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RESEARCH ARTICLE

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DESIGN OF A COMPACT AND MULTI-BAND FREQUENCY SELECTIVE SURFACE

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ABSTRACT

This paper presents an effort of designing a compact Frequency Selective Surface with six resonating frequencies. Both simulated and experimental investigations have been performed on the designed FSS to check its practical implementation. The designed FSS also has the ability to provide a compactness of 92.52%. The proposed FSS is simulated using Ansoft Designer version 2.2. The FSS is designed to operate in S, C and X bands, and thus can be used for wireless networks, long-distance radio telecommunications, radars, satellite communications, etc.

Key words— Compactness, Frequency Selective Surface, Multiple frequency operation.

INTRODUCTION

Frequency Selective Surfaces (FSS) can be defined as a periodic array of patches on a dielectric substrate or apertures of regular or arbitrary geometries within a metallic screen [1-2]. They have the property to reflect or transmit electromagnetic waves and thus can be treated as microwave filters. There are two types of FSSs. The first one being Patch type FSS which behaves as Band Reject Filter and the second one is aperture type FSS which acts as Band Pass Filter [3]. From the last few decades FSS is treated to be an intensive topic of research. [4-8]. There are several methods that can be used to design a muli-band FSS, such as Combined elements, Complex elements (fractal elements), multilayered FSS, and the combination of several of those techniques [9-12]. But in this paper a muti-frequency FSS is designed by only introducing slots on the patch of the FSS and here lies the simplicity of the proposed design. The applications of FSSs are vast and wide, ranging from simple home appliances to large scale applications such as communication networks [13-16].

DESIGN OF THE FREQUENCY SELECTIVE SURFACE

The conventional patch type FSS is designed by using a two dimensional array of a square shaped patch of dimension 20 mm × 20 mm. The metallic patches are present on one side of the thin dielectric slab. The metal used here is copper and the copper coating on the other side of the dielectric slab is removed completely. The periodicity taken in both horizontal and vertical direction is 24 mm. The dielectric used in designing the FSS is Acrylic Sheet having a dielectric constant of 2.8. The height of the dielectric is taken to be 1.6 mm. The conventional patch type FSS is shown in Fig1.

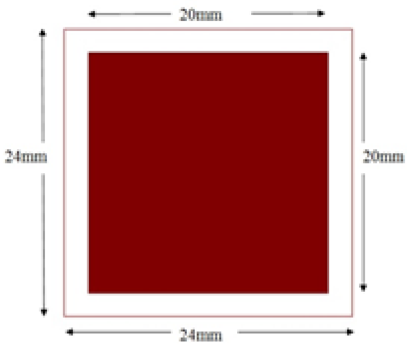

Fig. 1. Patch of the conventional FSS.

The conventional patch type FSS is then modified by introducing alternate slots of thin strip like structures having width of 1mm. Only the middle strip is of width 2 mm. The structure of the designed FSS is shown is Fig2, along with all other dimensions.

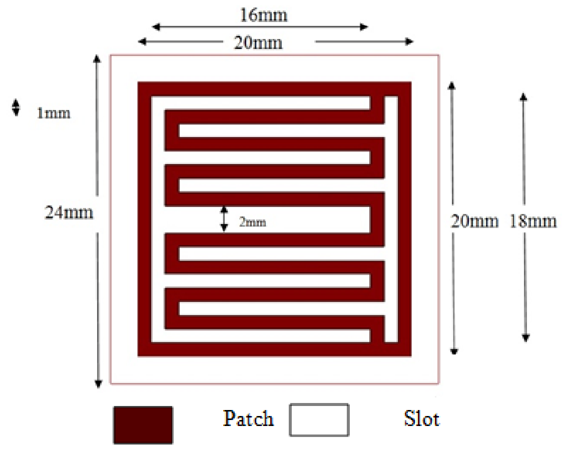

Fig. 2. Proposed FSS structure.

The periodicity in both the horizontal and vertical direction is shown in Fig 3.

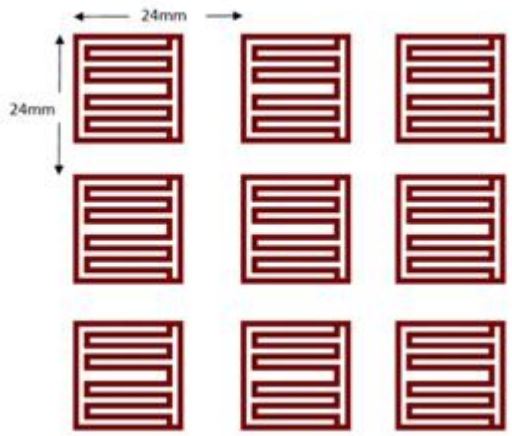

Fig 3: 9 unit cells of FSSs showing periodicity in both horizontal and vertical directions.

