Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.

2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.

3) The language errors such as grammatical, spelling errors should not be given more importance (Not applicable for subject English and Communication Skills.

4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.

5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.

6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.

7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q.1.

A. Attempt any six of the following: **12**

i. Explain the necessity of modulation in electronic communication system. (Any four points, 1M each)

Need for Modulation:

1. Reduction in the height of antenna
2. Avoid mixing of signals
3. To increase the range of communication
4. To make multiplexing possible
5. To improve quality of reception.

1. **Reduction in the height of antenna:** for the transmission of radio signals the antenna height must be multiple of λ/4, where λ is wavelength.
   λ=c/f, cis velocity of light, f is frequency of the signal to be transmitted minimum antenna height required to transmit a baseband signal of f= 10KHz(without modulation)

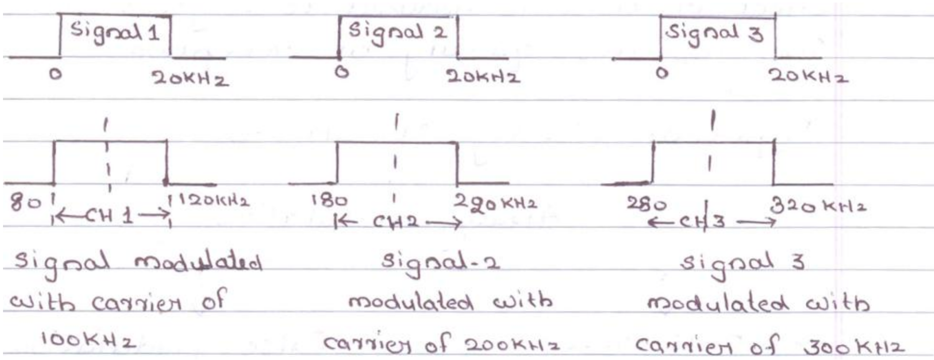
$$\textbf{minimum antenna height} = \frac{\lambda}{4} = \frac{\frac{c}{f}}{4} = \frac{c}{4f} = \frac{3\times10^8}{4\times10\times10^3} = 7500m = 7.5km$$

The antenna of this height is impossible to install. Consider a modulated signal at f=1MHz the minimum height is given by

$$\textbf{minimum height} = \frac{\lambda}{4} = \frac{\frac{c}{f}}{4} = \frac{c}{4f} = \frac{3\times10^8}{4\times1\times10^6} = 75m$$

This antenna can be easily installed. Thus modulation is needed to reduce the height of the antenna.

2. **Avoid mixing of signals:** if the baseband signals are transmitted without modulation by more than one transmitter since all the signals are in the same frequency range is 20Hz to 20KHz, all the signals get mixed together of the receiver cannot separate them from each other. So baseband signals are modulated with different carrier then they will occupy different slots in the frequency domain. Thus modulation is necessary to avoid mixing of signals.



3. **To increase the range of communication:** the frequency of the baseband signal is low. Therefore it cannot travel a long distance, when they are transmitted. They get heavily attenuated. The attenuation of signal reduces with increase in frequency of the transmitted signals and they travel long distance. The modulation process increases the frequency of the signal to be transmitted. Hence modulation increases the range of communication.

4. **To increase the range of communication:** multiplexing is a process in which two or more signals can be transmitted over same communication channel simultaneously. This is possible only with modulation.
Example: Many TV channels can use the same frequency range, without getting mixed with each other.

5. **To improve quality of reception:** with frequency Modulation (FM) and the digital communication technique like PCM, the effect of noise is reduced to a great extent. This improves quality of reception.

ii. Find out the digital data from given waveforms of Bipolar AMI encoding. (4M)

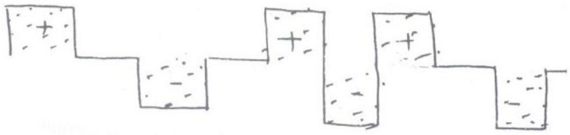


Fig. 1.1

Ans: 101011101

iii. Identify following waveforms belongs to which modulation technique.

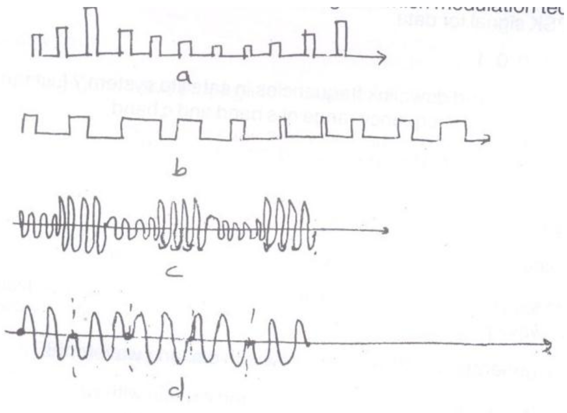


Fig. 1.2

(Each, 1M)

1. PAM(Pulse Amplitude Modulation)
2. PWM(Pulse width Modulation)
3. ASK(Amplitude Shift Keying)
4. PSK(Phase Shift Keying)

iv. An AM transmitter uses carrier freq. of 1600 KHz with 8 Volt amplitude. It is modulated to depth of 75% with signal of 2000Hz. Determine amplitude and frequencies of side bands.

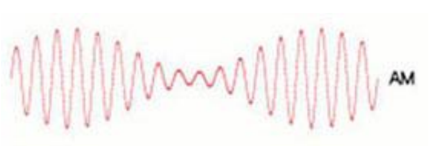
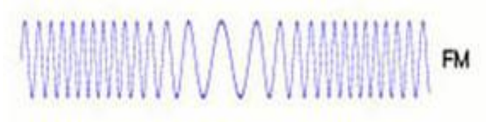
$$f_c = 1600KHz$$
$$V_C = 8V$$
$$m_a = 0.75$$
$$f_m = 2000Hz(2kHz)$$
$$\text{amplitude} = \frac{V_C m_a}{2} = \frac{0.75 \times 8}{2} = 3\text{V} - - - (\mathbf{2M})$$

$$\text{frequencies of side bands} = \text{f}_\text{c} + \text{f}_\text{m}(\text{USB})$$
$$= \text{f}_\text{c} - \text{f}_\text{m}(\text{LSB})$$
$$\text{f}_\text{USB} = \text{f}_\text{c} + \text{f}_\text{m}$$
$$\text{f}_\text{USB} = 1600\text{KHz} + 2\text{KHz} = 1602\text{KHz} - - - (\mathbf{1M})$$
$$\text{f}_\text{LSB} = \text{f}_\text{c} - \text{f}_\text{m}$$

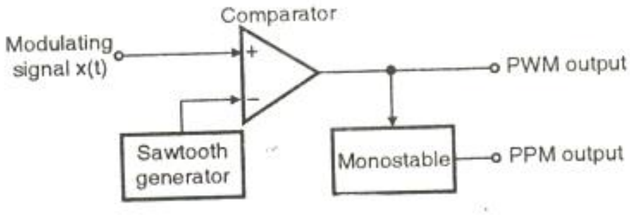
$$\text{f}_\text{LSB} = 1600\text{KHz} - 2\text{KHz} = 1598\text{KHz} - - - (\mathbf{1M})$$

B. Attempt any One: 6

i. Write the difference between AM and FM on the basis of definition, waveform, bandwidth and noise immunity, modulation index and frequencies used for transmission.
(Each for 1M)

