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Circular Polarized Broad Band Microstrip Patch Antenna for C band

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ABSTRACT

The paper demonstrates a novel antenna design which can achieve a wide impedance bandwidth and circularly polarized bandwidth. The antenna is excited using probe feeding. Ground plane is modified using slotting technique and rectangular patch is miniaturized. Measured results show that the CP antenna features a wide operating bandwidth of 37.22% ranging from 4.70 GHz to 6.85 GHz (VSWR <2 and axial ratio <1 dBi) and acceptable return loss of -19.74 dB has been obtained. The efficiency of proposed antenna is ranging from 60% to 70% over return loss -10dB and the antenna has its application utility under C band. The antenna is designed and simulated in IE3D software.

Keyword: Wideband, Circular Polarized, Slotted ground plane, probe fed, miniaturized rectangular patch.

1. INTRODUCTION

In the near past decades, microstrip patch antenna technique has beenmatured and developed rapidly [1-6]. However, the design of a broadband circularpolarized patch antenna that uses a single feed has long been achallenging problem, as compared to the design of linear polarized (LP) and the dual-fed circularly polarized (CP) patch antennas [7, 8]. Especially, the single-fed single-patch CP antenna has axial ratio (AR) and narrow impedance bandwidths of 1%-2% [9, 10]. In order to achieve enhanced circular polarised bandwidth, several single-fed single-element patch antenna designs using an form substrateor air-layerhave also been shown [11-13], in which the reported circular polarised bandwidths are about 3.5% [11, 12] and 7.2% [13]. Besides that, the L-probe and U-slot techniques have been applied to single-layer single-feed circular polarized antennas [14-17]. These techniques make use of thick substrates, and are benefited axial-ratio bandwidths as large as 13%. Apart from these, the technique of an E-shaped patch used for a wide impedance bandwidth is modified to generate circularly polarized radiation in [18], which uses a single layer probe fedpatch antenna with a relatively wideband axial ratio (9% for 3 dB AR), without the necessarily it being square or comer-trimmed.Moreover H-shaped wideband patch antenna for circular polarization is described in [19], which adapts a printed monopole which is diagonally coupled to the H-shaped copper plate and obtains a broad operational bandwidth of 19.4%. These researches give us some effective methods to achieve wideband CP antenna. In this paper, a circular polarized N-shaped slotted microstrip patch antenna that is significantly smaller than the conventional patch antenna is presented and has realized broadband circular radiation characteristics. A single-feed circularly polarized microstrip antenna configuration has been achieved at a relatively low gain, narrow impedance bandwidth and multi narrow band circularly polarized radiation. Therefore, another design with an EBG (electromagnetic band gap) structure is proposed and included to improve these parameters.

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With EBGs, forbidden frequency bands pertain to EM waves that are scattered within the structure and destructively added. Hence, electromagnetic waves with a frequency inside the forbidden band cannot propagate through the EBG material, irrespective of their angle of incidence [11]. EBG could be used to improve the efficiency of antennas [12], due to the substrate losses andsuppression of surface waves, which are the predominant losses in microstrip antennas. In [16], by incorporating two pairs of narrow slots parallel to the edges of the upper square patch and cutting slits in the bottom square patch, triple bandcircular polarization radiation is achieved. In [17], I-slot and three stacked patches with a slit have been used to achieve three circular polarized bands. In [18], the multiple stacked patches are used to achieve the quad band circular polarization.

In [21], a single-fed single-patch broadband circularly polarized antenna is proposed for RFID (radio frequency identification) reader, which results that a thicker substrate is used to enhance the axial ratio bandwidth respectively and a probe- fed meandered strip feed technique is proposed to tune the impedance matching frequency band to overlap the 3 dB axial ratio frequency band. But the relative 3 dB AR bandwidth of 7.9% makes more roomto be broadened further. Moreover, the probe-fed meandered strip is not easy to match in practice. Based on that antenna model, the proposed design gives a novel antenna structure using a rectangular strip in place of the meandered one, which not only simplifies the antenna structure, but also can obtain a good performance with an impedance bandwidth (VSWR <2:0) of 770MHz (31.43%), a 3 dB AR bandwidth of 250MHz (10%) and a 6 dB AR bandwidth of 560MHz (22.45%).

