A Novel Wireless Charging System for IMDs Using 2.4GHz EM Waves

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Thirty-five million Americans have an implanted medical device (IMD), like a pacemaker. IMDs have a fixed battery life (~7-12 years), requiring invasive surgery to replace the battery, with ~10-20% complication rates. This research uses EM waves to instead recharge the IMD battery. The Wireless Charging System (WCS) consists of a 9-element Phased Array to transmit energy as 2.4GHz EM waves, a 3-Fresnel Lens system to focus the EM waves into a concentrated power beam, and a small 2.4GHz Rectenna to convert the EM waves into DC energy. EM waves rapidly lose energy over free-space (transmitted power decays quadratically, 1/distance squared), through skin and the Receiver antenna, and through the Rectenna's signal path. To counteract free-space loss, original EM Fresnel Lenses were created to concentrate, collimate, and phase-align the waves for 1-2m, resulting in a narrow and efficient power beam. The novel 3-Fresnel Lens system reduces the Half-Power-Beam-Width from 34° to 11°, increases the gain by 7dB within 1m, and narrows the beam to 10cm wide . Additionally, Antennas and hand prototyped Rectifiers were optimized for energy capture. Original PCB Rectifiers were tested, with the final designs having over 85% RF to DC energy conversion efficiency. Based on annual energy requirements (70mWh), the WCS could charge a pacemaker battery during a 20-30 minute doctor's visit by transmitting 1W(30dBm) power, with 8dB loss through free space/skin/antenna, and 75% efficiency of the designed rectifier. This WCS could serve as a solution to recharge IMD batteries, making invasive surgeries obsolete.

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