PhD in ELECTRICAL, ELECTRONICS AND COMMUNICATIONS ENGINEERING

Research Title: Inductive charging of electric vehicles. Theoretical and experimental analysis.

Funded by	Istituto Nazionale di Ricerca Metrologica - INRiM

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Context of the research activity	The proposed research activity is related to a European Research project taking place from 1 September 2017 to 31 August 2020. The research activity of the PhD student would therefore be part of such research project. Inductive charging is a wireless charging technology that will be very likely used for electric vehicles (EVs) in the near future [1]. This offers many advantages over traditionally fuelled and current EVs such as charging whilst in motion, smaller batteries, high autonomy, and high-efficiency power transmission, all leading to the reduction of CO_2 and fossil fuel consumption. The research activity aims to advance inductive power transfer (IPT) for EV charging by developing metrology techniques for measuring IPT efficiency and reliable demonstration of compliance with existing safety standards for human exposure. Voltages from 400 V up to 1 kV supply the charging units of EV inductive charging systems and currents are of tens of ampere. Such waveforms require dedicated measurement techniques, which take into account an adequate calibration and characterization of the transducers, especially as regards dynamic charging. In dynamic charging, the supply of power to the vehicle takes place instantaneously, the moment the vehicle is aligned with the coil under the road

	[2]. It is clear, however, that the transient regime poses non-trivial measurement problems, for instance the presence of harmonics in the power measurements, and a transient regime for human exposure assessment. [1] "Strategic Analysis of Inductive Charging for Global Electric Vehicles", Frost and Sullivan Report, M9B8-18, April 2014 [2] Zicheng Bi at al., *"A review of wireless power transfer for electric vehicles: Prospects to enhance sustainable mobility"*, Applied Energy 179, 413–425, 2016

Objectives	Specific objectives of the student research activity will be chosen among the following: i) to develop and characterize a power measurement system for static wireless power transfer for on-board measurement with a relative uncertainty in the DC circuit of 10^{-3}; ii) to develop methods to determine the efficiency of a static wireless power transfer system with a relative uncertainty of 10^{-3} and taking the relevant parameters, particularly airgap and misalignment between the coupled coils into account, iii) to define the requirements for a power measurement unit for dynamic wireless power transfer, identify the relevant parameters (e.g. traffic conditions, speed, vehicle dimensions, power converter state, coil configurations) and estimate their effect on the measurement of the power transferred to the vehicle and on the system efficiency, iv) to develop simulation tools and measurement protocols for the assessment of the human exposure to the electromagnetic fields generated by these technologies [3], in static and dynamic conditions, taking the compliance with the limits indicated by the guidelines of the International Commission on Nonionizing Radiation Protection (ICNIRP) into account. The student will join an international research team and will be guided to achieve some of the many possible research goals. [3] Shimamoto T., Laakso I., Hirata A., "In-situ electric field in human body model in different postures for wireless power transfer system in an electrical vehicle", Phys Med Biol, 60, pp 163-173, 2015.

Skills and competencies for the development of the activity	Basic knowledge in electromagnetism Good preparation in Electrical and/or Electronics engineering. Basic knowledge of electrical and electronic measurement techniques