National University of Computer and Emerging Sciences
Lahore Campus

Analog and Digital Communication (EE3003)

Final Exam

Total Time (Hrs): 3
Total Marks: 100
Total Questions: 5

Date: December 30, 2024

Course Instructor(s)

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2. Mohsin Yousuf

7638 _____ Roll No

5 A _____ Section

_____ Student Signature

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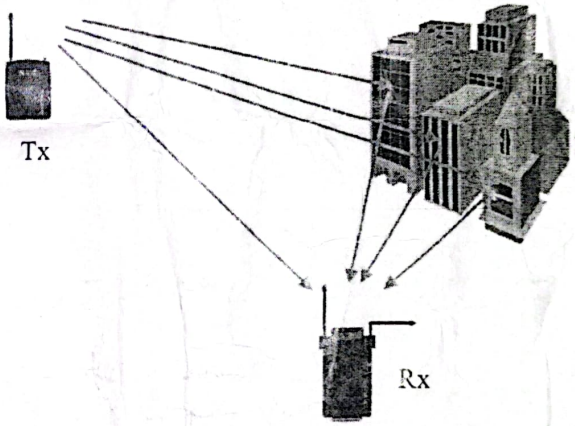
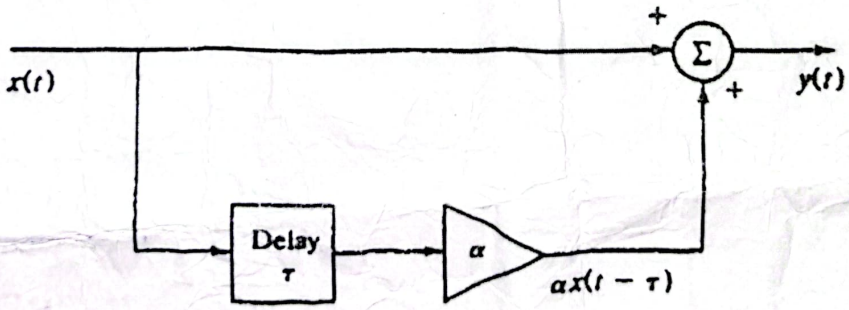
1. **Attempt all the questions. Attempt all parts of the same question together.**
2. **Show all the steps with the help of diagrams and mathematical equations.**

CLO # 01: Recognize the parameters of a communication system and the noise/distortion therein.

Q1: A multipath transmission occurs when a transmitted signal arrives at the receiver by two or more different paths as shown in the figure ahead. **[20 marks]**



A simple model for a multipath (in this case two) communication channel is illustrated in the figure below.



(a) **Write** the output $y(t)$ and the system transfer function, $H(\omega)$ for this multipath channel. **[12]**

(b) **Sketch** the magnitude spectrum $|H(\omega)|$ *vs* ω for $\alpha = 1$ and 0.5 on the same plot. **[8]**

CLO # 02: Compute energy and power spectral density of the signal.

Q2: **[20 marks]**

(a) For the signal, **[10]**

$$g(t) = \frac{12a}{t^2 + a^2}$$

Determine the essential bandwidth B Hz of $g(t)$ such that the energy contained in the spectral components of $g(t)$ of frequencies below B Hz is 95% of the signal energy.

Hint part (a):

$$e^{-a|t|} \Leftrightarrow \frac{2a}{a^2 + \omega^2}$$

Use symmetry property:

$$G(t) \Leftrightarrow 2\pi g(-\omega)$$

to find the spectrum $G(\omega)$.

The energy can be computed as:

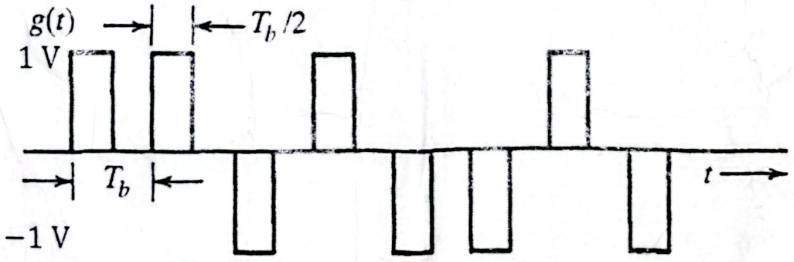
$$E_g = \frac{1}{\pi}\int_0^{\infty} |G(\omega)|^2 d\omega$$

(b) Figure shows a random binary pulse train $g(t)$. The pulse width is $T_b/2$ and one **bi**nary digit (**bit**) is transmitted every T_b seconds. A binary **1** is transmitted by the positive pulse of amplitude 1 V, and a binary **0** is transmitted by a negative pulse of amplitude -1 V. The two symbols are equally likely and occur randomly. **[10]**

Determine the autocorrelation function $\mathcal{R}_g(\tau)$ and PSD $S_g(\omega)$. **Sketch** them as well.

