Troubleshooting 4-20 mA Current Loops

General:

The MINCO Temptran™ converts an RTD's (resistance temperature detector's) signal into a dc current whose value is proportional to the RTD's temperature. The current matches the temperature range marked on the Temptran: 4 mA at the lowest temperature of the range, 20 mA at the top of the range. The power supply leads carry the current signal.

Installation:

Locate the Temptran near the RTD in an area where the ambient temperature stays within the range 32 to 122°F. Mount the Temptran with a screw into the mounting hole from the bottom.

Connect the Temptran as shown below, observing the +/- polarity of the current loop. Maximum DC supply voltage = 35 VDC. The RTD connections have no polarity. For the RTD, good connections are a must; a few ohms of resistance in the connection can cause an error of several degrees.

The Temptran has been factory-calibrated for its marked temperature range. Do not change the zero or span adjustments.

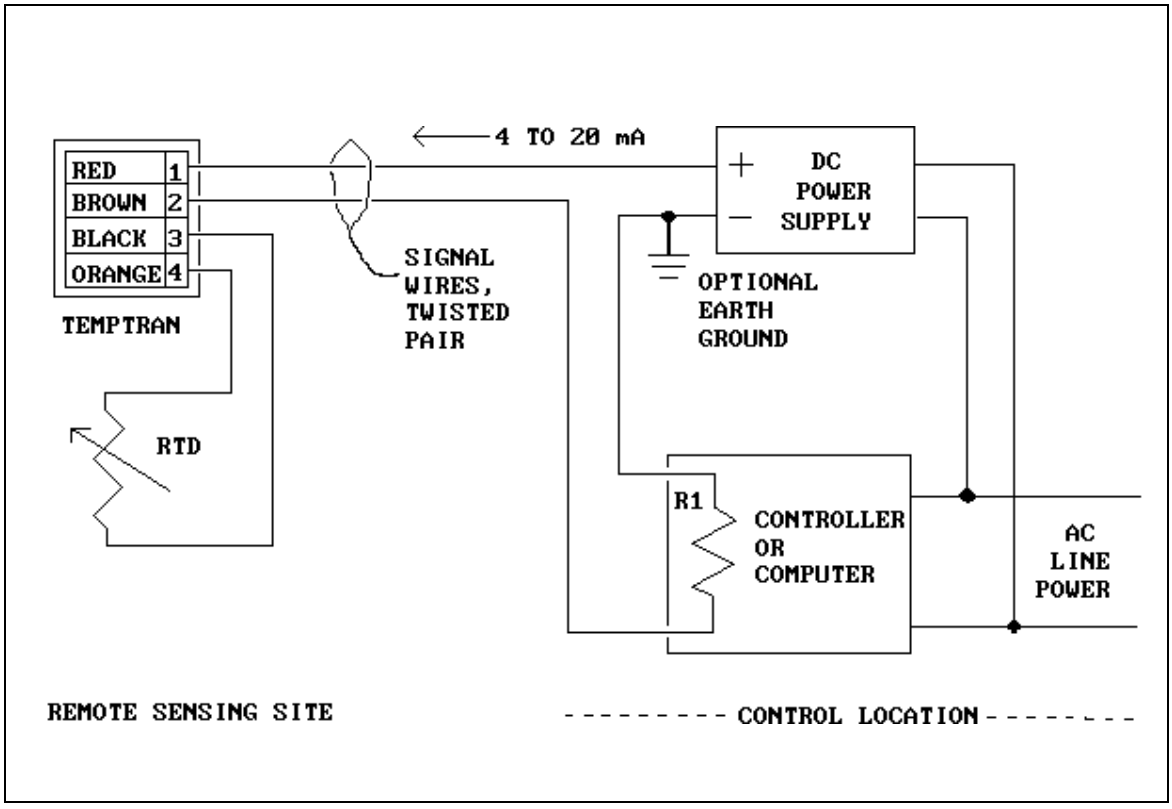

Figure 1 Typical hookup of a single current loop

Terminology:

RTD (Resistance Temperature Detector): The temperature sensor.
Current Loop: The pair of wires, which simultaneously carry power to the transmitter and the temperature signal, as a current, from the transmitter.

