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Research paper

Design of high directional crossed dipole antenna with metallic sheets for UHF and VHF applications

I. Govardhani, M. Venkata Narayana, A. Navya, A.Venkatesh, S.Charles Spurjeon, S. Sai Venkat, S. Sanjay

Department of ECE, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Guntur, Andhra Pradesh, India 522502
**Corresponding author E-mail: govardhanee_ec@kluniversity.in*

Abstract

A compact dual band cross dipole antenna surrounded with metallic plates at five sides has been proposed in this article. comparative analysis has been done between the dipole and cross dipole antenna. On comparing these two antennas the proposed antenna has the high gain of 7db and radiation efficiency of 95 percent. The peak directivity of the proposed antenna is 5DB and its front to back ration is 60. The return loss, gain, radiation patterns and co polarization and cross polarization of the antenna has been observed and analysed using AN-soft HFSS v13.The proposed antenna works at the range of 0.6GHz to 1.5GHz which covers the applications like GSM, GNSS and some of the applications which covers in the range of UHF and VHF.

Key words: *Dipole antenna, cross dipole antenna, Metallic sheets, HFSS v13.*

1. Introduction

To increase the impedance bandwidth [1] of an antenna for WLAN/LTE applications, a printed dual-wideband U-shaped antenna which is of magneto-electric dipole having u shape tapered line and meandering t shape and omnidirectional antenna having composite feeding structure is proposed. The antenna is fabricated on fr4 substrate which is compared with the existing technique like ME dipole is proposed in [2] axial ratio and impedance enhancement has been highlighted by the author the proposed antenna is working in the GPS i.e., L1 band which is used for the GPS application the magnetoelectric dipole antennas are observed in [3] which are of unique dimensions. The impedance characteristics and the bandwidth range front to back ratio, radiation efficiency, gain of the proposed antenna has been discussed. The ME antenna works at 2.4GHz which is under the range of WiMAX and Wi-fi. [4] proposed an antenna conventional substrate integrated waveguide concept with ME dipole antenna with a 4*4 element arranged for the substrate integrated waveguide. [5] proposed an antenna which is nearer to the Wi-MAX and Wi-fi bands. The antenna structures consist of two dipole models which are loaded with the ferrite coaxial cables is modelled and simulated on the commercially equipped tool of HFSS which is based on the FDTD method. [6] An axe dipole antenna is proposed by Thomas which has radiation efficient of 307MHz which is used for the textile approach which is having light weight and other increasable features. Some of the methods which are used for the proposed antenna performance can be used for the aerospace applications. [7] proposed a magneto electric dipole antenna which is having high gain, circular polarization and the impedance bandwidth. The gain of the antenna shows some variable changes and also this effect also increases the bandwidth and range of the antenna and also by using meta surface technique also the enhancement of range for frequency as well as bandwidth has been observed. [8] A dual-band dipole antenna with small quartz-copper reflector which is used as linear and planar set of elements. The proposed antenna has radiation efficiency more than 65 percent at operating bands and having the maximum gain of 18.7 dB at 5.2 THz frequency. [9] proposed a dual-polarized antenna which is having gain of 7.2 GHz the vswr radiation patterns of the proposed antenna has been discussed in this paper. A sum of nine horizontal dipoles and eight vertical dipoles have been placed in the proposed antenna [10] proposed an antenna which is the extensions of the stack parameters. The interesting parameters like impedance to the dipole length have been calculated in this work [11] furnished a work regarding the planar elliptical element dipole antenna which is of graphene floakes with high radiation efficiency and he also worked on the flexibility of that sheet by making it to a conformal structure and observed at different bending angles. [12] proposed antenna which is loaded with CRLH to load a dipole antenna. The proposed antenna is triple band antenna which is analysed with the gain characteristics. By using CLRH technique author noticed that the size reduction of about 5 percent is reduced when compared to conventional dipole. This antenna can be used in WIFI, digital cellular service and GPS bands. [13] A three layered dipole antenna has been proposed by the which is varied to work on the unlicensed band i.e., 57 to 71GHz resulted with deep discussion on it have been discussed in this article [14] a dipole antenna like structures consists of the piezoelectric components.[15] long has proposed two antennas that is probe fed rectangular shaped E-dipole design and the orthomode transducer fed triangular shaped E-dipole design.[16] author proposed a single-port broad beam cross-dipole antenna with enhanced low-elevation gain. Antenna consists of two dipoles using a cylindrical back cavity with corrugations on the sidewall. [17] combining the CP ME-dipole with single layer GWG for wide band feed network.

