# A 500 MHz 11 cm Hybrid Birdcage with Improved Tuning Range

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**Synopsis:** Numerical evaluations of 500 MHz hybrid birdcages of 11 cm diameter and 9 cm rung length suggested that a useful advantage over the conventional high-pass birdcage can be obtained with a derivative of the 8-section shielded hybrid birdcage, provided the capacitors are such that the coil is much closer to high-pass than low-pass conditions.

**Introduction:** Hybrid (or bandpass) birdcages have been proposed for extending the range of large birdcages to higher frequencies, but previous approaches have often resulted in (1) inhomogeneous modes being impractically close to the homogeneous mode and/or (2) inadequate tuning range to accommodate a useful range of loads.

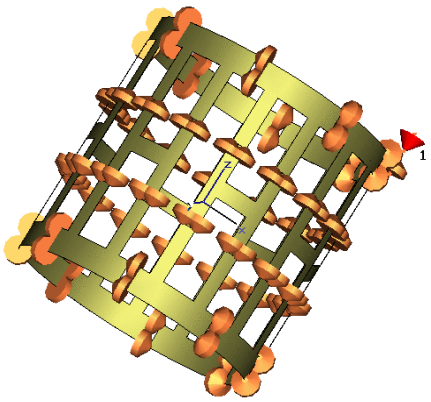

Figure 1. The hybrid birdcage coil. The capacitors are depicted by small, chamfered disks.

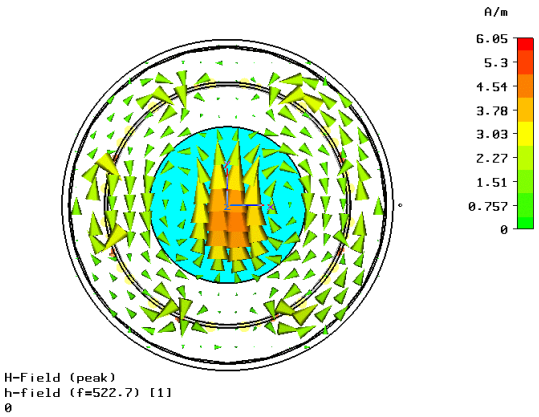


Figure 2. $B_1$ field vector plot.

**Methods:** **Figure 1** shows the coil geometry (less external rf shield, sample, and matching elements), as simulated using full-wave EM software by CST, MWS 5.1.

A four-point-drive tune/match network was used to improve symmetry.

The coil experimentally accommodated 50 mM saline loads up to 76 mm diameter by 90 mm length without difficulty, even though strong dielectric resonance behavior was observed in the field profiles. The simulations predicted an unusual (but expected) increase in the resonant frequency for larger loads, and this upward shift in frequency was experimentally confirmed.

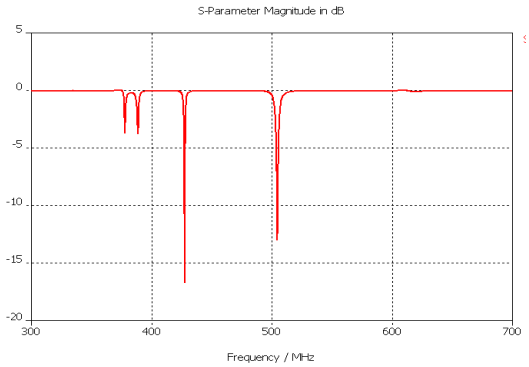


Figure 3. S11 plot for the coil with a 50 mM cylindrical sample of 30 mm diameter.

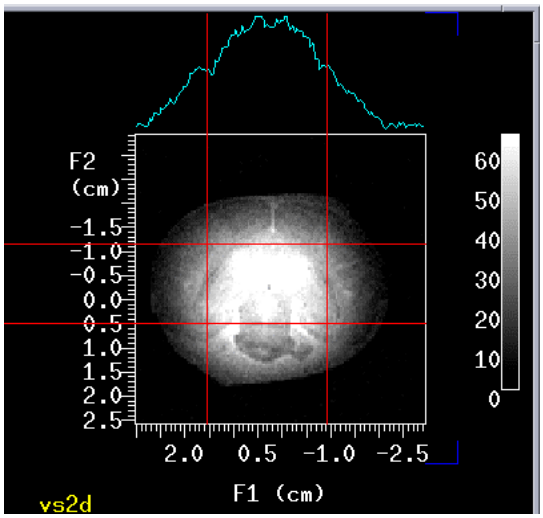


Figure 4. Fast spin echo, fixed baboon brain.

**Results:** The instantaneous $B_1$ field vector plot for the z=0 plane for a 50 mM saline cylindrical phantom of 70 mm diameter and 90 mm length for linear excitation at a particular phase, as shown in **Figure 2**, illustrates the interesting flux behavior, showing flux reversal in the center. The mean circular polarization (CP) field (not shown here) shows similar strong central brightening and weak edge brightening, but with circular intensity profiles. For a 30 mm saline sample, the CP field was quite homogeneous, and the S11 plot is shown in **Figure 3**. Although the simulations indicated that additional capacitors oriented radially from the mid-point of the rungs to the external shield would move the nearest inhomogeneous mode farther away, they were found to be unnecessary experimentally. The tuning range with moderate load and good channel isolation exceeded 20 MHz. The simulations indicated the coil retained good symmetry over this range. The central brightening is also quite evident in the fixed baboon brain image shown in **Figure 4**, acquired in this coil using a fast spin echo sequence.

**References:** 1. S. Crozier, D. M. Doddrell, US Pat #5,642,048, 1997.
2. James Tropp, 'Image Brightening in Samples of High Dielectric Constant,' *JMR* 167, 12-24, 2004.

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