5 Decoupled Sets of Coupled Coils: An 8-20 Channel Subject-Insensitive Array for 7T Applications.

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Introduction: Recent results of PTX approaches [1-3] have emerged as answers for alleviating the RF inhomogeneity issues as well as the, potentially unsafe, local and global RF power deposition associated with ultrahigh field human MRI. Several major obstacles have dampened the enthusiasm for widespread implementation of parallel transmission methods for ultrahigh field imaging including: 1) the need for accurate B_1^+ field mapping, 2) coil and subject dependent increases in local/global SAR at low flip angles as a result of RF excitation (B_1^+ field) losses, and 3) concerns regarding the unclear RF safety assurance of the PTX experiment due to inappropriate electromagnetic models for the estimation of the SAR at ultra-high fields (mapping the B_1^+ field does not provide the complete picture of the electric field and thus power deposition.) The work aims at alleviating these issues through the extension of the 4-port Tic Tac Toe coil [4] to a more elaborate (covers the whole head volume,) 8-20 Tx channel, subject insensitive array for imaging at ultra high fields.

Methods: The current configuration of the 5-sided multi-transmit array contains 2 2X2 sides, 1 1X2 side, and 2 1X3 sides. This design was realized from extensive simulations and practicality (photograph of the array is shown in Fig. 1.

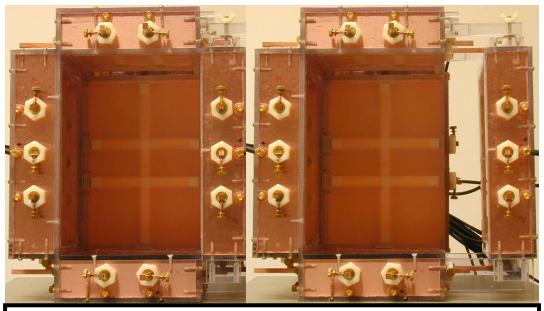

Fig. 1: Photograph of the 5-sided, geometrically-adjustable, subject-insensitive multi-transmit array (8, 16, or 20 Tx ports.)

Results and Discussion: The coupling matrix of the loaded 5-sided array is shown in Fig. 2. The strong coupling in this design exists only between elements on an array side, minimal coupling (maximum of -15.4dB and an average well below -25dB) is observed between elements on different sides (thus marinating the subject-insensitivity attribute.) In our tuning of the 5-sided RF array, we did not attempt to decouple the sides; rather we only focused on tuning every element of interest. Thus, it is possible to further lower the side to side coupling.

As we currently posses an 8-channel transmit array, the 5-sided coil was tested using 8-ports (front and back Tx port or top and sides Tx ports.) Figs 3-5 shows wide variety of B_1^+ shimming results on 4 different subjects (as of to date this coil has been successfully tested on a total of 6 subjects.) The results show excellent insensitivity to different subjects as the B_1^+ maps were seamlessly exchanged between different subjects with minimal (if any) observable effects on the design of the B_1^+ shimming patterns. Clearly the B_1^+ field distribution is dominated by positioning in the coil geometry rather than in the subject as the designed excitation patterns are observed in the same coil positioning.

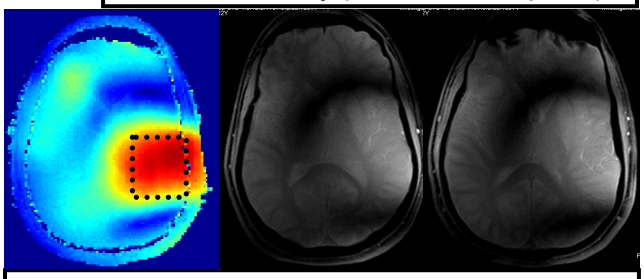

Fig 4: Left: Subject **A**: Experimentally measured B_1^+ map (optimized for localization in the dotted box) using B_1^+ shimming (8 ports.) Middle: Subject **A**: Corresponding image. Right: Subject **B**: 128x128 image obtained without B_1^+ measurements and with the exact pulses that was utilized for Subject **A**. The coil was not retuned or re-matched between the two subjects.

