TRANSMITTER CALIBRATION

In this laboratory study, you will be asked to calibrate two of four different devices. To do so, you will need to write the equation defining the performance of the unit. Use this equation to predict the output of the unit with a known value of input.

The transmitters under study are:

- TCS Model TX-1504 temperature transmitter calibrated for an RTD input. The input range is either 50-150 ^{o}F or 40-240 ^{o}F. The output range is 4-20 mA. This is a loop powered current device requiring an input voltage of 8-35 VDC.

- Contractor Instruments Model P855 static pressure transmitter. Input range is either 0 to 3 in w.g. or –0.25 to 1.75 in w.g. The output range is 4 to 20 mA. This is a loop powered current device requiring an input voltage of 8-40 VDC.

- Omega Model FLSC-18B flow transmitter designed for use with any number of their flow sensors. This particular transducer is a loop powered current device with a 4 to 20 mA output. The input signal is the frequency of a magnetic pulse as output from the flow sensor.

PROCEDURE

In all cases, you must first be able to determine the output of the device for a given input. If the manufacturer does not provide a table, you can develop the equation for the device. The equation should be written so as to predict the transmitter output with a known input of simulated temperature, pressure or flow.

TCS Model TX-1504

The input to the transmitter will be a resistance. The attached table correlates resistance to temperature for a 1000 Ω sensor. Select two appropriate resistors. Do not rely on the stated rating of the resistor. Use a multimeter to measure its resistance. Once the actual resistance of each is measured, determine what temperature this represents. For example, assume you selected a resistor with a resistance of 1130.5 Ω. Referring to the attached resistance table, note this falls between 92 ^{o}F and 93 ^{o}F. Interpolating, we find:

$$\left(\frac{1130.5-1129.662}{1131.812-1129.662}\right)*\left(93-92\right)+92=92.39\ ^{o}F$$

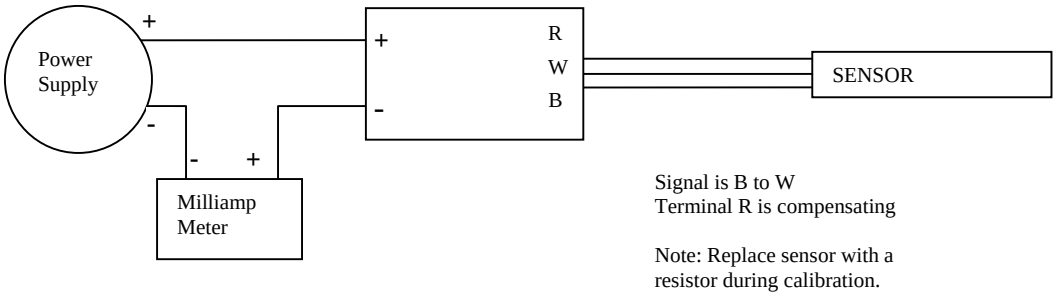
Using the equation you developed, you can now predict the output of the transmitter.

If a desired resistance cannot be found, you can parallel two resistors to obtain that desired resistance. To determine the resistance of two resistors in parallel, remember that:

$$\frac{1}{R}=\frac{1}{R_1}+\frac{1}{R_2}$$

where: R=desired resistance
R_1 = resistance of first resistor
R_2 = resistance of second resistor

Connect the device as shown below. Ensure the device is properly configured for a 1000 Ω sensor and a 200 ^{o}F temperature span as shown in the attached specification sheet. Your instructor will inspect the wiring prior to switching on the power supply.



With the power supply off, connect the resistor of the lowest value to the input terminals (B to W) or (B to R) of the transducer. Before switching on the power supply, ensure the proper voltage range is selected and the voltage output is turned down. Turn the voltage up on the power supply while monitoring it with the built-in voltmeter or a handheld multimeter until you read 24 VDC. Current output will read on the analog milliamp meter. Adjust the zero pot on the transducer until you read your desired milliamp output.

