European Metrology Programme for Innovation and Research

Delivering Impact

Addressing interference problems due to PIM in high frequency telecom networks

Enabling fast, cost-effective deployment of very-high-capacity networks has been, and still is, a focus of the European Commission. The 2025 "Gigabit Infrastructure Act" includes support for 5th generation mobile technology which uses a higher radio frequency spectrum than used in earlier generations. The Passive Inter Modulation interference phenomena at these frequencies require new metrology for reliable communication performance.

Europe's National Measurement Institutes working together

The European Metrology Programme for Innovation and Research (EMPIR) has been developed as part of Horizon 2020, the EU Framework Programme for Research and Innovation. EMPIR funding is drawn from 28 participating EURAMET member states to support collaborative research between Measurement Institutes, academia and industry both within and outside Europe to address key metrology challenges and ensure that measurement science meets the future.

Challenge

Advancing technology has increased demand for access to high-speed telecommunications. First generation mobile phones, introduced in the 1980s, utilised the 800 MHz part of the radio frequency (RF) spectrum with maximum data speeds of ~2.4 kilobits per second, increasing to 2 megabits per second in 2001, almost a thousand times faster. In 2019, to meet requirements for internet download speeds, using the 24 GHz to 100 GHz range, 5G increased this to 20 Gigabits per second – almost a million times faster than the first generation. FDD frequency bands are more likely to experience interference due to "Passive Inter Modulation" (PIM) phenomenon. This is a form of interference that arises from damaged or corroded components such as cables, connectors and antennas which allow two or more signals to mix, generating undesirable spurious signals. This can degrade network performance, providing a lower quality of service for the consumer. PIM is a major problem for network providers.

Although all new components now carry "PIM ratings", at the start of 2020 there was no National Metrology Institute (NMI) in the world able to provide a traceable characterisation of PIM signals.

Solution

During FutureCom, seven consortium members, including PTB and CMI, the NMIs of Germany and Czechia, and five industry partners, including Nokia, established PIM measurement facilities at their respective laboratories. Using 8 PIM travelling standards, a measurement intercomparison was performed on industry-grade connectors 7/16 and 4.3-10, typically used for telecommunications installations. All results were compared to a PIM reference, and based on these results, recommendations for standardised PIM measurements were developed.

Nokia's bench exceeded the capabilities of classical PIM measurement setups, utilising two power amplifiers to generate test signals. These connected to each under test travelling standard and PIM interferences were measured using a spectrum analyser. PIM rated components were used in the testbench, allowing measurements over a large dynamic range. Use of continuous wave and modulated test signals enabled further offline analysis, such as predicting how various PIM scenarios can affect data rate in a mobile communication channel.

Impact

Nokia is world renowned for providing advanced network infrastructure and technology solutions, delivering mobile broadband, advanced 5G and internet services to their clients and customers. The company is using the test bench developed in the project to verify their own theoretical calculations and to develop an automated PIM estimation tool to test if network components are prone to unwanted interference, allowing improvements to be made if required. This is important because, as well as improving the quality of service to users, a network constructed with PIM in mind costs less to maintain and demonstrates cleaner performance than sites not PIM tested.

FutureCom has given NMIs and companies in Europe greater knowledge about identifying and measuring PIM issues. This is timely as in 2025 the EC published its "Gigabit Infrastructure Act" setting out a comprehensive framework to support faster and more cost-effective deployment of very-high-capacity networks across Europe - including 5G networks.

As technology continues to advance so will the requirement for increased capacity from telecommunications. The advent of 6G, allowing applications such as virtual reality environments, quantum technologies and AI are likely to employ higher radio frequency bands, so potential issues must be addressed beforehand, supported by metrology and NMIs.

Developing the metrology for present and future telecommunication networks

Overall, FutureCom achievements were:

- demonstrated a Thru-Reflect-Line calibration technique for vector network analysers with an accuracy up to 220 GHz
- performed measurements with a resolution less than 20 µm to determine the limitations of the electro-optical near-field probing system
- developed a novel RF probe manufacturing technique, demonstrating a reduction in probe pitch from 50 µm to 25 µm
- published a Good Practice Guide on the characterisation of active devices and circuits operating under non-50 Ω loading conditions and for large-signal measurement systems up to 220 GHz
- designed wafers to characterise electromagnetic interference, similar to those used for signal intensity and power integrity analysis and performed field measurements
- established PIM measurement capabilities at partner laboratories, with accurate and traceable RF power and S-parameter measurements for industrial RF connector systems (7/16 and 4.3-10 types) at 1.8 GHz and 2.1 GHz and compiled a Good Practice Guide for reliable PIM measurements

These advancements support energy-efficient communications and contribute to broader sustainability goals.

EMPIR EURAMET

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Dilbagh Singh

NPL, UK
dilbagh.singh@npl.co.uk

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