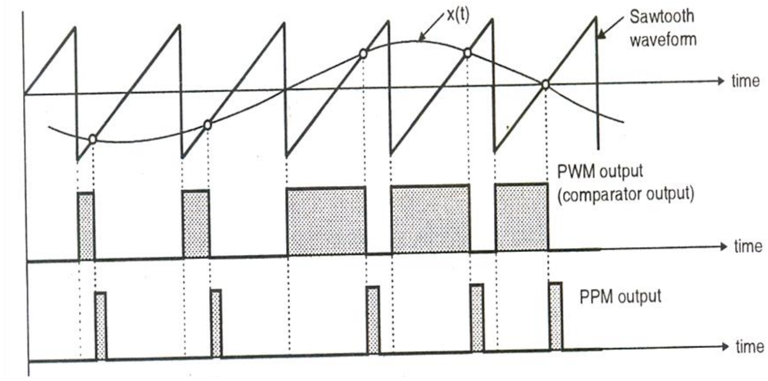
Parameter	**AM**	**FM**
definition	Amplitude of carrier is varied in accordance with amplitude of modulating signal keeping frequency and phase constant.	Frequency of carrier is varied in accordance with the amplitude of modulating signal keeping amplitude and phase constant.
waveform		
bandwidth	BW=2f_m , less	BW=2(δ+ $f_{m(max)}$), more
noise immunity	less	more
modulation index	m=E_m/E_c	m=δ/ f_m
frequencies used for transmission	540-1600KHz	88.1-108.1KHz

ii. Draw and explain method of PWM generation using comparator with w/f.
(Diagram 2M; Explanation 2M, waveform 2M)
Block Diagram:

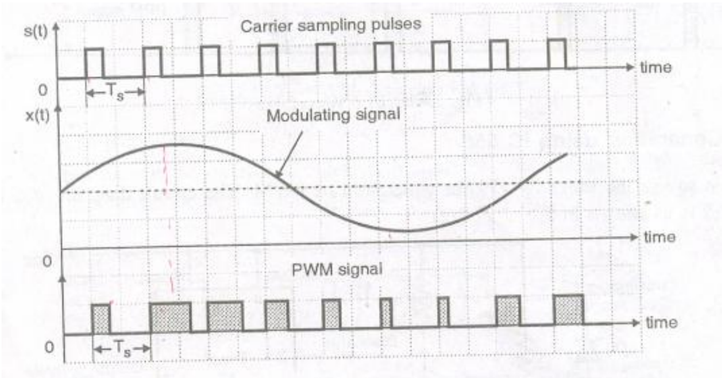


Working:

- The modulating signal is applied to the non inverting terminal of the comparator.
- A sawtooth generator generates a sawtooth signal of frequency f_s. Therefore sawtooth signal is the sampling signal..This is applied to the inverting terminal of the comparator.
- The comparator output will remain high as the instantaneous amplitude of x(t) is higher than that of ramp signal.
- This give rise to a PWM signal as the comparator output.

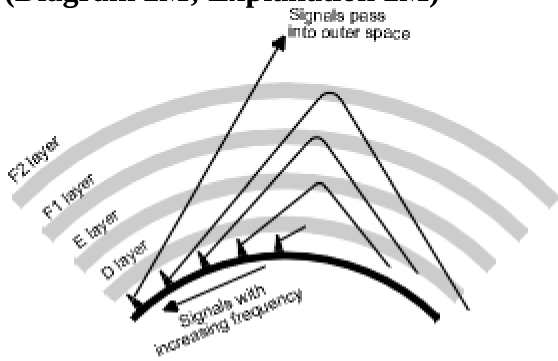


OR



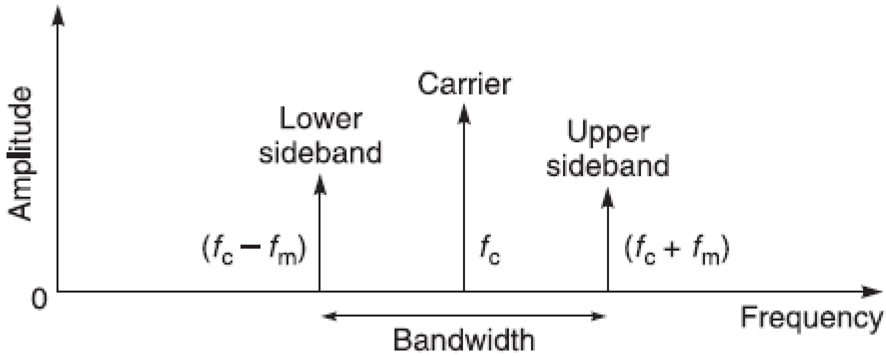
Q.2. Attempt any four: 16

i. With neat sketch explain ionospheric propagation.
(Diagram 2M; Explanation 2M)



Electromagnetic waves that are directed above the horizon level are called as sky waves. Typically, sky waves are radiated in a direction that produces a relatively large angle with reference to earth. Sky waves are radiated toward the sky, where they are either reflected or refracted back to earth by the ionosphere. Because of this, sky wave propagation is sometime called as ionospheric propagation. The ionosphere is the region of space located approximately 50km to 400 km above Earth surface. The ionosphere is the upper portion of earth's atmosphere. Therefore it absorbs large quantities of the sun radiant energy, which ionizes the air molecules, creating free electrons. When radio wave passes through the ionosphere the electric field of the wave exerts a force on the free electrons, causing them to vibrate. The vibrating electron decreases current, which is equivalent to reducing the dielectric constant. Reducing the dielectric constant increases the velocity of propagation and causes electromagnetic waves to bend away from the regions of high electron density toward regions of low electron density. As the wave moves farther from earth ionization increase; however, there are fewer air molecules to ionize. Therefore, the upper atmosphere has a higher percentage of ionized molecules than the lower atmosphere. The higher the ion density, the more refraction. Also because of the ionosphere's non uniform composition and its temperature and density variations, it is stratified. Essentially, three layers makeup the ionosphere (the D, E, Flayers).

ii. **Give bandwidth equations for AM and FM signal in frequency domain with neat sketch.**
(Each for 1M)



Bandwidth=2f_m where f_m is frequency of modulating signal

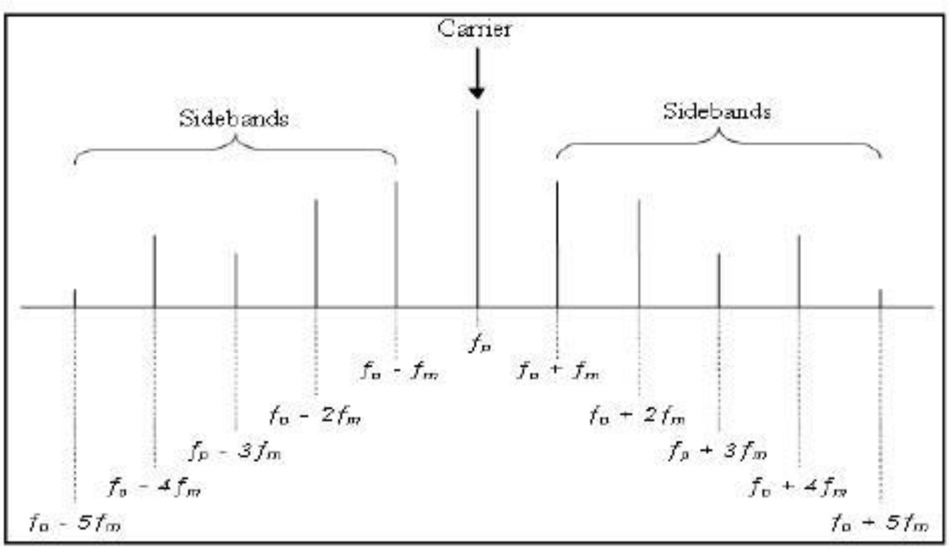


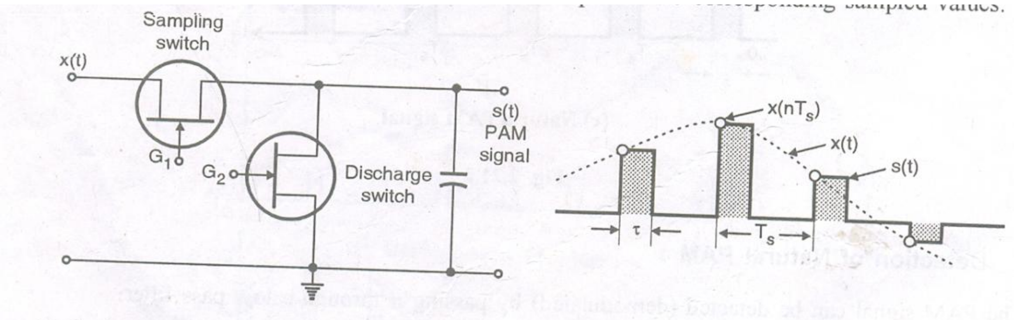
Figure 3. An FM signal's frequency spectrum

