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Performance Enhancement of Microstrip Dipole Antennas Through The Use of Minkowski Frequency Selective Surfaces as A Reflector

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Abstract**:** *In this paper, we present Frequency Selective Surface (FSS)s to be used as reflectors to enhance performances of microstrip dipole antennas throughout their operation bandwidth. Firstly it should be noted that Finite-Integration- based code (CST Microwave Studio) is used for all the modelling, analyses and simulations on FR4(ε_r= 4.4, loss tangent =0.0035). Thus, as a first stage, a broad band microstrip dipole antenna is designed operating between 4GHz-10GHz. In the second stage, the performances of this dipole antenna are investigated using the various FSSs as reflector planes. Finally, the Minkowski unit is found as the most appropriate FSS cell element to enhance significantly in the gain performance of the dipole antenna that is optimized to arise the gain up to 3~4 dB while return loss remains approximately as the same.*

Keywords: *Electromagnetic Band Gap, FSS, Microstrip Dipole, Reflector*

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I. Introduction

With the appalling growth of wireless industry the attention of many researchers are focused on the design of low cost, broadband, high gain antennas. Microstrip patch antenna designs are most commonly used antennas in wireless communication because of their low cost of fabrication, small sizes and light weights. However comparison of their performances with the counterpartsm is resulted that the microstrip antennas performances need to be enhanced. In these enhancement processes, high technology products such as metamaterials, high performance substrates, FSSs can be utilized.

FSSs are used with antennas to improve their various parameters like radiation pattern, directivity, gain and bandwidth. Recently, FSSs are being used for performance enhancement of antenna systems in [1-5].FSS and partial reflecting surfaces have been integrated with printed antennas to enhance the performance of the antenna along a narrow or a broadband. Herein, a Minkowski Frequency Selective Surface (MFSS) design to enhance the performance of microstrip dipole antenna is presented. Firstly a simple microstrip dipole antenna design is presented. Then, the performance of the antenna is investigated by adding a simple various FSS reflectors. Finally in order to enhance the performance of the antenna, the Minkowski unit is found to be optimum to be designed as the FSS cell.

In this work, Minkowski reflector is a typical 2D EBG design application. Electromagnetic band gap designs are defined as artificial periodic (or sometimes non-periodic) structures that effects the propagation characteristics of electromagnetic waves in a selected operation frequency [6]. EBG designs can be classified in three groups with respect to their geometrical shapes and designs. These are 3-D volumetric structures, 2-D planar surfaces and 1-D transmission lines. Every form prefer different advantages. 2-D EBG designs advantages are being low profile, light weight and low fabrication cost. Thus 2-D EBG surfaces are largely figured in antenna engineering. Due to these features we use 2-D EBG surfaces in this paper. Herein it is aimed to obtain an EBG design for improving the performance of a microstrip dipole antenna in operation frequency of 4-10GHz. In the next sections the antenna design and simulation results of the work had been explained in details.

II. Antenna Design and Simulation

The proposed antenna design is aimed to operate at frequency band of 4-10GHz. Herein, FR4 is used as dielectric material with ε_r = 4.4, loss tangent =0.0035, which is the most recommended material for the designing of the microstrip dipole antenna. By using these materials the values of designing parameters and the size of the antenna is reduced. It produces the maximum radiation pattern along its transmission side. This material is used because the entire structure of the antenna is minimized, cost of the designing procedure is reduced and at the same time we get output of the microstrip dipole antenna in a good and accurate manner.

The antenna design had been feed with a microstrip transmission line. The schematic and design parameters of the antenna are given in Fig. 1 and table 1 alongside of its simulated Gain and Return Loss performance results in Figs. 2-3.