2. ANTENNA GEOMETRY

Fig. 1 illustrates the geometry of the basic microstrip antenna. First theoretical antenna is designed for 6 GHz. Fig. 2 depicts the multi-band circularly polarized microstrip antenna. A rectangular patch with length L = 13 mm and W = 18 mm the dimensions of the ground plane are 22mm × 27mm. The patch antenna and the ground plane are etched on the opposite sides of the substrate which is made from FR4 with thickness h = 1.5mm, relative permittivity εr = 4.4 and tan(δ) = 0.02. The patch is given the stepped structure and the design is analyst using transmission line model It is short with the ground plane. Microstrip patch antennas are usually designed to operate at a feed matching condition. Edge fields are also important and they bring an equivalent additional length to the antenna. This length is proportional the relative permittivity of the dielectric substrate thickness and patch width. One of the most used formulas is given in [21] and they are used to determine the dimensions of this antenna. The ground plane is loaded with the slot. Modified inverted U shaped is given to the ground plane which lowers the frequency band and increase the bandwidth.

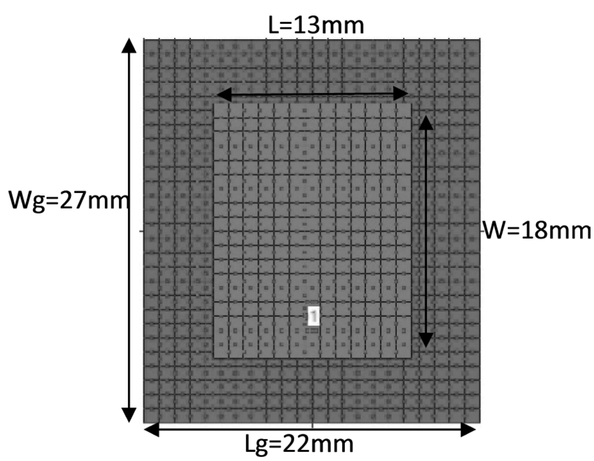
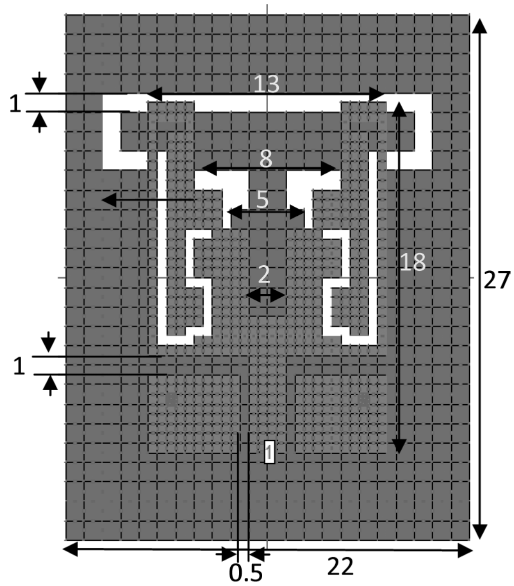


Figure 1: Theoretical Antenna



*all dimensions are in mm.

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Figure 2: Proposed Antenna

3. SIMULATION RESULTS AND DISCUSSION

The simulated results for the performance of the antennas are tabulated in Table 1. The simulation analysis of these antennas is carried out in IE3D software. The software package is based on the method of moment.Also, simulation measurements for the return loss *S*11, VSWR, axial ratio, gain, and efficiency are carried out.

3.1. Return loss

The simulated design achieved the return loss of -19.74 dB at 5 GHz. And return loss below -10dB is from 4.70 GHz to 6.85GHz.

