King Fahd University of Petroleum & Minerals

Electrical Engineering Department

EE370: Communications Engineering I (071)

Major Exam I

October 28, 2007

7:00 PM-8:30PM

Building 59-2001/2002

Please write your Serial #

Name:________________KEY__________

ID# :______________________________

Section (3) Dr. Kousa, SMW 9:00-9:50am

Please circle your section

(2) Dr. Kousa, SMW 10:00-10:50am

(1) Dr. Muqaibel, UT 8:30-9:45am

(4) Dr. Muqaibel, UT 10:00-11:15am

Question	Mark
1	/10
2	/12
3	/12
4	/11
Total	/45

Instructions:

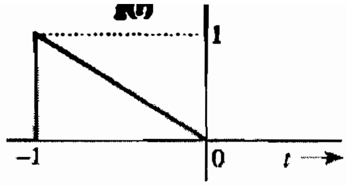
1. This is a closed-book/notes exam.
2. The duration of this exam is one and half hours.
3. Read the questions carefully. Plan which question to start with.
4. CLEARLY LABEL ALL SIGNIFICANT VALUES ON BOTH AXIES OF ANY SKETCH
5. Work on your own.
6. Mobile phones are not allowed in the exam room.
7. Tables of Fourier Transform pairs, FT properties and Trigonometric Identities are provided in the last sheet.

<u>Problem 1:</u> (10 points)

<u>Clearly</u> write True (T) or False (F).

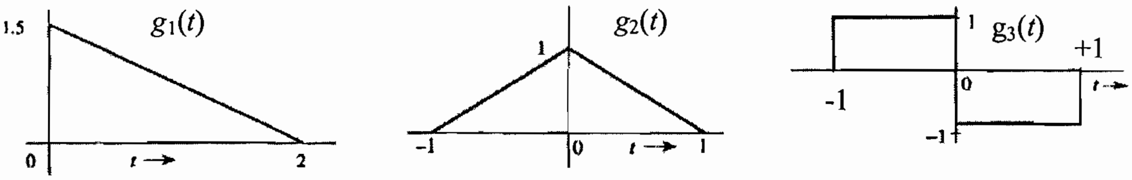
a	The antenna dimension is inversely proportional to the transmitting frequency	**T**
b	$x^2\delta(x\text{-}1) \neq 1$	**T**
c	For a distortionless system, the amplitude spectrum must be constant, and the phase must be a linear function of frequency.	**T**
d	For a modulating signal that is real, the SSB modulated signal is complex.	**F**
e	Envelope detection is a type of coherent demodulation.	**F**
f	AM (DSB with carrier) provides saving in the bandwidth at the cost of higher transmitted power.	**F**
g	The Hilbert transform of the Hilbert transform of a signal is the negative of the signal itself.	**T**
h	To allow for non-coherent detection in AM (DSB with carrier) the modulation index should be greater than 1	**F**
i	The energy of a power signal is finite.	**F**
j	The bandwidth *efficiency* of Quadrature Amplitude Modulation (QAM) is the same as that of DSBSC modulation	**F**

Problem 2: (12 points)

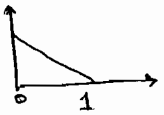


Consider the function $g(t)$ shown to the right.
Let its FT be denoted by $G(\omega)$.

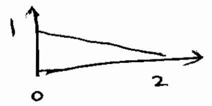
Express $g_1(t)$, $g_2(t)$ and $g_3(t)$ in terms of $g(t)$ and find their spectra in terms of $G(\omega)$.



$g_{Temp}(t) = g(t-1)$



$g_{Temp_2}(t) = g\left(\frac{t}{2}-1\right)$



$\boxed{g_1(t) = 1.5\, g\left(\frac{t}{2}-1\right)} = 1.5\, g\left(\frac{t-2}{2}\right)$

other correct solutions are also possible.