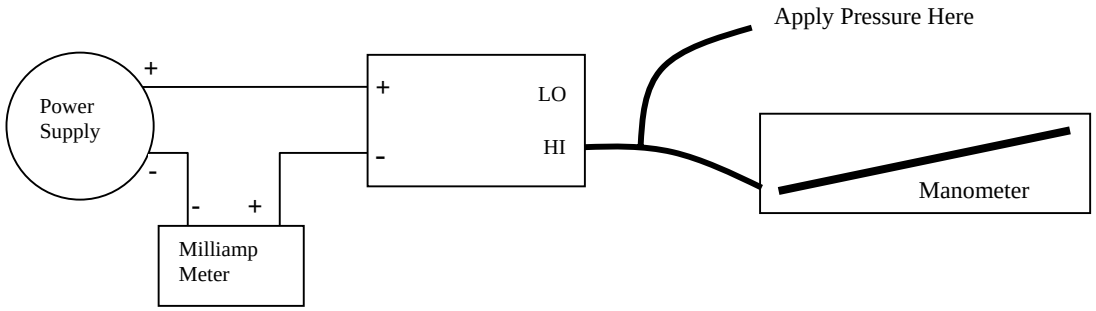
Now switch the power off, replace the resistor with a higher value and turn the power back on. Adjust the span pot to read the desired value of current output.

Repeat the procedure by switching resistors and adjusting zero and span until they settle out to the desired values. The transducer is now calibrated. Check your calibration by connecting any value of resistance that falls within the specified input range and observe the output. Is this what you expect?

CAUTION We have found the TCS transducers often calibrate just the opposite of what is normally expected. In other words, you may need to adjust the zero pot with the high resistance connected and the span pot with the low resistance connected.

CONTRACTOR INSTRUMENTS Model P855

The Contractor Instruments static pressure transmitter accepts wither a 0-3 in w.g. or –0.25-1.75 in w.g. static pressure as stated on the nameplate. The output is 4-20 mA. Connect the transmitter as shown in the diagram below.



Pressure input will be measured with an Airflow Manometer. Connect a tube to the high port of the transmitter and the manometer so they both read static pressure. ***Be extremely cautious of attaching and removing tubes from the sensor. The barbs are plastic and break easily.***

By blowing into the tube, apply a pressure to the manometer/transmitter close to the upper end of its range and pinch it off with a pair of vice grips. Read the pressure on the manometer and the current from the milliamp meter. Based

on the equation you developed for this unit, determine what current you should be reading. Adjust the span pot as necessary to read the proper voltage.

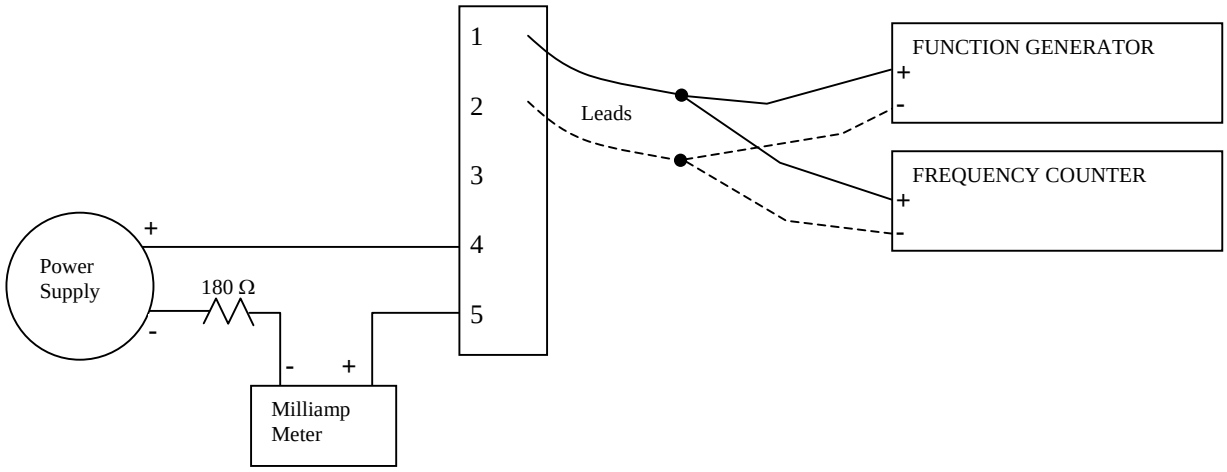
Now release the pressure. This should be zero pressure. Read the current. If it is not what you expect, adjust the zero pot.

Repeat the procedure by alternating between zero pressure and any other pressure (close to the upper end of the sensor span) until the readings settle out to what you've calculated. The transmitter is now calibrated. Check your calibration by applying any pressure within the range of the transmitter and observing the current. Is the current what you expect?

