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Original Article

A Double Band Frequency Selective Surface Design for WLAN Bands Shielding

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Abstract: *This research introduces a frequency-selective surface (FSS) through a dual-band stop designed specifically for wireless local area network (WLAN) running on 2.4 GHz besides 5 GHz. The dimensions of the element cell are 0.2 λ × 0.2 λ, wherever λ denotes the wavelength of its initial resonant frequency. FR4 takes a thickness of 7.1 mm, a permittivity of 3.2, and a loss tangent of 0.025. The presented design achieved an reduction of 31 dB on 2.4 GHz then 24 dB on 5 GHz. A comprehensive examination of incidence angles, substrate thickness, outer width, and inner width had been performed. The design exhibits angular stability at angles of up to 90° degrees in the circumstance of transverse electric (TE) and transverse magnetic (TM) polarization.*

Keywords: *Band stop FSS, Dual-band FSS, FSS, WLAN FSS.*

I. INTRODUCTION

In recent times, frequency-selective surfaces (FSSs) have stayed used to modify the physical circumstances for wireless propagation inside buildings, improving wireless security and optimizing WLAN range. The special filters can be integrated into a building's walls and windows to block electromagnetic interference and to protect humans from high levels of radio electric exposure [1-6]. FSS, or frequency selective surfaces, are arrays of slots or patches arranged in a periodic manner in either two or three dimensions. These patches or slots are imprinted onto one or both sides of the substrate, which can be either single- or multi-layered. They can be employed in a variety of applications, such as EM shielding, enhancing antenna gain, besides radar cross-section reduction (RCS) as a result of their unique qualities [7–10].

The frequency response is influenced through the incoming wave's polarization, the planar circuit's configuration, the distance between FSS elements, in addition the thickness besides permittivity of the substrate [3, 11-14]. Several FSSs have also been built to provide EMI shielding for WLAN signals. The study in [15] examined a single-layer double square loop for suppressing both WLAN bands. The basic geometry is conformal, and the operation in two frequency bands demonstrates excellent rotational stability up to an angle of 60. A compact and adjustable dual-band FSS was demonstrated in [16]. The FSS's frequency responses was 9.4 GHz and 16.7 GHz, respectively, and it was offers effective shielding in the X and Ku bands. The design that has been suggested was independent of polarization and offers a consistent frequency response across different incidence angles.

A frequency selective surface with two layers of convoluted design for the 2.4 and 5.8 GHz was presented in [17]. The design has attenuated incoming signals regardless of the polarization and incident angles, which are ranging between 0 and 60 degrees by at least 20 dB.An ISM band-stop FSS double circular loop shape is intended for 2.4 GHz and 5.8 GHz, as presented in [18]. The proposed design has a frequency response that remains stable up to 30° incidence angles, with attenuation values of 20 dB intended aimed at the 2.4 GHz band then 15 dB for the 5.8 GHz band. A dual-band polarization-insensitive FSS design aimed at Wi-Fi and WLAN protection submissions was proposed in [19]. The strategy's concentrical square, along with circular loops, gave more than 45° of angular stability with equally TE and TM polarizations. The design achieved a reduction of 38 dB on 2.4 GHz then 32 dB on 5.9 GHz.

The research is set in order like follows: Section II covers the suggested FSS structural strategy. Section III examines the simulation. The final annotations are found in Section IV.

II. FSS PROPOSAL

The electrical characteristics of an FSS are represented by its ability to transmit and reflect electromagnetic waves, fluctuate dependent arranged the size then shape of the element cell along with the arrangement of the array of cells. The design procedure begins by modeling two square loops composed of copper material, having 1 mm width. The structural parameters of the FSS cell be situated listed in Table 1.

Table 1: The Dual Band FSS's Geometric Dimensions

Name	Size
Outer square loop side	20 mm
Inner square loop side	13 mm
Inner width of the square loop	1 mm
Outer width of the square loop	1 mm
Thickness of the substrate	7.1 mm
Thickness of the square loop	0.035 mm

The structure was investigated through the use of CST modeling software to attain the desired bandstop properties. The unit cell has a periodicity of 25×25 mm. The frequency of the outer square loop is adjusted toward 5 GHz, whereas the frequency of the inner square loop is adjusted towards 2.4 GHz. The proposed bandstop FSS utilizes a element cell shape, as seen in Fig. 1. The proposal is implemented on a 7.1-mm FR4 substrate by 3.2 relative permittivity and 0.025 dielectric loss tangent.

