KING FAHD UNIVERSITY OF PETROLEUM & MINERALS

ELECTRICAL ENGINEERING DEPARTMENT

SECOND SEMESTER 2010-2011 (102)

Course Title:	**Communication Engineering I**
Course Number:	**EE 370**

Exam Type:	**MAJOR EXAM I**
Date:	**March 23, 2011**
Time:	**7:00 pm – 8:30 pm (1 & 1/2 hours)**

Student Name: ______________Key__________________

Student ID: ________________00000________________

Section: ________________________________

Serial Number: ________________________________

GRADING		
Question 1	**10**	
Question 2	**10**	
Question 3	**20**	
Question 4	**20**	
Total:	**60**	

Be neat, organized, and show all your work and results.

Question 1:

Mark the following clearly as true (T) or false (F).

1	DSBSC has a power efficiency of about 67% which makes it more power efficient compared to AM signal having a power efficiency of 33% at best.	(F)
2	AM signal can be demodulated coherently	(T)
3	When using switching modulators for DSBSC, it is necessary to use double balanced modulators.	(F)
4	In compact trigonometric Fourier series, $(C_n = \sqrt{a_n^2 + b_n^2})$ is complex and it contains the amplitude and phase information of the frequency spectra.	(F)
5	The amplitude spectrum of a real signal is even and the phase spectrum is odd.	(T)
6	Both AM and DSBSC modulations need twice the bandwidth of the modulating signal and a carrier frequency of at least twice the bandwidth of the modulating signal.	(F)
7	Distortionless systems have constant amplitude spectrum and exponential phase spectrum.	(F)
8	The time constant, RC, of the low-pass filter for the envelope detector depends on the value of the modulation index.	(T)
9	In QAM demodulation, phase mismatch is less damaging than frequency mismatch	(T)
10	Band-limited signals have infinite bandwidth.	(F)

Question 2:

a) Find the complex (exponential) Fourier series of $x(t)=\cos(2000\pi t)+\sin^2(2000\pi t)$. (4 marks)

b) Plot the amplitude spectrum and phase spectrum (two sided) of the signal $x(t)$. (4 marks)

c) Show whether $x(t)$ is a power or energy signal and find its corresponding power or energy if possible. (2 marks)

a) $x(t)=\cos(2000\pi t)+\frac{1}{2}[1-\cos 4000\pi t]$

$=\frac{1}{2}+\cos(2000\pi t)-\frac{1}{2}\cos 4000\pi t$

$=\frac{1}{2}+\frac{1}{2}[e^{j2000\pi t}+e^{-j2000\pi t}]-\frac{1}{4}[e^{j4000\pi t}+e^{j4000\pi t}]$

$=\frac{1}{2}+\frac{1}{2}e^{j2000\pi t}+\frac{1}{2}e^{-j2000\pi t}-\frac{1}{4}e^{j4000\pi t}-\frac{1}{4}e^{-j4000\pi t}$

note that $x(t)=\sum_{n=-\infty}^{\infty}D_n e^{jn\omega_0 t}$

$\therefore D_0=\frac{1}{2}\angle 0$ at $\omega=n\omega_0=0$

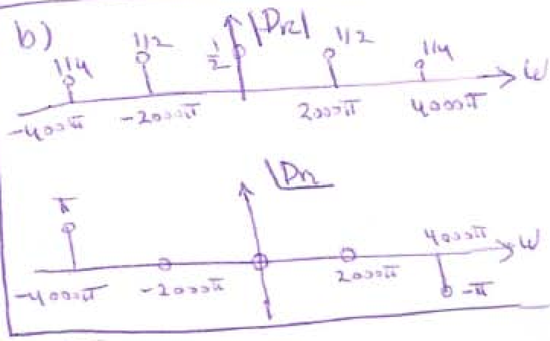
$D_1=\frac{1}{2}\angle 0$ at $\omega=n\omega_0=2000\pi$

