Design and Simulation of Wideband Monopole Microstrip Antenna

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Abstract

The paper explicates an optimal antenna using a monopole with defective ground plane for wideband operation. The radiator is an etched square with square slots at the corners and is intended for radio communication. To realize wideband operation and to improve the gain of the antenna defected ground arrangement is utilized. Finite element method is used to analyze the presented design. This radiator can show maximum response at four different operating frequencies in the frequency range of $3X10^3$MHz to $9X10^3$ MHz and presents the gain of 9.06dB, 3.83dB, 3.48dB,4.40dB at $3.0X10^3$ MHz, $5.5X10^3$ MHz, $6.9X10^3$ MHz,$9.1X10^3$ MHz respectively. The radiator which is designed in the current work is implemented for many uses like wireless broadband implementation applicable to stable wireless communications, WLAN, remote sensing/fixed metrological and satellite communications. The HFSS simulation tool is employed to simulate the developed antenna design.

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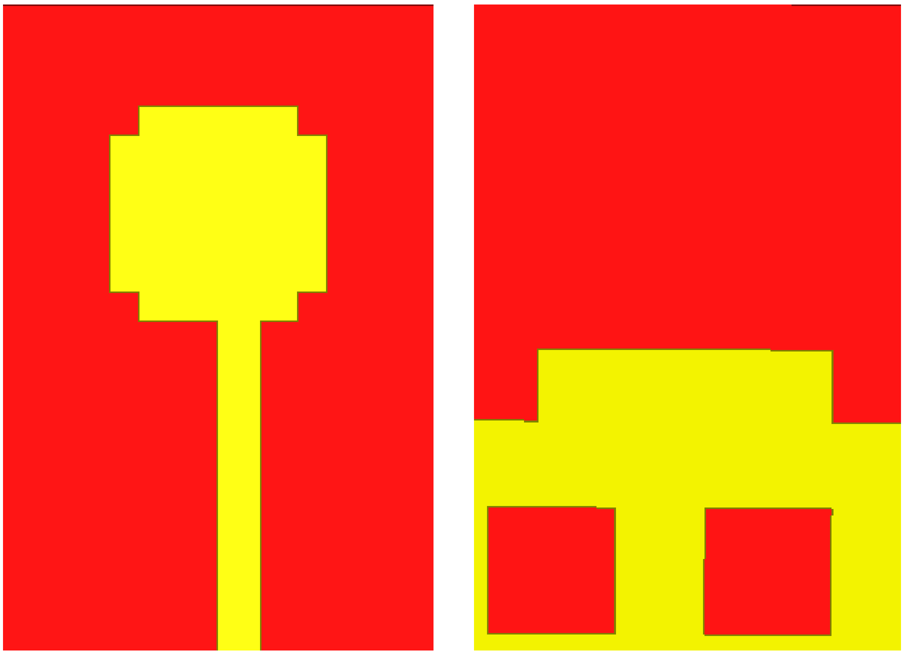
1 Introduction

The need for the wideband antennas has grown along with the wireless devices. Wideband antennas are capable of handling multiple applications for short range communications. Though the radiated power in not uniform and will have a very less gain it is having its own range of necessity in the devices with short range communications. Many wireless protocols like WLAN, WIMAX, Bluetooth are used for the short range communications[1]. An antenna which is capable of handling all the required frequency bands with a uniform radiation pattern is of very use for the applications

