Reduction of Resonant Frequencies of Frequency Selective Surface by Introducing Different Types of Slots

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ABSTRACT
In this paper, frequency Selective Property of a rectangular patch has been investigated. Study is based on patch without slot and the same patch with slot. In a fixed patch different shapes of slots have been cut and simulated results are noted. Observations are reported with different periodicities. The investigation includes a comparative study also.

Keywords: Frequency Selective Surface (FSS), Patch, Slot.

1. INTRODUCTION
Frequency Selective Surface is a two dimensional array of patches on a dielectric substrate or that of apertures within a metallic screen. Depending upon the nature of the surface it can exhibit band pass or band reject property. Generally patch type FSS acts like a band reject filters and aperture like FSS acts like a band pass filters. Frequency Selective Surfaces will reflect waves at some frequencies, and pass waves at other frequencies. Frequency Selective Surfaces are used in various applications, such as band pass radomes for missiles, sub-reflectors for dual frequency reflector system [1–3], microwave, optical and infrared filters, etc. To analyze different types of FSS structures theoretically investigations on arrays of elements of different shapes like the Jerusalem cross [4], annular ring [5], and square loop [6] have been carried out earlier. Generally theoretical analyses of the surfaces are done by three methods. Finite Difference Time Domain method (FDTD), Finite Element Method (FEM) and Method of Moment (MOM). Ansoft is software which works based on method of moment. This procedure is most complicated but accuracy is highest. Here in our study proposed FSS structure has been theoretically analyzed by Ansoft Designer® and then these theoretical results are compared.
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2. DESIGN OF THE FSS
A rectangular patch of measurement 15mmX5mm is taken. Periodicity varies from 25mmX25mm to 16mmX10mm. The FSS was designed in such a way that it may resonate at a frequency lesser than the frequency obtained from the patch without slot. The dielectric slab with thickness of 1.6mm was used. Its dielectric constant was 2.4.Three types of slots have been cut within the rectangular patch of 15mmX5mm Shown in figure 1, figure 2 and figure 3.

In first case "U" shaped slot has been cut within the fixed patch. All the dimensions in detail are shown in fig. 1.

In second case one "F" type and two "I" type slots are cut within the same patch.

In last case one "U" type and two "I" type slots are cut within the patch. All the dimensions in detail are shown in figure 2 And Figure 3 respectively.

