

Homework #4

Due on **Sept. 30, 2010, Thursday**

(The TA will collect homeworks in classroom during 2pm-2:15pm on Sept. 30.)

1. [10 points](Partially from L&D Exercise 3.8-1) Show that the autocorrelation function of $g(t) = C \cos(2\pi f_0 t + \theta_0)$ is given by $\mathcal{R}_g(\tau) = \frac{C^2}{2} \cos 2\pi f_0 \tau$, and the corresponding PSD is $S_g(f) = \frac{C^2}{4} [\delta(f - f_0) + \delta(f + f_0)]$. (Hint: To compute the autocorrelation function, you may need to use $\lim_{T \rightarrow \infty} \frac{\sin(2\pi f_0 T + \theta)}{T} = 0$.)

2. [10 points] (Partially from L&D Exercise 3.8-5) Consider a linear system with impulse response $e^{-2t}u(t)$. The linear system input is

$$g(t) = x(t) + w(t)$$

where $x(t)$ is the signal component of input, and $w(t)$ is the noise component of input. Suppose

$$x(t) = \cos\left(6\pi t + \frac{\pi}{3}\right)$$

and the PSD of $w(t)$ is given by

$$S_w(f) = \Pi\left(\frac{f}{4}\right).$$

(a) Find the output power of the signal component due to $x(t)$. (Hint: Use the result from problem 1.)

(b) Find the output power of the noise component due to $w(t)$.

(c) Find the output signal-to-noise ratio (SNR), i.e., ratio of output power due to the signal $x(t)$ and the output power due to the noise signal $w(t)$.

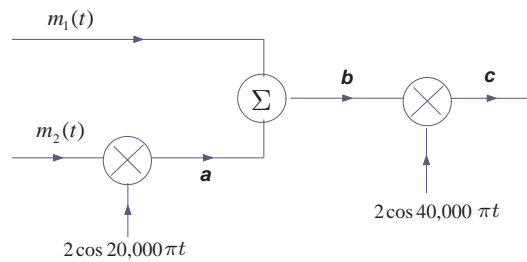
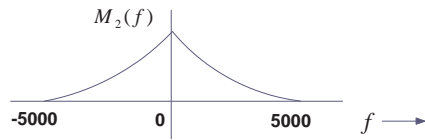
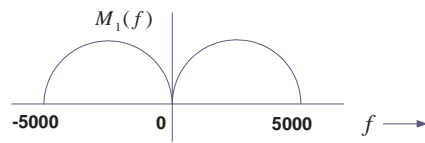
3. [10 points] (Partially from L&D Exercise 4.2-1) You are given a baseband signal $m(t) = \cos 1000\pi t$.

(a) Sketch the spectrum of $m(t)$.

(b) Sketch the spectrum of the DSB-SC signal $m(t) \cos 10,000\pi t$.

(c) Identify the upper sideband (USB) and the lower sideband (LSB) spectra.

4. [10 points] (L&D Exercise 4.2-7) Two signals $m_1(t)$ and $m_2(t)$, both band-limited to 5000Hz, are to be transmitted simultaneously over a channel by the multiplexing scheme shown in the figure below. The signal at point b is the multiplexed signal, which now modulates a carrier of frequency 20,000 Hz. The modulated signal at point c is transmitted over a channel.



- (a) Sketch signal spectra at points a , b and c .
- (b) What must be the bandwidth of the distortionless channel? (Hint: The channel must pass the modulated signal entirely so that the signal is not distorted.)
- (c) Design a receiver to recover signal $m_1(t)$ from the modulated signal at point c .