

## A 7 T receive array for in vitro studies of human brain tissue

A. Peter<sup>1</sup>, M. Kladeck<sup>2</sup>, O. Speck<sup>2</sup>, and J. G. Korvink<sup>1,3</sup>

<sup>1</sup>Department of Microsystems Engineering - IMTEK, University of Freiburg, Freiburg, Germany, <sup>2</sup>Biomedical Magnetic Resonance, Otto-von-Guericke University, Magdeburg, Germany, <sup>3</sup>Freiburg Institute of Advanced Studies (FRIAS), University of Freiburg, Freiburg, Germany

### Introduction

In this contribution, we present a 19-channel, 2D coil array for large in vitro studies of human brain tissue, such as whole brain slices at 7 T. Such studies at high field become increasingly popular since they can combine very high anatomical resolution with large scanning volumes. The 5 cm thick sample is to be placed in a separate container horizontally between two of these arrays. The coil array has a hexagonal shape with an edge length of 14 cm, each hexagonal coil element has an edge length of 3 cm. The channels are amplified and decoupled from their neighbours by home-made low impedance low noise amplifiers (low-Z LNAs).

### Experimental

The isolation of adjacent coils by geometric overlapping is a well-known technique since the beginning of array development [1]. Decoupling of non-adjacent coils is performed by home-made low-Z LNAs. The correct overlap of the coil elements was optimised by ADS/Momentum [2]. Fig. 1 shows the layout of the 19 coil elements. Tracks in blue color are fabricated on the top of the PCB, the red tracks are on the bottom. A section of four coils (three overlapping and one non-neighbouring coil) has been full-wave simulated by Momentum. The resulting S-parameter matrix was then imported into ADS in order to design the tuning, matching and LNA circuitry. The results from the ADS/Momentum simulation show an isolation between neighbouring coils better than 30 dB. Between non-neighbouring elements the isolation provided by the LNAs is better than 20 dB. A simulation of the  $B_1$  field distribution has been performed by Biot Savart's law. Fig. 2 shows the homogenous  $B_1$  field in a plane, 20 mm above the coil array surface. The highest level of uniformity is confined to the inner 7 coils of the array.

The hexagonal coil elements are fabricated on a double-sided 1.5 mm thick FR4 PCB with 2 mm wide and 70  $\mu\text{m}$  thick copper tracks. Fig. 3 shows a picture of the PCBs of the demonstrator. Single coils are segmented by non-magnetic capacitors on each edge to avoid wavelength effects. The LNAs are placed on five separate PCBs perpendicular to the array surface. The total height of the array with the LNA boards is only 6 cm.

Each coil element is tuned by a varactor diode (BB639) and matched to the low-Z LNA by a  $\lambda/4$  balun, also adjustable by two varactor diodes. In order to use the array for reception only, PIN diodes (BAP64-03) are used to detune the elements during transmission. The low-Z LNAs are home-made by two HEMTs (ATF54143) and provide an input impedance  $\sim 1.5 \Omega$ . They are noise-matched to 50  $\Omega$  with a low noise figure of  $\sim 0.5$  dB and provide a gain of 35 dB.

### Results & discussion

In order to verify the achievement of the optimisation, we first tuned and matched the coil elements to 50  $\Omega$  without the LNAs. We measured the coupling between all elements of the unloaded array by means of a network analyser at 300 MHz. All adjacent elements show an isolation of  $> 26$  dB, the next neighbouring elements 15 dB between each other. The values will be further reduced by the low-Z LNAs. The circuit Q of a single element was calculated by the bandwidth of the input reflection measurement and is on average 100 [3].

### Conclusion

We have designed and build a new very high-density coil array for the examination of large samples with limited thickness in a 7T MRI. The design, including the tuning and matching circuit as well as the LNAs, was fully based on optimizations performed in EM-simulations. The experimental performance on the RF-bench confirms the simulations and has to be reproduced inside the MR system.

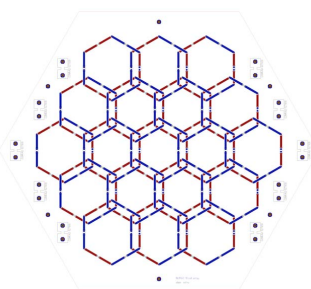


Fig 1. Layout of the 19-channel coil array.

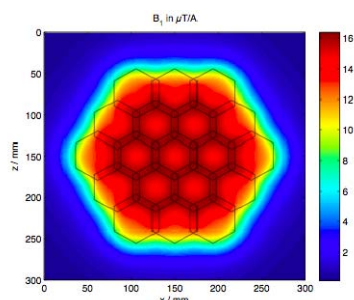


Fig 2. Simulation of the  $B_1$  field, 20 mm above the array surface.

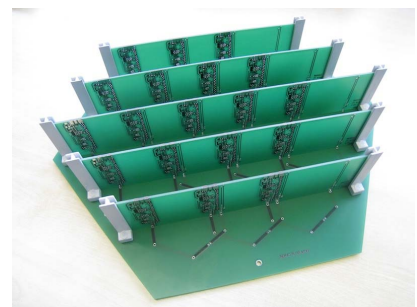


Fig 3. Picture of the PCBs of the coil array demonstrator together with the LNAs.

**Acknowledgment** This work is part of the INUMAC project supported by the German Federal Ministry of Education and Research, grant #13N9208

**References:** [1] Roemer et al., Magnetic Resonance in Medicine 16, 192-225 (1990); [2] Agilent GmbH, Böblingen; [3] Mispelter et al., NMR Probeheads (2006).