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A Two Layer Frequency Selective Surface for Dual Band Applications.

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Abstract— This paper deals with the theoretical investigation on size reduction and bandwidth enhancement of a two layer frequency selective surface (FSS). Two single layer FSS arein cascade arrangement with an air gap of 10 mm. The composit structure exhibits a size reduction of 88%. Over more the low profile FSS with unit cell dimension 22 mm× 22mm provides dual stop band response below -10 dB at 3.43 GHz and 6.76GHz with 31.62% and 41.63% of bandwidth respectively. As the proposed design of unit cell arrangement is symmetrical about X and Y axis of the design plane, the response is independent on 90 degree polarization.

Index Terms—Frequency Selective Surface, Cascade arrangement, Percentage of bandwidth, Percentage of Size Reductioin, Polarization,Dual stop band response, Circular patch.

1 Introduction

FREQUENCYSelective Surface is a wireless counter part of an electrical filter used as a spatial filter in case of Radio Frequencies (RF). Generally an FSS is built as a two dimensional array of metallic patches on a dielectric slab (gives band stop response) or an array of apertures of dielectric, perforated from a metal sheet (gives band pass response) [1]. Recently a frequency selective surface is used to improve the workings of radomes, sub-reflectors, antennas, absorbers, satellite transponders by its broad band and multi bands characteristics[2]-[6]. In [2], Kazemzadeh and Karlsson proposed a design of an ultra wideband (UWB) absorber operating for a large range of incident angles and different polarizations. The authors designed a three layered capacitive absorber to get an ultra wide band frequency response. Ranga *et al.* in [3] and [4] also used a multilayer FSS and optimized to improve the gain of a UWB antenna. Pasian *et al.* in [4] used an FSS to increase the efficiency and bandwidth in UWB antenna arrays. To extend the frequency range of usability, an FSS was sandwiched between the antenna and the ground plane, providing an additional reflecting plane for a higher frequency band. The proposed backing structure composed by the FSS and the ground plane was designed to be used in conjunction with an UWB array of connected dipole antennas. To enhance the bandwidth of the stop band responses some novel ideas are proposed. Li et al. in [7] obtained a wideband response by using two layer FSS with complex geometries. The bandwidth obtained was 4.22 GHz to 6.98GHz (51 %) though there was not vital size reduction. In [8]-[10] multiple FSS layers are cascaded to achieve multiband and broad band responses.

In this paper a two-layer FSS arrangement is proposed. FSS-I and FSS-II layers are designed by array of modified circular metallic patch which are different in design to each other. The proposed structure gives dual band-stop transmission characteristics below -10db reference level. Thus this structure offers a good reflectivity to two frequency bands (3.16-4.33 GHz with 31.62% bandwidth and 5.61-8.5GHz with 41.13% bandwidth). The FSS layers individually and the cascaded structure are simulated by ANSOFT Designer® software.

2 Design of FSS

The reference FSS consists of two dimensional periodic array of circular metallic patch with 10 mm in radius. Glass-PTFE (ε=2.8) is taken as dielectric substrate with thickness of 1.6mm. The conventional unit cell patch has a periodicity of 22mm×22mm in X-Y direction. The geometry of reference patch is shown in **Fig. 1**. This circular patch is modified to the proposed geometrical patches to get a better response. These modified patches are selected as unit cell patch design for FSS I and FSS II. The geometrical design of both patches is shown in **Fig. 2** and **Fig. 3** respectively. Transmission characteristics of these two layers slightly differ from each other. These two FSS layers are arranged in cascade with 10 mm air gap in between them, so that the consecutive bands are staggered causing bandwidth enhancement. The three dimensional view of this proposed structure is shown in **Fig. 4.** The width of the di-electric in case of FSS I (w1) and FSS II (w2) are selected as 16 mm.

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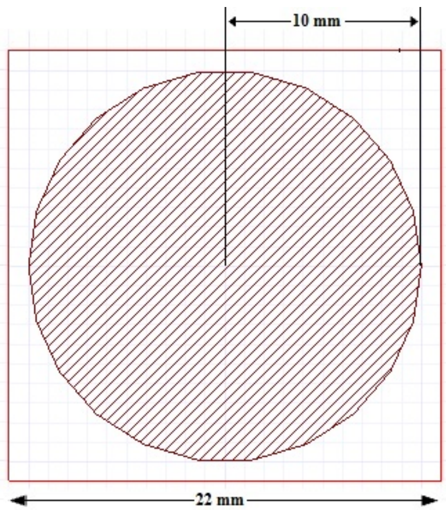

Fig. 1. Geometry of reference patch.

