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Analysis of the effect of substrate thickness on a rhombus shaped slot triangular Patch Antenna for WLAN application

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Abstract: ***A compact CPW fed rhombus shaped slot triangular patch antenna is proposed and analyzed. The radiating structure consists of a rectangular patch with a rhombus shaped slot to reduce the overall dimensions. The antenna is designed on FR4 substrate and characterized by measuring return loss, VSWR, gain and radiation pattern. The proposed antenna is configured with coplanar waveguide (CPW) feed and is suitable for WLAN applications. The model is analyzed for different substrate thicknesses using Finite Element Method based Ansoft High Frequency Structure Simulator***

Index Terms: CPW, Return loss, VSWR, WLAN.

I. INTRODUCTION

The design of an efficient wideband small size antenna for recent wireless applications is a major challenge. The microstrip patch antenna have found extensive applications in wireless communication systems owing to their advantages such as low profile, conformability, low fabrication cost and ease of integration with feed network. Microstrip patch antennas comes with drawback of narrow bandwidth, but wireless communication applications require broad bandwidth and relative high gain in order to achieve that we need to increase the substrate thickness, use of low dielectric substrates and various impedance matching feeding techniques and slotting techniques [1-2].

The printed slot antennas fed by coplanar waveguide (CPW). The CPW fed planar slot antennas possess features like wide impedance bandwidth, omni-directional radiation pattern, constant gain, low profile, high radiation efficiency with simple structures, low radiation loss, less dispersion and easy integration to monolithic microwave integrated circuits. Therefore, CPW fed planar slot antennas are most promising design for wideband wireless applications [3-5].

A compact CPW-fed patch antenna with slots and mitered corners to meet the specifications of WLAN bands is proposed. Characteristics of the proposed antenna are simulated using High Frequency Structure Simulator.

II. ANTENNA DESIGN

The antenna is designed on FR4 substrate of thickness 2.5 mm with dielectric constant, $\varepsilon_r = 4.4$. A 50Ω CPW fed transmission line which consists of a single strip having width of 4 mm is used to feed the antenna as shown in Figure 1. The overall size of the antenna is 30mm x 27mm x 2.5mm. A triangle of base 10mmand height 5mm is attached to the feed line and a slot of shape rhombus is made in ground to reduce the size of the antenna and to increase the performance. The gap between the ground and patch is 0.2mm.

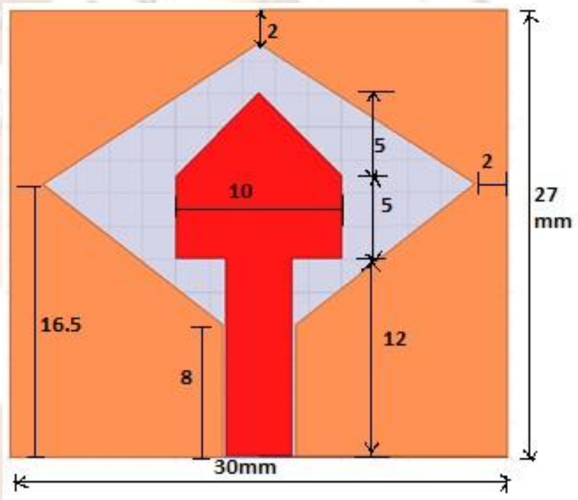

Figure 1: Proposed Antenna Structure

The antenna with the proposed geometry is analyzed using High Frequency Structure Simulator. It exhibits a Voltage Standing Wave Ratio (VSWR) of less than 2 in the operating frequency range with less Return Loss and acceptable Gain quasi omni-directional and bi-directional radiation patterns. A comparative analysis is made by varying the substrate thickness and its effect on Return Loss and Resonant frequency variation is observed.

III. RESULTS AND DISCUSSION

A CPW fed rhombus shaped slot antenna with triangular patch is simulated and it exhibited a resonant frequency at 5.84 GHz which can be used for WLAN application. The antenna can be operated in a frequency range of 5.4GHz to 6.3GHz. The Return Loss at the resonant frequency is -48.9 dB and the plot is shown in figure 2.

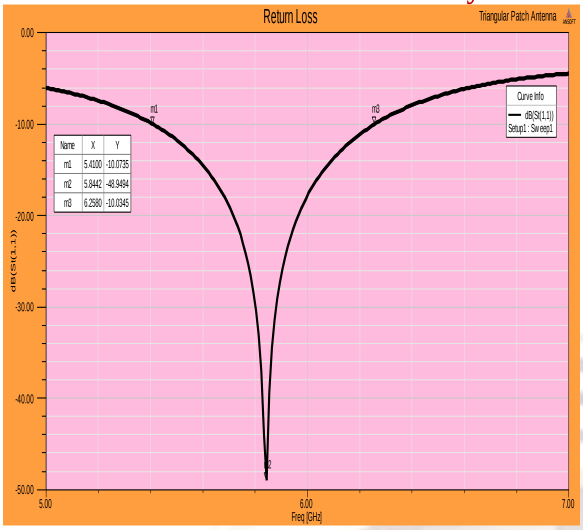

Figure 2: Return Loss – S11 vs. Frequency

The proposed antenna is tested for various substrate thicknesses of 1 mm, 1.5 mm, 2mm and 2.5 mm. From the Figure 3, when the substrate thickness increases, the reflection loss of the antenna is reduced and the resonant frequency is shifted towards the left. When h = 1mm, 1.5 mm, 2 mm, 2.5 mm, the corresponding return losses are -34 dB, - 37 dB, -39 dB and – 48.9 dB respectively.

