Conformal Dual-Band Frequency Selective Surface on Textile: Design, Prototyping and Expriment

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***Abstract*—In this study, a textile based dual band conformal frequency selective surface has been proposed in order to filter the electromagnetic waves. A commonly known split ring resonator (SRR) is used for unit cell design and an array with 4×6 elements used for planar design presented. The proposed array is bended on a sphere having a radius of 22.45 cm. The performance of the conformal structure is evaluated and compared with the planar one. Measurement results have also been presented.**

Keywords—electromagnetic pollution; frequency selective surface; split ring resonator; textile metamaterials.

I. Introduction

Frequency selective surfaces (FSSs) are angular depended behavioral structures, which are generally used for filtering the plane waves and are constructed as periodic structures with a variety of different shapes and materials [1]. They can have either a band-pass or a band-stop ability according to the various situations based on the combinations of different patterns, material properties and incident angle. FSSs can find wide application areas such as increasing the directivity, gain and purity of the received signal in both planar and conformal antennas [1]. They can also be used in radome design and reducing the radar cross section (RCS). Although such surfaces find a variety of application areas, extra features such as conformity are currently being demanded. For these purposes, there is an increasing demand on flexible materials. Textile materials seem to be a strong candidate to achieve these requirements. Especially the conformality and flexibility made the textile materials popular in several application areas such as wearable networks. The wearable technology, which is actually a multidisciplinary field, united the textile engineers with electrical engineers [2]. In this study, a textile based dual band frequency selective surface has been proposed by using common SRRs that are commonly studied in literature [3][4]. The frequency values are adjusted to fall in a region in which electromagnetic pollution occurs. The design is realized as a 4×6 array and bended on a sphere having a radius of 22.45 cm. The results are presented in the following sections.

II. Dual Band Textile Based Unit Cell Design

The top view of the unit cell design of the proposed structure has been presented in Fig. 1. The substrate is a cotton textile having a side length denoted with *a* and it has a thickness value of h_s. The conductor part of this commonly known split ring resonator consists of two loops with lengths of b_1 and b_2. The gap for each SRR is denoted as *g* and the thickness value of the conductor is h_c.

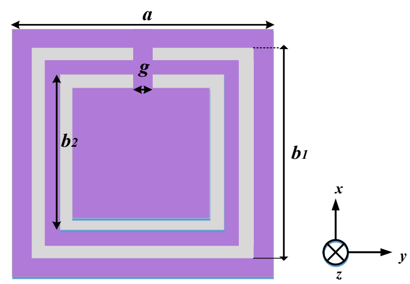

Fig. 1.Unit cell geometry top view.

The excitation of the unit cell determined to have electric field component in *y* direction and the direction of the propagation is in *z* direction. The physical parameters of the proposed unit cell is presented in Table 1.

TABLE I. Parameters of the proposed unit cell

Physical parameters					
b_1	b_2	g	a	h_c	h_s
50mm	30mm	5mm	70mm	0.035mm	0.2mm

The cotton fabric is a commercial fabric with an unknown permittivity value so at the first step of the study we considered an air layer having the same thickness of the fabric and the same pattern at the top. After that we conducted simulations via CST Microwave Studio. For the design having an air layer, the scattering parameters are evaluated and the results presented in Fig. 2. As seen in the figure, the unit cell has an S_{11} resonance at 2657 MHz. Dual resonance is obtained for S_{21}, where the lower frequency is at 2015 MHz and the upper frequency is at 3926 MHz. The surface current distributions (lower frequency on the left, upper frequency on the right) of the loops are presented in Fig. 3. The simulation results are based on an array of infinite unit cells in both *x*- and *y*-directions for periodic boundary conditions. In order to mimic the array with better accuracy and measure the S_{21} characteristics, a measurement set-up is arranged.

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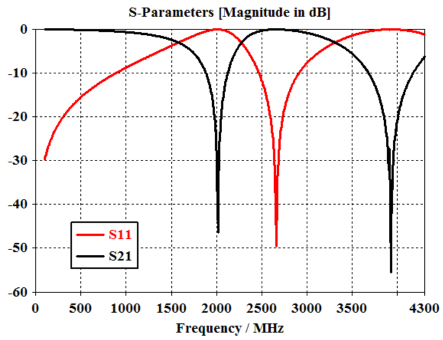

Fig. 2.Scattering parameters of the unit cell.

