



UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 4 Examination in Engineering: January 2022

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 a band limited channels due to the Inter Symbol Interferences.
- Explain what you understand by the term "Inter Symbol Interference". [3 Marks]
 - Briefly explain how the Inter Symbol Interference can be avoided in a communication system. [2 Marks]
- b) A PCM system uses bipolar signaling to transmit symbols 1 and 0 over a noisy channel. A received signal of the communication system is given by

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

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 $-k < r < k$, the decision at the receiver is '0'. Otherwise, the decision is '1'.

- Determine a suitable value for the parameter k to recover the transmitted binary symbols with minimum error. [1 Mark]
- What is the error probability of making a wrong decision when binary '0' is transmitted? [1 Mark]
- What is the error probability of making a wrong decision when binary '1' is transmitted? [1 Mark]
- 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) "One of the practical limitations of conventional Amplitude Modulation (AM) and Double Sideband Suppressed Carrier (DSB-SC) modulation is the waste of channel bandwidth".

i) Do you agree with the above statement? Justify your answer by using frequency domain representations of AM and DSB-SC modulated waveforms. For illustration purpose, you may use a triangular shape spectrum as the message signal. [3 Marks]

ii) Which types of continuous wave modulation schemes can be used to overcome the above problem? [1 Mark]

iii) List one of the limitations of the continuous wave modulation scheme given in part a) ii). Justify your answer. [1 Mark]

b) FM modulated signal with carrier frequency $\omega_c = 2\pi \times 10^5$ Hz is given by

$$s(t) = 10\cos(\omega_c t + 5 \sin 3000t + 10 \sin 2000\pi t)$$

i) Find the average power of the signal. [1 Mark]

ii) Determine the maximum frequency deviation of the signal. [2 Marks]

iii) Use Carson's rule to compute the transmission bandwidth of the signal. [2 Marks]

Q3 a) Consider the Double Sideband Suppressed Carrier (DSB-SC) modulation system shown in Figure Q3. The output current i_0 and the input voltage V_i of the ideal nonlinear device are related by $i_0 = a_1 V_i + a_3 V_i^3$. Here, a_1 and a_3 are constants. The mid-band frequency and the bandwidth of the bandpass filter are given as f_c and $2W$ respectively.

i) Write a mathematical expression for the output current i_0 at point A. [2 Marks]

ii) Sketch the amplitude spectrum of the i_0 at point A. Assume that $m(t)$, $m^2(t)$ and $m^3(t)$ occupy the frequency intervals $-W < f < W$, $-2W < f < 2W$ and $-3W < f < 3W$ respectively. For illustration purpose, you may use triangular shape amplitude spectrum for $m(t)$, $m^2(t)$ and $m^3(t)$. [2 Marks]

iii) Show that f_c must be greater than $6W$ to extract DSB-SC signal with carrier frequency f_c from i_0 at point B. [2 Marks]

b) Frequency discriminator is used to demodulating FM signals. [2 Marks]

i) What are the main components of the frequency discriminator? [2 Marks]

ii) Explain the main functionalities of the components given in part b) i). [2 Marks]

- Q4 a) i) Briefly explain sampling, quantization and encoding operations performed in a Pulse Code Modulation (PCM) system. [2.5 Marks]
- ii) Explain two types of quantization errors that occur in Delta Modulation (DM). Use appropriate diagrams to support your answer. [2.5 Marks]
- b) A PCM system which operates at a bit rate of 50Mbps uses a midrise type uniform quantizer followed by a 7-bit binary encoder.
- i) What is the maximum message bandwidth if the system operates satisfactorily? [2.5 Marks]
- ii) Determine the quantization error in the PCM system. Assume that the quantization error is a uniformly distributed random variable and the message signal is a sinusoidal signal that swings between -1 and +1. [2.5 Marks]
- Q5 a) i) List two simple digital passband modulation techniques. [2 Marks]
- ii) Draw the modulated waveforms of two digital passband modulation techniques listed in part a) i) when the input bit stream is 10010111001. [3 Marks]
- b) i) List two M-ary digital modulation schemes. [2 Marks]
- ii) Explain in which situation M-ary digital modulation schemes are preferred over binary digital modulation schemes. Use appropriate equations to support your answer. [3 Marks]

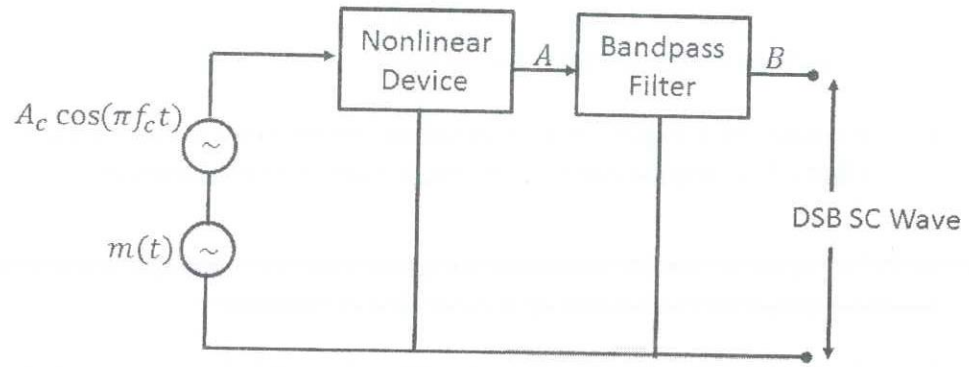


Figure Q3 : DSB-SC Modulation System.