高能同步辐射光源

High Energy Photon Source | HEPS

The Development and Application of Motion Control System for HEPS Beamline

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Introduction

In synchrotron radiation facilities such as the High Energy Photon Source (HEPS), numerous motorized actuators are equipped on the optics devices of HEPS beamline to manipulate the orientation of crystals and mirrors, thereby altering the position and characteristics of X-rays. The motion control system (MCS) play a important role in this optics devices of HEPS beamlines, such as monochromator, K-B mirror and sample plants. In order to acquire the specify properties of X-ray and satisfy the complex experimental requirements, HEPS has developed a standardized motion control system for synchrotron radiation applications.

The Hardware Structure

The MCS is built of three main hardware components: master controller, control rack and driver board. The MCS as the distributed system separates the control unit and driver unit. The master controller and control rack belong to the control unit. The controllers of ACS products (SPiiPlusEC and PDIcl) are the core of control unit where SPiiPlusEC is the master controller and PDIcl is the slave module, which are connected through EtherCAT fieldbus. The driver unit includes two-phase driver and five-phase driver, both of which are composed of core driver module (e.g. Phytron, Melec and oriental motor) and interface board.

- ✓ The distributed system support up to 64 axis.
- ✓ Uniform electrical interface is compatible with two-phase and five-phase steppers.
- ✓ Wide drive current and Micro-step
- ✓ Supporting AqB, Biss-C and Endat2.2 encoder simultaneously.
- ✓ Supporting real-time position event trigger and high speed position capture.

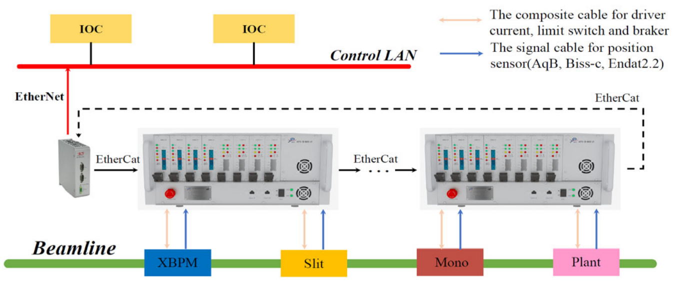

Figure 1. The overall hardware architecture of HEPS MCS

EPICS IOC

SPiiPlus EC is a multi-threading programmable controller which support multiple host applications may communicate with the controller simultaneously via a single physical connection. To fully take advantage of this device, this application includes two IOCs, where the Motor IOC is implemented to realize the basic motion, as well as the script&data collection IOC are used to execute control buffer program, random commands and acquire the real-time data.

The Motor IOC based on the asynMotor framework, which use the instruction set to communicate with master controller. It's different for script&data collection IOC that doesn't use instruction set to communication with controller through the asynPortdriver interface, instead of using linux OS dynamic library.

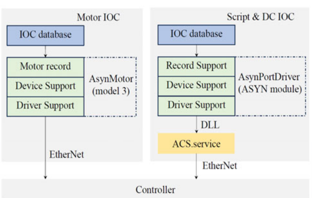

Figure 2. The software framework of HEPS MCS

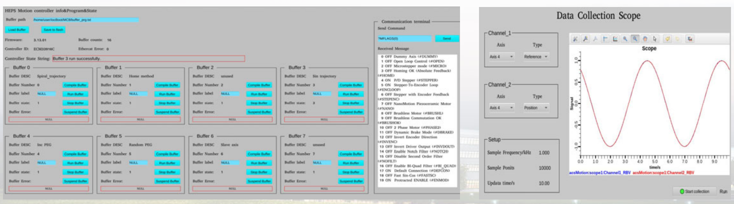

Figure 3. The OPI of HEPS MCS

The Applications

- ◻ Synchronization of multiple axis motions: Combing the motor record and other EPICS record can realize the complex control function by the channel access (CA) protocol of EPICS.
- ◻ Complex trajectory planning and real-time position event trigger: These complex motion function must be realized in controller hardware. The IOC of MCS supply the interface of buffer program, making it convenient for user to realize the special functions through customized scripts. Python is used as the high level applications, which supply the GUI(PyQt5) to generate the script and communicate with EPICS IOC(PyEPICS).

Figure 4. The OPI of white beam mirror

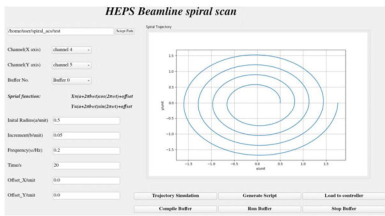

Figure 5. The high-level GUI of spiral scan

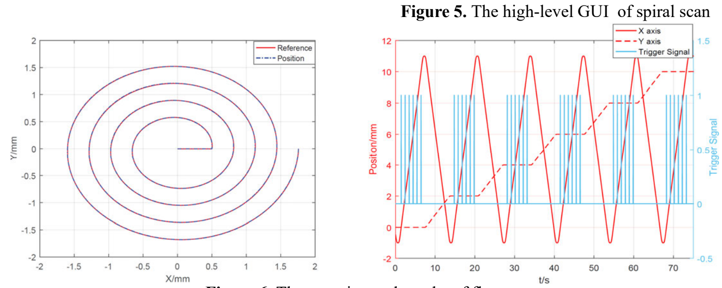

Figure 6. The experimental results of flyscan

Conclusion and Future work

- ◻ The advanced motion control system was proposed which will be widely applied in HEPS beamline, and the framework of hardware and software of this system has been described in detail. The design of standardized interface and modular structure allow for flexibility to be compatible with all of stepper axis in the HEPS. The driver support of EPICS IOC has been accomplished, which based on the asynMotor development framework.
- ◻ In the hardware, we will intend to develop the more cost-effective driver board for stepper motor to minimize equipment expenses. And the development of control system based on EtherCAT of servo motor and piezo-plant will be prioritized. In the software, we will continue maintain the EPICS IOC repository of MCS, ensuring that its features are updated to satisfy future requirements. Most importantly, We will push forward the development of this system in the flyscan experiments, and hope to use the Mamba as the high level application of its software.

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