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Wide Band and Miniaturized Partial Ground Plane Microstrip Antenna for X & Ku Band Applications

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ABSTRACT

A compact wide band miniaturized microstrip antenna is proposed for wideband applications. The anticipated antenna attains wide impedance bandwidth by cutting the rectangular shape radiating patch into the defected shape. The ground and the radiating patch are on the identical side of the material (FR-4).The overall size of anticipated antenna is 25 × 23 × 1.6 mm^3. The anticipated antenna is simulated, fabricated and experimented for the desired results. The antenna results which are obtained by CST software are in good accordance with experimental results. The anticipated antenna resonates at three frequencies 11.2, 12.5 and 14.3 GHz from 10.5 to 16.4 GHz, which is applicable for X and Ku band applications.

Keywords: Partial Ground, Wide Band, X band & Ku band.

1. INTRODUCTION

Microstrip antenna plays a major role in any wireless communication system. They are used in high performance aircrafts, radar, missiles and other spacecraft [1].These antennas have attracted the attention of many researchers due to its reward such as light weight, effortless formation, low profile configuration, ease of combination with other circuits and low fabrication cost [2-3]. The conventional monopole antenna suffers limited bandwidth and low gain. To overcome this problem researchers have developed various shapes for obtaining wideband such as U-shape, E shape, hexagonal shape, M shape, A shape and defected shape [4]-[9].Coplanar waveguide fed (CPW) is a very promising technique in the field of wideband microstrip patch antennas. It has many advantages over other microstrip feeing techniques, some of them are as: low distribution, low radiation outflow, and the skill to control the distinctive impedance [10]-[15].

In this paper, a defected shape CPW fed wideband microstrip antenna is anticipated and deliberated. The antenna is composed of a defected shape radiating patch to achieve wide frequency range and good radiation patterns from 10.5 to 16.4 GHz. In CPW fed technique the ground and radiating patch are on the same plane of the substrate to reduce the height of the antenna. The ground is extended towards both sides of the single radiator. Thus, the enormous gap close to the radiator can be totally utilized. The proposed structure of the microstrip antenna has an advantage that it covers a wide frequency band with three resonant frequencies and covers Ku band applications [16]-[22]. The anticipated structure of the antenna is shown in Figure 1.The subsequent section deals with antenna designing technique in detail, and effects of parameters variation through simulated results are discussed in detail. Section 3covers the effects of experimental results and its discussion. The conclusion is discussed in section 4.

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2. ANTENNA CONFIGURATION

The anticipated antenna is fabricated on low cost FR-4 substrate with dielectric constant $\varepsilon_r = 4.4$ and height of the substrate, $h = 1.6$ mm. The overall size of anticipated antenna is $25 \times 23 \times 1.6$ mm^3 which is a very compact and operates on the frequency band between 10.5 to 16.4 GHz. Therefore, the anticipated antenna is suitable for Ku band applications. The proposed antenna has three resonant frequencies 11.2 GHz, 12.5 GHz and 14.3 GHz respectively. The basis of the anticipated antenna was a rectangular patch with length L_{p2} and width W_{p2}. Then hexagon shape was obtained by cutting the edges in rectangular patch and finally the proposed design was obtained to enhance the operating bandwidth. Note that, in all these three shapes the ground plane is same.

Figure 1, depicts the schematic configuration of the defected shape microstrip antenna for wideband applications. In proposed antenna the width of microstrip feed line is constant at 3 mm to obtain 50Ω distinctive impedance. A photograph of the proposed fabricated antenna is shown in Figure 2.

The electromagnetic solver, Ansofts HFSS (license v 14.0) [20] has been used to design and optimize the results produced by the antenna. Initially, the rectangular patch shown in Figure 3 trace (i), was used to obtain the desired bandwidth, then the rectangular patch was modified to hexagon shape patch shown in Figure 3 trace (ii), for achieving wide bandwidth and finally the defected shape radiating patch shown in Figure 3 trace (iii), gives the wide band ranging from 10.5 to 16.4 GHz. Note that, in all these three cases the unspecified dimensions are equivalent as listed in Table 1. The simulated return loss for rectangular

