STATUS OF THE ALBA CONTROL SYSTEM

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Abstract

Alba [1] is a synchrotron light source under installation located nearby Barcelona. This 3 GeV third generation light source is planned to deliver the first X-rays beam to the users in 2010. This paper describes the progress in the development and installation of the control system for the accelerators and beamlines. Solutions for interfacing devices, networking, interlocks, diagnostics etc. are presented and the current status of installations and commissioning is given.

Figure 1: View of the Accelerator tunnel and BL11 and BL13 Beamline hutches. Picture taken on 8 September 2009 (J.Klora).

INTRODUCTION

The commissioning of the 100 MeV Linac (outsourced to Thales Communication) was finished in September 2008. Booster mechanical installation and cabling has finished in October 2009, whereas commissioning is scheduled in December 2009. The commissioning of the storage ring and beamlines will take place in 2010.

The main infrastructure of the control system is already operational. Boot servers, Tango [2] databases and archivers run on boxes located in the computing room. The computing room hosts DELL poweredge servers running databases and services. The main Tango database (alba03), the archiver server running a mysql database and boot servers are run in the computing room. The CCD device servers for fluorescence screens (GigE) run in four virtual machines also located in the control room. IOCs (Input Output Controllers) are cPCI (Compact PCI) and Industrial PCs (ADLINK). The accelerators control system is distributed in IOCs located in the Service Area, the place surrounded by the tunnel. All IOCs for the accelerators controls are diskless. In the case of beamlines there is an independent Tango database per beamline running in Industrial PCs with disk. All run OpenSUSE 11.1 (32 bits). Tango device servers are developed in Python and C++, although few are Java ones, borrowed from our partners in the Tango community. Graphical user interfaces and other clients are mostly based on Python [3] and Qt [4] (TAU, Sardana Device Pool [5]) while most Tango standard tools are written in Java (ATK [2]), so are some custom graphical user interfaces.

ACCELERATORS

Architecture

Ethernet is widely used by the control electronics. Power supplies, Libera electronics for control and data acquisition from beam position monitors, CCD cameras for fluorescence screens, oscilloscopes for diagnostics, and all IOCs are connected by Ethernet. IOCs get a dynamic address by Dynamic Host Configuration Protocol (DHCP). The network configuration files for various services (i.e., Domain Name System, or DHCP or Radius) are automatically generated from the Controls and Cabling Database [6]. Operator's interfaces communicated by Ethernet with the controls networks are installed in the controls room. No other electronics besides the main cabinet of the personnel safety system (PSS) is cabled to the control room.

The physical architecture of the control system is organized around Virtual Local Area Networks (VLANs) for the different subsystems. The communication between IOCs and Liberas (8 per sector), power supplies (around 20 per sector), vacuum, etc. is handled by the main controls VLAN of the sector. CCD cameras and oscilloscopes are connected to a separate VLAN.

In addition to the controls network, Programmable Logic Controllers (PLCs) are intercommunicated between them in a separate independent VLAN (Ethernet powerlink).

Linac and Booster

The Linac has been delivered as a turn-key system. Controls and data acquisition are handled by five Siemens S300 PLCs. The Linac to Booster Transfer line and the diagnostics Line have been installed and tested for the commissioning of the Linac. It is running since April 2008. The booster commissioning is scheduled in December 2009. The network cabling and services have been commissioned in September 2009. IOCs are booted and the applications for control and data acquisition are started. The booster cabling is ready at the end of September 2009 and the control system cables and software will be commissioned in October. A snapshot of the main application including a synoptic is shown in figure 3.

Radio Frequency (RF)

The storage ring has six radio frequency plants with a power of 160 kW (two transmitters of 80 kW each). The booster has an additional 80 kW RF plant. Transmitters comprise High Voltage Power Supplies (HVPS) and Inductive Output Tubes (IOT). They are manufactured by Thomson and are controlled by Siemens PLCs. The Low Level RF system regulates both phase and amplitude (I/Q loops), and the resonance frequency of the cavity. This is actuated by a plunger controlled by stepper motor. The analogue regulation for the booster has been replaced by a digital system of the same type of the ones used for the Dampy cavities in the storage ring.

The Digital Low Level RF (DLLRF) is based on a commercial cPCI board with 16 ADCs, 8 DACs and 2 FPGA (Virtex-4) from Lyrtech Ltd [8]. A fast data logger system is integrated in the board and complemented by an "external" one based on ADLINK simultaneous ADC cards.

