IFMIF EVEDA RFQ LOCAL CONTROL SYSTEM TO POWER TESTS*

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Abstract

In the IFMIF EVEDA project, normal conducting Radio Frequency Quadrupole (RFQ) is used to bunch and accelerate a 130 mA steady beam to 5 MeV. RFQ cavity is divided into three structures, named super-modules. Each super-module is divided into 6 modules for a total of 18 modules for the overall structure. The final three modules have to be tested at high power to test and validate the most critical RF components of RFQ cavity and, on the other hand, to test performances of the main ancillaries that will be used for IFMIF EVEDA project (vacuum manifold system, tuning system and control system). The choice of the last three modules is due to the fact that they will operate in the most demanding conditions in terms of power density (100 kW/m) and surface electric field (1.8*Ekp). The Experimental Physics and Industrial Control System (EPICS) environment [1] provides the framework for monitoring any equipment connected to it. This paper report the usage of this framework to the RFQ power tests at Legnaro National Laboratories [2][3].

INTRODUCTION

The RFQ Local Control System (LCS) Architecture approved by the IFMIF-EVEDA Collaboration is designed to optimize the reliability, robustness, availability, safety and performance minimizing all the costs related to it (purchase and maintenance). Following this philosophy and the IFMIF-EVEDA Guidelines, we proposed to realize a control system network composed by two different kinds of hosts:

- Physical machines for critical control system tasks;
- Virtual hosts in machines where no particular functional task or hardware is required.

The architecture realizes the 3-layer structure described in the Guidelines and each layer defines a proper hosts group (equipment directly connected to the apparatus, control devices, Human-Machine Interface) while the EPICS framework provides the interface between them.

LCS CORE SYSTEM

The core server is based on a HP workstation server DL380 which hosts various services.

That server provides capabilities that enable controls engineers to deploy customized environments for their application perfectly aligned with the “Common Software Guidelines”. All the regular EPICS services, like the archiving system, are backed up regularly and can be moved and cloned easily. A key enabling technology for this is the virtualization and the provisioning; this approach allows the installation saves floor space, power, and cooling per unit of processing capacity. In addition, operations, administration, and maintenances can be addressed more efficiently and less expensively.

For having a robust system, server’s disks are setup with hardware RAID and use the Logical Volume feature to partition it. Today’s Linux servers have reached a level of maturity in the enterprise that calls for more file systems that are more versatile, configurable and manageable. Linux Logical Volume Management (LVM), using Physical Volumes and Volume Groups, provides a high degree of freedom and flexibility in the developing and maintenance steps and lets users optimize the resources at any time. In the IFMIF-EVEDA RFQ control system architecture, Logical Volumes are used to define main server’s partition table and the virtual hard disks used to realize virtual hosts. In this way, using LVM capabilities, it is possible to manage any resourceful saturation in according to the free resources provided by the main server, giving the possibility to extend, clone and manage comfortably all the servers. Because of the role covered by the server, all the unnecessary services and ports are switched off following an hardening policies to keep safe as much as possible the control system.

Figure 1: RFQ LCS Racks for Power Tests.

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Archiver

The Channel Archiver is an archiving tool-set for EPICS based control systems. It can archive any kind of record available through the EPICS Channel Access. The largely used Archiver version is still based on the original design and the last release (2006) is based on its own binary file format to archive Process Variables (PVs). This kind of Archiver was chosen to implement the archiving machine. By default, the deployable Archiver prepared into the manager server is ready to use and configured yet to monitor a couple of channels available in the base distribution. This setup makes easy to check the new archiver machines when they are installed. In order to make as easy as possible to the final user the access to the stored data, we adopt the web browser interface solution made at the Helmholtz Zentrum of Berlin. After the commissioning, this archiver will be switched off and replaced from the central one available from the Central Control System (CCS)

Deploy and Backup

In any control network, cases of hardware failure or breakdown can be very dangerous, especially when they are associated with the management of an infrastructure similar to the IFMIF facility. The need to restore the controls functionality in the shortest time is therefore fundamental. The manager machine is designed to realize, through appropriate applications and services, an automated management for new machinery's configuration inside the RFQ LCS. In particular, it is possible to connect a new device to the network, indicate which type of play rule it must realize and the network itself will auto-configure it without the need of having operators to perform this task. For example, a generic archiver machine EPICS can be put into production in about 10-15 minutes. The manager host uses dedicated open source software for provisioning the entire control system network, while backup service saves through proper customized scripts the principal files of interest associated with the main machineries (physicals and virtual) present in the LCS. These backups are stored in a Network Attached Storage (NAS) RAID machine connected to the local control network.

