Mohamed Sathak AJ College of Engineering

Department of Electronics and Communication Engineering

EC8501 Digital communication

Question Bank

Unit 1: Discrete Memory less source, Information, Entropy, Mutual Information - Discrete Memory less channels – Binary Symmetric Channel, Channel Capacity - Hartley - Shannon law - Source coding theorem - Shannon - Fano& Huffman codes

1.	Outline the concept of discrete memory less source
2.	Define amount of information
3.	Calculate the amount of information if pk =1/4.
4.	What is entropy and give its mathematical equation.
5.	What are the properties of entropy?
6.	An event has six possible outcomes with probabilities {1/2, 1/4, 1/8, 1/16, 1/32, 1/32}. Solve for the entropy of the system
7.	A discrete memory less source produces four symbols whose probabilities are in the ration of 0.25:0.5 :0.75:1.What is the entropy of the source.(N/D'20)
8.	Describe information rate.
9.	Interpret the theory of mutual information.
10.	List out the properties of mutual information
11.	What is channel capacity of a discrete signal??
12.	What is the channel capacity of a Gaussian channel with 1 MHZ bandwidth and signal power to noise power spectral density ratio is 10^4 Hz?
13.	Examine the types of discrete memory less channel.
14.	Mention the main idea of channel capacity.
15.	Define Shannon's law
16.	What is Shannon's limit.(April/May2017)
17.	Define Shannon's first theorem
18.	Define Shannon's second theorem
19.	Define channel capacity theorem or information capacity theorem.
20.	State Shannon Hartley theorem
21.	Formulate the steps involved in Shannon-fano coding
22.	Distinguish the different source coding techniques
23.	Write about BSC.
24.	What is the channel capacity of a BSC and BEC
25.	What is data compaction?
26.	Define source coding. State the significance of source coding.
27.	Why is Huffman code called as minimum redundancy code?
28.	Mention the drawbacks of channel coding theorem
	PART B
1.	(i)Enumerate on measure of information and its properties. (ii)Find out the amount of information if binary digits occur with equal likelihood in binary PCM
2.	Illustrate the following with equation (i)Average Information (ii)Properties of Entropy (iii)Calculate entropy when Pk= 0 and when Pk=1

3.	Explain the following (i)Mutual information and its properties (ii)Channel capacity and its equation.
4.	(i)What is the main idea of discrete memory-less channel and its matrix form involving transition probabilities? (ii)Explain the concept of Binary symmetric channel with Binary communication channel.
5.	Consider the two sources X and Y emit symbols [x1,x2,x3} and {y1,y2,y3} with the joint probability p(X,Y) as given below Calculate the entropy H(X),H(Y),H(Y/X) and H(X,Y)
6.	
7.	Analyze on Information rate R of an analog signal which is bandlimted to B Hz and sampled at Nyquist rate. The samples are quantized in to 4 levels. Each level represents one message for which the probabilities of occurrence of these 4 messages are given as P1=P4=1/8, P2=P3=3/
8.	A source emits one of four symbols S1,S2,S3 and S4 with probabilities {1/3, 1/6, 1/4, 1/4}. Calculate entropy, average code word length and coding efficiency using Huffman coding
9.	Four symbols of the alphabet of discrete memory less source and their probabilities are given as {S1,S2,S3,S4) and {1/3, 1/6, 1/4, 1/4}. Point out the symbols using Shannon fano coding and calculate the average code word length and efficiency
10.	The DMS has five symbols and their probabilities are {0.4, 0.2, 0.1, 0.2and 0.1}. Construct the symbols using Huffman coding and calculate the average codeword length and efficiency
11.	Five symbols of the alphabet of discrete memory less source and their probabilities are given as{S1,S2,S3,S4,S5) and {0.4,0.19,0.16,0.15,0.15}. Construct using Shannon fano Coding and calculate the code efficiency.
12.	Consider a discrete source that emits the symbols {X1,X2,X3,X4,X5,X6,X7,X8} with probabilities {0.48,0.15,0.1,0.07,0.05,0.03,0.02}. Construct a binary code using Shannon-Fano technique. Compute the efficiency of the code.(N/D'20)
	UNIT II WAVEFORM CODING & REPRESENTATION
	Prediction filtering and DPCM - Delta Modulation - ADPCM & ADM principles-Linear Predictive Coding- Properties of Line codes- Power Spectral Density of Unipolar / Polar RZ & NRZ – Bipolar NRZ – Manchester
	PART A
1.	What is linear predictor? On what basis are predictor coefficients are determined.
2.	Identify the need of prediction filtering.
3.	List the 2 properties of linear prediction.
4.	Summarize the need of Line Codes.
5.	Why Delta Modulation is superior to Differential Pulse Code Modulation?
6.	Express the data 10011 using the Manchester code format.
7.	Discuss about delta modulation and its limitations.
8.	Demonstrate the techniques to overcome slope overload and granular noise in delta modulation system.
9.	Interpret the principle of DM and ADM.
10.	Illustrate the difference between DM and ADM.
11.	Point out the slope overload distortion in delta modulation systems.

12.	Recall the advantages of delta modulator.
13.	Inspect the concept of ADPCM.
14.	Outline the theory of APB and APF.
15.	Show the properties of line coding.
16.	Recall Manchester coding.
17.	Assess the principle of linear predictive coder .
18.	Summarize the applications of LPC.
19.	Formulate the model of LPC.
20.	Construct unipolar and RZ code for the binary data 01101001.
21.	List the advantages of DM over PCM
22.	What are the Advantages of ADM over DM?
23.	Inspect the concept of DPCM.
24.	List the advantages and disadvantages of DPCM
25.	What is mean by granular noise in delta modulation? How can it be avoided?N/D'20 .
26.	What are the line codes? List the 4 popular line code.N/D'20
	PART B
1.	(i) Evaluate the structure of linear predictor. (ii) Assess the process of prediction error.
2.	(i) Summarize adaptive delta modulator with continuously variable step size and explain with block diagram. (ii) Explain the difference between PCM systems and delta modulation systems.
3.	(i) How would you explain delta modulation and its quantization error? (ii) Explain how adaptive delta modulation performs better than gains more SNR than delta modulation.
4.	Describe delta modulation system in detail with a neat block diagram. Also illustrate two forms of quantization error in delta modulation.
5.	Construct a DPCM system. Derive the expression for slope overload noise Of the system.
6.	(i) State in your own words the functioning of ADPCM system with block diagram. (ii) A delta modulator with a fixed step size of 0.75v is given a sinusoidal message signal. If the sampling frequency is 30 times the Nyquist rate, what is the best maximum permissible amplitude of the message signal if slope overload is to be avoided?
7.	How would you show your understanding of (i) Adaptive quantization schemes (ii) Adaptive prediction schemes.
8.	A signal having bandwidth of 3kHz is to be encoded using 8 bit PCM and DM system. If 10 cycles of signal are digitized, state how many bits will be digitized in each case if sampling frequency is 10 kHz? Also find bandwidth required in each case.

9.	Write the comparison of various line coding techniques and list their merits and demerits.
10.	Recall the need for line shaping of signals. Derive the PSD of an unipolar BZ and NRZ, line code and compare their performance.
11.	What is the function of LPC model and explain with diagrams.
12.	Illustrate and explain the properties of line codes.
13.	Examine the power spectral density of NRZ bipolar and unipolar data format assume that 1s and 0s of input binary data occur with equal probability.
14.	How would you classify the various types of speech encoding techniques?
15.	Draw the block diagram of adaptive delta modulation system transmitter and receiver with continuously varying step size and explain N/D'20
16.	Derive the expression for the PSD unipolar RZ data format. N/D'20
	PART C
1.	A television signal with a bandwidth of 4.2 MHz is transmitted using binary PCM. The number of quantization level is 512. Calculate (i) determine the code word length and transmission bandwidth (ii) Can you find Final bit rate and Output signal to quantization noise ratio.
2.	In a single integration DM scheme the voice signal is sampled at a rate of 64 kHz, the maximum signal amplitude is 1v, voice signal bandwidth is 3.5 kHz . (i) Determine the minimum value of step size to avoid slope overload (ii) Determine the granular noise $N_{o.}$ (iii) Assuming the signal to be sinusoidal, calculate the signal power and signal to noise ratio.
3.	A 1 kHz signal of voice channel is sampled at 4kHz using 12 bit PCM and a DM system. If 25 cycles of voice signal are digitized. Solve in each case (i) Signaling rate (ii)Bandwidth required (iii) No of bits required to be transmitted.
4.	For the sequence 10111001, Develop the waveform supporting the following data formats. (i) Unipolar RZ (ii) Polar NRZ (iii) Alternate mark inversion (iv) Manchester coding. Draw the corresponding spectrum of the above formats and explain.
	UNIT III - BASEBAND TRANSMISSION& RECEPTION
	ISI – Nyquist criterion for distortion less transmission – Pulse shaping – Correlative coding – Eyepattern – Receiving Filters- Matched Filter, Correlation receiver, Adaptive Equalization
1.	Give the practical difficulties of ideal nyquist channel.
2.	Summarize the raised cosine spectrum.
3.	Define roll off factor.
4.	Describe the full cosine roll off characteristics.
5.	What is meant by ISI in communication system? How it can be minimized?
6.	Show the frequency response of duo binary signal.
7.	Point out duo binary system. What are the drawbacks of it?

