32 Channel Receive-Only SENSE Array for Brain Imaging at 7T

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Introduction: The recent availability of thirty-two receive channels on 7T MRI scanners raises the question of how to optimally make use of these channels for brain imaging. Previously, 7T thirty-two channel overlapped geodesic dome(1), thirty-two channel transmission line (2), and twenty-four channel gapped designs (3) have been presented. For this work, we describe a thirty-two channel receive-only SENSE optimized array using radially gapped columns of overlapping elements parallel to B_0 for brain imaging at 7T.

Methods: The receive-only array consisted of thirty-two coil elements placed on a curved splittable whole brain former (4). On the bottom half, twenty elements were placed in a 2D arrangement with five radially gapped columns each consisting of four overlapped coils parallel to B_0 (e.g. z axis of magnet bore). On the top half, twelve elements were also placed in five radially gapped columns: the most anterior three columns each consisted of two elements each, while the side columns consisted of three elements (Fig 1). Individual coil size was approximately 5x4cm Coverage was designed to include the lower temporal lobe regions as well as the cerebellum in the posterior. The fewer element number on the top half allowed the face and particularly the visual fields to remain unobstructed. Each element was designed for approximately 30% gap relative to element width.

Each receive-coil element was tuned 298MHz with multiple distributed capacitors and matched to 50 ohm cable with a bridge balun. A PIN diode across the bridge balun detuned each element during transmit. One or more secondary passive traps were placed on each receive coil. In each column, cables from the inferior coils were routed in a bundle over the superior coils. Three common mode cable traps were implemented in the 50cm of cable which connecting each receive coil to a high impedance 298MHz preamplifier.

A 30cm ID shielded volume transmitter was used to provide the transmit B_1 field (Model NM-008-7T, Nova Medical, Inc.). Imaging tests were performed on a General Electric 7T MRI scanner located at National Institutes of Health in Bethesda MD, USA. Data for the thirty-two element array was obtained from successive images using the scanner provided sixteen channels with unused coils being preamp isolated during receive. Human imaging was done under institution review board approval.

Results and Discussion: Bench measurements showed that the loaded to unloaded ratio of the individual elements ranged from approximately 1.3:1 to 2:1 when placed on the former which provided a head to coil distance of between 1-2cm. This ratio includes losses in matching networks, cables, and adjacent gapped preamplifier “detuned” elements. The PIN diode detuning was found to provide >40dB isolation of the receive coils which increased to >50dB with activation of the passive traps.

Compared to the shielded quadrature volume coil (Fig 2), peak cortical SNR was improved up to 7-10 fold, a number similar to that described in (1,3). Sensitivity was superior to the volume coil in all regions of the brain including the brainstem, cerebellum, and inferior temporal lobes. Individual array coil images showed good isolation between coil elements as well as some effects of high frequency wave phenomenon (Fig 3). SENSE G factors are shown in Fig 4 and were very low for both rate 2 (av=1.015), rate 3 (av=1.12). 2D SENSE g factors were also very low in for axial rate 2x2 (av=1.03) and axial rate 3x3 (av=1.3) imaging. Fig 5 shows detail of a high-resolution anatomic scan.

Conclusion: This study demonstrates the feasibility a 32 channel array for brain imaging at 7T with radially gapped columns of overlapped elements along the B_0 axis. Sensitivity was dramatically improved over a quadrature volume coil though only modest sensitivity improvements were seen compared to arrays of similar configuration with fewer elements (3). While precise comparison of G factors is difficult, the axial plane G factors appeared improved compared with previous work. The coil geometry additionally allows for SENSE acquisition with non-axial phase encoding. While optimal number of receiver channels remains an open question (5), from our data, further increases in element numbers seem unlikely to provide significant improvements in sensitivity for 7T head imaging. However, there may be additional gains to be found in parallel imaging performance with additional receiver channels.

References:

1) Wiggins, et al, Proc ISMRM 2006, 415.
2) Adriany, et al, Proc. ISMRM 2006, 126.
3) Ledden, et al Proc ISMRM 2006, 422.
4) de Zwart, el al, MRM (2004) 51(1):22-6.
5) Wald, L, Proc ISMRM 2006, 202.

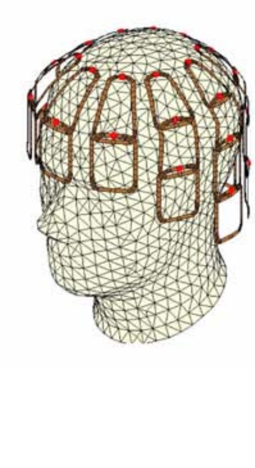

Fig 1: Element Geometry

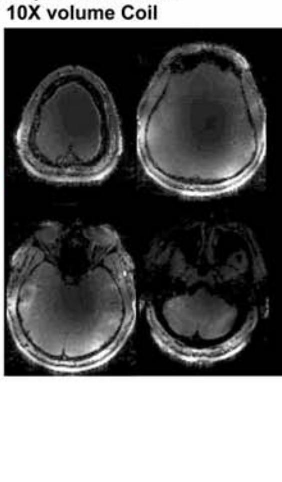

Fig 2: Relative SNR Maps: Max White = 10X volume Coil

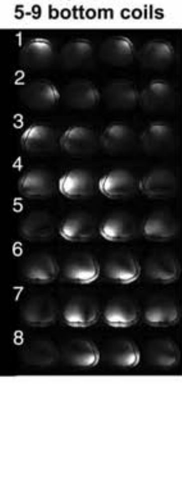

Fig 3: Indv. Coils 1-3 top coils 5-9 bottom coils

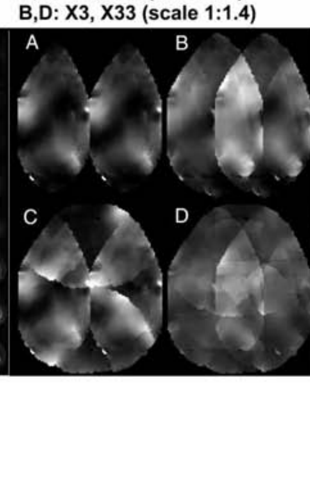

Fig 4:SENSE G Factors A,C: X2, X22 (scale 1.1) B,D: X3, X33 (scale 1:1.4)

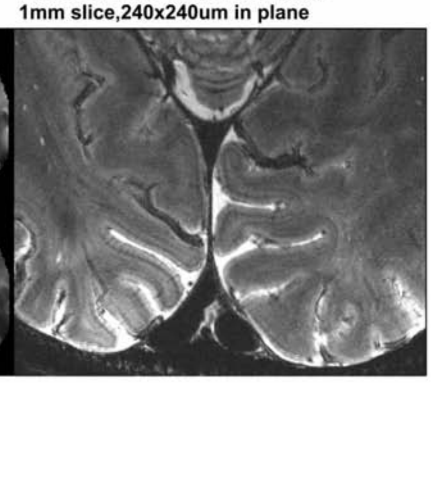

Fig. 5: Image Detail, GRE, flip 60 TE/TR 30/1000, 1024x768 matrix, 1mm slice,240x240um in plane