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A Reduced Sized Wideband FSS with N and Rectangular Shaped Slots Alternately

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Abstract

In this chapter a band stop Frequency Selective Surface (FSS) is investigated using Method of Moment(MOM). Unit cell of FSS is formed by cutting alternately N and rectangular slots in square patch. The proposed design is verified with experiments. The dielectric substrate is varied. The enhancement of the bandwidth and miniaturization may be adjusted keeping same periodicity throughout. The designed FSS provides 88.36% bandwidth. Theoretical investigations have been done by Ansoft® software.

Keywords

Frequency Selective Surface; Method of Moment; Square Strip; Broadband; Size Reduction; Fabrication; Practical Measurement

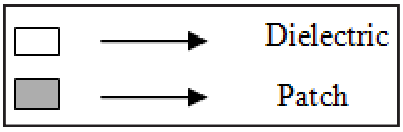
I. Introduction

An array of metallic patches on a dielectric substrate or a metallic sheet perforated by the apertures in periodic fashion acts as a frequency selective surface to the EM wave. In microwave engineering Frequency Selective Surfaces (FSSs) behave as the wireless filters which are used in communication system [1]. In literature, according to the FSS geometries, it is divided in two types. One of them is aperture type which acts as band pass filter and other one acts as band stop filter known as patch type FSS. Due to the incident EM wave, aperture type and patch type FSS exhibits total transmission and total reflection characteristic respectively [2]. Frequency selective surface has broad application such as in electromagnetic shielding application, quasi-optical frequency duplexer, band pass radomes for radar, sub reflector of a multi frequency reflector system etc. [3-5]. It has been noticed that introduction of slots on the metallic patch results is increased compactness and bandwidth enhancement [6-7]. To design wideband FSS, the array of elements are arranged alternately or the thickness of the supporting dielectric material is increased. [8]. Planar frequency selective surfaces consist of radiating patch over the dielectric layer for getting the good effect of resonance frequency. It is stated that the bandwidth of the FSS is related to the permitivity closely [9].

This chapter contains the variation of dielectric substrate analysis theoretically and practical measurement is investigated for the proposed design. While the design leads to a tuning effect, i.e., resonant frequencies are decreased by introducing slots. By this optimized broadband is also achieved.

II. Design of FSS

The reference patch is a square metallic aluminum patch of 26 mmx26mm in x and y directions .FSS is designed on a dielectric slab with relative permittivity 2.8 and thickness 3mm. The periodicity of single cell is 28mm in both horizontal and vertical directions. A 2-dimensional array of these cells is considered for this study and is simulated accordingly.



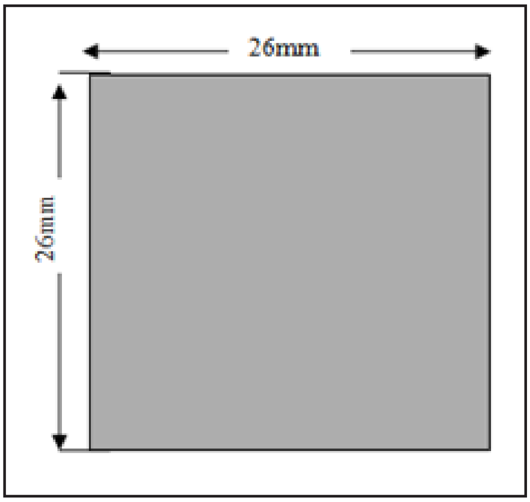


Fig. 1: Reference Patch

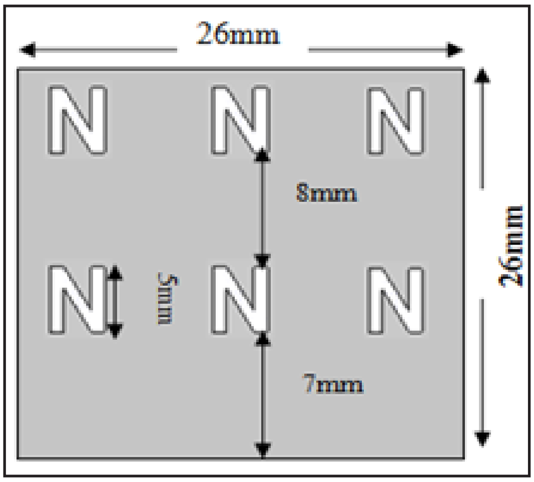


Fig. 2: Modified FSS(1st Step)

