Adaptive Short-Range Wireless Power Transfer

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This project considers adaptive short range inductive wireless power transfer (WPT) using resonant techniques and suitable for applications in home electronics, medical implants, electric vehicles and others. 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 in order to understand challenges and limitations and thus making attempts to optimize efficiency by considering all available options simultaneously and in real-time. A transmission range of approximately 0.5 meters will be targeted with PTE > 60%. This project will make use of resonant circuits to improve range and efficiency at the lower ISM bands, i.e. 6.75 MHz, 13.75 MHz and 27.12 MHz). Specific areas of interest for this project include:

- Self-adaptation to coil lengths and geometries (i.e. with a fixed coil length, which geometry offers best efficiency?)
- Design of resonant coils with best immunity to orientation and misalignment.
- Efficient switched Transmitters (Tx) in commercially available Gallium Nitride technology.
- Self-adaptation by the use of communication channels (i.e. Bluetooth LE to monitor received power and adapt/reconfigure hardware to address frequency detuning, human and small animal detection and protection, temperature compensation, etc.)

This project will ideally support 4 to 6 students with a strong background in ELEC 3105, 3509 and 3909 and who should ideally take 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, resonant circuit loss as a function of separation, adaptive system integration including: required analog/digital components, hardware requirements for self-adaptation. Consideration of overall size and cost of solution.
2. HDL and hardware design and implementation of the required hardware and algorithms to drive the adaptive wireless power networks. Specifications will be fluid and driven directly from system analysis. A Bluetooth adaptive communication channel will be implemented here.
3. 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.
4. Detailed circuit design and implementation of efficient Rx energy harvesting rectifiers in ADS or LT Spice with optimum efficiency at the frequency of choice.
5. Resonant coil design using EM solvers such as Keysight’s Momentum, Ansys HFSS or Sonnet. Specific task include choice of topology, required lengths, parametric effect due to process variations, misalignment and others. Results from this task will feed directly into systems analysis.
6. Resonant coil circuit design in ADS including impedance matching networks.