Abstract No: P12

Title: Equipping FFC MRI for Nuclear Quadrupole Double Resonance

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Abstract:

Fast Field-Cycling Magnetic Resonance Imaging (FFC MRI) differs from conventional MRI techniques in the ability to vary the magnetic field strength of the scanner. This additional functionality is exploited to access contrast arising from the non-linear way relaxation rates depend on field strength [1], one example of which is found at magnetic field strengths in which the proton Larmor frequency is resonant with an NQR frequency of a coupled quadrupole.

NQDR methods, developed in solid-state NMR, potentially allow more sensitive detection enabling relaxation effects to be seen in samples with lower concentrations of quadrupole nuclei [2]. These techniques involve the additional RF irradiation at one or more frequencies during an experiment cycle and as such it was necessary to develop an RF coil capable of being tuned and matched during a pulse sequence.

By utilising varactor diodes as voltage-controlled capacitors, a system was developed where commands from the scanner's console (MR Solutions Inc., U.K.) were used to tune the coil to frequencies within its attainable range. This was achieved through intermediary cascaded serial-to-parallel 74HC595 shift registers which passed the console's data to two 16-bit DAC715 Digital-to-Analogue Converters (DAC) allowing control using just three TTL lines. The DACs outputs provide the reserve bias voltage across varactors arrays used for tuning and matching. For tuning flexibility, a calibration procedure was designed to allow MATLAB 2013a (The MathWorks Inc., U.S.) to calculate the critical variables used in the pulse sequence code.

It was found that memory-efficient code could tune the coil every 1.2 milliseconds. Carefully selecting the inductance of the coil and amount of addition, fixed capacitance, a tuneable range of 2 MHz – 3 MHz was achieved. Importantly this covers the two highest NQR frequencies found in most ^{14}N organic samples. Future work aims to explore the effects of applied irradiation to quadrupole-containing samples in FFC MRI.

References

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

[2] Edmonds D.T., Nuclear Quadrupole Double Resonance. *Phys.Rep.* **29**, 233-290 (1977).

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