Troubleshooting Guide - Malfunction or incorrect operation may be caused by:

1. Reversed polarity:
   Check the wiring. If the temperature of the thermocouple increases while the current magnitude decreases, the problem could be caused by reversed polarity of the:
   a. thermocouple wiring
   b. power supply leads
   c. monitor instrument.

2. Loose or broken wires:
   Check each terminal connection for tightness. Move each wire back and forth, and note any changes in operation.

3. Too high a load resistance in the output current loop or too low a current rating on the power supply:
   a. Measure the total resistance of each device (excluding the transmitter and power supply) in the 20-mA loop, including the resistance of the lead wires.
   b. Calculate maximum allowable loop resistance using the formula: Loop Resistance (maximum) = $\frac{V_{supply} - 7V}{0.020A}$

      For example, a 24V power supply would give a maximum loop resistance of 17V/0.20A = 850 ohms.

   c. Make sure the power supply is rated for at lease 28 mA times the number of TX93 transmitters being powered. For example, if the supply is powering five transmitters, the supply should be rated for at least 140 mA.

TROUBLESHOOTING:

Look up the troubleshooting procedure according to the symptoms you have.

Symptoms:	See "POTENTIAL CAUSES"
TEMPERATURE DOES NOT CHANGE	1 to 10, 11 to 13
TEMPERATURE STAYS BELOW BOTTOM OF RANGE (below 4 mA)	2 to 11, 14, 16 to 20, 23
TEMPERATURE STAYS ABOVE TOP OF RANGE (above 20 mA)	1, 2, 7 to 10, 12 to 14, 22, 24 to 26
TEMPERATURE CHANGES UNPREDICTABLY/UNEXPECTEDLY	6, 7, 14, 17, 19 to 22, 27 to 29
TEMPERATURE CHANGES WHEN OTHER ELECTRICAL LOADS ARE SWITCHED ON OR OFF	7, 14, 15, 27 to 29
TEMPERATURE IS SEVERAL DEGREES TOO HIGH OR LOW	6 to 10, 14, 21 to 23, 25, 30
TEMPERATURE IS JUST A DEGREE HIGH OR LOW	8 to 10, 13, 23, 25, 30 to 32
TEMPERATURE KEEPS INCREASING OR DECREASING DAY-BY-DAY	7, 13, 24, 30

POTENTIAL CAUSE		TEST PROCEDURE
1.	RTD open-circuited or Temptran short-circuited.	CHECK THAT THE RTD IS OPERATING CORRECTLY A. Turn power to Temptran off because the current may rise above 20 mA while the RTD is disconnected.
2.	RTD resistance too high or low.	
3.	RTD short-circuited	B. Disconnect the RTD and ohm it. Its resistance should approximately agree with the room temperature values listed in Table 1, below. Caution - it may read high if your hands accidentally warm it up. If you're not sure which kind of RTD you have, read it from the code on the transmitter, e.g. for a TT151PD1A use the "PD or PE" column in Table 1.

Ambient temperature	Sensing Element type (resistance in ohms)						
			PD or				
(°F)	PA	PB	PE	PF	NA	FB	FC
60	106.2	106.2	106.1	1060.7	131.2	975.4	1950.7
70	108.4	108.4	108.2	1082.2	135.4	1000.0	2000.0
80	110.6	110.5	110.4	1103.8	139.5	1025.0	2050.0

