Application Note 1
Using the Brew Data Solid State Temperature Sensor

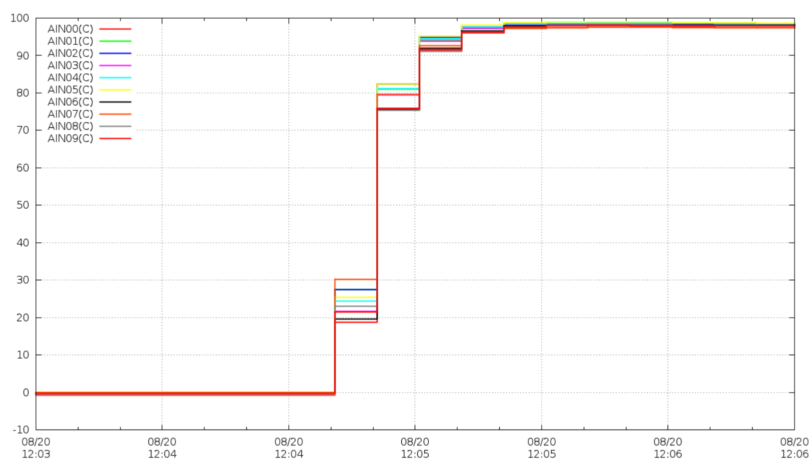
Introduction

All of the temperature measurement probes manufactured by Brew Data utilize the Brew Data solid state temperature sensor. This sensor is well suited for general scientific and industrial applications where the temperature range is between -40C and 125C. Within this temperature range these sensors are much easier to wire and interface when compared to RTDs, thermocouples, or thermistors. Unlike RTDs and thermocouples there are no special wiring requirements. Unlike thermocouples and thermistors they are highly linear and do not require calibration. Generally, they will also be more accurate. This is because most of the inaccuracies in RTDs or thermocouples occur in the wiring and signal conditioning. The specifications for the thermocouples or RTD may seem very good by themselves, but a careful error analysis of the whole system often reveals that wiring and signal conditioning errors dominate the measurement error. These sensors essentially have built-in signal conditioning making them tolerant to wiring errors. Not only does this improve accuracy, but it lowers the total installed cost by removing the need for signal conditioning modules, special wire, and terminal blocks.

Unlike many other solid state temperature sensors these are ESD protected and are compensated to drive long lines or capacitive loads. They can also measure the -40C and 125C temperature range with only one positive power supply.

Thermal Response

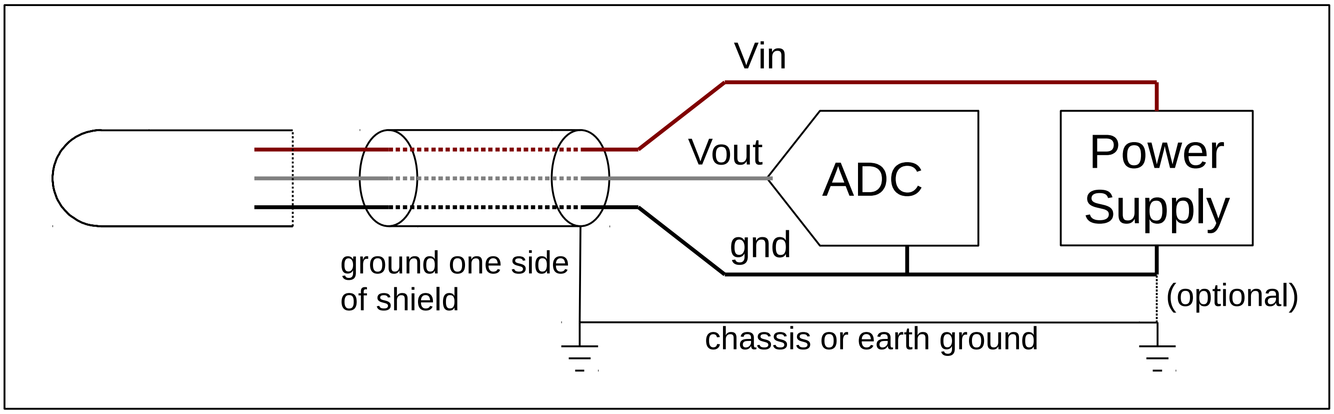
All of the Brew Data temperature probes have very similar thermal response characteristics. The response speed is generally limited by the thermal mass of the stainless steel probe. The following graph shows a typical thermal response of a group of probes moved from an ice bath to boiling water. Note that the data was taken at 10 second intervals.



Typical thermal response (°C) for a group of 10 probes.

