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Improved S- Parameters and Radiation Characteristics of Dual Band Microstrip Patch Antenna by Using 2D Photonic Crystal Structure

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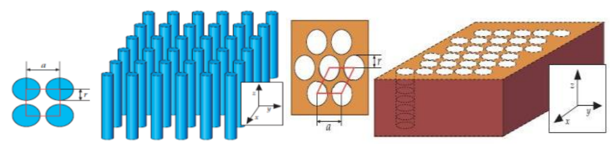
***Abstract* - Photonic crystal (PhC) structure is an artificial periodic dielectric structure which provides the controllability of photons whereas semiconductors show for electrons. In this paper, a concept of photonic crystal structure is used to design a microstrip patch antenna (MSA) to enhance the performance parameters. The CST microwave studio 2011 is used to design and simulate proposed MSAs. Improved S-parameters and radiation characteristics are achieved for 2.4GH$_z$ and 5.3GH$_z$ bands by using photonic crystal concept.**

***Keywords*— CST, Microstrip patch antenna, Photonic crystal structures, S-parameter**

I. INTRODUCTION

Photonic crystals depend on a periodic phonological microstructure which when allied into a material, causes a change its optical behavior. These are giving the accessibility to confine and modal the light in a cage. Essentially, the photonic crystal contains interior regions of high and low refractive index with regular repetition [1]. So we can organize it into three categories like one, two and three-dimensional photonic crystals [1, 2]. Mostly 2D photonic crystals are easy to fabricate and also provide better applications than others. There are two ways to make 2D PhCs; dielectric rods in air background and air holes in dielectric material as shown in fig.1.

There are many devices based on 2D photonic crystal structure and which are widely used in optical communication systems such as optical filters [3], sensors [4], logic gates [5], WDDM [6] etc. Similarly this concept is also utilized in the designing of microstrip patch antenna.



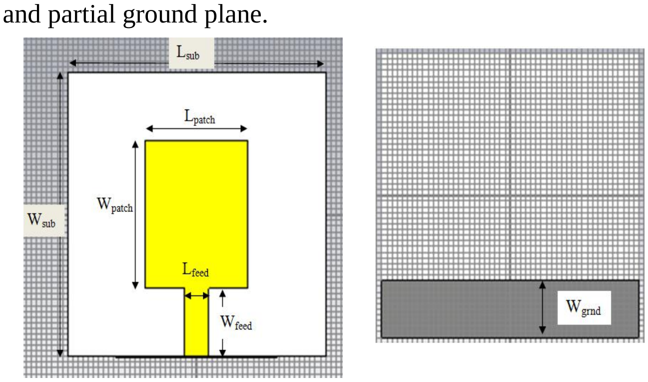
(a) (b)

Figure 1: A perfect look of 2D photonic crystal structure (a) Square lattice having the arrangement of Dielectric rods in air host (b) Another triangular lattice showing air holes in dielectric material as host [1].

The MSA is sandwiched structure of dielectric substrate between patch and ground plane. The concept of 2D crystal structure is achieved in patch as well as in substrate of MSA.

II. ANTENNA DESIGN AND RESULTS

First of all a microstrip patch antenna is designed without using concept of 2D photonic crystal structure. Fig. 2 represents geometry of proposed dual band microstrip patch antenna named MSA1 having a rectangular patch on dielectric substrate (Rogers RT5880 (lossy), epsilon 2.2) and partial ground plane.



