# *Ω* OMEGA™

# User's Guide

# DP41-TC, DP41-RTD
# High Performance
# Temperature Indicator

# ΩΞ OMEGA™

**omega.com   info@omega.com**

## Servicing North America:

**U.S.A.**
**Headquarters:**

Omega Engineering, Inc.
Toll-Free: 1-800-826-6342 (USA & Canada only)
Customer Service: 1-800-622-2378 (USA & Canada only)
Engineering Service: 1-800-872-9436 (USA & Canada only)
Tel: (203) 359-1660                    Fax: (203) 359-7700
e-mail: info@omega.com

## For Other Locations Visit omega.com/worldwide

# Table of Contents - Digital Panel Meter

# 1. Introduction

This manual is applicable to all meters with serial numbers 1520525 and larger.

## 1.1 DESCRIPTION

The OMEGA DP41 temperature meter series is a complete line of process indicators/controllers, offering exceptional performance.

The DP41 temperature meter is front-panel programmable to accept any of 9 thermocouple calibrations, (J, K, T, E, N, R, S, B, and DIN J) or 100 ohm Pt (385 or 392 curve) or 10 ohm Copper RTDs with either 2-, 3-, or 4-wire configuration. The DP41 meter will accept inputs from 0.6 to 6000 ohms. All temperature inputs may be displayed in °C, °F or Kelvin.

The DP41 temperature meter can also be used as a precise 2-, 3-, or 4-wire ohmmeter for resistance in the range 0.6 to 6000 ohms; this linear usage is also described in this manual.

A unique linearization method allows the microprocessor in the DP41 to utilize the entire NIST calibration tables.

Configuring the DP41 is accomplished through the 5 front panel buttons. If the optional RS-232 or RS-485 communications are installed, the user may remotely set the display parameters.

Options for the DP41 include analog and BCD outputs, relay outputs, and RS-232 or RS-485 communications.

## 1.2 FEATURES

The following is a list of features of the DP41.
• 1.0°, 0.1°, 0.01° resolution
• 9 Thermocouple calibrations J, K, T, E, N, R, S, B, DIN J
• 2-, 3-, or 4-wire 100 ohm Pt or 10 ohm Cu RTDs
• Peak & Valley detection and memory
• Up to 12 readings per second
• 4 isolated open-collector outputs(standard) and optional isolated relay or isolated BCD and isolated analog outputs
• Optional Isolated RS-232 or RS-485 communications
• NEMA-4 Front-Panel/IP65
• Non-volatile memory without battery back-up
• 115 V ac, 50/60 Hz, 230 V ac, 50/60 Hz power supply

# 1

## 1.3 AVAILABLE MODELS

The following options are available installed at the time of pur-
chase or as separate items installed by the user after purchase:

Analog Output Board, BCD Output Board, Relay Output Board,
RS-232 Communications Board, and RS-485 Communications
Board.

The following DP41 models are available from OMEGA Engineering:

| MODEL NUMBER | DESCRIPTION OF DESIGNER MODELS |
|---|---|
| DP41-TC | Thermocouple Indicator (115 V ac) |
| DP41-RTD | RTD Indicator (115 V ac) |
| DP41-TC-230 | Thermocouple Indicator (230 V ac) |
| DP41-RTD-230 | RTD Indicator (230 V ac) |

**NOTES:** Red display is standard. To obtain a green display, add
"-GN" to the end of the model number.

To order an analog output, add "-A" to the end of the model number.

To order the Classic Bezel (Optional Housing; refer to the cover)
add "-OH" to the end of the model number.

### ANALOG OUTPUT OPTION

| MODEL NUMBER | DESCRIPTION |
|---|---|
| DP40-A | Isolated Analog Output Board |

### CONTROL/BCD OUTPUT OPTIONS

| MODEL NUMBER | DESCRIPTION |
|---|---|
| DP40-B | Isolated BCD Output Board |
| DP40-R | Dual 7A Form-C Relays |

**NOTES:** Choose only one Control/BCD output option per meter.
A 40-pin mating connector is included with the BCD option.

**SERIAL COMMUNICATIONS OPTION**

| MODEL NUMBER | DESCRIPTION |
| --- | --- |
| DP40-S2  * | Isolated RS-232 Communications |
| DP40-S4  ** | Isolated RS-485 Communications |

NOTES: Choose only one option per meter.  Both computer communications come with 3.5" and 5.25" set/programming disks (1 each) and one 6 ft. communications cable with phone plug termination.

\* Recommend purchase of DP40-9SC2 or DP40-25SC2 (see below)
\** Recommend purchase of DP40-9SC4 or  DP40-25SC4 (see below)

**OTHER OPTIONS**

| MODEL NUMBER | DESCRIPTION |
| --- | --- |
| DP40-9SC2 | 9-pin Serial Connector for RS-232 |
| DP40-9SC4 | 9-pin Serial Connector for RS-485 |
| DP40-25SC2 | 25-pin Serial Connector for RS-232 |
| DP40-25SC4 | 25-pin Serial Connector for RS-485 |

# 1

## Introduction

**Notes:**
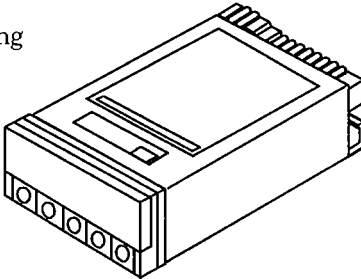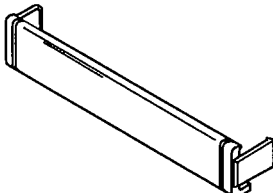
# 2. Unpacking

Remove the Packing List and verify that all equipment has been received. If there are any questions about the shipment, please call the OMEGA Customer Service Department at 1-800-622-2378 or (203) 359-1660.

Upon receipt of shipment, inspect the container and equipment for any signs of damage. Take particular note of any evidence of rough handling in transit. Immediately report any damage to the shipping agent.
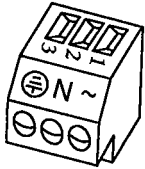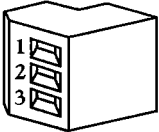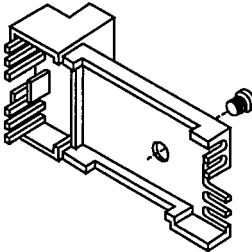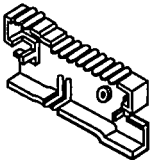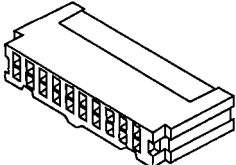
**NOTE:** The carrier will not honor any claims unless all shipping material is saved for their examination. After examining and removing contents, save packing material and carton in the event reshipment is necessary.
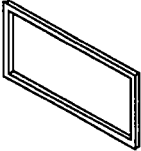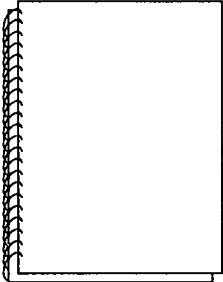
When you order your DP41 meter, you will receive the following items in the shipping box:

| QTY | DESCRIPTION | ILLUSTRATION |
|-----|-------------|--------------|
| 1 | Basic Meter in a Mounting Sleeve with Gasket | |
| 1 | Front-Panel Button Cover | |

# 2

**Unpacking**

| QTY | DESCRIPTION | ILLUSTRATION |
|-----|-------------|--------------|
| 1 | AC Power Connector (orange - P1) | |
| 2 | Input Connectors (gray - P3 and P9) | |
| | **OR** | |
| 1 | Thermocouple Rear Protective Cover with Screw | |
| 1 | RTD Rear Protective Cover with Screw | |
| 1 | 20-Socket Ribbon Connector (P2 Connector) | |

| QTY | DESCRIPTION | ILLUSTRATION |
|-----|-------------|--------------|
| 2 | Panel-Mounting Gaskets | |
| 1 | Temperature Owner's Guide | |
| 1 | Quick Reference Guide | |

Other items may also be in the box depending on the options ordered. Refer to specific options described previously.

# 2

**Unpacking**

**Notes:**

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

# 3. Safety Considerations

The meter is protected in accordance with Class II of IEC 348 and VDE 0411.

> WARNING: If your meter is to be wired to sensors or control inputs which could have hazardous potentials, these potentials will be carried through to the 20-pin digital output connector at the rear, and will be present on the meter's circuit boards. Install the rear 20-pin mating connector and insert the electronics into the case **before** connecting the meter to any source of possible high voltage.
>
> DO NOT contact any exposed metal parts or interconnect any option board(s) or change any jumpers on this meter while it is connected to AC voltage.

To provide safe operation, follow these guidelines:

## 3.1 POWER WIRING

The meter has no power-on switch, so it will be in operation as soon as power is applied.

## 3.2 HUMIDITY

Do not expose your meter to rain or condensing moisture.

## 3.3 FUMES AND GASES

Do not operate your meter in flammable or explosive atmospheres.

# Notes:

# 3

**Safety
Considerations**

# 4. Parts of the Meter

## 4.1 FRONT OF THE METER

The following is a brief description of each part of the front of the meter.



Figure 4-1. Front Detail

| ITEM | DESCRIPTION |
|------|-------------|
| 1 | –.8.8.8.8.8. or 8.8.8.8.8.8.<br><br>6-digit, 14 segment, alphanumeric 0.54" high LED display with programmable decimal point. |
| 2 | SETPOINT LED<br><br>These LEDs, labeled 1 through 4, display the status of setpoints 1, 2, 3 (Alarm 1), and 4 (Alarm 2). |
| 3 | SETPTS BUTTON<br><br>This button functions only in the run mode. When the Setpoint/Alarm features are unlocked, pressing this button sequentially recalls the previous setpoint settings to the display. After the '▶/MIN' and '▲/MAX' buttons are used to alter those values as desired, pressing the 'SETPTS' button, again, stores these new values.<br><br>Unless the 'SETPTS' button is pressed, each of the four setpoint values is displayed for approximately 10 seconds after the last press of THE "SETPTS" button. Holding the 'SETPTS' button depressed stalls this automatic sequence, retaining the most recent setpoint number on the display. |

# 4

**Parts of
the Meter**

| ITEM | DESCRIPTION |
|------|-------------|
| 4 | ▲ /MAX BUTTON<br><br>During run mode, pressing this button displays the "HI RDG" (peak reading) value that has occurred up to the moment the 'MAX' button is pressed. This peak reading flashes, to distinguish its value from the current readings. Since this is a dynamic peak reading, the value will change if the value increases while reviewing it.<br><br>To return to display of the current readings without resetting the peak-value memory to zero (0), press the 'MAX' button once again.<br><br>To reset the peak-value memory (start a new peak determining period), press the 'RESET' button once.<br><br>During the configuration mode, the 'MAX' button is used to change the numerical value of the flashing digit displayed. For submenu items, such as "L1C.1=0", pressing the 'MAX' button toggles the choice from "0" to "1".<br><br>The meter allows rapid changes of a displayed numerical value by making "0" the first value to occur when the 'MAX' button is pressed. After that, the numbers increase to "9" and then roll over to "0" again. A negative ("–") symbol may be displayed in the most significant digit (i.e. the digit at the far left such as shown here "–.8.8.8.8.")<br><br>In the SETPT (SETPOINT) mode (SP1, SP2, etc), pressing the 'MAX' button causes the flashing digit to increment by 1 from 0 to 9. |
| 5 | ▶ /MIN BUTTON<br><br>During run mode, pressing the 'MIN' button recalls the "LO RDG" (valley reading) measured since the last press of the 'RESET' button. This lowest value flashes, to distinguish it from the current process display. Since this is a dynamic valley reading, the value will change if the value decreases while reviewing it. |

| ITEM | DESCRIPTION |
|------|-------------|
| | To return to the actual process display, without resetting the low-value memory, press the 'MIN' button once again. |
| | To reset the memory for current-value readings (start a new observation period), press the 'RESET' button once and the meter will return to the run mode. |
| | In the configuration mode, once in a submenu (like TC type) the 'MIN' button allows you to scroll through the available choices such as "J", "K", etc. |
| | In the SETPT mode, the 'MIN' button advances the flashing digit to the right. |
| 6 | MENU BUTTON |
| | In the run mode, this button terminates the measurement process and allows you to enter the configuration mode, advancing through the configuration menus. |
| | In the configuration mode, this button will store changes in the non-volatile memory at the same time advancing the display to the next menu item. |
| 7 | RESET BUTTON |
| | In the run mode, pressing the 'RESET' button once erases the memories of peak ("HI RDG"), valley ("LO RDG"), and ALARM latches. The display then returns to the run mode. |
| | WARNING: *Pressing the 'RESET' button two (2) times will result in a hard reset of the meter. This will clear the Peak & Valley, Alarm latches and meter readings and immediately begin a new measurement.* |
| | In the configuration mode, pressing the 'RESET' button once, displays the previous selection. For example, if you were in "IN CNF" then pressed the 'RESET' button once, the display will then show "RD.SC.OF". Press the 'RESET' button two times to return to the run mode. |

## 4.2 REAR OF THE METER

The following is a brief description of each part of the rear of the meter. The label on the top of the mounting sleeve (not the case) identifies the location of the connectors found at the rear of the meter. Figure 4-2 shows this label.

### P2/CABLE CONNECTOR

| | | | |
|---|---|---|---|
| TARE (T) | 1 | 2 | PEAK (P) |
| VALLEY (V) | 3 | 4 | SWLIN2 |
| PEAK/VALLEY OR EXT. RESET | 5 | 6 | PUSH TO CAL |
| DIG GND | 7 | 8 | +5V |
| DISPLAY HOLD | 9 | 10 { | LOCKOUT EEPROM & MENU PUSH BUTTON |
| RESET ALARMS AND/OR PRINT COMMAND | } 11 | 12 | NONSTANDARD RX |
| NONSTANDARD TX | 13 | 14 | PUSH TO CAL |
| +V EXT | 15 | 16 | SP1 |
| SP2 | 17 | 18 | AL1 |
| AL2 | 19 | 20 | GND EXT |

**P4/RS-232**

| | |
|---|---|
| 6 | N/C |
| 5 | COMM GND |
| 4 | RX |
| 3 | TX |
| 2 | RTS |
| 1 | N/C |

**P4/RS-485**

| | |
|---|---|
| 6 | N/C |
| 5 | B RX |
| 4 | A RX |
| 3 | COMM GND |
| 2 | B TX/RX |
| 1 | A TX/RX |

**P6/RELAY**

| | |
|---|---|
| 1 | NO1 |
| 2 | CM1 |
| 3 | NC1 |

**P7/RELAY**

| | |
|---|---|
| 1 | NO2 |
| 2 | CM2 |
| 3 | NC2 |

**P5 ANALOG OUT**

| | |
|---|---|
| 1 | RETURN |
| 2 | 4-20 MA |
| 3 | 0-10 V |

**P1/AC PWR**

**P1/PWR**

| DC | AC |
|---|---|
| N/C | HI |
| +DC | LO |
| GND | GND |

**P9 & P3/SIGNAL IN**

| | |
|---|---|
| | +E |
| | +S |
| | − S |
| | − E |
| | +R |
| | − R |

P6  P7  P8 BCD  P9  P5  P4  P2  P1  P3

Figure 4-2. Connector Label for Rear Connectors

Figure 4-3 shows the rear of the meter with the optional relay output board installed.

Figure 4-3. Rear View

Figure 4-4 shows the rear of the meter with the optional BCD output board installed.
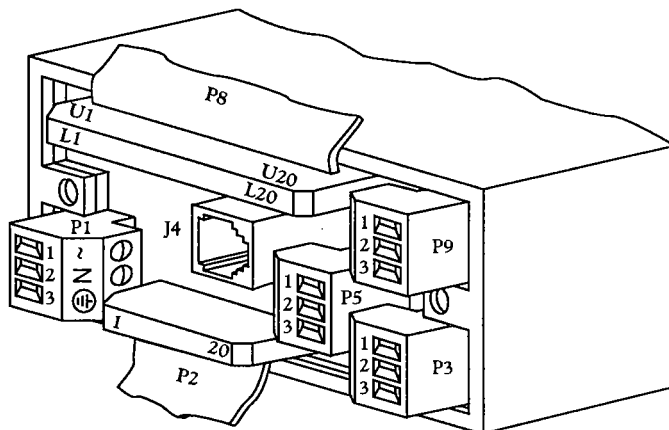


Figure 4-4. Rear View

TABLE 4-1 REAR CONNECTOR DESCRIPTIONS

| CONNECTOR # | DESCRIPTION |
|---|---|
| P1 | AC Power Connector |
| P2 | External I/O Connector |
| P3 | Input Connector, –E, +R, –R |
| J4 | Optional RS-232 or RS-485 Phone Jack Connector |
| P5 | Optional Analog Out Connector |
| P6 | Optional Form-C Relay #1 Connector |
| P7 | Optional Form-C Relay #2 Connector |
| P8 | Optional BCD Connector |
| P9 | Input Connector, +E, +S, –S |

# Notes:

**4**

**Parts of
the Meter**

# 5. Setup

## 5.1 CONDITIONS REQUIRING DISASSEMBLY

You may need to open the meter for several reasons:

1. To inspect the rating label on the case (not the same label as on the sleeve) (Section 5.2.1).

2. To check or change the 115 V ac or 230 V ac or main board jumpers (Sections 5.2.2 and 5.2.4).

3. To install optional output board(s) (Section 5.2.3).

4. To mount the meter in a panel (Section 5.2.5).

**5**

Setup

## 5.2 DISASSEMBLY

The following procedure describes how to open up the meter. Figure 5-1 shows the meter with the bezel and Figure 5-2 shows the meter with the optional housing.

1. Make sure the AC power is removed from the meter.

2. Remove the cover mounting screw and set aside.

3. Remove the rear protective cover and set aside.

4. Remove all wiring connectors from the rear of the meter.

5. Remove both thumbnuts and set aside.

6. Remove the sleeve and set aside.

7. Bend the side panel detents on the case (shown in Figure 5-3) outward to release the boards. Pull the board assembly out of the case by the mounting screw stem.

**Note:** From this point forward, these 7 steps are referred to as "Reveal the main board".

# 5

REAR
PROTECTIVE
COVER

COVER
MOUNTING
SCREW

THUMBNUTS

GASKET

SLEEVE

AC POWER BOARD

MAIN BOARD ASSY

CASE

BEZEL
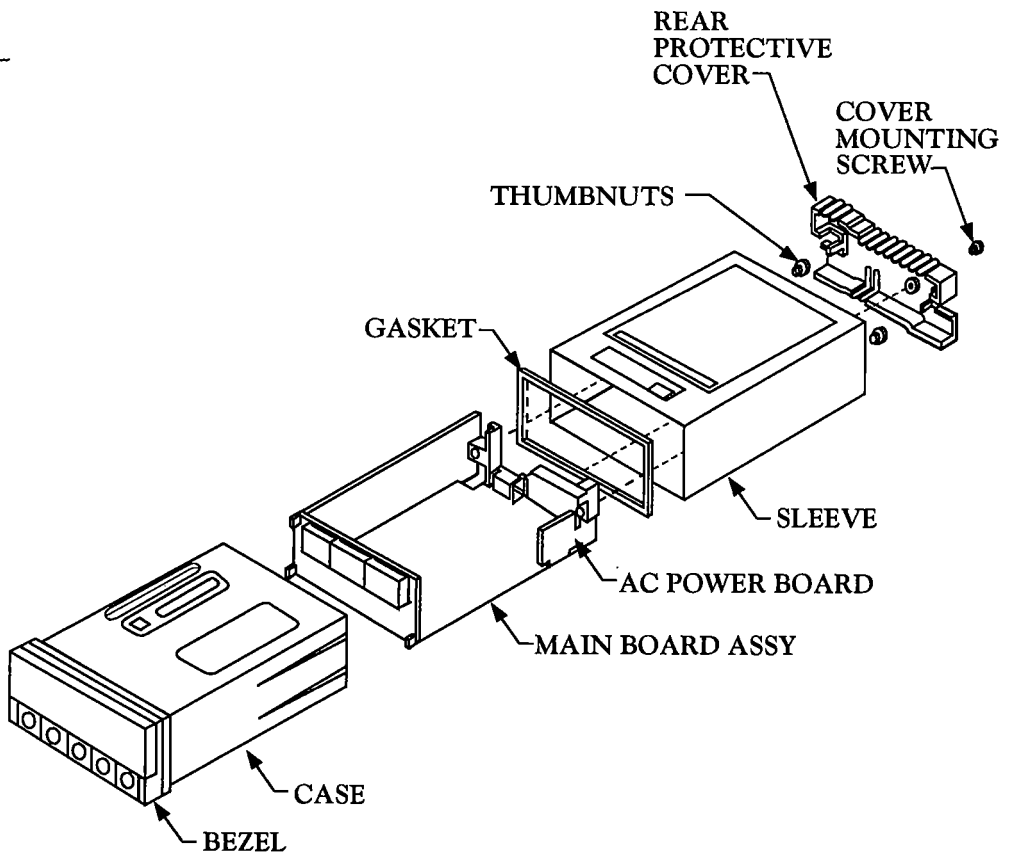
Figure 5-1. Meter Exploded View

REAR
PROTECTIVE
COVER

COVER
MOUNTING
SCREW

CONNECTOR
LABEL

MADE IN
U.S.A. LABEL

RETAINER
(NOT USED WITH
BCD OPTION)

THUMBNUTS

FRONT-PANEL
PUSHBUTTONS

SLEEVE

SERIAL NUMBER LABEL

MODEL TAG

AC POWER BOARD

MAIN BOARD
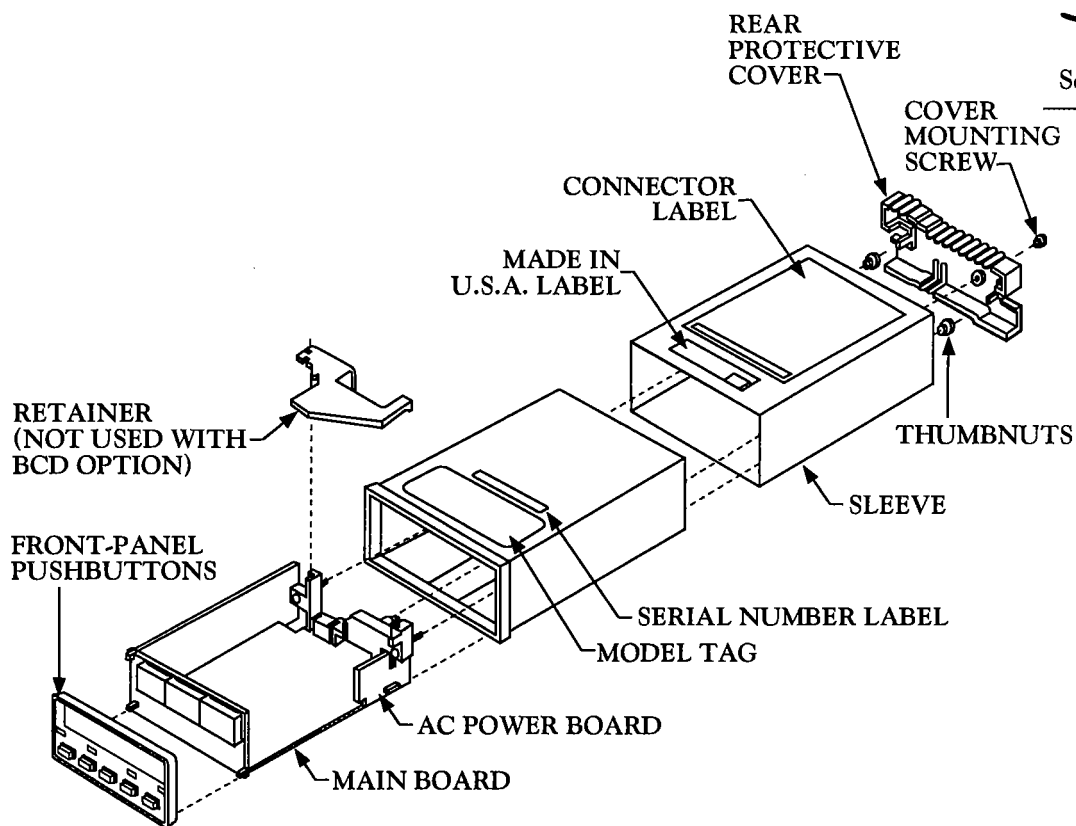
Figure 5-2. Meter Exploded View (with optional housing)

## 5.2.1 RATING/PRODUCT ID LABEL

To look at the Rating/Product ID label on the case, you must follow the first 6 steps as described in Section 5-2. Refer to Figure 5-3 for the location of the Product Identification Label.

**5**

Setup

PRODUCT IDENTIFICATION LABEL

TO INSTALL
TO REMOVE

MOUNTING SCREW STEM

SIGNAL INPUT JUMPER LABEL

MAIN BOARD ASSY

BEND DETENTS OUTWARD TO INSTALL MAIN BOARD

CASE
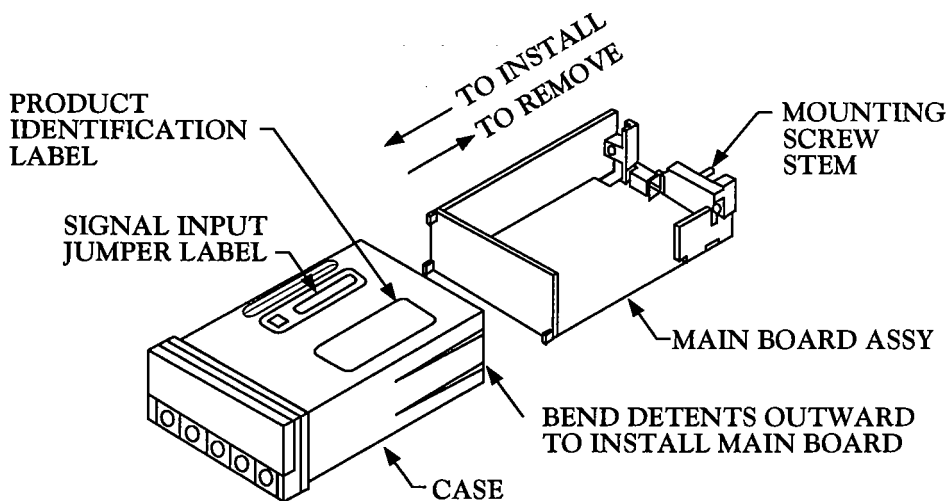
Figure 5-3. Board Assembly Removing/Installing Detail

T1

MAIN BOARD

W2
W3
W1

AC POWER BOARD

REAR OF METER
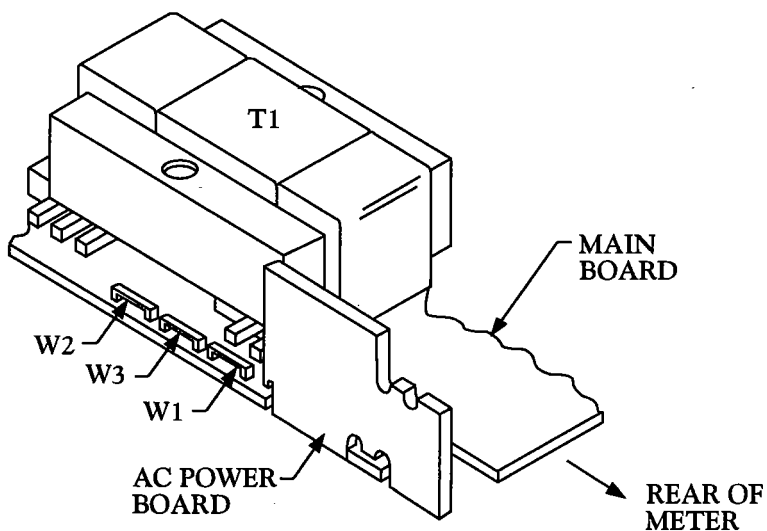
Figure 5-4. Transformer Jumpers

## 5.2.2 MAIN BOARD POWER JUMPERS

To check voltage jumpers from 115 V ac to 230 V ac:

1. "Reveal the Main Board" (refer to Section 5.2, Disassembly).

2. Locate the main board assembly and position it in front of you the same way as shown in Figure 5-4.

3. On the main board, locate the transformer jumpers W1, W2, and W3 near the transformer T1.

5

Setup

## 5.2.3 PRINTED CIRCUIT BOARD(S) INSTALLATION

To install optional printed circuit board(s):

1. "Reveal the Main Board" (refer to Section 5.2, Disassembly).

2. Using Figure 5-5 as a reference, insert option board(s) into the corresponding slot(s) on the main board. Each circuit board is keyed to fit in it's own position.

3. To re-assemble the meter, follow the steps in Section 5.2 in reverse order.

BCD BOARD

J20

P20 — INTERCONNECT BOARD
(PART OF BCD ASSY)

P14

RETAINER
(ALWAYS USED
EXCEPT FOR
BCD OPTION)

REAR
PROTECTIVE
COVER

COVER
MOUNTING
SCREW

P12

RELAY BOARD

P11

ANALOG
OUTPUT BOARD

P10

RS-232/RS-485 BOARD

THUMBNUTS

SLEEVE

J12   J11   J10

GASKET

J14

AC POWER BOARD

MAIN BOARD ASSY

BEND DETENTS OUTWARD
TO INSTALL MAIN BOARD

CASE
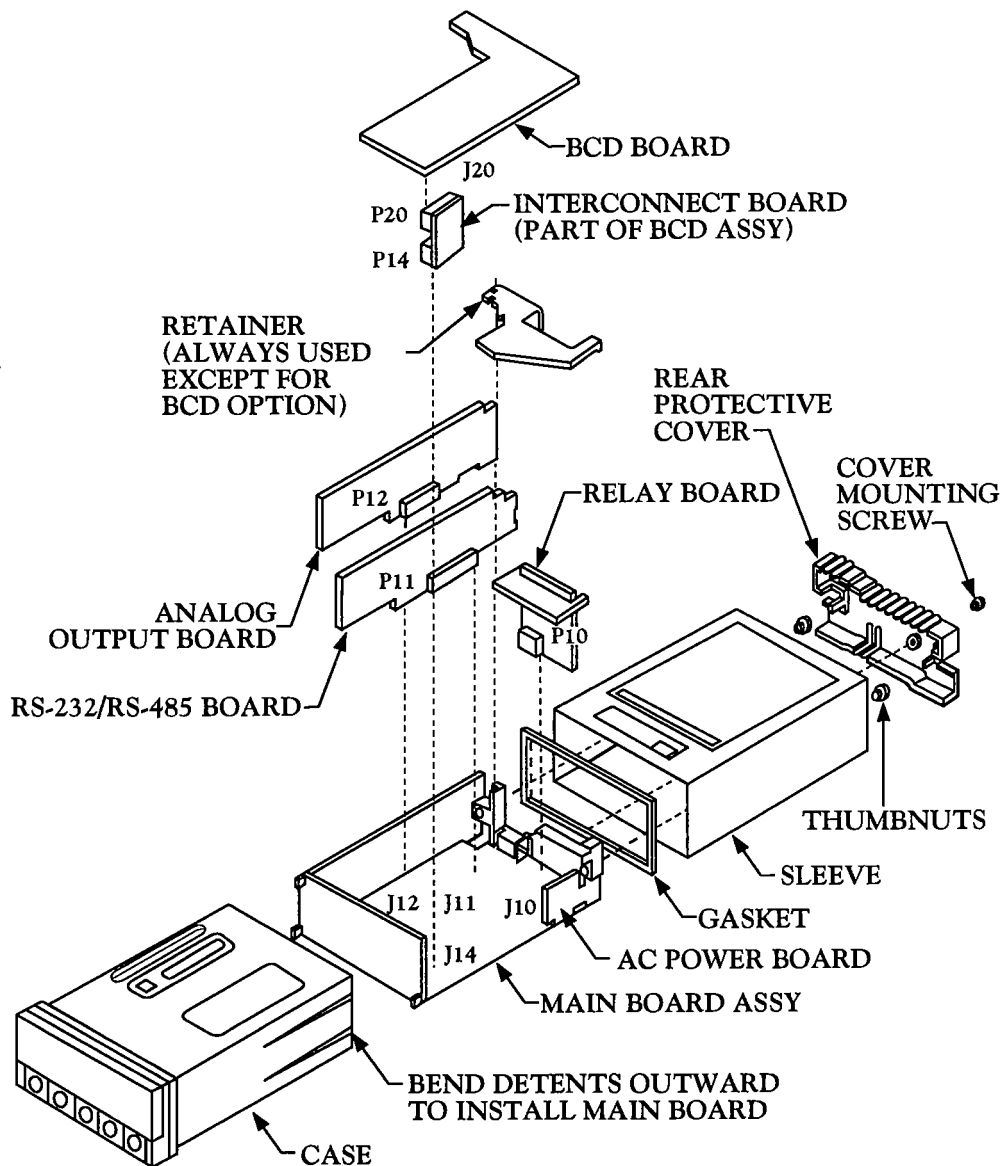
Figure 5-5. Optional Printed Circuit Board Locations

## 5.2.4 HOW TO ACCESS JUMPERS

To gain access to jumpers on the various printed circuit boards:

1. "Reveal the main board" (refer to Section 5.2, Disassembly).
   NOTE: To access the S1 and S2 jumpers on the Signal Input
   Board, you only need to remove the mounting sleeve.

2. To re-assemble the meter, follow the steps in reverse order.

Figures 5-6 through 5-12 show the layout of the seven (7) printed
circuit boards with respective jumper blocks, where applicable, used
in the meter. Figures 5-8 through 5-12 show the optional boards.

# 5

Setup
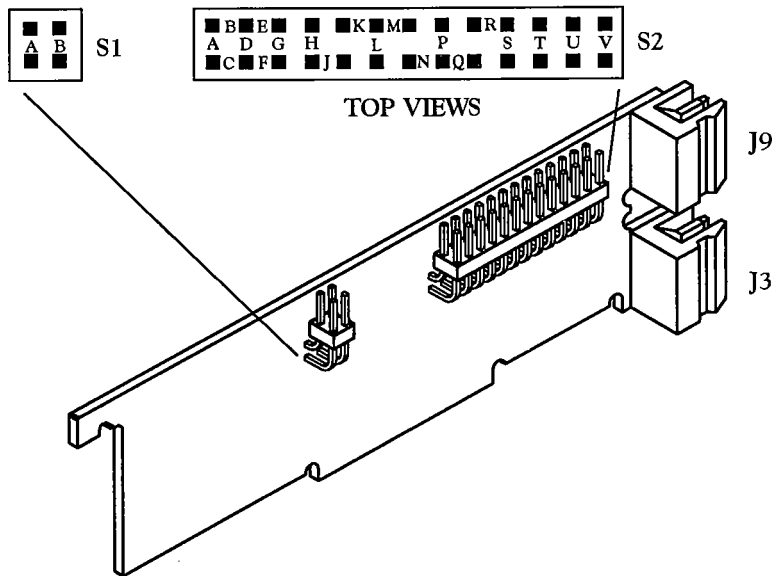


Figure 5-6. Signal Input Board
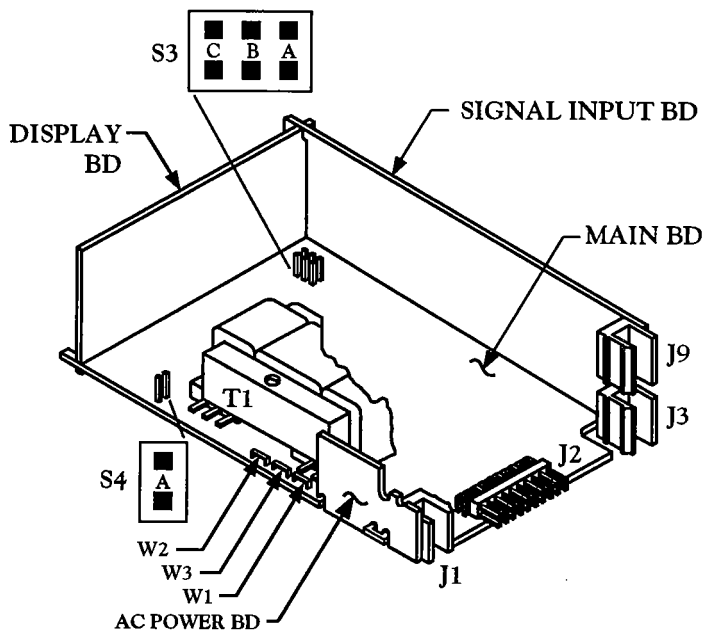
Figure 5-7.  Main Board
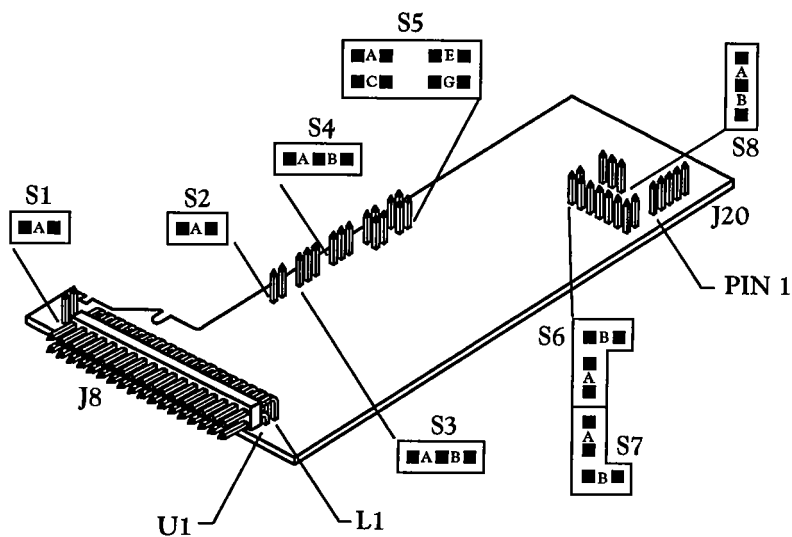


Figure 5-8.  BCD Option Board
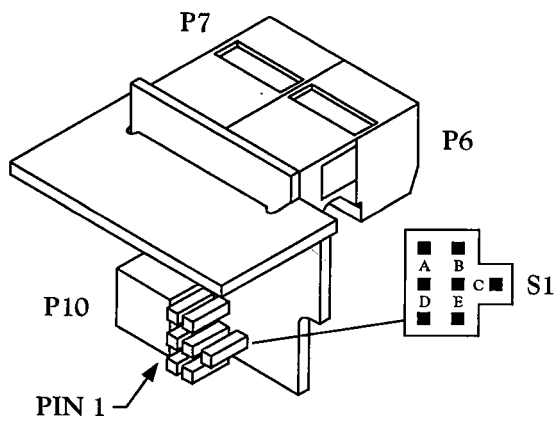
Figure 5-9. Relay Option Board
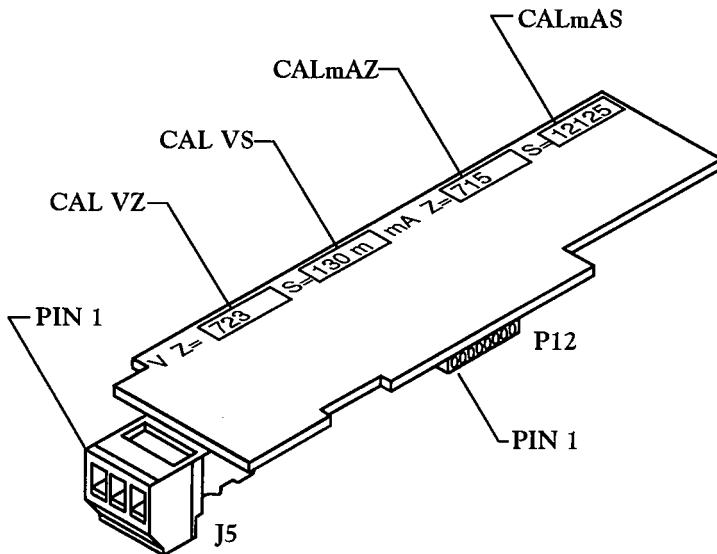


Figure 5-10. Analog Output Option Board
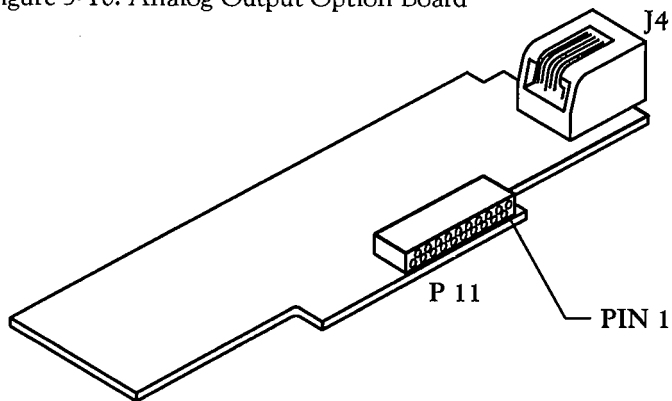


Figure 5-11. RS-232 Option Board
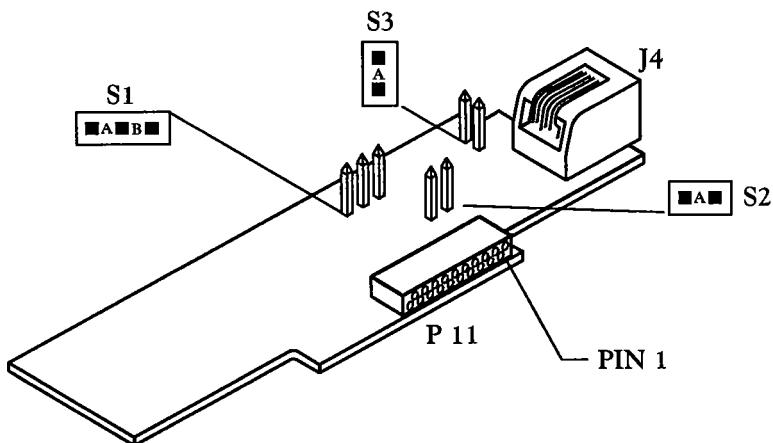
Figure 5-12. RS-485 Option Board

## 5.2.5 PANEL MOUNTING

To mount the meter in a panel:

1. "Reveal the Main Board" (refer to Section 5.2, Disassembly).
   You don't need to do step 7.

2. Using the panel cutout diagram shown in Figure 5-13, cut a hole
   in the panel.
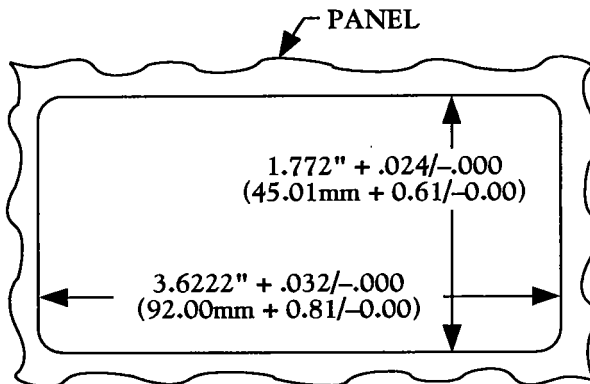


Figure 5-13. Panel Cutout Dimensions

3. Insert the case and meter into the hole, so that the gasket seals
   between the bezel and the front of the panel.
   Refer to Figure 5-14.

REAR PROTECTIVE COVER

COVER MOUNTING SCREW

THUMBNUTS

PANEL

SLEEVE

METER

CASE

GASKET

BEZEL
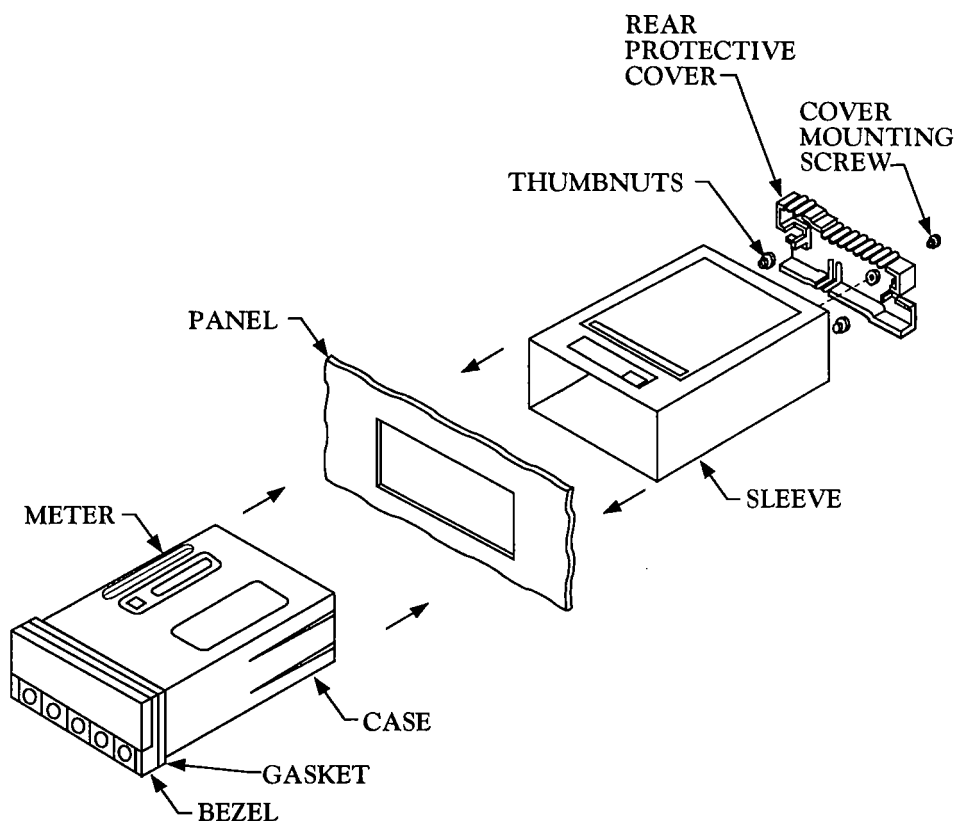
Figure 5-14. Panel Mounting

4. Slip the sleeve over the rear of the case.

5. Re-attach and tighten the thumbnuts to hold the meter firmly in the panel.

6. Replace the wire connectors at the rear of the meter.

7. Replace the applicable rear protective cover and secure with the cover mounting screw.

8. Re-apply power. Section 5.3 covers how to wire the power connector, if you haven't already done so.

The meter display should light, and pass through "RESET 2" to run or display mode. If the meter flashes an overscale or overload message, press the 'MENU' button to advance to the configuration mode. Do not be concerned about overloads (the +S input can stand 120 V continuously and current inputs can handle ten times rated current).

