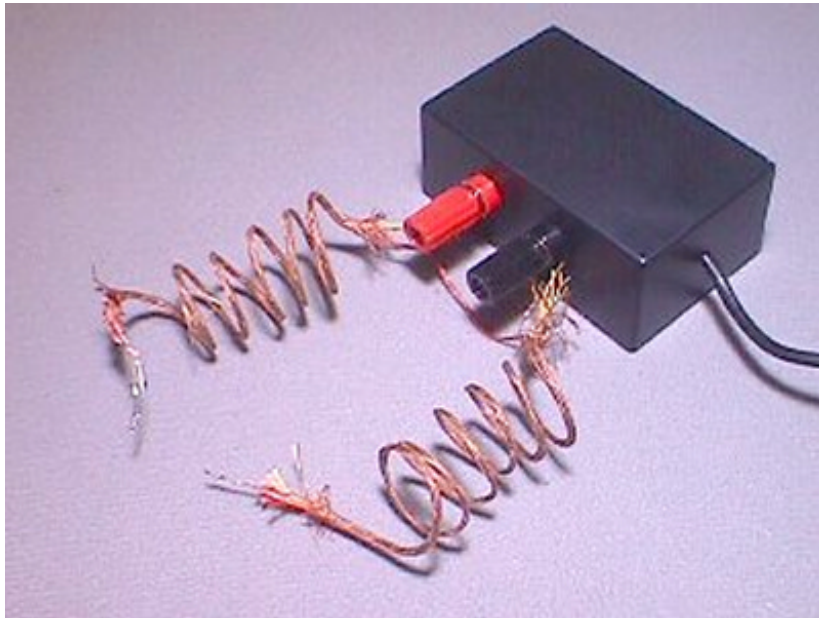


# **thermocouple**

## **TEMPERATURE SENSOR**

### **Description D035**



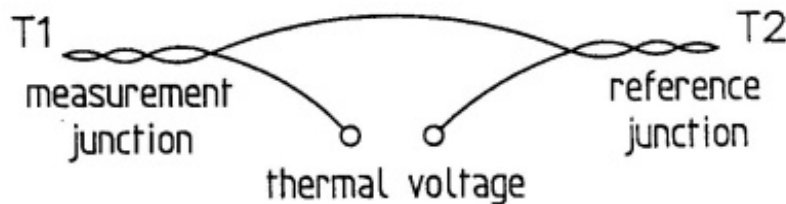
**Figure 1.** The thermocouple

### Short description

The thermocouple measures temperatures between -200 and 1400 °C.

Type K thermocouple wire is used. Chromel<sup>TM1</sup> (chromium - nickel) wire and Alumel<sup>TM</sup> (aluminum - nickel) wire are twisted together to form two junctions. The thermal voltage is proportional to the temperature-difference between the junctions.

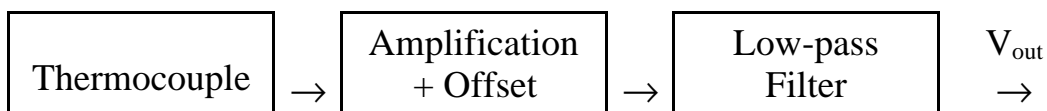
One of the junctions, *the reference junction* on the end of the black socket, is placed where its temperature is kept steady. The other junction (at the red socket) is the *measurement junction*.



**Figure 2.** The thermocouple

When the reference junction is left in an ice bath positive Celsius temperature can be measured. The thermal voltage varies between 0 V at 0°C and 46.5

This signal is amplified (45.45x) and given a small offset (40-60 mV). Besides the signal is filtered with a low-pass filter (16 Hz).



**Figure 3.** Block scheme of the thermocouple temperature sensor.

As result of the signal conditioning, the signal ( $V_{out}$ ) will vary between approx. 0V at -30°C and approx. 2.2 V at 1400°C.

As the offset can differ for each sensor, precise ranges cannot be given.

The thermocouple is delivered with 4-mm plugs and can be connected to the following interfaces:

- UIA/UIB through Measuring Console (via 0520 adapter)
- CoachLab
- CoachLab II
- SMI (via 0520 adapter)

<sup>1</sup> Chromel<sup>TM</sup> - Alumel<sup>TM</sup> are registered trademarks of HOSKINS, Hamburg USA

- Texas Instruments CBL™ datalogger.

There is an adapter (art 0520) to connect sensors with BT-plugs to 4-mm inputs.

### **Suggestion for experiments**

- Measurements of the temperature inside a Bunsen burner flame or candles.
- Measurement of breath.
- Experimentally determine the melting point of copper, bismuth, or other solids.

### **Reference temperature and measuring negative temperatures**

For accurate measurements, place the reference junction where its temperature is kept steady (usually in an ice bath).

If the reference junction is hold 'free' in the air, you always measure with respect to a variable room temperature.

When measuring temperatures below the reference temperature, use the wire at the red socket as reference junction and the other one as measurement junction. In this way - with the reference junction in an ice bath - the temperatures in the range between -200°C and 0°C can be measured.

Note that when you measure temperatures below zero, the thermocouple will not measure as accurately as it does when used for positive temperatures.

### **Calibration**

The temperature can be approximated by the following linear relationship

$$T = T_{ref} + \frac{1}{G}(V - V_0)$$

$T$  : the temperature in °C

$V$  : the sensor signal in V

$G$  : the sensitivity of the sensor =  $1.88 \cdot 10^{-3}$  V/°C

$V_0$  : the offset in V

$T_{ref}$  : the reference temperature in °C

A more accurate calibration can be performed by using a table for thermal voltages in chromium-nickel and aluminium - nickel junctions. When you calculate the sensor signal, you have to take into account the offset, the amplification rate (45.45x) and the reference temperature.

### **Measuring the offset**

The offset can be measured by reading the sensor signal, while keeping both junctions at the same temperature (for instance in water).


### **Calibration for measurement in a restricted temperature range**

If you want to use the sensor in a smaller temperature range, signal

amplification is recommended.

The name of the temperature sensor in the sensor library of Coach 5 program is **Thermocouple (035) (CMA) -30° ..1400° C.**

### Technical data

Sensitivity	1.88 mV/°C (0.0413 mV/°C x 45.45)
Output voltage range	0 - 2.6 V
Temperature range	-0°C to 1400°C when used with wire at the black socket as a reference junction in ice bath
Typical accuracy	±5 or 10 °C
Temperature range	-200°C to 0°C when used with wire at the red socket as a reference junction in ice bath
Typical accuracy	±20 °C
Resolution using 12 bit 5V A/D converter	0.65 °C
Amplification	45.45 x
Offset	40 - 60 mV
Filtering	Low-pass, at 16 Hz
Sensor box	84 x 76 x 35 mm
Chromel <sup>™2</sup>	Length = 50 cm
Alumel <sup>™</sup>	Length = 50 cm
Power	0.05mA @ 5VDC
Connection	 BT (British Telecom) plug

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