

## PROGRESS ON THE DIAMOND CONTROL SYSTEM

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### *Abstract*

Diamond is a new synchrotron light source currently being designed and constructed in the UK. The control system for Diamond will be a site-wide monitoring and control system for the accelerators, beamlines and conventional facilities. Progress on the detailed design of the control system is presented. This includes refinement in the choice of EPICS tools, the development of tools and applications, and design of the control system structure, including solutions for interface options, control system networking, machine protection, wide band signals and physical implementation.

### INTRODUCTION

Diamond is a 3rd generation, 3GeV synchrotron light source currently being constructed in the UK. The storage ring is based on a 24-cell double bend achromatic lattice of 561m circumference. It uses a full energy booster synchrotron and linac for injection. The spectral output is optimised for high brightness up to 20keV from undulators and high flux up to 100keV from multipole wigglers. Initial construction includes seven photon beamlines.

The project is currently in a detailed design, procurement and construction stage. Phase one of the building work, covering the enabling works, site preparation and foundations, was recently completed. Phase two of the building work, including the annular accelerator building and office block together with the enclosures for the three accelerators, is now commencing. Tenders have been invited for major contracts to supply accelerator components, including the Linac, RF cavities, magnets and girders, and these contracts are being placed. Details of the project status are described in [1].

The outline design for the control system was reviewed in [2], which presented the choice of control system tool kit, the estimated interface requirements and the initial requirements for software applications, and indicated how these would be realised. This paper follows on from the above work and refines the specification in these areas.

### DEVELOPMENT ENVIRONMENT

#### *EPICS Tool Kit*

The current development work makes use of EPICS base 3.13.4 and VxWorks 5.4, with development taking place on PCs running RedHat Linux 7.3. This is proving

to be a stable environment. It is planned to move to EPICS base 3.14.X prior to the main installation.

#### *Application Development Environment.*

Developers generally work on a local Linux PC with shared drive access to a central server. This makes for an environment that provides good performance and is cost-effective. The central server is again a Linux based PC and provides disc services. It further provides a central directory structure where production work is installed and from which the object files and databases for operational IOCs will be derived.

#### *Version Control*

CVS [3] is used to manage version control and the migration of work from the local development PCs to the central server production area, i.e. work is checked in to CVS from local PCs and checked out into the production area.

Once in the production area, it is planned that all database templates are substituted to create fully instantiated databases. These are loaded by the IOCs and are further loaded into an Oracle RDBMS. This provides a mechanism to query the installed control system.

#### *EPICS Database Design tool*

Development has now standardised on VisualDCT [4] as the principal tool for the design of the EPICS database. Databases are being created as templates for particular instruments or subsystems and substitution files are being created to realise the instances.

### APPLICATIONS

The principal application requirements can be met through the standard EPICS tools; synoptic panels through EDM, alarm management through Alarm Handler and archiving through Channel Archiver together with scripting languages for rapid application development.

Recent work has successfully evaluated Java and the Abeans [5] component from CosyLab, for developing applications which require programmatic functionality.

A standard application for viewing and controlling channels in a tabular form is planned, the design being based on the Control Desk [6] program used on the SRS at Daresbury. This will be developed in Java.

Soft records are currently being used to simulate the technical systems. In particular a linear model of the storage ring is being created to run on an EPICS IOC,

enabling the physics group to develop physics applications which communicate through channel access.

## PHYSICAL STRUCTURE

### *Equipment Interface*

The interface from the control system to the equipment will be through VME64X Input Output Controllers (IOCs). IOCs will be installed for each technical system e.g. Vacuum and for each geographical area, i.e. per cell on the storage ring, giving a total of around 235 IOCs, as shown in table 1. These will use PowerPC processor boards, Industry Pack carriers and modules as the principal interfaces. The preferred interfaces to equipment will be analogue, digital and serial (RS232, RS422 etc). Each IOC will also contain an event receiver for synchronous operation and accurate time stamping of data. This combination allows for a high density of IO from a compact VME system, with most requirements being satisfied by four VME modules housed in seven-slot crates.

Table 1: Numbers of IOCs

IOCs	Linac	Tx Paths	Booster	SR	BLs (7)
Main Magnets		1	1	25	
Steering Magnets		1	1	24	
RF	1		2	5	
Vacuum	1	2	4	48	7
Diagnostics	1	2	4	25	
Pulsed PSUs			1	1	
Personnel Safety	1			2	2
Vessel protection				24	
Rad. Monitors	1			2	2
IDs or Motors				35	7
Misc				5	2
TOTALS	5	6	13	191	20

### *Serial Interfaces*

The decision has been taken to support the interfacing of equipment through serial interfaces. This offers benefits in being able to use commercial off-the-shelf equipment, reduced wiring, better correlation with local equipment values, and reduced installation and commissioning times. It is recognised that serial data processing will impose an IOC CPU overhead and supporting multiple vendor specific protocols will impose a development overhead.

