THE STATUS OF HLS CONTROL SYSTEM

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Abstract

HLS (Hefei Light Source) at NSRL (National Synchrotron Radiation Lab) consists of three parts: 200Mev linac, transport line and 800Mev storage ring. The control system was upgraded based on EPICS (Experimental Physics and Industrial Control system) from 1999 to 2004. This paper will cover the experience of using inexpensive hardware under EPICS, data archiving, and some high level tools for physics and operation use.

INTRODUCTION

HLS is a dedicated synchrotron radiation light source. It consists of a 200 MeV linac, a beam transport line, and an 800 MeV electron storage ring. As a part of NSRL phase II project, the upgrade of HLS control system was based on EPICS from 1999 to 2004. For practical and economic reason, inexpensive equipments play the main role in the control system. For example, a large number of industrial PCs (IPCs) are used as OPI, IOC and device controllers. Now, the system includes the following subsystems:

- Power supply control: ring main magnet PS, ring corrector magnet PS, ring octupole magnet PS, ring skew quadrupole magnet PS; wiggler PS; transport line magnet PS, linac magnet PS, analysis magnet PS, switch magnet PS; klystron focusing coil PS; injection system pulse PS, linac modulator pulse PS
- RF control
- Vacuum control: ring vacuum, linac and transport line vacuum
- Beam measurement
- Interlock
- Water control

There are about 2,500 records resident in 19 IOCs. MEDM is used to edit and manage most of man-machine interfaces. Tcl/Tk and SDDS toolkit are used for complicated control such as ramping control. PHP is used to develop the web page server code. We can browse the machine status and query history data with web browser.

HARDWARE STRUCTURE

Figure 1 gives an overview of HLS control system hardware structure. SUN workstations and several PCs with Linux operating system are used as OPIs. SUN workstations are mainly used to control the ring main magnet power supplies and other key subsystems.

IPC is used as IOC in most subsystems. IOC communicates with device controllers via opto-coupled RS422/485, RS232 over optical fiber. The MOXA's multi-serial card C168P is used to expand the serial ports. Correspondingly the device driver is written to add the VxWorks's "tty" [1].

IPC is employed for most device controllers due to the inexpensive price and the support of a large amount of commercially available hardware and software products. Besides IPC, PLC and single-chip microcomputer are also used as device controllers.

100M-Ethernet is used in the local area network (LAN). 3 Cisco Switch are located at the central control room, the storage ring hall and the linac control room separately.

SOFTWARE DEVELOPMENT

IOC

There are about 2,500 records resident in 19 IOCs that compose the distributed database. The following record types are frequently used: AI, AO, BI, BO, Mbbi (Multi-bit Binary Input), Mbbo (Multi-bit Binary Output), MbbiDirect (Direct Multi-bit Binary Input), MbboDirect (Direct Multi-bit Binary Output), Subroutine. Before using DCT to create a run time database for the IOC, we write the Device Support and Device Drivers (if necessary) for each type of record.

The state notation language and sequencer are used to interlock and protect the devices.

OPI

Solaris and Linux are used as operating system for OPIs. Some OPI tools are used. For example, MEDM is used to edit and manage most of man-machine interfaces; sddslogger is used to archive data.

Some Tcl/Tk scripts are developed to perform high level control, which are used in the routine machine operation and machine study, for example, ramping control, slow orbit feedback. PHP is used to develop the web page server code. The details are shown in the following paragraphs.

