Improving B1 uniformity in a Birdcage Coil at 7T by Offsetting Along the Z Axis

G. McKinnon[1], E. Boskamp[1]
[1]GE Medical Systems, Waukesha, WI, United States

Introduction

In the course of numerically comparing a high-pass birdcage and a TEM resonator, with respect to head imaging at 7T, it was noticed that the B_1^+ uniformity of the TEM was superior to that of the birdcage when both coils were centered on the head.

Here it is shown how the B_1^+ uniformity of the birdcage can be improved by offsetting it in the superior direction.

Methods

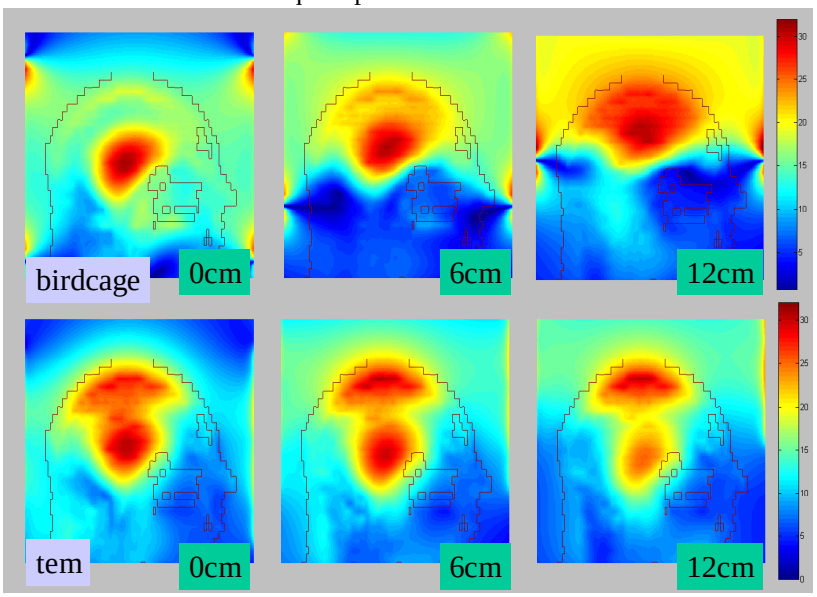
The finite-difference-time-domain (FDTD) algorithm [1] was employed for the simulations. The FDTD cell size was 3mm in the x and y directions, and 9mm along z. The FDTD space extended 51cm in the x and y directions and 99cm along z, and was bounded by an eight cell thick perfect matching layer. Each simulation was run for 13,000 time steps (over 20 periods) to insure that a steady state was reached; then the B_1^+ field, RMS E field, and SAR were calculated over a subsequent period.

Visible-man data, with electrical properties appropriate for 7T [2], were used to simulate the human head. The visible-man data was positioned with the head in the center of the coil; and the data were truncated such that no tissue was closer than 6 FDTD cells from the perfect matching layer.

TEM and birdcage coils were modeled with rungs = 32, coil length = 24cm, coil radius = 15cm, shield radius = 17cm, and strip width = 1cm. The coils were driven using current sources, supplying the ideal current, at the usual capacitor locations.

The coils could be offset along the z-axis. For offsets of 0cm, 6cm and 12cm, the shield lengths were 24cm, 36cm and 48cm respectively. This meant that the shield ends were equidistant from the shoulders in all cases.

The B_1^+ uniformity within the head was determined, as was the normalized peak E field on a 14cm radius cylinder, and the SNR (defined as peak B_1^+ in the head divided by the power deposited in the body).



Results

The B_1^+ uniformity, in 28cm FOV sagittal sections, is shown in the above figure for the two coils at various z offsets. Notice that at 0cm offset the TEM uniformity is superior; whereas with an offset of 12cm, the birdcage could be labeled “better” - although the sensitivity doesn’t penetrate so far inferiorly as in the TEM case.

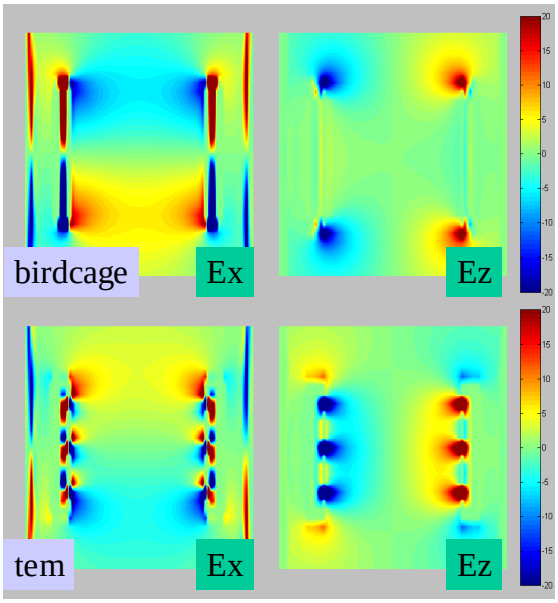
For the two optimal configurations, the SNR of the birdcage coil was 35% higher than that of the TEM; and the TEM coil had a 41% higher normalized peak E field.

Discussion

The results demonstrate that even though the free space B_1^+ uniformity is reasonably similar over the imaging FOV for these two different types of coils, the uniformity in a head at 7T can be quite different.

This is not so surprising when one considers that their respective free space E fields are quite different (as shown opposite over a 50cm coronal FOV).

Note that halving the coil length, and using an end-cap, can also achieve this “offset-birdcage” effect.



References

[1] Taflove & Hagness, “Computation Electrodynamics”, 2nd Ed. (2000)
[2] Gabriel, www.brooks.af.mil/AFRL/HED/hedr/reports/dielectric