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An Optimization Of Circularly Polarized Knight's Helm Shaped Patch Antenna For Ultra Wide Band Application

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Abstract: *In this paper, the radiation performance of a small printed knight's helm shape patch antenna designed on glass epoxy FR4 substrate discussed. The proposed antenna is capable to cover Wi MAX, Wi Fi, WBAN and Bluetooth operations and UWB applications. The Simulated results for various parameters like radiation patterns, total field gain, return loss, VSWR, radiation efficiency etc. are also calculated with high frequency structure simulator HFSS. Its simulate 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.*

Keywords: *Ultra-Wide Band, Multiband Band, Patch antenna*

I. 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.

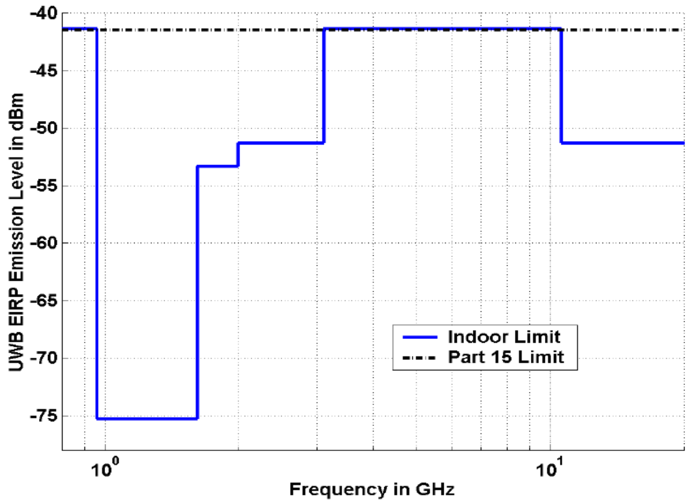

Fig. 1 UWB Spectral Mask per FCC (Modified) Part 15 Rules [1]

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].

II. Antenna Configuration And Design

For patch antenna the length and width are used as calculated from the equations. The expression for ε_{reff} is given by Balanis as [8]:

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{1/2} \qquad (1)$$

The dimensions of the patch along its length have now been extended on each end by a distance ΔL, which is given empirically by Hammerstad as:

$$\Delta L = 0.412h \frac{(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)} \qquad (2)$$

The effective length of the patch L_{eff} now becomes:

$$L_{eff} = L + 2\,\Delta L \qquad (3)$$

For a given resonance frequency f_o , the effective length is given by

$$L_{eff} = \frac{c}{2 f_o \sqrt{\varepsilon_{reff}}} \qquad (4)$$

For a rectangular microstrip patch antenna, the resonance frequency for TM mn mode is given by James and Hall as-

$$f_o = \frac{c}{2\sqrt{\varepsilon_{reff}}}\left[\left(\frac{m}{L}\right)^2 + \left(\frac{n}{W}\right)^2\right]^{1/2} \qquad (5)$$

For efficient radiation, the width W is given by –

$$W = \frac{c}{2f_o\sqrt{\frac{\varepsilon_r + 1}{2}}} \qquad (6)$$

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 Fig 2 the two slots have a dimension of 2 mm x4 mm with a distance of 3 mm apart.

Table 1 Dimensions (in mm) of a CPM antenna

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

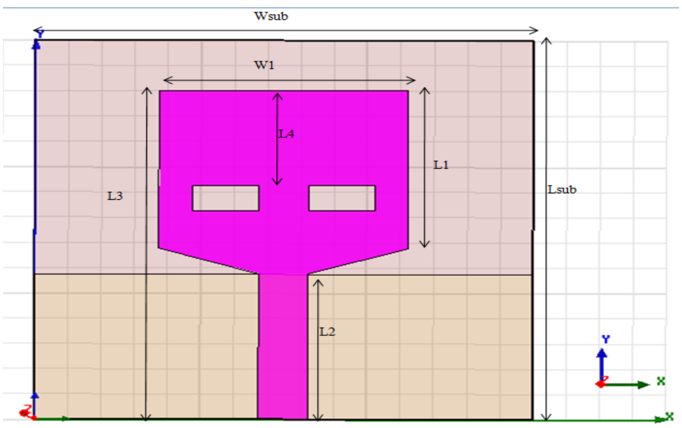

Fig. 2 Geometry of double slotted rectangular patch tapered Antenna

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

III. Simulation Results

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.

