A Novel S Shaped Wide Band Patch Antenna with Split Ground for Digital Multimedia Broadcasting and LTE

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***Abstract*— A simple and miniaturized S shaped wide band microstrip patch antenna is presented and measured in this paper. Antenna is developed using a FR4 epoxy (dielectric constant = 4.4) substrate on a Split or partial ground. The proposed antenna has a wide band response and useful in wireless and other applications. The antenna can be used in Digital multimedia broadcasting DMB (frequency range: 2.58 GHz – 2.88 GHz) as well as LTE 2500 MHz. The presented 'S' shaped antenna has been designed, simulated and measured using high frequency structural simulator (HFSS) v15 Software and microwave antenna testing unit. The results are attractive with VSWR< 2 for the required frequencies. The wide band can be seen from 3.38 GHz to 7.3 GHz which can be useful for WLAN/WiMAX etc. The Return loss and radiation patterns are observed to be omnidirectional with moderate gain. Reduction in size of the antenna is obtained by taking slots in the patch and split or partial ground concept. The overall reduction in size of the antenna is around 70%. The simulated and measured results show that the antenna is suitable for DMB, LTE, WLAN, WiMax and satellite uplink applications. The dimension of the proposed antenna is 30 mm×34 mm×1.6 mm.**

***Index Terms*— Wireless, 'S' shaped, Split Ground, Long Term Evolution (LTE), Digital Multimedia Broadcasting (DMB), FR4 epoxy.**

I. INTRODUCTION

The Microstrip patch antennas are the most widely used antennas in various wireless applications because of their low cost and ease of fabrication [1]. In recent years, extensive research activities are being dedicated towards the development of multiband and wide band antennas for wireless and other related applications [1-12]. A simple design of wide band microstrip patch antenna for Digital multimedia Broadcasting DMB applications as well as LTE, WLAN, WiMax and satellite uplink etc has been proposed in this paper. The proposed antenna covers all the 5.2/5.8 GHz WLAN/WiMAX IEEE operating bands. The antenna can be fed by direct feeding using a 50 ohm microstrip line. The Proposed antenna has been designed and various parameters such as return loss, directivity, bandwidth, gain and VSWR of microstrip patch antenna with slots are analyzed through high frequency structure simulator (HFSS) Software. HFSS (High frequency Structure simulator) [13] works on the principle of FIT (Finite Integration Technique). The proposed wide band microstrip patch antenna with 'S' shape structure is presented by the way of simple slot configuration that can be applied as a printed antenna.

The proposed antenna has improved band width, return loss, gain and polarization characteristics having dual band. The first band applied for Digital multimedia Broadcasting DMB with a bandwidth of 302 MHz having frequency range of 2.58 GHz – 2.88 GHz and LTE 2500 MHz. The second band is a wide band which ranges from 3.38 GHz – 7.3 GHz for mobile applications like WLAN/WiMAX etc. The considered frequency ranges have return loss below -10db. The antenna design has been verified using Ansoft HFSS software [13].

II. PROPOSED ANTENNA DESIGN

The basic structure of rectangular microstrip patch antenna with split ground build on a substrate FR4 (Flame resistant-4) Epoxy having a dielectric constant of 4.4 is shown in figure 1. The feed to the antenna is given by a 50 Ω microstrip line. Partial ground [14] concept is used here to improve the impedance matching of the antenna ranging from 3.4 GHz to 4.1GHz. The simulation results of return loss V/s frequency shown in figure 2 indicate the impedance bandwidth of 700 MHz. The modification from the basic rectangular patch antenna to obtain 'S' shaped antenna to meet the desired specified frequency bands such as 2.58 GHz to 2.88 GHz with peak resonant frequency at 2.69 GHz with return loss of -23.80 dB and 3.38 GHz to 7.3 GHz with peak resonance at 6.11 GHz with return loss of -21.3 dB. The proposed 'S' shaped antenna structure is as shown in figure 3 which consists of a radiating patch, dielectric substrate and a ground plane. The patch and the ground planes have conducting material such as copper. We are using low cost substrate such as FR4 (Flame resistant-4) Epoxy having a dielectric constant of 4.4. The feeding to the patch antenna is a microstrip line and a split ground plane is on the other side of the substrate. Figure 4 shows proposed geometry of the split ground plane of the antenna with complete dimensions.

