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Optimizing Highly Directional Crossed Dipole Antennas with Metallic Sheets for UHF and VHF Frequency Ranges

I. Govardhani, Koneru Lakshmaiah Education Foundation (KLEF), Vaddeswaram 522302, Andhra Pradesh, India

Abstract

The proposed antenna achieves a peak directivity of 5 dB and boasts a notably high front-to-back ratio of 60. Thorough observations and analyses, including parameters such as return loss, gain, radiation patterns, co-polarization, and cross-polarization, have been meticulously conducted using AN-soft HFSS v13. This comprehensive examination aims to elucidate the intricate behavior and performance characteristics of the antenna. Operating effectively within the frequency range of 0.6 GHz to 1.5 GHz, the proposed antenna design caters to crucial applications such as GSM, GNSS, and a spectrum of other utilities encompassing the UHF and VHF frequency bands. The strategic placement of metallic plates surrounding the antenna plays a pivotal role in enhancing its performance, bolstering its gain, directivity, and overall efficiency. In conclusion, this article introduces an innovative and compact dual-band cross-dipole antenna configuration, enriched by the integration of metallic plates, which significantly enhances its performance."

Introduction

In the realm of wireless communication systems such as WLAN and LTE, the quest for enhanced performance has led to the development of innovative wideband antenna designs. This article presents a comprehensive overview of cutting-edge techniques and approaches employed to increase impedance bandwidth, catering to the requirements of applications like Wi-Fi, WiMAX, and GPS. The proposed solution introduces a printed dual-wideband U-shaped antenna [1], featuring a magneto-electric (ME) dipole configuration with unique elements like a tapered u-shaped line and a meandering t-shape. This design also incorporates an omni directional antenna structure with a composite feeding approach. Fabricated on an FR4 substrate, the antenna's performance is evaluated and compared with existing techniques [2]. Various strategies have been explored to achieve enhanced performance. Notably, the ME dipole concept has been implemented, showcasing improvements in axial ratio and impedance. The proposed antenna's operation within the GPS L1 band offers potential for GPS applications. Additionally, magneto electric dipole antennas operating at 2.4 GHz (WiMAX and Wi-Fi bands) have been investigated [3]. Incorporating advancements in substrate integrated waveguide (SIW) technology, a dual-band ME dipole antenna with a 4x4 element arrangement has been proposed [4]. The introduction

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of meta-surface techniques and unique dipole configurations has further expanded the antenna's bandwidth and frequency range. A comprehensive exploration of diverse dipole configurations, such as dual-polarized arrays, graphene-based structures, and innovative loading methods, has yielded antennas with impressive radiation efficiency, gain, and multi-band capabilities

Design topology:

