An Optimised 16-Element Head Coil for 7T with Integrated Preamplifiers

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Introduction

We describe here the development of a hybrid transmit,16-Channel phased array receive head coil for imaging of the brain. For a coil of this type, coil elements need to be positioned as close as possible to the head to assure that coil loading will be tissue dominated. It is also important for integrated amplifiers located as close as possible to the phased array elements to improve coil isolation. Competing with these requirements are the need to cover a large range of head sizes, to minimize claustrophobia with openness and ventilation, and to provide access for functional MRI apparatus. A mechanical former therefore requires careful design to meet these requirements and work within the bore of a volume transmit coil.

Methods

A dome-shaped former was developed using SolidWorks™ 3-D modeling. A series of elliptical-shaped cylinders were designed and fabricated using rapid prototyping on a Z Corporation 3-D printer. A range of head sizes were evaluated, allowing for a 6 mm foam pad beneath the head and 1 cm spacing above the forehead for large head size (64 cm circumference). Optimal major and minor axes were found to be 216 mm A-P and 194 mm L-R, respectively, for the inner surface. The dome shape at the top of the head was formed by rotation of the elliptical cross section about a vertical axis at the dome-cylinder interface. Through this process it was determined that the top section of the former could be truncated near the location of the eye brows and still provide access by the top elements of the array. A split between top and bottom sections of the former was placed 25 mm above the center to accommodate more elements in the bottom section. A 10 cm diameter cylindrical hole for ventilation was also placed 25 mm above the z-axis of the coil in the dome.

Full brain coverage was achieved by first placing a single layer of 12 elements, all 11 cm in length around the dome of the head. Five of the elements were located in the top former, and seven more elements were placed in the bottom former in the same z-location, as indicated in Fig. 2. Four more elements then added to the bottom array to provide coverage of the cerebellum. These were staggered in location with respect to the dome elements, providing 3 cm of overlap in the region of the optical cortex (Fig. 2). All of the 12 dome elements were non-overlapped azimuthally to improve SENSE encoding. Transformer decoupling was used to decouple neighboring elements, including elements adjacent to the split in the former. The four inferior elements over the cerebellum were connected via balanced transmission line segments, shielding their signals from the dome elements (Fig. 2). The g-factor for R=2 for x was calculated using Biot-Savart modeling for the fields (Fig. 3). The coil was tested in the hybrid Tx/Rx configuration on similar GE 7T systems at both NIH and at UC San Francisco.

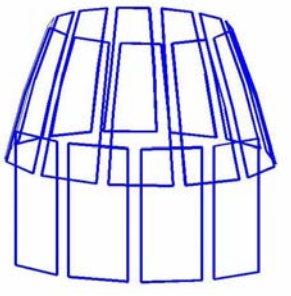

Fig. 1.

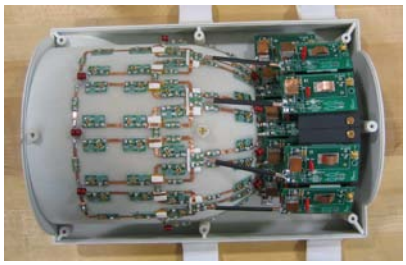

Fig. 2.

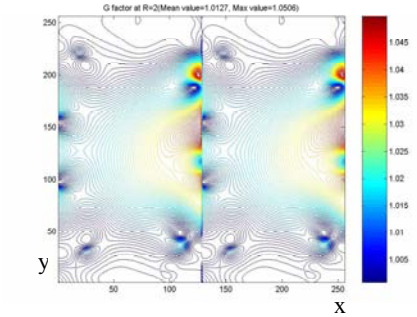

Fig. 3.

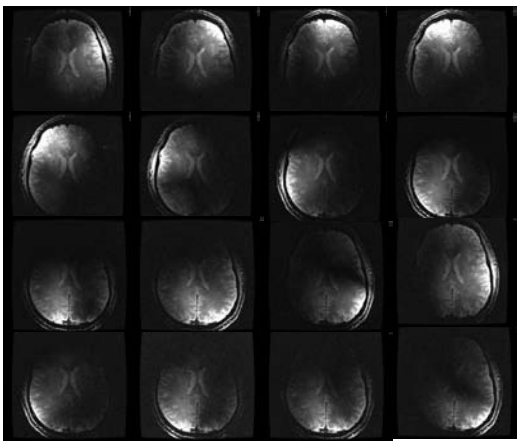

Fig. 4.

Results

The phased array elements show good isolation (Fig. 4), with isolations all better than -15 dB using bench measurements. In Fig. 5, sagittal and axial images show good brain coverage with some intensification in the frontal lobe and region of the optical cortex. The latter was expected from the 3 cm overlap of these elements.

Conclusions

The coil is an open design that accommodate large heads while positioning the elements close to the brain. It exhibits good isolation as evidenced by the images in Fig. 4. The sagittal view shows good whole-brain coverage, and low g-factors in the axial plane, near the elements. Full FDTD simulations need to be used to determine the g-factor near the center of the head.

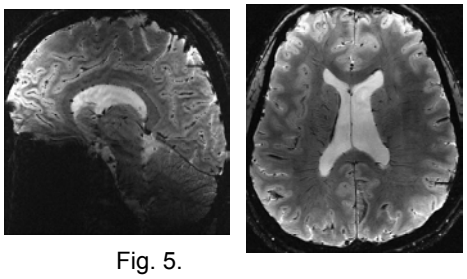

Fig. 5.

References

1. Patrick J. Ledden, et al Proc. of ISMRM 2005, Miami p. 322
2. Lawrence L. Wald, et al Proc. of ISMRM 2005, Miami p. 921

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