PhD subject description
Starting date: October 1st 2021

Contactless Characterization of Miniature and Buried Antennas Within Reverberation Chamber

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1 Context

Antenna miniaturization as well as their integration in complex environments (antennas on vehicles, antennas buried in the ground, intra-body antenna) modify antenna radiation characteristics and strongly degrade their efficiency. The estimation of such efficiency, critical parameter to limit power consumption, is barely possible with conventional measurement methods in the case of buried and miniature antennas. Indeed, conventional measurement approaches necessitate to connect the antenna under test to an analyzer whereas the presence of the cables in the antenna reactive near-field zone disturbs the radiation and impedance properties. This perturbation can be considered as negligeable for large antennas but not for small ones. Besides, conventional antenna characterizations in anechoic chamber require the alignment between the antenna under test and the reference antenna; in the case of small antennas or buried ones, this precise alignment becomes very difficult even impossible. Therefore, the use of reverberation chamber (RC) as a measurement environment is better suited in these cases. In that context, innovative methods that are contactless [1],[2] and applied within RC [3],[4] are under research at the ESYCOM lab in order to overcome current limitations of conventional anechoic chamber methods.

2 Subject of the PhD work

Objectives

Several antenna characterization methods within RC have been developed in the last few years, so that antenna efficiency measurements are now commonly performed in such environment. Recent works have also addressed radiation pattern measurement within RC [5] but invasive cables are still required, making it irrelevant for miniature antennas. Contactless estimation of antenna losses within RC has been studied in [6] but intrinsic antenna radiation parameters were not extracted.

This PhD objective is to establish the proof of concept of a novel antenna radiation efficiency measurement method that is contactless (noninvasive) and takes into account the effect of the environment in the vicinity of the antenna (lossy material for example). Based on techniques to retrieve the absorption and diffusion cross sections [7] of lossy objects in RC, that will be extended to the antenna specific case, this new approach will enable miniature and buried antenna characterization for the first time. The 700 MHz frequency band, as part of the 5G spectrum, is targeted for this study.

Work plan

A theoretical development will be first conducted to model the absorption and diffusion properties of an unconnected antenna within RC. The measurement protocol required to retrieve the antenna radiation efficiency will then be set up. After a validation on canonical antennas, this method will be applied on miniature antennas and the uncertainties will be evaluated. Finally, the theoretical development will be adjusted to take into account the case of buried antennas and experimental validations will be performed.

3 Scientific and academic setting

Reverberation chamber and antennas at the ESYCOM laboratory

The ESYCOM laboratory has a strong expertise both in RC, in particular in the evaluation of its statistical properties [8],[9], and in miniature antenna [10] and antenna characterization within RC [3],[4]. The lab owns a large mode-stirred RC (19 m^3), three anechoic chambers of different size, and several analyzers and RF devices including VNAs up to 67 GHz.

Other collaborations

Collaborations outside of the laboratory are to be expected with Julien de Rosny (CNRS Research Director at Institut Langevin, Paris) and Philippe Besnier (CNRS Research Director at IETR, Rennes).

4 Sought profile for the candidate

Educational background

The ideal applicant has a degree in electrical engineering. Students with a physics background are also encouraged to apply.

Scientific and technical skills

Knowledge in electromagnetism as well as antennas is a hard requirement. The successful applicant should also have some background in statistics. Prior exposure to reverberation chamber will be highly appreciated.

Language

French and/or English.

5 Practical information

Starting date and duration

The PhD is expected to start between October and December 2021 for an exact duration of three years (36 months).

Compensation

The PhD is fully funded for its whole duration, with a monthly compensation of about 1350 euro per month net salary. This salary can be increased by about 300 euros per month if the PhD candidate is additionally recruited for a teaching assistant position (64 hours per year teaching duty). Note however that the availability of teaching vacancies varies each year, and that they remain usually limited for non-French speaking PhD candidates.

Geographical location

The PhD candidate will work at the ESYCOM laboratory location, in Champs-sur-Marne, Paris metropolitan area. The center of Paris is at about 20 minutes using public transportation.

Housing

The university can help foreign PhD students to find housing at an affordable price.

6 Contact

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Applications (a cover letter, a resume and full academic transcripts) have to be sent to both contacts.

7 Bibliography

[1] A. Reis, F. Sarrazin, E. Richalot, S. Méric, J. Sol, P. Pouliguen and P. Besnier, *Radar cross-section pattern measurements in a mode-stirred reverberation chamber: theory and experiments*, **IEEE Trans. Antennas Propag**., doi: 10.1109/TAP.2021.3060581, to be published.

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[5] A. Soltane, G. Andrieu, E. Perrin, C. Decroze, A. Reineix, *Antenna Radiation Pattern Measurement in a Reverberating Enclosure Using the Time-Gating Technique,* **IEEE Antennas and Wireless Propag. Lett.**, vol. 19, no. 1, pp 183-187, 2020.

[6] A. Cozza, *Power Loss in Reverberation Chambers by Antennas and Receivers*, **IEEE Trans. Electromagn. Compat.**, vol. 60, no. 6, pp. 2041-2044, Dec. 2018.

[7] G. Lerosey and J. de Rosny, *Scattering Cross Section Measurement in Reverberation Chamber*, **IEEE Trans. Electromagn. Compat.**, 2007.

[8] F. Sarrazin and E. Richalot, *Accurate Characterization of Reverberation Chamber Resonant Modes From Scattering Parameters Measurement*, **IEEE Trans. Electromagn. Compat.**, vol. 62, no. 2, pp. 303-314, April 2020, doi: 10.1109/TEMC.2019.2902361.

[9] K. Selemani, J. -. Gros, E. Richalot, O. Legrand, O. Picon and F. Mortessagne, *Comparison of Reverberation Chamber Shapes Inspired From Chaotic Cavities*, **IEEE Trans. Electromagn. Compat**., vol. 57, no. 1, pp. 3-11, Feb. 2015, doi: 10.1109/TEMC.2014.2313355.

[10] F. Sarrazin, S. Pflaum and C. Delaveaud, *Radiation Efficiency Improvement of a Balanced Miniature IFA-Inspired Circular Antenna*, **IEEE Antennas Wireless Propag. Lett**., vol. 16, pp. 1309-1312, 2017, doi: 10.1109/LAWP.2016.2633308.