The simple method to calculate the band width is
BW=2fmX number of significant side bands
OR
According to carson's rule

$$BT = 2(\Delta f + fm)$$

iii. Draw circuit diagram of PAM generation to obtain flat top sampling. Explain operation with help of waveforms.
(Diagram 1M, waveform 1M, explanation 2M)(Any other relevant diagram may also be considered)

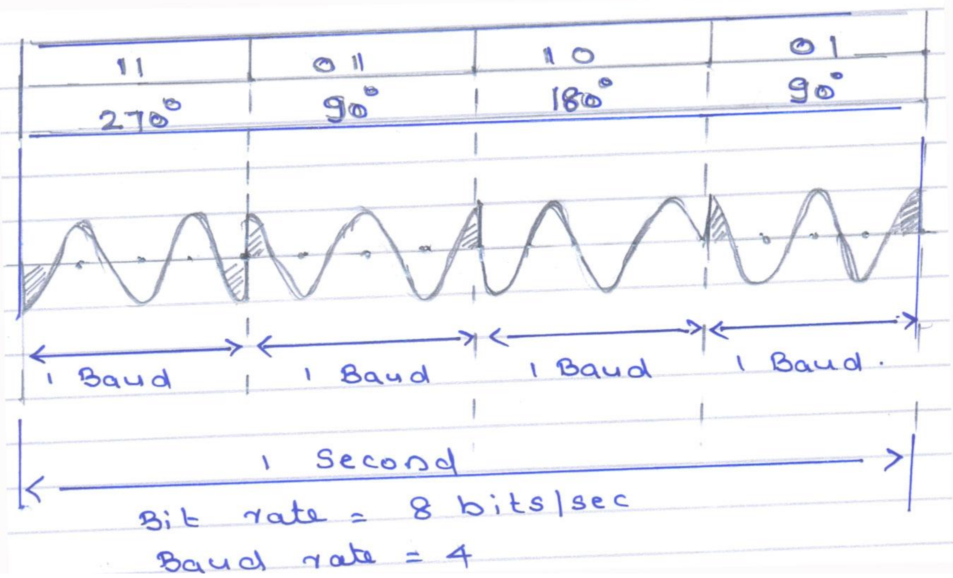
Flat Top PAM



(a) Sample and hold circuit to obtain the flat topped PAM (b) Flat top PAM signal
Fig. 2.21.5

- The flat top PAM can be obtained by sample and hold circuit.
- The sample and hold circuit consists of two FET switches and a capacitor.
- The analog signal x(t) is applied at the input this circuit and sampled signal is obtained across the capacitor.
- A gate pulse will be applied to gateG1 at the instant of sampling for a very short time. The sampling switch will turn on and the capacitor charges through it to the sample value x(nTs).
- The sampling switch is then turned off . Both the FETs will remain OFF for a duration of " τ " seconds and the capacitor will hold the voltage across it constant for this period. Thus the pulse is stretched to "τ "seconds
- At the end of the pulse interval(τ) a pulse is applied to G2. Ie gate terminal of discharge FET.
- This will on the discharge FET and short circuit the capacitor. The output voltage then reduces to zero.

iv. Draw QPSK signal for data 11011001
(4M)



v. What are uplink and downlink frequencies in satellite system? List range of uplink and downlink frequency ranges of s band and c band.
(Definition 1M each; Frequency range 2M)

Uplink frequency:

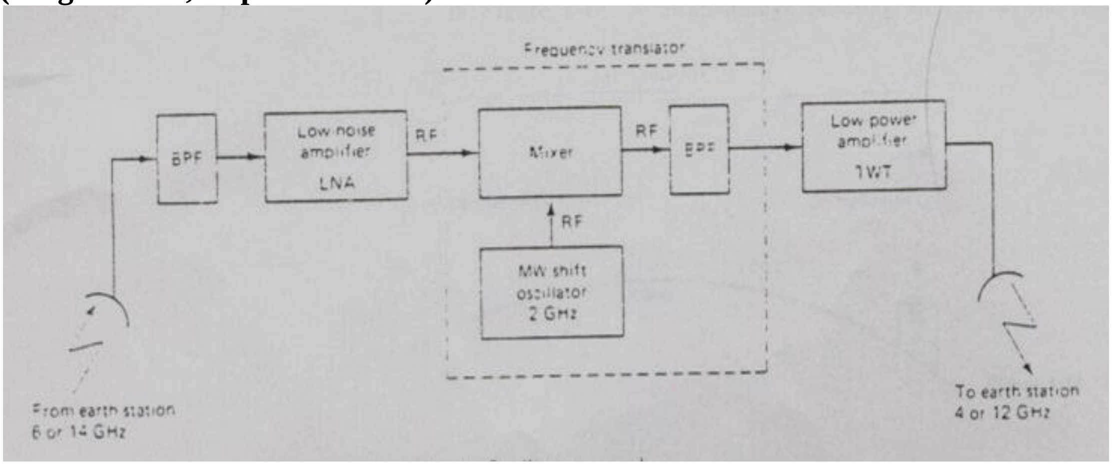
It is the range of frequencies transmitted from a ground station up to satellite.
Or transmitting antenna frequency is up link frequency.

Downlink frequency:

It is the range of frequencies transmitted from a satellite down to one or more ground station/receivers. Or receiving antenna frequency is u link frequency.

Band	Downlink GHz	Uplink GHz
S	1.9	2.2
C	4	6

vi. Draw block diagram of transponder and explain operation.
(Diagram 2M; Explanation 2M)

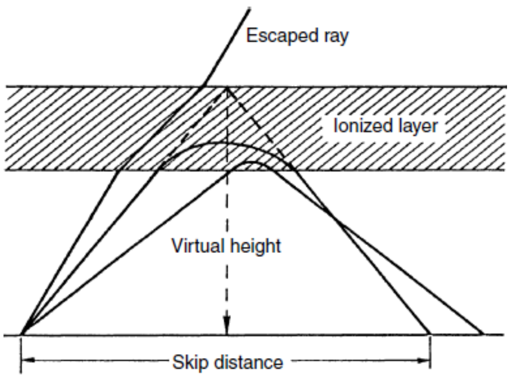


A typical satellite transponder consists of :
1. An input bandlimiting device (BPF)
2. An input low-noise amplifier (LNA)
3. A frequency translator
4. A low-level power amplifier
5. An output bandpass filter.

Figure shows a simplified block diagram of a satellite transponder.
BPF: The input BPF limits the total noise applied to the input of the LNA.
LNA: LNA is the highly sensitive, low noise device such as a tunnel diode amplifier.
Frequency translator: it sis consists of a Mixer, Microwave Shift Oscillator; BPF. The output of the LNA is fed to a frequency translator (a shift oscillator and a BPF) which converts the high-band uplink frequency to the low-band downlink frequency.
The low-leve1 Amplifier: The low-level power amplifier, which is commonly a traveling-wave tube, amplifies the RF signal for transmission through the downlink to the earth station receivers. Each RF satellite channel requires a separate transponder.

Q.3. Attempt any four: 16

i. What is virtual height? Explain actual height and virtual height with waveforms.
(Diagram 2M; Explanation 2M)



When the wave is refracted by the ionosphere it is bent down gradually rather than sharply. Below the ionized layer, the incident and refracted rays follow path that are exactly the same as they would have been. If reflection had taken place from a surface located at a greater height. This height is called the virtual height of the layer.

ii. Describe space wave propagation and state advantages and disadvantages of space wave propagation.

