I -12471

Register No. | | | | | | | | |

BTech Degree Examination May 2022

Fourth Semester

Information Technology

20ITT41 – PRINCIPLES OF COMMUNICATION

(Regulation 2020)

Time: Three hours | Maximum: 100 marks

Answer all Questions

Part – A ($10 \times 2 = 20$ marks)

1. For an AM – DSBFC modulator with carrier frequency fc = 100 KHz and a maximum modulating signal frequency fm (max) = 5 KHz. Determine the frequency limits for lower and upper side bands. [CO1,K3]

2. Write the advantages of AM modulation. [CO1,K1]

3. The audio signal having frequency 500 Hz and voltage 2.6V, shows a deviation of 5.2 KHz in a frequency modulation system. If the audio signal voltage changes to 8.6 V, Calculate the frequency deviation obtained. [CO2,K3]

4. Determine the peak frequency deviation (Δf) and modulating index (m) for an FM modulator with a deviation K_f = 5 kHz/V and a modulating signal $V_m(t) = 2\cos(2\pi 2000t)$. [CO2,K3]

5. ASK is called as ON-OFF Keying. Justify it. [CO3,K1]

6. Specify any two important advantages of PCM. [CO3,K1]

7. Draw the NRZ and RZ waveforms for the pulse stream 10101011. [CO4,K1]

8. Infer which data communication code is the most powerful and why? [CO4,K2]

9. Mention the significance of PN Sequence. [CO5,K1]

10. List the applications of spread spectrum techniques. [CO5,K1]

Part – B ($5 \times 16 = 80$ marks)

11. a. Illustrate the concepts of AM modulation and derive the equation of an AM wave. Draw the phasor diagram, frequency spectrum and modulated AM wave for various degrees of modulation index. (16) [CO1,K2]

(OR)

b. Draw the block diagram for an AM Superheterodyne receiver and describe its operation and the primary function of each stage. (16) [CO1,K2]

12. a. i) Consider an angle modulated signal (10) [CO2,K3]
$X(t) = 3\cos(2\pi\, 10^6 t) + 2\sin(2\pi\, 10^3 t)$.
Find its
1) Instantaneous frequency
2) Carrier frequency
3) The modulating frequency
4) Maximum phase deviation
5) Maximum frequency deviation.

ii) Derive the expression for phase deviation and modulation index for angle modulated signal. (6) [CO2,K3]

(OR)

b. i) Elaborate the operation of varactor diode modulator and Derive the equation for instantaneous frequency. (10) [CO2,K3]

ii) An angle modulated signal has the form $v(t) = 100\cos[2\pi f_c t + 4\sin 2000\pi t]$ where $f_c = 10$ MHz. Find (6) [CO2,K3]
1) The average transmitted power
2) Peak Phase deviation
3) Peak frequency Deviation
4) Is this FM or a PM signal? Explain.

13. a. i) Discuss in detail about the working principle of BPSK with neat sketch. (10) [CO3,K1]

ii) Investigate the operation of FSK transmitter. (6) [CO3,K2]

(OR)

b. Elaborate the operation of T_1 carrier system with neat sketch and calculate line speed of T_1 digital carrier system. (16) [CO3,K1]

14. a. i) Investigate the concept of Data Communication circuits with a basic block diagram. (8) [CO4,K2]

ii) Illustrate the Architecture of ISDN with neat sketch. (8) [CO4,K1]

(OR)

b. Elaborate any three types of error detection methods with examples. (16) [CO4,K2]

15. a. With a Suitable example, briefly illustrate the concept behind Frequency Hopping Spread Spectrum. (16) [CO5,K2]

(OR)

b. Investigate the operation of Direct Sequence Spread spectrum and also derive the equation for processing gain and probability of error. (16) [CO5,K2]

Bloom's Taxonomy Level	Remembering (K1)	Understanding (K2)	Applying (K3)	Analysing (K4)	Evaluating (K5)	Creating (K6)
Percentage	26	52	22	-	-	-

Kongu Engineering College-638060

Department of Information Technology

20ITT41- Principles of Communication

Key for Evaluation

Part - A

1. **Amplitude Modulation**

   UpperSide band Limit
   (100-105 KHz)
   UpperSide band Limit
   (95-100 KHz)

2. **Advantages of AM modulation:**

   - it is relatively easy to detect with simple equipment
   - it has a narrower bandwidth than FM, and wider coverage compared with FM radio

3. frequency deviation.

   $f_m = 500\,HZ$, $\Delta\theta = 5.2\,KHZ$ $V_m = 2.6\,V$

   $$\Delta\theta = \frac{k_f \cdot V_m}{f_m} = \frac{k_f \cdot 2.6}{500} = 5.2$$

   $k_f = 10\,K$, $\Delta f = 86\,KHZ$

4. Modulation Index.

   $V_m = 2$, $f_m = 2000$, $\Delta f = k_f \cdot V_m = 10\,KHZ$

   $m = k_f \cdot V_m / f_m = 5$

5. **ASK called ON-OFF Keying:**

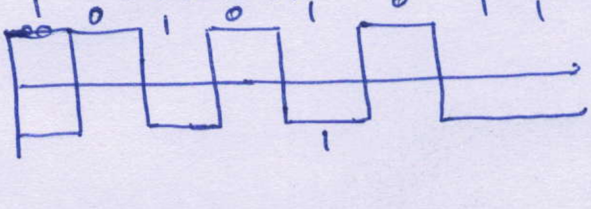
   - The carrier waves continuously switch between 0 and 1 according to the high and low level of the input signal.

6. **Advantages of PCM:**

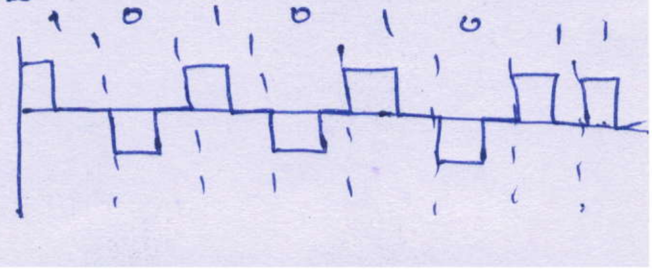
   - Encoding is possible in PCM.
   - Very high noise immunity, i.e. better performance in the presence of noise.
   - Convenient for long-distance communication.
   - Good signal to noise ratio.

7. Line coding.

10101011



RZ



8. **Which Data Communication Code is powerful:**

ASCII Code

- Characters in ASCII encoding include upper- and lowercase letters A through Z, numerals 0 through 9 and basic punctuation symbols.
- It also uses some non-printing control characters that were originally intended for use with teletype printing terminals.

9 **Significance of PN sequence:**

- It has applications in scrambling, cryptography, and spread-spectrum communications.
- It is also commonly. referred to as the Pseudo-Random Binary Sequence (PRBS).
- widely used in communication.

10 **Applications of Spread Spectrum:**

- It used in mobile communications.
- It is used in distance measurement.
- It is used in selective calling.
- It is used in CDMA communication.