2. Design Topology

The designs of dipole antenna, crossed dipole antenna and crossed dipole antenna with metallic sheets has been made with the help of An-soft HFSS v13.The proposed antenna is the crossed dipole antenna which is surrounded by metallic plates with one side open. The design has made like this to obtain high directivity. Half wave dipole antenna the name itself indicates that this length is equal to the half wavelength at its operational frequency.
The height of this dipole antenna is 74mm and its resonant frequency is about 0.92GHz. The height of this halfwave dipole antenna is calculated by using the formulae shown below.

$$E_\theta = \frac{j\eta I_0 e^{-jkr}\cos\left(\frac{\Pi\cos\theta}{2}\right)}{2\Pi r\sin\theta}$$

$$H\phi = \frac{E_\theta}{\eta}$$

2.1 Dipole Antenna

A dipole antenna is nothing but a conductor which will measure the half wavelength but the feed line is connected to the center. The dipole antennas are used as a feed antenna for many devices besides of having complex antennas like phased array antenna, Yagi-uda antenna, reflective array antenna and parabolic antenna.

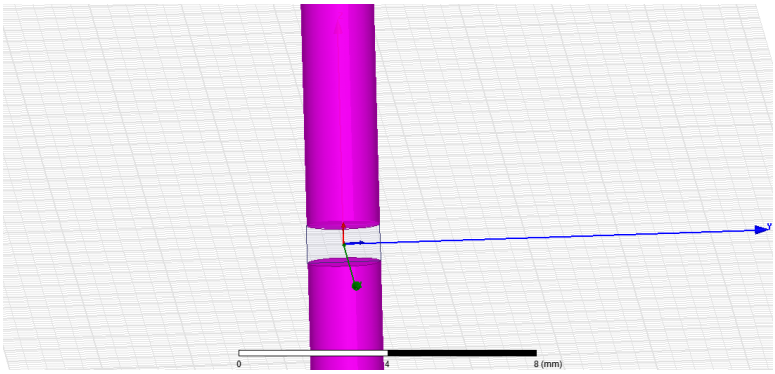

Fig.1: Structure of a Dipole antenna

2.2 Crossed dipole antenna

Crossed dipole antenna is nothing but the two dipole antennas are crossed with each other with 90^0 phase shifts as the long antennas are not suitable for every application. Here the length of the rod is about 74mm and the radius is 1mm this was chosen depending upon its operational frequency. Here these dipole antennas are made with the conducting material called aluminium.

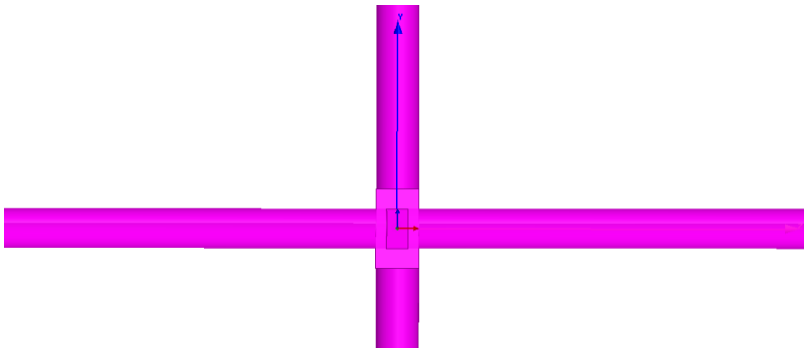

Fig.2: Structure of the crossed Dipole antenna

2.3 Crossed dipole antenna with metallic sheets

This has been made with the help of the crossed dipole antenna surrounded by the metallic sheets on all sides except one side because to improve the directivity of an antenna. Thus, the radiation pattern, return loss and gain of antenna is increased.