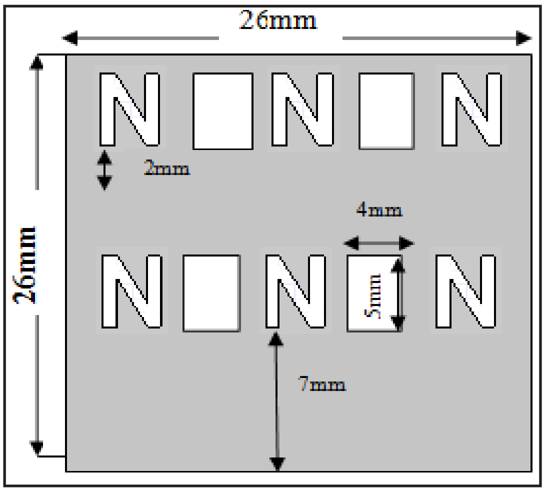


Fig. 3: Modified FSS (2nd Step)

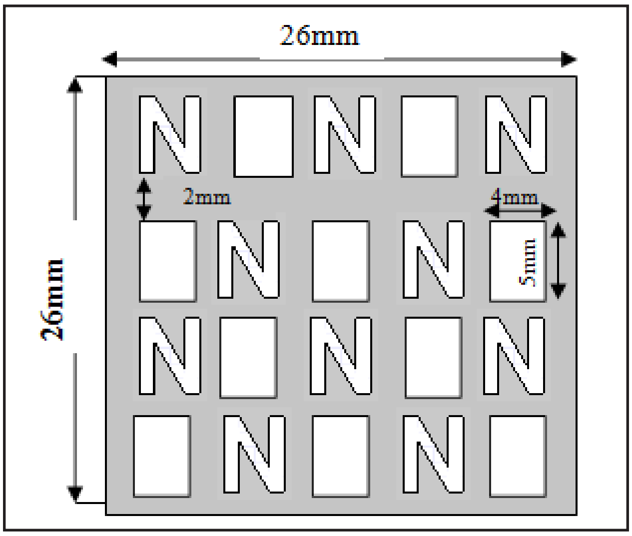


Fig. 4: Proposed FSS(Final step)

All the steps including reference patch for designing Proposed FSS is shown in the fig. 1-fig. 4. In the fig. 2 the slots like as "N" with 1mm width and 5mm length are designed keeping fixed the periodicity. In fig. 3, 4mmX5mm rectangular slots are introduced between two "N" slots. Now at the final step, in fig. 4 "N" and rectangular slots are arranged in alternate fashion

III. Simulated and Measured Result

Computed transmission characteristics for Reference patch and all designed FSS are shown in the below figures from fig. 5-fig. 8 stepwise using Ansoft software.

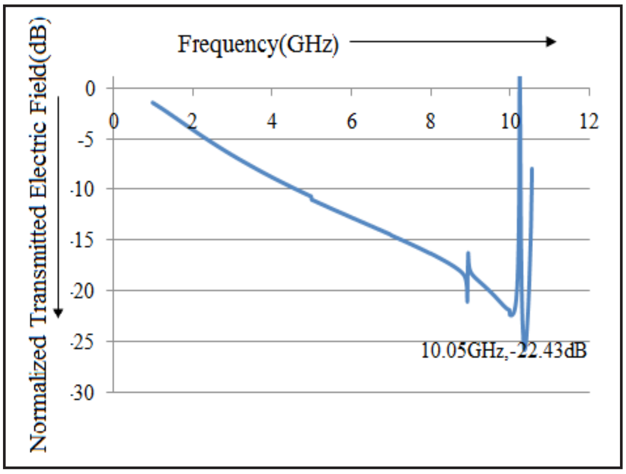


Fig. 5: Transmission Charecteristics of Reference Patch

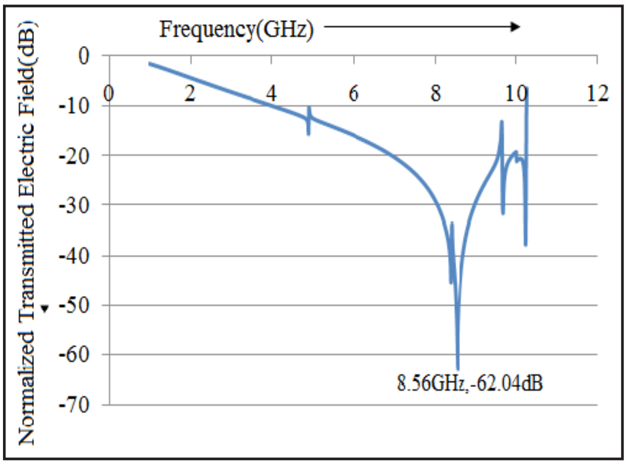


Fig. 6: Transmission Charecteristics of Modified FSS (1st Step)

