DSB, SSB, and AM (Lectures 5 & 6)

1. Consider a message signal with a bandwidth of 10 kHz and an average power of P =10 watts. Assume the transmission channel attenuates the transmitted signal by 40 dB, and adds noise with a power spectral density of:

$$\mathbb{S}(f) = \begin{cases} N_o\left(1 - \dfrac{|f|}{200 \times 10^3}\right), & |f| < 200 \times 10^3 \\ 0, & otherwise \end{cases}$$

where $N_o = 10^{-9}$ watts/Hz.

What is the predetection SNR at the receiver if each of the following modulation schemes is used? Assume that a suitable filter is used at the input of the receiver to limit the out-of-band noise.

(a) Baseband

(b) DSB-SC with a carrier frequency of 100kHz and a carrier amplitude of $A_c = 1V$.

(c) DSB-SC with a carrier frequency of 150kHz and a carrier amplitude of $A_c = 1V$.

2. Consider the standard AM modulation, where the transmitted signal is given by

$$s(t) = [A + m(t)]\cos(2\pi f_c t),$$

where $m(t)$ is the message signal. Assume that the modulating wave is a sinusoidal wave, i.e., single-tone modulation,

$$m(t) = A_m cos(2\pi f_m t).$$

Given the baseband signal-to-noise ratio $SNR_{Baseband}$, consider an AM envelope detector when the noise power is small. Compute the output SNR in terms of the modulation index μ, which is defined as $\mu \triangleq m_p/A$, where m_p is the peak value of the message signal. What value of μ gives the maximum output SNR?

3. For each of the baseband signals: (i) $m(t) = \cos 1000\pi t$; (ii) $m(t) = 2\cos 1000\pi t + \sin 2000\pi t$; (iii) $m(t) = \cos 1000\pi t \cos 3000\pi t$, do the following.

(a) Sketch the spectrum of $m(t)$.

(b) Sketch the spectrum of the DSB-SC signal $m(t)\cos 10000\pi t$.

(c) Identify the upper sideband (USB) and the lower sideband (LSB) spectra.

(d) Identify the frequencies in the baseband, and the corresponding frequencies in the DSB-SC, USB, and LSB spectra. Explain the nature of frequency shifting in each case.

4. Repeat Prob. 3 [parts (a), (b), and (c) only] if (i) $m(t) = \text{sinc}(100t)$; (ii) $m(t) = e^{-|t|}$; (iii) $m(t) = e^{-|t-1|}$. Observe that $e^{-|t-1|}$ is $e^{-|t|}$ delayed by 1 second. For the last case, you need to consider both the amplitude and the phase spectra.

5. Sketch the AM signal $[A + m(t)]\cos(2\pi f_c t)$ for the periodic triangle signal $m(t)$ shown in Fig. P4.3-2 corresponding to the modulation indices (a) $\mu = 0.5$; (b) $\mu = 1$; (c) $\mu = 2$; (d) $\mu = \infty$; How do you interpret the case of $\mu = \infty$?

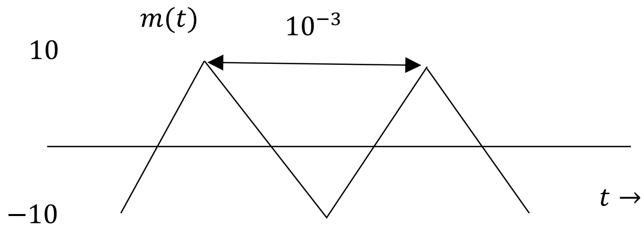

Figure P.4.3-2

6. **For the AM signal with $m(t)$ shown in Fig. P.4.3-2 and $\mu = 0.8$:**

(a) **Find the amplitude and power of the carrier.**

(b) **Find the sideband power and the power efficiency η.**