HIGH ACCURACY MICROOHMMETER AND RTD MONITOR

MODEL R1L-D1

Operation and Maintenance Manual

PN# R1L-D1-900-01
Publication Date: March 2017
REV. H

Applies to serial numbers 10100 and above for units purchased under U.S. Government contract, and serial numbers 2010114R1L-D1 and above for all other units. This manual supersedes all revisions of *Operation and Maintenance Manual (Commercial Version)*, PN R1L-D1-900-02.

NOTE: This User's Manual was as current as possible when this product was manufactured. However, products are constantly being updated and improved. To ensure you have the latest documentation, please refer to www.tegam.com.

10 TEGAM WAY • GENEVA, OHIO 44041 • 440-466-6100 • FAX 440-466-6110
• sales@tegam.com

(Inside of Cover, intentionally blank)

10 TEGAM WAY • GENEVA, OHIO 44041 • 440-466-6100 • FAX 440-466-6110
• sales@tegam.com

TABLE OF CONTENTS

SECTION 1

INSTRUMENT DESCRIPTION

INTRODUCTION

1.1 Purpose

The Model R1L-D1 is a portable microohmmeter designed to measure low resistances and resistance temperature detectors (RTD's) with high accuracy. Normally, 4-wire measurements are utilized in order to eliminate any errors caused by the lead resistance. Additionally, 2 or 3-wire measurements may be made. Two leads are used to pass a regulated current through the resistance under test in series with an internal precision calibrated resistor. Two separate leads are used to measure the voltage drop across the external resistor; this voltage is then compared with the voltage drop across the internal resistor. The value of the external resistor is then calculated from the ratio of these two voltage readings. A microprocessor, with TEGAM proprietary firmware functions, performs all calculations such as range selection, display information etc.

1.2 Performance Characteristics

This is an automatic range-selection instrument, with manual over-ride of one range step.

Range	Full Scale (Ω)	Resolution (Ω)	Test Current Peak (mA)
1	0.199999	1 µ	50
2	1.99999	10 µ	50
3	19.9999	100 µ	50
4	199.999	1 m	0.5
5	1999.99	10 m	0.5

Table 1: Ranges

Accuracy:
Accuracy of all resistance measurements are affected by the test leads unless 4-wire Kelvin measurement connections are used.

Range	Full Scale (Ω)	4-Wire Kelvin	3-Wire	2-Wire	Test Current
1	0.199999	±0.05% ±15 LSD*	Not Specified	Not Specified	50 mA
2	1.99999	±0.05% ±2 LSD*	Not Specified	Not Specified	50 mA
3	19.9999	±0.05% ±1 LSD*	Not Specified	Not Specified	50 mA
4	199.999	±0.05% ±1 LSD*	±0.05% ±1 LSD*	±0.05% ±1 LSD*[1]	0.5 mA
5	1999.99	±0.05% ±1 LSD*	±0.05% ±1 LSD*	±0.05% ±1 LSD*[1]	0.5 mA

*LSD= Least Significant Digit
[1] Does not include test lead or contact resistance

Table 2: Specifications

When making low resistance measurements, variables such as test lead resistance, contact resistance of all the connections, as well as ambient temperature will affect the measurement accuracy. When using 4-wire connections, these effects are minimized.

When making 2 and 3-wire measurements, even if all the test leads are of known value, the variables of temperature and contact resistance remain unpredictable and will add to the uncertainty of the measurement. The R1L-D1 accuracy is not specified for 2 and 3-wire mode on ranges 1 to 3. This does not mean that the R1L-D1 cannot be operated in these ranges, but the user needs to be aware of the issues and compensate for the variables that affect measurement accuracy outside of the instrument. Errors that can be introduced at these resistance levels will likely result in measurement accuracies beyond the intrinsic accuracy of the R1L-D1. Therefore the accuracy specification is not given.

3-wire operation balances the resistance of one lead against a second lead, compensating for the lead resistance as long as the leads are identical. Therefore in 3-wire mode, the test leads and their connections must be of identical resistance

and composition or the measurement accuracy will be negatively affected.

Operating an ohmmeter with two wires results in lead resistance, which is in series with the resistor under test, being added to the unknown resistance. Further, copper wire resistance has a large temperature coefficient. Two leads of relatively heavy 18 gauge wire, each 8 feet long, will add approximately 0.1 Ω to the measured value. Therefore, 2-wire operation should not be used with low-value resistors, without subtracting the resistance of the test leads.

Note that the R1L-D1 is a 5 ½ digit instrument in order to provide 10 mΩ resolution when reading 1060 Ω RTD's. On lower ranges, this provides finer resolution, down to 1 µΩ on the 0.1 Ω range. However, with a maximum of 50 mA of test current, the voltage signal for 1 µΩ is only 0.05 µV, easily obscured by noise picked up in the leads. Thus, it should not be expected to read one count accurately on the low resistance ranges.

This unit will operate over a temperature range from 0 to 50 °C. This unit will comply with the requirements of MIL-PRF-28800 Class 3 for shipboard applications.

1.3 Description of Equipment

Physical: A rugged heavy-duty case is provided to contain and protect the instrument. When closed, a gasket seals the lid to protect the instrument against water and dirt while the instrument is carried through rainstorms or other hazardous conditions. When the lid is open, for operation of the instrument, a second gasket provides additional, although reduced, protection. Feet are molded into the bottom of the case and projections provide for stacking several units high during temporary storage.

Dimensions: 356 mm (14”) x 269 mm (11”) x 153 mm (6”). Weight is 3.6 kg (8 lb). With the lid open for operation, the front panel and its controls are readily accessible. Controls

and connectors are of a size and spacing such that the instrument may be operated while wearing safety gloves.

Electrical: Power is from five rechargeable Ni-Cad C-cells, rated at 3000 mA-hours each, series-connected. Nominal voltage is 1.2 V each, totaling 6.0 V. Current drain varies with range and back-lighting; but is approximately 20 mA with no connection, providing approximately 140 hours of operation when fully charged. To charge the battery, check that the mains input module is set to the correct voltage, plug the line cord into the front panel AC receptacle, with the other end connected to a source of AC power. See Section 2.2. The battery will be charged (from a discharged condition) in less than 8 hours; no damage will occur if charged for a longer period. Charging power consumption from nominal AC power line is less than 10 W average. This instrument may be operated while connected to the AC line without damage.

