X-Band Tunable Frequency Selective Surface with Embedded Bias Network

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***Abstract* –An x-band tunable bandpass frequency selective surface (FSS) is presented in this article. The designed FSS is composed of three stacked metallic layers. They combine each other with metallic via, which provides the bias for the varactor at the same time. This configuration can decrease undesirable response associated with the added bias grid. The simulation is provided to illustrate its feasible. The results show that by changing the varactor capacitance from 0.1pf to 0.4pf, the center frequency of the designed FSS is tuned from 8.5GHz to 13GHz and with an insertion loss about 2dB.**

***Index Terms* — FSS, electronic tuning, varactor, bias network.**

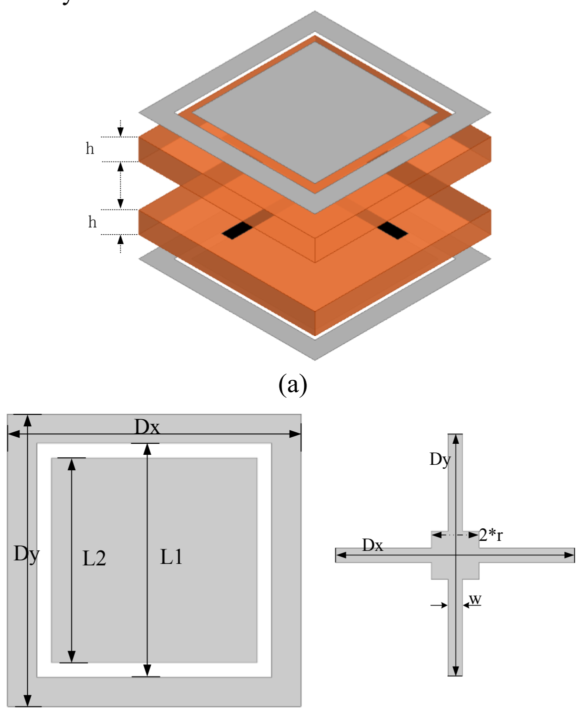
1. Introduction

Frequency selective surface (FSS) has been an active subject for many years [1-3]. They are widely used in various microwave applications, such as sub-reflectors of the frequency reuse system, stealth technology for radar cross section (RCS) reduction as well as spatial filters for radar communication system and so on [4-6]. Nowadays, the vast demands and rapid developments in multifunctional radar and commutation systems necessitate tunable FSS. Therefore, various designs of tunable FSS has been proposed so far. Such as the case in [7], it was achieved by mechanical deformation. Another tunable FSS was designed by using MEMS in the structure [8]. Although these methods are low cost and require no bias network, they suffer from slow tuning speeds and limited tuning ranges. A well-known method for tunable FSS is to use lumped components such as surface varactors. They can provide high speed and wideband tuning with compact size. However, one disadvantage in designing these FSSs is the need of bias network for varactors and RF isolation should also be considered.

In this paper, a bandpass FSS is proposed with varactor-based tuning capability. The designed structure consists of three metallic layers and two thin dielectric substrates. This configuration enables capability without the necessary for any additional bias network for the varactor, only a RF choke is needed. Furthermore, because of the symmetry of the element, it can provide stable frequency response with respect to the incidence angle of the EM. In what follows, the design procedure, simple theoretical analysis and simulation results of the proposed FSS are presented and discussed.

2. FSS Design

A three-dimensional view of the designed FSS and unit cell are demonstrated in Fig. 1. Fig.1. (a) is perspective view of this structure. Fig.1. (b) is the top view of the proposed top and bottom metallic layers. Fig.1. (c) is the top view of the middle layer.



