

Development of the Control System for ERLP

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ABSTRACT

ERLP will be a fully functional prototype for the Forth Generation Light Source (4GLS) a new machine to be built at Daresbury Laboratory. 4GLS will be a world-leading photon facility to enable internationally outstanding science by the ‘low-energy’ community in the UK and internationally. It will involve super-conducting linac technology with energy recovery and there will be a suite of light sources – spontaneous SR sources (*i.e.* traditional SR but in more intense, shorter bursts), stimulated sources (*i.e.* free electron lasers) and combinations of these sources with each other and with conventional lasers. The control system for ERLP is reusing some equipment and design philosophies from the Synchrotron Radiation Source (SRS) but using EPICS and VxWorks on VME64x. The status control and interlock protection system of the SRS uses close coupling of the plant equipment and its associated interlocks the latest generation uses an in-house CANbus hardware controller, this controller been integrated into the EPICS philosophy for use on ERLP. The reuse of recovered equipment has been encouraged but has resulted in increased the development time. The prototype nature of the project has presented additional challenges, which are addressed by a geographical approach to the control system design, together with flexibility designed into each sector.

INTRODUCTION

4GLS will be a uniquely flexible source of ultra-high brightness continuous and pulsed radiation covering the IR to XUV parts of the spectrum. It is the first light source in the world that is planned from the outset to be a multi-user, multi-source national facility combining ERL (energy recovery linac) and FEL (free electron laser) technology. ERL technology provides high brightness, short pulse radiation, which vastly surpasses that provided by conventional storage ring technology. It also allows tailored pulse characteristics, leading to a high level of experimental flexibility. [1]

When completed the ERLP (Energy Recovery Linac Prototype) (Figure 1) will be the first operational example of energy recovery 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 majority of the control system will use hardware which has existing driver support, apart from the SRS Status System which will be described in this paper.

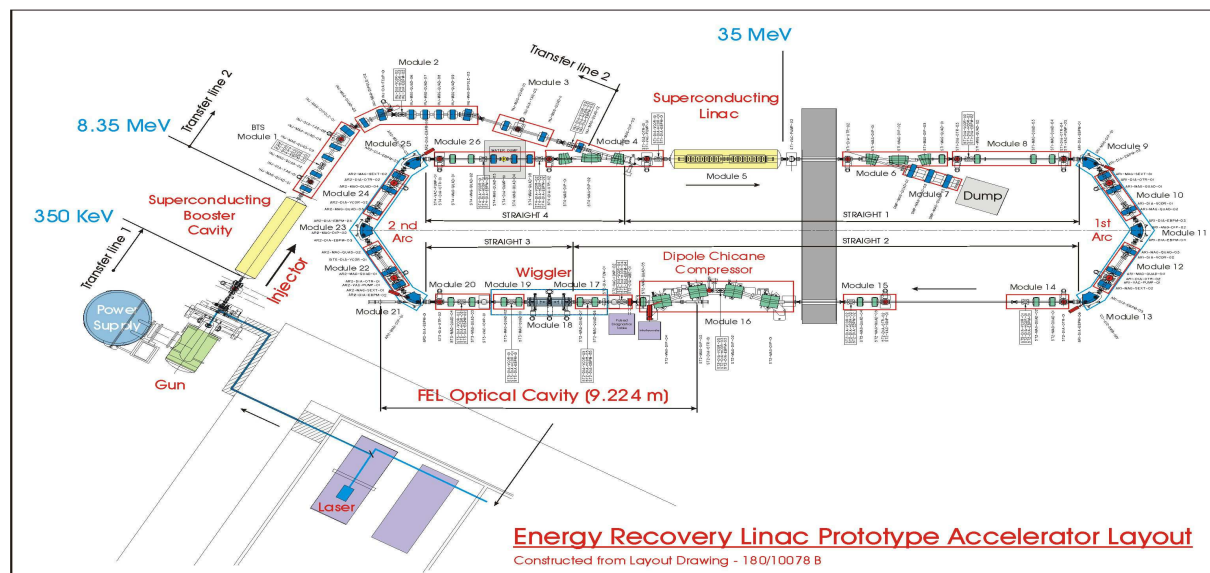


Figure 1 ERLP

CONTROL SYSTEM DESIGN PHILOSOPHY

Two clear goals were identified at the start of the project: to minimise development costs and to gain useful experience for 4GLS. The initial goals lead to the following decisions, (a) Re-use existing equipment, designs and sub systems where possible, (b) Only integrate essential systems into the control system, (c) Use where possible software and hardware systems that are most likely to be used on 4GLS.

CONTROL SYSTEM CHOICES

Control System software

The control system has also been approached as a prototype for the 4GLS control system. EPICS and VxWorks on MVME2304 and VME64x have been chosen for ERLP allowing experience and knowledge to be gained in probably the most standard EPICS hardware and software configuration. Although EPICS is the logical choice for 4GLS, experiences with ERLP will also be used to evaluate the choice of platform and display manager.

