# element design for increased sensitivity in 64-channel wide-field-of-view microscopy

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## Introduction

Previous work by our group in RF encoding has focused on the need to maintain highly localized field patterns from 64 long and narrow array elements in order to achieve the ability to acquire ($64xN_{readout}$) images in a single echo, with the coil elements entirely responsible for the localization in the phase encoding direction [1]. The same 64-element array of planar pair elements has been used to acquire accelerated 3D and wide-field-of-view microscopy images [2, 3], establishing the concept of using the same probe to traverse the extremes of the spatio-temporal paradigm (depicted in Fig. 1). The emphasis of our first coil design on pattern localization was a design optimization to reach the temporal extreme, shown as "fast mode" in Fig. 1; however, narrow patterns imply shallow imaging depth – somewhat incompatible with the needs/applications of 3D microscopy associated with the other end of the regime, shown as "hi-res mode" in Fig. 1. This paper presents modeling, bench, and imaging results for a "raised-leg" planar pair 64-element array coil design intended to provide the increased penetration depth and SNR needed to more suitably operate in "hi-res" mode. SNR comparison results between the previous in-plane planar pair design and the presented raised-leg planar pair design show significant improvements in SNR at increasing imaging depths from the array.

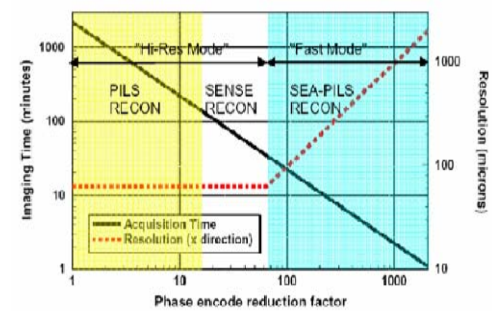



Fig. 1 Depiction of the ability to traverse the "spatio-temporal" framework with a single probe

## Methods

The planar pair element design [4] originally provided the field pattern localization necessary to implement Single Echo Acquisition (SEA) imaging. The raised-leg planar pair element design retained the same footprint (2mm wide by 8cm long) as the in-plane planar pairs used for the original 64-channel array. However, the ground legs on the sides were moved to the bottom layer of the 1/16" thick PC board in order to reduce the field cancellations and increase the sensitive region of the coils. Quasi-static modeling results (shown in Fig. 3) confirm the expected increase in sensitivity. This necessarily led to a significant increase in element-to-element coupling, however, and a geometric decoupling mechanism using two half loops on two boards was implemented. One loop was on the back side of the coil and the other on the second board, shown in Fig. 2. The boards were wired back to back to increase the flux in the overlapping area. The optimal areas for the two-board decoupling loops were analyzed in a preliminary study to be $13.5x10^{-3}$ $in^2$. The array elements were tuned by DC-driven varactor diodes, and each element was matched with a variable capacitor. S-parameter bench measurements were obtained using an Agilent E5071 Network Analyzer. Spin echo images (TR/TE=500/30 msec, matrix=256x256, FOV=140mm, st=1mm) were acquired using both arrays (in-plane and raised-leg) with a 4.7T/33cm Varian INOVA scanner with a dish phantom containing 1g/L $CuSO_4$ and a "stairstep" structure to indicate slice location. Using our 64-channel receiver, fully encoded data for all 64 coils were simultaneously obtained for multiple slices varying from 1mm to 9mm (0.5 to 4.5 coil widths) off the array. Sum of squares images for both array designs were compared with regard to SNR for the slice closest and slice farthest from the array coils.

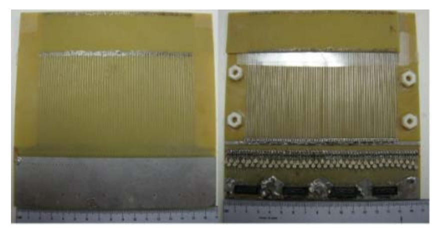


Fig2. Left: Top (imaging) side of the raised leg array. Right: Bottom side of the coil with decoupling board attached at top and match/tune networks at bottom.

## Results & Discussion

A representative sample (4 elements of 64) of the s-parameter measurements collected from the raised-leg array are shown in Table 1 and indicate successful decoupling of the elements. The imaging and SNR comparisons for slices closest and farthest from the two arrays are shown in Fig. 4. As would be expected, the relative SNR improvements of the raised-leg design increase with increasing imaging depth. The raised-leg design shows a 13.3% improvement in SNR at the slices closest to the array coils and 2.7 times SNR improvement in the slices farthest from the array coils, indicating that the 64-channel raised leg coil design can offer up to an order of magnitude improvement in imaging time at depths far more than an element width from the array. Some instability in the design due to wired connections between the two physically separated boards has led us to investigate a modified design on a single multi-layer board to avoid wiring shorts to adjacent coils and provide consistent decoupling loop areas.

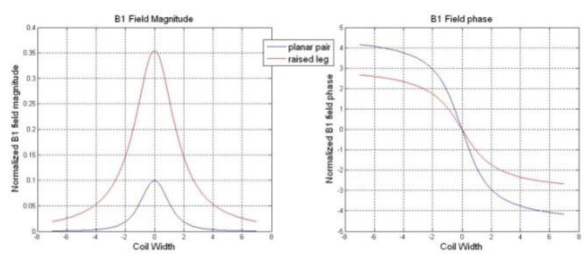



Fig. 3 Modeled magnitude and data for in-plane planar pair coils compared to raised leg planar pair coils.

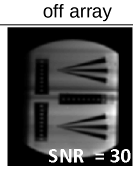
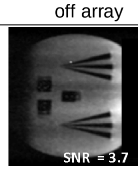
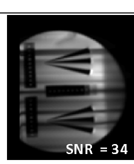
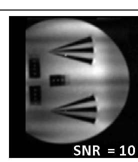
| | 3mm off array | 9mm off array |
|---|---|---|
| Array coil 1, in-plane planar pairs |   |   |
| Array coil 2, raised-leg planar pairs |   |   |

Fig. 4 Sum of Squares SNR comparisons between the original in-plane 64-channel planar pair array coil and the modified 64-channel "raised-leg" planar pair coil. At depths close to the array, SNR improvements are slight, but at depths farther from the array, the raised leg design offers substantial benefits.

| Element number | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | -27.4 | -19.8 | -25.7 | -30.1 |
| 2 | | -24.4 | -20.1 | -27.8 |
| 3 | | | -22.0 | -21.2 |
| 4 | | | | -23.1 |

Table 1. S-Parameter Measurements [dB] at 200 MHz for raised-leg coil

References 1.McDougall,et al. MRM 2005;386-392 2.McDougall,et al. ISBI 2007;1072-1075 3.McDougall, et al. JMRI2007; 25:1305-1311. 4.Hyde, et al. Med Phys 1986; 13(1):1-7.

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