King Fahd University of Petroleum & Minerals
Electrical Engineering Department
EE370: Communications Engineering I (102)

Major Exam II

May 7, 2011
7:00 PM-8:30 PM
Building 59-

Room 2001 for Dr. Muqaibel
Room 2002 for Dr. Shaikhi
Room 2003 for Dr. Saad

Name: KEY

ID# 000

Serial # 0

Sec # 0

Question	Mark
1	/10
2	/8
3	/6
4	/6
Total	/30

Instructions:

1. This is a closed-books/notes exam.
2. The duration of this exam is one and half hours.
3. Read the questions carefully. Plan which question to start with.
4. CLEARLY LABEL ALL SIGNIFICANT VALUES ON BOTH AXIES OF ANY SKETCH.
5. Work in your own and show your steps
6. Strictly no mobile phones are allowed.

Good luck

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Problem 1: **(10 points)**

A. For FM Radio the message bandwidth is 15 kHz, the maximum deviation in an FM broadcast system is 75 kHz, find the deviation ratio, and estimate the bandwidth of the FM signal. **(2 points)**

$\beta = \frac{\Delta f}{BW_m} = \frac{75\,kHz}{15\,kHz} = 5$

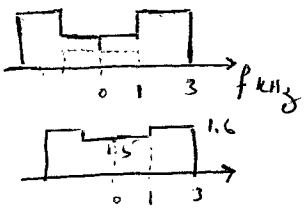
$BW_{FM} = 2(\Delta f + BW_m)$

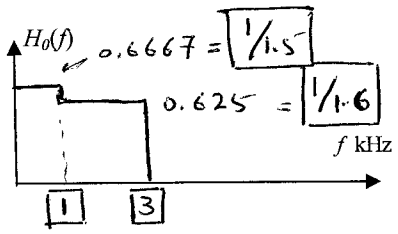
$= 2(75k + 15k) = 180\,kHz$

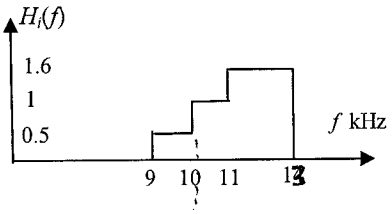
Deviation ratio= 5

Estimated bandwidth= 180 kHz

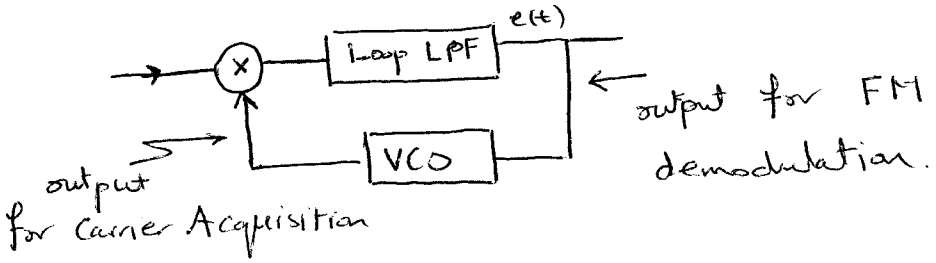
B. The carrier frequency of a certain VSB signal is 10 kHz, and the baseband signal bandwidth is 3 kHz. The VSB shaping filter is shown in the figure below. Sketch the output filter $H_o(f)$ required for distortionless perfect reception? *Show number on both axes.* **(2 points)**







C. Sketch the block diagram of the PLL. Where do we take the output if the PLL is used for carrier acquisition? Where is the output if the PLL is used for FM demodulation? **(2 points)**



D. Given the angle modulated signal $x_{EM}(t) = 10\cos(2\pi\times10^5 t + 20\cos 10\pi t)$, for the message $m(t) = -100\sin(10\pi t)$. Is $x_{EM}(t)$ FM or PM? Find the value of k i.e (k_p or k_f) and why? **(2 points)**

$f_i = \frac{2\pi \times 10^5 - 20(10\pi)\sin 10\pi t}{2\pi} = 10^5 - 100\pi \sin 10\pi t$

It is FM signal because the freq. is proportional to the message.

We can also prove that by comparing with the general form $\varphi_{FM}(t) = A\cos(\omega_c t + k_f \int_{-\infty}^{t} m(\lambda)\,d\lambda)$

By Comparison $K_f \int_{-\infty}^{t} m(\lambda)\,d\lambda = 20\cos 10\pi t \Rightarrow$ $K_f = 2\pi$ rad/sec/V

$\varphi_{PM}(t) = A\cos(\omega_c t + k_p m(t))$

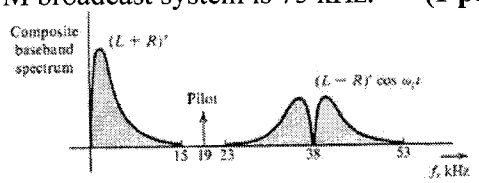
or $K_f = 1$ Hz/V

E. The concept of super-heterodyne receivers is used for both FM and AM receivers. If the intermediate frequency for FM=10.7 MHz, what is the frequency of the image station for Bahrain Holy Quran station 106.1 MHz? **(1 point)**

