Task IV.: Monitoring 1

Required knowledge: Measuring of the body temperature and blood pressure.

1. Measuring of surface skin temperature with a thermocouple

Thermocouples are simple and widely used sensors for measuring temperature.

Classic thermocouple, as shown in Figure 1, consists of two wires of different metals connected at one end which forming the measuring ("Hot") connection. Their second end on which wires are not connected, are connected to wires of measuring circuit, which are typically made of copper. This connection between the metal thermocouples and copper wires is called the reference ("cold") connection.

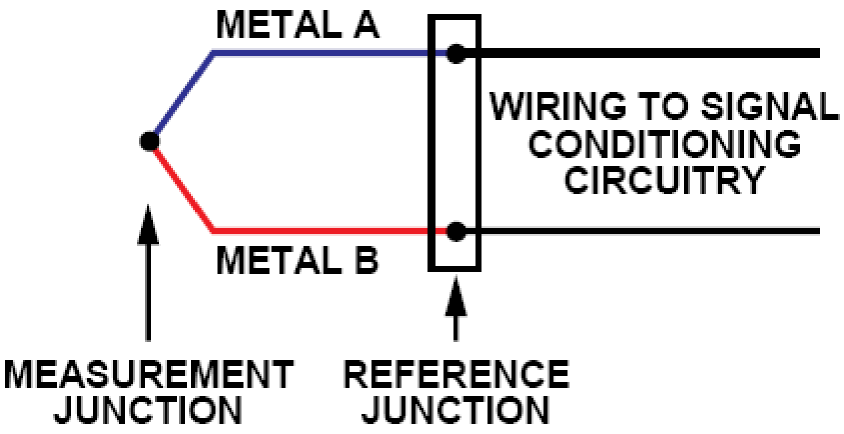

Fig.1

The voltage on the reference connection depends both on temperature measurement connections, so the temperature of the reference connection. Despite the thermocouple is differential device rather than a device for measuring of the absolute temperature, the temperature of the reference connection must be known in order to obtain accurate absolute temperature. This process is known as cold junction compensation.

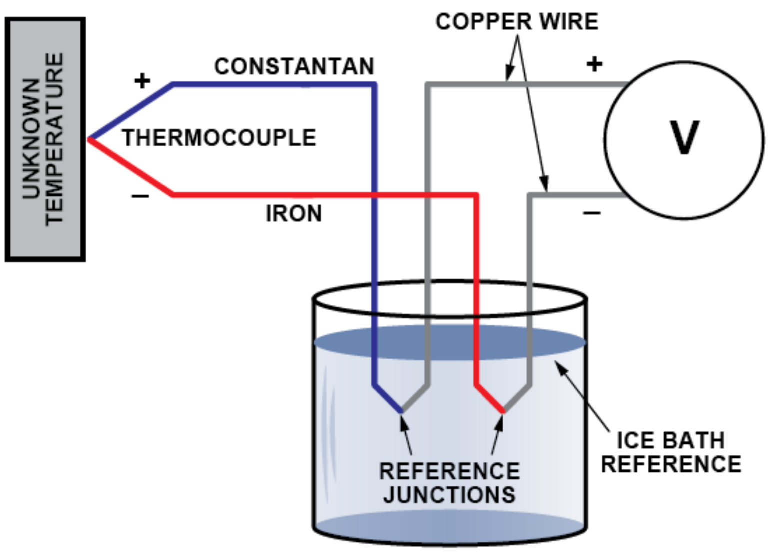

Fig. 2

The process of cold junction compensation can be done in two ways. The first method is schematically illustrated in Figure 2, when both ends of the thermocouple are located in a place with constant temperature, usually as the Dewar vessel with the environment at 0 ° C. Another option is compensation using an electric circuit. In this case it is necessary to know the temperature of the cold end, which is primarily measured by using a thermistor or termodiod (location in the same place as the cold end).

Thermocouples are used in various applications to measure temperature up to about +2500 ° C. The most popular is the thermocouple type K, consisting of Chromel ® and Alumel ® (trade names of alloys containing nickel, chromium and aluminium, manganese and silicon), with measuring range from -200 ° C to +1250 ° C.

Benefits

• Temperature range: depending on the metal thermocouple. Thermocouples can measure temperatures between -200 ° C to +2500 ° C.
• The size and robustness: Thermocouples are small and yet robust device that is immune to shock and vibration and are suitable for use in environments exposed to mechanical stress.
• Quick response: because thermocouples are (in particular the measurement section) small and have low thermal capacity, they can quickly respond to temperature changes. Thermocouples (depending on its size) can respond to rapidly changing the temperature over several hundred milliseconds.

Disadvantages

• Transfer and signal processing: It is needed to convert thermocouple thermovoltage to the specific temperature value, which may be burdened with some error (algorithm, nonlinearity, sampling)
• Accuracy and measurement error: a thermocouple temperature measurement is accuracy as is precisely defined temperature at the reference (cold) connection. The temperature is usually measured within errors of 1 ° C to 2 ° C.
• Susceptibility to corrosion: Whereas thermocouples is consist of two different metals, in some environments may cause the corrosion, and this may result in to decrease of accuracy. It can be eliminated by coating.
• Sensitivity and Noise: when the signal range at the level of microvolts is measured, there can be a problem with the presence of electric and magnetic fields. This situation can be eliminated by using shielded cables. The device should also include the possibility of filtering and suppressing signals (either in hardware or software), with a strong rejection frequency 50 Hz/60 Hz and its harmonic multiples.

