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A Parallel-Transmit Halbach Magnet TRASE MRI System

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We have designed and constructed a low-field TRASE RF imaging system. In TRASE k-space encoding is achieved by refocusing with RF phase gradients. The system includes a motorized rotatable magnet, twin RF power amplifiers, two geometric decoupled truncated twisted solenoid RF transmit coils (1D radial TRASE encoding), and a multi-channel transmit software-defined-radio console. The magnet is a 2.85 MHz 8-ring Halbach design (25 kg). All components are custom made. An inherent axial gradient of the inhomogeneous magnet function as slice selection. The unique feature of this imaging configuration is the simplicity. Two RF channels and rotation provide multi-slice projection reconstruction imaging.

Magnet: The constructed 66.7 mT magnet design with a measured homogeneity of 11,152 ppm in a 12.7 cm diameter, 1 cm long cylindrical region of interest. To rotate the Halbach magnet, we used a hybrid stepper motor and a 2-phase hybrid stepper servo driver. Angular precision is 0.04 deg.

RF Coils: Coils are based on a geometrically decoupled nested twisted solenoid design.
The RF coil set was a pair of truncated twisted solenoids (suitable for rotation experiments). In each case coils are geometrically decoupled (i.e. no PIN diode switching). Coil diameters were 100mm and 125mm with length 230mm. Imaging volume 80mm diam; 100mm length. Phase gradient strengths: 5.8deg/cm inner; 5.15 deg/cm outer coil.

NMR Console: A new parallel transmit console ('DNMR') was designed and built for this project. The console is based around an AD9106 4-channel 12-bit DAC and waveform generator ADC chip (180 MSPS, 24-bit tuning word), and an ADC-SoC FPGA-CPU board (Terasic).

Results: 1D TRASE profiles have been obtained at a series of angles. The main current limitation is that improved magnet homogeneity is required. Several shimming approaches being investigated will be discussed.

Conclusion: The concept behind this design was to minimize the technology requirements for MRI. A new robust configuration for low-field 2D multislice MRI has been presented. The minimal requirement is a rotatable inhomogeneous low-field magnet with axial gradient; two RF transmit channels; two twisted solenoids Tx coils, moderately well geometrically decoupled (˜ S12 -15 dB).

J. C. Sharp, S.B. King, MRI using radiofrequency magnetic field phase gradients, Magn. Reson. in Med. 63 (2010) 151–161. doi:10.1002/mrm.22188.

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