STATUS OF THE MAX IV LABORATORY CONTROL SYSTEM

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Abstract

The MAX IV Laboratory is a new synchrotron light source being built in Lund, south Sweden. The whole accelerator complex consists of a 3GeV 250m long full energy linac, two Storage Rings of 1.5GeV and 3GeV and a Short Pulse Facility for pump and probe experiments with bunches around 100fs long. First x-rays for the users are expected to be delivered in 2015 for the SPF and 2016 for the Storage Rings. This paper describes the progress in the design of the control system for the accelerator and the different solutions adopted for data acquisition, synchronisation, networking, safety and other aspects related to the control system.

INTRODUCTION

While the construction of the buildings for the two Storage Rings is still ongoing, installation of equipment in the Linac building has already started. Linac commissioning is scheduled to start in March 2014 while the 3GeV and 1.5GeV Storage Rings will start commissioning in July 2015 and October 2015 respectively.

Table 1: Parameters of Storage Rings

	1.5GeV Ring	3GeV Ring
Circumference	96m	528m
Straight sections	12	20
Injection	Full energy top-up	Full energy top-up
Max Stored current	500mA	500mA
Revolution frequency	3.123MHz	0.568MHz
Hor. Emittance	6nm*rad	0.326nm*rad
Min. RF	99.931MHz	99.931MHz

THE FACILITY

The accelerator complex consists of 3 main components (see Fig.1): a 250m long Linac that accelerates electrons generated in the gun area up to 3.4GeV and two Storage Rings, one low emittance 528m circumference 3GeV main Storage Ring and another smaller 96m circumference 1.5GeV Storage Ring targeting the UV and IR synchrotron radiation community. At the end of the Linac, after a bunch compressor, a Short Pulse Facility will host beamlines aiming to carry out time-resolved X-ray diffraction studies with pulse lengths below 100fs.

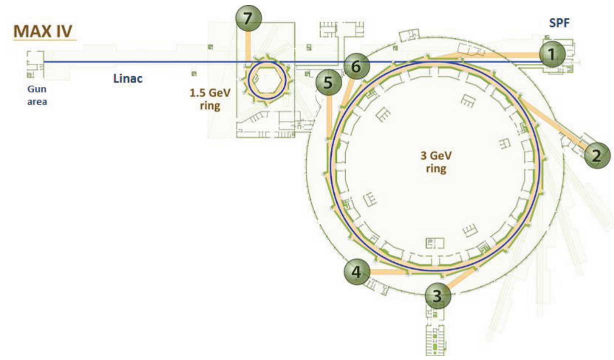

Figure 1: MAX IV Laboratory facility layout.

At the beginning of the Linac, in the gun area, two guns will be used as drivers:

- A photocathode gun that, driven by a Ti-Sapphire laser locked to a 80MHz oscillator will be used to drive the SPF.
- A thermionic RF gun, followed by a chopper system will serve as injector for the rings. See [1] for more details.

ARCHITECTURE

The control system is based on a 3-tiers architecture. The hard real time tasks are guaranteed by the controllers and specific hardware at the field bus level. Ethernet is used extensively as a field bus. The TANGO[2] framework represents the second tier, the primary control system. Most equipment comes with TCP/IP capabilities avoiding in most cases the use of intermediate general purpose controllers.

The network for the accelerators is independent from the office network and beamlines networks.

A central server room hosts the hardware where virtual machines will run the TANGO device servers for the different control system tasks.

The SARDANA[3] distribution has been selected for the client layer. It allows interacting with the control system through both Graphical User Interfaces based on Taurus or an IPython-based Command Line Interface. The physicists will have the possibility to interact with MATLAB[4] too thanks to a TANGO binding.

The standard services of TANGO running on MYSQL[5] will be used for archiving and alarm purposes.

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SUBSYSTEMS

Linac RF

The Linac is divided in 18 sections associated to a set of accelerating cavities. Each of them hosts a modulator with a klystron and SLED cavity plus different elements to adjust attenuation and phase shift of the RF fed to the structures. The first 3 sections have a drive amplifier with independent pulse length adjustment, while the rest of the downstream sections get the RF amplified from the 3rd section that is distributed along the Linac via a main drive line.

The Scandinova modulators (see Fig.2) hosting the klystrons have their own control unit that is accessible via Ethernet and whose control is fully developed by the manufacturer. The drive amplifier and some attenuators are interfaced via Allan Bradley PLCs. Motors in SLED and mechanical phase shifters are driven via our standard motion controller whereas the fine phase shifters of the first 3 Linac sections have their own timing controller from Stanford Research.

All those devices are Ethernet interface what allows to run the control software remotely from the server room.

Figure 2: Scandinova Modulators used at MAX IV Laboratory Linac.

