### PART-A (2 Mark Questions)

**Unit-I**

1. Draw the block diagram of pulse code modulation.

2. A TV signal with a bandwidth of 4.2MHz is transmitted using PCM with 512 quantization levels. Calculate binary word code length and transmitted bit rate.

3. Define quantization noise power.

4. What is meant by uniform quantization?

5. What is meant by Quantization?

6. The input to the delta modulator is \( m(t) = 5t \) and sampling rate is 5000 samples/sec. Determine the step size.

7. Give an advantage and a disadvantage of digital communication.

8. Compare uniform and non uniform quantization.

9. An analog signal is sampled at the Nyquist rate of 20KHz and quantized into \( L = 1024 \) levels. Find the bit rate and the time-duration of one bit of the binary encoded signal.

10. 10 voice signals are transmitted through a channel using TDM. Each sample is encoded into 8 bits. The time taken to complete one revolution of the commentator is 125µsec. Determine the bit rate of multiplexed signal.

11. What is quantization error? How does it depend upon the step size.

12. Explain the errors present in delta modulation system.

13. Explain the need for non uniform quantization in digital communications.

14. A six bit single channel PCM system gives an output of 60 kilo bits per second. Determine the highest possible modulating frequency for the system.

15. The input to the delta modulator is \( 5\cos(2\pi 1000t) \). The pulse rate is 56,000 pulses/sec. Determine the step size.

16. Describe differential pulse code modulation system.

17. Explain slope overload distortion present in delta modulation system. Write the condition to overcome slope overload distortion.

18. Describe Adaptive delta modulation.

19. What is meant by Manchester code signaling? Explain with an example.

20. Prove that Quantization noise power in pulse code modulation system is \( \Delta^2/12 \)

21. What is meant by Differential encoding signaling? Explain with an example.

22. What is quantization in PCM?

23. Write a simple model of nonuniform quantizer.

24. Define the term quantization noise.

25. Compare the features of PCM and DPCM.

26. List the advantage gained by the use of robust quantization.

27. Define an output signal-to-quantization ratio.

28. Mention two major sources of noise which influence the performance of a PCM system.
29. Draw the Manchester coding line code for a given input data “101001”.

30. Mention the advantages of DM over PCM.

**Unit-II**

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<td>What is a matched filter?</td>
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<td>2.</td>
<td>Give two applications for eye pattern.</td>
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<td>3.</td>
<td>Draw the ASK and FSK waveforms for 011011.</td>
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<td>4.</td>
<td>Sketch the block diagram of ASK generation.</td>
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<td>How does pulse shaping reduce inter symbol interference?</td>
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<td>Find the signal amplitude for minimum quantization error in a DM system, if the step size is 2volts having repetition period 1msec. The information signal operates at 100Hz.</td>
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<td>7.</td>
<td>Show the space representation of BPSK and QPSK</td>
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<td>8.</td>
<td>Explain the Bandwidth, power and energy calculations for PSK signal.</td>
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<td>9.</td>
<td>Why PSK is always preferable over ASK in coherent detection?</td>
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<td>10.</td>
<td>Differentiate between Coherent and Non coherent detection?</td>
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<td>11.</td>
<td>Derive an expression for error probability of coherent Amplitude Shift Keying scheme.</td>
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<td>12.</td>
<td>Explain Phase shift keying with relevant equations and waveforms.</td>
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<td>13.</td>
<td>Find the band width required for frequency shift keying and draw its spectrum.</td>
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<td>14.</td>
<td>List the properties of matched filter.</td>
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<td>15.</td>
<td>Explain non coherent detection of Amplitude shift keying.</td>
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<tr>
<td>16.</td>
<td>Prove that the probability of error for Amplitude shift keying is ( P_e = Q \left(\frac{E_b}{\eta}\right)^{1/2} )</td>
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<td>17.</td>
<td>Draw the constellation diagram for Quadrature phase shift keying.</td>
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<td>18.</td>
<td>Find the transfer function for the matched filter.</td>
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<td>19.</td>
<td>Explain coherent detection of frequency shift keying. What should be the relationship between bit rate and frequency shift for a better performance?</td>
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<td>20.</td>
<td>The input to the matched filter is given by ( S(t) = \begin{cases} 10 \sin 2\pi f_0 t \quad &amp; 0 &lt; t &lt; 10^4 \text{ sec} \ 0 &amp; \text{otherwise} \end{cases} ) Find the peak amplitude of the filter output.</td>
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<td>21.</td>
<td>What is correlation receiver?</td>
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<td>22.</td>
<td>Sketch the FSK waveforms for a given input data “1101”.</td>
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<td>23.</td>
<td>Mention the assumptions while delivering the expressions for the probability of error.</td>
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<td>24.</td>
<td>Draw the block diagram of Coherent detection of FSK.</td>
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<td>25.</td>
<td>For the signals, the given bit rate is 10Kbps. Calculate the bandwidth for ASK and FSK signals.</td>
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<td>26.</td>
<td>What is the importance of correlation receiver?</td>
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<td>27.</td>
<td>Write the power spectral density of the random binary ASK signal with ( f_c &gt;&gt; r_b ).</td>
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<td>28.</td>
<td>Compare Amplitude-shift keying and frequency-shift keying.</td>
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<td>29.</td>
<td>What is the functionality of optimum receiver for binary digital modulation schemes.</td>
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<td>30.</td>
<td>What is coherent and non-coherent ASK scheme.</td>
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**Unit-III**

