

Theory of Antennas, Its Advantage & Applications in Communication Systems

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Abstract - This paper gives you a brief introduction about antenna .advantage, disadvantage & careers of antenna Types of antenna, Dipole antenna,, Half-wave Folded Dipole, The characteristics of each type of antenna and antenna application. This paper is not a comprehensive study of antennas, but serves as an introduction to antenna types and their applications

Keyword: antenna, antenna types and their application

INTRODUCTION

In the 1890s, there were only a few antennas in the world. These rudimentary devices were primarily a part of experiments that demonstrated the transmission of electromagnetic waves. By World War II, antennas had become so ubiquitous that their use had transformed the lives of the average person via radio and television reception. The number of antennas in the India was on the order of one per household, representing growth rivaling the auto industry during the same period.

By the early 21st century, thanks in large part to mobile phones, the average person now carries one or more antennas on them wherever they go (cell phones can have multiple antennas, if GPS is used, for instance). This significant rate of growth is not likely to slow, as wireless communication systems become a larger part of everyday life. In addition, the strong growth in RFID devices suggests that the number of antennas in use may increase to one antenna per object in the world (product, container, pet, banana, toy, cd, etc.). This number would dwarf the number of antennas in use today. Hence, learning a little (or a large amount) about of antennas couldn't hurt, and will contribute to one's overall understanding of the modern world. Have you ever tried searching for the word antenna on the Internet? Well, I recently did just that, and Google returned 153,000,000 results. The most popular topics had something to do with TV antennas. The “images” tab showed predominantly reflector (“dish”), log-periodic, and Yagi-Uda antennas

An Antenna is a transducer, which converts electrical power into electromagnetic waves and vice versa.

An Antenna can be used either as a **transmitting antenna** or a **receiving antenna**.

- A **transmitting antenna** is one, which converts electrical signals into electromagnetic waves and radiates them.
- A **receiving antenna** is one, which converts electromagnetic waves from the received beam into electrical signals.
- In two-way communication, the same antenna can be used for both transmission and reception.

Antenna can also be termed as an **Aerial**. Plural of it is, **antennae** or **antennas**. Now-adays, antennas have undergone many changes, in accordance with their size and shape. There are many types of antennas depending upon their wide variety of applications.

Following pictures are examples of different types of Antennas.



NEED OF ANTENNA

In the field of communication systems, whenever the need for wireless communication arises, there occurs the necessity of an antenna. **Antenna** has the capability of sending or receiving the electromagnetic waves for the sake of communication, where you cannot expect to lay down a wiring system. The following scenario explains this.

SCENARIO

In order to contact a remote area, the wiring has to be laid down throughout the whole route along the valleys, the mountains, the tedious paths, the tunnels etc., to reach the remote location. The evolution of wireless technology has made this whole process very simple. Antenna is the key element of this wireless technology.

The basic communication parameters are discussed in this paper to have a better idea about the wireless communication using antennas. The wireless communication is done in the form of waves. Hence, we need to have a look at the properties of waves in the communications.

In this paper, we are going to discuss about the following parameters –

- Frequency
- Wavelength
- Impedance matching
- VSWR & reflected power
- Bandwidth
- Percentage bandwidth
- Radiation intensity

In this paper, you are going to learn the basic concepts of antenna, specifications and different **TYPES OF ANTENNAS**.

Antennas have to be classified to understand their physical structure and functionality more clearly. There are many types of antennas depending upon the applications applications.