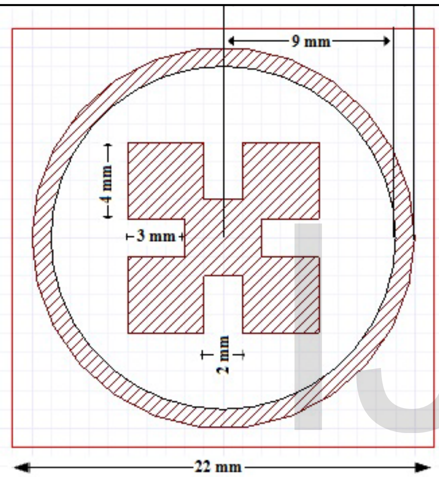

Fig. 2. Geometry of first modified patch (FSS-I).

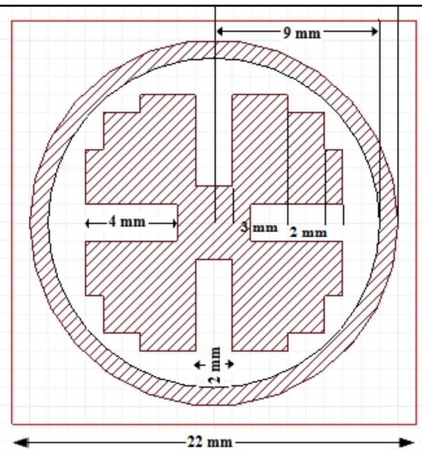

Fig. 3. Geometry of second modified patch (FSS-II).

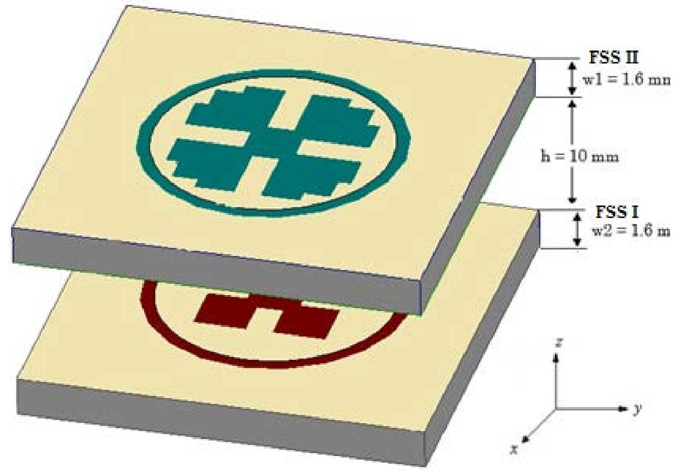

Fig. 4. 3-D view of proposed unit cell arrangement.

3 SIMULATED RESULT ANALYSIS AND PARAMETRIC STUDY

The full wave EM simulation for the reference patch, individual FSS unit cell patches and unit cell of cascaded structure are carried out by ANSOFT Designer® software and normalized transmission coefficient is achieved. During the simulation an infinite periodic array of unit cell in x and y direction is assumed by defining the infinite array with dimension 22mm×22mm. At next, the corresponding structure is exited by plane wave in horizontal-horizontal (H-H) polarization. Normalized transmitted electric field of the reference model is shown in **Fig. 5.**

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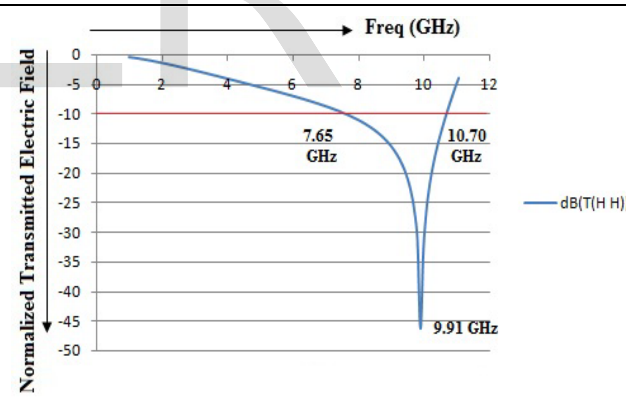

Fig. 5. Simulated transmission characteristics of reference patch.

Thesecorresponding software simulations are done for the frequency range 1GHz to 10GHz. **Fig. 5** shows a band stop response (7.65GHz- 10.70GHz) at 9.91GHz. The frequency band in the transmission characteristics where insertion loss is below of -10db level is treated as stop band. The corresponding transmission characteristics for first (FSS I) and second (FSS II) modified patches are shown in **Fig. 6** and **Fig. 7** respectively.

