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Wide Band W-Shaped Microstrip Patch Antenna With Inverted U-Slotted Ground Plane For Wireless Applications

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ABSTRACT:

In this paper, a Wide Band antenna with W-shaped patch prototyped on FR4 Substrate is proposed and analyzed. The antenna is fed by co-axial probe with an impedance matching of 50 ohms. A parametric study is performed by varying the feed location and the variations in Return Loss are observed. The simulation results of the parameters like VSWR, Return loss, Radiation pattern etc., satisfied the theoretical conditions. An Impedance Bandwidth if 24.5% (9.55 GHz - 12.18 GHz) is obtained with a ground plane having multiple inverted U-shaped slots. The model is analyzed using Finite Element Method based Ansoft High Frequency Structure Simulator v.13.

***INDEX TERMS**: Co-axial feed, Impedance Bandwidth, Wide Band and VSWR.*

I. INTRODUCTION

Microstrip Patch antennas are widely used because of its advantages like Low Profile, Ease of installation, Low weight etc., but a drawback is narrow bandwidth. Many techniques are introduced to overcome narrow bandwidth. One of the techniques is using parasitic elements [1]. Another technique is utilization of thick substrates with less dielectric constant [2]. Because of large inductance introduced by increased length of probe feed, it also not achieved more bandwidth. By using stacked patches, enhancement in bandwidth is obtained but has a complexity in fabrication. The addition of U-shaped slots and L-shaped probes increased the impedance bandwidth [3-4]. The use of various impedance matching and feeding techniques [5] and slot antenna geometry [6] also improved the bandwidth of microstrip patch antennas. With the rapid development of Wireless communications, slotted single patch antennas with wide bandwidth have gained more importance.

A single layer microstrip patch antenna is designed for wideband applications. The proposed antenna is simulated using Finite Element method based High Frequency Structure Simulator version 13. The simulated results are par to the theoretical results.

II. ANTENNA DESIGN

The proposed antenna has dimensions of 32mm x 32mm x 1.6mm. It is prototyped on FR4 substrate of with dielectric constant, ε_r = 4.4 and fed by Co-axial probe having an impedance of 50ohms. The proposed antenna model is shown in Figure 1. The model consists of a W shaped patch with equal arms of length 20mm. Inverted U-shaped slots are made on ground plane which has arm length of 5mm. To increase the bandwidth of the antenna, nine Inverted U-shaped slots are used.

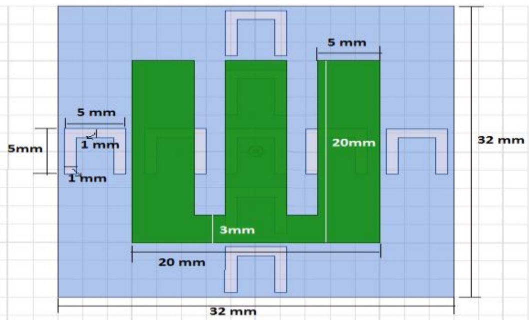


Figure 1: Proposed W-shaped Antenna Model

The proposed model is analyzed using High Frequency Structure Simulator. The simulation results show that Voltage Standing Wave Ratio (VSWR) is less than 2 in the operating frequency range. This model resonates at multiple frequencies with less return losses. An acceptable Gain is achieved and the radiation patterns are quasi omni-directional patterns. Variations in the Return Loss are observed by varying the feed location. An observation is made to find the impedance matching location by varying the feed locations.The simulation results of practical importance like Return Loss, VSWR, Gain and Radiation Pattern are analyzed and discussed in the next chapter.

III. RESULTS ANALYSIS

A Co-axial probe fed W-shaped Microstrip patch antenna with Inverted U-shaped slots in ground plane prototyped on FR4 substrate which has a dielectric constant of 4.4 is simulated using HFSS. By varying the feed location, the variations in Return Loss are plotted and represented in Figure 2. The proposed model is analyzed for different feed locations (0mm, 0mm), (7mm, 0mm) and (7mm, 7mm). Among these locations, at (0mm, 0mm), the proposed model exhibited wide band characteristics and resonated at multiple frequencies.

