Simple and Symmetric U Shape Radiating Patch with Rectangular Ground Wideband Microstrip Antenna

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Abstract——**In this paper, simple and low profile wideband U-shape radiating structure with rectangular ground microstrip monopole antenna is proposed. Designed antenna has control over the entire ultra wideband. It is suitable for 3.5 to 13.6 GHz by controlling the dimension of U-shape radiating structure and optimizing the ground plane. Antenna presents resonance tuning ability within the impedance bandwidth by varying the length and width of the U-shape radiating structure. The simulated return loss of the antenna is less than -10 dB over the entire frequency range, and its impedance bandwidth is 118.12%. As compare to other wideband antennas, the proposed antenna gives wider bandwidth with less complexity. The overall size of the printed circuit board (PCB) is 16x22 mm^2. In addition, some key parameters of the structure and the ground plane are varied. Omni directional radiation patterns of the antenna are suitable for WiFi, WiMAX, X-band, and other ultra wideband wireless communication applications.**

Keywords- ***Wideband antenna, Ultra wideband, WiFi, WiMAX, U- shape antenna.***

I. INTRODUCTION

In modern wireless communication systems and other telecommunication applications, the microstrip patch antennas have a great demand. The advantages of the microstrip antenna (MSA) are light weight, low profile, compatibility and integration to the other communication circuits. As the Patch is on the same PCB the fabrication cost is less and the size is compact. However, narrow impedance bandwidth and lower gain are the main drawbacks. Many researchers are trying to improve the impedance bandwidth of the MSA and they adopted various methods to overcome these serious drawbacks to achieve ultra-wideband (UWB) performance [1-2].

Many researchers are attracted towards Ultra wideband (UWB) technology due to various applications in the wireless world [12]. Reducing the size of the MSA's usually decreases their impedance bandwidth. Therefore the compact antenna with reduced radiating structure for wideband operation has been demanded. Many techniques have been reported to minimize the size and at the same time widen the impedance bandwidth. In [3], compact wideband microstrip radiating structure with an asymmetric E-shape patch is presented. Bandwidth enhancement and compactness is achieved by connecting an asymmetric T-shape patch loaded by a horizontal stub to the ground plane [4]. A compact ultra-wideband planer monopole antenna with nested U- shaped slot with rectangular ground is presented in [5]. A circularly polarized U-slot wideband antenna is presented in [6]. High gain wideband U-Shaped radiating patch is introduced in [7]. Different methods to improve the bandwidth of the monopole antenna are the implementation of stacked patched antenna [8] and the L probe fed antenna [9]. In [10-11], they reported shorted patch and shorting pins antennas to improve the bandwidth.

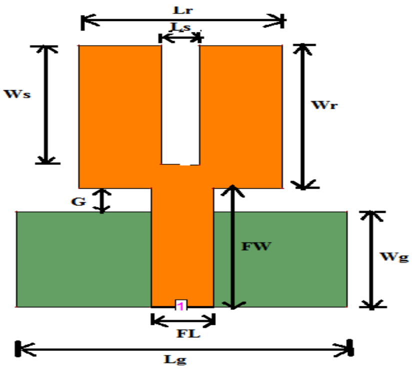
Lately compact structure having omnidirectional radiation patterns and compatibility with the printed circuit board technique has been reported in [3-7]. In all these antennas, the UWB radiations are obtained by monopole radiators with various shapes, where the resonant surface current has different electrical lengths at different frequencies. However the reduction of the antenna size and simplicity is quite difficult for these antennas.

In this paper, the U-shape radiating patch with rectangular ground plane is proposed. Initially simple rectangular patch having length and width is considered for optimization. Then the rectangular slot is cut in the centre of the radiating patch to form the two symmetric arms of the monopole. The two arms of the U-Shape are acts as a two monopole. The arms are generating multiple resonances. These multiple resonances are optimized to enhance the impedance bandwidth. The optimization is done by taking several combinations of the key parameter which is given in section 4 of this paper. The antenna design is in section 2, and the simulation result in section 3. The section 5 is about the conclusion and section 6 is acknowledgment.

