UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 4 Examination in Engineering: September 2023

Module Number: EE4301 **Module Name: Communication Systems I**

[Three Hours]

[Answer **all questions**, each question carries 10 marks]

Q1 a) Bit errors occur in binary waveforms transmitted over band limited channels due to Inter Symbol Interferences and noise. The noise effect is modeled as Additive White Gaussian Noise. Explain what you understand by the following terms.

i) Band limited channel

[1 Mark]

ii) Inter Symbol Interference

[2 Marks]

iii) Additive White Gaussian Noise

[2 Marks]

b) A received signal of a binary communication system is given by

$$r = \begin{cases} A + n, & \textit{when binary '1' is transmiited} \\ n, & \textit{when binary '0' is transmitted} \end{cases}$$

where A is a constant and n is a zero mean Gaussian random variable with variance σ_n^2. The probability density function of n is given by $p(n) = \frac{1}{\sqrt{2\pi\sigma_n^2}} e^{-n^2/2\sigma_n^2}$. If $k > r$, the decision at the receiver is '1'. Otherwise, the decision is '0'. Here, k is the decision threshold.

i) Determine a suitable value for the decision threshold to recover the transmitted binary symbols with minimum error.

[1 Mark]

ii) Compute the total error probability of this communication system. Assume, the transmitter of the communication system produces binary '1'and '0'with equal probability.

[**Hint:** The tail integration of a Gaussian probability density function p(x) can be approximated by $Q(x) = \frac{1}{\sqrt{2\pi}} \int_x^{\infty} e^{-y^2/2}\, dy$]

[4 Marks]

Q2 a) Suppose you are given two conventional AM modulators, an oscillator and a summer to design a DSB-SC modulation scheme. The message signal is given by $m(t)$ and the local oscillator can generate a sinusoidal signal $A_c \cos(2\pi f_c t)$. The summer can be used to add two analog signals. Assume that both conventional AM modulators are identical and have the same amplitude sensitivity.

i) Sketch the block diagram of your design by clearly indicating the input and output signals at each block in the diagram.

[3 Marks]

ii) Explain one limitation of the modulation scheme designed in part a) i).

[2 Marks]

b) Consider the circuit diagram of a continuous wave modulation system shown in Figure Q2.a. The spectrum of inputs $m_1(t)$ and $m_2(t)$ applied to the system are shown in Figure Q2.b. and Figure Q2.c.

i) Write mathematical expressions for the outputs at points A, B and C in Figure Q2.a.

[1.5 Marks]

ii) Sketch the spectrum of the outputs at points A, B and C in Figure Q2.a.

[1.5 Marks]

iii) Sketch a block diagram of a receiver to recover the signals $m_1(t)$ and $m_2(t)$ from the modulated signal at point C in Figure Q2.a.

[2 Marks]

Q3 a) i) What is the difference between narrowband and wideband Frequency Modulation (FM)?

[2 Marks]

ii) Describe the direct approach of generating FM waves.

[2 Marks]

iii) State two different FM demodulation techniques.

[1 Mark]

b) FM modulator modulates a periodic square wave signal $m(t)$ shown in Figure Q3.a. with frequency deviation $\Delta f = 1\ kHz$. The carrier frequency $f_c = 10\ kHz$ and the carrier amplitude is A_c. The FM modulated signal is then demodulated by a method shown in Figure Q3.b.

i) Explain the frequency demodulation method shown in Figure Q3.b.

[2 Marks]

ii) Sketch the waveforms at points A, B, C, D and E in Figure Q3.b.

[3 Marks]

Q4 a) i) Compare the sampling requirements in Delta Modulation to those in Differential Pulse Code Modulation (DPCM).

[2 Marks]

ii) A linear delta modulator is designed to operate on speech signals limited to 3.4 kHz. The specifications of the modulator are as follows.

sampling rate, $f_s = 10 f_{Nyquist}$

step size, $\Delta = 100\ mV$

The modulator is tested with 1 kHz sinusoidal signal. Determine the maximum amplitude required from this test signal to avoid slope overload.

[3 Marks]

b) An audio signal has a bandwidth of 4.5 MHz. The signal is sampled, quantized and binary coded to obtain a PCM signal.

i) Determine the sampling rate if the signal is to be sampled at a rate 20% above the Nyquist rate.

