Z-U-T-S SHAPED STRUCTURES IN AN INTEGRATED CPW FED PRINTED MONOPOLE ANTENNA

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Abstract— A dual band co-planar waveguide fed Z-U-T-S shaped monopole antenna is proposed. The antenna is fabricated on an h = 1.6mm FR4 epoxy substrate with dielectric constant ε_r = 4.3 and loss tangent tan δ = 0.008. The size of the radiating element is 15.9 X 11.4 mm^2. The antenna operation presents attractive characteristics; each monopole is independently optimized to the resonant frequency and the impedance bandwidth without affecting those of other bands.

Key words-:monopole antenna; bandwidth; radiation pattern; return loss

I. INTRODUCTION

In recent years, many dual-band antennas have been developed to meet the increasing demand for a modern wireless communication device which is capable of integrating more than one communication standard into a single system. Various types of antenna designs for this have been reported [1]-[7].

In this paper, a novel antenna design with Z-U-T-S shaped structures is presented which not only has good dual band operation performance, but also a simple structure and compact size. By adjusting the length of the different shaped structures the resonant frequency can be tuned and a good impedance match can be obtained. The asymmetric ground plane is used to enhance the bandwidth. The detailed design and experimental results for the proposed antenna are demonstrated.

II. ANTENNA DESIGN

The geometry of the proposed antenna is illustrated in Figure 1. The antenna is fabricated on an h = 1.6mm FR4 epoxy substrate with dielectric constant ε_r = 4.3 and loss tangent tan δ = 0.008. The size of the radiating element is 15.9 X 11.4 mm^2. The fabricated proposed antenna with Co-planar Waveguide (CPW) feed is shown in Figure 2. The 'U' shaped branch of length 16.5mm and 'Z' shaped branch of length 6.8mm combined together to form a monopole antenna of length 23.3mm which is close to $\lambda_0/4$ at a frequency 4.6 GHz. The stepped 'T' shaped branch having a length 20.7 mm, close to $\lambda_0/4$ length at a frequency 4.8 GHz is combined withmonopole antenna. The antenna has two resonant paths, one resonant path is in the monopole antenna and another one is in the stepped 'T' shaped branch, thereby supports two resonances at 4.8 and 4.6 GHz which are close to each other and hence these two frequencies can be combined results in wide bandwidth.

To further enhance the bandwidth in the upper frequency region, three more $\lambda_0/4$ branches namely, extended 's' shaped, horizontal asymmetrical 'u' shaped and vertical asymmetrical 'u' shaped branches, shown by L_4, L_5 and L_6 in Figure 3 supports three resonances close to 6.1, 6.3 and 6.5 GHz. The total length (L_4+L_5+L_6) of the resonant path for these branches is around 30.8mm which is close to 3 $\lambda_0/4$ at a frequency 6.2 GHz.

To increase the resonant path, stepped 'T' shaped branch, extended 's' shaped branch, horizontal asymmetrical 'u' shaped branch and vertical asymmetrical 'u' shaped branches are used. Due to increase in the current path length,the sonance frequency is decreased and hence the bandwidth is increased. Asymmetrical structures provide wide bandwidth.

widths for the strips are chosen to be 0.5 mm. Also note that, very different from a conventional one, the CPW structure of the proposed design has two asymmetrical finite ground planes, one 'L' shaped ground with vertical dimensions of 0.8 x 12 mm^2 and a horizontal section with dimensions of 7.2 mm x 12.2 mm and another 'L' shaped ground including a vertical section with dimensions of 0.8 mm x 9.4 mm and a horizontal section with dimensions of 4.2 mm x 3.9 mm. This ground plane provides best impedance matching and enhance the bandwidth. In this geometry, IE3D software is used to design the antenna

