RESEARCH ARTICLE OPEN ACCESS

Broadband Rhombus Shaped Microstrip Patch Antenna With U Shaped Slot For Wimax Applications

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ABSTRACT
The aim of this paper is to enhance the bandwidth of Rhombus ShapedMicrostrip Patch Antenna.For this purpose, we cut 'U' shaped slot in the proposed antenna geometry. The dielectric substrate material of the antenna is glass epoxy FR4 having ε_r=4.4 and loss tangent 0.025. The performance of the final modified antenna is compared with that of a conventional Rectangular Patch Microstrip Antenna and conventional Rhombus Shaped Microstrip Patch Antenna. The designed antenna has two resonant frequencies 5.20 GHz and 5.58 GHz. So this antenna is best suitable for the WiMax applications. The designed antenna offers much improved impedance bandwidth 22.32%. This is approximately six times higher than that in a conventional rectangular patch antenna (Bandwidth= 3.6%) having the same dimensions.
***Keywords*–** Broadband, FR4 substrate, slot, Gain, Resonant frequency

I. INTRODUCTION

In the recent years, there has been rapid growth in wireless communication. Day by day users are increasing, but limited bandwidth is available and operators are trying hard to optimize their network for larger capacity and improved quality coverage. This surge has led the field of antenna engineering to accomadte the need for broadband, low cost miniaturized and easily integrated antennas[1]. The microstrip patch antenna has 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 come with a drawback of narrow bandwidth, but wireless communication applications require broad bandwidth and relatively high gain [2]. The serious problem with patch antenna is their narrow bandwidth due to surface wave losses and large size of the patch. As a result, various techniques to enhance the bandwidth are proposed [3]. Microstrip antennas are very popular nowadays due to their unbeaten advantage and qualities. The shape of antenna varies according to their use, the work is continuously getting occurred to achieve faithful factors, by small size antenna for broadband communication [4]. Several techniques have beenused to enhance the bandwidth by interpolating surface modification in patch configuration [5].

In past decades of communication world, microstrip antennas have played an active role and have become a major research topic due to their advantages and ease in fabrication and integration with solid state devices [6-9]. To increase the bandwidth of the proposed antenna, a 'U' shaped slot is introduced at the middle side of the antenna geometry.

This paper has four sections. Section I deals with brief introductions and literature survey. Geometry of proposed antenna is discussed in section II. Simulations and result analysis is elaborated in section III. Section IV concludes the paper.

II. ANTENNA DESIGN

In the designing process, first of all a conventional Rectangular Patch Microstrip Antenna(RPMA) is considered. Dimension for this conventional patch were taken as Length L=36 mm and Width W= 42 mm. FR4 substrate is used to design the antenna. The dielectric constant of FR4 is 4.4, loss tangent is 0.025 and the thickness of FR4 substrate is 1.6 mm. The coaxial probe feed technique is used to excite the patch. Design and simulation process were carried out using IE3D simulation software 2007 version 12.30. The geometry of the RPMA is depicted in figure 1.

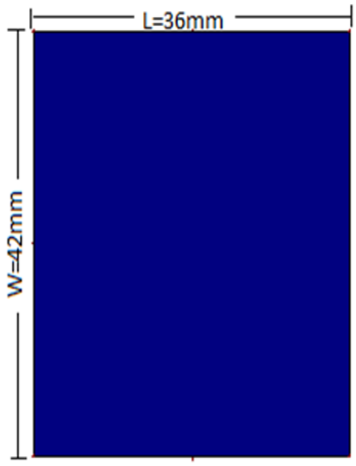

Figure 1: Geometry of Conventional RPMA

III. RESULTS

The conventional rectangular patch microstrip antenna is simulated first using IE3D software. This simulated reflection coefficient curve shows that the conventional rectangular patch microstrip antenna is resonating at frequency 4.99 GHz as shown in figure2.

