Question 15.1:

Which of the following frequencies will be suitable for beyond-the-horizon communication using sky waves?

(a) 10 kHz

(b) 10 MHz

(c) 1 GHz

(d) 1000 GHz

Answer

(b) Answer:

10 MHz

For beyond-the-horizon communication, it is necessary for the signal waves to travel a large distance. 10 KHz signals cannot be radiated efficiently because of the antenna size. The high energy signal waves (1GHz − 1000 GHz) penetrate the ionosphere. 10 MHz frequencies get reflected easily from the ionosphere. Hence, signal waves of such frequencies are suitable for beyond-the-horizon communication.

Question 15.2:

Frequencies in the UHF range normally propagate by means of:

(a) Ground waves.

(b) Sky waves.

(c) Surface waves.

(d) Space waves.

Answer

(d) Answer:

Space waves

Owing to its high frequency, an ultra high frequency (UHF) wave can neither travel along the trajectory of the ground nor can it get reflected by the ionosphere. The signals having UHF are propagated through line-of-sight communication, which is nothing but space wave propagation.

Question 15.3:

Digital signals

(i) Do not provide a continuous set of values,

(ii) Represent values as discrete steps,

(iii) Can utilize binary system, and

(iv) Can utilize decimal as well as binary systems.

Which of the above statements are true?

(a) (i) and (ii) only

(b) (ii) and (iii) only

(c) (i), (ii) and (iii) but not (iv)

(d) All of (i), (ii), (iii) and (iv).

Answer

(c) Answer:

A digital signal uses the binary (0 and 1) system for transferring message signals. Such a system cannot utilise the decimal system (which corresponds to analogue signals). Digital signals represent discontinuous values.

Question 15.4:

Is it necessary for a transmitting antenna to be at the same height as that of the receiving antenna for line-of-sight communication? A TV transmitting antenna is 81m tall. How much service area can it cover if the receiving antenna is at the ground level?

Answer

Line-of-sight communication means that there is no physical obstruction between the transmitter and the receiver. In such communications it is not necessary for the transmitting and receiving antennas to be at the same height.

Height of the given antenna, $h = 81$ m

Radius of earth, $R = 6.4 \times 10^6$ m

For range, $d = 2Rh$, the service area of the antenna is given by the relation:

$A = \pi d^2$

$= \pi\ (2Rh)$

$= 3.14 \times 2 \times 6.4 \times 10^6 \times 81$

$= 3255.55 \times 10^6\ m^2$

$= 3255.55$

~ 3256 km^2

Question 15.5:

A carrier wave of peak voltage 12 V is used to transmit a message signal. What should be the peak voltage of the modulating signal in order to have a modulation index of 75%?

Answer

Amplitude of the carrier wave, A_c = 12 V

Modulation index, m = 75% = 0.75

Amplitude of the modulating wave = A_m

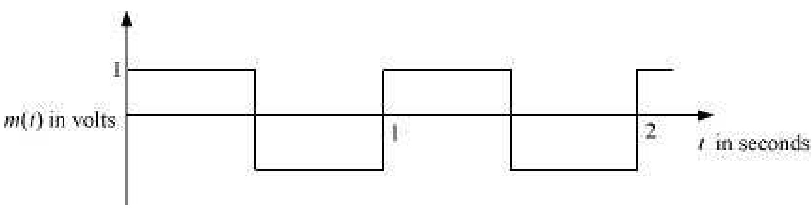
Using the relation for modulation index:

$$m = \frac{A_m}{A_c}$$

$$\therefore A_m = m\ A_c$$
$$= 0.75 \times 12 = 9\ \text{V}$$

Question 15.6:

A modulating signal is a square wave, as shown in Fig. 15.14.



The carrier wave is given by $c(t) = 2\sin(8\pi t)$ volts.

(i) Sketch the amplitude modulated waveform

(ii) What is the modulation index?

