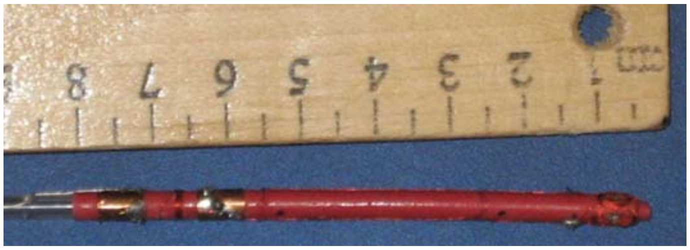
Transmit Power Optimization for Multimode Coil

K. N. Kurpad[1], E. T. Bieging[2], E. K. Brodsky[1,3], and O. Unal[3]

[1]Radiology, University of Wisconsin - Madison, Madison, WI, United States, [2]Biomedical Engineering, University of Wisconsin - Madison, Madison, WI, United States, [3]Medical Physics, University of Wisconsin - Madison, Madison, WI, United States

Introduction:

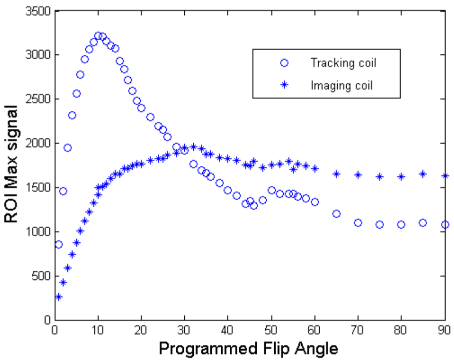
In previous work, we introduced the concept of the multimode coil [1]. The multimode coil consists of a tracking coil connected in series with a multi-turn imaging coil and simultaneously performs the functions of active tip tracking, imaging and inductively coupled wireless marker. The tracking and imaging coils have conflicting design requirements. While the region of sensitivity of the tracking coil must be highly localized, that of the imaging coil must reach as far as possible. In addition, the tracking peak must dominate the overall signal profile of the coil in order to enable robust tracking. Furthermore, the multimode coil is inductively coupled to the external transmit or transmit/receive coil as the case may be in order to enable the wireless marker functionality. This results in the magnification of the transmit B_1 field within the region of sensitivity of the multimode coil, leading to larger flip angles compared to regions outside the coil sensitivity. Furthermore, the magnification of the B_1 field due to the tracking component of the multimode coil is greater than that due to the imaging component. Optimization of the transmit power from the external transmit coil is therefore necessary to enable robust tip tracking and imaging.



Methods:

A multi-mode coil (figure 1) was constructed on a flexible nylon tube (3.175mm outer diameter) using 36 gauge wire. The tracking component of the multimode coil consisted of two orthogonal 6-turn Helmholtz pairs placed at the distal end of the catheter. The two Helmholtz pairs were connected in parallel to each other. The parallel Helmholtz pairs were then connected in series with a 3-turn imaging loop as shown in figure 1. The Helmholtz pairs consisted of closely placed, elongated windings and were designed to yield a high signal from a localized region to enable tip tracking, independent of coil orientation. The imaging loop was 30mm long and spanned the outer diameter of the nylon tube. Each Helmholtz pair was tuned to series resonance using series capacitors (single layer capacitors, ATC, AZ). The inductance of the imaging loop was also controlled using series capacitors such that the overall impedance of the multimode coil was sufficiently inductive to enable easy matching and tuning. A π matching network was used to match the resultant loaded coil impedance to a 50Ω micro-coaxial cable (42 AWG inner conductor, Alpha Wire Company., NJ).

Transmit power calibration was performed with a gourd phantom. As the central volume of the gourd consisted of a cavity, the multimode coil was placed inside an acrylic tube (diameter 18.375 mm) that was inserted into the cavity of the gourd and filled with tap water. In the imaging mode, the multi-mode coil was connected to the single channel receive only port of a 1.5T GE Signa MRI scanner via a decoupling circuit. The body coil was used in transmit-only mode.



Using a standard FGRE pulse sequence (TR/TE = 7.1/3.324 ms) with flip angle of 10°, the optimum RF power amplifier transmit gain that resulted in the maximum signal from the multimode coil was determined. The transmit gain was adjusted during a manual prescan procedure in the scan T/R mode. The permissible range of transmit powers for which the tip tracking peak dominated the signal profile of the multimode coil was then determined for various flip angles, ranging from 1° to 90°. As shown in figure 2, two ROIs were defined corresponding to the tracking and imaging components of the multimode coil. The maximum signal from each ROI was plotted against the flip angle setting.

Results and Discussion:

A plot of the maximum signal intensity in the tracking coil ROI shows a peak corresponding to a 10° flip angle (figure 3), at which, the transmit power was optimized. This implies that body coil transmit power that causes a flip angle of 10° undergoes amplification at the multimode coil due to signal induction. The signal intensity from the tracking coil falls off for flip angle settings that are greater than 10°. At a flip angle of 30°, the maximum signal intensities due to the tracking coil and the imaging coil intersect. For body coil transmit powers corresponding to flip angles greater than 30°, the signal intensity due to the tracking component falls below that due to the imaging component. As the simultaneous 3D tracking and imaging technique [2] tracks the maximum intensity point localized by three orthogonal projections, flip angles greater than 30° cannot be used for accurate tip tracking.

Conclusions:

In conclusion, we have determined the range of transmit powers for which optimal performance may be extracted from a multi-mode coil.

References:

[1] Kurpad K.N, et al., ISMRM, 1398, 2007., [2] Unal O, et al., ISMRM, 2007.