Design of CPW-Fed Triangular Shaped UWB Antenna for Multiband Applications

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Abstract - *— In this paper, a novel compact CPW-fed ultra-wideband (UWB) antenna is designed. The antenna is designed on a single-layer copper-cladding substrate. The substrate material is FR4-epoxy with relative permittivity of 4.4, and the antenna has a compact dimension of 24 mm × 32.4 mm × 1.6 mm. The antenna design consists of a triangular shaped patch antenna with single folded capacitive loaded line resonator (CLLR), two rectangular ground on the same plane and fed by standard feed line of 50 Ω microstrip. This paper proposes a new triangular shaped CPW-fed UWB antenna that the bandwidth, covers 1.7 – 10.8 GHz frequency range and resonance at three different frequencies such at 2.9 GHz, 5.6 GHz and 8.4 GHz respectively. The proposed designed antenna is successfully simulated with the help of Ansoft HFSS simulator tool which is working on the principle of FEM. The results obtained from the simulation indicate that the designed antenna attains a good bandwidth from 1.7 GHz – 10.8 GHz with VSWR < 2, return loss < -10 dB. This shows that the antenna has omnidirectional radiation patterns and good gain flatness that is suitable for UWB applications.*

Key Words: CPW, Ultra-wideband (UWB), CLLR, Resonant frequency, Return loss, VSWR, HFSS, FEM

I.INTRODUCTION

In 2002, the Federal Communications Commission (FCC) announces the frequency bandwidth of ultra wideband (UWB) system for commercial communication applications [1]. UWB technology and its potential applications in wireless communications systems have been attracting increasing interests from both academia and industry. The antenna is an important component which determines the performance of UWB systems, one of principal subjects in UWB device is to design a compact antenna. Ultra-wideband (UWB) technology is one of the most promising solutions for future communication systems due to its high-speed data rate and excellent immunity to multi-path interference. Traditional Ultra-wideband (UWB) antennas have been unable to combine with the modern integrated system for their complex structures and large volumes, miniaturized ultra-wideband printed antennas being good candidates for their low profile. Due to the very large frequency spectrum of UWB from 3.1 – 10.6 GHz, very fast development in wireless communication system and a very large number of researcher have given their research interest in designing and implementation of various type of antenna for UWB applications. The UWB antenna has a numbers of merits as low power consumption, high data rate, omnidirectional with maximum accuracy. For communication applications, the FCC provides -41.3dBm/MHz as an effective isotropic spectral power density for UWB bandwidth system [2] The CPW-fed antennas have received considerable attention due to good radiation properties and easy integration with system circuits.

The design of UWB antenna also face some challenges including the ultra-wideband performances of the impedance matching and radiation stability, the compact antenna size and the low manufacturing cost for consumer electronics applications, electromagnetic interference (EMI) for the entire UWB frequency band 3.1 – 10.6 GHz [3]. In past many researcher reported different CPW-fed antenna designs [4-7]. The miniaturization technique provides to decrease in the resonant frequency, therefore a large number of small planar antenna have been designed [8-10]. In CPW-fed UWB microstrip patch antenna, it consists of radiating patch on the upper side of antenna called dielectric substrate whereas ground is designed on the same plane of antenna. Similarly variety of antenna structures for planar wideband monopole antennas have been designed and studied and reported for UWB applications [11-13]. Recently, several broadband monopole configurations, such as circular, square, elliptical, half disc, pentagonal and hexagonal, have been proposed for UWB applications [14-18]. A novel design of printed circular disc monopole fed by micro strip line is proposed and investigated [19]. A more specific definition for an Ultra Wide Band (UWB) antenna is a non-resonant low-Q radiator whose input impedance remains constant over a wide-band operating frequency [20], this type of antenna requires a well matched transition to space to avoid energy reflection [21].

In this paper, a simple and compact CPW-fed antenna is proposed for UWB and multiband applications. The design consists of a triangular shaped patch antenna which is attached with an inverted L-shaped strip. Rectangular grounds are also designed on the same plane of proposed antenna [22].

II. ANTENNA DESIGN

The layout of the proposed UWB antenna is shown in Fig. 1. The basic design of the proposed antenna includes a triangular patch which is attached with an inverted L typed strip line with coplanar grounds.

