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Design of A Compact, Tetra-band Frequency Selective Surface for Communication Purpose

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ABSTRACT: *This paper presents Simulated and Experimental investigation on a compact, multi band Frequency Selective Surface using simple geometry. The designed Frequency Selective Surface consists of periodic array of Patches, where each patch has five interconnected rhombus shaped slots inside it. It's experimentally found that four bands of resonating frequencies 2.89GHz,8.14 GHz, 10.15GHZ and 11.61GHz are exhibited within the operating frequency band of the proposed FSS. Also 93% Size reduction is obtained. Simulation of the proposed design is done using ANSOFT Designer® software. The design is fabricated and measurement is done. Measured and simulated results are in close parity. The designed FSS operates in C and X bands so it can be used for long distance radio telecommunication, satellite communication, radar, terrestrial broad band, space communication etc.*
Keywords: *Frequency Selective Surface, Slot, Size Reduction, ResonatingFrequency.*

I. INTRODUCTION

A two dimensional, periodic array consisting of conducting patch or aperture elements is known as frequency selective surface or dichroic[1]. Similar to the frequency filters in traditional radio frequency (RF) circuits, the FSS may have low pass or high pass spectral behavior, depending upon the array element type (i.e.patch or aperture).[1]. Early work was concentrated on the use of FSS in Cassegrainiansub reflectors used in parabolic dish antennas. FSS are now employed in microwave, radomes (terrestrial and airborne), missiles and electromagnetic shielding applications [2-3].FSS structures are basically analyzed by three methods -Finite Difference Time Domain Method (FDTD), Finite Element Method (FEM) and Method of Moment (MOM) [4]. In this paper FSS structure has been analyzed theoretically by using ANSOFT Designer® software which is based on Method of Momentum and theoretical result is also compared with the practically measured result simultaneously.

II. DESIGN APPROACH OF FSS

The FSS structure consists of two dimensional arrays of patches. The arrays of metallic patches are aligned on the top of a glass PTFE substrate of dielectric constant 2.8 and thickness 1.6mm in the conventional FSS structure as shown in fig.1. Each patch size is 20mm X 20 mm as shown in fig 1. Periodicity is taken 24 mm X 24 mm for constructing the array of patches.

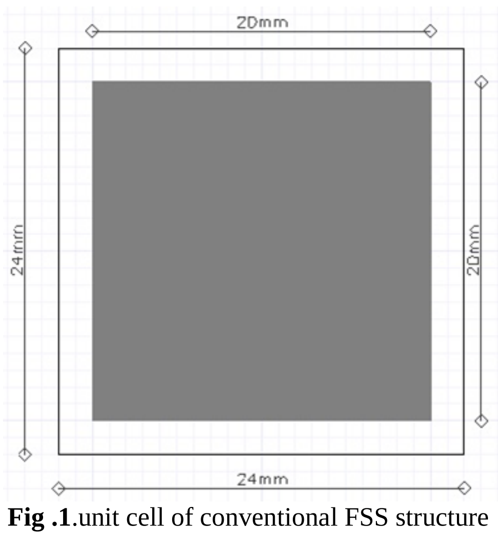

Fig .1.unit cell of conventional FSS structure

Now we design the modified FSS array by etching out five interconnected rhombus shaped slots from the square patch element as shown in fig 2. Width of each line of interconnection is 1mm.

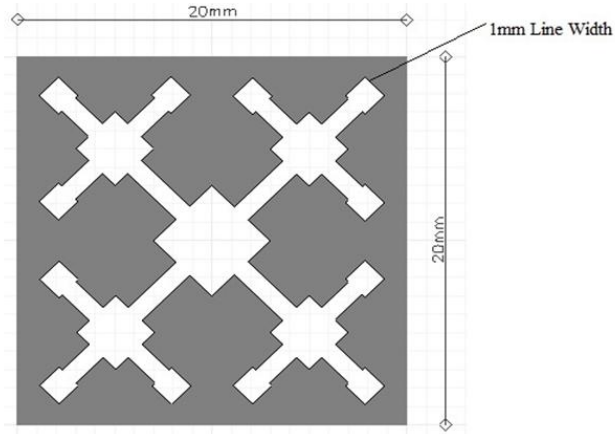

Fig. 2. Unit cell of the proposed FSS structure

The two dimensional array of patches with periodicity is taken 24mm both in x and y-directions as shown in fig 3.

