TECH NOTE

Temperature Measurement Using A Linearized Thermistor Network

OVERVIEW

The LDT-5412B and LDT-5416 Thermoelectric Temperature Controllers have a unique mode which allows these simple all analog temperature controllers to display and control temperature without the need to enter Steinhart-Hart calibration constants.

OPERATING PRINCIPLE

Converting thermistor resistance to temperature is complicated by the non-linear behavior of NTC thermistors and typically a microprocessor and Steinhart-Hart constants are required to accurately measure temperature. Uncalibrated thermistors can have temperature accuracies greater than ±2.0°C. Using the linearized thermistor mode of the LDT-5412B or LDT-5416 and specific 10kΩ thermistors allow temperature accuracy of ±1.0°C to be achieved over a temperature range of 10°C to 40°C.

The linearized thermistor mode of the LDT-5412B and LDT-5416 switches in a 10kΩ resistor in parallel with the 10kΩ NTC thermistor. This has an effect of reducing the non-linear behavior of the 10kΩ NTC thermistor due to addition of resistors in parallel which allows a much more linear input into the temperature control circuit when the thermistor changes with temperature.

The following equations were used to determine the parallel resistance of the thermistor at specific value:

$$R_{Therm} = R_{25} e^{\beta\left(\frac{1}{T} - \frac{1}{T_{25}}\right)}$$

$$R_{Linearized} = \frac{1}{\frac{1}{R_{Therm}} + \frac{1}{R_{10k}}}$$

Where β is the Beta value of the thermistor, R_{25} is the resistance value at 25°C, R_{10k} is the resistance value of a 10kΩ resistor and T_{25} is the reference temperature of 25°C converted to Kelvin.

SELECTING A THERMISTOR

Selecting a proper 10kΩ NTC thermistor will be critical to maintaining the range specified for linearized thermistor mode. The two values of which to pay attention are Beta value (β) and Resistance Accuracy of the Thermistor.

Figure 1

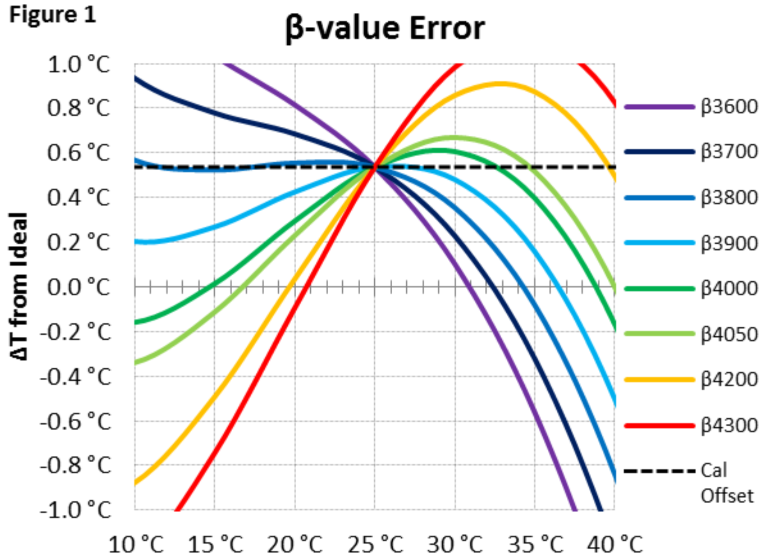

Figure 1 shows the values of 10kΩ resistor in parallel with 10kΩ thermistor of varying β values.

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Figure 2

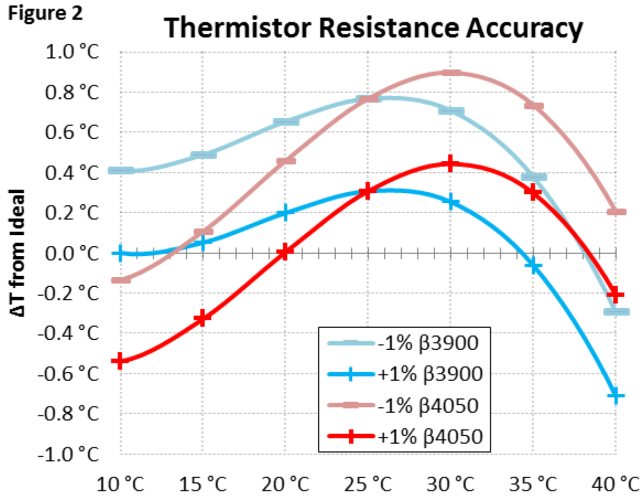

Figure 3

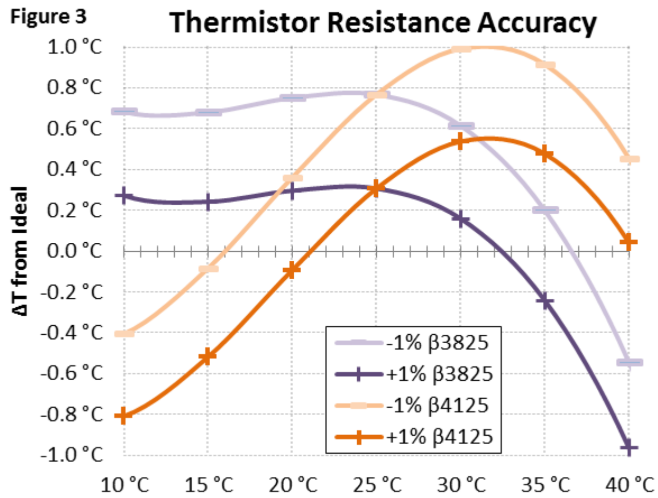

Figure 2 shows the resistance accuracy of 10kΩ thermistors with β values of 3900 and 4050 in parallel with 10kΩ resistor.

The ideal calibration value to maximize the range in which the linearized thermistor network will be accurate causes the calibration offset which is shown in Figure 1.

These two figures show that a 10kΩ thermistor in the β range of 3900 to 4050 will have the closest average ΔT from the ideal value over the specified range.

Additionally, Figure 2 shows that ΔT from the ideal using a thermistor with a resistance accuracy of ±1% would be within the specified temperature range.

Figure 3 shows the theoretical limits of 10kΩ thermistors with a resistance accuracy of ±1%. These β values allow for less than 0.01°C on the upper and lower limits of the specified instrument. This upper and lower limit show why the β range of 3900 to 4050 was chosen, as they are equidistant from the worst case scenario.

CONCLUSION

By selecting a proper thermistor for use in linearized thermistor mode, the LDT-5412B and LDT-5416 eliminate the need for a microprocessor to enter Steinhart-Hart constants in a common temperature control range. A 10kΩ thermistor with resistance accuracy of ±1% or better with a β value between 3900 and 4050 will allow this instrument to accurately control and display within ±1.0°C in the range of 10°C - 40°C with a sufficient margin of error.