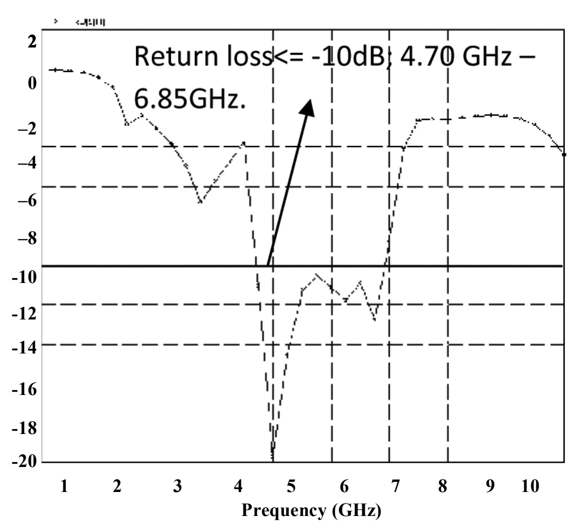

Figure 3: return loss

3.2. VSWR

The simulated design achieved the VSWR<= 2 for the frequency 4.70 GHz to 6.85 GHz. And bandwidth is 37.22%. The VSWR achieved at 5 GHz is 1.25.

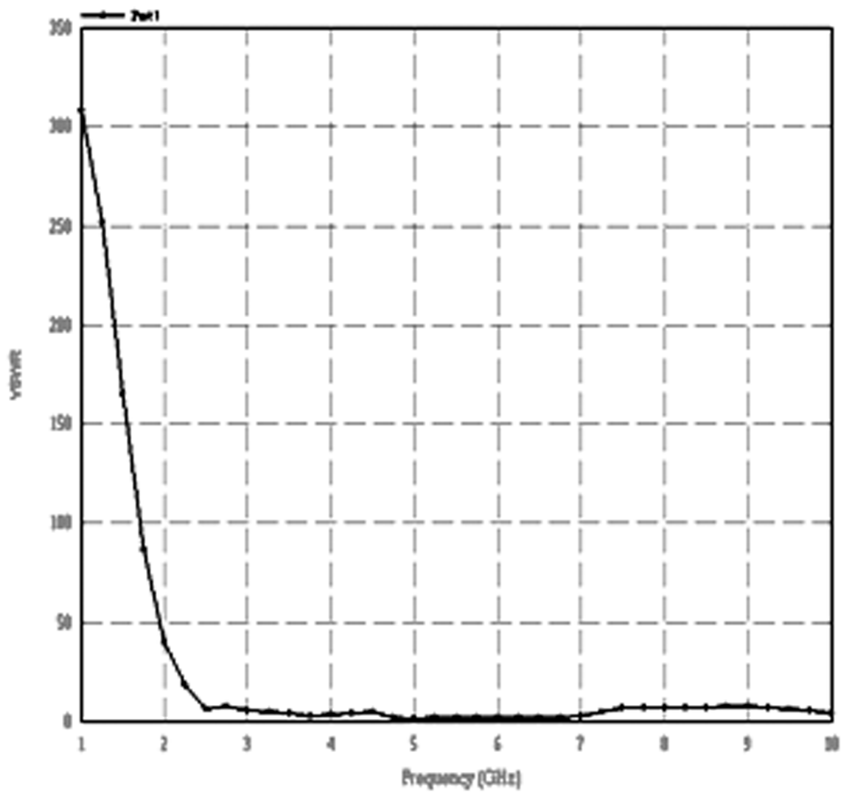

Figure 4: VSWR

3.3. Axial Ratio

The simulated result of Axial Ratio shows that the proposed design is highly circular in polarisation having axial ratio less than 1dBi for the obtained return loss bandwidth.