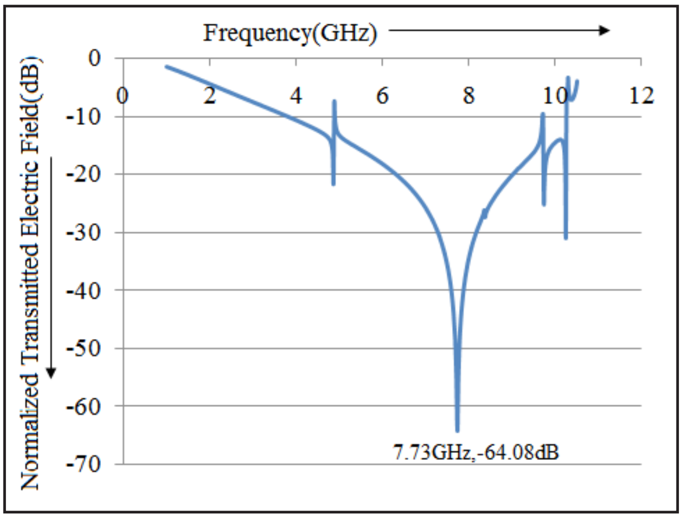


Fig. 7: Transmission Charecteristics Modified FSS(2nd Step)

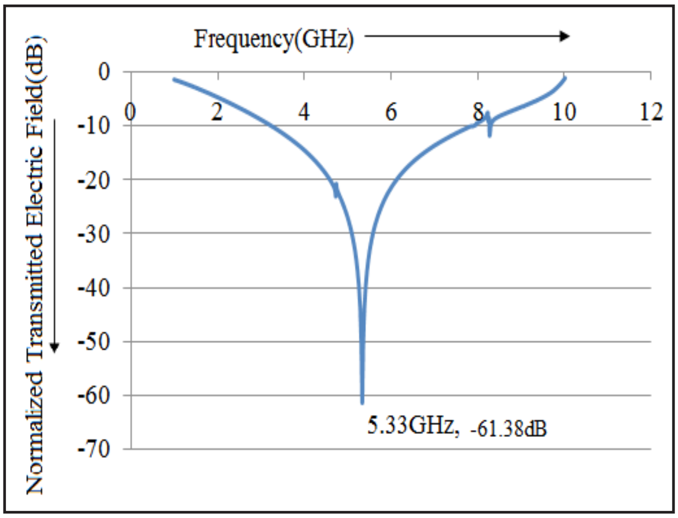


Fig. 8: Transmission Charecteristics Proposed FSS (Final step)

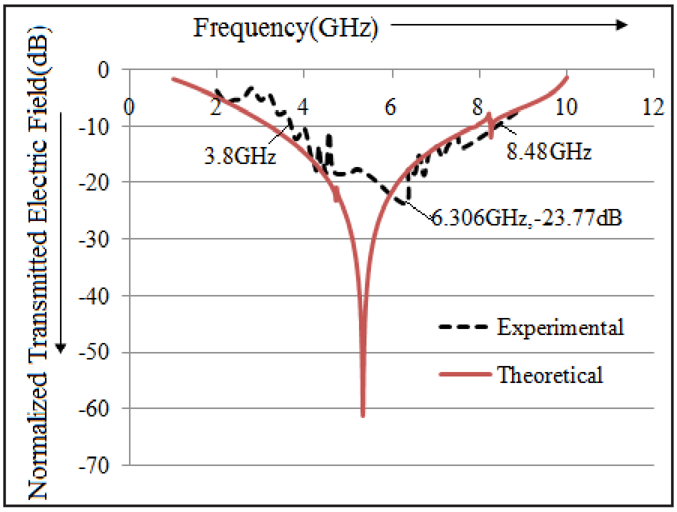


Fig. 9: Experimental and Theoretical Transmission Charecteristics Graphs of the Proposed FSS

Here, from graph it is observed that the resonating frequency and percentage bandwidth (BW) are decreased and increased respectively in each steps. This is the desirable condition for a good FSS. The analysis data of each graph are in tabular form in the Table 1 including practical measurement data. The final step is considered as proposed FSS whose bandwidth is maximum i.e 88.36% (theoretical)compared to others.

