ST.ANNE'S

COLLEGE OF ENGINEERING AND TECHNOLOGY

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ANGUCHETTYPALAYAM, PANRUTI – 607 106.

QUESTION BANK

PERIOD: AUG - NOV 2021   **BATCH**: 2019 – 2023

BRANCH: ECE   **YEAR/SEM:** III/V

SUB CODE/NAME: EC8501 – DIGITAL COMMUNICATION

UNIT I INFORMATION THEORY

PART – A

1. **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 rate of information 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 probabilities, the encoder has to work on longer blocks of signal data. This entails longer delays and higher computational requirements.

2. **Define entropy and find the entropy of a discrete memory less source with probability s1=1/2, s2=1/4 and s3=1/4. [D]**

   Entropy is the measure of the average information content per second. It is given by the expression $H(X) = -\sum_{i} P(x_i) \log_2 P(x_i)$ bits/sample.

   Entropy= $(1/2) \times \log_2(1/2) + (1/4) \times \log_2(1/4) + (1/4) \times \log_2(1/4)$

3. **State Shannon's Channel capacity theorem. [D]**

   The capacity 'C' of an additive Gaussian noise channel is $C = B\log_2(1 + \frac{S}{N})$

   B= channel bandwidth, S/N=signal to noise ratio.

4. **Explain Shannon-Fano coding. [D]**

   An efficient code can be obtained by following a simple procedure, known as Shannon- Fano algorithm. List the source symbols in order of decreasing probability. Partition the set into two sets that are as close to equi-probable as possible, and assign 0 to the upper set and 1 to the lower set. Continue this process, each time partitioning the sets with as nearly equal probabilities as possible until further partitioning is not possible.

5. **Define entropy and its properties. [D]**

   Entropy is the measure of the average information content per second. It is given by the expression $H(X) = -\sum_{i} P(x_i) \log_2 P(x_i)$ bits/sample.

6. **Define mutual information and channel capacity. [D]**

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.

7. State the properties of mutual information. [D]

I(X, Y)=I (Y, X)

I(X, Y) $\geq$ 0

I(X,Y)=H(Y)-H(Y/X)

I(X,Y)=H(X)+H(Y)-H(X,Y), I(X,Y) isthe mutual information and H(X)- entropy of the source, H(Y)- entropy of the sink, H(X/Y)- conditional entropy of Y

8. Give the relation between the different entropies. [D]

H(X,Y)=H(X)+H(Y/X)=H(Y)+H(X/Y)

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

9. Define code redundancy?[D]

Redundancy (γ) = 1 – code efficiency

$\gamma = (1 - \eta)$

10.   Define information rate. [D]

If the time rate at which source X emits symbols is r symbols per second. The information rate R of the source is given by R=r H(X) bits/second, where H(X)- entropy of the source.

11.   What is data compaction? [D]

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.

12. State the property of entropy. [D]

1.Symmetry: $H(P_{k,}, P_{k-1}) = H(P_{k-1}, P_{k,})$

2. Additivity: If the alphabet 'X' has symbols X = {S_0. S_1, ….,S_n} then partitioning of emtropy into different subsets does not affect the value of entropy H (X)

$H(X) = H (S_0, s_1, ….,S_m) + H (S_{m+1}, ……, S_n)$

3. Extremal property: $0< H(X) <\log_2 K$, is the radix of the alphabet X of the source.

4. Continuous Property: the entropy H(X) is continuous in the interval $0 <P_k< 1$.

5. Extension property: $H (X)^n = n H (X)$

13. Mention the drawbacks of channel coding theorem. [D]

   i)   It doesn't show us hoe to construct a good code

   ii)   Power and bandwidth constraints also hidden here.

14. What is differential entropy? [D]

The average amount of information per sample value of x(t) is measured by

H(X)=f_x(x)log f_x(x)dx bit/sample, where

H(X) –differential entropy of X.

15. What is the channel capacity of a discrete signal? [ID]

The channel capacity of a discrete signal C= max{I(X,Y)P(x$_i$)},where I(X,Y)-mutual information.

16. What is source coding and entropy coding? [D]

A conversion of the output of a discrete memory less source (DMS) into a sequence of binary symbols is called source coding. The design of a variable length code such that its average code word length approaches the entropy of the DMS is often referred to as entropy coding.

17. State Shannon Hartley theorem. [D]

The capacity 'C' of an additive Gaussian noise channel is $C = B\log_2(1+\dfrac{S}{N})$, where B= channel bandwidth, S/N=signal to noise ratio.

18. What is the entropy of a binary memory-less source? [D]

The entropy of a binary memory-less source H(X)=-p$_0$ log$_2$p$_0$-(1-p$_0$)log$_2$(1-p$_0$)

p$_0$-probability of symbol '0',p$_1$=(1- p$_0$) =probability of transmitting symbol '1'.

19. How is the efficiency of the coding technique measured? [D]

Efficiency of the code =H(X) /L, where L=$\sum l_i p_i$ is the average code word length. l_i =length of the code word.

20. What happens when the number of coding alphabet increases? [ID]

When the number of coding alphabet increases, the efficiency of the coding technique decreases.

21. What is channel diagram and channel matrix? [D]

The transition probability diagram of the channel is called the channel diagram and its matrix representation is called the channel matrix.

22. What is information theory? [D]

It deals with the mathematical modeling and analysis of a communication system rather than with physical sources and physical channels

23. What is the channel capacity of a BSC and BEC? [ID]

For BSC the channel capacity is given by C=1+plog$_2$ p + (1-p) log$_2$(1-p).For BEC the channel capacity C=(1-p).

24. Define information capacity. [D]

The information capacity of a communication system represents the number of independent symbols that can be carried through the system in a given unit of time and the most basic symbol is the binary digit (bit).

25. State the advantages of Lempel-Ziv Coding. [D]

i) Receiver does not require prior knowledge of the coding table constructed by the transmitter ,
ii) Synchronous transmission.

26. Calculate the entropy of the source and symbol probabilities 0.6, 0.3, 0.1. [ID]

H= 0.6 log$_2$ 1/0.6+0.3 log$_2$ 1/0.3+0.1 log$_2$ 1/0.1 = 0.44+0.52+0.33 = 1.29 bits /symbol.

27. Define Rate Bandwidth and Bandwidth efficiency. [D]

It is defined as the ratio of the data rate in bits per second to the effectively utilized channel bandwidth. $\rho = R_b/B$ bits/Hz where R_b = data rate.

28. Define Source Coding. [D]

Source coding is a procedure for mapping a given set of message $[m_1, m_2, \ldots m_N]$ into a new set of encoded messages $[c_1, c_2, \ldots c_N]$ in such a way that the transformation is one to one for each message and there is only one encoded message. This is called source coding.

29. Why Huffman coding is said to be optimum? [ID]

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 memoryless channel.

30. Define the Bit of information. [D]

Bit is the basic unit of information. It is defined as the quantity of information required to permit a correct selection of one out of a pair of equiprobable events.

31. State noise coding theorem. [D]

In information theory, the noisy-channel coding theorem (sometimes Shannon's theorem or Shannon's limit), establishes that for any given degree of noise contamination of a communication channel, it is possible to communicate discrete data (digital information) nearly error-free up to a computable maximum rate through .

