Switchable Frequency Selective Surface Based on Composite Flexible Substrate for Modern Communication Systems

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Abstract

This paper presents a switchable frequency selective surface (FSS) based on composite flexible substrate. The performance of the proposed design on a flexible substrate has been assessed by comparing it with its rigid counterpart. To make the FSS switchable, various combinations of switches are used and the corresponding behavior is analyzed. It is noted that the design exhibits stop band and pass band characteristics. Moreover, in pass band it provides single wideband and dual band operations. The flexible substrate design results show a good agreement with the rigid design and the added value of flexibility makes it suitable for modern communication systems.

1. Introduction

Frequency Selective Surfaces (FSSs) are attracting the attention of researchers due to their attractive features [1] and their usage in wide range of applications such as filters [2-5], absorbers [6], polarizers [7], antennas [8-10], artificial magnetic conductors (AMC) [11, 12], planar metamaterials and radomes [13]. FSSs are arrangement of periodic structures in either one or two dimensions that perform a filtering operation to pass or stop electromagnetic waves. They have the key advantages of being light weight, low profile, easy fabrication and cost effective, making them more encouraging among other periodic structures. The unit cell geometries used for FSS typically include square loops, circular rings, hybrid loops/rings, fractals shapes and dipoles. Jerusalem-cross is also a well-known shape used in FSSs [6-8, 10-14]. Previously, we have demonstrated a switchable FSS based on modified Jerusalem-cross geometry [14, 15]. By selecting appropriate switches combination, it can provide single and dual pass-band around 2.45GHz and 5GHz. It also shows a stable resonance frequency at lower band while the resonance frequency of the higher band can be varied. Flexible substrates have been investigated for wearable applications [16-18], such as for embroidery based antenna applications [19]. In this paper, we present a switchable FSS unit cell based on flexible substrate, Polydimethyl-siloxane (PDMS) composite (dielectric constant ε = 3, loss tangent *tan* δ = 0.01) and its performance has been compared to its rigid counterpart designed using Rogers Ro3003 (dielectric constant ε = 3, loss tangent *tan* δ = 0.001). Section II explains the design layout and switch configuration of proposed FSS. Results are presented in Section III and the paper is concluded in Section IV.

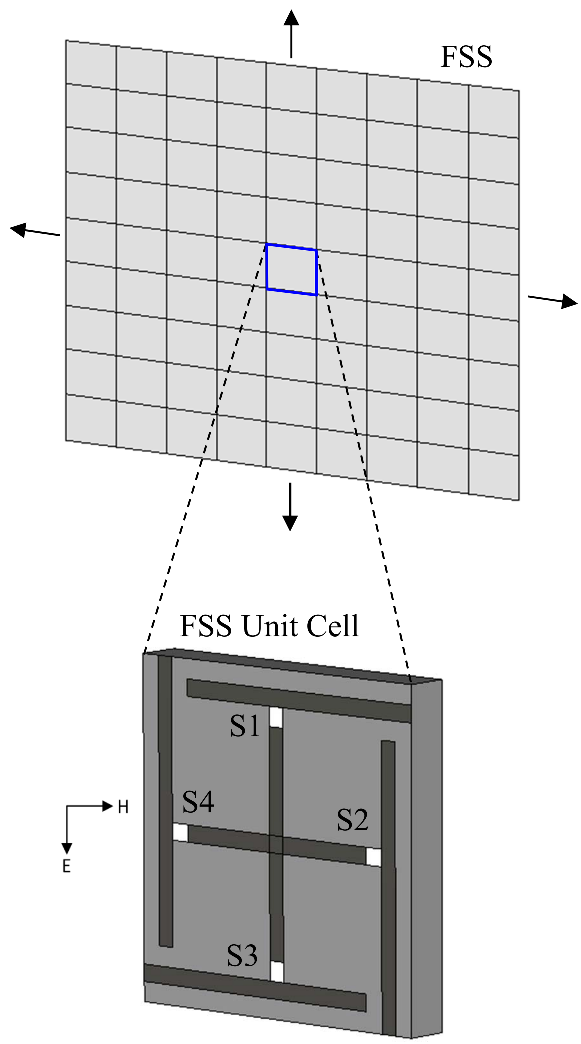

Figure 1. Geometry and switches location of the proposed FSS unit cell.