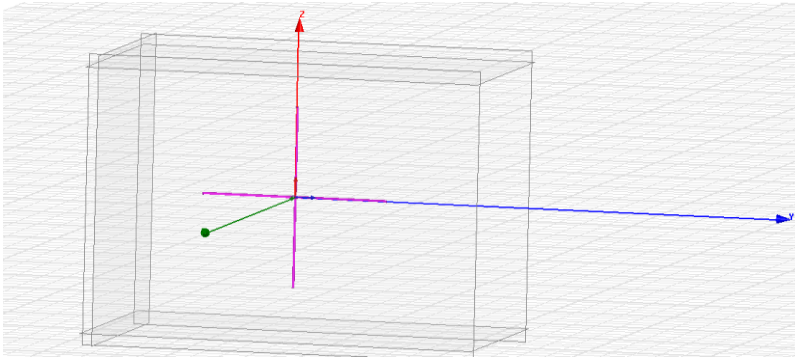

Fig.3: Crossed Dipole antenna with Metallic sheets

The above figure represents the crossed dipole antenna of radius 1mm and height of 74mm. here aluminium is used as the material because it is a perfect conducting material for the cylinders. The proposed antenna designed and excited using 50Ω coaxial line feeding. For practical applications the use of coaxial line feeding makes better antenna performance. At first a single dipole antenna is designed later a cross dipole is employed to the structure. A perfect electric conductor plates is applied on the five sides of the faces outside the cross-dipole antenna where one side is opened to generate the higher resonant mode.

3. Results & discussion

Antenna performance is shown in terms of gain, directivity and radiation pattern and those parameters are shown for dipole antenna, crossed dipole antenna and crossed dipole antenna with metallic sheets and each parameter is shown with the help of the schematic diagrams.

3.1 Dipole antenna

The parameters like return loss, gain, radiation pattern and VSWR for dipole antenna has been studied and their corresponding diagrams are shown with their corresponding plots.

3.2 Return loss

The return loss curve is as shown in the below figure and it is observed that the measured return loss is about -15.6dB at a frequency of 0.92GHz which may be treated as the resonant frequency.

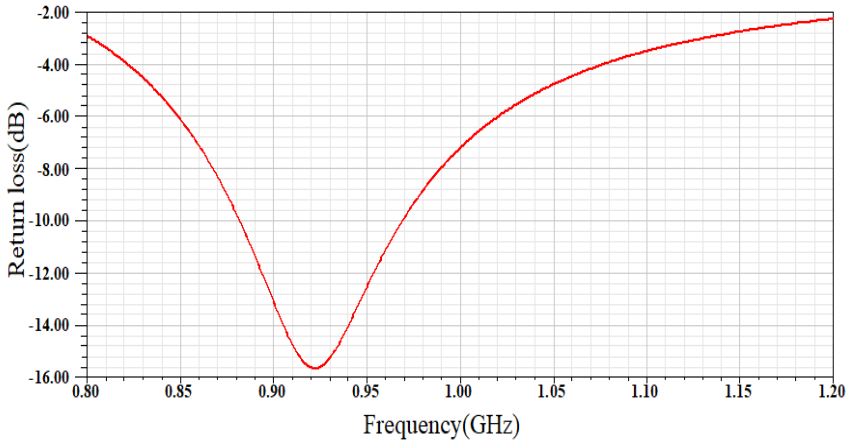

Fig.4: Return loss for Dipole antenna

3.3 Gain

A maximum gain of 2.5dB is obtained at a frequency range of 0.8GHz to 1.20GHz in which the 3D polar plot is as shown the below figure.

