Simulation and construction of a CP Dual Helmholtz saddle Tx / 8–ch.-Rx head-coil for 7T whole body system

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Introduction:

Although higher fields in principle should provide a higher signal-to-noise ratio (SNR) and improved spectral resolution ultra-high-field conditions such as the B1-inhomogeneity require new solutions for transmitting and receiving the RF-energy. Commercial RF-coils usually have to cover the needs common to a large user group while for some experiments such as acoustic fMRI at 7T special solutions are required. Simulation of the B1-field distribution helps as a starting point to optimize the RF-coils. Besides an optimized and homogeneous distribution of the B1-field the Q and the specific absorption rate (SAR) are important measures to characterize RF-coils. Simulation of the RF-coil material, the geometry and RF-distribution eases the developing process considerably especially when considering the optimum distance between Tx and Rx coil to fit in headphones for acoustic fMRI and shifting there receiver coils to gain more space for visual stimulation. In a joint project between 2 MRI-research groups an 8-ch. head-coil was simulated and built for 7T MRI (**Fig. 2**).

Methods:

The basic coil configuration consisted of a CP Helmholtz saddle configuration for the transmit coil (Tx) and an 8 element phased array coil (Rx) **[1]. [2],[4],[5]** for the receive part. The coil was planned to be used in visual and auditory fMRI examinations thereby requiring additional space in the frontal parts and for inserting headphones. Coil elements and geometry were simulated using the field simulation software MWS **[3]**. Varying geometry such as distance between the Rx and Tx elements, coil configuration and coil positions as well as values of the capacitors led to an optimized configuration (**Fig. 1**). To evaluate the distribution of the RF-energy to calculate the SAR within the biological tissue a human voxel software model was included into the field simulation software. The 8-channel head-coil was tested at a 7T Siemens whole body scanner (Siemens, Erlangen, Germany).

Sequence Parameters: (**Fig 3.**) GRE Sequence TR: 2180ms, TE: 3.77ms, Image-Matrix: 128x128, slice thickness: 1.11mm, slice distance: 1.5mm, FoV: 181x181mm; (**Fig 4.**) GRE Sequence TR: 750ms, TE: 21.6ms, Image-Matrix: 896x1024, slice thickness: 2mm, slice distance: 4mm, FoV: 224x256 mm.

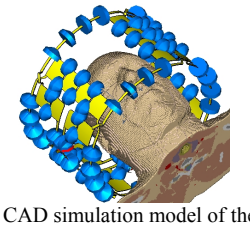

Fig. 1 CAD simulation model of the CP Dual Helmholtz saddle Tx / 8–ch.-Rx head-coil with Human Voxel Model of the Visible Human Project

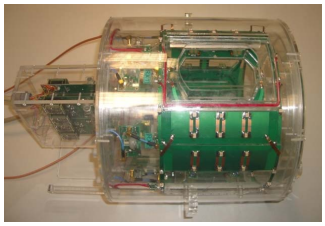

Fig. 2 The final CP Dual Helmholtz saddle Tx / 8–ch.-Rx head-coil

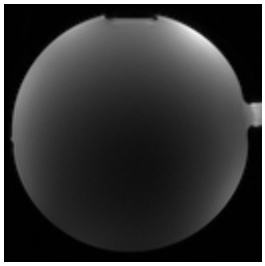

Fig. 3 MRI with Oil phantom acquired with CP Dual Helmholtz saddle Tx / 8–ch.-Rx head-coil

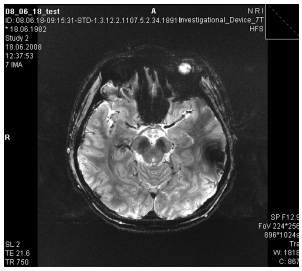

Fig. 4 The final CP Dual Helmholtz saddle Tx / 8–ch.-Rx head-coil with transversal slice image of an human head

Results and conclusion:

The simulation allowed the optimized positioning of the capacitors and the extension of the frontal space between the phased array coils to enable visual fMRI experiments. Inclusion of the software model into the CAD coil model enabled the analysis of the RF distribution within the head model (**Fig. 1**). Simulation and phantom measurements proved that the SAR was within the biological limiting ranges which are the prerequisites for in-vivo use. SNR was 20% lower and image quality was decrease in phantom measurements than in in-vivo measurements as the 8-channel head-coil was matched to the load of a human head. Nevertheless the CP Dual Helmholtz saddle Tx / 8–ch.-Rx head-coil has even more capabilities for use in special fMRI studies.

References:

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