Design and Construction of the Slow Control System for the CLAS12 Ring Imaging Cherenkov Counter

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Abstract

One of the major goals in the upgrade to the CLAS12 spectrometer in Hall B of Jefferson Lab is to enhance the particle identification capabilities over the whole momentum range by integrating an aerogel Ring Imaging Cherenkov Counter (RICH). A RICH functions by detecting a ring of radiated photons that is emitted by particles moving faster than the speed of light in the radiator. In the RICH design for CLAS12, 391 multi-anode photomultipliers (MAPMTs) serve as the photon detectors and require a slow control system to ensure safe operation and achieve complete data acquisition for each of the 25,024 channels. The slow control behind the RICH detector must communicate with the hardware by changing the high voltage going to the MAPMTs along with the low voltage going to the front-end electronics and by monitoring the temperature of the front-end electronics and parameters of the RICH gas system. Graphical user interfaces (GUIs) were created for the high voltage, low voltage, temperature, N2 purge, and cooling systems—all of which mirrored the actual geometrical layout of the RICH detector. With a simulated input/output controller (IOC), these GUI screens were tested.

I. Introduction

As a charged particle travels through the aerogel at velocities greater than the speed of light in the radiator, Cherenkov photons are emitted with an angle dependent on the particle velocity. Due to the immense cost of engineering a large PMT array, both spherical and flat mirrors will be used to redirect the radiated photons onto a smaller trapezoidal array consisting of 391 64-channel MAPMTS. The MAPMTS are arranged into two or three panel groups, reducing the number of communication channels to 138.

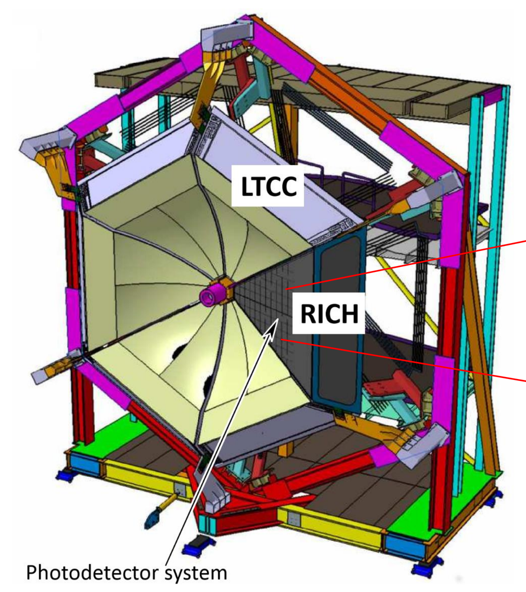


Figure 1: Design of the RICH counter inside the CLAS12 detector [1].

Figure 2: Images of how the MAPMTS will be arranged into 2 or 3-member groups [1].

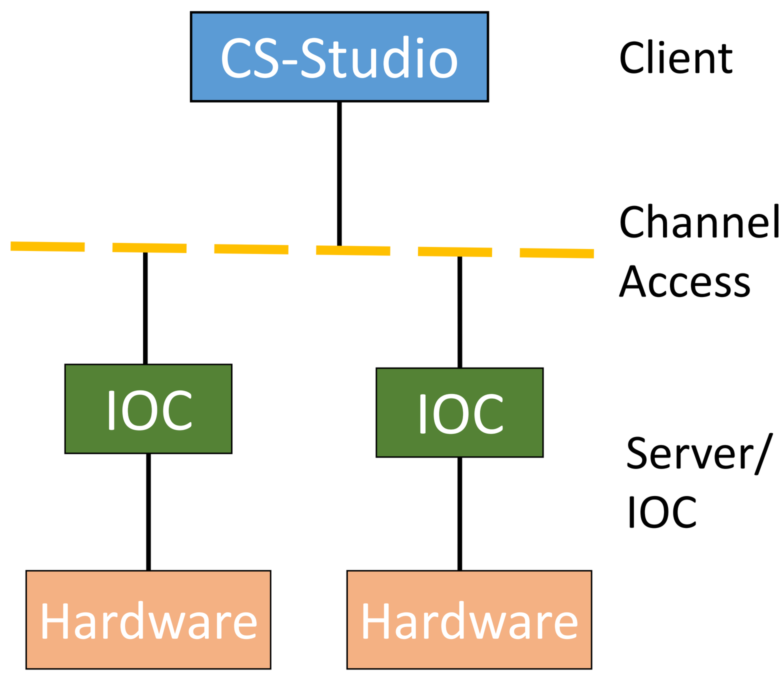
II. Methods

Figure 3: CS-Studio software where the GUIs were designed and constructed.

