UNIT-I: PCM & Delta modulation system

Q.1 Explain the difference between cross talk & intersymbol interference.

Q.2 What is Quantization error? How does it depend upon the step size? Suggest some method to overcome the difficulties encountered when the modulating signal amplitude swing is large.

Q.3 Explain with the help of block diagram that the Adaptive Delta modulation system reduces the slope error at the expense of quantization error? Draw the wave forms comparing the response of the ADM and linear DM.

Q.4 Explain the PCM technique and evaluate the expression for SNR in PCM. What important functions are performed by the regenerator? Why is Equalization carried out?

Q.5 With an example explain how multiplexed PCM channels are transmitted using T1 carrier system.

Q.6 A voice frequency signal band limited to 3Mhz is transmitted with the use of the DM system. The pulse repetition frequency is 30,000 pulses per second, and the step size in 40mv.determine the maximum possible speech signal amplitude to avoid a slope overload.

Q.7 24 Telephone channels, each band limited to 3.4 KHz, are to be time division multiplexed by using PCM. Calculate the bandwidth of the PCM system for 128 quantization level and an 8 KHz sampling frequency.

Q.9 Explain the need of predictor by DPCM to make voice and video transmission comparable to that of PCM.

Q.10. What are the two major sources of noise in a PCM system? Derive the expression for the output signal to quantization noise ratio in PCM?

Q.11 A µ-Law compander is defined as \( y = \pm \ln(1+ \mu |x|)/\ln(1+\mu), \) if the peak of input is 10v and one of bits available of quantization are 8, than find the smallest and largest separation between levels. Consider \( \mu = 255. \)

\( \text{(ans: 1.75mv, 0.43v)} \)

Q.12 What are optimum and matched filters? Find there transfer functions? Is it true that in matched filter error probability depends on signal energy and not on wave shape? Explain.

Q.13. Consider a sine wave of frequency \( f_m \), amplitude \( A_m \), which is applied to a delta modulator of step size \( \Delta \). Show that slope overload distortion will occur if

\[
A_m > \frac{\Delta}{2\pi f \pi T_s},
\]

where \( T_s \) is the sampling period.

What is the maximum power that may be transmitted without slope overload distortion.

Q.14 (a)For an equiprobable binary baseband data the optional receiver -5mv for ‘0’ and +5mv forbs corrupted for with white noise of PSD \( 10^{-9} \) W/Hz. With optimum decision threshold what is the probability of error in reception if data rate is 9600 bps.
(b) Find the percentage increase in error rate if data rate is doubled.

(c) If we want probability of error at increased error at increase data rate same as (a) What should be input voltage levels?

Ans; (a) $P_e=0.0534$; (b) $P_e=0.1271$

(b) % inc. in error rate =138.03%

(c) ±7.07mv

Q.15 PCM system uses a uniform quantizer followed by a 7bit binary encoder, the bit rate of the system is equal to 50 Mbps.

(1) What is maximum message signal bandwidth for which the system operates satisfactory?

(2) Calculate the output signal to quantization noise rate when a full load sinusoidal modulating wave of frequency 1 MHz is applied to the input.

Q.16 Prove that the maximum SNR for the matched filter is found to be

$\frac{S}{N}_{o max} = \alpha \frac{E}{N_0}$

Q.17 For the given signal n(t)

(a) Determine the impulse response of the filter matched to this signal & sketch it.

(b) Plot the output of the matched filters.

Q.18 The information in an analog signal voltage waveform is to be transmitted over a PCM system in an accuracy of ±0.1% (full scale). The analog voltage waveform has a bandwidth of 100Hz & an amplitude range of -10 to +10v.

(1) Find the minimum sampling rate required.

(2) Find the number of bits in each PCM word.

(3) Minimum bit rate required in the PCM signal.

(4) Find the minimum absolute channel bandwidth required for the transmission of the PCM signal.

UNIT-II: BASE BAND TRANSMISSION

Q.1 Which are desirable properties of digital waveform? To transmit a bit sequence 10011011, draw the resulting waveform using:-

Unipolar RZ; Unipolar NRZ; Bipolar RZ ; AM, RZ ; Manchester(split phase) ; Any where m=4(polar quaternary)

Compare above scheme for their bandwidth requirements.

