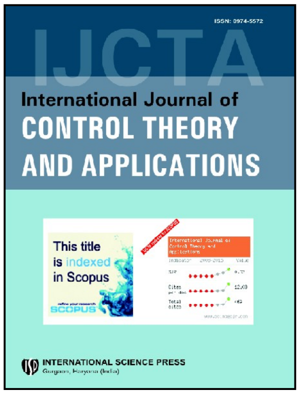

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Compact Circular Slot Wideband Monopole Antenna

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Abstract: In this work, a novel compact co-planner waveguide fed circular slot monopole antenna is designed for wide band communication systems. The proposed antenna model occupying a dimension of 20×24×1.6mm on FRA substrate material with permittivity 4.4. The designed antenna model is providing a huge bandwidth of morethan 13GHz with impedance band width of 70%. The proposed antenna is providing a peak realized gain of 3.2 dB in the operating band with peak directivity of 3.6 dB. Antenna is providing almost omnidirectional radiation pattern in H-plane and monopole like radiation in the E-plane.

Keywords: Circular slot, Compact, Impedance bandwidth, Monopole, Wideband.

1. INTRODUCTION

Nowadays tremendous attention has been focused on ultra wide band communication system because of their applicability in different fields. These systems are suitable candidate for exchanging high rate information. To get such high performance communication systems in many fields UWB antennas need to be integrated. One of the major challenges in the design of UWB antennas is the design of small size antenna while providing wide band width, Omni directional radiation pattern and stable gain. In spite of their light weight, low-cost, ease of integration, and conformal structure, printed antennas suffer from the low bandwidth. To broaden the bandwidth of printed antennas, much effort has been made such as surface meandering, aperture coupled patches, or near frequencies resonators.

An efficient technique to increase significantly the antenna bandwidth is the use of modified shape of monopole antennas. The best suited structures can be implemented with both coplanar waveguide and microstrip technologies. Some of the techniques and models proposed by the researchers to achieve high bandwidth and stable gain are available from literature. B. Yuan [1], *et al.* proposed a novel triple-band rectangular ring antenna with two L-shaped strips. The antenna occupies an area of 21×33×1.6mm^3. The designed antenna only covers the 2.4/5.2/5.8GHz WLAN bands and 3.5/5.5GHz WiMAX bands. In [2], the proposed antenna arc shaped monopole strips and a rectangular ground plane. The antenna peak gain of 4.68 dBi for the lowest band, 2.74 dBi for the middle band, and 3.11 dBi for the highest band. B.S. Yildirim [3] proposed low-proûle and planar antenna suitable for WLAN/Bluetooth and UWB applications. The 10-dB return loss bandwidth of the antenna at high-band spans from about 4.5 GHz-11 GHz. L. Xiong [4], et al proposed a novel compact triple frequency planar monopole antenna. The designed antenna has a size of 17"30mm^2. The antenna has the impedance bandwidth of 540 MHz (3.26-3.8 GHz), and 1970 MHz (5.03-7 GHz). J.J Xie [5], et al proposed a rhombic slot antenna with a truncated corner. It can cover both the WLAN bands (5.15–5.35 GHz and 5.725–5.825 GHz) and the WiMAX bands (3.4–3.6 GHz and 5.25–5.85 GHz). In [6], the proposed antenna consists of a rectangular radiating element fed asymmetrically by a 50 Omega microstrip line and a shaped trapezoidal ground plane. The antenna operates in dipole configuration outlining overall dimensions of 38 times 30 times 0.8 mm^3. In [7], the proposed antenna consists of an L-shaped monopole radiator and a protruding meander-micro strip ground stub (M-stub) on the other side. The antenna covers the2.44-5.4 GHz WLAN band. The antenna occupies an area of 25 × 25mm^2. X.L. Design of antennas for wideband communication systems are very essential, but gain parameter should be taken care. Maintaining stable gain without degradation in the bandwidth is challenging for the researchers [8-11]. Sun [12], et al proposed antenna consists of an L-shaped and E -shaped radiating elements to generate two resonant modes for dual-band operation. The antenna can only cover the 2.44-5.5 GHz WLAN band. In [13], the proposed novel has three dual band planar monopole antennas. The proposed antennas cover the frequency bands of the IEEE 802.11a/b/g (2.4–2.48GHz, 5.15– 5.35GHz and 5.725–5.825GHz). In [14], the proposed antenna operates over the frequency ranges 950MHz (2.28–3.23GHz), 660MHz (3.28–3.94GHz), and 1120MHz (5.05–6.17GHz) suitable for WLAN and WiMAX applications. X. Ren [15], et al proposed a novel compact tri-band monopole antenna. The antenna size is 38 × 20 × 1 mm^3. The antenna can only cover the WLAN 2.4/5.8 GHz and WiMAX 3.5 GHz applications. In [16], the proposed antenna is open- ended slot constructed of crossed double T-shaped slots is aimed to obtain resonant modes at 2.4/3.5GHz. The upper resonant frequency point at 5.8GHz is achieved. In [17], the proposed miniaturized multi-band antenna can generate three separate impedance bandwidths to cover the 2.4/5.2/5.8-GHz WLAN operating bands and the 2.5/3.5/5.5-GHz WiMAX bands. By using novel structures and techniques [18] the optimized models should be designed to fulfill the current day communication applications.