$D_{-1}=\frac{1}{2}\angle 0$ at $\omega=n\omega_0=-2000\pi$

$D_2=\frac{-1}{4}=\frac{1}{4}\angle -\pi$ at $\omega=n\omega_0=4000\pi$

$D_{-2}=\frac{-1}{4}=\frac{1}{4}\angle \pi$ at $\omega=n\omega_0=-4000\pi$

b)



c) $x(t)$ is periodic $\Rightarrow$ it is a power signal

Using parseval's theorem

$P_x=\sum_{n=-\infty}^{\infty}|D_n|^2=(\frac{1}{2})^2+(\frac{1}{2})^2+(\frac{1}{2})^2+(\frac{1}{4})^2+(\frac{1}{4})^2$

$=\frac{7}{8}=0.875$ watt

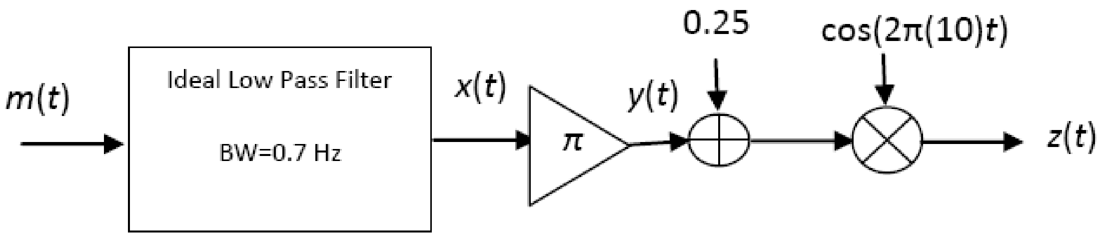
you can use also

$P_x=C_0^2+\frac{1}{2}\sum_{n=1}^{\infty}C_n^2=(\frac{1}{2})^2+\frac{1}{2}(1)^2+\frac{1}{2}(\frac{1}{2})^2$

$=\frac{7}{8}=0.875$ watt

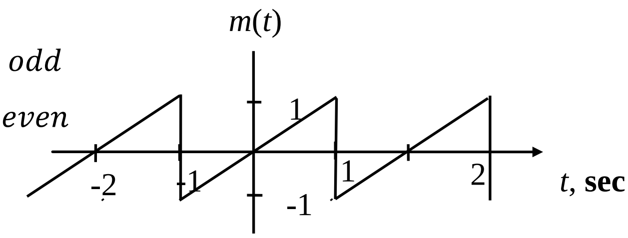
Question 3:

The system below , takes the input signal, low-pass filter it with cut off frequency of 0.7 Hz, then amplify it with a gain equals to π, then add a constant of 0.25, and finally multiply the resultant with a carrier of 10Hz



The input signal, *m*(*t*), is periodic and can be represented by its Fourier series expansion as:

$$m(t) = \sum_{n=1}^{\infty} \frac{2}{n\pi}\cos\left(n\pi t + \theta_n\right), \quad \text{where } \theta_n = \begin{cases} -\frac{\pi}{2} & n\ odd \\ +\frac{\pi}{2} & n\ even \end{cases}$$



a. Find the percentage of power at the output of the filter compared to the input power. Hint: you will need to find the power of *m*(*t*) and *x*(*t*) and compare them.

$$P_{g(t)} = \frac{1}{T_0}\int_{t_0}^{t_0+T_0} |g(t)|^2 dt$$

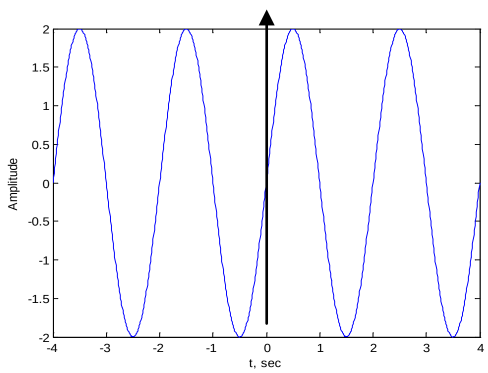
$$P_{m(t)} = \frac{1}{2}\int_{-1}^{1} t^2 dt = \frac{1}{2}\frac{1}{3}[(1)-(-1)] = \frac{1}{3}$$