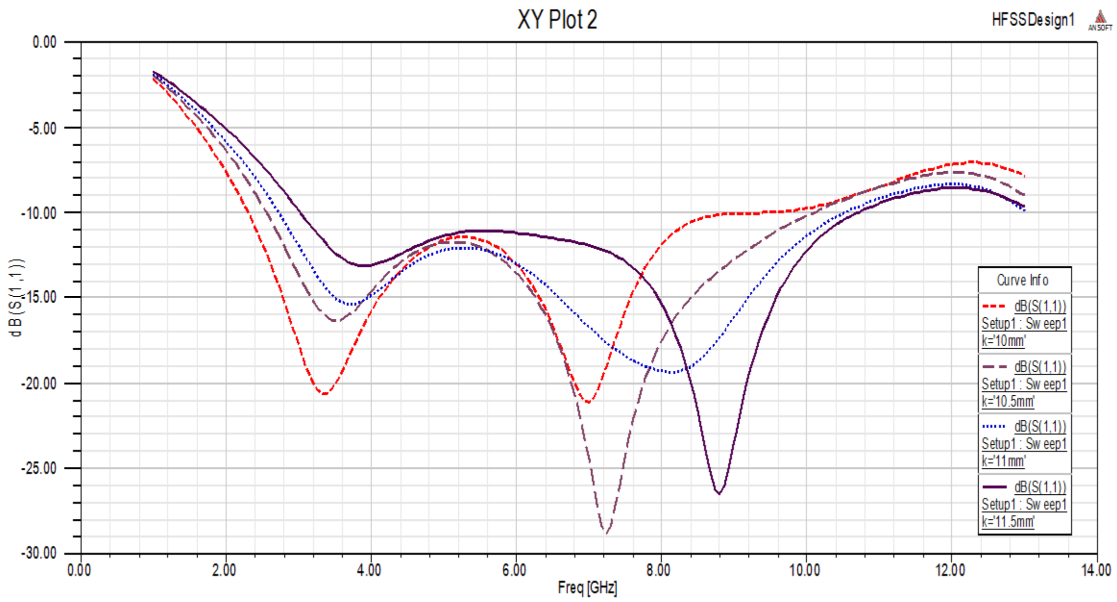

Fig. 3 To optimize the ground length Lg = 11.5 mm at 10 GHz

Form the Fig. 3 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. The VSWR, total field gain 3.49 dB, directivity 4.15, radiation efficiency 86%, radiate power 94%, incident power 100%, E and H fields at 10GHz are also calculated in Fig. 5 to Fig. 13 respectively.