Storage Rings RF

The RF stations[6] are based on single or combined 60kW transmitters, circulators to isolate cavities from the transmitters and a digital low level RF system to regulate the amplitude and phase of the RF field and resonance frequency of the cavities to compensate for transient beam loading and temperature variations.

The control of the digital LLRF system is based on a commercial cPCI format FPGA board where the correction algorithms are implemented providing at the same time fast interlock utilities and fast diagnostics for post mortem analysis. Furthermore, a fast data logger system is integrated in the system. External control software is directly based on TANGO with a TAURUS graphical user interface on top.

Vacuum

The Digitel SPCe Ion Pump Controllers from Gamma Vacuum are the main component for vacuum control, both for powering the Ion Pumps and to readout the pressure. It is equipped with Ethernet interface that allows remote control and readout of pressures from the central servers. It also features a set of I/O that can be connected to the PLCs of the Machine Protection System.

Other components like Valves and Fast valves are interfaced via the Allan Bradley PLC system too.

Power Converters

Power supplies at MAX IV Laboratory belong to three different families:

- High power unipolar converters from Danfysik used in the Storage Rings to drive dipoles, sextupoles and octupoles.
- Medium power unipolar converters from Delta for the rings and Linac.
- Low power bipolar converters from Itest for the correctors of the Linac and the Storage Rings.

All of them are equipped with Ethernet interfaces and temperature switches for machine protection purposes.

Timing System

The timing system, still under design, will follow the extended event generation/reception model. Three different event clock domains for the SPF and the two rings are required. The elements common to the three systems are triggered from a shared main trigger line.

Another paper in these proceedings describes the current status with more detail[1].

Diagnostics

The electron beam trajectory is tracked with BPM readout electronics from I-tech. In the Linac 12 Libera Single Pass E cover the travel of the electron bunches till the SPF. They are triggered from the main trigger line and each of them controls up to 4 sets of BPM.

In the Storage Rings the BPMs are connected to Libera Brilliance+ electronics (see Fig.3). The 3GeV Storage Ring has 60 of these devices, whereas only 12 are necessary for the 1.5GeV Storage Ring.

Figure 3: Libera Brilliance+ as used at MAX IV Laboratory Storage Rings.

Apart from the BPM readout cards, Brilliance+ can host a FPGA based module with memory and up to 4 SFP slots that will be used in the future to implement the fast orbit feedback for both rings.

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Another important set of diagnostic signals in the Linac will be read via real time oscilloscopes from R&S. They are expected to generate data at up to 100Hz Linac repetition rate.

MPS and PSS

Both systems are based on Allan Bradley Controllogix 1756 PLC systems. These are modular systems with a full portfolio of CPUs, interfaces and I/O cards that include a very simple and well integrated programming environment.

For PSS specific systems, a ‘Safety partner’ module allows to use the same backplane reaching SIL3 safety level, while profiting from using the same software development environment.

PSS system is completely independent from the control system but can be accessed from it for monitoring of internal variables.

Motion Control

MAX IV Laboratory has joined the IcePAP collaboration lead by the ESRF and will use the IcePAP motion control system for driving all motors in the accelerators and beamlines. The system, allowing Ethernet access and synchronous control of up to 16 chassis with a total of 128 intelligent drivers fits all the requirements in motion control of the facility. The possibility of adding new features via firmware update of the different processing units will enable us to expand functionality in the future.

Beamlines, Front Ends and IDs

The project includes 7 beamlines in the first phase to start user operation in mid-2016.

Industrial PCs have been selected as IOCs where PCI/PCIe cards for data acquisition or synchronisation are required. They will expose the functionality through the CentOS/TANGO stack.

Synchronisation of IDs and beamline optical components will be achieved via our standard IcePAP motion controller. Standards are been selected too for common beamline instrumentation like Gigabit Ethernet cameras, electrometers and others.

Project Management

The control system team is composed by 4 software engineers, 2 hardware engineers, 1 network engineer and 1 system administrator. The recruitment planning includes 2 more software engineers for late 2013 and 2 more hardware engineers for early 2014.

The collaboration [7] and the automation of the repetitive tasks[8] form the strategy of the software development where Scrum[9], an Agile methodology, is used to follow the different tasks.

CONCLUSIONS

As this paper is being completed, the installation of the linac proceeds at an increasing pace (see Fig.4). The first components of the control system are being installed in the second half of October. Subsystem tests will follow till March 2014 when the Linac commissioning will start.

In parallel, the development of the control system for the Storage Rings and the beamlines continues steadily, based in all the hardware and software choices (Ethernet, TANGO, SARDANA,…) already made and described in this paper.

Despite the small size of the control group, the flexibility and the maturity of the chosen components will together contribute to the successful delivery in time and matching the expected requirements. The appearance of new requirements will have to be dealt with via negotiation and rescheduling of other tasks with the different stakeholders.

Figure 4: MAX IV Laboratory 3GeV construction state.

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