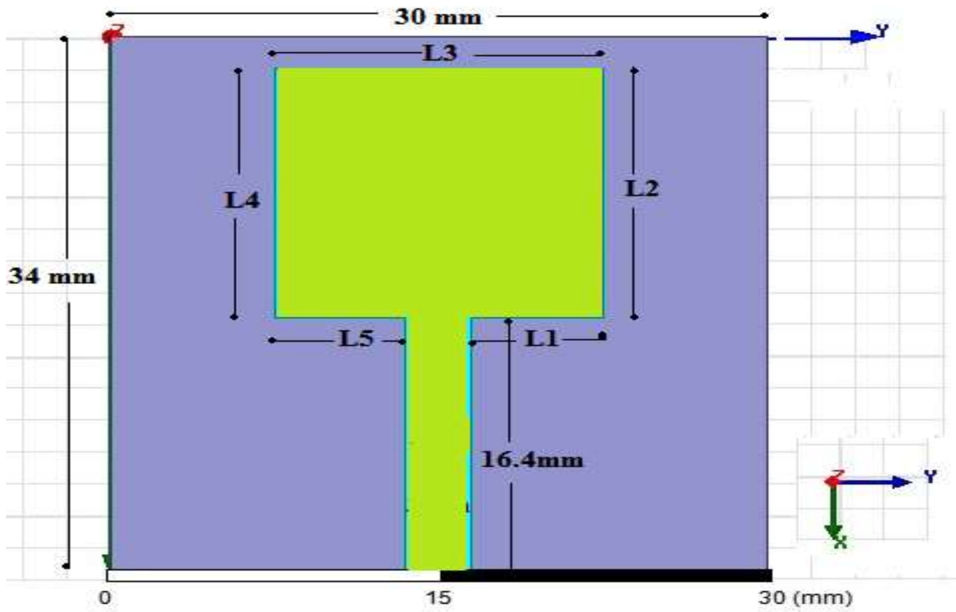


Fig. 1: Rectangular Microstrip patch antenna.

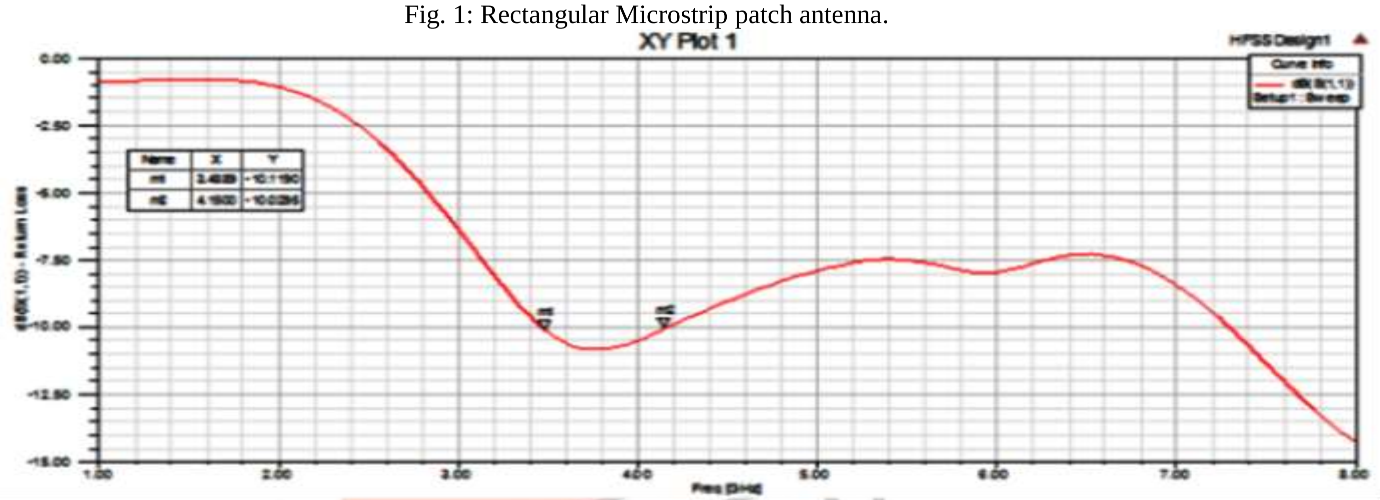
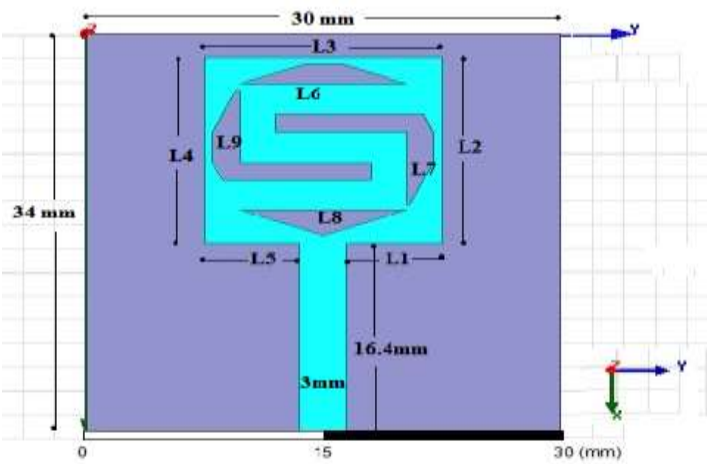


Fig. 2: Plot of Simulated Return Loss(dB) vs Frequency(GHz).

The proposed antenna is constructed on a substrate with dimension of 30 mm x 34 mm having dielectric constant $\epsilon r=4.4$ and thickness h=1.6 mm. The dimension of the radiating patch Structure is as shown in the figure 3. The dimensions are as follows. L1= L5=6 mm, L3=15 mm, L2=L4=15.6 mm, L6=L8=10.60 mm, L7=L9=6.10 mm, the gap in 'S' structure is 1.5 mm. The microstrip feed line is of length 16.4 mm and width 3 mm. The dimension of the ground plane has a width of 17.5 mm x 15.5 mm with an Inverted 'L' Shape structure at the corner having dimensions of G1=15 mm, G2=12.5 mm, G3=1.8 mm, G4=18.2 mm, G5= 1.5 mm. The antenna is fed using a 50 ohms direct microstrip line feeding.