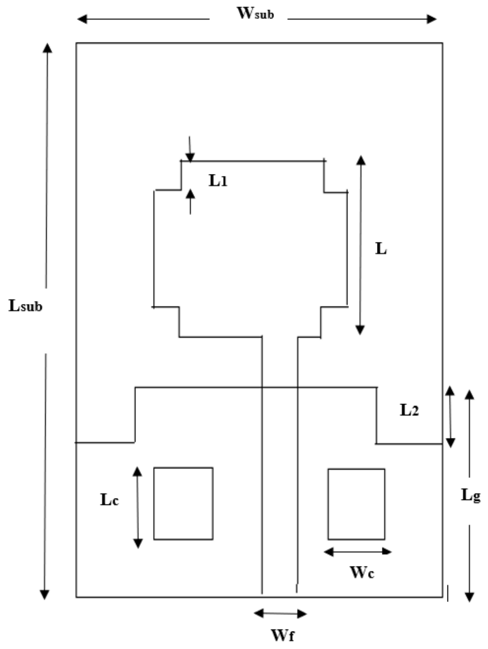
[2-8]. Generally, to enhance bandwidth we use the techniques of etching slots in the patch or ground, using shorting pins or shorting plates to short the radiating patch to the ground plane to generate high impedance, using monopoles with partial ground planes to enhance the bandwidth is also a good technique[9]. But all these techniques have one or the other drawback like having low gain or non-uniform radiation patterns[10-13]. An antenna which can overcome all the above drawbacks is a need of the day. Here, new antenna model which integrate multiple techniques of Monopole radiator, Partial ground plane, truncated patch is proposed and a defective ground structure to enable the antenna to have wide frequency of operation along with considerably good gain with uniform radiation pattern.

2Antenna Design configuration

This paper gives a newly designed antenna which has a planar structure and is accommodated on a FR4 substrate of size 45mm×30mm with 4.4 as the dielectric constant as shown in Fig.1. The software used for antenna design is ANSYS HFSS. In order to simulate electro-magnetic fields, full wave 3D HFSS simulation tool is the most commonly used software. It is more beneficial in the development of speedy electronic designs and high frequency implementations because of its good computing capabilities. Complex problems can be solved by utilizing latest hybrid methods. The radiator is a square patch with truncations at all the four corners and the ground is defected with two square slots in a partial ground plane. Later, with the help of the line feeding technique current is passed through it from the ground. The various antenna parameters are shown in the table1.



(a) Top View (b) Rare View



(c) Antenan Schematic

Fig. 1 Antenna geometrical Configuration

Parameters	Values(mm)
Lsub	45
Wsub	30
L	15
L1	2
L2	5
Wf	3
Lg	21
Lc, Wc	8.8,8.8

Table 1. Design Parameters

3. Radiation characteristics

The developed antenna radiates in the range of microwave frequencies. Initiallyat $3X10^3$ MHz operating frequency,-18.9dB radiation return loss, gain of 9.06dB and VSWR of 1.25 is observed. Other resonant frequency is at $5.5X10^3$ MHz with -16 dB return loss, gain of 3.83 dB and VSWR of 1.37. It is observed that, radiation parameters return loss, gain and VSWR at$6.9X10^3$ MHz frequency are -19.2 dB,3.48dB and 1.24. Finally, at $9.1X10^3$ MHz the antenna shows return loss of -23.8 dB, gain of 4.4 dB and VSWR of 1.13.

Normally, radiation return-loss resulted because of reflected power in the un-matched transmission line. The Fig. 2 shows the return loss characteristics of the presented antenna. It is verified thatthe return loss values of the given antenna at various operating frequencies of $3X10^3$ MHz, $5.5X10^3$ MHz, $6.9X10^3$ MHz, and $9.1X10^3$ MHzare -18.9dB, -16dB, -19.2dB, and - 23.8dB.

