User's Manual

Model 234

Temperature Transmitter

and

Model 234D

Temperature Transmitter/Monitor

Includes Coverage for:
Model 2308-01 Benchtop Enclosure
Model 2308-12 VMEbus Rackmount Case

For Use with the Following Lake Shore Sensors:
Series CGR Carbon-Glass Resistance Temperature Sensors
Series CX Cernox™ Resistance Temperature Sensors
Series GR-200 Germanium Resistance Temperature Sensors

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Rev. 1.7 P/N 119-026 **1 March 2016**

LIMITED WARRANTY STATEMENT – WARRANTY PERIOD: ONE (1) YEAR

1. Lake Shore warrants that this Lake Shore product (the "Product") will be free from defects in materials and workmanship for the Warranty Period specified above (the "Warranty Period"). If Lake Shore receives notice of any such defects during the Warranty Period and the Product is shipped freight prepaid, Lake Shore will, at its option, either repair or replace the Product if it is so defective without charge to the owner for parts, service labor or associated customary return shipping cost. Any such replacement for the Product may be either new or equivalent in performance to new. Replacement or repaired parts will be warranted for only the unexpired portion of the original warranty or 90 days (whichever is greater).
2. Lake Shore warrants the Product only if it has been sold by an authorized Lake Shore employee, sales representative, dealer or original equipment manufacturer (OEM).
3. The Product may contain remanufactured parts equivalent to new in performance or may have been subject to incidental use.
4. The Warranty Period begins on the date the Product ships from Lake Shore's plant.
5. This limited warranty does not apply to defects in the Product resulting from (a) improper or inadequate maintenance, repair or calibration, (b) fuses, software and non-rechargeable batteries, (c) software, interfacing, parts or other supplies not furnished by Lake Shore, (d) unauthorized modification or misuse, (e) operation outside of the published specifications or (f) improper site preparation or maintenance.
6. To the extent allowed by applicable law, the above warranties are exclusive and no other warranty or condition, whether written or oral, is expressed or implied. Lake shore specifically disclaims any implied warranties or conditions of merchantability, satisfactory quality and/or fitness for a particular purpose with respect to the product. Some countries, states or provinces do not allow limitations on an implied warranty, so the above limitation or exclusion might not apply to you. This warranty gives you specific legal rights and you might also have other rights that vary from country to country, state to state or province to province.
7. To the extent allowed by applicable law, the remedies in this warranty statement are your sole and exclusive remedies.
8. Except to the extent prohibited by applicable law, in no event will lake shore or any of its subsidiaries, affiliates or suppliers be liable for direct, special, incidental, consequential or other damages (including lost profit, lost data or downtime costs) arising out of the use, inability to use or result of use of the product, whether based in warranty, contract, tort or other legal theory, and whether or not lake shore has been advised of the possibility of such damages. Your use of the Product is entirely at your own risk. Some countries, states and provinces do not allow the exclusion of liability for incidental or consequential damages, so the above limitation may not apply to you.
9. Except to the extent allowed by applicable law, the terms of this limited warranty statement do not exclude, restrict or modify, and are in addition to, the mandatory statutory rights applicable to the sale of the product to you.

CERTIFICATION

Lake Shore certifies that this product has been inspected and tested in accordance with its published specifications and that this product met its published specifications at the time of shipment. The accuracy and calibration of this product at the time of shipment are traceable to the United States National Institute of Standards and Technology (NIST); formerly known as the National Bureau of Standards (NBS), or to a recognized natural standard.

TRADEMARK ACKNOWLEDGEMENT

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CHAPTER 1

INTRODUCTION

1.0 GENERAL

The Model 234 is designed and manufactured in the USA by Lake Shore Cryotronics, Inc. In general, references to the Model 234 applies to both the Model 234 Transmitter and 234D Transmitter/Monitor. Specific references are made where appropriate. This chapter provides a General Description of the Model 234 in Paragraph 1.1, Model 234D General Description in Paragraph 1.2, Model 2308-1 Enclosure Description in Paragraph 1.3, and Model 2308-12 Case Description in Paragraph 1.4.

We welcome comments on this manual. Although we try to keep it error-free, some may occur. To report an error, describe it briefly and include the appropriate paragraph, figure, table, and page number. Send comments to Lake Shore Cryotronics, Attn: Technical Publications, 575 McCorkle Blvd., Westerville, Ohio 43082-8888. This manual is subject to change without notice.

1.1 MODEL 234 GENERAL DESCRIPTION

The Model 234 Temperature Transmitter sends temperature data from its position near a sensor to a data acquisition channel or strip chart recorder. A Model 234D also displays the temperature (or resistance).

The Model 234 operates with Cernox™, Carbon-Glass, Germanium, or other resistance temperature sensors. The Lake Shore CGR Series Carbon-Glass resistance temperature sensors are the best choice for a highly reproducible sensor from 1.4 K to 325 K and above in magnetic fields up to 19 tesla or higher. The Lake Shore GR Series Germanium resistance temperature sensors are recognized "secondary standard thermometers" used in temperature measurement up to about 100 K for over 30 years. Sensitivity for both devices increases rapidly with decreasing temperature (both devices are classified according to their 4.2 K resistance value).

Cernox, Carbon-Glass, and Germanium sensing elements are suspended in a strain-free mounting which causes the thermal path through the connecting leads, making measurement method and mounting critical to accurate temperature measurements.

The Model 234 excites the sensor with a constant voltage of 10 mV or less to minimize the effects of sensor self-heating at low temperatures.

The Model 234 employs an analog control circuit to maintain a constant voltage signal across the sensor. A series of reference resistors convert the resulting sensor current to a voltage. A microcontroller reads the voltage with an A/D converter, calculates sensor resistance, and converts the resistance to temperature by table interpolation (requires a CalCurve™ for temperature conversion). The sensor excitation voltage is reversed each reading to compensate for thermal voltages and offsets.

A current of 4 to 20 milliamps representing either sensor resistance temperature or log transmits. The transmitted current changes linearly with resistance temperature or log. Output scale depends on the selected temperature range. Several switch selected ranges are available. Highest accuracy and sensitivity are achieved when the output is set for a narrow temperature band. A 0 to 20 mA output is also available to convert output to a voltage scaled from zero. A 500 ohm, ±0.02% output load resistor produces the maximum full scale output of 10 volts.

A serial interface (operating at 9600 baud) can be used for service purposes to read sensor resistance, temperature, and configuration, install and review the CalCurve, and calibrate the transmitter.

A single +5 VDC supply powers Model 234 circuitry. The outputs are isolated so several Model 234s can run off the same supply without interference. +5 VDC can also be supplied from the pins on the VME bus connector.

The Model 234 is built on a standard A-Size VME Card. It fits directly into a single height (3U) VME card holder. The transmitter does not use the electrical bus format, only its physical shape and power supply.

The Model 234 Temperature Transmitter is available as a stand-alone unit or with one of two enclosures: a Model 2308-1 single space enclosure (included with the Model 234D), or Model 2308-12 rackmount case that holds 12 units. See Figure 1-1, and Tables 1-1 and 1-2.

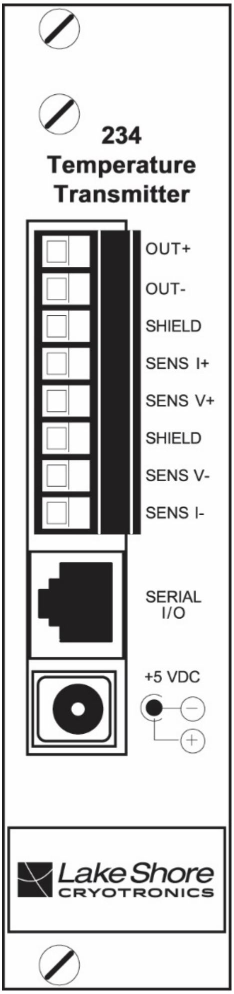


Figure 1-1. Typical Model 234 Front Panel
(and Model 234D Rear Panel)

1.2 MODEL 234D GENERAL DESCRIPTION

In addition to Model 234 features, the Model 234D also provides local display of the temperature or resistance of a single sensor via a 6-digit LED Display. It maintains full transmitter capabilities, serial interface commands, and curve format of the standard Model 234. The display is updated at one half the rate of the transmitter output.

Choose to display temperature in kelvin (K) or resistance in ohms (Ω) by placing DIP switch S1 (see Figure 5-3), switch 7, to T (open) for temperature or R (closed) for resistance. The temperature display is capable of 1 mK resolution, but actual resolution is no better than the measurement resolution listed in Table 1-1.

Place S1 Switch 7 to R (closed) to cause the display to read in ohms (Ω). Note the display shows R, not log(R), present at the transmitter output in this configuration. The maximum resistance resolution is shown below. The resistance display is capable of these resolutions, but the actual resolution is not better than the measurement resolution listed in Table 1-1.

Range	*Display Resolution*	*Display*
0 – 1 Ω	—	Short
1 – 10 Ω	0.01 mΩ	1.00000 to 9.99999 Ω
10 – 100 Ω	0.1 mΩ	10.0000 to 99.9999 Ω
100 – 1 kΩ	1 mΩ	100.000 to 999.999 Ω
1k – 10 kΩ	10 mΩ	1000.00 to 9999.99 Ω
10k – 100 kΩ	0.1 Ω	10000.0 to 99999.9 Ω
100k – 300 kΩ	1 Ω	100000 to 399999 Ω
>≈400 kΩ	—	Open

Model 234D front panel and dimensions appear in Figure 1-2.

