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Modeling and Simulation of Tunable Software-Defined Metasurfaces

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Abstract: Metasurfaces (MS) are thin layered metamaterials whose macroscopic electromagnetic behaviour is determined by subwavelength features inscribed on their surface. Tunable MS with enhanced functionality can be designed by providing for local control. The most attractive control mechanism for microwave and mm-wave applications is the implementation of voltage-controlled continuously-tunable electrical networks, appropriately connected in each unit cell of the MS. These networks contribute an equivalent lumped impedance (expressed in terms of S-parameters) which modifies the surface impedance of each unit cell, something that can be used to effectively tune the MS response to incident waves of different frequency, angle and polarization. Arranging the unit cells in appropriately configured super cells can be translated into various concurrent MS functions including wavefront shaping, beam focusing, steering and perfect absorption. Application areas span antenna design, wireless propagation, communications and compatibility (EMC), while the designs are in principle scalable to other spectral regions (THz, IR, optical) and material platforms (e.g. graphene). The deployment of interconnected locally-tunable adaptive MS, in the form of tiles which operate as a concerted EM “organism”, enables the broad vision of smart devices in the emerging *Internet of Things* paradigm. In this work, we present our methodology for designing and optimizing MS aimed for steering and perfect absorption applications in the microwave spectrum, by blending theoretical modelling with computational EM simulation. Finally, to broaden the reach of this technology, we foresee the embedding of software modules into the MS, thus providing the groundwork for exposing the end-functionality of the device to users without specialized skills.
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