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Super Wide-Band Slotted Trishul-Shaped Microstrip Patch Antenna for Wireless Applications

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Abstract**: *In this article, a Trishul-shaped or rotated E-shaped microstrip patch antenna (MPA) rotated by 270 degrees is proposed. Two rectangular slots have been etched both from the top and bottom of the rectangular radiator to give it the shape of rotated E and inset-cut feed line respectively. The strip of copper is used as a ground plane which is behaving as a parasitic element in this case. The overall antenna size is 30.9 X 25.7 mm^2 designed on FR4 substrate. Computer Simulation Technology Microwave Studio Version (CST MWS) tool is used to design and simulate the proposed antenna structure. The antenna has an extremely wideband coverage of 15.401GHz (1.61 to 17 GHz). Consequently, this antenna has an advantage of covering a wide range of wireless applications. The antenna is further fabricated and tested to check for the close approximation of simulated and measured results.***

Index Terms**: *Trishul, CST MWS Software, Microstrip patch antenna, Parasitic element, wideband.***

I. INTRODUCTION

In modern scenario, the wireless communication system needs a wide-band antenna which supports video, voice data to be transmitted simultaneously. But there are few communication systems which needs low profile and miniaturized antennas as in portable devices such as mobile phones, tablets, laptops etc. [1]-[5]. One of the drawback of Microstrip antennas (MPA) is narrow bandwidth which can be overcome by using various techniques. In MPA design the type of substrate, size of the radiating patch, feed line design plays an important role in achieving desired antenna characteristics. For covering wider bandwidth one of the popular technique is to introduce slots on the radiating patch [6] [7]. In [8] a stacked microstrip antenna was proposed for WLAN/WiMAX applications. It used proximity coupling and defected ground structure (DGS) to achieved size reduction and wider bandwidth. The purpose of the research presented in this paper is to cover many frequency bands supporting various wireless technologies. Table 1 presents different frequency bands for various applications.

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Factitious feed radiation can be eliminated when the microstrip line is used to feed the microstrip slot antenna resulting in wider bandwidth. Different shapes and sizes of slots can be used in MPA to achieve multiband and wideband behaviour. MPA size also gets reduced by loading it with slots [9] - [11].

Table 1. Frequency bands and their applications

Frequency band(GHz)	Bandwidth (MHz)	Applications
1.710-1.805	95	GSM1800
1.850-1.990	140	GSM1900
2.3-2.4	100	IMT
2.7-2.9	200	IMT
3.4-4.2	800	IMT
4.4-4.9	500	IMT
2.4-2.484	84	WLAN
5.15-5.35	200	WLAN
5.725-5.825	100	WLAN
2.4-2.5	100	Bluetooth
2.5-2.69	190	WiMAX
3.4-3.69	290	WiMAX
5.25-5.85	600	WiMAX
Uplink 5.9-6.4 Downlink 3.7-4.2	500	C-Band Fixed, point to point ground stations, non-military
Uplink 7.9-8.4 Downlink 7.25-7.75	500	X-Band Mobile(Ships, aircrafts), radio relay, Military
Uplink 14-14.5 Downlink 11.7-12.2	500	Ku-Band Broadcast and fixed point service, on military

In this paper, a super wideband patch antenna is proposed covering various cellular and non-cellular frequency bands [12]. Section II confers about the proposed antenna structure. Section III presents and discusses the simulation results, Section IV presents the measurement results obtained using Vector Network Analyzer (VNA). Finally, Section V presents the conclusion of the paper.

II. ANTENNA DESIGN

A super wide-band microstrip patch antenna of rotated E-shape with its front view and back view is depicted in Fig. 1 and Fig. 2. It is designed with the dimensions of 30.9 X 25.7 mm^2 covering a wide frequency range of 1.61 to 17 GHz supporting numerous applications.

