

MICROOHMMETER AND BOND TESTER

MODEL R1L-BI, R1L-BIR



Instruction Manual
PN# R1L-BI/BIR-900
Publication Date: May 2019
REV. B

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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, refer to www.tegam.com

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SECTION 1

INSTRUMENT DESCRIPTION

1.1 Introduction

The Model R1L-BI/R1L-BIR is a digital Microohmmeter / Bond Tester with full scale ranges from 2 m Ω to 20 Ω . The instrument utilizes the four-terminal, Kelvin technique to eliminate errors caused by the resistance of the leads. The resistance reading is displayed on a 3½ digit liquid crystal display on the front panel. An over-range condition is indicated as a "1" followed by three blank digits (the decimal point is also displayed in its normal position for the range selected). Model R1L-BIR is electronically identical to model R1L-BI, but it has a rugged case as the enclosure rather than an open front panel.

1.2 Performance Characteristics

This is a range-selection instrument, with a rotary 5 range selector switch.

Range	Full Scale (Ω)	Resolution (Ω)	Test Current Peak (A)
1	1.999 m	1 μ	1.4
2	19.99 m	10 μ	140 m
3	199.9 m	100 μ	14 m
4	1.999	1 m	1.4 m
5	19.99	10 m	140 μ

Reactive loads not to exceed 2mH or 100 μ F with a minimum of 5 $\mu\Omega$ per μ H of series resistance. See figure 1 below.

Table 1: Specifications

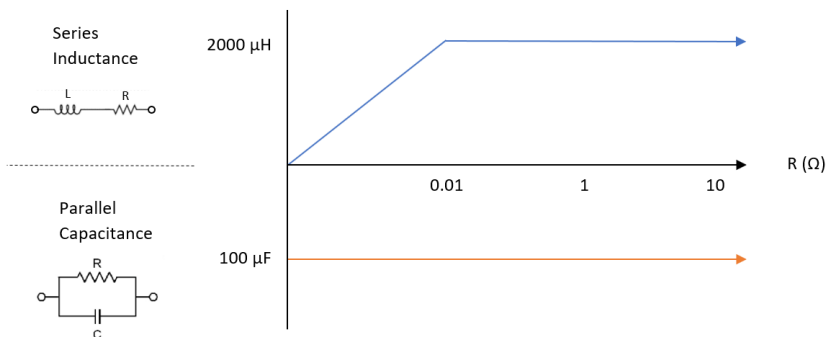


Figure 1

Accuracy:

Accuracy on all ranges: \pm (0.25% of reading + 1 count), when powered from the batteries only.

1.3 Description of Equipment

Physical: The R1L-BI circuitry is enclosed in a bench top case, while the R1L-BIR circuitry is enclosed in a rugged portable case.

Dimensions:

R1L-BI: 101 mm (4") x 292 mm (11.5") x 203 mm (8"). Weight is 1.6 kg (3.6 lb).

R1L-BIR: 127 mm (5") x 254 mm (10") x 228 mm (9"). Weight is 3 kg (6.7 lb).

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

Electrical: The R1L-BI/R1L-BIR is powered by an internal battery consisting of three rechargeable NiCad 'C' cells (2800 mAh - 3500 mAh) with a built-in charger. Input power for the charger is 90 to 250 VAC at 50 Hz or 60 Hz. Charging power is supplied via a removable line cord; one end of which plugs into a line filter on the front of the R1L-BI/R1L-BIR, and the other end being a standard three-pin grounded line plug.

Fuse: ¼ A 3AG Slow blow, TEGAM PN#FU-202

Input Protection: The R1L-BI/R1L-BIR will not be damaged by a signal of 1 Vp-p applied across any pair of input terminals.

Environmental: This unit will operate over a temperature range from 0 °C to 50 °C, 75% RH non-condensing, up to 3050 m altitude.

Front Panel Controls and Displays (See figures 1a and 1b)

RANGE Switch. The rotary 5 range selector switch may be used to step through all five ranges.

POWER Switch. Used to turn the power on or off to the instrument.

DISPLAY is a 3 ½ digit, displaying readings from 1.999 to 199.9.

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 3.2 below.

