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Simulation of Induced Eddy Current and Heat Dissipation of MRI-compatible PET Detector due to an MRI Varying Magnetic Field (G)*

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Advances in medical imaging and demands for better diagnoses brought up the idea to combine complementary image modalities with the aim to provide better image quality and more information. Many combined PET/MRI scanners designed for truly simultaneous operation are still in the developing stage. One of the main interferences between PET and MRI arises from the different material magnetic susceptibilities and the presence of metal inside the MRI field of view that could produce eddy current and increase the temperature of PET electronics. In this report, we discuss the effect of MRI gradient on the PET electronics.
We consider a 3 T MRI with an open bore diameter of 50 cm, gradient with slew rate of 200 mT/m/s and RF coil with outer diameter of 30 cm with an avalanche photodiode (APD)-based PET detector located at outer surface of the RF coil. Sensitive materials in PET detectors include application-specific integrated circuits (ASICs) (mainly silicon and copper wiring) of 23.5 × 11.5 mm2 with 0.650 mm diameter ball grid arrays (BGAs) made of SAC305 (Sn96.5Ag3Cu0.5).
Since APD performance is sensitive to temperature and the PET detector electronics are designed in a way that low frequency RF could not disturb its biasing and signaling, the induced eddy current and the associated heat loss in the PET detector have been evaluated using the COMSOL magnetic field module. To model the eddy current and heat loss, we used magnetic vector potential and the skin depth (δ) of materials. The skin depth of copper and SAC305 are 652.3 µm and 1636 µm at 10 kHz, respectively.
The induced current density was simulated in one individual SAC305 sphere and in a detector with 116 spheres as BGAs along with two ASICs in presence of the gradient field. By volumetric integration of current, the induced current density in one BGA was calculated as 0.3 µA.m and the heat loss was 37.3 pW. The total eddy current density norm and heat dissipation for one detector would then be 1.7 mA.m and 0.6 µW, respectively. Our results show that by using non-ferromagnetic materials in small quantity and low distribution, the induced current and heat dissipation due to gradient changes are so small that they would not raise the detector temperature to a level that would affect the PET performance.

Author: Ms MOGHADAM, Narjes (universite de Sherbrooke)

Co-authors: Prof. LECOMTE, Roger (Univrsite de Sherbrooke); Prof. FONTAINE, Réjean (universite de Sherbrooke)

Presenter: Ms MOGHADAM, Narjes (universite de Sherbrooke)

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