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ENHANCED ISOLATION MIMO ANTENNA WITH DGS STRUCTURES FOR LONG TERM EVOLUTION SYSTEMS

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ABSTRACT
In this communication, a new multi-antenna system based on two microstrip antennas is analyzed and proposed for LTE (Long Term Evolution) terminals. The multi-input multi-output (MIMO) antenna is printed on a FR4 substrate with size of 60×100×1.6 mm^3. The proposed design, in its basic form, operates around 2.3 GHz, and provides a transmission coefficient of -19 dB. In order to improve the isolation between the two antenna ports, some rectangular and circular slots are inserted in the ground plane between the two antennas. With this modification, the mutual coupling of -59 dB was achieved, which are 40 dB improvements over the initial antenna. The simulated results are presented and discussed in term of reflection coefficients, transmission coefficients and radiation patterns.

Keywords: Microstrip antenna, Isolation, LTE terminals, MIMO system.

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Contribution/ Originality

This study presents a new antenna design, proposed for MIMO/LTE application. This proposed antenna provide a low mutual coupling (less than -59 dB) between the two ports which ensure a high isolation.

1. INTRODUCTION

The need to increase data transmission rates leading researchers in the field of wireless communications to continuously improve existing communication systems for future standards [1]. However, the most feature of wireless communications is the propagation environment of the electromagnetic waves. Indeed, these propagation environments are most often multipath channels, because the type of propagation mechanisms such as reflection, dispersion, diffusion or

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diffraction caused by the obstacles in these channels radio. These can cause fainting phenomenon of the received signals and thus affect the quality of communications [2]. The fading effects of these signals can be offset by the use of multiple antennas at the transmitter and / or in reception. Multi-antenna technologies have allowed the development of conventional communication systems; SISO (Single Input Single Output), SIMO (Single Input Multiple Output), MISO (Multiple Input Single Output) and MIMO (Multiple Input Multiple Output) with respective configurations of multiple antennas in reception and transmission. The MIMO communication systems have attracted much attention as a practical method to increase significantly the wireless channel capacity without need for additional power or spectrum [3]. Many investigations have been performed to develop suitable antenna for the MIMO systems [4-6]. The researchers was looking for compact structures which results in low isolation between the antenna ports that makes distorted radiation pattern and decreases channel capacity [7]. Recently, some work are reported in order to reduce the mutual coupling in the MIMO antenna structures such as; using DGS (Defected Ground Structure) [8] add EBG (Electromagnetic Band Gap) material between the antennas [9] and DMN (Decoupling Matching Networks) structure to achieve decoupling [10]. In this letter, we propose a new microstrip antenna for MIMO applications. The proposed structure is composed of two rectangular patches excited from two ports and operated around 2.3 GHz, covering the LTE band. In addition, the concept exhibits more high isolation between the two antenna ports.

2. DESIGN OF THE MIMO ANTENNA

Fig. 1 shows the configuration of the proposed structure. It consists of two rectangular patch antennas printed on FR4_epoxy dielectric substrate with dielectric constant of ε_{rs}=4.4 and thickness of 1.6 mm. The microstrip line feeding mechanism is used to excite the two antennas independently from port 1 and port 2. In the initial form of the proposed concept, the ground plane is completely printed on the underside of the substrate. To reduce the mutual coupling between the two antenna ports, two rectangular slots and twelve circular cuts are inserted in the ground plane, as illustrated in Fig.1.b. The optimized parameters of the proposed structure are given in Table 1.

Table-1. Optimal dimensions of the antenna structure.

