National University of Computer and Emerging Sciences
Lahore Campus

Analogue & Digital Communication (EE3003)

Sessional-I Exam

Date: September 22, 2025

Course Instructor(s)

1. Mohsin Yousuf (Course Moderator)
2. Aroosa Umair

Total Time (Hrs):	**1**
Total Marks:	**60**
Total Questions:	**2**

Roll No ____________ Section ____________ Student Signature ____________

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

***CLO # 01: Explain** the behavior of a communication system and the noise/distortion therein.*

Q1: **[30 marks]**

(a) **Draw** block diagram of Shannon-Weaver Model for Communication. **Discuss** in detail the channel impairments caused by *noise* (both external and internal) and *distortion* (both linear and non-linear) with examples. [5]

(b) **Describe** the exponential relationship between SNR (Signal-to-Noise ratio) and B (Bandwidth) elaborating the exchange between them for *power-limited* and *band-limited* channels. [5]

(c) A wireless receiver block is shown in the Fig 1. below. It consists of a receiving antenna which delivers a signal to a bandpass filter. The antenna feed has a loss of −3.6 dB and the filter's loss is −3.1 dB. [4]

$$P_{osc} = +14.2 \text{ dBm}$$

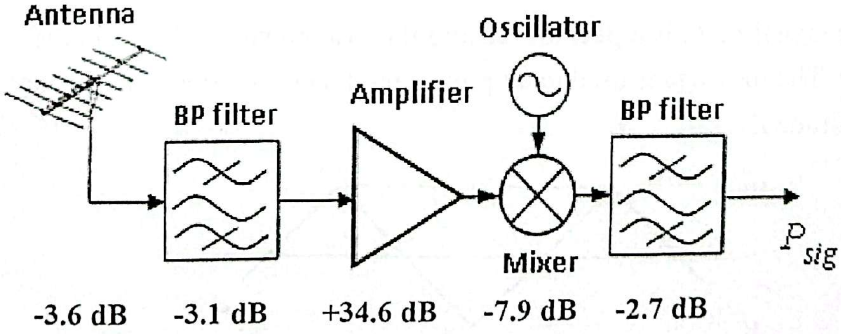


Figure 1. Wireless Receiver with Gain and Loss

The filter's output drives an amplifier with gain of +34.6 dB and this RF signal is input to a mixer which performs a frequency translation to an IF signal (but the mixer has a loss of −7.9 dB).
Finally, the IF signal travels through another bandpass filter with a nominal loss of −2.7 dB. If the signal strength output by the last filter is $P_{sig} = -90$ dBm, **find** the signal strength of the signal P_{ant} incident upon the antenna itself and **express** P_{ant} in milliwatts (mW).

(d) A communication channel has a signal power $S = 25$ milliwatts (mW) with an average noise power $N = 3$ mW. The channel's transmission medium has a bandwidth B of 2 MHz. **[6]**

(i) **Find** the channel capacity.

(ii) Again, **compute** the channel capacity if the SNR is doubled and the bandwidth B is reduced by a factor of 4.

(e) A certain channel has ideal amplitude, but non-ideal phase response as shown in the Fig. 2, given by **[10]**

$|H(\omega)| = 1$

$\theta_h(\omega) = -\omega t_0 - k \sin \omega T\,, \qquad k \ll 1$

Hint: Use approximation,

$e^{-jk \sin \omega T} \approx 1 - jk \sin \omega T.$

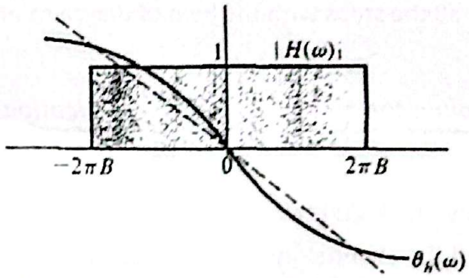
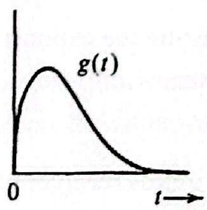


Figure 2. A filter with nonideal phase response

(i) A pulse $g(t)$ bandlimited to B Hz is applied at the input of this filter. **Find** and **sketch** the output, $y(t)$.

(ii) **Discuss** whether and how this channel will affect TDM and FDM systems from the view point of interference among multiplexed signals.



*CLO # 02: **Apply** the concept of sampling, analog amplitude and frequency modulation and demodulation techniques*

Q2: **[30 marks]**

(a) The message signal $m(t)$ is a **periodic triangular waveform** as shown in the Fig 3. below. The message is used to amplitude modulate a carrier of frequency ω_c and amplitude A_c.

