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An adjustable anti-resonance frequency controller for a dual-stage actuation semi-active vibration isolation system

Key words: Semi-active vibration isolation; Dual-stage actuation; Dynamic vibration absorption; Adjustable anti-resonance frequency controller

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Motivation

1. Existing isolators cannot properly isolate the disturbance of inertial force on a platform base during frequency sweeping (the frequency is between 0 Hz and the natural frequency).

2. Make full use of the anti-resonance characteristics of the dual-stage actuation semi-active vibration isolation system.

3. Design and provide a system and controller with good vibration isolation performance to guarantee an ultra-low vibration environment.

Main idea

1. The proposed controller is designed to add an adjustable anti-resonance frequency to fully use this unique anti-resonance characteristic.

2. By designing some parameters of the controller, two resonance points are eliminated and an adjustable anti-resonance point is added.

3. By applying pulse disturbance and frequency sweep disturbance to the platform base, load vibrations before and after the use of the controller are compared to verify the effectiveness of the system and the controller.

Method

1. An added anti-resonance frequency is used which can be adjusted from 0 Hz to the initial anti-resonance frequency by changing the parameters of the proposed controller.

2. The difference between the expected value and the actual one of the payload displacement is used as the input of the controller, and the outputs are the current value of the coil and the voltage value of the piezoelectric actuator (PZT). The main frequency of the base vibration f is obtained by fast Fourier transform (FFT), which is used as a reference to determine the newly added anti-resonance frequency.

Method (Cont'd)