Surveillance

It is difficult to supervise status and operations of all the services desired. In a critical system like the RFQ Local Control System, administrators should be constantly updated on this state and must be able to intervene promptly if any machine or service does not respond correctly. There are several solutions on the market, both free and pay, that allow a capillary network management through various tools for diagnostics and notification. In the local control network an open source solution was chosen to perform this task: it provides computer system monitor and network monitoring software application. It basically watches hosts and services, alerting users when things go wrong and again when they get better. This software has several features, including the possibility to have the monitoring of services, resources, and any other information that can be shared through the network. One of the most interesting features of the software is the total customization of monitoring system through dedicated plugins; in this way the operators can have all the information of interest desired. Among the various plugins available on the network, there is a plugin developed entirely within Laboratori Nazionali di Legnaro that allows state supervision of EPICS Process Variables in a control network; this involves the possibility, through a single program, to monitor both the EPICS control system network and the computer network. The entire network can be controlled through a proper web interface and, in case of warning or critical problem, email notifications are sent to the system network administrators; an sms notification is possible too, but the hardware is not available yet.

Project Management Documentation Server

Software projects are getting larger and more complicated year after year stressing the need for efficient and reliable tools and agile project management methods. Widely used and recognized tools in Open Source development, Subversion (SVN) and Bugzilla, have been proven to be suitable for most kind of software projects and have lately been accompanied in many projects with an emerging document and content management system, Wiki. These tools provide an effective and seamless software configuration management (SCM) environment for professional software development allowing developers and managers to keep on track of projects and quality issues. Environment where everything from specification and code to bug reports and code modifications are all integrated and easily accessible improves tremendously both quality and productivity of a project. With this target the RFQ LCS should be managed and documented using these tools:

- Bugzilla [4] is a "*Defect Tracking system*" based on MySQL and managed by a regular web browser;
- Wiki service is provided by MediaWiki [5], the largest used wiki which provides the engine of the famous Wikipedia. MediaWiki uses MySQL and Apache;
- Subversion [6] server will contain all software development usually, but can be used to manage the revision of document like this one. A nice server named WebSVN has been setup to have the access of SVN by web pages.

EPICS softIOCs Virtual Server

In subsystem to control where the acquisition rate is the most critical requirement and in situation where dedicated devices must be integrated, the control system is developed directly in EPICS,

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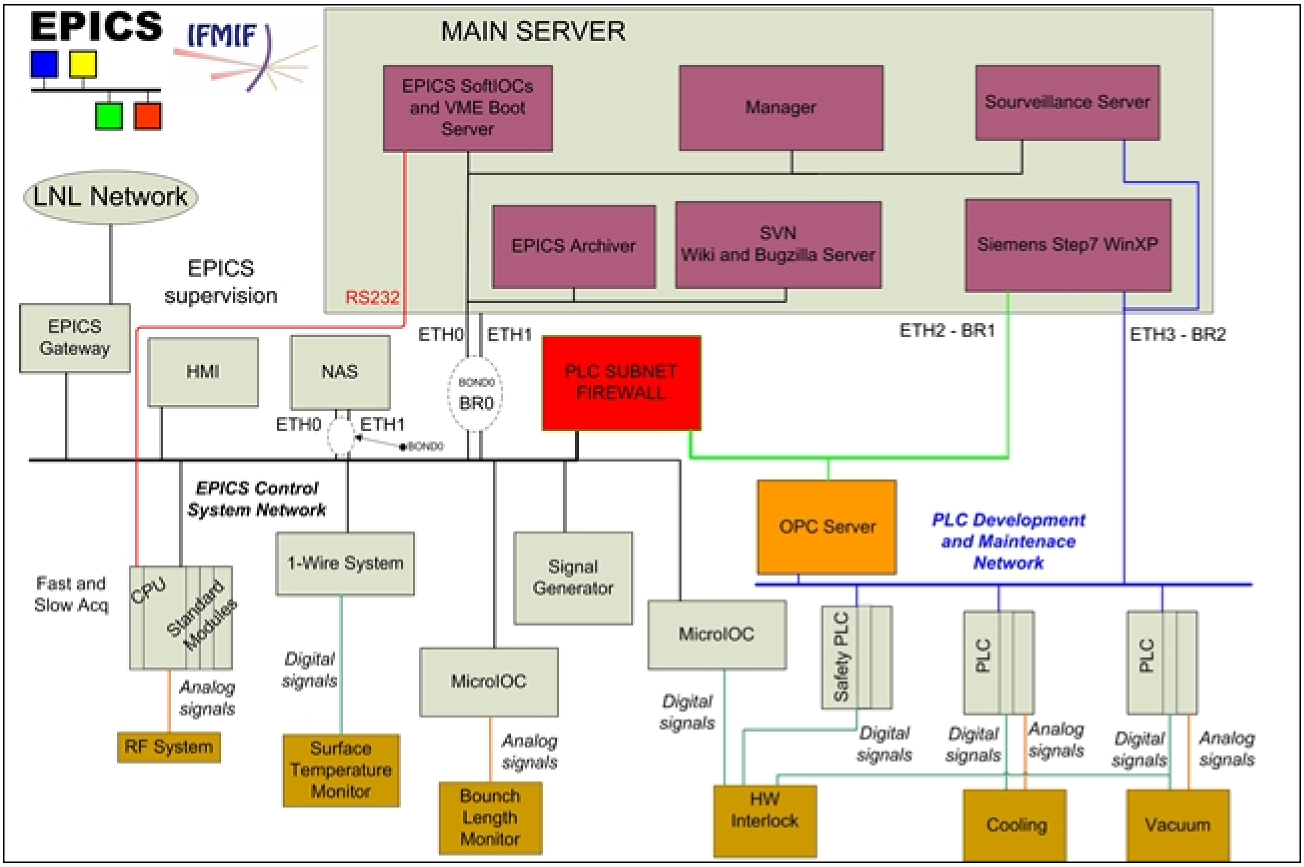