Brew Data LLC, Cedar Rapids, IA 52403, www.brew-data.com, info@brew-data.com

Wiring



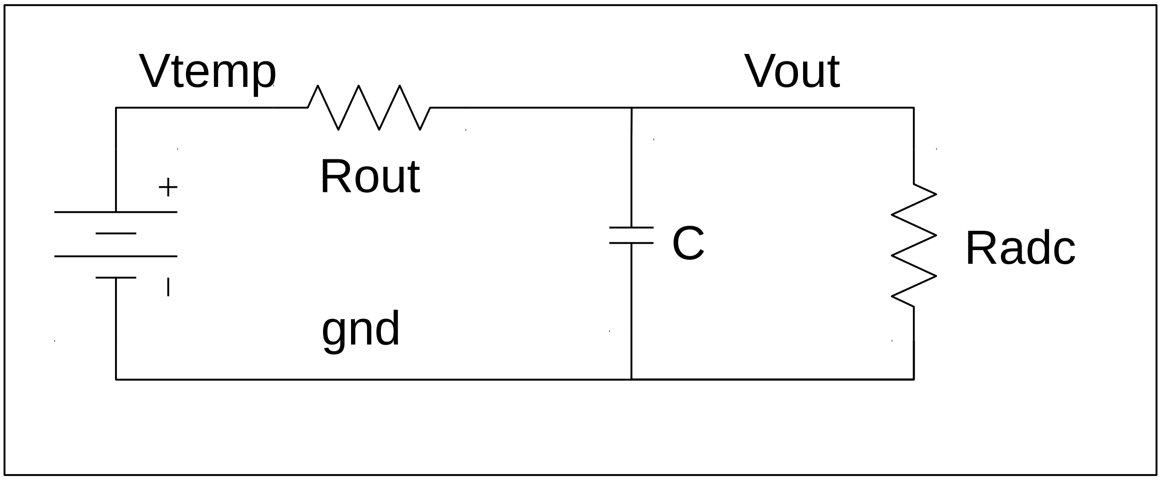
No special wiring requirements are needed. Wiring nuts may be used to connect the probe to a cable. Terminal blocks or soldering may also be used if this is more convenient. Cable length is not an issue under several hundred feet, however shielded cable is recommended. When connecting the probe to a cable, it is recommended to use a shielded cable with 20AWG stranded wires. Smaller or larger wire gauge may be used, but smaller wire will be difficult to connect using wire nuts, and cable with larger wire will be more expensive and less flexible. The cable can be spliced in the middle of a run. When splicing, the shields or drain wires should also be spliced.

As with other electronic devices, it is important to observe proper grounding and shielding techniques. Shields should be connected to a good chassis or earth ground on one side of the cable only. If both sides are grounded, then the shield becomes a conductor and "ground loops" can form where current begins to flow through the shield generating electric noise. Note that this is in contrast to a coaxial cable where the shield is generally grounded at both ends of the cable.

When wiring multiple sensors to the same power supply, single point ground and power supply connections should be used if possible.

Considerations when connecting to measurement device

The output impedance of the sensor is very close to 1000Ω and is resistive. When connecting to an ADC or measurement device, this is significant in two ways. The first is that a voltage divider will be set up with the effective input impedance of the ADC and that can introduce a measurement error. The second is that this makes it very easy to add a simple anti-aliasing or noise filter.



In the illustration above, Rout is the output impedance of the temperature probe. Radc is the effective input impedance of the ADC or measurement device. Vtemp is the actual output of the temperature sensor and Vout is the measured voltage. C is the optional filter cap explained later. The formulae to calculate Vout and Radc are:

$$Vout = Vtemp \times \frac{Radc}{Rout + Radc} \Rightarrow Radc = \frac{Rout}{\frac{Vtemp}{Vout} - 1}$$

For the sake of demonstration, assume it is desired to limit the additional measurement error to ±0.25ºC at room temperature (20ºC). At 20ºC the sensor voltage (Vtemp) will be 638mV. Including a -0.25ºC error makes the output or measured voltage (Vout) 636.4mV. From this, the minimum ADC impedance (Radc) can be calculated:

$$Radc = \frac{Rout}{\frac{Vtemp}{Vout} - 1} = \frac{1000\,\Omega}{\frac{638\text{mV}}{636.4\text{mV}} - 1} = 398\text{K}\,\Omega$$

Most general purpose ADCs exhibit Radc >>398KΩ.

A simple anti-aliasing or noise filter can be built by placing a capacitor from the input to the measurement device to ground. This forms a one pole low pass filter using the output resistance of the sensor. For example, if a noise filter with a 100Hz cutoff is desired, this C is calculated by:

$$C = \frac{1}{2 \times \pi \times Rout \times F} = \frac{1}{2 \times \pi \times 1000 \times 100} = 1.59\text{uF}$$

In this case either a 1.5uF, 16V, X7R ceramic or a 1.5uF film capacitor would be a good choice.

Brew Data LLC, Cedar Rapids, IA 52403, www.brew-data.com, info@brew-data.com