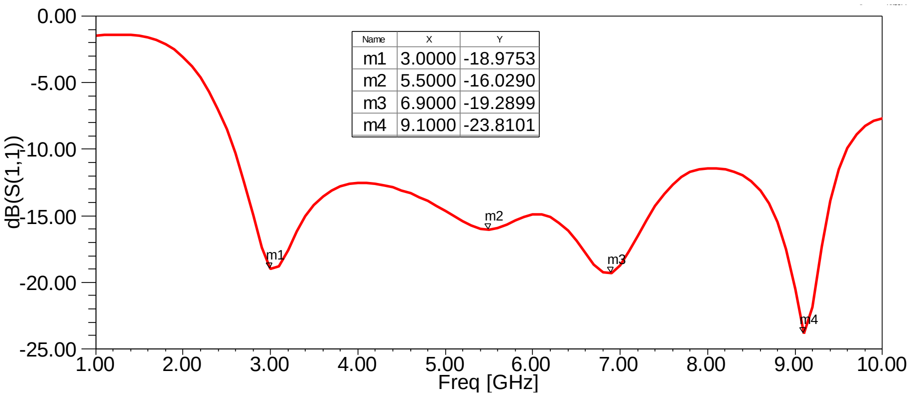


Fig.2. Simulated Return Loss of antenna

The Voltage Standing Wave Ration (VSWR) gauges standing wave voltages brought on by transmission line impedance mismatches with the load. For the resonant frequency, VSWR values that are lesser than or equals to 2 dB are acceptable. With VSWR less than 2, as illustrated in Fig. 3, the proposed antenna's VSWR pattern exhibits good conducting qualities. The proposed antenna's VSWR measurements at $3X10^3$ MHz, $5.5X10^3$ MHz, $6.9X10^3$ MHz, and $9.1X10^3$ MHz are 1.25, 1.37, 1.24, and 1.13, respectively.

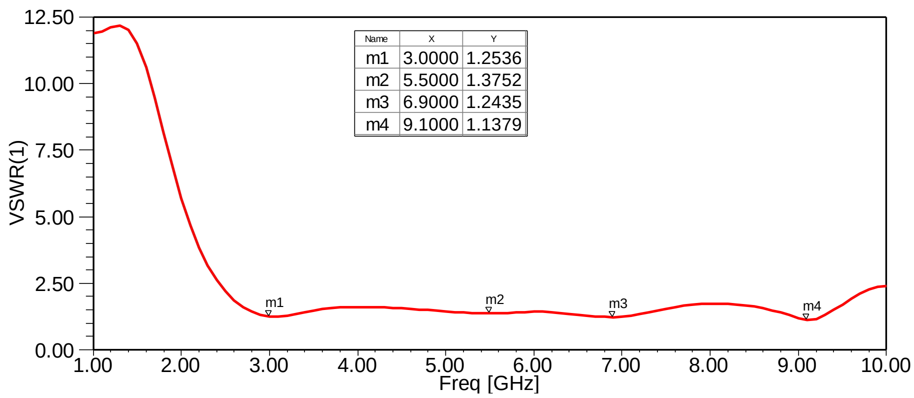
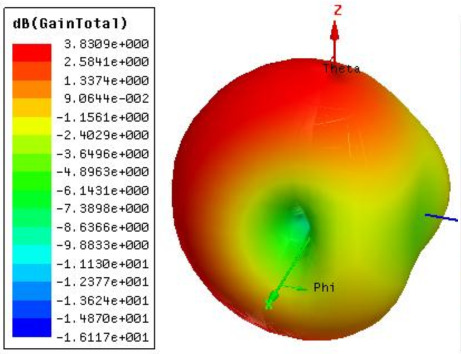


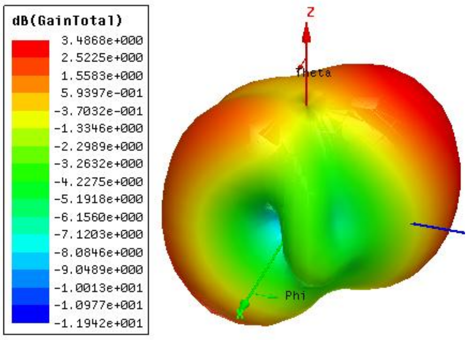
Fig.3. Simulated VSWR of the antenna.

