OCEAN: Offset Centre-Frequency Encoded Array Network

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INTRODUCTION

Spatial encoding using multiple RF or B_0 coils has great potential for rapid localised imaging without the drawbacks of gradient encoding for special applications (1, 2). High temperature superconducting (HTS) coils can improve SNR by significant factors, especially at low magnetic field strengths (3). However, there are potential difficulties in decoupling arrays of HTS coils tuned to the same frequency due to their high Q values and hence strong coupling. It is also difficult to solder active detuning components to HTS coils. We propose to create an array of HTS coils which are tuned to different frequencies to minimise coupling.

METHODS
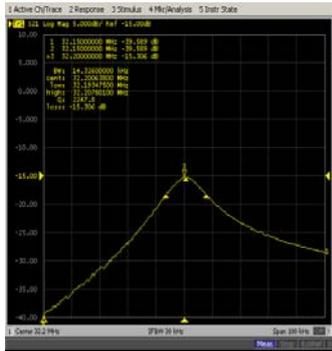
HTS coils can achieve very high unloaded and loaded Q values e.g. 14000 and 2000 respectively (Figure 1, Data acquired at 32MHz). At low field, say 250kHz, the bandwidth of a loaded coil is only 125Hz which is only really adequate for spectroscopic imaging. Tuning a 3x3 array of coils in steps higher than the bandwidth, say 1000Hz, will result in an overall array bandwidth of 8kHz but without the coupling obtained with a tuned array. Application of a single broadband pulse with a bandwidth of 8kHz from a volume transmit coil will then excite the coils at their own resonance frequencies but without significant interaction between coils. The array is thus intrinsically decoupled and the noise from the coils is highly uncorrelated in separate frequency bands. This data can be sampled on a single channel, separated by bandpass digital filtering and then each frequency band corresponds to data from a specific spatial location without any applied gradient encoding. A simulation of the coil array and a reconstructed image including coil crosstalk for different Q values has been performed using Matlab.

RESULTS

Figure 2 shows simulations of the Lorentzian frequency response for a 3x3 array of HTSC coils with Q's of 400 (left), 2000 middle and 4000 (right) with tuning offset in steps of 1000 Hz at a nominal centre frequency of 250kHz.
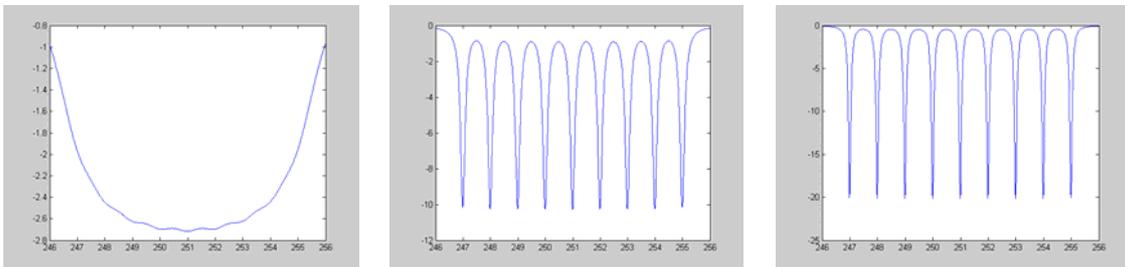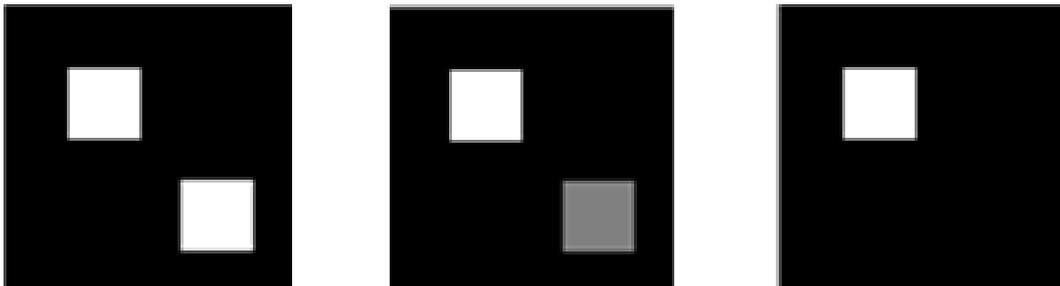

Figure 2 shows a simulation of image crosstalk for two coils containing equal samples with adjacent frequency tunings and Q values corresponding to the relevant figures above, showing the effective removal of image crosstalk with the higher Q coils.

CONCLUSION

Due to the low intrinsic bandwidth of high Q HTS coils at low field, offseting the centre frequency should allow an array of minimally interacting coils to be produced. These arrays could be used for low bandwidth 1D or 2D spectroscopic imaging of planar samples or for instant imaging of flow or other dynamic processes in a plane similarly to the SEA or MAMBA 2D methods. Alternatively they could be used to acquire data from multiple samples simultaneously on a single channel with high SNR. The number of elements would be limited by available RF power and bandwidth, although multiple frequency transmit systems could be used to extend this. An array of HTS coils is currently being designed for testing of the OCEAN method in a recently constructed low field hybrid whole body magnet operating at 250kHz.

REFERENCES

1. McDougall M et al., MRM, 2005, 54(2);386   2. Lee K et al., MRI 2002,   20(1); 119 3. Poirier-Quinot et al. MRM 2008, 60;917