PART B
[FIRST HALF]
DISCRETE MEMORYLESS SOURCE, INFORMATION, ENTROPY, MUTUAL INFORMATION

1. State and prove mutual information and write the properties of mutual information.**[D] (8)**

2. What is the mutual information and channel capacity of the given system **[D] (8)**

$$P(x_0) = 0.6$$
$$P(x_1) = 0.4$$
$$P\left(\frac{y}{x}\right) = \begin{bmatrix} 0.8 & 0.2 \\ 0.3 & 0.7 \end{bmatrix}$$

3. One experiment has four mutually exclusive outcomes Ai,i=1,2,3,4 & second experiment has three mutually exclusive outcomes Bj=1,2,3 .The joint probabilities are P(A1,B1)=0.10,P(A1,B2)=0.08,P(A1,B3)=0.13,P(A2,B1)=0.05,P(A2,B2)=0.03,P(A2,B3)=0.09,P(A3,B1)=0.05,P(A3,B2)=0.12,P(A3,B3)=0.14,P(A4,B1)=0.11,P(A4,B2)=0.04,P(A4,B3)=0.06.

(i)Determine the probabilities P(Ai),i=1,2,3,4 & P(Bj),j=1,2,3

(ii)Suppose we have the outcomes of A. Determine the mutual information and the average mutual information. **[ID] (13) (Nov 2018)**

4. Define Mutual information. Find the relation between the mutual information and joint entropy of the channel input and channel output.(ii) What are the implications of the information capacity theorem. **[13] [D]**

5. Prove that the entropy of a discrete memory less source is maximized when the symbol are equiprobable. **[8] [D]**

6. Derive the expression for entropy, also state and prove the properties of entropy. **[D] [8]**

7. Explain the need for source coding & channel coding? Explain how channel capacity can be improved, Explain SNR in detail**. [D] [8](May 2014)**

8. (i) The two binary random variables X and Y are distributed according to the joint PMF given by P(X=0, Y=1) = 1/4; P(X = 1, Y=1)=1/2; P(X=1,Y=1)=1/4; Determine H(X,Y), H(X), H(Y), H(X/Y) and H(Y/X).
   (ii) Define entropy and plot the entropy of a binary source. **[8] [D] (Nov/Dec 2015)**

DISCRETE MEMORYLESS CHANNELS – BINARY SYMMETRIC CHANNEL

9. (i)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. **[D] [8] (April/May 2017)**

10. (i)Find the channel capacity of the binary r= symmetry channel as shown below. **(D) (13) (April/May 2017)**
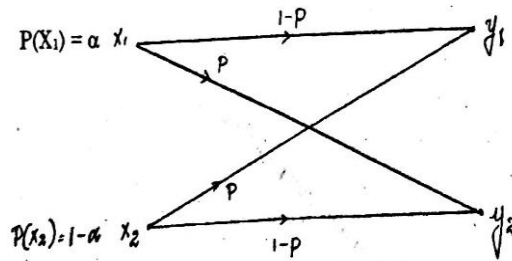
   (ii).A source is emitting equi-probable symbols .construct a Huffman code for source.

11. Derive the channel capacity of Binary symmetric channel. **[D] [8]**

[SECOND HALF]

CHANNEL CAPACITY - HARTLEY - SHANNON LAW

12. 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) [D] (M/June 16)**

13. Derive the channel capacity of a continuous band limited white Gaussian noise channel. **[10] [ID]**

14. Discuss about rate distortion theory**. [6] [D]**

15. Derive the capacity of a Gaussian channel.**(D) (8)**

SOURCE CODING THEOREM - SHANON FANO CODING & HUFFMANN CODING

16. Explain the huffmann coding algorithm with a flow chart and illustrate it using an example **[13] [D] (N/D 15)**

17. (i) 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) [ID] (MAY 2016)**

18. A discrete memory less source emits 5 symbols whose associated probabilities are as given below. Construct Shannon Fano code and determine the efficiency. **(8) [ID] (MAY 2016)**

   Symbols: X0   X1   X2   X3   X4

Probabilities: 0.4 0.19 0.16 0.15 0.1

19. 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)**

20. 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. **[D] (13)**

21. i)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. **[D] (8)**

UNIT II WAVEFORM CODING

PART – A

1. **List few digital modulation schemes used for voice communication?[ID] [April/May2019]**

   - Delta Modulation
   - Adaptive Delta Modulation
   - Binary Frequency Shift Keying
   - Binary Phase Shift Keying
   - Quadrature Phase Shift Keying
   - Quadrature Amplitude Modulation

2. **What is a linear predictor? On what basis are the predictor coefficients determined?[ID] [APRIL/MAY 2019, 2017]**

   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. **For the binary data 0110100, draw Manchester coded signal? [ID] [April/May 2019]**

4. **Draw the NRZ-M and Biphase–M baseband encoding forms for the data [1010110010]. [D] (N/D 18)**
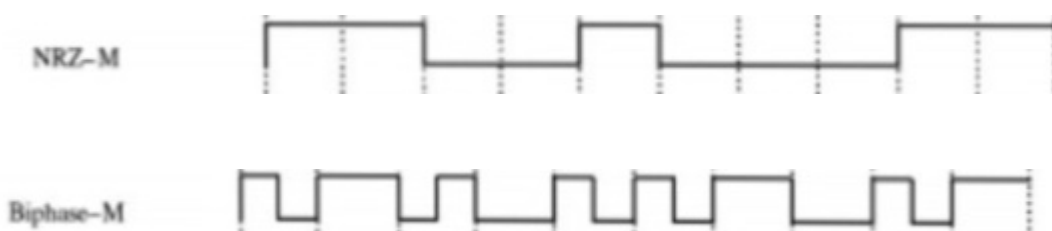
5. **Write the expression for output signal to noise ratio of DPCM receiver mentioning both the predictive gain and prediction error to quantization noise ratio. [ID] (NOV 2018)**

$$(SNR)_O = \left(\frac{\sigma_x^2}{\sigma_E^2}\right)\left(\frac{(\sigma_E^2)}{(\sigma_Q^2)}\right) = G_P * (SNR)_P$$

G_p is the predictor Gain and $(SNR)_P$ is the signal to noise ratio of predictor.

6. **A delta modulation system is tested with a 10KHz sinusoidal signal with 1V peak to peak at the input. It is sampled at 10 times the nyquist rate. What is the SQNR? [ID] (NOV 2018).**

The sampling rate is fs = (10*1000*2)10= 0.2Msamples/sec

SQNR= 1.76+ 6.02*N

7. **What is meant by delta modulation systems? [D] [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.

8. **Why delta modulation is superior to differential pulse code modulation? [D] [Apr/May-2018]**

Delta modulation encodes one bit per samples. Hence signalling rate is reduced in DM.

9. **What is meant by granular noise in a delta modulation system? How can it be avoided? [D] [A/M17]**

It occurs due to large step size and very small amplitude variation in the input signal.

10. **What is the need of prediction filtering? [D] [Nov/Dec 2016]**

- 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.

11. **How to overcome the slope overlap? [ID] [Nov/Dec 2016]**

Reduce the step size we can overcome from slope over distortion in delta modulation

12. **What are the advantages of delta modulator? [D] [May/June-2016]**

The advantages are

- High SNR
- Low bandwidth consumption

Usage of cost effective systems

13. **Define APF and APB. [ID] [Nov/Dec 2015]**

Adaptive prediction with forward estimation (APF), is one in which unquantized samples of the input signal are used to derive estimates of the predictor coefficients.

Adaptive prediction with backward estimation (APB), in which samples of the quantizer output and the prediction error are used to derive estimates of the prediction error are used to derive estimates of the predictor coefficients.

14. **Write the limitations of delta modulation. [D] [Nov/Dec 2015]**

1. Slope of overload distortion.
2. Granular noise.

15. What is the need for coding speech at low bit rates? [D]

To remove redundancies from the speech signal as far as possible,

To assign the available bits in a perceptually efficient manner.

