Vibration Mitigation Using An Inerter-based Isolation System

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INTRODUCTION

- There are many methods to mitigate vibrations in structures to prevent or reduce probable damages.
- Recently, the inerter has gain attention from engineers and researchers as it is attractive for many structural control methods.
- Many investigations have been done regarding the effectiveness of the inerter in reducing the vibration, but most are theoretical.
- Experimental studies featuring inerters, particularly regarding of isolation systems, have been limited.

INERTER

- An inerter can produce large mass effects despite having a small physical mass through the transformation of translational motion to the rotational motion.
- Can be made with ball-screw or lead-screw to provide the linear motion and a flywheel for rotational motion.
- In this study, the flywheel can be modified to provide two inertance values.
- Self-aligning ball bearing is used to reduce alignment issues with the inerter in the isolation layer during the test.

ANALYTICAL MODEL & PROPERTIES

System Parameters	Value	unit
ms	3.13	kg
mb	2.13	kg
ks	870890	N/m
kb	114210	N/m
b (bigger flywheel)	28.41	kg
b (smaller flywheel)	2.32	kg

❖ Inertance

$\omega = \alpha(\dot{u}_b)$

$\alpha = 2\pi/\rho$

$T = \frac{1}{2}J\omega^2$

$J = (J_1 + J_2 + J_3)$

$T = \frac{1}{2}J\alpha^2(\dot{u}_b)^2$

$\frac{d}{dt}\left(\frac{\partial T}{\partial \dot{u}_i}\right) = J\alpha^2(\ddot{u}_b)$

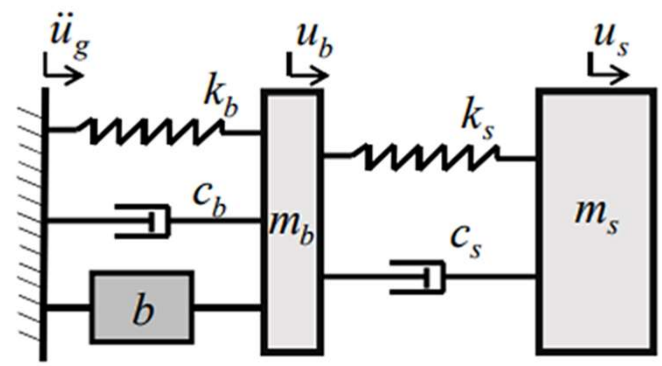


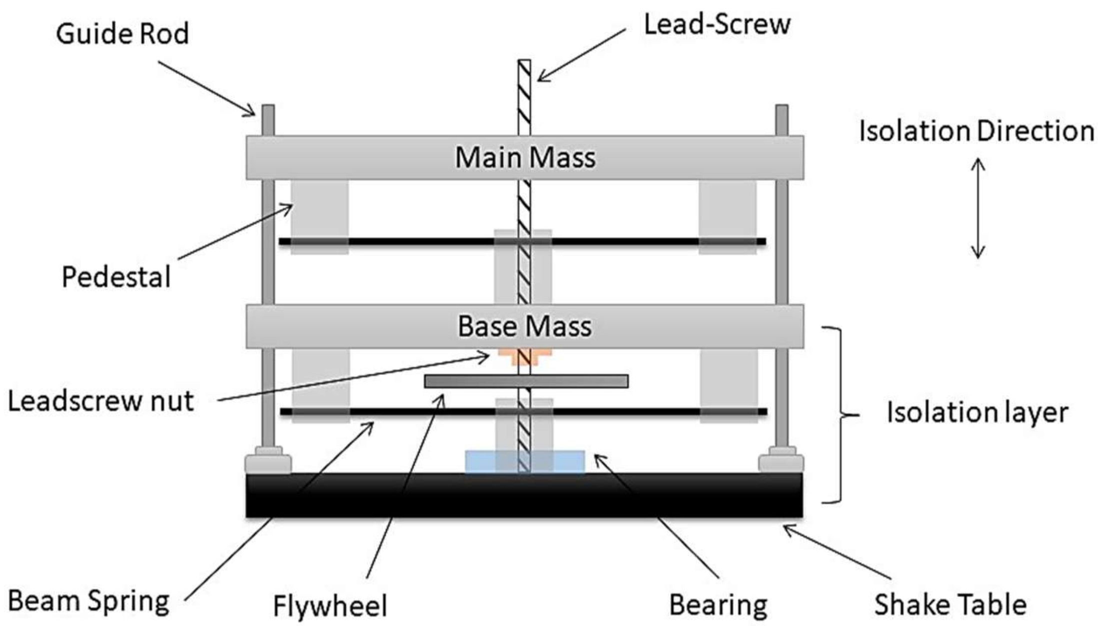
Diagram of the system with isolation featuring a rotational inertial damper

