A 4T Four Channel Transceive Spine Array

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Introduction

High field MRI systems lacking a body RF coil for excitation require alternative transmit (Tx) and receive (Rx) coil designs. Power requirements and specific absorption rate (SAR) may also play a role in the size of such coils and make generation of efficient transmit B1 vital. In spine imaging at 4T it is preferred to have a spine coil that does not significantly reduce the available bore space, and that allows the investigator to acquire images anywhere along the spine without having to move the patient or coil. This means that the Tx- and Rx-coil must either cover the entire spine or a smaller coil must be freely movable underneath the patient. Due to having only 4-receivers, but mostly due to SAR issues, we report on a small but movable transceive phased array design for spine MRI on a 4T whole body MRI system.

Methods

MRI experiments were performed on a 4T (170.3 MHz) Varian MRI scanner. To limit SAR we chose to Tx and hence Rx with elements totaling 30 cm in the z-dimension, with two 15 cm loop-butterfly pairs (Fig.1-left). We chose to make this coil in the transceive configuration by splitting power from the transmitter appropriately into all four elements, ideally with equal magnitude and loop phases equal, butterfly phases equal but 90° different from the loop current. We applied a common technique using a first stage split using a 90° hybrid and a second stage split into 4 equal voltages using a 90° hybrid at each of the two outputs of the first stage. This results in four output ports with equal magnitude and phases 0°, -90°, 180°, -90°, as required with a simple polarity reversal to one of the loop elements. Additional phase shifters were placed after each output to allow the phase rewinding from different splitter–to-coil cable lengths, and to allow B1 phase fine-tuning. On the bench we loaded the coil as in Fig. 1-left, and with a search probe and 8752 network analyzer, measured the Tx B1 field 12 cm above the coil at three points, one centred above each loop and the third directly above the gap. We used our own preamps (input impedance = 1.2Ω, NF = 0.6 dB) and T/R switching networks including a 1A PIN diode driver controlled by the systems T/R switching logic signal. Gradient echo images were obtained for SNR and transmit B1-field mapping and results compared to a single 15cm x 30cm Tx/Rx loop (using the Varian preamps and T/R switch).

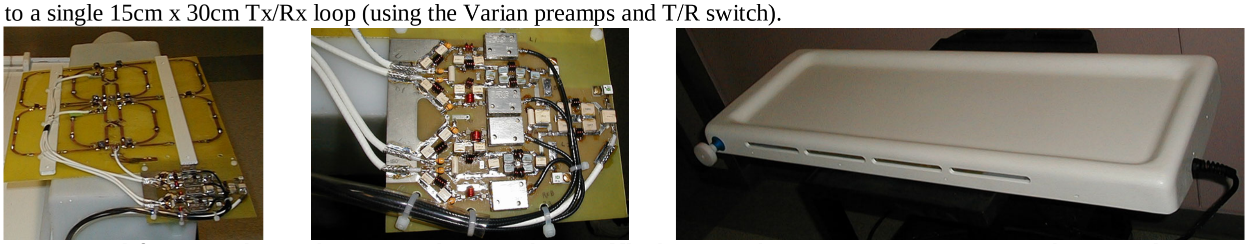

Fig. 1 Transceive array (***left***), power splitter with preamps and T/R switching (***middle***), housing with transceiver array movement mechanism (***right***).

Results and Discussion

Coil elements were matched to better than –20dB with S21 isolations all better than –21dB. The bench Tx B1-field was adjusted to obtain a uniform B1 field along the z-dimension, measured to be:

Loop/Butterfly1: Bx=-59.7 dB, By=-60.0dB, φ=93°, ***Gap:*** Bx=-58.5 dB, By=-59.7dB, φ=97°, ***Loop/Butterfly2:*** Bx=-59.8 dB, By=-58.8dB, φ=92°

The MRI B1 map (*Fig2:left*) showed a slightly weaker B1 field in the center (80° flip) not seen on the bench data, but the Tx B1 field was mistakenly not optimized in a bore simulator possibly explaining the difference. Such a small inhomogeneity would only result in a signal reduction of 2.5% in the SNR images. The SNR gain was 2-3 fold compared to a non-quadrature T/R loop (*Fig.2*) with the Varian preamps located somewhat further away from the coil. We chose an array design with separation to allow improved parallel MRI, with the intension of recovering SNR with another method [1]. In this preliminary design, we therefore see significant SNR reduction between separated array elements. Due to propagation effects, significant B1 artifact is present within the large conductive sample used (not present in results obtained using an oil phantom) and possibly more significant in the transceive array. We will need to use a gel-type phantom for more realistic results.

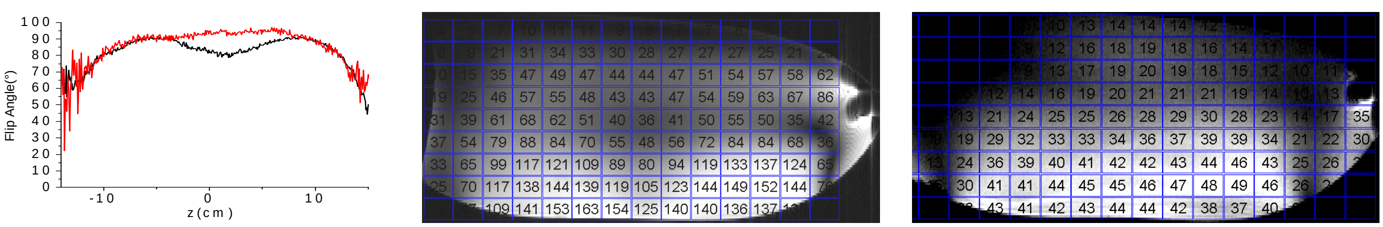

Fig. 2: MRI measured B1-field along the z-direction (***left***) for the Tx/Rx loop (red) and Transceive array (black), SNR map from the transceiver array (***middle***), SNR map from the Tx/Rx Loop (***right***).

Conclusions

As expected, the transceive array had significantly higher (2-3 fold) SNR compared to a linear Tx/Rx loop, which would be partly due to the quality and location of the preamps used for the transceive array. The Tx B1 field measured on the scanner was uniform to within ±6%, but may be improved through fine-tuning within a bore simulator. Additional SNR gains can be obtained by quadrature combination of loop-butterfly pairs and subsequently using the remaining two receivers for twisted array elements[1].

References

[1] S.B. King ISMRM 2005 (submitted).

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