THE CONTROL SYSTEM OF THE CERN PLATFORM FOR THE TEST OF THE HIGH LUMINOSITY LHC SUPERCONDUCTING MAGNETS

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ABSTRACT

A new generation of superconducting magnets is being developed in the framework of the HL-LHC upgrade project. Several laboratories in Europe, USA, Japan and Russia collaborate on this project. One of the tasks assigned to CERN is to conduct the optimization tests and later the series tests for the MQXFS and MQXF-A/B magnets.

A new dedicated test bench has been built at the CERN superconducting magnet test facility (SM18), where these magnets will be evaluated under their operational conditions in the LHC tunnel. To fulfill the test conditions on these high performance magnets, a new high frequency data acquisition system (DAQ) has been designed, associated to a new software used to control two 15 kA power converters.

This article presents all the technical aspects of these two major components of the test platform, from the PXIe hardware selection of the DAQ system to the operational applications deployment. The commissioning phase and results of the first measurement campaign are also reported.

HARDWARE SETUP

The DAQ System

CPU

NI PXIe-8840
2.7 GHz dual core
Intel Core i5 4400E
250 GB HD
2 GB/s controller BW

LF DAQ CARDS (2)

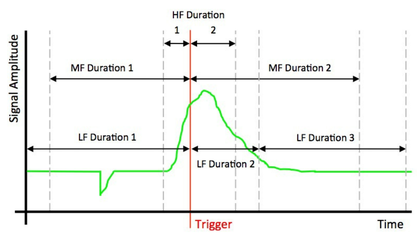
NI PXIe-6365
144 AI SE / 72 AI DIFF.
16-Bit , 1 MS/s
+/- 10 V
1.66 mV Accuracy

HF DAQ CARDS (13)

NI PXIe-6358
16 AI DIFF.
Simultaneous sampling
16-Bit , 1.25 MS/s/ch
+/- 10 V
2.68 mV Accuracy

CHASSIS

NI PXIe-1085
18-Slot
16 Hybrid Slots
1 Timing Slot



The timeline of a magnet recorded event

The DAQ system allows recording of a wide range of analog signals from the superconducting magnet under test.

- Up to 208 differential channels can be read in HF/MF mode (5-200 kHz/1-5 kHz), with a typical duration of 500 ms.
- Up to 144 differential channels can be read in LF mode (0-1 kHz), with a typical duration of 5 s.
- An optional archive mode can log the data points every ten minutes or each second on signal change.

The two 15 kA Power Converters

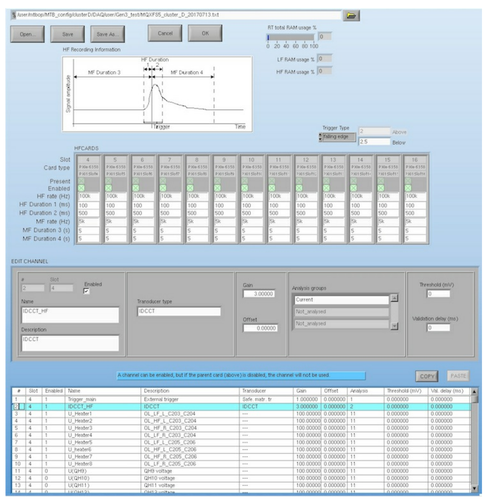
The selected powering topology is to connect two existing 15 kA power converters in parallel, to provide the 30 kA.

The cryostat to test the new MQXF magnets

- Useful length 5000 mm / diameter 800 mm
- Working temperature 1.9 - 4.2 K
- Vertical arrangement

