Name ________________________ ID3 _ _ _

ECS 332: Principles of Communications **2019/1**

HW 8 — Due: November 15, 4 PM

Lecturer: Prapun Suksompong, Ph.D.

Instructions

(a) This assignment has 8 pages. Problems 4 to 8 are optional. Pages 5 to 8 can be downloaded from the course website.

(b) (1 pt) Hard-copies are distributed in class. Original pdf file can be downloaded from the course website. Work and write your answers **directly on the provided hardcopy/file** (not on other blank sheet(s) of paper).

(c) (1 pt) Write your first name and the last three digits of your student ID in the spaces provided on the upper-right corner of this page. Furthermore, for online submission, your file name should start with your 10-digit student ID, followed by a space, the course code, a space, and the assignment number: "5565242231 332 HW8.pdf"

(d) (8 pt) Try to solve all non-optional problems.

(e) Write down all the steps that you have done to obtain your answers. You may not get full credit even when your answer is correct without showing how you get your answer.

Problem 1. Find the instantaneous frequency of the signal $g(t) = 3\sqrt{2}\cos\left(12t^3 + t^2\right)$

(a) at time $t = 0$

(b) at time $t = 2$

Problem 2. Consider the message $m(t)$ along with the carrier signal $\cos(2\pi f_c t + \phi)$ plotted in Figure 8.1. Note that $m(1.5) = 40$.

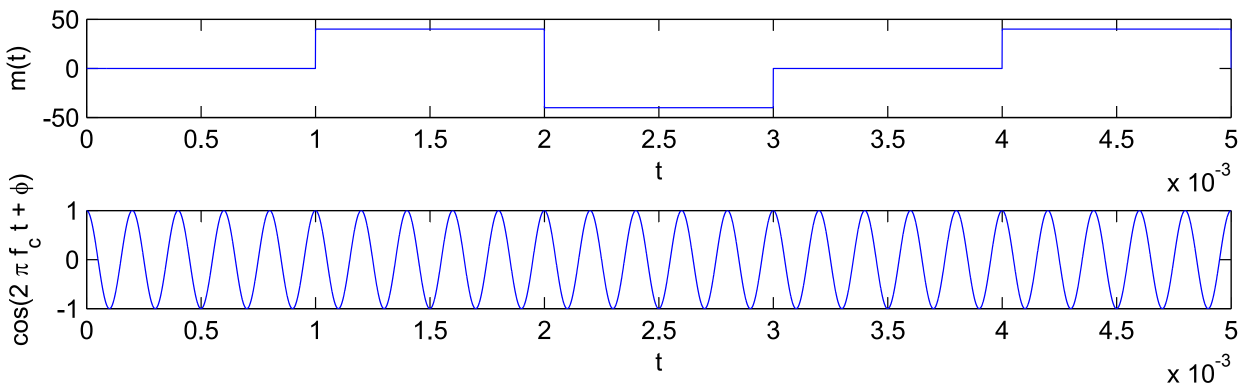

Figure 8.1: The message and the carrier signals for Problem 2.

(a) Find the carrier frequency f_c from the plot. (Hint: It is an integer.)

(b) Sketch the following signals. Make sure that (the unspecified parameter(s) are selected such that) the important "features" of the graphs can be seen clearly.

(i) $x_{\text{AM}}(t) = (A + m(t))\cos(2\pi f_c t + \phi)$ whose modulation index $\mu = 100\%$.

(ii) $x_{\text{FM}}(t) = A\cos\left(2\pi f_c t + \phi + 2\pi k_f \int\limits_{-\infty}^{t} m(\tau)d\tau\right)$. Assume $m(t) = 0$ for $t < 0$.

(iii) $x_{\text{PM}}(t) = A\cos(2\pi f_c t + \phi + k_p m(t))$ with $k_p = \frac{\pi}{m_p}$.

