

King Fahd University of Petroleum & Minerals
Electrical Engineering Department
EE370: Communications Engineering I (091)

Major Exam I

November 11, 2009
8:00 PM-9:30 PM
Building 59-2002

Serial #

○

Name: KEY

ID# _____

Question	Mark
1	/10
2	/10
3	/10
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.
6. Strictly no mobile phones are allowed.

Good luck

Coordinator & Instructor Sec1 & Sec2 : Dr. Ali H. Muqabel

Instructor Sec3: Dr. M Abdul Haleem,

Lab Coordinator & Instructor Sec4: Dr. Azzedine Zerguine,

Problem 1: (10 points)

A. Find the power, rms value, and energy of the shown signal (show steps) **(3 points)**

Consider one period 1

$$g(t) = \begin{cases} t, & -1 \leq t \leq 1 \\ 0, & \text{otherwise} \end{cases}$$

$$\text{Power} = \frac{1}{2} \int_{-1}^1 |g(t)|^2 dt = \frac{1}{2} \int_{-1}^1 t^2 dt = \frac{1}{2} \left[\frac{t^3}{3} \right]_{-1}^1 = \frac{1}{2} \left[\frac{1^3 - (-1)^3}{3} \right] = \frac{1}{3}$$

$$\text{RMS value} = \sqrt{\text{Power}} = \frac{1}{\sqrt{3}}$$

$$\text{energy} = \int_{-\infty}^{\infty} |g(t)|^2 dt = \infty$$

Note: may ask to categorize the signal as to whether energy/power signal

B. Choose the correct answer (only one) **(1 point)**

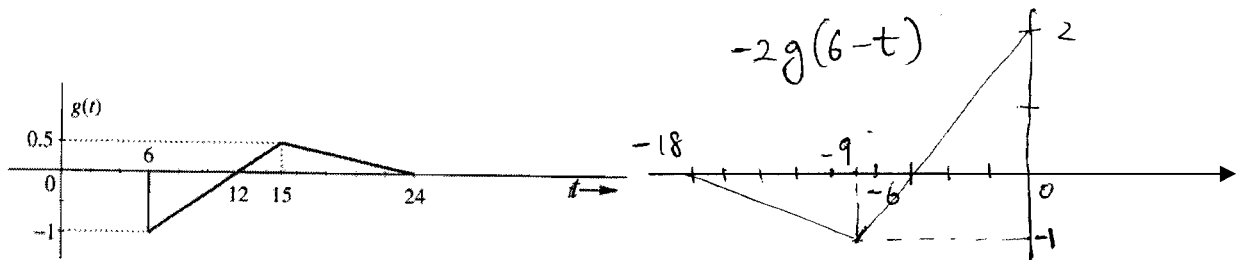
1. For AM signals the envelope detector can be used if the modulation index > 3.14
- ② Vestigial Sideband (VSB) is more bandwidth efficient compared with double side band suppressed carrier.
3. The root mean square value (rms) equals to the square of the power.
4. Hilbert transform, $m_h(t)$, of a signal has double the power of $m(t)$.
5. Single Sideband (SSB) can never be demodulated with envelope detector.

C. In Vestigial Sideband (VSB), if $H_1(\omega)$ is the filter used at the modulator, and $H_2(\omega)$ is the filter used at the demodulator, write a relation for $H_2(\omega)$ in terms $H_1(\omega)$ **(1 point)**

Assume the carrier frequency is ω_c

$$H_2(\omega) = 1 / [H_1(\omega + \omega_c) + H_1(\omega - \omega_c)]$$

D. For the signal $g(t)$ shown in the Figure, sketch the signal $-2g(6-t)$ **(3 points)**



E. An AM superheterodyne receiver is tuned to a carrier frequency of 850 kHz. If the the tuning frequency of the Intermediate Frequency (IF) stage is 455 kHz, what is the local oscillator frequency at the mixer (frequency converter)? **(1 point)**

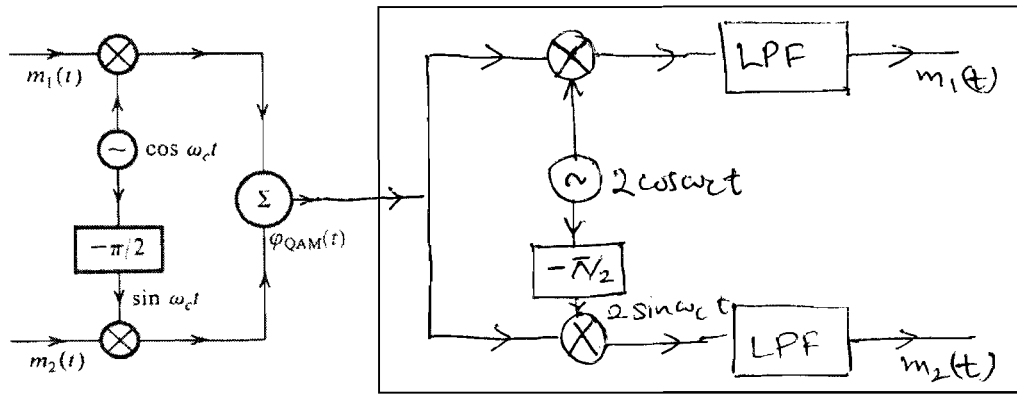
$$850 + 455 = 1305 \text{ kHz}$$

F. An AM superheterodyne receiver, What is the image station for the channel centered at 850 kHz **(1 point)**

$$850 + 2 \times 455 = 1760 \text{ kHz}$$

Problem 2: (10 points)