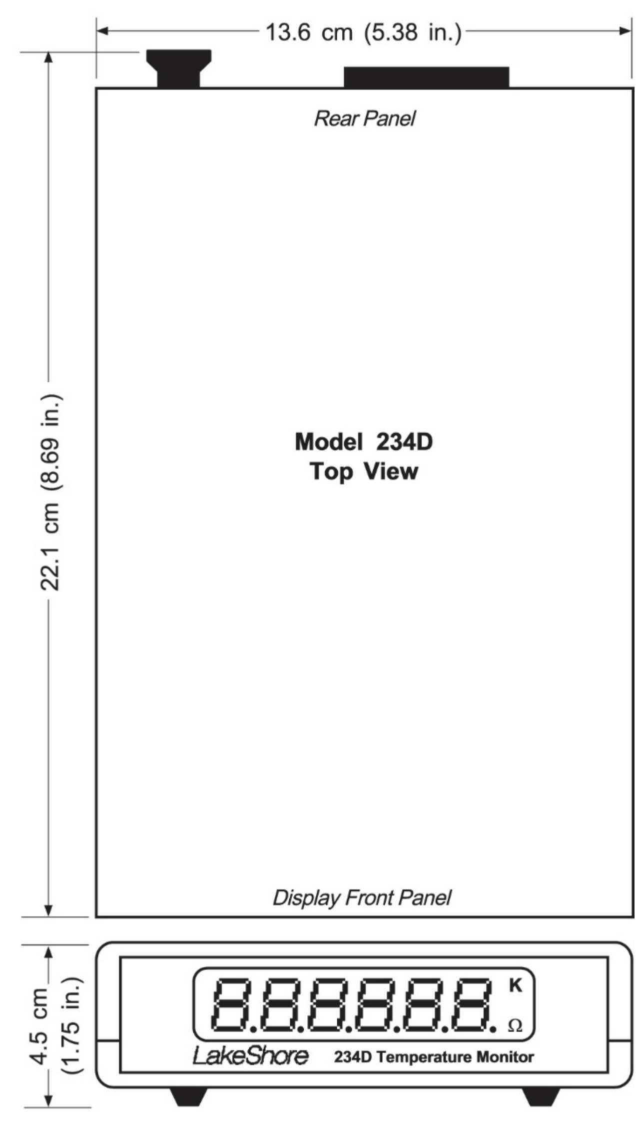


Figure 1-2. Model 234D Front Panel and Dimensions

Table 1-1. Model 234 Specifications

THERMOMETRY:

Number of Inputs: One

Measurement Type: Four-lead Differential

Sensor Type: Cernox, Carbon-Glass, or Germanium Resistance Temperature Sensor

Sensor Units: Ohms (Ω)

Input Range: 1 Ω to 300 kΩ

Sensor Excitation: Constant voltage pinned at 5 mV or 10 mV dependent on resistance range.

Update Rate: 4 readings / second (2 readings / second on Scale 0 only).

CalCurve Storage: 1 curve, factory or field loaded into EEPROM via serial interface.

Example Lake Shore Sensor: CGR-1-1000 with 1.4L calibration

Temperature Range: 1.4 K – 325 K with CGR-1-1000

Standard Sensor Curve: Requires Calibrated Sensor and CalCurve

Typical Sensor Sensitivity: –700 Ω/K at 4.2 K; –0.15 Ω/K at 77 K; –24 Ω/K at 10 K; –0.02 Ω/K at 300 K

Measurement Scales, Excitation, Resolution, and Accuracy:

Scale	Sensor Resistance (Ω)	Excitation Voltage (mV)	Resolution (Ω)	Accuracy ±(% Rdg + Ω)
0	1 - 6	5	0.0003	0.5 + 0.0006
1	4.5 - 12.5	5	0.0001	0.1 + 0.0013
2	9 - 60	10	0.001	0.1 + 0.006
3	45 - 125	5	0.001	0.1 + 0.013
4	90 - 360	10	0.003	0.1 + 0.036
5	290 - 1.25 K	10	0.01	0.1 + 0.13
6	900 - 3.6 K	10	0.03	0.1 + 0.36
7	2.9 K - 12.5 K	10	0.1	0.1 + 1.3
8	9 K - 36 K	10	0.3	0.1 + 3.6
9	29 K - 300 K	10	6.8	0.5 + 30

Measurement Resolution Temperature Equivalence:

±0.04 mK at 4.2 K ±6.6 mK at 77 K
±0.12 mK at 30 K ±67 mK at 300 K

Electronic Measurement Equivalence Temperature Accuracy:

±2 mK at 4.2 K ±18 mK at 77 K
±8 mK at 10 K ±1.2 K at 300 K

Measurement Temperature Coefficient:

Measurement Units: 0.0125% of resistance reading per °C

Temperature Equivalence:

±0.18 mK/°C at 4.2 K - (0.126 Ω) ±18 mK/°C at 77.35 K - (0.0027 Ω)
±0.8 mK/°C at 10 K - (0.0185 Ω) ±100 mK/°C at 300 K - (0.0015 Ω)

Typical Sensor Calibration Accuracy:

±4 mK at 4.2 K ±45 mK at 77.35 K
±4 mK at 10 K ±250 mK at 300 K

Table 1-1. Model 234 Specifications (Continued)

Typical CalCurve Target Accuracy:

±1 mK below 10 K	±100 mK 40 K - 100 K
±5 mK 10 K - 20 K	±1 K above 100 K
±25 mK 20 K - 40 K	

Magnetic Field Use: Carbon-Glass: T ≥ 2 K and B ≤ 19 T.
Cernox: Recommended.
Germanium: Not Recommended.

OUTPUT:

Number of Outputs: One

Output Type: Current source, isolated from power source.
Output or sensor can be grounded, but not both.

Output Range: 4 - 20 mA or 0 - 20 mA
(for 0 - 10 V with 500 Ω, 0.02%, 25 PPM Resistor).

Output Compliance: 10 V (500 Ω maximum load).

Output Temperature Ranges:

0 - 10 K (Range 1)	0 - 100 K (Range 3)	0 - 300 K (Range 5)
0 - 20 K (Range 2)	0 - 200 K (Range 4)	75 - 325 K (Range 6)

4 – 20 mA Output (I/V OUT Switch in I Position):

Output Resolution:

Current: 1.22 µA (0.006% of full scale)

Temperature Equivalence:

0 - 10 K	0.8 mK	0 - 200 K	15.3 mK
0 - 20 K	1.5 mK	0 - 300 K	22.9 mK
0 - 100 K	7.6 mK	75 - 325 K	19.1 mK

Output Electronic Accuracy:

Current: ±5 µA (±0.025% of full scale)

Temperature Equivalence:

0 - 10 K	3.1 mK	0 - 200 K	62.5 mK
0 - 20 K	6.2 mK	0 - 300 K	93.7 mK
0 - 100 K	31.2 mK	75 - 325 K	78.1 mK

Output Temperature Coefficient:

Current: ±2 µA/°C (±0.01%/°C)

Temperature Equivalence:

0 - 10 K	±1 mK/°C	0 - 200 K	±20 mK/°C
0 - 20 K	±2 mK/°C	0 - 300 K	±30 mK/°C
0 - 100 K	±10 mK/°C	75 - 325 K	±25 mK/°C

**0 – 20 mA Output (I/V OUT Switch in V Position,
0 – 10 V Out with 500 Ω, 0.02%, 25 PPM Load Resistor):**

Output Resolution:

Voltage: 0.61 mV

Temperature Equivalence:

0 - 10 K	0.6 mK	0 - 200 K	12.2 mK
0 - 20 K	1.2 mK	0 - 300 K	18.3 mK
0 - 100 K	6.1 mK	75 - 325 K	15.2 mK

Table 1-1. Model 234 Specifications (Continued)

Output Electronic Accuracy:

Voltage: ±4.5 mV (±0.025% of full scale ±0.02% resistor accuracy)

Temperature Equivalence:

0 - 10 K	4.5 mK	0 - 200 K	90.0 mK
0 - 20 K	9.0 mK	0 - 300 K	135.0 mK
0 - 100 K	45.0 mK	75 - 325 K	112.5 mK

Output Temperature Coefficient:

Voltage: ±1.25 mV/°C (±0.01%/°C + ±0.0025%/°C of load resistor)

Temperature Equivalence:

0 - 10 K	±1.2 mK/°C	0 - 200 K	±25 mK/°C
0 - 20 K	±2.5 mK/°C	0 - 300 K	±36 mK/°C
0 - 100 K	±12 mK/°C	75 - 325 K	±30 mK/°C

COMPUTER INTERFACE *(For full serial interface specifications, see Table 4-1.)*

Type: RS-232C Electrical Format, Serial Three-Wire

Connector: RJ11 telephone type jack

MECHANICAL

Ambient temperature range: 15 °C to 35 °C (59 °F to 95 °F)

Power requirement: +5 (±0.25) VDC, 500 mA (234) / 750 mA (234D)

234 Size: 12.8 cm (5 in.) high, 18.5 cm (7.3 in.) deep, 3 cm (1.2 in.) wide

234D Size: 4.4 cm (1.7 in.) high, 23 cm (9 in.) deep, 14 cm (5.5 in.) wide

234 Mounting: Euroboard end panel and back plane. Transmitter does not use electrical bus format, only its physical shape and power supply.

NOTES

1. Product Specifications are subject to change without notice.

2. Total system temperature accuracy in a given temperature range is the sum of the specifications given for input, calibration, and output.

1.3 MODEL 2308-1 ENCLOSURE DESCRIPTION

The Model 2308-1 Single Enclosure Case holds one Model 234 (see Figure 1-4). It is the same enclosure that houses the Model 234D.

1.4 MODEL 2308-12 CASE DESCRIPTION

The Model 2308-12 VMEbus Rackmount Case holds up to twelve Model 234 Temperature Transmitters. A +5 VDC power supply with universal input comes with the case. See Table 1-2 and Figure 1-5. See Paragraph 2.5 for further information on the built-in power supply.

CAUTION: The Model 2308-12 bus is designed to power multiple Model 234s and may *not* be used with standard VME cards.

