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A TMD DESIGN APPROACH FOR REDUCTION OF ACCELERATION AND JERK USING H_2 SYNTHESIS

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Abstract. *Vibration control with Tuned-Mass Dampers (TMD) has been widely investigated in recent years. The objective, however, has been mainly the reduction of displacement. In this paper, a TMD with passive elements is synthesized for optimal acceleration and/or jerk reduction. In order to use conventional feedback control, passive elements of the TMD are presumed active, replacing velocity/displacement feedback components. Using H_2 norm and output feedback control, we obtain feedback gains for the system and then use them as the coefficients of passive elements. It is thereby shown that we can reduce jerk and/or acceleration excessively compared to the design based on displacement reduction. Also, using these elements parallel with force actuator in a combined passive-active system, results in further reduction of the required power. The overall performance of three types of: passive, active and passive-active systems are finally compared.*
Keywords: Jerk, Tuned-mass damper, Vibration control, Active/Passive control

1. Introduction.

Vibration problems have extensively been studied for more than a century. Excessive vibration causes excessive vibratory displacement, velocity, acceleration, and consequently excessive force and jerk of moving components. Different techniques have been therefore developed to treat vibration problems including passive, semi-active and active control systems [1,9,19].

One of the classical concepts for vibration isolation proposed by Karnopp et al. [10] was the use of tuned mass dampers. Several researches have since focused on applying TMDs to structures, specially skyscrapers to minimize the displacement [5,11,18]. They were also employed for seismic protection of civil structures. TMDs can be useful in controlling the resonances in many instruments which are exposed to forced vibrations.

Reduction of vibration in vehicles using TMDs has also been investigated. Sunwoo et al. [17] introduced a reference model and adaptive control in order to control automotive suspension system considering state variables of a skyhook damper. Alleyne and Hedrick [2] used nonlinear dynamics of an electro-hydraulic actuator and adaptive control to find the skyhook optimal force for a suspension system. Bakhtiari-nejad and Karami Mohammadi [4] used a half-vehicle model with an active suspension to design a model reference adaptive controller; the reference model was an active system with skyhook damper. The result showed improvement of ride comfort and safety.

Hrovat [8,9] investigated different methods of control including TMD. Suspension systems of the vehicles were studied using different models: $1/4$, $1/2$ and full car model along with TMD, active, semiactive, adaptive and nonlinear control. Also, Pannil et al. [15] used H_2 to design a controller to stabilize an unstable system and dampen the closed-loop