Birdcage Volume Transmit, Eight Channel Receive Array System for Brain Imaging at 7T

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Introduction: The use of a volume transmit coil with receive-only array coils is the imaging method of choice for most MRI studies. Actively detunable volume TEM coils used with array receivers have been described for at body imaging at 4T (1) and head applications at 7T(2). Birdcage body coils with PIN diode disabling networks have been shown to work extremely well at 3T (3). For this work we show the feasibility of a detunable birdcage volume transmitter used with an eight channel gapped receive array for brain imaging at 7T.

Methods: The volume coil consisted of 16 element high pass birdcage coil of diameter 30cm and length 20cm placed inside a shield of diameter 37.5cm and length 30cm. The shield was slotted to minimize eddy currents and was open at both ends. Detuning of the volume coil was accomplished with trap circuits between each rung of the birdcage. These trap circuits were activated by forward biased MAPK2000 Pin diodes (M/A-COM, Lowell, MA, USA) and disabled the volume coil during receive.

The receive array consisted of eight gapped elements placed on a curved splittable whole brain former (4). Each receive-coil element was roughly 12cm long by 5cm wide and tuned to 298MHz with multiple distributed capacitors. The receive elements were gapped and there was no overlap or isolating circuits to minimize mutual inductive coupling. Each receive coil was matched to 50 ohms with a bridge balun which also functioned as a active detuning circuit in combination with a PIN diode. A secondary passive trap was placed on each receive coil on the end opposite the bridge balun. Three common mode cable traps were implemented in the 45cm of cable which connected each receive coil to a high impedance 298MHz preamplifier.

PIN diode bias of +/- 12V for the volume and surface coils was provided by PIN diode driver driven from a TTL logic signal from the scanner. Fault detection was included in the pin diode drivers and the volume coil was only placed in the tuned state for transmit if all receive-coil pin diodes were intact.

Imaging tests were performed on a General Electric 7T MRI scanner located at National Institutes of Health in Bethesda MD, USA.

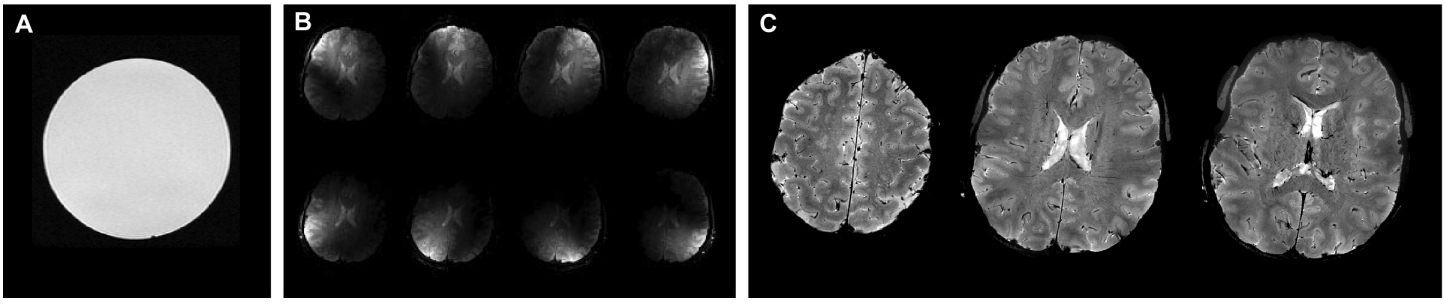
Results and Discussion:. Bench measurements showed that the loaded to unloaded ratio of the shielded volume coil was 2:1 in free space which increased to 4:1 when the coil was placed in a 61cm diameter RF shield. The ratio of coupling between two shielded field probes decreased 35dB when the volume coil was switched from tuned to detuned mode. Receive coil loaded/unloaded ratio was approximately 4:1 and increased slightly inside the volume coil shield. The PIN diode detuning was found to provide >35dB isolation of the receive coils which increased to 45dB with activation of the passive traps.

On a silicon oil phantom, B1 homogeneity of the volume coil was excellent (figure 1A: TE/TR 15/200, 256x128 matrix, 20x20cm FOV). The volume coil required approximately 1000W peak power for a 3.2ms sinc shaped 180 degree pulse on an average head (central lobe 1.8ms long). Transmit voltage was effected less than 15% by placement of the array receive coil inside the volume coil. The detuned receive-coil elements minimally affected the volume coil B1 field.

Individual array coil images showed good isolation between the preamplifier isolated receive-coil elements (figure 1B, TE/TR 40/500, 512x384 matrix, 20x15cm FOV, 1mm slice, 3.5min acquisition). Individual receive coil field profiles show the effect of high frequency wave effects in the human head. Combined images from the array are seen in figure 1C (imaging parameters same as 1B). Peak cortical SNR was increased approximately 2.2X over a similar size sixteen channel array at 3T (4).

Conclusion: This study demonstrates the feasibility of a birdcage volume transmit, receive-only array coil system for brain imaging at 7T. The high pass shielded birdcage transmit coil was found to provide a reasonably efficient and homogeneous excitation field. PIN diode detuning circuitry allowed good isolation of the transmit and receive coils. The non-inductively isolated receive array elements were adequately isolated from each other during receive using preamplifier input impedance as the sole decoupling method. Overall SNR of the system provided substantial increases in sensitivity over 16 channel array systems at 3T and single channel quadrature volume coils at 7T.

Figure 1A: Volume coil silicon oil phantom TR image **B:** Individual receive coil images **C:** Combined receive array images



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