Homework 4

1. **SSB Modulation** (30 points)
Consider the phase shift method to generate SSB depicted in Fig. 1. The spectrum of the message signal at point (a) is a triangular pulse as shown on the left hand-side of the figure.

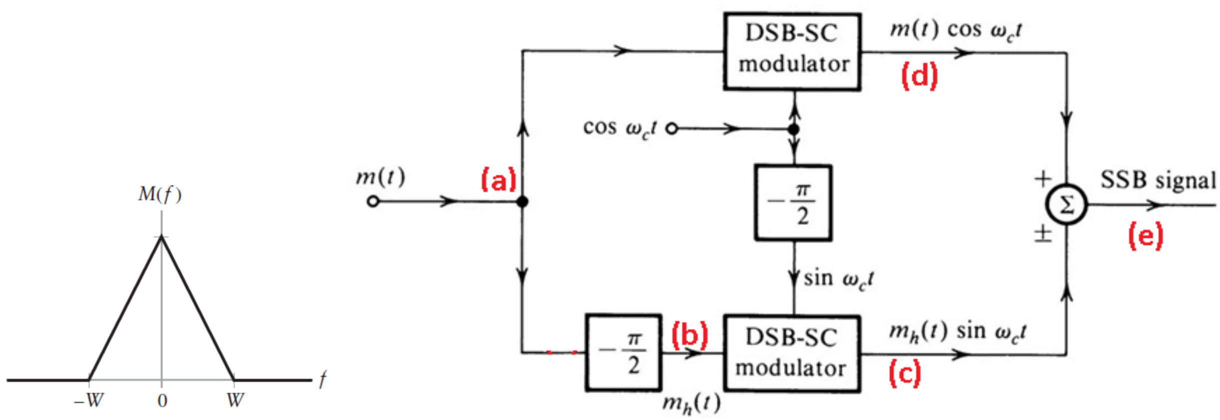

Figure 1: Problem 1

Evaluate the spectrum of the signal at points (b), (c), (d), and (e). Note that at point (e) you need to find the spectrum for the + and - cases separately. Which case (+ or -) corresponds to the USB modulation?

2. **SSB Modulation** (20 points)
Using the single-tone modulation signal $\cos \omega_m t$ verify that the output of the above SSB generator (or its time domain equivalent) is indeed an SSB signal and show that USB and SSB result from subtraction or addition on the summation junction.

3. **VSB Modulation** (20 points)
Show that for distortionless demodulation of a VSB signal using the modulator/demodulator given in Fig. 2 the frequency response $H(f)$ of the VSB filter must satisfy

$$H(f - f_c) + H(f + f_c) = constant \qquad for \ \ |f| \leq W,$$

where W is the message bandwidth.

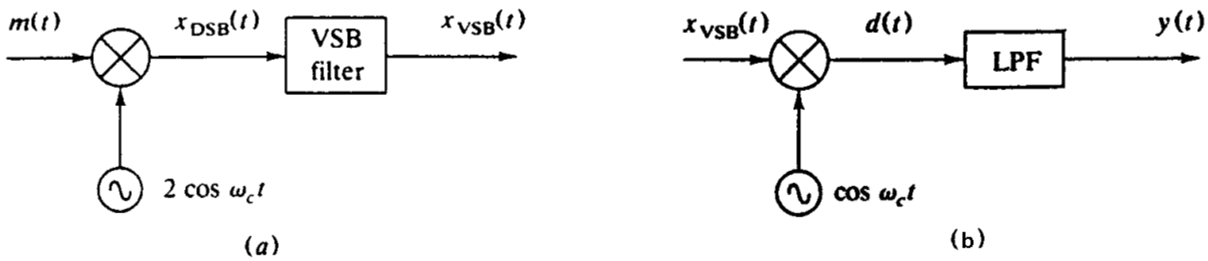

Figure 2: Problem 3

4. **AM Stereo** (30 points) Problem 3.15 of the text.
A particular version of AM stereo uses quadrature multiplexing. Specifically, the carrier $A_c \cos 2\pi f_c t$ is used to modulate the sum signal

$$m_1(t) = V_0 + m_l(t) + m_r(t)$$

where V_0 is a DC offset included for the purpose of transmitting the carrier component, $m_l(t)$ is the left-hand audio signal, $m_r(t)$ is the right-hand audio signal. The quadrature carrier $A_c \sin 2\pi f_c t$ is used to modulate the difference signal

$$m_2(t) = m_l(t) - m_r(t)$$

(a) Show that an envelope detector may be used to recover the sum $m_l(t) + m_r(t)$ from the quadrature-multiplexed signal. How would you minimize the signal distortion produced by the envelope detector?

(b) Show that a coherent detector can recover the difference $m_l(t) - m_r(t)$

(c) How are the desired left- and right-hand audio signals (i.e., $m_l(t)$ and $m_r(t)$) finally obtained ?

Hint: The envelope of $a \sin x + b \cos x$ is $\sqrt{a^2 + b^2}$, for any x. Similarly, the envelope of $a(t) \sin x + b(t) \cos x$ is $\sqrt{a^2(t) + b^2(t)}$.

■ Curious about the distinction between mono and stereo sounds? Watch