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An Improved Bandwidth for Electromagnetic Gap Coupled Rhombus Shaped Microstrip Patch Antenna for C Band Application

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ABSTRACT
This paper presents simulation and analysis of a Stacked Electromagnetic Gap Coupled Rhombus Shaped Microstrip Patch Antenna (SEGCRSMPA) to increase the bandwidth. The aim of this paper is to improve the bandwidth of Electromagnetic Gap Coupled Rhombus Shaped Microstrip Patch Antenna (EGCRSMPA). To improve the bandwidth, stacking principle has been used. In this paper an assembly of one central rectangular patch with four triangular patches forming rhombus shaped microstrip patch antenna is discussed. IE3D simulation software is used for simulation. The performance of the proposed microstrip patch antenna is compared with that of a conventional rectangular microstrip antenna and EGCRSMPA having same dimensions. The proposed designed microstrip patch antenna offers much improved impedance bandwidth 47.62%.
Keywords- Broadband, Stacked, Electromagnetically coupled, FR4 Substrate, Gain

I. INTRODUCTION

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[1-2]. The shape of antenna varies according to their use, gain and bandwidth they support [3]. In the method of air gap filled substrates anair gap is added to the substrate to reduce the dielectric constant of the feeding substrate. This consequently increases the bandwidth [4].Achieving broadband behavior in microstrip antennas have always been challenging. Literature approves successful implementation of different broad banding techniques such as multilayer stacked patches. This consequently increases the bandwidth [5].

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 GEOMETRY AND DESIGN

The proposed antenna consists of two patches placed in front of each other and separated with air gap whose dielectric constant is unity. A cross sectional view of the proposed antenna structure is shown in figure 1.

In order to have increase in bandwidth stacking of microstrip patch antenna is done. Modified antenna structure is radiated by electromagnetic gap coupling technique. A comparative analysis is done by varying the air gap between the two patches i.e. top patch and bottom patch and observing its effect on antenna performance.

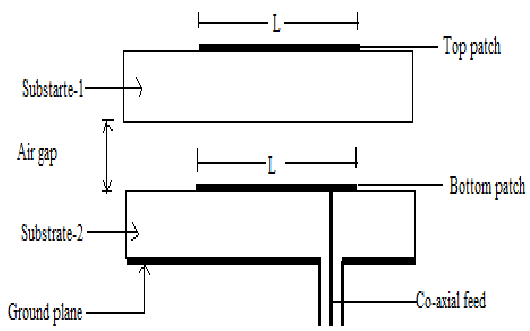

Figure 1: Cross section view of the proposed antenna

In the designing process initially an Electromagnetic Gap Coupled Rhombus Shaped Microstrip Patch Antenna (EGCRSMPA) with 0.8 mm gap coupling has been considered. Dimension of patch is 40 mm x 64 mm. Substrate used is FR4. The Z top for FR4 substrate is 1.6 mm, loss tangent is 0.025 and dielectric constant is 4.4. Simple coaxial probe feed technique is used to excite the patch. The geometry of this antenna is presented in figure2.

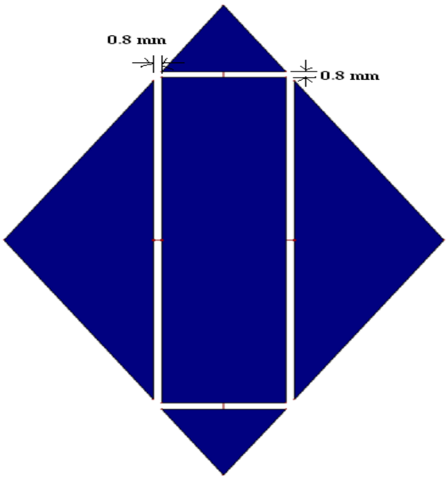

Figure 2: Structure of EGCRSMPA with 0.8mm gap coupling

III. SIMULATION AND RESULT ANALYSIS

The proposed design is an enhanced version of our previous paper where we have obtained the bandwidth 25.71 % [6].

In the designing process, initially two EGCRSMPA has been considered with an air gap of 0.2 mm between them. This proposed antenna is identified as Stacked Electromagnetic Gap Coupled Rhombus Shaped Microstrip Patch Antenna (SEGCRSMPA). For this antenna, variation of reflection coefficient with frequency is shown in figure 3. It shows that the antenna is resonating at resonant frequencies 5.29 GHz and 6.39 GHz.

