SUPERVISION APPLICATION FOR THE NEW POWER SUPPLY OF THE CERN PS (POPS)

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Abstract

The power supply system for the magnets of the CERN PS has been recently upgraded to a new system called POPS (POwer for PS). The old mechanical machine has been replaced by a system based on capacitors. The equipment as well as the low level controls have been provided by an external company (CONVERTEAM). The supervision application has been developed at CERN reusing the technologies and tools used for the LHC Accelerator and Experiments (UNICOS and JCOP frameworks, SIMATIC WinCC Open Architecture SCADA tool). The paper describes the full architecture of the control application, and the challenges faced for the integration with an outsourced system. The benefits of reusing the CERN industrial control frameworks and the required adaptations will be discussed. Finally, the initial operational experience will be presented.

THE NEW POWER SUPPLY OF THE CERN PS

The Proton-Synchrotron (PS) accelerator at CERN is supplied by a new power system (see Fig. 1). This new power system called POPS (Power for PS) [1] replaces the existing power system (including a 90MVA rotating machine), which feeds the main magnets of the PS accelerator. The PS magnets require a maximum DC current of 6kA with a maximum DC voltage of ±10kV. The new power system is based on three-level converters with capacitive energy storages and is rated at 60MW peak power. POPS will supply the PS magnet without drawing all the power from the network. The maximum stored energy in the magnets is 14MJ. The capacitor banks supply this energy. DC/DC converters control this exchange of energy between the capacitor banks and the load. The system is connected to the electrical network by two AC/DC converters (Active Front End). These converters charge the capacitor banks and supply the losses of the load and of the converters.

The POPS control is made up of two different structures that interact to provide the required performances; these are the Function Generator/Controller (FGC) and the CONVERTEAM [2] (CVT) control system. The FGC generates the reference voltage (V_{ref}) for the POPS output voltage and the CVT control system is in charge of producing and maintaining it. The CVT control software has been developed in a proprietary environment called P80i. Once the V_{ref} is set by the FGC the CVT control has to divide it into as many components as the number of DC/DC converters connected in series. This operation called “Voltage Dispatching” is done by assigning coefficients proportional to the amount of energy stored in the capacitors (based on the maximum and minimum voltage for the capacitors that is different depending on whether the capacitor is of floating or charger type). As a general indication the voltage dispatching is done by allowing the floating capacitors to take only part of the inductive contribution to the V_{ref}, leaving all the rest to the chargers.

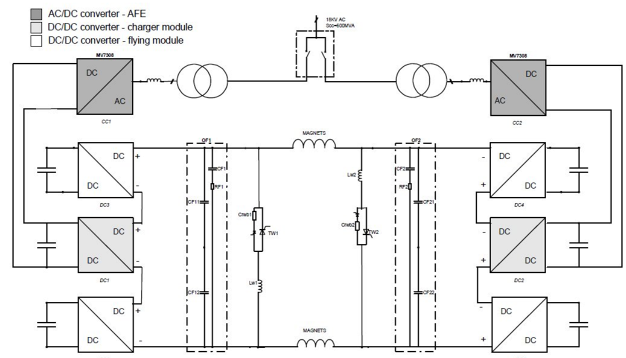

Figure 1: Topology of the power system.

CONTROL ARCHITECTURE

The POPS control system architecture (see Fig. 2) is a three layer control system composed of:

- Field layer with remote input/output module connected to the control layer. This layer is composed of WAGO modules interfaced with the control layer via the PROFIBUS fieldbus.
- Control layer with CONVERTEAM hardware and software based on VME cards, holding the closed control loops and the voltage and capacitors control. The CONVERTEAM control system is distributed over four CPUs and remote IO modules. Each CPU is monitoring the link with the Supervision layer; the interruption of the communication stops the powering of the system.
- Supervision layer. In this layer, process views are provided for the monitoring and the control/command interface of the control system. Other typical functions (e.g. archiving, trending, alarm handling) are also provided by this layer.

