Association of Professional Engineers of Ontario

Annual Examinations - Dec 2003
98-Elec-A3

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 calculator (Casio FX-991 or Sharp EL-540) 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 questions are of equal value.

1) **An AM signal has a modulation index of $a = 0.5$. The message signal is a triangular wave with frequency equal to 1 KHz and the carrier frequency is 1 MHz. The signal has an average power of 10W.**

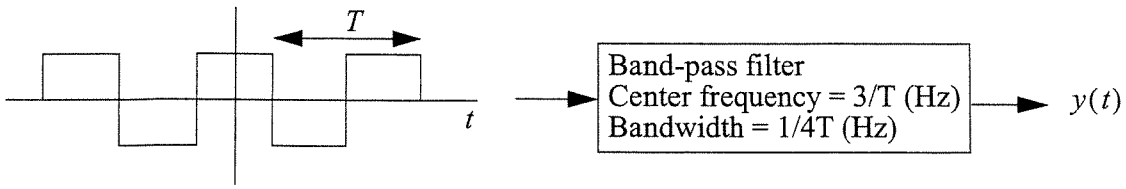
a) Determine the peak value of the signal.

b) Plot the signal in the time domain.

c) Determine the power efficiency of the AM signal.

d) Give the diagram of a circuit to demodulate the AM signal and give approximate values for any parameters in the circuit.

2) **A square wave with period T and amplitude 1 is input to an ideal band-pass filter as follows:**



Find the output signal $y(t)$.

3) **An FM modulator has the following characteristics: When a 2 volt dc signal is applied the frequency of the signal changes by 5 KHz from the nominal frequency, f_c (with input grounded).**

a) Determine the output of the modulator when the input is equal to $m(t) = \cos(2\pi f_1 t) + 3\sin(4\pi f_1 t)$, where $f_1 = 2$ KHz, i.e. Give the expression for the modulator output. Specify all the parameters.

b) Give an approximate value for the bandwidth of the signal at the modulator output in a).

c) Give the block diagram of a suitable demodulator.

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

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

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).

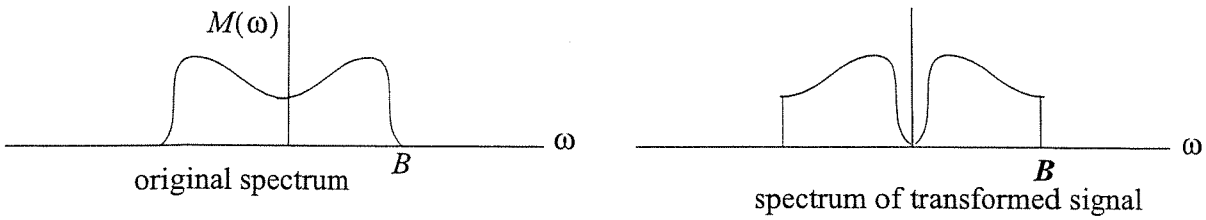
b) Find the impulse response of the system.

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

d) Is the system stable?

5)

a) A baseband signal has the spectrum given by $M(\omega)$, where the bandwidth is B. We want to transform the signal so that it remains a low-pass signal but high frequency components become low frequency components and vice-versa as shown in the following figure.

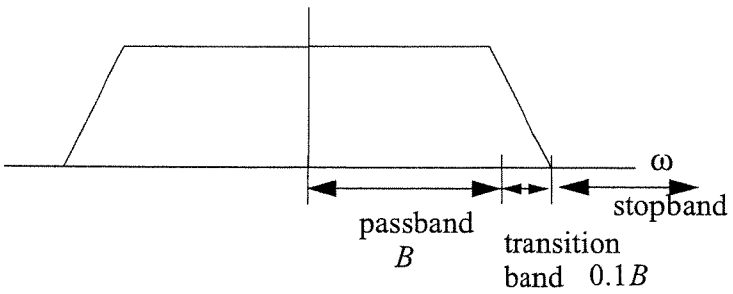


Give the block diagram of a system to perform the above transformation.

b) A bandpass signal $x(t)$ has a carrier frequency f_c = 80 MHz and bandwidth B = 10 KHz. Give a circuit diagram that converts the carrier frequency to 90 MHz.

c) Suppose that in b) above we add another bandpass $y(t)$ signal with carrier frequency f_0 to $x(t)$, where the spectrums of $x(t)$ and $y(t)$ do not overlap. For what value of f_0 will there be maximum interference on the converted signal (at 90 MHz).

6) A speech signal has a bandwidth equal to 8 KHz. It is to be transmitted using PCM with uniform quantization. The reconstructed signal is to have an SNR equal to 33 dB. The reconstruction low-pass filter has a transition region from the passband to the stopband equal to 10% of the pass-band as shown in the following Figure.



a) Determine the sampling rate for the speech signal if we are to have perfect signal reconstruction.

b) Design a quantizer for the system giving the number of levels and the thresholds.

c) Design an encoder for the system, and give the resulting bit rate.

d) What is the bandwidth required for the transmission of the signal if we use baseband transmission with sinc pulses, each the sinc pulses have four possible applitudes.