REJUVENATION OF CONTROL SYSTEM OF THE UNDULATOR 50 IN TAIWAN LIGHT SOURCE

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Abstract

The Undulator 50 (U50) for Taiwan Light Source (TLS) was installed on March 1997 at NSRRC. It provides service for more than 15 years. Control system of U50 includes a PC running MS-DOS for local control. Motion controller contains two indexers with driver via RS-232 interface. It equip with IEEE-488 interface to connect to the VME system for remote access. The response time for command and reply is in the order of second, thus the throughput of the experiment for energy scan is time-consuming. New U50 control system will share the standard environment for insertion devices (ID) control for the Taiwan Photon Source (TPS) project. Ethernet based motion controller was chosen to drive motor drivers. All control functionality will coordinate by the cPCI EPICS IOC. To compatible with TLS existed control environment, a server program was develop to translate the protocol to EPICS PVs. All existed GUI of TLS still can be used. These improvements of control system for U50 are essential upgrading geared to avoid obsolescence of the control related parts, increase productivity and support on-the-fly experiments. The progress of the controls plan will be summarized in this report.

INTRODUCTION

The Taiwan Light Source (TLS) has been operated since 1993, which is a third generation of synchrotron light source built at the National Synchrotron Radiation Research Center (NSRRC) site in Taiwan. The TLS consists of a 50 MeV electron Linac, a 1.5 GeV booster synchrotron, and a storage ring with 360 mA top-up mode injection. The insertion device (ID) plays crucial role in third generation light source. The Undulator 50 (U50) [1], as shown in Fig. 1, for TLS was installed on March 1997. It provides service for more than 15 years. The main parameters of the U50 are shown in Table 1.

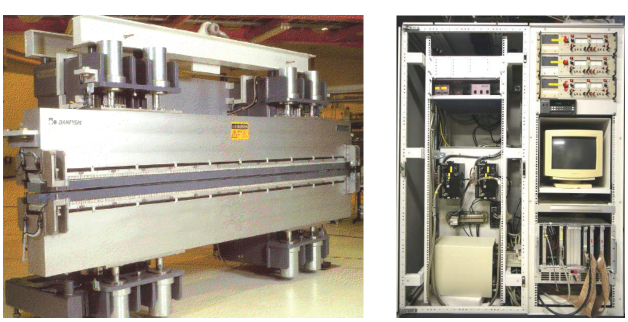

Figure 1: Photograph of U50 Insertion Device (left) and control rack (right).

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Table 1: The Main Parameters of the Undulator 50

Margin	Parameter
Type	Hybrid
λ (mm)	50
Min. gap (mm)	18
Number of periods	76
Photon energy (keV)	0.06-1.5
Deflection K	2.99
Bmax. (T)	0.64
Phase error Θ	3°
θx/θy (µrad)	6/11
δx/δy (µm)	7/10
Beam duct aperture (cm^2)	1.3x8
Max. magnetic force (ton)	3
Total length (m)	3.9

SYSTEM CONFIGURATION

There are several control elements for the insertion device (ID) operation such as motor driver, controller, trim coils power supply, interlock and temperature monitoring. The VME crate controller is the core of the control system configuration for all ID at TLS [2, 3]. Since the ID control functionalities are effectively shifted to the cPCI EPICS IOC for the TPS project. Thus, the new U50 control system shares this standard environment.

Old System Layout

The black diagram of the system layout is shown in Fig. 2, which includes a PC running MS-DOS for local control, GPIB interface for local compensation and DMM drivers, and RS485 interface for motor indexer and driver devices. The control system VME crate system connected to the U50 control system via a dedicated IEEE-488 link. There are several disadvantages of this system, such as:

- Special care needs to deal with obsolete hardware and software. There are no any supports now.
- The slow response of GPIB and RS485 interface cannot support fast energy scan for experiments.
- Response time for command and reply is in the order of second.
- Homing of the motion control system is needed after shutdown which takes a long time (~10 min) to process.

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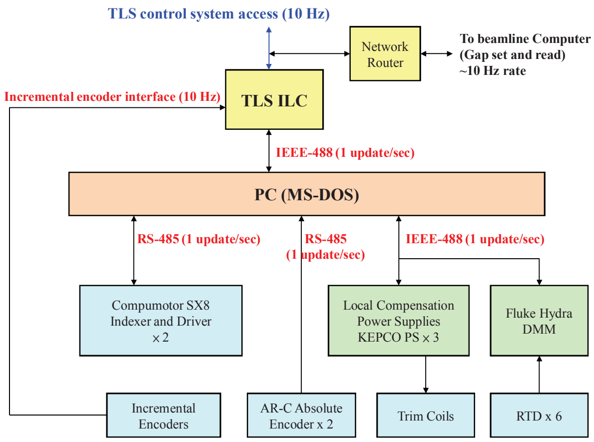

Figure 2: Original U50 undulator control environment.