(Space wave propagation 2M; One Advantage 1M; ; One Disadvantage 1M)

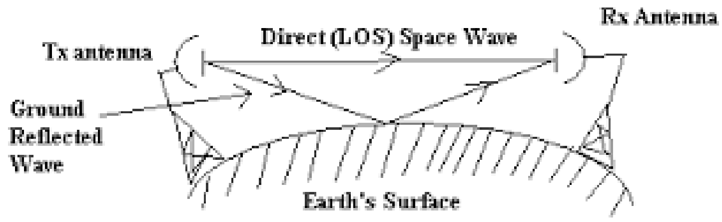


Figure :- Space Wave Propagation

A direct wave travel in a straight line from the transmitting antenna. It is also called line of sight communication. Direct wave or space waves do not get refracted nor do they follow the curvature of the earth. The signal travels horizontally from the antenna until they reach the horizon where it is blocked. If the signal is to be received beyond the horizon, then the antenna should be high enough to intercept the straight line radio waves.

$$d = \sqrt{2ht}, \quad D = \sqrt{2ht} + \sqrt{2hr}$$

The above formulae are used to determine the height of transmitting and receiving antenna without being intercepted by the horizon.

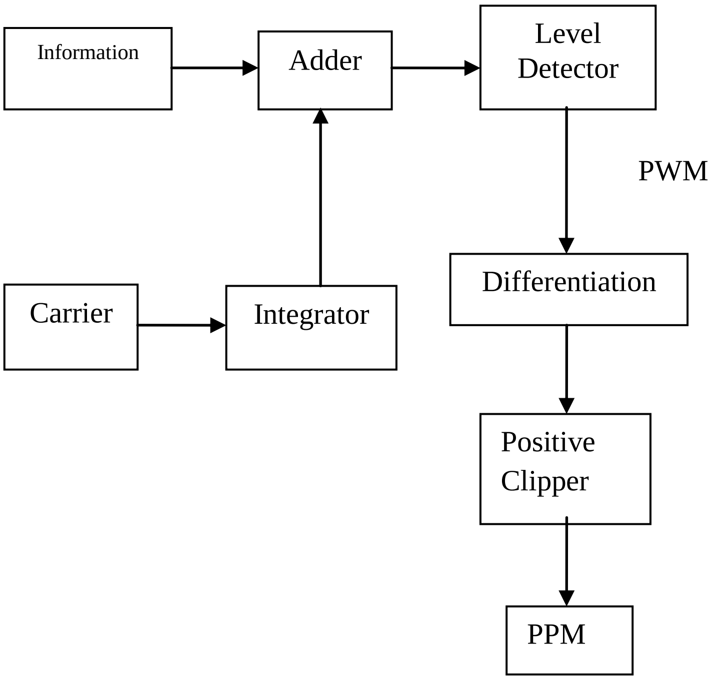
Advantages

- It is the line of sight transmission and covers almost the city area.
- Simplicity of its propagation.

Disadvantages

- Transmission distance at these frequencies is extremely limited
- Very high antennas are used.

iii. Describe generation of PPM from PWM with diagram and waveforms. (Diagram 2M, Explanation 2M)



Pulse position modulation (PPM)

It is the process of modulation in which the position of the carrier is varied in accordance to the instantaneous voltage of the modulating signal keeping the carrier width and amplitude constant.

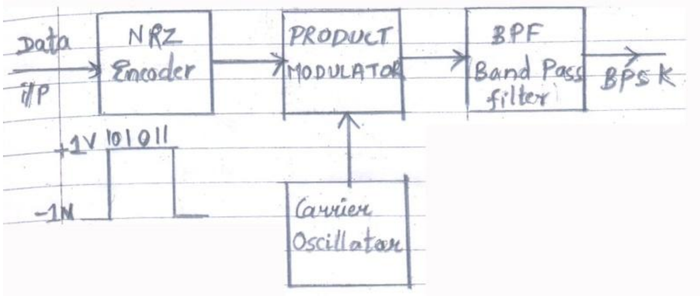
PPM Signal is obtained from PWM signal. In PWM, the Positive or the leading edge appears after fixed interval of time. But the negative edge of the trailing edge does not appear after a fixed interval of time. It appears after time propagation to the width of the pulse. The width of the pulse is proportional to the modulating signal at that instance. Thus the position of the trailing edge is proportional to the instantaneous voltage of the modulating signal.

To obtained PPM from PWM

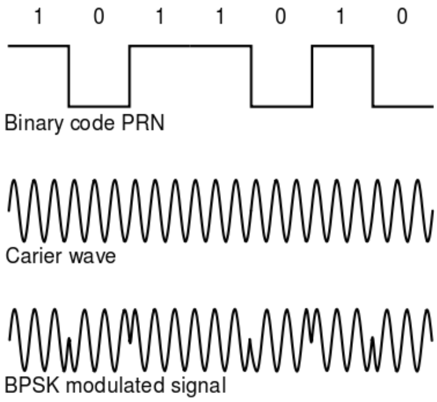
The trains of PWM pulses are given to the differential whose output is proportional to differential input which produces positive and negative spikes. The positive spikes are equidistant and negative spikes are position modulated. The positive spikes are removed by a positive chipper and the negative spikes represent the PPM signal.

iv. Draw block diagram of BPSK generation and explain with w/f. (Block diagram 2M; waveform 1M; explanation 1M)

- NRZ encoder counters binary data into NRZ bipolar signal. Consider, the NRZ bipolar signal to be having amplitude +1V corresponding to binary 1 and -1V corresponding to binary 0.
- The carrier oscillator generates line wave carrier signal ($\sin w_c t$).
- The product modulator multiplies the i/p encoded signal with the carrier signal producing +1 ($\sin w_c t$) signal and -1 ($\sin w_c t$). The difference of phase between the two signals is 180^0, thus generating BPSK.
- The band pass filter (BPF) limits the frequency band of BPSK.



Waveform:

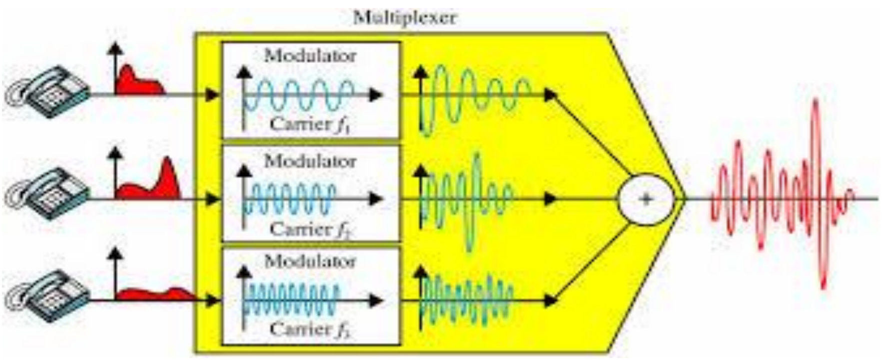


v. Explain concept of FDM using block diagram of FDM transmitter and receiver. (Diagram 2M; Explanation 2M)

