Birzeit University
Faculty of Engineering and Technology

Department of Electrical and Computer Engineering

Communication Systems ENEE 339

Midterm Exam

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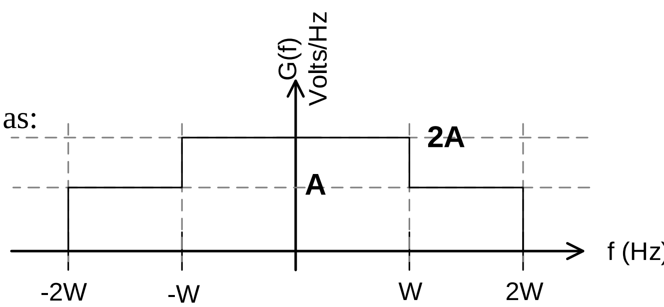
Problem 1: 25 Points

The Fourier transform G(f) of a signal g(t) is given as:



$$G(f) = \begin{cases} 2A & -W \le f \le W \\ A & W \le |f| \le 2W \\ 0 & |f| > 2W \end{cases}$$

a. Find the absolute bandwidth of g(t)
b. Find the energy in g(t).
c. If g(t) is passed through an ideal low pass filter with bandwidth 3W/2, find the energy in the signal at the filter output.
d. Use the table of Fourier transform pairs at the end of the exam to find g(t).

Problem 2: 25 Points

The message sign $m(t) = 2\cos(2\pi 40t) + 4\cos(2\pi 80t)$alalong with the carrier signal$c(t) = 4\cos(2\pi 1000t)$ are applied to a modulator that generates the double sideband suppressed carrier signals(t)

a. Find the average power of m(t).
b. Find the time-domain expression of the modulated signal s(t).
c. Find the bandwidth of the transmitted signal in Hz.
d. Draw the block diagram of the demodulator used to recover m(t) from s(t) without distortion specifying the details of each block

Problem 3: 25 Points

The message $m(t) = 0.3\cos(2\pi 500t)$is applied to a normal amplitude modulatorwith a sensitivity k_a= 0.2/V and a carrier$c(t) = 10\cos(2\pi 10000t)$to produce the signal$s(t) = A_c\cos(2\pi f_c t)(1 + k_a m(t))$

a. Find the modulation index.
b. Find the average power in the carrier and in each of the sidebands.
c. Find the power efficiency

Problem 4: 25 Points

Consider the FM signal $s(t) = 10\cos[2\pi(10000)t + 1.2sin 2\pi(200)t]$

a. Find the instantaneous frequency of $s(t)$
b. Find the peak frequency deviation of $s(t)$.
c. Find the 90% power bandwidth of $s(t)$.

Good Luck

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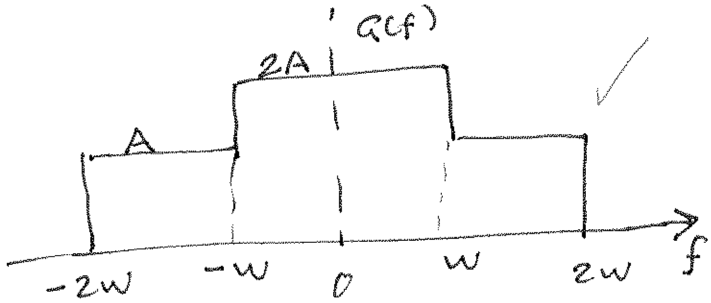
Solution to Midterm April 23, 2017

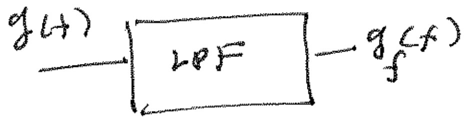


Problem 1

a. B.W = 2W

b. $E_g = 2\int_0^W (2A)^2 df + 2\int_W^{2W} (A)^2 df$

$E_g = 10 A^2 W$



c. $E' = 2\int_0^W (2A)^2 df + 2\int_W^{5W/2} (A)^2 df$

$E' = 9 A^2 W$

d. $G(f) = A \, \text{rect}\left(\frac{f}{4W}\right) + A \, \text{rect}\left(\frac{f}{2W}\right)$ (1)