Table 1: Summarized Result

Designs	Parameters of designed FSSs				
	Resonating Frequencies(GHz Dielectric constant)	Lower cut-off frequency at -10dB(GHz)	Upper cut-off frequency at -10dB(GHz)	%Bandwidth (Bandwidth in GHz)	Size Reduction (%)
Patch without slot(reference)	10.05	4.65	10.57	58.90 (5.92)	--------
Patch with No of 6 'N'slot(fig. 2)	8.56	4.03	10.26	72.78 (6.23)	27.42
Patch with No of 6 'N' & 4 rectangular slot(fig. 3)	7.73	3.80	10.26	83.57 (6.46)	41.52
Patch with 'N' & rectangular slot alternately (fig. 4)	5.33	3.23	7.94	88.36 (4.71)	71.86
Fabricatd proposed design(fig. l0)	6.306	3.8	8.48	80.55 (5.08)	60

The comparison transmission characteristics curve of theoretical and experimental measurement is shown in the fig. 9. Theoretical as well as simulated percentage bandwidth are very close to each other.

The top view of the fabricated FSS is shown in the fig. 10. The gap between each element is 2mm in x and y directions respectively

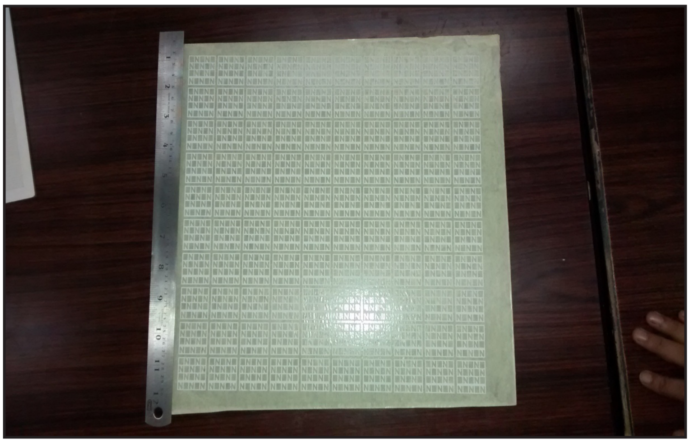


Fig. 10: Fabricated Design of Proposed FSS

A. Dielectric Substrate Variation of Proposed FSS

Now , the dielectric substrate has been changed for the proposed FSS. Then the transmission characteristics curves for different dielectric constant is shown in the below fig. 11 are analyzed.

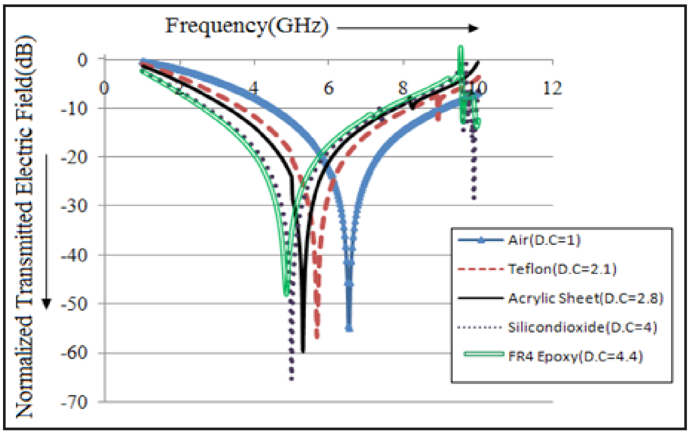


Fig. 11: Transmission Charecteristics Graphs for Different Dielectric Constants of the Proposed FSS

The results of the proposed FSS on the basis of variation of the dielectric constant are presented in the Table 2 .

Table 2: Effects Due to Dielectric Variation

Different dielectric substrate variation	Obtained resonating frequency and percentage bandwidth variation of dielectric constant in designed FSS e Column			
	Dielectric substrate	Dielectric substrate	Resonating frequency(GHz)	Band Width(%)
	Air	1	6.50	70.30
	Teflon	2.1	5.67	80.42
	Acrylic Sheet	2.8	5.33	88.36
	Silicon di- oxide	4	5.00	89.80
	FR4 Epoxy	4.4	4.86	100.40

From the above Table 2 it is observed that , the best result is obtained when FR4 Epoxy is used as dielectric substrate. In this chapter Acrylic sheet is used as it gives comparatively good result with a very low fabrication cost.

IV. Conclusion

Bandwidth enhancement is one of the important achievements of the FSS design, which is very essential in various applications. In the first design, only six no of 'N' type slots are loaded in the reference patch. The resonant frequency and percentage bandwidth are improved but size reduction is not good. In the next step of design, four 5mmX4mm rectangular slots are introduced.Now bandwidth is increased (83.57%). Again introducing 'N' and rectangular slots alternately, the percentage bandwidth as well as size reduction become 88.36% and 71.86% respectively. It is very challenging to improve percentage bandwidth, size reduction simultaneously.The percentage bandwidth for the fabricated design is 80.55%.The compactness is also achieved by increasing the dielectric constant.The designed FSS may be useful in the field of weather radar and satellite communications.

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