International Journal of Applied Engineering Research ISSN 0973-4562 Volume 14, Number 11, 2019 (Special Issue)
© Research India Publications. http://www.ripublication.com

Optimized FSS with Band-Stop Response for Satellite Application

Indumathi Uthrapathy
Communication Systems , Master of Engineering
SSN College of Engineering
Rajiv Gandhi Salai,Kalavakkam,Chennai, India,603110

Ramprabhu Sivasamy
Department of Electronics and Communication
SSN College of Engineering
Rajiv Gandhi Salai,Kalavakkam,Chennai, India,603110

Abstract

A Novel Frequency Selective Surface (FSS) with a band-stop response at 9.6 GHz is presented in this research paper. The FSS has miniaturized dimension with the unit-cell measurement of 0.16 λ_0 x 0.16 λ_0, where λ_0 signifies the free-space wavelength equivalent to the resonant frequency. The proposed design comprises of convoluted S structured section bent at the radial center. The proposed FSS delivers 1100 MHz bandwidth at the resonant frequency with an insertion loss of 20 dB. The transmission response of the proposed FSS is analyzed for the different incident angle and is found to be consistent at 0˚, 30˚ and 60˚. The proposed FSS provides polarization independence and stable for oblique incidences of both TM and TE oriented polarizations.

Keywords: Frequency Selective Surface (FSS), Polarization independence, Narrowband.

Introduction

Frequency Selective Surfaces (FSSs) are widely used as reflectors, spatial filters, and electromagnetic absorbers. In addition, FSSs are used to isolate undesirable and detrimental radiation in microwave L-and S-bands in schools, a medical environment like hospital and domestic environments like home [7]. A variety of FSS structures were proposed in literature with bandstop performance catering to multiple applications.FSS design comprising of unit cell resembling crooked cross geometry is reported in [8].A dual-bandstop frequency selective surface (FSS) is designed with unit cells composed of square metallic loops enclosing novel curves is also discussed in [10]. Yet another FSS consists of a unit cell with two metallic spiral strips of different lengths and a dielectric substrate in the middle. By changing the lengths of outer strips, the miniaturization amount and bandwidth can be adjusted. To meet the demand of wideband and large incident wave angle, a triple loop FSS is designed as a multilayer sandwiched structure [11]. An FSS with interlace grids of anchor-shaped loops for compactness is illustrated in [13] which provides a stable response for both TE and TM polarizations. An L shaped miniaturized unit cell FSS reported in [14] provides polarization and angular independent operation.Section II highlights the unit cell geometry of the FSS. Section III portrays the simulations and their results. Section IV deals with the conclusion.

Unit Cell Design

The unit cell geometry of the proposed FSS is shown in Fig. 1. The unit cell comprises of quadruple symmetrical S-shaped arms at each end originating from the center. The unit cell dimension of the FSS measures 0.16 λ_0× 0.16 λ_0. To achieve compactness, the convolution technique is used and also symmetric nature is preserved to cater to the polarization requirement. The unit cell is designed on FR-4 substrate of thickness 1.6 mm, and the distance amongst the unit cell is maintained at 0.3 mm.

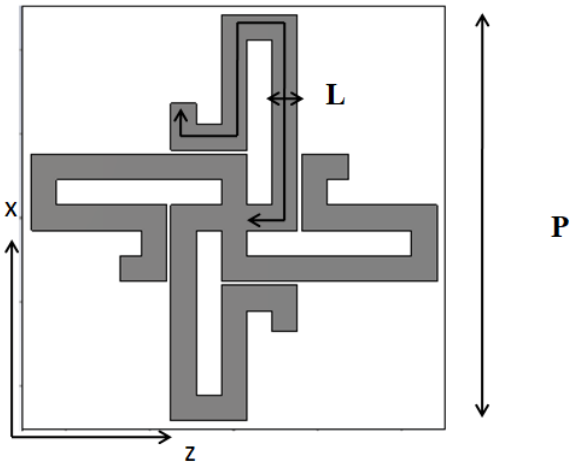

Figure 1 Proposed Unit-Cell Geometry with Dimensions L=4.3 mm, P=5 mm

Simulated Results

The proposed FSS is simulated using commercially available CST microwave studio software package. Floquet ports with periodic boundary conditions are used to analyze the functionality of the FSS. The simulated transmission characteristics of the FSS are illustrated in Fig. 2. It is evident that the convoluted unit cell with incremental electrical length displays band-stop characteristics at 9.6 GHz with an attenuation value of 34 dB. To prove the angular stability of the FSS, transmission characteristics of the FSS is analyzed for different incident angles of θ = 0˚, 30˚ and 60˚ for both TE and TM Mode in Fig. 2 and 3 respectively.