Part – B
(5*13=65 marks)

11 a. Concept and Derivation of AM modulation: Explanation: (8) 3 Marks

- The amplitude of the carrier signal varies in accordance with the instantaneous amplitude of the modulating signal
- The amplitude of the carrier signal containing no information varies as per the amplitude of the signal containing information, at each instant.

According to definition of AM, we change the amplitude of the carrier

[7 Marks]

$$AM(t) = [A_c + m(t)]cos\omega_c t$$

$$= [A_c + \ A_m cos\omega_m t]\ cos\omega_c t$$

$$= \ A_c cos\omega_c t + \ A_m cos\omega_m t\ cos\omega_c t$$

By rearranging

$$AM(t) = \ A_c cos\omega_c t + \frac{1}{2}.2\ A_m cos\omega_m t\ cos\omega_c t$$

$$= \ A_c cos\omega_c t + \ \frac{A_m}{2}\ 2\ cos\omega_m t\ cos\omega_c t \qquad 2\cos A\cos B = \cos(A+B) + \cos(A-B)$$

$$= \ A_c cos\omega_c t + \ \frac{A_m}{2}\ [\cos(\omega_c + \omega_m)t + \cos(\omega_c - \omega_m)t]$$

$$= \ A_c cos\omega_c t + \ \frac{A_m}{2}\frac{A_c}{A_c}\ [\cos(\omega_c + \omega_m)t + \cos(\omega_c - \omega_m)t]$$

$$= \ A_c cos\omega_c t + \ \frac{A_c}{2}\frac{A_m}{A_c}\ [\cos(\omega_c + \omega_m)t + \cos(\omega_c - \omega_m)t]$$

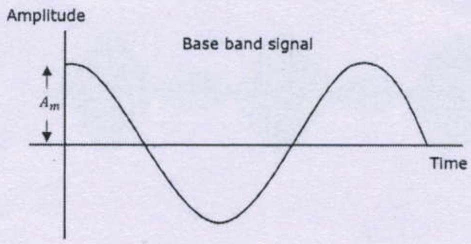
$$= \ A_c cos\omega_c t + \ \frac{A_c m_a}{2}\ \cos(\omega_c + \omega_m)t + \frac{A_c m_a}{2}\ \cos(\omega_c - \omega_m)t$$

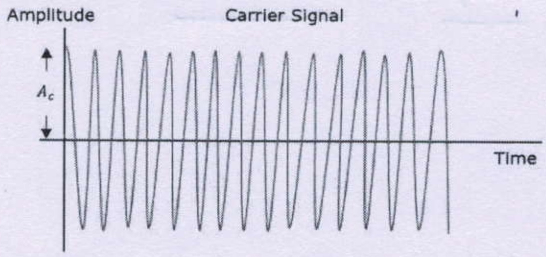
$$= \ \underbrace{A_c cos\omega_c t}_{\text{carrier}} + \ \underbrace{\frac{A_c m_a}{2}\ \cos 2\pi(f_c + f_m)t}_{\text{USB}} + \underbrace{\frac{A_c m_a}{2}\ \cos\ 2\pi(f_c - f_m)t}_{\text{LSB}}$$

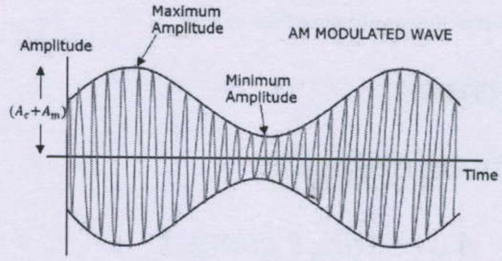
$$where\ m_a = modulation\ index = \frac{A_m}{A_c}$$

AM Envelope

[3 Marks]

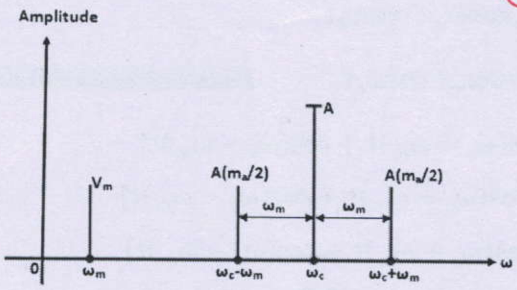




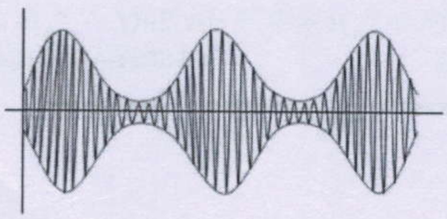


Frequency Spectrum:

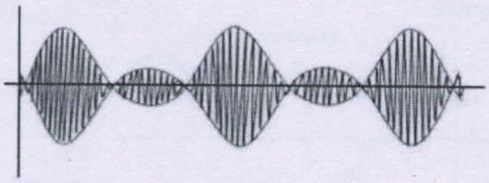
[3 Marks]



Under-Modulated wave

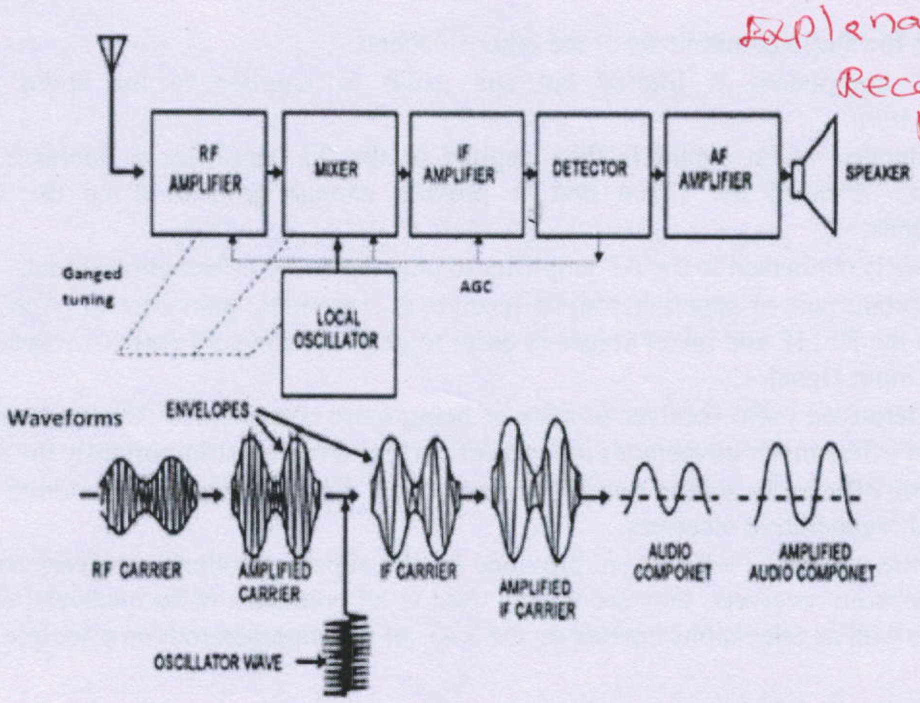


Over-Modulated wave



11b. AM Superhedrodyne Receiver.