[2 Marks]

ii) If the samples are quantized into 1024 levels, determine the number of binary pulses required to encode each sample.

[2 Marks]

iii) Determine the transmission bandwidth required for the transmission of PCM signal.

[1 Mark]

Q5 a) i) Briefly explain the difference between digital baseband modulation techniques and digital passband modulation techniques in terms of frequency range, transmission medium, modulation type and bandwidth.

[2 Marks]

ii) Figure Q5.a illustrates a snapshot of a modulation board employed during a laboratory session. Assume that the modulation board operates under typical laboratory conditions, and a connection exists between point 1 and point 2, and another connection is established between point 3 and point 4. Sketch the output signals observed at points 1, 3, and 5. It is imperative that you align the time scales of these signals in the diagram to ensure clarity and accuracy.

[3 Marks]

b) i) Explain the bandwidth efficiency of M-ary Phase Shift Keying (MPSK) modulation schemes compared to Binary Phase Shift Keying (BPSK) modulation schemes. Support your answer with appropriate equations.

[2 Marks]

ii) Sketch BPSK and QPSK modulated signals corresponding to the binary sequence "1101100011".

[3 Marks]

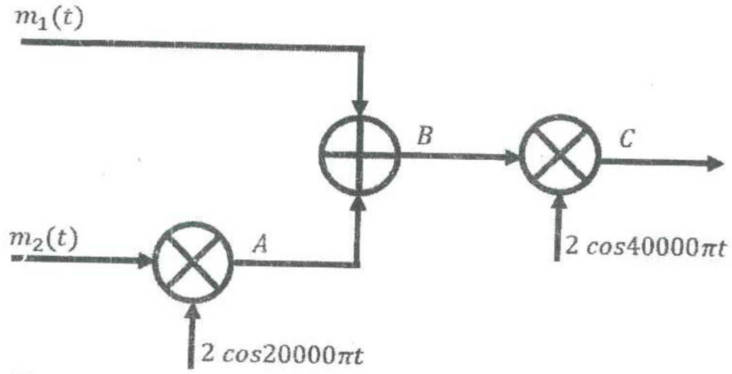

Figure Q2.a. Continous Wave Modulation System.

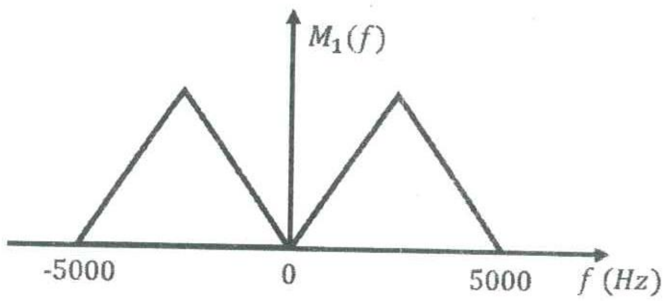

Figure Q2.b. Spectrum of $m_1(t)$.

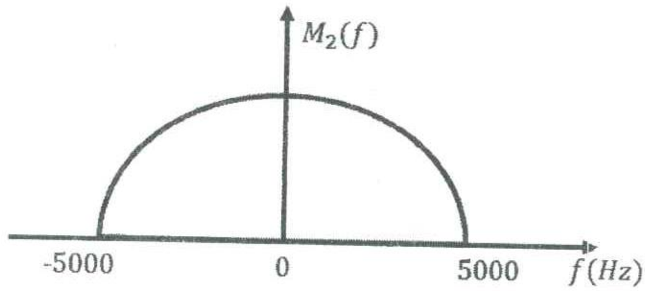

Figure Q2.c. Spectrum of $m_2(t)$.

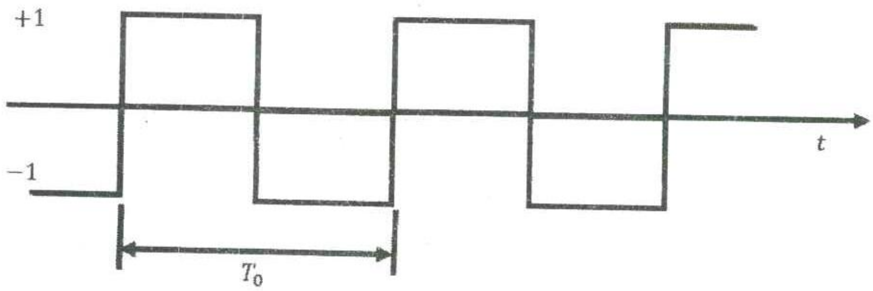

Figure Q3.a. A periodic square wave signal $m(t)$.