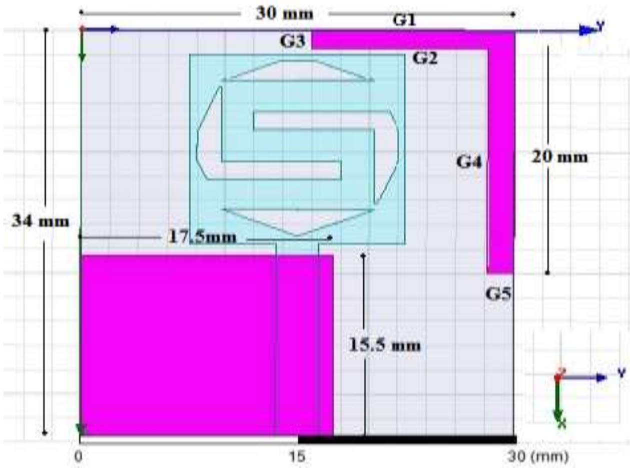


Fig.3 and 4 Proposed 'S' shaped Wide band Patch (Top view) and Slotted Ground plane(Bottom view).

III. RESULTS AND DISCUSSIONS

The figure 5 shows the simulated return loss plots for proposed wide band 'S' shaped microstrip patch antenna. The antenna resonates at various frequencies. We choose the frequency band from the point where it exhibits the return loss of -10db. We have got two useful bands. The first band resonates from 2.58GHz to 2.88GHz with peak resonant frequency at 2.69 GHz with return loss of -23.80 dB. Hence first band has an application in the field of Digital multimedia broadcasting DMB and WiMAX (Worldwide Interoperability for Microwave Access). The second band is a wide band which ranges from 3.38 GHz to 7.3 GHz with peak resonance at 6.11 GHz with return loss of -21.3 dB. The wide band has various applications such as Satellite Radio Uplink (7.05 GHz – 7.075 GHz), Radio Altimeters (4.2 GHz – 4.4 GHz), ISM: WLAN 5.2 GHz and 5.8 GHz, WiMAX (3.5 GHz) and WiMAX (5.55 GHz) etc. In the Plot of figure 5, using markers we have tried to show the return loss for corresponding frequencies. 3-D Plot of Simulated Return Loss vs Frequency is shown in figure 6. We have marked the VSWR too in the figure 7. The VSWR for the proposed antenna is less than 2 as per simulated results shown in figure 7, which satisfies the bandwidth requirement for specified frequency range. Figure 8 shows the simulated gain of the proposed antenna at 2.65 GHz.

A broad wide band operating bandwidth of about 5.6 GHz (ranging from 2.4 GHz to 8 GHz with return loss better than 6 dB (i.e., 3:1 VSWR) is obtained for the proposed design. As a universal criterion, the 3:1 VSWR definition can be adopted for the internal mobile terminal device antenna for WLAN operations and also serves as a commonly accepted industrial standard [2].

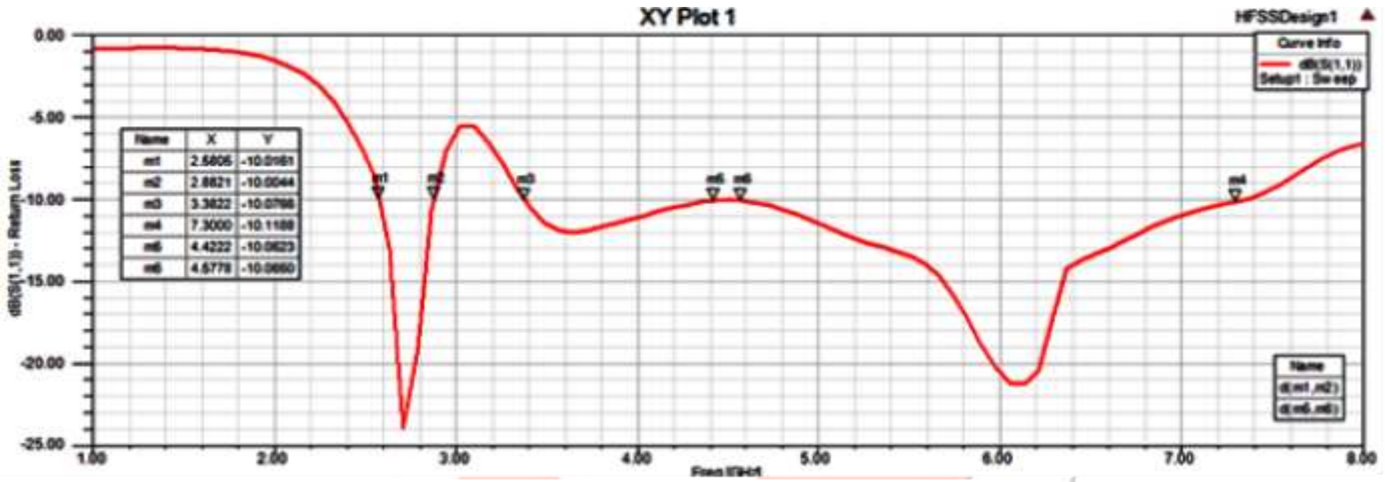


Fig. 5: Plot of Simulated Return Loss(dB) vs Frequency(GHz)