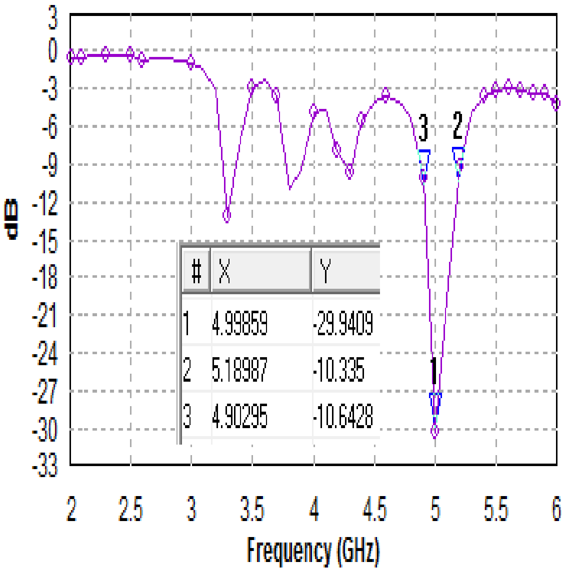

Figure 2: Variation of Reflection Coefficient v/s Resonant Frequencies

The value of impedance bandwidth of this antenna is 3.6%. The simulated input impedance of the antenna at resonance frequency 4.99 GHz is (48.96- j 2.69) ohm which is close to 50 ohm impedance. Since the RPMA has low bandwidth, so to improve the bandwidth some modification is done in the geometry of RPMA. A Rhombus Shaped Microstrip Patch Antenna (RSMPA) is designed by cutting four triangles from the corner sides of RPMA. The structure of Rhombus Shaped Microstrip Patch Antenna (RSMPA) is shown in figure 3.

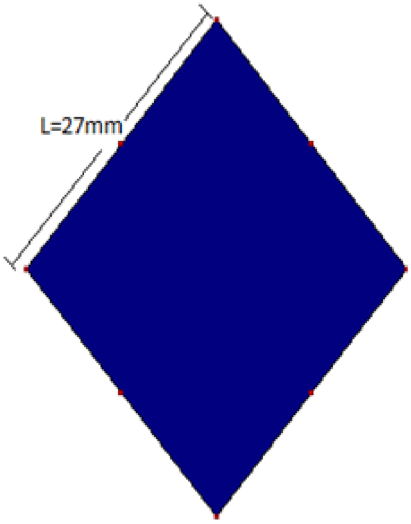

Figure 3: Structure of RSMPA

Variation of reflection coefficient with resonance frequency is depicted in figure 4.

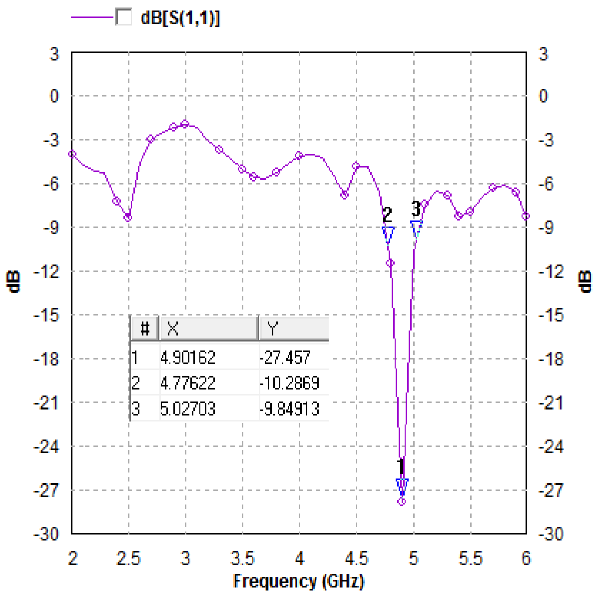

Figure 4: Variation of Reflection Coefficient v/s Resonance Frequency

It shows that RSMPA is resonating at 4.90 GHz frequency. So after modification, the value of impedance bandwidth is 5.1%. The simulated result shows that the input impedance at resonant frequency 4.90 GHz is (50.42 – j5.21) ohm which is very close to 50ohm. Still, a precise bandwidth is not obtained. So in the next step of designing process, a U shaped slot is introduced in the geometry of RSMPA to get wider bandwidth. The structure of RSMPA with 'U' shaped slot is shown in figure 5.

