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A Position Feedback Control System for the Test Facility of JLC

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Abstract

In order to develop an alignment system for the Japan Linear Collider(JLC), we have constructed a test facility to study the position control system with multiple degrees of freedom for massive load. Noticeable points of the test facility are as follows.

(1)Feedback fine alignment system which consists of piezoelectric actuators and laser interferometers.
(2)High-speed controller using VME modules.
(3)Level positioner driven by stepping motors.

The controller can easily be connected with other computers by using RS-232C or Ethernet, so that their states such as positions can be monitored by another computer system. This facility achieves the alignment of multi-degrees of freedom with the accuracy of the order of submicron.

I. INTRODUCTION

It is commonly recognized that a submicron alignment system will be required for the final focusing magnets of the future e^+e^- collider. As found in recent study, JLC beams at the interaction point will be as small as 1.4 nm in vertical and 230 nm in horizontal to have enough luminosity [1]. On the other hand, ground motion of the order of 100 nm is expected even at deep underground and the vibration due to the cooling water pulsation is also expected. Therefore we must keep the magnets stable against the vibration and we are considering to realize the magnet position stability by means of a feedback control, called the active alignment [2].

We have constructed a test facility for a 1.5 t magnet. The facility achieves the fine active alignment of five degrees of freedom with piezoelectric actuators. It also has the level positioners of six degrees of freedom as the coarse movers. In this report we will describe the test facility and its control system.

II. TEST FACILITY

The test facility is schematically illustrated in Fig.1 and its photograph is shown in Fig.2. The magnet support table is designed to have enough stiffness (the least natural frequency is above 100 Hz) so that it keeps its own shape unchanged under the usual vibration. The magnet support table is supported by eight piezoelectric actuators (four for vertical and four for horizontal) and the whole active alignment unit is supported by four level positioning units driven by stepping motors.

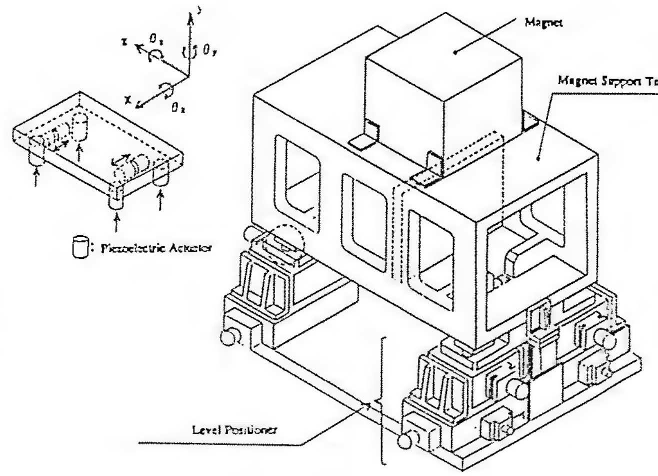

Fig.1 Schematic illustration of the test facility.

Fig.2 Photograph of the test facility.

III. CONTROL STRATEGY AND SYSTEM

Each level positioning unit has a function of three-axis positioning. Each axis has an absolute linear gauge of 1 μm resolution. With a cooperative move of the four level-

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positioning units, we can bring the table position to within the dynamic range of the piezoelectric actuator.

The fine active alignment of five degrees of freedom, X, Y, θ_X, θ_Y and θ_Z is achieved by the feedback of the table position. We must use a high-speed controller because the fast sampling time and the on-line geometrical calculation are required for the high gain feedback control to suppress the vibration disturbance. The adoption of the VME modules as the controller enables us to use the commercially available boards and the multi CPU structure. Figure 3 shows a schematic illustration of the control system. For the CPU's, we use MC68020 with a clock signal of 20 MHz and obtain a sampling time of 2 ms for the fine active alignment.