OMEGA Model FLSC-18B

The input to the transducer will be a pulse at a certain frequency. The attached table correlates pulse frequency with flow in gpm. Select two appropriate values of input frequency. Determine the appropriate gpm flow these values represent and the current output of the transducer.

Connect the device as shown below. The 180 Ω resistor simulates the receiver display or the controller.



Select a square wave output on the function generator and adjust the output to your desired frequency. Use the frequency counter to measure the frequency output of the function generator. Set the frequency counter for DC Coupling, 20X attenuation, and LP (Low Pass) filter on. These settings will filter out the electrical noise within the lab as a result of the fluorescent lighting and the effects of the local radio stations (RF Interference).

With the output of the function generator on low frequency, measure the output of the transmitter on the milliamp meter. Adjust the zero pot if necessary.

Change the output of the function generator to your desired high frequency. Measure the output of the transmitter. Adjust the span as necessary to obtain the desired output.

Repeat the procedure by alternating between high and low frequencies until the readings settle out to what is calculated. The transmitter is now calibrated. Check your calibration by applying any other frequency within the range of the transmitter and observing the output. Is the output what you expect?

53226 Return
53226 Makeup

OMEGA®
An OMEGA Technologies Company
One Omega Drive, Box 4047, Stamford, CT 06907-0047

CALIBRATION DATA SHEET

MODEL NUMBER: FTB-101
SERIAL NUMBER: 53325
TEST RANGE: .36 to 3.45 GPM
TEST STAND: 7
TEST FLUID: WATER at 70F Degrees
COIL TYPE: PC24-45G
DATE: 5/03/94

ACCOUNT NUMBER:
PURCHASE ORDER:
JOB NUMBER:

85.698 3.45

#	METER FREQUENCY (HZ)	METER FLOW RATE (GAL/MIN)	METER K FACTOR (P/GAL)	FREQUENCY VISCOSITY (HZ/CTS)
1	89.09	.364	14696.54	86.40
2	99.45	.405	14732.47	96.44
3	129.78	.528	14751.14	125.86
4	162.92	.663	14750.60	158.00
5	210.30	.858	14714.11	203.94
6	282.37	1.154	14687.45	273.83
7	369.76	1.512	14672.64	358.58
8	497.60	2.036	14661.48	482.55
9	604.43	2.480	14625.98	586.15
10	841.51	3.454	14619.88	816.06
	856.988	3.500		

WE CERTIFY THAT ALL TEST EQUIPMENT USED IN THE PERFORMANCE OF THE CALIBRATIONS ARE ACCURATE AND TRACEABLE TO THE NATIONAL BUREAU OF STANDARDS. ALSO, WE CERTIFY THAT OUR QUALITY ASSURANCE SYSTEM IS IN COMPLIANCE WITH MIL-I-45208A AND MIL-STD-45666A.

LINEARITY +/- .45 %

'K' AVERAGE 14691.2 PULSES/GAL
.229

OPERATOR MM

ENGR. APPROVAL

DESCRIPTION

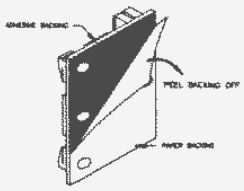
The TX series are accessory temperature transmitters which accept either 100 or 1000 ohm two-wire or three-wire platinum RTD sensors and provide a two-wire, 4 to 20mA output that is linear and proportional to the sensed temperature. The TX series are available in many factory calibrated ranges, yet can easily be field calibrated for any span greater than 35°F. The TX series are equipped with an adhesive backing for easy mounting.

MOUNTING

The Basys Controls TX series are designed to be mounted using any of the TQ1000 series mounting assemblies, or on any suitable flat surface. The TX series comes with an adhesive backing that will adhere to any clean, dry surface.

TX Series Adhesive Tape

All TX series temperature transmitters are equipped with an adhesive backing. Always clean the desired surface before mounting!



WIRING

Input: The TX series accept either 100 or 1000 ohm platinum RTD sensors. These sensors conform to IEC751 standards and have a temperature coefficient of .00385 ohm/ohms/°C. The TX series temperature transmitter is also designed to accept either a two- or three-wire RTD sensor. All the Basys Controls TS series RTD sensors are color coded. The following section explains the typical wiring for these devices.

