Dual Frequency Circularly Polarized Microstrip Antenna

Ira Joshi, Abhishek Joshi, R.P.Gupta

Abstract - *Design and analysis of a single-feed arrangement of rectangular patches is proposed, which is capable of providing dual frequency circular polarization along with broadband performance. An antenna is designed on a glass epoxy FR-4 substrate with overall thickness of the structure less than 8 mm or 0.11λ_0. Axial ratio bandwidth better than 1.04 % and impedance bandwidth better than 10.89% may be achieved with the proposed geometry. Measured gain and axial ratio variations of the proposed antenna with frequency are compared to simulated results for better understanding. The measured E- and H-plane radiation patterns in the entire impedance bandwidth are identical in shape, and the direction of maximum radiations is normal to the patch geometry. In the entire axial ratio bandwidth range of the proposed antenna, the E-plane left circularly polarized patterns are nearly 15 dB.*

IndexTerms – *Axial ratio bandwidth, broadband, circularly polarized, radiation patterns, rectangular microstrip antenna.*

I. INTRODUCTION

The Compact circularly polarized broadband microstrip antennas are becoming useful structures for modern communication systems including mobile, wireless, and global positioning systems [1], [2]. Microstrip antennas are small in size, easily mountable on the host surface, and can be integrated with other planer components. Three main limitations associated with the conventional microstrip structures are their capability to resonate at a single frequency, narrow impedance bandwidth, and low gain.

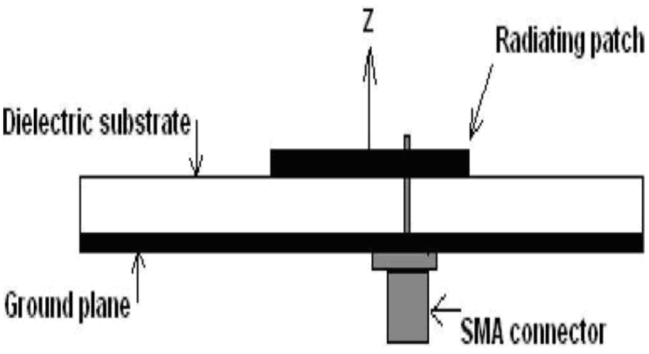

Fig.1. Side view of rectangular patch antenna

However with the demand of compact-size antennas for modern communication systems, several alterations in these antennas were proposed [3]-[5]. The bandwidth of conventional microstrip antennas may be improved considerably by applying suitable narrow stub [6], [7] at an appropriate location on the patch [9]. Circular polarization in conventional patches may be achieved by suitable selection of the feed location [10]. With conventional patches, it is extremely difficult to achieve large impedance bandwidth and large axial ratio bandwidth simultaneously. In this paper, the design and performance of a compact single-feed arrangement of an antenna for circularly polarized broadband performance is reported. The proposed antenna provides improved impedance and axial ratio bandwidths and also presents improved gain.

II. ANTENNA DESIGN AND RESULTS

Single-Layer Rectangular Microstrip Antenna with a Stub

First, we have considered a single-layer rectangular patch antenna with a narrow slot as shown in Fig. 2. This antenna is designed on a glass epoxy FR-4 substrate (ε_r -4.4, tanδ - 0.025, substrate thickness *h* - 1.58 mm). The simulation analysis of this antenna is carried out by applying IE3D simulation software [11]. The antenna is fed through a single inset feed arrangement by using an SMA connector. The patch has patch dimensions *L* - 30 mm and *W*- 40 mm.. With optimization in slot dimensions, it is realized that the best performance with such an antenna may be achieved by connecting stub.

