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Research Article

A Compact Multi Antenna System with DGS

Sheetal Mehta[Ȧ*] and Ramanjeet Singh[Ȧ]

[Ȧ]Department of ECE, Ludhiana College of Engineering & Technology, Ludhiana

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Abstract

*A compact multi antenna system with DGS (Defective Ground Structure) for ECM (Electronic Countermeasure) applications is proposed in this paper. Two monopoles are located on the opposite corners of the PCB and spaced 10 mm apart by a small ground portion. To decrease the mutual coupling caused by near-field two monopoles are decoupled by using the metal strip. The proposed Wang-shaped DGS of size 30mm*16mm is placed in ground plane. It does provide a method to improve antenna performance. In this way, performance parameters with $S_{11} \leq -10$ dB and $S_{21} \leq -18$dB at resonance frequency 6.18 GHz are achieved. The analysis has been done by using IE3D software based on MOM (Method of Moments).*

Keywords: *DGS, Multi Antenna, Return Loss, Gain, Directivity, Antenna Efficiency, Radiation Efficiency*

1. Introduction

In modern wireless communication systems and increasing of other wireless applications, wider bandwidth, multiband and low profile antennas are in great demand for both commercial and military applications. This has initiated antenna research in various directions; one of them is using Multiple-input Multiple-output antenna elements. The use of multiple antenna technique has gained overwhelming interest throughout the last decade. The idea of using multiple antenna configuration instead of a single one has proven to be successful in enhancing data transfer rate, coverage, security and overall the performance of radio networks. Traditionally, each antenna operates at a single or dual frequency bands, where different antenna is needed for different applications. This will cause a limited space and place problem. In order to overcome this problem, multi-band antenna can be used where a single antenna can operate at many frequency bands. MIMO antenna (Qing-Xin Chu *et al* 2012) systems require high decoupling between antenna ports and a compact size for application in portable devices. There are a number of techniques that are used to suppress level of coupling between the antenna elements. Antenna array with low mutual coupling, operating at 2.45 GHz is reported in (Sonkki, M *et al* 2010) and the improvement of 40 dB isolation is achieved by etching two λ/2 slots on the ground plane. In (Fakhr *et al* 2009) and (Li. H. *et al* 2009) the mutual coupling effect has been suppressed to -20 dB for a spacing of around λ/4, while for (Li. H. *et al* 2009) by adding the slit, mutual coupling can be suppressed also to -20 dB. Overall, the mutual coupling effect achieved in these resent works is to -20 dB; however these results were achieved by increasing the distance between elements.

*Corresponding author: **Sheetal Mehta**

In this paper, a compact MIMO antenna with Wang-shaped DGS without using much spacing between the elements is proposed. The purpose of using DGS as a technique to improve antenna performance parameters is to make use of the ground plane itself to prove a filter effect which in turn suppresses the surface waves. DGS is also used in reduction of mutual coupling by suppressing surface wave propagations. The proposed antenna is designed to work at frequency 6.18 GHz for EMC applications.

2. MIMO antenna with DGS

The configuration of proposed antenna is shown in figure1. The MIMO antenna with DGS consists of two identical monopoles of size 18mm*15 mm mounted on the same ground plane and spaced 10 mm apart by a small ground portion. The size of the ground plane and the length of the antennas are the same as for the single antenna. The MIMO antenna is printed on the upper part of a partially grounded FR4 substrate with dimensions $78mm*40mm*1.6mm^3$ and relative permittivity 4.4. On the back surface of the substrate, the main rectangular ground plane of 40 mm in width and 60mm in length is printed. A metal strip of size 18*1mm, which is placed between the two monopoles, is applied to decrease the mutual coupling caused by near-field. In order to reduce the mutual coupling caused by the surface currents two bent slits with a length of 22 mm are etched into the ground plane. Moreover, each slit is coupled fed by a 50Ω microstrip line, and consequently the slits can be considered as slit antennas. To reduce the effect of the slits on the lower part of the impedance bandwidth, the slits are bent by 90° to suppress the mutual coupling between the two slit antennas, they are set perpendicular to each other. Two triangles with height $T_h = 3$ mm and width $T_l = 4$ mm are cut from the ground plane to change the distribution of the ground surface currents. To further improve the performance parameters like antenna efficiency, directivity, gain, radiation efficiency wang-shaped DGS (30mm*16 mm) is etched into the ground plane.

