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Reduced Ground plane E-shaped Wideband Microstrip Patch Antenna for WLAN Systems

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Abstract— A wideband E shaped microstrip patch antenna with reduced ground plane is designed on a substrate of 1.6 mm thickness at resonant frequency of 5.4GHz.The proposed antenna is slotted into an E-shape to enhance its bandwidth. The composite effect of integrating reduced ground structure and by introducing the novel slotted patch, offer a low profile, broadband, high gain, and compact antenna element. The proposed antenna provides very good return loss S_{11} characteristics and impedance behavior. The surface current and power plots verify the design of proposed antenna for WLAN applications.

Keywords: Broadband antenna, Microstrip patch antenna, Slotted E-patch, Reduced Ground plane structure.

I. INTRODUCTION

The design of an efficient wide band small size antenna, for recent wireless applications, is a major challenge. Microstrip patch antennas are suitable for wireless communication systems owing to their advantages such as low-profile, conformability, low- fabrication cost and ease of integration with feed networks [1, 2]. However, conventional microstrip patch antenna suffers from very narrow bandwidth. This poses a design challenge for the microstrip antenna designer to meet the broadband requirements [7]. The well-known methods to increase the bandwidth of antennas include increase of the substrate thickness, the use of a low dielectric substrate, the use of various impedance matching and feeding techniques [3, 5].

In this paper, reduced ground plane structure [8, 9, 10] and a novel slotted E-shape patch is investigated for enhancing the impedance bandwidth on FR4 substrate. The paper is organized in the following sections. The design of the wideband microstrip patch antenna is presented in section-II. The results and discussion are given in section-III.

II. ANTENNA DESIGN

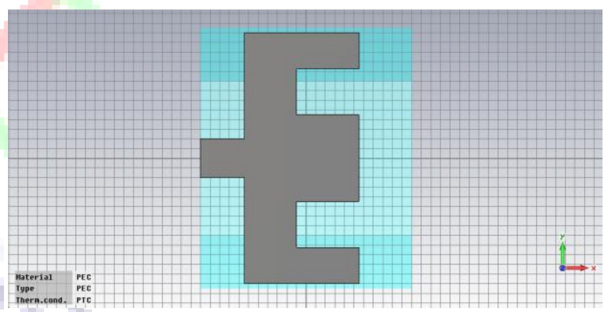

Fig1. Slotted E-patch antenna with reduced Ground plane structure

In this proposed design, antenna patch and ground plane are made of perfect electric conductor having relative permittivity of 1. Antenna is designed to resonate at frequency of 5.4 GHz. The patch is mounted on a FR4 substrate with relative permittivity, ε_r=4.4 and height of 1.6 mm. This composite structure is placed on the reduced ground plane with the following antenna dimensions:

Ground Plane: 22mm x 27mm x 0.02mm.

Substrate: 22 mm x 27mm x 1.6.

Patch: 11.9 mm x 26 mm x 0.02 mm.

E-Slots:

The rectangular patch is then slotted into E-shape to obtain a wide band around the resonating frequency of 5.4GHz.the dimensions of the slots being:

E-slot1: a rectangular slot is cut from the patch with dimensions-L=6.5mm, W=14mm, h=0.02mm to get a C shaped patch.

E-slot2: a rectangular Perfect Electric Conducting strip is added at the centre of the C- patch so formed having dimensions: 6mm x 6mm x h=0.02mm.

Feed:

The rectangular patch is fed by a microstrip feed transmission line extending from the substrate edge at -11mm to the patch edge at -6.4mm on X-axis.

Simulations are performed using CST Microwave Studio, a 3D full-wave electromagnetic field simulator. CST provides E- and H-fields, Surface currents, S11 parameter and near and far radiated field results using Finite Difference Time Domain (FDTD) for EM simulation. It integrates simulation, visualization, solid modeling and automation.

III. PARAMETRIC STUDY OF ANTENNA

It has been noticed in the simulation that the operating bandwidth of the slotted E-shape microstrip patch antenna is critically dependent on the dimensions and position of the ground plane, patch and the slots cut from the rectangular patch of the antenna to increase the bandwidth of the antenna.

The width and position of the stripline feed determine the impedance matching of the antenna at a particular resonant frequency, so parametric study of the proposed antenna is needed to get optimal size, bandwidth and gain.