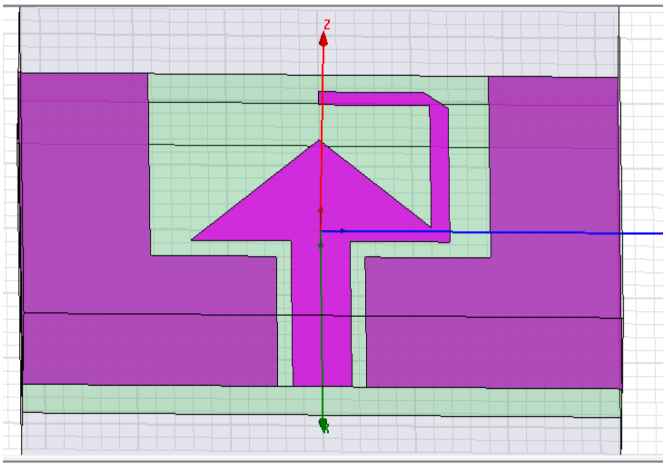


Fig.1. A general view of proposed antenna

The antenna is designed on a FR4 substrate with substrate dimension of 24 × 32.4 mm^2 and thickness h = 1.6 mm. The substrate has relative permittivity of 4.4.

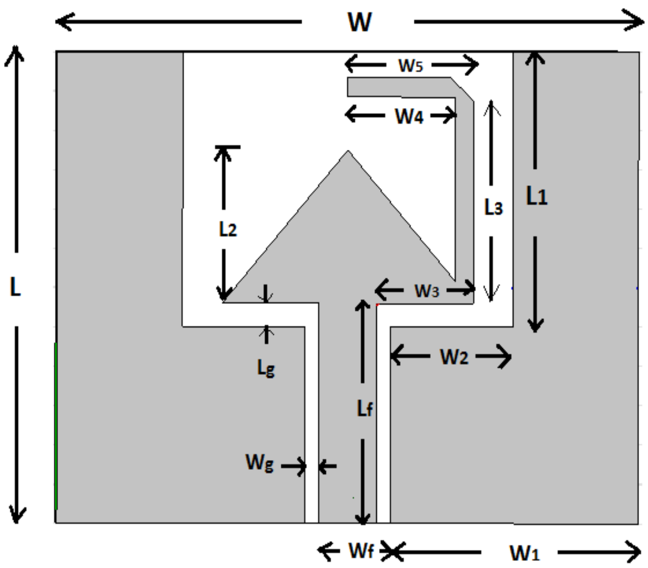
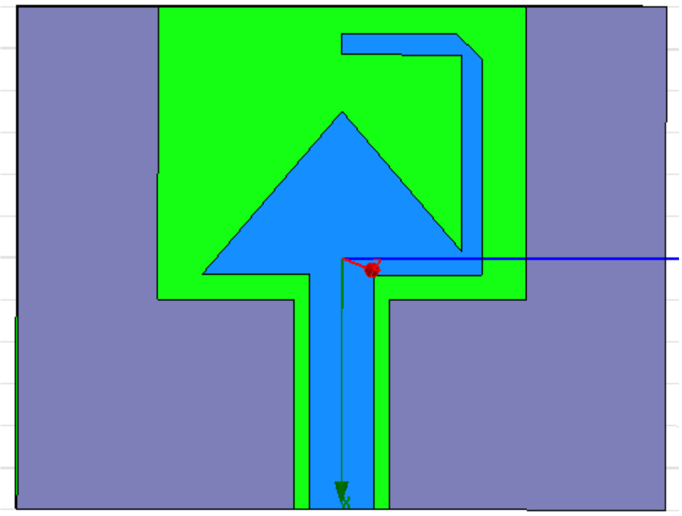
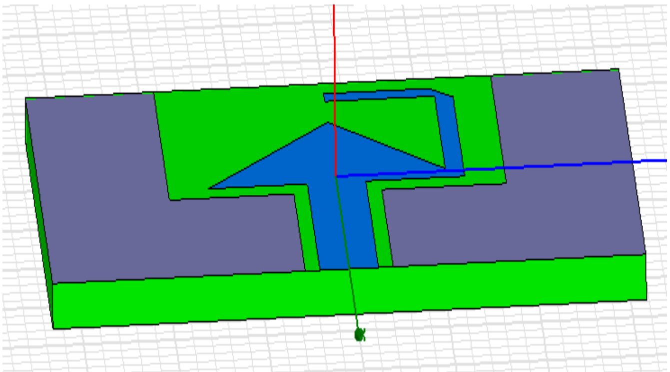


Fig.2. Geometry and dimensions of the proposed UWB antenna

The proposed antenna has a small size of L × W. The ground plane dimensions are W1 = 13.8 mm, W2 = 6.8 mm, L1 = 14 mm. A 50Ω CPW feed line, having the width of the CPW-fed line Wf = 3.2 mm, gap of distance Wg = 0.8 mm and length Lf = 11.2 mm. The spacing between the triangular terminal and edge of the ground plane is Lg = 1.2 mm. The dimension of the strip L3 = 10.5 mm with strip width of 1 mm. The triangular terminal of height L2 is connected to the end of the CPW feed line. The triangular -shaped patch has only two parameters: L2 (height of the patch) and W3. The geometry and dimensions of the proposed antenna is shown in fig.2 The design structure and dimensions of the antenna is given in fig.2.