Front Panel Controls and Displays (See Figure 1)

MODE pushbutton, is used to select 4-wire, 3-wire, or 2-wire operation. When power is first turned on, the default is to 4-wire operation. Successive operations of this pushbutton will step the unit through 3-wire and 2-wire operation, then back to 4-wire operation. Note that this is indicated on the display by a 4, 3, or 2, at the left end of the display.

RANGE pushbutton. Note that the R1L-D1 selects the proper range automatically, but the RANGE pushbutton may be used to step through all five ranges, plus auto-range, manually.

BACK-LIGHT pushbutton. One operation turns the back-light of the display on. A second operation turns the back-light off.

POWER pushbutton (alternate action). One operation to turn the power on, and a second operation to turn the power off. Note that the display may be used as an indication that power is on.

DISPLAY is a 16 character alphanumeric back-lit LCD. The first character, a 2, 3 or 4 indicates 2, 3 or 4-wire measurement. The next four characters will normally be "WIRE"; however, they will also read "OVER", if over-range, or "BATT", for low battery voltage. The sixth character is either blank or an asterisk, which indicates auto-range. The next seven characters display the resistance reading (six digits and the decimal point). Note that while auto-ranging, this block of characters will read "RANGE". The final characters (to the right) display the Ω symbol, with the prefix k or m, as required for kΩ or mΩ.

Note that although the front panel lists the two lowest ranges as 0.2 and 2 Ω for the sake of simplicity, the display shows them as 200.000 and 2000.00 mΩ. Also, as is typical of digital voltmeters, full scale readings are rounded off as 2xxx, but actual full-scale readings are 1.99999, etc.

A front panel LED marked "AC POWER" indicates that AC power is connected.
A front panel LED marked "BATTERY CHARGING" indicates that the battery is in fast charge mode. If the unit is connected to AC power and this LED is not on, the Batteries are in trickle charge mode.

Four binding posts for connection of test leads are marked +I, +E, -E, and -I. Proper connections to the resistor under test are described in Section 2.2 below.

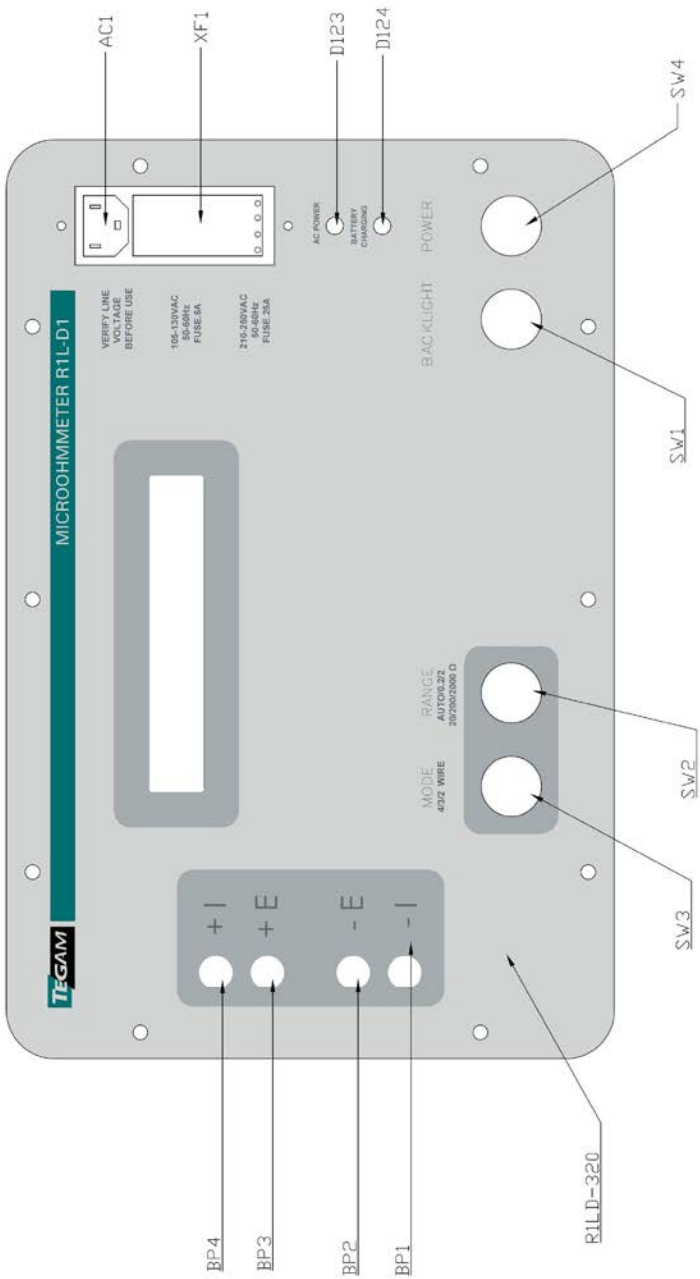

Figure 1: Front Panel Layout

1.4 List of Items Furnished

1 each Model R1L-D1 with power cord
5 each NiCad battery cells.
1 each Instruction Manual.

1.5 Tools and Test Equipment Required for Maintenance

Soldering iron, solder, Phillips No. 1 & 2 screwdriver and a small flat-bladed screwdriver.
Test equipment: See Section 4.3 below.

1.6 Storage and Shipping Requirements

The R1L-D1 should be stored in a relatively dust free environment.
Temperature: -40 to +71 °C.
Relative humidity: 0 to 100%, non-condensing.
See Section 4.7 below for shipping requirements.

SECTION 2

PREPARATION FOR USE AND INSTALLATION

2.1 Unpacking and Inspection

Upon receipt, the R1L-D1 should be carefully unpacked and removed from the shipping container. Separate the units from the packing material and inspect both the instrument and the accessory kit for any external damage.

- If any dents, broken, or loose parts are seen, do not use the equipment. Notify TEGAM immediately.

2.2 Preparation for Use

- Release the two latches which secure the lid of the Model R1L-D1, and open the lid. Since the lid is well gasketed, it may be difficult to open if there is an appreciable difference between internal and external air pressure.
- Note that the instrument is shipped with its battery removed. Unwrap the five NiCad C-cells which comprise the battery.
- Inspect the MAINS power entry module and make sure that it indicates the proper voltage for the MAINS to be used (120 or 240 VAC).

