# *Measurement systems*

Problem set 8

**Exercise 1 (Resolution)**

a) The resolution $R$ of the $A/D$ converter, with $N_1$ bits and a full scale $FS_1$ is:

$$R = \frac{FS_1}{2^{N_1}} = 977\ \mu V$$

b) We calculate the resolutions $R_2$ and $R_3$ of the $A/D$ converters:

$$R_2 = \frac{FS_2}{2^{N_2}} = 19.53\ mV \qquad R_3 = \frac{FS_3}{2^{N_3}} = 2.4\ mV$$

We find a reduction $\lambda$ between resolutions $R_2$ and $R_3$ :

$$\lambda = \frac{R_2}{R_3} = \frac{FS_2}{FS_3} \cdot 2^{N_3 - N_2} = 8$$

**Exercise 2 (Binary code and sample-and-hold circuit)**

a) The binary code b is converted to a decimal value $N_{\text{dec}}$ $(N = 8)$ :

$$(b)_2 = (10101101)_2 = 1 \cdot 2^7 + 0 \cdot 2^6 + 1 \cdot 2^5 + 0 \cdot 2^4 + 1 \cdot 2^3 + 1 \cdot 2^2 + 0 \cdot 2^1 + 1 \cdot 2^0 = (173)_{10} = (N_{dec})_{10}$$

The output voltage is then $U_s$ :

$$U_s = \frac{FS}{2^N} \cdot n = \ 1.352\ V$$

b) The maximum time is $\Delta T$ :

$$\Delta T = \frac{N}{f_0} = 16\ \mu s$$

c) $f = \frac{f_0}{\pi \cdot 2^{N+1} \cdot N} = 38.85\ Hz$

➔ The use of a sample-and-hold circuit is necessary as the bandwidth of the signal is greater than $f$.

**Exercise 3 (Accelerometer and *A/D converter*)**

a) The maximum quantization error $\varepsilon_{max}$ on the measured quantity is :

$$\varepsilon_{max} = \frac{1}{S} \cdot \frac{FS}{2^{N+1}} = 1.2 \cdot 10^{-3}\ g$$

b) First, we find the output voltage $U_s$ as a function of $N_{dec}$ and then we obtain $a_N = f(N\_dec)$ :

$$U_s = \frac{FS}{2^N} \cdot N_{dec} - U_0 \qquad \Longrightarrow \qquad a_N = \frac{U_s}{S} = \frac{1}{S} \cdot \frac{FS}{2^N} \cdot N_{dec} - \frac{U_0}{S}$$

c) The acceleration $a_N$ for $N_{dec} = 3658$ is:

$$a_N = 3.9307 \pm 1.2 \cdot 10^{-3}\ g$$