$\boxed{g_2(t) = g(t-1) + g(-t-1)} = g(t-1) + g(-(t+1))$

$\boxed{g_3(t) = \frac{d}{dt} g_2(t) = \frac{d}{dt}\left[g(t-1) + g(-t-1)\right]}$

steps

$G_{temp}(\omega) = G(\omega)\, e^{j\omega}$

$G_{temp_2}(\omega) = G(2\omega)\, e^{j2\omega}$

$G_1(\omega) = 1.5(2) G(2\omega)\, e^{-j\omega(+2)}$

$\boxed{G_1(\omega) = 3\, G(2\omega)\, e^{-j\omega 2}}$

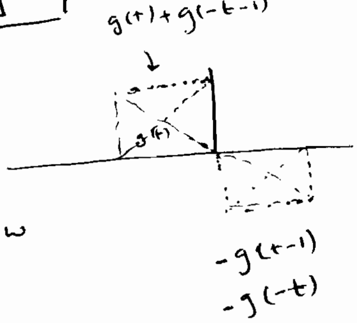
$\boxed{G_2(\omega) = G(\omega)\, e^{-j\omega(+1)} + G(-\omega)\, e^{+j\omega}}$

$$\boxed{\begin{aligned} G_3(\omega) &= j\omega\, G_2(\omega) \\ &= j\omega\left[G(\omega)\, e^{-j\omega} + G(-\omega)\, e^{j\omega}\right] \end{aligned}}$$

We may also write.

$g_3(t) = g(t) + g(-t-1) - g(-t) - g(t-1)$

$G_3(\omega) = G(\omega) + G(-\omega)\, e^{j\omega} - G(-\omega) - G(\omega)\, e^{-j\omega}$



Problem 3: Amplitude Modulation (12 points)

An AM (DSB with carrier) modulator operates with the message signal:

$$m(t) = 4\cos(2\pi 10t) + 6\cos(2\pi 30t)$$

The un-modulated carrier is given by $\cos(2\pi 1000t)$

Hint: *the maximum and minimum values of* $m(t)$ *are 10, -10, respectively*

(a) If the modulation index is set to 0.5,

2 (i) Write an expression for the modulated signal, $\varphi_{AM}(t)$.

(ii) Sketch the magnitude spectrum of the modulator output, $\varphi_{AM}(t)$, showing the values at all frequencies of interest.

(iii) Determine the modulator efficiency, η, defined by the ratio between the power of sidebands (message) and the total power.

(b) If envelope detection is going to be used for the detection of the above modulated signals, design proper a value for the circuit time constant RC.

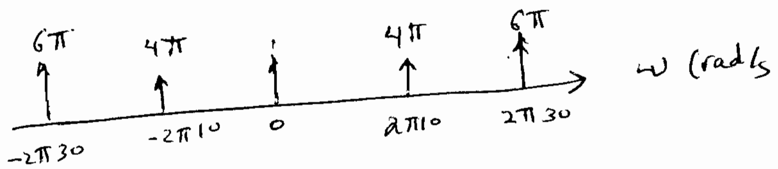
$$\mu = \frac{m_p}{A} = \frac{10}{A} = 0.5 \Rightarrow A = 20 \quad 1$$

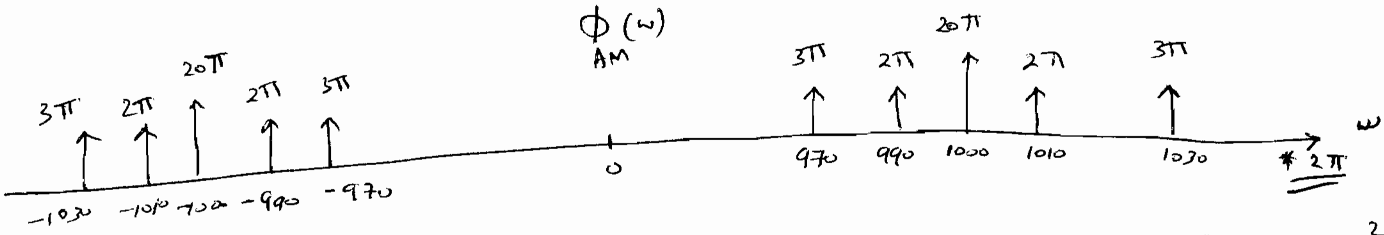
(a) (i)

$$\varphi_{AM}(t) = [m(t) + A] \cos \omega_c t$$

$$= [4\cos(2\pi 10t) + 6\cos(2\pi 30t) + 20] \cos(2\pi 1000t) \quad 1$$

(ii)





iii) =

$$\eta = \frac{P_m}{P_{total}} \% =$$

1

$$\eta = \frac{13 \times 100}{213} \% = 6.1 \%$$

$$P_{message} = \frac{1}{2} \widetilde{m^2} = \frac{1}{2}\left[\frac{1}{2}(4^2) + \frac{1}{2}(6)^2\right]$$

$$= \frac{1}{2}[8 + 18] = 13 \quad 2$$

$$P_{Carrier} = \frac{1}{2}(20)^2 = 200 \quad 1$$

b)

$$\frac{1}{\omega_c} \ll RC \ll \frac{1}{2\pi B}$$

This is supposed to be 10

$$\frac{1}{2\pi(1000)} \ll RC \ll \frac{1}{2\pi(30)}$$

$$1.59 \times 10^{-4} \ll RC \ll 5.3 \times 10^{-3}$$

possible value would be in between. 1×10^{-3} sec

Problem 4: (11 points)

