

Full-spectrum Reconfigurable Intelligent Surfaces (RIS): Advancing Communication, Sensing, and Localization from Microwave to Optical

Qammer H. Abbasi

University of Glasgow, United Kingdom

Abstract— Reconfigurable Intelligent Surfaces (RIS) have emerged as a transformative technology for next-generation wireless networks, enabling precise control of electromagnetic waves to enhance communication, sensing, and localisation. RIS leverages programmable metasurfaces composed of sub-wavelength reflective elements to dynamically manipulate the amplitude, phase, and polarization of incident waves. This capability supports diverse applications in 6G scenarios, including high-speed data transmission, real-time health monitoring, and indoor localisation. Here, we will discuss what's hot in the state-of-the-art of RIS technologies over full electromagnetic spectrum from microwaves, mmwaves to THz and optical regime. RIS holds immense potential in integrated sensing and communication (ISAC) systems, paving the way for innovative solutions in smart homes, healthcare, and urban environments. By addressing challenges such as NLoS coverage, hardware constraints, and energy efficiency, RIS is poised to play a critical role in realising the vision of ubiquitous, intelligent, and sustainable wireless networks.

Qammer H. Abbasi (SMIEEE, FRET, FRSA, FEAI, FIET), Professor of Applied Electromagnetics & Sensing with the James Watt School (JWS) of Engineering, Theme lead for Connecting People priority at JWS, Director for Communication Sensing and Imaging (CSI) Hub and UK Government's Policy Advisor in Department for Science Innovation & Technology. He has grant portfolio of £13M+ and contributed to more than 500+ leading international technical journal (including nature portfolio) and peer reviewed conference papers, 11 books and received several recognitions for his research including UK exceptional talent endorsement by Royal Academy of Engineering, Sensor 2021 Young Scientist Award, University level



Teaching excellence award in addition to coverage by various media houses globally, BBC news, Scotland TV, Fiercewireless, theEngineers and many other media houses. Prof. Abbasi is an IEEE senior member and is chair of IEEE APS/MTT UK, Ireland and Scotland joint chapter. He is an Associate editor for IEEE Sensors, IEEE open journal of Antenna and Propagation, IEEE JBHI and scientific reports. He is IEEE APS distinguished lecturer (2024-26), Vice-Chair of IEEE APS Young professional committee, Sub-committee chair for IEEE YP Ambassador program, committee member for IEEE 1906.1.1 standard on nano communication, IEEE APS/SC WG P145, IET Antenna & Propagation and healthcare network. He is/was Fellow of Royal Society of Arts, industrial Fellow of Royal Academy of Engineering (2022-23), Fellow of Institution of Engineering & Technology and Fellow of European Alliance of innovation.