Design of an Aperture Type Frequency Selective Surface with Sharp Roll -off

Poulami Samaddar, Sushanta Sarkar, Srija De, Sushanta Biswas, Debasree Chanda Sarkar and Partha Pratim Sarkar

Abstract In this paper effort has been given to design a broad band high roll off aperture type frequency selective surface. To achieve this, different structures like circular, hexagonal, square and tripole are investigated and compared. Tripole is proved to be the best element to achieve high roll off and broad band. The design is modified as double layer to make it even more selective filter. The final design is fabricated and measured to validate. Measured result follows the simulated result closely.

Keywords Frequency selective surface · Aperture type · Band pass · Sharp roll off

1 Introduction

Frequency selective surface (FSS) is a periodic array of conducting patch type element or dielectric aperture type element [1]. These types of structures show band stop or band pass property for microwave communication. The patch type FSS shows band reject property and aperture type FSS shows band pass property. For

P. Samaddar (✉) · S. Sarkar · S. De · S. Biswas · D.C. Sarkar · P.P. Sarkar
Department of Engineering and Technological Studies, University of Kalyani, Kalyani, India
e-mail: poulami_samaddar@rediffmail.com

S. Sarkar
e-mail: sushantasarkar@aol.com

S. De
e-mail: srijade@gmail.com

S. Biswas
e-mail: biswas.su@gmail.com

D.C. Sarkar
e-mail: dsarkar70@gmail.com

P.P. Sarkar
e-mail: parthabe91@yahoo.co.in

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this nature FSS is used in different devices like antenna radome, frequency sub-reflector system and many other military applications [2, 3]. This type of single layer frequency filters suffers from very poor filtering due to bad roll off. Unwanted frequency band interfere with desired band. To improve this problem different types of processes like cascade technique, microstrip line technique etc. [4, 5] can be adopted. But these kinds of process make the design complicated and very tough for practical implementation.

In this paper different types of basic FSS elements are investigated to achieve maximum roll off. Simulation is done using Method of Moment based software FEKO. The simulated result is compared with practically measured result. Both the results are in good parity.

2 Design

This paper deals with aperture type FSS. Different type of shapes (like circular, square, hexagon, tripole etc.) etched out from a metallic sheet in a periodic interval. These FSSs show band pass property [1]. Dielectric constant of the dielectric (acrylic sheet) used for this experiment is 2.8 and width is 1.6 mm. The dimension of the single element of all the four FSS is showed in the Fig. 1. The periodicity and other perimeters of the structures are kept same so that results can be compared properly. At the time of simulation every element is considered as a part of an infinite array. The infinite model excites with plane wave excitation.

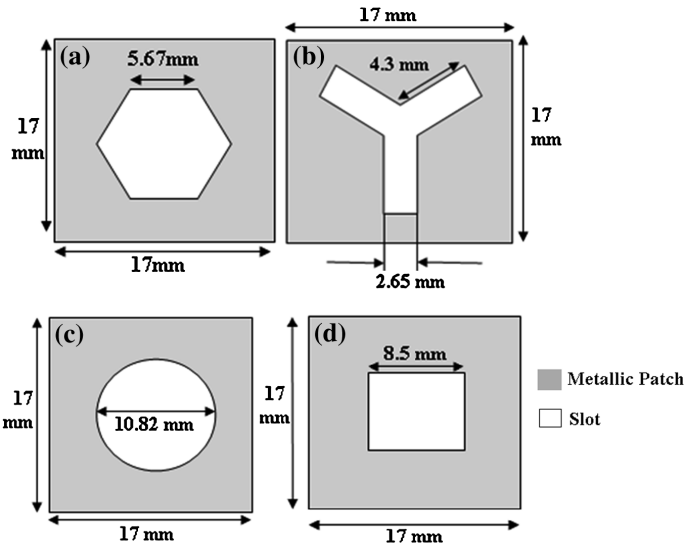

Fig. 1 Single cell of **a** hexagon, **b** circular, **c** square and **d** tripole aperture type FSS

The four designs are simulated and transmission coefficients of each of them are compared. Tripole type FSS shows best roll off among them. To get even better roll off double layer tripole structure is also investigated. The simulation is done by FEKO software which uses MoM for calculation purpose.

