Joint Research Project

Metrology for optical and RF communication systems

Newsletter November 2015

Introduction

We are pleased to welcome you to the third newsletter for "MORSE". This project aims to provide metrological support tailored to the needs of RF and optical communication R&D supporting the EU "2020 Digital Agenda for Europe" and future Horizon 2020 projects. It also builds on earlier work "Ultrafast" (Metrology for ultrafast electronics and high-speed communications), which improved the capability in Europe for traceable waveform measurement, and will underpin "MET5G" (Metrology for 5G Communications). The Physical Layer is only part of the communications system but research in this area supports the introduction of new equipment which affects the capacity and operating costs of the system.

Metrology for High-Speed Optical QPSK and 16-QAM Coherent Transmission at Chalmers University, Sweden

Metrology support for the next generation of optical communication systems (400 -1000 Gbits/sec) is a key element of the EMRP IND51 MORSE project. NPL, CMI and Chalmers University bring together the necessary waveform, communication metrology and Optical test-bed facilities and expertise for this work.

Martin Hudlicka (CMI), Irshaad Fatadin (NPL) and David Humphreys (NPL) worked with Carl Lundström at Chalmers in the Photonics Laboratory over a three-week period in March 2015, using the optical communications test-bed at Chalmers with picosecond pulse sources from NPL and test-equipment loaned by Keysight and EXFO. The short-term objective was to quantify the optical communication system behaviour and apply waveform metrology and signal processing techniques to improve the test-bed system in the Photonics Laboratory at Chalmers. The long-term objective is to economically characterise optical transmitters and receivers so that Europe remains cost-competitive.

State-of-the-art optical communications systems are based on coherent detection and modulation formats such as QPSK and 16-QAM [1,2], which are commonly used for radio-communications. Our initial investigation aimed to understand and compensate the errors introduced by the test equipment. We have altered the analysis to give 25 instead of <4 points per symbol (x7 improvement) making the waveform errors clearly visible [3]. We believe that this will help future research work and allow our colleagues at Chalmers to "clean-up" the system, reducing the coherent digital transmitter waveform errors from 13% to below 2%. This is an essential step for exploring more complex modulation schemes.

Error vector magnitude (EVM) is a figure of merit to characterise imperfections in the transmitter and receiver. Martin Hudlicka has been working with us on the relationship between EVM, receiver optical signal-to-noise ratios (OSNR) and bit-error ratio (BER). The data-analysis to apply these corrections embeds metrology into the test-bed system so we can achieve traceable measurements of optical EVM. Instrument manufacturers, component manufacturers and standards organisations will be the main beneficiaries of this work in addition to the research community.

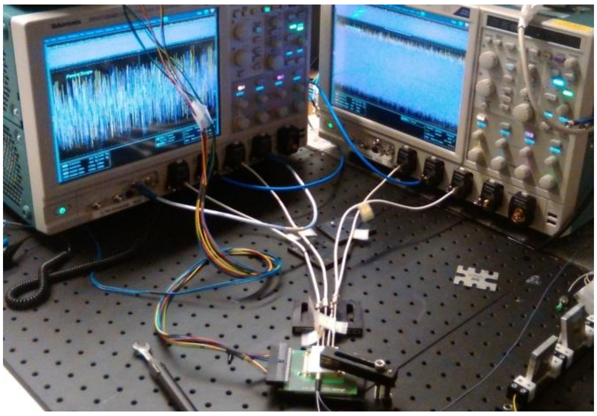

Fig. 1: 100 GSa/s Real-Time Oscilloscopes.

References

[1] R. Schmogrow et al., "Error vector magnitude as a performance measure for advanced modulation formats," IEEE Photon. Technol. Lett., vol. 24, no. 1, pp. 61–63, Jan. 2012.

[2] H. Sunnerud, M. Skold, M. Westlund, and P. A. Andrekson, "Characterization of Complex Optical Modulation Formats at 100 Gb/s and Beyond by Coherent Optical Sampling," J. Lightwave Technol., vol. 30, no. 24, pp. 3747–3759, Dec. 2012.