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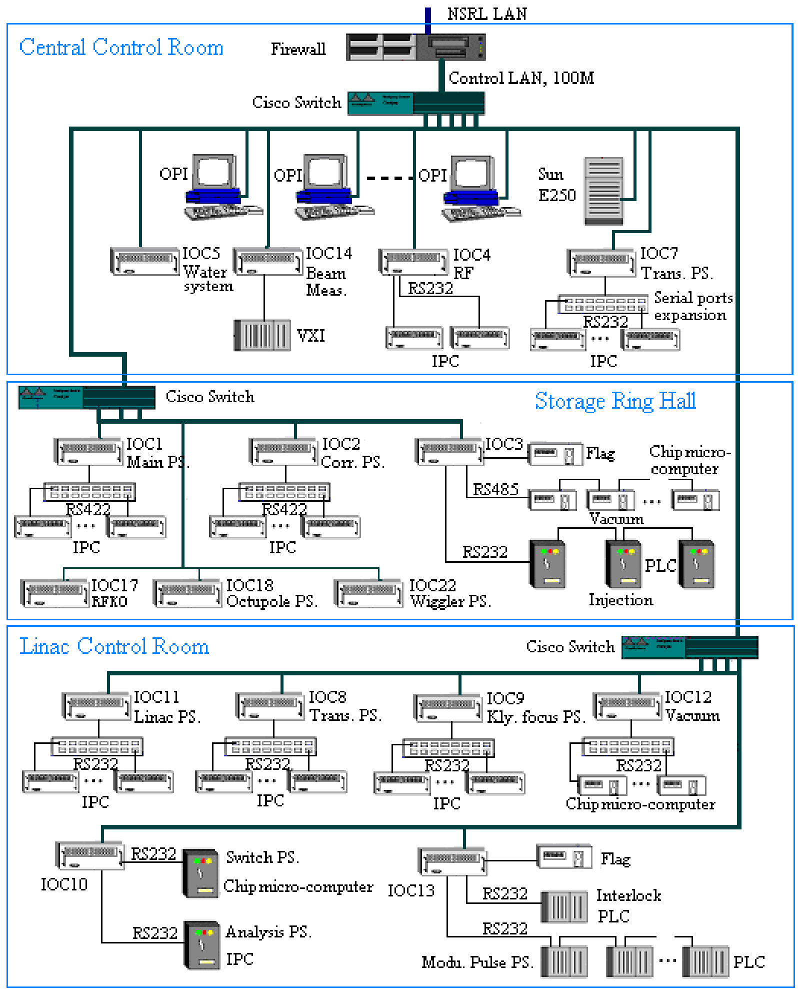

Figure 1: The hardware structure of HLS control system.

Ramping Control

There are 12 dipole, 32 quadrupole and 14 sextupole magnets along the HLS storage ring. The dipoles are powered by a 1000A regulated power supply; the quadrupoles are divided into 8 groups, each is powered by a 500A regulated power supply; the sextupoles are divided into 2 groups, each is powered by a 250A regulated power supply. Each power supply is controlled by a device controller. There are 11 device controllers in total. An IOC communicates with these device controllers via opto-coupled RS422.

After injected into the storage ring at energy of 200MeV, beam energy will be ramped up to 800MeV. Because the beam lifetime is calculated to be only 10 to 20 minutes at low energy, the ramping operation should not be too slow. At present, the ramping time is about 3 minutes.

The current waveforms of the magnets during a ramp are calculated based on beam dynamics and results of magnet field measurements. As the magnetization characters and time constants of the magnets are different, the current waveforms of each power supply will be different. The currents have to track each other during ramping in order to keep the ring lattice unchanged. The main function of ramping control is to assure the synchronization and accuracy of the magnet currents.

The code for the calculation of current waveforms is written in C language and the result is saved in a file. A Tcl/tk script is developed for the ramping process control and man-machine interface, as shown in fig.2. There is no dedicated hardware, and we call it soft ramping control. The functions of ramping, ramping down and tune ramping are realized easily with the method of soft ramping control [2].

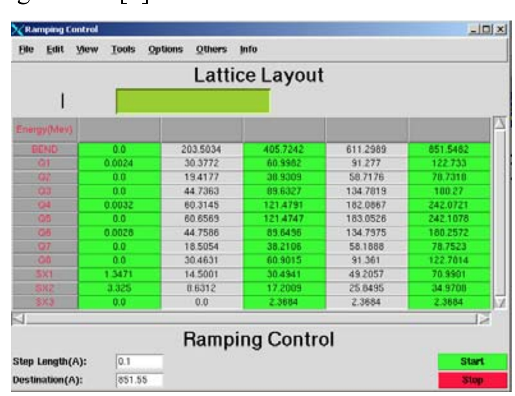

Figure 2: The panel of HLS beam ramping control.