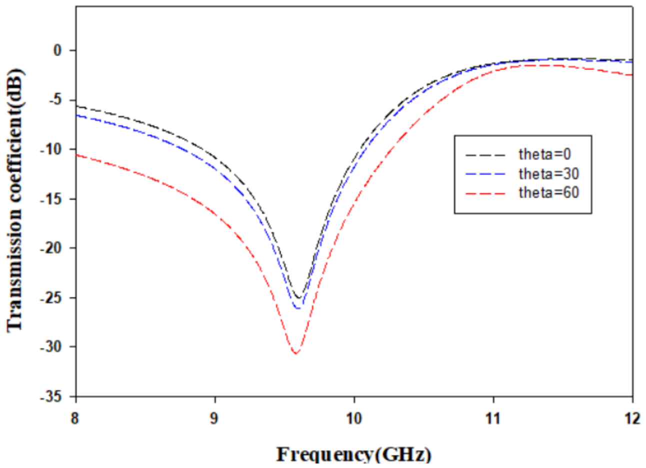

Figure 2 TE mode transmission characteristics for various angles of theta

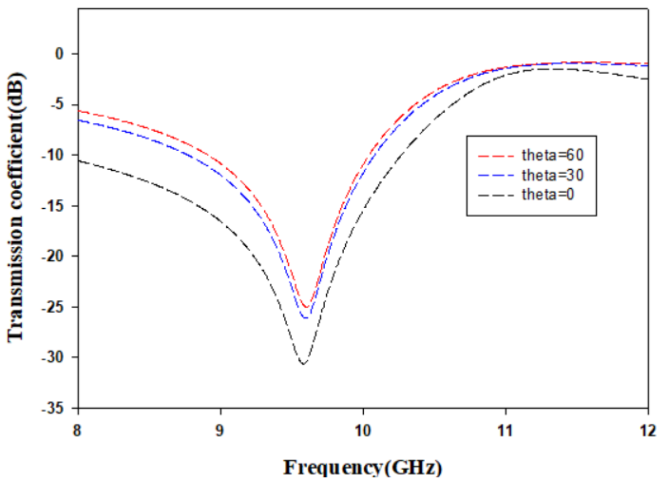

Figure 3 TM mode transmission characteristics for various angles of theta

Also, the transmission characteristics of the FSS for different incident angles of ϕ = 0˚, 30˚ and 60˚ for both TE and TM Mode is lustrated in Fig. 4 and 5 respectively. It is observed that the transmission characteristics confirm the angular stability of the FSS for both TE and TM Mode of operation. Hence conforming to the polarization and angular independence requirements of the FSS.

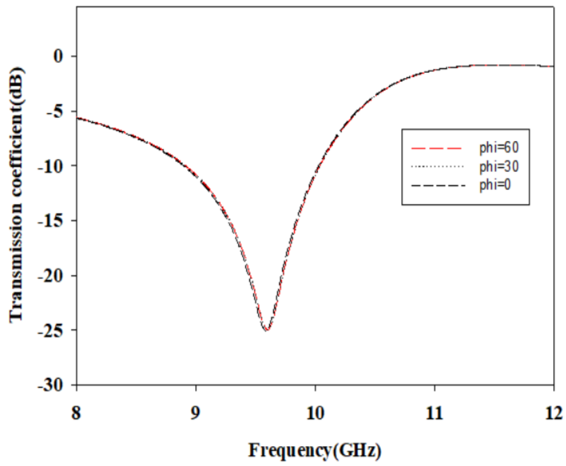

Figure 4 TE mode transmission characteristics for various angles of phi

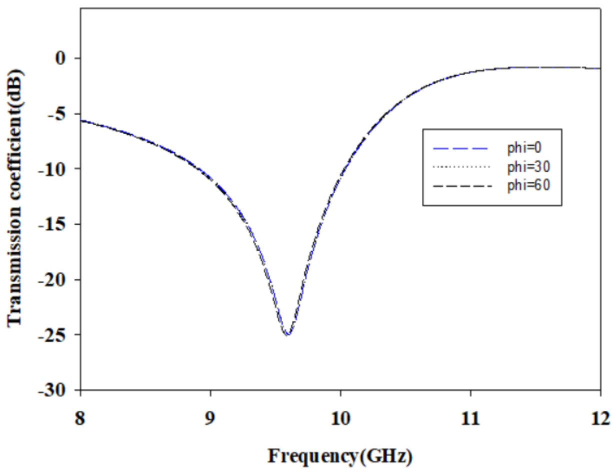

Figure 5 TM mode transmission characteristics for various angles of phi

The surface current distribution of the proposed FSS is illustrated in Fig. 6.

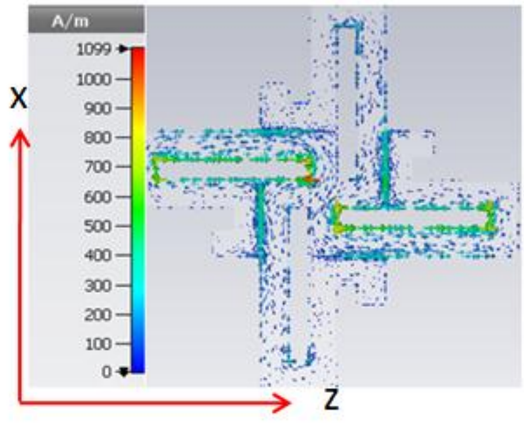

Figure 6 Surface current distribution of the proposed FSS at 9.6 GHz

It is apparent that the resonant arms with maximum-surface current density are signified by red color and those with minimal-surface current density symbolized by blue color details the electrical length contributing to the resonance of the band stop FSS at 9.6 GHz.