Diagram - 7 marks
Explanation - ~~7~~ marks
Receiver permeters } - 2 mar



- In the superheterodyne receiver, the incoming signal through the antenna is filtered to reject the image frequency and then amplified by the RF amplifier.
- RF amplifier can be tuned to select and amplify a particular carrier frequency within the AM broadcast range. Only the selected frequency and it two sidebands are allowed to pass through the amplifier.
- The carrier of the received signal is called radio frequency carrier and its frequency is radio frequency fRFfRF and the local oscillator signal operates at fOSCfOSC. The amplified RF frequency is then mixed with the local oscillator frequency.
- The combining of these two signals is done at the mixer which produces sum and difference frequency signals of the incoming carrier signal and local oscillator signal,
- The sum frequency is rejected by the filter and the remaining difference frequency signal which is a down converted frequency signal is called as intermediate frequency (IF) carrier.
- The frequency of local oscillator is not same as the frequency to which RF amplifier is tuned. Local oscillator is tuned to a frequency that may be either higher or lower than the incoming frequency by an amount equal to the IF frequency.
- Thus idea of the superheterodyne receiver is to reduce the high frequency radio components of the incoming carrier to a fairly low, fixed value such as to be processed at the different stages of the receiver.
- The modulation of the IF carrier signal is same as that of the original carrier signal and it has a fixed frequency of 455kHz which is amplified by one or more stages of amplification.
- The IF signal is amplified with the help of IF amplifier which raises its level for the information extraction process.
- IF amplifier operations are independent to the frequency at which receiver is tuned, maintaining the selectivity and sensitivity of the superheterodyne receiver considerably constant throughout the tuning range of the receiver.
- This amplified IF signal is applied to the detector to detect the information signal component from 455 kHz IF, to reproduce the original information data, which is generally in the form of audio signal.
- The detector stage eliminates one of the sidebands which is still present and separates the

RF from the audio components of the other sideband.

- The RF component is filtered out and audio is supplied to the audio stages for amplification.
- The generated audio signal is then applied to the AF amplifier to increase the audio frequency level of the signal and to provide enough gain to drive the speaker or headphones.
- A speaker is connected to the AF amplifier to play the audio information signal.
- An important part of superheterodyne receiver is Automatic gain control (AGC) which is given to the RF, IF and mixer stages in order to generate constant output irrespective of the varying input signal.
- Superheterodyne radio receiver in spite of being more complicated than some of the other receivers offers many advantages in terms of performance, most importantly the selectivity.
- It is more efficiently able to remove unwanted and distorting signals than other forms like TRF and regenerative receivers.
- Due to the enormous advantages provided by the superheterodyne receivers compared to the other radio receivers, they are widely used in all broadcast radio receivers, commercial radios as well as televisions operate on the basis of the superheterodyne principle.

12)
a)i Problem:

Given

modulated Signal [2 Marks)

$$x(t) = 3\cos(2\pi \times 10^6 t) + 2\sin(2\pi 10^3 t).$$

$V_m = 3, \quad f_c = 10^6 Hz, \quad f_m = 10^3 Hz, \quad m = 2$

i) Instantaneous frequency. [2 Marks]

$$= f_c + k_p . V_m \cos 2\pi f_m t.$$

$$= 10^6 + 2 \times 3 \cos 2\pi \times 10^3 t = 10^6 + 6\cos 2\pi \times 10^3 t.$$

2) Carrier frequency. [1 Marks)

$$f_c = 10^6 \times Hz$$

3) modulating frequency [1 Mark]

$$f_m = 10^3 Hz$$

$$= 1000\ kHz$$

4) maximum phase deviation: [2 Marks]

$$\Delta\theta = m_p$$
$$= 2\ \text{rad}$$

5) maximum frequency deviation. [2 Marks]

$$\Delta f = k_p \cdot V_m \cdot f_m$$
$$= 2 \times 3 \times 10^3$$
$$= 6 \times 10^3$$

$$\boxed{\Delta f = 6 \times 10^3}$$

12) a) ii **Derivation Expression for phase deviation and modulation Index:**

[3 Marks]

$$\theta_i(t) = 2\pi f_c t + k_p V_m \sin 2\pi f_m t$$
$$\Delta\theta = k_p V_m \sin 2\pi f_m t$$
$$\Delta\theta = k_p V_m$$
$$f_i(t) = \frac{1}{2\pi}\frac{d\theta(t)}{dt}$$
$$= \frac{1}{2\pi}\left[2\pi f_c + k_p \cdot V_m\, 2\pi f_m \cos 2\pi f_m(t)\right]$$
$$= f_c + k_p \cdot V_m \cos 2\pi f_m t$$
$$\delta f = k_p V_m f_m.$$

[3 Marks]

modulation index.

$$m_p = \frac{\Delta f}{\cancel{f_m}} = \frac{k_p V_m \cdot \cancel{f_m}}{\cancel{f_m}}$$
$$= k_p \cdot V_m.$$

K_p - Phase sensitivity

V_m - amplitude of msg signal.

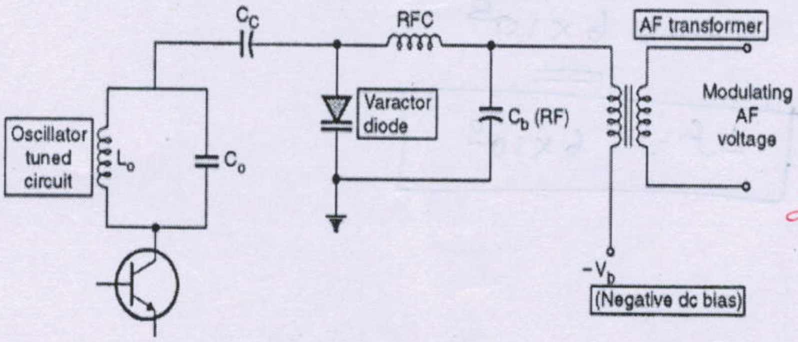
$K_p V_m$ - maximum phase deviation.

12) b). i) **Varactor Diode:**

Diagram – 3 Marks

Explanation – 3 Marks

derivation – 4 Marks



- Varactor diode modulator is the direct method of FM generation wherein the carrier frequency is directly varied by the modulating signal.
- Varactor diode is a semiconductor diode whose junction capacitance varies linearly with applied voltage when the diode is reverse biased.
- Varactor diodes are used along with reactance modulator to provide automatic frequency correction for an FM transmitter

$$C = \frac{\varepsilon A}{\omega}$$

instantaneous frequency.

$$f_i = \frac{1}{2\pi\sqrt{L.m(t)}} = \frac{1}{2\pi\sqrt{L(C_0 + \Delta C\, m(t))}}$$

$$f_i = f_c\left[1 + \frac{\Delta m(t)}{C_0}\right]^{-1/2}$$

$$\boxed{f_i = f_c\left[1 - \frac{\Delta C.m(t)}{2C_0}\right]}$$

12) b). ii) Angle modulated signal.

Given

modulated signal $v(t) = 100\cos[2\pi f_c t + 4\sin 200\pi t]$

$f_c = 10\times10^6$ Hz

$E_c = 100$

i) Transmitted Power.