## 5.2.6 BENCH TOP USE

The sleeve has no mounting function in bench-top use, but covers the input-jumper opening and provides additional protection. Attach the appropriate wires to the signal connectors P3, P9 (and the Cold-Junction Compensation board, if used) and plug them in to the rear of the assembly. The label on the case sleeve shows the connectors and terminal designators.

Attach the rear protective cover with the cover mounting screw. Plug in the power connector: the meter should light, and display "RESET 2", then return to the run mode. If the meter flashes an overscale or overload message refer to Section 17, Troubleshooting Guide. Do not be concerned about overloads (the +S input can stand 120 Vac continuously and current inputs can handle ten times rated current).

## 5.3 AC WIRING

The orange (power) connector must be wired according to the following procedure (refer to Figure 5-15):

| USA WIRING CODE | INTERN'L WIRING CODE | CONNECTION | PIN # ON ORANGE CONNECTOR |
|---|---|---|---|
| Black | Brown | AC High (HI) | 1 |
| White | Blue | AC Neutral(LO) | 2 |
| Green | Green/Yellow | AC Ground | 3 |

(ORANGE)
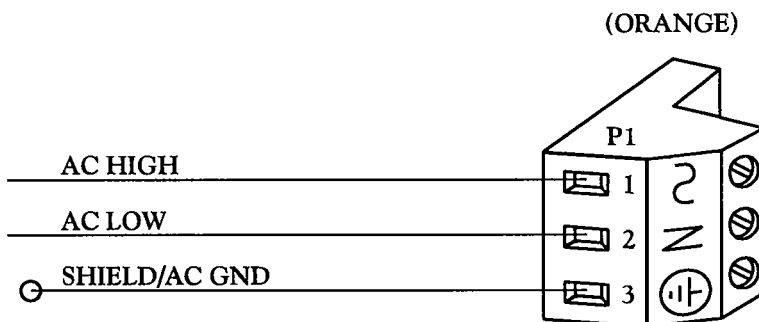


Figure 5-15. AC Connector Wiring

## 5.4 COLD JUNCTION COMPENSATION BOARD INSTALLATION FOR THERMOCOUPLES

To setup the rear protective cover with the P3 and P9 connectors (and Cold-Junction Compensation Board), proceed with the following (Refer to Figure 5-16):

1. Obtain P3 and P9 connectors and the thermocouple rear protective cover.

2. Put the two (2) connectors P3 and P9 into the corresponding male connectors at the rear of the meter. Refer to Figure 4-2 for the location of the male connectors. P3 and P9 are identical and interchangeable connectors.

3. Using a long slotted screwdriver (one that is at least 4" long), loosen the 6 screws on the connectors.

4. Carefully install the thermocouple rear protective cover onto the connectors making sure the pins in the rear cover make good contact with the holes in the connectors.

5. Tighten the 6 screws (do not over tighten).

6. Fasten down the cover with the cover mounting screw.
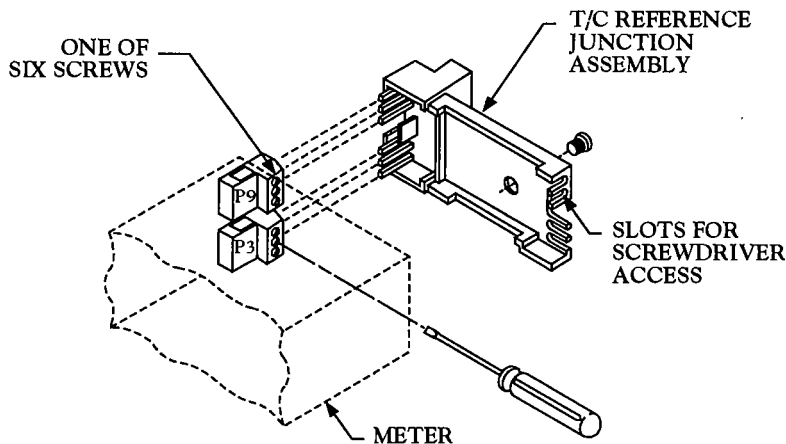


Figure 5-16. Installation of Thermocouple Cold-Junction Compensation Board Assembly

### 5.4.1 COLD-JUNCTION COMPENSATION BOARD WIRING

Figure 5-17 shows the wiring hookup for thermocouples. Use the following table to determine which colored wires get connected to the positive and negative terminals. Note: positive and negative wiring designations are molded into the plastic cover.
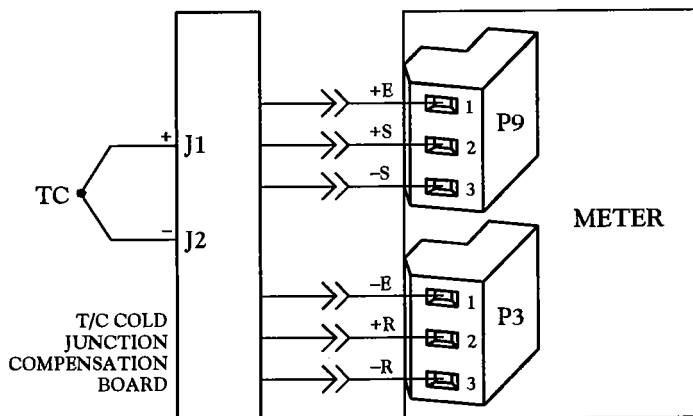
Figure 5-17. Directly-Connected Thermocouple

### 5.4.2 THERMOCOUPLE WIRE COLORS

TABLE 5-1. THERMOCOUPLE WIRE COLORS

| USA | | |
|---|---|---|
| T/C TYPE | WIRE COLORS | |
| | + LEAD | – LEAD |
| J | White | Red |
| K | Yellow | Red |
| T | Blue | Red |
| E | Purple | Red |
| N | Orange | Red |
| R | Black | Red |
| S | Black | Red |
| B | Grey | Red |
| DIN J | Red | Blue |

| | FRANCE | | GERMANY | |
|---|---|---|---|---|
| T/C TYPE | WIRE COLORS + LEAD | – LEAD | WIRE COLORS + LEAD | – LEAD |
| J | Yellow | Black | Red | Blue |
| K | Yellow | Purple | Red | Green |
| T | Yellow | Blue | Red | Brown |
| E | Yellow | Purple | Red | Black |
| N | No Standard-See USA | | No Standard-See USA | |
| R | Yellow | Green | Red | White |
| S | Yellow | Green | Red | White |
| B | Use Copper Wire | | Red | Gray |
| DIN J | Red | Blue | Red | Blue |

| | JAPAN | | UNITED KINGDOM | |
|---|---|---|---|---|
| T/C TYPE | WIRE COLORS + LEAD | – LEAD | WIRE COLORS + LEAD | – LEAD |
| J | Red | White | Yellow | Blue |
| K | Red | White | Brown | Blue |
| T | Red | White | White | Blue |
| E | Red | White | Brown | Blue |
| N | No Standard-See USA | | No Standard- See USA | |
| R | Red | White | White | Blue |
| S | Red | White | White | Blue |
| B | Red | Gray | No Standard- See USA | |
| DIN J | Red | Blue | Red | Blue |

Once you have installed all applicable printed circuit boards in the meter and mounted the meter in your panel (if desired), and wired the meter, you can proceed to:

Section 6 for an example of how to operate the meter with a Type K thermocouple.

Or

Section 7 for an example of how to operate the meter with an RTD.

Or

Section 8 for details on how to hook up a non-linear transmitter.

# Notes:

**5**

Setup

# 6. Type K Thermocouple Setup Example

## 6.1 INTRODUCTION

This section provides you with details on how to set up and use your meter with a Type K thermocouple. The typical factory preset thermocouple type will be a Type K. However, YOUR factory setup may be different. If you want to change these characteristics of the meter, refer to Sections 6.6 and 6.7. Follow these steps to ensure the meter will operate properly:

| METER'S FACTORY PRESET CHARACTERISTICS |
| --- |
| Units of measurement in Degrees Fahrenheit, Display on the meter °F, and 0.1 degree resolution 115 V ac powered (unless 230 V ac ordered). |

1. Attach power wires to the power connector (orange) and attach to the rear of the meter. Refer to Section 6.4.

2. Attach the Cold-Junction Compensation Board and rear protective cover assembly to the meter. Refer to Section 6.3.

3. Attach thermocouple wires to the rear protective cover. Refer to Section 6.5.

4. Power up the meter and verify operation.

## 6.2 JUMPER INFORMATION

S1, S2, and S3 are factory configured as shown in Figures 6-1 and 6-2.
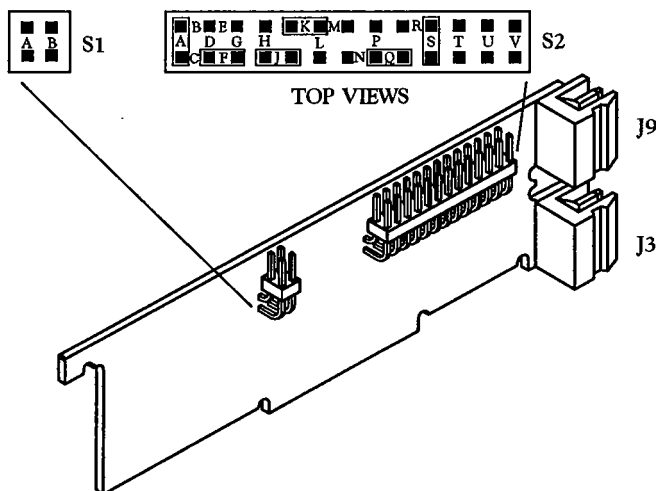
Figure 6-1. Signal Input Board Jumper Diagram with S1 and S2 Jumpers

| JUMPER | BOARD | NOTES |
|--------|-------|-------|
| no S1A* | Input | Slower (3/sec) reading rate |
| no S1B** | Input | Unipolar input range |
| S2A & S2F | Input | −10 to +110 mV range |
| S2J & S2K | Input | Connects Cold-Junction Compensation |
| S2Q | Input | Adds 1.25 V excitation |
| S2S | Input | Upscale Open-TC Indication |

\* Software switch "INP.2" must also be set to "=0".
\*\* Software switch "INP.3" must also be set to "=0".
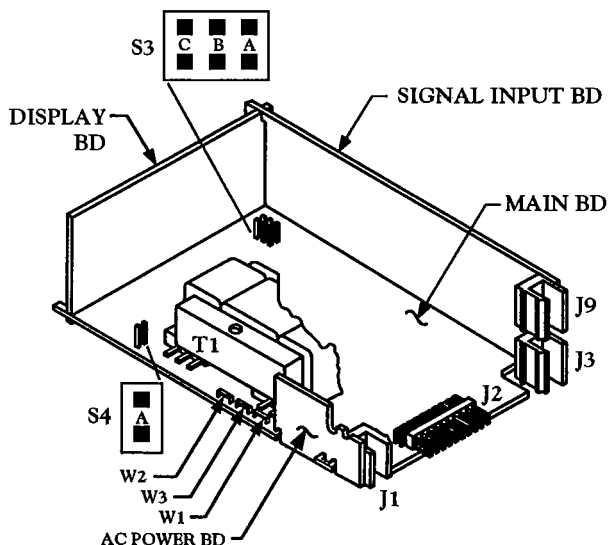


Figure 6-2. Main Board with S3 and S4 Jumpers

6-2

| JUMPER | BOARD | NOTES |
|--------|-------|-------|
| S3A | Main | Unlocks button programming |
| S3C | Main | Unlocks Lockout menu programming |

Typically, you would not require a read rate faster than 3 per second (thermocouples are typically slow in responding to temperature changes). However, you may select a faster read rate of 12 per second by installing a jumper in "S1A" on the Signal Input Board and changing the software selection in "IN CNF" (Input Configuration) to read "INP.2=1".

S2A, S2F, S2J, S2K, S2Q block out the input attenuator and do not insert any offset, thereby using the meter's basic 100 mV range. They also connect the meter's curvalinear cold-junction compensation circuit to the input. For upscale open sensor indication with an open thermocouple, use jumper S2S (for downscale, use S2R).

> WARNING: *Failure to complete both the hardware and software changes will result in erroneous readings.*

## 6.3 COLD JUNCTION COMPENSATION BOARD INSTALLATION

To setup the rear protective cover with the P3 and P9 connectors (and Cold-Junction Compensation Board), go through the following (Refer to Figure 6-3):

1. Obtain P3 and P9 connectors and the thermocouple rear protective cover.

2. Put the two (2) connectors P3 and P9 into the corresponding male connectors at the rear of the meter. Refer to Figure 4-2 for the location of the male connectors. P3 and P9 are identical and interchangeable connectors.

3. Using a long slotted screwdriver (one that is at least 4" long), loosen the 6 screws on the connectors.

4. Carefully install the thermocouple rear protective cover onto the connectors making sure the pins in the rear cover make good contact with the holes in the connectors.

5. Tighten the 6 screws (do not over tighten!).

6. Carefully remove the rear protective cover WITH the P3 and P9 connectors attached to it and set aside. Continue to Section 6.4 for AC wiring.

> **NOTE:** DO NOT ATTACH THE REAR COVER TO THE METER WITH THE COVER MOUNTING SCREW UNTIL YOU FIRST INSTALL THE P1 POWER CONNECTOR IN THE REAR OF THE METER.

# 6

**Type K Thermocouple Setup Example**
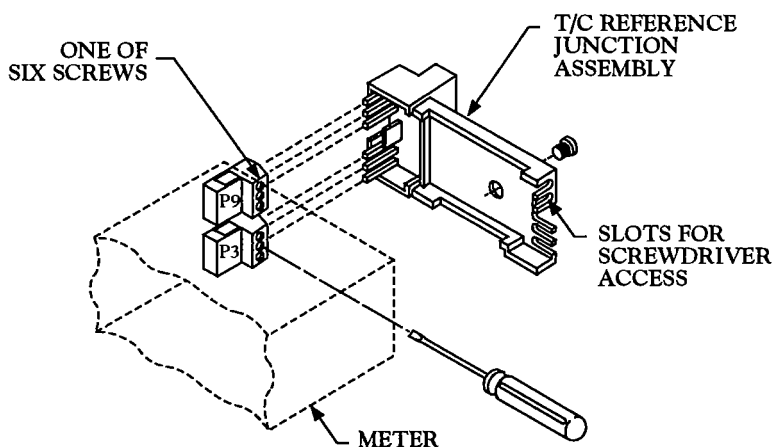
Figure 6-3. Installation of Cold-Junction Compensation Board Assembly

## 6.4 AC WIRING

1. Wire the orange power connector (P1) using the AC wiring information listed below.

| USA WIRING CODE | INTERN'L WIRING CODE | CONNECTION | PIN # ON ORANGE CONNECTOR |
|---|---|---|---|
| Black | Brown | AC High (HI) | 1 |
| White | Blue | AC Neutral(LO) | 2 |
| Green | Green/Yellow | AC Ground | 3 |

2. Insert the orange power connector, which you just wired, into the connector located at lower left rear of the meter. Refer to Figure 6-4 for the location of P1.

3. CAREFULLY install the rear protective cover assembly (with the P3 and P9 connectors) onto the rear of the meter making sure you have a good fit between the P3 and P9 male and female connectors.

4. Fasten the rear protective cover with the cover mounting screw. Continue to Section 6.5 for Cold-Junction Compensation Board Wiring.
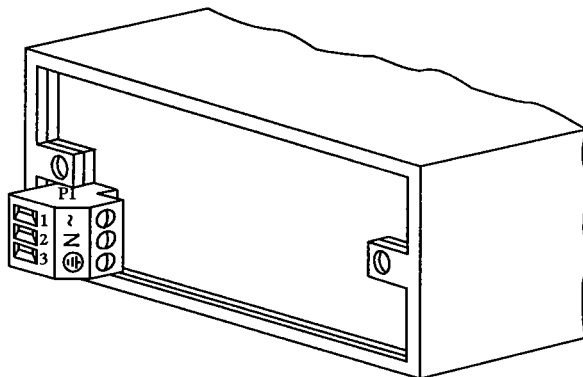
Figure 6-4.  Rear View of the Meter

## 6.5  COLD-JUNCTION COMPENSATION BOARD WIRING

Figure 6-5 shows the wiring hookup for any thermocouple type.  For Type K, hook up the yellow wire to the +terminal and the red wire to the -terminal on the rear protective cover.  Notice that the cover has positive and negative wiring designations molded into the plastic.
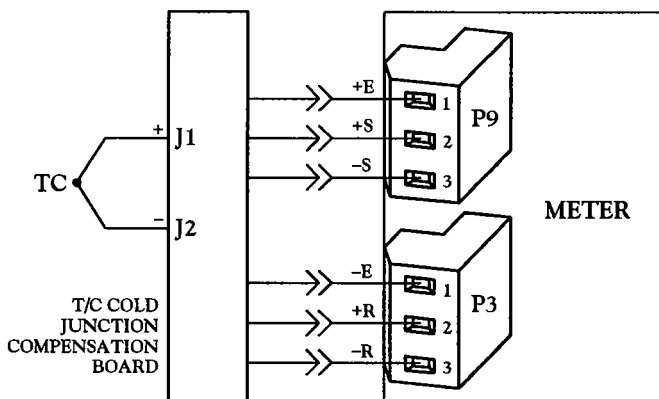


Figure 6-5.  Directly-Connected Thermocouple

Sections 6.6 and 6.7 provide details on how to change the characteristics of your meter (for example: you want to change to a Type J thermocouple and/or you want to measure in °C, etc.)

## 6.6 RE-CONFIGURING THE METER FOR OTHER CHARACTERISTICS

Make sure the meter is set up according to the steps in Section 6.1.

### 6.6.1 TO SELECT THERMOCOUPLE TYPE

**6**

Type K
Thermocouple
Setup
Example

| PRESS | THEN PRESS (TO CHANGE IF REQUIRED) | UNTIL DISPLAY SHOWS | COMMENTS |
|---|---|---|---|
| 'MENU' | | "INPUT" | You need the display to show "INPUT". |
| 'MIN' | 'MAX' | "TC" | Press the 'MIN' button to have the meter display (flashing) an input type. Press the 'MAX' button to select TC. |
| 'MENU' | | "STORED" then "TC" | Display will most often momentarily show "STORED" and then show "TC". |
| NOTE: In each and every case where the parameter is changed and then the 'MENU' button is pressed, the display will show "STORED". To simplify matters, "STORED" is not shown in the future but is understood. | | | |
| 'MIN' | 'MAX' | The input type of your choice | Press the 'MIN' button to have the meter display a signal type. Press the 'MAX' button to select either Type J, K, T, E, N, R, S, B, or DNJ. (Make sure the proper thermocouple type is connected to your meter). |

> NOTE: Thermocouple wire colors are listed in Section 5.4.2 so you can wire your meter accordingly.

## 6.6.2 TO SELECT THE UNITS OF MEASUREMENT

| PRESS | THEN PRESS (TO CHANGE IF REQUIRED) | UNTIL DISPLAY SHOWS | COMMENTS |
|---|---|---|---|
| 'MENU' | | "RDG.CNF" | Stores signal type. Setup reading configuration. |
| 'MIN' | 'MAX' | "RDG.5=0", "RDG.5=1", or "RDG.5=2" | Determine the units of measure to be used: degrees C (if "=0"), degrees F (if "=1") K (if "=2"). By pressing the 'MIN' button 5 times, the meter advances to RDG.5. The 'MAX' button allows you to change the "0", "1" or "2". |

**6**

Type K
Thermocouple
Setup
Example

## 6.6.3 TO SELECT WHETHER TEMPERATURE UNITS ARE DISPLAYED

| PRESS | THEN PRESS (TO CHANGE IF REQUIRED) | UNTIL DISPLAY SHOWS | COMMENTS |
|---|---|---|---|
| 'MIN' | 'MAX' | "RDG.6=0" or "RDG.6=1" | Determine whether the temperature units is NOT to be displayed (if "=0") or if the temperature units is to be displayed (if "=1"). By pressing the 'MIN' button again, the meter advances to "RDG.6". The 'MAX' button allows you to change the "0" or "1". |
| 'MENU' | | "RDG SC" or "RD.SC.OF" | Stores "RDG.6" selection. Advance to "RDG SC" or "RD.SC.OF". |

### 6.6.4 TO SELECT THE DISPLAY RESOLUTION

| PRESS | THEN PRESS (TO CHANGE IF REQUIRED) | UNTIL DISPLAY SHOWS | COMMENTS |
|-------|-------|-------|----------|
| 'MENU' | | "DEC PT" | Advance to DEC PT (you don't need "RDG SC" or "RD.SC.OF"). |
| 'MIN' | 'MAX' | "FFFFFF", "FFFFF.F" or "FFFF.FF" | Determine where you want the decimal point. By pressing the 'MIN' button, the meter displays the previously selected decimal point location within the "F's" or the factory preset location. The 'MAX' button allows you to change the location of the decimal point. |
| 'MENU' | | "CNT BY" | Stores the decimal point location and the display will show "CNT BY". |
| 'RESET' 'RESET' | | Measured | Press the 'RESET' button two times. The display momentarily shows "RUN" and then the currently measured values. |

NOTE: The choice of decimal point location is restricted to a display resolution of whole degrees, tenths, or hundredths of a degree.

## 6.7 COLD JUNCTION COMPENSATION OFFSET PROCEDURE

The meter has been calibrated with the cold-junction compensation board included with your unit. If you change the board or want to verify the calibration, proceed with the procedure in Section 6.7.1.

## 6.7.1 SET THERMOCOUPLE ZERO

In order to set thermocouple zero you must complete the following steps:

| PRESS | THEN PRESS (TO CHANGE IF REQUIRED) | UNTIL DISPLAY SHOWS | COMMENTS |
|---|---|---|---|
| 'MENU' | | "C.JUN.OF" | This is the cold-junction compensation main menu. |
| 'MAX' | | "XXXXX" | Display will show the cold-junction offset number. |
| | 'MIN' & 'MAX' | "00000" | Using the 'MIN' and 'MAX' buttons enter all zeros ("00000") on the display. |
| 'MENU' | | | Press the 'MENU' button to store the change(s) and the meter will return to the run mode. |

**NOTE:** You must verify that the "DEC PT" is set to a resolution of 0.0 (tenths).

Now you must record the actual offset reading by using one of the following procedures:

Connect the proper thermocouple type to the meter and place the thermocouple into an ice point cell. After the reading on the display has stabilized, record the displayed offset (T) and proceed with the "C.JUN.OF" calculation formula.
or
Connect a thermocouple calibrator and set the input for icepoint 0°C or 32°F. After the reading on the display has stabilized, record the displayed offset (T) and proceed with the "C.JUN.OF" calculation formula.

6

Type K
Thermocouple
Setup
Example
-------------------

Calculate the "C.JUN.OF" cold junction offset number to be entered into the meter by using one of the following formulas:

T= your recorded display with ice point input

For °F: (T–32.0) x 150= offset number

For °C: T x 270 = offset number

Note: If your offset number is a positive number, just enter it, or
If your offset number is zero, enter all zeros into the meter

If your offset number is a negative number disregard the negative sign and add the value to 32767 and enter this number into your meter.

Example: If your calculated offset number was "–122" then you would add your calculated value of "122" to "32767", which equals "32889". Enter this number into your meter.

### 6.7.2 SPECIAL COLD-JUNCTION CALIBRATION

In order to assure the specified accuracy for measurements below –40 degrees, you must first apply a negative millivolt input signal to your meter (to determine the error), record the reading, then complete the following calculation:

–FS = a temperature within 5 degrees of the maximum negative temperature of any thermocouple type in °C or °F range.

Icepoint= 0.0°C (32.0°F)
Sensitivity at –FS= $\Delta$mV input for $\Delta$ 1°C (°F)
Sensitivity at Icepoint= $\Delta\mu$V input for $\Delta$1°C (°F)

$$T = \text{error at –Full Scale} \times \frac{\text{Sensitivity at –FS}}{\text{Sensitivity at icepoint}}$$

T= Error at negative full scale (–FS) times sensitivity at negative full scale (–FS) divided by sensitivity at icepoint 0.0°C (°F).

An Example would be as follows:

–270 °C Type K input
Display reads –266.1°C
Error equals 3.9 °C

$$T = \frac{3.9 \times 1\mu V/°C}{39\,\mu V/°C} = 0.1°C$$

$$T = 0.1°C$$

Offset number = 0.1 x 270 = 27

> WARNING: *Before entering your offset number you must first complete the SET THERMOCOUPLE ZERO procedure as described in Section 6.7.1.*

If meter displays "–OPEN", reduce –FS input 5 degrees.

TO ENTER YOUR COLD-JUNCTION OFFSET NUMBER, YOU MUST COMPLETE THE FOLLOWING PROCEDURE:

**6**

Type K
Thermocouple
Setup
Example

| PRESS | THEN PRESS (TO CHANGE IF REQUIRED) | UNTIL DISPLAY SHOWS | COMMENTS |
|---|---|---|---|
| 'MENU' | | "C.JUN.OF" | This is the cold-junction compensation main menu. |
| 'MAX' | | "00000" | Display will show the cold-junction offset number "00000" which was entered earlier. |
| | 'MIN' & 'MAX' | "XXXXX" | Using the 'MIN' and 'MAX' buttons enter your calculated cold-junction offset number into the meter. |
| 'MENU' | | | Press the 'MENU' button to store your entry and the meter will return to the run mode. |

If you have a non-linear transmitter hooked up to your meter, refer to Section 8 for details.

If there are other characteristics you want to change, refer to Section 9 for full details.

After you have completed your programming, you may want to go back and remove the jumper in S3A position on the main board to insure against any unauthorized changes or refer to specific lockout functions (software) in Section 9.

# 6

**Type K
Thermocouple
Setup
Example**

# Notes:

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

# 7. 3-Wire 100 OHM Platinum (Din) RTD/Ohms Setup Example

Section 7 is divided into two parts:
1) 3-wire, 100 Ω platinum RTD, and
2) 4-wire, 10 Ω copper RTD.

## 7.1 3-WIRE 100 OHM PLATINUM RTD INFORMATION

This section provides you with details on how to set up and use your meter with a 3-wire 100 Ω platinum (DIN) RTD. Other factory preset characteristics are listed below. Proceed through the following steps in order to assure your meter operates correctly.

| METER'S FACTORY PRESET CHARACTERISTICS |
|---|
| Units of measurement in degrees Fahrenheit, Display on the meter °F, and 0.1 degree resolution and 115 V ac power (unless you ordered 230 V ac) |

**7**

3-Wire RTD
Setup Example

1. Connect the RTD to P3 and P9 connectors. Refer to Figure 7-3.

2. Attach power wires to the power connector (orange) and attach to the rear of the meter. Refer to Section 7.4.

3. Power up the meter, observe readings and verify operation.

NOTE: IF YOU HAVE A LINEAR 2-, 3-, OR 4-WIRE RTD, (SUCH AS 4-WIRE, 10 Ω COPPER) YOU WILL NEED TO FOLLOW SECTION 7.7.

## 7.2 JUMPER INFORMATION

S1, S2, S3, and S4 are factory configured as follows (Refer to Figures 7-1 and 7-2):

TOP VIEWS

# 7

**3- Wire RTD
Setup Example**
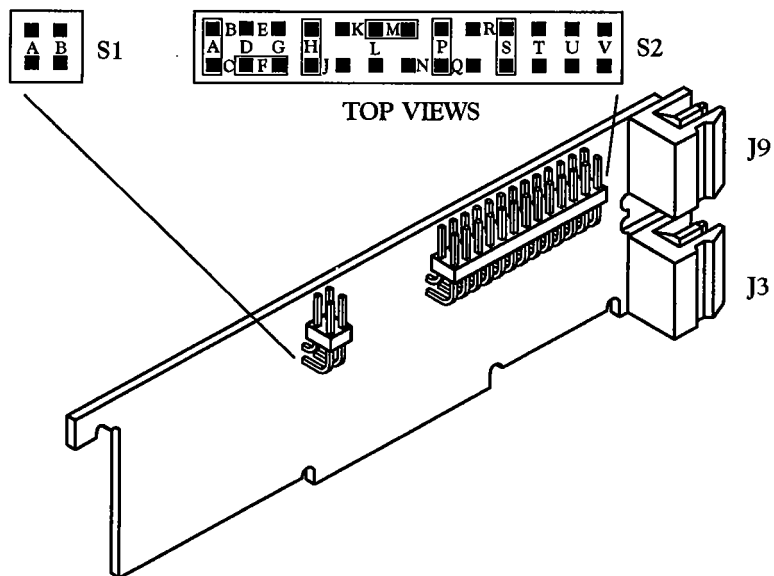
Figure 7-1. Signal Input Board Jumper Diagram with S1 and S2 Jumpers

| JUMPER | BOARD | NOTES |
|---|---|---|
| no S1A* | Input | Slower (3/sec) read rate |
| no S1B** | Input | Unipolar input |
| S2A & S2F | Input | –10 to 110 mV range (factory configuration) |
| S2A & S2D | Input | –0.1 to 1.1V range for RTD or resistances over 600 Ω |
| S2H | Input | For 3- or 4-wire RTD's |
| no S2K, L | Input | No aux. divider |
| S2M | Input | 2-wire measurement |
| S2P | Input | Connect 160 mA current source |
| S2V | Input | Install if RTD less than 60 Ω's |
| S2S | Input | Upscale open-sensor indication |

\* Software switch "INP.2" must also be set to "=0".
\*\* Software switch "INP.3" must also be set to "=0".
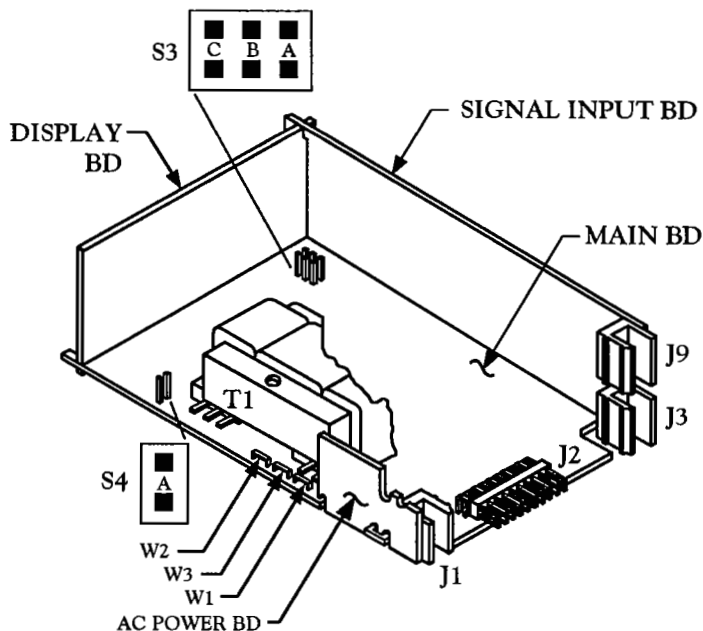
Figure 7-2. Main Board with S3 and S4 Jumpers

| JUMPER | BOARD | NOTES |
|--------|-------|-------|
| S3A | Main | Unlocks pushbutton programming |
| no S3B | Main | Meter calibration locked out |
| S3C | Main | Unlocks lockout menus |
| no S4A | Main | Not applicable, selects 10 or 24 V dc sensor excitation |

## 7.3  INPUT CONNECTIONS

Figure 7-3 shows the input connections and input-connector jumper needed for 3-wire RTD. This (most popular) connection works best with RTD/Ohms leads which are closely equal in resistance. The meter measures the RTD plus upper and lower lead drop voltage and then subtracts twice the measured drop in the lower supply current lead, producing excellent lead-resistance cancellation for balanced measurements.

3-wire measurement lowers the measurement rate by approximately twenty (20) percent.
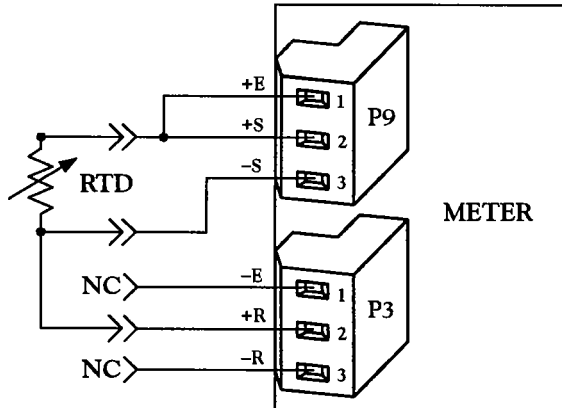
Figure 7-3. 3-Wire RTD

## 7.4 AC WIRING

Setup the meter using the AC wiring information listed below:

| USA WIRING CODE | INTERN'L WIRING CODE | CONNECTION | PIN # ON ORANGE CONNECTOR |
|---|---|---|---|
| Black | Brown | AC High (HI) | 1 |
| White | Blue | AC Neutral(LO) | 2 |
| Green | Green/Yellow | AC Ground | 3 |

1. Insert the P1 connector at the rear of the meter. Refer to Figure 7-4 for the location of P1.

2. Insert P3 and P9 in the male pins.

3. Put the rear protective cover onto the rear of the meter.

4. Fasten down the rear protective cover with the cover mounting screw.
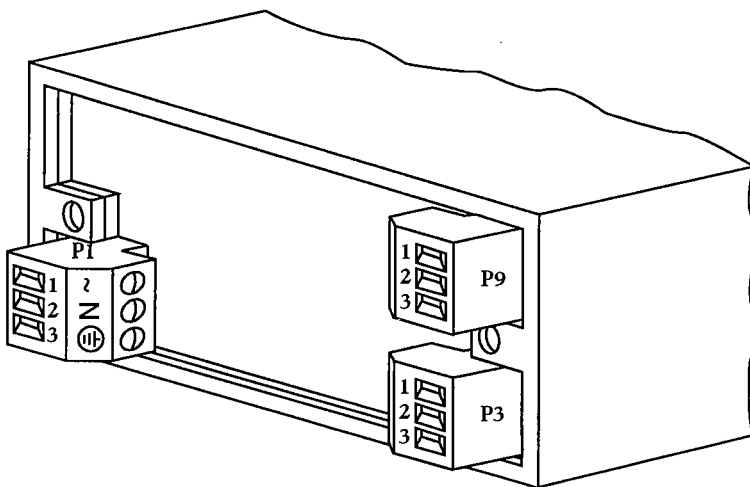
Figure 7-4. Rear View of the Meter

Sections 7.5 and 7.6 provide details on how to change the characteristics of your meter (for example, you have 2-wire NIST RTD, or want to measure in °C, etc.)

7

3-Wire RTD
Setup Example

## 7.5 RE-CONFIGURING THE METER FOR OTHER CHARACTERISTICS

### 7.5.1 TO SELECT RTD TYPE

Make sure the meter is setup according to the 3 steps in Section 7.1.

**7**

**3- Wire RTD Setup Example**

| PRESS | THEN PRESS (TO CHANGE IF REQUIRED) | UNTIL DISPLAY SHOWS | COMMENTS |
|---|---|---|---|
| 'MENU' | | "INPUT" | You need the display to show "INPUT". |
| 'MIN' | 'MAX' | "RTD" | Press the 'MIN' button to have meter display (flashing) an input type. Press the 'MAX' button to select RTD. |
| 'MENU' | | "STORED" the "RTD" | Display will momentarily show "STORED" (only "RTD" when a change has been made) and then show "RTD". |
| **NOTE:** in each and every case where the parameter is changed and then the 'MENU' button is pressed, the display will show "STORED". To simplify matters, "STORED" is not shown in the future but is understood. | | | |
| 'MIN' | 'MAX' | Your Input choice | Press the 'MIN' button to have the meter display show a signal type. Press the 'MAX' button to select either 2PT392, 3PT392, 4PT392, 2PT385, 3PT385, 4PT385 or LINEAR. |

## 7.5.2 SELECT THE UNITS OF MEASUREMENT

| PRESS | THEN PRESS (TO CHANGE IF REQUIRED) | UNTIL DISPLAY SHOWS | COMMENTS |
|---|---|---|---|
| 'MENU' | | "RDG.CNF" | Set reading configuration |
| 'MIN' | 'MAX' | "RDG.5=0", "RDG.5=1", or "RDG.5=2" | Determine the units of measure to be used: °C (if "=0"), °F (if "=1") or K (if "=2"). By pressing the 'MIN' button 5 times, the meter advances to "RDG.5". The 'MAX' button allows you to change the "0", "1" or "2". |

## 7.5.3 TO SELECT TEMPERATURE UNITS

| PRESS | THEN PRESS (TO CHANGE IF REQUIRED) | UNTIL DISPLAY SHOWS | COMMENTS |
|---|---|---|---|
| 'MIN' | 'MAX' | "RDG.6=0" or "RDG.6=1" | Determine whether the Temperature units is NOT to be displayed (if "=0") or if the Temperature Units is to be displayed (if"=1"). By pressing the 'MIN' button again, the meter advances to "RDG.6". The 'MAX' button allows you to change the "0" or "1". |
| 'MENU' | | "RDG SC" or "RD.SC.OF" | Stores "RDG.CNF". Advance to "RDG SC" or "RD.SC.OF". |

7

3-Wire RTD
Setup Example

## 7.5.4 TO SELECT THE DISPLAY RESOLUTION

| PRESS | THEN PRESS (TO CHANGE IF REQUIRED) | UNTIL DISPLAY SHOWS | COMMENTS |
|---|---|---|---|
| 'MENU' | | "DEC PT" | Bypass "RDG SC" or "RD.SC.OF". Advance to "DEC PT". |
| 'MIN' | 'MAX' | "FFFFFF." or "FFFFF.F" or "FFFF.FF" | Determine where you want the decimal point. By pressing the 'MIN' button, the meter displays the previously selected decimal point location within the "Fs" or the factory preset location. The 'MAX' button allows you to change the location of the decimal point. |
| 'MENU' | | "CNT BY" | To store decimal point location. Advance to "CNT BY". |
| 'RESET', 'RESET | | Measured Values | Press the 'RESET button two times. The display momentarily shows "RUN" and then the currently-measured values. |

NOTE: the choice of decimal point location is restricted to a display resolution of whole degrees, tenths, or hundredths of a degree.

After you have completed your programming, you may want to go back and remove the jumper in S3A position on the Main Board to insure against any unauthorized changes or refer to specific lockout functions (software) in Section 9.

## 7.6 2-WIRE AND 4-WIRE RTD WIRING

Figure 7-5 shows the input connections and input-connector jumpers required for hookup of a 2-wire RTD (resistor). 2-wire connection is the simplest, but does not compensate for lead-wire temperature change and often requires calibration to cancel lead-wire resistance offset.
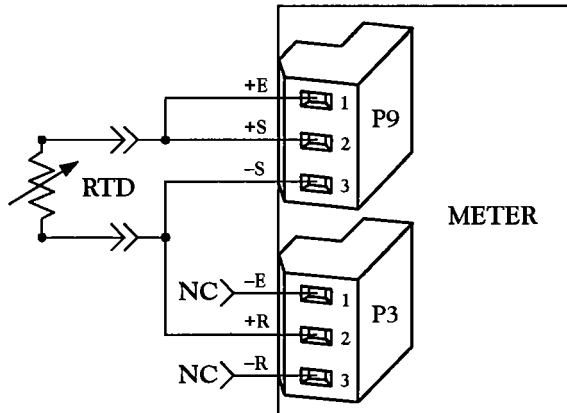


Figure 7-5. 2-Wire RTD

Figure 7-6 shows the input connections for 4-wire RTD (or ohm-meter, if "INP.5=1" was selected) hookup, applicable to low-ohm sensors or to unbalanced lead resistances. The fourth wire enables the meter to measure the RTD-plus-lower-lead-drop voltage and then to measure and subtract that lead voltage; this produces the best lead-resistance cancellation.
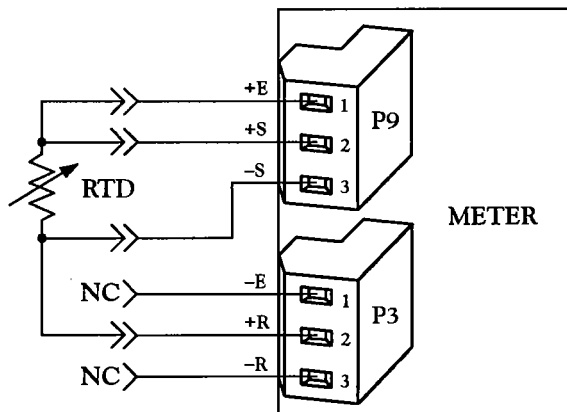


Figure 7-6. 4-Wire RTD

7

3-Wire RTD
Setup Example

7-9

When lead resistance is compensated by 4-wire measurement, the reading rate is slightly lowered (this decrease is less than 20%).

## 160-MICROAMPERE CURRENT SOURCE

Each meter stores the calibration correction for its current source in its EEPROM. This factor is used to bring the readings produced by the actual current (somewhat less than 160 microamperes) up to the values that would be produced by precisely 160.0 microamperes. The meter, therefore, always enters the linearizing tables at the correct point.

For ohmmeter use, this calibration is less important, since no linearization is used and any scale-factor correction may be entered either with IN.SC.OF or RD.SC.OF controls. If both these scale factors are set to 1.0 with no offset, each ohm creates a display of "160" (the nominal current in microamperes), which may then be scaled as desired.

This low excitation current (using jumper S2P) value produces very low self-heating in the RTD element. This low current combined with the meter's low noise and high sensitivity to permit accurate measurement of RTDs or ohms from 0.6 to more than 6000 ohms on the high-input-impedance range (S2A and S2F jumpers).

If the ohms to be measured exceed 600 (up to 6000), the 1V range of your meter can be used (jumpers S2A and S2D); now the one-megohm input impedance of this range causes a very slight decrease in RTD sensitivity, which can be cancelled by the meter's input scaling and offset (IN.SC.OF).

## 1.6 MILLIAMPERE CURRENT SOURCE

Adding jumper S2V on the input board raises the current to 1.6 mA nominal, suitable for sensor resistances from less than one to 60 ohms. This current value, however, is not factory-calibrated, so that field calibration (using the meter's IN.SC.OF, INput SCaling and OFfset) is required by the following procedure (unless you have a linear input, in which case RD.SC.OF calibration is adequate):

To linearize correctly, it is necessary that the microvolts produced (displayed by the meter on its 100 mV range) by this high current

flowing in 10 ohms be adjusted to the same value as that of the calibrated low current flowing in 100 ohms.

To complete the data needed for automatic meter calibration, two additional microvolt readings are recorded at higher ohm values (for example, 30 ohms with high current and 300 ohms with low current, respectively).

When these four readings have been made on the 100 mV range and the meter switched back to RTD, the IN.SC.OF data are entered as:

INPUT1 = microvolts, 10 ohms, high current
READ 1 = microvolts, 100 ohms, low current
INPUT2 = microvolts, 30 ohms, high current
READ 2 = microvolts, 300 ohms, low current

This current-source calibration procedure places no limitation on the display scaling capability (RD.SC.OF), which is additionally available to handle conversion of the corrected input to any desired display units-of-measure.

Both current-source ranges have excellent load-voltage rejection, i.e., the current is virtually constant despite changes in the sensor voltage up to 1.5 volts across the load (well beyond the normal 100 mV full scale, or even the 1 V full scale).

# 7.7  10 Ω, 4-WIRE COPPER RTD INFORMATION

This section provides you with details on how to set up and use your meter with a 4-wire 10 Ω Copper RTD. Go through the following steps in order to have a correctly operating meter.

