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Antennas' and It's Application

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Abstract: *An Antenna is the most significant part in wireless communication systems. Antenna converts electrical signals into radio waves and vice versa. Which is mainly used as a transmitting as well as receiving Antenna? There are different types of antennas. In this paper, we present various types of antennas that can be used for different application according to their parameters such as radiation pattern, gain, impedance matching, bandwidth, size, transmission range etc. Our main aim is to categorize these antennas according to their applications.*

Keywords: Antenna, Wireless Communications, Radio Waves, Applications.

I. Introduction

Antennas plays vital role in communication systems. An antenna is a device used to transfer an Radio Frequency (RF)signal, which is traveling on a conductor, into an electromagnetic wave in free space. The Conventional antennas are subject to reciprocity theorem. Reciprocity states that the receive and transmit properties of an antenna are same.

An antenna must have identical frequency band of the radio system to which it is coupled. When a signal is transferred into an antenna, the antenna will emit radiation dispersed in space in a certain way.

A graphical representation of the relative dispersal of the radiated power in space is called a radiation pattern.

II. Why do we need Antennas?

There are several reasons to explain that why we need or why we use antennas, but the most significant reason to use antennas is that they offer a simple way to transfer signals from transmitter to receiver, where other devices are impossible. Wireless communication is the only possible option to communicate but Antennas are the only one gateway for wireless communication. There are many locations or applications where cables are used over wireless communication with antennas (For example high speed Ethernet or the connection between gaming console and the T.V.

III. Parameter Of Antennas

- Radiation pattern
- directive gain
- power gain
- polarization
- Antenna resistance
- Directivity
- Antenna gain
- Power density

Radiation pattern: -A graph or diagram which tells us about the manner in which an antenna radiates more power in different directions is known as the radiation pattern of antenna.

Directive gain: - Directive gain is defined as the ratio of the power density in a particular direction of one antenna to the power density that would be radiated by isotropic antenna in the same direction.

Power gain: -The power gain of an antenna is defined as the ratio of power fed to an isotropic antenna to the power fed to a directional antenna, to develop the same field strength at the same direction.
Polarization-It is defined as the direction of the electric field vector in the electromagnetic wave radiated by the transmitting antenna.
Antenna Resistance – The component of the antenna resistance that accounts for the power radiated into space and is equal in ohms to the radiated power in watts divided by the square of the effective current in amperes at the point of power supply.
Antenna Gain – The directional antennae radiate more power in specific direction. The Omni-directional antenna radiates power equally in all directions. A directional antenna is said to have 'gain' in a particular direction.
Directivity- The directive gain can be defined in any direction. However, directivity means the maximum directive gain which is obtained in only one direction in which the radiation is maximum.

Directivity = Maximum Directive gain

Power density- The power density at any distance from an isotropic antenna is simply the transmitter power divided by the surface area of a sphere (4πR2) at that distance.

IV. Types of Antennas

There are different types of antennas are as follows:

- Resonant antenna and
- Non-resonant antenna types.

4.1 Resonant Antenna

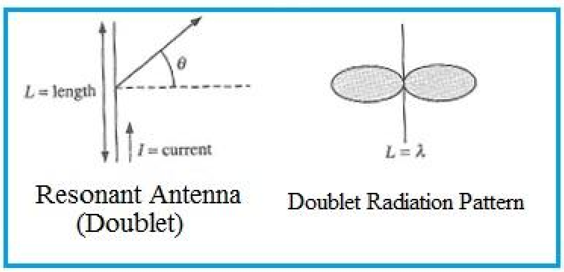

Fig 1 Resonant Antenna and its radiation pattern

The resonant antennas are like as resonant transmission lines. The dipole antennas are example of resonant antennas type. dipole antennas are open ended at far end with resonant length. The term resonant length refers to multiple of quarter wavelength. It is placed at a point on the transmission line where it has low impedance. Usually, this location is quarter wavelength (i.e. λ/4) from the open circuit end. Thes half wave dipole and its radiation pattern looking like a doublet.

4.2 Non-Resonant Antennas

The Non-resonant antennas are like as non resonant transmission lines. The Non resonant transmission lines do not have standing waves. Hence they do not have any reflected signal and they have only forward travelling signal.