The most common thermocouple types are J, K, and T. At room temperature, their voltage changes depending on the ambient temperature changes of 52 uV / °C (type J), 41 uV / °C (type K) respectively. 41 uV / °C (type T) - which tabulated and called as a Seebeck coefficient **α** (Table 1, Chart 1). Other less common types of thermocouples may also have a smaller voltage change with increasing temperature.

Voltage change (ΔU) is proportional to the temperature difference and Seebeck coefficient - for small voltage differences (formula 1.)

formula 1. $$\Delta U = \alpha \cdot \Delta t$$

$$Emf = \int_{T_1}^{T_2} S_{12} \cdot dT = \int_{T_1}^{T_2} (S_1 - S_2) \cdot dT$$

.
Table 1 compares the sensitivity of different types of thermocouples.

Table 1. Voltage Change vs. Temperature Rise (Seebeck Coefficient) for Various Thermocouple Types at 25°C.

Thermocouple Type	Seebeck Coefficient (µV/°C)
E	61
J	52
K	41
N	27
R	9
S	6

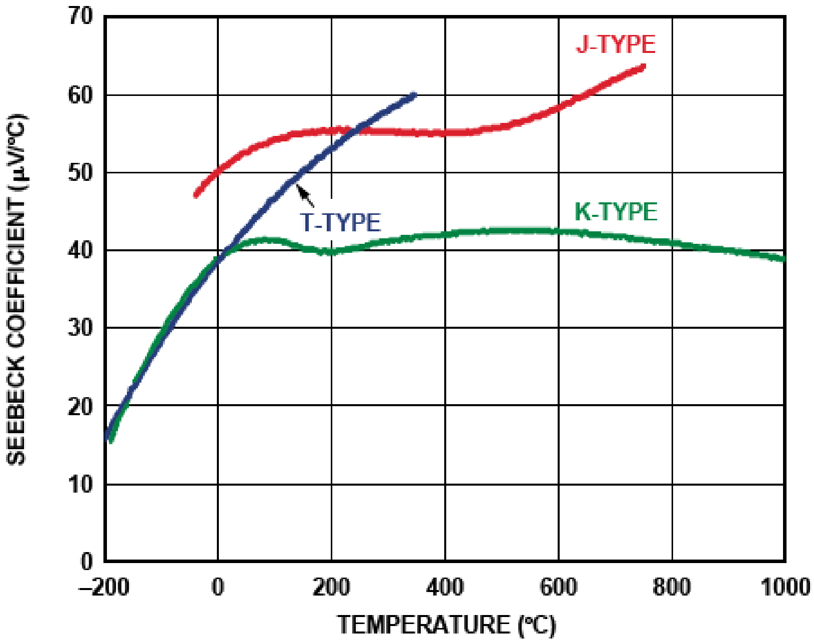

Figure 1
Ref: Matthew Duff and Joseph Towe, Analog Dialogue 44-10, October (2010)

Instructions for the task

1 - Pour into a beaker water of suitable temperature (tap water with aprox. 20°C) and place it on the heater. Attach a thermometer, that the reservoir of mercury is about the middle of the water column. Insert the thermocouple probe (which is attached to a multimeter) to the same height as a reservoir of mercury to the beaker.

2 - Verify that the multimeter is measured voltage U in mode DC (turn rotary switch to the position mV and by pressing the button SELECT select mode DC).

3 - Switch on stirrer and wait about two minutes, then read and write the temperature on the mercury thermometer and a corresponding value of the thermoelectric voltage on the multimeter.

4 - Switch on the heating. Read temperature values and corresponding thermovoltage for every increase of temperature by step 5°C up to 50°C. Slower increasing allows more accurate calibration of temperature measurement.

5 - Remove thermocouple from the beaker, dry it by paper tissue, disinfect it with ethanol and measure the temperature (by the thermovoltage) on the face, nose, palm, armpit and inside the container on the table.

Points to do in Protocol:
1-Create graph of thermovoltage dependent on temperature
2- Determine the temperature of measured parts of the human body by using extrapolation and interpolation and also inside the container placed on the table.
3- Calculate the Seebeck coefficient for the thermocouple type and estimate what kind of thermocouple was used in the task.

(Extrapolation - To estimate (a value of a variable outside a known range) from values within a known range by assuming that the estimated value follows logically from the known values.
Interpolation - To estimate a value of (a function or series) between two known values)

2. Blood pressure measurement by the auscultation method

Main tasks:
Blood pressure measurement by the auscultation method by the mercury tonometer
Blood pressure measurement by the auscultation method by the digital tonometer

Needs for measurement:
Stethoscope, mercury and digital tonometers.

Procedure:
1.) Measuring by the mercury tonometer. Attach the inflatable cuff to the arm of the subject at the height of the heart. Put the mercury tonometer to the same height (on the table). By means of palpation of the pulse (feeling the pulse) search in the elbow pit the position of a. brachialis and put the sensor of the stethoscope on this artery. By means of the ball inflate the cuff to approximately to 160mmHg. Lower gradually the air pressure in the cuff and read the systolic and the diastolic blood pressure. Repeat measurement 3 times. Calculate the mean of the systolic and the diastolic blood pressure and convert the values from mmHg to kPa.
2.) Measuring by the digital tonometer. Attach the inflatable cuff to the arm of the subject at the height of the heart. Put the digital tonometer to the same height (on the table). Measure the blood pressure 10 times (use for concrete digital tonometer specific manual). Calculate the mean of the systolic and the diastolic blood pressure and convert the values from mmHg to kPa.
3.) Compare results obtained by the digital and mercury tonometer.