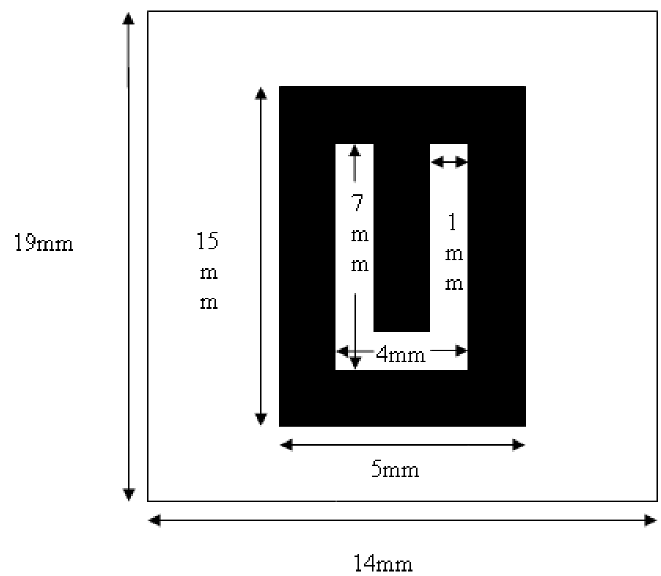

Figure 1.Rectangular Patch with 'U' shaped slot

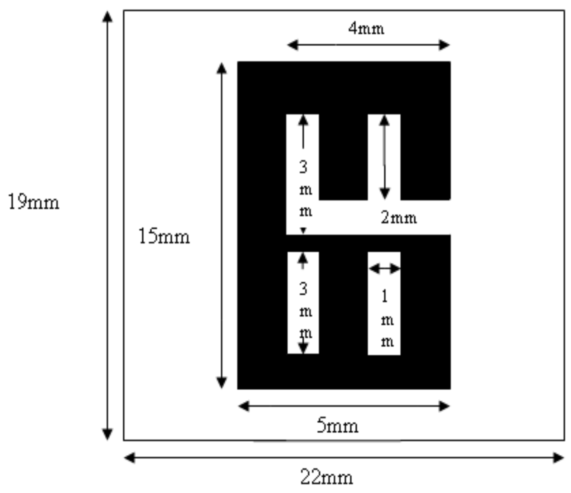

Figure 2. Patch with one "F" shaped slot and two "I" shaped slots

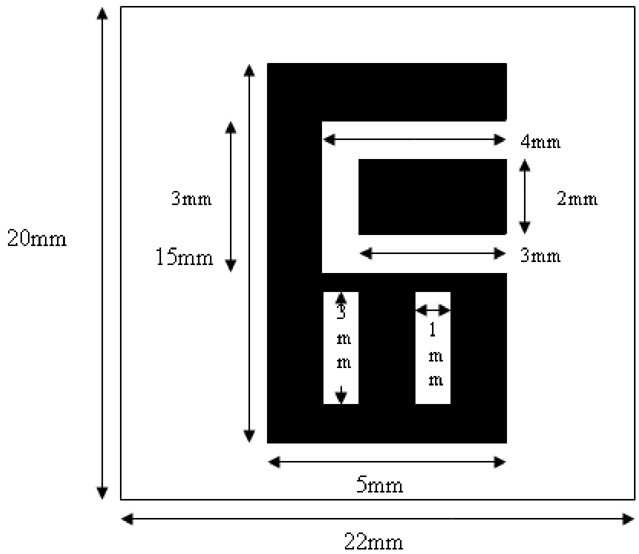

Figure 3. Patch of 15mmX5mm having one "U" Shaped slot and two "I" shaped slots

3. SIMULATIONS

Simulations were made in the frequency range upto 12.0GHz with an interval of 0.01 GHz. Transmitted electric fields for FSS structure 1(shown in figure 1) is calculated by Ansoft Designer® for the frequency range of 4GHz to 11GHz and is shown by firm line in Figure 4.The periodicity was 19mmX14mm.In the same figure the dotted line curve is for rectangular patch in the same FSS structure without slot (shown in figure 4).From the simulated data, normalized transmitted electric field vs. frequency for figure 2 was plotted as shown in Figure 5 and the same rectangular patch of measurement 15mmX5mm having periodicity 19mmX22mm without slot was also shown in figure 5 by dotted line. Normalized transmitted electric field vs. frequency for figure 3 was plotted as shown in Figure 6. The plot includes the results for the patch without slot and with slot also.

The total results are presented in tabular form in table 7.

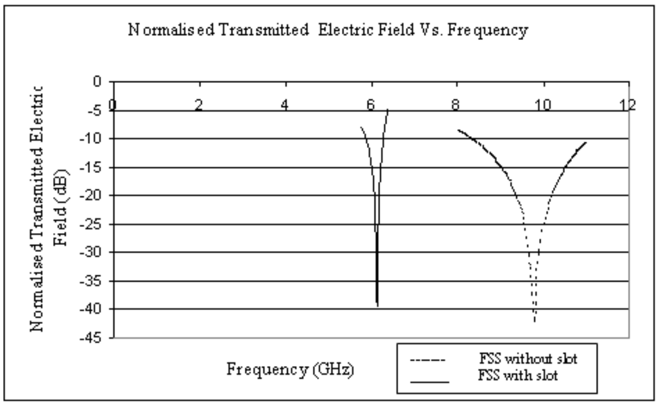

Figure 4. Normalised Transmitted Electric Field Vs. Frequency Plot For FSS structure 1

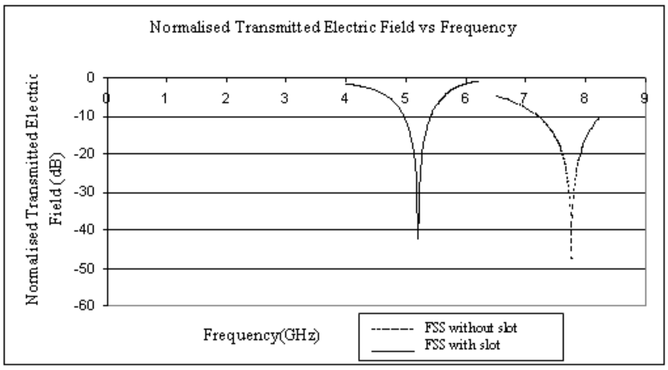

Figure 5. Normalised Transmitted Electric Field Vs. Frequency Plot For FSS structure 2

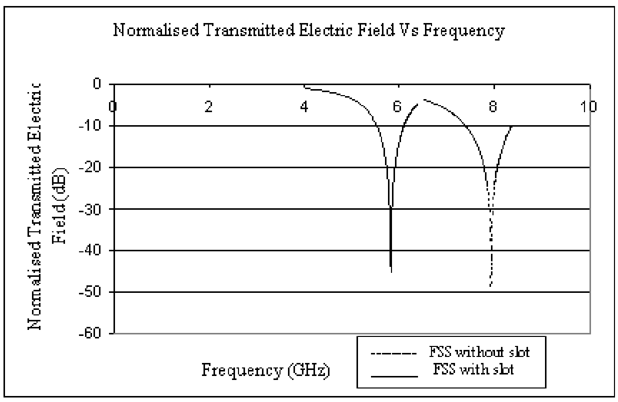

Figure 6. Normalised Transmitted Electric Field Vs. Frequency Plot For FSS structure 3

Periodicity	Slot	Shape	Drop In dB	Reflection Bandwidth	Resonant Frequency (GHz)
19mmX14mm	No		-40	(8.5-11) 2.5GHz	9.7
19mmX14mm	Yes	Figure 1	-30	(5.9-6.3) 0.4GHz	6.1
19mmX22mm	No		-40	(7.2-8.2) 1GHz	7.7
19mmX22mm	Yes	Figure 2	-33	(4.9-5.4) 0.5GHz	5.2
20mmX22mm	No		-38	(7.3-8.3) 1GHz	7.9
20mmX22mm	Yes	Figure 3	-36	(5.5-6.1) 0.6GHz	5.8

Table 7

Some results for other shapes of patches shown in fig 8 & 9 are also cited as in fig 10 & 11.In figure 10 & 11 it is observed that resonant frequency with slot is 7.2GHz approximately. The resonant frequency is not much lesser than the resonant frequency without slot.

