ELECTRICAL, ELECTRONICS AND COMMUNICATIONS ENGINEERING

CNR/IEIIT - Ultra wideband sub-THz communications and intelligent reflecting surfaces for 6G and beyond applications

Funded By	C.N.R. - CONSIGLIO NAZIONALE DELLE RICERCHE [P.iva/CF:02118311006]
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Context of the research activity	The research primary objective is to investigate the challenges and prospects associated with ultra-wideband communications operating at sub-THz frequencies in the context of indoor wireless mobile systems and for the design of future (6G) networks. Special emphasis will be placed on exploring the seamless integration of these communication techniques with smart radio environments and intelligent reflecting surfaces.
Objectives	The research topics to be investigated are part of ongoing worldwide efforts to enhance the performance and capabilities of wireless communication systems, as we approach the development of the sixth generation (6G) and beyond of mobile networks. Specifically, the activity will be focused on the utilization of intelligent reflecting surfaces (IRS) for handling ultrawideband (UWB) signals at sub-THz frequencies for indoor high performance communications. UWB communication, which utilizes a large portion of the radio frequency spectrum for high data rates and short-range communications, has been studied extensively for various indoor and outdoor applications. Intelligent reflecting surfaces (IRS), also known as reconfigurable metasurfaces, have recently garnered considerable attention for their potential to improve signal propagation and coverage by intelligently modifying signal paths. However, communication systems utilizing, at the same time, UWB signals, arrays of antennas and IRSs are prone to the beam-squint effect, causing significant performance losses and signal dispersion in space. Then, one of the research objectives is to investigate efficient techniques to configure the transmission system, effectively mitigating the beam-squint effect in a straightforward and efficient manner. In this regard, understanding and characterizing the sub-THz indoor communication channel is a crucial step, as well as quantifying the actual advantages that intelligent surfaces can bring to such scenarios. A special focus will be also given on the analysis of near-field communications, where the size of the reflecting surfaces is comparable to

	the distance that separates them from the transmitter and the receiver. Currently, the IRS available on the market primarily operate at frequencies below 6 GHz and, in some cases, at millimeter-wave frequencies (20-30 GHz) whereas they are still at a very early concept stage for higher (sub-THz) frequencies since they require expensive and highly miniaturized components. In this regard the research aims to find viable and cost-effective alternatives to ensure wireless coverage in indoor environments. Overall, overcoming the above described challenges will be crucial for the successful integration of ultrawideband sub-THz communications and IRS in 6G indoor communication systems. Also, advances in antenna design, signal processing, channel estimation, and adaptive control mechanisms will play a vital role in releasing the full potential of these technologies for indoor communications in the 6G era. Theoretical studies carried out during the PhD course will be complemented by measurements carried out through laboratory instruments, generating significant amounts of data to be shared with other researchers and the scientific community.

Skills and competencies for the development of the activity	- Understanding of fundamental concepts in wireless communication - Knowledge of calculus, probability theory, linear algebra, and optimization techniques - Some programming skills (C, MATLAB, Python) - Understanding of radio wave propagation principles and the effects of fading, shadowing, and interference.