

EECS 562
Homework 12

1. An AM receiver uses an envelope detector. The transmitter operates at total transmit power of 50KW with a 75% modulation index. The information signal is $x_{bb}(t) = \cos(2\pi f_m t)$, $f_m = 10\text{kHz}$. The path loss between the transmitter and AM receiver is 90 dB. The noise power spectral density of $N_0 = -117 \text{ dB}_W/\text{Hz}$. The RF bandwidth is 20kHz.
 - a. What is the post-detection S/N?
 - b. Repeat part a. with DSB-SC.
2. A 20 kHz message signal is transmitted using DSB-SC with a carrier frequency $f_c = 980\text{kHz}$ over a noisy channel with noise power spectral density of $N_0/2 = 10^{-14} \text{ W/Hz}$. The receiver sensitivity is -50 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. 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 0.75
 - a. What is the $(S/N)_{\text{pre}}$ in dB?
 - b. What is the $(S/N)_{\text{post}}$ 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 you change and by how much?
 - d. Repeat b. with FM with $\beta = 5$.
4. A 4 kHz message signal is transmitted using DSB-SC with a carrier frequency $f_c = 610\text{kHz}$ over a noisy channel with noise power spectral density of $N_0/2 = 4 \times 10^{-15} \text{ W/Hz}$. The received signal power is -50dB_m .
 - a. What is the post-detection S/N?
 - b. Repeat part a. with FM with $\beta = 1$.
5. Suppose the following costs have been determined for a specific communication system.

RF Bandwidth: \$250/kHz
Power: \$3/watt
The customer wants a $(S/N)_{\text{post}} = 20 \text{ dB}$.
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 $N_0 = 0.5 \times 10^{-9} \text{ watts/Hz}$.

 - 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. Consider a communication system with a required $(S/N)_{\text{post}}$ of 27 dB and an information signal bandwidth of 10 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 $\mu=1$
- d. FM $\beta=0.2$
- e. FM $\beta=5$

7. Consider an FM transmitter with a transmitter power of 40KW. The path loss is 92dB, $N_0=-110$ dBW/Hz. The baseband bandwidth is 200 kHz.

- a. Find β such that the $(S/N)_{\text{post}}=25$ dB?
- b. What is BRF in kHz?

8. Comparison of system resources (power and BRF) for different modulation schemes. In this case:

- Path loss = 97dB
- $N_0=-110$ dBW/Hz
- B_{bb} = baseband bandwidth = 100 kHz

- a. Fill out the table below to meet a required output signal-to-noise ratio, $(S/N)_{\text{post}}=35$ dB

BW Expansion Factor = $B_{\text{RF}}/B_{\text{bb}}$

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.