8.	State Nyquist criteria.
9.	Utilize Nyquist second and third criteria to realize zero ISI.
10.	Discuss how pulse shaping reduce ISI.
11.	List four applications of eye pattern.
12.	Examine correlative level coding.
13.	Outline the causes for ISI.
14.	Justify the statement 'ISI cannot be avoided'.
15.	Compare the coherent and non-coherent receivers.
16.	Illustrate Eye pattern with diagram.
17.	Define Equalization.
18.	Assess the need for adaptive equalization in a switched telephone network.
19.	Propose the methods used to implement adaptive equalizer.
20.	Generalize the need for equalization filter.
21.	What is mean by correlative level coding?N/D'20
22.	What is a matched filter? N/D'20
	PART B
1	Outline the modified Duo binary coding technique and its performance by illustrating its frequency and impulse response. What is modified Duo binary signaling scheme? Draw the block diagram od signaling scheme and explain N/D'20
2	(i) . Write the concept of Non Linear Decision feedback Adaptive Equalizer. Describe the adaptive equalization with block diagram
3	Derive the formula for LMS algorithm and draw the signal flow graph of LMS algorithm.
4	Illustrate "raised cosine spectrum". Discuss how does it help to avoid ISI?
5	What is ISI ? List the various methods to remove ISI in s communication system. Also state and prove Nyquist first criterion for Zero ISI.
6	(i) Summarize the benefits of Nyquist pulse shaping. (ii) Predict the information provided in eye diagram.
7	Discuss how Nyquist criterion eliminates interference in the absence of noise for distortion less baseband binary transmission.
8	(i) Describe any one method for ISI control.
	(ii) Explain the principle of signal reception using a correlator type receiver.
	(i) Interpret the pulse shaping method to minimize ISI.
9	(ii) Demonstrate how eye pattern illustrates the performance of data transmission system with respect to Inter Symbol Interference with neat sketch.
10	Elaborate how ISI occurs in base-band binary data transmission system.
11	Evaluate in detail about the M-ary baseband system
12	Point out the types of Adaptive Equalizers in detail with neat diagrams Draw the block diagram of Adaptive Equalizer and explain with adaptive algorithmN/D'20
	(i) Analyzing adaptive MLSE equalizer with block diagrams. (ii) Identify the merits and demerits of Duo binary signaling.
13	Examine the principle of obtaining eye pattern and mark important observations made from the eye pattern.
	PART C

1	Generalize the realizations of the receiving filters based on the signal correlator and matched filter.
2	Discuss in detail about inter symbol interference (ISI) and the nyquist criterion for minimizing ISI. Elaborate the difficulties in implementing it in a practical system.
3	Discuss in detail about correlative coding to eliminate ISI.
4	(i) Deduce the equation for the impulse response coefficients of the zero forcing equalizer.
	(ii) Explain the two operation modes of adaptive equalizers.
	UNIT IV - DIGITAL MODULATION SCHEME
	Geometric Representation of signals - Generation, detection, PSD & BER of Coherent BPSK, BFSK & QPSK - QAM - Carrier Synchronization - Structure of Non-coherent Receivers - Principle of DPSK
1.	Outline the need for geometric representation of signals.
2.	Draw the block diagram of a coherent BFSK receiver.
3.	Identify the difference between BPSK and QPSK techniques.
4.	What is QPSK? Write down the expression for the QPSK signal.
5.	Sketch the BER curve for ASK,FSK,BPSK digital modulation schemes.
6.	A BFSK system employs two signaling frequencies f1 and f2. The lower frequency f1 is 1200 Hz and signaling rate is 500 Baud. Compute f2.
7.	A BPSK system makes errors at the average rate of 100 errors per day. Data rate is 1 kbps. The single-sided noise power spectral density is 10 W/Hz. Assume the system to be wide sense stationary, predict the average bit error probability.
8.	Compare coherent and non coherent reception.
9.	Distinguish the error probability for BPSK and QPSK.
10.	Discuss the drawbacks of ASK.
11.	Indicate why PSK always preferable over ASK in Coherent detection.
12.	Write the special features of QAM.
13.	Reproduce the signal space diagram for QAM signal for M=8.
14.	Illustrate about the constellation diagram.
15.	Design a carrier synchronization using M^{th} power loop.
16.	Formulate the concept of memory less modulation.
17.	Identify the difference between coherent and non-coherent digital modulation techniques.
18.	Analyze the concept of spectral efficiency.
19.	Evaluate the error probability of DPSK.
20.	Assess the features of DPSK.
21.	For the binary sequence 1100, sketch the wave form of QPSK together with in phase and quardrature components wave forms. N/D’20
22.	What are the three levels of synchronization needed for coherent band pass signaling system? Which is not necessary for non-coherent system? N’/D’20
	PART B
1.	(i) What is digital modulation scheme? Derive geometrical representation of signal. (ii) Write about the geometric representation of BPSK signal and BFSK signal.
2.	Explain the generation and detection of a coherent binary PSK signal and derive the power spectral density of binary PSK signal and plot it.
3.	Explain the non-coherent detection of FSK signal and derive the expression for the probability of error. N/D’20
4.	Discuss the transmitter, receiver and signal space diagram of QPSK and describe how it produces the original sequence with the minimum probability of error with neat sketch.

	Discuss the generation and detection of coherent QPSK signals with neat block diagram N/D'20
5.	Summarize the transmitter, receiver and generation of non-coherent version of PSK with neat sketch. derive the power spectral density of binary PSK signal
6.	Outline the generation and detection of a coherent ASK signal and derive the power spectral density of binary ASK signal and plot it.
7.	(i) Produce the BER comparison of coherent PSK, coherent QPSK and coherent FSK. (ii) Show the difference between coherent and non-coherent scheme
8.	(i) Illustrate Carrier Synchronization in QPSK. (ii) Calculate the BER for a Binary phase shift keying modulation from first principles.
9.	(i) List the difference between QAM and QPSK. (ii) Describe QPSK signaling with diagrams.
10.	(i) Analyzing the transmitter, receiver and signal space diagram of Quadrature Amplitude Modulation. (ii) Outline the power spectral density and bandwidth of QAM signal with neat diagrams and mention its advantages.
11.	(i) Analyzing the constellation diagram of QPSK scheme. (ii) Identify the error performance of coherent detection QAM system.
12.	(i) Evaluate the Quadrature Receiver structure for coherent QPSK with appropriate diagram. (ii) In a QPSK system, the bit rate of NRZ stream is 10 Mbps and carrier frequency is 1GHz. Tell the symbol rate of transmission and bandwidth requirement of the channel.
13.	(i) Explain the principle of working of an "early late bit synchronizer". (ii) Develop the expression for bit error probability of QPSK system.
14.	(i) Identify the principle of DPSK? Explain the transmitter and receiver of DPSK scheme. (ii) Point out the Probability of error for coherently detected BFSK.
	PART C
1.	(i) Explain Carrier and symbol synchronization
2.	(ii) A set of binary data is sent at the rate of R_b= 100 Kbps over a channel with 60 dB transmission loss and power spectral density ▫= 10-12 W/Hz at the receiver. Evaluating the transmitted power for a bit error probability P_e= $10^{-3}$for the following modulation schemes. (a) FSK (b) PSK (c) DPSK (d) 16 QAM
3.	Draw the signal space diagram of a coherent QPSK modulation scheme and also find the probability of error if the carrier takes on one of four equally spaced values 0^o,90^o, 180^o and 270^o.
4.	In digital CW communication system, the bit rate of NRZ data stream in 1 Mbps and carrier frequency is 100 MHz. Solve for the symbol rate of transmission and bandwidth requirement of the channel in the following cases of different techniques used. (i) BPSK system (ii) QPSK system (iii) 16-ary PSK system

5.	(i) Find the error probability of BFSK system for following parameters. PSD of white noise $N_o/2 = 10^{-10}$ Watt/Hz Amplitude of carrier is , A = 1mV at receiver input. Frequency of baseband NRZ signal is f_b=1kHz. (ii) Binary data is transmitted using PSK at rate 2Mbps over RF link having bandwidth 2MHz. Find signal power required at the receiver input so that error probability is less than or equal to 10^{-4} Assume noise PSD to be 10^{-10}Watt/Hz.
	UNIT V - ERROR CONTROL CODING
	Channel coding theorem - Linear Block codes - Hamming codes - Cyclic codes - Convolutional codes - Viterbi Decoder
1.	State Channel Coding Theorem and its need.
2.	Analyzing the need for error control codes.
3.	Outline the features of linear code.
4.	Discuss the code rate of a block code.
5.	Demonstrate the significance of minimum distance of a block code.
6.	Express the syndrome properties of linear block code.
7.	Distinguish Hamming Distance and Hamming weight.
8.	Deduce the Hamming distance between 101010 and 010101. If the minimum Hamming distance of a (n, k) linear block code is 3, what is the minimum Hamming weight?
9.	Summarize the advantages and disadvantages of Hamming codes.
10.	Discuss two properties of generator polynomial.
11.	List the properties of cyclic codes.
12.	Illustrate the systematic code word with its structure.
13.	When a binary code does is said to be cyclic codes?
14.	Propose the generator polynomial of a cyclic codes.
15.	Generate the cyclic code for (n, k) syndrome calculator.
16.	The code vector [1110010] is sent, the received vector is [1100010]. Identify the Syndrome.
17.	What is meant by constraint length of a convolutional encoder?
18.	What is convolutional code? How is it different from block codes?
19.	Show how Trellis diagram is used to represent the code generated by convolutional coder and mention its advantages.
20.	Determine the various techniques/algorithms used. in encoding and decoding of convolutional code.
21.	What is mean by systematic block code? N/D ‘20
22.	What is the meaning and the minimum distance of a block code?
	PART B
1	Consider a linear block code with generator matrix

