International Journal of Computer Applications in Engineering Sciences
[VOL III, SPECIAL ISSUE ON CCSN 2012, MAY 2013] [ISSN: 2231-4946]

Polarization Independent Triple-Band Single Layer Frequency Selective Structure

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***Abstract*— This paper deals with single layer polarization independent Frequency selective surface (FSS) which acts as a triple band reject filter. The two stop bands are broad with percentage bandwidth 11.16% and 10.13% and one is narrow with 3.33% bandwidth. The band ratio is more than 1.5 and band separation is around 30-35dB. This design is investigated theoretically by ANSOFT® Designer software and practically by standard microwave test bench and the both results show a good agreement.**

***Keywords*— Frequency Selective Surface; Band reject filter; Band separation; Frequency ratio; Polarization Independent.**

I. INTRODUCTION

Traditional frequency-selective surface (FSS) structures, with resonant unit cells, have been investigated over the years for a variety of applications. These include bandpass and bandstop spatial filters, absorbers, and artificial electromagnetic bandgap materials. A typical frequency-selective surface is a 2-D planar structure consisting of one or more metallic patterns, each backed by a dielectric substrate [1, 2]. These structures are usually arranged in a periodic fashion; therefore, their frequency response is entirely determined by the geometry of the structure in one period called a unit cell. These surfaces exhibit total reflection or transmission, for the patches and apertures respectively, in the neighborhood of the element resonances. The most important step in the design process of a desired FSS is the proper choice of constituting elements for the array [3].

This paper shows two FSS designs. The primary design has only two bands, but the modified design has three. This type of designs is investigated in past also [4-7]. But the novelty of this paper is the triple band with such a good bandwidth. Every design is theoretically investigated by ANSOFT Designer / Nexxim v 2.2 software which uses method of Moment (MOM) process to calculate the results. To confirm the stimulated result, the FSS is fabricated and experimentally tested. Every FSS is designed with dielectric (Glass PTFE, relative permittivity of 2.4 and 1.6mm thickness) and metal (copper).

II. DESIGN OF FSS

A. Primary Design

In this design three concentric circular metallic rings with different shapes are used as a cell in the FSS. During theoretical study the FSS is taken as an infinite array of unit cell. In Fig.1 a small part of FSS is shown. The distance between two cells is 2mm. The widths of the three rings are same, 1mm. The outside radius of the largest ring is 6mm; middle ring is 4mm and smallest ring is 3mm. The diameter of the largest ring is 12mm so the periodicity of the FSS is 14mm. A single cell is shown in Fig.2. A special fetcher can be noted here that the centre position of the unit cell is hollow. That means at centre of the rings there is not any kind of metallic layer of a cell. This design is used previously [3] but here we introduce some modification for broad band.

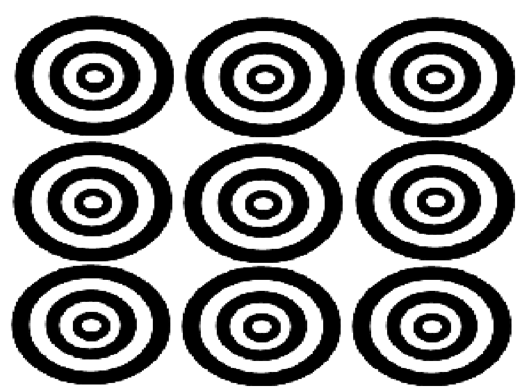

Fig. 1 FSS with Multi-ring Patch

Fig. 2 Extended single cell

B. Modified Design

This design is quite similar with the previous design, only the ring sizes are different and a metallic layer is present at the centre of the individual cell. In Fig.3 a part of the FSS is shown. The radiuses of the rings are 7mm, 5mm, 3mm and inner circle is 1mm. The widths of the rings are 1mm. The diameter of the outer-most ring is 14mm and the periodicity of the FSS is 16mm. So the each cell is 2mm apart from each other. Fig.4 shows a single cell of this FSS. This FSS is fabricated and practically tested in the laboratory. The length of the fabricated FSS is 14 cm and breath is 13 cm. Fig.5 shows the fabricated FSS.