16. What are the types of adaptive predictors? [D]

Adaptive prediction with forward estimation (APF),

Adaptive prediction with backward estimation (APB)

17. Mention the use of Vocoders. [D]

Vocoders are used to remove redundancies from the speech signal and to constantly adapt to the speech statistics.

18. What is the advantage of DM over PCM? [ID]

DM uses one bit to encode one sample.Hence bit rate of delta modulation is lower compared to PCM and also the transmission bandwidth is small.

19. Draw the Unipolar NRZ ,Polar NRZ format, Unipolar RZ & Bi[polar RZ for the data sequence 1101001. [ID] (May 2018)
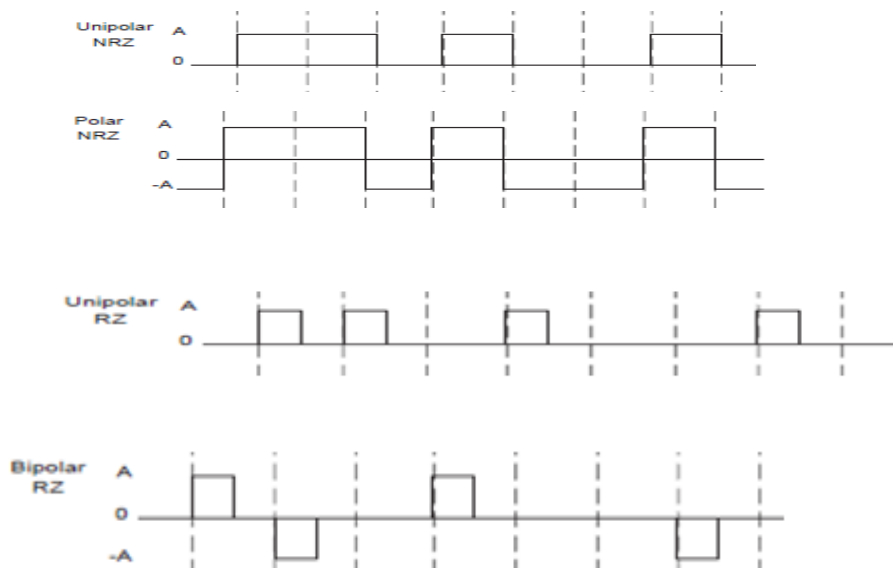
20. Define Adaptive delta modulation. [D]

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.

21. What is meant by transparency with respect to line codes? [ID] (May 2013)

Transparency is defined as a line code in which the bit pattern does not affect the accuracy of the timing. A transmitted signal would not be transparent if there are a long series of 0's which would cause an error in the timing information. Such that receiver does not go out of synchronization with the any sequence of data symbols. A clock is must for this synchronization.

22. What is NRZ polar format and RZ polar format? [ID]

Symbol 0 is represented by negative pulse and symbol 1 is represented by a positive pulse. For NRZ format, the pulse will occupy the entire symbol duration.

Symbol 0 is represented by negative pulse and symbol 1 is represented by a positive pulse. For RZ format, the pulse will occupy the half the symbol duration.

23. Why DM is not suitable for high dynamic range speech? [ID]

DM requires a lesser transmission bandwidth than PCM to achieve the same SNR.Speech signal requires large dynamic range,but to avoid slope overload noise DM has small dynamic range. So DM is not suitable for high dynamic range speech.

24. What is meant by Prediction error? [D]

The difference between the actual samples of the process at the time of interest and the predictor output is called prediction error.

25. State the differences between DPCM and DM. [D]

i) DM uses only one bit information for transmission

ii) Replacement of the prediction filter in DPCM by a single delay element constitutes DM system.

26. Mention two merits of DPCM. [ID]

Bandwidth requirement of DPCM is less compared to PCM.

Quantization error is reduced because of prediction filter, and

Number of bits used to represent one sample value is reduced as compared to PCM.

27. What are the advantages of adaptive delta modulation? [D]

The advantages of adaptive delta modulation are

1. Slope overload noise is reduced

2. Granular noise is reduced

3. Lesser number of bits is used

28. Define ADPCM. [D]

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.

29. Mention the use of adaptive quantizer in adaptive digital wave form coding scheme. [D]

Adaptive quantizer changes its step size according to the variance of the input signal. Hence quantization error is reduced. ADPCM uses adaptive quantization. The bit rate of such schemes is reduced due to adaptive quantization.

30. What do you understand from adaptive coding? [D]

In adaptive coding quantization step size and prediction filter co-efficients are changed as per properties of input signals. Thus quantization error and number of bits used to represent the sample value is reduced. Adaptive coding is used for low bit rates.

31. Give the properties of line codes. [D] (Dec 2012, May 2017)

The properties are

1. Self-synchronization, 2.Error detection3.Bandwidth compression4. Differential encoding

5. Noise immunity 6. Spectral compatibility with channels 7. Transparency

PART – B

[First Half]

Prediction Filtering and DPCM

1. Describe the delta modulation system in detail with a neat block diagram. Also, illustrate the two forms of quantization error in delta modulation.**(D) (13) [April/May 2019]**

2. Elucidate a DPCM system .derive the expression for slope overload noise of a system? **(7) [D] [A/M'18]**

3. Explain the DPCM system .derive the expression for slope overload noise. show that SNR of DPCM is better than that of PCM. **(8) [D]**

4. Write short notes on prediction filtering? **(8) [D]**

Delta Modulation

5. Explain in detail about delta modulation transmitter & receiver. A sinusoidal signal$X(t)= a_0.cos(2\pi f_0 t)$ is applied to delta modulator that operates at sampling time of Ts and step size = 2δ.

   (i) Find the expression for the amplitude to avoid slope overload noise.

   (ii) Compute the maximum permissible value of the output signal power.

   (iii) Compute the variation of quantization noise in delta modulation.

   (iv) Find the maximum value of output signal to noise ratio. **[ID] (13) (Nov 2018)**

6. Describe and illustrate Delta modulation and it quantization error? **(8) [D] [Nov/Dec-15]**

7. Compare PCM with delta modulation system? **(8) [D] [May/June 16]**

8. Describe delta modulation system in detail with a neat diagram and illustrate the two forms of quantization error in delta modulation? **(10) [D][Nov/Dec-16]**

[Second Half]

ADPCM and ADM Principles

9. Describe the Adaptive Delta Modulation with neat sketch and compare it with Delta Modulation of ADPCM. **(13) [D] (April/May 2019)**

10. Explain how Adaptive delta modulation performs better and gains more SNR and delta modulation.**(10) [ID] [Nov/Dec-15]**

11. Illustrate how adaptive time domain coder codes the speech at low bit rate and compare it with the frequency domain coder? **(6) [ID] [Nov/Dec-15]**

12. Draw the block diagram of ADPCM system and explain it function? **(8) [D] [May/June- 16]**

13. Draw the block diagram of an Adaptive delta modulator with continuously variable step size? **(7) [D] [May/June-16]**

14. Describe ADM with neat diagram and compare it with delta modulation? **10 [D] [Nov/Dec-16]**

15. Explain the construction features and working of adaptive delta modulation? **10 [D] [Apr/May-2018]**

16. With a neat diagram explain the adaptive delta modulation and demodulation system? **[D] [April/May-17]**

Linear Predictive Coding

17. Consider the linear prediction of a stationary autoregressive process, x(n) generated from the first-order difference equation x(n)=0.9x(n-1)+v(n) is the white noise of zero mean and unit variance. Determine the tap weights of the second order forward prediction error filters. **(ID) (13) (Nov 2018)**

18. Explain speech synthesis using LPC. **(8) [D]**

19. Explain speech model based encoding technique. **(7) [D] [May/June-13]**

Power Spectral Density of Unipolar / Polar RZ & NRZ – Bipolar NRZ - Manchester

20. Derive and plot the power Spectra of NRZ unipolar and bipolar format signals. **[D] [April/May 2019]**

21. Compare the various line coding techniques and list their merits and demerits. **(8) [D] [May/June 2016]**

22. What is need for line shaping of signals ?derive the PSD of a unipolar RZ and NRZ ,line code and compare their performance? **(10) [ID] [Apr/May-2018]**

23. Determine the power spectral density for NRZ bipolar and unipolar data formats. Assume that 1s and 0s in the input binary data occur with equal probability? **[ID] [Nov/Dec- 2015.]**

24. Derive the power spectral density of unipolar NRZ data format and list its properties? **(8) [D][M/J 2017]**

25. Sketch the power spectra of (a) Polar NRZ and (b) bipolar RZ signals. **(8) [D] [May/June- 2016]**

UNIT III BASE BAND TRANSMISSION

PART – A

1. **What is meant by ISI in communication system? How can it be minimized? [ID] [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. 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.