The gain of an antenna denotes as the ratio of the power radiated into the far field to the power generated as a result of potential losses in an isotropic antenna along the axis of antenna's beam. The proposed antenna shows a good gain in terms of various frequencies at $3X10^3$ MHz, $5.5X10^3$

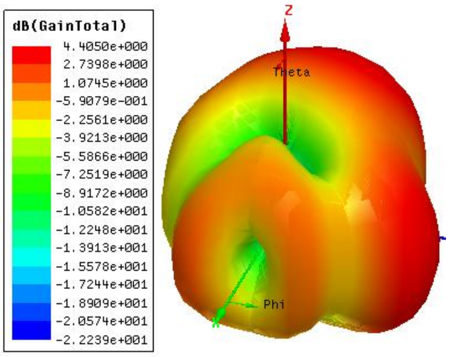
MHz, 6.9X10^3 MHz, and 9.1X10^3 MHzare 9.06dB, 3.83dB, 3.48dB, and 4.40dB respectively as shown in Fig. 4.



(a) at 3X10^{3}MHz



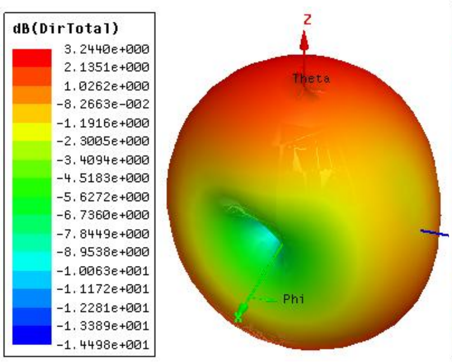
(b) at 6.9X10^3 MHz



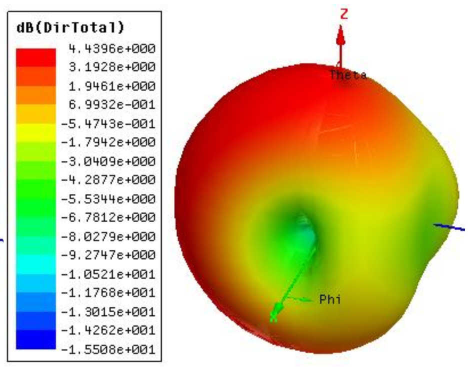
(c) at 9.1X10^3 MHz

Fig. 4. Gain Plots

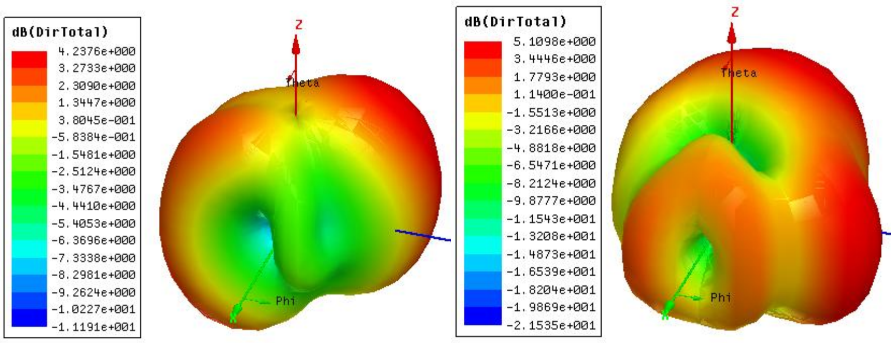
The directivity of an antenna is defined as the ratio of the highest power radiated in the distant field to the average of power generated as a result of fictitious loss in isotropic antenna along the antenna's beam axis. The directivity of the proposed antennaat various frequencies of 3X10^3 MHz, 5.5X10^3 MHz, 6.9X10^3 MHz, and 9.1X10^3 MHz are 3.24dB, 4.43dB, 4.23dB, and 5.10 dB respectively as shown in Fig. 5.