2 **(a)** The impulse response of a Hilbert transform is $1/(\pi t)$. Derive its transfer function $H(\omega)$.

(b) Consider the phase shift method of generating LSB-SSB waves.

4 (i) Sketch the block diagram of the system.

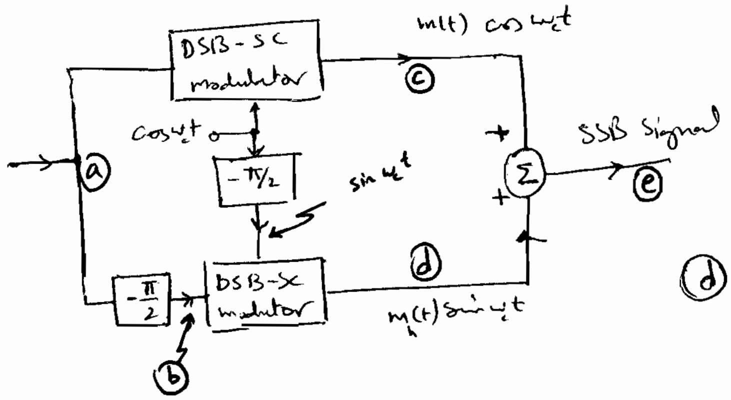
5 (ii) Let the input to the system be the message $\cos(2\pi t)$, and let the carrier signal be $\cos(20\pi t)$. Trace the signal throughout the system mathematically and graphically in the TIME DOMAIN. (That is, **write** the expression and **sketch** the signal after each stage).

$\mathrm{sgn}(t) \leftrightarrow \frac{2}{j\omega}$ for $g(t) \leftrightarrow G(\omega)$, $G(t) \leftrightarrow 2\pi g(-\omega)$

so $j\frac{\mathrm{sgn}\, t}{2\pi} \leftarrow \frac{1}{\pi\omega}$ $\frac{1}{\pi t} \leftrightarrow 2\pi \frac{j}{2\pi}\mathrm{sgn}(-\omega) = -j\,\mathrm{sgn}(\omega)$ $\mathrm{sgn}(-\omega) = -\mathrm{sgn}(\omega)$ odd function

(a) . application of duality property to pair 12 of Table 3.1 "short table of Fourier Transform yeilds. $\frac{1}{\pi t} \Leftrightarrow -j\,\mathrm{sgn}(\omega)$

(b)



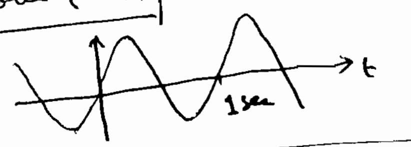
at (a)

$\boxed{m(t) = \cos 2\pi t}$

$f_m = 1\text{ Hz}$

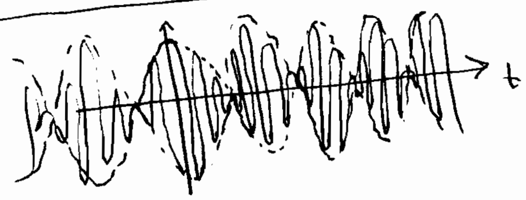
(b)

$\boxed{\cos(2\pi t - \frac{\pi}{2}) = \sin(2\pi t)}$



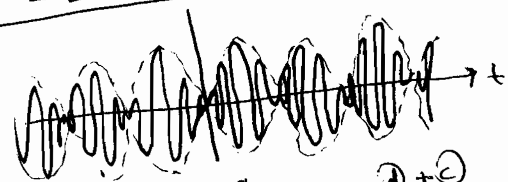
(c)