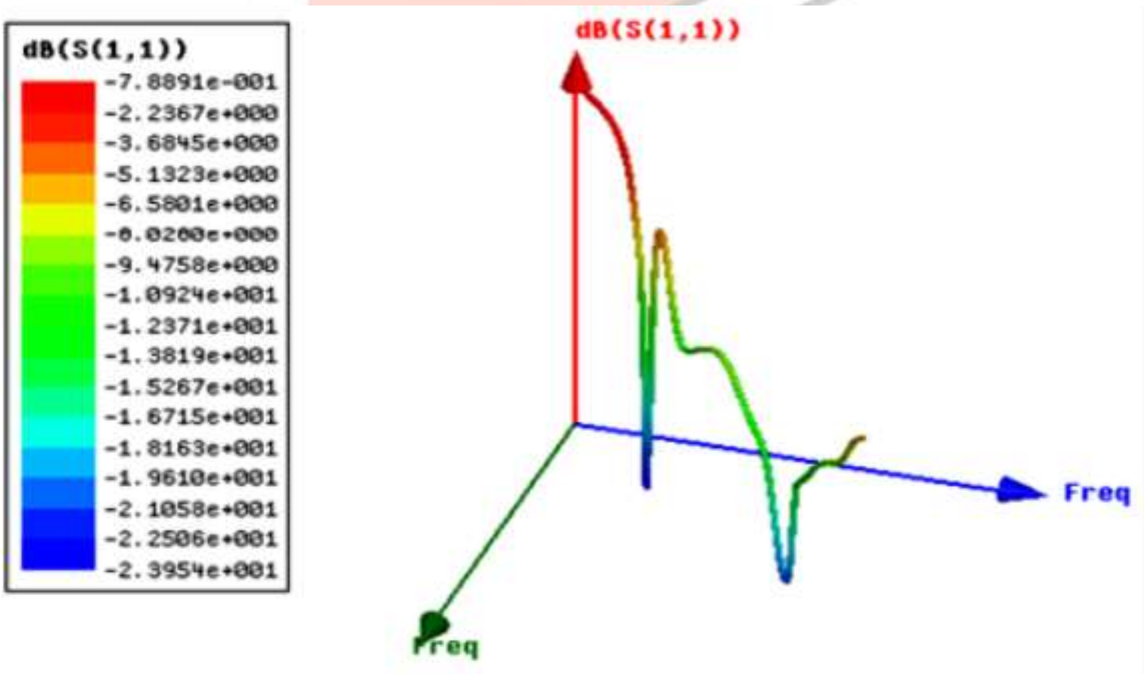


Fig. 6: 3-D Plot of Simulated Return Loss vs Frequency.