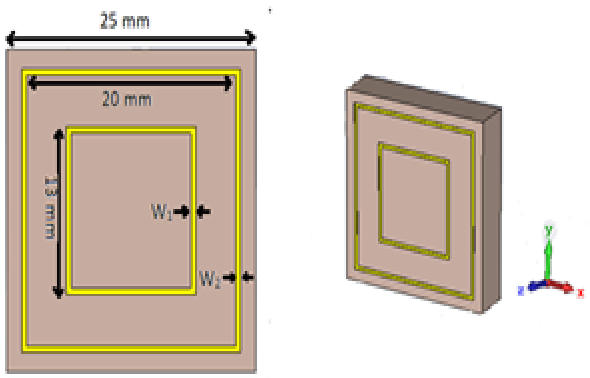

Figure 1 : Geometry of the Unit Cell

When placing an FSS near a dielectric wall, it is essential to take into consideration the dielectric qualities of the substrate since they can cause the resonant structures to become detuned. The design's effective dielectric constant operating when one side is facing free space while the alternative side is facing a wall could be estimated using references [3, 20,21].

$$\varepsilon_{reff} = \frac{(1 + \varepsilon r_2)}{2} \qquad (1)$$

Where εr_2 represents the wall substrate's dielectric constant. Then the guided wavelength λg can be obtains by:

$$\lambda_g = \frac{\lambda_0}{\sqrt{\varepsilon_{reff}}} \qquad (2)$$

The Floquet port is used for TE /TM mode analysis.

III. RESULTS AND DISCUSSION

The suggested double band square loop simulated transmission and reflection responses are illustrated in Fig. 2. The Figure demonstrated that there are two transmission attenuations at 2.4 GHz and 5 GHz, as well as a third frequency at 3.4, which is the consequence of the mutual coupling between the loops. The minimum below 20 dB transmission attenuation is achieved at both resonance frequencies.

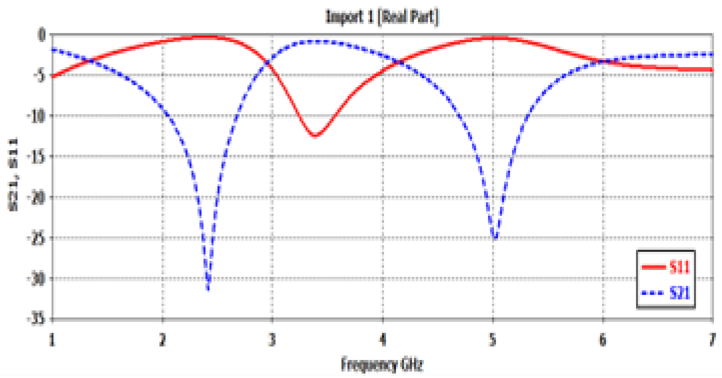

Figure 2 : The Simulated S21 for Various Incidence Angles Under TE Polarization

Figure 3 shows the transmission coefficients for TE polarization at incidence angles fluctuating as of 0 to 90. The resonant frequencies at 0 are 2.4 GHz and 5 GHz; they remain constant until the 90-degree angle of incidence. The comparable transmission coefficients at 0 are 31.1 dB and 24.08 dB, respectively, and remain constant up to 90. This indicates that the proposed FSS keeps a consistent frequency response regardless of the angle of incidence, which ranges beginning 0 to 90 degrees.

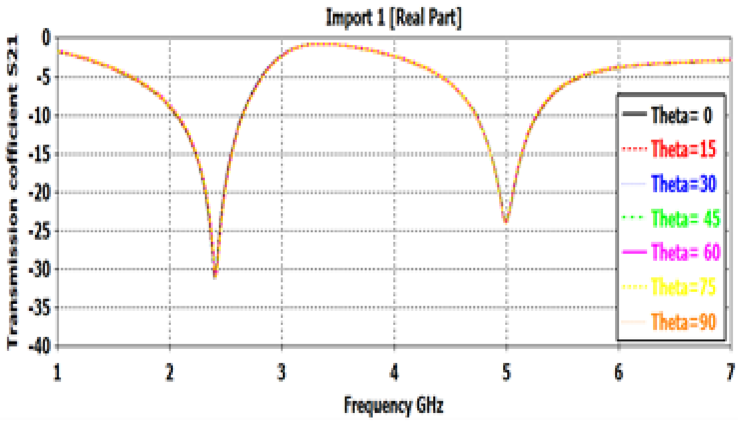

Figure 3 : The Simulated S21 for Various Incidence Angles Under TE Polarization

Figure 4 shows the TM polarization transmission coefficients for incidence angles 0–90 degrees. The resonant frequencies on 2.4 GHz besides 5 GHz remain the same until 90. The corresponding transmission coefficients, 31 dB and 24 dB, also stay the same at 90, respectively. So, the results concluded that when the angle of incidence changes between 0 and 90, the FSS response remains relatively constant aimed at equally TE and TM polarizations.

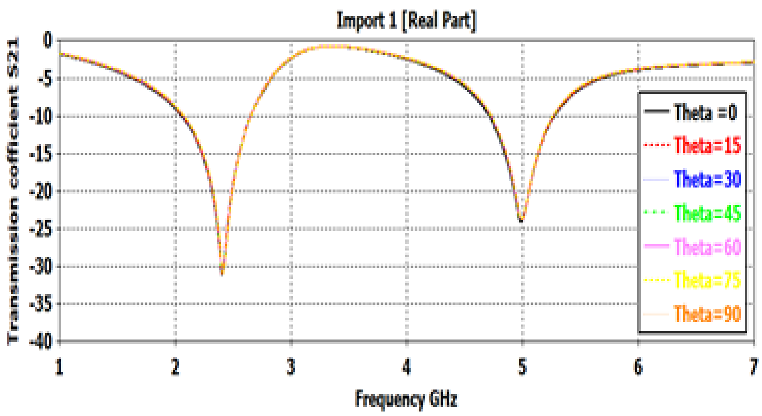

Figure 4 : The Simulated S21 for Various Incidence Angles Under TM Polarization

A parametric analysis of the substrate height h on the frequency responses at the bandstop was performed as shown in Figure 5. The simulation outcomes displayed that changing h from 6 mm to 8 mm shifts the higher bandstop frequency from 5.02 to 4.97 GHz, while the lower bandstop band moves beginning 2.41 to 2.40 GHz.

