Passive Shock Switch

Paul M. Rady Mechanical Engineering, University of Colorado Boulder

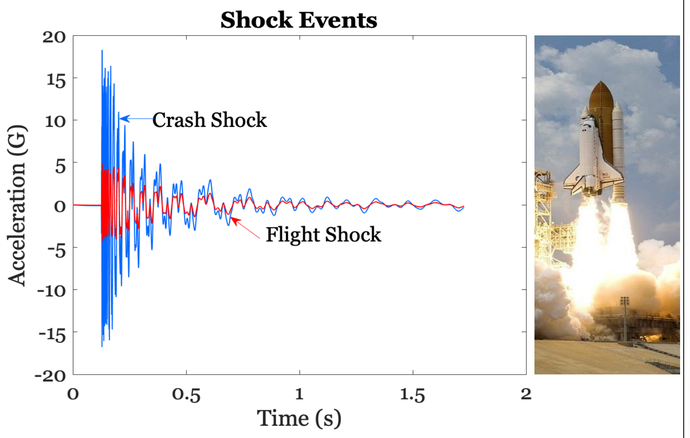
Los Alamos National Laboratory

Team Shock the World | University of Colorado Boulder | Los Alamos National Laboratory

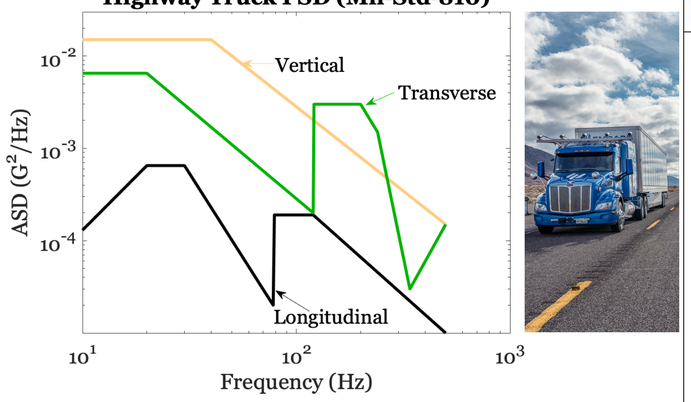
Luc Bollen | Ayla Gotoh-Mack | Zachary Majors | Justin McMahon | Ricky Orban | Greg Textoris

Background

- Passive monitoring
- Design a switch that completes an electrical circuit and latches when it experiences the specific shock events and ignores transportation vibration
- Data collection when circuit is completed



- Shock events' acceleration time traces that the switch should latch on
- Crash Shock is the requirement and Flight Shock is the goal

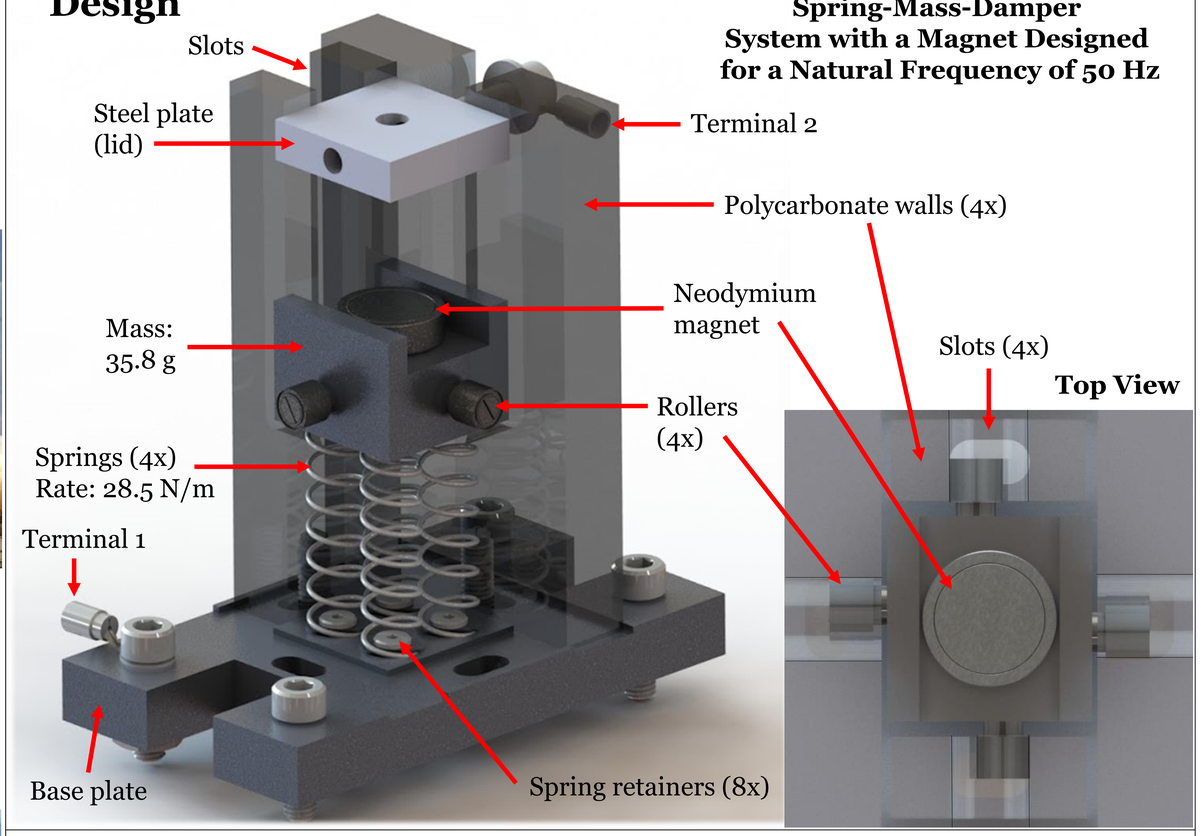


- Power Spectral Density (PSD) highway truck vibration the switch should not latch on
- Switch should only respond to vertical direction

