Comparison of Three Transmit Arrays for Parallel Transmit

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Introduction: The inhomogeneous transmit B1 pattern in conventional volume coils at higher field strengths has motivated the development of new RF excitation strategies with multiple transmit channels. The array approach allows the transmit B1 field inhomogeneity to be addressed by B1 shimming[1] or by using accelerated spatially tailored 2D or 3D RF pulses[2]. There are number of challenges encountered in the development of transmit array coil at high field strengths, the most significant one among them being the decoupling with the neighboring elements. In this paper we constructed three 8-channel transmit array coil designs and studied their relative merits for accelerating spatially tailored 2D RF pulses. The designs included an array of overlapping circular coils ("loop array coil"), a strip line array and a Degenerate Birdcage Coil (DBC). The DBC coil was used in two configurations, by either exciting each loop in the birdcage separately ("loop array basis set") or by driving the loops with the birdcage mode phase relationships via a Butler matrix ("orthogonal BC mode basis set").

Methods: All the coils were tested on a prototype 3T MAGNETOM Trio, A Tim System (Siemens Medical Solutions, Erlangen, Germany) with 8 independent transmit channels. All the coils were made on a 28 cm o.d acrylic tube. Each of the coil loops contained a series pin diode controlled with a bias to detune the coil (with a reverse bias) if an additional coil was in use. For the results shown, we used the uniform body RF coil for reception. RF Cable traps were added to the coaxial cable to reduce cable interactions and a TR switch was used to block noise from the power amplifiers. To compare the performance of parallel excitation with the different coils a 4 fold accelerated (4X) 2D spatial pattern ("MIT logo") was created by transmission during a 4X accelerated spiral gradient trajectory. An RF shimming experiment was also performed by optimizing for a uniform target profile with a slice selective excitation with amplitude and phases calculated using the same parallel TX formalism [3]. All experiments were performed on a 17cm dia oil phantom with loading ring. Correlation co-efficients between the observed image and the target excitation pattern were computed for each array for R=4X acceleration and the coefficient of variation (S.D/Mean) was measured in the homogenous excitation (RF shimming) experiment. The relative transmit efficiency was measured in the center of the phantom and expressed as the B1 field in µT for a 100V RF input and a 8 ms long sinc-like pulse, by fitting the signal intensity in GRE images acquired with 6 different transmit powers to the expected flip angle relationship.

Fig 1: Parallel Transmit coils, the constructed overlapped loop coil, stripline coil and the degenerate birdcage coil (left to right).

Results & Conclusion: Fig 1 shows the constructed coils. Figure 2 shows the excitation B1 amplitude and phase profiles of the various modes, measured by exciting the modes one at a time and receiving with the RF body coil. Fig 3 shows the obtained results for the R=4x 2D excitation and the single spoke homogenous slice selection with the different coils. The coupling, transmit efficiency, correlation factor of the R=4x accelerated image with the target profile and the coefficient of variation in the homogenous single spoke slice selection are summarized in Table 1. The stripline based array showed a lower artifact burden for the 2D spatial pattern and the least homogeneity for the spokes and the least efficient B1 field than the other coils. The loop based array has a good trade-off between B1 efficiency and artifact burden, while the DBC coil when used as a orthogonal birdcage basis set, with its efficient uniform mode, gave the second best artifact load, the highest B1 homogeneity, and most efficient production of B1 in the phantom center (uniform mode).

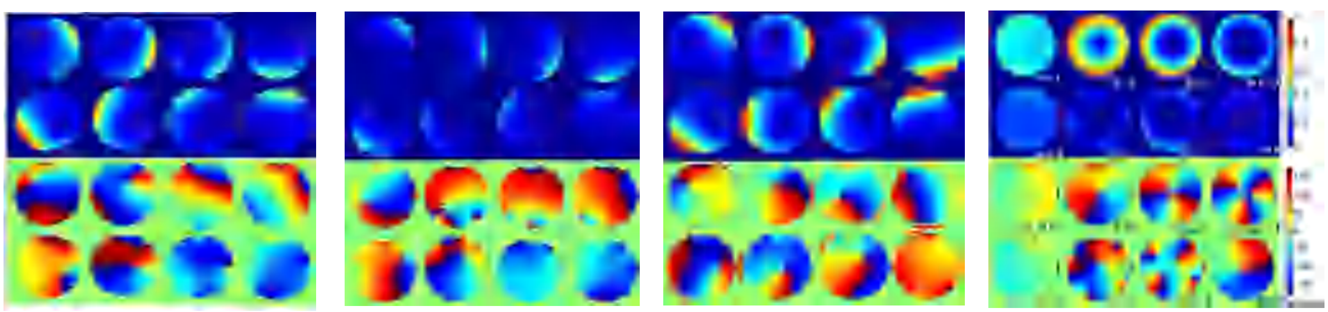

Fig 2: The normalized amplitude and phase of the excitation profile of the overlapped loop, stripline coil, DBC loop coil, DBC orthogonal BC coil (L to R)

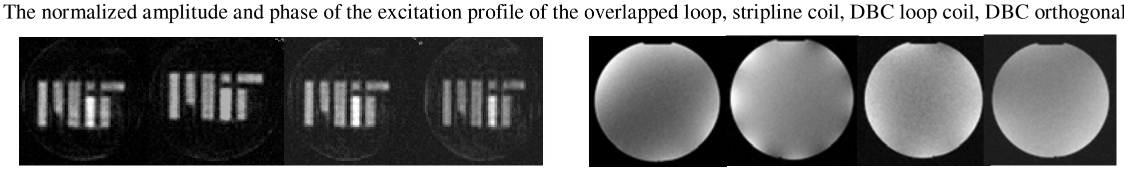

Fig 3: The R=4x 2D excitation and the homogenous excitation with the overlapped loop, stripline coil, DBC loop coil, DBC orthogonal BC modes (L to R)

Coil parameter	Loop array	Strip line array	DBC, loop basis set	DBC, orthogonal BC modes
Average S_{12} (dB) coupling	**- 17.06 dB**	**-26.4 dB**	**-20.17 dB**	**-32.3 dB**
B_1 (uT) at center	**2.03 µT**	**1.15 µT**	**2.6 µT**	**4.26 µT (uniform mode)**
Correlation factor R= 4x	**95.6 %**	**96.02 %**	**95.7 %**	**95.84 %**
Co-eff variation, homogenous slice selecion	**20.05%**	**20.7%**	**16.48%**	**15.26%**

Table 1: The Coil comparison parameters

1. Collins, C.M., et al., *Combination of optimized transmit arrays homogeneous images at very high frequencies.* Magn Reson Med, 2005. **54**(6): p. 1327-32.
2. Stenger V.A, et al, *B1 inhomogeneity reduction with transmit SENSE.* Proceedings of the 2nd international workshop on parallel MRI, Zurich, 2004: p. 94.
3. Setsompop, K., et al., *Parallel RF Transmission with Eight Channels at 3 Tesla.* Magn Reson Med, 2006. **56**(5): p. 1163-1171.

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