(a) Top view



(b) Side view

Fig.3. Different configuration of antenna (a) Top view (b) Side view

In the proposed UWB antenna, the strip is designed at the right side of the triangular patch antenna. The width of the strip is 1 mm.
To design the resonator, λg/4 can be taken as length [23] where   is given by

$$\lambda_g = \frac{c}{f\sqrt{\varepsilon_{eff}}}$$

$$\varepsilon_{eff} = {(\varepsilon_r + 1)}/{2}$$

From the above equation, λg/4 can be determined from the resonant frequency, velocity of light and permittivities.

The proposed antenna designing parameters are mention in Table 1.

Table -1: Proposed antenna design parameters

Parameters	Value (mm)	Parameters	Value (mm)
L	24	W1	13.8
L1	14	W2	6.8
L2	7.8	W3	7
L3	105	W4	6
Lf	11.2	W5	7
Lg	1.2	Wf	3.2
W	32.4	Wg	0.8

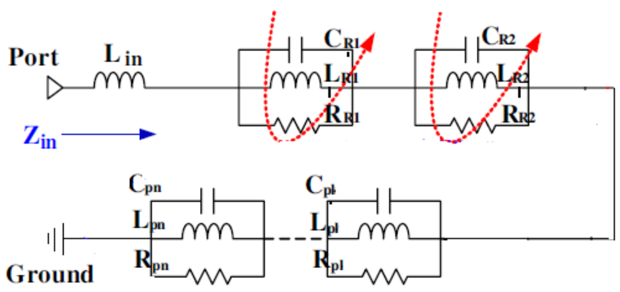


Fig.4. Equivalent circuit model of proposed CPW-fed UWB antenna

III. SIMULATION RESULT AND ANALYSIS

The commercial simulation software Ansoft HFSS 11 based on the finite element method (FEM) is employed to perform the design and optimization process [24]. The simulated results of the projected antenna are discussed below.

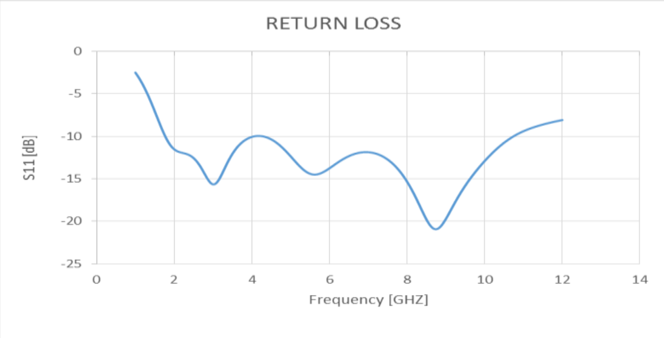


Fig.5. Simulated Return loss (S11)

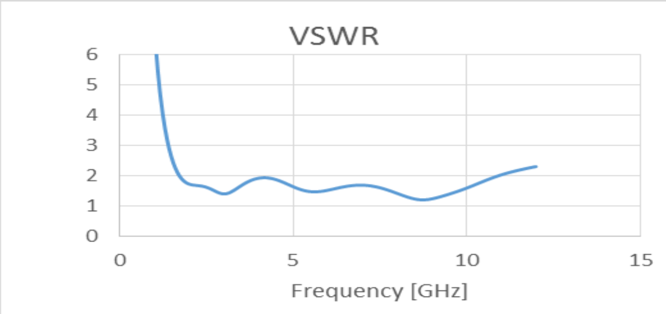
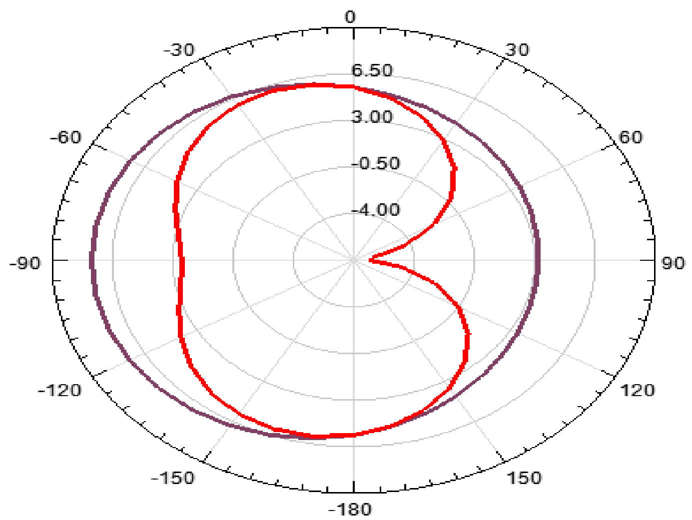