MAINS Setup

If the mains voltage is not correct, proceed as follows:

a. Pry the top of the MAINS cover open by inserting a flat bladed tool at the top of the module just down from the mains terminals.

b. Remove the fuse assembly and replace the fuse with the correct one.
For 115 VAC operation: FU-203; Bussman AGC 0.5 A / Littelfuse 0312.500 (Fast Blow)
For 230 VAC operation: FU-1804-2; Bussman GDC 0.25 A / Littelfuse 0218.250 (Slow Blow)
The single 1/4"x1.25" 0.5 A 120 V fuse goes on one side

of the fuse holder (the side with the metal jumper), and the dual 5x20mm fuses get installed on the other side.

c. Pull the voltage selector card from its slot at the bottom end of the mains entry module and reposition the plastic indicator for the required mains voltage (120 or 240).
d. Insert the voltage selector card back into its slot such that the plastic indicator is at the top of the module assembly.
e. Close the door and note that the indicator pin now indicates the correct mains voltage. If it is not indicated properly, then remove as in points a to d and ensure that the proper voltage is selected.

Battery Installation

Remove the ten screws around the outside edge of the panel, which secure the instrument to the case. The instrument may now be lifted out of the case by holding the binding posts.

WARNING

DO NOT CONNECT THE AC LINE CORD PRIOR TO REMOVING THE UNIT FROM ITS CASE OR WHILE THE UNIT IS OUT OF ITS CASE, OR ELSE THE MAINS VOLTAGE WILL PRESENT A POSSIBLE SHOCK HAZARD.

CAUTION

DO NOT OPERATE THIS INSTRUMENT WITHOUT ITS INTERNAL BATTERY.

Remove the four screws holding the battery cover to its mounting spacers and install the five C-cells in their holder at the bottom of the instrument; be sure to install them with the correct polarity, as marked on the holder. While installing the cells, rotate them lightly to ensure connection to the holder contacts.

After installing the cells, reinstall the battery cover with its four screws, and reinstall the instrument in its case and secure the ten mounting screws.

To charge the battery before use, use the power cord appropriate for the mains (120 VAC cord supplied). Allow approximately 8 hours for a full charge; the "BATTERY CHARGING" LED will turn off when the battery is fully charged. After charging, remove the power line cord, although no harm will result if it is left plugged in. Note that with a fully discharged battery, the charger may turn off after a few minutes (because the rapid increase in voltage could be interpreted as the fully charged condition). If that occurs, unplug the power cord briefly and then plug it in again; the unit should now charge for several hours.

WARNING

ALTHOUGH THE FRONT PANEL IS NORMALLY GROUNDED VIA THE GROUND PIN OF THE POWER CABLE, IF THIS CONNECTION IS FAULTY AND IF THE HIGH SIDE OF THE POWER CABLE IS SHORTED TO THE PANEL, THE PANEL COULD POSSIBLY HAVE MAINS VOLTAGE ON IT; SO DO NOT TOUCH THE PANEL WHEN AC POWER IS CONNECTED.

Connection to Resistor under Test

Connect the resistor under test to the 4 front-panel binding posts as follows:

For 4-wire operation, connect the +I and +E binding posts to one end of the resistor under test and -I and -E to the other end of the resistor under test.
For *3-wire operation*, connect +I and +E to one side of the 3-wire RTD and connect –I to the other side of the RTD. –E is not connected.
For 2-*wire operation*, use +I and –I, +E and –E are not connected.

WARNING

DO NOT TOUCH THE BINDING POSTS WHEN THEY ARE CONNECTED TO EXTERNAL CIRCUITS. LETHAL VOLTAGES MAY BE PRESENT AT THESE POSTS.

SECTION 3

OPERATING INSTRUCTIONS

The R1L-D1 is designed for bench-top or field operation. Use the cables (available from TEGAM), connecting their banana plug terminations to the four binding posts marked +I, +E, -E, and -I. Set the shorting bar so that it does NOT connect -I to -E, unless you plan to make 2 or 3-terminal measurements. Note that the test current is actually AC, and the + and - indications are used only to signify HIGH and LOW, as well as to indicate that the +E and +I go together and the -E and -I go together.

3.1 Pushbutton Functions

Operation of the Model R1L-D1 is essentially automatic and extremely simple. There are only four pushbuttons, three momentary and one latching.

The MODE pushbutton selects 4-wire, 3-wire, or 2-wire operation. When power is turned on, it defaults to 4-wire operation. Successive operations of this pushbutton will step the unit through 3-wire and 2-wire operation, then back to 4-wire operation. Note that this is indicated by a 4, 3, or 2 at the left end of the display.

The RANGE pushbutton will manually scroll through the five ranges and auto-range. Default condition when power is turned on is Auto-range. In Auto-range, the R1L-D1 automatically steps thru the ranges until the displayed signal is between 20,000 and 199,999 counts. An asterisk in the sixth character of the display indicates auto-ranging.

Full scale on any range may be described as 200,000 (actually 199,999), since this is a 5 ½ digit meter. If the unit sees readings exceeding 199,999 counts, it will automatically step to the next higher range. If it sees readings less than 20,000 counts, it automatically steps down a range, so that

it will read 199,999 counts, or less. The decimal point is located automatically for the correct reading.

Thus, it is not necessary to use the RANGE pushbutton. However, if a specific range is desired for any reason, depress the RANGE pushbutton several times to step through the five ranges. The first step after Auto-range is the 0.2 Ω range; each step following is to a higher range, as seen on the display. After the 2 k range, the next step is to Auto-Range, again. If the selected range is too low for the value of the resistor under test, the display will show over-range.

Note that if a resistor value is very close to 200,000 counts, the unit may cycle between 199,999 on one range and 20,000 counts on the next lower range. If that should occur, use manual ranging and set it to the lower range reading 20,000 counts.

The BACK-LIGHT pushbutton turns on the back-light behind the display, to be used only in dim light, because it does increase the drain on the battery. The back-light will stay on until turned off by a second operation of the back-light switch or until power is turned off. When power is turned on, the default condition is back-light off.

The POWER pushbutton turns on the power to operate the unit. This is an “alternate-action” (latching) pushbutton; a second operation turns the power off. The appearance of the display will show that power is on; absence of the display indicates that either power is off, batteries are discharged, or there is some malfunction. Note that when power is turned off, it may take several seconds to discharge circuit capacity to completely blank the display. The black markings seen have no effect and disappear when power is turned back on.

