Novel Splittable N-Tx/2N-Rx Transceiver Phased Array to Optimize both SNR and Transmit Efficiency at 9.4 T

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Introduction: Ultra-high field (UHF) ($\geq$ 7T) transceiver (Tx/Rx) head phased arrays with a tight fit have been shown to improve transmit (Tx) efficiency (1,2) in comparison to Tx-only arrays, which are usually larger to fit receive-only (RX) arrays inside (3). However, increasing the number of elements in head transceiver arrays above 16 is rather difficult and unpractical due to difficulties in decoupling and the limited number of available independent Tx-channels (commonly 8 or 16). At the same time the number of Rx-elements needs to be higher (e.g. $\geq$ 32) to satisfy requirements for parallel reception and SNR comparable with currently available nested UHF Tx-only/ Rx-only arrays (3). In this work, we developed and constructed a 4-channel Tx / 8-channel Rx prototype of a novel splittable transceiver phased array at 9.4 T (400 MHz). The splittable array allows doubling the number of Rx-elements without necessity of moving the Tx-elements further away from the subject. Both Tx and Rx performance can be optimized at the same time using this technology.

Methods: The array (Fig.1) consists of 4 flat surface Tx-loops (8 x 9 cm). Each loop can be split into two smaller overlapped Rx-loops during the reception (Fig. 1B). Splitting is provided by 4 PIN diode switches, S_1, S_2 (Fig.1B). During transmission four larger loops are produced by shortening S_1 and opening S_2 switches. High impedance of open S_2 switches also provides protection of preamplifiers. Open S_1 and shortened S_2 switches produce a set of two smaller Rx-loops during reception. All 4 switches are connected in series and driven from the same 100 mA current source. During transmission the large loops are decoupled using transformer (1) and RID (4) decoupling. Additionally during reception the smaller Rx-loops are decoupled by overlapping and preamplifier decoupling. The array can also be used in 4-channel transceiver mode without splitting using an additional home-built 4-channel interface with 4 T/R switches and 4 preamplifiers. In both modes - 4 channel transceiver and 4 channel Tx / 8 channel Rx - a 4-way splitter with 100º phase shift (based on EM simulations) between the loops was used during transmission. B_1^+ maps were obtained using the AFI sequence (5) and a rectangular phantom (26 x 20 x 12 cm) matching tissue properties (ε=58.6, σ=0.64 S/m) (3). Experimental SNR and g-factor maps were obtained using non-accelerated and GRAPPA accelerated gradient echo imaging (GRE) with acceleration factors (AF) from 2 to 4 as described in (3) for comparison of the 4-channel versus 8-channel Rx modes. Data were acquired on the Siemens Magnetom whole body 9.4T human MRI system.

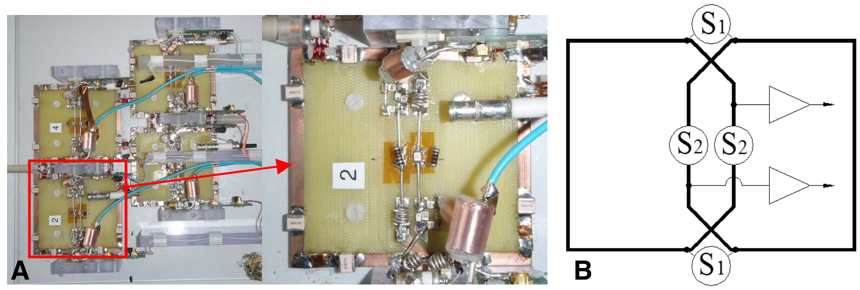

***Fig. 1**: Photo (A) and the schematic (B) of the splittable phased array.*

Results and Discussion: Fig.2 shows experimental data including B_1^+, SNR and g-factor maps obtained using the splittable phased array in either 4 or 8-channel Rx mode for the same coronal slice located near the surface of the array. Table 1 shows experimental g-factor values averaged over the entire slice, which were obtained using GRAPPA with different AFs. As seen from the data the prototype setup is fully functioning in both Tx and Rx modes and both SNR and parallel reception were substantially improved by doubling the number of Rx-elements from 4 to 8. The total number of array elements can be further extended and their arrangement adapted to future head or body applications at different field strength. Also the direction of splitting can be chosen depending on the most beneficial direction of acceleration. Alternatively, Tx-elements splittable into an even larger number of Rx-elements (e.g. 4 or 8) would allow acceleration in both directions.

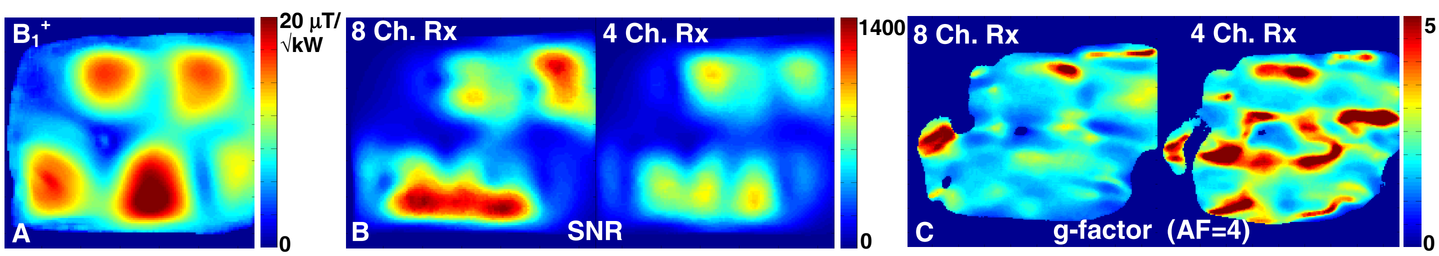

***Figure 2**: Tx B_1^+ (A), SNR (B), and g-factor (C) maps obtained for the same coronal slice near the loops using 4 and 8 channel reception.*

AF	2	3	4
8 Ch	0.96	1.48	1.91
4 Ch	1.07	1.80	2.71

***Table 1**: Experimental average g-factors obtained using 8 small versus 4 large Rx loops with different acceleration factors.*

Conclusions: As a proof of concept we developed and constructed a novel splittable transceiver phased array, which allows doubling the number of Rx-channels without necessity of moving the Tx-elements further away from the subject. Both Tx and Rx performance can be optimized at the same time using this method.

References: 1) Avdievich NI et al, Appl. Magn Res, 41:483, 2011. 2) Avdievich NI et al, Proc. ISMRM 22, 2014, p 622. 3) Shajan G, MRM, 71:870, 2014.4) Avdievich NI et al, NMR in Biomed, 26:1547, 2013. 5) Pohmann R, Scheffler K, NMR in Biomed, 26:265, 2013.