A Micro strip feed Knight's Helm Shaped Patch Antenna using FR-4 substrate for UWB Application

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Abstract— In the last decade, Ultra-wideband (UWB) has come up as a revolutionary and contemporary wireless technology which has generated a great deal of interest for use in the industry and academia. In recent years many studies are concentrated on UWB microstrip antenna structures for important purposes in wireless communication systems, medical imaging, and radar sensor resolution. In this paper, the radiation performance of a small printed knight's helm shape patch antenna designed on glass epoxy FR4 substrate is discussed. The antenna has compact dimension of 30 mm x 30 mm and it is capable to cover Wi MAX, Wi Fi, WBAN and Bluetooth operations and UWB applications. The simulated results for various parameters like total field gain, return loss, VSWR, radiation efficiency etc. are calculated with High Frequency Structure Simulator (HFSS) and with the help of network analyzer experimental result are calculated. Its simulated results display impedance bandwidth from 3.04 GHz to 10.96GHz. The antenna complies with the return loss of S_{11} less then -10db and VSWR < 2 throughout the impedance bandwidth. The proposed antenna is easy to integrate with microwave circuitry for low manufacturing cost. The antenna structure is flat, and its design is simple and straight forward.

Keywords— Patch antenna, UWB antenna, FR4 substrate, HFSS

INTRODUCTION

FCC (Federal communications commission) allocated a block of radio spectrum from 3.1GHz to 10.6 GHz for UWB operations [1].UWB systems can support more than 500 Mbps data transmission within 10m [2]. Compact size, low-cost printed antennas with Wideband and Ultra wideband characteristic are desired in modern communications. The Ultra wide band antennas can be classified as directional and Omni-directional antennas [3]. A directional antenna have the high gain and relatively large in size. It has narrow field of view. Whereas the omni-directional antenna have low gain and relatively small in size. It has wide field of view as they radiates in all the directions [4].

The UWB antennas have broad band. There are many challenges in UWB antenna design. One of the challenges is to achieve wide impedance bandwidth. UWB antennas are typically required to attain a bandwidth, which reaches greater than 100% of the center frequency to ensure a sufficient impedance match is attained throughout the band such that a power loss less than 10% due to reflections occurs at the antenna terminals. Various planar shapes, such as square, circular, triangular, and elliptical shapes are analyzed [5].Compared with monopole based planar antennas, the design of ultra wide band circular ring type antennas is difficult because of effect of the ground Plane.

The bandwidth of the micro strip antenna can be enhanced by modifying the ground plane [6]. Many designers have tried various ways to improve the structure of the traditional rectangular antenna, and many valuable results have been obtained [7].

ANTENNA CONFIGURATION AND DESIGN

The motivation of UWB antenna is to design a small and simple omnidirectional antenna that introduces low distortions with large bandwidth. The knight's helm shape antenna presented is fabricated on a 30 mm x30 mm 1.6-mm-thick FR4 board with a double slotted rectangular patch tapered from a 50-Ohm feed line, and a partial ground plane flushed with the Feed line. The geometry of the antenna is as shown in Figure 1, the two slots have a dimension of 2 mm x 4 mm with a distance of 3 mm apart.

Table 1. Dimensions of antenna (in mm)

W_{sub}	L sub	L1	L2	L3	L4	W1
30	30	12.5	11.5	26	7.5	15

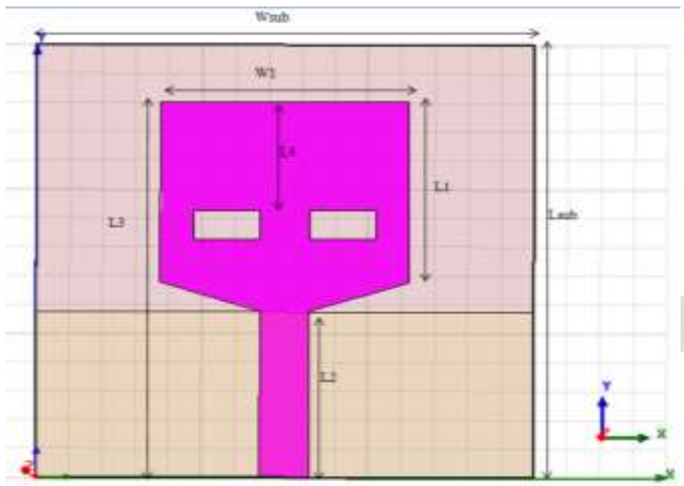

Figure 1. Geometry of double slotted rectangular patch tapered Antenna

The proposed antenna designed on a FR-4 substrate with dielectric constant $\varepsilon_r = 4.4$ and height of the substrate is h = 1.6 mm. The substrate has length L= 30 mm and width W = 30 mm.The substrate is mounted on ground of 11.5mm length and 30 mm width. The dimensions of proposed antenna are shown in Table 1.