	$$\begin{bmatrix}1&1&0&1&0&0&0\\0&1&1&0&1&0&0\\1&1&1&0&0&1&0\\1&0&1&0&0&0&1\end{bmatrix}$$ (i) Enumerate the parity check matrix. (ii) Trace the error detecting and capability of the code. (iii) Draw the encoder and syndrome calculation circuits. (iv) Write the syndrome for the received vector r = [1 1 0 1 01 0].
2	(i) Analyzing the generation of (n, k) block codes and audit how block codes can be used for error control. (ii) Consider a (6, 3)block code and explain how error syndrome helps in correcting a single error for a data 110.
3	(i) Cite an example and explain one decoding procedure of linear block codes. (ii) Find the (7, 4) systematic and non-systematic cyclic code words of the message word 1101. Assume the generator polynomial as $1 + x^2 + x^3$.
4	(i) Describe the steps involved in the generation of linear block codes. (ii) Explain the properties of syndrome.
5	Illustrate how the errors are corrected using hamming code with an example.
6	Examine that the generator polynomial of a (7, 4) cyclic code is $1+X+\square^3$. Discover the correct code word transmitted if the received code word is (i) 1011011 and (ii) 1101111
7	With suitable numerical examples, describe the cyclic codes with the linear and cyclic property and also represent the cyclic property of a code word in polynomial notation.
8	Develop the cyclic codes with the linear and cyclic property. Also represent the cyclic property of a code word in polynomial notation.
9	(i) Determine how Viterbi decoding algorithm is used for convolutional code. (ii) Explain the different types of error detected by CRC code.
10	Draw the diagram of the ½ rate convolutional encoder with generator polynomials $G^1(D)=1+D$ $G^2(D)=1+D+D^2$ And complete the encoder output for input sequence 101101.
11	(i)Draw the code tree of a Convolutional code of code rate r = 1/2 and constraintlength of K = 3 starting from state table and state diagram for an encoderwhich is commonly used. (ii) Draw and explain the trellis diagram representation of convolutional codes.
12	(i) Demonstrate the generation of a code using a convolutional encoder with k=1, n=2 and r = ½. (ii) Calculate the encoded output for the input message 10011. (For a Convolutional encoder of constraint length 3 and rate ½.
13	(i) Identify a block code for a message block of size eight that can correct for single errors. (ii) Diagnose a convolutional coder of constraint length 6 and rate efficiency **½.** Draw its tree diagram and trellis diagram.
14	(i) Devise the Maximum Likelihood decoding of Convolutional codes. (ii) Construct the state diagram for the convolutional encoder with k=1, n=2 and r=1/2., starting with the all zero state, trace the path that corresponds to the message sequence 10111…
15	For a systematic linear block code, the three parity check digits P_1, P_2,P_3 are given by $P_{k,n-k} = \begin{bmatrix}101\\111\end{bmatrix}$

	110 011 (i) Construct generated matrix. (ii) Assess the t code generated by the matrix. (iii) Determine error correcting capacity. (iv) Decode the received words with an example.
16	For a systematic (7,4) linear block code , whose generated matrix is given below $G = \begin{bmatrix} 1\,0\,0\,0 : 1\,1\,1 \\ 0\,1\,0\,0 : 1\,1\,0 \\ 0\,0\,1\,0 : 1\,0\,1 \\ 0\,0\,0\,1 : 0\,1\,1 \end{bmatrix}$ (i) Solve all the code vectors (ii) Find parity check matrix (H) (iii) Predict minimum weight
17	(i) Explain Viterbi algorithm with an appropriate coder and received input word of length 12. Assume a coder of constraint length 6 and rate efficiency ½. (ii) Assess a (7,4) binary cyclic code with a generator polynomial $g(x) = 1 + x + x^3$ draw the syndrome circuit.
18	A convolutional code is described by g1=[1 0 0], g2=[1 0 1], g3=[1 1 1] (i) Build the encoder corresponding to the code. (ii) Develop the state transition diagram for this code. (iii) Draw the trellis diagram. (iv) Estimate the transfer function.
19	The generator polynomial of (7,4) binary cyclic code is given $g(x) = 1 + x + x^3$ .Determine the codeword in systematic form for the following messages N/D'20 1. 1011 2. 1111
20	For the rate ½ rate convolution encoder with generator polynomials N/D '20 G(D)=[1 1+D+D$^{3]}$ i.Draw the encoder diagram ii.Deteremine the generator matrix iii For input sequence U = 1011, find the code polynomial and code sequence..

Mohamed Sathak AJ College of Engineering

Department of Electronics and Communication Engineering
EC8501 Digital communication
EPC Question Bank

Unit 1: Discrete Memory less source, Information, Entropy, Mutual Information - Discrete Memory less channels – Binary Symmetric Channel, Channel Capacity - Hartley - Shannon law - Source coding theorem - Shannon - Fano& Huffman codes

1. Define amount of information and information rate.

Amount of information gaining after observing the event S=sk which occure with probability Pk as log function I(sk)= log (1/Pk).

Information rate.: The information rate R of the source is given by R=r H(X) bits/second. where H(X)-entropy of the source

2. What is entropy and give its mathematical equation. What are the properties of entropy?

Entropy can be defined as a measure of the average information content per source symbol

$$H(\mathcal{S}) = E[I(s_k)] = \sum_{k=0}^{K-1} p_k I(s_k) = \sum_{k=0}^{K-1} p_k \log_2\left(\frac{1}{p_k}\right)$$

The entropy H(f) of such a source is bounded as follows
0≤H(f)≤log2K

(1) Some Properties of Entropy

Consider a discrete memoryless source whose mathematical model is defined by Eqs. 2.1–2.2. The entropy $H(\mathcal{S})$ of such a source is bounded as follows

$$0 \le H(\mathcal{S}) \le \log_2 K \qquad (2.10)$$

where K is the *radix* (number of symbols) of the alphabet $\mathcal{S}$ of the source. Furthermore, we may state that

1. $H(\mathcal{S}) = 0$, if and only if the probability $p_k = 1$ for some k, and the remaining probabilities in the set are all zero. This lower bound on entropy corresponds to *no uncertainty*.
2. $H(\mathcal{S}) = \log_2 K$, if and only if $p_k = 1/K$ for all k (i.e., all the symbols in the alphabet $\mathcal{S}$ are *equiprobable*). This upper bound on entropy corresponds to *maximum uncertainty*.

3.Extended Property: The entropy of extended source is equal to n times of H(f), the entropy of original source,

$$H(\mathcal{S}^n) = nH(\mathcal{S})$$

3. Define entropy and find the entropy of a discrete memory less source with probability sl=1/2, s2=l/4, and s3=1/4

4. Interpret the theory of mutual information.

Mutual information I(X, Y) of a channel is defined by I(X, Y)=H(X)-H(X/Y) bits/symbol

H(X)- entropy of the source, H(X/Y)- conditional entropy of Y

List out the properties of mutual information
1.The mutual information of the channel is symmetric I(X, Y)= I (Y, X)
2.The mutual information always non negative I(X:Y)≥0)
3.The mutual information of a channel is related to the joint entropy of the channel and the channel output by
I(X,Y)=H(X)+H(Y)-H(X,Y)

5. Define Shannon's law 1. Define Shannon's first theorem (Source coding Theorem) 2. Define Shannon's second theorem(Channel coding Theorem)

First theorem states that as Given a discrete memory less source of entropy H(S), the average codeword word length $\overline{L}$ for any distortion less source encoded is bounded as

$$\overline{L} \geq H(S)$$

Second Theorem:

The channel coding theorem for a discrete memoryless channel is stated in two parts as follow:

(i) Let DMS with an alphabet S have entropy H(S) and produce symbols at every Ts seconds. Let DMC have capacity C and used once every Tc seconds. Then if,

$$\frac{H(S)}{T_s} \leq \frac{C}{T_C}$$

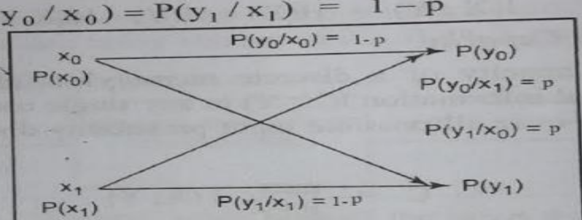
There exists a coding scheme for which source output can be transmitted over the channel and can be reconstructed with small probability of error.

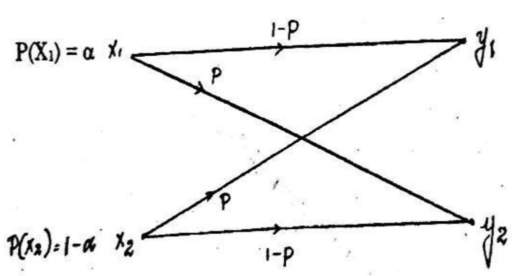
$$\frac{H(S)}{T_s} = \frac{C}{T_C}$$

Then the system is said to be signaling at the critical rate.

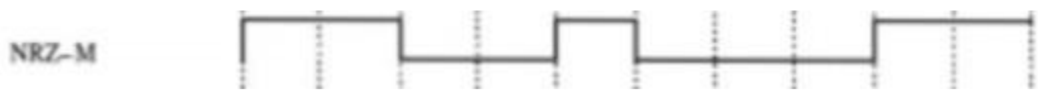
(ii) If, $\frac{H(S)}{T_s} > \frac{C}{T_C}$

No possibility of transmission and reconstruction of information with small probability of error.

6.	What is Shannon's limit.(April/May2017) The theorem can be stated in simple terms as follows (i).A given communication system has a maximum ratc or' infonuation C known as the channel capacity (ii).If the transmission information rate R is less than C, then the data transmission in the presence of noise can be made to happen with arbitrarily small error probabilities by using intelligent coding techniques (iii).To get lower error probabi litres, the encoder has to work on longer blocks of signal data. This entai1s longcr delays and higher computational requirements
7.	Define channel capacity theorem or information capacity theorem. Or State Shannon Hartley theorem Information Capacity of a continuous channel of Bandwidth B hertz, perturbed by additive white Gaussian noise of power spectral density $N_0/2$ and limited in bandwidth to B is given by, $C = B\log_2\left[1+\frac{P}{N_0B}\right]$ bits/sec *Express the equation for Channel Capacity with respect bandwidth and Signal – Noise Ratio.* Channel Capacity of a Gaussian channel, in terms of SNR is given as, $C = B\log_2\left[1+\frac{S}{N}\right]$ bits/sec
8.	Write about BSC. What is the channel capacity of a BSC and BEC ***What is BSC?*** A Binary Symmetric Channel (BSC) channel has two inputs ($x_1 = 0$, $x_2 = 1$) and two outputs ($y_1 = 0$, $y_2 = 1$). This channel is symmetric because the probability of receiving a 1 if a 0 is sent is the same as the probability of receiving a 0 if a 1 is sent. $P(y_0/x_0) = P(y_1/x_1) = 1 - p$  BSC can be represented using a matrix as, $\begin{bmatrix}P(y_0)\\P(y_1)\end{bmatrix} = [P(x_0)P(x_1)]\begin{bmatrix}1-p & p\\p & 1-p\end{bmatrix}$
9.	What is data compaction? For efficient signal transmission the redundant information must be removed from the signal prior to transmission .This information with no loss of information is ordinarily performed on a signal in digital form and is referred to as data compaction or lossless data compression
10.	Why is Huffman code called as minimum redundancy code?

