EECS 562

Homework 12

1. (Concept: Processing Gain for AM and DSB-SC) An AM receiver uses an envelope detector. The transmitter operates at total transmit power of 50KW with a 85% modulation index. The information signal is $x_{bb}(t) = \cos(2\pi f_m t)$, f_m=10kHz. The path loss between the transmitter and AM receiver is 87 dB. The noise power spectral density of

N_0=-117 dB_W/Hz. The RF bandwidth is 20kHz.

a. What is the post-detection S/N?

b. Repeat part a. with DSB-SC.

2. (Concept: Post-detection S/N for DSB-SC) A 10kHz message signal is transmitted using DSB-SC with a carrier frequency f_c=980kHz over a nosey channel with noise power spectral density of $N_0/2=10^{-14}$ W/Hz. The receiver sensitivity is -47 dB_m. The receiver sensitivity is defined as the minimum received signal power (pre-detection) that will provide a demodulated signal with acceptable performance. What is the post-detection S/N?

3. (Concept: Link budget with processing gain for DSB-LC and FM) A radio link has the following parameters:

Transmit power	10 dB_W
Transmitter Antenna Gain	5 dB
Path loss	130 dB
Antenna temperature	290 K
Receiver antenna gain	10 dB
Receiver noise figure	4 dB
Antenna Temperature	290
Information signal bandwidth	6 MHz

DSB-LC with modulation index 0.85

a. What is the $(S/N)_{pre}$ in dB?

b. What is the $(S/N)_{post}$ in dB?

c. Your supervisor tells you that to reduce the receiver cost there has been a design change and the receiver noise figure has changed to 6dB. The customer wants same output S/N found in part a). What system parameter would your change and by how much?

d. Repeat b. with FM with β=3.

4. (Concept: Post-detection S/N using processing gain for DSB-SC and FM) A 4 kHz message signal is transmitted using DSB-SC with a carrier frequency f_c=610kHz over a nosey channel with noise power spectral density of $N_0/2=2\text{x}10^{-15}$ W/Hz. The received signal power is -47dBm.

a. What is the post-detection S/N?

b. Repeat part a. with FM with β=2.

5. (Concept: Factoring bandwidth and power costs with post-detection S/N constraint) Suppose the following costs have been determined for a specific communication system.

RF Bandwidth: $250/kHz

Power: $3/watt

The customer wants a (S/N)post= 20 dB.
The fixed link parameters are an information bandwidth of 10 kHz, a path loss of 60 dB, and a constant noise power spectral density of $N_0 = 0.5 \times 10^{-9}$ watts/Hz.

a. Calculate the cost to the customer if DSB-LC is used with a 85% modulation index .
b. Repeat a. for SSB.
c. Repeat a. for DSB-SC.

6. (Concept: Comparison of required power for different modulation formats) Consider a communication system with a required (S/N)post of 40 dB and an information signal bandwidth of 20 kHz. The received signal consists of the transmitted signal plus noise where $S_n(f) = \frac{N_0}{2} = 2 \times 10^{-15}$ watts/Hz. The path loss between the transmitter and receiver is 100 dB.
Find the required transmitter power in dB_W for:

a. SSB
b. DSB-SC
c. DSB-LC μ=1
d. FM β=0.2
e. FM β=3

7. (Concept: Noise performance of FM) Consider an FM transmitter with a transmitter power of 35KW. The path loss is 75dB,
N_0 =-110dBW/Hz. The baseband bandwidth is 200 kHz.

a. Find β such that the (S/N)post =41.2 dB?
b. What is B_{RF} in kHz?

8. (Concept: Trade-off between power and bandwidth) Comparison of system resources (power and B_{RF}) for different modulation schemes. In this case:

- Path loss = 85dB
- N_0=-110dBW/Hz
- B_{bb}= baseband bandwidth = 100 kHz

a. Fill out the table below to meet a required output signal-to-noise ratio, (S/N)post =35dB
BW Expansion Factor = B_{RF}/B_{bb}

Mod	Mod Index	Gp(dB)	Pt(dBw)	Pt(KW)	Brf (kHz)	BW Expansion Factor
DSB-SC						
SSB						
AM	0.75					
AM	1					
FM	1.67					
FM	2					
FM	4					

b. For the FM cases above discuss the trade-off between B_{RF} and P_T.
c. Comment of the feasibility of using each modulation format given the required transmit power.