URSI GASS 2021, Rome, Italy, 28 August - 4 September 2021

Six-Decades Overview of the Near-Field Methodology Deployment for Wireless Communications

Jean-Charles Bolomey[(1)] and Gabriele Gradoni[(2)]
(1) Paris-Saclay University, Supelec, France; e-mail: jch.bolomey@gmail.com
(2) University of Nottingham, United Kingdom; e-mail: gabriele.gradoni@nottingham.ac.uk

In six decades of intense research, Near-Field (NF) techniques have considerably broadened their field of applications. Initially dedicated to large microwave antenna measurements, they have been successfully extended to the characterization of a wide class of radiating systems, under both their essential and non-intentional aspects. As such, they now apply not only to assess the transmission performances of wireless communication systems, but also their undesirable effects in terms of electromagnetic compatibility (EMC) with surrounding equipment and, possibly, health safety of human beings exposure, whether or not they are users. NF techniques have been used for checking radiating systems performances, as well as for providing invaluable assistance at design level thanks to their diagnosis capability, with a direct impact on reducing time-to-market for new products. Furthermore, the NF methodology has been progressively extended toward very-near-field (VNF) testing and diagnosing techniques for complex circuit components down to low frequency ranges. Last but not least, NF methods have overflowed the wireless communication world for Industrial Scientific and Medical (ISM) applications, a rich investigation area yet hard to address due to other existing competing methodologies. This presentation aims to provide a timeline of NF techniques evolution and mutation. NF techniques are born with the discovery of electromagnetic waves. Indeed, Hertz's experiments demonstrating the existence of electromagnetic waves and enabling to measure their velocity were conducted in a NF setup, due to the reduced electrical dimension of the laboratory at the operating frequency. In the early 60's, the accurate measurement of wave velocity with a microwave Michelson interferometer inspired a National Bureau of Standards, USA, project. This served as pretext for developing the well-known plane wave spectrum analysis, still already extensively used today, to account for interactions between an antenna and a scatterer, namely, in this case, the interferometer mirror. The first NF antenna measurement configuration was built in 1961 by Brown and Jull (Univ. College London, UK). Then modal expansions for spherical (Techn. Univ. Denmark, DK) and cylindrical (Georgia Tech Res. Inst, USA) coordinate systems, were increasingly developed including probe correction. The appearance of automatic network analyzers allowed for replacing costly amplitude-phase receivers. At that time, the NF approach was mainly dedicated to electrically large communication and radar antennas. As compared to Long Range and Compact Range facilities, NF techniques were offering a much larger filling factor (defined as the ratio of the quiet zone volume to the test range volume) but were much more time consuming and required post-processing of measured data. These drawbacks were to be overcome, by the rapid and continuous growing of the computer power for NF to FF transformations and, in a more disruptive way in the late 80's, by the introduction of probe array technology (Supelec, F) to reduce the measurement duration resulting to the mechanical scan of a single probe. Almost at the same time, another disruptive field transform approach was introduced: the inverse source method (Syracuse Univ., USA). Then researchers realized that NF techniques were not only dedicated to electrically large antennas, and could be used for a large variety of antennas, including those integrated in wireless devices, whatever for personal use or mounted on vehicles or aircrafts. Later, their field of application was extended to many aspects of measurement techniques related to the development of wireless communication systems, including modulated emissions, phase-less wave transformation algorithms, EMC (coupling assessment, random emissions, parasitic source modeling, printed circuit board diagnosis), dosimetry (fast SAR measurements) and imaging algorithms for non-invasive diagnosis in ISM applications. Today, the challenge is to combine numerical modeling and measurements in the most efficient way. To conclude, NF techniques have demonstrated their efficiency and constitute a powerful investigation approach requiring a minimum number of measurements combined with the flexibility of computer codes for obtaining a maximum of information about the device under test in various operating scenarios. At this URSI GASS Conference celebrating the centenary of URSI, this paper takes some standoff to show how the NF approach has been exploited and its research is still vivid with a growing impact on the daily routine activity of many engineers.