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# THE INTEGRATED HV, LV AND LIQUID RADIATOR CONTROL SYSTEM FOR THE HMPID IN THE ALICE EXPERIMENT AT LHC

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## Abstract

The complexity and the underground location of the new generation experiments (ALICE, ATLAS, CMS and LHCb) at the CERN Large Hadron Collider (LHC) requires a reliable and user friendly control system to operate such large detectors remotely. Control system experts at CERN are deeply involved in developing the JCOP (Joint Controls Project) 'Framework'<sup>1</sup>, a software running in the PVSSII SCADA<sup>1</sup> (Supervisory Control And Data Acquisition) system, that will provide a homogeneous and ready to use tool for the control system developers of the LHC experiments. The High Momentum Particle Identification Detector (HMPID) [1], one of the ALICE<sup>2</sup> sub-detectors, is being equipped with a Detector Control System (DCS) developed within the JCOP Framework. In this paper the basic features and the first results of the DCS prototype are presented.

## 1 INTRODUCTION

The HMPID is a proximity focusing Ring Imaging Cherenkov (RICH) detector. It consists of a  $C_6F_{14}$  liquid radiator and a multiwire proportional chamber (MWPC) with a pad segmented photo-cathode coated with a thin CsI layer acting as photon converter. The MWPC is continuously flushed with  $CH_4$  at NTP, while a CAEN SY1527 crate with the A1821P board, provides 2.1 KV to the anode wires. Seven modules ( $1.5 \times 1.5$  m<sup>2</sup> each) arranged in a cross-like geometry constitute the final detector.

In order to design and implement the HMPID DCS it has been subdivided in five subsystems: High Voltage (HV), Low Voltage (LV),  $C_6F_{14}$  Liquid Circulation System (LCS), physical parameters (e.g. pressures and temperatures) and  $CH_4$  gas system. To ensure a safe and easy integration of the control of each subsystem in the HMPID DCS, and later in the ALICE DCS, each individual process is represented as a finite state machine from whom a control program can be deduced. Ref. [2] reports on preliminary studies on GRAFCET<sup>2</sup> (GRAphe Fonctionel de Command Etape/Transition), a graphical language that has been adopted to represent each subsystem, as well as the entire HMPID, as a finite state machine and to deduce

the relevant control programs. The key features of GRAFCET are the capability to deal with synchronised parallel processes (Master-Slave configuration) and concurrent sub-processes in a main process. Its application, tested on the LCS [2], was successful although its conversion to the control program (instruction list) for a Siemens PLC, has been done via a dedicated algorithm<sup>2</sup>. The first HMPID DCS prototype operates on the HV, LV and LCS subsystems. The remaining devices will be integrated in the next version. As for the LCS, GRAFCET has been adopted for the design and implementation of the LV control system since the control device of the LV power units are also based on the Siemens PLC. The bubble chart, the more detailed GRAFCET diagram and the preliminary results on the sensitivity of the LV control program are reported in Ref. [3].

Due to the simplicity of the HV process (many controls on voltage, current, board temperature, etc, are already implemented at the level of the crate and board), its representation has been accomplished just through a bubble chart diagram from where the relevant control program has been written in the PVSSII environment.

## 2 THE INTEGRATED HMPID CONTROL SYSTEM

The DCS prototype is intended to allow the HMPID operator to run and monitor the detector.

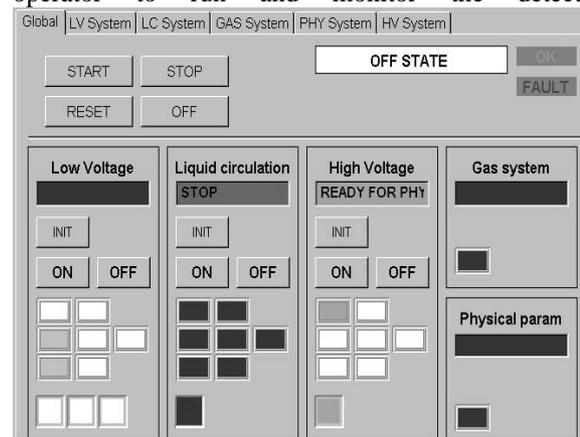


Figure 1: Main panel of the HMPID DCS  
Figure 1 shows the Graphic User Interface (GUI) which integrates the HV, LV and LCS sub-systems.

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<sup>1</sup> <http://itcowww.cern.ch/jcop/welcome.html>

<sup>2</sup> <http://richp2.ba.infn.it>

This task has been accomplished by exploiting the JCOP Framework which acts as an interface between the PVSSII data points structure and the user application. It provides the user with an environment where logical and physical devices can be defined as well as their connectivity to provide data to the control program and/or directly to the GUI.

