Massachusetts Institute of Technology
Department of Aeronautics and Astronautics
Cambridge, MA 02139

Unified Engineering
Spring 2005

Problem Set #13

Due Date: Tuesday, May 10, 2005 at 5pm

	Time Spent (minutes)
S17	
S18	
S19	
C16/C17	
C18	
C19	
C20	
Study Time	

Name: ________________

Problem S17 (Signals and Systems)

Consider the *quadrature modulation/demodulation* system shown below. The purpose of the system is to transmit two signals, $x_1(t)$ and $x_2(t)$, over the same frequency band simultaneously. $x_1(t)$ and $x_2(t)$ are bandlimited signals, with bandwidth W. That is, their Fourier transforms $X_1(f)$ and $X_2(f)$ satisfy

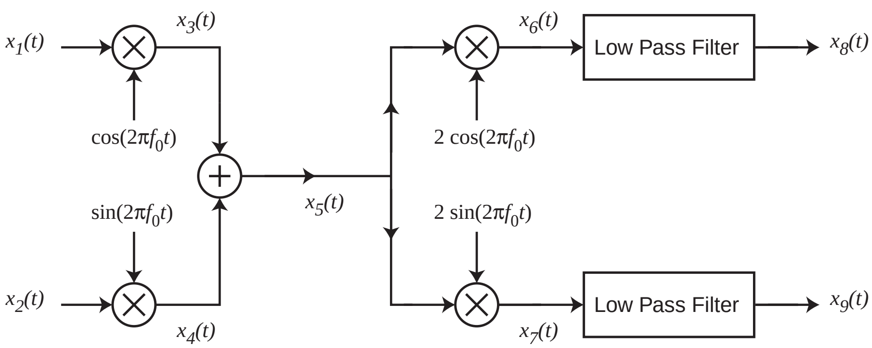
$$X_1(f) = 0, \quad |f| \geq W$$

$$X_2(f) = 0, \quad |f| \geq W$$

The bandwidth is much less than the modulation frequency, f_0. The lowpass filters shown in the diagram are ideal, with transfer function

$$L(f) = \begin{cases} 1, & |f| < W \\ 0, & |f| > W \end{cases}$$

Find the Fourier transforms of the signals $x_3(t)$, $x_4(t)$, $x_5(t)$, $x_6(t)$, $x_7(t)$, $x_8(t)$, and $x_9(t)$ in terms of $X_1(f)$ and $X_2(f)$.



Problem S18 (Signals and Systems)

Do problem 8.26 from Openheim and Willksy, *Signals and Systems*, reprinted below:

8.26. In Section 8.2.2, we discussed the use of an envelope detector for asynchronous demodulation of an AM signal of the form $y(t) = [x(t) + A]\cos(\omega_c t + \theta_c)$. An alternative demodulation system, which also does not require phase synchronization, but does require frequency synchronization, is shown in block diagram form in Figure P8.26. The lowpass filters both have a cutoff frequency of ω_c. The signal $y(t) = [x(t) + A]\cos(\omega_c t + \theta_c)$, with θ_c constant but unknown. The signal $x(t)$ is band limited with $X(j\omega) = 0$, $|\omega| > \omega_M$, and with $\omega_M < \omega_c$. As we required for the use of the envelope detector, $x(t) + A > 0$ for all t.

Show that the system in Figure P8.26 can be used to recover $x(t)$ from $y(t)$ without knowledge of the modulator phase θ_c.

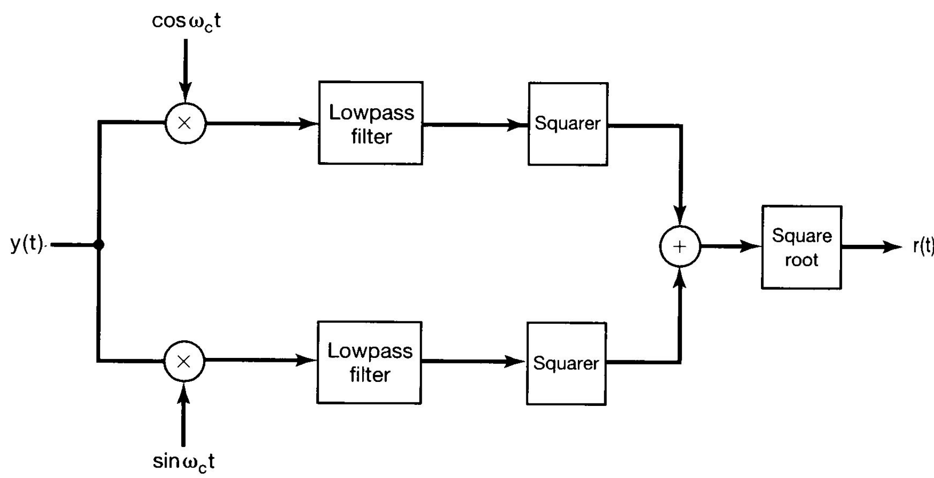


Figure P8.26

Problem S19 (Signals and Systems)