Table 1 Comparison of proposed FSS with other FSSs

Ref	Resonant Frequency (GHz)	Dielectric Constant	Unit cell Size
5	6.5	4.3	0.205λ x 0.205λ
9	10	2.2	0.227λ x 0.227λ
12	2.4 & 5.1	4.4	0.17λ x 0.17λ
This Work	**9.6**	**4.3**	**0.16λ x 0.16λ**

Table 1 compares the proposed FSS with FSSs available in the literature. It is evident that the proposed FSS with its unique unit cell geometry is of compact and also offers angular and polarization independence.

Conclusion

A miniaturized S-shaped convoluted FSS for band stop operation with a unit cell dimension of 0.16 λ_0 x 0.16 λ_0 is presented in this paper. The FSS exhibits polarization independence and stable angular characteristics for oblique incidences of an electromagnetic wave. The proposed FSS can be a potential candidate for satellite application.

References

[1] S. Cimen, "Novel closely spaced planar dual-band frequency-selective surface," in IET Microwaves, Antennas & Propagation, vol. 7, no. 11, pp. 894-899, 20 August 2013.

[2] C. Chiu and W. Wang., ‘A Dual-Frequency Miniaturized-Element FSS With Closely Located Resonances,’ in IEEE Antennas and Wireless Propagation Letters, vol. 12, pp. 163-165,2013.

[3] S. Ghosh et al.: "An Angularly Stable Dual-Band FSS With Closely Spaced Resonances Using Miniaturized Unit Cell," in IEEE Microwave and Wireless Components Letters, vol. 27, no. 3, pp. 218-220, March 2017.

[4] T. Hong, W. Xing, Q. Zhao, Y. Gu and S. Gong. (April 2018), ‘Single-Layer Frequency Selective Surface With Angular Stability Property,' in IEEE Antennas and Wireless Propagation Letters, vol. 17, no. 4, pp. 547-550.

[5] I.G. Lee and I.P. Hong, "3D frequency selective surface for the stable angle of incidence," Electronics Letters, vol. 50, no. 6, pp. 423–424, 2014.

[6] W. Li, T. Zhang, G. Yang, Q. Wu and J. Hua, "Novel Frequency Selective Surfaces with compact structure and ultra-wideband response," 2012 Asia-Pacific Symposium on Electromagnetic Compatibility, Singapore, 2012, pp. 557-560.

[7] B. A. Munk, Frequency Selective Surfaces: Theory and Design, 1st ed. New York, NY, USA: Wiley, 2000.

[8] R. Sivasamy and M. Kanagasabai, "A Novel Dual-Band Angular Independent FSS With Closely Spaced Frequency Response," in IEEE Microwave and Wireless Components Letters, vol. 25, no. 5, pp. 298-300, May 2015.

[9] Nauman M, Saleem R, Rashid A K, “A miniaturized flexible frequency selective surface for X-band applications,” IEEE Transactions on Electromagnetic Compatibility, vol. 58, no. 2, pp. 419-428, 2016.

[10] S. Khajevandi, H. Oraizi, and M. Poordaraee, "Design of Planar Dual-Bandstop FSS Using Square-Loop-Enclosing Superformula Curves," in IEEE Antennas and Wireless Propagation Letters, vol. 17, no. 5, pp. 731-734, May 2018.

[11] P. Lu, G. Hua, C. Yang, and W. Hong, "A wideband bandstop FSS with a triple loop," *2013* Proceedings of the International Symposium on Antennas & Propagation, Nanjing, 2013, pp. 1291-1294.

[12] M. Yan et al,A Miniaturized Dual-Band FSS With Second-Order Response and Large Band Separation,' in IEEE Antennas and Wireless Propagation Letters, vol. 14, pp. 1602-1605,2015.

[13] M. Yan et al., "A Miniaturized Dual-Band FSS With Stable Resonance Frequencies of 2.4 GHz/5 GHz for WLAN Applications," in IEEE Antennas and Wireless Propagation Letters, vol. 13, pp. 895-898, 2014.

[14] S. Ünaldı et al.: "A Novel Dual-Band Ultrathin FSS With Closely Settled Frequency Response," in IEEE Antennas and Wireless Propagation Letters, vol. 16, pp. 1381-1384, 2017.

[15] A. Balanis.’Antenna Theory Analysis and Design', Second Edition,JohnWiley Sons <https://www.sanfoundry.com/best-reference-books-antenna-theory-design/>