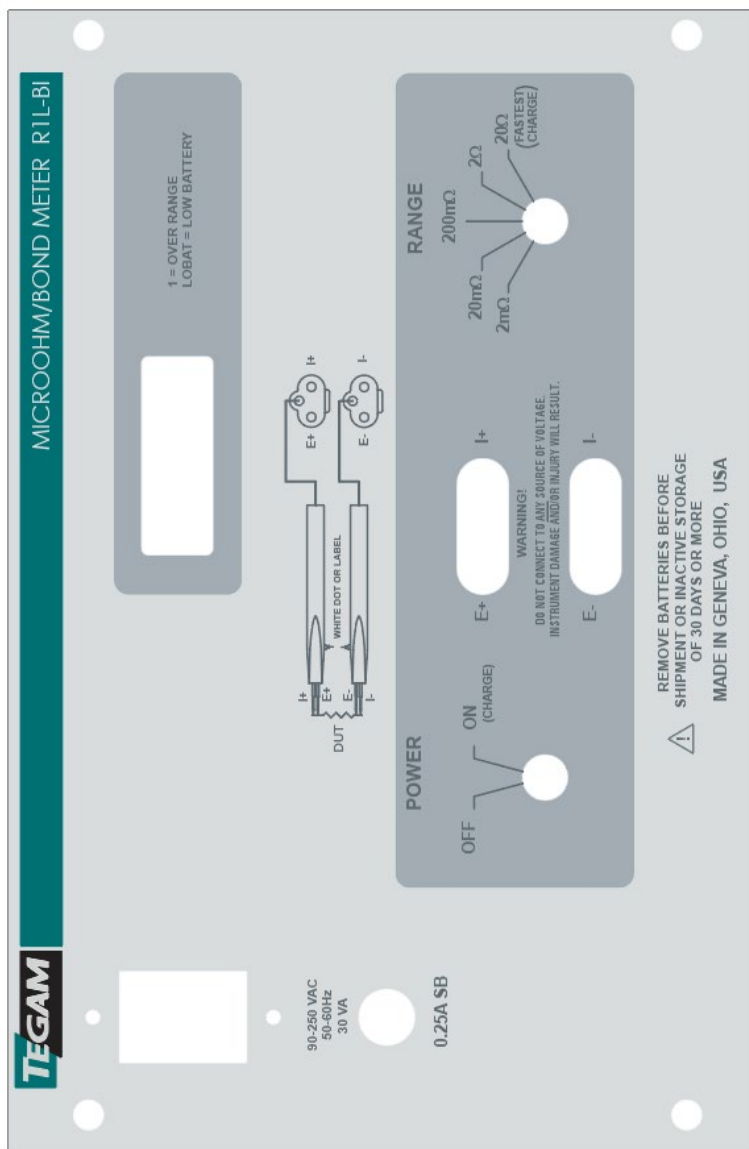


Figure 2a: R1L-BI Front Panel Controls

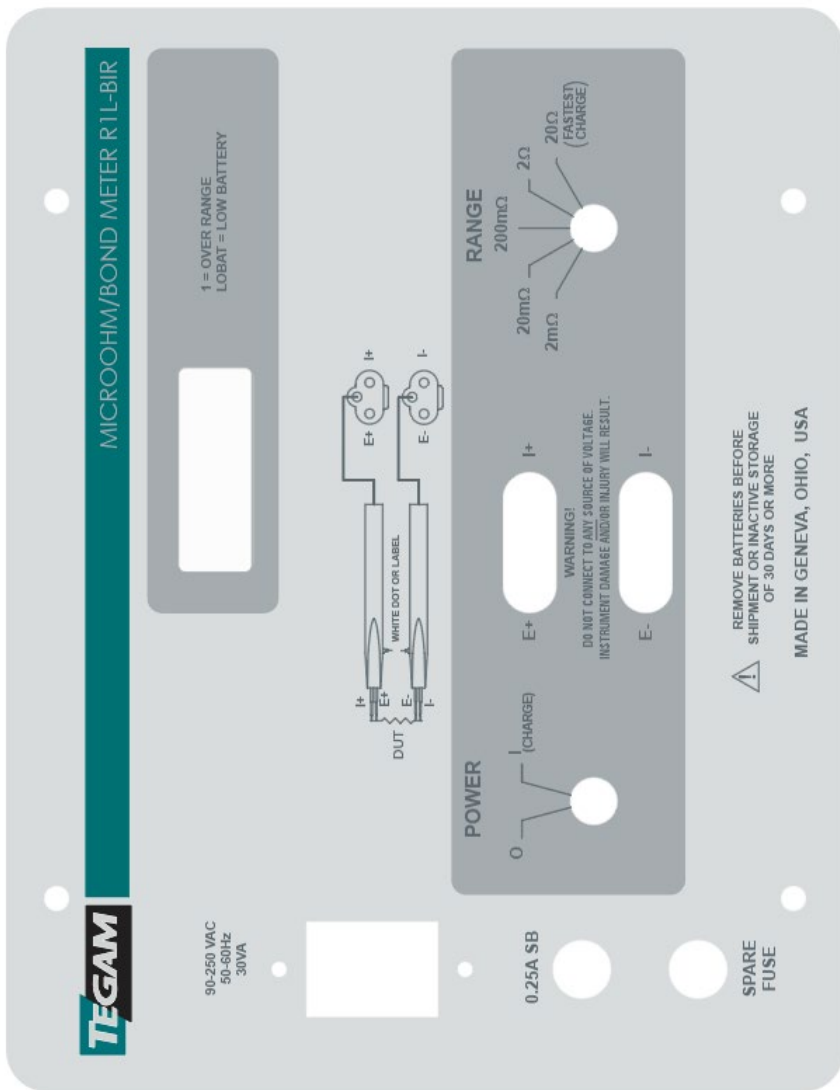


Figure 2b: R1L-BIR Front Panel Controls

1.4 List of Items Furnished

- 1 each Model R1L-BI/R1L-BIR with power cord
- 3 each rechargeable NiCad battery cells (P/N: BA-110)
- 2 each Kelvin Clip Cables, one end with a dual banana plug and the other end with a gold plated Kelvin clip (P/N: KTL-100) (only included with the R1L-BI)
- 1 each R1L-BI/R1L-BIR Instruction Manual (P/N: R1L-BI/BIR-900-01)

1.5 Storage and Shipping Requirements

Standard precautions which apply to electronic test instruments should be followed. Care should be taken to prevent damage to associated cables.

Remove the battery cells for inactive storage of 30 days or more.

Temperature: -40 °C to +71 °C.

Relative humidity: 0 to 100%, non-condensing.

Altitude: 4570 m

See Section 5.7 below for shipping requirements.

1.6 Safety Information and Precautions



Grounding the Equipment

This product is grounded through the grounding conductor of the power cord. To avoid electrical shock or other potential safety hazards, plug the power cord into a properly wired receptacle before using this instrument. The proper grounding of this instrument is essential for safety and optimizing instrument operation.

Danger Arising from Loss of Ground

If the connection to ground is lost or compromised while charging the batteries, a floating potential could develop

in the instrument. Under these conditions all accessible parts, including insulating parts such as knobs and terminals could develop a hazardous voltage and put the user at risk.

Use the Proper Fuse

To avoid fire hazard, use only the correct fuse type as specified for the AC power supply in the "Description of Equipment" or "Maintenance" sections of this manual.

Do Not Use in Explosive Environments

The R1L-BI/R1L-BIR microohmmeter is not designed for operation in explosive environments.

SECTION 2

PREPARATION FOR USE AND INSTALLATION

2.1 Unpacking and Inspection

Upon receipt, the R1L-BI/R1L-BIR and accessories should be carefully unpacked and removed from the shipping container. Separate the units from the packing material and inspect both the instrument and the accessories (if any) for any external damage.

- If any dents, broken, or loose parts are seen, do not use the equipment. Notify TEGAM immediately.
- Check that all items are present. If any items are missing, notify TEGAM immediately.

2.2 Preparation for Use

Battery Installation

Note that the instrument is shipped with its battery removed. Unwrap the 3 cells which comprise the battery.

Be sure the power line cord is disconnected. Check that the Power Switch is in the OFF position. Remove the four screws at the corners of the R1L-BI/R1L-BIR's top (control/display) panel. Carefully lift the unit out of its cabinet. Place the unit upside down on a surface which will not mar or damage the control/display panel.

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

BE SURE TO OBSERVE THE PROPER POLARITY WHEN INSERTING THE BATTERY CELLS OR DAMAGE MAY RESULT.

For R1L-BI units only, remove the two screws that secure the battery retention plate.

Insert the battery cells, one at a time, in accordance with the polarity indications marked on both the battery cell and the battery holder. Insert the positive end of the battery cells first.

After installing the cells, reinstall the plate (for R1L-BI only), reinstall the instrument in its case, and secure the four corner screws.

Power Up

Plug the power cord into the R1L-BI/R1L-BIR front panel receptacle, and plug the other end into a standard AC outlet. For battery operation (with charged battery cells), this step is omitted. Turn on the POWER rotary switch. Note that this switch turns on both line and battery power.

Charging the Battery Cells

Prior to battery operation, it is recommended the R1L-BI/R1L-BIR Microohmmeter be plugged into AC power for at least 14 hours to charge the battery cells. To charge the battery cells, the Power Switch must be turned ON, and the Range Switch should be set to 20 Ω . With the Range Switch set to lower ranges, the charge rate decreases and the batteries will be discharged, especially on the 2 m Ω range, even with no resistance connected to the instrument. (However, the discharge rate in this range will permit operation for at least 14 hours with no resistance connected.)

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.

SECTION 3

OPERATING INSTRUCTIONS

Use the cables connecting their banana plug terminations to the four binding posts marked +I, +E, -E, and -I.

WARNING

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

3.1 Rotary Switch Functions

Operation of the Model R1L-BI/R1L-BIR is extremely simple. There are only two switches.

The RANGE rotary switch manually scrolls through the five ranges.

Full scale on any range may be described as 2,000 (actually 1,999), since this is a 3½ digit meter. If the readings are exceeding 1,999 counts, step to the next higher range. If the readings are less than 2,000 counts, step down a range, so that it will read 1,999 counts, or less. The decimal point is located automatically for the correct reading.

If the selected range is too low for the value of the resistor under test, the display will show over-range.

The POWER rotary switch turns on the power to operate the unit or turns off the power to the unit. 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.

3.2 General Theory Of Operation

Measurement Principle

A 4-terminal measurement method is used to determine the resistance of the item under test. This method allows the accurate measurement of low values of resistance in spite of the other resistances present in the connection leads. A known current is supplied to the item under test via two wire leads connected to the +I and -I binding posts on the R1L-BI/R1L-BIR Microohmmeter front panel. Two other wire leads connected to the +E and -E binding posts on the R1L-BI/R1L-BIR front panel sense the voltage developed across the resistance under test due to the supplied known current. The R1L-BI/R1L-BIR then calculates the resistance of the item under test utilizing Ohm's law, and displays it on a 3 ½ digit display.

Kelvin Klip Cable Description

A Kelvin clip consists of two opposing jaws of an alligator style clip which are insulated from each other, so one jaw may be used to connect a source of current to the resistance under test, and the other jaw used to measure the voltage at the test point. The two jaws are spring loaded to clamp onto a cylinder of ½ inch diameter or less.

WARNING

OPERATING THE R1L-BI/R1L-BIR MICROOHMMETER AND TAKING RESISTANCE MEASUREMENTS ON A POWERED OR ENERGIZED COMPONENT COULD CAUSE SERIOUS HARM TO THE OPERATOR AND/OR DAMAGE THE INSTRUMENT. BE SURE THE ITEM TO BE MEASURED IS DISCONNECTED FROM OTHER COMPONENTS AND APPARATUS.

If the battery cells have not been installed, refer to section 2.2. Battery only operation will result in the most stable and accurate readings. The R1L-BI/R1L-BIR may be operated

while charging the batteries, however it will not conform to specifications in this configuration.

NOTE: The amount of current available for charging the battery decreases as lower resistance ranges are selected. In the 2 m Ω range, the current supplied to the resistance under test exceeds the charging current, and the battery will be drained.

To obtain the best accuracy, allow the R1L-BI/R1L-BIR to warm up for 15 minutes on the 20 Ω range before making measurements. Even if in battery operation, this will not cause appreciable battery discharge.

Using the Kelvin-Clip cables

Plug one Kelvin-Clip cable dual banana plug across the +E and +I binding posts, and plug the other Kelvin-Clip cable dual banana plug across the -E and -I binding posts. Note that in both cases, the small "I" marked on the dual banana plug should go into the respective I binding post.

If Kelvin-Clip cables are not used, a pair of shielded cables may be utilized. As occurs in the Kelvin-Clip cables in the above paragraph, one cable should have its shield connected to the "+I" binding post and its center conductor connected to the +E binding post. Similarly, the other cable should have its shield connected to the -I binding post and its center conductor to the -E binding post. It is also recommended that the resistance of the cables should not exceed 350 m Ω /conductor.

NOTE: Particularly in the 2 m Ω range, where a test current of approximately 1.4 A is used, excessive lead resistance will prevent an accurate measurement.

Set the Range Switch to the desired measurement range and read the resistance on the liquid crystal display. If the resistance is higher than the selected range, the display will show a "1" and three blank digits, indicating over-range. The

decimal point will also appear in the proper location for the selected range.

After prolonged operation on battery power, when the battery voltage approaches the end of its useful range, the "LO BAT" indicator will be seen on the display. Although the battery cells are not fully discharged and they will not be damaged by additional use, this is a warning to the operator that the battery cells need to be charged.