	The Coding is said to be optimum since no other uniquely decodable set of code words, has a smaller average code word length of a given discrete memory less channel
	Sample Problems
11.	Calculate the amount of information if pk =1/4.
12.	An event has six possible outcomes with probabilities {1/2, 1/4, 1/8, 1/16, 1/32, 1/32}. Solve for the entropy of the system
13.	A discrete memory less source produces four symbols whose probabilities are in the ration of 0.25:0.5 :0.75:1.What is the entropy of the source.(N/D'20)
14.	What is the channel capacity of a Gaussian channel with 1 MHZ bandwidth and signal power to noise power spectral density ratio is 10^4 Hz?
	PART B
1.	(i)Enumerate on measure of information and its properties. (ii)Find out the amount of information if binary digits occur with equal likelihood in binary PCM
2.	Illustrate the following with equation (i)Average Information (ii)Properties of Entropy (iii)Calculate entropy when Pk= 0 and when Pk=1
3.	Explain the following (i)Mutual information and its properties (ii)Channel capacity and its equation.
4.	(i)What is the main idea of discrete memory-less channel and its matrix form involving transition probabilities? (ii)Explain the concept of Binary symmetric channel with Binary communication channel.
5.	Consider the two sources X and Y emit symbols [x1,x2,x3} and {y1,y2,y3} with the joint probability p(X,Y) as given below Calculate the entropy H(X),H(Y),H(Y/X) and H(X,Y)
	Consider a binary memoryless source X with two symbols x1 and x2 .prove that H(X) is maximum when both x1 and x2 are equipropable. **[8]** (**April/May 2017)** (i)Find the channel capacity of the binary r= symmetry channel as shown below. **) (13) (April/May 2017)**  A source is emitting equi-probable symbols .construct a Huffman code for source.
6.	Analyze on Information rate R of an analog signal which is bandlimted to B Hz and sampled at Nyquist rate. The samples are quantized in to 4 levels. Each level represents one message for which the probabilities of occurrence of these 4 messages are given as P1=P4=1/8, P2=P3=3/

7.	Derive Shannon - Hartley theorem for the channel capacity of a continuous channel having an average ower limitation and perturbed by an additive band - limited white Gaussian noise.**(13) (M/June 16)**
8.	**Huffman coding**
9.	A source emits one of four symbols S1,S2, S3 and S4 with probabilities {1/3, 1/6, 1/4, 1/4}. Calculate entropy, average code word length and coding efficiency using Huffman coding
10.	The DMS has five symbols and their probabilities are {0.4, 0.2, 0.1, 0.2and 0.1}. Construct the symbols using Huffman coding and calculate the average codeword length and efficiency
11.	Consider a discrete memory less source with seven possible symbols X_i={1,2,3,4,5,6,7} with associated probability P_r={0.37,0.33,0.16,0.07,0.04,0.02,0.01}. Construct the Huffman"s code and determine the coding efficiency and redundancy**. (8) (MAY 2016)**
	Encode the source symbols with the set of probabilities {0.4, 0.2, 0.12, 0.08, 0.08, 0.08, 0.04} using Huffman"s algorithm. Determine the coding efficiency./ Explain the Huffman coding algorithm with a flow chart and illustrate it using an example. **(8) (Nov 2015)**
	Find the Huffman coding for the probabilities P={0.0625,0.25,0.125,0.125,0.25,0.125,0.0625} and the efficiency of the code
	Shannon fano coding
12.	Four symbols of the alphabet of discrete memory less source and their probabilities are given as {S1,S2,S3,S4) and {1/3, 1/6, 1/4, 1/4}. Point out the symbols using Shannon fano coding and calculate the average code word length and efficiency
13.	Five symbols of the alphabet of discrete memory less source and their probabilities are given as{S1,S2,S3,S4,S5) and {0.4,0.19,0.16,0.15,0.15}. Construct using Shannon fano Coding and calculate the code efficiency.
14.	Consider a discrete source that emits the symbols {X1,X2,X3,X4,X5,X6,X7,X8} with probabilities {0.48,0.15,0.1,0.07,0.05,0.03,0.02}. Construct a binary code using Shannon-Fano technique. Compute the efficiency of the code.(N/D'20)
15.	The source has five outputs symbols denoted by (M1 M2 M3 M4 M5) with the following set of probabilities {0.41, 0.19, 0.16, 0.15, 0.09}. Encode the source using Shannon fano algorithm and determine the coding efficiency
	UNIT II WAVEFORM CODING & REPRESENTATION
	Prediction filtering and DPCM - Delta Modulation - ADPCM & ADM principles-Linear Predictive Coding- Properties of Line codes- Power Spectral Density of Unipolar / Polar RZ & NRZ – Bipolar NRZ – Manchester
	PART A
1.	**List few digital modulation schemes used for voice communication? [April/May2019]** Delta Modulation, Adaptive Delta Modulation, Binary Frequency Shift Keying and BPSK,QPSK,QAM
2.	**What is linear predictor? On what basis is predictor coefficients are determined.**

	Prediction filtering is done to reduce the error which occurs due to encoding the actual sample directly. Linear predictor is a filter that uses linear combination of finite set of present and past samples of a stationary process to predict a sample of the process in the future. The predictor coefficients are determined in such a way that it minimizes the mean square value of the prediction error
3.	**Identify the need of prediction filtering.** The filter designed to perform the prediction is called a predictor. A special form of estimation. The requirement is to use a finite set of present and past samples of a stationary process to predict in a sample of the process in the future.
4.	**Express the data 10011 using the Manchester code format.** **For the binary data 0110100, draw Manchester coded signal? [ID] [April/May 2019]** **Draw the NRZ-M and Biphase–M baseband encoding forms for the data [1010110010]. (N/D**  **18)**
5.	**What is meant by delta modulation systems? [Apr/May-2018]** Delta modulation is the one-bit version of differential pulse code modulation. The present sample value is compared with the previous sample value and this result whether the amplitude is increased or decreased is transmitted. **Write the limitations of delta modulation. [Nov/Dec 2015]** 1. Slope of overload distortion. 2. Granular noise. **What are the advantages of delta modulator? [May/June-2016]** 1.HIGH SNR, 2. Low bandwidth consumption
6.	**Q:What are the two types of quantization errors that occur in delta modulation?** **Q:Demonstrate the techniques to overcome slope overload and granular noise in delta modulation system**. **Q:What is mean by granular noise in delta modulation? How can it be avoided?N/D'20** 1) Slope over load error: The step size of quantization is not enough to follow the large changes in input signal. Hence there is difference between approximated signal and input signal. It is called slope overload error. Reduce the step size we can overcome from slope over distortion in delta modulation 2) Granular noise: The step size is to large, hence approximated signal cannot follow the small variations in input Signal. For every small variation in input signal, there is large change in approximated signal. It is called hunting or granular noise. It occurs due to large step size and very small amplitude variation in the input signal

7.	. **Q:Why Delta Modulation is superior to Differential Pulse Code Modulation?** Delta modulation encodes one bit per samples. Hence signalling rate is reduced in DM. **Q:List the advantages of DM over PCM** Delta modulation uses one bit to encode one sample. Hence bit rate of delta modulation is low compared to PCM.
8.	**Interpret the principle ADM.** In adaptive delta modulation, the step size of the modulator assumes a time varying form. In particular, during a steep segment of the input signal the step size is increased. Conversely when the input signal is varying slowly the step size is decreased. **Q:Why adaptive Delta Modulation is superior to Differential Pulse Code Modulation?** Adaptive Delta modulation encodes with variable step size. Hence signaling rate is reduced
9.	**Write the expression for output signal to noise ratio of DPCM receiver mentioning both the predictive gain and prediction error to quantization noise ratio** $$(SNR)_O = \frac{(\sigma_x^2)}{(\sigma_E^2)}\left(\frac{(\sigma_E^2)}{(\sigma_Q^2)}\right) = G_P * (SNR)_P$$ G_p is the predictor Gain and $(SNR)_P$ is the signal to noise ratio of predictor.
10.	Q:**Define ADPCM** **Q: Inspect the concept of ADPCM**. It means adaptive differential pulse code modulation, a combination of adaptive quantization and adaptive prediction. Adaptive quantization refers to a quantizer that operates with a time varying step size. The autocorrelation function and power spectral density of speech signals are time varying functions of the respective variables. Predictors for such input should be time varying. Hence adaptive predictors are used
11.	**Q: What are the line codes? Give the properties of line codes.** **Q: Give the properties of line codes. (Dec 2012, May 2017)** **Q: What are the line codes? List the 4 popular line code. N/D'20** In telecommunication, a line code is a pattern of voltage, current, or photons used to represent digital data transmitted down a communication channel or written to a storage medium Unipolar NRZ, Uniplar RZ,Polar RZ, Polar NRZ, Manchester , Bipolar NRZ ,Differential Manchester **The properties are** 1. Self-synchronization, 2.Error detection3.Bandwidth compression4. Differential encoding . 5.Noise immunity 6. Spectral compatibility with channels 7. Transparency
12.	**Construct unipolar and RZ code for the binary data 01101001**.