Miniaturization of FSS can be done by two processes. The first one is by using dielectric with high permittivity. The other one is by increasing the effective electrical length of the metallic patch. The first method is avoided because it provides greater losses and thus they are less efficient. They also have relatively smaller bandwidths [17-18]. Therefore the second method for miniaturization of the FSS is opted while designing the proposed FSS structure. This is done by introducing meander type of slots on the patch of the FSS which in turn meanders the patch surface current. Thus multiple resonating frequencies are obtained along with decrease in resonating frequencies thus leading to the compactness of the FSS. The fabricated Frequency Selective Surface is shown in Fig4.

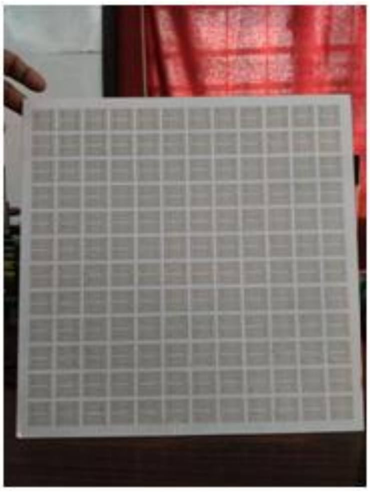

Fig. 4. Fabricated FSS structure.

RESULTS

The simulated result is obtained using MOM based Ansoft Designer Software. Simulated results are plotted in Fig 6. The results are also tabulated in Table 1.

Transmission test for the proposed FSS is done using microwave test bench, in the microwave laboratory as shown in Fig 5. Two horn antennas were used, one for transmission and the other one for reception. The designed FSS were placed between the two horn antennas, mounted on a wooden frame stand. The transmitting horn antenna was connected to Agilent Signal Generator, while the receiving horn antenna was connected to Power meter. Different horn antennas were used for the frequency range of 2-12 GHz. Measurements were done in the frequency range of 2-12 GHz with an interval of 0.1GHz for the incident waves with angles zero degree to the normal. The signal generator radiates power which is blocked at all frequencies except at 3 GHz, 3.6 GHz, 6.5 GHz, 8.2 GHz, 9.4 GHz, 11 GHz. This was verified by the readings in the power meter. The measured data were noted down and a graph of normalized transmitted electric field versus frequency was plotted for the designed FSS in the same Fig 6 for comparison with the simulated result.

Fig. 5. Experimental set up for the Fabricated FSS structure.

After the experiment was performed it was observed that the designed FSS had 6 resonating frequencies at 3 GHz, 3.6 GHz, 6.5 GHz, 8.2 GHz, 9.4 GHz and 11 GHz with a percentage bandwidth of 16.33%, 22.22%, 10.77%, 6.10%, 10.11% and 16.18% respectively.

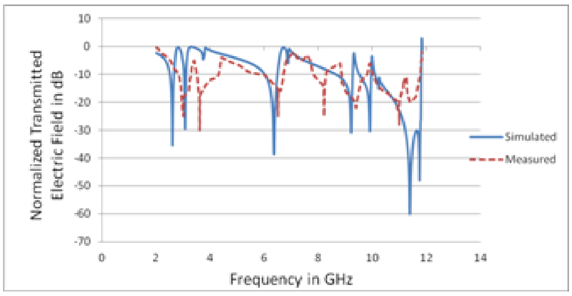

Fig 6: Transmission characteristics of the designed FSS.

Table 1

FSS	RESONATING FREQUENCY (GHz)	PERCENTAGE COMPACTNESS
Reference	10.97	--
Proposed	2.59(simulated) 3.00(measured)	94.42 %(simulated) 92.52 %(measured)
	3.07(simulated) 3.60(measured)	--
	6.35(simulated) 6.50(measured)	--
	9.21(simulated) 8.20(measured)	--
	9.91(simulated) 9.40(measured)	--
	11.30(simulated) 11.00(measured)	--

CONCLUSION

From the simulated and measured data obtained, it is observed that the designed FSS can be operated in six multiple frequencies. The percentage bandwidth for each of the operating frequencies of the designed FSS is also good. In comparison to the conventional patch type FSS to that of the designed FSS the resonating frequency is decreased from 10.97 GHz to 3 GHz. For the reference FSS when no slots were introduced, the resonating frequency was 10.97 GHz. To obtain the resonating frequency at 3 GHZ, it would require the area of the patch to be 1811.50 mm^2 approximately. The area of the reference patch is calculated to be 135.40 mm^2 approximately. Therefore the size reduction is calculated as [(1811.50-135.40)/1811.50]*100, which results in a compactness of 92.52%.

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