International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 04 Issue: 02 | Feb -2017 www.irjet.net p-ISSN: 2395-0072

Isolation Enhancement of a Very Compact UWB-MIMO Slot Antenna With Two Defected Ground Structures Used in Multi band Applications

Maddula Sai Teja[1] , P.Srinivas Rao[2]

Department of Electronics , St.Ann's College of Engineering and Technology, Chirala, INDIA

---****---

***Abstract*—A multiple-input multiple-output (MIMO) antenna which has a compact size of 22×26 mm² that operates in ultra wide band range of 3.1-10.6 GHz is presented. The antenna exhibits high isolation to improve the impedance matching characteristics in low frequencies as well as reduces mutual coupling less to than 18db for high frequencies. A T shaped slot is cut from the ground. The performance of this antenna is studied and measured by simulation. The results indicate that the proposed antenna is a good candidate for UWB applications.**

I. INTRODUCTION

ULTRAWIDEBAND (UWB) is a rapidly growing technology which makes use of wide frequency band to transmit signals at low energy level. It has promising applications in short-range high-data-rate transmission, radar imaging and cancer sensing, etc. Since the authorization from the Federal Communications Commission in the US for the unlicensed use of 3.1–10.6 GHz spectrum for applications with low power emission in 2002 [3], UWB systems have attracted much attention. Like other wireless communication systems, UWB systems suffer from multipath fading. It is well-known that multiple-input- multiple-output (MIMO) technology can be used to provide multiplexing gain and diversity gain to improve the capacity and link quality, respectively, of wireless systems. UWB systems using huge bandwidths already have high data rates, so MIMO technology can be used for fade countermeasure through diversity gain.

With increase of demand of wireless communication systems, personal communication devices are required to operate at multiple frequencies to cater to different applications. In addition to multiband operation, it is necessary that the antenna is small with light weight, low profile and easy integration with other circuit structures.

The basic concept of MIMO/diversity is to use multiple antenna elements to transmit or receive signals with different fading characteristics. Since it is unlikely that all the received signals will experience deep fading at the same time, the system reliability can be increased by proper selection/combining of the received signals. However, installing multiple antenna elements on the small space available in portable devices will inevitably cause severe mutual coupling and significantly degrade the diversity performance. Thus, one of the main challenges to employ MIMO technology in portable devices is the design of the small MIMO antennas with low mutual coupling.

Some MIMO antennas for UWB applications were proposed in the past few years [6]–[10]. In order to achieve the best performance of the MIMO systems, high isolation is accomplished by orthogonally feeding [6]–[8], introducing defected ground structure (DGS) to suppress surface wave [8], [9], using directional antenna elements [9], adding protruding ground stub or parasitic element as reflective component [6], [7], [10], and adopting a neutralization line to cancel out the original coupling [11]. All of the decoupling methods can reduce the mutual coupling to -15 dB or less. To integrate multiple antennas at the user terminals that are becoming smaller and thinner each day, the design of a very compact UWB-MIMO antenna covering the whole operating frequency band is one of the most essential requirements. However, reducing the size of a MIMO antenna usually brings about reduced operating bandwidth and strong coupling between antenna elements. Moreover, most decoupling structures bring occupation of too large space, which are not suitable for a very small MIMO antenna.

In this letter, a very compact MIMO antenna with high isolation is presented for UWB systems. The antenna measures only 26×26 mm² . In order to improve isolation of such a compact MIMO antenna, two defected ground structures are utilized. The T-shaped slot etched on the ground has two functions, extending the current path, which can reduce the first resonant frequency of the antenna, and suppressing surface currents, enhancing isolation at the band of 4–10.6 GHz. To reduce the coupling at the band of 3–4 GHz, a line slot is used to bring new coupling to cancel out the original coupling, which works as a novel neutralization line and has a very small occupied space. Compared to the traditional neutralization line technology, which is connected at radiation patch or feeding line to produce an additional current path between two antenna elements, the DGS has less effect on original antenna impedance because the additional current path is realized by etching a coupling slot on the ground.