From Table $\text{rect}\left(\frac{t}{T}\right) \rightarrow T \, \text{sinc} fT$

$\text{sinc} \, 2Wt \rightarrow \frac{1}{2W} \text{rect}\left(\frac{f}{2W}\right)$

$\Rightarrow 2W \, \text{sinc} \, 2Wt \rightarrow \text{rect}\left(\frac{f}{2W}\right)$ (2)

using (2), (1) becomes in the time domain

$$g(t) = A(4W) \, \text{sinc} \, 4Wt + A(2W) \, \text{sinc} \, 2Wt$$

Problem 2

$m(t) = 2\cos 2\pi(40)t + 4\cos 2\pi(80)t$

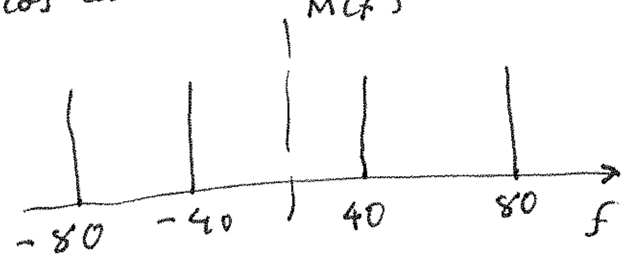
$c(t) = 4\cos 2\pi(1000)t$

a. $\langle m(t)^2 \rangle = \frac{(2)^2}{2} + \frac{(4)^2}{2}$; terms are orthogonal

$= 2 + 8 = 10\ W$

b. $s(t) = A_c\, m(t) \cos 2\pi f_c t$

$s(t) = 5\left[2\cos 2\pi(40)t + 4\cos 2\pi(80)t\right] \cos 2\pi(1000)t$

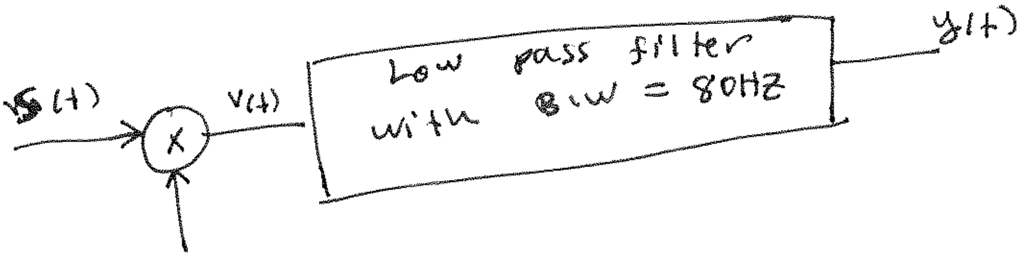


B.W $= 2W$

$= 2(80)$

$= 160\ Hz$

c.



$A_c' \cos 2\pi f_c t$

$A_c' \cos 2\pi(1000)t$

Analysis: $v(t) = A_c' \cos 2\pi f_c t\ s(t)$

$= A_c A_c' \cos 2\pi f_c t \cos 2\pi f_c t\ m(t)$

$= A_c A_c'\, m(t) \cos^2 2\pi f_c t$

$= \frac{A_c A_c'}{2} m(t) \left[1 + \cos 4\pi f_c t\right]$

$\Rightarrow \quad y(t) = \frac{A_c A_c'}{2} m(t).$

Problem 3

$s(t) = A_c \cos 2\pi f_c t \; (1 + k_a m(t))$; $A_c = 10$, $f_c = 10000$
$k_a = 0.2$

