Design of triangular Monopole Microstrip Patch Antenna for UWB Wireless Applications

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Abstract
Antennas have wide range of applications from radio astronomy to deep space communications and from biomedical industry to indoor personal Communications. The performance characteristics of the Communication system are heavily influenced by the selection, position and design of the antenna suite. This paper presents design of a triangular Monopole Microstrip Patch antenna designed for UWB wireless applications. The proposed antenna exhibits wideband characteristics ranging from 4.2 GHz to 10.75 GHz having return loss < -39 dB to < -24 dB. Obtained return loss reflects the perfect impedance matching. The results of the designed antenna are further improved by using partial ground planes. The advantages of tuning stubs are exploited for the tuning of reflection coefficient and resonant frequency. The antenna is designed and simulated in Ansoft HFSS Software.

Keywords
Triangular, VSWR, Monopole, Return Loss

I. Introduction
The rapid increase of wireless communication systems has opened a wide range of opportunities to a new kind of antennas such as narrow single band, dual band, wide band, ultra wide band (UWB) and multi-band antennas. Microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side. They are very popular due to their size, weight, low-cost, and ease of installation, bandwidth, and radiation properties. The patch is generally square, rectangular, circular, triangular, and elliptical [1-2]. In this paper a design of triangular monopole microstrip patch antenna is proposed. Patch antennas can be excited using either a microstrip feed line or a coaxial probe feed. These two feeding methods are very similar in operation. No doubt coaxial probe feed has some advantages over microstrip feed line such as less spurious radiation but due to ease of fabrication and robustness of microstrip line, some of the features can be traded off. Moreover coaxial probe is less reliable, as in coaxial probe feed the central conductor has to be soldered to the patch, which can create many problems when exposed to extreme environmental conditions such as in outer space. For such applications, microstrip feed line should be the first choice.

II. Design Methodology
To analyze and simulate the proposed designs, High Frequency structure Simulator (HFSS) software tool is used. HFSS is a high performance full-wave electromagnetic (EM) field simulator for arbitrary 3-D volumetric passive device modeling. It integrates simulation, visualization, solid modeling and automation in an easy-to-learn environment where solutions to 3-D EM problems are quickly and accurately obtained [3]. Ansoft HFSS employs the Finite Element Method (FEM), adaptive meshing, and brilliant graphics to give unparalleled performance and insight to all 3-D EM problems. Ansoft HFSS can be used to calculate parameters such as S-Parameters, Resonant Frequency, and Fields. HFSS is an interactive simulation system whose basic mesh element is a tetrahedron thus allowing us to solve any arbitrary 3-D geometry.

III. Analysis of Triangular Patch Antenna
The triangular microstrip patch antenna is designed for wireless applications. The configuration is chosen to be triangular because it occupies less metalized area on substrate as compared to other existing configurations like rectangular and circular geometries which are commonly used. The geometry of triangular patch antenna is shown in Fig. 1. The triangular patch antenna is separated from the ground plane by a substrate of 'FR4 Epoxy' of thickness 1.58 mm [4]. In this design, the side of the triangular patch is 9.08 mm. Dielectric constant of substrate FR4 is 4.4. Microstrip line feed technique is used to feed the antenna. Figure 2 shows the detailed geometry of proposed microstrip Patch Antenna with tuning Stubs and partial ground planes. The detailed parameter specifications are tabulated in Table 1.

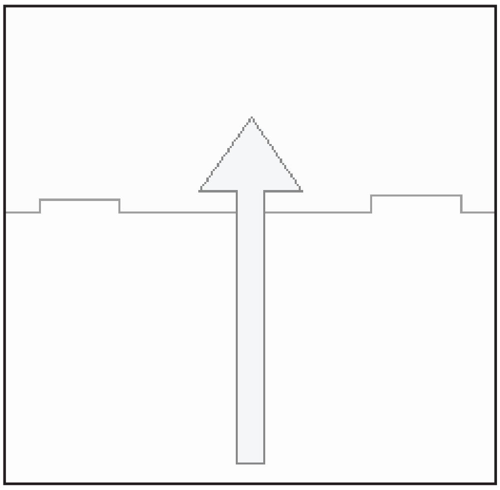

Fig. 1: Proposed Design of Triangular Microstrip Patch Antenna

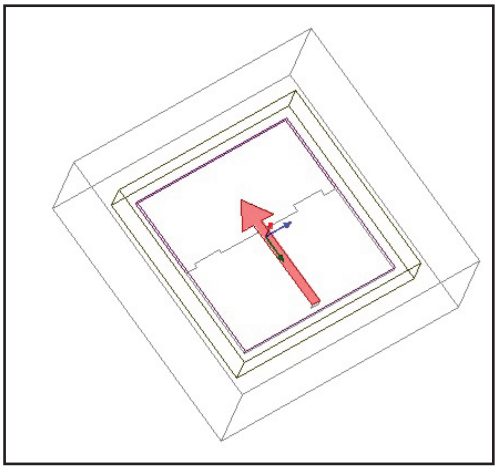

Fig. 2: Complete Geometry Triangular Microstrip Patch Antenna

Table 1: Parameter Specifications of Triangular Microstrip Patch Antenna

Antenna Dimensions	Millimeters (mm)
Width of Substrate	49
Length of Substrate	50
Thickness of Substrate	1.58
Side of Triangular patch	9.08
Width of Partial Ground Plane	49
Length of Partial Ground Plane	27
Width of Feed Line	2.7
Length of Feed Line	27

The impedance bandwidth and gain enhancement is accomplished by making use of partial ground planes [5-7]. This is a technique in which ground plane dimensions are reduced to enhance the performance characteristics of Antenna. By incorporating partial ground plane structure, it is possible to increase the gain, impedance and front to back ratio of the antenna.

