A 15-Channel receive array and 16 channel detunable transmit coil for human brain imaging at 9.4T

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Introduction: The radio frequency (RF) magnetic field (B_1) distribution becomes more complex in MR experiments employing higher static magnetic field (B_0) due to shorter wavelength in tissue. The B_1^+ inhomogeneities from a predefined volume of interest is reduced by influencing the amplitude and phase of the transmit current on a transceiver array coil [1, 2]. Significant gains in SNR was achieved at 7T using 32 channel receive arrays assembled on close fitting formers [3, 4]. In this study, we combine the benefits of these two methods for human brain MRI at 9.4T (400MHz). Our imaging setup consists of a 15-element receive array together with a 16-element actively detunable transmit array and hence the additional flexibility to employ RF shimming methods.

Methods: Experiments were performed on a 9.4T MR scanner (Siemens Medical Solutions, Erlangen, Germany) equipped with a whole body magnet and a head gradient insert. A 32 cm 16-element cylindrical transceiver coil was constructed using microstrip transmission line elements (fig. 1). During signal acquisition, the array is actively detuned by PIN diodes placed across the input tuning capacitor. The transmit RF power is split into 16 equally phased components using a 1x16 power splitter and coaxial cables connect the output of the splitter to the transmit coil elements. For quadrature excitation, a relative transmit phase delay of 22.5° on adjacent coil elements was realized using these coaxial cables.

The receive coils were arranged in 2 rows on a close-fitting fiberglass helmet with the following dimensions: 185mm in RL, 210mm in AP and 210mm in SI. The bottom row has 6 elements and the second row has 9 hexagonal elements each with 8 to 10 equally distributed capacitors (fig. 2). While the adjacent elements within the row are inductively decoupled, the neighboring elements between the 2 rows were decoupled geometrically. Impedance matching, active decoupling and balun for rejecting common mode current were incorporated on the input feed board.
The coil elements are connected to a circuit board assembly which carried custom built preamplifier (NF = 0.7 dB, Zin = 3 Ohm and gain = 30dB), shielded cable trap, phase shifting cables for preamplifier decoupling and bias-tee to feed DC into the RF cable for PIN diode detuning. In addition to the active detuning, the receive elements has 2 UM9989 diodes (Microsemi, MA, USA) connected back to back for passive detuning. The complete RF setup is shown if Fig. 3.

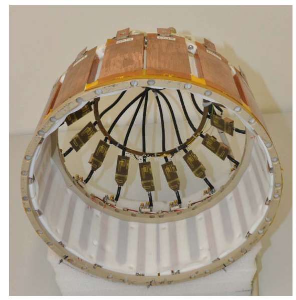

Fig. 1: 16 element actively detunable transceiver array

Fig. 2: 24 receive elements assembled in 3 rows. The results shown here are acquired with 15 elements from the bottom 2 rows.

Results and Discussion: The decoupling between adjacent elements of the same row, decoupled inductively, was at least -20dB. Geometric decoupling is less efficient (-11dB on average), probably due to capacitive coupling between the overlapped conductor tracks. Phase length needed to optimize preamplifier decoupling was realized by using semi flexible sucoform cables assembled in front of the preamplifiers. Figures 4 a and b are initial results acquired with the first 15 receive elements with the transmit coil driven in quadrature. The weaker signal seen in the top brain region on the sagittal and coronal slices is due to the limited coverage offered by the 15 receive elements. Signal voids due to inhomogeneous transmit B_1 is highlighted in these images and this could be eliminated using slice selective RF shimming [2].

Conclusion: A 15-element receive only head coil and detunable 16 element transmit array were constructed for human MRI at 9.4T. Along with the high SNR evident from these initial results, transmit field inhomogeneities can also be seen which could be mitigated by RF shimming methods.

Fig. 3: The complete RF setup with the Tx array, Rx array and the preamplifier assembly

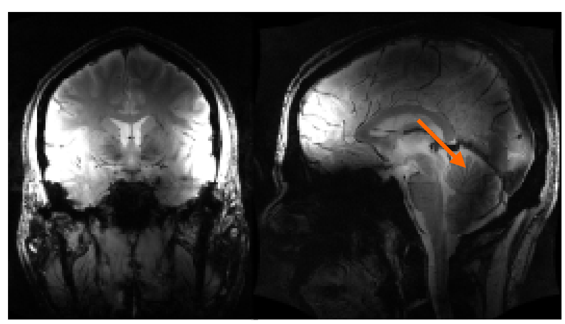

Fig 4: Coronal and Sagittal slices acquired with 15 elements of the receive array. Signal dropout due to transmit B_1 inhomogeneity is highlighted. The transmit coil is driven in the quadrature mode.

References:
[1] Van de Moortele PF et al. MRM 54, 1503-1518(2005),
[2] Hoffmann J et al. Proc. ISMRM 2010 p1470,
[3] Wiggins GC et al. Proc. ISMRM 2006 p415,
[4] Ledden PJ et al. Proc. ISMRM 2007 p242.