LHC POWERING CIRCUIT OVERVIEW: A MIXED INDUSTRIAL AND CLASSIC ACCELERATOR CONTROL APPLICATION

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Abstract

Three systems are involved in the powering of the LHC magnets: the QPS (Quench Protection Systems), the PIC (Powering Interlock Controllers) and the Power Converters. They have been developed and managed by different teams. The requirements were different; in particular, each system has its own controls and expert software. The first experience from LHC hardware commissioning has shown that a single access point to all related powering equipment should make the tests easier. Therefore, a new application has been designed to centralise the circuit information from three pieces of expert application. It shows summary information, through homogenous graphical interfaces, from various sources: PLCs (Programmable Logic Controllers), WorldFip agents via FESA (Front-End Software Architecture) and via gateways Front-Ends. During LHC operation, it will provide powering circuit overview. This document describes the Circuit Overview application based on an industrial SCADA (Supervisory Control And Data Acquisition) system named PVSS II® with the UNICOS (Unified Industrial Control System) framework. It also explains its integration into the LHC accelerator control infrastructure.

INTRODUCTION

The LHC superconducting magnets are powered separately in each of the eight symmetric sectors and are grouped into 28 powering sub sectors. The circuits are powered and protected by means of three control systems: the Powering Interlock System assures the protection of superconducting magnets in the LHC by interfacing with the Quench Protection System and the Power Converters. The first tests during LHC commissioning have shown the need of common graphical interfaces to monitor the data. The PVSS II® industrial SCADA system with the UNICOS framework has been chosen for this application in order to reuse the development already done for the PIC and QPS monitoring tools. This paper explains three different equipments and applications involved in the powering and illustrate how the Circuit supervision has been developed on top of them.

SCADA SYSTEM

A SCADA system is used to perform data collection and control at the supervisory level. PVSS II® from ETM [1] has been selected as common SCADA at CERN in 2003 because it provides features necessary for the CERN versatile needs.

Some features are relevant:

- It is device oriented.
- The tool can be easily customized and extended directly in C/C++.
- Both Windows and Linux platforms are supported.
- Several PVSS II® projects can be linked together via a distributed method.
- This is a multi-process system with a Real Time Database.

The UNICOS Framework

The UNICOS framework [2] was developed to produce control applications for three-layer industrial control systems. The framework proposes a common method to design and develop the control applications [3]. It is an open framework where new devices and components can easily be added. The UNICOS applications can be deployed on Schneider and Siemens front-ends. It also allows interfacing to FESA front-ends. The SCADA framework contains user interface components libraries (widgets and faceplates for each device type) and general-purpose facilities to be used in the Accelerator Control environment (central Logging, Alarms and CERN Controls MiddleWare CMW). The PVSS II® UNICOS framework integrates several integrity checks and manages the views according to the system/device status. The colour and letter conventions are used to display the value with its quality (e.g.: connection error with a front-end, invalid data, etc).

CIRCUIT CONTROL SYSTEMS

There are three control systems involved in the powering and protection of the magnet circuit: QPS, PIC and Power Converters.

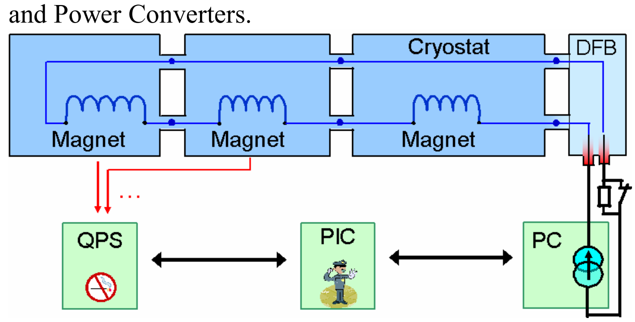

Figure 1: Powering and protection of the magnet circuit

QPS

The Quench Protection System guarantees the integrity of the superconducting elements; in case of a quench, switch opening, failure, etc. Acquisition modules and controllers read signals which are transmitted to the supervision via LynxOS® front-end (developed on FESA framework) with a publish/subscribe mechanism on the middleware (CMW). The role of the supervision is to monitor, trace all the QPS signals and interface them to the commissioning and QPS expert tools and to allow the operators and experts access to the related equipment. The supervision was developed with the UNICOS PVSS II® framework.