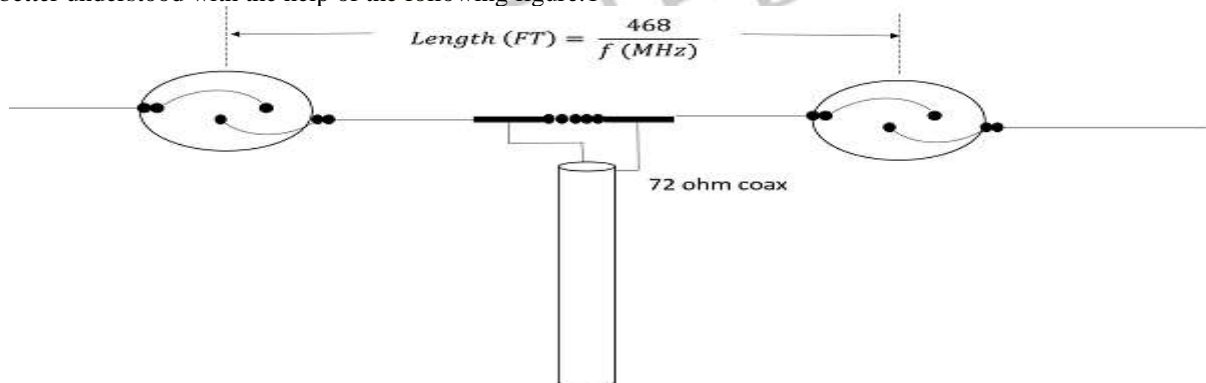
Type of antenna	Examples	Applications
Wire Antennas	Dipole antenna, Monopole antenna, Helix antenna, Loop antenna	Personal applications, buildings, ships, automobiles, space crafts
Aperture Antennas	Waveguide (opening), Horn antenna	Flush-mounted applications, air-craft, space craft
Reflector Antennas	Parabolic reflectors, Corner reflectors	Microwave communication, satellite tracking, radio astronomy
Lens Antennas	Convex-plane, Concave-plane, Convex-convex, Concaveconcave lenses	Used for very high frequency applications
Micro strip Antennas	Circular-shaped, Rectangularshaped metallic patch above the ground plane	Air-craft, space-craft, satellites, missiles, cars, mobile phones etc.
Array Antennas	Yagi-Uda antenna, Micro strip patch array, Aperture array, Slotted wave guide array	Used for very high gain applications, mostly when needs to control the radiation pattern

DIPOLE

The radiation of energy when done through such a bent wire, the end of such transmission line is termed as **dipole** or dipole antenna.

The reactance of the input impedance is a function of the radius and length of the dipole. The smaller the radius, the larger the amplitude of the reactance. It is proportional to the wavelength. Hence, the length and radius of the dipole should also be taken into consideration. Normally, its impedance is around 72Ω.

This is better understood with the help of the following figure.1



A dipole is a half-wave antenna fed at the center. Here, the impedance at the center is near 72 ohms.

The figure shows the circuit diagram of a normal dipole connected to a transmission line. The current for a dipole is maximum at the center and minimum at its ends. The voltage is minimum at its center and maximum at its ends.

The types of wire antennas include Half-wave dipole, Half-wave folded dipole, Full-wave dipole, Short dipole, and Infinitesimal dipole. The dipole antenna is cut and bent for effective radiation. The length of the total wire, which is being used as a dipole, equals half of the wavelength (i.e., $l = \lambda/2$). Such an antenna is called as **half-wave dipole antenna**. This is the most widely used antenna because of its advantages. It is also known as **Hertz antenna**.

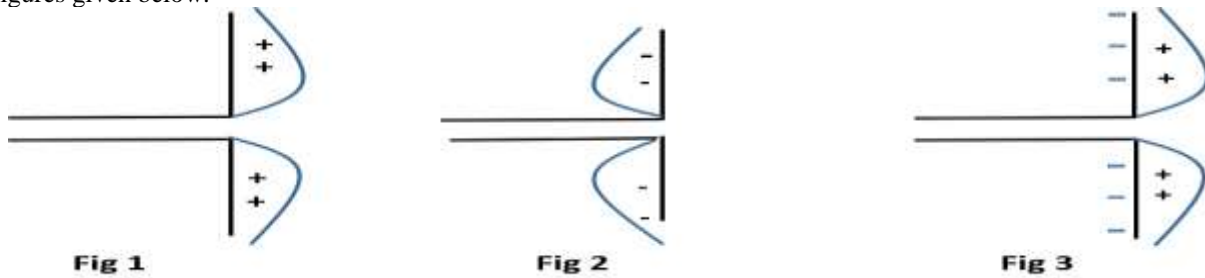
FREQUENCY RANGE

The range of frequency in which half-wave dipole operates is around 3KHz to 300GHz. This is mostly used in radio receivers.

