National Examinations - May 2018

16-Elec-A3, Signals and Communications

3 hours duration

Notes:

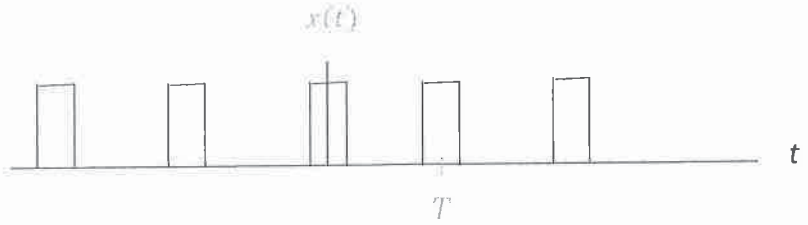
1) If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper a clear statement of any assumption made.

2) **"Closed-Book". One of two calculators is permitted - any Casio or Sharp approved model.**

3) Answer all 5 questions.

4) All 5 questions are of equal value.

1. Consider a signal that is a periodic pulse train as in the following Figure where the duty cycle is 25%.



a) If the amplitude of $x(t)$ is A, give an expression for the third harmonic of the signal in terms of the signal parameters.

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

c) Determine the duty cycle so that the amplitude of the third harmonic is maximized.

d) Determine the average power in the third harmonic in c).

2) A PCM system with uniform quantization is used to transmit a speech signal. The bandwidth of the signal is equal to 8 KHz. Assume that the signal has a dynamic range that varies between -2 and 2 volts (i.e. peak to peak value equal to 4V), and that the quantization noise (absolute value) must be less than 2 mV.

a) What is the minimum sampling rate for the speech signal?

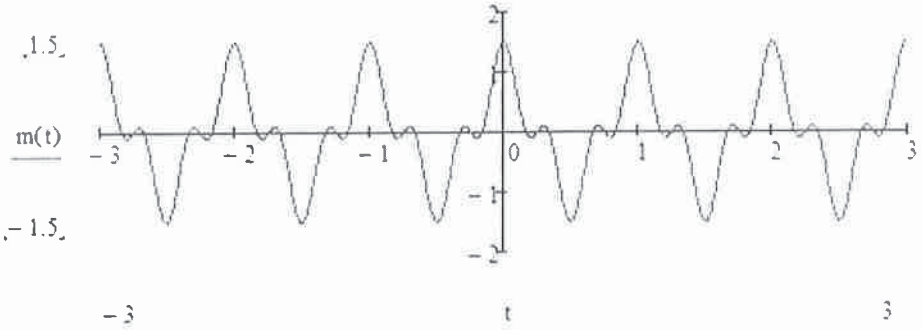
b) What is the quantization step size?

c) In the signal quantization what is the smallest possible number of quantization levels?

d) Now, model the signal as a sinusoid and model the quantization noise as a triangular wave. Determine the SNR for the reconstructed signal.

e) What is the bit rate of the PCM signal, using the number of quantization levels in c) and the sampling rate in a)?

3) An AM signal has a modulation index $\mu = \frac{1}{2}$ and a maximum peak to peak value of 4 V. The message is given by $m(t) = \cos(2\pi f_m t) + \frac{1}{2}\cos(6\pi f_m t)$ as plotted in the following figure where the time axis has been normalized by the frequency f_m. The carrier frequency is 10 MHz and $f_m = 4$ Kz.



a) Give an expression for the AM signal in the time domain in terms of $m(t)$, and plot it based on the plot of the message in the above figure.

b) Plot the spectrum of the AM signal exactly.

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

d) Give the diagram for an electronic circuit that will demodulate the AM signal. Specify suitable values for any components.

e) Give the block diagram for a coherent detector that will demodulate the AM signal.

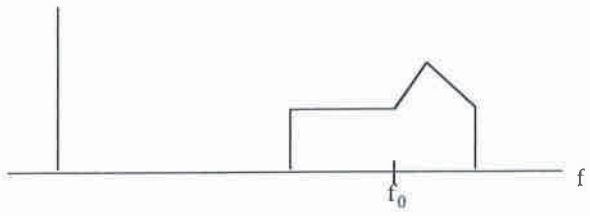
4) A discrete time linear system has impulse response given by $h(n) = e^{-\alpha n}u(n)$, where $u(n)$ is the discrete step function.

a) Determine the output of the system if the input is $x(n) = u(n - n_0)$ where n_0 is a fixed positive integer.

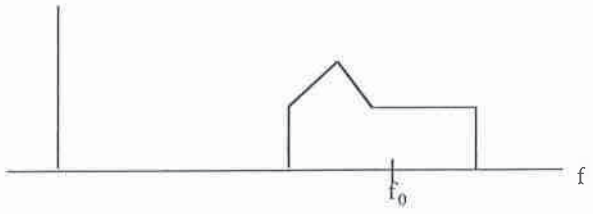
b) For the case $\alpha = 1$, and $n_0 = 4$, plot the output of the system.

c) Determine the frequency response of the system.

5) A real band-pass signal has the spectrum and center frequency 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 band-pass 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.