II. ANTENNA DESIGN

Fig. 1 shows the geometry of the proposed UWB-MIMO antenna. It is printed on the FR4 substrate with compact size of 22×26 mm², thickness of 0.8 mm, and relative dielectric constant of 4.4. The top layer consists of two 50Ω microstrip lines and the bottom layer is a metal ground with a T-shaped slot, a line slot and two stepped slots. A microstrip line and a stepped slot compose a UWB antenna element and the two

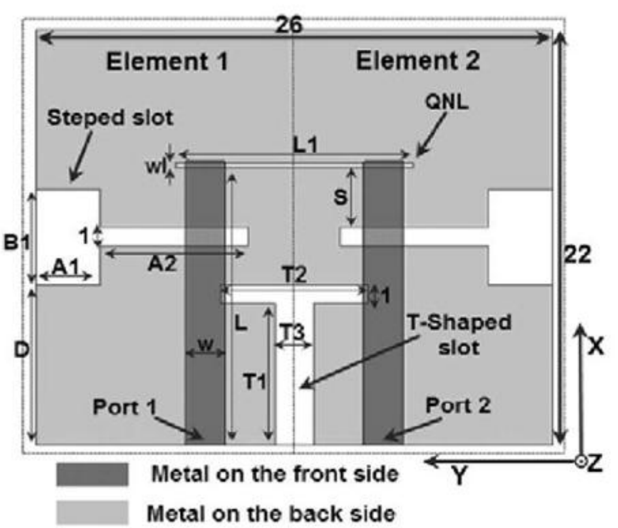
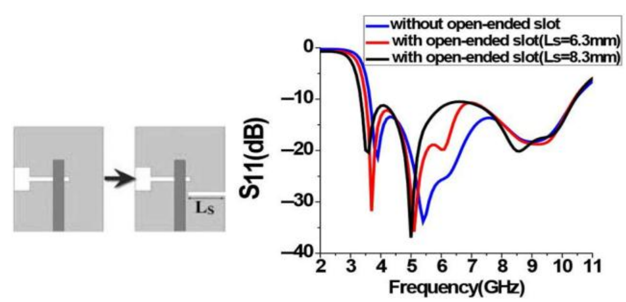


Fig. 1. Geometry of proposed antenna (top layer and bottom layer).

antenna elements are symmetrically arrayed. To improve the impedance matching characteristic and reduce the mutual coupling, a T-shaped slot and a line slot are used on the ground. More details will be discussed in the following. The optimized dimensions are derived using the commercial software CST. The design parameters optimized for the antenna were eventually determined with W=2mm, L=15mm, A1=32mm, A2=75mm, B1=5mm, L1=12mm, W1=0.2mm, T1=6.5mm, T2=9.4mm, T3=2mm, D=8.5mm, S=3.2mm

As shown in Fig. 2(a), the stepped slot antenna which is similar to that in [12] is adopted as an element of the proposed MIMO antenna. By tuning the parameters of the stepped slot and the position of the feed line, broadband impedance bandwidth can be easily achieved, which is due to the gradual change structure. However, like the antenna in [12], the -10 dB impedance bandwidth is only from 3.8 to 10.6 GHz, which does not cover the entire UWB band (3.1 to 10.6 GHz). In order to improve the impedance matching characteristic in the low frequency, an open-ended slot is etched on the back of the feed. The simulated S_{11} of the stepped slot antenna with and without the open-ended slot is illustrated in Fig. 2(b). As observed, the open-ended slot makes the first resonant frequency of the antenna becomes lower. Moreover, the simulated S_{11} for different the length of the open-ended slot (L_s) indicates the L_s mainly affects the lowest operating frequency f_{min} . With L_s increasing from 6.3 mm to 8.3 mm, f_{min} changes from 3.5 to 3.1 GHz. That is because the increased slot changed the current distribution and extended the current path effectively. The longer path of the open-ended slot was extended, the lower the first resonant frequency could be obtained. The longer was the extended path of the open-ended slot, the lower could be the first resonant frequency.



