument, set to operate in the manual mode, and select 1 A test current. Let the battery pack run down. This should take approximately 7 hours.

Battery Charger

The battery charger has no user serviceable parts. In the event of a problem, return the charger to AVO International for repair as described in the Repair section.

Calibration

Note: Read the entire calibration procedure before attempting calibration. Make sure that the battery pack is fully charged before beginning calibration.

The following equipment is required:

<u>Resistor</u>	<u>Tolerance</u>
200 Ω	0.05% or better
20 Ω	0.05% or better
2 Ω	0.05% or better
0.2 Ω	0.05% or better
0.02 Ω	0.05% or better
0.002 Ω	0.05% or better
0.0002 Ω	0.05% or better

To calibrate the DLRO, perform the following procedure:

1. While the instrument is in the automatic or manual mode (but not performing tests), simultaneously press and release the following three keys: DATA left arrow, backlight, and MAN/AUTO.
2. Respond to the display prompt "PASS" (password) by sequentially pressing:
 - a. Backlight key
 - b. MAN/AUTO key
 - c. DATA right arrow
 - d. DATA left arrow
 - e. TEST push button

After the password is entered, there will be a brief delay. If the keystrokes comprising the password are not correctly entered, then the instrument returns to the normal operating screen from which a test can be started. If the password is correctly entered, then the instrument displays “Hi” alternating with “Cal.” This is the first half of a calibration cycle. For this cycle, connect the C1 and C2 leads to the C terminals of the appropriate calibration standard. For example, use the 200- Ω standard for the 200- Ω range, etc. Connect the P1 and P2 leads together.

The second half of the calibration cycle shows the display “Lo” alternating with “Cal.” For this cycle, leave the C leads connected and connect the P1 and P2 leads to the P terminals of the calibration standard. Repeat the sequence for each range.

3. Press the RANGE arrow keys to select the range to be calibrated. The highest range (200 Ω) is selected by default. During calibration, the instrument automatically advances through the ranges.

A cycle consists of a “Hi Cal” and a “Lo Cal” for each range. The display indicates that calibration is in progress and the amount of completeness for the range being calibrated. Different ranges take different amounts of time to calibrate. When the “Hi Cal” has been set for the range, the display will show “Lo” alternating with “Cal.” Press the TEST push button again to continue calibrating.

When the “Lo Cal” has been set for the range, the instrument will beep once and display “donE” for a second or two. The RANGE LED will then move to the next range to be calibrated.

Note: All user calibrations are stored separately from the original factory calibrations so that factory calibrations can be restored.

4. To save and exit, press both DATA arrow keys simultaneously. The display will show “ConF.” Then, press the TEST push button to save the calibrations performed and exit the calibration mode.

To discard all calibration settings from this session, press the RANGE up arrow and the MAN/AUTO keys simultaneously. The previous calibration settings will be restored. Then press any other key to return the instrument to previous settings before saving and exiting.

Restoring Factory Calibrations

To restore factory calibrations at any time, perform the following procedure:

1. While the instrument is in the automatic or manual mode (but not performing tests), simultaneously press and release the following three keys: DATA left arrow, backlight, and MAN/AUTO.

2. Respond to the display prompt “PASS” (password) by sequentially pressing:
 - a. RANGE up arrow
 - b. TEST push button
 - c. MAN/AUTO key
 - d. TEST push button.

After the password is entered, there will be a brief delay. If these keystrokes comprising the password are not correctly entered, then the instrument returns to the normal operating screen from which a test can be started. If the password is correctly entered, then the instrument displays “ConF.”

3. Press the TEST push button to restore all factory calibrations. Pressing any other key will abort this operation.

Lead Continuity Adjustments

Note: Removal of the instrument from its case and any adjustments should only be performed by qualified personnel.

Internal adjustments are rarely required, however, changes due to normal component aging may require adjustments to be made. Before removing the instrument from its case, verify that an adjustment is truly required. For verification and actual adjustment, the following equipment is required:

- Digital multimeter capable of measuring true rms ac voltage
- Decade box with X 100 Ω and X 1 k Ω dials or
- One 800- Ω , 1% resistor
- One 1-k Ω , 1% resistor
- One 1.2-k Ω , 1% resistor

To verify the need for lead continuity adjustment, perform the following procedure:

1. Connect the standard test leads to the DLRO at connector J1.
2. Turn on the DLRO.
3. Connect the C1 and C2 leads across the decade box and set box to 1 k Ω . Short the P1 and P2 leads together. Both P and C OPEN LEAD LEDs should be extinguished. If the C OPEN LEAD LED is blinking, then skip to step 5.
4. Set decade box to 1.2 k Ω . The C OPEN LEAD LED will blink. Adjustment is not required. If the C OPEN LEAD LED does not blink, adjustment is required. Follow the adjustment procedure.