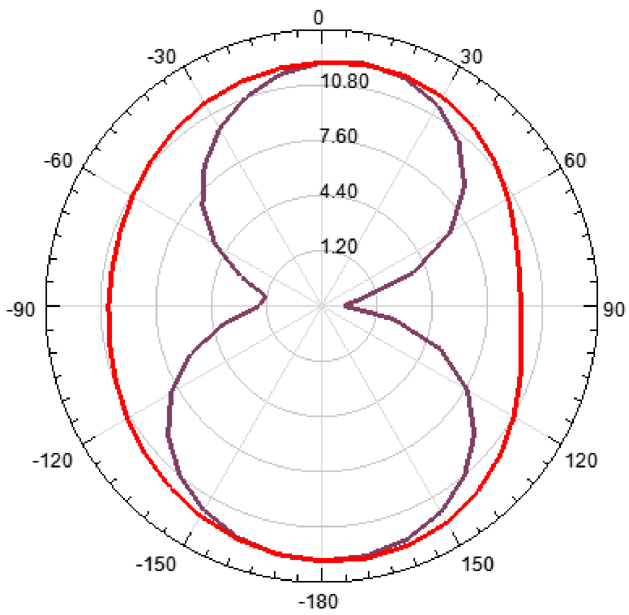
Fig.6. Simulated VSWR

Fig.5 shows the return loss of the proposed UWB antenna. Which clearly indicate that the designed antenna covers entire UWB range from 3.1 GHz to 10.6 GHz. From the graph, antenna has also three other resonance frequencies at 2.9 GHz, 5.6 GHz and 8.4 GHz with return loss of -15 dB, -14.99 dB and -20.91 dB respectively.

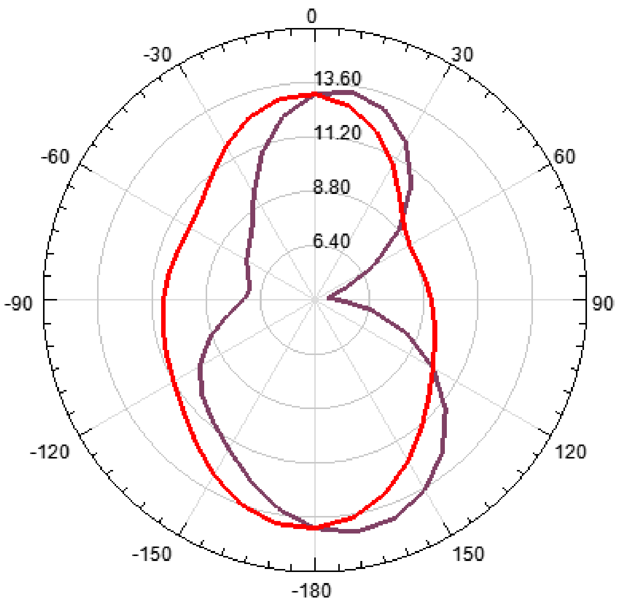
Fig.6 shows the simulated VSWR result. It is also under the desired condition (VSWR≤2) for entire UWB range.



