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Original Research Paper

Engineering

Design of Dipole Antenna and various radiation patterns for various lengths

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ABSTRACT

The dipole antenna or dipole aerial is one of the most important and commonly used types of RF antenna. It is widely used on its own, and it is also incorporated into many other RF antenna designs where it forms the driven element for the antenna. In this paper, an attempt has been made to investigate new half wave dipole antenna for GSM Applications. A dipole antenna approximately one half wavelength long is the half wave dipole antenna. The dipole antenna is very well known among the amateur community so this may be old hat to many. I am providing this page because the dipole antenna is often overlooked nowadays as an effective means to getting on the air. Many hams these days believe it is necessary to purchase an expensive commercial antenna or have a large antenna at great heights in order to be successful at HF/VHF communications. On the other hand, when other simple antennas are constructed many of the designs chosen require an extensive ground system to be effective. The loss due to an inadequate. A dipole can be fed with RF energy anywhere along its length although center feed is the most common followed by end feed. The antenna is made to resonate at the 1.995 GHz frequency. Matlab Software is used for the simulation and design calculations of the dipole antennas. The antenna exhibits a frequency band from 1.877 GHz to 2.1199 GHz which is suitable for applications.

KEYWORDS :

I.Introduction

In radio and telecommunications a dipole antenna or doublet is the simplest and most widely used class of antenna. The dipole is any one of a class of antennas producing a radiation pattern approximating that of an elementary electric dipole with a radiating structure supporting a line current so energized that the current has only one node at each end.A dipole antenna commonly consists of two identical conductive elements such as metal wires or rods, which are usually bilaterally symmetrical. The driving current from the transmitter is applied, or for receiving antennas the output signal to the receiveris taken, between the two halves of the antenna. Each side of the feedline to the transmitter or receiver is connected to one of the conductors. This contrasts with a monopole antenna, which consists of a single rod or conductor with one side of the feedline connected to it, and the other side connected to some type of ground. A common example of a dipole is the "rabbit ears" television antenna found on broadcast television sets.

The most common form of dipole is two straight rods or wires oriented end to end on the same axis, with the feedline connected to the two adjacent ends, but dipoles may be fed anywhere along their length. This is the simplest type of antenna from a theoretical point of view. Dipoles are resonant antennas meaning that the elements serve as resonators with standing waves of radio current flowing back and forth between their ends. So the length of the dipole elements is determined by the wavelength of the radio waves used. The most common form is the half-wavedipole, in which each of the two rod elements is approximately 1/4 wavelength long, so the whole antenna is a half-wavelength long. The radiation pattern of a vertical dipole is omnidirectional it radiates equal power in all azimuthal directions perpendicular to the axis of the antenna.

For a half-wave dipole the radiation is maximum, 2.15 dBi perpendicular to the antenna axis, falling monotonically with elevation angle to zero on the axis, off the ends of the antenna. Several different variations of the dipole are also used, such as the folded dipole, short dipole, cage dipole, bow-tie, and batwing antenna. Dipoles may be used as standalone antennas themselves, but they are also employed as feed antennas (driven elements) in many more complex antenna types such as the Yagi antenna, parabolic antenna, turnstile antenna, log periodic antenna, and phased array. The dipole was the earliest type of antenna; it was invented by German physicist Heinrich Hertz around 1886 in his pioneering investigations of radio waves.

II.Dipole Antenna Characteristics

As the name suggests the dipole antenna consists of two terminals or "poles" into which radio frequency current flows. This current and the associated voltage causes and electromagnetic or radio signal to be radiated.

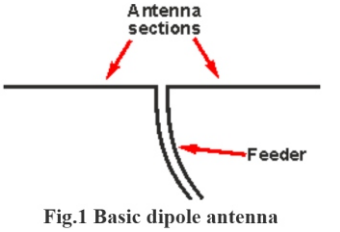

Fig.1 Basic dipole antenna

As seen the antenna consists of a radiating element that is split, normally in the centre to allow a feeder to apply power to it from a transmitter, or to take power from it to a receiver.

The length of the radiating element determines many of the properties of the dipole antenna from its impedance, centre operating frequency, etc. As such this is an important feature of the antenna.Often the term dipole antenna tends to indicate a half wave dipole. This is by far the most widely used length for a dipole. It forms a resonant circuit which resonates where the electrical length is half a wavelength long - the electrical length differs from the wavelength of the signal in free space because of a number of the effects of the radiating element on the signal and it is very slightly shorter than the signal e/m wavelength in free space.

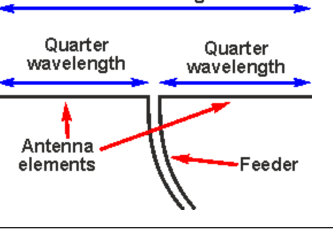

Fig.2 Half wave dipole antenna

Although the half wavelength dipole antenna is the most popular, a variety of other formats are also available.

Dipole Types

The dipole antenna consists of two conductive elements such as metal wires or rods which are fed by a signal source or feed energy that has been picked up to a receiver. The energy may be transferred to and from the dipole antenna either directly straight into a from the electronic instrument, or it may be transferred some distance using a feeder. This leaves considerable room for a variety of different antenna formats.

