ANTENNA AND WAVE PROPAGATION

0

Introduction

- Electromagnetic Wave(Radio Waves) travel with a vel. of light.
- These waves comprises of both Electric and Magnetic Field.
- The two fields are at right-angles to each other and the direction of propagation is at right-angles to both fields.
- The Plane of the Electric Field defines the Polarisation of the wave.



- Electromagnetic Wave(Radio Waves) travel with a vel. of light.
- These waves comprises of both Electric and Magnetic Field.
- The two fields are at right-angles to each other and the direction of propagation is at right-angles to both fields.
- The Plane of the Electric Field defines the Polarisation of the wave.

POLARIZATION

- The polarization of an antenna is the orientation of the electric field with respect to the Earth's surface.
- Polarization of e.m. Wave is determined by the physical structure of the antenna and by its orientation.
- Radio waves from a vertical antenna will usually be vertically polarized.
- Radio waves from a horizontal antenna are usually horizontally polarized.

Classification of Radio Wave Propagation

Radio waves

Ground or Surface Wave Propagation

_Space Wave Propagation—

Direct Wave or Line of Sight (LOS)

Indirect or Ground Reflected Wave

- Sky Wave Propagation

<u>GROUND WAVE, SPACE</u> WAVE, SKY WAVE



Ground Waves or Surface Waves

Ground Waves or Surface Waves

- Frequencies up to 2 MHz
- follows the curvature of the earth and can travel at distances beyond the horizon (upto some km)
- must have vertically polarized antennas
- strongest at the low- and medium-frequency ranges
- AM broadcast signals are propagated primarily by ground waves during the day and by sky waves at nightis a Surface Wave that propagates or travels close to the surface of the Earth. It follows contour of the earth



Ground-Wave Propagation

Ground or surface wave radiation from an antenna.

Ground Wave Propagation

Advantages

- Given enough power they can be used to communicate between any two points in the world
- They are relatively unaffected by changing atmospheric conditions like sky waves.

Ground Wave Propagation (Contd.)

Requires relatively high transmission power

- They are limited to very low, low and medium frequencies which require large antennas
- Losses on the ground vary considerably with surface material
- Ground Wave get attenuated

due to earth imperfection, absorption and reflection by earth surface and attenuation increases with frequency.

 by the tilt in the wave as it progresses along curvature of earth. Due to this horizontal component of electric field get shorted, which reduces strength of electric field.

Space Wave Propagation

- This type of radio waves include radiated energy that travels in the lower few miles of the earth's atmosphere. They include both direct and ground reflected waves.
- A high gain and horizontally polarized antenna is thus highly recommended.
 - The field intensity at the receiving antenna depends on the distance between the two antennas and whether the direct and ground reflected waves are in phase.



Space Wave Propagation

Radio Wave Propagation through Space: Direct Waves

- A direct wave, or space wave, travels in a straight line directly from the transmitting antenna to the receiving antenna. Direct-wave radio signaling is often referred to line-of-sight communication.



 Direct or space waves are not refracted, nor do they follow the curvature of the earth. These waves are deviated (reflected) by obstructions and cannot travel over the horizon or behind obstacles.

Line-of-Sight Propagation

Space Wave Propagation

- At higher frequencies and in lower levels of the atmosphere, any obstruction between the transmitting antenna and the receiving antenna will block the signal.
- Line-of-sight communication is characteristic of most radio signals with a frequency above 30 MHz, particularly VHF, UHF, and microwave signals.

SPACE WAVE(Line of Sight waves) Line of sight waves

> travel directly from an antenna to another without reflection on the ground.

Occurs when both antennas are within line of sight of each another, distance is longer that line of sight because most space waves bend near the ground and follow practically a curved path.

> Antennas must display a very low angle of emission in order that all the power is radiated in direction of the horizon instead of escaping in the sky.

Line-of-Sight Equations

• Optical line of sight $d = 3.57\sqrt{h}$

• Effective, or radio, line of sight $d = 3.57\sqrt{Kh}$

- d = distance between antenr and horizon (km)
- h = antenna height (m)
- K = adjustment factor to account for refraction



Space-Wave Propagation (Line of Sight Propagation)



Maximum distance between two antennas for LOS propagation:

$$3.57\left(\sqrt{Kh_1} + \sqrt{Kh_2}\right)$$

 h_1 = height of antenna one

 h_2 = height of antenna two

Line-of-sight comm. by direct or space waves

Effect of Imperfect Earth

- Attenuation and attenuation distortion
- Free space loss
- Noise
- Atmospheric absorption
- Multipath
- Refraction
- Thermal noise

Space-Wave Propagation

Radio-Wave Propagation Through Space: Space Waves

- Repeater stations extend the communication distance at VHF, UHF, and microwave frequencies.
- A repeater is a combination of a receiver and a transmitter operating on separate frequencies.
- The receiver picks up a signal from a remote transmitter, amplifies it, and retransmits it (on another frequency) to a remote receiver.
- Repeaters are widely used to increase the communication range for mobile and handheld radio units.

