Control for Elliptically Polarizing Undulator at SRRC

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Abstract

A Sasaki-type elliptically polarizing undulator (EPU) which will be an important project of insertion device at SRRC is in the construction phase. It can produce an elliptically polarization for advance study in soft X-ray region. The precision of phase is main issue for this control system. The loads of the motor drivers vary with different magnetic force which results from changing the phase and the gap position to result in affecting positioning precision. For minimizing the steady state error and getting a better tracking performance, the parameters of the control loop are necessary to optimize. The control system provides the functions so beamline users can adjust gap or phase. The graphical user interface provides a easy operation interface for operators. The details of the EPU control will be presented in this report.

1 Introduction

There are two insertion devices, a 1 m EPU prototype and a EPU5.6. The 1 m EPU is 1 meter long with a 56 mm undulator period, and is used on engineering test. However, the EPU5.6 is 3.9 meters long with a 56 mm undulator period and 65 periods which is in construction phase and will be installed in the storage ring in 1998. It is optimized to provide a highly polarizing light in the 80 eV to 1400 eV range[1][2]. The purposes of control system for the EPU are to achieve the simplicity, easy maintenance and good performance that are properties of insertion devices control at SRRC.

2 Structure of the VME crate controller

The VME crate controller is the core of the control system. The 1 m EPU is a engineering prototype, it exists only with phase control and the encoder type is different from the EPU5.6. The following structure is described for the VME crate controller of the EPU5.6 system[3].

2.1 Software

There are two operation modes, local/remote control, on the control system. In the local control mode, the system can be operated independently with computer via network or a terminal via RS232, and a program exists for local debugging and maintenance. A PMC form-factor VGA interface is mounted on the CPU board to establish a monitor environment. The current status of the system is displayed whether the right of control is on local control mode or remote control mode. In the remote control mode, the processes of the VME crate controller include setting service process, ID (insertion device) service process, DDB (dynamic database) upload process, general reading process and motion control related logical process. The setting service process handles all settings from the console computer and the ID service process is necessary to set the interface modules, which deals with the setting from the beamline end-station computer. The DDB upload process is responsible for uploading the DDB to the console computer 10 times per second, whereas the update rate of the DDB is 100 times per second from setting and reading processes and motion control related information. The motor information update and correctors gap/phase control is to collect information from motion controllers, to control motors and to execute residual field compensation mechanism. The software structure on VME controller is shown in Figure 1.

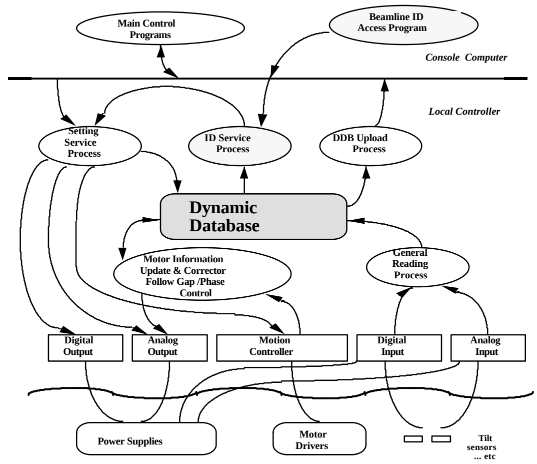


Figure 1. Software structure on EPU controller

2.2 Hardware

The hardware of the VME crate controller is composed of a CPU board running LynxOS, two motion controllers, one analog-to-digital interface card and one digital-to-analog interface card for end-pole corrector power supplies control and tilt sensors readings, one serial EnDat interface card for reading absolute linear encoders, a digital input card for status monitoring and a digital output to disable the motor drivers if an interlock occurrs. In the development phase, there is only a dumb terminal connected to a RS232 port on the CPU board in order to run a local debugging and maintenance program.

3 Properties of control system

The control system needs the requirements of high precision, good reproducibility, fast control response, multiple axes synchronization as well as reliability. The considerations of the control system are described in the followings.

3.1 Motion control

The motion control is a key point in insertion device control. To meet the requirements, the servo mode motion control method is chosen. The gap and phase are the elements of the motion control for the EPU5.6 system.There are two absolute linear encoders with incremental signals and EnDat signals for gap information, and four incremental linear encoders with incremental signals for phase information. The incremental signals of the absolute linear encoders and incremental linear encoders are used as the control feedback loop signals to different motion controllers. For getting better performance, there will be different PID (proportional, integral and derivative) parameters on the motion controllers. It is needed particularly for the phase motion control because of the magnetic force effect.

3.2 Residual field compensation mechanism

The residual field compensation mechanism provides a easy operation and maintenance for machine physicist. When the gap is in movement, it includes a compensation table that uses the end-pole correction power supplies supporting current for the end-corrector winding to compensate for the residual field. The setting values of the end-pole correction power supplies are followed the corresponding gap value. When the gap is in target position, another compensation table which the setting values of the end-pole correction power supplies follow the corresponding gap value and phase position. The control system provides a convenient method to machine physicist who needs to edit a table file on the control server and to issue an updating event via graphic user interface on main control. The file sharing system (NFS, network file system) is used to download the table to VME crate controller. The new compensation table will be built and the compensation procedure can be done 10 ms per step .

