Reduction of SNR Losses Due to RF Coil Coupling via Coil Current Sensing

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Introduction

It has become clear that many channel coil RF arrays often suffer SNR loss if the coil element count is very high (and the unit coils are small). (1,2) The causes of these losses in SNR have been postulated to include unnecessary conductor losses, non-invertible noise coupling, shielding effects of many channels and cable current losses (3). The industry universally employs mis-matched preamplifiers (4) that introduce a high resistance into each loop. As the mismatch increases and the effective resistance in the loop increases, the coupling monotonically decreases and the relative percentage of coupled noise from this added resistance increases. This means that the noise coupled from a given loop is very different than the noise which emerges from the preamplifier on that loop. This effect makes inversion of the noise impossible; however if the preamplifier (preamp) were noiseless it would be possible (5). In the following, an approach to convert non-invertible noise to invertible noise is demonstrated.

Methods

This method employs a new paradigm in multi-channel RF coils in which coupling (in moderate amounts) is not detrimental as long as it is measurable. Accurate measurement of the coupling signals permits algebraic inversion. Consider Figure 1 which depicts two preamps on a single loop, one (preamp A) with the impedance mismatched used to provide the standard inductive decoupling, but the other (preamp B) matched to produce minimal impact on the loop impedance. The idea is to still provide decoupling but allow preamp B to measure the residual current in the loop and therefore a model of voltage coupled in other nearby coils. Two six inch diameter coils, as depicted in Figure 1, were produced, sample loaded and coupled to one another as depicted in Figure 2. The bottles used were 2.2 liters of distilled water, 4.42g of $CuSo_4.5H_2o$ and 4.42g of NaCl.

Results

SNR measurements were made on noise optimally combined (4) images (either 2 or 4 channel) with data collected in 3 different configurations. In Case 1 (4 channel), both preamp A and preamp B were operational. In Case 2 (2 channel), preamp B was attached but not powered, and in Case 3 (2 channel), preamp B was removed (this is the standard approach). Case 2 provides a measurement of the loss of SNR caused by adding the second preamp (assuming that the impedance of preamp B changes little when powered, and that it produces little or no additional noise at its input). Figure 3 shows a plot of relative SNR for all 3 cases at different separation distances (and thus coupling amounts). As expected, the SNR for Case 2 behaves the same as Case 3 except that it is lowered by a constant value (about 10%) due to the added resistance of the second preamp (B). Case 1 shows a different curve. At the separation point of about 6.75 inches, (where coupling was low), Case 2 and Case 1 coincide, but as the separation drops and the coupling increases, the relative SNR increases and at a separation of about 3.75 inches utilizing preamp B begins to provide improved SNR over the standard approach.
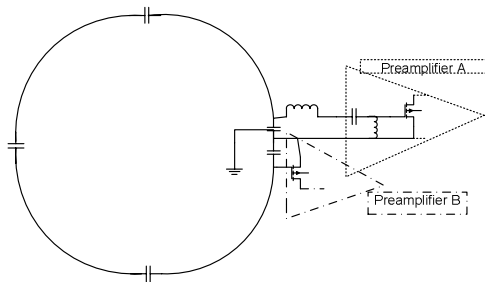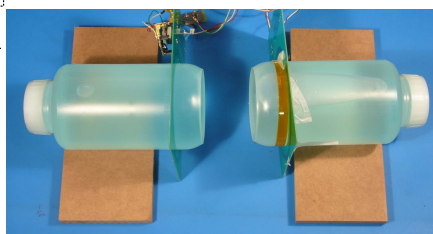

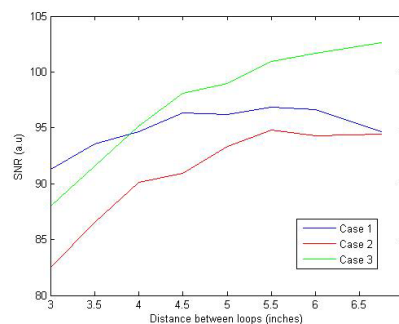Figure 1. Two preamplifiers per loop

Figure 2. Two loaded, coupled coils

Figure 3. Relative SNR plots, all Cases

Discussion

It has been shown that measurement of coil current (including noise from the standard preamplifier) allows for correction of coupling losses. Noise optimal reconstruction automatically makes this correction. To make this approach valuable, it is necessary to lower the loss associated with the second preamplifier (B), confirm that the approach works for many weak coupling pairs instead of one strong coupling pair, and that the much lower signal from preamplifier B (close to 20 dB lower) still allows proper sampling of both signals.

Acknowledgements

References

(1) Boskamp, EB et al. Proc ISMRM 2007 p1048, (2) Wiggins, GC et al. Proc ISMRM 2005, p671 (3) Wiggins, GC et al. Proc ISMRM 2007 p243 (4) Roemer, PB et al. MRM 1990: 16(2): 192-225 (5) Duensing GR et al, JMR B 111 (1996) 3: p.230-235