A flexible 8-channel RF transmit array system for parallel excitation

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Introduction: Imaging of human sized subjects at ultra high fields, such as 7T, suffers intrinsically from the interaction of the B1 field with the dielectric human tissue [1]. The B1 field distribution achievable is therefore significantly different to that experienced at lower field strengths. B1 shimming and TX-Sense acceleration [2,3,4,5] of otherwise lengthy RF pulses with tailored spatial profiles have been proposed to improve the homogeneity of the B1 field. With the exception of the 3 channel system of Ullman et al [6], previous parallel excitation work has been limited to modelling with a single TX channel system. In this work, we demonstrate a modular approach to adding TX channels to a clinical scanner. In addition to accelerating spatially tailored RF pulses, the system is well suited to multinuclear spectroscopy and ASL experiments utilizing multiple labelling coils, as well as dynamic shimming with up to 21 shim channels.

Method and results: An 8-channel TX proto type system was constructed and tested based on a Siemens 3T TRIO a Tim system MR scanner. Multiple duplicate versions of the gradient and RF waveform generation HW, the so-called PCI-TX module were configured in a master and slave configuration. The single master channel synchronizes the waveforms of the 7 slave PCI-TX systems. Each of the TX systems can drive 1 RF excitation channel and 3 gradient channels and support multiple MR frequencies (1H, 19F, 31P, 3He etc.) for which an independent sequence environment is implemented. Since one goal of the system was to allow spatially tailored RF excitation pulses to be played out during a fast spiral gradient trajectory, digital B_0 eddy current compensation of the RF was incorporated in each channel. Additionally an SAR monitoring system, RFSWD, is part of each of the 8kW RF excitation channels. While the 21 additional gradient channels were not utilized in this study, they could, in principle, be useful to drive dynamic shim channels as proposed by de Graaf et al. [7] The system was tested using an 8 channel head transmit coil [8]. Data were received with the standard body coil. A spiral gradient trajectory was used for accelerated Sense encoding [9] of a square box profile. Figure 2 shows 7 of the 8 individual coil element profiles and the resulting square box excitation (lower middle: w/o acceleration, lower right: with acceleration).

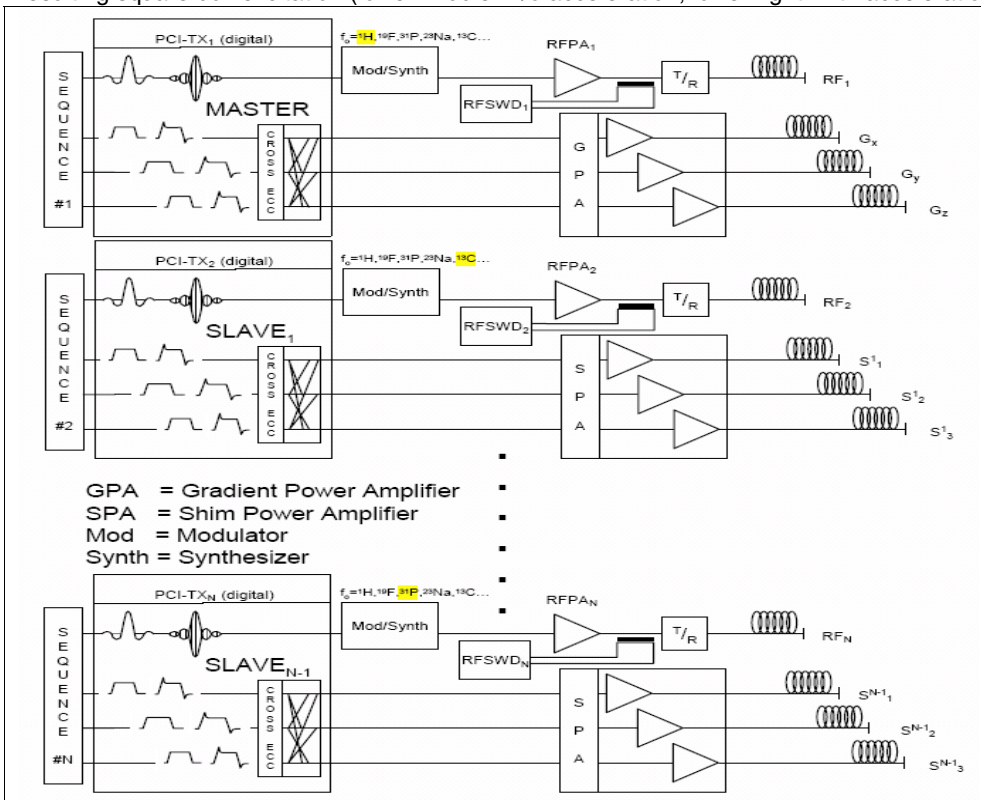

Figure 1: TX Array overview: A master PCI-TX is synchronized to 7 slaves

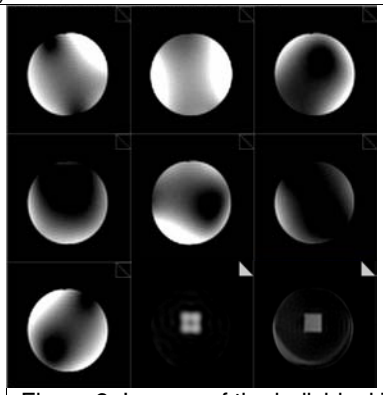

Figure 2: Images of the individual TX coil elements acquired with all 8 TX channels hooked up and resulting shaped excitation

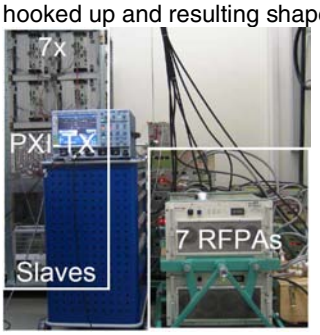

Figure 3: TX array setup

Conclusion: An 8 channel TX-array was build for multiple use. It fits into an extra cabinet of the same size as the standard host and contro cabinet (fig.3). The system topology allows the use for 1.5T, 3T and 7T systems. Besides B1 shimming and TX-Sense, ASL with externa labelling coils, decoupling MRS experiments using simultaneous TX and dynamic shimming can be performed with this setup as wel offering new possibilities for MR imaging and MR spectroscopy.

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