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A COMPACT TRIBAND FSS APPLICABLE FOR WLAN APPLICATIONS

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Abstract

The paper proposes a miniaturized dual-band frequency selective surface (FSS) structure, which can realize the band rejection characteristics of first band 3.4GHz, second band of 9.08GHz and 16.04GHz through three frequency points, and the characteristics of FSS are verified through physical tests. suitable for antenna stealth. The FSS has dual-band rejection characteristics at the corresponding frequency points of the three band. The unit-cell architecture resembles the shape of a Swastik to achieve miniaturization. The parameters of the surface element and analyzes the transmission characteristics of the surface element by the equivalent circuit method. The suggested device ensures angular independence by maintaining a constant response to TE and TM polarization patterns and oblique incident angles. The measured findings from the constructed FSS are used to validate the computed results. Finally, a new unit structure is provided for the application of FSS in antenna stealth. The designed structure not only has two closely adjacent resonance points that can be adjusted independently but also has the advantages of miniaturization and incident angle stability up to 45°. The proposed structure is suitable for antenna stealth technology.

Keywords - miniaturized, frequency selective surface, antenna stealth, transmission characteristics, resonant frequency, angular independence, measured findings, prototype, anechoic enclosures.

Introduction

A frequency selective surface (FSS) is a type of material that can selectively reflect, transmit, and absorb electromagnetic waves of certain frequencies. In antenna engineering, FSSs are commonly used to design antennas with reduced radar cross-section (RCS), a property commonly known as antenna stealth. One approach to designing an FSS-based antenna is to use a compact triband FSS. It is an endless periodic array of metal patches or apertures that can be optimized by loading lumped elements or materials with specific impedance, and the resonance frequency can be modified by controlling the size of the FSS and the loaded resistance. The paper proposes a tiny dual-band FSS structure suitable for antenna stealth, with dual-band rejection characteristics at the corresponding frequency points of the S-band and C-band. The unit-cell architecture resembles the shape of an "S" to achieve miniaturization, and the suggested device ensures angular independence by maintaining a constant response to TE and TM polarization patterns and oblique incident angles. The measured findings from the constructed FSS are used to validate the computed results, and a new unit structure is provided for the application of FSS in antenna stealth. A dual-frequency FSS is an FSS that can operate at three distinct frequencies.

This is achieved by designing the FSS with two different resonant modes. One of the resonant modes is designed to operate at a low frequency, while the other is designed to operate at a high frequency. The miniaturization of the FSS is achieved by reducing the size of the FSS elements, which allows the FSS to operate at higher frequencies. To design a tri-band frequency miniaturized FSS suitable for antenna stealth, several factors need to be considered. These include the size of the FSS elements, the spacing between the elements, and the choice of materials used to construct the FSS. The size of the FSS elements is critical to achieving miniaturization.

The spacing between the FSS elements is also critical. The spacing determines the resonant frequency of the FSS. By adjusting the spacing between the FSS elements, it is possible to design an FSS that can operate at two distinct frequencies.

The smaller the elements, the higher the frequency at which the FSS can operate. However, reducing the size of the elements can also reduce the bandwidth of the FSS, which can limit the range of frequencies that the FSS can operate.

The materials used should have low losses at the frequencies of interest and should be able to withstand the environmental conditions in which the FSS will be used. The triband frequency miniaturized FSS can be an effective approach for designing antennas with reduced RCS. However, the design process requires careful consideration of the size of the FSS elements, the spacing between the elements, and the choice of materials used to construct the FSS.

FSS Design

A Frequency Selective Surface (FSS) is a thin and planar structure consisting of an array of closely spaced conductive elements. It is designed to selectively reflect, transmit or absorb electromagnetic radiation in a specific frequency range. The FSS operates on the principle of electromagnetic wave interference. When an electromagnetic wave encounters an FSS, the wave is scattered, and the phase and amplitude of the scattered wave depends on the geometry and spacing of the FSS elements.

