UE16EC352#478#22

SRN

PES University, Bangalore

(Established under Karnataka Act No. 16 of 2013)

UE16EC352

END SEMESTER ASSESSMENT (ESA): B.Tech. 6th SEM. – May 2019

UE16EC352 –DIGITAL COMMUNICATION

Time: 3 Hrs | Answer All Questions | Max. Marks: 100

1. (a) The signal $x(n) = A\cos\omega_o n$ is uniformly quantized with N bits per sample. Assuming N to be large, find the expression for the SNR of the quantized signal in dB. (6)

   (b) $x(n)$ is a sequence of samples from a uniform distribution over $[-8, 8]$. It is input to a DPCM system that uses an N-bit quantizer. The error signal $e(n)$ is uniformly distributed over $[-1, 1]$. The SNR is 60.06 dB. Find i) the prediction gain in dB, and ii) N. (6)

   (c) The signal $x(t) = A\cos 1000\pi t$ undergoes delta modulation with step size $\delta = 0.1$ and sampling frequency $f_s = 10$ kHz. What is the maximum value that A can take if slope overload is to be avoided? (4)

   (d) Indicate the bandwidth required for the following schemes, with $T_b = 0.1$ ms. (No need to derive it) (4)

   i. Bipolar NRZ

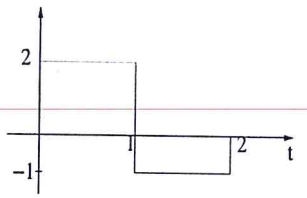
   ii. Manchester Coding NRZ

2. (a) Write the expression for the raised cosine pulse $p(t)$ and its spectrum $P(f)$. Derive the expression for $p(t)$ when $\alpha = 1$. (6)

   (b) An octal communication system ($M = 8$) uses raised cosine pulse shaping with $\alpha = 0.75$. If the first zero crossings of the raised cosine pulse $p(t)$ occur at $\pm 100\mu s$, find i) the symbol rate, ii) the bit rate, and iii) the bandwidth. (6)

   (c) Starting from the MAP decision rule, derive the minimum distance decision rule for the AWGN channel. Draw the block diagram of i) detector and ii) vector receiver. (8)

3. (a) Consider the signal $s(t)$ shown below.



   i. Plot $h(t)$, the impulse response of the filter matched to $s(t)$.

   ii. Suppose $s(t)$ is input to the matched filter. What is the output SNR at $t = 2$ sec, if the additive white Gaussian noise has a two-sided power spectrum $S_w(f) = 10^{-4}$ W/Hz? (4)

(b) Write the expression for the QPSK signal in terms of the basis signals and draw its constellation diagram. Derive the expression for the probability of symbol error. (7)

(c) A digital modulation system uses a bandwidth of 3 MHz. The additive white Gaussian noise has $N_0 = 10^{-19}$. Find the average carrier power required to achieve $P_e = 10^{-4}$, for the following cases: i) BFSK, ii) BASK, and iii) DPSK. Note that $erfc(2.75) = 10^{-4}$. (9)

4. (a) A fair coin is tossed 3 times. Let X indicate the number of Heads. Let the random variable Y be defined as follows:

$$Y = \begin{cases} 1 & \text{number of Heads} > \text{number of Tails} \\ 0 & \text{otherwise} \end{cases}$$

Find $H(X,Y)$ and $I(X;Y)$. (8)

(b) For any source, prove that the average length of any prefix code is greater than or equal to its entropy. (5)

(c) Find the Huffman code for the source whose symbols $\{x_1, \ldots, x_6\}$ have the probabilities $\{0.3, 0.25, 0.18, 0.10, 0.09, 0.08\}$. Also find the efficiency of the code. (7)

5. (a) Let X and Y indicate the input and the output respectively of a binary symmetric channel with $P_e = 0.15$. Another binary symmetric channel with $P_e = 0.1$ takes Y as input and outputs the random variable Z. Suppose $P(X = 0) = 0.4$. Find i) $I(X;Y)$ and ii) the capacity of the channel between X and Z. (7)

(b) Derive the capacity of the Gaussian channel $Y = X + Z$, where the noise Z is Gaussian with zero mean and variance σ^2. X satisfies the constraint $E[X^2] \leq P$. X and Z are independent. (7)

(c) An analog signal bandlimited to 6 kHz is sampled at twice the Nyquist rate, resulting in a sequence of independent samples. The samples are uniformly quantized into 256 equally likely levels.

i. Find the average information rate of this source.

ii. If this data is to be transmitted without errors over a channel with a bandwidth of 100 kHz, what is the minimum transmit power required? The additive white Gaussian noise has $N_0 = 10^{-10}$. (6)