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<td>2.</td>
<td>Define entropy and give the expression for it.</td>
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<td>3.</td>
<td>State the channel capacity theorem.</td>
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<td>4.</td>
<td>Let ( X ) represents the outcome of a single roll of a fair die. What is the entropy of ( X )?</td>
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<td>5.</td>
<td>What is transition probability and when it does it will occur?</td>
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<td>6.</td>
<td>State and explain the two properties of Mutual information.</td>
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<td>7.</td>
<td>State the properties of Entropy.</td>
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<td>8.</td>
<td>What is discrete memory less channel and give the channel matrix expression.</td>
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<td>9.</td>
<td>What is channel coding theorem and how it is different from source coding theorem?</td>
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<tr>
<td>10.</td>
<td>Consider a discrete memory less source with source alphabet ( S = {s_0, s_1, s_2} ) and source statistics ( {0.7, 0.15, 0.15} ). Calculate the entropy of source.</td>
</tr>
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</table>
11. What is entropy? Show that the entropy is maximum when all the symbols are equi probable. Assume M=2.

12. Define information. Show that information contained by a symbol is inversely proportional to the probability of that symbol.

13. An event has six possible outcomes with the probabilities P1= ½, P2= ¼, P3= 1/8, P4=1/16, P5= 1/32, P6=1/32. Find the entropy of the system.

14. Prove that H(X, Y)=H(Y/X) + H(X). Where X is the transmitter and Y is the receiver.

15. Find the conditional entropy for a noise free channel.


17. What is coding efficiency? Show that the coding efficiency is maximum when P(0)=P(1).

18. Let X represent the outcome of a single roll of a fair die. What is the Entropy of X.

19. Explain the Huffman coding algorithm with one example.

20. Show that the mutual information of a channel is symmetric; that is I(x; y) = I(y; x). if x is the transmitter and y is the receiver.

21. What is the markoff statistical model for information sources?

22. What is the need of measuring information?

23. Define discrete memory less channels.

24. State shannon’s theorem.

25. The capacity of a channel using Gaussian channel capacity?

26. How to calculate the capacity of a channel using Gaussian channel capacity?

27. What is parity check matrix and how it is used?

28. An (n, k) linear block code for minimum can correct up to the errors_________.

29. Give systematic cyclic code generation formula.

30. Consider a single error correcting code with a 2bit symbol. i.e., t=1 and m=2. Determine the code rate.

31. Define code rate for linear block code.

32. What are minimum distance considerations?

33. The generator polynomial of (15,11) cyclic code is g(x)= 1+x+x^4. Determine the parity polynomial h(x) of this code.

34. Draw the Encoder diagram for the (7,4) cyclic code generated by g(x)= 1+x+x^3.

35. The generator polynomial of (7,4) cyclic code is g(x)= 1+x+x^4. Determine generator and parity matrices in systematic form for this code.

36. Mention two basic steps of linear block encoding scheme.

37. What is an Hamming distance?

38. Write an simple example for a block coder.

39. What is encoding using an (n-k) bit shift register?

40. What is a syndrome? What is the importance of syndrome bits?
### PART-A

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<td>What is the importance of generator polynomial?</td>
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<td>What is a single error-correcting hamming codes?</td>
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<td>30.</td>
<td>State minimum distance of a linear block code.</td>
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#### Unit-V

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<tr>
<td>1.</td>
<td>What is maximum likelihood detector?</td>
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<td>2.</td>
<td>Why RS codes are called maximum distance separable codes?</td>
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<td>3.</td>
<td>What is constraint length of convolution code.</td>
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<td>4.</td>
<td>Give advantages of convolutional codes</td>
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<tr>
<td>5.</td>
<td>State the difference between convolutional code and block code.</td>
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<tr>
<td>6.</td>
<td>Write the graphical representations of convolutional codes.</td>
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<tr>
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<tr>
<td>7.</td>
<td>Draw the encoding diagram for 3,2,1 convolutional encoder.</td>
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<td>8.</td>
<td>What is sequential decoding?</td>
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<td>9.</td>
<td>Write about the Convolutional interleaving.</td>
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<td>10.</td>
<td>Compare coded and uncoded transmission techniques with respect to Probability of error.</td>
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<tr>
<td>11.</td>
<td>Consider the (3,1,2) nonsystematic convolution encoder with $g^0 = (1, 1, 0), g^1 = (1, 0, 1), g^2 = (1, 1, 1)$. Draw the encoder block diagram.</td>
</tr>
<tr>
<td>12.</td>
<td>A convolution encoder has 3 shift registers with two stages, two modulo-2 adders and an output multiplexer. The generator sequences of the encoder are as follows. $g^0 = (1, 1, 1, 1), g^1 = (1, 0, 1, 0, 1)$. Draw the block diagram of the encoder.</td>
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<td>13.</td>
<td>Consider the (3,1,2) nonsystematic convolution encoder with $g^0 = (1, 1, 0), g^1 = (1, 0, 1), g^2 = (1, 1, 1)$. Find the constraint length and the rate efficiency of the code.</td>
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<td>17.</td>
<td>Give the differences between linear block codes and convolution codes.</td>
</tr>
<tr>
<td>18.</td>
<td>Define metric and survivors in viterbi algorithm with one example.</td>
</tr>
<tr>
<td>19.</td>
<td>A convolutional encoder has single shift register with two stage, three modulo 2 adders, and an output multiplexer. The generator sequences of the encoder are as follows: $g^1 = (1, 0, 1), g^2 = (1, 1, 0), g^3 = (0, 1, 1)$. Find the constraint length and the rate efficiency of the code.</td>
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<td>20.</td>
<td>A convolutional encoder has single shift register with two stages, (i.e., constraint length $K=3$), three modulo 2 adders, and an output multiplexer. The generator sequences of the encoder are as follows: $g^1 = (1, 0, 1), g^2 = (1, 1, 0), g^3 = (1, 1, 1)$</td>
</tr>
<tr>
<td>21.</td>
<td>Draw the block diagram of the encoder.</td>
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<tr>
<td>22.</td>
<td>Draw the block diagram of the encoder.</td>
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<tr>
<td>23.</td>
<td>Define the term trellis in convolution code.</td>
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<td>25.</td>
<td>What is a fano metric</td>
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<td>26.</td>
<td>What is sequential decoding algorithm?</td>
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<td>27.</td>
<td>What is the feature of fano algorithm?</td>
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<td>28.</td>
<td>State maximum-likelihood decoding rule for the binary symmetric channel.</td>
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#### PART-B (5 Mark Questions)

