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Physics-based Model of Reflecting Intelligent Surfaces for Optimal Link Budget Desing

Michele Borgese(1), Giuliano Manara (1) and Filippo Costa (1)
(1) University of Pisa, Pisa, 56122, https://www.dii.unipi.it/

Reflecting Intelligent surfaces (RISs) have been recently proposed as a solution for 6G communication networks thanks to their capability to reflect and deviate the beams impinging into them by adjusting the biasing state of active components mounted on unit elements of the RIS. Differently from MIMO arrays which require amplifiers and other complex microwave components to receive, down-convert and retransmit the impinging signals, RISs provide an energy efficiency solution for future wireless systems [1].

RISs are essentially thin resonant cavities that fully reflect incident waves with an arbitrary reflection phase. Ideally, they should totally reflect the impinging signal but in practice some field dissipation needs to be considered. The not reprogrammable version of the surface is also known in the electromagnetic community as Artificial Impedance Surface (AIS) [2, 3]. An AIS comprises a periodic surface printed on the top of a grounded dielectric slab. The periodic surface can vary in shape but is essentially a two–dimensional capacitive sheet formed by disconnected metal obstacles. The reconfigurability can be achieved in various ways but the simplest approach is based on varactor diodes which connect neighbouring unit cells. In order to focus a significant amount of the power towards the user, RISs dimensions might be considerably large because the collected power is related to the physical area of the reflecting surface. Consequently, it is common that both the transmitter and the receiver are located in the near field of the surface [4]. A current limitation of the in RIS-assisted wireless communication is the lack of accurate models that describe the reconfigurable metasurfaces as a function of their electromagnetic properties. The vast majority of research works available to date rely on the assumption that metasurfaces provide a perfectly controlled phase and amplitude reflection. Some papers employ empirical models for considering the reflection losses but the reflection curves are not related to all the parameters which may influence RISs reflection coefficient [5]. Actually, the response of RISs to the radio waves depends on the geometrical and electrical properties of the designed surface, on the choice of substrates (low-loss materials lead to lower losses but the cost of the surface scales rapidly with the size) and the characteristics of the tunable components. Moreover, an important role is also played by the properties of the impinging EM wave such as the angle of incidence, the angle of reflection and the polarization [3]. Designing RISs by neglecting some important aspects such as the change of the response at oblique incidence (spatial dispersion) does not allow to achieve optimal performance. Moreover, the hard separation between link budget requirements and EM aspects is not beneficial since some optimistic solutions may not have a correspondent physical design. It would be important that commonly adopted approaches for the design of the radio link, may be supported by some realistic, accurate and fast EM models. In this talk, we present an accurate and simple analytical model for the computation of the phases of the RIS which takes into account incidence angle and examples of RIS-assisted communications designed though the proposed model will be shown.

References

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