EECS 562

Homework 4

1. Let the message signal be

$x_{bb}(t) = 1\cos(3000\pi t) + 2\cos(2000\pi t) + 3\cos(1000\pi t)$

be input to a DSB-SC modulator at a carrier frequency of 50kHz and an unmodulated carrier amplitude of 10.

a. Find the Fourier transform of the DSB-SC signal.

b. Plot the spectrum of the DSB-SC signal.

c. Identify the upper and lower sideband in the DSB-SC signal.

d. What is the RF bandwidth?

e. What is the total transmitted power?

2. Let the message signal be $x_{bb}(t) = 5\text{rect}(t/0.001)$ be input to a DSB-SC modulator at a carrier frequency of 40kHz and an unmodulated carrier amplitude of 5.

a. Find the Fourier transform of the DSB-SC signal.

b. Plot the spectrum of the DSB-SC signal.

c. What is the RF bandwidth?

3. Let the message signal be $x_{bb}(t) = 1000\,\text{sinc}^2(5000t)$ be input to a DSB-SC modulator at a carrier frequency of 50 kHz and an unmodulated carrier amplitude of 10.

a. Plot the spectrum of the DSB-SC signal.

b. What is the RF bandwidth?

4. Consider a sequence of information bits b_i {….0,1,0,1,0,1,0,1….}, That is, alternating 0's and 1's. A baseband analog message signal m(t) is formed as

$$m(t) = \sum_{k=-\infty}^{\infty} d_i\, rect[\frac{t-\frac{(2k+1)\tau}{2}}{\tau})]$$

where d_i=-4 if $b_i = 0$ and d_i=+4 if $b_i = 1$

a. With τ=1ms, plot m(t) for k=1…6.

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

c. Find the Fourier Series of m(t) and plot its amplitude spectrum.

d. DSB-SC modulation is used to transmit m(t) with a carrier wave of carrier signal $10\cos(2\pi f_c t)$ with f_c = 20kHz. Plot the RF signal.

e. Plot the spectrum of the DSB-SC modulated signal

f. With τ=1ms find the average energy per bit in the modulated signal.

g. How would the spectrum of the RF signal change with a different mapping of bits to levels, specifically, changing d_i=-2 if $b_i = 0$ and d_i=+4 if $b_i = 1$ to d_i=0 if $b_i = 0$ and d_i=+4.

5. Let s(t) be an DSB-SC signal, $x_{RF}(t) = x(t)\cos(2\pi f_c t)$ with f_c=100kHz and $x(t)=\cos(2000\pi t)$.

a. There is only a frequency error in the coherent detector of Δf=20Hz. Find the output of the coherent detector, y(t) and plot y(t).

b. There is only a phase error in the coherent detector of 45^0. Find the output of the coherent detector, y(t) and plot y(t).

6. In BPSK receivers why is both carrier and bit synchronization needed?

7. A received binary signal with a bit rate of 1kb/s is with f_c=100 KHz

$10^{-5}\cos(2\pi f_c t)\ \ 0 \le t \le T_b$

or

$-10^{-5}\cos(2\pi f_c t)\ \ 0 \le t \le T_b$

a. Is this a BPSK or ASK signal?

b. What is the bandwidth of RF signal?

c. What is the E_b the energy/bit?

8. Assume that a DSB-SC signal is subjected to intentional interference I(t). The received signal is of the form,

$y(t)=10\,x(t)\cos(2\pi f_c t)+I(t)$

Where

$x(t)=\cos(2\pi 10000t)$

and

$I(t)=\sqrt{2}\cos(2\pi(f_c+\Delta f)t)$ where $\Delta f<10$kHz that is, the interferer is in the passband of the DSB-SC signal,

a. What is the bandwidth of y(t)?

b. What is the power in y(t)?

c. Find the Signal-to-interference power ratio (in dB) at the output of a synchronous receiver?

9. In the BPSK receiver output of the receiver filter is sampled at the bit rate and the sample value compared to a threshold, why the threshold value = 0.

10. In the ASK receiver output of the receiver filter is sampled at the bit rate and the sample value compared to a threshold, why the threshold value not equal to zero.