Dipole Antenna

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

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

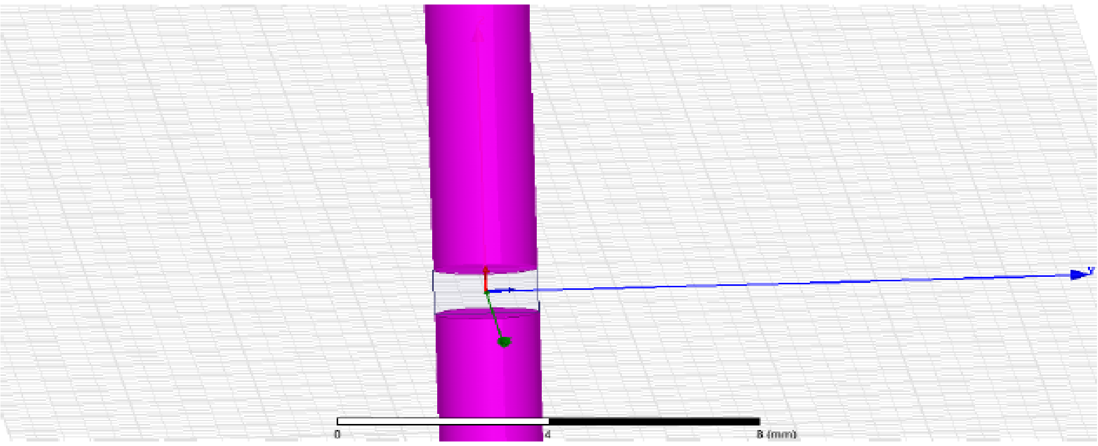

Fig.1: Structure of a Dipole antenna

Crossed Dipole Antenna

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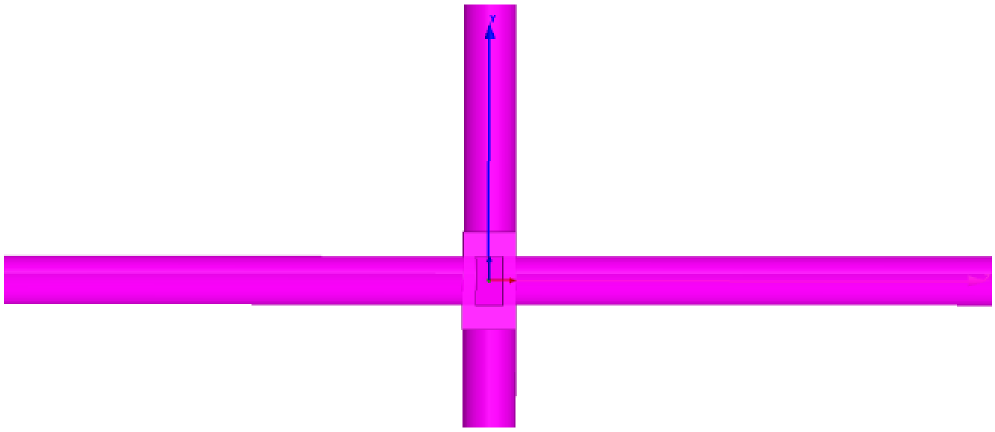