Use of HTP-100 probes with the R1L-BI/R1L-BIR:

1. Connect the BLUE spade lug from the LEFT HTP-100 Probe to the RED E+ terminal of the R1L-BI/R1L-BIR.
2. Connect the RED spade lug from the LEFT HTP-100 Probe to the RED I+ terminal of the R1L-BI/R1L-BIR.
3. Connect the WHITE spade lug from the RIGHT HTP-100 Probe to the BLACK E- terminal of the R1L-BI/R1L-BIR.
4. Connect the BLACK spade lug from the RIGHT HTP-100 Probe to the Black I- terminal of the R1L-BI/R1L-BIR.
5. Hold the RED HTP-100 Probe in your left hand and the WHITE HTP-100 Probe in your right hand, and push the probe points against the surface to be measured with sufficient force to cause the points to retract slightly.

SECTION 4

PRINCIPLES OF OPERATION

Power Supply

The internal switching power supply U8 accepts nominal line voltages between 90 and 250 VAC 50/60 Hz, allowing operation worldwide. C1, C2, U1, R1, R2 and R101 form a constant current regulator set to approximately 758 mA for charging the battery. D5 is used to isolate the AC power for the battery. D7 serves to clamp the voltage to less than 5 V when the battery is disconnected. The negative 3.6 volt power supply for U2 and U10 is developed by U5.

Test Current Path

The test current used to perform the resistance measurement originates from the battery + terminal connected to the +3.6 V power symbol at the emitter of Q1. It flows through Q1 into the COM1 terminal of SW1 and out of the terminal selected by the switch for the measurement range chosen. Each pole of the COM1 section of SW1 is connected to a different tap on the current sensing resistor string made up of R13, R48, R50, R52 and R54. The test current flows into the sense resistor string at the tap selected, out of R54 into D3 and out of D3 to the I+ test jack. The external test leads conduct the current through the resistance being measured and back to the I- test jack, where it returns to ground and then to the battery - terminal.

Test Current Regulator

The test current is controlled to a constant value for each range with a feedback loop. The main loop amplifier is U9A. The output of U9A controls the conduction of Q1 using Q2, such that if the output voltage of U9A increases, the test current increases. The inputs of U9A compare the voltage across the current sensing resistor string with a 3 volt reference voltage produced by U4, the voltmeter IC. The voltage across the sensing resistor string is maintained at 1.5 V, half the value of the reference voltage because R9 and R11

are twice the value of R8 and R9. The reference voltage of 3 V is present between the VREF signal at one end of R9 and the +3.6 V power supply present at one end of R11. The voltage at one end of the sensing resistor string is present at U11A pin 1 which feeds R8. The voltage at the other end of the sensing resistor string is present at U11B pin 7 which feeds R10. U11A and U11B are very high input impedance buffer amplifiers which sense the voltage across the current carrying portion of the sensing resistor string without causing errors in the test current. R127, R129 and CR1 provide overvoltage input protection for pin 3 of U11A, and similarly R46, R128 and CR2 for U11B. U2B will shut off the current source if the voltage on the I+ binding post becomes less than about -3 V.

Test Current Adjustment

The test current on the 2 milliohm range is 1.4 amps. It is very stable, but not adjustable. The 1.4 A current stability is determined by the stability of R54, the 3 V reference developed by U4 and to a minor extent other circuit components. The test currents on the four other ranges are adjusted to approximately 1/10, 1/100, 1/1000 and 1/10000 of the actual value of the 2 milliohm range test current during the calibration/ adjustment process. Trimpots R53, R51, R49 and R114 are used for this adjustment, and are adjusted sequentially in that order. Adjusting the current affects the readings, so current adjustment INDEPENDENT of the readings adjustment is not possible.

Voltage Measurement

The voltage across the resistance being measured is amplified by U10A, U10B and U9B. The E+ and E- test jacks are the input to this differential amplifier, and the output is connected to the voltmeter IC U4 pins 38 and 39. R130, R131, R141, R142, CR3 and CR4 provide overvoltage input protection. U10A, U10B, R132, R133 and R134 provide a differential gain of 5: the voltage between U10A pin 1 and U10B pin 7 is 5 times the voltage between E- and E+. U9B provides voltage gain of 10, and develops its output between VREF at pin 40 of U4 and VIN+ at pin 39 of U4. An adjustable bipolar offset voltage is added to this output by R143 before it is applied to

VIN- at pin 38 of U4. C18 and 140 are a low pass filter to reduce noise.

The voltmeter IC U4 converts the amplified voltage across the resistance being measured into a displayed reading. Because the test current is precisely regulated along with the various gains chosen in the circuit, the displayed value is directly proportional to the resistance being measured. U4 develops a reference voltage of 3 V between pins 8 and 40. The reference is divided by the resistor string R31, R32, R146 and R143. R146 provides an adjustable voltage used as the analog to digital conversion reference to pin 44. R143 provides an adjustable zero reading.

Display

U4 directly drives the LCD, except for the decimal points and the LOBAT indicator. The decimal point associated with the range selected is displayed when the range switch SW1 provides a +3.6 V signal to one of the inputs of U7. The LOBAT signal is displayed when U2A detects the voltage at pin 40 of U4 falls below ground. Since this pin is maintained by U4 at the reference voltage of 3 V below the battery voltage, LOBAT will be displayed when the battery is less than approximately 3 V.

SECTION 5

MAINTENANCE

5.1 Inspection

These units should be inspected semi-annually. Cables should be periodically inspected to make sure they are in good condition. Check that the switches turn smoothly. Check all four binding posts to ensure that they operate smoothly. No other maintenance is required, other than to keep the battery charged through power line operation. Charging should be done for at least 14 hours after long periods (several months) of storage or after considerable use on battery power.

5.2 Cleaning

The instrument should be cleaned periodically, as is necessary, using mild soap and a damp cloth, followed by a second damp rinsing cloth.

Clean the LCD window using a soft cloth moistened with water or "Windex" type window cleaner. **DO NOT** use common paper towel products as some brands may contain fibers which could scratch the display window. **DO NOT** apply significant pressure to the LCD as it could separate from the front panel. **DO NOT** use alcohol, solvents, or harsh chemicals to clean the LCD window.

5.3 Test Equipment and Tools Required for Calibration and Repair

Calibration of the R1L-BI/R1L-BIR is recommended on a yearly basis, and is done at a temperature of $23\text{ }^{\circ}\text{C} \pm 1\text{ }^{\circ}\text{C}$. To obtain best results, keep the unit at $23\text{ }^{\circ}\text{C} \pm 1\text{ }^{\circ}\text{C}$ for at least 8 hours, and allow it to warm up for 30 minutes before making any adjustments.

Precision four terminal resistors with accuracy of 0.05% or better: 1 m Ω , 1.9 m Ω , 19 m Ω , 190 m Ω , 1.9 Ω , and 19 Ω

A standard 4 ½ digit digital voltmeter: with 2 V range, accuracy better than 0.03% of reading ± 1 count.

Screwdrivers: Medium Phillips and small slotted for trim-pot adjustment.

Three 20 AWG approximately 4 inch long Buss Wires

Four 18 AWG Wires (or dual wire cable) approximately 2 feet long with clips

5.4 Calibration

CAUTION

SAFETY PRECAUTIONS MUST BE TAKEN WHEN HANDLING THIS INSTRUMENT WHEN THE LINE CORD IS PLUGGED IN AND THE R1L-BI/R1L-BIR HAS BEEN REMOVED FROM ITS CASE, TO ENSURE THAT CONTACT IS NOT MADE WITH THE AC POWER CONNECTIONS OR OTHER POTENTIALLY HARMFUL POINTS. FAILURE TO OBSERVE PROPER SAFETY PRECAUTIONS MAY CAUSE SERIOUS HARM TO THE OPERATOR AND/OR DAMAGE THE INSTRUMENT.

A. Preparation

1. Remove the front panel assembly from the case by removing the four retaining screws. Retain the four screws for reinstallation.
2. Install a new set of approved batteries into the UUT as required. Observe polarity.
3. Plug UUT in and turn on setting the range switch to 20 Ω range, allow a 14 hour charge time. (Skip this step if batteries have already been charged.)
4. After the UUT has been charged, unplug the UUT.
5. Allow a 10 minute COOL DOWN.

NOTE: Heat from the charging circuit causes the UUT to drift. The COOL DOWN period is only necessary if the UUT has been charging for an extended period of time.

6. Turn the voltmeter on allowing a 10 minute warm up.
 - a) Set unit to measure DC voltage.
 - b) Set unit to Auto range.
7. Connect clip leads to the voltmeter.

B. AC Circuitry Check

1. Set the range switch to 20 Ω on the UUT.
2. Connect the voltmeter to the UUT;
 - a) Voltmeter Red test lead to TP1 of the UUT,
 - b) Voltmeter Black test lead to TP2 of the UUT.
3. Plug the UUT into AC and turn on.
4. Verify the reading on the voltmeter reads between 1.0 to 1.5 VDC.
5. Disconnect the UUT from the AC source.
6. Disconnect the Voltmeter from the UUT.

NOTE: The UUT is to be unplugged from AC during the remaining portions of the procedure.

