TUAT003

STATUS OF THE SLS CONTROL SYSTEM

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Abstract

The Swiss Light Source is a high brightness synchrotron light source at the Paul Scherrer Institute in Switzerland. It consists of a 100 MeV electron Linac, a booster synchrotron, a 2.4 GeV storage ring, and experimental beam lines. The machine and beamline control system consist of 150 VME crates running Epics on Motorola power PC processors. The network is based on switched 100mbit/sec and Gigabit Ethernet technology. Consoles and servers are PCs running Linux. To achieve high availability of the control system, emphasis has been put on software engineering and the use of a relational database for all system configuration. Most hardware channels are directly connected to VME input/output cards rather than using a field-bus, and this has resulted in higher performance, better reliability, and reduced costs. Any of the 100,000 data channels can be archived at high speed, and the resulting data accessed through the Web. The VME input/output cards can be 'hot-swapped' in case of failure, and have circular buffers for post-mortem analysis in case of beam loss. Having all machine parameters available through the control system in a consistent and easy to use manner has contributed to the fast and successful commissioning of the machine.

1 SLS COMPONENTS

The Swiss Light Source is a third generation synchrotron light source at the Paul Scherrer Institute, Switzerland. It consists of a 100Mev electron Linac, a full energy booster synchrotron, a 2.4GeV 400mA storage ring, and initially four beam lines: A materials science beamline with a minigap wiggler; A protein crystallography beamline with a minigap in-vacuum undulator; a microscopy beamline with a permanent magnet undulator; and a spectroscopy beamline with an electromagnetic undulator.

2 STATUS

2.1 Schedule and Costs

The SLS came into operation this year on schedule and under budget. During the three year construction phase the building construction, technical system installation, and machine and beamline commissioning were completed.

2.2 Performance

The SLS has met or exceeded all of its design parameters. It is now running routinely in top-up mode where electrons are injected every few seconds to ensure a constant beam current. This provides very stable beam conditions for the experiments. Beam stability is very high with an RMS orbit error of less than one micron measured over a 17 hour time period.

2.3 Reliability

The SLS is running very reliably with most beam time now dedicated to user operations. Users consist of internal PSI research, external university groups and industry. The control system has contributed to less than four hours of lost beam time in the year since storage ring commissioning started. This was mainly due to configuration errors not hardware failures.

3 CONTROL SYSTEM ARCHITECTURE

3.1 Equipment interface level

Monitor and control of equipment is via the direct connection to 150 VME crates running Epics [1]. Standard I/O modules provide interfaces for analogue and digital input and output as well as motor control, temperature measurement, serial line connection, scaler modules and position encoders. Most interfaces are industry pack (IP) modules mounted on hot-swap VME 64X carrier boards. Connection to signals is on the rear of the crate using 80mm deep transition modules.

3.2 Network

The SLS controls network is a 100M bit switched Ethernet network, with some 1 Gbit connections. The network is isolated, with no routing to the rest of the institute or to the Internet. Some devices such as the file and database servers are on both the private and general network, allowing the exchange of data to office and central systems.

3.3 Operator interface level

The operator interface level consists of Linux PCs used as consoles and servers. Consoles in the control room have four screens each, and a number of single screen consoles, which also act as boot servers, are located in the technical gallery and on beam lines.

4 HIGHLIGHTS

4.1 Timing

The controls timing system [2] is a high performance design based on the APS timing system. Its high resolution and low jitter performance allows the accurate synchronization of hardware signals and software across the SLS control system. Its use simplifies the operation of the machine allowing complex sequences of events to be carried out by changing very few parameters. Its integration into Epics means timing parameters can be treated just like any other control system variable.

4.2 On line model server

The on-line model server and physics applications are provided by the beam dynamics group [3]. The model server can read the beam positions and actual magnet strengths form the control system and can very accurately predict the effects of proposed new settings before they are implemented. The very close agreement of the model and machine make it possible to achieve very good machine performance including beam stability.

4.3 Integration of Beamlines

Beamline controls [4] are handled by the same hardware and software used for machine controls. As well as reducing costs and development time this has enabled controls engineers to work on either system as priorities dictate.

4.4 Integration of sub-systems with turn-key controls

Both the Linac and the RF modulator systems were delivered by industry as turn key contracts [5]. These systems were delivered with an Epics control system making it simple to integrate into the global control system.

4.5 Moving physics applications and parameters into the control system

Calculation of some machine parameters has been moved from high-level applications into the low-level control system [6]. This provides more stability and higher performance. It also allows the use of our standard tools such as the archiver, alarm handler and save-restore tools.

4.6 Digital power supply control

Control of the 500 booster and storage ring magnets is carried out using individual fully digital power supplies. This has contributed to the very high stability of the electron beam. Interface to the VME crates from the power supply controller is via a custom designed optical serial link. All internal control parameters and readings can be read and set via this link and appear as standard Epics process variables.

4.7 Hot swap and post mortem analysis

Most of our I/O modules support the features of hot swap and have hardware buffers for post-mortem analysis following loss of beam or other events. The analogue input modules also support over-sampling of data to give 18-bit resolution and noise reduction by averaging.

4.8 Relational database

An oracle relational database is used for system configuration, and operational management. Features provided include generating configuration files (Archiving, Cdev, etc.), reporting of bugs and system failures, tracking the location of all hardware modules, and generating Epics substitution files. Users interrogate and modify database tables using a web interface.

5 REASONS FOR SUCCESS

5.1 Standardization

We have succeeded in standardizing on a small number of different hardware modules. The same hardware is used to monitor and control a large variety of devices. This has reduced development time and makes maintenance easier. The same version of software is loaded into all systems and regularly automatically updated. This includes low-level software (Epics system code and drivers) , as well as system code, application code, and configuration files on Linux servers and workstations. When a developer changes an application on request the changes are distributed to all systems.

5.2 Not building hardware in house

Where possible, commercial off the shelf modules have been used. Where such modules were not available to meet our requirements, contracts were placed with industry for design and production of the necessary modules. Contracts for design and production of VME and industry pack modules now include the provision of Epics drivers. This has further reduced the time for testing and integration into the control system.

5.3 No Fieldbus

By having direct connection using VME I/O rather than using a fieldbus level, the system is simpler, more robust and has higher performance. Cost per channel is low due to high signal densities, and maintenance and debugging are easier.

5.4 Not making major software developments

By largely using existing software components, we have been able to concentrate on solving the controls problems needed for each sub system. This has meant we were able to deliver working controls systems early in the project, and did not experience any major problems bringing the system into operation. Even when some tools did not provide all of the features we would have ideally liked, we have lived with a slightly reduced functionality, rather that embark on major developments.

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