Hint part (b):

$$\Delta\left(\frac{t}{\tau}\right) \Leftrightarrow \frac{\tau}{2}\text{sinc}^2\left(\frac{\omega\tau}{4}\right)$$



CLO # 03: Demonstrate the concept of analog amplitude modulation and demodulation techniques.

Q3: Consider an AM signal with dual-tone modulation where the modulation signal $m(t)$ is given by **[20 marks]**

$$m(t) = \cos\omega_m t + 2\sin 3\omega_m t$$

and the carrier $c(t)$ is given by

$$c(t) = 5\cos\omega_c t; \quad where\ \omega_c \gg \omega_m$$

Find the following: **[12]**

(i) $\varphi_{AM}(t)$, AM modulated signal.

(ii) $\Phi_{AM}(\omega)$, the spectrum of the AM modulated signal.

(iii) **Sketch** the spectrum of the dual tone AM modulated signal.

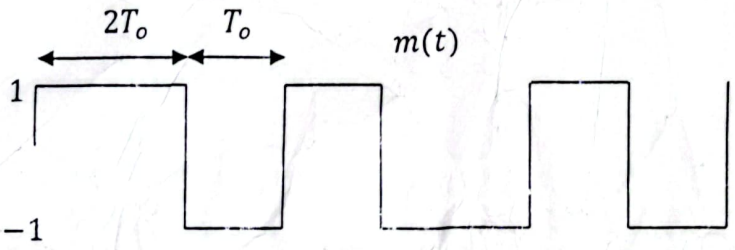
(b) An amplitude modulated signal is given by [8]

$$\varphi_{AM}(t) = 2.5\,[b + 3\cos\omega_m t]\cos\omega_c t, \quad for\ \omega_m \ll \omega_c$$

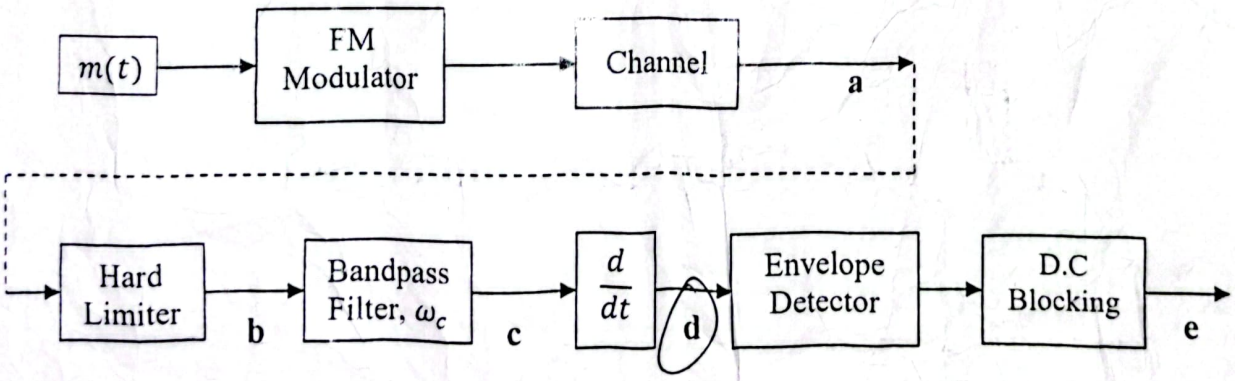
Find the power efficiency 'η' of the AM signal for, **(i)** $b = 9$ and **(ii)** $b = 3$. Suggest which value of b results in better η.

CLO # 04: Demonstrate the concept of analog frequency modulation and demodulation techniques.

Q4: A message signal $m(t)$, shown in figure below, modulates a carrier with frequency $f_c = 10\ kHz$ with $\Delta f = 1\ kHz$. The carrier amplitude is A. When the modulated signal is passed through the channel its amplitude is changed randomly. The received signal is demodulated by passing through different blocks as shown in the following block diagram. **[20 marks]**



Sketch the output wave form, approximated, at points **a, b, c, d,** and **e**. **Find** the values of f_c and Δf at point **c**.



CLO # 05: Demonstrate analog signal to digital signal conversion with encoding and interpret demodulation/detection of digital signals.

Q5: **[20 marks]**

(a) **Draw** the block diagram of DPCM (Differential Pulse Code Modulation) transmitter and receiver by using a 3rd order linear predictor. Why we need a Quantizer block at the transmitter side? **Demonstrate** with the help of necessary equations. **[10]**

(b) Five telemetry signals, each of bandwidth 2 kHz, are to be transmitted simultaneously by binary PCM. The maximum tolerable error in sample amplitudes is 0.15% of the peak signal amplitude. The signals must be sampled at least 25% above the Nyquist rate. Framing and synchronizing requires an additional 1% extra bits. Answer the following: **[10]**

(i) **Determine** the *sampling rate* by considering the criteria given above.

(ii) **Determine** the *minimum possible data rate* possible to achieve by catering multiplexing and the extra bits.

(iii) Also, **find** the *minimum transmission bandwidth* required to transmit the signal.
