Noninvasive Wireless Chargers for Implantable Devices and Epidermal Electronics

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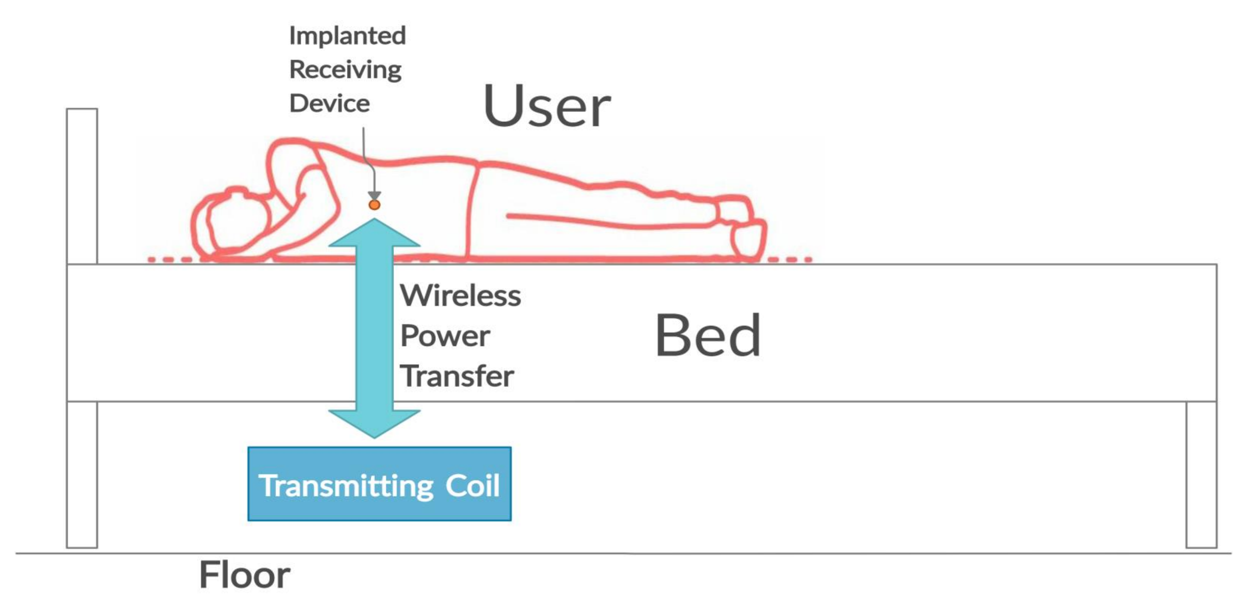
Abstract

Conventional powering of implanted medical devices such as pacemakers requires painful and invasive periodic surgeries for battery replacement, and in the case of medical epidermal monitoring electronics, power is supplied through large invasive wires which can damage the fragile skin of neonatal babies. Wireless charging presents a convenient and noninvasive solution to these problems by providing an easy and pain-free power source.

Introduction

Wireless charging operates on the principle of magnetic induction. A small conductive receiver coil exposed to a time-varying magnetic field produced by a larger transmitter coil will have an alternating current induced in it. A wireless charging station can be formed by a user with a receiver coil sleeping in their bed. This configuration will provide approximately 7 to 8 hours of charging per day.