2. **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. [ID] (Nov 2018)**
    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"}

3. **State Nyquist second and third criteria to realize zero ISI. [ID] [Apr/May-2018, Nov/Dec 2017]**

    The spectra of the transmitted pulse should satisfy following equation $\sum\limits_{n=-\infty}^{\infty} P(f - nR_b) = T_b$,

    where P(f) is the spectrum of the transmitted pulse p(t) and $R_b = 1/ T_b$ is the rate at which pulses are transmitted.

4. **What is an eye diagram? [ID] [April/May- 2017]**

    An **eye pattern**, also known as an **eye diagram**, is an oscilloscope display in which a digital signal from a receiver is repetitively sampled and applied to the vertical input, while the data rate is used to trigger the horizontal sweep. It is so called because, for several types of coding, the pattern looks like a series of eyes

between a pair of rails. It is a tool for the evaluation of the combined effects of channel noise and intersymbol interference on the performance of a baseband pulse-transmission system.

5. **What is ISI? What are the causes of ISI? [ID] [May/June -2016]**

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. **Define correlative level coding. [ID] [Nov/Dec- 2016]**

Practical means of achieving the theoretical maximum signalling rate of $2B_o$ bits per sec in a bandwidth of B_o Hz by adding ISI in a controlled manner.

7. **List the properties of syndrome. [ID] [Nov/Dec- 2015]**

Syndrome depends only on the error pattern and not on transmitted code word
☐ All error pattern differing by a code word will have the same syndrome.
☐ The syndrome is the sum of those columns of matrix H corresponding to the error location
☐ With syndrome decoding and (n,k) linear block code can correct upto the error per code word if n and k satisfy the hamming bound.

8. **Compare M-ary PSK and M-ary QAM. [ID] [Nov/Dec- 2015]**

SI.NO	M-ary PSK	M-ary QAM
1	The in phase and quadrature component are interrelated and the phase of the carrier takes one of M possible values with $\theta i = \frac{2i\pi}{M}$ where i=0,1,.....M-1	The in phase and quadrature component are independent and it enables the transmission M= L2 independent symbols over the same channelbandwidth
2	It has rectangular constellation	It has circular constellation

9. **How the impulse response of the optimum filter is related to the input signal.**

The impulse response is equal to the input signal displaced to a new origin at t=to and folded about this point so as to run backward. $H_{opt}(t) = K\ x(to-t)$.

10. **Define ISI(Dec2014,May2018)**

There are effects of imperfection in the frequency response of the channel ie. Dispersion of the false shape by the channel. The residual effect of all other transmitted bits on the received bit is called as Inter symbol interference.

11. **What is minimum bandwidth required to transmit data at the rate of R_b bits per sec?**

The minimum bandwidth required is $B = \frac{R_b}{2}$ Hz.

12. **What is the function of equalizing filter? (Dec 2014)**

Equalizing filters are used in the receiver; it cancels any residual ISI present in the received signal.

13. **What is eye pattern? (Nov 2013, May 2017)**

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 (T_b) 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.

14. 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

15. 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.

16. What is the information that can be obtained from eye pattern regarding the signal quality? (May2014)

From the eye pattern-

(i) **WIDTH** defines the time interval over which the received signal can be sampled without error from ISI.

(ii) **SLOPE** determines the sensitivity of the system to timing error.

(iii) **HEIGHT** defines the margin over noise. For zero ISI, the eye is widely opened. For more ISI,the eye will be closed completely.

17. ISI cannot be avoided. Justify the statement.(May2013, May 2018)

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.

18. Mention two properties of matched filter? (Nov2013)

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, $\int_0^b |S(f)|^2 df = E$

19. What is matched filter? (Nov2013, May2014)

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.

20. State the principle of maximum likelihood detector. (May2013)

For equally likely symbols, the detector decides in favour of a particular transmitted symbol whose likelihood function is greater than the other. This strategy is called maximum likelihood detection.

**21. 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.

22. 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. (Nov 2018)
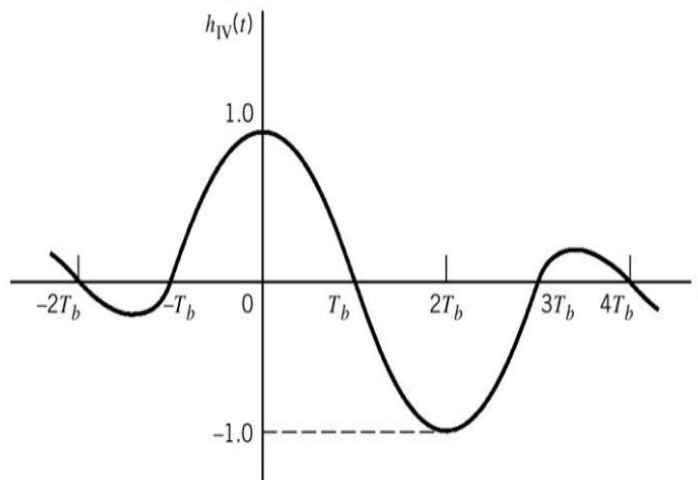
The decision rule for precoded duo-binary is

Ck = { ± 2V , bk is decided in favour of symbol "0"

    0V, bk is decided in favour of symbol "1"}
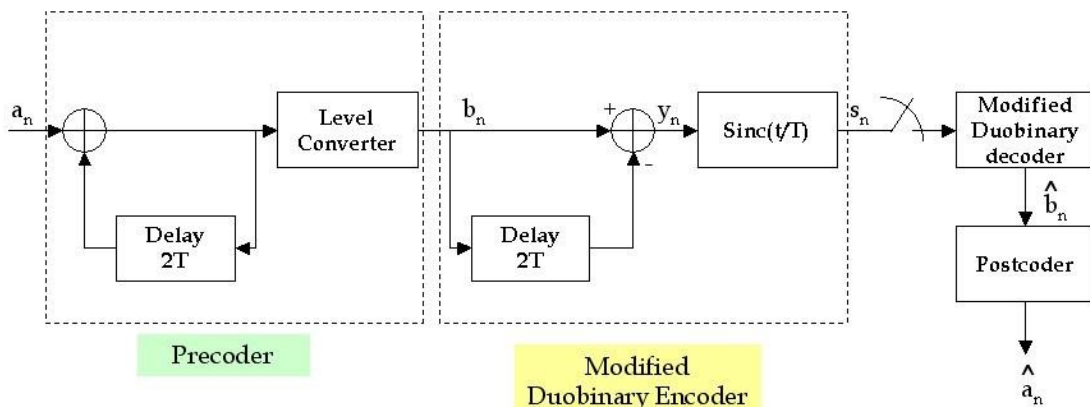
23. Draw the frequency and phase response of Modified duobinary system.

