A 32 Channel RF array and integrated gradient insert

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INTRODUCTION

Neonatal MR is a particularly challenging application requiring fast imaging to reduce motion artifacts especially when anaesthetics are not used. However, on conventional MR system fast imaging sequences produce high levels of acoustic noise and can yield high SAR. Increased SNR and gradient strength can be achieved while obeying acoustic noise and SAR restrictions using smaller scale gradient coils and transmit-receive arrays. The aim of this project was to design and construct a 32 channel Transmit-Receive (TR) array and integrated local insert gradient set using a printed circuit board manufacturing technique for use with a neonatal incubator at 1.5T. The gradient and RF insert has been assembled and bench tested and the TR RF array coil initially tested at 1.5T through acquisition of MR FID signals from each of the 8 coils from one side of the array.

METHODS

The gradient set was designed on the surface of a 250mm cube with X and Y coils on upper and lower vertical and left and right horizontal surfaces respectively. Simulation of the gradient fields from the coils was performed in 3D using a Matlab Bio-Savart law solver. The X and Y coils were designed as a spiral of 15 tracks with a 0.5mm trackwidth on one side of a double sided printed circuit board. The Z coil was created from a set of 15 parallel tracks with 1mm trackwidth on the other side. The Z coils were joined to form helical windings for a square Maxwell pair around the surface of the cube using a set of wires offset by one track each turn after preliminary assembly of the four sides of the insert. The RF transmit-receive surface coils were laid out in a 4x2 array of 112x46mm coils on each of the four double sided PCB's with an 11mm overlap in the Z direction and a 3mm gap in the horizontal and vertical directions (Figure 1). Each coil was tuned and matched to 64MHz and 50 ohms using a pair of variable ceramic capacitors (5-50pF) and a network analyser (Hewlett Packard, USA). All the coils were driven from a single 1.2Kw RF amplifier split in parallel to each of the coils. A parallel passive crossed diode pair (1N4148) across each BNC connector was used to decouple the surface coils during transmit and another serial pair of diodes used to isolate the transmitter from each coil during receive. The printed circuit boards were sandwiched between two layers of 250mm square acetal sheet for mechanical and electrical protection and fixed in place with nylon nuts and bolts (Figure 2). Each of the coils from one side of the insert was tested individually using an independent 32 channel MR spectrometer with 8 active RF channels (InnerVision MRI Ltd, London, UK) with a 1.5T HDx MR system magnet (GEHC, Milwaukee, USA). Efficiency and linearity was measured for each gradient coil using 5A current from a DC power supply and a Gaussmeter (GM05, Hirst Magnetics, UK) to measure gradient fields as a function of position.

RESULTS

The gradient coil measured efficiencies agreed within 10% of the calculated values at 1.5mT/m/A for X, Y and 1.25mT/m/A for Z.

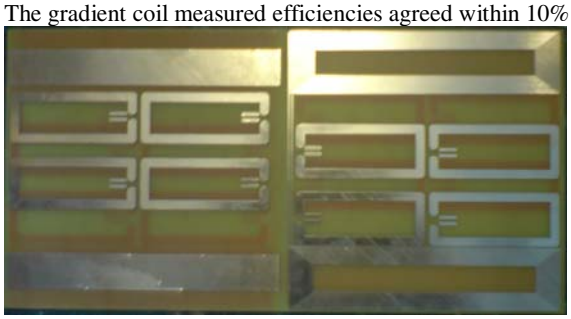

Figure 1. Both sides of one of the four printed circuit boards showing the 4 x 2 TR array and the integrated set of X,Y and Z gradient coils

Figure 2. One side of the cube with the RF interface box for testing prior to soldering the Z gradient coil cables and assembling the four sides together.

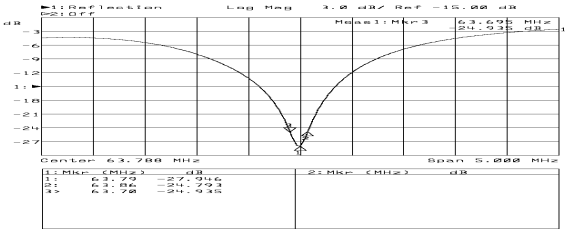

Figure 3 shows a typical S11 response of one of the coils of the array tuned to 64MHz with unloaded and loaded Q's of 420 and 160 respectively.

DISCUSSION

A novel integrated TR array and integrated insert gradient coil design has been designed and constructed for use in a neonatal incubator with the benefit of reduced acoustic noise and SAR performance relative to a standard 1.5T imaging system. Future work will complete integration with the spectrometer and test the imaging and safety performance inside a neonatal incubator. It will also be possible in future to use the 32 channel RF array in receive only mode on the Signa 1.5T HDx system using a custom built 32 channel interface box (GEHC, Europe).