CAUTION

DO NOT USE EXCESSIVE FORCE TO OPERATE ANY OF THE PUSHBUTTONS. POWER OFF DOES NOT OCCUR UNTIL BUTTON IS RELEASED.

3.2 2, 3, and 4-Wire Operation

See Section 2.2 for connection instructions.

Operating an ohmmeter with two wires results in the lead resistance, which is in series with the resistor under test, being added to the unknown resistance. Two leads of relatively heavy 18 gauge wire, each 8 feet long, will add 0.1 Ω to the measured value. Obviously, 2-wire measurement should not be used with low-value resistors, without subtracting the resistance of the test leads. Accuracy is reduced with 2 or 3-wire operation.

3-wire measurement balances the resistance of one lead against a second lead, compensating for the lead resistance if the leads are identical. It is better than 2-wire measurement, but not as good as 4-wire.

4-wire measurement uses two leads to deliver (and return) the test current to the resistor under test. The two voltage leads are then used to measure the I x R drop directly at the unknown resistor. This is the most accurate method of measuring small values of resistance.

SECTION 4

MAINTENANCE

4.1 Inspection

These units should be inspected semi-annually. Check that the case opens and closes with no binding. Check that the four pushbuttons rate smoothly. Check all four binding posts to ensure that they operate smoothly.

4.2 Cleaning

The instrument should be cleaned periodically, as is necessary, using mild soap and a damp cloth both on the outside of the case and on the front panel. No lubrication is required.

4.3 Test Equipment Required for Calibration and Repair

Calibration of the R1L-D1 is recommended on a yearly basis, and is done at a temperature of 23 ± 1 °C.

A computer with RS-232 interface and with terminal emulation software such as HyperTerminal.

Precision decade resistance box covering the range from 0.1 Ω to 1.06 k, such as a PPM, Inc., Model R6-111.111K, or equal. Required accuracy is ± 0.01% of setting + 0.002 Ω.

*For equivalent R1L-D1 calibrator box use the following resistors:

Calibrator position	nominal resistance
1	0.100000
3	1.000000
5	10.00000
7	100.0000
9	1000.000

A standard digital voltmeter (accuracy of 0.01% of reading, or better) and an oscilloscope (bandwidth of 50 MHz, or more). Suggested voltmeter is a Keithley Model 2000; suggested Tektronix oscilloscope Model TDS 360.

Variable 4-7 V DC Power Supply, at 1.0 A min.

Thin Nylon Battery Terminal Insulating Strip

4.4 Performance Verification

1. Connect the four binding posts to the precision decade resistor box. For 4-wire hook-up, use banana plugs to connect the +I lead to the top of the "High" binding post and -I to the top of the "Low" binding post. Use spade lugs to connect the +E lead to the bottom of the "High" binding post and -E to the bottom of the "Low" binding post.

2. The Model R1L-D1 should default to 4-wire measurement and auto-ranging when turned on. For measurements of all five ranges listed below, check readings via auto-ranging, and then repeat after stepping through the manual ranges, to ensure proper operation with either Auto-range or manual range selection.

3. Set the resistor box to 1060 Ω and operate the R1L-D1. Check that the R1L-D1 reads between the resistor box 1060 Ω setting's actual value ± 0.54 Ω in Auto-Range (default condition when power is turned on). Then step through the ranges to the 2 k manual range and check that the R1L-D1 reads between the resistor box 1060 Ω setting's actual value ± 0.54 Ω.

4. Set the resistor box to 100 Ω and operate the R1L-D1. Check that the R1L-D1 reads between the resistor box 100 Ω setting's actual value ± 0.051 Ω in Auto-range. Then step through the ranges to the 200 Ω manual range and check that the R1L-D1 reads between the resistor box 100 Ω setting's actual value ± 0.051 Ω.

5. Set the resistor box to 10 Ω and operate the R1L-D1. Check that the R1L-D1 reads between the resistor box 10 Ω setting's actual value ± 0.0051 Ω in Auto-range. Then step through the ranges to the 20 Ω manual range and check that the R1L-D1 reads between the resistor box 10 Ω setting's actual value ± 0.0051 Ω.

6. Set the resistor box to 1 Ω and operate the R1L-D1. Check that the R1L-D1 reads between the resistor box 1 Ω setting's actual value ± 0.52 mΩ in Auto-range. Then step through the ranges to the 2 Ω manual range and check that the R1L-D1 reads between the resistor box 1 Ω setting's actual value ± 0.52 mΩ.

7. Set the resistor box to 0.1 Ω and operate the R1L-D1. Check that the R1L-D1 reads between the resistor box 0.1 Ω setting's actual value ± 0.065 mΩ in Auto-range. Then step through the ranges to the 0.2 Ω manual range and check that the R1L-D1 reads between the resistor box 0.1 Ω setting's actual value ± 0.065 mΩ.

8. To check 3-wire operation, disconnect the wire between the -E binding post and the resistor under test. Repeat the tests listed in 4.4.3 and 4.4.4. Note that the accuracy will be degraded if the lead from the +E binding post and the +I lead do not have exactly the same resistance. Other ranges are not specified.

9. To check 2-wire operation, disconnect the wires between the +E binding post and the resistor under test. (This leaves only +I and –I wires connected). Repeat the tests listed in 4.4.3 and 4.4.4. Note that the accuracy will be degraded by the resistance of the leads. Other ranges are not specified.

4.5 Calibration

CAUTION
DANGEROUS VOLTAGES ARE PRESENT DURING PARTS OF THIS PROCEDURE.

1. If the R1L-D1 rechargeable battery cells have not been previously charged, or are low on charge, connect the R1L-D1 AC line cord and allow a charge time of at least one-half hour. The R1L-D1 "Battery Charging" LED (as well as "AC Power" LED) should illuminate. Note: If the R1L-D1 battery cells are being charged for the first time or are heavily discharged, the R1L-D1 may switch into trickle charge ("Battery Charging" LED goes out) during the first fifteen minutes. If this happens, unplug the AC line cord and then reconnect it. The "Battery Charging" LED should re-illuminate and stay ON.

2. Unplug the AC line cord from the R1L-D1 front panel. Connect the Resistance Box to the R1L-D1. Connect the 10 Ω standard using 4-wire connection. Remove the R1L-D1 front panel from the yellow case and turn it upside down. Connect the AC line cord.