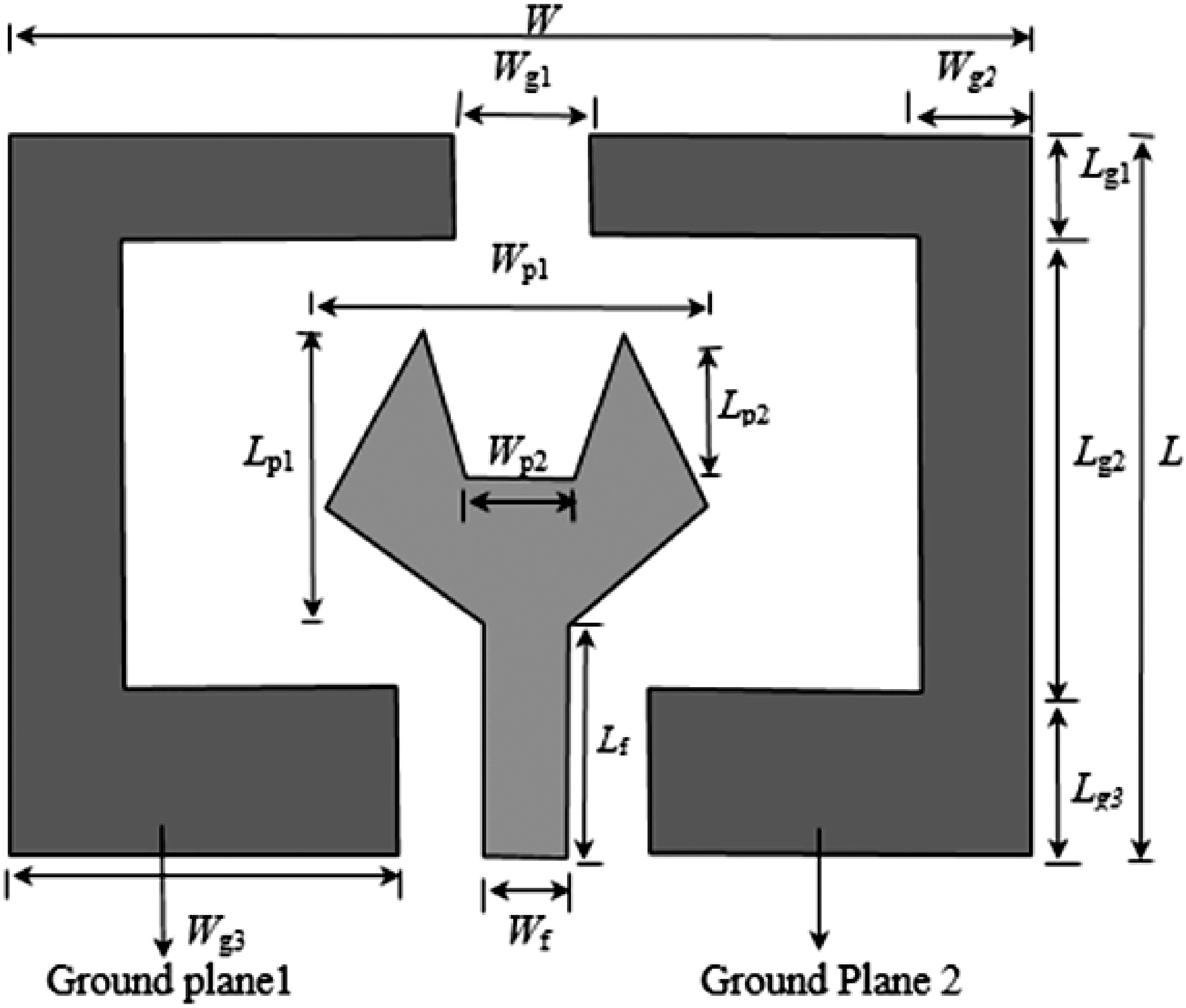


Figure 1: Configuration of proposed microstrip antenna

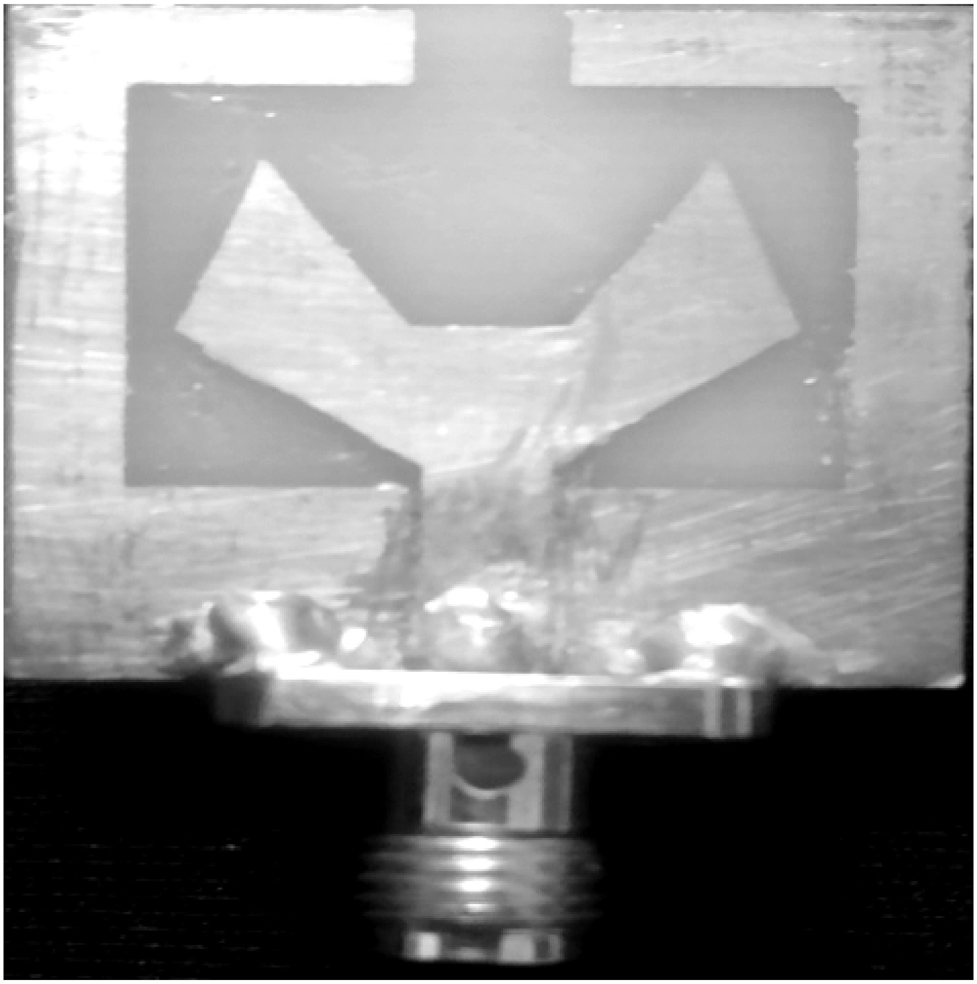


Figure 2: Photograph of fabricated proposed microstrip antenna

Table 1
Optimized design parameters of the anticipated microstrip antenna

Parameters	L_f	L_{p1}	L_{p2}	L_{g1}	L_{g2}	L_{g3}
Unit (mm)	8.5	11	6	2.5	15	7.5
Parameters	W_{p1}	W_{p2}	W_{g1}	W_{g2}	W_{g3}	W_f
Unit (mm)	15	4	4	2.5	9.5	3

shape, hexagon shape and defected shape has been denoted by black, red, blue colored curves respectively in the Figure 3.

2.1. Variation of Design parameters

Figure 4, illustrates the simulated return loss of the anticipated antenna with variation of length L_{p1} from 10.0 mm to 12.0 mm. It can be seen that the bandwidth for the return loss less than 10 dB of the antenna increases as the value of L_{p1} increases from 10.0 mm to 11.0 mm. For further increase in the value of L_{p1} from 11 mm to 12 mm the value of return loss decreases and also a change in the impedance bandwidth is observed. Therefore, it is certain to take L_{p1} = 11.0 mm as the most favorable value with the bandwidth from 10.5 to 16.4 GHz.