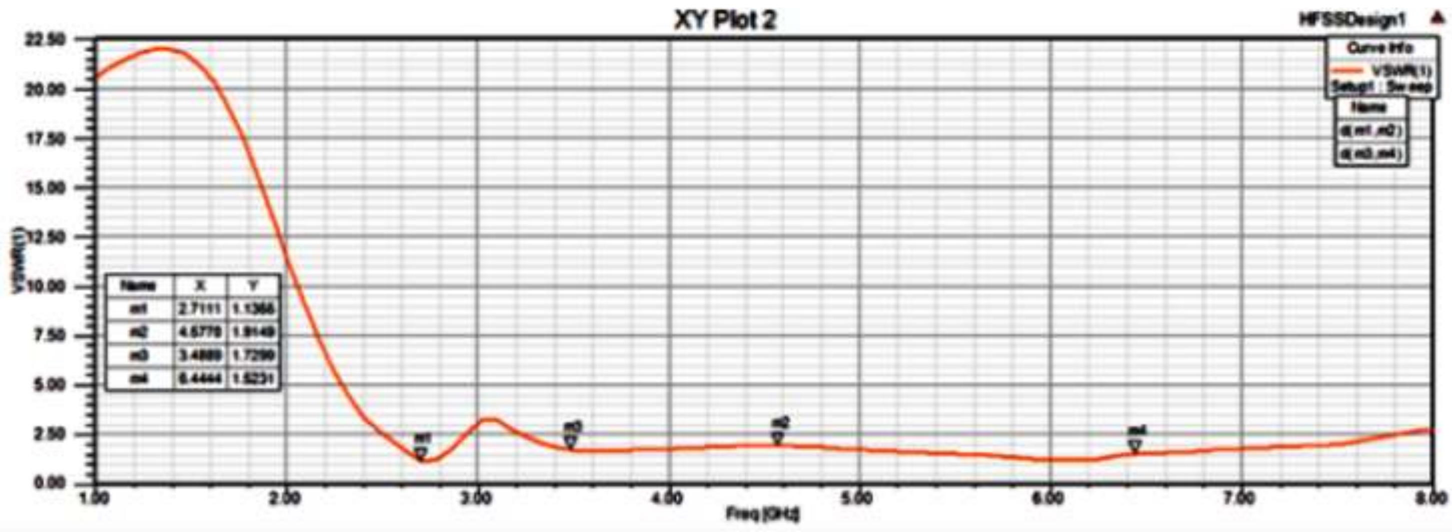


Fig. 7: Plot of VSWR v/s Frequency

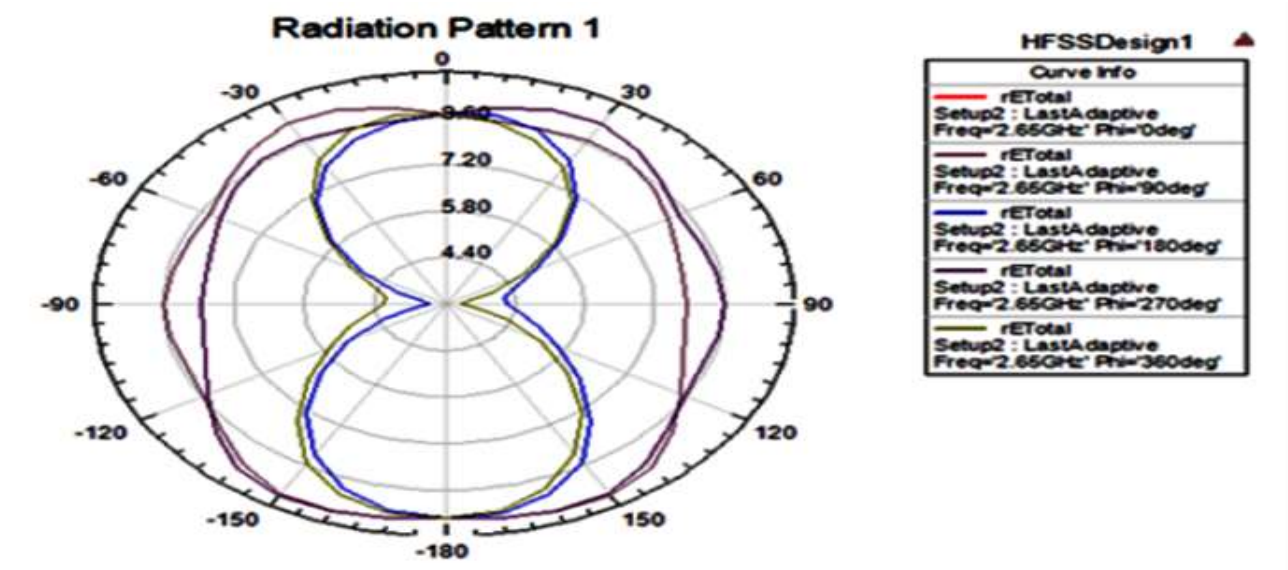


Fig. 9: Plot of Radiation Pattern at 2.65 GHz.

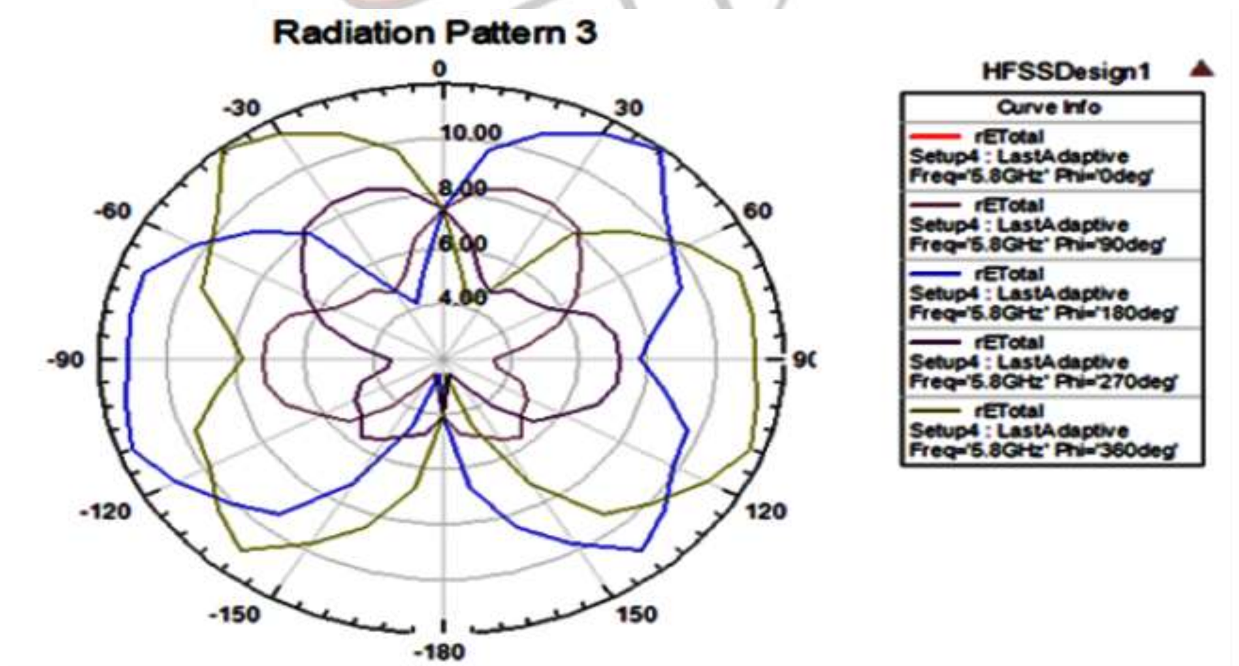


Fig. 10: Plot of Radiation Pattern at 5.8 GHz.

