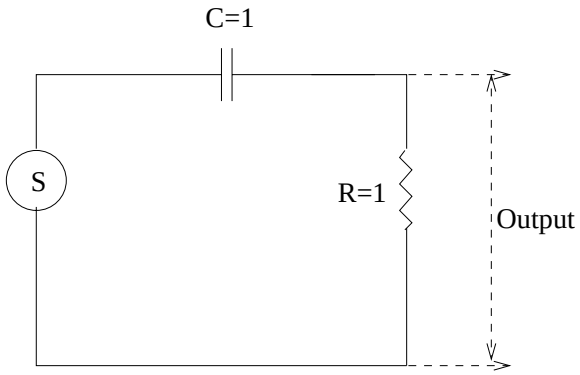
University of Waterloo
Department of Electrical and Computer Engineering

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 (questions are of equal mark)

Problem 1: Consider the following circuit:



There is a white thermal noise of power (square voltage) spectral density $\eta/2 = 1$ associated with the resistor. The signal source (S) is a signal of the form $(1 + 2\cos 2\pi t)\cos(4\pi t)$. Compute the ratio of the signal to noise over the output resistor.

Problem 2: The upper sideband of an AM waveform (DSB-LC) with sinusoidal modulation and modulation index $m = 1$ is multiplied by a factor α, where: $1 \leq \alpha \leq 2$.

2.1. Derive a relationship for the peak (i.e., maximum) phase deviation from the carrier as a function of α.

2.2. Determine the minimum amount of carrier one needs to add the resulting modulated signal such that envelope detection is possible.

Problem 3: In a DSB modulation system the carrier is $c(t) = \cos(20\pi t)$ and the modulating signal is $m(t) = \sum_{k=-\infty}^{\infty} \mathrm{Sa}[2\pi(t - kP)]$.

3.1. Find the range of values of P such that the signal $m(t)$ is equivalent to the sum of two sinusoids (excluding any possible dc component).

3.2. For the case computed in part 3.1 (with P as a parameter), assume that the carrier $2\cos(\omega_c t)$ is used to frequency modulate the signal $m(t)$. Compute the frequency domain representation and the total power of the resulting signal.

Problem 4: The following system is used for the amplitude modulation of the signal $x(t) = \cos(\omega_m t)$. Derive some conditions on the system parameters (α, K, a, b) such that the output is an AM signal with modulation index one and total power 2.

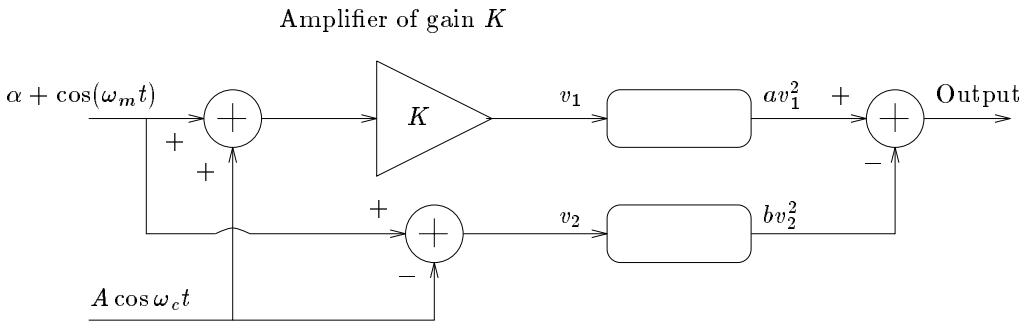


Figure 1: Modulator for problem 4.

Problem 5: The Fourier series coefficients of a signal is shown in Fig. 2.

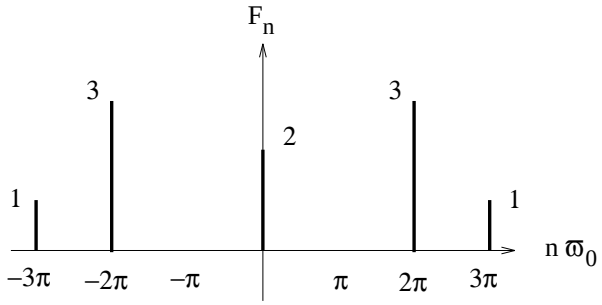


Figure 2: Related to Problem-5

5.1 What is the period of the signal?

5.2 What is the average value (DC value) of the signal?

5.3 Compute the autocorrelation function of the signal.

5.4 The signal is passed through the linear system,

$$H(\omega) = \begin{cases} \dfrac{1}{1 + (|\omega|/\pi)}, & |\omega| < \dfrac{5\pi}{2}, \\ 0 & \text{otherwise} \end{cases}$$

and the output of $H(\omega)$ is multiplied by $P(t) = A\sum_{n=-\infty}^{\infty} \text{rect}(t - 10n)$, compute the Fourier Transform of the final output.

Problem 6: A communication system operates in the presence of white noise with a two sided power spectral density $S_a(\omega) = 0.25 \times 10^{-14}$ W/Hz and with total path losses (including antennas) of 100dB. The input bandwidth is 10-KHz. Calculate the minimum required carrier power of the transmitter for a 10-KHz sinusoidal input of and a 40dB output S/N ratio if the modulation is: (i) AM (DSB-LC), with m=0.707, (ii) FM, with $\Delta f = 30$KHz, and PM, with $\Delta\theta = 3$rad