Professional Engineers Ontario

Annual Examinations

98-Phys-B4, December 2016

Communications

3 hours duration

Notes:

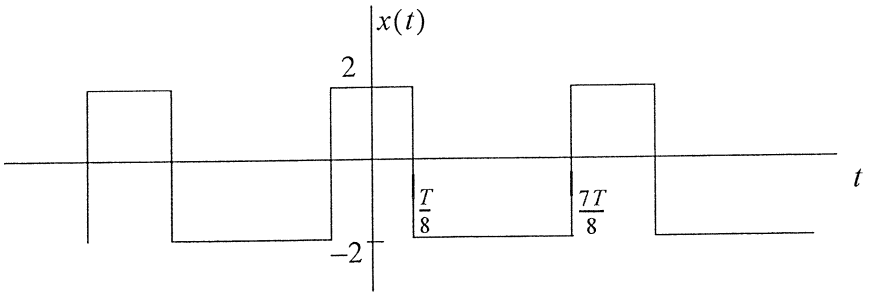
1) If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper a clear statement of any assumption made.

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. The following periodic signal is input to an ideal low pass filter of bandwidth 25 KHz.



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

b) If $T = 0.1$ ms, give the output of the filter as a function of time, $y(t)$.

c) Determine the average power of the signal $y(t)$

d) Determine the bandwidth of the signal $y(t)$, considered as a baseband signal.

e) Now assume that the signal $x(t)$ (with $T = 0.1$ ms) is instead input to an ideal high pass filter with cut-off frequency 8 KHz. Plot the output of the filter.

2) A discrete time system is described by the following transfer function

$$H(z) = \frac{1 + 2z^{-1}}{1 - \frac{1}{4}z^{-2}}$$

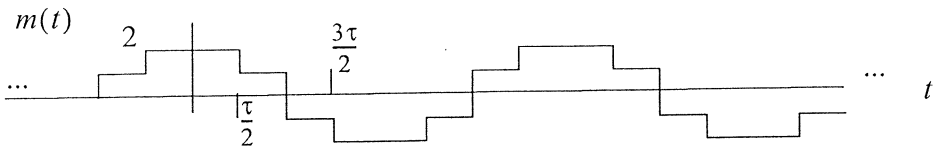
a) Give a block diagram to implement the system using delay elements, multipliers, and adders. Use the smallest possible number of delay elements (all of the same delay).

b) Find the impulse response of the system.

c) Give a difference equation, in terms of the input and output, to describe the system.

d) Is the system stable?

3) The following message signal with $\tau = 1$ ms is input to a Double Sideband Modulator (DSB) with carrier frequency $f_c = 10$ KHz. (Note that the plot is to scale and the signal is periodic).



a) Plot the modulated signal in the time domain.

b) Give an exact expression for the DSB signal in the time domain in terms of the message signal $m(t)$, if the average power of the DSB signal is 10.

c) Assume an AM modulation scheme with the same message, $m(t)$, with modulation index $\mu = 0.8$. Plot the AM signal in the time domain. (Marks will consider neatness).

d) Assuming AM, give an exact expression for the signal in the time domain, in terms of $m(t)$, if the AM signal has an average power equal to 10.

e) What is the power efficiency of the AM modulation scheme in c).

f) Assume that the AM signal in c) is fed into an envelope detector, give (plot) the output signal.

g) Assume that for the signal $m(t)$ we can neglect the harmonics beyond the 7th. Specify the minimum frequency band required to transmit the AM signal (give the lowest and highest frequencies).

4) A pulse code modulation (PCM) scheme is used to transmit a video signal with bandwidth equal to 4.5 MHz. As a result of imperfect filters we use a sampling rate that is 15% greater than the minimum theoretical sampling rate required when we have perfect filters. Uniform quantization is used where the quantization error is a maximum of .05% of the peak value of the signal. The transmission uses binary encoding.

a) Determine the sampling rate for the system.

b) Determine the bit rate in the channel.

c) What is the SNR of the reconstructed signal if we assume that the video signal can be modeled as having a uniform probability density.

5) In a modulation scheme the message signal is given by $m(t) = (\cos 2\pi f_m t)^3 + \dfrac{\sin(\pi f_m t)}{\pi f_m t}$ and the carrier is equal to $A\cos(2\pi f_c t)$, where $f_c = 20 f_m$.

a) Plot the spectrum of the message signal. What is the bandwidth?

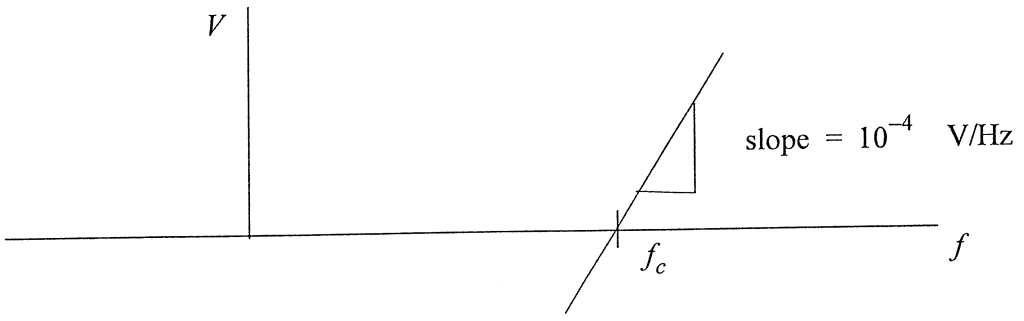
b) Plot the spectrum of the modulated signal assuming DSB modultion. What is the bandwidth of the signal?

c) Plot the spectrum of the signal assuming lower-sideband SSB. What is the bandwidth of the modulated signal?

d) Give a block diagram of a system to recover the message signal exactly from the DSB signal. The system should work for arbitrary message signals with the same message signal bandwidth.

e) Give a block diagram of a system which takes the DSB signal in b) and outputs a DSB signal with carrier frequency equal to $25 f_m$.

6) A VCO has the characteristics shown in the following Figure:



a) If this VCO is used to implement an FM modulator, give an expression for the output of the FM modulator if the message signal is $m(t)$ and the modulator output power is equal to 10.

b) Give the block diagram of a demodulator for the above FM signal.

c) Give an approximate value for the bandwidth of the FM signal if the bandwidth and peak value of the message signal are 10 KHz and 2 V respectively.