Physical picture of the designed DSA-SAVIS

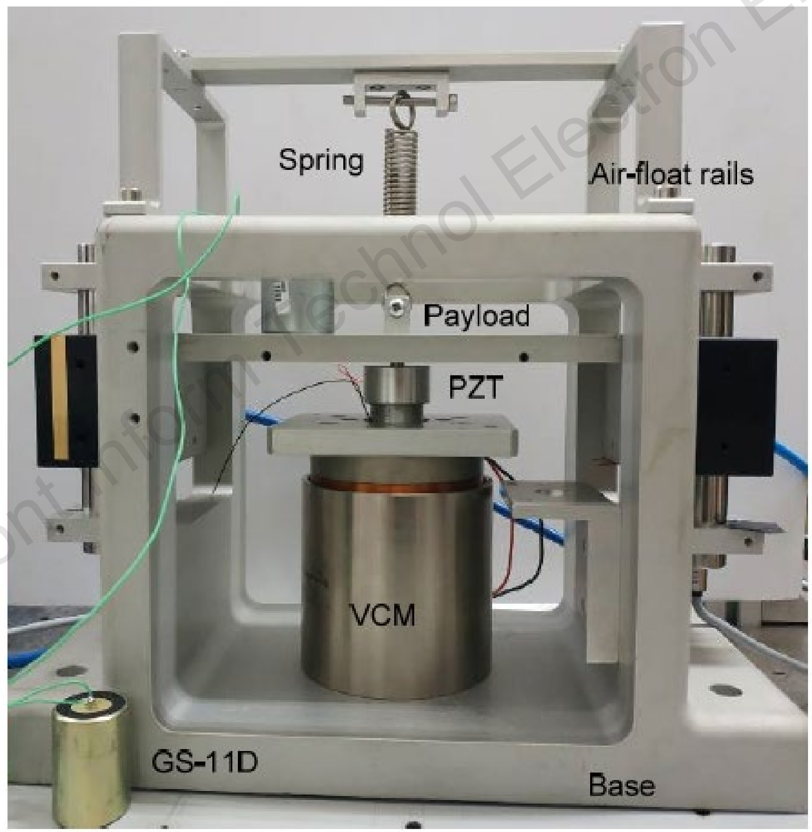


Fig. 9 Physical picture of the designed DSA-SAVIS

Major results

1. Results of adjusting the added anti-resonance frequency

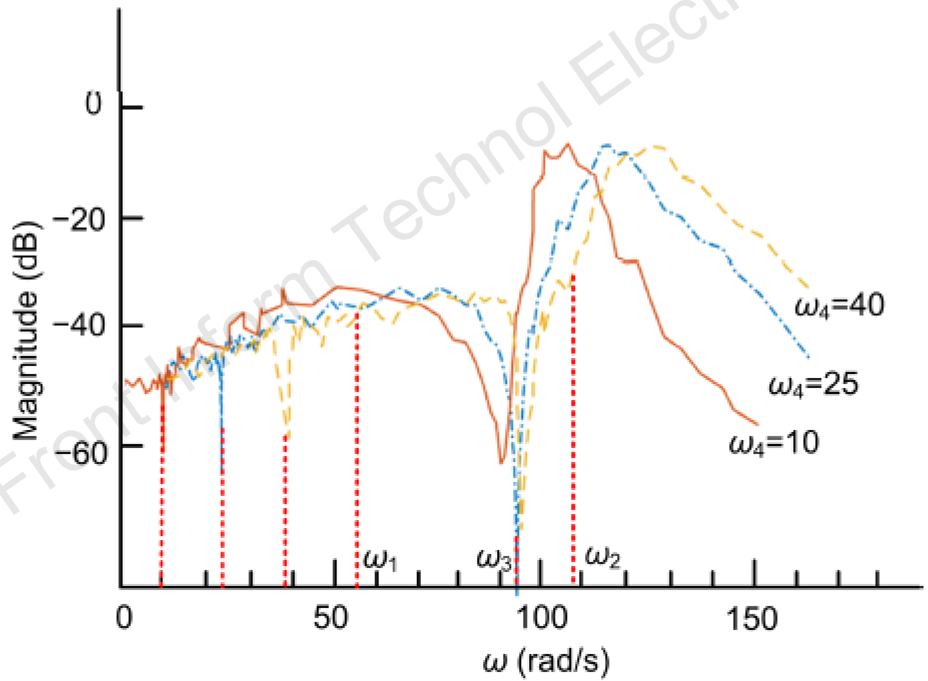
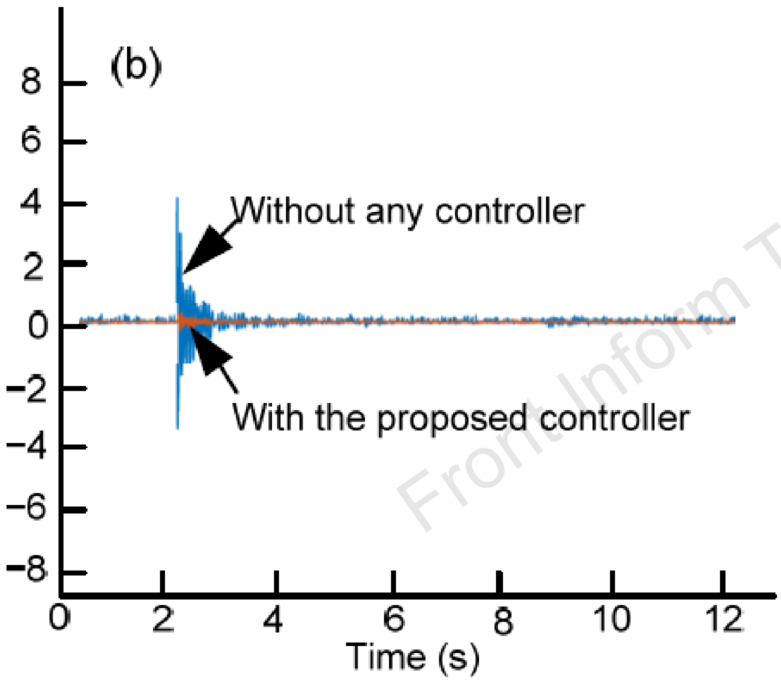


Fig. 12 Transmissibility curve with the designed controller

Major results (Cont'd)

2. Velocity of the payload and base with impulse disturbances



Velocity of the payload with and without a controller

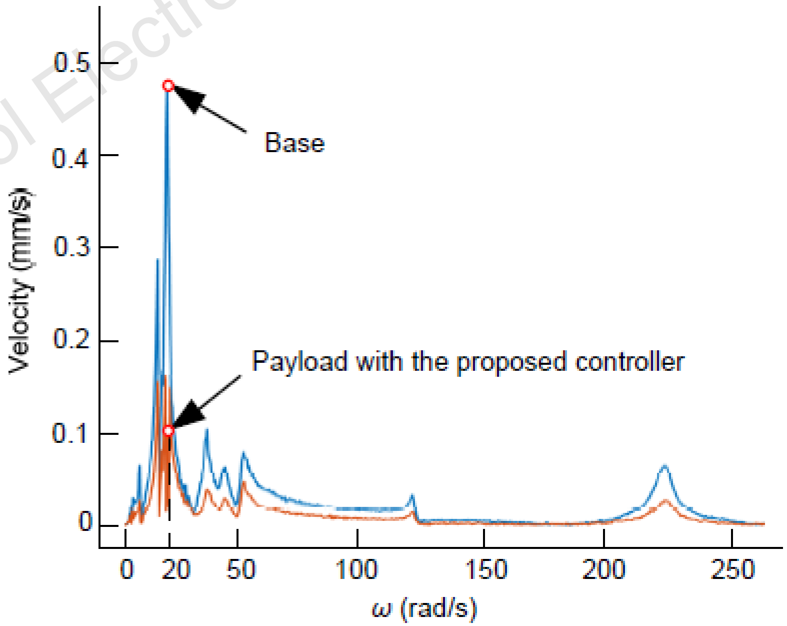


Fig. 14 Frequency spectrum of the base and the payload's velocity

Major results (Cont'd)