Table I RESISTANCE OF SEVERAL TYPES OF MINCO RTD's AT ROOM TEMPERATURE

4.	Temptran or current loop open-circuited.	A. Ohm the current loop wiring. B. Verify the Temptran connections to the loop.
5.	Current loop and RTD connections swapped.	Check wiring at Temptran.
6.	Below minimum operating voltage at Temptran's current loop terminals due to excess resistance in the current loop.	Voltage across Temptran's current loop terminals must be at least 8.5 VDC - measure it. Note: The voltage may range as high as the power supply's voltage and the voltage across the Temptan will change when the current signal changes. Some Temptran models, in the round cases, require 12 volts minimum. Check total resistance of the loop: A. Turn off power supply, temporarily place a short across its terminals. B. Disconnect the two current loop wires from the Temptran and ohm the loop. Resistance should be less than that given by this formula: $R_{LOOP\ MAX} = (V_{SUPPLY} - 8.5)/.02$ amps for example, if you're using a 24 VDC supply, (24 - 8.5)/.02 = 775 ohms max.
7.	RTD or current loop misconnected to other control wiring, current loops, or voltages.	With meter, check for unwanted currents, voltages, and connections.
8.	Temptran type does not match RTD type.	Read the RTD element code off the Temptran label and check that the color-coded wires of the RTD are in agreement (see Table 2 below), e.g. a Temptran labeled

POTENTIAL CAUSE

TEST PROCEDURE

TT111PB1C should have a sensor whose leadwires are colored red, white, and white (or just red and white for a 2-lead sensor *).

RTD Element Code	RTD Leadwire Color lead number 1	2	3 *	RTD Description
FB	Red	Red	**	1000 Ω nickel-iron
FC	White	White	**	2000 Ω nickel-iron
PB	Red	White	White	100 Ω platinum, TCR = .00391
PD	Yellow	White	White	100 Ω platinum, TCR = .00385
PE	Yellow	White	White	100 Ω platinum, TCR = .00385
PF	Yellow	Red	Red	1000 Ω platinum, TCR = .00385

Note: This table applies only to Minco's standard Energy Management RTD's with model numbers between S400 and S499.

*Some RTD's do not have a third lead and some Temptrans require only 2 leads. If you have a 3-lead sensor and the Temptran only has terminals for two, connect the common-color wires together. For example, connect the two white wires of a PD sensor together in the same terminal of the Temptran and connect the yellow lead to the second Temptran terminal.

** FB & FC element codes are not available with a third leadwire.

Table II IDENTIFYING RTD TYPES

POTENTIAL CAUSE	TEST PROCEDURE
9. Wrong Temptran range installed.	Check against your records/plans that the temperature range matches the one listed on Temptran's label and that it matches what the computer is programmed for.
10. Energy Management System scaled for another temperature range or is not reading correctly.	If everything matches and the RTD's resistance ohms okay (see 3B), you can test that the computer is reading correctly: 1. Connect as shown in Fig. 2. 2. The variable resistor should have a resistance which covers the sensor's range of resistance (printed on the Temptran label), e.g., for a 100 ohm PD platinum RTD, use a decade box or a 250 ohm pot to simulate the 97 to 119 ohm resistance of the sensor from 20 to 120°F. 3. Set the decade box or RTD simulator or variable resistor/potentiometer to whatever it takes so that the Temptran puts out 4 mA, as measured by your current meter. Check that the computer's reading is correct. 4. Set the variable resistor so Temptran puts out 20 mA. Check computer's reading.

