The Control Performance of Elliptically Polarizing Undulator at SRRC

C.S.CHEN, JENNY CHEN, K.T.HSU, K.T. PAN
Synchrotron Radiation Research Center, Hsinchu, Taiwan

Abstract

There are two elliptically polarizing undulators (EPUs) with a period length of 56 mm at SRRC. One is a engineering prototype 1-meter-long EPU which is being installed for beam test. The other is a final version 4-meters-long EPU (EPU5.6) which will be installed in the end of this year. The requirements of the control performance are a fast polarization switch, good magnet gap control resolution for getting precise photon energy and multiple axes tracking during changing gap and adjusting phase. There are four axes horizontal magnetic array to adjust phase position for 1 m EPU. Due to magnet force, the adjacent and non-adjacent two axes will possess different effects during moving magnetic array. Residual field compensation mechanism function to provide to preclude the beam orbit from drift. For achieving a high performance, it should be fine tuned the proportional-integral-derivative (PID) parameters of the servo loop. The results will be reported in this paper.

1. INTRODUCTION

From the viewpoint of beamline users, the requirements of the EPU5.6 need the good reproducibility of the gap and phase, the minimum deviation between two gaps or phases during movement, the good position accuracy of the gap drive system and fast response. Therefore, the structure design considerations of hardware and software of the control system are to meet the specifications of the EPU5.6 [1].

2. STRUCTURE OF THE VME CRATE CONTROLLER

2.1 Hardware

The controller of the EPUs is based on VMEbus system. The key module is PowerPC CPU running with LynxOS. Because the controller is a diskless computer, the control programs saved in server computer will be downloaded automatically to the controller. The embedded VMEbus motion controller is used to improve system response. The other components are absolute linear encoder readout module and general purpose input/output module. Because the absolute linear encoder is with incremental and absolute signal output at same time. Therefore, the incremental signals are used for gap control servo loop purpose, the absolute values are read by absolute linear encoder readout module with the bidirectional synchronous-serial (EnDat) interface.

2.2 Software

The controller consists of four processes. The dynamic database upload process uploads data in 10 times per second. The setting service process deals with setting command from console computer. The general reading process reads from analog inputs and digital inputs in 100 times per second. The motion control related process is for motion control including residual field compensation mechanism. The insertion device (ID) service process supplies the beamline users can directly access ID information. For local testing and debugging proposes, a program can be run in controller. It uses a common share memory located by local controller. Thus, some of the ID information can be uploaded to console computer when the program is run. The relationship of processes is shown in Figure 1.

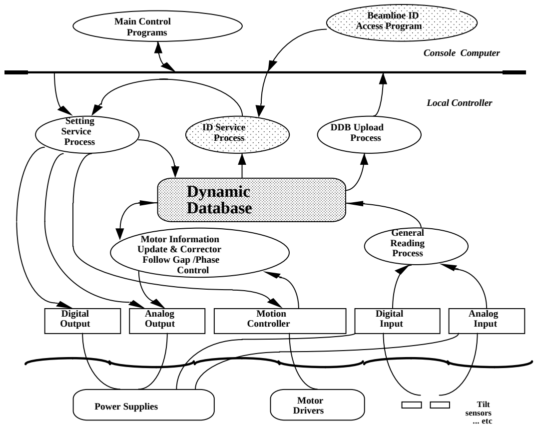


Figure 1. Software structure on EPU controller

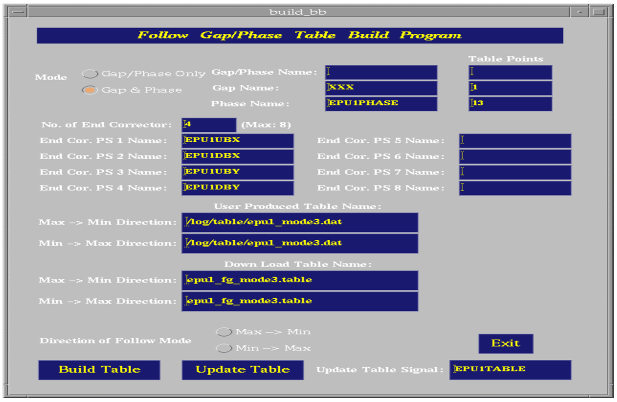
3. HIGHLIGHT OF THE EPU CONTROL

3.1 Motion control

Motion control is an important issue on ID control. For getting fast response and better tracking, the servo loop control is used. The proportional-integral-derivative (PID) control method is supplied by motion control module. The maximum speed of the gap and phase movement are limited by driven mechanism, that is 1 mm/sec and 6 mm/sec, respectively.