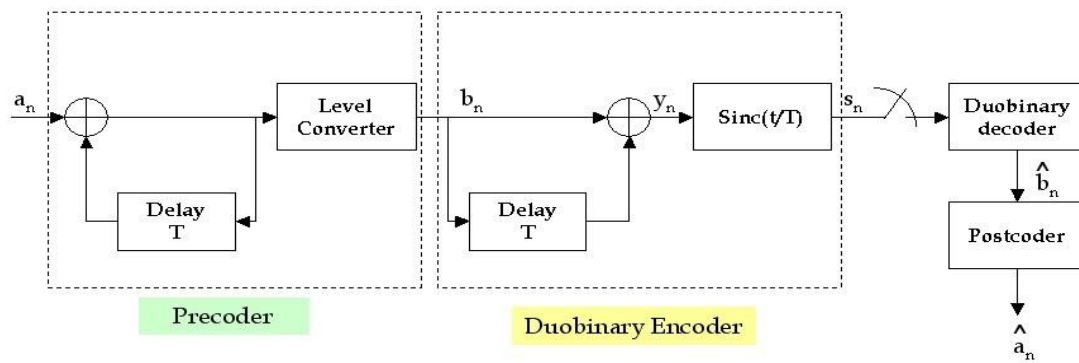(a)   (b)
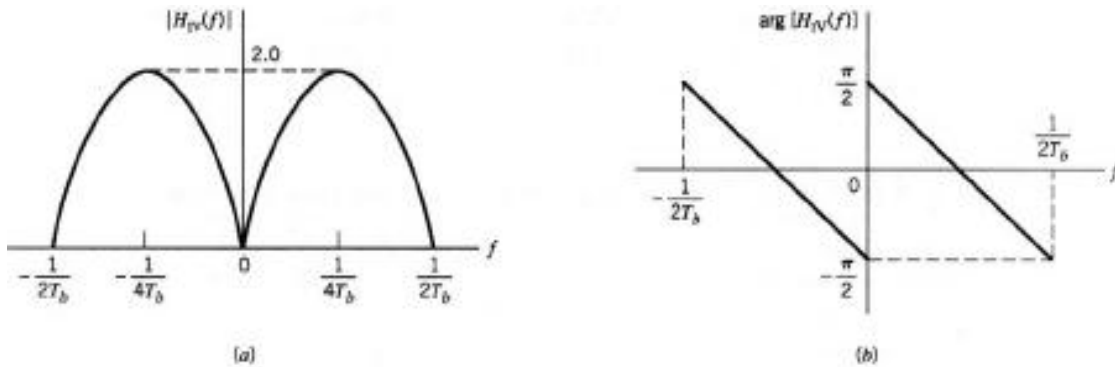
24. Draw the impulse response of ModifiedDuobinary system.

25. Draw the modified duobinary system.

26. Draw the block diagram of Duobinary system.

Precoder block diagram labels: a_n, Level Converter, Delay T, b_n, Delay T, y_n, Sinc(t/T), s_n, Duobinary decoder, $\hat{b}_n$, Postcoder, $\hat{a}_n$, Precoder, Duobinary Encoder

27. What is intersymbol interference in baseband binary PAM systems? [ID]

In baseband binary PAM, symbols are transmitted one after another. These symbols are separated by sufficient time durations. The transmitter, channel and receiver acts as a filter to this baseband data. Because .of .the .filtering characteristics, transmitted PAM pulses are spread in time.

28. What is mean by base band transmission? [D]

In base band transmission ,the data is transmitted without any modulation.there is no carrier used.

29. Define Duobinary baseband PAM system K. [ID]

Duobinary encoding reduces the maximum frequency of the baseband signal.

The word „duo" means to double the transmission capacity of the binary system.

Let the PAM signal ak represents kth bit. Then the encoder the new waveform as

$Ck = ak + ak\text{-}1$

Thus two successive bits are added to get encoded value of the kth bit. Hence Ck becomes a correlated signal even though ak is not correlated. This introduces intersymbol interference in the controlled manner to reduce the bandwidth.

30. How is eye pattern obtained on the CRO? [D]

Eye pattern can be obtained on CRO by applying the signal to one of the input channels and given an external trigger of $1/Tb$ Hz. This makes one sweep of beam equal to Tb seconds.

31. Why do you need adaptive equalization in a switched telephone network. [ID]

In switched telephone network the distortion depends upon

1) Transmission characteristics of individual links.

2) Number of links in connection

PART – B

[First Half]

ISI

1. What is ISI and what are the various method to improve ISI in communication system .also state and prove nyquist first criterion for zero ISI. **13 [D] [Apr/May-2018]**

2. What is a raised cosine spectrum? Discuss how it helps to avoid ISI**. (May 2017)**

3. What is ISI? List the various methods to remove ISI in a communication system. Also state and prove Nyquist first criterion for zero ISI. **(Dec 2017)**

   Nyquist's criteria

4. State and prove the Nyquist criteria for distortion less baseband transmission.**[D]** (**Nov 2018**)

5. Describe the Nyquist's criteria for distortion less base band transmission. **8 [D] [May/June-2017]**

6. Obtain an expression for Nyquist criterion for distortion - less baseband transmission for zero symbol interference. **(May2013,2015, 2017)**

7. What is a "raised Cosine spectrum"? Discuss how does it help to avoid IST? **(6) [ID] [M/J 2017]**

8. Explain how Nyquist's Criterion eliminates interference in the absence of noise for distortion -less baseband binary transmission. **(16) [ID] [Nov/Dec- 2016]**

Pulse shaping - **Correlative coding**

9. Write short notes on (1) Pulse shaping (2) Correlative coding.

[Second Half]

Eye Pattern

10. Discuss the principle of obtaining eye pattern and important observations made from the eye patterns. **[D] [April/May 2019]**

11. Describe how eye pattern is helpful to obtain the performance of the system in detail with a neat sketch. **16 [D] Nov/Dec- 2016**

12. Describe how eye pattern illustrates the performances of a data transmission system with respect to inter symbol interference with neat sketch? 8**[ID][Nov/Dec- 2015].**

13. Describe how eye pattern can be obtained and can be used for observing the characteristics of a communication channel. **(Dec2014,2015)**

14. Describe how eye pattern is helpful to obtain the performance of the system in detail with a neat sketch. **(Dec 2016)**

15. Illustrate the modes of operation of an adaptive equalizer with neat diagram? **8 [D][Nov/Dec- 2015].**

Matched Filter

16. Describe the implementation of the matched filter demodulator with a sample signal s(t) and its matched filter response h(t). (**May 2018**)

Adaptive Equalization

17. The binary data 00 11 01 001 is applied to a duobinary system, Construct the duobinary output and corresponding receiver output.**[ID]** (**Nov 2018**)

18. 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**. [ID]** (**Nov 2018**)

19. Draw the block diagram of duo binary signaling scheme without and with precoder and explain. **(9) [D] [May/June- 2016]**

20. Explain the adaptive equalization with block diagram. **(7) [D] [May/June-2016]**

21. Write short notes on tapped delay line filter, adaptive equalization.**(7) [D]**

22. Derive an expression for a maximum likelihood detector and prove that the ML detector reduces to minimum distance detector for special case of a white Gaussian noise vector channel. **(May 2018, Nov 2018)**

23. Explain modified duo-binary signaling scheme without & with precoder. **(Dec2015, May 2016)**

24. Illustrate the modes of operation of an adaptive equalizer with a neat block diagram.**(May 2016)**

25. Explain the duobinary signalling technique in detail.

UNIT IV DIGITAL MODULATION SCHEMES

PART – A

1. 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
- Local carrier generated at the receiver not be phase locked with the
- carrier at the transmitter.
- Synchronous detection is not possible.
- High probability of error

2. What is QPSK? Write the expression for the signal set of QPSK. [ID] [A/M'19, M/ N/D'16,A/M'17]

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 $\pi/4$, $3\pi/4$, $5\pi/4$

and $7\pi/4$.The expression for QPSK is given by $s_i(t) = \begin{cases} \sqrt{\dfrac{2E}{T}} \cos\left[2\pi f_c t + (2i-1)\dfrac{\pi}{4} \right] & 0 \le t \le T \\ 0 & \text{elsewhere} \end{cases}$, where

I=1,2,3,4 and E be the transmitted signal energy per symbosl, T be the symbol duration and f_c be the carrier frequency.

