# Optimized Whole-Body RF Coil for Imaging Applications at 7 Tesla

T. Ibrahim[1], R. Abraham[2], D. Abraham[2]

[1]School of Electrical and Computer ENgineering, The University of Oklahoma, Norman, Oklahoma, United States, [2]School of Electrical and Computer ENgineering, The University of Oklahoma, Norman, OK, United States

## Introduction:

As human MRI is now reaching field strengths of 7 to 9.4 Tesla, experiments and numerical modeling effort [1-3] has demonstrated the need for using non-conventional (out of the box) approaches for dealing with the associated RF inhomogeneity. The physical feasibility as well as the potential for clinical applications has been demonstrated by such systems [4-6]. What remains now is the development of solid RF engineering approaches, ensuring that MRI continues its meteoric ascent in human medicine. In this work, we provide a whole-body RF coil design that is optimized for volume abdominal applications at 7 Tesla.

## Methods:

A finite difference time domain (FDTD) model of a thirty-two port TEM resonator of length 16.2 cm, inner diameter 60.6 cm, and outer diameter 72.6 cm was designed for 7 Tesla abdominal applications. An anatomically accurate body model (*ftp://starview.brooks.af.mil/EMF/dosimetry models*) was then used to load the coil, and positioned such that the coil surrounded the region of the body from the bottom of the ribcage to the waist. This system, which consisted of over 7 million cells at 6 mm resolution, was excited individually at sixteen ports and analyzed at 298 MHz using the FDTD method. Next, the fields at three axial slices, one sagittal slice, and one coronal slice of the portion of the body within the coil were extracted. These slices were used to determine the optimal excitation strength and phase at each of the sixteen ports in order to achieve maximum field homogeneity within the body structure of the coil.

## Results:

Figure 1 displays the coil spectrum loaded with the body model. It shows the coil modes, including the operational mode tuned to approx 298 MHz. Figure 2 displays axial, sagittal, and abdominal slices before optimization and after optimization with the multi-element drive system. The standard deviations of the superposition of the magnetic fields from sixteen port excitations are given below for the non-optimized as well as optimized cases.

| | Axial Slice 1 | Axial Slice 2 | Axial Slice 3 | Sagittal Slice | Coronal Slice |
|---|---|---|---|---|---|
| Non-optimized | 1.0701 | 1.1091 | 1.1546 | 1.1161 | 1.2137 |
| Optimized | 0.4224 | 0.4448 | 0.4892 | 0.2007 | 0.3810 |

## Discussion:

These preliminary results demonstrate the feasibility for developing a body coil at 7 Tesla. While the non-optimized transmit fields show significant inhomogeneity, the multi element excitation technique provides significant enhancement in the performance ranging from a standard deviation decrease of 60% for a mid axial slice to 82% for the sagittal slice (Figure 2 and above table). Results obtained with tuning the coil to non-conventional operating modes show that the homogeneity could be further improved in specified anatomical regions with the multi-element driving schemes which only required a few minutes on a standard 2GB RAM Pentium PC.

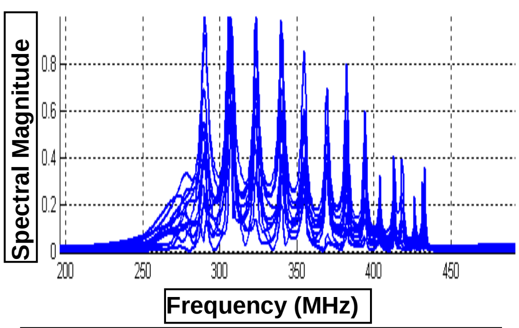


Figure 1: Spectral magnitudes of the 32-strut body coil loaded a with whole-body accurate model

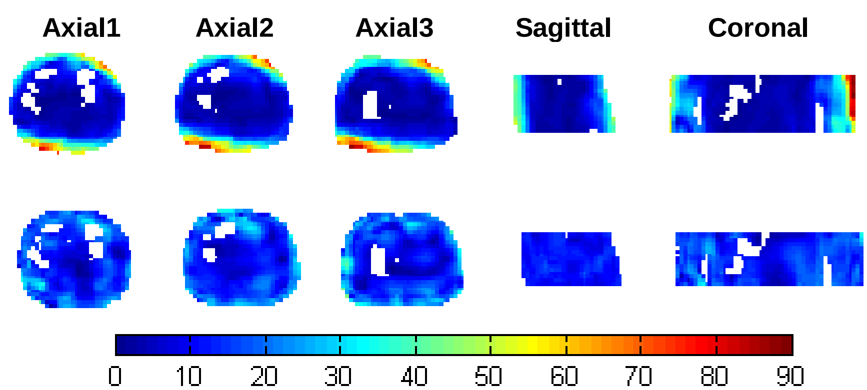


Figure 2: Three axial slices, one sagittal slice, and one coronal slice showing the magnetic fields within the portion of the body inside the coil before (top) and after (bottom) optimization. The color scale represents the flip angle.

## References:

[1] Chen, J., et al, IEEE Trans. Biomedical Eng., Vol. 45, pp.650-659 (1998)
[2] Collins, C.M., et al, Magnetic Resonance in Medicine, Vol.40, pp.846-856 (1998)
[3] Ibrahim, T.S., et al, Magnetic Resonance Imaging, Vol.18, pp.733-742 (2000)
[4] Abduljalil A.M., et al, J Comp Assist Tomogr, Vol.23, pp.832–841 (1999).
[5] Vaughan, J.T., et al., Magn. Reson. Med., 46, 24-30 (2001).
[6] Graham C.W., et al., ISMRM, Kyoto, p36 (2004)