$R = 100\Omega$

[1 Mark]

$$P_t = \frac{E_c^2}{2R} = \frac{\cancel{100}^{50} \times \cancel{100}}{2 \times \cancel{100}}$$

$$= 50\,W$$

ii) Peak Phase Deviation.

[1 Mark

m = Peak phase deviation

$$\boxed{m = 4}$$

Peak phase deviation = 4

iii) Peak frequency deviation.

[2 Marks]

$$m = \frac{\Delta f}{f_m}$$

$$\Delta f = m \cdot f_m$$

$$= 4 \times 100$$

$$= 400\,Hz.$$

$$2\pi f_m = 200\pi$$

$$f_m = \frac{\cancel{200}^{100}\cancel{\pi}}{\cancel{2\pi}}$$

$$= 100$$

iv) Angle modulated wave is Phase modulated signal.

Explanation [2 Marks]

13) a)i) **BPSK:**

[Explanation – 3 Marks]

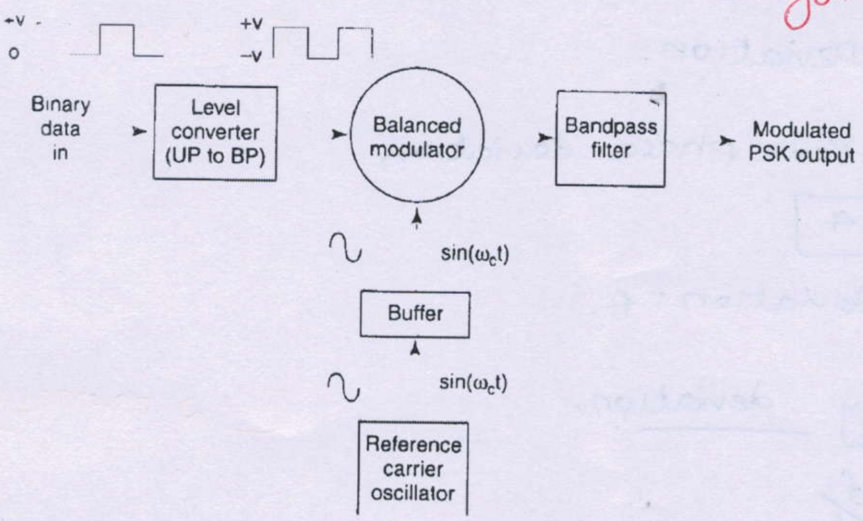
Binary Phase-Shift Keying The simplest form of PSK is binary phase-shift keying (BPSK), where N = 1 and M = 2.

Therefore, with BPSK, two phases ($2^1 = 2$) are possible for the carrier.

One phase represents a logic 1, and the other phase represents a logic 0. As the input digital signal changes state (i.e., from a 1 to a 0 or from a 0 to a 1), the phase of the output carrier shifts between two angles that are separated by 180°.

Hence, other names for BPSK are phase reversal keying (PRK) and biphase modulation. BPSK is a form of square-wave modulation of a continuous wave (CW) signal.

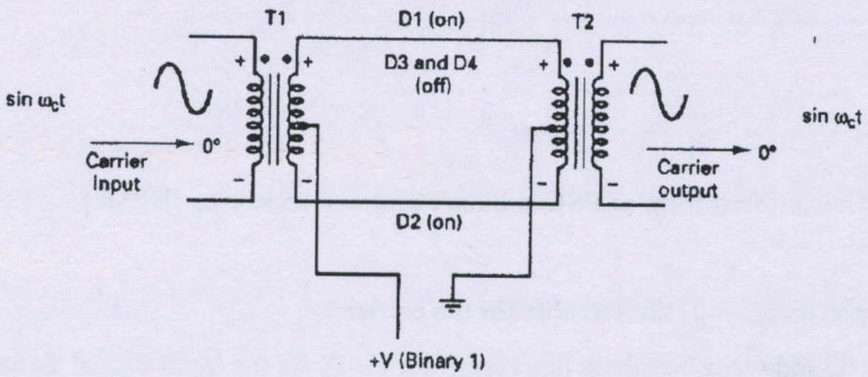
Diagram (2 Marks)

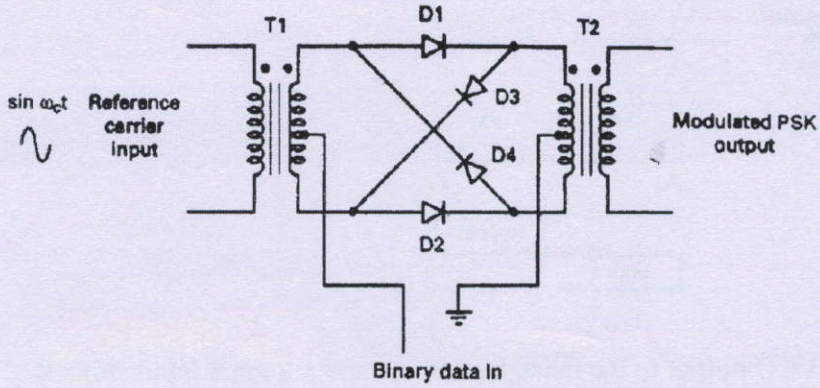


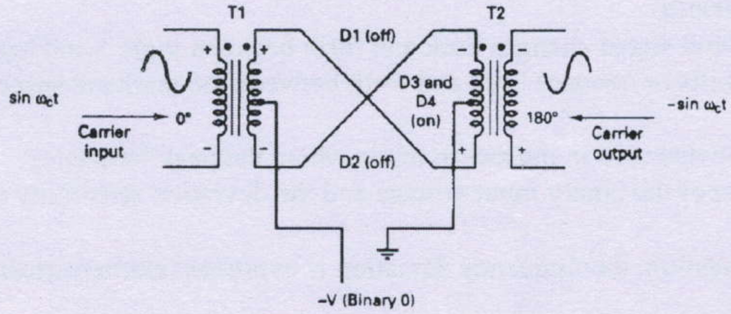
BPSK transmitter

[5 Marks]

- The balanced modulator acts as a phase reversing switch.Depending on the logic condition of the digital input, the carrieris transferred to the output either in phase or 180° out of phasewith the reference carrier oscillator.
- For the balanced modulator to operate properly, the digitalinput voltage must be much greater than the peak carriervoltage.
- This ensures that the digital input controls the on/off state ofdiodes D1 to D4. If the binary input is a logic 1(positivevoltage), diodes D 1 and D2 are forward biased and on, whilediodes D3 and D4 are reverse biased and off.
- With the polarities shown, the carrier voltage is developedacross transformer T2 in phase with the carrier voltage across T1.
- Consequently, the output signal is in phase with the referenceoscillator.If the binary input is a logic 0 (negative voltage), diodes Dl andD2 are reverse biased and off, while diodes D3 and D4 areforward biased.
- The carriervoltage is developed across transformer T2 180° out of phasewith the carrier voltage across T 1.