3. Confirm the "Charging" LED is illuminated. Set the Digital Multimeter to read DC volts, and connect its negative lead to TP 104 (Circuit Ground). Connect the positive Multimeter lead to TP 103. Verify a voltage reading between +0.25 and +0.27 V. Disconnect the R1L-D1 AC line cord.

4. Move the positive Multimeter lead to TP105 and turn the R1L-D1 Power Switch ON. Verify a voltage reading between +4.8 and +5.2 V.

5. Move the positive Multimeter lead to TP106 and verify a voltage reading between +4.8 and +5.2 V.

6. Turn the R1L-D1 OFF. Insert the Nylon Insulator Strip between one of the R1L-D1 battery cell's negative end

and its battery holder terminal to disconnect battery power. Connect the negative lead from the Multimeter to TP103, and the positive lead from the Multimeter to TP102 (should read less than 3 V). Adjust the Variable DC Power Supply for 7.0 ± 0.1 V and turn it OFF. **OBSERVING PROPER POLARITY,** connect the negative DC Power Supply lead to TP103 and the positive lead to TP102. Carefully orient the R1L-D1 front panel so you can observe its LCD readout. Turn ON the DC Power Supply and turn ON the RIL-D.

7. Adjust the DC Power Supply voltage downward, and verify the R1L-D1 LCD reading does not vary by more than ± 1 count as the voltage is turned down to where "BATT", indicating low battery voltage is displayed on the LCD. Also verify "BATT" appears at a Power Supply voltage of 5.35 ± 0.1 V.

8. Turn the R1L-D1 OFF. Disconnect the DC Power Supply and Multimeter leads. Connect the serial cable from the personal computer (PC) to the R1L-D1, open HyperTerminal and setup the RS-232 parameters with following setting. Rest the R1L-D1 front panel in its proper orientation in its yellow case.

Step 1: Enter a name such as 'R1L-D1'.

Step 2: Do not enter a phone number. Use COM port selectable in the drop down menu “Connect using”

Step 3: Enter port settings shown on the right.

9. Connect the 1 Ω standard and turn ON the R1L-D1. Confirm the R1L-D1 automatically goes to the 2 Ω range, and indicates 4-wire, an asterisk for auto-range, and the resistance. Resistance values should also appear on the PC screen.

10. Type a lower case "r" and ENTER on the PC keyboard. Verify a temperature sensor reading between 20 and 30 °C on the PC screen.

11. Type an upper case "L" followed by 12000 (i.e. L12000) and ENTER on the PC keyboard for LCD temperature compensation at 0 °C.

12. Type an upper case "L" followed by 22000 (i.e. L22000) and ENTER on the PC keyboard for LCD temperature compensation at +40 °C.

13. Type "F3" (not function key) and ENTER on the PC. Verify a filter setting of 80 mSec on the PC screen.

14. This step and the next will calibrate the five R1L-D1 resistance ranges in 4-wire mode. Each calibration resistance must be entered as a ten-digit number, with the last digit being μΩ. Connect the 100 mΩ standard, and depress the R1L-D1 "Range" button to place the R1L-D1 in the manual 200 mΩ range. Wait until a stable set of readings are displayed on the PC screen. Type "CAL" followed by the 10 digit calibration number followed by ENTER on the PC. An example for this range might be CAL0000099860 followed by ENTER. Wait to observe a few readings close to the calibration value on the PC screen.

15. Connect the 1 Ω standard, and depress the R1L-D1 "Range" button to place the R1L-D1 in the 2 Ω range. Input the calibration value as in the previous step. Repeat this procedure with the 10 Ω range, 100 Ω range, and 1 kΩ range.

16. Turn the R1L-D1 OFF, wait 10 seconds, and turn it back ON. Connect the 1 Ω standard and verify a reading of within ± 0.00015 Ω of the calibration value. Connect the 1 kΩ standard, and verify a reading of ± 0.1 Ω of the calibration value.

17. Disconnect only the -E side of the test leads from the R1L-D1 terminals (leaving -E open). Depress the R1L-D1 "Mode" button to place the R1L-D1 in 3-wire mode. Connect the 1 kΩ standard, and verify a reading of ± 0.4 Ω of the calibration value. Connect the 10 Ω standard,

and verify a reading of ± 0.004 Ω of the calibration value.

18. Disconnect the +E side of the test leads from the R1L-D1 (leaving connections between the +I and -I terminals). Depress the R1L-D1 "Mode" button to place the R1L-D1 in 2-wire mode. Connect the 10 Ω standard, and verify a reading of ± 0.1 Ω of the calibration value. Connect the 1 kΩ standard, and verify a reading of ± 0.4 Ω of the calibration value.

19. Push the R1L-D1 "Backlight" button and verify the backlight turns ON and OFF.

20. Place the R1L-D1 in 4-wire mode and reconnect the leads to the 10 Ω standard. Toggle the R1L-D1 backlight ON and OFF, and verify the displayed reading does not change by more than ± 1 count.

21. Depress the R1L-D1 "Range" button to manually place the R1L-D1 in the 2 Ω range. Verify the R1L-D1 LCD indicates "4OVER 2000 mΩ".

22. At a convenient time, fully charge the R1L-D1 battery cells by connecting the AC line cord to the R1L-D1. Leave the R1L-D1 switched OFF. The R1L-D1 battery cells should be fully charged within approximately 8 hours after AC power is applied.

4.6 Troubleshooting

Test with the precision decade resistance box, if the unit fails to perform in accordance with these tests, repair and/or calibration is required. First recalibrate, as described. If the unit still fails to perform, repair is required.

Check voltages at the following test points (all voltages are read with respect to TP104 (common). Location of these test point is indicated on the Parts Layout drawing, Figure 4.

TP101: Nominal +9 V ± 10%.
TP102: Nominal +7.5 V min with battery fully charged.
TP103: Nominal +0.22 V min when charging dead battery.
TP105: Nominal +5 V ± 5%.
TP106: Nominal +5 V ± 5%.
TP201: 2.45 MHz sine wave, minimum 1 V p-p (± 10%).
TP301: ± 8 V min pulsed (RS-232 Transmitted Data).
TP302: ± 8 V min pulsed (RS-232 Received Data).
TP303: 0 to 5 V ± 5% pulsed (RS-232 Transmitted Data).
TP304: 0 to 5 V ± 5% pulsed (RS-232 Received Data).
TP701: Nominal +2.5 V ± 10%.

