Design and Manufacturing of the First Industrial-Grade CLIQ Units for the Protection of Superconducting Magnets for the High-Luminosity LHC Project at CERN

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Introduction

Coupling-Loss Induced Quench (CLIQ) is an innovative quench protection method based on a discharge resulting in high inter-filament and inter-strand coupling losses.

Current change
Magnetic field change
Coupling losses (Heat)
Temperature rise
QUENCH

Courtesy Emmanuele Ravaioli
Introduction

- It will be used in the HL-LHC as a complement of the Quench Heater systems

- Two different prototype versions of CLIQ have been manufactured at CERN
How to create the capacitive discharge?

Layout of the CLIQ unit

![Diagram of CLIQ unit layout]
User interface

Front panel

Capacitor charger panel

Trigger card panel

Rear panel
Safety first

- Equipment stop button stop, mains current breaker, on/off switch
- Interlock triggers when user opens the door for capacitance selection
- Padlocks on the capacitance selectors

→ The stored energy is dissipated in the resistor bank
Energy storage circuit

- **Capacitor Bank**: 5x10 mF, 1000 V capacitors in parallel (dry, bipolar, metallized polypropylene)
- **Charger**: 100 mA charging current, 1000 V in ~8 min for 50 mF
- **Resistor bank**: 40 resistors, 100 W, 1 kΩ ($R_{eq}=400$ Ω)
- **24 VDC relays**
Trigger and discharge circuit

- Two 24 VDC power supplies
- Two trigger circuit generators (on the same board)
- Two pulse transformers boards
- The user (i.e. Quench Detectors) starts the trigger by opening a current loop → 500 ms → 10 kHz pulse train
- Two Bi-directional Controlled Thyristors
A glimpse into the CLIQ unit

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D. Carrillo
Individual System Tests

- Warm 7 mH load
- Hi-pot 2 kV
- Thyristors performance
- Power shutdown
- Discharge 100 V to 1000 V
- Visual displays
Conclusions

Δ The CLIQ v2 units are on the starting block to be used in an extensive R&D program at the test facilities at CERN on superconducting magnets also for the HL-LHC program

Δ A further optimization of parameters and the unit is expected in the following months → CLIQ v3
Conclusions

Δ CLIQ v3 is intended to protect the LHC inner triplet magnets following their installation in 2024-25

18 kA
Q1 Q2a Q2b Q3
± 2 kA ± 2 kA
C
C+
+ C+ C+ C
C+
+
DFHX  DFHX  DFHX  DFHX  DFHX  
P1 P4 P2 P3 P1 P4 P2 P3 P1 P4 P2 P3
± 35 A High Impedance
Thank you for your attention
References


