DIPARTIMENTO DI INGEGNERIA
CORSO DI DOTTORATO IN INGEGNERIA INDUSTRIALE E DELL'INFORMAZIONE - PHD COURSE IN INDUSTRIAL AND INFORMATION ENGINEERING - 36TH CYCLE

Title of the research activity:	Wireless RF Systems for Industrial Application in Harsh Enviroinment Scientific field: ING-INF/01 – Electronics
State of the Art:	RF and microwave circuits have been widely used in the last decades to develop monitoring systems in a huge variety of applications ranging from Automotive (Formula 1 as well as consumer cars for efficient maintenance) to supply chain. Recently, the evolution of ICT to IoT, and the yielded paradigm shift, increased tremendously the potential applications of RF circuits and systems towards new monitoring solutions. New materials, new architectures, new protocols are allowing monitoring approaches even more remoted, distributed, capillary, precise and accurate; so that a better picture of the scenario under observation can be achieved at reasonable costs. Among these evolutionary trajectories, particular attention has been attracted by the so-called area of "harsh environments". Since ever, in fact, harsh environment, has been representing, by definition, a challenging field of investigation and application for new monitoring technologies. IoT evolution contributes profitably also in this field, allowing for providing new feasible and competitive alternatives to the use of conventional technologies. The main novelty is represented by the introduction of a synergic and concurrent adoption of technologies such as Wireless Power Transfer (WPT) and Energy Harvesting (EH) for a better, more flexible and efficient, capability to make remote sensors and sensor nodes autonomous; new materials, flexible, organic, bio-degradable (in a few words: "green"), mass-producible, and very low cost, able to make final systems and subsystems compatible with disposable adoption and massive deployment in the areas to be controlled. Last but not least, the adoption of new protocols (RFID, LoRa, LoRaWAN, Sigfox, etc.) has to be considered to provide connectivity respectful of the stringent power supply and coverage constraints posed by these new challenges.

	The present Ph.D. research aims at exploring these novel opportunities from the hardware conception of the sensors to their on-field exploitation. The proposed activity will be mainly carried-out within the European research project CALL H2020-ECSEL-2019-1-IA: *"Challenging environments tolerant smart systems for IoT and AI"* (CHARM), co-funded in 2019 by EU, MUR and "Regione Umbria".
Short description and objectives of the research activity:	The primary objective of the present Ph.D. research is to develop, experimentally validate and demonstrate technologies for monitoring the working conditions of an industrial apparatus represented by a large dimension paper building machine (each roll is 12-meter-long and has a diameter larger than one meter). The main challenge is represented by the inaccessibility of the rotating rolls and by the extremely harsh environment present within the rolls. This volume, in fact, is characterized by, an atmosphere rich of mixed-element aerosol (oil, water, grease…), vibrations, temperature gradients, strong EM fields, etc… On the other hand, within the roll, several elements, potentially responsible of misfunctioning, are present: electric engines, seals, hydraulic pumps… The goal of the project is to extract parameters from the inner part of the roll that are significant to evaluate real time the working conditions of the internal equipment, in order to reduce the risk of sudden shutdown, increase the possibility of early intervention and increase the efficiency of the overall maintenance program. To obtain these strategic objectives, some goals can be envisaged: • Development of a transponder able to gather information from inside the roll and transfer it to outside. This system should be integrated in the corona of the roll with minimum invasivity and maximum performance in terms of data transfer capacity, or, alternatively on the circular side of the roll. • Development of a wireless power supply systems able to power supply the transponder without any additional constraint (i.e. without ohmic interconnection between the transponder, located on the rotating part and the stator where grid energy is present.) • Development of wireless sensor nodes to be located on the roll and on the stator able to provide the required information.

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