Both of the modified designs exhibit dual stop band transmission characteristics. For first modified patch (FSS I) there are two stop bands in transmission characteristics at 3.88GHz (with 0.66 GHz bandwidth) and 8.24 GHz (with 1.26 GHz

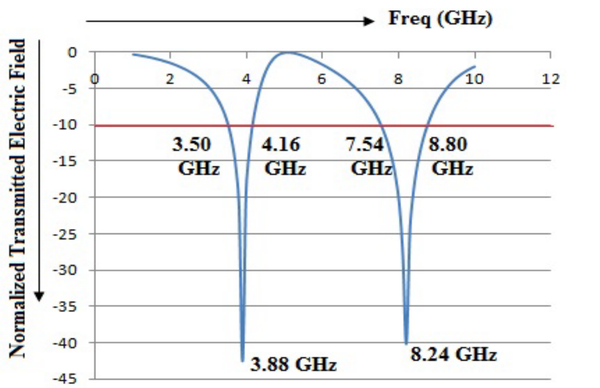

Fig. 6. Simulated transmission characteristics of first modified patch (FSS-I).

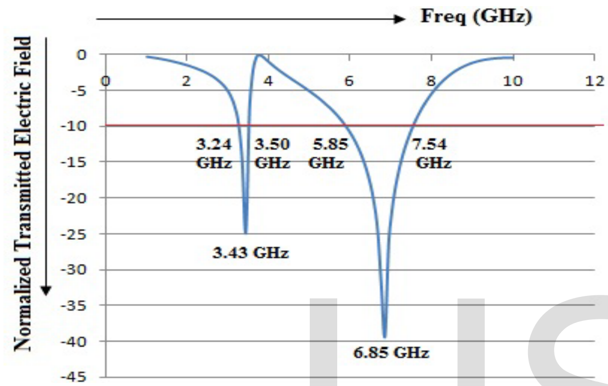

Fig. 7. Simulated transmission characteristics of second modified patch (FSS-II).

bandwidth). In case of second modified patch (FSS II) there are also two stop bands in transmission response at 3.43 GHz (with 0.26 GHz bandwidth) and 6.85 GHz (with 1.69 GHz bandwidth).

Simulated result for the proposed cascaded structure is shown in **Fig. 8.** This transmission characteristics show that it is the modified characteristics by staggering two transmission characteristics of FSS I and FSS II.

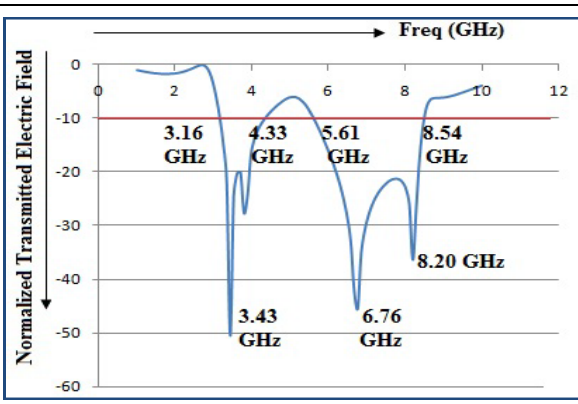

Fig. 8. Simulated transmission characteristics of cascaded structure.

The transmission characteristics of FSS I, FSS II and that of proposed cascaded structure is shown in **Fig. 9**.

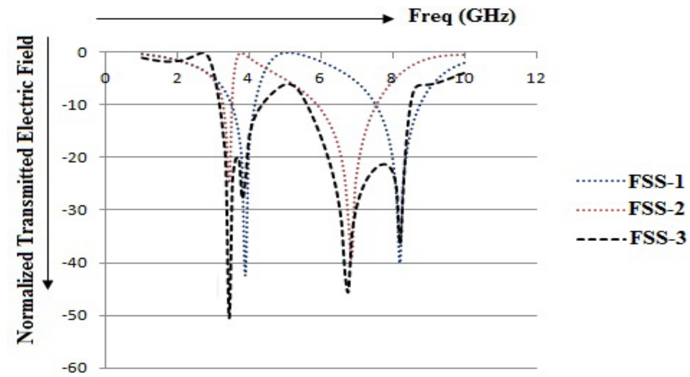

Fig. 9. Simulated transmission characteristics of FSS-I, FSS-II and proposed cascaded structure.