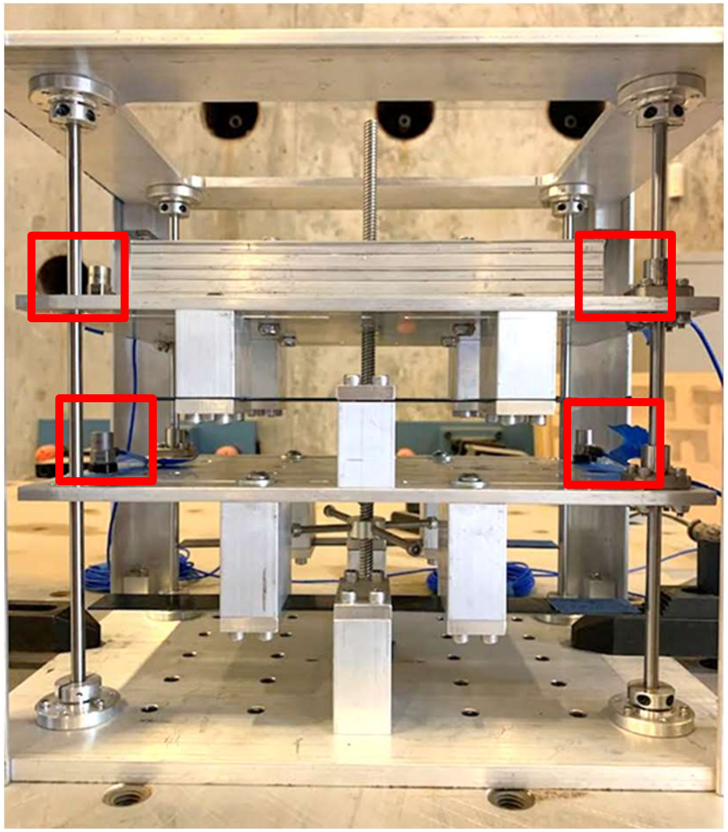
❖ EOM

$$m_s\ddot{u}_s + c_s(\dot{u}_s - \dot{u}_b) + k_s(u_s - u_b) = -m_s\ddot{u}_g(t)$$

$$(m_b + b)\ddot{u}_b + c_s(\dot{u}_b - \dot{u}_s) + c_b\dot{u}_b + k_s(u_b - u_s) + k_b u_b = -m_b\ddot{u}_g(t)$$

EXPERIMENTAL MODEL





- System configuration including isolator configuration with concentrated rotational mechanism paired with beam spring isolators