2. ANTENNA GEOMETRY

Figure 1 shows the proposed antenna structure in CST microwave studio. The basic construction of the antenna is carried out by placing a rectangular patch on FR4 substrate material with stepped stair case at the bottom side of the radiating element. Additional strips are added to improve the impedance bandwidth of theantenna i.e., to attain wide band characteristics. Closed circular ring cut has been employed in the radiating element to improve the reflection coefficient characteristics. The radiating element and the ground plane are printed on the same side

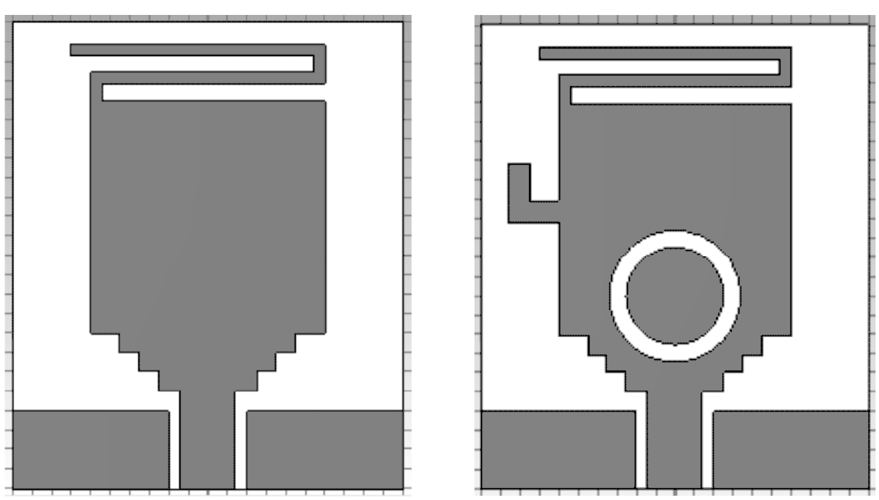

Figure 1: Antenna models, (a) Basic CPW Fed Antenna, (b) Proposed circular Slot Monopole

of the substrate and a coplanar waveguide feeding is used to excite the patch element. A 50&! SMA connector is connected at the feed port to measure antenna characteristics.

The dimensions of the antenna are as follows. The length and width of the substrate is 20 and 24 mm respectively. The height of the substrate is 1.6 mm. the feed line length is 4 mm and stepped stair case length is 4.1 mm. the radiating element length is 11.9 mm and the meandered strip on the top side is around 2 mm. the width of the radiating element is 4 mm and the circular slot inner radius is 2.4 mm and outer radius is 3.2 mm respectively. Length of additional strip on the left side of the patch element is 3 mm and the width is 2 mm. the distance between stepped stair to additional strip on the patch is around 5.7 mm. the length of the ground plane is 4 mm and the width is 8 mm, the gap between feed line and the ground plane is 0.9 mm.

