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RESEARCH ON ACTIVE VIBRATION ISOLATION SYSTEM*

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Abstract

Based on the increase of accuracy requirements coming from increasing instrument precision, advanced isolation components are required, and active vibration control method is proposed. This paper mainly shows the experimental system, and some work has been done at present. Now that we are still at the beginning research of active vibration isolation, we hope it will be steadily used in the support systems of some precision equipment and instruments.

INTRODUCTION

Micro-vibration study is one of the important research project in synchrotron light sources, the girder system with passive vibration isolation and damping technology which are effective for beam stability has been widely researched in different institutes, active vibration isolation system, for some uncontrollable factors exist in the control system and actors, its application in synchrotron light source has been constrained. While for the increase of accuracy requirements coming from increasing instrument precision, alone use of passive vibration can't satisfy the requirements, active vibration will play an important role in high precision instruments [1]. This paper firstly shows active vibration isolation research in accelerator, and then the experimental system and some work we have been done at present will be introduced.

The active vibration isolation system in accelerator is mainly used in the future compact linear collider (CLIC) [2], two nanometre size particle beams are accelerated and steered into collision to create high energy collisions between electrons and positrons, to achieve the expected performance, the beams need to be vertically stabilized at the nanometre scale, many institutes have done much preliminary development, early in 1996, Christoph had researched the active stabilization of mechanical quadrupole vibrations with one piezo actuator used in one support system [3]. J. Frisch et al had constructed a prototype system by using of active vibration damping to control magnet motion [4]. C. Collette et al researched on the nano-motion control system for heavy quadrupoles by using two actuators in one support [5, 6]. R. Le Breton et al. had researched on the nanometre scale active ground motion isolator with four actuators in one support [1]. All these research experiments show that active vibration isolation can play a positive role on nanometre scle. Now that we are still at the beginning research of active vibration isolation, we hope it will be steadily used in the support system of some precision equipment and instruments.

ACTIVE VIBRATION ISOLATION SYSTEM

A two stage support system which include passive stage and active stage is shown in Figure 1, the passive stage is composed of springs and damping, while the active stage is made up of springs and actuators. High stiffness springs, which result in high normal mode frequencies, provide relatively low amplitude motion and good stability in the absence of feedback, while low stiffness springs allow large amplitude low frequency motions, but attenuate high frequencies. This paper mainly research on the active stage.

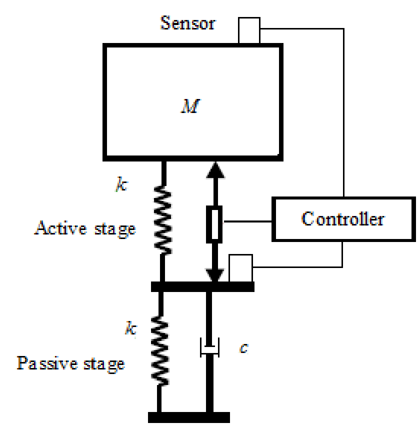

Figure 1: Single d.o.f support system.

To reduce expenditure, the active stage with three springs and one actuator is designed as shown in Figure 2. Different actuator technologies can be used for active isolation system, base on the advantages of high resolutions, wide bandwidths and strong forces, piezoelectric actuator is chosen in this stage. The load on the stage is about 100kg, and it's expected to be effective with the frequencies in the range 1-20 Hz.

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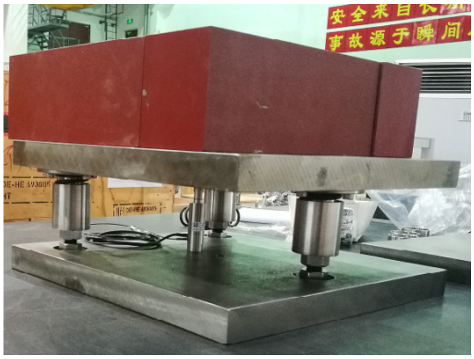

Figure 2: The structure of active stage.

As shown in Figure 3, the active isolation system consists of a actuator, a actuator power amplifier, two types of sensors measuring displacement and acceleration, two instrumentation amplifiers and a hardware for rapid control prototyping.

to obtain the velocity of the stage. The sensor with a sensitivity of 0.3V·s^2/m offers a suitable bandwidth for this application (0.25～80 Hz).

Capacitive sensor PI D-E20 is chosen to observe the elongation of the actuator, although the sensor can't give direct information about the stage motion, it's used to get the electromechanical model of the structure. Open loop performance platform is established as shown in Figure 4, it consist of a signal generator, a power amplifier, D/A, A/D, a capacitive sensor, an instrumentation amplifier, a actuator and a actuator controller. The multimeter DMM7510 is also used to measure the precision of the piezoelectric actuator and the capacitive sensor, due to the controller is not the original controller to the actuator and error exists between them, the precision is measured within 5 nm.