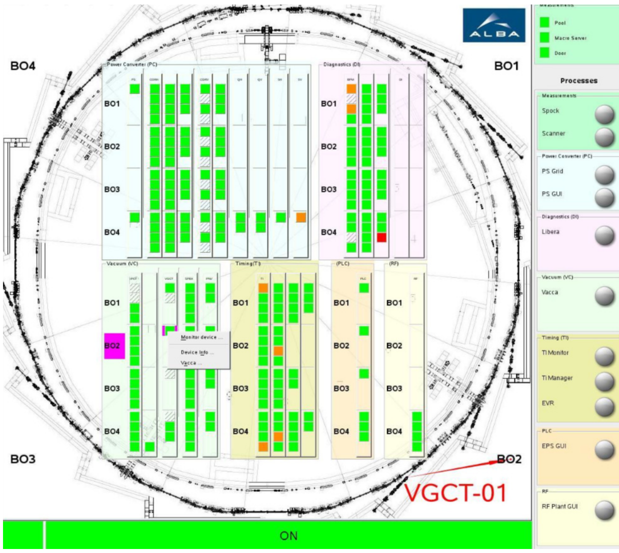

Figure 2: Main graphical user interface for the booster controls.

Power Converters

Power converters for the booster and transfer lines are manufactured by Bruker, the ones for the storage ring by Hazemeyer, and pulsed power supplies are provided by PPT. All of them have an Ethernet interface supporting TCP/IP and an external trigger for synchronization. Communications with the correctors of the storage ring (Ocem) is carried out by the PSI [11] interface for power supplies. It comprises electronics for digital regulation, and a fiber optics link with IOCs. On the IOC, a cPCI carrier with 2 IP modules, and a transition board having the fiber optics transceivers are installed. Currently the Bruker power Supplies for the Booster and Linac to Booster Transfer Lines are installed in the racks. They have been tested in the Site. The control system is ready for the commissioning in November 2009.

Timing System

The Timing system manufactured by Microresearch Finland is based on events. A new bidirectional link has been added. Consequently, the timing system, besides synchronizing the different elements of the machine, is the base of the fast interlock system. The timing system consists of an event generator, several fiber optics fan-outs, and event receivers. An event can be generated in the event generator (the normal operation for synchronization), or can be the result of an interlock signal that appeared in one of the leaves of the tree and has been transmitted to the generator which sends it back to all leaves. All "fast" interlocks are also monitored by the PLCs and transmitted in a redundant "slow" way over the PLC network (PowerLink). The hardware and fiber optics have been tested and the Software is being commissioned at the moment (September 2009).

Diagnostics and Beam Dynamics

The storage ring includes 88 Libera BPM electronics [7] and 88 correctors in each plane for orbit correction. Corrector magnets are integrated in the sextupoles as extra coils. Data from the BPMs is passed through the Liberas to the neighbors and up to the cPCI crate. This data transmission, meant to be used for the fast orbit correction uses a dedicated fiber optics link. A tango server for every Libera box runs in the Compact PCI crate and is accessible from the control system for the slow orbit correction, displays, archiving etc... This so called slow control goes over the normal Ethernet link. Furthermore, 30 Basler CCD cameras (SCA1000-30GM 1034x779 pixels 12 bits 30 fps) for fluorescence screens are interfaced using the E-Giga protocol, whereas other signals like Beam Charge Monitors are read by analogue input cards in the cPCI crates. Oscilloscopes are used for Fast Current Transformers, Faraday cups, annular electrodes, among others, and are accessed over VNC or NX connections. Beam Lost Monitors are read through RS485 link by a Tango device server.

BEAMLINES

Seven beamlines are installed in the first phase. Although beamlines are very different one from the other, all of them are controlled by the Sardana Device Pool [5]. Two-phase stepper motors are standardized and all of them controlled by the Icepap (developed at the ESRF). In the few cases where the design of a particular component requires a DC motor (like the direct drive Monochromator provided by FMB Oxford), Delta-Tau controllers are used. Data acquisition is very much dependent on the detector, however step scans, continuous scans, sequences, and rapid integration of new hardware for a particular experiment are common requirements shared by all of them. Classic scans and plotting are managed by the Sardana Device Pool [5], whereas data acquisition systems are being developed following particular requirements of the different beamlines.