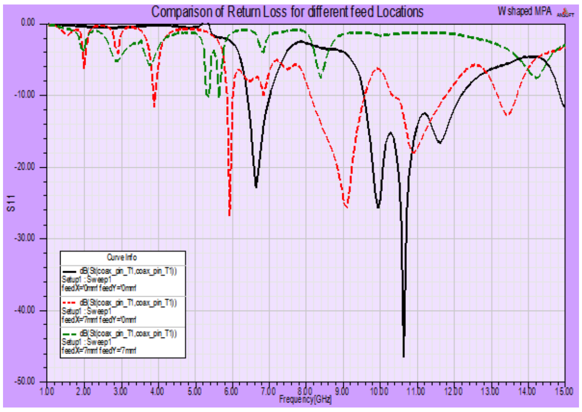


Figure 2: Return Loss curves for different feed locations

At (0mm, 0mm), the proposed model resonates at 6.6281 GHz, 9.9347 GHz, 10.6382 GHz and 11.6231 GHz. The Return Loss at the resonant frequencies is -22.9217 dB, -25.7955 dB, -46.4759 and -16.6076 respectively. The bandwidth of this model is 3.2477 GHz. The Frequency versus Return Loss plot is shown in figure 3.

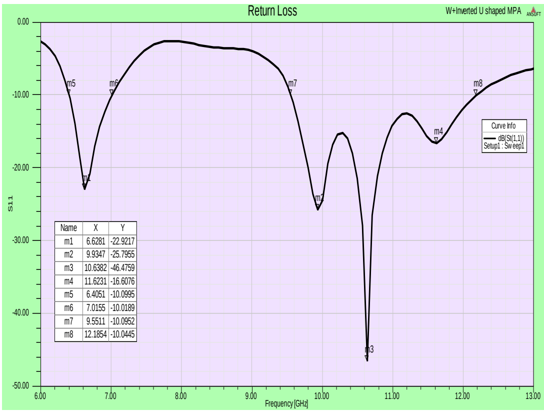


Figure 3: Frequency vs. Return Loss

The measure of reflected power of an antenna is defined as Voltage Wave Standing Ratio (VSWR) and the permissible limit is less than 2. Figure 4 shows the VSWR and it is less than 2 in the operating range. The VSWR at the resonant frequencies is are1.1539, 1.1082, 1.0095 and 1.3468 respectively.

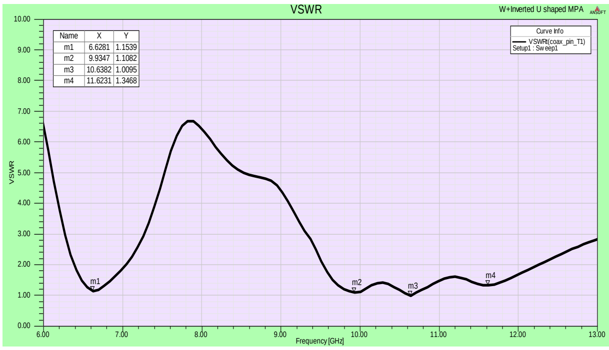


Figure 4: VSWR vs. Frequency

For a transmitting antenna, Gain is defined as the measurement of the efficiency of converting input power to radio waves in a specified direction and vice versa for receiving antenna. Antenna gain is measured with respect to a hypothetical lossless Isotropic antenna and hence the units are dBi. For the proposed antenna, the Antenna gain is shown in figure 5.

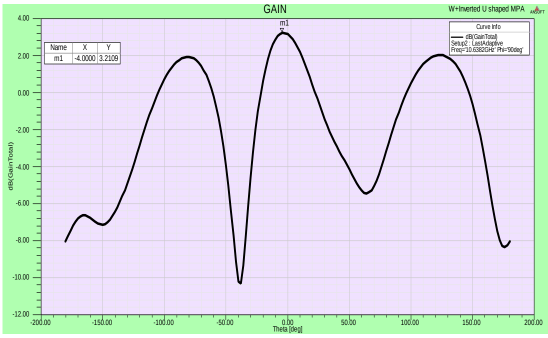
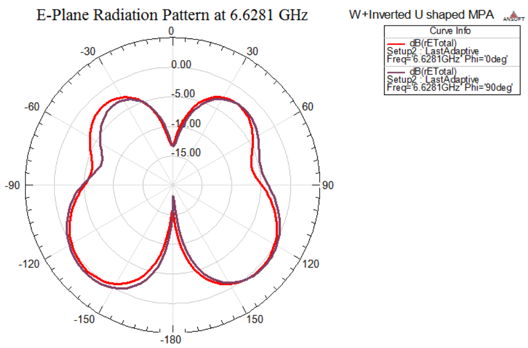