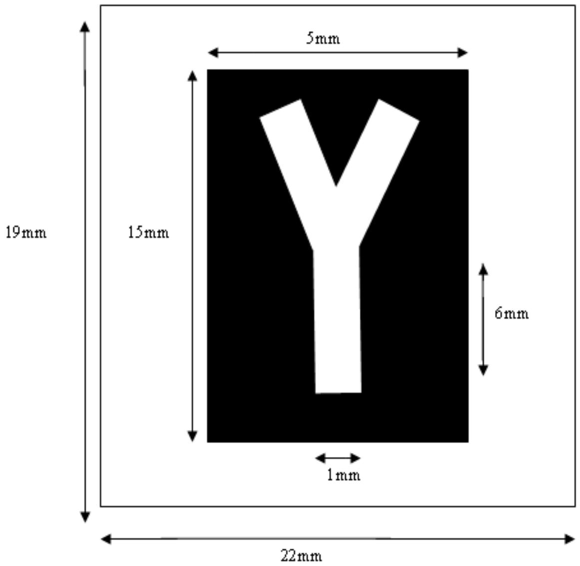

Figure 8.Patch of 15mmX5mm having one "Y" shaped slot

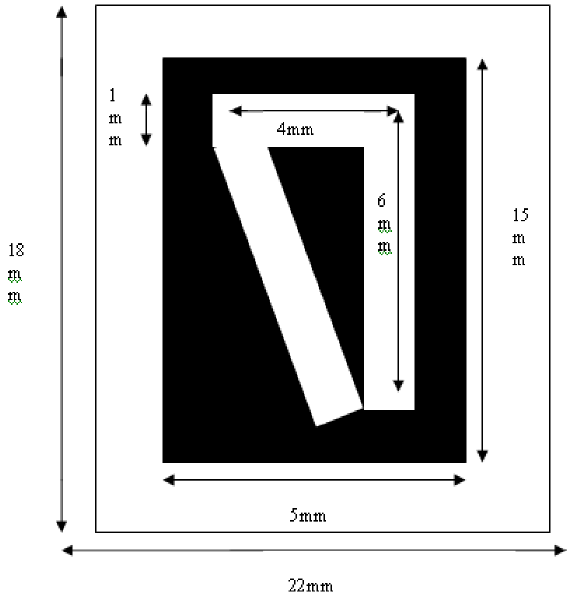

Figure 9.15mmX5mm Patch with slot

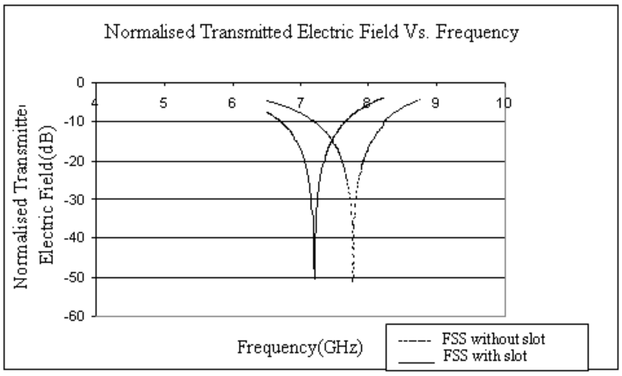

Figure10. Normalized Transmitted Electric Field vs. Frequency Plot For Figure 8

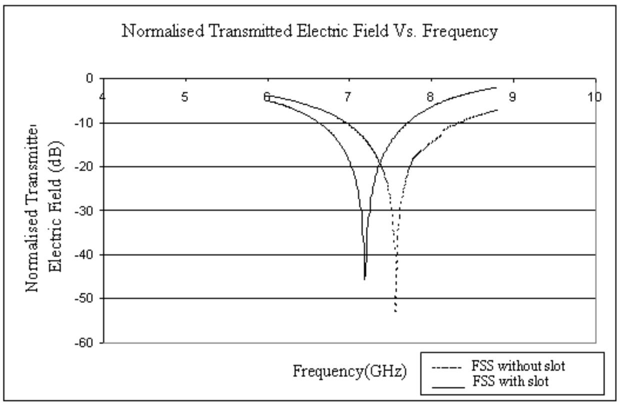

Figure11. Normalized Transmitted Electric Field vs. Frequency Plot for Figure 9

4. CONCLUSION

It is observed that by cutting different slots resonant frequencies may be decreased. That means compactness or size reduction of the FSS structure is possible in this method. Reduction of resonant frequency has been achieved to the level of approximately 40 %.

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