Miniaturized-Element Frequency Selective Surfaces with Narrowband, Higher-Order Bandpass Responses

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The selectivity and response type of the frequency response of a frequency selective surface (FSS) are important factors that determine the suitability of an FSS for a given application. A common application of FSSs is to use them to shield sensitive electronic devices form unwanted interference or jamming signals with frequencies close to the main transmission band of the device. In such situations, spatial filters with highly-selective and narrowband transmission windows are required. FSSs with higher-order bandpass or bandstop responses acts similar to coupled-resonator filters. Therefore, their operational bandwidths are inversely related to quality factors of their resonators. Thus, to achieve a narrow-band response, higher quality factors are needed. For the case of traditional FSSs, these resonators are created using resonant elements within a unit cell. Miniaturized-element frequency selective surfaces (MEFSSs), on the other hand, use the combination of non-resonant reactive surfaces with capacitive and inductive surface impedances to create distributed-type resonators. For both approaches, the minimum-attainable feature sizes used in the metallic patterns of the structures are the bottleneck of achieving high quality-factor resonators. In practice, the minimum gap spacing and trace widths are determined by the minimum feature size that can be reliably fabricated using standard PCB lithography techniques. Therefore, achieving very high-quality factors and accordingly narrowband frequency responses for both configurations is rather challenging.

In this presentation, we report a new technique for designing MEFSSs with narrowband bandpass responses of order $N \geq 2$. The proposed structure is composed of two-dimensional periodic arrays of sub-wavelength inductive wire grids separated from one another by dielectric substrates. The synthesis procedure of the device is based on the equivalent circuit model of the structure, which is a shunt-inductance coupled-resonator filter. To achieve high quality factors, the proposed design uses dielectric cavities as resonators, which are coupled together using k-type impedance inverters. Following this comprehensive synthesis procedure, a prototype of the proposed MEFSS structure having a second-order bandpass response with the center frequency of 21 GHz and the fractional bandwidth of ≈5% is designed. The designed structure is a low-profile structure with unit cell dimensions of $\approx 0.21\lambda_\circ \times 0.21\lambda_\circ$, where $\lambda_\circ$ is the free space wavelength at the center frequency of operation. Due to the sub-wavelength features of the elements, the frequency response of the present prototype is relatively stable for incidence angles in the range of $\pm 40°$. Detailed design procedure as well as the simulation and measurement results of the fabricated prototype will be presented and discussed at the symposium.