

RF Coil Array for Accelerated Excitation in Three Dimensions

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Introduction Since the seminal paper from Roemer et al [1], coil arrays have found widespread application in MRI. With the introduction of high field scanners and the concomitant problems of RF field homogeneity, arrays have also been utilised for transmission. Most of the TX arrays use elements oriented along the z-direction of the scanner, e.g. microstrips, because of their low coupling properties. However, the sensitivities of these elements do not vary along z so that transmit acceleration is only possible in maximal two directions. Recently a transmit system using a stacked array of coils that is operated in time duplex has been described [2]. We extend this idea to a three-dimensional loop array for transmission and present first imaging results in a 9.4T high-field system.

Method Because of the large bore diameter of our 9.4T system, the high sensitivity of loops and the low overlap of their sensitivity profiles [3], we have opted to employ these as fundamental building blocks. In an exemplary investigation we have evaluated the performance of the three geometrical arrangements shown in Fig. 1 – each consisting of four elements – against transmit array performance measures (condition number of the sensitivity matrix [4], transmit g-factor [5] and simulated excitation accuracy [6]). The stacked loop array performed best except for transversal slices at the upper and lower extension of the coil. However, since performance was better in other areas and peak SAR of the excitation pulses was smaller for the stacked coil design we chose to implement this design for use *in vivo*. As we also noted an increased (receive) g-factor in outer transversal slices the array was realised with 16 elements which act independently during reception while neighbouring loops are combined to form 8 transmit coils. For comparison an eight-element transceiver array without sensitivity variation in z-direction was constructed. Both coils are shown in Fig. 2.

Results Fig. 3 shows the measured B_1^+ sensitivities in $\mu\text{T/V}$ of the realized array acquired using the AFI sequence with spoiling improvements [7, 8] applied in an interferometric experiment [9] and a phantom matched to average brain tissue properties. Clearly, transmit sensitivity variations are visible along the z-direction albeit with the usual deteriorations commonly encountered in high field systems. First results of B_1 shimming with the 2x8 element array are shown in Fig. 4 along with an *in vivo* image acquired without shimming.

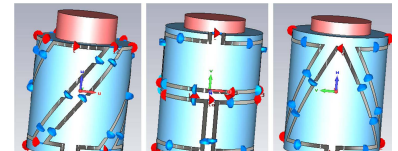


Figure 1: Simulated coil arrays

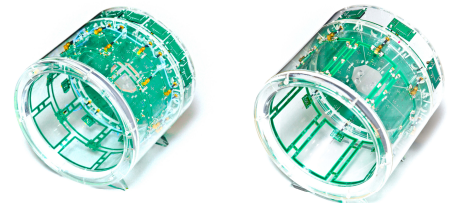


Figure 2: Realized coil arrays

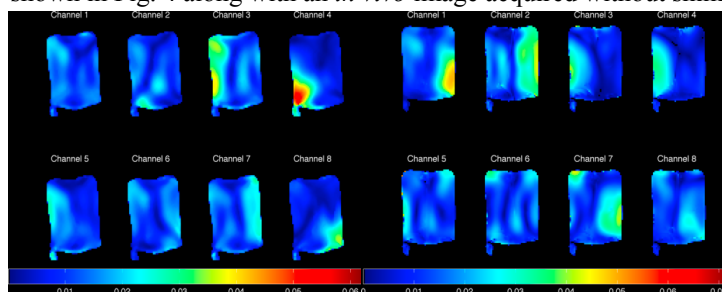


Figure 3: B_1^+ sensitivities in $\mu\text{T/V}$ (sagittal) for the stacked (left) and the conventional array (right)

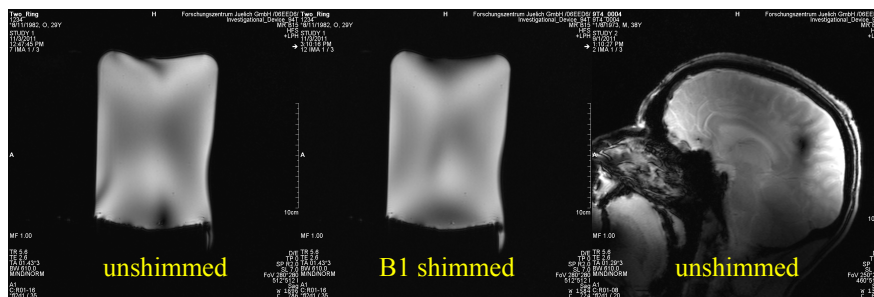


Figure 4: B_1 shimming and *in vivo* image

Discussion Stacking elements in the z-direction provides a simple implementation of arrays capable of three-dimensional accelerated excitation. Drawback is slightly reduced excitation fidelity at the top and bottom of the coil because a lower number of elements – when keeping the number of transmitter channels fixed – has significant transmit sensitivity in these areas. This can be alleviated by combining multiple elements during transmission while individually receiving with each coil. We have gained permission from the federal government agencies to apply the coil arrays in a running clinical trial and are currently working on *in vivo* shimmed imaging and selective excitation for further evaluation of the proposed coil arrays.

Literature [1] Roemer et al., MRM 16:192-225 (1990), [2] Nicolai et al., Proc. ISMRM 2011, 163 [3] Vahedipour et al., Proc. ESMB 2011, 61 [4] Morell, IEEE Trans. Med. Imag. 29:523-30 (2010) [5] Zhu, Proc. ISMRM 2006, 599 [6] Krämer, Diploma thesis, RWTH Aachen, 2011 [7] Yarnykh et al., MRM 57:192-200 (2007) [8] Nehrke et al., MRM 61:84-92 (2009) [9] Brunner et al., MRM 61:1480-1488 (2009)