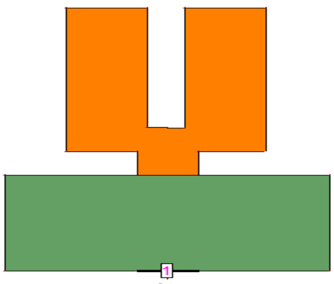
II. ANTENNA DESIGN AND CONGIGURATION

The proposed antenna design and its configuration is shown in Figure 1. Proposed antenna is composed of symmetric U-shape radiating structure with rectangular ground plane. The proposed candidate is printed on an FR4 substrate of thickness 1.6 mm and the permittivity is 4.4. The loss tangent is 0.02 for the FR4 substrate. The radiating structure is fed through 50 ohm transmission line and terminated by SMA connector.

Initially, several different simple shapes for the patch antenna were used. But, in order to minimize the size of the patch and at the same time maximize the bandwidth it was found that the rectangular with the cut slot of 2 mm gives the optimum bandwidth. The optimized geometry of the whole structure (the ground plane dimension, separation between the patch and ground and feed line position) gives the best possible impedance bandwidth.



a)



b)

Figure 1: Configuration of the proposed antenna a) Front View b) Back View.

It should be mentioned that the two arms of the monopole gives multiple resonance, and the optimized bandwidth is obtained by varying the length and the width of radiating arms. Again the gap between the radiating structure and the ground plane plays a key role to optimize the structure. Optimizing the ground plane is crucial and the lot of iteration gives the optimum impedance bandwidth.

TABLE I. DIMENSIONS OF THE ANTENNA (UNITS IN MM)

Parameters	Wr	Lr	Ws	Ls	FL	FW	Wg	Lg	G
Values	10	10	8	2	3	10	8	16	2

III. SIMULATION RESULTS

The simulation results are implemented using commercially available HL3D software from Mentor Graphics version 15.2. The proposed candidate operates from 3.5 to 13.6 GHz and its simulated impedance bandwidth is 118.12% with VSWR is less than 2. The impedance variation vs. frequency plot is shown in Figure 2. It is observed from the impedance plot, the antenna gives the impedance within the SWR circle for the entire impedance bandwidth. The VSWR characteristics of the proposed antenna are shown in Figure 3. The VSWR graph of the antenna cuts the VSWR = 2 line at 3.5 GHz and remains below the line till 13.6 GHz. VSWR plot of the proposed antenna shows there is good impedance matching between the microstrip transmission line and the radiating patch. The U-shape improves the impedance bandwidth of the proposed antenna. Figure 4 shows the surface current distribution on the radiating patch at four different frequencies. It is clear that the surface current distribution is unequal for different frequencies.

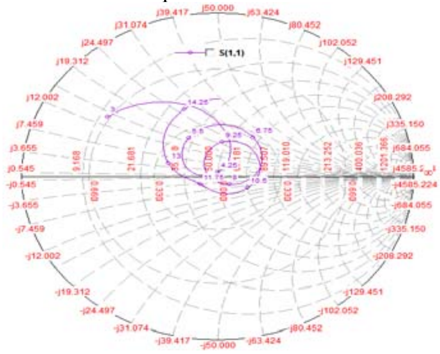


Figure.2: Impedance variation of the proposed antenna.

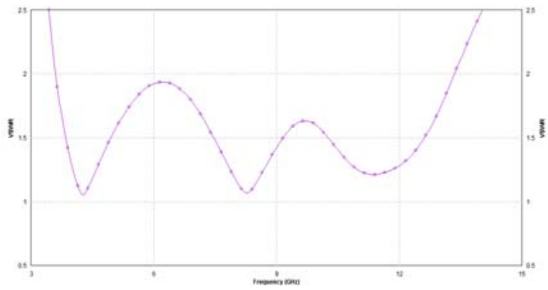
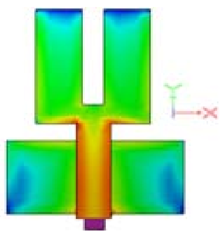


Figure.3: VSWR vs. Frequency of the proposed antenna.



