THE DESIGN OF CONTROL SYSTEM FOR THE OPTICAL CAVITY ADJUSTER OF A FEL-THZ SOURCE

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Abstract

Optical cavity adjusters used to adjust the position and angle of the optical cavity with a high precision are important apparatuses in a FEL-THz source. In view of the requirements of the optical cavity adjuster of the FEL-THz source, this paper presents the design of the control system of the optical cavity adjuster. The design of the control system based on a PC and a motion controller is adopted. The motion controller controls high-precision linear stage to adjust linear direction and picomotors are used to enable the adjustment of roll and yaw. According to relevant calculation, the range of linear direction and the accuracy can be reached at ±3mm and 0.2~0.5μm; the range of the adjustment of roll and yaw and the accuracy can be reached at ±2° and 20″. In summing up it can be stated that the design meets the requirements and it also lays the foundation for engineering on developing the optical cavity adjuster.

INTRODUCTION

The control system of optical cavity plays an important role in FEL-THz source [1]. As we had to control the optical cavity to move in three different directions with a high precision, some methods must be compared to reach the needs. In order to meet the needs, we will use several methods to realize the adjustment in different directions. As the mirror of the optical cavity must be kept stable, the adjustments for the three directions should maintain independent relatively. And this paper will introduce the equipment and the ways to realize the whole process of control system. Besides, some problems will be mentioned.

CONCEPTUAL DESIGN OF THE CONTROL SYSTEM

The design of control system for the optical cavity adjuster is considered to use reliable methods and offers good human-computer interaction, which will make it easy for online control.

The design is used to set several platforms to realize the adjustment of roll, yaw and linear direction, respectively. The optical cavity adjuster is made up of optical table, linear stage, mirror adjuster, vacuum chamber and mirror from bottom to top. The entire system is figure 1.

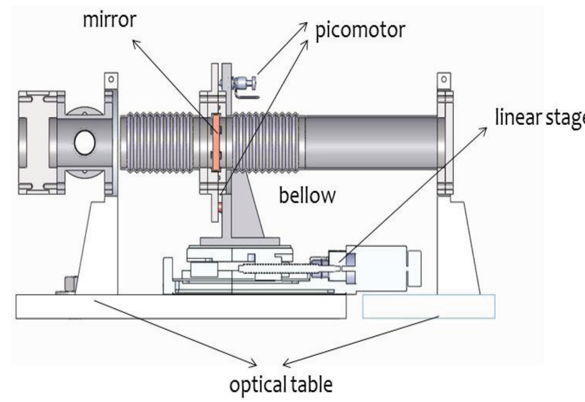

Figure 1: The entire structure of the system.

The picomotors on the mirror mount are used to enable the adjustment of roll and yaw. And it pushes the mirror mount to move to change the angles with a controller controlling the voltages of piezoelectric actuator. The linear movement is achieved with a motor in the linear stage. When the motor in the linear stage is run, it will meet the movement of linear direction. And the optical table keeps the whole device in a relative level position.

Hardware of the Control System

The hardware is comprised of computer, drivers, stepper motor actuator, mechanical transmission and position detection unit. The block diagram of whole control system is figure 2.

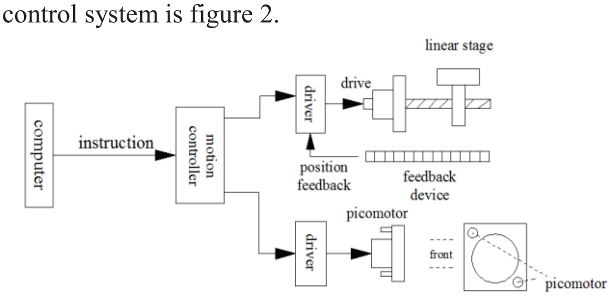

Figure 2: The block diagram of whole control system.

Through analysis and calculations, motion controller will transfer the decision command in the form of digital pulse signal or analog voltage signal to the motor drive, the driver performing power transformation, drives motor to act with instructions. With a transmission mechanism, motor drive the mechanical structure move and we can get the expected movement parameters and forms.

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The NEW FOCUS 8310 closed loop picomotor actuator (figure 3) is ideal for applications where closed-loop control and absolute position calibration is required.

Figure 3: 8310 closed loop picomotor actuator.

With an integrated rotary encoder and forward and reverse limit switches, this unique device offers the best attributes of the standard picomotor actuator <30 nm resolution, >5 lbs (22 N) of force along with set and forget long-term stability, with the added benefits of exceptional accuracy and ±1-µm bi-directional repeatability over the entire half-inch travel range. The proper position of the picomotors is figure 4.

When the picomotors are installed on the mirror mount, one of them can be chosen to work to adjust the angle of roll or yaw. As there are several modes of operation for picomotors, we consider to use the computer to control the picomotor driver. And through controlling the driver, the picomotor can move to the position which we need.

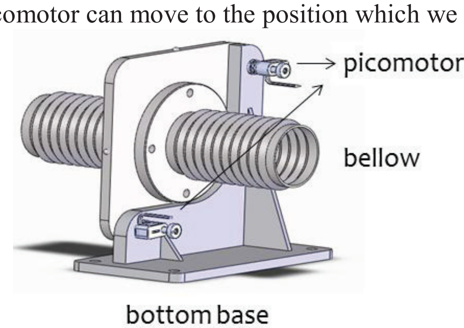

Figure 4: The proper position of the picomotor.