Figure 5 depicts the simulated results of the anticipated antenna with the variation of $L_{p2}$from 7.0 mm to 5.0 mm. It is observed that in case of L_{p2}= 7.0 mm and 5.0 mm, the impedance bandwidth for the return loss

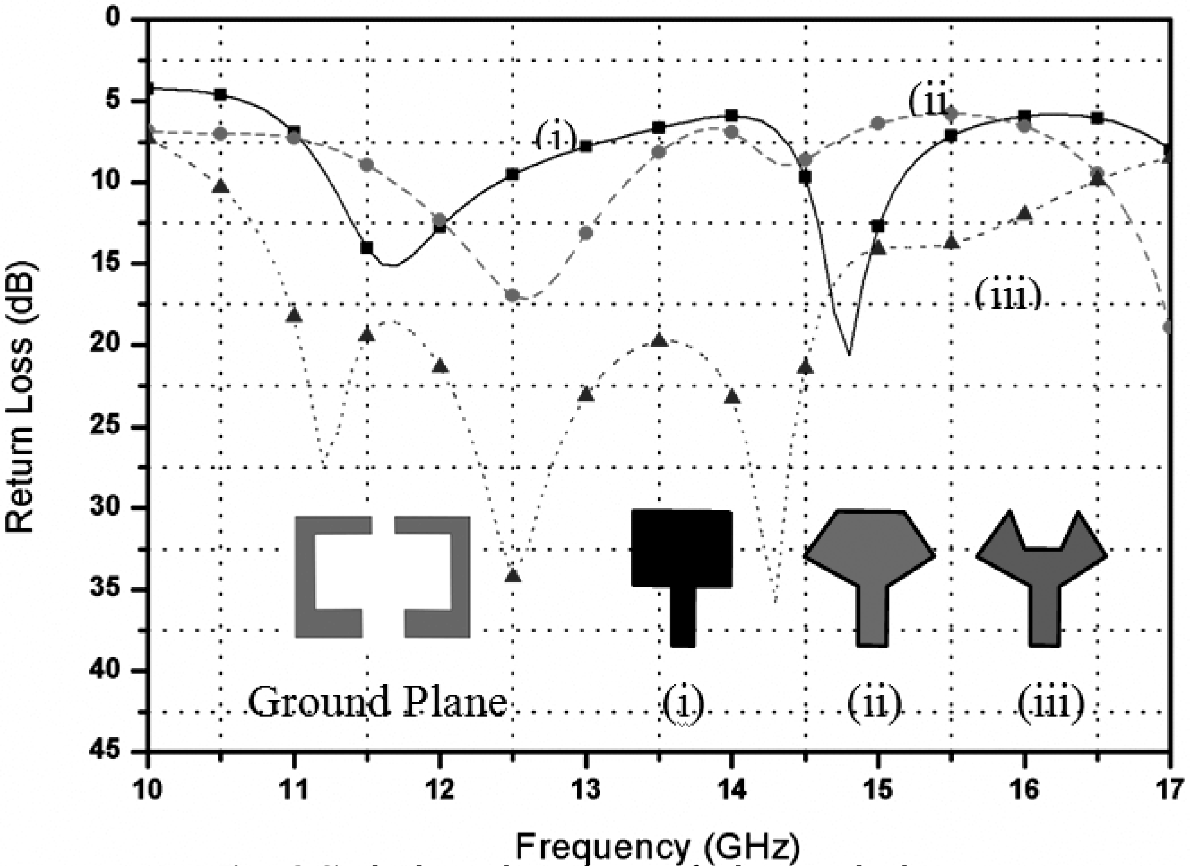


Figure 3: Simulated return loss vs. frequency for the rectangular shape, hexagonal shape and proposed microstrip antenna.

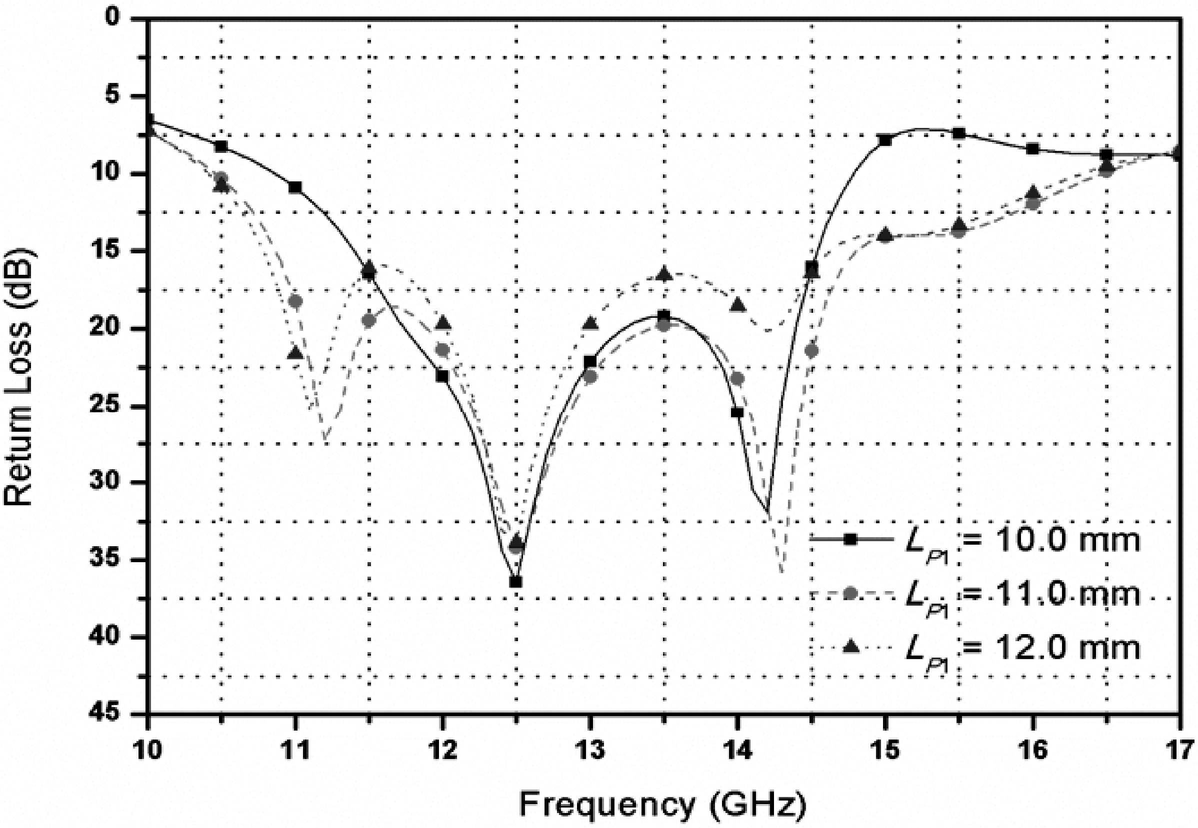


Figure 4: Simulated return loss vs. frequency of proposed microstrip antenna with various L_{p1}.