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The proposed antenna consists of a rectangular shaped patch loaded with four slots on a FR4 substrate with thickness of 1.56 mm. For exciting the radiating patch a 50 ohm microstrip line is used. It is also shown in Fig. 1 that the four slots on the patch namely 1, 2, 3 and 4 where slot 1 size is equal to slot 2 and that of slot 3 size is equal to slot 4. A strip of dimensions of 8mm x 8mm is used as the ground plane. The microstrip feed lines have a length and width of 0.4 mm and 3.25 mm respectively.

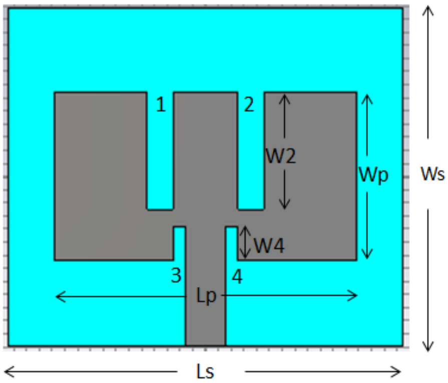


Figure 1. Front view of the proposed antenna design

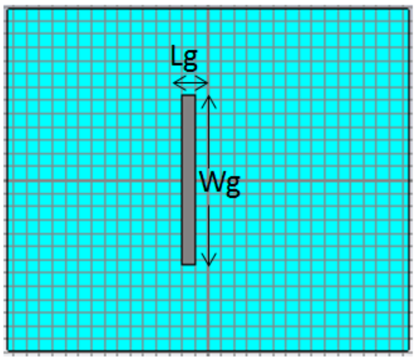
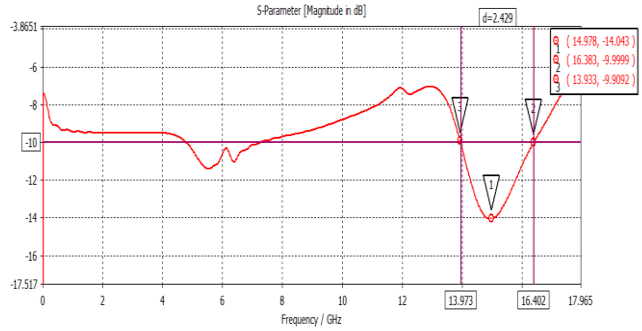


Figure 2. Back view of the proposed antenna design

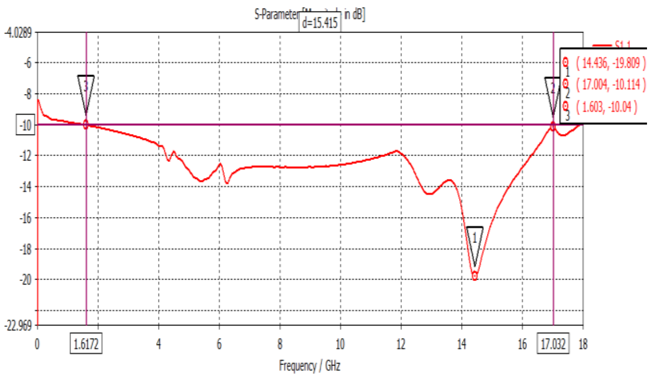
III. SIMULATION RESULTS

CST MWS Studio software [13] is utilized to design and simulate the proposed antenna structure and various antenna parameters are observed. Parametric analysis on various dimensional variables of the antenna resulted in optimized structure and desired antenna performance is achieved. Ultimately, the optimal dimensions were acquired as follows: Ls= 30.9 mm, Ws= 25.7 mm, Lg= 1 mm, Wg=12.8 mm, Lp=23.5 mm, Wp=12.8 mm, W2=8.9 mm and W4=2.55 mm. The width of slots 1 and 2 is 2mm and of slots 3 and 4 is 1mm.

(A) Return Loss (S_{11}): This antenna parameter is one of the important performance metric to know about the resonances and bandwidth supported by the antenna. Fig. 3 presents S_{11} plot of the proposed antenna. The plot shown in Fig. 3 (a) is obtained with only slots 3 and 4 on the radiating patch resulting in two bands, one near 6 GHz and another band from 13.973 GHz to 16.40 GHz.