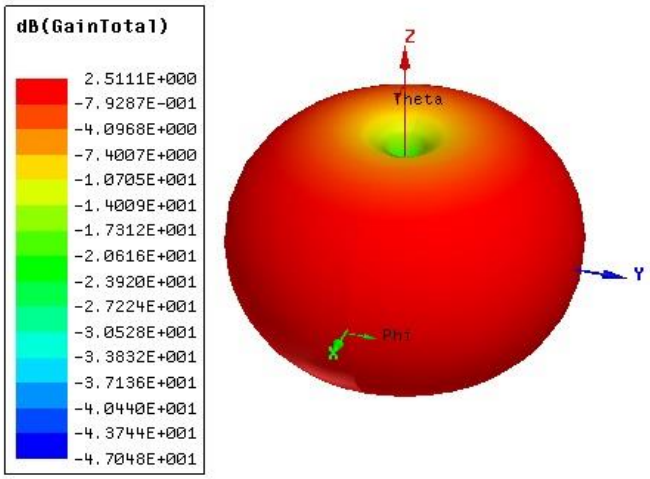

Fig.5: Gain for dipole antenna

3.4 Radiation pattern

The radiation pattern for the basic dipole antenna is as shown in the below figure and it is observed that it is having omnidirectional radiation pattern which is suitable for radar applications

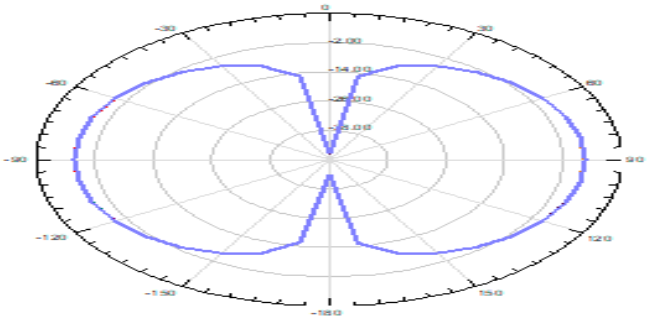

Fig.6: Radiation pattern for dipole antenna

3.5 VSWR

Generally, the voltage standing wave ratio for antenna should be greater than 2 and the plot for the voltage standing wave ratio is as shown in the below figure.

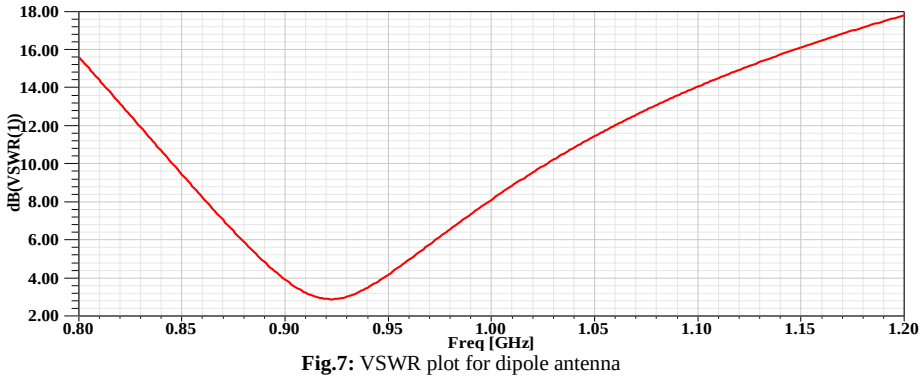

Fig.7: VSWR plot for dipole antenna

3.6 Crossed Dipole Antenna

The parameters like return loss, gain, radiation pattern and VSWR for crossed dipole antenna has been studied and their corresponding diagrams are shown with their corresponding plots.

3.7 Return loss

The return loss curve is as shown in the below figure and it is observed that the measured return loss is about -10.5dB at a frequency of 0.92GHz which may be treated as the resonant frequency.

