Measuring systems

Problem set n° 8

Exercise 1 (Resolution)

a) What is the resolution R of an A/D converter, N_1 bits, if the full scale is FS_1?

b) What is the change in resolution λ if one replaces an A/D converter, N_2 bits, with a full scale of FS_2, with another A/D converter, N_3 bits, with full scale FS_3.

Numeric values :

$N_1 = 10$ bits $\qquad\qquad\qquad\qquad\qquad\qquad FS_1 = 0 - 1\,V$
$N_2 = 8$ bits $\qquad\qquad\qquad\qquad\qquad\qquad\; FS_2 = 0 - 5\,V$
$N_3 = 12$ bits $\qquad\qquad\qquad\qquad\qquad\qquad FS_3 = \pm 5\;V$

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

We use an A/D converter (N bits with full scale FS) with successive approximation with an internal oscillator that has a clock frequency f_0.

a) What is the input voltage U_i giving a binary code b (see numerical values at the end of this problem)?

b) What is the minimum time delay ΔT before one can convert another value?

c) Is the use of a sample-and-hold circuit necessary if one wants to convert a sinusoidal signal of bandwidth B_p ?

Numerical values:

$b = 10101101$ $\qquad\qquad\qquad\qquad\qquad\qquad f_0 = 500\,kHz$
$FS = 0 - 2\,V$ $\qquad\qquad\qquad\qquad\qquad\qquad B_p = 0 - 100\,Hz$

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

An accelerometer with sensitivity S has a measurement range E. Its output is converted into a digital signal by an A/D converter (N bits with full scale FS), resulting in an ADC value N_{dec}.

a) Give the maximum quantization error ε_{max} on the measured quantity.

b) Express the relationship $a_N = f(N_{dec})$ that gives the measured acceleration as a function of the ADC value N_{dec}, knowing that the output of the sensor is U_0 when the acceleration is zero.

c) Calculate the acceleration a_N that corresponds to the ADC value N_{dec}.

Numerical values:

$S = 500\,mV/g$ $\qquad\qquad\qquad\qquad\qquad\qquad E = \pm 5\,g$
$N = 12$ bits $\qquad\qquad\qquad\qquad\qquad\qquad\quad FS = 0 - 5\,V$
$N_{dec} = 3658$