3. RESULTS AND DISCUSSION

A co-planner waveguide fed circular slot monopole antenna is designed in CST microwave studio and the modified structure is reconstructed in HFSS tool for validation. By constructing basic monopole antenna without L-shaped strips, we observed dual band characteristics with low bandwidth at higher resonant frequency. A modified structure by placing L-shaped strip resulting improvement in the bandwidth at higher resonant frequency.

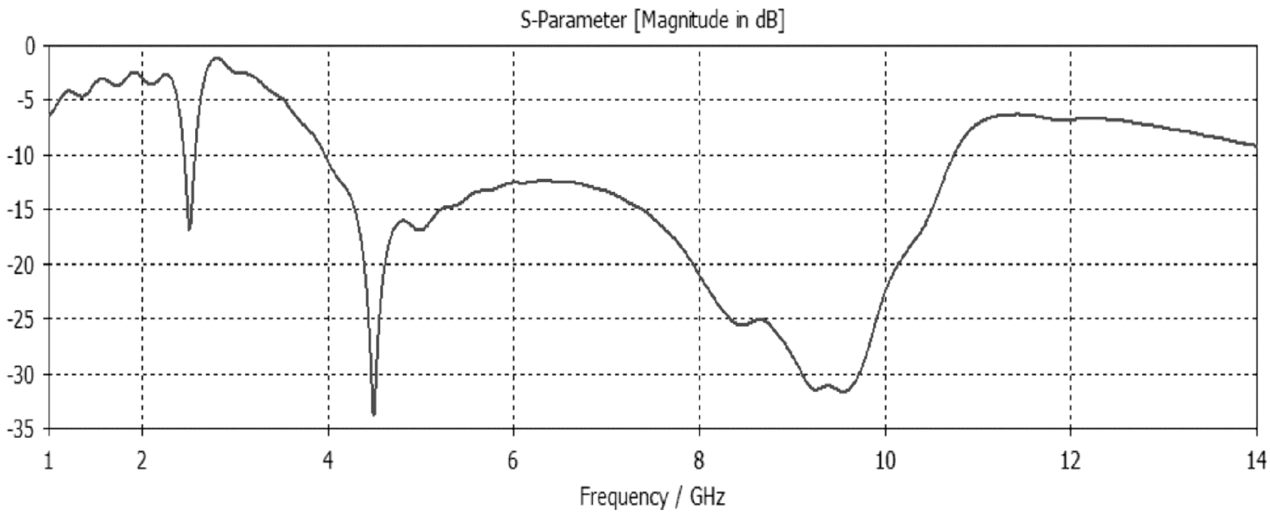

Figure 2: Returnloss Vs Frequency of Basic Antenna model in CST

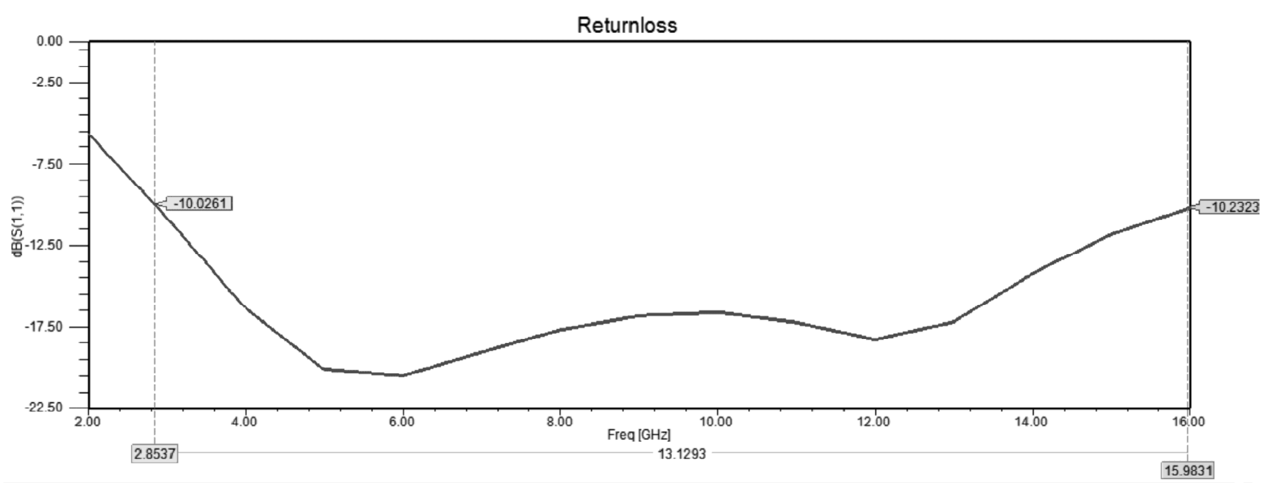

Figure 3: Returnloss Vs Frequency of Proposed Antenna model in HFSS

The proposed antenna model is reconstructed in finite element method based HFSS tool. The results obtained from HFSS for the current design shows superior characteristics compared with CST microwave studio. The evidence for this discussion can be observed from Fig 2. The bandwidth for basic antenna model at lower resonant frequency is about 0.1GHz and at higher resonant frequency it is above 4.5GHz. The reconstructed model with strips in HFSS tool is providing a bandwidth of 13 GHz which covers most of the communication applications like Bluetooth, WI-Fi and WLAN etc from Fig 3. The VSWR characteristics of the proposed antenna in both the software tools are presented in Fig 4 and 5.