As the accuracy of the linear stage is very high, we choose GTS70 high precision linear stage (figure 5) of Newport. The stage provides high sensitivity and outstanding trajectory accuracy in a compact, robust and cost effective package. GTS stages are machined from stress-relieved 7075 aluminum for long-term strength and stability. A high-torque DC motor with a precision ground and preloaded, low friction ball screw eliminates stick-slip effects and delivers ultra-smooth motion with 100 nm incremental motion capability over a 70 mm travel range [3].

Figure 5: GTS70 high precision linear stage.

Software of the Control System

The software of the control system is mainly consisted of communication module, motion control module and data acquisition module. When programmed on the computer, through the motion controller, the electrical machine will act automatically with the instructions from driver.

We use LabVIEW to develop a display interface to show the entire control process, as in figure 6.

In the display interface, the working state of the picomotor will be shown. While the linear stage will work with the instructions sent from the computer. The real time location with alarm and error information will be shown in interface display.

And the manual mode and automatic mode is in the display interface. When the manual mode is chosen, we can adjust the picomotor and the axis to move from point to point so as to reach the targeted position. But if the automatic mode is chosen, the picomotor and the axis will move with the instructions from the computer to meet the needs. At the same time, the location data can be read accurately and saved completely for research and future reference.

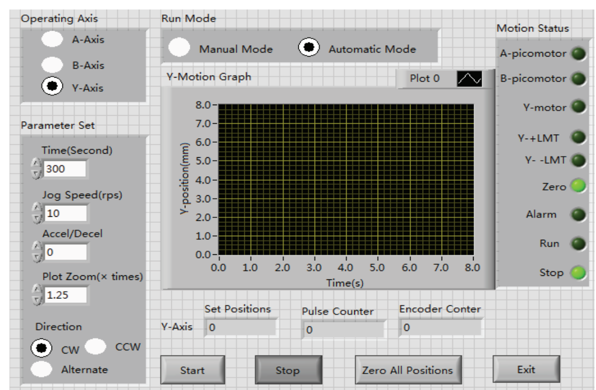

Figure 6: The display interface of the control system.

THE WHOLE PROCESS OF THE CONTROL SYSTEM

As we all know, the magnetic axis of the undulator, the optical axis of the resonator and the electron beam propagation axis must be coaligned to high precision [2]. The adjustment of roll and yaw is completed when we install the whole optical cavity. And the adjustment of linear position is done while the electron beams are going through the undulator. So when the roll and yaw have been adjusted, we can keep it for the position. But the linear direction has to be adjusted until it meets spontaneous emission [4].

The whole process of the control system is figure 7.

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CONCLUSION

When we finish the whole process of control system, we have to know whether the position is changed or not. If the position is not changed, we don't need to do anything. But if the position is changed, we have to adjust it. That is to say, we should create a detecting system, so as to detect the position time to time.

Whether the adjustment of roll and yaw is arrived at the targeted position, which is mainly through an alignment laser. And the grating ruler is installed so as to measure the distance of the linear stage. Besides, the grating ruler is used to test whether the linear stage arrived at a targeted position.

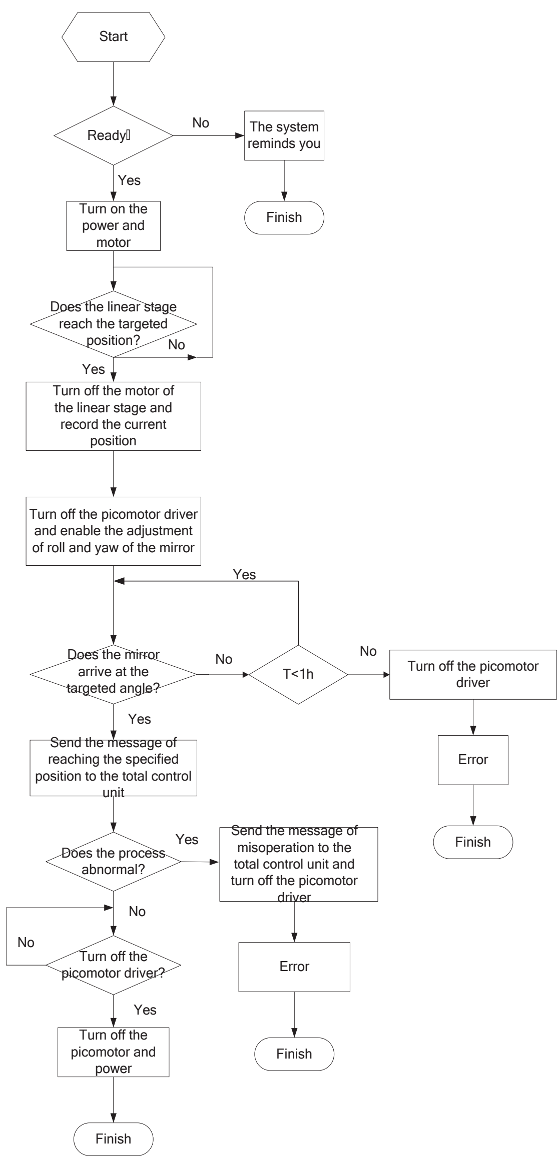

Figure 7: The whole process of the control system.

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