EECS 562
Homework #3

1. 3.27

2. The IF frequency of a commercial broadcast AM superheterodyne receiver is 455 KHz. Suppose we wish to "tune in" station KLWN at 1320 on the dial.
   a. What are the two possible frequencies for the local oscillator?
   b. For each LO frequency in part a, what is the corresponding image frequency?

3. An SSB modulator (as in Figure 3.19 of Haykin/Moher) becomes a spectrum inverter (a simple form of encryption) if the following changes are made. First, the oscillator input to the product modulator should have a frequency equal to W, the bandwidth of the message signal. Then, replace the BPF with an ideal LPF having bandwidth W.
   a. Illustrate the result of this system with a message signal having a triangular spectrum as in Figure 3.11(a). Specifically, sketch the output spectrum for such an input spectrum.
   b. Describe how the original message signal could be restored.

4. For broadcast FM (see Table 3.2 of Haykin/Moher) what are the Local Oscillator frequencies for FM stations at KANU @ 91.5 MHz and at KKSW @105.9 MHz.

5. Given a set of information bits {1, 0 ,1, 0}.
   a. Let $x_1(t) = +2$ for 1 ms for a bit = 0 and $x_1(t) = -2$ for 1 ms for a bit = 1. A modulated RF signal is $y_1(t) = x_1(t)\cos(2\pi f_c t)$ where f_c=10kHz. Plot $y_1(t)$.
   b. An envelope detector can be used to demodulate $y_1(t)$ in part a) to recover the information bits. TRUE or FALSE. Justify
   c. Let $x_2(t) = +4$ for 1 ms for a bit = 0 and $x_2(t) = 0$ for 1 ms for a bit = 1. A modulated RF signal is $y_2(t) = x_2(t)\cos(2\pi f_c t)$ where f_c=10kHz. Plot $y_2(t)$.
   d. An envelope detector can be used to demodulate $y_2(t)$ in part c) to recover information bits. TRUE or FALSE. Justify
   e. Let $x_3(t) = +5$ for 1 ms for a bit = 0 and $x_3(t) = 0$ for 1 ms for a bit = 1. A modulated RF signal is $y_3(t) = 2\cos(2\pi(x_3(t)*1000 + f_c)t)$ where f_c=10kHz. Plot $y_3(t)$.
   f. An envelope detector can be used to demodulate $y_3(t)$ in part e) to recover information bits. TRUE or FALSE. Justify [Hint: Consider this modulation as two version of the modulation used in part c, where one carrier frequency 10kHz is used for bit = 1 and another one carrier frequency 15 kHz is used for bit = 0.]

6. A audio signal has a baseband bandwidth of 20kHz. The signal is SSB modulated on a carrier frequency of 1 MHz. What is the required RF bandwidth?

7. A software defined radio (SDR) can be used as an commercial (standard) AM receiver. Here the IF signal is digitized and the IF processing is done entirely in software, i.e., digital signal processing used to demodulate the message signal. What maximum sampling frequency would be needed for this SDR. Do a web search to find a suitable SDR for this application.

8. Why is coherent (or synchronous) detection required for DSB-SC?

9. Let z_i be a complex symbol for i=1…4

$z_1 = 1 + j,\ z_2 = 1 - j,\ z_3 = -1 + j,\ z_4 = -1 - j$

Each pair of bits (2 bits) in an information signal is mapped into one complex symbol, e.g., (0,0) →z_1; so a sequence of information bits is mapped into a sequence of complex symbols. The modulated RF signal $y_i(t) = \mathrm{Re}(z_i e^{j2\pi f_c t})$ for $i = 1...4$ for 1 ms; i.e., a complex symbol is transmitted every symbol time of 1 ms. This modulated RF signal $y_i(t)$ is processed by a Quadrature receiver (see figure 3.17 b in Haykin/Moher).

a. Find the demodulated outputs (one output for demodulating with cos and one output for demodulating with sin) for $y_i(t)$ i=1…4. Use results from Homework 1-Problem 4. (Assume $A_c = A'_c = 1$).

b. What is the transmission bit rate? [Hint: the units of bit rate is bits/sec.]

10. Watch 8VSB, From Transport Stream to RF Signal
http://www.theonlineengineer.org/TheOLEBLOG/8vsb-a-tutorial/

a. What does the 8 refer to in 8VSB?
b. Mathematically explain how shifting the signal by 1.25 V generates the pilot signal.