THERMOCOUPLE SENSOR WITH TWO RANGES[1]

–200..1300 °C AND -20..110 °C

Description D0135i[2]

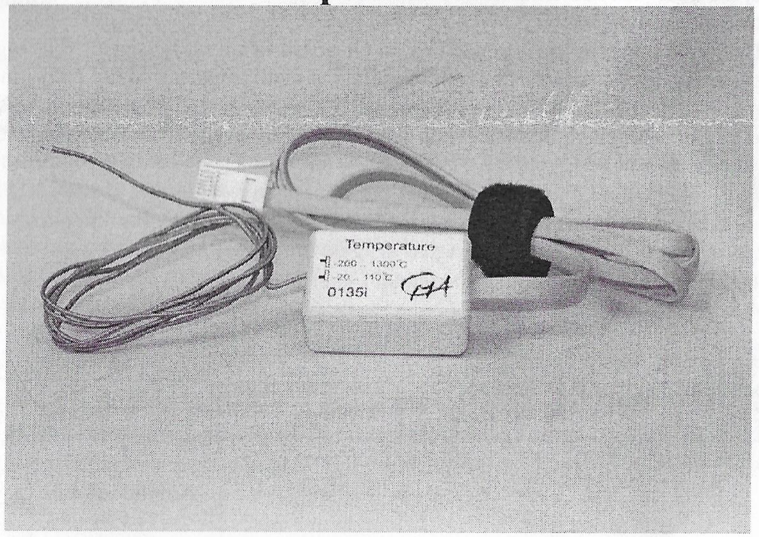

Figure 1. The Thermocouple sensor

Description

The Thermocouple sensor measures temperatures in two ranges:

- -200 .. 1300 °C (wide range), and
- -20 .. 110 °C (narrow range).

These ranges are selected using the switch placed on the side of the sensor box, next to the thermocouple wire.

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[1] To use a thermocouple in the Coach 5 program you need to update the Coach library. For update information see http://www.cma.science.uva.nl/english section Support > Coach 5.

[2] For our Dutch customers…
De Nederlandstalige versie van deze handleiding kunt u downloaden van de CMA website.

The sensor uses a thermocouple type K. The thermocouple consists of Chromega™ (Nickel - Chromium) and Alomega™ (Nickel - Aluminium) wires that are welded together at one end to form a measuring (hot) junction. The other ends of the wires form the so-called cold junction.
Temperature at the measuring junction of a thermocouple is determined by measuring the voltage appearing at the thermocouple's cold junction. Since the voltage produced by the thermocouple is a function of the temperature difference between these two junctions, the cold junction temperature must be known in order to produce accurate temperature measurements.
The cold junction temperature is sensed by an on-board temperature sensor. The signal of this sensor is added to the thermocouple voltage signal. Such automatic cold-junction temperature (CJT) compensation is a method used to get accurate temperature readings measured by the thermocouple even when the temperature at the sensor box varies.

The thermal voltage varies between -5.9 mV at -200 °C and +52.4 mV at 1300 °C. This signal is amplified 76.45x and filtered with a low-pass filter (6 Hz). For the narrow temperature range (-20 .. 110 °C) the signal is again amplified 11.06x.
As result of the signal conditioning, the signal (V_{out}) will vary between approx. 0 V and approx. 4.9 V.

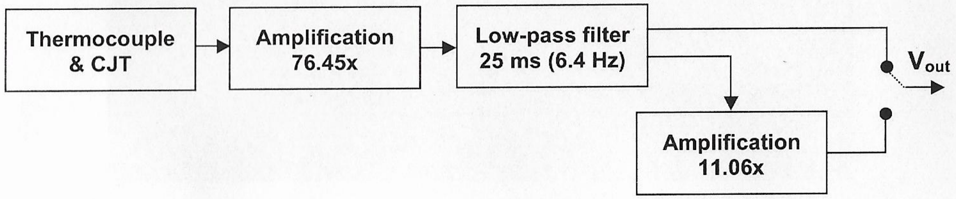

Figure 2. Block scheme of the thermocouple temperature sensor

The thermocouple sensor is equipped with a BT-plug and can be connected to the following CMA interfaces:

- ULAB
- CoachLab
- CoachLab II
- UIA/UIB through Measuring console (via the adapter 0520[3]).

Furthermore the sensor can be used in combination with other interfaces, like Texas Instruments CBL™, CBL2™ and Vernier LabPro without the need of an adapter.

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[3] The CMA adapter art. nr 0520 allows connecting sensors with BT-plugs to 4-mm inputs.