Figure 5: 2D Gain

The plot is Theta versus gain and it shows a peak gain of 3.2109 dBi at 10.6382 GHz at theta=-4 degrees. The variation of power radiated by an antenna as a function of direction away from the antenna is defined as Radiation Pattern. There are two reference planes for an antenna. They are E-Plane and H-Plane which are 90 degrees apart. The far-zone electric field lies in the E-Plane and far zone magnetic field lies in H-Plane [7]. The Radiation pattern in both E-Plane and H-Plane for all the resonant frequencies 6.6281 GHz, 9.9347 GHz, 10.6382 GHz and 11.6231 GHz are shown in figure 6 and figure 7 respectively. In E-Plane, the radiation patterns at Phi=0 degrees and 90 degrees are represented. In H-Plane, the radiation patters at Theta=0 degrees and 90 degrees are represented.



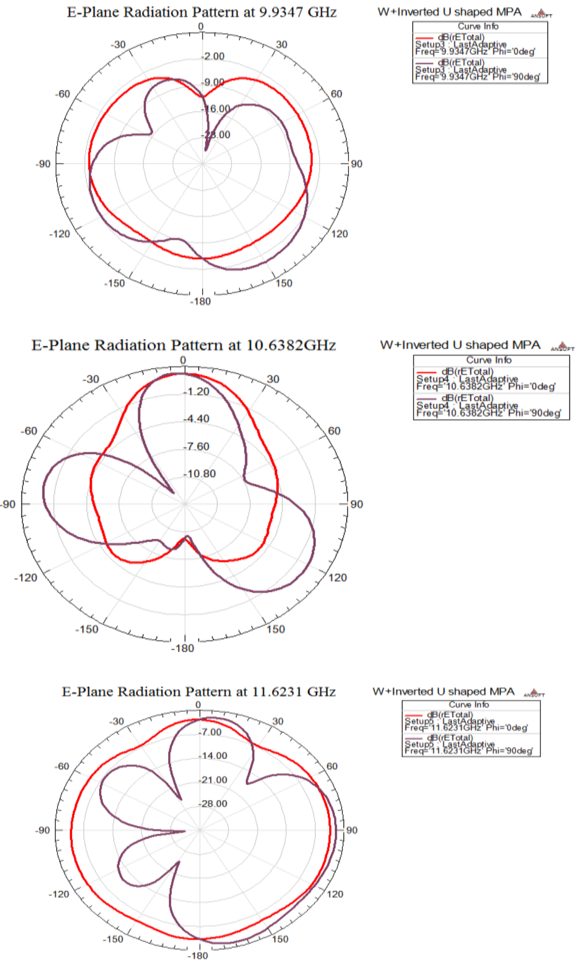
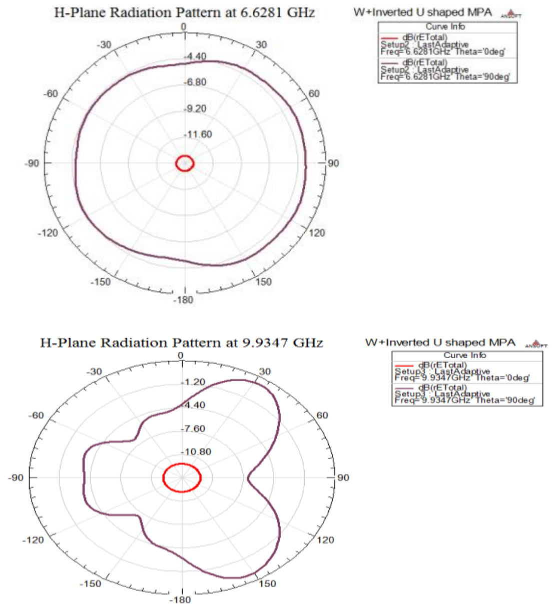


Figure 6: E-Plane Radiation Patterns at Resonant Frequencies

The simulated radiation patterns typify a Quasi Omni-directional radiation pattern in both E-plane and H-plane of the antenna.



