Optimization of RF Coils for High Field Imaging: Why the Head is Different Than Symmetrical Phantoms

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INTRODUCTION

The B_1 field can be optimized by altering the manner in which the RF coil is driven. This is similar to that utilized in microwave hyperthermia cancer treatments [1]. This method is conceptually similar to an antenna array, with the exception that the near field is involved rather than the far field. This concept is also applicable in high frequency MRI. In here, we extenuate why this feature is unique for optimizing the homogeneity for biological structures and not for symmetrically shaped loads.

METHODS

We will consider a 16-strut TEM resonator loaded with an 18.5 cm sphere filled with 0.125 M NaCl or with the 18-tissue anatomically detailed human head model (OSU 2mm mesh). We will also consider a high pass birdcage coil loaded with a 6-tissue model (REMCOM 3mm mesh) and an 18.cm-diameter, 22 cm-length, phantom with dielectric properties similar to muscle. In addition to the standard 4-port excitation, (fixed magnitude and progressive phase shifts (FPFM)), we will consider optimized-phase and optimized-magnitude (OPOM) excitation. The optimizations criteria will be different for the two coils. In the TEM coil, minimization of the standard deviation is considered while minimization of the difference between the maximum and minimum values will be considered for the birdcage coil case. For the TEM coil, the results are presented at 340 MHz, while 200 MHz was utilized for the birdcage coil simulations.

RESULTS AND DISCUSSIONS

Figure 1 displays FDTD calculated circularly polarized component of the excitation (B_1^+) field inside the 18.5 cm sphere and inside the head model which are both loaded in a TEM coil which is tuned to 340 MHz and utilizing 4-port standard FPFM (left Column), and OPOM (right column) excitations. The same results are shown for the birdcage coil at 200 MHz for the different head model and the cylindrical phantom [2]. The results show no improvement is achieved in the standard deviation when switching from FPFM to OPOM excitation for the spherical phantom case in the TEM resonator and these findings are also true for the cylindrical phantom case in the birdcage coil. Note that this is even true with two different types of fillings in the phantoms. This is expected since for a symmetrical homogeneous object, the standard progressive phase shifts would provide the best possible homogeneity for the circularly polarized field. However for the human head the situation differs since for asymmetrical, inhomogeneous, and irregular shape loading (human head), 0, pi/2, pi, and 3pi/2 are not the necessary phase shifts needed on the excitation sources in order to obtain a homogeneous circularly polarized B_1 field. In this case an approx. In other simulations with a 24-strut coil it was found that increasing the excitation ports can improve the homogeneity up to 203 [3].

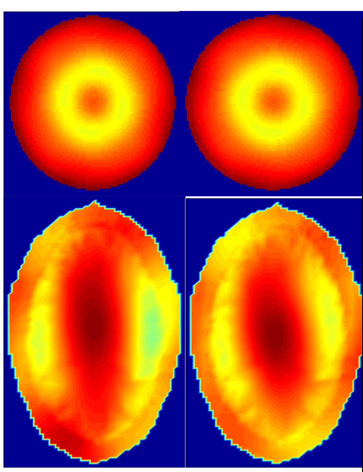
REFRENCES:

[1] Chen, J. Y., and O. P. Gandhi, Numerical Simulation of annular-phased arrays of dipoles for hyperthermia of deep-seated tumors, IEEE Trans. Biomed. Eng., 209--216, 1992.

[2] Ibrahim, T. S., et al., Application of finite difference time domain method for the design of birdcage RF head coils using multi-port excitations Magn. Reson. Imaging, 18, 733--742, 2000.

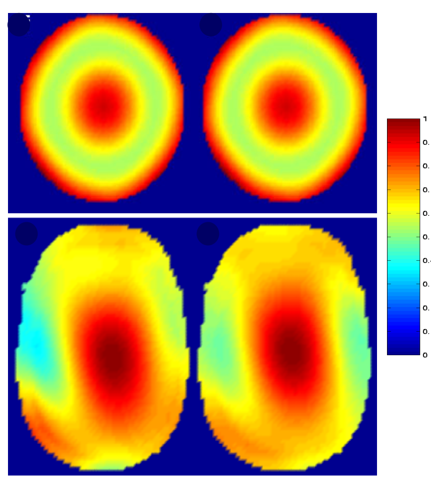
[3] Ibrahim T. S., et al., ``Effect of RF coil excitation on field inhomogeneity at ultra high fields: a field optimized TEM resonator'', *Magnetic Resonance Imaging*, Vol 19, pp 1339-1347, December 2001.

TEM COIL



FDTD calculated field inside a 0.125 M NaCl 18.5 cm sphere and inside the 6-tissue head model (bottom), both loaded in a 16-strut TEM coil tuned to 340 MHz and utilizing 4-port standard (fixed phase-fixed magnitude) (left) and optimized phase-optimized magnitude (right) excitations

Birdcage Coil



FDTD calculated field inside a muscle cylindrical phantom and inside the 6-tissue head model (bottom), both loaded in a 16-strut birdcage coil tuned to 200 MHz and utilizing 4-port standard (fixed phase-fixed magnitude) (left) and optimized phase-optimized magnitude (right) excitations