URSI-RCRS 2024, ARIES/GEHU, Bhimtal, India, 22 - 25 October, 2024

On Beam-Steering from Reconfigurable Intelligent Surfaces for Oblique Incidences

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Reconfigurable intelligent surface (RIS) is a metasurface with reconfigurable phase and/or magnitude which can provide dynamic beamforming. The RISs are inherently low-profile and light-weight. Moreover, unlike a phased array which requires multiple RF chains, an RIS requires only one RF chain. Therefore, they consume less power. Due to the ability to provide minimum SWaP (size, weight and power), the RIS can be very useful for future-generation sensing and communications. In general, two different scenarios of EM wave incidence are considered while designing and analyzing an RIS. One is plane wave incidence and the other one is incidence from a dedicated source (feed) at near field. However, in most of the works on RIS, normal incidence is considered for both the above scenarios. As the demand of RIS for practical applications is increasing, we have considered oblique incidence of both the plane wave incidence and dedicated near-field source. The necessary compensating phase on the aperture of a 1-bit coding metasurface-based RIS is calculated for beam steering of oblique incidence of plane wave as well as dedicated near-field source. Thereafter, the radiation patterns of the reflected beams are theoretically calculated by considering the oblique incidence of the above two scenarios. As for the design of the unit cell of RIS for oblique incidence is considered, full-wave simulator is used. The unit cell should be oblique incidence insensitive for good performance under arbitrary incident and reflection angles. It is found that a miniature unit cell with low thickness gives better oblique incidence insensitivity. After constructing an array of M×N unit cells, full-wave simulations are carried out for RIS beamforming with oblique incidence. It is observed that the full-wave simulated results exhibit good agreement with the theoretically calculated results. The above theory, design and analysis will be helpful for practical applications of RIS.

Keywords: Beamforming, metasurface, oblique incidence, reconfigurable intelligent surface