3 Result

The rolls off for different structures are shown in Table 1. A comparative roll off vs. frequency plot is shown in Fig. 2 for Hexagonal, circular, square and tripole type elements. It is clear from Table 1 and Fig. 2 that tripole type element is best candidate for that. The double layer tripole type FSS provided even better roll off than the one layer tripole FSS.

Double layer tripole is also studied. Tripoles of same dimension printed both side of a dielectric plate. This design shows even better roll off. Comparison between both double layer and single layer tripole is shown in Table 2 and Fig. 3. The final double layer tripole FSS is fabricated using laser cutting technology [6]. Measurement is done in laboratory by standard microwave test bench. The practical result shows good parity with the simulated result as shown in Fig. 4.

Table 1 Comparison of roll off for different types of elements

Elements	Upward roll off (dB/GHz)	Downward roll off (dB/GHz)
Circular	2	2.67
Hexagon	1.98	2.85
Square	2.2	3.08
Tripole	5	4.63

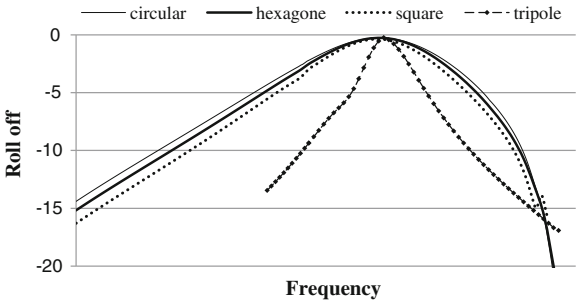

Fig. 2 Roll off versus frequency plot for different element to compare roll off

Table 2 Comparison of roll off for single layer and double layer tripole elements

Type of FSS	Upward roll off (dB/GHz)	Downward roll off (dB/GHz)
Single layer	5	4.63
Double layer	15	33.33

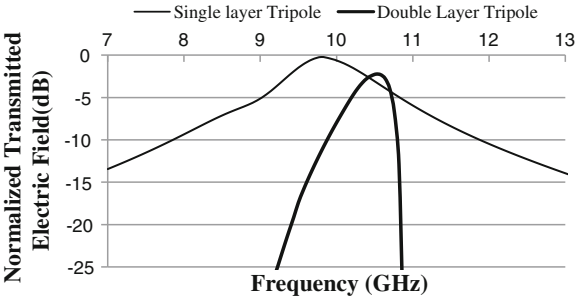

Fig. 3 Transmitted electric field versus frequency plot for single and double layer tripole element to compare roll off

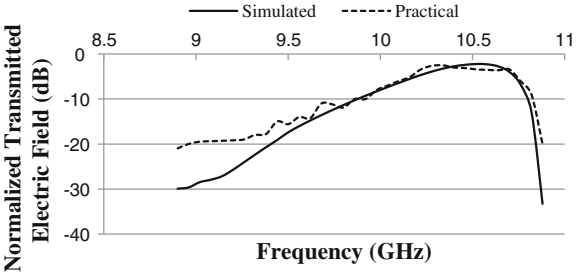

Fig. 4 Simulated and practical transmitted electric field versus frequency plot for double layer tripole FSS

4 Conclusion

From the studies it is observed that tripole type FSS is the best selection among circular, hexagonal and square element for high roll off factor. Roll off for tripole FSS increases even more if double layer FSS is used. Although band width is to be sacrificed to achieve sharp roll off, reasonable bandwidth is achieved in the final design. The design may be used in many satellite communications, military etc. applications etc. This work may be further extended to obtain high bandwidth and flat response.

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