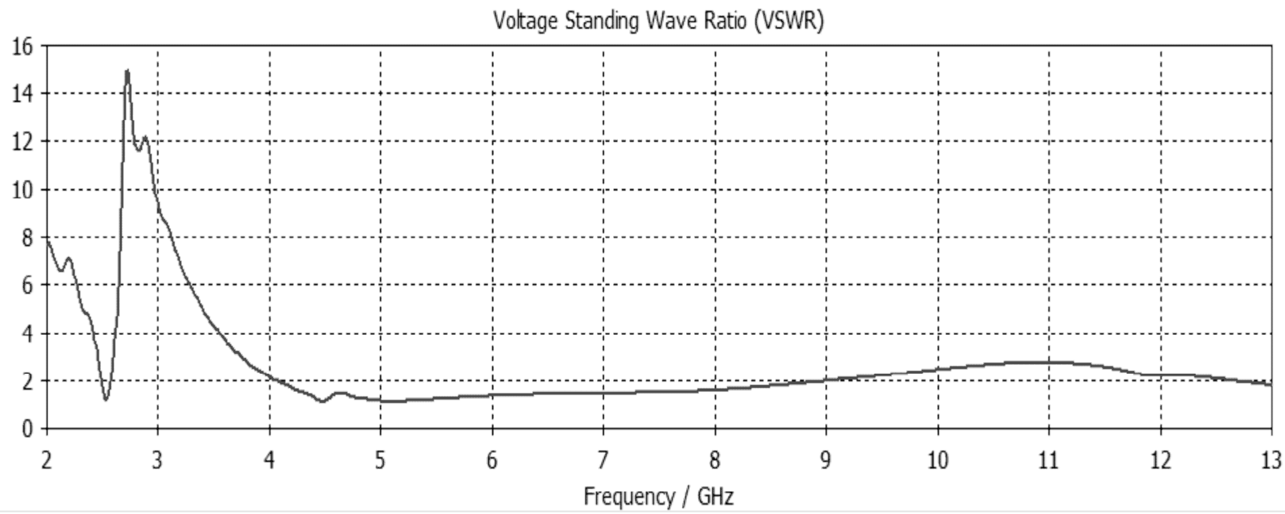

Figure 4: VSWR Vs Frequency of Basic Antenna model in CST

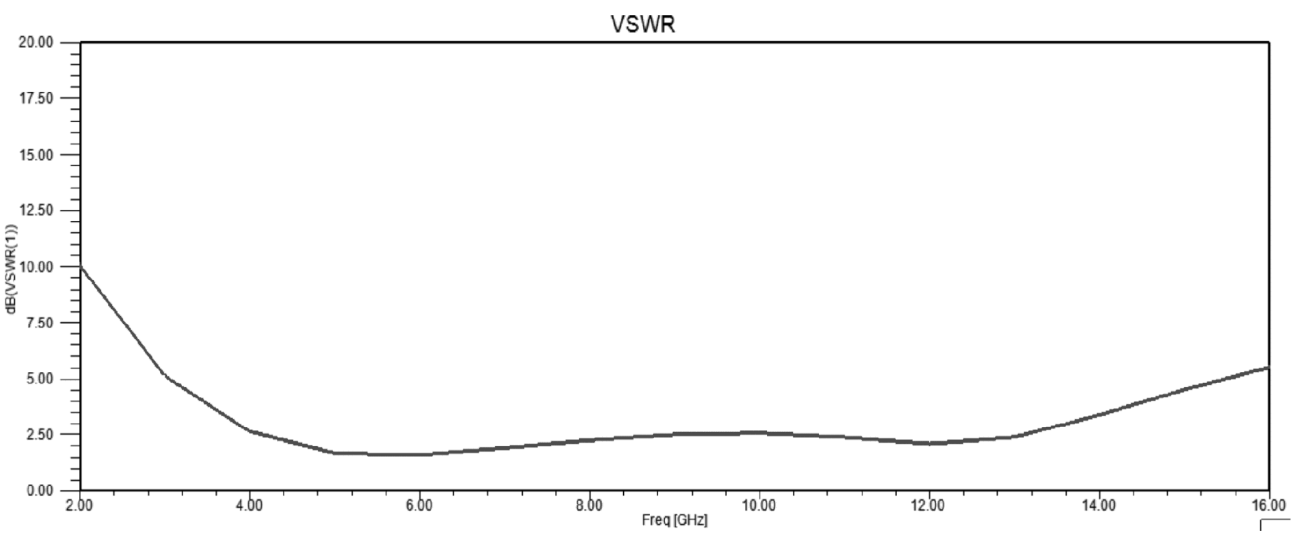

Figure 5: VSWR Vs Frequency of proposed Antenna model in HFSS

Fig 6 shows the radiation pattern of the antenna models at resonating frequencies, where significant consistency is achieved. The basic antenna displays good omnidirectional radiation pattern