UNIVERSITÀ DI PISA

DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE

Dottorato di Ricerca in Ingegneria dell'Informazione

Doctoral Course

"Measurement techniques for microwave devices and antennas"

Prof. Marcos Rodriguez Pino

Full Professor – Universidad de Oviedo (SPAIN,) Visiting Fellow at the University of Pisa

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Short Abstract: The course aims to give an overview of the measurement techniques and instrumentation that are specific for the characterization of devices and antennas at RF and microwave frequency bands. After an introduction on the main characteristic parameters of typical devices and antennas used in high-frequency wireless systems, basic RF instrumentation will be presented together with related measurement procedures. Experimental sessions will be included to let the students to practice their measurement skills.

Antenna measurement techniques refers to the testing of antennas to ensure that the antenna meets specifications or simply to characterize it. Typical parameters of antennas are gain, bandwidth, radiation pattern, beamwidth, polarization, and impedance. The antenna pattern is the relative power density of the wave transmitted by the antenna in a given direction. A multitude of antenna pattern measurement techniques have been developed. The first technique developed was the far-field range, where the antenna under test (AUT) is placed in the far-field of a range antenna. Due to the size required to create a far-field range for large antennas, near-field techniques were developed, which allow the measurement of the field on a surface close to the antenna (typically 3 to 10 times its wavelength). This measurement is then predicted to be the same at infinity. A third common method is the compact range, which uses a reflector to create a field near the AUT that looks approximately like a plane-wave.

Course Contents in brief:

- Introduction to Scattering Parameters (S) and microwave devices.
- Microwave/millimetric measurements. VNA and Instrumentation
- Measurements of microwave devices parameters:
  - Scattering Parameters (S) of single-port passive devices
  - Scattering Parameters (S) of multi-port passive devices
- Introduction to antenna measurements. What to measure? General setup and elements
- Measurement of far field radiation patterns
  - Distance requirements for far field antenna measurements
  - Radiation pattern and directivity. Gain

    - Polarization, Co-polar and cross-polar patterns
- Antenna measurement ranges classification:
    - Indoor ranges. Absorbing material
    - Far field ranges. Compact ranges. Near Field ranges
    - Positioners, probes, rotatory joints. RCS ranges
- Near field measurements
    - Spherical, Cylindrical, Planar.
    - NF-to-FF Transformation and Diagnosis
- Experimental practice with spherical range scale-model

Total # of hours of lecture: 16 hours

Prof. Prof. Marcos Rodriguez Pino: 12 hours

Dr. Andrea Motroni: 4 hours

References:

[1] Munoz-Acevedo Alfonso, Sierra-Castaner Manuel "Antenna Measurements at Millimeter Wavelengths" LAP Lambert Academic Publishing (28-11-2012). ISBN-13 : 978-3659211133

[2] Kraus, John D.; Marhefka, Ronald J. "Antennas and Wave Propagation, 5Th Edition" Mc Graw Hill India, 2017. ISBN 13: 9789352606184

[3] Vadim S. Kalashnikov , et al. "Near-Field Antenna Measurements" Springer 2021. ISBN: 978-981-33-6436-3

CV of the Teachers

Prof. Prof. Marcos Rodriguez Pino

Linked to the f the University of Oviedo since November 2001. In Oct. 2005 obtains an Associate Professor position and in dec. 2021 obtains a Full Professor position that maintains to this day. Throughout this period, he has been involved in the implementation of the Telecommunications Eng. degrees at the University of Oviedo, both in teaching tasks and in the preparation of study plans. In management tasks, he has been Vice-principal of Telecommunications Engineering at the Polytechnic School of Engineering since Nov. 2008 to Jun. 2012.

In research tasks, since joining the research group of the Signal Theory and Communications (TSC-Uniovi) of the University of Oviedo, the research activity has been framed in numerous research projects having as its main axis the research projects requested within the Spanish National Plan. That, without interruption, the research group to which it belongs has obtained funding in the last 23 years. Collaterally, funding has been obtained from the Regional Research Plan, European projects and also from several contracts with companies. Collaboration with European research groups has also been established, more specifically with the group of Prof. Paolo Nepa from the University of Pisa. As a result of a research project within the framework of Spain-Italy bilateral actions, a close and productive collaboration in research has been maintained since 2008.

The research lines have been focused on the development of computational techniques analysis of radiation and electromagnetic scattering problems, design of antennas for several applications as RFID, satellite communications, 5G and plane wave generators. Most of these have involved the design, prototype and characterization of the antenna prototypes. For this last purpose, numerous campaigns for the antenna measurement inside spherical and planar ranges in anechoic environments have been carried out during the last 20 years. In these research lines more than 70 articles have been published in international journals and over 100 communications have been presented in international conferences.

Dr. Andrea Motroni

Andrea Motroni received the M.E. (with honors) degree in Telecommunication Engineering and the Ph.D. (with honors) degree in Information Engineering from the University of Pisa, Pisa, Italy, in 2017 and 2021, respectively, where he is currently an Assistant Professor in Applied Electromagnetics. In 2019, he was the President of the IEEE Student Branch of the University of Pisa. In 2020, he was a Visiting Ph.D. Student with the Graz University of Technology, Graz, Austria. He has joined the Organizing Committee and has been Session Chair of several IEEE international conferences. Dr. Motroni was a Finalist at the IEEE CRFID Educational Mega Challenge (2018), a recipient of Best Paper Award and Best Student Paper Award at IEEE RFID-TA 2019, and a recipient of the Young Scientist Award from the International Union of Radio Science, Commission B, in 2021 and 2023. In 2022, Dr. Motroni was awarded with the IEEE/ABB Italy Section award for PhD Thesis, with the "2021 Best PhD Dissertation in the field of Information and Industrial Engineering" from University of Pisa and with the "Best Poster Award" at IEEE M&N 2022. His current research interests include indoor radiolocalization systems, with specific focus on UHF-RFID and UWB technology for robot and vehicle localization, the integration of robotic systems with RFID towards new systems for industry and logistics, UHF-RFID smart gates and other RFID-based applications for Internet of Things, Industry 4.0, and people safety in both indoor and outdoor environments.

Final Exam: Report including the results and discussion of the experimental measurements of a couple of microwave devices. One or more hands-on measurement sessions for the PhD students will be planned during the course days, whose schedule will be defined on the basis of the number of registered attendees.

Room and Schedule

Room: *Aula Riunioni del Dipartimento di Ingegneria dell'Informazione, Via G. Caruso 16, Pisa – Ground Floor*

Schedule:

Day1 – time 25 sept. 2023 9-13 (4 hours)

Day2 – time 26 sept. 2023 9-13 (4 hours)

Day3 – time 27 sept. 2023 9-13 (4 hours)

Day4 – time 28 sept. 2023 9-13 (4 hours)