Answer

It can be observed from the given modulating signal that the amplitude of the modulating signal, A_m = 1 V

It is given that the carrier wave $c(t) = 2 \sin(8\pi t)$

∴Amplitude of the carrier wave, A_c = 2 V

Time period of the modulating signal T_m = 1 s

The angular frequency of the modulating signal is calculated as:

$$\omega_m = \frac{2\pi}{T_m}$$

$$= 2\pi \text{ rad s}^{-1} \qquad \dots(i)$$

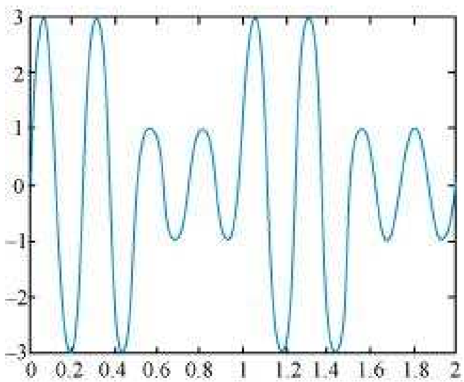
The angular frequency of the carrier signal is calculated as:

$$\omega_c = 8\pi \text{ rad s}^{-1} \qquad \dots(ii)$$

From equations (i) and (ii), we get:

$$\omega_c = 4\omega_m$$

The amplitude modulated waveform of the modulating signal is shown in the following figure.



(ii) Modulation index, $m = \frac{A_m}{A_c} = \frac{1}{2} = 0.5$

Question 15.7:

For an amplitude modulated wave, the maximum amplitude is found to be 10 V while the minimum amplitude is found to be 2 V. Determine the modulation index μ. What would be the value of μ if the minimum amplitude is zero volt?

Answer

Maximum amplitude, A_{max} = 10 V

Minimum amplitude, A_{min} = 2 V

Modulation index μ, is given by the relation:

$$\mu = \frac{A_{max} - A_{min}}{A_{max} + A_{min}}$$

$$= \frac{10 - 2}{10 + 2} = \frac{8}{12} = 0.67$$

If $A_{min} = 0$,

$$\text{Then } \mu' = \frac{A_{max}}{A_{max}} = \frac{10}{10} = 1$$

Question 15.8:

Due to economic reasons, only the upper sideband of an AM wave is transmitted, but at the receiving station, there is a facility for generating the carrier. Show that if a device is available which can multiply two signals, then it is possible to recover the modulating signal at the receiver station.

Answer

Let ω_c and ω_s be the respective frequencies of the carrier and signal waves.

Signal received at the receiving station, $V = V_1 \cos(\omega_c + \omega_s)t$

Instantaneous voltage of the carrier wave, $V_{in} = V_c \cos \omega_c t$

$$\therefore V\,V_{in} = V_1 \cos(\omega_c + \omega_s)t.(V_c \cos \omega_c t)$$
$$= V_1 V_c \left[\cos(\omega_c + \omega_s)t.\cos \omega_c t\right]$$

$$= \frac{V_1 V_c}{2}\left[2\cos(\omega_c + \omega_s)t.\cos \omega_c t\right]$$

$$= \frac{V_1 V_c}{2}\left[\cos\{(\omega_c + \omega_s)t + \omega_c t\} + \cos\{(\omega_c + \omega_s)t - \omega_c t\}\right]$$

$$= \frac{V_1 V_c}{2}\left[\cos\{(2\omega_c + \omega_s)t + \cos \omega_s t\}\right]$$

At the receiving station, the low-pass filter allows only high frequency signals to pass through it. It obstructs the low frequency signal ω_s. Thus, at the receiving station, one can record the modulating signal $\frac{V_1 V_c}{2}\cos \omega_s t$, which is the signal frequency.

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10. COMMUNICATION SYSTEMS

GIST

1. COMMUNICATION

The sending and receiving of message from one place to another is called communication. Two important forms of communication systems are (i) Analog and (ii) digital.

In analog communication the signal is continuous while in digital communication the signal is discrete.

2. THREE BASIC ELEMENTS OF COMMUNICATION

(i) Transmitter (ii) Communication channel (iii) Receiver

3. MODULATION

The superposition of (audio frequency) message signal (20 Hz-20 kHz) over (high frequency) carrier wave (≈ 1MHz) is called modulation.