Video of the experimental test of the box with the inerter and the flywheel

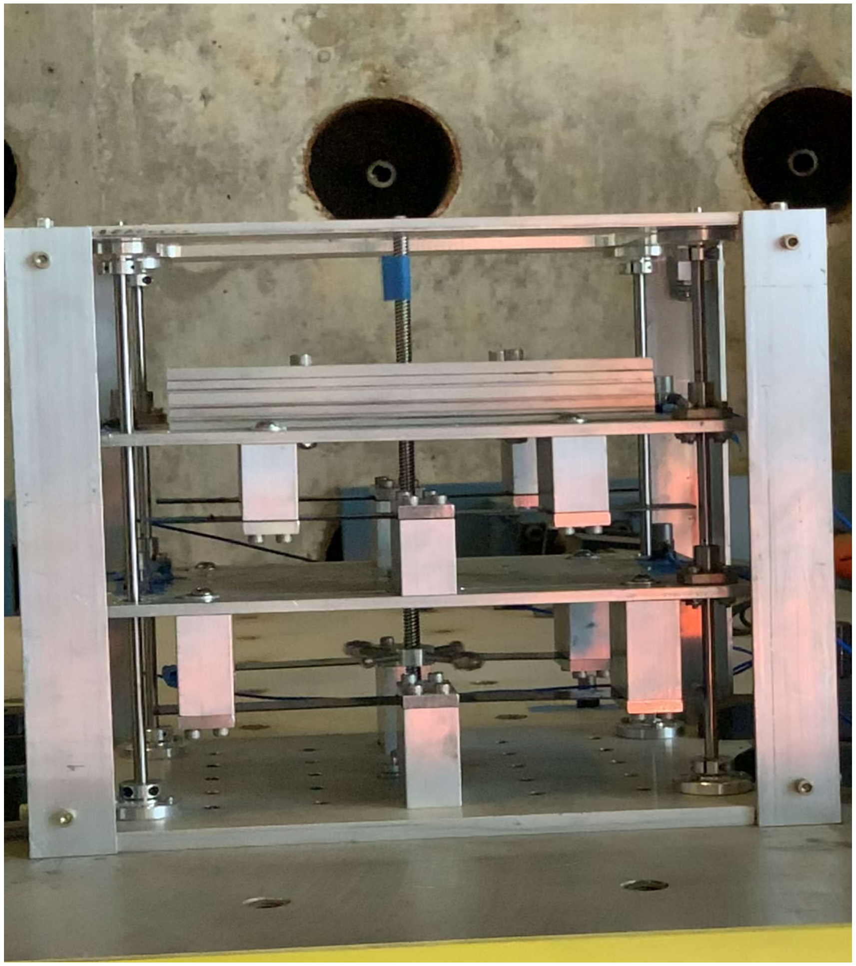