Linux PC servers and consoles running Red Hat 9 are used throughout allowing the use of EDM. The EPICS channel Archiver and alarm handler will also be used. To allow the Accelerator Physicists to customise the control it is intended to interface MATLAB to the control system.

Control System Hardware

The prototype machine began as a physics concept leading to a mechanical layout. The specification has continually changed, gathering enough information to form a full control specification has proved impossible therefore the decision was made to divide the machine into four geographical areas which reference to four equipment bays in a control equipment room each with an EPICS IOC or "Control Station" designated to it. It is hoped that by providing extra capacity in each of the "Control Stations" that the continually changing specification resulting from a prototype machine can be accommodated.

The early adoption of a naming convention allowed designers to allocate equipment to the correct area of the machine together with control requirements.

The use of recovered equipment was encouraged but this, in a lot of cases, has resulted in increased development time, to control a variety of equipment which in most cases has also required modification for control and safety requirements.

Commonality where possible with the DIAMOND [2] control system has resulted in reduced resource use. The current DIAMOND systems that are being used are some Ion Pumps, Radiation Monitors and the Personnel Safety System [3] which is adapted from the SRS system.

IP modules have been used for all IOC interface requirements allowing extra capacity to be easily added.

The design and implementation of the network was one of the first tasks completed, it is configured to allow patching either of two networks into any area of the machine, the Daresbury site network and a routed ERLP control network.

A multi-port terminal server is used in the control equipment room to allow remote control and development of the Control Station IOC's.

For on/off control the existing CANbus Status System was chosen. This is an in house design developed for use on the SRS. The advantages of using this system over a PLC solution are cost and familiarity of use by installation and design staff. While the majority of equipment can be interfaced using the standard EPICS drivers this is not the case for the Status System. The development of the software to integrate the status system will now be described.

CANBUS STATUS SYSTEM EPICS INTEGRATION

The CANbus Status System is a series of control interfaces used for equipment on/off 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.

The CANbus Status Interface

A CANbus hardware controller originally designed in-house for use on the SRS has proved very reliable and at a lower cost than PLC control solutions. The design uses a Motorola 8bit micro controller, with built-in CAN controller, to interface between the plant and the CANbus (see Fig 2). This receives all CAN messages, decodes the messages destined for that module, writes the outputs and reads the inputs to reply to message requests, write status, read status with 8 interlocks, read status with 16 interlocks and reserved functions. The write status message is used to refresh a watchdog timer in the microcontroller by toggling a bit in alternate messages. The watchdog has a time-out period of 160 msec and enables the signals to drive the output relays. [4][5]

The CAN status module includes the option to be configured as a dual channel module consisting of two groups of status signals and 8 interlocks each, or as per the original standard of one channel of status, and 16 interlocks.

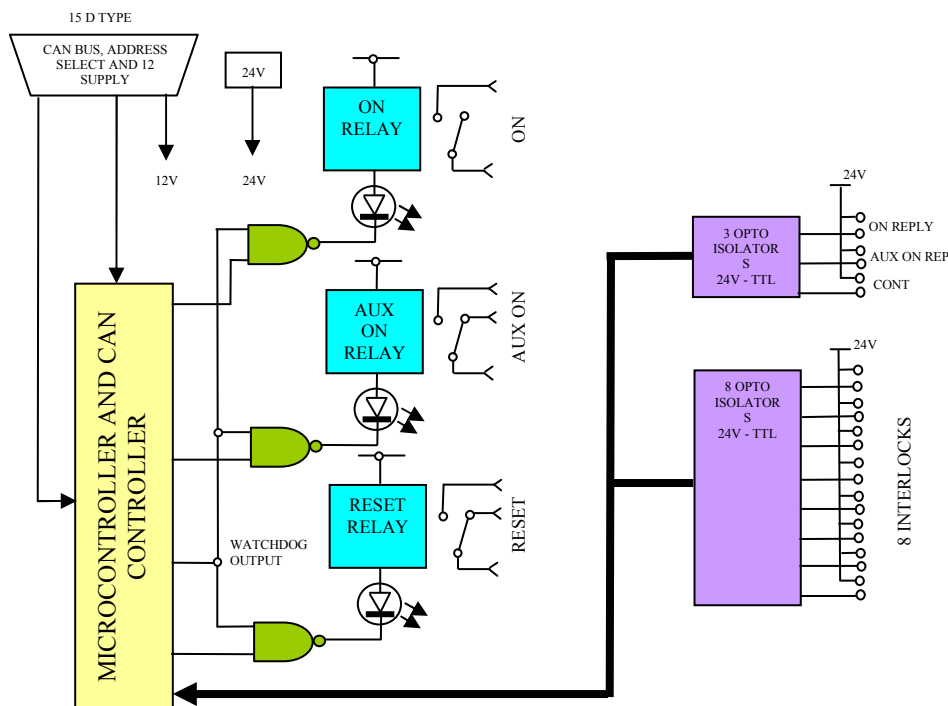


Figure 2 One Half of the CAN Status Module

EPICS Control

When the IOC is booted a service process is started. This is required to ensure that the 160mS watchdog timer in the status interface is kept alive (see Figure 3). The records must also process at a much lower rate to keep an auxiliary EPICS watchdog alive. This ensures that if any component in the chain fails the controlled equipment will be disabled.