(a) (b)

Figure 2: Geometry of proposed MSA1 (a) Front view (b) Back view

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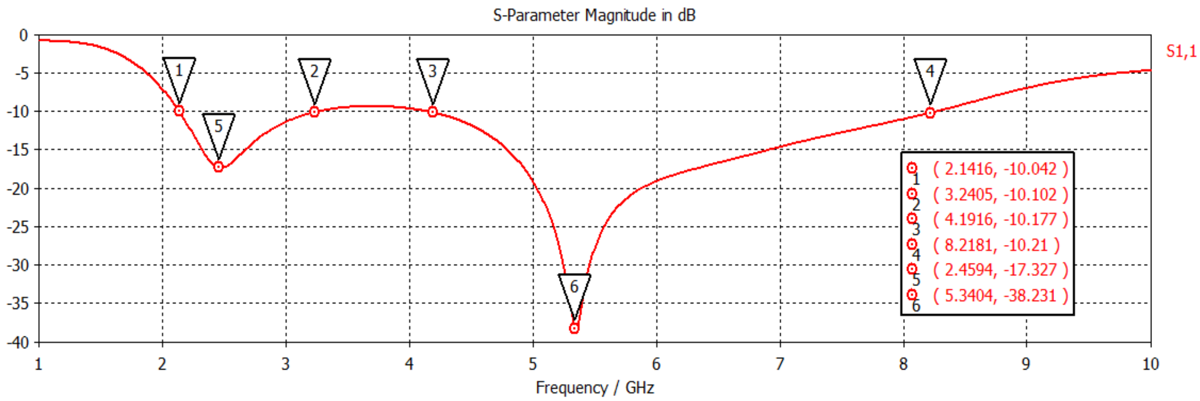
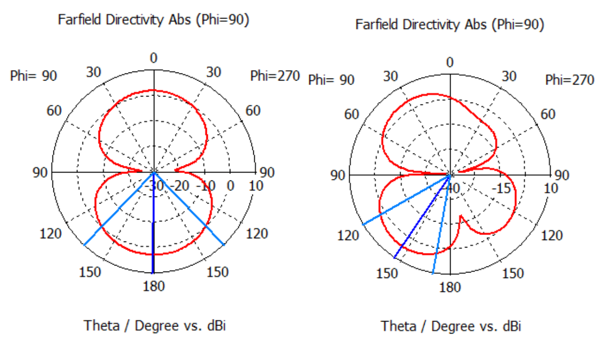


Figure 3: S - parameter magnitude in dB for MSA1

The rectangular patch has dimensions L_{patch} = 20mm and W_{patch} = 26mm. The substrate is taken of dimensions L_{sub} × W_{sub} × H_{sub} (50×50×1.575 mm^3). CST microwave studio is used to design and simulate MSA1. After successful implementation and simulation of MSA1, dual bands (2.13-3.277 GH_z) and (4.13- 8.24GH_z) for VSWR < -10dB are obtained. The frequencies 2.4 and 5.3GH_z are used for radiation characteristics. The s-parameters and radiation characteristics are obtained as shown in fig. 3.

It is very clear from the fig. 3 that MSA1 has novel VSWR notch of -17.327dB at 2.4GH_z and -38.23dB at 5.3GH_z. The radiation pattern of MSA1 is similar to '8' for both frequencies.



(a) **(b)**

Figure 4: Radiation characteristics for frequency (a) 2.4GH_z and (b) 5.3GH_z

Now another design named MSA2 is implemented based on 2D photonic concept in the rectangular patch shown in fig.5.

The periodic structure is obtained by repetitive air holes in the patch having radius of air holes is taken as '*r*' and distance between two successive air holes called lattice constant is taken '*a*'. All other dimensions are same as MSA1. These air holes are similar to slots cut from the patch.

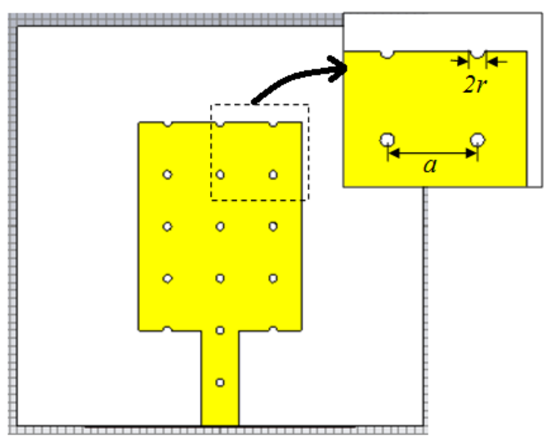


Figure 5: Front view of MSA2 with 2D crystal structure.