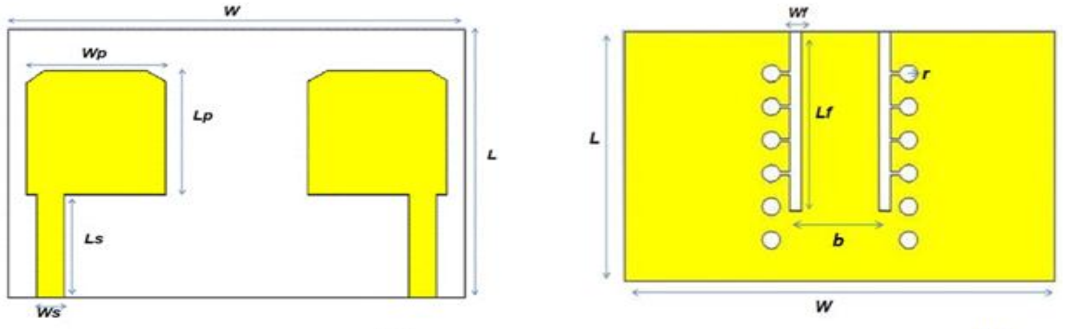
Parameter	Value (mm)	Parameter	Value (mm)
L	60	Wf	1.8
W	100	r	2.1
Lp	13.75	h	1.6
Ws	6	Ls	24
Lf	27		

3. SIMULATED RESULTS AND DISCUSSION

The commercial CST Microwave Studio, has been used to analyze the electromagnetic characteristics of the designed antenna such as S parameter, radiation patterns and gain.

A. Current Distribution Density

In order to study the principle of the isolation, the surface current distribution analysis is used. The simulated surface current distributions at 2.35 GHz for Ports 1, with and without the slots, are depicted in Fig. 2.



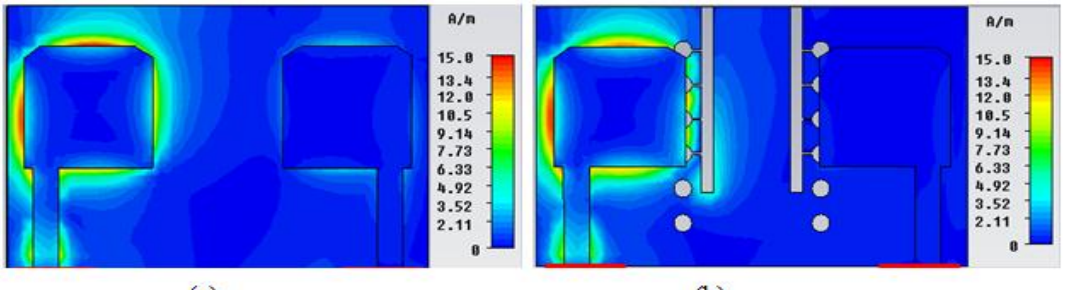
(a) (b)

Fig-1. The geometry of the proposed structure; (a) Top view, (b) Bottom view.

From the figure 2 (a), when the port 1 is excited and the port 2 is terminated with 50 **Ω**, it can be seen that the antenna excited from port 2, contains current excitation, which explains the mutual coupling between the two antennas. Moreover, When the slots are added to the ground plane, the surface current density on the other patch antenna is significantly reduced, as illustrated in figure 2 (b). Hence, the introduction of ground plane slots improves isolation between the two antenna ports.

B. S-Parameters

The S-parameters of the proposed structure, with and without integrating slots, are simulated and presented in figure 3, when the structure is excited from port 1 and port 2, separately. Fig. 3.a includes the simulated reflection coefficients of the two structures illustrated in Fig. 2.



(a) (b)

Fig-2. Surface current distributions on the MIMO antenna excited from Port1 at 2.35GHz; a) without slots, (b) with slots.

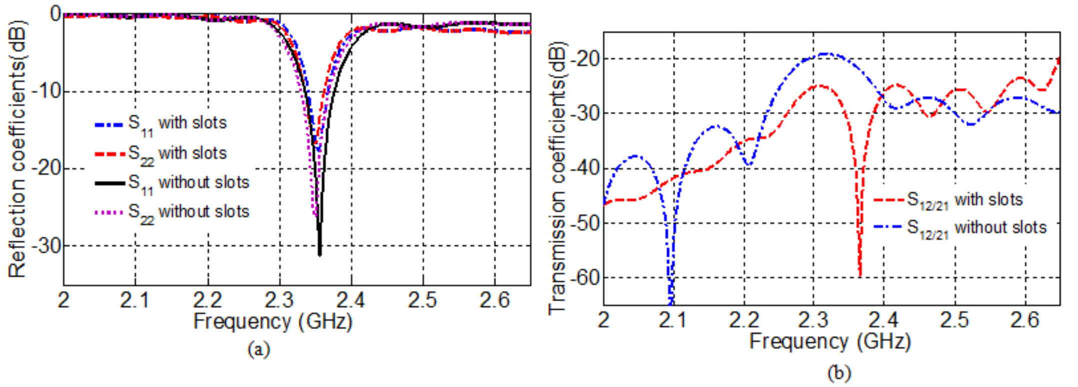


Fig-3. Simulated S-parameters of the MIMO antenna: a) Reflection Coefficients, b) Transmission Coefficients.