C. Zero the Display

1. Set the range switch to 2 m Ω on the UUT.
2. Short out all four terminals of the UUT in the following order, +I to -I, -I to +E, +E to -E using the three pieces of buss wire.
3. Adjust R143 for a zero reading ± 1 count on the least significant digit as displayed by the UUT.
4. Set the range switch to the next higher range.
5. Verify a zero reading within ± 1 count on the least significant digit.
6. Repeat steps 4 and 5 for all remaining ranges.
7. Disconnect the buss wires from the UUT.

D. 2 m Ω Adjust (Main Gain Adjust)

1. Set the range switch to 2 m Ω on the UUT.

2. Connect a 1.9 m Ω standard to the UUT using the clip leads.
3. Adjust R32 for a display reading of the actual standards value ± 3 counts (± 0.003 m Ω) on the display of the UUT, typically 1.900. Allow adequate time for any thermals to dissipate and the unit to settle.
4. Repeat sections C-D until both values are with-in specifications.
5. Disconnect the resistance standard.
6. Connect a 1 m Ω standard to the UUT using the clip leads.
7. Verify that the display of the UUT displays the actual standard value ± 2 counts.
8. Disconnect the resistance standard.

NOTE: The following adjustment steps build upon each other, and must be performed in sequence. It appears that the connection of standards will be more convenient if the steps are performed in reverse order, from H to E, but this will not provide a satisfactory adjustment, as (for example) the Step E adjustment changes the Step H reading.

E. 20 m Ω Adjust

1. Set the range switch to 20 m Ω on the UUT.
2. Connect a 19 m Ω standard to the UUT using the clip leads.
3. Adjust R53 for a display reading of the actual standards value ± 3 counts (± 0.03 m Ω) on the display of the UUT, typically 19.00. Allow adequate time for any thermals to dissipate and the unit to quit drifting.
4. Disconnect the resistance standard.
5. Connect a 1.9 m Ω standard to the UUT using the clip leads.
6. Verify that the display of the UUT displays the actual standard value ± 2 counts.
7. Disconnect the resistance standard.

F. 200 m Ω Adjust

1. Set the range switch to 200 m Ω on the UUT.

2. Connect a 190 m Ω standard to the UUT using the clip leads.
3. Adjust R51 for a display reading of the actual standards value ± 3 counts (± 0.3 m Ω) on the display of the UUT, typically 190.0. Allow adequate time for any thermals to dissipate and the unit to quit drifting.
4. Disconnect the resistance standard.
5. Connect a 19 m Ω standard to the UUT using the clip leads.
6. Verify that the display of the UUT displays the actual standard value ± 2 counts.
7. Disconnect the resistance standard.

G. 2 Ω Adjust

1. Set the range switch to 2 Ω on the UUT.
2. Connect a 1.9 Ω standard to the UUT using the clip leads.
3. Adjust R49 for a display reading of the actual standards value ± 3 counts (± 0.003 Ω) on the display of the UUT, typically 1.900. Allow adequate time for any thermals to dissipate and the unit to quit drifting.
4. Disconnect the resistance standard.
5. Connect a 190 m Ω standard to the UUT using the clip leads.
6. Verify that the display of the UUT displays the actual standard value ± 2 counts.
7. Disconnect the resistance standard.

H. 20 Ω Adjust

1. Set the range switch to 20 Ω on the UUT.
2. Connect a 19 Ω standard to the UUT using the clip leads.
3. Adjust R114 for a display reading of the actual standards value ± 3 counts (± 0.03 Ω) on the display of the UUT, typically 19.00. Allow adequate time for any thermals to dissipate and the unit to quit drifting.
4. Disconnect the resistance standard.
5. Connect a 1.9 Ω standard to the UUT using the clip leads.

6. Verify that the display of the UUT displays the actual standard value ± 2 counts.
7. Disconnect the resistance standard.

5.5 Troubleshooting

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	Batteries Power cord Power switch U6	Check for batteries installed & polarity. Check the power cord is plugged in. Check the power switch is ON. Check for a square wave between pin 4 & 40 of U4, if present, replace U6.
Battery won't charge	Connections Batteries Fuse Fuse (F1) U1 R1/R101 D5	Remove battery cells and bend contact arms inward to ensure better contact with the battery cells. Clean connections if required. Try a new set of batteries. Check fuses. Check for 12 VDC across C1. If not check for mains on pins 1 & 2 of U8. If not replace U8. If ok, check for approx. 6 VDC (ref. to common) at the output of U1. If not, replace U1. If above ok, check for approximately 4.5 VDC (ref. to common) at the anode of D5, if not, replace R1/R101. If above ok, check for approximately 3.6 VDC (ref. to common) at the cathode of D5, if not, replace D5.
Display reads zero with cables connected to a good resistor	Current o/p Kelvin Clip U9/U11/Q1 U10/U9	Check for proper current o/p between +I and - I. If above ok, check the Kelvin cable for continuity from each side to the banana plug. If no current, troubleshoot the const. current circuit and replace U11 or other component(s) if defective. If the current and cables are both ok, check the voltage amplifier and replace U10,U9 or other component(s) if defective.

Table 2: Fault Symptoms and Repair Actions

After trouble-shooting and repair, the instrument must be recalibrated in accordance with 5.4 above.

Disassembly

- First remove the line cord and any other connecting wires. Then remove the four screws at the corners of the top (display) panel. Carefully lift the unit out of its cabinet. For R1L-BI units only, remove the two screws that secure the battery retention plate. Remove the three battery cells.
- Loosen the set screws in the knobs for the Power and Full Scale switches, and remove these knobs.
- To separate the printed circuit board from the front panel, disconnect the connector from the battery holder board and the connector from the AC line connector. Remove the four screws from the battery holder. Remove the two screws from the lower corners of the PCB and the two standoffs from the upper corners of the PCB. Remove the four nuts from the binding post. Disconnect the connectors from the remote U1 and Q1.

Re-assembly

To reassemble the unit, repeat the above steps in reverse order, taking care to install the lock washers on the proper screws.

5.6 Preparation for Shipment

The original shipping carton is not reusable.

Remove the battery cells prior to shipment (or inactive storage of 30 days or more) and package them separately. Disassemble the R1L-BI/R1L-BIR as per section 5.5, and extract the negative end of the battery cells first.

Packaging must provide sufficient resilient material, in accordance with standard packaging practices, to prevent excessive shock to the power supply and display during shipment.

5.7 Overhaul Instructions

The R1L-BI/R1L-BIR is an all solid-state unit and requires no periodic overhaul, other than routine cleaning, inspection of cables per section 5, and calibration per section 5.4.

However, some disassembly is required to remove and install the batteries. This level of disassembly is detailed in section 5.5, and battery cells should be removed at the negative end first.

Tools and test equipment used for disassembly, calibration, and troubleshooting of the R1L-BI/R1L-BIR are listed in section 5.3.

Troubleshooting suggestions are given in section 5.5.

The only component expected to require replacement is the battery. The battery designation is listed on the Replacement Parts List, with battery cell removal and installation instructions given in section 2.2.

