Microstrip Patch Antenna with Defected Ground Structure for X-Band Applications

Surya Deo Choudhary, Manish Kumar, Neel Kamal, Vineet Shekher

Abstract-: ***In this paper a microstrip patch antenna with defected ground structure is proposed for X-band applications. The antenna is compact with size profile of 20 x 25 x 1.6 mm^3 and the used substrate for designing the present antenna is FR-4 epoxy. The substrate has relative permeability of 1 and relative permittivity of 4.4 with a loss tangent of 0.02. The impedance bandwidth of the proposed antenna is 0.38 GHz (8.06 GHz - 8.44 GHz) with resonates at 8.22 GHz and 0.54 GHz (9.79 GHz – 10.33 GHz) with resonates at 10.06 GHz. The excitation supplied through a 50ohm microstrip feed line. The performance of the present antenna has been simulated and analyzed with the High Frequency Structure Simulator (Ansys HFSS v15.0).***

Index Terms: Microstrip, Antenna, Permittivity, Defected Ground, X-band, Excitation.

I. INTRODUCTION

Wireless communication applications such as radar and satellite communication, radio frequency identification (RFID), global positioning system (GPS), mobile, Wi-MAX, etc. Presently, the main attraction of researchers in antenna is towards low-cost, light weight, compact size, and easy fabrication [1]-[5]. Microstrip patch antennas are widely used to perform various operations needed by various wireless technology networks [3]. Shapes of commonly used microstrip antenna are square, circular, and elliptical of t << λ_0 (free space wavelength), height of the substrate ranges from 0.003 λ_0 to 0.05λ_0 above the ground and length of the rectangular patch ranges $\lambda_0/3$ to $\lambda_0/2$. A dielectric substrate is used between ground and patch with dielectric constant in the ranges from 2.2 to 12 [1]-[11]. In the present paper microstrip patch antenna with deflected ground structure is used for satellite and radar applications. The proposed antenna of dimension 25 x 20 x 1.6 mm^3 is used which covers the desired applications. This band is achieved by designing slots on microstrip feed line, substrate and ground plane

II. ANTENNA DESIGN

The proposed antenna is designed on a low-cost FR-4 substrate with dielectric constant 4.4, loss tangent 0.02, and thickness h=1.6mm. The antenna structure is shown in figure 1 and figure 2, which consists of rectangular ground with the dimension of 20 x 25 mm^2, and substrate with the dimension of 20 x 25 x 1.6 mm^3. The material used for ground and reflector is of copper and substrate is taken of FR-4 Epoxy. Dimension of the proposed paper is mentioned in table-1. In the proposed paper ground is deflected by cutting a circular slot. A microstrip feed line is used for feeding the antenna. The feed line has a width of 3mm. For feeding the proposed patch antenna a microstrip feed of characteristic impedance 50ohm is taken. To meet with desired result VSWR must be less than or equal to 2. Figure 3 shows fabricated antenna.

TABLE - I
Dimension of the parameters used in proposed antenna

Parameter	Dimension(mm)	Parameter	Dimension(mm)
A	8.3	F	4.5
B	3	G	4.5
C	3.5	R1	8
D	3.5	R2	5
E	4.1		