at 2.5 GHz. Within the operating frequency band, nearly symmetric and equal radiation patterns in the E- and H-planes are achieved from Fig 7. In addition, the measured cross-polarization levels in E- and H-planes are generally low across the whole frequency bandwidth.

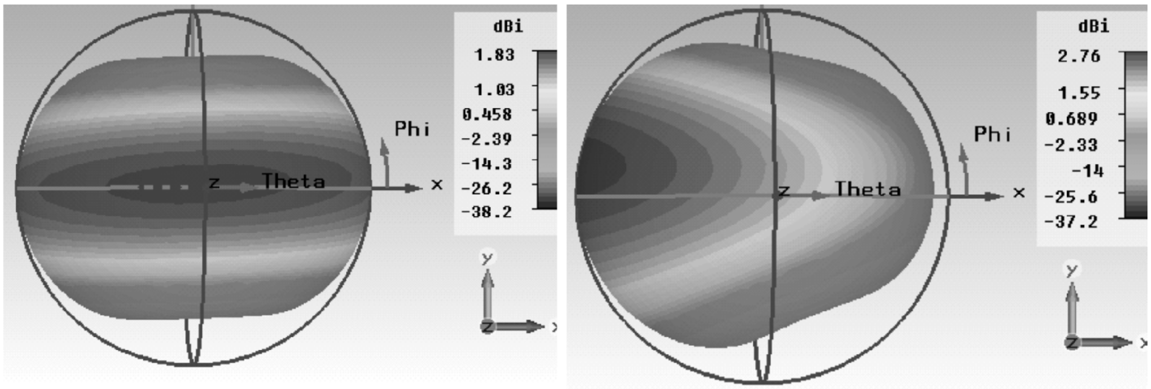

Figure 6: 3D-Radiation Pattern of Basic antenna model at (a) 2.5 GHz, (b) 4.5 GHz

