Design of Frequency selective surface for Satellite Applications

Ch V Ravi Sankar, Associate professor,
T Malleswara rao, Assistant professor,
Department of Electronics and Communication Engineering.
AIMS COLLEGE OF ENGGINERING, Mummidivaram.

Abstract:
Frequency selective surface (FSS) is used for filtering both passing and rejecting signals in multiple selected frequency bands and for use in contact with an antenna and in Satellite, or communication systems. The frequency selective surface can favourably be used to filter out signals at a certain frequency. In this paper Analysis of FSS elements on a flat surface i.e., to turn these elements to resonate at x-band frequency with cross slot elements with different thickness and the dielectric constant material of the substrate is Roger's RT5880.The complete analysis carried out on an effective electromagnetic simulator CST MICROWAVE STUDIO

keywords: FSS, satellite, flat surface, CST microwave studio.

I. INTRODUCTION

A Frequency Selective Surface is a periodic assembly of one or two-dimensional resonant structures, either as apertures in a thin conducting sheet or as metallic patches on a substrate, which may have a band pass or band-stop function respectively[1]. A one or two-dimensional periodic array of resonant structures on a backing material, either apertures in a metallic sheet or metallic patches on a substrate, acts as a filter for a plane wave arriving from any angle of incidence[2].

Since the FSS would be used on curved structures like radomes, it is desirable that the FSS have the sameresonant frequency for allincident plane angles. The most important step in the design process of a desired FSS is the proper choice of constituent elements for the array[3]. Planar and curved FSSs are used for a variety of applications including design of antenna radomes, reflectors and sub reflectors, reflect array lenses. The integration of a FSS with a protective radome can considerably reduce the radar cross section (RCS) of the enclosed antenna outside its operating band, but may influence the electrical performance for the enclosed antenna such as reduction of polarization purity, increase of side lobe level, and transmission losses.

FSS can be used to increase the reflection of surfaces at specific band of frequency which would give collision avoidance systems by providing a larger return for them to focus on, or can be tuned to only permit radiation at specific bands to provide a band-limited connection between waveguide elements, antennas, enclosures, or the like. Frequency selective surfaces are especially useful for satellite antenna systems where multiple signals at different frequencies may be present and only selected frequency signals are to be transmitted to or from a given antenna system device[4].

A radome is a superstate designed to protect an antenna from the effects of its physical environment without degrading its electric performance. The other application of FSS is in reflector antenna systems, there FSS reflectors are used to separate feeds of different frequency bands.

II DESIGN OF UNIT CELL

In Figure.1 shows that the passive array type, in which the incident plane wave will be partly transmitted in the forward direction and partly reflected in the specular direction**.** Under resonant condition and for no grating lobes the amplitude [5] of the reflected signal may equal to E^i while $E^t = 0$.

The mathematical specular reflection coefficient is represented as [6][7]

$$\varGamma = \frac{E^r}{E^i} \quad \text{.........(Eq1)}$$

Where $\mathbf{E^r}$ and $\mathbf{E^i}$ in general are referenced to the plane of the array.

Similarly the Transmission coefficient is defined as

$$\tau = \frac{E^t}{E^i} \quad \text{.......(Eq2)}$$

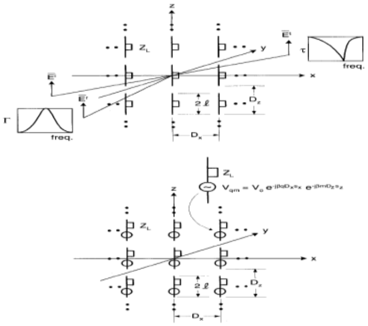

Fig.1.Passive array representation

Development of surface of single cross element is shown below. The development of this element is quite instructive. In below Fig we show a simple cross element which is placed on both the dielectric slab and metal . Here we use a material Roger's RT5880 with dielectric constant 2.2 for dielectric slab and for the metal we use copper with dielectric constant 5.8 for the cross element we use vacuum.

The cross slot is designed to resonate at 10GHz with dimensions, the dielectric substrate is taken with a thickness of 0.125mm, whole cross element is rotated with 30^0 so that to fit into the dimensions of a waveguide with length of 20.6mm and width of 11.7mm.