The application is usually supplied as a complete turnkey system by CONVERTEAM. However in the context of CERN, tools for the Supervision layer already exist, allowing a smooth integration into the CERN control complex. The Field and Control layer were provided by the company manufacturing the power system. The Supervision layer was developed at CERN. Furthermore, with the usage of CERN tools the interface to the FGCs and the integration of data from the cooling and ventilation subsystem via DIP (Data Interchange

Protocol) [4] was very straightforward. This information is made available in the POPS process view and it is very useful for the operation.

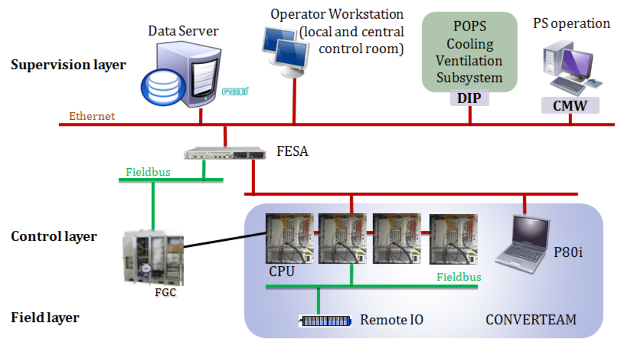

Figure 2: POPS control hardware architecture.

PUTTING IT ALL TOGETHER

Interfaces

Two solutions were used for the interface to the CONVERTEAM control layer: OPC (OLE for Process Control) [3] and a proprietary protocol based on TCP/IP. The first deployment of the supervision application was done with the OPC interface. Later a dedicated front-end program based on the FESA framework [5] was developed to interface with the proprietary protocol.

All the devices defined in the control layer are listed in an Excel spread sheet, which is used by CONVERTEAM to configure their system with the P80i programming console. A dedicated tool (see Fig 3) was developed to extract from this Excel spread sheet all the information for the supervision layer: list of devices, definition, configuration, etc.

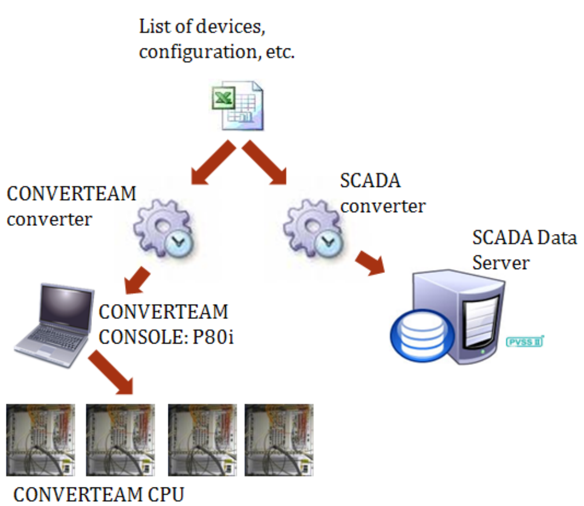

Figure 3: System configuration workflow.

SCADA Framework

The supervision layer of POPS was based on the UNICOS framework [6] developed at CERN. This framework is used to develop control applications. It provides the developers with the means to rapidly develop full control or monitoring applications and provides the operators with ways to interact with all the items of the process from the most simple (e.g. I/O channels) to the high level composite devices. In addition, UNICOS offers tools to diagnose problems in the process, the control system and to access and operate the devices without specific development. It is based on SIMATIC WinCC Open Architecture ® [7] (WinCC OA previously released under the name of PVSS) and it offers at the supervision level, in both Linux and Windows operating systems, functionalities such as: interface to include additional packages, device and file access control, interface to the LHC software suite, a homogenous user interface entirely customizable with features such as navigation capabilities between panels and trends (WWW browser like, contextual buttons, pop-up navigation), access to the devices without creating a specific view (Tree Device Overview), process alarm and event list. A device includes some libraries of code, a set of widgets (summarized view of the device status), a faceplate (detailed view of the device) and the device actions interface. A tool is provided to import the device configuration into the supervision layer. A developer of a UNICOS supervision application does not need any deep WinCC OA knowledge (e.g. scripting). He just needs to import the instances of the process devices; to create the application specific process views using the provided catalogue of devices and to configure the required trends.