Fig.2: Structure of the crossed Dipole antenna

Crossed Dipole Antenna with meatallic sheets

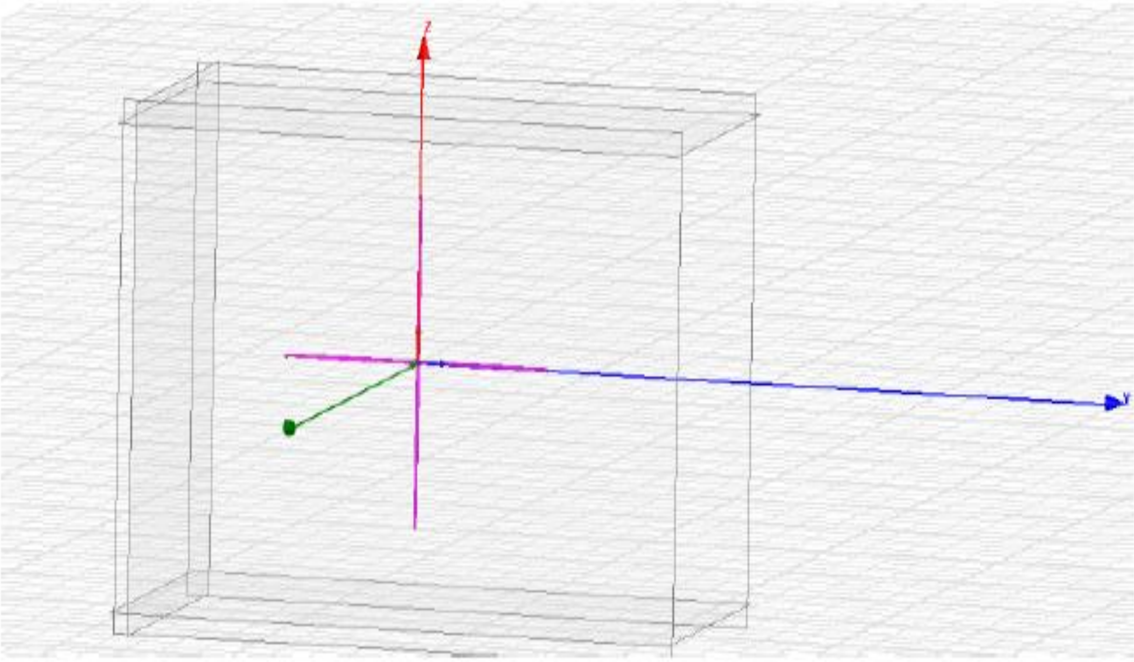

Fig.3: Crossed Dipole antenna with Metallic sheets

Results

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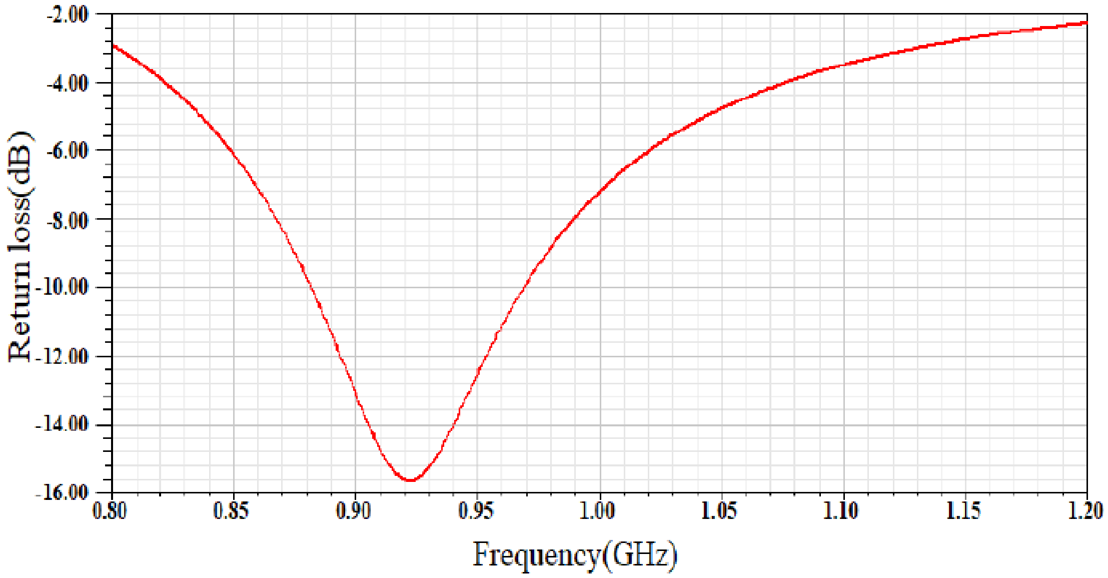