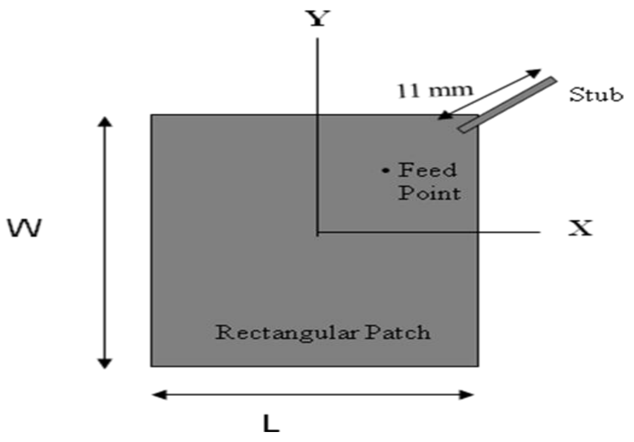

Fig.2. Proposed design of rectangular patch antenna

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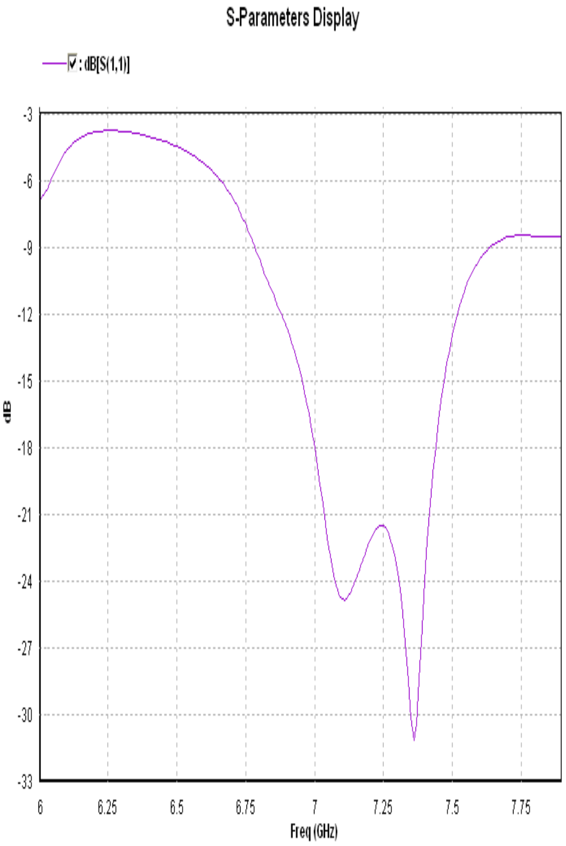

Fig.3. S-Parameter of single layer rectangular patch with a stub

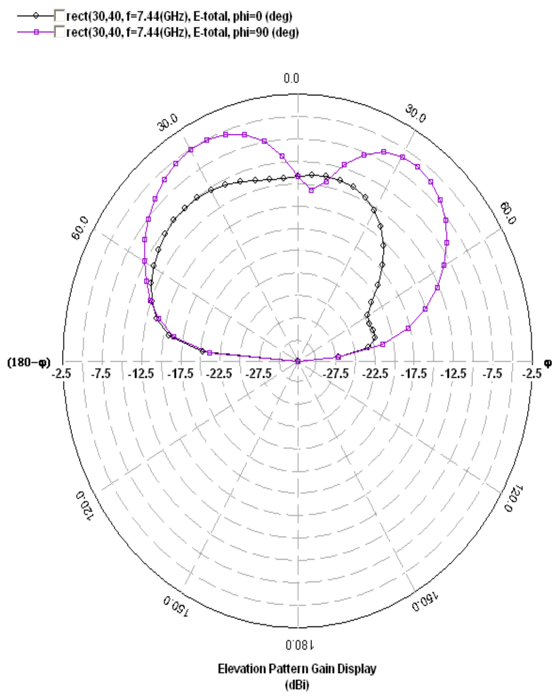

Fig. 4.Elevation pattern curve at frequency 7.44 GHz for single layer rectangular patch with a stub

Fig 3. show the s parameter of the proposed design. This curve shows that the antenna resonate at two frequency.Fig 4 & 5 shows the Elevation pattern curve of dual frequency circularly polarized microstrip antenna at frequency 7.44 and 7.1 GHz respectivaly.Fig 6 shows the smith chart of the proposed design. Smith chart curve shows that the antenna is circularly polarized.

