EE 320 Communications Principles

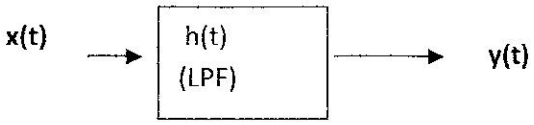
Midterm# # 1 (1st Semester 1433/1434H) *Name:*________________________________

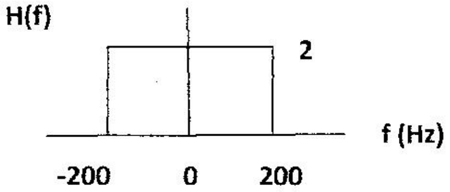
Monday, October 15, 2012 *Student-ID:*________________________________

Total Marks=60 Total Time = 90 Minutes

Question#1 (20 *marks*):

(a) Consider a signal $x(t) = 2000 sinc(1000t)$ applied to a low pass filter (LPF) whose frequency response H(f) is sketched below





a. [8] Determine the energy spectral density (ESD) and autocorrelation function at the **input** of the low-pass filter
b. [2] Calculate the energy at the **input** of low pass filter using autocorrelation function only.
c. [8] Determine the energy spectral density (ESD) and autocorrelation function at the **output** of the low-pass filter
d. [2] Calculate the energy at the **output** of low pass filter using energy spectral density only.

Question#2 (20 *marks*):

Consider an AM signal with carrier $c(t) = A_c \cos(2\pi f_c t)$ and the message signal $m(t) = A_m \cos(2\pi f_m t)$. Suppose the total power delivered by this AM wave to a 50 ohm resistance is 500 watts with the percentage modulation, μ=70%. Assume AM signal to be a voltage waveform. For this AM wave determine:

a) [4] The carrier amplitude, A_c
b) [4] Power in the Carrier.
c) [4] Power in Upper and Lower Side Bands.
d) [4] Percentage of total power wasted in carrier i.e. wasted power.
e) [4] Percentage of total power in side bands, i.e. efficiency

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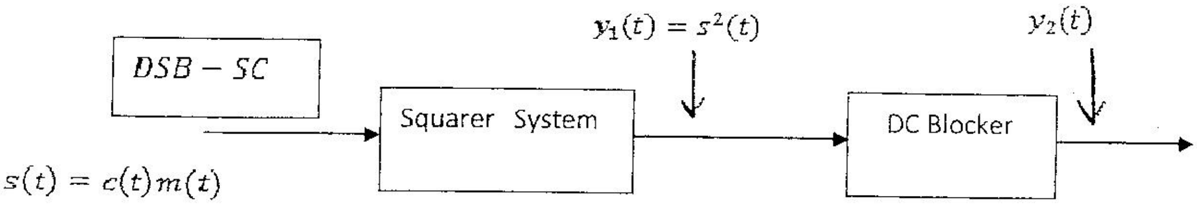
Question#3 (20 *marks*):

Consider the DSB-SC signal $s(t) = c(t)m(t)$, with carrier $c(t) = 4\cos(2\pi 1000t)$ and the message signal $m(t) = 2\cos(2\pi 100t)$. Consider a squaring system which will generate $y_1(t) = s^2(t)$. This signal is input to a DC blocker system (the system which will block DC or f=0 frequency component). The output of DC blocker is $y_2(t)$.

(a) [8] Write down the simplified $y_1(t)$ and then sketch $Y_1(f)$ i.e. Fourier transform of $y_1(t)$. Make sure to label the axes correctly.

(b) [8] Write down the simplified $y_2(t)$ and then sketch $Y_2(f)$ i.e. Fourier transform of $y_2(t)$. Make sure to label the axes correctly.

~~(c) [4] Design an ideal low-pass filter to extract the **exact** message signal from $y_2(t)$. [Design mean what is the gain in passband and cutoff frequency of the LPF]~~

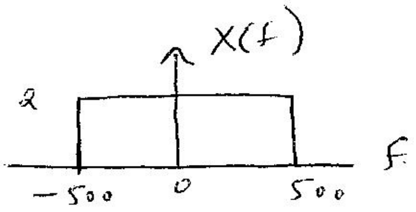


EE-320, Solution, Mid #1, Fall 2012

P# 1

$$x(t) = 2000\,\mathrm{Sinc}(1000t)$$

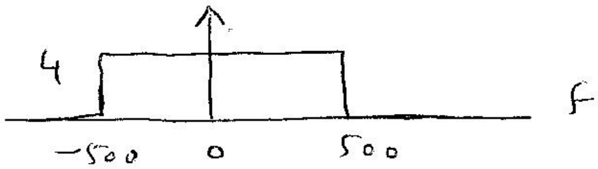
$$X(f) = 2\,\mathrm{Rect}\left(\frac{f}{1000}\right)$$



(a)

$$\Psi_x(f) = |X(f)|^2$$

$$\Psi_x(f) = 4\,\mathrm{Rect}\left(\frac{f}{1000}\right)$$

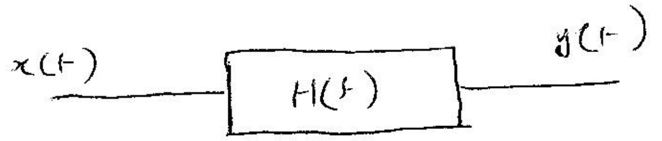


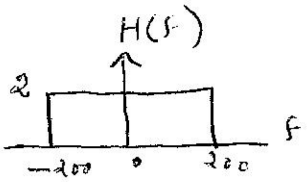
$$R_x(\tau) = 4000\,\mathrm{Sinc}(1000\tau)$$