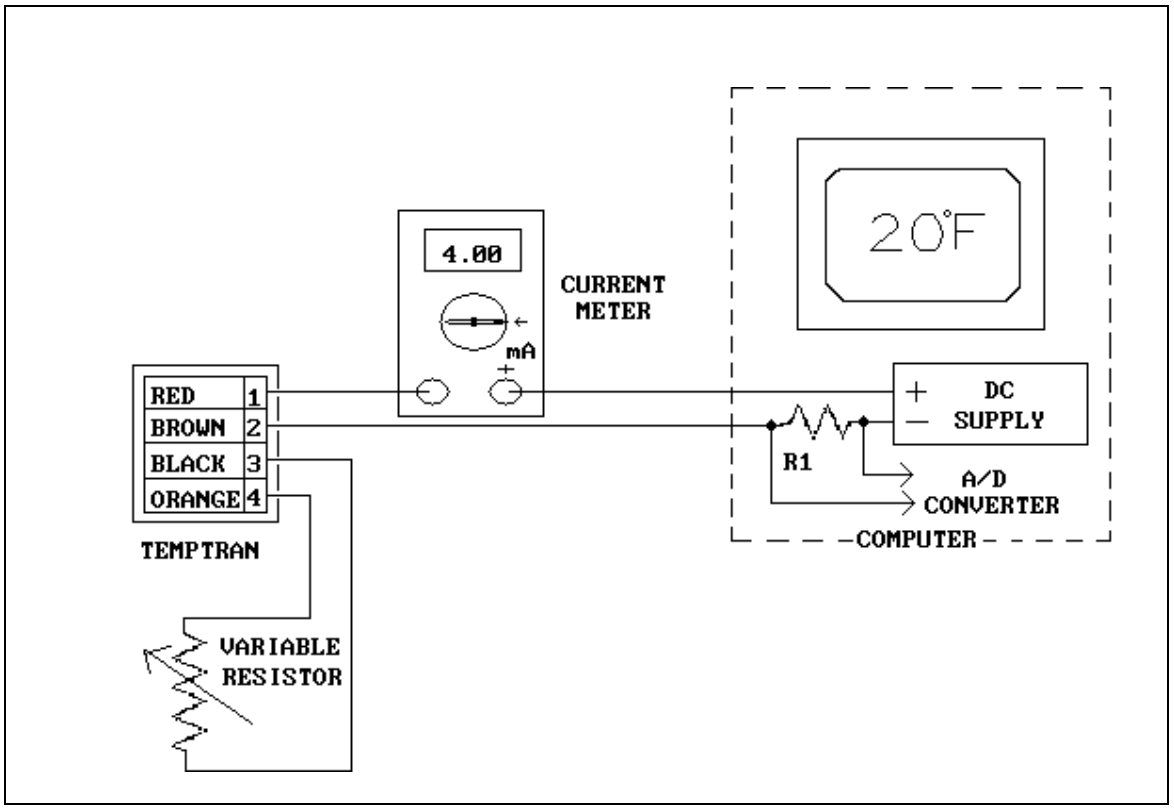

Figure 2 Check computer's reading

11. Current loop polarity reversed.	Using voltmeter, check the polarity of the voltage at the Temptran's current loop terminals. Temptran terminal 1, or the red lead on a model with wire leads, should be positive.
12. Current loop wires shorted together at some point.	Check for short.