Table 1-2. Model 2308-12 Case Specifications

No. of Card Slots: 12
Size: 45 cm (17.7 in.) wide × 18 cm (7 in.) high × 26 cm (10.3 in.) deep
Weight: 5.5 kilograms (12 pounds)
Output Voltage: +5 VDC, 100 mV Peak to Peak Ripple
Output Current: 6 amperes (maximum)
Input Power: Universal 85 to 265 VAC, 47 to 440 Hz, 60 Watts
Ambient Temp. Range: 15 to 35 °C (59 to 95 °F)

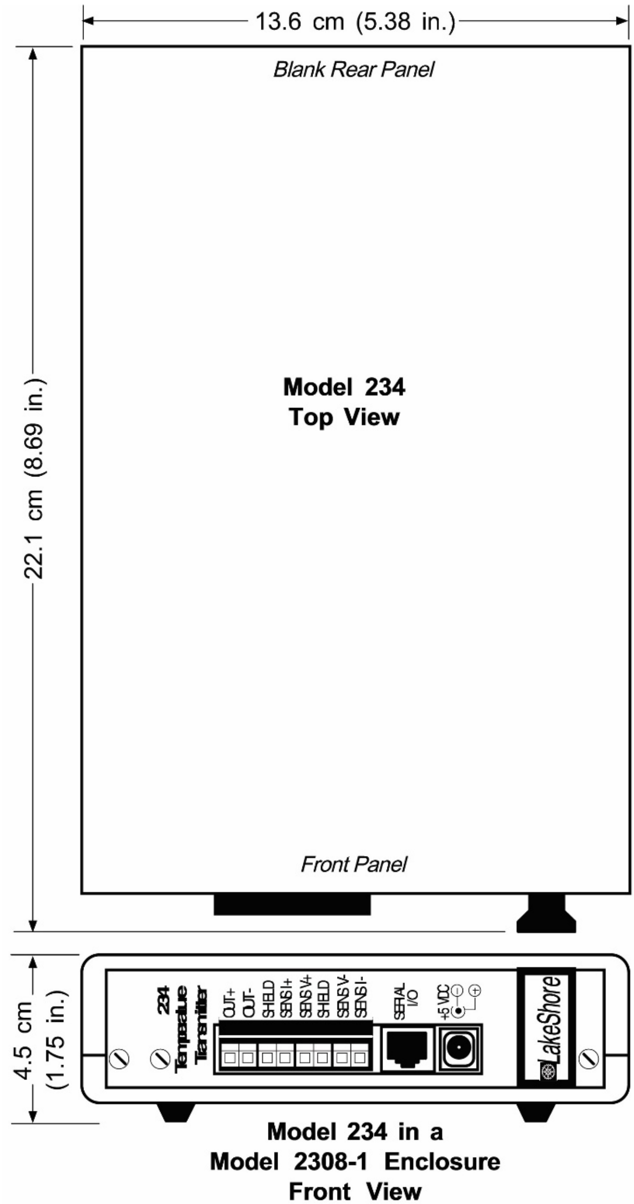


Figure 1-3. Model 2308-1 Enclosure Physical Dimensions

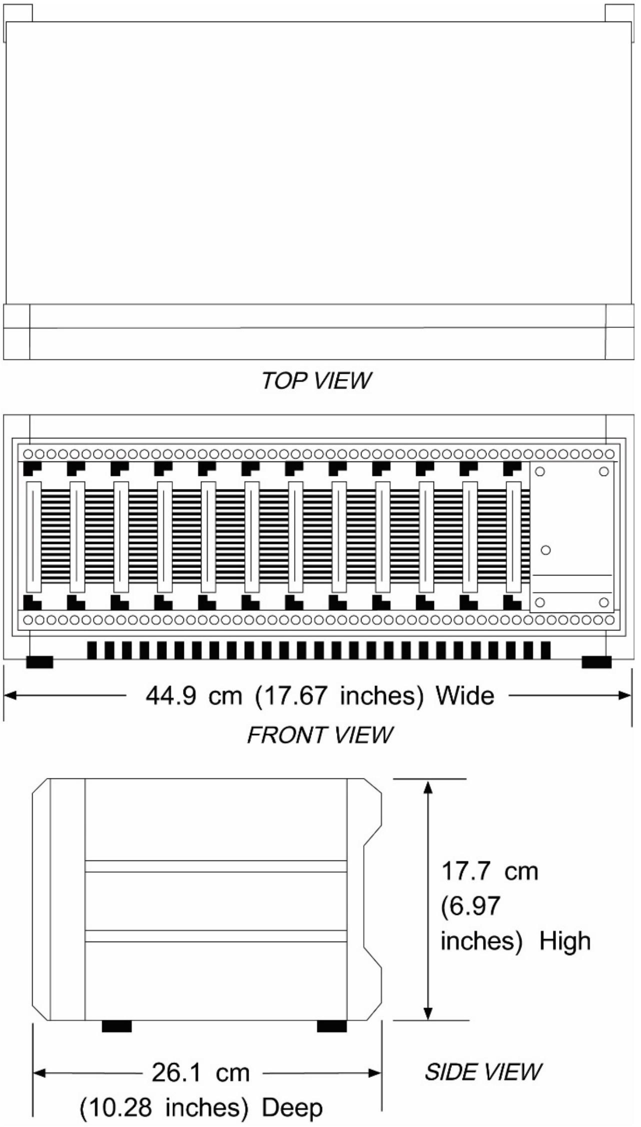


Figure 1-4. Model 2308-12 Case Physical Dimensions

CHAPTER 2

INSTALLATION

2.0 GENERAL

This chapter covers Inspection and Unpacking in Paragraph 2.1, Repackaging for Shipment in Paragraph 2.2, Sensor Installation Recommendations in Paragraph 2.3, Sensor Measurement in Paragraph 2.4, and Power Connections in Paragraph 2.5.

2.1 INSPECTION AND UNPACKING

Inspect shipping containers for external damage. Make all claims for damage (apparent or concealed) or partial loss of shipment in writing to Lake Shore within five (5) days from receipt of goods. If damage or loss is apparent, please notify the shipping agent immediately.

Open the shipping containers. Use the packing list included with the system to verify receipt of the instrument, sensor, accessories, and manual. Inspect for damage. Inventory all components supplied before discarding any shipping materials. If there is freight damage to the instrument, file proper claims promptly with the carrier and insurance company and notify Lake Shore. Notify Lake Shore immediately of any missing parts. Lake Shore cannot be responsible for any missing parts unless notified within 60 days of shipment. See the standard Lake Shore Warranty on the A Page (immediately behind the title page).

2.2 REPACKAGING FOR SHIPMENT

To return the Model 120CS or accessories for repair or replacement, obtain a Return Goods Authorization (RGA) number from Technical Service in the United States, or from the authorized sales/service representative from which the product was purchased. Instruments may not be accepted without a RGA number. When returning an instrument for service, Lake Shore must have the following information before attempting any repair.

1. Instrument model and serial number.
2. User name, company, address, and phone number.
3. Malfunction symptoms.
4. Description of system.
5. Returned Goods Authorization (RGA) number.

Repack the system in its original container (if available). Affix shipping labels and FRAGILE warnings. Write RGA number on the outside of the container or on the packing slip. If not available, consult Lake Shore for shipping and packing instructions.

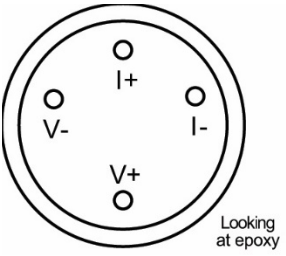
2.3 SENSOR INSTALLATION RECOMMENDATIONS

See the Lake Shore Product Catalog for installation details and sensor specifications. Call Lake Shore for copies of application notes or sensor installation questions.

1. Do not ground the sensor.
2. Shield leads and connect shield wire to SHIELD on screw terminal connector only. Do not connect shield at other end of cable.
3. Keep leads as short as possible.
4. Use twisted-pair wire. Use Lake Shore Duo-Twist™ wire (or equivalent) for two-wire, or Quad-Twist™ wire (or equivalent) for four-wire applications.
5. Thermally anchor lead wires.

2.3.1 Sensor Mounting

Before installing the carbon-glass or Germanium sensor, identify the leads as shown. Be sure lead identification remains clear even after sensor installation. Record the sensor serial number and location.



Key	Color
I +	White
V -	Green
V +	Yellow
I -	Black

When installing the sensor, make sure there are no electrical shorts or current leakage paths between the leads or between the leads and ground. If IMI-7031 varnish or epoxy is used, it may soften varnish-type lead insulations so that high resistance shunts appear between wires if *sufficient time for curing is not allowed*.

Slide Teflon® spaghetti tubing over bare leads when the possibility of shorting exists. Avoid putting stress on the device leads and allow for thermal contractions that occur during cooling which could fracture a solder joint or lead if installed under tension at room temperature.

For temporary mounting in cold temperature applications, apply a thin layer of Apiezon® N Grease between the sensor and sample to enhance thermal contact under slight pressure.

CAUTION: Lake Shore will not warranty replace any device damaged by user-designed clamps or solder mounting.

For semi-permanent mountings, use Stycast epoxy instead of Apiezon® N Grease. In all cases, periodically inspect the sensor mounting to verify good thermal contact to the mounting surface is maintained.

2.3.2 CONNECTING LEADS TO THE SENSOR

Excessive heat flow through connecting leads to any temperature sensor may differ the temperature between the active sensing element and the sample to which the sensor mounts. This reflects as a real temperature offset between what is measured and the true sample temperature. Eliminate such temperature errors with proper selection and installation of connecting leads.

To minimize heat flow through the leads, select leads of small diameter and low thermal conductivity. Phosphor-bronze or Manganin wire is commonly used in sizes 32 or 36 AWG. These wires have a fairly low thermal conductivity, yet electrical resistance is not large enough to create measurement problems.

Thermally anchor lead wires at several temperatures between room temperature and cryogenic temperatures to guarantee no heat conduction through the leads to the sensor.

2.3.3 Four-Lead Measurements

Measure all sensors, including both two-lead and four-lead devices, in a four-lead configuration to eliminate the effects of lead resistance. The exact point at which the connecting leads solder to the two-lead sensor normally results in a negligible temperature uncertainty.

Always use the four-lead measurement configuration with Series CGR Carbon-Glass and Series GR Germanium Resistance Temperature Sensors attached to the Model 234.

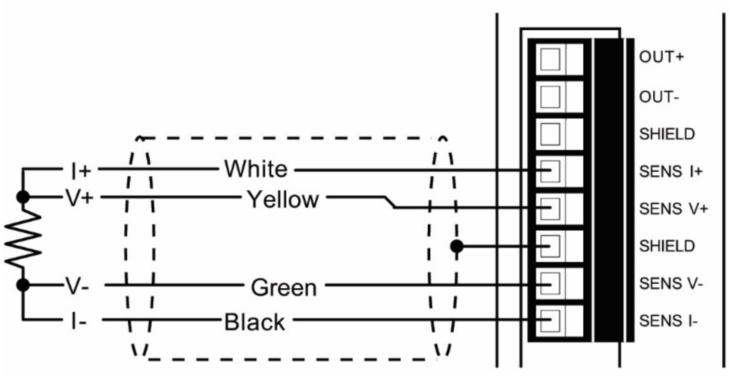


Figure 2-1. Typical Model 234 to Sensor Connections

2.3.4 Proper Shielding Techniques

Since the Model 234 excitation voltage is so low, shield resistance sensor leads to avoid inducing measurement errors due to AC noise. Use twisted pair cable, one pair for current and one for voltage, with an overall shield. The most common shield configuration connects the shield to the Model 234 SHIELD connection (measurement ground potential) at one end and leaves the other end open. The other end of the shield is left open since most vacuum jackets, or feedthrough bulkheads, are at earth ground potential. Connecting the shield at both ends produces a ground loop that adversely affects measurement.