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<th>Question Number</th>
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| 1. | Explain a) Channel Noise  
b) Quantization noise in DM and derive expression for them? |
| 2. | A signal $m(t)$ Band limited to 4 KHz is sampled at twice the Nyquist rate & its samples transmitting by PCM. An output SNR of 47 dB is required: |
3. (a) Draw the Block diagram of DPCM system.
   (b) A voice frequency signal band limited to 3 KHz is transmitted with the use of the DM system. The
   prf is 30,000 pulses/second and step size is 40 mV. Determine the maximum permissible speech signal
   amplitude to avoid error.

4. For a DM system, signal sampled at 76 KHz and Amax = 4
   (a) Assuming that the signal is sinusoidal determine output signal power & SNR.
   (b) Determine the minimum transmission Band width? Derive the relations.

5. What is quantization error? How does it depend upon the step size? Suggest some methods to
   overcome the difficulties encountered depending on the modulating Amplitude swing?

6. The input to the PCM system is m(t)=10cos2πx10^4t, the signal is sampled at nyquist rate, each sample
   is encoded in to 4-bits. Determine i) Bit rate
      ii) Bandwidth,
      iii) Signal to Noise ratio.

7. (a) Explain the need for non-uniform quantization in digital communications.
   (b) Explain μ-law and A-law.

8. The input to the DM is a sinusoidal signal having a peak amplitude of 1v and frequency 5KHz. The
   sampling rate is 8 times the Nyquist rate.

   i) Determine step size.

   ii) Determine the noise power at the output of the LPF.

   iii) Determine the signal to noise ratio if the cut-off frequency of the LPF is W=10KHz.

9. A message signal m(t) = 4cos2πx10^4t is sampled at nyquist rate and transmitted through a channel
   using 3 bit PCM.

   (a) Determine quantization levels
   (b) The sampled values are 3.8, 2.1, 0.5,-2.7,-3.1,-4. Determine the quantizer output, encoder
   output and quantization error for each sample.

10. A sinusoidal signal is band limited to 5KHz and transmitted through a channel using PCM. The
    sampling rate is twice the nyquist rate. The maximum quantization error should be 0.1% of the peak
    signal amplitude. Determine the bit rate of PCM.

11. Explain pulse code modulation. Draw one complete cycle of some irregular waveform and show how
    it is quantized, using eight standard levels.

12. Explain Delta modulation system. What are its limitations? How can they be overcome.

13. A voice frequency signal band limited to 3 KHz is transmitted with the use of the Delta modulation
    system. The pulse repetition frequency is 30,000 pulses per second, and the step size is 40mV.
    Determine the maximum permissible speech signal amplitude to avoid a slope overload.

14. The input to the DM is a sinusoidal signal having a peak amplitude of 1v and frequency 10KHz. The
    sampling rate is 4 times the Nyquist rate.

    i) Determine step size.

    ii) Determine the noise power at the output of the LPF.

    iii) Determine the signal to noise ratio if the cut-off frequency of the LPF is W=8KHz.

15. Consider an audio signal with spectral components limited to the frequency band of 300 to 3300Hz. A
    PCM signal is generated with a sampling rate of 8000 samples/sec. The required output signal to
    quantization noise ratio is 30dB.

    a) What is the minimum number of uniform quantizing levels needed, and what is the minimum
    number of bits per sample needed?

    b) Calculate the minimum system bandwidth required.

16. A message signal m(t)= 4 cos2πx10^4t is sampled at nyquist rate and transmitted through a channel
    using 3 bit PCM.
a) Determine all the parameters of PCM.
b) Determine quantization levels
c) The sampled values are 3.9, 2.3, 0.5, -2.7, -3.3, -4. Determine the quantizer output, encoded output and the quantization error.

17. Prove that the signal to quantization noise power ratio in pulse code modulation system is \((1.8+6n)\) dB.

18. Consider a sine wave of frequency \(f_n\) and amplitude \(A_n\) applied to a delta modulator of a step size \(\Delta\). Show that slope overload will occur if \(A_n > \Delta/(2\pi f_n T_s)\) where \(T_s\) is the sampling rate.

19. Prove that the signal to quantization noise power ratio in delta modulation is \((3/8\pi^2)\left(\frac{T_s}{f_m}\right)^3\).