$\boxed{\cos 2\pi t \cos(20\pi t) = \frac{1}{2}[\cos(18\pi t) + \cos(22t)]}$



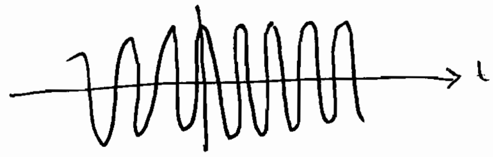
(d)

$\boxed{\sin 2\pi t \sin 20\pi t = \frac{1}{2}[\cos(18\pi t) - \cos(22\pi t)]}$



(d) + (c)

(e) = $\boxed{\cos(18\pi t)}$



Short Table of Fourier Transforms

	$g(t)$	$G(\omega)$	
1	$e^{-at}u(t)$	$\dfrac{1}{a+j\omega}$	$a>0$
2	$e^{at}u(-t)$	$\dfrac{1}{a-j\omega}$	$a>0$
3	$e^{-a\|t\|}$	$\dfrac{2a}{a^2+\omega^2}$	$a>0$
4	$te^{-at}u(t)$	$\dfrac{1}{(a+j\omega)^2}$	$a>0$
5	$t^n e^{-at}u(t)$	$\dfrac{n!}{(a+j\omega)^{n+1}}$	$a>0$
6	$\delta(t)$	1	
7	1	$2\pi\delta(\omega)$	
8	$e^{j\omega_0 t}$	$2\pi\delta(\omega-\omega_0)$	
9	$\cos\ \omega_0 t$	$\pi[\delta(\omega-\omega_0)+\delta(\omega+\omega_0)]$	
10	$\sin\ \omega_0 t$	$j\pi[\delta(\omega+\omega_0)-\delta(\omega-\omega_0)]$	
11	$u(t)$	$\pi\delta(\omega)+\dfrac{1}{j\omega}$	
12	$\operatorname{sgn} t$	$\dfrac{2}{j\omega}$	
13	$\cos\omega_0 t\ u(t)$	$\dfrac{\pi}{2}[\delta(\omega-\omega_0)+\delta(\omega+\omega_0)]+\dfrac{j\omega}{\omega_0^2-\omega^2}$	
14	$\sin\omega_0 t\ u(t)$	$\dfrac{\pi}{2j}[\delta(\omega-\omega_0)-\delta(\omega+\omega_0)]+\dfrac{\omega_0}{\omega_0^2-\omega^2}$	
15	$e^{-at}\sin\omega_0 t\ u(t)$	$\dfrac{\omega_0}{(a+j\omega)^2+\omega_0^2}$	$a>0$
16	$e^{-at}\cos\omega_0 t\ u(t)$	$\dfrac{a+j\omega}{(a+j\omega)^2+\omega_0^2}$	$a>0$
17	$\operatorname{rect}\left(\dfrac{t}{\tau}\right)$	$\tau\operatorname{sinc}\left(\dfrac{\omega\tau}{2}\right)$	
18	$\dfrac{W}{\pi}\operatorname{sinc}(Wt)$	$\operatorname{rect}\left(\dfrac{\omega}{2W}\right)$	

Trigonometric Identities

cos A cos B = ½[cos (A+B) + cos (A-B)]

sin A sin B = ½[cos (A-B) – cos (A+B)]

sin A cos B = ½[sin (A+ B) + sin (A- B)]

Fourier Transform Operations

Operation	$g(t)$	$G(\omega)$
Addition	$g_1(t)+g_2(t)$	$G_1(\omega)+G_2(\omega)$
Scalar multiplication	$kg(t)$	$kG(\omega)$
Symmetry	$G(t)$	$2\pi g(-\omega)$
Scaling	$g(at)$	$\dfrac{1}{\|a\|}G\left(\dfrac{\omega}{a}\right)$
Time shift	$g(t-t_0)$	$G(\omega)e^{-j\omega t_0}$
Frequency shift	$g(t)e^{j\omega_0 t}$	$G(\omega-\omega_0)$
Time convolution	$g_1(t)*g_2(t)$	$G_1(\omega)G_2(\omega)$
Frequency convolution	$g_1(t)g_2(t)$	$\dfrac{1}{2\pi}G_1(\omega)*G_2(\omega)$
Time differentiation	$\dfrac{d^n g}{dt^n}$	$(j\omega)^n G(\omega)$
Time integration	$\displaystyle\int_{-\infty}^{t} g(x)\,dx$	$\dfrac{G(\omega)}{j\omega}+\pi G(0)\delta(\omega)$