13.	**Draw the line encoding wave forms for the binary dada using (i) Unipolar NRZ and (ii) bipolar NRZ**
14.	**What are the Advantages of ADM over DM?** 1) ADM eliminates slope overload error and granular noise. 2) ADM has wide dynamic range. 3) Bandwidth utilization is better.
15.	**Inspect the concept of DPCM. List the advantages and disadvantages of DPCM** If the redundancy is reduced, then the overall bit rate will decrease and the number of bits required to transmit one sample will also reduce. This type of digital pulse modulation technique is called differential pulse code modulation. The DPCM works on the principle of prediction. The value of the present sample is predicted from the previous samples Mention two merits of DPCM. Or Advantages of DPCM i) Bandwidth requirement of DPCM is less compared to PCM. ii) Quantization error is reduced because of prediction filter. iii) Number of bits used to represent one sample value are also reduced compared to PCM
16.	.**What is the main difference in DPCM and DM?** DM encodes the input sample by only one bit. It sends the information about , i.e. step rise or fall. DPCM can have more than one bit for encoding the sample. It sends the information about difference between actual sample value and predicted sample value
	PART B
1.	(i) Evaluate the structure of linear predictor. (ii) Assess the process of prediction error.
2.	(i) Summarize adaptive delta modulator with continuously variable step size and explain with block diagram. (ii) Explain the difference between PCM systems and delta modulation systems.
	DPCM Draw the block diagram of DPCM transmitter and receiver with predictor and explain. What are the advantages of using predictor in DPCM Construct a DPCM system. Derive the expression for slope overload noise Of the system
	DM Describe delta modulation system in detail with a neat block diagram. Also illustrate two forms of quantization error in delta modulation. How the error can be eliminated?.
3.	(i) How would you explain delta modulation and its quantization error? (ii) Explain how adaptive delta modulation performs better than gains more SNR than delta modulation.
4.	**ADM** Draw the block diagram of adaptive delta modulation system transmitter and receiver with continuously varying step size and explain N/D'20
5.	**Line Coding**

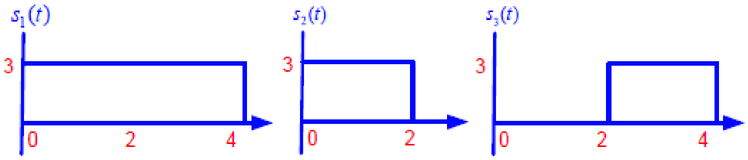
	Drive the expression for power spectral density of bipolar NRZ data format and list its properties Drive the expression for power spectral density of polar NRZ data format and list its properties Drive the expression for power spectral density of unipolar NRZ data format and list its properties Derive the expression for the PSD unipolar RZ data format. N/D'20 Write the comparison of various line coding techniques and list their merits and demerits.
6.	For the sequence 10111001, Develop the waveform supporting the following data formats. (i) Unipolar RZ (ii) Polar NRZ (iii) Alternate mark inversion (iv) Manchester coding. Draw the corresponding spectrum of the above formats and explain.
7	What is the function of LPC model and explain with diagrams.
	Problems
1	(i) State in your own words the functioning of ADPCM system with block diagram. (ii) A delta modulator with a fixed step size of 0.75v is given a sinusoidal message signal. If the sampling frequency is 30 times the Nyquist rate, what is the best maximum permissible amplitude of the message signal if slope overload is to be avoided
2	A signal having bandwidth of 3kHz is to be encoded using 8 bit PCM and DM system. If 10 cycles of signal are digitized, state how many bits will be digitized in each case if sampling frequency is 10 kHz? Also find bandwidth required in each case.
	PART C
1.	A television signal with a bandwidth of 4.2 MHz is transmitted using binary PCM. The number of quantization level is 512. Calculate (i) determine the code word length and transmission bandwidth (ii) Can you find Final bit rate and Output signal to quantization noise ratio.
2.	In a single integration DM scheme the voice signal is sampled at a rate of 64 kHz, the maximum signal amplitude is 1v, voice signal bandwidth is 3.5 kHz . (i) Determine the minimum value of step size to avoid slope overload (ii) Determine the granular noise $N_{o.}$ (iii) Assuming the signal to be sinusoidal, calculate the signal power and signal to noise ratio.
3.	A 1 kHz signal of voice channel is sampled at 4kHz using 12 bit PCM and a DM system. If 25 cycles of voice signal are digitized. Solve in each case (i) Signaling rate (ii)Bandwidth required (iii) No of bits required to be transmitted.
4.	
	UNIT III - BASEBAND TRANSMISSION& RECEPTION
	ISI – Nyquist criterion for distortion less transmission – Pulse shaping – Correlative coding – Eyepattern – Receiving Filters- Matched Filter, Correlation receiver, Adaptive Equalization
1.	What is ideal nyquist channel? Give the practical difficulties of ideal nyquist channel.

2.	**What is meant by ISI in communication system? How does ISI occur in digital transmission?** **What is meant by ISI in communication system? How can it be minimized? [A/M 2019]** A communication channel is always band limited hence it always disperses or spreads a pulse waveform passing through it. ISI means the spreading of signal pulses and overlapping between consecutive pulses. It occurs due to amplitude and phase change of signal during transmission through the channel Equalization techniques are used to combat ISI. So, signal quality is affected by noise as well as by ISI. Even if noise is absent, ISI may be present in a high speed digital communication system.
3.	**ISI cannot be avoided. Justify the statement** A communication channel is always band limited hence it always disperses or spreads a pulse waveform passing through it.ISI means the spreading of signal pulses and overlapping between consecutive pulses. Equalization techniques are used to combat ISI. So, signal quality is affected by noise as well as by ISI. Even if noise is absent, ISI may be present in a high speed digital communication system
4.	**How does pulse shaping reduce inter symbol interference.** Pulse shaping compresses the bandwidth of the data impulse to a smaller bandwidth greater than the Nyquist minimum, so that they would not spread in time. System performance is not degraded
5.	**What is ISI? What are the causes of ISI? [May/June -2016] , Define ISI(Dec2014,May2018)** ISI is a form of distortion of a signal in which one symbol interferes with subsequent symbols. This is an unwanted phenomenon as the previous symbols have similar effect as noise, thus making the communication less reliable. Spreading of the pulse beyond its allotted time interval causes it to interfere with neighbouring pulses. ISI arises due to imperfections in the overall response of the system
6.	**What is eye Pattern?. Use of eye pattern.** When the sequence is transmitted over a baseband binary data transmission system, the output is a continuous time signal. If this signal is out at each interval (Tb) and all such pieces are placed over one another, then we obtain eye pattern. It looks like eye. Eye pattern is particularly useful in studying ISI problem **State any two applications of eye pattern. (Dec 2012, May 2015** To study the Intersymbol interference To measure the additive noise, timing synchronization, jitter & non –linearity in the channel **What is the information that can be obtained from eye pattern regarding the signal quality? (May2014)** **WIDTH** defines the time interval over which the received signal can be sampled without error from ISI **SLOPE** determines the sensitivity of the system to timing error. **HEIGHT** defines the margin over noise. For zero ISI, the eye is widely opened. For more ISI,the eye will be closed completely.
7.	Summarize the raised cosine spectrum.

8.	**Examine correlative level coding.** Practical means of achieving the theoretical maximum signaling rate of 2Bo bits per sec in a bandwidth of Bo Hz by adding ISI in a controlled manner.
9.	**Q: Define Equalization. What is the need for equalization filter?** **Q: Why do we need equalization in base band pulse transmission**? The process of removing distortion in channel is called Equalization. When the signal passed through the channel distortion is introduced in terms of 1.Amplitude 2. Delay. This distortion creates a ISI. In order to avoid the equalizer is necessary basically it is a filter
10.	**Q: Assess the need for adaptive equalization in a switched telephone network.** **Q:What in meant by adaptive equalization?** An adaptive equalizer is an equalizer that automatically adapts to time-varying properties of the communication channel. Depends upon the received signal filter coefficients are adjusted to eliminate the distortion It is also frequently used with coherent modulations such as phase-shift keying, mitigating the effects of multipath propagation and Doppler spreading.
11.	**What is mean by correlative level coding? N/D'20** Practical means of achieving the theoretical maximum signaling rate of $2B_o$ bits per sec in a bandwidth of B_o Hz by adding ISI in a controlled manner.
12.	**Q: What is a matched filter? N/D'20** It is a linear filter designed to provide maximum SNR at its output for a given transmitted signal. A matched filter is obtained by correlating a known signal with the unknown signal to detect the presence of the known signal. In communication the matched filter is used to detect the transmitted pulse in the presence of noise **Q:Mention the properties of Matched filter** **Property1:** The peak pulse SNR of a matched filter depends only on the ratio of the signal energy to the power spectral density of noise. Max.SNR = $2E/\eta$ **Property: 2** The integral of the squared magnitude spectrum of a pulse signal with respect to frequency is equal to the signal energy, $\int_0^b \|S(f)\|^2 df = E$
13	**Write the down the decision rule for detecting the original input sequence {bk} form the output binary sequence {ck}of a precoded duo-binary scheme**. The decision rule for precoded duo-binary is Ck = { ± 2V , bk is decided in favour of symbol "0" 0V, bk is decided in favour of symbol "1"}

