PROPAGAGIATION OF EM WAVES

In communication system wireless transmission is done using electro-magnetic waves and the signals after due modulation are converted to carrier waves which are send from transmitter to the Rx through a channel.

Antenna is used at both the ends, transmitter end and receiver end.

The size of an antenna should be $\lambda/4$, where λ is the wavelength of the signal.

There are many possible ways for the transmission of electromagnetic waves —

- Ground wave propagation
- Sky wave propagation
- Space propagation and satellite propagation.

Ground wave propagation :— Ground wave propagation is used for transmission of low freqn signals. In this propagation the signal wave is parallel to ground. while this transmission there is oscillation of wave, so they include another wave in the surface of the earth as in figure 1.

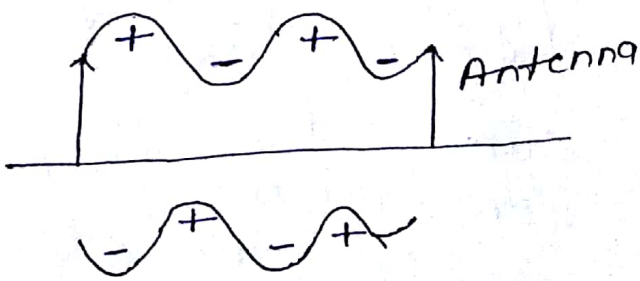

Fig 1: Ground wave

The induced wave in the ground attenuate electromagnetic wave at a short range (due to leakage of energy of wave at earth's poorn

surface), hence ground wave propagation is only used for short range communication.

The attenuation of surface waves increases very rapidly with increase in frequency, hence ground wave propagation is used for low freqn and large wavelength i.e. AM waves.

The range of freqn is from a few KHz to few MHz (5MHz).

Advantages:-

- Ground wave propn can only be used for short range.
- As it is the amplitude modulated, it gathers noise while transmission.
- As the freqn range is also small only a small number of transmitters can be used.

As ground wave propagation works with low freqn range and short distance, so it is not suitable for radio signal txn, hence the use of ground wave propagation is very limited.

Sky wave Propagation:-

When cosmic rays coming from the sun hits the atmosphere of the earth, ionisation takes place. The incoming cosmic ray hit an atom of air molecule resulting in elimination of electron from the outer-most shell of the atom and making it a

free electron. The degree of ionization varies with the height.

The density of atmosphere decreases with height. At great hights there are only few molecules so number of cosmic rays penetrate deeper to the next layer. here the number of molecules is greater as density is increased, so the number of ions produced is high.

close to the earth even though the number of molecules is very high the number of cosmic rays is very low as the maximum number of rays are consumed by upper layer; so that the ionization is again low.

Hence at some intermediate heights, ionization is very large as this layer is know as ionosphere.

The ionosphere is divided into different layers as shown in figure 2. It extends from a height of 65 km to 300 km above the earth's surface.

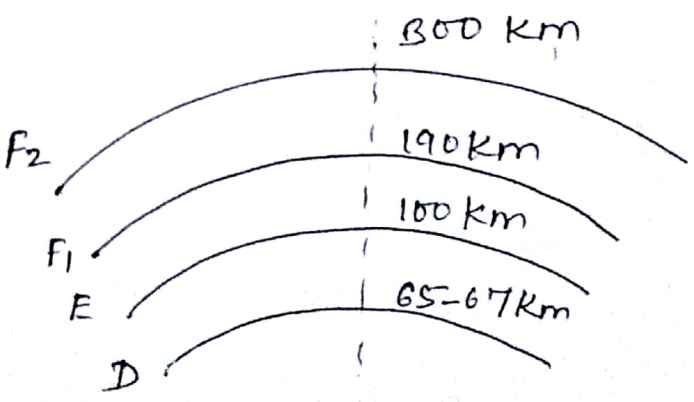

Fig 2: Ionospheric layers.

In communication system electromagnetic waves are used. when these electromagnetic waves hits the ionosphere containing ions they are reflected back down towards the surface of the earth.

Lower freqn electromagnetic wave is reflected by a lower layer with less ionisation strength, while higher freqn EM wave is reflected by a higher layer with high ionisation strength. Upto a certain value of freqn the wave can be reflected back and the wave beyond that freqn will not be reflected instead it escape in space.