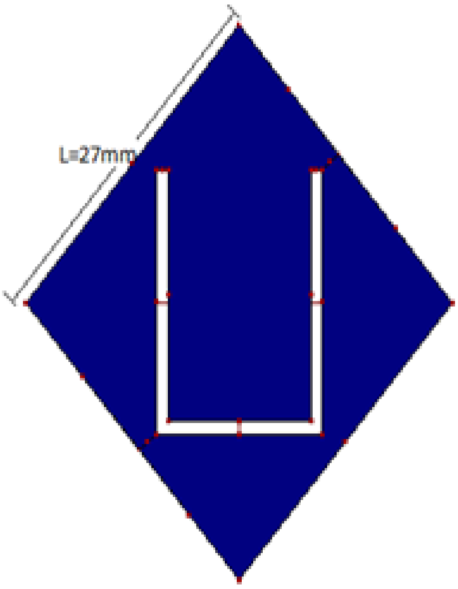

Figure 5: Structure of RSMPA with 'U' shaped slot

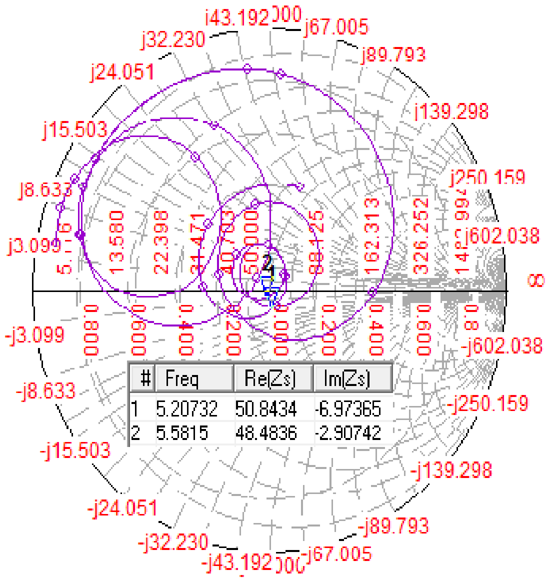

Figure 7: Smith chart curve

The figure 6 shows the variation of reflection coefficient with resonant frequencies.

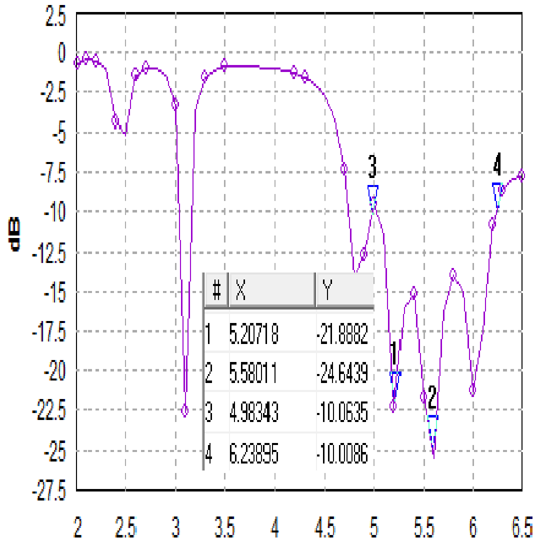

Figure 6: Variation of Reflection Coefficient v/s Resonance Frequencies

It shows that the after introducing 'U' shaped slot in RSMPA, the antenna is resonating at two resonant frequencies 5.20 GHz and 5.58 GHz. In this case the obtained bandwidth is 22.32%. So finally a broadband antenna is achieved. The smith chart for this antenna is shown in the figure 7. At the resonant frequencies 5.20 GHz and 5.58 GHz input impedances are (50.84- j 6.97) ohm and (48.48 – j2.90) ohm respectively.

The gain curve for this modified RSMPA antenna is shown in figure 8. The simulated gain at frequencies 5.20 GHz and 5.58 GHz are 0.21 dBi and 1.31 dBi respectively.

