Separated Volume Transmit / Volume Receive Arrays for Use in a 7T Head Gradient

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Objective: Construct RF volume coils with independent transmit and receive elements and visual presentation capabilities for use in a 7T head gradient.

Introduction: Compared to full-body gradients, the smaller size of head gradients allows stronger gradient amplitudes and faster slew rates – ideal for EPI imaging. However, the smaller inner diameter (i.d.) of a head gradient reduces the volume available for RF coils and visual stimulus presentation. There is less than 34 cm vertical clearance available and a large head will occupy 24 cm. The remaining space must be used efficiently. Transceive coils, where a single coil is used for both transmission and reception, have been successful in this tight arrangement.[1] Separated transmit and receive arrays allow the flexibility of individually optimizing the transmit and receive array, but is 5 cm radial distance enough to implement two coils? In this work, separated transmit coils and low-impedance pre-amplifier decoupled receive coils are demonstrated working within these spatial constraints.

Materials & Methods: Two RF coils were designed, built, and characterized. The first uses an inductively-coupled TEM (icTEM) resonant structure (one RF power input) with 16 preamplifier decoupled receiver loops nestled inside. The second coil uses 8 decoupled, independently driven transmit microstrip TEMs (8Tx), and 16 receivers arranged in two rows of eight loops. The TEM/loop combination was chosen to make the magnetic field patterns more distinct between transmit and receive arrays. The dimensions were similar for both coils: patient opening: 244 mm i.d., receiver i.d.: 250 mm, transmission coil i.d.: 265 mm. For the parallel transmit compatible 8Tx coil the o.d. was restricted to 320 mm, the maximum curvature that would fit in the patient table; for the icTEM, the patient bed was slightly modified to accommodate an extra 10 mm in diameter. An example of the coil layout for the icTEM is shown in Fig 1a, and the coil itself in Fig 1b. Space for a sliding mirror was reserved in the icTEM by not placing a resonant element over the nose and adjusting the remaining elements to accommodate the missing element. The sliding mirror allows the projection screen for visual stimulus to be placed on either side of the magnet. The transmitter and the receiver are actively detuned. For each coil, fully-relaxed double-angle method B_1 maps were acquired.[2] The 8-channel coil was evaluated with the RF phases in circularly-polarized phase distribution (n*45°, n=0 to 7). Noise scans, T1-weighted IR images (TR/TE/TI = 2220/2.86/1500 ms, 1 mm^3,NEX=2,R=2), T2-weighted TSE images (TR/TE=6000/96 ms, 0.6x0.6x4 mm, R=3), and spin-echo weighted images were acquired to evaluate performance.

Results & Discussion: The B_1^+ maps in Fig 3 are shown in μT per volt per channel. The larger icTEM coil was able to produce as much field per watt as comparable in-house 16-channel transceive coils, showing that separated transmit and receive coils are feasible inside a head gradient. Preliminary results with the smaller 8Tx coil suggest it is not as efficient as the icTEM. The 16 receiver loops, arranged as in Figure 1a, produced the noise correlation in Fig 2. For this same receive coil, the average g-factors were calculated to be: 1x2(A-P) 1.03, 1x3(A-P) 1.26; 1x2(L-R) 1.07, 2x2 1.15. In the future, a larger number of smaller coils will further improve these g-factors. The SNR was improved in the center of the head compared to a 16-channel TEM transceive coil. The images in Fig 4, demonstrate the performance of the coils, the extent of the coverage, and head-gradient accelerated EPI images.

Conclusion: Independent, actively-detuned, transmit and receive coils can be successfully implemented in the restricted space of a head gradient.

References: **1** Adriany G, et al. MRM 2005;53(2):434-45.
2 Insko & Bolinger, J Magn Reson A. 1993;102:82-5.

Acknowledgements: NIH-NIBIB-EB000895, NIH-NIBIB-EB006835, NIH-NIBIB-EB007327, NIH-NCRR-P41-RR08079, and the Keck Foundation.

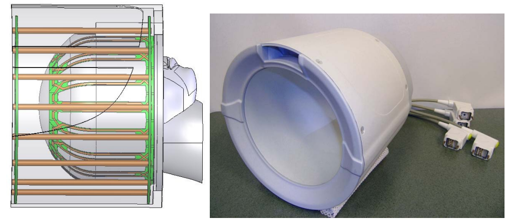

Fig 1. Model showing the relative placement of the transmit and receive elements (a), and the completed icTEM coil (b).

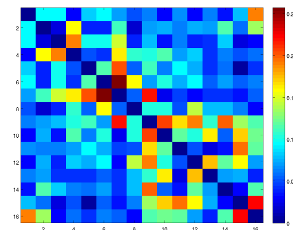

Fig 2. Noise Correlation, icTEM

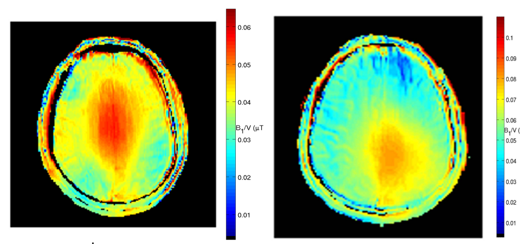

Fig 3. B_1^+ maps in μT/V per channel for icTEM (one channel) (**a**) and 8Tx (eight channels) (**b**).

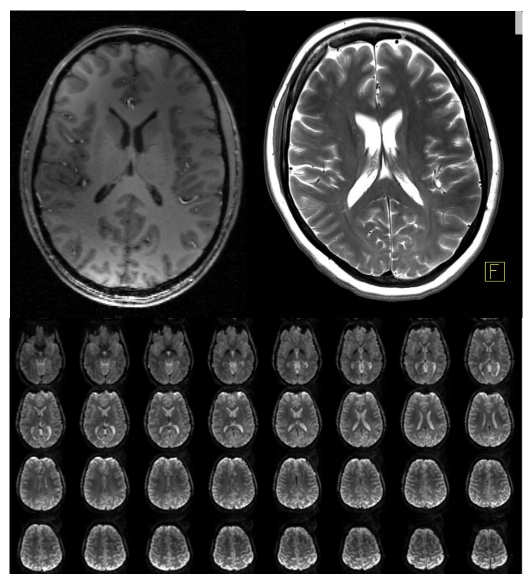

Fig 4. A slice from a 7T 3D IR T1 weighted image collected with the 8Tx coil (**a**). A T2-weighted TSE (**b**) and a spin-echo EPI data set (**c**) collected with the icTEM coil.