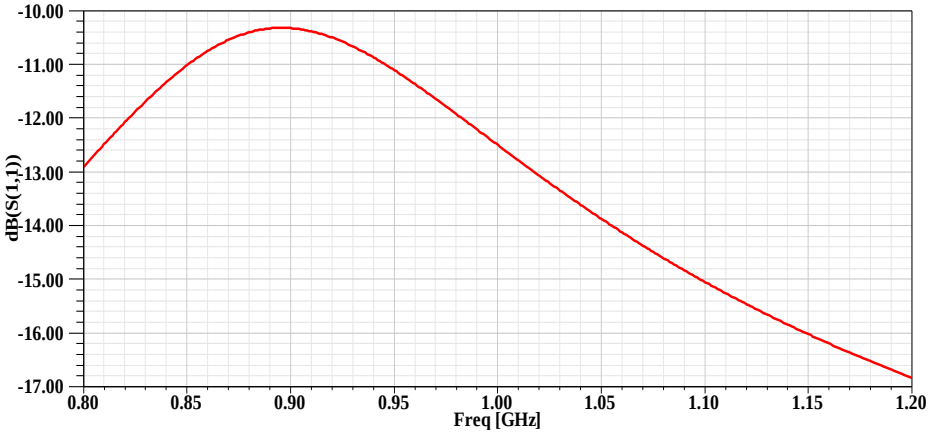

Fig.8: Return loss for crossed dipole antenna

3.8 Gain

A maximum gain of 2.8dB is obtained at a frequency range of 0.8GHz to 1.20GHz in which the 3D polar plot is as shown the below figure.

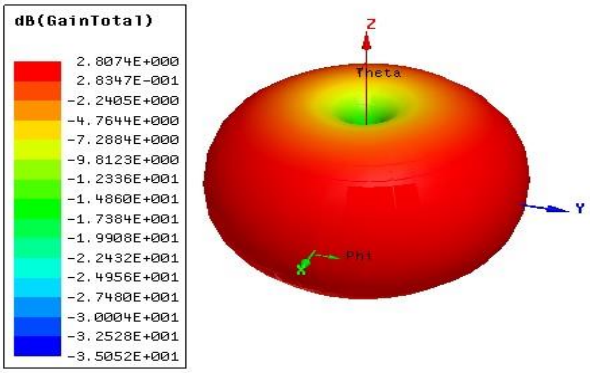

Fig.9: Gain of crossed dipole antenna

3.9 Radiation pattern

The radiation pattern for the crossed dipole antenna is as shown in the below figure and it is observed that it is having omnidirectional radiation pattern which is suitable for radar applications.

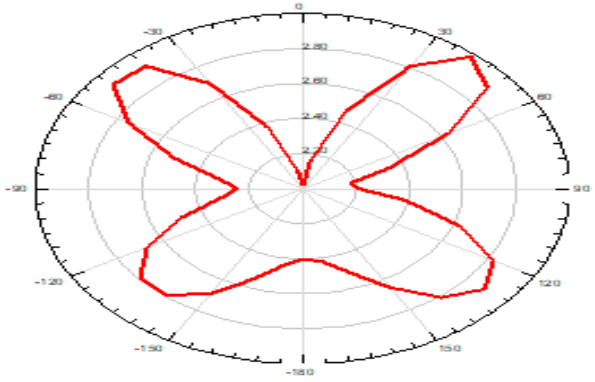

Fig.10: Radiation pattern for crossed dipole antenna

3.10 VSWR

Generally, the voltage standing wave ratio for antenna should be greater than 2 and the plot for the voltage standing wave ratio is as shown in the below figure.

