Bandwidth Enhancement of a Narrowband Rectangular Microstrip Antenna on a Radial Electromagnetic Band-Gap (EBG) Patch Structure

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Abstract

Bandwidth enhancements have been one of the important but tricky niche areas for antennas researchers. There are a bountiful amount of ideas and techniques to accomplish and tackle the problem involved. A creative technique has been explored in enhancing the bandwidth of a rectangular patch antenna by introducing a radial Electromagnetic Band Gap (EBG) structure between a narrowband patch antenna and its ground plane. An increment of up to 8% BW has been realized and achieved. This paper present the methodology, simulations and experimental works carried out in accomplishing the objective above. Microwave Office 2006 software has been used to initially simulate and find the optimum design and results.

1. INTRODUCTION

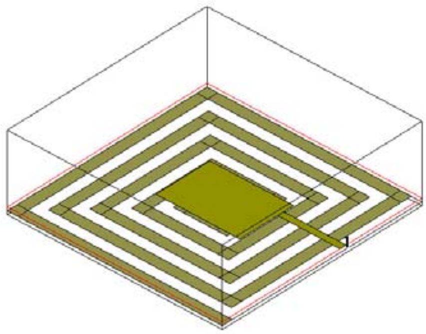
Electromagnetic bandgap (EBG) structures have two commonly employed configurations, namely the perforated dielectric and the metallodielectric structures. The perforated EBG structures consists of a periodically arranged air-columns, which effectively suppress unwanted substrate modes commonly exist in microstrip antennas, and on the other hand, the metallodielectric EBG structures consists of printed array of metallized elements, used to suppressed substrate modes [1]. The later exhibits an attractive reflection phase future where the reflected field changes continuously from 180° to -180° versus frequency. It allows a low profile wire antenna to radiate efficiently with enhance bore sight gain, reduced back radiation and side lobes levels [2].

EBG substrates have found possible applications in the antenna technology to improve performance like reducing mutual coupling between antennas on the same substrate or reduce side lobe effects due to truncated surface waves that would be excited in a standard antenna substrate [3]. EBG substrates can also be used to eliminate scan blindness phenomena presented in array antennas. EBG layers have also been used as a top cover of a Fabry-Perot Cavities to produce highly-directive radiators [4]. Recently, EBG structures have been used to mimic perfect magnetic conductors (PMC) over a narrow frequency range, for use as a ground plane in a low-profile antenna configuration [5].

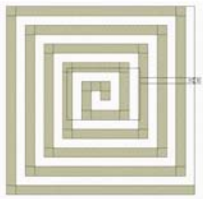
In this research, we focus our study on the effect of introducing a radial EBG patch structures between a narrow band resonator, a rectangular patch for this case, and the ground plane. A parametric study on the performance of the antenna, especially on enhancing the bandwidth was done using AWR simulation software and the optimum results was confirmed through fabrication of a model of the antenna (Figure 6). It was found that the results correlate well.

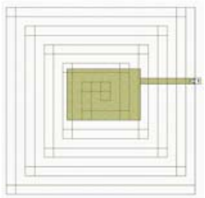
2. PARAMETRIC STUDY

A clockwise and an anticlockwise radial EBG patch structure were introduced between a narrowband; transmission line feed rectangular patch and its ground plane. This structure was chosen due to its simplicity of design and less time consuming when simulated using the AWR software. Figure 1 show the geometry of the antenna involves, which consist of two 1.6 mm thick FR4 substrate with an εr of 4.6, one with a rectangular resonator patch on the top plane and the other, with the radial transmission line (TL) shape EBG patch structure, on top of a ground plane. The width and length of the rectangular patch was calculated to resonate at 2.4 GHz while the width and length of the radial shape transmission line EBG patch structure was varied proportionally (Figure 1.b) to obtain the optimum results, as mentioned above.



(a)





(b) (c)

Figure 1 (a) Perspective view (b) The anticlockwise radial EBG patch structure (c) Rectangular patch Microstrip Antenna.

3. THE EFFECT OF INTRODUCING THE EBG STRUCTURE

Figure 2 and 3 shows the simulated and measured return loss for the narrowband antenna with an anticlockwise radial shape transmission line EBG structure at a different number of turns. By increasing the turns of the radial EBG patch structure, some good matching characteristics was observed and they shift to either lower frequencies, when they terminates at the right/left side of the Length side of the rectangular patch or shifted to the higher range of frequencies when they terminates at the top/bottom of the Width side of the rectangular patch, as shown in Figure 4.

