# A 4-channel Transceive Surface Coil Array for Small Animal Imaging at 9.4T

**S. O. Oduneye[1,2], and R. S. Menon[2,3]**

[1]Biomedical Engineering Graduate Program, The University of Western Ontario, London, Ontario, Canada, [2]Imaging Research Labs, Robarts Research Institute, London, Ontario, Canada, [3]Department of Medical Biophysics, The University of Western Ontario, London, Ontario, Canada

## Introduction

As operational frequencies increase linearly with higher static fields, the wavelength approaches the size of the sample being imaged. The resulting standing wave mode deteriorates image homogeneity. Fortunately, with phased array surface coils, the produced B1 field can be tailored to overcome the so called 'dielectric resonance effect', high RF power deposition and signal radiation losses (*1, 2*). Here we present a novel high field transceive surface coil array for small animal imaging at 9.4T. Additionally, this design allows the coil to be employed for fast parallel imaging techniques while maintaining the high signal to noise ratio (SNR) inherent advantage of surface coil designs.

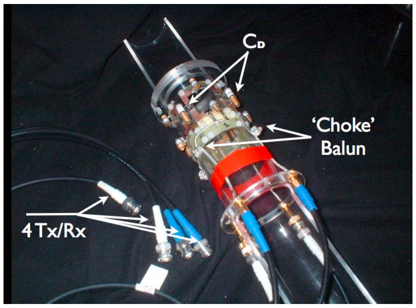


Figure 1 – Transceive array with choke balun and $C_D$ capacitive decoupling network.

## Methods

A four-channel transceive coil array (TC) (see figure 1) was designed and built on an acrylic cylindrical former of 63.5 mm inner diameter. We mounted four identical surface coil elements (40 x 40 mm) on the former at 0°, 90°, 180° and 270° with respect to the center axis. Each coil element was then tuned and matched to 400 MHz and 50 Ω respectively. To reduce mutual inductance effect of the nearest neighboring element (noticeable by the resonance peak splitting), we used a decoupling network formed by a variable capacitor connected between adjacent coils in a "T" configuration (*3*). Common mode currents were reduced by connecting a 'choke' balun at the terminals of each coil element. A feed network was used to split the transmit signal into four equally powered signals, which were incrementally shifted 90° out of phase and was also used to recombine the signal during receive operation. One other RF coil was used in this study, a hybrid birdcage (BC) consisting of 8 rungs and measuring 63.5 mm in diameter. The hybrid birdcage coil was used as a reference system in order to assess the performance of the transceive coil against a standard reference. We performed imaging experiments with a Varian 9.4T 31cm actively shielded horizontal MRI system and Varian Imaging console interfaced with a 1-KW RF amplifier. A 2D fast low angle shot (FLASH) sequence was used for the acquisition of all the images. Magnitude images were acquired with the following parameters: $FOV_x$ = 100mm, $FOV_y$ = 100mm , TR = 25 ms, TE = 3.5 ms, slice thickness of 2 mm a tip angle of 11° and 256 x 256 complex points. Reduced data images were reconstructed using sensitivity encoding (SENSE) (*4*).

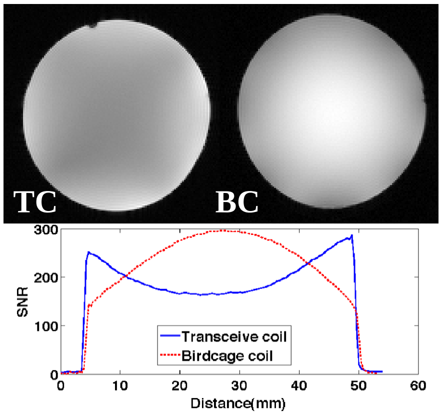


Figure 2 – Axial magnitude images of phantom obtained with Transceive coil and Birdcage coil (top). SNR plot profile along the centre of the axial image (bottom).

## Results

The transceive coil array was loaded with a spherical phantom containing $CuSO_4$ and RF measurements at each coil revealed similar and consistent RF spectrum profiles compared to the RF spectrum profile of an identical single element in isolation verifying that the coils were properly decoupled and isolated. The average isolation between neighboring coils was measured and found to be an average of 12.1 dB. The SNR calculations were performed taking into account statistical distribution of background noise (*5*). SNR decrease of 48.4% over the center of the phantom and SNR increase of 42.7% over the peripheral regions of the phantom was measured for the transceive coil compared to the birdcage coil. SENSE reconstruction was performed by varying the reduction factor from R=1.0 (no reduction) up to R=3.0 and images were undersampled in the phase encoding direction.

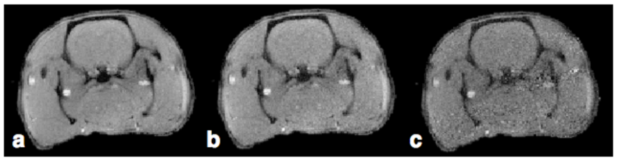


Figure 1 - SENSE reconstructed images of a rat head for different reduction factors, R=1 (a), R=2 (b) and R=3 (c). The noise inhomogeneity increases as the reduction factor increases as the number of pixels to unfold approaches the number of available coils.

## Discussion

The SNR plot profile for the birdcage shows the presence of the standing waves effect, whereas the plot profile of the transceive coil exhibits the characteristic signal fall off of surface coil arrays from the marginal regions towards the center regions. However, the high SNR in the peripheral regions is a significant advantage for studies that require high signal intensity in the outer regions. Additionally, these results suggest the need to explore surface coil array design in animal systems at high fields, where standing waves effects are notable. As expected, figure 3 shows an increase in noise inhomogeneity corresponding with the increase in acceleration factor. Although it was beyond the scope of this paper, noise effects could have been limited by optimizing the coil design to obtain an ideal g-factor/SNR ratio. Transceive coil design offers many advantages in small animal imaging. However, to exploit the phased array design it's imperative to overcome the transmit homogeneity issues. A solution to this problem is the independent control of amplitude and phase for each channel.

## References

1. G. Adriany *et al.*, *Magn Reson Med* **53**, 434 (2005).
2. J. T. Vaughan *et al.*, *Magn Reson Med* **52**, 851 (2004).
3. J. Wang, *Proc ISMRM 4* 1434 (1996).
4. K. P. Pruessmann *et al.*, *Magn Reson Med* **42**, 952 (1999).
5. C. D. Constantinides *et al.*, *Magn Reson Med* **38**, 852 (1997).