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Electromagnetic Validation of an End-to-End Communication Model for Reconfigurable Intelligent Surfaces based on Mutual Impedances

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Reconfigurable Intelligent Surfaces (RISs) constitute a promising new technology for controlling and managing the wireless propagation channel, enabling the idea of the wireless environment as a service [1]. RISs are large electronically-controlled electromagnetic metasurfaces (MS) comprising a huge number of low-cost passive sub-wavelength reflecting elements, referred to as unit cells. By properly tuning the reflection phase and amplitude of these individual elements, one can engineer the desired electromagnetic (EM) properties of the reflected wavefront to obtain specific EM functionalities, e.g., beam steering, focusing, interference mitigation, coverage extension, and more [2], [3]. Modelling the electromagnetic propagation of signals in such RIS-enabled environments has therefore become a point of crucial importance in future beyond 5G/6G architectures, and faces significant EM modelling challenges [3]. In [4] the authors introduced an electromagnetic compliant communication model for the end-to-end RIS-assisted wireless channel, based on an impedance matrix formalism. This model has been verified for minimum scattering linear antennas and there is now need to validate the mathematical structure in the far-field with real-life prototypes In this work, a procedure to validate the proposed model is presented that relies on the extraction of impedance matrices from commercial full-wave EM software. In particular, two RISs based on different unit-cell designs, operating at 5 GHz and 29 GHz respectively, were tested. The first structure is the design of a 2×2 unit cells RIS (2 ports on each unit cells) operating at 5 GHz. This unit cell, designed by Greenerwave [5], uses a p-i-n diodes to control a binary reflection phase on both the vertical and the horizontal polarizations. The second structure is a 2×2 RIS designed at CEA-Leti, which operates at 29 GHz. In this case, two p-i-n diodes are used to implement a binary phase control on a single linear polarization. For both configurations, a very good agreement has been found between model predictions from the end-to-end formulation and the analysis conducted via full-wave simulations. Achieved results pave the way to the integration of EM models within optimization algorithms adopted in wireless communication networks.

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