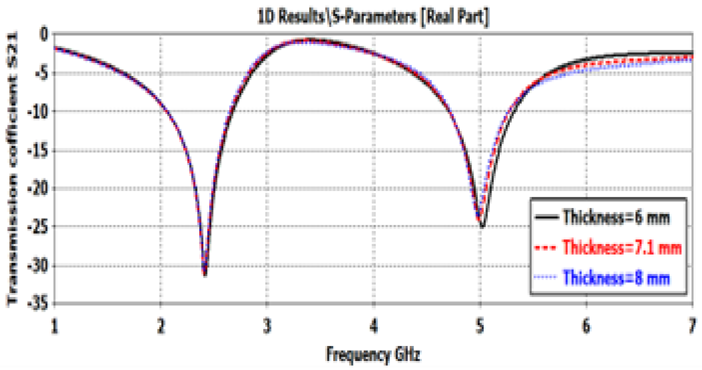

Figure 5 : The Simulated Response for the Proposed FSS at Various Values of Substrate Thicknesses H.

Then, the simulator was used to changes to the bandstop frequencies concerning the inner width of the square loop, as illustrated in Figure 6. It is observed that with increasing inner width, the two resonance frequencies move beginning 2.40 to 2.37 GHz and from 5 to 4.95 GHz. The transmission coefficient dropped 3 dB at the second resonance frequencies.

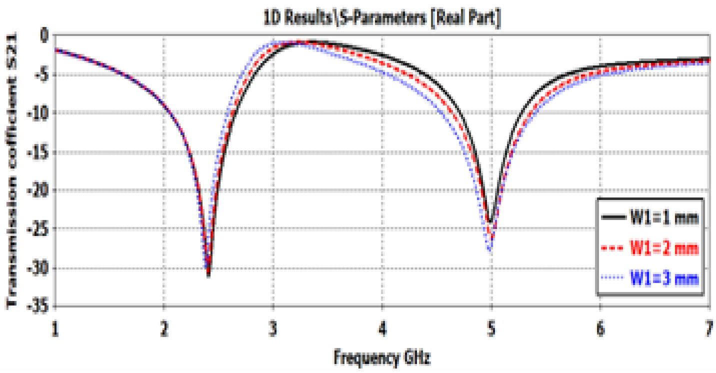

Figure 6 : The Simulated Response for the Proposed FSS at Various Values of Width W1

Figure 7 depicts the simulated transmission coefficient findings for square loop elements with outer widths varying from 1 to 3mm. The influence of the inner width on this resonance frequency is shown in Fig. 7, which shows a substantial shift towards a lower frequency and a 6 dB reduction in the transmission coefficient in the first operational band due to changing the outer square ring width. However, the upper operational band remained unaltered.

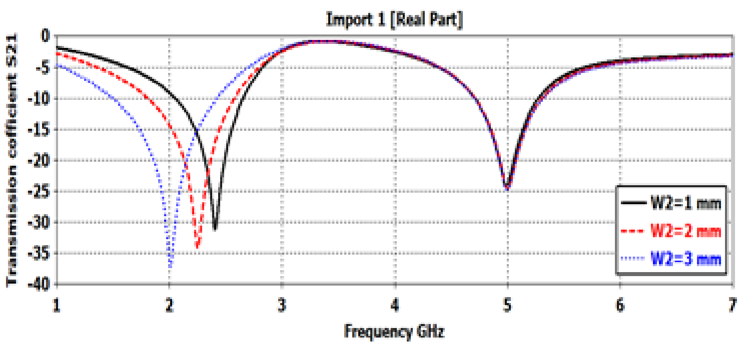

Figure 7 : The Simulated Response for the Proposed FSS for Various Values of Width W2.

IV. CONCLUSION

In this research, the existing design band-stop geometry was designed to mitigate interference and ensure the security of WLAN operating in the 2.4 and 5 GHz frequencies. The suggested strategy provides a constant frequency response aimed at TE and TM modes across a range of incident angles up to 90 degrees while achieving attenuation values of 31 dB and 24 dB aimed at the 2.4 and 5 GHz frequency bands. The suggested design showed how changing the inner square loop's width, outer square loop's width, and thickness affected a resonance frequency. The results indicated that the width of the inner square loop's affected the higher resonance frequency while outer square loop's affected the lower resonance frequency This design can be used as wallpaper in a building to differentiate between various Wi-Fi standards, reducing interference and improving wireless security.

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