THE CONTROLLER DESIGN FOR KICKER MAGNET ADJUSTMENT MECHANISM IN SSRF

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Abstract

The kicker magnet adjustment mechanism controller in SSRF is to improve the efficiency of injection by changing the magnet real-time, especially in the top-up mode. The controller mainly consists of Programmable logic controller (PLC), stepper motor, reducer, worm and mechanism. PLC controls the stepper motors for adjusting the azimuth of the magnet, monitors and regulates the magnet with inclinometer sensor. It also monitors the interlock. In addition, the controller is provided with local and remote working mode. This paper mainly introduces related hardware and software designs for this device.

INTRODUCTION

Shanghai Synchrotron Radiation Facility, currently in routine operation stage for nearly two years, as a 3rd generation light source in China. SSRF storage ring will run in top-up operation mode[1]. Therefore, the SSRF injector will be in top-up injection .while in the Injecting, the electron beam which comes from the high energy beam transport line will be bumped to the closed orbit. To ensuring photon beam position stability, the beam in the storage must be remaining its orbit while travelling the injector. However, because of the manufacturing and installation differences, the magnetic field is not completely the same. This may make the beam deviate from the designed orbit, and reduce the injection efficiency. In order to reduce the impact of injection, we developed this device. It can be able to precisely measure the magnetic azimuth angle, and adjust it in real time.

ARCHITECTURE

Figure 1 shows the kicker magnet adjustment mechanism's architecture. In this system, the controller based on PLC, with the auxiliary hardware circuit, it selects the control object, adjusts the platform motion, detects the position and provides the protection. As the four kickers is not adjusted in the same time, we design one controller to adjust four platforms in instalments .By the switching, the controller can scan the current location of four the platform as well as focus on one. While in the scanning mode, the four position feedback information is received by the PLC cycle, and displayed on the control interface, and the power of motor is cut off. Otherwise, when in the adjusting mode, one of four kickers is focused, and the power supply of other kicker motor is cut off, so as to ensure the accuracy of selected objects, but also improve the safety performance. In addition, the stepper motors are equipped with brake system used as motion safety protection. Then there is an emergency, the motor is braking, and the platform is secured. Besides local interface, the controller also provides remote interface via Ethernet.

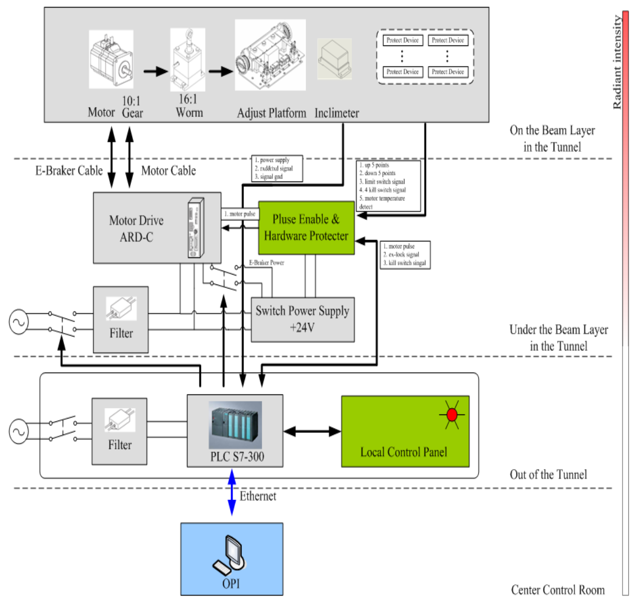

Figure 1: Adjust Platform Control System.

MECHANICAL STRUCTURE AND POSITIONING ACCURACY

Figure 2 is the motion scheme of the adjustment mechanism. The Platform is fixed on the point O. and the other underlay is the worm. When the stepper motor rotates, the worm controls points A movement up and down, then the magnet platform rotates slightly as the centre O, the relative position between magnet and beam then to be adjusted. In this Design, the motor step angle is 0.36°, and 1000 steps per revolution. With the mechanical design, the step motor can control the adjustment platform in less than 6 μrad。 The speed of the motor is determined by the pulse frequency come from fm353. Considering the actual situation, the real adjusting range is very small, and the speed of the adjustment can be very slow.

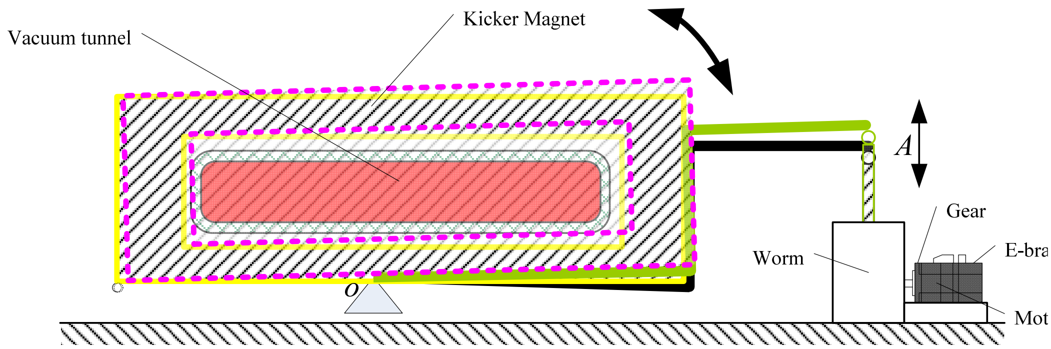

Figure 2: Motion scheme.