(a) at 3X10^{3}MHz



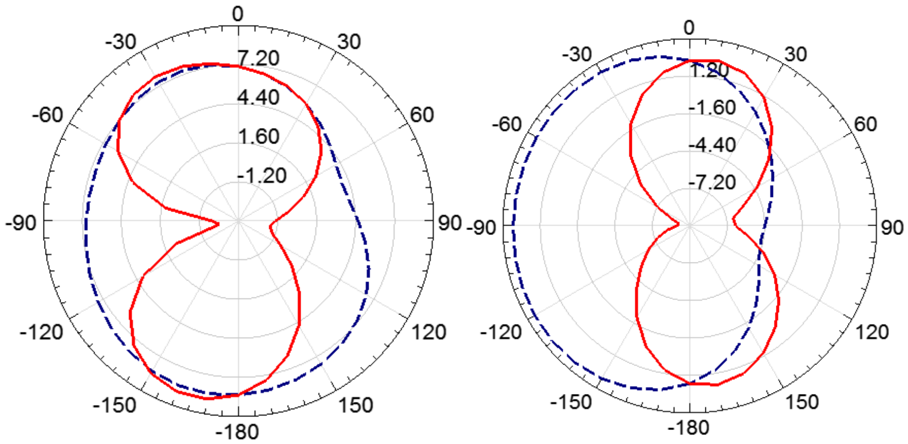
(b) at 5.5X10^3 MHz



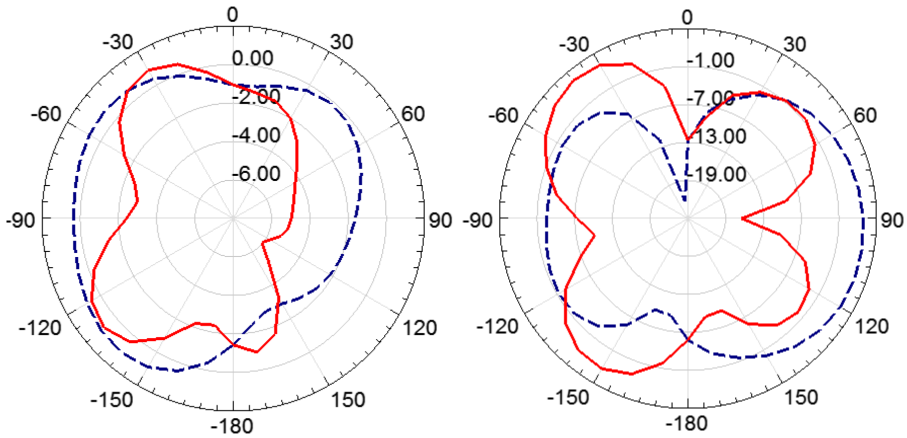
(c) at 6.9X10^3 MHz (d) at 9.1X10^3 MHz

Fig. 5. Gain Plots

The radiation pattern describes the intensity of fields in a certain antenna direction. The term "radiation" is used to describe the emission or receipt of a wave front at an antenna and to describe the intensity of the wave front. The radiation parameters are improved by a defective ground structure.The radiation pattern's for proposed antenna at various frequencies of3X10^3 MHz, 5.5X10^3 MHz, 6.9X10^3 MHz, and 9.1X10^3 MHzare shown in Fig 6.



