STATUS OF THE ERLP CONTROL SYSTEM

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Abstract

The Energy Recovery Linac Prototype (ERLP) is a 35 MeV superconducting linac currently being commissioned at Daresbury Laboratory. Its purpose is to demonstrate the technology necessary to design and build a 600 MeV energy recovery linac (4GLS), which, together with a suite of XUV, VUV, and IR FELs can be used to undertake pump-probe experiments to investigate dynamic systems. The ERLP control system is based on EPICS, VME64x hardware and the VxWorks operating system. Status control and interlock protection are handled by a Daresbury-designed CANbus system that has been tightly integrated into EPICS. Construction and commissioning of ERLP have taken place in parallel, and this introduced a number of problems in the planning and implementation of the control system. This paper describes the ERLP control system and discusses the successes and difficulties encountered during the early phases of commissioning. Plans are already in place to extend the control system to cover EMMA, a novel, non-scaling, fixed-field alternating gradient (FFAG) accelerator that will be added to ERLP in 2008/9.

INTRODUCTION

When completed, the ERLP (Figure 1) will be the first operational example of an energy recovery linac in Europe. The building of ERLP will allow experience to be gained with energy recovery and to allow 4GLS design problems to be investigated.

The initial cost constraints and the development of a prototype machine have created a number of challenges for the control system. Non-standard and reconditioned equipment has been widely used. The decision was made at the start of the project to use EPICS and VxWorks.

The control system for ERLP is now nearing completion but the control system for EMMA will present new challenges such as providing real time feedback.

CURRENT STATUS

There are two stages of the ERLP. Build phase 1 was to complete the photo-injector into a test beamline. This was to characterise the injector before connecting to the main energy recovery ring. First beam was achieved in August 2006 and the control system was fully operational in time for this milestone. Phase 2 involves removing the diagnostic line and completing the ERLP machine layout to achieve energy recovery.

At present, the test beamline is still in place but the main ring has been built up in parallel allowing the control systems to be commissioned. The cryogenic systems are now fully operational; RF commissioning is also well advanced.

Energy recovery is now planned to take place in March 2008.

SYSTEM OVERVIEW

Hardware

The ERLP control system has 8 IOCs (6 VME crates, 1 rack-mount PC and 1 desktop PC.

For on/off control the existing CANbus Status System was chosen. This is an in-house design developed for use on the Synchrotron Radiation Source (SRS) [4].

Serial interfaces are widely used for motor drives, radiation monitors and PSUs. Serial and network-based GPIB interfaces are used for BPM multiplexing and laser