SIMULATION RESULTS

The simulated results for various parameters like total field gain, return loss, VSWR, radiation efficiency etc. are calculated with High Frequency Structure Simulator (HFSS) [8]. This antenna is suitable for operating frequency 3.04GHz to 10.96 GHz allotted by IEEE 802.16 working group for UWB applications. The VSWR obtained is less than 2 the patch antenna is found to have the compact size and 90% Maximum Fractional Bandwidth. The return loss value of band is -25.72dB at 8.8GHz. Fig. 3 shows the comparative analysis for the optimization of ground length at Lg = 11.5 mm.

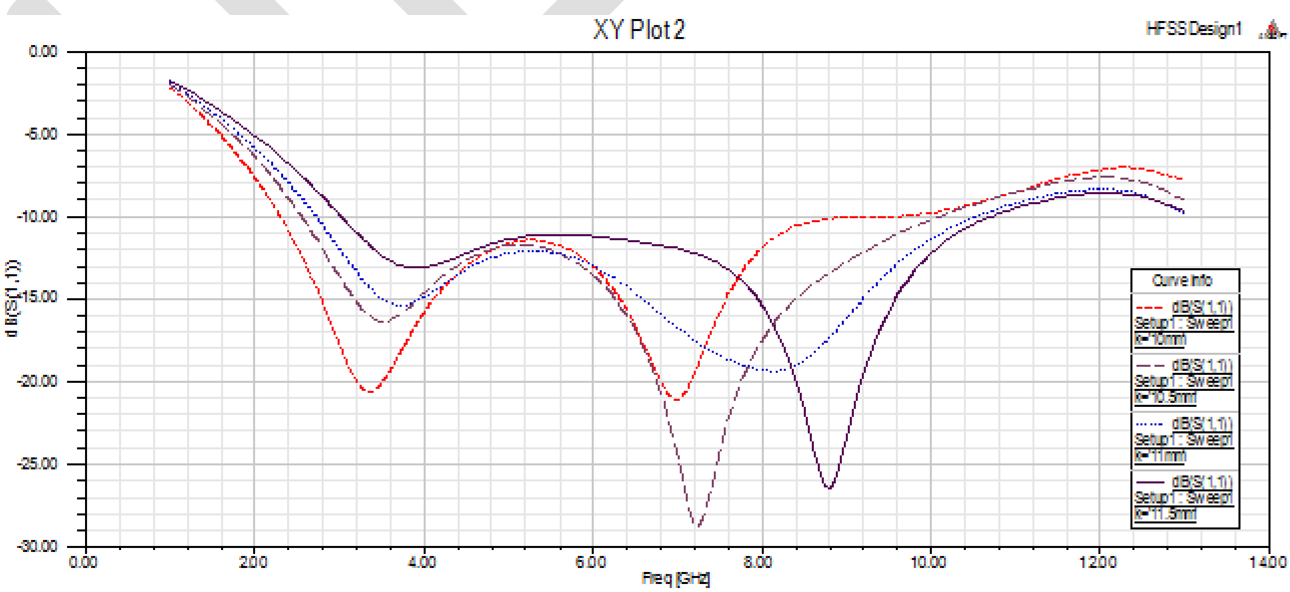

Figure 2. To optimize the ground length Lg = 11.5 mm at 10 GHz

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Form the figure 2. we can conclude that if we decrease the ground length (Lg) of substrate up to a specific manner, we can obtain the higher values of return loss and VSWR and antenna offers excellent performance in the range of 3.9 GHz - 10.96 GHz rather than various different shapes antennas used in this range to obtain higher values of return loss and notch frequencies at Lg = 11.5 mm. Various simulated results are stated in table 2 shown below. The VSWR, total field gain, the E and H fields at 10 GHz are also simulated and shown in Figure 4. to Figure 7. respectively.

