APPLICATION OF AC LOSS ON HTS MAGNET USING FREQUENCY LOSS INDUCED QUENCH (FLIQ) PROTECTION SYSTEM

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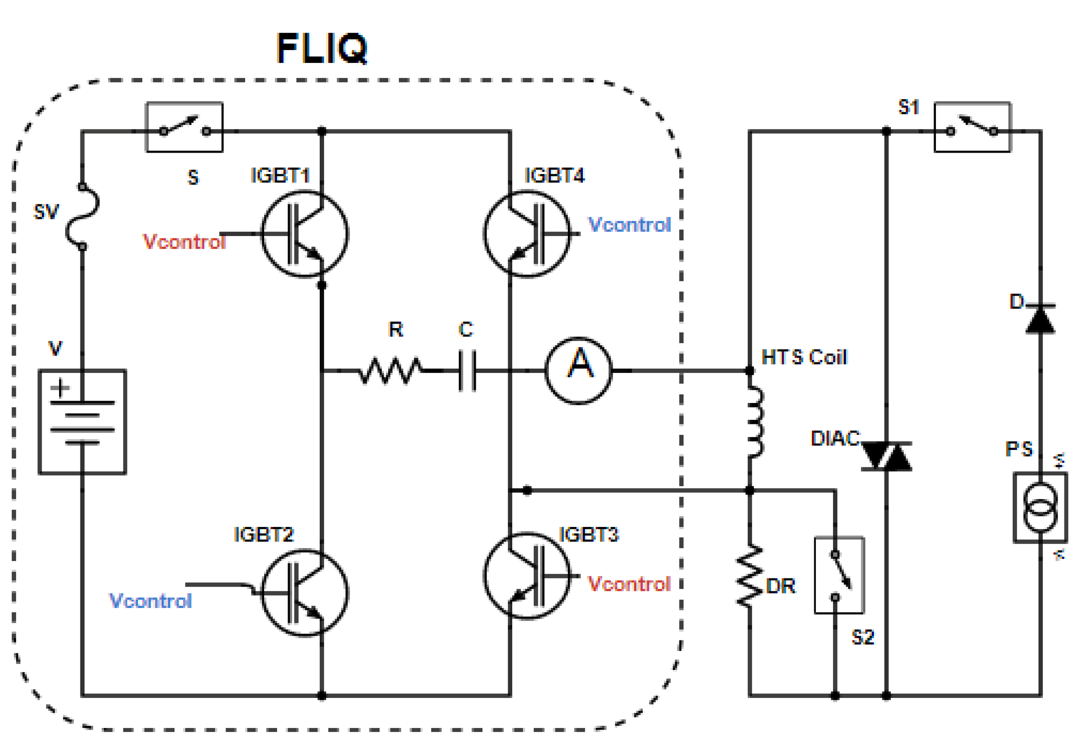
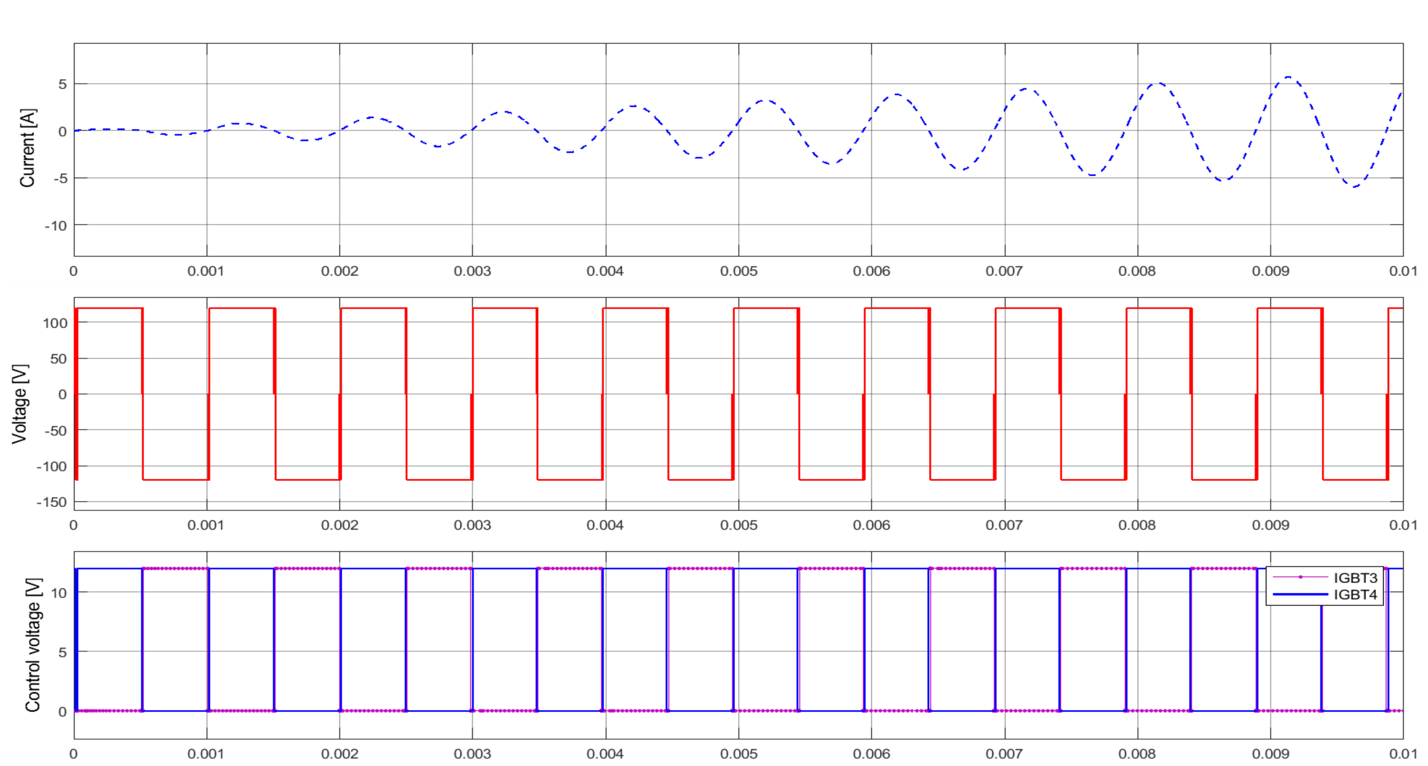
Abstract