From these curves, it is clear that the MIMO antenna operates around 2.35 and provides an impedance bandwidth of 2.34-2.37 GHz for the initial structure and 2.34-2.365 GHz with integrating slots for both ports 1 and 2 which cover the LTE band. In addition, the transmission coefficients of the two structures (with and without slots) are plotted in Fig. 3.b. It can be seen that the antenna structure in its first form exhibits a mutual coupling lower than -19 dB. However, when the slots are inserted in the ground plane, the transmission coefficient of -59 dB was achieved, which provides high isolation between the ports with an improvement of 40 dB compared with the initial antenna structure.

C. Radiation Patterns and Gain

The E-plane (φ=0°) and H-plane (φ=90°) radiation patterns of the proposed structure antenna excited at 2.35 GHz from both port 1 and 2, are depicted in the figures 4 and 5, respectively. The maximum gain of the proposed antenna was 6 dB, achieved at theresonant frequency 2.35 GH.

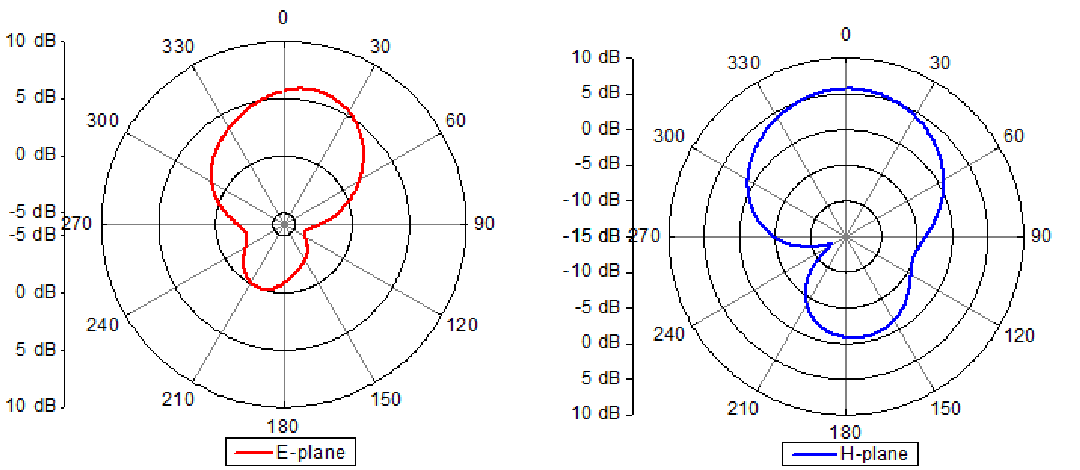


Fig-4. Radiation patterns of the proposed antenna excited at 2.35 GHz from Port 1