14	**What are the uses of precoder in modified duobinary system?** The precoder helps in reducing the propagation of error form previous output to the next output as they are correlated.
	PART B
1.	**Nyquist criterian for distortion less base band transmission** Q: Elaborate how ISI occurs in base-band binary data transmission system. Obtain the expression for Nyquist criterian for distortion less base band transmission for zero intersymbol interference**(May2013,2015, 2017)** Q:What is ISI ? List the various methods to remove ISI in s communication system. Also state and prove Nyquist first criterion for Zero ISI **[Apr/May-2018], Dec 2017)** Q:State and prove the Nyquist criteria for distortion less baseband transmission (**Nov 2018)** OR Describe the Nyquist's criteria for distortion less base band transmission**[May/June-2017]** QI:llustrate "raised cosine spectrum". Discuss how does it help to avoid ISI? **(May 2017)** Interpret the pulse shaping method to minimize ISI.
2.	**Correlative Level Coding** Outline the modified Duo binary coding technique and its performance by illustrating its frequency and impulse response. What is modified Duo binary signaling scheme? Draw the block diagram of signaling scheme and explain N/D'20,
3.	**Correlative Level Coding** Explain Duo binary with necessary diagram and expressions and with precoder
5.	**Eye Pattern** What is meant by eye pattern? What are the parameters observed from eye pattern? Explain with help of suitable diagram. Demonstrate how eye pattern illustrates the performance of data transmission system with respect to Inter Symbol Interference with neat sketch **Nov/Dec- 2016** Examine the principle of obtaining eye pattern and mark important observations made from the eye pattern **[April/May 2019]** Describe how eye pattern can be obtained and can be used for observing the characteristics of a communication channel. **(Dec2014,2015** Describe how eye pattern is helpful to obtain the performance of the system in detail with a neat sketch. **(Dec 2016)**

6.	**Correlator Receiver or optimum Filter** Draw the block diagram of correlator receiver and explain its working. Draw the detector part of matched filter receiver and explain how to maximize the SNR with necessary expressions Describe the implementation of the matched filter demodulator with a sample signal s(t) and its matched filter response h(t).). (**May 2018**)
7.	**Adaptive Equalization** Describe the adaptive equalization with block diagram. Explain the two operation modes of adaptive equalizers. Derive the formula for LMS algorithm and draw the signal flow graph of LMS algorithm **[May/June-2016], [Nov/Dec- 2015].** Write short notes on tapped delay line filter, adaptive equalization.
	Problems
1.	The binary data 00 11 01 001 is applied to a duobinary system, Construct the duobinary output and corresponding receiver output. (**Nov 2018)**
2.	The binary data 00 10 11 0 is applied to a duobinary system. Construct the duobinary coder output and corresponding receiver output. Assume that there is a precoder at the input**.** (**Nov 2018)**
	PART C
1	Generalize the realizations of the receiving filters based on the signal correlator and matched filter.
2	Discuss in detail about inter symbol interference (ISI) and the nyquist criterion for minimizing ISI. Elaborate the difficulties in implementing it in a practical system.
	UNIT IV - DIGITAL MODULATION SCHEME
	Geometric Representation of signals - Generation, detection, PSD & BER of Coherent BPSK, BFSK & QPSK - QAM - Carrier Synchronization - Structure of Non-coherent Receivers - Principle of DPSK
	Distinguish between coherent and non-coherent reception.[D] [A/M 2019, N/D 2016, M/J 2016] **Coherent detection** ▪ Local carrier generated at the receiver is phase locked with ▪ the carrier at the transmitter. ▪ Synchronous detection ▪ Low probability of error ▪ Complex in design **Non-coherent detection** o Local carrier generated at the receiver not be phase locked with the o carrier at the transmitter. o Synchronous detection is not possible. o High probability of error
1.	Outline the need for geometric representation of signals.
2.	**Obtain the orthonormal basis function for the signal. (Nov 2018)** Three signals $s_1(t)$, $s_2(t)$ and $s_3(t)$ are as shown in Figure. Apply Gram-Schmidt procedure to obtain and orthonormal basis functions for the signals. Express the signals $s_1(t)$ $s_2(t)$ and $s_3(t)$ in terms of orthonormal basis functions.



Solution:

$$E_1 = \int_0^T s_1^2(t)dt = \int_0^{T/3} 1^2 dt = T/3$$

$$\phi_1(t) = \frac{s_1(t)}{\sqrt{E_1}} = \frac{1}{\sqrt{T/3}} = \sqrt{3/T}$$

s_{21} is

$$s_{21} = \int_0^T s_2 t(t)\phi_1(t)dt$$
$$= \int_0^{T/3} 1\sqrt{3/T}dt = \sqrt{3/T}$$

$$E_2 = \int_0^T s_2^2 t dt = \int_0^{2T/3} (1$$
$$= \frac{2T}{3}$$

$$\phi_2(t) = \frac{s_2(t) - s_{21}\phi_1(t}{\sqrt{E_2 - s_{21}^2}}$$
$$= \sqrt{3/T}$$

3.

What is PSK?

Definition: If the transmitted signal is sinusoid of fixed amplitude then it is called as Binary – phase-shift keying. It has one fixed phase when the data is at one level & when the data is at another level the „phase" is different by 180

Mention the advantages of PSK systems (ID) (Dec2014).

i) Generation and Detection of PSK signals require simple circuit

ii) Information transmission rate is higher because of reduced bandwidth iii)Carrier power remains constant

Applications of PSK

- Multi-channel WDM delay, Delay and add a modulator , Local oscillator
- Optical communication , Nonlinear effect of WDM transmission
  Wireless LAN like Bluetooth and RFID

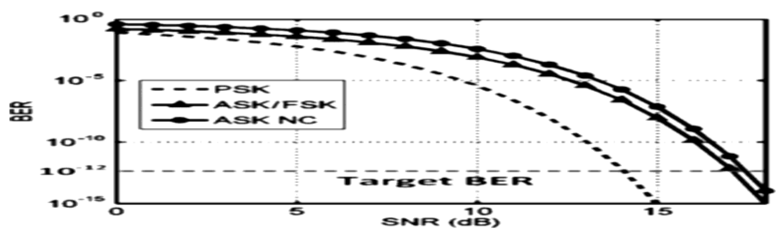
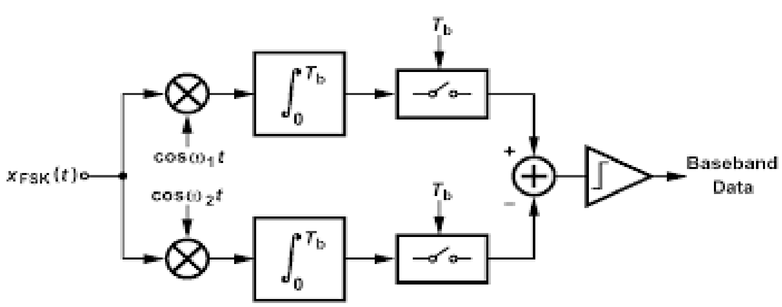
4.

What do you understand by non-coherent detection? [April/May- 2017]

We have seen that non-coherent detection is a detection technique that can be implemented without using carrier frequency which the performance asymptotically approached that of the coherent detection. However, differential detection is an attractive alternative to coherent detection.

Define non coherent detection schemes. [Apr/May-2018]

When the receiver does not utilize the phase reference information, then the detection is non coherent

5.	What is QPSK? Write down the expression for the QPSK signal. Quadrature Phase Shift Keying (QPSK) is a form of Phase Shift Keying in which two bits are modulated at once, selecting one of four possible carrier phase shifts (0, 90, 180, or 270 degrees). QPSK allows the signal to carry twice as much information as ordinary PSK using the same bandwidth. In QPSK, the phase of the carrier wave takes on one of four equally spaced values, namely π/4, 3π/4, 5π/4 and 7π/4.The expression for QPSK is given by $$s_i(t) = \begin{cases} \sqrt{\frac{2E}{T}} \cos\left[2\pi f_c t + (2i-1)\frac{\pi}{4}\right] & 0 \le t \le T \\ 0 & \text{elsewhere} \end{cases}$$, where I=1,2,3,4 and E be the transmitted signal energy per symbosl, T be the symbol duration and f_c bethe carrier frequency
6.	Sketch the BER curve for ASK,FSK,BPSK digital modulation schemes. (Nov 2018) 
7.	**Draw a block diagram of a coherent BFSK receiver. [D] [Nov/Dec- 2015, 2016]** 
8.	A BFSK system employs two signaling frequencies f1 and f2. The lower frequency f1 is 1200 Hz and signaling rate is 500 Baud. Compute f2.
9.	A BPSK system makes errors at the average rate of 100 errors per day. Data rate is 1 kbps. The single-sided noise power spectral density is 10 W/Hz. Assume the system to be wide sense stationary, predict the average bit error probability.

10. **Compare coherent and non coherent reception.**

Differentiate coherent and non-coherent detection methods. (D) (May&Dec 2016, Dec2017)

In coherent method, carrier is regenerated at the receiver
In non-coherent method, carrier need not be regenerated at the receiver side

11. **Identify the difference between BPSK and QPSK techniques**

S No	BPSK	QPSK
1.	Two phases are used	Four different phases are used
2.	Lower data rate	Higher data rate

12. **Indicate why PSK always preferable over ASK in Coherent detection.**

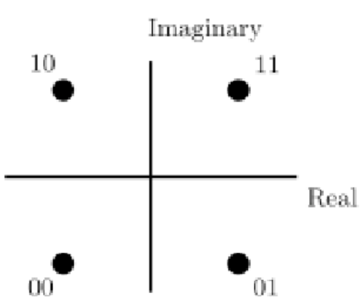
ASK is on-off signaling where as the modulated carrier is continuously transmitted in PSK. Hence peak power requirement is more in ASK, where it is reduces in PSK

13. **Write the special features of QAM.**

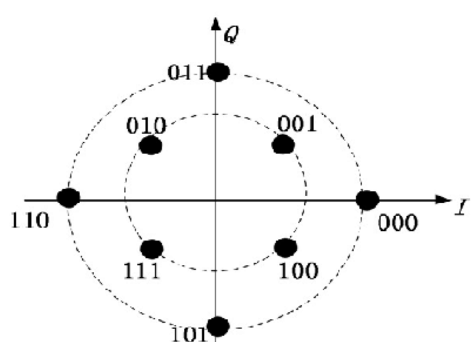
What is QAM? (May2013)

In quadrature amplitude modulation, the information is contained in both amplitude and phase of the transmitted carrier. Signals from two separate information sources modulate the same carrier frequency at the same time. It conserves the bandwidth

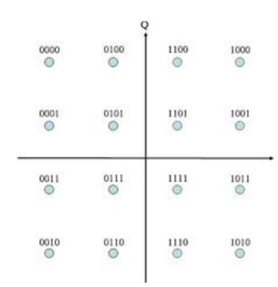
14. **Reproduce the signal space diagram for QAM signal for M=8.**



4 QAM



8 QAM



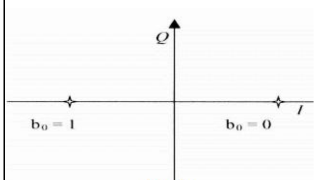
16 QAM

15. **Illustrate about the constellation diagram**.

