Wirelessly Powering Biomedical Implants Through Magnetoelectric Transducers

Erik Andersen, Binh Duc Truong and Shad Roundy
University of Utah, Department of Mechanical Engineering, Salt Lake City, Utah

Project Objectives and Goals

- **Objective 1:** Optimize the coil transmitter subject to safety and practical system constraints
- **Objective 2:** Optimize the magnetoelectric (ME) receiver parameters to maximize the power delivered to the implant

Background

The wireless power transfer system (WPTS) contains (i) a ME receiver consisting of laminated composite of two magnetostrictive and one piezoelectric layers, and (ii) an electromagnetic solenoid coil transmitter that generates a magnetic field used for power transfer.

Data and Results

- **Objective 1:** A mathematical model of the WPTS transmit coil’s B-field was constructed and an optimization algorithm was used to find the optimal parameters for the WPTS transmitter subject to:
  - i. B-field human exposure limits
  - ii. Either geometric or electrical current constraints

Analytical Modeling and Experimental Setup

- **Objective 1:** The optimal design of the WPTS T can be a solenoid whose parameters depend on the chosen constraint.
- **Objective 2:** If the current is the limiting constraint:
  - The radius of the T depends on the distance of the implant relative to a critical distance.
  - The radius is equal to \( R_{opt} = \sqrt{2z_{crit}} \)

Metaspecific

- **Objective 2:** Optimize the ME coefficient (defined by the derivative of the generated electric field with respect to the applied magnetic field), and (ii) the power transferred to a load resistance, are derived and rigorously validated by experiments.

Conclusion

- We experimentally validated a model describing the physical insight of the ME effects.
- A thorough analysis and guidelines for designing an optimal transmit coil were discussed. Experimental validations of the findings were presented.

Future Studies

- Optimize the receiver parameters for maximum output power based on the validated model.
- Investigate the performances of the optimal system with optimal transmit coil and receiver.

Acknowledgement

This work is generously supported by the NSF Grant ECCS-1611438.

**Experimental Validations of the ME effects**

**Objective 2:**

- Based on the two-port theory, the explicit analytical solutions of, (i) the ME coefficient (defined by the derivative of the generated electric field with respect to the applied magnetic field), and (ii) the power transferred to a load resistance, are derived and rigorously validated by experiments.

**Fig. 4 Experimental setup.** Left: a Helmholtz coil is utilized as a transmitter. Right: Permanent magnets are used as DC field bias and a ME beam, 1 x 0.5 cm, with two Galfenol and one PZT layers.

**Fig. 5 Frequency response comparisons between the experimental data and simulation results by the model.**

**Fig. 6 Output power as a function of load resistance with different applied B-field amplitudes.**

**Fig. 7 Output power as a function of applied B-field amplitudes, in comparison with the limit on transferable power.**