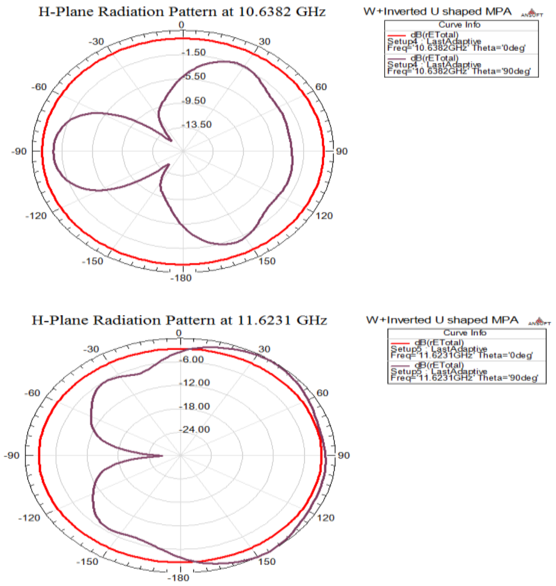


Figure 7: H-Plane Radiation Patterns at Resonant Frequencies

The Distribution of Electric field, Magnetic field and Surface Current density on the W-shaped patch at the resonant frequencies 6.6281 GHz, 9.9347 GHz, 10.6382 GHz and 11.6231 GHz is shown in figure 8, figure 9 and figure 10 respectively.

