Department of Electronics & Communication Engineering
Indian Institute of Technology Roorkee

ECN 203 – Signals & Systems (DG)

TUTORIAL #1

1. Consider the discrete-time sequence

$$x[n] = \cos\left(\frac{n\pi}{8}\right)$$

Find two different continuous-time signals that would produce this sequence when sampled at a frequency of $f_s = 10$ Hz.

2. If the Nyquist rate for $x_a(t)$ is Ω_s, what is the Nyquist rate for each of the following signals that are derived from $x_a(t)$?

(a) $\frac{d}{dt}x_a(t)$ (b) $x_a^2(t)$

3. An image is to be sampled with an SQNR (Signal-to-Quantization-Noise-Ratio) of at least 80 dB. Assume that the sampling device is calibrated so that the input sampled image intensities are uniformly distributed in the range from 0 to 1. How many bits are needed to achieve the desired SQNR?

Hint: Quantization Noise in a uniform quantizer (with equal length quantization intervals and reconstruction level at the mid-point in every interval) is equal to $\Delta^2/12$, where Δ is the quantization interval length.

4. A continuous-time signal, given as

$$x(t) = 10\cos(400\,\pi t) + 5\cos(800\,\pi t)$$

is sampled at a rate 600 Hz and then passed through an ideal low-pass filter with cut-off frequency 300 Hz. Determine the output of the filter.

5. A continuous-time signal $x_a(t)$ is band-limited with $X_a(j\omega) = 0$ for $|\omega| > \omega_0$. If $x_a(t)$ is sampled at or above the Nyquist rate, how is the energy in $x[n]$,

$$E_d = \sum_{n=-\infty}^{+\infty} |x[n]|^2$$

related to the energy in $x_a(t)$,

$$E_a = \int_{-\infty}^{+\infty} |x_a(t)|^2 dt$$

and the sampling period T_s?