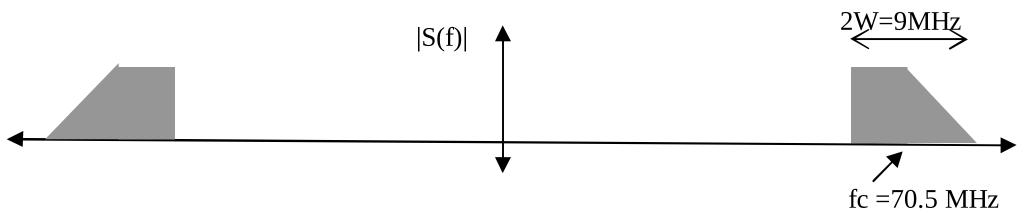
EC-305 Communication Systems

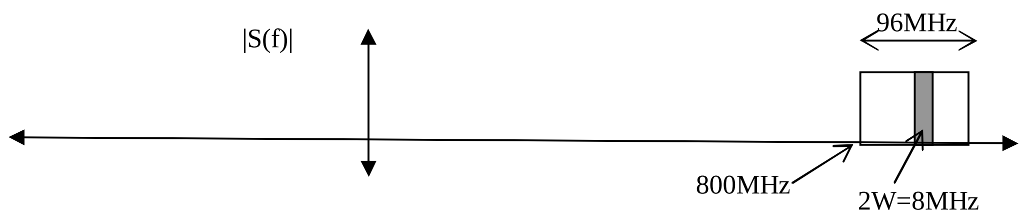
Sept. 2009 **Tutorial #1** KG / IITM

1. For the QCM signal with magnitude response as below, find the least possible band-pass sampling rate. Make a rough plot of the frequency response of the sampled sequence around 0Hz.



2. In the above problem, assume that the received signal has a phase offset of θ radians; in other words, $s(t) = m_1(t)Cos(2\pi f_c t + \theta) + m_2(t)Sin(2\pi f_c t + \theta)$. Now, what will be the time-domain representation of the sampled sequence? For the special case when $\theta = \pi/2$,what will be the samples of the received signal?

3. A dozen DSB-SC signals of one-sided (low-pass) bandwidth W = 4MHz are present between 800MHz and 896MHz, as shown below. Describe the operations (sampling, rate-conversion, filtering) that you need to do to recover Nyquist rate samples of the 7th DSB-SC signal (i.e., the signal present between 848Mz and 856MHz).



4. From the EC-305 Tutorial #1 of year 2008, solve problems 1, 2, 4, & 5 on uniform quantization.

5. Llyod-Max Non-uniform Quantization: Assume that a random signal x(t) with $x=x(t=t_0)$, follows a probability density function $f_X(x)$. and the objective is to find the N-1 signal levels $\{a_1, a_2, \cdots, a_{N-1}\}$and the corresponding N quantized values $\{\hat{x}_1, \hat{x}_2, \cdots, \hat{x}_N\}$ such that the quantization noise variance given by

$$E_q = E[(x - x_q)^2] = \int_{-\infty}^{a_1} (x - \hat{x}_1)^2 f_X(x)\,dx + \sum_{i=2}^{N-1} \int_{a_{i-1}}^{a_i} (x - \hat{x}_i)^2 f_X(x)\,dx + \int_{a_{N-1}}^{\infty} (x - \hat{x}_N)^2 f_X(x)\,dx$$

is minimized. In other words, differentiate E_q w.r.t$\{a_1, \cdots, a_{N-1}\}$and$\{\hat{x}_1, \cdots, \hat{x}_N\}$, equate them to zero, and show the following:

$$(i)\, a_i = \frac{\hat{x}_i + \hat{x}_{i+1}}{2} \quad \text{and} \quad (ii)\, \hat{x}_i = \frac{\int_{a_{i-1}}^{a_i} x\, f_X(x)\,dx}{\int_{a_{i-1}}^{a_i} f_X(x)\,dx}$$

6. The Llyod-Max quantizer indicates that the signal level should be the mid-point of the quantization interval (see (i)), and that the quantized value is the "centroid" of the corresponding interval (see (ii)). However, a practical method to construct this non-uniform quantizer is given by the iterative method below for a k-bit quantizer where N=2^k:

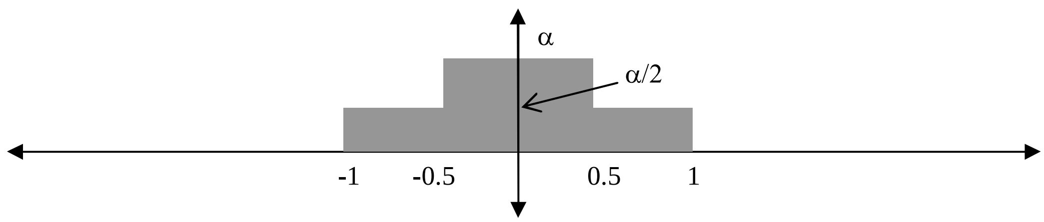
Step 1: choose N-1 uniform intervals $\{ a_1, a_2, \cdots, a_{N-1} \}$

Step 2: find the corresponding centroids $\{ \hat{x}_1, \hat{x}_2, \cdots, \hat{x}_N \}$using ($ii$)

Step 3: re-compute $\{a_i\}$ using (ii) in (i)

Iterate between steps 2 and 3 until "convergence"

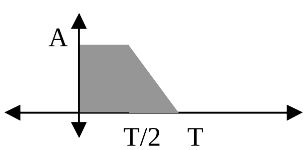
Use the above procedure for 3 iterations to define the 2-bit LM quantizer for the below source pdf. Compare the E_q obtained between the uniform quantizer (mid-tread) and the LM quantizer.

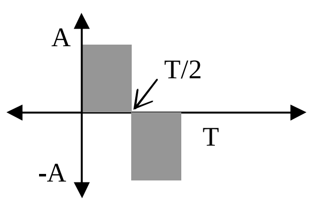


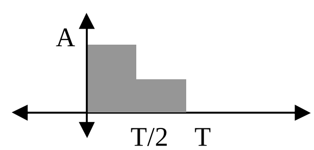
7. From the EC-305 Tutorial #1 of year 2008, solve problem 6 on non-uniform quantization.

8. From "Digital Telephony" J.C.Bellamy, 3rd Ed., pp. 158-160: Problems **3.1, 3.2, 3.3, 3.4, 3.5, 3.8*, 3.14*, 3.16*,3.17*, 3.18,** and **3.19.**

9. Draw the output of the matched filter over 3 symbol intervals for the bit-sequence 1,-1,1 for each of the below choices of the pulse-shape $g(t)$:







10. For a bit-stream with 8 consecutive bits given by 1,-1,1,-1,-1,-1,1,1, make a rough plot of the following line-codes: (a) NRZ (b) AMI (c) Split-phase Manchester (d) CMI (e) Differential Modulation (f) Differential Split-phase Manchester (g) B3ZS (or HDB3)

11. A state-dependent Miller code of rate 1/2 is defined by the following rule:

(a) input "0" → output di-bit is: x 0 where x=0 if preceding input bit is "1" (and "x=1" otherwise)

(b) input "1" → output di-bit is: 0 1

Use this code on the bit-sequence in Pbm.10. What properties of the Miller code do you observe?