

Self-Decoupled Asymmetric Saddle Coil Array for SENSE Imaging

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Synopsis: The quest for lower g-factor and higher reduction factor for a SENSE-optimized coil array often results in a trade-off of lower intrinsic SNR for higher SENSE SNR due to the non-overlap nature of the adjacent coils. In this paper, we present an asymmetric saddle (Asaddle) coil array with each of its Asaddle coils having one wing significantly smaller than the other and being able to decouple from its adjacent Asaddle coils without overlap. The Asaddle coil array not only can preserve the intrinsic SNR as a conventional array but also can provide significantly lower g-factor than the conventional array.

Introduction: Recent study [1] has shown that RF coil arrays optimized for SENSE imaging often require the adjacent coils to have a gap between them in order to improve the distinctiveness of the complex sensitivity of each coil element and hence achieve lower g-factor and higher reduction factor. This arrangement for SENSE imaging may compromise the intrinsic SNR of the coil array due to the higher intrinsic noise introduced by the stronger-coupled adjacent coils. So far, to our best knowledge, no RF coil array design allows non-overlap adjacent coil elements to naturally decouple themselves from each other without using addition methods, for examples, transformers [2], preamplifier decoupling and so on, to minimize the mutual inductance among them. Here we demonstrate that if a conventional saddle coil is modified into an asymmetric saddle (Asaddle) coil with one wing significantly smaller than the other wing, as shown in Fig. 1(a), the net magnetic flux generated by the Asaddle coil inside a neighboring loop coil will be much weaker when the loop coil is adjacent to the small wing than it is adjacent to the large wing. By properly adjusting the size of the small wing, i.e., its width in x-direction, the Asaddle coil can become self-decoupled from its neighboring coil that is adjacent to the small wing.

Methods and Materials: To test the self-decoupling nature of Asaddle coil, an Asaddle coil and a loop coil (both in size of 20x15cm²) were built. The three different configurations of the two coils are shown in Fig. 1. The Asaddle has a 1.5cm-wide small wing, a 12.3cm-wide large wing, and 1.2cm separation between the two returning conductors. The isolation value between the two coils, under unloaded condition, was measured using a network analyzer (S12). Figure 2 shows the isolation values as a function of the distance (X) between the adjacent edges of the two coils. When the Asaddle coil is outside the loop coil, as shown in Figs. 1(a) and 2, the worst isolation is still 16dB (at X=-2cm) indicating that the two coils are well decoupled from each other. This clearly demonstrates that self-decoupling nature of the Asaddle coil allows it to be decoupled naturally from its neighboring coil elements without overlap. The maximum isolation value (minimum mutual inductance) occurs when the edge of the small wing of the Asaddle coil is 0.8cm outside the loop coil (D1=0.8cm). The second maximum isolation value occurs at D2 when the edge of the small wing of the Asaddle coil is 0.2cm inside the loop coil (D2=0.2cm), as illustrated in Figs. 1(b) and 2. As the small wing of the Asaddle coil moves further into the loop coil, it starts to couple strongly to the loop coil and the two coils detune each other. After the small wing of the Asaddle coil is entirely inside the loop coil and the large wing of the Asaddle coil starts to move into the loop coil, the mutual inductance between the two coils starts to decrease due to the contribution of magnetic flux from the large wing of the Asaddle coil. Eventually, isolation reaches the third maximum value at D3 when the small wing of the Asaddle coil is 6cm inside the loop coil, as shown in Figs. 1(c) and 2. To compare the performance of Asaddle coil against conventional loop coil, a 4-Asaddle coil array, as shown in Fig. 3, and a 4-loop coil array (not shown) were built on 20cm OD cylindrical formers. The size, width of small and large wings of each Asaddle coil are 20x16cm², 1.5cm and 13.5cm, respectively. The size of each loop coil is 20x19.6cm² with 3.6cm overlap between adjacent coils. Phantom images of both coil arrays were obtained on a GE 1.5T Excite III scanner. G-factor map for reduction factor of two (R=2) in left-right (L/R) phase encoding (PE) direction was also calculated for three coil array configurations, (a) 4 loop coils with a 3.6cm overlap between two adjacent coils, (b) 4 loop coils with a gap of 3.5cm between two adjacent coils and (c) 4 Asaddles.

Results and Discussions: Figure 5 shows the SNR comparison between the 4-Asaddle and 4-loop coil arrays. The SNR values were obtained along the center line of an axial image of a cylindrical phantom (16cm ID and 26cm long). The SNR of the 4-Asaddle coil array is slightly (-5%) lower at the center of the phantom than that of the 4-loop coil array but it is significantly higher (30%) at the region close to the coil elements. The overall SNR of the entire image area shows that the 4-Asaddle coil array is about 20% better than the 4-loop coil array. In Fig. 6, the average g-factor value of the 4 Asaddle coils is the lowest among the three coil array configurations.

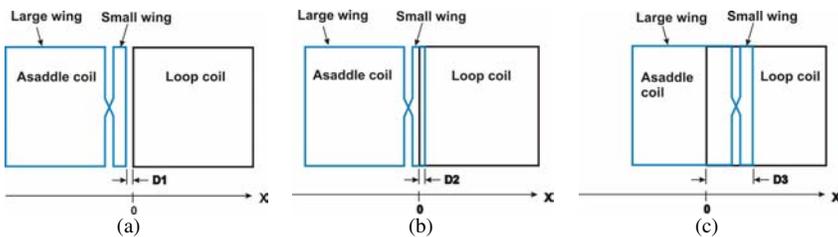


Fig. 1. Three decoupling positions between the Asaddle and loop coils.

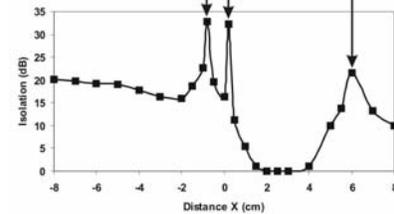


Fig. 2. Isolation between the Asaddle and loop coils.



Fig. 3. 4-Asaddle coil array.

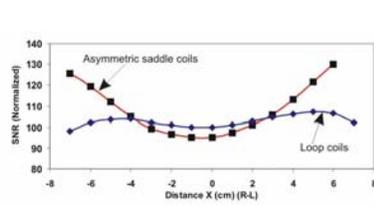
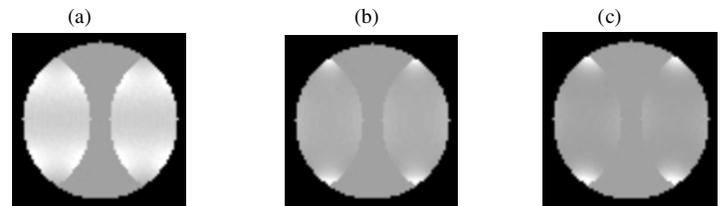


Fig. 5. SNR comparison.



(a) $G_{max}=1.63, G_{avg}=1.23$
4 Loops with 3.6cm overlap
(b) $G_{max}=1.97, G_{avg}=1.07$
4 Loops with a 3.5cm gap
(c) $G_{max}=1.93, G_{avg}=1.03$
4 Asaddles

Conclusions: The self-decoupling nature of an Asaddle coil allows it to be decoupled from its neighboring coil elements without overlap. An Asaddle coil array system not only can preserve its intrinsic SNR but also can lower geometric noise for SENSE imaging.

References: 1) Weiger, M., et al., MRM, 45, p495-504, 2001. 2) Boskamp, E.B., et al., Proc. 10th ISMRM, p852, 2002.