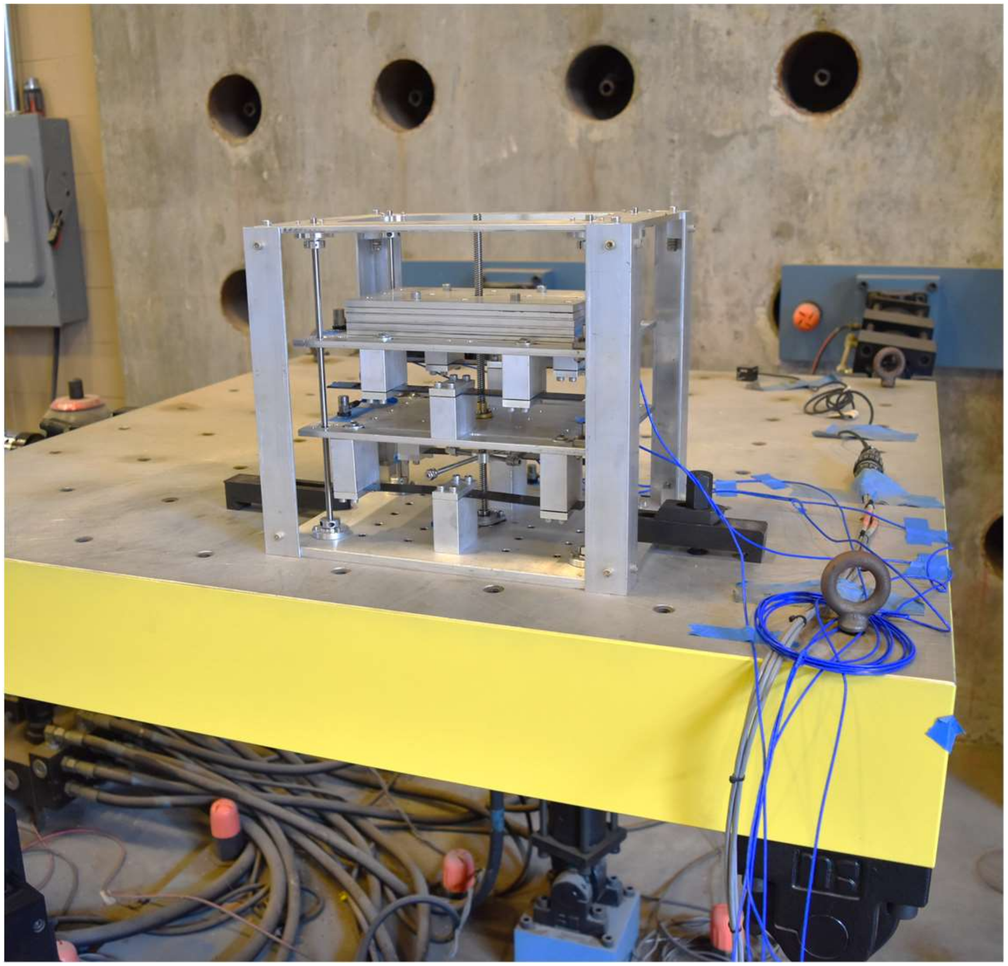
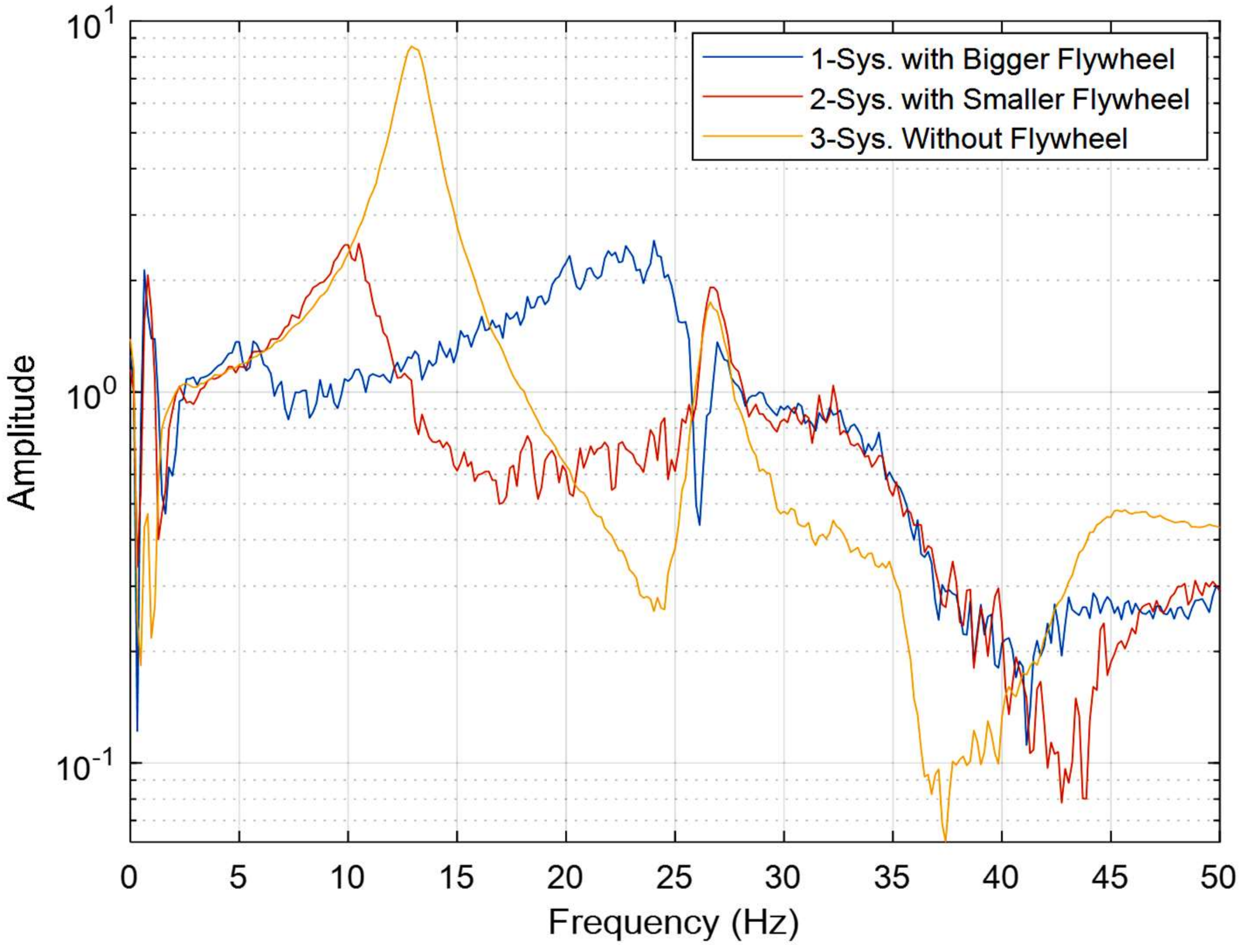


