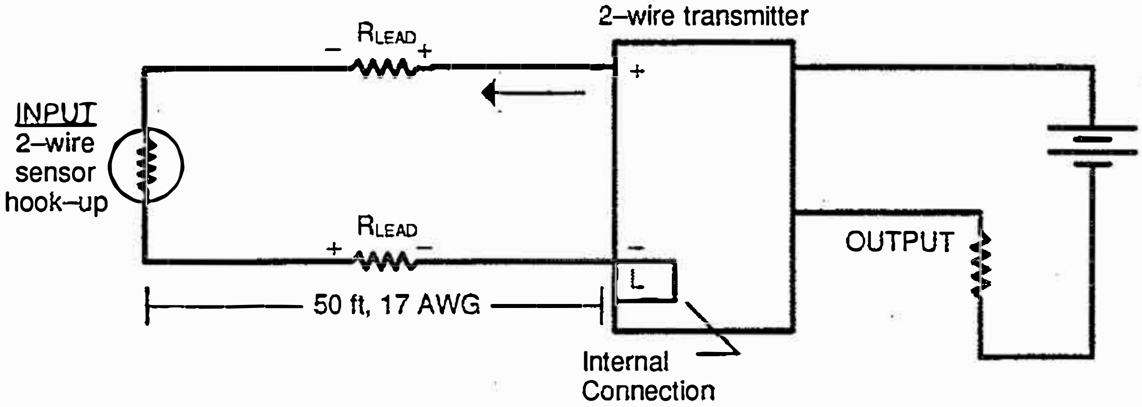
SERIES 250T TWO–WIRE RTD TRANSMITTERS
FAIL–SAFE HOOK–UP APPROACH

The following analysis will be referencing Acromag's 250T series RTD (100 ohm platinum) 2–wire transmitters and their "hook–up" to achieve a FAIL–SAFE configuration. Consider the following diagram:



This type of hook–up is typically not used because the effects of lead–wire resistance inaccuracies are additive to the RTD measurement. However, when addressing the problem of FAIL–SAFE, this configuration offers the most predictable output behavior. Also, if the RTD hook–up is properly done, the inaccuracies due to lead wire resistance can be minimized. The following is a list of most probable failures that could happen to the input sensor. An analysis will be performed to address each failure and predict the output of the transmitter.

1. Lead wires +/– could break open
2. The RTD sensor could fail open up
3. The input could become grounded
4. The input +/– could become shorted

Conditions/assumptions for FAIL–SAFE hook–up approach:

1. RTD type: 100 ohm platinum
2. Lead–wire length: 50ft (or shorter)
3. "–" & "L" connection: internal
4. Max. temp. change for lead wires: 50°C
5. Lead wire gauge: 17 AWG (0.005 ohms/ft)
6. RTD break detection: UP

Based on these conditions, we can derive accuracies for this type of approach.

ANALYSIS:

1. Total lead wire resistance:

   2 * 50 ft * (.005 ohms/ft) = 0.5 ohms (static value)

   NOTE: This lead wire resistance is a static value which means that at 25°C, it's effect can be calibrated out of the transmitter. The value of the most concern, however, is the dynamic resistance change of the lead wires over temperature.

2. The following equation is a good approximation for copper wire resistance with temperature changes of up to 50°C.

$$R_t = R(25°C) * [1 + (\Delta T)(0.004)]$$

$$R_t = 0.5 * [1 + (50)(0.004)]$$

$$R_t = 0.6 \text{ ohms}$$

Thus, the dynamic resistance change of the lead wires is:

Dynamic change = 0.1 ohms (maximum temperature change = 50°C)

SUMMARY OF ERRORS INTRODUCED:

Since 100 ohm Platinum changes approximately 0.4 ohms/°C and the maximum change in ohms introduced by the lead wires is 0.1 ohms, then, the lead wires are only introducing a 0.25°C error into the measurement.

0.1 ohms/(0.4 ohms/°C) = 0.25°C

Further, accuracies for transmitters are typically based on input spans. For an RTD transmitter that is calibrated for 0 to 200°C, the inaccuracy caused by the lead wires would be:

[(0.25°C/200°C) * 100] = 0.13% error

PREDICTING THE OUTPUT OF THE 2–WIRE:

1. If the lead wires (+/–) break open to the sensor:

   OUTPUT: Upscale

   The output will inherently go upscale because the resistance will appear to be very high (infinity).

2. The RTD sensor becomes open:

   OUTPUT: Upscale

   This case is really the same as case #1. The output will inherently drive upscale because the input will appear to be a very high resistance (infinity).

3. The input becomes grounded:

   OUTPUT: No effect

   As long as the 2–wire transmitter being used has input isolation (standard on Acromag 250T Series Transmitters) the output will not be affected if the input is grounded (i.e. the input sensor will perform as desired with up to 250V AC common mode voltage).

4. The input +/– becomes shorted:

   OUTPUT: Downscale

   This is the only instance that the output does not drive in the same direction as the other fault conditions. In the event that the input becomes shorted, the output will immediately drive downscale because it will appear to be a very low resistance (zero ohms) to the transmitter. Moreover, the output will drive below 4mA to its minimum operating level.

SUMMARY:

The approach described above will allow a user to solve FAIL–SAFE RTD transmitter concerns. The conditions and assumptions described above are designed to illustrate worst case errors. By improving on the conditions of this example (lower gauge wire, shorter lead wire lengths, or lower ambient temperature change on lead wires), the user can improve accuracies.

Table 1.0 lists inaccuracies for different gauge lead wires used with this approach:

Acromag
LEADER IN SIGNAL CONDITIONING

TABLE 1.0

AWG	APPROX. OHMS/FT	DYNAMIC CHANGE OF LEAD WIRES (OHMS) (over 50°C chg.)	INACCURACY (°C) (dynamic change/ 0.4ohms per °C)
26	.0410	0.82	2.05
25	.0324	0.648	1.62
24	.0257	0.51	1.28
23	.0203	0.406	1.02
22	.0162	0.324	0.81
21	.0128	0.256	0.64
20	.0100	0.200	0.50
19	.0080	0.160	0.40
18	.0064	0.128	0.32
17	.0050	0.100	0.25
16	.0040	0.080	0.20
15	.0032	0.064	0.16
14	.0025	0.050	0.125

APPROX. OHMS/FT: Based on copper at 25°C

DYNAMIC CHANGE OF LEAD WIRES EQUATION:

$$R(dyn) = [(R(25°C) * [1 + (50)(0.004)]) - R(25°C)] * 100 \text{ (ft)}$$

INACCURACY EQUATION:

$$R(dyn)/0.4 \text{ (ohms/° C)}$$