New System Layout

New U50 control system shares the standard EPICS environment for insertion devices (ID) control of the Taiwan Photon Source (TPS) project. The main components, include the motors with encoders for gap adjustment, interlock system (limit switches, tilt sensor) for safety, trim coil power supply for corrector magnets, and temperature sensor for ID magnet blocks monitoring, as shown in Fig. 3. All control functionalities are coordinated by the cPCI EPICS IOC. Some of the major updates include:

- Replace PC/MS-DOS environment into cPCI EPICS IOC under linux OS (Kernel 2.6.29, Fedora core 11, EPICS Base 3.14.10).
- Replace RS-485 based indexer by Galil DMC-40x0 series Ethernet based motion controller, and replace the phase out motor driver to new module.
- Replace the incremental linear encoder to SSI interface absolute linear encoder, and directly connect to the motion controller.
- Add the cPCI based DI/DO module, and ADC/DAC IP (Industry Packs) modules, for monitoring the interlock signals, tilt sensor, and controlling the trim coil power supplies.
- Replace the IEEE-488 temperature monitoring module to PoE Ethernet based temperature module (ICPDAS PET-7015).

The Ethernet based motion controller was chosen to control motor drivers, and receives commands from the EPICS IOC to handle motor motion and read encoder positions, limit switches, position error and other states for monitor and software protection. The status of all axes updated by the motion controller and its time period can be configured to 5 msec. To achieve the update rate in EPICS, an interrupt produced by a kernel driver is involved. The kernel driver and char device driver are installed for the data access for EPICS processes (data receiver and passing interrupts), as shown in Fig. 4. The streamDevice and asynDriver of EPICS are used for sending position commands to the motion controller.

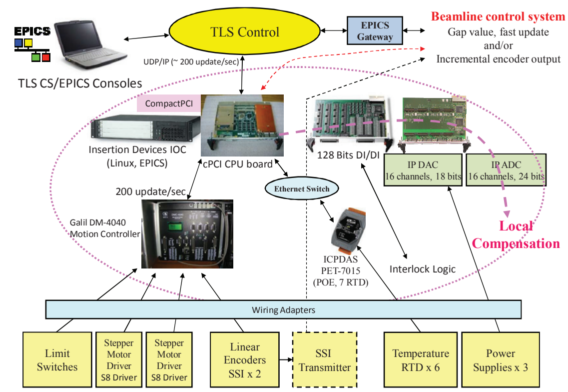

Figure 3: TLS U50 undulator new control environment.

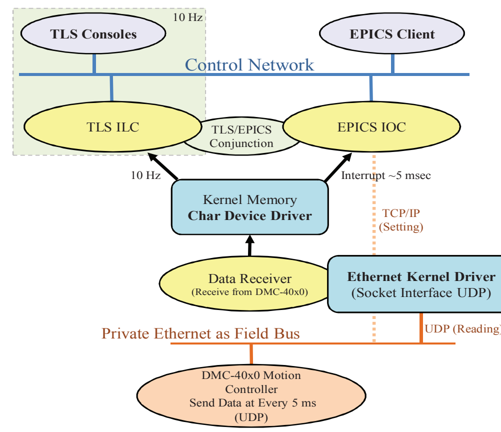

Figure 4: Relationship between major software components.

BEAMLINE SUPPORT

On-the-fly experiments which synchronize ID gap and beamline monochromator for energy scanning are interesting recently to increase the productivity and to meet requirements of scientific goals. There are two schemes available for new U50 control system via network or access encoder signals (SSI/incremental) for on-the fly experiments, as follows:

- Scheme A – PVs mode: beamline or experiment station computer can directly read the gap position over the network through EPICS PV channel access (100 times per second or faster).
- Scheme B – Absolute encoder signal mode (Slave SSI): ID control system sends the Clock and Data to the beamline or experimental station (updated once every 1 msec). Signals converted into parallel output 25 bits (BCD code, Binary Code, or Gray code) or RS-232 output or incremental encoder signal (A/B/Index) are also available.

OPERATOR INTERFACE

The Xm/X11 libraries under common desktop environment (CDE) are used to develop the user interface for TLS control system. The control page of the U50 is shown in Fig. 5. The new control system is based on TPS framework (EPICS IOC), thus, a simulated TLS intelligent local controller (ILC) is also developed and

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running with EPICS IOC on the same cPCI platform. As a result, the TLS U50 existed GUI is still workable. The user interface implemented by using EPICS EDM (Extensible Display Manager) was also created. A EDM control page with ID images, as shown in Fig. 6, is for general operation and a detail maintenance page can show all status and adjustable PVs parameters (PID, torque limit … etc).