The HMPID can be operated respectively through the Start, Stop, Off and Reset action buttons, located on the panel upper-left zone. The lower part of the GUI is used for monitoring via code colors per detector module and per device. For test or debugging purposes each HMPID sub-system can also be operated independently once the main control has been released by activating the OFF button. If a fault status is shown on one module, then clicking on it, a table containing the related list of set and monitored parameters is presented.

If a detailed sub-system monitoring is required, in the top-edge of the GUI there are five tabs. By selecting each of them, the related panel appears.

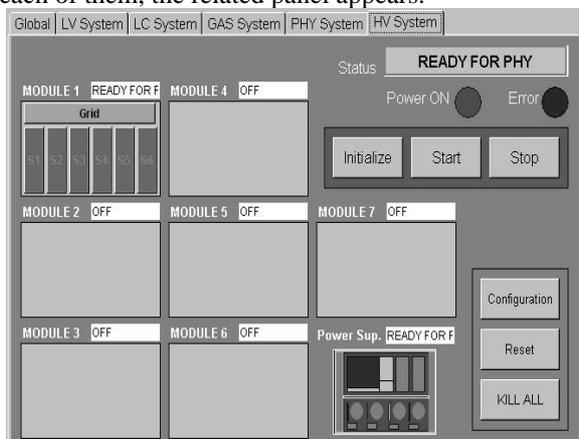


Figure 2: HV Control System panel

Figure 2 shows the HV panel representing all the seven HMPID modules. To deal with some possible HV failure conditions, the MWPC of each module has been split in seven (S1-6, Grid) segments. Each segment is individually powered by a dedicated A1821P board channel. From the panel, clicking on one module's segment, the monitoring and archiving of the voltage and the current values can be inspected (see fig. 5).

In order to modify the detector HV-configuration, by means of the relevant button (bottom-right of the panel), a configuration file, can be uploaded in the PVSS environment. This file contains the HV segments to be switched ON/OFF and related values can be set, e.g. current-limits, voltages, V ramp up V ramp down.

Once the HV configuration has been accomplished, the action buttons Initialize, Start and Stop, operates the HV subsystem. These actions represent a subset of those reported in the bubble chart in the figure 3. A

software engine written in the PVSSII language ( a script language similar to the interpreted C) makes the system looping through the states, provided the transition conditions are fulfilled. The transitions marked with a "\*", are crossed automatically as soon as the actions in the previous state are accomplished.

The bottom-right part of the panel shows the CAEN SY 1527 monitoring icon. Clicking on it, the related panel with all the crate relevant parameters and the housed boards (HV hardware configuration), is presented to the user.

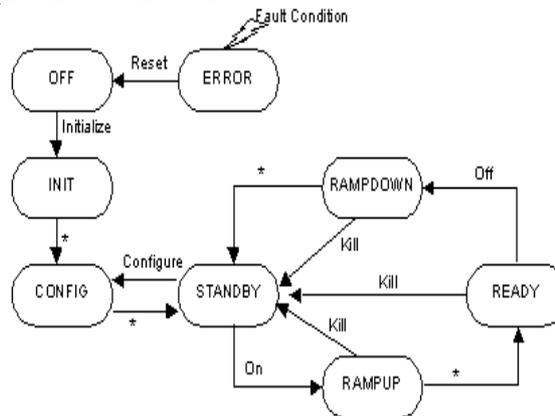


Figure 3: The bubble chart of the HV system.

The data exchange between the HV device and the control program is based on the CAEN OPC (OLE (Object Linked and Embedded) for Process Control) server and the PVSSII OPC client.

Figure 4 shows the GUI diagram of the LCS.

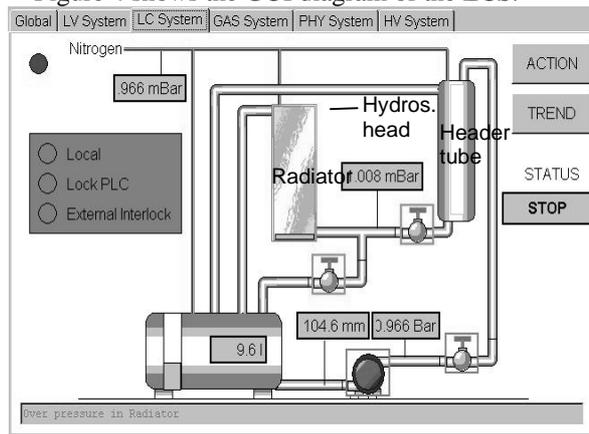


Figure 4: Schematic of the liquid circulation system

It is intended for expert users for detailed monitoring and operation purposes.