3. Obtain the orthonormal basis function for the signal. (ID) (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.
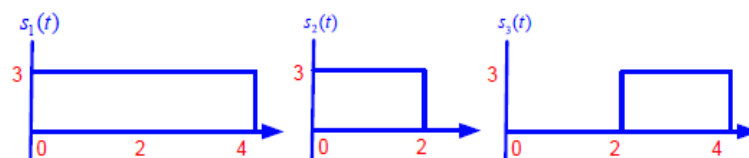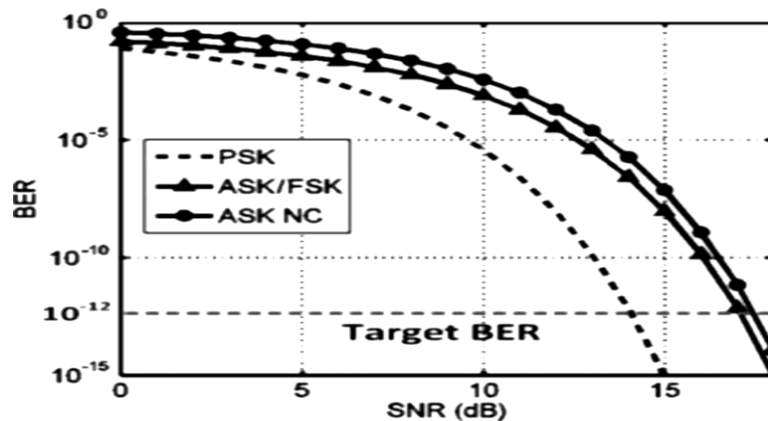
Solution:

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

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

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

$$= \frac{2T}{3}$$

s_{21} is

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

$$= \int_0^{T/3} 1\sqrt{3/T}\, dt = \sqrt{3/T}$$

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

$$= \sqrt{3/T}$$

4. **Draw the BER curve for ASK, FSK & BPSK. (ID) (Nov 2018)**

5. **Compare M-ary modulators. (ID) (May 2018)**

M-ary FSK requires a considerably increased bandwidth in comparison with M-ary PSK. The probability of error for M-ary FSK decreases as M increases. for M-ary PSK probability of error increases with M.

6. **Draw the PSK and QPSK wave forms of a bit stream 11110011.[ID] [Apr/May-2018]**

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

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

8. **Define PSK. (ID) (Dec 2017)**

PSK is a modulation technique achieved by keying the phase of the carrier between either of two possible values corresponding to the binary symbols 0,1 with fixed limits set by the channel.

9. **What do you understand by non-coherent detection? [D] [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.

10. **Draw a block diagram of a coherent BFSK receiver. [D] [Nov/Dec- 2015, 2016]**
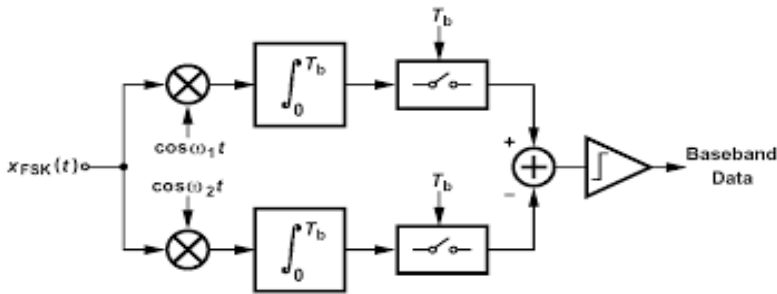
11. Distinguish BPSK and QPSK techniques. [ID] [Nov/Dec- 2015]

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

12. What is memory less modulation? (D) (Dec 2012, May2015)

If the symbol to waveform mapping is fixed from one interval to the next, i.e., m $\rightarrow s_m(t)$, then the modulation is memoryless. If the mapping from symbol to waveform in the n-th symbol interval depends on previously transmitted symbols (or waveforms) then the modulation is said to have memory.

13. What is coherent detection/receiver? (D) (Nov2013, May2015)

When the receiver exploits the knowledge of the carrier's phase to detect the signal, then the detection is coherent.

14. What is QAM? (ID) (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.

15. Mention two properties of matched filter? (D) (Nov 2013)

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 = $2E/\eta$

Property2: The integral of the squared magnitude spectrum of a pulse signal with respect to frequency is equal to the signal energy.

16. 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.

17. 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

18. Compare M-ary PSK and M-ary QAM. (ID) (Dec2015)

S No	M-ary PSK	M-ary QAM
1.	Carrier experiences phase modulation	Carrier experiences amplitude and phase

		modulation
2.	Signal constellation is circular	Signal constellation is square

19. Define false alarm errors. (D) (May2015)

Let hypothesis H_0 represents the presence of only noise and hypothesis H_1 represents presence of signal in addition to noise. False alarm represents the selection of H_1 when H_0 is the correct answer.

20. Define false dismissal errors. (D) (May2015)

Let hypothesis H_0 represents the presence of only noise and hypothesis H_1 represents presence of signal in addition to noise. False dismissal represents the selection of H0 when H_1 is the correct answer.

21. What is the probability of error of BPSK? (ID) (Dec 2012)

$P_e = \frac{1}{2}\,\text{erfc}\left(\sqrt{\frac{E_b}{N_o}}\right)$ E_b= Transmitted signal energy, N_o = Noise PSD, erfc= error function

22. What is Signal Constellation diagram? (D)

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.

23. What are the applications of digital modulation technique? (D)

1.Voice grade modems uses 8 phase DPSK technique,2 Digital Radio uses 16-ary QAM,3.Satellite communication uses BPSK,QPSK technique,4.Voice grade telephone channel uses FSK,5.4 phase DPSK is used as international standard for modems operating at 2400 bits/sec.

24. What is meant by Binary phase shift keying? (D)

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°

25. How the BPSK signal is generated? (ID)

The BPSK signal is generated by applying the waveform $\text{Cos}(u_o t)$ as a carrier to a 'balanced modulator' and applying the base band signal b(t) as the modulating waveform,in this sense BPSK can be thought of as an AM signal.

26. Define FSK. (ID)

PSK is a modulation technique achieved by keying the phase of the carrier between either of two possible values corresponding to the binary symbols 0,1 with fixed limits set by the channel.

27. Define bandwidth efficiency. (D)

Bandwidth efficiency is the ratio of data rate to channel bandwidth, measured in units of bits per second per hertz.

28. List the types of synchronization? (D)

    a. Carrier Synchronization

    b. Symbol and bit synchronization

    c. Frame synchronization

29. Why synchronization is needed? (D)

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.