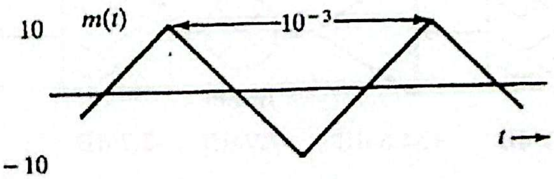


Figure 3. Modulating signal waveform m(t)

(i) **Sketch** the AM signal, $\varphi_{AM}(t)$ corresponding to the modulation index: $\mu = 0.5$. [5]

(ii) **Calculate** the carrier power P_c, sideband power P_{SB}, and the total transmitted power P_T. [5]

(iii) **Find** the power efficiency η of the AM system. [5]

(b) Fig. 4 shows a switching demodulator circuit used for amplitude demodulation. **Draw** the circuit between ab. **Mention** the type of demodulation and mathematically **exposit** the output expression $z(t)$. [15]

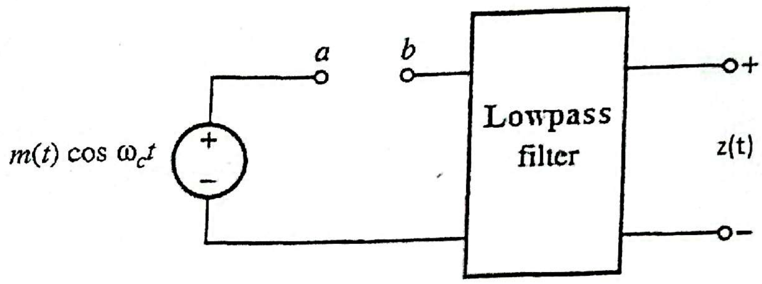


Figure 4. Switching Demodulator Circuit

Hint:

$$w(t) = \frac{1}{2} + \frac{2}{\pi}\left(\cos\omega_c t - \frac{1}{3}\cos 3\omega_c t + \frac{1}{5}\cos 5\omega_c t - \ \ldots\right)$$

$$w_0(t) = \frac{4}{\pi}\left(\cos\omega_c t - \frac{1}{3}\cos 3\omega_c t + \frac{1}{5}\cos 5\omega_c t - \ \ldots\right)$$

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Analog and Digital Communication (EE3003)

Final Exam

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

Date: December 24, 2025

Course Instructor(s)

1. Mohsin Yousuf (Course Moderator)
2. Aroosa Umair

Roll No 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.**

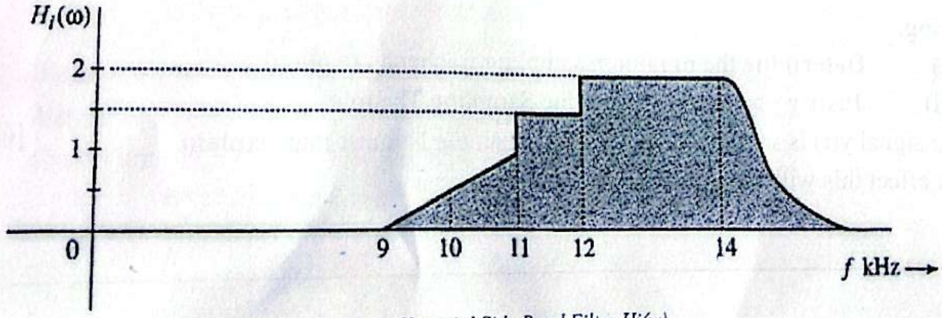
CLO # 02: ***Apply the concept of sampling, analog amplitude and frequency modulation and demodulation techniques.***

Q1: **[20 marks]**

(a) **Name** three modulation schemes that are bandwidth efficient. [5]

(b) **Draw and mathematically exposit** Vestigial Sideband (VSB) transmitter (modulator) and receiver (demodulator). Clearly **label** each block and **describe** its function. [7]

(c) The transfer function of a vestigial sideband filter $H_i(\omega)$ is shown in Fig. 1 given below. The carrier frequency is $f_c = 10$ kHz and the baseband signal bandwidth is 4 kHz. **Determine and sketch** the corresponding transfer function of the equalizer filter $H_o(\omega)$ at the receiver. [8]



CLO 02

Figure 1. Vestigial Side Band Filter Hi(w)

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Q2: Given that the frequency sensitivity $k_f = 200{,}000\pi$ and phase sensitivity $k_p = 10$. Assume the bandwidth of $m(t)$ to be equal to the third harmonic frequency of $m(t)$. **[20 marks]**

For the modulating signal

$$m(t) = \sin(2000\pi t)$$

(a) **Estimate** and **calculate** the bandwidth of frequency modulated signal B_{FM} and the phase modulated signal B_{PM}. **[8]**

(b) **Analyze and comment** on the effect on bandwidth for the following cases: **[12]**

- **(i)** when the amplitude of $m(t)$ is doubled.
- **(ii)** when $m(t)$ is time expanded by a factor of 2.
- **(iii)** when the frequency of $m(t)$ is doubled.