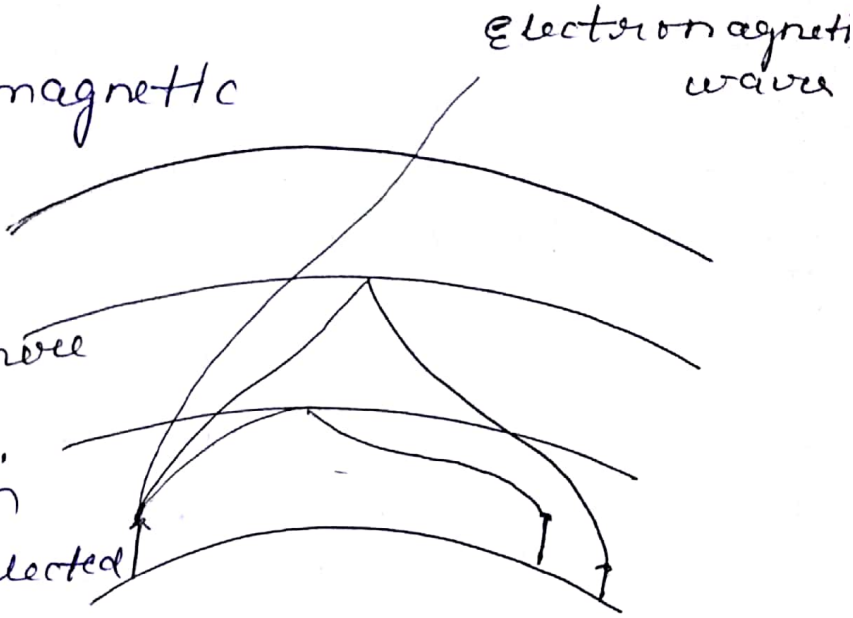

Fig3 Reflection of EM waves from ionosphere

The freqn range for sky wave propagation is from 3 MHz to 32 MHz.

The phenomenon responsible for sky wave propagation is reflection due to Ionosphere and type of reflection is total internal reflection

Advantages

Sky wave propagation can be used for long distance communication.

Space wave Propagation:- The high freqn EM wave is not reflected back by the ionosphere, so to use high freqn EM wave in communication we used space wave propagation.

Space waves are used in two type of communication -

- Line-of-sight (LOS) propagation
- Satellite communication

Line-of-sight propagation:-

In line-of-sight propagation, space waves are very powerful the signal are very clear, the BW is very large and huge amount of information can be transmitted.

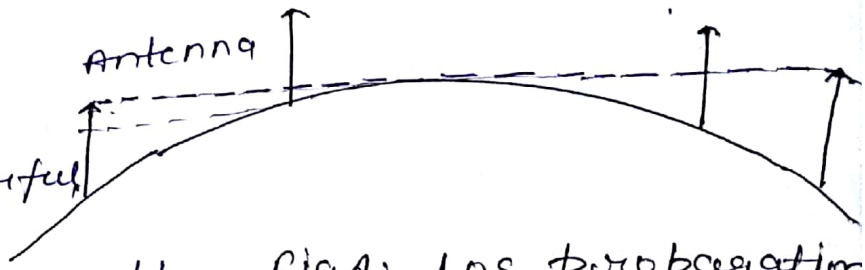

Fig 4: LOS propagation

In LOS propagation, direct waves get blocked at some point by the curvature of earth. If the signal is Rxed beyond the horizon the the Rxing antenna must be high enough to intercept the line-of-sight waves. Range of txn is

dependent upon the height of the antenna relation b/w range and height of antenna is given by

From figure –

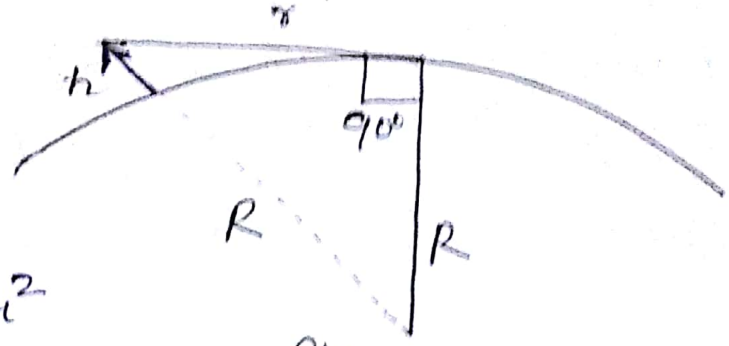

Fig:

$$(R+h)^2 = R^2 + r^2$$

$$\therefore R^2 + 2hR + h^2 = R^2 + r^2$$

As, we know, radius of earth is approx 6400km while the height of antenna is few meters, so we can neglect h^2.

fig: Range of LOS commh

$$\therefore 2hR = r^2$$

$$\Rightarrow r = \sqrt{2hR}$$

where,
r = range
h = height of antenna
R = Radius of earth

Observation :– For a greater range of EM wave, an antenna of large height is required.