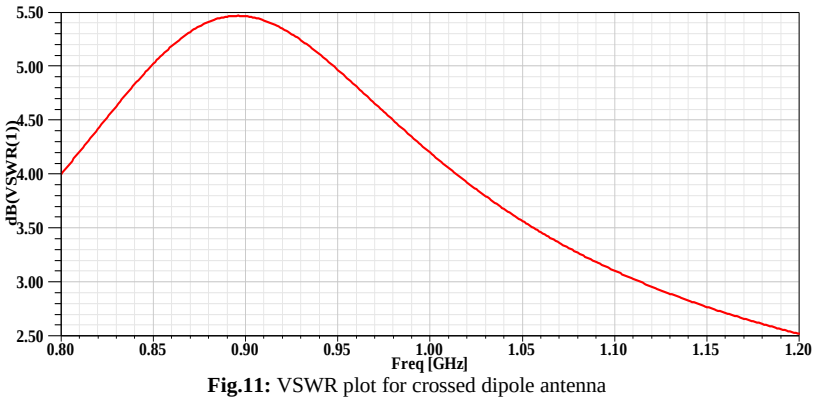

Fig.11: VSWR plot for crossed dipole antenna

3.11 Crossed Dipole Antenna with Metallic sheets

The parameters like return loss, gain, radiation pattern and VSWR for crossed dipole antenna with metallic sheets has been studied and their corresponding diagrams are shown with their corresponding plots.

3.12 Return loss

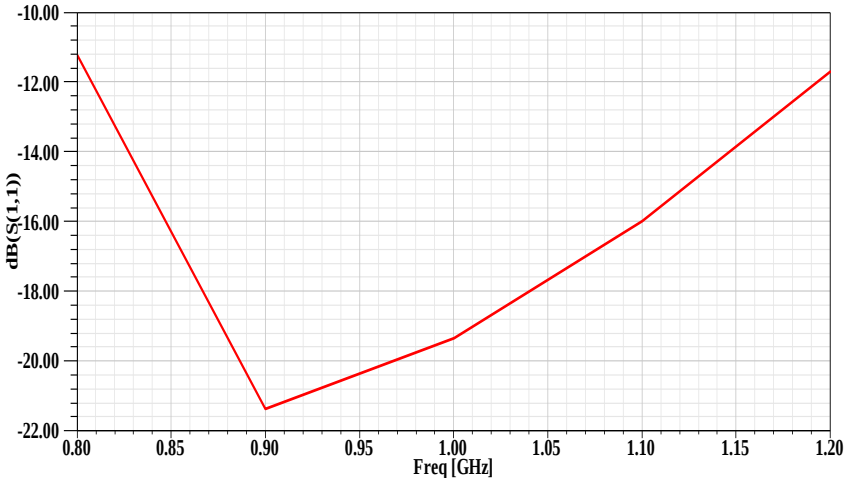

Fig.12: Return loss for crossed dipole antenna with metallic sheets.

The return loss curve is as shown in the below figure and it is observed that the measured return loss is about -21dB at a frequency of 0.92GHz which may be treated as the resonant frequency.

3.13 Gain

A maximum gain of 7.71dB is obtained at a frequency range of 0.8GHz to 1.20GHz in which the 3D polar plot is as shown the below figure.

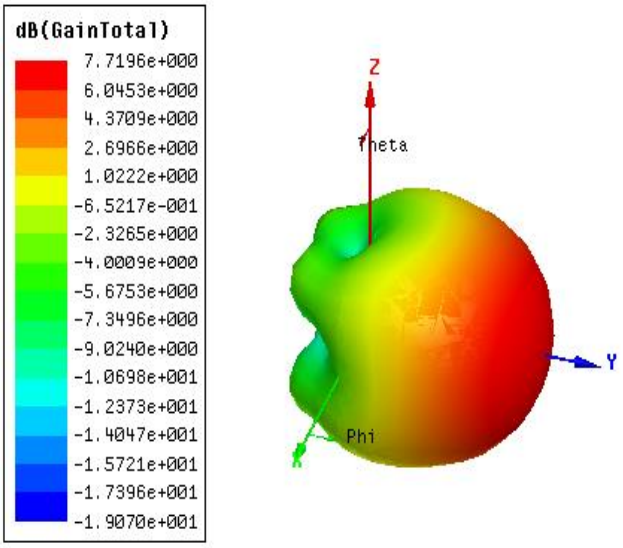

Fig.13: Gain for crossed dipole antenna with metallic sheets.