20. A signal \(m(t) = 4 \cos(60\pi t) + 2 \cos(160\pi t) + \cos(280\pi t)\) is sampled at
   i. 150 Hz,
   ii. 75 Hz,
   iii. 300 Hz.
Find the frequency components of the signal that appear at the output of an ideal LPF with cut off at 290 Hz. in each case. What is the Nyquist rate of sampling and Nyquist interval for \(m(t)\)?

21. a) Explain the difference between PCM and DM.
b) The input to the DM is \(m(t) = 6\cos2\pi(500)t\). The sampling rate is 56,000 samples/sec. Determine the step size.

22. a) Explain the importance of regenerative repeater in PCM system.
b) Consider a binary data “110010”. Sketch the differential encoding and Manchester encoding line codes.

23. Describe the working of regenerative repeater in PCM with the help of diagram.

24. In a single integration DM scheme, the voice signal is sampled at a rate of 32KHz. The maximum signal amplitude is 1 volt, voice signal bandwidth is 2.5KHz.
   i) Determine the minimum value of stepsize to avoid slope overload and Granular noise.
   ii) Assuming signal to be sinusoidal, calculate signal power and signal to noise ratio.
   iii) Assuming that noise signal amplitude is uniformly distributed in the range [-1,1]. Determine the signal power to noise ratio

25. Derive the expressions for quantization noise and signal to noise ratio for a PCM system.

26. A PCM system uses a uniform quantizer followed by a 7-bit binary encoder. The bit rate of the system is equal to 50*10^6 bits per sec. Determine the output signal-to-noise ratio when a full-load sinusoidal modulating wave of frequency 1 MHz is applied to the output.

27. Illustrate the working of DPCM transmitter and receiver with the help of diagram.

28. Enumerate the quantization error in delta modulation.

29. Give the comparison between PCM and DM systems.

30. a) How to avoid slope overload distortion in DM.
b) The input to the DM is \(m(t) = 8\sin2\pi x10^4t\). The step size \(\delta = 0.314\) volts. Determine the bit rate.

Unit-II

1. a) Write in detail about
   i) FSK
   ii) PSK with waveforms and equations
b) Assume that 3600 bits/sec data is sent over a pass band channel by FSK signaling scheme. Find the transmission bandwidth.

2. (a) Prove maximum output SNR of a matched filter is
(b) Explain the need of matched filter.
3. Assume that 4800 bits/sec random data are sent over band pass channel by using the following schemes:
   a) BFSK
   b) FSK

   Find the transmission BW.

4. A voice signal is sampled at the rate of 5000 samples/sec and each sample is encoded into 5-bits using PCM system. The binary data is transmitted into free space after modulation. Determine the bandwidth of the modulated signal, if the modulation used is
   i) ASK
   ii) PSK
   iii) FSK where \( f_1 = 8 \text{MHz} \) and \( f_2 = 6 \text{MHz} \).

5. Derive probability of error for
   (a) ASK and
   (b) PSK systems.

6. a) Explain the demodulation of FSK using coherent detection.
   b) Draw the block diagram of QPSK receiver.

7. a) Derive the expression for bit error probability due to a matched filter.
   b) Explain the generation of PSK signals.

8. a) Discuss QPSK signaling.
   b) Derive the bit error probability due to PSK receiver.

9. The binary sequence 1100100010 is applied to DPSK transmitter.
   a) Sketch the resulting waveform at the transmitter output.
   b) Applying waveform to the DPSK receiver, show that in the absence of noise, the original binary sequence is reconstructed at the receiver output.

10. (a) Explain the spectrum of FSK signal derive the expression for B.W
    (b) Derive the expression for energy of the ASK signal.

11. Find the probability of error and threshold level for Amplitude shift keying.

12. a) Binary data is transmitted over an RF band pass channel with a usable bandwidth of 10MHz at a rate of \( 4.8 \times 10^6 \) bits/sec using an ASK signaling method. The carrier amplitude at the receiver antenna is 1mV and noise power spectral density at the receiver input is \( 10^{-15} \text{Watt/Hz} \). Find the error probability of a coherent receiver.
    b) Explain the demodulation of DPSK signal.

13. Binary data is transmitted over an RF band pass channel with a usable band-width of 10MHz at a rate of \( 4.8 \times 10^6 \) bits/sec using an ASK singling method. The carrier amplitude at the receiver antenna is 1mV and the noise power spectral density at the receiver input is \( 10^{-11} \text{watts/Hz} \). Find the error probability of a coherent receiver.

14. A band pass data transmission scheme uses a phase shift keying signaling with \( s_1(t) = A_c \cos W_c t \), \( s_2(t) = -A_c \cos W_c t \) where \( W_c = 10 \text{MHz} / T_b \), \( T_b = 0.2 \text{msec} \). The carrier amplitude at the receiver input is 1mv and PSD of additive white Gaussian noise at the input is \( 10^{-11} \text{watts/Hz} \). Assume that ideal correlation receiver is used. Calculate the average bit error rate of the receiver.

15. Prove that the maximum output signal to noise ratio of a matched filter is \( \text{SNR} = 2E/N_0 \).


17. Prove that the probability of error for phase shift keying is \( P_e = Q(2S_{av} T_b / N_0)^{1/2} \) and the threshold level is zero.

18. Binary data has to be transmitted over a telephone link that has a usable bandwidth of 3000Hz and
maximum achievable SNR power ratio of 6DB at its output.

i) Determine the maximum signaling rate and $P_e$ if a coherent ASK scheme is used for transmitting binary data through this channel.

ii) If the data rate is maintained at 300bits/sec, calculate the error probability.