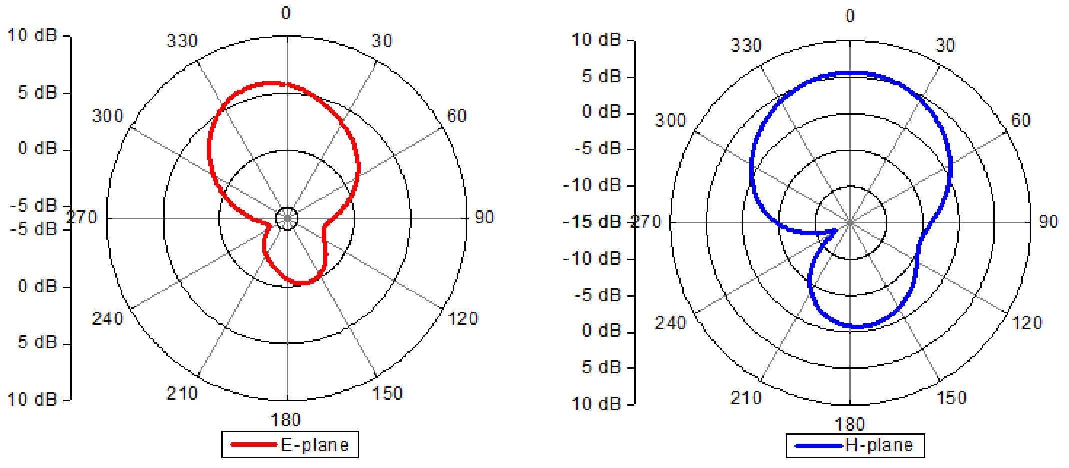


Fig-5. Radiation patterns of the proposed antenna excited at 2.35 GHz from Port 2.

4. CONCLUSION

A novel tow-port Multi-Input Multi-output (MIMO) antenna system has been studied and simulated. The proposed antenna operated around 2.35 GHz, when the structure excited from both port 1 and port 2. Some slots were inserted in the ground plane to improve the isolation between the two antenna ports. Comparing with the initial antenna structure, the mutual coupling was reduced by 40 dB. Furthermore, the radiation characteristics are also studied in term of radiation patterns and gains, using the software tool CST Microwave Studio. With these features, this structure can be a suitable candidate for LTE MIMO applications.

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REFERENCES

[1] R. G. Vaughan and J. B. Andersen, "Antenna diversity in mobile communications," *IEEE Trans. Veh. Technol.*, vol. VT-36, pp. 149–172, 1987.

[2] G. J. Foschini and M. Gans, "On limits of wireless communications in a fading environment when using multiple antennas," *Wirel. Personal Commun.*, vol. 6, pp. 311–335, 1998.

[3] A. S. Konanur, K. Gosalia, S. H. Krishnamurthy, B. Hughes, and G. Lazzi, "Increasing wireless channel capacity through MIMO systems employing co-located antennas," *IEEE Trans. Microw. Theory Tech.*, vol. 53, pp. 1837–1843, 2005.

[4] I. Messaoudene, T. A. Denidni, and A. Benghalia, "CDR antenna with dual-band 1.9/2.7 GHz for MIMO-LTE terminals," *Microw. Opt. Technol. Lett.*, vol. 57, pp. 2388–2391, 2015.

[5] R. Addaci, K. Haneda, A. Diallo, T. P. Le, C. Luxey, R. Staraj, and P. Vainikainen, "Dual-band WLAN multiantenna system and diversity/MIMO performance evaluation," *IEEE Trans. Antennas. Propag.*, vol. 62, pp. 1409–1415, 2014.

[6] I. Messaoudene, T. A. Denidni, and A. Benghalia, "Two-port MIMO cylindrical dielectric resonator antenna for LTE systems," presented at the 2014 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting, July 6-11, 2014, Memphis, Tennessee, USA, 2014.

[7] B. S. Collins, "The effect of imperfect antenna cross-polar performance on the diversity gain of a dual-polarised receiving system," *Microwave Journal*, vol. 43, pp. 84–94, 2000.

[8] S. Y. Lin and H. R. Huang, "Ultra-wideband MIMO antenna with enhanced isolation," *Microw. Opt. Technol. Lett.*, vol. 51, pp. 570–573, 2009.

[9] Y. Q. Fu, Q. R. Zheng, Q. Gao, and G. H. Zhang, "Mutual coupling reduction between large antenna arrays using electromagnetic bandgap (EBG) structures," *Journal of Electromagnetic Waves and Applications*, vol. 20, pp. 819–825, 2006.

[10] M. S. Khan, A. D. Capobianco, A. I. Najam, I. Shoaib, E. Autizi, and M. F. Shafique, "Compact ultra-wideband diversity antenna with a floating parasitic digitated decoupling," *IET Microwaves, Antennas & Propagation*, vol. 8, pp. 747–753, 2014.