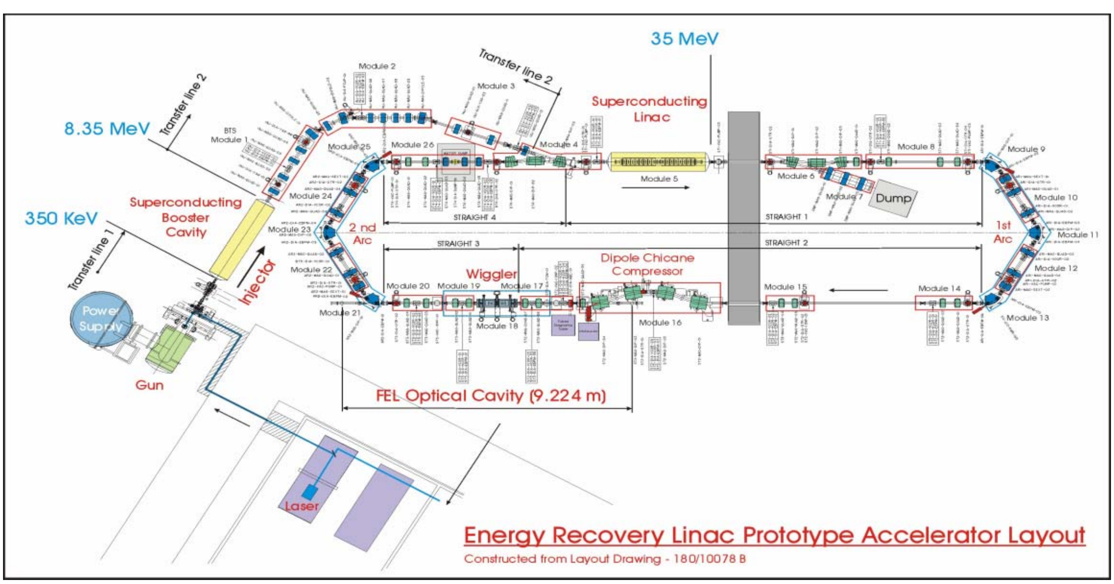

Figure 1: The ERLP Layout.

timing generation.

Analogue read back is used on all vacuum equipment specified to be manual control only.

Software

All IOCs run EPICS 3.13.4 apart from a Windows PC which runs 3.14.8. Two main consoles and two portable laptop consoles allow commissioning in the machine areas. Three Linux servers are used for IOC boot, archive and web interface; all run Linux Red Hat 9 apart from archiver which uses Fedora Core 5 because Red Hat 9 does not readily support the SATA disk interface that is found in the current PCs.

Network

Two 100MB HP switches are used; one in the main equipment room and one in the control room. They interconnect with a 1GB link. One switch has an external fibre feed. Each switch is configured to have half its ports on a dedicated private control network and half to the external office network, this configuration allows any connection in the machine area to be connected to the control system or site office network. VLANs are used to connect to development machines in remote office areas. Routing is done internally on one of the switches thus allowing the incoming fibre to be disconnected isolating the control system from external influence.

SYSTEM HIGHLIGHTS

CAN Bus Status System

The CANbus Status System[2][3][4] is a series of control interfaces used for equipment status control. It relies upon a real time operating system to control the bus. It was decided that the IOC would be used to control the CANbus directly.

Controlling the CANbus directly from an IOC has proved very successful and flexible. Allowing the EPICS records to control plant interlocks has proved to have some good advantages:

- Interlocks can be easily patched between controlled devices.
- Changes can be easily made on line to disable or move interlocks.
- Analogue parameters can be fed into conditional expressions and then used to output to interlock bits.

GUI Production

A Tcl/Tk hierarchical menu system is used to launch the control screens all of which are produced by EDM, but it is planned to move to using a Windows .NET platform which is currently being developed [5]. The decision to develop on the windows platform was derived form comparisons between the ERLP EDM and the SRS Visual Basic control screens.

Web Interface

To allow machine conditioning to be monitored externally a web interface was requested.

To achieve this, a Linux PC hosts an EDM display containing all the main ERLP vacuum parameters. This window is then captured and transferred to a web server.

LINDE Cryo Interface

The cryogenic system was originally specified as a stand alone system to save costs. When RF commissioning started it soon became apparent that information from the cryogenic system needed to be integrated into the control system. The problem was solved at no additional cost by installing EPICS OPC version 3.14.8[6] on the Linde control PC. The tags from the Linde control synoptic are converted to epics records on the PC and can then be displayed on the EDM screens and accessed by all IOC's (see Fig 2).

