Control System

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1 Introduction

The CLS control system is responsible for the monitoring and control of the technical components of the facility. These include the:

- Electron gun
- Timing system
- Magnet power supplies
- RF modulator controls
- CW RF controls
- Vacuum valves
- Slit drives
- Photon beam shutters

The control system is not responsible for the operation of:

- Beam line equipment beyond the front-end equipment.
- Personnel safety systems
- Equipment safety systems
- Fast vacuum valves
- HVAC control
- Undulators

The control system may monitor the operations of these systems but will not provide control signals to them. The control system will provide a veto signal to the undulator controls to ensure that undulator changes take place only when the CLS operator has allowed such changes.

2 EPICS

The CLS control system will be based on EPICS (Experimental Physics and Industrial Control System). EPICS is based on a distributed network of computer nodes. The hardware building blocks of EPICS are the Input/Output Controllers (IOCs), the Operator Interfaces (OPIs) and a Local-Area Network (LAN). The IOCs communicate with the devices to be monitor and controlled through Field Buses. The distributed nature of EPICS makes it possible to control any piece of equipment from any workstation on the network. Security restrictions can be applied to ensure that any given signal can be controlled from a particular subset of workstations or operators.

The EPICS run-time environment provides several components which share a standard communications layer. There are components for data acquisition, supervisory control, continuous control and sequential control. Other components provide interfaces to modelling and analysis packages.

The run-time environment uses a database to isolate the hardware characteristics of the I/O devices from the higher-level control routines. The database is distributed among the IOCs so that each IOC contains information on the signals for which it is responsible.

Data flow through EPICS is event driven. It is not necessary to poll a data source. Instead, the data source will inform all consumers when the data changes. This dramatically reduces the communication traffic between data sources and data consumers.

The EPICS state-notation language will be used to automate many of the tasks now performed by the operater. The aim is to make operation of starting the machine and delivering a high-quality electron beam to the booster ring as simple as clicking an 'ON' button on a control-room workstation screen.

EPICS also provides extensive support for handling alarm conditions from equipment. Alarm display screens will provide immediate indication of the location and type of equipment or software failure.

3 CLS Input/Output Controllers

The EPICS IOC routines may be run on a wide range of hardware. Initially the CLS project will use the MVME167 VME single-board computers which were used at SAL for experiment data acquisition. Future IOCs will use more modern, and much faster, VME single-board computers such as the Motorola MVME2400 series.

Work done at the CLS has shown that the EPICS IOC core software can be run directly on the embedded controllers developed at the CLS. This will allow us to greatly increase the number of EPICS IOC's and reduce costs by reducing the number of field bus connections between IOC's and other equipment. For example, we will install an embedded controller in each of our existing magnet power supplies to replace the CAMAC IGOR modules which had been used to control the supplies. It is now possible to run the EPICS IOC core routines directly on the embedded controller and treat each power supply as an EPICS IOC.

4 CLS Operator Interfaces

Sun and PC/Linux workstations will be used to develop the operator interface display and control software. Several workstations will be installed in the control room. Some of these workstations will be used to display information from various monitor systems and others will be used for controlling the linac, transport lines, and rings. The EPCIS operator interface code will also be installed on some laptop computers to allow local control of equipment during testing and maintenance.

As many control and monitoring functions as possible will be implemented by the EPICS control system. This will minimize the number of discrete control elements (buttons, knobs, displays) the operators will have to deal with to control the machine.

Knob boxes will be available in the new control system.

5 CLS Control System LAN

Separate LAN segments joined to an Ethernet switch will be used to join the IOCs and the OPIs. A router will control access between the control system network and the general laboratory network. The control system LAN will be a twisted-pair 100 Megabit/second network. If necessary, some fibre optic segments will be used in very electrically-noisy locations.

The 'field-bus' Ethernet segments will be 10 Mbits/sec twisted-pair (10base2). Each such segment will include a connection to a router to the main control system network. This will allow control of the devices even if the IOC for that segment has failed.

6 CLS Field Buses

EPICS supports a number of Field Buses which are used to communicate information between I/O Controllers and smaller embedded computers which operate the devices to be monitored and controlled. The CLS will employ several of these buses:

- VME
  The IOCs are VME single-board computers. In most cases the actual control operations will be handled by smaller, remote, processors connected to the IOC through one of the field buses mentioned below. In some cases, though, additional modules will be added to the IOC VME crates to handle special operations such as:
  - Programmable delay generation
  - Peak-sensing analog to digital conversion
  - Time-to-digital conversion
  - Video digitization
- Ethernet
  EPCIS uses Ethernet as the LAN to communicate between IOCs and OPIs. The IOCs will be equipped with additional Ethernet interfaces to be used as field buses to equipment such as:
  - Magnet power supplies
  - Stepper motors
  - Timing system

  The recent porting of the EPICS IOC core to the CLS embedded controllers will allow many of these Ethernet field buses to be replaced with small EPICS IOCs.
- Allen-Bradley
- Modicon
  Allen-Bradley and Modicon controllers will be used for low-level control of equipment such as heat exchangers and the RF modulators. These controllers communicate with each other over a DeviceNet link and with the IOCs over a serial RS-232 link or a TCP/IP ethernet connection.
- FieldPoint
  National Instruments FieldPoint devices will be used for monitoring interlocks, temperatures, water pressures and other slow-changing analog signals. These devices communicate with each other over a serial RS-485 link and will communicate with the IOCs over a serial RS-232 link or a TCP/IP ethernet connection.
- GPIB
  GPIB will find more application in various monitor subsystems but will also be used to communicate between the control system and devices such as:
  - Voltmeters
  - Digital oscilloscopes
  - Spectrum analyzers

  GPIB/Ethernet adapters will be used to communicate between GPIB devices and IOC ethernet field buses.
- CAMAC
  The existing SAL control system uses CAMAC modules in crates connected to the control computer by a serial highway. This system will be replaced by the field buses noted above, but to provide control during the early stages of the conversion a serial highway driver will be installed in an EPICS IOC. It is anticipated that all CAMAC equipment will have been replaced by the the time the CLS is to be commissioned.

EPICS is distributed with support for all of the above field buses except Ethernet and FieldPoint. EPICS drivers will have to be written for devices connected to these field buses.

7 CLS IOC Assignments

The number and location of the Input/Output Controllers will be determined after more experience has been gained in the operation of EPICS. An initial estimate is that 12 VME IOC devices will be used:

- Facility conventional controls (monitoring only)
- Linac and transport line beam monitors
- LINAC (RF Modulators, Magnet power Supplies) and LTB1 transport line
- Booster ring including booster to storage transport line
- Storage ring magnets, heat exchangers, etc. (4)
- Storage ring RF
- Storage ring beam monitors
- Storage ring orbit correction

In addition, small embedded IOCs will be installed in each existing magnet power supply and in other locations such as the stepper motor controllers.

The degree to which monitor and control functions are shared between the IOCs in each area of the facility remains to be determined.