Table 2. Various simulated results

Parameter	Value
Gain	3.4 dB
Directivity	4.15 dB
Absolute Bandwidth	7.72 GHz
Radiation Efficiency	86 %
antenna efficiency	79%
Radiate Power	94 %
Incident Power	100 %

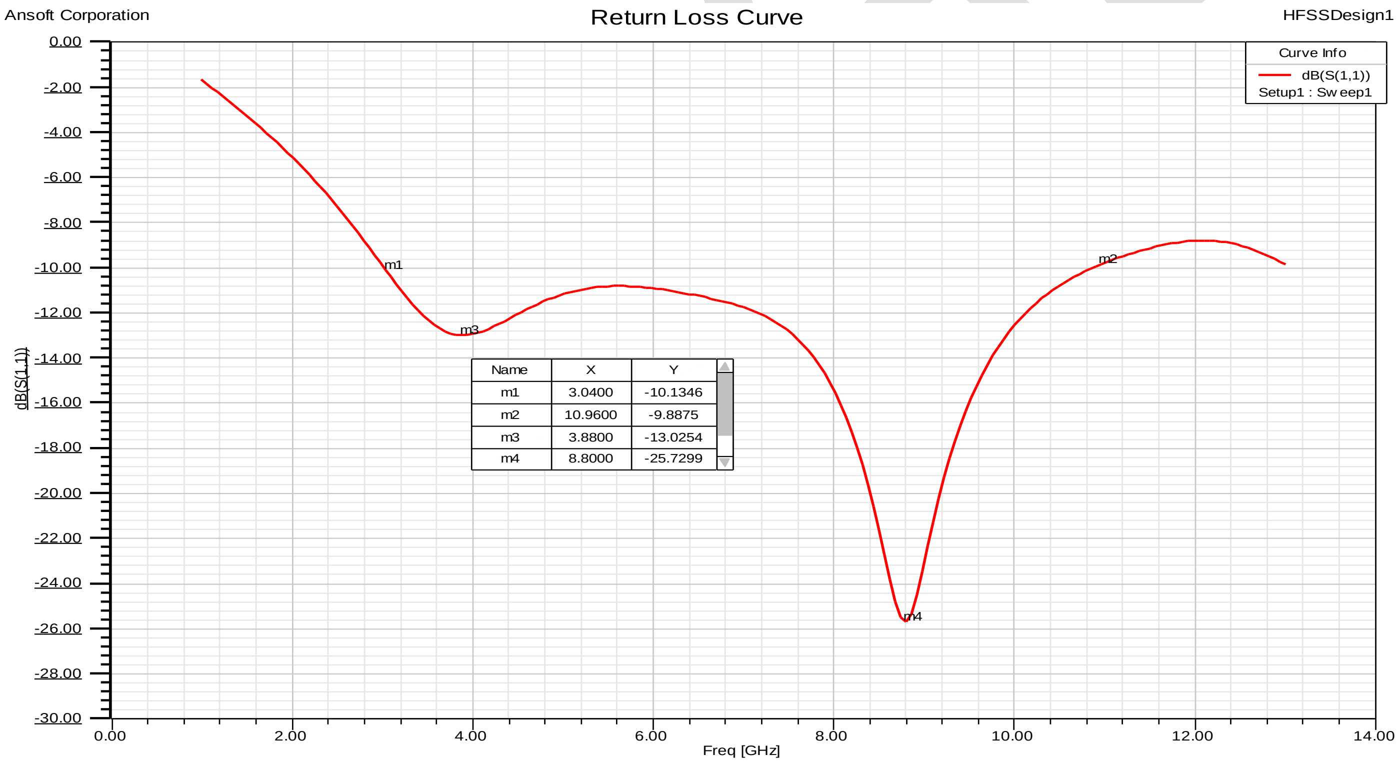

Figure 3. Return Loss Curve with optimized ground length Lg = 11.5 mm

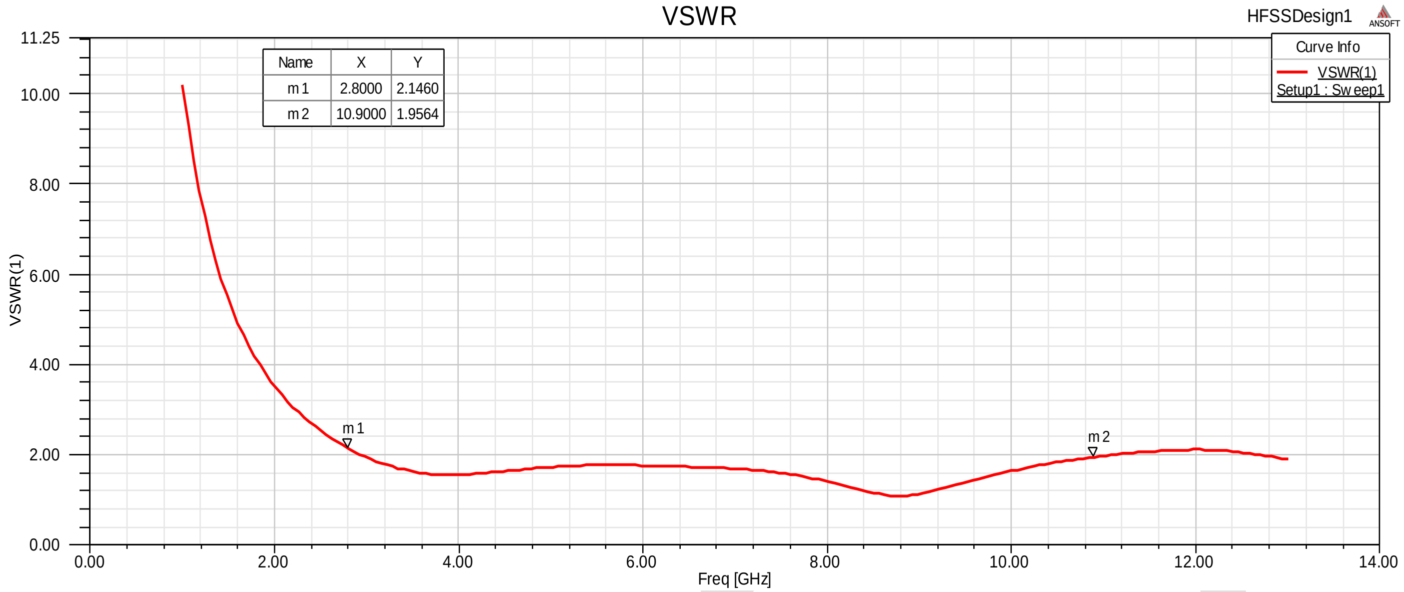

Figure 4. VSWR with optimized ground length Lg = 11.5 mm

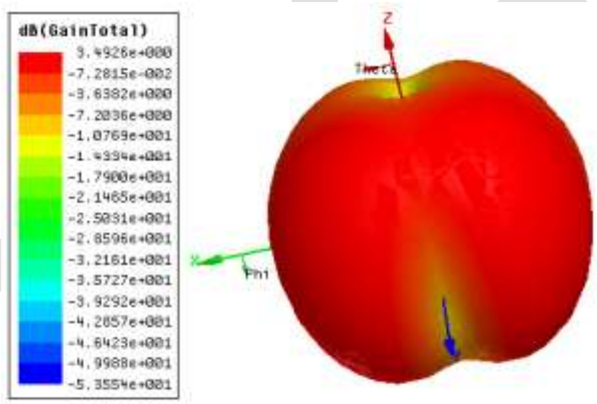

Figure 5. Gain Total with optimized ground length Lg = 11.5 mm