1. S1, S2, and S3 are factory configured. (Refer to Section 7.7.1).

2. Attach power wires to the power connector (orange) and attach to the rear of the meter.  Refer to Section 7.7.3.

3. Power up the meter, observe readings and verify operation.

## 7.7.1 JUMPER INFORMATION FOR 10 Ω COPPER RTD

S1, S2, and S3 are factory configured as follows (refer to Figures 7-7 and 7-8):



**TOP VIEWS**

7

**3- Wire RTD
Setup Example**
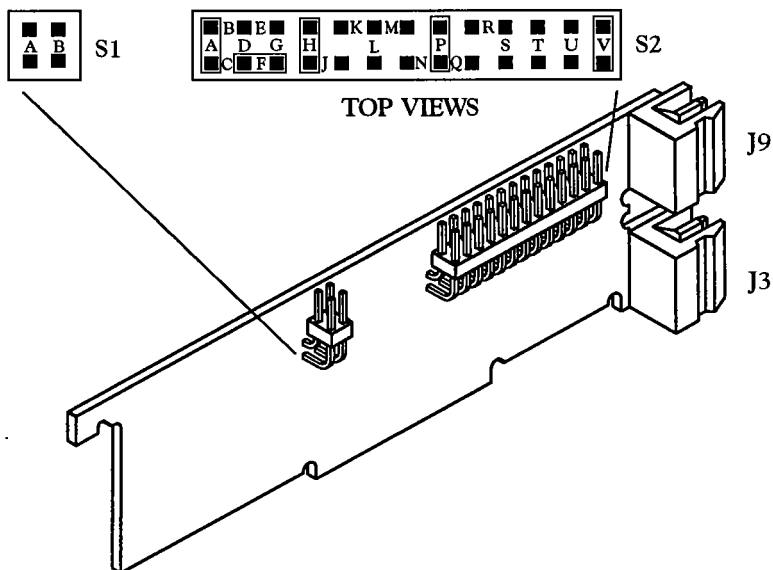
Figure 7-7. Signal Input Board Jumper Diagram with S1 and S2 Jumpers

| JUMPER | BOARD | NOTES |
|--------|-------|-------|
| no S1A | Input | Slower (3/sec) read rate |
| no S1B | Input | RTD, unipolar input |
| S2A & S2F | Input | -10 to 110 mV range (factory configuration) |
| S2H | Input | Brings lower lead voltage to meter |
| S2P | Input | Connect 160 μA current source |
| S2V | Input | Install if RTD is less than 60 ohms (1.6mA) |
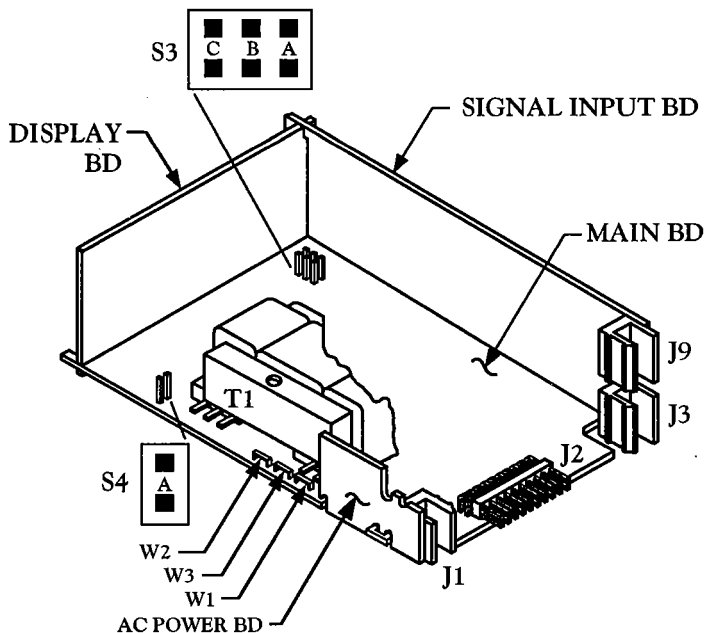
Figure 7-8. Main Board with S3 and S4 Jumpers

| JUMPER | BOARD | NOTES |
|--------|-------|-------|
| S3A | Main | Unlocks pushbutton programming |
| S3C | Main | Unlocks lockout menus |
| no S4A | Main | Not used for RTD inputs |

## 7.7.2 INPUT CONNECTIONS

Figure 7-9 shows the input connections for 4-wire RTD.
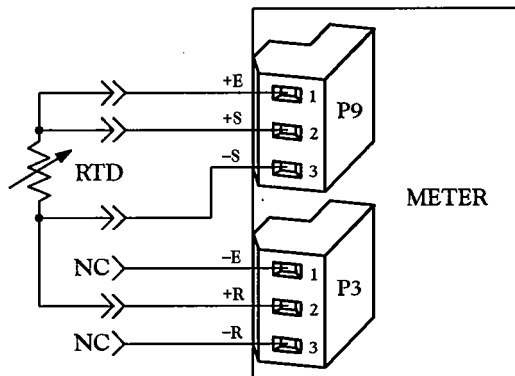


Figure 7-9. 4-Wire RTD

### 7.7.3 AC WIRING

Wire the meter following the AC wiring information listed below.

| USA WIRING CODE | INTERN'L WIRING CODE | CONNECTION | PIN # ON ORANGE CONNECTOR |
|---|---|---|---|
| Black | Brown | AC High (HI) | 1 |
| White | Blue | AC Neutral(LO) | 2 |
| Green | Green/Yellow | AC Ground | 3 |

1. Insert the P1 connector at the rear of the meter. Refer to Figure 7-10 for the location of P1.

2. Put the rear protective cover onto the rear of the meter.

3. Fasten down the rear protective cover with the cover mounting screw.
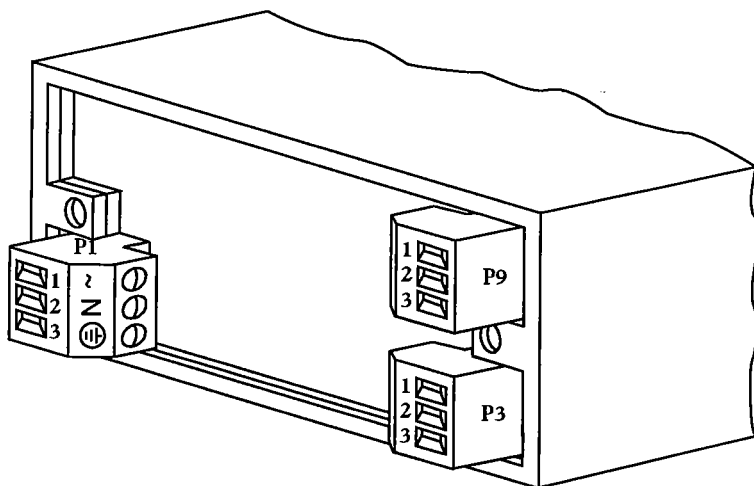


Figure 7-10. Rear View of the Meter

## 7.7.4 PROGRAMMING THE METER FOR THE CALIBRATION RUN

Make sure the meter is setup according to the 3 steps in Section 7.1.

| PRESS | THEN PRESS (TO CHANGE IF REQUIRED) | UNTIL DISPLAY SHOWS | COMMENTS |
|---|---|---|---|
| 'MENU' | | "INPUT" | You need the display to show "INPUT". |
| 'MIN' | 'MAX' | "RTD" | Press the 'MIN' button to have the meter display (flashing) an input type. Press the 'MAX' button to select RTD. |
| 'MENU' | | "STORED" then "RTD" | Display will most often momentarily show "STORED" and then show "RTD". |
| **NOTE:** In each and every case where the parameter is changed and then the 'MENU' button is pressed, the display will show "STORED". To simplify matters, "STORED" is not shown in the future but is understood. | | | |
| 'MIN' | 'MAX' | "LINEAR" | Press the 'MIN' button to have choice the meter display show a signal type. Press the 'MAX' button to select "LINEAR" (copper is linear). |
| 'MENU' | | "RDG.CNF" | Set reading configuration. |
| 'MIN' | 'MAX' | "RDG.1=0" | Set "RDG.1=0" (Direct format) by pressing the 'MIN' button, and the display advances to "RDG.1". The 'MAX' button allows you to select "RDG.1=0". The 'MIN' and 'MAX' button descriptions are the same for subsequent steps. |

**7**

3-Wire RTD
Setup Example

| PRESS | THEN PRESS (TO CHANGE IF REQUIRED) | UNTIL DISPLAY SHOWS | COMMENTS |
|-------|-------------------------------------|---------------------|----------|
| 'MIN' | 'MAX' | "RDG.2=0" | Make sure the display shows "RDG.2=0". |
| 'MIN' | 'MAX' | "RDG.3=0" | Make sure the display shows "RDG.3=0". |
| 'MIN' | 'MAX' | "RDG.4=1" | Make sure the display shows "RDG.4=1". |
| 'MIN' | 'MAX' | "RDG.5=1" | Make sure the display shows "RDG.5=1". |
| 'MIN' | 'MAX' | "RDG.6=1" | Make sure the display shows "RDG.6=1". |
| 'MENU' | | "RDG SC" | Stores RDG.CNF. Advance to "RDG SC". |
| 'MIN' | 'MAX' | "1.00000" | Unity gain for calibration run. |
| 'MENU' | | "RDG OF" | Stores RDG SC value. Advance to "RDG OF". |
| 'MIN' | 'MAX' | "000000" | No offset (decimal point can go anywhere). |
| 'MENU' | | "IN CNF" | Stores RDG OF value. Set Input Configurations. |
| 'MIN' | 'MAX' | "INP.1=0" | Make sure the display shows "INP.1=0". |
| 'MIN' | 'MAX' | "INP.2=0" | Make sure the display shows "INP.2=0". |
| 'MIN' | 'MAX' | "INP.3=0" | Make sure the display shows "INP.3=0". |

**7**

**3- Wire RTD Setup Example**

| PRESS | THEN PRESS (TO CHANGE IF REQUIRED) | UNTIL DISPLAY SHOWS | COMMENTS |
|---|---|---|---|
| 'MIN' | 'MAX' | "INP.4=0" | Make sure the display shows "INP.4=0". |
| 'MIN' | 'MAX' | "INP.5=1" | This RTD is 4-wire. |
| 'MIN' | 'MAX' | "INP.6=0" | Make sure the display shows "INP.6=0". |
| 'MIN' | 'MAX' | "INP.7=0" | Make sure the display shows "INP.7=0". |
| 'MENU' | | "IN.SC.OF" | Stores IN CNF values. Advance to "IN.SC.OF". |
| 'MENU' | | "DEC PT" | Advance to "DEC PT". Set the decimal point. |
| 'MIN' | 'MAX' | "FFFFF.F" | Make sure the decimal point is in the 0.1 degree resolution. |
| 'MENU' | | "CNT BY" | Stores DEC PT location. Advance to "CNT BY". |
| 'MIN' | 'MAX' | "001" | Make sure the display shows "001". |
| 'MENU' | | "FIL.CNF" | Stores "CNT BY". Set Filter Configuration. |
| 'MIN' | 'MAX' | "FIL.1=0" | Make sure the display shows "FIL.1=0". |
| 'MIN' | 'MAX' | "FIL.2=1" | Make sure the display shows "FIL.2=1". |

**7**

**3-Wire RTD Setup Example**

| PRESS | THEN PRESS (TO CHANGE IF REQUIRED) | UNTIL DISPLAY SHOWS | COMMENTS |
|---|---|---|---|
| 'MIN' | 'MAX' | "FIL.3=0" | Set "FIL.3=0" for unfiltered Analog Output. |
| 'MENU' | | "FIL TI" | Stores FIL.CNF. Set Filter Time Constant. |
| 'MIN' | 'MAX' | "032" | Set to 032 for typical average number of samples. |
| 'RESET', 'RESET' | | Measured Values | Press the 'RESET' button two times. The display momentarily shows "RUN" and then the currently measured values. |

## 7.7.5 TAKING THE INPUT CALIBRATION DATA

For 10 ohm copper RTD with alpha of 0.00386, the following data can be used.

INPUT1: 1600 (µA) x 10.00 (ohm) = 16000
READ 1: 25°C or 77°F
INPUT2: 1600 (µA) x 15.217 (ohm) = 24347.2
READ 2: 160°C or 320°F

For highest accuracy, calibrate the meter using Sections 7.7.5 and 7.7.6.

## 7.7.6 ENTERING THE CALIBRATION DATA IN INPUT SCALE AND OFFSET (EXAMPLE)

| PRESS | THEN PRESS (TO CHANGE IF REQUIRED) | UNTIL DISPLAY SHOWS | COMMENTS |
|---|---|---|---|
| 'MENU' | | "INF CNF" | Set Input Configuration. |
| 'MIN' | 'MAX' | "INP.6=1" | By pressing the 'MIN' button 6 times, the meter advances to INP.6 (Input Scale and Offset). The 'MAX' button allows to you to select "INP.6=1". |
| 'MENU' | | "IN.SC.OF" | Stores IN CNF. Advance to "IN.SC.OF". |
| 'MIN' | | "INPUT 1" | Put in first cal display reading. |
| 'MIN' | 'MAX' | "16000" | Reading from Appendix or from display. |
| 'MENU' | | "READ 1" | Enter corresponding temperature. |
| 'MIN' | 'MAX' | "00077.0" | Degrees from (77°F) calculations. |
| 'MENU' | | "INPUT2" | Put in upper point. |
| 'MIN' | 'MAX' | "24347.2" | Reading from Appendix or from display. |

7

3-Wire RTD
Setup Example

| PRESS | THEN PRESS (TO CHANGE IF REQUIRED) | UNTIL DISPLAY SHOWS | COMMENTS |
|---|---|---|---|
| 'MENU' | | "READ 2" | Enter corresponding temperature. |
| 'MIN' | 'MAX' | "00320.0" | Degrees from Appendix or from calculations. |

<table>
<tr><td colspan="4">
<p align="center"><strong>DO NOT PREVIEW YOUR VALUES</strong></p>
The INPUT values are entered in non-volatile memory and you cannot preview them. Every time you re-enter INPUT to preview the value, all zeroes will be displayed, though the value is in memory. If you press the 'MENU' button after seeing the zero values, the zero values will be entered into memory. Therefore, <strong>DO NOT TRY</strong> to preview your INPUT values.
</td></tr>
</table>

| 'MENU' | | "DEC PT" | Stores IN.SC.OF values. Advance to "DEC PT". |
|---|---|---|---|
| 'RESET', 'RESET' | | Measured Values | Press the 'RESET' button two times. Connect RTD and verify correct temperature reading. If that doesn't show, repeat this procedure. |

## 7.7.7 10 Ω COPPER RTD CALIBRATION WITH HIGHEST ACCURACY

1. Replace the copper RTD with a carefully-measured resistor of approximately 10 ohms (or use a precision decade box). This resistance is "RO1".

2. Record the meter's displayed values as "INPUT1".

3. Read the 10 Ω copper RTD table from the RTD manufacturer or use one of three formulas for °F, °C, and Kelvin temperatures shown below for 10 Ω copper with an alpha of 0.00386 to obtain "RO1". This is "READ 1".

**7**

**3- Wire RTD Setup Example**

**Condition formulas:**

if "RDG.5=0"    (for Celsius), use this formula:
READ 1 = 25 + 25.9 * (RO1 – 10)

if "RDG.5=1"    (for Fahrenheit), use this formula:
READ 1 = 77 + 46.61 * (RO1 – 10)

if "RDG.5=2"    (for Kelvin), use this formula:
READ 1 = [25 + 25.9 * (RO1 – 10)] + 273.2

4. Replace the resistance with another carefully measured value close to 15 ohms; this is "RO2".

5. Record the meter's displayed value as "INPUT2".

6. Read the table or use one of the three formulas for °F, °C, or Kelvin temperatures shown below for 10 ohm copper with an alpha of 0.00386 to obtain "RO2". This is "READ 2".

**Condition formulas:**

if "RDG.5=0"    (for Celsius), use this formula:
READ 2 = 25 + 25.9 * (RO2 - 10)

if "RDG.5=1"    (for Fahrenheit), use this formula:
READ 2 = 77 + 46.61 * (RO2 -10)

if "RDG.5=2"    (for Kelvin), use this formula:
READ 2 = [25 + 25.9 * (RO2 - 10)] + 273.2

7. Return to programming mode by pressing the 'MENU' button.

## 7.7.8 VERIFYING THE NUMBERS

1. Replace the high-ohm cal resistor with the lower-ohm value (10.12 ohm in the example).

2. If the display now reads "82.6F", the calibration is correct; if not, repeat the procedure in Section 7.7.7.

3. Replace the cal resistor with the actual RTD; the display value should closely agree with other temperature indicators in that vicinity.

### 7.7.9 TECHNICAL DISCUSSION

#### 7.7.9.1 USE OF LINEAR SCALE FOR COPPER

Copper has an "alpha" (average temperature coefficient for the first 100 degrees) of 0.003860 per Kelvin (K), or 0.002145 per degree Fahrenheit (°F). This is identical to some platinum, but copper is more than 5 times closer to a straight line with temperature than platinum (much smaller dependence on the square of temperature). For the 500°F usual copper range, the maximum departure from the best straight line is approximately 0.5 degrees. Therefore, platinum uses a linearization routine and copper does not.

#### 7.7.9.2 USE OF SLOWER READ RATE

Because most temperature measurements involve long time constants (large thermal masses), the slower read rate (3/sec) is recommended to reduce noise effects.

#### 7.7.9.3 RTD OHMS AND METER CURRENT

The most sensitive meter range is used, which can accommodate, a copper resistance.

The resistance-detection current for these smaller-ohm RTDs is chosen to be ten times the normal 160 microamperes, for higher accuracy and less noise.

This excitation current, 1.6 mA nominal, flows from the meter's +E terminal, (P9-1), through the temperature-sensitive resistor (RTD), and back to the meter's –S terminal (P9-3).

The resistance of the two current-carrying leads is eliminated from the meter's measurement by using two more leads, from the top of the RTD to the meter's +S terminal (P9-2), and from the bottom of the RTD to the meter's +R terminal (P3-2).

If the RTD is not provided with four wires for your lead connections, connect the +S lead as close as possible to the top of the RTD and the +R lead as close as possible to the bottom of the RTD.

### 7.7.9.4  2-WIRE HOOKUP

It is possible that your leads to and from the RTD are of negligible resistance (for example, short and heavy-gauge wires), and that you are satisfied with the accuracy of a 2-wire hookup.

In this case:

1. Program your meter exactly as for a plain linear input.

2. Move jumper S2H to S2M on the signal input board.

3. Jumper the +E (P9-1) and +S pins (P9-2), on the connector at the rear of the meter.

4. Do not attach any lead to +R (P3-2).

### 7.7.9.5  3-WIRE HOOKUP

If you have a 3-wire RTD, it is recommended that you use leads of equal resistance (equal lengths of the same gauge) to get full advantage of the meter's line-drop-cancellation capability.

In this case, the hookup is the same as for 4-wire except that the lead from the top of the RTD to +S (P9-2) is replaced by a jumper on the connector from +E, (P9-1) to +S (P9-2).

In this 3-wire case, there is just one programming change: set "INP.5=0";  this invokes the meter's 3-wire lead-drop cancellation computation rather than that for 4 wires.

**7**

3-Wire RTD
Setup Example

--------------

# Notes:

# 7

**3- Wire RTD
Setup Example**

# 8. Transmiter Hookup Example with RTD

## 8.1 JUMPER INFORMATION

S1, S2 and S3 are factory configured as follows (refer to Figures 8-1 and 8-2):



TOP VIEWS
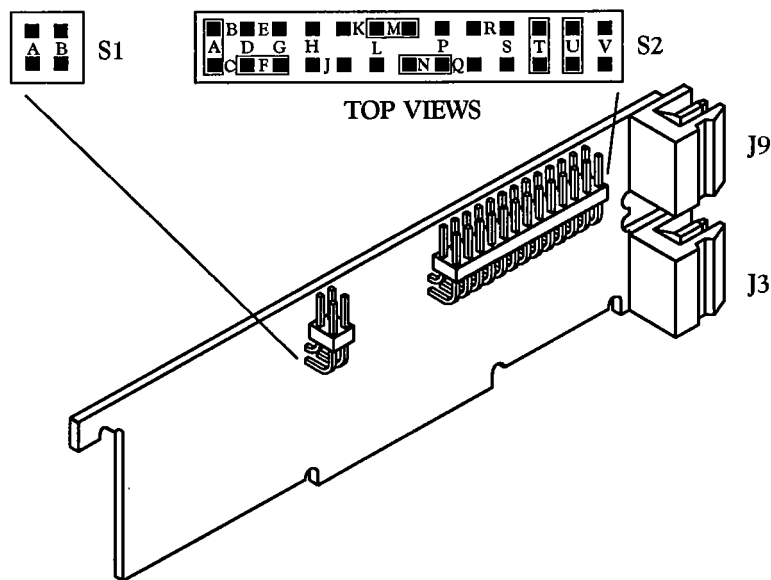
Figure 8-1. Signal Input Board Jumper Diagram with S1 and S2 Jumpers

| JUMPER | BOARD | NOTES |
|---|---|---|
| no S1A | Input | Slow (3/sec) read rate |
| no S1B | Input | Unipolar input range |
| S2A,S2F & S2U | Input | 20 mA input range |
| S2M | Input | 2-wire measurement |
| S2N & S2T | Input | Bring out meter excitation |
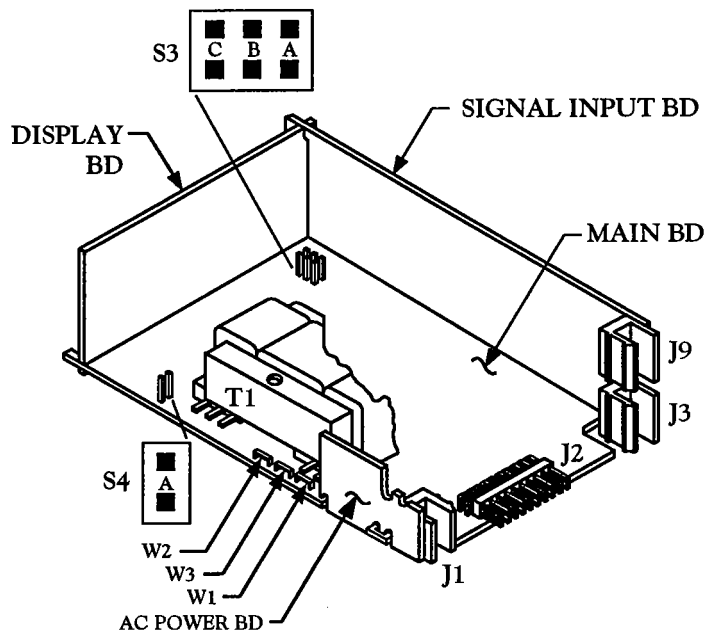
Figure 8-2. Main Board with S3 and S4 Jumpers

| JUMPER | BOARD | NOTES |
|--------|-------|-------|
| S3A | Main | Unlocks pushbutton programming |
| no S3B | Main | Meter calibration locked out |
| S3C | Main | Unlocks the lockout menus |
| no S4A | Main | 24 V is recommended; if installed, you get 10 V excitation |

## 8.2 TRANSMITTER INPUT CONNECTIONS

Refer to Figure 8-3 for the wiring diagram for 2-wire RTD current-loop transmitter hookup. Figure 8-4 shows 4-wire RTD transmitter hookup.
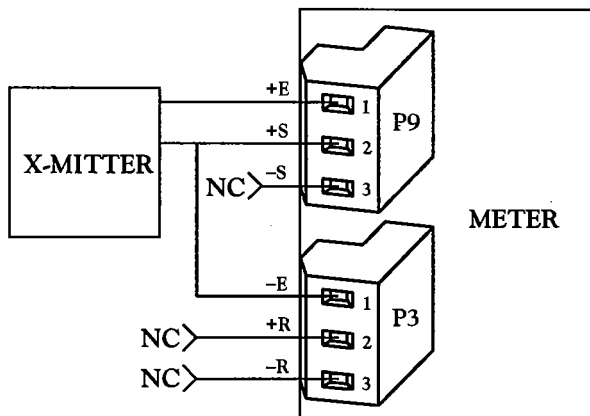
Figure 8-3.  2-Wire RTD Current-Loop Transmitter Hookup
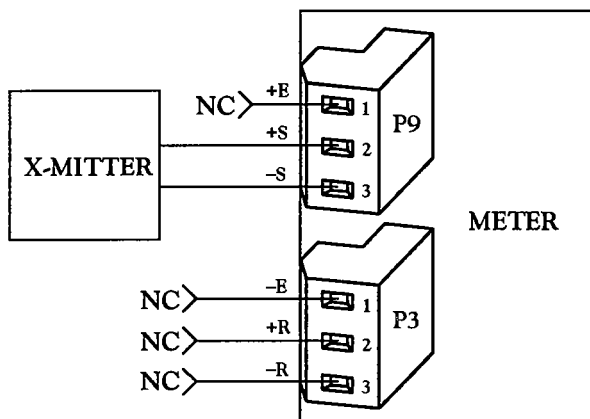


Figure 8-4.  4-Wire RTD Transmitter Hookup

## 8.3  WIRING WITH TRANSMITTER

### 8.3.1  FOR RTDS

The RTD is excited by and provides the signal for a current-loop
transmitter, which in turn is powered by and feeds the current signal
to the meter.  To convert this current to the basic input range
(0-100mV), install a jumper in the S2U position on the signal input
board, which will convert this current to a voltage by an internal
5 $\Omega$ resistor.

The input attenuator is blocked out by installing S2A and S2F on
the signal input board.

With a transmitter input, if the current-loop is accidentally opened, the meter will read zero since the current-shunt resistor is across the input; therefore no open-lead jumper (S2R or S2S) is used.

When a transmitter requires excitation, install jumpers S2N and S2T on the signal input board to bring out the 24 V excitation to drive the transmitter's current loop.

The current for the RTD in this case is furnished by the transmitter, which in turn is driven by the meter's power loop. The meter's internal scaling will be used to remove transmitter zero, span, and current error.

It is, of course, possible to use the meter as a current receiver from a transmitter which has its own power ("4-wire" transmitter). In this case, no connection is made to P9-1, the positive (+) E terminal. The current from the transmitter's positive (+) terminal is now put in the meter's positive (+) S pin (P9-2) and the negative (−) S pin (P9-3) connected to the transmitter's negative (−) terminal.

For "2-wire" transmitters, the meter's positive (+) E terminal (P9-1) now supplies the voltage to the transmitter's positive loop terminal, and the transmitter's negative loop terminal is brought back to the meter's positive (+) S signal input terminal (P9-2). To complete the loop, the input connector's negative (−) E terminal (P9-1) is jumpered to ground (P9-3), same potential as negative (−) S on (P9-3).

S2H is not used for either transmitter or 2-wire RTD input, but in both cases this auxiliary input is tied to ground by inserting S2M.

### 8.3.2  FOR THERMOCOUPLES

The thermocouple's millivolt output is converted to a 4-20mA signal similar to the RTD.

8

Transmitter
Hookup Example
with RTD

# 8.4 TC/RTD TRANSMITTER CALIBRATION

The following information must be carefully adhered to (Do not leave out any steps).

| PRESS | THEN PRESS (TO CHANGE IF REQUIRED) | UNTIL DISPLAY SHOWS | COMMENTS |
|---|---|---|---|
| 'MENU' | | "INPUT" | You need the display to show "INPUT". |
| 'MIN' | 'MAX' | "RTD" | Press the 'MIN' button to have meter display (flashing) an input type. Press the 'MAX' button to select RTD. |
| 'MENU' | | "STORED" then "RTD" | The display will then most often momentarily show "STORED" and then show "RTD". |
| NOTE: In each and every case where the parameter is changed and then the 'MENU' button is pressed, the display will show "STORED". To simplify matters, "STORED" is not shown in the future but is understood. | | | |
| 'MIN' | 'MAX' | "LINEAR" | Press the 'MIN' button to have the display show a signal type. Press the 'MAX' button to select LINEAR. |
| 'MENU' | | "RDG.CNF" | Set reading configuration. |

**8**

Transmitter
Hookup Example
with RTD

**8**

**Transmitter
Hookup Example
with RTD**

| PRESS | THEN PRESS (TO CHANGE IF REQUIRED) | UNTIL DISPLAY SHOWS | COMMENTS |
|---|---|---|---|
| 'MIN' | 'MAX' | "RDG.1=0" | Set "RDG.1=0" (Direct format) By pressing the 'MIN' button, the meter advances to RDG.1. The 'MAX' button allows you to select "RDG.1=0". The 'MIN' and 'MAX' button descriptions are the same for subsequent steps. |
| 'MIN' | 'MAX' | "RDG.2=0" | Make sure the display shows "RDG.2=0". |
| 'MIN' | 'MAX' | "RDG.3=0" | Make sure the display shows "RDG.3=0". |
| 'MIN' | 'MAX' | "RDG.4=1" | Make sure the display shows "RDG.4=1". |
| 'MIN' | 'MAX' | "RDG.5=2" | Make sure the display shows "RDG.5=2". |
| 'MIN' | 'MAX' | "RDG.6=0" | Make sure the display shows "RDG.6=0". |
| 'MENU' | | "RDG SC" | Stores "RDG.CNF". Advance to "RDG SC". |
| 'MIN' | 'MAX' | "1.00000" | Unity gain for calibration run. |
| 'MENU' | | "RDG OF" | Stores "RDG SC". Advance to "RDG OF". |
| 'MIN' | 'MAX' | "00000.0" | No offset (decimal point can go anywhere). |

| PRESS | THEN PRESS (TO CHANGE IF REQUIRED) | UNTIL DISPLAY SHOWS | COMMENTS |
|-------|-----------------------------------|---------------------|----------|
| 'MENU' | | "IN CNF" | Stores "RDG OF". Set Input Configurations. |
| 'MIN' | 'MAX' | "INP.1=0" | Make sure the display shows "INP.1=0". |
| 'MIN' | 'MAX' | "INP.2=0" | Make sure the display shows "INP.2=0". |
| 'MIN' | 'MAX' | "INP.3=0" | Make sure the display shows "INP.3=0". |
| 'MIN' | 'MAX' | "INP.4=2" | Make sure the display shows "INP.4=2". |
| 'MIN' | 'MAX' | "INP.5=0" | Make sure the display shows "INP.5=0". |
| 'MIN' | 'MAX' | "INP.6=0" | Make sure the display shows "INP.6=0". |
| 'MIN' | 'MAX' | "INP.7=0" | Make sure the display shows "INP.7=0". |
| 'MENU' | | "IN.SC.OF" | Stores IN CNF. Advance to "IN.SC.OF". |
| 'MENU' | | "DEC PT" | Advance to "DEC PT". Set the decimal point. |
| 'MIN' | 'MAX' | "FFFFFF." | Make sure the decimal point is in the 1 degree resolution. |
| 'MENU' | | "CNT BY" | Stores "DEC PT". location. Advance to "CNT BY". |

# 8

Transmitter
Hookup Example
with RTD

| PRESS | THEN PRESS (TO CHANGE IF REQUIRED) | UNTIL DISPLAY SHOWS | COMMENTS |
|---|---|---|---|
| 'MIN' | 'MAX' | "001" | Make sure the display shows "001". |
| 'MENU' | | "FIL.CNF" | Stores "CNT BY" value. Set Filter Configuration. |
| 'MIN' | 'MAX' | "FIL.1=0" | Make sure the display shows "FIL.1=0". |
| 'MIN' | 'MAX' | "FIL.2=1" | Make sure the display shows "FIL.2=1". |
| 'MIN' | 'MAX' | "FIL.3=0" | Set "FIL.3=0" for unfiltered Analog Output. |
| 'MENU' | | "FIL TI" | Stores "FIL CNF". Set Filter Time Constant. |
| 'MIN' | 'MAX' | "128" | Set to 128. |
| 'MENU' | | "STORED" then "SP.CNF" | Press the 'MENU' button to store your "FIL TI" selection. The display will momentarily show "STORED" and then will display "SP.CNF" |
| 'RESET', 'RESET' | | Measured Values | Press the 'RESET' button two times. The display will momentarily show "RUN" and then the currently-measured values. |

## 8.5  RECORDING THE CALIBRATION VALUES FOR RTD

### 8.5.1  SETTING THE LOWER OF THE TWO INPUTS

| NOTE: You must complete this section before continuing on. |
|---|

Replace the temperature sensor with a precision decade box for
RTDs or calibrators for Thermocouples with the bottom value of

the desired range of operation. Refer to the appropriate Section 21 in the rear of this manual for the resistance value.

Record resistor value here: _____

If the transmitter output is exactly 4mA, the display will read 20,000 µV (4000 µA x 5 ohms). If the display is significantly different from 20,000 µV (the meter is not outputting 4 mA), the transmitter zero may be suppressed too heavily and the current loop is below the minimum current for accurate operation. Adjust the transmitter as needed.

This first meter reading should be recorded as "INPUT1" for use in IN.SC.OF.

Record "INPUT1" value here: _____

Multiply above noted resistor value by 160.000 (microamperes): the resulting microvolt value is "READ1".

Record "READ1" value here: _____

## 8.5.2 SETTING THE UPPER OF THE TWO INPUTS

Adjust the decade box with the value of the top of the desired range. Refer to the appropriate Appendix in the rear of this manual for the resistance value.

Record the resistor value here: _____

If the transmitter output is exactly 20mA, the display will read 100,000 µV (20,000 µA x 5 ohms). The display is not supposed to exceed 110,000 µV. If the display is above 110,000 µV, the span may be too high and the loop current forced to an inaccurate high value. Adjust the transmitter as needed.

This second meter reading should be recorded as "INPUT2".

Record "INPUT2" value here: _____

Multiply the resistance by 160.000 (microamperes) to calculate "READ2".

Record "READ2" value here: _____.

Now that you have the data for "IN.SC.OF", proceed as follows:

| PRESS | THEN PRESS (TO CHANGE IF REQUIRED) | UNTIL DISPLAY SHOWS | COMMENTS |
|---|---|---|---|
| 'MENU' | | "INPUT" | You need the display to show "INPUT". |
| MAKE SURE THE PROPER SENSOR (RTD OR THERMO-COUPLE) IS ATTACHED TO THE TRANSMITTER. | | | |
| 'MIN' | 'MAX' | "RTD" | Press the 'MIN' button to have meter display (flashing) an input type. Press the 'MAX' button to select RTD. |
| 'MENU' | | "STORED" then "RTD" | The display will most often momentarily show "STORED" and then show "RTD". |
| NOTE: In each and every case where the parameter is changed and then the 'MENU' button is pressed, the display will show "STORED". To simplify matters, "STORED" is not shown in the future but is understood. | | | |
| 'MIN' | 'MAX' | "2PT385" | Press the 'MIN' button to have the meter display a signal type. Press the 'MAX' button to select 2PT385. |
| OR | | | |
| 'MIN' | 'MAX' | "TC" | Press the 'MIN' button to have meter display (flashing) an input type. Press the 'MAX' button to select "TC". |

8

**Transmitter Hookup Example with RTD**

| PRESS | THEN PRESS (TO CHANGE IF REQUIRED) | UNTIL DISPLAY SHOWS | COMMENTS |
|---|---|---|---|
| 'MENU' | | "STORED" then "TC" | The display will most often momentarily show "STORED" and then show "TC". |
| 'MIN' | 'MAX' | "K" | Press the 'MIN"button to have the meter display a signal type. Press the 'MAX' button to select Type K. |
| 'MENU' | | "RDG.CNF" | Stores signal type. Set reading configuration. |
| 'MIN' | 'MAX' | "RDG.5=1" | Make sure the display shows "RDG.5=1". |
| 'MIN' | 'MAX' | "RDG.6=1" | Make sure the display shows "RDG.6=1". |
| 'MENU' | | "RDG SC" | Stores "RDG.CNF". Advance to "RDG SC". |
| 'MENU' | | "RDG OF" | Bypass "RDG SC" Advance to "RDG OF". |
| 'MENU' | | "IN CNF" | Bypass "RDG OF". Set Input Configurations. |
| 'MIN' | 'MAX' | "INP.2=0" | Make sure the display shows "INP.2=0". |
| 'MIN' | 'MAX' | "INP.6=1" | Make sure the display shows "INP.6=1". |
| 'MENU' | | "IN.SC.OF" | Stores "INP CNF". Advance to "IN.SC.OF". |

# 8

Transmitter
Hookup Example
with RTD

# 8

**Transmitter Hookup Example with RTD**

| PRESS | THEN PRESS (TO CHANGE IF REQUIRED) | UNTIL DISPLAY SHOWS | COMMENTS |
|---|---|---|---|
| 'MIN' | | "INPUT1" | Allows you to put in calculated data into the meter. |
| 'MIN' | 'MAX' | "uuuuuu" | Insert INPUT1 value here. |
| 'MIN' | | "READ 1" | Allows you to put in calculated data into the meter. |
| 'MIN' | 'MAX' | "xxxxxx" | Insert READ1 value here. |
| 'MIN' | | "INPUT2" | Allows you to put in calculated data into the meter. |
| 'MIN' | 'MAX' | "vvvvvv" | Insert INPUT2 value here. |
| 'MIN' | | "READ 2" | Allows you to put in calculated data into the meter. |
| 'MIN' | 'MAX' | "yyyyyy" | Insert "READ 2" value here. |
| 'MENU' | | "DEC PT" | Stores "IN.SC.OF". Advance to "DEC PT". |
| 'MIN' | 'MAX' | "FFFF.FF" | Make sure the decimal point is in the 0.01° resolution. |
| 'MENU' | | "CNT BY" | Stores the decimal point location. Advance to "CNT BY". |

| PRESS | THEN PRESS (TO CHANGE IF REQUIRED) | UNTIL DISPLAY SHOWS | COMMENTS |
|---|---|---|---|
| 'MENU' | | "FIL.CNF" | Bypass "CNT BY". Advance to "FIL TI". |
| 'MENU' | | "FIL TI" | Bypass "FIL.CNF". |
| 'RESET', 'RESET' | | Measured Values | Press the 'RESET' button two times. The display momentarily shows "RUN" and then the currently measured values. |

For a detailed explanation of each menu item (for example, "INPUT", "RDG.CNF", etc.), refer to Section 9.

# 8

**Transmitter Hookup Example with RTD**

# Notes:

# 8

**Transmitter Hookup Example with RTD**

# 9. Detailed Explanation of Lockout Configurations and Meter Function Menus

| HOW TO USE THE TABLES IN SECTION 9 | |
|---|---|
| MIN/MAX/MENU BUTTONS | These are the buttons on the meter you are to press to access the parameters given in the same column. |
| MAIN MENU/ SUBMENU: | These are headings for the table columns. |
| DISPLAYED INFORMATION: | These are parameters seen on the display after pressing either 'MIN', 'MAX', or 'MENU' button(s). |

**NOTE:** If you press the 'RESET' button two times while the meter is in the run mode, all Setpoints, Alarms, Peak & Valley will be reset and the meter will begin new measurements.

If you press the 'RESET' button one time while in the configuration mode, you will move one MAIN MENU backwards and any selection will not be saved. If you press the 'RESET' button two times while in the configuration mode, you will reset the meter and only those menu items saved by pressing the 'MENU' button will be saved.

## 9.1 INDIVIDUAL LOCKOUT INFORMATION

To restrict access to different parameters of the program in the meter, you may want to lockout parts of the meter. When you lock out a parameter, it will no longer appear when you scroll through the menu. To lock out specific parameters of the meter (setpoint, scaling), refer to the following tables.

Once set (to unlock useful features for a given application and to lock out any features), these four "L1C", "L2C", "L3C", and "L4C" can be rapidly skipped over by pressing the 'MENU' button four times.

| MENU BUTTON MAIN MENU | MIN/MAX* BUTTON SUB MENU | CONDITION |
|---|---|---|
| "L1 CNF": | | LOCKOUT CONFIGURATION #1 |
| | "L1C.1=0" | Setpoint 1 change unlocked. |
| | "L1C.1=1" | Setpoint 1 change locked out. |
| | "L1C.2=0" | Setpoint 2 change unlocked. |
| | "L1C.2=1" | Setpoint 2 change locked out. |
| | "L1C.3=0" | Setpoint 3 (Alarm 1) change unlocked. |
| | "L1C.3=1" | Setpoint 3 (Alarm 1) change locked out. |
| | "L1C.4=0" | Setpoint #4 (Alarm 2) change unlocked. |
| | "L1C.4=1" | Setpoint #4 (Alarm 2) change locked out. |
| | "L1C.5=0" | Valley-value (LO RDG) display is permitted. |
| | "L1C.5=1" | Valley-value (LO RDG) display is not permitted. |
| | "L1C.6=0" | Peak-value (HI RDG) display is permitted. |
| | "L1C.6=1" | Peak-value (HI RDG) display is not permitted. |
| | "L1C.7=0" | INPUT CLASS (TC or RTD) can be selected. |
| | "L1C.7=1" | INPUT CLASS (TC or RTD) - INPUT CLASS is locked out. |
| | "L1C.8=0" | INPUT TYPE (J, K, E, T, N, R, S, B, DIN J or 2-, 3-, 4-wire RTD) can be selected. |
| | "L1C.8=1" | INPUT TYPE (J, K, E, T, N, R, S, B, DIN J or 2-, 3-, 4-wire RTD) - INPUT TYPE is locked out. |

* The 'MIN' button allows you to sequence through L1C.1, L1C.2, L1C.3, L1C.4, L1C.5, L1C.6, L1C.7 and L1C.8.

The 'MAX' button allows you to select the "0" or "1" state for each "L1C" condition.

The 'MENU' button stores the selected values for all "L1C" condition(s) changed and advances the meter to "L2 CNF". Do not press the 'MENU' button after each change within the submenu or the meter will advance to the next menu item.

Every underlined "0" or "1" state is the factory preset value.

| MENU BUTTON MAIN MENU | MIN/MAX* BUTTON SUB MENU | DESCRIPTION |
|---|---|---|
| "L2 CNF": | | LOCKOUT CONFIGURATION #2 |
| | "L2C.1=0" | RDG.CNF (scale/offset method and display features) may be chosen. |
| | "L2C.1=1" | RDG.CNF (scale/offset method and display features) is locked out. |
| | "L2C.2=0" | Either RDG SC (computed input-to-display scale factor) or RD.SC.OF (two data points, which determine the reading scale/offset) may be entered. |
| | "L2C.2=1" | Either RDG SC (computed input-to-display scale factor) or RD.SC.OF (two data points, which determine the reading scale/offset) is locked out. |

# 9

Meter
Function
Menus

| MENU BUTTON MAIN MENU | MIN/MAX* BUTTON SUB MENU | CONDITION |
|---|---|---|
| | "L2C.3=0" | RDG OF (offset computed in display digits) may be entered. |
| | "L2C.3=1" | RDG OF (offset computed in display digits) is locked out. |
| | "L2C.4=0" | INP.CNF (meter rates, front-end features, prelinearizing scale/offset) may be chosen. |
| | "L2C.4=1" | INP.CNF (meter rates, front-end features, prelinearizing scale/offset) may not be locked out. |
| | "L2C.5=0" | IN.SC.OF (two data points for additional scale/offset) may be entered. |
| | "L2C.5=1" | IN.SC.OF (two data points for additional scale/offset) may not be entered. |
| | "L2C.6=0" | DEC PT (decimal-point location) may be chosen |
| | "L2C.6=1" | DEC PT (decimal-point location) may not be chosen. |
| | "L2C.7=0" | CNT BY (round off of display) can be specified. |
| | "L2C.7=1" | CNT BY (round off of display) cannot be specified. |
| | "L2C.8=0" | FIL CNF (adaptive/fixed filtering and for which output(s)) can be chosen. |
| | "L2C.8=1" | FIL CNF (adaptive/fixed filtering and for which output(s)) cannot be chosen. |

* The 'MIN' button allows you to sequence through L2C.1, L2C.2, L2C.3, L2C.4, L2C.5, L2C.6, L2C.7, and L2C.8.

The 'MAX' button allows you to select the "0" or "1" state for each "L2C" condition.

The 'MENU' button stores the selected values for all "L2C" condition(s) changed and advances the meter to "L3 CNF". Do not press the 'MENU' button after each change within the submenu or the meter will advance to the next menu item.

Every underlined "0" or "1" state is the factory preset value.

| MENU BUTTON MAIN MENU | MIN/MAX* BUTTON SUB MENU | CONDITION |
|---|---|---|
| "L3 CNF": | | LOCKOUT CONFIGURATION#3 |
| | "L3C.1=0" | FIL TI (# of samples in average) can be chosen. |
| | "L3C.1=1" | FIL TI (# of samples in average) cannot be locked out. |
| | "L3C.2=0" | SP CNF (mode of action of setpoints 1 & 2 LEDs, transistors and relays) can be selected. |
| | "L3C.2=1" | SP CNF (mode of action of setpoints 1 & 2 LEDs, transistors and relays) cannot be locked out. |
| | "L3C.3=0" | AL CNF (mode of action of Setpoints 3 & 4, often used as alarms) can be locked out. |
| | "L3C.3=1" | AL CNF (mode of action of setpoints 3 & 4, often used as alarms) cannot be locked out. |
| | "L3C.4=0" | AL FNC (Setpoints 3 & 4 independent or ganged with Setpoints 1 and 2) can be selected. |

**9**

Meter
Function
Menus

| MENU BUTTON MAIN MENU | MIN/MAX* BUTTON SUB MENU | CONDITION |
|---|---|---|
| | "L3C.4=1" | AL FNC (Setpoints 3 & 4 independent or ganged with Setpoints 1 and 2) cannot be accessed. |
| | "L3C.5=0" | AL RDG (# of out-of-range readings before trip of setpoints 3 & 4) can be selected. |
| | "L3C.5=1" | AL RDG (# of out-of-range readings before trip of setpoints 3 & 4) cannot be accessed. |
| | "L3C.6=0" | SP DB (hysteresis or deadband of Setpoints and Alarms) can be specified. |
| | "L3C.6=1" | SP DB (hysteresis (deadband) of Setpoints and Alarms) cannot be accessed. |
| | "L3C.7=0" | OUT.CNF (analog & BCD outputs, setpoint display flashing) can be specified. |
| | "L3C.7=1" | OUT.CNF (analog & BCD outputs, setpoint display flashing) cannot be accessed. |
| | "L3C.8=0" | OT.SC.OF (2-data-point method for independent analog-output scale/offset) can be entered. |
| | "L3C.8=1" | OT.SC.OF (2-data-point method for independent analog-output scale/offset) cannot be accessed. |

\* The 'MIN' button allows you to sequence through L3C.1, L3C.2, L3C.3, L3C.4, L3C.5, L3C.6, L3C.7, and L3C.8.

**9**

Meter
Function
Menus

The 'MAX' button allows you to select the "0" or "1" state for each "L3C" condition.

The 'MENU' button stores the selected values for all "L3C" condition(s) changed and advances the meter to "L4 CNF". Do not press the 'MENU' button after each change within the submenu or the meter will advance to the next menu item.