Problem 3. Consider the FM transmitted signal

$$x_{\text{FM}}(t) = A\cos\left(2\pi f_c t + \phi + 2\pi k_f \int_{-\infty}^{t} m(\tau) d\tau\right),$$

where $f_c = 5$ [kHz], $A = 1$, and $k_f = 75$. The message $m(t)$ is shown in Figure 8.2.

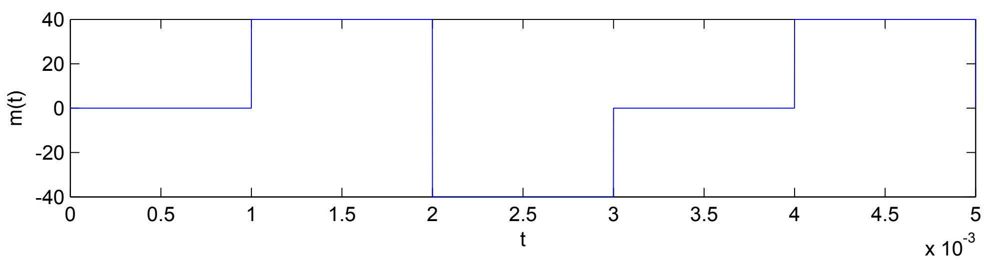

Figure 8.2: The message $m(t)$ for Problem 3

The magnitude spectrum $|X_{\text{FM}}(f)|$ is plotted in Figure 8.3.

(a) Find the values of f_1, f_2, and f_3.

(b) Find the width W in Figure 8.3.

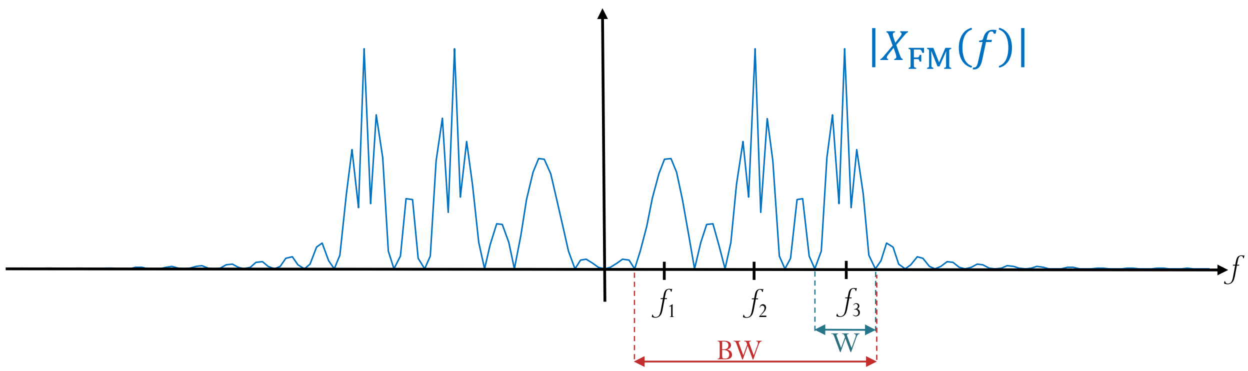

Figure 8.3: The magnitude spectrum $|X_{\text{FM}}(f)|$ for Problem 3

(c) Find the bandwidth denoted by BW in Figure 8.3.

Extra Questions

Here are some optional questions for those who want more practice.

Problem 4. Recall that, in QAM system, the transmitted signal is of the form

$$x_{\text{QAM}}(t) = m_1(t)\sqrt{2}\cos(2\pi f_c t) + m_2(t)\sqrt{2}\sin(2\pi f_c t).$$

In class, we have shown that

$$\text{LPF}\left\{x_{\text{QAM}}(t)\sqrt{2}\cos(2\pi f_c t)\right\} = m_1(t).$$

Give a similar proof to show that

$$\text{LPF}\left\{x_{\text{QAM}}(t)\sqrt{2}\sin(2\pi f_c t)\right\} = m_2(t).$$