(a) Radiation pattern at 2.9 GHz

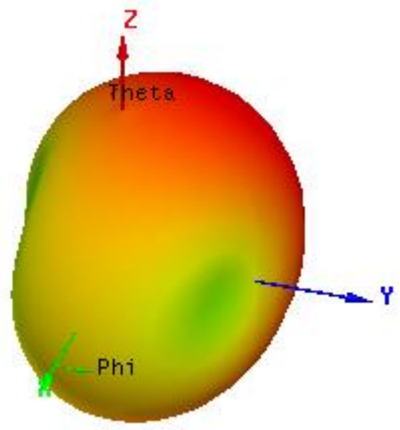


(b) Radiation pattern at 5.6 GHz

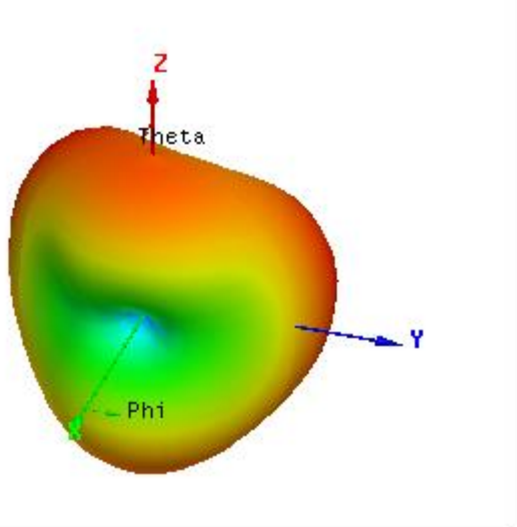


(c) Radiation pattern at 8.4 GHz

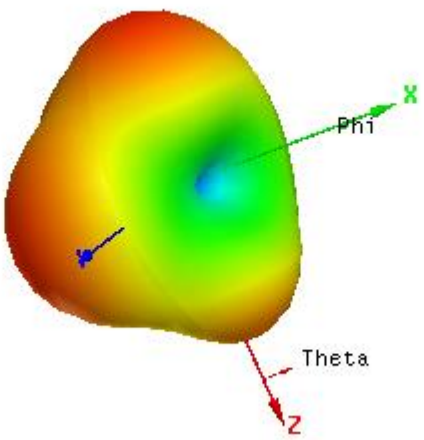
Fig.7. Far-field radiation pattern (a) at 2.9 GHz (b) at 5.6 GHz and (c) 8.4 GHz



(a) 3-D Polar Far Field pattern at 2.9 GHz

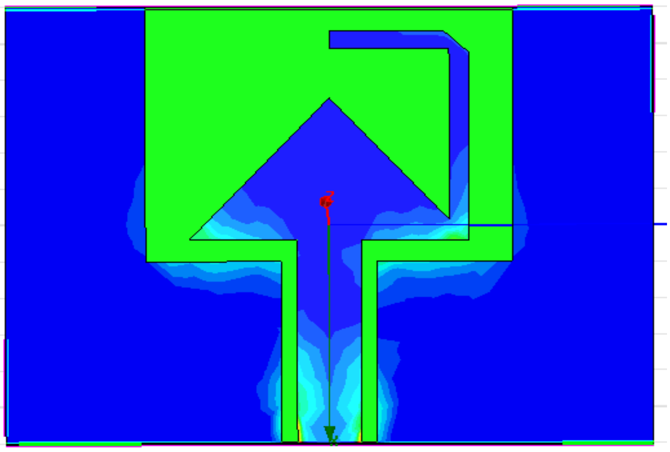


(b) 3-D Polar Far Field pattern at 5.6 GHz

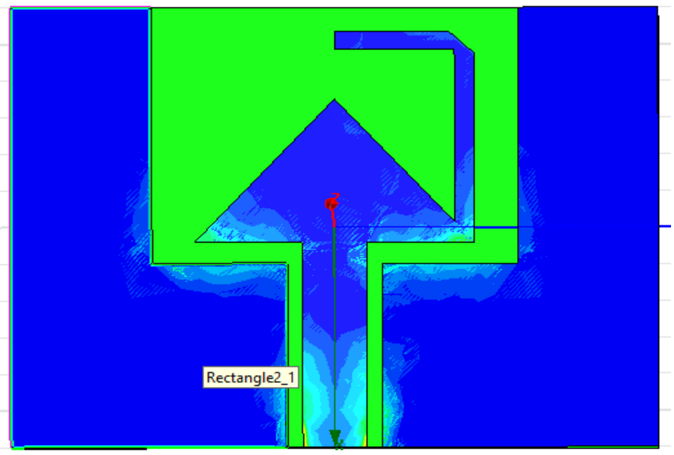


(c) 3-D Polar Far Field pattern at 8.4 GHz

Fig.8 3-D Far-field radiation pattern of the proposed antenna (a) at 2.9 GHz (b) at 5.6 GHz and (c) 8.4 GHz



(a) E –field



(b) H –field

Fig.9. Field plot of the proposed UWB antenna (a) E- field and (b) H-field

IV. CONCLUSION

A compact CPW-fed UWB antenna with triangular shaped tuning patch is designed. The antenna has compact size of 24 × 32.4 mm2. The proposed antenna has excellent return loss, VSWR and gain from 1.7 GHz to 10.8 GHz of bandwidth 9.1 GHz. This result also covers the entire UWB frequency range (3.1-10.6 GHz). The simulated UWB antenna features omni-directional radiation pattern and stable radiation pattern and this makes the proposed antenna is a suitable candidate for UWB applications and systems integrated with other three multiband applications.

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