LHC MAGNET TEST BENCHES CONTROLS RENOVATION

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Abstract

The LHC magnet test benches controls were designed in 1996. They were based on VME data acquisition systems, Siemens PLCs control and interlocks systems. After a review of renovation of superconducting laboratories at CERN in 2009, it was decided to replace the VME systems with a PXI based systems and the obsolete Sun/Solaris workstations with Linux PC's. This paper covers the requirements for the new system and shares the experience of the upgrade of the magnet test benches to these new platforms.

OVERVIEW

A review of superconductors and magnet laboratories took place in May 2009 [1]. It concluded that the removal of the facilities of Block4 to SM18 [2] was desirable to save money, to stop the Block4 refrigeration plant and to increase of efficiency by staff regrouping. Another important reason was related to the FRESCA2 magnet for the superconducting cable test, which was not possible to be installed in Block4 due to the lack of space.

Merging the two facilities allowed the creation of an integrated magnet test facility, adding to the existing horizontal test benches a vertical test station for prototype magnets, a test bench for the existing insertion region magnets, as well as a test station for the new generation inner triplet magnets presently under design.

The ageing infrastructure, the computer systems and the instrumentation needed to be modernised and the controls of the different systems of the two magnet test facilities to be homogenised.

This paper describes the Magnet Test Benches (MTB) controls renovation project. The project targets the Power Converter Controls and the Measurement Systems. A common objective is to bring them as close as possible to the systems presently installed in the LHC to make the MTB look like the "ninth" LHC sector (the LHC has 8 sectors) from the control system point of view. This is important for tests such as the tracking measurements. This effort is complemented by the migration from the General Purpose Network (GPN) to the accelerator Technical Network (TN) and the implementation of the Role-Based Access Control (RBAC) to increase cybersecurity.

THE NEW MTB FACILITY

The new MTB facility (Fig. 1) was created in three main steps.

First, the removal of the vertical test station from the Prévessin site to the SM18 site; second, the modification of one horizontal test bench in order to allow testing the spares of the present inner triplets and other magnets that were produced and tested by two US laboratories; finally the modification of one horizontal test bench to allow the testing of the new inner triplet prototype magnets. These three different parts are independent and can be realized at different times.

The removal was also the opportunity to upgrade the vertical test station. It was equipped with 4 cryostats of different dimensions for different purposes: 3 of them were used in the previous facility and a 4th, the biggest, was procured within the High Field Magnet (HFM) project for the FRESCA2 magnet.

These cryostats allow to test the present LHC corrector magnets, diodes for LHC main dipoles and quadrupoles, new inner triplet correctors, new inner triplet quadrupole model, and the HFM prototypes. With some modification of one cryostat, we should be capable to test also the present LHC HTc current leads.

The vertical test station will also allow the test of Fast Cycled Magnets (FCM) and Superconducting Links (Sc link) for the new inner triplet and FP7 (EUCARD) project.

A 20 kA and 25 V power supply from the former facility have been recovered for the new station together with several 600 A and +/- 12 V power supply to assure the powering of the present LHC and future new inner triplet magnets. The existing commutation switch of 20 kA completes the installation.

This new station profits from the cryogenic installations and He gas recuperation system of the test area.

The FCM and the Sc link, not operating at the same time, will use a common cryogenic distribution box, existing in the hall.

A modification of the liquid distribution, gas recuperation and the control system of the cryogenics of the new station has still to be done.

The former protection and detection systems and the data acquisition system of the vertical test stand were obsolete and could not be integrated into the new system. Therefore a new one had to be developed and installed in the same time with the new station.

The horizontal benches to test the LHC main magnets, such as dipoles and corrector magnets, will now share optimally the resources with the vertical benches.

Figure 1: Part of the merged MTB facility.

Power Converter Control Upgrade

Every power converter is controlled by a Function Generator Controller (FGC) that hosts the control software. Normally a set of FGCs is connected to the Control Middleware (CMW) [3] via a gateway PC through a WorldFIP bus.

The upgrade of the FGC gateways was a relatively simple operation. The operating system needed to be switched from LynxOS to SLC5 Linux, and the start-up sequence had be updated to be identical to the one used in the LHC.

Following the upgrade, commands are sent through the CMW and must be accompanied by a valid Role-Based Access Control token [4]. RBAC rules granting access to the power converters have been defined. A new RBAC role and RBAC location has been created and is populated with the names of the new Linux controls consoles.