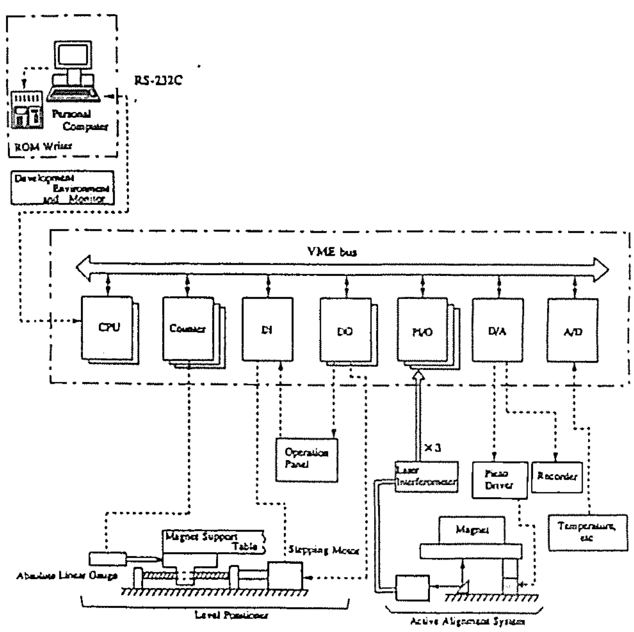
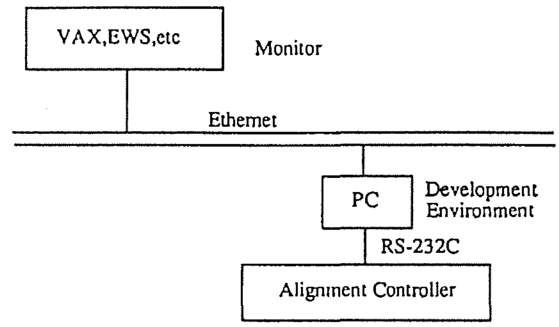
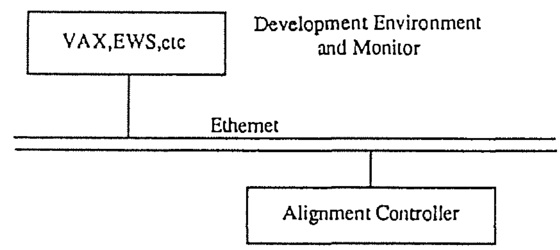


Fig.3 Schematic illustration of the control system.

When we want to connect the control system with a host computer, it is necessary to monitor the data and the status and to change the status by the host computer. We have already made a real-time data monitoring system by using RS-232C as shown in Fig.3. Ethernet is available via a personal computer with this monitoring system. Direct communication between the host computer and this control system with Ethernet is also possible by using the VME module with an Ethernet port and the necessary software. Figure 4 shows some possible network configurations of this VME-based alignment system.



(a)With the personal computer.



(b)With the VME module having an Ethernet port.

Fig.4 Possible network configurations.

IV. TEST

We have tested the precision of the level positioner. The test results are described in rms values of 100 trials as shown in table 1. Positions and tilts of the table have been measured by three laser interferometers in the vertical direction and two capacitance microsensors in the horizontal direction.

As for the fine alignment, we have tested the control performance of three degrees of freedom, Y, θ_X and θ_Z using laser interferometers whose resolution is 10 nm. To investigate the response of the active alignment system to vibration, we have added a white noise with a cutoff frequency of 3 Hz as disturbance to one of the laser interferometer feedback data. The noise has caused imaginary random vibration which simulates the ground motion of Y, θ_X and θ_Z. In Fig.5 showing the response in the time domain, we can see the vibration of amplitude of 1.5 µm peak to peak is damped to less than 0.2 µm.

Table 1 Precision of the level positioner.

	Positioning Accuracy (RMS)
X	0.217 µm
Y	0.750 µm
θ_X	3.00 µrad
θ_Y	2.27 µrad
θ_Z	1.29 µrad

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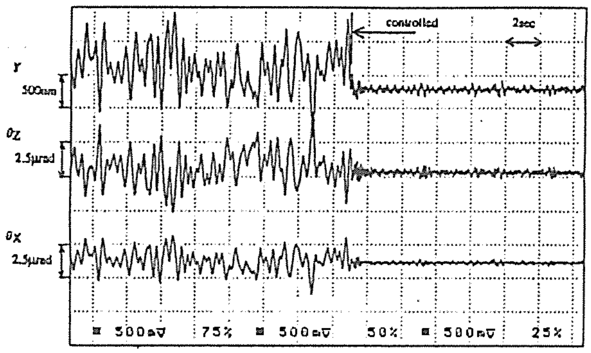

Fig.5 Damping response against the white noise with 3 Hz cutoff frequency.

V. REFERENCES

[1] K.Yokoya, Proceedings of the First Workshop on Japan Linear Collider, KEK, October 1989, pp.26.
[2] N.Ishihara et al., Proceedings of the Second International Workshop on Accelerator Alignment, DESY, September 1990, pp.453.