30. What is the bandwidth efficiency of M-ary PSK? (ID)

The bandwidth efficiency of M - ary PSK is given by $\rho = \dfrac{\log_2 M}{2}$

31. What is the bandwidth efficiency of M-ary FSK? (ID)

The bandwidth efficiency of M-aryFSk is given by $\rho = \dfrac{2\log_2 M}{M}$

32. What is DPSK?(ID)

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.

33. A binary shift keying system employs two signal frequencies f_1 and f_2, the lower frequency is 1200Hz and the signaling rate is 500 baud .Calculate f_2. (ID)

f_2=1200+500=1700Hz

<div align="center">

PART – B

[First Half]

</div>

Geometric Representation

1. Explain the geometric representation of signals? (**9**) **[D]**

   BPSK

2. Describe with diagrams, the generation and detection of coherent binary PSK. Derive the error probability of Binary PSK. Illustrate power spectra of BPSK. (**13**) **(D)** **(May'17, Dec'16, Nov 2018).**

3. Illustrate the transmitter receiver and the generation of the non coherent version of PSK with neat diagram. (**7**) **[D] [Nov/Dec- 2015]**

4. Calculate the BER for a binary phase shift keying modulation from first principles. **6 [D] [A/M-2018]**

5. Explain in detail the detection and generation of BPSK system. Derive the expression for its bit error probability. (**13**) **[D] [April/May- 2017]**

6. Explain the principle of wórking of an "early late-bit synchronizer". (**8**) **[D] [April/May- 2017]**

7. Describe the generation and detection of Coherent binary PSK Signals. (**8**) **[D] [Nov/Dec- 2016]**

8. Illustrate the power spectra of binary PSK signal. (**6**) **[D] [Nov/Dec- 2016]**

9. 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**) **[D] [May/June- 2016]**

   BFSK

10. Describe the operation of modulation and demodulation of binary FSK signals. (**13**) **[D] [A/M'19]**

11. Describe with diagrams, the generation and detection of coherent binary FSK. Derive the error probability of Binary FSK. (**13**) **(Nov2013, May2015,May 2018)**

12. Explain the non-coherent detection of FSK signal and derive the expression for probability of error. **(13) [D]** **[May/June- 2016]**

13. Explain the geometric representation of orthogonal BFSK? **(6)[D]**

14. Explain the spectrum and band width of BFSK .**(7) [D]**

15. Explain the graphical representation and principle of BPSK signals? **(8) [D]**

[Second Half]

QPSK

16. Describe the generation and detection of Coherent QPSK Signals. **(12) [D] [Nov/Dec- 2016]**

17. Illustrate the power spectra of QPSK signal. **(4) [D] [Nov/Dec- 2016]**

18. Derive the expression for bit error rate probability of a QPSK system? **(7) [D] [Apr/May-2018]**

19. Draw and explain the quadrature receiver structure for coherent QPSK? **(8) [D] [Apr/May-2018]**

20. Describe with diagrams, the generation and detection of coherent binary QPSK. Derive the error probability of Binary QPSK.**(D) (13) (May2013, May2015,Dec2015,2016, 2017)**

21. 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 0̇,90',180' and 270'**. (8) [D] [Apr/May-2018]**

22. Illustrate the transmitter receiver and signal space diagram of quadrature phase shift keying and describe   how it reproduces the original sequence with the minimum probability of symbol error with neat sketch. **(15) [D] [April/May 2019, Nov/Dec- 2015]**

QAM

23. Describe the generation and detection of QAM and Derive the expression for BER? **(13) (D)**

Principle Of DPSK

24. Explain the principle of DPSK encoding. **(8) [ID] [April/May- 2017]**

UNIT-5 ERROR CONTROL CODING

PART – A

1. **What is a linear code?[D] [April/May 2019, May/June-2016]**

   In linear code, the parity bits are generated as a linear combination of message bits.

2. **What is meant by constraint length of a convolutional encoder? [D] [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.

3. **The generator polynomial G(D) for a(7,4) cyclic code is G(d)=1+D^2+D^3. Find the code vector for data [1010] [D] (Nov 2018)**

We know g(x) = x^3 + x^2 + 1,Consider a data vector d = 1010

impliesd(x) = x^3 + x

So,x^{n-k}*d(x) = x^6 +x^4

$$
\begin{array}{r}
x^3 + x^2 + 1 \;\leftarrow q(x) \\
x^3 + x^2 + 1 \overline{)\; x^6 + x^4 } \\
\underline{x^6 + x^5 + x^3} \\
x^5 + x^4 + x^3 \\
\underline{x^5 + x^4 + x^2} \\
x^3 + x^2 \\
\underline{x^3 + x^2 + 1} \\
1
\end{array}
$$

$C(x) = x^3 d(x) + p(x) = x^3 (x^3 + x) + 1 = x^6 + x^4 + 1$ and hence C= 1010001

4. **What is meant by syndrome of linear block code? [D][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

5. **Write the various techniques /algorithms used in encoding and decoding of convolutional code. [D] [Apr/May- 2018]**

State diagram,(b) Code tree,(c)Trellis. It shows the transition between various states.

6. **Explain the term syndrome. [D] (Dec 2017)**

The syndrome S of the received code word R is defined as $S = RH^T$. If S is not zero then there are one or more errors. If the syndrome is zero then either there are no error or the errors are so many that a transmitted code word has been changed to a different code word

7. **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.

8. **What are the different methods of describing the structure of a convolutional code?[D] [April/May- Nov/DEC 2017]**

    i. State diagram,
    ii. Code tree,
    iii. Trellis

These methods show the transition between various states.

9. **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.
    d. To be able to decode the symbol in a fast and efficient way.

10. **Generate the cyclic code for (n, k) syndrome calculator. [D] [Nov/Dec- 2016]**

Code rate = k/n, where k is the length of message bits and n is length of the code word.

11. **Define Constraint length. [D] (May 2015, 2016)**

Constraint length is the number of shifts over which a message bit can influence the encoder output.

12. **State the channel coding theorem. [D] [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 memorylesschannel have capacity C be used once every T_c seconds. Then if,

$\frac{H(s)}{T_S} \leq \frac{C}{T_C}$, there exists a coding scheme for which the source output can be transmitted over the channel

and be reconstructed with an arbitrarily small probability of error. The parameter $\frac{C}{T_C}$ is called critical rate.

13. List the properties of cyclic codes. [D] [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.

14. Write the properties of syndrome in linear block codes. [D] (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.

15. Find the hamming distance between 101010 and 010101.If the minimum hamming distance of a (n,k) linear block is 3.What is the minimum hamming weight? [D] (Dec 2012)

Hamming Distance = 6.

d_{min} (3) $\leq$ n-k+1.

Hamming weight is no. of ones in the codeword.

16. Define hamming distance. [D] (May2014, May2015)

The hamming distance between two codes is equal to the number of elements in which they differ.

17. State the significance of minimum distance of a block code. [D] (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.

18. What is Channel Encoding? [D]

The channel encoder systematically adds digits to the message. These redundant bits carry no information. But used to detect and correct errors in the receiver side.

19. What are the types of error control methods? [D]

   a. Error detection and retransmission (ARQ – Automatic Repeat Request Method)
   b. Error detection and correction (FEC – Forward Error Correction method)

20. What is Convolutional Code? [D]

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

21. Differentiate block code and convolutional code[D]

In block code the encoder accepts a k-bit message block and generates an n-bit codeword. Thus, codewords are produced on a block by block basis.

In Convolutional code the encoder accepts the message bits come in serially rather than in large blocks and generates n- bit codeword. The resultant bits are generated using modulo-2 additions.

22. What is meant by line codes? [D] (Nov2013)

The channel coded data is mapped to a particular pulse waveform before transmission. This waveform is called Line Coding.

