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

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Abstract **-** An innovative and novel technique has been explored in enhancing the bandwidth of a rectangular patch antenna by introducing a spiral fan-shape Electromagnetic Band Gap (EBG) structure between a narrowband patch antenna and its ground plane. Measured result shows an excellent return loss and good impedance matching which resulted in an increment of the bandwidth from about 4 % for a single layered narrow band rectangular microstrip patch, to more than 17 % after the EBG structure was introduced. 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.

Keywords: Microstrip, Antenna, electromagnetic Band-Gap, Narrow Ban & Broad band Antenna

1. Introduction

Electromagnetic band-gap (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, but it also creates disadvantageous in terms of fabrication. On the other hand, the metallodielectric EBG structures consists of printed array of metallized elements, used to suppressed substrate modes [1]. The later was more practical and proofed to 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 an EBG structures in the form of periodic spiral fan-shape patches 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. It was found that the results were excellent.

2. Parametric Study

A spiral fan-shape EBG patch structure was introduced between a narrowband; coaxial 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 spiral fan-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 radius of the spiral fan-shape EBG patch structure was varied proportionally (Figure 1.b) to obtain the optimum results, as mentioned above.

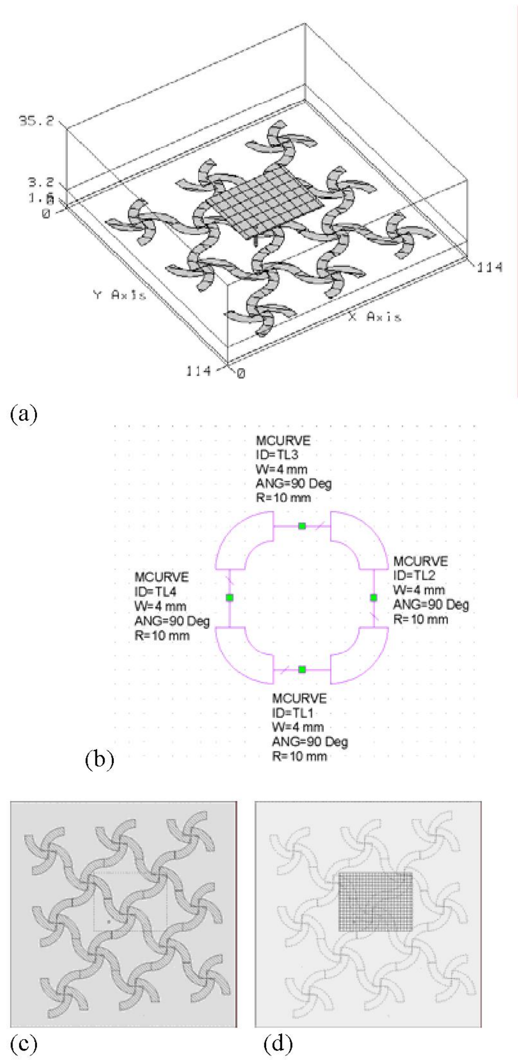

Figure 1: (a) Perspective view (b) the circuit schematics of the radial fan (c) The spiral fan-shaped EBG patch structure (d) Rectangular patch Microstrip Antenna.

3. The Effect of Introducing the EBG Structure

Figure 2 shows the simulated return loss for the narrowband antenna with a spiral fan-shaped EBG structure. By increasing the number of spiral fan-shaped EBG patch structure, some good matching characteristics were observed. The best results were observed when the number reached 13 units and above. From the simulation results, the bandwidth was enhanced up to 7.5%. But this also means that the structure or the size of the overall patch increases too.

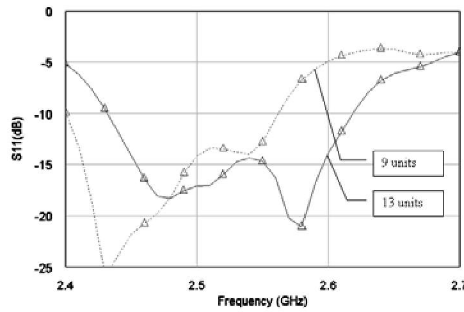

Figure 2: Simulated results of the (9 and 13 units) spiral fan-shaped EBG Structure.

4. EBG Patch Size

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 number of spiral fan-shape and the overall 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 spiral fan-shaped structure was fabricated on a 100mm x 100mm x 1.6mm and a 80mm x 80 mm x 1.6mm FR4 substrate with dielectric constant of 4.6.

The number of spiral fan-shaped was varied until an optimum result obtained. From the measured results, it was observed that the bandwidth increases when the number of spiral fan-shaped increases and the rectangular patch positioned at a particular position as shown in the diagram in Figure 3.

As predicted, it can be seen (figure 4) that a significant improvement of bandwidth up to more than 17% was observed with the lower frequency at 2.38 GHz and the higher frequency at 2.82 GHz at -10dB reference level. The overall thickness of the antenna is 3.2mm.

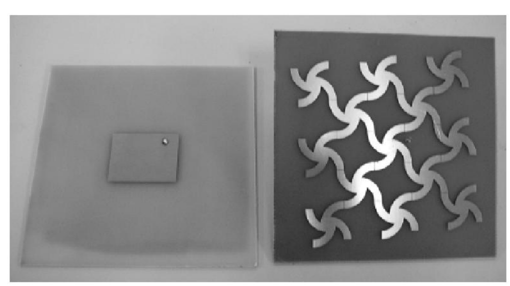

Figure3: The fabricated spiral fan-shape EBG patch Structure.

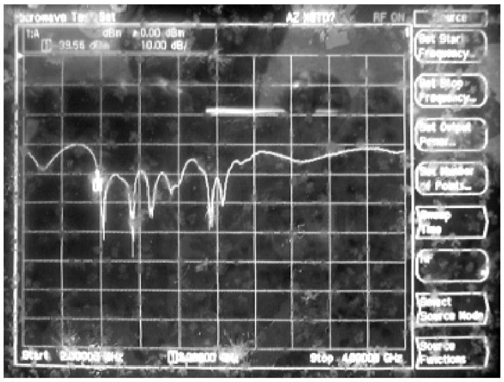

Figure 4: Measured results of the spiral fan-shape EBG structure shows bandwidth enhancements up to more than 17% with the lower frequency at 2.38 GHz and the higher frequency at 2.82 GHz at -10dB reference level.

5. Summary

An initial parametric study was done on the spiral fan-shape EBG structure positioned between a narrowband rectangular microstrip antenna and its ground plane. Measured result shows an excellent return loss and good impedance matching which resulted in an increment of the bandwidth from about 4 % for a single layered narrow band rectangular microstrip patch, to more than 17 % after the EBG structure was introduced. Further investigation on the radiation characteristic will be carried out in the future and different EBG structure's shapes and sizes will also be look upon to.

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