Eight-channel ICE-decoupled monopole RF array for ultrahigh field human head MR imaging

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INTRODUCTION Unlike the conventional L-C resonator based RF coils, radiative coils, e.g. monopole antennas [1-2], have a special distributed circuit structure which makes traditional decoupling techniques difficult to use when designing radiative coil arrays. Consequently, current radiative coil arrays use no decoupling treatments. This dramatically limits their imaging capability and performance. The induced current elimination (ICE) technique [3] , which does not need physical connections between coil elements and decoupling elements, might be an efficient approach to address this problem. In this study, we aim to investigate the feasibility and performance of the ICE decoupling in volume-type monopole arrays for human head imaging at ultrahigh magnetic fields.

METHODS To achieve this goal, two 8-channel monopole array coils with and without the ICE decoupling were constructed on cylindrical acrylic formers (diameter 25 cm), as shown in Fig. 1 [1]. L-shape capacitive networks were applied for matching and finely tuning [4]. The decoupling element consists of a conductor and a serial capacitor. The length of the monopole elements and the decoupling elements is 25 cm. The two monopole arrays were used for both transmission and reception, and were matched to 50 Ω and tuned to 297.2 MHz, the Larmor frequency of our 7T MRI system (Siemens Healthcare, Erlangen, Germany).

S-parameter matrices of the two monopole arrays loaded with a human head were measured with an Agilent E5071C network analyzer. GRE images on a health human head using the two monopole arrays were acquired. GRE parameters: FA=25^0, TR/TE =120/6 ms, FOV=250×250 mm^2, matrix= 256×256, thickness=5 mm, NEX=1. Transverse GRE images were shown for SNR comparison between the two arrays. The SNR was determined by: SNR=*SI*/*SD*×0.655, where *SI* is the signal intensity (15×15 pixels) and *SD* is the standard deviation of the noise (50×50 square in the image background). To demonstrate the parallel imaging performance of the two monopole arrays, accelerated GRE images, residual images and g-factor maps with reduction factor (R) of 1 (no acceleration), 2, 3 and 4 in the sagittal plane were shown.

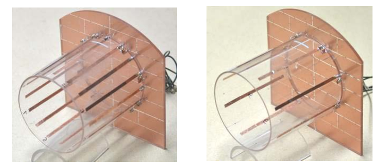

Figure 1 Photographs of 8-ch monopole transceiver coil arrays with (left) and without (right) ICE decoupling.

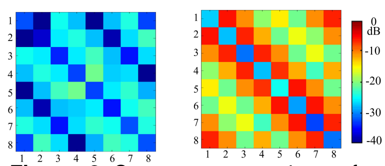

Figure 2 S-parameter matrices of 8-ch monopole arrays with (left) and without (right) ICE decoupling.

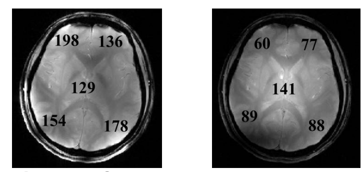

Figure 3 GRE images acquired using 8-ch monopole arrays with (left) and without (right) the ICE decoupling.

RESULTS AND DISCUSSIONS Fig. 2 shows S-parameter matrices of the two arrays. S_{11} of each element in both arrays was better than -25 dB, indicating excellent matching performance. For the monopole array without any decoupling treatments, S_{21} between adjacent, next adjacent and opposite elements were about -7.1 dB, -11.5 dB and -15.6 dB, respectively, which indicated that obvious coupling existed. When the ICE method was employed, S_{21} between adjacent, next adjacent and opposite elements were only about -25.4 dB, -25.1 dB and -40.3 dB, respectively. This indicated that the coupling between any two monopole elements can be well reduced by using the ICE decoupling method.

Fig. 3 shows the SNR comparison of human head images for the two arrays at 7T. These images were reconstructed from raw data without using filters, and were shown in the same signal intensity scale (RSS combined). An overall SNR gain of 80% was achieved for the 8-ch monopole array when the ICE decoupling method was applied, which might be due to the better decoupling performance and the “shielding effect” of the decoupling elements. Fig. 4 shows the accelerated images, residual images and g-factor maps with R=1, 2, 3, and 4 in the sagittal plane using the two arrays. Both the residual images and g-factor results demonstrated that the ICE-decoupled array has better parallel imaging ability over the array without decoupling treatments.

CONCLUSION For the 8-ch human head monopole array, the distance between adjacent elements is only 9 cm, about 1/10 λ at 300 MHz. Therefore the EM coupling among the monopole elements could not be ignored. In this study, the feasibility and performance of the ICE decoupling for volume-typed monopole arrays have been validated and comparative investigated. Both the bench test and imaging results demonstrated that the ICE decoupling is a simple and efficient approach to designing high performance monopole transceiver arrays for human head parallel imaging at ultrahigh fields. Although the this method is only validated for the monopole array herein, it would also be potentially suitable for dipole coil arrays.

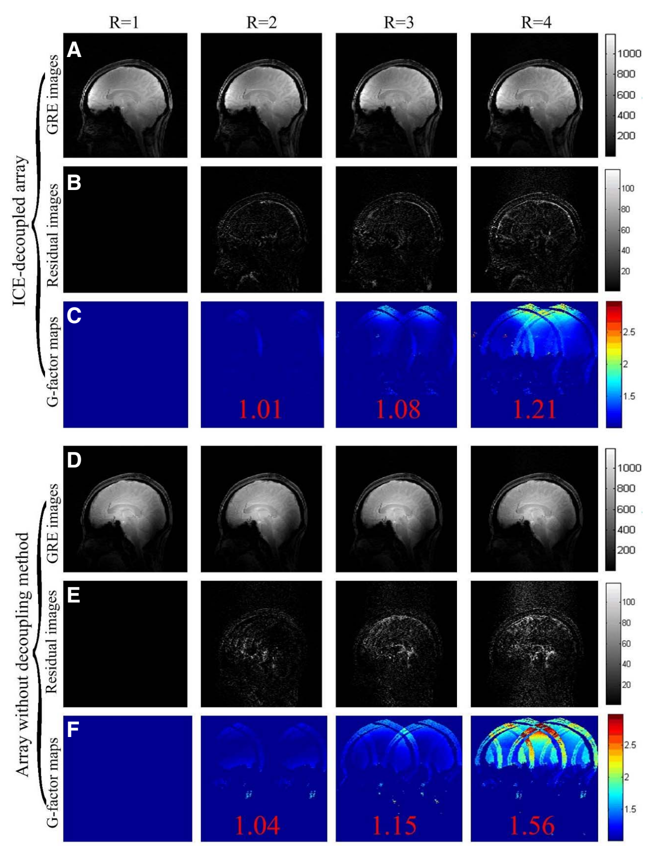

Figure 4 GRE images, residual images, and g-factors maps of the ICE decoupled monopole array (A-C) and the monopole array without decoupling methods (D-F) with the acceleration factor R of 1 (no acceleration), 2, 3 and 4 in the sagittal plane.

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REFERENCES [1] S. M. Hong, et al. MRM, 71:1944-1952 (2014). [2] G. Chen, et al. ISMRM, 4809 (2014). [3] Y. Li, et al, Med Phys, 38: 4086-4093 (2011). [4] X. Yan, et al, QIMS, 4(2):79-86 (2014).