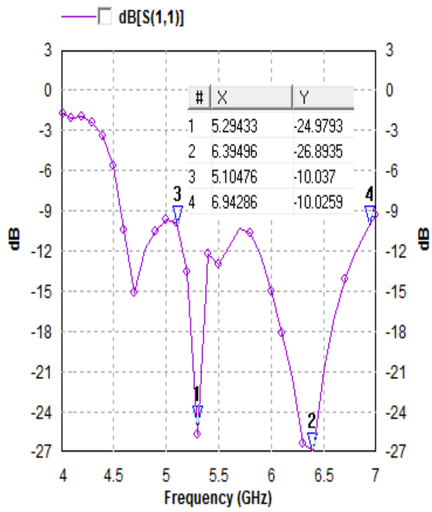

Figure 3: Variation of Reflection Coefficient v/s Resonance Frequencies of SEGCRSMPA with 0.2 mm air gap coupling

After modification the obtained bandwidth is 29.90% as indicated in the figure 3. The performance is better than the previous one. To improve the performance further modification is proposed by increasing the air gap between the two patches. By keeping the air gap of 0.8 mm between the two patches the obtained bandwidth is 47.62%.

The feed point is at X= 04 mm and Y= 10 mm. The reflection coefficient curve with respect to resonance frequencies is shown in figure 4.

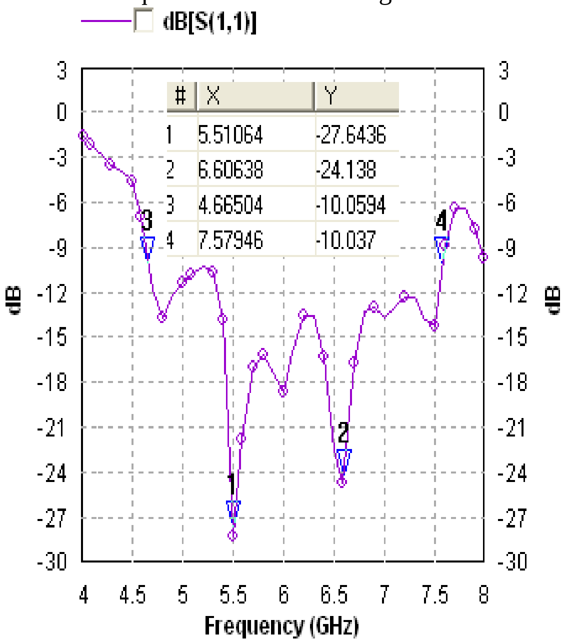

Figure 4: Variation of Reflection Coefficient v/s Resonance Frequencies of SEGCRSMPA with 0.8mm air gap coupling.

It is clear from figure 4 that this antenna mainly resonates at frequencies 5.51GHz and 6.60GHz. The bandwidth offered by this antenna is now 47.62%. This is approximately seven times higher than that in a conventional rectangular patch antenna having the same dimension. The smith chart of this antenna is depicted in figure 5. It may be further verified that the impedances are (51.65-j2.01) ohm and (48.84-j6.27) ohm at two resonant frequencies 5.51GHz and 6.60GHz respectively.

