INSERTION DEVICES CONTROL DEVELOPMENT AT SRRC

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Abstract

Insertion devices are the most important gadget of the third generation Taiwan Light Source at SRRC. These insertion devices include the turn-key systems and in-house developed systems in SRRC. The corresponding control configurations are different due to historical reason. However precision, fastness, simplicity, and uniformity in insertion devices control are the most desirable from practical viewpoint. The proposed uniform control systems are first applied successfully to undulator U10 prototype and experimental one meter length adjusted polarizing undulator. The new system provides several features which are not available in existed insertion device control system. The residual field compensation procedure can be done with 100 times per second. The compensation table is updated from the server of the control system. The software design supports the beamline users to adjust gap after granting permission from the control room operator. The detailed descriptions about the features and performances will be presented in this report.

1. INTRODUCTION

There are three installed insertion devices systems, wiggler (W20), undulator (U5, U10P). Two of them are turn-key systems (W20, U5). The undulator U10P is homemade. There are two insertion devices in development phase in house, elliptically polarizing undulator (1 m EPU prototype and 4 m EPU). The undulator U9 has contracted with vendor. The control system of the U10P is built to achieve the simplicity, minimum man power and good performance that are prospects of insertion devices control at SRRC.

2. SYSTEM CONFIGURATION

The VME crate controller is the core of the control system configuration for all insertion devices. The W20 [1] and the U5 [2] are similar configuration. The VME crate controller connects with personal computer (PC) through GPIB bus, using the PC as local controller to control motion controller and motor drivers and to monitor encoders via GPIB bus or RS232. The control system of the undulator U9 will be similar to the undulator U10Pofthe SRRC. It integrates the intelligent motion controller in the VME crate controller without PC. Figure: 1 represents the software structure on U10P controller.

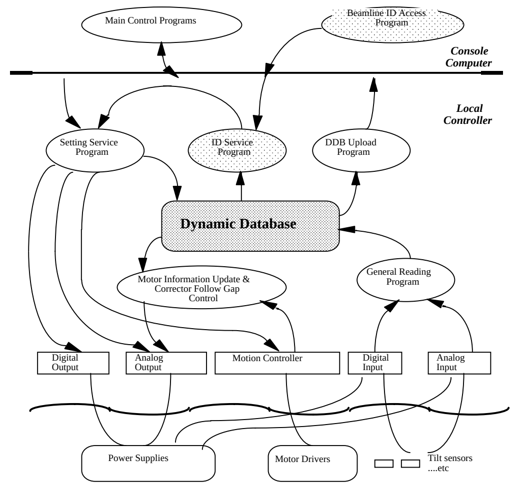

Figure: 1 Software structure on U10P controller

3. ISSUES OF INSERTION DEVICES CONTROL

3.1 *Motion control*

The motion control is a key point in insertion device control. It needs the requirements of the high precision, good reproducibility and multiple axes synchronization as well as fast control response.

3.2 *Residual field compensation mechanism*

The residual field compensation mechanism provides a easy operation and maintenance for machine physicist. The compensation table which the setting of the end-pole correction power supplies follows the corresponding gap value is a text file and saves on a NFS (network file system) server. The machine physicist needs to edit a table file on server and issues an updating event via graphic user interface on main control system. The new compensation table will be rebuilt and the compensation procedure can be done 10 ms per step [3][4][5]. For the W20 system, the residual field compensation table is stored on the PC. The gap and phase information will be included in the table for the EPU system.

3.3 Homing

When the power which provides to the incremental encoder is lost, the incremental encoder information will be lost. There is an optional method which saves the

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information on non-volatile RAM or harddisk to avoid information lost. If the position information is lost by accident, the homing procedure is necessary to recover the information. The U10P control system is with four incremental linear encoders. The encoder inform- ation is stored in the user accessible area of the non-volatile RAM. Whereas, the encoder information is saved on harddisk for the W20 control system. For the system of the U9 and the 4 m EPU, the absolute linear encoder will be used to measure the gap information. Hence, no homing procedure is needed.

3.4 *Protection and interlock*

The safety of the system is the one of the important considerations. For the U10P system, there are the tilt and slip detection, software limits protection, maximum and minimum limit switches. If one of the these interlocks is active, the four motors would be immediately stop. The controller supports error recovery functions used by the operator to eliminate errors. For the W20, U5, U9 and EPU are similar to the U10P.

4. CONTROL ROOM OPERATOR INTERFACE

The operator interface is a graphic mode interface. Normal operation page includes the setting and reading of the gap position and end-pole corrector power supplies, the monitoring of the tilt sensors, limit switches and drivers status and motors stop function. For the critical functions such as errors recovery, reset motor controller, homing procedure and updating the residual field compensation table are hidden in another page.