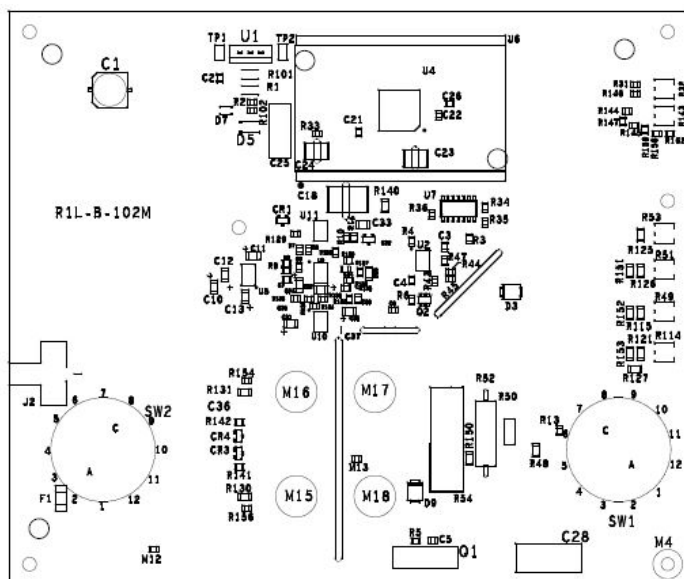


Figure 3: Parts Layout

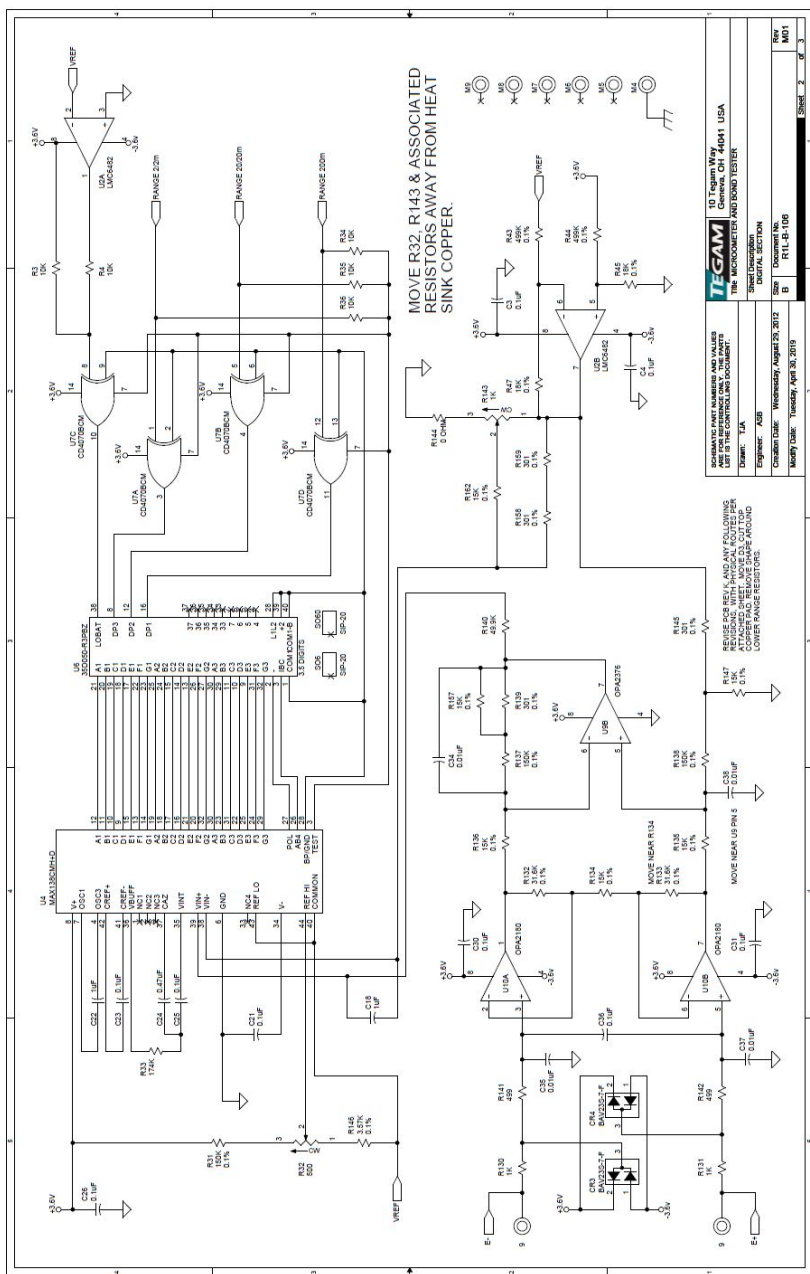


Figure 4: Digital Section

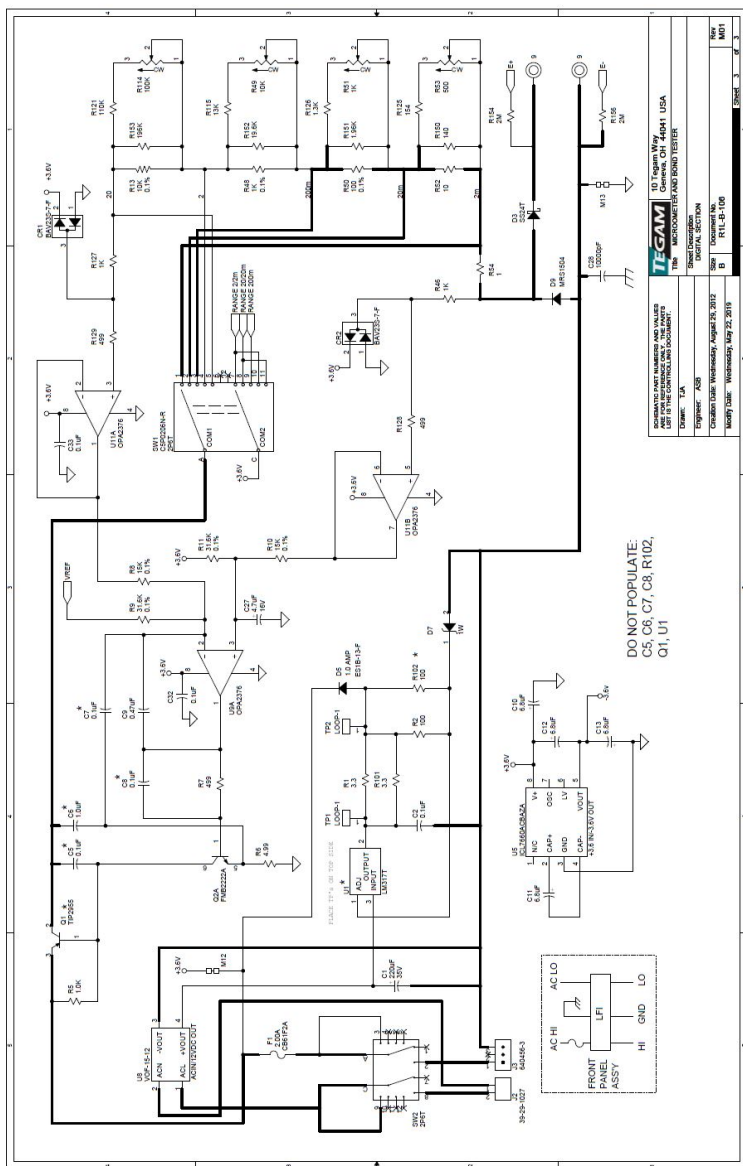


Figure 5: Analog Section

Part Number: R1L-B-100

Item	Qty	Part Reference	Value	Description	Manufacturer P/N	Manufacturer	TEGAM P/N
1	1	C1	220uF	CAP ALUM 220uF 35V F	EEE-1VA221UP	PANASONIC	C-328-220UF
2	6	C2 C3 C4 C21 C26 C36	0.1uF	CAP CER 50V X7R 0805	C0805C104K 5RACTU	KEMET	C-610-0.1UF
3	1	C9	0.47uF	CAP CER 50V X7R 0805	UMK212B747 4KG-T	TAIYO YUDEN	C-610-0.47UF
4	4	C10 C11 C12 C13	6.8uF	CAP TANT 16V 10% E1AA	TR3A685K01 6C3000	VISHAY	C-606-6.8UF
5	1	C18	1.0uF	CAP FILM(PEN) 1.0uF 100V	ECWU1105KC V	PANASONIC	C-335-1.0UF
6	1	C22	1.0uF	CAP CER 50V X7R 0805	GRM21BR71H 105KA12L	MURATA	C-0805K-1.0UF
7	1	C23	0.1uF	CAP FILM(PEN) 0.1uF 100V 2416	ECWU1104JC 9	PANASONIC	C-630-0.1UF
8	1	C24	0.47uF	CAP FILM(PEN) 0.47uF 16V 2416	ECWU1C474J C9	PANASONIC	C-632-0.47uF
9	1	C25	0.1uF	CAP FILM(PP) 0.1uF 250V RAD 10MM	ECWF2104JA Q	PANASONIC	C-514-0.1UF
10	1	C27	4.7uF	CAP TANT 16V E1AA	TR3A475K01 6C1500	VISHAY	C-606-4.7UF
11	1	C28	10000pF	CAP CER 250VAC RAD 7.5MM	DE2F3KH103 MA3B	MURATA	C-595-10000PF
12	4	C30 C31 C32 C33	0.1uF	CAP CER 0.1UF 50V X7R 1206	C1206C104K 5RAC	KEMET	150036
13	4	C34 C35 C37 C38	0.01uF	CAP CER 0.01UF 50V X7R 0805	C0805C103K 5RACTU	KEMET	C-610-10000PF
14	4	CR1 CR2 CR3 CR4	BAV23 S	DIO FAST DUAL 200V 400mA SOT-23-3	BAV23S-7-F	DIODES INCORPORATED	DZ-228
15	1	D3	SS24	DIO SCHOTTKY 40V 2A SMB	SS24T3G	ON SEMICONDUCTOR	DZ-157
16	1	D5	ES1B	DIO FAST 100V 1A SMA	ES1B-13-F	DIODES INCORPORATED	DZ-172
17	1	D7	5.6V	DIO ZENER 5.6V 1W POWERDI123	DFLZ5V6	DIODES INCORPORATED	DZ-180
18	1	D9	1.5 AMP	DIO GP 400V 1.5A SMB	MRS1504T3G	ON SEMICONDUCTOR	DZ-130
19	1	F1	2A	FUSE 2A 125VAC/DC 2410	CB61F2A	COOPER BUSSMANN	FU-25
20	1	J2	39-29-102	CONN HEADER RIGHT ANGLE 2X1 4.2MM	39-29-102	MOLEX	CS-22
21	1	J3	640456-3	CONN HEADER VERTICAL 1x3 2.54MM	640456-3	TE CONNECTIVITY	CS-199
22	4	M15 M16 M17 M18	9	M-F THRD HEX STAND-OFF	92700A452	McMASTER-CARR	ST-318
23	1	Q2	FMB22 22A	XSISTOR BJT NPN DUAL 40V 500mA TSOT-23-6	FMB2222A	FAIRCHILD SEMICONDUCTOR	TG-270
24	2	R1 R101	3.3	RES CARBON FILM 5% 1W MELF 0207	CMB02070X3 308JB200	VISHAY-BEYCHLAG	R-250-3.3
25	2	R2 R50	100	RES THICK FILM 1% 1/8W 0805	ERJ-6ENF1000V	PANASONIC YAGEO	R-618-100