A fundamental challenge with High Temperature Superconductors (HTS) is their high critical temperature (Tc) values and the stability that they impart when used in a magnet device with sufficient stored energy. Low normal propagation velocities and high stability of HTS wires cause localized damage due to an excessive peak hot spot temperature during a quench. Protection of HTS magnets for reliable operation has proven to be a challenge with the large amount of energy that is required to raise a significant fraction of the conductor above its local critical temperature which will dissipate the stored energy throughout the volume of the coil. Frequency Loss Induced Quench (FLIQ) system is a novel technique that relies on AC losses to uniformly heat up a superconducting coil or sections of the coil to quench the coil accordingly. FLIQ drives an imbalance in the transport current between two or more sections of the magnet through a capacitor. To drive the imbalance, FLIQ uses an H-bridge design with Insulated Gate Bipolar Transistor (IGBT)s, whose gates are driven based on the current feedback control that allows the system to operate at resonance. Demonstration of FLIQ performance on Bi-2212 is presented.

Experimental Set-Up



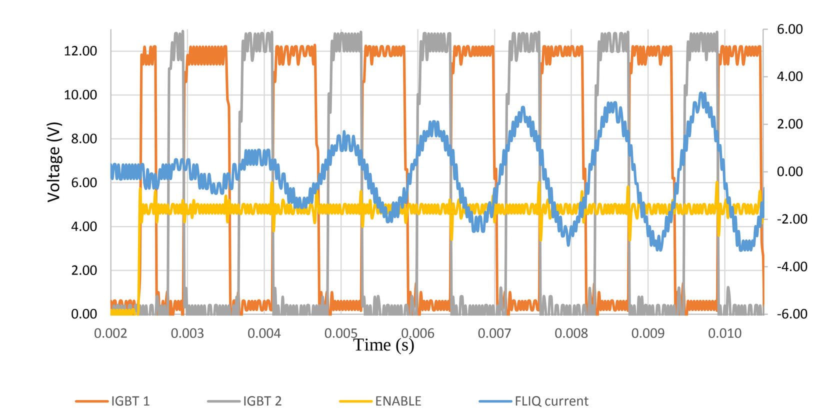
Schematic of the FLIQ system connected to the HTS coil.



Simulated operation of FLIQ at 120V 1 kHz , showing current, voltage and IGBT control voltages at no background field and transport current.

