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Integration of ultrasound-based wireless powering (UWP) within medical implants to fulfill application-specific (mW – W) energy requirements

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Active medical implant functionality is spanning an ever-expanding scope – from neurostimulators, to pumps, drug-delivery systems, *in situ* physiologic monitoring systems and therapeutic devices. Powering of these systems involves either primary, secondary (re-chargeable) batteries, or the implant is wirelessly powered from an external energy source. Wireless powering is intended to provide greater patient safety and comfort. Ultrasound is an energy modality that propagates through material media and offers a differentiable wireless powering option compared to existing approaches. Ultrasound energy is a mainstay for non-invasive diagnostic and therapeutic medical applications due to well-established bio-physical understanding of its propagation at MHz frequency fields through tissue media safely, using compact device design. Favorable physical characteristics of ultrasound energy are, mm-sized wavelength at low-MHz energy transfer frequencies, beam collimation, beam steerability, and propagation through metal layers. This presentation describes examples of UWP prototype development relevant to implant-based applications. Power transfer results, ranging from mW, with miniaturized prototype form factors, up to finite-sized implantables, several cubic-centimeters in volume, will be discussed. *In vivo* and benchtop testing results using UWP, for examples of packaging and power transfer will be presented.

Inder Raj Makin, MD, PhD, is Chief Technology Officer of Piezo Energy Technologies, LLC, an ultrasound-based wireless powering solutions company (UWP). Dr. Makin is a scientist-innovator in the area of medical instrumentation and ultrasound, having published >35 peer-reviewed publications and book chapters and ~60 issued patents. He was Principal Scientist at J&J Ethicon Endo-Surgery, and co-founder of Ulthera, Xthetix, and Guided Therapy Systems. Dr. Makin is currently a tenured Professor at A.T. Still University, AZ, working in diverse areas of device development, medical ultrasound research as well as teaching and training medical physicians.

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Summary

- UWPT provides a distinct platform-based energy modality for implantable and non-implantable applications
- Power transfer from mW – several Watts is feasible
- Good understanding of non-idealities → Beam propagation, attenuation, misalignment, thermal considerations, etc.
  - Effective knowledge-based design implementation for specific applications
- UltraPower/PET is looking for co-development and/or licensing opportunities to further advance the use of UWP for select implant applications

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Further Details

- Delivering wireless ultrasound energy to remote systems: Design implications for powering medical implants requiring milliwatt versus several watts of power. Inder Raj S. Makin, Acoustics 2023, Sydney https://acousticalsociety.org/wp-content/uploads/2023/04/Sydney_program.pdf
- Tech Note: "Fast-charging of micro-batteries using directive ultrasound;" 2023 www.ilika.com
- Popular Interest Article: "Charging devices inside the body or outside: Ultrasound Wireless Powering offers several possibilities;" 2022 https://acoustics.org/4pba8-charging-devices-inside-the-body-or-outside-ultrasound-wireless-
- "Demonstration of Healthcare-Specific Li-ion Battery Charging Using Ultrasound Power Delivery;" 2021 IEEE-WPTC https://ieeexplore.ieee.org/document/9458228
- "In vivo demonstration of ultrasound power delivery to charge implanted medical devices via acute and survival porcine studies;" 2016 Ultrasonics
- www.gopiezo.com www.ultrasound-power.com