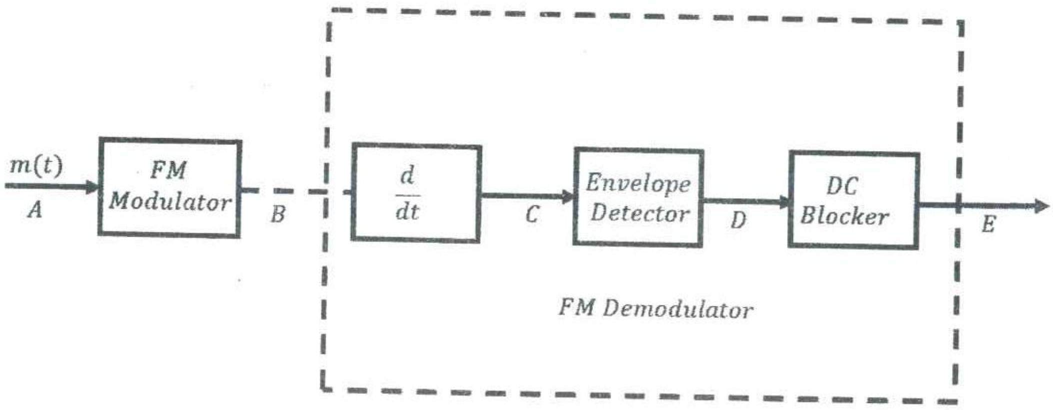

Figure Q3.b. FM Modulation and Demodulation.

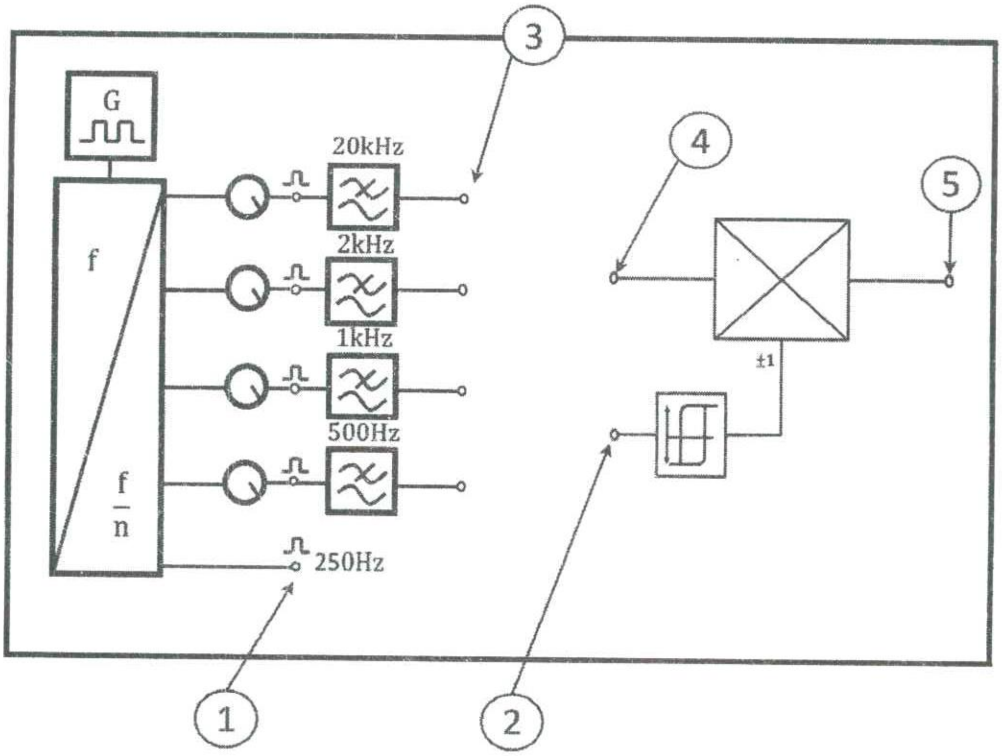

Figure Q5.a. Modulation Board.