

Measurement Systems

Problem set n° 3

Sensors and signal conditioning circuits

Exercise 1 (General model, specifications and errors: pressure sensor)

We find for the pressure sensor *MPXM2202A Series* :

- The input range P_e : $P_e = 200 \text{ kPa}$
- Sensitivity S : $S = 0.2 \text{ mV/kPa}$
- The output range U_{FSS} : $U_{FSS} = S \cdot P_e = 40 \text{ mV}$

Note that the sensor is used in a pressure range $P_{use} \in [80; 120] \text{ kPa}$ and a temperature range $\Delta T_{use} = 30 \text{ }^\circ\text{C}$ centered on the reference temperature. The extent of the voltage used corresponds to $U_{use} = P_{use} \cdot S \in [16; 24] \text{ mV}$. In addition, the sensor piezoresistive is conditioned by a Wheatstone bridge (see datasheet notes 2: *ratio metric* $\rightarrow e_{V,m}$).

The desired size x_d : the pressure in *Pa*:

$$x_d = P = \frac{U}{S}$$

The Interfering variables x_i :

- Error $e_{off,i}$ *Offset*: $e_{off,i} = \pm \frac{2 \text{ mV}}{S} = \pm 10 \text{ kPa}$
- Error $e_{lin,i}$ *Linearity* : $e_{lin,i} = \pm \frac{1}{100} \cdot P_e = \pm 2 \text{ kPa}$
- Error $e_{p. hys,i}$ *Pressure Hysteresis* : $e_{p. hys,i} = \pm \frac{0.1}{100} \cdot \frac{\Delta P_{use}}{100 \text{ kPa}} \cdot P_e = \pm 0.08 \text{ kPa}$
- Error $e_{T. hys,i}$ *Temperature Hysteresis* : $e_{T. hys,i} = \pm \frac{0.5}{100} \cdot \frac{\Delta T_{use}}{165 \text{ }^\circ\text{C}} \cdot P_e = \pm 0.18 \text{ kPa}$
- Error $e_{T,i}$ *Temperature Offset* : $e_{T,i} = \pm \frac{1 \text{ mV}}{S} \cdot \frac{\Delta T_{use}}{85 \text{ }^\circ\text{C}} = \pm 1.8 \text{ kPa}$
- Error $e_{s,i}$ *Offset Stability* : $e_{s,i} = \pm \frac{0.5}{100} \cdot P_e = \pm 1 \text{ kPa}$

The modifying variables x_m :

- Error $e_{FSS,m}$ *Full Scale Span* : $e_{FSS,m} = \pm \frac{1.5 \text{ mV}}{S} \cdot \frac{120 \text{ kPa}}{200 \text{ kPa}} = \pm 4.5 \text{ kPa}$
- Error $e_{T,m}$ *Temperature Sensitivity* : $e_{T,m} = \pm \frac{2}{100} \cdot \frac{\Delta T_{use}}{85 \text{ }^\circ\text{C}} \cdot \frac{120 \text{ kPa}}{200 \text{ kPa}} \cdot P_e = \pm 0.85 \text{ kPa}$
- Error $e_{V,m}$ *Voltage Sensitivity* (see gauge): $e_{V,m} = \pm \frac{0.5 \text{ V}}{10 \text{ V}} \cdot \frac{120 \text{ kPa}}{200 \text{ kPa}} \cdot P_e = \pm 6 \text{ kPa}$

The **maximum error** E_{max} and the **probable error** E_{prob} correspond to:

$$E_{max} = \pm 26.4 \text{ kPa}$$

$$E_{prob} = \pm 12.9 \text{ kPa}$$