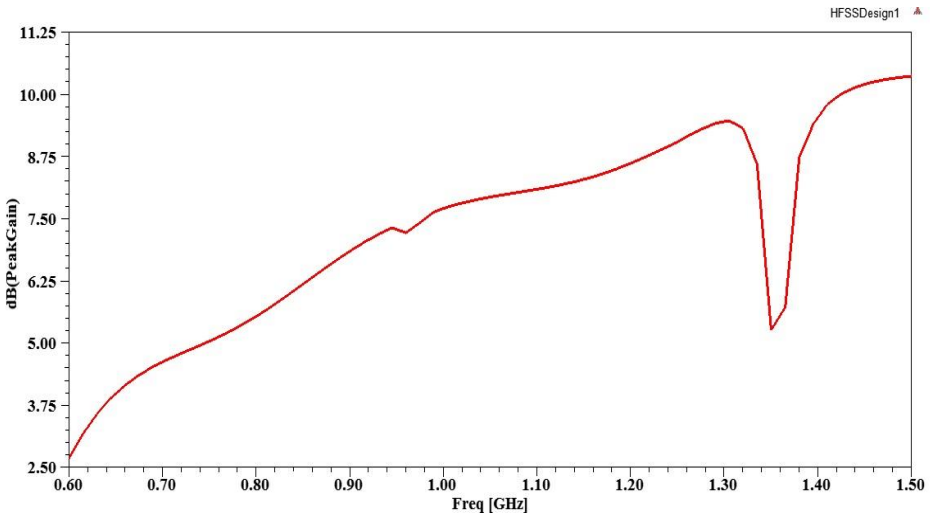

Fig.14: Gain vs Frequency of the crossed dipole antenna with metallic sheets

The plot gain vs frequency clearly indicates the gain enhancement and depletion in the region of the notch bands. A slight dip in the first notch band and a high dip at the other notch band. The proposed antenna having a peak gain of 7db.

The radiation pattern for the crossed dipole antenna with metallic sheets is as shown in the below figure and it is observed that it is having omnidirectional radiation pattern which is suitable for radar applications and it is having co-polarisation and cross-polarisation radiation pattern shown below.

3.14 Radiation Pattern

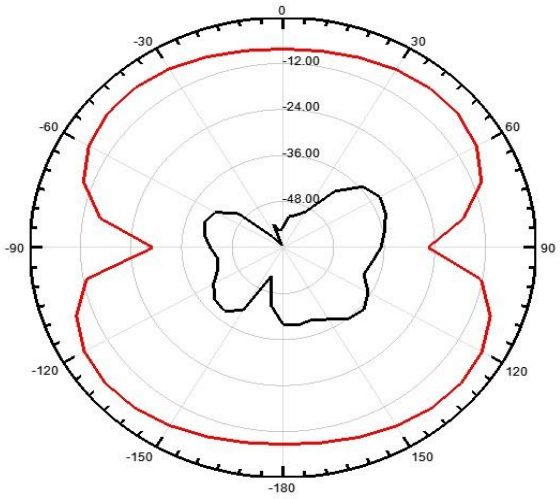

Fig.15: Co-polarisation radiation pattern for crossed dipole antenna with metallic sheets.

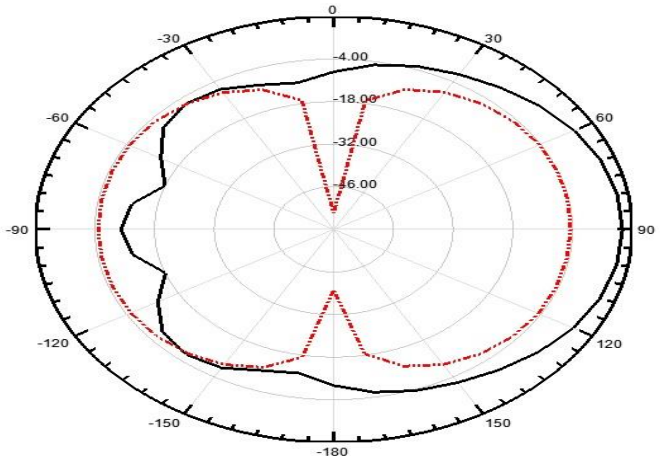

Fig.16: Cross-polarisation radiation pattern for crossed dipole antenna with metallic sheets.

