UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 4 Examination in Engineering: December 2018

Module Number: EE4301 **Module Name: Communication Theory**

[Three Hours]

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

Q1 a) i) List the components of a typical communication system and briefly explain their functions.

[3 Marks]

ii) State three benefits of modulation in a communication system.

[1 Marks]

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

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

If $r > 0$, the decision at the receiver is '1'. Otherwise, the decision is '0'. 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 $p(n) = \frac{1}{\sqrt{2\pi\sigma_n^2}} e^{-n^2/2\sigma_n^2}$.

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

[1.5 Marks]

ii) What is the error probability of making 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 $Q(x) = \frac{1}{\sqrt{2\pi}} \int_x^\infty e^{-y^2/2}\, dy$]

[3 Marks]

Q2 a) i) List two practical limitations of conventional Amplitude Modulation (AM) scheme.

[1 Mark]

ii) Briefly explain how the limitations listed in part i) are solved in Double Sideband Suppressed Carrier (DSB-SC), Single Sideband (SSB) and Vestigial Sideband (VSB) modulation schemes.

[2 Marks]

iii) Briefly explain why the envelope detection cannot be used to demodulate DSB-SC modulated waveforms.

[1 Marks]

b) The message signal $m(t)$ whose spectrum is shown in Figure Q2-a is passed through the system shown in Figure Q2-b. The bandpass filter has the bandwidth of $2W$ and centered at f_0 and the low pass filter has a bandwidth of W.

i) Write mathematical expressions for the time domain and frequency domain representations of the signals at points A, B, C, D and E in Figure Q2-b.

[2.5 Marks]

ii) Sketch the spectrum of the signals at points A, B, C, D and E.

[2.5 Marks]

iii) Determine the bandwidth of signals at points A, B, C, D and E.

[1 Marks]

Q3 a) i) List two types of frequency modulation schemes.

[1 Mark]

ii) Explain the difference between the frequency modulation schemes listed in part i).

[1.5 Marks]

iii) Use Carson's rule to approximate the transmission bandwidth of the frequency-modulated signals.

[1.5 Marks]

b) The message signal $m(t) = 10\ sinc(400t)$ frequency modulates the carrier $c(t) = 100\ cos(2\pi f_c t)$. The modulation index is 6.

i) Write a mathematical expression for the FM modulated signal.

[2 Marks]

ii) Determine the maximum frequency deviation of the signal.

[2 Marks]

iii) Using Carson's rule, find the bandwidth of the modulated signal.
[Hint: $\mathcal{F}[sinc(at)] \Leftrightarrow \frac{1}{a} rect[\frac{f}{a}]$]

[2 Marks]

Q4 a) i) List three basic operations performed in a Pulse Code Modulation (PCM) system.

[1 Mark]

ii) Briefly explain the functions of the three basic operations listed in part i).

[3 Marks]

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

i) Determine the minimum sampling rate required.

[2 Marks]

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

[2 Marks]

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

[2 Marks]

Q5 a) i) Explain the difference between digital baseband modulation techniques and digital passband modulation techniques.

[2 Marks]

ii) List three simple digital passband modulation techniques and draw the modulated waveforms of them for the input bit stream 0111001001.

[3 Marks]

b) i) Explain in which situations M-ary digital modulation schemes are preferred over binary digital modulation schemes.

[2 Marks]

iii) Explain how the input bit stream 0111001001 can be modulated with QPSK digital modulation scheme.

[3 Marks]

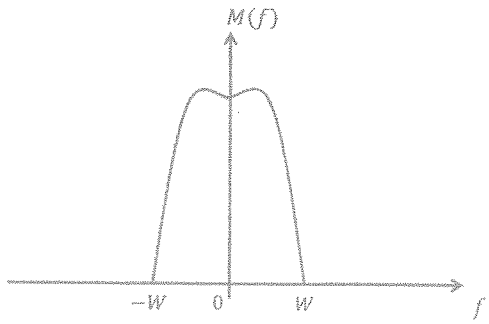

Figure Q2-a Spectrum of message signal $m(t)$.

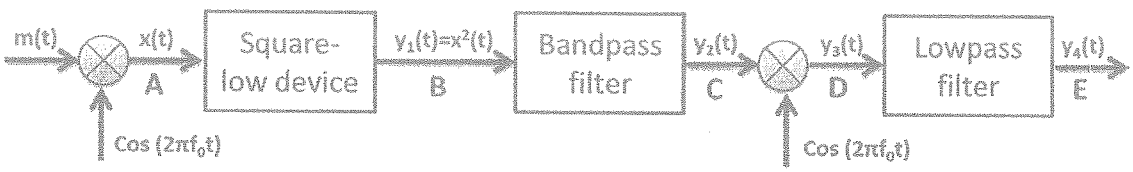

Figure Q2-b Block diagram of AM communication system.