(a) (b)

Fig. 2. (a) Configurations and (b) S_{11} of UWB antennas with and without the open-ended slot

III. RESULTS AND DISCUSSION

This part will discuss the performance of proposed MIMO antenna by using computer simulation. The simulated S_{11} S_{22} S_{21} plots for the UWB MIMO antenna designed in this paper is shown in Fig.2, Fig.3, Fig.4 respectively. The result in

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 04 Issue: 02 | Feb -2017 www.irjet.net p-ISSN: 2395-0072

Fig.3 and Fig.4 shows that for port 1 and port 2 $S_{11} < -10$dB in the entire and it can be operated in between 3-4 4-5 & 6-7 GHz frequencies as a Multi band. UWB range and so satisfying impedance matching requirement for the entire UWB specified by the FCC.

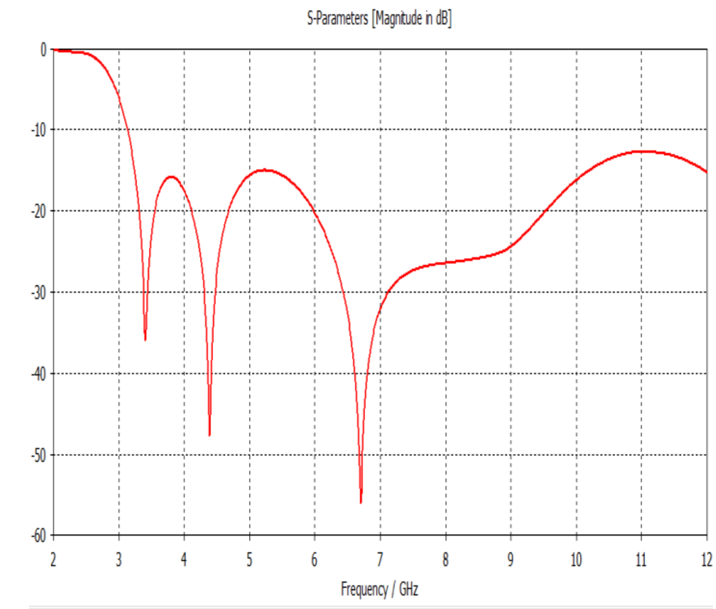


Fig 2: S_{11} plot for the proposed antenna

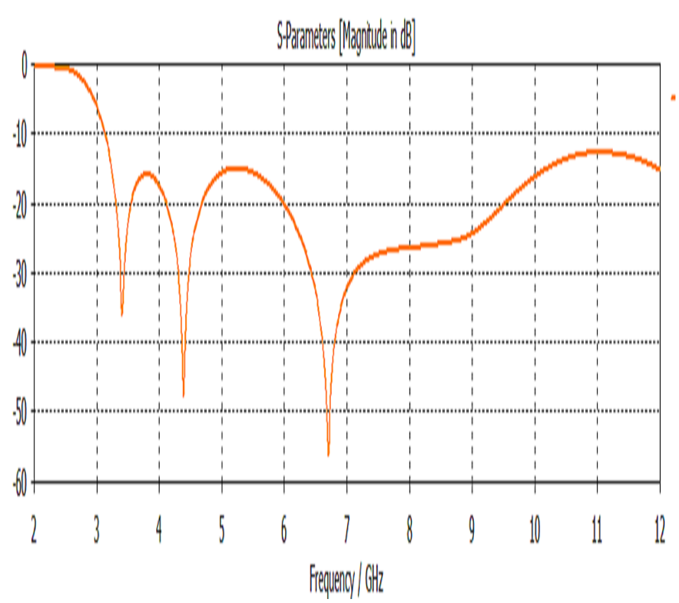


Fig 3: S_{22} plot for the proposed antenna

Mutual coupling less than 15 dB is considered enough for good performance [7], [11], [15], [16]. Fig.4 shows the simulated S_{21} [mutual coupling] between the two input ports Fig.4 shows that the mutual coupling is less than -15dB across the entire UWB band and so this makes the proposed antenna suitable for MIMO applications in the UWB range