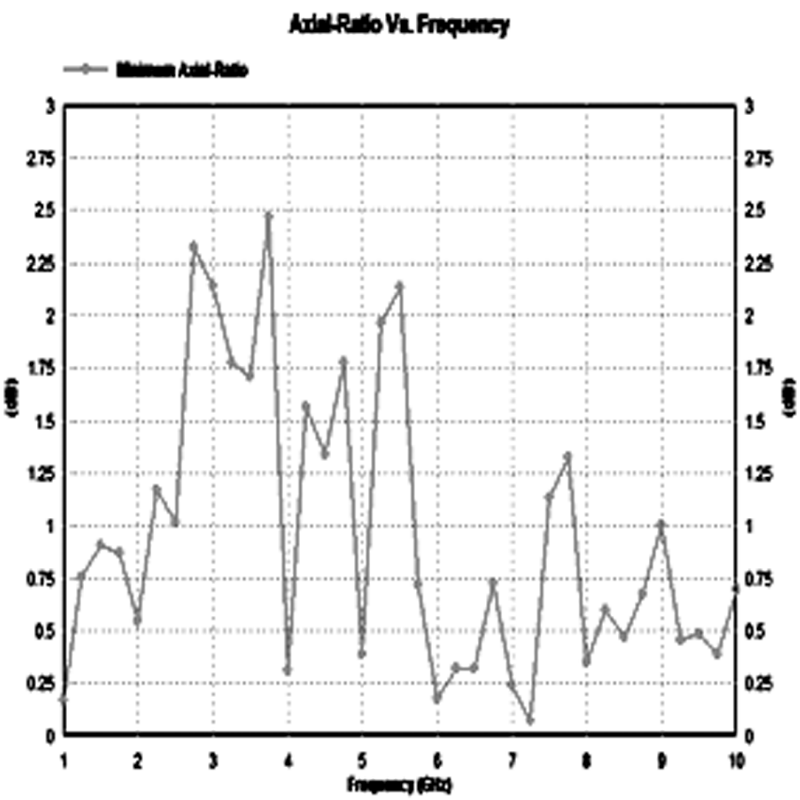

Figure 5: Axial Ratio

3.4. Gain

The gain of the proposed antenna for return loss < = -10dB bandwidth is in range of 3dBi to 4.5dBi.

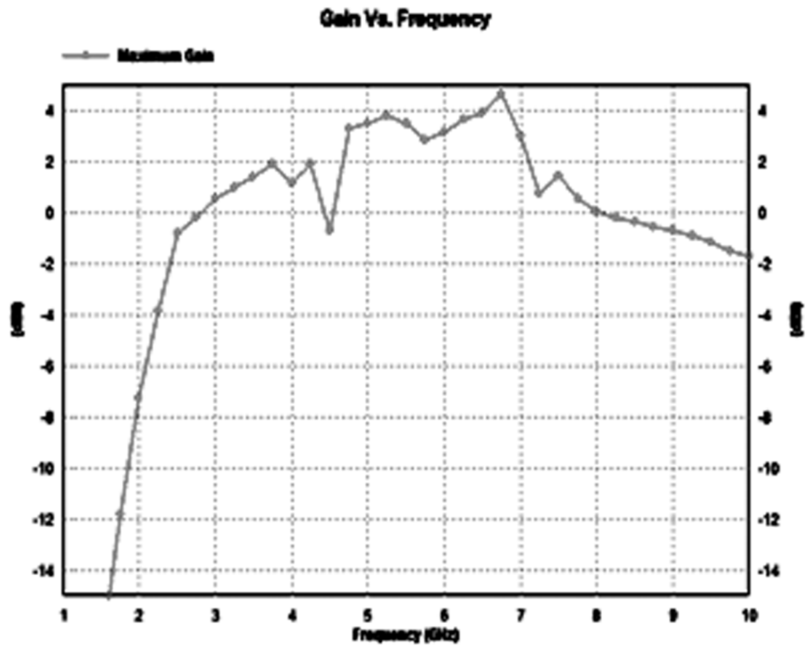

Figure 6: Gain

3.5. Directivity

Directivity of antenna varies from 5dBi to 6.5dBi, shown in figure.