POTENTIAL CAUSE	TEST PROCEDURE
13.You're asking for Duct #1's temperature but the computer is answering with Duct #4's temperature, for example.	Open the current loop at the Temptran for Duct #1 or else short the sensor's terminals (see #34 below). The computer should correctly sense that the temperature is below the bottom of the range.
14.Ground loop currents are adding or subtracting from current loop because circuit is earth-grounded at some point.	Ohm from each current loop to earth ground or other suspect wiring to check for accidental shorting along the wire run. None of the Temptran's connection points should be grounded. However, some control systems may intentionally connect the positive or negative side of the current loop to earth ground as shown in Fig. 1.
15.RTD element or its leads are not insulated from mounting hardware.	Disconnect the RTD from the Temptran, and while installed, ohm from the RTD leads to its mounting hardware - the resistance should be greater than 2 megohms.
16.Power supply voltage too low or high.	Measure the voltage at the power supply's terminals to see that it is within your system's tolerances.
17.Power supply not connected to current loop.	Check for loose wires.
18.DC power supply not plugged in/turned on.	Check for correct voltage at the power supply output terminals.
19.Power supply overloaded - too many current loops on one supply.	Measure the voltage at the power supply's terminals to see that it is within your system's tolerances. Low output voltage is a sign of overloading the supply. Alternatively, compare measured output voltage and current with the supply's specs.
20.Wrong AC source for power supply, e.g. trying to run off 115 VAC with input switch set to 230 VAC.	Check for proper 115 or 230 VAC wiring and switch settings.
21.Poor RTD connections or broken/intermittent wires at terminations.	To discover broken lead wires, monitor the temperature or current as you flex the lead wires.
22.Corrosion has increased resistance at the RTD terminations.	Clean connections & wire.
23.Shunting by a high resistance path across RTD connections is causing lowered reading.	Remove dirt & debris, clean. 2 megohms is the threshold where shunting may become a problem. Don't try to ohm the Temptran's terminals - they are a low impedance.
24.Operating temperatures beyond ratings of RTD.	Maximum temperature of standard Energy Management RTD's is 275°F (135°C). Note: Max ambient for the Temptran is 122°F (50°C) for TT110 & TT111.
25.Calibration pot settings disturbed.	RECALIBRATE Temptran: Use a decade resistance box, a fixed point RTD simulator, or some other variable resistor, which you can set very accurately to ± 0.02%. (If your resistor is not precisely 100 ohms or your decade box will not provide the exact resistances required, calculate the offsets they cause and calibrate to include them.

POTENTIAL CAUSE	TEST PROCEDURE
	1. Connect as shown in Fig. 3. 2. Set calibration resistor to value for 4 mA (printed on the side of the Temptran). Adjust the ZERO pot of the Temptran to get 0.4000 ± .0016 volts. 3. Set the calibration resistor to value for 20 mA (printed on the side of the Temptran). Adjust the SPAN pot of the Temptran to get 2.0000 ± .0016 volts. 4. Since the pots interact slightly, repeat steps 2 and 3 until both currents are calibrated.

In troubleshooting and calibrating, be aware that getting good accuracy is difficult. The accuracy tolerances of some voltmeters, current meters, and temperature meters may be as poor as ±0.5% of reading range, while you would like to calibrate with instruments whose accuracy is five to ten times better than the ±0.1% accuracy of the Temptran.