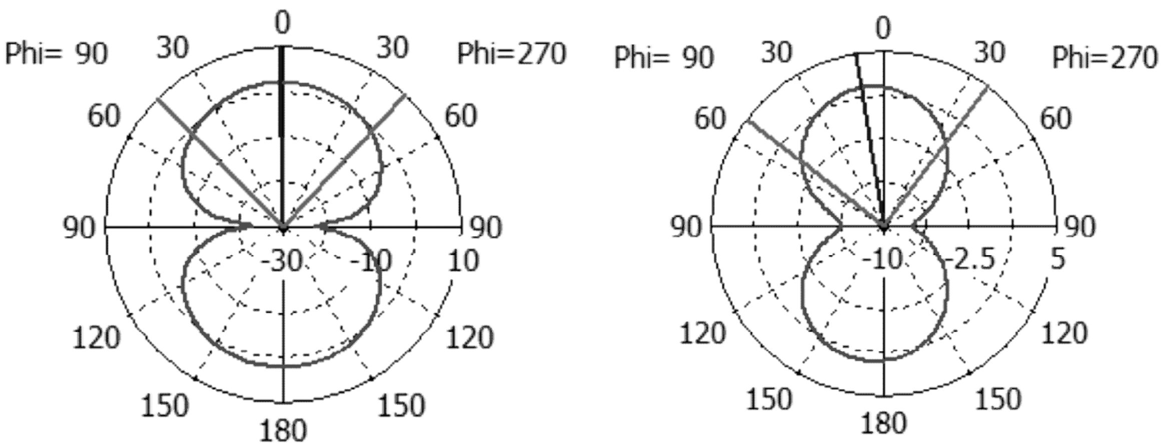

Figure 7: Radiation Pattern of Basic antenna model in polar coordinates at (a) 2.5 GHz, (b) 4.5 GHz

The radiation field strength in different directions can be observed from this appearance in Fig 8 for proposed antenna model in HFSS. Asymmetry in the structure induces an asymmetric field distribution in the ground plane as shown in Fig 8. Feed line and lower half of the patch surface is showing more field intensity compared with ground plane. Omni directional pattern in H-plane and quasi omni in E-plane can be observed from the radiation pattern plots of proposed antenna.

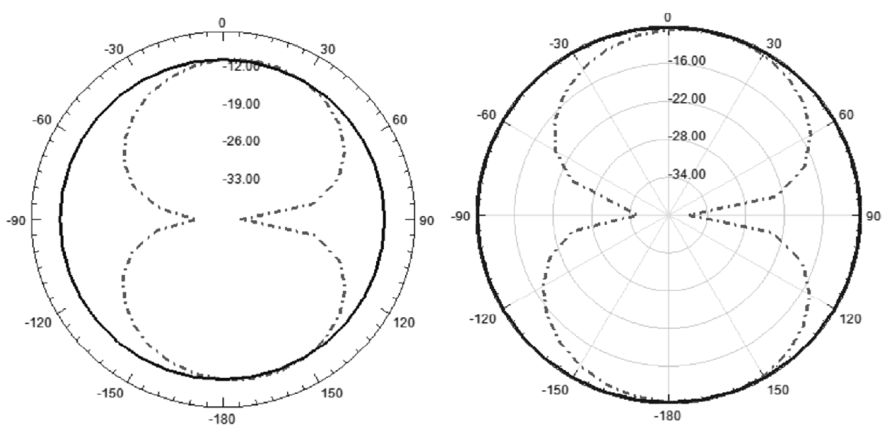

Figure 8: Radiation Pattern of proposed antenna at 2.5 GHz, (a) E-Plane, (b) H-Plane

