UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 4 Examination in Engineering: November 2022

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

[Three Hours]

[Answer all questions, each question carries 10 marks]

Q1 a) Inter Symbol Interference can be avoided by using pulse shaping filters.

i) Explain how you can use a series of sinc pulses for pulse shaping to avoid Inter Symbol Interferences that may occur during the transmission of the sequence 1011010.

[2 Marks]

ii) List two limitations of the proposed method given in part a) i).

[2 Marks]

iii) Propose an alternative pulse shape to overcome the limitations given in part a) ii).

[1 Mark]

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

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

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 $r > 0$, the decision at the receiver is '1'. Otherwise, the decision is '0'.

i) What is the error probability of making a wrong decision when binary '1' is transmitted?

[1.5 Marks]

ii) What is the error probability of making a wrong decision when binary '0' is transmitted?

[1.5 Marks]

iii) Find 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 $Q(x) = \frac{1}{\sqrt{2\pi}} \int_x^\infty e^{-y^2/2}\, dy$]

[2 Marks]

Q2 a) i) "FM signals have a great advantage over AM signals in radio broadcasting". Do you agree with the above statement? Justify your answer.

[2 Marks]

ii) A message signal $m(t) = cos[2\pi(200)t]$ is the input to an FM modulator with a carrier frequency $f_c = 2000$ Hz and the frequency deviation $\Delta = 20$ Hz/V. Calculate the modulation index and sketch the magnitude spectrum of the modulator output.

[2 Marks]

iii) Determine whether the output signal of the FM modulator given in part a) ii) is a Narrowband FM signal or a Wideband FM signal. Justify your answer.

[1 Mark]

b) An AM modulated signal is given by

$$s(t) = Acos[2\pi(200)t] + Bcos[2\pi(180)t] + Bcos[2\pi(220)t].$$

The carrier power is P_c and the power efficiency is η.

i) Derive an expression for η in terms of P_c, A and B.

[2 Marks]

ii) Determine A, B and modulation index when $P_c = 200W$ and $\eta = 30\%$.

[3 Marks]

Q3 a) Consider the circuit diagram of a continuous wave modulation system shown in Figure Q3.a. The input applied to the top conventional AM modulator is $m(t)$ and the input applied to the bottom AM modulator is $-m(t)$. Assume that both conventional AM modulators have the same amplitude sensitivity.

i) Write a mathematical expression for the output $s(t)$ at the point A.

[2 Marks]

ii) What type of a continuous wave modulation scheme generates the signal extracted at the point A?

[1 Mark]

iii) Explain one limitation of the continuous wave modulation scheme given in part a) ii).

[2 Marks]

b) Frequency demodulation is the process that is used to recover the original message signal from a frequency modulated signal.

i) State two different frequency demodulation techniques.

[2 Marks]

ii) Briefly explain one of the demodulation techniques given in part b) i).

[3 Marks]

Q4 a) Consider a ramp signal $f(t) = at$ is applied to a Delta modulator that operates with a sampling duration T_s and step size $\Delta = 2\delta$.

i) Show that the slope – overhead distortion occurs if $\delta < aT_s$.

[2 Marks]

ii) Sketch the outputs when $\delta = 0.75T_s$ and $\delta = 1.25T_s$.

[3 Marks]

b) A PCM system is used to convey information in an analog voltage waveform. The analog voltage waveform has a bandwidth of 200 Hz and an amplitude range of -10V and+10V. The maximum allowable quantization error for this system is ±0.04V.

i) Determine the minimum sampling rate required.

[2 Marks]

ii) Determine the number of bits in each PCM code.

[2Marks]

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.

[2 Marks]

ii) Draw the Binary Phase Shift Keying (BPSK) modulated waveforms for the input bit stream 10110011101.

[3 Marks]

b) QPSK is a M-ary digital modulation scheme and the transmitted signal is defined by

$$s_i(t) = \sqrt{\frac{2E}{T}} \cos\left(2\pi f_c t + (2i-1)\frac{\pi}{4}\right), \quad 0 \le t \le T$$

where $i = 1,2,3,4$. E is the transmitted signal energy per symbol and T is the symbol duration. The carrier frequency is given as f_c.

i) Explain in which situation QPSK digital modulation schemes are preferred over BPSK digital modulation schemes. Use appropriate equations to support your answers.

[2 Marks]

ii) Explain how the input bit stream 0011011001 can be modulated with the QPSK digital modulation scheme.

[3 Marks]

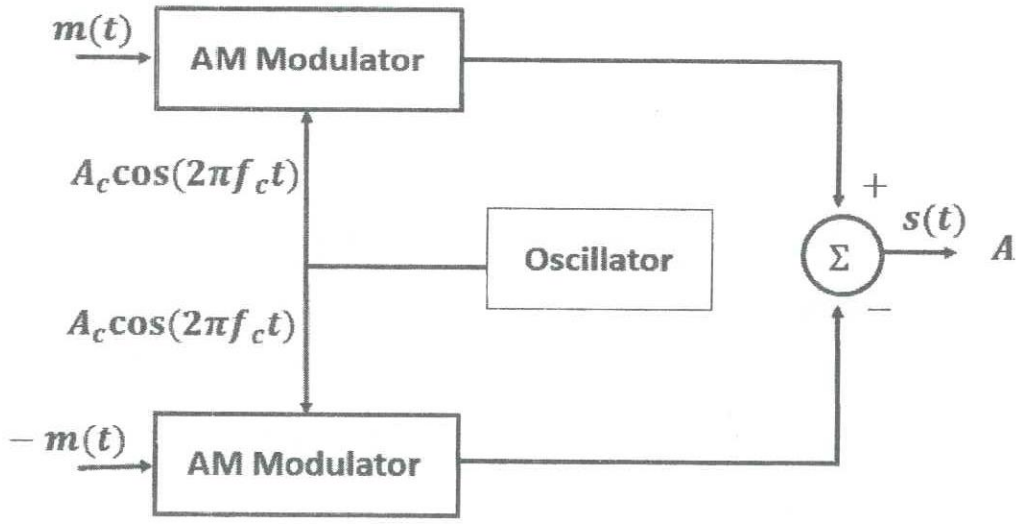

Figure Q3.a. Continous Wave Modulation System.