Total number of printed pages–5

53 (EC 502) DGCM

2021

DIGITAL COMMUNICATION

Paper : EC 502

Full Marks : 100

Time : Three hours

The figures in the margin indicate full marks for the questions.

*Answer **any five** questions.*

1. *(a)* State 'Sampling theorem' for a band-limited low-pass signal. What is meant by 'aperture effect' in flat-top sampling? 2+3

   (b) Show that the output quantization SNR in a binary PCM is given by $SNR_Q\big|_{dB} = 1{\cdot}8 + 6 \times n$; where 'n' is the number of bits in a code word. 10

   (c) Discuss briefly the operation of a binary PCM. 5

Contd.

2. *(a)* Discuss the operation of a delta modulator. What are the two sources of noise in the delta modulator? Discuss briefly. 6+2+2

(b) Prove that the destination SNR for linear delta modulator (only granular noise) is given by

$\left(\frac{S}{N}\right)_D \leq \frac{3}{8\pi^2} \times \left(\frac{f_s}{W}\right)^3$; where 'f_s' is the sampling frequency and W is the LPF bandwidth. 10

3. *(a)* A delta modulator transmitter with a fixed step size of $0{\cdot}5V$ is given a sinusoidal message signal. If the sampling frequency is 20 times the Nyquist rate, find *(i)* the maximum permissible amplitude of the message signal avoiding slope-overload, *(ii)* the maximum destination SNR. 6+4

(b) Show that the BER (error probability) for a polar NRZ signal using matched filter technique is given by

$$P_e|_{\substack{Polar \\ NRZ}} = Q\left[\sqrt{\frac{2E_b}{\eta}}\right];$$

where E_b/η is the input SNR to the matched filter and Q is the Marcum Q-function. 10

4. *(a)* A baseband binary system transmits signal $S_1(t)$ for logic '1' and $S_2(t)$ for logic '0', where $S_1(t)$ and $S_2(t)$ are given by 12

$$S_1(t) = \begin{cases} A & ; \quad 0 \le t \le T/2 \\ A/2 & ; \quad T/2 \le t \le T \\ 0 & ; \quad \text{elsewhere} \end{cases}$$

and

$$S_2(t) = \begin{cases} A/2 & ; \quad 0 \le t \le T/2 \\ -A/2 & ; \quad T/2 \le t \le T \\ 0 & ; \quad \text{elsewhere} \end{cases}$$

The channel may be assumed to be AWGN with a noise PSD of $\eta/2$ and that the symbols are equiprobable. Find the energy of the two transmitted signals $S_1(t)$ and $S_2(t)$ and hence find the average energy per bit 'E_b'. Also prove that the bit error probability is given by

$$P_e = Q\left[\sqrt{\frac{5E_b}{7\eta}}\right]$$

(b) If $x(t)$ is a triangular pulse of $1ms$ width and 10^{-2} volts height, calculate the SNR at the output of a matched filter. Assume the channel noise to be white with a PSD of $10^{-8}\ W/Hz$. 8

5. (a) Discuss the coherent detection of BASK band pass signals and hence calculate the minimum error probability for such scheme. 10

(b) A microwave link is used for transmitting binary data at the rate of $1Mbps$. Assuming the two sided PSD of the noise at the input of the receiver to be $10^{-10}\ W/Hz$, find the average carrier power required to be maintained if the error probability (P_e) is not to exceed 10^{-4} ; when *(i)* coherent BPSK and *(ii)* coherent BFSK is used. Given that the inverse complementary error function of 2×10^{-4} is 2·629. 5+5

6. (a) For a lossless channel, show that $H(X|Y)=0$; where the symbols have their usual meaning. 10

(b) Write the channel matrix for a BSC channel. 5

(c) A certain BSC has an error probability of $p = 0{\cdot}2$, the probabilities of a logic '0' and logic '1' at the input are 0·4 and 0·6 respectively. What is the probability of receiving a logic '1' at the receiving end ? 5