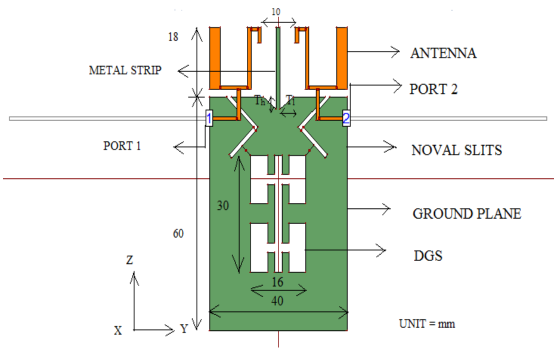

Fig: 1 (a) Proposed MIMO Antenna with DGS

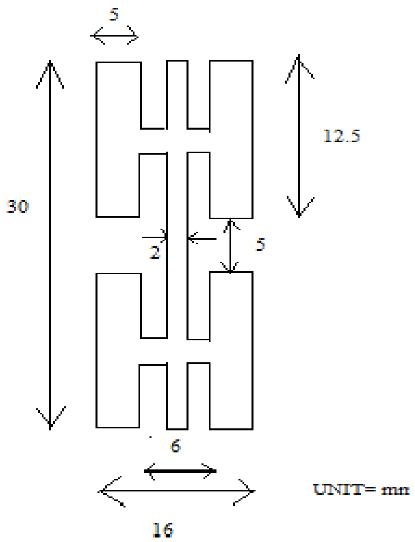

Fig: 1 (b) Wang-Shaped DGS

3. Results and Discussion

MIMO antenna with DGS structure presented in this paper has been designed and simulated using IE3D software. There is a great improvement in performance parameters of MIMO antenna with DGS as compared to MIMO antenna.

Performance Parameters of MIMO Antenna with DGS Structure

(i) S- Parameters

It describes the amplitude of a reflective wave relative to that of incident wave. S_{11} represents how much power is reflected from the antenna, and hence is known as the reflection coefficient (sometimes written as gamma or return loss).

Simulated results of S_{11} and S_{21} of the MIMO antenna system with wang -shaped DGS are shown in figure 2 (a). According to the simulated results, S_{11} (Return loss) is found to be less than -10 dB from 6.02-6.25 GHz. After the addition of the wang -shaped DGS return loss is found to be less than -10 dB from 6.03-6.45GHz, thus providing a bandwidth enhancement of 82.60%.

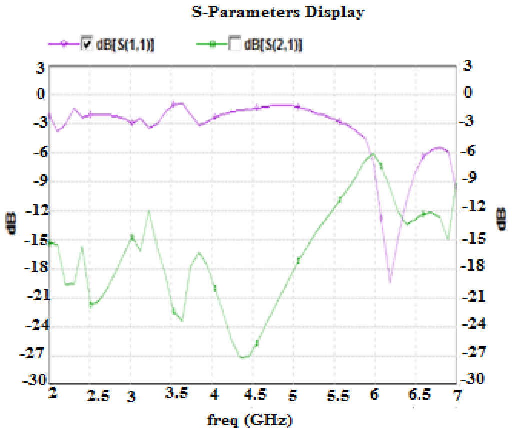

Fig: 2(a) S Parameters of antenna with DGS

(ii) Gain

As a transmitting antenna, gain defines how well the antenna converts input (electrical) power into radio (electro-magnetic) waves headed in a particular direction. As a receiving antenna, gain defines how well the antenna converts radio waves arriving from a specified direction into electrical power. Higher range antennas have the advantage of long range and better signal quality but must be aimed carefully in a particular direction.

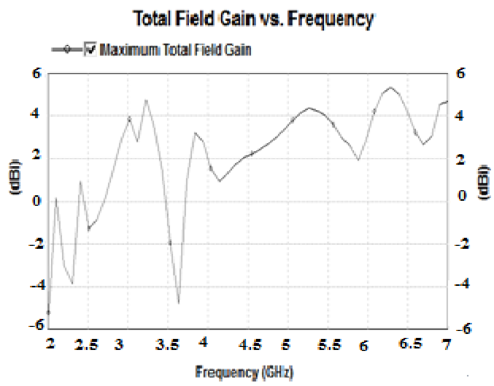

Fig: 2(b) Gain of antenna with DGS

Figure 2(b) depicts the simulated graph of gain of proposed design. According to the simulated results, value of gain is found to be 1.06 dBi at 6.08 GHz. After the addition of the wang-shaped DGS value of gain is found to be 5.08 dBi at 6.18GHz showing improvement against the MIMO system.

(iii) Directivity

Directivity is the ability of an antenna to focus energy in a particular direction when transmitting, or to receive energy better from a particular direction. It is defined as a ratio of power radiated by antenna in a particular direction to power radiated by an ideal isotropic radiator. Value of directivity varies from 1.76dBi for short dipole to 50 dBi for large dish antennas.

Simulated results of directivity of the MIMO antenna system with wang -shaped DGS are shown in figure 2 (c). According to the simulated results, value of directivity is found to be 5.31 dBi at 6.08 GHz. After the addition of wang-shaped DGS value of directivity is found to be 7.33 at 6.18GHz showing improvement against the MIMO system.

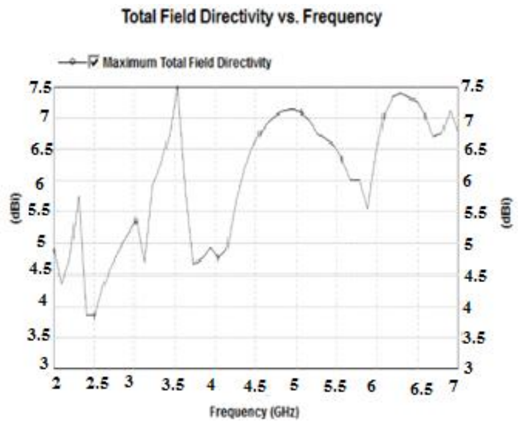

Fig: 2(c) Directivity of antenna with DGS

(iv) Efficiency

The antenna efficiency (or radiation efficiency) can be written as the ratio of the radiated power to the input power of the antenna.

