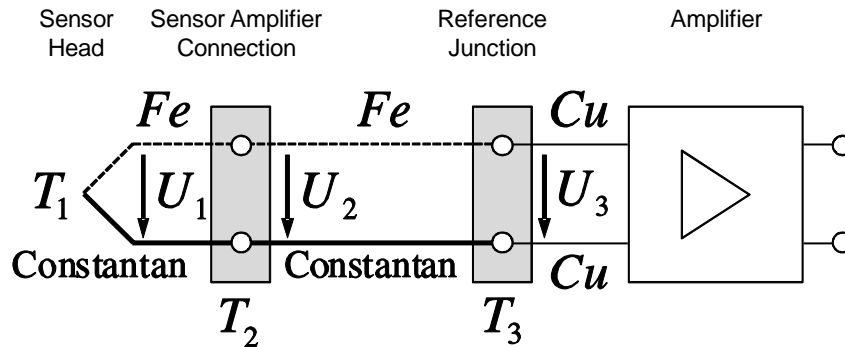


Thermo couple

The following circuit is used to measure high temperatures T_1 in the range from 0°C to 500°C . The temperature at the reference junction is $T_3=20^\circ\text{C}$.



The following constants are given:

$$k_{\text{FePt}} = 1.9 \text{ mV}/100\text{K}$$

$$k_{\text{ConstPt}} = -3.1 \text{ mV}/100\text{K}$$

- What is the significance of the sensor connection and the reference junction?
- Calculate the voltage U_3 depending on the voltages at all material junctions.
- Which techniques can be used to obtain a constant and known temperature at the reference junction?
- Calculate the sensitivity of U_3 with respect to the temperature T_1 . What is the value of the voltage U_3 at a temperature $T_1=200^\circ\text{C}$?
- What happens to the voltage U_3 if the wires at the sensor connection are connected in a wrong way?

Piezo

The properties of a piezoceramic material (thickness: 1 mm, area: 10 mm x 10 mm) metalized on each side are characterized by the following material parameters:

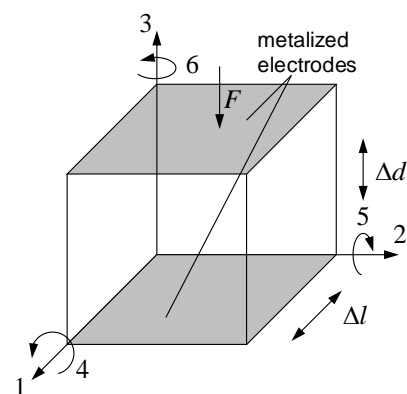
$$d_{31} = -171 \times 10^{-12} \text{ As/N}$$

$$d_{33} = 374 \times 10^{-12} \text{ As/N}$$

$$E = 6,5 \times 10^{10} \text{ N/m}^2 \text{ (elasticity modulus)}$$

$$\epsilon_r = 1600$$

$$k_q = 4,2 \times 10^{-4} \text{ As/(K m}^2\text{)} \text{ (Pyrocoefficient).}$$



- Calculate the amount of charge that is produced by a weight of 100g placed on the material.
- Which voltage is generated from this charge at the metalized electrodes?
- Which change in thickness of the ceramic material is caused by the weight of 100g?

- d) If the temperature changes by 1K, which additional charge is generated at the metalized plates?

Application of Pt100 Thermometer

A Pt100 thermometer should work in the temperature range of $T = 80^{\circ}\text{C}$ with a measuring current as large as possible because of the increment of interference resistance. The measuring current should be so large that the heat from itself

$$\Delta T_{th} = R_W \cdot P$$

(with the power of P and the heat resistance R_W) is just as large as the value of the maximal error T_{err} , which is specialized for this temperature.

$$\Delta T_{err} = 0,15\text{K} + 0,002 \cdot |T - T_0| \quad \text{with } T_0 = 0^{\circ}\text{C}.$$

The resistance of Pt 100 thermometer depends (approximately) on the temperature according to

$$R = R_0 \cdot (1 + \alpha \cdot (T - T_0))$$

with $R_0 = 100\ \Omega$ and $\alpha = 3.908 \cdot 10^{-3}\ 1/\text{K}$

- a) Calculate numerically the tolerance for $T = 80^{\circ}\text{C}$
- b) Calculate generally and numerically the maximal current for the measurements in air at this operating point with $R_W = 300\ \text{K/W}$.
- c) Sketch the measuring arrangement for the measurement at a distance of L away from the measuring device.
- d) What is the maximal voltage measured at 80°C ?
- e) What is the voltage drop on the measuring wire per $1\ \Omega$ resistance? What is the additional measurement error of temperature due to the voltage drop?
- f) Name a measuring arrangement, which can avoid the influence of the measuring wire on the measurement result.
- g) Is the measuring current permitted smaller or larger in the measurement in water?