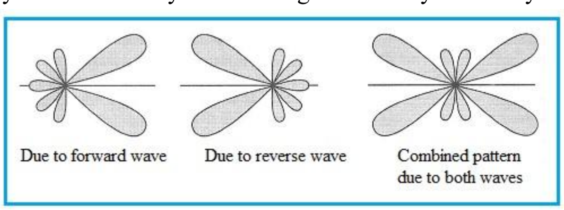

Fig 2 Non-Resonant radiation pattern

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When the antenna is terminated about $(2/3)^{rd}$ power is transmitted as forward waves and remaining power is dissipated and there is no reflected power towards the input.

From the radiation patterns of both, the difference between resonant antenna and non resonant antenna is as follows.

- The Non resonant antennas are uni-directional and The resonant antennas are bi-directional.
- In non resonant antennas only forward waves exists and in resonant antennas both forward and reflected waves are exists.

4.3 Dipole Antenna

A dipole antenna also known as a doublet or dipole aerial. It is defined as a type of RF (Radio Frequency) antenna, containing of two conductive elements such as rods or wires. The dipole is any one of the varieties of antenna that gives a radiation pattern approximating that of an elementary electric dipole. Dipole antennas are the simplest and most extensively used type of antenna. A 'dipole' means 'two poles' hence the dipole antenna contains of two identical conductive elements such as rods or metal wires. The length of the metal wires is about half of the maximum wavelength in free space at the frequency of operation.

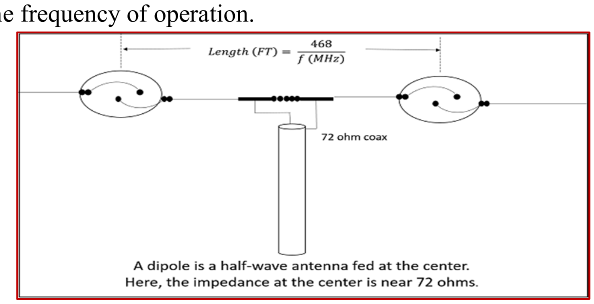

Figure 3: Dipole Antenna

4.4 Half Wave Dipole Antenna

- Half wave dipole is a resonant antenna. A resonant antenna corresponds to the resonant transmission lines.
- One of the most extensively used antenna types is the half-wave dipole also called a doublet.
- Half-wave dipole antennascorrespond to a resonant transmission line. i.e., exact half-wave length (λ /2) long and open-circuited at one end.
- The dipole antennas has lengths of λ /2,λ, 3 λ /2 etc. which are all multiple of λ /2. Hence, the dipole antennas are resonant antennas

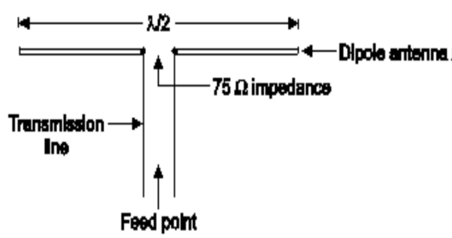

Figure 4 Half Wave Dipole Antenna

Radiation Pattern of a Basic Dipole Antenna

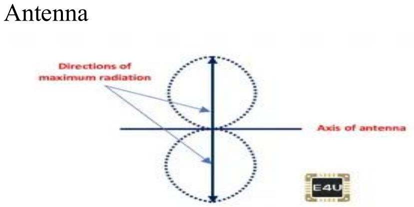

Figure 5: Radiation Pattern of a Basic Dipole Antenna

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Advantages of half-wave dipole antenna

- The Input impedance is not sensitive.
- It Matches well with transmission line impedance.
- It Has reasonable length.
- Length of thisantenna matches with size and directivity.

Disadvantages of half-wave dipole antenna −

- It is not much effective due to single element.
- It can work well only with a combination.

Applications

- It Used in radio receivers.
- It Used in television receivers.
- When working with others, used for wide variety of applications.

4.5 Loop Antennas

Figure 7 Loop Antennas

The loop antenna is a coil carrying radio frequency current. It may be in any shape such asrectangular,circular, triangular, square or hexagonal according to the requirement.

