New Decoupling Method for Spiral Phased Array HTS coil

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Introduction

In MRI, high SNR can be obtained by phased array coil [1]. Even though some recent research to apply the phased array technique to HTS coil for high quality images with larger FOV [2] has been reported, the decoupling between the coils in an array remains to be solved. In low-field MRI, spiral configuration has an advantage over interdigital one, because spiral coil has a high quality factor. Minimizing the mutual coupling between HTS spiral coils through overlapping is difficult and has not been published in MRI applications.

Though most antennas deal with a far EM field, antenna technology can sometimes be used for MRI as an example of phased array. Decoupling between two spiral loops has been successfully used in antenna design [3].

Investigation of mutual coupling between sprial array HTS coils is presented in this work. Because these coils have much higher Q than conventional coils, eliminating their cross-talk or mutual coupling is significant in their applications.

Simulation Methods

Consider two circular HTS spiral coils placed on the same plane as shown in Fig.1. The HTS spiral coils are made of YBCO thin film on 3-inch LAO substrate, the thickness of substrate is 0.508mm,relative dielectric constant is 23, with no ground conductor plane.

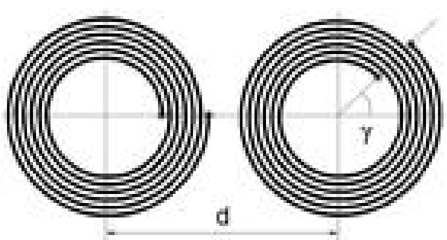

Fig.1 Geometry of two spiral HTS coils placed on the same plane. r is the relative rotated angle between the two spiral coils

In order to calculate the mutual coupling between spiral coils, we consider the two coils as a two-port device. The reflection coefficient, S11, is used to describe the return loss of the two-port device and the transmission coefficient, S21, is used to describe the mutual coupling between HTS coils. These s-parameters can be derived from the current on HTS spiral coils. A mixed potential integral equation described in equation (1) combined with the method of moment (MoM) is used to obtain the current.

$$\iint_S -j\omega G^{A}(\rho,z,z')\bar{J}(\bar{r}') + \frac{1}{j\omega}\nabla[G^{V}(\rho,z,z')\nabla'\cdot\bar{J}(\bar{r}')]\,dS + \bar{E}^{in}(\bar{r}) = Z_s\bar{J}(\bar{r}'), \qquad (1)$$

where Zs is the surface impedance of the HTS material obtained from the enhanced two-fluid model [4]. This method has been demonstrated in [5].

Results

The relation between the mutual coupling (S21) of the two spiral coils and their relative rotated angle has been simulated and presented in Table1. The return losses (S11) for their different relative rotated angles are shown in Fig.2 (a), (b), (c), (d). The return loss of a single HTS spiral coil is compared with the two-coil performance in Fig. 2 (e)

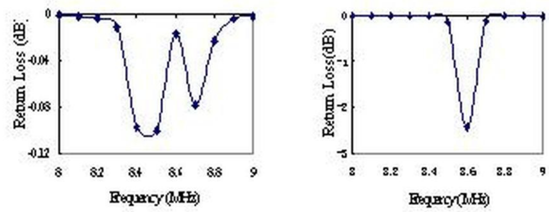

Fig.2(a) r=0 Fig.2(b) r=90

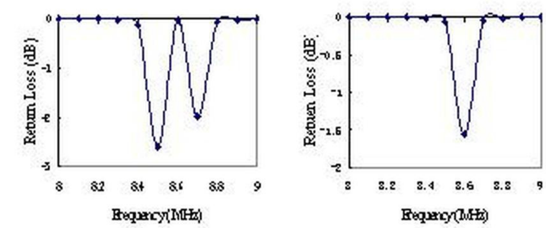

Fig.2(c) r=180 Fig.2(d) r=270

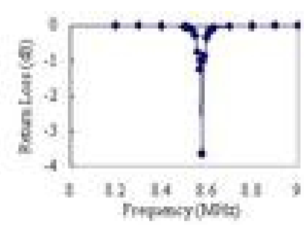

Fig.2(e) Single HTS coil

Fig.2 The return loss S11 of HTS coil in different relative rotated angle r, the distance of two coils is 70 mm.

γ	0		90	180		270
F (MHz)	8.49	8.78	8.58	8.52	8.75	8.58
S21	18dB	21dB	33dB	11dB	14dB	23dB

Table 1. The mutual coupling of HTS spiral coils versus r

The results show that the mutual coupling of two HTS spiral coils can be eliminated when the relative rotated angle between two spiral coils is 900 or 2700 for their distance (d=70 mm) at the frequency of 8.58MHz.

Conclusion

The mutual coupling of HTS spiral coil is simulated by numerical method. The results show that the mutual coupling of HTS spiral can be eliminated by adjusting their relative rotated angle.

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