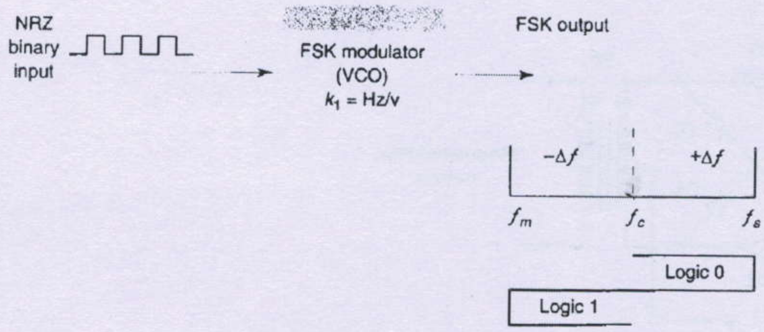
Bandwidth considerations of BPSK.

- In a BPSK modulator. the carrier input signal is multiplied bythe binary data.
- If + 1 V is assigned to a logic 1 and -1 V is assigned to a logic0, the input carrier (sin $\omega_c t$) is multiplied by either a + or - 1 .
- The output signal is either + 1 sin ωct or -1 sin wct the firstrepresents a signal that is *in phase* with the reference oscillator.
- The latter a signal that is 180° out of phase with the referenceoscillator.
- Each time the input logic condition changes, the output phase
- changes.
- Mathematically, the output of a BPSK modulator isproportional to
- BPSK output = [sin (2πfat)] x [sin (2πfct)]
  where
- fa = maximum fundamental frequency of binaryinput (hertz)
- fc = reference carrier frequency (hertz)
- Solving for the trig identity for the product of two sinefunctions,

0.5cos[2_(fc – fa)t] – 0.5cos[2_(fc + fa)t]

13)a). ii) FSK Transmitter: Explanation: 2 Marks

- FSK modulator is very similar to a conventional FM modulator and is very often a voltage-controlled oscillator (VCO).
- The center frequency (fc) is chosen such that it falls halfwaybetween the mark and space frequencies.



[2 Marks]

[2 Marks]

- A logic 1 input shifts the VCO output to the mark frequency, and a logic 0 input shifts the VCO output to the space frequency.
- Consequently, as the binary input signal changes back and forth between logic 1 and logic 0 conditions, the VCO output shifts or deviates back and forth between the markand space frequencies.
- A VCO-FSK modulator can be operated in the sweep mode where the peak frequency deviation is simply the product of the binary input voltage and the deviation sensitivity of the VCO.
- With the sweep mode of modulation, the frequency deviation is expressed mathematically as

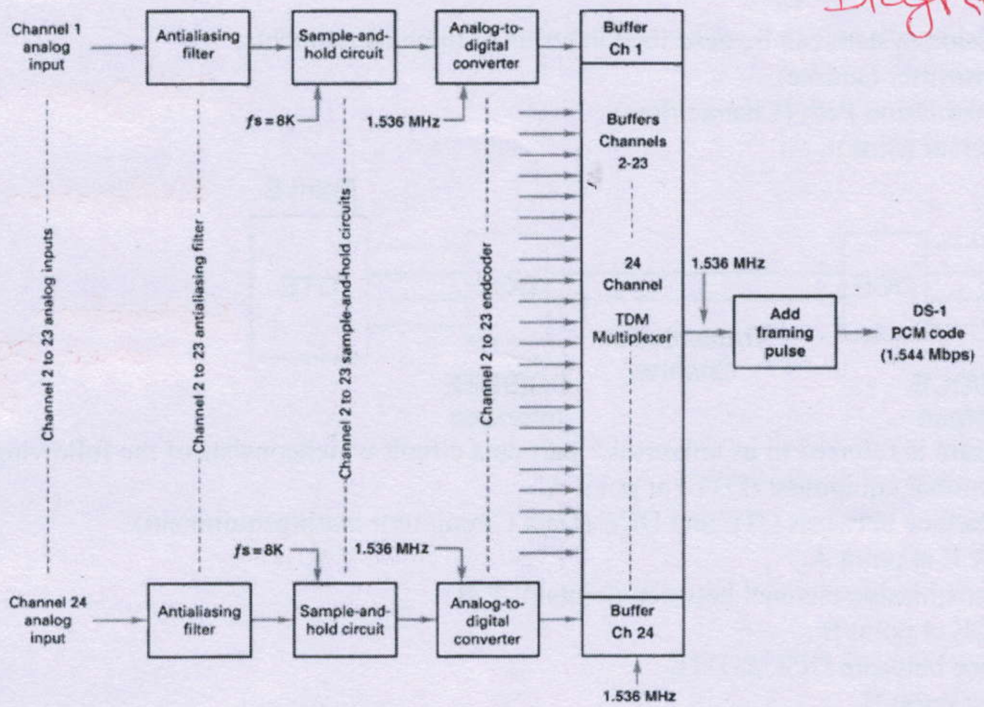
$$\Delta f = v_m(t)k_l$$

vm(t) = peak binary modulating-signal voltage (volts)
kl = deviation sensitivity (hertz per volt).

13)b) **Digital T1 Carrier System:** Explanation — 4 Marks

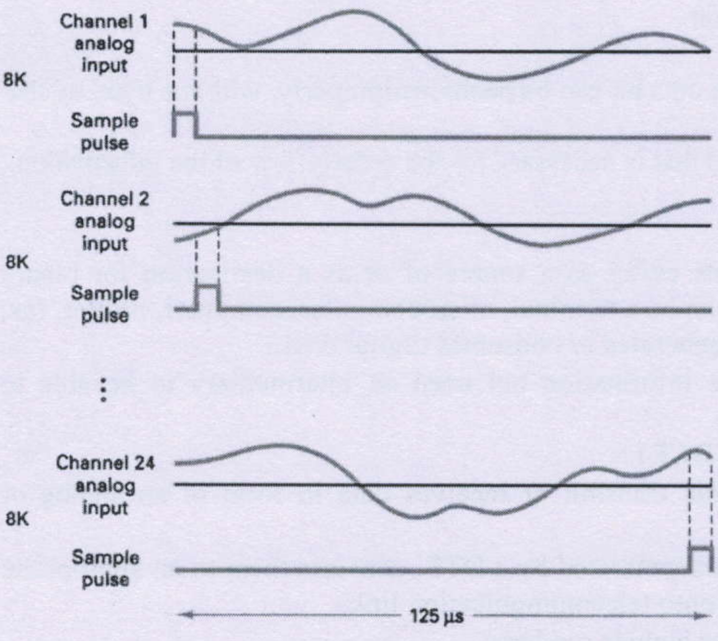
- T-Carrier systems provide digitized communication for voice or data traffic across a telephone provider's network.
- The T-Carrier specification defines the Layer-1 aspects of the multiplexed communication. The two most prevalent T-Carrier systems are T1 and T3 circuits.
- The Digital Signal (DS) refers to the signaling rate and framing of the TCarrier. The basic unit is the DS0, referred to as a channel or timeslot.
- The DS0 channel was designed to support one voice call, with a throughput of 64 kbps. It is possible to multiplex multiple DS0's to form a higher-capacity link:
    - A T1 circuit consists of 24 DS0 channels, for a total throughput of 1.544 Mbps.
    - A T3 circuit consists of 672 DS0 channels, or 28 T1 circuits, for a total throughput of 44.736 Mbps.
- It is also possible to utilize only a subset of channels on a T1, referred to as a fractional T1 (or frac T1).
- The terms T1 and DS-1 are often (incorrectly) used interchangeably to refer to a 24-channel multiplexed line.
- Remember: the term T1 refers to the hardware aspect of the technology, whereas DS1 refers to the framing. A T1 line can operate over as few as two copper pairs (4 wires). One pair is used to transmit data, and the other pair is used to receive data.
- In European and Asian countries, an E-carrier system is used instead of Tcarrier.
- An E1 consists of 30 channels of 64 Kbps, for a total throughput of 2.048 Mbps.