Q.2 What is the difference between source coding & line coding?
Q.3 A polar NRZ waveform has to be received into the help of a matched filter. Here binary ‘1’ is represented as a rectangular positive pulse. Also binary ‘0’ is represented by a rectangular negative pulse. Determine the impulse response of the matched filter. Also sketch it.

Q.4 What do you understand by intersymbol interference? What are the factors responsible for it & what are its effects? How can ISI be reduced?

Q.5 Derive the expression for the Nyquist criterion for distortion less baseband transmission in the absence of noise.

Q.6 Derive the mathematical expression for raised cosine spectrum.

Q.7 Let X(f) be the raised cosine spectrum with a roll off factor α. Show that \[ \int_{-\infty}^{\infty} X(f) \, df = 1 \]

Q.8 (a) A telephone line of bandwidth 4Khz required to transmit data at 6kbps using raised cosine pulses. Determine the roll off factor α.

(b) What data rate is supported for α=0.25 & full roll off.

Q.9 In a certain telemetry system, eight message signals having 2 kHz bandwidth each are time division multiplexed using a binary PCM Technique. the error in sampling amplitude cannot be greater than 1% of the peak amplitude. Determine the minimum transmission bandwidth required if raised cosine pulses with roll off factor α=0.2 are used. the sampling rate must be at least 25% above the Nyquist rate.

UNIT-III: Digital Modulation Techniques

Q.1 What is gram Schmitt orthogonalization procedure. Explain?

Q.2 Explain the geometric representation of signals.

Q.3 Given the signals \( s_1(t), s_2(t), s_3(t) \) & \( s_4(t) \) given below. Use the gram Schmitt orthogonalization procedure to find an orthonormal basis for the set of signals.

Q.4 (a) Represent QPSK Signals in the signal space and find distance between them. what is the significance of each.

(b) Explain the working of QPSK with the help of block diagram.

Q.5 Determine the bandwidth required for M-any FSK system. Draw the geometrical representation of m-any FSK Signal and find out the distance between the signals.

Q.6 Give the block diagram of a coherent signal reception system. Explain the effect of phase error & timing error on the error probability in a BPSK System employing coherent reception giving necessary deviation.
Q.7 Draw the block diagram of DPSK Modulator & explain how synchronization problem is avoided for its detection.

Q.8 Obtain the MSK Waveform for the binary bit sequence of 11001011. Use bipolar NRZ waveform to present this bit sequence. What are the advantage & draw backs of MSK as compared to QPSK.

Q.9 Describe minimum shift keying and explain why it is named so.

Q.10 An ON/OFF system uses pulse waveform as described.

\[ s_1(t) = \begin{cases} \frac{At}{T}, & \text{for } 0 \leq t \leq T \\ s_2(t) = 0, & \text{for } 0 \leq t \leq T \end{cases} \]

AWGN with a power spectral density of \(10^{-15} \text{W/Hz}\) is added to the signal. Evaluated the probability of bit error when \(P(s_1) = P(S_2) = 1/2\). Take \(A=0.2 \mu\text{v}, T=2\mu\text{s}\).

Q.11 A Band pass data transmission scheme uses a PSK signaling scheme with \(x_2(t)=A \cos(2\pi f_c t)\) & \(x_1(t)=-A \cos(2\pi f_c t)\), \(0 \leq t \leq T_b\), \(T_b=0.2\text{ms}\) & \(f_c=5f_b\). The carrier amplitude at the receiver input is 1 mV & psd of AWGN at I/P is \(10^{-11} \text{W/Hz}\). Assume that an ideal correlation receiver is used. Calculate probability of error \(P_e\) of the receiver.

Q.12 Determine the bit error probability (BEP) for a BPSK system having a bit rate of 1Mbps. The receiver receives the waveforms \(s_1(t)=A \sin(\omega_c t)\), \(s_2(t)=-A \sin(\omega_c t)\). The received signals are coherently detected using a matched filter. If \(A=10\text{mv} & \) single side noise power spectral density is \(No=10^{-11} \text{W/Hz}\). Assume that the signal power and energy per bit rate are normalized.