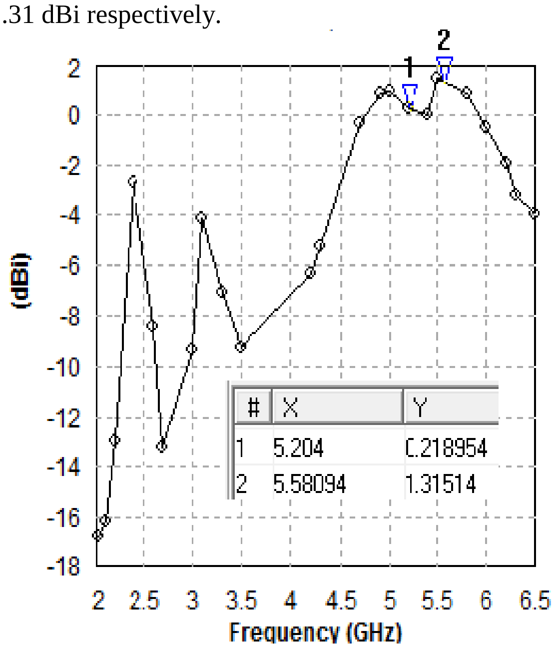

Figure 8: Variation of gain v/s resonance frequencies

The curve between directivity and resonant frequencies is shown in figure 9. The directivity of this antenna is 7.59 dBi and 6.58 dBi for the resonant frequencies 5.20 GHz and 5.58 GHz respectively.

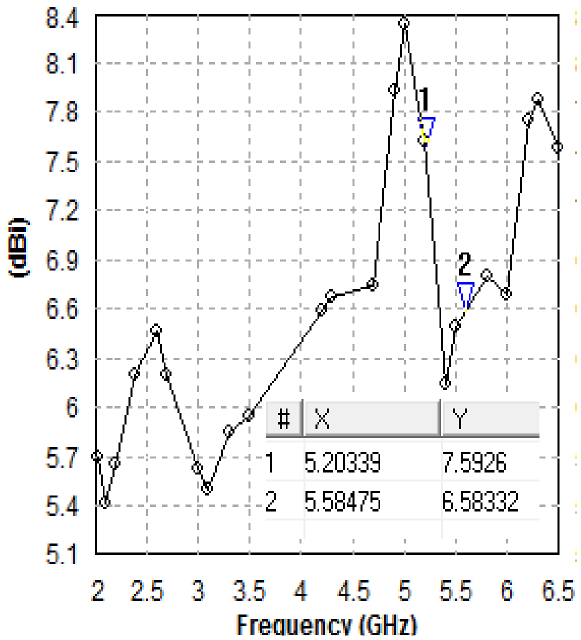

Figure 9: curve between directivity and resonant frequencies

The curve between radiation efficiency and resonant frequencies is shown in figure 10.

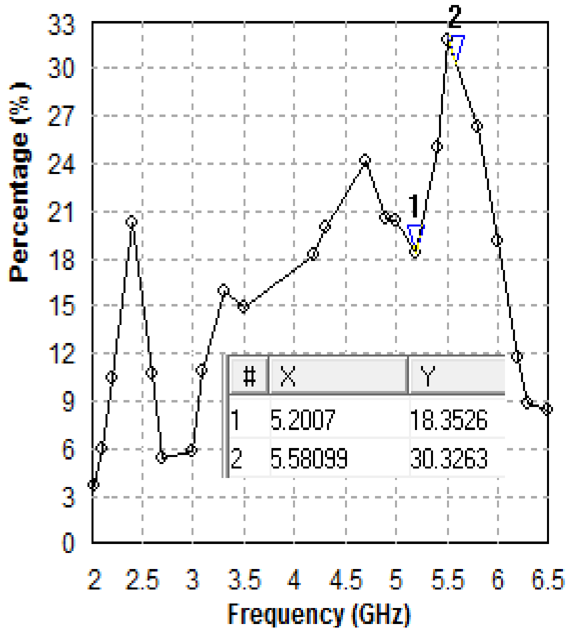

Figure 10: curve between radiation efficiency and resonant frequencies

The radiation efficiency of the antenna is 18.35% at 5.20 GHz and 30.32 % at 5.58 GHz. The variation of VSWR with the resonance frequencies is shown in figure 11. The values of VSWR at resonance frequencies 5.20 GHz and 5.58 GHz are 1.18 and 1.12 respectively.

