University of Waterloo

Department of Electrical and Computer Engineering

E&CE-318 – Communication Systems, W'96

Final Examination

Instructor: A. K. Khandani

Time allowed: 3 hours.

NO AIDS ALLOWED except for one sheet (A4, double-sided) of formulas.

Attempt all the questions.

The marking scheme is shown in the left margin and [60] constitutes full marks.

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(10) **Problem 1:** The output (modulated) signal from an AM modulator is:

$$u(t) = 5\cos(1800\pi t) + 20\cos(2000\pi t) + 5\cos(2200\pi t)$$

1.1. Determine the modulating signal $m(t)$ and the carrier signal $c(t)$.

1.2. Determine the modulation index. Can the signal $m(t)$ be recovered using an envelope detector?

1.3. Determine the ration of the power in the side-bands to the power in the carrier.

(10) **Problem 2:** A communication system operates in the presence of white noise with a two sided power spectral density $S_a(\omega) = 10^{-14}$ W/Hz and with a path loss of 20dB. Calculate the minimum required band-width and the minimum required carrier power of the transmitter for a 10-KHz sinusoidal input and a 40dB output S/N ratio if the modulation is:

2.1. DSB-SC

2.2. SSB-SC

2.3. FM, with $\Delta f = 10$KHz.

(10) **Problem 3:** The block diagram of a modulator is shown in Fig. 1, where $f_1 = W/2$ and $f_2 = f_c - (W/2)$. Compute the output signal when the input is equal to: $m(t) = \cos(2\pi f_m t)$ where $f_m < W$. What kind of modulation is this?

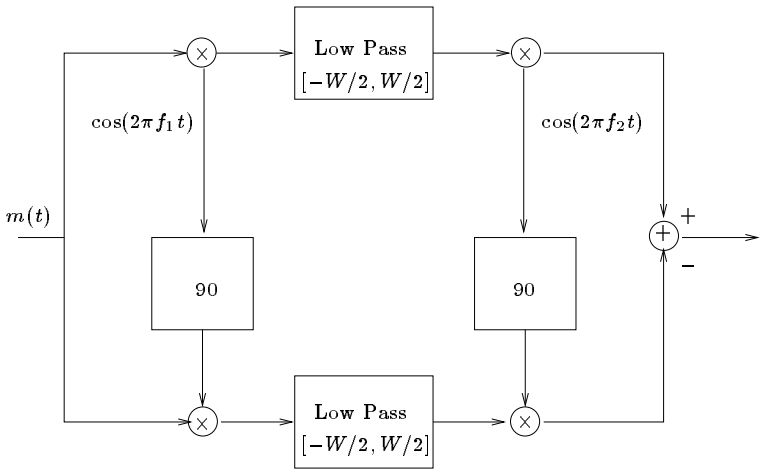

Figure 1: Related to problem 3.

(10) **Problem 4:** A VSB modulation scheme is shown in Fig. 2.

4.1. Show that the demodulator can recover the signal $m(t)$. What should be the band-width of the demodulator filter?

4.2. Assume that $m(t) = \cos(\pi W/2)$ where W is defined in Fig. 2. Compute the modulated signal $u(t)$ and the output of the demodulator, $m'(t)$.

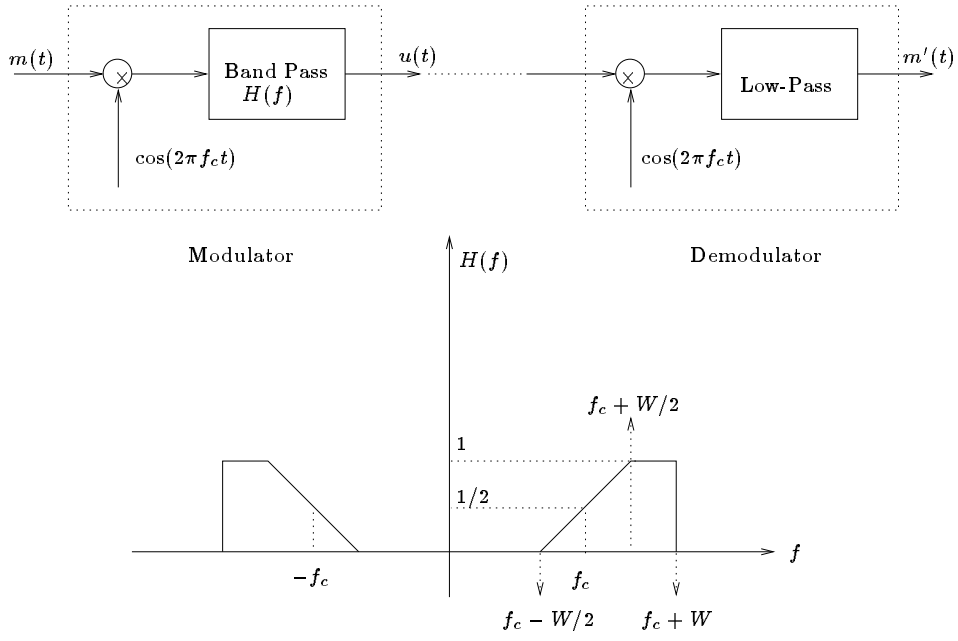

Figure 2: Related to problem 4.

(10) **Problem 5:** Consider the PM modulation (with $k_p = 1$) of the following periodic signal (of period T):

$$m(t) = \begin{cases} -1 & 0 \le t \le T/2 \\ 1 & T/2 \le t \le T \end{cases}$$

5.1. Determine the frequency spectrum of the resulting PM signal

5.2. What is the peak frequency and peak phase deviation.

(10) **Problem 6:** An angle modulation signal has the form:

$$u(t) = 10\cos(2\pi f_c t + 3\sin 2000\pi t + 4\sin^2 1000\pi t)$$

where $f_c = 10$ MHz.

6.1. Is this an FM or a PM signal? Explain.

6.2. Determine the average transmitted power.

6.3. Determine the modulation index, the peak-phase and the peak-frequency deviations.

6.4. What is the approximate band-width of the signal.

6.5. Give an expression for the frequency spectrum of the output signal.