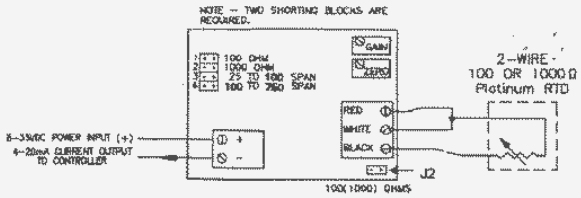
TCS Basys Controls®

TX Series

Temperature Transmitters

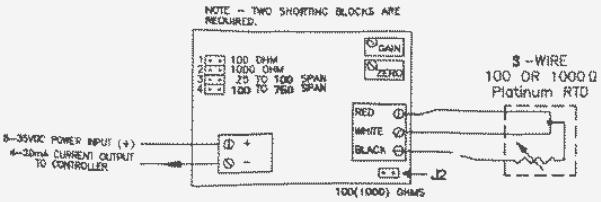
Using Two-Wire RTD Sensors: Insert one end of he RTD sensor into the transmitter's terminal block labeled "RED". Connect a jumper wire from the "RED" terminal to the "WHITE" terminal of the transmitter board. Connect the other end of the RTD sensor to the terminal labeled "BLACK" on the transmitter. See diagram.

Two - Wire RTD Connection



Using Three-Wire RTD sensors: Connect the red color coded lead to the terminal labeled "RED" on the temperature transmitter. Connect the white color coded lead to the terminal labeled "WHITE". Connect the black color coded lead to the terminal labeled "BLACK".

Three - Wire RTD Connection



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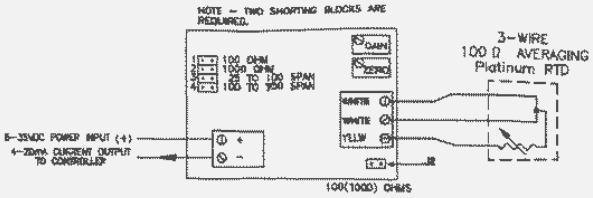
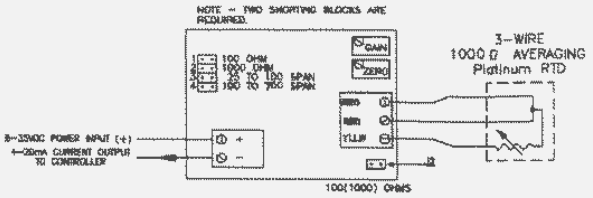
Using Three-Wire Averaging elements: The Basys Controls series of averaging elements are not color coded the same as the single point RTD's. The following examples show the correct wiring for these sensors.

100 Ohm Averaging Connection



1000 Ohm Averaging Connection



WARNING: All wiring is low voltage and should be in accordance with local regulations and the National Electrical Code.

CAUTION: Wiring should not be run in the same conduit as line voltage wiring or other conductors that supply highly inductive loads (e.g., generators, motors, contactors, etc.).

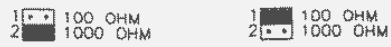
Output: The TX series temperature transmitters provide a 4 to 20mA output signal. The transmitter derives its internal power from the 4 to 20mA loop. The TX series transmitters require a minimum of 8VDC for internal operations.

Connect the supply voltage to the "+" terminal on the transmitter. Connect the "-" output of the transmitter to the "+" input of the monitoring device or channel input.

SETUP

Determine the sensor input type and place a shorting block on the appropriate pins. See diagram.

RTD Sensor Type Selection



The TX series transmitters are calibrated at the factory by placing a shorting block on position 3 or 4 in order to match the calibration range requested on your order.

Calibration Span Select

Do not, under any circumstances, reposition the shorting block. This will invalidate the factory calibration and impair the proper functioning of the transmitter.

OPERATING ADJUSTMENTS

The TX series temperature transmitters are calibrated at the factory to match the spans referenced in the price list. If the the sensed temperature output of the transmitter is found to be slightly out of calibration, use the ZERO potentiometer to re-calibrate the device. Do not adjust the ZERO pot more than +/- 10% of total calibration. Doing so will move the higher and lower limits of calibration out of acceptable tolerance limits.

FIELD RE-CALIBRATION PROCEDURE: The TX1500 series transmitters can be easily re-calibrated for a minimum span of 35°F and a maximum pan of 500°F by following these instructions:

Items Needed:

1) An 8 - 35VDC (Regulated) power supply.
2) An accurate (DMM) current meter.
3) A T.C.S. temperature simulator or decade box.

