Multiplexed RF Transmission for Transceiver Arrays at 7T

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Introduction: At high frequency (7T head, 3T body), large transmit single drive volume coils suffer from poor homogeneity and low efficiency. Transceiver arrays provide improved homogeneity and transmission efficiency; however their use is limited by longitudinal coverage and SNR concerns. These limitations can be overcome by increasing the number of coils in the transceiver array by use of multiple rows of smaller coils along the z axis (Fig 1). This increases both longitudinal coverage and SNR. However this approach requires more independent transmit channels (one per coil), which is costly and not available on clinical platforms. Splitting the power of one channel to drive two coils in the array is ineffective, as the required phase and amplitude relationships between any two coils will vary depending on loading. Thus the goal of this work was to develop pulse sequence methods that enable a small number of independent transmit channels (4 or 8) to drive transceiver arrays with larger numbers of coils (8 or 16).

Methods: All studies were performed on a 7T human system using an 8 (Fig 1A) or 16 coil transceiver (2 rows x 8 coils per row) array (Fig 1B) and using 4 or 8 independent channels. To drive 16 coils with only 8 transmit channels within a single TR, high power PIN diodes switches were used to route the output to different RF coils in the arrays.

Results: Theoretically, performance virtually equivalent to true simultaneous transmission can be achieved by temporally concatenating or interdigitating the rf pulses to different coil groups, provided the phase precession between pulses and the rotation angle of any individual pulse in the waveform is small. For 3D acquisitions using low angle non-selective pulses, the waveforms can be concatenated at the end of each pulse (Fig 2A). Displayed in Fig 2B and C are 3D images (sagittal) using 8 transmit channels to drive an 8 element array (true simultaneous transmission, Fig.2B) or the 16 element array (concatenated waveform, Fig. 2C). Note the absence of image artifacts for the region between the two coil arrays (corpus callosum) and increase in spatial coverage for the 16 coil array.

Fig 1A

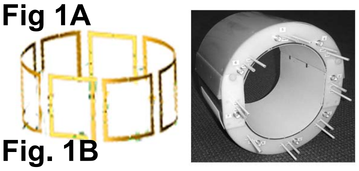


Fig. 1B

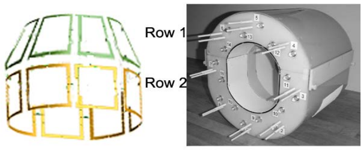
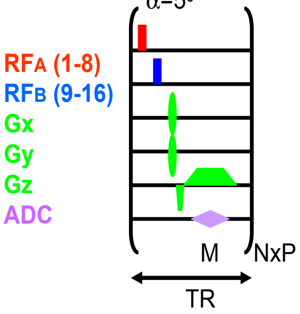
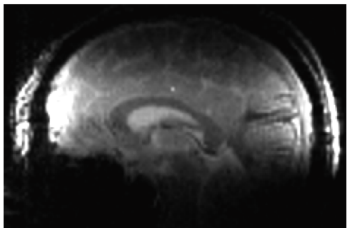


Fig 2A



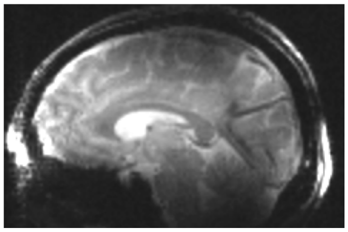
2B

Simultaneous Tx - 8 Channel Array



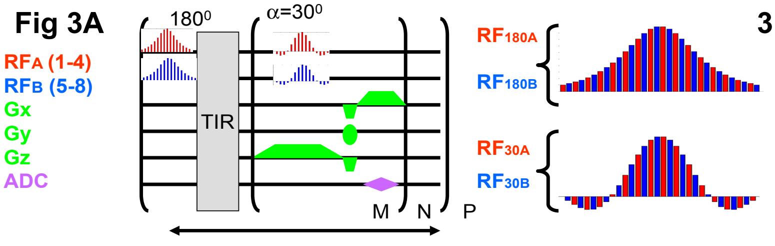
2C

Concatenated Tx - 16 Channel Array



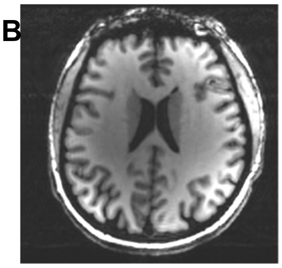
For slice selective imaging sequences or sequences using adiabatic pulses, to satisfy the criteria listed above, the waveforms to different coil groups need to be interdigitated (Fig 3A). With short inter-pulse intervals, 20us, the sidebands of excitation, 50kHz, can be placed outside of the sample or spatial envelopes of the coils. The images displayed in Figs 3B and C were acquired using simultaneous transmission to all 8 (Fig. 3B) or with interdigitated waveforms (pulse sequence Fig. 3A) for both the adiabatic inversion and slice selective pulses (Fig. 3C). The axial images are virtually indistinguishable.

Fig 3A



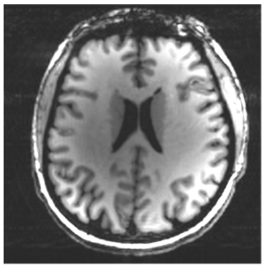
3B

Simultaneous Tx 1-8



3C

Interdigitated Tx 1-4 & 5-8



Conclusions: We have shown that homogeneous excitation for multiple row transceiver arrays can be achieved using a smaller number of independent RF channels with appropriate pulse sequence methods and coil symmetry. Although we have used 4 or 8 transmit channels to drive 8 or 16 coils, the method can be easily extended to larger numbers of transmit coils (24 or 32) while retaining the same number of independent transmit channels.