By controlling the geometry and spacing of the FSS elements, it is possible to create a filter that can allow certain frequencies to pass through while reflecting or absorbing others. This makes FSSs useful in a wide range of applications, such as radar systems, communication systems, and electromagnetic shielding. FSSs can be designed to operate at various frequencies ranging from radio frequencies to microwaves and even higher frequencies such as terahertz waves. They can also be designed to have polarization selective properties, where they can selectively transmit or reflect waves with certain polarizations.

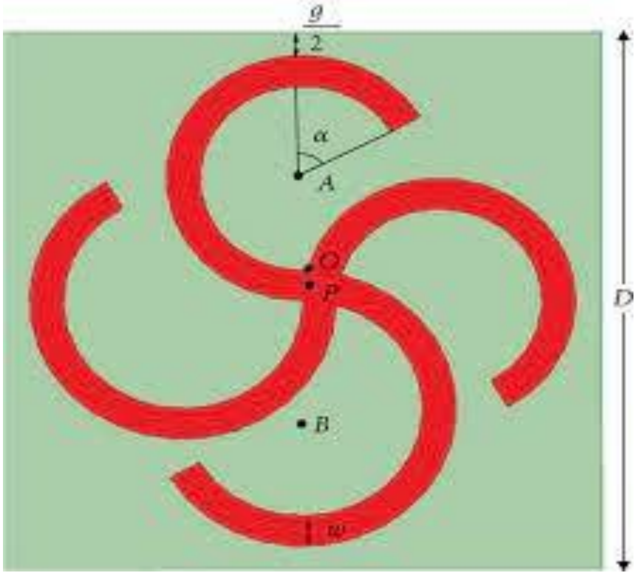
FSSs are generally lightweight, compact, and can be easily integrated into various devices. They also have the advantage of being passive components, meaning they do not require an external power source to function.

Existing Method

The Dual-Frequency Miniaturized Frequency Selective Surface (DFM-FSS) is a previous structure that is designed to be suitable for antenna stealth applications. The structure consists of two layers of rectangular patches with different dimensions, separated by a thin dielectric layer.

The previous method for creating the DFM-FSS involves optimizing the dimensions and spacing of the rectangular patches to achieve selective attenuation of two different frequencies. The structure is optimized using a numerical simulation method, such as Finite Element Method (FEM) or Method of Moments (MoM).

The rectangular patches in the upper layer are designed to attenuate the higher frequency, while the rectangular patches in the lower layer are designed to attenuate the lower frequency. The dielectric layer between the two layers serves to increase the isolation between the two frequency bands. The DFM-FSS is miniaturized, which means that it can be used in applications where space is limited. It is also designed to be lightweight, which is important for applications where weight is a concern.



The DFM-FSS structure has several advantages over traditional frequency selective surfaces. It provides dual-band attenuation, which allows for greater frequency selectivity. It is also highly efficient, which means that it can achieve high attenuation levels with low insertion loss. Additionally, the structure is designed to be compatible with a wide range of antenna designs, making it highly versatile This can be used to control the polarization of the transmitted or reflected waves, which is important in many applications.

These are typically thin and planar, which makes them lightweight and easy to integrate into a wide range of devices. Overall, the DFM-FSS structure offers a promising solution for antenna stealth applications, where it can be used to reduce the detectability of antennas and improve the performance of stealth technologies.It is designed to selectively transmit or reflect waves with certain polarizations.

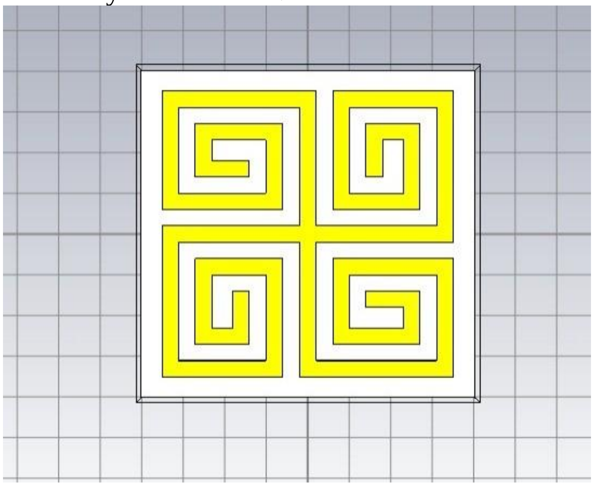
Proposed Method

The design and implementation of a dual-layer compact triband frequency selective surface (FSS) applicable for WLAN application. The FSS structure consists of two layers of metallic patches separated by a thin dielectric layer.