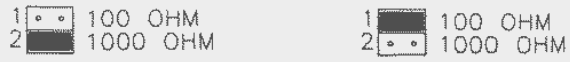
Basic wiring hookup: Connect the "+" of the power supply to the "+" of the temperature transmitter. Connect the "-" of the temperature transmitter to the "+" input terminal on the current meter. Then connect the "-" terminal on the current meter to the ground of the power supply.

To connect the Basys QE50 or QE51 simulator to the temperature transmitter, connect one terminal of the simulator to the transmitter terminal labeled "BLACK". Connect the other terminal of the simulator to the transmitter terminal labeled "RED".

Using a small piece of wire, connect the RED terminal to the WHITE terminal of the transmitter.

Configure the transmitter shorting block for 100 or 1000 ohm RTD sensor, depending on the type of calibrator purchased.

RTD Sensor Type Selection



Sensor values required: Determine the range or span for the temperature transmitter. For this example, the range is 50°F to 150°F with a 1000 ohm sensor. For all the Basys Controls temperature transmitters, "4mA" equals the lowest temperature (50°F), "20mA" equals the highest temperature (150°F), and all values in between are fully linear. Use the appropriate chart below to find the resistance values for 50°F and 150°F.

Current values needed: Determine the current values that the temperature transmitter will be set at in order to calibrate the unit for "50°F to 150°F". Use the formula below to calculate the currents.

F = Temperature [°F]
SH = High end of Span [150°F]
S L = Low end of Span [50°F]
C = Current at the (°F)

$$C = \frac{(F - SL)}{(SH - SL)} \times 16 + 4$$

In this example, 50°F = 4mA and 150°F = 20mA

Calibration procedure:

1. Apply power to the circuit.
2. Set the simulator for 50°F @ 1039.04 ohms.
3. Using the "ZERO" pot, adjust the current for 4mA.
4. Set the simulator for 150°F @ 1253.73 ohms.
5. Using the "GAIN" pot, adjust the current output for 20mA's.
6. Repeat steps 2 through 5. Unit calibration will be within 1% of FSO or better.

Conversion Table: 100 Ohm RTD's

DEG°F	DEG°C	OHMS	DEG°F	DEG°C	OHMS	DEG°F	DEG°C	OHMS	DEG°F	DEG°C	OHMS
-50.0	-45.5	82.070	60.0	15.5	106.053	170.0	76.6	129.606	280.0	137.6	152.727
-40.0	-40.0	84.268	70.0	21.1	108.212	180.0	82.1	131.726	290.0	143.2	154.808
-30.0	-34.4	86.462	80.0	26.6	110.368	190.0	87.7	133.842	300.0	148.7	156.885
-20.0	-28.9	88.653	90.0	32.2	112.520	200.0	93.2	135.954	310.0	154.3	158.958
-10.0	-23.3	90.841	100.0	37.7	114.668	210.0	98.8	138.064	320.0	159.8	161.028
0.0	-17.8	93.025	110.0	43.3	116.813	220.0	104.3	140.169	330.0	165.4	163.094
10.0	-12.2	95.205	120.0	48.8	118.954	230.0	109.9	142.271	340.0	170.9	165.157
20.0	-6.7	97.382	130.0	54.4	121.091	240.0	115.4	144.369	350.0	176.5	167.216
30.0	-1.1	99.555	140.0	59.9	123.225	250.0	121.0	146.464	360.0	182.0	169.272
40.0	4.4	101.725	150.0	65.5	125.356	260.0	126.5	148.555	370.0	187.6	171.324
50.0	10.0	103.891	160.0	71.0	127.483	270.0	132.1	150.643	380.0	193.1	173.372