Photo of the model on shake table at The University of Tennessee

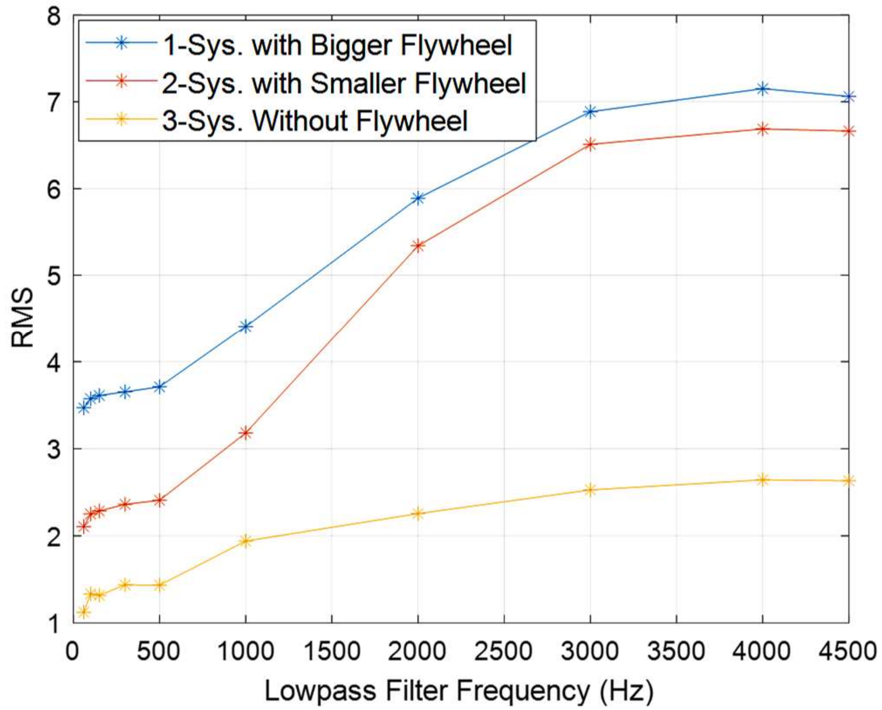


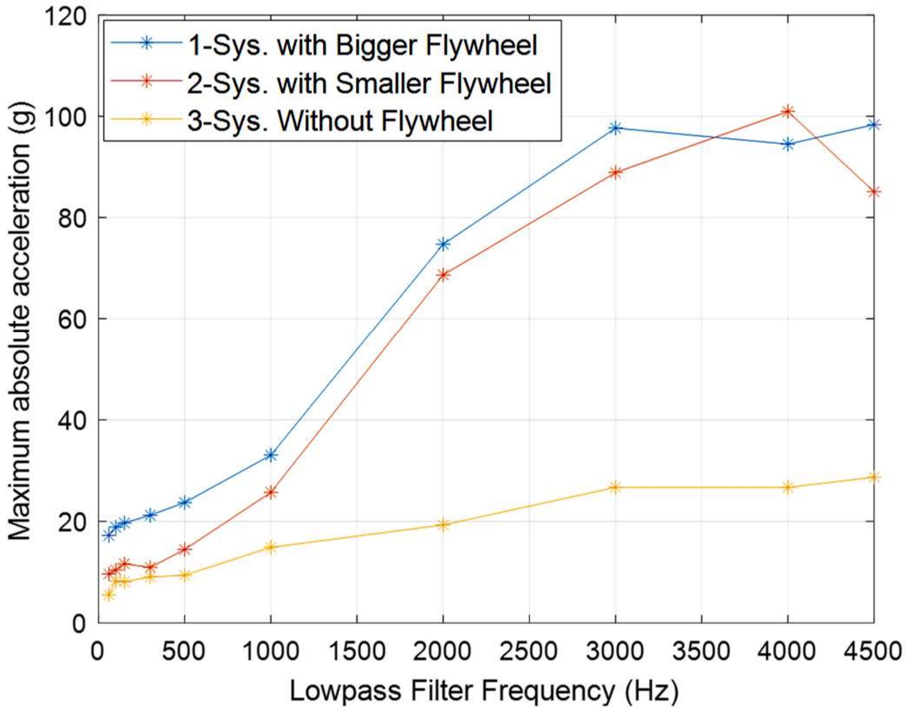
EXPERIMENTAL RESULTS

Ground acceleration to top mass acceleration transfer function for different configurations of the inerter