Some systems can benefit from continuous shielding, such as those in which the shield is carried as a conductor through the bulkhead, rather than terminated at it, or those in which the vacuum jacket is not at earth ground potential. Try different shielding configurations if "noisy" readings are encountered.

2.4 SENSOR MEASUREMENT

The Model 234 analog control loop maintains a constant excitation voltage of 5 mV or 10 mV across the sensor. Multiple scale resistors (see Paragraph 5.4) convert the resulting sensor current to voltage. The scale resistor with the best measurement resolution is selected. Once the proper scale is determined, the voltage across the scale resistor is measured. The excitation voltage is then reversed. The new reading is combined with the previous reading to eliminate any thermals present and the sensor resistance and log resistance is calculated.

With no CalCurve present, the output is the log of the resistance. Place the **T/R** switch in the **R** position. If the **I/V OUT** switch is in the **I** position (4 - 20 mA out), the output is 4 mA for the log(R) equal to 0 (1 Ω) and 20 mA for the log(R) equal to 6 (1 MΩ). A resistance of 1 kΩ results in an output of 12 mA (log(R) equal to 3). If input resistance is greater than 400 kΩ, output is 0 current. A resistance greater than 400 kΩ is considered an open and 0 current is used as an alarm indication for a 4 - 20 mA loop. If the **I/V OUT** switch is in the **V** position (0 - 20 mA out), output is 0 mA for the log(R) equal to 0 (1 Ω) and 20 mA for the log(R) equal to 6 (1 MΩ). A resistance of 1 kΩ results in an output of 10 mA (log(R) = 3). (For the Model 234D only, although the transmitter output is still log (R), the display is simply R.)

2.4.1 CalCurve™

CalCurve (formerly called Precision Option) is the easiest way to combine the performance of a Lake Shore calibrated sensor with the Model 234. If CalCurve is present, Place the **T/R** switch in the **T** position. See Paragraph 3.1 for output current temperature ranges.

The factory stores the optional Model 8001-234 CalCurve in the unit if it is ordered with the unit. The Curve EPROM (see Figure 5-4) is labeled with the sensor serial number. See Chapter 5 for Curve EPROM field installation.

The optional Model 8001-234 CalCurve data is stored in a temperature versus log of resistance breakpoint table. The log of resistance is uniformly spaced over three regions: log(R) of 0 to 2.98 is spaced every 0.02; log(R) of 3.0 to 3.96 is spaced every 0.04; and log(R) of 4.0 to 5.6 is spaced every 0.1. Six temperature digits are stored to the 1 mK place. A summary of curve breakpoints, sensor resistance, log of resistance, and maximum temperature error comes with each CalCurve. See Chapter 4 for Curve programming or verifying curve data via the serial interface.

2.5 POWER CONNECTIONS

A +5 VDC supply in the VME rack or an external power supply powers the Model 234. Regulate the voltage to within ±0.25 VDC. Each Model 234 draws up to 500 mA from the supply (750 mA for the Model 234D). The external power supply connector must be S-760 or S-765 Switchcraft (or equivalent) plug (0.218 inch O.D., accepts 0.08 inch diameter pin) with +5 VDC on the sleeve and return on the center pin.

A wall plug-in power supply Model 2007-XX +5 VDC Regulated Power Supply can be used with the Model 234. Power Supply input is based on local power requirements as follows:

MODEL	INPUT POWER
2007-12	120 V 60 Hz. power source
2007-22	230 V 50 Hz. power source

CAUTION: Never ground both the sensor and the 4–20 mA output. Ground either the sensor, or the output, but not both.

The Model 2308-10 VMEbus rackmount case has a built-in power supply for use with up to twelve Model 234s. The built-in power supply has a universal input: 85 to 265 VAC, 47 to 440 Hz, 60 watts.

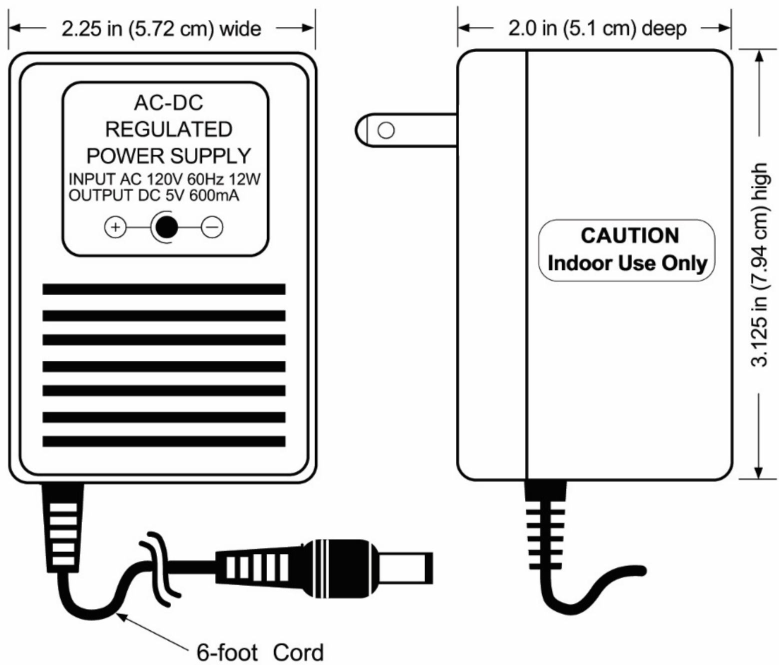


Figure 2-2. Typical Wall Plug-In Power Supply

CHAPTER 3

OPERATION

3.0 GENERAL

This chapter covers Printed Circuit Board (PCB) DIP Switch Settings in Paragraph 3.1, Output Current and Voltage to Temperature Conversion in Paragraph 3.2, and Output to log(R) Conversion in Paragraph 3.3.

3.1 PCB DIP SWITCH SETTINGS

Before placing the unit into service, properly configure the Model 234 DIP switch (S1). To access the PCB, use a flat blade screw driver to loosen the top- and bottom-most screws on the front panel of a Model 234 mounted in a Model 2308-1 or -12 enclosure, or the back panel of a Model 234D. Then see Figure 5-3 for location of Switch S1.

If the optional CalCurve is present, set the **T/R** switch to **T**. If CalCurve is not shipped with the unit, the factory setting is **R**.

If operating in temperature, enable the corresponding range number on the PCB DIP Switch (S1). See Figure 3-1. Select only one range at a time. The range is enabled when the switch is closed (ON). Units ship from the factory with the DIP switch set to RANGE1 closed (0 to 10 K).

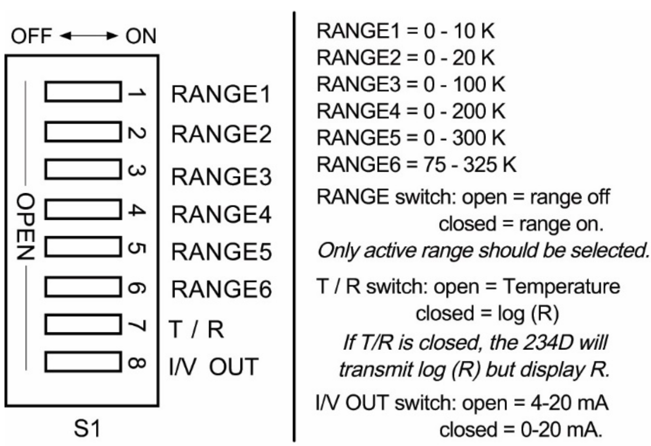


Figure 3-1. Model 234 DIP Switch (S1) Settings

PCB DIP Switch Settings (Continued)

Current/Voltage (I/V) OUT is for selection of proper output type. Open is for 4–20 mA and closed is for 0–20 mA. The 4–20 mA is an industry standard, while the 0–20 mA translates output into voltage scaled up to 10 V. For a 0-10 V output, use a 500 Ω ±0.02% output load resistor across the OUT+ and OUT– terminals. Load resistors less than 500 Ω can convert the output to voltage using the following formula:

$$V_{out} = \frac{I_{out}(mA)}{1000} \times R_{out}(\Omega)$$

.

Unless otherwise specified, units ship from the factory with the DIP switch set with I/V OUT open (4-20 mA).

3.2 OUTPUT TO TEMPERATURE CONVERSION

Output current or voltage are directly proportional to the temperature reading. For the 4-20 mA output, the following formula converts output current to temperature:

$$T = A + B \times I_{out}$$

where **T** = temperature in kelvin, $\mathbf{I_{OUT}}$ = output current in mA, and **A** and **B** are constants (from Table 3-1) depending on temperature.

For the 0-20 mA output (using a 500 Ω resistor for 0-10 V), this formula converts output voltage to temperature:

$$T = C + D \times V_{out}$$

where **T** = temperature in kelvin, $\mathbf{V_{OUT}}$ = output voltage, and **C** and **D** are constants (from Table 3-1) depending on temperature.

Table 3-1. Conversion Parameters for Temperature in K

		4–20 mA		**0–10 V**	
RANGE	**TEMP. (K)**	**A (K)**	**B (K/mA)**	**C (K)**	**D (K/V)**
RANGE1	0 – 10	–2.5	0.625	0	1.0
RANGE2	0 – 20	–5.0	1.25	0	2.0
RANGE3	0 – 100	–25.0	6.25	0	10.0
RANGE4	0 – 200	–50.0	12.5	0	20.0
RANGE5	0 – 300	–75.0	18.75	0	30.0
RANGE6	75 – 325	12.5	15.625	+75	25.0

3.3 OUTPUT TO LOG(R) CONVERSION

When no CalCurve is present, set the **T/R** switch to **R**. The output current or voltage are directly proportional to the log of the resistance reading. This is the transmitter output for both the Model 234 and 234D. Only the display of the Model 234D is resistance only.