Conversion Table: 1000 Ohm RTD's

DEG°F	DEG°C	OHMS	DEG°F	DEG°C	OHMS	DEG°F	DEG°C	OHMS	DEG°F	DEG°C	OHMS
-50.0	-45.5	820.695	60.0	15.5	1060.534	170.0	76.6	1296.060	280.0	137.6	1527.273
-40.0	-40.0	842.677	70.0	21.1	1082.123	180.0	82.1	1317.257	290.0	143.2	1548.079
-30.0	-34.4	864.623	80.0	26.6	1103.677	190.0	87.7	1338.419	300.0	148.7	1568.849
-20.0	-28.9	886.533	90.0	32.2	1125.196	200.0	93.2	1359.546	310.0	154.3	1589.583
-10.0	-23.3	908.408	100.0	37.7	1146.678	210.0	98.8	1380.636	320.0	159.8	1610.282
0.0	-17.8	930.247	110.0	43.3	1168.125	220.0	104.3	1401.691	330.0	165.4	1630.945
10.0	-12.2	952.051	120.0	48.8	1189.537	230.0	109.9	1422.711	340.0	170.9	1651.572
20.0	-6.7	973.819	130.0	54.4	1210.913	240.0	115.4	1443.695	350.0	176.5	1672.164
30.0	-1.1	995.551	140.0	59.9	1232.253	250.0	121.0	1464.643	360.0	182.0	1692.720
40.0	4.4	1017.247	150.0	65.5	1253.557	260.0	126.5	1485.555	370.0	187.6	1713.241
50.0	10.0	1038.908	160.0	71.0	1274.826	270.0	132.1	1506.432	380.0	193.1	1733.726

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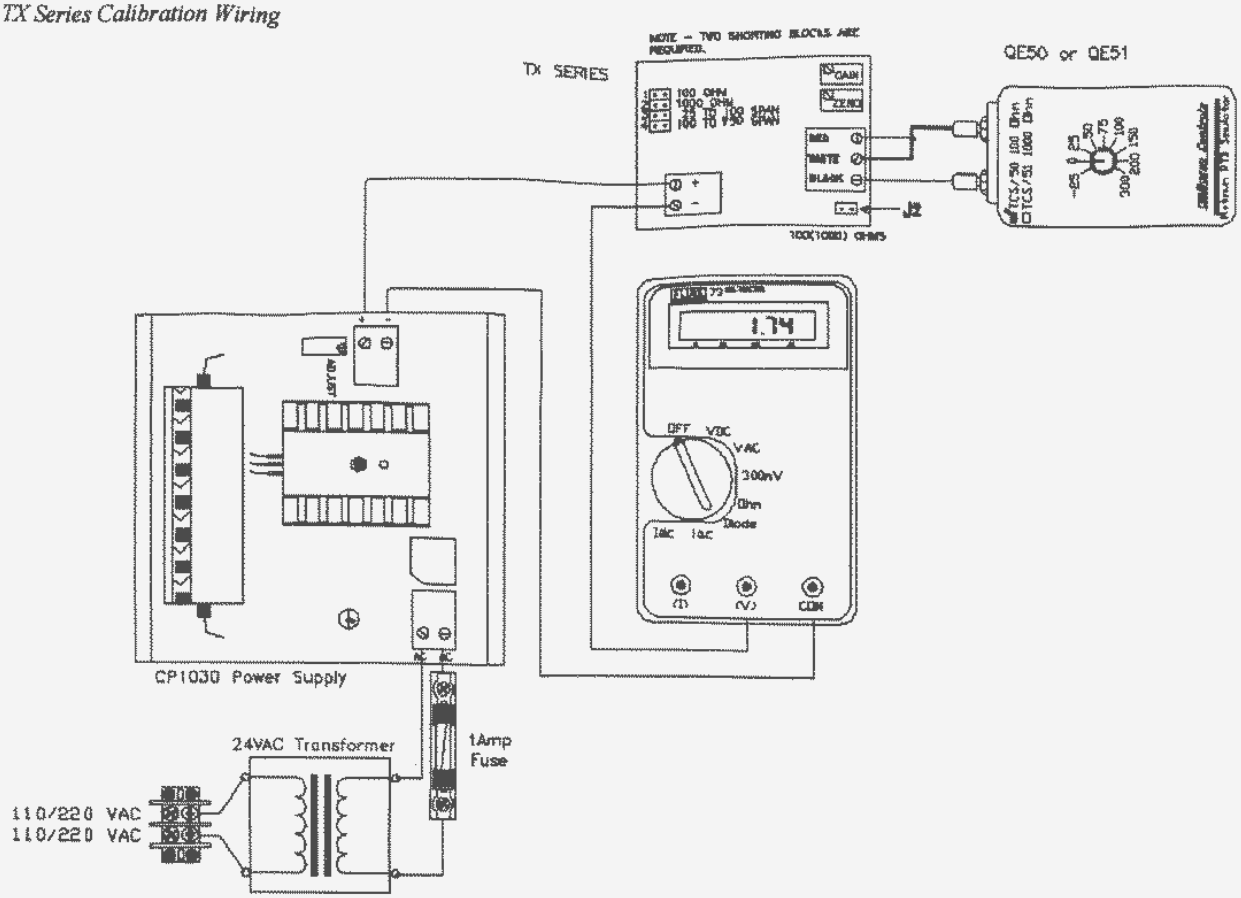
TX Series Calibration Wiring