					RC0805FR-07100RL		
Item	Qty	Part Reference	Value	Description	Manufacturer P/N	Manufacturer	TEGAM P/N
26	5	R3 R4 R34 R35 R36	10.0K	RES THICK FILM 1% 1/8W 0805	ERJ-6ENF1002V RC0805FR-0710KL	PANASONIC YAGEO	R-618-10K
27	1	R5	1.00K	RES THICK FILM 1% 1/8W 0805	ERJ-6ENF1001V RC0805FR-071KL	PANASONIC YAGEO	R-618-1K
28	1	R6	4.99	RES THICK FILM 1% 1/8W 0805	RC0805FR-074R99L	YAGEO	R-618-4.99
29	5	R7 R128 R129 R141 R142	499	RES THICK FILM 1% 1/8W 0805	ERJ-6ENF4990V	PANASONIC	R-618-499
30	8	R8 R10 R134 R135 R136 R147 R157 R162	15.0K	RES THICK FILM 0.1% 1/8W 0805	ERA-6AEB153V	PANASONIC	R-638-15K
31	4	R9 R11 R132 R133	31.6K	RES THICK FILM 0.1% 1/8W 0805	ERA-6AEB3162V	PANASONIC	R-638-31.6K
32	1	R13	10.0K	RES THICK FILM 0.1% 1/8W 0805	ERA-6AEB103V PFC-W0805LF-03-1002-B-1739	PANASONIC TT ELEC./IRC	R-638-10K
33	3	R31 R137 R138	150K	RES THICK FILM 0.1% 1/8W 0805	ERA-6AEB154V	PANASONIC	R-638-150K
34	2	R32 R53	500	RES TRIMMER 1/4W 12-TURN 4mm SQ SMD	3224G-1-501E	BOURNS	RP-103-500
35	1	R33	174K	RES THICK FILM 1% 1/8W 0805	ERJ-6ENF1743V RC0805FR-07174KL	PANASONIC YAGEO	R-618-174K
36	2	R43 R44	499K	RES THICK FILM 0.1% 1/8W 0805	ERA-6AEB4993V	PANASONIC	R-638-499K
37	2	R45 R47	18.0K	RES THICK FILM 0.1% 1/8W 0805	ERA-6AEB183V	PANASONIC	R-638-18K
38	4	R46 R127 R130 R131	1.00K	RES THICK FILM 1% 1/4W 1206	ERJ-8ENF1001V	PANASONIC	R-515-1K
39	1	R48	1.00K	RES THICK FILM 0.1% 1/4W 1206	RG3216P-1001-B-T1	SUSUMU	R-550-1.0K
40	1	R49	10K	RES TRIMMER 1/4W 12-TURN 4mm SQ SMD	3224G-1-103E	BOURNS	RP-103-10.0K
41	1	R50	100	RES METAL FILM 0.1% 1/2W AX	CMF55100R0 0BEEB	VISHAY	R-169-100
42	2	R51 R143	1K	RES TRIMMER 1/4W 12-TURN 4mm SQ SMD	3224G-1-102E	BOURNS	RP-103-1.0K
43	1	R52	10.0	RES WW 1% 3W AX	43F10RE	OHMITE	R-275-10
44	1	R54	1.00	RES WW 1% 5W AX	45F1R0E	OHMITE	R-341-1
45	1	R114	100K	RES TRIMMER 1/4W 12-TURN 4mm SQ SMD	3224G-1-104E	BOURNS	RP-103-100.0K
46	1	R115	13.0K	RES THICK FILM 1% 1/4W 1206	ERJ-8ENF1302V	PANASONIC	R-515-13K
47	1	R121	110K	RES THICK FILM 1% 1/4W 1206	ERJ-8ENF1103V	PANASONIC	R-515-110K
48	1	R125	154	RES THICK FILM 1% 1/4W 1206	ERJ-8ENF1540V	PANASONIC	R-515-154

49	1	R126	1.30K	RES THICK FILM 1% 1/4W 1206	ERJ- 8ENF1301V	PANASONIC	R-515- 1.3K
Item	Qty	Part Reference	Value	Description	Manufactur er P/N	Manufacturer	TEGAM P/N
50	4	R139 R145 R158 R159	301	RES THICK FILM 0.1% 1/8W 0805	ERA- 6AEB301V	PANASONIC	R-638- 301
51	1	R140	49.9K	RES THICK FILM 1% 1/4W 1206	ERJ- 8ENF4992V	PANASONIC	R-515- 49.9K
52	1	R144	0.0	RES THICK FILM JUMPER 1/8W 0805	ERJ- 6GEY0R00V RC0805JR- 070RL	PANASONIC YAGEO	R-618-0
53	1	R146	3.57K	RES THICK FILM 0.1% 1/8W 0805	ERA- 6AEB3571V RG2012P- 3571-B-T5	PANASONIC SUSUMU	R-638- 3.57K
54	1	R150	140	RES THICK FILM 1% 1/4W 1206	ERJ- 8ENF1400V	PANASONIC	R-515- 140
55	1	R151	1.96K	RES THICK FILM 1% 1/4W 1206	ERJ- 8ENF1961V	PANASONIC	R-515- 1.96K
56	1	R152	19.6K	RES THICK FILM 1% 1/4W 1206	ERJ- 8ENF1962V	PANASONIC	R-515- 19.6K
57	1	R153	196K	RES THICK FILM 1% 1/4W 1206	ERJ- 8ENF1963V	PANASONIC	R-515- 196K
58	2	R154, R156	2.0M	RES THICK FILM 1% 1/8W 0805	ERJ- 6ENF2004V	PANASONIC	R-618- 2.0M
59	2	SO6 SO60	SIP-20	CONN SIL- SOCKET 0.472" STANDOFF HEIGHT 20-POS	316-93-120- 41-008000	MILL-MAX	SO-314- 20
60	2	SW1 SW2	2P6T	SW ROTARY DP 6-POS	C5P0206N-R	ELECTROSWIT CH	SW-419
61	2	TP1 TP2	S1751- 46R	TP LOOP SMD	S1751-46R	HARWIN INC.	CS-122
62	1	U10	OPA21 80	IC OPAMP DUAL ZERO-DRIFT SOIC-8	OPA2180IDR	TEXAS INSTRUMENTS	IC-352
63	2	U11 U9	OPA23 76	IC OPAMP DUAL LOW NOISE SOIC-8	OPA2376AID	TEXAS INSTRUMENTS	IC-358
64	1	U2	LMC64 82	IC OPAMP DUAL CMOS SOIC-8	LMC6482IM/ NOPB	TEXAS INSTRUMENTS	IC-251
65	1	U4	MAX13 8	IC 3.5 DIGIT ADC W/LCD DRIVER QFP-44	MAX138CMH	MAXIM	IC-241
66	1	U5	7660	IC REGULATOR SWITCHED CAP SOIC-8	ICL7660ACBA ZA	INTERSIL	IC-809
67	1	U6	3.5DIG IT LCD	DISPLAY 3.5 DIGIT W/ ± AND LOBAT IND., USE NO BACKLIGHT	35D050- R3PBZ	FEMA ELEC.	DD-206
68	1	U7	4070B	IC QUAD 2- INPUT XOR SOIC-14	CD4070BM96	TEXAS INSTRUMENTS	IC-863
69	1	U8	VOF- 15-12	PS 12VDC 1.25A OPEN FRAME PCB MOUNT	VOF-15-12	CUI INC	PS-128

Table 3: Parts List – Main Board Assembly

Part Number	Part Description	Qty	UM	Manufacturer	Cage Code	Mfg Part
BA-110	BATT,C,NICAD,3000mAh	3	EA	PANASONIC	0HF77	P-280CR
				SANYO	00JU0	N-3000CR
				TENERGY	55R99	20400
R1LB-040	FRONT PANEL ASSY	1	EA	TEGAM, INC	49374	
HO-1	R1L-B ENCLOSURE	1	EA	BOPLA ENCLOSURES	C2317	UMP62014FP
CO-115	LINECORD	1	EA	VOLEX	U7112	17250-10-B1
KTL-100	CBL,DUAL-BAN-KKLIP,7'	1	EA	TEGAM, INC	49374	
6X5/8PPH	SCW,SHT METL,#6X5/8 PPH	4	EA	MPT FASTENER	45T10	BY DESCRIPTION
12460	CABINET BACK PANEL	1	EA	AMERICAN METAL SPECIALTIE	5JH28	PER PRINT
R1L-B/BR-900-01	OPERATION MANUAL	1	EA	ACTIVITIES PRESS		R1L-B-900-01
R1L-B/BR-841	CD MANUAL MILITARY	AR	EA	TEGAM, INC	49374	
RTV102	SILICONE RUBBER SEALANT	AR	EA	GE SILICONES	L3160	RTV102
HO-30	HARD CASE R1L-B ACCES	AR	EA	PACKATEERING	52948	
MC-1058	R1L-B ACCES CONT LABEL	AR	EA	METAL CRAFT		
MIL-STD-130	UID LABEL	AR	EA	METAL CRAFT		