Q.13 Binary data is transmitted at a rate of \(10^6\) bps over a channel having a BW of 3MHz. Assume that the noise PSD at the Rx is \(No/2=10^{-10} \text{W/Hz}\). Determine the average carrier amplitude required at the receiver i/p for coherent PSK & DPSK signally schemes to maintain \(P_e<10^{-4}\).

Q.14 (a) With the help of waveforms describe ASK, QPSK, FSK, 64 QPSK w.r.t. spectrum of the modulated signal, Detection using coherent and non coherent receiver.

(b) What is QPSK? how is it modified for use with satellite?

(c) Determine the probability of error of PSK,ASK,FSK system and their required bandwidth.

Q15. Compare 16 ary PSK, 16 ary FSK, 16 ary QASk in context to error probability and transmission BW.

**UNIT-IV: INFORMATION THEORY**
Q.1 Consider an AWGN channel with 4 KHz bandwidth and noise power spectral density of \(10^{-12}\) W/Hz. The signal power required at receiver is 0.1 MW.

Q.2 Consider a telegraph source having two symbols, dot and dash. The dot duration is 0.2. The dash duration is 3 times the dot duration. The probability of the dot’s occurring is twice that of the dash and the time between symbols is 0.2 sec. Calculate the information rate of the telegraph source.

Q.3 Write short note on Huffman and Shannon Fano coding.

Q.4 (a) An analog signal band limited to 10 KHz quantize is 8 levels of PCM System with probability of \(1/4, 1/5, 1/10, 1/20, 1/20, 1/20\), and \(1/20\) respectively. Find the entropy and rate of information.

(b) Show that:
\[
H(X,Y) = H(X) + H(Y|X) = H(Y) + H(X|Y)
\]

Q.5 (a) Find the capacity of the discrete channel shown in fig.

(b) An information source produces 8 different symbols with probabilities \(\frac{1}{2}, 1/4, 1/8, 1/16, 1/32, 1/64, 1/128, 1/256\) respectively. These symbols are encoded as 000, 001, 010, 011, 100, 101, 110, and 111 respectively:
(i) What is the amount of information symbol?
(ii) What are the probabilities of occurring for \(P(0)\) and \(P(1)\).
(iii) What is the efficiency of the code?
(iv) Give an efficiency code with the help of the method of Shannon.

Q.6 A Binary symmetric channel shown in fig. Find the rate of information transmission over this channel when \(p=0.8\). Assume that the symbol (or bit) rate is 1000/sec.

Q.7 Explain the concept of information capacity of a channel. A CRT terminal is used to enter alphanumeric data into a computer. The CRT is connected to the computer through a voice grade telephone line having a usable band width of 3 KHz and an output S/N of 10bb. Assume that terminal has 128 characters and that the data sent from the terminal consist of independent sequence of equiprobable characters.
(a) Find the capacity of channel.

(b) Find the maximum rate at which data can be transmitted from the terminal to the computer without errors.

Q.8 For a continuous random variable x constrained to a peak magnitude M(-M<x<M) shows that the entropy is maximum when x is uniformly distributed in the range (-m, m) and has zero probability density outside this range. Show that maximum entropy is given by $(\log_2 m)$.

Q.9 Define mutual information and equivocation in transmission of information. Hence obtain Shannon-Hartley law.

Q.10 Write short note on Shannon’s theorem and its bound.

Q.11 A discrete memory less source has an alphabet of seven symbols with probability for its output, as described here:

<table>
<thead>
<tr>
<th>Symbol</th>
<th>prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_0$</td>
<td>0.25</td>
</tr>
<tr>
<td>$S_1$</td>
<td>0.25</td>
</tr>
<tr>
<td>$S_2$</td>
<td>0.125</td>
</tr>
<tr>
<td>$S_3$</td>
<td>0.125</td>
</tr>
<tr>
<td>$S_4$</td>
<td>0.125</td>
</tr>
<tr>
<td>$S_5$</td>
<td>0.0625</td>
</tr>
<tr>
<td>$S_6$</td>
<td>0.0625</td>
</tr>
</tbody>
</table>

(a) Compute the Huffman code for this source and explain why the compute source code has an efficiency of 100 percent.