Slow Orbit Feedback System

The closed orbit of the stored electrons in HLS storage ring often shifts due to some nonideal errors. The perturbed closed orbit, known as COD (Closed Orbit Distortion), has many bad effects, such as the decrease of beam lifetime, the photon position change at the front-end of photon beamlines. In order to correct the orbit distortion, we developed a slow orbit feedback system, which can be periodically or manually invoked to correct the global closed orbit and adjust the orbit position at some points using local bump [3].

There are 24 BPMs, 3 photon BPMs and 32 corrector magnet power supplies along the storage ring. The slow orbit feedback system gets BPM data and sets corrector strength via Channel Access. SVD method is used to obtain the corrector strength or corrector factors in global or local orbit correction. The code for slow orbit feedback system is written in Tcl/Tk script combined with SDDS toolkit [4].

For stable operation of experiment stations, the vertical photon position drift for some sensitive photon beamlines is limited within ±30 μm. Figure 3 shows the vertical photon position drift is about 60 μm within 6 hours at MCD photon beam line before correction. Figure 4 shows that the drift is adjusted within ±30 μm after correction.

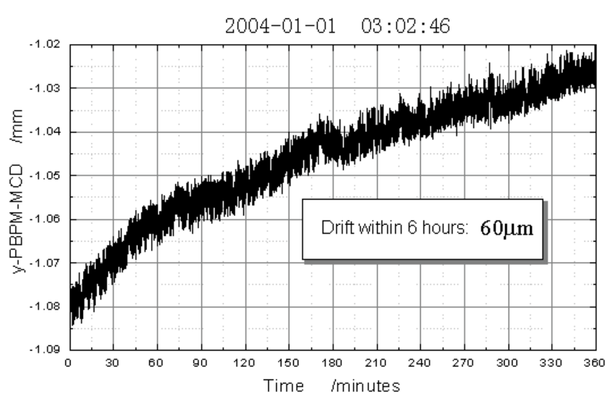

Figure 3: The vertical photon position drift at MCD photon beam line before correction.

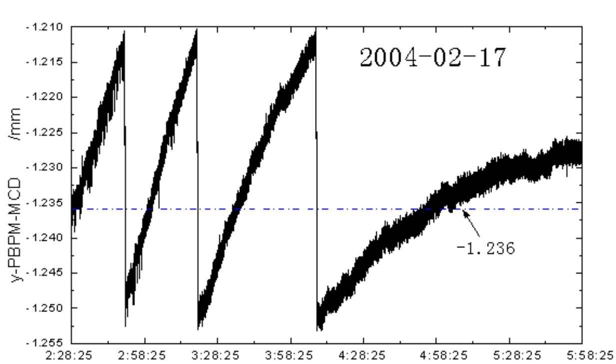

Figure 4: The vertical photon position drift at MCD photon beam line after correction.

Machine Status Online and History Data Query

A PC (Linux operating system) with double network cards is used as web server. We use sddslogger to archive data. PHP is used to develop the web page server code. We can browse the machine status and query history data with web browser. Fig. 5 shows the machine status online.

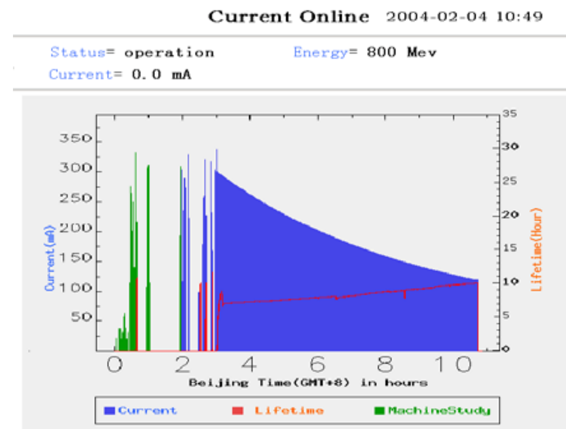

Figure 5: Machine status online of HLS.

CONCLUSION

Most subsystems of HLS control system have been in operation for over 2 years. It can satisfy the demands of the routine machine operation and machine study. Our experiences have proven that a control system is built with inexpensive controllers, for example IPC, PLC and single-chip microcomputer not only is extremely cost effective but also works fine.

ACKNOWLEDGEMENTS

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