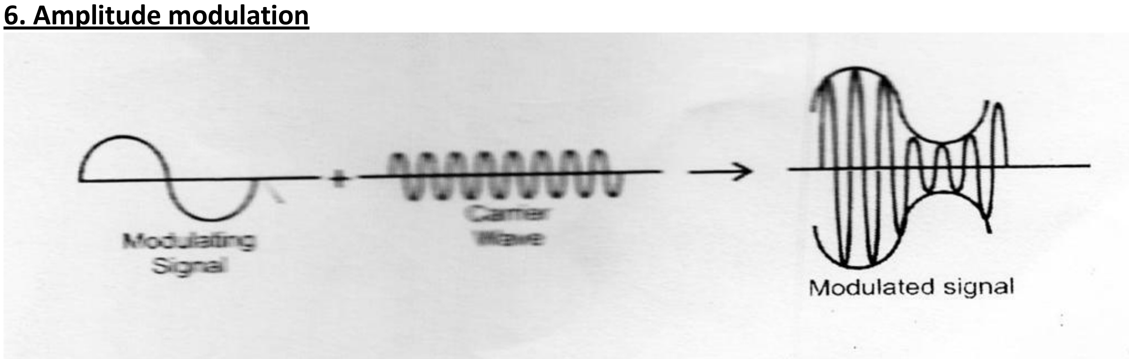
4. NEED FOR MODULATION:

* Size of antenna h= λ/4 so, for high frequency. Height will be large which is impossible.
* Effective power radiated by an antenna P α $\frac{1}{\lambda^2}$
* Mixing up of signals from different transmitters.

5. TYPES OF MODULATION

There are two broad types of modulation: (i) Continuous wave modulation
(ii) Pulse modulation.
1. Continuous wave modulation is of three types:
(i) Amplitude modulation (AM): In amplitude modulation, the amplitude of carrier wave varies in accordance with instantaneous voltage of information (or message) signal.
(ii) Frequency modulation (FM): In frequency modulation the frequency of carrier wave is varied in accordance with instantaneous voltage of information signal.
(iii) Phase modulation (PM): In phase modulation, the phase of carrier wave is varied in accordance with the information signal.

6. Amplitude modulation

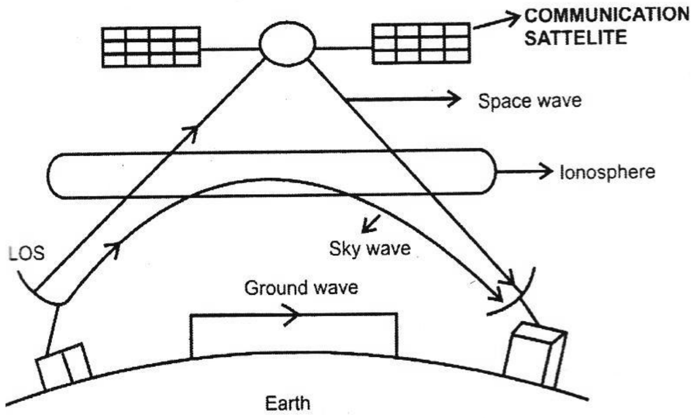


8. SPACE COMMUNICATION

Space communication uses free space between transmitter and receiver.

Space communication is via:

(i) ground waves (ii) space waves (iii) sky waves



9. GROUND OR SURFACE WAVE PROPAGATION is a mode of wave propagation in which the ground has a strong influence on the propagation of signal wave from the transmitting antenna to receiving antenna .In this propagation ,the signal waves glides over the surface of earth, Ground waves are heavily absorbed by earth and not suitable for long range communication. Ground wave propagation can be sustained only at low frequencies (500 kHz-1500 kHz).

10. SKY WAVE PROPAGATION is a mode of wave propagation in which the radiowave emitted from the transmitter antenna reach the receiving antenna after reflection by ionosphere. Sky wave propagation is possible because of reflection of carrier signals from ionosphere or satellite.

11. SPACE WAVE PROPAGATION higher than 30MHz is that mode of wave propagation in which the radiowaves emitted from the transmitter antenna reach the receiving antenna through space. These radiowaves are called space waves. It is also called **line of sight** communication. Space wave is suitable for UHF/VHF regions.

Band width of the signal

Type of signal	**Band width**
Speech	2800 Hz
Music	20 KHz
Video	42 MHz
Video & Audio (T.V)	6.0 MHz

12. COVERING RANGE OF T.V. TRANSMITTING TOWER is $d=\sqrt{2R_eh}$, where h is height of tower and R_e radius ofearth. T.V. waves are frequency modulated waves. VHF T.V. waves range from 47 to 230 MHz and UHF T.V. waves have range from 470 to 960 MHz.

