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FSS with Inbuilt Triangular Slots for Dual Band Operation

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ABSTRACT: This paper presents a miniaturized Frequency Selective Surface (FSS) intended for dual band frequency operation. The FSS design along with a discussion on its performance is outlined. The proposed Frequency Selective Surface structure has been theoretically analyzed by Ansoft HFSS 13.0 software which works on the Finite Element Method.

KEYWORDS: Frequency Selective Surfaces, Reduced size, dual frequency band, slot

I. INTRODUCTION

Dichroic or frequency selective surface (FSS) is an infinite periodical array of two dimensions. These surfaces comprise of periodically arranged metallic-patch elements or aperture elements within a metallic screen, which exhibit total reflection or transmission characteristics respectively in the neighbourhood of the element resonance. Actually FSS can be viewed as a spatial filter whose characteristics are immensely affected by the change of incident angle, polarization, and frequency. As spatial filter, FSS is widely used in the fields of microwave and optics [1-5]. This includes its use as sub-reflector, as in Voyager, Galileo, and Cassini space mission's frequency reuse system. Frequency reuse of reflectors thus accomplished via the use of a dichroic surface, allows the sky radiation to be filtered at different frequencies, and therefore be processed by different receivers concurrently. FSS can be used as superstrates above the patch antennas to enhance the antenna directivity and FSS radomes help the RCS reduction. The use of frequency selective surfaces has also been successfully proved as a potential means to increase the communication capabilities for satellites. The growing demands on potential multi-functional antennas for radio communications also require complex FSS with multi-band requirements. In this paper, we have discussed the design of a thin-screen compact frequency-selective surface (FSS) that utilizes the printed circuit technology for multiband operation.

II. PROPOSED DESIGN OF THE FSS

The designed FSS consists of an array of equilateral triangular patches shown in Fig. 1 (left). The patches are actually metallic (copper) screen. The sides of each triangular patch are 121.24mm. The distance between the centroids of two adjacent triangles is 160mm i.e. the size of a unit cell is 160mm x 160mm. On each patch we have etched one inverted triangular slot of side 60.6 mm as shown in Figure 1 (right). The substrate is 1.6mm thick. The dielectric constant is 2.8. As the dielectric structure is very thin, the structure was not affected by loading effect [6]. The complete FSS is shown in Fig. 2.

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Although FSS is an infinite array theoretically but in practical applications FSS has to be finite. When the infinite period of FSS is truncated, remarkable changes take place in FSS's performance. It is therefore necessary to use sufficient number of unit cells or elements to keep the characteristics of designed FSS close to those of infinite FSS. However, when the operating frequency is low, the size of element is so large that it is difficult to design a finite FSS array with sufficient number of elements in a reasonable size to mimic an infinite FSS. As a result, miniaturization [7] is of great significance at low frequency, along with other wanted features such as wide band, insensitiveness to changes of source polarization angles [8] and high level of separation between transmission and reflection at resonant frequency.

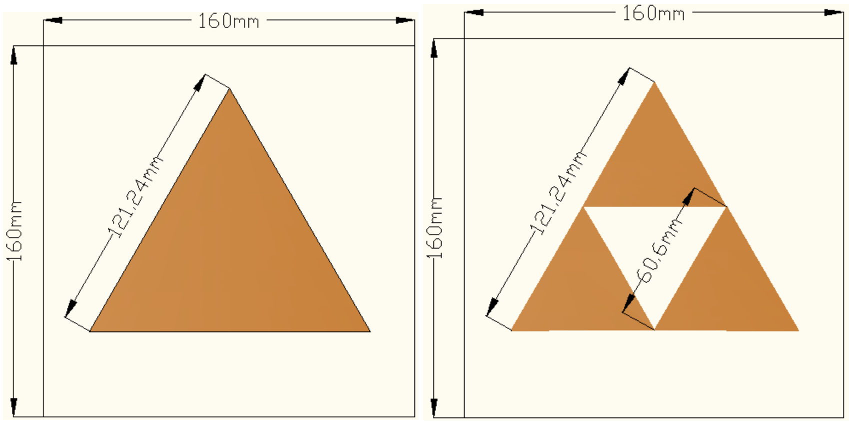

Fig. 1 Unit Cell Structure of the FSS without slot (left) and Unit Cell Structure of the FSS with slot (right).
(Copper Colour indicating Copper and white colour indicating substrate)