Diagram – 5 Marks



(a)

Sampling Sequence: [4 Marks]



(b)

line speed Calculation: 3 Marks

14)a).

i A data transmission system can be described in terms of three components:

(i) Transmitter (source)

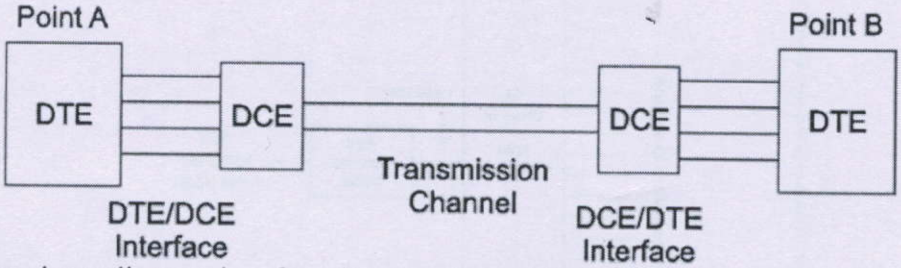
(ii) Transmission Path (Channel/line)

(iii) Receiver (Sink)

Diagram : 2 Marks

Explanation : 3 marks

Explanation about DCE & DTE } - 3 marks



The above diagram is referred to as universal 7 part data circuit whichconsists of the following:

(i) Data terminal equipment (DTE) at point A

(ii) The interface between DTE and DCE (Data Circuit terminatingequipment)

(iii) The DCE at point A

(iv) The transmission channel between points A & B

(v) The DCE at point B

(vi) Interface between DCE & DTE

(vii) DTE at point B

The information received is identical to the informationtransmitted.For uniform flow of data, the following important points shouldbe agreed upon by the sender and the receiver:

1. The nominal rate of the transmission

2. The specified information code

3. A particular scheme by which each data bit can be positionedproperly, within a byte, by the receiver

4. A protocol (handshaking sequence) that is necessary for the orderlyflow of the information.

Data Terminal Equipment (DTE) :

- It includes any unit that functions either as a source of or as a destination for binary digital data. At physical layer, it can be a terminal, microcomputer, computer, printer, fax, machine or any other device that generates or consumes digital data.
- DTEs do not often communicate information but need an intermediary to be able to communicate.

Data Circuit Terminating Equipment (DCE) :

- It includes any functional unit that transmit or receives data in form of an analog or digital signal through a network.
- At physical layer, a DCE takes data generated by a DTE, converts them to an appropriate signal, and then introduces signal onto telecommunication link.
- Commonly used DCEs at this layer include modems.
- In any network, a DTE generates digital data and passes them to a DCE. DCE converts that data to a form acceptable to transmission medium and sends converted signal to another DCE on network.
- The second DCE takes signal off line, converts it to a form usable by its DTE, and delivers it.

Diagram - 4 marks

Channel description } - 2 marks

General description } - 2 marks

14)a). **ISDN Architecture:**
ii

ISDN Architecture:

*) Designed to support an entirely new physical connector for the customer, a digital subscriber loop & variety of transmission services.

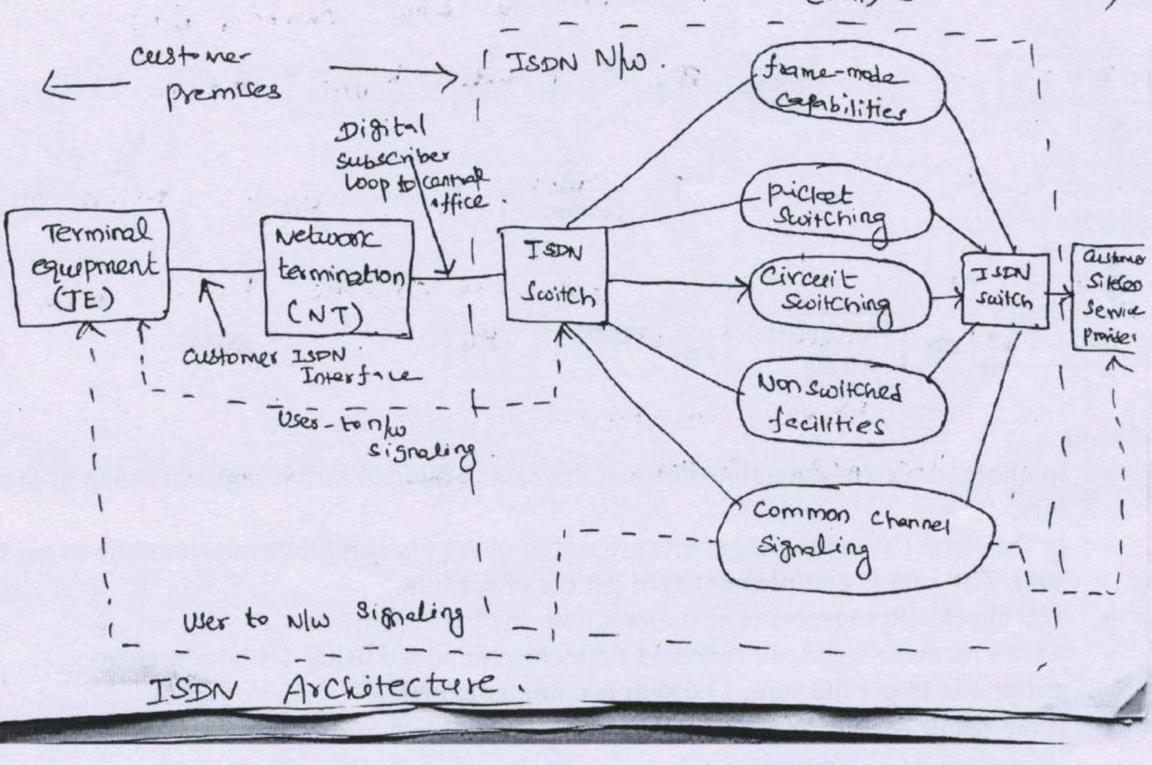
*) Common physical is defined to provide a standard Interface connection.

*) Single interface will be used for telephones, computer terminals & video equipment.

*) So, various protocols are used, that allow the exchange of control information b/w customer's device & the ISDN n/w.