CONSTRUCTION & WORKING OF HALF-WAVE DIPOLE

It is a normal dipole antenna, where the frequency of its operation is **half of its wavelength**. Hence, it is called as half-wave dipole antenna.

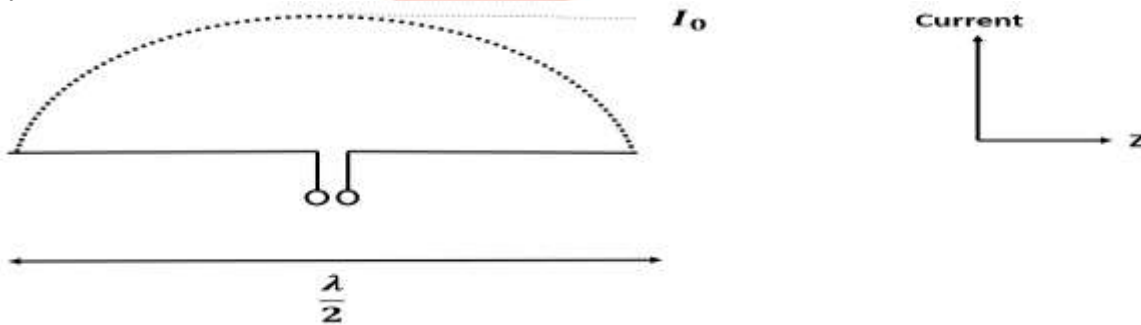
The edge of the dipole has maximum voltage. This voltage is alternating (AC) in nature. At the positive peak of the voltage, the electrons tend to move in one direction and at the negative peak, the electrons move in the other direction. This can be explained by the figures given below.



The figures given above show the working of a half-wave dipole.

- Fig 1 shows the dipole when the charges induced are in positive half cycle. Now the electrons tend to move towards the charge.
- Fig 2 shows the dipole with negative charges induced. The electrons here tend to move away from the dipole.
- Fig 3 shows the dipole with next positive half cycle. Hence, the electrons again move towards the charge.

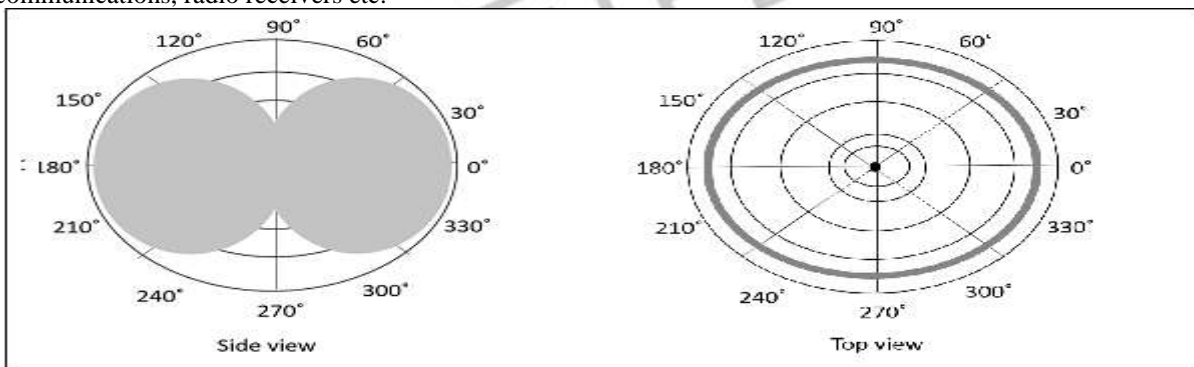
The cumulative effect of this produces a varying field effect which gets radiated in the same pattern produced on it. Hence, the output would be an effective radiation following the cycles of the output voltage pattern. Thus, a half-wave dipole **radiates effectively**.



