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50 kV Fail-Safe Quench Detection System for Large Superconducting Magnets

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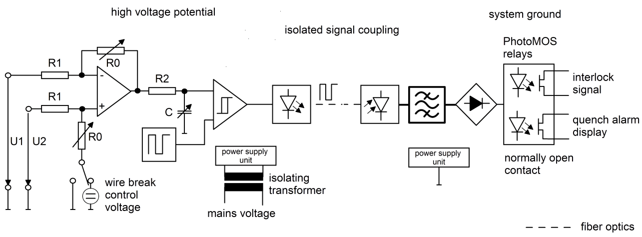
Intro

- Dedicated quench detection (QD) systems are indispensable for superconducting magnets with large stored energy and have to withstand high voltages generated during fast discharge
- Hardware-based QD systems offer inherent safety of detecting QD-internal failures and line breakages
- Software-based QD solutions allow to adjust QD parameters conveniently, but include the risk of major damage to the magnet system in case of undetected failures or false settings.

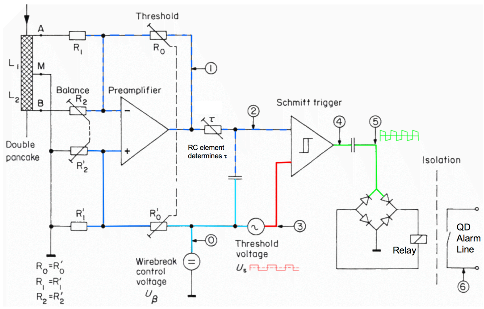
Fail-safe QD system with 50 kV design value

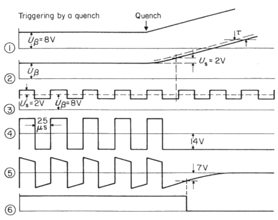
- KIT has advanced the hardware based QD system technology to an fail-safe QD system with 50 kV design value [2].

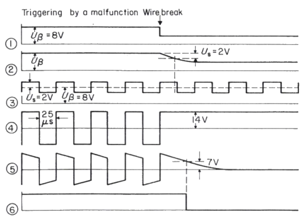


Fail-safe QD system developed for LCT testing

- A fail-safe hardware-based QD system [1] was developed for LCT testing with a nominal voltage of 2.5 kV and serves here as an example



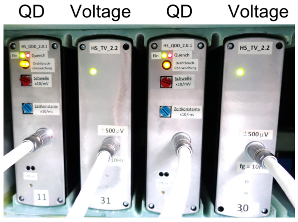




50 kV QD, Voltage and Temperature Modules

- Potential-free QD modules were designed and constructed with design voltage of 50 kV ($U_{op} \leqq 35$ kV)
- In addition, voltage and temperature measurement modules were constructed with a design voltage of 50 kV, too.
- All modules transmit the signals via fiber optics to the low voltage data acquisition. The receiver of the QD signal is equipped with a correspondent fail-safe logic to disconnect the QD line when the square wave signal from the Schmitt trigger is lost which triggers a fast discharge.

QD Voltage QD Voltage



Temp. Temp. Temp.

Discussion and Summary

- A hardware-based QD system is more difficult during commissioning but provides inherent safety.
- Software-based QD systems can offer an easy setup mode to find easily an almost optimized balancing for the QD input. Time constants and QD level settings can be changed by a click. However, this comfort has the drawback of an inherent risk. An operating error, a misuse or a simple hardware error can lead to the loss of the magnet(s).

- **Considering the cost of one or several large superconducting magnet(s), the use of software-based QD only, is risky.**

- **A combination of hardware and software QD would be ideal.**
- Use of a hardware-based QD system with coarse settings that nevertheless ensure magnet safety, is strongly recommended.
- An additional software based QD system can help to find the (almost) ideal initial balancing of the QD system.
- The software-based system with more restrictive settings compared to the hardware QD system, may then be used during operation in a comfortable way.

Pros and Cons of Hardware based QD systems

- Fail-safe hardware
  In the LCT test, two such QD systems were used in an anti-redundancy. Only when **BOTH** QD systems recognized a quench or showed a failure, a coil discharge was triggered!
- No false adjustment by accident (assuming access restrictions and careful manual adjustment by trained personal, only).

- Difficult manual balancing of QD system during commissioning
- Changes have to be done manually for each QD system

References:

[1] G. Nöther et al., "Quench detection system of the EURATOM coil for the Large Coil Task", Cryogenics Vol. 29 (1989) p. 1148

[2] M. Hollik et al., Design of electronic measurement and quench detection equipment for the Current Lead Test facility Karlsruhe (CuLTKa), FED 88 (2013) 1145 - 1448

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