(6)

B.Sc. in EEE, 4th Semester May 29, 2024 **(Morning-Group B)**

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

Semester Final Examination
Course No.: EEE 4403
Course Title: Communication Engineering I

Summer Semester, A. Y. 2022-2023
Time: 3 Hours
Full Marks: 150

There are 3 **(three)** questions. Answer all 3 **(three)** questions. The symbols have their usual meanings. Programmable calculators are not allowed. Marks of each question and corresponding COs and POs are written in the brackets.

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1. a) For an OFDM receiver system employing coherent demodulation, show that different received sinusoidal signals are orthogonal. **15** **CO1, PO1**

   b) Followings are the user's code for a CDMA system: **10** **CO1, PO1**

   User A code = [-1, -1, 1, 1, -1, –1, 1, 1]
   User B code = [-1, -1, -1, -1, 1, 1, 1, 1]
   User C code = [-1, 1, 1, -1, 1, -1, -1, 1]

   Find:
   i) Transmission from A, receiver attempts to recover A's transmission,
   ii) Transmission from B, receiver attempts to recover A's transmission,
   iii) Transmission from B and C, receiver attempts to recover B's transmission.

   c) Assume that the sampling period is normalized to be $T_s = 1$ second and the amplitude of the signal $\mathbf{m}(kT_s)$ is zero mean and uniformly distributed in (-Vmax,Vmax) (first-order statistics). Also the correlation function (second-order statistics) is given by **15** **CO1, PO1**

   $$R_m(\tau) = e^{-|\tau|/100}$$

   i) Assume that the number of quantization levels is 256. Calculate the mean-square quantization error for an optimum quantizer designed for $\mathbf{m}(kT_s)$.
   ii) Consider the differential quantization system and assume that a first-order linear predictor has been used as illustrated in Figure 1(c). Choose the coefficient of the linear predictor under the minimum mean-square error (MMSE) criterion.

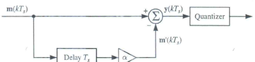

Figure 1(c): Differential quantization with a first-order linear predictor

d)	Derive the SNR of a PPM system using sinusoidal modulation. Mention the steps to be followed for the detection of PPM waves.	10	CO1, PO1

2. a) Twenty-four voice signals are sampled uniformly and then time division multiplexed (TDM). The sampling operation uses flat-top samples with 1 μs duration. The multiplexing operation includes provision for synchronization by adding an extra pulse also of 1 μs duration. The highest frequency component of each voice signal is 3.4 kHz. — 10 — CO1, PO1

   i) Assuming a sampling-rate of 8 kHz and uniform spacing between pulses, calculate the spacing (the time gap between the ending of a pulse and the starting of the next pulse) between successive pulses of the multiplexed signal.
   ii) Repeat your calculation using Nyquist-rate sampling.

b) Consider a source, m(t), whose amplitude statistics are as follows: — 10 — CO1, PO1

$$f_m(m) = \begin{cases} \frac{1}{4}, & -1 \le m \le +1 \\ \frac{1}{12}, & -4 \le m \le -1 \\ \frac{1}{12}, & +1 \le m \le +4 \\ 0, & \text{otherwise} \end{cases}$$

   i) Design an optimum three-bit quantizer.
   ii) Determine the SNR_q.

c) Consider a narrowband FM signal approximately defined by — 15 — CO1, PO1

$$s(t) \approx A_c \cos(2\pi f_c t)\, \beta A_c \sin(2\pi f_m t) \sin(2\pi f_c t).$$

   i) Determine the envelope of s(t). What is the ratio of the maximum to the minimum value of this envelope.
   ii) Determine the total average power of the narrowband FM signal. Determine the total average power in the sidebands.

d) Consider the mobile radio link illustrated in Figure 2(d). In the figure a user stands at point A, at a distance d from the base station. The propagation delay from point A to the base station is T_d. Consider that a single tone $s(t) = \cos(2\pi f_c t)$ is transmitted from the user and let f_c =1.2 gigahertz. Neglecting the noise, the waveform received at the base station is $r(t) = \cos[2\pi f_c(t+T_d)]$. — 15 — CO1, PO1

   i) If the user moves away from the base station to point B, or toward the base station to point C, find the minimum distance of the movement that will cause a 2π rotation of the received waveform.
   ii) Find the impact of 2π phase rotation. Find the minimum distances of the user's movement that cause $\pi/2$ and π phase rotations.

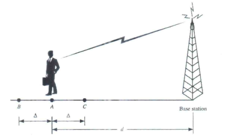

Figure 2(d)

3. a) Figure 3(a) shows the block diagram of a wideband frequency modulator using the indirect method. Note that a mixer is essentially a multiplier, followed by a bandpass filter which allows only the difference frequency component. This transmitter is used to transmit audio signals in the range 100 Hz to 15 kHz. The narrowband frequency modulator is supplied with a carrier of frequency $f_1 = 0.1$ MHz. The second oscillator supplies a frequency of 9.5 MHz. The system specifications are as follows: carrier frequency at the transmitter output $f_c = 100$ MHz with frequency deviation, $\Delta f = 75$ kHz. Maximum modulation index at the output of the narrowband frequency modulator is 0.2 rad. **15** **CO1, PO1**

   i) Calculate the frequency multiplication ratios n_1 and n_2.
   ii) Specify the value of the carrier frequency at the output of the first frequency multiplier.

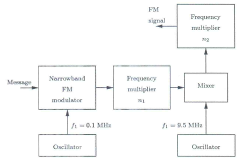

Figure 3(a): Wideband frequency modulator using the indirect method

b) Describe the followings: **20** **CO1, PO1**

i) Delta modulation,
ii) Advantage of PPM over PWM,
iii) Quantization and Sampling,
iv) TDMA.

c) With pictorial demonstration of sinusoidal modulated signal, explain frequency and phase modulation scheme. **05** **CO1, PO1**

d) An angle-modulated signal with carrier frequency $\omega_c = 2\pi \times 10^6$ is described by the equation: **10** **CO1, PO1**

$$\varphi_{EM}(t) = 10\cos\,(\omega_c t + 5\sin 3000t + 4\sin 2000\pi t).$$

i) Assuming that this is an FM signal, determine the modulation index and the transmitted signal bandwidth.
ii) Assuming that this is an PM signal, determine the modulation index and the transmitted signal bandwidth.