Magnetic wall decoupling for dipole transceiver array for MR imaging: a feasibility test

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INTRODUCTION: Dipole antenna arrays have been applied for ultrahigh field MRI to obtain stronger B_1 field at the areas located deep in human body or head [1, 2]. Currently dipole arrays have been designed with no decoupling circuits, resulting in non-optimized decoupling performance In this study, we investigated the possibility and performance of magnetic wall (MW) or induced current elimination (ICE) decoupling technique [3] in dipole coil arrays at 7T.

MATERIALS AND METHODS: Two-channel dipole arrays without decoupling treatments (Figures 1A and 1C) and with the MW decoupling method (Figures 1B and 1D) were constructed. Each dipole element was shortened by two series inductors (L_s, Figures 1C and 1D) and had a length of 26 cm. The distance between two dipole elements of each array is 7 cm. For the MW decoupled array, an independent dipole, referred to as the decoupling element, was symmetrically placed between the two dipole elements (Figures 1B and 1D). The decoupling element had the same length as the dipole element and was shorted by a series inductor L_d. Bench test results were measured by an Agilent network analyzer. GRE images on the water phantom using the two arrays were measured, calculated and compared. A cylindrical water phantom (σ = 0.59 S/m; ε_r = 78) with an outer diameter of 16 cm and a length of 37 cm was placed 2.5 cm below the dipole arrays (Figure 1E). GRE parameters: FA =25^0, TR/TE=100/10 ms, FOV=250×171 mm^2, matrix=256×176, thickness=5 mm, NEX =1. MR experiments were performed on a 7T whole-body MRI scanner (Siemens, Germany). During the experiments, one dipole element was used for both transmission and reception with the other one terminated with 50-Ω load.

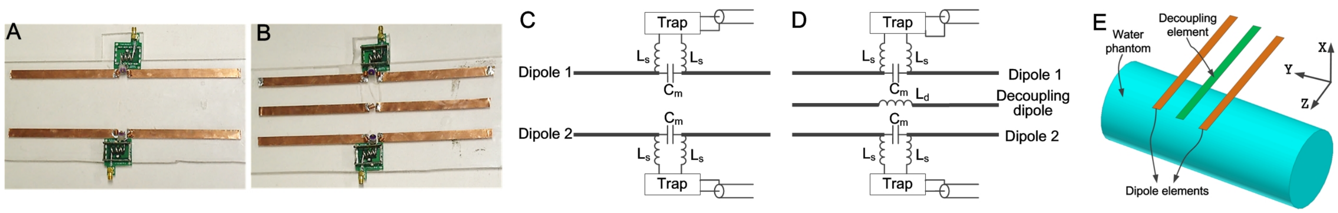

Figure 1 A-D: Photographs and sketches of the two-channel dipole arrays without decoupling treatments (**A** and **C**) and with magnetic wall decoupling (**B** and **D**). **E**: Position of the dipole arrays vs. the water phantom.

RESULTS: Figure 2 shows the measured S-parameters of the two arrays loaded with phantom. S_{11} of each dipole element is better than -20 dB. For the dipole array without decoupling treatments, S_{21} between the dipole elements was only about -3.6 dB. Q_{UL} and Q_L of a single element were about 13.3 and 9.5, respectively. For the ICE-decoupled dipole array, S_{21} could be reduced -16.5 dB. The average Q_{UL} and Q_L of a single element were 48.1 and 29.2, respectively. The MW decoupled array exhibits higher Q value which might be due to the better decoupling performance and shielding effect of the decoupling element.

GRE images from each dipole element of the two-channel arrays were shown in Figure 3. Figures 3A and 3B show the images from two coupled dipoles and the 1D profiles of the images. Figures 3C and 3D show the images from two MW decoupled dipoles and the 1D profile of the images. This significant decoupling effect, as obtained from the S_{21} plots, could also be clearly observed in MR images. Well defined image profiles of MW decoupled dipole array were obtained, indicating sufficient EM decoupling between the two elements.

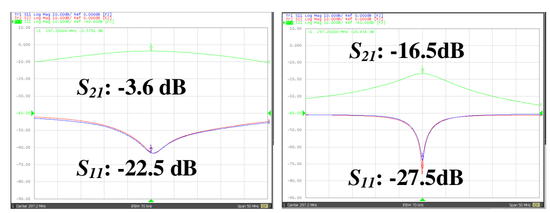

Figure 2 Measured S11 and S21 plots vs. frequency of two dipole elements loaded with the water phantom. A: Without decoupling treatments. B: With the MW decoupling method.

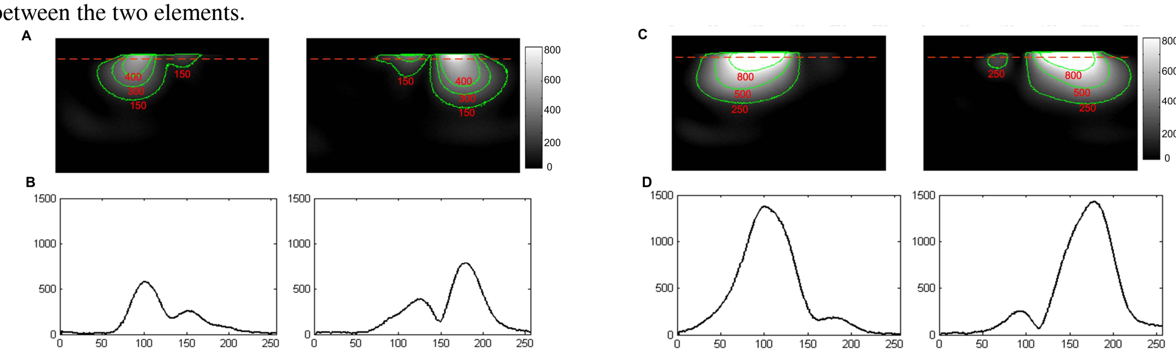

Figure 3 A: Images from two coupled dipole elements. **B**: Profile of the red dotted line of the images in A. **C**: Images from two MW decoupled dipole elements. **D**: Profiles of the red dotted line of the images in C.

DISCUSSIONS AND CONCLUSION: The magnetic wall decoupling technique, which does not need physical connections between coil elements and decoupling circuits, has proven to be a simple and efficient approach for dipole transceiver array in MRI. Due to improved decoupling performance, the MW decoupled dipole array demonstrates well defined image profiles and improved signal intensity from each dipole element. Its decoupling performance might be further improved by optimizing the length of the decoupling element. This study has paved the way for designing MW decoupled multi-channel volume-typed dipole array for human MR imaging at ultrahigh fields.

REFERENCES [1] A.J. Raaijmakers, et al, MRM. 66, pp. 1488-1497, 2011. [2] G. C. Wiggins, et al, p.541, ISMRM, 2012. [3] Y. Li, et al, Med. Phys., 38, pp. 4086-4093, 2011.