Adaptive Long-Range RF Wireless Power Transfer and Energy Harvesting

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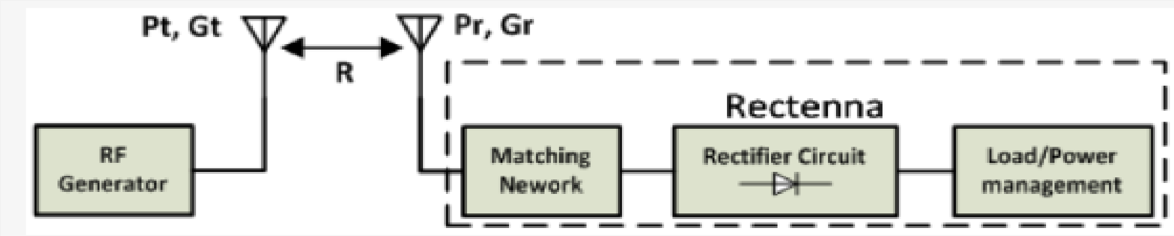

This project considers adaptive long-range RF wireless power transfer (WPT). Emphasis will be placed on power transmission efficiency (PTE) and self-adaptation techniques to ensure PTE is always optimum under varying operational/environmental conditions. The project will require an investigation of system/circuit components to understand challenges and limitations and thus make attempts to optimize efficiency by considering all available options simultaneously and in real-time. A transmission range of over 100 meters will be targeted with PTE > TBD. This project will use resonant circuits and antennas targeting ISM bands (900MHz, 2.4GHz, 5.8GHz, 24GHz). Specific areas of interest for this project include:

- RF system analysis and propagation, including engineered surfaces.
- Design of rectennas with multi-band matching and differential topologies.
- Efficient RF Transmitters (Tx) in commercially available Gallium Nitride MMIC technology.
- Rx RF receivers, adaptive analog behaviour, multi-band, differential topologies.

This project is designed to fully utilize the strong background of 4 students in ELEC 3105, 3509 and 3909, and potentially ELEC 4505, 4503 and 4706 in their fourth year. The breakout for the proposed work includes:

1. System analysis and simulation using Keysight's SystemView/ADS or Matlab Simulink to assess the impact of the choice of frequency, required Tx and Rx efficiency, RF circuit loss as a function of separation, adaptive system integration including required analog/digital components, hardware requirements for self-adaptation. Consider the overall size and cost of the solution, as well as control and optimization algorithms—engineered surfaces to be considered to reshape the propagation environment.
   Detailed circuit design and implementation of switch mode power oscillators in ADS or LT Spice with optimum efficiency at the selected frequency for this project.
2. Detailed circuit design and implementation of efficient Rx energy harvesting rectifiers in ADS and HFSS with optimum efficiency at the frequency of choice. Including power rectification, impedance matching networks, differential topologies, and adaptive analog control.
3. Design rectennas using EM solvers such as Keysight's Momentum, Ansys HFSS, or Sonnet. Specific tasks include choosing the topology, determining the required lengths, and determining the parametric effect due to process variations. The results from this task will feed directly into systems analysis.
4. Tx RF circuit design in ADS, including Adaptive Power Amplifier with impedance and frequency tuning. Gallium nitride MMICs are to be considered.

1. Reference: ***Wireless Power Transfer via Radiowaves***, *Naoki Shinohara, Wiley 2014*
2. https://www.mdpi.com/2079-9292/7/7/125