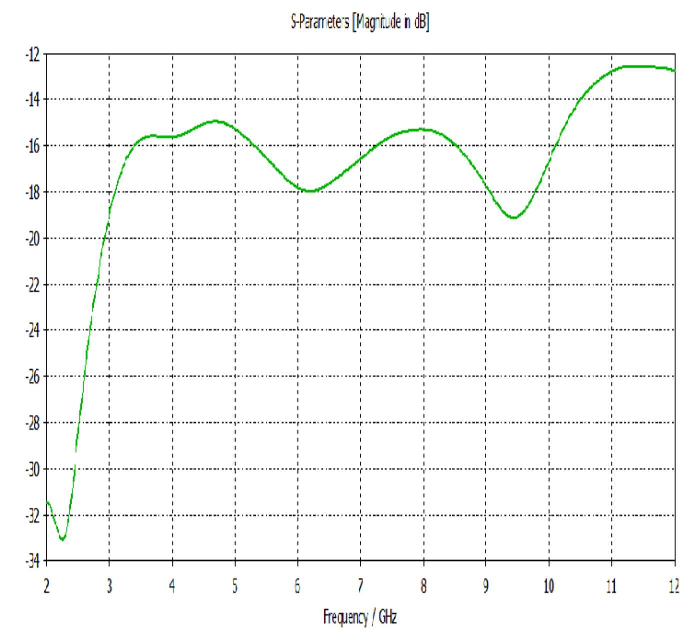


Fig 4: S_{21} plot for proposed antenna

The radiation pattern of an antenna is a plot of far-field radiation properties of an antenna as a function of the spatial co-ordinates which are specified by the elevation angle θ and the azimuth angle φ. The radiation patterns for the proposed antenna at resonating frequency 7GHz is shown in Fig.5 and Fig.6 respectively.

