Application Note #5481

Interfacing Temperature Sensors with Galil products

Deciding on what temperature sensor to use can be a confusing matter, so this application note will go over some common temperature sensors and show sample circuits of how to integrate each one into a standard Galil analog input. The information presented in this note can be used for any Galil controller that has analog inputs and is also valid for the RIO Pocket PLC.

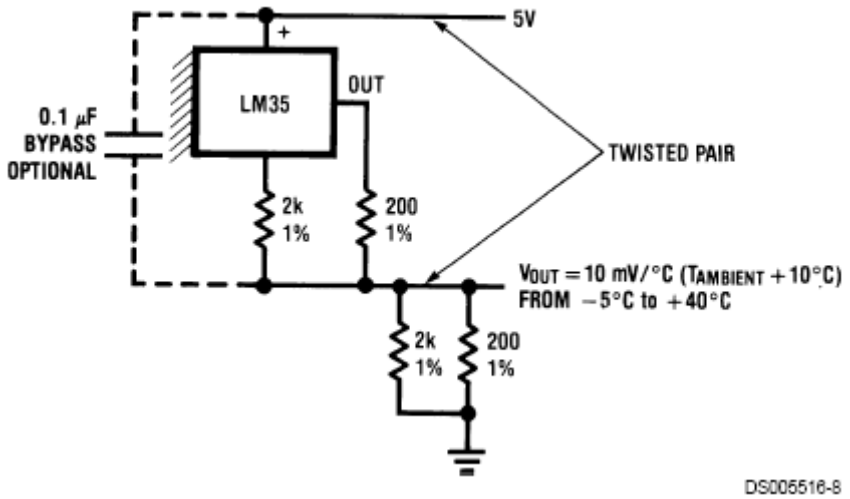
The four types of temperature sensors we will go over are:

- LM35
- RTDs
- Thermistors
- Thermocouples

LM35

The LM35 temperature sensor is the easiest of all the temperature sensors to use because it is an integrated circuit that outputs a voltage proportional to the temperature in degrees Celsius. The sensor itself takes care of the non-linear effects that occur with some other sensors so the sensor input circuitry is simplified. Another benefit is that the output voltage is higher than other sensors (such as thermocouples) and therefore an amplifier circuit is not necessary. The scale factor for a typical LM35 is 0.01V/°C. It has a typical accuracy of ±1/4°C at room temperature and ±3/4°C over a full −55 to +150°C temperature range.

Typical Circuit:



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The conversion factor is 100°C/V so a voltage reading of 0.234V is 23.4°C. When connecting to Galil, a +12 or +5V supply can be used to power the LM35.

Datasheet:
http://cache.national.com/ds/LM/LM35.pdf

Digikey Product Search:
http://search.digikey.com/scripts/DkSearch/dksus.dll?Cat=1966391;keywords=LM35

RTDs

An RTD is a Resistive Temperature Device that takes advantage of the fact that a material's resistance changes as a function of temperature. Most RTD elements consist of a fine coiled wire wrapped around a ceramic or glass core. The RTD element is made from a pure material whose resistance at different temperatures is known. Since the material used has a predictable change in resistance based on temperature – this is used to accurately measure temperature. Typical materials used for RTD's include: Platinum (most common), Nickel, Copper, Balco, or Tungsten.

Some benefits of RTDs are:

- Wide temperature range (-200 to 850°C)
- Good Accuracy (better than Thermocouples)
- Repeatability and resistance to electrical noise
- Long-Term stability (ie: aging)

RTDs are positive temperature coefficient (PTC) sensors which mean their resistance increases with temperature.

Typical Circuit:
http://ww1.microchip.com/downloads/en/AppNotes/00687b.pdf

Digikey Product Search:
http://search.digikey.com/scripts/DkSearch/dksus.dll?Cat=1966810;keywords=RTD

Thermistors

A Thermistor is an inexpensive and readily available temperature sensor that is most commonly used for simple temperature measurements less than 200°C. Like an RTD, a thermistor can be thought of as a resistor that is extra sensitive to changes in temperature. The semiconductor material that a thermistor is made from takes advantage of this property to produce a temperature measurement. However, since the change in resistance is not linear with respect to temperature - an equation must be used to extract the temperature based on the resistance. This is known as the Steinhardt-Hart equation. To get a temperature value from resistance, you can use the following formula:

$$T = 1/[A + B*\ln(R) + C*(\ln(R))^3]$$

where R is in Watts and T in ^oK.

Because the resistance characteristic drops down with increasing temperature they are called negative temperature coefficient (NTC) sensors

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Typical Circuit:
http://www.maxim-ic.com/appnotes.cfm/appnote_number/1753/

Digikey Product Search:
http://search.digikey.com/scripts/DkSearch/dksus.dll?Cat=1966148;keywords=thermistor

Thermocouples

A thermocouple is based on the "thermoelectric effect" which occurs when two different metals are connected together – a voltage is produced that is dependant on the type of metals used and the temperature. In order for the thermal voltage to produce a current, the metals must be connected together at both ends so that a closed circuit is formed. If the temperature is the same at both ends, there is no flow of current. Thus, a thermocouple can only measure temperature differences. For this reason, the reference junction temperature must be known for an accurate measurement to occur. Since the reference temperature point is generally lower than the measured temperature – it is generally called the cold junction. At the "cold junction" or reference junction, an RTD or similar temperature sensor is used to have an accurate reference temperature. The voltage produced by a thermocouple is very small and amounts to only a few microvolts per degree Celsius. Thermocouples are generally not used in applications in the range of -30 to 50°C because the difference between the reference temperature and the measurement temperature is too small to get accurate noise-free signals. However, compared with other sensors – thermocouples offer the clear advantage of a higher upper temperature limit (up to several thousand degrees Celsius) and are therefore frequently used to measure temperatures in ovens, furnaces, etc.

Typical Circuit:
http://ww1.microchip.com/downloads/en/AppNotes/00844a.pdf

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