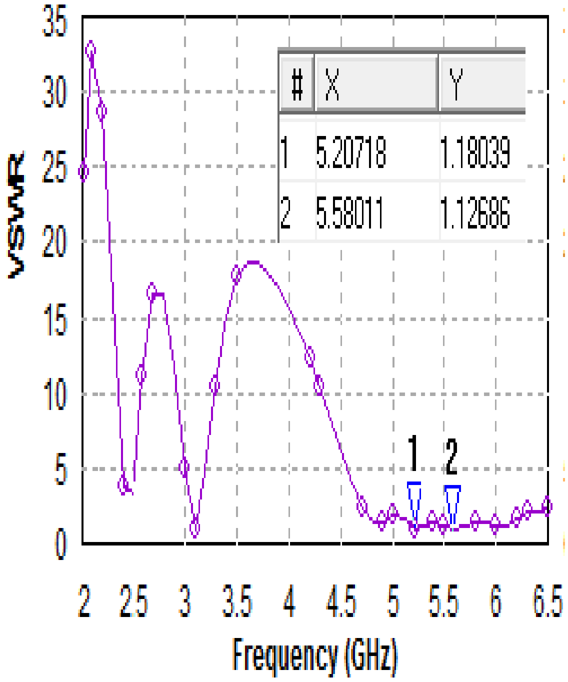

Figure 11: curve between VSWR and resonant frequencies

The radiation patterns of resonant frequencies 5.20 GHz and 5.58 GHz are shown in figure 12 and figure 13 respectively.

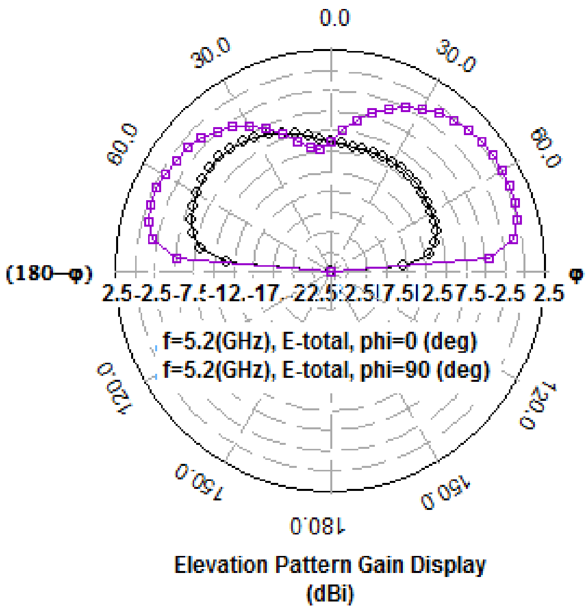

Figure 12: 2D polar Radiation pattern at 5.2 GHz

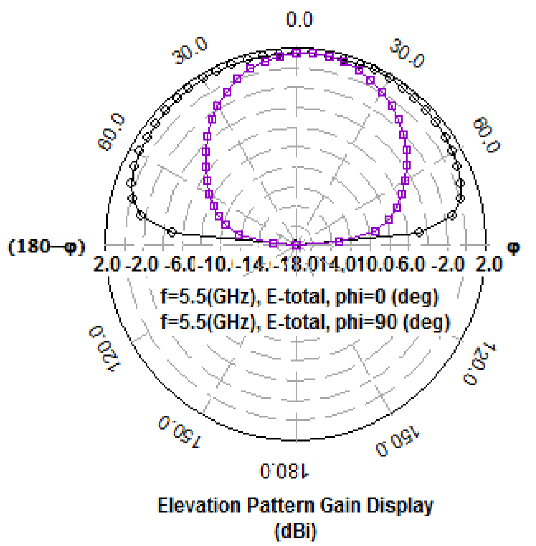

Figure 13: 2D polar Radiation pattern at 5.5 GHz

At 5.20 GHz the direction of maximum radiation is shifted 60° left and 60° right side to normal to the patch geometry. At 5.5 GHz the direction of maximum radiation is normal to the patch.

IV. CONCLUSION

The proposed Rhombus Shaped Microstrip Patch Antenna with 'U' shaped slot resonates at two frequencies 5.20 GHz and 5.58 GHz. By using this antenna we got much improved bandwidth of 22.32% in comparison with a conventional rectangular patch antenna having a bandwidth of 3.6%. The designed antenna exhibits a good impedance matching of about 50 ohm. From the analysis of simulated results it can be verified that the proposed antenna is best suitable for WiMax applications.

V. ACKNOWLEDGEMENT

The authors would like to express their gratitude towards Dr. Rakesh Duggal, Director, Poornima Group of Institutions, Jaipur for his kind cooperation in this research work.

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