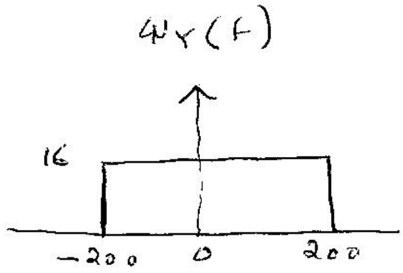
(b)

$$R_x(0) = E_x = 4000$$

(c)







$$\Psi_Y(f) = 16\,\mathrm{Rect}\left(\frac{f}{400}\right)$$

$$R_Y(\tau) = 6400\,\mathrm{Sinc}(400\tau)$$

(d)

$$E_y = \int_{-200}^{200} 16\,df = 6400$$

P # 2

$$P_C = \frac{1}{2}\frac{A_c^2}{R}$$

$$P_{USB} = \frac{1}{2}\left(\frac{\mu A_c}{2}\right)^2 \times \frac{1}{R} = \frac{\mu^2 A_c^2}{8R}$$

$$P_{LSB} = \frac{\mu^2 A_c^2}{8R}$$

$$P_T = P_C + P_{USB} + P_{LSB}$$

$$P_T = \frac{1}{2}\frac{A_c^2}{R} + \frac{\mu^2 A_c^2}{4R}$$

(a) $$P_T = A_c^2\left[\frac{1}{2R} + \frac{\mu^2}{4R}\right] = 500$$

$$A_c^2\left[\frac{1}{100} + \frac{(0.7)^2}{200}\right] = 500.$$

$$A_c = 200.4$$

(b) $$P_C = \frac{1}{2} \times \frac{A_c^2}{R} = 401.6 \text{ Watt}$$

$$P_{USB} = P_{LSB} = \frac{\mu^2 A_c^2}{8R} = 49.2 \text{ watt}$$

(d) $$\text{Wasted Power} = \frac{P_C}{P_T} = 80.32\ \%$$

(d) $$\text{Effeciency} = \frac{P_{USB} + P_{LSB}}{P_T} = 19.68\ \%$$

P#3 (a)

$$y_1(t) = s^2(t)$$

$$y_1(t) = \left[8\cos(2\pi 1000t)\cos(2\pi 100t)\right]^2$$

$$y_1(t) = 64\cos^2(2\pi 1000t)\cos^2(2\pi 100t)$$

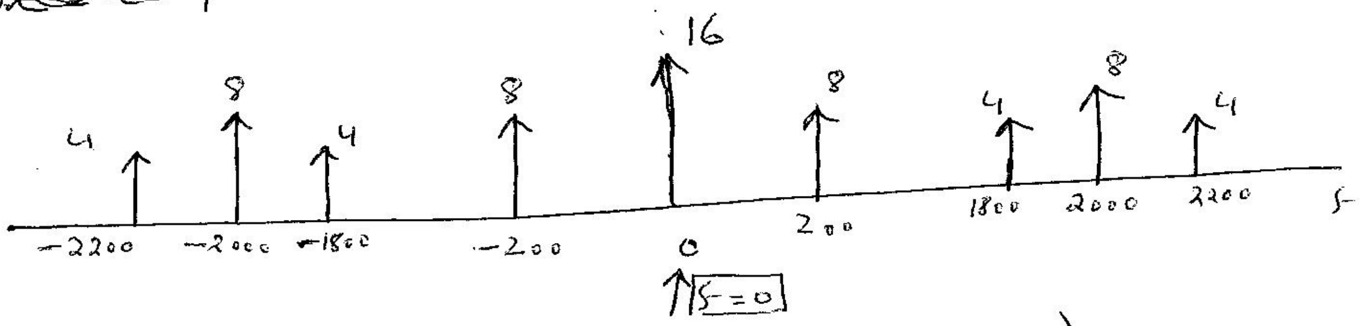
$$y_1(t) = \frac{64}{4}\left[1+\cos(2\pi 2000t)\right]\left[1+\cos(2\pi 200t)\right]$$

$$y_1(t) = 16\left[1+\cos(2\pi 2000t)\cos(2\pi 200t)+\cos(2\pi 2000t) + \cos(2\pi 200t)\right]$$

$$y_1(t) = 16 + 8\cos(2\pi 2200t) + 8\cos(1800t) + 16\cos(2\pi 2000t) + 16\cos(2\pi 200t)$$

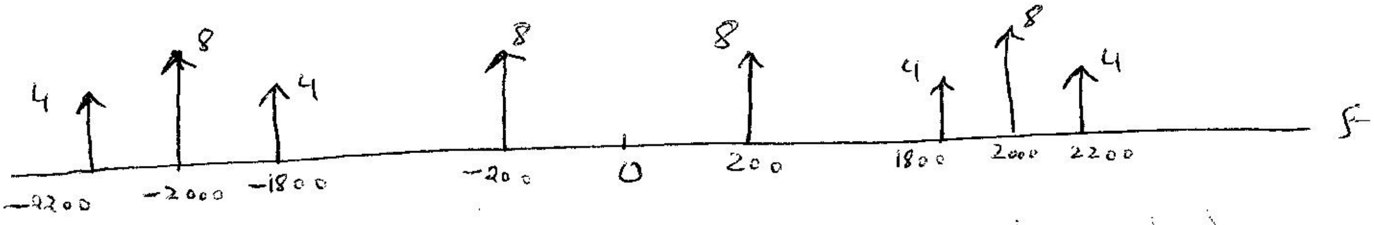
~~DC component:~~

$Y_1(f)$



(b)

$$y_2(t) = 8\cos(2\pi 2200t) + 8\cos(1800t) + 16\cos(2\pi 2000t) + 16\cos(2\pi 200t)$$



$Y_2(f)$

~~$200 < f_{cutoff} < 1800$~~

(c) Gain $= \frac{1}{8}$