FEEDBACK CONTROL AND SOFTWARE DESIGN

Feedback Control

Position feedback is derived from inclinometer through optical fiber, through which PLC's SM340 module can acquire the real-time and high-precision position information. The benefit of inclinometers is the measurement is more direct with 2d angle and not subject to mechanical platform installation space conditions [2]. The inclinometer has many output forms such as RS232/RS484,CAN2.0,0.5-4.5V and 4-20mA. Furthermore, Inclinometer can measure the temperature and send it with the angle. With a view to actual position feedback form, special attention should be paid to check and confirm the increment direction of inclinometer during control system debug and assemble stage. If we set a wrong increment direction of inclinometer, we would get a decreasing angle but actually we need a increasing angle, and vice versa. Thus, such condition must be avoided.

The controller based on SIEMENS S7-300 PLC has so fast scanning speed and the adjusting range is so small that it can use close-loop control technology while the inclinometer is not very fast. During motors keep moving, PLC judges continuously whether motors have got to the destination position set by user through comparison between destination angle and current angle from inclinometer.

Safety Protection

With the exception of accurate motion control, the controller must ensure the safety protection. In this controller, software limit, kill switch and mechanical hard stop are used to implement up and down position protection. Software limits on the one hand prohibit setting value beyond the normal range; on the other hand, through comparison between software limits and feedback values from inclinometer, PLC must stop motor immediately and give warning indication. Kill switch can cut off pulses by hardware as well as give signal to PLC. Mechanical hard stops are used to stall the motor if the kill switch fails.

Software Design

Software designs are composed of two parts, one is program design based on PLC, and the other is program design based on EPICS.

PLC program design environments are SIEMENS Step 7 and WinCC Flexible 2008. Step 7 is used to develop motor control program and WinCC Flexible 2008 is used to develop application based on local panel. According to actual application, PLC's task modules mainly consist of motion control, inclinometer reading, safety protection, communication with EPICS and etc. Of all PLC's function modules, motion control is one key part. Because we utilize close-loop technology to realize accurate angle of magnet platform, we must adjust the motor speed into appropriate range in accordance with characteristic speed curve of stepper motor. Local panel program communicated with PLC via Ethernet mainly utilize WinCC Flexible 2008 to implement right status configuration and display.

Present EPICS environment is based on EPICS base-3.14.9 and Linux environment is Fedora Core 11. The communication between soft IOC and PLC is via Ethernet TCP/IP. To make EPICS save the last running statuses and parameters after IOC restarting, the autosave module is applied in the S7plc driver packages. Figure 3 is the interface in remote mode.

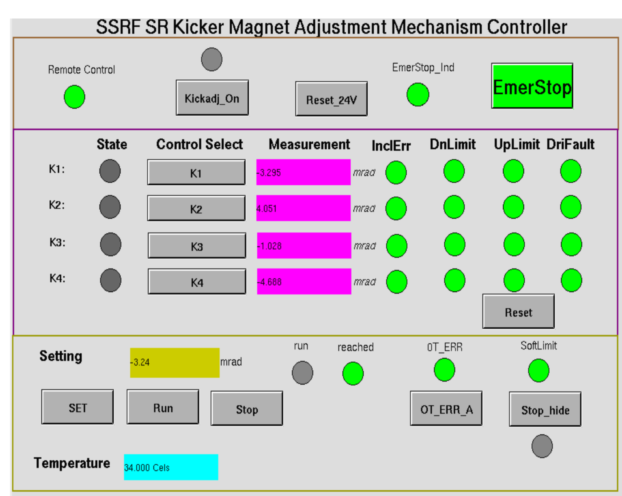

Figure 3: Interface in remote mode.

CONCLUSIONS

The adjustment mechanism has been installed on the storage ring injection kicker, and works well. The adjusting range can be achieved from -10mrad to -10mrad, the running accuracy is ±20urad. With the Software limit、kill switch and mechanical hard stop, the controller works in stable and reliable operation. By using this device to tilt the magnet, the rms value of the first 200 laps Track is less than ±4µm, which one can reached ±100µm before tilt optimized.

REFERENCES

[1] Z. T. Zhao and H. J. Xu, "SSRF: A 3.5 GEV SYNCHROTRON LIGHT SOURCE FOR CHINA", EPAC'04, Lucerne, July 2004, THZCH03, p. 2368 (2004); http://www.JACoW.org.
[2] SST500S inclinometers manual operation (2009).