International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 04 Issue: 03 | March -2017 www.irjet.net p-ISSN: 2395-0072

Novel Ultra-Wide Band Microstrip Patch Antenna design for space research and radio astronomy applications

Prince[1], Payal Kalra[2], Ekambir Sidhu[3]

[1]*Student, Department of Electronics and Communication Engineering, Punjabi University Patiala, India*
[2]*Student, Department of Computer Engineering, Punjabi University Patiala, India*
[3]*Assistant Professor, Department of Electronics and Communication Engineering, Punjabi University Patiala, India*

---***---

Abstract - *This paper presents the design and performance analysis of an ultra-wide band (UWB) microstrip patch antenna for space research and radio astronomy applications. The proposed antenna design employs Flame Retardant (FR-4) material as substrate having a dielectric constant of 4.4 and thickness of 1.3mm. The copper material is used for patch and ground due to its low resistivity and high mechanical strength having thickness of 0.05mm. The reduction in dimensions of ground has been done to enhance the following antenna parameters impedance bandwidth, gain and directivity. The proposed antenna design has an impedance bandwidth of 5.606 GHz (10.846 GHz to 16.452 GHz) having corresponding resonant frequency at 11.82 GHz. The value of minimal return loss at corresponding resonant frequency is -31.181 dB. The calculated fractional bandwidth of the proposed antenna design is 47.42%. The performance of proposed antenna design has been analyzed in terms of impedance bandwidth (GHz), return loss (dB), gain (dB), directivity (dBi), VSWR (voltage standing wave ratio), HPBW (half power beam width) and impedance (ohms). It has been observed that the proposed gigahertz rectangular antenna design has a value of directivity and gain as 4.605 dBi and 3.973 dB, respectively at the corresponding resonant frequency. The proposed antenna has been simulated and designed using CST microwave Studio 2016. The proposed antenna can be suitably used for fixed-satellite, broadcasting satellite, space research, radiolocation and radio astronomy applications.*

Key Words: CST Microwave Studio 2016, directivity, gain, patch antenna, radio astronomy, return loss, space research.

1. INTRODUCTION

In recent years, the significant advancement in the wireless communication system demands antennas having superior performance, multiband operation, light weight and low profile.[1] The micro strip patch antenna is one of the most preferred antenna structure due to their ease of fabrication and low profile.[2] The micro strip patch antenna can be explained in simplest form as antenna with dielectric substrate confined in between two metal surfaces with radiating surface known as patch on the one side and ground surface on the other side.[3] There are varieties of substrates available with different values of dielectric constant but in the proposed antenna design, FR4 (Flame Retardant) material with dielectric constant (ε_r) of 4.4 has been used.[4] An antenna can be fed by various feeding techniques, for example, co-axial feed line, proximity coupled micro strip feed, micro strip feed line.[5] The technique of feeding can be defined as the means to transfer the power from the feed line to the patch, which itself act as a radiator.[5] The International Telecommunication Union Radio communication Sector (ITU-R) has defined UWB (ultra-wide band) as an antenna transmission for which emitted signal bandwidth exceeds the 20% value of fractional bandwidth.[6] Apart from above mentioned applications, the low profile antennas have some limitations, for example, narrow bandwidth, low gain, low power handling capacity, etc.[7] The bandwidth of microstrip patch antenna can be improved by using reduced ground plane.[8][9]

2. ANTENNA DESIGN

The positioning of the patch, feedline, substrate and ground is shown in Fig. 1 corresponding to their respective thickness. In the proposed Gigahertz antenna, the substrate of thickness 1.4mm has been employed. The rectangular shaped substrate is made up of Flame Retardant (FR-4) material having a dielectric constant of 4.4. The topmost layer of the designed antenna is the radiating patch made up of copper with a thickness of 0.05 mm having dimensions as shown in the Fig. 2. The bottom view of the proposed antenna is shown in Fig. 3 with dimensions of reduced ground.