(i) Microstrip feed line:

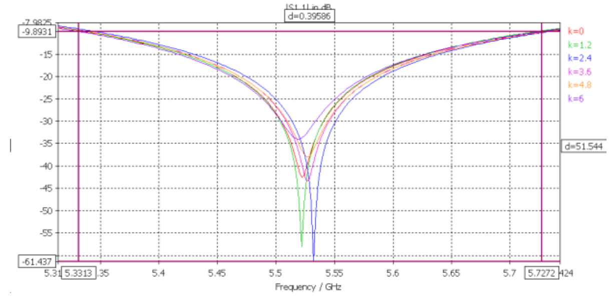

Fig2. Sweep function of Length of Feed line

Sweep is applied to the Length of the feed from k=-2 to 2 and we select the best curve at k=2.4, providing a bandwidth of 395.86MHz and Return loss S11 parameter of -61.437. The effect of varaiation feed length is shown in figure 2.

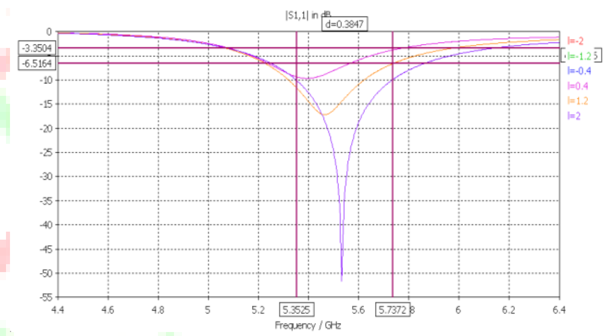

Fig3. Sweep characteristic for Width of Feedline

The width of the feedline is swept from l=-2 to 2 and we obtain the best curve with respect to antenna bandwidth and return loss at a value of l=2 as shown inn figure 3.

(ii) Reduced Ground plane structure:

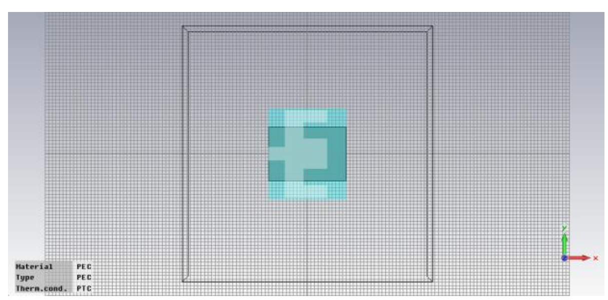

Fig4. Reduced ground Plane Structure

The ground plane is stripped off along the width to create the reduced ground plane structure with best sweep value of g=4. It improves the return loss parameter, S11 and it also causes the bandwidth to increase from 390MHz to 574.77MHz as shown in figure 4.

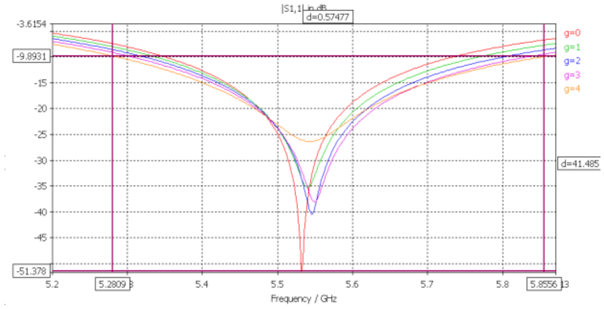

Fig5. Sweep function of Reduced Ground Plane

(i) Slotted E-shaped Patch:

The rectangular patch is slotted along the side opposite to the feedline, along the width, in the shape of 'E' and the effect of variation of the position and dimension of each slot on the bandwidth is studied and plotted in the return loss characteristics.

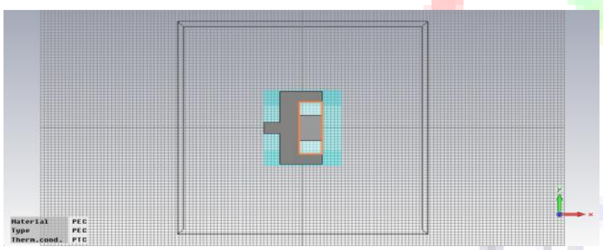

Fig6. E- slot1

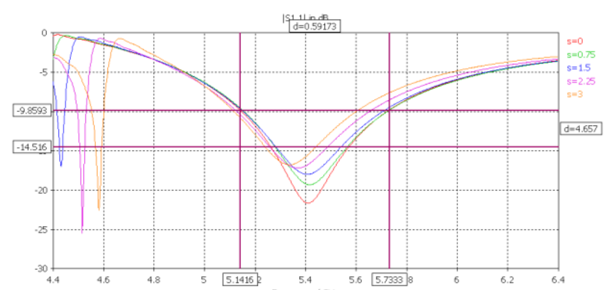

Fig7. Sweep function for E-slot1

Applying sweep on width of slot1 we find that at a varying the slot width from -7 to7yeilds a bandwidth of 591MHZ and return loss of -36.4dB.

