20-Ch Tx Modular Array for 7T PTX Applications

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Introduction: The use of multi-channel Tx coils at 7T is common practice to address issues of RF control through Tx SENSE and/or B1 shimming. The underlying principle of these existing coils is that transmit RF field distributions are a function of the network of elements (antennas) as a whole, rather than the additive effect of individual constituents, due to the practical limit of the isolation and coupling between elements. For example, in a TEM coil, if the RF profile was to be optimized by the ad hoc addition of targeted RF structures (elements TEM coil), all of the excitation ports in the coil would be affected to varying degrees and elements would risk being pushed into sub-optimal operating modes. The lack of isolation between functional elements does not enable them to superimpose without consideration for the entire system. In this work, we present the design of a modular transmit head array from sets of coils with highly-coupled elements. The 20-ch Tx array is subject-insensitive and no RF field measurements are needed. Rather one set of RF field measured or numerically obtained can be utilized.

Theory: This design proposes to create a system of isolated coil panels that can be conveniently substituted with each other to affect predictable changes in the RF field. Due to the high degree of isolation between panels, the RF distribution of each set can be defined independently of the other coils in the configuration. Within a set, the high coupling between elements dominates any interactions with other panels. As such, the user can perform hardware optimizations to tailor the RF field to given subject or excitation pattern in a specific volume. Attempts have been made at designing modular receive arrays at high field [1], but this is a first of a kind attempt for a transmit head coil built specifically for UHF strengths and for parallel transmission. The coil designed is capable of 20-ch transmission and was successfully tested in phantoms and in-vivo at 7T.

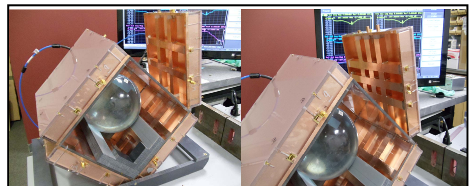

Fig. 1: 20-Ch Tx Modular head Array. a.) 2x2 coil & b.) 3x3 coil being added.

Methods: The modular head coil was constructed from a selection of five square, highly-coupled coil panels to an open box. Fig. 1 shows the head coil constructed with two variations of panels: a.) a 2x2 element and b.) a 3x3 element. Each panel has 4 independent TX channels. A quantitative measure of the coil sensitivity to the presence of different geometries was obtained by measuring the S-Matrix for cases were all panels are 2x2, a 3x3 panel is substituted on top and a 3x3 panel is subtitled on the side. The baseline configuration was taken as a coil composed entirely of 2x2 element panels. All coupling measurements are for a human head load (Fig. 2) shows when switching between the 2x2 and 3x3 panels, the coupling between channels on a side is virtually unchanged.

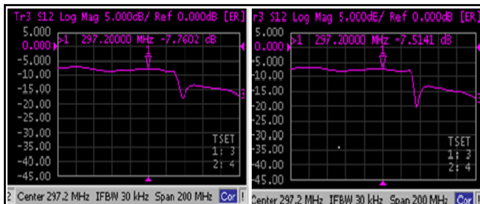

Fig. 2: Coupling between adjacent elements on a side in the 20-Ch Tx/Rx 7T modular head coil loaded with a human head. Left side is S34 of side 1 with all other sides and top are 2x2. Right side is the same with all other sides are 2x2 and top is 3x3.

Results and Discussion: GRE images were then taken over several slices in each plane of the coil, for an arbitrary of excitation patterns of the four elements, on each of the three panel configurations to approximate the B1 field. Data was collected for a spherical water phantom and a human subject. Images across the aforementioned configurations were compared to identify the sensitivity of transmit field to changes in other coils. The results are shown in Fig. 3. The field pattern is consistent with changing a panel.

Figs 4 shows wide variety of B1 shimming results on sample 4 different subjects (15 different subjects have been imaged using this modular coil.) The B1 maps were interchanged between subjects and the Tx Pulse design was directly implemented from one subject to another. The results show excellent insensitivity to different subjects as the B1 maps were seamlessly exchanged between different subjects with minimal (if any) observable effects on the design of the B1 shimming patterns. The B1 field distribution is dominated by positioning in the coil geometry rather than in the subject. The modular coil has no distinctive rotation, thus resulting in comparable field coverage in the axial plane and in the z direction.

2x2 Panels Only	Side Panel replaced by 3x3

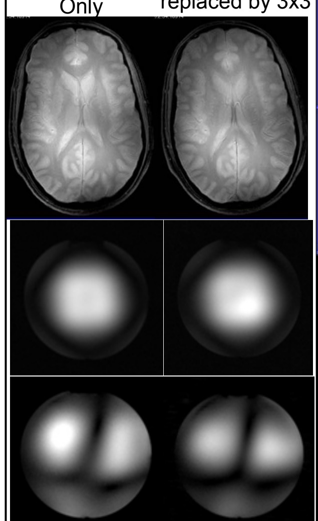

Fig. 3: In-vivo and phantom GRE images for the test configurations of the modular head coil.

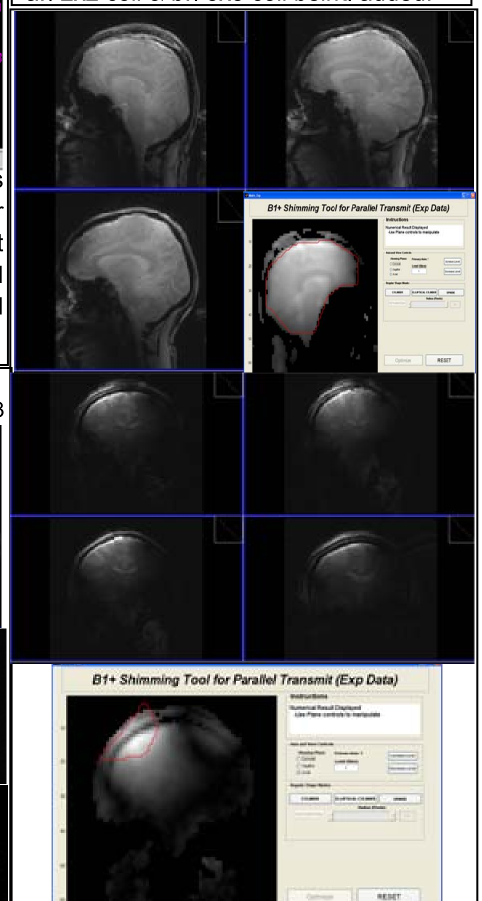

Fig 4. Homogenous & localized B1 shimming. Studies have been performed on 15 subjects with one set of B1 maps and tuning (one field set fits all.) Sample is shown on 4 subjects.

References: De Zanche, N., et. al. NMR Biomed, p.644-654, 2008.
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