Fig.4: Return loss for Dipole antenna

Gain

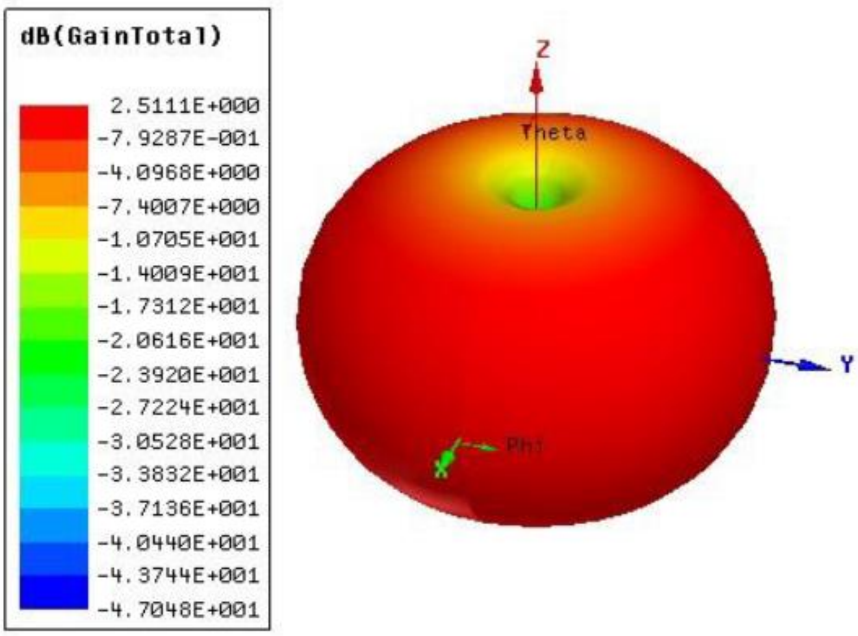

Fig.5: Gain for dipole antenna

Radiation pattern

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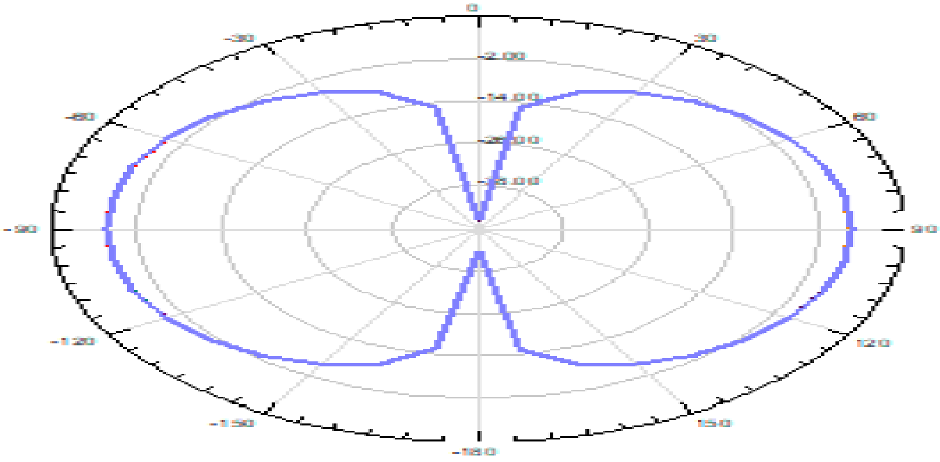