Open loop response of the actuator at different frequencies with 0.1 Hz, 0.5 Hz, 1 Hz have been tested, Figure 5

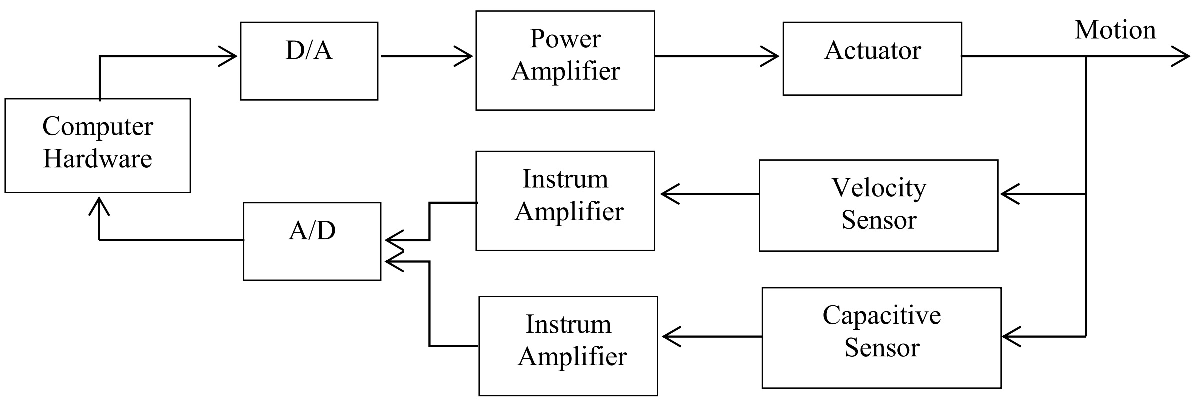

Figure 3: Control system of the active isolation system.

P-845preload stack piezoelectric actuator from PI is chosen as the actuator in the active stage, a preload ensures that the actuator will not be damaged when the driven close to the frequencies of the structure.

Because it is impossible to obtain the absolute displacement of the ground due to lack of fixed reference, the ground motion can be measured by only acceleration or velocity sensors. The sensor 941B which at different tap position can measure velocity or accelerator is chosen

Figure 4: Open loop performance platform.

shows the response at 1 Hz, in which the first curve is the signal from the signal generator, the second carve is the signal from the actuator controller, and the third carve is the signal from the capacitive sensor, these carves indicate that the actuator and the capacitive sensor have nice response to the input signal at a single low frequency.

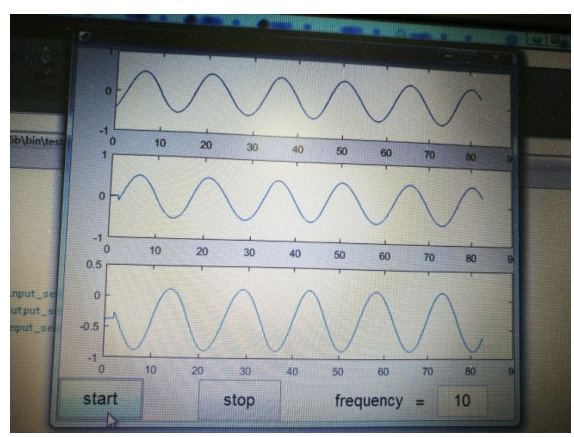

Figure 5: Open loop response at 1 Hz.

The response with the frequencies of 0.5 Hz and 1 Hz coupling has been tested, and the result is shown in Figure 6. The response with the frequencies of 0.5 Hz, 1 Hz

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and also with random signal coupling has also been tested, and the result is similar to Figure 6, which is considered to be suitable.

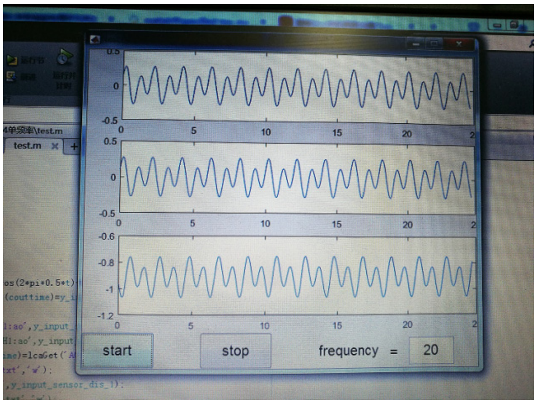

Figure 6: Open loop response with 0.5 Hz and 1 Hz coupling.

CONCLUSION

For active isolation can be widely used in different fields, like interfometers, microscopes, high precision manufacturing and so on, now we are still at the beginning research of active vibration isolation, there are much work such as closed loop response, two or three actuators work together and so on need to be done.

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