For optimized value of radius '*r'* and lattice constant '*a'* parameter sweep is taken as shown in fig.6 and fig.7.

The air hole's radius '*r'* is optimized from fig. 6 and taken as 0.5mm and lattice constant '*a'* is taken as 6.5mm for the better results which is clear from fig. 3 and fig. 6. Improved VSWR is obtained for MSA2 which is -18.27dB at 2.4GH_z and -47.93dB at 5.3GH_z.

As shown in fig. 8 that radiation pattern of MSA2 is improved than MSA1. It has wide coverage for both frequencies 2.4GH_z and 5.3GH_z.

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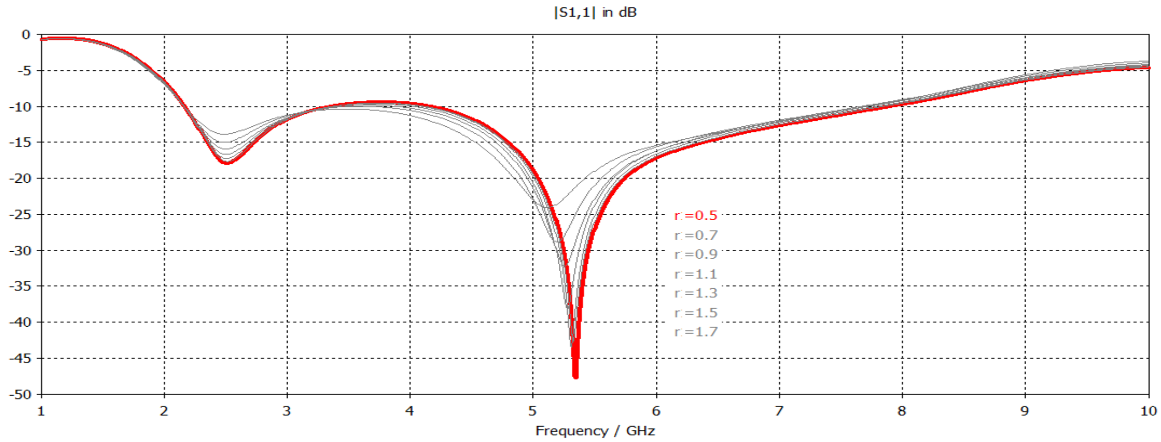