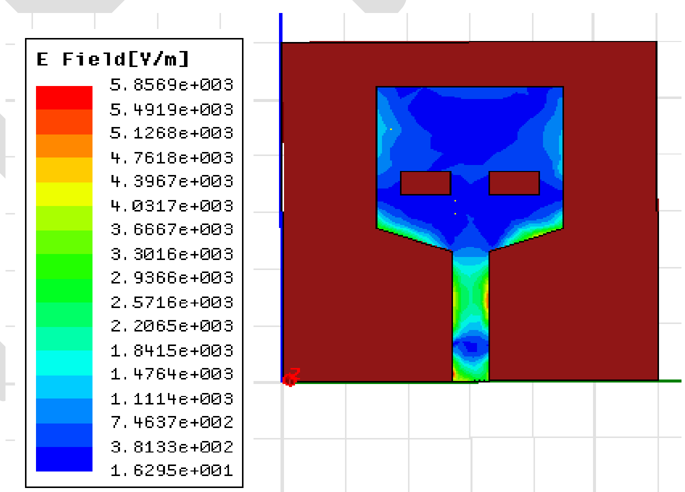

Figure 6. E- Field with ground length Lg = 11.5 mm

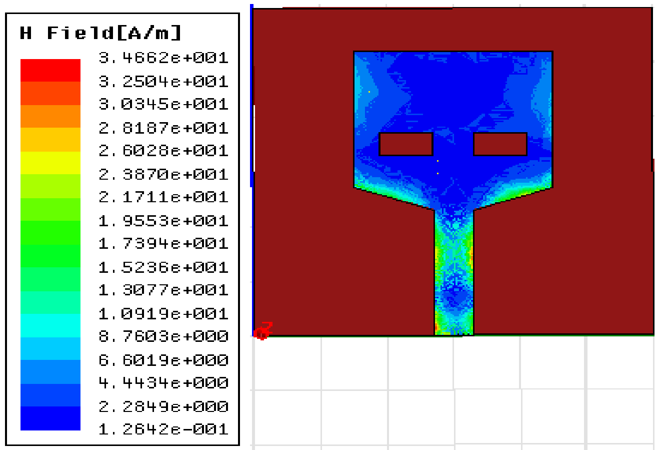

Figure 7. H – field with ground length Lg = 11.5 mm

FABRICATION

After the simulation results of the antenna, .dxf file is exported out of the HFSS and print out of the .dxf file is taken out on glossy paper. The pattern printed on the glossy paper is taken on the FR4 substrate and then similar to PCB designing process is carried out on the double sided FR4 substrate.

After fabrication process the SMA connector is soldered on the antenna which is shown in figure 8 and figure 9.

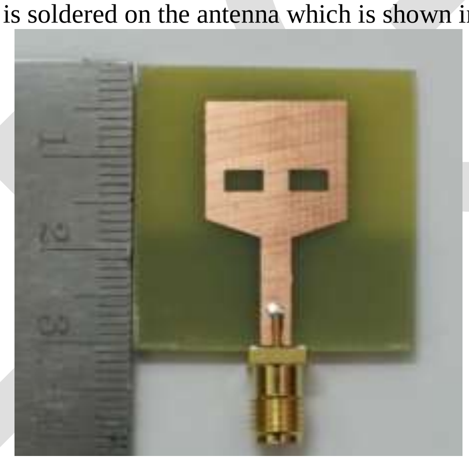

Figure 8. Fabricate Antenna (Top View)

Figure 9. Fabricate Antenna (Bottom View)

MEASURED RESULTS

After the fabrication of the antenna the antenna is tested at the DRDO, Jodhpur on Vector Network analyzer by which the readings of return loss (S11) and VSWR are provided.

Using these reading plots for S11 and VSWR are ploted in MATLAB and are shown in figure 10 and figure 11 respectively.