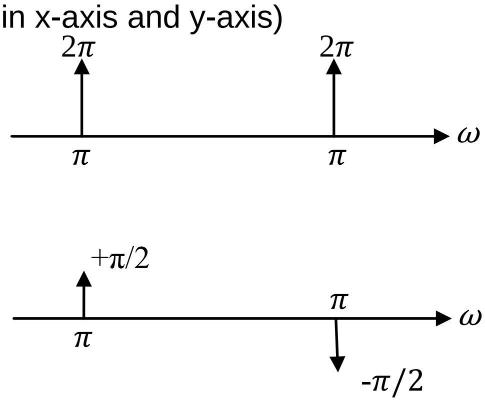
After the low-pass filter only the first harmonic will pass, Note that T_0=2 ➔ f_0=0.5 Hz

The fist harmonic is given to be $x(t) = \frac{2}{\pi}\cos\left(\pi t - \frac{\pi}{2}\right) = \frac{2}{\pi}\sin(\pi t)$. Power of sinusoidal is $\frac{\left(\frac{2}{\pi}\right)^2}{2} = \frac{2}{\pi^2}$=0.2026

Power ratio=(0.2026)/(1/3)=0.6079≈60.8 %.. (5 points) Sketch the signal *y*(*t*) in time domain <u>and</u> its magnitude and phase spectra. (show all values in x-axis and y-axis)

$y(t) = 2\sin(\pi t)$

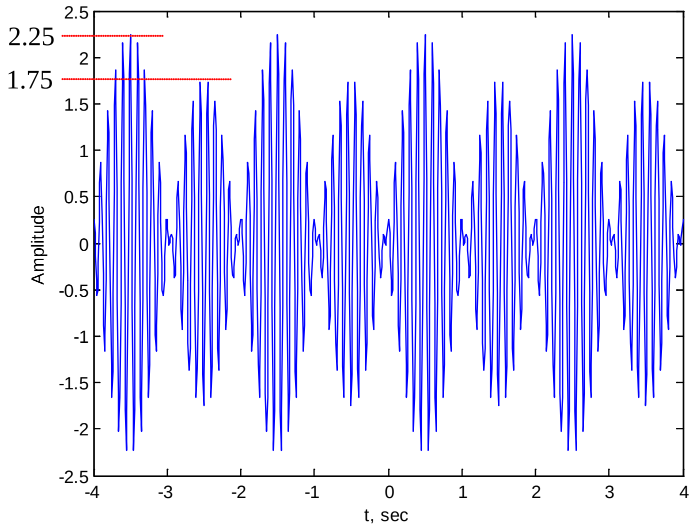


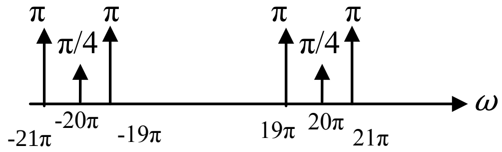


(3 points , note that for the sin is 0 at t=0)

If you could not solve the above assume *y*(*t*)= $\cos(\pi)t$

b. Sketch *z*(*t*) and its magnitude spectrum. (show all important values on the sketch)





(4 points)

c. Notice that *z*(*t*) is the AM modulated signal for *y*(*t*), find the values of the modulation index and the power efficiency? Comment on the value of the efficiency.

$$\mu = \frac{m_p}{A} = \frac{2}{0.25} = 8$$

$Power\ effeceincy = \frac{\tilde{m}^2}{\tilde{m}^2 + A^2} = \frac{2^2/2}{\frac{2^2}{2} + (0.25)^2} = 0.977$, 97.7%. We can also use the other equation because it is single tone

$$Power\ effeceincy = \frac{\mu^2}{\mu^2 + 2} = \frac{64}{64 + 2} = 0.977$$

The value of the efficiency is very high and it is expected not to exceed 33.33 % for single tone if a non coherent detector is to be used. This system is over-modulated and cannot be recovered non coherently

(4 points)

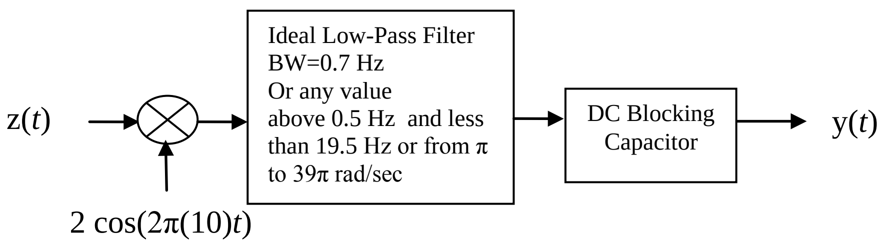
d. Can *y*(*t*) be recovered from *z*(*t*) using a non-coherent detector? Why?

