8 Channel Multi-coils and Transmit Coil with Dynamic Disabling Switches for 7T Head Imaging

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Introduction

Multi-coil is a key technology to take maximum advantage of high SNR on 7T. There are several considerations on 7T that are not critical issues at 1.5T. Radiation loss becomes a more substantive issue in designing circuits, which requires circuits with less radiation loss. Dielectric constants of imaging objects have a dominant effect on 7T imaging, which means that coil geometry should be optimized under loaded conditions. These issues need coils to be designed based on different design scheme from that used for lower field. We describe 15cm long birdcage coil with dynamic disabling switches designed using distribution circuit made of semi-rigid coaxial cable as the transmit coil and 2 types of 8 channel multi-coils constructed of 40mm diameter round coil, and evaluate the coils performances.

Methods & Material

Transmit coil and two type of 8 channel multi-coils were designed and tested on Signa 7T MRI system (GE Healthcare, WI, USA). The transmit coil was 32 element high-pass self-shielded birdcage coil with 16 dynamic disabling switches. The radii of coil elements and RF shield were 150mm and 165mm respectively. The coil elements were constructed of 25.4mm copper foil tape of 0.04mm thickness. The axial length of coil elements and RF shield were 150mm and 170mm respectively. Dynamic disabling switches were designed based on reference (1) except that a part of semi-rigid cable was replaced with ceramic capacitor to shorten its physical length. (Fig.1) 16 dynamic disabling switches were alternatively connected to either end of the birdcage coil. Two adjacent dynamic disabling switches shared a switching bias in series; 0.3A forward bias in transmit mode and -5V reverse bias in receive mode.

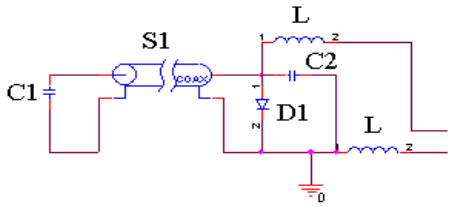

Fig.1 Schematics of dynamic disabling circuit. C1; tuning capacitor on birdcage end ring, C2; tuning capacitor for dynamic disabling switch, S1; λ/4 semi-rigid cable, D1; switching diode, L; inductance for low-pass filtering of switching bias.

Two types of 8 channel multi-coils were built. These multi-coils were constructed of 40mm diameter round coils with 6mm width and 0.018mm thickness. Each coil element was tuned to 298MHz under human head loaded condition when located inside the disabled transmit coil. Trap circuits were built on semi-rigid cables between coil elements and coil interface of the system to reduce shield current. One of these coils was 8 channel wrap-around array mounted on the 268mm O.D. cylinder with 45° azimuth gap which was located concentrically with the transmit coil. (Fig.2) The other was 8 linear array coil mounted on 120° arc former with 268mm radius, which was located under head. (Fig.2) The adjacent coils were overlapped by about 9mm to cancel mutual inductance between adjacent coils.

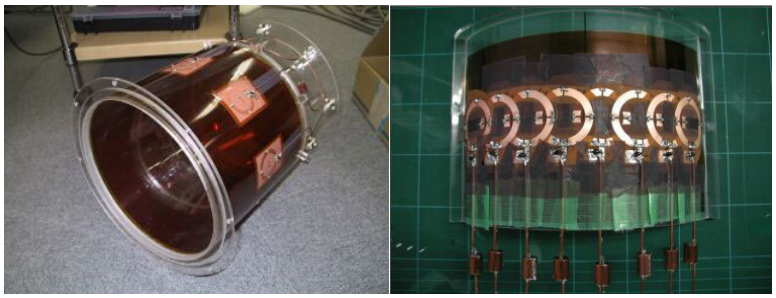

Fig.2 8 channel wrap-around coil (left) and 8 channel linear array coil (right)

Results and discussion

There was no apparent coupling between any pair of the coil elements with respect to 8 channel wrap-around array. With 8 channel linear array, overlap was not enough to decouple mutual inductance between any pair of the coil elements under unloaded condition, however the decoupling was acceptable level for tuning coil elements under human head loaded condition. m=1 mode frequency of transmit coil shift +0.01MHz and +1.01MHz with disabled wrap-around array and disabled linear array inside respectively when human head was loaded. There was apparent m=1 mode split when disabled linear array was located inside the transmit coil, though there was no apparent split with respect to wrap-around array. Silicon phantom (dielectric constant:2.8) and NiCl (dielectric constant:86) spherical phantom with 18cm diameter were imaged with Spin echo sequence (TR/TE=800/14, BW=15.63kHz, slice thickness=3mm, FOV=24cmx24cm, resolution=256x256, and 1NEX, Fig.3). It was found that 40mm round coil had deeper sensitivity inside phantom than expected on the basis of lower field. It was though because of dielectric effect.

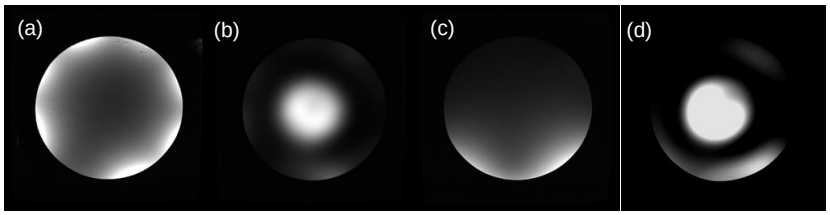

Fig.3 Silicon phantom image (a) and NiCl phantom image (b) by 8 channel wrap-around coil. Silicon phantom image (c), and NiCl phantom image by 8 channel linear array coil.

Conclusion

7T multi-coil imaging was performed using the transmit coil with dynamic disabling switches using distribution circuit made of semi-rigid coaxial cable and 8 channel multi-coils constructed of 40mm diameter round coil. The dynamic disabling switches effectively switched the birdcage coil between enabling and disabling. B1 of 8 channel multi-coil constructed of 40mm diameter round coil covered larger volume than expected on the basis of experience at lower field.

Reference

(1) Nabetani & Watkins, Proceedings of ISMRM 2004, p1574

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