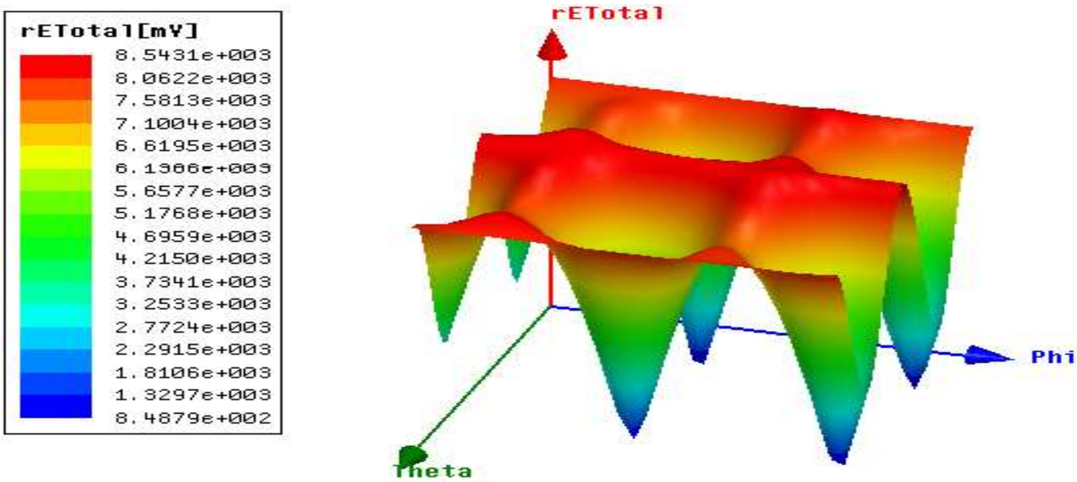


Fig 11: Simulated 3D rectangular radiation pattern.

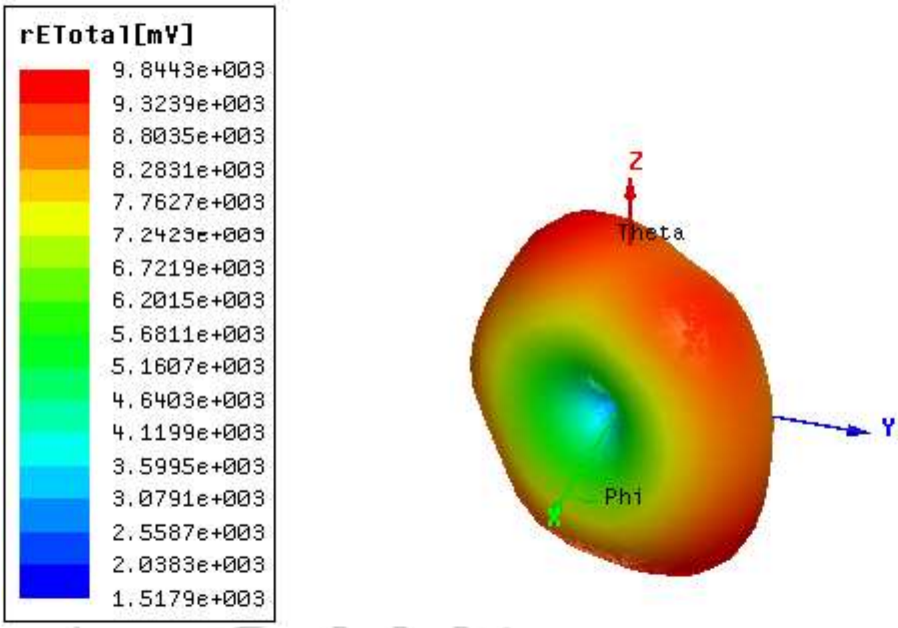
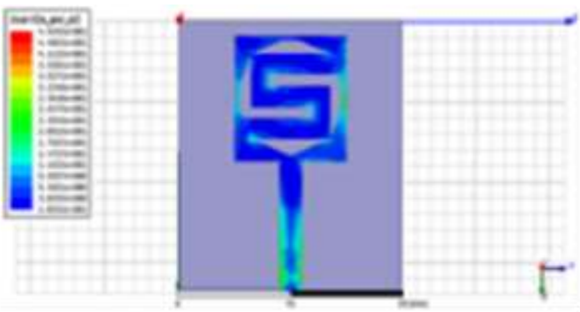


Fig 12: Simulated 3D Polar radiation pattern

The figures 9 and 10 show the simulated radiation patterns in the E-plane and H- planes at 2.65 GHz and 5.8 GHz. We can observe that the radiation patterns are moderately omnidirectional. Thus we can say that the 'S' shaped wide band antenna shows stable omnidirectional radiation patterns over all the frequency bands as well as relatively consistent group delay across the UWB frequencies [5]. Simulated 3-D polar radiation pattern is represented in figure 12. The Surface Current density distribution at various frequencies such as 2.65 GHz and 5.8 GHz has been studied. The below figures 13 and 14 depicts the same. The figures 15 and 16 depict the Electric field distribution at various frequencies such as 2.65 GHz and 5.8 GHz.