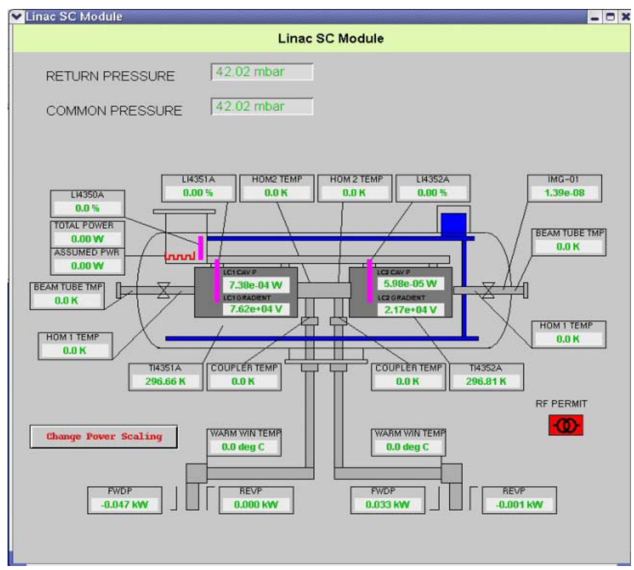

Figure 2: Combined Cryo and RF display.

Stepper Motor Control

Multi axis stepper motor control equipment was recovered from redundant SRS Beamlines. The Parker 6K controllers now drive a variety of equipment, including moving arcs, diagnostic screens and collimating slits. The 6K also drives a laser attenuator which requires a complex sequence of moves to align two filters with one motor, all of which is achieved automatically using the subroutine record (Figure 2). Each 6K controller has 8 axis control commanded by one serial line using Steam Device.

Photo-Injector Cathode Charge Counter

The photo-injector cathode has a limited life and it is therefore essential to know as precisely as possible the amount of current extracted from each cathode.

Laser parameters are summed and conditional records monitor all the conditions necessary for producing photo cathode output. When all conditions are correct the output current display is accumulated for the life of the current cathode (Figure 3).

BPM Multiplexing

The processing electronics for BPM signals are high cost therefore only a quarter of the position signals on ERLP could be read back. This problem was solved by using three HP3488A Switch control units and six HP44478A 1.3GHz switching units. These HP units multiplex the signals from the BPM buttons. The switching units are then operated via stream device controlling a Brainbox serial to GPIB interface.

Figure 3: Filter wheel control & Cathode Charge Counter.

500 kV Photo-cathode Gun Supply

The stability and control of the photo-cathode PSU is critical to the operation of the ERLP injector. The control system controls the ramp rate for normal operation, but also shuts down if any out-gassing is sensed from ion pump current fluctuations. Conditioning of the surfaces in the gun can be a lengthy process, operators can adjust voltage, current and vacuum limits/trips during the process.

The implementation of EPICS control for the Glassman PK500 PSU proved troublesome in that the RS232 control protocol acted on more than one parameter per instruction. A dedicated driver was written to circumvent the aforementioned difficulty, allowing independent access of individual parameters from EPICS records. This solution also facilitated a simple means of monitoring integrity of communications.

50 kV IOT Supply

RF is supplied to ERLP via IOT amplifiers that require a 50 kV supply. The direct interlock and ramp control for the supply is achieved using a Siemens S7 PLC this is then controlled via the network by transferring a data block.

COMISSIONING ISSUES

Heat Loading

Excessive running temperatures were observed on moderately populated IOCs – sufficient to melt soldered joints. Mitigation took the form of installing an additional fan, the largest physically possible, in each IOC. The result of the above was to reduce running temperatures to acceptable levels.

Boot-up Problems

Pre-expanded databases are now preferred as they have been found to improve boot-up times. In some instances serial devices have been moved to a separate IOC as they have been found to degrade other systems. A new version of the Status System has been developed which is more robust, contains addition diagnostics and uses new notation.

CONCLUSIONS

The ERLP project differs from most projects; due to cost constraints the initial control system was minimal. The decision to design systems with 50% reserve has proved to be the correct choice to accommodate a dynamic specification. Commissioning still remains to achieve energy recovery. After energy recovery is achieved work will still be needed to make ERLP an operational user machine.

New projects are now underway which will make use of the ERLP facility; a multi-Terawatt laser has been installed and work is now underway on the design and build of the TW laser to ERLP transport line. This project can be accommodated within the current control system.

The FFAG machine EMMA will require a new control system in a new location and more demanding challenges to provide the real time beam position feedback and control.

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