Fig.6: Radiation pattern for dipole antenna

VSWR

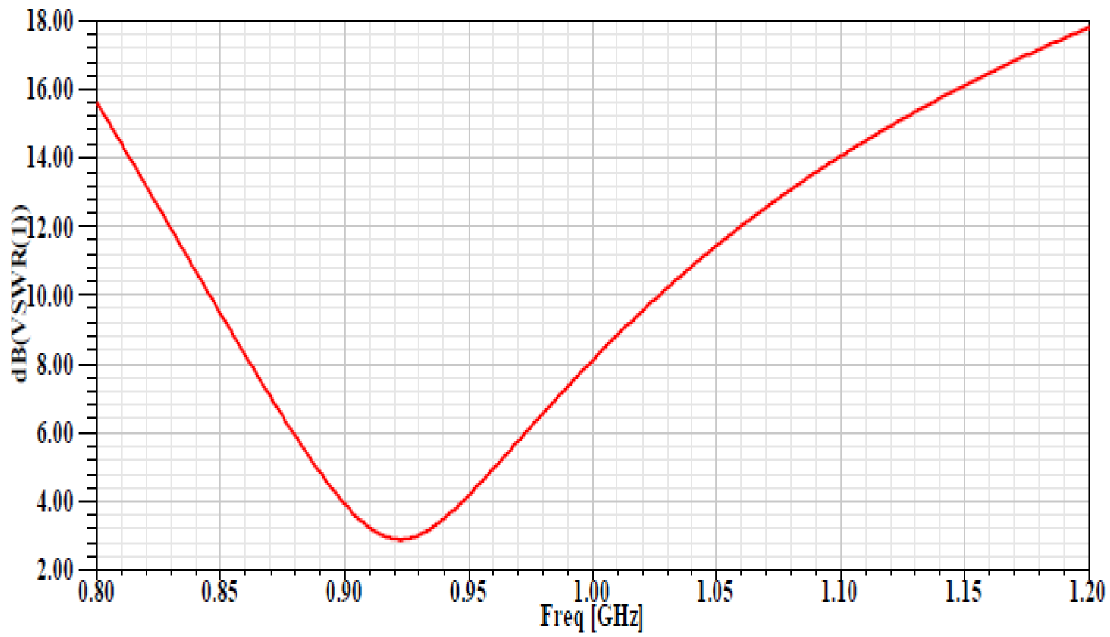

Fig.7: VSWR plot for dipole antenna

Crossed dipole antenna

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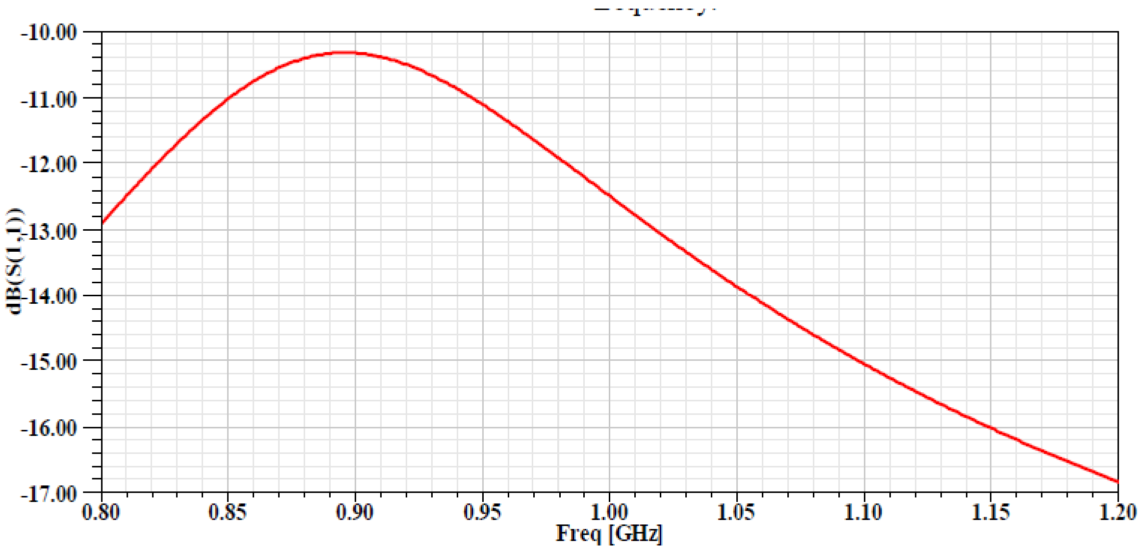

Fig.8: Return loss for crossed dipole antenna

Gain

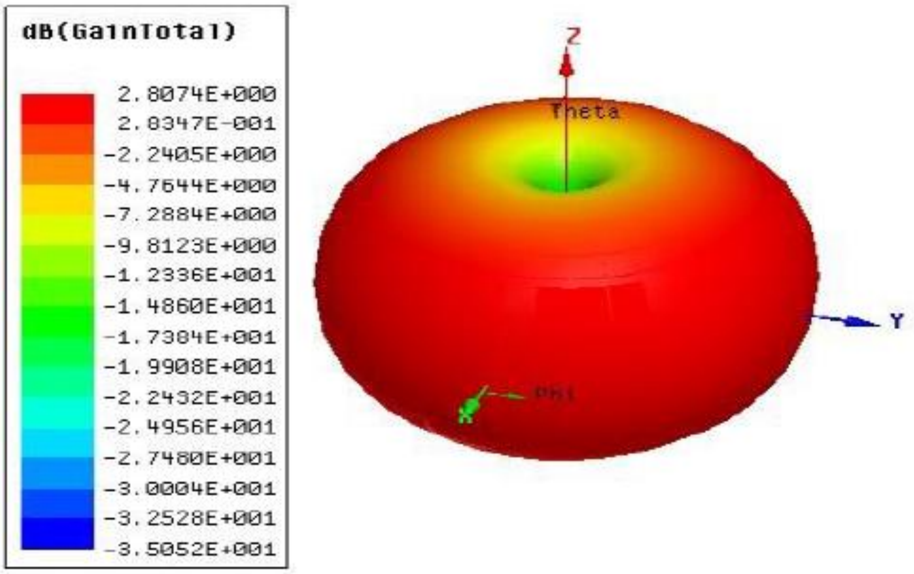

Fig.9: Gain of crossed dipole antenna

Radiation pattern

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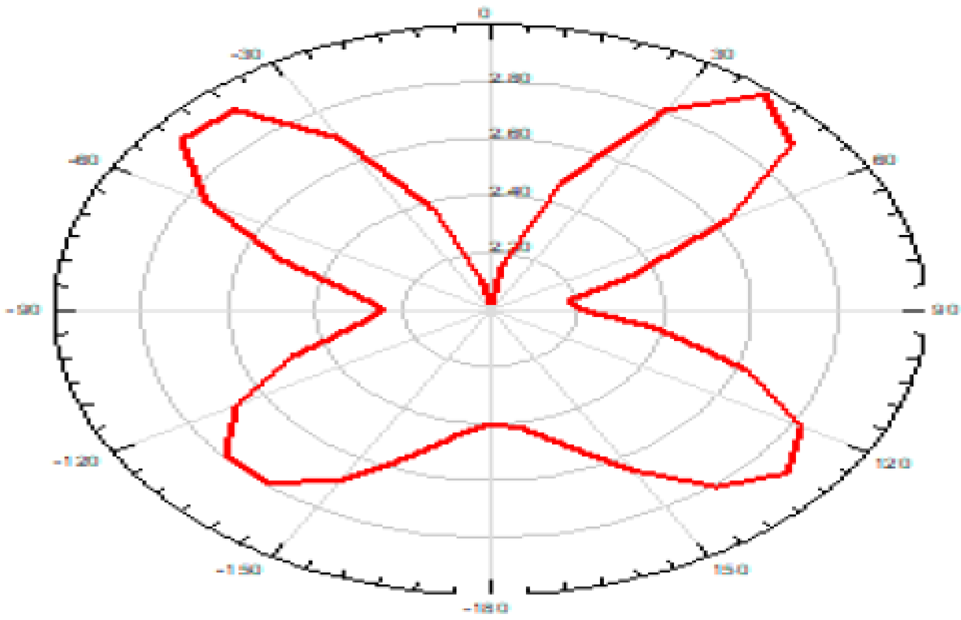

