

Overlap Decoupling in Hole-Slotted Arrays

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Introduction

Since the first phased array design, the overlap decoupling became the most often used decoupling technique. At a certain amount of overlap, the mutual inductance between adjacent array coil elements is forced to be zero. Therefore the interaction between neighbouring coil elements is eliminated [1]. The hole-slotted coil design has been shown to provide a deeper RF penetration into the sample compared to a standard loop design. This hole-slotted geometry is based on the magnetron's design theory and has already been shown to operate as an array, in which the elements are capacitive decoupled [2]. Generally, capacitive decoupling is associated with a larger number of variables increasing the array complexity. In order to simplify the array construction, the applicability of overlap decoupling in a hole-slotted loop-geometry array is investigated and compared with conventional loop coils at 1.5 and 7 Tesla.

Methods

At 1.5 T: All experiments were performed on a 1.5 T whole body scanner. Two receive only arrays were built with the same dimensions using overlap decoupling, figure 1 top, and each array consisting of 2 elements. The first array has conventional loop design and the second with the hole-slotted design. The individual elements were 80 mm in outer diameter. Each element was tuned to 63.6 MHz and matched to 50 Ω. SNR maps were calculated from a series of 10 phantom measurements.

At 7 Tesla: Experiments were performed on a 7 T small animal system. Three receive only coil arrays each consisting of 2 individual elements were built (see figure 1 bottom). All three array designs had the same geometry of 29 mm in inner diameter. The individual elements are 27 mm in diameter for the hole-slotted design and 27 mm in length for the conventional loop array. Each element is tuned to 300.3 MHz and matched to 50 Ω. As a phantom, a plastic tube filled with a physiological NaCl solution (4.7 g/mol) was used. The loops are actively decoupled by a 300.3 MHz tuned trap circuit including a PIN diode in transmission. As transmitter a 1H quadrature birdcage coil with a diameter of 72 mm was used. Again, SNR maps were calculated from a series of 20 phantom measurements for all three array designs.

Results

At 1.5 T: The factor Q of the loop array dropped by a factor of 1.8 from unloaded to loaded case. For the hole-slotted array the Q factor dropped by a factor of 1.7. Active decoupling was better than -20 dB. The isolation between elements in both arrays was -18 dB which is improved by an additional -15 dB by the preamplifier decoupling. The overlap decoupling for the hole-slotted array was found at the workbench by shifting the elements for the optimal isolation in both field strengths, shown in figure 2. In Figure 3 top, SNR profiles of both arrays are shown.

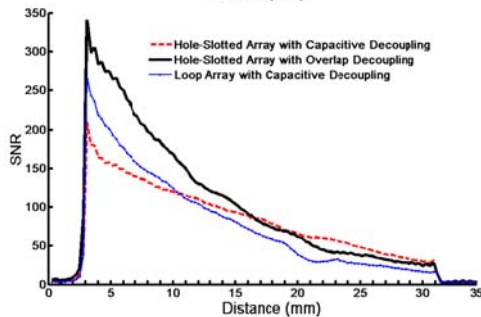
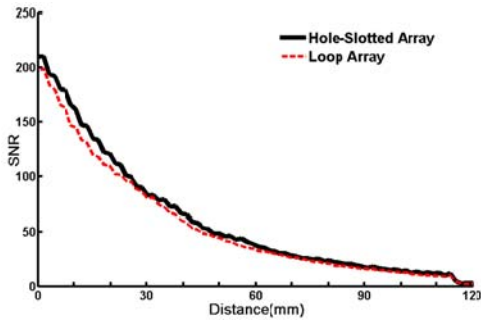


Figure 3, Top: SNR profiles of the hole-slotted array and the loop array at 1.5T, bottom: SNR transverse profiles of the three arrays at 7 T.

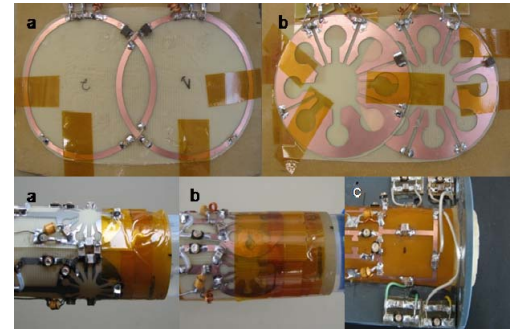


Figure 1, Top: views of the 1.5 T arrays (a) loop array, (b) hole-slotted array, Bottom: (a) capacitive hole-slotted array, (b) overlap hole-slotted array, (c) capacitive loop array.

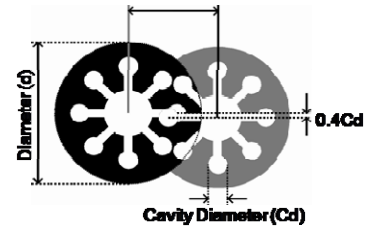


Figure 2, Schematic of the optimal overlap decoupling found for the Hole-slotted

for the hole-slotted array was found at the workbench by shifting the elements for the optimal isolation in both field strengths, shown in figure 2. In Figure 3 top, SNR profiles of both arrays are shown.

At 7 Tesla: The quality factor Q of each element in the capacitive decoupled arrays dropped by a factor of 1.8 from unloaded to the loaded case for both elements. In the overlap decoupled array the quality factor Q dropped by a factor of 1.8. Active decoupling was -20dB. The decoupling between elements using capacitive decoupling was -22dB. The overlap decoupling was -26 dB. In figure 3 bottom, SNR profiles of all three array designs are shown.

Discussion/Conclusion

The overlap ratio for an optimal decoupling has been experimentally derived to be 0.61d instead the theoretical optimal overlap of 0.75d for conventional loops. **At 1.5 T:** The hole-slotted geometry has shown to be a well-suited design in an array setup using overlap decoupling, although its performance can be the same as a loop array.

At 7 T: The overlap decoupling using hole-slotted elements has shown also to be well-suited in an array. It shows higher SNR on the surface of the sample as compared with capacitive decoupling, since there is no gap between elements. Both hole-slotted designs however have significantly better RF penetration than the loop array design. Applications of the hole-slotted array design for whole body systems must be further investigated as well as the viability to built arrays with more than two elements using overlap decoupling.

References

1. Roemer PB et al. MRM, 16: 192-225 (1990)
2. Lopez MA et al. Proceedings ISMRM 2009. Hawaii, USA

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