All control passes through the service process but the equipment on, off, and fault control decisions are via the records. A single Binary input record is used for each interlock this allows good flexibility for example an interlock input can be used from another module on a different IOC.

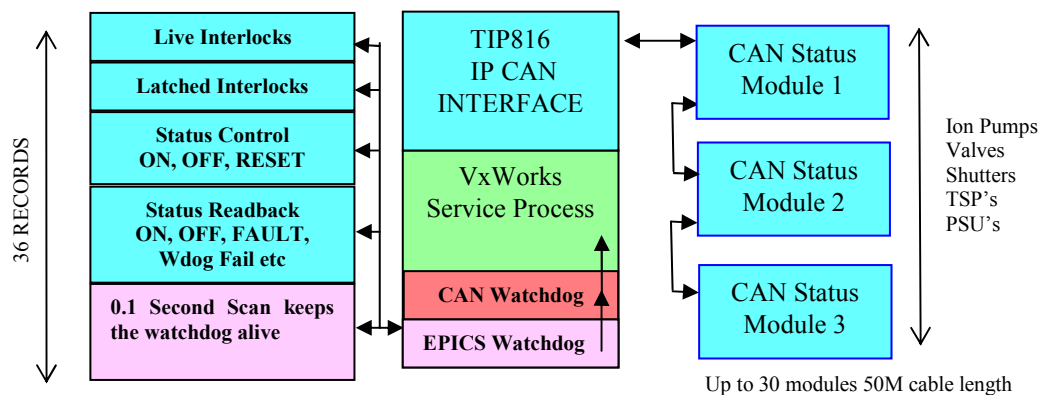


Figure 3 CAN Status module control

Templates for CAN Modules

To control one half of the status module requires approx 36 records by using a template for the records, duplicates were created and modified so that the differing characteristics of the equipment to be controlled can be easily catered for see figure 4.

```

file Valve.db - Template for a Valve
{
pattern {mod,address,in1,in2,in3,in4,in5,in6,in7,in8,is1,is2,is3,is4,is5,is6,is7,is8,time }
{ INJ-LSR-SHUT-02,0007, - Parameter and CAN Address
"24v off",
"Closed Limit",
"LSR MOT not Idle ",
"LSR Fil not Idle",           - Interlock names
"P Safety Lsr GLA",
"P Safety Lsr GLB",
" ",
" ",
"INJ-VAC-AUXL-01:IL.B0",
"INJ-LSR-SHUT-02:IL.B1",
"INJ-LSR-FILT-01:IDLE",
"INJ-LSR-FILT-01:FIDL",
"INJ-LSR-SHUT-02:IL.B4",     - Interlock Sources
"INJ-LSR-SHUT-02:IL.B5",
"INJ-LSR-SHUT-02:GOOD",
"INJ-LSR-SHUT-02:GOOD",
"60"                         - Max opening time
}
    
```

Figure 4 Substitution entries for a shutter

PROGRESS

The ERLP project is still in the build phase. The first stage is to complete and commission the photo-injector. Two control stations and the personnel safety system are installed and working together with servers and consoles in the control room.

CONCLUSIONS

It would have been the easy choice to use the SRS control system for ERLP but the experience gained in using EPICS and VxWorks will prove to be invaluable when a choice of control system for 4GLS is to be made.

Extra capacity was built into the network and Control Station infrastructure this has proved worthwhile because areas of the machine that were designated as manual control have subsequently been added to the control system.

The use of a naming convention has proved essential allowing all disciplines to understand the nature of equipment and its location.

Record name and field length was an unexpected limitation in EPICS version 3.13.4 a later version could not be used because it would require VxWorks to be upgraded incurring the cost of a new licence.

It was found that the development of EDM panels is better achieved by direct access to a LINUX PC rather than using Exceed because of problems with fonts. Setting a standard set of fonts and colours would also be recommended at the start of a project.

As anticipated extra requirements are discovered each month, ERLP differs from most synchrotron projects by having a photo-injector this has also provided control challenges such as automatically filtering the laser light to protect detection cameras.

REFERENCES

[1] <http://www.4gls.ac.uk/>

[2] <http://www.diamond.ac.uk>

[3] "Upgrading the Daresbury Personnel Safety Interlock System" by J R Alexander and M T Heron, International Conference on Accelerator and Large Experimental Physics control Systems, 2005, Geneva.

[4] S. V. Davis, M. T. Heron, A. Oates, B. G. Martlew, A. Quigley "Principles of Status Control and Interlock Protection System for the SRS" International Conference on Accelerator and Large Experimental Physics control Systems, 2003, Gyeongju, Korea.

[5] J. R. Alexander, B. Corker, S. V. Davis, M. T. Heron, A. Oates, "A CAN Based Status Control and Interlock Protection System for the SRS", International Conference on Accelerator and Large Experimental Physics control Systems, 1999, Trieste, Italy.