Array with Multiple loops for Vertical Field System

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Introduction

Most array coils have been designed and applied on horizontal MRI system. For vertical field MRI applications, the structure of the loop array is quite different from those in a horizontal-magnetic-field system. When the coil array for vertical fields consists of multiple loops, one of the design difficulties is how to reduce their mutual coupling. Some conventional decoupling techniques, for example the coil overlap [1], capacitive decoupling circuits or networks [2-5], are not easy to extend to vertical MRI system. Low-impedance preamplifiers are not sufficient for isolation due to the strong coupling among the adjacent loops. So far the coil array with 2 channels (including two loop coils) have been investigated on open low-field MRI [6], the array with more than three loop coils is sparsely reported. In this study, we present a decoupling technique using inductors for vertical-field loop coils. A four-channel prototype consists of three loops and a saddle coil has been built for 0.5T vertical field system. In comparison with single coils, no obvious Q-factor reduction was observed by introducing those decoupling inductors. The isolations between loops were better than –13dB without using the low-impedance preamplifiers.

Method

The connection of the decoupling inductors is shown in Fig.1. It is assumed that there are four coupled loops along superior-inferior (SI) direction. A section of loop strips are shown in the figure. A ground line is connected between the four loops to provide a reference point. C_1 and C_2 represent the tuning capacitors on each loop; L_{ij} represents the inductor which is used to decouple the loop (i) and loop (j). This decoupling method can be explained by analysis the phase of the induced current on coil loop and the current passing through the decoupling inductors. Considering the mutual coupling between loop1 and loop2 with the primary coil of loop1, the voltage of C can be set to zero. If assuming the current in loop1 has zero phase, the induced current in loop2 (I_{induce}) has the same phase as loop1. The voltage of point A and B are 180^o out of phase, while voltage of B has 90^o phase. Thus the current passing to L_{12} (I_L) also has zero phase. The cross-talk current in loop2, which is the subtraction of I_{induce} and I_L, can be canceled.

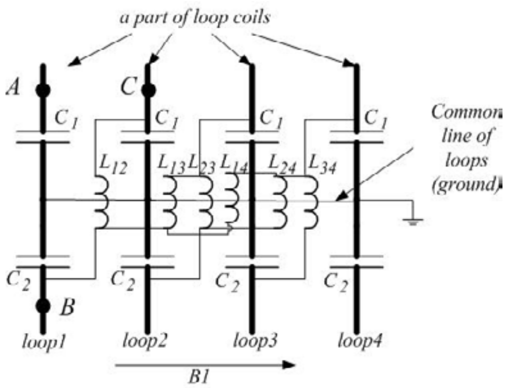

Fig.1. Decoupling inductors for four loop coils.

A prototype was built for 0.5T vertical field open system (Fig.2 and 3). The three loops and a saddle coil were fabricated on a cylinder with 16.0cm o.d. and 15.4cm i.d. Three loops were evenly placed with 4.0cm distance. A saddle coil with size of 42cm×16cm was placed across the loops. All the coils were fabricated with 1.25cm wide 3M copper tape. Three inductors L12, L23 and L13 were used to reduce the coupling between loops.

Result

Experiments show that the required decoupling inductance decreases with the mutual coupling between loops, so that the L_{13} in Fig.3 is larger than other inductors. The required decoupling inductance can be adjusted by varying the proportion of C1 and C2. Thus the appropriate C1 and C2 can be selected to avoid the inconvenience by using too large or small decoupling inductors. If there is no decoupling inductor, the strong coupling among coils caused the resonant peak split (Fig.4a). After introducing the decoupling inductors, all four coils could be tuned and matched without load or loaded with human knee. No resonance peak split could be observed. The isolation between loops were measured in the range –13dB~-18dB (Table 1 and Fig.4b). The average loaded Q of loops was 97, very close to the single loop coil's Q of 103 with the other two loops open-circuit.

	loop1	loop2	loop3	saddle
loop1		-16dB	-13dB	-9dB
loop2	----		-18dB	-14dB
loop3	----	----		-8dB
saddle	----	----	----	

Table 1. S21 between elements

Conclusion

A new inductively decoupling method to isolate multiple loops on vertical field system has been presented. Based on this method, a four-channel array for 0.5T system has been fabricated and bench tested. The result shows good isolation between coil elements.

Acknowledgement

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Reference

[1] Roemer. P.B. et al., MRM 16, p192-225 (1990). [2] Wang, J., Proc ISMRM 4, p1434 (1996). [3] Lian, J. and Roemer, P.B., US Patent 5,804,969 (1998). [4]. Jevtic J., Proc ISMRM 9, p17(2001). [5]. Lee R.F. et,al., MRM 48. p203-213(2002). [6] M. Takizawa, et al., Proc ISMRM 10 p907(2002).

Fig.2. Four channel array for 0.5T

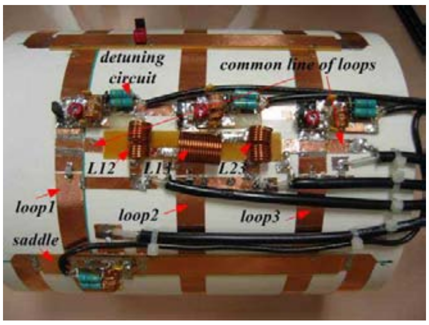
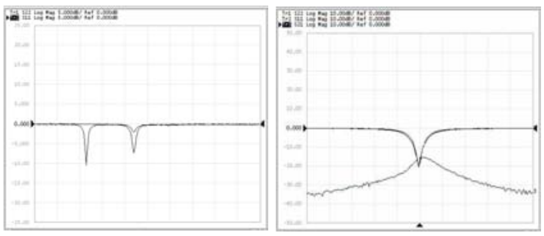


Fig.3. Decoupling circuits



(a) (b)

Fig.4. (a): S11 and S22 parameter of loops before mounting the decoupling inductors (frequency-centered on 21.5MHz with a span of 10MHz). (b) S parameters after decouple (frequency-centered on 21.5MHz with a span of 2MHz), S21=-16dB.