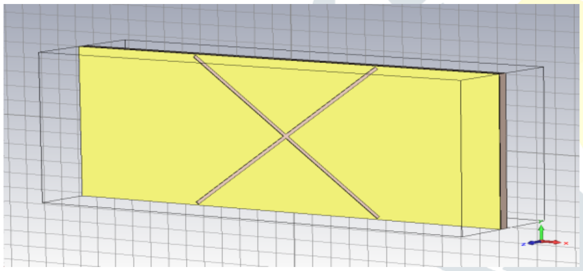

Fig. 2.Single cross element with thickness of 0.125 mm

The designed FSS is shown in figure 3 is composed of an array cross elements. The presented FSS shows a wide pass band from 8 to 12 GHz. The cross elements are designed to resonate at the central frequency at 9 GHz, the dimensions of cross length 12mm and its thickness is 2.8mm, spacing between the elements on the metal is 12 mm. The dielectric material used here is Rogers RT/Duroid5880 with dielectric constant of 2.2, and a thickness of 0.125 mm.

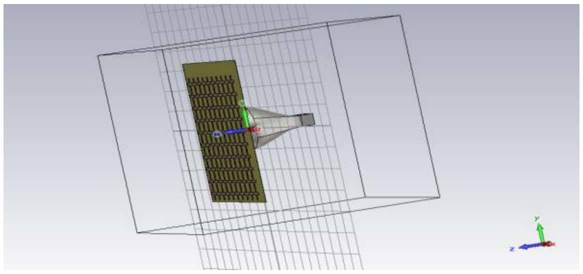

Fig. 3. 10×10 Array cross slot with dielectric thickness of 0.125mm

An antenna array consists of many individual 'elements' which are grouped together in order to improve theoverall performance of the structure. This is often necessaryto improve bandwidth and directionality as a single element isunable to fulfill this within the spatial constraints.The array has to sit inside a radome which has a frequency selective surface embedded in it . The FSS is present in order to minimize detection of the antenna system, and to provide some jamming immunity.

III. RESULTS

FSS is simulated with unit cell by using CST software, below figure 4 shows that the reflection and transmission coefficients for single cross on 0.125 thickness substrate with 2.2 dielectric constant, it allows 9GHz pass band frequency with 1GHz bandwidth.

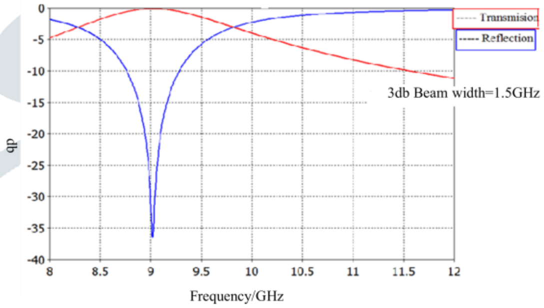

Fig. 4. The transmission and reflection coefficients for the single slot element

Figure 5. shows that the reflection and transmission coefficients for 10×10 array of cross elements are placed on 0.125 thickness substrate with 2.2 dielectric constant, it allows 9.6GHz pass band frequency with 150GHz bandwidth.

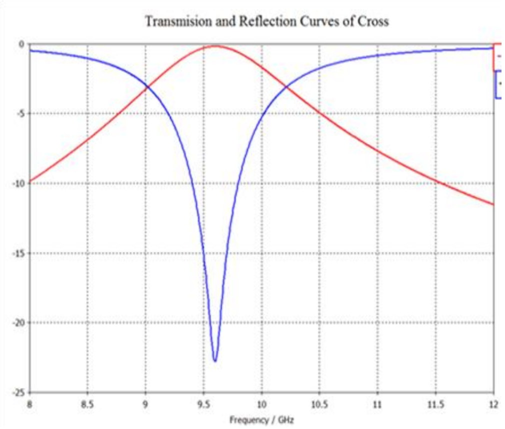

Fig. 5. The transmission and reflection coefficients for 10×10array.

IV. CONCLUSION

Analysis of FSS for cross elements are invovled in designing a radome.The cross elements are having the property to allow the particular frequency of signal at 9GHz and attenuates the other frequencies. The FSS has also been simulated along with the 10×10 array in which it allows frequency of 9.3GHz signal. The designed Frequency Selective surface is usefull in satellite and radar applications.

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