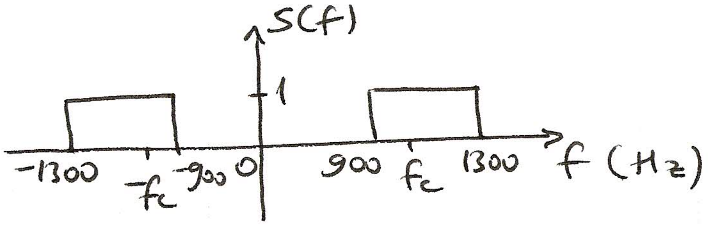
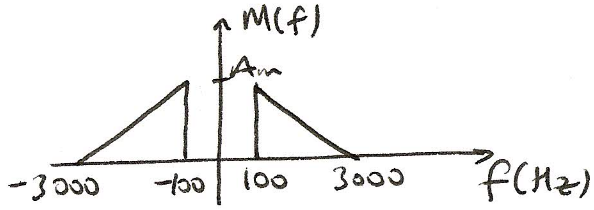
Apr 28th, 2013

IZMIR UNIVERSITY OF ECONOMICS
EEE 302 MIDTERM EXAM

Q1.(25 points) a) Find the complex baseband equivalent $\tilde{s}(t)$ and the corresponding I and Q components $s_I(t)$ and $s_Q(t)$ for the following bandpass signal s(t) given that carrier frequency f_c = 1 kHz.



b) The spectrum of the message signal m(t) is shown below. Sketch the spectra of the corresponding AM, DSB-SC, USSB, LSSB, and VSB modulated signals using the carrier frequency f_c = 95.7 MHz. Compute the required transmission bandwidth (B_T) in each case?



Q2.(25 points) Consider a square-law detector whose transfer characteristic is defined by

$$y(t) = a_1 x(t) + a_2 x^2(t)$$

where a1, a2 are constants, x(t) is the input and y(t) is the output.

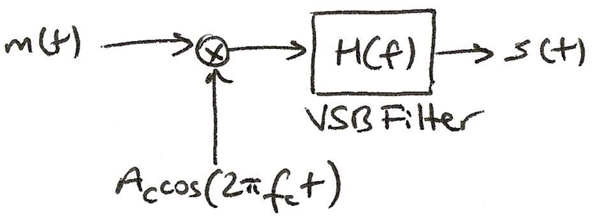
a) Assume the input is the AM wave,

$$x(t) = A_c[1 + k_a m(t)]\cos(2\pi f_c t)$$

Evaluate the output y(t).

b) Find the conditions and a system for which the message signal m(t) can be recovered from y(t).

Q3.(25 points) In Amplitude Modulation, as a trade-off between bandwidth efficiency and system complexity, we can transmit one sideband plus a vestige of the other unwanted sideband, resulting in VSB modulation.



a) Find the spectrum S(f) at the modulator output in terms of H(f) and M(f).

b) Draw a block diagram for coherent VSB demodulator and derive expressions for the demodulator output in Fourier domain.

c) How should the filter H(f) be designed such that there is no distortion in recovering m(t) at the demodulator output?

Q4.(25 points) A carrier wave of frequency 100 MHz is frequency-modulated by a sinusoidal wave of amplitude 20 V and frequency 100 kHz. The frequency sensitivity of the modulator is 25 kHz per volt.

a) Write down the expression of FM signal $s_{FM}(t)$?

b) Determine the approximate bandwidth of FM signal using the Carson's rule.

c) Repeat part b) for these two cases: i) assuming that the amplitude of the modulating signal is doubled.

ii) Assuming that the modulation frequency is doubled.

d) Draw and write down expressions for the FM signal demodulator.

Theorems

	Property	Signal	Fourier Transform in f	Fourier Transform in ω
1	Linearity	$ax_1(t)+bx_2(t)$	$aX_1(f)+bX_2(f)$	$aX_1(\omega)+bX_2(\omega)$
2	Time delay	$x(t-t_0)$	$X(f)e^{\ j2\pi f t_0}$	$X(\omega)e^{\ j\omega t_0}$
3	Time scaling	$x(at)$	$\frac{1}{\lvert a\rvert}X\left(\frac{f}{a}\right)$	$\frac{1}{\lvert a\rvert}X\left(\frac{\omega}{a}\right)$
4	Freq. Trans.	$x(t)e^{j2\pi f_0 t}$	$X(f-f_0)$	$X(\omega-\omega_0)$
5	Modulation	$x(t)\cos(2\pi f_0 t)$	$\frac{1}{2}[X(f-f_0)+X(f+f_0)]$	$\frac{1}{2}[X(\omega-\omega_0)+X(\omega+\omega_0)]$
6	Convolution	$x_1(t)*x_2(t)$	$X_1(f)\cdot X_2(f)$	$X_1(\omega)\cdot X_2(\omega)$
7	Multiplication	$x_1(t)\cdot x_2(t)$	$X_1(f)*X_2(f)$	$\frac{1}{2\pi}X_1(\omega)*X_2(\omega)$
8	Differentiation	$\frac{d^n}{dt^n}x(t)$	$(j2\pi f)^n X(f)$	$(j\omega)^n X(\omega)$
9	Integration	$\int_{\infty}^{t} x(\tau)\,d\tau$	$\frac{1}{j2\pi f}X(f)+\frac{1}{2}X(0)\delta(f)$	$\frac{1}{j\omega}X(\omega)+\pi X(0)\delta(\omega)$
10	Parseval's thm.	$\int_{\infty}^{\infty}\lvert x(t)\rvert^2\,dt$	$\int_{\infty}^{\infty}\lvert X(f)\rvert^2\,df$	$\frac{1}{2\pi}\int_{\infty}^{\infty}\lvert X(\omega)\rvert^2\,d\omega$