The above figure shows the current distribution in half wave dipole. The directivity of half wave dipole is 2.15dBi, which is reasonably good. Where, 'i' represents the isotropic radiation.

RADIATION PATTERN

The radiation pattern of this half-wave dipole is **Omni-directional** in the H-plane. It is desirable for many applications such as mobile communications, radio receivers etc.



The above figure indicates the radiation pattern of a half wave dipole in both H-plane and V-plane.

The radius of the dipole does not affect its input impedance in this half wave dipole, because the length of this dipole is half wave and it is the first resonant length. An antenna works effectively at its **resonant frequency**, which occurs at its resonant length.

ADVANTAGES

The following are the advantages of half-wave dipole antenna –

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

DISADVANTAGES

The following are the disadvantages of half-wave dipole antenna –

- Not much effective due to single element.
- It can work better only with a combination.

APPLICATIONS

The following are the applications of half-wave dipole antenna –

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

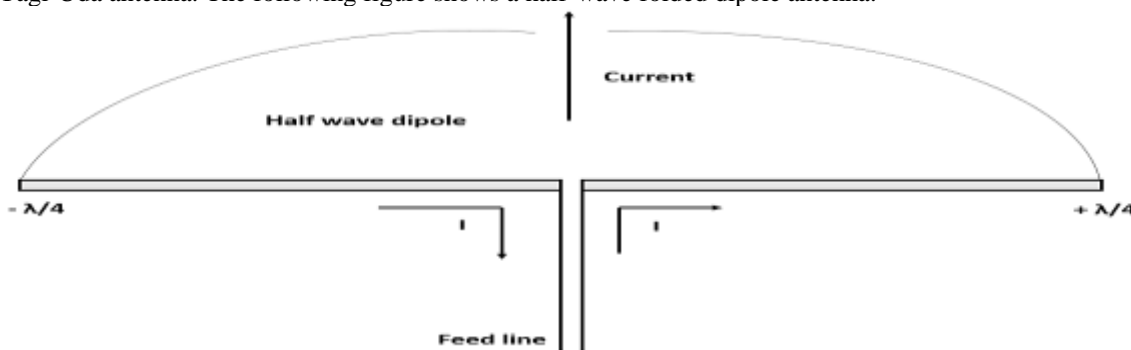
folded dipole is an antenna, with two conductors connected on both sides, and folded to form a cylindrical closed shape, to which feed is given at the center. The length of the dipole is half of the wavelength. Hence, it is called as **half wave folded dipole antenna**.

FREQUENCY RANGE

The range of frequency in which half wave folded dipole operates is around 3KHz to 300GHz. This is mostly used in television receivers.

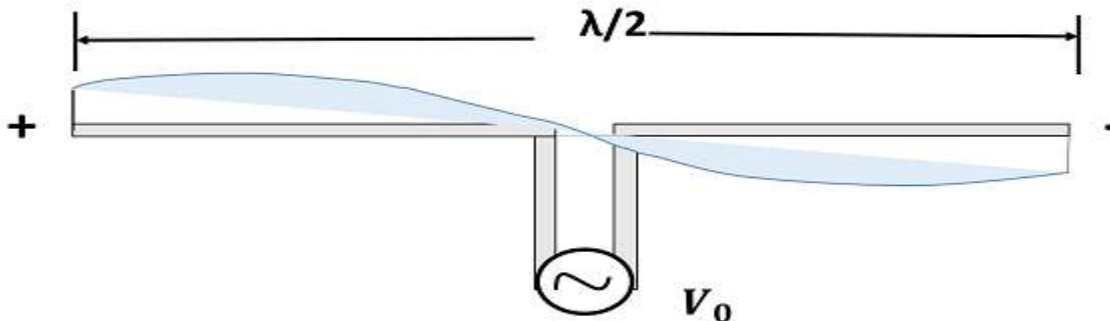
CONSTRUCTION & WORKING OF HALF-WAVE FOLDED DIPOLE

This antenna is commonly used with the array type antennas to increase the feed resistance. The most commonly used one is with Yagi-Uda antenna. The following figure shows a half-wave folded dipole antenna.