[3] D.A. Humphreys, M. Hudlicka and I. Fatadin, "Calibration of Wideband Digital Real-Time Oscilloscopes," in Instrumentation and Measurement, IEEE Transactions on , vol.64, no.6, pp.1716-1725, June 2015.

Contact & further information

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Near Field Setup for Millimetre-Wave System Embedded Antennas

Millimetre-wave integrated systems are gathering more interest [1] targeting low-cost, potentially high volume, commercial application, such as data communication and automotive imaging. These systems require the antenna to be placed in close proximity to the active device in order to achieve the required broadband performance and a small volume. Conventionally, the characterization of high-frequency antennas is performed by employing a vector network analyser (VNA) transmission measurement on a stand-alone replica of the radiating element. At millimetre-wave frequencies antennas are directly embedded in the chip package or on a dedicated module, thus creating potentially strong interactions which need to be accounted for during the characterization process.

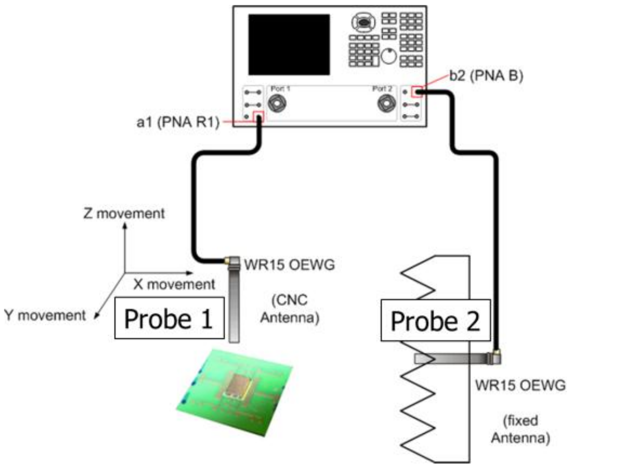

Fig. 1: Simplified block scheme of the proposed setup. Probe 1 represents the conventional scanning antenna, while probe 2 is used to provide a reference signal. OEWG: open-ended waveguide.

A new technique, based on a planar near field scanner, using a second probe antenna to provide the reference signal to the VNA was developed specifically for the characterization of system embedded antennas [2]. The results show very good agreement with respect to EM simulations and conventional far-field systems, while allowing one to achieve full three dimensional radiation patterns in few minutes.

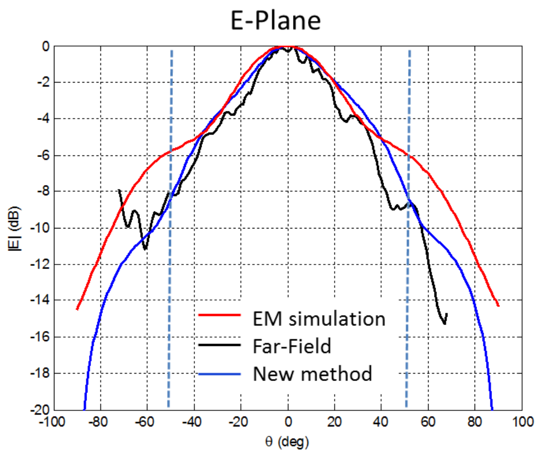

Fig. 2: Measurement of the embedded antenna on a data communication board (60 GHz), comparing 3D EM simulation of the entire board, conventional far-field measurement and the proposed two antenna near field method. Vertical dashed lines represent the confidence interval due to the finite scan area.

References

[1] Y.P. Zhang, L. Duixian, "Antenna-on-Chip and Antenna-in-Package Solutions to Highly Integrated Millimeter-Wave Devices for Wireless Communications," IEEE Transactions on Antennas and Propagation 57, 2830-2841 (2009).

[2] M. Spella, A. de Graauw, "A low-cost high-efficiency broadband integrated antenna for 60-GHz transceiver modules," Proceedings of the 6th European Conference on Antennas and Propagation (EUCAP), 1271-1275 (2012).

Contact & further information

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Antenna reference for signal processing assessment

One work package of the MORSE projects focuses on developing new signal processing techniques to improve the measurement time and the accuracy achievable using spherical near-field antenna test ranges, compact antenna test range and planar near-field measurement system [1]. The developed algorithms are under development and will be assessed by comparing the initial measurement and the processed measurement in several ranges. They include the derivation of the electric field inside the compact range quiet zone with the derivation of the uncertainties [2].