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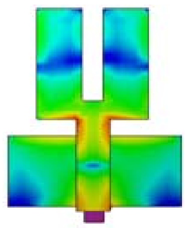

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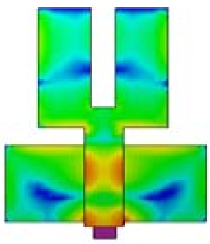

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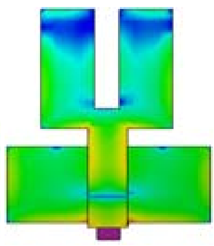

d)

Figure 4: Surface current distribution of the proposed antenna at a) 3.5 GHz b) 6 GHz c) 10.5 GHz d) 13.5 GHz frequencies.

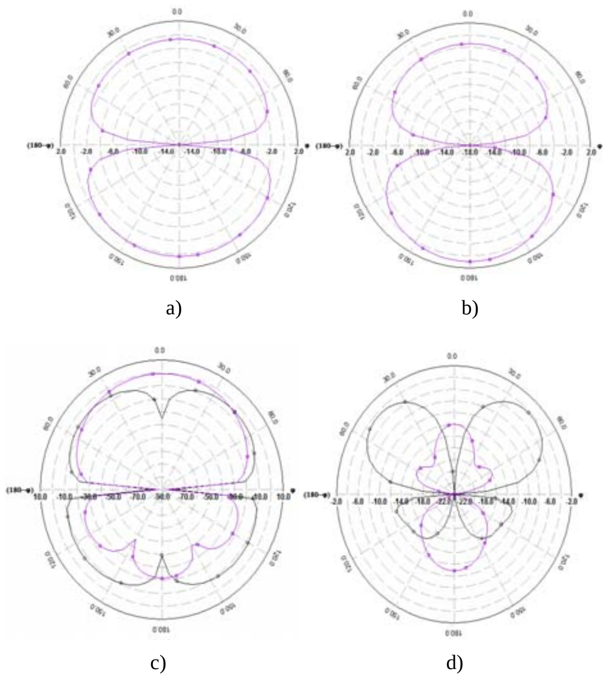

Figure 5: Radiation pattern of the proposed antenna at at a) 3.5 GHz b) 6 GHz c) 10.5 GHz d) 13.5 GHz frequencies with E theta and E phi at phi=0^0.

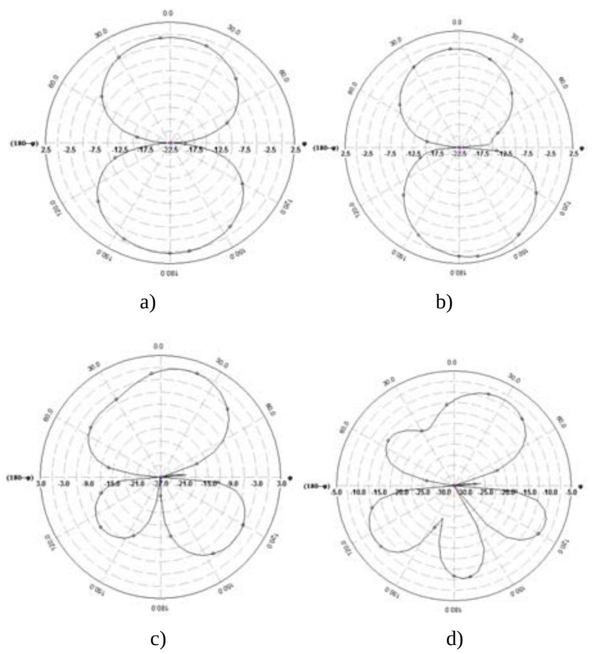

Figure 6: Radiation pattern of the proposed antenna at at a) 3.5 GHz b) 6 GHz c) 10.5 GHz d) 13.5 GHz frequencies with E theta and E phi at phi=90^0.

Figure 5 and 6 shows the radiation pattern of the proposed antenna at different frequencies with an angle 0^o and 90^o. Radiation pattern is not same for the same frequencies with different angle of phi. Another thing is that there is cross polarization occurs at higher frequencies. Nevertheless, the proposed antenna presents good broadside radiation patterns.