$F_{image} = 106.1 + 2F_{IF} = 106.1 + 2(10.7)$

$= 127.5\,MHz$

F. Compare the bandwidth of Stereophonic FM modulated signals with monophonic FM modulated signals? The maximum deviation in an FM broadcast system is 75 kHz. **(1 point)**

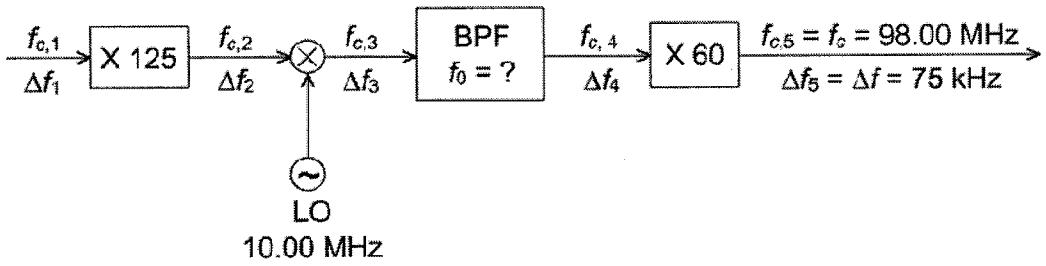


$BW_{mono} = 2(\Delta f + BW_m) = 2(75k + 15k) = 180k$

$BW_{stereo} = 2(\Delta f + BW_m) = 2(75k + 53k) = 256k$

ratio $= \frac{256k}{180k} = 1.422$

Problem 2: **(8 points)**



The indirect FM generator (Armstrong) scheme shown, consisting of 5 stages as shown in the figure, stage 1 is the output of the NBFM modulator:

a) Find the values of $f_{c,i}$ and Δf_i for i = 1, 2, 3 and 4 . What should be the centre frequency, f_0 , of the BPF. Assume up conversion is used in the mixer. Also assume that the filter is wide enough to allow the up converted signal to fully pass. *Show your steps then fill the table below.* **(5 points)**

$f_4 = \frac{f_5}{60} = 1.633\ MH_3$

$\Delta f_4 = \frac{\Delta f_5}{60} = 1.25\ KH_3$

$f_3 = f_4$, $f_3 = f_2 \pm 10M = 18.367\ MH_3$
$= 10M - f_2 = 1.633\ MH_3$

$\Delta f_3 = \Delta f_4$

$\Delta f_2 = \Delta f_3$

$10M - f_{c_2} = f_{c_3}$ ↙ up conversion

$f_{c_2} = 10M - 1.633 = 8.367 MH_3$

$\Delta f_1 = \frac{\Delta f_2}{125} = \frac{1.25K}{125} = 10H_3$

$f_{c_1} = \frac{f_{c_2}}{125} = \frac{8.367M}{125}$
$= 66.936\ KH_3$

$f_c = f_{c_3} = f_{c_4}$

or 18.367 MHz

Stage	1	2	3	4	
f_c	66.936K	8.367 MH3	1.633 MH3	1.633 MH3	f_0
Δf	10 H3	1.25 KH3	1.25 KH3	1.25 KH3	1.633 MH3

Considering one band

b) Determine the bandwidth at each stage. Assume $m(t)$ is of bandwidth 15 kHz. **(3 points)**

$BW_{\phi} = 2(B_m + \Delta f)$
$= 2(15K + \Delta f)$

$BW_5 = 2(15K + 75K) = 180K$

$BW_4 = 2(15K + 1.25K) = 32.5K$

$BW_2 = BW_3 = BW_4 = 32.5K$

$BW_1 = 2(15K + 10)$
$= 30.02\ KH_3$
$\approx 30\ KH_3$

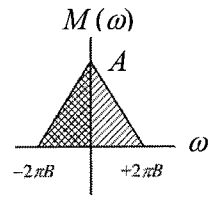
Stage	1	2	3	4	5
Bandwidth	30.02 KH3	32.5 KH3	32.5 KH3	32.5 KH3	180 KH3

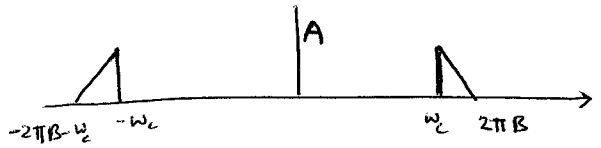
Considering one band

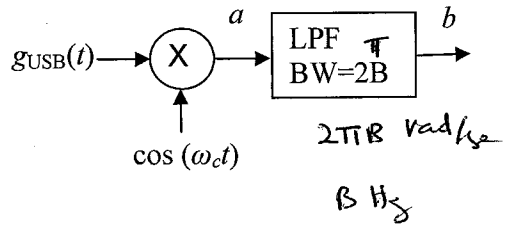
Problem 3: **(6 points)**

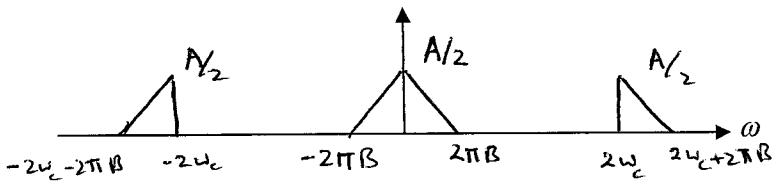
USB-SSB signals, $g_{USB}(t) = m(t)\cos(\omega_C t) - m_h(t)\sin(\omega_C t)$, is applied to system shown below. The spectrum of the message, $m(t)$ is also shown