PIC

The powering interlock system is composed of a set of Powering Interlock Controllers checking good powering conditions for each electrical circuit. Each controller is based on an industrial PLC with remote I/O units connected via Profibus. It is connected by hardwired cables to the QPS and Power Converters of the corresponding powering subsector in charge. The supervision developed with UNICOS PVSS II® framework retrieves the information from the 36 PLCs. The main function is to monitor and manage the powering permissions.

Power Converters

The control system for the LHC Power Converters uses a dedicated controller embedded in each Power Converter. The FGC (Function Generator/Controller) is responsible for Power Converter state monitoring and control. The FGC gateway front-end manages FGC's attached to WorldFIP real-time field buses. The software in the gateway supports client applications via CMW middleware. The hardware and software controls systems are managed by the AB/PO/CC section.

LHC POWERING CIRCUIT OVERVIEW

Requirements

The specifications for the application are:

- Summarise information from QPS, PIC and Power Converters for each powering sub sector and circuit.
- Provide one single access point and common interfaces to show the circuit exchange data.
- Monitor some data from the Power Converters.
- Mix trends from independent sources.

Architecture

QPS and PIC monitoring systems have been developed on top of the UNICOS PVSS II® framework (Fig. 2).

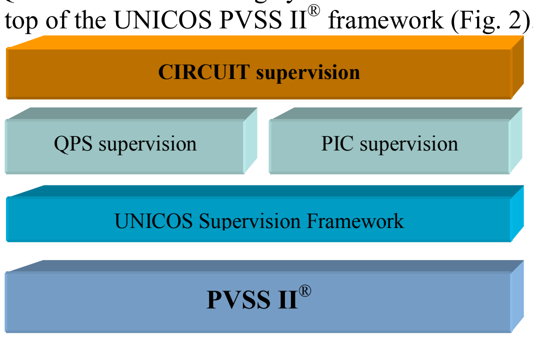

Figure 2: Framework architecture.

Although the supervisions are based on the same framework, they have been developed and managed separately. The technical solutions for the front-ends are quite different and the requirements specific for each application. The common entity between the Quench Protection System, the Powering Interlock System and the Power Converters is the Electrical Circuit. A Power Converter device was developed to get the relevant data from the Power Converter front-ends. The UNICOS PVSS II® framework provides a CMW Middleware client interface to get the Power Converters data into the Circuit supervision server (Fig. 3). The distributed functionality of PVSS II® is used to access the data from the QPS and PIC systems without development and deployment.

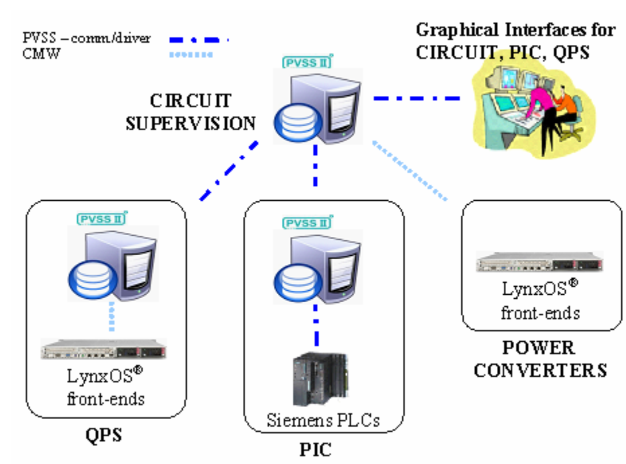

Figure 3: Circuit supervision architecture.

Each system has its own data representation via the device models. The circuit application unifies all the circuit device data from the circuit point of view.

Configuration Data from the Layout DB

The Circuit supervision system needs to monitor more than 1700 powers converters. Each PIC controller manages several electrical circuits and exchanges information with the QPS and Power Converters systems. This configuration is complex but important for the Circuit supervision. The electrical circuit is set accurately in each device definition. To avoid configuration mistakes and speed up the deployment, the device/circuit information is extracted from a common reference database: the LHC Layout Database [4].

Functionality

The device/circuit functionality allows:

- Switch from expert to circuit visualisation mode.
- Display data from a complete circuit overview to every single device.
- Access details views from the Circuit supervision as if the user was directly on the corresponding supervision.