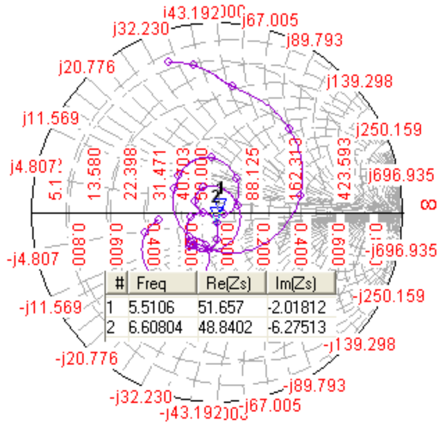

Figure 5: Smith chart for SEGCRSMPA with 0.8mm air gap coupling

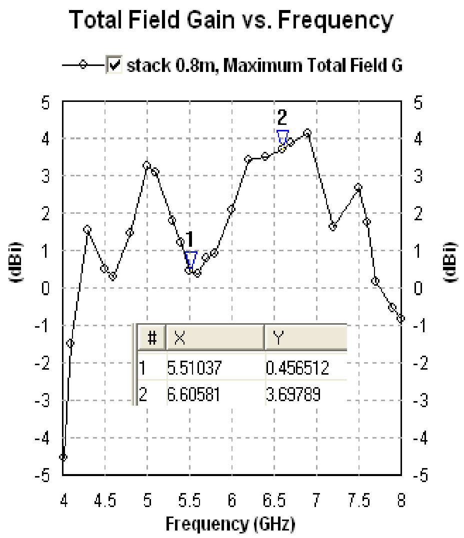

Figure 6: Variation of gain v/s resonance frequencies

Figure 6 shows the gain curve for this SEGCRSMPA. The simulated gain at frequencies 5.51 GHz and 6.60 GHz are 0.45 dBi and 3.69 dBi respectively. So finally a broadband antenna has been achieved. The curve between directivity and resonant frequencies is shown in figure 7. The directivity of this antenna is 8.73 dBi and 8.24 dBi for the resonant frequencies 5.51 GHz and 6.60 GHz respectively.

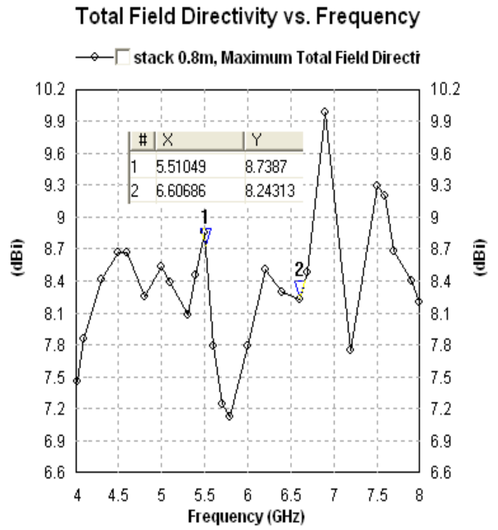

Figure 7: Curve between directivity and resonant frequencies

The curve between radiation efficiency and resonant frequencies is shown in figure 8.

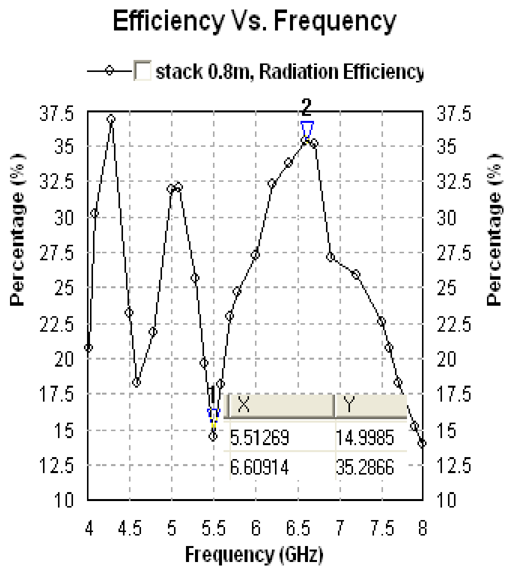

Figure 8: Curve between radiation efficiency and resonant frequencies

The radiation efficiency of the antenna is 14.99 at 5.51 GHz and 35.28 at 6.60 GHz. The variation of VSWR with the resonance frequencies is shown in figure 9.

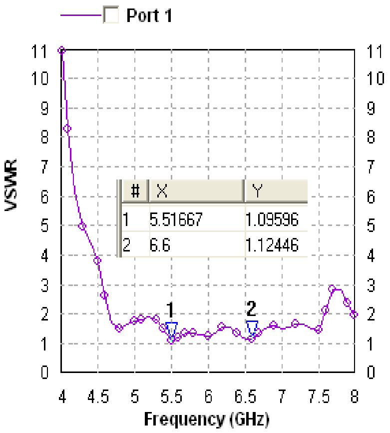

Figure 9: Curve between VSWR and resonant frequencies

The values of VSWR at resonance frequencies 5.51 GHz and 6.60 GHz are 1.09 and 1.12 respectively. The achieved VSWR at the resonant frequencies is remarkable since the VSWR should be equal to unity for the good performance of the antenna. The radiation patterns of resonant frequencies 5.51 GHz and 6.60 GHz are shown in figure 10 and figure 11 respectively