Distance b/w two antennas for LOS propagation is given by –

$$r_1 = \sqrt{2h_1R}$$

$$r_2 = \sqrt{2h_2R}$$

$$\Rightarrow r_1 + r_2 = \sqrt{2R(h_1+h_2)}$$

where r_1 = range of antenna 1
r_2 = " " " 2
h_1 = height of antenna 1
h_2 = " " " 2
R = radius of earth

Area covered by transmitting antenna is given by —

$$\text{Area} = \pi r^2$$

where, $r^2 = 2hR$

$$\Rightarrow \text{Area} = 2\pi hR$$

Satellite Communication :—

For a freqn more than 40 MHz, ground wave proph and sky wave propagation can't be used. So, this high freqn signals are txed at a particular angle from the surface of the earth towards the satellite. After hitting the satellite, the signal wave is reflected back if the satellite is an inert satellite but the reflected wave is very weak so it is not possible to Rx it back.

Instead of inert satellite, active satellite is used for the satellite comm.

Active satellite should have the following characteristics —

- It should be geo-stationary satellite.
- The satellite has a repeater system i.e. it includes a Receiver Rx, amplifier and transmitter.

Working of satellite Commn :- In satellite communication the process of transmitting signal wave towards the satellite is known as uplinking. The satellite has Receiver that receives the incoming msg signal and then amplifies the signal and the freqn of the signal is also changed, after which the msg signal is fixed back to earth. This type of propn is known as space wave propn and as satellite is used the commn is called as satellite commn.

The range for receiving the signal fixed from the satellite is more than 1/3rd of the earth.

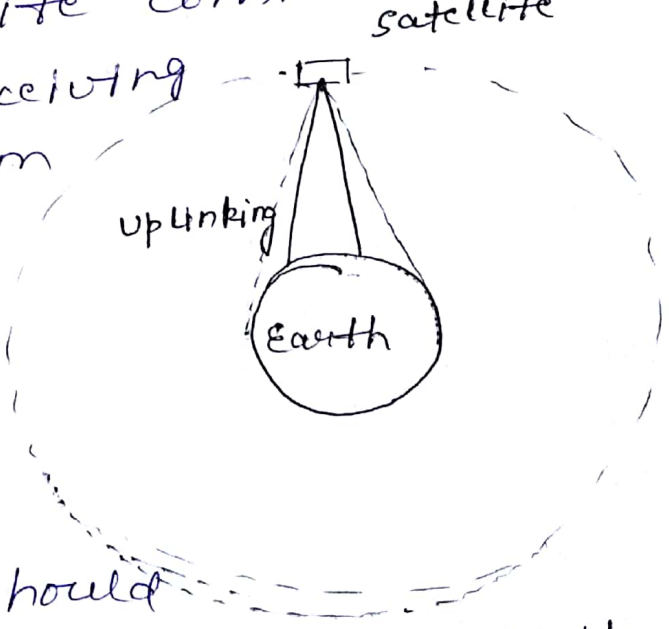

Fig: 7. Satellite commn.

It is required that the signal should reach to a distance larger than the range of the satellite, then global commn system is used which is combn of three different satellites.

when the sig msg signal is to be txed beyond the range of a satellite that particular satellite sends the msg signal to another satellite via a special freqn and the msg signal is delivered.

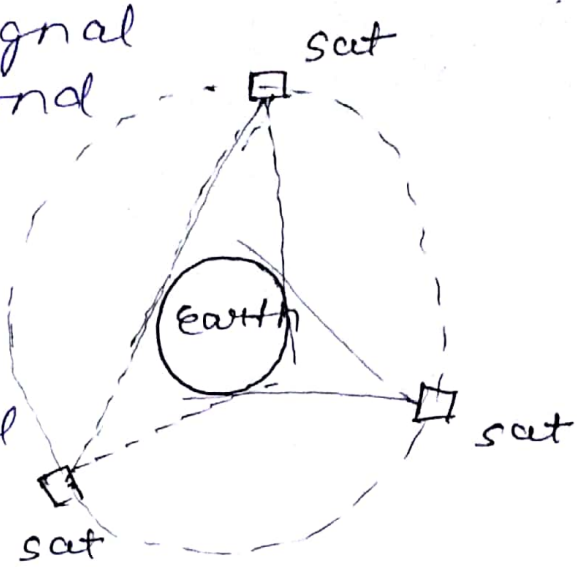

Fig 8: Global satellite comm n