Table 4a: Parts List – R1L-BI Final Assembly

Part Number	Part Description	Qty	UM	Manufacturer	Cage Code	Mfg Part
BA-110	BATT,C,NICAD,3000mAh	3	EA	PANASONIC	0HF77	P-280CR
				SANYO	00JU0	N-3000CR
				TENERGY	55R99	20400
R1LBR-040	FRONT PANEL ASSY	1	EA	TEGAM, INC	49374	
5010	CASE, R1MA/AR	1	EA	AMERIPACK	0TJ49	5000
CO-115	LINECORD	1	EA	VOLEX	U7112	17250-10-B1
BR-5011MP	MOUNT PNL F/CSE 5011 RLBR	1.5	EA	AMERIPACK	0TJ49	5000-RING
PK-5011	POCKT PNLF/CAS 5011 RLBR	1	EA	AMERIPACK	0TJ49	PK-5011
R1L-B/BR-900-01	OPERATION MANUAL	1	EA	ACTIVITIES PRESS		R1L-B-900-01
R1L-B/BR-841	CD MANUAL MILITARY	AR	EA	TEGAM, INC	49374	
MC-1207	R1L-BR CASE LABEL	1	EA	NUTRON NAMEPLATE	30236	MC-1207 PRINT

Table 4b: Parts List – R1L-BIR Final Assembly

Part Number: R1L-B-040

Part Number	Part Description	Reference	Qty	UM	Manufacturer	Cage Code	Mfg Part
BP-50-0	BIND POST CON GLD-PLT BLK	BP -I, BP -E	2	EA	POMONA ELECTRONICS	5D6S9	3750-0
BP-50-2	BIND POST CON GLD-PLT RED	BP +I, BP +E	2	EA	POMONA ELECTRONICS	5D6S9	3750-2
CS-104	CON,DUL,BINDPOST BASE BLK	BP +I, +E,-I,-E	2	EA	POMONA ELECTRONICS	5D6S9	3862
PE-2	PWR ENTRY LINEFILTER 3A	LF1	1	EA	CORCOM	38AS8	3EEA1
					TYCO,TE CONNECTIVITY	1Z830	6609000-4
FH-20	FUSE HLD PNL MNT 6.3X32MM	XF1	1	EA	LITTELFUSE	7E222	03453LF1H
FU-202	FUSE,1/4A 3AG SLOW BLOW	F1	1	EA	LITTELFUSE	7E222	313.25
					LITTELFUSE	7E222	313.250HXP
IN-7	SIL-PAD,HEATPAD TO -220		2	EA	BERGQUIST	55285	3223-07FR-90
					BERGQUIST	55285	SP400-0.007- 00-90
WA-20	WSH,NYLON #4	Q1,U1	2	EA	THERMALLOY	13103	7721-7PPS
					THERMALLOY	13103	7721-7PPSG
					TEGAM, INC	49374	210117800
					ITW PANCON	0K1B5	CE100F22-3-D
210108	LUG,SOLDER,#4		1	EA	KEYSTONE ELECTRONICS	91833	908
12373	DISPLAY GASKET R1L-B		2	EA	GASKO	6R887	12373
ST-318	STNDOF,8- 32X1/2"HEX BRS Z		4	EA	MCMaster-CARR	0KVE6	92700A452
WA-244	WSH,#8 LOCK,GLD PLATED		4	EA	MPT FASTENER	45T10	BUY WIT NUT- 8/32 & WA-242
NUT- 8/32GLD	NUT,HEX,8-32,GLD PLATED		4	EA	MPT FASTENER	45T10	BUY WITH WA- 242 & WA-244
MS51957- 13	SCR PH 4-40 X 1/4 LG		6	EA	MPT FASTENER	45T10	NON MIL EQUAL BY DESC
4- 40X1/2PFH BLK	SCW,PFH,4/40X1/2, SS,BLK		2	EA	MPT FASTENER	45T10	
3538	NUT,HEX,4-40		6	EA	BEAVER BOLT	0B6M9	3538
					MPT FASTENER	45T10	4-40 HEX NUT 18-8
MS35338- 135	WSH LOCK #4		15	EA	MPT FASTENER	45T10	NON MIL EQUAL BY DESC
6168	WIRE,N18 STR GRN TFLN		AR	FT	BIRNBACH	71002	8518/19 GRN
					BELDEN WIRE AND CABLE	3HXC8	83029 005100
					TEGAM, INC	49374	079-145-5
					TEGAM, INC	49374	600005
					BELDEN WIRE AND CABLE	3HXC8	83009-10
					TEGAM, INC	49374	079-145-10

					TEGAM, INC	49374	600010
Part Number	Part Description	Reference	Qty	UM	Manufacturer	Cage Code	Mfg Part
KN-106	KNOB,ROUND,KNUR LED.6,4MM		2	EA	MULTICOMP/SPC	75498	MC21051
CS-21	CONN,PUSH ON		1	EA	MOLEX	KB925	39012020
CS-105	CONN,TERM,FEMLE, 18-24 AWG		2	EA	MOLEX	KB925	39-00-0039
015-317	IC VOLT REG ADJ		1	EA	FAIRCHILD SEMICONDUCTOR	4E8P4	LM317T
					NATIONAL SEMICONDUCTOR		LM317T
TG-34	XISTOR,BIPOLAR,PN P		1	EA	MOTOROLA		TIP34
					ST MICROELECTROIN CS	SCE76	TIP34C
					TEGAM, INC	49374	079-148-8
					TEGAM, INC	49374	600008
TX-20-3/16	TUBING SHRINK 3/16		AR	EA	ALPHA WIRE & CABLE	92194	FIT221 3/16
					ALLIED WIRE & CABLE	92194	HST221-3/16
					TEGAM, INC	49374	6196
ST-335	STANDOFF,4- 40X3/4 HEX		4	EA	MCMMASTER-CARR	0KVE6	91780A745
MS35338- 137	WSH LOCK,SPLT,#8		4	EA	TEGAM, INC	49374	50626
					TEGAM, INC	49374	NAS1676C8
					MPT FASTENER	45T10	NON MIL EQUAL BY DESC
R1LB-320	FRONT PANEL		1	EA	NUTRON NAMEPLATE	30236	R1LB-320
R1L-B-100	PC ASSY, R1L-B		1	EA	TEGAM, INC	49374	
999920- 000	WIR,20 AWG TFE BLACK		AR	EA	BELDEN WIRE AND CABLE	3HXC8	83007-010
999920- 008	WIR,20 AWG TFE GREY		AR	EA	BELDEN WIRE AND CABLE	3HXC8	83007-008
ST-317	STNDOF,4-40X.25 M/F STEEL		4	EA	MCMMASTER-CARR	0KVE6	93620A430
R1L-B-200	PC ASSY R1L-B BATT BRD		1	EA	TEGAM, INC	49374	
R1L-B-302	BATTERY RETAIN PLATE R1L-B		1	EA	AMERICAN METAL SPECIALTIE	5JH28	
ST-215	STANDOFF,4- 40X1.25F/F1/4H		2	EA	MCMMASTER-CARR	0KVE6	91780A169
MS51957- 15	SCR PH 4-40 X 3/8 LG		4	EA	MPT FASTENER	45T10	NON MIL CERT MS51957-15
IN-17	2X3.5 INSULATOR		1	EA	TEGAM, INC	49374	
LOCTITE26 3	LOCTITE,263,HI STG,THRD		AR	EA	LOCTITE	05972	263