CLO 02

Q3: The signals $g_1(t) = 10^4\, rect(10^4 t)$ and $g_2(t) = \delta(t)$ are applied at the inputs of ideal low-pass filters with frequency responses, **[20 marks]**

$$H_1(\omega) = rect\left(\frac{\omega}{40{,}000\pi}\right), \qquad H_2(\omega) = rect\left(\frac{\omega}{20{,}000\pi}\right)$$

The outputs are then multiplied to produce $y(t) = y_1(t)\, y_2(t)$.

CLO 02

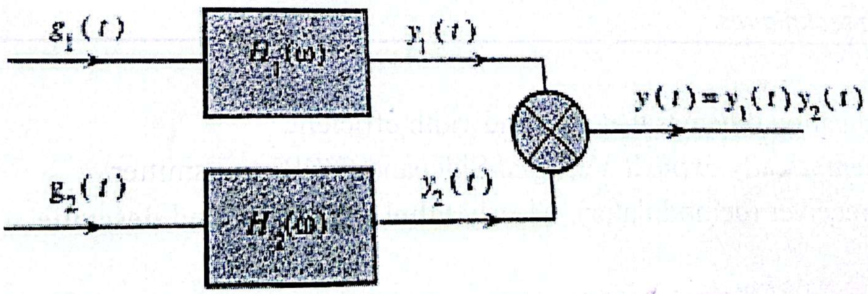

Figure 2. Low Pass Filter

(a) **Determine** the outputs $y_1(t)$ *and* $y_2(t)$ of the two filters. **[4]**

(b) **Find** the Nyquist rate of $y_1(t), y_2(t)$ and the combined signal $y(t)$. **[4]**

(c) Assume that the signal $y(t)$ is to be sampled and reconstructed without aliasing. **[6]**

- **i)** **Determine** the minimum sampling frequency required.
- **ii)** **Justify** your answer using the Sampling Theorem.

(d) If the signal y(t) is sampled at a rate lower than the Nyquist rate, **explain** what effect this will have on the reconstructed signal. **[6]**

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CLO # 03: Analyze different digital communication techniques, modulation schemes, and coding methods to evaluate system performance under noise and channel impairments.

Q4: **CLO 03** **[20 marks]**

(a) A band-limited video signal $v(t)$ of $4\ MHz$ bandwidth is sampled at a rate of $33\frac{1}{3}\%$ higher than the Nyquist rate. The maximum allowable error in the sample amplitude (i.e. the maximum quantization error) is 0.45% of the peak amplitude v_P. Assuming binary encoding PCM, answer the following: **[12]**

- **i)** **Find** the Nyquist rate and the Actual rate of sampling.
- **ii)** **Find** the number of bits, n to be transmitted per sample and the quantization levels, L.
- **iii)** **Define** *maximum information rate* theorem and **find** the minimum transmission bandwidth of the channel to transmit 32 such encoded binary signals (also known as $T1$ line in the Bell Telephone system).

(b) **Draw** the block diagram of Delta-Modulated (DM) transmitter (modulator) and receiver (demodulator) with mathematical **exposition.** **[4]**

(c) A DM system is designed to operate at eight (8) times the Nyquist rate. The signal bandwidth B at its input port is $4\ kHz$ and the quantized step Δ is $350\ mV$. Assuming $f_m = 2\ kHz$ message sinusoidal input, **find** the maximum amplitude A_m of this tone that avoids slop overload. **[4]**

Q5: **CLO 03** **[20 marks]**

(a) Consider the binary sequence "**0 1 1 0 0 1 0 1**", **find** and **draw** the waveforms of the following signaling formats: **[12]**

- **i)** Binary Unipolar NRZ signaling
- **ii)** Bipolar RZ (AMI) signaling
- **iii)** Manchester (Split-Phase) signaling
- **iv)** Differential Manchester encoding

(b) **Discuss** the advantages and disadvantages of Bipolar NRZ scheme. **[4]**

(c) Answer the following as ***True*** or ***False***. For the ***False*** ones, **give** the correct answer. For the ***True*** ones, **justify** your answer. **[4]**

- **i)** Binary encoded waveforms occupy more bandwidth than $m(t)$.
- **ii)** Baud-rate is always higher than bit rate.
- **iii)** Increasing the number of quantization levels has no effect on bandwidth.
- **iv)** Line codes are used to reduce bandwidth requirement.

