Principle and Control of Active Engine Mount Based on Magnetostrictive Actuator

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Abstract

The engine mount system affects the automobile NVH performance. Active mounts would achieve excellent vibration isolation and relative displacement control performance in a broad frequency bandwidth by outputting controlled force to the mounting system. The actuator and control method of the active mounts determine the system performance. In this paper, an active mount based on the smart material - Terfenol-D rod is proposed, which mainly includes three parts: rubber spring, magnetostrictive actuator (MA), and hydraulic amplification mechanism. Dynamic model of the active mount is correspondingly established. A state feedback control method based on x-LMS algorithm is proposed as well. Specifically, with the consideration of the unmeasurable state parameters in the active mounting system, an x-LMS state feedback controller with the system state as the reference signal is constructed by employing Sage-Husa Kalman filter to realize the state estimation of the active mounting system. Then a detailed analysis of the proposed control method is conducted, with deriving iterative formula of tap-weight vector. Sequentially, the problem of the dependence on the excitation signal in the x-LMS algorithm is addressed. The feasibility and capability of the proposed control method are verified and evaluated by simulation of a two-degree-of-freedom active mounting system.

Full Text

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Figures

Figure 1

Two-degree-of-freedom active mounting system model

(a)

(b)

Figure 2

The proposed active mount: (a) the configuration and (b) the principle

(a)

(b)

Figure 3

The control diagram: (a) x-LMS algorithm [9] and (b) x-LMS algorithm with state feedback

Figure 4

Control principle of the active mounting system

Figure 5

Dynamic force experiment platform of the MA

Figure 6

Dynamic force test results of the MA

Figure 7

Output force-current relationship of the MA

(a)

(b)

Figure 8

Comparison results of active mount and passive mount at the engine speed of 750 r/min: (a) the relative displacement and (b) the transmitted force

Figure 9

Comparison between estimated system state and real system state at the engine speed of 750 r/min: (a) X_1 : engine displacement, (b) X_2 : engine velocity, (c) X_3 : sprung mass displacement, and (d) X_4 : sprung mass velocity

(a)

(b)

Figure 10

Comparison results of active mount and passive mount at the engine speed of 3000 r/min: (a) the relative displacement and (b) the transmitted force

(a)

(b)

(c)

(d)

Figure 11

Comparison between estimated system state and real system state at the engine speed of 3000 r/min:
 (a) X_1 : engine displacement, (b) X_2 : engine velocity, (c) X_3 : sprung mass displacement, and (d) X_4 : sprung mass velocity

Figure 12

The process of variable engine speed

Figure 13

Comparison results of active mount and passive mount under variable engine speed conditions (engine speed increased from 750 r/min to 2100 r/min): (a) the relative displacement and (b) the transmitted force

Figure 14

Comparison between estimated system state and real system state under variable engine speed condition (engine speed increased from 750 r/min to 2100 r/min): (a) X_1 : engine displacement, (b) X_2 : engine velocity, (c) X_3 : sprung mass displacement, and (d) X_4 : sprung mass velocity