Then by using tuning stubs in ground plane, S11 curve is improved further and gain is adjusted in UWB range of frequencies. The optimized tuning stubs of length 1.2 mm and width 8 mm are placed on both sides of patch in the ground plane as shown in Fig. 1.

IV. Experimental Results

The proposed antenna is designed, simulated and evaluated by using Ansoft HFSS software. Fig. 3 shows the measured return loss of the proposed design.

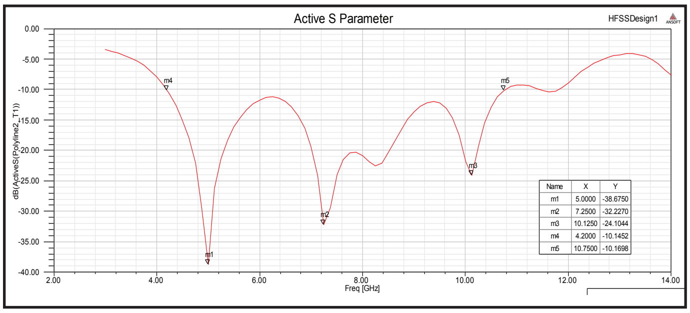

Fig. 3: Return Loss of the Proposed Microstrip Patch Antenna

After grounding the antenna partially, tuning stubs are introduced to achieve the ultra-wideband response. It is observed from the figure that triangular microstrip patch antenna is exhibiting a wideband frequency response ranging from 4.2 GHz to 10.8 GHz which fulfills the requirement of high bandwidth in today's high speed internet world. The return loss experienced by antenna is also depicting the perfect impedance matching between the microstrip line feed and the triangular patch. Fig. 4 is showing the radiation pattern of the proposed antenna.

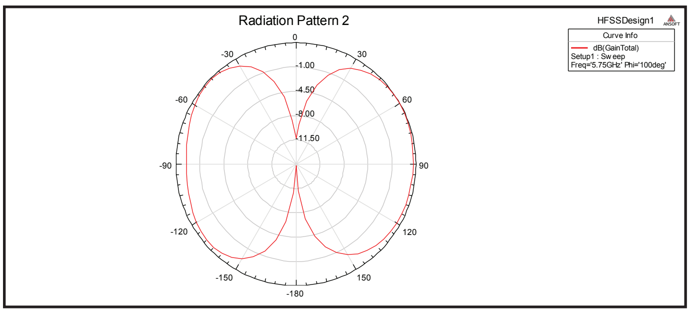

Fig. 4: Radiation Pattern of the proposed Microstrip Patch Antenna

Various techniques have been employed to enhance the proposed antenna characteristics like partial ground, using of tuning stubs on the both sides of patch and optimization of length of ground plane and microstrip feed line.

A. Analysis of the Antenna by Varying the Length of Ground Plane

The proposed antenna is optimized to give the best performance characteristics by varying the length of Ground Plane from 26 mm to 28 mm and adjusting the step size to 0.5 mm.

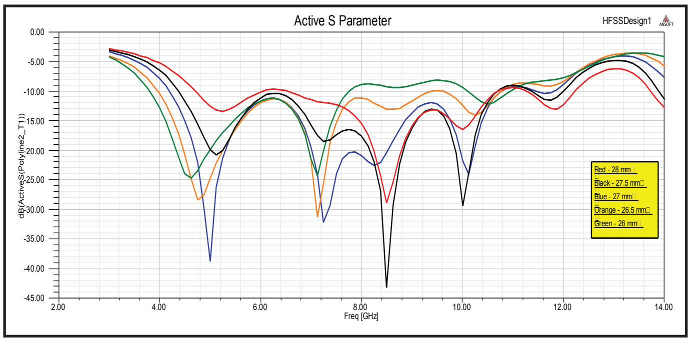

Fig. 5: Return Loss of the Proposed Microstrip Patch Antenna by varying Length of Ground Plane

Fig. 5 clearly shows that the condition of minimum acceptable return loss of -10 dB is exhibited throughout the wideband frequency range only by keeping length of ground plane at 27 mm. Fig. 6 shows the VSWR experienced by antenna at different ground plane lengths.