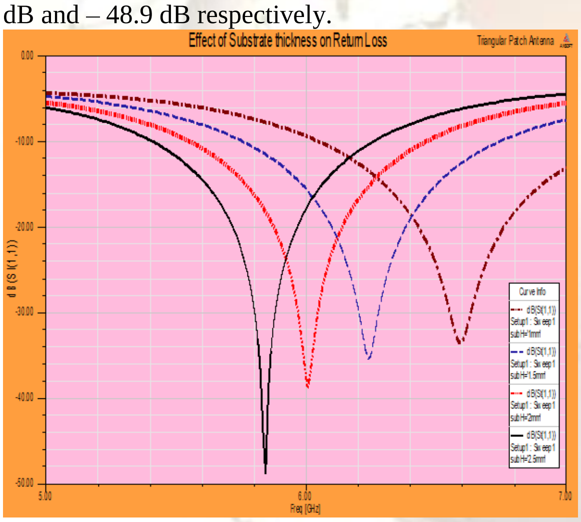

Figure 3: Return Losses for different substrate thickness

It is clear from the Figure 4 that the simulated voltage standing wave ratio (VSWR) of the proposed antenna is less than 2 for entire frequency range of 5.4 GHz to 6.3 GHz. At 5.84 GHz, the VSWR value is 1.01.

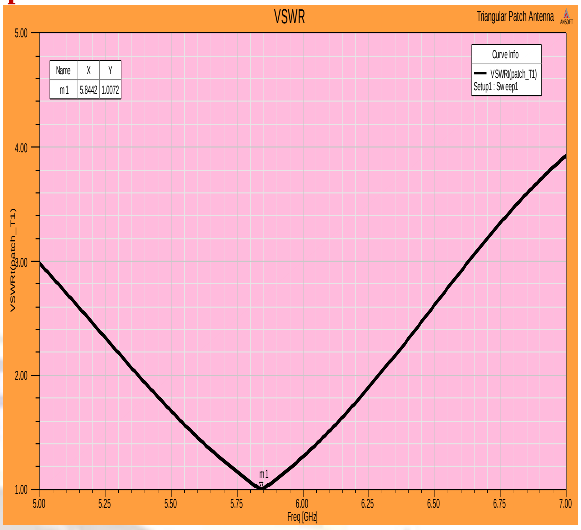

Figure 4: VSWR vs. Frequency

Figure 5 shows the input impedance smith chart. The impedance bandwidth of 15.4% is attained from the current design

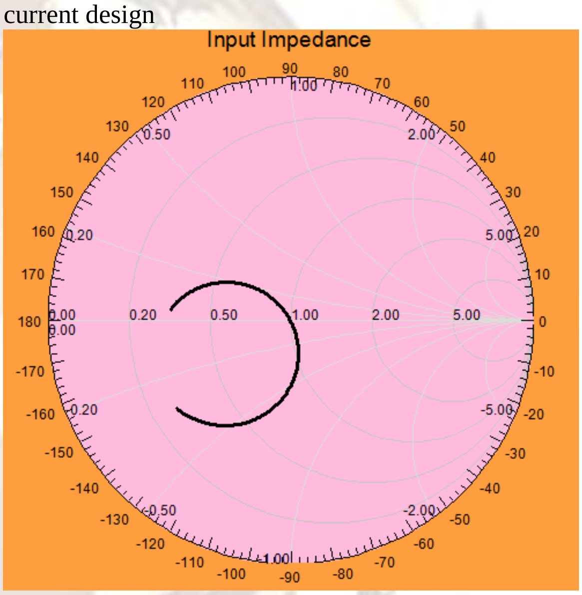

Figure 5: Input Impedance Smith Chart

The antenna gain is observed and displayed in Figure 6. It represents Gain versus Frequency plot. At 5.84 GHz, the antenna gain is 3.9 dBi owing to high return loss of -48.9 dB. Antenna gain is often related to the gain of an isotropic radiator, resulting in units dBi.

