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Investigation on Double Layered Broadband Frequency Selective Surface

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ABSTRACT: *This paper presents a novel proposal for the design of a double layered Frequency Selective Surface (FSS) for broadband applications. The structure of the proposed FSS has been designed using two different steps. The first step comprises of designing two separate FSS structures to resonate at 10.97 GHz and 7.53 GHz, with a percentage bandwidth of 34.73% and 55.77% respectively. In the second step these two structures are cascaded in order to attain broadband characteristics. Also an air gap is introduced between the two cascaded FSSs and a relative study is done by varying the height of the air gap. When no air gap is introduced between the two structures, the deigned FSS resonates at 5GHz and a bandwidth of 145% is achieved. It can be operated for C band and X band applications. The proposed FSS structure has been designed using Ansoft Designer software and verified practically using microwave test bench.*

KEYWORDS: *Broadband, Double layered, Frequency Selective Surface, Percentage bandwidth and Resonating Frequency.*

I. INTRODUCTION

A two dimensional periodic array of metallic patches on a dielectric substrate or aperture elements within a metallic screen having regular or arbitrary geometries is called a frequency selective surface[1-2]. They can exhibit transmission and reflection properties when an electromagnetic wave is incident on them and thus act as wireless counterpart of electrical filters in microwave engineering. Patch type FSS can be used as Band Reject Filter while aperture type FSS can be used as as Band Pass Filter [3]. The ability of the FSS to filter the frequency depends on various factors like the size of the unit cell element, the periodicity between the unit cells, the dimensions of the structure and the substrate parameters [4]. FSSs are widely used in microwave and millimetre-wave applications in order to construct high-impedance surfaces [5], antenna reflectors [6], electromagnetic band-gap resonator antenna [7], shields and absorbers [8] and in radomes [9].

During the last few decades numerous research works are being done on frequency selective surfaces [10-14]. So far research on Multilayered FSS structures have been studied for different applications like GPS and DCS1800 mobile communication and in designing microwave absorber [15-16]. In this paper a dual layered FSS is studied with identical periodicities for both the layers to produce higher bandwidth in comparison to single layer FSS. Till now by using dual layer FSS, bandwidth has been enhanced up to 74.70% [17]. But in this paper, the bandwidth obtained is 145%.

II. DESIGN OF THE PROPOSED FSS

At first a conventional patch type FSS is designed by using a two dimensional array of a square shaped patch of dimension 20 mm × 20 mm. On one side of the thin dielectric slab the metallic patches are present and the copper coating on the other side of the thin dielectric slab is completely removed. The metal used here is copper. The periodicity in both horizontal and vertical direction is taken to be 24 mm. Acrylic sheet is used as the dielectric material with a dielectric constant of 2.8. The height of the dielectric used here is 1.6mm. Fig 1 shows the conventional patch type FSS

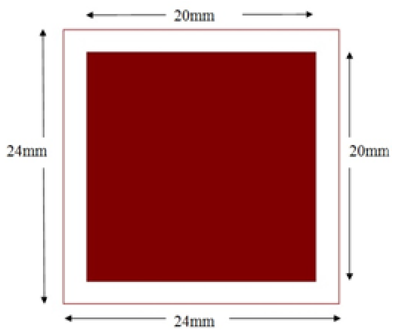

Fig.1. Patch of the conventional FSS.

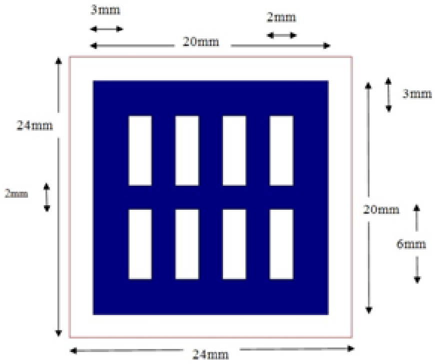

Fig 2. Upper layer of proposed FSS.

Now the structure of the dual layered FSS is designed by using this conventional patch type FSS to be the bottom layer of the dual layered FSS. The upper layer of the FSS is designed by introducing eight slots of dimension 6mm X 2mm. All other parameters are kept unchanged. The structure of the upper layer is shown in Fig 2.

The 3-D view of the proposed dual layer Frequency Selective Surface is shown in Fig. 3. Δh denotes the height of the air gap introduced in between the two layers of the FSS. A parametric study is done by varying the height of the air gap and its effect has been studied and discussed.

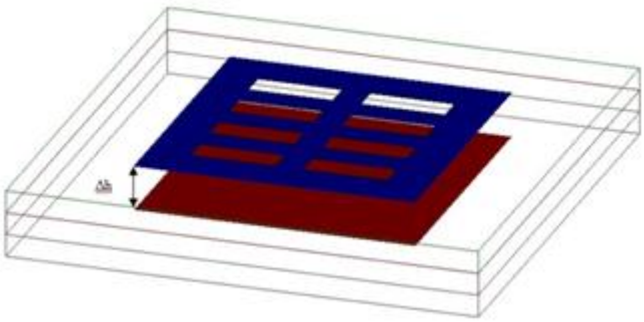

Fig.3. 3D Structural View of Proposed FSS

III. SIMULATED AND EXPERIMENTAL RESULTS

The simulated results for the proposed FSS are obtained from Ansoft Designer version 2.2. It has been observed that when only the bottom layer is present, the FSS resonates at 10.97 GHz and a bandwidth of 34.73% is achieved. The fabricated structure of the bottom layer is shown in Fig4. The transmission characteristic for only the bottom layer is shown in Fig6.