Maximum line of sight distance $d_m = \sqrt{2Rh_T} + \sqrt{2Rh_R}$.

14. MAXIMUM USABLE FREQUENCY

It is that highest frequency of radio waves which when sent at some angle towards the ionosphere, gets reflected from that and returns to the earth.

16. SATELLITE COMMUNICATION

The communication satellite is used for reflecting sky waves without any disturbance. Its height is 35800 km above earth's surface. To cover entire globe of earth simultaneously 3-satellites are employed.

II. IMPORTANT FORMULAE

1. Marconi antenna is grounded, and its ***length = λ/4,*** where λ is wavelength of the waves transmitted. It is called quarter wave antenna.

2. Hertz antenna is not grounded, and its ***length = λ/2.*** It is called half wave antenna.

3. Side band frequencies in AM wave are $\upsilon_{SB} = \upsilon_c \pm \upsilon_m$ where υ_m is frequency of modulating (audio) signal.

4. **Modulation index,** $m_a = E_m / E_c$

Modulation index, $m_a = E_{max} - E_{min} / E_{max} + E_{min}$

6. Coverage range (*d*) for a given height (*h*) of antenna

$d = \sqrt{2hR}$ where R = radius of earth.

$d = \sqrt{2Rh_r} + \sqrt{2Rh_R}$, where h_T, h_R are the heights of transmitter and receiver antennas.

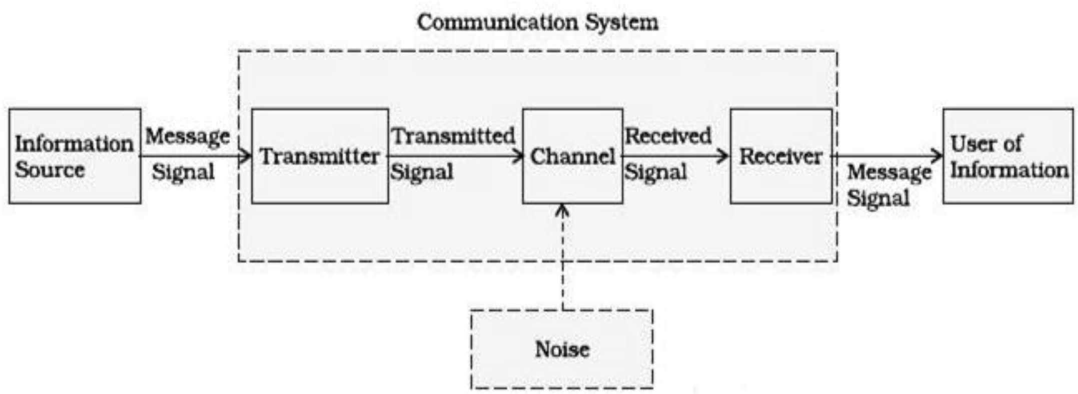
7. Population covered = population density x area covered.

8. **Number of channels,**

N = Total band width of channels / Band width per channel

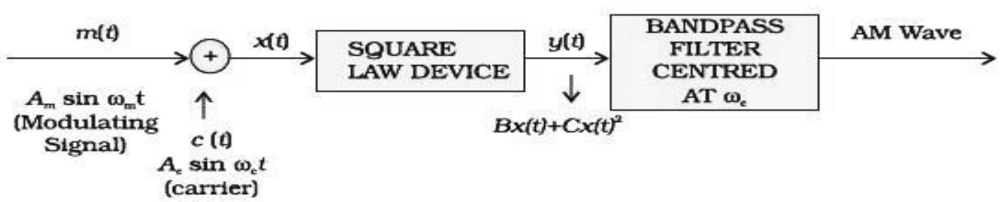
III. Communication System – Block Diagrams

1)

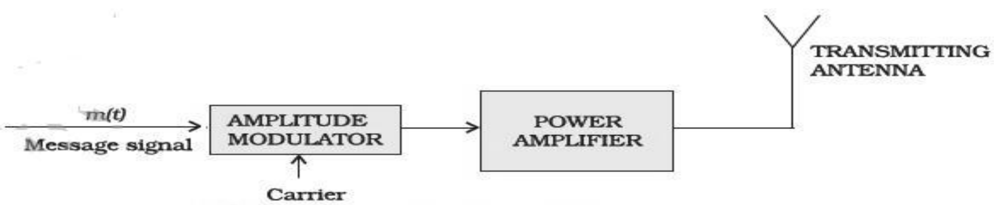


Block diagram of a generalised communication system.