2. Design and Layout

The geometry of the proposed FSS geometry is shown in Fig. 1. The size of the FSS sheet can be selected depending upon the application requirements. The FSS unit cell has a square geometry with dimensions of 11.55mm x 11.55mm. The upper metallic surface uses modified Jerusalem-cross with extended top loading [14]. The metallic strip used are 0.44mm wide, whereas, the side strips are 9.46mm long and the central cross strips are 7.47mm long. Figure 1 also shows the location of the switches used between the central and side metallic strips to realize the switching functionalities.

Table I. Pass and stop bands corresponding to different switch combinations.

Switch combinations	Band-1 (GHz)	Band-2 (GHz)
All ON	2.05 – 2.65	5.5 – 6.0
All OFF	-------------	-------------
S2, S4 ON	3.04 – 4.92	-------------

3. Results

The simulations of the proposed FSS unit cell are carried out using CST Microwave Studio. To investigate the characteristics of the proposed FSS, different switch combinations have been considered. The performance of both, flexible and rigid designs is compared and the corresponding reflection and transmission coefficients are presented in Fig. 2 and Fig. 3, respectively. The corresponding pass and stop bands results are tabulated in Table I. Results show that when all switches are in OFF state, stop band operation is achieved. When all switches are in ON state, dual pass-band behavior is noted around a lower resonance frequency of 2.4GHz and a higher resonance frequency of 5.8GHz. A wide pass band with bandwidth of about 1.9GHz is noted when only two switches (i.e. S2 and S4) are in ON state. Results are in good agreement and negligible variation is due to variation in dielectric loss tangent.

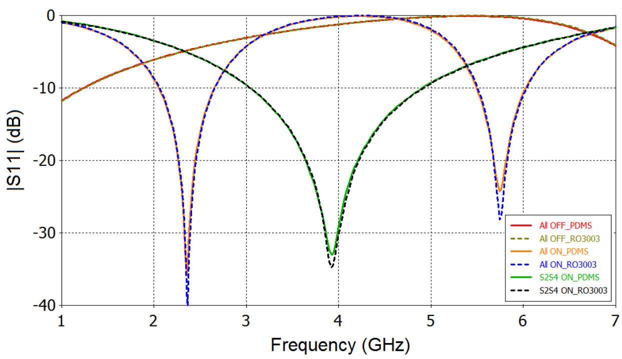

Figure 2. Predicted |S11| corresponding to different switch combinations.

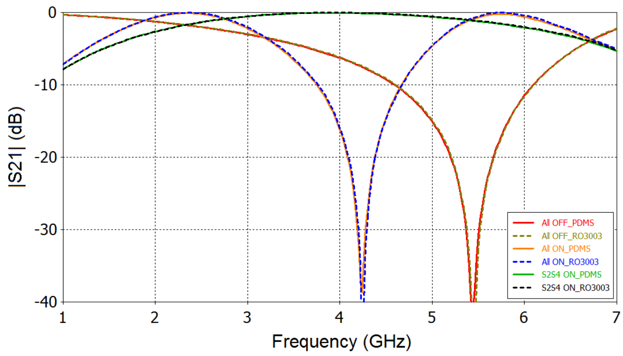

Figure 3. Predicted |S21| corresponding to different switch combinations.

4. Conclusion

A switchable frequency selective surface based on composite flexible substrate is presented. The performance has been compared with its rigid substrate counterpart. Results show that by selecting appropriate switch combinations, stop band and pass band characteristics can be achieved. Moreover, single wide pass band and two narrower pass bands can be achieved with the pass band operation. The proposed FSS is easy to fabricate due to its simple geometry and the use of flexible substrate makes it a bendable reconfigurable solution.

7. References

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