A high efficiency antenna has most of the power present at the antenna's input radiated away. A low efficiency antenna has most of the power absorbed as losses within the antenna, or reflected away due to impedance mismatch.

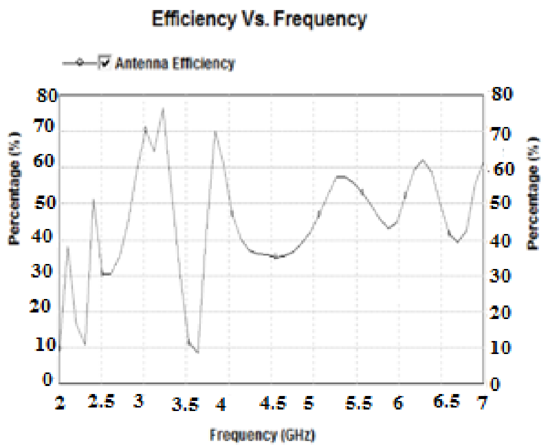

Fig: 2(d) Antenna Efficiency of Antenna with DGS

Figs. 2(d) & 2(e), depicts variations of efficiency (antenna efficiency, radiation efficiency) characteristics with frequency. The proposed antenna has an antenna efficiency of 59.34 % and 71.37 % at resonant mode.

Table1show the readings or variations of different performance parameters (resonance frequency, 10 dB bandwidth, return loss, gain, directivity, antenna efficiency and radiation efficiency) with respect to frequency and we have noted these variations from the above graphs.

Results show good improvement in performance parameters of MIMO Antenna with wang-shaped DGS as compared to MIMO Antenna at 6.18 GHz.

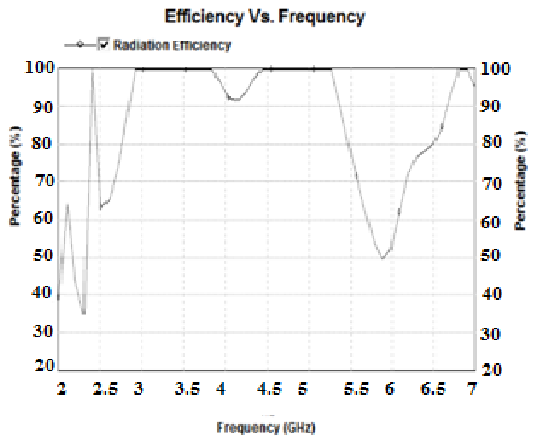

Fig: 2(e) Radiation Efficiency of Antenna with DGS

Table: 1 Comparison of Measured and Simulated Results

S. No.	Parameter	Measured Results	Simulated Results
1	Resonance Frequency	6.08 GHz	6.18 GHz
2	10 dB	6.02-6.25 GHz	6.03 – 6.45 GHz
3	Return Loss	-15.13 dB	-19.79 dB
4	Gain (G)	1.06 dBi	5.08 dBi
5	Directivity (D)	5.31 dBi	7.33 dBi
6	Antenna	37.83 %	59.34 %
7	Radiation	46.80 %	71.37 %

Conclusion

This paper presents a compact MIMO antenna with defected ground for ECM applications. The proposed structure itself is simple and does not require any special design for the radiating elements. A wang-shaped defect on the ground plane of the antenna is inserted. By suppressing the surface waves, it provides a very low mutual coupling between antenna elements which enhance the values of gain, directivity. The Wang shaped DGS antenna has been analyzed with IE3D software and results show good improvement in performance parameters of MIMO antenna with wang-shaped DGS as compared to MIMO Antenna at 6.18 GHz. The technique may be useful in a number of technologies including MIMO antennas.

References

Qing-Xin Chu, Tian - Gui Huang, and Jian - Feng Li (Feb 2012), Compact Wideband MIMO Antenna with Two Novel Bent Slits, *IEEE Trans. on Antennas and Propag*, Vol. 60, no. 2.

Sonkki, M. and E. Salonen (2010), Low Mutual Coupling Between Monopole Antennas By Using Two Slots, *IEEE Antennas Wireless Propag. Lett.*, Vol. 9, pp. 138-141.

Fakhr, R. S. (2009), Compact Size And Dual Band Semicircle Shaped Antenna for MIMO, Applications *Progress In Electromagnetics Research C*, Vol. 11, pp. 147-154.

Li. H., J. Xiong, and S. He (2009), A Compact Planar MIMO Antenna System of Four Elements with Similar Radiation Characteristics and Isolation *Structure, IEEE Antennas and Wireless Propagation Letters*, Vol. 8, pp. 1107-1110