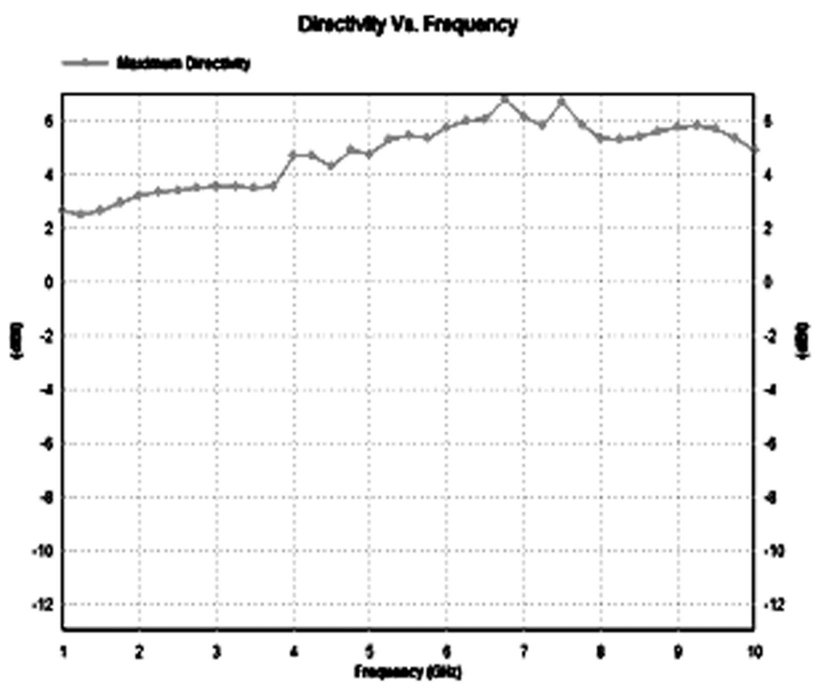

Figure 7: Directivity

3.6. Efficiency

The Radiating efficiency of the simulated antenna varies from 60% to 70% and Antenna efficiency varies from 60% to 70% which is shown in figure

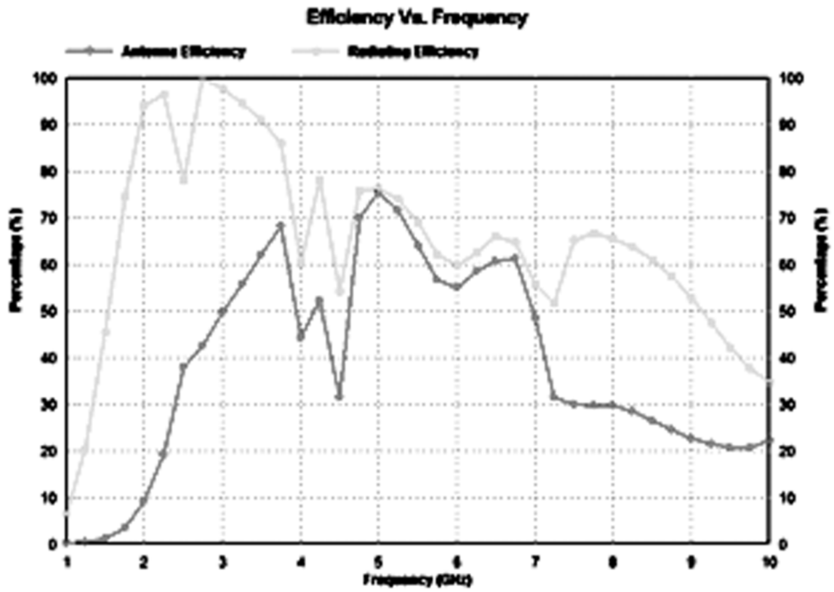

Figure 8: Efficiency

4. RESULT

Table 1
Result Summary

Return Loss	-19.74 dB at 5 GHz
VSWR<=2	4.70 GHz -6.85 GHz
Axial ratio	Less than 1dBi
Gain	3-4.5 dBi
Directivity	5–6.5 dBi
Efficiency	60%–70% (Antenna Efficiency)
Percentage Bandwidth	37.22% (VSWR)
Bandwidth	4.70–6.85 GHz (2.15 GHz)

In this paper the microstrip slot antenna with defected ground plan is proposed and the simulated results are presented which shows it is highly circular polarised for the return loss <= 10dB. The simulated results of proposed antenna suggest that it is suitable for C band application which is used for satellite TV communication. Commonly used in areas that are subjected to tropical rainfall and also this antenna can be in application where data rates are of less important.

5. CONCLUSION

A new small circular polarized patch antenna suitable for C-band application is proposed.The antenna comprises step structured slots added on the patch to provide the required broad-band aswell as reducing the overall antenna size. And defects in ground plane is introduced which increase the return loss bandwidth. Some problems rose up due to the small size such as decreasingthe impedance bandwidth and relatively low gain.

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