Fig.10: Radiation pattern for crossed dipole antenna

VSWR

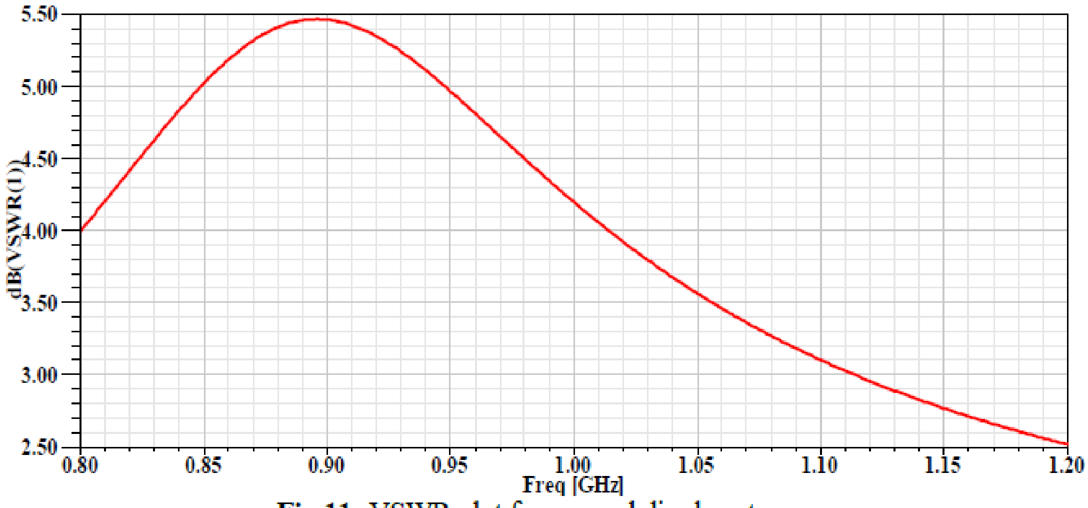

Fig.11: VSWR plot for crossed dipole antenna

Crossed dipole antenna with metallic sheets

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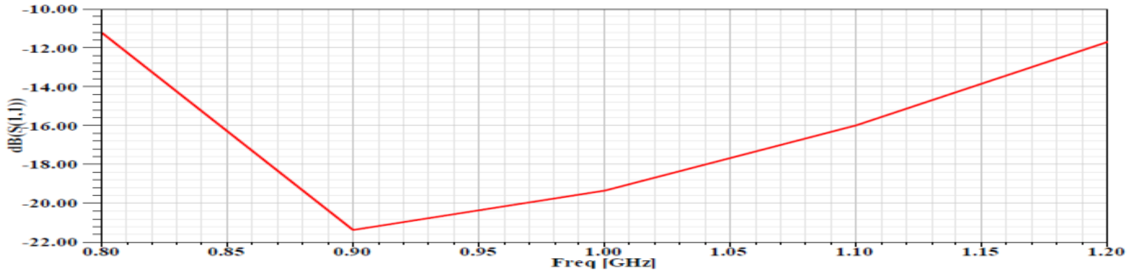

Fig.12: Return loss for crossed dipole antenna with metallic sheets.

