What thermocouples are

Thermocouples are two different types of metal wire welded together at one end. When there is a heat difference between two ends of the wire, the two metals produce a small voltage. This is typically very small, for 'k' type thermocouples for instance, this is about 40 millionths of a Volt per Centigrade change in temperature. This voltage is so small that ordinary voltage reading chips, Analogue to Digital Converters (ADC), cannot easily read them to any reasonable accuracy. The small signal is usually amplified into a range that a computer chip (i.e. ADC) can read. The TH7 has an amplifier that takes the small voltage and amplifies it by 100. It can then be read into the Raspberry Pi where it can be converted to a temperature reading with adequate accuracy. Wikipedia has a good entry on thermocouples. https://en.wikipedia.org/wiki/Thermocouple.

Cold Junction Compensation

The tables and equations to convert thermocouple voltage to temperature all assume that the instrument end is at zero centigrade.

Because the voltage read at the TH7 input is not at zero centigrade (well not normally!) the junction of the wires *at the connector block* makes a thermocouple itself, but in opposition to the one at the measurement end. For instance, with a 'k' type thermocouple the voltage read at $25°C$ would read around $1000\mu V$ low!

The TH7 has a temperature measurement chip placed right by the terminal block for the thermocouple inputs. By knowing this temperature, the TH7 works out what the missing voltage is and adds it in before calculating the final temperature. This is commonly known as cold junction compensation.

Using the TH7 as a micro-volt reader

The TH7 can be used as a general purpose micro-volt reader. The voltage source must be floating i.e. not grounded. A range of $\approx -6mV \rightarrow 40mV$ can be read.

Availability

TH7 boards are currently available with a four week lead time.

The TH7 is compatible with the Raspberry Pi models 3 and 4.

TH7 boards may be customised for any thermocouple type. An example for 'k' type may be found on GITHUB

https://github.com/robin48gx/TH7

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S.D.S. TH7: Seven Channel Thermocouple Pi Hat

Scientific Data Systems

May 10, 2020

TH7 Description

The TH7 is a Raspberry Pi hat that provides seven thermocouple inputs(see figure 1). This means seven different temperatures can be read simultaneously. Its possible uses are logging/monitoring and control of temperature sensitive processes. With on-board PCB temperature measurement, the PCB temperature is used to implement full Cold Junction Compensation (CJC). Uncalibrated, the TH7 gives a typical accuracy of $\pm\ 2°C$. The TH7 also provides two user programmable LEDs; and makes available the PCB temperature, and the supply voltage to the Raspberry Pi (USB voltage can vary between 4.7 to 5.2).

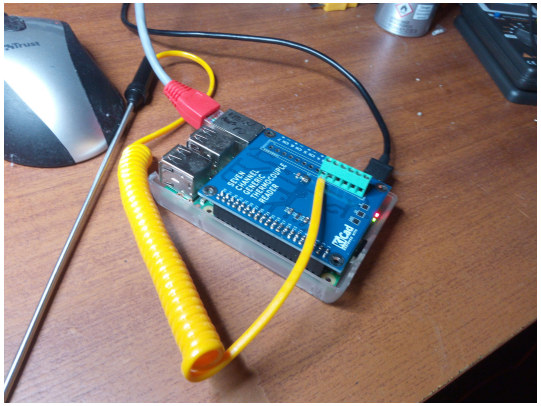

Figure 1: TH7 with a 'k' type probe fitted.

The TH7 is a generic thermocouple reader, and therefore should work with any thermocouple type. Software defines its micro-volt to temperature and CJC characteristics. Software support has currently only been written for the 'k' type.

Characteristics

The TH7 offers:

- Full cold junction compensation;
- Thermocouple disconnection or open-circuit detection;
- Seven inputs;
- Uses the Rasberry Pi standard python SPI interface;
- Two user programmable LEDs;
- On chip PCB temperature measurement;
- Can be used as a general-purpose micro-volt reader with a range of $\approx -6000\mu V \rightarrow 40000\mu V$.

Instructions

Connection to terminal block

Connect the thermocouples using the hital tech connectors and ensure the wires make contact with the connector metal clamps (see figure 2).

Conection to the device being measured

Always apply insulation to the thermocouples (i.e. do not ground them). Epoxy resin is often useful for gluing thermocouples to devices under long term temperature tests.

Figure 2: Image shows wiring for European standard 'k' type thermocouples wiring (green is plus and the white is minus; other countries may use different colour schemes.) If the thermocouple is inserted with incorrect polarity it will read incorrectly and temperature will be seen to go down when heat is applied.

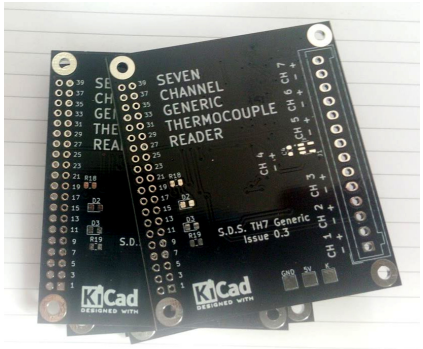

Figure 3: TH7 thermocouple Interface PCB/Raspberry Pi Hat

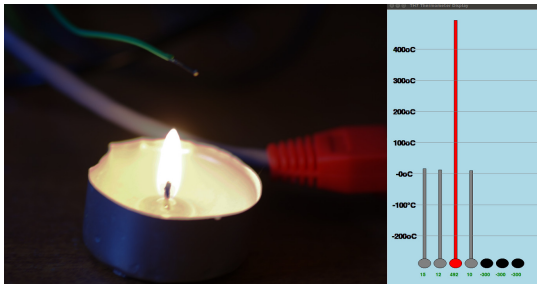

Figure 4: Thermocouple over a tea light flame at circa $500°C$.

Contact: info@scientificdatasystems.co.uk

Youtube tutorial:
https://www.youtube.com/watch?v=EcGQWLSwX3U