Miniaturized Frequency Selective Surface with Bionic Structure

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Abstract- **A novel miniaturized frequency selective surface (FSS) is proposed. The size reduction is achieved by using the model of leaf arrangement. Compared with conventional cross FSS, the operation frequency of this novel bionic FSS is changed from 10.4 GHz to 4.74 GHz at the same size. Both theoretical and experimental investigations are carried out. It is observed that the miniaturized FSS presents excellent frequency stability with the increase of the incident angle. The proposed FSS can be a candidate for FSS whose miniaturization is required.**

I. INTRODUCTION

Frequency selective surface (FSS) has attracted much attention in the past few decades for their spatial filtering characteristic. FSS is infinite periodically arranged metallic-patch elements or aperture elements within a metallic screen. It can be used in various applications, such as sub-reflectors of the frequency reuse system, band-pass radomes for radar cross section controlling and so on[1-2]. FSS should be an infinite array theoretically but in practical applications FSS is finite. It is very necessary to use sufficient elements to keep the characteristics of infinite FSS. However, when the operation frequency is low, the size of elements will be so large that it is difficult to fill enough elements in a reasonable size. Miniaturization is of great significance at low frequency [3-6]. The proposed novel miniaturized FSS in this letter is designed based on the model of leaf arrangement. Both theoretical and experimental investigations are carried out. The results show that compared to the reference cross FSS, the novel bionic FSS has lower resonance frequency and favorable related performances. Hence, applying bionics principle to FSS is proved feasible, which will serve as a good candidate for the future FSS design.
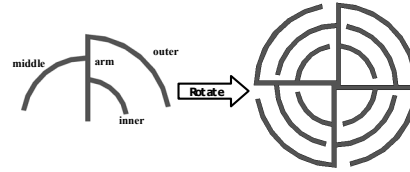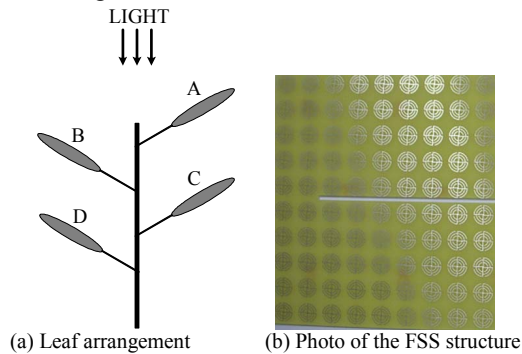

(a) Leaf arrangement   (b) Photo of the FSS structure

(c) Element of the FSS
Figure 1. Gemetry of the proposed bionic FSS

II. FSS DESIGN

A novel miniaturized frequency selective surface (FSS) is proposed. The size reduction is achieved by using the model of leaf arrangement. The proposed element of FSS is shown in Fig. 1. It is the transformation of traditional cross cell. Its arm has three branches：outer, middle, and inner ones. The three branches are arranged as the way that leaves generate along the arm of a tree. The arc shaped branches lengthen the electrical length of FSS. Then the single arm is rotated $90°$, $180°$, and $270°$, another three arms will appear. The four arms are joined together, and the FSS element is obtained. As shown in the Fig. 1, the middle one located in the opposite side of the other two branches, which expands the distance not only between the outer and inner branches, but also between itself and the other two branches. Hence, the coupling between the three branches is avoided within the small area. A set of optimal dimensions is shown as: $L = 11mm$; $w = 0.25mm$; $w_1 = 4.5mm$; $w_2 = 3.39mm$; $w_3 = 2.28mm$; $\theta_1 = \theta_2 = \theta_3 = 10°$. The proposed FSS array has a rectangular lattice and a substrate with relative permittivity of 2.65, a loss tangent of 0.001 and a thickness of 1mm. The picture of the fabricated FSS is also shown in Fig. 1.

III. RESULTS AND DISCUSSION

The compared frequency response of the proposed FSS and the reference cross FSS with a same size are presented in Fig. 2. The figure shows that the center frequency of the two FSS is 3.9 GHz and 10.4GHz, separately. Compared with the reference cross FSS, the proposed bionic FSS has lower resonance frequency with the same size. It is obtained that the introduction of the branches expands the electrical size of the FSS greatly, which makes the resonance frequency of bionic FSS lower than that of cross FSS magnificently. The application of interactive branches increases the distance and avoids the coupling between the adjacent branches. The transmission characteristics at different oblique incident

angles of $0°$, $30°$, $45°$, and $60°$ are also obtained and shown in Fig. 3. The results show that the proposed bionic miniaturized FSS has excellent center frequency stability. Fig. 4 shows the schematic picture of the FSS measurement setup. Measurement is implemented in the anechoic chamber. Measured and simulated frequency response of the proposed FSS is shown in Fig. 5. The theoretical and experimental results are in good agreement except for the noise. The measured results validate the correctness of the theoretical analysis.
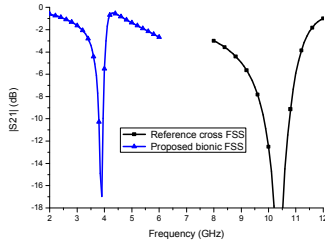
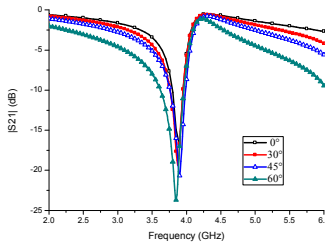Figure 2. Frequency response of the two FSS

Figure 3. The transmission characteristics at different angles
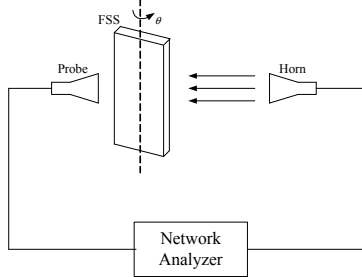

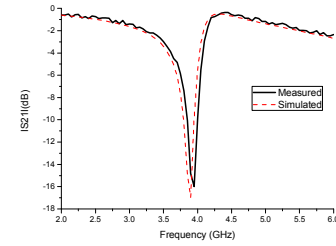Figure 4. The schematic picture of the FSS measurement setup

Figure 5. Measured and simulated results of the proposed FSS

IV. CONCLUSION

In this paper a novel miniaturized FSS with bionic structure is proposed. Compared to the conventional cross FSS, the centre frequency of the proposed FSS is reduced 62.5%. The size reduction is realized by the introduction of the bionic structure. Experimental and theoretical results agree well with each other. The miniaturized FSS has excellent centre frequency stability. It will be a good candidate for FSS radomes. This paper supplies a novel direction to the future design of FSS with or without a requirement of miniaturization.

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