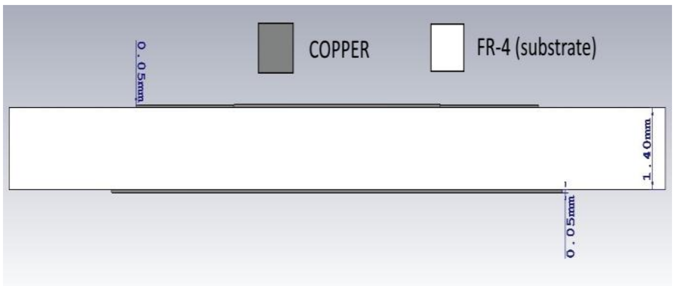

Fig -1: Side view of the proposed antenna

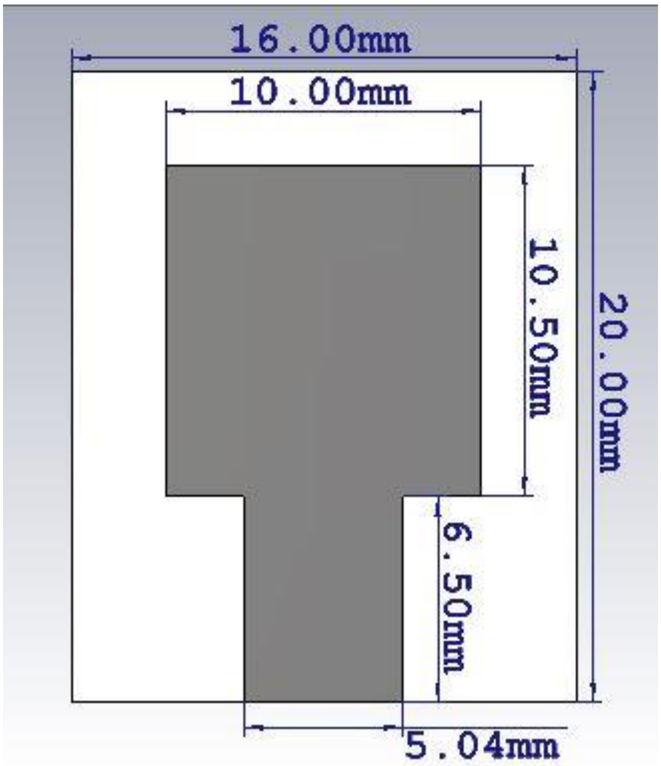

Fig -2: Front view of the proposed antenna

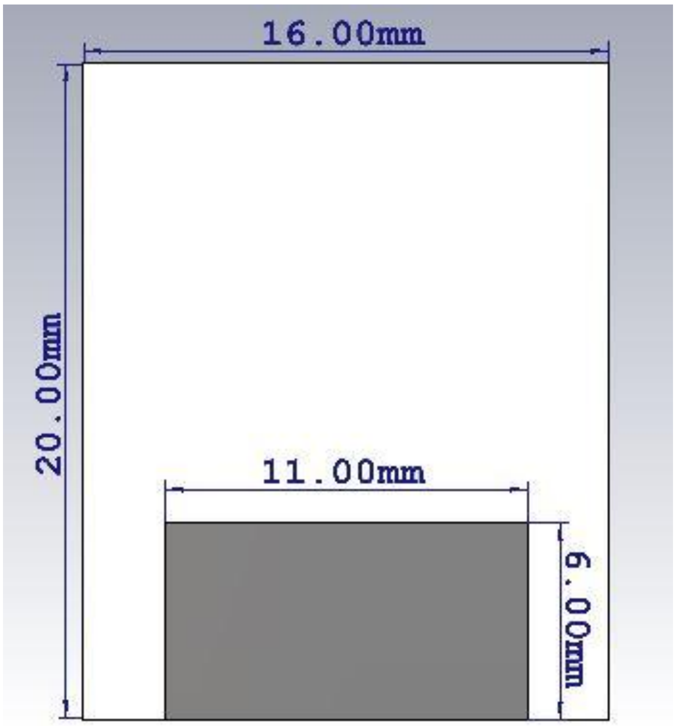

Fig -3: Back view of the proposed antenna

3. RESULTS AND DISCUSSION

The results of the proposed antenna design have been observed in terms of impedance bandwidth (GHz), return loss (dB), impedance (Ω), gain (dB), directivity (dBi), VSWR (voltage standing wave ratio) and HPBW (half power beam width). The proposed antenna design has been simulated and designed using CST microwave studio 2016. The return loss of proposed antenna design is shown in Fig. 4 having a value of -31.181 dB corresponding to resonant frequency at 11.82 GHz. In Fig. 5, the impedance bandwidth of the proposed antenna design has been shown and indicated by using marker numbered as 1 and 2. The Impedance of the proposed antenna design has been shown in Fig. 6 having value of 50.38Ω. The directivity and gain of the proposed gigahertz antenna are found to be 4.605 dBi and 3.973 dB as shown in the Fig. 7 and Fig. 8, respectively.

