An 8-channel non-overlapped spinal cord array coil for 7T MR imaging

Z. Xie[1], and X. Zhang[1,2]

[1]Department of Radiology, UC San Francisco, San Francisco, CA, United States, [2]UCSF/UC Berkeley Joint Graduate Group in Bioengineering, San Francisco & Berkeley, CA, United States

Introduction Surface coil arrays offer high sensitivity and large coverage that is particularly suitable for spinal cord MR imaging. To apply parallel imaging technique, sufficient decoupling among resonant element in coil arrays is required for independent signal detection and encoding. Although decoupling could be yielded between two overlapped coils, the increased g-factor in their overlapping area degrades the signal-to-noise ratio (SNR) of images. In this report, we designed and constructed an 8-channel non-overlapped surface coil array using with strong decoupling performance and good coverage for spine parallel imaging. Different from conventional decoupling methods for non-overlapping design such as the method using lumped L/C decoupling circuits (1, 2), we use a new magnetic-wall decoupling method to decouple the resonant elements. The magnetic wall is generated by the microstrip circuits positioned between two adjacent surface coil elements. Without physical connection between the decoupling microstrip and array elements, theoretically this method is not frequency-sensitive. Therefore the decoupling performance can be maintained in a broad frequency range. Bench test and preliminary imaging results are shown using the proposed coil array at 7T.

Methods The 8-channel surface coil array using the proposed magnetic-wall decoupling technique was built on an acrylic board with a thickness of 0.375". Fig.1 shows the prototype coil array. Eight of the 2.125-inch x 5-inch square coils were placed with 0.25" gaps. Between these elements, there were 7 microstip lines that generate magnetic wall to minimize the coupling between the coils. The decoupling microstrip line measure 5.5" long and was capacitively terminated on its two ends. The width of all the strips used for surface coils and the strip conductor of the decoupling microstrip line was 0.125". The surface coils are tuned to 298.144 MHz, the Larmor frequency of proton at 7T. In theory, the mutual inducted currents between each coils would be cancelled by the mutual inducted current from decoupling elements, therefore the mutual inductance between coils is minimized or become zero. Because there were no physical connections between any of the decoupling elements and coil elements, the mutual current and magnetic inductance cancellation occurred locally. To improve the coverage of the array coil, the gaps between coil elements were optimized to 0.375" and the isolating layer between the array coil and the water phantom was 0.5" in thickness. Bench test on the resonant modes and isolation between eight loop coils were implemented on a network analyzer (Agilent E5070B). The termination capacitance measurement was conducted on a RCL meter (Fluke PM6303A). The MR imaging experiments were performed on a GE 7T/90cm magnet (GE Healthcare, Waukesha, WI). A bottle of pure water was used as a phantom in this preliminary study. The phantom was a cylinder with a dimension of 2.5" O.D. and 20" length. A set of gradient echo images in axial orientation were acquired using the coil array. Acquisition parameters were –TR = 100ms, TE = 6.8ms, thickness = 5mm, flip angle = ~30^0, FOV = 35cm, no average.

Results and Conclusions Each coil element was matched to system 50 Ohm by a series capacitor. By adjusting the capacitors of decoupling elements, the decoupling between the two elements was greater than 25dB. No resonant peak split is observed for coil elements. These results indicate that the eight channels are decoupled sufficiently. Fig 2 shows the MR images from 6 elements of the 8-element array, in which no signal is observed from other coil when using individual element, indicating the effectiveness of the proposed decoupling technique at ultrahigh field of 7T. The other 2 channel were out of the FOV. Fig 3 shows the MR image of the whole phantom after sum the magnitudes of each channel, indicating a good imaging coverage of the spine coil array. The proposed array coil provides a robust approach to design of parallel imaging arrays at ultrahigh fields. The future work will be focused on investigation of the proposed decoupling technique with more resonant elements and evaluation of the g-factor of the design.

Reference (1) Wu B, et al, 13th Annual Meeting of ISMRM 949 (2005); (2) Wu B, et al, JMR 182:126–132 (2006); (3) Zhang X, et al, MRM 46:443-450 (2001).

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Fig.1 The 7T microstrip coil array with 8 decoupled loop coils and 7 decoupling elements which generate magnetic wall.

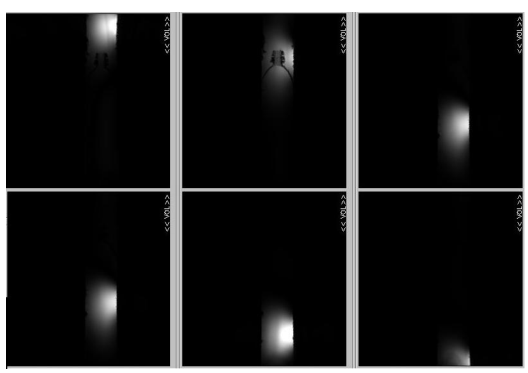

Fig.2 The 7T MR imaging results of a water phantom from 6 channels of eight coil elements. Well-defined image profiles indicate the great decoupling performance of the proposed magnetic wall decoupling technique.

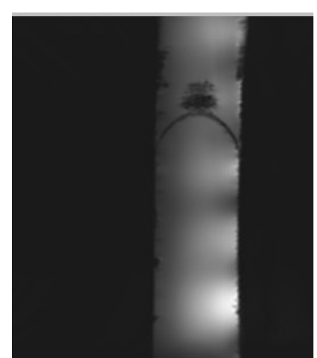

Fig.3 The 7T MR imaging result of a water phantom with structures.