16-channel Tx array and 32-channel Rx array for brain MRI at 7T

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TARGET AUDIENCE: RF engineers, ultra-high field MRI and pTx researchers.

PURPOSE: Ultra-high field MRI (7T & above) can potentially improve diagnostic power particularly when parallel transmit and 32-channel receive RF arrays are employed. Separate designs of transmit array and receive array have been discussed[1]. To improve the overall imaging quality of both the pTx and pRx system, we combined a 16-channel transmit array[2] and a 32-channel overlapped-loop receive array in a sliding configuration for easy patient access while retaining gapless Rx and the ability to perform parallel transmit excitations.

METHODS: Experiments were performed on a 7T system equipped with 8x1 kW transmit channels and 32 receive channels. ***Transmit array:*** In this work, a 16ch Tx shared-conductor loop array[3] was modified to be a transmit-only coil with diodes in each loop to activate the element during transmit. The coupling between two nearest neighbors was adjusted by the shared capacitor. The 16 loops were driven in birdcage modes via a Butler matrix. The coupling matrix of the entire array was measured in a 17 cm dia. saline phantom. ***Receive array:*** The Rx array consists of 32 overlapped loop elements (~9 cm dia.) arranged on a curved surface of the coil former, that was designed to create a tight fitting to the human head (Fig 1). The loops were arranged in a hexagonal tiling pattern (six loops surrounding a central loop). A 16-AWG thick tin-plated copper wire was used to form the loops with bridges in the wire to allow the wires to cross-over one another without touching. Each loop is divided symmetrically into 6 segments, separated by the discrete components mounted on a small circuit board. There were 3 types of discrete component boards, including a single capacitor pad, a tuning circuit board (variable capacitor and fuse) and an output matching circuit (matching capacitors and active PIN diode trap). Preamplifiers containing an internal cable trap were placed adjacent to each loop to avoid RF losses. ***Acquisition:*** Coil performance was evaluated on an anthropomorphic head phantom[3], which consists of multiple tissue compartments that match those of the human head both in terms of their geometry and their electrical properties. ***B_1^+ map:*** A fast B_1 mapping method with pre-saturation pulse and turbo-FLASH readout were used to measure the B_1^+ maps of the birdcage modes[4]. ***SNR***: The SNR maps of the 32-channel array were acquired using the uniform birdcage mode (10° flip near the brain center) for a GRE sequence and computed using the Kellman's method[5]. Inverse G-factor maps were calculated at various 1D and 2D SENSE acceleration factors (R) using a uniform birdcage mode for transmit.

RESULTS: Fig 2 shows the coupling matrix in the 16-channel Tx array. The coupling between elements of Tx array was slightly increased when the Rx array was present. Fig 3 shows B_1^+ magnitude maps of the 8 birdcage modes from 16ch Tx array. For 32-channel Rx array, the ratio of unloaded/loaded Q is ~10 (150/14) for the Rx loops. Coupling between Rx neighbor elements (S_{21}) were at least -10 dB on bench. The average of noise correlation coefficient matrix for the off-diagonal elements was 19.6%. Figures 4 and 5 show the SNR maps and the inverse G-factor maps. The SNR maps reflect both the true receive profile and the Tx profile of the birdcage mode excitation in this center-brightened phantom.

CONCLUSION: We combined the advantage of transmit arrays at 7T with the benefits of a tight fitting 32-channel receive array. The 32-channel Rx array offers a strong spatial modulation of signal intensity, which is important for accelerated parallel imaging. Therefore, the combined coil setup provides high sensitivity, low G-factors during image acceleration, and B_1^+ control needed for clinical and functional high field MRI research.

REFERENCES: 1. Adriany G, et al., MRM (2010) 63:1478-1485; 2. Zhao W, et al., ISMRM 2012: 310; 3. Graedel N, et al. ISMRM2012: 314; 4. Lee J., et al., ISMRM 2010, 2835; 5. Kellman,et al., MRM (2010) 54:1439-1447.

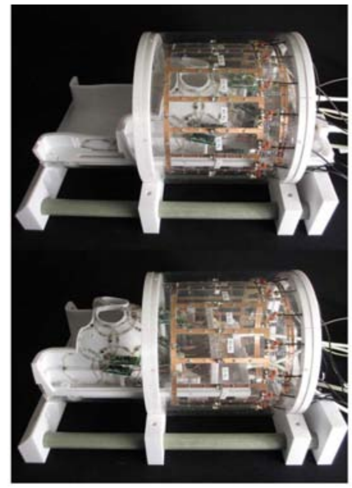

Figure 1. *7T 16ch Tx array and 32ch Rx array in sliding construction.*

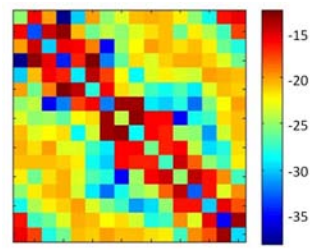

Figure 2. *Coupling matrix for 16ch Tx array with detuned 32ch Rx array and 17 cm dia. saline phantom.*

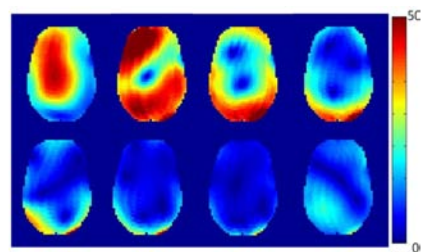

Figure 3. *B_1^+maps of 8 birdcage modes in sagittal plane with the head phantom.*

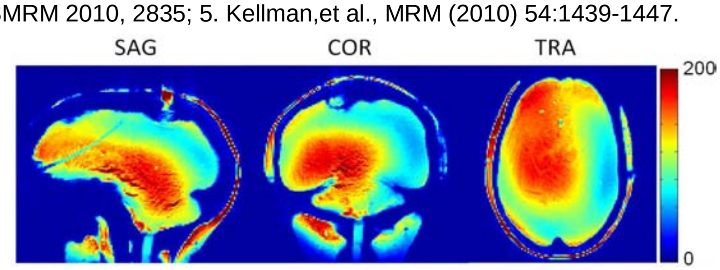

Figure 4. *SNR maps in sagittal, coronal and transversal planes (orientation), using gradient echo images (TR/TE/BW 1800 ms/6 ms/890 Hz/pixel, slice thickness 5 mm, matrix: 128×128, FOV: 200×200.*

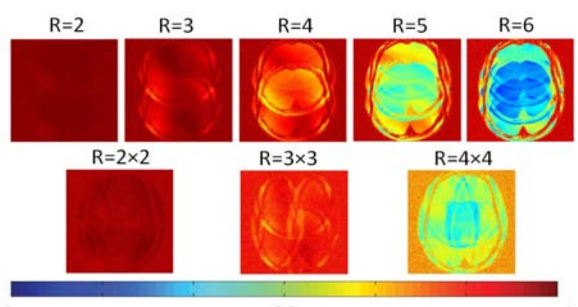

Figure 5. *Inverse G- factor maps of 32ch Rx array in uniform birdcage mode.*