An MRI System with 128 Seamlessly Integrated Receive Channels for Multi-Nuclear Operation

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Introduction: Many groups are investigating the feasibility and advantages of array coils with an increasing number of coil elements beyond the industry standard of 16 to 32 channel systems. Several prototypes have been described with 64 channels [1], 96 channels [2], and with 128 channels [3, 4]. This paper describes the second 128 receive channel MR system installed at a customer site, based on a commercial 3T MAGNETOM Tim Trio, which allows the simultaneous acquisition and online reconstruction of images from 128 receivers. Unlike the system described in [3], this system offers multi-nuclear capability. Amongst many other options, this enables exploration of highly accelerated parallel imaging of hyperpolarized media. This combination of hyperpolarization with a very high number of receive elements represents an attractive proposition for a number of reasons: Firstly hyperpolarized media provide an initial boost of SNR based on the higher polarization compared to thermal polarization of protons. Secondly, the SNR in conventional thermally polarized parallel imaging is inevitably reduced by increasing acceleration factors, whereas hyperpolarized imaging works with a fixed pool of polarization that does not recover, and thus the flip angle for each excitation can be proportionally increased in the presence of acceleration, so that the SNR loss traditionally associated with parallel imaging may be mitigated or even eliminated [5, 6]. Furthermore, applications can be realized that critically depend on short scan intervals. As an example, we show 128 channel lung images with hyperpolarized helium (^{3}He).

Technical description: The system is based on a commercial 3T MAGNETOM Trio, A Tim System (Siemens Medical Solutions, Erlangen, Germany) equipped with 32 independent receive channels and an additional broadband RF power amplifier for x-nucleus operation, which is part of the standard multi-nuclear option. The system was expanded by one cabinet shown in Figure 1 that contains an additional 96 receivers. Together with the standard 32 receivers the system can simultaneously receive on a total of 128 independent channels and accepts signals from the following nuclei: ^{1}H, ^{19}F, ^{3}He, ^{31}P, ^{7}Li, ^{129}Xe, ^{23}Na, ^{13}C, and ^{17}O. Because hyperpolarized media are of special interest, a 128 element receive array (clam shell design with 8x8 elements on top and 8x8 elements on bottom as shown in Figure 2) also equipped with 2 hardware-combined transmit elements and tuned to ^{3}He frequency was constructed [7] and used to perform human lung imaging at helium frequency. First healthy volunteer lung images after inhalation of helium are shown in Figure 3. ^{3}He was polarized by spin exchange with an optically pumped rubidium vapor to the level of 35-45% using GE Healthcare helium polarizers. Helium diluted with N_2 to a net polarization level of 10% was transferred to 1 liter Tedlar plastic bags and delivered to the subject. A multislice 2D GRE sequence was used with the parameters: TR: 118 ms, TE: 2.9 ms, Flip Angle: uncalibrated, Excitation Pulse Amplitude: 350V, BW: 500 Hz/pixel, FOV: 400 x 400 mm^2, matrix size: 128×128, Slice thickness: 10 mm, Acquisition time: 15 sec. No acceleration was employed for this first experiment.

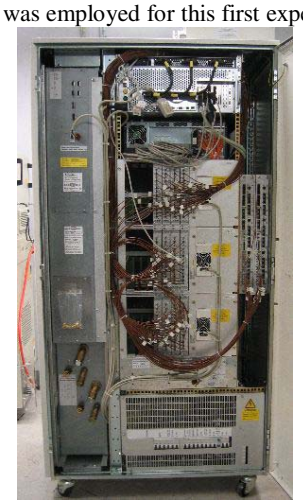

Figure 1: Additional electronics cabinet for seamless integration of additional 96 receivers

Figure 2: Photo of the 128 channel system with the 128 element lung array for hyperpolarized ^{3}He on the patient table

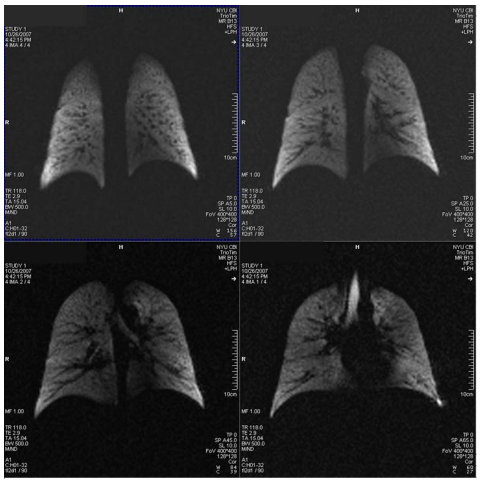

Figure 3: First volunteer images with a 2D GRE sequence (4 coronal slices)

Conclusion and perspective: The multi-nuclear 128 channel system was successfully tested with a 128 element lung array operating at helium frequency. The seamless integration of the additional hardware allowed the 128 channel images to be reconstructed using the standard reconstruction software on the scanner. Using hyperpolarized ^{3}He gas will allow the exploration of the frontiers of very high acceleration in parallel imaging.

References:

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