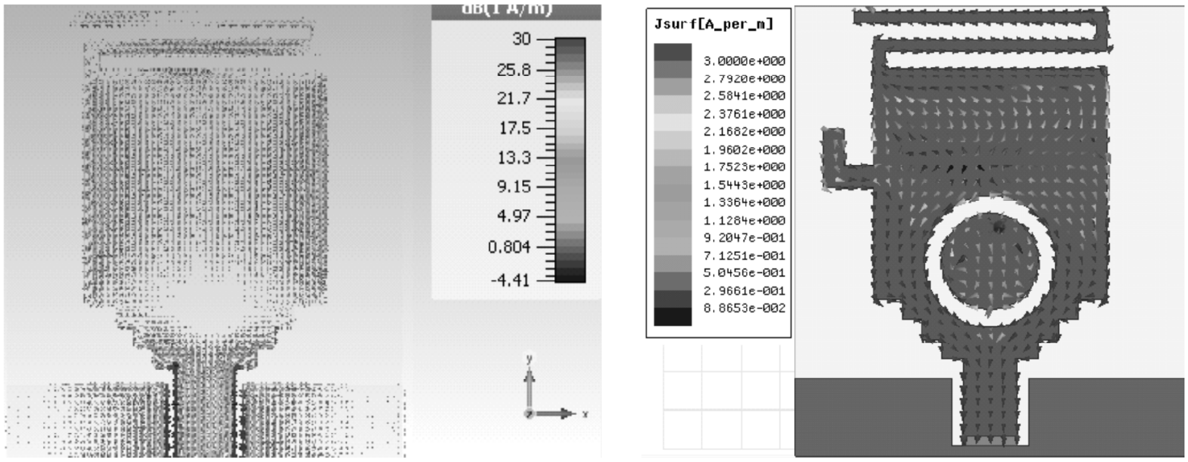

Figure 9: Current distribution of Basic antenna model and proposed antenna at 2.5 GHz

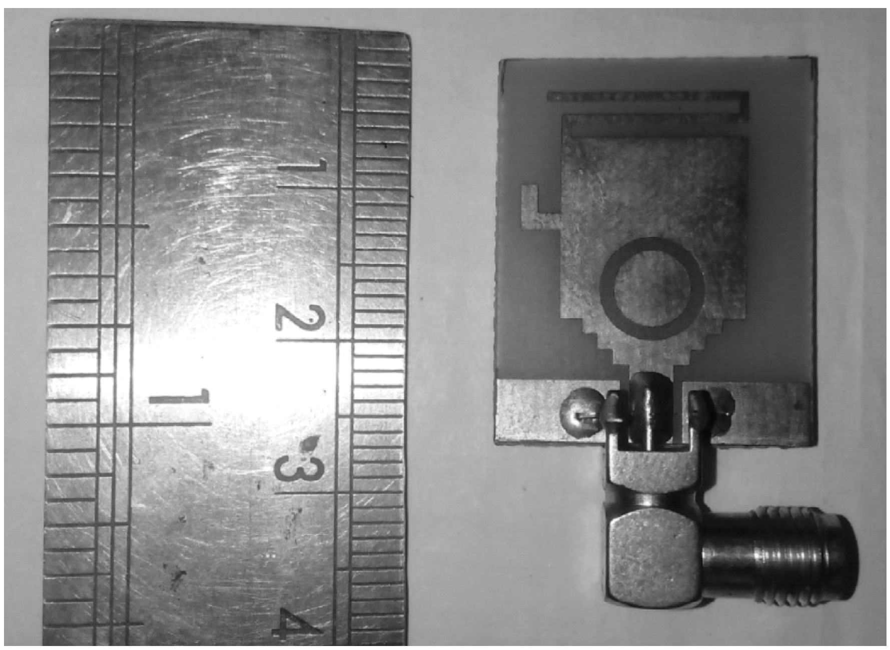

Figure 10: Prototyped Antenna

A gain of 2.76 dB is attained from basic antenna model and the proposed antenna model is giving gain more than 3.2 dB in the wideband. The current distribution characteristics of the antenna models are shown in Fig 9. Basic antenna model is showing current density more nearer to feed line edges and ground plane. The proposed antenna model is showing most of its current density on radiating element rather than ground plane. Fabricated antenna model is shown in Fig 10. The prototyped antenna is showing similar kind of results with simulation results.

CONCLUSION

A novel compact circular monopole antenna is designed in this work. The proposed model is constructed from base model of coplanar wave guide fed stepped monopole antenna. Basic model from CST microwave studio is providing dual band characteristics with low bandwidth, whereas the proposed circular monopole antenna is providing huge bandwidth of more than 13 GHz. The proposed antenna is providing a peak realized gain of 3.2 dB in the operating band with peak directivity of 3.6 dB. Antenna is providing almost omnidirectional radiation pattern in H-plane and monopole like radiation in the E-plane.

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