A reference antenna visible in Fig. 1 has been developed by the Technological University of Delft, manufactured and measured at the University of Rennes 1 using the newly installed compact antenna test range and will be measured at the National Physical Laboratory in a spherical near-field setup. The first measurement results (see Fig. 2) show a good agreement with the simulation and provide a good test-case for the validation of the developed algorithms.

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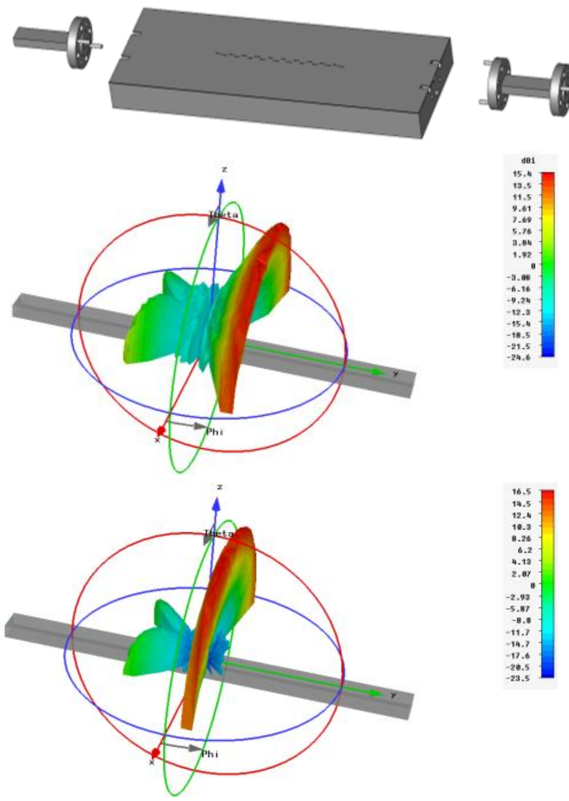

Fig. 1: Schematic view and simulated radiation patterns of the slot reference antenna (55 GHz and 65 GHz).

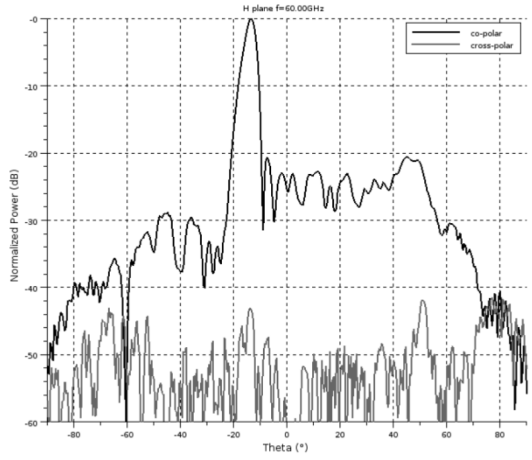

Fig. 2: Measured H-plane radiation pattern of the slot reference antenna at 55 GHz.

References

[1] L. Le Coq, B. Fuchs, T. Kozan, T. Andersson, and S. Burgos, "IETR Compact Antenna Test Range: implementation and validation," submitted to European Conference on Antennas and Propagation (EUCAP), April 2015.

[2] M. Charles, Y. Le Sage, P. Vincent-Drouart, and J.M. Lerat, "Calcul numérique de l'incertitude de l'holographie extraite d'une mesure de champ proche planaire", Congrès International de Métrologie 2015.

Contact & further information

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Important dates and events

8th – 9th June 2016, NPL, Teddington, UK: MORSE final meeting (8th June) and open workshop (save the date: 9th June). Please email jessica.cheung@npl.co.uk if you are interested in attending the open workshop.

10th -15th July 2016, Ottawa, Canada: Conference on Precision Electromagnetic Measurements CPEM with contributions from project partners.

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Imprint This work has been supported by the European Metrology Research Programme (EMRP) project "IND51 MORSE". The EMRP is jointly funded by the EMRP participating countries within EURAMET and the European Union.

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