Every underlined "0" or "1" state is the factory preset value.

| MENU BUTTON MAIN MENU | MIN/MAX* BUTTON SUB MENU | DESCRIPTION |
|---|---|---|
| "L4 CNF": | | LOCKOUT CONFIGURATION #4 |
| | "L4C.1=0" | BAUD (communication rate) can be chosen. |
| | "L4C.1=1" | BAUD (communication rate) cannot be accessed. |
| | "L4C.2=0" | SER.CNF (parity/stop-bit length) is selectable. |
| | "L4C.2=1" | SER.CNF (parity/stop-bit length) is not selectable. |
| | "L4C.3=0" | ADDRES (meter address # on a multipoint bus) can be changed. |
| | "L4C.3=1" | ADDRES (meter address # on a multipoint bus) cannot be accessed. |
| | "L4C.4=0" | DAT FT & BUS FT (format of data stream and bus interaction for digital communications) can be altered. |
| | "L4C.4=1" | DAT FT & BUS FT (format of data stream and bus interaction for digital communications) cannot be accessed. |

**9**

Meter
Function
Menus

| MENU BUTTON MAIN MENU | MIN/MAX* BUTTON SUB MENU | DESCRIPTION |
|---|---|---|
| | "L4C.5=0" | SERCNT (interval # of readings for the automatic digital output of meter) can be changed. |
| | "L4C.5=1" | SERCNT (interval # of readings for the automatic digital output of meter) cannot be accessed. |
| | "L4C.6=0" | Analog output trim input can be entered. |
| | "L4C.6=1" | Analog output trim input cannot be entered. |
| | | Unlocked C.JUN.OF: Cold-junction offset (for TC input only) |

**9**

**Meter Function Menus**

\* The 'MIN' button allows you to sequence through L4C.1, L4C.2, L4C.3, L4C.4, L4C.5, L4C.6

The 'MAX' button allows you to select the "0" or "1" state for each "L4C" condition.

The 'MENU' button stores the selected values for all "L4C" condition(s) changed and advances the meter to "INPUT". Do not press the 'MENU' button after each change within the submenu or the meter will advance to the next menu item.

Every underlined "0" or "1" state is the factory preset value.

## 9.2 METER FUNCTION MENUS

> **NOTE:** Sections 9.2.1 through 9.2.23 are also shown in the Quick Reference Guide.

### 9.2.1 INPUT

By pressing the 'MAX' and 'MENU' buttons you can select and then store respectively either "TC" or "RTD" (input type). Refer to the chart below to go the next level of programming of the meter.

| MAX/MENU BUTTON MAIN MENU | MAX/MENU * BUTTON SUB MENU | DESCRIPTION |
|---|---|---|
| "TC": | | SIGNAL TYPE |
| | "J" | J Thermocouple |
| | "<u>K</u>" | K Thermocouple |
| | "T" | T Thermocouple |
| | "E" | E Thermocouple |
| | "N" | N Thermocouple |
| | "DNJ" | J DIN Thermocouple |
| | "R" | R Thermocouple |
| | "S" | S Thermocouple |
| | "B" | B Thermocouple |
| "RTD" | "2PT392" | 2-wire 100 Ω platinum NIST RTD, (alpha = 00.00392) |
| | "3PT392" | 3-wire 100 Ω platinum NIST RTD, (alpha = 00.00392) |
| | "4PT392" | 4-wire 100 Ω platinum NIST RTD, (alpha = 00.00392) |
| | "2PT385" | 2-wire 100 Ω platinum DIN RTD, (alpha = 00.00385) |
| | "<u>3PT385</u>" | 3-wire 100 Ω platinum DIN RTD, (alpha = 00.00385) |
| | "4PT385" | 4-wire 100 Ω platinum DIN RTD, (alpha = 00.00385) |
| | "LINEAR" | Any linear RTD such as 10 Ω copper |

* After pressing the 'MAX' button, press the 'MENU' button to store the selection and the meter will then display "RDG.CNF".

Every underlined item is the factory preset setting.

## 9.2.2 RDG.CNF (READING CONFIGURATION)

Reading configuration is used to select:
- reading scale and offset (direct vs 2-point) [RDG.1]
- active or independent decimal point [RDG.2]
- display brightness [RDG.3]
- leading zero suppression on your meter display [RDG.4]
- units of measure (F, C or K) [RDG.5]
- display of units of measure (F, C or K) on the meter display [RDG.6]

Direct scale and Offset: these two values are used in the straight line equation, $y = mx + b$.

Display = m times input plus b or [ m (input) + b ] (where m is the RDG SC and b is the RDG OF).

The 2-data-point method allows the user to use two known points to convert from one scale to another. For example, to convert from degrees Fahrenheit to degrees Rankine, enter two (2) known points, such as -459.67°F = 0°R and 0°F = 459.67°R. The meter will automatically compute scale and offset and display the correct value.

| MENU BUTTON MAIN MENU | MIN/MAX/ MENU * BUTTON SUB MENU | DESCRIPTION |
|---|---|---|
| "RDG.CNF": | | READING CONFIGURATION |
| | | Reading Scale & Offset: |
| | "RDG.1=0" | Direct Format |
| | "RDG.1=1" | 2-Coordinate format |
| | | Decimal point effect: |
| | "RDG.2=0" | Active |
| | "RDG.2=1" | Not used for temperature |
| | | Display Brightness: |
| | "RDG.3=0" | Normal |
| | "RDG.3=1" | 50% of Normal |
| | | Leading Zeros on Display: |
| | "RDG.4=0" | Displayed |
| | "RDG.4=1" | Not Displayed |
| | | Unit of Temperature: |
| | "RDG.5=0" | C: Celsius |
| | "RDG.5=1" | F: Fahrenheit |
| | "RDG.5=2" | K: Kelvin |
| | | Temp. Unit on Display: |
| | "RDG.6=0" | Not Displayed |
| | "RDG.6=1" | Displayed |

**9**

Meter
Function
Menus

| MENU BUTTON MAIN MENU | MIN/MAX/ MENU * BUTTON SUB MENU | DESCRIPTION |
|---|---|---|
| | "RDG.7=0" "RDG.7=1" | Resetting Mode: Grounding P2-5 causes Hard Reset (RESET 2) Grounding P2-5 causes Peak/Valley (HI/LO) Reset |

\* The 'MIN' button allows you to sequence through RDG.1, RDG.2, RDG.3, RDG.4, RDG.5, RDG.6, and RDG.7.

The 'MAX' button allows you to select the "0" or "1" state for each "RDG" condition.

The 'MENU' button stores the selected values for all "RDG.CNF" condition(s) changed and advances the meter to "RD SC". Do not press the 'MENU' button after each change within the submenu or the meter will advance to the next menu item.

Every underlined "0" or "1" state is the factory preset value.

### 9.2.3 RDG SC (READING SCALE) AND RDG OF (READING OFFSET)

Typically, this would not be used if the thermocouple input or 100 ohm platinum RTD input is chosen, since there is a linearization procedure which tracks the entire NIST tables. This would only be used if you are connecting a 10 ohm copper RTD input or platinum RTD other than 100 ohm, or for ohms scaling.

If "RDG.1=0" were chosen, then you go automatically into "RDG SC" and "RDG OF" where:
"RDG SC" is reading scale from – 99999 to +499999 where you set the display to "1.00000" and "RDG OF" is reading offset from – 99999 to 999999 when you set the display to "000000".

When "RDG SC" is displayed, press the 'MIN' button to see the previously-set value. For temperature measurement, scale is set to "1.00000" using the 'MIN/MAX' buttons since the scale was selected previously to F, C or K by "RDG.5". Store by pressing the 'MENU' button.

**9**

Meter
Function
Menus

--------------------

For "RDG OF", you may choose to enter a reference temperature offset here (e.g., "-100.00") so that the display will read deviation of the input from the boiling point (or some other temperature).

If "RDG.1 = 1" were chosen, then you go automatically into "RD.SC.OF".

| MENU BUTTON MAIN MENU | MIN/MAX* BUTTON SUB MENU 1 | MIN/MAX /MENU** BUTTON SUB MENU 2 | DESCRIPTION |
|---|---|---|---|
| "RD.SC.OF": | | | READING SCALE & OFFSET |
| | INPUT 1 | | Item #1 of Coordinate #1. |
| | | 000000. ("00000.0") | Enter the first value displayed by the meter. |
| | READ 1 | | Item #2 of Coordinate #1. |
| | | 000000. ("00000.0") | Enter first desired value. |
| | INPUT 2 | | Item #1 of Coordinate #2. |
| | | 000000. ("10000.0") | Enter the second value displayed by the meter. |
| | READ 2 | | Item #2 of Coordinate #2. |
| | | 000000. ("10000.0") | Enter second desired value. |

\* The 'MIN' button allows you to sequence through "INPUT 1", "READ 1", "INPUT 2", and "READ 2" headings.

The 'MAX' button sends you to the value corresponding to "INPUT 1", "READ 1", "INPUT 2", or "READ 2" so you can change it (go to the SUB MENU 2 item).

\*\* The 'MIN' button allows you to step through the digits of the applicable number being changed.

The 'MAX' button changes the value of the digit to be displayed.

The 'MENU' button stores the selected values for each input required in "RD.SC.OF". After the last value ("READ 2") has been entered and the 'MENU' button is pressed, the meter display will advance to "IN CNF".

Every underlined item is the factory preset value.

## 9.2.4 IN CNF (INPUT CONFIGURATION)

Input configuration is used to select:

- 50 or 60 Hz line frequency [INP.1]
- slow or fast read rate [INP.2]
- unipolar or bipolar inputs (temperature inputs must be unipolar [INP.3]
- cold junction compensation [INP.5]
- (INP.6 must be set to "INP.6=0" to disable the input scale and offset since you are not using a transmitter)
- (INP.7 must be set to "INP.7=0")

INP.1 and INP.2 are related to each other. If your power requirements require 50 Hz, you can have optimum integration in FAST read mode (12/sec). In the FAST mode, you need a jumper in the S1A position on the vertical Signal Input Board. If you set the SLOW read rate, this jumper should be removed to avoid overloading the integrator. SLOW read rate produces less noise.

Since you can only select "INP.4=0", this means that you are not utilizing input scale or offset and not disabling the meter's cold junction compensation.

If an external ice-point cell or constant-temperature oven is used to terminate the thermocouple wires (to a pair of copper wires which are then brought to your meter), you do not want to use the Cold-Junction Compensation Board; "INP.5=1" is used in such a case. With a reference-junction oven you would use your meter's input offset capability (IN.SC.OF) to cancel out that temperature so that the linearization table is entered at the proper point.

| MENU BUTTON MAIN MENU | MIN/MAX /MENU * BUTTON SUB MENU | DESCRIPTION |
|---|---|---|
| "IN CNF": | | INPUT CONFIGURATIONS |
| | "INP.1=0" "INP.1=1" | Line Frequency: 60 Hz 50 Hz |
| | "INP.2=0" "INP.2=1" | Read Rate: Slow Fast |
| | "INP.3=0" "INP.3=1" | Input Voltage Unipolar (for T/C): Bipolar |
| | "INP.4=0" "INP.4=1" "INP.4=2" | Transmitter Type: No Transmitter Not used Not used |
| | THERMOCOUPLE MODE: "INP.5=0" "INP.5=1" | Cold-Junction Compensation for T/C: Compensated Not Compensated |
| | RTD MODE: "INP.5=0" "INP.5=1" | 3-wire linear 4-wire linear |
| | "INP.6=0" "INP.6=1" | Input Scale and Offset: Disabled Enabled |
| | "INP.7=0" "INP.7=1" | Type of Reading: (not used for Temperature, set "INP.7 = 0") Non Ratiometric Not used |

* The 'MIN' button allows you to sequence through INP.1, INP.2, INP.3, INP.4, INP.5, INP.6, and INP.7.

The 'MAX' button allows you to select the "0" or "1" state for each "INP" condition.

The 'MENU' button stores the selected values for all "IN CNF" condition(s) changed and advances the meter to "IN.SC.OF". Do not press the 'MENU' button after each change within the submenu or the meter will advance to the next menu item.

Every underlined "0" or "1" state is the factory preset value.

## 9.2.5 IN.SC.OF (INPUT SCALE AND OFFSET)

Input scale and offset is typically used only when you want to recalibrate your meter (using two input data points). Since your thermocouple is directly connected, ignore this meter function item.

| MENU BUTTON MAIN MENU | MIN/MAX * BUTTON SUB MENU 1 | MIN/MAX/ MENU ** BUTTON SUB MENU 2 | DESCRIPTION |
|---|---|---|---|
| "IN.SC.OF": | | | INPUT SCALE & OFFSET<br><br>Input scale and offset in 2-Coordinate Format |
| | INPUT 1 | | Item #1 of Coordinate #1. |
| | | 000000. ("00000.0") | Enter the first value displayed by the meter. |
| | READ 1 | | Item #2 of Coordinate #1. |
| | | 000000. ("00000.0") | Enter first desired value. |

*continued next page*

9

Meter
Function
Menus

| MENU BUTTON MAIN MENU | MIN/MAX * BUTTON SUB MENU 1 | MIN/MAX/ MENU ** BUTTON SUB MENU 2 | DESCRIPTION |
|---|---|---|---|
| | INPUT 2 | | Item #1 of Coordinate #2. |
| | | 000000. ("10000.0") | Enter the second value displayed by the meter. |
| | READ 2 | | Item #2 of Coordinate #2. |
| | | 000000. ("10000.0") | Enter second desired value. |

\* The 'MIN' button allows you to sequence through "INPUT 1", "READ 1", "INPUT 2", and "READ 2" headings.

The 'MAX' button sends you to the value that corresponds to "INPUT 1", "READ 1", "INPUT 2", or "READ 2" so you can change it (go to the SUB MENU 2 item).

\*\* The 'MIN' button allows you to sequence through the digits of the applicable number being changed.

The 'MAX' button changes the value of the digit to be displayed.

The 'MENU' button stores the selected values for each input required in "IN.SC.OF". After the last value ("READ 2") has been entered and the 'MENU' button is pressed, the meter display will advance to "DEC PT".

Pressing the 'MENU' button allows you go to the next SUB MENU 1 item automatically.

After changing the last value at the bottom of the chart, pressing the 'MENU' button once more stores everything that was changed and advances the meter to the next configuration ("DEC PT").

Every underlined item is the factory preset value.

## 9.2.6 DEC PT (DECIMAL POINT)

Decimal point is used to select the resolution of your meter display such as in one degree, tenths of a degree, and hundredths of a degree. (This also applies to ohms, but the six-digit display permits milliohm units when RDG SC is set equal to 10 or more).

For thermocouples, RTDs and ohms, the decimal-point control is selected as "active" ("RDG.2=0"), i.e., changing the decimal point location moves the data digits along with it.

"FFFFF.F" is often used, since the linearization conformity is 0.2°F (0.1°C).

If "ERR 01" is displayed, check that "RDG OF" is within the display range.

| MENU BUTTON MAIN MENU | MIN/MAX/ MENU * BUTTON CONDITION | DESCRIPTION |
|---|---|---|
| "DEC PT": | | DECIMAL POINT POSITION |
| | "FFFFFF." | Position 1 (one-degree) |
| | "FFFFF.F" | Position 2 (tenths of a degree) |
| | "FFFF.FF" | Position 3 (hundredths of a degree) |

**9**

Meter
Function
Menus

---

* Press the 'MIN' button to show all "F's" on the display.

Press the 'MAX' button to move the decimal point.

Press the 'MENU' button to store the decimal point location and the meter will advance to "CNT BY".

The underlined item is the factory preset value.

## 9.2.7 CNT BY (COUNT BY)

Count by is used to round off the meter values by 1's, 2's, 5's, 10's, 20's, 50's, or 100's. This feature is normally set to "001" so that the display shows all possible values for the least-significant digit.

If the combination of input-signal noise and selected degree resolution is high, however, your meter can round off the display to the nearest 2, 5, 10, 20, 50 or even 100 digits. This can eliminate annoying display jitter without introducing any filter time delays.

For most thermocouple applications, however, the read rate and Adaptive Bandwidth Control filter of your meter are much faster than the thermal time constants, so that "CNT BY" should be set to 001.

| MENU BUTTON MAIN MENU | MIN/MAX/ MENU * BUTTON SUB MENU | DESCRIPTION |
|---|---|---|
| "CNT BY": | | COUNT BY ROUNDING OFF THE VALUE |
| | "001" | (the decimal point |
| | "002" | position is ignored) |
| | "005" | |
| | "010" | |
| | "020" | |
| | "050" | |
| | "100" | |

\* Press the 'MIN' button to show "001", "002", "005", "010", "020", "050", or "100".

Press the 'MAX' button to select one of the above.

Press the 'MENU' button to store the Count By number and the meter will advance to "FIL.CNF".

The underlined item is the factory preset value.

## 9.2.8 FIL.CNF (FILTER CONFIGURATION)

Filter configuration is used to select:

* Adaptive Bandwidth Control^ (ABC) filtering or moving average filter [FIL.1]
* whether the value displayed on the meter is filtered or unfiltered [FIL.2]
* whether the value sent to the optional analog output is filtered or unfiltered [FIL.3]

"FIL.1=0" for Adaptive Bandwidth Control (ABC filtering, which averages over a larger number of samples when the input is not moving, but drops down to no averaging for systematic input changes). "FIL.1=1" is for averaging over a fixed number of samples. The number of samples to be used is selected in "FIL TI".

"FIL.3=0" removes the selected filtering from the analog output (if that option is installed in your meter). "FIL.3=1" puts the selected filtering on that output. Usually you choose "FIL.3=0", relying on the signal conditioning available at the device receiving the analog output data.

<div style="text-align: right;">

# 9

Meter
Function
Menus

</div>

| MENU BUTTON MAIN MENU | MIN/MAX/ MENU * BUTTON SUB MENU | DESCRIPTION |
|---|---|---|
| "FIL.CNF": | | FILTER CONFIGURATION |
| | | Filter Type: |
| | "FIL.1=0" | ABC Filter |
| | "FIL.1=1" | Moving Average Filter |
| | | Value to be displayed: |
| | "FIL.2=0" | Unfiltered |
| | "FIL.2=1" | Filtered |
| | | Value to be transmitted on Analog Output |
| | "FIL.3=0" | Unfiltered |
| | "FIL.3=1" | Filtered |
| | "FIL.3=2" | Peak value |
| | "FIL.3=3" | Valley value |

* The 'MIN' button allows you to sequence through FIL.1, FIL.2, and FIL.3.

The 'MAX' button allows you to select the "0", "1", "2", or "3" state for each "FIL" condition.

The 'MENU' button stores the selected values for all "FIL.CNF" condition(s) changed and advances the meter to "FIL TI". Do not press the 'MENU' button after each change within the submenu or the meter will advance to the next menu item.

·^ Adaptive Bandwidth Control takes the average of the samples except when the input is rapidly changing. Patent applied for.

Every underlined "0", "1", "2", or "3" is the factory preset value.

### 9.2.9  FIL TI (FILTER TIME CONSTANT)

Filter time constant is used to determine the number of readings the meter will average before displaying an input value. The choices are 001, 002, 004, 008, 016, 032, 064, or 128.

For fixed filtering, the averaged number of samples is fixed; for Automatic Bandwidth Control, the chosen value is the maximum number of samples in the average computed by ABC when the input is not changing significantly (ABC, for slowly-moving signals, filters by averaging the "TI" number of samples, but follows signal changes rapidly by decreasing that averaging number).

Pressing the 'MENU' button stores your selection and moves on to "RESET 1" and then to "RUN" (unless setpoints, outputs, or communications have been unlocked for programming change).

| MENU BUTTON MAIN MENU | MIN/MAX/ MENU * BUTTON SUB MENU | DESCRIPTION |
|---|---|---|
| "FIL TI": |  | FILTER TIME CONSTANT |
|  | "001" "002" "004" "008" "016" "032" "064" "128" | Number of readings used in averaging. |

* Press the 'MIN' button to show "001", "002", "004", "008", "016", "032", "064" or "128".

Press the 'MAX' button to select one of the above.

Press the 'MENU' button to store the selection made and to advance the meter to the next menu ("SP CNF").

The underlined item is the factory preset value.

**9**

## 9.2.10 SP CNF (SETPOINTS 1 & 2 CONFIGURATION)

Setpoint configuration is used to select:

- the active zone of each setpoint to above and below the setting [SPC.1 & SPC.4]
- whether the open-collector output is on or off [SPC.2 & SPC.5]
- whether the reading compared with the setpoints is filtered or unfiltered [SPC.3 & SPC.6]
- enabled or disabled setpoints [SPC.7]
- enabled or disabled setpoint LED displays [SPC.8]

| MENU BUTTON MAIN MENU | MIN/MAX/ MENU * BUTTON SUB MENU | DESCRIPTION |
|---|---|---|
| "SP CNF": | | SETPOINTS 1 & 2 CONFIGURATIONS |
| | "SPC.1=0" "SPC.1=1" | Setpoint 1 Active Zone: Above Below |
| | "SPC.2=0" "SPC.2=1" | Setpoint 1 open-collector or relay output Active ON or OFF: On Off |
| | "SPC.3=0" "SPC.3=1" | Filtered/unfiltered reading compared with Setpoint 1 value: Unfiltered Filtered |
| | "SPC.4=0" "SPC.4=1" | Setpoint 2 Active zone: Above Below |
| | "SPC.5=0" "SPC.5=1" | Setpoint 2 open-collector or relay output Active ON or OFF: On Off |
| | "SPC.6=0" "SPC.6=1" | Filtered/unfiltered reading compared with Setpoint 2 value: Unfiltered Filtered |
| | "SPC.7=0" "SPC.7=1" | Setpoints 1 & 2 action: Enabled Disabled |
| | "SPC.8=0" "SPC.8=1" | Setpoint 1 & 2 LEDs action: Enabled Disabled |

\* The 'MIN' button allows you to sequence through SPC.1, SPC.2, SPC.3, SPC.4, SPC.5, SPC.6, SPC.7 and SPC.8.

The 'MAX' button allows you to select the "0" or "1" state for each "SPC" condition.

The 'MENU' button stores the selected values for each "SPC" condition changed and advances the meter to the next configuration ("AL CNF").

Every underlined "0" or "1" is the factory preset value.


## 9.2.11 AL CNF (ALARM CONFIGURATION)

Alarm configuration is used to select:

• the active zone for each alarm point to above or below the setting [ALC.1 & ALC.4]
• whether the open-collector output is on or off [ALC.2 & ALC.5]
• whether the readings compared with the alarm points are filtered or unfiltered [ALC.3 & ALC.6]
• enabled or disabled alarm points [ALC.7]

| MENU BUTTON MAIN MENU | MIN/MAX/ MENU * BUTTON SUB MENU | DESCRIPTION |
|---|---|---|
| "AL CNF": | | ALARMS 1 & 2 (SETPOINTS 3 & 4) CONFIGURATIONS |
| | | Alarm 1 Active zone (Setpoint 3): |
| | "ALC.1=0" "ALC.1=1" | Above Below |
| | | Alarm 1 open-collector or relay output Active ON or OFF: |
| | "ALC.2=0" "ALC.2=1" | On Off |

| MENU BUTTON MAIN MENU | MIN/MAX/ MENU * BUTTON SUB MENU | DESCRIPTION |
|---|---|---|
| | "ALC.3=0" "ALC.3=1" | Filtered/unfiltered reading compared with Alarm 1 (Setpoint 3) value: Unfiltered Filtered |
| | "ALC.4=0" "ALC.4=1" | Alarm 2 Active zone (Setpoint 4): Above Below |
| | "ALC.5=0" "ALC.5=1" | Alarm 2 open-collector or relay output Active ON or OFF: On Off |
| | "ALC.6=0" "ALC.6=1" | Filtered/unfiltered reading compared with Alarm 2 (Setpoint 4) value: Unfiltered Filtered |
| | "ALC.7=0" "ALC.7=1" | Alarms 1 & 2 (Setpoints 3 & 4) action and LEDs: Enabled Disabled |
| | "ALC.8=0" "ALC.8=1" | Alarm reset at P2-11 connector: Disabled Enabled |

**9**

Meter
Function
Menus

\* The 'MIN' button allows you to sequence through ALC.1, ALC.2, ALC.3, ALC.4, ALC.5, ALC.6, ALC.7 and ALC.8.

The 'MAX' button allows you to select the "0" or "1" state for each "ALC" condition.

The 'MENU' button stores the selected values for each "ALC" condition changed and advances the meter to the next configuration ("AL FNC").

Every underlined "0" or "1" is the factory preset value.

### 9.2.12 AL FNC (ALARM FUNCTION)

Alarm function is used to select:

- whether the alarms are used in the process, high-deviation, low-deviation or band deviation modes [ALF.1 & ALF.3]
- whether or not to latch the alarms [ALF.2 & ALF.4]

| MENU BUTTON MAIN MENU | MIN/MAX/ MENU * BUTTON SUB MENU | DESCRIPTION |
|---|---|---|
| "AL FNC": | | ALARMS 1 & 2 FUNCTION |
| | | Alarm 1 State: |
| | "ALF.1=0" | Process Mode |
| | "ALF.1=1" | High Deviation Mode |
| | "ALF.1=2" | Low Deviation Mode |
| | "ALF.1=3" | Band Deviation Mode |
| | | Alarm 1 Latch Action: |
| | "ALF.2=0" | Unlatched |
| | "ALF.2=1" | Latched |
| | | Alarm 2 State: |
| | "ALF.3=0" | Process Mode. Process Mode means the deadband is equally above and below the setpoint. |
| | "ALF.3=1" | High Deviation Mode |
| | "ALF.3=2" | Low Deviation Mode |
| | "ALF.3=3" | Band Deviation Mode |
| | | Alarm 2 Latch Action: |
| | "ALF.4=0" | Unlatched |
| | "ALF.4=1" | Latched |

**9**

Meter
Function
Menus

----

* The 'MIN' button allows you to sequence through ALF.1, ALF.2, ALF.3 and ALF.4.

The 'MAX' button allows you to select the "0", "1", "2", or "3" state for each "ALF" condition.

The 'MENU' button stores the selected values for each "ALF" condition changed and advances the meter to the next configuration ("AL RDG").

Every underlined item is the factory preset value.

## 9.2.13  AL RDG (ALARM READINGS)

Alarm reading is used to select the number of readings (from 01 to 15) the meter must make prior to activating the alarms.

| MENU BUTTON MAIN MENU | MIN/MAX/ MENU * BUTTON SUB MENU | DESCRIPTION |
|---|---|---|
| "AL RDG": | | ALARM NUMBER OF READINGS |
| | "00 00" ("03 03") | Number of readings to delay activation of Alarms 1 & 2 (from "01" to "15") (AL1), (AL2) |

* Press the 'MIN' button to show the current number of readings on the display (left pair of digits are flashing).

The 'MAX' button is used to change the value of the flashing digits (from 01 to 15).

Pressing the 'MIN' button allows you go to the second set of digits.

The 'MAX' button is used to change the value of the flashing digits.

After changing the last number, if necessary, pressing the 'MENU' button stores everything that was changed and advances the meter to the next configuration ("SP DB").

The underlined item is the factory preset value.

9

Meter
Function
Menus

## 9.2.14 SP DB (SETPOINT DEADBAND)

Setpoint deadband is used to select the amount of hysteresis for the setpoints (programmable from "0000" to "9999").

| MENU BUTTON MAIN MENU | MIN/MAX/ MENU * BUTTON SUB MENU | DESCRIPTION |
|---|---|---|
| "SP DB": | | SETPOINTS 1 & 2 DEADBAND |
| | "0000" ("0020") | Hysteresis for (w/system decimal points) Setpoints 1 and 2 (Programmable from "0000" to "9999") |

\* Press the 'MIN' button to show the value on the display.

The 'MIN' button also allows you to sequence through the digits of the number being changed.

The 'MAX' button changes the value of the digit to be displayed.

The 'MENU' button stores the selected values for each "SP DB" condition cahnged and advances the meter to the next configuration ("AL DB"):

The underlined item is the factory preset value.

## 9.2.15 AL DB (ALARM DEADBAND)

Alarm deadband is used to select the amount of hysteresis for the alarms (programmable from "0000" to "9999").

| MENU BUTTON MAIN MENU | MIN/MAX/ MENU * BUTTON SUB MENU | DESCRIPTION |
|---|---|---|
| "AL DB": | | ALARMS 1 & 2 DEADBAND |
| | "0000" ("0020") | Hysteresis for (w/System decimal points) Alarms 1 & 2 (Programmable from "0000" to "9999") |

**9**

Meter
Function
Menus
---------------------------

* Press the 'MIN' button to show the value on the display.

The 'MIN' button also allows you to sequence through the digits of the number being changed.

The 'MAX' button changes the value of the digit to be displayed.

Press the 'MENU' button to store the changes and advances the meter to the next configuration ("OUT.CNF").

The underlined item is the factory preset value.

### 9.2.16 OUT.CNF (OUTPUT CONFIGURATION)

Output configuration is used to select:

- whether or not to send data to the optional analog output board [OUT.1]
- the analog output signal of 0-10 V dc or 4-20 mA DC [OUT.2]
- whether or not to send data to the optional BCD output board [OUT.3]
- to send peak value via the optional BCD output board [OUT.4]
- to select type of BCD output [OUT.5]
- enable or disable the flashing display [OUT.6]

| MENU BUTTON MAIN MENU | MIN/MAX/ MENU * BUTTON SUB MENU | DESCRIPTION |
|---|---|---|
| "OUT.CNF": | | OUTPUT CONFIGURATION |
| | | Data on the Analog Output Board: |
| | "OUT.1=0" | Disabled |
| | "OUT.1=1" | Enabled |
| | | Analog Output Mode: |
| | "OUT.2=0" | 0-1 V, 0-5 V, 1-5 V, 0-10 V |
| | "OUT.2=1" | 0-20 mA or 4-20 mA |

| MENU BUTTON MAIN MENU | MIN/MAX/ MENU * BUTTON SUB MENU | DESCRIPTION |
|---|---|---|
| | | Data out on Parallel BCD Board: |
| | "OUT.3=0" | Disabled |
| | "OUT.3=1" | Enabled |
| | | |
| | | Type of data out on BCD Board: |
| | "OUT.4=0" | Display |
| | "OUT.4=1" | Peak |
| | | |
| | | BCD Output: |
| | "OUT.5=0" | Used for standard parallel printers. |
| | "OUT.5=1" | Used for Specialty printers. |
| | | |
| | | Type of Display Flashing: |
| | "OUT.6=0" | Disabled - display flashing. |
| | "OUT.6=1" | SP1 active - display flashing. |
| | "OUT.6=2" | SP2 active - display flashing. |
| | "OUT.6=3" | SP3 active - display flashing. |
| | "OUT.6=4" | SP4 active - display flashing. |
| | "OUT.6=5" | any SP active - display flashing. |

**9**

Meter
Function
Menus

* The 'MIN' button allows you to sequence through OUT.1, OUT.2, OUT.3, OUT.4, OUT.5, and OUT.6.

The 'MAX' button allows you to select the "0", "1", "2", "3", "4" or "5" state for each "OUT" condition.

The 'MENU' button stores the selected values for each "OUT" condition changed and advances the meter to the next configuration ("OT.SC.OF").

Every underlined item is the factory preset value.

## 9.2.17  OT.SC.OF (OUTPUT SCALE AND OFFSET)

Output scale and offset is used to calibrate your optional analog
output to correspond to the engineering units you desire.

| MENU BUTTON MAIN MENU | MIN/MAX * BUTTON SUB MENU 1 | MIN/MAX/ MENU ** BUTTON SUB MENU 2 | DESCRIPTION |
|---|---|---|---|
| "OT.SC.OF": | | | OUTPUT SCALE AND OFFSET |
| | READ 1 | | Item #1 of Coordinate #1. |
| | | 000000. ("00000.0") | Enter the first value displayed by the meter. |
| | OUTPT1 | | Item #2 of Coordinate #1. |
| | | 00.0000 ("04.0000") | Enter first desired output value. |
| | READ 2 | | Item #1 of Coordinate #2. |
| | | 000000. ("10000.0") | Enter the second value displayed by the meter. |
| | OUTPT2 | | Item #2 of Coordinate #2. |
| | | 00.0000 ("20.0000") | Enter second desired output value. |

\* The 'MIN' button allows you to sequence through "READ 1",
"OUTPT1", "READ 2", and "OUTPT2" headings.

The 'MAX' button sends you to the value corresponding to
"READ 1", "OUTPT1", "READ 2", and "OUTPT2" so you can
change it (go to the SUB MENU 2 item).

Meter
Function
Menus

** The 'MIN' button allows you to step through the digits of the applicable number being changed.

The 'MAX' button changes the value of the digit to be displayed.

The 'MENU' button stores the selected values for each input required in "OT.SC.OF". After the last value ("READ 2") has been entered and the 'MENU' button is pressed, the meter display will advance to "BAUD".

Every underlined item is the factory preset value.

## 9.2.18 BAUD (BAUD RATE)

Baud is used to select the baud rate for communication via the optional RS-232 or RS-485 communications boards. The choices are 300, 600, 1200, 2400, 4800, 9600, and 19200.

| MENU BUTTON MAIN MENU | MIN/MAX/ MENU * BUTTON SUB MENU | DESCRIPTION |
|---|---|---|
| "BAUD": | | BAUD RATE |
| | "00300" | |
| | "00600" | |
| | "01200" | Select baud rate for |
| | "02400" | communications via |
| | "04800" | RS-232 or RS-485 |
| | "09600" | |
| | "19200" | |

**9**

Meter
Function
Menus

---

* Press the 'MIN' button to show "00300", "00600", "01200", "02400", "04800", "09600", or "19200".

Press the 'MAX' button to select one of the above.

Press the 'MENU' button to store the changes and the meter advances to the next configuration ("SERCNF").

The underlined item is the factory preset value.

## 9.2.19  SERCNF (SERIAL COMMUNICATION CONFIGURATION)

Serial communication configuration is used to select:

- no parity, odd parity, or even parity for communications [SER.1]
- 1 stop bit or 2 stop bits [SER.2]

| MENU BUTTON MAIN MENU | MIN/MAX/ MENU * BUTTON SUB MENU | DESCRIPTION |
|---|---|---|
| "SERCNF": | | SERIAL COMMUNICATION CONFIGURATION |
| | | Select parity for communications via RS-232 or RS-485: |
| | "SER.1=0" | No parity |
| | "SER.1=1" | Odd parity |
| | "SER.1=2" | Even parity |
| | | Select stop bits for communications via RS-232 or RS-485: |
| | "SER.2=0" | 1 Stop Bit |
| | "SER.2=1" | 2 Stop Bits |

* The 'MIN' button allows you to toggle between SER.1 and SER.2.

The 'MAX' button allows you to select the "0", "1", or "2" state for each "SER" condition.

The 'MENU' button stores the selected values for each "SER" condition changed and advances the meter to the next configuration ("ADDRES").

Every underlined "0", "1" or "2" is the factory preset value.

## 9.2.20 ADDRES (MULTIPOINT COMMUNICATIONS DEVICE ADDRESS)

Address is used to give each meter a unique address while on a local area network using the optional RS-485 board.

| MENU BUTTON MAIN MENU | MIN/MAX/ MENU * BUTTON SUB MENU | DESCRIPTION |
|---|---|---|
| "ADDRES": | | MULTIPOINT COMMUNICATIONS DEVICE ADDRESS |
| | "000" ("001") | Enter address as an integer value: "000" to "199" |

* Press the 'MIN' button to show the value on the display.

The 'MIN' button also allows you to change the position of the digit being changed.

The 'MAX' button changes the value of the digit to be displayed.

Press the 'MENU' button to store the changes and advances the meter to the next configuration ("DAT FT").

The underlined item is the factory preset value.

## 9.2.21 DAT FT (DATA FORMAT)

Data format is used to set all the parameters to be transmitted via the optional RS-232 or RS-485 serial communications board. Data format allows you to select:

• whether to transmit Alarm 1 or 2 status character [DAT.1]
• whether to transmit peak and valley status character [DAT.2]
• whether or not the data transmitted is filtered or unfiltered [DAT.3 & DAT.4]

**9**

Meter
Function
Menus
------------------------

- whether or not to transmit the peak and valley readings
  [DAT.5 & DAT.6]
- the type of separator [DAT.7]
- whether or not to transmit the unit of measure [DAT.8]

| MENU BUTTON MAIN MENU | MIN/MAX/ MENU * BUTTON SUB MENU | DESCRIPTION |
|---|---|---|
| "DAT FT": | | DATA FORMAT |
| | | Alarms 1 & 2 Status Character: |
| | "DAT.1=0" | Excluded |
| | "DAT.1=1" | Included |
| | | HI/LO (Peak/Valley) Status Character: |
| | "DAT.2=0" | Excluded |
| | "DAT.2=1" | Included |
| | | Type of data to be transmitted: |
| | "DAT.3=0" | Unfiltered |
| | "DAT.3=1" | Filtered |
| | | Filtered value to be transmitted: |
| | "DAT.4=0" | No |
| | "DAT.4=1" | Yes |
| | | Peak value to be transmitted: |
| | "DAT.5=0" | No |
| | "DAT.5=1" | Yes |
| | | Valley value to be transmitted: |
| | "DAT.6=0" | No |
| | "DAT.6=1" | Yes |
| | | Separator for above items: |
| | "DAT.7=0" | Space |
| | "DAT.7=1" | <CR> |
| | | Unit of measurement to be transmitted: |
| | "DAT.8=0" | No |
| | "DAT.8=1" | Yes |

\* The 'MIN' button allows you to sequence through DAT.1, DAT.2, DAT.3, DAT.4, DAT.5, DAT.6, DAT.7, and DAT.8.

The 'MAX' button allows you to select the "0" or "1" state for each "DAT" condition.

The 'MENU' button stores the selected values for each "DAT" condition changed and advances the meter to the next configuration ("BUS FT").

Every underlined "0" or "1" is the factory preset value.

## 9.2.22 BUS FT (BUS FORMAT)

Bus format is to select:

- whether or not to include check sum with reading [BUS.1]
- whether or not to include line feeds [BUS.2]
- whether or not to have the meter respond in echo mode [BUS.3]
- multipoint or point-to-point mode [BUS.4]
- (if in point-to-point mode) select whether to communicate continuously or on command [BUS.5]
- whether a message character is used in handshake or continuous mode [BUS.6]
- whether or not you have installed the RS-485 board [BUS.7]
- whether or not to enable the external print coomand at P2-11.

9

Meter
Function
Menus

| MENU BUTTON MAIN MENU | MIN/MAX/ MENU * BUTTON SUB MENU | DESCRIPTION |
|---|---|---|
| "BUS FT": | | BUS FORMAT |
| | | Check sum with reading: |
| | "BUS.1=0" | Excluded |
| | "BUS.1=1" | Included |
| | | Line feed following all <CR>'s: |
| | "BUS.2=0" | Excluded |
| | "BUS.2=1" | Included |

| MENU BUTTON MAIN MENU | MIN/MAX/ MENU * BUTTON SUB MENU | DESCRIPTION |
|---|---|---|
|  | "BUS.3=0" "BUS.3=1" | Response from the meter (echo): No Yes |
|  | "BUS.4=0" "BUS.4=1" | Point to Point mode or Multipoint mode: Pt-Pt Multi-Pt |
|  | "BUS.5=0" "BUS.5=1" | Point-to-Point mode only: Continuous On Command |
|  | "BUS.6=0" "BUS.6=1" | Handshake if continuous mode: Message Character |
|  | "BUS.7=0" "BUS.7=1" | RS-485 Board installed?: Not installed Installed |
|  | "BUS.8=0" "BUS.8=1" | Print Command at P2-11: Disabled Enabled |

* The 'MIN' button allows you to sequence through BUS.1, BUS.2, BUS.3, BUS.4, BUS.5, BUS.6, BUS.7 and BUS.8.

The 'MAX' button allows you to select the "0" or "1" state for each "BUS" condition.

The 'MENU' button stores the selected values for each "BUS" condition changed and advances the meter to the next configuration ("SERCNT").

Every underlined "0" or "1" state is the factory preset value.

## 9.2.23 SERCNT (SERIAL COUNT)

Serial count is used to program the number of readings the meter must take (programmable from "00001" to "59,999") between transmissions of data via the optional RS-232 or RS-485 serial communications board.

Once you are done with the changes, press the 'MENU' button to display the normal operating display. The meter advances to run mode showing the currently measured values. Pressing the 'RESET' button two times allows you to return to the run mode.

| MENU BUTTON MAIN MENU | MIN/MAX/ MENU * BUTTON SUB MENU | DESCRIPTION |
| --- | --- | --- |
| "SERCNT": | | SERIAL COUNT |
| | | This specifies the number of readings between data transmissions: |
| | "00000" ("00001") | "00001" to "59999" |

\* Press the 'MIN' button to show the value on the display.

The 'MIN' button also allows you to change the position of the digit being changed.

The 'MAX' button changes the value of the digit to be displayed.

Press the 'MENU' button to store the changes and advances the meter to "RESET 2" and returns to the run mode.

The underlined item is the factory preset value.

> **NOTE:** After you complete your programming you may want to go back and remove the jumper in S3A position on the main board to insure against any unauthorized changes.

9

Meter
Function
Menus

## 9.2.24 ANALOG OUTPUT CALIBRATION NUMBERS

The analog output calibration numbers (see Figure 12-1) are printed on the optional analog output board. These four numbers (CAL VZ, CAL VS, CAL mAZ, and CAL mAS) must be entered into the meter to ensure that the analog output board is calibrated with the microprocessor.

| MENU BUTTON MAIN MENU | MIN/MAX/ MENU * BUTTON SUB MENU | DESCRIPTION |
|---|---|---|
| "CAL VZ" | 0 to 59999 | Calibration number marked on the analog output board must be entered for voltage zero. |
| "CAL VS" | 0 to 59999 | Calibration number marked on the analog output board must be entered for voltage span. |
| "CAL mAZ" | 0 to 59999 | Calibration number marked on the analog output board must be entered for current zero. |
| "CAL mAS" | 0 to 59999 | Calibration number marked on the analog output board must be entered for current span. |

NOTE: After you complete your programming you may want to go back and remove the jumper in S3A position on the main board to insure against any unauthorized changes.

Once you are done with the changes, press the 'MENU' button to display. The meter advances to run mode showing the currently measured values.

# 10. Setpoints/Alarms

Setpoints 1 through 4 can be configured for a very large variety of zone and level signalling.

SP1 and SP2 have balanced configurable hysteresis and are non-latching, suitable for control-level signalling. SP3 and SP4 are often used as ALarm 1 and ALarm 2, because they have single-sided hysteresis and can be configured for latching action.

The levels of these setpoints are entered during run mode via the front-panel pushbuttons (refer to Section 10.11). Many perfor-mance options are entered during the configuration mode (refer to Sections 10.2 through 10.10).

## 10.1 FEATURES OVERVIEW

1. Four full-range levels with many menu programmable features.

2. Independent operation or ganged action (including guard-band assignments).

3. Active above or below level, outside or inside band.

4. SP1 and SP2 have configurable hysteresis, 50% on either side of setpoint.

5. SP3 and SP4 have configurable hysteresis, 100% on inactive side.

6. SP3 and SP4 is configurable for latching action.

7. Setpoint levels can be compared to the unfiltered or filtered input signal measurements.

8. Configurable delays in alarm action.

9. Individual front-panel LED indicators.

10. Four (4) open-collector transistor outputs with clamping diodes, are isolated from signal input.

11. Setpoints can be displayed and reset as desired without interrupting measurements.

**10**

Setpoints/
Alarms

Setpoints 1 and 2 have selectable hysteresis, allocated 50% on either side of the setpoint level. A single setpoint can now generate on/off control signals for an operating region defined by the hysteresis. Refer to Figures 10-1 and 10-2 to understand how hysteresis works:
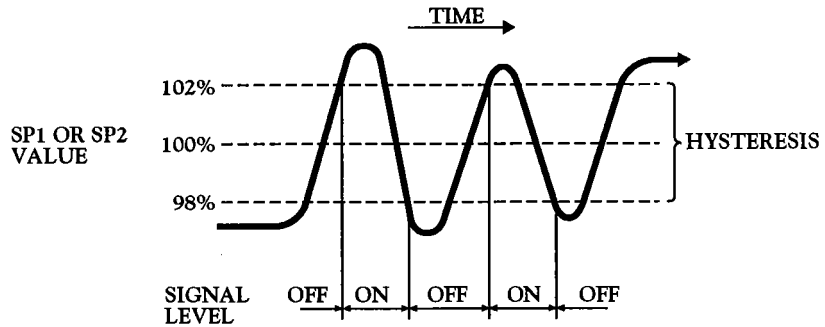


Figure 10-1. Setpoints 1 & 2 Action
(Setpoint at 100 with 4% hysteresis)

These two setpoints have selectable single-sided hysteresis. When used as alarms, the action is immediate (unless a delay is programmed) going into the alarm zone but turning off is deferred (if latching is not programmed) by the hysteresis amount.
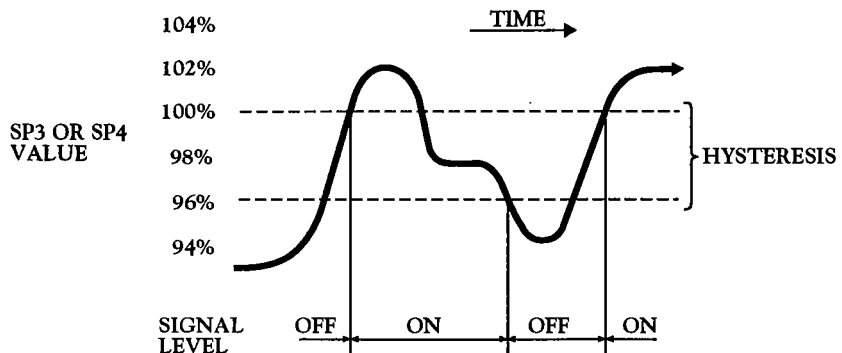


Figure 10-2. Setpoints 3 & 4 Action
(for Low Alarm with Relay on at -100, relay off at -96 with a hysteresis of 4)

You are now able to program the setpoint features (as described in the following sections).

# 10

Setpoints/
Alarms

## 10.2 UNLOCKING THE FEATURES

All setpoint values and features can be set via the front-panel buttons or the optional serial communications boards (RS-232 or RS-422/ 485). Control from the front-panel buttons can be locked out by jumpers on S3A and S3C on the main board or by setting lockout bits "L3C.2", and "L3C.6" in Lockout configuration "L3 CNF".

