Angularly Stable Bandstop Frequency Selective Surface Based on Lumped Inductors

Yiwei Chen, Yang Yang, Xiaoxiang He, Beibei Ma, Zhenyu Shen

Introduction

This article presents an angularly stable bandstop frequency selective surface(FSS) based on lumped inductors. The proposed FSS uses a modified square-loop structure as the basic unit cell and is loaded with passive lumped elements to further improve angular stability. Loaded lumped elements allow for lower resonant frequency and thus enable miniaturization compared to the modified square-loop FSS without lumped inductors. The simulation results exhibit great angularly stable performance with incident angles varying from 0° to 80° for both TE and TM polarizations. Furthermore, changing the slit width between unit cells will change the resonant frequency, but still, maintain great angular and polarization stability. Therefore, the proposed FSS can meet the needs of different frequency bands in practical applications and has high application value.

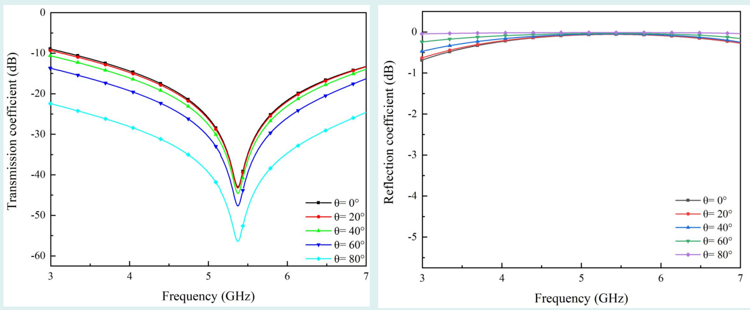


Figure 1: Simulation results of the proposed FSS under TE polarization.
a. S21 curves; b. S11 curves.

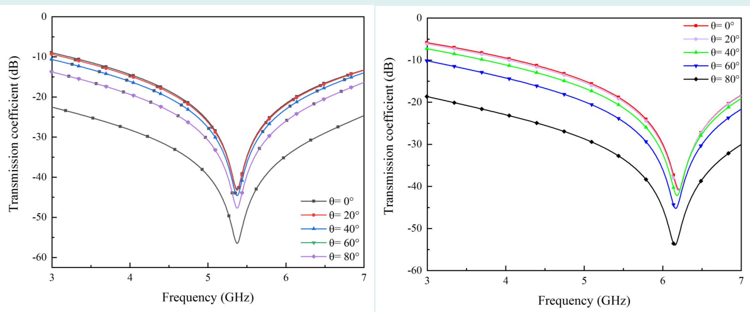


Figure 2: Simulation results of different q under TE polarization.
•a. q=7.8; b. q=7.7.

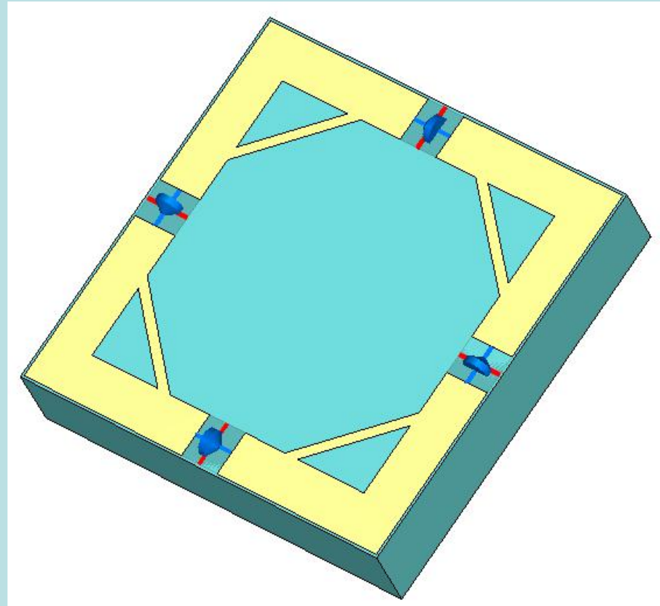
Structure Introduction

The structure consists of two parts: the metal patch layer and the dielectric substrate layer. The metal patch part uses a simple square-loop model as the basic unit cell and the patch material is PEC. Then it introduces four narrow metal strips at the corners of the simple square-loop, followed by four passive lumped inductors at the center of the four arms of the square ring, with an inductance L= 0.8nH. The dielectric substrate part adopts FR-4 lossy dielectric board whose relative permittivity is 4.3 and loss tangent is 0.025. The thickness of substrate h is 1.60 mm.

Results and Analysis

When the electromagnetic wave is incident at TE polarization, Fig.1a and Fig.1b shows the transmission and reflection characteristics of the proposed FSS. The results show that the structure resonates at 5.38GHz and the resonant frequency does not change when the incidence angle varies from 0 to 80° with a step of 20° . The transmission and reflection characteristics under TM polarization are similar with TE polarization. The structure resonates at 5.38GHz at the vertical incidence and just a little variation in resonant frequency can be observed for the incidence angle 0° -80° with a step of 20° . Therefore, the simulation results above show that the structure has great stability for the incident angle 0° -80° under TE and TM polarization.

In addition, Fig.2 gives the reflection characteristics of the proposed FSS with the incidence angle 0-80° at different patch lengths q under TE polarization. The FSS is polarization independent due to its symmetrical structure, so we use the electromagnetic waves under TE polarization as an example. Fig.1a and Fig.2 show that the resonant frequencies are 5.38, 5.8 and 6.15GHz when q= 7.9, 7.8 and 7.7mm, respectively, and that the resonant frequencies remain largely unchanged. Varying the patch length q is equivalent to varying the slit width between the unit cells. Therefore, the simulation results indicate that changing the slit width between unit cells will change the resonant frequency, but still maintain great angular stability.



Principle Introduction

The surface currents are concentrated in the four narrow metal strips. The introduction of metal strips helps to distribute the surface current and also reduces the path length compared to a simple square-loop. It makes resonant frequency raise and enhances attenuation levels. In addition, a relatively large current distribution at the lumped inductors is also observed. According to the equation $f = 1/2\pi\sqrt{LC}$, the introduction of inductors reduces the resonant frequency and enables the FSS miniaturization, thus improving angular stability.

Conclusion

An angularly stable frequency selective surface based on lumped inductors is proposed. The proposed FSS uses a modified square-loop structure and loads passive lumped inductors to realize great angular stability for 0-80° under TE and TM polarization. Compared to the FSS without lumped inductors, the proposed FSS achieves miniaturization. In addition, the FSS has a stable performance with different slit widths. This means that the proposed novel FSS element can be applied in different frequency bands.