Resistive Coil Test

Parameters	Value
ID [mm]	56.5
OD [mm]	84.85
Height [mm]	137.64
Number of Turns	81
Inductance [mH]	8.5

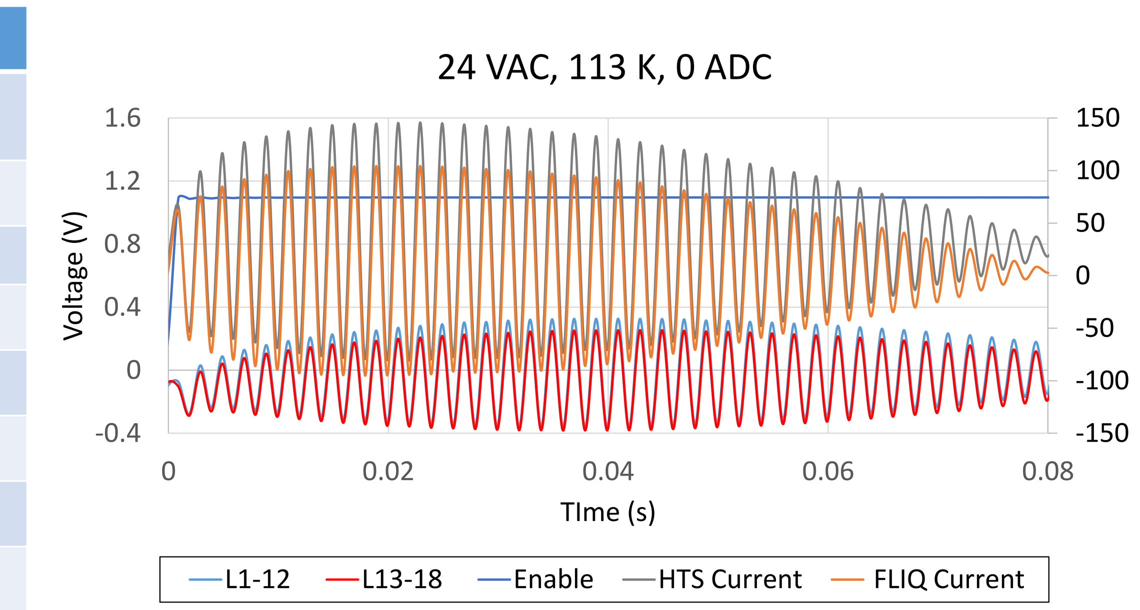


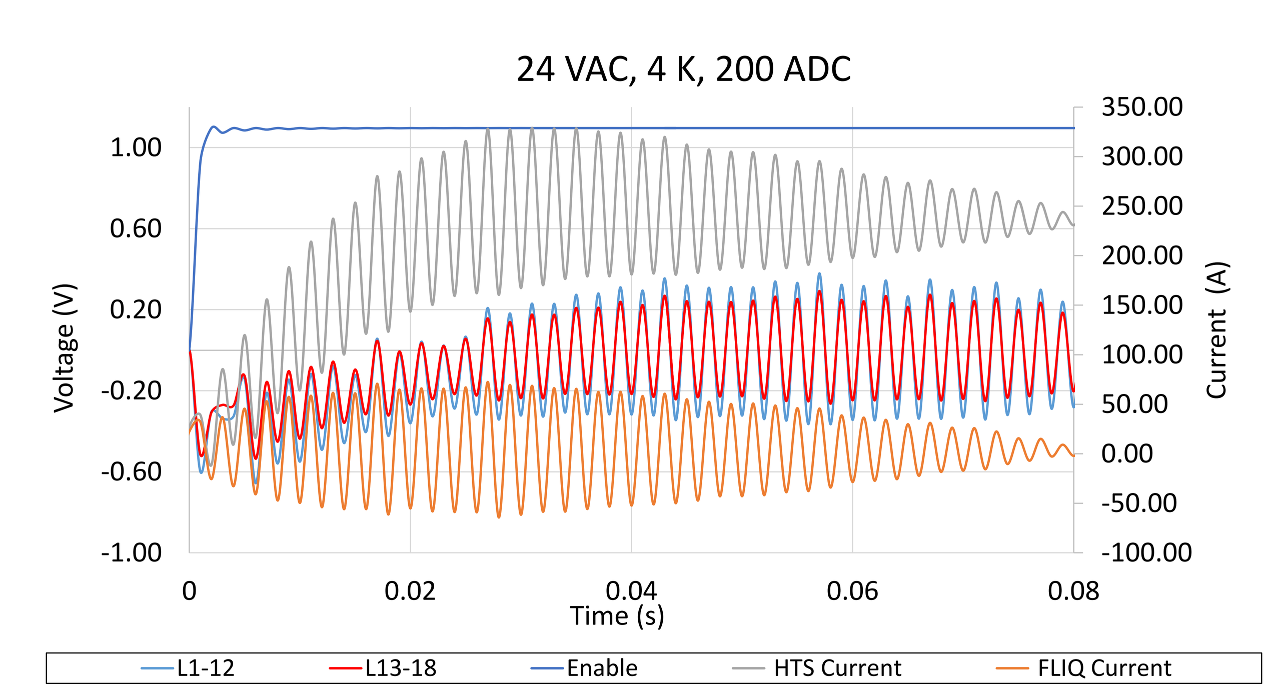
Key Features

- ❖ Capacitance can be modified
- ❖ FLIQ optimizes frequency as the IGBTS switch at the same frequency as the load
