Effect Of Receive Only Array Inserts on B1+ Field and Specific Absorption Rate (SAR)

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Introduction: This study is aimed at investigating the effect of head receive-only arrays on the MRI excitation field, and on the local and average SAR. [1] Has observed the currents induced in a receive coil can distort the transmit field, and cause local increased SAR. We seek to investigate the effects of a detuned and thin 32-loop receive-only head insert on transmit coil performance. The study was conducted at 7 tesla (300 MHz).

Method: Two anatomically-detailed head models (23 and 19 tissue types) were used in the simulation. Full wave finite-difference time domain (FDTD) electromagnetic simulation was used to model an 8-element TEM [2] transmit-only coil. Four ports of the TEM coil were connected in quadrature excitation mechanism. Figure 1 displays a sample S matrix obtained from FDTD simulations and with a network analyzer connected to the constructed TEM coil. The results show excellent correlation between the experimental and simulated data. A flexible 32 channel surface Rx-array insert was designed to accommodate different subjects. The Rx-array insert geometry was created using Solidworks (Dassault Systèmes SolidWorks Corp. Concord, MA 01742) and Matlab (The Mathworks, Inc. Natick, MA 01760). A thin 1/16" copper trace was used for the 32 receive loops, See figure 2.

Results and Discussion:

Effects on SAR: The average per 10gm of radio frequency (RF) signal deposition in tissue (normalized to total absorbed power, i.e 1 watt CW) of head1 and head2 are shown. Peak SAR increased with the receive array for head1 while it decreased for head2. The location of peak SAR did not change. The peak SAR **(TEM only, TEM with receive-only array)** were (0.6799, 0.7174) W/Kg/10gm for head1 and (2.528, 2.414) W/Kg/10gm for head2. With the same input power to the coil, the average SAR over the head remained the same with or without the receive-only array. Thus, the TEM coil radiation did not change in the presence of the receive-only insert.

New hot spots appeared with the receive array in both head models and the intensity of existing hot spots increased. See figure 3. In head1 the intensity increase was observed at the bridge of the nose, at the back of the neck and eyes, while in head 2 new hot spot appear at the parieto-occipital area (back of the head). Comparing all voxels 36568 voxels (size = $(1/16")^3$) head1 showed an increase in SAR from 0.059 through 0.304 W/Kg/10gm, while 29076 voxels of head2 showed an increase in SAR from 0.043 through 0.740 W/Kg/10gm. The SAR in the remaining voxels remained the same or decreased by less than ~0.03 W/Kg/10gm.

Effects on B_1^+ Field and Transmit Coil Tuning: The peak and average B_1^+ value increased with the receive array in head1 as shown in figure 4. The scatter parameters with the receive array showed minor changes. The resonance frequency (lowest Sxx in dB) in head1 shifted by 0.3MHz, but no similar trend was found in head2. The value of reflection at desired Larmor frequency of 297.22MHz did not change appreciably in the two head models, with or without the receive array. The unaltered reflection coefficient at desired frequency explains the similar input power and absorbed power in the two simulations.

Conclusion: The 1/16" copper traces of a 32 detuned receiver loops had marginal effect on the Tx coil tuning and coupling. However new local higher SARs (while still lower than the peak SAR over the head volume) appeared. The locations of the new higher local SARs were different for the two head models. We anticipate more significant effects when using wider copper traces, or when the overlapped decoupling design is used for the receive-only array inserts.

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Reference: [1] N. D. Zanche 'MRI Technology: Circuits and Challenges for Receiver Coil Hardware' Medical Imaging John Wiley & Sons 2009.

Figure 2: Schematic of a 32- channel receive-array insert

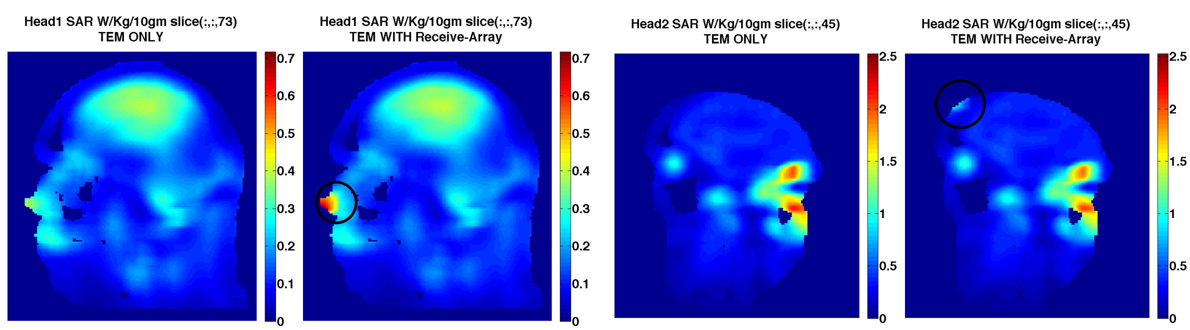


Figure 3: Head1 and Head2 SAR, New hot spots appeared with the receive–array insert

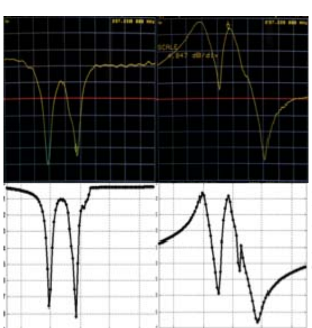
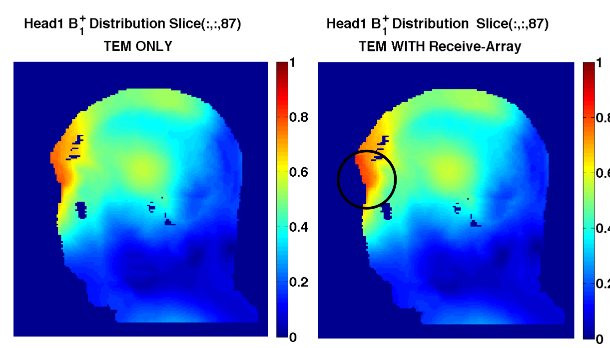


Figure 1: Simulated (FDTD) and experimentally measured S11 (left) and S12 (right) of the 8-element TEM coil loaded with spherical saline phantom.

Figure 4: B_1^+ field distribution



[2] J. T. Vaughan, et. a., "High Frequency Volume Coils for Clinical NMR Imaging and Spectroscopy., " Magn Reson Med, 32, pp. 206-218, 1994.