(b) (c)

Fig.1 structure of the FSS. (a) Perspective view of the FSS. (b) Top view of the top and bottom layer. (c) Top view of the middle layer

The proposed FSS element is composed of three metallic layers that are separated from each other by two identical thin dielectric substrates. The top and bottom metal are square loop apertures. The middle layer is made of inductive wire grids. The top and bottom metallic layers are exactly the same and the whole structure is symmetric with respect to the middle layer. The crossing points of the grids in middle layer are aligned with the center of the patches on the top and bottom layer. These two identical thin dielectric substrates are of a relative permittivity of 2.2 and a dielectric of loss tangent of 0.002. As shown in Fig.1, the dimensions of the unit cell along x and y direction are specified, the detailed parameters of the element are shown in Table I.

TABLE I

Dx\Dy	h	L1	L2	W	r
5mm	0.6mm	4mm	3.5mm	0.3mm	0.5mm

The proposed FSS can be simply modified by changing the surface varactor loaded in the top and bottom layers, as shown in Fig. 2. A metallic via in each unit cell is used as the bias network to connect the top and bottom layer. By applying a DC bias voltage between the middle layer and the top and bottom layers, the equivalent capacitance of the varactor can be varied and as a result, a tunable frequency response for the FSS can be obtained.

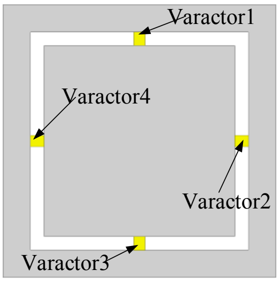


Fig. 2 the view of the top and bottom layer

3. Simulation Results

Simulations were performed by the Ansoft HFSS 15.0 tool, which utilizes the finite element method to determine and analyze the EM behavior of the structure. Floquet ports were used to imitate the periodic and determine the transmission coefficients of the proposed FSS unit cell. The frequency response of this proposed FSS unit is presented in Fig.3, it can be seen that by changing the equivalent capacitance from 0.1 pF to 0.4 pF, the center frequency varying from 8.5 GHz to 12.5GHz, among the depravation insert loss about 2dB.

The sensitivity of the designed FSS transmission response to the EM polarization is exhibited in Fig.4. Since the symmetry of the structure, it can be seen that the response for TE and TM polarization are exactly the same.

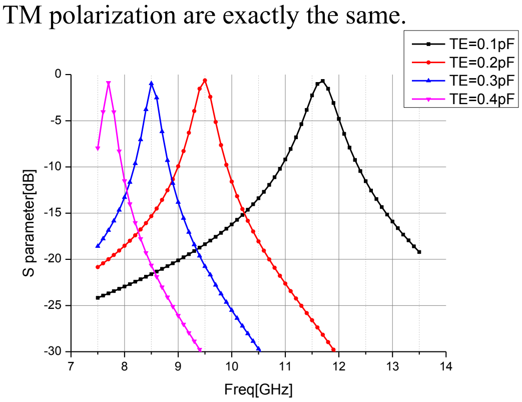


Fig.3 Transmission response of the designed FSS

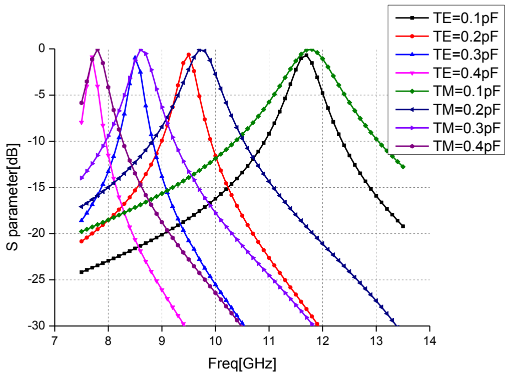


Fig.3 Transmission response of the designed FSS

4. Conclusion

In this paper, we propose and report a tunable band-pass frequency selective surface. A simulation is performed by the commercial software to obtain the characteristics of the structure. It is observed that the proposed structure can provide an effective tunable frequency range by integrating varactor diodes in the metallic layer. Regret is that the presented structure in this letter is under fabrication for experimental verification.

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