Types of Loop antennas

- Large loop antennas
- Small loop antennas

A. Large Loop Antennas

These antennas are also called as resonant antennas. They have high radiation efficiency. These antennas have length nearly equal to the intended wavelength.

$L=\lambda$

Where, L is the length of the antenna

λ is the wavelength

The main constraint of this antenna is its perimeter length, which is about a wavelength and should be an enclosed loop. It is not a good idea to meander the loop so as to reduce the size, as that increases capacitive effects and results in low efficiency.

B. Small Loop Antennas

These antennas are also called as a magnetic loop antenna. These are less resonant antenna. These are mostly used as receivers. These antennas are of the size of one-tenth of the wavelength.

$L=\lambda/10$

Where, L is the length of the antenna

λ is the wavelength

The features of small loop antennas are given below

- It has low radiation resistance. If multi-turn ferrite core structures are used, then high radiation resistance can be achieved.
- Small loop antennashas low radiation efficiency due to high losses.
- Small loop antennas construction is simple with small size and weight.

Due to its high reactance, its impedance is difficult to match with the transmitter. If loop antenna has to act as transmitting antenna, then this impedance mismatch would definitely be a problem. Hence, these loop antennas are better operated as receiver antennas.

4.6 Telescopic Antenna

An antenna whose receiving or radiating elements, such as the arms of a dipole, are arranged in the form of an extensible structure of metal tubes or rods of approximately equal length. Such a design allows changing the length of the antenna elements during tuning and permits the size of the antenna to be reduced when it is not in operation Example, during transport or storage.

Figure 8: Telescopic Antenna

For each pair of telescoping tubes, the interiordiameter of the outer tube is almost equal to the exterior diameter of the inner tube. The tubes fit into one another with some friction, which is needed to offer electrical contact and to maintain the required length of each element of the telescopic antenna under operating conditions

Applications

It used in combination with radio receivers, radio trans receiver, television receivers, and television receivers installed in moving objects, such as automotive vehicles; such antennas are also used as indoor television antennas.

4.7 Yagi–Uda Antenna

Yagi–Uda Antenna isone of the most common directional antennas at HF, VHF, and UHF frequencies. Contains of multiple half-wave dipole elements in a line, with a single driven element and multiple parasitic elements which serve to create a uni-directional or beam antenna. Yagi–Uda Antenna typically have gains between 10–20 dB depending on the number of elements used, and are very narrow band though there are derivative designs which relax this limitation. It is used for rooftop television antennas, point-to-point communication links, and long distance shortwave communication using skywave ("skip") reflection from the ionosphere.

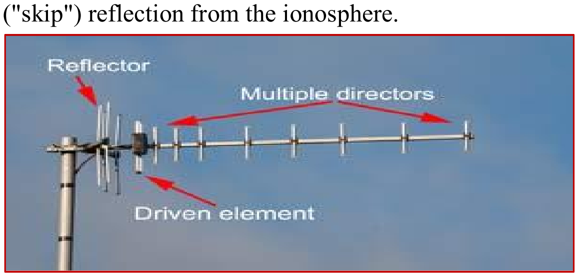

Figure 9: Yagi–Uda Antenna

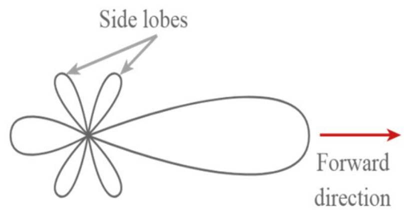

Figure 10: Yagi–Uda Antenna Radiation pattern

There are three types of element within a Yagi uda antenna:

- Driven element: It is the Yagi antenna element to which power is applied. It is normally a half wave dipole or often a folded dipole.
- Reflector: The Yagi antenna will usually only have one reflector. Reflector is behind the main driven element, i.e. the side away from the direction of maximum sensitivity
- Director: The director or directors are located in front of the driven element, i.e. in the direction of maximum sensitivity. Typically, each director will increase around 1 dB of gain in the forward direction, although this level reduces as the number of directors increases.