Figure 6: Parameter *'r'* sweeping from 0.5 to 1.7mm

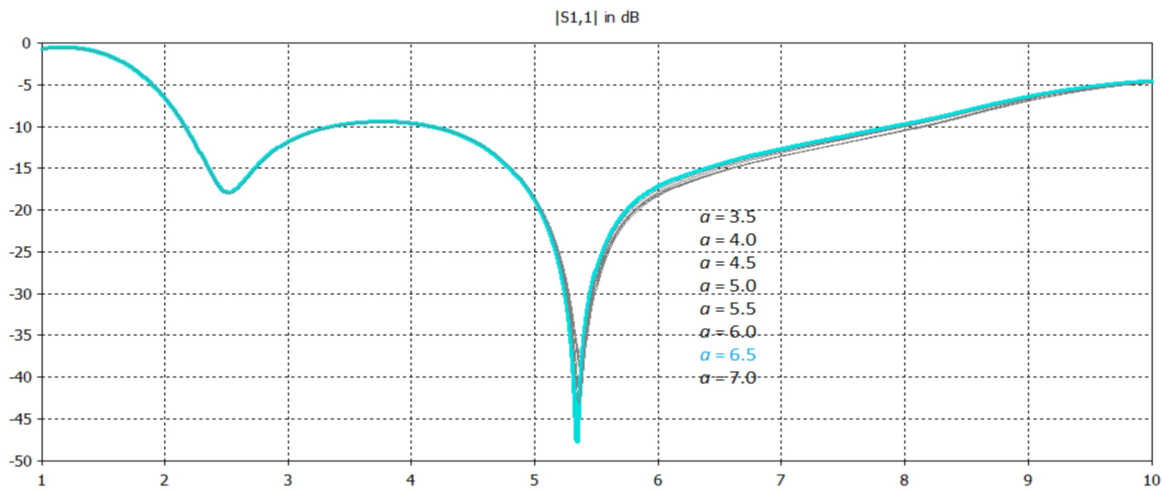
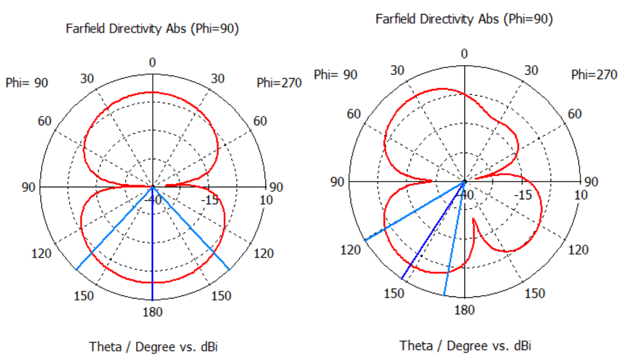


Figure 7: Parameter *'a'* sweeping from 3.0 to 14mm



(a) **(b)**

Figure 8: Improved radiation characteristics of MSA2

Now third design named MSA3 is implemented by using 2D PhC in the substrate (keeping all other parameters same as MSA1) which is shown in fig. 9.

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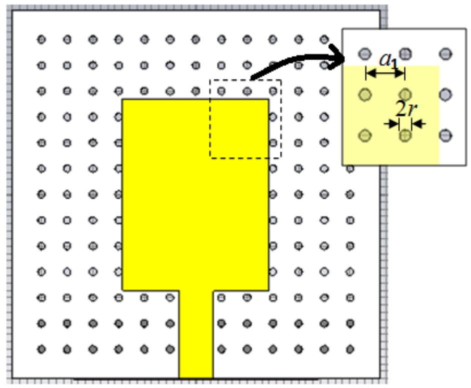


Figure 9: Front view of third proposed design of MSA3

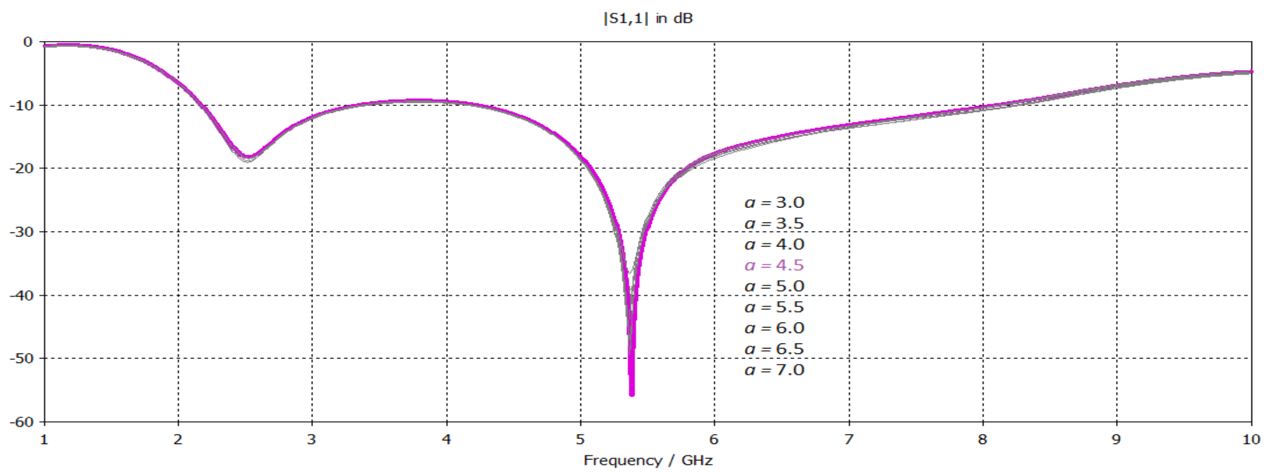
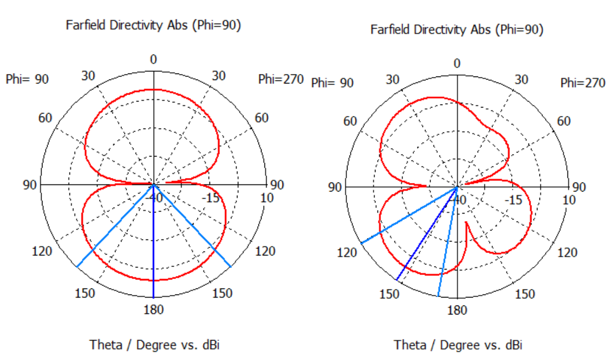