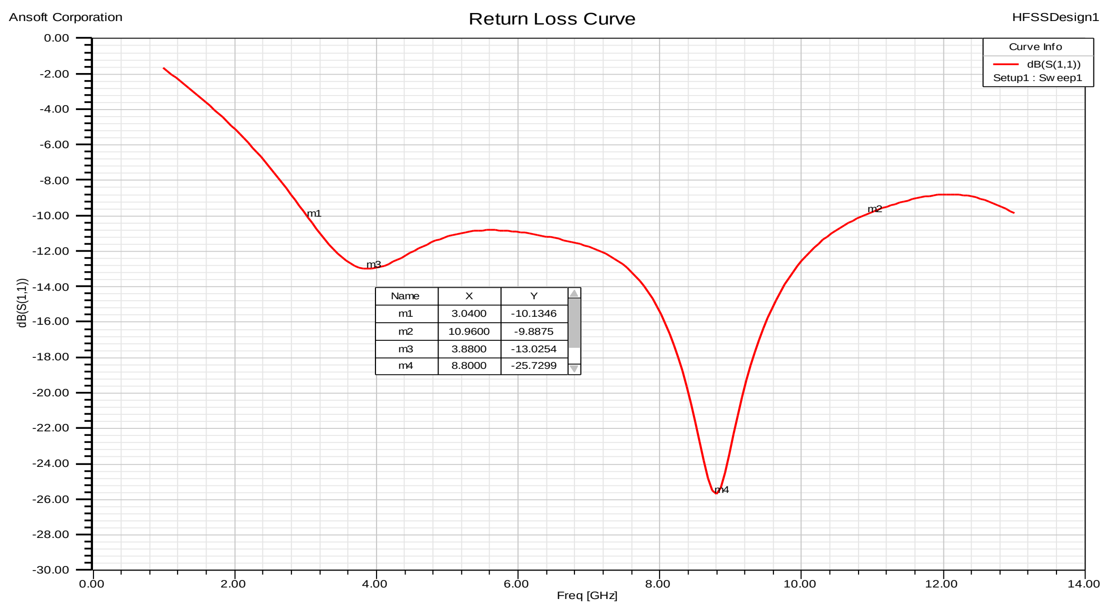

Fig. 4 Return Loss Curve with optimized ground length Lg = 11.5 mm

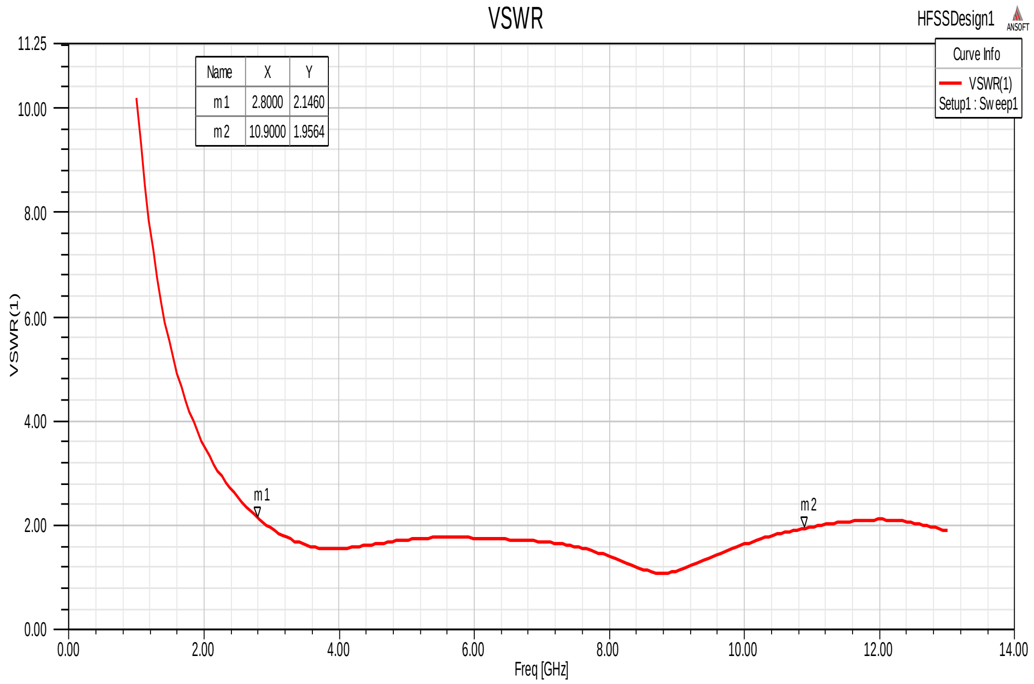

Fig. 5 VSWR with optimized ground length Lg = 11.5 mm

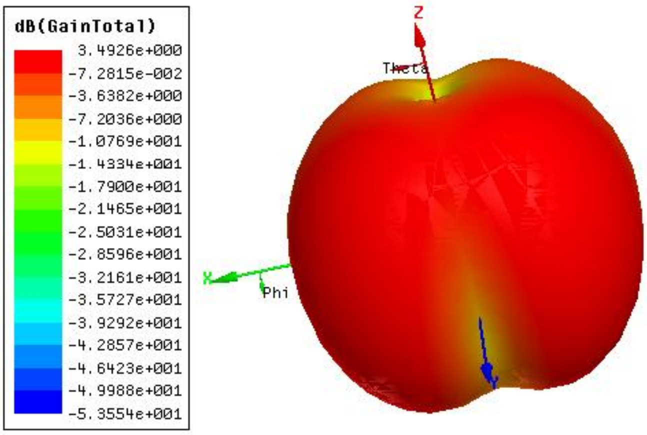

Fig. 6 Gain Total with optimized ground length Lg = 11.5 mm

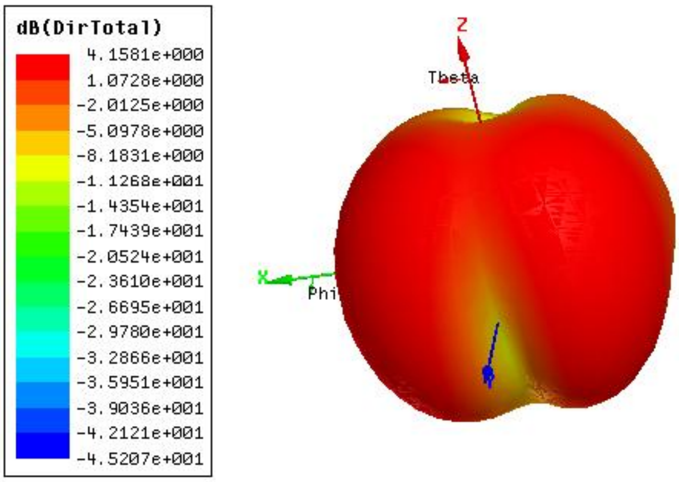

Fig. 7 Directivity with optimized ground length Lg = 11.5 mm

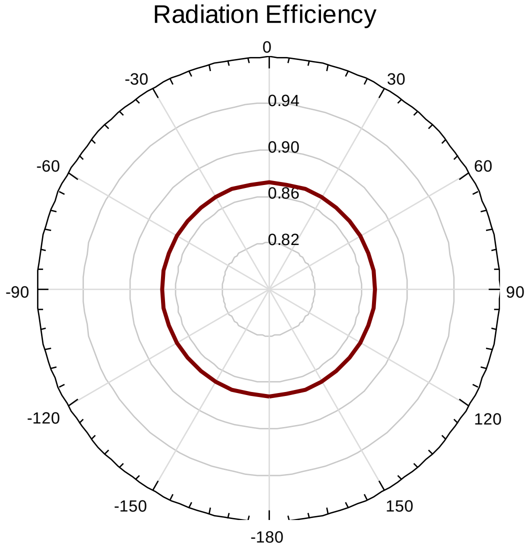

Fig. 8 Radiation Efficiency optimized ground length Lg = 11.5 mm

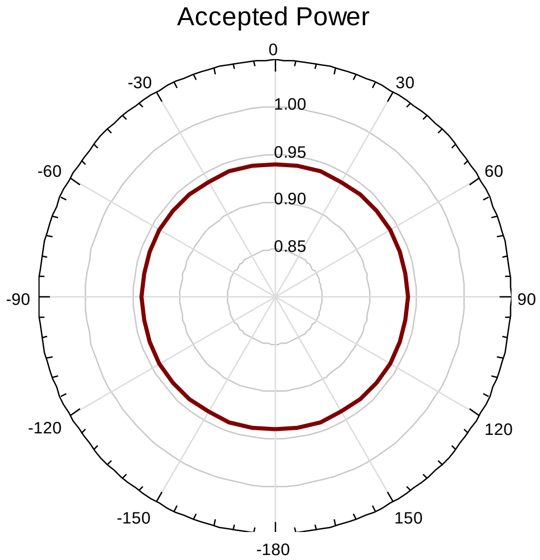

