Association of Professional Engineers of Ontario

Annual Examinations
98-Phys-B4 , December 2015

Communications

3 hours duration

Notes:

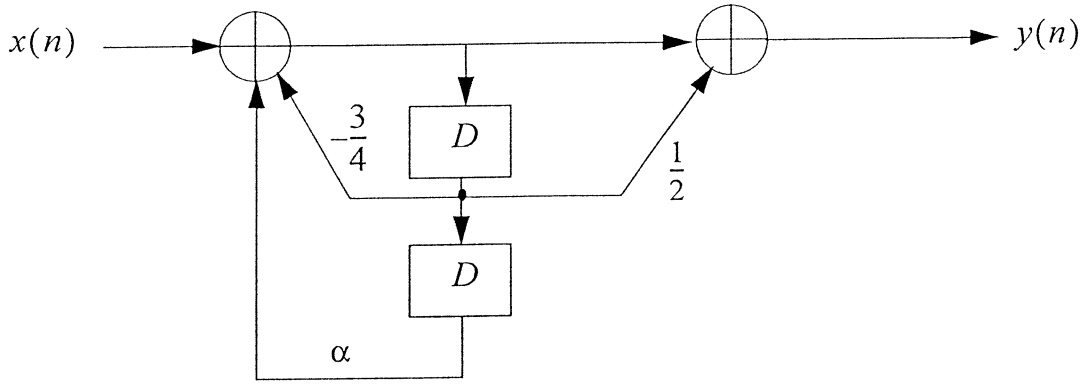
1) If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper a clear statement of any assumption made.

2) "Closed-Book" - no aids other than a standard non-programmable (no text storage) calculator are permitted.

3) Any five questions constitute a complete paper. Only the first five questions as they appear in your answer book will be marked.

4) All 6 questions are of equal value.

1) A discrete time linear system is described by the following block diagram:

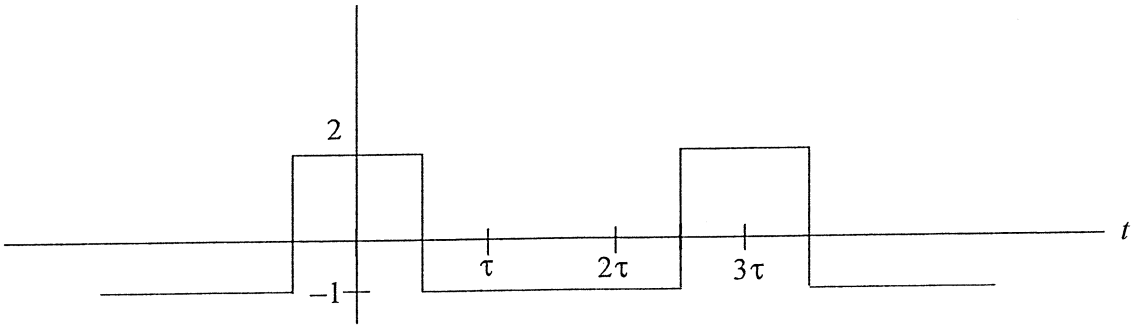


a) Give the transfer function of the system.

b) For which values of the parameter α is the system stable?

c) Find the inpulse response of the system if $\alpha = \frac{1}{2}$..

2) Consider the following periodic time signal where $\tau = 100\ \mu s$:



a) Determine the Fourier series of $x(t)$ in terms of real basis functions.

b) Determine the power spectral density of the signal $x(t)$.

c) If the signal $x(t)$ is input to an ideal band pass filter with center frequency 10 KHz and bandwidth $B = 5$ KHz, determine the output signal in the time domain.

3) An AM signal has a modulation index $a = 0.8$ and an average power equal to 2W. The message is a triangular wave with frequency equal to 10 KHz. The carrier frequency is 10 MHz.

a) Give an expression for the AM signal in the time domain including all parameter values, and plot it.

b) What is the power efficiency of this modulation scheme.

c) Plot the spectrum of the AM signal assuming that all harmonics of the message beyond the 4th can be neglected.

d) Plot the envelope of the AM signal. Give all the parameters.

e) Give the block diagram for an envelope detector that will demodulate the AM signal.

4) An audio signal is to be transmitted using PCM in a baseband channel. The bandwidth of the signal is equal to 8 KHz and the signal has a dynamic range of 2V peak to peak. The signal is to be reconstructed using a low pass filter that has a transition region (from the passband to the stopband) equal to 10% of the bandwidth of the passband of the filter. The reconstructed signal must have a quantization noise that is less than 1 mv rms. Assume that the frequency response of the filter is constant within the passband.

a) What is the required sampling rate so that we can reconstruct the signal with zero distortion except for quantization noise?

b) Find the smallest number of bits required to represent each sample of the signal.

c) What is the bit rate of the resulting PCM signal?

d) Suppose 10 of the above PCM signals (as in c)) are to be multiplexed and transmitted through a baseband channel using a binary scheme. What is the minimum bandwidth required for the channel assuming optimum filtering of the transmitted pulses?

5) An FM signal has the form $s(t) = A_c\cos(2\pi f_c t + \phi(t))$, where $A_c = 5$ $\phi(t) = a\cos(2\pi f_1 t) + b\cos(2\pi f_2 t)$, $a = 1$, $b = 2$, $f_1 = 2000$ Hz, and $f_2 = 2f_1$

a) Determine the message signal $m(t)$, assuming that the frequency deviation constant is 5 KHz/volt.

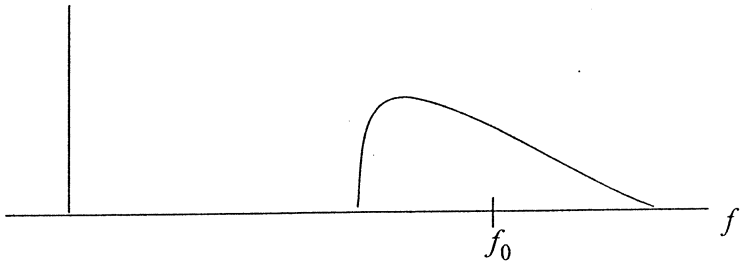
b) What is the average power of the FM signal $s(t)$?

c) Determine the peak frequency deviation of the FM signal.

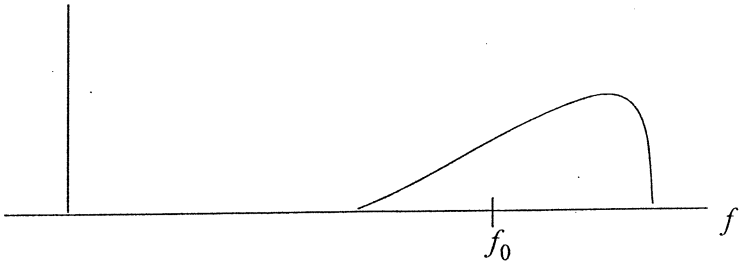
d) Determine the bandwidth of the FM signal.

e) Give the block diagram of a suitable demodulator.

6) A real bandpass signal has center frequency f_0 as shown in the following Figure (shown only for positive frequencies).



a) Give the block diagram of a system that transforms the above signal to a bandpass signal with the same carrier frequency but with a spectrum that is the mirror image about the carrier frequency (for positive frequencies), i.e. the spectrum is as follows (for positive frequencies).



b) A modulated signal has a carrier frequency equal to 10 MHz. We wish to convert the carrier frequency to 12 MHz. We have a local oscillator that produces a square wave and it has a variable frequency setting up to a maximum of 1 MHz. Give the block diagram of a system to perform the frequency conversion. No other oscillators are to be used.