Table 5a: Parts List – R1L-BI Front Panel Assembly

Part Number: R1L-BR-040

Part Number	Part Description	Reference	Qty	UM	Manufacturer	Cage Code	Mfg Part
BP-50-0	BIND POST CON GLD-PLT BLK	BP -I, BP -E	2	EA	POMONA ELECTRONICS	5D6S9	3750-0
BP-50-2	BIND POST CON GLD-PLT RED	BP +I, BP +E	2	EA	POMONA ELECTRONICS	5D6S9	3750-2
CS-104	CON,DUL,BINDPOST BASE BLK	BP +I, +E,-I,-E	2	EA	POMONA ELECTRONICS	5D6S9	3862
PE-2	PWR ENTRY LINEFILTER 3A	LF1	1	EA	CORCOM	38AS8	3EEA1
					TYCO\TE CONNECTIVITY	1Z830	6609000-4
FH-20	FUSE HLD PNL MNT 6.3X32MM	XF1	2	EA	LITTELFUSE	7E222	03453LF1H
FU-202	FUSE,1/4A 3AG SLOW BLOW	F1	2	EA	LITTELFUSE	7E222	313.25
					LITTELFUSE	7E222	313.250HXP
IN-7	SIL-PAD,HEATPAD TO -220		2	EA	BERGQUIST	55285	3223-07FR-90
					BERGQUIST	55285	SP400-0.007- 00-90
WA-20	WSH,NYLON #4	Q1,U1	2	EA	THERMALLOY	13103	7721-7PPS
					THERMALLOY	13103	7721-7PPSG
					TEGAM, INC	49374	210117800
					ITW PANCON	0K1B5	CE100F22-3-D
210108	LUG,SOLDER,#4		1	EA	KEYSTONE ELECTRONICS	91833	908
12373	DISPLAY GASKET R1L-B		2	EA	GASKO	6R887	12373
ST-318	STNDOF,8- 32X1/2"HEX BRS Z		4	EA	MCMaster-CARR	0KVE6	92700A452
WA-244	WSH,#8 LOCK,GLD PLATED		4	EA	MPT FASTENER	45T10	BUY WIT NUT- 8/32 & WA-242
NUT- 8/32GLD	NUT,HEX,8-32,GLD PLATED		4	EA	MPT FASTENER	45T10	BUY WITH WA- 242 & WA-244
MS51957- 13	SCR PH 4-40 X 1/4 LG		6	EA	MPT FASTENER	45T10	NON MIL EQUAL BY DESC
4- 40X1/2PFH BLK	SCW,PFH,4/40X1/2, SS,BLK		2	EA	MPT FASTENER	45T10	
3538	NUT,HEX,4-40		6	EA	BEAVER BOLT	0B6M9	3538
					MPT FASTENER	45T10	4-40 HEX NUT 18-8
MS35338- 135	WSH LOCK #4		11	EA	MPT FASTENER	45T10	NON MIL EQUAL BY DESC
6168	WIRE,N18 STR GRN TFLN		AR	FT	BIRNBACH	71002	8518/19 GRN
					BELDEN WIRE AND CABLE	3HXC8	83029 005100
					TEGAM, INC	49374	079-145-5
					TEGAM, INC	49374	600005
					BELDEN WIRE AND CABLE	3HXC8	83009-10

					TEGAM, INC	49374	079-145-10
					TEGAM, INC	49374	600010
Part Number	Part Description	Reference	Qty	UM	Manufacturer	Cage Code	Mfg Part
KN-106	KNOB,ROUND,KNUR LED.6.4MM		2	EA	MULTICOMP/SPC	75498	MC21051
CS-21	CONN,PUSH ON		1	EA	MOLEX	KB925	39012020
CS-105	CONN,TERM,FEMLE, 18-24 AWG		2	EA	MOLEX	KB925	39-00-0039
015-317	IC VOLT REG ADJ		1	EA	FAIRCHILD SEMICONDUCTOR	4E8P4	LM317T
					NATIONAL SEMICONDUCTOR		LM317T
TG-34	XISTOR,BIPOLAR,PN P		1	EA	MOTOROLA		TIP34
					ST MICROELECTROIN CS	SCE76	TIP34C
					TEGAM, INC	49374	079-148-8
					TEGAM, INC	49374	600008
TX-20-3/16	TUBING SHRINK 3/16		AR	EA	ALPHA WIRE & CABLE	92194	FIT221 3/16
					ALLIED WIRE & CABLE	92194	HST221-3/16
					TEGAM, INC	49374	6196
ST-335	STANDOFF,4- 40X3/4 HEX		4	EA	MCMaster-CARR	0KVE6	91780A745
MS35338- 137	WSH LOCK,SPLT,#8		4	EA	TEGAM, INC	49374	50626
					TEGAM, INC	49374	NAS1676C8
					MPT FASTENER	45T10	NON MIL EQUAL BY DESC
R1LB-320	FRONT PANEL		1	EA	NUTRON NAMEPLATE	30236	R1LB-320
R1L-B-100	PC ASSY, R1L-B		1	EA	TEGAM, INC	49374	
999920- 000	WIR,20 AWG TFE BLACK		AR	EA	BELDEN WIRE AND CABLE	3HXC8	83007-010
999920- 008	WIR,20 AWG TFE GREY		AR	EA	BELDEN WIRE AND CABLE	3HXC8	83007-008
ST-317	STNDOF,4-40X.25 M/F STEEL		4	EA	MCMaster-CARR	0KVE6	93620A430
R1L-B-200	PC ASSY R1L-B BATT BRD		1	EA	TEGAM, INC	49374	
LOCTITE26 3	LOCTITE,263,HI STG,THRD		AR	EA	LOCTITE	05972	263

Table 5b: Parts List – R1L-BIR Front Panel Assembly

Part Number: R1L-B-200

Part Number	Part Description	Qty	UM	Manufacturer	Cage Code	Mfg Part
R1L-B-172	PCB BATTERY BRD R1L-B	1	EA	ALPHA CIRCUITS	33TM7	R1L-B-172
BH-107	BATT HOLDER END "C" INSUL	6	EA	KEystone ELECTRONICS	91833	87
EY-35	EYELET 3/32X0.156	12	EA	KEystone ELECTRONICS	91833	35
BH-25	BATT HOLDER KEY INSUL	3	EA	KEystone ELECTRONICS	91833	59
Part Number	Part Description	Qty	UM	Manufacturer	Cage Code	Mfg Part
CS-211-3	CONN,3 PIN,IDC INLINE	1	EA	ITW PANCON	0K1B5	CE100F22-3-C
				ITW PANCON	0K1B5	CE100F22-3-D
999924-000	WIR,24 AWG,TEFLON BLK	AR	IN	BELDEN WIRE AND CABLE	3HXC8	83003-10/BLK
999924-002	WIR,24 AWG,RED,TEFLON	AR	IN	BELDEN WIRE AND CABLE	3HXC8	83003-2(RED)
999924-003	WIR,24 AWG,TFE,ORANGE	AR	IN	BELDEN WIRE AND CABLE	3HXC8	83003-3(ORNG)
TX-20-3/16	TUBING SHRINK 3/16	AR	EA	ALPHA WIRE & CABLE	92194	FIT221 3/16
				ALLIED WIRE & CABLE	92194	HST221-3/16
				TEGAM, INC	49374	6196
ST-420	SPA, INS PCB, NYL,,250X.260	2	EA	KEystone ELECTRONICS	91833	9029

Table 6: Parts List –Battery Board Assembly

Manufacturer	Cage Code	Manufacturer	Cage Code
ABBATRON HH SMITH	91967	MAXIM	1ES66
ALPHA	92194	MCMaster CARR	OKVE6
AMERIPACK	OTJ49	MICRO COMMERCIAL	374W0
AVX	16299	MILL MAX	3N087
BELDEN	3HXC8	MOLEX	KB925
BOURNS	F0978	MOTOROLA	0G546
C&K	63HW9	MPT FASTENER	45T10
COMMERCIAL-SEE MCMaster CARR		MULTICOMP	75498
CONCORD	18310	MULTI-CONTACT	0WCJ0
COOPER BUSSMANN	1UW16	MURATA ELECTRONICS NA	3EH09
CORCOM	38AS8	NATIONAL SEMICONDUCTOR	0G557
CUSTOM COIL	0VYL0	OHMITE	03615
DIALIGHT (DIALCO)	96312	OLDAKER	64882
DISCH-SEE TEGAM		ON SEMICONDUCTOR	59PE1
EAGLE	0MPC5	PANASONIC	0HF77
ELECTROSWITCH	8T045	PHILIPS	0TBA7
ELECTRO-TECH SYSTEMS	56541	POMONA	5D6S9
ETCHED METAL-SEE TEGAM		PPM-SEE TEGAM	
FAIRCHILD SEMICONDUCTOR	4E8P4	SPRAGUE	5079
FEMA	OP7Z6	SUSUMU	SAW40
GE (MG CHEMICALS)	L3160	ST MICROELECTRONICS	SCE76
GRAYHILL	81073	TEGAM, INC	49374
HARWIN INC.	06EX9	TEXAS INSTRUMENTS	8T904
ILLINOIS CAPACITOR	74840	TYCO	Z9V34
INTERSIL CORPORATION	K0331	TYTON	3E655
KEMET ELECTRONICS	31433	VISHAY	56845
KOA	59124	VOLEX POWER CORDS	U7112
LITTLEFUSE	7E222		

Table 7: Vendor Cage Code Directory

SECTION 6

SERVICE INFORMATION

Preparation for Calibration or Repair Service

Once you have verified that the cause for R1L-B/R1L-BR 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 your 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.

TEGAM, Inc. certifies the above listed instrument has been inspected and calibrated and meets or exceeds all published specifications and has been calibrated using standards whose accuracies are traceable to the International System of Units (SI) through the National Institute of Standards and Technology (NIST) or other recognized National Metrology Institutes.

Contact Information

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GENEVA, OHIO 44041

CAGE Code: 49374

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