The transmission characteristics of cascaded structure give two stop bands of frequencies. For first band resonating frequency is remained unchanged at 3.43 GHz where as the bandwidth is 1.17 GHz (31.62% bandwidth) which is noticeably larger than both single layered FSS. The second stop band is received at 6.76 GHz with a larger bandwidth of 2.93GHz (41.63% bandwidth). Transmission characteristics of reference model, FSS I, FSS II and cascaded structure is presented in **Table 1**.

Table 1:compression on transmission characteristics of above mentioned FSS layers and cascade structure.

	1st Band			*2nd Band*			**Size reduction (%)**
	Resonating Freq.	**BW**	**%BW**	**Resonating Freq.**	**BW**	**%BW**	
Reference model	9.91 GHz	3.05GHz	30.77 %	NA	NA	NA	NA
FSS I	3.88 GHz	0.66GHz	17.01 %	8.24 GHz	1.26 GHz	15.3%	84.67 %
FSS II	3.43 GHz	0.26 GHz	7.5%	6.85 GHz	1.69 GHz	24.67%	88.0 %
Cascade Structure	3.43 GHz	1.17 GHz	31.62 %	6.76 GHz	2.93 GHz	41.63%	88.0 %

In **Fig. 10** the transmission characteristics of different values of

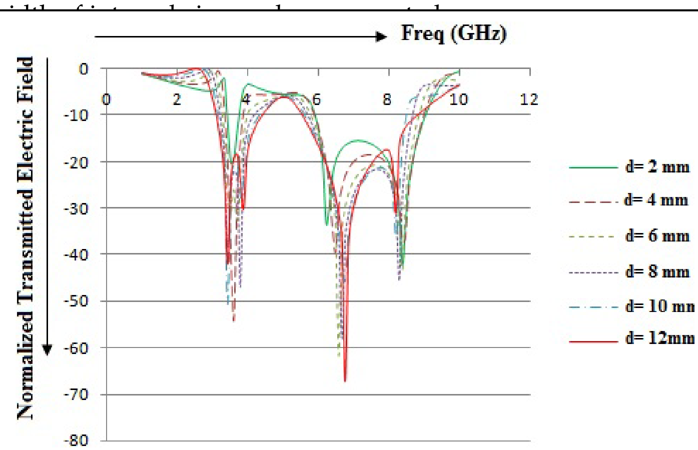

Fig. 10. Simulated transmission characteristics of cascaded structure for different values of h or d.

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In **Fig. 11** the comparison graph of percentage bandwidth of 1st and 2nd band for different values of internal air gap between two FSS layers (d) is shown. It shows that as internal air gap in between two FSS layers are varied from 2mm to 12 mm with a step difference 2mm. Percentage bandwidth of the second band is more or less same throughout the variation, whereas the same of the first one is increased gradually. Percentage bandwidths of first and second band are 10% and 42% respectively for d=2mm. For d=12 mm they are 35% and 43% respectively.

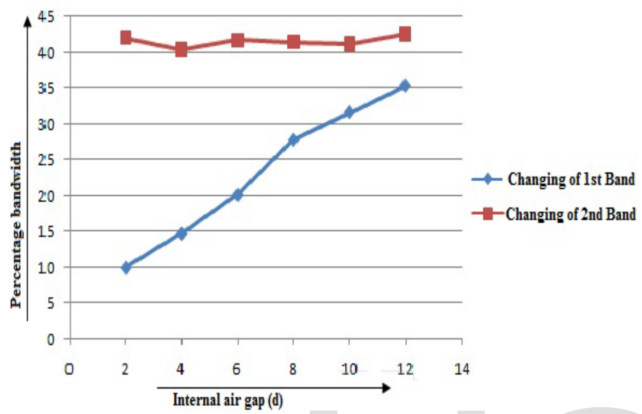

Fig. 8. comparison graph of percentage bandwidth of two stop bands of cascade structure for different values of d.

4 Conclusion

All the designs proposed in this work can be deployed as band stop filters having less than -10db insertion loss at the stop band region. The resonating frequency of the proposed arrangement is reduced to 3.43 GHz where the same of reference design is at 9.91 GHz. As a result, 88.01% of size reduction is achieved. Also dual bands occurred at 3.16 GHz to 4.33 GHz and 5.61 GHz to 8.54 GHz with a percentage bandwidth of 31.62% and 41.13% with a good band ratio. The proposed design may be used in S (2- 4 GHz) and C (4- 8GHz) bands effectively. It isalso understood that as the air gap in between two layers are increased, the bandwidth of the first band in response is enhanced. And as air gap is decreased the roll off of second one is increased. As the design of patches of the unit cell arrangement is symmetrical in X and Y direction the transmission response will be independent on horizontal or vertical polarization of it**.**

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