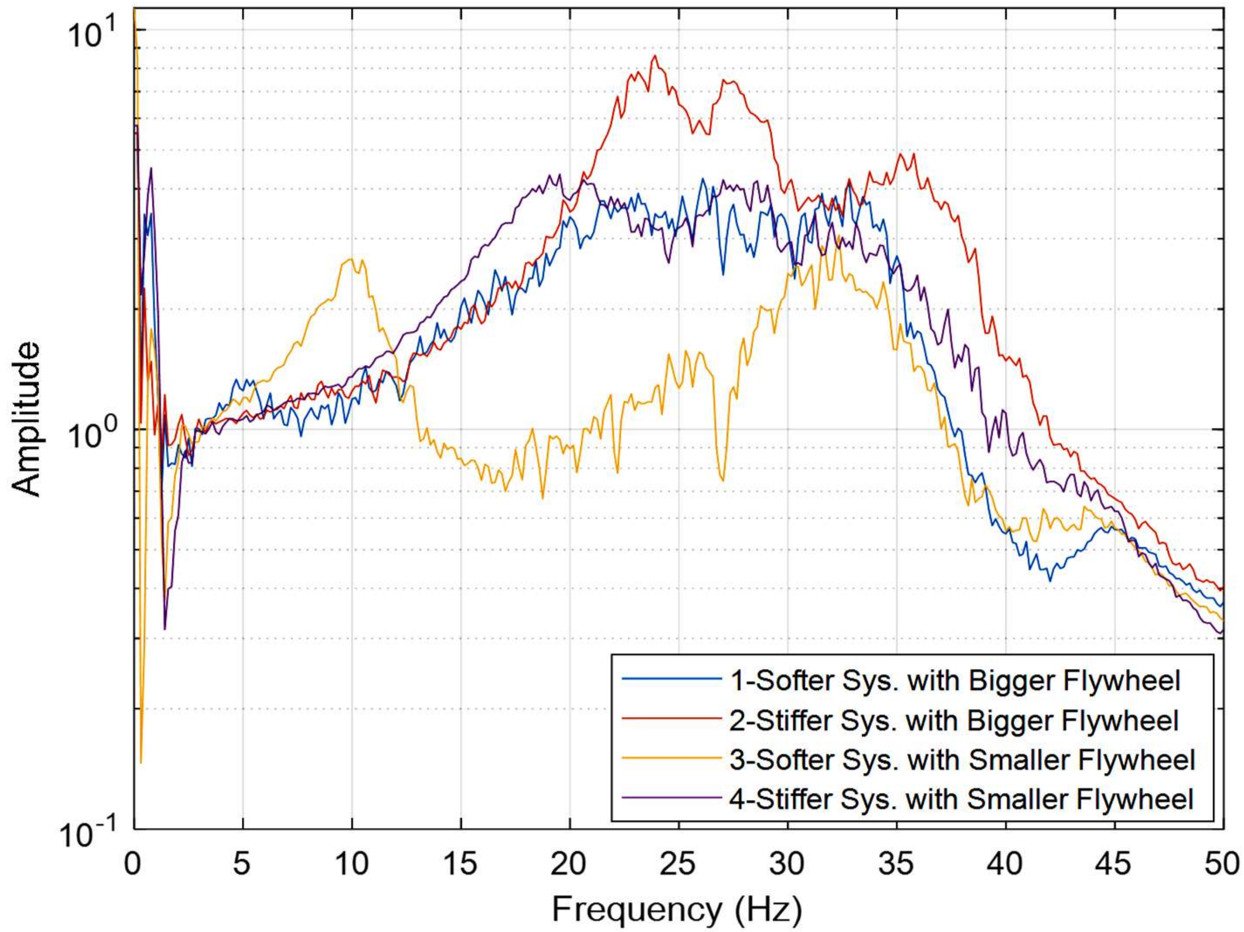
RMS and maximum absolute acceleration considering various filter passband