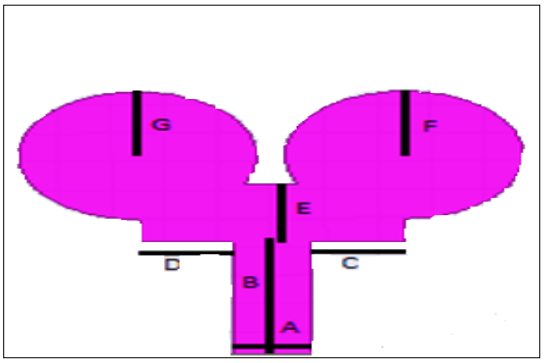

Figure 1: Top view of proposed antenna

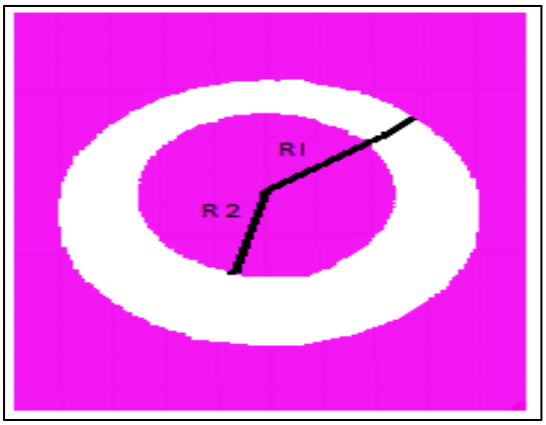

Figure 2: Bottom view of proposed antenna

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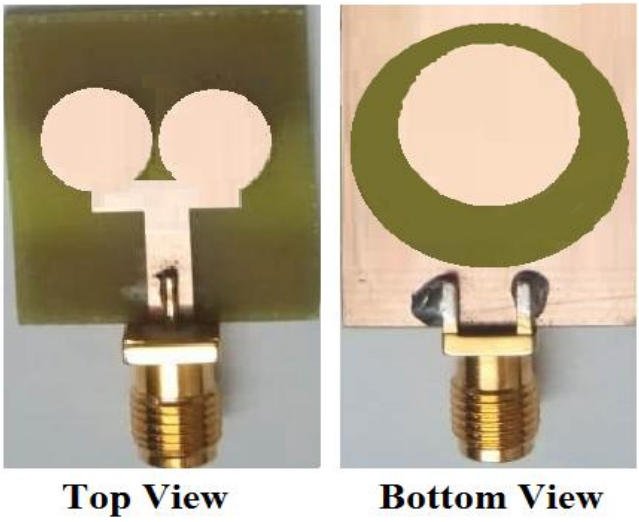


Figure 3: Fabricated antenna

III. RESULT AND DISCUSSION

The antenna performance has been analyzed by High Frequency Structural Simulator (HFSS v.15.0.0). In the presented paper VSWR, E-Field, H-Field, S11, and 2D Radiation Pattern like different parameters are observed for the parametric studies. In the presented paper impedance matching better than -10dB return loss for frequency range 8.06 GHz – 8.44 GHz and 9.79 GHz – 10.33 GHz. Figure 5 shows the simulated 2-D radiation pattern of the proposed antenna. Figure 3 shows fabricated antenna. Figure 4 shows that the antenna has the maximum return loss of -22.38 dB in S_{11} graph. Figure 5 shows the VSWR value lesser than 2 for the entire frequency range. Figure 6, Figure 7, figure 8 and Figure 9 shows the 2D radiation pattern, E-field, H-field and surface current of the proposed antenna respectively. The operating frequency of the proposed antenna design falls in X-band which allows satellite and radar communication.

