A thin-walled, cylindrical 4-channal receive-only coil array suitable for PatLoc imaging at 9.4 T

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Introduction

In this work, we present a very **thin-walled**, cylindrical four-channel receive-only surface coil array on flexible substrate for small-animal MRI at **9.4 T** (400 MHz). The very small wall thickness enables the use of this array together with a **PatLoc** gradient coil [1]. With increasing field strength, wavelength effects become more and more important [2]. Thus, the design of coils with diameters of several centimeters cannot be successfully performed in a reasonable time without the aid of full-wave simulation tools. We present the straightforward design and manufacturing process of a four-channel coil array.

Methods

The layout of the coil array was simulated in order to find optimal values for all lumped components. Details about this work are reported in another abstract.
The optimized layout from the simulation was used to produce a PCB of the coil array on **flexible substrate** (18 µm copper on a 50 µm polyimide foil). Each coil has an unwrapped size of 50mm x 50 mm, the tuning and matching circuit adds additional 40 mm so the complete length of the coil is 90 mm. Wrapped around a hollow PEEK cylinder of 61 mm inner diameter, it forms a cylindrical coil array with only **4.5 mm overall wall thickness**. Figure 1 shows a picture of the coil array.
All adjacent coils are decoupled by fixed shared capacitors (SRT microceramique) at the center of their common conductor. The full wave simulation shows an improvement in the B_1 field homogeneity with a common conductor width of 6 mm compared to the width of all remaining conductors of 1 mm. A further segmentation by a fixed capacitor of the top conductor reduces the wavelength effects at 400 MHz. The parallel tuning capacitor is split into a fixed and a variable one of approximately the same size at the bottom end of each coil to balance the design. Two capacitors in series allow matching the coil to 50 Ohms. The fixed capacitor is used as a DC block and it also adjusts the range of the variable capacitor. Both the tuning and the matching capacitor of each coil are implemented by reversed biased **varactor diodes** (Infineon BB639). RF blocks feed two individual DC voltages to the diodes. An additional parallel inductor provides a DC return path for the matching diode. The tolerances of the layout and the used components between the four coils are so tight, that two single voltages can be used for tuning and matching all four coils at the same time with a sufficient accuracy. An anti-parallel diode pair (1N4148) at each coil performs the passive detuning during transmission.

Results

All electrical measurements were performed with a four-port network analyzer (Agilent 5071C). Figure 2 shows a comparison of the S-parameters obtained by the simulation and the measurement. The single unloaded coil has a Q-factor of 67. The imaging experiments were performed inside a Bruker BioSpec 94/21 Magnet at 9.4 T (Bruker BioSpin GmbH Germany). For transmission, a Bruker linear coil (inner diameter 72 mm) was used, a bottle of silicone oil and various fruit were used as samples. The coils were interfaced as an array; figure 3 shows an acquired image of a lemon as sum-of-square recombination of the four channels.

Discussion

Simulation and measurements of S-parameters are in **good agreement**. The tolerances of the components result only in a small frequency shift between the individual coils. Decoupling between two adjacent coils is less than -20 dB; even both opposite coils show a decoupling of -17 dB respectively without additional effort. A proper operation as an array even without low-impedance LNAs is feasible. The preliminary MR image in figure 3 shows a reasonable **good homogeneity** of the coil array. The next steps will be an assembly together with a self-made transmit volume coil to form a very compact thin-walled TX/RX coil array for **PatLoc** experiments.

Fig 1. Four-channel receive coil array on flexile substrate, wrapped around a thin-walled PEEK cylinder.

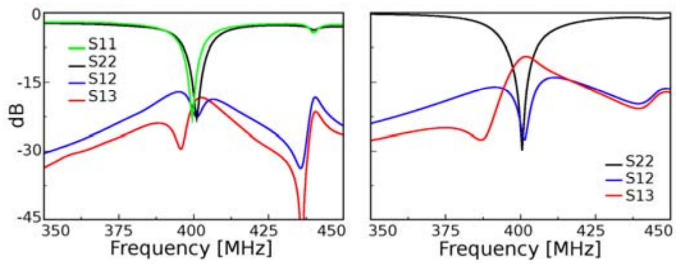

Fig 2. Measured (left) and simulated S-parameters (right) of the four-channel coil array. Coil 1 and 2 are adjacent, coil 3 is opposite to coil 1.

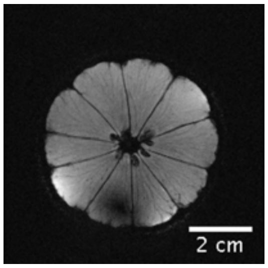

Fig 3. Axial slice (2mm) of a lemon, acquired with the coil in four-channel array mode.

[1] Hennig et al, Proc.Ann.Meeting ISMRM, Berlin, p.453 (2007); [2] Yang et al, Proc. SMRM, New York, p. 912 (1993)

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