Ref. No. : Ex/ET/T/313/2018

BETCE THIRD YEAR FIRST SEMESTER – 2018

Subject: DIGITAL COMMUNICATION SYSTEMS

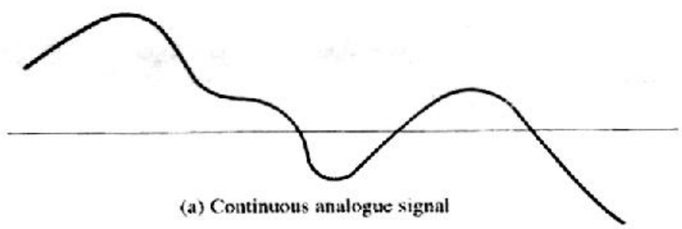
Time : 3 hours **Full Marks :100**

Answer Q.1 and any 4 from the rest

For each attempted question answer must be written at one place

2x10 =20

Q.1 a) The analog signal is shown in the Fig. below. Construct the digital and binary version of this signal.



(a) Continuous analogue signal

b) What are the performance metrics for digital communication system? What is the goal for communication system design?

c) Highlight some advantages of digital communication in terms of flexibility and reliable data reproduction.

d) Define the three fundamental steps for digital communication transformation ?

e) Define M-ary digital modulation and demodulation; coherent detection and non-coherent detection.

f) Show that auto correlation function and power spectral density of a random signal is a Fourier transform pair.

g) Draw the signal amplitude representation of a PAM-4 signal. Consider the signal of your choice.

h) The A-law compression characteristic is shown below. Explain the significance of the curve in terms of A and C(x).

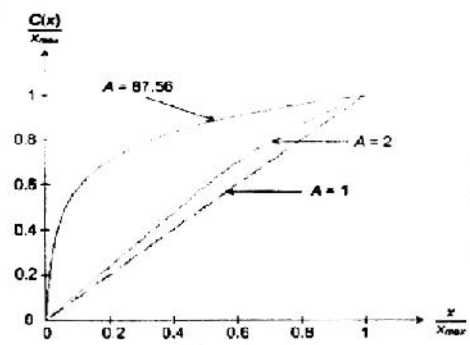
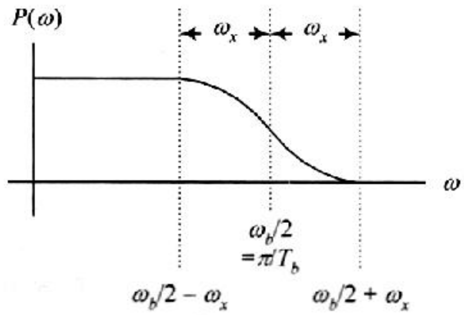


Fig. A-law compression characteristic

[Turn over

i) If the k^{th} sample of a signal is represented by $m[k] = a_1 m[k-1] + a_2 m[k-2] + ...+ a_N m[k-N]$, design th delta modulator circuit from this.

j) The spectrum of pulse shaping filter is shown below, what will be the roll of factor?



Q.2 a) Consider a baseband signal m(t) with signal excursion in the range of +4 V (V_{max}) to -4V (V_{min}) . Dra and justify the quantized version of the signal $m_q(t)$ with 8 equal levels. Give the quantized code values ar encoded words for 8 levels. What will be the quantization error? How does this error depend on step size and number of levels L? 4+2+2+2

b) When and why does non-linear quantization use? Name one important method of non linear quantization and highlight main principal of operation. 2+3

c) Let x(t) be modeled as the sample function of a zero mean stationary process X(t) with uniform PDF in the range of (-V, V). Find the *output signal to-quantization noise ratio* $(SNR)_{0,q}$, assume an R –bit code word per sample would be generated. What will happen if the code word length is increased from 3 to 4? 05

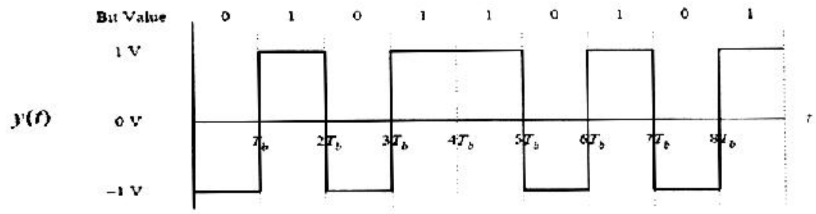
Q.3 a) State Shannon's information capacity theorem. Explain its significance interns of efficiency of digital communication and trade off between bandwidth and channel SNR. 0 5

b) For a discrete memory less system with symbol source S= $\{s_1, s_2, ...s_n\}$, and symbol probabili $\{p_1, p_2, ..., p_n\}$, what is the measure of information for s_i? Write the different properties of information ar remark on it. 0 5

c) What will be the average information from S, and information rate ? When is error free representation of source possible? 04

d) Draw the binary symmetric channel and find the Channel capacity for that. When dose entropy of this channel maximize? 06

Q.4 a) Consider the following Polar NRZ line code *y(t)*.



