EECS 562

Homework 7

1. A DSB-LC signal can be defined as $y_{RF}(t) = A_c(1+\ k_a x_{bb}(t))\cos(2\,\pi f_c t)$. k_a is the amplitude sensitivity of the modulator. For a message signal of $x_{bb}(t) = 2\cos(2\,\pi f_m t)$ volts where f_m=25 Hz and the unmodulated RF signal of is $100\cos(2\,\pi f_c t)$ volts where f_c=1 kHz and a the percent modulation (sometimes called modulation index or modulation factor) of 75%, 100%, 125% answer the following questions.

a. Find A_c and k_a.

b. Plot the RF signal in the time domain to scale.

c. What is the total RF transmitted power for a modulation index=1, assume a 1 ohm load.

d. What is the power in the carrier wave modulation index=1, assume a 1 ohm load.

e. What is the RF bandwidth?

f. Plot the one-sided power spectral density of the RF signal modulation index=1.

g. What is the impact of overmodulation, e.g., a modulation index of 125%, on the RF signal in the time domain?

2. For a sequence of information bits b_i ={1,1,0,0,1,0}; i=1..6, the message signal is formed as $m(t)=\sum_{i=1}^{6} b_i \text{rect}(t-(i-1)-0.5)$

a. Plot m(t)

b. For 50% AM percent modulation plot the RF time-domain signal (use f_c=10Hz)

c. For 100% AM percent modulation plot the RF time-domain signal (use f_c=10Hz)

d. Can an envelope detector be used to recover the transmitted bits?

3. Let s(t) be an DSB-LC (AM) signal. The unmodulated transmitted power is 150 KW. The message signal is $x_{bb}(t) = \cos(2\,\pi f_m t)$. The power in the sidebands is 50 KW.

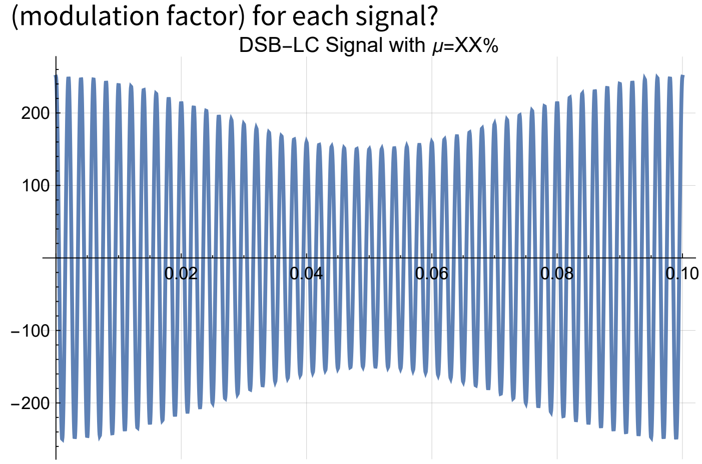
a. Find the corresponding carrier amplitude, A_c

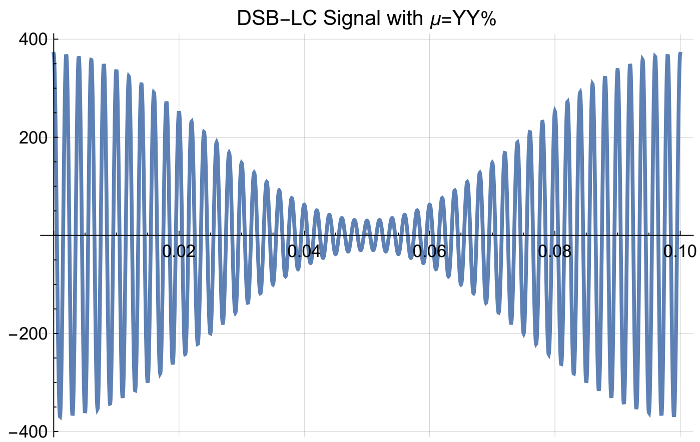
b. What is the modulation factor?

c. What is the power efficiency?

d. What is the RF bandwidth?

4. An DSB-LC RF signals are plotted in the time domain below. What is the modulation index (modulation factor) for each signal?





5. Consider a sequence of information bits bi {….0,1,0,1,0,1,0,1….}, That is, alternating 0's and 1's. A baseband analog message signal is formed as where a_i=-1 if $b_i = 0$ and a_i=+1 if $b_i = 1$, Here the bit rate is 100 bits/sec, T_b=10ms.

$x_{bb}(t)=\sum_{k=-\infty}^{\infty} a_i \text{rect}(\frac{t-kT_b/2}{T_b})$

a. Plot x_{bb}(t).

b. What is the DC (or average value) of m(t)?

c. Find the Fourier Series of x_{bb}(t) and plot its one sided amplitude spectrum.

d. DSB-LC (AM) modulation is used to transmit x_{bb}(t) with a unmodulated carrier 100 cos(2 πf_ct) with f_c=10kHz. Plot the RF signal in the time domain for 50% AM percent modulation.

e. DSB-LC (AM) modulation is used to transmit x_{bb}(t) with a unmodulated carrier 100 cos(2 πf_ct) with f_c=10kHz. Plot the RF amplitude spectrum for 90% AM percent modulation.

6. Given an information signal of cos(2000πt) and

$y_{RF}(t) = 40(1+0.75\cos(2000\pi t)) \cos(100000\pi t)$

a. Identify the modulation type.

b. What is the total power in y_{RF}(t)?

c. What is the power in the upper sideband?

e. Is the power in the lower sideband the same as the power in the upper sideband?

f. What is the power efficiency.

7. A square-law modulator for generating an DSB-LC signals relies on the use of a nonlinear device (e.g., diode). Ignoring higher order terms, the input-output characteristic of the diode-load resistor circuit is represented by a square law, i.e., $v_{out}(t) = a_1 v_{in}(t) + a_2 v_{in}^2(t)$

a. With $x_{in}(t) = A\cos(2\pi f_c t) + x_{bb}(t)$ where $x_{bb}(t)$ has a bandwidth B_{bb}. Find v_{out}(t) and identify the terms that represent a DSB-LC signal.

b. Draw the block diagram of a DSB-LC modulator that uses a square law device as defined in this problem.

8.

a. Explain why a DC blocking capacitor is required in an envelope detector.

b. What is the impact of the DC blocking capacitor is required in an envelope detector on the performance of commercial AM radio receivers.