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Towards an Ultrasonically Powered Efficient Multichannel Neurostimulator Implant

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During the last few decades, electrical neural stimulators have successfully been employed as a means of treatment for a wide range of neurological disorders. By targeting the peripheral and central nervous systems, electrical neurostimulators activate/inhibit neural activity by manipulating the stimulus-induced electric field arising at the targeted area through diverse electrode configurations. Aiming at reducing the overall size of implanted stimulator systems, these are being designed to be wirelessly powered and batteryless. Technologies for wireless power transfer to implants are mainly based on inductive coupling and, more recently, ultrasonic waves.

To increase the power efficiency and thereby minimize the power consumption of the implant, we have previously proposed a stimulation technique that alters the electric field at the tissue by delivering charge in small packets in a very rapid manner (e.g. 1 Mpps). This charge is consequently accumulated by the tissue's integrating nature.[1] This approach removes the need to ensure continuous accurate control of the stimulus current amplitude, resulting in power savings. To the same end, in an ultrasonically powered system, unnecessary power-conversion blocks can be eliminated, as the incoming ultrasonic wave is harvested, converted into an electrical signal, rectified, and then directly used for stimulation.[2]

Inspired by the above, this work focuses on providing a discrete-component multi-channel neural stimulator, powered wirelessly through ultrasound (US), to activate and inhibit neural activity. The use of mostly commercially available discrete components will ensure reproducibility by other research labs and help provide a platform technology that can be used as an experimental tool in a variety of applications.[3] The US pressure wave obtained at the receiving US transducer will be converted into electrical energy and used both for powering the system as well as to shape the charge packets of the eventual stimulus pulse. In this manner, the need for DC-DC up-conversion, typically needed for neuromodulation, will be eliminated.[4] A charge-balancing technique, matching the fast pulse repetition rates (PRR) required for inhibition of neural activity (typically $\geq$ 5 kHz), will ensure the safety of the implant, while the injected charge will be constantly monitored and adapted for safe and efficacious activation/inhibition.

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