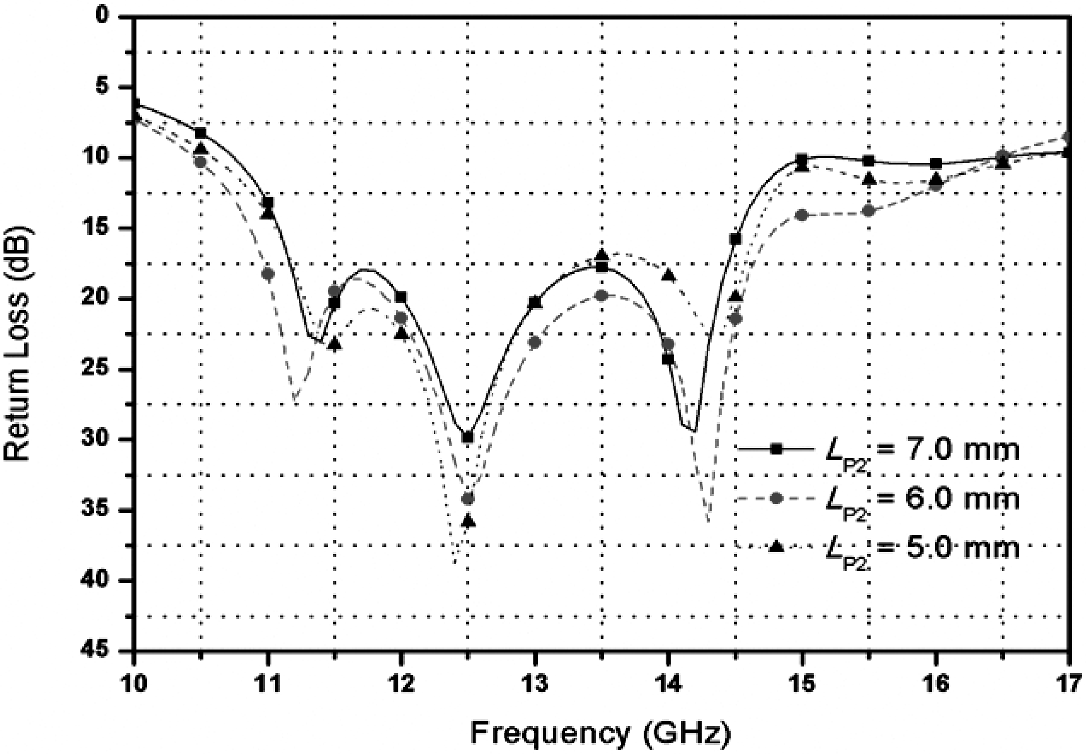


Figure 5: Simulated return loss vs. frequency of proposed microstrip antenna with various L_{p2}.

less than 10 dB of the anticipated antenna is smaller as compared to 6.0 mm. Hence, it is decided to take L_{p2} = 6.0 mm is taken as the most favorable value with the bandwidth from 10.5to 16.4 GHz.

2.2. Variation of feed parameters

The simulated result of the anticipated antenna with variation in feed width from 2.0 mm to 4.0 mm is shown in Figure 6. It can be seen that the impedance bandwidth decreases greatly for W_f= 2.0 mm. However,

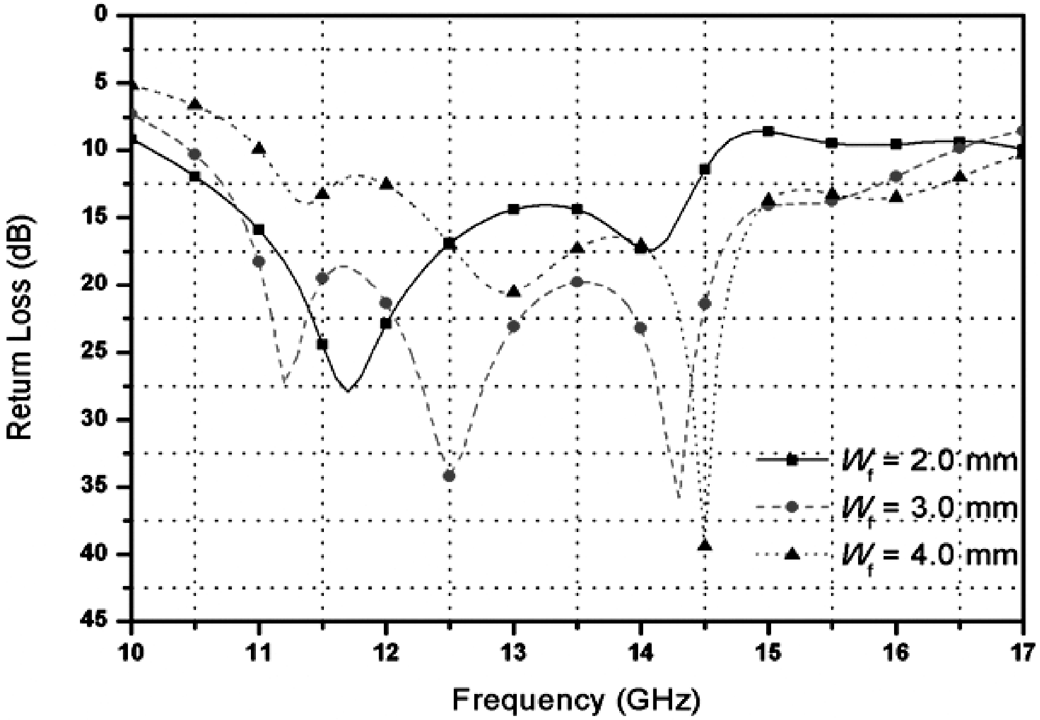


Figure 6: Simulated return loss vs. frequency of proposed microstrip antenna with various W_f.

for the case of for W_f= 4.0 mm the impedance bandwidth increases greatly, but for the case of W_f= 3.0 mm the proposed antenna shows maximum impedance bandwidth in the operating band. Therefore, it is certain to take W_f= 3.0 mm as the best possible value with the bandwidth from 10.5 to 16.4 GHz.

2.3. Variation of ground parameters

Figure 7 reveals the simulated results of the anticipated antenna with deviation in $W_{g1}$from 3.0 mm to 5.0 mm. It is keenly observed that for W_{g1}= 3.0 mm the bandwidth for the return loss less than 10dB shifts

