Characterization of a novel 8 channel microstrip head array at 7 T – Numerical simulation and experimental verification

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Introduction

Microstrip resonators are interesting basic elements for the design of RF volume coils at high frequencies [1]. These elements are used in conventional birdcage resonators as well as in arrays for use with parallel transmit and receive techniques. In this work we describe a novel 8 channel microstrip array at 7 T which provides good B_1-Field homogeneity in combination with decreased mutual coupling. The novelty implemented in this coil is the use of meanders at both ends of the coil elements.

Figure 1: SAR measurement setup.

Material and Methods

The microstrip elements were built on PMMA ($\varepsilon_r = 2.2$, $\tan(\delta) = 0.02$) with a substrate height of 20 mm. The ground plane has dimensions of 250 mm x 100 mm, the width of the microstrip was 15 mm. In order to achieve maximum homogeneity of the magnetic field in the longitudinal direction and low mutual coupling a combination of end capacitors and meander line structure was used like depicted in Figure 1. The feeding network is based on [2]. The single elements were mounted inside a regular octagon with an inradius of 160 mm.
Simulations for all elements were done using the commercially available software package Empire™. A cylindrical phantom ($\varepsilon_r = 43.4$, $\sigma = 0.8$ mhO/m) with a height of 210 mm and a radius of 86 mm was positioned in the center of the array.
Measurements were based on the dosimetric measurement system DASY (Figure 1). The B_1-Field and SAR distribution were determined in a PE phantom with a shell thickness of 3 mm which was filled with tissue simulating liquid ($\varepsilon_r = 44.9$, $\sigma = 0.78$ mhO/m). In addition the S-parameters were determined with a conventional VNA.

Results and Discussion

Figure 2 shows the most relevant S-parameters. The performance of the single element is good ($s_{11} < -25$ dB, $s_{21} < -14$ dB measured) both in measurement and simulation. In Figure 3 the normalized B_1-Field and the SAR are depicted for the central transversal plane. The simulation shows a slightly increased B_1-Field concentration around the excited element compared to the measurement result. This effect can be seen for the SAR also. Apart from this, the agreement between simulation and measurement is excellent. The difference between the measured and simulated maximum SAR – normalized to $B_{1,max}^2$ - is below 1 dB. Figure 4 shows the B_1-Field along the central longitudinal line 10 mm inside the phantom. Because of the center feeding the B_1-Field is also symmetric with respect to x = 0 m. In addition only a small decrease of the B_1-Field near the ends of the array can be observed, which is comparable with the results in [1]. This will lead to a good coverage in the longitudinal direction which will be verified in a next step by MR measurements on a Siemens 7 T whole body scanner.

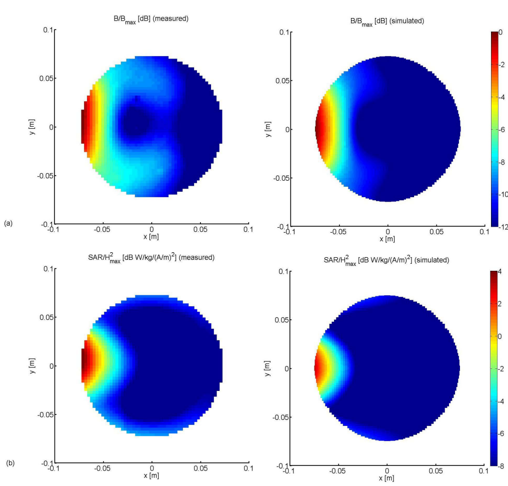

Figure 3: Comparison of measurement and simulation, (a) normalized B_1- Field, (b) SAR.

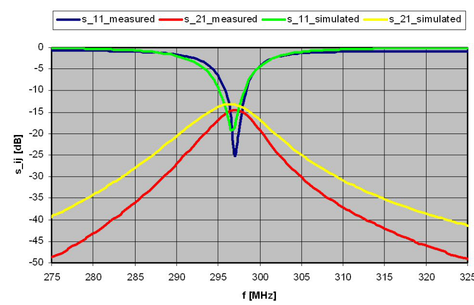

Figure 2: Matching and coupling results of the loaded array.

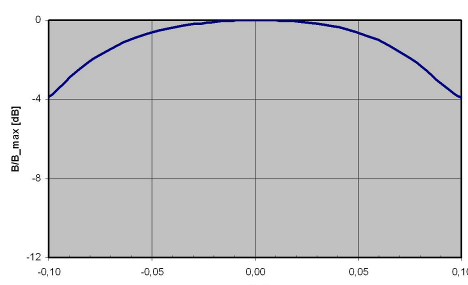

Figure 4: Simulated B_1-Field along the central longitudinal line of the excited element.

[1] X. Zhang et al. EEE Trans. Biomed. Eng. 49, 345-354 (2005). [2] D.O. Brunner et al. Proc. Intl. Soc. MRM 15 (2007)