COMMON SYSTEMS

Hardware and software have been chosen to be reusable in the different subsystems. Furthermore, many components of the control system are shared by beamlines and accelerators. This is the case of vacuum device servers, motion controls, DAQ software, archivers, etc. The technology and standards for interlocks, safety systems are also standard.

Vacuum

MKS gauge controllers and Varian Dual Ion Pump controllers combined with high voltage splitters are the main electronics for vacuum. Both gauges and pumps controllers are interfaced by serial lines. The control software runs on industrial PCs equipped with 16 ports RocketPorts cards. Software comprises serial connections, Tango servers for the different controllers, and connections with the different PLCs.

Archiver

All databases used by the control system, Archiving, Tango, and Cabling databases, have been implemented on MySQL. The archiver system uses the configuration tools and the database design developed at Soleil. Various stress tests have been successfully performed; storing 6000 attributes every 10 seconds in the historical database and every 1 second for the temporal database [12].

Commissioning

IOCs have been preinstalled with the required DAQ cards and pre-cabled in the racks. The remote booting parameters, drivers and Tango servers have been installed and tested. All tests are recorded in the cabling database. Information and documentation regarding equipment types, position, channels, cables, and even equipment tests are stored in the database. The database also stores information needed by network services in order to generate config files automatically (DNS, DCHP, Radius). The cabling database is a "corporative database" for controls hardware and software configuration, whereas the Tango database is meant for controls software operation.

Equipment Protection System (EPS)

The equipment protection system manages permits and interlocks avoiding damaging the hardware. It is built on B&R PLCs with CPUs installed in cabinets in the service area. Shielded boxes for distributed I/Os are installed inside the tunnel. PLCs manage interlocks, temperature readouts, actuators for shutters and fluorescence screens, etc. Vacuum devices, RF plants, and power supplies interlocks are also managed by the EPS. Most code on PLCs is automatically generated from the Cabling database reducing errors and time and increasing consistency.

Personnel Safety System (PSS)

The PSS ensures that nobody gets irradiated during operation. This comprises access control to bunkers, intrusion and malfunction detection as well as radiation level monitoring. The system is based on Safety PLCs from Pilz, and the system is designed for being SIL3 compliant (IEC/EN 61508), following the golden rule of redundancy and diversity. Twenty-four radiation monitors (Thermo) are installed in service area and experimental hall, each of them having two safe connections to the PSS. Those are two alarm levels that have different actions depending on the position in the network.

CONCLUSION

The control software is installed and tested in the IOCs, prior to be preinstalled in the racks. All subsystems are ready to be commissioned for the booster control. There are more than thousand Ethernet devices around the service area, which are being commissioned at the Moment. The Tango based control system has proven to work well with a certain number of devices. The test of the booster will be the first non-simulated test of all control services together.

CONTRIBUTIONS

Many developers are working on this project: The Director of the computing division, J. Klora, the controls group, T. Coutinho (PyTango, TAU, Device Pool), S. Rubio (Vacuum, Archiver, DAQ), G. Cuní (Motion, beamlines), S. Blanch (CCDs, diagnostics, beamlines), F. Becheri (IDs, GUIs), R. Suñé (RF, DAQ, Timing, Drivers), L. Krause (Power Supplies, Linac), Z. Reszela (Tau widgets, beamlines), J. Moldes (Libera BPMs, beamlines), A. Milán (RF, beamlines), M. Niegowski (Radiation Monitors, GUIs), C. Pascual-Izarra (Data analysis and Visualization), R. Ranz (EPS, cabling, PLCs), A. Rubio (PSS, PLCs), R. Montaño (PLCs). The electronics group, headed by D. Beltran, and in particular O. Matilla, J.V.Gigante and J. Lidón, who are among other duties responsible for cabling, fast interlock units, vacuum splitters, etc. The system administrators, in particular S. Pusó and the head of the group, J. Metge. The MIS group headed by V. Prat, who developed and maintain the cabling database. We would like to thank the Tango collaborators who have written most of the standard Tango Applications and Tools available for the community: ESRF, Soleil, Elettra and DESY, and in particular E. Taurel, A. Homs, V. Rey, M. Pérez, S.Petitdemange, G. Berruyer, M. Guijarro (ESRF) and N. Leclercq (Soleil) for their great contributions.

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