DESIGN OF THE GIRDER CONTROL SYSTEM FOR HEPS-TF

Shujin Li, Chunhua Li, Jia Liu, Haijing Wang, Zihao Wang
Insititute of High Energy Physics, China, Beijing

Abstract

To make the alignment become easier, the HEPS-TF (High Energy Photon Source-Test Facility) magnet girder, which is different from the conventional one, is designed to achieve the goal of adjusting the girder's position and orientation online. The control system is one of the key sub-parts. This Paper will describe the control system design, especially on the hardware configuration, software programming as well as user interface design.

INTRODUCTION

To build a high performance photon source, a test facility called as HEPF-TF(High Energy Photon Source-Test Facility)is under R&D now. The mechanical and alignment system, which plays a significant role in the whole project, has high requirement in magnet girder since the HEPS-TF aims at the extremely low emittance and beam size [1]. According to the physics requirements, the 6-axes automatic control girder with high precision is designed to achieve a 6 DOFs (Degree of Freedom) accurate motion so that magnets, which are put on different girders, could be aligned easily [2]. The whole mechanical system is shown in Figure 1.

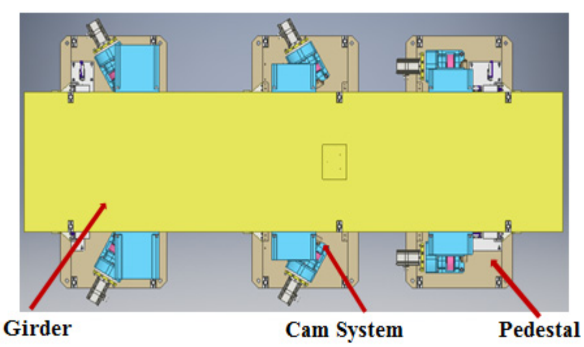

Figure 1: Structure of girder I.

There are 6 cam systems mounted on three pedestals. The girder body and magnet are hold by 6 cams. In this case, when the cam has a rotation, the location of the girder body is changed. The whole system, especially on the motion control aspect is due to this theory.

DESIGN OF GIRDER CONTROL SYSTEM

The control system is one of the key sub-parts. This paper will describe hardware design, program design and HMI (Human Machine Interface) design.

Hardware System Design

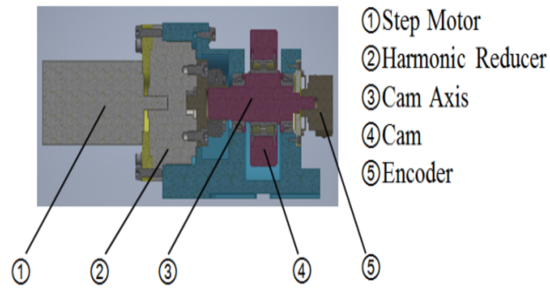

Figure 2: Mechanical design of cam motion system.

The cam motion system is shown in Figure 2. The five-phase step motor connected with Harmonic Reducer could give out a certain large torque output since the reducer's reduction ratio is 1:160.While the cam axis turn at different position, the cam have a movement from the original position. To avoid the step losing issue, an encoder is installed at the end of the axis.

To get the accurate position and orientation, there are several length gauges and one inclination sensor mounted on the girder. Also considering the inherent frequency, the locking system is fixed between the girder and the pedestals. Each locking system is driven by a DC motor and several position limits.

For all modules mentioned above, the whole control system is designed considering the function and cost. The control system hardware design for this girder use standard industrial controller and modules.

After research work about several brands in current mainstream market, Beckhoff system is chosen since it has a convenient way to use in Windows X86 frame.

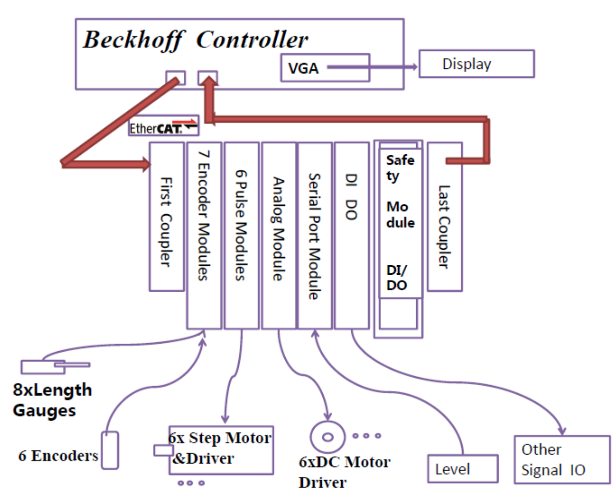

Figure 3: Control system frame.

Figure 3 shows the control system. There are several kinds of modules corresponding to different equipment, such as pulse direction module for 6 step motors, Endat module for Heidenhain length gauge and encoder, analog module for DC Motors. Besides, safety module is installed to make sure that even the main controller shut down accidently, the girder still can have a safety stop. Beckhoff CX series controller is used as main controller. And it has some ports to connect the display, the mouse and the keyboard. In the whole system, a redundant loop is built by using the EtherCAT fieldbus.