[Assume ASK bandwidth=$3R_b$] and [Qv12=0.0003].

19. Assume that 4800 bits/sec random data are sent over band pass channel by using the following schemes:
   a) BPSK
   b) FSK

Find the Transmission bandwidth.

20. A band pass data transmission scheme uses a PSK signaling scheme with $S_1(t)=-A_c\cos w_c t$, $S_2(t)=A_c\cos w_c t$ and $w_c=10\pi/T_b$ where $T_b=0.2$msec. The carrier amplitude at the receiver input is 1mV and the PSD of the additive white Gaussian noise at the input is $10^{-11}$ Watt/Hz. Assume that an ideal correlation receiver is used.

i) Calculate the average bit error rate of the receiver.

ii) Find the receiver impulse response.[where Qv10=0.0008].

21. Compare the average power requirements of binary noncoherant ASK, coherent PSK, DPSK signaling schemes operating at a data rate of 1000 bps over a bandpass channel having a b/w of 3000Hz, $n/2=10^{-10}$ watt/Hz and $P_e=10^{-5}$

22. The bit stream 11011100101 is to be transmitted using DPSK. Determine the encoded sequence and the transmitted phase sequence.

23. a) Explain the modulation of QPSK.

b) Explain and draw the constellation diagram for PSK signaling scheme.

24. Binary data has to be transmitted over a telephone link that has a usable b/w of 3000Hz and a maximum achievable signa-to-noise power ratio of 6dB at its output, Determine the maximum signaling rate and $P_e$ if a coherent Ask scheme is used for transmitting binary data through this channel.

25. Explain binary FSK signaling schemes.

26. Give the comparison of digital modulation systems w.r.t binary, power requirements.

27. Illustrate the significance of the impulse response of a matched filter by taking an example.

28. Compare the choice of the waveforms for various types of digital modulation schemes.

29. Discuss different assumptions while deriving the expression for the probability of error.

30. Explain the working of DPSK modulator and demodulator.

Unit-III

1. (a) Prove that the entropy for a discrete source is a maximum when the output symbols are equally probable.
   (b) Prove that the mutual information of a channel is related to the joint entropy of the channel input and channel output.

2. Explain
   (a) Shannon-fano coding algorithm using an example.
   (b) Huffman coding algorithm using an example.

3. A DMS X has 4 symbols $x_1, x_2, x_3, x_4$ with $p(x_1)=1/2$, $p(x_2)=1/4$, $p(x_3)=1/8$, $p(x_4)$. 
   (a) Construct Shannon-fano code.
   (b) Repeat for the Huffman code and compare the results.

4. Consider the binary symmetric channel. Let $P_0$ denote the probability of choosing binary symbol $X_0=0$ and let $P_1 = 1- P_0$ denote the probability of choosing binary symbol $X_1=1$. Let $p$ denote the transition probability of the channel. Calculate the average mutual information between the channel input and channel output.

5. A source emits one of four possible symbols during each signaling interval. The symbols occur with the
probabilities. \( p_1=0.4, p_2=0.3, p_3=0.2, p_4=0.1 \). Find the information gained by observing the source emitting each of these symbols.

6. (a) A source emits one of 4 symbols \( s_0, s_1, s_2, s_3 \) with probabilities \( 1/3, 1/6, 1/4, 1/4 \) respectively. The successive symbols emitted by the source are statistically independent. Calculate the entropy of the source.
(b) Derive the channel capacity theorem for discrete channels.

7. A DMS has an alphabet of five symbols with their probabilities \( (0.55, 0.15, 0.15, 0.10, 0.05) \). Compute two different Huffman codes for this source. Hence find
(a) The average code-word.
(b) The variance of the average code word length over the ensemble of source symbols.

8. A DMS has an alphabet of eight letters, \( x_i, i=1,2,3,4,5,6,7,8 \), with probabilities \( 0.25, 0.2, 0.15, 0.12, 0.1, 0.08, 0.05, 0.05 \).
(a) Determine the average number of binary digits per source letter
(b) Determine the entropy of the source

9. A voice grade channel of the telephone network has a bandwidth of 3.4 kHz
(a) Calculate the channel capacity of the telephone channel for a signal to noise ratio of 30dB.
(b) Calculate the minimum signal to noise ratio required to support information transmission through the telephone channel at the rate of 4800bps.

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

11. A DMS has an alphabet of eight letters, \( x_i, i=1,2,3,4,5,6,7,8 \), with probabilities \( 0.25, 0.2, 0.15, 0.12, 0.1, 0.08, 0.05, 0.05 \).
(a) Determine the average number of binary digits per source letter
(b) Determine the entropy of the source

13. A system is having a bandwidth of 3KHz at a SNR of 29db. Find
(a) the information carrying capacity
(b) capacity of the channel if its bandwidth is doubled while the transmitted signal power remains constant?

14. A memory less source has the alphabet \( \{-5,-3,-1,0,1,3,5\} \) with corresponding probabilities \( \{0.05,0.1,0.15,0.05,0.25,0.3\} \).
(a) Find the entropy of the source
(b) Design a Shannon-Fano code that encodes a single level at a time and determine the average bit rate.

15. A voice grade channel of the telephone network has a bandwidth of 3.4 kHz
(a) Calculate the channel capacity of the telephone channel for a signal to noise ratio of 30dB.
(b) Calculate the minimum signal to noise ratio required to support information transmission through the telephone channel at the rate of 4800bps.