Although the dipole antenna is often though in its half wave format, there are nevertheless many forms of the antenna that can be used.

- Half wave dipole antenna: The half wave dipole antenna is the one that is most widely used . Being half a wavelength long it is a resonant antenna. Multiple half waves dipole antenna: It is possible to utilise a dipole antenna or aerial that is an odd multiple of half wavelengths long.
- Folded dipole antenna: As the name implies this form of the dipole aerial or dipole antenna is folded back on itself. While still retaining the length between the ends of half a wavelength, an additional length of conductor effectively connects the two ends together.
- ·Short dipole: A short dipole antenna is one where the length is much shorter than that of half a wavelength. Where a dipole antenna is shorter than half a wavelength, the feed impedance starts to rise and its response is less dependent upon frequency changes. Its length also becomes smaller and this has many advantages. It is found that the current profile of the antenna approximately a triangular distribution. Read more about the Short-dipole
- Non-resonant dipole: A dipole antenna may be operated away from its resonant frequency and fed with a high impedance feeder. This enables it to operate over a much wider bandwidth.
- III. Dipole Antenna Current & Voltage Distribution

The current and voltage on a radiating element vary along the length of the dipole. This occurs because standing waves are set up along the length of the radiating element and as a result peaks and troughs are found along the length.The current falls to zero at the end and rises towards the middle. Conversely, the voltage peaks at the end and falls as the distance from the end increases.

Both the current and voltage on the dipole antenna vary in a sinusoidal manner, meaning that there may be other peaks and troughs along the length of the radiating sections dependent upon their length. The most popular form of dipole antenna is the half wave and for this, the current is at a minimum at the ends and rises to a maximum in the middle where the feed is applied. Conversely the voltage is low at the middle and rises to a maximum at the ends. It is generally fed at the centre, at the point where the current is at a maximum and the voltage a minimum. This provides a low impedance feed point which is convenient to handle. High voltage feed points are far less convenient and more difficult to use. When multiple half wavelength dipoles are used, they are similarly normally fed in the centre. Here again the voltage is at a minimum and the current at a maximum. Theoretically any of the current maximum nodes could be used.

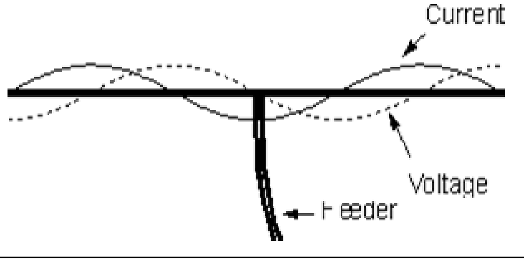

Fig 3.Three half wavelength wave dipole antenna

The dipole antenna is a particularly important form of RF antenna which is very widely used for radio transmitting and receiving applications. The dipole is often used on its own as an RF antenna, but it also forms the essential element in many other types of RF antenna. As such it is the possibly the most important form of RF antenna.

Half wave dipole length

As the name implies the length of the dipole is a half wavelength. The actual length is slightly shorter than a half wavelength in free space because of a number of effects.Calculations for the for the length of the half wave dipole antenna take into account elements such as the ratio of the thickness or diameter of the conductor to the length, dielectric constant of the medium around the radiating element and so forth.

It is possible to shorten the length of a half wave dipole antenna, or any antenna radiating element for that matter by adding a loading inductor. This is placed in the radiating element. It works because the dipole antenna can be considered as a resonant circuit consisting of a capacitor and inductor. Adding additional inductance will lower the resonant frequency, i.e. a given antenna length will resonate at a lower frequency than that which would be possible had no inductor be present. In this way it is possible to shorten the length of the antenna.

Half wave dipole field strength

It is possible to plot the field strength for an antenna at a distance from the radiating element to see its radiation pattern. For a complete 3D view of the radiation pattern both φ and θ angels are required. However to simplify the overall calculations it is possible to express the field strength levels in the planes of interest. These are generally viewed as cross sections through the overall 3D pattern. The most frequently used one are the horizontal where φ=90° and the vertical planes.

$$E = \frac{60\,I}{r}\left(\frac{\cos\left(\frac{\pi}{2}\cos\theta\right)}{\sin\theta}\right)$$

Using the half wave dipole formula given above it is possible to determine the radiation pattern of the half wave dipole antenna from the far field E vector.

Half wave Dipole Radiation pattern & Directivity

Using the half wave dipole formula, it is possible to calculate the radiation pattern and hence determine the directivity.

As expected the maximum half wave dipole directivity shows the maximum radiation at right angles to the main radiator.

At other angles, the angle θ in the half wave dipole formula above can be used to determine the field strength.

