A Fast Field-Cycling MRI system for clinical applications

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Introduction: Fast Field-Cycling MRI[1] (FFC-MRI) is a novel MRI technique in which the external magnetic field is switched rapidly during the imaging experiment. By doing this, FFC-MRI grants access to information which is invisible to conventional MRI scanners, including the variation of T_1 with magnetic field which is known as T_1 dispersion. The construction of an MR imaging system capable of rapidly switching the B_0 magnetic field and reaching ultra-low fields (e.g. 200 μT) requires novel magnets, power supplies and control electronics. Here we describe progress on a new whole-body human sized FFC imaging system and present images obtained using the scanner.

Methods: The magnet (Tesla Engineering Ltd, Storrington, UK) is of a resistive design with a length of 2 m and an inner bore diameter of 500 mm. The primary magnet is driven by three racks of six current amplifiers (IECO, Helsinki, Finland). Each amplifier rack is capable of supplying a maximum current of 650 A, so the total current supplied to the magnet is 1950 A, corresponding to a maximum field strength of 0.2 T. The system can switch between zero and maximum field in 20 ms, corresponding to a maximum dB/dT of 10T/s. The scanner is also equipped with a set of three orthogonal 2-metre wide square Helmholtz coils (Figure 1) centred on the isocentre of the magnet to provide earth's field cancellation.

Figure 1: The FFC-MRI system and earth's field cancellation coils.

The gradients and RF system are controlled by a commercial MRI console (MR Solutions Ltd, Guildford, UK) while the main magnet coil, shim coils and earth's-field cancellation coils are controlled by in-house software written in Labview (National Instruments, Austin, US). The main magnetic field is set and controlled by a 16-bit, high-precision DAC which provides a B_0 field resolution of 3 μT.

Discussion: The system has been fully commissioned and we are currently using the scanner to image patients with ischaemic stroke to assess the diagnostic potential of ultra-low field (200 μT) and T_1 dispersion contrast.

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1. Lurie, D. J. *et al.* Fast field-cycling magnetic resonance imaging. *Comptes Rendus Phys.* **11,** 136–148 (2010).