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B.Sc. Engg. (EE), 7th Sem. Date: 04 October, 2023 (Afternoon)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

Mid-Semester Examination — Summer Semester, A. Y. 2022-2023
Course No.: EEE 4703 — Time: 90 Minutes
Course Title: Communication Engineering II — Full Marks: 75

There are **3 (three)** questions. Answer **all 3 (three)** questions. The symbols have their usual meanings. Marks of each question and corresponding CO and PO are written in brackets.

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1. a) In *natural sampling*, an analog signal $g(t)$ is multiplied by a periodic train of rectangular pulse $c(t)$, each of unit area. Given that the pulse repetition frequency of this period train is f_s and the duration of each rectangular pulse is T (with $f_s T << 1$), do the following: (10)
(i) Find the spectrum of the signal $s(t)$ that results from the use of natural sampling; you may assume that time $t = 0$ corresponds to the midpoint of a rectangular pulse in $c(t)$.
(ii) Show that the original signal $g(t)$ may be recovered exactly from its naturally sampled version, provided that the conditions embodied in the sampling theorem are satisfied. **CO1, PO1**

b) Find the optimal decision rule for FSK modulation technique and compare its BER with that of the ASK and BPSK modulation. (5)

c) Five telemetry signal, each of bandwidth 1 kHz, are to be transmitted simultaneously by binary PCM. The maximum tolerable error in sample amplitudes is 0.2% of the peak signal amplitude. The signals must be sampled at least 20% above the Nyquist rate. Framing and synchronizing requires an additional 0.5% extra bits. Determine the minimum possible data rate (bits per second) that must be transmitted, and the minimum bandwidth required to transmit this signal. (10)

2. a) The purpose of a radar system is basically to detect the presence of a target, and to extract useful information about the target. Suppose that in such a system, hypothesis H_0 is that there is no target present, so that the received signal $x(t)=w(t)$, where $w(t)$ is white Gaussian noise with power spectral density $N_0/2$. For hypothesis H_1, a target is present, and $x(t) = w(t) + s(t)$, where $s(t)$ is an echo produced by the target. Assumed that $s(t)$ is completely known and the probability of the existence of a target is 0.5. (10) **CO1, PO1**
(i) Determine the structure of the optimal receiver.
(ii) Determine the PDF of the decision variable and the optimal decision threshold.
(iii) Evaluate the *probability of false alarm* defined as the probability that the receiver decides a target is present when it is not.

b) Derive the overall probability of symbol error of QPSK scheme. 10

c) Find the condition for maximum SNR of a digital communication receiver system. 5

3. a) Consider a digitally modulated signal with pulse shaping $p(t) = \text{sinc}(Ft)$, where $\text{sinc}(x) = \sin(\pi x)/\pi x$. The transmitted waveform is $a_0 p(t)$, and symbol a_0 belongs to a BPSK constellation with inter symbol spacing d. The noise at the receiver is additive white Gaussian with autocorrelation $\eta\delta(\tau)/2$. At the receiver, the signal is passed through the optimal filter followed by sampling at T. 5 **CO1, PO1**

(i) Find the signal power at the output of the matched filter.
(ii) Find the noise power at the output of the matched filter.

b) Derive the transfer function of Duobinary Signaling. 10

c) A system using matched filter detection of equally likely BPSK signals, $s_1(t) = \sqrt{2E/T}\cos\omega_0 t$ and $s_2(t) = \sqrt{2E/T}\cos(\omega_0 t + \pi)$, operates in AWGN with a received E_b/N_0 of 6.8 dB. Assume that $E\{z(T)\} = \pm\sqrt{E}$. 10

(i) Find the minimum probability of bit error, P_B, for this signal.
(ii) If the decision threshold is $\gamma = 0.1\sqrt{E}$, find P_B.