16. A discrete memory less source has an alphabet of six symbols with their probabilities for its output as below.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>( S_1 )</th>
<th>( S_2 )</th>
<th>( S_3 )</th>
<th>( S_4 )</th>
<th>( S_5 )</th>
<th>( S_6 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability</td>
<td>0.30</td>
<td>0.25</td>
<td>0.20</td>
<td>0.12</td>
<td>0.08</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Compute the Shannon-Fano code and find the average code-word length

17. A Binary Symmetric channel is shown in figure.
Find the mutual information and rate of information transmission over this channel when \( p = 0.9 \) and \( P(0)=0.5 \). Assume that the symbol rate (or bit) is 1000/sec.

18. Show that the channel capacity of an ideal Additive white Gaussian noise channel with infinite bandwidth is given by \( C \approx 1.44 \frac{S}{\eta} \) b/sec. where \( S \) is the average signal power and \( \eta/2 \) is the power spectral density of white Gaussian noise.

19. A discrete memory less source has an alphabet of seven symbols with their probabilities for its output as below.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>( S_1 )</th>
<th>( S_2 )</th>
<th>( S_3 )</th>
<th>( S_4 )</th>
<th>( S_5 )</th>
<th>( S_6 )</th>
<th>( S_7 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability</td>
<td>0.25</td>
<td>0.25</td>
<td>0.125</td>
<td>0.125</td>
<td>0.125</td>
<td>0.0625</td>
<td>0.0625</td>
</tr>
</tbody>
</table>

Compute the Huffman coding and find the average code-word length

20. Two binary symmetric channels are connected in cascade. Find the overall channel capacity of the cascaded connection, assuming that both channels have the same transition probability.

21. A source emits one of the four possible messages \( m_1, m_2, m_3, m_4 \) with the probabilities \( \frac{1}{4}, \frac{1}{8}, \frac{1}{8} \) respectively. Calculate the information content of each message and average information per message.

22. For a source emitting symbols in independent sequences, show that the source entropy is maximum when the symbols occur with equal probabilities.

23. A source emits an independent sequence of symbols from an alphabet consisting of five symbols A, B, C, D and E with symbol probabilities \( \frac{1}{4}, \frac{1}{8}, \frac{1}{8}, \frac{3}{16}, \frac{5}{16} \) respectively. Find the entropy of the source.

24. Explain the general cases of Markoff statistical model for information sources.

25. Illustrate the entropy and information rate of Markoff sources with an example.

26. Explain the Markoff source with an example.

27. A binary source is emitting an independent sequence of o’s and 1’s with the probabilities \( p \) and \( 1-p \), respectively. Plot the entropy of this source versus \( p (0<p<1) \)

28. Illustrate Shannon-fano coding technique by taking an example.

29. A discrete source emits one of five symbols once every millisecond. The symbol probabilities are \( \frac{1}{5}, \frac{1}{5}, \frac{1}{8}, \frac{1}{16}, \frac{1}{16} \) respectively. Find the source entropy and information rate.

30. Find the entropy of a source that emits one of three symbols A, B, C in a statically independent sequence with probabilities \( \frac{1}{3}, \frac{1}{4}, \) and \( \frac{1}{4} \) respectively.

**Unit IV**

1. The polynomial \( x^{15}+1 \) when factored gives \( x^{15}+1=(x^4+x^3+1)(x^4+x^3+x^2+x+1)(x^4+x+1)(x^2+x+1)(x+1) \)

   (a) Construct a systematic (15,2) code using the generator polynomial \( g(x)=(x^4+x^3+x^2+x+1)(x^4+x+1)(x^4+x^3+1)(x+1) \).

   (b) List all the code words.

2. Construct all the possible systematic code words for (15,5) cyclic code with the following generator polynomial \( g(x)=x^{10}+x^9+x^8+x^7+x^6+x^5+x^4+x^3+x^2+x+1 \). Derive the encoder circuit for this.

3. For a (6,3) systematic linear block code the three parity check bits \( c_4, c_5, c_6 \) are formed from the following equations: \( c_4=d_1 \) (xor) \( d_3 \); \( c_5=d_1 \) (xor) \( d_2 \) (xor) \( d_3 \); \( c_6=d_1 \) (xor) \( d_2 \).

   (a) Write down the generator matrix \( G \)

   (b) Suppose that the received word is 010111. Decode this received word by finding the location of the error and the transmitted data bit

4. In a single-parity-check code, a single parity bit is appended to a block of \( k \) message bits \( (m_1, m_2, m_3, ..., m_k) \). The single parity bit, \( b_1 \) is chosen so that the code word satisfies the even parity rule: \( m_1 + m_2 + m_3 + b_1 = 0 \) mod-2. For \( k=3 \), set up the \( 2^k \) possible code words in the code defined by this rules.

5. The generator polynomial of a (7, 4) cyclic code is \( g(x)=1+x+x^3 \). Find the 16 code words of this code:
(a) By forming the code polynomials using \( v(x) = D(x) g(x) \), where \( D(x) \) is the message polynomial.

(b) Draw the encoder block diagram.

6. The polynomial \( x^{15}+1 \) when factored gives \( x^{15}+1=(x^4+x^3+x^2+x+1)(x^4+x^3+1)(x^2+x+1)(x+1) \)
   (a) Construct a systematic \((15,5)\) code using the generator polynomial \( g(x) = (x^4+x^3+x^2+x+1)(x^4+x^3+1)(x^2+x+1)(x+1) \).
   (b) What is the minimum distance of the code?
   (c) How many random errors per code word can be corrected?