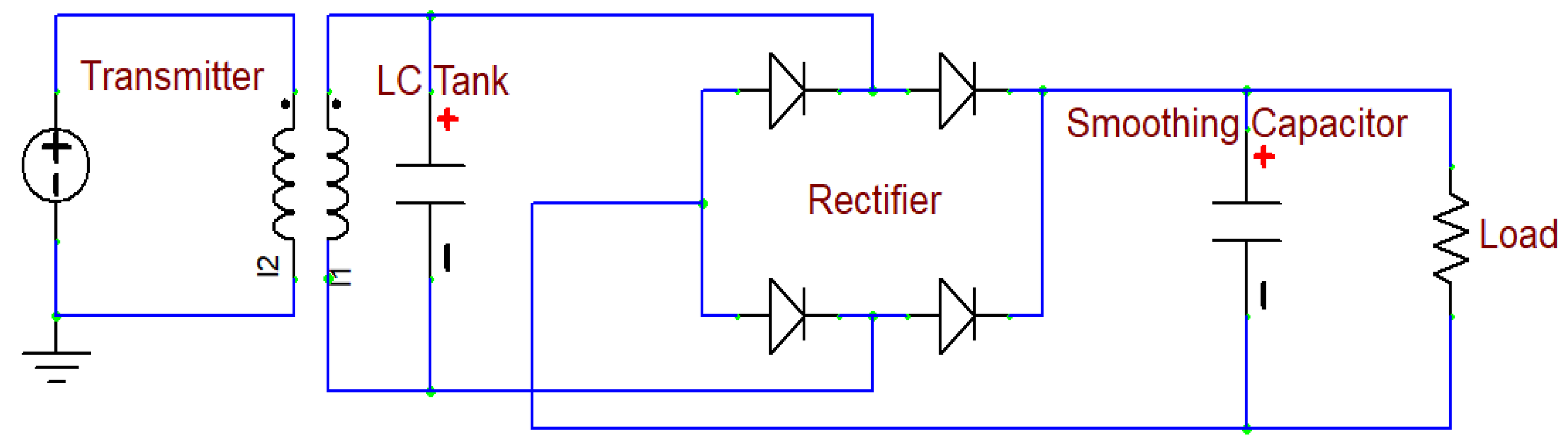


Project Objectives

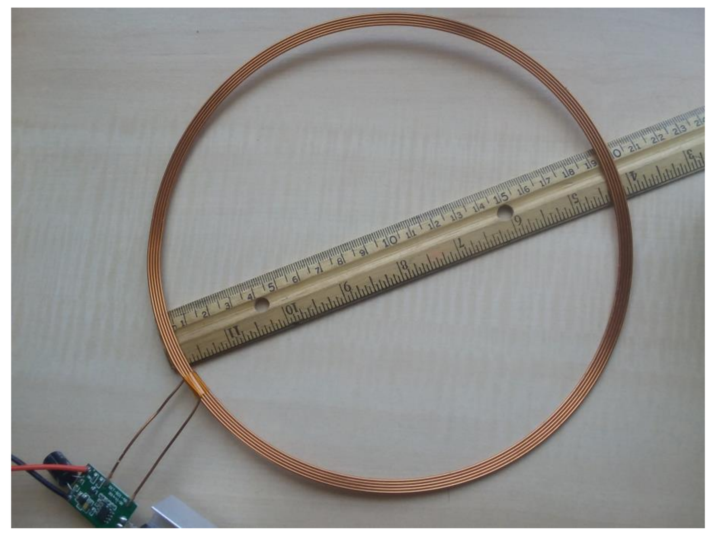
- Design and implement a wireless charging configuration with coils that are an appropriate size for biomedical applications such as pacemakers, bone-anchored hearing aids, and epidermal health monitoring electronics.
- Demonstrate sufficient power transfer at realistic distances through the human body.