A centre strip added to the C patch so formed is swept around the centre along Xaxis to give the best value at a slot width of w=-1.5 and positional variation of c=0.

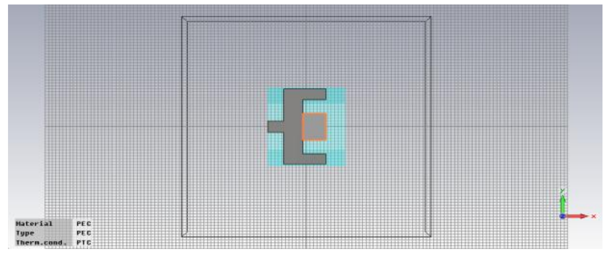

Fig8. E- Centre slot

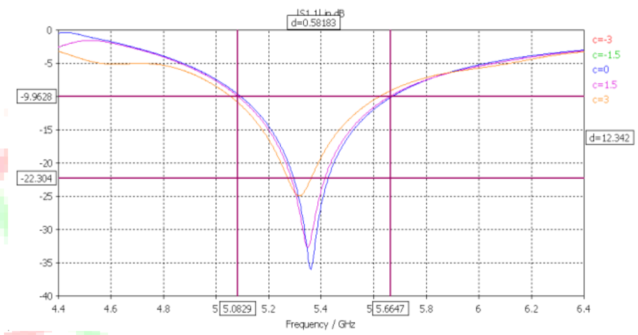

Fig 9. Sweep run for position of centre E-slot

Then the width, w of the centre slot 1.e. slot 2 is varied using the sweep function and the return loss curve gives best value at w=1.5

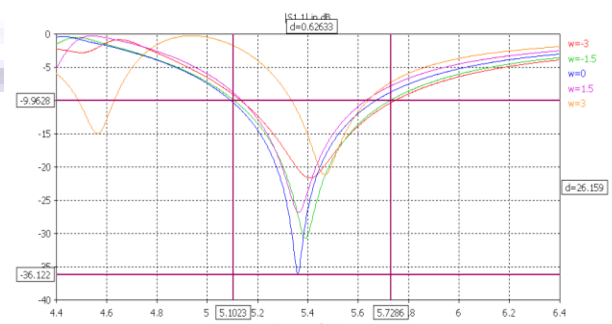

Fig 10. Sweep for Width of center slot

(iii) Optimization of parameters:

The optimal results are obtained in terms of bandwidth and S11 parameter using the built-in optimization tool in CST to get a composite curve for all the variations applied through sweep function.

IV. RESULTS AND DISCUSSION

A. Return Loss Characteristic and Impedance Bandwidth

The proposed antenna is simulated and analyzed using CST Microwave studio at a resonant frequency of 5.4GHz. Return loss characteristics depict a bandwidth of 610MHz with return loss S11 value of -30.64dB.

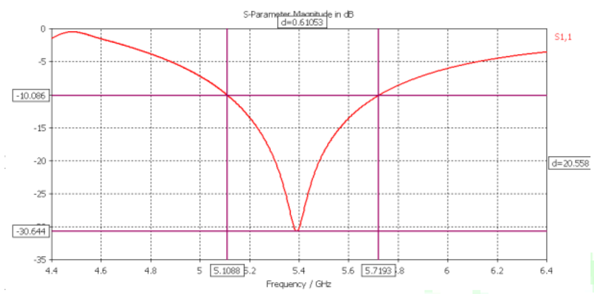

Fig 11. Return Loss S11 parameter variation with frequency.

VSWR is also calculated and its value is found to be 1.005 at the resonating frequency of 5.4 GHz.