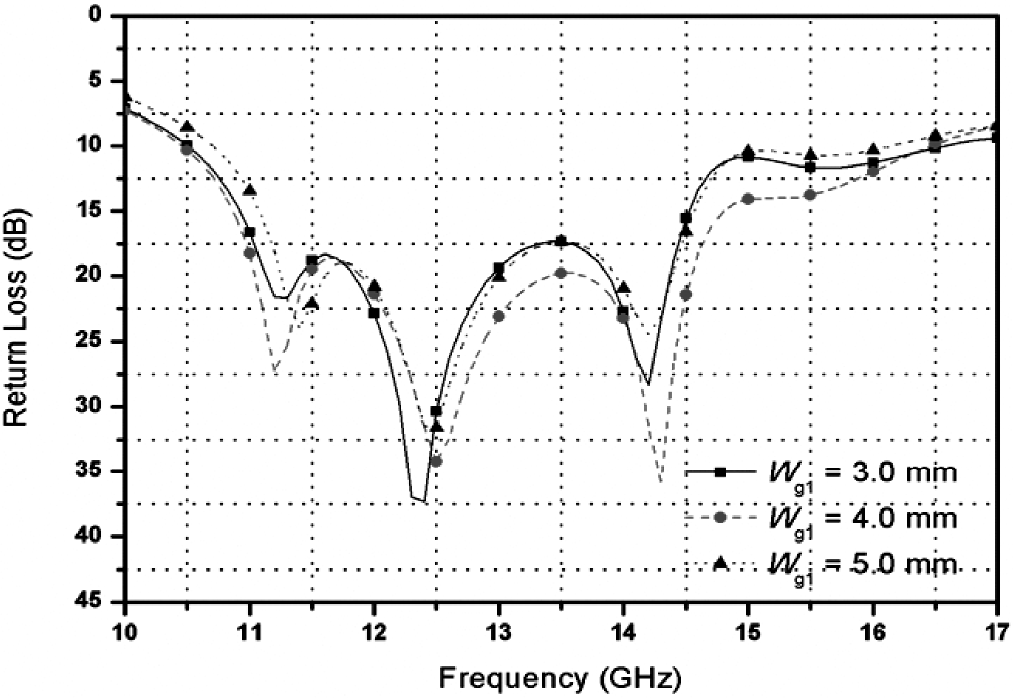


Figure 7: Simulated return loss vs. frequency for the CPW-fed microstrip antenna with various W_{g1}.

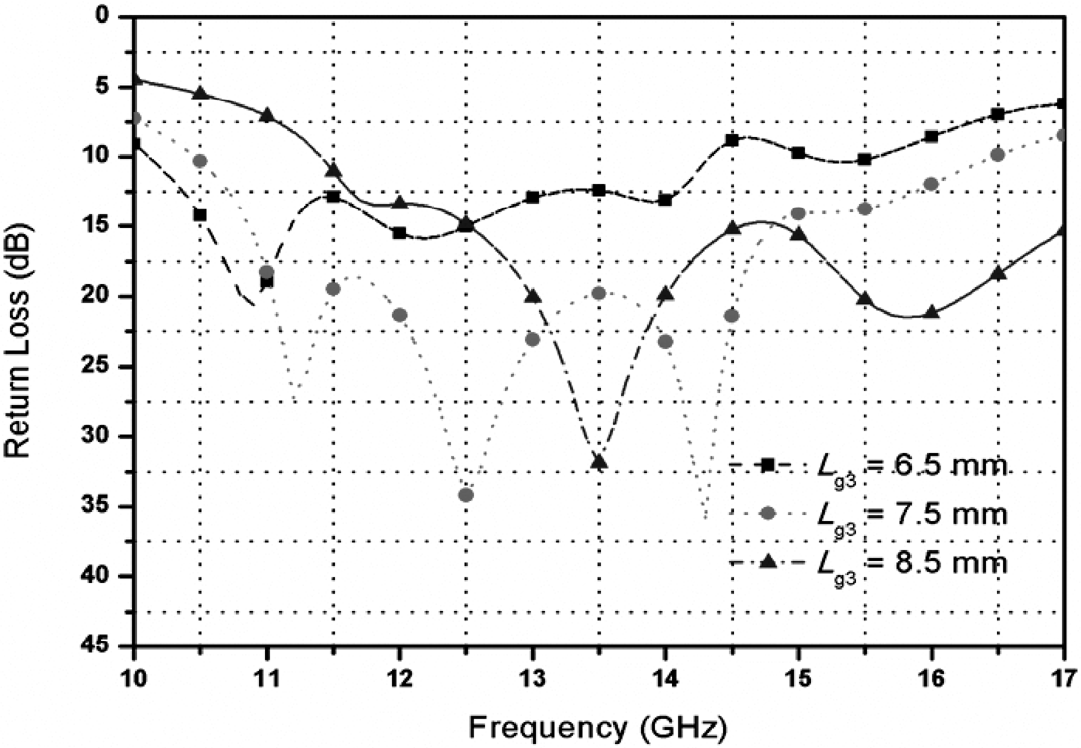


Figure 8: Simulated return loss vs. frequency of presented microstrip antenna with various L_{g3}.

Table 2
Comparison of reference antennas with proposed antenna.

Reference	*Antenna type*	*Overall Size (mm^3)*	*Operating Frequency Band (GHz)*	*Applications*
[15]	Wideband	30 × 25 × 105	8-12	X band
[16]	Wideband	25 × 25 × 1.6	2.96-7.95	S and C band
[17]	Ultra wideband	32 × 52 × 1.59	3.11–13.15	WLAN
[18]	Ultra wideband	25 × 25 × 1.6	2.6-13.04	UWB
[19]	Dual band	36 × 36 × 1.6	1.86-1.97, 3.0-10.0	WLAN, UWB
Proposed Antenna	Wideband	25 × 23 × 1.6	10.4-16.5	X and Ku band

slightly towards lower frequency band, while the same condition appears in the case of W_{g1}= 5.0 mm. But, for the case of W_{g1} =4.0 mm the proposed antenna shows maximum impedance bandwidth that operates on the frequency band between 10.5 to 16.4 GHz. Therefore it is certain to take W_{g1} = 4.0 mm as the most favorable value for the proposed antenna. Figure 8, illustrates the simulated return loss for various values of L_{g3} that varies from 6.5 mm to 8.5 mm. It is clear from the figure that impedance bandwidth of the anticipated antenna is maximum only in the case of L_{g3} = 7.5 mm while for the case of L_{g3} = 6.5 mm and 8.5 mm the impedance bandwidth is very less. Therefore, it is decided to take L_{g3} = 7.5 as the optimum value for the proposed antenna.