IV. Discussion on Key Parameters

In this section, we describe the effect of some key parameters to investigate the performance of the proposed candidate. Figure 7 shows the return loss vs. frequency plot with different length of the radiating patch. The optimized length of the patch is 12 mm, and the increasing length of the patch widens the first harmonic as well as increased the impedance bandwidth. Also it shifts the bandwidth towards the higher frequency. Figure 8 shows the return loss vs. frequency plot with different length of the slot. The optimized width of the slot is 2 mm. and the increasing width of the slot shifting the higher frequency. Figure 9 shows the return loss vs. frequency plot at different radiating widths. When the widths of the radiating patch is increased the lower frequency shifts towards the lower end. The optimized width of the radiating patch is 12 mm. The increased widths not only shifted the lower frequency but also decreased the return loss from -10 dB to -9 dB. Figure10 shows the return loss vs. frequency for different length of the ground plane. The ground plane dimension plays a key role in the proposed antenna. The increased length of the ground plane increases the impedance bandwidth.

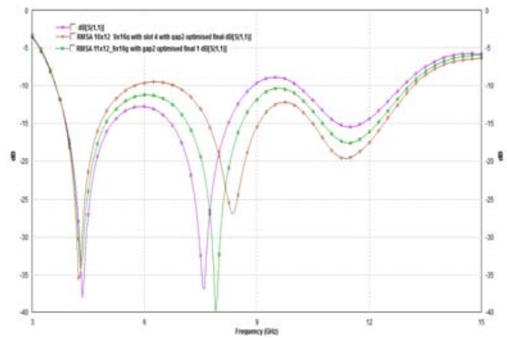

Figure 7: Return loss vs. frequency of the proposed antenna with different Lr.

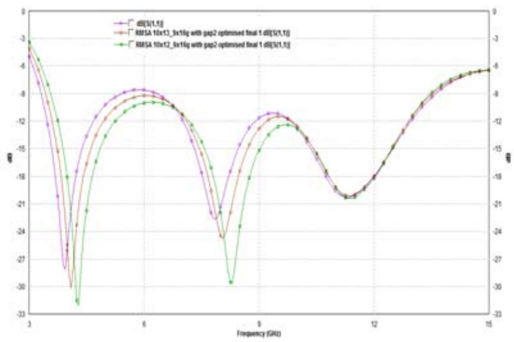

Figure 8: Return loss vs. frequency of the proposed antenna with different Ls.

Another important key parameter is the gap between the radiating patch and the ground plane. The optimized gap for the proposed antenna is 2 mm. When the gap is reduces to 1 mm, the lower frequency shifts from 3.5 to 3.9 GHz. Also the reducing the gap introduce the cross polarization and reducing the optimum impedance bandwidth. The FL and FW again are very important for impedance matching. The length and width of the microstrip line for the proposed antenna is 3 mm and 10 mm respectively.

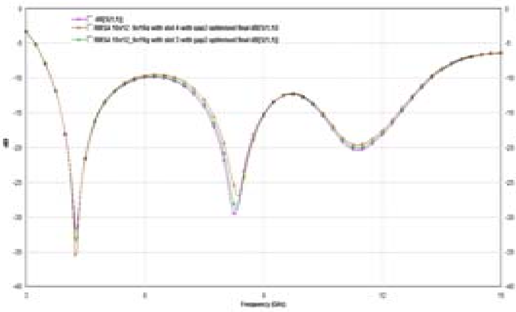

Figure 9: Return loss vs frequency of the proposed antenna with different Wr.

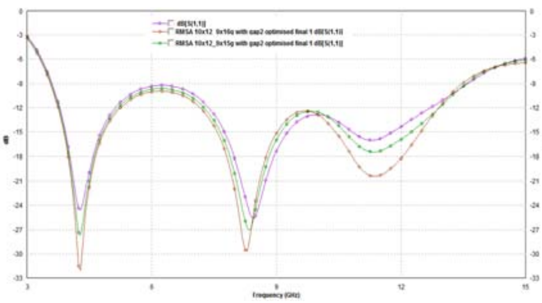

Figure 10: VSWR of the proposed antenna with different Wg.

