S-72.245 Transmission Methods in Telecommunication Systems
Tutorial 9

Objectives
● Study and compare ideal sampling and practical chopper sampling. Get familiar with sampling theorem and aliasing concept.
● To investigate quantization and PCM principles.
● To understand line coding and repeaters.

Quizzes

Q8.1 Suppose the PCM quantization error ε_k is specified to be no greater than $\pm P\%$ of the peak-to-peak signal range in linear quantization. Obtain the corresponding condition on the number of bits ν in terms of number of quantization levels M and P.

Q8.2 Suppose $x(t)$ has the spectrum as shown below with $f_u = 25$ kHz and $W = 10$ kHz. Sketch the spectrum $X_\delta(f)$ of the ideally sampled signal $x_\delta(t)$ for the sampling frequency of $f_s = 60, 45, 25$ kHz. Comment in each case the possible reconstruction of $x(t)$ from $x_\delta(t)$.
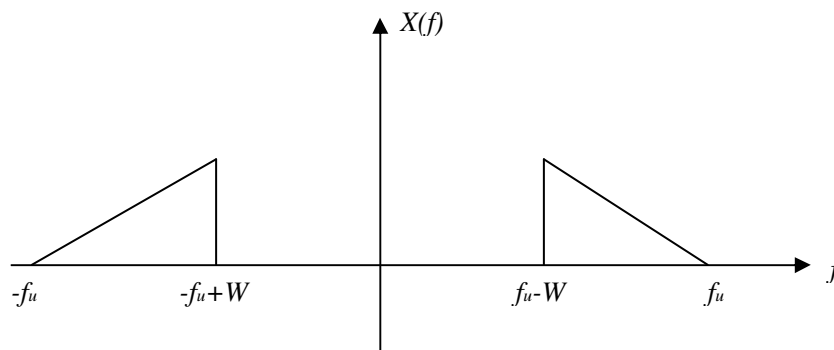
Q8.3 Consider binary PCM transmission of a video signal with the sampling frequency of $f_s = 10$ MHz. Calculate the signaling rate needed to get $(S/N)_D \geq 50 \ dB$ when $S_x = 1$.

Q8.4 A polar, binary system has 20 repeaters, each with $(S/N)_1 = 20 \ dB$. Find P_e when the repeaters are regenerative and non-regenerative.

<u>Q8.5</u> The zero-order hold circuit shown in the figure below is often used to reconstruct signal *x(t)* from its samples.
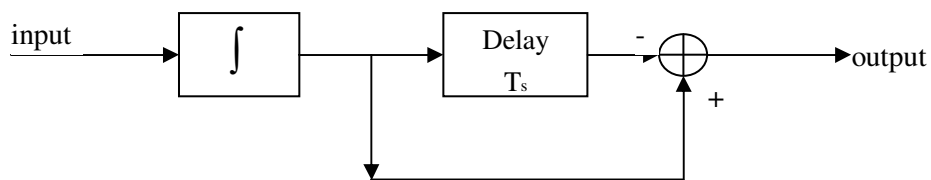
a) Find the impulse response of this circuit.

b) Find the respective transfer function $H(\omega)$

c) Show that when $x_s(t)$ is applied at the input of this circuit, the output is a staircase approximation of *x(t)*. The sampling interval is T_s.

<u>Matlab assignments</u>

<u>M8.1</u> Plot $\cos(2\pi 10t)$ and $\cos(2\pi 70t)$ for $0 \le t \le 1/10$ on the same axis by using

Matlab, and find the sample values at $t = 0$, 1/80, 2 / 80,..., 8 /80, which correspond to

the sampling frequency of $f_s = 80\ Hz$.

<u>M8.2</u> Generate $\omega = 1$ rad/s, unit amplitude sinusoidal signal. Then quantize it by using uniform PCM sampling to (a) 8, (b) 16 levels. Plot the original signal and the respective quantized signals on the same figure.