Sensing Solutions

HOW–TO GUIDE

COMPUTER INTERFACING TO AN NTC THERMISTOR

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Using a precision NTC thermistor as a sensor for a uC or computer based instrument can be accomplished in a fairly straightforward manner. A thermistor/resistor voltage divider bridge can supply a strong signal to an A-D converter, which can then be interfaced to the desired instrument (Figure 1). Using the entire range of the thermistor (–55°C to 125°C), a 12 bit A-D can give a resolution of 0.04°C, a 10 bit 0.175°C and an 8 bit 0.70°C. Since an NTC thermistor exhibits a nonlinear change in resistance with a linear change in temperature, the voltage output of the bridge must be interpreted for the actual temperature. This can be accomplished with an R-T look up table, or through the use of an equation which characterizes the thermistor response.

APPLICATION USING AN R-T LOOK UP TABLE

Using this method, the A-D count is simply used as an offset to correlate to the temperature recorded in the table. The table is created by calculating or measuring the A-D count when the thermistor is at a given temperature or resistance value, and recording this in the table. This method has the advantage of the ability to manipulate the table to fit a particular thermistor's R-T characteristic very closely.

The following example uses a 10K ohm thermistor/10K ohm fixed resistor bridge network, and an 8 bit A-D converter.

R-T multiplier @ –55°C = 96.4
Thermistor R @ –55°C = 964K ohm
Bridge voltage @ –55°C = 4.948V

R-T multiplier @ 125°C = .03461
Thermistor R @ 125°C = 346.1 ohm
Bridge voltage @ 125°C = 0.00048V

R-T multiplier @ 25°C = 1
Thermistor R @ 25°C = 10K ohm
Bridge voltage @ 25°C = 2.5V

Using these values, the A-D high ref would be set at 4.984V, and the low ref at 0.00048V, yielding (4.984V-0.00048V)/256 count or ~0.0194V per A-D count, giving the following:

A-D count at 125°C = 00000000, table element 0 = 125
A-D count at –55°C = 11111111, table element 255 = –55
A-D count at 25°C = 2.5V/0.0194V = 128.8dec = 10000001bin, table element 129 = 25

The in-between values are calculated in the same manner. The number of values in the table can be any power of 2 up to the resolution of the A-D converter. By dividing the A-D count by the appropriate number and using linear interpolation between the table entry numbers, required table memory space can be reduced with a minimum decrease in accuracy.

```
DIM TABLE (255) AS SINGLE      'this is the lookup table
        TABLE (0) = 125
              •
              •
              •
        TABLE (129) = 25
              •
              •
              •
        TABLE (255) = –55
OPEN "A-D" FOR INPUT AS #1     'open A-D
INPUT #1, ADCOUNT              'and get count
TEMP = TABLE (ADCOUNT)         'get temperature at pointer
PRINT TEMP                     'and the final output in degrees Celsius
```

The following is an example in BASIC how to implement this using a 64 element lookup table and 8 bit A-D converter.

```
DIM TABLE (64) AS SINGLE                'this is the lookup table
        TABLE (0) = 125
              •
              •
              •                         'this is ~129/4
        TABLE (32) = 25
              •
              •
              •
        TABLE (63) = –55
              •
              •
              •
OPEN "A-D" FOR INPUT AS #1              'open A-D
INPUT #1, ADCOUNT                       'and get count
TABLEOFFSET = INT(ADCOUNT/4)            'divide by 4 for lookup table of 64 elements.  Round result to next lowest
                                          integer value.
TEMP = TABLE (TABLEOFFSET)              'get temperature at pointer
NEXTTEMP = TABLE (TABLEOFFSET+1)        'get temperature above pointer (next 'pointer location).  Actual temperature
                                          is between these two.
DIFFTEMP = ABS (ADCOUNT-(TEMP*4))       'this is the distance from TEMP between TEMP and NEXTTEMP.  This is the
                                          interpolated temperature.  Remember that values in table decrease as the
                                          A-D count increases.  Note that this assumes that a table point lies on 0.  If
                                          there is no 0 entry separating positive and negative table entries, some
                                          additional conditions must be added to correctly interpolate.
INTERPTEMP = TEMP +
  (((TEMP-NEXTTEMP)/4)*DIFFTEMP)
PRINT INTERPTEMP                        'and the final output in degrees Celsius.
```

APPLICATION USING THERMISTOR CHARACTERIZATION EQUATION

The equation for thermistor characterization is known as the Steinhart-Hart Equation. This equation requires the computation of the coefficients a, b, c and d. These can also be obtained from the thermistor manufacturer. The resulting temperature is given in degrees K. The following BASIC program demonstrates this method, using the same circuit as above, with A-D high ref = bridge voltage (5V) and A-D low ref at 0V.

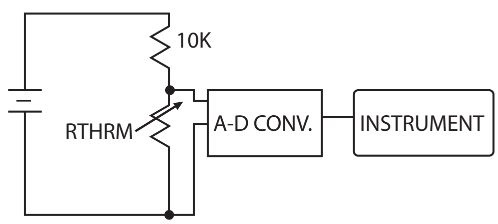

Figure 1. (Left) A thermistor/resistor voltage divider bridge can supply a strong signal to an A-D converter, which can then be interfaced to the desired instrument.

```
a = ?                                          'these constants need to be entered
b = ?
c = ?
d = ?
resolution = 256                               'for 8 bit A-D
vref = 5                                       'bridge voltage
rfix = 10000                                   'fixed bridge resistor
OPEN "A-D" FOR INPUT AS #1                     'open A-D
INPUT #1, ADCOUNT                              'and get count
VBRIDGE = ADCOUNT*(vref/resolution)            'convert to voltage across thermistor
RTHERM = VBRIDGE/((vref-VBRIDGE)/rfix)         'find thermistor resistance.  Convert to temperature using given
                                                 coefficients and equation.  This is the standard Steinhart-Hart
                                                 equation, with the 273.15 added to yield degrees Celsius.
TEMP = (1/(a + b*(lnRTHERM) + c*(lnRTHERM)^2 +
  d*(lnRTHERM)^3)) – 273.15
PRINT TEMP                                     'and the final output in deg C
```

ABOUT QTI SENSING SOLUTIONS

QTI Sensing Solutions was founded in 1977 to meet the increasing demand for high quality electronic components for the aerospace industry. Since then, QTI has exceeded the requirements of some of the most stringent high cost of failure applications, changing the landscape of the supply chain for the entire industry.

Today, QTI continues to maintain its leadership position for mission-critical applications as well as for medical and industrial applications by supplying the world's top companies with innovative products and services. In fact, QTI developed the highest standard for surface mount thermistors with the introduction of qualified surface mount parts to MIL-PRF-32192; supplying design engineers with fully qualified Defense Logistics Agency options for two PTC and three NTC surface mount package styles. Additionally, QTI has partnered with the NASA Goddard Space Flight Center for surface mount thermistors qualified to S311-P827, an industry first!

In addition to QTI's accomplishments, our ISO:09001:2000 and AS9100 certified manufacturing and testing facilities in Idaho enhances our ability to meet the needs of today's challenging temperature measurement and control applications.

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If you would like to learn more about how QTI can help you, please contact us today. We would be happy to discuss your project with you and help with the product selection process. Additionally, if you are unable to find the item you need, our engineers may be able to produce a custom component for your individual application.