What is Signal Constellation diagram?

The diagram which defines the collection of M message points in N dimensional Euclidean space is called signal constellation diagram. It helps to find the probability of error.

Diagram:



BPSK

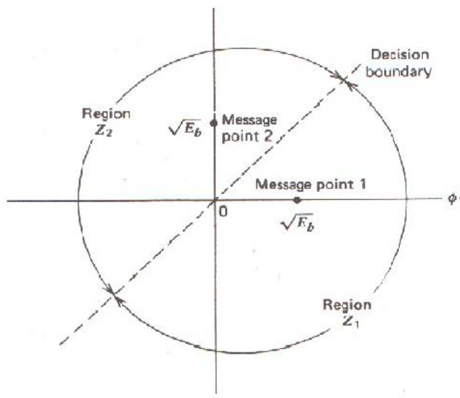
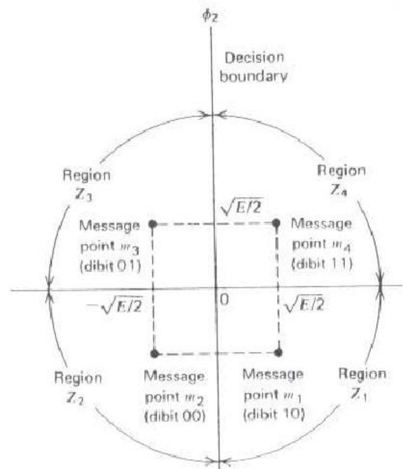


Fig. Signal Space diagram of Coherent binary FSK system.



QPSK

16. Identify the difference between coherent and non-coherent digital modulation techniques.

Coherent Binary Modulation
The local carrier generated is phase
locked with the carrier at the transmitter

It is also called as synchronous detection It is also called as envelope detection

Noncoherent Modulation
The receiver carrier need not be phase locked with transmitter.
It is simple but it has higher probability of
error

17. **What is DPSK? Assess the features of DPSK. Evaluate the error probability of DPSK.**

Differential phase shift keying uses differential encoding. Phase shift keying is modulated at the transmitter side. Receiver performs detection by comparing the phase of received symbol with that of previous symbol. Non coherent receiver is used

What are the advantages and disadvantages of differential phase shift keying?

Advantages:

1) DPSK does not need carrier at its receiver, Hence the complicated circuitry for generation of local carrier is avoided.

2) The bandwidth requirement of DPSK is reduced compared to that of BPSK.

Disadvantages:

1) The probability of error or bit error rate of DPSK is higher than that of BPSK.

2) Since DPSK uses two successive bits for its reception, error in the first bit creates error in the second bit. Hence error propagation in DPSK is more. Whereas in PSK single bit can go in error since detection of each bit is independent.

3) Noise interference in DPSK is more. In DPSK previous bit is used to detect next bit. Therefore if error is present in previous bit, detection of next can also go wrong. Thus error is created in next bit also. Thus there is tendency of appearing errors in pairs in DPSK.

18. For the binary sequence 1100, sketch the wave form of QPSK together with in phase and quardrature components wave forms. N/D'20

19. **What are the three levels of synchronization needed for coherent band pass signaling system? Which is not necessary for non-coherent system? N'/D'20**

Need of Synchronization: Signals from various sources are transmitted on single channel by multiplexing. So, synchronization is needed, it is also required for detectors to recover the digital data properly from the modulated signal

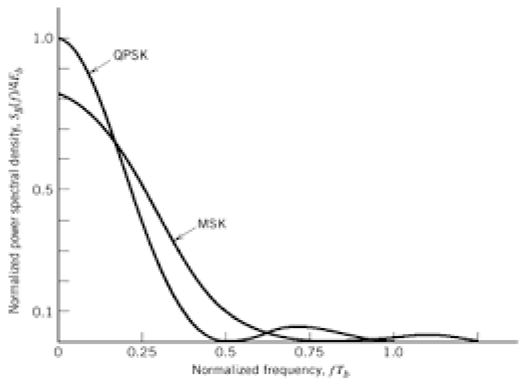
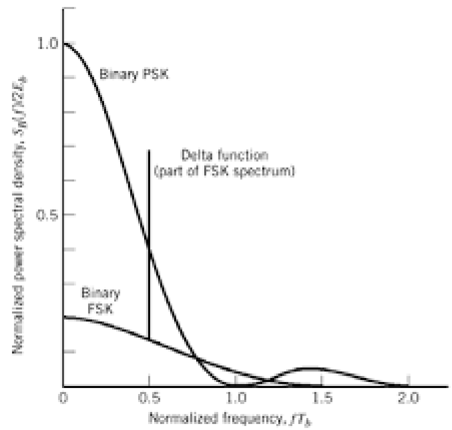
Carrier Synchronization

Symbol and bit synchronization

Frame synchronization

20. **List the error probability of Different modulation techniques**

$Modulation$	$Detection\ method$	$Bit\ error\ rate(P_b)$
$BPSK$	$Coherent$	$0.5erfc(\sqrt{\frac{E_b}{N_0}})$
$QPSK$	$Coherent$	$0.5erfc(\sqrt{\frac{E_b}{N_0}})$
$M-PSK$	$Coherent$	$\frac{1}{m}\, erfc\left(\sqrt{\frac{mE_b}{N_0}}sin(\frac{\pi}{M})\right)$
$M-QAM(m=even)$	$Coherent$	$\frac{2}{m}\left(1-\frac{1}{\sqrt{M}}\right)erfc\left(\sqrt{\frac{3mE_b}{2(M-1)N_0}}\right)$
$D-BPSK$	$Non-coherent$	$0.5e^{-\frac{E_b}{N_0}}$
$D-QPSK$	$Non-coherent$	$Q_1(a,b)-0.5I_0(ab)e^{-0.5(a^2+b^2)}$ $where\ a=\sqrt{\frac{2E_b}{N_0}\left(1-\frac{1}{\sqrt{2}}\right)}$ $b=\sqrt{\frac{2E_b}{N_0}\left(1+\frac{1}{\sqrt{2}}\right)}$ $Q_1(a,b)=$ Marcum Q -function $I_0(ab)=$ Modified Bessel-function

21.	**Draw the power spectral density of BPSK,BFSK,QPSK,MSK** 
	PART B
1.	(i) What is digital modulation scheme? Derive geometrical representation of signal. (ii) Write about the geometric representation of BPSK signal and BFSK signal.
2.	**BPSK** Explain the generation and detection of a coherent binary PSK signal and derive the power spectral density of binary PSK signal and plot it. **(May'17, Dec'16, Nov 2018,** Explain in detail the detection and generation of BPSK system. Derive the expression for its bit error probability. **May'17** Explain the generation and detection of a coherent binary PSK signal and derive the power spectral density of binary PSK signal and plot it. (**13) [May/June- 2016]**
3.	**BFSK** Explain **the non-coherent detection** of FSK signal and derive the expression for the probability of error. **N/D'20, [May/June- 2016]** Describe with diagrams, the generation and detection of **coherent binary FSK**. Derive the error probability of Binary FSK. **(13) (Nov2013, May2015,May 2018** Describe the operation of modulation and demodulation of binary FSK signals. **(13) [A/M'19]**

4.	**QPSK** Discuss the generation and detection of coherent QPSK signals with neat block diagram **N/D’20** Describe with diagrams, the generation and detection of coherent binary QPSK. Derive the error probability of Binary QPSK. **(13) (May2013, May2015,Dec2015,2016, 2017)** Discuss the transmitter, receiver and signal space diagram of QPSK and describe how it produces the original sequence with the minimum probability of error with neat sketch. **April/May 2019, Nov/Dec- 2015]** Draw the signal space diagram of a coherent QPSK modulation scheme and also find the Probability of error .if the carrier takes on one of four equally spaced values 0˙,90‟,180˝ and 270‟**. (8) [D] [Apr/May-2018]**
5.	Identify the principle of DPSK? Explain the transmitter and receiver of DPSK scheme.
6.	(i) Analyzing the transmitter, receiver and signal space diagram of Quadrature Amplitude Modulation. (ii) Outline the power spectral density and bandwidth of QAM signal with neat diagrams and mention its advantages.
7.	Explain Carrier and symbol synchronization
	PART C
1.	(ii) A set of binary data is sent at the rate of R_b= 100 Kbps over a channel with 60 dB transmission loss and power spectral density □= 10-12 W/Hz at the receiver. Evaluating the transmitted power for a bit error probability P_e= $10^{-3}$for the following modulation schemes. (a) FSK (b) PSK (c) DPSK (d) 16 QAM
2.	Draw the signal space diagram of a coherent QPSK modulation scheme and also find the probability of error if the carrier takes on one of four equally spaced values 0^o,90^o, 180^o and 270^o.
3.	In digital CW communication system, the bit rate of NRZ data stream in 1 Mbps and carrier frequency is 100 MHz. Solve for the symbol rate of transmission and bandwidth requirement of the channel in the following cases of different techniques used. (i) BPSK system (ii) QPSK system (iii) 16-ary PSK system