Fig. 3 FSS with multi-ring patch

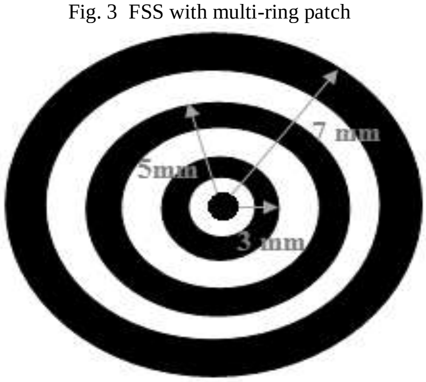

Fig. 4 Single cell of the FSS

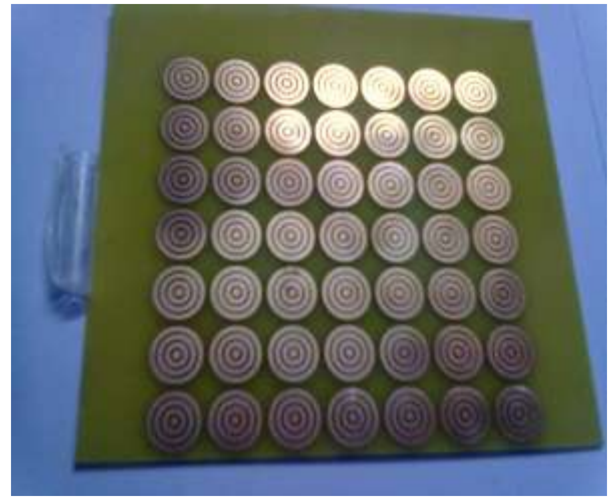

Fig.5 Fabricated FSS

III. RESULT

A. Primary Design

The simulated result is shown in the Table.1 and a frequency vs. Normalized transmission field plot is shown is Fig.6.

TABLE I

Resonating Frequency (GHz)	7.84	13.48
Bandwidth (GHz)	0.93	1.58
Percentage Bandwidth	11.86	11.72

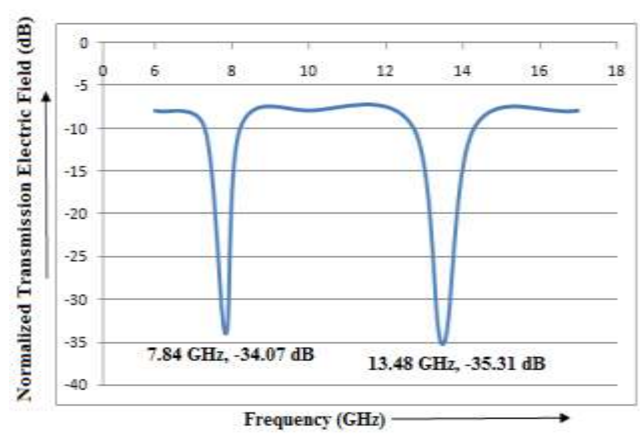

Fig. 6 Normalized transmission field vs. frequency Plot (Primary design)

B. Modified Design

The modified design is fabricated and practically investigated. The practical investigation is done by standard microwave test bench as shown in fig.7. Agilent made microwave generator is connected to a transmitting horn. Receiving horn antenna is connected to an Agilent made power meter (model no E4418 B, EPM Series Power Meter) with sensor (model no E4412 A, E Series CW Power Sensor). The horn antennas and generators are changed for different frequencies bands like 4GHz – 6GHz, 6GHz - 8GHz, 8GHz - 12GHz etc. Both the practical and theoretical results for the fourth design are shown in the table 2 and transmission characteristic is shown in Fig.8.

Fig 7. Standard microwave test bench

TABLE III

	Theoretical results	Practical Results	Theoretical results	Practical Results	Theoretical results	Practical Results
Resonating Frequency (GHz)	6.45	6.3	10.26	10	16.18	15.9
Bandwidth (GHz)	0.72	0.9	1.04	2	0.54	1.7
Percentage Bandwidth	11.16	14.29	10.13	20	3.33	10.7

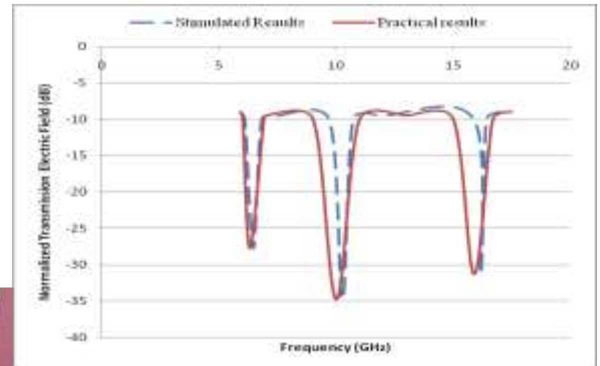

Fig. 8 Normalized transmission field vs. frequency Plot (Modified Design)

IV. CONCLUSIONS

It is observed for such structures, that the size reduction takes place by compromising the bandwidth. That means when the structure resonates in a lower frequency the bandwidth of the structure is also reduced. The novelty of this paper is that the structure resonates at lower frequency than the primary design, but bandwidth is same for the both designs. Moreover, this work includes multi-frequency operation. So simultaneously compactness, bandwidth enhancement and multi frequency operation are achieved by the same structure.

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