NATIONAL HIGH MAGNETIC FIELD LABORATORY
2017 ANNUAL RESEARCH REPORT

Development of Quench Protection of Bi-2212 Test Solenoid

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Introduction

Quench protection is vital for any large scale magnet system. The Applied Superconductivity Center is developing a superconducting magnet technology for over-pressure heat treated (OP-HT) Ag-alloy sheathed $Bi_2Sr_2CaCu_2O_x$ (Bi-2212) wire, with the goal of LTS/HTS hybrid magnets for ~1 GHz class NMR spectroscopy. The implementation of Bi-2212 conductor in such magnets poses various materials, magnet manufacturing, quench protection, and other challenges that are being addressed in a series of test coils. Methods developed for LTS that utilize AC losses such as coupling-loss induced quench (CLIQ) seem well suited to magnets built using Bi-2212 due to the conductor's similarities to LTS (twisted, multifilament, macroscopically isotropic, round strand) and CLIQ's ability to deposit energy quickly within the magnet volume, reducing the peak quench temperature. We are building a CLIQ unit that will be utilized with Bi-2212 test solenoids, cable race track dipoles, and CCTs.

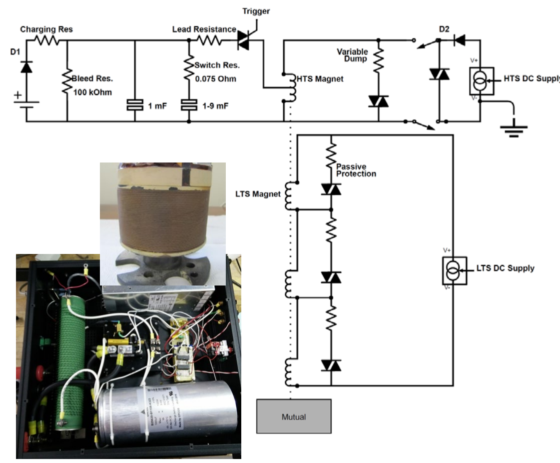

Fig.1 Simplified circuit diagram of the CLIQ and magnet system with an image of the coil and CLIQ trigger unit.

Experimental

The CLIQ TRIAC trigger unit with a single capacitor was developed, with a focus on safety. Internal discharge of stored energy and the disabling of charging or triggering to load are available by the depression of a red push button on the face of the unit. Isolation between the capacitor and control voltages is maintained with optical isolation. An enclosed variable 9 mF parallel capacitor bank was constructed with individual disconnect switches for each 1 mF dry film capacitor rated for 1.32 kV.

A test coil was equipped with a middle terminal to allow the CLIQ currents to generate large field changes at the center of the coil volume. External blocking and free-well diodes were constructed to allow safe operation of the system. A continuously adjustable power resistor is used to dump the excess stored energy at the end of the quench measurements.

The system was tested at both liquid nitrogen and liquid helium temperatures, with and without external field from a cryo-cooled large bore 8 T LTS magnet. The capacitor charging voltage was sequentially increased for various capacitances and initial current values. Simulations were compared to the data to determine the range of key parameters in order to evaluate the effectiveness of the system for larger magnets.

Results and Discussion

The observed losses were lower than the simulations predicted in all cases. This may be accounted for by the uncertainty in the transverse resistivity of the wire and the damping resistance of the warm sections of the circuit, after small variations in the capacitance and dump resistor settings were corrected. The tests were limited to a small fraction of the short sample I_C of the superconductor by the low I_C of the inner current terminal introducing heat into the windings.

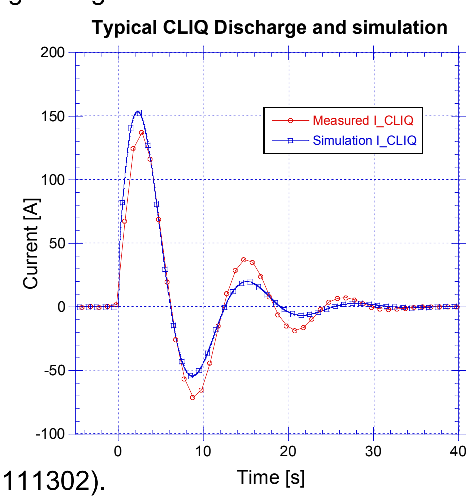

Fig.2 CLIQ current oscillation with a Bi-2212 solenoid and simulation

Acknowledgements

A portion of this work was performed at the National High Magnetic Field Laboratory, which is supported by National Science Foundation Cooperative Agreement No. DMR-1157490 and the State of Florida. This work is also supported by the Department of Energy (HEP Award No. 227011-520-032288), the National Institute of Health (Award No. R21GM111302).

References

[1] Davis, D.S., *et al.*, EUCAS, Geneva, Switzerland (2017).