1. The GUIs were designed in Control System Studio (CS-Studio) in accordance with their geometrical layout. For the high voltage and temperature screens, python scripts were used to generate the trapezoidal array.
2. A naming system for the process variables (PVs) was established.
3. If necessary, a script was attached to the objects that changed the background color based on the value of the PV.
4. An alarm system was developed.
5. An input/output controller was simulated to test the GUI screens.

III. Data Communication Layer

Data communication is done through Experimental Physics and Industrial Control System (EPICS) software. EPICS operates based on a server/client framework. Loaded on the input/output controllers (IOCs) are databases containing records with certain process variables (PVs) pertaining to the state of the hardware. These PVs can be monitored or changed on the client side through the CS-Studio GUIs and EPICS channel access protocol [2].



IV. Results

High Voltage

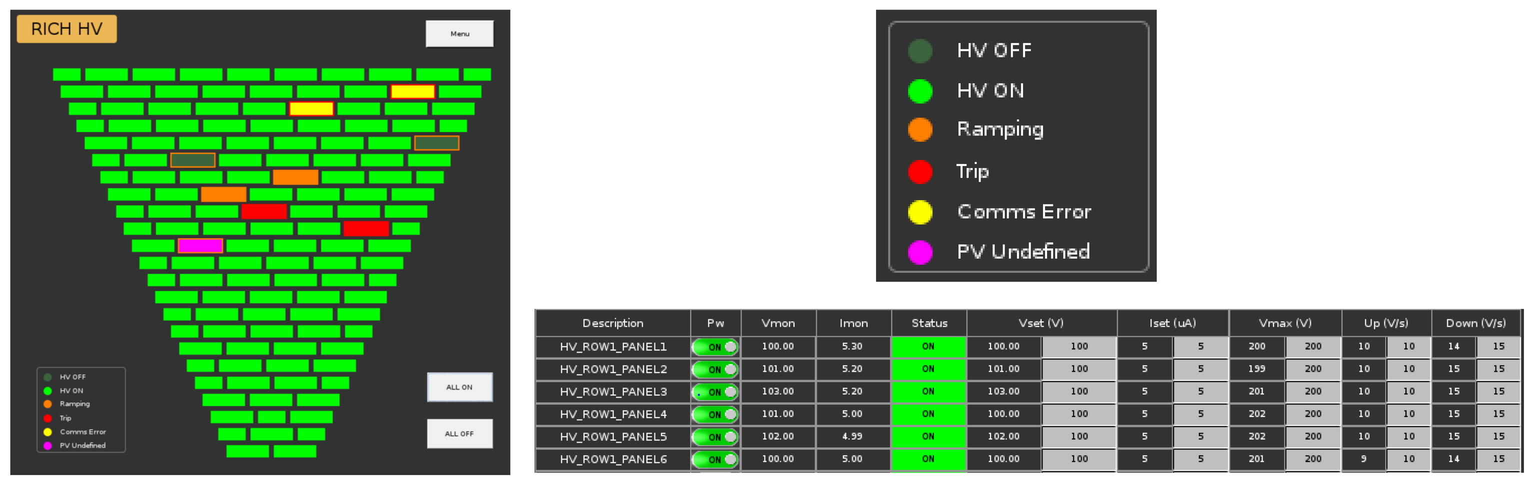


Figure 4: GUI screen for the high voltage (HV) system. Each rectangular widget represents the HV for a group of 2 or 3 MAPMTs. The color of the rectangles represents the status of the of the HV channel. Clicking on a rectangle will display a full description of the HV channel. Clicking the "See All Channels" option in the menu button will display a full description of all channels. Buttons on the bottom right corner of the screen turn the entire detector ON/OFF.

Temperature

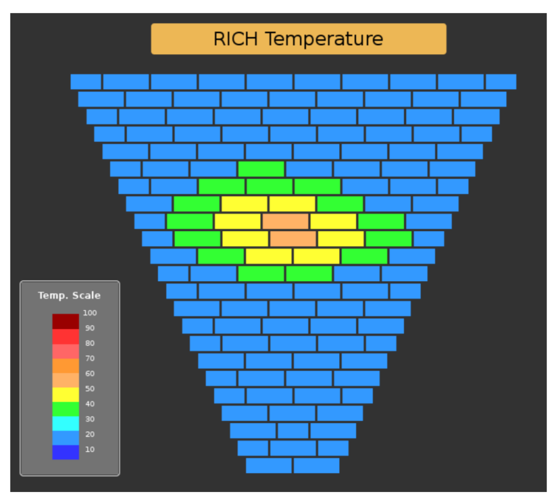


Figure 5: Simulation of a temperature hotspot on the front-end electronics panels. The color of the rectangles were dynamically set based on its temperature reading according to the given color scale. The alarm GUIs will trigger upon overheating.