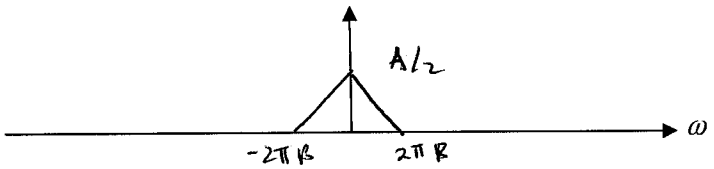
(a) Sketch the spectrum of the signal at each points (a and b). **(3 points)**











(b) Write the simplified time domain expression of the signal at each point (a and b). **(2 points)**

at a

$g_{USB}(t)\cos\omega_c t$

$m(t)\cos(\omega_c t)\cos(\omega_c t) - m_h(t)\sin(\omega_c t)\cos(\omega_c t)$

$= \frac{m(t)}{2}\left[1 + \cos 2\omega_c t\right] - \frac{m_h(t)}{2}\sin 2\omega_c t$

$= \frac{m(t)}{2} + \frac{m(t)}{2}\cos 2\omega_c t - \frac{m_h(t)}{2}\sin 2\omega_c t = \frac{1}{2}\left[m(t) + \varphi_{USB}(t)\right]$ at $2\omega_c$

at b $\frac{m(t)}{2}$

(c) What is the function of this system? **(1 point)**

Demodulator

Problem 4: **(6 points)**

Before FM demodulation we usually have a hard limiter. The hard limiter is made of two blocks what are they? and what is the function of each? **(2 points)**

1) hard limiter : limit the signal to a square wave with magnitude +1 or -1

2) Band pass filter: a band pass filter to convert the square signal to sinusoidal.

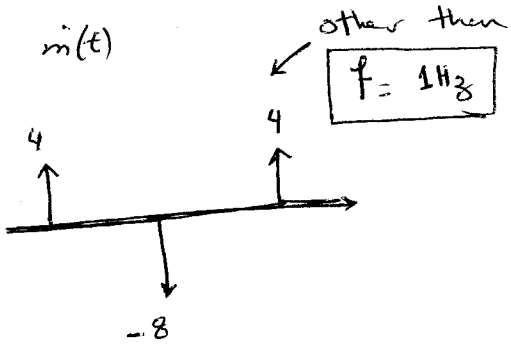
Although FM requires larger bandwidth than AM, FM is widely used. Why? Mention two distinct advantages of FM over AM? **(1 point)**

1) Immunity to non linearity

(3) Exchange BW for Quality $SNR \propto (BW)^2$

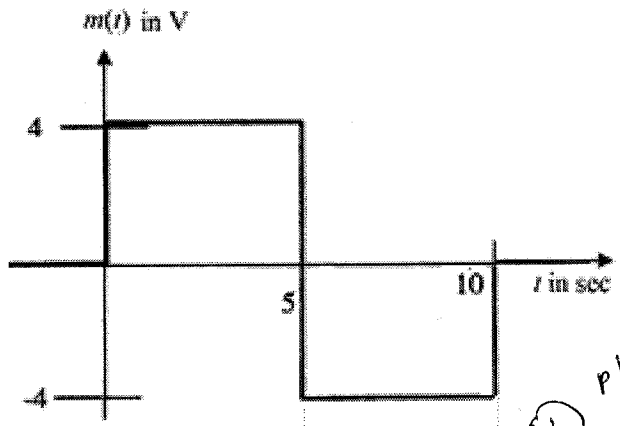
2) Constant Power "Independent of the message".

Sketch the PM signal for the following message assume f_c=1 Hz and k_p=π/16 rad/V. *Show your steps and all important values. Sketch to scale.* **(3 points)**



other then the deltas, the value = zero.

$f = 1$ Hz



Because there are deltas we will check there impact on the phase.

$$\varphi_{PM}(t) = A\cos(\omega_c t + k_p m(t))$$

$$= A\cos(2\pi(1)t + \frac{\pi}{16} m(t))$$

for $m = 0$

$$\varphi_{PM}(t) = A\cos(2\pi t)$$

(1.5)

for $m = 4$

$$\varphi_{PM}(t) = A\cos(2\pi t + \frac{\pi}{16}(4))$$

$$= A\cos(2\pi t + \frac{\pi}{4})$$

for $m = -4$

$$\varphi_{PM}(t) = A\cos(2\pi t - \frac{\pi}{4})$$

← difference of 90°

phases (1) (0.5) freq