Numerical Simulation of AIMD Compatibility in an MRI Environment

Dawei Li, Yan Liu, and Ji Chen
Department of ECE, University of Houston, Houston, TX 77204-4005

Radio Frequency (RF) induced heating of human tissue around Active-Implantable Medical Devices (AIMD) poses a potential safety risk to patients in a magnetic resonance imaging (MRI) environment. The RF heating is caused by the local electromagnetic fields and the induced currents around the implants due to the interaction between the device and the incident RF fields. Considering the variation with AIMD structure, RF coil type, patient size, anatomy parameters and AIMD position, numerical simulations play an important role in the understanding of MRI-related AIMD compatibility when experimental methods cannot be performed.

According to the ISO/TS 10974 AIMDs standard, a four-tiered approach is proposed to estimate RF related heating in order to accommodate the diversity of AIMD configurations and applications. Tier 1 provided the most conservative approach by determining the maximum electrical field inside entire human body. Tier 2 and 3 approaches focus on getting an average electric field in the region of interest or along the path of the medical devices, while the Tier 4 approach will perform comprehensive simulations of the actual devices inside human subject models. From the Tier 1 to the Tier 4 approach, a more accurate estimation of the device heating can be achieved at the cost of more computational resources.

In this work, Tier 2 and Tier 3 approaches are studied for five different human models including an obese male, adult male, adult female, boy and girl. Various parameter variations are studied here. From a data analysis of the results, a maximum electric field value in the implanted regions and the tangential electric field along the lead pathway are obtained, and these provide an effective reference for predicting the temperature rise and the MRI-related heating effects around AIMD devices.