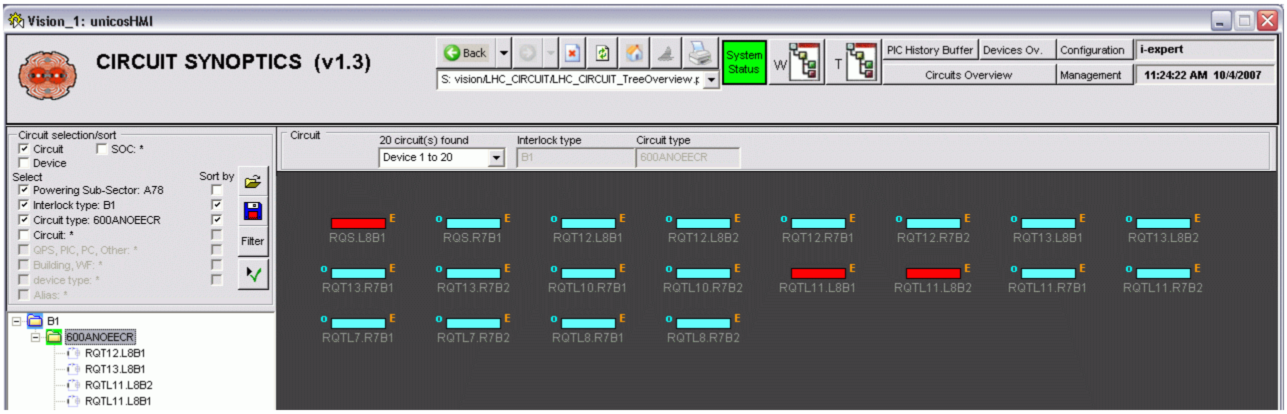

Figure 4: Circuit Overview.

Figure 4 is an example of a circuit view. Each symbol represents a summary status for a circuit. The quality of the information is also displayed via additional letters and colours. The exchanged data between the QPS, PIC and Power Converters systems are monitored through a circuit synoptic view (Fig. 5).

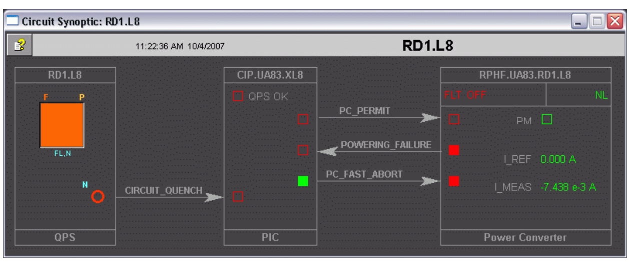

Figure 5: Circuit synoptic view.

The device definition can be accessed directly from the circuit synoptic view (Fig. 6).

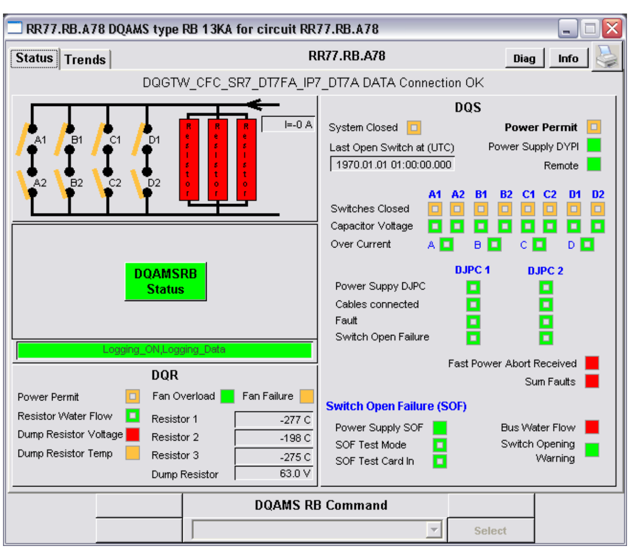

Figure 6: One of the QPS monitoring expert view.

All the views used for operation and diagnostic are created dynamically by the application, according to the circuits specifications and device definition.

CONCLUSION

A primary version of the circuit supervision system has been tested during the first Hardware Commissioning of the LHC sector 7-8. The hardware commissioning operators and system experts used the application extensively successfully. The Circuit supervision was acquiring data from three systems and presenting them to users through a common interface with summaries and detailed information.

From this experience, the hardware commissioning team requested the integration of data of other systems like the Cryogenic systems. To complete the Circuit supervision, the relevant Cryogenic data for powering of the electrical circuits will be displayed in the circuit synoptic. By this way, the temperatures for the current leads, pressures, levels and position of the valves for the electrical DFB (Distribution Feed Boxes) will be present in the same view as powering information. The supervisions for the Cryogenic systems have also been implemented using PVSS II® and the UNICOS framework [5]. Therefore, the integration will be straight forward as it was done for the PIC and QPS. The challenge will be to manage data coming from more than 30 different PVSS servers.

REFERENCES

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