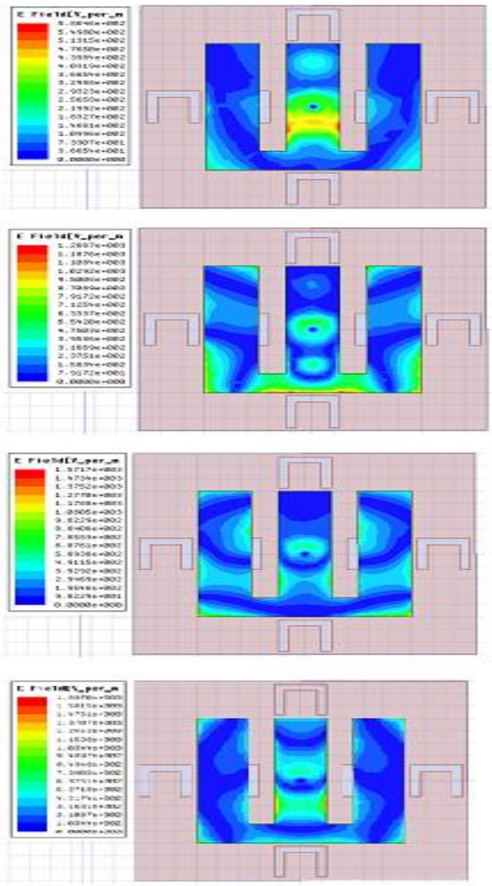


Figure 8: E-field distribution at resonant frequencies

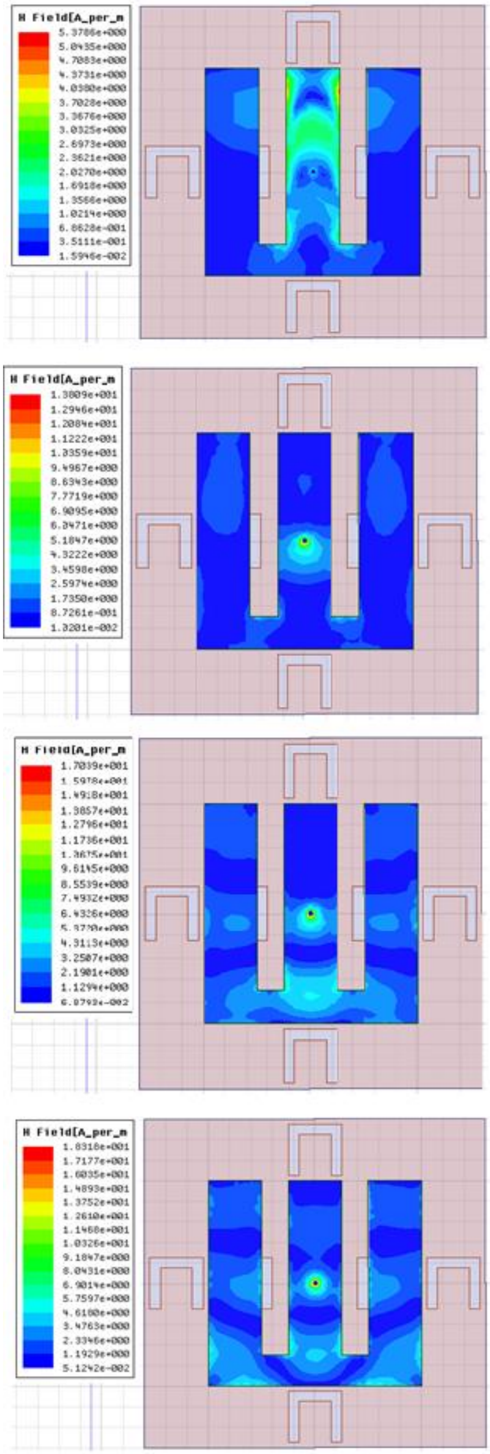


Figure 9: H-field distribution at resonant frequencies

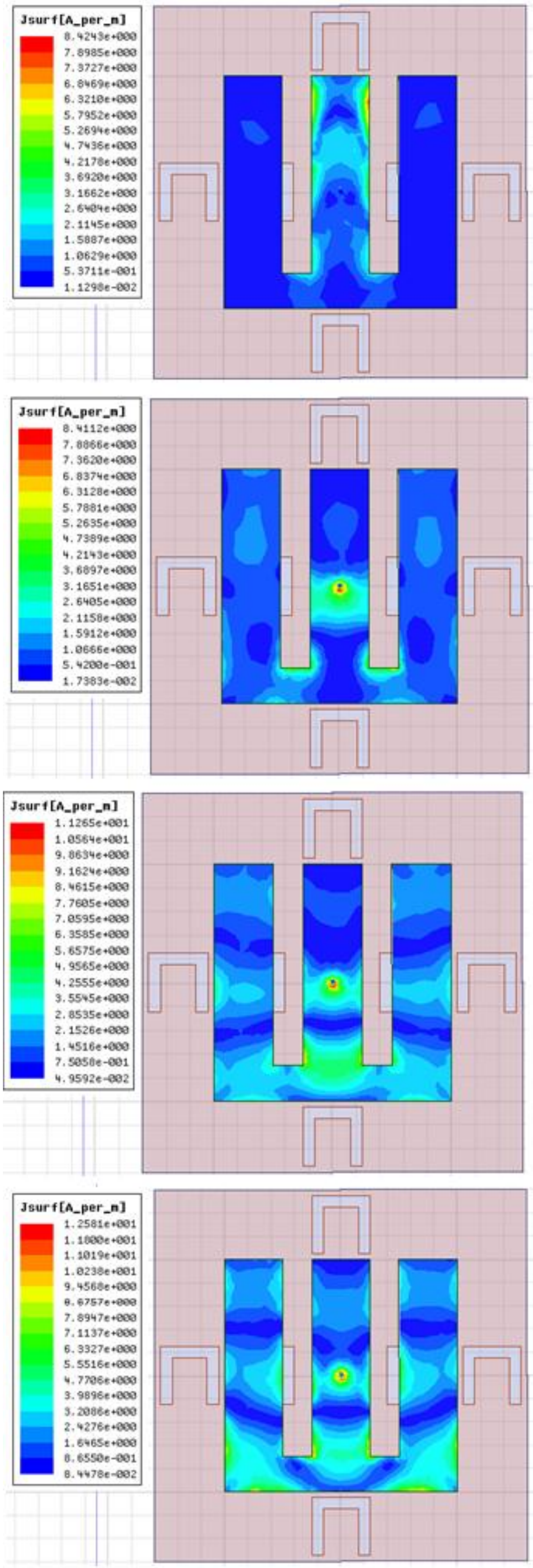


Figure 10: Surface Current Density distribution

IV. CONCLUSION

A Co-axial probe fed W-shaped microstrip patch antenna with Inverted U-shaped slots in ground is designed for wide band wireless applications. The antenna is very compact with minute dimensions of 32mm x 32mm x 1.6mm prototyped on FR-4 substrate. A comparative analysis is made for the identification of impedance matching by varying the feed locations. All the parameters like Return Loss, VSWR, Gain and Radiation patterns etc., are appreciable and can be used for wireless applications like WLAN, Wi-Fi, and Bluetooth etc.

ACKNOWLEDGMENT:

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