1. Check that main board jumpers S3A and S3C are installed (to permit memory storage of program and data along with button controls).

> **NOTE:** Jumper S3B should NOT be installed. This jumper is reserved for factory recalibration!

2. Press the 'MENU' button to see "L1 CNF" and then press the 'MIN' button to view "L1C.1=0" if "SP 1" is unlocked. If "L1C.1=1", change to equal "0" by pressing the 'MAX' button.

3. Press the 'MIN' button again to advance to "L1C.2" and set equal to "0" to unlock "SP 2".

4. Repeat for "L1C.3=0" and "L1C.4=0" to access "SP 3" and "SP 4".

5. Press the 'MENU' button to save these choices and advance to "L2 CNF". Skip over "L2 CNF" by pressing the 'MENU' button and advance to "L3 CNF".

6. Press the 'MIN' and 'MAX' buttons to set "L3C.2=0", "L3C.3=0", "L3C.4=0", "L3C.5=0", "L3C.6=0", "L3C.7=0" to gain access to the programming for the setpoints. All changes are then saved by pressing the 'MENU' button.

# 10

Setpoints/
Alarms

## 10.3 SELECTING "SP CNF" SETPOINT CONFIGURATION FEATURES

These eight bits select the modes for "SP 1" and "SP 2" (see Section 10.5 for "SP 3" and "SP 4").

1. Press the 'MENU' button until "SP CNF" is displayed, then press the 'MIN' button to sequence through the selections. Use the 'MAX' button to choose alternate choice.

2. "SPC.1=0" makes "SP 1" active ABOVE its level;
"SPC.1=1" sets "SP 1" active BELOW.

3. "SPC.2=0" turns "SP 1" transistor ON when "SP 1" is active.
"SPC.2=1" turns it OFF.

4. "SPC.3=0" compares the "SP 1" level to the UNFILTERED
measurements.
"SPC.3=1" compares "SP 1" to the FILTERED measurements.

5. "SPC.4=0" makes "SP 2" active ABOVE setpoint.
"SPC.4=1" makes "SP 2" active BELOW setpoint.

6. "SPC.5=0" turns "SP 2" transistor ON when "SP 2" is active.
"SPC.5=1" turns it OFF.

7. "SPC.6=0" compares the "SP 2" level to the UNFILTERED
measurements.
"SPC.6=1" compares "SP 2" to the FILTERED measurements.

8. "SPC.7=0" Enables both setpoints 1 and 2.
"SPC.7=1" Disables both setpoints 1 and 2.

9. "SPC.8=0" ENABLES the two front-panel LED indicators for
setpoints 1 and 2 when you have chosen "SPC.7=0".
"SPC.8=1" DISABLES the two front-panel LED indicators for
setpoints 1 and 2. (use with caution; recommended only when
other external over-range indicators are present).

10. Press the 'MENU' button to store your selections and advance
to "AL CNF" (Alarm Configuration).

## 10.4 DEVIATION FUNCTION FOR ALARMS

Deviation functions apply to Alarms 1 and 2 (Setpoints 3 and 4) and
act as buffer zones to control setpoint action. The Alarm 1 deviation
is the sum of the Alarm 1 value plus the Setpoint 1 value; the Alarm
2 deviation is the Alarm 2 value plus the Setpoint 2 value. The four
types of deviation functions are Process (no deviation), High, Low,
and Deadband. The following illustrate the ways in which the
deviation function alters the alarm response.
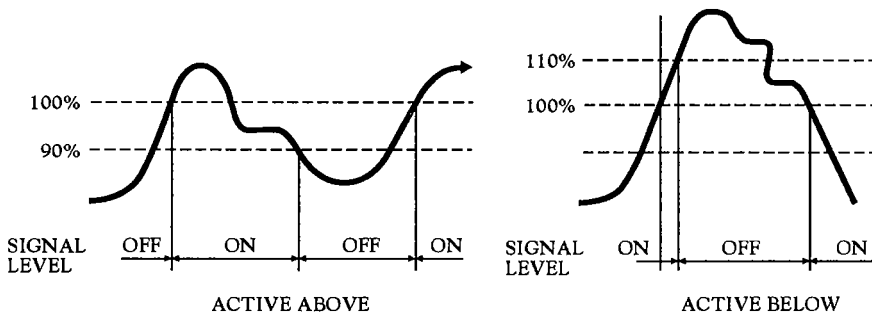
Figure 10-3.  Process Deviation
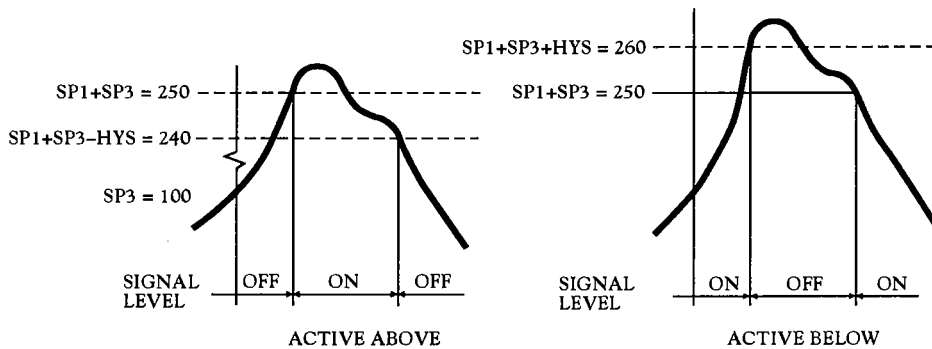


Figure 10-4.  High Deviation for both Active Above and
Active Below
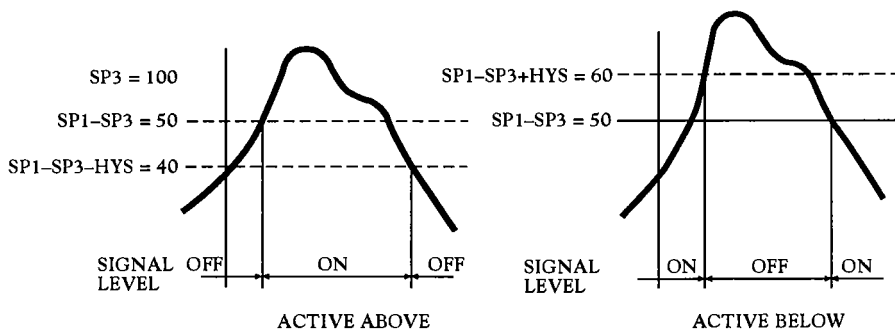


Figure 10-5.  Low Deviation for both Active Above and
Active Below

**10**

Setpoints/
Alarms

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
SP1+SP3+HYS = 260
SP1+SP3 = 250
SP1+SP3–HYS = 240

SP3 = 100

SP1–SP3+HYS = 60
SP1–SP3 = 50
SP1–SP3–HYS = 40

SIGNAL
LEVEL

ACTIVE ABOVE                    ACTIVE BELOW
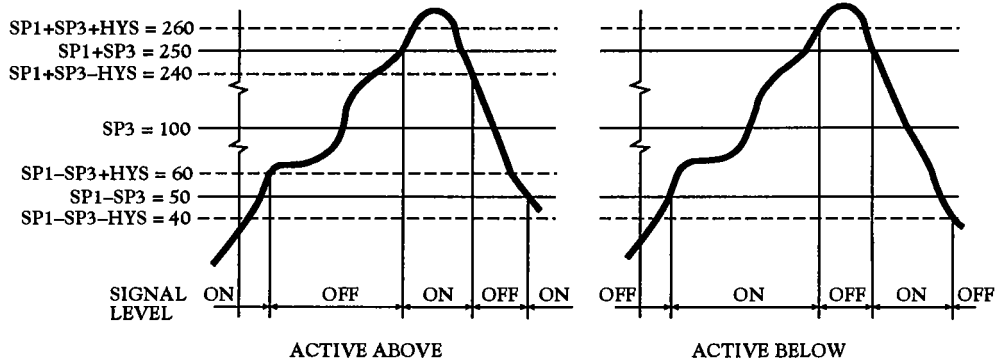
Figure 10-6. Band Deviation for both Active Above and
Active Below

## 10.5 SELECTING "AL CNF" ALARM CONFIGURATION FEATURES

These bits offer the same selections for "SP 3" and "SP 4" as "SP
CNF" did for "SP 1" and "SP 2", except for the last bit, which
controls "SP 3" and "SP 4" LATCH reset.

1. "ALC.1=0"  makes Alarm 1 (Setpoint 3) active above the
Setpoint value.
   "ALC.1=1"  makes Alarm 1 (Setpoint 3) active below the
Setpoint value.

When Alarm 1 (Setpoint 3) is assigned to place a band about the
Setpoint 1 level (by setting "ALF.1=3", described in Section 10.6),
"ALC.1=0" makes Alarm 1 (Setpoint 3) active ABOVE and
BELOW the band (OUTSIDE the band), with the chosen hyster-
esis for Alarm 1 (Setpoint 3) now inside the band. If "ALC.1=1",
Alarm 1 (Setpoint 3) is active INSIDE the band, with the chosen
hysteresis for Alarm 1 (Setpoint 3) now outside the band.

Figure 10-7 Illustrates the Alarm configuration for hysteresis.

**10**

Setpoints/
Alarms

SP3 = ±5        ALF .1=3          ALF .1=3
                ALC .1=0          ALC .1=1

ALARM ON  [⟍⟍⟍]

DEAD BAND  [∶∙∙∙∙∶]
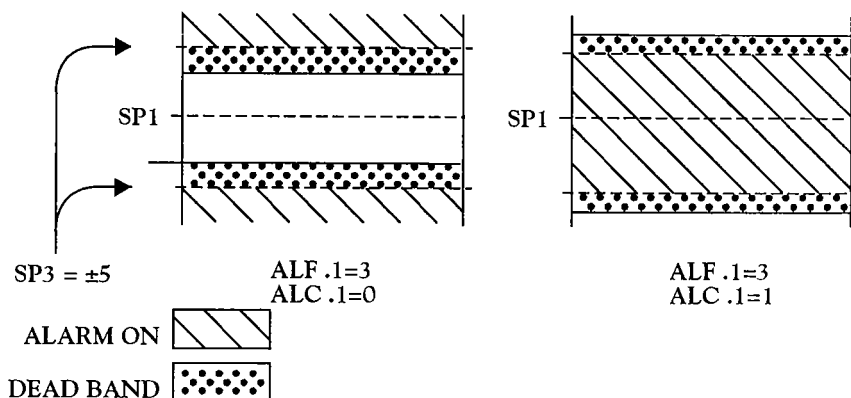
Figure 10-7.  AL CNF Hysteresis

2. "ALC.2=0"  turns the Alarm 1 (Setpoint 3) open-collector
              output ON when Setpoint 3 is active.
   "ALC.2=1"  turns it OFF.

3. "ALC.3=0"  compares the Alarm 1 (Setpoint 3) level to the
              UNFILTERED measurements.
   "ALC.3=1"  compares the Alarm 1 (Setpoint 3) level to the
              FILTERED measurements.

4. "ALC.4=0"  makes Alarm 2 (Setpoint 4) active ABOVE the
              Setpoint value.
   "ALC.4=1"  makes Alarm 2 (Setpoint 4) active BELOW the
              Setpoint value.

When Alarm 2 (Setpoint 4) is assigned to place a band about the
Setpoint 4 level (by setting "ALF.1=3", described in Section 10.6),
"ALC.4=0" makes Alarm 2 (Setpoint 4) active ABOVE and
BELOW the band (OUTSIDE the band), with the chosen hyster-
esis for Alarm 2 (Setpoint 4) now inside the band.  If "ALC.4=1",
Alarm 2 (Setpoint 4) is active INSIDE the band, with the chosen
hysteresis for Alarm 2 (Setpoint 4) now outside the band.

5. "ALC.5=0"  turns the Alarm 2 (Setpoint 4) open-collector
              output ON when Setpoint 1 is active.
   "ALC.5=1"  turns it OFF.

6. "ALC.6=0"  compares the Alarm 2 (Setpoint 4) level to the
              UNFILTERED measurements.
   "ALC.6=1"  compares the Alarm 2 (Setpoint 4) level to the
              FILTERED measurements.

# 10

Setpoints/
Alarms

10-7

7. "ALC.7=0" ENABLES both Alarms 1 and 2 (Setpoints 3 and 4) action and LEDs.
   "ALC.7=1" DISABLES both Alarms 1 and 2 (Setpoints 3 and 4) action and LEDs.

8. "ALC.8=0" DISABLES Alarm reset at the P2-11 connector.
   "ALC.8=1" ENABLES Alarm reset at the P2-11 connector.

Press the 'MENU' button to store any changes and advance to "AL FNC" (Alarm Function).

## 10.6  SELECTING "AL FNC" ALARM FUNCTION FEATURES

This byte allows you to select independent or ganged operation for "SP 3" and "SP 4", and whether or not they should latch once triggered.

1. "ALF.1=0" makes Alarm 1 (Setpoint 3) INDEPENDENT, with a level equal to the value inserted for Setpoint 3.
   "ALF.1=1" assigns Setpoint 3 ("SP 3") to Setpoint 1 ("SP 1"), placing it ABOVE Setpoint 1 ("SP 1") by the amount entered for Setpoint 3 ("SP 3").
   "ALF.1=2" places "SP 3" BELOW "SP 1" by the amount entered for "SP 3".
   "ALF.1=3" places "SP 3" ON BOTH SIDES OF "SP 1" by the amount entered for "SP 3".

2. "ALF.2=0" makes Alarm 1 (Setpoint 3) a NON-LATCHING Alarm.
   "ALF.2=1" makes Alarm 1 (Setpoint 3) LATCHING. This means that once Alarm 1 (Setpoint 3) is triggered it will remain active until it is reset by pressing the 'RESET' button one time or by grounding P2-11 when configuration bit "ALC.8=1" is set. Reset can also be accomplished via the optional RS-232 or RS-485 serial communication board.

3. "ALF.3=0" makes "SP 4" INDEPENDENT, with a level equal to the value inserted for "SP 4".
   "ALF.3=1" assigns "SP 4" to "SP 2", placing it ABOVE "SP 2" by the amount entered for "SP 4".
   "ALF.3=2" places "SP 4" BELOW "SP 2" by the amount entered for "SP 4".

   "ALF.3=3" places "SP 4" ON BOTH SIDES OF "SP 2" by the amount entered for "SP 4".

# 10

Setpoints/
Alarms

4. "ALF.4=0" makes Alarm 2 (Setpoint 4) a NON-LATCHING Alarm.

"ALF.4=1" makes Alarm 2 (Setpoint 4) LATCHING. This means that once Alarm 2 (Setpoint 4) is triggered it will remain active until it is reset by pressing the 'RESET" button one time or by grounding P2-11 when configuration bit "ALC.8=1" is set. Reset can also be accomplished via the optional RS-232 or RS-485 serial communication board.

Press the 'MENU' button to store any changes and advance to "AL RDG" (Alarm Reading).

## 10.7 "AL RDG": ALARM READINGS-SELECT DELAY IN ALARM ACTION

This byte allows you to select the number of input readings required to trigger Alarm 1 (Setpoint 3) and Alarm 2 (Setpoint 4) action.

When "AL RDG" is displayed, press the 'MIN' button to see two 2-digit numbers, with the first one flashing, indicating that you can reset the delay for SP3 by pressing the 'MAX' button.

After choosing "SP 3" delay, press the 'MIN' button and select the delay for "SP 4" by pressing the 'MAX' button.

Store your selections or changes by pressing the 'MENU' button and advance to "SP DB" (Setpoint Deadband).

## 10.8 "SP DB": SELECT "SP 1" AND "SP 2" DEADBAND (HYSTERESIS)

The deadband (hysteresis) for Setpoint 1 ("SP 1") and Setpoint 2 ("SP 2") is displayed with the same decimal point location as chosen for run mode.

This selected hysteresis value is EVENLY SPLIT on both sides of the levels chosen for "SP 1" and "SP 2".

View the value by pressing the 'MIN' button, reset by pressing the 'MAX' button, and store by pressing the 'MENU' button. Advance to "AL DB" (Alarm Deadband).

**10**

Setpoints/
Alarms

## 10.9 "AL DB": SELECT ALARM 1 ("SP 3") AND ALARM 2 ("SP 4") DEADBAND (HYSTERESIS)

This selected deadband (hysteresis) for Alarm 1 ("SP 3") and Alarm 2 ("SP 4") is placed on the INACTIVE side of the selected levels. This results in immediate action (if zero (0) delay is selected in "AL RDG") when an alarm limit is exceeded, but defers recovery when the input returns to pre-alarm levels.

Press the 'MIN' button to view the values, change the values of each flashing digit by pressing the 'MAX' button, store any changes by pressing the 'MENU' button. Advance to "OUT.CNF" (Output Configuration).

## 10.10 "OUT.CNF": CONTROL FLASHING OF THE DISPLAY

You may wish to bring abnormal conditions to immediate attention by causing the display to flash.
Press the 'MIN' button to see "OUT.6".
Press the 'MAX' button to select "0", "1", "2", "3", "4", or "5".

"OUT.6=0" disables display flashing.
"OUT.6=1" flashes the display if SP1 is active.
"OUT.6=2" flashes the display if SP2 is active.
"OUT.6=3" flashes the display if SP3 is active.
"OUT.6=4" flashes the display if SP4 is active.
"OUT.6=5" flashes the display if any SP is active.

Save your choice or changes by pressing the 'MENU' button and the meter will momentarily display "STORED", then "RUN" and proceed with normal operation ( go into run mode).

## 10.11 ENTERING SETPOINT LEVELS (IN RUN MODE)

When you have completed selecting the setpoint(s) (and other features), the last press of the 'MENU' button stores any changes and the meter will automatically return to the run mode (the display will momentarily display "RESET2"). The stored values are placed into operation, and the meter proceeds with normal measurements.

10

Setpoints/
Alarms

Now you can view and reset all four setpoint levels.

1. Press the 'SETPTS' button. The meter now starts its setpoint display cycle; every 15 seconds, the display flashes the SP number, and then displays the value of that setpoint, with a flashing left-hand digit.

2. You can restart the time-out of any of these display intervals by pressing the 'MIN' button (to shift the flashing [alterable] digit position), or by pressing the 'MAX' button (to increment the value of that digit).

3. When you change the value of any setpoint and then decide to revert to the original value instead, just press the 'RESET' button or allow the display to return to "RUN" at the end of its cycle. The meter does not store a new value for the setpoint in either case.

4. To save a newly-entered setpoint value, press the 'SETPTS' button again.

5. You may return to viewing the measurements by pressing the 'RESET' button or repeatedly pressing the 'SETPTS' button (or by letting the meter complete its setpoint display cycle).

# 10

**Setpoints/**
**Alarms**

# Notes:

# 10

**Setpoints/
Alarms**

# 11. Peak and Valley Readings

The meter examines every new reading to see if it is greater than the stored PEAK or less than the stored VALLEY readings.

If you have unlocked access to these values with "L1C.5=0" and "L1C.6=0" (part of the first lockout byte "L1 CNF"), you can view the PEAK ("HI RDG") by pressing the 'MAX' button, or the VALLEY ("LO RDG") by pressing the 'MIN' button while in the run mode.

Selection of either PEAK or VALLEY causes the display to flash giving the indication that it is NOT the current measurement value. If the meter measures a more extreme value while displaying the PEAK or VALLEY measurement, the new value will immediately replace the old.

Unlike the setpoint display, there is no time out period. Press the 'SETPTS' button or 'MENU' button to return to current-value display WITHOUT resetting the PEAK or VALLEY memory.

Press the 'RESET' button to return to run mode and start a new PEAK/VALLEY measurement period.

The BCD option can be programmed to read the PEAK (but not the VALLEY) instead of the current measurement (refer to Section 13).

Both PEAK and VALLEY readings (and/or a PEAK/VALLEY status summary character) can be transmitted by the RS-232 or RS-422/485 digital communications (refer to Section 15).

The PEAK or VALLEY value can be transmitted via the optional analog output board (refer to Section 12).

**11**

Peak and
Valley
Readings

# Notes:

# 11

**Peak and Valley Readings**

# 12. Analog Output Option

If you received your meter with the optional analog board installed, you should not have to enter the trim data as described in Section 12.5.

Your meter converts display readings into an independently-scaled-and-offset isolated voltage and/or current analog output. Isolation is accomplished via opto-isolators on the board. Your meter has the capability of transmitting SIMULTANEOUS voltage and current outputs although when this is done, the current analog output is not as accurate.

## 12.1 FEATURES OVERVIEW

1. Precise analog levels are generated from digital code using a proprietary ASIC chip.

2. Voltage (to 10 V) is available at the same time as current (to 22 mA), but the total current drawn should not exceed 24 mA.

3. Load resistance for the voltage output can be as low as 500 ohms (20 mA at 10 V out) when current output is not used.

4. Loop resistance for the current output can be as high as 600 ohms (12 volts compliance) with negligible current from the voltage output.

5. Both outputs are galvanically isolated from both power and measurement circuits of the meter: 354 V per IEC spacing, 500 V test.

6. Precision calibration is applied by the meter to either the voltage output or the current output (but not to both simultaneously). When both outputs are used simultaneously, the non-calibrated output is stable but does require external adjustment if fine-trimming is required.

7. Independent, 15-bit resolution OuTput SCale and OFfset (OT.SC.OF) can convert a wide range of meter readings to the desired current or voltage output span.

**12**

Analog
Output
Option

8. The output resolution permits good accuracy for turndown ratios (offset/span) as high as 100:1.

9. 50° to 104°F (10° to 40°C) accuracy within 0.1% after installation calibration.

10. 10% to 90% step response time is 50 milliseconds (plus filter delay, if any, programmed for the analog output).

11. Configurable so that output will track the PEAK or VALLEY measurement.

## 12.2 UNLOCKING

1. Press the 'MENU' button until "L3 CNF" is displayed, then press the 'MIN' button until "L3C.7" is displayed.

2. Press the 'MAX' button (if required) to set "L3C.7=0", unlocking the choice of current or voltage as the calibrated output.

3. Press the 'MIN' button (and the 'MAX' button if required) to set "L3C.8=0", unlocking OT.SC.OF.

4. Press the 'MENU' button to store these choices.

5. If your analog board is NEWLY INSTALLED, you will need to enter the four trimming constants (refer to the one-time only procedure in Section 12.5). To unlock this feature, press the 'MIN' button and then the 'MAX' button to set "L4C.6=0" and store by pressing the 'MENU' button.

## 12.3 "OUT.CNF": CONFIGURING THE OUTPUT

1. Press the 'MENU' button until "OUT.CNF" is displayed, then press the 'MIN' button to display "OUT.1=0" or "OUT.1=1".

2. Press the 'MAX' button to set "OUT.1=1"if you wish the analog output to be driven at once when you return to run mode. (You can leave this as "OUT.1=0" and complete all the other programming if you wish to activate the analog output at a later time by returning to this configuration bit).

**12**

Analog
Output
Option

3. Press the 'MIN' button (and the 'MAX' button if required) and set "OUT.2=0" for calibrated VOLT output (0-1 V, 0-5 V, 1-5 V, or 0-10 V) or "OUT.2=1" for calibrated CURRENT (0-20mA or 4-20 mA) output.

4. Press the 'MENU' button to store these choices (the rest of the "OUT.CNF" byte controls BCD and display-flashing features).

After pressing the 'MENU' button again, you advance to "OT.SC.OF" (Output Scale and Offset).

# 12.4 "OT.SC.OF": SETTING OUTPUT SCALE AND OFFSET

Any two data points can be used here: a data point is specified by a value of the display ("READ") and the desired output ("OUTPT") for that display.

1. Press the 'MIN' button to see "READ1" and then use the 'MIN' and 'MAX' buttons to enter a small display value, for example, "000.000", where the center decimal point position is used as an example.

2. Store this value by pressing the 'MENU' button and then you see "OUTPT1". Use the 'MIN' and 'MAX' buttons to specify the desired output value, for example, "04.0000" if current calibration had been selected ("OUT.2=1"), or "00.0000" for voltage.

3. Store this value by pressing the 'MENU' button and then advance to "READ2". Use the 'MIN' and 'MAX' buttons to enter a large display value, for example, "123.456", for the display that you want the analog output at full scale.

4. Store this value by pressing the 'MENU' button and then advance to "OUTPT2". Use the 'MIN' and 'MAX' buttons to enter the desired output for the display value in step 3. For example, enter "20.0000" for calibrated current or "10.0000" for calibrated voltage.

5. Press the 'MENU' button to store. Press the 'RESET' button two times to return to run mode and check calibration points, unless your analog output board is newly installed; in this case, follow Section 12.5.

# 12

Analog
Output
Option

_____

## 12.5 BOARD INSTALLATION; ENTERING THE TRIM DATA

To precisely calibrate your analog output board with your meter, each analog output board has been supplied with voltage and current zero trim values printed on the board. "CAL VZ" is for the voltage output and "CALmAZ" is for the current output.

Similarly, the fine trim for output gain is "CAL VS" for the voltage output and "CALmAS" for the current output.

These 4 data points are obtained from the factory calibration of each analog output board and are inscribed on the top edge of each board, as shown in Figure 12-1.
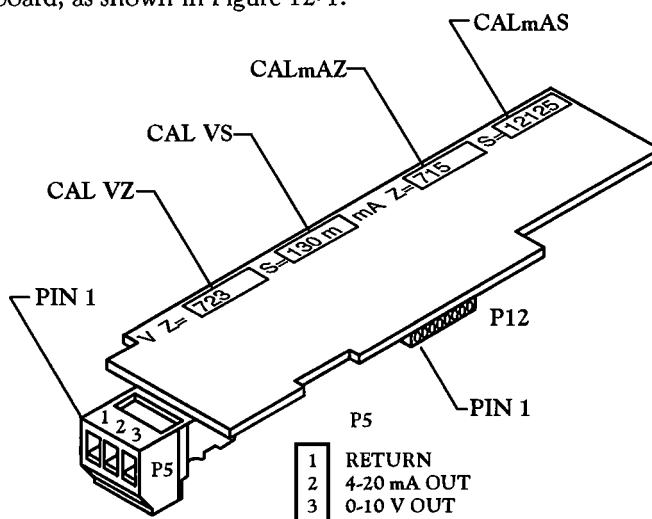


Figure 12-1. Analog Option Board

If you are installing an analog output board, follow this "one time only" procedure:

1. Write down the four (4) numbers inscribed on the top edge of your analog output board below:

   CAL VZ =_____

   CAL VS =_____

   CALmAZ =_____

   CALmAS =_____

2. "Reveal the main board" and install the analog output board using the procedures outlined in Section 5.2.

3. Attach connector wires, insert connectors, and apply power to the meter as described in Section 5.3.

4. If not already unlocked, press the 'MENU' button until "L4 CNF" is displayed and press the 'MIN' button six times. Now press the 'MAX' button to set "L4C.6=0".

5. Press the 'MENU' button to store and advance to "CAL VZ". Use the 'MIN' and 'MAX' buttons to enter the value (recorded from the edge of the board).

6. Press the 'MENU' button to store and advance to "CAL VS". Use the 'MIN' and 'MAX' buttons to enter the value.

7. Repeat for "CALmAZ".

8. Repeat for "CALmAS".

9. Press the 'MENU' button to store your entries and then you will see "C.JUN.OF". Press the 'RESET' button two times and you will see "RESET2", followed by "RUN". Verify your calibration points for the analog output.

# 12.6  FILTER CONFIGURATION "FIL.CNF" VALUE TO BE TRANSMITTED ON ANALOG OUTPUT

1. Press the 'MENU' button until the display shows "FIL.CNF".

2. Press the 'MAX' button until the display shows "FIL.3=0", "FIL.3=1", "FIL.3=2", or "FIL.3=3".

3. "FIL.3=0" Transmits the unfiltered value of your signal input.
   "FIL.3=1" Transmits the filtered value of your signal input.
   "FIL.3=2" Transmits the recorded PEAK ("HI RDG") value(s).
   "FIL.3=3" Transmits the recorded VALLEY ("LO RDG") value(s).

4. Press the 'MENU' button to store your selection or changes and the meter will advance to "FIL TI" (Filter Time Constant). Press the 'RESET' button two times to return to the run mode.

**12**

Analog
Output
Option

# Notes:

**12**

Analog
Output
Option

# 13. BCD Option

## 13.1 FEATURES OVERVIEW

1. 6 BCD digits (24 lines plus 1 polarity, 3 decimal-point location code, 1 overflow, 1 timing, 1 control, 4 card address, and 3 isolation power lines).

2. Furnished 40-line mass-terminated connector: pin compatibility with 50-pin BCD cable assignments.

3. Can be jumpered for internal, non-isolated drive or external power with isolation (354 V per IEC spacing, 500 V test).

4. Upper 3 BCD digits can be multiplexed onto lower 3 BCD lines for 3 digits at a time readout.

5. All outputs tri-state, TTL/CMOS compatible, 10 LSTTL loads.

6. Data always valid (stored, buffered).

7. Selectable 4-line card address (with internal pull-ups) or single-line activation.

Figure 13-1 shows the rear of the meter case with the 40-line edge connector highlighted and the upper and lower pin assignments.
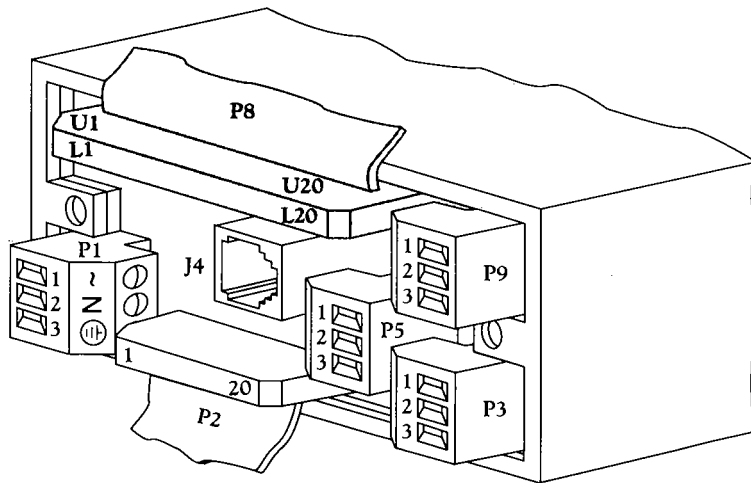


Figure 13-1. BCD 40-Pin Cable Connector (P8)

Figure 13-1 shows the rear of the meter case with the 40-line edge connector highlighted and the upper and lower pin assignments.
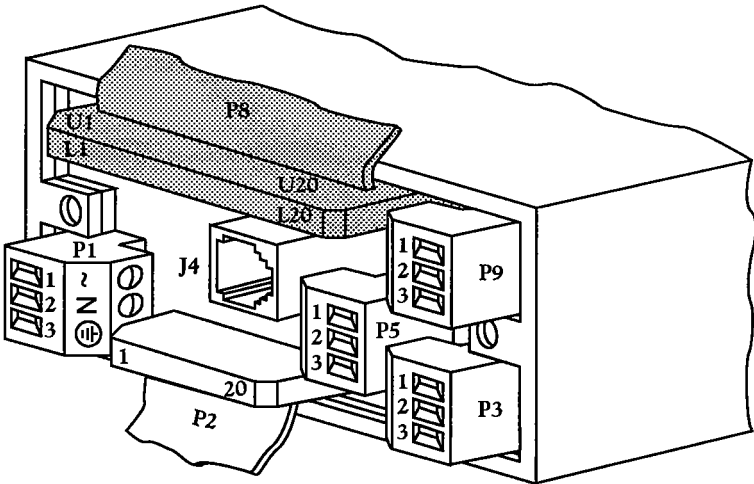


**P8**

| | | | |
|---|---|---|---|
| BCD 400K | L1 | U1 | BCD 800K |
| BCD 100K | L2 | U2 | BCD 200K |
| ISO GND | L3 | U3 | SPARE |
| BCD 40K | L4 | U4 | BCD 80K |
| BCD 10K | L5 | U5 | BCD 20K |
| BCD 4K | L6 | U6 | BCD 8K |
| BCD 1K | L7 | U7 | BCD 2K |
| D.P. 2 | L8 | U8 | D.P. 4 |
| BCD 400 | L9 | U9 | BCD 800 |
| BCD 100 | L10 | U10 | BCD 200 |
| BCD 40 | L11 | U11 | BCD 80 |
| BCD 10 | L12 | U12 | BCD 20 |
| BCD 4 | L13 | U13 | BCD 8 |
| BCD 1 | L14 | U14 | BCD 2 |
| ISO GND | L15 | U15 | D. P. 1 |
| DATA READY | L16 | U16 | POLARITY |
| ISO V+ | L17 | U17 | $\overline{HOLD}$ |
| SPARE | L18 | U18 | $\overline{OVERFLOW}$ |
| ADDRESS $\overline{B4}$ | L19 | U19 | ADDRESS $\overline{B8}$ |
| ADDRESS $\overline{B1}$ | L20 | U20 | ADDRESS $\overline{B2}$ |

# 13

**BCD Option**

Figure 13-1.  BCD 40-Pin Cable Connector (P8)

Figure 13-2 shows the board connections and pin designators.
The locations of the jumpers are also shown.
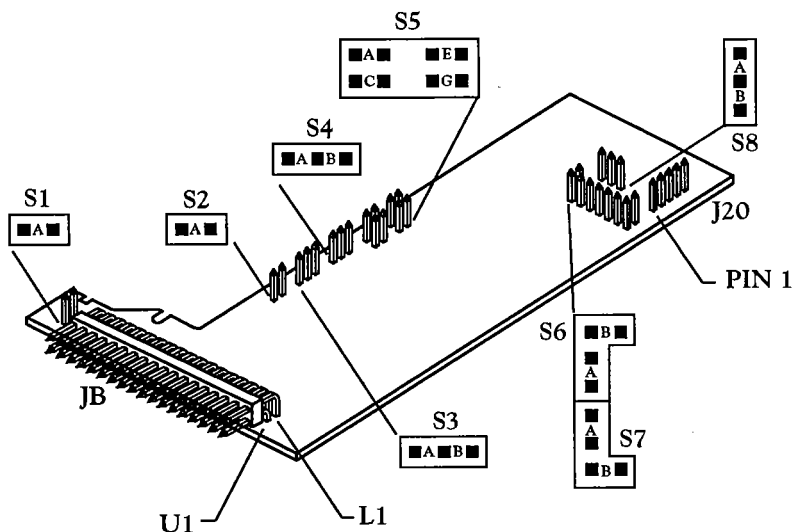


Figure 13-2. BCD Option Board

## 13.2 BCD CARD JUMPER TABLE

| JUMPER | WHEN USED |
|--------|-----------|
| S1A | Brings OVERFLOW signal to P8-U18 |
| S2A | Insert for 3-digit multiplex<br>Remove for 6-digit readout |
| S3A | Insert for 3-digit multiplex or one-line card-address enable<br>**OR** |
| S3B | 4-line card-address enable |
| S4A | Insert for 3-digit multiplex<br>**OR** |
| S4B | Insert for 6-digit readout |
| S5A | P8-U20 must be low to enable card<br>Remove for high or open enable |

| JUMPER | WHEN USED |
|---|---|
| S5C | P8-L20 must be low to enable card<br>Remove for high or open enable |
| S5E | P8-U19 must be low to enable card<br>Remove for high or open enable |
| S5G | P8-L19 must be low to enable card<br>Remove for high or open enable |
| S6A, S6B,<br>S7A, S7B | Install for internal power<br>Remove for isolated power |
| S8A | Output data is negative-true<br>**OR** |
| S8B | Output data is positive-true |

## 13.3  INTERCONNECT BOARD

For mechanical support and electrical interconnection, each BCD board is shipped with a small 5-pin INTERCONNECT board. Insert onto the main board pins immediately behind the right-hand side of the display board. The BCD board itself (component side down) is then plugged into the interconnect board at J20, with the PCB connection fingers protruding from the case rear. For assembly detail, refer to Figure 5-5 (in Section 5).

## 13.4  50-LINE CABLE COMPATIBILITY

The 40 lines of the BCD connector are compatible with lines 9 through 48 of some 50-line busses (left-most 8 and right-most 2 are not used by this BCD option).

## 13.5  SELECTING THE SOURCE OF BCD DATA: "OUT.CNF"

If "L3C.7=0" has been selected to unlock the OUTput CoNFiguration byte, set "OUT.3=1" to send data to this BCD board. "OUT.4=0" selects that data as the DISPLAYED (current) measurement value. "OUT.4=1" sends the PEAK (HI) value to the BCD. Save your selection by pressing the 'MENU' button.

**13**

BCD Option

## 13.6 HOLD CONTROL

P8-U17 is the $\overline{\text{HOLD}}$ line, referenced to the same ground as the BCD outputs (on P8-L15 and P8-L3). Pulling this line low freezes the BCD outputs (useful for a slow reading device or asymmetric cable delays).

When released, all 6 digits of the BCD data are updated together.

## 13.7 DATA READY TIMING PULSES

The tri-state BCD outputs are always valid (to within a few nanoseconds; a single update pulse controls all the digits).

To generate a timing marker, P8-L16, $\overline{\text{DATA READY}}$, goes active low for approximately 200 microseconds at the time of each BCD update. The polarity of this line is NOT CHANGED by S8, the data polarity control jumper.

## 13.8 BRINGING OUT THE BCD OVERFLOW LINE

P8-U18 can be used for BCD OVERFLOW by inserting jumper S1A. If this line is used for another purpose by some other equipment on the BCD bus, remove this jumper.

## 13.9 3 DIGIT AT A TIME MULTIPLEX

When jumpers S2A, S3A, and S4A are used, P8-L20 and S5C control when the upper 3 digits of the 6-digit BCD value appear on the output line (P8-U9 through P8-L14).

With jumper S5C, a LOW level on P8-L20 activates those upper 3 digit outputs; a high or open level disables those digits.

With jumper S5C removed, a high or open level on P8-L20 enables those upper 3 digits and a low level disables them.

When the upper 3 digits are NOT enabled, the lower 3 digits can be enabled in just the same way by jumper S5A and P8-U20, and they now appear on the same 12 lines.

# 13

BCD Option

# 13.10  6 DIGIT AT A TIME CARD ADDRESS

Jumpers S2A and S4A are removed for full parallel (6-digit output).

If jumper S3A is installed, the outputs are enabled by line P8-L20 ALONE: a low level enables the outputs when jumper S5C is installed, and a high or open level does the job if S5C is removed.

When jumper S3A is removed, the outputs are enabled only when the selected 4-line address is applied to P8-U19, L19, U20 and L20. Each of these four is exclusive-OR'd with its jumper, and the following four outputs are AND'd to create a 1 of 16 enable code.

If jumper S5A is installed, P8-U20 must be LOW to enable the card (BIT 2).
If jumper S5C is installed, P8-L20 must be LOW to enable the card (BIT 1).
If jumper S5E is installed, P8-U19 must be LOW to enable the card (BIT 8).
If jumper S5G is installed, P8-L19 must be LOW to complete enabling the card outputs (BIT 4).

| BINARY BIT | 1 | 2 | 4 | 8 | | 1 | 2 | 4 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| JUMPER S5– | C | A | G | E | | C | A | G | E |
| 00 | X | X | X | X | 08 | X | X | X | |
| 01 | | X | X | X | 09 | | X | X | |
| 02 | X | | X | X | 10 | X | | X | |
| 03 | | | X | X | 11 | | | X | |
| 04 | X | X | | X | 12 | X | X | | |
| 05 | | X | | X | 13 | | X | | |
| 06 | X | | | X | 14 | X | | | |
| 07 | | | | X | 15 | | | | |

Figure 13-3. Address Programming Chart for 4-line Address

NOTE: "X" in chart indicates jumper that must be installed.

EXAMPLE: For a positive true address of 03, install jumpers S5-G and S5-E.

If any of these jumpers are removed, the corresponding line must go HIGH or OPEN to assist the card enable; if all four jumpers are missing, for example, the card outputs are enabled ONLY when all four lines are HIGH or OPEN, a ground on any of the four input lines causes the outputs to go to the high impedance state.

# 13

BCD Option

## 13.11 SELECT DATA POLARITY: JUMPER S8

Inserting the jumper in S8B (the usual shipping position) makes the output data (including decimal point code) positive-true.

Placing the jumper in S8A converts the data to negative-true.

## 13.12 DECIMAL POINT ADDRESS CODE

P8-U15, P8-L8 and P8-U8 output a 3-bit positive-true binary code for the location of the decimal point: "001" for the extreme right position and "110" for the extreme left position (just to the right of the left-hand digit).

Panel-mounted printers, however, may require an inverted/shifted decimal point code. You can create this by setting "OUT.5=1" in the "OUT.CNF" byte (unlocked by setting "L1C.7=0"), rather than the normal "OUT.5=0".

## 13.13 APPLYING NON-ISOLATED/ISOLATED POWER

Non-isolated power from the meter is connected to this board by inserting jumpers S6A, S6B, S7A, and S7B (bridging the isolation separation distance on the board). Current drawn is less than 10 mA.

To isolate these outputs from the other meter circuits, remove the four jumpers described earlier, and connect an external, nominal 5 V supply to P8-L17, with its ground return connected to P8-L15.

## 13.14 DRIVING A PRINTER

Direct connection of the 24 BCD lines and the 3 decimal point address lines is all that is needed for positive-true printers that accept a binary-coded decimal point address (which do not print the decimal point).

If your printer has more than 6 digits, tie the unused inputs to ground or V+ or leave open (whichever produces blanks in those locations).

For negative-true decimal point addresses, found in some panel-mounted printers, set "OUT.5=1" (part of menu item "OUT.CNF", unlocked by "L1C.7=0").

# 13

BCD Option

# Notes:

**13**

BCD Option

# 14. Relay Option

## 14.1 FEATURES OVERVIEW

1. Two isolated (354 V per IEC spacing, 500 V test) 7-ampere Form C electro-mechanical relays are provided on a small vertical board that plugs into J10 on the main board.

2. Each relay has its 3-pin screw-terminal connector protruding from the rear of the case. Each connector is keyed to prevent inadvertent insertion of the power screw terminal connector.

3. Clamp diodes to the V+ supply limit coil turn-off spikes.

4. 200 ohm, 2500pf snubbers are provided for each normally open contact.

5. Relay 1 can be driven by either SP1 or SP3.

6. Relay 2 can be driven by either SP2 or SP4.

Figure 14-1 shows the board connections and jumper locations.



| P6 | |
|---|---|
| 1 | RELAY 1 (N. O.) |
| 2 | RELAY 1 (COMMON) |
| 3 | RELAY 1 (N. C.) |

| P7 | |
|---|---|
| 1 | RELAY 2 (N. O.) |
| 2 | RELAY 2 (COMMON) |
| 3 | RELAY 2 (N. C.) |
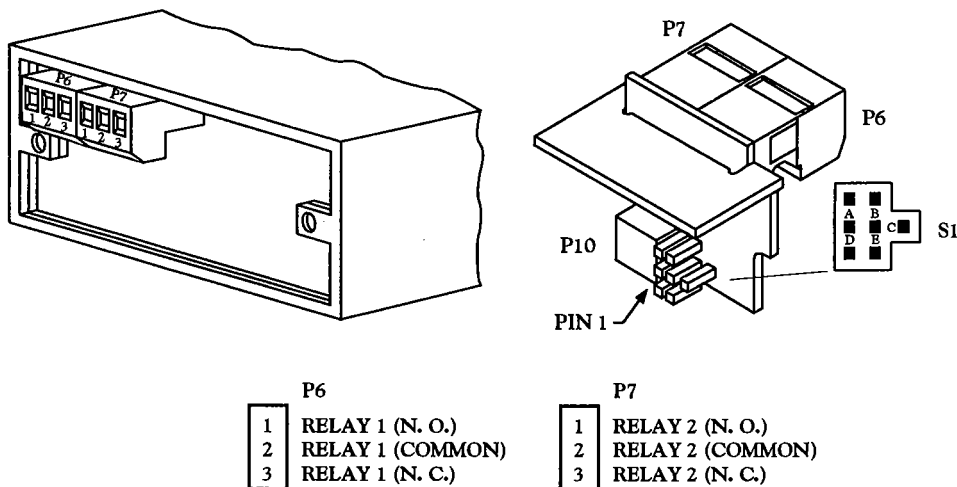
**14**

Relay Option

Figure 14-1. Relay Option Board

## 14.2  RELAY BOARD JUMPER TABLE

| JUMPER | FUNCTION |
|--------|----------|
| S1A*   | Drives Relay 1 from SP3 |
| S1B    | not used |
| S1C    | Drives Relay 2 from SP2 |
| S1D    | Drives Relay 1 from SP1 |
| S1E*   | Drives Relay 2 from SP4 |

* Factory preset jumper locations

# Notes:

_____

_____

_____

_____

_____

# 14

**Relay Option**

_____

_____

_____

# 15. RS-232 or RS-485 Option Board

## 15.1 FEATURES OVERVIEW

1. When you order either option board, you will also receive
   2 software diskettes (one 5-1/4" and one 3-1/2"), a complete
   configurations setup program, and a six foot communications
   cable that plugs into J4. Optional female 9-pin and 25-pin "D"
   computer connector-adapters are offered for either RS-232 or
   RS-422/485 hookup.

2. The communications board you ordered, plugs into the main
   board socket (P11 connects into J11 next to the transformer)
   with the 6-pin telephone socket. J4 is then protruding out of
   the rear of the case.

3. Install, run, establish communication and meter setup informa-
   tion are described in Section 15.3; screen error messages are
   described in Section 15.4 and a sample basic program to read the
   meter information to your screen is described in Section 15.5.