Circuit tracing should start with the power supply and check of all power voltages at the test points listed above. If the display functions normally, but resistance readings are very low or over-range, check test point TP701 which indicates proper test current to the external resistor. Continue with the next section.

Assembly

After removal of the instrument from its case, the basic instrument consists of a front panel assembly, a main printed-circuit board assembly with a display, plugged into and bolted to the main circuit board assembly, and the battery assembly. See the R1L-D Assembly Drawing in Figure 2.

Disassembly

See the illustration in Figure 2. To disassemble, first remove the nine screws holding the main circuit board assembly to the front panel spacers. To remove the display from the main circuit board assembly, remove the two screws at each end of the display and carefully unplug the display from the main board. Four screws secure the battery cover plate; these must be removed to replace the battery. All integrated-circuits, including the microprocessor and the A-D converter, are plugged into sockets and may be removed easily, with no need for unsoldering. Other components, such as resistors, capacitors, etc., must be unsoldered for removal.

Re-assembly

After trouble-shooting and repair, re-assemble all parts in reverse order from above. Do not tighten the screws until all have been installed, to ensure that all parts are centered properly. Check that all three cable connectors are secured.

Following are possible symptoms, diagnosis, and repair suggestions for use in trouble-shooting (the most likely causes are listed first).

Symptom	Faulty Component	Repair
No display	Battery needs charge	Charge battery.
	Battery connection	Check all five cells.
	R801	Adjust, replace if bad.
	Display	Replace display.
	U101	Check for +5 V at Pin 2. If not, replace U101.
	U111	Check for +5 V at Pin 2. If not replace U111.
	Loose cable connector	Tighten connector.
	U201	Check J801-5 for activity, if none replace U201.
	Y201	If no 2.45 MHz signal at TP201, replace Y201.
Battery won't charge	U120	Replace U120.
	Q121	Replace Q121.
	D121, D122, or D123	Replace D121, D122, D125
	T121	Replace T121.
	R122	Replace R122.
	B101-B105	Replace B101-B105.
Ranges 1-3 faulty	Q701	Replace Q701.
	R704	Replace R704.
Ranges 4-5 faulty	Q701	Replace Q701.
Faulty readings	U700	Replace U700.
	J701	Check connection at binding posts.
	Q702 or Q703	Replace Q702 or Q703.
	U702	Check TP701, replace U702 if no voltage present.

Table 3: Fault Symptoms and Repair Actions

After trouble-shooting and repair, the instrument must be recalibrated in accordance with 4.5 above.

4.7 Preparation for Shipment

The original shipping carton is not reusable.

The unit should be repackaged in a humidity-sealed carton in accordance with MIL-P-116J, which is the specification governing covering and preservation used in the initial shipment from the manufacturer.

The Model R1L-D1 is a rugged instrument and requires no special covering, preservation or special cradles. Packaging must provide sufficient resilient material, in accordance with standard packaging practices, to prevent excessive shock to the power supply and display during shipment.

4.8 Overhaul Instructions

The Model R1L-D1 is an all solid-state unit and requires no periodic overhaul, other than routine cleaning and inspection, as listed in Sections 4.1 and 4.2 and circuit calibration, described under Section 4.5 above.
However, some disassembly is required to remove and to install the battery. Disassembly instructions may be found under Sections 2 and 4.6 above. Re-assembly instructions are listed in Section 4.6 as well.

Tools required are listed in Section 1.6 and test equipment required is listed in Section 4.3.

Trouble-shooting is listed in Section 4.6.

The only component expected to require replacement is the battery. Battery designation is listed in the Replacement Parts List, and installation instructions are listed in Section 2.1.

A fully charged battery should power the R1L-D1 for approximately 140 hours continuously, without connection to an external resistor and without the backlight on. Operation on any of the three lowest resistor ranges will reduce this to approximately 24 hours, and operation with the backlight on will reduce this to approximately 20 hours. The battery may be discharged and recharged at least 100 completed cycles before requiring replacement. Note that, it is recommended that NiCad batteries be completely discharged before recharging or their effective capacity is reduced.