7. Consider the \((8,4)\) linear block code with \( G = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 \\ 0 & 0 & 1 & 1 & 0 & 0 & 1 & 1 \\ 0 & 1 & 0 & 1 & 0 & 1 & 0 & 1 \end{bmatrix} \)
   (a) Construct all the possible code words
   (b) Construct all the single error patterns.

8. Consider the \((8,4)\) cyclic code with \( G = \begin{bmatrix} 1 & 0 & 0 & 0 & 1 & 1 & 1 & 1 \\ 0 & 1 & 0 & 0 & 1 & 1 & 1 & 1 \\ 0 & 0 & 1 & 0 & 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 1 & 0 & 1 \end{bmatrix} \)
   (a) Construct all the possible code words
   (b) Construct all the single error patterns.

9. For a cyclic code the generator polynomial \( g(x) = (x^3+x^2+1) \). Determine the code for data bits \( 1010, 1111, \) and \( 0001 \).

10. Consider the \((7,4)\) cyclic code with \( g(x) = 1+x^3+x^4+x^6+x^7+x^8 \).
    Find the code vector (in systematic form) for the message polynomial \( D(x) = x^2+x^3+x^4 \).

11. Consider a \((7,4)\) cyclic code with \( G = \begin{bmatrix} 1 & 0 & 0 & 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 1 & 1 & 1 & 1 \\ 0 & 0 & 1 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 1 & 0 & 1 & 1 \end{bmatrix} \)
    (a) Construct all the possible code words
    (b) Construct all the single error patterns.

12. For a \((6,3)\) systematic linear block code, the three parity check bits \( c_4, c_5, c_6 \) are formed from the following equations.
    \[ C_4 = d_1 + d_3, \quad C_5 = d_1 + d_2 + d_3, \quad C_6 = d_1 + d_2 \]
    a) Write the generator matrix \( G \).
    b) Construct all possible code words.

13. Consider a \((7,4)\) linear code whose generator matrix is
    \[ G = \begin{bmatrix} 1 & 0 & 0 & 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 1 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 1 & 0 & 1 & 1 \end{bmatrix} \]
    (a) Find all the code vectors of this code.
    (b) Find the parity check matrix for this code.
    (c) Find the minimum weight of this code.
    (d) Show the error correction capability of this code.

14. The generator polynomial of \((15,7)\) cyclic code is \( g(x) = 1+x^4+x^6+x^7+x^8 \).
    Find the code vector (in systematic form) for the message polynomial \( D(x) = x^2+x^3+x^4 \).

15. A \((15, 5)\) linear cyclic code has a generator polynomial
    \[ G(x) = 1 + x + x^2 + x^4 + x^5 + x^8 + x^{10} \]
    Draw the block diagram of encoder and syndrome calculator for this code.

16. The parity check bits of a \((8, 4)\) block code are generated by
    \[ C_6 = d_1 + d_2 + d_4, \quad C_5 = d_1 + d_2 + d_3, \quad C_7 = d_1 + d_3 + d_4, \quad C_8 = d_2 + d_3 + d_4 \]
    Where \( d_1, d_2, d_3, \) and \( d_4 \) are message bits. Find
    (a) the generator matrix and parity check matrix for this code.
17. The generator polynomial of a \((7, 4)\) cyclic code is \(g(x) = 1 + x + x^3\). Find the 16 code words of this code:
(a) By forming the code polynomials using \(v(x) = D(x) g(x)\), where \(D(x)\) is the message polynomial.
(b) Draw the encoder block diagram.

18. Consider a \((6, 3)\) generator matrix.

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

Find (a) All the code vectors of this data. (b) The parity check matrix for this code. (c) Minimum weight of this code.

19. Develop a standard array for a \((6, 3)\) linear block code with a generator matrix.

20. Design a single error correcting linear block code with a message block size of 11. Show that with an example the code can correct single error.

21. The generator matrix for a \((6, 3)\) generator matrix is given below, Find all code vectors of this code.

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

22. Prove the linear block code with a minimum distance \(d_{\text{min}}\) can correct up to \(\left\lfloor (d_{\text{min}} - 1)/2 \right\rfloor\) errors detect up to \(d_{\text{min}} - 1\) errors in each codeword, where \(\left\lfloor (d_{\text{min}} - 1)/2 \right\rfloor\) denotes the largest integer no greater than \((d_{\text{min}} - 1)/2\).

23. Design a linear block code with a minimum distance of three and a message block size of eight bits.

24. Prove the minimum distance of a linear block code is equal to the minimum weight of any nonzero word in the code.

25. Design an encoder for the \((7, 4)\) binary cyclic code generator by \(g(x) = 1 + x + x^3\) and verify its operation using the message vector \((0101)\).

26. Examine the steps in encoding operation using an \((n - k)\) bit shift register.

27. A convolutional encoder has a single shift register with two stages, \((K=3)\) three modulo -2 adders and an output multiplexer. The generator sequence \(s\) of the encoder are as follows. \(g^{(1)} = (0, 1, 1)\); \(g^{(2)} = (1, 0, 1)\); \(g^{(3)} = (1, 1, 1)\). Draw the block diagram of the encoder. Construct the state diagram of the above encoder.

28. Determine the encoder output when the binary data is 10010 using tree diagram approach.

29. Consider a convolutional encoder with \(K=3\) and \(V=2\) and \(g^{(1)} = (1, 1, 0)\); \(g^{(2)} = (1, 1, 1)\).

(a) Draw the encoder circuit
(b) Draw the tree diagram and trellis diagram to determine the encoded output.