4.	(i) Find the error probability of BFSK system for following parameters. PSD of white noise $N_o/2 = 10^{-10}$ Watt/Hz Amplitude of carrier is , A = 1mV at receiver input. Frequency of baseband NRZ signal is f_b=1kHz. (ii) Binary data is transmitted using PSK at rate 2Mbps over RF link having bandwidth 2MHz. Find signal power required at the receiver input so that error probability is less than or equal to 10^{-4} Assume noise PSD to be 10^{-10}Watt/Hz.
5.	(i) Evaluate the Quadrature Receiver structure for coherent QPSK with appropriate diagram. (ii) In a QPSK system, the bit rate of NRZ stream is 10 Mbps and carrier frequency is 1GHz. Tell the symbol rate of transmission and bandwidth requirement of the channel
	UNIT V - ERROR CONTROL CODING
	Channel coding theorem - Linear Block codes - Hamming codes - Cyclic codes - Convolution codes - Viterbi Decoder
1.	**What is the need of channel coding?[D] [April/May- 2017]** The design of goal channel coding is to increase the resistance of a digital communication system to channel noise. Channel coding consists of mapping the incoming data sequence into a channel input sequence and inverse mapping the channel output sequence into an output data sequence in such a way that the overall effect of the channel noise is reduced.
2.	**State the channel coding theorem. [Nov/Dec- 2016, Nov/Dec- 2015]** Let a discrete memoryless source with an alphabet S and an entropy H(S), produce symbols once every T_s seconds. Let a discrete memoryless channel have capacity C be used once every T_c seconds. Then if, $\frac{H(S)}{T_s} \le \frac{C}{T_c}$ there exists a coding scheme for which the source output can be transmitted over the channel. The parameter is called critical rate.
3.	**What is a linear code? [April/May 2019, May/June-2016]** In linear code, the parity bits are generated as a linear combination of message bits
4.	**What is mean by systematic block code? N/D '20** Any linear block code can be a systematic code, until it is altered. Hence, **an unaltered block code** is called as a systematic code. **What is meant by syndrome of linear block code? [Apr/May-2018]** The non zero output of the produce YH.is calleTd syndrome & it is used to detect errors in y. Syndrome is denoted by S & given as, S=YH T

	Write the properties of syndrome in linear block codes. (Dec 2015) The syndrome depends only on the error pattern, and not on the transmitted codeword. All error pattern that differ at most by a codeword have the same syndrome The syndrome S is the sum of those columns of the matrix H corresponding to the error locations **State the significance of minimum distance of a block code. (May2013)** The minimum distance d_{min} of a linear block code is the smallest hamming distance between any pair of code vectors in the code. Minimum distance is an important parameter of the code. It determines the error correcting capability of the code
5.	Discuss the code rate of a block code.
6.	Hamming distance The hamming distance between two codes is equal to the number of elements in which they differ
7.	**What is hamming code?** Hamming codes are of (n,k) linear block codes that have the parameters Block Length = $2^m - 1$, Number of message bits k = $2^m - m - 1$, Number of parity bits, n-k = m where m≥3 so called Hamming code
8.	**Define Hamming weight? Determine the Hamming weight of the codeword 0110100. [D] (May2015)** Hamming weight is the number of non-zero elements in the code vector. Hamming weight = 3 for 011010
9.	Deduce the Hamming distance between 101010 and 010101. If the minimum Hamming distance of a (n, k) linear block code is 3, what is the minimum Hamming weight?
10.	Summarize the advantages and disadvantages of Hamming codes.
11.	Discuss two properties of generator polynomial.
12.	**List the properties of cyclic codes. [Nov/Dec 2015]** Linearity property: Sum of any two code word is also a codeword in the given code. Cyclic property: Any cyclic shift of a code word is also a codeword in the given code
13.	**What is Convolutional Code?** Fixed number of input bits are stored in the fixed length shift register and they are combined with the help of modulo-2- adders. This operation is equivalent to binary **What is meant by constraint length of a convolutional encoder? [A/M 2019, May/June-2016]** Constraint length is the number of shift over which the single message bit can influence the encoder output. It is expressed in terms of message bits

	Write the various techniques /algorithms used in encoding and decoding of convolutional code. [Apr/May- 2018],2017 a) State diagram,(b) Code tree,(c)Trellis. It shows the transition between various states
13.	**List the four objectives of a Channel code or error control code. [D] (Dec2014, May 2017)** a. To have the capability to detect and correct errors. b. To be able to keep the process of error detection and correction as more practicable. c. To be able to encode the symbol in a fast and efficient way. To be able to decode the symbol in a fast and efficient way
14.	**Generate the cyclic code for (n, k) syndrome calculator. [Nov/Dec- 2016]** Code rate = k/n, where k is the length of message bits and n is length of the code word.
15.	**Define Constraint length. Or what is meant by constraint length of a convolutional encoder? (May 2015, 2016)** Constraint length is the number of shifts over which a message bit can influence the encoder output
16.	**What are the limitations of Viterbi decoding?** Viterbi decoding can correct up to 2 errors. A triple error pattern is uncorrectable by the Viterbi algorithm. Constraint length increases, complexity also increases exponentially. Remedy: Sequential decoding procedure is used. In which the error probability decreases easily, Decoding procedure is independent of constraint length
17.	Propose the generator polynomial of cyclic codes.
18.	The code vector [1110010] is sent, the received vector is [1100010]. Identify the Syndrome.
	PART B
1	Consider a linear block code with generator matrix
	$\begin{bmatrix} 1101000 \\ 0110100 \\ 1110010 \\ 1010001 \end{bmatrix}$ (i) Enumerate the parity check matrix. (ii) Trace the error detecting and capability of the code.
	(iii) Draw the encoder and syndrome calculation circuits. Write the syndrome for the received vector r = [1 1 0 1 01 0]. Identify the error corrected vector.
	Consider the (7,4) linear block code whose generated matrix is given below. **[A/M 2019]**

$$G = \begin{bmatrix} 1\,0\,0\,0 : 1\,1\,1 \\ 0\,1\,0\,0 : 1\,1\,0 \\ 0\,0\,1\,0 : 1\,0\,1 \\ 0\,0\,0\,1 : 0\,1\,1 \end{bmatrix}$$

	Find **(i)** Find all the code vectors **(4)** **(ii)** Find parity check matrix(H) **(5)** **(iii)** Find the minimum of weight code **(4)**
	(i) Analyzing the generation of (n, k) block codes and audit how block codes can be used for error control. (ii) Consider a (6, 3)block code and explain how error syndrome helps in correcting a single error for a data 110.
	The generator matrix for a (6,3) block code is given below, find the all code vectors 1. C= 1 0 0: 0 1 1 0 1 0:1 0 1 0 0 0 1:1 1 0
	(i) Cite an example and explain one decoding procedure of linear block codes. (ii) Find the (7, 4) systematic and non-systematic cyclic code words of the message word 1101. Assume the generator polynomial as $1 + x^2 + x^3$.
	(i) Describe the steps involved in the generation of linear block codes. Explain the properties of syndrome.
	For a systematic linear block code, the three parity check digits P_1, P_2,P_3 are given by $P_{k,n-k}$ =[101 111 110 011] (i) Construct generated matrix. (ii) Assess the t code generated by the matrix. (iii) Determine error correcting capacity. Decode the received words with an example.
	Hamming Code
2	Illustrate how the errors are corrected using hamming code with an example.
	Cyclic Code
3	Examine that the generator polynomial of a (7, 4) cyclic code is $1+X+\square^3$. Discover the correct code word transmitted if the received code word is (i) 1011011 and (ii) 1101111
	With suitable numerical examples, describe the cyclic codes with the linear and cyclic property and also represent the cyclic property of a code word in polynomial notation.
	Develop the cyclic codes with the linear and cyclic property. Also represent the cyclic property of a code word in polynomial notation.
	The generator polynomial of (7,4) binary cyclic code is given $g(x) = 1 + x + x^3$ .Determine the codeword in systematic form for the following messages N/D'20

	1. 1011 2. 1111
	Convolution Code
4	(i) Determine how Viterbi decoding algorithm is used for convolutional code. (ii) Explain the different types of error detected by CRC code.
	A convolutional code is described by g1=[1 0 0], g2=[1 0 1], g3=[1 1 1] (i) Build the encoder corresponding to the code. (ii) Develop the state transition diagram for this code. (iii) Draw the trellis diagram. Estimate the transfer function
	Draw the diagram of the ½ rate convolutional encoder with generator polynomials $G^1(D)=1+D$ $G^2(D)=1+D+D^2$ And complete the encoder output for input sequence 101101.
	(i)Draw the code tree of a Convolutional code of code rate r = 1/2 and
	constraintlength of K = 3 starting from state table and state diagram for an encoderwhich is commonly used. (ii) Draw and explain the trellis diagram representation of convolutional codes.
	(i) Demonstrate the generation of a code using a convolutional encoder with k=1, n=2 and r = ½. (ii) Calculate the encoded output for the input message 10011. (For a Convolutional encoder of constraint length 3 and rate ½.
	For the rate ½ rate convolution encoder with generator polynomials N/D '20 $G(D)=[1\ 1+D+D^{3]}$ i.Draw the encoder diagram ii.Deteremine the generator matrix iii For input sequence U = 1011, find the code polynomial and code sequence..
	(i) Identify a block code for a message block of size eight that can correct for single errors. (ii) Diagnose a convolutional coder of constraint length 6 and rate efficiency **½.** Draw its tree diagram and trellis diagram.
	(i) Devise the Maximum Likelihood decoding of Convolutional codes.
	(ii) Construct the state diagram for the convolutional encoder with k=1, n=2 and r=1/2., starting with the all zero state, trace the path that corresponds to the message sequence 10111…
	Viterbi algorithm
5	(i) Explain Viterbi algorithm with an appropriate coder and received input word of length 12. Assume a coder of constraint length 6 and rate efficiency ½. (ii) Assess a (7,4) binary cyclic code with a generator polynomial $g(x) = 1 + x + x^3$ draw the syndrome circuit. 2. Given code Construct Viterbi decoder