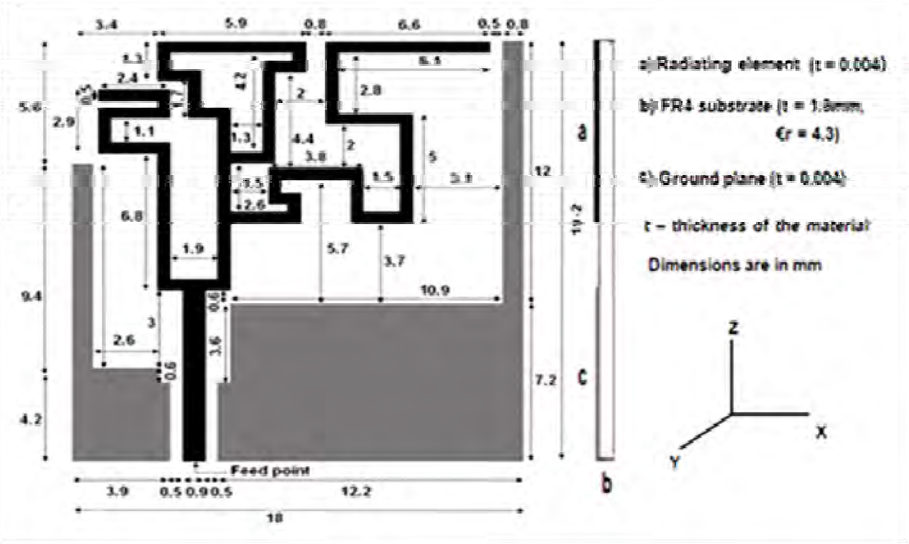

Figure 1. Geometry of the Z-U-T-S shaped antenna front and side view

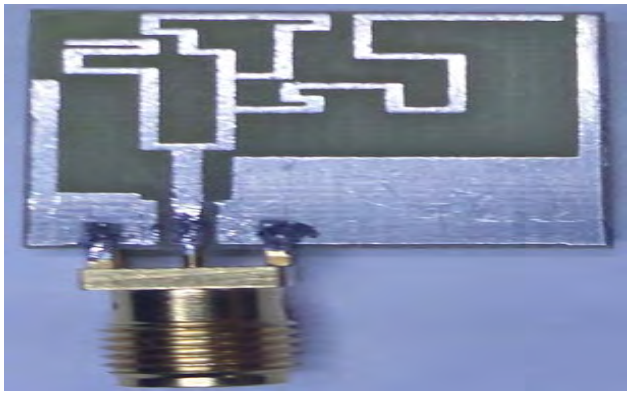

Figure 2. Fabricated Z-U-T-S shaped antenna

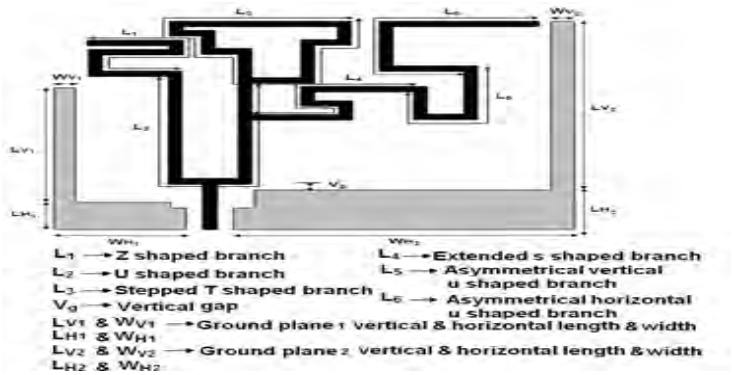

Figure 3. Parameters of Z-U-T-S shaped antenna

III. RETURN LOSS

The simulated and measured results for -10 dB return loss are plotted in Figure 4. The measured -10 dB return loss bandwidth is from 4.5 to 5.2GHz (14.43%) with respect to the centre frequency at 4.8 GHz and 6 to 6.7 GHz (11.02%) with respect to the centre frequency at 6.5 GHz. The measurement of return loss and VSWR are carried out with HP 8757D Scalar Network Analyzer. A relative good agreement in between measurement and simulation can be observed. Figure 5 shows the photograph of the Return loss measurement set up.