Fig. 9 Accepted Power with optimized ground length Lg = 11.5 mm

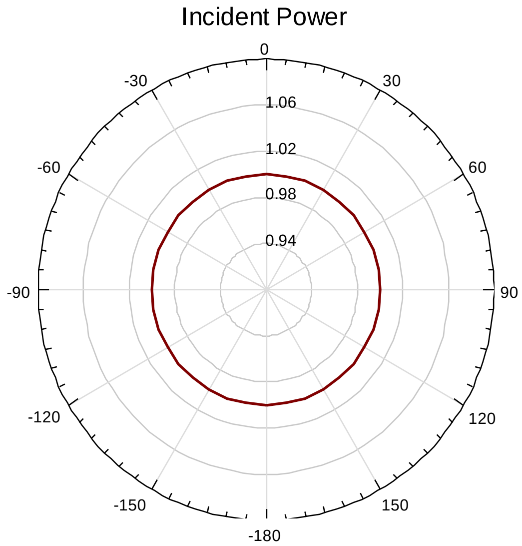

Fig. 10 Incident Power with optimized ground length Lg = 11.5 mm

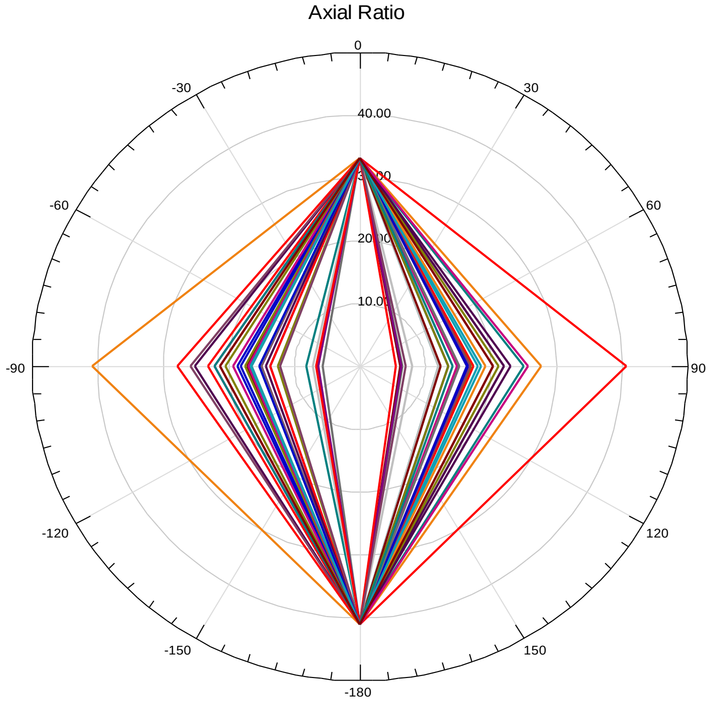

Fig. 11 Axial Ratio with ground length Lg = 11.5 mm

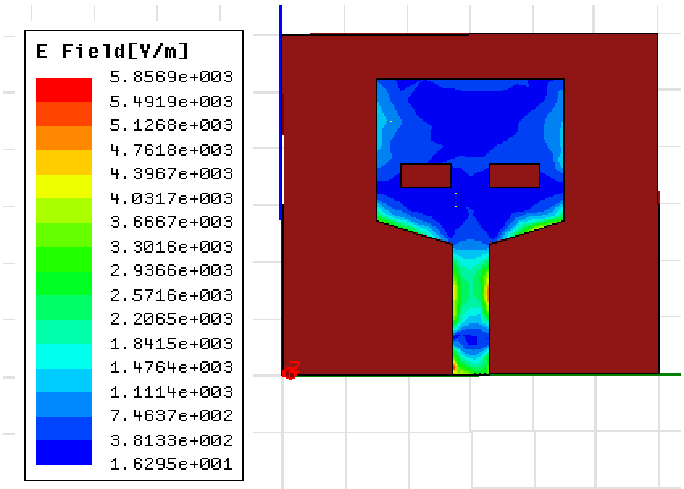

Fig. 12 E- Field with ground length Lg = 11.5 mm

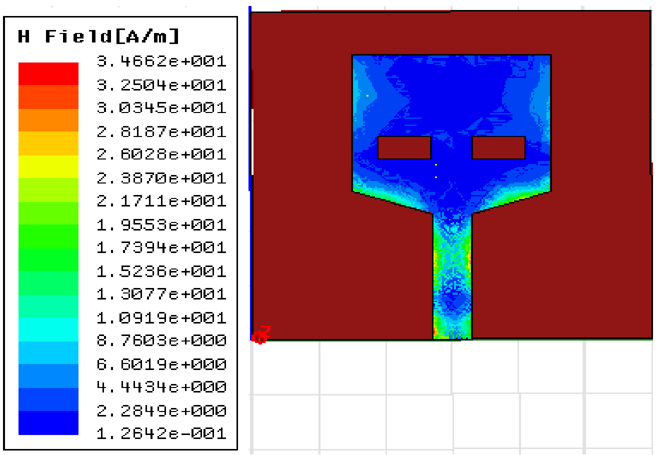

Fig. 13 H – field with ground length Lg = 11.5 mm

IV. Fabrication

The antenna structure is fabricated on a printed circuit board (PCB) using Photolithography