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A Compact CPW-Fed Defected Ground Microstrip Antenna for Ku Band Application

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Abstract

A simple, compact, wide band microstrip antenna for Ku band application is proposed. The defected ground and CPW feeding is used to achieve wideband antenna. The presented antenna is designed on FR-4 substrate with dielectric constant of 4.4. The overall size of antenna is 25 × 23 × 1.6 mm. This Ku band antenna has been simulated using an Ansoft HFSS, electromagnetic simulation tool. The designed antenna resonates at three frequencies 11.2, 12.5, and 14.3 GHz with the return loss of −27.2191, −34.2027, and −35.896, respectively. It covers a bandwidth of 5.9 GHz extending from 10.5 to 16.4 GHz. It has maximum gain of 1.6 dB. Antenna has stable radiation pattern and group delay.

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Keywords Partial ground · Wide band · Ku band · CPW fed

1 Introduction

The frequency range of 12–18 Hz has been chosen as Ku band. Ku band is generally utilized for satellite communication as Ku band provides broadcasting as well as two-way communication [1–3]. Other advantages of Ku band are less signal interference from other communication systems, more reliable, secured connectivity, small antennas, and versatile spectrum.

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Microstrip antenna plays very significant role in wireless communication system. Microstrip antennas are used in high performance aircrafts, radar, missiles, and other spacecraft. It has many advantages such as its light weight, simple structure, ease of integration, and less cost. Microstrip antenna requires very less space for installation as these are simple and small in size. The only space these require is the space for the feed line which is placed behind the ground plane. Microstrip antennas are low profile, simple, conformable to planar, and non-planar surfaces, inexpensive to manufacture using modern printed circuit technology [4–9]. Microstrip antenna has gained much importance due to its low profile, simple design, ease of integration, and ease of fabrication.

The designed antenna is fed using CPW feeding mechanism. CPW feeding technique has many advantages over other microstrip feeing techniques. Some of the advantages are low dispersion, low radiation leakage, and the ability to control the characteristic impedance. CPW feeding mechanism can also be integrated with active devices. Microstrip antennas can be designed in various shapes and sizes. However, size of the antenna cannot exceed certain values as these need to be compact in size so that they can be easily installed on the surfaces of aircrafts, radars, or satellites. Smaller size reduces the weight of antenna which is a desirable characteristic for microstrip antenna [10–13]. Microstrip antennas with different shapes such as double U shaped, E shaped, hexagonal shaped have been reported. For Ku band application, triangular slots on patch and elliptical slot cut in the ground plane have been reported [14–16].

In this paper, CPW-fed patch and defected ground plane has been used to increase bandwidth. The designed antenna covers a bandwidth of around 5.9 GHz from 10.5 to 16.4 GHz, which covers most of the Ku band.

2 Antenna Design

The presented antenna operates for three resonant frequencies which is shown in Fig. 1. If there is more than one resonant part available with each operating at its own resonant frequency then the overlapping of multiple resonance leads to broadband applications. The basis of the proposed antenna was a rectangular patch with length L_{p2} and width W_{p2}. Then U shape was obtained by cutting a U-shaped slot from the rectangular patch and finally the proposed design was obtained to enhance the operating bandwidth. Ground plane is same for all the three designs and is made by cutting three small rectangular slots from the main rectangular ground plane.

The patch has been designed on FR-4 substrate with dielectric constant equal to 4.4 and height of the substrate is equal to 1.6 mm. The overall size is 25 × 23 × 1.6 mm which is a very compact size and hence suitable for satellite applications. 50 Ω characteristic impedance is achieved on fixing the feed length at 3 mm. The design parameters of anticipated antenna is shown in Table 1.

