A Fast Field-Cycling MRI system for clinical applications
P. J. Ross, L. M. Broche, G. R. Davies, D. J. Lurie
Aberdeen Biomedical Imaging Centre, School of Medicine, Medical Sciences & Nutrition, University of Aberdeen, Aberdeen AB25 2ZD

Introduction: Fast Field-Cycling MRI (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 T1 with magnetic field which is known as T1 dispersion. The construction of an MR imaging system capable of rapidly switching the B0 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.

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 B0 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 T1 dispersion contrast.

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