An eight-channel transmit/receive phased-array head coil with an ICE decoupling method at 7T

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INTRODUCTION A new decoupling method based on induced current compensation or elimination (ICE) for microstrip transmission line (MTL) planar array has been proposed recently [1-3]. In this study, we aim to test the feasibility of the ICE decoupling method for volume-type L/C loop-array coils. An eight-channel transmit/receive loop-array coil using this decoupling method was designed and built for human head MR imaging at 7T. One narrow rectangular loop was placed between adjacent coil elements to reduce the mutual coupling. Isolation between the adjacent loop elements is better than -25dB with human head load. Human head images in transverse and sagittal planes were measured to evaluate the coil array's performance. To demonstrate the parallel imaging capabilities of this coil array, GRE images using the GRAPPA acceleration were acquired and corresponding average g-factors at reduction factors of 2, 3 and 4 were calculated.

MATERIALS and METHODS The eight-channel array coil was built on a cylindrical acrylic former with an outer diameter of 25cm, as shown in Fig. 1. Rectangular loop (length 17cm, width 6.8cm) with 6 capacitors in each loop was used as the coil element. One smaller rectangular loop (length 17cm, width 2.8cm) with 6 distributed capacitors, referred as the decoupling loop, was placed between adjacent coil elements to reduce the mutual coupling. All the coil elements and decoupling loops were built using Printed Circuit Board to ensure the design accuracy. The width of the conductor is 5mm and the thickness is 100µm. Ca1=Ca2=Cb1=Cb2=3.7pF, CDa1=CDa2=CDb1=CDb2=10pF (Fig. 1). The tuning capacitor Ct, matching capacitor Cm and decoupling capacitors CDt, CDm were chosen individually to achieve a good matching and decoupling performance for each loop.

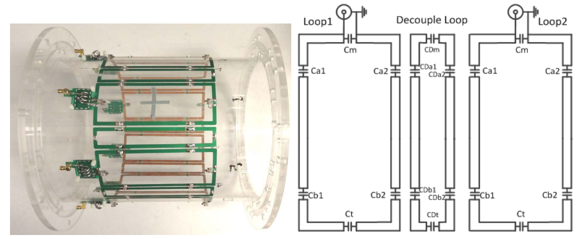

Figure 1: Photograph of an ICE-decoupled array (left) and a schematic plot of two coil elements and one decoupling loop of the ICE-decoupled array (right).

Reflection (S11) and transmission (S21) coefficients of eight elements of the ICE-decoupled array were measured with an Agilent E5071C network analyzer. The S11 measurement was also used to calculate the coil's unloaded Q value (Q_{UL}) and loaded Q value (Q_L). To further evaluate the performance of the coil array for human head imaging, combined GRE images and sub-images from each coil element in transverse and sagittal planes were shown. Imaging parameters used were: FA=25deg, TR=120ms, TE=6ms, FOV=250×250 mm^2, Matrix=256×256, ST(Slice Thickness)=5mm, Bandwidth=260Hz/pixel. GRE images in the sagittal plane with no reduction factor and with reduction factors of 2, 3 and 4 using GRAPPA were shown to demonstrate the performance of parallel imaging. MR imaging experiments on human head were performed on a whole-body MRI scanner (7T MAGNETOM, Siemens Healthcare, Erlangen, Germany).

RESULTS The average Q_{UL} and Q_L of a single element were 120 and 49, respectively. Reflection coefficient S11 of all coil elements was better than -30dB. The transmission coefficient S21 between adjacent elements was better than -25dB (Fig 2). The isolation between two next adjacent elements was better than -17dB (Fig. 2) and the isolation between two opposite elements was better -20dB. Individual GRE images from each coil element and their combinations with the SOS (sum of squares) method in transverse and sagittal planes are shown in Fig. 3a and 3c. Corresponding intensity corrected images were shown in Fig. 3b and 3d. GRE images obtained at reduction factors (R) of 1, 2, 3, and 4 in the sagittal plane are shown in Fig. 4. The average g-factors of whole brain with R=2, 3 and 4 are 1.03, 1.04, 1.14, respectively. The g-factors were relatively lower or better [4], especially for high reduction factor, e.g., R=4. For parallel imaging, SNR of the accelerated images is inversely proportional to the g-factor [5]. This indicates that better image quality under acceleration can be achieved by using the ICE-decoupled transceiver coil array.

DISCUSSION AND CONCLUSION An eight-channel loop-array coil for 7T human head imaging using the induced current compensation decoupling method has been designed and the feasibility of this coil array has been validated through bench tests and MR imaging experiments. Isolation between the adjacent loop elements is better than -25dB. Coupling between two next adjacent elements and opposite elements was also small enough (better than -17dB and -20dB, respectively) even though no extra decoupling method was applied. For *in vivo* human experiments, preliminary human head images were acquired and demonstrated using this coil array at 7T. The ICE–decoupled array also showed better parallel imaging ability that the average g-factor of human head in the sagittal plane was as low as 1.14 when acceleration factor achieved 4. The experimental results indicate that the transceiver array design with the ICE decoupling technique might be a promising solution to designing high performance transmit/receive coil arrays for human head imaging at ultrahigh fields.

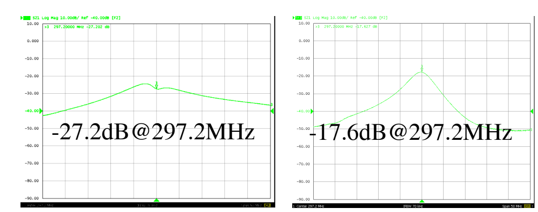

Figure 2: S21 plots between two adjacent elements (left) and next adjacent elements (right). Isolation between any two elements in this transceiver array is better than -17 dB.

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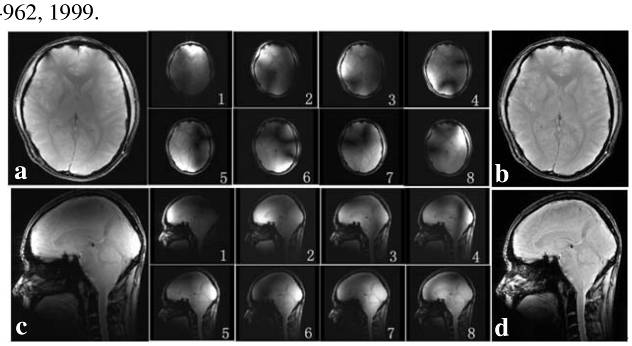

Figure 3: (a) Combined GRE image and sub-images form each coil element in the transverse plane. (b) Intensity corrected image of Fig. 3a. (c) Combined GRE image and sub-images from each coil element in the sagittal plane. (d) Intensity corrected image of Fig. 3c.

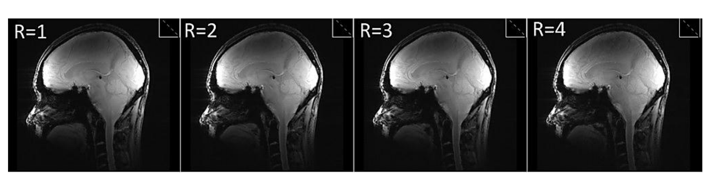

Figure 4: GRE images with accelerate factors 1 (no acceleration), 2, 3 and 4 using GRAPPA in the sagittal plane. Compared with the full k-space image, nearly all the anatomic details are preserved in those accelerated images, even at R=4 for this 8-element array coil.