Persistent-Mode High-Temperature Superconducting Shim Coils to Enhance Spatial Magnetic Field Homogeneity for Superconducting NMR and MRI Magnets
Technology #15211

Applications

This invention has applications in the development of more efficient high field magnets for NMR and MRI devices.

Problem Addressed

The high magnetic fields required for high frequency (> 1 GHz) NMR imaging can only be achieved using magnet designs combining low-temperature superconducting (LTS) main coils with high-temperature superconducting (HTS) inserts. HTS coils generate large screening-current fields (SCF) which result in spatial irregularities in the magnetic field generated by the device. Therefore, all high-field LTS/HTS magnets used for high-resolution NMR require additional shim coils to correct the magnetic field and keep field errors below 0.01 ppm over the sample volume.

Conventionally, these shim coils are made from LTS materials such as NbTi, which are incapable of operating under high magnetic fields (> 10 T) such as those encountered within the bore of main magnets. This limitation forces magnet designers to place conventional NbTi shim coils outside the main magnet coils and far away from the center of the magnet, resulting in poor field efficiency. This invention describes a radially compact HTS shim coil design that can be placed within the high-field regions of primary magnets for improved field efficiency.

Technology

This invention describes an HTS shim coil fabricated from a rectangular loop cut laser cut from commercially available YBCO-coated sheets. The rectangular loop is rolled such that its long sides form two coaxial circles connected by its short sides, which are overlapped. Subsequently, a pair of charging leads and a heater, which acts as a persistent current switch (PCS), are attached to the shim coil. To start up the coil, the heater is turned on to open the PCS and a charging current is passed across the shim coil through the charging leads. Once the desired field strength is achieved, the heater is turned off to allow the initially resistive section to cool to superconducting temperatures and the charging current is turned off. This transition causes a persistent current to flow within the superconducting shim coil with minimal resistive dissipation, thereby inducing a stable shimming field which neutralizes spatial inhomogeneities in the field generated by the primary coils.

The choice of YBCO as the superconductor allows shim coil operation under background fields over 23.5 T, while the use of thin (~80 µm) sheets allows the coil to achieve radial thicknesses as low as 1 mm. Collectively, these advances allow at least some of the shim coils in LTS/HTS NMR devices to be placed in the small annular space between the main coil and the insert, which makes possible higher-efficiency shim coils.
Categories For This Invention:

Life Sciences  
Imaging  
MRI  
Research Tools

Intellectual Property:

Persistent-Mode High-Temperature Superconducting Shim Coils To Enhance Spatial Magnetic Field Homogeneity For Superconducting Magnets  
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