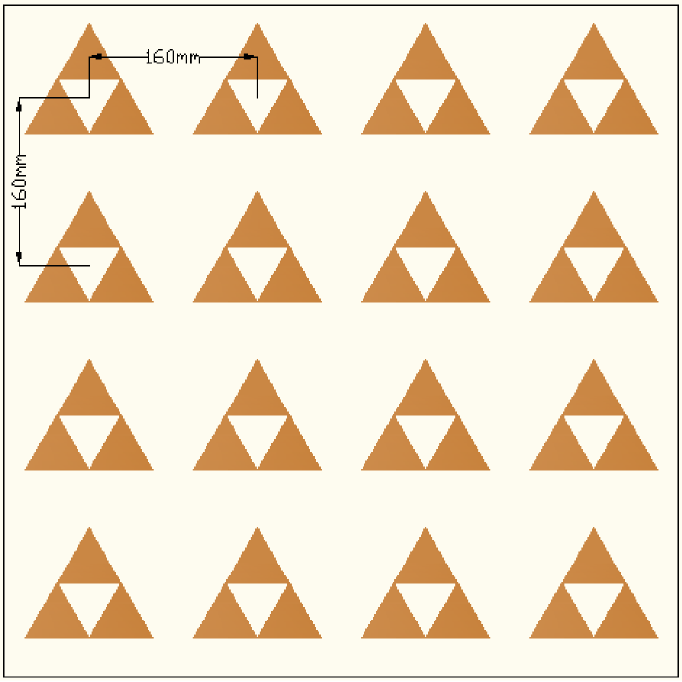

Fig. 2 A Complete FSS
(Copper Colour indicating Copper and white colour indicating substrate)

III. RESULTS AND DISCUSSION

The FSS is analysed by Ansoft HFSS 13.0 software for the frequency range of 1GHz to 5GHz to obtain Normalized Transmitted Electric Field and Surface Current Density on the metal at different frequencies.

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A. Analysis of Transmitted Electric Field

Normalized transmitted electric field vs. frequency curve calculated for the frequency range of 1GHz to 5GHz is shown in Fig. 3. From Fig. 3 we see that two frequency bands below -10dB is observed in case of the slotted FSS as compared to a single frequency band below -10dB for the FSS without slots. While the resonant frequency for the triangular patch is 1.5GHz with 20% bandwidth, the achieved percentage bandwidths are 22.7% and 6.25% at the first and second resonant frequencies of 1.1 GHz and 3.2GHz respectively for the slotted FSS.

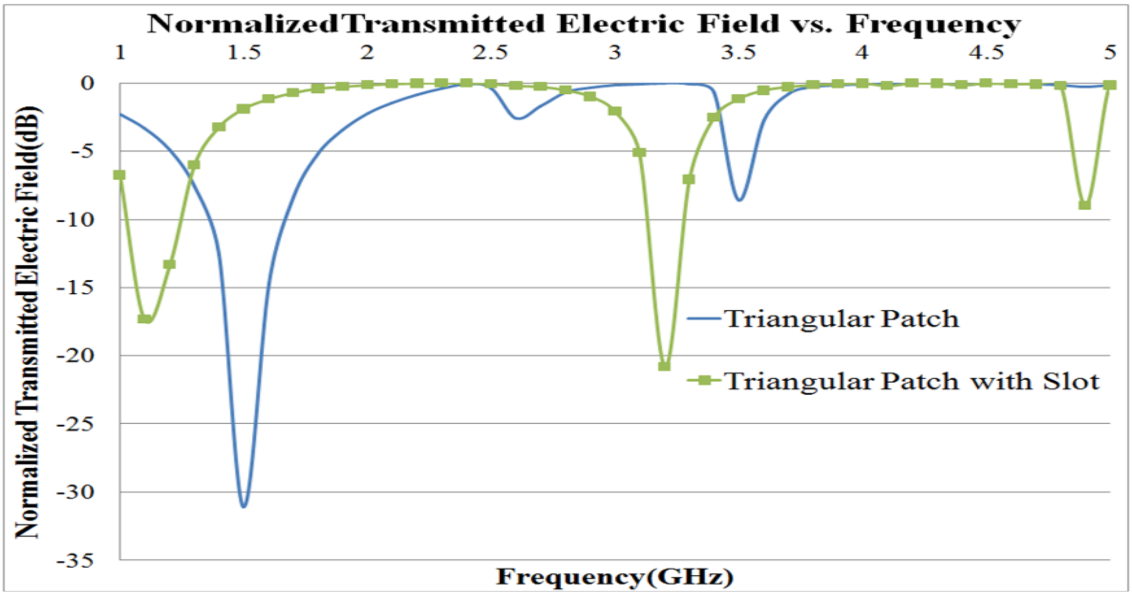

Fig. 3 Normalized Transmitted electric fields vs. frequency

B. Analysis of Surface Current Density

Fig. 4 shows the simulated current densities on the FSS when no slot is drawn. Very high current density is observed. As shown in Fig. 5 the surface current density is reasonably high on the outer vertices of the inner inverted triangular slots with less current density elsewhere corresponding to 1.1 GHz resonant frequency mode. Similarly from Fig. 6 the surface current density is seen to be moderately high along the edges of the inner and outer triangles with less current density elsewhere corresponding to the 3.2 GHz resonant frequency mode.

