Comparison of array decoupling mechanisms on rat arrays at 1.5 T

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Introduction

For many physicians it is starting to get an interesting option to use human whole body scanners for small animal imaging. However, dedicated animal-coils for clinical field-strengths are not well established. For these relatively small coils compared to the wavelength it is especially important to have a well optimized array-design. In this abstract we compare three in-house built four channel receive-only rat-volume-arrays. These coil-arrays are compared with respect to SNR- and Parallel Imaging (PI)-performance.

Methods

All arrays have an inner diameter of 72 mm and a length of 90 mm in z-direction. Each array uses a different mechanism for decoupling neighboring elements. Array A is a gap-design, array B has a shared-conductor-design for decoupling and array C is decoupled via geometric overlap (Fig.1). All coils have built-in high input impedance preamplifiers for improving the decoupling between opposing elements.

Workbench characterization was done with an Agilent network-analyzer and without preamplifiers connected to the coil elements.

All imaging experiments were performed on a Siemens Avanto 1.5 T whole body scanner. For every coil-array a gradient echo sequence was used to measure g-factors and SNR. The noise correlation was derived from a noise image. For finding the optimum phase encoding direction for parallel imaging, the phase encoding directions were varied in 22.5° steps with the default direction (0°) leading through the centers of two opposing elements.

Results and Discussion

Fig.2 shows the coil parameters measured on the workbench. The unloaded to loaded Q-ratio shows that all coil-arrays are sample noise dominated. The gap-design has the lowest Q-ratio because of the small size of the coil elements. All neighboring coil elements are decoupled to better than -20 dB. Opposing coil-elements have a slightly higher coupling due to the fact, that these elements are not directly decoupled from each other. The frequency split $\Delta\nu$ can be observed. The quotient of $\Delta\nu$ and the larmor frequency ν_0 is a measure for the mutual inductance of the elements. The calculated noise correlations (Fig.3) show good noise-figures except for the large correlated noise between opposing elements in the overlap design. This is due to the large coil size in this design, which results in a strong coupling. A tendency can be seen, that opposing elements have the highest correlated noise. The correlation is also getting stronger with bigger element sizes, which is a hint, that inductive coupling is a dominant factor. The SNR performance of the arrays on a phantom was measured in a circular ROI in the center of the array for a tranversal slice. For the gap design it was measured to be SNR_A=65. The shared-conductor design has a SNR_B=100 and the overlap design a SNR_C of 48 (Fig.4). The SNR of the overlap design is worse than the SNR of the shared conductor design, despite the bigger element size. The reason is, that the strong noise correlation of opposing elements in the overlap-design have not been considered for these calculations.

The g-factor calculations (Fig.5) show that for an acceleration factor of R=2 the choice of the phase encoding direction does not make any difference. For an acceleration factor of R=3 the mean g-value is very robust to the phase encoding direction too, whereas in the 99 percentile changes of up to 70% can be observed. The 0°-position shows for all three coil arrays the best g-factors. For all encoding directions and acceleration factors the gap-design is showing the best PI-performance.

Conclusion

All three coil arrays show a good PI-performance for an acceleration factor of R=2. The direction of the phase encoding direction is not an issue for low acceleration factors. Due to the highest intrinsic SNR the shared-conductor design is the best compromise between good g-factors and a high signal to noise ratio.

References

[1] Roemer PB, et al.: The NMR Phased Array. MRM 1990, 16:192
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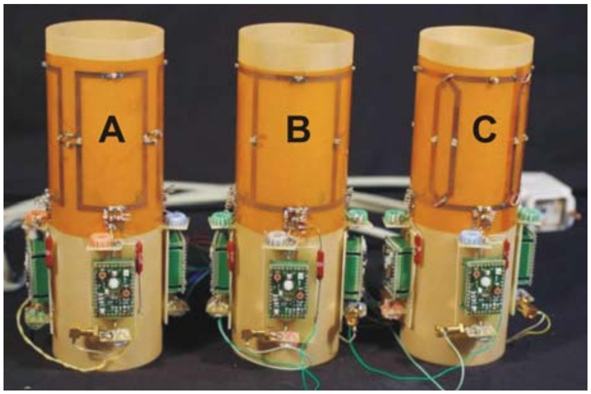

Fig.1: Three four channel rat arrays with different decoupling methods: A gap-design, B shared conductor-design (middle), C overlap-design (right)

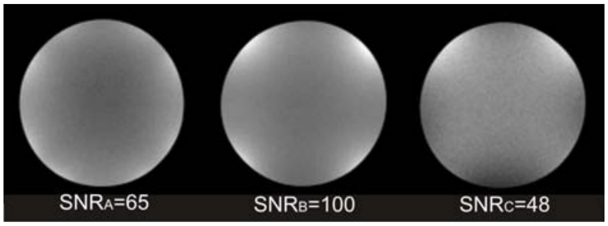

Fig.4: Sum of Squares reconstructions of the three arrays

		A		B		C	
	R	**mean**	**99%**	**mean**	**99%**	**mean**	**99%**
0°	2	1.1	1.2	1.1	1.3	1.5	2.2
	3	1.6	2.5	1.9	3.7	3.1	9.2
22.5°	2	1.1	1.2	1.1	1.3	1.4	2.1
	3	1.5	2.6	1.9	3.9	3.2	11.3
45°	2	1.1	1.2	1.1	1.3	1.4	2.0
	3	1.6	3.7	2.0	4.5	3.5	15.2

Fig.5: g-factor calculations for the three coil-arrays and an acceleration factor of R=2 and 3 in one direction. The phase encoding direction was varied in 22.5° steps. For each g-factor map the mean value and the 99 percentile were computed.

A				
%	**ch.1**	**ch.2**	**ch.3**	**ch.4**
ch.1	100	2	4	17
ch.2	2	100	23	2
ch.3	4	23	100	1
ch.4	17	2	1	100

B				
%	**ch.1**	**ch.2**	**ch.3**	**ch.4**
ch.1	100	15	32	13
ch.2	15	100	10	20
ch.3	32	10	100	14
ch.4	13	20	14	100

C				
%	**ch.1**	**ch.2**	**ch.3**	**ch.4**
ch.1	1	11	58	10
ch.2	11	1	8	53
ch.3	58	8	1	12
ch.4	10	53	12	1

Fig.3: Noise Correlation for the coil-arrays.