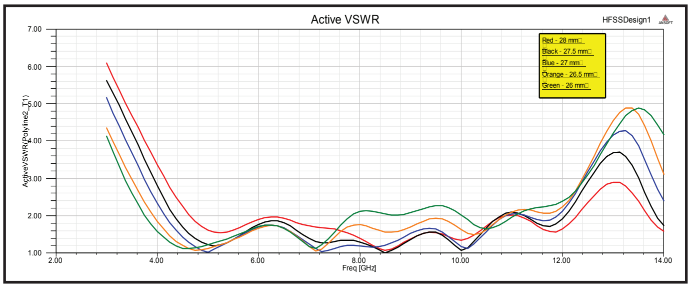

Fig. 6: VSWR of the proposed Patch Antenna by varying Length of Ground Plane

B. Analysis of the Triangular Microstrip Patch Antenna by varying the length of Microstrip Feed Line

Again the simulated antenna is analyzed for best impedance matching, gain and bandwidth requirements by varying the length of Microstrip feed line from 26 mm to 28 mm as shown in Figure 7. It is observed that results are optimum at the feed line length of 27 mm.

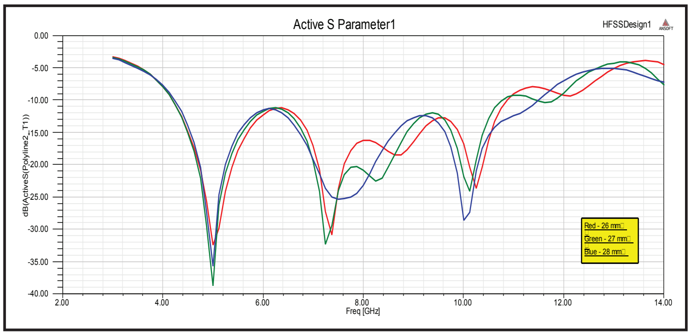

Fig. 7: Return Loss of the Proposed Microstrip Patch Antenna by varying Length of Feed Line

Fig. 8 shows the VSWR variation with the corresponding variation of length of feed line.

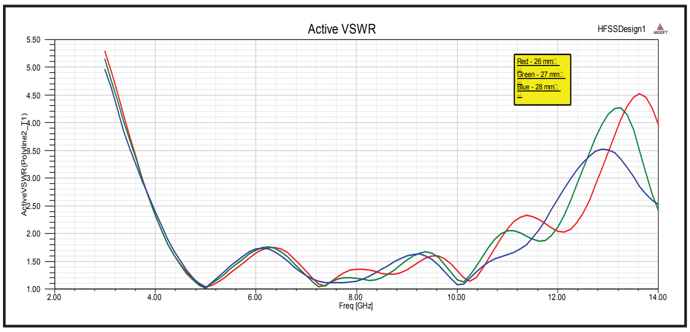

Fig. 8: VSWR of the Proposed Microstrip Patch Antenna by Varying Length of Feed Line

V. Conclusion

A novel Microstrip Line fed high gain and broadband Patch antenna has been successfully simulated. The proposed antenna is horizontally polarized and operates in the frequency band ranging from 4.2 GHz to 10.8 GHz. The gain of this antenna is 6.18 dB. These results demonstrate that the proposed design offers a significant coverage over the ultra-wideband frequency range [8] which makes it ideal for the use of applications like radars, wireless communication, Personal area networks and many more. The proposed antenna is analyzed to have optimized partial ground plane and microstrip feed line. The return loss is reaching up to -40 dB and radiation patterns are acceptable throughout the entire frequency range. In addition, the antenna's structure offers great advantages due to its simple design and small dimensions.

References

[1] R. Garg, P. Bhartia, I. J. Bahl, A. Ittipiboon,"Microstrip Antenna Design Handbook", Artech House, Boston, Mass, USA, 2001.

[2] K.L. Wong,"Compact and Broadband Microstrip Antennas", John Wiley & Sons, New York, NY, USA, 2002.

[3] Alam, M.S., M.T. Islam, N. Misran, "Design analysis of an electromagnetic band gap microstrip antenna", Am. J. Applied Sci., 2011.

[4] F. Yang, X-X Zhang, X. Ye, Y. Rahmat-Samii,"Wide- Band E-Shaped Patch Antennas for Wireless Communications", IEEE Trans. Antennas and Propagation., Vol. AP-49, pp. 1094–1100, 2001.

[5] Nesasudha M., Divya Mathew,"Effect of Partial Ground Plane on the Microstrip Patch Antenna Performance for Wireless Sensor Networks," Journal of Electronic Design Technology, Vol. 4, No. 3, 2013.

[6] P. C. Ooi, K. T. Selvan,"The Effect of Ground Plane on the Performance of a Square-Loop CPW-fed Printed Antenna", Progress in Electromagnetics Research Letters, Vol. 19, pp. 103–111, 2010.

[7] Hong-min Lee,"Effect of partial ground plane removal on the front-to-back ratio of a Microstrip antenna," Antennas and Propagation (EuCAP), 2013 7th European Conference on 8-12 April 2013.

[8] "Fractional Bandwidth (FBW) (2014)," [Online] Available: http://www.antenna-theory.com/definitions/fractionalBW.php