When only the upper layer is present, it is noted that it resonates at 7.53 GHz, with a bandwidth of 55.77%. The fabricated structure of the upper layer is shown in fig 5. The transmission characteristic for only the upper layer is shown in Fig7.

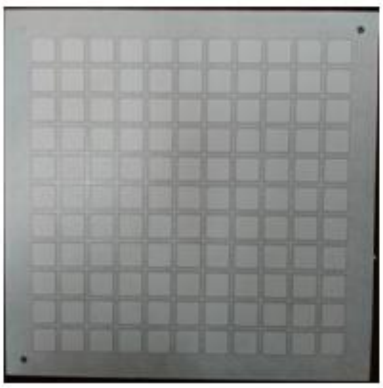

Fig 4. Fabricated structure of bottom layer **.**

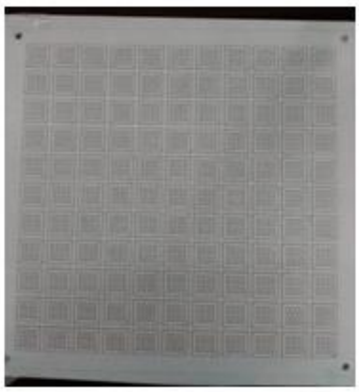

Fig.5. Fabricated structure of upper layer.

Experimental investigations for the proposed dual layered FSS is done using microwave test bench. Two horn antennas were used for transmission and reception purposes. The proposed FSS mounted on a wooden frame stand were placed between the two antennas. The transmitting antenna was connected to Agilent Signal Generator and the receiving antenna was connected to Power meter. The measured data were noted down from the power meter and a graph of normalized transmitted electric field versus frequency was plotted for the proposed dual layered FSS.

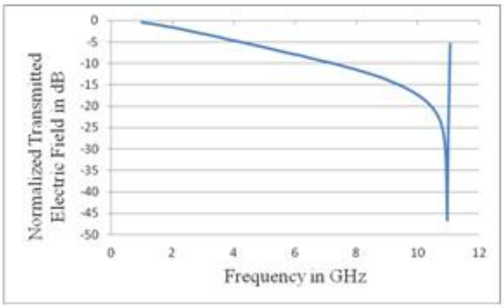

Fig 6: Transmission characteristics of the bottom layer.

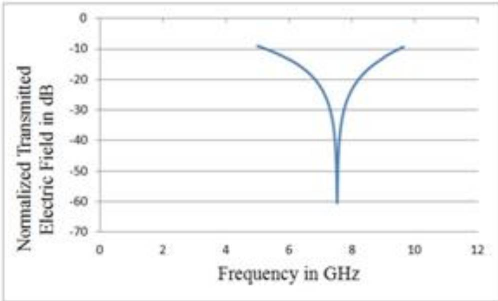

Fig 7: Transmission characteristics of the upper layer.

Now cascading these two layers an air gap is introduced between them and the simulated results are studied and tabulated in table1. It is observed that when air gap is of 20 mm the percentage bandwidth obtained is 101.06% and when no air gap is present, i.e., the two layers are joined together in an intact manner, the percentage bandwidth obtained is 168.28%. The comparison of the transmission characteristics varying the air gap is shown in Fig8. Thus it is observed that with increasing air gap between the layers decreases the percentage bandwidth. So considering no air gap to be present between the two layers, the dual layered structure is verified experimentally and a graph is plotted between the simulated and measured results as shown in Fig9. The graph shows a good agreement between the simulated and measured results. Table2 summarizes the results obtained for the designed FSS.

Table1.

Air gap (Δh) in mm	Resonating Frequency in GHz	Bandwidth (Simulated)
20	7.53	101.06%
10	6.73	100.74%
2	5.19	110.22%
1.8	5.12	111.72%
1.6	5.05	113.26%
1.4	4.96	115.52%
1.2	4.87	118.06%
1	4.77	120.96%
0	3.72	168.28%

Table2.

FSS		Lower Cut-Off Frequency (GHz)	Higher Cut-Off Frequency (GHz)	Resonating Frequency (GHz)	Bandwidth
Bottom Layer		7.24	11.05	10.97	34.73%
Upper Layer		5.28	9.48	7.53	55.77%
Proposed Structure	Simulated	3.66	9.92	3.72	168.28%
	Measured	4.60	11.85	5.00	145.00%

IV. CONCLUSION

In this paper it has been observed that two separate FSSs resonating at two adjacent frequencies when cascaded together results in a broadband FSS. The two layers of FSSs separately possess a bandwidth of 34.73% and 55.77%. When the two separate FSSs are simply cascaded into one single composite FSS, the bandwidth is enhanced up to 145.00%. The proposed FSS can be operated in C band and X band. Also by varying the air gap between the two layers it is observed that on decreasing the air gap the resonating frequency decreases as well as the percentage bandwidth increases. When no air gap is present a percentage bandwidth of 145% is achieved.

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