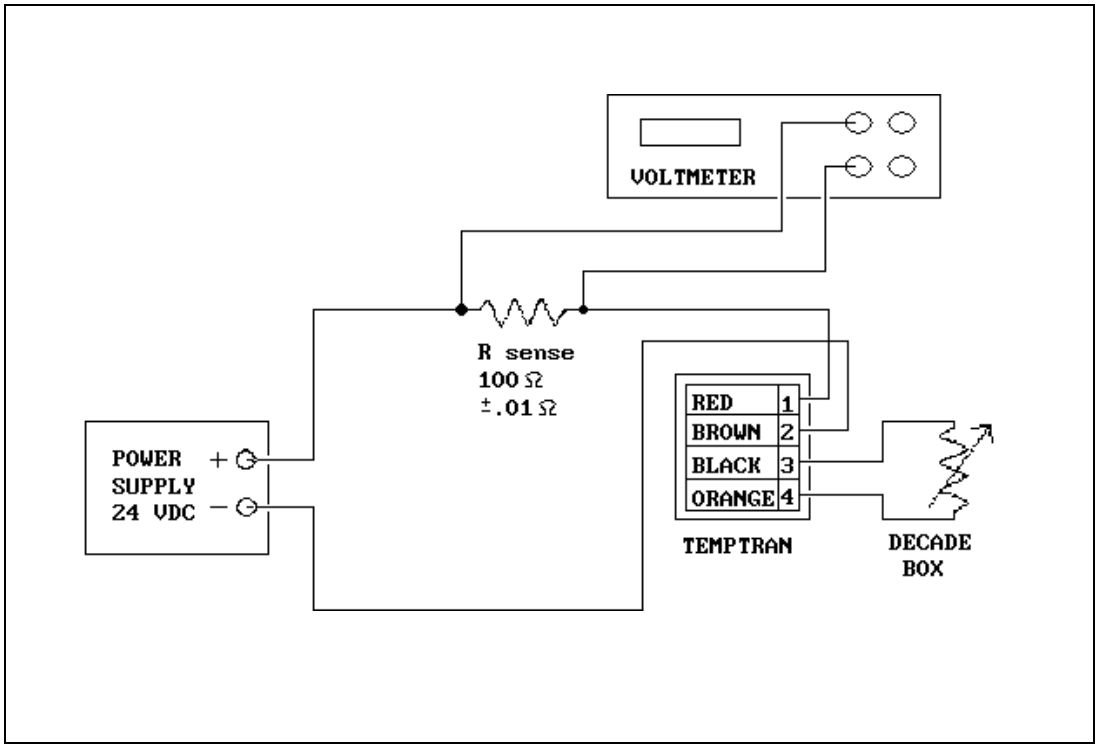

Figure 3 Calibration

26.Power supply connected in parallel with loop readout resistor.	Check for this miswiring and correct.
27.Leadwires are in area of high AC noise.	Because of the good AC noise rejection of modern instruments, electrical noise is not normally a problem. Switch your current meter to the AC scale to check for noise above the background AC level; read the background with meter leads shorted together. Next, clip the leads across the R1 sense resistor shown in Figure 1. Test if AC pickup is through the RTD leads by shorting the RTD terminals together right at the Temptran to see if the AC decreases. You will have to judge how much AC is too much for your computer. The 4-20 mA current loop is highly immune to noise pickup, however, any noise picked up in long RTD input leads will show up

POTENTIAL CAUSE	TEST PROCEDURE
	in the current signal. When extending the leads of the RTD, use twisted pair. If you want to use shield braid around the twisted extension leads to the RTD, connect the shield braid to the negative current loop terminal of the Temptran (terminal 2, or brown wire) at the Temptran end; do not connect the shield at the end by the RTD.
28.Noise picked up on current loop.	Use twisted pair instead of straight wires.
29.AC power applied to the current loop terminals of Temptran. or Power supply is providing AC riding atop the DC.	Set meter to AC volts scale and connect to Temptran current loop terminals. If you find excess AC, check power supply and check for accidental connection to other wiring.
30.Ambient temperatures are too high or low for Temptran.	Move the Temptran to a more moderate environment and extend the lead wires to the RTD using twisted pair. TT110 & TT111 Temptrans' ambient limits are 32 to 122°F (0 to 50°C). The Temptran will function outside these limits, but the factory spec.'s are not guaranteed. Prolonged operation at temperatures above 122°F is likely to cause more calibration drift than operation at temperatures below 32°F.
31.Temptran calibrated for a specific sensor has been connected to the wrong sensor.	Temptrans of certain model numbers are calibrated to one individual RTD. If there is a number tag on the RTD which matches the number printed on the Temptran's label, then you have a matched set. If Temptrans or RTD's were swapped around, an error of a few degrees is likely.
32.Temptran or sensor has drifted just a degree or two.	Adjust ZERO pot of Temptran or recalibrate per #25 above.

Notes:

33. As the temperature increases, causing an increase in the current signal to 20 mA, the voltage across the Temptran's current loop terminals always drops.

34. By temporarily shorting the RTD's terminals with a wire or paper clip, the current loop may be forced to a 2 to 3 mA value to test the computer's readout. The Temptran will not be harmed and calibration will not be changed.

35. You can check the current in a loop without causing a discontinuity or a change in current to be seen by the computer: To insert a current meter into a loop, connect its leads to the wire or terminals on each side of the point where you're going to break the loop - then go ahead and open the loop there. The Temptran will handle the meter's added resistance with no change in current.