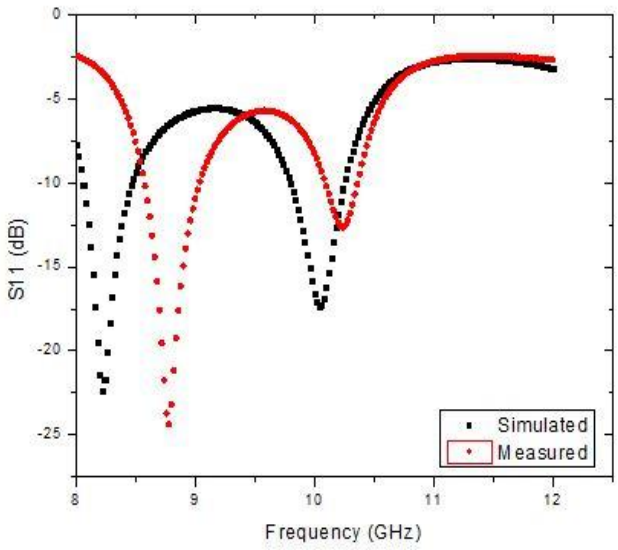


Figure 4: Simulated and Measured S_{11} of proposed antenna

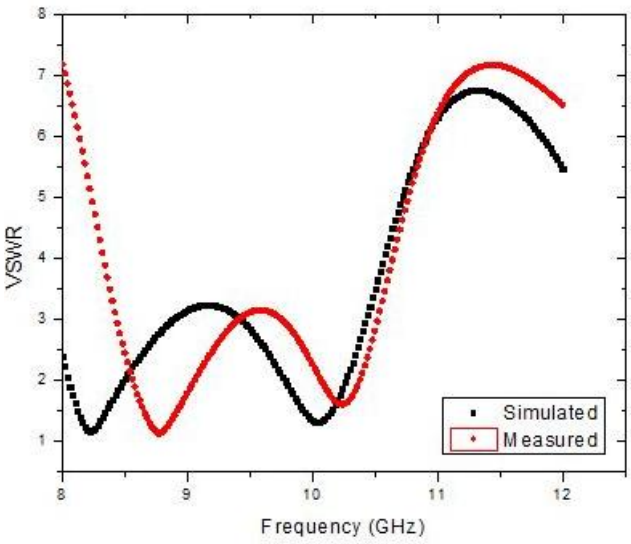


Figure 5: Simulated and Measured VSWR of proposed antenna

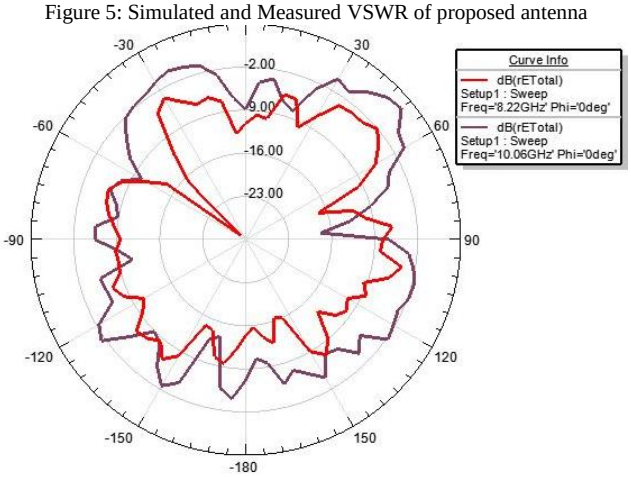


Figure 6: Simulated 2D radiation pattern of proposed antenna

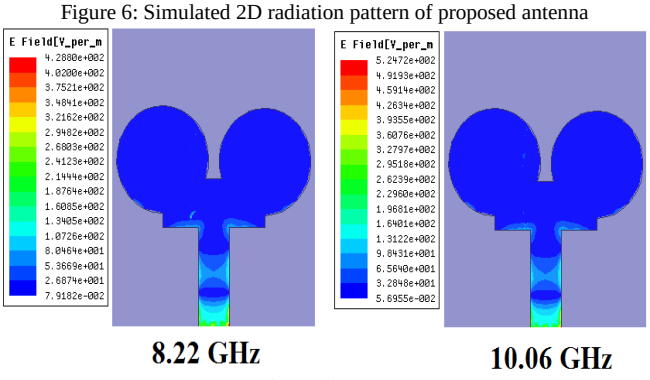


Figure 7: E-field of proposed antenna

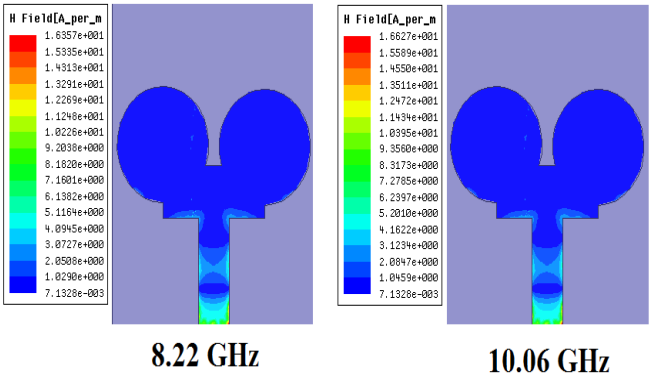
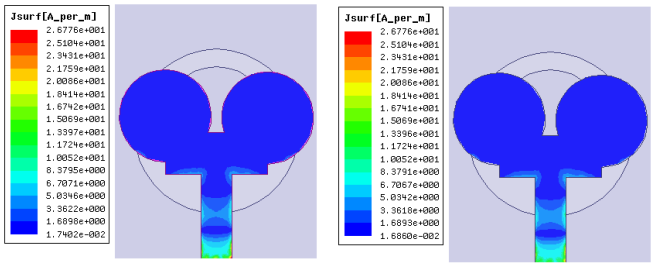


Figure 8: H-field of proposed antenna



8.22 GHz **10.06 GHz**

Figure 9: Surface Current of proposed antenna

IV. CONCLUSION

A simple structured microstrip patch antenna with DGS is present for X-band applications such as radar, satellite communications etc. As compare to the other antenna it is quite simple in structure and achieves good impedance matching, radiation pattern, VSWR, radiation characteristics and return loss. The simulated antenna has bandwidth of 0.38 GHz (8.06 GHz - 8.44 GHz) with resonates at 8.22 GHz and 0.54 GHz (9.79 GHz – 10.33 GHz) with resonates at 10.06 GHz for the return loss below -10dB.

REFERENCES

1. M. Meloui and M. Essaaidi, “A dual ultra wide band slotted antenna for C and X bands application, “Progress In Electromagnetic Research Letters, vol.47, pp. 91-96, 2014.
2. JC. A. Balanis, “Antenna Theory Analysis and Design”, 2nd ed. Hoboken , NJ,USA : Wiley-Interscience, 2005.
3. R.K. Gupta “Printed TRI-BAND Monopole Antenna Structure for wireless Applications” Issue 2, Vol I, Apr 2010.
4. G. Adamiuk, M. Janson, W. Wiesbeck, and T. Zwick, “Dual-polarized UWB Antenna Array, “ 2009 IEEE International Conference on Ultra-Wideband (Icuwb 2009), pp.164-169, 2009.
