

EECS 562
Homework 4

1. (Concept: Properties of DSB-SC signals)

Let the message signal be

$$x_{bb}(t) = \cos(3000\pi t) + 3\cos(2000\pi t) + 6\cos(1000\pi t)$$

be input to a DSB-SC modulator at a carrier frequency of 60kHz 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. (Concept: Spectrum of DSB-SC signals)

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 20kHz 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. What is the RF bandwidth?

3. (Concept: Spectrum of DSB-SC signals)

Let the message signal be $x_{bb}(t) = 1000 \text{sinc}^2(1000t)$ be input to a DSB-SC modulator at a carrier frequency of 20 kHz and an unmodulated carrier amplitude of 10.

- a. Plot the spectrum of the DSB-SC signal.
- b. What is the RF bandwidth?

4. (Concept: Relating DSB-SC to BPSK modulation)

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

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

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

- a. With $\tau = 1\text{ms}$, plot $m(t)$ for $k = 1 \dots 6$.
- 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 $f_c = 10\text{kHz}$. Plot the RF signal.
- e. Plot the spectrum of the DSB-SC modulated signal
- f. With $\tau = 1\text{ms}$ 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 $d_i = -1$ if $b_i = 0$ and $d_i = +1$ if $b_i = 1$ to $d_i = 0$ if $b_i = 0$ and $d_i = +2$ if $b_i = 1$.

5. (Concept: Impact of frequency and phase errors on the demodulation of DSB-SC signals)

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

- a. There is only a frequency error in the coherent detector of $\Delta f = 10\text{Hz}$. Find the output of the coherent detector, $y(t)$ and plot $y(t)$, compare $y(t)$ to the output of a coherent detector

with no frequency error.

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

6. (Concept: synchronization)

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

7. (Concept: Analysis of DSB-SC signals and finding the signal-to-Interference ratio)

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

$$y(t) = 16x(t)\cos(2\pi f_c t) + I(t)$$

Where

$$f_c = 60 \text{ kHz and the information signal is } x(t) = \cos(2\pi 5000t)$$

and

$I(t) = 2\sqrt{2}\cos(2\pi(f_c + \Delta f)t)$ where $\Delta f = 2.5 \text{ kHz}$ 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?

8. (Concept: Bit detection of BPSK signals)

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.

9. (Concept: Bit detection of ASK signals)

In ASK the baseband signal is 0, A. 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 equal to $\frac{A}{2}$.