Technical Notes: Adding long runs of sensor lead wire may change the actual temperature transmitter readings because of added resistance from the lead wire. To compensate for lead wire resistance, TCS/Basys Controls transmitters use three-wire RTD connections. The third lead wire is used to measure the actual lead wire resistance and subtract it from the current output reading.

Mount the temperature transmitters as close to the RTD sensor as possible and avoid adding any extra lead wire to the original sensor leads. The RTD sensor leads are extremely sensitive to EMI and RF signals. Adding extra lead wire to the sensor leads creates an antenna for these unwanted signals. By keeping the RTD lead wires short and extending the 4 to 20mA leads to the system, problem from "noise" are less likely to arise.

WARNING

Familiarize yourself with the line voltage rectification principles and the grounding requirements of these controlled devices. **THE BASYS CONTROLS SYSTEM MUST BE POWERED WITH A SEPARATE, DEDICATED TRANSFORMER.** Failure to wire TCS/Basys Controls control modules or devices according to specifications can lead to damage of the controls, the controlled devices or both. TCS/Basys Controls will not assume any responsibility for damages caused by wiring errors of this type. If you have a question regarding the proper set up and installation of TCS/Basys Controls products, free technical support is available by calling 1-800-288-9383 between the hours of 8:00 A.M. and 5:00 P.M. C.S.T., Monday through Friday.

CONVERSION TABLE: DEG. F TO OHMS

DEG. F	OHMS	DEG. F	OHMS	DEG. F	OHMS
-40.000	842.590	61.000	1062.832	162.000	1279.249
-39.000	844.790	62.000	1064.994	163.000	1281.373
-38.000	846.990	63.000	1067.157	164.000	1283.498
-37.000	849.190	64.000	1069.319	165.000	1285.622
-36.000	851.390	65.000	1071.481	166.000	1287.746
-35.000	853.591	66.000	1073.643	167.000	1289.871
-34.000	855.791	67.000	1075.805	168.000	1291.995
-33.000	857.991	68.000	1077.968	169.000	1294.120
-32.000	860.191	69.000	1080.130	170.000	1294.230
-31.000	862.391	70.000	1082.270	171.000	1296.351
-30.000	864.570	71.000	1084.428	172.000	1298.472
-29.000	866.767	72.000	1086.587	173.000	1300.592
-28.000	868.964	73.000	1088.745	174.000	1302.713
-27.000	871.162	74.000	1090.904	175.000	1304.834
-26.000	873.359	75.000	1093.062	176.000	1306.955
-25.000	875.556	76.000	1095.220	177.000	1309.076
-24.000	877.753	77.000	1097.379	178.000	1311.196
-23.000	879.950	78.000	1099.537	179.000	1313.317
-22.000	882.148	79.000	1101.696	180.000	1317.420
-21.000	884.345	80.000	1103.830	181.000	1319.537
-20.000	886.510	81.000	1105.976	182.000	1321.654
-19.000	888.703	82.000	1108.121	183.000	1323.772
-18.000	890.897	83.000	1110.267	184.000	1325.889
-17.000	893.090	84.000	1112.412	185.000	1328.006
-16.000	895.283	85.000	1114.558	186.000	1330.123
-15.000	897.477	86.000	1116.704	187.000	1332.240
-14.000	899.670	87.000	1118.849	188.000	1334.358
-13.000	901.863	88.000	1120.995	189.000	1336.475
-12.000	904.056	89.000	1123.140	190.000	1338.580
-11.000	906.250	90.000	1125.360	191.000	1340.694
-10.000	908.420	91.000	1127.511	192.000	1342.807
-9.000	910.609	92.000	1129.662	193.000	1344.921
-8.000	912.799	93.000	1131.812	194.000	1347.034
-7.000	914.988	94.000	1133.963	195.000	1349.148
-6.000	917.178	95.000	1136.114	196.000	1351.262
-5.000	919.367	96.000	1138.265	197.000	1353.375
-4.000	921.556	97.000	1140.416	198.000	1355.489
-3.000	923.746	98.000	1142.566	199.000	1357.602
-2.000	925.935	99.000	1144.717	200.000	1359.700
-1.000	928.125	100.000	1146.840	201.000	1361.810
0.000	930.290	101.000	1148.987	202.000	1363.920
1.000	932.475	102.000	1151.134	203.000	1366.030
2.000	934.661	103.000	1153.281	204.000	1368.140
3.000	936.846	104.000	1155.428	205.000	1370.250
4.000	939.032	105.000	1157.575	206.000	1372.360
5.000	941.217	106.000	1159.722	207.000	1374.470
6.000	943.403	107.000	1161.869	208.000	1376.580
7.000	945.589	108.000	1164.016	209.000	1378.690
8.000	947.774	109.000	1166.163	210.000	1380.790
9.000	949.959	110.000	1168.290	211.000	1382.896
10.000	952.110	111.000	1170.433	212.000	1385.003
11.000	954.292	112.000	1172.576	213.000	1387.109
12.000	956.473	113.000	1174.720	214.000	1389.216
13.000	958.655	114.000	1176.863	215.000	1391.322

