Passive Shock Switch

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

Highway Truck PSD (Mil-Std-810)
- 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

Spring-Mass-Damper System with a Magnet Designed for a Natural Frequency of 50 Hz
- Terminal 1
- Steel plate (lid)
- Terminals
- Springs (4x) Rate: 28.5 N/m
- Polycarbonate walls (4x)
- Neodymium magnet
- Rollers (4x)
- Slots (4x)
- Base plate
- Spring retainers (8x)

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

Testing and Results

Shake Table Input: Crash Shock (7.1 mm) | Flight Shock (5.2 mm) | PSD (7.1 mm)
---|---|---
Latch (Number of Trials): 52 | 1 | 0
Did Not Latch (Number of Trials): 0 | 1 | 35

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

Analysis

Maximum Mass Displacement (Q=17.64)
- 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

Theoretical Mass Response to Crash Shock
- 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

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