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Design and control of active vibration isolation system with an active dynamic vibration absorber operating as accelerometer

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Abstract- This paper exhibits the development of a vibration isolation system using an active dynamic vibration absorber (ADVA) as an accelerometer in a low-frequency range; whereas, it operates as a vibration control device in a high-frequency range. The control signal of the ADVA gives an information of the low-frequency acceleration. At the same time, in the active vibration isolation system, an air spring is employed as a low-frequency control device and an inexpensive MEMS-type accelerometer is used to measure the acceleration of the vibration in a high-frequency range. The sensor fusion technique is applied to integrate the output of the MEMS-type accelerometer and the acceleration estimated from the ADVA. The motions of the vibration isolation table and the absorber mass of the ADVA are controlled by PID control. The integrated acceleration by the sensor fusion is transmitted through a low-pass filter to the air spring and through a high-pass filter into the ADVA to attain additional acceleration and velocity feedback to the PID controls. Several experimentations and observations are conducted to measure the transmissibility and compliance. The experimental and simulation results demonstrate that the performance and operative precision of the developed active vibration isolation system are improved by the additional absolute acceleration and velocity feedbacks in terms of compliance as well as transmissibility characteristics.

Keywords- Active vibration isolation, Dynamic vibration absorber, MEMS, Sensor fusion, Accelerometer, Vibration control

1. Introduction

At present, an expanding need of high performance vibration isolation system exists in various fields of research and industry. Such systems are employed in silicon wafer, high-precision measuring devices, space equipment and semiconductor industries for attaining the isolation of vibration [1]. Vibration isolation systems are classified into active and passive types. A typical passive vibration isolation system uses spring and damper to reduce vibration [2]. However, passive vibration system cannot suppress the vibration over a wide range of frequencies [3]. It indicates that the accuracy and operative performance of the passive vibration isolation is limited even though damping at high frequency can be reduced by replacing a simple damper by a Maxwell unit consisting of a spring and a damper in series [4].

In contrast, active vibration isolation system can overcome such limitations of performance. However, conventional active control system needs high-performance sensors like servo-type accelerometer for detecting vibration in a low-frequency range, which are rather expensive [5]. Similarly, to attain higher