The design is based on the principal of a resonant cavity, where the two layers of patches create a resonant cavity between them. The FSS structure is fabricated using low-cost and standard printed circuit board (PCB) technology. The performance of the fabricated FSS structure is evaluated experimentally using a Vector Network Analyzer (VNA).

The method operates based on the principle of electromagnetic wave interference. When an electromagnetic wave encounters an FSS, the wave is scattered, and the phase and amplitude of the scattered wave depends on the geometry and spacing of the FSS elements. By controlling the geometry and spacing of the FSS elements, it is possible to create a filter that can allow certain frequencies to pass through while reflecting or absorbing others. It can be designed to operate at various frequencies ranging from radio frequencies to microwaves and even higher frequencies such as terahertz waves. They can also be designed to have polarization selective properties, where they can selectively transmit or reflect waves with certain polarizations. It is used in a wide range of applications, such as radar systems, communication systems, and electromagnetic shielding.

It is used in a wide range of applications, such as radar systems, communication systems, and electromagnetic shielding. They are often used in the design of microwave and millimetre-wave antennas, where they can be used to control the radiation pattern and improve antenna performance. FSSs are also used in stealth technology to reduce the radar cross-section of aircraft and other objects.It can be designed to selectively attenuate or reflect electromagnetic radiation within a specific frequency range. This makes them useful in a wide range of applications where frequency selectivity is important. designed to selectively transmit or reflect waves with certain polarizations. This can be used to control the polarization of the transmitted or reflected waves, which is important in many applications. It can be used in sensing applications, such as in biosensors. In these systems, FSSs are used to selectively filter out certain frequencies of light, which can be used to detect specific molecules or biomolecules. can be used in energy harvesting applications, such as in solar cells. FSSs can be designed to selectively transmit certain frequencies of light, which can be used to increase the efficiency of solar cells.



It be used in energy harvesting applications, such as in solar cells. FSSs can be designed to selectively transmit certain frequencies of light, which can be used to increase the efficiency of solarcells.

The materials used to construct FSSs can vary, but typically consist of metal, dielectric, or a combination of both. The metal is usually copper or aluminium, while the dielectric material is typically a substrate made of apolymer, ceramic, or glass material.including This method is able to reduce the RCS of the antenna by selectively filtering out certain frequencies of the incident radiation that are most likely to be detected by radar. By doing so, the antenna becomes less visible to radar and is more difficult to detect. Miniaturized frequency selective surface is a specialized structure that can selectively filter electromagnetic waves at two different frequencies. It is designed to be small and suitable for antenna stealth applications by reducing the radar cross-section of the antenna.The metal is usually copper or aluminium, while the dielectric material is typically a substrate made of a polymer, ceramic, or glass material including periodic, aperiodic, multilayer, and gradient index FSSs. Periodic FSSs have a regular pattern of conductive elements, while aperiodic FSSs have a non uniform pattern. Multilayer FSSs consist of multiple layers of FSSs stacked on top of each other, while gradient-index FSSs have a varying refractive index across the structure. FSS can be fabricated using a variety of techniques, including photolithography, laser etching, and inkjet printing. These techniques allow for precise control of the FSS geometry and spacing, which is important for achieving the desired frequency response. Although FSSs have many advantages, there are some limitations to consider. For example, FSSs have a narrow bandwidth and can only operate with in a specific frequency range. They are also susceptible to polarization and incident angle variations, which can affect their performance. This method is also designed to be suitable for antenna stealth applications. Antenna stealth refers to the ability of an antenna to remain undetected or hidden from radar detection. This is achieved by reducing the radar cross-section(RCS) of the antenna, which is a measure of how well it reflects electromagnetic waves.