1. The QAM modulator is shown in the Figure. Complete the figure by drawing the demodulator in the provided space. (2 points)



2. The Fourier transform (FT) of a function $g(t)$ is given by $G(\omega) = \int_{-\infty}^{\infty} g(t)e^{-j\omega t} dt$. (8 points)

- (a) Find and sketch the Fourier transform $G(\omega)$ of the gate function $g(t)$ given by $g(t) = \text{rect}(t) = \begin{cases} 1, & |t| < 1/2 \\ 0, & |t| > 1/2 \end{cases}$. Sketch $g(t)$ and $G(\omega)$. [Hint: $\sin(x) = \frac{e^{jx} - e^{-jx}}{2j}$, $\text{sinc}(x) = \frac{\sin(x)}{x}$]
- (b) A signal having the form of gate function as in (a) is passed through a filter with frequency response as in Fig. 1. Write down and sketch the frequency spectrum of the output signal.

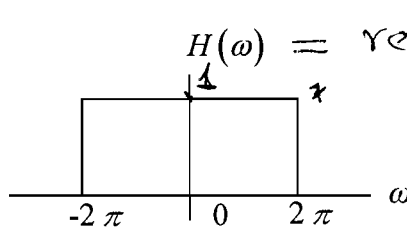
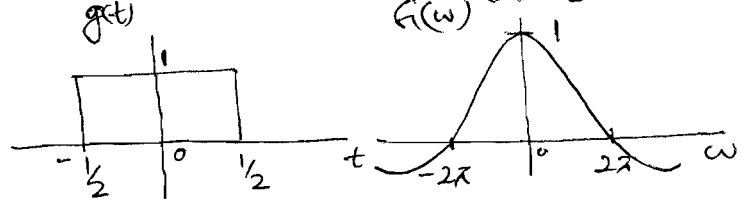


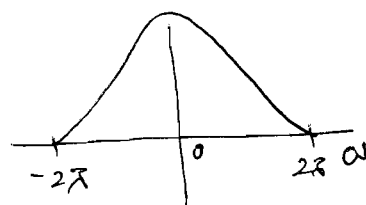
Figure 1.

(c) The impulse response of a filter is defined as the Inverse Fourier transform (IFT) of the frequency response. Find the impulse response of the above filter [Hint: if the Fourier transform of $g(t)$ is $G(\omega)$, then the Fourier transform of $G(t)$ is $2\pi g(-\omega)$, Scaling property: $g(at) \Rightarrow \frac{1}{|a|} G(\frac{\omega}{a})$]

$$\begin{aligned}
 (a) \quad G(\omega) &= \int_{-1/2}^{1/2} e^{-j\omega t} dt = \left[\frac{e^{-j\omega t}}{-j\omega} \right]_{-1/2}^{1/2} \\
 &= \frac{1}{-j\omega} [e^{-j\omega/2} - e^{j\omega/2}] \\
 &= \frac{e^{j\omega/2} - e^{-j\omega/2}}{2j(\omega/2)} \\
 &= \frac{1}{\omega/2} \left[\frac{e^{j\omega/2} - e^{-j\omega/2}}{2j} \right] \\
 &= \frac{\sin(\omega/2)}{\omega/2} = \text{sinc}(\omega/2)
 \end{aligned}$$



$$(b) \quad H(\omega)G(\omega) = \begin{cases} \text{sinc}(\omega/2), & |\omega| < 2\pi \\ 0, & \text{otherwise} \end{cases}$$



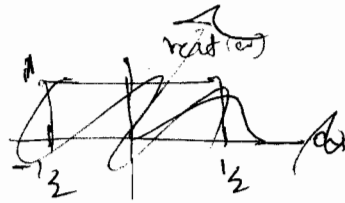
(c) $g(t) = \text{rect}(t) \iff G(\omega) = \text{sinc}(\omega/2)$
 Let FT of $G(t)$ is $G(\omega) = \text{sinc}(\omega/2)$.
 $2\pi g(\omega) = 2\pi \text{rect}(-\omega) = 2\pi \text{rect}(\omega)$