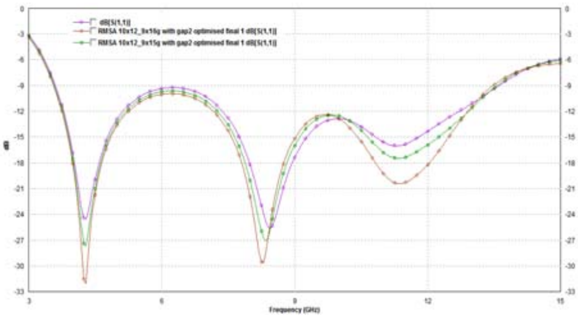

Figure 11: VSWR of the proposed antenna with different Lg.

V. CONCLUSION

In this paper, simple U-Shape radiating structure with rectangular ground plane antenna is designed for UWB applications. The impedance bandwidth is less than -10 dB return loss for the entire frequency range. The proposed candidate is operating from 3.5 to 13.6 GHz with some cross polarization at higher frequencies. The various key parameters which are affecting the impedance bandwidth are discussed. Radiation patterns are stationary within the impedance bandwidth and compared to other microstrip patch antennas of high bandwidths this proposed structure has the attractive features of low profile, smaller patch size and being simple to design. The proposed antenna with reasonable omnidirectional radiation patterns suitable for many wireless communication applications.

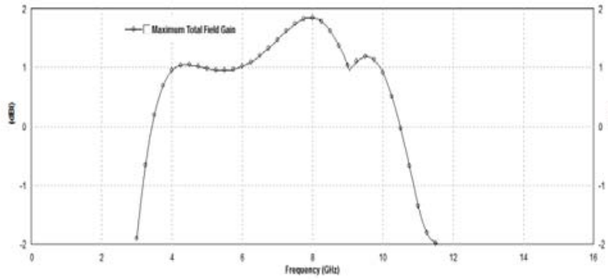

Figure 12: Total field gain vs frequency.

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REFERENCES

[1] G. Kumar and K P. Ray, Broadband Microstrip Antennas, Norwood, MA Artech house, 2003.

[2] Constantine A. Balanis, Antenna Theory and Design, 3rd Edition, John Wiley and sons Inc. USA, 2005

[3] Hossein Malekpoor, Shahrokh Jam, "Miniaturised asymmetric E-shaped microstrip patch antenna with folded-patch feed," IET Microwaves, Antennas & Propagation, vol.7, iss.2, pp.85-91, Jan 2013.

[4] Reza Zaker, Abdolali abdipour, "Bandwidth enhancement and miniaturization of fork- shaped monopole anenna," IEEE Antennas and wireless propagation letters, vol. 10, July 2011.

[5] Jyoti R. Pande, aditya S.R, Saladi and Rakesh, S Kshetrimayum, " A compact 3.4/5.5 GHz dual band-Notched UWB monopole antenna with nested U- shaped slots," IEEE international Conf. on computing, communication and networking Technologies, 2010.

[6] Ka Yan Lam, Kwai-Man luk, Hang Wong, Kung Bo Ng," Small circularly polarized U-slot wideband patch antenna," IEEE Antennas and wireless propagation letters, vol. 10, July 2011.

[7] Kaushik Mandal and Partha Prtim Sarkar," High gain Wide band U-Shaped patch antennas with modified ground planes", IEEE Transactions on Antennas and Propagation, vol. 61, no. 4. April,2013.

[8] Maartin, M.A., Sharif, B.S., Tsimenidis, C.C.," Probe fed stacked patch antenna for wideband applications," IEEE Trans. Antennas Propagat., vol. 55, pp. 2385-2388, 2007.

[9] Guo, y.X., Mak, C. L., Luk, k. M., Lee, k. F., "Analysis and design of L-probe proximity fed-patch antenna", *IEEE Trans. Antennas Propag.*, Vol. 49, pp. 145–149, 2001.

[10] Kuo, j.S., Wong, K.L,"A low cost microstrip line fed shorted patch antenna for a PCS base station,"Microwave optical Techno. Letters. vol. 29, pp. 146-147, 2001.

[11] Guha, D. Antar, Y.M.M, "Circular microstrip patch loaded with balanced shorting pinsfor improved bandwidth," *IEEE. Antennas wireless Propag letters.*, Vol. 5, pp. 217-219, , 2006.

[12] Federal Communications Commission, First order and report: Revision of part 15 of the Commission's rules regarding UWB transmission systems, Apr. 22, 2002.

[13] HL3D software version 15.2 from Mentor Graphics.