5. MithileshKumar, “Triple Band inverted F-Slot Microstrip Patch Antenna for WiMAX Application”,2014 International conferenceon medical imaging, m-health and Emgineering Communication Systems(MedCom).
6. Rappaport, Theodore S. Wireless Communications: Principles and Practice. 2nd ed., Prentice Hall PTR, 2010.
7. Sana Arif, SyedaAreebaNasir, Muhammad Mustaqim and Bilal A. Khawaja, “Dual U-Slot Triple Band Microstrip Patch Antenna for Next GenerationWireless Networks,” PNEC, National University of Sciences and Technology (NUST). Karachi, Pakistan,” International Conference on Sensor Network Security Technology and Privacy Communication System (SNS & PCS), PP.1-6, 9-10 Dec 2013.
8. Kai-Fong Lee , Shing Lung Steven Yang and Ahmed A. Kishk, “Dual- and Multiband U-Slot Patch Antennas,” IEEE Antennas and Wireless Propagation Letters, Vol. 7, pp.645-647,2008.
9. K. Li, M. Ingram, and E.RAUSCH, “Multibeam antennas for indoor wireless communications,” IEEE Trans.Comm., vol.50, no.2, pp.192-194, Feb. 2002.
10. K.Pengthaisong, P.kracchodnok, and R.wongsan, “Design of a Dual-band Antenna using a Patch and Frequency Selective Surface for WLAN and WIMAX,” International Conference on Electrical Engineering/Electronics, Computer, Tele-communications and Information Technology (ECTI-CON), pp.1-4, 15-17 May 2013.
11. R.Jothi Citra, K.Jayanthi, V.Nagaraja, “Design ofMicrostrip slot Antenna for WiMAX Application,” IEEE International Conference on Communication and signal processing (ICCSP), PP.645- 649, 22-23 March 2013.

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