4. There are no jumpers on the RS-232 card (all software con-
   trolled with or without button programming).

5. Only 3 RS-422/485 jumpers (half/full duplex and impedance-
   matching resistors).

6. Choose baud rate from 300 to 19200. Standard factory setting
   is 9600.

7. Wide choice of commands and message formats available.

Figure 15-1 gives the board connections and pin designators for
RS-232.

RS-232 (P4) AT J4

| 1 | N/C |
| 2 | RTS |
| 3 | TX |
| 4 | RX |
| 5 | COMM GND |
| 6 | N/C |

J4

P11

PIN 1
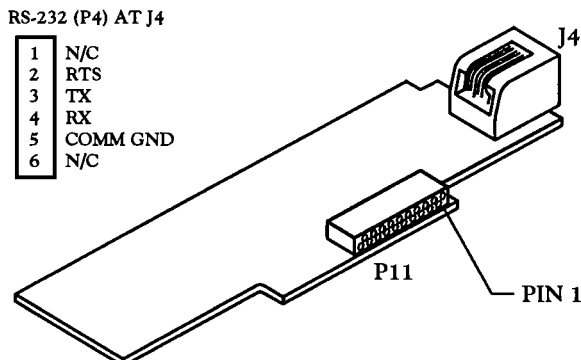
Figure 15-1. RS-232 Option Board

Figure 15-2 shows board connections and pin designators for RS-485.

RS-485 (P4) AT J4

| 1 | TX/RX (A) |
| 2 | TX/RX (B) |
| 3 | COMM GND |
| 4 | RX (A) |
| 5 | RX (B) |
| 6 | N/C |

S3

J4

S2

P11

PIN 1

S1
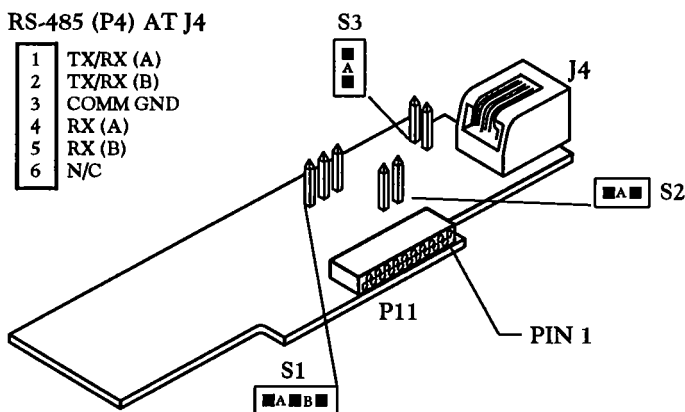
Figure 15-2. RS-485 Option Board

## 15.2  FRONT-PANEL PUSHBUTTON CONFIGURATION

Setup configuration can be accomplished via the front panel
buttons or via your computer if you use the configuration setup
program.  If you are going to use a computer, your choices include
"AUTO SET" or "MANUAL SET" for establishing communica-
tion with your meter.  "AUTO SET" cycles through the possible
combinations of baud rate, parity and stop bits to find a match for
your meter settings.  For faster action, you may enter the values for
your meter via "MANUAL SET". ·

If your meter communications settings are unknown or need
changing, you can insert the factory-set values with the front panel

buttons (or, after communications has been established, from your keyboard).

1. Unlock the communications bits by setting "L4C.1=0", "L4C.2=0", "L4C.3=0", "L4C.4=0" and "L4C.5=0".

2. Press the 'MENU' button until "BAUD" is displayed, then press the 'MAX' button until the baud rate you require is displayed. Press the 'MENU' button to store this choice and your meter will display "SERCNF".

3. Press the 'MIN' button until you see the display show "SER.1=0" for no parity, "SER.1=1" for odd parity, or "SER.1=2" for even parity. Press the 'MAX' button to select the parity required for your system. Once you have done that, press the 'MIN' button and advance to "SER.2=0" or "SER.2=1".

4. By pressing the 'MAX' button you can select the "SER.2" value. Setting "SER.2=0" picks the value to one stop bit; "SER.2=1" selects two stop bits. Select "SER.2=0".

5. Pressing the 'MENU' button stores these choices and then the meter advances to "ADDRES". Use the 'MAX' button to set to "001" (unless your meter is one of several on an RS-485 bus, in which case you must give a different address to each device and use those addresses when communicating from your computer).

6. Press the 'MENU' button again and press the 'RESET' button two times to return to the run mode. The remaining communications format and options are set from your keyboard.

## 15.3  INSTRUCTIONS FOR USING THE SETUP PROGRAM

1. Requirement: 640 K or more RAM and DOS 3.1 or higher.

2. Insert appropriate size diskette into your computer drive.

3. If you are using an LCD screen computer, at the DOS prompt "A:\>", "B:\>", or "C:\>", type "MODE MONO" (or, for some DOS version, type "MODE BW80"), then press 'ENTER'.

4. If loading from the floppy (rather than moving the program onto your hard disk, if any) with a CRT computer, at the DOS prompt "A:\>" or "B:\>", type "INF" and then press 'ENTER'.

5. To copy the program from floppy disk to the hard drive, at the DOS prompt "C:\>", type "MD INF" and press 'ENTER'. Now type "CD\INF" and press 'ENTER' again. Type "COPY A:*.*" (or "COPY B:*.*" for the other floppy drive) and press 'ENTER'.

To start the program, type "INF" and press 'ENTER'.

Your screen now displays a WELCOME message and the program begins to load into your RAM. (**NOTE:** Loading time can vary from seconds to 3 minutes depending on computer speed and the drive chosen; hard disk drives are the fastest).

When loading is completed, the COPYRIGHT screen appears. Press 'ESC' to go to the top level screen.

---

TOP-LEVEL MENU

GUIDE TO MENUS AND KEYSTROKES

SERIAL COMMUNICATIONS MENU

METER SETUP MENU

QUIT

---
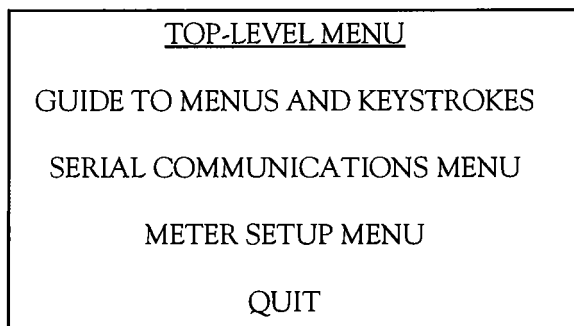
The GUIDE selection shows you all the different menus and keystrokes used in the program.

The SERIAL COMMUNICATIONS MENU is to be used before the SETUP MENU, to identify your meter, initialize the communication parameters, and establish communication with the meter.

The METER SETUP MENU is used AFTER communication with the meter is established and will lead you through the selection of all the meter features to specialize it to your application.

---

*WARNING: IF YOU ATTEMPT TO SEND THE METER SETUP DATA BEFORE ESTABLISHING COMMUNICATIONS, YOUR COMPUTER MAY LOCK UP (AND THEN YOU MUST START FROM THE BEGINNING BY REBOOTING THE SOFTWARE).*

---

After selecting SERIAL COMMUNICATIONS MENU (by moving the highlight to this line with your arrow keys and then pressing 'ENTER'), the screen shows:

```
COMMUNICATION PROTOCOL

RS-232 PROTOCOL

RS-485 PROTOCOL
```

Use your up or down arrow key, highlight your choice and press 'ENTER'. Now the screen shows:

```
SET RSxxx

AUTO SET

MANUAL SET
```

(where xxx is either 232 or 485).

If you choose:

AUTO SET with RS-232: the program will cycle through the possible choices of baud rate, parity, stop bits and recognition symbols in trying to talk to the meter.

**NOTE:** This takes some time, so be patient!

AUTO SET with RS-485: the only item necessary is the meter's address.

If you have selected MANUAL SET and pressed 'ENTER', the screen shows:

```
           RS-232 CONFIGURATION
COMMUNICATION PORT:              1
BAUD RATE:                       9600
PARITY:                          ODD
STOP BIT(S):                     ONE
TRANSMIT/RECEIVE
SWITCHING DELAY:                 100 ms
```

**OR**

# 15

```
┌─────────────────────────────────────┐
│      RS-485 CONFIGURATION            │
│  METER ADDRESS:            1         │
│  COMMUNICATION PORT:       1         │
│  BAUD RATE                9600       │
│  PARITY:                   ODD       │
│  STOP BIT(S):              ONE       │
│  TRANSMIT/RECEIVE                    │
│  SWITCHING DELAY          100 ms     │
└─────────────────────────────────────┘
```

The above values are the factory settings. If your meter differs, enter its values on this screen by moving the highlight with the arrow keys, changing values with the number keys, and storing each entry by pressing 'ENTER'.

After pressing 'ENTER', the program starts to establish communications with your meter.

When the program successfully establishes communication, your screen shows:

```
┌─────────────────────────────────────┐
│   COMMUNICATION ESTABLISHED         │
│   PLEASE PRESS 'ESC' TO CONTINUE    │
└─────────────────────────────────────┘
```

If, however, an error message is displayed instead, refer to Section 15.4 to interpret the message and start over again after correcting the error.

When you press 'ESC', the TOP LEVEL MENU is displayed again. Highlight "METER SETUP MENU" and press 'ENTER'.

You will now be guided through the different meter configuration selections required for your application such as "INPUT", "INPUT TYPE[2], etc.

After completing your selections, select 'SEND TO (THE METER)' on your screen and press 'ENTER'. The program now transmits the proper codes to load the meter's non-volatile memory with your choices.

If there is an error, you will be prompted with the appropriate flashing error message.

If the program completes successfully, you will see:

> COMMUNICATION COMPLETED
> PLEASE PRESS 'ESC' TO CONTINUE

You may now start to program another meter, make changes, or
select "QUIT" from the TOP LEVEL MENU, and then press
'ENTER'.

## 15.4  SCREEN ERROR MESSAGES

| MESSAGE | PROBABLE SOURCE |
|---|---|
| COMMUNICATION ERROR: | No meter response, so:<br><br>1. Hardware: bad connections, no meter power, bad cable, boards not inserted correctly, defective boards, etc.<br><br>2. Baud rate or stop bits mismatched between computer and meter.<br><br>3. Computer communications port not correct.<br><br>4. RS-485 meter address does not match. |
| PARITY ERROR: | Meter setting and computer selection do not agree. |
| COMMAND ERROR: | Command character wrong. |
| FORMAT ERROR: | Transmitted characters do not have proper length or are not valid characters. |
| CHECKSUM ERROR: | Noise causing errors in received characters. |

| MESSAGE | PROBABLE SOURCE |
|---|---|
| EEPROM LOCKOUT: | Meter not storing data: jumper S3A on main board is missing, or pin 10 on the meter's P2 rear connector is grounded. |
| DECIMAL POINT FRACTION TOO LARGE: | Selected decimal point location is too far to the left to permit READING OFFSET or SETPT value storage. Everything is stored here except the decimal point. |

**NOTE:** "ECHO" command mode is recommended for all communications since it always produces a response for successful communication. Otherwise, the program cannot warn you with a COMMUNICATION ERROR message.

# 15.5  SERIAL COMMUNICATIONS SAMPLE PROGRAM

The following sample program will allow you to send a request for information to the meter and receive a response.

**NOTE:** The codes in this sample program are found in the serial communications operators guide.

## 15.5.1  PROGRAM OBJECTIVES

1. Clear screen

2. Print "Enter a Command>"

3. Accept "X01" (requests unfiltered meter reading)

4. Accept "X02" (requests PEAK meter reading)

5. Accept "X03" (requests VALLEY meter reading)

6. Accept "X04" (requests filtered meter reading)

7. Accept any other command code and suffix, ("ccc") from list in the Serial Communications Operator's guide.

8. Screen echoes the chosen command

9. Computer sends request to meter

10. Stall for 0.5 seconds, then look for response

11. Put watchdog message on screen if no response in 10 seconds

12. Print meter response on screen

13. User selects Quit or more commands.

## 15.5.2   CODE AND [NOTES]

```
1000      CLS [Clear screen command]

1010      COMM$ = "COM1" [Label for communications
          port COM1]

1020      BAUD$ = "9600" [Label for choice of 9600 baud]

1030      PARITY$ = "0" [Label for Odd parity]

1040      STOPBT$ = "1" [Label for one stop bit]

1050      CLOSE #1 [Get ready to reopen #1]

1060      OPEN COMM$ + BAUD$ + "," + PARITY$ + ",7," +
          "CS,DS,RS" AS #1 [OPENS COM1]

1070      INPUT "ENTER A COMMAND >",CMD$
          [Prompts and Labels Input]

1080      IF CMD$ <>"^AE" THEN CMD$ = "*" + CMD$
          [Add recognition character unless command is that for
          setup data]

1090      PRINT CMD$ [Screen echoes command]

1100      PRINT #1, CMD$ [Send command to meter]

1110      N = 0 [Initialize watchdog]

1120      SOUND 32767,27:SOUND 32767,1:
          SOUND 32767,1 [Delay 0.5 seconds]

1130      N = N + 1 [Increment watchdog]

1140      IF N <> 20 THEN 1180 [Test for timeout]
```

**RS-232 or
RS-485
Option Board**

1150    INPUT "NO RESPONSE YET: TYPE 'C' TO
CONTINUE, 'Q' TO QUIT",B$ [10 second timeout]

1160    IF B$ = "Q" THEN 1230 [Exit if desired]

1170    N = 0 [Restart watchdog]

1180    IF LOC(1) = 0 THEN 1120 [Stall until buffer
has contents]

1190    A$ = INPUT$(LOC(1),#1)
[Read and label contents of COM1]

1200    PRINT A$ [Put data onto screen]

1210    INPUT "TYPE 'M' FOR MORE COMMANDS OR
'Q' TO QUIT", B$

1220    IF B$ = 'M' THEN 1070

1230    END

# 16. External Control Lines

P2, the 20-pin connector at the rear of the main board, connects to the setpoint transistor collectors and permits remote control of significant meter features.

The meter case label gives the names (abbreviated functions) of each of the twenty pins of P2, the center-bottom connector. Refer to Figure 16-1.



**P2**

| | | | |
|---|---|---|---|
| TARE (T) | 1 | 2 | PEAK (P) |
| VALLEY (V) | 3 | 4 | SWLIN2 |
| PEAK/VALLEY OR EXT. RESET | 5 | 6 | PUSH TO CAL |
| DIG GND | 7 | 8 | +5V |
| DISPLAY HOLD | 9 | 10 { | LOCKOUT EEPROM & |
| RESET ALARMS AND/OR | } 11 | | MENU PUSH BUTTON |
| PRINT COMMAND | | 12 | NONSTANDARD RX |
| NONSTANDARD TX | 13 | 14 | PUSH TO CAL |
| +V EXT | 15 | 16 | SP1 |
| SP2 | 17 | 18 | AL1 |
| AL2 | 19 | 20 | GND EXT |

Figure 16-1.  Connector Label Detail

## 16.1 TARE (PIN 1)

Tare is not available for the temperature meters.

## 16.2  PEAK (PIN 2)

When this is connected to P2-4 by an external switch, the meter displays the stored PEAK ("HI RDG") value rather than the current reading. The display flashes to distinguish this value.

## 16.3  VALLEY (PIN 3)

When this is connected to P2-4 by an external switch, the meter displays the stored valley ("LO RDG") value rather than the current reading. The display flashes to distinguish this value.

## 16.4  SWLIN2 (PIN 4)

Completes the circuit for any of the above three signals.

## 16.5  PEAK & VALLEY OR EXTERNAL RESET (PIN 5)

Connecting this to ground (P2-7) when "RDG.7=0" has been programmed causes a "HARD" RESET (when you see "RESET2" on the display). If you set "RDG.7=1", grounding causes only a PEAK/VALLEY RESET.

## 16.6  PUSH TO CAL (PIN 6)

Not applicable for temperature meters.

## 16.7  DIGITAL GROUND (PIN 7)

This is a non-isolated ground to be used for the digital controls provided on this P2 connector.

WARNING: THIS METER GROUND IS NOT ISOLATED FROM THE SIGNAL INPUT AND SHOULD NOT BE CONNECTED TO EXTERNALLY-GROUNDED DEVICES UNLESS ISOLATION IS PROVIDED EITHER AT THE SIGNAL INPUT OR AT THIS EXTERNAL-LOGIC CON-NECTION.

## 16.8  +5 V (PIN 8)

Up to 20 mA is available for driving external devices, but isolation should be provided if there is a possibility of common mode (ground) currents, since this supply is NOT isolated from the signal input.

## 16.9  DISPLAY HOLD (PIN 9)

Grounding this pin to P2-7 freezes the display value.  However, the meter continues to take new samples and update the other outputs, such as Analog Output, BCD, Setpoints/Alarms, and Peak/Valley.

## 16.10  LOCKOUT EEPROM (AND 'MENU' BUTTON) (PIN 10)

Grounding this pin to P2-7 stops any configuration changes and new storage into the non-volatile memory, and when in run mode does not allow entry into the setup mode when the 'MENU' button is pressed.

## 16.11  PRINT COMMAND AND/OR RESET OF ALARMS (PIN 11)

Grounding this pin to P2-7 when "BUS.8=1" has been programmed will initiate a meter printout via serial communications in the format previously selected.  If "ALC.8=1" it causes the alarm latches to reset.

## 16.12  NONSTANDARD RX (PIN 12) AND NONSTANDARD TX (PIN 13)

These two pins allow digital communications with the meter using 5 V CMOS logic levels and RS-232 protocols and format.  This access is normally reserved for specialized equipment communication in a calibration lab or at the factory.

## 16.13  PUSH TO CAL (PIN 14)

NOT USED

## 16.14  +V EXT (PIN 15)

This is the pin on which to bring in isolated external 5 to 30 V to power the snubbing diodes of the four setpoint/alarm open-collector transistors.

## 16.15  SP1 (PIN 16)

The open-collector of the first setpoint transistor (can carry 150 mA).

## 16.16  SP2 (PIN 17)

The open-collector of the second setpoint transistor (can carry 150 mA).

## 16.17  AL1 (PIN 18)

The open-collector of the third setpoint (first alarm) transistor (can carry 150 mA).

## 16.18  AL2 (PIN 19)

The open-collector of the fourth setpoint (second alarm) transistor (can carry 150 mA).

## 16.19  GND EXT (PIN 20)

This is the return to the external ground (P2-20) of the external power for the setpoint transistors and snubbing diodes brought in on P2-15, 16, 17, 18 and 19.  Figure 16-2 shows an example of a circuit using an external relay with SP1 (Setpoint 1).  If a solid state relay is used, delete connection to Pin 15.
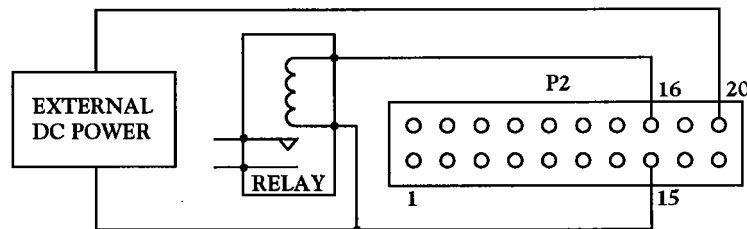


FIGURE 16-2. Connection of External Power for Setpoint Transistors

# 17. Troubleshooting - Display Messages and Troubleshooting Guide

A flashing alpha-numeric message in the display generally indicates an incorrect combination of jumpers and/or configuration values.

## 17.1 ERROR MODE MESSAGES

### 17.1.1 FLASHING "999999" (NUMERICAL OVERFLOW)

The maximum number of counts in the display cannot exceed –99999 or 999999. If, by moving the ACTIVE decimal point one or more places to the left, you cause the display to move beyond the maximum number of counts it is capable of showing (for example, 12345.0 to 12345.00), the display will indicate the overflow by flashing "999999".

### 17.1.2 FLASHING "ERR 01" (OFFSET OVERFLOW)

When an offset value has been entered and then the ACTIVE decimal point has been moved one or more places to the left, causing the offset display reading to move beyond the maximum number of counts it is capable of showing (for example, 1000.00 to 1000.000), the display will go into offset overflow.

NOTE: The meter will only display 6 digits (999999) maximum.

### 17.1.3 FLASHING "ERR 02" (SETPOINT OVERFLOW)

After a Setpoint (or Alarm) value has been entered and then the ACTIVE decimal point has been moved one or more places to the left, causing the setpoint display reading to move beyond the number of counts it is capable of showing (for example, setpoint at 100.00 and then a decimal point change to 100.0000), the display will indicate the SETPOINT OVERFLOW by momentarily flashing "ERR 02" before returning to the run mode.

NOTE: The meter will only display 6 digits (999999) maximum.

# 17

## Troubleshooting

### 17.1.4 "NOSTOR" & "STORED" (PROGRAMMING ENTRIES IN EEPROM)

If you are in the configuration mode and you make a CHANGE to any setup parameter (for example, changing "RDG.1 = 1" to "RDG.2 = 0") and press the 'MENU' button, the display will MOMENTARILY flash either "STORED" or "NOSTOR" and then go to the next menu item. If you are in a submenu, this will only occur when you press the 'MENU' button to go to the next menu item.

### 17.1.5 FLASHING "+OVLD" (POSITIVE INPUT OVERLOAD)

If the input signal exceeds the range selected (for example, 0-100 mV range selected and greater than 110 mV is applied to the input), the display will flash a "+OVLD".

### 17.1.6 FLASHING "+OPEN" (OPEN SENSOR INDICATION)

Coupled with the proper jumper selection, the display will indicate an open sensor.

### 17.1.7 FLASHING "-OPEN" (OPEN SENSOR INDICATION)

Coupled with the proper jumper selection, a "-OPEN" indicates the input is below the bottom limit of the range selected.

### 17.1.8 FLASHING "I OVSC" (INPUT OVERSCALE)

This display occurs when the input scale and/or offset applied to the input signal causes the display to go into a numerical overflow.

### 17.1.9 FLASHING "R OVSC" (READING OVERSCALE)

This display occurs when the reading scale and/or offset applied to the input signal causes the display to go into a numerical overflow.

### 17.1.10 FLASHING "CB OVF" (COUNT BY OVERFLOW)

When a display value near the maximum display capability is forced into a numerical overflow by changing the CNT BY menu (for example, the display reads 999997 and the count by is changed from 001 to 005 and rounds the display up to 1000000).

## 17.1.11 FLASHING "UOM.OVF" (UNIT OF MEASURE OVERFLOW)

If a unit of measure is selected and you are near the full scale capability of the display and in the ACTIVE decimal mode, the display will shift one digit to the left (for example, to a display of 1065.33 you add a unit of measure such as "F" for a display of 1065.33F), the display will flash "UOM.OVF".

# 17.2 TROUBLESHOOTING GUIDE

**"99999"**

POSSIBLE CAUSE: Active decimal point change driving the display into numerical overload.

TO CORRECT: Press the 'MAX' button to reset the entire display to all zeros, then enter a revised number into the submenu item that caused the overflow.

**"ERR 01"**

POSSIBLE CAUSE: Active decimal ("RDG.2=0") has been selected and/or DEC PT (decimal point) position has been moved one or more places to the left driving the programmed offset value into numerical overflow.

TO CORRECT: Press the 'MENU' button and the meter will show the left most decimal point position possible for the chosen offset: by pressing the 'MENU' button again this revised entry is stored.

Alternately, the amount of RDG.OF may be reduced to get the decimal point further to the left.

**"ERR 02"**

POSSIBLE CAUSE: Active decimal (RDG.2) has been selected and/or DEC PT (decimal point) position has been moved one or more places to the left driving the programmed Setpoint value into numerical overflow.

TO CORRECT: Display will flash "ERR 02" message for a short period of time, then automatically

# 17

### Troubleshooting

correct the setpoint's decimal point position and move to the next menu item. Press the 'SETPT' button until the meter displays flashing "999999". Then press the 'MAX' button to reset the display to "000000" and enter a new valid setpoint value.

**"+OVLD"**

POSSIBLE CAUSE: In the LINEAR (RTD) mode, jumpers S2A and S2F on the signal input board are installed and input signal exceeds 690 ohms or jumpers S2A and S2D are installed and the input signal exceeds 6900 ohms. (Place the active decimal point all the way to the right side:"FFFFFF.").

TO CORRECT: Check both the input range and the actual input to find the error condition. To correct, either reduce the input or change jumpers to a higher input range for more input attenuation.

**"+OPEN"**

POSSIBLE CAUSE: Input sensor is open or broken, or the connection to the meter is open or broken. Input sensor is not wired to the proper input terminals.

TO CORRECT: Check thermocouple or RTD wiring.

**"-OPEN"**

POSSIBLE CAUSE: The input sensor is open or broken, or the connection to the meter is open or broken. The input sensor is not wired to the proper input terminals. The input signal is below the minimum specified (refer to Section 18, Specifications).

TO CORRECT: When jumper S2R on the signal input board is used, this will be indicated if a sensor lead is broken or otherwise opened. Check thermocouple or RTD wiring.

**"I OVSC"**

POSSIBLE CAUSE: The input scale and/or offset values chosen are large enough to drive the display into numerical overflow.

TO CORRECT:     Reduce the input and/or the input scaling/
                offset. Refer to "IN.SC.OF" in
                Section 9.2.5.

**"R OVSC"**

POSSIBLE CAUSE:  The reading scale and/or offset values
                 chosen are large enough to drive the display
                 into numerical overflow.

TO CORRECT:     Reduce the READING scale/offset and/or
                move the active decimal point to the right.
                Reducing INPUT scale/offset is not required,
                because the input overscale message has
                higher priority than this message and would
                be displayed if there were an input
                overscale.

**"CB OVF"**

POSSIBLE CAUSE:  CNT BY (count by value) has been
                 changed causing the display to round up to
                 a numerical overflow.

TO CORRECT:     Reduce the "CNT BY" count by value
                to 001. If you have an active decimal point
                selected, move the decimal point one or
                more positions to the right.

**"UOM.OVF"**

POSSIBLE CAUSE:  Selection of unit of measure displayed
                 ("RDG.6=0") moves the display reading
                 one place to the left causing a numerical
                 overflow.

TO CORRECT:     If you have an active decimal point, move
                the decimal point position one or more
                positions to the right.

**"SERIAL"**

POSSIBLE CAUSE:  A configuring change has been attempted
                 via the front panel buttons while the serial
                 communications port is actively communi
                 cating with the meter.

TO CORRECT:     Either lockout the front panel buttons by
                removing the jumpers S3A & S3C or
                disconnect the serial communications
                option.

# 17

**Troubleshooting**

# Notes:

# 18. Specifications

## 18.1 THERMOCOUPLE INPUT

| TC Type | Degrees, Temperature : Accuracy | |
|---------|---------------------------------|---|
| | Celsius | Fahrenheit |
| J | −210 to 760 : 0.2 | −346 to 1400 : 0.3 |
| K | −270 to 1372 : 0.2 | −454 to 2500 : 0.3 |
| E | −270 to 1000 : 0.2 | −454 to 1832 : 0.3 |
| T | −270 to 400 : 0.2 | −454 to 752 : 0.3 |
| N | −270 to 1300 : 0.2 | −454 to 2372 : 0.3 |
| R | −50 to 1768 : 0.2 | −58 to 3214 : 0.3 |
| S | −50 to 1768 : 0.2 | −58 to 3214 : 0.3 |
| B | +100 to 1820 : 0.3 | +212 to 3300 : 0.5 |
| DIN J | −200 to 900 : 0.6 | −328 to 1652 : 1.0 |

> **NOTE:** For accurate full scale measurements below −40 degrees, you may need to complete the full scale cold junction calibration procedure (Refer to Section 6.7.2, Special Cold-Junction Calibration).

Calibration: NIST #125, DIN 43710

Reference Junction: Either a remote ice-point cell or an oven can be used in place of the supplied Cold-Junction Compensation Board. Curvalinear correction to better than 40 dB ambient-temperature rejection.

## 18.2 RTD INPUT

| RTD Type | Temperature : Accuracy | |
|----------|------------------------|---|
| | Celsius | Fahrenheit |
| Pt100 NIST | −200 to 850 : 0.2 | −328 to 1562 : 0.3 |
| Pt100 DIN | −200 to 900 : 0.2 | −328 to 1652 : 0.3 |
| Cu10 (Linear) | −200 to 200 : 1.0 | −328 to 392 : 2.0 |

# 18

## Specifications

(Either of the two linearizations or the non-linearized scaling may be applied to RTDs with R-zero values as low as 10 ohms or as high as 1000 ohms, using field calibration and selection of excitation and input range.)

| | |
|---|---|
| RESOLUTION: | 1, 0.1, 0.01 |
| VOLTAGE EXCITATION: | |
| Transmitters: | 24 V, to 25 mA |
| CURRENT: | 160 µA, factory calibrated, auto-compensation |
| EXCITATION: | 1.6 mA, can be field calibrated with EEPROM storage (RTDs or OHMS): |

LEAD RESISTANCE (for specified accuracy)

| | |
|---|---|
| THERMOCOUPLES: | to 100 ohms, total |
| 2-wire 100 ohm RTD | 50 milliohms/lead |
| 3-wire 100 ohm RTD: | 5 ohms/lead, balanced |
| 4-wire 100 ohm RTD: | 10 ohms total, unbalanced |

## 18.3 GENERAL

| | |
|---|---|
| SCALE: | Celsius (C), Fahrenheit (F), or Kelvin (K) (programmable units display) |
| | +0.000001 to +500000 or –0.0001 to –99999, multiplier capability both before and after linearization (for transmitter input); also for conversion of any ohmic sensor to engineering units. |
| OFFSET: | Zero to +999999 or –99999, both before and after linearization (for transmitter input); also for offsets of resistance inputs. |
| POLARITY: | Automatic Input range jumpered for –10/+110% or –55/+55% of selected span |

# NOISE REJECTION

| | |
|---|---|
| NMR: | 60 dB, 50 or 60 Hz, + selected filter |
| CMR: | 120 dB |
| CMV: | 1500 V peak test, 354 V per IEC spacing |

|  |  |
|---|---|
| ACCURACY at 25°C: | |
| MAX ERROR: | ±0.005% of reading |
| SPAN TEMPCO: | less than 20 ppm/deg C |
| STEP RESPONSE: | 1 second to 99.9% |
| WARMUP: | 55 minutes to rated accuracy. It is recommended that the unit be continuously running to insure its accuracy. |

# 18

Specifications
———————————————

## CONVERSION

| | |
|---|---|
| TECHNIQUE: | Dual-slope |
| | READ RATE/Programmable |
| INTEGRATION TIME: | 3 samples/sec: 100msec |
| | 12 samples/sec, 60 Hz: 16.7msec |
| | 11 samples/sec, 50 Hz: 20msec |

## DISPLAY

| | |
|---|---|
| LEDs: | 6, 0.54" (13.8mm)h, red, 14-segment |
| | 4, 0.12" x 0.24" (3 x 6mm), red lamp |
| SYMBOLS: | –.8.8.8.8.8. or 8.8.8.8.8.8. |
| DECIMAL POINT POSITION: | Programmable |

## COMMUNICATIONS INFORMATION

| | |
|---|---|
| BREAK PROTECTION: | Up- or down-scale, programmable |
| OUTPUTS (STANDARD): | 4, TTL isolated open-collector; 150 mA at 1V sink; 30 V open |
| BCD OUTPUT: (OPTIONAL) | Tri-state, TTL/CMOS compatible; internal 5 V supply for non-isolated, external 5 V supply for isolated. |

| | |
|---|---|
| DUAL RELAYS: (OPTIONAL) | Form C, 7A at 30V dc or 230VA ac (Resistive) |
| ANALOG OUTPUT: (OPTIONAL) | 0-5 V, 1-5 V, 0-10 V, 0-20 mA, 4-20 mA level; compliance, 12 V at 20 mA; 15-bit resolution; 0.1% accuracy; programmable zero and span. |

# 18

## Specifications

## TURNDOWN RATIO

| | |
|---|---|
| (MAX OFFSET- MIN SPAN): | 1000 with 0.1% or 100 with 0.01% resolution |
| RS-232 COMMUNICATIONS: (OPTIONAL) | RJ11 4-wire connection; complete program setup and message display capability; programmable to transmit current display, alarm status, min/max, and status |
| BAUD RATES: | 300, 600, 1200, 2400, 4800, 9600, 19200 |
| RS-485 COMMUNICATIONS: (OPTIONAL) | RJ12 6-wire connection; addressable from "000" to "199". |
| BAUD RATES: | 300, 600, 1200, 2400, 4800, 9600, 19200 |

## FLASHING MESSAGES

DURING PROGRAMMING (configuration mode)

| | |
|---|---|
| NUMERICAL OVERFLOW: | "999999" |
| OFFSET OVERFLOW: | "ERR 01" |
| SETPOINT OVERFLOW: | "ERR 02" |
| NOT STORED IN EEPROM: | "NOSTOR" |
| VALUE PUT IN EEPROM: | "STORED" |

DURING MEASUREMENT (RUN MODE)

| | |
|---|---|
| INPUT TOO LARGE, POSITIVE: | "+ OVLD" |
| INPUT TOO LARGE, NEGATIVE: | "– OVLD" |
| INPUT OUT OF RANGE, POSITIVE: | "+ OPEN" |
| INPUT OUT OF RANGE, NEGATIVE: | "– OPEN" |
| EXCESS INPUT SCALE/OFFSET: | "I OVSC" |
| EXCESS DISPLAY SCALE/OFFSET: | "R OVSC" |
| COUNT-BY DISPLAY OVERFLOW: | "999999" |

# 18

**Specifications**

DURING SETPOINT ADJUST (RUN MODE)

| | |
|---|---|
| OUT OF SELECTED DIGIT RANGE: | "999999" |
| NOT STORED IN EEPROM: | "NOSTOR" |
| VALUE PUT IN EEPROM: | "STORED" |

**POWER**

| | |
|---|---|
| AC VOLTAGES: | 115 V ±10%, 60/60 Hz or<br>230 V ±10% (RMS) |
| DC VOLTAGE: | 9.5 to 32 V at nominal line:<br>5 W with no options, 10W loaded |

ENVIRONMENTAL

| | |
|---|---|
| OPERATING TEMP RANGE: | 32 to 122°F (0 TO 50°C) |
| STORAGE TEMP RANGE: | –40 to 185°F (–40 to 85°C) |
| HUMIDITY: | up to 90% non-condensing at<br>104° F (40° C) |
| FRONT-PANEL: | NEMA-4 rated |

**MECHANICAL**

# 18

Specifications

DIMENSIONS (H x W x D): 1.89" x 3.78" x 5.86"
(48mm x 96mm x 148.8mm)
(add 0.27 inches or 6.8mm depth
for Cold-Junction Compensation
Board). Refer to Figure 18-1 for
the dimensions of the standard
meter with the bezel. Refer to
Figure 18-2 for dimensions of the
basic meter with the optional
bezel.

WEIGHT: 1.316 pounds (600 g)

MATERIAL: 94V-0 UL-rated Polycarbonate

Dimensions in inches (mm)

RTD
5.86
(148.8)
MAX

TC
6.13
(155.7)
MAX

TC PROTECTIVE COVER

TOP VIEW

1.89
(48.0)

.70
(17.8)

CASE

5.23
(132.8)

SLEEVE

SIDE VIEW
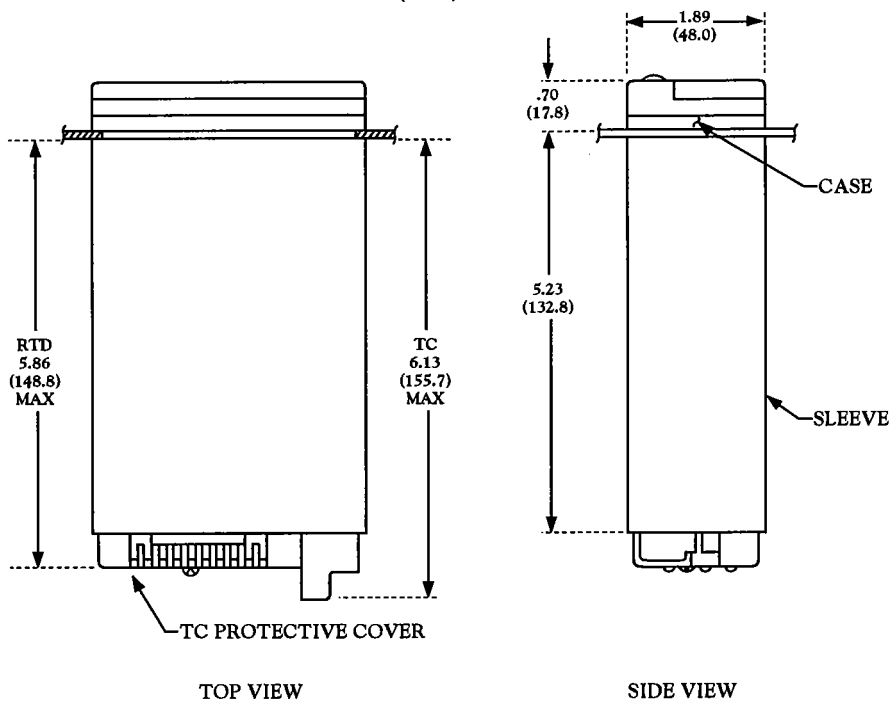
Figure 18-1. Meter Dimensions

**18**
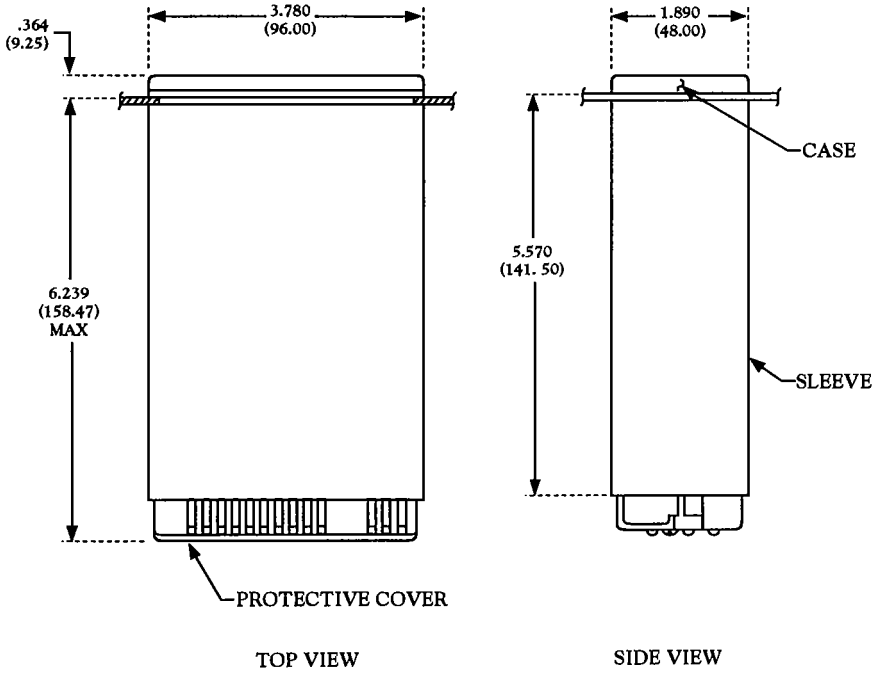
Figure 18-2. Meter Dimensions Optional ("OH") Housing

# Notes:

# 18

**Specifications**

# 19. Factory Preset Values

**JUMPER POSITIONS:**

Thermocouple
S1: C             S2: A, F, J, K, O, S
S3: A, C          S4: NONE

RTD
S1: NONE          S2: A, F, H, P, S
S3: A, C          S4: None

**LOCKOUT CONFIGURATION(S)**

| L1 CNF   | L2 CNF   | L3 CNF   | L4 CNF   |
|----------|----------|----------|----------|
| L1C.1=0  | L2C.1=0  | L3C.1=0  | L4C.1=0  |
| L1C.2=0  | L2C.2=0  | L3C.2=0  | L4C.2=0  |
| L1C.3=0  | L2C.3=0  | L3C.3=0  | L4C.3=0  |
| L1C.4=0  | L2C.4=0  | L3C.4=0  | L4C.4=0  |
| L1C.5=0  | L2C.5=0  | L3C.5=0  | L4C.5=0  |
| L1C.6=0  | L2C.6=0  | L3C.6=0  | L4C.6=1  |
| L1C.7=0  | L2C.7=0  | L3C.7=0  | L4C.7=0  |
| L1C.8=0  | L2C.8=0  | L3C.8=0  |          |

Input Class:     For Thermocouple: "TC"
                 For RTD: "RTD"

Input Type:      For Thermocouple: "K"
                 For RTD: "3PT385"

Reading Configuration "RDG.CNF":
RDG.1=1       RDG.2=0       RDG.3=0       RDG.4=1
RDG.5=1       RDG.6=1       RDG.7=0

Reading Scale & Offset
(2-Coordinate Format):
INPUT 1= 00000.0      READ 1= 00000.0
INPUT 2= 10000.0      READ 2= 10000.0

Input Configuration "IN CNF":
INP.1=0       INP.2=0       INP.3=0       INP.4=0
INP.5=0       INP.6=0       INP.7=0

# 19

## Factory Preset Values

Input Scale and Offset "IN.SC.OF":
    INPUT 1: 00000.0      READ 1: 00000.0
    INPUT 2: 10000.0      READ 2: 10000.0

Decimal Point "DEC PT" Position:  FFFFF.F

Count By "CNT BY": 001

Filter Configuration "FIL.CNF": FIL.1=0 FIL.2=1 FIL.3=1

Filter Time Constant "FIL TI": 064

Setpoint Configuration "SP CNF":
| SPC.1=0 | SPC.2=0 | SPC.3=1 | SPC.4=0 |
|---------|---------|---------|---------|
| SPC.5=0 | SPC.6=1 | SPC.7=0 | SPC.8=0 |

Alarm Configuration "AL CNF":
| ALC.1=0 | ALC.2=0 | ALC.3=1 | ALC.4=0 |
|---------|---------|---------|---------|
| ALC.5=0 | ALC.6=1 | ALC.7=0 | ALC.8=0 |

Alarm Function "AL FNC":
| ALF.1=0 | ALF.2=0 | ALF.3=0 | ALF.4=0 |
|---------|---------|---------|---------|

Alarm Number of Readings "AL RDG":   03 03 for (AL1) (AL2)

Setpoints 1 & 2 Deadband "SP DB":     0020

Alarms 1 & 2 Deadband "AL DB":     0020

Output Configuration "OUT.CNF":
| OUT.1=0 | OUT.2=1 | OUT.3=0 | OUT.4=0 |
|---------|---------|---------|---------|
| OUT.5=1 | OUT.6=0 | | |

Output Scale and Offset "OT.SC.OF":
    READ 1: 00000.0    OUTPT 1: 04.0000
    READ 2: 10000.0    OUTPT 2: 20.0000

Baud Rate "BAUD": 09600

Serial Communication Configuration "SERCNF":
    SER.1=1    SER.2=0

Address "ADDRES" (for RS-485):    001

Data Format "DAT FT":

| | | | |
|---|---|---|---|
| DAT.1=0 | DAT.2=0 | DAT.3=1 | DAT.4=0 |
| DAT.5=0 | DAT.6=0 | DAT.7=0 | DAT.8=0 |

Bus Format "BUS FT":

| | | | |
|---|---|---|---|
| BUS.1=0 | BUS.2=0 | BUS.3=1 | BUS.4=0 |
| BUS.5=1 | BUS.6=0 | BUS.7=0 | BUS.8=1 |

Serial Count "SERCNT": 00001

## ANALOG OUTPUT

| | |
|---|---|
| CAL VZ: | _____ |
| CAL VS: | _____ |
| CAL mAZ: | _____ |
| CAL mAS: | _____ |

## TC COLD-JUNCTION OFFSET

| MENU | SUB MENU | DESCRIPTION |
|---|---|---|
| CJUN.OF: | _____ | Calibration of TC offset. Enter offset = 270 x error in degrees C if positive; or = −270 x error in degrees C + 32767 if negative. |

# Notes:

# 19

**Factory
Preset
Values**

# 20. Record Your Setup Values

**JUMPER POSITIONS:**

Thermocouple
S1: _____    S2: _____
S3: _____    S4: Not used

RTD
S1: _____    S2: _____
S3: _____    S4: Not used

**LOCKOUT CONFIGURATION(S)**

| L1 CNF | L2 CNF | L3 CNF | L4 CNF |
|---|---|---|---|
| L1C.1=___ | L2C.1=___ | L3C.1=___ | L4C.1=___ |
| L1C.2=___ | L2C.2=___ | L3C.2=___ | L4C.2=___ |
| L1C.3=___ | L2C.3=___ | L3C.3=___ | L4C.3=___ |
| L1C.4=___ | L2C.4=___ | L3C.4=___ | L4C.4=___ |
| L1C.5=___ | L2C.5=___ | L3C.5=___ | L4C.5=___ |
| L1C.6=___ | L2C.6=___ | L3C.6=___ | L4C.6=___ |
| L1C.7=___ | L2C.7=___ | L3C.7=___ | L4C.7=___ |
| L1C.8=___ | L2C.8=___ | L3C.8=___ | |

Input Class:       "TC": _____
(check one)        "RTD": _____

Input Type:        For Thermocouple: _____
                   For RTD: _____

Reading Configuration "RDG.CNF":
RDG.1=__        RDG.2=__        RDG.3=__        RDG.4=__
RDG.5=__        RDG.6=__        RDG.7=__

Reading Scale and Reading Offset "RDG SC" and "RDG OF"
(Direct Format):
   Reading Scale "RDG SC": _____
   Reading Offset "RDG OF": _____

Reading Scale & Offset
(2-coordinate Format):
   INPUT 1= _____      READ 1= _____
   INPUT 2= _____      READ 2= _____