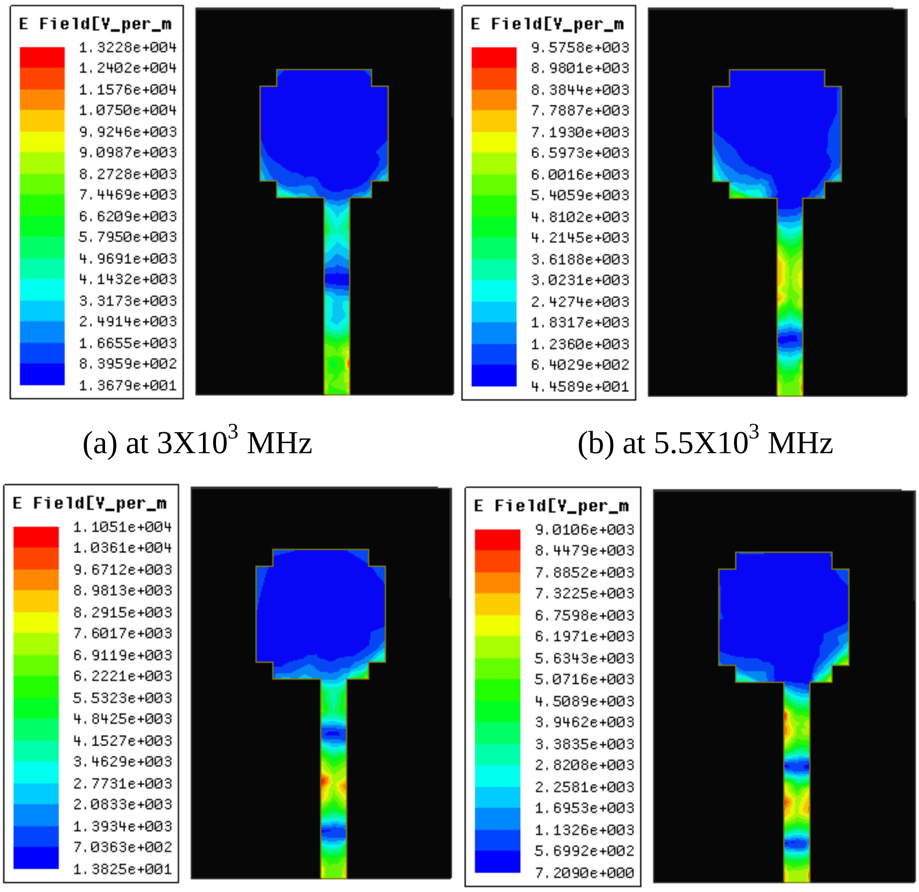
(a) at 3X10^{3}MHz (b) at 5.5X10^3 MHz



(c) at 6.9X10^3 MHz (d) at 9.1X10^3 MHz

Fig. 6 Power Distribution Patterns

Voltage or Current distribution in antenna based on the design of radiator. Current distribution at any point in patch antennacan be measured and analysis is done using an electromagnetic numerical method like Method of Moments (MOM). The maximal current will occur in the centreas the electrons moving from one end of the dipole to the other must flow through the center to get from one side to the other.The current distributions of the proposed antenna at various frequencies of$3X10^3$ MHz, $5.5X10^3$ MHz, $6.9X10^3$ MHz, and $9.1X10^3$ MHz are shown in Fig.7.



(a) at $3X10^3$ MHz (b) at $5.5X10^3$ MHz

(c) at $6.9X10^3$ MHz (d) at $9.1X10^3$ MHz

Fig. 7 Electric Field Distribution Patterns

4. Conclusion

In this paper, an optimum monopole radiator with modified ground plane is depicted and it is preferred for wideband implementation.The geometrical form of radiating elementis an etched square shape with cornered square slots. To realize extensive working frequencies, the developed design is utilized Defected Ground Structure technology to enhance the gain of the antenna.It is verified from the radiation performance characteristics that the antenna is functioning from $3X10^3$

MHz to $9X10^3$MHz. Similarly,the radiation outcomesare displayed at different resonantfrequencies like $3X10^3$ MHz, $5.5X10^3$ MHz, $6.9X10^3$ MHz, and $9.1X10^3$MHz.Each frequency band is unique and is mostly suitable for many commercial applications. For example, $3X10^3$ MHz band has significant usage in802.16e, mobile Wi-Max, fixed Wi-Max, 4G LTE systems.The band $5.5X10^3$ MHz is applicable for WLAN 802.11a communication and $6.9X10^3$ MHz band is employed for satellite technology. The other frequency band of $9.1X10^3$ MHz is operated for fixed meteorological satellites or remote sensing operations.

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