# A Volume Coil Transmit, Surface Coil Receive System for Brain Imaging at 3T

Patrick J. Ledden[1,2], Lawrence L. Wald[1], J. Thomas Vaughan[1,2]
[1] Massachusetts General Hospital-NMR Center, Dept. of Radiology, Charlestown MA, USA
[2] Enon Microwave Inc., Topsfield MA, USA

**Purpose:** In this work we demonstrate an actively detuned transverse electro-magnetic (TEM) volume coil transmitter for use with receive-only surface coils. The system was characterized for head imaging at 3T.

**Introduction:** The use of a large volume transmit coil with a receive-only surface coil is the method of choice for many MRI applications needing high sensitivity. The desirability of this system stems from the combination of the homogeneous excitation provided by the volume coil and the unsurpassed sensitivity of small surface coil detectors.

One barrier to the implementation of this system at higher field strengths has been the lack of suitable large volume coils. At higher field strengths, standard volume coil designs lose efficiency due to increased tissue conductive and dielectric losses in combination with the radiation of RF energy [1,2]. Transmit efficiency becomes increasingly important at 3T due to increased SAR concerns as higher peak power is applied to obtain a given peak B1 level.

The TEM coil design [2] by virtue of its inherently shielded design and distributed circuit elements is an efficient high frequency resonator. In this study we constructed a large, actively detuned TEM resonator with room for local receive-only coils and demonstrated the volume transmit, surface coil receive system in phantom and brain images at 3T.

**Methods:** The volume coil consisted of a scaled-up version of a previously described TEM coil [2] with the addition of PIN diode detuning circuitry. The cavity wall had longitudinal slots with overlapping segments to minimize the eddy currents encountered in EPI while providing a good radiofrequency (RF) ground and was closed at one end to decrease radiation losses. The diameter of the shielded cavity was 39 cm with a longitudinal length of 23 cm. Twenty-four coaxial type elements were mounted evenly around the coil 2.5 cm inside the cavity wall. These coaxial elements were composed of a center 0.62 cm diameter copper rod separated from an outer 1.25 cm dia. copper tube by a Teflon dielectric. Two elements located 90 deg. from each other were capacitively matched to 50Ω and driven in quadrature.

Detuning was accomplished with Microsemi UM9415 diodes. Each diode was placed to short the posterior end of a coaxial element to the cavity wall. While optimally all elements should be detuned, in this implementation only eight diodes were used: one on each driving element and every third element thereafter symmetrically around the coil. These diodes were biased through RF chokes. This bias connection was separate from the RF signal path. The bias driver was controlled via a TTL signal from the GE Signa 3T Scanner.

A 10cm by 10cm square surface coil was constructed with 1/4" width copper tape and seven distributed capacitors. This loop was driven with a balun. A standard resonant trap circuit with a UM9415 PIN diode was used to detune the surface coil during transmit.

Phantom and brain images were obtained with the 3T Signa GE/ANMR system using spin echo, gradient echo, and echo-planar imaging. The transmit power needed for a 90 degree excitation was compared to a commercial transmit-receive unshielded birdcage. Signal to noise ratio (SNR) was measured by comparing image intensity with background noise.

**Results and Discussion:** Despite its larger size, the head-loaded transmit efficiency of the TEM coil with diode detuning was only 1 dB lower than a commercial unshielded birdcage coil. The PIN diode detuning was found to provide >30dB isolation. The combination of the receive-only surface coil with the TEM resonator used only for transmit produced high SNR images with signal intensity decreasing as a function of distance from the surface coil. No evidence of surface coil focusing of the transmit field was observed in the phantom images. The SNR of the small receive-only surface coil was up to 3 fold higher than that obtained with the volume head coil.

**Conclusion:** This study demonstrates the feasibility of a volume coil transmit, receive-only surface coil system for brain imaging at 3T. The TEM transmit coil was found to provide an efficient and homogeneous excitation field. The PIN diode detuning system provided adequate decoupling from the surface coil. The use of a detunable TEM resonator with receive-only surface coils will enable full utilization of the inherent increased SNR of the high field MR systems.

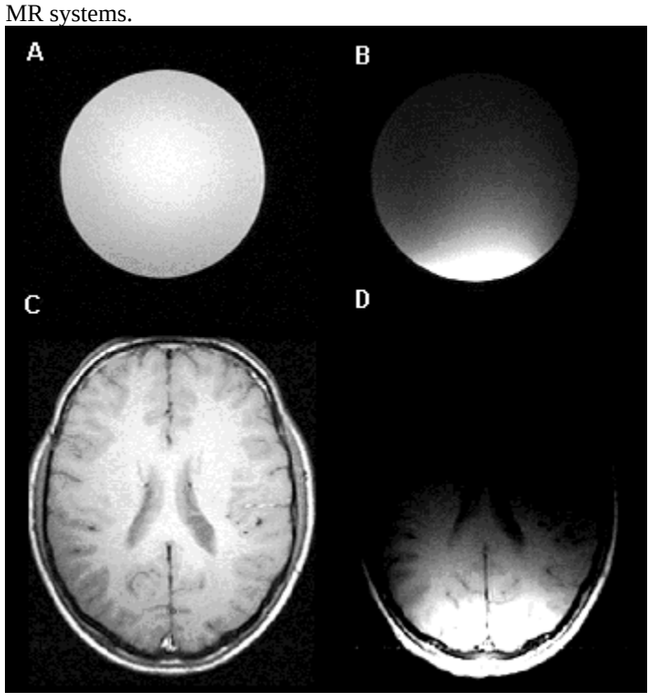


Figure 1. A) Phantom image with TEM coil used both for transmit and receive, B) Phantom image with TEM coil used only for transmit, surface coil for receive C) human brain image with TEM coil used both for transmit and receive D) human brain image with TEM coil used only for transmit, surface coil for receive.

**References:**

1)Vaughan, J.T., Hetherington, H.P., Oto, J.O., Pan, J.W, Pohost, G.M., Magnetic Resonance in Medicine 32:206-218, 1994
2) P Roschmann, Med. Phys. 14(6):922--931, 1987

**Acknowledgements:** This work was supported by Small Business Technology Transfer Program Grant 1R41RR13230-01