Decompose this signal into two signals, the information signal x(t) represented by a sequence of delta functions that have positive or negative areas depending on the corresponding bits (0's or 1's) and a that pulse signal p(t) to be convoluted with x(t) to get y(t). If y(t) is transmitted through a channel of impulse response c(t) and bandwidth B_c , show that the square pulses in y(t) will be spread out in output process r(t) that causes ISI. Show that by pulse shaping p(t), the ISI can be reduced. What will be the best pulse shape for p(t) and why? 10

b) From problem (a), establish Nyquist Criterion for zero ISI. Establish that raised–cosine pulses can satisfy Nyquist criterion. What will be the cost to provide for reduced ISI with this method? 5+5

Q.5 a) Given the data stream 1110010100, sketch the transmitted sequence of pulses for each of the following: Unipolar NRZ, Polar NRZ, Unipolar RZ, Bipolar RZ and Manchester code. 08

b) Find the expression for auto correlation function and power spectral density for Unipolar NRZ format. What change in spectral density for NRZ polar will occur? 5+2

c) Discuss about pros and cons of Manchester coding. What are the desirable properties of line codes? 05

Q.6 a)Consider a sine wave of frequency f_m and amplitude A_m , which is applied to a delta modulator of step size Δ. Show that the slope overloaded distortion will occur if $A_m > \Delta / 2\pi f_m T_s$ Where T_s is the sampling period. What is the maximum power that may be transmitted without slope overloaded distortion? 06

b) Find the minimum sampling frequency $(f_s)_{min}$, to avoid slope overload when $x(t) = \cos(2\pi\, 800t)$ and $\delta = 0.1$. 02

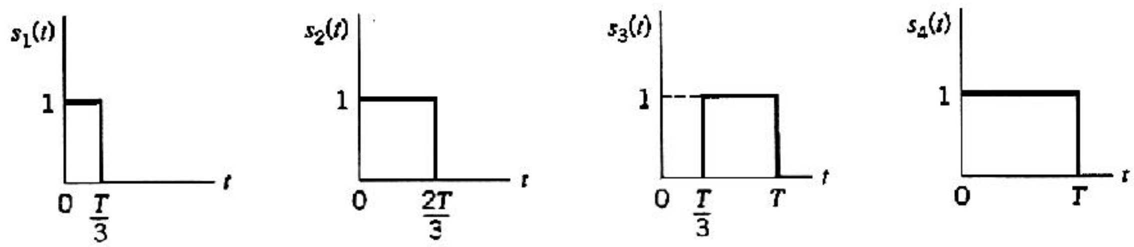
c) Adaptive Delta Modulation, a modification of LDM with step size $\delta(n)$ modulation $\delta_{min} \le \delta(n) \le \delta_{max}$, when to use δ_{min} and δ_{max}? What is the algorithm to determine $\delta(n)$? Draw the transmitter and receiver of ADM? 2+2+4

d) The input to a linear delta modulator is a sinusoidal signal whose frequency can vary from 200 Hz to 4000 Hz. The input is sampled at eight times of Nyquist rate. The peak amplitude of the sinusoidal signal is 1 Volt. Determine the value of the step size in order to avoid slope overload when the input signal frequency is 800 Hz. 04

Q.7 a) What will be the condition for maximum likelihood decision rule such that messaged point would be the closest to the received signal point?

Based on this rule draw the circuit for optimum correlation receiver with $\vec{R} = \{r_1, r_2, \ldots \ldots r_N\}$ is the received signal and $\vec{S} = \{S_{11}, S_{12}, \ldots \ldots S_{1N}\}$ are the BPSK transmitted signal. 08

b) Using Gram-Schmidt orthogonalization procedure, find an orthonormal basis for this set of signals. Construct the corresponding signal space diagram. 08



c). Define the two types of error probability in the binary 1, 0 bits transmission when having equally likely Tx-probable rate with pictorial representation. 04

Q.8 a) Sketch the waveforms of the in-phase and quadrature component of the MSK signal in response to the input binary sequence 1100100010. Sketch the MSK waveform for this sequence. 06

b) Write the expression for signals for 4-ary FSK . Show that if the frequencies are separated by fs = 1/Ts, they are orthogonal to each other. Calculate the bandwidth B under this condition. 06

c) Give the BFSK generation circuit diagram. Write the auto correlation expressions for BFSK signal for inphase and quadrature components and then find the power spectral density. 08

Q.9 a) Find the Error probability of QPSK modulation. What will happen for the error probability of OQPSK? Contrast the error probability of QPSK with BPSK. 10

b) In a coherent FSK system s_1 (t) and s_2(t) represent the symbol 1 and 0 respectively and are given as below, where fc > Δf,

$$s_1(t),\ s_2(t) = A_c \cos\left[2\pi \left(f_c \pm \frac{\Delta f}{2}\right) t\right] \quad ; \quad 0 \leq t \leq T_b$$

Show that the signal correlation coefficient of the signals s_1 (t) and s_2(t) is given by

$$\rho = \frac{\int_0^{T_b} s_1(t)\, s_2(t)\, dt}{\int_0^{T_b} s_1^2(t)\, dt} \simeq \text{sinc}\,(2\,\Delta f\, T_b)$$

a. Find minimum frequency shift Δf for which s_1 and s_2 are orthogonal and correlate with MSK. What will be the error probability of BFSK for this ρ (expression only). 4+5+1