If the 4 – 20 mA output is used, the current is calculated by:

$$I_{out} = 16 \times \frac{\log R}{6} + 4$$

where I_{OUT} is the current measured from the Model 234. Use the following formula to convert the output current to resistance:

$$R = 10^{3/8\left(I_{out} - 4\right)}$$

For the 0 – 20 mA output, the current is calculated by:

$$I_{out} = 20 \times \frac{\log R}{6}$$

where I_{OUT} is the current measured from the Model 234. Use the following formula to convert the output current to resistance:

$$R = 10^{0.3 I_{out}}$$

If the 0 – 10 V output is used (with a 500 Ω ±0.02% output load resistor), the following formula is used to compute the voltage:

$$V_{out} = 10 \times \frac{\log R}{6}$$

where V_{OUT} is the voltage measured from the Model 234. Use the following formula to convert output voltage to resistance:

$$R = 10^{0.6 V_{out}}$$

Example: If the **I/V OUT** switch is in the **I** position (4 - 20 mA out), the output is 4 mA for the log(R) equal to 0 (1 Ω) and 20 mA for the log(R) equal to 6 (1 MΩ). A resistance of 1 kΩ results in an output of 12 mA (log(R) equal to 3). If input resistance is greater than 400 kΩ, output is 0 current. A resistance greater than 400 kΩ is considered an open and 0 current is used as an alarm indication for a 4 - 20 mA loop. If the **I/V OUT** switch is in the **V** position (0 - 20 mA out), output is 0 mA for the log(R) equal to 0 (1 Ω) and 20 mA for the log(R) equal to 6 (1 MΩ). A resistance of 1 kΩ results in an output of 10 mA (log(R) = 3.

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CHAPTER 4

REMOTE OPERATION

4.0 GENERAL

This chapter covers the Serial Interface in Paragraph 4.1, and Serial Interface Commands in Paragraph 4.2.

4.1 SERIAL INTERFACE

The Model 234 has a serial interface for communications with a host computer. It is an unbalanced (single ended), non-terminated line used over short distances (typically 10 feet or less). The Model 234 serial interface complies with the electrical format of the RS-232C Interface Standard.

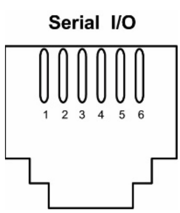
Table 4-1. Serial Interface Specifications

Type: RS-232C Electrical Format, Serial, Three Wire
Baud Rate: 9600
Timing Format: Asynchronous
Bits per Character: 1 Start, 8 Data, No Parity, 1 Stop
Parity Type: None
Voltage Levels: EIA
Terminators: Carriage Return (0DH) and Line Feed (0AH)
Connector: RJ11 Modular (Telephone) Jack

4.1.1 Serial Interface Connections

A standard 6 wire RJ-11 modular (telephone) jack is the serial interface connector (see Figure 4-1). Lake Shore Model 2001 data type cables, which maintain pin 1 polarity, simplify interconnection. Lake Shore offers the Model 2002 RJ-11 to DB-25 adapter and Model 2003 RJ-11 to DE-9 adapter for connecting to the host computer. See Figure 4-2.

Figure 4-
(RJ11)
Pin



PIN	DESCRIPTION
1	No Connection
2	Serial In (RxD)
3	Serial Ground
4	Serial Ground
5	Serial Out (TxD)
6	No Connection

1. Serial I/O
Connector
Definitions

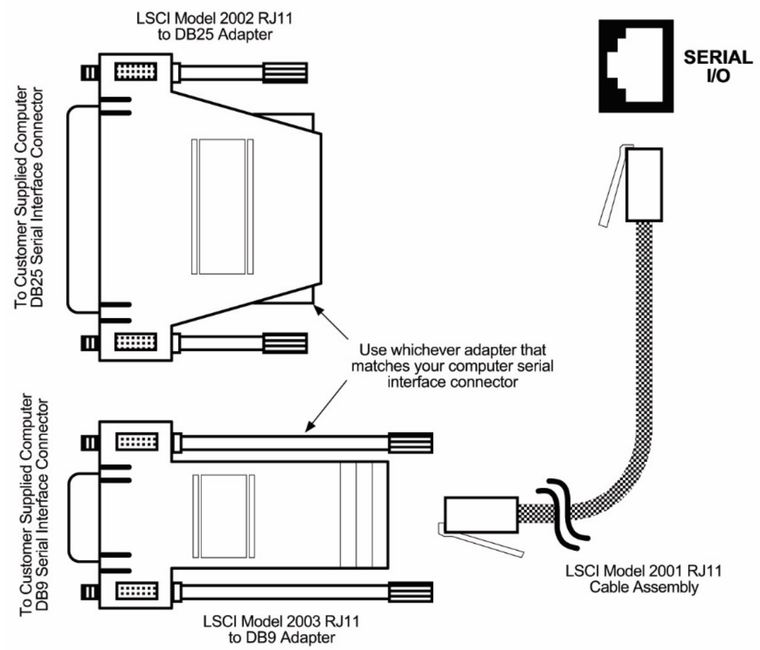


Figure 4-2. Serial Interface Connections

4.1.2 Serial Interface Operation

The host computer initiates serial interface link operation; it transmits either a command or a query to the Model 234. The Model 234 stores the characters in a 16 character buffer until the carriage return (CR), line feed (LF) terminator sequence. After receiving the terminators, the Model 234 responds to a query, if present, and stores the new input parameters.

Queries result in output of the requested data immediately following the processing of the command and terminator sequence. **Communication is half-duplex.** For example, the command string **TAG 234-1** sets the electronic tag number of the unit to 234-1. The query **TAG?** returns the electronic tag number of the unit.

When programming a Model 234 from the serial interface, consider the following:

- The serial interface transmission mode (asynchronous half duplex), format (10 bits per character; 1 start, 8 data, no parity, and 1 stop), and baud rate (9600) are factory set as outlined in Paragraph 4.1.
- End of string terminators are fixed at (CR)(LF).
- At 9600 baud, each character takes about 1 millisecond to transmit. Some host computers DMA serial interface access. Programs must allow for transmission time delay before looking for a query response.
- The unit stores received characters in a 16-character buffer. After receiving terminators, the unit responds to a query, if requested, and stores any new parameters. The unit requires about 50 milliseconds to store new parameters before it can receive any new commands (it requires 3 seconds for curve parameters, and 10 seconds for input calibration). The second command string of multiple command strings sent less than 50 milliseconds (or 3 seconds or 10 seconds) apart is ignored or returns a unpredictable response.
- The unit implements new parameters and updates measurement data internally once per 250 millisecond operation cycle (500 milliseconds for Scale 0). Sending new parameters or data requests at a rate faster than 2 Hz (or 1 Hz) is not recommended.

4.1.3 QuickBasic Programming Considerations

When communicating with a unit using a QuickBasic program, **do not** use the **LINE INPUT #** statement to retrieve data from the unit. The **LINE INPUT #** statement reads all characters from a **data file** up to a carriage return (CR) and then skips over the carriage return line feed (CR)(LF) sequence. The **LINE INPUT #** statement does not work this way for the communications port. It reads characters up to the (CR) and continues program operation while the unit transmits the (LF). In most cases, the (LF) remains as the first character of the next input. This could cause communications contention problems.

The QuickBasic 4.5 manual, Section 3.5.2 Communications through the Serial Port, reads, "Since every character is potentially significant data, both **INPUT #** and **LINE INPUT #** have serious drawbacks for getting input from another device. This is because **INPUT #** stops reading data into a variable when it encounters a comma or new line (and, sometimes, a space or double quote), and **LINE INPUT #** stops reading data when it encounters a new line. This makes **INPUT$** the best function to use for input from a communications device, since it reads all characters."

The program in Paragraph 4.1.4 uses the INPUT$ function instead of the LINE INPUT # statement to retrieve responses from the Controller.

4.1.4 QuickBasic Sample Program

The following program for a PC is an interactive program that prompts the user for a command to send the unit and displays the response. A query must be part of the command to get a response from the unit.

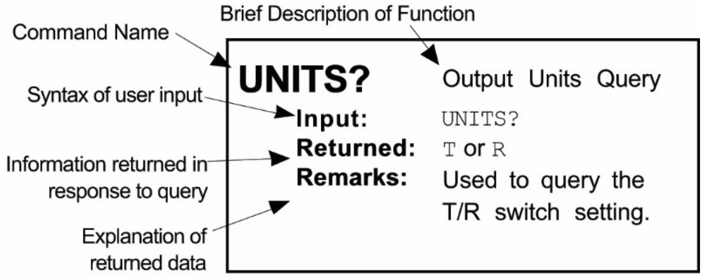
```
'    SEREXAM.BAS      EXAMPLE PROGRAM FOR SERIAL INTERFACE
'    This program works with QuickBasic 4.0/4.5 or QBasic for use
'    on an IBM PC or compatible with a serial interface.
'
'    To use, enter an instrument command or query at the prompt.
'    The command is sent to the instrument and any query response
'    displays. "EXIT" will exit the program.
'
'    NOTE: The INPUT instruction in this example accepts no commas
'    as part of an input string. The curve breakpoint command will
'    not operate from this program. TIMEOUT may need to be increased
'    for computers running faster than 50 MHz.
'
'*******************************************************************

      CLS                                   'Clear screen
      PRINT " SERIAL COMMUNICATION PROGRAM"
      PRINT
      TIMEOUT = 2000                        'Read timeout (may need more)
      BAUD$ = "9600"                        'BAUD rate
      TERM$ = CHR$(13) + CHR$(10)           'Terminators are <CR><LF>
      OPEN "COM1:" + BAUD$ + ",N,8,1,RS" FOR RANDOM AS #1 LEN = 1024

LOOP1: INPUT "ENTER COMMAND (or EXIT):"; CMD$ 'Get command from keyboard
      CMD$ = UCASE$(CMD$)                   'Change input to upper case
        IF CMD$ = "EXIT" THEN CLOSE #1: END 'Get out on Exit
      CMD$ = CMD$ + TERM$
      PRINT #1, CMD$;                       'Send command to instrument

      IF INSTR(CMD$, "?") <> 0 THEN         'Test for query
        RS$ = ""                            'If query, read response
        N = 0                               'Clr return string & count

        WHILE (N < TIMEOUT) AND (INSTR(RS$, TERM$) = 0) 'Wait for response
          IN$ = INPUT$(LOC(1), #1)          'Get one character at a time
          IF IN$ = "" THEN N = N + 1 ELSE N = 0 'timeout + 1 if no chr
          RS$ = RS$ + IN$                   'Add next chr to string
        WEND                                'Get chrs until terminators

        IF RS$ <> "" THEN                   'See if return string is empty
          RS$ = MID$(RS$, 1, (INSTR(RS$, TERM$) - 1)) 'Strip off terminators
          PRINT "RESPONSE:"; RS$            'Print response to query
        ELSE
          PRINT "NO RESPONSE"               'No response to query
        END IF
      END IF                                'Get next command
      GOTO LOOP1
```

4.2 SERIAL INTERFACE COMMAND SUMMARY

This Paragraph summarizes Model 234 Serial Interface Commands.

