ORDRE DES INGÉNIEURS DU QUÉBEC

NOVEMBER 2011 SESSION

Open-book examination Calculators: only authorised models Duration: 3 hours

07-ELEC-A3 SIGNALS AND COMMUNICATIONS

Problem No. 1 (20 %)

Consider an FM modulator with output

$$x_c(t) = 100 \cos [2\pi (1000) t + \varphi(t)]$$

The modulator operates with a frequency deviation constant $f_d = 8$ and has the input message

$$m(t) = 5 \cos 2\pi(8)t$$

The modulator is followed by a band pass filter with a center frequency of 1000 Hz and a bandwidth of 56 Hz, as shown in Figure 1.

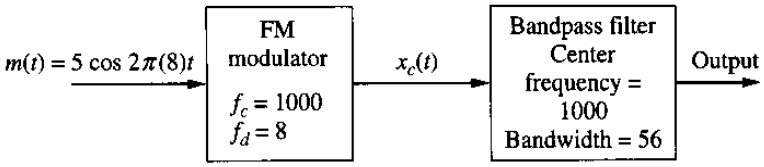

Figure 1. FM system.

The pass band of the band pass filter is shown in Figure 2 below.

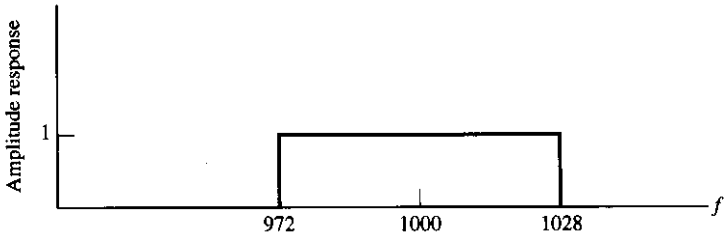

Figure 2. Amplitude response of bandpass filter

Determine the power at the filter output.

Problem No. 2 (20 %)

Three messages signals are periodic with period T, as shown in Figure 3. Each of the three message signals is applied to an AM modulator.

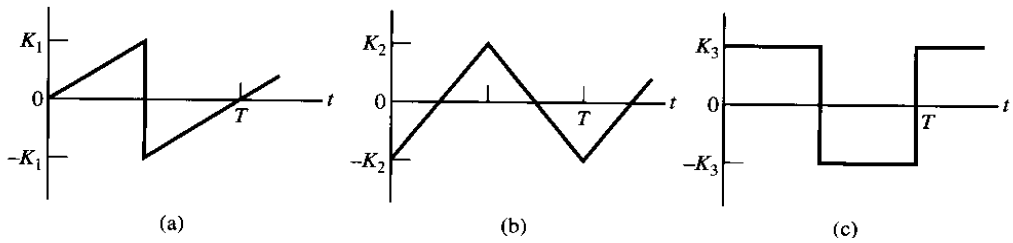

Figure 3. Applied messages to the AM modulator

For each message signal, determine the modulation efficiency for a=0.4, a=0.6 and a=1 where a is the modulation index.

Problem No. 3 (15 %)

The sum of two or more sinusoids may or may not be periodic depending on the relationship of their separate frequencies.
For the sum of two sinusoids, let the frequencies of the individual terms be f_1 and f_2, respectively.
For the sum to be periodic, f_1 and f_2 must be commensurable; that is, there must be a number f_0 contained in each an integral number of times. Thus, if f_0 is the largest such number,

$$f_1 = n_1 f_0 \qquad et \quad f_2 = n_2 f_0$$

where n_1 et n_2 are integers and f_0 is the fundamental frequency.

Which of the signals given below are periodic?

(a) $x_1(t) = 2\cos(2t) + 3\sin(5\pi t)$

(b) $x_2(t) = \cos(6\pi t) + 5\cos(20\pi t)$

(c) $x_3(t) = 3\sin(4\pi t) + 5\sin(14\pi t)$

(d) $x_4(t) = 2\cos(4\pi t) + 5\cos(6\pi t) + 6\sin(22\pi t)$

Find the periods of those that are periodic.

Problem No. 4 (15%)

A continuous data signal is quantized and transmitted using a PCM system. If each data sample at the receiving end of the system must be known to within ± 0.5 % of the peak-to-peak full scale value,

a) how many symbols must each transmitted digital word contain?
(assume that the message signal is speech and has a bandwidth of 4 kHz)

b) estimate the bandwidth of the resulting PCM signal.

Problem No. 5 (15 %)

The Fourier transform of a given signal f(t) is

$$F(\omega) = (1 - j\omega)\frac{\omega^2 + 2}{\omega^4 + 3\omega^2 + 2} + \pi\delta(\omega).$$

Determine

a) the average (dc) value of the signal

b) the signal f(t).

Problem No. 6 (15 %)

The FM signal (in volts),

$$\varphi(t) = 20 \cos (2\pi 10^7 t + 10 \sin 2\pi 10^3 t)$$

is present across a 50-ohms resistive load.

a) what is the total average power?

b) what percentage of this power is at 10 MHz ?

c) find the peak frequency deviation?

d) determine the approximate bandwidth of $\varphi(t)$, using Carson rule.

e) can you determine from $\varphi(t)$ whether this is FM ou PM ? Explain.