3. MEASURED RESULTS AND DISCUSSION

Measured results are obtained through an Agilent 8757E scalar network analyzer. Figure 9 shows the simulated and the measured results of the anticipated antenna. The simulated result of the proposed antenna was found

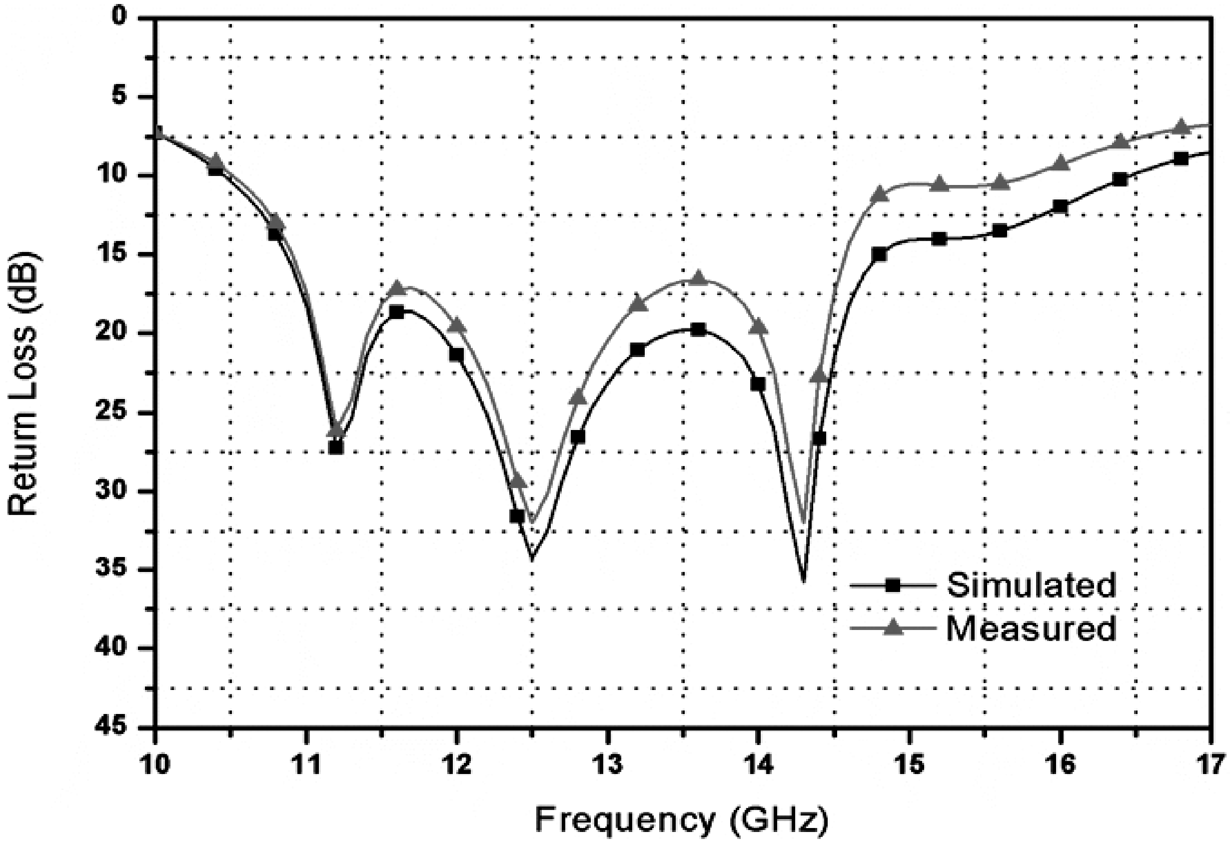
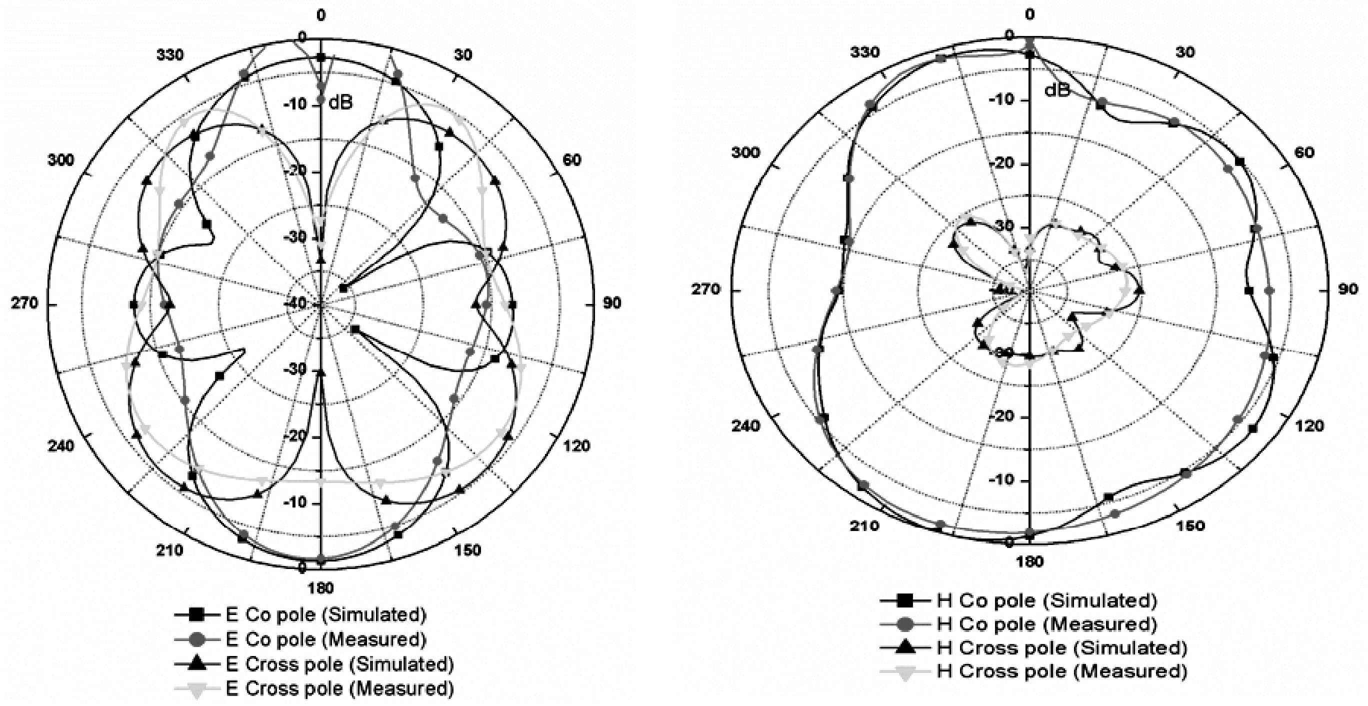
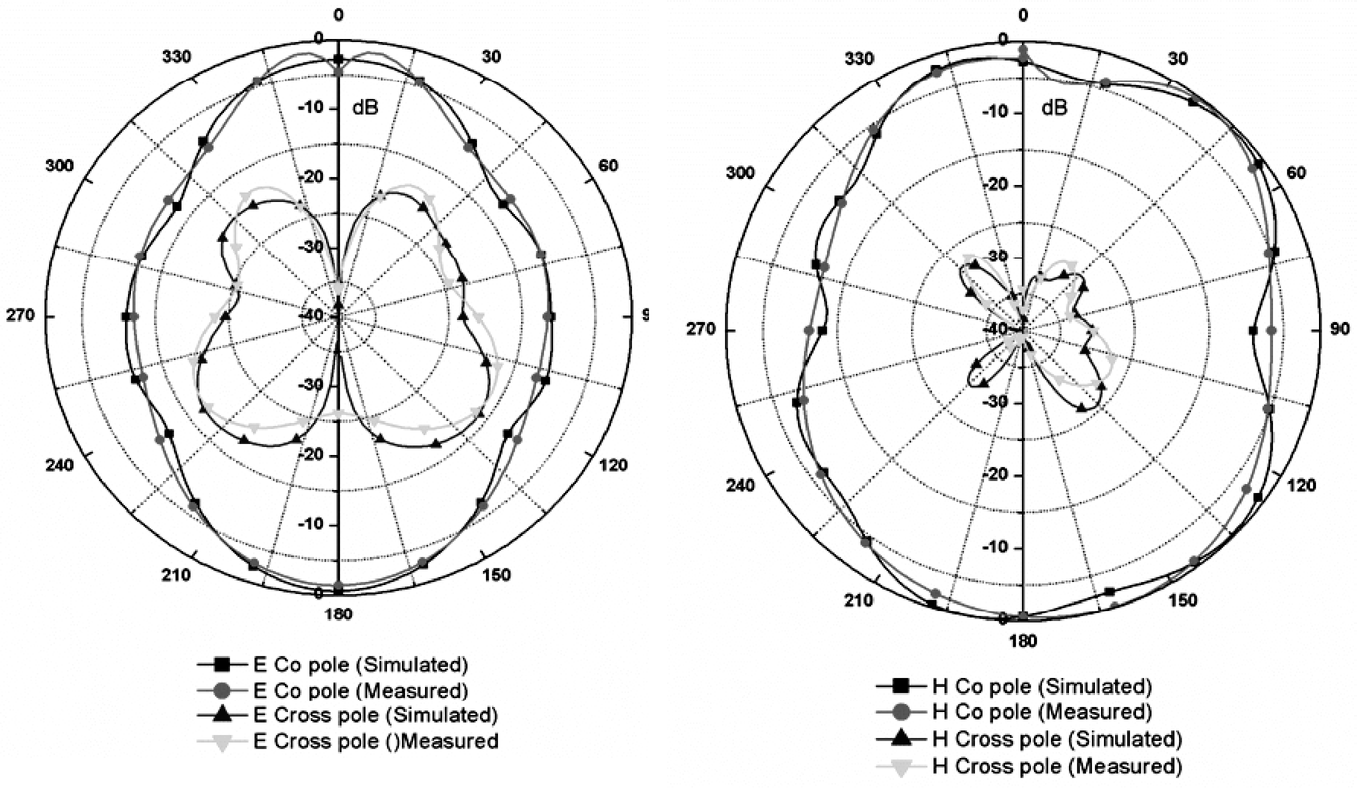