Do problem 8.8 from Openheim and Willksy, *Signals and Systems*, reprinted below. Note that this system implements a type of single sideband amplitude modulation. In addition to parts (a) and (b) below, do part (c).

8.8. Consider the modulation system shown in Figure P8.8. The input signal $x(t)$ has a Fourier transform $X(j\omega)$ that is zero for $|\omega| > \omega_M$. Assuming that $\omega_c > \omega_M$, answer the following questions:

(a) Is $y(t)$ guaranteed to be real if $x(t)$ is real?

(b) Can $x(t)$ be recovered from $y(t)$?

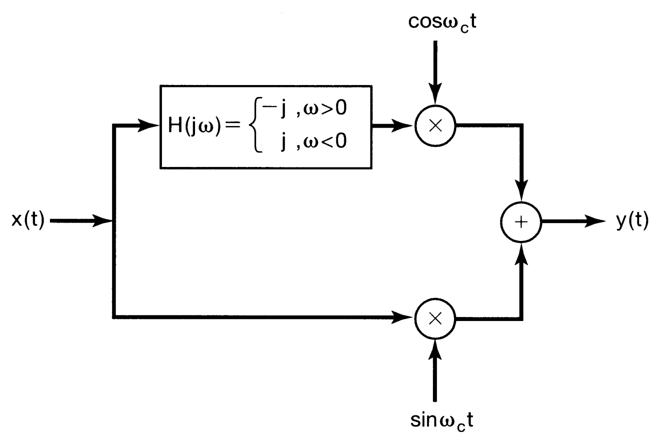


Figure P8.8

(c) For a representative spectrum $X(f)$, plot the resulting spectrum $Y(f)$. You may assume that the spectrum $X(f)$ is real, but plot both the real and imaginary parts of $Y(f)$. Does this system in fact produce single sideband modulation?

The problems in this problem set cover lectures C16, C17, C18, C19 and C20.

Download and unzip the following file from the C&P class webpage:

`C&P_PSet7_Files.zip`

There are NO electronic submissions this week. All submissions should be hardcopy.

Problem C16/C17. Data Flow Testing

Download the following files from the class website

❖ `my_test_package.ads`
❖ `my_test_package.adb`
❖ `demo_simple_dataflow.adb`

a. Draw the data flow diagram for the complete program i.e. the data flow across both the `my_test_package` package and `demo_simple_dataflow` subprogram.

b. Identify the test cases that cover:

- All def's
- All Uses
- All def's and some use.

Justify your answers based on the data flow diagram.

Problem C18. Expression Representation Using Truth Tables

a. Draw the truth table for the following Boolean expression:

$$(A + \bar{B}C) \langle (\bar{A}C + B\bar{C})$$

b. Represent the Boolean expression as a circuit using logic gates (i.e: OR, AND, NOR, NAND, NOT, etc…).

Note: You should recognize that '+' is OR and '•' is AND.

Problem C19. Expression Simplification

a. Simplify the following expression using Boolean algebra theorems:

$$(((A + \bar{B}C) \cdot (\bar{A}C + B\bar{C})) + ((A\bar{B} + \bar{C}) \cdot (\bar{A}B + \bar{B}C)))$$

Show all the steps in the simplification.

b. Simplify the same expression using 3 variable K-Maps

c. Represent the simplified expression as a circuit using only NAND gates.

Problem C20. Expression Conversion

a. Using Boolean algebra theorems, convert the following expression in Sum-Of-Products Form

$$(A + \bar{B}) \cdot (\bar{A} + B) \cdot (\bar{B} + \bar{C}) \cdot (\bar{A} + C)$$

b. Convert the SOP expression derived in 4a into Canonical SOP form

c. Convert the expression shown in 4a. into canonical SOP using K-Maps

d. Using K-Maps, convert the expression shown below into simplified POS form

$$\overline{ABCD} + \bar{A}B\bar{C} + A\overline{BCD} + A\bar{B}C\bar{D} + AB\bar{C}D + \overline{AB}C\bar{D} + \bar{A}BCD$$