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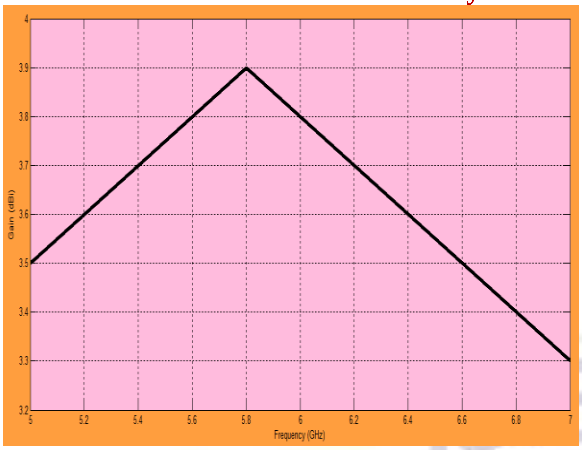

Figure 6: Gain vs. Frequency

Figures (7), (8) show the radiation pattern of the antenna. The far-zone electric field lies in the E-plane and far-zone magnetic field lies in the H-plane. The patterns in these planes are referred to as the E and H plane patterns respectively. Figure 7 shows the radiation pattern in E-plane for Phi=0 degrees and Phi=90 degrees. Figure 8 shows the radiation pattern in H-plane for Theta=0 degrees and Theta=90 degrees.

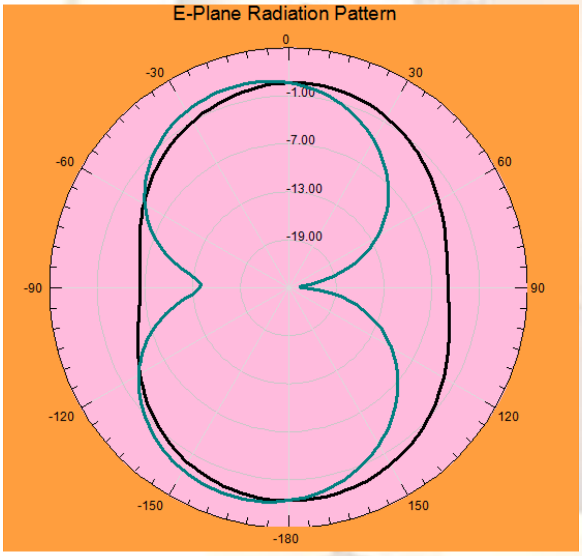

Figure 7: E-Plane Radiation Pattern at Phi=0 deg and Phi=90 deg

Figure 9 represents the meshing of proposed antenna ground and patch. Table 1 represents the output parameters of the antenna like Peak Directivity, Radiated Power and Radiation Efficiency etc.

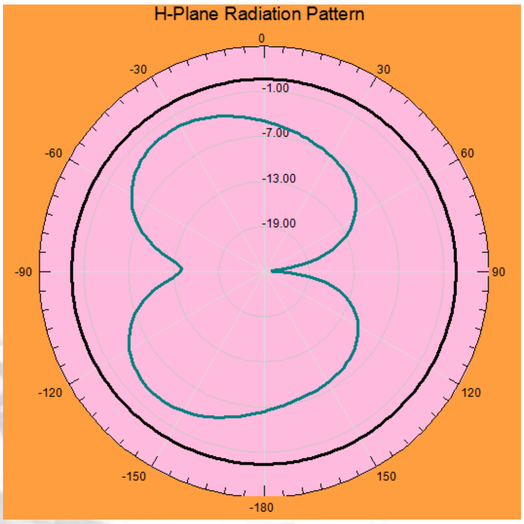

Figure 8: H-Plane Radiation Pattern at Theta=0deg and Theta=90 deg

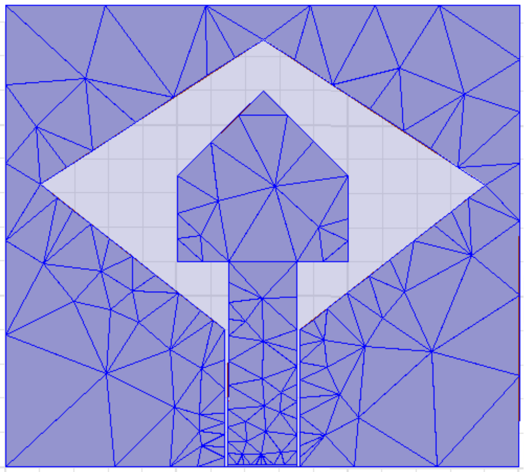

Figure 9: Mesh Generation

S. No	Quantity	Value at 5.84 GHz
1	**Max U**	0.0021184 W/sr
2	**Peak Directivity**	2.9346
3	**Peak Gain**	2.6944
4	**Peak Realized Gain**	2.6621
5	**Radiated Power**	0.0090714 W
6	**Accepted Power**	0.0098801 W
7	**Incident Power**	0.01 W
8	**Radiation Efficiency**	0.91814

Table 1: Antenna output parameters

IV. CONCLUSION

A CPW fed triangular shaped patch antenna with rhombus shaped slot is proposed for Wireless Local Area Network (WLAN) application at 5.4 GHz. The size of the antenna is compact and prototyped on FR4 substrate of thickness 2.5mm. The effect of substrate thickness on the Return Loss and Resonant frequency shifts is observed. The fundamental parameter Return Loss is less than -10dB and VSWR is less than 2. A satisfactory gain of 3.9 dBi is achieved.

V. ACKNOWLEDGMENT

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