Challenges of HTS Volume Coil: Decoupling and Cryostat

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Abstract:
High Temperature Superconducting (HTS) volume RF coil has significant advantages in RF penetration and field homogeneity over HTS surface coils for MR applications. Two types of HTS coils are implemented and compared in 1.5T system. The key issues in designing a HTS volume coil: decoupling method and cryostat are presented in detail. Existing difficulties and further improvement for cryostat are also discussed.

Introduction:
Surface coils made of HTS have demonstrated a substantial improvement in signal to noise ratio (SNR) on NMR and MRI applications (1-4). However, B1 inhomogeneity of surface coils limits its applications. In this abstract, we present the design of an HTS volume coil, specifically its decoupling method and cryostat.

Methods:
HTS coil:
The configurations of HTS surface coil can be designed as "interdigital" or "spiral" as shown in Fig.1. For high field (1.5T or higher) MRIs, "interdigital" is better because such design has a low inductance. Its resonant frequency can be easily controlled through adjusting the interdigitated fingers during the processing of fabrication.

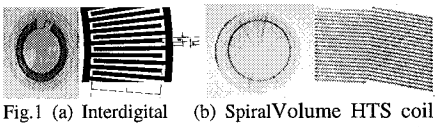

Fig.1 (a) Interdigital (b) SpiralVolume HTS coil consists of two pairs of Helmholtz coils that are perpendicular to each other to eliminate their mutual coupling, as shown in Fig. 2.Decoupling method:
In HTS coil design, it is not practical to directly connect a pair of Helmholtz coils because of the difficulties involved in the fabrication. Isolated and mutually coupled parallel loops is a feasible alternative. However, the resonant frequency can be split far away because of the mutual coupling between two identical resonant loops, especially for HTS coil with very high Q as shown in Fig.3.
In clinical MRI, HTS coils normally function as receive only mode for better field homogeneity. Therefore, the decoupling between body coil and HTS coils is critical. HTS coil can only be self-resonant when immersed in liquid nitrogen, thus the decoupling circuit with capacitors and diodes should be implemented in the pick up coil. The pick up coil was designed in such a way that it resonates at the center frequency during the transmit mode to shift the frequency of the HTS coil and is non-resonant during the receive mode to function as a pick up coil and get the RF signal from HTS coils.
Cryostat:
Improving thermal performance of cryostat for HTS probe is challenging due to its design trade off between volume and the effectiveness of cryostat. It should handle warm and cold tensile and yield strengths. G10 was used in this project which can

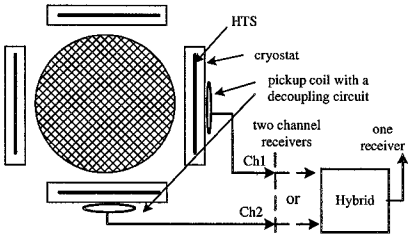

Fig.2 Phased Array or quad volume coil
keep low temperature as long as 20 minutes. The whole HTS package with a pick up coil was shown in Fig. 4(a).The individual HTS package as other part of Helmholtz pair was shown in Fig. 4(b).

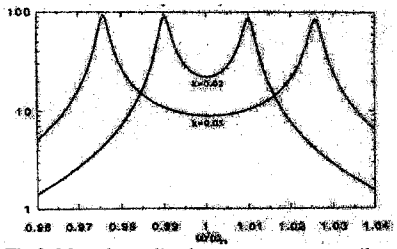

Fig 3: Mutual coupling between resonance coils

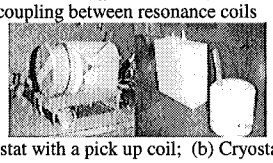

Fig. 4 (a) Cryostat with a pick up coil; (b) Cryostat package

Results and Discussions:
The Interdigitate HTS coil and Spiral HTS coil were compared in 1.5 T. The loading factor of Interdigital is better than Spiral. The performance of the volume coil was simulated and compared with the performance of a single surface HTS coil as shown in Fig. 5.

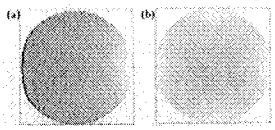

Fig. 5. B1 field of (a) a HTS surface coil; (b) HTS volume coil.
The cryostat is still not stable enough and the tuning and matching procedure is tedious. The chamber for cryostat can be further improved using Fiber-Epoxy Composites which are strong and light, and have low thermal conductivity and good vacuum characteristics.

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