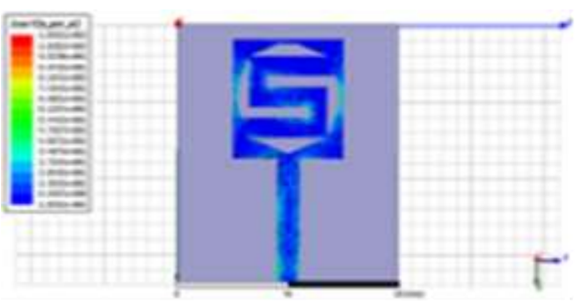


Fig. 13 and 14: Plot of Surface current density at 2.65 GHz and 5.8 GHz

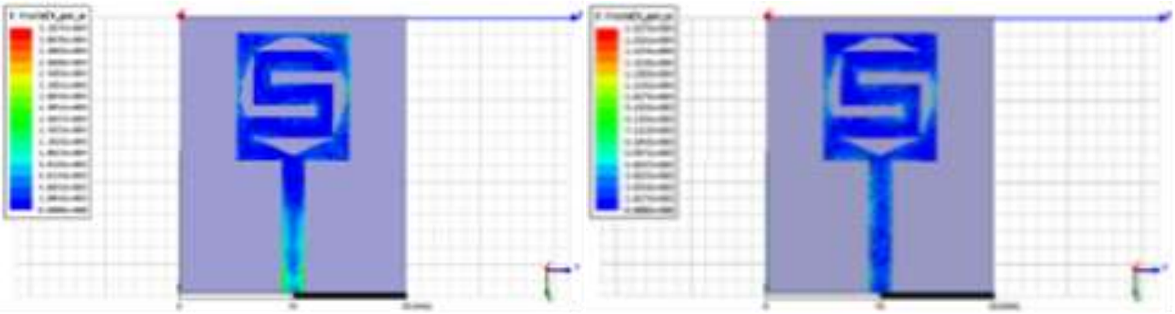


Fig. 15 and 16: Electric field density distribution at 2.65 GHz and 5.8 GHz

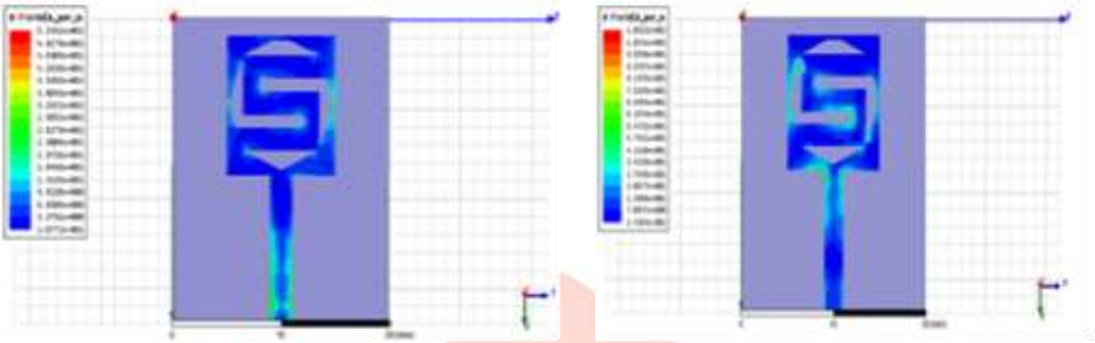


Fig. 17 and 18: Magnetic field density at 2.65 GHz and 5.8 GHz

The figures 17 and 18 shows the Magnetic field distribution at various frequencies such as 2.65 GHz and 5.8 GHz respectively. Let us discuss the Measured results with the simulated now. We have compared the Simulated results with the measured values by finetuning some values using sigma plot. We can observe that the measured results are almost in good agreement with the simulated results.