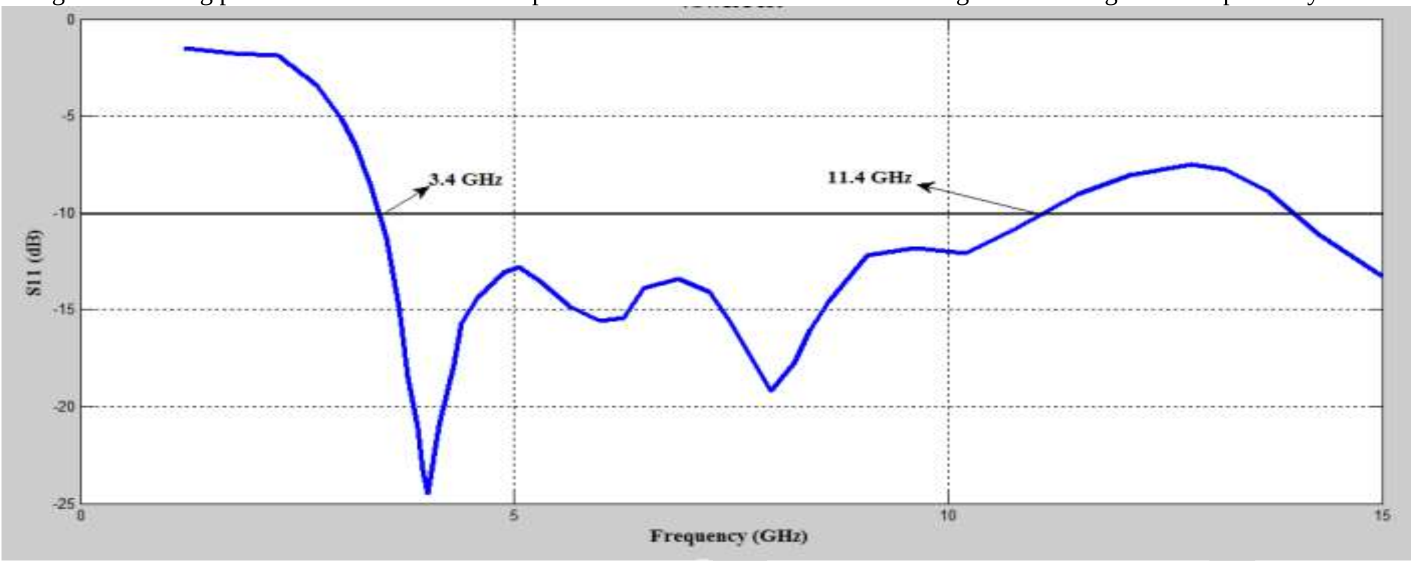

Figure 10. Measured Return loss for the fabricated antenna

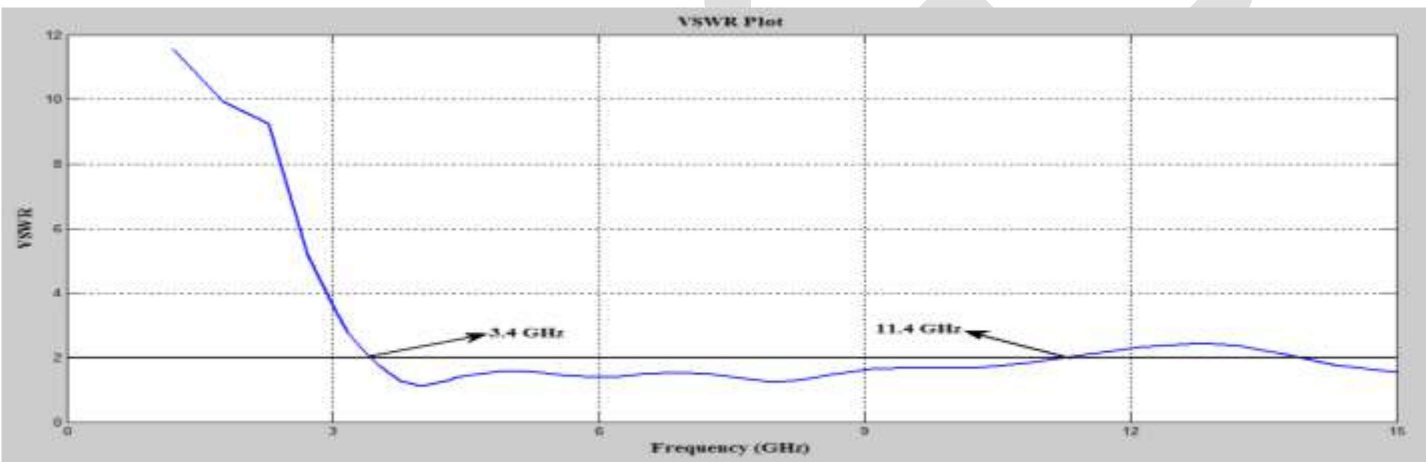

Figure 11. Measured VSWR for the fabricated antenna

CONCLUSION

The fabricated antenna has advantages of small size, easy fabrication and simple construction. Antenna is circularly polarized and operates at 3.04 GHz -10.96 GHz with Absolute Bandwidth 7.72 GHz. The simulated results indicate that an ultra wide band antenna with Maximum Fractional Bandwidth 90% can be achieved by cutting two slots of 2mm x 4mm in a complete rectangular patch. The radiation efficiency 86% and antenna efficiency 79% achieved and we conclude that proposed geometry is applicable for ultra wide band from 3.1 GHz to 10.6 GHz. In future the Radiation performance of novel shape rectangular patch antenna can be improved by using different feeding techniques.

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