This antenna uses an extra conducting element (a wire or a rod) when compared with previous dipole antenna. This is continued by placing few conducting elements in parallel, with insulation in-between, in array type of antennas.

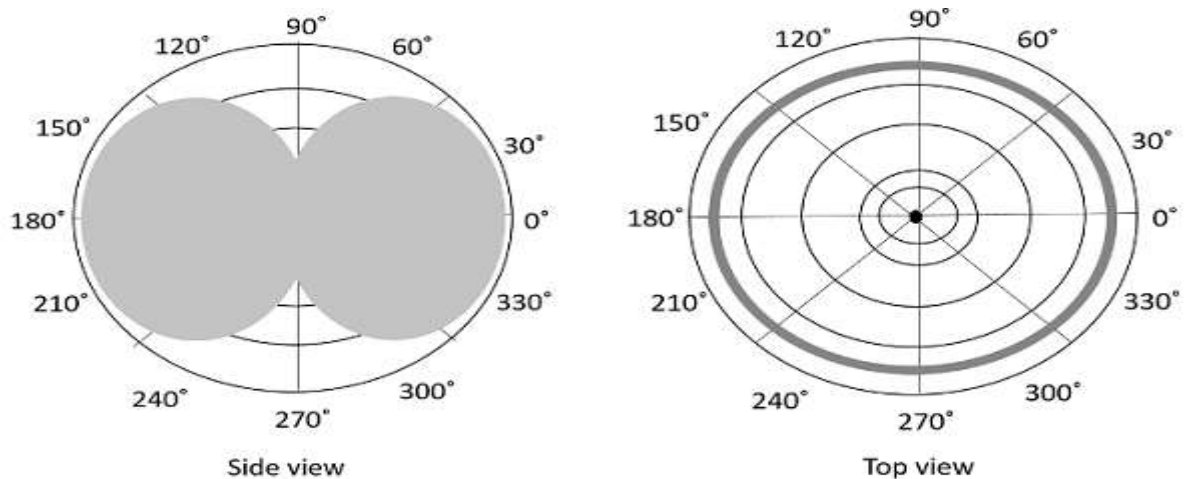
The following figure explains the working of a half-wave folded dipole antenna, when it is provided with excitation.



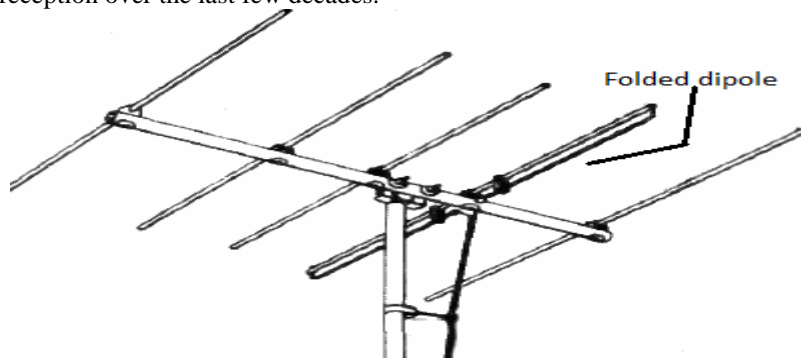
If the diameter of the main conductor and the folded dipole are same, then there will be four folded (two times of squared one) increase in the feed impedance of the antenna. This increase in feed impedance is the main reason for the popular usage of this folded dipole antenna. Due of the twin-lead, the impedance will be around 300Ω .

RADIATION PATTERN

The radiation pattern of half-wave folded dipoles is the same as that of the half-wave dipole antennas. The following figure shows the radiation pattern of half-wave folded dipole antenna, which is **Omni-directional** pattern.