23. Prove that in linear block codes syndrome depends on error pattern not message bits. [D]

$S = (x + e)\, H^T = x\, H^T + e\, H^T = e\, H^T;$ Thus the syndrome pattern S depends on error pattern and not on message bits

24. What is meant by cyclic codes? [D]

A cyclic code has property that a cyclic shift on one code word forms another code word and is important because they are algebraic properties, which allow them to be easily encoded or decoded.

25. Write the advantages of cyclic codes over block codes. [D]

1). Cyclic codes are easy to encode,

2). Cyclic codes possess a well-defined mathematical structure, which has led to the development of very efficient decoding schemes for them.

26. What is systematic code? [D]

A code in which the message bits are transmitted in an unaltered form.

27. What is hamming code? [D]

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 $m \geq 3$ so called Hamming code

28. 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 0110100

29. What are the limitations of Viterbi decoding? [D]

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.

30. What is a perfect code? [D]

Let C be an error-correcting code consisting of N code words, in which each code word consists of n letters taken from an alphabet A of length q, and every two distinct code words differ in at least $d = 2e + 1$ places. Then C is said to be perfect if for every possible word w_0 of length n with letters in A, there is a unique code word w in C in which at most e letters of w differ from the corresponding letters of w_0.

It is straightforward to show that C is perfect if

$$\sum_{i=0}^{e} \binom{n}{i} (q-1)^i = \frac{q^n}{N}.$$

If C is a binary linear code, then $q = 2$ and $N = 2^k$, where k is the number of generators of C, in which case C is perfect if

$$\sum_{i=0}^{e}\binom{n}{i} = 2^{n-k}.$$

Hamming codes and the Golay code are the only nontrivial examples of perfect codes.

31. Define code efficiency or code rate. [D]

Code efficiency or code rate is the ratio of message bits in a block to the transmitted bits for that block by the encoder.

32. What is Viterbi decoding scheme? [D]

A **Viterbi decoder** uses the Viterbi algorithm for decoding a bitstream that has been encoded using convolutional code or trellis code.

The Viterbi algorithm is the most resource-consuming, but it does the maximum likelihood decoding. It is most often used for decoding convolutional codes with constraint lengths $k \leq 3$. Where in

Metrics: It is the discrepancy between the received signal and the decoded signal at particular node. **Survivor path**: This is the path of decoded signal with minimum metric.

PART – B
[First Half].

Channel coding theorem

1. State and explain shannon's theorem on channel capacity.**(8) [D]**

Linear block codes

2. Consider the (7,4) linear block code whose generated matrix is given below.**(13) [D] [A/M 2019]**

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

  (i)   Find all the code vectors **(4)**

  (ii)   Find parity check matrix(H) **(5)**

  (iii)   Find the minimum of weight code **(4)**

3. Explain the step involved in generation (n,k) linear block codes.

4. Explain the matrix representation of linear block codes.

5. Consider a linear block code with generator matrix. **(15) [D] [April/May 2019, May/June-2016]**

$$G = \begin{pmatrix} 1\;1\;0\;1\;0\;0\;0 \\ 0\;1\;1\;0\;1\;0\;0 \\ 1\;1\;1\;0\;0\;1\;0 \\ 1\;0\;1\;0\;0\;0\;1 \end{pmatrix}$$

  (i)   Determine the parity check matrix.

  (ii)   Determine the error detecting and capability of the code.

(iii)   Draw the encoder and syndrome calculation circuits.

(iv)   Calculate the syndrome for the received vector r = [1 1 0 1 0 1 0]. Identify the error corrected vector.

6. For a systematic linear block code, the three parity check digits P_1, P_2, P_3 are given by

$$P_{k,n-k} = \begin{bmatrix} 1 & 0 & 0 \\ 1 & 1 & 1 \\ 1 & 1 & 0 \\ 0 & 1 & 1 \end{bmatrix}$$

i) Construct generator matrix. ii) Construct codewords iii) Determine the error correcting capacity. v) Decode received words with an example. **(13) (D) (Nov 2018)**

7. For a systematic linear block code ,the three parity check digits p_1, p_2, p_3 are given by **13 [D] [N/D'15]**

$$PK_{n-k} = \begin{pmatrix} 1 & 0 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 0 \\ 0 & 1 & 1 \end{pmatrix}$$

   a. Construct generated matrix
   b. Construct code generated by the matrix
   c. Determine error correcting capacity
   d. Decode the received words with an example.

Hamming Codes

8. Describe how the errors are corrected using Hamming code with an example. **13 [D] [Nov/Dec- 2016]**

9. The code vector [1110010] is sent, the received vector is [1100010]. Calculate the syndrome.. **(4) [ID] [Nov/Dec- 2016]**

[Second Half]

Cyclic Codes

10. With suitable numerical examples, describe the cyclic codes with the linear codes with the linear and cyclic property and also represent the cyclic property of a code word in polynomial notation. **(13) (D) (A/M 2019)**

11. The generator polynomial (7,4) cyclic code is $G(P)=P^3+P+1$. Find the Codeword for the message X=[1100] in systematic form. Also find out the generator matrix and parity check matrix. **(13)(D) (N/D'18)**

12. The generator polynomial of a (7, 4) cyclic code is $1 + X + X3$. Develop encoder and syndrome calculator for this code. **(10) [D] [May/June-2016]**

13. Explain the principle and design of binary cyclic codes. **10 [D]**

14. The generator polynomial of a (7,4) linear systematic cyclic block code is $1+X+X^3$. Determine the correct if the received word is (i) 1011011 and (ii) 1101111. **(13) (D) (May 2017)**

15. Find the (7,4) systematic and non systematic cyclic code words of the message word 1101 .assume the generator polynomial as $1+x^2+x^3$.   **13 [ID] [Apr/May-2018]**

16. Develop the code for an (n,k) linear cyclic code and explain its working**. 8[D]   [Apr/May-2018]**

17. Describe the cyclic codes with the linear and cyclic property. Also represent the cyclic property of a code word in polynomial notation**. 12 [D] [Nov/Dec- 2016]**

18. List the different types of errors detected by CRC code. **(4) [D] [Nov/Dec- 2016]**

    Convolutional codes

19. A rate 1/3 convolutional encoder with constraint length of 3 uses the   **[ID] [April/May-2017]** generator sequences: g1 = (100), g2 =(1 0 1) and g3 = (1 1 1).

    (i)   Sketch encoder diagram

    (ii)   Draw the state diagram for the encoder

    (iii)   Determine the dfree distance of the encoder

20. A convolution code is described by g1=[100]:g2=[101];g3=[111].   **[D]   [Nov/Dec-2015]**

    (i)   Draw the encoder corresponding to this code.

    (ii)   Draw the state transition diagram for this code .

    Viterbi decoder

21. A rate 1/3 convolutional encoder with constraint length of 3 uses the generator sequence $g_1=$ (100), $g_2=$ (101) and $g_3=$ (1,1,1)

    (i) Sketch encoder diagram(ii) Draw the state transition diagram(iii) Determine trellis diagram (iv) the input message signal is [1 1 0 10 1 0 0]. The received sequence with error is [100 110 111 101 001 101 001 010], using Viterbi algorithm find the transmitted code word sequence. **(Nov 2018)**

22. Explain viterbi algorithm with an appropriate coder and a received input word of length 12.assume a coder of constraint length 6 and rate efficiency ½.   (**10) [D] [Apr/May-2018]**

23. What is need of digital modulation in digital communication? explain any one modulation scheme? **8 [D] [Apr/May-2018]**

24. Explain Viterbi decoding algorithm for convolutional code. **(8) [D]**