Development

The use of the UNICOS framework allowed us to develop the supervision in two phases:

- Phase I: with low-level dedicated devices interfaced via OPC to the control layer. During this phase the equipment and the feedback control loops were validated.
- Phase II: using the FESA interface instead of OPC. High level device widgets encapsulating the low-level devices were added to the Phase I devices. These widgets were developed using the UNICOS widget interface in which a widget can be attached to a hardware device or to a generic device. These widgets were used directly by the operators and the control experts to create the process views.

Both the low-level and high-level device widgets present the device data and the communication link state to the CONVERTEAM CPU. Dedicated 32 bit devices for alarm, interlock and default status were created. Analog input and 32 bit status devices were re-used from other packages without any new development.

INITIAL OPERATIONAL EXPERIENCE

The supervision layer was successfully used during the commissioning and the operation of POPS. Thanks to the UNICOS flexible configuration, the graphical interface (see Fig 4) was customized and divided in three main areas:

- A header: showing the global state of the control system: communication alarm link, shortcut for fast access to the views, user login.
- A status area: presenting the most important state information of the equipment.
- A bottom area: for the most important commands, these commands are protected depending on which user is logged in.
- A central area: where the detailed views for the operators are displayed. About 35 different views were developed for the operation and diagnostic: detail view on the AC/DC, DC/DC, output connections, cooling, interlocks, etc. An expert having no deep knowledge of WinCC OA made the views with the high level widgets.

During the commissioning, each input/output was tested in order to check the complete control chain, from the sensor up to the supervision with the Tree Device Overview, a UNICOS built in feature. Later on, the POPS complete graphical interface was released and commissioned. The event list, another built in utility, was also used to understand the sequence of faults in case of the powering failure of POPS. This event list is based on a sequential list of 32 bit state words. The individual bits for the statuses, the alarms and default states are extracted and ordered by time. As the timestamp of these events comes from the control layer, one can diagnose the exact sequence of faults.

The navigation features provided by the UNICOS framework were also very useful to go directly from one view to another one without having to search within the list of all the views.

Multiple instance of the POPS supervision graphical interface can be started from many places, for instance from local control room, during commissioning or development time, from central control room for the daily operation. This interface in the central control room is very useful for the operators to make a first diagnostic before calling the experts.

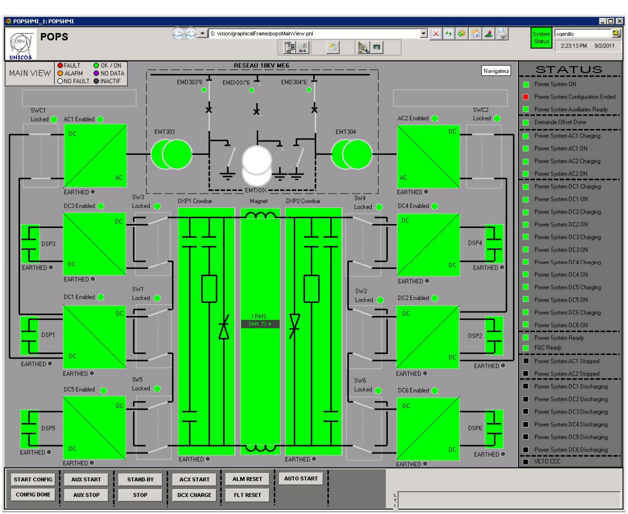

Figure 4: POPS graphical interface.

Later a dedicated interface to the PS operation tool was provided by using the server middleware interface [8] of the LHC Software suite built in UNICOS. This interface publishes the states of devices and a set of commands to act directly on the control layer: stop, start, etc. New states and commands can be easily added by reconfiguring this interface without any development.

CONCLUSION

The control systems of the LHC and the experiments have been running successfully for the last years. This success goes beyond the original scope, the same tools which had been used for their development were used to build new applications like POPS.

The reuse has only been possible because at an early stage of the different LHC projects it was decided to base the developments for industrial controls in a common generic frameworks and components. This choice implied a certain overhead which today is paying off when facing new projects.

The controls for POPS have been developed in a short time frame and with a small team. In addition, it has seamlessly integrated in the CERN controls infrastructure. Any future maintenance and upgrades will also be simplified.

REFERENCES

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