The acceptable value for Voltage Standing Wave Ratio (VSWR) of a patch antenna is between 1 and 2. In Fig. 9, it is shown that the VSWR value of proposed antenna design lies between 1 and 2 for entire band represented by markers. The polar plot of the proposed antenna has been shown in Fig. 10 having an angular width of 54.9 degrees at corresponding resonant frequency of 11.82 GHz.

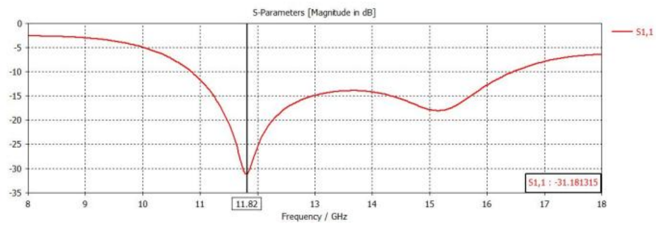

Fig -4: Return loss plot of the proposed antenna

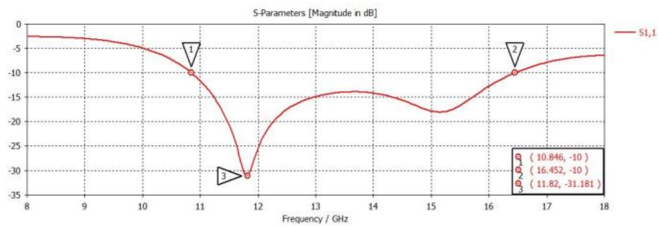

Fig -5: Bandwidth plot of the proposed antenna

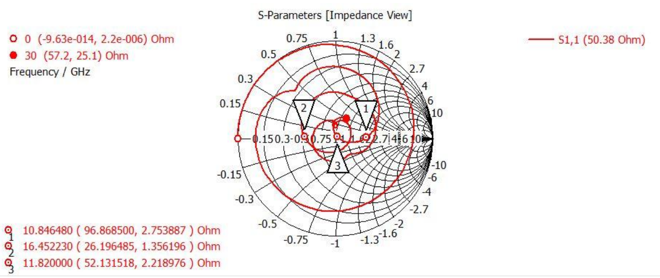

Fig -6: Smith Chart of the proposed antenna

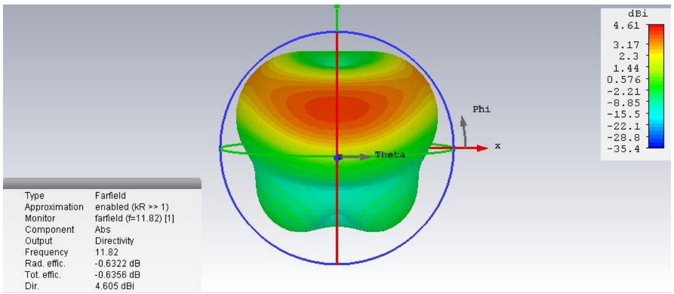

Fig -7: Directivity of the proposed antenna

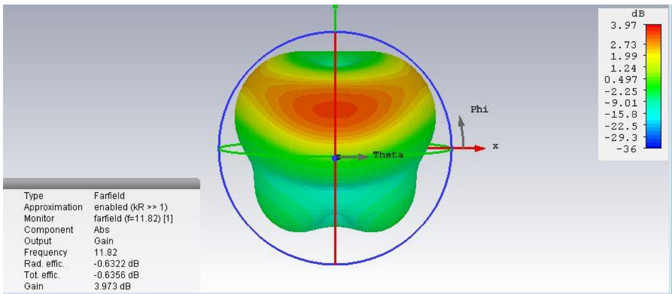

Fig -8: Gain of the proposed antenna

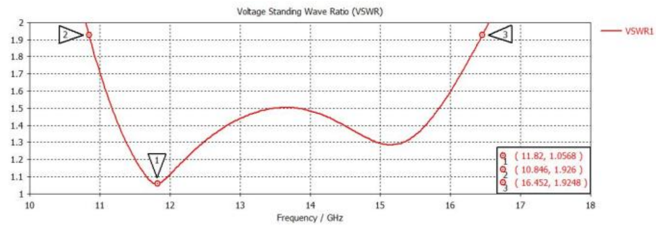

Fig -9: VSWR of the proposed antenna

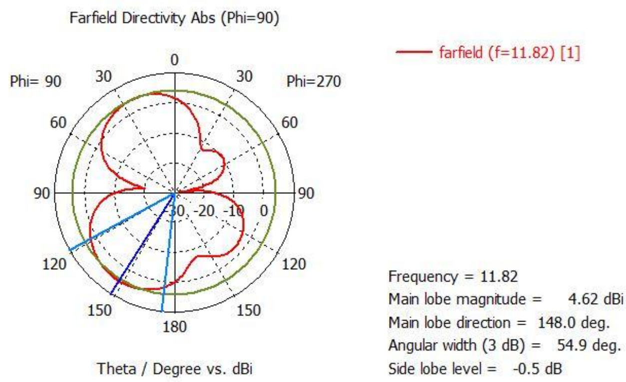

Fig -10: Polar plot of the proposed antenna

4. CONCLUSION

In this paper, the rectangular shaped gigahertz microstrip patch antenna design with reduced ground has return loss of -31.181 dB at resonant frequency of 11.82 GHz has been proposed. The proposed antenna design has gain and directivity of 3.973 dB and 4.605 dBi, respectively. The proposed antenna design is an ultra-wide band antenna having fractional bandwidth of 47.42% which makes it an ultra wideband antenna. The impedance bandwidth of 5.606 GHz (10.846 GHz to 16.452 GHz) covered by the proposed antenna design which can be suitably used for fixed-satellite, broadcasting satellite, space research, radiolocation and radio astronomy applications.

ACKNOWLEDGEMENT

We would like to thank our Prof. Ekambir Sidhu, Assistant Professor, Department of Electronics and Communication Engineering, Punjabi University, Patiala for his guidance and support for the successful completion of this research work.

REFERENCES

[1] Ekambir Sidhu, Akshay Kumar and Amarveer Singh, “Horse-Shoe ShapedStacked Microstrip Patch Antenna for WLAN, WiMAX and IMT Applications”, An International Journal of Engineering Sciences, January 2016, Vol. 17,pp. 525-531.