$$\text{sinc}(t/2) \Leftrightarrow 2\pi \text{rect}(\omega)$$

$$\frac{1}{2\pi} \text{sinc}(t/2) \Leftrightarrow \text{rect}(\omega)$$

In the given ~~fig~~ Figure,

$$h(\omega) = \text{rect}\left(\frac{\omega}{4\pi}\right)$$



Scaling property is if $g(t) \Leftrightarrow G(\omega)$

$$g(at) \Leftrightarrow \frac{1}{|a|} G\left(\frac{\omega}{a}\right)$$

$$\frac{1}{2\pi} \text{sinc}(4\pi t) \Leftrightarrow \frac{1}{4\pi} \text{rect}\left(\frac{\omega}{4\pi}\right)$$

$$\text{or } \text{sinc}(2\pi t) \Leftrightarrow \frac{1}{2} \text{rect}\left(\frac{\omega}{4\pi}\right)$$

i.e., IFT of $\text{rect}\left(\frac{\omega}{4\pi}\right)$ is $2 \text{sinc}(2\pi t)$

$$h(t) = 2 \text{sinc}(2\pi t)$$

1) **Problem 3: (10 points)**

1. An amplitude modulated (AM) signal is given by $\phi_{AM}(t) = [A + m(t)] \cos \omega_c t$, let $m(t) = \mu A \cos \omega_m t$. For $\mu = 0.75$, find the power efficiency. **(3 points)**

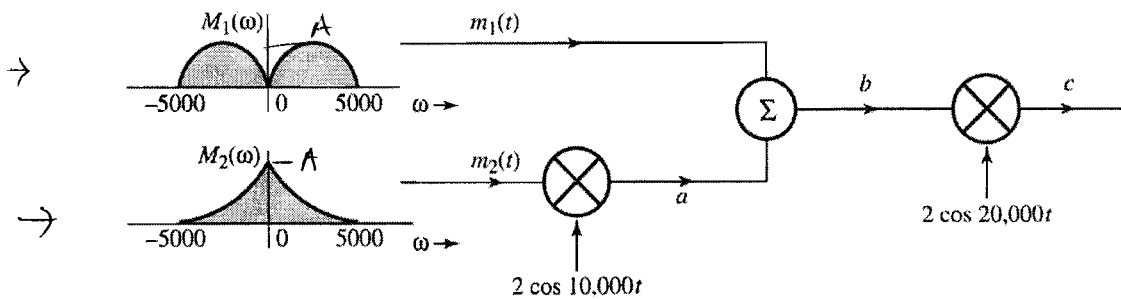
$$\phi_{AM}(t) = A \cos \omega_c t + \mu A \cos \omega_m t \cos \omega_c t$$

Signal power
 $= 2 \times \frac{1}{2} \left(\frac{\mu A}{2}\right)^2 = \left(\frac{\mu A}{2}\right)^2 = A^2 \cos^2 \omega_c t + \frac{\mu A}{2} [\cos(\omega_c + \omega_m)t + \cos(\omega_c - \omega_m)t]$

Carrier power = $A^2/2$

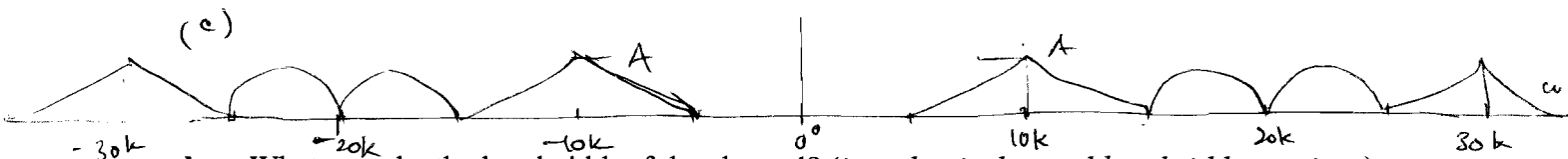
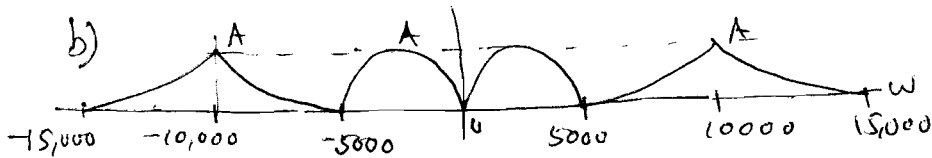
efficiency = $\frac{(\mu A/2)^2}{A^2/2 + (\mu A/2)^2} = \frac{\mu^2}{2 + \mu^2} = \frac{0.75^2}{2 + 0.75^2} = 0.2195 \approx 22\%$

2. For the multiplexing system shown in the figure



- a. Sketch signal spectra at points a, b, and c. **(3 points)**

a) $2 \times \frac{1}{2} [M_2(\omega + 10,000) + M_2(\omega - 10,000)]$



- b. What must be the bandwidth of the channel? (i.e. what is the total bandwidth at point c), compare with the bandwidth required if the two signals were transmitted using QAM **(1 point)**.

BW = 30,000 rad/sec @ AM BW = 10,000 rad/sec

- c. Design an efficient receiver to recover signals $m_1(t)$ and $m_2(t)$ from the modulated signal at point c. Note: No bandpass filter can be used. **(3 points)**