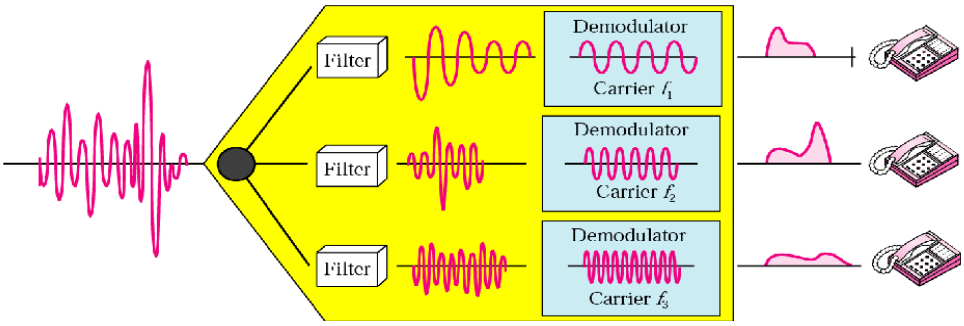
- In FDM, signal generated by each sending device modulate different carrier frequencies these modulated signal are combined into a single composite signal that can be transported by the link. Carrier frequencies are separated by guard bands to prevent over lapping of signal. Though it is an analog multiplexing system, digital signals can also be sending by continuing them into analog signals.
- The demux uses a serried of filters to decompose the multiplexed signal into its constituent carrier signals these modulated carrier signals are passed through demodulators to separate them from their carrier and then are passed to their output lines**.**

Frequency Division Multiplexing (FDM)

Modulation:



Demodulation:

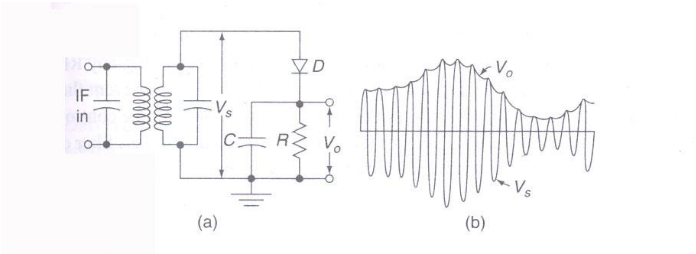


Q.4.

a) Attempt any three: 12

i. Draw simple detector for AM detection; describe its working with waveforms.
(Diagram 2m; waveform 1M; explanation 1M)

The diode is common device used for AM demodulation (or detection). On the circuit of figure, C is a small capacitance and R is a large resistance. The parallel combination of R and C is the load resistance across which the rectified output voltage V_0 id developed. At each positive peak of RF cycle, C changes up to a potential almost equal to the peak signal voltage V_S . the difference is due to the diode drop since the forward resistance of the diode is small (but not zero). Between peaks a little of the charge in C decays through R, to be replenished at the next positive peak. The result is the voltage V_0, which reproduces the modulating voltage accurately, except for the small amount of RF ripple as small as possible, but sufficiently fast for the detector circuit to follow the fastest modulation variations.



Simple diode detector. (a) Circuit diagram; (b) input and output voltages

ii. Define Bit rate and Band rate. In digital to analog modulation system signal carries 4 bits per signal element. If no. of signal elements per second are 500, calculate bit rate.
(Each definition 1M; 2M problem)

Bit rate:

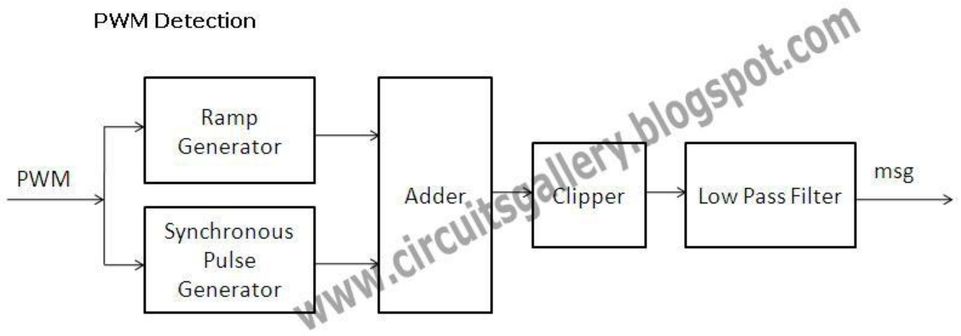
Bit rate is the number of bits transmitted during one second in the data communication system and it is expressed in bits per second.

Baud rate:

It is the rate of change of a signal on the transmission medium after the encoding and modulation in a data communication system.

Given:
Number of signal element /sec=500
Bit rate is the no. of bit transmitted in 1 second.
The no .of bits in 1 signal element is 4
Therefore bit rate= 500 signal element X 4=2000bps.

iii. How PWM is demodulated? Explain with block diagram and waveforms. (diagram 2M; explanation 2M)



The basic theory behind Pulse width demodulation is that **converting** the **PWM** signal to **PAM** (Pulse Amplitude Modulation) signal. PAM can be easily detected by suitable **low pass filter**.

- Input PWM wave is applied to Ramp generator and Synchronous Pulse generator Synchronous pulse generator will generate a pulse waveform such that the pulse will **end at the beginning of each PWM** pulse.
- Ramp generator will produce a ramp signal whose **amplitude** is proportional to **width** of the PWM signal.
- Now apply these Ramp and Synchronous pulse to an **Adder** circuit which adds these signals together.
- The next block is a positive Clipper with a specific voltage; Clipper clips the waveform at a particular level as shown in fig.
- The **output** of clipper will be **PAM** signal, now the PWM signal gets converted to PAM signal.
- The PAM can be demodulated by Low Pass filtering method. Thus next block is Low Pass Filter.

iv. Explain methods of satellite stabilization viz spin Stabilization and 3 Axes Stabilization. (Spin Stabilization 2M; 3 Axes Stabilization 2M)

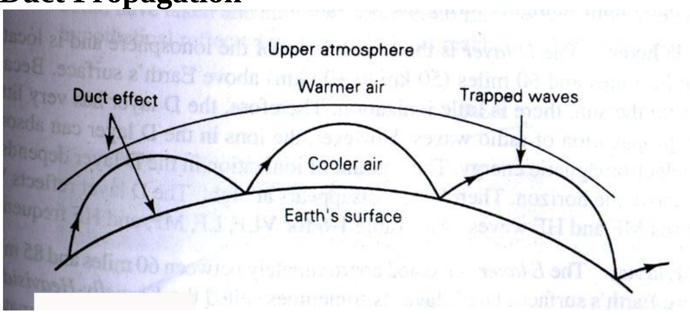
Spin stabilization and three-axis stabilization are two methods that are used to orient satellites. With spin stabilization, the entire spacecraft rotates around its own vertical axis, spinning like a top. This keeps the spacecraft's orientation in space under control. The advantage of spin stabilization is that it is a very simple way to keep the spacecraft pointed in a certain direction. The spinning spacecraft resists perturbing forces, which tend to be small in space, just like a gyroscope or a top. Designers of early satellites used spin-stabilization for their satellites, which most often have a cylinder shape and rotate at one revolution every second. A disadvantage to this type of stabilization is that the satellite cannot use large solar arrays to obtain power from the Sun. Thus, it requires large amounts of battery power. Another disadvantage of spin stabilization is that the instruments or antennas also must perform "despin" maneuvers so that antennas or optical instruments point at their desired targets.