Software Design

TwinCAT, which is the programming software for Beckhoff, is based on PLCopen. So it is very convenient to develop the program by using ST (Standard Text) language according to the PLCopen Standard [3].

The main program's flow chart is shown in Figure 4.At the beginning of the program, the axis should be powered on. At the same time, the data from all kinds of sensors, such as encoder, length gauge and inclination sensor, is imported into the program. Also some other boolean variables is monitored as soon as the program starts. After that, each axis's position is set to the original position according to the mechanical algorithm. Before mounting the girder on 6 cams, each axis should be test by jogging. When all of the axes are turning correctly as well as setting position limitation, the girder can be put on the cams. TwinCAT provides a Matlab-Simulink tool so that the algorithm could be easily packed and called as a module in the main program.

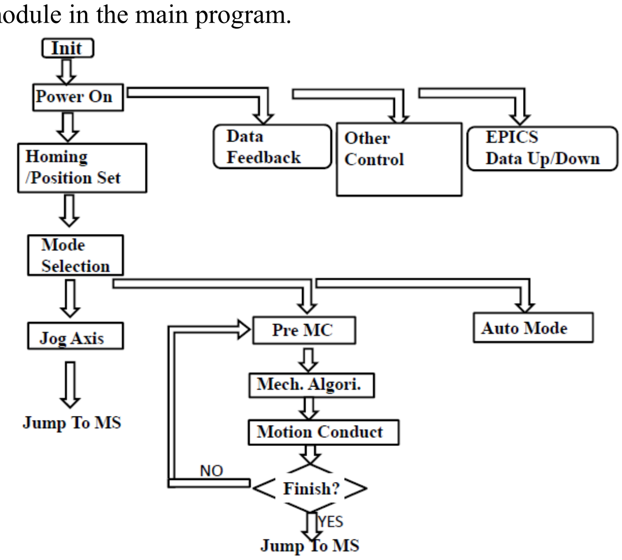

Figure 4: Program flow chart.

After the main program get the destination position, each axis should conduct the motion by calling the motion function block in TwinCAT motion standard library. After one step motion is done, the girder's position and orientation should be checked by calculating the data from the sensors. If the distance between the target position and current position, next step of motion will be carry on until the girder reaches the ideal position.

For the whole HEPS-TF system, there is a database system called EPICS (Experimental Physics and Industrial Control System). The girder's control system should have a port to update or download data. TwinCAT ADS function is a very flexible way for doing data interaction. So while the motion is done, the main controller could send out the current status of the girder if necessary.

HMI Design

The test HMI is already designed so far. It can show a nice interface. And from the test HMI, most of important real-time variables can be monitored while several instruction inputs can be wrote into the program.

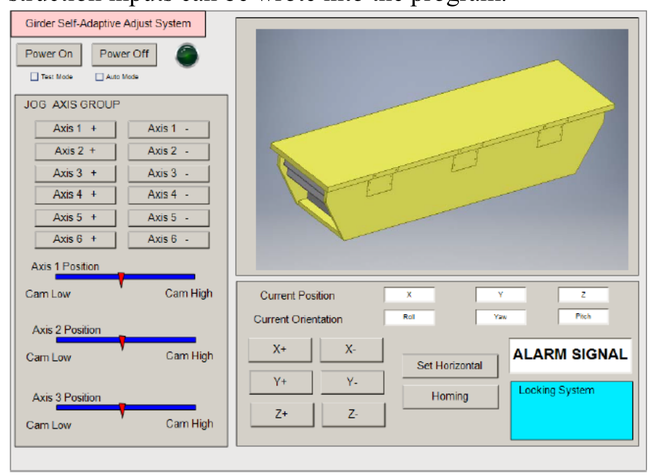

Figure 5: Test HMI.

From Figure 5, several buttons are made, such as power-on the axes, jogging each of the axis. The test HMI shows the real time status including position and orientation during the motion. Locking System for the girder is designed in another page separately since it has some relays to control. Besides, the test HMI should have a alarm signal preventing the axes or the sensors beyond limitations or even at the dangerous status.

CONCLUSION

The girder control system is quite significant to the whole girder project. So far the design in this paper reduces the cost obviously. This paper describes the overall design of the control system. The further study will focus on the detail improvement and performance tests.

REFERENCES

[1] Haijing Wang *et al.* "Overall design of magnet girder system for HEPS-TF", *In Proc. 7th Int. Particle Accelerator Conf. (IPAC'16)*, Bexco, May, 2016, paper WEPMR047.

[2] Tse-Chuan Tseng *et al.* "A Precise 6-axies Girder System with Cam Mover Mechanism", In *Proc. MEDSI 2006*, Japan.

[3] TwinCAT PLC Senior programming manual, Beijing, China, Beckhoff Automation Ltd, 2006: 280-200.

ISBN 978-3-95450-182-3