Effects of curvature of Earth

- Radio-Wave Propagation Through Space: Space Waves
 - In a trunked repeater system, multiple repeaters are under the control of a computer system that can transfer a user from an assigned but busy repeater to another, available repeater, thus spreading the communication load.
 - **Communication satellites** act as fixed repeater stations.
 - The receiver-transmitter combination within the satellite is known as a **transponder.**

Sky Wave Propagation

Sky Wave:

The propagation of Space and Ground waves are limited by the curvature of earth.

So for long distance comm. of thousands of Km or more are performed by Sky waves or ionospheric waves.

Also Known as Skip/ Ionospheric/ Hop/ wave.

HF radio communication (2 and 30 MHz) is a result of sky wave propagation.

Examples:Amateur radio



Sky Wave Propagation

- Signal reflected from ionized layer of atmosphere back down to earth
- Signal can travel a numor of hops, back and for the between ionosphere earth's surface
- Reflection effect caused by refraction





Sky-Wave Propagation



Sky wave propagation

Sky-Wave Propagation (Related terms)

- Sky-wave propagation refers to radio wave propagation via the ionosphere. Each reflection from the ionosphere is a hop.
- Reception of sky-wave propagation is called skip.
- The skip zone is the region between the max. ground-wave and min. sky-wave where a station can not be heard.

Sky-Wave Propagation

The higher the region in the ionosphere where the hop occurs, the greater the distance the wave can travel. F2 skip can travel up to 2500 miles E skip can travel up to 1200 miles



Sky wave propagation

The virtual height is the height from which the radio wave appears to be reflecting.



Sky-Wave Propagation

- Sky-wave propagation can include multiple hops between the Earth and the ionosphere.
- Sky-wave signals due to fluctuations in the ionosphere which can create multiple paths for the signal (multipath). The combination of multipath signals can cause some distortion or fading.
- If the ionosphere is very dense, then the critical angle is high and short skip is possible.
 - Short skip distances are much shorter than the usual skip distances.
 - Short skip on the 10 M band is a good indicator that skywave propagation is possible on 6 M.

Ionospheric Propagation

For many years, numerous organisations have been employing the High Frequency (HF) spectrum to communicate over long distances.

It was recognised in the late 30's that these communication systems were subject to marked variations in performance.

It was hypothesised that most of these variations were directly related to changes in the ionosphere.

Ionospheric Propagation (Contd.)

Considerable effort was made to investigate ionospheric parameters and determine their effect on radio waves and the associated reliability of HF circuits.

World-wide noise measurement records were started and steps were taken to record observed variations in signal amplitudes over various HF paths.

Ionospheric Propagation (Contd.)

The results of this research established that ionised regions ranging from approximately 70 to 1000 km above the earth's surface provide the medium of transmission for electromagnetic energy in the HF spectrum (2 to 30 MHz) and that most variations in HF system performance are directly related to changes in these ionised regions. The ionisation is produced in a complex manner by the photoionization of the earth's high altitude atmosphere by solar radiation.

Ionospheric Propagation(Contd)

Within the ionosphere, the recombination of the ions and electrons proceeds slowly enough (due to low gas densities) so that some free electrons persist even throughout the night. In practice, the ionosphere has a lower limit of 50 to 70 km and no distinct upper limit, although 1000 km is somewhat arbitrarily set as the upper limit for most application purposes.

Ionospheric Propagation(Contd.)

The vertical structure of the ionosphere is changing continuously. It varies from day to night, with the seasons of the year, and with latitude. Furthermore, it is sensitive to enhanced periods of short-wavelength solar radiation accompanying solar activity. In spite of all this, the essential features of the ionosphere are usually identifiable, except during periods of unusually intense

geomagnetic disturbances.

PREDICTABLE IONOSPHERIC PARAMETERS

The presence of free electrons in the ionosphere produces the reflecting regions important to High Frequency (HF) radio-wave propagation. In the principal regions, between the approximate heights of 75 km and 500 km, the electrons are produced by the ionising effect of ultraviolet light and soft x-rays from the sun. for convenience in studies of radio-wave propagation, the ionosphere is divided into three regions defined according to height and ion distribution: the D,E, and F regions.