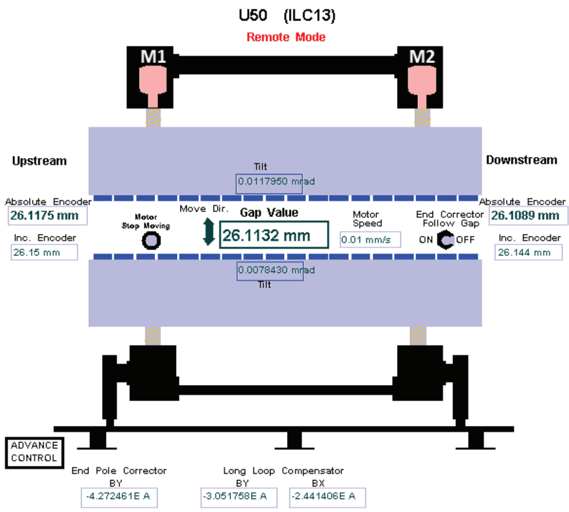

Figure 5: TLS U50 undulator control GUI (existed).

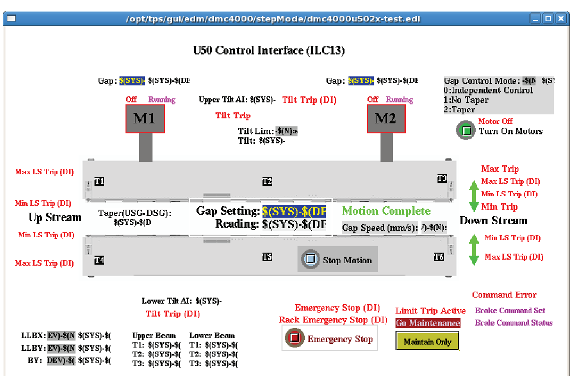

Figure 6: EDM based TLS U50 undulator control GUI.

MOTION CONTROL PERFORMANCE

The comparison of response of the encoder reading for gap change from 20 to 30 mm between old and new control system were tested. Fig. 7 shown the step change of the gap position is due to the slow update of the old controller. The encoder update rate is improved drastically under new control system, as shown in Fig. 8. The response of the control system has significant improvement from second to tens milliseconds order (around 100 times faster) which can offer better resolution of position change behaviour for motion study. The new control system is more flexible and will provide better support for the beamline to develop on-the-fly scan techniques.

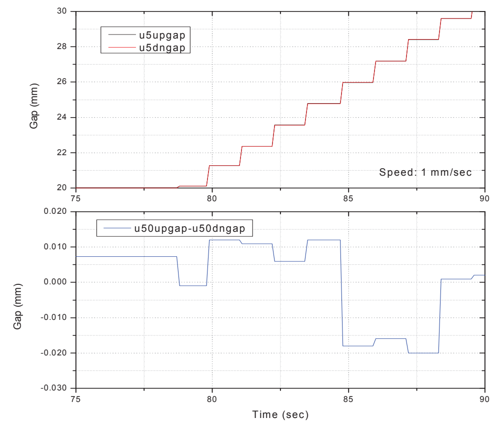

Figure 7: Response of old control system. Encoder reading of gap change from 20 to 30 mm (top) and difference between the upstream and downstream gap (bottom).

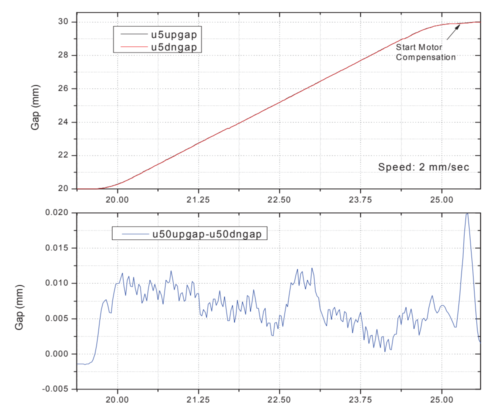

Figure 8: Response of new control system. Encoder reading of gap change from 20 to 30 mm (top) and difference between the upstream and downstream gap (bottom).

SUMMARY

The undulator U50 for Taiwan Light Source (TLS) was upgrade to the EPICS framework successfully at August 20, 2012. The response of the control system has significant improvement. The benefits for this rejuvenation not only improve the response time, but also avoid obsolesce of the old control environment, easy to maintain and no need to do position homing after system shutdown. In order to compatible with TLS existed control environment, a server program was develop to translate the protocol to EPICS PVs. All existed GUI still can be used.

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