*) Three basic types of ISDN channels

1. B channel : 64 kbps
2. D. Channel : 16 kbps or 64 kbps
3. H Channel : 384 kbps (H0), 1536 (H11) or 1920 kbps (H12)



ISDN Architecture.

D Channel

- 16 or 64 kbps
- Carries signalling information to control circuit-switched calls on B channels
- Can also be used for packet switching or lowspeed telemetry

H – Channel:

- Carry user information at higher bit rates 384kbps or 1536kbps or 1920kbps
- Can be used as a high-speed trunk
- Can also be subdivided as per user's own TDM scheme
- Uses include high speed data, fast facsimile, video, high-quality audio.

B – Channel:
Four kinds of connection possible

- Circuit-switched
- Packet-switched - X.25
- Frame mode - frame relay (LAPF)
- Semipermanent - equivalent to a leased line

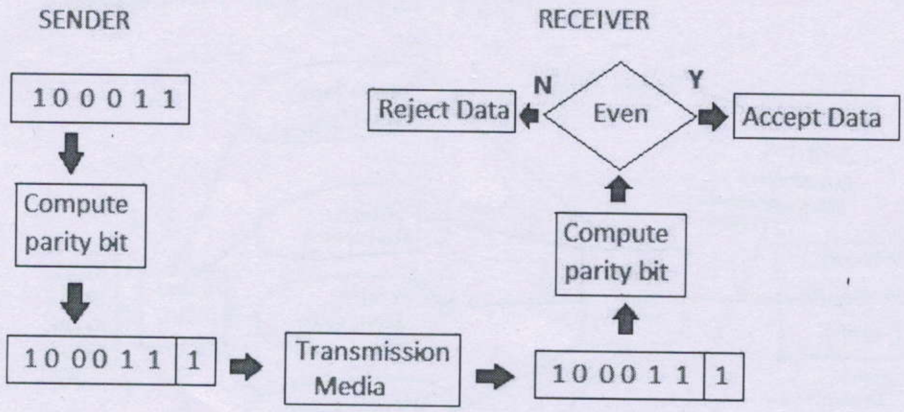
14. **Error detection Methods:**
b).

Example : 8 Marks
Explanation: 8 Marks

1.Simple Parity check
Blocks of data from the source are subjected to a check bit or parity bit generator form, where a parity of :

- 1 is added to the block if it contains odd number of 1's, and
- 0 is added if it contains even number of 1's

This scheme makes the total number of 1's even, that is why it is called even parity checking

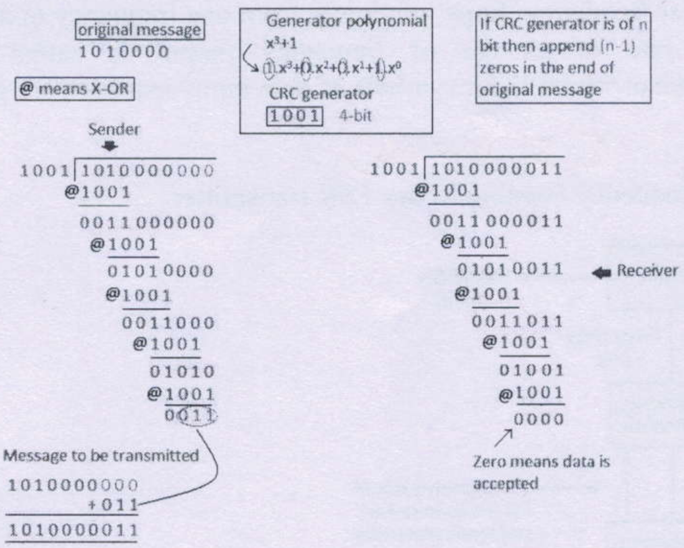


Checksum

- In checksum error detection scheme, the data is divided into k segments each of m bits.
- In the sender's end the segments are added using 1's complement arithmetic to get the sum. The sum is complemented to get the checksum.
- The checksum segment is sent along with the data segments.
- At the receiver's end, all received segments are added using 1's complement arithmetic to get the sum. The sum is complemented.
- If the result is zero, the received data is accepted; otherwise discarded.

Cyclic redundancy check (CRC)

- Unlike checksum scheme, which is based on addition, CRC is based on binary division.
- In CRC, a sequence of redundant bits, called cyclic redundancy check bits, are appended to the end of data unit so that the resulting data unit becomes exactly divisible by a second, predetermined binary number.
- At the destination, the incoming data unit is divided by the same number. If at this step there is no remainder, the data unit is assumed to be correct and is therefore accepted.
- A remainder indicates that the data unit has been damaged in transit and therefore must be rejected.



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15 a) **Frequency Hoping Spread Spectrum:** (15)

- In the direct sequence spread spectrum modulation, the pseudo-noise sequence of large bandwidth is multiplied with the narrowband data signal.
- The output signal is spreaded over the complete output bandwidth at every instant.
- The ability to overcome jamming is determined by the processing gain of system.
- The processing Gain = N; length of pseudo-noise sequence.
- As the number of bits **'N'** of pseudo-noise sequence (chips) are increased per data bits, the bandwidth of output signal becomes more. Hence processing gain is also more.
- But there is limitation of the physical devices which generates pseudo-noise sequence. Hence very large bandwidth are not possible with direct sequence modulation.
- To overcome this problem, frequency hop spread spectrum is used.

Principle of Frequency Hop Spread Spectrum [3 Marks]

- Frequency hopping means to transmit the data bits in different frequency slots. The total bandwidth of the output signal is equal to sum of all thesefrequency slots or **'hops'**.
- Since the frequency hopping is random (which is known only to the transmitter and recognized receiver) unwanted receivers has to cover the complete output bandwidth.
- This bandwidth is in GHz and hence unwanted receivers find it difficult to receive the

frequency hop signal.

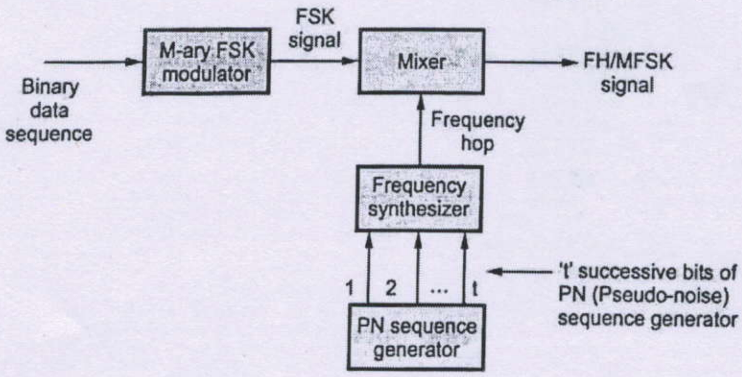
- Thus in the frequency hop spread spectrum the carrier frequency hops randomly from one frequency to another.
- Normally M-ary FSK is used along with frequency hop spread spectrum.
- There are to basic types of frequency hop spread spectrum.
  i. Slow frequency hopping and
  ii. Fast frequency hopping.

