On the Design and Electromagnetic Safety Assessment of Telemetry Coils for a Retinal Prosthesis

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Abstract

Age related Macular Degeneration (AMD) and Retinitis Pigmentosa (RP) are among the leading causes of blindness affecting over 10 million people worldwide through progressive photoreceptor loss in the retina. Recent advances in ophthalmologic research have shown that such blind patients can regain a moderate amount of vision by means of a retinal prosthetic device.

Currently considered prototypes of a retinal prosthesis system are composed of two units: external and implanted. The external unit includes a camera, a data encoding chip and a primary telemetry coil for transmission of power and data. The implanted unit consists of a receiving/secondary telemetry coil, power and signal transceiver, a processing chip and a stimulating electrode array placed in the epi-retinal region.

The primary coil and the secondary coil comprise the inductive link used for wireless energy and data transfer. A measure of the performance of the inductive link is its coupling efficiency, which is a function of several factors, such as distance, orientation, size. Other practical dependencies, especially for the secondary coil, include: resistive loss leading to heating, parasitic capacitance, and shape/dimension imposed by the need to conform to the eye geometry.

Quasi-static methods like partial inductance methods were used to optimize the design of the telemetry coils in terms of coupling coefficient and at the same time keeping in mind the constraints of coil thickness, range of motion of the eye and curvature of the implanted coil needed to fit on the human eye. Further, we have enhanced our quasi-static computational code with capacitance calculation based on models valid for a range of design configurations.

In this work we will review the telemetry needs for a retinal prosthesis system and present result of inductance, mutual inductance, and capacitance obtained for various options of telemetry coil design that would be suitable for a dual-unit epiretinal prosthesis, discussing advantages and disadvantages of them. We further present FDTD simulations for some of the considered design as well as validation of our results with measurements using an electric field probe. Issues such as calibration with simple coil geometries and sensitivity in the frequency range of interest (1 – 10 MHz) will be addressed, and experimental and FDTD results for test coils and actual potential coils for the retinal prosthesis will be provided. These results provide insights on numerical and experimental methods for the complete development of telemetry systems for the retinal prosthesis from design, implementation, and electromagnetic safety assessment.