Gain

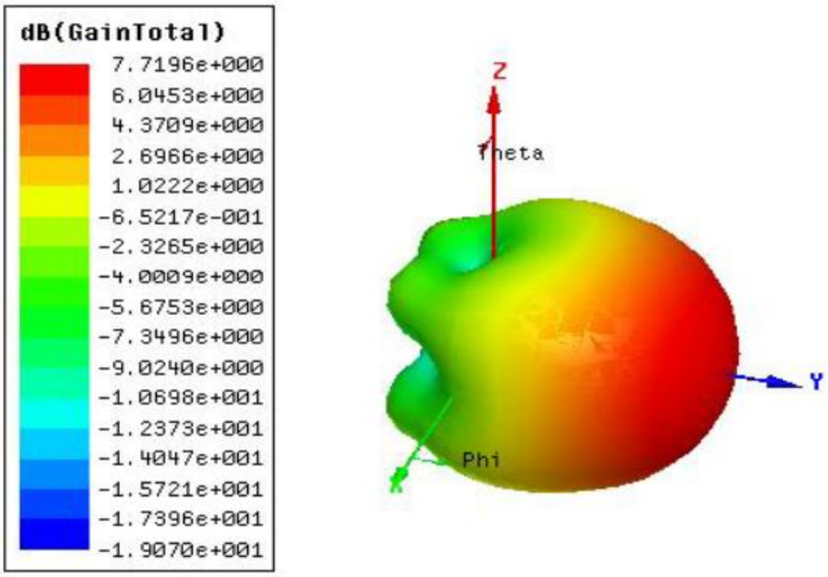

Fig.13: Gain for crossed dipole antenna with metallic sheets.

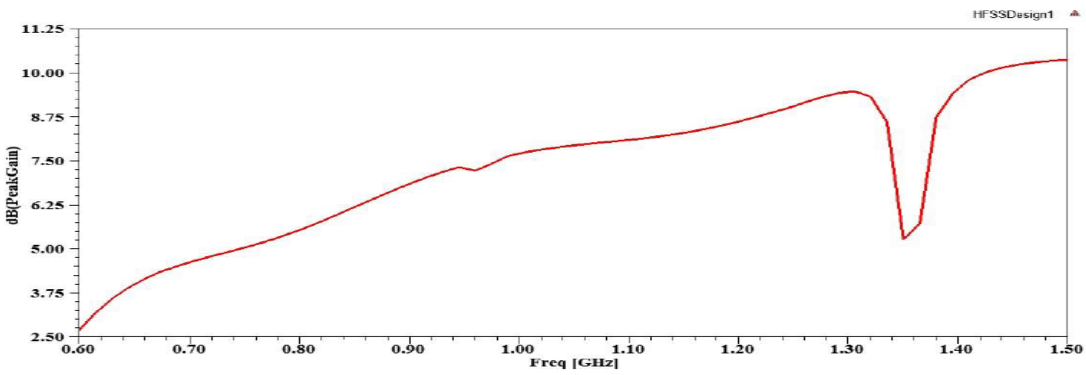

Fig.14: Gain vs Frequency of the crossed dipole antenna with metallic sheets

Radiation pattern

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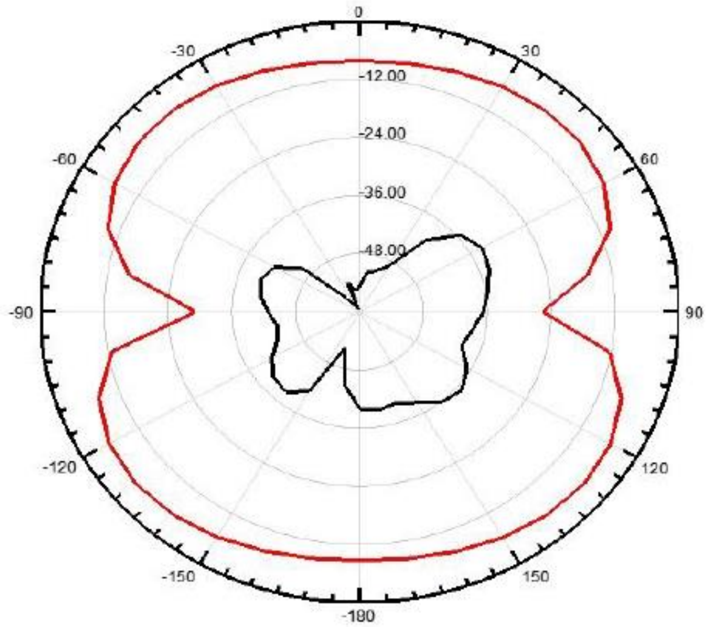

Fig.15: Co-polarisation radiation pattern for crossed dipole antenna with metallic sheets.