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1. Adriany, G., et al., MRM, 2005. **53**: p. 434-45.
2. Alagappan, V., et al. in *ISMRM*. 2006. Seattle.
3. Ohliger, M.A., et al., MRM, 2005. : p. 1248-60.
4. Ibrahim, T.S., et al. *ISMRM* 2008. Toronto.

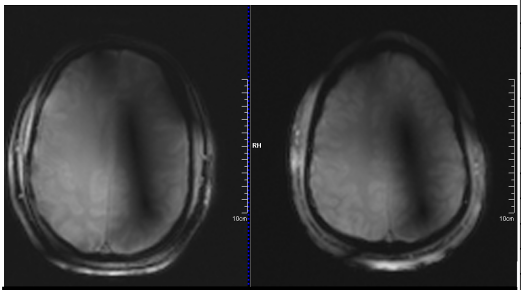

Fig 3: Left: Subject **C**: 128x128 image obtained using arbitrary but 8 specified amplitudes/phases. Right: Subject **D**: image obtained with the same amplitudes & phases.

Side /Port # on Side	1 L1	2 L2	3 L3	4 R1	5 R2	6 R3	7 B1	8 B2	9 T1	10 T2	11 T3	12 T4	13 BO1	14 BO2	15 BO3	16 BO4
1 L1	-30	-7.4	-5.4	-16.3	-17.3	-30	-16.8	-15.3	-22	-20	-29.2	-25	-20.8	-22.7	-20.9	-22.5
2 L2		-30	-5.9	-19.2	-16	-23	-15.3	-18.9	-22	-32	-24.5	-33	-20.4	-18.8	-21.4	-20.7
3 L3			-21	-25.4	-34.1	-30	-17.4	-15.4	-28.2	-22	-30.6	-28	-43.1	-27.5	-30.5	-33.1
4 R1				-23	-7.7	-7	-16.7	-16.7	-18.3	-22	-18	-18	-27.2	-22.3	-27.7	-19.7
5 R2					-23	-7	-21.6	-18.6	-21.5	-21	-22.6	-20	-18.2	-26.7	-17.3	-20.4
6 R3						-21	-15.5	-16.9	-23.4	-33	-23.7	-25	-19.4	-31.9	-19.3	-26.3
7 B1		L = Left side					-18	-8.7	-29.3	-25	-36.2	-26	-35.3	-18.2	-36.3	-19.2
8 B2		R = Right side						-20	-19.2	-19	-25.6	-21	-21.3	-26.2	-21.9	-28.2
9 T1		B = Back							-26	-8.1	-2.5	-9.9	-29.6	-28.9	-27.5	-28.5
10 T2		T = Top								-22	-10	-2.4	-35.3	-24.6	-35.6	-23.4
11 T3		BO = Bottom									-26	-8.2	-27.7	-31.1	-26.5	-30.6
12 T4												-28	-46.4	-23.2	-43.4	-23.1
13 BO1		Represents Coupling (Sxy) Between Sides											-26	-10.7	-2.3	-8.4
14 BO2		Represents Matching (Sxx): Distributed Caps (No Lumped Elements)												-24	-8.6	-2.3
15 BO3		Represents Coupling on the Same Side													-22	-12
16 BO4		Represents Highest Coupling between Sides														-23

Fig. 2: Coupling & Matching (Sxy,Sxx) Measurements for the Loaded, 5-Sided, 16-Port Tx Array.

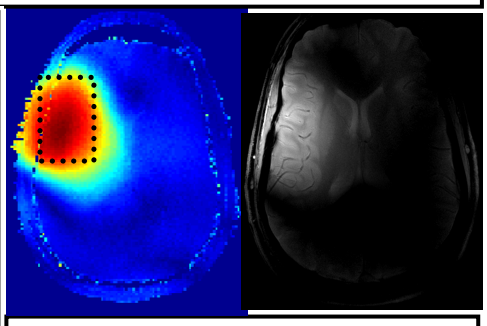

Fig 5: Left: Subject **A**: Experimentally measured B_1^+ map (optimized for localization) using B_1^+ shimming. Right: Subject **B**: 512x512 image obtained without specific B_1^+ measurements and with the exact pulses that was utilized for Subject **A**. The coil was not retuned or re-matched between subjects.