Hardware Used

Initially designed a substrate, length and width of 8mm, thickness of 1.6mm, And the material used is FR-4(lossy).Then the patch is designed by four-legged loaded FSS with an arm width of 0.4mm and a length of 7mm.The material used for patch is copper(annealed).The spacing between each branch was 0.5mm. After the swastik structure, a square spiral is added with the use of boolean method. Then it is rotated into 90 degree to obtain a equal square spiral.

1)Substrate Material: A thin, flexible substrate material is used to support the DFMFSS structure. The substrate may be made of a variety of materials, such as Kapton, Mylar, or Rogers.The substrate material used in compact triband FSS suitable for antenna stealth is an important component of the structure. The substrate serves as a support material for the conductive elements and also provides mechanical stability to the entire structure. The properties of the substrate material can have a significant impact on the performance of the triband FSS, including its electrical properties, mechanical strength, and thermal stability
2)Conductive Material: A conductive material, such as copper, is used to create the periodic elements of the triband FSS. These elements are typically etched onto the substrate using a photolithography process.The conductive material used in compact triband FSS suitable for antenna stealth is a critical component that provides the necessary electromagnetic functionality to the structure. The conductive material is typically deposited on the substrate to create a pattern of metallic elements that form the periodic structure of the FSS
3)Etching Equipment: Etching equipment is used to create the periodic elements of the triband FSS. This

equipment typically includes a mask aligner, which is used to transfer the pattern of the periodic elements onto the substrate, and a chemical etching tank, which is used to remove the unwanted material from the substrate.There are several etching techniques used in the fabrication of this method, including wet etching and dry etching. Wet etching involves the use of a chemical solution to remove the unwanted portions of the conductive material, while dry etching involves the use of a plasma to selectively remove the conductive material.The equipment used for wet etching typically includes a mask aligner, which is used to transfer the pattern of the periodic elements onto the substrate, and an etching tank, which is used to immerse the substrate in the etchant solution. The mask aligner is used to align the patterned mask with the substrate, ensuring precise placement of the periodic elements. The etching tank contains the etchant solution, which is typically an acid or base solution that selectively removes the conductive material.

4)Measurement Equipment: RF measurement equipment, such as a Vector Network Analyzer (VNA), is used to measure the transmission and reflection properties of the method.. This equipment is used to validate the design and optimize the performance of the structure.scattering parameters of a device or circuit. It is commonly used in RF and microwave measurements to evaluate the performance of antennas, filters, and other passive components. A VNA can measure the reflection and transmission coefficients of this method over a range of frequencies, providing information on its frequency response. spectrum analyzer is a device used to measure the spectral content of an electrical signal. It is commonly used in RF and microwave measurements to evaluate the frequency response of a device or circuit. A spectrum analyzer can be used to measure the reflection coefficient and transmission coefficient of a triband at a single frequency, providing information on its frequency selectivity.Antenna measurement systems are used to measure the performance of antennas and other electromagnetic devices. They can be used to measure the radiation pattern, gain, and polarization of an antenna, as well as the reflection and transmission coefficients of a triband compact fss when used in conjunction with an antenna.

5)Antenna: The triband fss is typically integrated with an antenna to create a low-RCS antenna. The specific type of antenna used will depend on the application, but common examples include patch antennas or dipole antennas.

Software Used

1) CST(Computer Simulation Technology) is a leading electromagnetic simulation software used for designing and analyzing electromagnetic structures and devices.