Command	Function
QIDN?	Identification Query
QRST	Reset Command
C	Program Curve Breakpoint
C?	Curve Breakpoint Query
CAL	Calibrate Resistance Measurement Input
DA0	Set Current Output To Zero
DA4	Set Current Output To 4 mA
DA20	Set Current Output To 20 mA
ERASE!	Erase Curve
LOGR?	Logarithm of Sensor Resistance Query
OHMS?	Sensor Resistance Query
RANGE?	Output Temperature Range Query
SCALE?	Resistance Measurement Scale Query
SID	Program Curve Identification
SID?	Curve Identification Query
TAG	Program Tag Identification
TAG?	Tag Identification Query
TEMP?	Temperature Query
UNITS?	Output Units Query

An explanation of the command structure is shown below.



QIDN? Identification Query

Input: Q**`IDN?`**
Returned: Manufacturer,model number,0,software date
Remarks: Identifies instrument model number and software level. The "0" in the returned syntax is in place of the serial number.
Example: LSCI,MODEL234,0,031093

QRST Reset Command

Input: Q**`RST?`**
Returned: Nothing
Remarks: Similar to turning the power off and back on again.

C Program Curve Breakpoint

Input: **`C x.xx,yyy.yyy`**
Returned: Nothing
Remarks: Programs the curve breakpoint where x.xx is log(R) uniformly spaced over three regions: log(R) of 0 to 2.98 is spaced every 0.02; log(R) of 3.0 to 3.96 is spaced every 0.04; and log(R) of 4.0 to 5.6 is spaced every 0.1, and yyy.yyy is 6 temperature digits to the 1 mK place. Input is free field.

There must be no missing breakpoints from the lowest log value to the highest log value over the area of interest.

To program a curve breakpoint for a resistance of 1000 Ω at 4.202 K, the command would be: **`C3.0,4.202`**

C? Curve Breakpoint Query

Input: **`C?x.xx`**
Returned: **`yyy.yyy`**
Remarks: Queries the curve breakpoint for log(R) of x.xx. Returns temperature in a fixed field with 3 digits above and below the decimal point. If no data is present for the log value, returns 7 dashes ("-------").

CAL Calibrate Resistance Measurement Input

Input: **`CAL0`**, **`CAL1`**, **`CAL2`**, **`CAL3`**, **`CAL4`**, or **`CAL5`**
Returned: Nothing
Remarks: Calibrates input scale for the calibration resistor attached to the input in place of the sensor. Allow 10 seconds for calibration to be completed.

CAL0	1 Ω	CAL3	1 kΩ
CAL1	10 Ω	CAL4	10 kΩ
CAL2	100 Ω	CAL5	100 kΩ

DA0 Set Current Output to Zero
Input: **DA0**
Returned: Nothing
Remarks: Holds current output at zero until another command or query is sent.

DA4 Set Current Output to 4 mA
Input: **DA4**
Returned: Nothing
Remarks: Holds current output at 4 mA until another command or query is sent.

DA20 Set Current Output to 20 mA
Input: **DA20**
Returned: Nothing
Remarks: Holds current output at 20 mA until another command or query is sent.

ERASE! Erase Curve
Input: **ERASE!**
Returned: Nothing
Remarks: Erases existing sensor curve. Do this prior to entering a new curve. If a new curve is entered without erasing the existing curve, data conflicts could occur.

LOGR? Log of Sensor Resistance Query
Input: **LOGR?**
Returned: **X.XXXXXX**
Remarks: Returns value with 1 digit above the decimal point and 6 digits below. Returns **SHORT** if input resistance is less than 1 Ω. Returns **OPEN** if input resistance >400 kΩ.

OHMS? Sensor Resistance Query
Input: **OHMS?**
Returned: **XXXXXX.** thru **X.XXXXX**
Remarks: Returns free field 6-digit value with a decimal point. The resistance reading is in Ω and not log (R). Returns **SHORT** if input resistance is less than 1 Ω. Returns **OPEN** if input resistance >400 kΩ.

RANGE? Output Temperature Range Query
Input: **RANGE?**
Returned: **1** thru **6**
Remarks: Queries range switch setting.

SCALE? Resistance Measurement Scale Query
Input: **SCALE?**
Returned: **0** thru **9**
Remarks: Queries resistance measurement scale.

SID Program Curve Identification
Input: **SID XXXXXXXX**
Returned: Nothing
Remarks: Programs the 8-character curve identification. When an optional CalCurve is stored, the sensor serial number is usually entered as the curve identification.

SID? Curve Identification Query
Input: **SID?**
Returned: **X XXXXXXX**
Remarks: Queries the 8 character curve identification.

TAG Program Tag Identification
Input: **TAG XXXXXXXX**
Returned: Nothing
Remarks: Programs the 8 character tag identification. When the unit is not assigned a specific tag number, the instrument serial number is entered as the tag identification.

TAG? Tag Identification Query
Input: **TAG?**
Returned: **XXXXXXXX**
Remarks: Queries the 8 character tag identification.

TEMP? Temperature Query
Input: **TEMP?**
Returned: **XXX.XXX**
Remarks: Returns fixed field value with 3 digits above and below the decimal point. Returns **SHORT** if input resistance is less than 1 Ω. Returns **OPEN** if input resistance > 400 kΩ. Returns **LOGR ON** if the T/R switch is in the **R** position.

UNITS? Output Units Query
Input: **UNITS?**
Returned: **T** or **R**
Remarks: Queries T/R switch setting: **T** = Temperature, **R** = Resistance.

CHAPTER 5

SERVICE

5.0 GENERAL

This chapter covers General Troubleshooting in Paragraph 5.1, Model 234 Connectors in Paragraph 5-2, CalCurve Field Installation in Paragraph 5.3, and Calibration in Paragraph 5.4.

5.1 GENERAL TROUBLESHOOTING

5.1.1 No Output (On-Board LED Off)

Verify output of external power supply is +5 VDC. If not, replace the supply. If using the front panel input jack (J2), verify center post of connector coming from power supply is NEGATIVE. If not, correct wiring. If using front panel input jack (J2), verify external power supply is regulated at +5 VDC and can supply a minimum of 500 mA. Also verify that OUT+ and SHIELD are *not* connected to each other.

Due to extensive protection circuitry installed in Model 234, all the above problems eventually cause the 1 A slow blow fuse to burn out. After correcting the cause, replace the blown fuse with identical size and type.

5.1.2 Output Stops Before Reaching Upper Limit

Normally caused by too high of a resistance from output monitoring device. Absolute maximum acceptable resistance is 500 Ω. Also verify that proper range DIP switch is selected.

5.1.3 Resistance Readings Are Incorrect

Verify correct voltage and current connections to the sensor. Parasitic resistances between the voltage and current connections inside the device can make the resistance measurement incorrect if the leads are connected incorrectly.

5.1.4 Open Condition

A sensor must be connected when power is applied. If not, an Open error will be displayed even if a sensor is re-connected. A power cycle must be performed with the sensor properly connected before the error will be cleared.

5.2 MODEL 234 CONNECTORS

There are four connectors on the Model 234. The three front panel connectors are the 8-pin terminal block (J3), RJ11 Serial I/O connector (J4), and the power connector (J2). See Figure 5-1. The Serial I/O Connector pins are defined in Figure 4-1. The rear connector (J1) is for connecting to the VMEbus. See Figure 5-2.

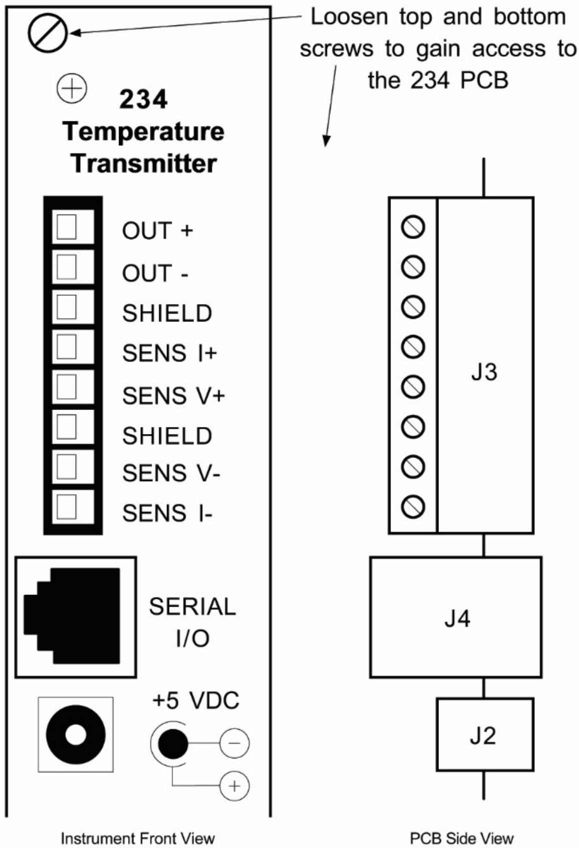
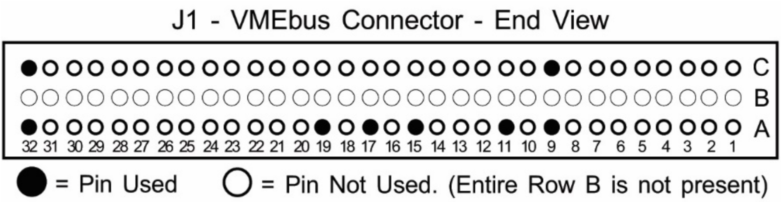


Figure 5-1. Front Panel Connector Details



PIN NO.	ROW A	ROW B	ROW C
1-8	Not Used		Not Used
9	GND	Entire Row	GND
10	Not Used	Not Present	Not Used
11	GND		Not Used
12-14	Not Used		Not Used
15	GND		Not Used
16	Not Used		Not Used
17	GND		Not Used
18	Not Used		Not Used
19	GND		Not Used
20-31	Not Used		Not Used
32	+5 VDC		+5 VDC

Figure 5-2. VMEbus Connector Details

5.3 CALCURVE FIELD INSTALLATION

The Model 8001-234 CalCurve is stored in an Electrically Erasable Programmable Read Only Memory (EEPROM). Use the following procedure to install or replace the CalCurve EEPROM.

