

## High Temperature Superconductivity Coil Design for Low Field MRI

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### Introduction:

Low field MR scanners, provides lower spatial resolution and lower signal to noise ratio (SNR), which is caused by low field strength and other factors such as radiofrequency noise; therefore, a long measurement time is usually necessary. This research paper is focused on the development of novel probes and preamplifiers for low field MR scanners to improve SNR and thus shorten the measurement time. The parameters such as spatial resolution and acquisition times are closely related to the SNR [1, 2, 3]. In this study we describe the design of a high impedance preamplifier and a HTS coil. This novel instrumentation was compared with uncooled and cooled copper coils. Improvement in SNR in the case of HTS coil is reported.

**Methods and Materials:** To achieve satisfying signal to noise ratio, the receiving probe should be exactly tuned to the main working frequency of the MR scanner and matched to the transmission path. Another option how to connect the receiving coil is to use a preamplifier with high input impedance. We have developed this type of preamplifier. Our preamplifier can be directly connected to the receiving or pickup coil as close as possible. Impedance matching is given by the distance between the receiving coil (HTS coil) and the pickup loop. Given that the preamplifier has high input impedance of 3.53 kΩ, this distance was set to 1.5 cm, as determined experimentally. Output of this preamplifier is fixed by matching to the transmission with characteristic impedance 50 Ohm.

The receiving coil significantly affects the quality of images at low field MR tomography. Our novel receiving coil was designed solenoid-like (volume coil), which has higher sensitivity compared to other types of volume receiving coils. The HTS receiving coil was built as a one loop (132 mm in diameter) of thin tape of bismuth strontium calcium copper oxide (BSCCO) with the width 2.6 mm. The HTS coil cooled down to 77 K had a high selectivity (Fig.1), therefore had to be closely tuned to the working frequency of scanner, in our case 7.605 MHz. For this purpose HTS coil was roughly tuned by fixed high-quality capacitors and capacitance diodes were added for fine-tuning.

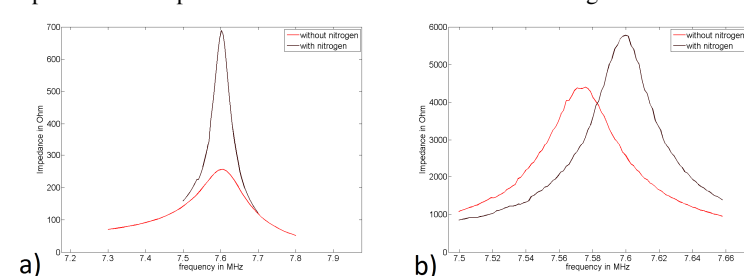


Fig. 1 Impedance characteristic of a) copper coil; b) HTS coil

based on the calculated SNR value. The decrease in frequency bandwidth with increased quality of the coil was detected, as generally expected. The detailed values of the coil properties are summarized in the Table I. The differences between the cooled copper coil and HTS coil were not observable by the naked eye, but the measured SNR is higher in the case of HTS coil.

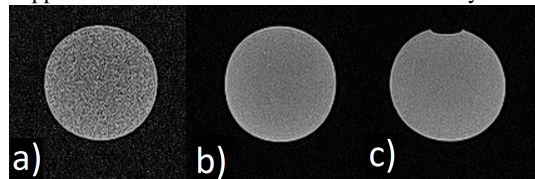


Fig.2 Images of the same slice of a water phantom: a) image obtained with uncooled copper coil, the SNR = 14.53, b) image obtained with cooled copper coil, the SNR = 38.75, c) image obtained HTS coil, the SNR = 52.9, in figure c is an air bubble visible, which has moved into this slice causing an artifact, but this did not compromise the SNR evaluation.

SNR of the uncooled copper coil was 14.53 and SNR of cooled copper coil achieved 38.75, what equals a 2.67 times greater SNR in the cooled state. In the case of HTS coil achieved SNR was 52.9, what is 3.6 times greater and 1.4 times greater than the SNR of uncooled and cooled copper coil, respectively. This improvement is significantly higher compared to previous study of HTS coil construction for high field [4], what shows that the lower fields benefit more from the HTS coil design.

Table I. Parameters of used coils

Coil	State	Bandwidth [kHz]	Quality of receiving coil
copper	uncooled	118	64.5
copper	cooled	41	185
HTS	cooled	23	330

**Conclusion:** It has been demonstrated that a receiving coil designed from HTS material with a dedicated preamplifier can significantly improve SNR of the obtained image at low fields, thus time-demanding signal averaging is no longer needed.

From the obtained results, the HTS materials appear to be suitable materials for the construction of complex receiving coils for low field scanners and can also find utilization also in micro imaging at high field scanners.

**References:** [1] D. I. Hoult and R. E. Richards, J. Magn. Reson., vol. 24, 1976; [2] C. Lauterbur, J. Magn. Reson. vol. 34, 1979; [3] J. Ch. Ginefri, et al. Methods, vol.43, 1997; [4] J. Yuan, et al. Physica C, vol.415, 2004