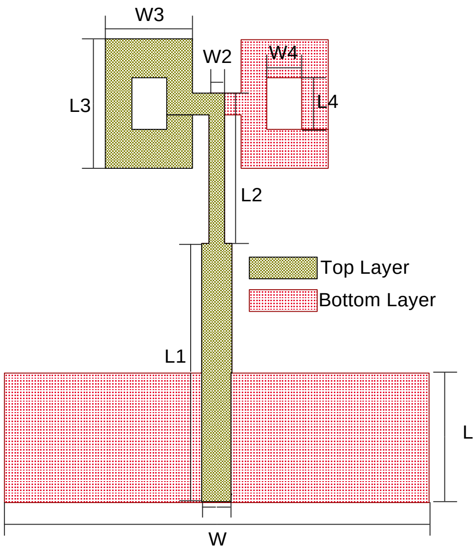


Fig. 1. Schematic view of the microstrip dipole antenna

TABLE I. DESIGN PARAMETERS OF THE MICROSTRIP DIPOLE ANTENNA IN (mm)

W	**W1**	**W2**	**W3**	**W4**
39	2.8	1.4	8	3.2
L	**L1**	**L2**	**L3**	**L4**
12	23.95	14	12	4.8

*Antenna size: 39x51

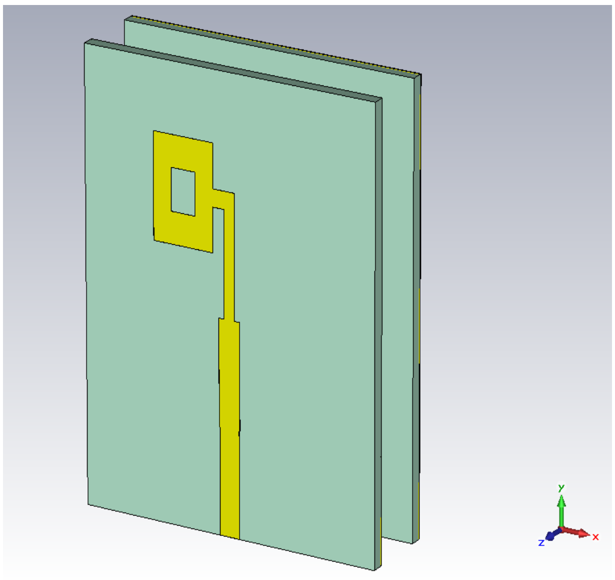
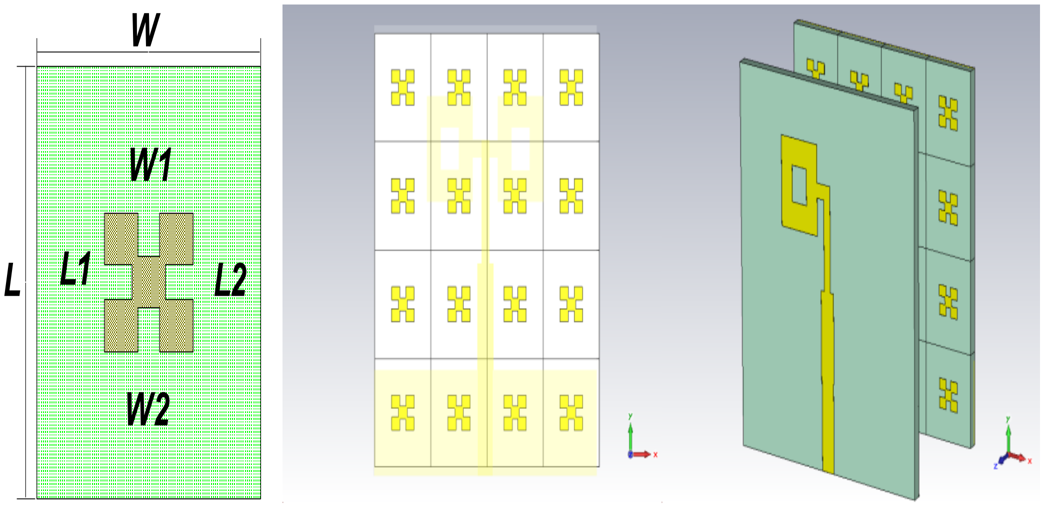


Fig. 2. 3D view of the microstrip dipole antenna with FR4 reflector (Size of the antenna and reflector are equal 39x51 mm)

In the second stage, a single sided FR4 substrate is used a reflector Fig. 4 for the dipole antenna design. The simulated Gain and Return Loss performance results of the antenna with FR4 reflector are given in Figs. 2-3. Finally a MFSS reflector is used to enhance the performance of the microstirp dipole antenna design. The schematic and design parameters of the antenna with MFSS reflector are given in Fig. 7 and table 2 alongside of its simulated Gain and return loss performance results in Figs. 8-9. For a low cost design goal, the FSS is design using FR4 substrate.