The majority of the power converters were controlled by old FGC1 hardware. In order for the FGC1s to work in conjunction with the new version of the gateway, a minor upgrade has been made to their software.

The first step to integrate the MTB power converters into the standard LHC architecture was to connect them and their control console to the Technical Network. This meant upgrading the obsolete network, removing the coaxial cables to be replaced with optical fibres and replacing the old star points. At the same time the objective was to improve the actual network (WiFi covered zones, GPN or TN, additional sockets for the office spaces) and to add new network sockets for the relocation of the test components.

This migration from coax GPN to structured TN network of all the devices has been done in a staged way to avoid stops in the MTB operation.

The upgrade of the building gateways was needed for the LHC software architecture (LSA) to directly control the power converters. LSA can directly control the FGC2 interfaces and with minor changes in the name of the properties the FGC1 interfaces. This additional flexibility will probably be needed in the future.

Once done, the existing direct current readout from the FGC1 used by the old measurement applications would not be available anymore and the control applications had to be upgraded.

The FGC2 interface is requested in order to have the "post mortem" data with the detailed executed current cycle or to investigate eventual problems offline in detail. Both systems (gateway and FGC) are synchronised with the Universal Time (UTC) as foreseen for all the accelerator systems at CERN, with a precision of 1 ms, that is considered necessary and sufficient.

Last but not least, it is worth to have the last electronic version (i.e. FGC2 interface) to control all converters for maintenance reasons and for the ongoing magnet control developments.

Measurement Systems Upgrade

The first step of the upgrade was to replace the existing VME based Data Acquisition (DAQ) system with a new one based on PXI hardware and LabVIEW RT.

Previously each cluster was equipped with an INCAA DAQ system for magnet power tests. These systems were getting old and the SUN Solaris operating system, on which the control consoles were based, has been phased out. Moreover LabVIEW was no longer updated on this operating system. The data acquisition systems used previously had to be renewed as the installations were 20 years old and were not reliable and adapted for the test of the new inner triplet magnets.

Therefore the installations had to be changed, adapted to those used at CERN presently.

A new architecture has been defined in our group (Fig. 2) and a prototype based on PXI has been built with the goal to test it on present LHC magnets and to qualify the solution to be applied on each horizontal bench and the vertical test station.
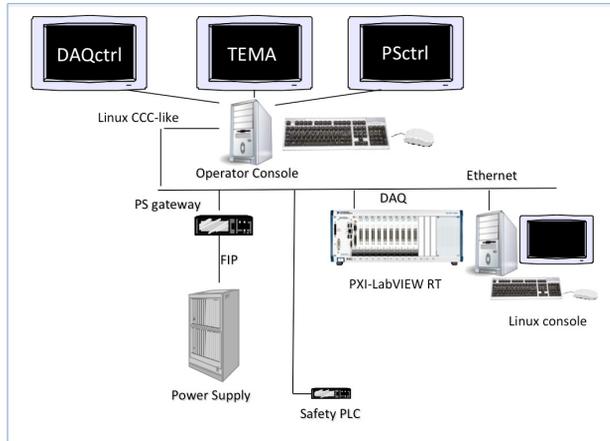

Figure 2: The control architecture.

The second step was to port the actual Test Master, the application that drives the sequence of tests, and Hardware Recognition, the application that allows to configure the electronics, on Linux with the addition of a DAQ control application.

The next step was to port the actual Power application on Linux to access all the Power Converters via the LHC Control Middleware using RADE [5] from the control room. The new control room has become similar to the CERN Control Room.

On the three screen consoles; the middle one shows the Test Master window, which is equivalent to the sequencer for the LHC Hardware Commissioning, and on the left and right screens there are the DAQ and the Power Converter control applications.

CONCLUSIONS

The review of superconductors and magnet laboratories concluded the removal of the facilities of Block4 to SM18 site. Merging the two facilities allowed the creation of an integrated magnet test facility, adding to the existing horizontal test benches a vertical tests station for prototype magnets.

Thanks to the merging we started a renovation program to replace the obsolete VME DAQ and Solaris consoles with modern PXI RT and Linux consoles. In addition the update of the FGCs has made the MTB look like the "ninth" LHC sector from the control system point of view.

The renovation of the control architecture started end of 2009 and involved 3 FTE up to now. The upgrade went in parallel with the standard magnet test benches operations to keep the compatibility between the new and the old systems as they needed to run in parallel.

The upgrade has now been completed and all the test benches are now commissioned.

Further improvements are ongoing until the end of this year.

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