With **three-axis stabilization**, satellites have small spinning wheels, called reaction wheels or momentum wheels that rotate so as to keep the satellite in the desired orientation in relation to the Earth and the Sun. If satellite sensors detect that the satellite is moving away from the proper orientation, the spinning wheels speed up or slow down to return the satellite to its correct position. Some spacecraft may also use small propulsion-system thrusters to continually nudge the spacecraft back and forth to keep it within a range of allowed positions. Voyagers 1 and 2 stay in position using 3-axis stabilization. An advantage of 3-axis stabilization is that optical instruments and antennas can point at desired targets without having to perform "despin" maneuvers.

b) Attempt any one: 6

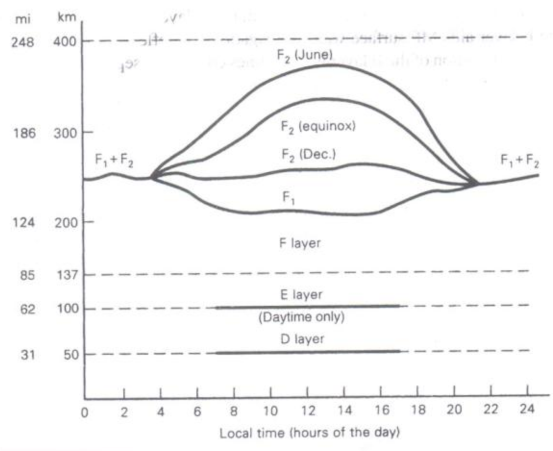
i. Describe Duct Propagation and ionospheric scatter propagation with diagram.
(Duct Propagation 3M, ionospheric scatter 3M)

Duct Propagation



As the height above earth increases, the air density decreases and refractive index increase.
A warm layer gets trapped above cooler air, often over surface of water.
The refractive index will decrease more rapidly with height than usual.
The microwaves will bend towards earth.
This is due to temperature inversion and a duct is formed

Ionospheric scatter propagation:



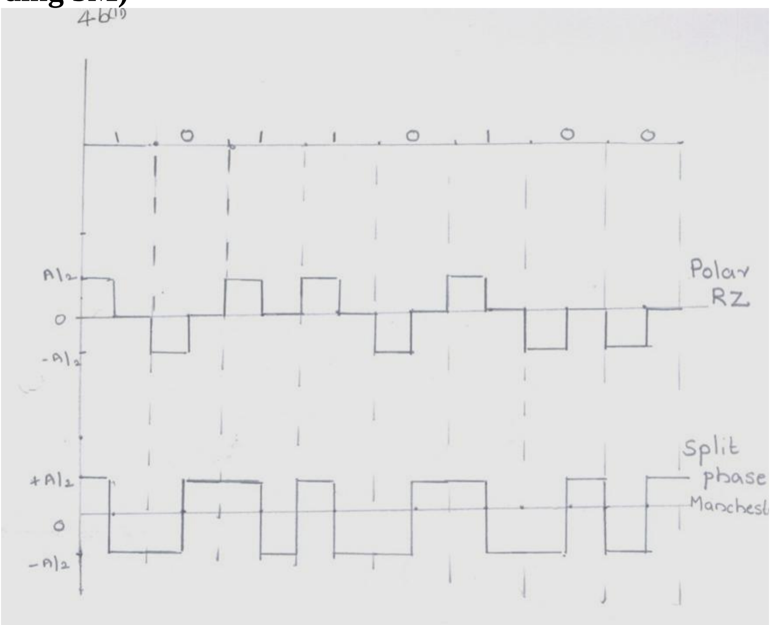
Ionospheric layers

The ionosphere is the upper portion of the atmosphere. It absorbs large quantities of radiant energy from the sun, get heated and ionized. There are variations in the physical properties of the atmosphere such as temperature, density and composition. Hence, the ionosphere tends to be stratified in its distribution. This result in four main layer D, E, F_1, & F_2 in ascending order. The last two combine at night and from one single layer.

D layer- lowest Average height of 70km having thickness of 10km.
Disappears in night it reflects VLF and LF waves
Absorbs MF and HF waves.

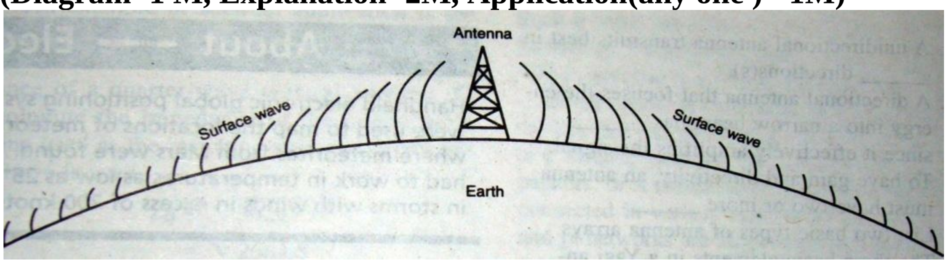
E-Layer- around 100Km height thickness-25km.
Disappears in night.
Help MF surface wave propagation and reflect HF wave in daytime.
F_1 layer: Height 180km
Thickness- 20km
Absorption for HF waves.
F_2 layer: reflecting medium for HF
Height 250-400km thickness-200kms.

ii. Draw Polar RZ and split phase Manchester data encoding for data 10110100. (Each encoding 3M)



Q.5. Attempt any four: 16

i. Describe ground wave propagation. State its applications. (Diagram=1 M, Explanation=2M, Application(any one)= 1M)



The ground or surface wave leaves the antenna & remains close to the earth. From fig. the ground wave will actually follow the curvature of the earth & can therefore travel of distances beyond the horizon.

Ground wave propagation is strongest at the low & medium frequency ranges that is ground waves are the main signal path for the radio signals in the 30 Khz to 3 Mhz range. The signals can propagate for hundreds & sometimes thousands of miles at these low frequencies. Amplitude modulation broadcast signals are propagated primarily by ground waves.

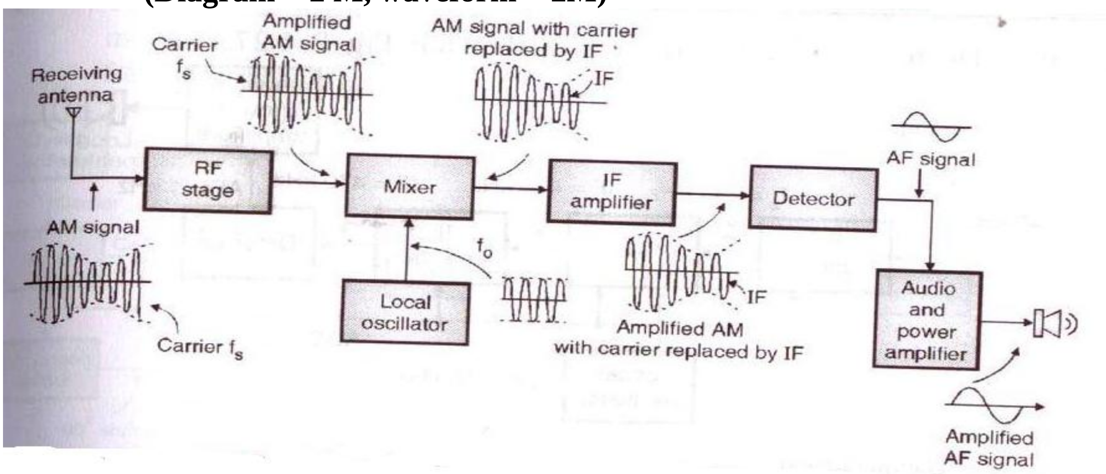
At the higher frequencies beyond 3 Mhz the earth begins to attenuate the radio signals. Objects on the earth & terrain features become the same order of magnitude in size as the wavelength of the signal & will therefore absorb & otherwise affect the signal for this reason the ground wave propagation of signals above 3 Mhz is insignificant except within several miles of the antenna.

Application of ground wave propagation:

1. In the AM radio broadcasting operating in MW band.
2. The VLF transmission is used for ship communications such as radio navigation & marine mobile communication.
3. The VLF transmission is also used for time & frequency transmission

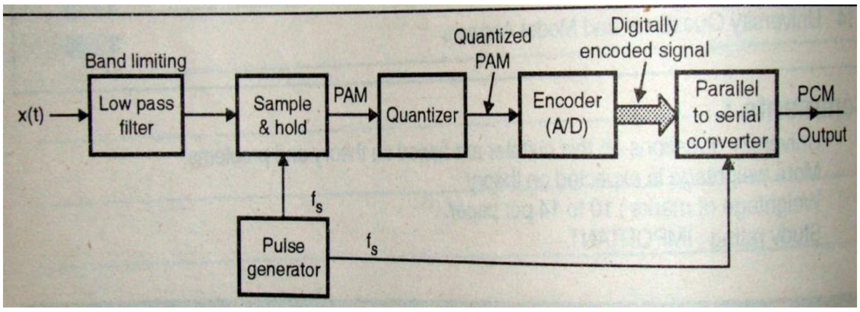
ii. Draw super heterodyne receiver block diagram and show waveform at intermediate points.

