3-D FREQUENCY-SELECTIVE STRUCTURE AND ITS APPLICATIONS

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ABSTRACT

Frequency-selective surfaces are 2-D infinite arrays that act as a filter for the incident electromagnetic waves. They have been used in hybrid radomes, dichroic main reflector, sub-reflector, microwave absorbers, absorptive frequency-selective surfaces, high impedance surfaces and many other applications. These 2-D arrays consist of slots in a conducting plate or conducting strips printed on a dielectric layer, which is able to produce band-pass or band-stop frequency response, respectively. The traditional 2-D frequency-selective surface suffers from some drawbacks, such as poor selectivity and for some cases its performance is sensitive to oblique incidence. Recently, 3-D frequency-selective structure was presented in the literature. By employing multi-mode resonators, pseudo-elliptic response can be achieved, which has better selectivity compared to 2-D surfaces. Here, we focus on multiband high-order bandstop frequency-selective structure, ultra-wideband absorber and absorptive frequency-selective transmission structure.

First, a general and systematic methodology is proposed to design multiband high-order bandstop 3-D frequency-selective structures. By adjusting the coupling between identical resonators, high-order response is achieved. Through introducing multiple resonators in a single unit cell, one can readily obtain multiband filtering response. Detailed analysis for the coupling between identical resonators is provided, so are equivalent circuit models to explain the operating principle. Two structures are designed, fabricated, and measured to verify the proposed methodology. The first structure is a tri-band second-order frequency-selective structure, while the second structure exhibits a dual-band third-order response.

Although the 3-D frequency-selective structure has a good performance, it has two problems; one is the thickness problem, which may limit its practical applications and the other is the operation under dual-polarized incident wave. A loop resonator is then proposed in the unit cell of the bandstop structure instead of microstrip resonator aiming to achieve maximum reduction in the

structure thickness. Using elliptical loop with stepped-impedance resonator, an 80% reduction in structure thickness is achieved without degrading the performance compared to the original structure, which makes it suitable for the practical applications.

In addition, folded substrate technique is employed for the bandpass frequency-selective structure to reduce its thickness. A 67% and 79% thickness reduction compared to the basic bandpass 3-D frequency-selective structure is achieved by employing three- and five-layer folded substrate, respectively. Moreover, a half-cylindrically shaped radome as an example of conformal frequency-selective surface is constructed based on the proposed technique and integrated with a broadband horn antenna. Besides working as a radome it shows good filtering properties. A fabricated prototype of this radome is measured in the presence of a broadband horn antenna.

Furthermore, double-sided parallel-strip line resonator is employed in the unit cell of a 3-D frequency-selective structure in order to exhibit the desired response (bandstop, bandpass and absorption) under an incident wave of arbitrary polarization. It is found that this unit cell supports the propagation of three quasi-TEM modes. A dual-polarized bandstop 3-D frequency-selective structure is then proposed. Moreover, a dual-polarized absorber is also realized employing a unit cell with double-sided parallel-strip line resonator. By properly exciting and absorbing the second mode of the modified unit cell, an ultra-wideband dual-polarized absorber is constructed.

As the last application example, which is absorptive frequency-selective transmission structure, a tailoring methodology is proposed to achieve arbitrary frequency response within a wide absorption band. An ultra-wideband absorber utilizing multiple resonances in the unit cell of 3-D frequency-selective structure is utilized as the textile for the proposed designs. Two structures are proposed; one is the absorptive frequency-selective reflection structure and the other is the absorptive frequency-selective transmission structure. Two prototypes are designed, fabricated, and measured to validate the proposed methodology. The first one is an ultra-wideband absorber, while the second one

is an absorptive frequency-selective transmission structure with wide absorption bands at both sides of its transmission window. A good agreement is achieved between simulated and measured results.

Finally, a few suggestions and recommendations are made for further investigation. For example, a tunable absorptive frequency selective transmission is proposed, which may be integrated with a tunable antenna to achieve a low radar cross-section tunable antenna system. The structure employing double-sided parallel-strip line resonator may be suitable for transmit / reflect arrays as well.

AUTHOR'S PUBLICATIONS

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