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Coupled Resonator Metasurface Supercell for Independent Control of Orthogonal Polarizations with Enhanced Complex Reflectance

Mohamed K. Emara, Leandro M. Rufail, and Shulabh Gupta*
Department of Electronics, Carleton University, Ottawa, ON, Canada, mohamed.emara@carleton.ca

A novel coupled resonator reflectarray supercell is proposed as shown in Fig. 1(a). Each sub-unit cell (i.e., quarter of the supercell) is based on two coupled resonators: a split-ring resonator (SRR) with tunable capacitance and resistance, and a dipole-ring resonator (DRR) with a tunable capacitance. The three controls in each sub-unit cell allow for an enhanced complex reflectance coverage (i.e., more control over the magnitude and phase at the desired frequency) [1]. While each sub-unit cell can control the complex reflectance of a single linear polarization, a supercell configuration comprised of two sets of orthogonal sub-unit cells can control the complex reflectance of two orthogonal linear polarizations independently, which allows for greater beamforming capabilities (e.g., polarization diversity). While this supercell concept was initially proposed in [2], it featured a limited control over the complex reflectance. The supercell proposed here however can achieve complete complex reflectance control

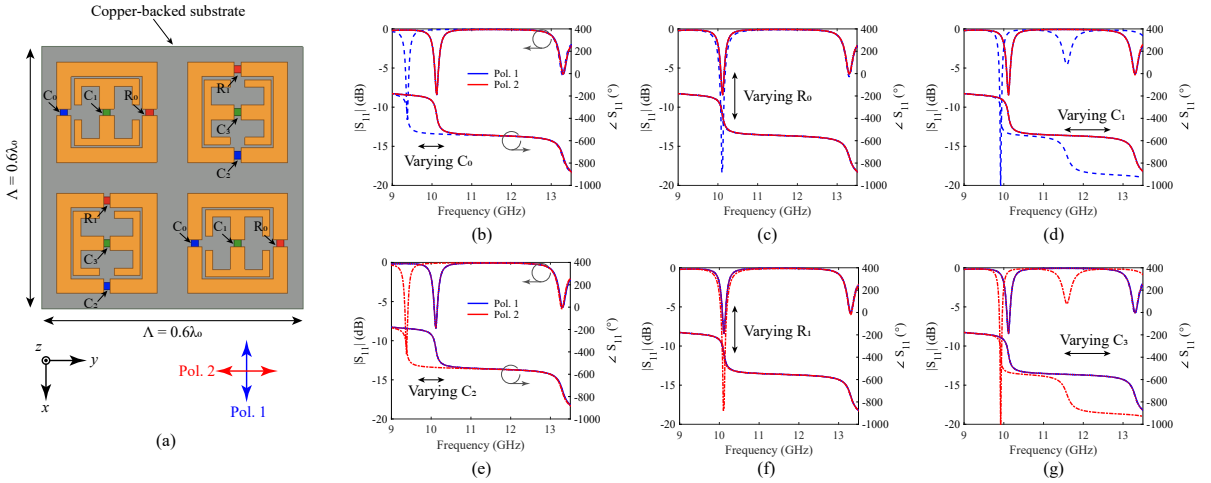

Figure 1. (a) Proposed supercell configuration comprised of unit cells based on coupled resonators, implemented on Rogers RO4003C ($\varepsilon_r = 3.55$, $\tan\delta = 0.0027$, and height, $h = 32$ mil). The supercell size is $\Lambda \times \Lambda$, where $\Lambda = 0.6\lambda_0$ at 10 GHz. Full-wave complex reflectance of the supercell for varying capacitance and resistance to control the complex reflectance of Pol. 1 ($x-$polarization): (b) C_0, (c) R_1, (d) C_1, and of Pol. 2 ($y-$polarization): (e) C_2, (f) R_1, and (g) C_3.

due to the coupled resonator configuration. The proposed supercell consists of twelve tunable elements, with the diagonal sub-unit cells utilizing identical variations of each control element. Elements C_0, R_0, and C_1 control the complex reflectance of the vertical polarization, while elements C_2, R_1, and C_3 control the complex reflectance of the horizontal polarization. Preliminary Ansys FEM-HFSS full-wave simulation results of the unit cell with periodic boundaries and Floquet port excitation are shown in Fig. 1(b)-(g), where an enhanced complex reflectance is successfully obtained at a design frequency of 10 GHz for two orthogonal polarizations independently.

References

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[2] L. M. Rufail, M. K. Emara, A. Z. Ashoor, and S. Gupta, "Metasurface Reflector with Independent Polarizations Control using a Supercell Concept," *2022 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting (AP-S/URSI)*, 2022, pp. 1880–1881.