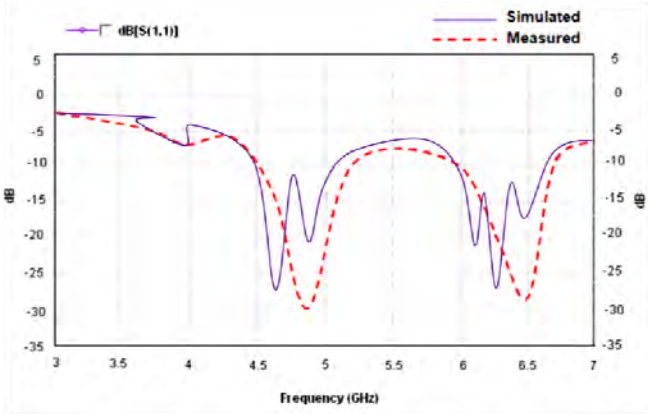

Figure 4. Return loss characteristics of a Z-U-T-S shaped antenna

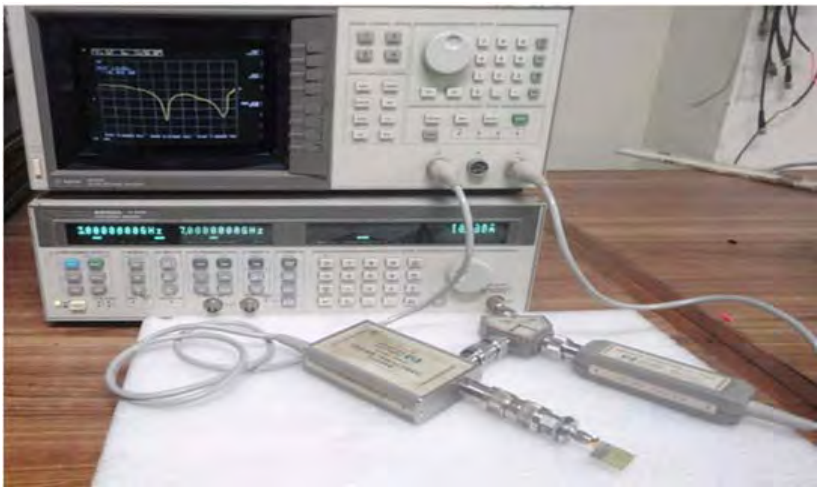

Figure 5. Return loss measurement using HP 8757D Scalar Network Analyzer for a Z-U-T-S shaped antenna.

IV. CURRENT DISTRIBUTION

The simulated surface current distribution at two different frequencies 4.6 GHz and 6.3 GHz are shown in Figure 6(a) & 6 (b). At 4.6GHz, the current in the 'Z' and 'U' shaped branch, the current is maximum at the end of 'U' shaped branch and minimum at the starting point of Z shaped branch. This shows monopole action. Similarly, the current is maximum in the starting point of stepped T shaped branch is maxmimum and the current is maximum at the end which shows dipole like behavior having electrical length close to a half wavelength.

At 6.3 GHz, the maximum current flow occurs in three different resonators as shown in Figure 3.9 (b). It is noticed that, in all the three resonators the current is maximum at the starting point shown in red colour and minimum at the ending point shown in blue colour. The overall current length for these three resonators monopole is approximately 3 λ_0/4. In most of the places in the Ground plane weak current distributions are seen.