Figure 10: Parameter 'a_1'sweeping from 3.5 to 7.0mm

Again parameter sweeping is done for both radius 'r' and lattice constant 'a' and it is observed that radius is similar as MSA2 but lattice constant is different named as 'a_1'. In the design of proposed MSA3, lattice constant a_1 is optimized as 4.5mm which is shown in fig. 10.



(a) **(b)**

Figure 11: Improved radiation characteristics of proposed MSA3.

The radiation patterns are almost similar of MSA2 and MSA3 but are improved than MSA1. From the fig. 10 it is observed that for MSA3 the VSWR reading is -57.23dB which very improved data than MSA1 and MSA2. The comparative S-parameters of all three designs MSA1, MSA2 and MSA3 are plotted in fig.12.

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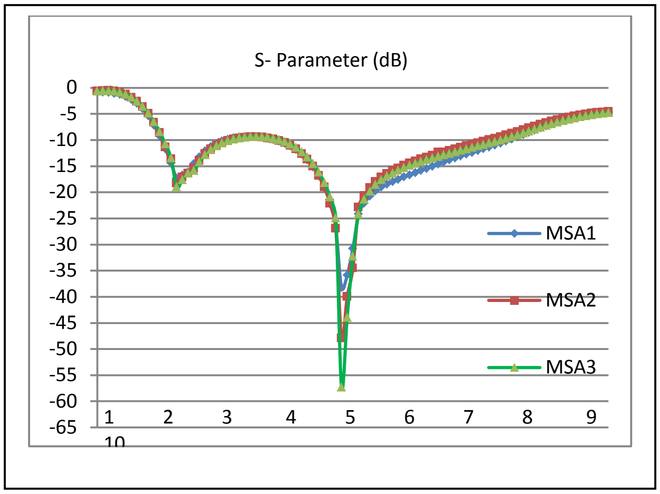

Figure 12: A comparative analysis of S- parameter of proposed three designs MSA1, MSA2 and MSA3.

III. CONCLUSION

All the work is concluded as three proposed design named MSA1, MSA2 and MSA3. Later two designs are based on 2D PhCs which show improved the S-parameter and radiation characteristics.

MSA1 has novel VSWR notch of -17.327dB at 2.4GH_z and -38.23dB at 5.3GH_z whereas MSA2 has -18.27dB at 2.4GH_z and -47.93dB (25.3% increased) at 5.3GH_z and MSA3 has -18.97dB at 2.4GH_z and -57.28dB (49.8% increased) at 5.3GH_z. The proposed designs have various applications such as Bluetooth, Wi-Fi / Wi- max, RFID etc. Further, various arrangement of air holes and their shapes can be implemented in future work.

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