ECE 359 **Spring 2003**

Handout # 17 April 17, 2003

HOMEWORK ASSIGNMENT 9

Reading: Text, Chapter 5 and Handouts 14, 15, 16

Due Date: April 23, 2003 (in class)

1. *SNR for Amplitude Modulation:* Consider a message signal with bandwidth $W = 5$ kHz, and a normalized power $P_{m_n} = 0.1$ (note that P_{m_n} is sometimes called the average-to-peak power ratio – why?). It is required to transmit this signal via a channel with that has a power attenuation of 50 dB. The channel noise is AWGN with $N_0 = 10^{-12}$ Watts/Hz. It is desirable to have an SNR of at least 20 dB at the receiver output.

   (a) Find the minimum required transmit power $P_{\text{s,t}}$ if DSB-SC modulation is used.

   (b) Find the minimum required transmit power $P_{\text{s,t}}$ if conventional AM with mod. index of $a = 0.5$ is used. (Assume coherent demodulation.)

   (c) With the $P_{\text{s,t}}$ of part (b), what is the maximum SNR that one can get for conventional AM (assuming of course that we do not overmodulate the message signal)?

2. *SNR for Angle Modulation:* Consider a message signal with bandwidth $W = 5$ kHz and an average-to-peak power ratio $P_{m_n} = 0.1$. It is required to transmit this signal via a channel with that has a power attenuation of 40 dB. The channel noise is AWGN with $N_0 = 10^{-12}$ Watts/Hz. It is desirable to have an SNR of at least 60 dB at the receiver output.

   (a) Find the minimum required transmit power $P_{\text{s,t}}$ for PM with $\beta_p = 10$.

   (b) Find the minimum required transmit power $P_{\text{s,t}}$ for FM with $\beta_f = 10$.

   (c) Find the minimum required transmit power $P_{\text{s,t}}$ for FM with PD, with $\beta_f = 10$ and $W/f_0 = 7.14$.

   (Check in all cases that the system is not in threshold)

3. *FM with PD:* In a certain FM system used in space communication, the output SNR is found to be 35 dB with $\beta = 6$. The modulating signal has a bandwidth $W = 10$ kHz and an average-to-peak power ratio $P_{m_n} = 1/9$. The system with $\beta = 6$ is not in threshold, but the output SNR is required to be at least 50 dB. Because power is premium in space communication, it is decided to increase the output SNR by increasing β (i.e., increasing the transmission bandwidth) as much as possible.

   (a) What are the maximum value of β and the corresponding transmission bandwidth that can be used without running into threshold? What is the corresponding output SNR?

   (b) What must be the minimum increase in transmitted power required to attain an output SNR of 50 dB? What are the corresponding values of β and the transmission bandwidth?
   Hint: You need to solve a cubic equation for this part – use Matlab to solve this equation.

4. Problem 5.9 on page 263 of the text.

5. Explain clearly in your own words (using phasors if necessary) how the two assumptions, $\beta > 5$ and $\overline{\Gamma} > 20(\beta + 1)$, are used in arriving at the approximation for $N_\phi(t)$.

6. Using the expression for $S_{N_o}(f)$ given in class, derive the formula for the output noise power for FM with PD

$$P_{\text{n,o}} = \frac{2N_0 f_0^3}{A_c^2 \alpha^2} \left[\frac{W}{f_0} - \tan^{-1}\left(\frac{W}{f_0}\right) \right]$$