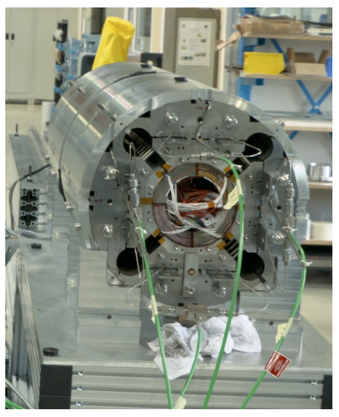
SYSTEM ARCHITECTURE

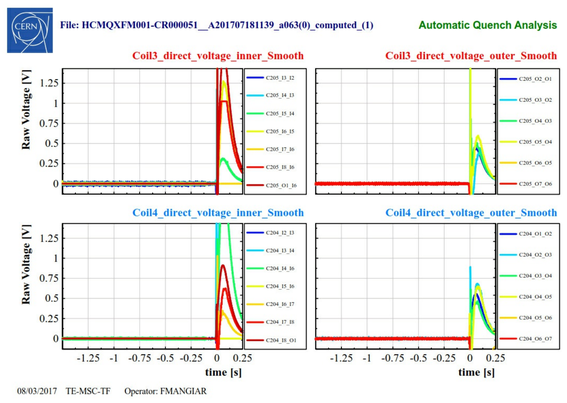
The DAQ application gives access to all the measurement setting functionalities through two HF/MF and LF dedicated panels.
Each of them provides an editor, where the operator can freely define the recording profile. Depending on the PXIe cards available in the chassis, all the related channels can be individually selected.



When the acquisition is started, the signals are stored in circular buffers, according to the selected duration D1 for HF/MF and LF.
Once a quench is detected by the dedicated quench detection system, the recording of the signals is triggered for the duration D2. The data is then stored in a TDMS file locally on the PXIe hard disk.
A FTP daemon transfers the file to a long term storage system, where it is made available for the offline analysis tools.

The magnet signals can be recorded either by an HF or LF card, according to the cabling done from the signals to the PXIe input modules.
Some intermediate signal conditioning cards are used to insure galvanic isolation between the superconducting magnet voltage taps and the acquisition system.

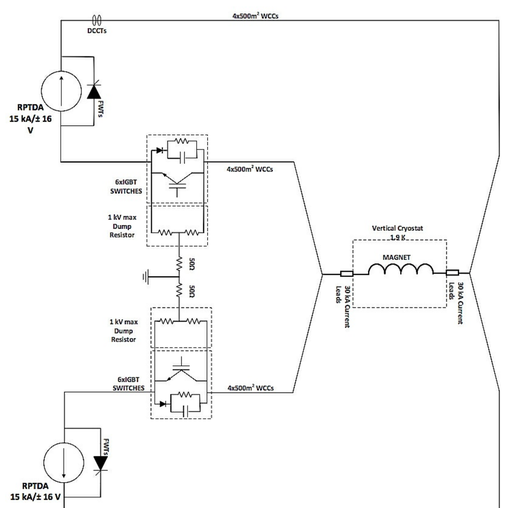




The Automatic Quench Analysis (AQA) tool developed in VBScript, permits to analyse series of magnet tests in an automatic or semi-automatic way.
See the TUMPA08 paper from this conference for more details.

The *POWER* application pilots synchronously the two 15 kA power converters from the control room.
All the status information from the Function Generator Controllers, version 2.00 (FGC2) and from the high power stages are presented to the operator.

The commands from the *POWER* application are sent to a Front-End Computer (FEC) gateway, which broadcast them through a WorldFIP real-time fieldbus, to the FGC2.
These controllers convert the received commands into actions on the high power stage of the converters.



The electric circuit connection topology used for the new test platform to achieve parallel operation for 15 to 30 kA.

CONCLUSIONS

The need for a test bench to evaluate a new generation of superconducting magnets in the framework of the HL-LHC project initiated several R&D activities. We handled those related to the data acquisition system and to the remote control of two 15 kA power converters. After a survey, the PXIe platform has been selected for the DAQ system and a dedicated application has been developed in LabVIEW™.

This graphical programming language has also been used to design new software to pilot synchronously two 15 kA power converters, from the control room of the test area. These three components have been fully assessed during the commissioning phase of the new test bench. They have proven to be well adapted to the actual needs, with several possibility of extension.

A new timing system is actually under development to allow synchronizing the data from the DAQ with other specific measurement benches, which should be added in the future, like magnetic measurements. The *POWER* application will be reused as a base for the development of a future operational tool, designated to remotely control up to nine power converters, within the framework of the CERN GSI-FAIR project.

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