CAUTION: Disconnect power to the instrument before performing this procedure.

1. Disconnect instrument power cord, or remove instrument from rack.
2. Locate the curve EEPROM U4. Note orientation of existing EEPROM (circular dot on the top of the device). See Figure 5-4.
3. Use an IC puller or small flat blade screwdriver to remove existing EEPROM from socket.
4. Install new curve EEPROM. Match the circular dot position of the new device with that of the old one. A label indicating the sensor serial number is on top of the curve EEPROM. This label should be able to be read with the front panel of the unit to the left. Match the orientation of the printing on the Microprocessor U5 adjacent to it.
5. Replace instrument power cord, or install the instrument in the rack.

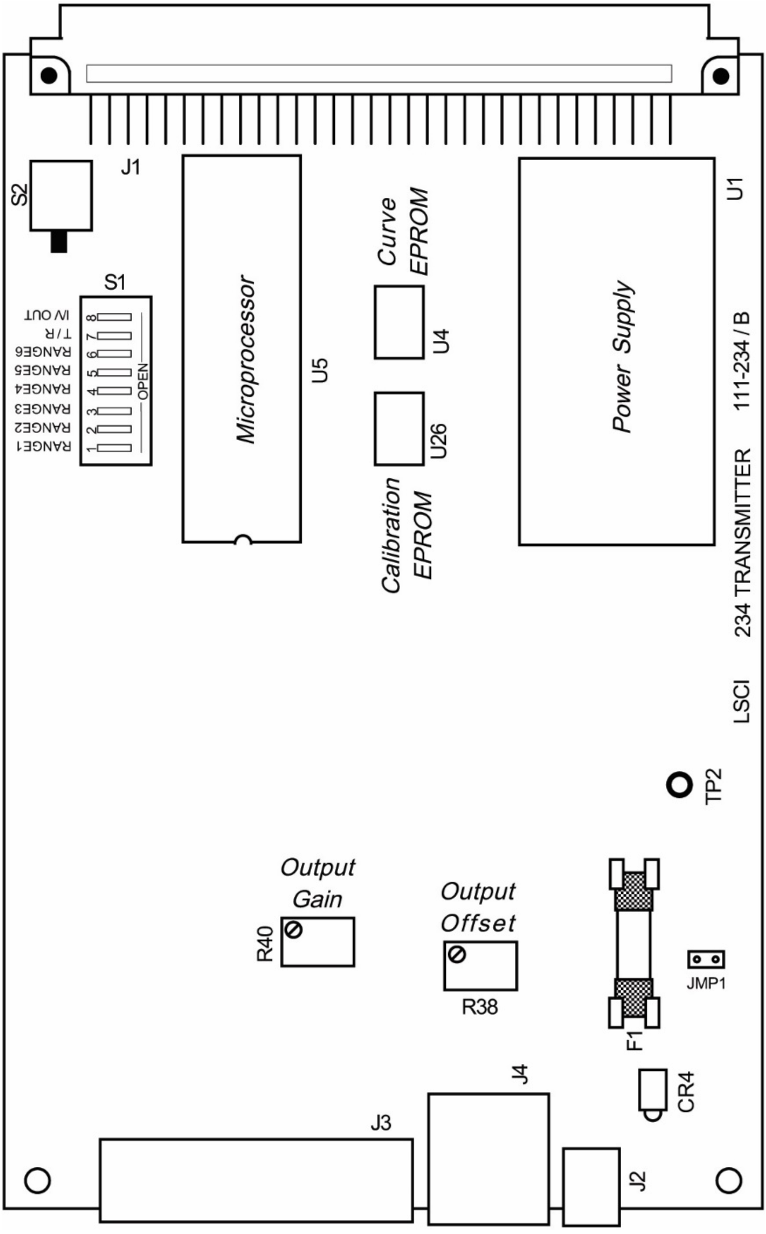


Figure 5-3. Model 234 PCB Details

5.4 CALIBRATION

The section covers Required Test Equipment in Paragraph 5.4.1, Reference Calibration procedure is provided in Paragraph 5.4.2. Finally, the calibration procedure is provided in Paragraph 5.4.3. See Figure 5-3 for the Model 234 PCB layout. Allow 5 minutes warm-up before performing any calibration procedures. The following resistance ranges are implemented on the Model 234 Temperature Transmitter:

Scale	Approximate Sensor Resistance	Internal Reference Resistance	Sensor Voltage	Internal A/D Voltage Reading
0	1 – 6 Ω	10 Ω	5 mV	0.15 to 1.0 V
1	4.5 – 12.5 Ω	100 Ω	5 mV	0.8 to 2.2 V
2	9 – 60 Ω	100 Ω	10 mV	0.35 to 2.2 V
3	45 – 125 Ω	1 kΩ	5 mV	0.8 to 2.2 V
4	90 – 360 Ω	1 kΩ	10 mV	0.55 to 2.2 V
5	290 – 1.25 kΩ	3.16 kΩ	10 mV	0.55 to 2.2 V
6	900 – 3.6 kΩ	10 kΩ	10 mV	0.55 to 2.2 V
7	2.9 k – 12.5 kΩ	31.6 kΩ	10 mV	0.55 to 2.2 V
8	9 k – 36 kΩ	100 kΩ	10 mV	0.55 to 2.2 V
9	29 k – 300 kΩ	316 kΩ	10 mV	0.21 to 2.2 V

Scale changing depends on the forward A/D voltage reading. The lower and upper range in resistance is approximately subject to variations in gains and offsets.

Note the sensor voltage continually switches between positive and negative values to obtain the forward and reverse readings. Thus, the sensor and A/D voltage cannot be read reliably with a DC voltmeter.

Calibration results in a forward A/D reading of approximately 0.65 or 2 volts at the time of calibration (See table below). This allows for over-ranging dependent on variation in gains and offsets. The reference resistance and approximate A/D voltages used for each value of calibration resistance is shown below.

Calibration Resistance	Internal Reference Resistance	Approximate A/D Voltage
1 Ω	10 Ω	1.0 V
10 Ω	100 Ω	2.0 V
100 Ω	1 kΩ	2.0 V
1 kΩ	3.16 kΩ	0.65 V
1 kΩ	10 kΩ	2.0 V
10 kΩ	31.6 kΩ	0.65 V
10 kΩ	100 kΩ	2.0 V
100 kΩ	316 kΩ	0.65 V

The table below indicates the serial command or **Range Switch** used in calibration. When the transmitter is calibrated with the Serial Computer Port, use the serial command shown in the table. When the Calibration Switch **S2** is used, then the **Range Switch** shown must be selected.

Serial Command	Range Switch	Calibration Resistance	Internal Reference Resistor(s)
CAL0	1	1 Ω	10 Ω
CAL1	2	10 Ω	100 Ω
CAL2	3	100 Ω	1 kΩ
CAL3	4	1 kΩ	3.16 kΩ10 kΩ
CAL4	5	10 kΩ	31.6 kΩ100 kΩ
CAL5	6	100 kΩ	316 kΩ

5.4.1 Required Equipment for Calibration

1. A digital voltmeter (DVM) that measures DC voltage of 10 mV and 10 volts accurately to 0.005%.
2. A regulated 5 VDC power supply with tolerance within ±0.25V, capable of sourcing 500 mA on an S-760 or S-765 Switchcraft or equivalent power plug (0.218 inch outside diameter, accepts 0.08 inch diameter pin). The positive 5V is on the sleeve, the return in the center pin.
3. The mating screw terminal to the Model 234 front panel signal connector.
4. 1 Ω, 10 Ω, 100 Ω, 1 kΩ, 10 kΩ, and 100 kΩ 0.01% resistors to simulate the sensor for calibration.
5. A 500 Ω, 0.02%, 1 – 3W resistor to load the 4-20 mA output.

5.4.2 Preparation and General Test

1. Function of the **I/V** switch. Position **I** (switch 8 open) of the **I/V** switch is normal operation with the output 4 to 20 mA. In position **V** (switch 8 closed), the output current is between 0 and 20 mA.
2. Function of the **T/R** Switch. Normal operation is with the **T/R** in the **T** position (switch 7 open) where a CalCurve option is chosen to produce an output in temperature. With the switch in the **R** position the output current is proportional to the logarithm (base 10) of the resistance of the sensor. In the **R** position, the **I/V** switch selects either 4 to 20 mA or 0 to 20 mA. In the **V** position the output is between 0 and 20 mA with 0 mA for log(R) =0 and 20 mA for log(R) = 6. With the **I/V** switch in the **I** position the output is between 4 and 20 mA with 4 mA for log(R) =0 and 20 mA for log(R) = 6.