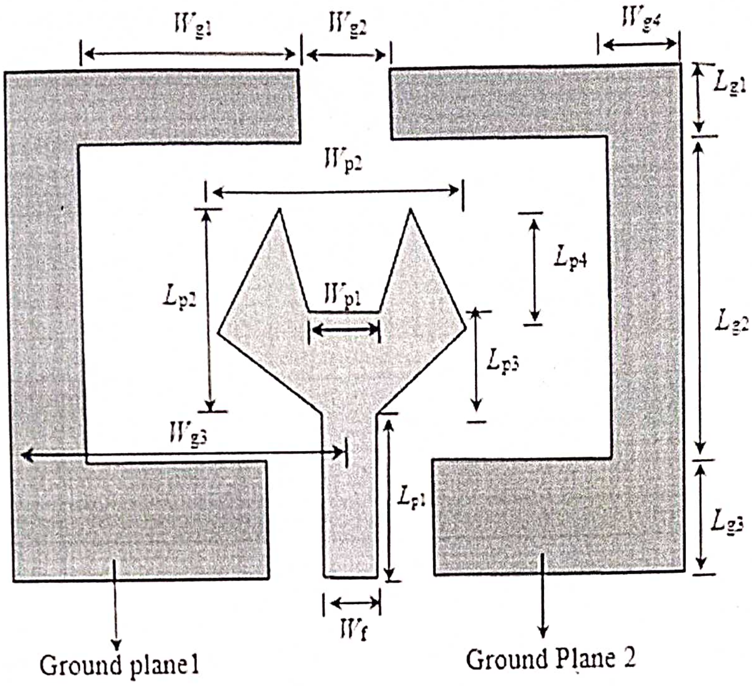

Fig. 1 Configuration of the proposed microstrip antenna

Table 1 Design parameters of the proposed CPW-fed shaped monopole antenna

Parameters	L_{p1}	L_{p2}	L_{p3}	L_{p4}	L_{g1}	L_{g2}	L_{g3}
Unit (mm)	8.5	11	5	6	2.5	15	7.5
Parameters	W_{p1}	W_{p2}	W_{g1}	W_{g2}	W_{g3}	W_{g4}	W_f
Unit (mm)	4	15	7	4	12.5	2.5	3

3 Optimization of Proposed Microstrip Antenna

The Ansoft HFSS-2010 has been used to design and optimize the results produced by the antenna. Initially rectangular patch was used to achieve the desired bandwidth, then the rectangular patch was modified to U-shaped patch and finally the proposed shaped patch was obtained to optimize the results. The return loss for rectangular, U shape, and proposed shape has been denoted by black, red, and blue colored curves respectively in Fig. 2. It can be clearly seen that there are three resonant bands at 11.2, 12.5, and 14.3 GHz, respectively.

3.1 Variation of Patch Parameters

Figure 3 shows the results of the proposed antenna with variation of length L_{p2}. It is seen that the bandwidth for the return loss less than 10 dB of the antenna remains almost constant. However, there is mismatch of impedance of radiating patch and input impedance at frequencies for L_{p2} = 10 and 12 mm. Thus L_{p2} = 11 mm has

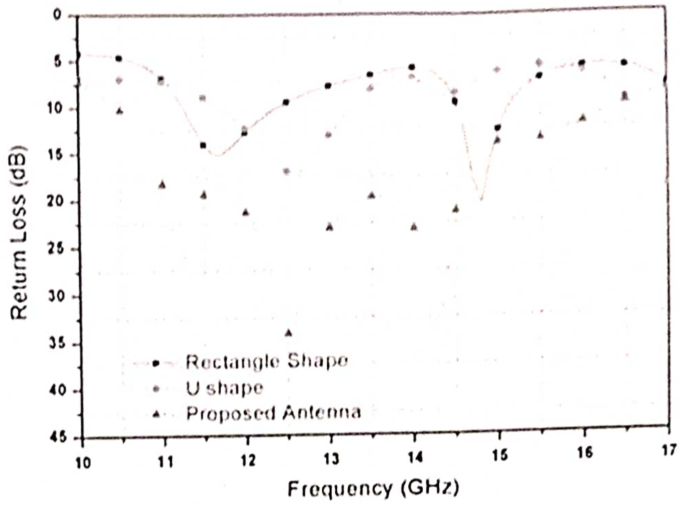

Fig. 2 Simulated return loss against frequency for the proposed microstrip antenna, rectangular antenna, and U-shaped antenna for the same ground plane

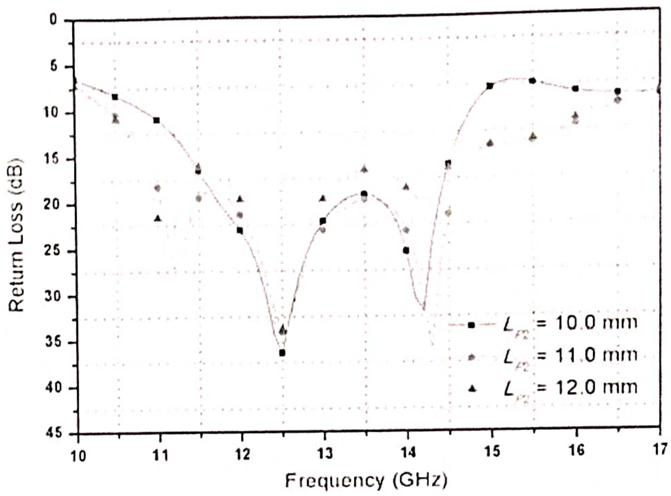

Fig. 3 Simulated return loss against frequency for the microstrip antenna with various L_{p2}

been chosen as the optimum parameter. The simulated results of the proposed antenna with L_{p3} from 4 to 6 mm have been shown in Fig. 4. It is observed bandwidth again remains constant, but better return loss has been obtained for the same resonant frequencies. Feed width was also varied from 2 to 4 mm and it was found that optimum bandwidth was obtained at W_f = 3 mm with more number of resonant modes which is shown in Fig. 5.