Slow Frequency Hopping (3 Marks)

- Normally **'k'** successive bits of input data sequence represent $2^k = M$ symbols.
- Those distinct **M** symbols are transmitted with the help of M-ary FSK modulation system.
- When spread spectrum modulation is to be used, then the M-ary FSK signal is further modulated to generate wideband signal.
- The spread spectrum carrier frequency **'hops'** randomly from one frequency to another.
- **Hop rate (R_h)** : The rate of change of frequency 'hops' is called hop rate. **Symbol rate (R_s) :** The rate at which K-bit symbols of data input sequence are generated is called symbol rate.

Transmitter of FH / MFSK [5 Marks)

Fig shows the block diagram of frequency hopping M-ary FSK transmitter.

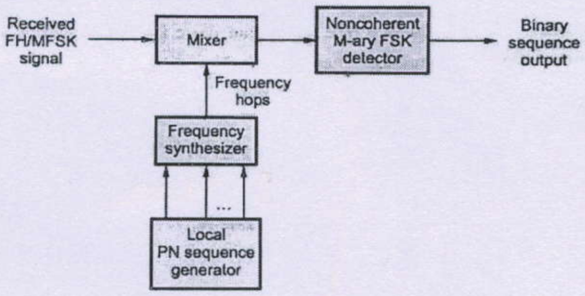


- The input binary data sequence is applied to the M-ary FSK modulator. This modulator output is the particular frequency (*out of* **'M'** *frequencies*) depending upon the input symbol.
- The output of FSK modulator is then applied to a mixer. The other input to the mixer is particular frequency from frequency synthesizer.
- The output of frequency synthesizer at particular instant is the frequency slot or **'hop'**. This hop is mixed with the FSK signal.
- The output of the mixer is the 'sum' frequency component of FSK signal and frequency hop from synthesizer.
- This signal is FH/MFSK signal and is transmitted over the wideband channel.

Receiver of FH/MFSK [5 Marks]

- The received FH/MFSK signal is applied to the mixer. The output of frequency synthesizer is also given to the mixer.
- The sum and difference frequencies are generated by the mixer. Only difference frequencies are allowed to pass out of the mixer.
- Those difference frequencies are exactly the M-ary FSK signals. These signals are given to the non-coherent M-ary FSK detector.

- The detector detects particular symbol transmitted.

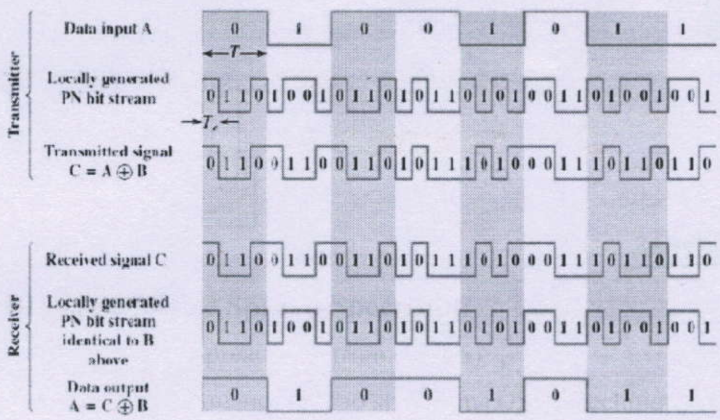


15 b) **Direct Sequence Spread Spectrum:**

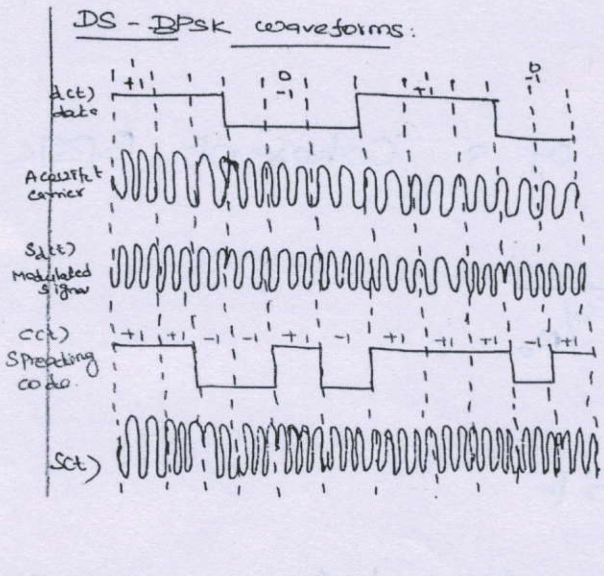
Direct Sequence Spread Spectrum (DSSS)

Explanation – 3 Marks

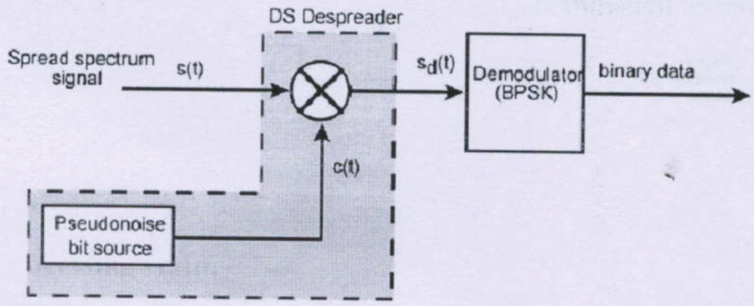
- The direct sequence spread spectrum (DSSS) technique expands the bandwidth of the original signal.
- Each bit is assigned a code of n bits, called chips, where the chip rate is n times that of the data bit.
- One method: — Combine input with spreading code using XOR — Input bit 1 inverts spreading code bit — Input zero bit doesn't alter spreading code bit — Data rate equal to original spreading code
- Performance similar to FHSS



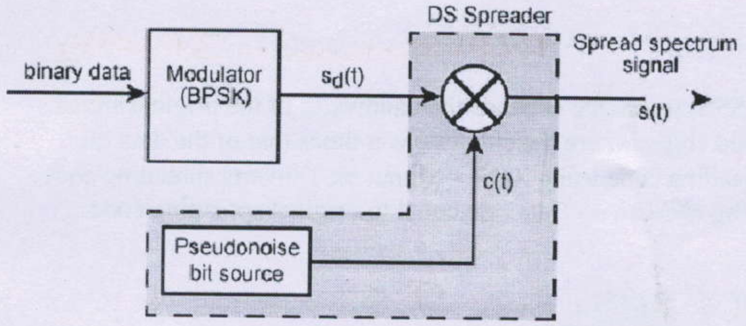
3 Marks



3 Marks



3 Marks



Processing Gain: [2 Marks]

$$G_p = \frac{\text{BW of spread spectrum signal}}{\text{BW of unspread signal.}}$$

$$G_p = \frac{1/T_c}{1/T_b} = T_b/T_c$$

$$G_p = T_b/T_c \qquad \boxed{\because T_b/T_c = N}$$

Probability Error: [2 Marks].

The probability error of a coherent BPSK given as

$$P_e = \frac{1}{2} \operatorname{erfc} \sqrt{E_b/N_0}$$

when

E_b = Energy per bit

$N_0/2$ = Noise power spectral density of white noise.