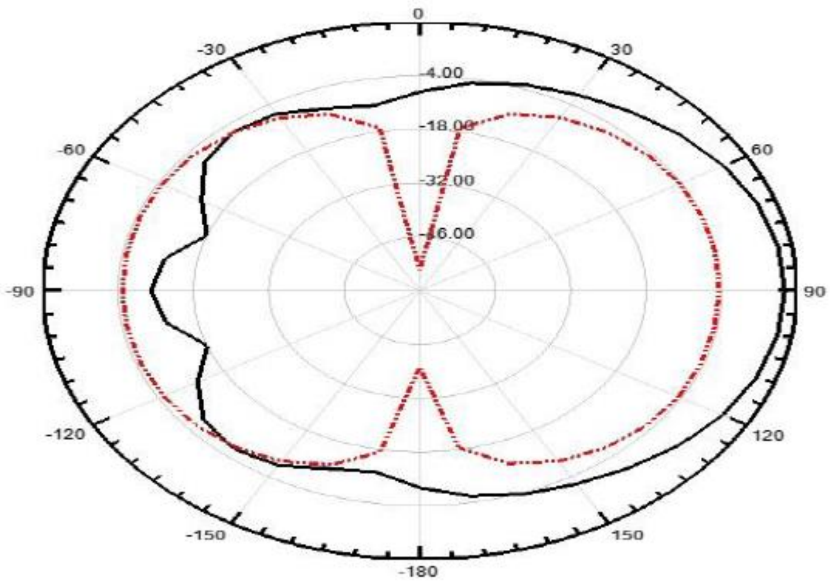

Fig.16: Cross-polarisation radiation pattern for crossed dipole antenna with metallic sheets.

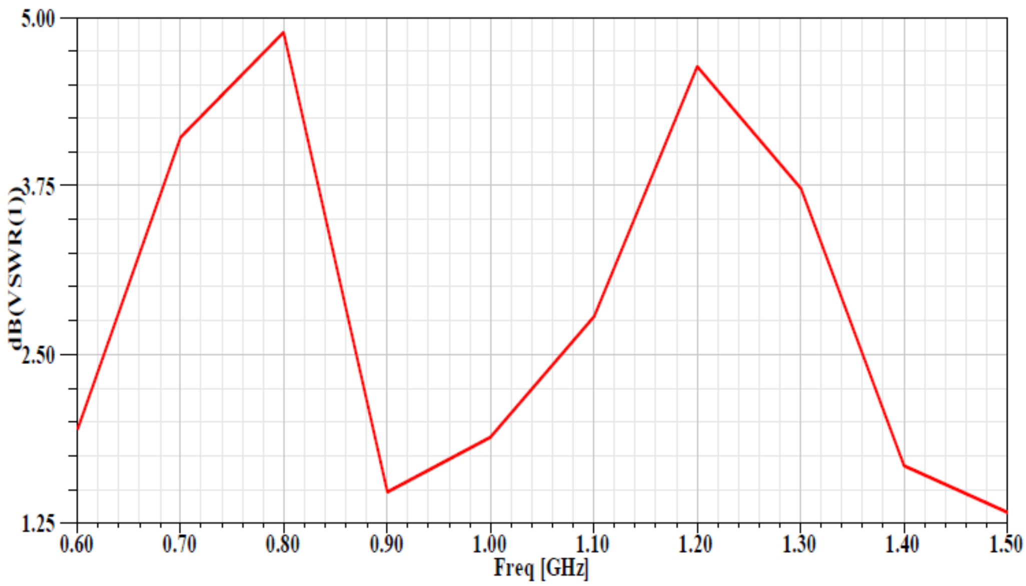

Fig.17: VSWR plot for crossed dipole antenna with metallic sheets.

Comparision of all models

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

Conclusion

"This study conducts a comprehensive comparison among three distinct antenna models: the Dipole antenna, the Cross Dipole antenna, and the Crossed Dipole antenna with metallic sheets. The primary objective is to discern their individual strengths and weaknesses, ultimately identifying the optimal design for specific requirements. Upon meticulous evaluation, the Crossed Dipole antenna with metallic sheets emerges as the preferred choice, primarily due to its unique attributes. During the comparative analysis, it becomes evident that this antenna possesses dual-band characteristics, effectively covering the frequency range of 0.6 GHz to 1.5 GHz. This dual-band capability positions it as a versatile solution suitable for a broad spectrum of applications. Furthermore, its ease of implementation adds to its appeal, making it a practical and feasible choice for real-world applications."

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