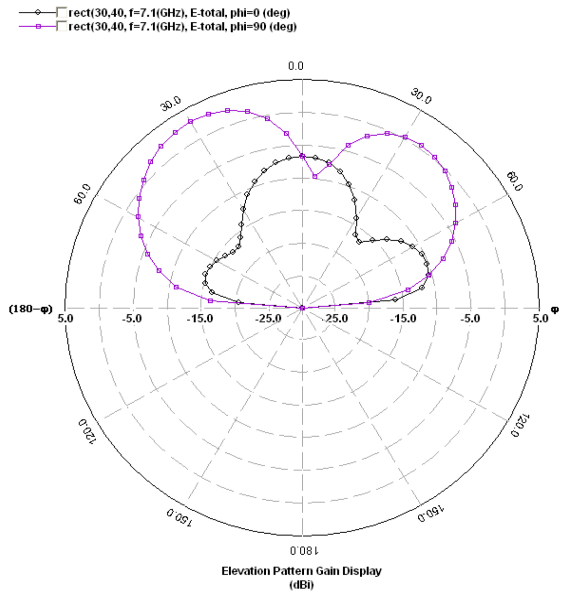

Fig.5. Elevation pattern curve at frequency 7.1GHz for single layer rectangular patch with a stub

The measured variation of the reflection coefficient (S_{11}) with frequency, as shown in Fig.3, indicates that the antenna resonates at two frequencies, 7.35 and 7.1 GHz, corresponding to two different modes of excitation. The measured input impedances presented by the antenna at these frequencies are close to 50 *iX*, but the simulated gains at these frequencies are very low. The third frequency (7.27 GHz) may be considered as non-radiation resonance frequency because the maximum realized gain at this frequency, in comparison to the other resonance frequencies, is very low. The impedance bandwidths of this antenna (for S_{11} < -10 dB) at both resonance frequencies (7.1 and 7.35 GHz) are narrow.

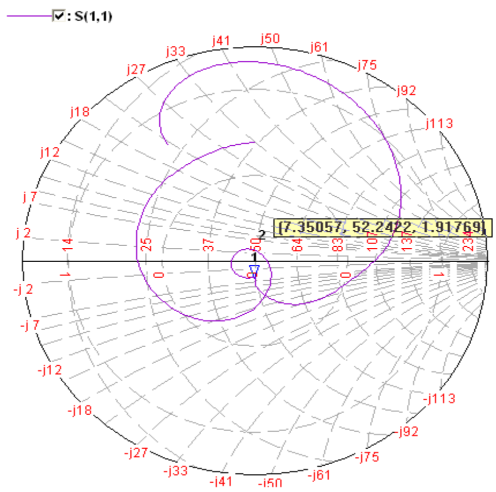

Fig. 6. Polarization of single layer rectangular patch with a stub

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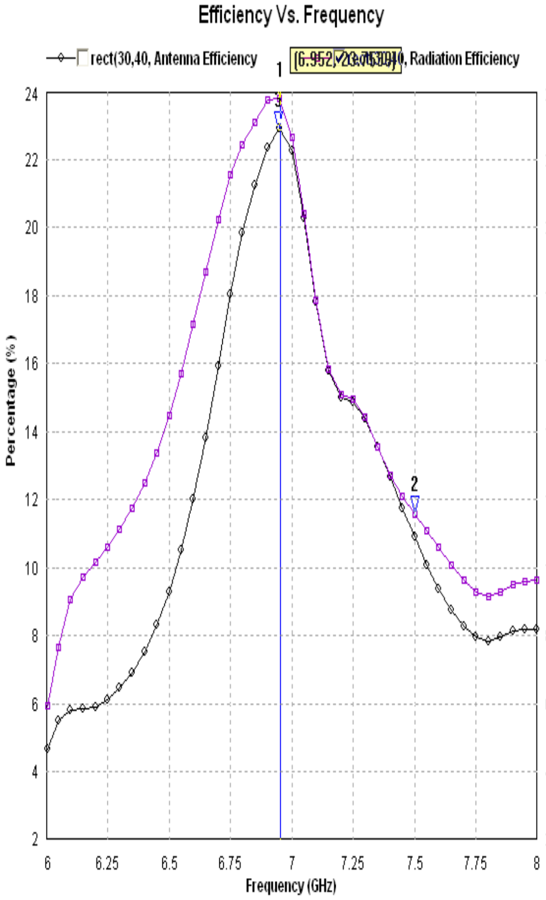

Fig.7. Efficiency vs. Frequency curve for single layer rectangular patch with a stub.

