NATIONAL EXAMS - DECEMBER 2017

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". Approved Casio or Sharp calculator is permtted.

3) Answer all 5 questions.

4) All 5 questions are of equal value.

1. Consider the design of a frequency doubler using an ideal full-wave rectifier followed by an ideal filter.

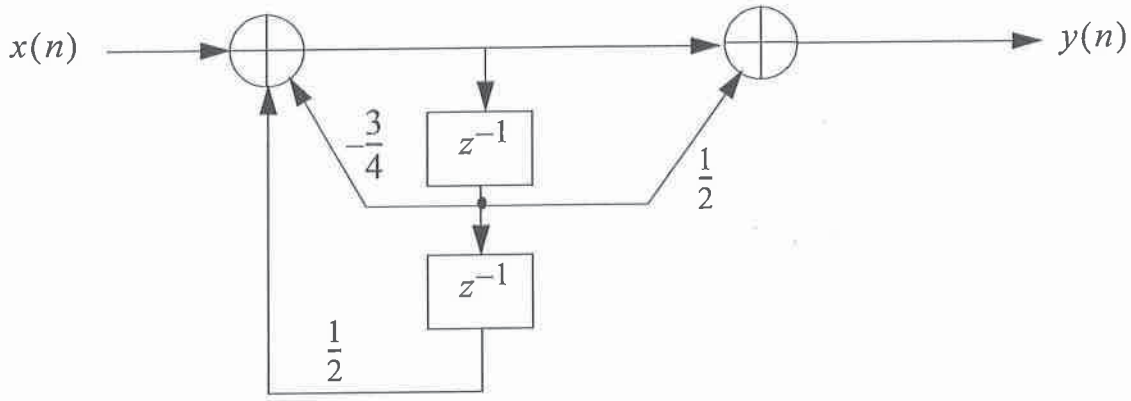
a) Assume that the input to the full-wave rectifier is given by $x(t) = 2\cos\left(2\pi f_0 t + \frac{\pi}{4}\right)$, where $f_0 = 10$ MHz. Find the Fourier series for the signal at the output of the full wave rectifier.

b) Specify the parameters for the filter, assuming a center frequency to bandwidth ratio equal to 10.

c) Give the exact expression for the output of the frequency doubler in the time domain.

d) The insertion loss of the frequency doubler is the power loss in the signal at the output versus the input. Determine the insertion loss for this frequency doubler in dB.

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

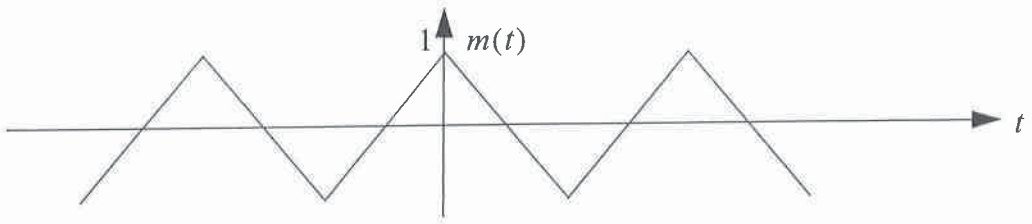


a) Give the transfer function of the system.

b) Determine the impulse response.

c) Determine the output of the system if the input is $x(n) = u(n) - u(n-2)$, where $u(n)$ is the step function.

3) An AM signal has a modulation index $a = 0.8$ and a maximum peak to peak value of 4 V. The message is a triangular wave with frequency equal to 5 KHz as in the plot below. The carrier frequency is 10 MHz.



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

b) Plot the spectrum of the AM signal (exact values of line spectra are not required - specify the computation procedure). Neglect AM signal components corresponding to message signal harmonics greater than the fifth.

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 PCM system with uniform quantization is used to transmit a speech signal. The bandwidth of the signal is equal to 6 KHz. At the receiver we require an SNR in the reconstructed signal equal to 40 dB. The speech signal varies between -3V and 3V.

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

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

c) What is the quantization step size?

d) What is the rms value of the quantization noise?

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

f) Explain the reason for using non-uniform quantizers.

5) A superheterodyne receiver has an IF frequency of 820 KHz. It is attempting to demodulate an AM signal with bandwidth 20 KHz and carrier frequency 2.2 MHz. The receiver uses upper side tuning.

a) What is the image frequency for the above station being received?

b) What is the frequency of the local oscillator required to receive the above station?

c) If we want to be able to tune over a range of stations, what is the advantage of using upper side tuning over lower side tuning?

d) We would like the above receiver to tune into stations with carriers over the range from f_L (lowest possible station) to $f_U = 2.2$ MHz, by using a fixed band-pass filter at the front-end of the receiver. Give a block diagram for the superheterodyne receiver. Specify the bandwidth and center frequency of the RF front-end filter. Specify the tuning range for the local oscillator required to tune to all the stations in the above range.