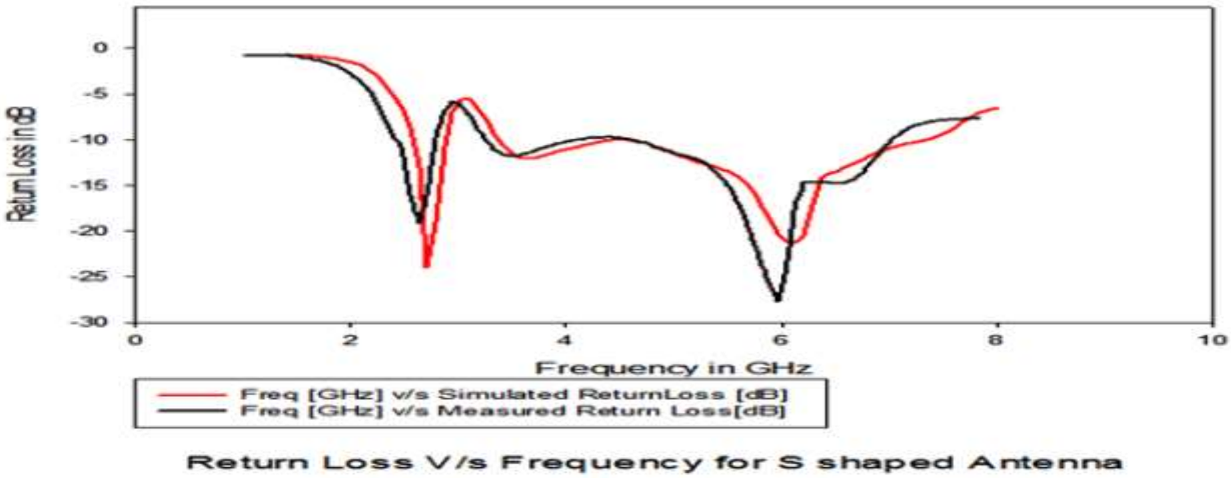


Fig. 19: Plot of Return Loss[dB] V/s Frequency[GHz](Measure and Simulated).

The above graph for return loss clearly shows that we have obtained the wide bands which can be used for various applications. As we are discussing the application for DMB we know that for Digital Multimedia Broadcasting applications we have DMB band frequency range: 2.605 GHz – 2.655 GHz and we can observe a band from 2.56 GHz- 2.88 GHz in our design. Hence we can use the 'S' Shaped antenna for DMB applications. From the plot of Return loss v/s frequency in figure 19 we can observe that the designed 'S' shaped antenna covers the DMB bands.

We observe the obtained results are good with VSWR < 2 for the required frequencies. We can see that from figure 19, The wide band can be seen from 3.38 GHz to 7.3 GHz with a special band useful for DMB from 2.56 GHz- 2.88 GHz and the Band useful for LTE 2500 MHz as well.

The proposed design for the 'S' shaped antenna has been fabricated using the machine based milling method. Below figures 20 and 21 shows the fabricated structure of the 'S' shaped wide band antenna which was designed using Ansoft HFSS Software[14]. The setup for testing and measuring chamber of antenna is shown in figure 22.

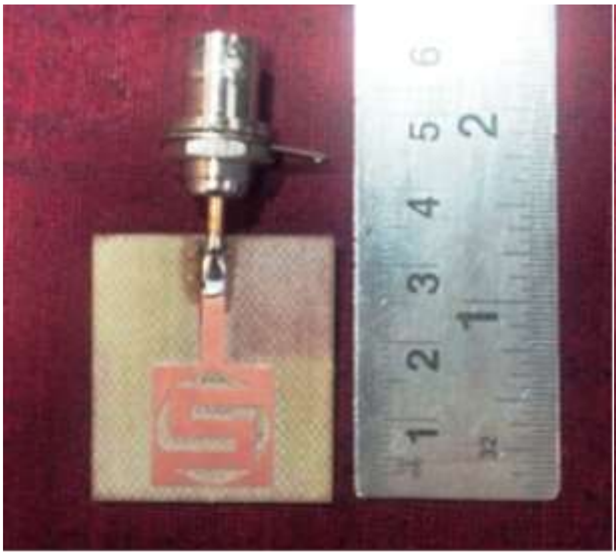


Fig. 20: Fabricated S Shape patch Antenna.

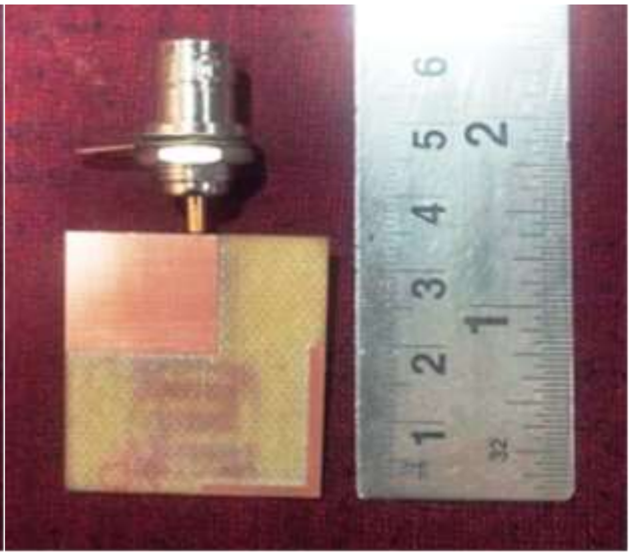


Fig. 21: Fabricated S Shape Antenna Slotted Ground.

Fig. 22: Antenna testing and measuring setup.

IV. CONCLUSION

This paper, ‘S’ shaped wide band microstrip patch antenna design has been proposed for Digital multimedia Broadcasting and LTE applications. The characteristics of the proposed antenna were simulated and validated experimentally. The frequencies in the wide band antenna can be controlled using slots and the ground plane structure. The obtained Excellent return loss, radiation patterns, higher gain and VSWR<2 makes the antenna suitable for its use in Digital multimedia broadcasting, LTE, WLAN/WiMAX, Radio Altimeter and Satellite radio uplink and various other applications. A wide operating bandwidth of about 5.6 GHz with return loss better than 6 dB is obtained for the proposed design. The proposed design is fabricated using mechanical method and tested results were studied.

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