2)



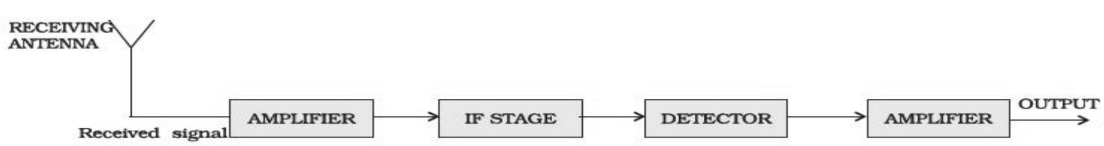
Block diagram of a simple modulator for obtaining an AM signal.



Block diagram of a transmitter.

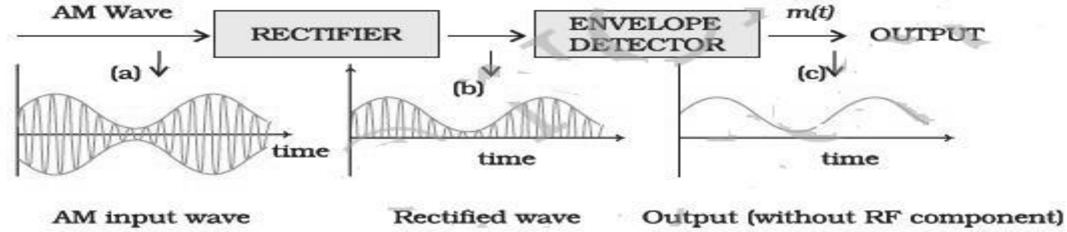
3)

4)



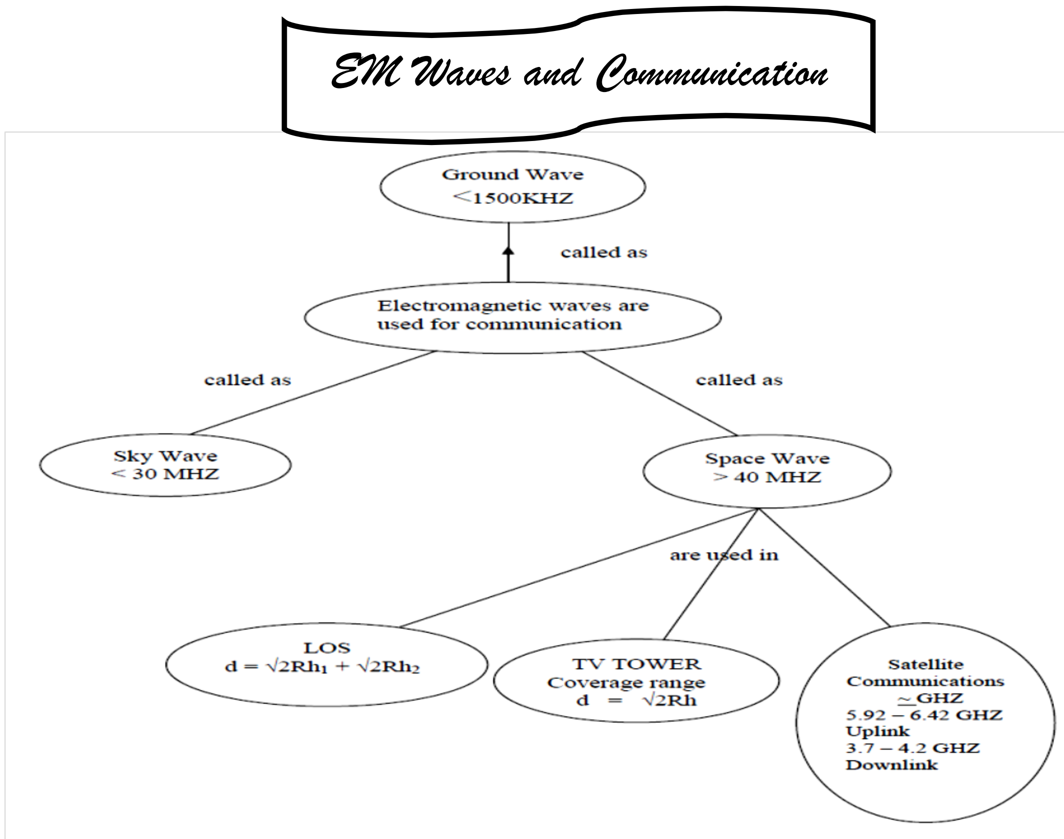
Block diagram of a receiver.