Intelligent sensor

The thermocouple sensor is an intelligent sensor. The sensor has a memory chip (EEPROM) with information about the sensor. Through a simple protocol (I^2C) the sensor transfers its data (name, quantity, unit and calibration) to the interface. The interface automatically displays the calibrated values and communicates the information to the Coach software. The interfaces CMA ULAB, TI CBL2 and Vernier LabPro support the intelligent sensors. The sensor is delivered with internal standard calibrations.

Suggested experiments

The thermocouple can be used for temperature measurements.
Examples of applications for the wide temperature range (-200 .. 1300 °C) are:
- Measurements of the temperature inside a Bunsen burner flame or candles;
- Experimentally determine the melting point of copper, bismuth, or other solids.

Examples of applications for the narrow temperature range (-20 .. 110 °C) are:
- Measuring freezing and boiling points;
- Specific heat experiments;

Measurement of breath.

Calibration

1. The output of the thermocouple is approximately linear with respect to temperature. This means that the sensitivity of the thermocouple is almost constant. It varies slightly with temperature e.g. at 0 °C the sensitivity is 39.5 μV/°C, at 100 °C is 41.4 μV/°C and at 1000 °C is 38.9 μV/°C.

To collect data you can:

2. Use the calibrations supplied by the sensor EEPROM memory (for ULAB, TI CBL2 and Vernier LabPro dataloggers)
3. Use the calibrations supplied in the standard sensor library of the Coach program.

The names of the thermocouple in the sensor library of the Coach 5 program are:
- **Thermocouple (0135i) (CMA) -200 .. 1300 °C**
- **Thermocouple (0135i) (CMA) -20 .. 110 °C.**

For the narrow temperature range (-20 .. 110 °C) the calibration in EEPROM and the calibration in the Coach sensor library are identical. The calibration is a simple linear function which approximates the real calibration curve with an error of less than 1°C.
For the wide temperature range (-200 .. 1300 °C) the calibration in EEPROM is a simple linear function which approximates the real calibration curve with an error of less than 7 °C in the range -60 .. 1100 °C. Outside of this temperature range the error shows a steep increase.

The calibration in the Coach sensor library gives a very good approximation over the whole temperature range -200 .. 1300 °C. The error is always less than 3 °C.

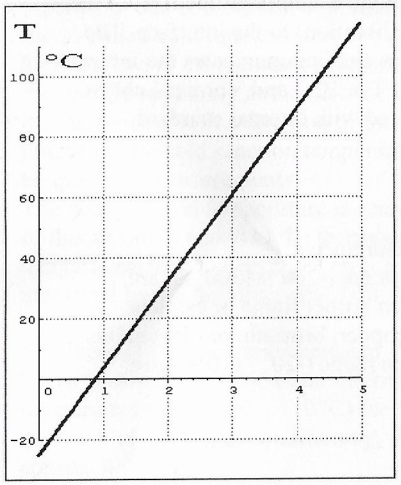


Figure 3.
Default calibration graph of the thermocouple for the range -20 .. 110 °C (used in the standard Coach library and sensor memory)

$T\ (°C) = 29.093 * V_{out}\ (V) - 26.33$

Coefficients of the calibration function:
a=29.093 ; b= -26.33

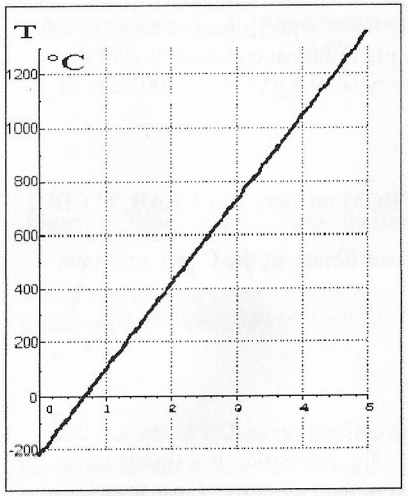
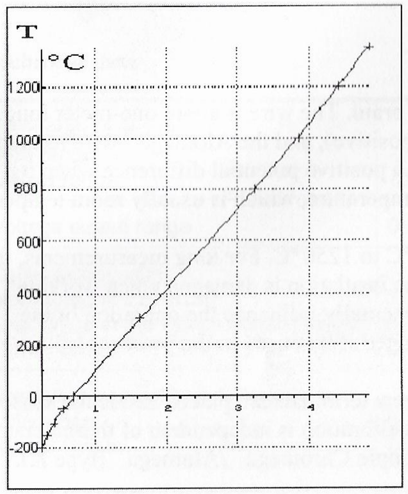


Figure 4.
Default calibration graph of the thermocouple for the range -200 .. 1300 °C used in the sensor memory.

