A Multi-Pole Extremely Thin Meramaterial Inspired Frequency Selective Surface

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Frequency selective surfaces (FSS) are planar structures consisting of periodic sub-wavelength resonant unit cells. These surfaces show filtering behavior when illuminated by electromagnetic waves. Miniaturized element or metamaterial inspired FSSs are a class of frequency selective surfaces whose unit cell size is much smaller than the wavelength ($\sim \lambda/10$) at the resonance frequency of the structure. As a result, in comparison with conventional FSSs, miniaturized element frequency selective surfaces (MEFSS) can be made much smaller in size ($\sim \lambda$), are less sensitive to the angle of incident and can be accurately modeled using equivalent circuits consisting of simple components. The small unit cell size of the MEFSSs also allows for localization of the bandpass characteristics on a small surface area and spatial filtering for an arbitrary wave phasefront.

A two layer MEFSS consisting of an array of metallic patches and a wire grid placed on the opposite sides of a very thin substrate was recently demonstrated. The patch-grid MEFSS shows a single-pole bandpass frequency response. Multiple MEFSSs can be cascaded to achieve a multi-pole response and higher bandwidth. It can be shown that in order to achieve a flat response using multiple layers of single pole FSS, the spacing between the layers should be close to a quarter of a wavelength (F. Bayatpur and K. Sarabandi, IEEE Tran. Micr. Theo. & Tech., Vol. 56, No. 12, 2742-2747). Increasing the spacing between the layers increases the angle dependency of the phase shift between two consecutive layers. As a result, the overall frequency response of the FSS becomes more sensitive to the angle of incident.

In this paper, a two pole band-pass MEFSS consisting of two layers of patch arrays and one layer of wire grid is introduced. This design utilizes the coupling between different layers to introduce new poles and therefore a $\lambda/4$ spacing between the layers is not necessary. The total thickness of the two pole MEFSS is less than $\lambda/15$ (compared to the commonly used $\lambda/4$) which drastically reduces the angle dependency of the frequency response. The performance of the designed two-pole MEFSS is compared with commonly used FSSs and the relationship between the bandwidth and angle dependency of the MEFSS is studied.