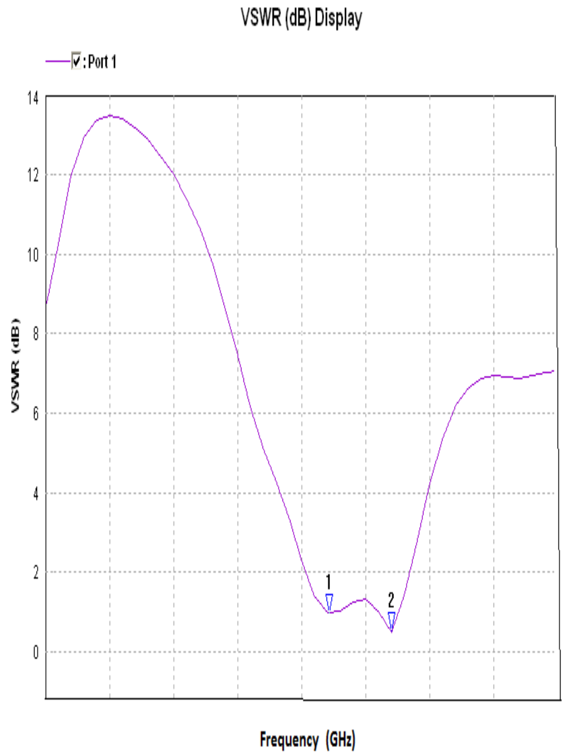

Fig. 8. VSWR for single layer rectangular patch with a stub

The efficiency of proposed design is about 24% shown in Fig. 7.

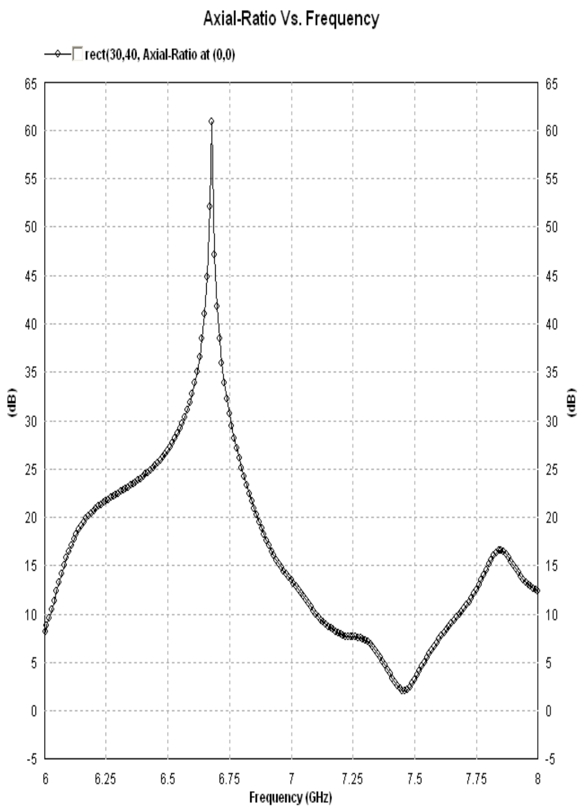

Fig. 9. Axial Ratio for single layer rectangular patch with a stub

The circular polarization behavior of the antenna is realized during the design of the antenna with simulation software. By varying the feed location on the patch, variation in axial ratio with frequency is obtained. The feed point is adjusted until the axial ratio attains a minimum value close to 1 dB. The simulated and measured variations of the axial ratio as a function of frequency are shown in Fig 9, which indicates that the measured axial ratio attains a minimum value at resonance frequency 7.44 GHz. The axial ratio below 3-dB range are 7.25~ 7.47 GHz (~80 MHZ) the entire axial bandwidth.

III. CONCLUSION

This paper presents the design and performance of single-feed rectangular patches on a glass epoxy FR-4 substrate. The dual frequency circularly polarized antenna presents improved impedance and axial ratio bandwidths and larger gain than a single-layer linear polarized antenna. These improved parameters are achieved without much increase in the thickness of the structure. In several modern-day satellite communication systems, circularly polarized radiations with higher axial ratio bandwidth are desired, and this antenna may prove to be a useful structure for these systems.

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