- ❖ FLIQ maintains continual resonance with excitation current as magnet load change

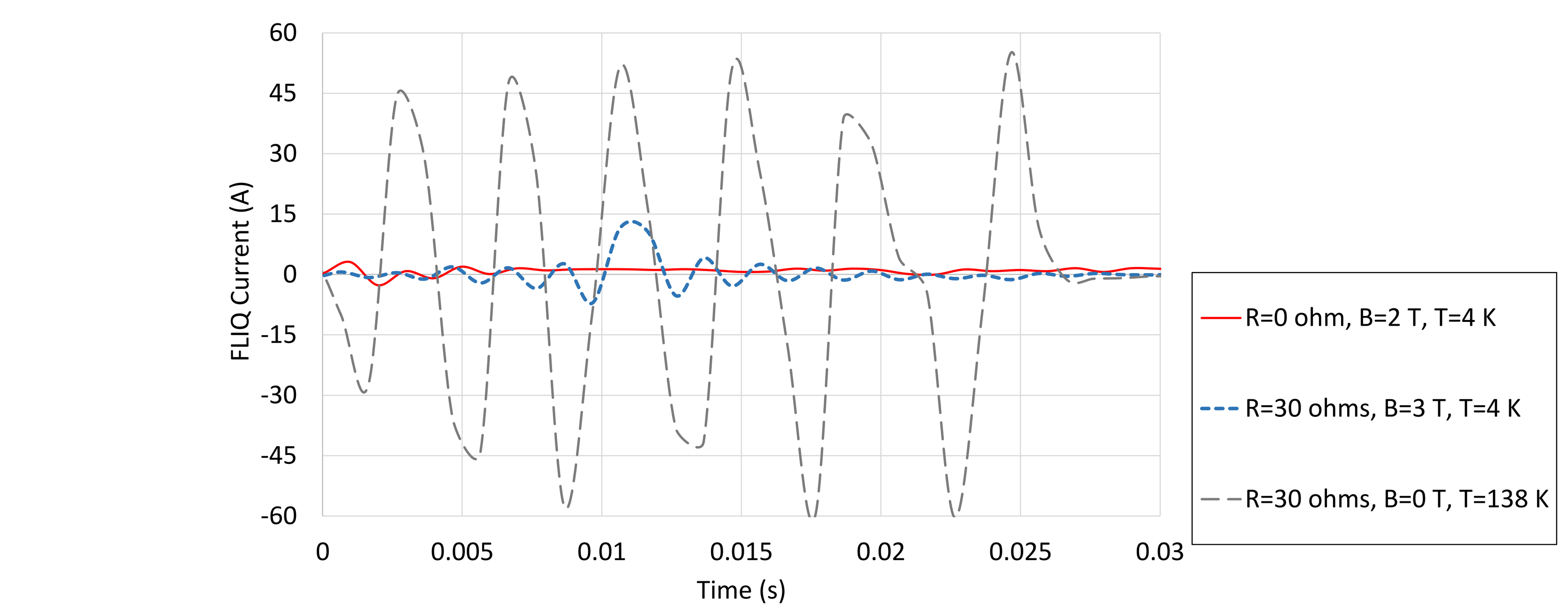
Bi-2212 Test

Parameters	Value
ID [mm]	27
OD [mm]	86.2
Height [mm]	25.5
Number of Turns	19
Number of Layers	18
Coil length [m]	70
Center field at 100A [T]	0.611
Inductance [mH]	5.91