3. Preparation.
   a. Connect the 1 kΩ calibration resistor to the screw terminal SENSOR I+ and SENSOR I– to simulate a sensor load to the Model 234. Use a shorting wire to connect SENSOR I+ to SENSOR V+, and another shorting wire to connect SENSOR I– to SENSOR V–.
   b. Connect the 500 Ω resistor to the screw terminal to simulate an output load to the Model 234. Use the OUT+ and OUT– pins.
   c. Set the **T/R** switch (7) to the **R** position (closed) and the **I/V** switch to the **V** (closed) position.
   d. Power the Model 234 Temperature Transmitter with the 5 VDC power supply.
4. General Input Test. The following test steps are recommended prior to calibration to verify that the Model 234 Temperature Transmitter current source and input stage operate properly:
   a. Verify the 1 kΩ calibration resistor is connected to the screw terminal SENSOR I+ and SENSOR I– and shorting wires connect SENSOR I+ to SENSOR V+, and SENSOR I– to SENSOR V–.
   b. Connect the DVM negative lead to OUT–, and positive lead to OUT+ of the Model 234.
   c. Make sure that the **I/V** to the **V** position (closed), and the **T/R** switch to **R** (closed).
   d. The DVM should read near 5 volts which is $10 \times \log(1000) / 6$.
   e. Remove the 1 kΩ from the SENSOR I+ and SENSOR I– screw terminals. The DVM should read about 0 volts.
   f. Put a short between the SENSOR I+ and SENSOR I– screw terminals. The DVM should read about 10 volts.

5.4.3 Calibration Procedure Using Range Switches & Pushbutton S2

Model 234 calibration consists of output calibration and input calibration.

NOTE: Allow about 30 minutes for the Model 234 Temperature Transmitter to warm up before continuing with calibration.

1. **Output Calibration.**

   a. Use a shorting wire to connect SENSOR I+ to SENSOR I–. This is a short circuit for the sensor.

   b. Make sure that the **T/R** switch closed (**R** position), and the **I/V** switch in the **V** position (closed).

   c. Connect the DVM negative lead to OUT–, and positive lead to OUT+. Make sure that the 500 Ω load resistor is also connected to OUT+ and OUT– terminals.

   d. Adjust trimpot R38, OUTPUT OFFSET, until the DVM reads zero ±0.05 mV.

   e. Remove the shorting wire from Step a., above.

   f. Adjust trimpot R40, OUTPUT GAIN, until the DVM reads 10.0000V ±0.05 mV. Output calibration is complete.

2. **Input Calibration.**

   a. Make sure that the **T/R** switch **R** position (closed), and the **I/V** switch **V** position (closed).

   b. Connect the DVM negative lead to OUT–, and positive lead to OUT+. Make sure that the 500 Ω load resistor is also connected to OUT+ and OUT– terminals.

   c. Connect the 1 kΩ calibration resistor to the screw terminal SENSOR I+ and SENSOR I– to simulate a sensor load to the Model 234. Use a shorting wire to connect SENSOR I+ to SENSOR V+, and another shorting wire to connect SENSOR I– to SENSOR V–.

   d. Switch all of the **RANGE** to **OPEN** except **RANGE 4** which is open to calibrate the input with the 1 kΩ calibration resistor.

   e. Press the **S2** pushbutton. Wait 5 seconds. The output should read 10 × log(1000) / 6 = 5.0000 volts. If it does not read 5.0000 ±1 mV then press the **S2** button again.

f. Repeat Steps c thru e for 1 Ω, 10 Ω, 100 Ω, 10 kΩ, and 100 kΩ 0.01% calibration resistors. For each resistor the **RANGE** switch to be closed is shown in the table below. When all ranges have been calibrated, the outputs should read as shown in the table below. Input calibration is complete.

Calibration Resistor	**Range Switch**	**Output ±1 mV Closed**
1 Ω	RANGE 1	0 V
10 Ω	RANGE 2	1.6667 V
100 Ω	RANGE 3	3.3333 V
1 kΩ	RANGE 4	5.0000 V
10 kΩ	RANGE 5	6.6667 V
100 kΩ	RANGE 6	8.3333 V

The output is 10 * log(Cal Resistor)/6.

5.4.4 Calibration Using Serial Interface Calibration Commands

Model 234 calibration consists of output calibration and input calibration.

NOTE: Allow about 30 minutes for the Model 234 Temperature Transmitter to warm up before continuing with calibration.

1. **Serial Interface Program**
   a. Connect the Serial Port of the computer to the transmitter via the RJ11 connector.
   b. Invoke QBASIC or QuickBasic.
   c. Enter the Model 234 program provided in Paragraph 4.1.4.
   d. Run the program.
   e. Issue a command to verify the program is running. For example, the ***IDN?** query to view the Model number and Software date.
2. **Output calibration using the DA0 and DA20 Commands:**
   a. Connect the DVM negative lead to OUT–, and positive lead to OUT+. Verify the 500 Ω load resistor is also connected to OUT+ and OUT– terminals.
   b. Issue the **DA0** serial interface command. Output should be close to zero.

c. Adjust trimpot R38, OUTPUT OFFSET, until the DVM reads zero ±0.05 mV.

d. Issue the **DA20** serial interface command. The output should be near 10 volts.

e. Adjust trimpot R40, OUTPUT GAIN, until the DVM reads 10.0000V ±0.05 mV.

f. The output calibration is complete.

3. **Input calibration using the CALX commands**

a. Make sure that the **T/R** switch **R** position (closed), and the **I/V** switch **V** position (closed).

b. Connect the DVM negative lead to OUT–, and positive lead to OUT+. Make sure that the 500 Ω load resistor is also connected to OUT+ and OUT– terminals.

c. Connect the 1 kΩ calibration resistor to the screw terminal SENSOR I+ and SENSOR I– to simulate a sensor load to the Model 234. Use a shorting wire to connect SENSOR I+ to SENSOR V+, and another shorting wire to connect SENSOR I– to SENSOR V–.

d. Issue the **CAL3** serial interface command. Wait 10 seconds.

e. Issue the **LOGR?** query. The transmitter should return 3.00000 ±.00010. If it reads correctly, proceed to the next step otherwise go back to step 4. Also monitor the output. The output should read 10 * log(1000) / 6 = 5.0000 volts.

f. Repeat Steps c thru e for 1 Ω, 10 Ω, 100 Ω, 10 kΩ, and 100 kΩ 0.01% calibration resistors. For each resistor the serial interface command to issue is shown in the table below. When all ranges have been calibrated, the outputs should read as shown in the table. Input calibration is complete.

Calibration Resistor	**Serial Command**	**Output ±1 mV**
1 Ω	CAL0	0 V
10 Ω	CAL1	1.6667 V
100 Ω	CAL2	3.3333 V
1 kΩ	CAL3	5.0000 V
10 kΩ	CAL4	6.6667 V
100 kΩ	CAL5	8.3333 V

5.4.5 Calibration Verification

1. Connect the DVM negative lead to OUT–, and positive lead to OUT+. Make sure that the 500 Ω load resistor is also connected to OUT+ and OUT– terminals.
2. Make sure that the **I/V** to the **V** position (closed), and the **T/R** switch to **R** (closed).
3. Put the 1 kΩ resistor between screw terminal SENSOR I+ and SENSOR I– and shorting wires connect SENSOR I+ to SENSOR V+, and SENSOR I– to SENSOR V–.
4. The DVM should read 5.000 volts ±1 mV.
5. Remove the 1 kΩ from the SENSOR I+ and SENSOR I– screw terminals. The DVM should read zero volts ±1 mV.
6. Put a short circuit between the SENSOR I+ and SENSOR I– screw terminals. The DVM should read 10.000 volts ±1 mV.
7. This concludes the Calibration Verification procedure.

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CHAPTER 6

OPTIONS AND ACCESSORIES

6.0 GENERAL

This chapter lists Model 234 enclosures, options, accessories, sensors, wires, and special equipment.

6.1 ENCLOSURES

Model	***Description Of Enclosure***
2308-1	Benchtop Enclosure for use with one Model 234 PCB.
2308-12	VMEbus rack mount case with built-in power supply for use with up to 12 Model 234s.

6.2 OPTIONS

Model	***Description Of Option***
8001-234	Factory Installed CalCurve™ (formerly known as Precision Option). Allows instrument to use the calibration data to calculate and output current proportional to temperature. Requires calibrated sensor.
8002-234	Field Installed CalCurve™. Requires field installation of a new Curve EEPROM. Allows instrument to use the calibration data to calculate and output current proportional to temperature. Requires calibrated sensor.

6.3 ACCESSORIES

Model	***Description Of Accessory***
103-626	Resistor, Precision, 500 Ω, ±0.02%
106-739	Input Terminal Mating Connector
2001	Modular Cable, RJ-11 to RJ-11, 4.6 m (14 ft.) long
2002	Adapter, RJ-11 to DB-25, for RS-232C Interface
2003	Adapter, RJ-11 to DE-9, for RS-232C Interface
2007-12	Wall Plug-in Power Supply, 120 V 60 Hz power source
2007-22	Wall Plug-in Power Supply, 230 V 50 Hz power source
2308-BP	VME rack blank panel
MAN-234	Model 234 User's Manual

6.4 WIRES

LSCI P/N	***Description Of Cable***
9001-005	**Quad-Twist™ Cryogenic Wire.** Two twisted pairs, phosphor-bronze wire, 36 AWG, 0.13 mm (0.005 inch) diameter.
9001-007	**Quad-Lead™ Cryogenic Wire**. Phosphor-bronze wire, flat, 32 AWG, 0.20 mm (0.008 inch) diameter.
9001-008	**Quad-Lead™ Cryogenic Wire**. Phosphor-bronze wire, flat, 32 AWG, 0.13 mm (0.005 inch) diameter.
—	Any quality dual shield twisted pair wire for dewar to Model 234 connector.

6.5 SENSORS

Sensor No.	***Description Of Sensor***
Series CGR	**Carbon-Glass Resistance Temperature Sensors** is a highly reproducible sensor that can be used from 1.0 K to 100 K and above in magnetic fields up to 19 tesla.
Series CX	**Cernox™ Thin-Film Resistance Temperature Sensors** offer a negative temperature coefficient, monotonic response over a wide temperature range, low magnetic field induced errors, and high resistance to ionizing radiation.
Series GR	**Germanium Resistance Temperature Sensors** are recognized "secondary standard thermometers" and have been employed in the measurement of temperature from 0.05 K to 30 K for more than 30 years.

6.6 SPECIAL EQUIPMENT

There are a number of 4 – 20 mA displays available for use with the Model 234. Suggested manufacturers include the following.

Acculex
440 Myles Standish Blvd.
Taunton, MA 02780
(508) 880-3660

Newport Electronics, Inc.
630 East Young Street
Santa Ana, CA 92705-5687
(714) 540-4914

Triplett Corp.
One Triplett Drive
Bluffton, OH 45817
1-800-874-7538

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