3.2 Residual field compensation mechanism and orbit control strategies

A residual field compensation mechanism is built in controller. The machine physicist can build or update the residual field compensation table which the end-pole correctors power supplies setting follow the gap change and phase change by himself. The power supplies setting can be done in 100 times per second. The table can be accessed by controller via the network file system (NFS). The residual field compensation table builder user interface is shown in Figure 2.



build_bb

Follow Gap/Phase Table Build Program

Mode: ○ Gap/Phase Only ● Gap & Phase

Gap/Phase Name:
Gap Name: XXX
Phase Name: EPU1PHASE

Table Points: (blank), 1, 13

No. of End Corrector: 4 (Max: 8)

End Cor. PS 1 Name: EPU1UBX
End Cor. PS 2 Name: EPU1DBX
End Cor. PS 3 Name: EPU1UBY
End Cor. PS 4 Name: EPU1DBY
End Cor. PS 5 Name:
End Cor. PS 6 Name:
End Cor. PS 7 Name:
End Cor. PS 8 Name:

User Produced Table Name:
Max -> Min Direction: /log/table/epu1_mode3.dat
Min -> Max Direction: /log/table/epu1_mode3.dat

Down Load Table Name:
Max -> Min Direction: epu1_fg_mode3.table
Min -> Max Direction: epu1_fg_mode3.table

Direction of Follow Mode: ○ Max -> Min ○ Min -> Max

Update Table Signal: EPU1TABLE

Figure 2. The residual field compensation table builder user interface

Two approaches can be used to compensate the orbit distortion due to the gap or phase change. One is the feedforward orbit compensation scheme that should build the table which correctors power supplies setting follow the gap change and phase adjustment in order to keep the orbit at certain orbit. The disadvantage is that it can not eliminate the uncertain disturbance and need more iterations to generate the table. If the gap and phase were needed to be changed at the same, then the table would be a little complexity to be generated. The other is orbit feedback that can eliminate other disturbance except caused by the gap change or phase adjustment of the insertion device.

3.3 Homing

The homing procedure is executed on phase axes using the incremental encoders. However, the absolute linear encoders are used on gap control. The advantage is to eliminate homing procedure when the controller is initially started or power loss.

3.4 Protection and interlock

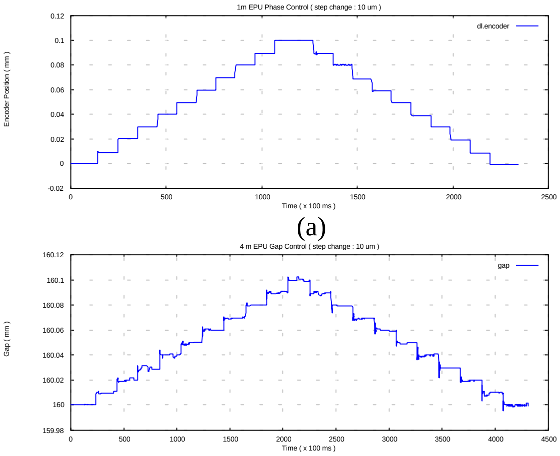
Hardware, software and firmware interlock are considered for system safety. The hardware interlock components include the tilt sensors, the limit switches, and hard stops. The software interlock includes tilt checking and torque limitation. The slip and over torque limit are firmware interlock functions.

4 . CONTROL PERFORMANCE

The control performance is tested on 1 m EPU phase control and EPU5.6 without magnetic blocks gap control [2]. The control achievable performance of two systems is shown in Table 1. Currently, the performance of the reproducibility and two axes tracking have been achieved to about 1 μ m. Figure 4. and Figure 5. show the control resolution and dynamic tracking, respectively.

Table 1. Performance of the 1 m EPU and EPU5.6

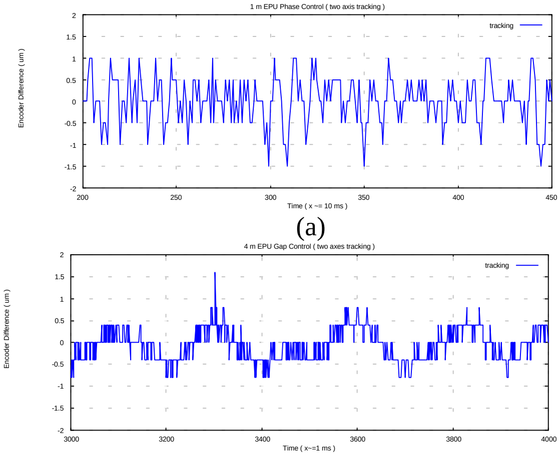
Items Device	encoder resolution	reproducibility	two axes tracking	gap/phase resolution
1m EPU (phase)	0.5 um	1 um	2 um (p-p)	1 um
EPU 5.6 (gap)	0.4 um	1 um	2 um (p-p)	1 um



(a)

(b)

Figure 4. (a) 1 m EPU phase control resolution (b) EPU5.6 gap control resolution



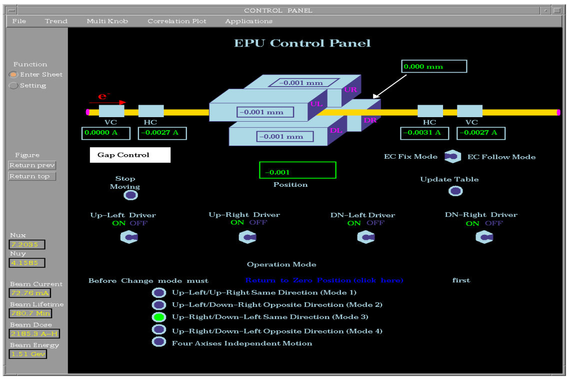
(a)

(b)

Figure 5. (a) 1 m EPU two axes tracking (b) EPU5.6 two axes tracking

5. OPERATOR INTERFACE

The 1 m EPU is phase control only and is ready for beam test, whereas the EPU5.6 is gap and phase control and in construction phase. For 1 m EPU, the operator interface is shown in Figure 3. However, the operator interface of the EPU5.6 will like as a real EPU system and show the devices related position.



