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Bending Analysis of Switchable Frequency Selective Surface Based on Flexible Composite Substrate

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***Abstract*— In this paper presents a switchable frequency selective surface (FSS) based on composite flexible substrate has been investigated. To make the FSS switchable, various combinations of switches are used. The design is bent along E-field and H-field directions over various bending curvatures and the corresponding behavior is analyzed. It is observed that design has less variation when bending is applied along the H-field direction. Whereas, slight variations are observed when bending is applied along the E-field direction. It is noted that the design exhibits stop band and pass band characteristics. Furthermore, in pass band it provides single wideband and dual band operations. These characteristics are preserved when bending is applied, thus making it suitable for wearable applications and modern communication systems.**

***Index Terms*—Frequency selective surface, FSS, flexible, bending, PDMS.**

I. Introduction

Frequency Selective Surfaces (FSSs) are periodic arrangement of structures, referred as unit cells, in either one or two dimensions that allow performing filtering operation to pass or stop electromagnetic waves. Due to their attractive features of They have the key advantages of being low profile, light weight, easy to fabricate and low cost, they are gaining high attention of researcher being [1, 2]. They are used in wide range of applications such as antennas, filters, polarizers, absorbers, radomes, planar metamaterials and artificial magnetic conductors (AMC) [3-9]. The metallic parts of the FSS, typically uses circular rings, square loops, hybrid loops/rings, dipoles and fractals shapes. Jerusalem-cross is also a renowned shape used in FSSs [3, 7-11]. Previously, we have reported a switchable FSS based on modified Jerusalem-cross geometry [11, 12]. By selecting appropriate switches combination, it can provide single and dual pass-band around 2.45GHz and 5GHz bands. Flexible substrates have been investigated for wearable applications [13, 14] where bending features are desired. In this paper, we present bending analysis of switchable FSS unit cell designed using flexible substrate, Polydimethyl-siloxane (PDMS) composite having dielectric properties as $\varepsilon = 3$, loss tangent tan $\delta = 0.01$. Its performance has been analyzed when bending is applied in the direction of E-field and H-field, respectively. Section II explains the design and switch configuration of FSS unit cell. Results are discussed in Section III and the paper is concluded in Section IV.

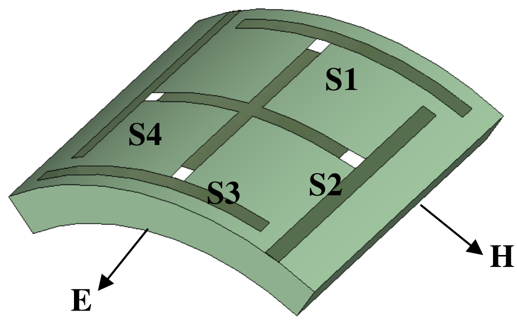

Fig. 1. Flexible Frequency Selective Surface unit cell with location of switches.

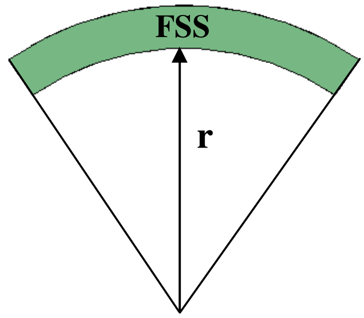

Fig. 2. Bending surface consideration with different radius.

II. Design and Configuration

The geometry of considered FSS unit cell and the location of the switches used are shown in Fig. 1. The FSS unit cell exhibit a square geometry with dimensions of 11.55mm x 11.55mm. Modified Jerusalem-cross with extended top loading is used to make the metallic surface about the substrate [11]. 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.

III. Results

The simulations of the proposed FSS unit cell are carried out using CST Microwave Studio. By using appropriate/ predefined switching combinations, stop and bass band characteristics are achieved. The performance of flexible designs is compared to its rigid design, and is found to be in good agreement. Results show that stop band characteristics are achieved, when all switches are in OFF state. In pass band, a single wide band and a dual band with relatively narrower bandwidths are achieved. In flat condition, a single wide pass band with bandwidth of about 1.9GHz is noted when only two switches (i.e. S2 and S4) are in ON state. 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.

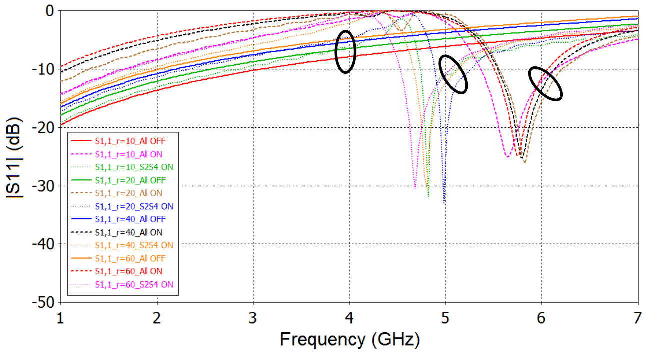

Fig. 3. Predicted |S11| corresponding to different switch combinations, when FSS bend along the E-field direction.

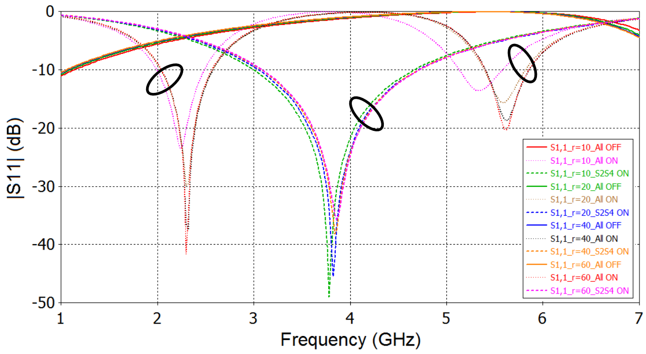

Fig. 4. Predicted |S11| corresponding to different switch combinations, when FSS bend along the H-field direction.

As illustrated in Fig. 2, the design is bent along E-field and H-field directions over various bending curvatures (i.e. r = 10, 20, 40, 60; units are mm) and the corresponding behavior is analyzed. Fig. 3 and Fig. 4 shows the corresponding reflection coefficient when FSS is bend along the E-field and H-field directions. It is observed that design has less variation when bending is applied along the H-field direction. Whereas, slight variations are observed when bending is applied along the E-field direction.

IV. Conclusion

A switchable frequency selective surface based on composite flexible substrate is analyzed under different bending conditions w.r.t. bending directions and bending curvatures. Results show that design has less variation when bending is applied along the H-field direction. Whereas, slight variations are noted when bending is applied along the E-field direction. The prime features of the design as stop band and pass band (single wide band and dual band) are also preserved.

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