(b) Calculate $H$.

(c) Use the Shannon fano algorithm to develop an efficient code and for that code, calculate the average number of bits/message compare with $H$.

Q.12 An analog signal having 4 kHz bandwidth is sampled at 1.25 times the Nyquist rate and each sample is quantized into one of 256 equally likely levels.

Assume that the successive samples are statistically independent:

(a) What is the information rate of this source?

(b) Can the output of this source be transmitted without error over an AWGN channel with a bandwidth of 10k Hz and S/N ratio of 20db?

(c) Find the S/N ratio required for error free transmission for port (b)

(d) Find the bandwidth required for an AWGN channel for error free transmission of the output of this source if the S/N ratio is 20db.
Q.13 The source ‘X’ generates M message, then prove the following inequality for source entropy \( H(x) \):
\[
0 \leq H(X) \leq \log_2 M.
\]

UNIT-V CODING

Q.1. Write short note on cyclic code.

Q.2. Give the specification of the following codes:
   (i) Hamming codes (ii) BCH codes (iii) Reed-Solomon codes.

Q.3. A parity check code has the parity check matrix:

\[
H = \begin{bmatrix}
1 & 0 & 1 & 1 & 0 & 0 \\
1 & 1 & 0 & 0 & 1 & 0 \\
0 & 1 & 1 & 0 & 0 & 1
\end{bmatrix}
\]

Determine the generator matrix \( G \). Find the code word that begins 101…. Suppose that the received word is 110110, then decode this received word.

Q.4 (a) Consider \((7, 4)\) linear code whose generator matrix is-

\[
G = \begin{bmatrix}
1 & 0 & 0 & 0 : 1 & 0 & 1 \\
0 & 1 & 0 & 0 : 1 & 1 & 1 \\
0 & 0 & 1 & 0 : 1 & 1 & 0 \\
0 & 0 & 0 & 1 : 0 & 1 & 1
\end{bmatrix}
\]

(i) Find all code vectors of this code.
(ii) Find the parity check matrix for this code.
(iii) Find the minimum weight of this code.
(v) Prove equation \( CH^T = 0 \)

(b) A source is transmitting six messages with probability 0.30, 0.25, 0.15, 0.12, 0.10 and 0.08 respectively.
   (i) Find the binary Huffman code.
   (ii) Determine its average word length, efficiency and redundancy.

Q.5. What is a block-code? Analytically compare the error performance of a block coded system with one without using error-correcting codes.

Q.6 Consider a DMS with symbols \( x_i, 0=1, 2, 3, 4 \)

\[ X_i \quad x_1 \quad x_2 \quad x_3 \quad x_4 \]
Above table lists two possible binary codes, show whether these codes satisfy Kraft inequality.

Q.7 Prove that a linear block code with a minimum distance \(d_{\text{min}}\) can correct up to \((d_{\text{min}} -1)/2\) errors in each code word, where \((d_{\text{min}} -1)/2\) denote the largest integer no. greater then \((d_{\text{min}} -1)/2\)?

Q.8. The generator polynomial of a (7,4) cyclic code is \(g(x)= 1 + x + x^3\). Find out 16 code words of this code?

Q.9. Consider a (7,4) linear block code with the parity-check matrix \(H\) given by:

\[
H = \begin{bmatrix}
1 & 0 & 1 & 1 & 1 & 0 & 0 \\
1 & 1 & 0 & 1 & 0 & 1 & 0 \\
0 & 1 & 1 & 1 & 0 & 0 & 1
\end{bmatrix}
\]

Construct code words for this (7,4) code. Show that this code is a Hamming code. Illustrate the relation between the minimum distance and the structure of the parity –check matrix \(H\) by considering the code word 0101100.