(a) (b) (c)

Fig. 3. (a) Unit cell of Minkowski FSS, (b) MFSS reflector, (c) 3D view of the microstrip dipole antenna with MFSS reflector

TABLE II. DESIGN PARAMETERS OF UNIT CELL MINKOWSKI FSS IN (mm)

Size	W	W1	W2	L	L1	L2
10x12.5	10	4	1	12.5	4	1

The performance of all antenna design are compare in table 3. As it seen from the table with the use of FSS structures as reflectors, it is possible to enhance the performance of antennas.

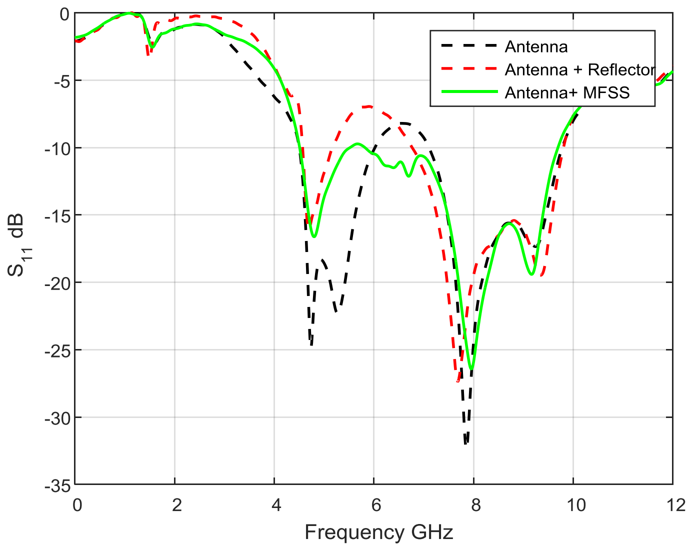


Fig 4. Simulated S_{11} of the microstrip dipole design with MFSS reflector

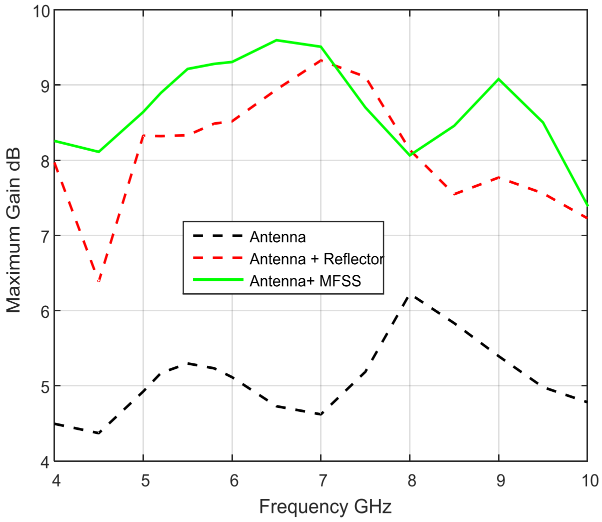


Fig 5. Simulated maximum gain of the microstrip dipole antenna with MFSS reflector

III. Conclusion

This paper features a Minkowski shaped Frequency Selective Surface (FSS), placed behind the patch antenna for the gain enhancement and reduction in return loss. In this paper benefits from EBG structures' features that improve antenna gain and scattering parameters. The FSS is a simple two-dimensional periodic array of square patch elements. In this paper we have used FR4 (εr = 4.4, loss tangent =0.0035) to implement the substrate of the antenna as well as that of the FSS. The simulation results of the proposed antenna with and without FSS are procured using the Computer Simulation Technology (CST). The realized gain has been enhanced up to 3~4 dB at the considered frequencies.

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