An Inductively Decoupled Coil Array for Parallel Imaging of Small Animals at 7T

G. C. Nascimento[1], F. F. Paiva[1], and A. C. Silva[1]
[1]NINDS, National Institutes of Health, Bethesda, Maryland, United States

INTRODUCTION

Proper design of RF coil arrays is of fundamental importance to parallel imaging. One of the critical aspects of building coil arrays is the elimination of inductive coupling among the coils without degradation of the signal to noise ratio [1, 2]. Recently, we proposed a novel method to interface receive-only RF coils to low-noise, 50 Ω preamplifiers by using a passive transformer to achieve the high reflection coefficient required for isolation of the different coils in the array [3]. The purpose of the present work is to demonstrate the implementation of such approach for brain imaging of small animals at 7T.

METHODS

Figure 1 illustrates the basic approach for interfacing the RF coil to the preamplifier. A passive transformer, consisting of N turns on the secondary side for each turn on the primary side, is directly connected to the RF coil via a tuned balun, which components L and C satisfy the resonance condition ω0 = 1/√L·C. The balun behaves as an impedance inversion circuit just as a λ/4 cable, but has the advantages of being less lossy and of occupying less space than the λ/4 cable. The equivalent input impedance as seen from the RF coil is given by

$$Z_{high} = \frac{1}{Z_{pre}} \cdot \frac{L}{C}$$

The effective impedance of the 50Ω preamplifier, as seen from the balun side, is lowered by a factor of $1/N^2$. Because both the primary and secondary coils of the transformer are isolated, both the preamplifier as well as the entire receive chain of the MRI scanner are electrically isolated from the RF coil, making the use of traps and further baluns unnecessary for removing standing waves present in the cables. Further advantages and issues related to the use of inductive balanced circuits can be found in [4]. The images were acquired using a FLASH sequence using the following parameters: TE=4ms; TR=350ms; FOV=5.12X5.12cm; matrix=128X128;

RESULT

A two-coil array for imaging the marmoset brain was implemented and tested in a 7T/30cm Bruker Avance MRI scanner.The coil loops were formed onto an anatomically shaped helmet. A PIN diode based decoupling circuitry was added to allow decoupling of the receive array from the transmit coil. The transformer was air core and implemented using AWG 26 cupper wire and a 1:6 turn ratio, conferring a theoretical effective impedance of about 1.4 ohms to the preamplifier. The preamplifier was build in house on a 12 x 60 mm FR4 PCB using an HEMT FET device (ATF-54143, Agilent Technologies). A gain of 19 dB and a noise-figure of 0.7 dB were achieved. The circuit's housing was properly shielded to support both the switching of the gradients and the excitation power emitted by the transmit coil.
The real impedance as seen from the coil was adjusted in the capacitance Cm, to the value of 300Ω for both channels. Figure 2 shows FLASH images obtained with each coils. The image in the left shows no coupling effect but the one in right a very little coupling can be observed that may be related to some miss adjustments in the circuit during the tests.

CONCLUSIONS

A two channel small animal coil array for 7T was designed based upon the method of inductive decoupling between the channels. The level of isolation can be adjusted by controlling the coupling from the primary and secondary on Tx, and the method shows a very nice immunity to standing waves, cross talking effects and other parasitic signals in the array channels. The acquired images shows also that the method provides a high signal to noise ratio.

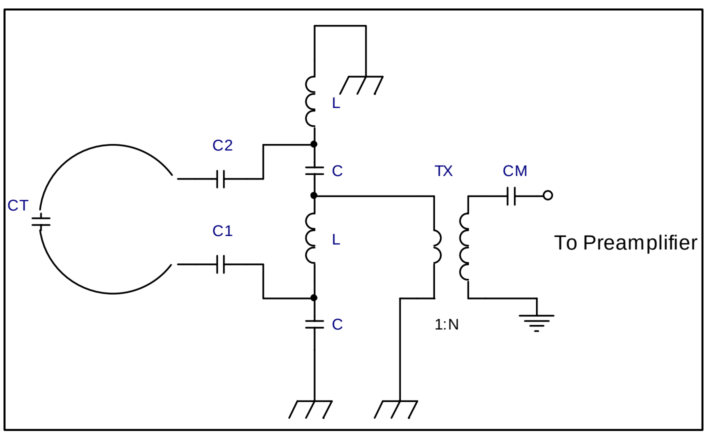

Figure 1. Approach for decoupling the detecting coils using a transformer.

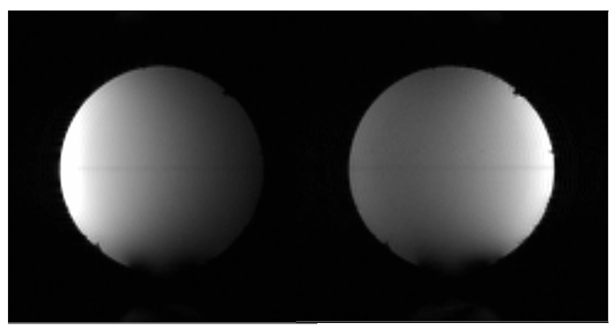

Figure 2. Individual Flash Images of the individual coils

REFERENCES

[1] [1] Ohliger MA et al, Magn Res Med, 2004; 52:628-638; [2] Roemer PB et al. Magn Reson Med, 1990; 16:192-225; [3] Nascimento G. C. et al, ISMRM Abstract, 2006; [4] Decorps M et al, J Magn Reson 1985; 65:100-109.