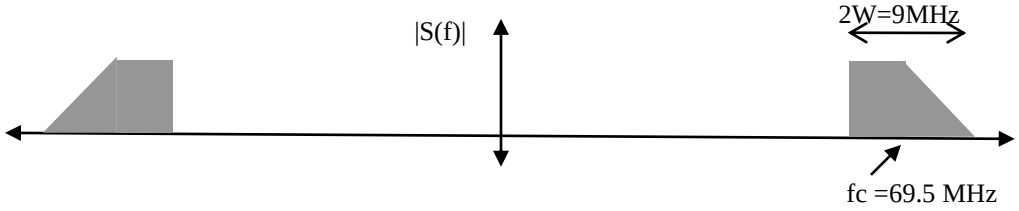
EE 3007: RF and Optical Communications

Feb. 2022 **Tutorial #1** KG / IITM

1. A low-pass signal of one-sided bandwidth of W=1.25MHz is sent as a DSB-SC signal. If the receiver uses an IF sampling scheme, with center frequency f_{IF} = 71MHz, determine the least sampling rate f_S required.

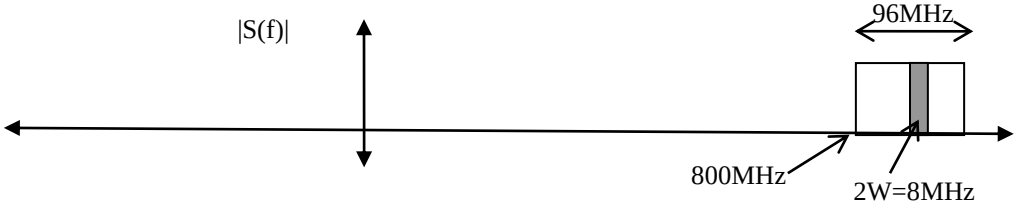
2. For the QCM signal with magnitude response as below, find the least possible band-pass sampling rate f_S. Make a rough plot of the frequency response of the sampled sequence around 0Hz. *Hint*: Use both the band-edges (i.e., f_c+W and f_c-W in order decide the "lowest" sampling rate).



3. In the above problem, let us discuss two possible sources of error:
(a) 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?
(b) Instead, assume $\theta = 0$ radians, but the incoming carrier frequency f_c' is offset by Δf Hz wrt to the sampling rate designed assuming f_c; i.e., f_c'= $f_c + \Delta f$ and use this f_c' this in place of f_c in the expression for $s(t)$ above. What is then the expression for the time-domain samples after the band-pass sampling ADC in terms of your sampling rate f_S and the Δf ? Say, for Δf = 1MHz, will some of I-Q samples at least be undistorted? Justify your answer.

4. A QCM signal $s(t) = m_1(t)Cos(2\pi f_c t) + m_2(t)Sin(2\pi f_c t)$ has the two message signals $m_1(t)$ and $m_2(t)$ of one-sided bandwidth of W_1=3KHz and W_2=4KHz, respectively, and take f_c=31KHz.
(a) Find the minimum band-pass sampling rate $f_s=1/T_s$ that gives un-aliased samples of the two signals.
(b) Assuming that the spectrum of $m_1(t)$ has a "triangular" shape between -3KHz to +3KHz, make a labeled, rough sketch of the spectrum of the samples $m_1(kT_s)$ between -40KHz and +40KHz.

5. A dozen DSB-SC signals of one-sided (low-pass) bandwidth W = 4MHz (including a "guard-band of 0.5MHz) 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).



6. In the question above, if the dozen signals were QCM, how does your answer change?