5)



Block diagram of a detector for AM signal. The quantity on y-axis can be current or voltage.

CONCEPT MAP



QUESTIONS

ELEMENTS OF COMMUNICATION SYSTEMS

1. Mention the functions of the transponder? (1)

Ans: A device fitted on the satellite which receives the signal and retransmits it after amplification.

2. What should be the length of dipole antenna for a carrier wave of 5×10^8 Hz? (1)

Ans: L = λ\2 = c\v x 2 = $3 \times 10^8 / 5 \times 10^8 \times 2 = 0.3$m.

3. *A device X can convert one form of energy into another. Another device Y can be regarded as a combination of a transmitter and a receiver. Name the devices X and Y. (1)

(a) Transducer (b) Repeater

4. Name the two basic modes of communication. Which of these modes is used for telephonic communication? (2)

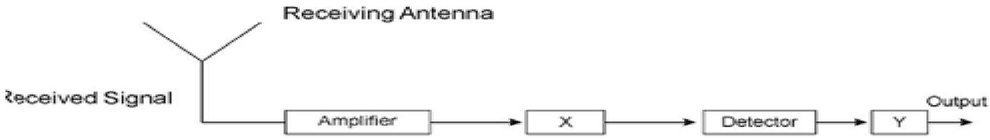
HINT:

Two basic modes of transmission are (i) Point-to-point and (ii) broad cast mode.
Point-to-point mode is used for Telephonic communication.

5. Differentiate an analog signal and a digital signal. How can an analog signal converted into a digital signal?
6.

(2)

Block diagram of a receiver is as shown :-

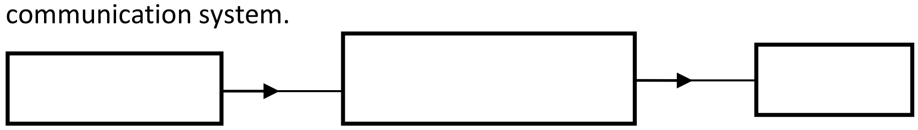


Identify X andY.

(2)

Hint: X= IF STAGE, Y = Amplifier

7.* Complete the following block diagram depicting the essential elements of a basic communication system. (3)



ANS:TRANSMITTER,MEDIUM AND RECIEVER

8.Calculate the length of a half wave dipole antenna at (3)
(a) 1 MHz (b) 100 MHz (c) 1000MHz
What conclusion you draw from the results?
Hint: Length of dipole antenna, L = λ/ 2
(a) **150m** (b) **1.5m** (c) **15 cm**

II. PROPAGATION OF EM WAVES

1. Name the types of communication that uses carrier waves having frequencies in the range 10^{12} to 10^{16} Hz.

Ans. Optical communication (1)

2. Write the expression for band width in FM. (1)

Ans. width = 2 times frequency of modulating signal

3. What is attenuation? (1)
4. What is the role of band pass filter in modulation circuit? (1)

Ans. If filters out low and high frequencies and only allow band of frequencies ($w_c - w_m$) to (w_c+w_m)

5. Distinguish between analog and digital communication. (1)
6. State the facts by which the range of transmission of signals by a TV tower can be increased?

Ans. by increasing height of transmitting antenna (1)
by increasing height of receiving antenna

7. What % of AM wave power is carried by side bands for m=1? (1)
8. Why moon cannot be used as a communicate satellite? (1)
9. Explain why medium waves are better parries of signals than radio waves? (1)

Hint: Uni-directional propagation.