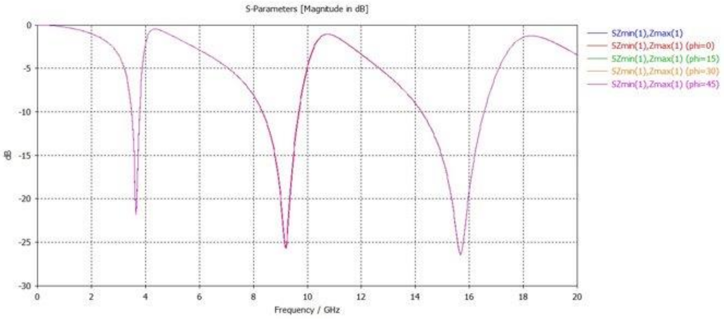
Electromagnetic simulation software: Electromagnetic simulation software is used to simulate the electromagnetic behavior of the triband FSS structure. This software can predict the reflection and transmission coefficients, as well as the frequency response of the structure. Popular electromagnetic simulation software tools include CST Studio Suite, Ansys HFSS, and FEKO.

Optimization software: Optimization software is used to optimize the design of the DFMFSS structure based on specific performance requirements. This software can be used to adjust the periodic element size and spacing, as well as the substrate and conductive material properties, to achieve the desired frequency response and reflection properties.

MATLAB: MATLAB is a programming language that can be used to perform various electromagnetic simulations and analysis. It is commonly used in research and development for the analysis and optimization of complex electromagnetic structures.

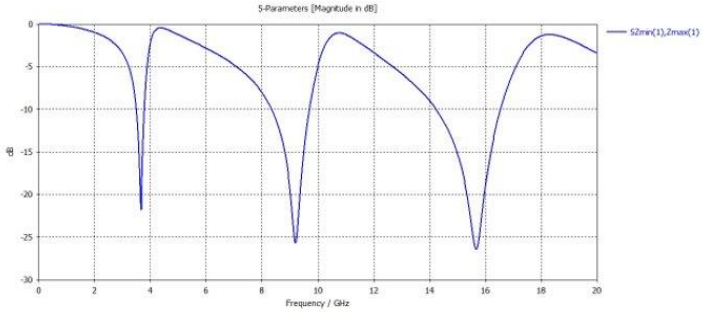
Conclusion

The results obtained in the frequency range from 2.0 GHz to 18.0 GHz The first band occur at 3.4GHz, second band at 9.08GHz and the last one at 16.04GHz. For horizontal polarization, only incident angles at the 9.08 GHz band have angular stability. The increase in branch length causes a distance between the rejection bands. Increasing the branch length means an increase in the electrical length. A compact FSS band with angular stability for TE and TM modes of polarization.



It proposes a new type of miniaturized tri-band -frequency structure suitable for antenna stealth, which can realize the band rejection characteristics first band

3.4GHz, second band of 9.08GHz and 16.04GHz through two dual-frequency points, and the characteristics of FSS are verified through physical tests. The results show that the designed structure not only has two closely adjacent resonance points that can be adjusted independently but also has the advantages of miniaturization and incident angle stability up to 60°. The article concludes that the proposed design has potential applications in antenna stealth technology, particularly for unmanned aerial vehicles used in air operations.The miniaturized triband frequency FSS has significant advantages over conventional FSS structures, such as smaller size, improved bandwidth, and enhanced stealth capability.There are possible areas of future research, such as optimizing the FSS design for specific frequency bands and integrating the FSS structure with other antenna components.



The focus of the result and conclusion of this paper is to evaluate the performance of the proposed FSS structure and demonstrate its potential for antenna stealth applications.The absorption principle of the design is based on strong electromagnetic resonance generated within the absorbing body, which converts energy into heat and other forms of energy loss. The design can be easily adjusted by changing the size of the square ring to accommodate different absorption frequency bands. The proposed FSS structure has potential applications in wireless communication and mobile computing.Various techniques have been proposed and studied to achieve this goal, including the use of miniaturized unit cells, fractal elements, metamaterials, and polarization diversity. These techniques have led to the development of dual-frequency FSS structures with enhanced bandwidth, attenuation, and size reduction capabilities.Several simulation and measurement studies have demonstrated the effectiveness of these structures in reducing the RCS of antennas, particularly in military applications such as aircraft, ships, and ground vehicles. However, further research is needed to optimize the performance of these structures and to explore their potential in other applications such as wireless communications and satellite systems.The main objective of such structures is to reduce the radar cross-section (RCS) of the antenna, while maintaining its electrical performance.

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