$s(t) = A_c [1 + 0.2 \times 0.3 \cos 2\pi (500) t] \cos 2\pi f_c t$

$s(t) = A_c [1 + 0.6 \cos 2\pi (500) t] \cos 2\pi f_c t$

a. M.I. = 0.6

b. $s(t) = 10 \cos 2\pi f_c t + 6 \cos 2\pi f_c t \cos 2\pi f_m t$

$s(t) = 10 \cos 2\pi f_c t + 3 \cos 2\pi (f_c + 500) t + 3 \cos 2\pi (f_c - 500) t$

carrier — sidebands

$P_{av}(\text{carrier}) = \frac{A_c^2}{2} = \frac{10^2}{2} = 50$

$P_{av}(2 \text{ sidebands}) = \left(\frac{3^2}{2}\right) \times 2 = 9$; each with 4.5 Watt

c. power efficiency $= \frac{\text{power in sidebands}}{\text{total transmitted power}}$

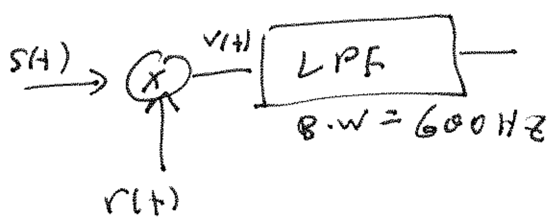
$= \frac{9}{50 + 9} = \frac{9}{59}$

$= 0.152$

Also, power efficiency $= \frac{\mu^2}{2 + \mu^2} = \frac{(0.36)^2}{2 + (0.36)^2}$

$= 0.152$; (formula derived in class)

d. $v(t) = A_c [1 + \mu \cos w_m t] \cos w_c t \cdot \cos w_c t$



$= \frac{A_c [1 + \mu \cos w_m t]}{2} \{1 + \cos 2 w_c t\}$

$\Rightarrow y(t) = \frac{A_c}{2} [1 + \mu \cos w_m t]$

problem 4 :

$s(t) = 10 \cos\left(2\pi(10000)t + 1.2 \sin 2\pi(200)t\right)$

$s(t) = 10 \cos\left(2\pi(10000)t + 1.2 \sin 2\pi(200)t\right)$.

a. $f_i(t) = \frac{1}{2\pi}\frac{d}{dt}\left(2\pi(10000)t + 1.2 \sin 2\pi(200)t\right)$

$= f_c + \frac{1}{2\pi} \times 1.2 \; (2\pi(200)) \cos 2\pi(200)t$

$= f_c + 240 \cos 2\pi(200)t$ (1)

b. peak frequency deviation = 240 from (1)

Also, $\beta = \frac{\Delta f}{f_m} \Rightarrow \Delta f_{\circ} = \beta f_m = (1.2)(200)$

$= 240$ HZ.

c. $s(t) = (10) J_0(1.2) \cos 2\pi f_c t$ $\equiv 6.711$

$+ (10) J_1(1.2) \cos 2\pi(f_c + f_m)t$ $\equiv 4.983$

$+ (10) J_{-1}(1.2) \cos 2\pi(f_c - f_m)t$ $= 4.983$

$+ (10) J_2(1.2) \cos 2\pi(f_c + 2f_m)t$ $= 0.1593$

$+ (10) J_{-2}(1.2) \cos 2\pi(f_c - 2f_m)t$ $= 0.1593$

Total average power $= \frac{(10)^2}{2} = 50$

carrier	$f_c + f_m$ $(f_c - f_m)$	$f_c + 2f_m$ $(f_c - 2f_m)$
$\frac{(6.711)^2}{2}$	$2 \times \frac{(4.983)^2}{2}$	$2 \times \frac{(1.593)^2}{2}$
22.5	24.83	2.537

94.6%
not enough

$\Rightarrow$ B.W $= 2 \times (2f_m)$

$= 4f_m$

$= 4(200)$

$= 800$ HZ