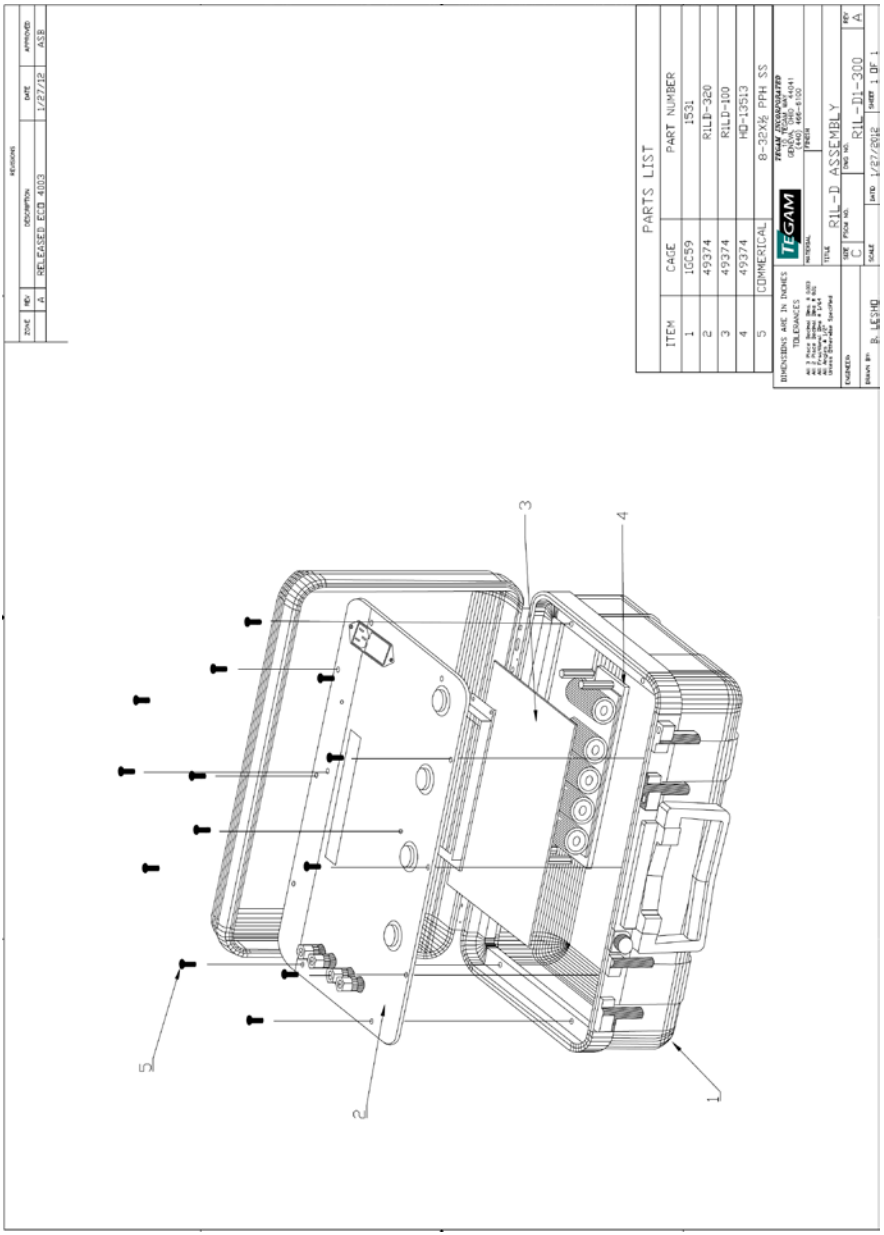

Figure 2: Assembly Drawing

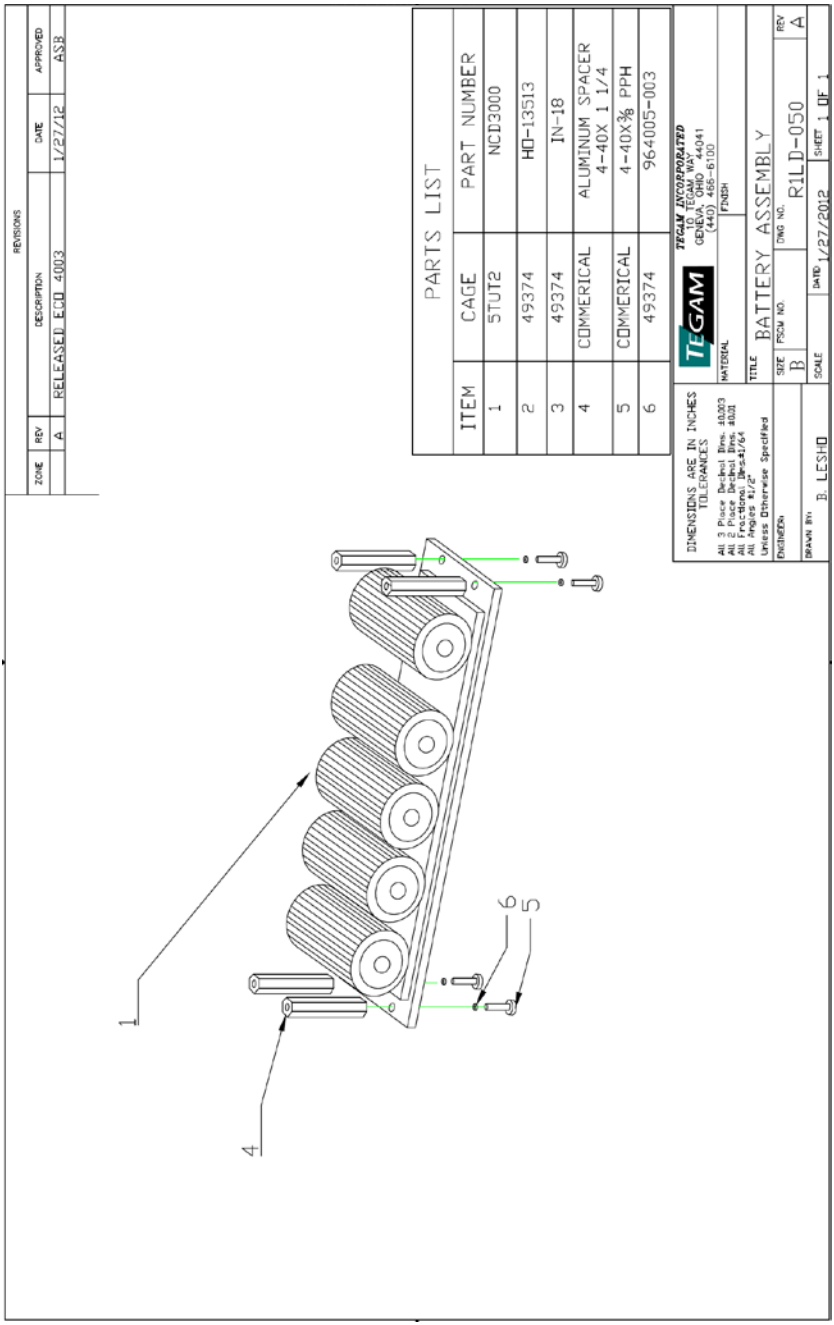

Figure 3: Battery Assembly Drawing

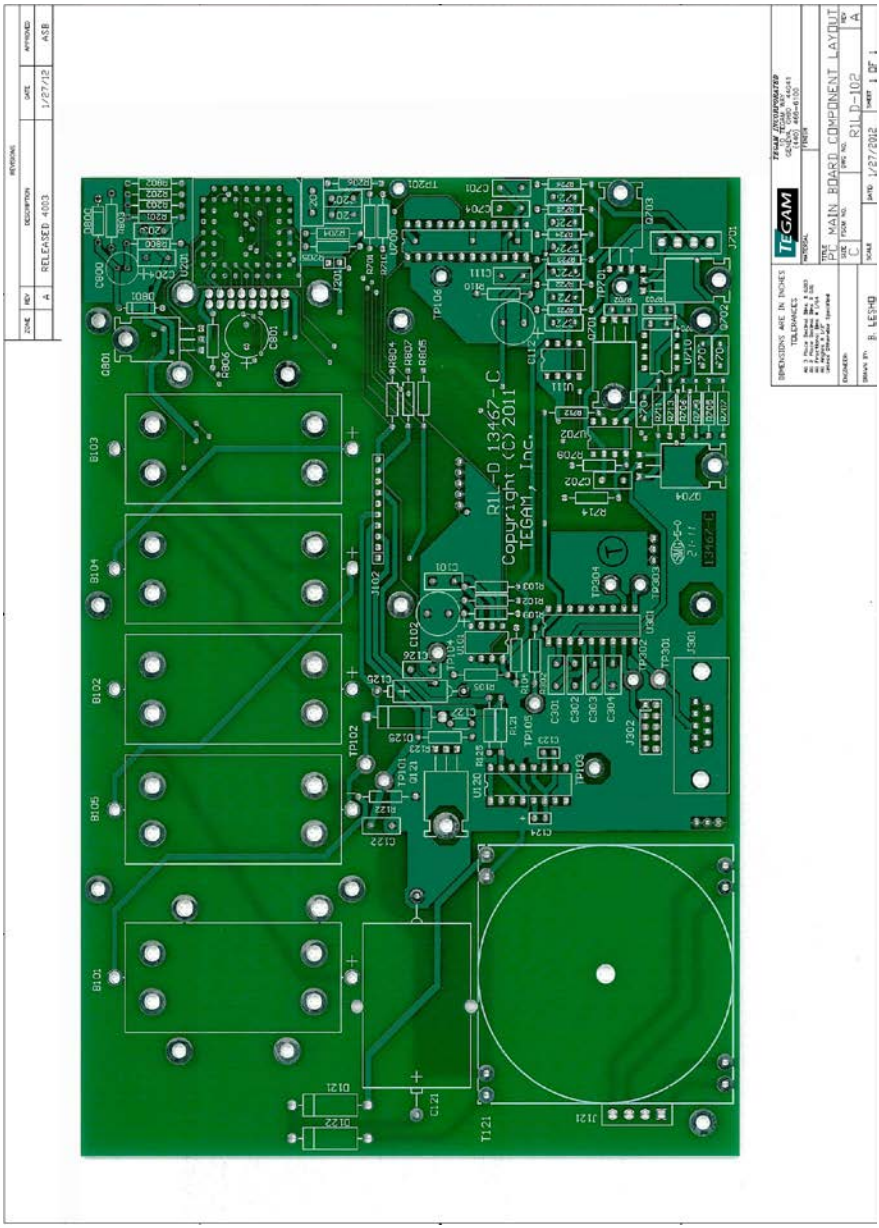

Figure 4: Main Board Parts Layout

SECTION 5

SERVICE INFORMATION

Preparation for Calibration or Repair Service

Once you have verified that the cause for R1L-D1 malfunction cannot be solved in the field and the need for repair and calibration service arises, contact TEGAM customer service to obtain an RMA, (Returned Material Authorization), number. You can contact TEGAM customer service via the TEGAM website, www.tegam.com or by calling 440.466.6100 (*All Locations*) OR 800.666.1010 (*United States Only*).

The RMA number is unique to your instrument and will help us identify you instrument and to address the particular service request by you which is assigned to that RMA number.

Of even importance, a detailed written description of the problem should be attached to the instrument. Many times repair turnaround is unnecessarily delayed due to a lack of repair instructions or of a detailed description of the problem.

This description should include information such as measurement range, and other instrument settings, type of components being tested, are the symptoms intermittent?, conditions that may cause the symptoms, has anything changed since the last time the instrument was used?, etc. Any detailed information provided to our technicians will assist them in identifying and correcting the problem in the quickest possible manner. Use a copy of the Repair and Calibration Service form provided on the next page.

Once this information is prepared and sent with the instrument to our service department, we will do our part in making sure that you receive the best possible customer service and turnaround time possible.

Expedite Repair & Calibration Form

Use this form to provide additional repair information and service instructions. The Completion of this form and including it with your instrument will expedite the processing and repair process.

RMA#:		Instrument Model #:	
Serial Number:		Company:	
Technical Contact:		Phone Number:	
Additional Contact Info:			

Repair Instructions:

☐ Evaluation ☐ Calibration Only ☐ Repair Only
☐ Repair & Calibration ☐ Z540

Detailed Symptoms:

Include information such as measurement range, instrument settings, type of components being tested, is the problem intermittent? When is the problem most frequent?, has anything changed with the application since the last time the instrument was used?, etc.

Warranty