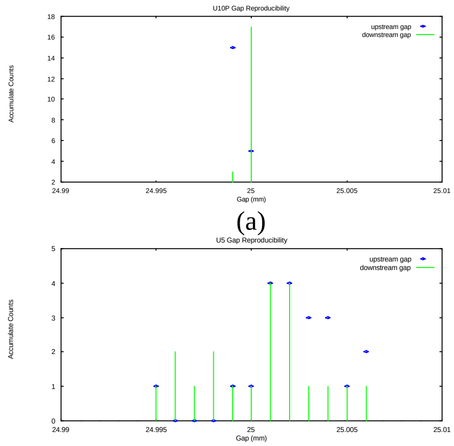
5. PERFORMANCE ISSUES

There are several control performance issues about insertion devices of the SRRC such as gap or phase resolution, reproducibility, two axes tracking. Table: 1 lists the performance of the U5, U10P and 1 m EPU [6]. The output signals of motion controller for the U10P are TTL pulse counts which represent the corresponding target position only. Thus the position errors are corrected at target position by using the encoder tracking function of the motion controller. It possesses a good reproducibility (shown in Figure: 2 (a)) but has not a good dynamic tracking on synchronous moving in multiple axes (shown in Figure: 3 (a)). For the U5 system, the reproducibility is worse than the U10P (shown in Figure: 2 (b)). For the 1 m EPU, the output signals of motion controller to motor drivers are analog voltages corresponding to the position error. It needs to optimize the proportional, integral and derivative parameters on feedback control system. Although it is more complexity than the U10P control, it offers the advantage of the good dynamic tracking. According to the resolution of the encoder is 5m, the two axes tracking performance is shown in Figure: 3(b). If the resolution of the encoder is 1 m, it will be achieved to several microns for the two axes tracking. The control response is hoped to achieve mechanical limitation. So far the response time of the U10P is about 1.2 sec per 0.1 mm.

Table. Performance of the insertion devices for SRRC

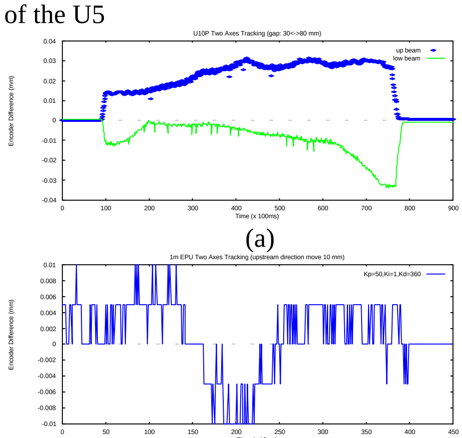
item \ insertion device	U5	U10P	1m EPU
encoder resolution	1 um	0.5 um	5 um
gap/phase resolution	_	~ 2 um	_
reproducibility	+/- 6 um	+/- 1 um	+/- 5 um
two axes tracking	+/- 30 um	+/-30 um	+/- 10 um

Table 1. Performance of the insertion devices



(b)

Figure: 2 Gap setting from different gap position to 25 mm (a) reproducibility of the U10P (b) reproducibility of the U5



(b)

Figure: 3 (a) Two axes tracking (upper beam and lower beam) of the U10P (b) Two axes tracking of 1 m EPU for phase only

6. BEAMLINE USER INTERFACE

The U10P controller possesses to accept the capability of issue commands from end-station computer to change gap directly via Ethernet. To execute the requests coming from the end-station, the controller should be granted by control room operator. Then the end-station user can send a command to U10P controller and monochromator system simultaneously. For the U5 control system, RS422 is used to communicate with the end-station (shown in Figure: 4). Figure: 5 is the simulation of the beamline request gap change scenario for the operation of U10P.

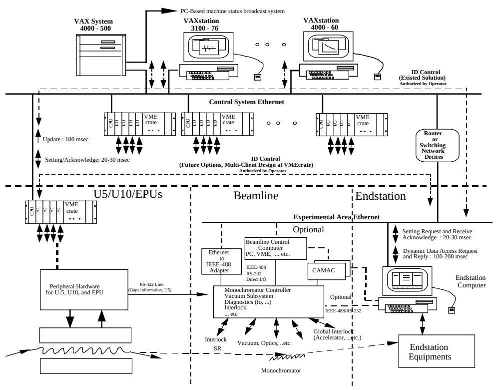


Figure: 4 Relation between main control system, U10P controller and the beamline end-station

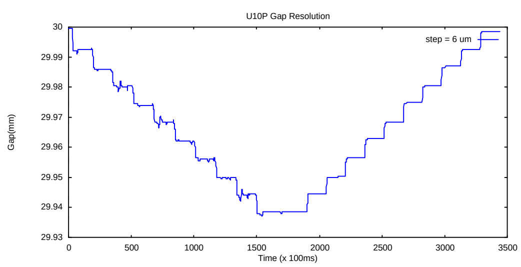


Figure: 5 Simulate beamline request gap change scenario for U10P

7. DISCUSSION

The effects of stepper mode and servo mode for the SRRC insertion devices control are as the follow :

a. *Dynamic tracking*

For the stepper mode, the output signal is pulse with constant motion profile that follows the acceleration, deceleration, velocity and target position counts. The position errors with varying time can not be corrected during moving. The feedback correction occurs only at target position. For the servo mode, output signal is a analog voltage, it can be changed following the position errors. It possesses a good dynamic tracking function.

b. *Overshoot*

Using the servo mode control on servo motor such as 1 m EPU prototype, it can improve the overshoot by adjusting the control parameters to critical damping region.

c. *Response time*

The response time of the U5 system is longer than the U10P system. Because the U5 need spend time on communication between personal computer and VME controller whereas the U10P need not. For the 1 m EPU, it adjusts the control parameters to achieve the optimum response. The fast response will be foreseeable.

d. *Protection, error reporting and recovery*

For the W20 system, according to the transmission structure was failed to result in the beam tilt. However it could not supply the tilt information to control system. The tilt sensors will be provided to increase the judgment of the W20 system working well or not. In the future, the information of the system status during the movement will be saved in the intelligent motion controller. If the error occurred, these information would be dumped as error analysis reference. And there will be a error reporting to suggest troubleshooting method.

8. ACKNOWLEDGMENTS

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