5. Set decade box to 800 Ω . The C OPEN LEAD LED should not blink. Adjustment is not required. If the C OPEN LEAD LED does blink, adjustment is required. Follow the adjustment procedure.
6. Repeat the preceding steps for the P1-P2 leads except connect the P1 and P2 leads across the decade box and short the C1 and C2 leads together. The LED references will now pertain to the P OPEN LED. Turn off the DLRO when verification is complete.

To adjust the lead continuity circuit, perform the following procedure:

Note: Before removing the rubber feet from the instrument, make sure that replacement feet are available or a suitable adhesive is available to refasten the original rubber feet.

1. Remove the rubber feet from the bottom of the instrument case to expose four screws. Remove these four screws and set aside.
2. Carefully lift the internal workings out of the case.
3. Locate the three potentiometers R5, R6, and R7 (output board). See Figure 8
4. Locate test points TP10 and TP21 also on the output board.
5. Connect the standard test leads to the DLRO at connector J1.
6. Connect the multimeter to TP10 and TP21. Set the meter to measure ac on the 20-V range. Remember to use a true rms responding meter.
7. Turn on the DLRO.
8. Adjust R5 for a reading of 4.24 V on the digital multimeter.
9. Connect the C1 and C2 leads across the decade box and set box to 1 k Ω . short the P1 and P2 leads together.
10. Adjust R6 until the C OPEN LEAD LED is just extinguished (no blinking).
11. Set decade box to 1.2 k Ω . The C OPEN LEAD LED will blink.
12. Connect the P1 and P2 leads across the decade box and set box to 1 k Ω . Short the C1 and C2 leads together.
13. Adjust R7 until the P OPEN LEAD LED is just extinguished (no blinking).

14. Set decade box to 1.2 k Ω . The P OPEN LEAD LED will blink.
15. Carefully install the instrument back into the case. Install the four case screws and replace the rubber feet.