Two software solutions have been adopted for serial support. The first, based on StreamDevice [7] uses a protocol file to define the messages as sscanf and printf format strings. This has limitations in the support of CRCs and some variable length terminations. The second approach uses ORNL Serial [8], which provides a framework for calling protocol-specific transmit and receive routines but requires code development for each protocol.

### *Programmable Logic Controllers(PLCs)*

Options for two PLC [9] requirements are being evaluated. One requirement is for a low-end unit, which will provide interlocking and control, e.g. for vacuum valves, and the other is for a high-end unit which will be used on the Linac controls, RF cavity controls and the cryoplant controls. The low-end unit will be interfaced to the IOC using a serial protocol over an RS232 connection and the high-end unit, using the Industrial Ethernet protocol over an Ethernet connection.

### *Equipment Protection*

Equipment protection is included within the control system where required, with the control system issuing hard-wired "permit to operate" signals to equipment. Three levels of protection, determined by assessment of damage/cost caused by failure, are: High Integrity, provided in hardware; Routine Interlocking, provided by PLCs; Prudent Operational Limits, provided by IOCs.

Machine Protection interlocks are required to protect the storage ring vessel and dipole magnets. These will be generated at each control and instrumentation area, converted and sent via the control system computer room over the fibre optic cables to the RF plant and dipole PSUs respectively.

### *Physical Structure*

The control system will interface to the other technical systems at 43 control and instrumentation areas (CIAs) covering the linac, booster, transfer lines, plant rooms, storage ring, first 7 beamlines and technical services (building and cryogenics). For the storage ring there will be one control and instrumentation area per cell, thereby ensuring that each cell is self-contained.

The CIAs are rooms within the building that contain the control and instrumentation. They are air conditioned to maintain a clean and temperature-stabilised environment for the instrumentation. The CIA structure provides sound insulation, reducing the noise level in the building by reducing the contribution from fans contained in the instrumentation which is located in the CIAs.

### *Network*

A fibre optic infrastructure is being installed from each of the CIAs back to the control system computer room and from there to the control room. It will consist of a mixture of single- and multi-mode fibres. Consideration is being given to installing these in a blown fibre [10] structure, thereby enabling future upgrade. The fibres will

provide two computer networks, a control system network and a secondary computer network, to enable effective management of traffic on the control system network. Each network will use a central switch in the control system computer room and a further layer of switches at each control and instrumentation area. One application of the secondary network will be to stream video images back to the control room using H.323 protocol. This will be used by video cameras on optical beam monitors and by cameras to monitor personnel access to the accelerator enclosures as part of the personnel safety system [11].

The fibres will further be used for event distribution, for the machine protection system, for the beam position feedback system and to realise wide band, up to 3 GHz, analogue connections to the control room. The solution being considered [12] uses point-to-point connections with direct modulation of the analogue signal on to the fibre.

## CONSTRUCTION

The detailed programme of work for construction phase of the project is currently being planned with latest options presented.

### *Procurement*

The majority of control system hardware is being procured on a component basis and integrated in house. This hardware comprises VME crates, processor boards, racks, generic IO modules, timing components, and PLC interlock sub-systems.

A number of systems are being procured as turnkey contracts complete with EPICS-based controls. Contracts along these lines have been placed for Linac, RF amplifiers and RF cavities. Tender exercises for permanent magnet insertion devices, girder motion control, diagnostics and other system with EPICS support are ongoing.

For each of the above, DLS has specified the EPICS components to use. It has provided these components in each case in the form of an EPICS development environment installed on a Linux PC which has been loaned to the supplier. It is envisaged that the resultant solution developed by the supplier will be easier to integrate into the Diamond application development environment so resulting in less overhead to DLS.

### *Commissioning*

Commissioning is planned to progress through the linac, booster and storage ring. The storage ring cells are each based on three girders, which support the vessel and magnets. These will be constructed offline and at this stage tested in conjunction with the control system. Because each cell of the storage ring is self-contained, once the technical systems for a cell are installed, the control system for that cell can be set to work and commissioned.

## CONCLUSION

The structure for the Diamond control system is now being defined. With the control system well specified early on in the project the detailed design can be resolved to ensure a high level of functionality available for day one commissioning.

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