Requirements

1. The switch will latch upon the specific shock event 90% of the time
2. The switch will not latch upon the truck vibration 90% of the time
3. Completes an electrical circuit
4. Less than 1 pound and scalable to a 4-inch cube
5. Reusable at least 10 times

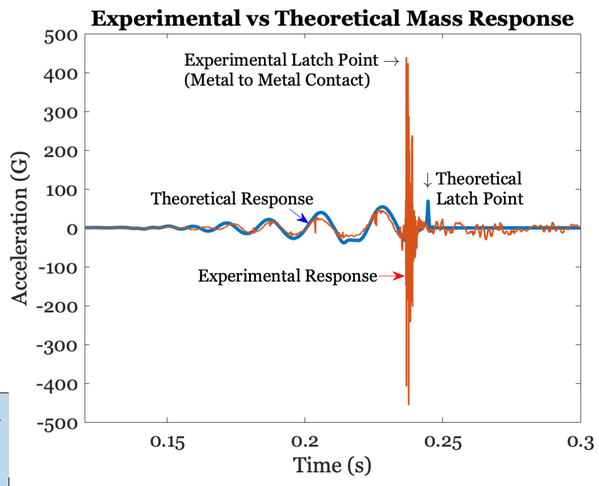
Design



Testing and Results

- Magnet and Spring Force Test
- Electrical Continuity Test
- Sine Sweep
  - Amplification factor and natural frequency
- Operating Range Tests
- Shock Tests
- Transportation Vibration Test
  - Ran at 125% power for 5-minute intervals

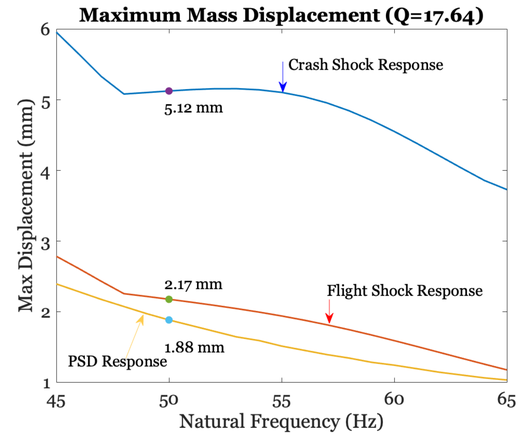
Shake Table Input	Latch (Number of Trials)	Did Not Latch (Number of Trials)
Crash Shock (7.1 mm)	52	0
Flight Shock (5.21 mm)	1	0
PSD (7.1 mm)	0	35



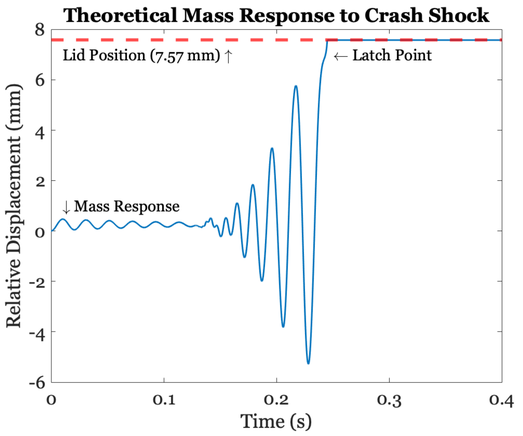
Lid Placement Results:

- Maximum lid distance the Crash Shock closed: 8.5 mm
- Maximum lid distance the Flight Shock closed: 5.21 mm
- Maximum lid distance the PSD did not close: 5.2 mm

Analysis



- Shocks: MATLAB ODE45 and transfer function
- PSD: largest peak distribution law
- Maximum displacement response of the mass is greater for shock inputs compared to PSD input at 50 Hz



- Added magnet to the model (nonlinear fit)
- Modeled the mass response to input base motion
- Found maximum latching distance to increase tolerance window

Conclusions

- 95% confident the switch will latch greater than 93% of the time for the Crash Shock
- 95% confident that the switch will not latch greater than 90% of the time for the highway truck vibration
- Difficult to discern between Flight Shock and PSD
- Completes an electrical circuit

Challenges

- No previous vibration or PSD experience
- Finding a shake table and software
- Positioning the lid relative to the mass
- Controlling the amplification factor

Special Thanks: Stuart Taylor, Kevin Buechele, Roger Pittel at Seagate, Dr. Jack Zable, VibrationView, Rachel Sharpe, Tom Irvine, Julie Steinbrenner, Daria Kotys-Schwartz, Greg Potts, and Chase Lodgson