8-channel transmit/receive head coil for 7 T human imaging using intrinsically decoupled strip line elements with meanders

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Introduction

Symmetrically excited meander elements have been shown to be superior to common strip line elements for 7 T imaging [1]. In particular, due to their higher intrinsic decoupling in coil arrays and the larger penetration depth inside the sample, a higher signal-to-noise ratio can be obtained by such elements. In the current study, the original meander element was further optimized and an 8ch transmit/receive head coil was built and tested.

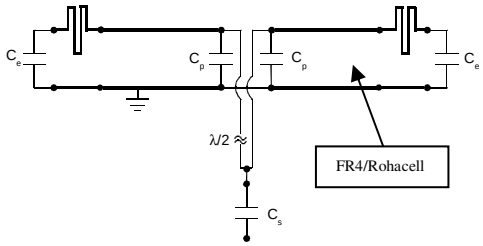

Figure 1: Sketch of the symmetrically fed meander element

Materials and Methods

A principle sketch of a single 25-cm-long meander element is shown in Fig. 1. It is composed of a symmetrically fed strip line with meanders. Instead of the originally proposed PMMA substrate, a sandwich construction of FR4 and Rohacell was used, which substantially increased the efficiency of the coil due to smaller losses. The 8 elements are attached to two octagonal polyamide frames [2], which also form a chassis for the mechanical housing which is made of PMMA with a thickness of 5 mm. The inner housing is octagonal with an inner diameter of 26 cm (Fig. 2). SAR calculations for the coil were performed for 3 anatomical human models [3] using CST Microwave Studio (Darmstadt, Germany). Imaging experiments were performed on a 7T whole-body MR system (Magnetom 7T, Siemens, Erlangen).

Results

Using the sandwich substrate, the intrinsic decoupling was enhanced by 2 dB so that the decoupling of neighbouring elements is better than -17 dB. Additionally, simulations showed that the penetration depth into a homogeneous flat phantom ($\varepsilon_r = 43.6$, $\sigma = 0.8$ 1/Ωm) was improved by 10 % in comparison to the old substrate. The 8ch T/R head coil was driven with a phase increment of 45° per element ("birdcage mode"). Fig. 3 shows *in vivo* flip angle maps for a commercially available 8ch head coil made of loop elements (length 20 cm, width 9 cm, coil inner diameter 23-25 cm) and the new coil with meander elements. The maps were acquired at the same input power with a vendor-provided B1-mapping sequence. For the meander element head coil, a 3 % higher flip angle in the center of the head is achieved as well as a more uniform flip angle distribution across the head and a larger useable excitation region. The SAR calculations (Fig. 4) show that, in order to stay inside the limits of 10g-averaged and whole-head SAR, the maximum permissible input power for the new coil is higher by a factor of 5.3 for the male model of the Visible Human Project, and 6.2 and 7.5 for the male and female model from the Virtual Family data set [3] than for the commercial coil.

Figure 2: Implemented 8ch T/R head coil with PMMA housing

Discussion

The presented results show that the head coil made of meander elements operated with 45° phase increment between the elements offers excellent imaging performance at 7 Tesla in terms of B1 efficiency, B1 homogeneity as well as SAR efficiency. The high power efficiency allows for higher flip angles, more slices in SE sequences or shorter TR times. The coil can also be operated with RF shimming hardware. It is expected that it will further improve imaging quality results obtainable with RF shimming.

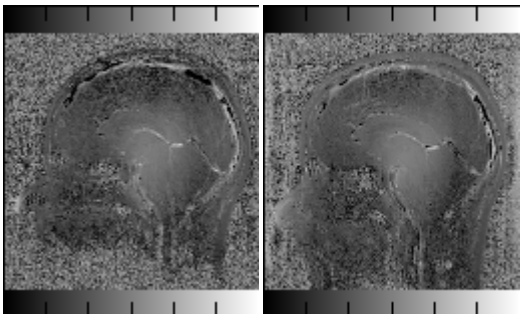

Figure 3: Measured flip angle maps in a human head. Left: commercial loop element head coil; Right: meander element head coil.

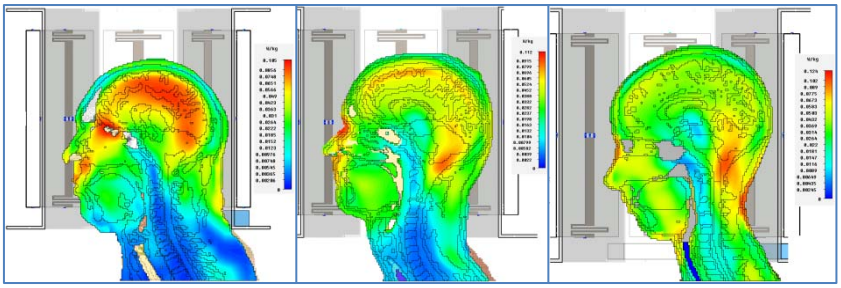

Figure 4: Simulated 10g SAR distribution (IEEE C95.3) for meander element head coil at input power of 1W. From left to right: Male model from the Visible Human Project, male and female models from the Virtual Family data set. Images are normalized to their own maximum.

[1] S. Orzada et al.. Proc. Intl. Soc. MRM 16 (2008), 2979. [2] A. Bahr et al., Proc Intl. Soc. MRM 16 (2008),2978. [3] CST MICROWAVE STUDIO®, User Manual Version 2008, CST GmbH, Darmstadt, Germany, www.cst.com. [3] Virtual Family Models, http://www.itis.ethz.ch/index/index_humanmodels.html