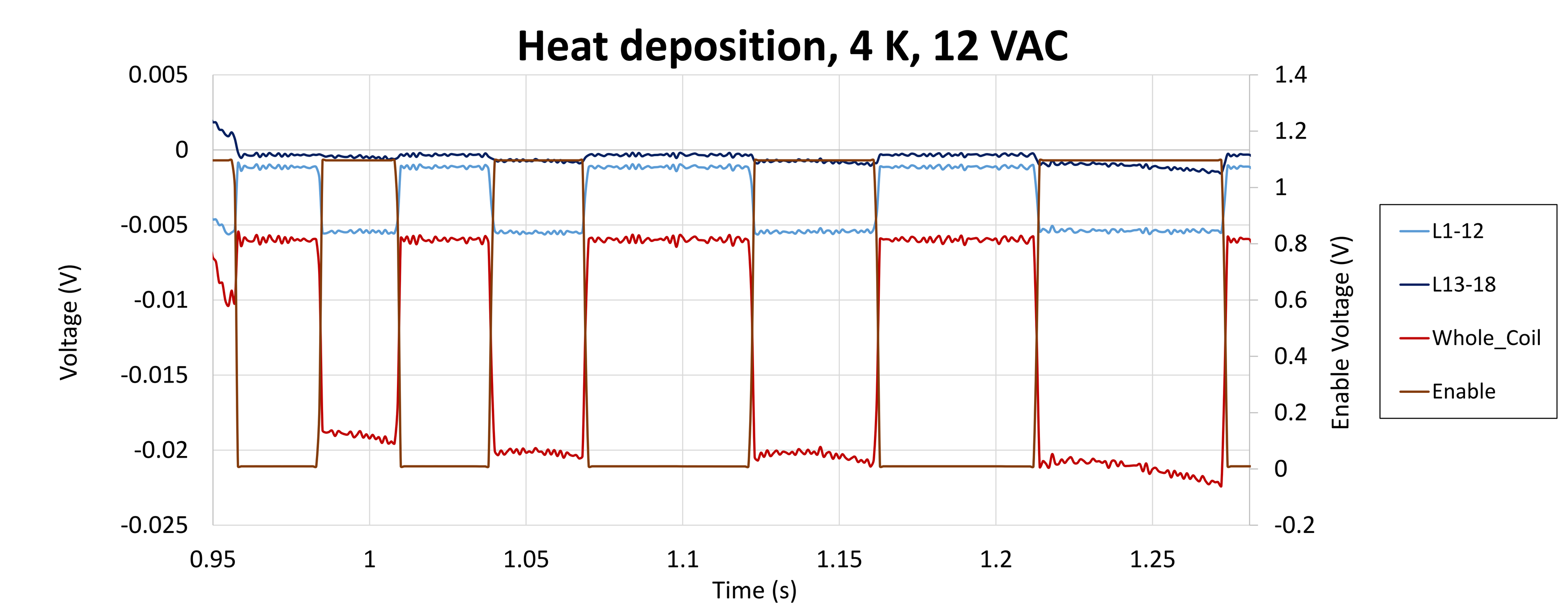




❖ FLIQ current was lower at 4 K but significant at non-superconducting temperature



❖ Increasing the load resistance resulted in higher current and self resonance



Discussion

Operated the FLIQ system at different time instant between $0.9I_c$ and $0.95I_c$ It was observed that some amount of heat was deposited. FLIQ could not quench the coil because its oscillation was limited during each half cycle. This is as result of increase in designed wait time when current changes state at high frequencies. FLIQ current was also limited by other components coupled to the coil.

- ❖ Simulations need to be improved to capture the effect of other components connected to the coil under different conditions.
- ❖ AC loss estimation needs to carried out to ensure FLIQ can safely protect the coil.
- ❖ Optimized parameter fit

Conclusion

The goal of this project is to advance active protection technology for High Temperature Superconducting coils by developing a system that can deposit high energy needed to quench the coil as quickly as possible. The results in this presentation shows the performance of FLIQ on Bi-2212 coil, conducted to demonstrate the validity of the circuit design. This development is in its early stages and will require optimization in the future.

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