(a)



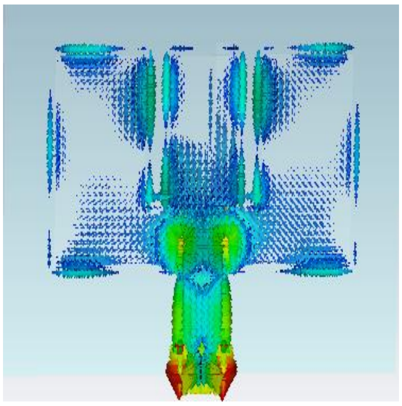
(b)

Figure 3. Return Loss plots (a) with slots 3,4 only (b) with slots 1, 2, 3 and 4

With the introduction of slots 1 and 2, the return loss improved as shown in Fig. 3 (b). The frequency range covered is from 1.6 to 17GHz (15.415 GHz) with resonance at 14.436 GHz and return loss value of -19.8 dB. The proposed antenna supports various applications as mentioned in Table 1.

(B) Current Distribution

The electromagnetic behaviour of an antenna can be studied from the current/field distributions. Fig. 4 (a) presents the current distribution on the radiating patch at 15.5 GHz and Fig. 4 (b) presents current distribution at 12 GHz.



(a) at 15.5 GHz

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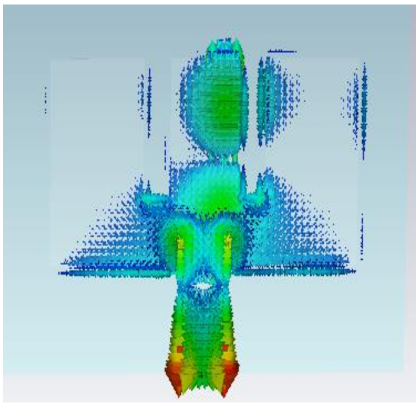

(b) at 12 GHz

Figure 4. Current distribution of the proposed antenna

It can be observed that at lower frequency the area between slots 1 and 2 is significantly contributing to the radiation while at higher frequency, the feed line and areas of slots 3 and 4 are significant.

IV. FABRICATION AND MEASUREMENT RESULTS

Fig. 5 presents the antenna prototype fabricated using FR4 substrate and with a SMA connector to connect the feed line to a source.

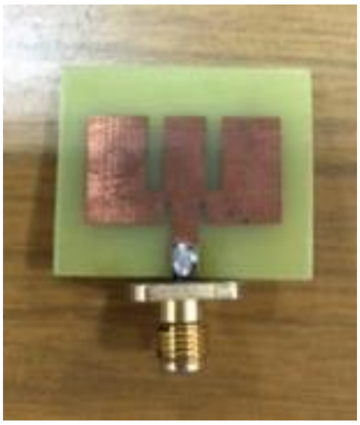

Figure 5. Fabricated prototype of the proposed antenna

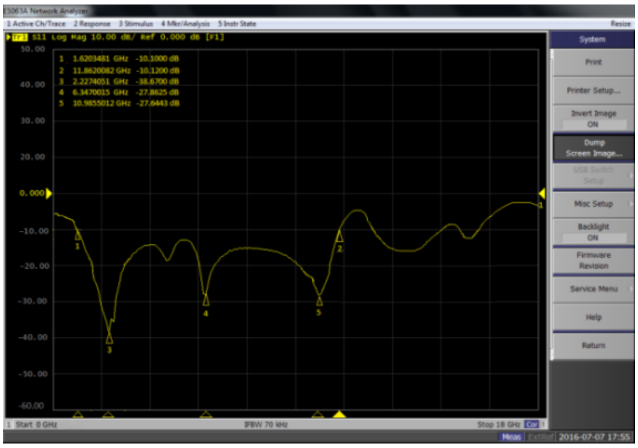

Figure 6. Measured return loss plot from VNA

Fig. 6 shows the measured return loss plot obtained from Vector Network Analyzer (VNA) model Agilent E5063A. Comparable to an impedance bandwidth of 152% the measured impedance bandwidth of the wide band obtained from 1.62 GHz to 11.86 GHz is approximately 10.24 GHz. There are three resonating frequencies at 2.2 GHz, 6.34 GHz and 10.98 GHz in this wide band. Second band is obtained from 12.5 GHz to 13.9 GHz with bandwidth of 1.4 GHz and a small band ranging from 14.7 GHz to 15.5 GHz with impedance bandwidths of 10.6% and 5.3% respectively.