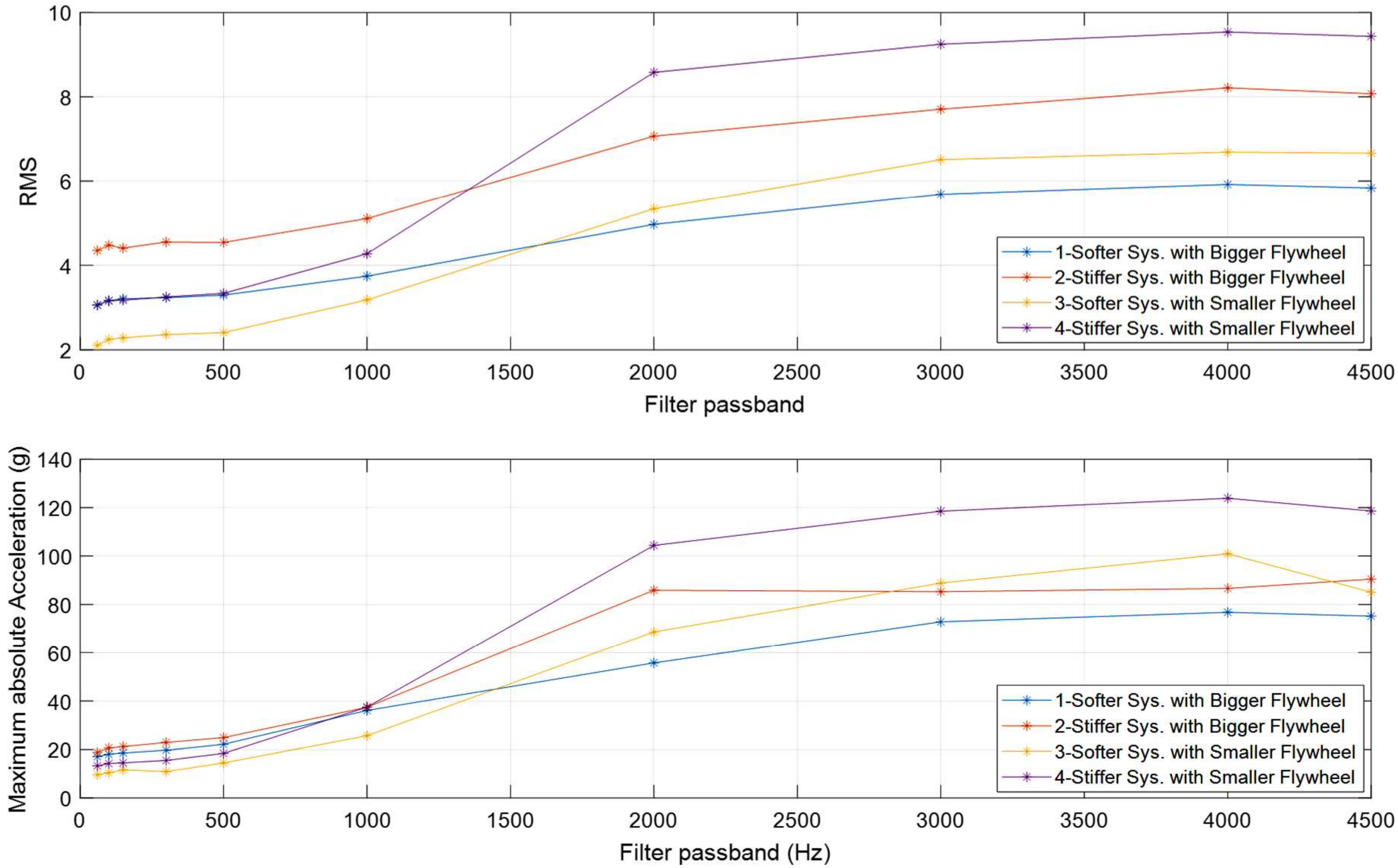


Results after making the base isolation stiffer

Ground acceleration to top mass acceleration transfer function for different configurations of the inerter



RMS and maximum absolute acceleration considering various filter passband



CONCLUSION

- Inerter creates large mass effects with only a small amount of physical mass.

- As expected from analytical models, the effect of the inerter is to reduce the isolation mode frequency.

- The amplitude of the isolation mode was shown to be significantly reduced.

- It is ideal for scenarios where a lower isolation frequency is required, but the static deflection or dynamic response of the isolation mode should not be increased.

- A drawback of using an inerter in the isolation layer was observed when considering the RMS and peak value of the acceleration response due to increased high frequency response.

- The results of this work experimentally demonstrate the potential of isolation systems with inerters and encourage their further study.

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Questions