10. What is the requirement of transmitting microwaves from one to another on the earth?

Ans: The transmitting and receiving antennas must be in line of sight. (1)

11. Name the type of radio waves propagation involved when TV signals broadcast by a tall antenna are intercepted directly by the receiver antenna. (1)
12. Why sky waves are not used for the transmission of TV signals? (1)

13. A TV tower has a height of 300m. What is the maximum distance upto which this TV transmission can be received?

Ans: $d = \sqrt{2Rh} = \sqrt{2 \times 6400 \times 1000 \times 300} = 62km$ (1)

14. How does the effective power radiated by an antenna vary with wavelength? (1)

15.*Why ground wave propagation is not suitable for high frequency? (OR)Why is ground wave propagation restricted to frequency up to 1500 kHz? **(1)**

Hint: It is because radio waves having frequency greater than 1500MHz are strongly absorbed by the ground.

16.*Why are signals not significantly absorbed by ionosphere in satellite communication?

Hint: It is because satellite communication employs HF carrier i.e. microwaves **(1)**

17. How many geostationary satellites are required to provide communication link over the entire globe and how should they be parked? **(1)**

18.* Why is the orbit of a remote sensing satellite called sun synchronous? **(1)**

Hint: it is because when ever such a satellites passes over a particular area of the Earth, the position of the sun with respect to that area remains the same.

19.At a particular place at a distance of 10km from a transmission station a person can receive signals but not able to receive signals at 100km, suggest a method how he can receive signal at 11 km By using antenna. **(1)**

20. The tuned circuit of oscillator in a single AM transmitter employs 50 uH coil and 1nF capacitor. The oscillator output is modulated by audio frequency up to 10KHz. Determine the range of AM wave. (2)

Hint: $\upsilon_c = 1/2\pi\sqrt{LC}$; USF = $\upsilon_{c} + \upsilon_m$; LSF = $\upsilon_{c} - \upsilon_m$

21. The TV transmission tower at a particular station has a height of 160 m. What is the Coverage range? (2)

22. What is the population covered by the transmission, if the average Population density around the tower is $1200km^{-2}$? (2)

Hint: **d** $= \sqrt{2Rh} = \sqrt{2 \times 6.4 \times 10^3 \times 160 \times 10^{-3}} = 45km$ Range $2d = 2 \times 45 = 90km$

Population covered=area × population density=1200×6359= 763020

23. A transmitting antenna at the top of tower has a height of 36m and the height of the receiving antenna is 49m. What is the maximum distance between them, for the satisfactory communication in the LOS mode? (Radius of the earth =6400km). (2)

Hint. Using $d = \sqrt{2Rh_t} + \sqrt{2Rh_r}$ we get =46.5km

24. Derive an expression for covering range of TV transmission tower (2)

25. * What is space wave propagation? Which two communication methods make use of this mode of propagation? If the sum of the heights of transmitting and receiving antennae in line of sight of communication is fixed at *h*, show that the range is maximum when the two antennae have a height h/2 each. (3)

Ans: Satellite communication and line of sight (LOS) communication make use of space waves.

Here $d_1 = \sqrt{2Rh_2}$ and $d_2 = \sqrt{2Rh_2}$

For maximum range,

$D_m = \sqrt{2Rh_1} + \sqrt{2Rh_2}$

where $d_m = d_1 + d_2 = d$

Given $h_1 + h_2 = h$

Let $h_1 = x$ then $h_2 = h - x$

Then $d_m = \sqrt{2Rx} + \sqrt{2R(h-x)}$,

$d\, d_m/dx = \sqrt{R/2x} - \sqrt{R/2(h-x)} = 0$

i.e., $1/2x = 1/2(h-x)$ i.e., $x = h/2$

=> $h_1 = h_2 = h/2$.