Nitrogen Gas Purge Screen

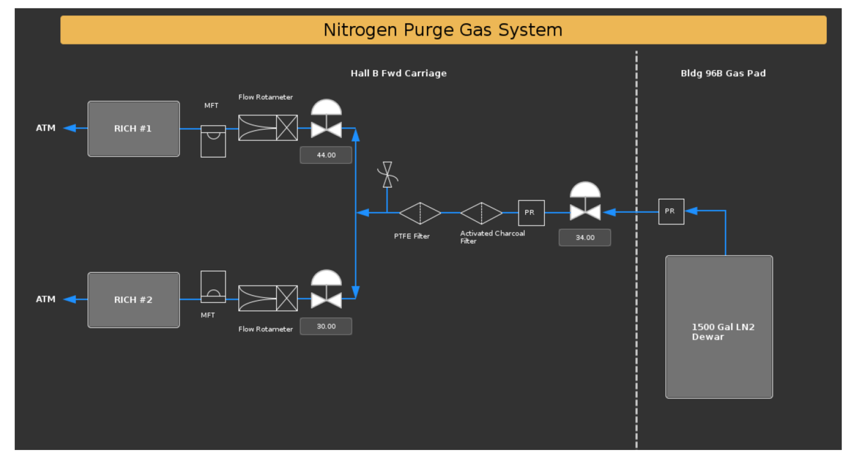


Figure 6: Screen for the N2 Gas Purge system. This system is needed to keep the humidity in the detector at the acceptable level for the aerogel. Flow of the N2 gas will be regulated by valves. In practice, valve pressures will be read from the hardware and alarmed with EPICS if the flow is not within a certain tolerance.

Cooling System

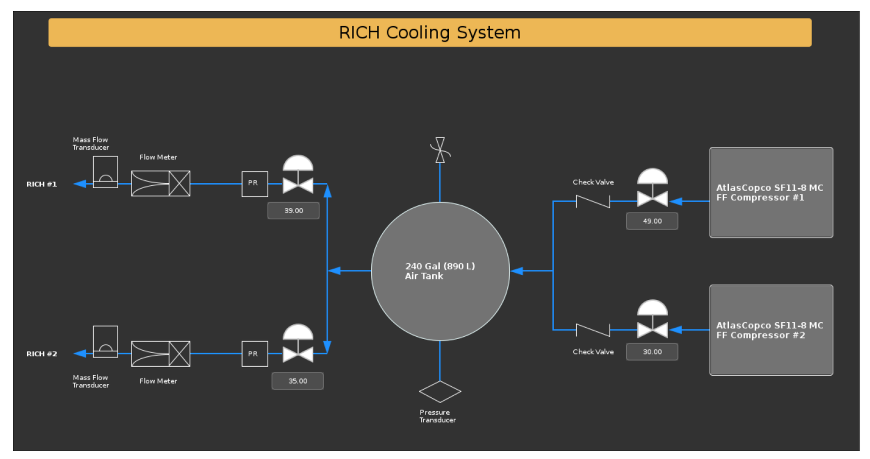


Figure 7: Screen for the cooling system. This system is needed to cool the front-end electronics. The air flow, pressure of the tank, and compressor status will be controlled. When the compressors are on, air flow and pressure must be within a certain limit. Valve pressures will be read from hardware and alarmed with EPICS.

V. Conclusions

The slow control system was successfully built and tested using a simulated input/output controller. Once the construction of the RICH is complete, these operator interfaces will be tested with real hardware.

VI. Acknowledgements

I would like to thank my mentors, Valery Kubarovsky and Nathan Baltzell, for allowing me to participate in their research endeavors. I would also like to acknowledge Thomas Jefferson National Accelerator Facility and the Department of Energy for giving me the opportunity to participate in the SULI program.

VII. References

[1] "CLAS12 RICH Technical Design Report." Aug. 2013.
[2] Johnson, Andrew. "EPICS Database Principles." 1999. http://www.aps.anl.gov/epics/docs/USPAS2010/Lectures/Database.pdf