3.3 Homing

When the power for the incremental encoder is lost, the incremental encoder information will be lost. However, there is an optional method that saves the information in non-volatile RAM on the CPU board to avoid information lost. If the position information is lost by accident, the homing procedure is necessary to recover the lost information. Thus, the homing procedure is needed for phase control. Whereas, the homing procedure for gap control is eliminated due to the use of absolute linear encoders.

3.4 Protection and interlock

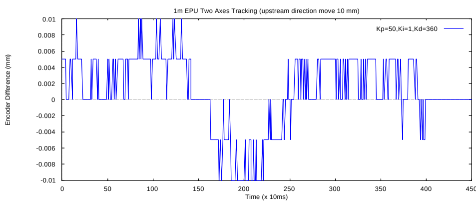
The safety of the system is an important consideration. There are the tilt and slip detection, software limits protection, maximum and minimum limit switches and torque limitation on motion controllers and motor drivers. If one of the these interlocks is active, the motors would stop immediately. There is an optional interlock in case a connector is disconnected or a wrong connection is made, in which case the controller would not operate.

4 Main operator interface

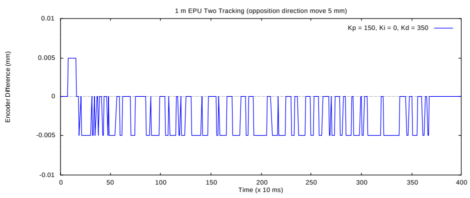
Normal operation includes the setting and reading of the gap and phase position and end-pole corrector power supplies, the status monitoring of the tilt sensors, limit switches and motor drivers, motors stopped function, local/remote switched and residual field compensation mechanism selected. For the critical functions such as errors recovery, reset motion controllers, homing procedure and updating the residual field compensation table are hidden in another page and can be used by system maintenance people only.

5 Control performance

There are several control performance issues about the EPU control system such as the resolution, reproducibility and multiple axes tracking for gap and phase. The definition of axes tracking is the axes synchronization during moving. Presently, the encoder resolution is 5m for the phase control of the 1 m EPU system. The two adjacent axes tracking performance is shown in Figure 2. The encoder resolution of phase and gap for the EPU5.6 system is 0.5m and 0.4m individually. From the control experience of the 1 m EPU system, the multiple axes tracking will be expected to achieve several microns for the phase and gap movement of the EPU5.6 control system.



(a)



(b)

Figure 2. Two adjacent phase axes tracking of a 1 m EPU (a) same direction (b) opposition direction

6 Beam line user interface

The controller possesses the capability to accept issued commands from the end-station computer to change gap or phase directly via Ethernet. There are three steps of the operation procedure to obey. The first, the end-station computer sends the request to main control system. The second, the VME crate controller should be acknowledged and the end-station computer should be granted simultaneously by the control room operator. Finally, the VME crate controller is linked with the end-station computer to execute the requests sent from the beamline end-station. The relation among main control system, EPU5.6 controller and the beamline end-station is shown in Figure 3.

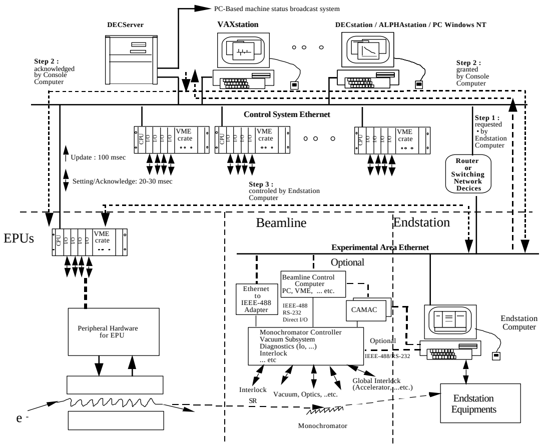


Figure 4. Relation among main control system, EPU controller and the beamline end-station

7 Discussion

Currently, the control effects of the 1 m EPU system are as following :

7.1 Dynamic tracking

According to adjacent phase axes, there is a magnetic loading varying with phase shift. If a phenomenon of a burst movement occurring on the same axis and same phase position during the two adjacent phase axes moving the same or opposite direction is found. More torque output from the motion controller overcomes the overshoot to recover the normal track. If there is no magnet array on the axes, the dynamic tracking is less than or equal to ±10μm.

7.2 Overshoot

It needs to adjust the parameters (PID) of the motion controller to critical damping region.

7.3 Response time

Currently, If the command setting is from the terminal via a RS232 port the response time is 0.1mm movement in 0.25 sec for phase movement. If the command setting is from main control computer, the response time will be expected to be 0.5 mm movement within 1 sec .

7.4 Protection, error reporting and recovery

The tilt sensor which is a dual-axis solid aluminum housing containing a Applied Geomechanic precision electrolytic transducers with a resolution of 0.1 microradian[5] is provided to promote the judgment for the drive mechanisms 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 an error occurred, this information would be dumped for error analysis reference. There will also be a error reporting function to suggest a troubleshooting method.

Acknowledgments

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