26. * A ground receiver station is receiving signals at (i) 5 MHz and (ii) 100 MHz, transmitted from a ground transmitter at a height of 300 m located at a distance of 100km. Identify whether the signals are coming via space wave or sky wave propagation or satellite transponder. Radius of earth = 6400 km; Maximum electron density in ionosphere, $N_{max} = 10^{12} m^{-3}$ (3)

Solution:

Maximum coverage range of transmitting antenna, $d = \sqrt{2R_e h}$

Therefore $d = \sqrt{2 \times 6400 \times 10^3 \times 300} = 6.2 \times 10^4$

The receiving station (situated at 100 km) is out of coverage range of transmitting antenna, so space wave communication is not possible, in both cases (i) and (ii) The critical frequency (or maximum frequency) of ionospheric propagation is $f_c = 9(N_{max})^{1/2} = 9 \times \sqrt{10^{12}} = 9 \times 10^6$ Hz = 9 MHz Signal (i) of 5MHz (< 9 MHz) is coming via ionosphere mode or sky wave propagation, while signal (ii) of 100MHz is coming via satellite mode.

27. * By what percentage will the transmission range of a TV tower be affected when the height of the tower is increased by 21%. ? (3)

Solution:

Transmission range of TV tower = $d = \sqrt{2hR}$ If the height is increased by 21%, new height

$h' = h + 21\backslash 100h = 1.21h$

If d' is the new average range, then $d'/d = \sqrt{h'} / \sqrt{h} = 1.1$% increase in range $\Delta d\backslash d \times 100\% = (d' - d \backslash d) \times 100\% = (d'/ d - 1) \times 100\% = (1.1 - 1) \times 100\% =$ **10%**

MODULATION

1. What type of modulation is used for commercial broadcast of voice signal? (1)

**2. ***Over modulation result in distortion of the signal in amplitude modulation. Why? (1)

Ans: When carrier wave is over modulated (i.e. $m_{a>}1$), the modulated wave will be absent at negative peak of modulating signal. This results in distortion of the signal.

3.*An AM wave contains more power than the carrier wave. Why? **(1)**

Ans: An AM wave contains three components, the carrier components and the two side band components (LSB and USB). It therefore contains more power than the carrier wave.

4.* Why is frequency modulation better than amplitude modulation? **(1)**

5.* What would be the modulation index for an amplitude modulated wave for which the maximum amplitude is '*a*' while the minimum amplitude is '*b*'? **(2)**

Ans. Modulation index, $a_m = E_m/E_c$ ... (1)

Maximum amplitude of modulated wave $a=E_c + E_m$ .....(2)

Minimum amplitude of modulated wave $b = E_c - E_m$ ...(3)

From (2) and (3), $E_c = a+b/2$, $E_m = a-b/2$

From (1), modulation index, $a_m = E_m/E_c = (a-b)/2 / (a+b)/2 = a-b/ a+b$

6. A carrier wave of peak voltage 20 V is used to transmit a message signal. What should be the peak voltage of the modulating signal, in order to have a modulation index of 80% ? (2)

Hint: Modulation index, $m_a = E_m / E_c$

$E_m = m_a \times E_c = 0.80 \times 20$ V = **16 V**

7. A message signal of frequency 10 kHz and peak value of 8 volts is used to modulate a carrier of frequency 1MHz and peak voltage of 20 volts. Calculate: (i) Modulation index
(ii) The side bands produced. (2)

Solution: (i) Modulation index, $m_a = E_m / E_c = 8/20 = 0.4$

(ii) Side bands frequencies = $f_c \pm f_m$

Thus the side bands are at 1010KHz and 990 kHz.

8.An amplitude modulation diode detector, the output circuit consists of resistance R = 1kΩ and capacitance C = 10pf. It is desired to detect a carrier signal of 100 kHz by it. Explain whether it is a good detector or not? If not what value of capacitance would you suggest? (3)

Solution: The satisfactory condition for demodulation is that reactance at carrier frequency must be much less than R.

$$\text{Reactance} = 1 / \acute{\omega}C = 1 / 2\pi f_C C = 1/ 2 \times 3.14 \times 100 \times 10^3 \times 10 \times 10^{-12}$$
$$= 1.59 \times 105\ \Omega = 159\ k\Omega$$

This is much greater than the given resistance, so it is not a good detector. For detection, the condition is $1 / 2\pi f_C C << R$ $= C >> 1 / 1.59 \times 10^{-9}$ fared or $C >> 1.59$ nF.

Thus for proper detection the capacitance of output circuit must be much greater than 1.59 nF. The suitable capacitance is 1µF.