Low E-Field and Low Acoustic Birdcage Coil Design

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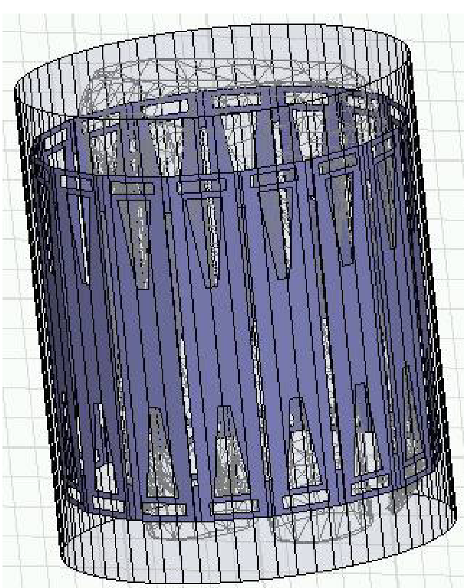
Introduction: During high field MR scans, patients become warm while scanning because of the high electric field (E-Field) generated from the RF body coil. This warming due to high RF power absorption by the human body increases with long scan times. Also the acoustic vibration/noise produced inside the patient bore generated by the eddy current from the gradient coil becomes uncomfortable for long scan times. Some of the previous work, which addresses the issues of acoustic vibration/noise are documented in [1]. The low E-field and low acoustic coil design described here addresses both these issues by significantly reducing the SAR heating and also the acoustic vibration/noise in a high pass Birdcage coil. In addition, the B1 field performance is also significantly improved in the imaging volume.

Result: Couple of 3.0T (nearly 128 MHz) whole body RF coils are studied here by means of a commercial FEM software (HFSS). The common architecture for both the coils are: 16 rung High Pass Birdcage RF body coils, 60 cm bore diameter, four-port driven with each port driven by constant power source and at 0, 90, 180 and 270 degree in phase respectively. The standard coil has the antenna rungs made of 5-6cm wide 1 oz. copper foil while the low E-field and low acoustic coil design is made of nearly 10-12 cm wide 1 oz. copper foil. Since, the wide nature of the antenna rungs in the later design have lower inductance, higher value of capacitance is needed at the end-ring locations (between the two rungs) to tune the coil to 128 MHz as compared to the 6cm wide rung coil. This low capacitive reactance reduces the E-field significantly at the end-ring locations, which in turn reduces the SAR heating and thus the patient warming. But one disadvantage of such a wide rung RF coil design is significant increase in acoustic vibration from the eddy current generated by the RF-gradient coil interaction. In order to reduce acoustic vibration/noise from gradient pulsing at the high intensity eddy current locations of the RF coil, cut outs have been made strategically in the antenna rungs and the end-rings. These strategic cut outs in the rungs/end-rings not only reduce the acoustic vibration/noise but also maintains the E-field at similar lower levels as they were without the cutouts. The reduction of E-field in this coil design thereby also improves the coil efficiency, which was nearly by 90%. Therefore, B1 field (intensity/uniformity/SNR) is significantly enhanced. Figure 1 below shows the low E-field/acoustic RF coil design with a human model of 212 lbs. For computational efficiency the head and legs of the human model have been removed. To show the difference in the E-field from the two loaded coils studied by HFSS, figures 2a and 2b have been plotted (scale shown on the right side and normalized to the same B1 field intensity) in the y-z plane at 128 MHz. Red region shows the highest E-Field intensity locations and the blue region is the lowest intensity locations. Also data from initial experimental measurements have shown significant performance improvement in SAR, B1 efficiency and acoustics.



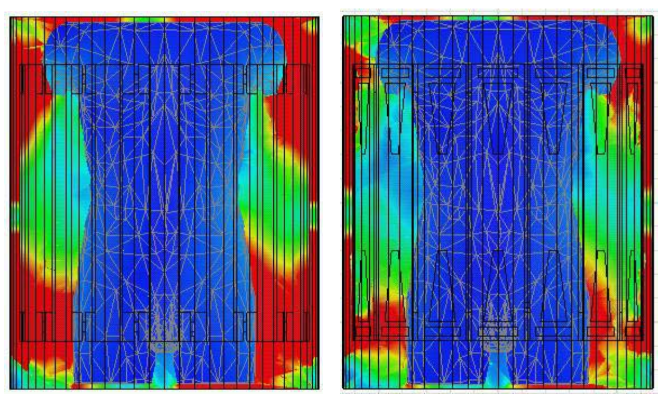


Figure 2a & 2b: E-field plots in narrow rung coil (left) & in wide rung Low E-Field/Acoustic design coil (right) at 128 MHz.

Figure 1: Low E-Field/Acoustic RF body coil loaded with a 212 lbs human model.

1) (ISMRM 2002) A Whole Body RF Coil Design to Reduce Acoustic Noise .
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