National University of Computer and Emerging Sciences 0076
Lahore Campus

Analogue & Digital Communication (EE3003)

Sessional-II Exam

Date: November 03, 2025

Course Instructor(s)

1. Mohsin Yousuf (Course Moderator)
2. Aroosa Umair

Total Time (Hrs): 1
Total Marks: 40
Total Questions: 2

_______________ _______________ _______________
Roll No Section Student Signature

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

CLO # 02: Apply the concept of sampling, analog amplitude and frequency modulation and demodulation techniques.

Q1: **[20 marks]**

(a) A modulating signal $m(t)$ is given by, **(10)**

$$m(t) = 10\cos(1500\, t)$$

The carrier angular frequency, ω_c is 10,000 rad/s.

- **(i)** **Determine** the Lower Sideband and Upper Sideband modulated signals denoted by $\varphi_{LSB}(t)$, $\varphi_{USB}(t)$ respectively.
- **(ii)** **Represent** these signals in the form of Single Sideband $\varphi_{SSB}(t)$.
- **(iii)** **Sketch** the corresponding frequency spectrum.
- **(iv)** Mathematically **exposit** that if carrier amplitude, $A \gg m(t)$, $m(t)$ can be recovered from φ_{SSB+C} using envelope or rectifier detection. Also **name** this type of demodulation.

(b) **(10)**

- **(i)** **Describe** the process of Sampling and **state** the Sampling Theorem precisely with the importance of Nyquist criterion.
- **(ii)** **Demonstrate** ideal interpolation for a signal $g(t)$ band-limited to B Hz both in time and frequency-domain with the help of equations and diagrams.

  Hint: $H(\omega) = T_s \operatorname{rect}\left(\frac{\omega}{4\pi B}\right)$

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CLO # 02: Apply** the concept of sampling, analog amplitude and **frequency modulation and demodulation techniques

Q2: **[20 marks]**

(a) The modulating signal $m(t)$ is a periodic sawtooth signal as shown in Figure 1, where $\omega_c = 2\pi \times 10^6$ rad/s, $k_f = 2000\pi$, and $k_p = \pi/2$. **(16)**

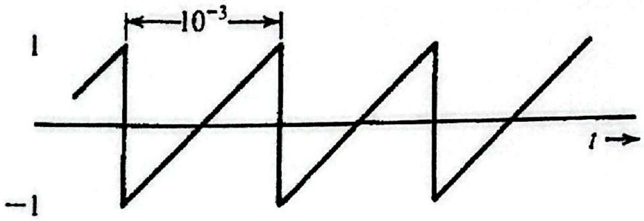

Figure 1. A periodic sawtooth waveform

(i) **Write** equations for $\varphi_{FM}(t)$ and $\varphi_{PM}(t)$.

(ii) **Determine** the frequency deviation Δf.

(iii) **Estimate** the bandwidth of the angle modulated signals, both B_{FM} and B_{PM}. Assume the bandwidth of $m(t)$ to be the fifth harmonic frequency of $m(t)$.

(iv) **Sketch** $\varphi_{FM}(t)$ and $\varphi_{PM}(t)$ for this signal $m(t)$.

(b) **Expose** the values for an Armstrong indirect FM modulator (for the block diagram in Figure 2) to generate an FM carrier with a carrier frequency of $98.1\ MHz$ and $\Delta f = 75\ kHz$. The following equipment is available: **(4)**

(i) NBFM generator with local oscillator of 100 kHz and $\Delta f = 10\ Hz$.

(ii) An adjustable frequency oscillator in the range of 10 to 11 MHz.

(iii) A BPF and frequency doublers, triplers, and quintuplers ($\times$ 5).

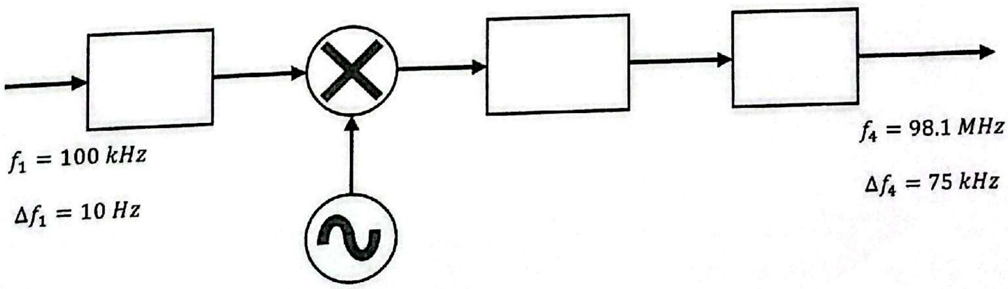

Figure 2. Block Diagram of the Indirect Armstrong FM Modulator