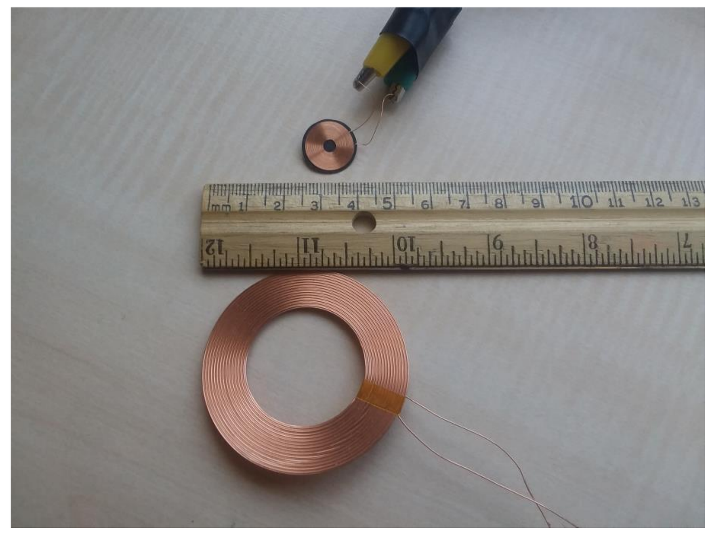
Methods and Materials

The transmitter and receiver coil couple together and effectively form an air-core transformer. The voltage induced in the receiver coil is then rectified to create a DC voltage which can charge a battery. Schottky diodes are used to maximize output voltage.

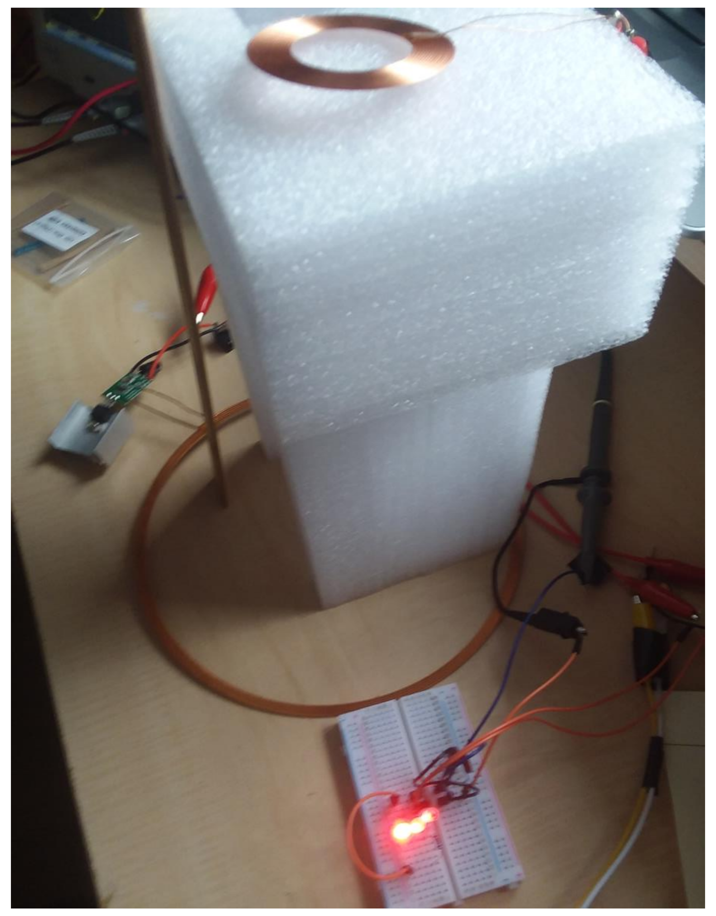


The transmitter (below left) is made by Taidacent and has a diameter of 20cm. Multiple receiver coils (below right) are tested and encapsulated in biocompatible PDMS.



