Homework 6 (Due on Oct. 30)

1. (Noise in DSB-SC Receiver) (30pts)

A DSB-SC modulated signal is transmitted over a noisy channel. The power spectral density of the noise is shown in Figure 1. The message bandwidth is 3 kHz and the carrier frequency is 200 kHz. Assuming that the average power of the modulated signal is 12 watts, determine the input signal-to-noise ratio (predetection SNR), output signal-to-noise ratio (postdetection SNR) and the detection gain (input SNR/output SNR).

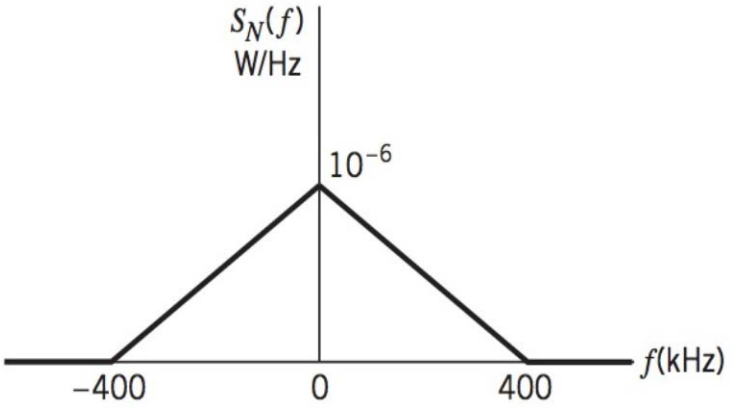

Figure 1

2. (Noise in SSB Receiver) (25pts)

Derive the equation for $y_D(t)$ for an USB-SSB system assuming that the noise is expanded about the frequency $f_c + \frac{W}{2}$. Derive the output SNR (postdetection SNR), detection gain and the figure of merit. Determine and plot the power spectral density of the in-phase component $n_c(t)$ and the quadrature component $n_s(t)$ of the narrowband noise.

3. (Noise in AM Receiver) (25pts)

Assume an AM system operates with a modulation index $a = 0.4$. The message signal is $m(t) = 5\cos(10\pi t)$.

1) Compute the transmission efficiency.
2) Assume the envelope detector operates above the threshold. Compute the output SNR (postdetection SNR) in decibels relative to the input SNR.
3) Compute the output SNR in decibels relative to the baseband SNR (P_T/N_0W).
4) Keep P_T (the average power of modulated signal) unchanged, determine the improvement (in decibels) in the output SNR if the modulation index is increased from 0.4 to 0.8. (Hint: Since the input SNR and baseband SNR are unchanged, we can calculate the improvement of output SNR based on its relationship with the input SNR and baseband SNR.)

4. (Noise in FM Receiver and FDM) (20pts)

An FDM system uses single-sideband modulation to form the baseband, and FM modulation for transmission of the baseband. Assume that there are eight channels and that all eight message signals have equal power P_0 and equal bandwidth W. For each signal, only the upper sideband is transmitted. The sub-carrier waves used for the first stage of modulation are defined by $c_k(t) = A_k \cos(2\pi k f_0 t), 0 \leq k \leq 7$. The width of the guardbands is 3W. The received signal consists of the transmitted FM signal plus white Gaussian noise of zero mean and two-sided power spectral density $N_0/2$. Assume the frequency discriminator at the receiver operates above the threshold.

1) Sketch the power spectral density of the signal produced at the frequency discriminator output, showing both the signal and noise components.
2) Find the relationship between the subcarrier amplitudes A_k such that the SSB modulated signals corresponding to different channels have equal output SNRs at the frequency discriminator output.