

Modular, decoupled yet bendable coil array system at 3T

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Introduction

The application of large numbers of receive coils in MRI has proven to yield faster acquisition times, a better signal to noise ratio (SNR) and hence a better resolution [1]. The challenge of decoupling an array of many single coils can be approached by either a suitable overlap between adjacent coils, pre-amplifiers featuring high input impedance, transformers, capacities, or by a combination thereof [1]. The tuning of an individual coil is usually achieved by manually reshaping the coil, which is potentially cumbersome and time consuming [2]. This paper addresses this challenge.

Methods

A hexagonal surface filling coil tiling has been designed and manufactured in flexible 50 μm thick Polyimide, featuring additional overlap loops on all six tips of a hexagon as is shown in figure 1. The additional loops serve the purpose of decoupling the next neighboring coils. The immediate neighbor coils are decoupled by overlaps along their edges (figure 2a). The optimal overlap area is numerically determined by automatically resizing the overlapping area through a shift of the coil bodies and a change in the length of the overlap noses, using the simulation tool *Advanced Design System (ADS)* from Agilent and *fasthenry* [3]. Alignment holes are implemented into the single coils to fix the position of the coils with respect to each other (figure 2). The coils are fixed and aligned on a flexible laser-cut 125 μm thick standard lamination foil by adjustment pins (nylon screws) as can be seen in figure 2b. The foils are structured using a laser cutter (VersaLaser 2.30) to fit the outer shape of the coil array. Openings are cut in the top face to assemble capacitances and connection cables into the single coil circuits (figure 2b). The single coils are staggered with respect to each other by sliding them onto the nylon screws in a defined order. The top layer of the structured lamination protection foil, as well as the printed circuit board, are fixed on the compound sandwich by the nylon screws [4].

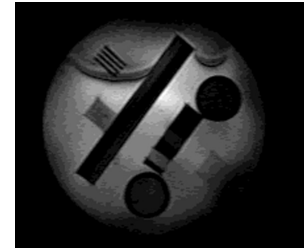
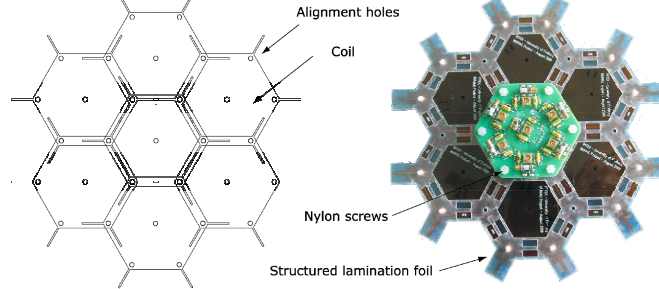
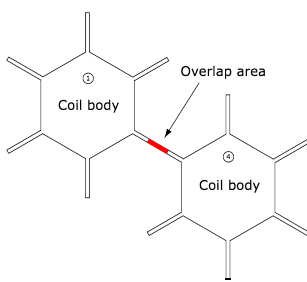


Figure 1: Decoupling of two next but one coil [4] **Figure 2:** Schematic (a) and photograph (b) of a coil arrangement [4]

Figure 3: Phantom image without any pre-amplification.

For testing, a tuning and matching circuit is designed, featuring 7 channels. It is assembled on top of the sandwich by using the alignment screws of the middle coil element (figure 2b). The circuit board is connected to a network analyzer (Agilent 5071C) and the respective coupling between all coil elements is measured. The measurement results are shown in table 1. The respective coupling between the single coils are -20 dB or better, even if bent at a radius of 15 cm along an arbitrary in-plane direction.

Table 1: Coupling of elements according to figure 2. The values remain stable for bending radii down to 15 cm.

Coil 7							
Coil 6	30.1 dB						
Coil 5	-24.4 dB	-24.9 dB					
Coil 4	-28.0 dB	-31.0 dB	-26.2 dB				
Coil 3	-25.0 dB	-20.0 dB	-31.6 dB	-25.8 dB			
Coil 2	-25.7 dB	-31.0 dB	-20.0 dB	-30.4 dB	-24.5 dB		
Coil 1	-24.7 dB	-26.0 dB	-27.7 dB	-20.5 dB	-34.5 dB	-25.0 dB	
Coupling	Coil 7	Coil 6	Coil 5	Coil 4	Coil 3	Coil 2	Coil 1
		Decoupling by coil body overlap		Decoupling by extra loop overlap		No decoupling	

Conclusions and Outlook

The proposed design presents a fast and convenient method to construct large numbers of decoupled coils for phased array sensing. Once the optimal overlap area of the coils is found, one and the same coil geometry can be used and arranged in various ways to create almost arbitrarily large phased array coils without the need of additional time-consuming decoupling procedures. By applying a flexible substrate to fix the coils onto, the compound can even be bent to radii down to 15 cm along one direction without losing electrical performance. For smaller coil diameters even smaller bending radii can be tolerated.

References

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