The best results were observed when the turns reached 5 times and above. But this also means that the structure or the size of the overall patch increases too.

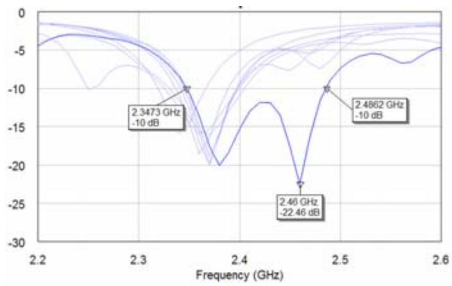


Figure 2: Simulated results of the Radial EBG Structure.

Figure 3: Measured results of 6 turns of the radial EBG structure.

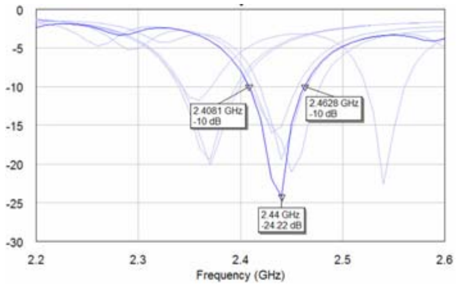


Figure 4: The resonance frequencies shift to the lower or higher frequencies depending on the position of the terminating ends of the radial EBG structure.

4. GROUND PLANE SIZE EFFECT

The ultimate goal in most AMC surfaces is to incorporate an antenna into the system to achieve a smaller, thinner and potentially lighter weight design compared to what would be possible using a conventional metallic (PEC) ground plane. So, in our study, the effect of the EBG structures' size on the antenna performance was also investigated.

Two different size of the EBG structure were designed, simulated, fabricated and measured. Both of the radial structure was fabricated on a 100mm x 100mm x 1.6mm FR4 substrate with dielectric constant of 4.6. The radial TL size (width) was varied until an optimum result obtained. Figure 5 below shows their simulated and measured return loss results. From the simulations results, it was observed that the bandwidth increases when the radial TL size (width) was decreased from 4mm to 3 mm and as the width of the radial TL decreases, the number of radials EBG structures also increases. As predicted, it can be seen that a smaller width and a larger number of radial turns can improve the matching performance and enhance the antenna's bandwidth up to more than 8%. The overall thickness of the antenna is 3.2mm.

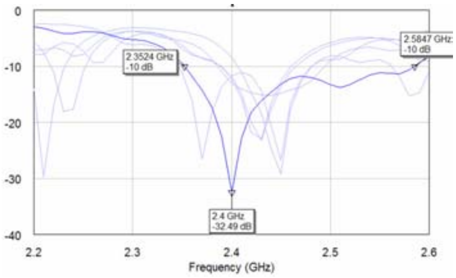


Figure 5: Simulation results shows a good return loss and an increment up to more than 8 % for a 6 turns of radial TL EBG structure.

5. CONCLUSION

An initial parametric study was done on the radial (TL) EBG structure positioned between a narrowband rectangular microstrip antenna and its ground plane. Simulated and measured results correlate well and a good return loss and impedance matching was observed which resulted in an increment of the bandwidth from 2 % to more than 8 %. Further investigation on the radiation characteristic using different feeding methods will be carried out in the future and different EBG structure's shape will also be look upon to.

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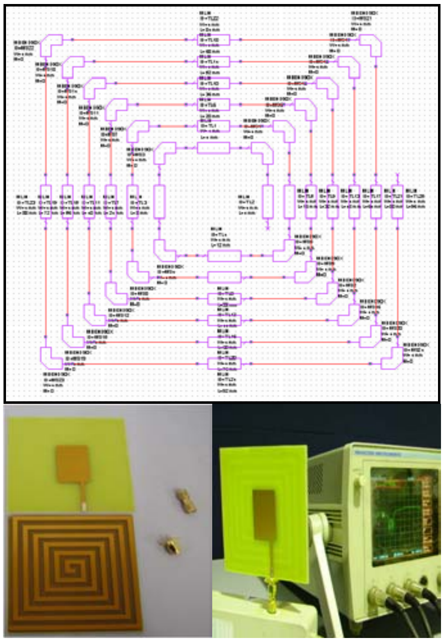

Figure 6: The circuit schematics and fabricated radial EBG patch Structure.