# 20

**Record your
Setup Values**

---

**Input Configuration "IN CNF":**
  INP.1=__  INP.2=__  INP.3=__  INP.4=__
  INP.5=__  INP.6=__  INP.7=__

**Input Scale and Offset "IN.SC.OF":**
  INPUT 1: _____  READ 1: _____
  INPUT 2: _____  READ 2: _____

**Decimal Point "DEC PT" Position:**  F__F__F__F__F__F__

**Count By "CNT BY":** _____

**Filter Configuration "FIL.CNF":** FIL.1=__ FIL.2=__ FIL.3=__

**Filter Time Constant "FIL TI":** _____

**Setpoint Configuration "SP CNF":**
  SPC.1=__ SPC.2=__ SPC.3=__ SPC.4=__
  SPC.5=__ SPC.6=__ SPC.7=__ SPC.8=__

**Alarm Configuration "AL CNF":**
  ALC.1=__ ALC.2=__ ALC.3=__ ALC.4=__
  ALC.5=__ ALC.6=__ ALC.7=__ ALC.8=__

**Alarm Function "AL FNC":**
  ALF.1=__ ALF.2=__ ALF.3=__ ALF.4=__

**Alarm Number of Readings "AL RDG":** _____ _____

**Setpoints Deadband "SP DB":** _____

**Alarms 1 & 2 Deadband "AL DB":** _____

**Output Configuration "OUT.CNF":**
  OUT.1=__  OUT.2=__  OUT.3=__  OUT.4=__
  OUT.5=__  OUT.6=__  OUT.7=__  OUT.8=__

**Output Scale and Offset "OT.SC.OF":**
  READ 1: _____  OUTPT 1: _____
  READ 2: _____  OUTPT 2: _____

**Baud Rate "BAUD":** _____

**Serial Communication Configuration "SERCNF":**
    SER.1=__       SER.2=__

**Address "ADDRES" (for RS-485): _____**

**Data Format "DAT FT":**

| | | | |
|---|---|---|---|
| DAT.1=__ | DAT.2=__ | DAT.3=__ | DAT.4=__ |
| DAT.5=__ | DAT.6=__ | DAT.7=__ | DAT.8=__ |

**Bus Format "BUS FT":**

| | | | |
|---|---|---|---|
| BUS.1=__ | BUS.2=__ | BUS.3=__ | BUS.4=__ |
| BUS.5=__ | BUS.6=__ | BUS.7=__ | BUS.8=__ |

**Serial Count "SERCNT": _____**

# 20

## ANALOG OUTPUT

| | |
|---|---|
| CAL VZ: | _____ |
| CAL VS: | _____ |
| CAL mAZ: | _____ |
| CAL mAS: | _____ |

## TC COLD-JUNCTION OFFSET

| MENU | SUB MENU | DESCRIPTION |
|---|---|---|
| CJUN.OF: | _____ | Calibration of TC offset. Enter offset = 270 x error in degrees C if positive; or = –270 x error in degrees C + 32767 if negative. |

# Notes:

# 20

**Record your
Setup Values**

# 21. Appendices

## APPENDIX A
## TYPE J MICROVOLTS AT EACH 10 DEGREES CELSIUS

| TEMP | μVOLT | TEMP | μVOLT | TEMP | μVOLT |
|------|-------|------|-------|------|-------|
| -210 | -8095.6 | 150 | 8008.1 | 500 | 27388.2 |
| -200 | -7890.5 | 160 | 8560.3 | 510 | 27948.7 |
| -190 | -7658.7 | 170 | 9113.4 | 520 | 28510.9 |
| -180 | -7402.2 | 180 | 9667.2 | 530 | 29075.1 |
| -170 | -7122.4 | 190 | 10221.7 | 540 | 29641.5 |
| -160 | -6821.0 | 200 | 10776.5 | 550 | 30210.3 |
| -150 | -6499.3 | 210 | 11331.7 | 560 | 30781.6 |
| -140 | -6158.8 | 220 | 11887.0 | 570 | 31355.7 |
| -130 | -5800.6 | 230 | 12442.4 | 580 | 31932.7 |
| -120 | -5426.0 | 240 | 12997.7 | 590 | 32512.7 |
| -110 | -5036.2 | 250 | 13552.9 | 600 | 33096.0 |
| -100 | -4632.1 | 260 | 14107.9 | 610 | 33682.7 |
| - 90 | -4214.8 | 270 | 14662.7 | 620 | 34272.9 |
| - 80 | -3785.2 | 280 | 15217.2 | 630 | 34866.7 |
| - 70 | -3344.1 | 290 | 15771.3 | 640 | 35464.3 |
| - 60 | -2892.5 | 300 | 16325.1 | 650 | 36065.6 |
| - 50 | -2431.0 | 310 | 16878.5 | 660 | 36670.8 |
| - 40 | -1960.4 | 320 | 17431.5 | 670 | 37279.9 |
| - 30 | -1481.4 | 330 | 17984.2 | 680 | 37892.9 |
| - 20 | - 994.6 | 340 | 18536.5 | 690 | 38509.7 |
| - 10 | - 500.6 | 350 | 19088.5 | 700 | 39130.2 |
| 0 | 0 | 360 | 19640.2 | 710 | 39754.4 |
| 10 | 506.7 | 370 | 20191.8 | 720 | 40382.0 |
| 20 | 1019.0 | 380 | 20743.2 | 730 | 41012.9 |
| 30 | 1536.4 | 390 | 21294.5 | 740 | 41646.8 |
| 40 | 2058.4 | 400 | 21845.9 | 750 | 42283.2 |
| 50 | 2584.8 | 410 | 22397.4 | 760 | 42922.0 |
| 60 | 3115.0 | 420 | 22949.1 | | |
| 70 | 3648.7 | 430 | 23501.2 | | |
| 80 | 4185.6 | 440 | 24053.8 | | |
| 90 | 4725.4 | 450 | 24607.1 | | |
| 100 | 5267.7 | 460 | 25161.1 | | |
| 110 | 5812.3 | 470 | 25716.1 | | |
| 120 | 6358.8 | 480 | 26272.1 | | |
| 130 | 6907.1 | 490 | 26829.5 | | |
| 140 | 7456.9 | | | | |

**21**

Appendix

# APPENDIX B
## TYPE K MICROVOLTS AT EACH 10 DEGREES CELSIUS

**21**

Appendix

| TEMP | μVOLT | TEMP | μVOLT | TEMP | μVOLT |
|------|-------|------|-------|------|-------|
| -270 | -6457.8 | 130 | 5327.4 | 530 | 21919.1 |
| -260 | -6441.2 | 140 | 5733.5 | 540 | 22345.5 |
| -250 | -6403.7 | 150 | 6137.2 | 550 | 22771.9 |
| -240 | -6343.9 | 160 | 6538.9 | 560 | 23198.3 |
| -230 | -6261.9 | 170 | 6939.2 | 570 | 23624.4 |
| -220 | -6158.5 | 180 | 7338.4 | 580 | 24050.4 |
| -210 | -6034.6 | 190 | 7737.3 | 590 | 24476.2 |
| -200 | -5891.4 | 200 | 8136.6 | 600 | 24901.6 |
| -190 | -5729.6 | 210 | 8536.6 | 610 | 25326.7 |
| -180 | -5550.2 | 220 | 8937.8 | 620 | 25751.4 |
| -170 | -5353.8 | 230 | 9340.6 | 630 | 26175.6 |
| -160 | -5141.0 | 240 | 9745.2 | 640 | 26599.3 |
| -150 | -4912.5 | 250 | 10151.5 | 650 | 27022.4 |
| -140 | -4668.7 | 260 | 10559.6 | 660 | 27445.0 |
| -130 | -4410.3 | 270 | 10969.3 | 670 | 27866.9 |
| -120 | -4137.9 | 280 | 11380.7 | 680 | 28288.1 |
| -110 | -3852.0 | 290 | 11793.4 | 690 | 28708.6 |
| -100 | -3553.2 | 300 | 12207.4 | 700 | 29128.3 |
| -90 | -3242.3 | 310 | 12622.6 | 710 | 29547.2 |
| -80 | -2919.8 | 320 | 13038.7 | 720 | 29965.3 |
| -70 | -2586.3 | 330 | 13455.7 | 730 | 30382.5 |
| -60 | -2242.5 | 340 | 13873.6 | 740 | 30798.9 |
| -50 | -1889.1 | 350 | 14292.2 | 750 | 31214.3 |
| -40 | -1526.6 | 360 | 14711.6 | 760 | 31628.7 |
| -30 | -1155.9 | 370 | 15131.6 | 770 | 32042.2 |
| -20 | -777.4 | 380 | 15552.3 | 780 | 32454.7 |
| -10 | -391.9 | 390 | 15973.6 | 790 | 32866.3 |
| 0 | 0 | 400 | 16395.4 | 800 | 33276.8 |
| 10 | 397.0 | 410 | 16817.9 | 810 | 33686.3 |
| 20 | 798.1 | 420 | 17240.9 | 820 | 34094.7 |
| 30 | 1203.1 | 430 | 17664.4 | 830 | 34502.1 |
| 40 | 1611.4 | 440 | 18088.4 | 840 | 34908.5 |
| 50 | 2022.4 | 450 | 18512.8 | 850 | 35313.8 |
| 60 | 2435.7 | 460 | 18937.6 | 860 | 35718.1 |
| 70 | 2850.3 | 470 | 19362.8 | 870 | 36121.3 |
| 80 | 3265.7 | 480 | 19788.4 | 880 | 36523.5 |
| 90 | 3680.9 | 490 | 20214.1 | 890 | 36924.6 |
| 100 | 4095.3 | 500 | 20640.2 | 900 | 37324.7 |
| 110 | 4508.1 | 510 | 21066.4 | 910 | 37723.8 |
| 120 | 4919.0 | 520 | 21492.7 | 920 | 38121.8 |

# APPENDIX B (cont.)
## TYPE K MICROVOLTS AT EACH 10 DEGREES CELSIUS

| TEMP | μVOLT | TEMP | μVOLT |
|------|--------|------|--------|
| 930 | 38518.7 | 1330 | 53438.6 |
| 940 | 38914.7 | 1340 | 53782.4 |
| 950 | 39309.6 | 1350 | 54125.0 |
| 960 | 39703.4 | 1360 | 54466.4 |
| 970 | 40096.3 | 1370 | 54806.9 |
| 980 | 40488.1 | | |
| 990 | 40878.9 | | |
| 1000 | 41268.7 | | |
| 1010 | 41657.5 | | |
| 1020 | 42045.2 | | |
| 1030 | 42431.8 | | |
| 1040 | 42817.5 | | |
| 1050 | 43202.0 | | |
| 1060 | 43585.5 | | |
| 1070 | 43967.9 | | |
| 1080 | 44349.1 | | |
| 1090 | 44729.3 | | |
| 1100 | 45108.3 | | |
| 1110 | 45486.1 | | |
| 1120 | 45862.7 | | |
| 1130 | 46238.0 | | |
| 1140 | 46612.1 | | |
| 1150 | 46984.9 | | |
| 1160 | 47356.3 | | |
| 1170 | 47726.4 | | |
| 1180 | 48095.1 | | |
| 1190 | 48462.3 | | |
| 1200 | 48828.0 | | |
| 1210 | 49192.3 | | |
| 1220 | 49555.0 | | |
| 1230 | 49916.1 | | |
| 1240 | 50275.6 | | |
| 1250 | 50633.5 | | |
| 1260 | 50989.7 | | |
| 1270 | 51344.4 | | |
| 1280 | 51697.4 | | |
| 1290 | 52048.7 | | |
| 1300 | 52398.5 | | |
| 1310 | 52746.7 | | |
| 1320 | 53093.3 | | |

# 21

Appendix

# APPENDIX C
## TYPE T MICROVOLTS AT EACH 10 DEGREES CELSIUS

| TEMP | µVOLT | TEMP | µVOLT | TEMP | µVOLT |
|------|-------|------|-------|------|-------|
| -270 | -6257.6 | 0 | 0 | 250 | 12011.3 |
| -260 | -6231.8 | 10 | 390.9 | 260 | 12571.7 |
| -250 | -6180.5 | 20 | 789.4 | 270 | 13136.9 |
| -240 | -6105.1 | 30 | 1196.2 | 280 | 13706.8 |
| -230 | -6006.8 | 40 | 1611.4 | 290 | 14281.1 |
| -220 | -5888.5 | 50 | 2035.2 | 300 | 14859.8 |
| -210 | -5753.3 | 60 | 2467.5 | 310 | 15442.8 |
| -200 | -5602.9 | 70 | 2908.1 | 320 | 16030.0 |
| -190 | -5438.6 | 80 | 3356.8 | 330 | 16621.4 |
| -180 | -5260.6 | 90 | 3813.3 | 340 | 17216.8 |
| -170 | -5069.4 | 100 | 4277.3 | 350 | 17816.4 |
| -160 | -4865.2 | 110 | 4748.7 | 360 | 18419.9 |
| -150 | -4648.2 | 120 | 5227.0 | 370 | 19027.2 |
| -140 | -4418.7 | 130 | 5712.2 | 380 | 19638.2 |
| -130 | -4176.8 | 140 | 6204.1 | 390 | 20252.3 |
| -120 | -3922.6 | 150 | 6702.4 | 400 | 20869.2 |
| -110 | -3656.4 | 160 | 7207.0 | | |
| -100 | -3378.2 | 170 | 7717.8 | | |
| - 90 | -3088.6 | 180 | 8234.7 | | |
| - 80 | -2787.6 | 190 | 8757.5 | | |
| - 70 | -2475.4 | 200 | 9286.1 | | |
| - 60 | -2152.4 | 210 | 9820.3 | | |
| - 50 | -1818.7 | 220 | 10360.2 | | |
| - 40 | -1474.7 | 230 | 10905.4 | | |
| - 30 | -1120.7 | 240 | 11455.8 | | |
| - 20 | - 756.7 | | | | |
| - 10 | - 383.0 | | | | |

# 21

**Appendix**

# APPENDIX D
# TYPE E MICROVOLTS AT EACH 10 DEGREES CELSIUS

| TEMP | µVOLT | TEMP | µVOLT | TEMP | µVOLT |
|------|-------|------|-------|------|-------|
| -270 | -9835.0 | 170 | 11222.0 | 570 | 42661.9 |
| -260 | -9796.7 | 180 | 11948.7 | 580 | 43470.0 |
| -250 | -9718.6 | 190 | 12681.0 | 590 | 44277.6 |
| -240 | -9604.2 | 200 | 13418.6 | 600 | 45084.7 |
| -230 | -9455.2 | 210 | 14161.3 | 610 | 45891.1 |
| -220 | -9273.9 | 220 | 14908.8 | 620 | 46696.8 |
| -210 | -9062.9 | 230 | 15660.8 | 630 | 47501.8 |
| -200 | -8824.5 | 240 | 16417.2 | 640 | 48305.9 |
| -190 | -8560.8 | 250 | 17177.5 | 650 | 49109.2 |
| -180 | -8273.2 | 260 | 17941.8 | 660 | 49911.5 |
| -170 | -7963.1 | 270 | 18709.6 | 670 | 50712.8 |
| -160 | -7631.3 | 280 | 19480.9 | 680 | 51513.0 |
| -150 | -7278.9 | 290 | 20255.5 | 690 | 52312.2 |
| -140 | -6906.9 | 300 | 21033.1 | 700 | 53110.3 |
| -130 | -6515.9 | 310 | 21813.6 | 710 | 53907.2 |
| -120 | -6106.8 | 320 | 22596.9 | 720 | 54703.0 |
| -110 | -5680.2 | 330 | 23382.7 | 730 | 55497.5 |
| -100 | -5236.7 | 340 | 24170.9 | 740 | 56290.8 |
| - 90 | -4776.8 | 350 | 24961.4 | 750 | 57082.8 |
| - 80 | -4301.3 | 360 | 25754.0 | 760 | 57873.4 |
| - 70 | -3810.8 | 370 | 26548.5 | 770 | 58662.7 |
| - 60 | -3305.8 | 380 | 27344.9 | 780 | 59450.7 |
| - 50 | -2786.8 | 390 | 28143.0 | 790 | 60237.2 |
| - 40 | -2254.4 | 400 | 28942.7 | 800 | 61022.3 |
| - 30 | -1709.1 | 410 | 29743.9 | 810 | 61805.8 |
| - 20 | -1151.3 | 420 | 30546.3 | 820 | 62587.9 |
| - 10 | -581.5 | 430 | 31349.9 | 830 | 63368.3 |
| 0 | 0 | 440 | 32154.7 | 840 | 64147.1 |
| 10 | 591.3 | 450 | 32960.3 | 850 | 64924.3 |
| 20 | 1191.5 | 460 | 33766.9 | 860 | 65699.7 |
| 30 | 1800.8 | 470 | 34574.1 | 870 | 66473.3 |
| 40 | 2419.2 | 480 | 35381.9 | 880 | 67245.2 |
| 50 | 3046.8 | 490 | 36190.3 | 890 | 68015.1 |
| 60 | 3683.4 | 500 | 36999.0 | 900 | 68783.1 |
| 70 | 4328.9 | 510 | 37808.0 | 910 | 69549.1 |
| 80 | 4983.2 | 520 | 38617.1 | 920 | 70313.2 |
| 90 | 5646.0 | 530 | 39426.3 | 930 | 71075.3 |
| 100 | 6317.1 | 540 | 40235.5 | 940 | 71835.3 |
| 110 | 6996.1 | 550 | 41044.6 | 950 | 72593.4 |
| 120 | 7682.9 | 560 | 41853.4 | 960 | 73349.6 |
| 130 | 8377.1 | | | 970 | 74103.9 |
| 140 | 9078.4 | | | 980 | 74856.6 |
| 150 | 9786.5 | | | 990 | 75607.7 |
| 160 | 10501.2 | | | 1000 | 76357.5 |

# 21

Appendix

# APPENDIX E
# TYPE N MICROVOLTS AT EACH 10 DEGREES CELSIUS

For negative temperatures, AWG 28 data; above 400, AWG 14 data; between, linear blend).

| TEMP | µVOLT | TEMP | µVOLT | TEMP | µVOLT |
|---|---|---|---|---|---|
| -270 | -4345.2 | 100 | 2778.8 | 450 | 14844.0 |
| -260 | -4335.7 | 110 | 3077.6 | 460 | 15221.9 |
| -250 | -4313.3 | 120 | 3380.0 | 470 | 15601.0 |
| -240 | -4277.0 | 130 | 3686.0 | 480 | 15981.1 |
| -230 | -4226.5 | 140 | 3995.4 | 490 | 16362.3 |
| -220 | -4161.8 | 150 | 4308.2 | 500 | 16744.4 |
| -210 | -4083.0 | 160 | 4624.2 | 510 | 17127.4 |
| -200 | -3990.4 | 170 | 4943.3 | 520 | 17511.3 |
| -190 | -3884.4 | 180 | 5265.5 | 530 | 17896.1 |
| -180 | -3765.6 | 190 | 5590.6 | 540 | 18281.6 |
| -170 | -3634.3 | 200 | 5918.7 | 550 | 18667.9 |
| -160 | -3491.0 | 210 | 6249.6 | 560 | 19054.9 |
| -150 | -3336.2 | 220 | 6583.2 | 570 | 19442.6 |
| -140 | -3170.3 | 230 | 6919.5 | 580 | 19830.9 |
| -130 | -2993.9 | 240 | 7258.4 | 590 | 20219.9 |
| -120 | -2807.5 | 250 | 7599.9 | 600 | 20609.3 |
| -110 | -2611.5 | 260 | 7943.8 | 610 | 20999.3 |
| -100 | -2406.6 | 270 | 8290.1 | 620 | 21389.8 |
| - 90 | -2193.2 | 280 | 8638.7 | 630 | 21780.7 |
| - 80 | -1972.1 | 290 | 8989.5 | 640 | 22171.9 |
| - 70 | -1743.8 | 300 | 9342.4 | 650 | 22563.6 |
| - 60 | -1509.0 | 310 | 9697.3 | 660 | 22955.5 |
| - 50 | -1268.4 | 320 | 10054.3 | 670 | 23347.8 |
| - 40 | -1022.6 | 330 | 10413.1 | 680 | 23740.3 |
| - 30 | -772.2 | 340 | 10773.7 | 690 | 24132.9 |
| - 20 | -517.9 | 350 | 11136.1 | 700 | 24525.8 |
| - 10 | -260.3 | 360 | 11500.1 | 710 | 24918.8 |
| 0 | 0 | 370 | 11865.8 | 720 | 25311.9 |
| 10 | 262.5 | 380 | 12233.1 | 730 | 25705.0 |
| 20 | 527.6 | 390 | 12601.9 | 740 | 26098.2 |
| 30 | 795.8 | 400 | 12972.2 | 750 | 26491.4 |
| 40 | 1067.4 | 410 | 13343.9 | 760 | 26884.5 |
| 50 | 1342.8 | 420 | 13717.1 | 770 | 27277.6 |
| 60 | 1622.1 | 430 | 14091.5 | 780 | 27670.6 |
| 70 | 1905.4 | 440 | 14467.1 | 790 | 28063.4 |
| 80 | 2192.6 | | | | |
| 90 | 2483.8 | | | | |

## TYPE N MICROVOLTS AT EACH 10 DEGREES CELSIUS

| TEMP | µVOLT | TEMP | µVOLT |
|------|-------|------|-------|
| 800 | 28456.1 | 1150 | 41966.2 |
| 810 | 28848.7 | 1160 | 42342.2 |
| 820 | 29241.0 | 1170 | 42717.0 |
| 830 | 29633.2 | 1180 | 43091.1 |
| 840 | 30025.1 | 1190 | 43464.0 |
| 850 | 30416.7 | 1200 | 43836.3 |
| 860 | 30808.0 | 1210 | 44207.3 |
| 870 | 31199.1 | 1220 | 44577.7 |
| 880 | 31589.7 | 1230 | 44946.9 |
| 890 | 31980.1 | 1240 | 45314.7 |
| 900 | 32370.2 | 1250 | 45682.0 |
| 910 | 32759.8 | 1260 | 46048.3 |
| 920 | 33149.0 | 1270 | 46413.1 |
| 930 | 33538.0 | 1280 | 46776.8 |
| 940 | 33926.5 | 1290 | 47140.3 |
| 950 | 34314.5 | 1300 | 47502.1 |
| 960 | 34702.1 | | |
| 970 | 35089.3 | | |
| 980 | 35476.1 | | |
| 990 | 35862.3 | | |
| 1000 | 36248.1 | | |
| 1010 | 36633.4 | | |
| 1020 | 37018.2 | | |
| 1030 | 37402.4 | | |
| 1040 | 37786.2 | | |
| 1050 | 38169.5 | | |
| 1060 | 38552.0 | | |
| 1070 | 38934.1 | | |
| 1080 | 39315.3 | | |
| 1090 | 39696.2 | | |
| 1100 | 40076.5 | | |
| 1110 | 40456.0 | | |
| 1120 | 40834.6 | | |
| 1130 | 41212.6 | | |
| 1140 | 41589.9 | | |

# 21

Appendix

## APPENDIX F
## TYPE R MICROVOLTS AT EACH 10 DEGREES CELSIUS

21

Appendix

| TEMP | μVOLT | TEMP | μVOLT | TEMP | μVOLT |
|------|-------|------|-------|------|-------|
| -50 | -226.4 | 300 | 2400.1 | 700 | 6741.2 |
| -40 | -187.7 | 310 | 2497.8 | 710 | 6859.8 |
| -30 | -145.5 | 320 | 2596.3 | 720 | 6978.9 |
| -20 | -100.0 | 330 | 2695.4 | 730 | 7098.4 |
| -10 | - 51.5 | 340 | 2795.3 | 740 | 7218.5 |
| 0 | 0 | 350 | 2895.7 | 750 | 7339.0 |
| 10 | 54.3 | 360 | 2996.8 | 760 | 7460.0 |
| 20 | 111.2 | 370 | 3098.5 | 770 | 7581.5 |
| 30 | 170.6 | 380 | 3200.9 | 780 | 7703.5 |
| 40 | 232.4 | 390 | 3303.7 | 790 | 7825.9 |
| 50 | 296.5 | 400 | 3407.2 | 800 | 7948.8 |
| 60 | 362.7 | 410 | 3511.2 | 810 | 8072.2 |
| 70 | 431.0 | 420 | 3615.7 | 820 | 8196.0 |
| 80 | 501.2 | 430 | 3720.8 | 830 | 8320.3 |
| 90 | 573.3 | 440 | 3826.4 | 840 | 8445.1 |
| 100 | 647.2 | 450 | 3932.5 | 850 | 8570.3 |
| 110 | 722.8 | 460 | 4039.1 | 860 | 8691.0 |
| 120 | 800.0 | 470 | 4146.3 | 870 | 8822.2 |
| 130 | 878.8 | 480 | 4253.9 | 880 | 8948.8 |
| 140 | 959.1 | 490 | 4362.0 | 890 | 9075.8 |
| 150 | 1040.7 | 500 | 4470.6 | 900 | 9203.4 |
| 160 | 1123.7 | 510 | 4579.6 | 910 | 9331.3 |
| 170 | 1208.0 | 520 | 4689.2 | 920 | 9459.7 |
| 180 | 1293.6 | 530 | 4799.2 | 930 | 9588.6 |
| 190 | 1380.3 | 540 | 4909.7 | 940 | 9717.9 |
| 200 | 1468.1 | 550 | 5020.6 | 950 | 9847.7 |
| 210 | 1557.1 | 560 | 5132.0 | 960 | 9977.9 |
| 220 | 1647.1 | 570 | 5243.9 | 970 | 10108.6 |
| 230 | 1738.1 | 580 | 5356.2 | 980 | 10239.7 |
| 240 | 1830.0 | 590 | 5469.0 | 990 | 10371.2 |
| 250 | 1922.9 | 600 | 5582.3 | 1000 | 10503.2 |
| 260 | 2016.7 | 610 | 5696.0 | 1010 | 10635.6 |
| 270 | 2111.3 | 620 | 5810.1 | 1020 | 10768.4 |
| 280 | 2206.8 | 630 | 5924.6 | 1030 | 10901.7 |
| 290 | 2303.0 | 640 | 6039.8 | 1040 | 11035.4 |
| | | 650 | 6155.4 | 1050 | 11169.5 |
| | | 660 | 6271.6 | 1060 | 11304.1 |
| | | 670 | 6388.3 | 1070 | 11439.1 |
| | | 680 | 6505.4 | 1080 | 11574.5 |
| | | 690 | 6623.0 | 1090 | 11710.2 |

# TYPE R MICROVOLTS AT EACH 10 DEGREES CELSIUS

| TEMP | µVOLT | TEMP | µVOLT |
|------|-------|------|-------|
| 1100 | 11846.3 | 1450 | 16740.5 |
| 1110 | 11982.7 | 1460 | 16881.6 |
| 1120 | 12119.4 | 1470 | 17022.5 |
| 1130 | 12256.5 | 1480 | 17163.4 |
| 1140 | 12393.9 | 1490 | 17304.1 |
| 1150 | 12531.5 | 1500 | 17444.7 |
| 1160 | 12669.5 | 1510 | 17585.2 |
| 1170 | 12807.7 | 1520 | 17725.6 |
| 1180 | 12946.2 | 1530 | 17865.9 |
| 1190 | 13084.9 | 1540 | 18005.9 |
| 1200 | 13223.9 | 1550 | 18145.8 |
| 1210 | 13363.1 | 1560 | 18285.5 |
| 1220 | 13502.5 | 1570 | 18425.1 |
| 1230 | 13642.1 | 1580 | 18564.4 |
| 1240 | 13781.8 | 1590 | 18703.5 |
| 1250 | 13921.8 | 1600 | 18842.4 |
| 1260 | 14061.9 | 1610 | 18981.0 |
| 1270 | 14202.2 | 1620 | 19119.4 |
| 1280 | 14342.6 | 1630 | 19257.5 |
| 1290 | 14483.2 | 1640 | 19395.3 |
| 1300 | 14623.9 | 1650 | 19532.9 |
| 1310 | 14764.7 | 1660 | 19670.2 |
| 1320 | 14905.6 | 1670 | 19807.1 |
| 1330 | 15046.5 | 1680 | 19943.7 |
| 1340 | 15187.6 | 1690 | 20079.7 |
| 1350 | 15328.7 | 1700 | 20215.1 |
| 1360 | 15469.8 | 1710 | 20349.7 |
| 1370 | 15611.0 | 1720 | 20483.4 |
| 1380 | 15752.2 | 1730 | 20616.1 |
| 1390 | 15893.5 | 1740 | 20747.5 |
| 1400 | 16034.7 | 1750 | 20877.7 |
| 1410 | 16175.9 | 1760 | 21006.4 |
| 1420 | 16317.2 | | |
| 1430 | 16458.3 | | |
| 1440 | 16599.5 | | |

# 21

Appendix

# APPENDIX G
# TYPE S MICROVOLTS AT EACH 10 DEGREES CELSIUS

**21**

Appendix

| TEMP | μVOLT | TEMP | μVOLT | TEMP | μVOLT |
|------|-------|------|-------|------|-------|
| -50 | -235.7 | 350 | 2785.8 | 700 | 6274.3 |
| -40 | -194.4 | 360 | 2879.8 · | 710 | 6379.9 |
| -30 | -150.1 | 370 | 2974.2 | 720 | 6485.8 |
| -20 | -102.8 | 380 | 3069.0 | 730 | 6592.0 |
| -10 | - 52.7 | 390 | 3164.2 | 740 | 6698.6 |
| 0 | 0 | 400 | 3259.7 | 750 | 6805.5 |
| 10 | 55.2 | 410 | 3355.7 | 760 | 6912.7 |
| 20 | 112.8 | 420 | 3451.9 | 770 | 7020.2 |
| 30 | 172.7 | 430 | 3548.5 | 780 | 7128.1 |
| 40 | 234.7 | 440 | 3645.5 | 790 | 7236.3 |
| 50 | 298.6 | 450 | 3742.7 | 800 | 7344.9 |
| 60 | 364.6 | 460 | 3840.3 | 810 | 7453.7 |
| 70 | 432.3 | 470 | 3938.2 | 820 | 7562.9 |
| 80 | 501.7 | 480 | 4036.4 | 830 | 7672.4 |
| 90 | 572.8 | 490 | 4134.8 | 840 | 7782.3 |
| 100 | 645.3 | 500 | 4233.6 | 850 | 7892.5 |
| 110 | 719.4 | 510 | 4332.7 | 860 | 8003.0 |
| 120 | 794.8 | 520 | 4432.0 | 870 | 8113.8 |
| 130 | 871.5 | 530 | 4531.6 | 880 | 8225.0 |
| 140 | 949.5 | 540 | 4631.6 | 890 | 8336.5 |
| 150 | 1028.7 | 550 | 4731.8 | 900 | 8448.3 |
| 160 | 1108.9 | 560 | 4832.3 | 910 | 8560.5 |
| 170 | 1190.2 | 570 | 4933.1 | 920 | 8673.0 |
| 180 | 1272.6 | 580 | 5034.2 | 930 | 8785.8 |
| 190 | 1355.8 | 590 | 5135.6 | 940 | 8898.9 |
| 200 | 1440.0 | 600 | 5237.3 | 950 | 9012.4 |
| 210 | 1525.0 | 610 | 5339.4 | 960 | 9126.2 |
| 220 | 1610.9 | 620 | 5441.7 | 970 | 9240.3 |
| 230 | 1697.5 | 630 | 5544.5 | 980 | 9354.8 |
| 240 | 1784.9 | 640 | 5647.7 | 990 | 9469.6 |
| 250 | 1872.9 | 650 | 5751.3 | 1000 | 9584.7 |
| 260 | 1961.7 | 660 | 5855.3 | 1010 | 9700.2 |
| 270 | 2051.0 | 670 | 5959.5 | 1020 | 9815.9 |
| 280 | 2141.0 | 680 | 6064.1 | 1030 | 9932.0 |
| 290 | 2231.6 | 690 | 6169.0 | 1040 | 10048.5 |
| 300 | 2322.7 | | | 1050 | 10165.2 |
| 310 | 2414.3 | | | 1060 | 10282.3 |
| 320 | 2506.5 | | | 1070 | 10399.7 |
| 330 | 2599.1 | | | 1080 | 10517.4 |
| 340 | 2692.2 | | | 1090 | 10635.4 |

| TEMP | μVOLT | TEMP | μVOLT |
|------|-------|------|-------|
| 1100 | 10753.6 | 1500 | 15576.5 |
| 1110 | 10872.0 | 1510 | 15696.7 |
| 1120 | 10990.7 | 1520 | 15816.8 |
| 1130 | 11109.5 | 1530 | 15936.8 |
| 1140 | 11228.6 | 1540 | 16056.6 |
| 1150 | 11347.9 | 1550 | 16176.2 |
| 1160 | 11467.4 | 1560 | 16295.6 |
| 1170 | 11587.1 | 1570 | 16414.8 |
| 1180 | 11706.9 | 1580 | 16533.8 |
| 1190 | 11826.9 | 1590 | 16652.6 |
| 1200 | 11947.1 | 1600 | 16771.2 |
| 1210 | 12067.4 | 1610 | 16889.5 |
| 1220 | 12187.8 | 1620 | 17007.6 |
| 1230 | 12308.4 | 1630 | 17125.5 |
| 1240 | 12429.0 | 1640 | 17243.1 |
| 1250 | 12549.8 | 1650 | 17360.4 |
| 1260 | 12670.7 | 1660 | 17477.4 |
| 1270 | 12791.7 | 1670 | 17594.2 |
| 1280 | 12912.7 | 1680 | 17710.5 |
| 1290 | 13033.8 | 1690 | 17826.4 |
| 1300 | 13155.0 | 1700 | 17941.7 |
| 1310 | 13276.2 | 1710 | 18056.2 |
| 1320 | 13397.5 | 1720 | 18169.8 |
| 1330 | 13518.8 | 1730 | 18282.3 |
| 1340 | 13640.1 | 1740 | 18393.7 |
| 1350 | 13761.4 | 1750 | 18503.8 |
| 1360 | 13882.8 | 1760 | 18612.4 |
| 1370 | 14004.1 | | |
| 1380 | 14125.4 | | |
| 1390 | 14246.7 | | |
| 1400 | 14368.0 | | |
| 1410 | 14489.2 | | |
| 1420 | 14610.3 | | |
| 1430 | 14731.4 | | |
| 1440 | 14852.4 | | |
| 1450 | 14973.4 | | |
| 1460 | 15094.2 | | |
| 1470 | 15215.0 | | |
| 1480 | 15335.6 | | |
| 1490 | 15456.1 | | |

# 21

Appendix

# APPENDIX H
# TYPE B MICROVOLTS AT EACH 10 DEGREES CELSIUS

(Designed for negligible cold-junction voltage at room temperatures so that no compensation is required, Type B temperatures are displayed by the meter only above 100 degrees C (33 microvolts)).

**21**

Appendix

| TEMP | µVOLT | TEMP | µVOLT | TEMP | µVOLT |
|------|-------|------|-------|------|-------|
| 100 | 33.2 | 450 | 1001.8 | 800 | 3154.0 |
| 110 | 42.7 | 460 | 1047.8 | 810 | 3230.8 |
| 120 | 53.4 | 470 | 1094.8 | 820 | 3308.4 |
| 130 | 65.2 | 480 | 1142.7 | 830 | 3386.7 |
| 140 | 78.0 | 490 | 1191.6 | 840 | 3465.8 |
| 150 | 92.0 | 500 | 1241.5 | 850 | 3545.7 |
| 160 | 107.1 | 510 | 1292.3 | 860 | 3626.4 |
| 170 | 123.2 | 520 | 1344.0 | 870 | 3707.8 |
| 180 | 140.5 | 530 | 1396.7 | 880 | 3790.0 |
| 190 | 158.8 | 540 | 1450.3 | 890 | 3872.9 |
| 200 | 178.2 | 550 | 1504.8 | 900 | 3956.5 |
| 210 | 198.7 | 560 | 1560.3 | 910 | 4040.9 |
| 220 | 220.2 | 570 | 1616.6 | 920 | 4126.0 |
| 230 | 242.8 | 580 | 1673.9 | 930 | 4211.9 |
| 240 | 266.5 | 590 | 1732.1 | 940 | 4298.4 |
| 250 | 291.2 | 600 | 1791.2 | 950 | 4385.7 |
| 260 | 317.0 | 610 | 1851.2 | 960 | 4473.7 |
| 270 | 343.8 | 620 | 1912.1 | 970 | 4562.4 |
| 280 | 371.7 | 630 | 1973.8 | 980 | 4651.8 |
| 290 | 400.6 | 640 | 2036.5 | 990 | 4741.9 |
| 300 | 430.5 | 650 | 2100.0 | 1000 | 4832.6 |
| 310 | 461.5 | 660 | 2164.4 | 1010 | 4924.1 |
| 320 | 493.5 | 670 | 2229.6 | 1020 | 5016.2 |
| 330 | 526.6 | 680 | 2295.7 | 1030 | 5109.0 |
| 340 | 560.7 | 690 | 2362.7 | 1040 | 5202.5 |
| 350 | 595.8 | 700 | 2430.5 | 1050 | 5296.6 |
| 360 | 631.9 | 710 | 2499.1 | 1060 | 5391.4 |
| 370 | 669.0 | 720 | 2568.6 | 1070 | 5486.8 |
| 380 | 707.1 | 730 | 2639.0 | 1080 | 5582.9 |
| 390 | 746.2 | 740 | 2710.1 | 1090 | 5679.6 |
| 400 | 786.4 | 750 | 2782.1 | 1100 | 5776.9 |
| 410 | 827.5 | 760 | 2854.8 | 1110 | 5874.9 |
| 420 | 869.6 | 770 | 2928.4 | 1120 | 5973.4 |
| 430 | 912.7 | 780 | 3002.8 | 1130 | 6072.6 |
| 440 | 956.7 | 790 | 3078.0 | 1140 | 6172.4 |

# TYPE B MICROVOLTS AT EACH 10 DEGREES CELSIUS

| TEMP | μVOLT | TEMP | μVOLT |
|------|-------|------|-------|
| 1150 | 6272.8 | 1500 | 10094.0 |
| 1160 | 6373.7 | 1510 | 10209.7 |
| 1170 | 6475.3 | 1520 | 10325.5 |
| 1180 | 6577.4 | 1530 | 10441.5 |
| 1190 | 6680.1 | 1540 | 10557.7 |
| 1200 | 6783.3 | 1550 | 10674.0 |
| 1210 | 6887.1 | 1560 | 10790.5 |
| 1220 | 6991.4 | 1570 | 10907.1 |
| 1230 | 7096.3 | 1580 | 11023.7 |
| 1240 | 7201.7 | 1590 | 11140.5 |
| 1250 | 7307.6 | 1600 | 11257.4 |
| 1260 | 7414.0 | 1610 | 11374.3 |
| 1270 | 7521.0 | 1620 | 11491.3 |
| 1280 | 7628.4 | 1630 | 11608.2 |
| 1290 | 7736.3 | 1640 | 11725.2 |
| 1300 | 7844.6 | 1650 | 11842.2 |
| 1310 | 7953.4 | 1660 | 11959.1 |
| 1320 | 8062.7 | 1670 | 12076.1 |
| 1330 | 8172.4 | 1680 | 12192.9 |
| 1340 | 8282.6 | 1690 | 12309.7 |
| 1350 | 8393.2 | 1700 | 12426.3 |
| 1360 | 8504.1 | 1710 | 12542.9 |
| 1370 | 8615.5 | 1720 | 12659.4 |
| 1380 | 8727.3 | 1730 | 12775.7 |
| 1390 | 8839.4 | 1740 | 12891.8 |
| 1400 | 8951.9 | 1750 | 13007.8 |
| 1410 | 9064.8 | 1760 | 13123.6 |
| 1420 | 9178.0 | 1770 | 13239.1 |
| 1430 | 9291.5 | 1780 | 13354.5 |
| 1440 | 9405.3 | 1790 | 13469.6 |
| 1450 | 9519.4 | 1800 | 13584.5 |
| 1460 | 9633.8 | 1810 | 13699.1 |
| 1470 | 9748.5 | 1820 | 13813.5 |
| 1480 | 9863.4 | | |
| 1490 | 9978.6 | | |

# 21

Appendix

# APPENDIX I
## DIN TYPE J MICROVOLTS AT EACH 10 DEGREES CELSIUS

(From DIN 43710, with smoothing added)

| TEMP | µVOLT | TEMP | µVOLT | TEMP | µVOLT |
|------|-------|------|-------|------|-------|
| -200 | -8150.0 | 200 | 10950.0 | 600 | 33670.2 |
| -190 | -7858.0 | 210 | 11510.0 | 610 | 34259.8 |
| -180 | -7557.0 | 220 | 12069.8 | 620 | 34851.5 |
| -170 | -7247.7 | 230 | 12627.9 | 630 | 35444.7 |
| -160 | -6929.0 | 240 | 13187.5 | 640 | 36039.4 |
| -150 | -6596.5 | 250 | 13749.6 | 650 | 36637.7 |
| -140 | -6252.5 | 260 | 14314.1 | 660 | 37241.8 |
| -130 | -5898.8 | 270 | 14877.3 | 670 | 37853.2 |
| -120 | -5533.2 | 280 | 15439.1 | 680 | 38473.0 |
| -110 | -5148.9 | 290 | 15999.8 | 690 | 39096.0 |
| -100 | -4744.8 | 300 | 16560.0 | 700 | 39719.3 |
| - 90 | -4321.5 | 310 | 17120.1 | 710 | 40346.6 |
| - 80 | -3885.2 | 320 | 17680.0 | 720 | 40982.8 |
| - 70 | -3437.9 | 330 | 18240.0 | 730 | 41625.0 |
| - 60 | -2982.7 | 340 | 18800.0 | 740 | 42271.5 |
| - 50 | -2511.9 | 350 | 19360.1 | 750 | 42921.6 |
| - 40 | -2026.2 | 360 | 19920.9 | 760 | 43574.1 |
| - 30 | -1527.3 | 370 | 20481.1 | 770 | 4229.3 |
| - 20 | -1024.2 | 380 | 21039.9 | 780 | 44887.7 |
| - 10 | -515.4 | 390 | 21597.3 | 790 | 45550.1 |
| 0 | 0 | 400 | 22157.8 | 800 | 46220.0 |
| 10 | 521.0 | 410 | 22722.1 | 810 | 46891.3 |
| 20 | 1046.6 | 420 | 23290.2 | 820 | 47570.0 |
| 30 | 1577.7 | 430 | 23859.5 | 830 | 48252.0 |
| 40 | 2113.5 | 440 | 24429.4 | 840 | 48940.5 |
| 50 | 2650.4 | 450 | 25000.7 | 850 | 49630.4 |
| 60 | 3188.0 | 460 | 25571.0 | 860 | 50322.8 |
| 70 | 3728.5 | 470 | 26140.0 | 870 | 51020.0 |
| 80 | 4272.1 | 480 | 26707.5 | 880 | 51722.9 |
| 90 | 4817.9 | 490 | 27278.2 | 890 | 52430.5 |
| 100 | 5365.4 | 500 | 27852.8 | 900 | 53140.0 |
| 110 | 5917.0 | 510 | 28430.6 | | |
| 120 | 6472.2 | 520 | 29010.0 | | |
| 130 | 7030.5 | 530 | 29589.8 | | |
| 140 | 7589.9 | 540 | 30170.1 | | |
| 150 | 8149.8 | 550 | 30748.8 | | |
| 160 | 8709.9 | 560 | 31327.3 | | |
| 170 | 9269.9 | 570 | 31908.4 | | |
| 180 | 9830.0 | 580 | 32494.1 | | |
| 190 | 10390.0 | 590 | 33081.8 | | |

## APPENDIX J - DIN 43760 RTD (ALPHA = 0.00385) OHMS AT EACH 10 DEGREES CELSIUS

| TEMP | OHMS | TEMP | OHMS | TEMP | OHMS |
|------|------|------|------|------|------|
| -200 | 18.493 | 150 | 157.315 | 500 | 280.896 |
| -190 | 22.803 | 160 | 161.043 | 510 | 284.218 |
| -180 | 27.078 | 170 | 164.760 | 520 | 287.529 |
| -170 | 31.320 | 180 | 168.465 | 530 | 290.827 |
| -160 | 35.531 | 190 | 172.158 | 540 | 294.115 |
| -150 | 39.714 | 200 | 175.840 | 550 | 297.390 |
| -140 | 43.869 | 210 | 179.510 | 560 | 300.654 |
| -130 | 47.999 | 220 | 183.168 | 570 | 303.907 |
| -120 | 52.106 | 230 | 186.815 | 580 | 307.147 |
| -110 | 56.190 | 240 | 190.451 | 590 | 310.377 |
| -100 | 60.254 | 250 | 194.074 | 600 | 313.594 |
| - 90 | 64.299 | 260 | 197.686 | 610 | 316.800 |
| - 80 | 68.325 | 270 | 201.287 | 620 | 319.995 |
| - 70 | 72.335 | 280 | 204.876 | 630 | 323.177 |
| - 60 | 76.328 | 290 | 208.453 | 640 | 326.349 |
| - 50 | 80.307 | 300 | 212.019 | 650 | 329.508 |
| - 40 | 84.271 | 310 | 215.573 | 660 | 332.656 |
| - 30 | 88.222 | 320 | 219.115 | 670 | 335.792 |
| - 20 | 92.160 | 330 | 222.646 | 680 | 338.917 |
| - 10 | 96.086 | 340 | 226.166 | 690 | 342.030 |
| 0 | 100.000 | 350 | 229.673 | 700 | 345.132 |
| 10 | 103.902 | 360 | 233.169 | 710 | 348.222 |
| 20 | 107.793 | 370 | 236.654 | 720 | 351.300 |
| 30 | 111.672 | 380 | 240.127 | 730 | 354.367 |
| 40 | 115.539 | 390 | 243.588 | 740 | 357.422 |
| 50 | 119.395 | 400 | 247.038 | 750 | 360.466 |
| 60 | 123.239 | 410 | 250.476 | 760 | 363.497 |
| 70 | 127.072 | 420 | 253.902 | 770 | 366.518 |
| 80 | 130.893 | 430 | 257.317 | 780 | 369.527 |
| 90 | 134.702 | 440 | 260.720 | 790 | 372.524 |
| 100 | 138.500 | 450 | 264.112 | 800 | 375.509 |
| 110 | 142.286 | 460 | 267.492 | 810 | 378.483 |
| 120 | 146.061 | 470 | 270.860 | 820 | 381.445 |
| 130 | 149.824 | 480 | 274.217 | 830 | 384.396 |
| 140 | 153.575 | 490 | 277.563 | 840 | 387.335 |
|      |        |     |        | 850 | 390.263 |