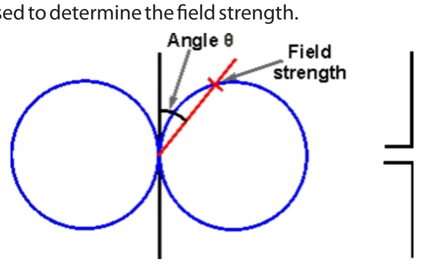

Fig .4 Half-wave dipole radiation pattern

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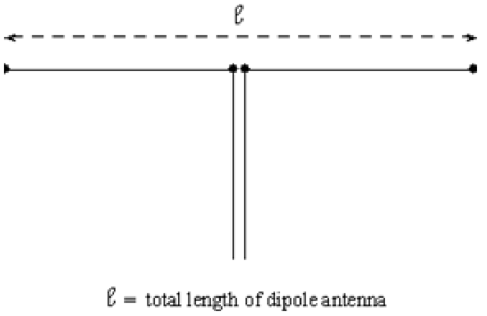
It is also possible to view the radiation pattern in terms of the plane looking around the dipole antenna, i.e. in the plane cutting the dipole in its field of maximum radiation.

IV. Dipole Antenna Radiation Pattern

The basic attributes of a dipole antenna pattern are illustrated in the following figure, in which the dimension labeled with a script l represents the length of the antenna:



Dipole radiation is lateral to the axis of the antenna and is simulated for a wide range of antenna lengths, from values less than the wavelength of the signal to values several times the wavelength.

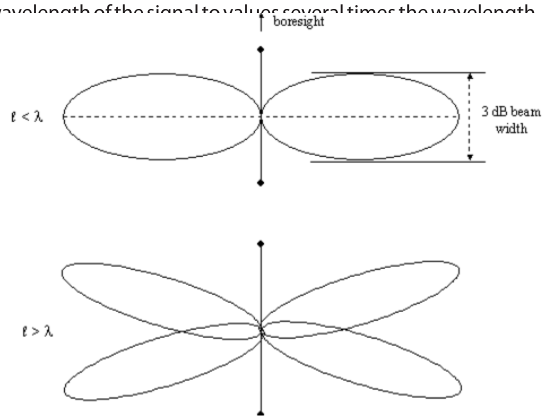
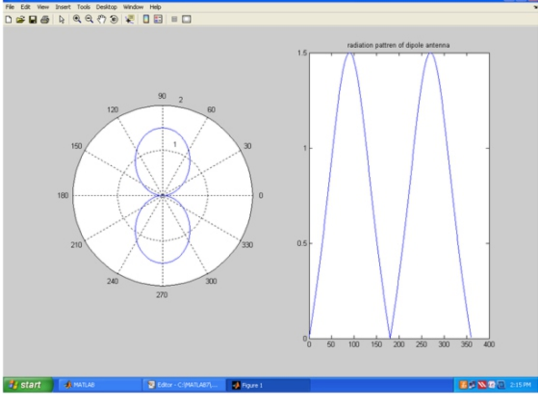


Fig.5 Dipole radiation & antenna length/wavelength ratio

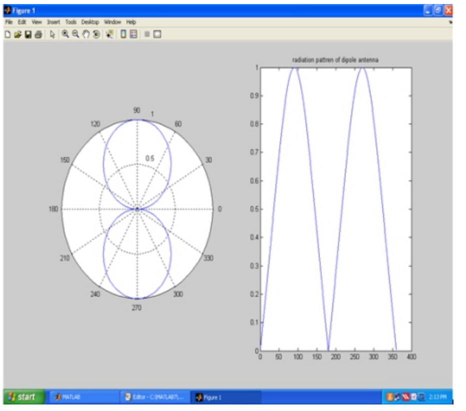
The antenna's 3 dB beam width is proportionate to its length in this case. However, if the antenna length exceeds the wavelength, the sidelobe splits one or more times and the 3 dB beamwidth is not predictable in the present model.

V. MATLAB RESULTS

Radiation Pattern Of Length λ/2



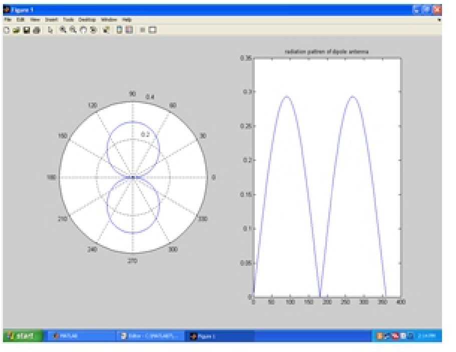
Radiation pattern of length λ/4

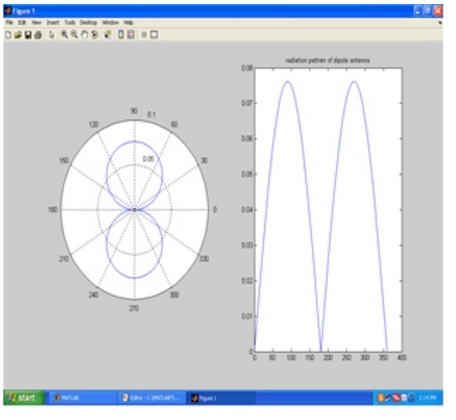


Radiation pattern of length λ/8

V. MATLAB RESULTS

Radiation Pattern Of Length λ/2





Radiation pattern of length λ/16

VI. Conclusion

The above results show that dipole antenna is designed for different various lengths and simulated in MATLAB with different variations of lengths.

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