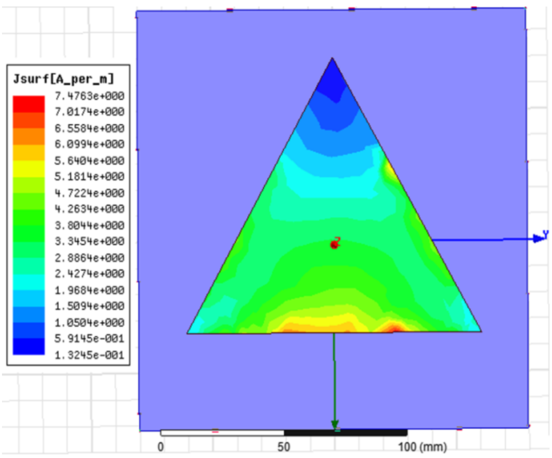

Fig. 4 Surface Current Density on the Triangular Patch at resonant frequency 1.5GHz

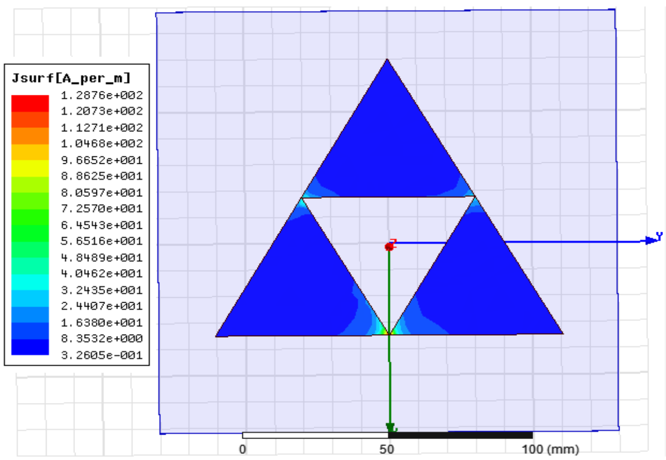

Fig. 5 Surface Current Density on the Triangular Patch at resonant frequency 1.1GHz

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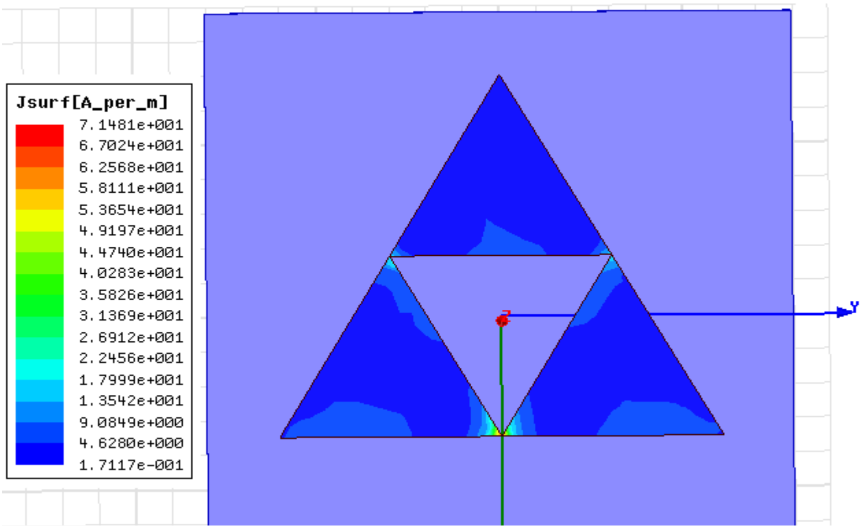

Fig. 6 Surface Current Density on the Triangular Patch at resonant frequency 3.2GHz

IV. CONCLUSION

The designed FSS with slot shows dual frequency band behavior as compared to single frequency band behavior of the FSS without slot. Also there is a significant left shift in resonant frequency value in the slotted FSS as compared to the FSS without slot. The resonant frequency for the FSS having no slot is 1.5GHz. But for the slotted FSS the resonant frequency is 1.1GHz.To resonate a FSS at 1.1GHz ,a larger FSS is required .But it is shown that with a compact FSS we get the resonant frequency of 1.1GHz.This leads to a size reduction of 26.67% compared to the traditional triangular patch FSS without slots. The size reduction is achieved by full use of the inner space of triangular patch. This is an extra advantage added to the fact that the designed FSS is also a dual broad band filter.

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Miss.Neha Rai is a 4th year student of Modern Institute of Engineering and Technology in Electronics and Communication Engineering Department. She is presently working towards the B.Tech Degree. Her area of interest is Frequency Selective Surfaces.

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