3.2 *Variation of Ground Parameters*

Figure 6 shows the simulated results of the proposed antenna with W_{g2} from 3 to 5 mm. It is observed that for W_{g2} = 4 mm the bandwidth for the return loss less than 10 dB shifts slightly toward lower frequency band. Hence W_{g2} = 4 mm is chosen as the optimum length of W_{g2}.

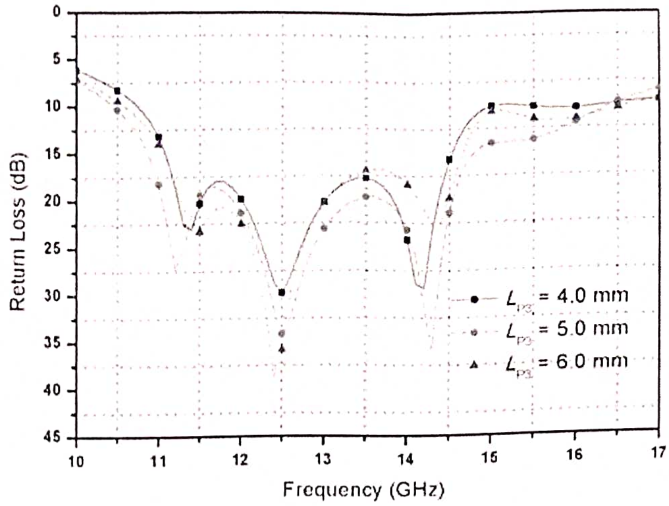

Fig. 4 Simulated return loss against frequency for proposed microstrip antenna with various L_{p3}

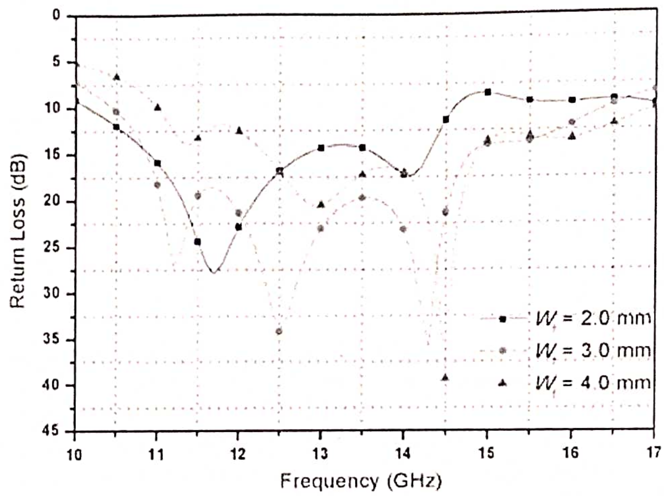

Fig. 5 Simulated return loss against frequency for proposed microstrip antenna with various W_f

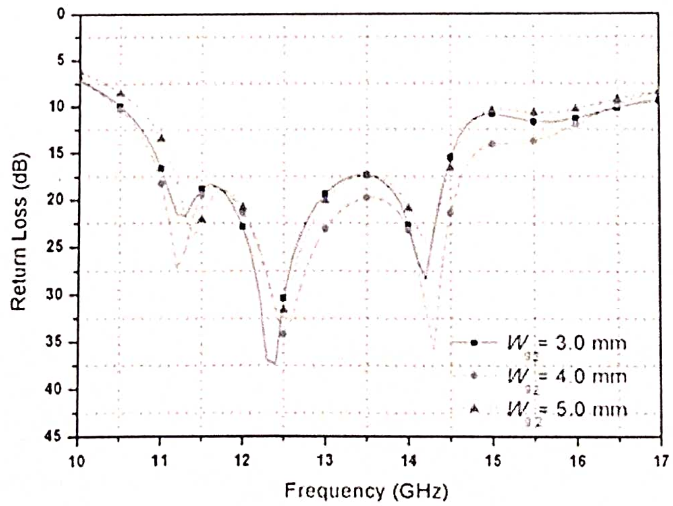

Fig. 6 Simulated return loss against frequency for proposed microstrip antenna with various W_{g2}