30. Construct the state diagram for the following encoder. Starting with all zero state, trace the path that corresponds to the message sequence 101101. Given convolutional encoder has 3 shift registers with two stages, two modulo-2 adders and an output multiplexer. The generator sequences of the encoder are as follows. \(g^{(1)} = (1, 1, 1); g^{(2)} = (1, 0, 1)\)

5. If the received data is 100010, determine the transmitted output, using Viterbi decoding algorithm.

6. A convolutional encoder has two shift registers two modulo-2 adders and an output multiplexer. The generator sequences of the encoder are as follows: \(g^{(1)} = (1, 0, 1)\); \(g^{(2)} = (1, 1, 1)\). Assuming a 5 bit message sequence is transmitted. Using the state diagram and the message sequence when the
7. If the received data is 0010111011, determine the transmitted output decode, using tree diagram.

8. Draw and explain State and Trellis diagram of convolutional encoder shown in Figure

9. A convolutional encoder has 3 shift registers with two stages, two modulo-2 adders and an output multiplexer. The generator sequences of the encoder are as follows. \( g^{(1)} = (1, 1, 1, 1) \); \( g^{(2)} = (1, 1, 0, 1) \). Draw the block diagram of the encoder. Find the encoder output produced by the message sequence 1011101 using time domain approach based on convolution?

10. Explain about the maximum likelihood detection by considering the received data as 10 01101100

11. A convolutional encoder has two shift registers two modulo-2 adders and an output multiplexer. The generator sequences of the encoder are as follows: \( g^{(1)} = (1, 0, 1) \); \( g^{(2)} = ( 1, 1, 1) \). Assuming a 5bit message sequence is transmitted. Draw the state diagram.

12. Figure below shows the encoder for a rate \( r=1/2 \), constraint length \( k=4 \) convolutional code. Determine the encoder output produced by the message sequence 10111..., using the time domain approach.

13. A convolution encoder has 3 shift registers with two stages, two modulo-2 adders and an output multiplexer. The generator sequences of the encoder are as follows. \( g^{(1)} = (1, 1, 1, 1) \); \( g^{(2)} = (1, 1, 0, 1) \). Draw the block diagram of the encoder. Find the encoder output produced by the message sequence 1011101 using time domain approach based on convolution?

14. Sketch the Tree diagram of convolution encoder shown in figure with Rate=1/2, constraint length \( L = 2 \).
15. Figure below shows the encoder for a rate \( r=1/2 \), constraint length \( k=4 \) convolutional code. Determine the encoder output produced by the message sequence 10111, using the transform domain approach.

16. A convolution encoder has single shift register with two stages, (i.e., constraint length \( K=3 \)), three modulo 2 adders, and an output multiplexer. The generator sequences of the encoder are as follows:
   \( g(1)=(1, 0, 1) \)
   \( g(2)=(1, 1, 0) \)
   \( g(3)=(1, 1, 1) \)
a) Draw the block diagram of the encoder.
b) Determine the encoder output produced by the message sequence 10111 using transform domain approach.

17. Suppose the convolutional encoder generates an all zero sequence that is sent over a binary symmetric channel, and there are two errors in the received sequence due to noise in the channel. Show that this double error pattern is correctable through the application of viterbi algorithm by considering the following state diagram.

18. Consider the rate \( r=1/2 \), constraint length \( K=2 \) convolutional encoder of figure below. The code is systematic. Find the encoder output produced by the message sequence.
19. Consider the convolution encoder shown in the figure. The message bits are shifted into the encoder two bits at a time.

(a) Find the constraint length and the rate efficiency of the code.

(b) Assume the initial content of the registers to be zero and find the code block for the input message block (110101).

20. A convolution encoder has 3 shift registers with two stages, two modulo-2 adders and an output multiplexer. The generator sequences of the encoder are as follows.
   \( g(1) = (1, 1, 1, 1) \); \( g(2) = (1, 1, 0, 1) \). Draw the block diagram of the encoder. Draw the code tree for this encoder.

21. A conventional encoder has a single shift register with two stages, three modulo-3 adders and an output multiplexer. The generator sequences of the encoder are as follows:
   \( g(1) = (1, 0, 1) \); \( g(2) = (1, 1, 0) \); \( g(3) = (1, 1, 1) \). Draw the block diagram of the encoder.

22. Illustrate the construction of code tree and trellis in convolution encoder by taking an example.

23. Enumerate different steps in viterbe algorithm.

24. Consider the convolution code with rate \( r = 1/2 \), used over a binary symmetric channel with transition probability \( p = 0.04 \). Each branch in the code tree has a binary label consisting of 2 bits. Calculate the possible branch matrix.

25. Explain the fano algorithm and write the flow chart of fano algorithm.

26. Illustrate the fano algorithm for the code tree of rate -1/2, constraint length-7 convolution code. Number of message bits \( L = 2 \), assume the path metric for each node of the tree. Threshold spacing is set at 4.

27. Compare bit metric, branch metric and path metric in sequential decoding.

28. Construct a convolution encoder constraint length -2 and rate -2/3.

29. Calculate the input-top adder and input-bottom adder output path using time-domain approach, for the convolution encoder with \( n = 2 \) and \( k = 3 \), constraint length of -3 and rate -1/2, encoder has the two generator sequences of length 3.

30. Enumerate the transform-domain approach of convolution codes by taking an example.