An 8-channel microstrip array coil for mouse parallel MR imaging at 7T by using magnetic wall decoupling technique

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Introduction Microstrip transmission line (MTL) resonators have shown the advantages of high quality factors, high reproducibility, and low radiation losses in designing volume RF coils at high and ultrahigh magnetic fields (1-4). In this work, we present an 8-channel microstrip volume coil array for mouse parallel imaging at 7T. The magnetic wall technique was introduced to decouple the resonant elements. The proposed magnetic wall decoupling technique allows intrinsic decoupling among the resonant elements regardless the distance between the elements. Unlike the conventional decoupling methods of non-overlapping array design, such as the method using lumped L/C decoupling circuits (3, 4), the circuit which generates the magnetic wall has no physical connection with the resonant elements of a coil array and decoupling performance is not frequency-sensitive. Therefore the decoupling performance can be maintained in a broad frequency range, resulting in a broadband decoupling. This decoupling property is particularly important and useful to decouple elements operating at two frequencies (e.g. ^{1}H frequency and ^{13}C frequency). Bench test and preliminary imaging results from the proposed coil array at 7T are shown.

Methods The microstrip array coil was built on a Teflon cylinder with dimensions of 6.6cm O.D by 5.2cm I.D by 10.2cm length. The Teflon cylinder serves as both dielectric material and supporter. Fig.1 shows a picture of the prototype array coil. For proton MR imaging, each of its 8 resonant elements was a λ/2 microstrip resonator with capacitive termination on both ends. The microstrip coils were tuned to 298.144 MHz, the Larmor frequency of proton at 7T. Another set of 8 circuits which generate magnetic wall, is made from quarter wavelength (λ/4) microstrip lines in this study and alternatively placed around the Teflon cylinder in order to achieve sufficient decoupling. The magnetic-wall-generating circuit can certainly be made form the type of circuits, for instance, a regular LC circuit operating at appropriate frequency. A diagram of two proton coil elements and one magnetic-wall-generating circuit are shown in Fig 2. *M is* the mutual inductance between two microstrip elements, and M_1 is the mutual inductance between microstrip coil and decoupling circuit (or element). Theoretically, when and only when the impedance of the decoupling elements satisfy $X_d = \frac{X_{M1}^2}{X_M}$, where $X_{M1} = j\omega \cdot M_1$ and $X_M = j\omega \cdot M$ are the mutual impedances. ω is the resonant frequency, the two resonant elements are intrinsically decoupled. At the resonant frequency of the coil arrays, $X_d > 0$. Therefore, the decoupling elements were performed as inductors and had lower resonant frequency than the coil array frequency. Bench test on coil decoupling between any two channels are implemented on a network analyzer (Agilent E5070B). The termination capacitance measurement is conducted on a RCL meter (Fluke PM6303A). The proton MR imaging experiments were performed on a GE 7T/90cm magnet (GE Healthcare, Waukesha, WI). A cylindrical water phantom was used in this preliminary study. A set of fast spin echo images in axial orientations were acquired using the coil. Acquisition parameters for proton imaging were – TR = 100ms, TE = 6.8ms, thickness = 3mm, flip angle = ~20^0, FOV = $100cm^2$, no average (i.e. NEX =1).

Results and Conclusions Each coil element was matched to system 50ohms by a series capacitor. By adjusting the capacitors of decoupling elements, the decoupling among elements can be easily achieved -15dB or better. No split resonance peak is observed. These results indicate that the eight channels are decoupled sufficiently for parallel imaging applications. Fig 3 shows the MR images from each element of the coil array, in which no signal is observed from other elements in each individual image, indicating the effectiveness of the proposed magnetic wall decoupling technique at the ultrahigh field of 7T. The proposed coil array 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) G. Adriany, et al. MRM. 53 (2005) 434-445; (2) Zhang X, et al. JMR 161 (2003) 242-251; (3) Wu B, et al, Thirteenth Annual Meeting of ISMRM, 949 (2005); (4) Wu B, et al, JMR 182:126–132 (2006)

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Fig.1 The photograph of the 8-channel microstrip array coil using magnetic wall decoupling technique for mouse imaging at 7T.

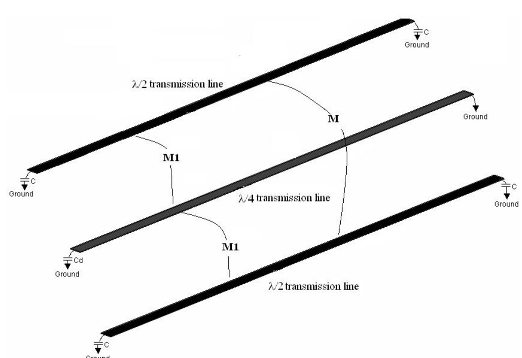

Fig.2 The diagram of two elements of the coil array and one magnetic-wall-generating circuit which is made from a quarter wave length microstrip line in this design.

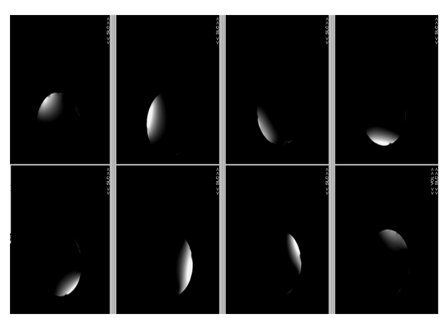

Fig.3 The MR images of a water phantom acquired using each element of the proposed 8-channel array at 7T. Well-defined image profiles illustrate the sufficient decoupling among the resonant elements which is essential for efficient parallel imaging.