[2] X. Liu et al., “Transparent and Nontransparent Microstrip Antennas on a CubeSat: Novel low-profile antennas for CubeSats improve mission reliability,” IEEE Antennas Propag. Mag., pp. 1–1, 2017.

[3] A. S. Dhillon, A. Kumar, T. K. Gill, and E. Sidhu, “Novel dumble shaped stacked micro strip patch antenna for Bluetooth/IMT/WLAN applications,” in 2016 International Conference on Wireless Communications, Signal Processing and Networking (WiSPNET), 2016, pp. 1764–1767.

[4] B. R. Behera and P. Suraj, “Effect of substrates on Metamaterial based Antenna design and analysis of antenna using different substrates,” in 2016 International Conference on Wireless Communications, Signal Processing and Networking (WiSPNET), 2016, pp. 665–669.

[5] A. A. Nour, F. Fezai, and T. Monediere, “Comparison of different feeding techniques of a low-profile dual-band circularly polarized microstrip antenna,” in 2016 10th European Conference on Antennas and Propagation (EuCAP), 2016, pp. 1–5.

[6] Amarveer Singh and Ekambir Sidhu, “Multiresonant slotted microstrip patch antenna (MPA) design for Bluetooth, IMT, WLAN and WiMAX Applications”, American Journal of Engineering Research, vol. 3, Issue 8, pp. 162-170, 2014.D. Kornack and P. Rakic, “Cell Proliferation without Neurogenesis in Adult Primate Neocortex,” Science, vol. 294, Dec. 2001, pp. 2127-2130, doi:10.1126/science.1065467.

[7] R. Kshetrimayum, “An introduction to UWB communication systems,” IEEE Potentials, vol. 28, no. 2, pp. 9–13, Mar. 2009.

[8] M. Gurnoor Singh Brar, Jaspreet Singh, Ekambir Sidhu, “High Gain Pentagonal Slotted Microstrip Patch Antenna Design for Radio Location Applications,” International Journal of Engineering and Technical Research (IJETR), Volume-5, Issue-2, June 2016, pp.126-128.

[9] K. Shafique, M. Mustaqim, B. M. Khan, and B. A. Khawaja, “A thin and flexible ultra wideband antenna for wireless body area networks with reduced ground plane effect,” in 2015 International Conference on Emerging Technologies (ICET), 2015, pp. 16.

[10] A.Joshi and R.Singhal, “Probe-fed regular hexagonal narrow-slot antenna with reduced ground plane for WLAN applications,” in 2016 IEEE Region 10 Conference (TENCON), 2016, pp. 13121316.