A 700MHz Receive Array using Patch Antenna for Spin Excitation

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Introduction: The concept of MR phased arrays [1], widely used to enhance the SNR in MR experiments, requires a large volume resonator for homogenous excitation and a multiple of smaller receive coils arranged over a large FOV. The RF fields produced by the conventional volume resonators suffer from interference effects due to shorter wavelength at higher magnetic fields, leading to volume coil designs with multi-port excitation or transceiver arrays. These designs are sensitive to changes in load and also lead to great cabling complexity especially in animal scanners with small bore size. The traveling wave concept [2] is significantly simpler to implement and has the potential to provide more uniform excitation over large volumes. We demonstrate the feasibility of MR imaging at 16.4T using a patch antenna for spin excitation and a 3-channel receive array optimized for signal reception in the rat brain.

Methods: Experiments were performed on a 16.4T, 26 cm horizontal bore magnet (Magnex Scientific, UK) attached to a BioSpec spectrometer (Bruker BioSpin MRI GmbH, Germany). A linearly polarized patch antenna (Fig.1) was constructed on a 6 mm thick ceramic slab (ε_r =9.6) of diameter 110mm. The radiating patch is 60 mm in diameter. To reduce eddy currents, the ground plane and the radiating patch are formed with meshed copper laid on kapton film. The transmit antenna is placed 4 cm away from the receive array. For signal reception, 3 equal sized coil elements with 25 mm longitudinal coverage were laid out on a semi cylindrical Teflon former (Fig.2). Geometric overlap reduces the inductive coupling between the neighboring coil elements while an inductive transformer decouples the next nearest elements. During the transmit mode, the receive elements are actively detuned by a PIN diode (MA4P7452F, MACOM) across the input circuit (Fig. 4). The receive-signals are amplified using custom built 2-stage low noise amplifiers (Gain 27dB, NF = 0.65dB). The preamplifiers are modular and are assembled onto a mother-board placed behind the transmit antenna. The coil elements are tuned and matched to a tissue equivalent rat brain phantom [3]. The SNR of the receive array was compared to a custom built shielded quadrature T/R surface coil with same physical dimensions. The RF power required to produce a 90^0 flip angle at the cortex region was determined. The SNR was estimated from fully relaxed images acquired using identical acquisition parameters. The reconstructed images of the array were combined as the sum of squares.

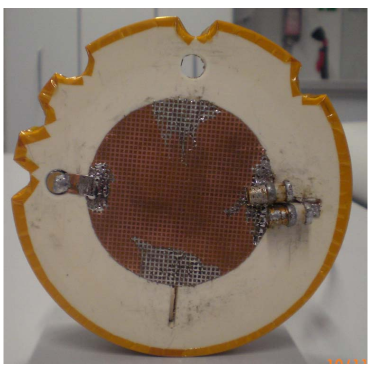

Fig.1: Capacitive tunable linear patch antenna. The slots along the edges are provided for cable routing.

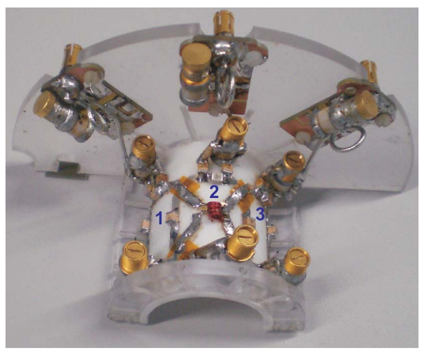

Fig. 2: 3-Channel receive array. The balun in the input circuit is mounted on the vertical plate.

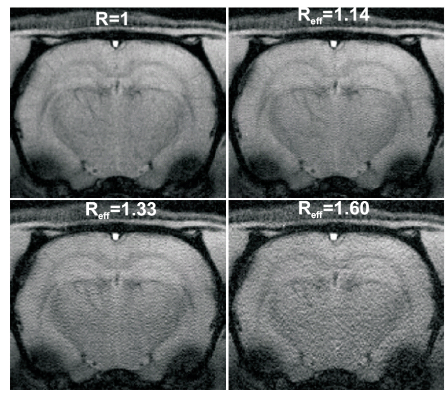

Fig.3: Initial accelerated images of the rat brain

Results and Discussion: S11 for each coil element was better than -25dB and the S12 isolation between the coil elements was better than -16dB. The SNR of the receive array is equivalent to that of the T/R quadrature surface coil. Among the 3 coil elements, the SNR of the middle element is significantly higher than the other 2 elements. The coil elements 1 and 3 are predominantly oriented towards the L/R direction. The transmit antenna polarization is along the A/P direction and hence the volume closer to elements 1 and 3 has a lower flip angle. Circularly polarizing the transmit antenna will improve the flip angle distribution along the L/R direction and hence enhances the signal received by coil elements 1 and 3, thereby increasing the overall SNR of this receive array. Initial imaging with the coil shows good results when accelerated imaging techniques are used (Fig.3).

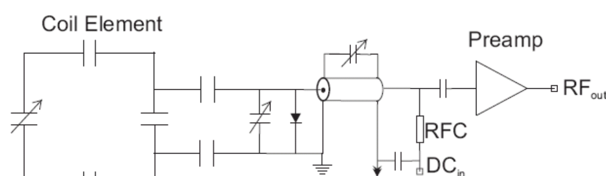

Fig.4: Circuit schematic of the receive chain

Conclusion: A novel Tx-Rx method that greatly simplifies an MR experiment especially for ultra high field animal scanners was developed. This concept can be extended to higher channel count receive coils to exploit the advantages of parallel imaging techniques on small animals.

References:

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