3. Velocity of the payload with frequency sweeping disturbances

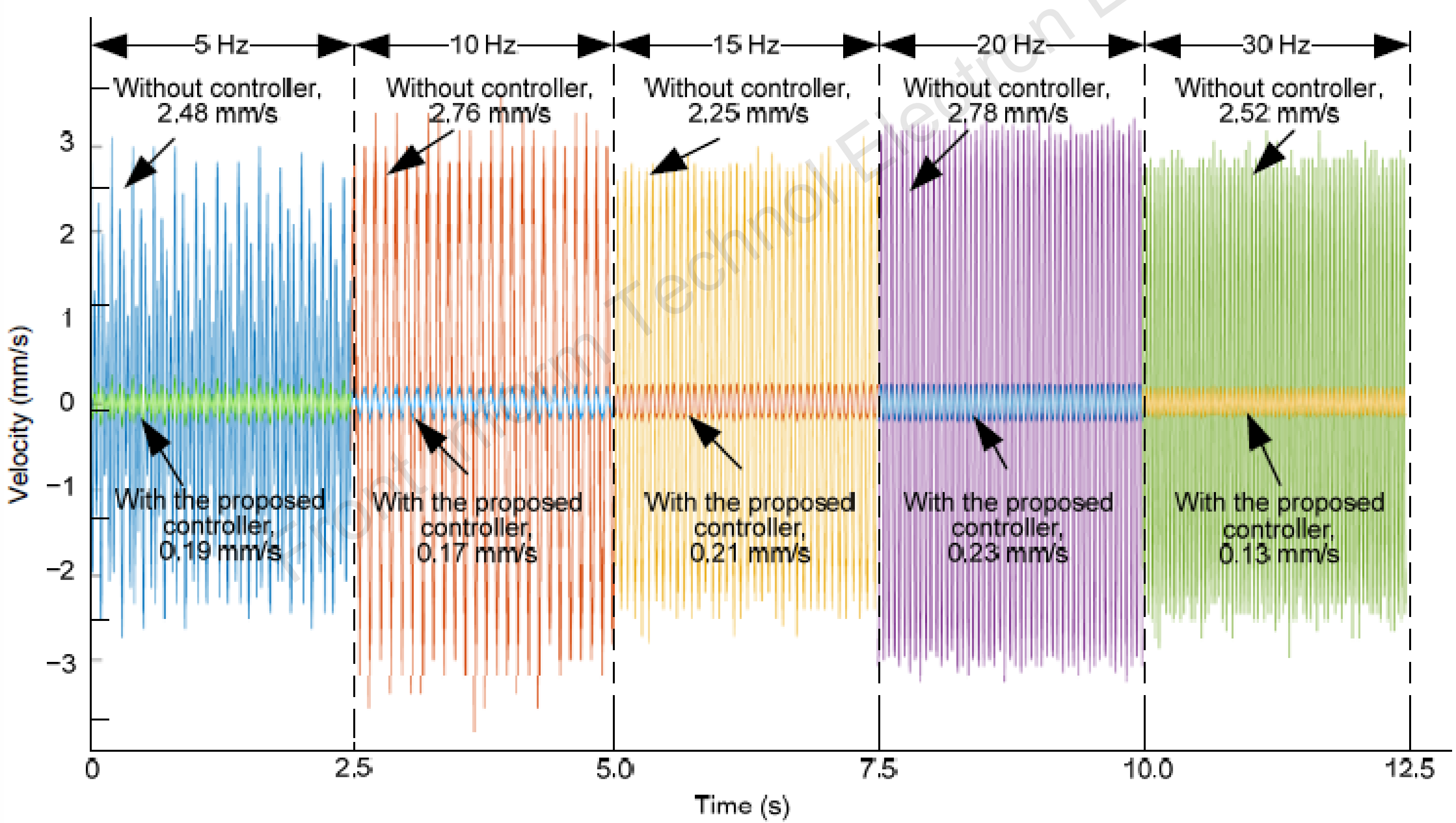


Fig. 15 Velocity of the payload with frequency sweeping disturbances

Conclusions

1. The closed-loop transmissibility is less than −30 dB around the added anti-resonance frequency, which can be adjusted from 0 Hz to the initial anti-resonance frequency.

2. With the proposed controller, the disturbance amplitude of the payload decays from 4 to 0.5 mm/s with a reduction of 87.5% for the impulse disturbance applied to the platform base.

3. The closed-loop transmissibility at a different sweeping frequency is below −25.7 dB, and the reduction is above 90.7% compared with that without the controller.

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