Whole Body RF Coil Design for a Simultaneous PET-MR System

Saikat Saha[1]
[1]GE Healthcare, GE, Waukesha, WI, United States

Introduction: In conventional whole body RF transmit coils, various RF components such as diodes, capacitors, inductors, cables etc. are placed throughout the coil for optimal MR performance. If such components are placed in the FOV of the PET detector in a simultaneous PET/MR system, they will scatter some of the PET signals (511keV annihilation photons), affecting image quality. To address this problem we have created a "zero PET attenuation" whole body transmit/receive coil with minimal use of high density RF components. We present design and performance for the resulting body coil as implemented in our 3.0T simultaneous PET/MR system.

Method & Result: Conventional approach of designing transmit/receive body coils for whole body MR systems involves decoupling boards with various RF components such as diodes, inductors, capacitors etc., thick RF power cables (which can carry 30-35kW of power), bias cables and so on near the center of the coil. These obstruct the 511keV photons from reaching the PET detectors placed at the center of the MR FOV in a simultaneous PET/MR system. Although the attenuation from these components can be corrected or accounted for during PET IQ calibration, it results in permanent singles loss which cannot be recovered, thereby degrading PET image quality. Hence the design of an RF coil with zero or minimal PET attenuation is necessary.

A 3.0T whole body RF transmit coil is described here for our simultaneous PET/MR system with minimal RF components in the PET FOV. The only RF components present in the FOV are the rungs of the 16 leg high pass birdcage coil as shown below in Figure 1a [showing the components on the inner diameter of the former]. Other features which help in making this coil PET friendly are end-ring decoupling implemented on the front end and power cables (for dual drive operation) on the rear end of the coil. Typical attenuation measured is ~2-3% in singles loss for capacitors, inductors, diodes, resistors and ~12-15% on the RF power cables. Another unwanted effect from the presence of these thick RF power cables is the eddy current heating during stressful gradient scan [EPI, Spiral, etc.]. It generates ~2^{o}C rise in localized temperature for the detector units residing close to the cables causing 16-20% energy peak shift. However, given the coil design described above, the overall singles loss is measured to be < 1% shown in Figure 1b. Some of the PET/MR system related performance parameters measured with the coil are as follows:

Empty Coil Q:	260
Peak B1 capability [empty]:	40.1uT
Peak B1 capability [50 kg Load]:	29.7uT
NEMA Body SNR:	93.5
NEMA Head SNR:	69.0
MR Image Uniformity:	95%
PET Singles Loss:	<1%

For reference an MR image (showing image uniformity) from a body phantom is shown in Figure 1c below. The average image intensity difference measured between ROIs 1 and 2 (shown in red) is ~10%.

Conclusion: In order to optimize the PET image quality in an already developed MR system, we have designed a nearly "zero PET" attenuating (<1%) whole body RF coil for our simultaneous 3.0T whole body PET/MR system. All the RF components except the thin copper rungs in this coil design have been moved outside the PET/MR FOV ensuring excellent PET IQ without compromising any MR IQ.

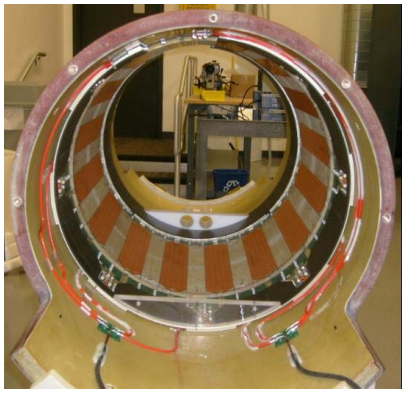

Fig 1a: Coil for PET/MR System

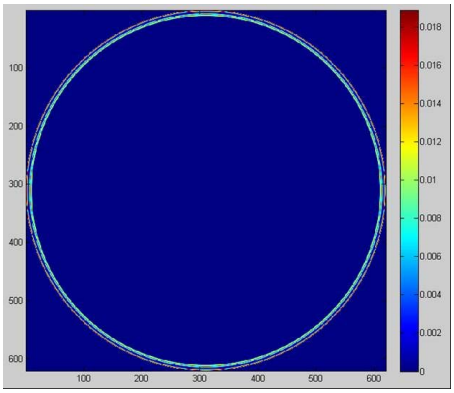

Fig 1b: Attenuation Map of PET signal for RF body coil

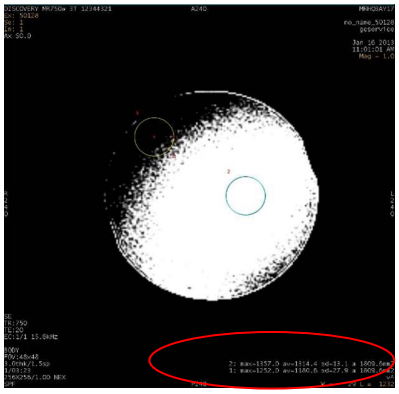

Fig 1c: MR Image showing Uniformity