TEGAM, Inc. warrants this product to be free from defects in material and workmanship for a period of three years from the date of shipment. During this warranty period, if a product proves to be defective, TEGAM Inc., at its option, will either repair the defective product without charge for parts and labor, or exchange any product that proves to be defective.

TEGAM, Inc. warrants the calibration of this product for a period of one year from date of shipment. During this period, TEGAM, Inc. will recalibrate any product, which does not conform to the published accuracy specifications.

In order to exercise this warranty, TEGAM, Inc., must be notified of the defective product before the expiration of the warranty period. The customer shall be responsible for packaging and shipping the product to the designated TEGAM service center with shipping charges prepaid. TEGAM Inc. shall pay for the return of the product to the customer if the shipment is to a location within the country in which the TEGAM service center is located. The customer shall be responsible for paying all shipping, duties, taxes, and additional costs if the product is transported to any other locations. Repaired products are warranted for the remaining balance of the original warranty, or 90 days, whichever period is longer.

Warranty Limitations

The TEGAM, Inc. warranty does not apply to defects resulting from unauthorized modification or misuse of the product or any part. This warranty does not apply to fuses, batteries, or damage to the instrument caused by battery leakage.
The foregoing warranty of TEGAM is in lieu of all other warranties, expressed or implied. TEGAM specifically disclaims any implied warranties of merchantability or fitness for a particular purpose. In no event will TEGAM be liable for special or consequential damages. Purchaser's sole and exclusive remedy in the event any item fails to comply with the foregoing express warranty of TEGAM shall be to return the item to TEGAM; shipping charges prepaid and at the option of TEGAM obtain a replacement item or a refund of the purchase price.

Statement of Calibration

This instrument has been inspected and tested in accordance with specifications published by TEGAM Inc. The accuracy and calibration of this instrument are traceable to the National Institute of Standards and Technology through equipment, which is calibrated at planned intervals by comparison to certified standards maintained in the laboratories of TEGAM Inc.

Contact Information
TEGAM INC.
10, TEGAM WAY
GENEVA, OHIO 44041
CAGE Code: 49374
WEB: ***http://www.tegam.com***