An integrated controller for real-time syncronization of industrial motion and vibration absorption

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Abstract

For the purpose of micro vibration in semiconductor and flat panel display (FPD) manufacturing, an integrated controller was developed for controlling motion and vibration simultaneously. The controller was composed of multiple function boards which interface sensors, motors, and air mounts in real time. The controller provided a programmable memory for control logic, sensor value and motion status, which can be used to synchronize position and vibration control.

1. Introduction

As nano processes widely come into use in semiconductor and FPD manufacturing, vibration becomes on environmental factor.[1] Even small vibration affects the product quality, so sensitive processes such as lithography require countermeasures about vibration. However, vibration is propagated through solid media - wall, floor and mechanical structures, therefore it is difficult to cut off. Nevertheless, vibration isolation and absorption are very popular issues but conventional studies have two problems: load weight and separated control of motion and vibration.[2,3] With most devices the vibration control was targeted under hundreds of kilogram and cannot sustain the heavy weight of manufacturing machines. Motion of the machines is operated with high speed and acceleration for production efficiency, but these motions generate unavoidable shock vibration. The response of vibration control is much slower than that of the motion, so the vibration control will be improved by checking motion information. Current vibration controllers are physically separated from motion controllers, so it is difficult to use the motion information in real time. Therefore, this study constructed an integrated and embedded controller which can synchronize the motion and vibration control. The controller provides real-time and multi-tasking interface for multiple external devices, various control status and control logics.

2. A motion stage and an air mount

A typical commercial stage is constructed for targeting motion by combining rotational and translational kinematics. The kinematics are commonly composed of motors, encoders, linear motion guides, gears and ball screws considering high speed (300mm/s) and acceleration (0.5G). The stage is usually constructed on a granite surface plate (1500kg) which is supported by 4 vibration control devices on a base frame. The vibration control device was composed of an air spring, a magnetorheological (MR) damper, and an electro-magnet for the isolation and absorption. Air springs are the most commonly used for large force, but have a low frequency resonance problem caused by low stiffness. Air mounts in this study were constructed by combining electromagnets and magnetorheological (MR) dampers without contact in the spring.[4] The air mounts isolate floor vibration in a steady state and absorb shock vibration induced by the stage motion. Figure 1 shows an air mount that is placed below a granite surface plate and has an internal MR damper in an air spring. Vibration was measured using submicron-resolution laser sensors (ILD-2200) whose data was transferred through Ethernet and TCP/IP. An XY stage was constructed using linear motors and encoders on the surface plate. 100kg of moving mass was attached on the stage for the purpose of the simulated shock vibration in manufacturing machines.

3. An integrated controller

Commercial motion controllers interface with motors and sensors in a manufacturing machine. High-end and high-speed motion techniques are applied to the manufacturing machine, and those motion controllers have high performance signal processing and mathematical computation. Vibration controllers measure vibration with sensors and interface with multiple signal ports in air mounts. It is better to check motion status for vibration control logic, but is not available due to the low communication speed to the motion controller. The distance between a vibration sensor and the controller is usually long, therefore digital communication is required as the signal is exposed to industrial noise.

Considering those facts, we constructed an integrated controller which can synchronize the motion and vibration control using UMAC. The integrated controller is composed of multiple expandable boards, such as the main CPU, motion, AD, DA, DIO, Ethernet and AMP. These boards are installed in a backplane, interface hardware devices with the sensor signals and compute digital status simultaneously in real time. The digital status is transferred to RAM in the main CPU board through 96pin BUS. Combined logic for motion and vibration control was built and was downloaded in a flash ROM. Both the motion and vibration were conducted simultaneously, referring the sensor signal and the digital status. If acceleration sensors can be attached to the stage and the base frame, it can be determined whether vibration source is caused internally or externally. Figure 2 is a diagram for data flow and signal interface in the integrated controller.

In the experiment, XY transitional motion was given to induce vibration to the stage with vibration control. Figure 3 shows a motion profile and responses from 4 vibration sensors. The responses were converted to 3 DOF vibration of the surface plate through coordinate conversion in real time.[1] The profile and the vibration were stored in DPRAM of the integrated controller and transferred to a PC after testing.

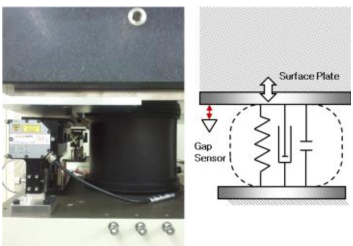

Figure 1: An air mount and a laser sensor

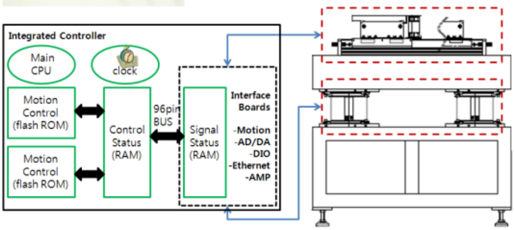

Figure 2: Interface diagram of a synchronized controller

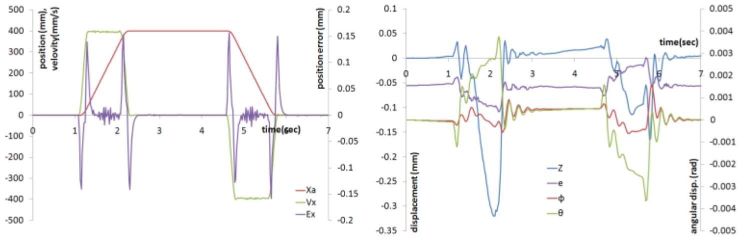

Figure 3: Motion and vibration status stored during stage movement

4. Conclusion

This study constructed an integrated controller which can interface various industrial signals and can synchronize motion and vibration control in real time. The integrated controller had expandable structure and programmable logic referring to digital status.

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