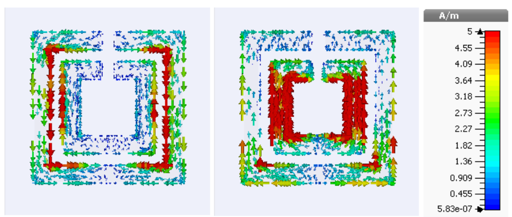

Fig. 3.Surface current distributions for lower and upper frequency values.

The structure is aligned to have 4×6 unit cells. The 4×6 array is located between the two horn antennas (model: Rohde & Schwarz HF907 double-ridged waveguide horn antennas (800 MHz-18 GHz)) to satisfy the far field range. The array is located at the center of the two horns. The surrounding absorber has been arranged to obtain more accurate results with minimum interference the measurement set-up has been calibrated before placing the array sample. Rohde & Schwarz ZVL13 Vector Network Analyzer (9 kHz- 13.6 GHz) VNA has been used during the measurements. The proposed SRR pattern is designed to have a cotton fabric layer at the bottom. The response of the S_{21} parameter is evaluated and measured with the experimental set up that was defined above. The measured results are compared with the simulated results and a good agreement is obtained as shown in Fig. 4.

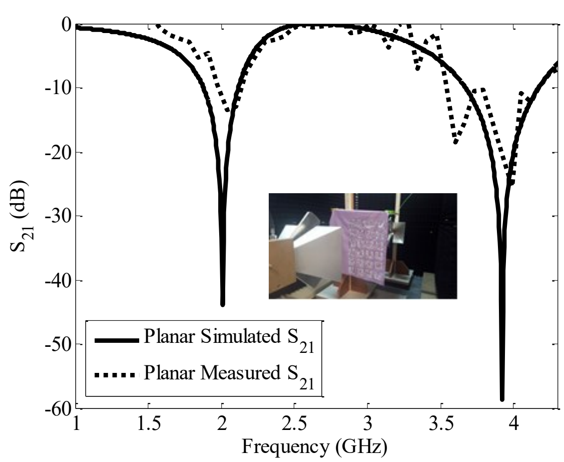

Fig. 4. Simulated and measured results of planar array.

As most of the frequency selective surfaces, the array should satisfy the matching conditions. In this case, the array should have an impedance value of 377ohm in order to match with the instrictic impedance of air. The proposed design satisfies this condition.

Frequency selective surfaces are angle dependent structures and their performances are sensitive to the geometry. For stability issues, the topologies performing similarly to their planar forms are claimed to have acceptable performance. For that purpose, the planar structure is bended on a spherical platform and measured with the set up shown in Fig. 5. The measurement set up and the materials used for measurement are the same as the previous procedure. Additionally, a plastic ball having a radius of 22.45cm is used, and the planar array is bended onto it. The measurement results are demonstrated in Fig 8, the lower S_{21} frequency is 1.96GHz (2.04GHz for the planar structure), and the upper S_{21} frequency is 3.76 GHz (3.99GHz for the planar structure). Therefore, satisfactory agreement is obtained for the conformal structure with the planar structure.

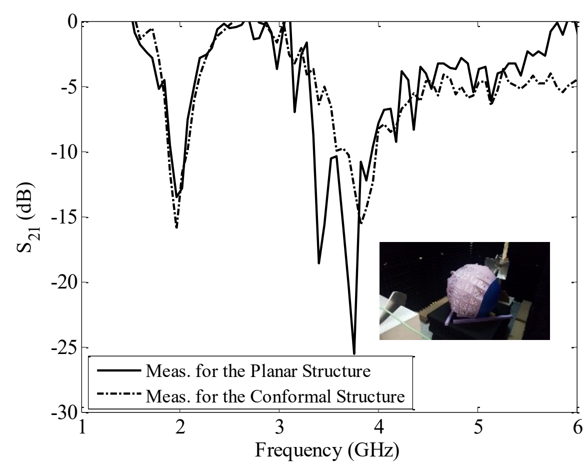

Fig. 5. Measurement comparison of conformal and planar structures.

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