Advantages

- It has High gain is achieved.
- It has High directivity is achieved.
- It has Ease of handling and maintenance.
- It has Less amount of power is wasted.

Disadvantages

- It is Prone to noise.
- It is Prone to atmospheric effects.

Applications

- Mostly used for TV reception purpose.
- Used where a single-frequency application is required.

4.8 Dish Antenna

- Dish antenna uses simple reflection principle, just as a mirror can reflect light and a curved mirror can reflect and focus light at a single point, the dish reflects and focuses the radio waves.
- This is the similar principle and shape that is used as reflector in a flashlight or headlight behind the bulb. It is used for systems that transmit and receive as well as receive only.

4.9 Parabolic-Reflector Antenna

The radiating surface of a parabolic antenna has very large dimensions related to its wavelength. The geometrical optics, which depends upon rays and wave fronts, are used to know about certain features of these antennas. Certain important properties of these antennas can be studied by using ray optics and of other antennas by using electromagnetic field theory.

One of the useful properties of Parabolic-Reflector antenna is the conversion of a diverging spherical Wavefront into a parallel wavefront that produces a narrow beam of the antenna. The several types of feeds that use this parabolic reflector include horn feeds, Cartesian feeds, and dipole feeds.

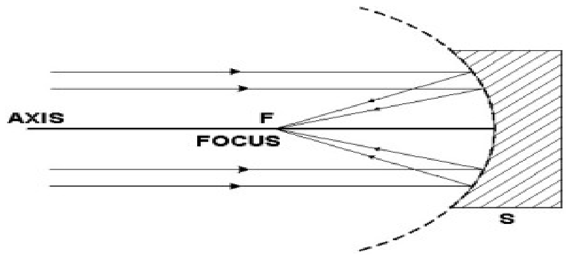

Figure 11: Parabolic-Reflector Antenna

Advantages

1. Most of the structure of the antenna is non-resonant type, so it can function over a wide range of frequencies.
2. It has Wide bandwidth
3. It has high directivity
4. It has High gain

Disadvantages

1. Needs reflector and drive element: It needs a feed system to be placed at the focus of the reflector.
2. Cost: The antenna needs to be manufactured with attention. In addition to this a feed system is also essential. This can add cost to the system.
3. Size: The Parabolic-Reflector Antennais not as small as some types of antenna, although many used for satellite television reception are quite compact.

4.10 Micro Strip

An array of patch antennas on a substrate fed by micro strip feed lines. Microwave antenna that can achieve large gains in compact space. Ease of fabrication by PCB techniques have made them popular in modern wireless devices. Beam width and polarization can be actively reconfigurable

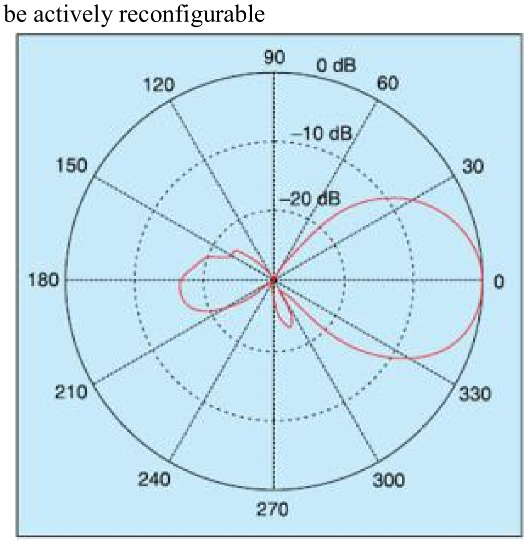

Figure 13: Typical radiation pattern of microstrip antenna

Advantages

1. They works at microwave frequencies where traditional antennas are not practicable to be designed.
2. This antenna type has smaller size and hence will offer small size end devices.
3. The microstrip based antennas are simply etched on any PCB.

4. The microstrip patches of many shapes e.g. rectangular, square, triangular etc. are easily etched. They have lesser fabrication cost.
5. Microstrip antennae are also useful in the fields of RFID (radio frequency identification), mobile communication and healthcare.