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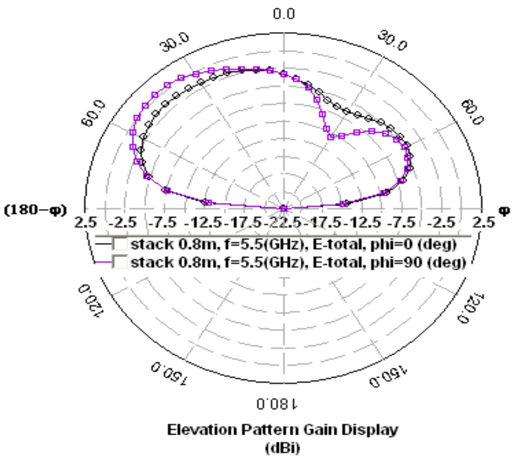

Figure 10: 2D polar Radiation pattern at 5.5 GHz

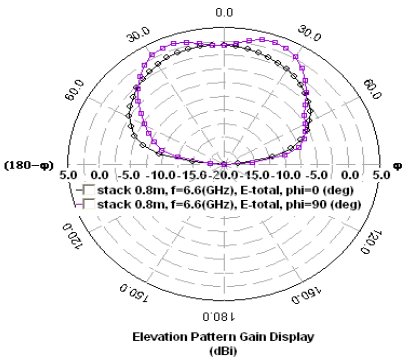

Figure 11: 2D polar Radiation pattern at 6.60 GHz

The direction of maximum radiation is shifted 30° left at 5.5 GHz to normal to the patch geometry. At 6.60 GHz the direction of maximum radiation is shifted 30° left and 30° right side of the normal to the patch as represented.

The graph shown in figure 12 clearly indicates the comparative results of air gap coupling on the bandwidth parameter of the proposed antenna.

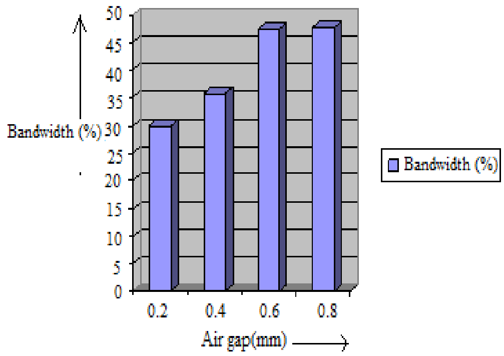

Figure 12: Graph comparing bandwidth of proposed antenna with respect to air gap coupling

IV. CONCLUSION

The proposed Stacked Electromagnetic Gap Coupled Rhombus Shaped Microstrip Patch Antenna (SEGCRSMPA) having a central rectangular patch with 0.8 mm air gap coupling resonates at two frequencies 5.51GHz and 6.60 GHz for C band applications. The designed antenna enhances the gain up to 3.69 dBi, this is quite encouraging. By using this antenna much improved bandwidth of 47.62 % has been achieved which is approximately two times higher in comparison with an Electromagnetic Gap Coupled Rhombus Shaped Microstrip Patch Antenna (EGCRSMPA) having a bandwidth of 25.71%.

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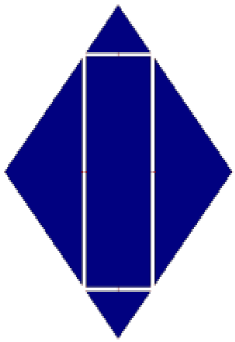
Table I: Variation of Antenna parameters for SEGCRSMPA with the air gap

Air gap between top patch & bottom patch(mm)	Designed Antenna	Resonating Frequency(GHz)	Gain(dBi)	Directivity(dBi)	Bandwidth(%)
0.2		5.29 6.39	-1.16 3.69	8.10 9.02	29.90
0.4		5.40 6.50	-0.78 2.85	8.36 8.16	35.63
0.6		5.49 6.50	0.045 03.28	8.59 8.13	47.29
0.8		5.51 6.60	0.45 3.69	8.73 8.24	47.62