Thermistor Accuracy With instruNet 100HC

Application Note #10, 8/13/2002

Summary

The instruNet 100HC supports the direct connection to YSI/Omega 4xx and 4xxxx series thermistors, requiring one external shunt resistor. The following table shows accuracies with 2 different kinds of shunt resistors (i.e. 0.025%-20ppm/C and 0.1%-25ppm/C resistor). The table excludes thermistor device errors; yet includes thermistor and shunt self-heating errors, shunt initial accuracy errors, voltage measurement errors, and linearization errors.

Thermistor (Ohms@25C)	Temp Range (C)	R Shunt (ohms)	V excitation (Volts)	.025%-20ppm/C Accuracy (+-C)	.1%-25ppm/C Accuracy (+-C)
2252	-80 to 40C	47K	4.90V	+- .2C	+- .24C
	0 to 70C	4.7K	.55V	+- .1C	+- .12C
	0 to 200C	200	.55V	+- .4C	+- .4C
10000	-80 to 40C	100K	4.90V	+- .3C	+- .32C
	0 to 70C	10K	.55V	+- .1C	+- .12C
	0 to 250C	2K	.55V	+- .16C	+- .18C

Conditions: 18-28C, excludes thermistor errors, 0.001 sec of integration, instruNet #iNet-100HC Rev 3, assumes temperature has not changed since instruNet 100 self-calibration.

Analysis

instruNet supports a direct connection to thermistors, and the measurement accuracy is the sum of the following components:

1) Errors within the thermistor itself (typically +/-.1C to +/-.2C). For more details, please consult your thermistor supplier.

2) Thermistor linearization error: +/- .05C.

3) Shunt Resistor Accuracy Error: This is dependent on the type of shunt resistor in use, the specific thermister in use, and the temperature one operates at. For example, if you use a Caddock #TN130-1K-0.025%-20 shunt resistor, then it's initial accuracy is 0.025%, which causes a .025% error in the thermister resistance measured by instruNet. For example, a 2252ohm thermister at 0C sports a resistance of 7355, and this value multiply by 1.00025 is 7356.8, which corresponds to a .005C error. Please consult your thermister resistance-to-temperature tables when making these calculations. In most cases, a .025% shunt resistor with a 20ppm temperature coefficient provides less than a .01C error. For details about resistors, or to buy precision resistors, please contact Caddock Electronics, Greg Gray, Tel 541-496-0700. He's a good guy.

4) Thermistor voltage measurement errors: These are due to the voltage measurement accuracy of instruNet 100 itself. With .001 sec of integration, one can expect instruNet 100 measurment errors of +/- 700uV, 75uV, 15uV, 10uV on the +/-5V, .6V, 80mV, 10mV ranges, respectively (for the instruNet 100 Rev 3). instruNet measures two voltages, the voltage divider excitiation voltage, and the voltage across the thermister itself (both introduce a small error). The thermistor resistance is calculated as follows:

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Rthermistor = Rshunt * Vthermistor / (Vexcitation-Vthermistor)
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where:

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Rthermistor = calculated thermistor resistance in ohms
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Rshunt = shunt resistance resistance in ohms
Vthermistor = voltage measured across the thermistor
Vexcitation = excitation voltage across the voltage divider
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5) Shunt resistor self-heating.

The power disipated by a resistor (shunt resistor or thermistor) is:

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PowerDisipated (Watts) = (VoltsAcrossRes * VoltsAcrossRes / Resistance).
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This power causes the resistor to heat up:

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TempChange (C) = ThermalResistance (C/Watt) * PowerDisipated (Watts)
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And this causes a change in resistance. For a Resistor:

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ChangeInRes (ohms) = TempChange (C) * TempCoeff (ppm/C) * ResValue (ohms)
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6) Thermistor thermal self-heating.

This is calculated in the same manner as the Shunt resistor self-heating above in (5); however, it is not necessary to calculate the ChangeInResistance in the end, since the 2nd equation already provides the change in temperature, which is the error of the thermistor heating up on it's own due to current passing through it. In most cases, one should put <100uW (75uW is better) through a thermister to keep it's thermal heating <.07C.

EXAMPLE CASE

Suppose we use a 2252 thermistor with a 1000ohm shunt resistor on a 0-70C range with .37V of excitation. instruNet would measure the excitation voltage on the +/-.6V range accurate to +/-75uV, resulting in a 75e-6V/.37V = .02% error, which corresponds to approximately .01C. At 25C, the thermistor resistance would be 2252ohms, and the voltage across the thermistor would be .37V * 2252ohms / (2252ohms + 1000ohms) = .25V. This would also be measured on the .6V range, which would induce a similar error of around .02C. At 70C, the thermistor resistance would be 394.5ohms, and the voltage across the thermistor would be .37V * 394.5ohms / (394.5ohms + 1000ohms) = .104V. This would also be measured on the .6V range accurate to +/- 75uV, resulting in a 75e-6V/.104 = .07% error, and .07% of 394.5 is 0.2ohms, which corresponds to approximately .02C. The thermal heating of the shunt resistor would be the worst when the thermistor was at it's maximum resistance of 7300ohms at 0C (.35V across the shunt). At this point, the power disipated across the resistor would be .1mWatt, and at 116C/Watt thermal heating, this would result in a .01C rise in shunt temperature. And with a 20ppm/C temperature coefficient, this would correspond to a .2e-3ohm change in resistance, which would result in a .2e-3/1000=.00002% error (not much). The error from the self-heating of the thermistor itself would be be tiny as well at 1.5e-5 degrees C. Notice that the excitation voltage, the shunt resistor resistance, and the measured temperature range all effect the accuracy calculation.