No, because the system is over-modulated. We did not add enough carrier. We still cannot distinguish the negative from the positive side for the message.

(2 points)

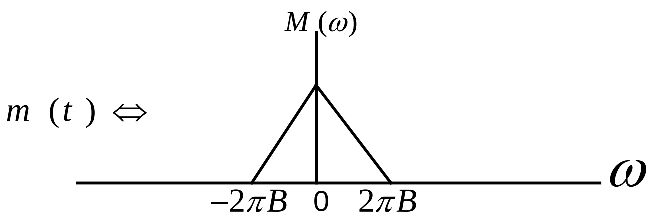
e. Sketch a system that can recover *y*(*t*) from *z*(*t*). (specify all possible values for the filter)

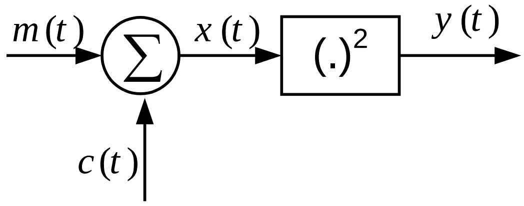
(2 points)



Question 4:

For the system shown, let the signal $c(t) = \cos \omega_c t$ and let $m(t)$ have the following spectrum:





a) Find the time domain signal $y(t)$ in terms of *m*(t) and sketch its amplitude spectrum. (6 marks)

b) What must you do to $y(t)$ to get DSBSC modulated signal out of it. (3 marks)

c) Assume you used instead of $m(t)$ the modulated signal $m(t)c(t)$, find the time domain signal $y(t)$ in terms of *m*(*t*). (5 marks)

d) From your result in part c, can this system be used to demodulate DSBSC signal? If yes, how; if not, why. (6 marks)

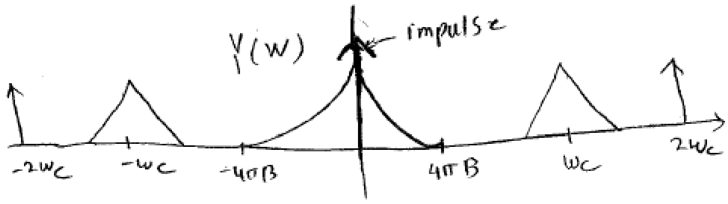
assume $w_c >> 2\pi B$

a) $y(t) = [m(t) + c(t)]^2$

$= m^2(t) + c^2(t) + 2m(t)c(t)$

$= m^2(t) + \frac{1}{2} + \frac{1}{2}\cos(2w_c t)$

$+ 2m(t)\cos w_c t$



b) use a bandpass filter of centre frequency w_c & BW of $4\pi B$.

c) $y(t) = [m(t)c(t) + c(t)]^2$

$= m^2(t)c^2(t) + c^2(t) + 2m(t)c^2(t)$

$= m^2(t)\left[\frac{1}{2} + \frac{\cos 2w_c t}{2}\right] + \frac{1}{2} + \frac{\cos(2w_c t)}{2}$

$+ m(t) + m(t)\cos(2w_c t)$

$= \frac{1}{2}m^2(t) + \frac{1}{2}m^2(t)\cos 2w_c t + \frac{1}{2}$

$+ \frac{1}{2}\cos 2w_c t + m(t) + m(t)\cos(2w_c t)$

d) at the base band we have

$\frac{1}{2}m^2(t) + \frac{1}{2} + m(t)$

So if we use LPF of BW $2\pi B$

we will get $\frac{1}{2} + m(t) + \frac{1}{2}m^2(t)$

we can get m(t) if $m(t) << 1$

So, $\frac{m^2(t)}{2}$ is negligable & using capacitor, we can get rid of the DC.