Disadvantages

1. The spurious radiation exists.
2. It offers low efficiency due to dielectric and conductor losses.
3. Microstrip antennae offers lower gain.
4. Microstrip antennae has higher level of cross polarization radiation.
5. It has lesser power handling capability.

Applications

In global positioning satellite (GPS) systems, circularly polarized micro strip antennae are used. 2.It is also used in the fields of RFID (radio frequency identification), mobile communication and healthcare.

Horn antenna is a type of antenna which is built when the end of the antenna is flared out or tapered in the shape of a horn. Horn antenna works in microwave frequency. These operate in ultra-high, super-high frequencies ranging between 300 MHz to 30 GHz.

It is normally considered as a waveguide whose one of the ends is widened out in the shape of the horn. Due to the flared-out construction of the antenna, there is greater directivity thus the emitted signal can be transmitted to longer distances.

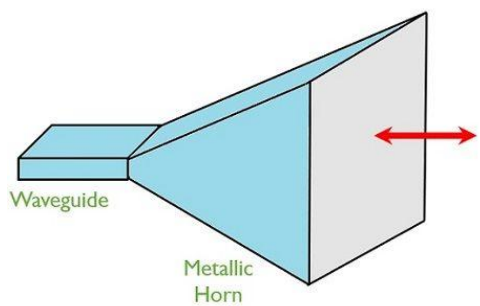

Figure 14: Horn antenna

Types of Horn Antenna

- **Pyramidal horn**: A type of horn antenna which is designed by flaring both the walls of the waveguide is known as pyramidl horn antenna.

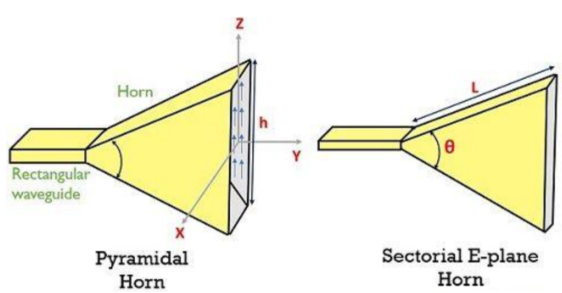

Figure 15: Pyramidal horn and Sectoral E plane hornantenna

- **Sectoral horn**: In this type of horn antenna flaring is made only along one of the walls of the waveguide. However, these are further classified as:

- **E-plane**: When one of the walls of the waveguide is flared along the direction of electric field vector is called as E-plane sectoral horn antenna.
- **H-plane**: When the wall of the waveguide is flared along the direction of the magnetic field vector then it is called as H-plane sectoral horn

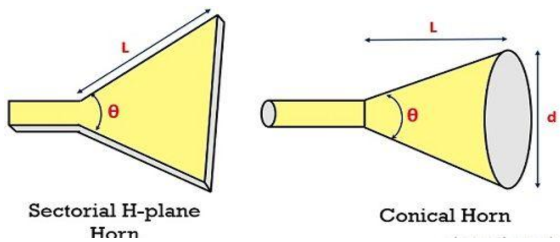

Figure 16: Sectoral horn H plane and conical horn antenna

- **Conical horn**: The construction of a conical horn antenna is a result of flaring a circular waveguide
- **Exponential horn**: Exponential horn antenna has a curved side. It is called the exponential horn antenna because the separating distance between the sides increases exponentially as a function of length.

Advantages

- It offers easy construction as can be easily configured with a waveguide.
- It operates over a wide bandwidth.
- It offers good impedance matching.
- It is highly directional in nature thereby providing higher directivity.
- Horn antenna offers less reflections.

Disadvantages

- The directivity of the horn antenna is dependent on the flare angle.
- The dimensions of the flare must be sufficiently large and this sometimes makes the horn antenna bulky.

Applications

Horn antennas are extensively used for applications such as radio astronomy, satellite, and terrestrial communication, plasma diagnostics, etc

V. Conclusion

Study concluded gives huge information about different forms of antennas. For wireless communication system we can select appropriate antenna to fulfill the requirement with the help of this research paper. In this paper, We introduced different types of antennas along with their advantages disadvantages and applications.

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