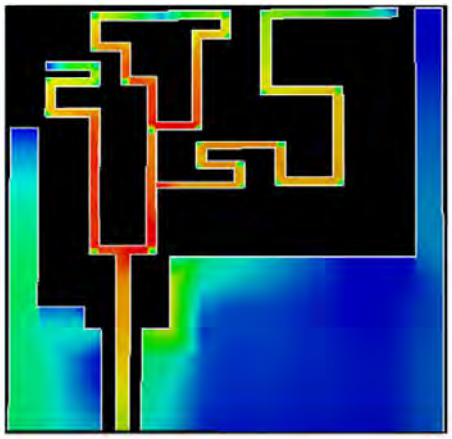

Figure 6 (a).Surface Current Distributions at 4.6GHz

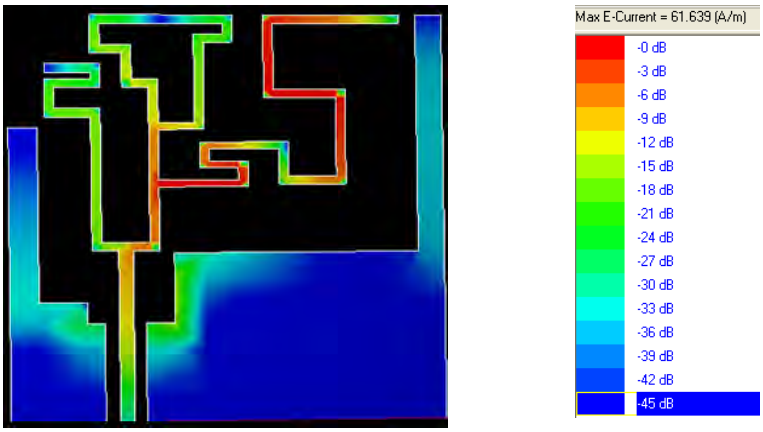

Figure 6 (b) Surface Current Distributions at 6.3GHz

V. RADIATION PATTERN

The simulated radiation patterns are shown in Figure 7 (a) and 7 (b). It is observed that at 4.6 GHz, the antenna has a dipole like radiation pattern and it is not symmetrical in the E plane. Not symmetrical pattern due to variation of current in the Z-U shaped and stepped 'T' shaped branches. At 6.3 GHz, the antenna has monopole like radiation pattern and it is not symmetrical one

In the H-plane, the antenna has nearly omnidirectional pattern at 4.6 GHz and 6.3 GHz as shown in Figure 3.10 (b).

External conductor of the SMA connector and may affect the radiation patterns.

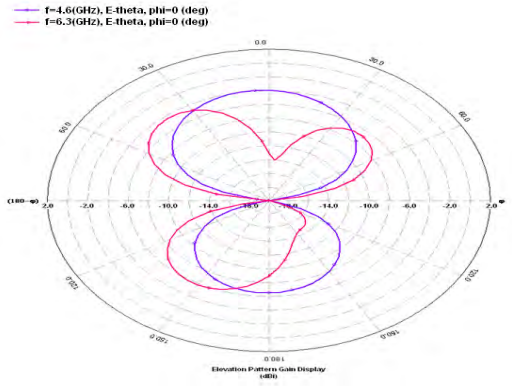

Figure 7(a). Simulated Elevation pattern (E phi at 4.6 GHz & 6.3 GHz)

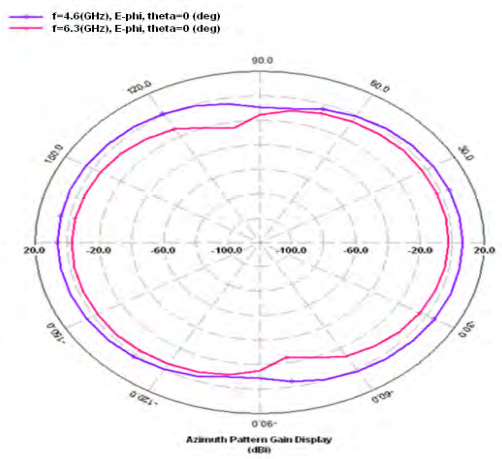

Figure 7 (b). Simulated Azimuth Pattern (E phi at 4.6 GHz & 6.3 GHz)

VI. GAIN

Figure 8 shows the Gain Characteristic of a Z-U-T-S shaped antenna. The peak gain is around 6 dBi at 4.6 GHz. The simulated peak gain at the lower operating frequencies varies from 0 to 6 dBi, and at the higher operating frequencies it varies from 2 to 4 dBi

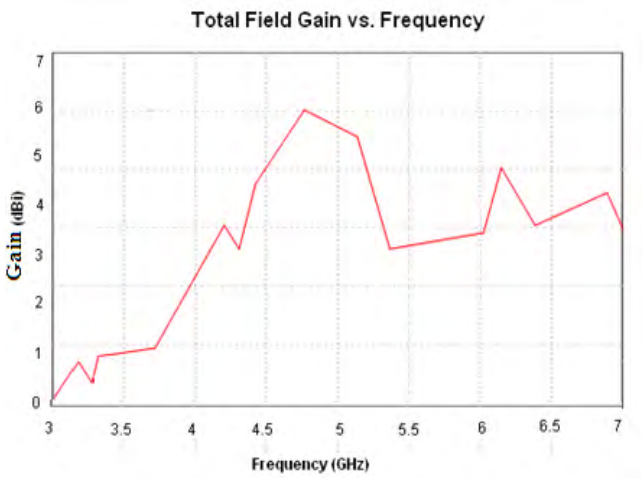

Figure 8. Gain Characteristic of a Z-U-T-S shaped antenna

VII. CONCLUSION

The proposed antenna can achieve an enhanced operating bandwidth of 4.5 - 5.2 GHz (14.43%) and 6.0 - 6.7 GHz (11.02%) for -10 dB return loss. The peak gain is around 6 dBi at 4.6 GHz. The size of the radiating element is 15.9 X 11.4 mm^2. This antenna is suitable for wireless applications.

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