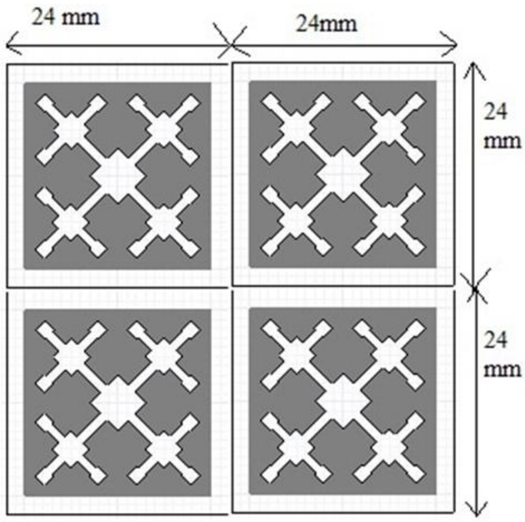

Fig 3. Two dimensional arrays of patches with different slots

The fabricated FSS is shown in fig 4.

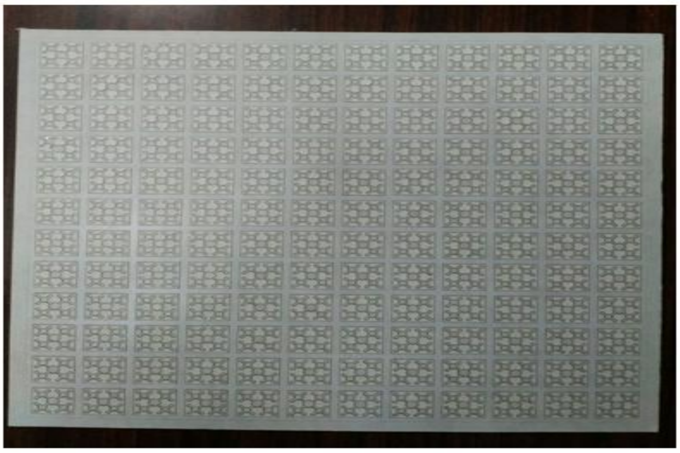

Fig 4. Fabricated FSS Structure

III. SIMULATED RESULT & DISCUSSION

Computed transmission characteristics for reference patch [Fig.1] using Ansoft Designer® is plotted in Fig.5, which shows that the FSS resonates at 10.99GHz while considering the first frequency band.

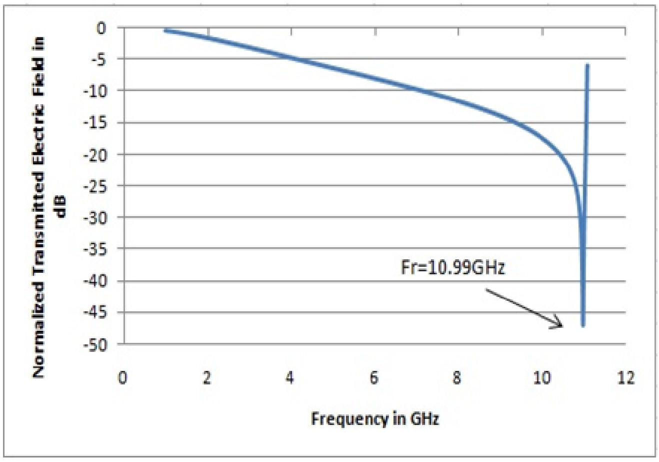

Fig 5: Study of normalized transmitted electric field vs. frequency(corresponding to Fig.1)

Computed transmission characteristics for proposed FSS [Fig.2] using Ansoft is plotted in Fig.6, which shows that the FSS resonates at 2.89GHz while considering the first frequency band. Before designing the FSS with proposed grid, the first resonating frequency is obtained at 10.99GHz [Fig.5]. To obtain the resonating frequency at 2.89 GHz required the area of the patch is 1952mm^2 approximately. The area of the reference patch is 135mm^2 (approx). So the size reduction of [(1952-135)/1952]*100% =93% (approx) has been achieved with the help of this proposed design.