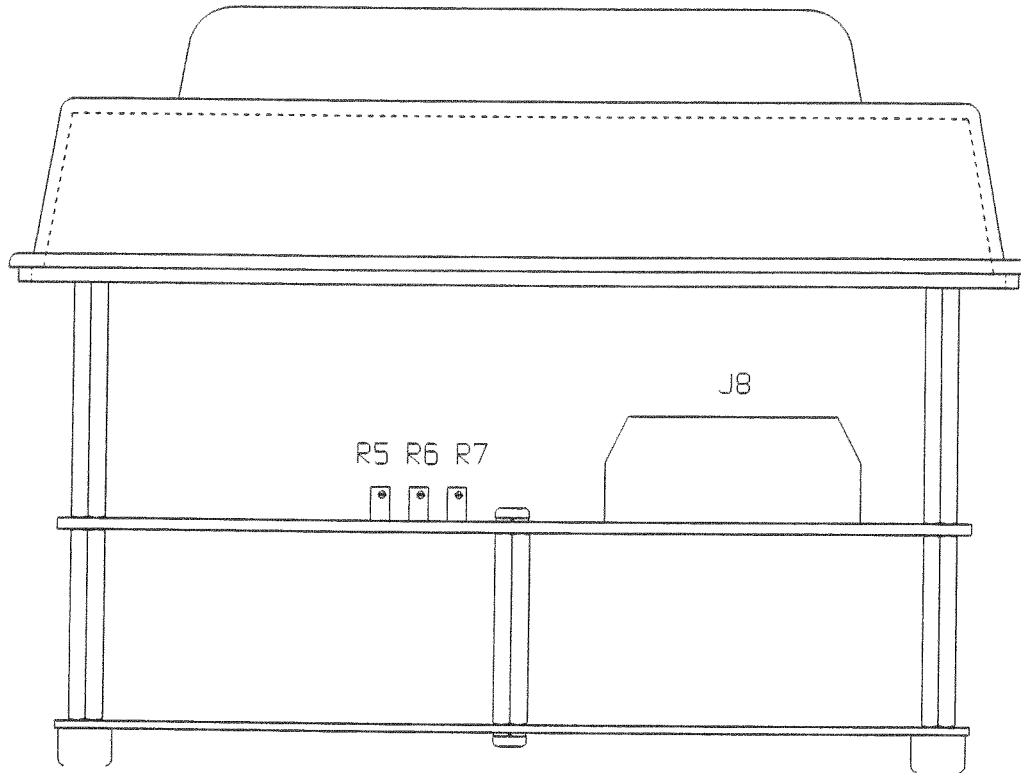


Figure 8: Location of Potentiometers

Repair

AVO International offers a complete repair service and recommends that its customers take advantage of this service in the event of any equipment malfunction. Call the repair department at 1-800-641-2349 to obtain a return authorization number (RA#) before shipping the instrument. Please include all pertinent information including the RA#, the catalog number, the serial number, and a description of the problem. Equipment returned for repair must be shipped prepaid and insured and marked for the attention of the repair department.

Appendix Adapter Block Option

The adapter block option (Cat. No.247710 including mounting hardware) allows the DLRO to be used with existing Cat. No. 2420XX-XX test leads. Wing-nut terminals marked TEST A and B are for connecting a user-supplied remote test switch.

To install the adapter block on the right side of the DLRO case, perform the following steps using a #2 Phillips head screwdriver:

1. Remove four perimeter screws from the right side of the DLRO case. Do not remove a fifth screw situated in the middle of the other four because it secures an internal mounting plate to the inside of the case.
2. Pry off two square rubber feet from the side of the case.
3. Attach the adapter block to the side of the DLRO by fastening two long screws with lock washers and flat washers through the assembly into the bottom two holes and two shorter screws with lock washers and flat washers through the assembly into the top two holes.
4. Connect the other end of the attached cable to receptacle J1 MEASUREMENT LEADS.

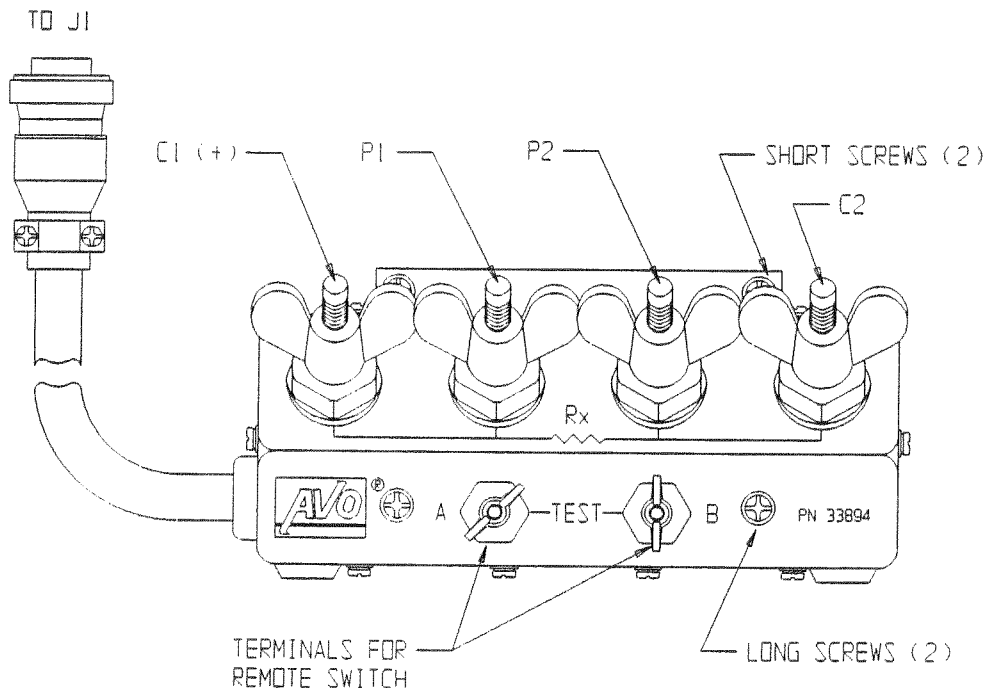


Figure: Adapter Block Option

Warranty

Products supplied by AVO International are warranted against defects in material and workmanship for a period of one year following shipment. Our liability is specifically limited to replacing or repairing, at our option, defective equipment. Equipment returned to the factory for repair must be shipped prepaid and insured. This warranty does not include batteries, lamps, or other expendable items, where the original manufacturer's warranty shall apply. We make no other warranty. The warranty is void in the event of abuse (failure to follow recommended operating procedures) or failure by the customer to perform specific maintenance as indicated in this manual.

MANUAL: AVTM247701J

DATE: 2/12/98