# 21

Appendix

## APPENDIX K · NIST PT-100 (ALPHA = 0.00392)
## OHMS AT EACH 10 DEGREES CELSIUS

| TEMP | OHMS | TEMP | OHMS | TEMP | OHMS |
|---|---|---|---|---|---|
| -200 | 16.919 | 150 | 158.451 | 500 | 284.557 |
| -190 | 21.310 | 160 | 162.254 | 510 | 287.949 |
| -180 | 25.666 | 170 | 166.045 | 520 | 291.329 |
| -170 | 29.988 | 180 | 169.824 | 530 | 294.697 |
| -160 | 34.280 | 190 | 173.592 | 540 | 298.053 |
| -150 | 38.542 | 200 | 177.347 | 550 | 301.398 |
| -140 | 42.777 | 210 | 181.091 | 560 | 304.731 |
| -130 | 46.987 | 220 | 184.824 | 570 | 308.052 |
| -120 | 51.172 | 230 | 188.544 | 580 | 311.361 |
| -110 | 55.335 | 240 | 192.253 | 590 | 314.659 |
| -100 | 59.478 | 250 | 195.950 | 600 | 317.945 |
| - 90 | 63.601 | 260 | 199.635 | 610 | 321.219 |
| - 80 | 67.706 | 270 | 203.309 | 620 | 324.481 |
| - 70 | 71.793 | 280 | 206.971 | 630 | 327.732 |
| - 60 | 75.865 | 290 | 210.621 | 640 | 330.970 |
| - 50 | 79.921 | 300 | 214.259 | 650 | 334.198 |
| - 40 | 83.963 | 310 | 217.885 | 660 | 337.413 |
| - 30 | 87.991 | 320 | 221.500 | 670 | 340.617 |
| - 20 | 92.006 | 330 | 225.103 | 680 | 343.808 |
| - 10 | 96.009 | 340 | 228.700 | 690 | 346.989 |
| 0 | 100.000 | 350 | 232.274 | 700 | 350.157 |
| 10 | 103.979 | 360 | 235.842 | 710 | 353.314 |
| 20 | 107.946 | 370 | 239.398 | 720 | 356.458 |
| 30 | 111.902 | 380 | 242.942 | 730 | 359.591 |
| 40 | 115.845 | 390 | 246.475 | 740 | 362.713 |
| 50 | 119.777 | 400 | 249.996 | 750 | 365.823 |
| 60 | 123.698 | 410 | 253.505 | 760 | 368.920 |
| 70 | 127.606 | 420 | 257.002 | 770 | 372.007 |
| 80 | 131.503 | 430 | 260.488 | 780 | 375.081 |
| 90 | 135.388 | 440 | 263.961 | 790 | 378.143 |
| 100 | 139.261 | 450 | 267.423 | 800 | 381.194 |
| 110 | 143.123 | 460 | 270.874 | 810 | 384.234 |
| 120 | 146.972 | 470 | 274.312 | 820 | 387.261 |
| 130 | 150.810 | 480 | 277.739 | 830 | 390.277 |
| 140 | 154.637 | 490 | 281.154 | 840 | 393.280 |
| | | | | 850 | 396.273 |

# 22. Temperature Conversion Chart

| to F° | From | to C° | to F° | From | to C° | to F° | From | to C° |
|-------|------|-------|-------|------|-------|-------|------|-------|
| — | -458 | -272.22 | — | -378 | -227.78 | — | -298 | -183.33 |
| — | -456 | -271.11 | — | -376 | -226.67 | — | -296 | -182.22 |
| — | -454 | -270.00 | — | -374 | -225.56 | — | -294 | -181.11 |
| — | -452 | -268.89 | — | -372 | -224.44 | — | -292 | -180.00 |
| — | -450 | -267.78 | — | -370 | -223.33 | — | -290 | -178.89 |
| | | | | | | | | |
| — | -448 | -266.67 | — | -368 | -222.22 | — | -288 | -177.78 |
| — | -446 | -265.56 | — | -366 | -221.11 | — | -286 | -176.67 |
| — | -444 | -264.44 | — | -364 | -220.00 | — | -284 | -175.56 |
| — | -442 | -263.33 | — | -362 | -218.89 | — | -282 | -174.44 |
| — | -440 | -262.22 | — | -360 | -217.78 | — | -280 | -173.33 |
| | | | | | | | | |
| — | -438 | -261.11 | — | -358 | -216.67 | — | -278 | -172.22 |
| — | -436 | -260.00 | — | -356 | -215.56 | — | -276 | -171.11 |
| — | -434 | -258.89 | — | -354 | -214.44 | — | -274 | -170.00 |
| — | -432 | -257.78 | — | -352 | -213.33 | -457.6 | -272 | -168.89 |
| — | -430 | -256.67 | — | -350 | -212.22 | -454.0 | -270 | -167.78 |
| | | | | | | | | |
| — | -428 | -255.56 | — | -348 | -211.11 | -450.4 | -268 | -166.67 |
| — | -426 | -254.44 | — | -346 | -210.00 | -446.8 | -266 | -165.56 |
| — | -424 | -253.33 | — | -344 | -208.89 | -443.2 | -264 | -164.44 |
| — | -422 | -252.22 | — | -342 | -207.78 | -439.6 | -262 | -163.33 |
| — | -420 | -251.11 | — | -340 | -208.67 | -436.0 | -260 | -162.22 |
| | | | | | | | | |
| — | -418 | -250.00 | — | -338 | -205.56 | -432.4 | -258 | -161.11 |
| — | -416 | -248.89 | — | -336 | -204.44 | -428.8 | -256 | -160.00 |
| — | -414 | -247.78 | — | -334 | -203.33 | -425.2 | -254 | -158.89 |
| — | -412 | -248.67 | — | -332 | -202.22 | -421.6 | -252 | -157.78 |
| — | -410 | -245.56 | — | -330 | -201.11 | -418.0 | -250 | -156.67 |
| | | | | | | | | |
| — | -408 | -244.44 | — | -328 | -200.00 | -414.4 | -248 | -155.56 |
| — | -406 | -243.33 | — | -326 | -198.89 | -410.8 | -246 | -154.44 |
| — | -404 | -242.22 | — | -324 | -197.78 | -407.2 | -244 | -153.33 |
| — | -402 | -241.11 | — | -322 | -196.67 | -403.6 | -242 | -152.22 |
| — | -400 | -240.00 | — | -320 | -195.56 | -400.0 | -240 | -151.11 |
| | | | | | | | | |
| — | -398 | -238.89 | — | -318 | -194.44 | -396.4 | -238 | -150.00 |
| — | -396 | -237.78 | — | -316 | -193.33 | -392.8 | -236 | -148.89 |
| — | -394 | -236.67 | — | -314 | -192.22 | -389.2 | -234 | -147.78 |
| — | -392 | -235.56 | — | -312 | -191.11 | -385.6 | -232 | -146.67 |
| — | -390 | -234.44 | — | -310 | -190.00 | -382.0 | -230 | -145.56 |
| | | | | | | | | |
| — | -388 | -233.33 | — | -308 | -188.89 | -378.4 | -228 | -144.44 |
| — | -386 | -232.22 | — | -306 | -187.78 | -374.8 | -226 | -143.33 |
| — | -384 | -231.11 | — | -304 | -186.67 | -371.2 | -224 | -142.22 |
| — | -382 | -230.00 | — | -302 | -185.56 | -367.6 | -222 | -141.11 |
| — | -380 | -228.89 | — | -300 | -184.44 | -364.0 | -220 | -140.00 |

**22**

Temperature
Conversion
Chart

# 22

## Temperature Conversion Chart

| to F° | From | to C° | to F° | From | to C° | to F° | From | to C° |
|---|---|---|---|---|---|---|---|---|
| -360.4 | -218 | -138.89 | -216.4 | -138 | -94.44 | -72.4 | -58 | -50.00 |
| -356.8 | -216 | -137.78 | -212.8 | -136 | -93.33 | -68.8 | -56 | -48.89 |
| -353.2 | -214 | -136.67 | -209.2 | -134 | -92.22 | -65.2 | -54 | -47.78 |
| -349.6 | -212 | -135.56 | -205.6 | -132 | -91.11 | -61.6 | -52 | -46.67 |
| -346.0 | -210 | -134.44 | -202.0 | -130 | -90.00 | -58.0 | -50 | -45.56 |
| | | | | | | | | |
| -360.4 | -208 | -133.33 | -198.4 | -128 | -88.89 | -54.4 | -48 | -44.44 |
| -356.8 | -206 | -132.22 | -194.8 | -126 | -87.78 | -50.8 | -46 | -43.33 |
| -353.2 | -204 | -131.11 | -191.2 | -124 | -86.67 | -47.2 | -44 | -42.22 |
| -349.6 | -202 | -130.00 | -187.6 | -122 | -85.56 | -43.6 | -42 | -41.11 |
| -346.0 | -200 | -128.89 | -184.0 | -120 | -84.44 | -40.0 | -40 | -40.00 |
| | | | | | | | | |
| -324.4 | -198 | -127.78 | -180.4 | -118 | -83.33 | -36.4 | -38 | -38.89 |
| -320.8 | -196 | -126.67 | -176.8 | -116 | -82.22 | -32.8 | -36 | -37.78 |
| -317.2 | -194 | -125.56 | -173.2 | -114 | -81.11 | -29.2 | -34 | -36.67 |
| -313.6 | -192 | -124.44 | -169.6 | -112 | -80.00 | -25.6 | -32 | -35.56 |
| -310.0 | -190 | -123.33 | -166.0 | -110 | -78.89 | -22.0 | -30 | -34.44 |
| | | | | | | | | |
| -306.4 | -188 | -122.22 | -162.4 | -108 | -77.78 | -18.4 | -28 | -33.33 |
| -302.8 | -186 | -121.11 | -158.8 | -106 | -76.67 | -14.8 | -26 | -32.22 |
| -299.2 | -184 | -120.00 | -155.2 | -104 | -75.56 | -11.2 | -24 | -31.11 |
| -295.6 | -182 | -118.89 | -151.6 | -102 | -74.44 | -7.6 | -22 | -30.00 |
| -292.0 | -180 | -117.78 | -148.0 | -100 | -73.33 | -4.0 | -20 | -28.89 |
| | | | | | | | | |
| -288.4 | -178 | -116.67 | -144.4 | -98 | -72.22 | -0.4 | -18 | -27.78 |
| -284.8 | -176 | -115.56 | -140.8 | -96 | -71.11 | +3.2 | -16 | -26.67 |
| -281.2 | -174 | -114.44 | -137.2 | -94 | -70.00 | +6.8 | -14 | -25.56 |
| -277.6 | -172 | -113.33 | -133.6 | -92 | -68.89 | +10.4 | -12 | -24.44 |
| -274.0 | -170 | -112.22 | -130.0 | -90 | -67.78 | +14.0 | -10 | -23.33 |
| | | | | | | | | |
| -270.4 | -168 | -111.11 | -126.4 | -88 | -66.67 | +17.6 | -8 | -22.22 |
| -266.8 | -166 | -110.00 | -122.8 | -86 | -65.56 | +21.2 | -6 | -21.11 |
| -263.2 | -164 | -108.89 | -119.2 | -84 | -64.44 | +24.8 | -4 | -20.00 |
| -259.6 | -162 | -107.78 | -115.6 | -82 | -63.33 | +28.4 | -2 | -18.89 |
| -256.0 | -160 | -106.67 | -112.0 | -80 | -62.22 | +32.0 | 0 | -17.78 |
| | | | | | | | | |
| -252.4 | -158 | -105.56 | -108.4 | -78 | -61.11 | +35.6 | +2 | -16.67 |
| -248.8 | -156 | -104.44 | -104.8 | -76 | -60.00 | +39.2 | +4 | -15.56 |
| -245.2 | -154 | -103.33 | -101.2 | -74 | -58.89 | +42.8 | +6 | -14.44 |
| -241.6 | -152 | -102.22 | -97.6 | -72 | -57.78 | +46.4 | +8 | -13.33 |
| -238.0 | -150 | -101.11 | -94.0 | -70 | -56.67 | +50.0 | +10 | -12.22 |
| | | | | | | | | |
| -234.4 | -148 | -100.00 | -90.4 | -68 | -55.56 | +53.6 | +12 | -11.11 |
| -230.8 | -146 | -98.89 | -86.8 | -66 | -54.44 | +57.2 | +14 | -10.00 |
| -227.2 | -144 | -97.78 | -83.2 | -64 | -53.33 | +60.8 | +16 | -8.89 |
| -223.6 | -142 | -96.67 | -79.6 | -62 | -52.22 | +64.4 | +18 | -7.78 |
| -220.0 | -140 | -95.56 | -76.0 | -60 | -51.11 | +66.0 | +20 | -6.67 |

| to F° | From | to C° | to F° | From | to C° | to F° | From | to C° |
|-------|------|-------|-------|------|-------|-------|------|-------|
| +71.6 | +22 | -5.56 | 215.6 | 102 | 38.89 | 359.6 | 182 | 83.33 |
| +75.2 | +24 | -4.44 | 219.2 | 104 | 40.00 | 363.2 | 184 | 84.44 |
| +78.8 | +26 | -3.33 | 222.8 | 106 | 41.11 | 366.8 | 186 | 85.56 |
| +82.4 | +28 | -2.22 | 226.4 | 108 | 42.22 | 370.4 | 188 | 86.67 |
| +86.0 | +30 | -1.11 | 230.0 | 110 | 43.33 | 374.0 | 190 | 87.78 |
| | | | | | | | | |
| +89.6 | +32 | 0.00 | 233.6 | 112 | 44.44 | 377.6 | 192 | 88.89 |
| +93.2 | +34 | +1.11 | 237.2 | 114 | 45.56 | 381.2 | 194 | 90.00 |
| +96.8 | +36 | +2.22 | 240.8 | 116 | 46.67 | 384.8 | 196 | 91.11 |
| +100.4 | +38 | +3.33 | 244.4 | 118 | 47.78 | 388.4 | 198 | 92.22 |
| +104.0 | +40 | +4.44 | 248.0 | 120 | 48.89 | 392.0 | 200 | 93.33 |
| | | | | | | | | |
| 107.6 | 42 | 5.56 | 251.6 | 122 | 50.00 | 395.6 | 202 | 94.44 |
| 111.2 | 44 | 6.67 | 255.2 | 124 | 51.11 | 399.2 | 204 | 95.56 |
| 114.2 | 46 | 7.78 | 258.8 | 126 | 52.22 | 402.8 | 206 | 96.67 |
| 118.4 | 48 | 8.89 | 262.4 | 128 | 53.33 | 406.4 | 208 | 97.78 |
| 122.0 | 50 | 10.00 | 266.0 | 130 | 54.44 | 410.0 | 210 | 98.89 |
| | | | | | | | | |
| 125.6 | 52 | 11.11 | 269.6 | 132 | 55.56 | 413.6 | 212 | 100.00 |
| 129.2 | 54 | 12.22 | 273.2 | 134 | 56.67 | 417.2 | 214 | 101.11 |
| 132.8 | 56 | 13.33 | 276.8 | 136 | 57.78 | 420.8 | 216 | 102.22 |
| 136.4 | 58 | 14.44 | 280.4 | 138 | 58.89 | 424.4 | 218 | 103.33 |
| 140.0 | 60 | 15.56 | 284.0 | 140 | 60.00 | 428.0 | 220 | 104.44 |
| | | | | | | | | |
| 143.6 | 62 | 16.67 | 287.6 | 142 | 61.11 | 431.6 | 222 | 105.56 |
| 147.2 | 64 | 17.78 | 291.2 | 144 | 62.22 | 435.2 | 224 | 106.67 |
| 150.8 | 66 | 18.89 | 294.8 | 146 | 63.33 | 438.8 | 226 | 107.78 |
| 154.4 | 68 | 20.00 | 298.4 | 148 | 64.44 | 442.4 | 228 | 108.89 |
| 158.0 | 70 | 21.11 | 302.0 | 150 | 65.56 | 446.0 | 230 | 110.00 |
| | | | | | | | | |
| 161.6 | 72 | 22.22 | 305.6 | 152 | 66.67 | 449.6 | 232 | 111.11 |
| 165.2 | 74 | 23.33 | 309.2 | 154 | 67.78 | 453.2 | 234 | 112.22 |
| 168.8 | 76 | 24.44 | 312.8 | 156 | 68.89 | 456.8 | 236 | 113.33 |
| 172.4 | 78 | 25.56 | 316.4 | 158 | 70.00 | 460.4 | 238 | 114.44 |
| 176.0 | 80 | 26.67 | 320.0 | 160 | 71.11 | 464.0 | 240 | 115.56 |
| | | | | | | | | |
| 179.6 | 82 | 27.78 | 323.6 | 162 | 72.22 | 467.6 | 242 | 116.67 |
| 183.2 | 84 | 28.89 | 327.2 | 164 | 73.33 | 471.2 | 244 | 117.78 |
| 186.8 | 86 | 30.00 | 330.8 | 166 | 74.44 | 474.8 | 246 | 118.89 |
| 190.4 | 88 | 31.11 | 334.4 | 168 | 75.56 | 478.4 | 248 | 120.00 |
| 194.0 | 90 | 32.22 | 338.0 | 170 | 76.67 | 482.0 | 250 | 121.11 |
| | | | | | | | | |
| 197.6 | 92 | 33.33 | 341.6 | 172 | 77.78 | 485.6 | 252 | 122.22 |
| 201.2 | 94 | 34.44 | 345.2 | 174 | 78.89 | 489.2 | 254 | 123.33 |
| 204.8 | 96 | 35.56 | 348.8 | 176 | 80.00 | 492.8 | 256 | 124.44 |
| 208.4 | 98 | 36.67 | 352.4 | 178 | 81.11 | 496.4 | 258 | 125.56 |
| 212.0 | 100 | 37.78 | 356.0 | 180 | 82.22 | 500.0 | 260 | 126.67 |

# 22

Temperature
Conversion
Chart

| to F° | From | to C° | to F° | From | to C° | to F° | From | to C° |
|---|---|---|---|---|---|---|---|---|
| 503.6 | 262 | 127.78 | 647.6 | 342 | 172.22 | 791.6 | 422 | 216.67 |
| 507.2 | 264 | 128.89 | 651.2 | 344 | 173.33 | 795.2 | 424 | 217.78 |
| 510.8 | 266 | 130.00 | 654.8 | 346 | 174.44 | 798.8 | 426 | 218.89 |
| 514.4 | 268 | 131.11 | 658.4 | 348 | 175.56 | 802.4 | 428 | 220.00 |
| 518.0 | 270 | 132.22 | 662.0 | 350 | 176.67 | 806.0 | 430 | 221.11 |
| 521.6 | 272 | 133.33 | 665.6 | 352 | 177.78 | 809.6 | 432 | 222.22 |
| 525.2 | 274 | 134.44 | 669.2 | 354 | 178.89 | 813.2 | 434 | 223.33 |
| 528.8 | 276 | 135.56 | 672.8 | 356 | 180.00 | 816.8 | 436 | 224.44 |
| 532.4 | 278 | 136.67 | 676.4 | 358 | 181.11 | 820.4 | 438 | 225.56 |
| 536.0 | 280 | 137.78 | 680.0 | 360 | 182.22 | 824.0 | 440 | 226.67 |
| 539.6 | 282 | 138.89 | 683.6 | 362 | 183.33 | 827.6 | 442 | 227.78 |
| 543.2 | 284 | 140.00 | 667.2 | 364 | 184.44 | 831.2 | 444 | 228.89 |
| 546.8 | 286 | 141.11 | 690.8 | 366 | 185.56 | 834.8 | 446 | 230.00 |
| 550.4 | 288 | 142.22 | 694.4 | 368 | 186.67 | 838.4 | 448 | 231.11 |
| 554.0 | 290 | 143.33 | 698.0 | 370 | 187.78 | 842.0 | 450 | 232.22 |
| 557.6 | 292 | 144.44 | 701.6 | 372 | 188.89 | 845.6 | 452 | 233.33 |
| 561.2 | 294 | 145.56 | 705.2 | 374 | 190.00 | 849.2 | 454 | 234.44 |
| 564.8 | 296 | 146.67 | 708.8 | 376 | 191.11 | 852.8 | 456 | 235.56 |
| 568.4 | 298 | 147.78 | 712.4 | 378 | 192.22 | 856.4 | 458 | 236.67 |
| 572.0 | 300 | 148.89 | 716.0 | 380 | 193.33 | 860.0 | 460 | 237.78 |
| 575.6 | 302 | 150.00 | 719.6 | 382 | 194.44 | 863.6 | 462 | 238.89 |
| 579.2 | 304 | 151.11 | 723.2 | 384 | 195.56 | 867.2 | 464 | 240.00 |
| 582.8 | 306 | 152.22 | 726.8 | 386 | 196.67 | 870.8 | 466 | 241.11 |
| 586.4 | 308 | 153.33 | 730.4 | 388 | 197.78 | 874.4 | 468 | 242.22 |
| 590.0 | 310 | 154.44 | 734.0 | 390 | 198.89 | 878.0 | 470 | 243.33 |
| 593.6 | 312 | 155.56 | 737.6 | 392 | 200.00 | 881.6 | 472 | 244.44 |
| 597.2 | 314 | 156.67 | 741.2 | 394 | 201.11 | 885.2 | 474 | 245.56 |
| 600.8 | 316 | 157.78 | 744.8 | 396 | 202.22 | 888.8 | 476 | 246.67 |
| 604.4 | 318 | 158.89 | 748.4 | 398 | 203.33 | 892.4 | 478 | 247.78 |
| 608.0 | 320 | 160.00 | 752.0 | 400 | 204.44 | 896.0 | 480 | 248.89 |
| 611.6 | 322 | 161.11 | 755.6 | 402 | 205.56 | 899.6 | 482 | 250.00 |
| 615.2 | 324 | 162.22 | 759.2 | 404 | 206.67 | 903.2 | 484 | 251.11 |
| 618.8 | 326 | 163.33 | 762.8 | 406 | 207.78 | 906.8 | 486 | 252.22 |
| 622.4 | 328 | 164.44 | 766.4 | 408 | 208.89 | 910.4 | 488 | 253.33 |
| 626.0 | 330 | 165.56 | 770.0 | 410 | 210.00 | 914.0 | 490 | 254.44 |
| 629.6 | 332 | 166.67 | 773.6 | 412 | 211.11 | 917.6 | 492 | 255.56 |
| 633.2 | 334 | 167.78 | 777.2 | 414 | 212.22 | 921.2 | 494 | 256.67 |
| 636.8 | 336 | 168.89 | 780.8 | 416 | 213.33 | 924.8 | 496 | 257.78 |
| 640.4 | 338 | 170.00 | 784.4 | 418 | 214.44 | 928.4 | 498 | 258.89 |
| 644.0 | 340 | 171.11 | 788.0 | 420 | 215.56 | 932.0 | 500 | 260.00 |

| to F° | From | to C° | to F° | From | to C° | to F° | From | to C° |
|---|---|---|---|---|---|---|---|---|
| 935.6 | 502 | 261.11 | 1310.0 | 710 | 376.67 | 2030.0 | 1110 | 598.89 |
| 939.2 | 504 | 262.22 | 1328.0 | 720 | 382.22 | 2048.0 | 1120 | 604.44 |
| 942.8 | 506 | 263.33 | 1346.0 | 730 | 387.78 | 2066.0 | 1130 | 610.00 |
| 946.4 | 508 | 264.44 | 1364.0 | 740 | 393.33 | 2084.0 | 1140 | 615.56 |
| 950.0 | 510 | 265.56 | 1382.0 | 750 | 398.89 | 2102.0 | 1150 | 621.11 |
| | | | | | | | | |
| 953.6 | 512 | 266.67 | 1400.0 | 760 | 404.44 | 2120.0 | 1160 | 626.67 |
| 957 2 | 514 | 267.78 | 1418.0 | 770 | 410.00 | 2138.0 | 1170 | 632.22 |
| 960.8 | 516 | 268.89 | 1436.0 | 780 | 415.56 | 2156.0 | 1180 | 637.78 |
| 964.4 | 518 | 270.00 | 1454.0 | 790 | 421.11 | 2174.0 | 1190 | 643.33 |
| 968.0 | 520 | 271.11 | 1472.0 | 800 | 426.67 | 2192.0 | 1200 | 648.89 |
| | | | | | | | | |
| 971.6 | 522 | 272.22 | 1490.0 | 810 | 432.22 | 2210.0 | 1210 | 654.44 |
| 975 2 | 524 | 273.33 | 1508.0 | 820 | 437.78 | 2228.0 | 1220 | 660.00 |
| 978.8 | 526 | 274.44 | 1526.0 | 830 | 443.33 | 2246.0 | 1230 | 665.56 |
| 982.4 | 528 | 275.58 | 1544.0 | 840 | 448.89 | 2264.0 | 1240 | 671.11 |
| 986.0 | 530 | 276.67 | 1562.0 | 850 | 454.44 | 2282.0 | 1250 | 676.67 |
| | | | | | | | | |
| 989.6 | 532 | 277.78 | 1580.0 | 860 | 460.00 | 2300.0 | 1260 | 682.22 |
| 993.2 | 534 | 278.89 | 1598.0 | 870 | 465.56 | 2318.0 | 1270 | 687.78 |
| 996.8 | 536 | 280.00 | 1616.0 | 880 | 471.11 | 2336.0 | 1280 | 693.33 |
| 1000.4 | 538 | 281.11 | 1634.0 | 890 | 476.67 | 2354.0 | 1290 | 698.89 |
| 1004.0 | 540 | 282.22 | 1652.0 | 900 | 482.22 | 2372.0 | 1300 | 704.44 |
| | | | | | | | | |
| 1007.6 | 542 | 283.33 | 1670.0 | 910 | 487.78 | 2390.0 | 1310 | 710.00 |
| 1011.2 | 544 | 284.44 | 1688.0 | 920 | 493.33 | 2408.0 | 1320 | 715.56 |
| 1014.8 | 546 | 285.56 | 1706.0 | 930 | 498.89 | 2426.0 | 1330 | 721.11 |
| 1018.4 | 548 | 288.67 | 1724.0 | 940 | 504.44 | 2444.0 | 1340 | 726.67 |
| 1022.0 | 550 | 287.78 | 1742.0 | 950 | 510.00 | 2462.0 | 1350 | 732.22 |
| | | | | | | | | |
| 1040.0 | 560 | 293.33 | 1760.0 | 960 | 515.56 | 2480.0 | 1360 | 737.78 |
| 1058.0 | 570 | 298.89 | 1778.0 | 970 | 521.11 | 2498.0 | 1370 | 743.33 |
| 1076.0 | 580 | 304.44 | 1796.0 | 980 | 526.67 | 2516.0 | 1380 | 748.89 |
| 1094.0 | 590 | 310.00 | 1814.0 | 990 | 532.22 | 2534.0 | 1390 | 754.44 |
| 1112.0 | 600 | 315.56 | 1832.0 | 1000 | 537.78 | 2552.0 | 1400 | 760.00 |
| | | | | | | | | |
| 1130.0 | 610 | 321.11 | 1850.0 | 1010 | 543.33 | 2570.0 | 1410 | 765.56 |
| 1148.0 | 620 | 326.67 | 1868.0 | 1020 | 548.89 | 2588.0 | 1420 | 771.11 |
| 1166.0 | 630 | 332.22 | 1886.0 | 1030 | 554.44 | 2606.0 | 1430 | 776.67 |
| 1184.0 | 640 | 337.78 | 1904.0 | 1040 | 560.00 | 2624.0 | 1440 | 782.22 |
| 1202.0 | 650 | 343.33 | 1922.0 | 1050 | 565.56 | 2642.0 | 1450 | 787.78 |
| | | | | | | | | |
| 1220.0 | 660 | 348.89 | 1940.0 | 1060 | 571.11 | 2660.0 | 1460 | 793.33 |
| 1238.0 | 670 | 354.44 | 1958.0 | 1070 | 576.67 | 2678.0 | 1470 | 798.89 |
| 1256.0 | 680 | 360.00 | 1976.0 | 1080 | 582.22 | 2696.0 | 1480 | 804.44 |
| 1274.0 | 690 | 365.56 | 1994.0 | 1090 | 587.78 | 2714.0 | 1490 | 810.00 |
| 1292.0 | 700 | 371.11 | 2012.0 | 1100 | 593.33 | 2732.0 | 1500 | 815.56 |

# 22

**Temperature
Conversion
Chart**

| to F° | From | to C° | to F° | From | to C° | to F° | From | to C° |
|-------|------|-------|-------|------|-------|-------|------|-------|
| 2750.0 | 1510 | 821.11 | 3470.0 | 1910 | 1043.3 | 4190.0 | 2310 | 1265.6 |
| 2768.0 | 1520 | 826.67 | 3488.0 | 1920 | 1048.9 | 4208.0 | 2320 | 1271.1 |
| 2786.0 | 1530 | 832.22 | 3506.0 | 1930 | 1054.4 | 4226.0 | 2330 | 1276.7 |
| 2804.0 | 1540 | 837.78 | 3524.0 | 1940 | 1060.0 | 4244.0 | 2340 | 1282.2 |
| 2822.0 | 1550 | 843.33 | 3542.0 | 1950 | 1065.6 | 4262.0 | 2350 | 1287.8 |
| | | | | | | | | |
| 2840.0 | 1560 | 848.89 | 3560.0 | 1960 | 1071.1 | 4280.0 | 2360 | 1293.3 |
| 2858.0 | 1570 | 854.44 | 3578.0 | 1970 | 1076.7 | 4298.0 | 2370 | 1298.9 |
| 2876.0 | 1580 | 860.00 | 3596.0 | 1980 | 1082.2 | 4316.0 | 2380 | 1304.4 |
| 2894.0 | 1590 | 865.56 | 3614.0 | 1990 | 1087.8 | 4334.0 | 2390 | 1310.0 |
| 2912.0 | 1600 | 871.11 | 3632.0 | 2000 | 1093.3 | 4352.0 | 2400 | 1315.6 |
| | | | | | | | | |
| 2930.0 | 1610 | 876.67 | 3650.0 | 2010 | 1098.9 | 4370.0 | 2410 | 1321.1 |
| 2948.0 | 1620 | 882.22 | 3668.0 | 2020 | 1104.4 | 4388.0 | 2420 | 1326.7 |
| 2966.0 | 1630 | 887.78 | 3686.0 | 2030 | 1110.0 | 4406.0 | 2430 | 1332.2 |
| 2984.0 | 1640 | 893.33 | 3704.0 | 2040 | 1115.6 | 4424.0 | 2440 | 1337.8 |
| 3002.0 | 1650 | 898.89 | 3722.0 | 2050 | 1121.1 | 4442.0 | 2450 | 1343.3 |
| | | | | | | | | |
| 3020.0 | 1660 | 904.44 | 3740.0 | 2060 | 1126.7 | 4460.0 | 2460 | 1348.9 |
| 3038.0 | 1670 | 910.00 | 3758.0 | 2070 | 1132.2 | 4478.0 | 2470 | 1354.4 |
| 3056.0 | 1680 | 915.56 | 3776.0 | 2080 | 1137.8 | 4496.0 | 2480 | 1360.0 |
| 3074.0 | 1690 | 921.11 | 3794.0 | 2090 | 1143.3 | 4514.0 | 2490 | 1365.6 |
| 3092.0 | 1700 | 926.67 | 3812.0 | 2100 | 1148.9 | 4532.0 | 2500 | 1371.1 |
| | | | | | | | | |
| 3110.0 | 1710 | 932.22 | 3830.0 | 2110 | 1154.4 | 4550.0 | 2510 | 1376.7 |
| 3128.0 | 1720 | 937.78 | 3848.0 | 2120 | 1160.0 | 4568.0 | 2520 | 1382.2 |
| 3146.0 | 1730 | 943.33 | 3866.0 | 2130 | 1165.6 | 4586.0 | 2530 | 1387.8 |
| 3164.0 | 1740 | 948.89 | 3884.0 | 2140 | 1171.1 | 4604.0 | 2540 | 1393.3 |
| 3182.0 | 1750 | 954.44 | 3902.0 | 2150 | 1176.7 | 4622.0 | 2550 | 1398.9 |
| | | | | | | | | |
| 3200.0 | 1760 | 960.00 | 3920.0 | 2160 | 1182.2 | 4640.0 | 2560 | 1404.4 |
| 3218.0 | 1770 | 965.56 | 3938.0 | 2170 | 1187.8 | 4658.0 | 2570 | 1410.0 |
| 3236.0 | 1780 | 971.11 | 3956.0 | 2180 | 1193.3 | 4676.0 | 2580 | 1415.6 |
| 3254.0 | 1790 | 976.67 | 3974.0 | 2190 | 1198.9 | 4694.0 | 2590 | 1421.1 |
| 3272.0 | 1800 | 982.22 | 3992.0 | 2200 | 1204.4 | 4712.0 | 2600 | 1426.7 |
| | | | | | | | | |
| 3290.0 | 1810 | 987.78 | 4010.0 | 2210 | 1210.0 | 4730.0 | 2610 | 1432.2 |
| 3308.0 | 1820 | 993.33 | 4028.0 | 2220 | 1215.6 | 4748.0 | 2620 | 1437.8 |
| 3326.0 | 1830 | 998.89 | 4046.0 | 2230 | 1221.1 | 4766.0 | 2630 | 1443.3 |
| 3344.0 | 1840 | 1004.4 | 4064.0 | 2240 | 1226.7 | 4784.0 | 2640 | 1448.9 |
| 3362.0 | 1850 | 1010.0 | 4082.0 | 2250 | 1232.2 | 4802.0 | 2650 | 1454.4 |
| | | | | | | | | |
| 3380.0 | 1860 | 1015.6 | 4100.0 | 2260 | 1237.8 | 4820.0 | 2660 | 1460.0 |
| 3398.0 | 1870 | 1021.1 | 4118.0 | 2270 | 1243.3 | 4838.0 | 2670 | 1465.6 |
| 3416.0 | 1880 | 1026.7 | 4136.0 | 2280 | 1248.9 | 4856.0 | 2680 | 1471.1 |
| 3434.0 | 1890 | 1032.2 | 4154.0 | 2290 | 1254.4 | 4874.0 | 2690 | 1467.7 |
| 3452.0 | 1900 | 1037.8 | 4172.0 | 2300 | 1260.0 | 4892.0 | 2700 | 1482.2 |

# 22

**Temperature
Conversion
Chart**

| to F° | From | to C° | to F° | From | to C° | to F° | From | to C° |
|---|---|---|---|---|---|---|---|---|
| 4910.0 | 2710 | 1487.8 | 5702.0 | 3150 | 1732.2 | 9302.0 | 5150 | 2843.3 |
| 4928.0 | 2720 | 1493.3 | 5792.0 | 3200 | 1760.0 | 9392.0 | 5200 | 2871.1 |
| 4946.0 | 2730 | 1498.9 | 5882.0 | 3250 | 1787.8 | 9482.0 | 5250 | 2898.9 |
| 4964.0 | 2740 | 1504.4 | 5972.0 | 3300 | 1815.6 | 9572.0 | 5300 | 2926.7 |
| 4982.0 | 2750 | 1510.0 | 6062.0 | 3350 | 1843.3 | 9662.0 | 5350 | 2954.4 |
| | | | | | | | | |
| 5000.0 | 2760 | 1515.6 | 6152.0 | 3400 | 1871.1 | 9752.0 | 5400 | 2982.2 |
| 5018.0 | 2770 | 1521.1 | 6242.0 | 3450 | 1898.9 | 9842.0 | 5450 | 3010.0 |
| 5036.0 | 2780 | 1526.7 | 6332.0 | 3500 | 1926.7 | 9932.0 | 5500 | 3037.8 |
| 5054.0 | 2790 | 1532.2 | 6422.0 | 3550 | 1954.4 | 10,002.0 | 5550 | 3065.6 |
| 5072.0 | 2800 | 1537.8 | 6512.0 | 3600 | 1982.2 | 10,112.0 | 5600 | 3093.3 |
| | | | | | | | | |
| 5090.0 | 2810 | 1543.3 | 6602.0 | 3650 | 2010.0 | | | |
| 5108.0 | 2820 | 1548.9 | 6692.0 | 3700 | 2037.8 | | | |
| 5126.0 | 2830 | 1554.4 | 6782.0 | 3750 | 2065.6 | | | |
| 5144.0 | 2840 | 1560.0 | 6872.0 | 3800 | 2093.3 | | | |
| 5162.0 | 2850 | 1565.6 | 6962.0 | 3850 | 2121.1 | | | |
| | | | | | | | | |
| 5180.0 | 2860 | 1571.1 | 7052.0 | 3900 | 2148.9 | | | |
| 5198.0 | 2870 | 1576.7 | 7142.0 | 3950 | 2176.7 | | | |
| 5216.0 | 2880 | 1582.2 | 7232.0 | 4000 | 2204.4 | | | |
| 5234.0 | 2890 | 1587.8 | 7322.0 | 4050 | 2232.2 | | | |
| 5252.0 | 2900 | 1593.3 | 7412.0 | 4100 | 2260.0 | | | |
| | | | | | | | | |
| 5270.0 | 2910 | 1598.9 | 7502.0 | 4150 | 2287.8 | | | |
| 5288.0 | 2920 | 1604.4 | 7592.0 | 4200 | 2315.6 | | | |
| 5306.0 | 2930 | 1610.0 | 7682.0 | 4250 | 2343.3 | | | |
| 5324.0 | 2940 | 1615.6 | 7772.0 | 4300 | 2371.1 | | | |
| 5342.0 | 2950 | 1621.1 | 7862.0 | 4350 | 2398.9 | | | |
| | | | | | | | | |
| 5360.0 | 2960 | 1626.7 | 7952.0 | 4400 | 2426.7 | | | |
| 5378.0 | 2970 | 1632.2 | 8042.0 | 4450 | 2454.4 | | | |
| 5396.0 | 2980 | 1637.8 | 8132.0 | 4500 | 2482.2 | | | |
| 5414.0 | 2990 | 1643.3 | 8222.0 | 4550 | 2510.0 | | | |
| 5432.0 | 3000 | 1648.9 | 8312.0 | 4600 | 2537.8 | | | |
| | | | | | | | | |
| 5450.0 | 3010 | 1654.4 | 8402.0 | 4650 | 2565.6 | | | |
| 5468.0 | 3020 | 1660.0 | 8492.0 | 4700 | 2593.3 | | | |
| 5486.0 | 3030 | 1665.6 | 8582.0 | 4750 | 2621.1 | | | |
| 5504.0 | 3040 | 1671.1 | 8672.0 | 4800 | 2648.9 | | | |
| 5522.0 | 3050 | 1676.7 | 8762.0 | 4850 | 2676.7 | | | |
| | | | | | | | | |
| 5540.0 | 3060 | 1682.2 | 8852.0 | 4900 | 2704.4 | | | |
| 5558.0 | 3070 | 1687.8 | 8942.0 | 4950 | 2732.2 | | | |
| 5576.0 | 3080 | 1693.3 | 9032.0 | 5000 | 2760.0 | | | |
| 5594.0 | 3090 | 1698.9 | 9122.0 | 5050 | 2787.8 | | | |
| 5612.0 | 3100 | 1704.4 | 9212.0 | 5100 | 2815.6 | | | |

# 22

Temperature
Conversion
Chart

# WARRANTY/DISCLAIMER

OMEGA ENGINEERING, INC. warrants this unit to be free of defects in materials and workmanship for a period of **61 months** from date of purchase. OMEGA's WARRANTY adds an additional one (1) month grace period to the normal **five (5) year product warranty** to cover handling and shipping time. This ensures that OMEGA's customers receive maximum coverage on each product.

If the unit malfunctions, it must be returned to the factory for evaluation. OMEGA's Customer Service Department will issue an Authorized Return (AR) number immediately upon phone or written request. Upon examination by OMEGA, if the unit is found to be defective, it will be repaired or replaced at no charge. OMEGA's WARRANTY does not apply to defects resulting from any action of the purchaser, including but not limited to mishandling, improper interfacing, operation outside of design limits, improper repair, or unauthorized modification. This WARRANTY is VOID if the unit shows evidence of having been tampered with or shows evidence of having been damaged as a result of excessive corrosion; or current, heat, moisture or vibration; improper specification; misapplication; misuse or other operating conditions outside of OMEGA's control. Components in which wear is not warranted, include but are not limited to contact points, fuses, and triacs.

**OMEGA is pleased to offer suggestions on the use of its various products. However, OMEGA neither assumes responsibility for any omissions or errors nor assumes liability for any damages that result from the use of its products in accordance with information provided by OMEGA, either verbal or written. OMEGA warrants only that the parts manufactured by the company will be as specified and free of defects. OMEGA MAKES NO OTHER WARRANTIES OR REPRESENTATIONS OF ANY KIND WHATSOEVER, EXPRESSED OR IMPLIED, EXCEPT THAT OF TITLE, AND ALL IMPLIED WARRANTIES INCLUDING ANY WARRANTY OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE HEREBY DISCLAIMED. LIMITATION OF LIABILITY: The remedies of purchaser set forth herein are exclusive, and the total liability of OMEGA with respect to this order, whether based on contract, warranty, negligence, indemnification, strict liability or otherwise, shall not exceed the purchase price of the component upon which liability is based. In no event shall OMEGA be liable for consequential, incidental or special damages.**

CONDITIONS: Equipment sold by OMEGA is not intended to be used, nor shall it be used: (1) as a "Basic Component" under 10 CFR 21 (NRC), used in or with any nuclear installation or activity; or (2) in medical applications or used on humans. Should any Product(s) be used in or with any nuclear installation or activity, medical application, used on humans, or misused in any way, OMEGA assumes no responsibility as set forth in our basic WARRANTY/DISCLAIMER language, and, additionally, purchaser will indemnify OMEGA and hold OMEGA harmless from any liability or damage whatsoever arising out of the use of the Product(s) in such a manner.

# RETURN REQUESTS/INQUIRIES

Direct all warranty and repair requests/inquiries to the OMEGA Customer Service Department. BEFORE RETURNING ANY PRODUCT(S) TO OMEGA, PURCHASER MUST OBTAIN AN AUTHORIZED RETURN (AR) NUMBER FROM OMEGA'S CUSTOMER SERVICE DEPARTMENT (IN ORDER TO AVOID PROCESSING DELAYS). The assigned AR number should then be marked on the outside of the return package and on any correspondence.

The purchaser is responsible for shipping charges, freight, insurance and proper packaging to prevent breakage in transit.

FOR **WARRANTY** RETURNS, please have the following information available BEFORE contacting OMEGA:

1. Purchase Order number under which the product was PURCHASED,
2. Model and serial number of the product under warranty, and
3. Repair instructions and/or specific problems relative to the product.

FOR **NON-WARRANTY** REPAIRS, consult OMEGA for current repair charges. Have the following information available BEFORE contacting OMEGA:

1. Purchase Order number to cover the COST of the repair,
2. Model and serial number of the product, and
3. Repair instructions and/or specific problems relative to the product.

OMEGA's policy is to make running changes, not model changes, whenever an improvement is possible. This affords our customers the latest in technology and engineering.

OMEGA is a trademark of OMEGA ENGINEERING, INC.

# Where Do I Find Everything I Need for Process Measurement and Control? OMEGA...Of Course!

## *Shop online at omega.com*

### TEMPERATURE

- ☛ Thermocouple, RTD & Thermistor Probes, Connectors, Panels & Assemblies
- ☛ Wire: Thermocouple, RTD & Thermistor
- ☛ Calibrators & Ice Point References
- ☛ Recorders, Controllers & Process Monitors
- ☛ Infrared Pyrometers

### PRESSURE, STRAIN AND FORCE

- ☛ Transducers & Strain Gages
- ☛ Load Cells & Pressure Gages
- ☛ Displacement Transducers
- ☛ Instrumentation & Accessories

### FLOW/LEVEL

- ☛ Rotameters, Gas Mass Flowmeters & Flow Computers
- ☛ Air Velocity Indicators
- ☛ Turbine/Paddlewheel Systems
- ☛ Totalizers & Batch Controllers

### pH/CONDUCTIVITY

- ☛ pH Electrodes, Testers & Accessories
- ☛ Benchtop/Laboratory Meters
- ☛ Controllers, Calibrators, Simulators & Pumps
- ☛ Industrial pH & Conductivity Equipment

### DATA ACQUISITION

- ☛ Communications-Based Acquisition Systems
- ☛ Data Logging Systems
- ☛ Wireless Sensors, Transmitters, & Receivers
- ☛ Signal Conditioners
- ☛ Data Acquisition Software

### HEATERS

- ☛ Heating Cable
- ☛ Cartridge & Strip Heaters
- ☛ Immersion & Band Heaters
- ☛ Flexible Heaters
- ☛ Laboratory Heaters

### ENVIRONMENTAL MONITORING AND CONTROL

- ☛ Metering & Control Instrumentation
- ☛ Refractometers
- ☛ Pumps & Tubing
- ☛ Air, Soil & Water Monitors
- ☛ Industrial Water & Wastewater Treatment
- ☛ pH, Conductivity & Dissolved Oxygen Instruments