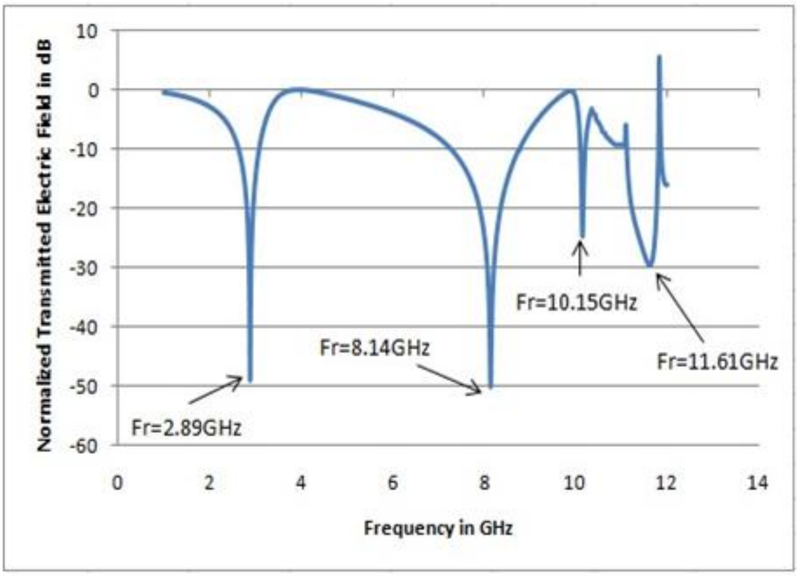

Fig. 6: Study of normalized transmitted electric field vs. frequency (corresponding to Fig.2)

IV. MEASUREMENTS

Experiment is necessary to verify the performance of a practical FSS structure and also to confirm the accuracy of theoretical/numerical models. The designed FSS is fabricated and tested in our microwave laboratory using Agilent made microwave generator, power meter, power sensor etc. Transmission tests are done at C and X bands. Two horn antennas (one for Transmission and other for reception) are placed at both sides of the FSS structures. The horn antennas are connected to Agilent Power source and Agilent Power meter to the Transmission and Receiving antennas respectively. Horn antennas of different sizes are used for measurement of frequency range of 2 to 12 GHz with 0.1 GHz interval.

Fig. 7: Experimental Set Up

After getting the readings, both simulated and measured results are plotted in a single graph of normalized transmitted electric field Vs frequency.

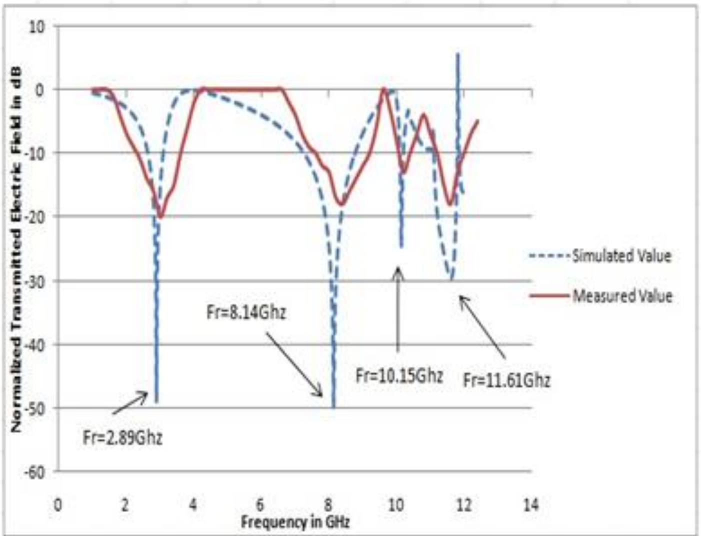

Fig. 8: Graph showing simulated and measured results of Normalized Transmitted ElectricField Vs Frequency for the designed FSS comprising of slots

TABLE 1: SUMMARIZED RESULTS

In the modified FSS multiple resonating frequencies have been obtained. The resonant frequencies with bandwidth and percentage compactness of simulated and measured FSS have been shown in tabular form.

FSS Structure	Resonant Frequency (GHz)	-10dB Bandwidth (GHz)	%Compactness
Simulated	2.89	0.46	93
	8.14	1.51	
	10.15	0.11	
	11.61	0.60	
Measured	3	1.2	92.54
	8.25	1.66	
	10.2	0.25	
	11.88	0.69	

V. CONCLUSION

In this paper, a single substrate layer with single metallic plane frequency selective surface was proposed. As the relative permittivity of the air and the PTFE substrate are different from each other, a part of the wave energy is reflected at the surface. This design also gives a huge compactness about 93% (approx) with the resonant frequency of 2.89GHz and this design is useful for different S, C, J, X & Ku-band applications in satellite communication & various microwave related communication purposes.

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