From a main tank the  $C_6F_{14}$  is pumped via a filter (not shown in the figure) into the header tube where the liquid reaches a maximum level slightly higher than the upper profile of the radiator (hydrostatic head). This allows the radiator to be filled by gravity flow and the liquid to be purified by means of

molecular sieve filters while circulating. Clicking on the action button, a panel with an active bubble chart appears and allows the user to operate the system. All the actions are linked to the control program which has been deduced from the GRAFCET diagram and downloaded into the control device, the Siemens PLC S300 series. It consists of CPU, ADC, relays and Digital I/O modules. The program also allows the user to select the LCS manual operation mode, where all the actions are under the direct control of the user. Activating the trend button on the LCS panel, the parameter measurements and data archiving are started (see fig. 6). The data exchange between the control program in the PLC and the GUI in the PVSSII environment, is ensured via the Siemens OPC server and the PVSSII OPC client.

Selecting the LV tab, an operating and monitoring panel similar to the HV, appears. For details on the LV process control refer to Ref. [3].

### 3 MEASUREMENTS AND FIRST RESULTS WITH THE DCS

Although the HMPID DCS prototype allows the simultaneous control of the HV, LCS and LV subsystem, the LCS and LV systems have been separately tested in the DCS laboratory, and the HV device during a test beam. In figure 5 is reported the monitoring on voltage (red curve) and current (blue curve) drained by the HMPID PROTO-3 during test beam at the T10 PS facility at CERN.

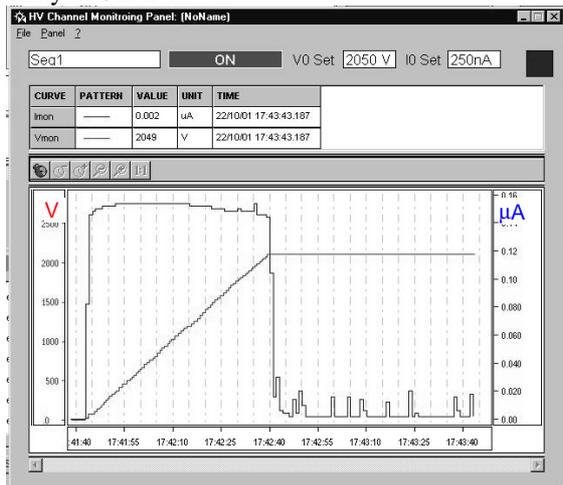


Figure 5. The HV ramp up (red curve) and current monitoring (blue curve) on the HMPID during the T10 test beam at the CERN.

The sensitivity and effectiveness of the CAEN 1527 HV crate and the A1821P (12 ch 3KV, 2 nA current resolution) board, have been verified and found to comply with experiment specifications. Although not yet optimized the DCS version clearly shows the

current peaks in the detector in coincidence with the beam spills.

In figure 6 a complete cycle for the radiator filling and purging is reported. The red curve represents the  $C_6F_{14}$  level in the main tank calculated with the pressure measured at the tank output (Rosemount sensor Mod 1151DP3E22), while the blue curve represents the pressure measured at the input of the radiator.

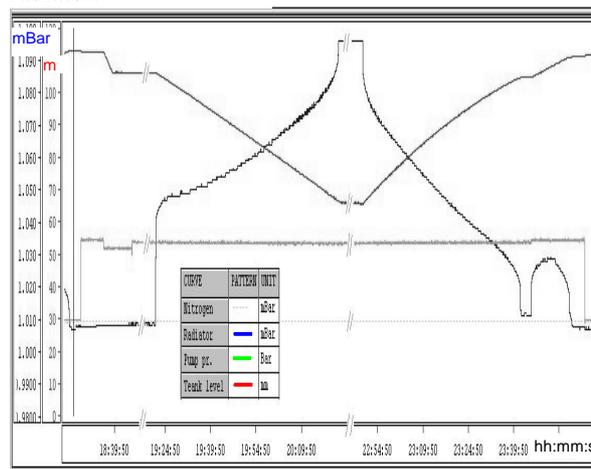


Figure 6: Radiator filling-purging cycle.

The bump at the end of the blue curve is due to the separate purging of the header-tube. Both pressure-sensors are read via a Siemens SM321 8ch 12bit ADC module ensuring a relative sensitivity  $\Delta P/P = 3 \cdot 10^{-4}$  on the relevant full scale values.

### 4 CONCLUSIONS

The first integration of the HMPID DCS in the JCOP Framework, running in the PVSSII SCADA system, has been accomplished. By means of a preliminary main panel the detector has been operated and monitored. The data collection via the CAEN and Siemens OPC server has proven to be effective and the device sensitivity adequate.

### REFERENCES

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