technique. The top view and bottom view of fabricated antenna is shown in Fig. 14.

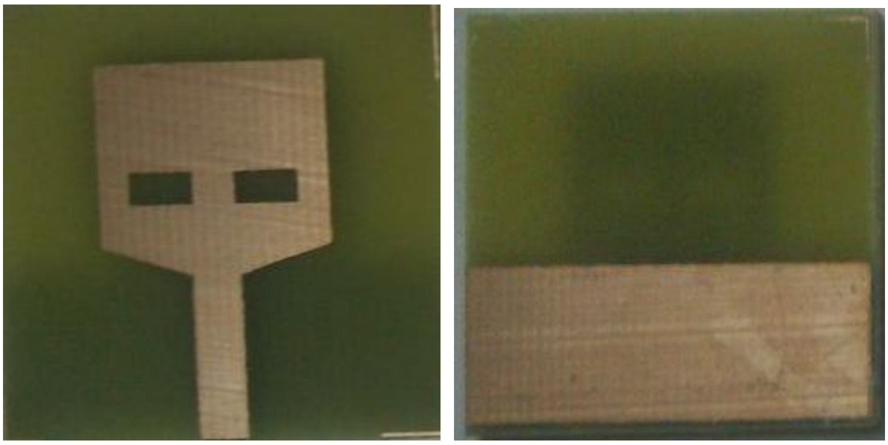

Fig. 14 Top and Bottom view of patch antenna

V. Conclusion

The fabricated antenna has advantages of small size, easy fabrication and simple construction. Antenna is circularly polarized and operates at 3.04GHz -10.96 GHz with Absolute Bandwidth 7.72 GHz. Radiation performance of patch antenna is also presented in this paper. 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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