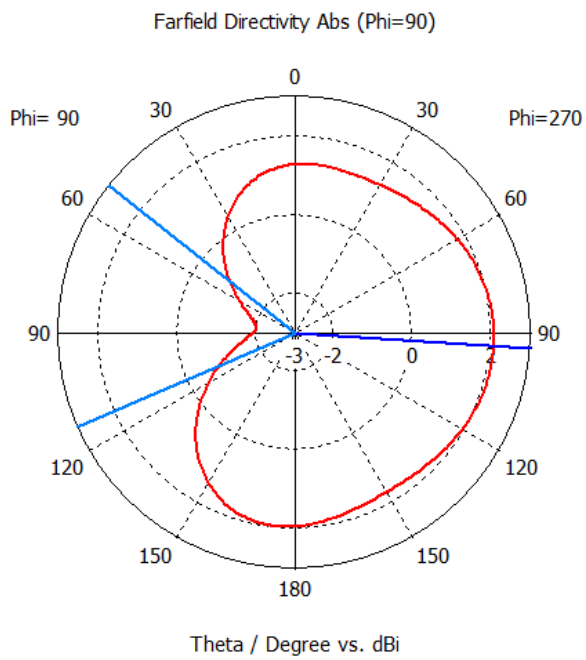


Fig 5: Polar plot at resonating frequency f = 7GHz

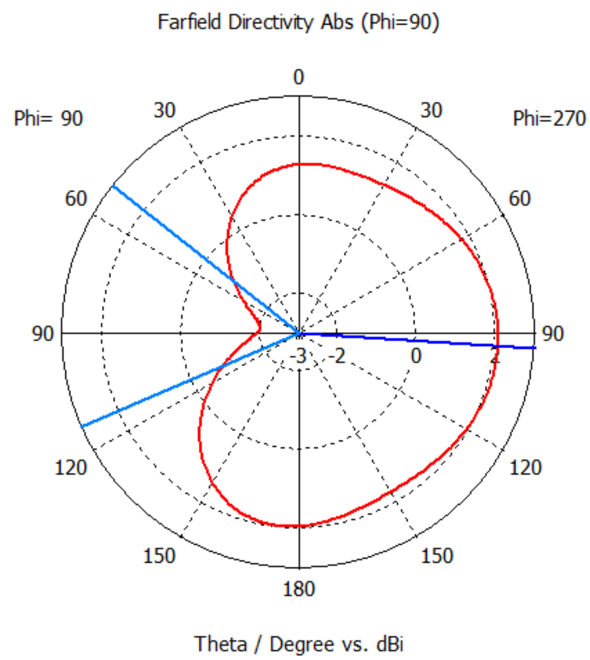


Fig 6: Polar plot at resonating frequency f= 7GHz

From the figures, it can be observed that the radiation is maximum at an angle 178º at resonating frequency 7 GHz

IV.CONCLUSION

In this paper, a compact UWB-MIMO antenna has been proposed. By implementing the proposed T shaped slot and a line slot, the performances in terms of impedance bandwidth and isolation can be enhanced significantly. Analysis results show that the proposed MIMO antenna guarantees an entire UWB bandwidth with high isolation and keeps omnidirectional radiation performance successfully. The performances of the proposed antenna proves that it is a good candidate to overcome multipath fading propagation problem in various portable UWB systems.

REFERENCES

[1] Isolation Enhancement of a Very Compact UWB-MIMO Slot Antenna with two Defected Ground Structures
[2] I. Oppermann, M. Hamalainen, and J. Iinatti, UWB Theory and Applications. New York, NY, USA: Wiley, 2004, ch. 1, pp. 3–4.
[3] Federal Communication Commission, "First report and order-revision of part 15 of the commission's rules regarding ultra-wideband trans-mission system," FCC 02 48, 2002.
[4] G. J. Foschini, "On limits of wireless communications in a fading environment when using multiple antennas," Wireless Pers. Commum., vol. 6, no. 3, pp. 311–335, 1988.
[5] T. Kaiser, Z. Feng, and E. Dimitrov, "An overview of ultra-wideband systems with MIMO," Proc. IEEE, vol. 97, no. 2, pp. 285–312, Feb. 2009.
[6] L. Liu, S. W. Cheung, and T. I. Yuk, "Compact MIMO antenna for portable devices in UWB applications," IEEE Trans. Antennas Propag., vol. 61, no. 8, pp. 4257–4264, Aug. 2013.
[7] B. P. Chacko, G. Augustin, and T. A. Denidni, "Uniplanar slot antenna for ultra wide band polarization-diversity applications," IEEE Antennas Wireless Propag. Lett., vol. 12, pp. 88–91, 2013.
[8] J. Ren, W. Hu, Y. Yin, and R. Fan, "Compact printed MIMO antenna for UWB applications," IEEE Antennas Wireless Propag. Lett., vol. 13, pp. 1517–1520, 2014.
[9] C.-X. Mao, Q.-X. Chu, Y.-T. Wu, and Y.-H. Qian, "Design and investigation of closely-packed diversity UWB slot-antenna with high isolation," Prog. Electromagn. Res. C, vol. 41, pp. 13–25, 2013.
[10] J.-M. Lee, K.-B. Kim, H.-K. Ryu, and J.-M. Woo, "A compact ultra-wideband MIMO antenna with WLAN Band-rejected

operation for mobile devices," IEEE Antennas Wireless Propag. Lett., vol. 11, pp. 990–993, 2012.
[11] T.-C. Tang and K.-H. Lin, "An ultrawideband MIMO antenna with dual band-notched function," IEEE Antennas Wireless Propag. Lett., vol. 13, pp. 1076–1079, 2014.
[12] Z.-A. Zheng, Q.-X. Chu, and Z.-H. Tu, "Compact band-rejected ultra-wideband slot antennas inserting with and resonators," IEEETrans. Antennas Propag., vol. 59, no. 2, pp. 390–397, Feb. 2011.
[13] M. Han and J. Choi, "Small-size printed MIMO antenna for next gen-eration mobile handset application," Microw. Opt. Technol. Lett., vol. 53, no. 2, pp. 248–352, Feb. 2011.