Figure 9: Measured and simulated return loss for the proposed microstrip antenna.



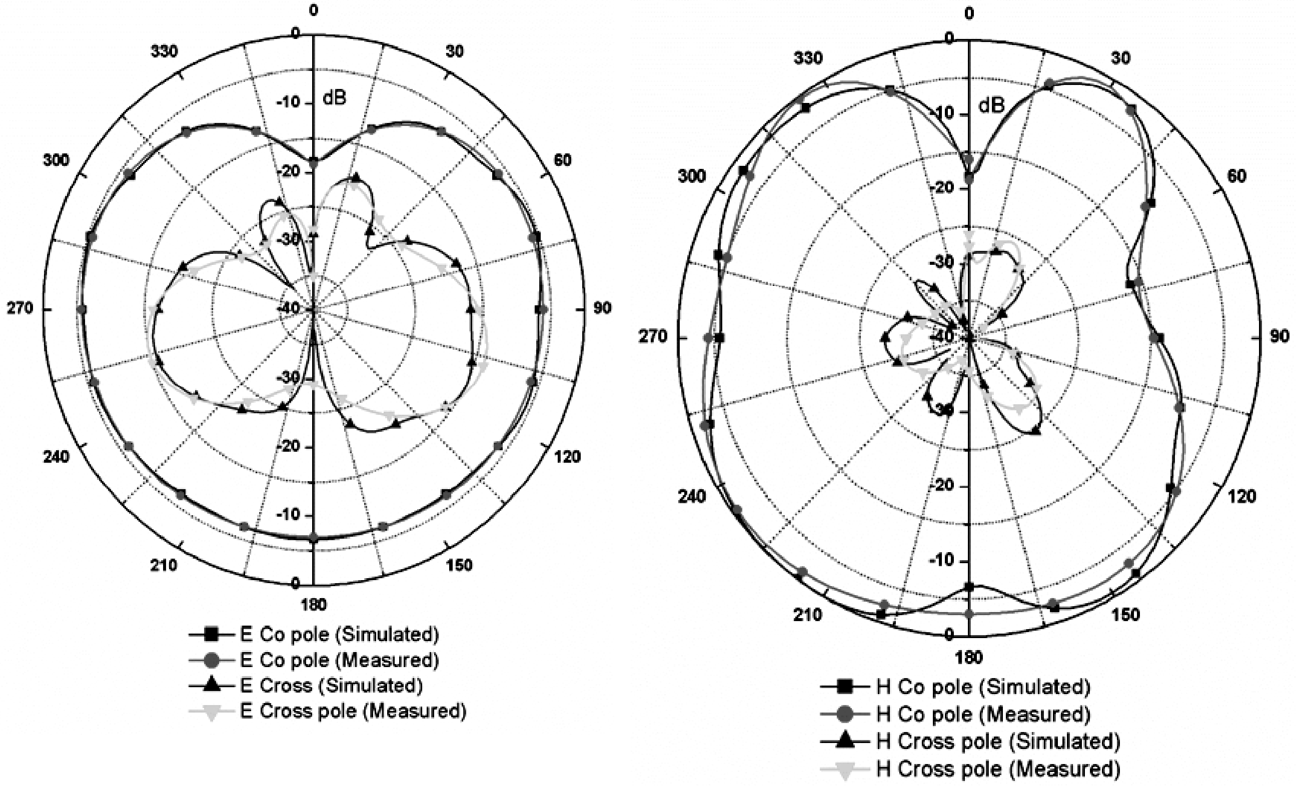
(a) 11.2 GHz



(b) 12.5 GHz

to be in accordance with the measured results. It is keenly observed that there is a minute distinction between the experimental and simulated result. This effect is due to the SMA connector soldering and fabrication tolerance. The proposed antenna has a wide bandwidth concert from 10.5 GHz to 16.4 GHz.