4 Conclusions

A CPW-fed microstrip antenna is proposed for Ku band application. The overall size (25 × 23 × 1.6 mm) is compacting thus suitable for installation on heavy satellites. The CPW feeding mechanism manages to minimize the dispersion loses as well as reduces the radiation leakage. The results are obtained using electromagnetic Ansoft HFSS-2010 solver. The antenna has maximum gain of about 1.6 dB. The antenna has stable radiation pattern and almost constant group delay over the entire 5.9 GHz bandwidth that extends from 10.5 to 16.4 GHz, thus making the antenna suitable for Ku band application.

References

1. Bhadouria, A.S., Kumar, M.: Wide Ku-band microstrip patch antenna using defected patch and ground. In: IEEE International Conference on Advances in Engineering and Technology Research (2015)
2. Gautam, A.K., Chandel, R., Kanaujia, B.K.: A CPW fed hexagonal shape monopole like UWB antenna. Microw. Opt. Technol. Lett. **55**(11), 2582–2587 (2013)
3. Gautam, A.K., Yadav, S., Kanaujia, B.K.: A CPW fed compact inverted L-strip UWB microstrip antenna. Microw. Opt. Technol. Lett. **55**(7), 1584–1589 (2013)
4. Sreenath, S., Ashkarali, P., Thomas, P., Dinesh, R., Anandan, C.K.: CPW fed compact bent monopole antenna for UWB applications. Microw. Opt. Technol. Lett. **55**(1), 56–58 (2013)
5. Singh, N., Singh, A.K., Singh, V.K.: Design & performance of wearable ultra wide band textile antenna for medical applications. Microw. Opt. Technol. Lett. **57**(7), 1553–1557 (2015)
6. Singh, V.K., Ali, Z., Ayub, S., Singh, A.K.: A wide band compact microstrip antenna for GPS/DCS/PCS/WLAN applications. In: Intelligent Computing, Networking, and Informatics, vol. 243, pp. 1107–1113. Springer, Berlin (2014)
7. Singh, V.K., Ali, Z., Ayub, S., Singh, A.K.: Bandwidth optimization of compact microstrip antenna for PCS/DCS/bluetooth application. Central Eur. J. Eng. **4**(3), 281–286 (2014)
8. Mandal, T., Das, S.: Ultra wideband printed hexagonal monopole antennas with WLAN band rejection. Microw. Opt. Technol. Lett. **54**(6), 1520–1525 (2016)
9. Gupta, N., Singh, V.K., Ali, Z., Ahirwar, J.: Stacked textile antenna for multi band application using foam substrate. In: International Conference on Computational Modelling and Security (CMS 2016). Procedia Computer Science, vol. 85, pp. 871–877 (2016)
10. Singh, N.K., Singh, V.K., Naresh, B.: Textile antenna for microwave wireless power transmission. In: International Conference on Computational Modelling and Security (CMS 2016). Procedia Computer Science, vol. 85, pp. 856 – 861 (2016)
11. Srivastava, R., Ayub, S., Singh, V.K.: Dual band rectangular and circular slot loaded microstrip antenna for WLAN/GPS/WiMax applications. In: International Conference on Communication Systems and Network Technologies (CSNT-2014), pp. 45–48 (2014)
12. Dhupkariya, S., Singh, V.K.: Textile antenna for C-band satellite communication application. J. Telecommun. Switching Syst. Netw. **2**(2), 20–25 (2015)
13. Singh, V.K., Singh, N.K.: Compact circular slotted microstrip antenna for wireless communication systems. J. Microw. Eng. Technol. **1**(1), 07–14 (2015)
14. Srilakshmi, A., Koteswararao, N.V., Srinivasarao, D.: X band printed microstrip compact antenna with slots in ground plane and patch. In: IEEE Conference on Recent Advances in Intelligent Computational Systems, pp. 851–855 (2011)

15. Yang, F., Zhang, X.X., Ye, X., Rahmat Samii, Y.: Wide band E-shaped patch antennas for wireless communications. IEEE Trans. Antennas Propag. **49**(7), 1094–1100 (2001)
16. Samsuzzaman, M., Misran, N., Islam, M.T., Mandeep, J.S.: Dual frequency new shaped microstrip patch antenna for Ku-band applications. In: IEEE Student Conference on research and development (2012)

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