$T\ (°C) = 316.9 * V_{out}\ (V) - 221.0$

Coefficients of the calibration function:
a=316.9; b= -221.0



V V	T °C
0.247	-200.000
0.322	-150.000
0.426	-100.000
0.553	-50.000
0.697	0.000
1.631	300.000
3.242	800.000
3.853	1000.000
4.430	1200.000
4.835	1350.000

Figure 5.
Default point-to-point calibration (graph and table) of the thermocouple for the range -200 .. 1300 °C used in the Coach sensor library.

Changing the default calibration in EEPROM of the sensor

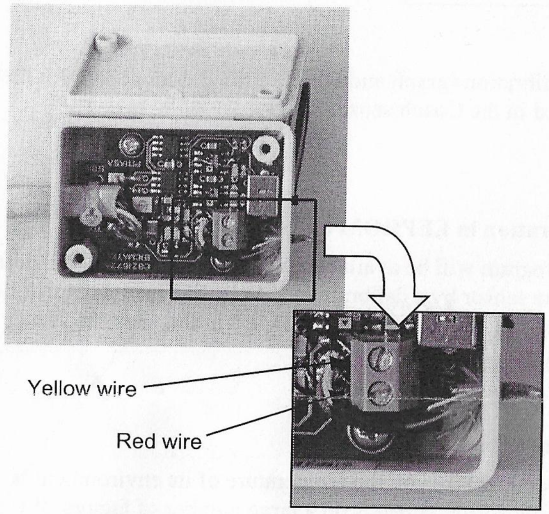
In the near future a special program will be available to enable replacing of the default calibration in EEPROM of the sensor by a calibration done by the user. This will be done while the sensor is connected to the ULAB datalogger. In this way the sensor can have its own, precise calibration.

Measuring rapid temperature change

The rate at which the thermocouple takes on the temperature of its environment is difficult to predict precisely, because it depends on a large number of factors. If the thermocouple is allowed to cool in reasonably still air, within 16 seconds its temperature will fall so that the difference with room temperature is reduced to 37 %.
In fast moving air this takes approx. 1 second. In a liquid the temperature will be followed almost directly.

Technical information

The thermocouple wire is insulated with glass braid. The wire is about one-meter long. The Chromega™ wire is in yellow insulation (positive), and the Alomega™ wire has red insulation (negative). The thermocouple gives a positive potential difference when its temperature is higher than the cold junction temperature, which is usually room temperature.
The thermocouple has a typical range of -200 °C to 1250 °C. For long measurements, the maximum temperature is limited to 870 °C. The insulation is damaged when working above 480 °C, but this does not normally detrimentally influence the operation of the thermocouple. The thermocouple may be damaged if it is used in the presence of sulphur, or under reducing conditions.
The thermocouple wire is interchangeable. Screw terminals are placed inside the sensor box (see the photo below). The thermocouple calibration is independent of thermocouple length and thickness as long as it is a thermocouple Chromega™/Alomega™ (type K).

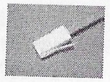


Yellow wire

Red wire

Figure 6.
Screw terminals for attaching the thermocouple wires.

Technical data

Temperature range wide range narrow range	 -200.. 1300 °C -20 .. 110 °C
Voltage output range	0 - 4.9 V
Calibration function wide range in EEPROM wide range in the Coach sensor library narrow range	 T (°C)= 316.9 * V_{out} (V) - 221 Point-to-point calibration, see figure 5. T (°C)= 29.093 * V_{out} (V) – 26.33
Resolution using 12 bit A/D converter wide range narrow range	 0.39 °C 0.035 °C
Typical accuracy	± 5 °C
Speed	In air: 16 s as for a 63% change towards the temperature of the environment In liquid: 0.1 s as above
Limitations	Can be damaged when used in the presence of sulphur or under reducing conditions.
Metal wires	Chromega™ (Nickel - Chromium) Alomega™ (Nickel - Aluminium)
Insulation	Glass braid insulation
Chromega™/Alomega™ wire	Length = 95 cm Diameter = 0.51 mm
Sensor box	50 x 35 x 20 mm
Filtering	Low-pass, at 6.4 Hz (t = 25 ms)
Power	5 mA @ 5VDC
Sensor information for Auto-ID and calibration	256 byte serial EEPROM
Connections	 BT (British Telecom) plug

This product is to be used for educational purposes only. It is not appropriate for industrial, medical, research, or commercial applications. 07/07/2004

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