(Diagram = 2 M, waveform = 2M)



iii. Draw block diagram of PCM transmitter and explain function of sampler, quantizer and A to D conversion.

(Diagram=1 M, explanation of sampler=1 M, explanation of quantizer= 1 M, explanation of and A to D conversion = 1 M)



Operation of PCM transmitter:

i. The analog signal x(t) is passed through a band limiting low pass filter, which has a cut-off frequency fc =WHz. This will ensure that x(t) will not have any frequency component higher than "W". This will eliminate the possibility of aliasing.
ii. The band limited analog signal is then applied to a sample and hold the circuit where it is sampled at adequately high sampling rate. Output of sample and hold block is a flat topped PAM signal.
iii. These samples are then subjected to the operation called "Quantization" in the "Quantizer". The quantization is used to reduce the effect of noise. The combined effect of sampling and quantization produces the quantized PAM at the quantizer output.
iv. The quantized PAM pulses are applied to an encoder which is basically an A to D converter. Each quantized level is converted into an N bit digital word by the A to D converter. The value of N can be 8,16,32,64 etc.
v. The encoder output is converted into a stream of pulses by the parallel to serial converter block. thus at the PCM transmitter output we get a train of digital pulses.

Quantization error:

The error between the original analog signal & its quantized version which is measured is called Quantization error.

iv. Calculate bits per second of PCM system in which sampling frequency is 8 KHz and each sample is converted into 8 bits with A.D.C.

(Analysis= 1M, formula= 1 M, calculation = 2 M)

$\boldsymbol{Given} \quad N = 8, f_s = 8KHz$

$Bit\ rate = N \times f_s = 8 \times 8KHz$

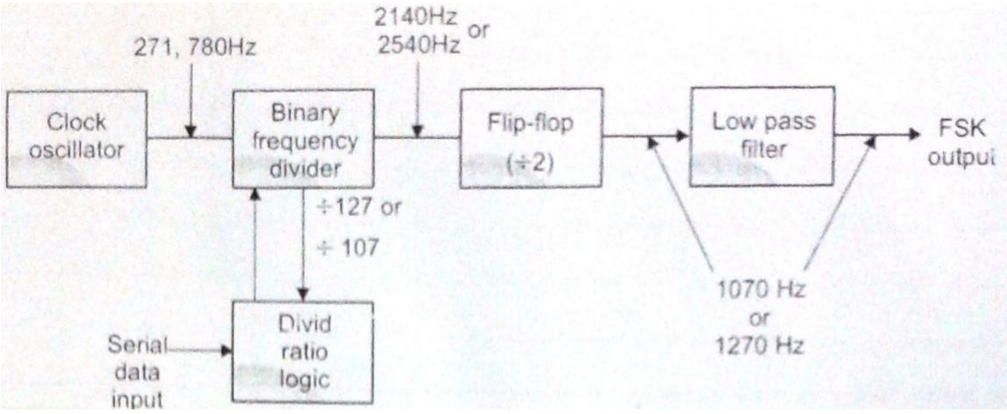
$Baud\ rate = bit\ rate = 64K\ bit/sec (as\ transmission\ is\ binay)$

v. Explain FSK modulation and demodulation with block diagram. Draw multiplexing hierarchy in FDM.

(FSK block diagram= 2 M, multiplexing hierarchy= 2M)

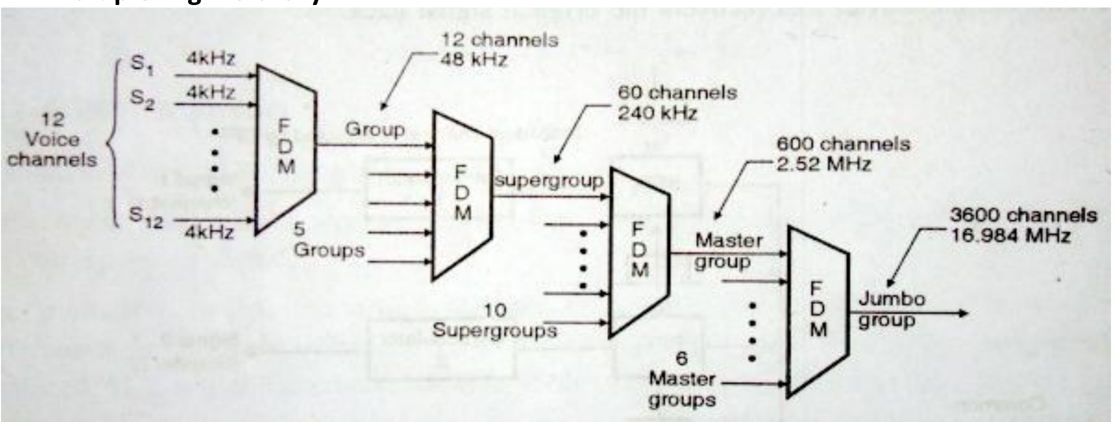
FSK: Frequency shifting keying (FSK) is a digital modulation in which frequency of sinusoidal carrier is shifted between two discrete values of frequency where amplitude &

phase remains constant. IN FSK, a binary information signal directly modulates the frequency of analog carrier.



Note that binary 1 corresponds to frequency 1270 Hz and binary 0 to frequency 1070 Hz
As shown in block diagram,
Clock Oscillator: Generates frequency of 271780Hz.
Divid ratio logic: Produces frequency division by 127
Frequency divider: when data input is zero, the frequency divider output will be 1/127 of its input. Then output frequency will be 2140 Hz.
Flip Flop: this divides the 2140 Hz frequency by 2, producing the desired 1070Hz output corresponding to binary '0' similarly, we get 1270 Hz frequency at binary '1' in which frequency divider will divide 107.
Low pass filter: Removes higher frequency harmonics producing sine wave output.

Multiplexing hierarchy in FDM



Q.6. Attempt any four:

i. Define MUF and critical frequency in respect to sky wave propagation.

(MUF= 2 M, critical frequency= 2 M)

MUF (Maximum Usable Frequency):

It is the highest frequency that can be used for the sky wave communication between two given points on the earth.

It is also given by

MUF = critical frequency/cos θ

$= f_c \text{ Sec } \theta$

MUF is defined for certain value of angle of incidence θ rather than defining it at normal as in case of critical frequency,

Critical frequency f_c :

It is maximum frequency that is returned back to the earth by that layer when wave is incident at an angle 90^0 (normal) to it.

ii. Derive expression of AM wave and prove that it contain 3 discrete frequency components fc, fc+fm and fc-fm.

(Derivation= 2 marks, Proof = 2 marks)

Let modulating signal be sinusoidal & be represented as $e_m = E_m \cos \omega_m t$

where e_m is instantaneous amplitude of modulating signal.

E_m is peak amplitude.

$\omega_m = 2\pi f_m$. & f_m = frequency of modulating signal.

Let carrier signal also be sinusoidal at much higher frequency than that of modulating signal. The instantaneous carrier signal e_c is given by

$e_c = E_c \cos \omega_c t$.

where E_c = Peak carrier amplitude

f_c = Carrier frequency &

$\omega_c = 2\pi f_c$.

The AM wave is expressed by following expression

$e_{AM} = A \cos(2\pi f_c t)$.

where A represent instantoneous value of the envelope. The modulating signal either adds or gets subtracted from peak carrier amplitude Ec. Hence instantaneous value of envelope is

$$A = E_c + e_m$$
$$= E_c + E_m \cos(2\pi f_m t)$$

Hence AM wave is given by

$$e_{AM} = A \cos(2\pi f_c t).$$
$$= [E_c + E_m \cos(2\pi f_m t)] \cos(2\pi f_c t)$$

$$e_{AM} = E_c \left[1 + \frac{E_m}{E_c} \cos(2\pi f_m t)\right] \cos(2\pi f_c t)$$

Let $m = E_m / E_c$ be modulation index.

$$\therefore e_{AM} = E_c [1 + m \cos(2\pi f_m t)] \cos(2\pi f_c t)$$

This expression represents AM signal in time domaim.

