PHENOMENOLOGY AND EXPERIMENTAL CHARACTERISATION OF DISTRIBUTED NONLINEARITIES IN PRINTED CIRCUIT COMPONENTS FOR WIRELESS COMMUNICATIONS

A. Shitvov[1] and A. Schuchinsky[1]

[1]*The Institute of Electronics, Communications and Information Theory (ECIT)*
Queen's University of Belfast
Queen's Road, Queen's Island, Belfast BT3 9DT, Northern Ireland, United Kingdom
e-mail: a.shitvov@qub.ac.uk

Printed circuit components constitute a conventional platform for modern communications designs. Their common use in printed antennas, diplexers, power amplifiers and receiver front-ends underpins the commercial viability of modern wireless communications. Indeed, to meet the ever-growing demands of evolving telecommunications for increasing data rates, higher signal integrity and reduced electromagnetic emission, the complexity of printed components is rapidly increasing. This trend puts a great emphasis on a range of qualities of materials and designs which are critical for robust high-speed communications and, in the end, have direct impact on commercial returns and retention of the subscribers.

Weak distributed nonlinearities in printed circuits have emerged as a critical issue for wireless communications quite recently. They manifest themselves in nonlinear distortions, of which passive intermodulation (PIM) presents arguably the most serious threat to the reliable signal transmission. PIM distortion is commonly defined as generation of the combinatorial frequency harmonics. The PIM products, being interspersed between actual signals, corrupt the transmitted data and debilitate the highly sensitive communications systems. When the third-order PIM products, arising from mixing two-tone carriers, fall in the receive band, they degrade the base station performance and may even completely stifle the GSM receivers. The signal distortion inflicted by the PIM products is a serious problem for ultra wide band (UWB) and frequency-hopping spread spectrum systems, while the inter-band PIM interference in the multi-band systems severely limits the operational capacity. The apparent ubiquity of the PIM phenomena and their far-reaching implications for signal integrity in modern communications systems dictate the need of reliable engineering techniques for PIM prediction and mitigation despite diversity and evasiveness of the PIM sources in passive devices.

This talk is aimed to examine the state-of-the-art of the modelling and experimental characterisation of distributed PIM generation in printed circuit components. A contemporary overview of the physical mechanisms of PIM generation in printed circuits and a means of identification and discrimination of PIM sources will be presented. The theoretical models of distributed PIM production will be discussed, alongside the methodologies for experimental characterisation of PIM performance of printed microwave circuits and waveguides. The main thrust of the theoretical studies is presently concerned with the development of the numerical-analytical and multi-physics models and analysis of the PIM generation by isolated, distributed and multiple interacting nonlinearities. A body of experimental results will be presented, primarily obtained with the aid of the near-field probing of PIM products. The near-field probing methodology is supported by the comprehensive theoretical models which enable not only the PIM metrology but also identification of the localised PIM sources and troubleshooting of the printed circuit design in antennas and packaged assemblies. The wider implications of the distributed PIM phenomenology and experimental techniques will be discussed, including optical communications and high-power metamaterials.