14.000	960.836	115.000	1179.006	216.000	1393.428
15.000	963.018	116.000	1181.149	217.000	1395.535
16.000	965.200	117.000	1183.292	218.000	1397.641
17.000	967.381	118.000	1185.436	219.000	1399.748
18.000	969.563	119.000	1187.579	220.000	1401.840
19.000	971.744	120.000	1189.710	221.000	1403.943
20.000	973.900	121.000	1191.849	222.000	1406.046
21.000	976.078	122.000	1193.989	223.000	1408.148
22.000	978.255	123.000	1196.128	224.000	1410.251
23.000	980.433	124.000	1198.268	225.000	1412.354
24.000	982.611	125.000	1200.407	226.000	1414.457
25.000	984.789	126.000	1202.546	227.000	1416.560
26.000	986.966	127.000	1204.686	228.000	1418.662
27.000	989.144	128.000	1206.825	229.000	1420.765
28.000	991.322	129.000	1208.965	230.000	1422.850
29.000	993.499	130.000	1211.090	231.000	1424.949
30.000	995.650	131.000	1213.226	232.000	1427.048
31.000	997.824	132.000	1215.361	233.000	1429.148
32.000	999.998	133.000	1217.497	234.000	1431.247
33.000	1002.171	134.000	1219.632	235.000	1433.346
34.000	1004.345	135.000	1221.768	236.000	1435.445
35.000	1006.519	136.000	1223.904	237.000	1437.544
36.000	1008.693	137.000	1226.039	238.000	1439.644
37.000	1010.867	138.000	1228.175	239.000	1441.743
38.000	1013.040	139.000	1230.310	240.000	1444.830
39.000	1015.214	140.000	1232.430	241.000	1446.926
40.000	1017.360	141.000	1234.562	242.000	1449.021
41.000	1019.530	142.000	1236.694	243.000	1451.117
42.000	1021.700	143.000	1238.825	244.000	1453.212
43.000	1023.870	144.000	1240.957	245.000	1455.308
44.000	1026.040	145.000	1243.089	246.000	1457.404
45.000	1028.209	146.000	1245.221	247.000	1459.499
46.000	1030.379	147.000	1247.353	248.000	1461.595
47.000	1032.549	148.000	1249.484	249.000	1463.690
48.000	1034.719	149.000	1251.616	250.000	1464.770
49.000	1036.889	150.000	1253.730	251.000	1466.862
50.000	1039.040	151.000	1255.858	252.000	1468.954
51.000	1041.206	152.000	1257.986	253.000	1471.046
52.000	1043.372	153.000	1260.114	254.000	1473.138
53.000	1045.538	154.000	1262.242	255.000	1475.230
54.000	1047.704	155.000	1264.370	256.000	1477.322
55.000	1049.870	156.000	1266.498	257.000	1479.414
56.000	1052.036	157.000	1268.626	258.000	1481.506
57.000	1054.202	158.000	1270.754	259.000	1483.598
58.000	1056.368	159.000	1272.882	260.000	1485.670
59.000	1058.534	160.000	1275.000	261.000	1487.758
60.000	1060.670	161.000	1277.124	262.000	1489.847