Practicable agreement between the simulated results and the measured results is achieved beyond a frequency deviation of ≤13%. Such variations usually occur due to fabrication errors, connector losses, etc. Therefore, the difference may be ascribed to the antenna feed and the connector.

V. CONCLUSION

A compact slotted microstrip antenna utilizing DGS technique is designed, fabricated and then tested for measurement results. The main objective of this design is to get a wide band covering wide range of applications. Although, reduction in impedance bandwidth is obtained after testing the fabricated design but that is due to various losses and errors involved. Corresponding to an impedance bandwidth of 152% the measured impedance bandwidth of the wide band obtained from 1.62 GHz to 11.86 GHz is approximately 10.24 GHz. It covers L, S, C, and X frequency bands. Therefore, it covers applications like GSM 1800, GSM 1900, IMT, WLAN, Bluetooth, WiMAX and satellite applications as well.

REFERENCES

1. Bahl, I. J., & Bharta, P., "Microstrip Antennas," Massachusetts (USA), Artech House, 1980.
2. Wong, K.L., "Compact and broadband microstrip antennas," Wiley, NJ, 2002, 1st edn.
3. Bakariya, P. S., Dwari, S., Sarkar, M., & Mandal, M. K. "Proximity-coupled multiband microstrip antenna for wireless applications", IEEE Antennas and Wireless Propagation Letters, Vo. 14, 646-649, 2015.
4. J. H. Yoon, Y. C. Rhee and Y. K. Jang, "Compact monopole antenna design for WLAN/WIMAX triple-band operations," Microwave and Optical Technology Letters, Vol. 54, No. 8, 1838-1846, 2012.
5. Nashaat, D., Elsadek, H.A., Abdallah, E., Elhenawy, H., Iskander, M.F.: "Multiband and miniaturized inset feed microstrip patch antenna using multiple spiral-shaped defect ground structure (DGS)", IEEE Antennas and Propagation Society International Symposium, 2009.
6. Azadegan, R., Sarabandi, K., "A novel approach for miniaturization of slot antennas", IEEE Trans. Antennas Propag., Vol. 51, No. 3, 421–430, 2009.
7. Chen, Z.N., Qing, X., "Slotted microstrip antennas for circular polarization with compact size", IEEE Antennas Propag. Mag., Vol.55, 124–137, 2013.
8. Prajapati, P.R., Kartikeyan, M.V., "Proximity coupled stacked circular disc microstrip antenna with reduced size and enhanced bandwidth using DGS for WLAN/WiMAX applications", IEEE Student's Conf. on Electrical, Electronics and Computer Science, 2012.
9. Sanjeeva Reddy, B. R., Vakula D., "Compact Zigzag-Shaped-Slit Microstrip Antenna With Circular Defected Ground Structure for Wireless Applications", IEEE Antennas and Wireless Propagation Letters, Vol. 14, 678-671, 2014.
10. Lee K. F., Luk K. M., Mak K. M., and Yang S. L. S., "On the use of U slots in the design of dual and triple band patch antennas," IEEE Antennas Propag. Mag., Vol. 53, 60-74, 2011.
11. Guha, D., Biswas, S., Kumar, C., "Annular ring shaped DGS to reduce mutual coupling between two microstrip patches", Proc. of IEEE Applied Electromagnetics Conf. (AEMC), Kolkata, India, 2009.
12. Kaur, A. and Kaur, J., "Wide Bandwidth Microstrip Antenna Designs for Various Applications Using Photonic Band Gap and Defected Ground Substrate Methods" (Masters dissertation), 2016.
13. "CST Microwave Studio," "3D EM Simulation Software," [Online]. Available: http://www.cst.com.

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