Simplifying we get.

$$e_{AM} = E_c \cos(2\pi f_c t) + m E_c \cos(2\pi f_m t) \cos(2\pi f_c t)$$

For second term in above expression use following identity.

$$2 \cos A \cos B = \cos(A+B) + \cos(A-B).$$

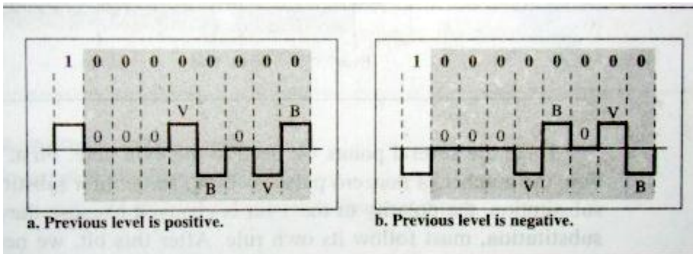
$$e_{AM} = \underbrace{E_c \cos(2\pi f_c t)}_{\text{Carrier}} + \underbrace{\frac{mE_c}{2} \cos 2\pi (f_c + f_m) t}_{\text{Upper sideband}} + \underbrace{\frac{mE_c}{2} \cos 2\pi (f_c - f_m) t}_{\text{Lower sideband}}.$$

iii. A 16KW carrier is amplitude modulated at 75% depth by audio signal. Calculate the sideband power and total transmitted power.
(Sideband power=2 M, total transmitted power=2 M)

Given:
$P_c = 16KW \ \ \& m = 0.75$
Side band power:
$$P_{USB} = P_{LSB} = \frac{m^2}{4} \times P_C = \frac{(0.75)^2}{4} \times 16 = 2.25KW$$
$$Total\ Sidebond\ power = 2.25 + 2.25 = 4.5KW$$
$$Total\ power(P_t) = P_c + P_{USB} + P_{LSB}$$
$$Total\ power(P_t) = 16 + 4.5 = 20.5KW$$

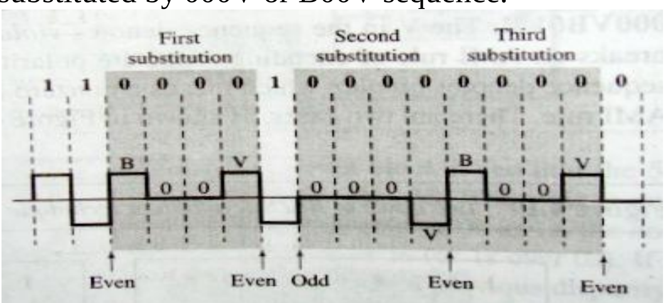
iv. Explain B8Z5 and HDB3 encoding techniques with waveforms.

(B8Z5= 2 M, HDB3=2 M)
B8ZS coding scheme (Bipolar with 8 zeroes substitution): This is used in USA. In this eight consecutive zeroes are substituted by 000VB0VB, the first violation pulse (V) is of the same polarity as the last pulse. Bipulse then follows the inverse polarity rule. The following V is of the same polarity as preceding B pulse. The last B pulse is of inverse polarity. The receiver recognizes the pattern & interprets the octet as consisting of all zeroes. It is also having error monitoring capacity.



HDB3 Code: It is a modification of AMI code & overcomes the problem of long string of binary 0s. If there are more than three consecutive zeros, a violation pulse (V) is substituted for the fourth zero. The violation pulse has the same polarity as the last pulse & it is easily identified at the receiver end.

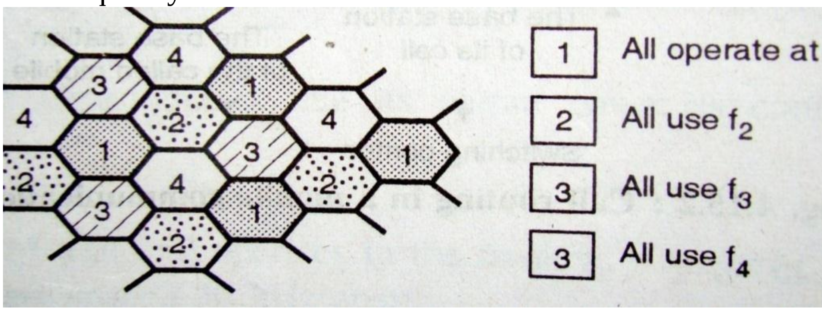
If there is long string of zeros then every fourth pulse will be violation pulse & all violation pulses in string will be of same polarity. To overcome this an additional bipolar (B) pulse to enable detection of violation pulses. Therefore the consecutive four zeros (0000) are substituted by 000V or B00V sequence.



v. Explain concept of frequency reuse and cell splitting in mobile communication.

(Frequency reuse=2 M, Cell splitting=2 M)

Concept of frequency reuse

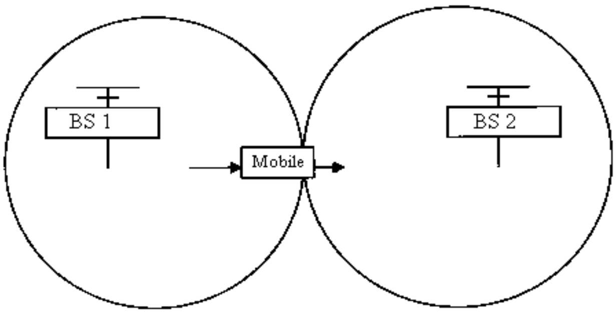


Frequency reuse

Frequency reuse is the process in which the same set of frequencies (channels) can be allocated to more than one cell. Provided the cells are separated by sufficient distance reducing each cells coverage area invites frequency reuse cells using the same set of radio channels can avoid mutual interference, provided they are properly separated. Each cell base station is allocated a group of channel frequencies that are different from those of neighboring cells & base station antennas are chosen to achieve a desired coverage pattern within its cell. However as long as a coverage area is limited to within a cells boundaries the same group of channel frequencies may be used in different cells without interfacing with each other provided the two cells are sufficient distance from one another.

vi. Define Handoff mechanism and list different types of handoff. Explain any one.
(Definition of Handoff=1 M, List= 1 mark, Explanation=2 M)

Hand Offs: When a mobile user travels from one area of coverage or cell to another cell within a call's duration the call should be transferred to the new cell's base station. Otherwise, the call will be dropped because the link with the current base station becomes too weak as the mobile recedes. Indeed, this ability for transference is a design matter in mobile cellular system design and is call handoff.



Two basic types of handoff are defined –

1. Hard handoff
2. Soft handoff

Hard Handoff:-

With hard handoff, the link to the prior base station is terminated before or as the user is transferred to the new cell's base station. That is to say that the mobile is linked to no more than one base station at a given time. Initiation of the handoff may begin when the signal strength at the mobile received from base station 2 is greater than that of base station 1. The signal strength measures are really signal levels averaged over a chosen amount of time. This averaging is necessary because of the Rayleigh fading nature of the environment in which the cellular network resides. A major problem with this approach to handoff decision is that the received signals of both base stations often fluctuate. When the mobile is between the base stations, the effect is to cause the mobile to wildly switch links with either base station. The base stations bounce the link with the mobile back and forth. Hence the phenomenon is called ping- ponging.

OR

Soft handsoff :-

Soft hand off is defined as a handover where a new connection is established before the old one is released. Soft hand off allocate same frequency. In soft hand off a handset may connect up to three or four radio links at the same time. Soft hand off used in CDMA and some TDMA systems. Soft handoff is more complicated than hard handoff, On the other hand, soft handoff degrades channel availability because a handset may consume multiple radio channels.