Half-wave folded dipole antennas are used where optimum power transfer is needed and where large impedances are needed. This folded dipole is the main element in **Yagi-Uda antenna**. The following figure shows a **Yagi-Uda antenna**, which we will study later. The main element used here is this folded dipole, to which the antenna feed is given. This antenna has been used extensively for television reception over the last few decades.



ADVANTAGES

The following are the advantages of half-wave folded dipole antenna –

- Reception of balanced signals.
- Receives a particular signal from a band of frequencies without losing the quality.
- A folded dipole maximizes the signal strength.

DISADVANTAGES

The following are the disadvantages of half-wave folded dipole antenna –

- Displacement and adjustment of antenna is a hassle.
- Outdoor management can be difficult when antenna size increases.

APPLICATIONS

The following are the applications of half-wave folded dipole antenna –

- Mainly used as a feeder element in Yagi antenna, Parabolic antenna, turnstile antenna, log periodic antenna, phased and reflector arrays, etc.
- Generally used in radio receivers.
- Most commonly used in TV receiver antennas.

SUPPOSING THAT YOU LIKE THE FIELD OF ANTENNAS AND ELECTROMAGNETICS SO MUCH THAT YOU WOULD CONSIDER DOING IT FOR A CAREER, WHAT TYPES OF OPPORTUNITIES ARE AVAILABLE

1. PRIVATE-SECTOR ANTENNA JOBS

- Consumer electronics companies (Research in Motion, Apple, Samsung, HP, etc) hire antenna engineers to assist in developing their products. The antenna engineers are responsible for these areas:
 - antenna design (including working with product development teams to define appropriate antenna volumes, geometry, impedance matching etc)
 - integration (ensuring the antenna continues to radiate as the product goes from prototype to production stage, ensuring antenna is manufacturable)
 - product testing (which includes defining minimum acceptance levels and ensuring product quality, setting VSWR specs, etc)
 - failure analysis (determining why failed or returned products fail and how this can be corrected).
- These jobs tend to be higher paying, but have longer hours and tighter deadlines.

2. DEFENSE DEPARTMENT OR GOVERNMENT JOBS

A big area for antenna engineers is working on defense programs, particularly in the India. I classify these as government jobs because the customer is the government, and they essentially set the rules and overall tone for the companies.

These jobs are less concerned with manufacturability and antenna design, and more focused on research and integration. Antenna engineers at defense companies tend to write a lot of code for antenna or general electromagnetic analysis.

Antenna systems on defense aircraft are to work over frequency ranges from "D.C. to daylight", which for practical purposes is something like 3 MHz - 40 GHz. As such, antenna systems on defense aircraft are typically very complex, often with upwards of a hundred antennas on a single aircraft. Antenna engineers in this world struggle with antenna to antenna coupling, field of view requirements, making radomes so antennas are more aerodynamic, etc.

3. RESEARCH (UNIVERSITY) JOBS

These careers are all about publishing in the journal IEEE Transactions on Antennas and Propagation. The positions can be as a professor or as a full-time researcher. These jobs are almost exclusively in the University world, but some National Labs also have research positions where the primary goal is to publish.

Some active areas of research include:

Meta-Material Antennas

Electromagnetic Solver Development (FDTD, MoM, FEM, etc.)

Experimental Areas such as "cloaking"

Antenna Miniaturization

Antenna Array Optimization (weights, positions, etc)

SAR reduction for mobile phone antennas

BROADBAND ANTENNAS

Obtaining these positions is all about publishing. A Ph.D. is a necessity, and the more conference and journal publications you have the more likely you are to land a position here. These jobs typically involve some amount of teaching responsibility, student mentorship, and a fair amount of grant or proposal writing to obtain funding for your research.

CONCLUSION

Antenna is a device that converts one form of energy into another form of energy. Antenna is very useful in the communication system. There are different types of antenna and they have different size . A few were mentioned in this paper

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