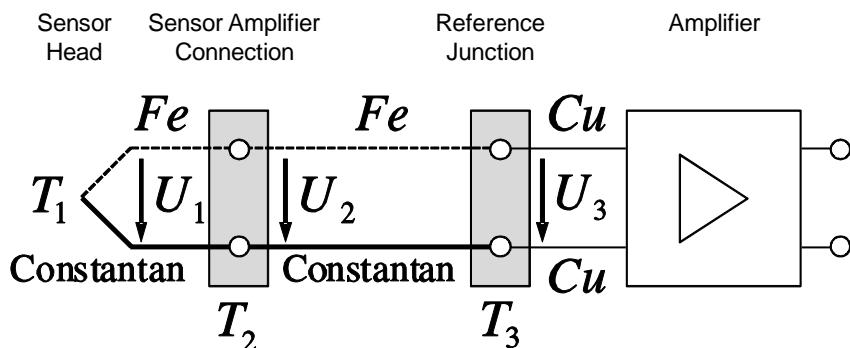


## Thermo couple

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:

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

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

- 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) metallized on each side are characterized by the following material parameters:

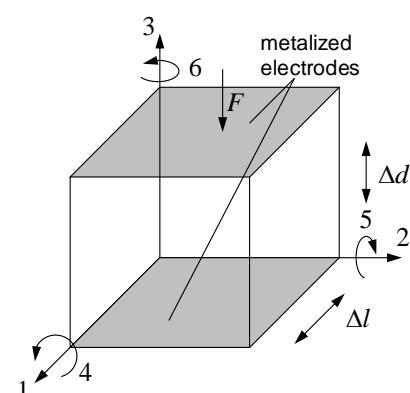
$$d_{31} = -171 \times 10^{-12} \text{ As/N}$$

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

$$E = 6.5 \times 10^{10} \text{ N/m}^2 \text{ (elasticity modulus)}$$

$$\epsilon_r = 1600$$

$$k_q = 4.2 \times 10^{-4} \text{ As/(K m}^2\text{)} \text{ (Pyrocoefficient).}$$



- 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 metallized 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.

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

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  $\alpha = 3.908 \cdot 10^{-3} \text{ 1/K}$

- 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  $80^\circ\text{C}$ ?
- 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?