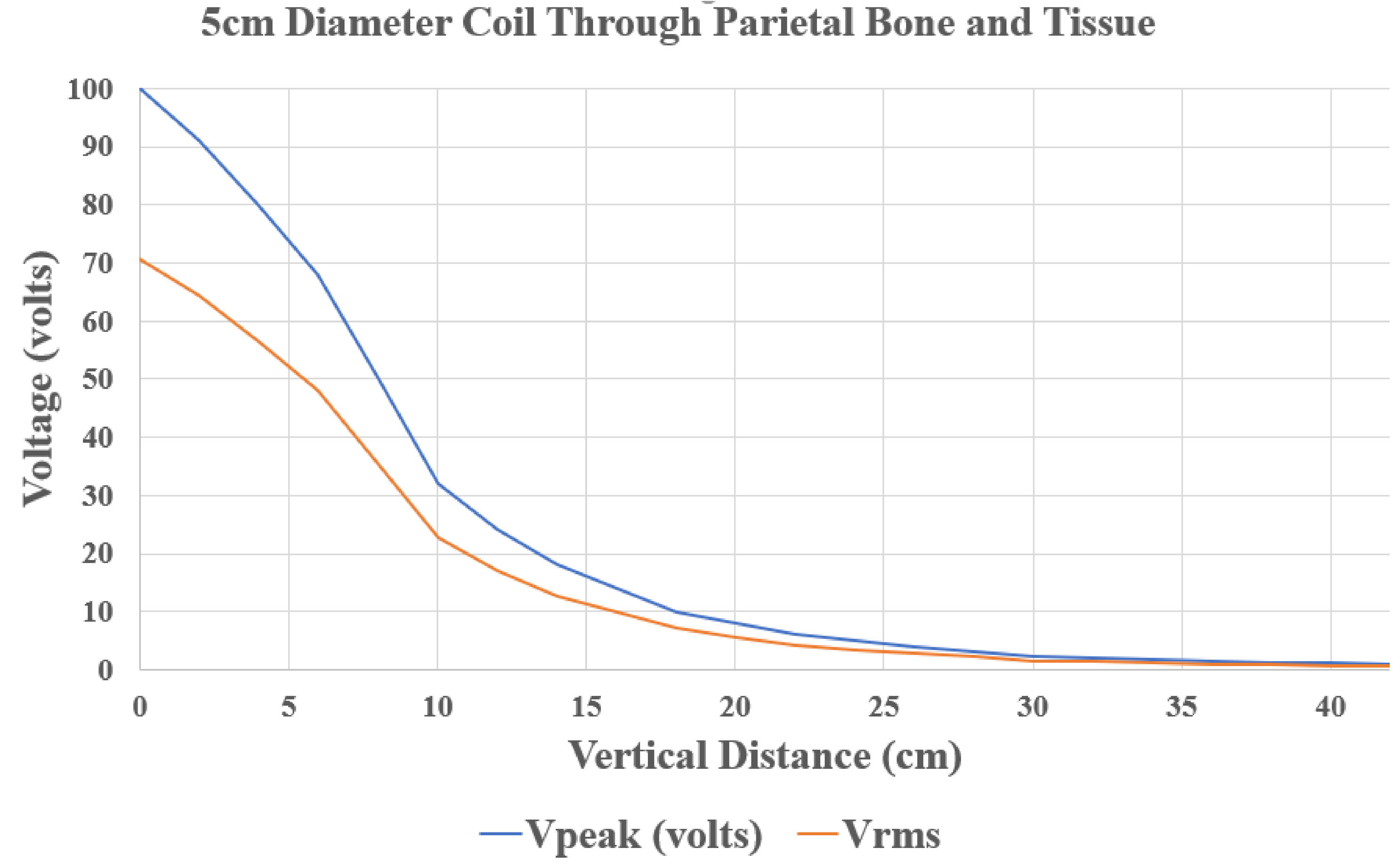


Wireless power transfer between coils is tested with synthetic human tissue analogues, baboon skull, and human parietal bone. The distance between the coils is increased and resultant power transfer is measured and recorded. An LED array (pictured right) is illuminated by wireless power with a distance of 26 cm between coils.



Results

Wireless power transfer is successful through all tested bone and tissue mediums with both receiver coils, however the 1.27 centimeter coil does not receive sufficient power at long enough distances for a successful implanted hearing aid application. The 5 centimeter outer diameter coil shows sufficient power transfer for a pacemaker application. The 5 centimeter diameter coil receives .7 Volts RMS at 46 centimeters above the transmitter, which is a sufficient voltage and distance.



Conclusions

Wireless charging offers a convenient solution to the problems involved with conventional power sources in implanted and epidermal medical devices. Low power transfer at longer distances is offset by the fact that devices like pacemakers only require 20 to 50 μW (microwatt).

Acknowledgements

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