VSWR

Generally, the voltage standing wave ratio for antenna should be greater than 2 and the plot for the voltage standing wave ratio is as shown in the below figure.

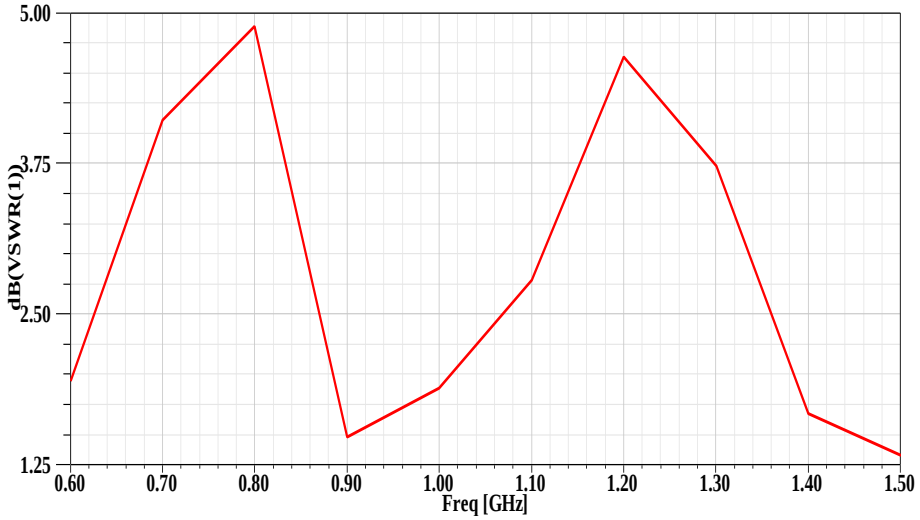

Fig.17: VSWR plot for crossed dipole antenna with metallic sheets.

4. Comparison of All the Models

All these models are compared along with their characteristics and has been presented. It is seen that the dipole antenna works at single band and cross dipole works throughout the band. It is observed that resonant frequency of dipole antenna is same as the low resonant frequency of cross dipole antenna. A new approach by implementing a metallic plate which is loaded with PEC material to five sides the cross-sectional antenna has been proposed. The antenna has good radiation characteristics and high gain when compared with the conventional dipole and cross dipole antenna. A gain of 7 dB and radiation efficiency of about 95 percent have been noticed in the proposed model. The crossed dipole antenna with metallic sheets is used in GSM, WCDMA and some biomedical antenna applications.

Model type	Maximum Return loss	Gain	Notches	Notch band range	Front to back ratio	Average radiation efficiency
Dipole Antenna	-15dB	2.5dB	-	-	60	78
Cross dipole Antenna	-20dB	2.8dB	-	-	57	80
Crossed dipole antenna with metallic sheets	-24dB	7.5dB	2	0.72-0.80GHz, 1.22-1.27GHz	62	85

5. Conclusion

Comparison between Dipole antenna, Cross dipole antenna and crossed dipole antenna with metallic sheets has been done. After comparing all these models, the crossed dipole antenna with metallic sheets has dual band characteristics in the range of 0.6 GHz to 1.5Ghz and it is easy to implement. The desired notch band characteristics have been observed at this crossed dipole antenna with metallic sheets. A high gain, notching and also good radiation patterns have been observed from this crossed dipole antenna with metallic sheets.

6. Future scope

In future cloaking concept may be applied to this crossed dipole antenna with metallic sheets, this is applied by enclosing this in a cylinder which may be treated as the radiation box and this is helpful to preserve the characteristics of an antenna like return loss gain and radiation pattern.

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