Four Channel Array for 9.4T Animal Studies

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Introduction

Parallel coil arrays are in common use for human clinical MRI studies because they provide several benefits. First, SNR is often improved compared to a volume coil due to the use of multiple surface coils to construct the array positioned close to the sample. Uniform sensitivity across the desired field of view is accomplished by proper arrangement of the individual array elements. In addition, parallel arrays are the basis for rapid imaging techniques such as SENSE that reduce scan times or improve image resolution at the expense of SNR [1]. Beyond an improvement in experimental efficiency, such reductions help lower blurring, signal losses, and distortion artifacts that occur due to field dependent T_2* and B_0 inhomogeneity effects. To date, parallel imaging has not been widely adapted for use on animal scanners, where the advantages for improved performance are sometimes less obvious. We have developed a four channel array intended for animal imaging at 9.4T, and have evaluated parallel imaging performance in rat brain.

Methods

Coil Design - A parallel receive array was constructed from four surface coils positioned orthogonally around a 38 mm ID cylinder. The individual coil elements consisted of a 45 x 22 mm rectangular loop with angled corners and four distributed capacitors (fig. 1). An additional adjustable capacitor was used to provide manual tuning of the loop. Matching was achieved using an adjustable capacitor balanced for coil symmetry. A lattice balun was put on the coil input for added symmetry and to minimize cable currents, suppressed by a figure-8 wrapped semi-rigid coax. Active detuning was accomplished with -230V/+12V DC bias to tune/detune a series pin-diode through RF chokes. Bias voltages were supplied by an Insight Neuroimaging driver box with output based on a received TTL input. The driver also controlled the detuning of an Insight linear microstrip volume coil (ID = 72 mm) used primarily for RF transmission, with four series triaxial baluns on its input. Surface coil decoupling was accomplished by overlap of neighbors, with coil isolation and Q assessed using a network analyzer.

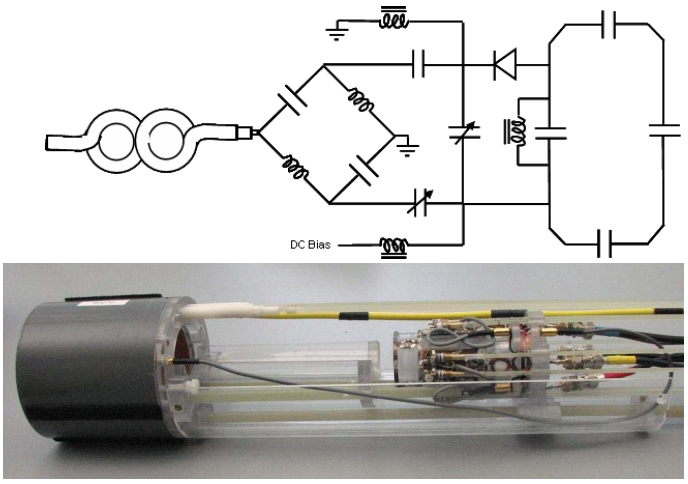

Figure 1 – Top: surface coil schematic, Bottom: constructed four channel receive array with transmit volume coil.

Imaging Tests - Live rat brain images were acquired using the array on a 9.4T Varian spectrometer with a DirectDrive console. A gradient echo sequence was applied with the following parameters: TR = 250 ms, TE = 4.77 ms, 30° flip angle, 34x36 mm FOV, 1 mm slice thickness, 5 acquisitions, 256x256 matrix. A second reduced image set was acquired at an R = 2 along the phase encode direction. Aliased images were then reconstructed and g-factor maps generated in Matlab using SENSE with coil maps processed as described [2]. Reconstruction SNR in two voxels was compared to that captured by the volume and top array coil only.

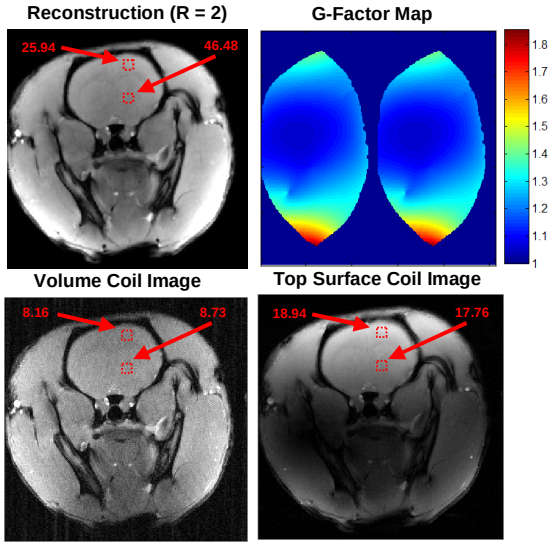

Figure 2 – R = 2 reconstruction, g-factor map, volume coil and top surface coil images.

Results

The measured array coil isolation was -17 dB on average, -13 dB for non-overlapped coils. Volume coil detuning provided -23 dB isolation from the array; likewise, array detuning provided -36 dB isolation from the volume coil. Unloaded and loaded surface coil Q values were measured to be 139/80 on average. SENSE reconstructions were uniform with no visible artifacts, and a mean and max g-factor of 1.16/1.86 (fig. 2). Regions of high g and brightening are believed to be the result of non-overlapped coil coupling. Array voxel SNR was 1.4 to 5.3 times higher than that obtained by the volume and top surface coil.

Discussion

The described four channel array is capable of producing SENSE reconstructed images of good quality at 9.4T. The combined images are uniform in appearance across the FOV, with good rat brain coverage for the application tested. Though constructed specifically to fit a rat head, the array could also be applied to mouse body or brain imaging studies. Future work will focus on coupling and cable current reduction, and applying it to functional and anatomical animal studies.

References [1] Pruessmann, KP, et. al., MRM 42: 952-962 (1999) [2] Wargo, CJ, et. al., ISMRM Berlin: 1748 (2007).