VC 0.0000 A
HC -0.0027 A
UR -0.001 mm
UL -0.001 mm
DL -0.001 mm
0.000 mm
HC -0.0031 A
VC -0.0027 A
Position -0.001
Up-Left Driver ON OFF
Up-Right Driver ON OFF
DN-Left Driver ON OFF
DN-Right Driver ON OFF
Nux 7.2035
Nuy 4.1585
Beam Current 72.76 mA
Beam Lifetime 780.7 Min
Beam Dose 2185.3 A-H
Beam Energy 1.51 Gev

Before Change mode must Return to Zero Position (click here) first
○ Up-Left/Up-Right Same Direction (Mode 1)
○ Up-Left/Down-Right Opposite Direction (Mode 2)
● Up-Right/Down-Left Same Direction (Mode 3)
○ Up-Right/Down-Left Opposite Direction (Mode 4)
○ Four Axises Independent Motion

Figure 3. 1 m EPU phase control user interface

6. BEAMLINE USER INTERFACE

Control system supports two different approaches to beam-line users to change the gap or phase of EPU5.6. End-station users can send command to machine control system or to VME crate controller directly to request the gap change. Relationship among main control system, EPU5.6 controller and the beamline end-station is shown in Figure 5.

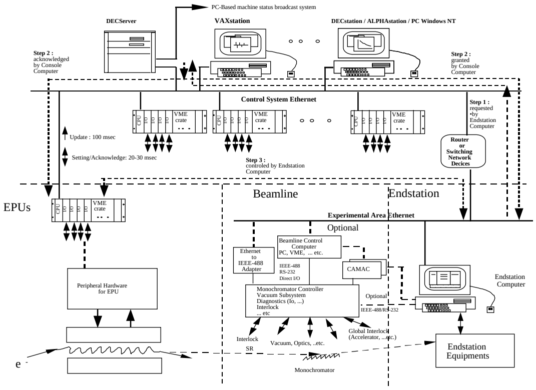


Figure 6. Relationship among main control system, EPU controller and the beamline end-station

7. DISCUSSION

7.1 Dynamic tracking

If the dynamic tracking were worse during the two axes gap control or two axes phase control, it would affect the experiment of the beamline users due to the photon energy shift.

7.2 Overshoot

Fine tuned of PID can minimize overshoot and steady state error. A smoothing function supported by motion controller. It can continuous and smooth acceleration to reduce overshoot.

7.3 Response time

When the controller receives the moving command from console computer, the motor will response in about 0.1 second. Then, the controller acknowledges the information to console computer within 0.2 second [3].

7.4 Error reporting and recovery

The motion control module supplies commands which can automatically record data about motion at 2 msec intervals. The recorded data are helpful for system maintenance if the system malfunction. The error recovery procedure functions are supported due to tilt or limit switch active.

7.5 Mechanical deflection

The tilt sensor is a dual-axis solid aluminum housing containing precision electrolytic transducers. One axis is to measure the girder tilt, the other is to measure the C-frame deflection during the gap change.

7.6 Mechanical problem

There is a abnormal moving occurred on 1 m EPU phase control. It always happens the same quantity of the overshoot on the same axis and same position. However, the overshoot can be compensated due to the servo control loop working well. It is shown in the solid line curve of Figure 7. From the point curve reading from resolver of Figure 7, it shows out the mechanical driver problem. The movement trajectory is shown in Figure 7.

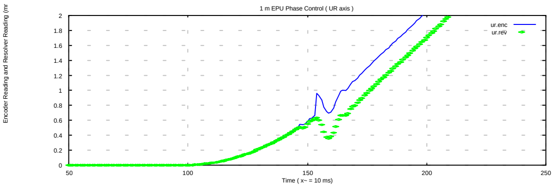


Figure 7. Line represents the encoder reading value; point represents the resolver reading value

8. ACKNOWLEDGMENTS

Thanks for H. H. Chen to help to solve problem during system testing and expand to colleagues of the C. H. Chang and C. S. Hwang to let the project to progress smoothly.

REFERENCES

[1] C.H. Chang, et al " Optimization design for SRRC Elliptically Polarizing Undulator", MT-15 Conference, Beijing, China, 1997
[2] Bahrdt, A. Gaupp, G. Ingold, M. Scheer "Status of the Insertion Devices for BESSY II", Proceeding of the 5th EPAC, Barcelona, June 1996
[3] K.T.Pan,et al, "Control for Elliptically Polarizing Undulator at SRRC ", Proceeding of the ICALEPCS'97