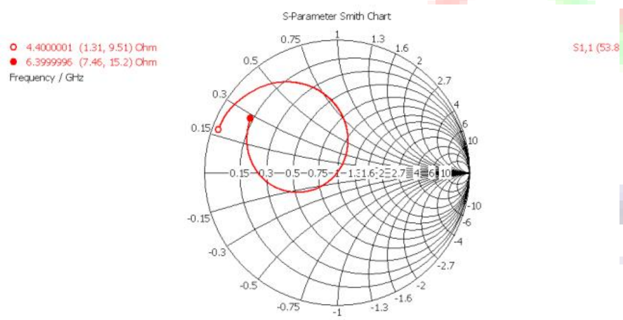

Fig 12. Smith chart for Impedance matching of the proposed antenna structure.

A considerable antenna gain of 6.90dB is obtained at the designed frequency.

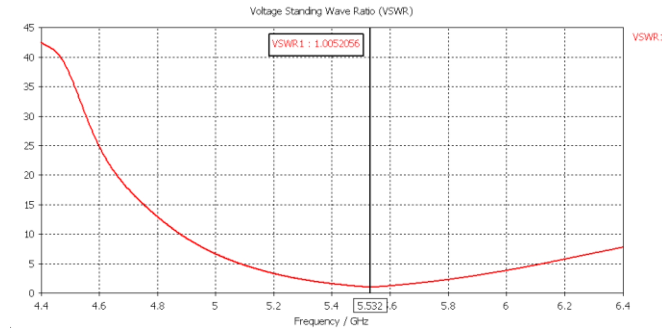

Fig.13. VSWR for the designed antenna

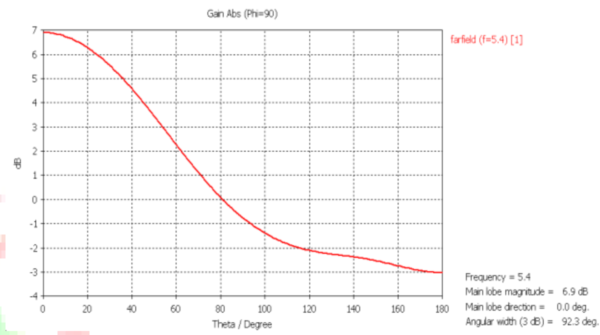

Fig.14. Gain for the designed antenna

B. Current distribution & Radiation pattern

With a series of simulations it is seen that the magnetic current at the central region and the electric current on the patch region of the antenna around the edges is crucial for resonance & radiation characteristics of such antenna.

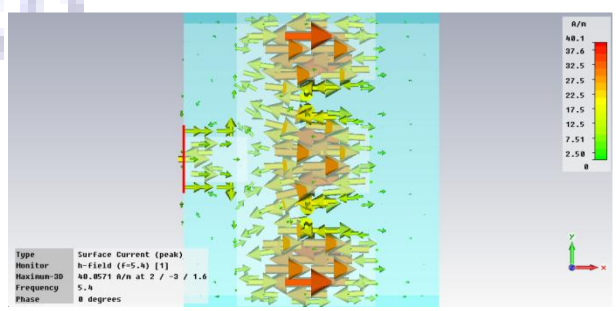

Fig.15. Simulated current density on the surface of the antenna at 5.5GHz .

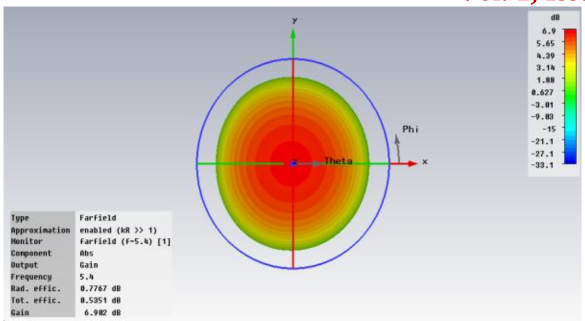

Fig.16. Radiation Pattern of E-slotted antenna.

The radiation pattern gives an insight into the manner in which antenna radiates at a particular frequency band. The designed antenna gain is 6.90dB as shown in fig. 16.

V. CONCLUSION

In this paper we present a design of a novel slotted E-shaped Microstrip patch Antenna with reduced Ground Plane structure to enhance the bandwidth of the conventional Microstrip Patch Antenna to be used in WLAN applications. Simulated results indicate that the antenna exhibits a good impedance bandwidth of 610MHz at a resonating frequency of 5.4GHZ. A return loss S11 parameter is found to be -30.64dB, and considerable antenna gain of 6.90dB at the designed frequency.

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