Figure 2: Control System Architecture for IFMIF EVEDA RFQ power tests.

Because of particular hardware to realize and manage the IOCs is not required, a properly configured virtual machine equipped with the entire EPICS environment is developed; in this way system administrator have a centralized server to supervise. This machine is created for having two tasks:

- Realize a EPICS IOC for every device and system which require it
- Provide a Boot Server for the VME system in charge of realize the RF acquisition

LOCAL CONTROL SYSTEM

The RFQ system is complex apparatus composed by many kinds of subsystems (radio frequency, vacuum, water cooling, etc.) developed using different hardware solutions. As consequence, every part of this structure must be properly integrated to obtain the desired degree of control. Following these criteria, the system has been designed and realized using these assumptions:

- PLC hardware is chosen in tasks where security is the most critical feature;
- VME system is used where the acquisition speed rate is crucial;
- Common hardware (such as embedded systems) is chosen when only integration is required, without any particular feature in terms of security.

Analyzing all the subsystems indicated in Figure 2, it is possible to observe that for every of it a particular solution based in one of the three assumptions mentioned above is adopted. From the functionalities point of view, the local control system could be resumed as follow:

- Fast acquisition system for the RFQ cavity power;
- RF signal generator;
- Vacuum system;
- Surface Temperature Monitor (STM) system;
- Bunch length monitor system;
- Cooling system;
- Machine Protection System (MPS).

The fast acquisition is based on VxWorks real time OS which run over a VME architecture. The most important channels: direct, reflex, and cavity power are sampled with a maximum rate of 1000KEvents per second. The scientist may use this feature instead of using any kind of scope. The absence of low level RF makes necessary a use of a signal generator to the power tests. For this reason, an EPICS driver has been written to integrate that instrument to these tests.

The vacuum system is already done from the PLC software until the human machine interface (HMI). The PLC realizes the control while the EPICS framework is on charge of HMIs, archiving and alarm managements. The surface temperature of a RFQ has never been analyzed before on other RFQs; we would try to map the temperature distribution along the RFQ with a high

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Figure 3: Human Machine Interface for RF analysis.

defined mesh, saving a wiring effort and at the reasonable price. 1-Wire®[2] devices satisfy this approach, providing simple and cheap technology; for this kind of device, an EPICS driver is developed to integrate this solution into the control system. We have estimated an amount of hundred sensors only to these three super modules.

IFMIF-EVEDA requires a system to measure the micro bunch length. A slim embedded solution with the needed ADCs/DACs is enough to this measure. This solution is more flexible and manageable instead of the common VME boards. An embedded PC accomplished this task. Through a dedicated machine, the EPICS Archiver stores all the data used by scientists for analysis of the experiment. Under EPICS environment, there is almost one EPICS database for every system managed exception for the mathematical side, which is composed by a set of databases where each one performs a particular calculus. The Human Machine Interface (HMI) is composed by a set of panels which let scientists to remote control the apparatus. The following table resumes the size of the whole EPICS application realized.

Objects	Numbers
IOCs	6
Databases	17
Process Variables (PV)	1153
PV Archived	970
HMIs	17

CONCLUSIONS

Preliminary tests on the singular control system tasks are done with positive results.

The cooling systems is already designed but all material needed to build that is not available yet. The cooling requirements and functionalities are not defined on details, therefore the software would be flexible enough to be adjusted and tuned during the experimental tests. MPS software is under development, the features are well defined and approved by safety experts. The most critical part of the vacuum control system will be tested in the next months. The fast acquisition is already tested and seems to works matching the requirements of the scientists.

Because of the importance of the power tests for the RFQ apparatus, this is a great test-bench for the entire control system architecture and a good feedback for the work realized.

REFERENCES

[1] http://www.aps.anl.gov/epics/
[2] http://www.lnl.infn.it/.
[3] http://www.lnl.infn.it/~epics/joomla/
[4] http://www.bugzilla.org/
[5] http://www.mediawiki.org/wiki/MediaWiki
[6] http://subversion.apache.org/

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