Figure 10(a), 11(b) and 11(c) represents the simulated and calculated two dimensional far field radiation patterns in H and E plane resonant frequencies 11.2, 12.5 and 14.3 GHz. The radiation pattern depicts that



(c) 14.3GHz

Figure 10: Radiation pattern for various resonance frequency for the anticipated defected shape microstrip antenna (a) 11.2 GHz, (b) 12.5 GHz and (c) 14.3 GHz

the proposed antenna has almost unidirectional radiation pattern for all frequencies in the E-plane (yz plane) and the H-plane (xy plane). The E-plane radiation pattern represents a monopole like radiation pattern and H-plane radiation pattern represent an omnidirectional radiation pattern. Gain is also a crucial parameter in the drawing of wideband antenna.

4. CONCLUSION

The anticipated coplanar waveguide (CPW) partial ground plane microstrip antenna is successfully designed and fabricated. Three resonant bands are observed at 11.2, 12.5, and 11.4 GHz over the entire operating band and it has wide bandwidth in the frequency range from 10.5 to 16.4 GHz. The overall size ($25 \times 23 \times 1.6mm^3$) is compact, thus suitable for small wireless devices. The antenna has constant radiation pattern over the impedance bandwidth that extends from 10.5 GHz to 16.4 GHz; therefore this antenna is suitable for X & Ku band applications.

REFERENCES

[1] Constantine A. Balanis,: Microstrip antennas, Antenna Theory: Analysis and Design, 2nd edition, New York, (1997).

[2] Kin Lu Wong and Kai- Pig Yang,: Compact dual frequency microstrip antenna with a pair of bent slots, Electronic Letters, vol. 34, pp. 225-226, (1988).

[3] H. Iwasaki:, A circularly polarized small size microstrip antenna with a cross slot, IEEE Transactions on antenna and propagation, vol. 44, no. 10, pp. 1399-1401, (1996).

[4] Sanjeev Dwivedi, Abhishek Rawat and R. N. Yadav,: Design of U- shape microstrip patch antenna for WiMAX applications at 2.5 GHz, Tenth International Conference on Wireless and Optical Communications Networks (WOCN), Bhopal, pp. 1-5, (2013).

[5] Fan Yang, Xue- Xia Zhang, Xiaoning Ye and Yahya Rahmat Samii,: Wide band E- shaped patch antennas for wireless communications, IEEE Transactions on Antennas and Propagation, vol. 49, pp. 1094-1101, (2001).

[6] Tapan Mandal and Santanu Das,: Ultra wideband printed hexagonal monopole antennas with WLAN band rejection, Microw. Opt. Technol. Lett., vol. 54, pp. 1520-1523, (2016).

[7] Manoj K. Srivastava, A. K. Gautam and Binod Kumar Kanaujia,: A M- shaped monopole- like slot UWB antenna, Microw. Opt. Technol. Lett., vol. 56, pp. 127-131, (2014).

[8] Manoj K. Srivastava, A. K. Gautam and Binod Kumar Kanaujia,: A novel A-shaped monopole like slot antenna for ultra wideband applications, Microw. Opt. Technol. Lett., vol. 54, pp. 1826-1829, (2014).

[9] M. K. Khandelwal, B. K. Kanaujia, Santanu Dwari and Sachin Kumar,: Analysis and Design of wideband microstrip line feed antenna with defected ground structure for Ku -band application, Int. J. Electron. Comm., vol. 68, pp. 951-957, (2014).

[10] A. K. Gautam, Richa Chandel and Binod Kumar Kanaujia,: A CPW fed hexagonal- shape monopole like UWB antenna, Microw. Opt. Technol. Lett., vol. 55, pp. 2582- 2586, (2013).

[11] A. K. Gautam, S. Yadav and B. K. Kanaujia,: A CPW fed compact inverted L strip UWB microstrip antenna, Microw. Opt. Technol. Lett., vol. 55, pp. 1584-1589, (2013).

[12] S. Sreenath, P. Ashkarali, P. Thomas, R. Dinesh and C. K Anandan,: CPW feed compact bent monopole antenna for UWB applications, Microw. Opt. Technol. Lett., vol. 55, pp. 56-58, (2013).

[13] M. Samsuzzaman, N. Misran, M. T. Islam and J. S. Mandeep,: Dual frequency new shaped microstrip patch antenna for Ku band applications, Research and Development (SCOReD), 2012 IEEE Student Conference on, Pulau Pinang, pp. 283-286, (2012).

[14] M. M. Sharma, Sanjeev Yadav, Ashok Kumar,: Compact elliptical microstrip patch antenna with slotted ground for Ku-band applications, Applied Electromagnetics Conference (AEMC), Kolkata, pp. 1-3, (2011).

[15] Amit Kumar Tripathi and B. K. Singh,: “A CPW feed X- band antenna for satellite and radar application, Microwave and Photonics (ICMAP), International Conference on, Dhanbad, pp. 1-3, (2013).

[16] Puneet Khanna, Amar Sharma, Kshitij Singhal, and Arun Kumar,: A defected structure shaped CPW- feed wideband microstrip antenna for wireless application, Hindawi Publishing Corporation Journal of Engineering, vol. 20116, pp. 1-7, (2016).

[17] Tapan Mandal and Santanu Das,: Ultra wideband- printed hexagonal monopole antennas with WLAN band rejection, Microw. Opt. Technol. Lett., vol. 54, pp. 1520-1524, (2012).

[18] A. K. Gautam and B. K. Kanaujia,: A CPW- fed compact UWB microstrip antenna, IEEE Antennas and Wireless propagation Letters, vol. 12, pp. 151-154, (2013).

[19] Raj Kumar, Praveen Naidu and Vivek Kamble,: A compact asymmetric slot dual band antenna feed by CPW for PCS and UWB applications, International Journal of RF and Microwave Computer Aided Engineering, vol. 00, pp. 1-12, (2014).

[20] Ansoft Corporation, Ansoft High-Frequency Structure Simulator (HFSS), version 14.0, Ansoft Corporation, Pittsburgh, Pa, USA.

[21] Rishabh Kumar Baudh, Ranjan Kumar, and Vinod Kumar Singh,: Arrow Shape Microstrip Patch Antenna for WiMax Application**,** Journal of Environmental Science, Computer Science and Engineering & Technology, vol. 3, no.1, pp. 269-274, (2013).

[22] Janabeg Loni, Shahanaz Ayub, and Vinod Kumar Singh,: Performance analysis of Microstrip Patch Antenna by varying slot size for UMTS application, IEEE Conference on Communication Systems and Network Technologies (CSNT-2014), pp. 01- 05, (2014).