

# A Comparison of Double Tuned Birdcage and Spiral Birdcage RF Coils.

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**Synopsis** Performance of several multiple frequency volume RF coils designed for 4.7T/30cm horizontal bore magnet has been investigated. Three coil types (spiral birdcage, four-ring birdcage and alternate tuned elements birdcage) have been compared with single frequency birdcage coil. All the coils have been loaded with a hollow center cylindrical phantom to measure  $B_1$  amplitude profile along axis Z. Our results show that the alternate tuned elements birdcage method retains most of the SNR of single tuned birdcage coils while preserving z-axis homogeneity, while the  $+\pi$  and  $-\pi$  spiral birdcage and four ring birdcage methods sacrifice SNR and z-axis homogeneity respectively at one of the two frequencies.

## Introduction

Doubly tuned RF coils [1-3] permit combination of  $^1\text{H}$  MR imaging with heteronuclear MR spectroscopy without disruptions associated with exchanging coils for imaging and spectroscopy examinations. They also facilitate accurate localization of spectra and improved shimming over the volume of interest. Majority of them provide rather homogeneous  $B_1$  but SNR is degraded at least at one frequency. This abstract reports upon performance comparisons of different double frequency RF coil designs.

## Methods

Converting a standard birdcage coil into a multi frequency set-up causes a reduction in efficiency. Several double frequency RF coils based on the birdcage design were reported. Spiral birdcage [3-5], four-ring birdcage [1] and birdcage with alternate tuned elements [2] are some of them.

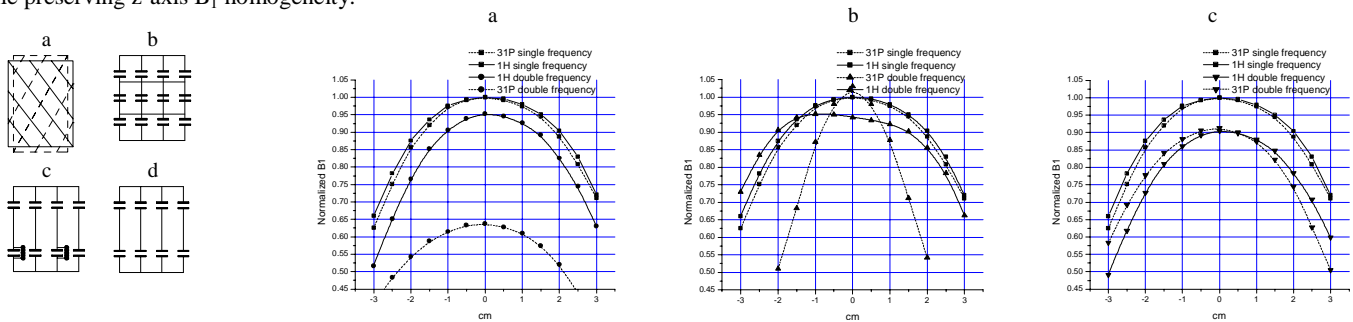
Set of five volume RF coil has been manufactured and tested:

- 81 MHz low pass eight element birdcage, which corresponds to  $^{31}\text{P}$  at 4.7T,
- 200 MHz high pass eight element birdcage, which corresponds to  $^1\text{H}$  at 4.7T,
- coaxial combination of  $+\pi$  and  $-\pi$  low pass eight element spiral birdcages separately tuned to 81 MHz and 200 MHz,
- four ring eight element low pass birdcage tuned to 81 MHz and 200 MHz,
- sixteen element low pass birdcage where alternate elements are tuned to 81 MHz and 200 MHz.

All the coils were manufactured with adhesive copper tape on acrylic former of 70 mm diameter and were 70 mm long. They were all matched (better than -25 dB reflected power) when loaded with a cylindrical phantom with a hollow center to accommodate a probe. The  $B_1$  field produced by the loaded RF coil was measured with a network analyzer using a 20 mm diameter shielded magnetic dipole field probe. The probe was moved along the central axis in 5 mm increments and the  $B_1$  (SNR equivalent output voltage) was measured and recorded.

## Results

The z-axis  $B_1$  homogeneity of the combination of  $+\pi$  and  $-\pi$  spiral birdcages [3] was similar to singly tuned to 81 MHz and 200 MHz birdcages. The higher frequency spiral coil had a modest -0.5 dB SNR reduction, but the lower frequency spiral had a -3 dB SNR decrease relative to its single tuned counterpart. Similarly, a small drop in  $B_1$  without homogeneity deterioration was observed at higher frequency in four-ring birdcage [1]. Lower frequency mode showed no reduction in  $B_1$  amplitude but provided much smaller homogeneity region when comparing to the regular birdcage (fig.2b). The alternate tuned elements method [2] shows only -1 dB SNR decrease at both frequencies when compared with a single frequency coil while preserving z-axis  $B_1$  homogeneity.



**Fig.1** Double frequency resonators tested: a) coaxial combination of  $+\pi$  and  $-\pi$  low pass eight element spiral birdcages; b) four ring eight element low pass birdcage; c) sixteen element low pass birdcage with alternate elements tuned for the alternate frequencies; d) low pass eight element birdcage.

**Fig.2** Comparison of  $B_1$  of the low pass single frequency birdcage with: a)  $+\pi$  and  $-\pi$  spiral birdcages; b) four ring birdcage; c) birdcage with alternate tuned elements.

## Conclusions

The  $+\pi$  and  $-\pi$  spiral birdcage method retains z-axis uniformity, but the lower frequency coil has a -3dB SNR penalty. Although the four-ring birdcage method achieves SNR comparable with single tuned birdcage coils for both frequencies, the frequency mode from the inner end ring section has substantially reduced z-axis uniformity. We found that the best choice for a double tuned volume birdcage coil is the alternate tuned elements birdcage method, which retains, at both frequencies, the z-axis uniformity with only a small (< 1 dB) SNR loss relative to a single tuned birdcage.

## References

[1] Murphy-Boesch, J., et al., J Magn Reson B 103:103-114, 1994; [2] Matson, G.B., et al., Magn Reson Med 42:173-182, 1999; [3] Wong, W.H., et al., US Patent 6,420,871. [4] Alsop, D.C., et al, Magn Reson Med 40:49-54, 1998; [5] G.R. Duensing, et. al, Proc. ISMRM, p.771, 2002.