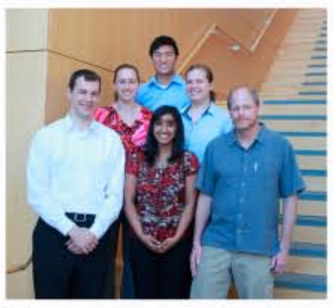
Developing New Applications for Active Vibration Control



Team Hutchinson/Barry Controls

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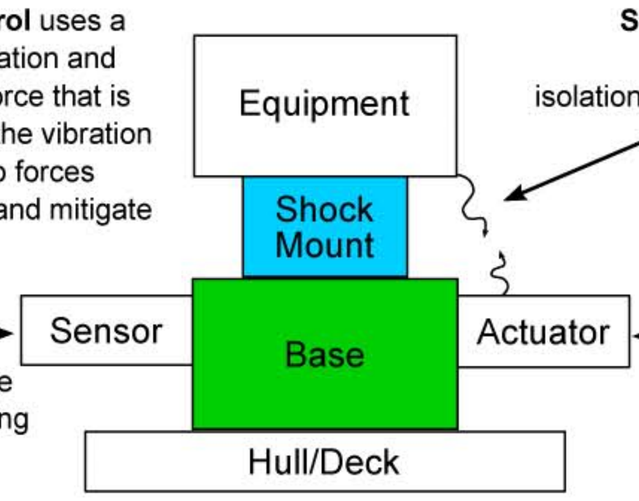
Company History and Project Goal

Barry Controls has a strong history of using passive devices to reduce vibration problems. Active Vibration Control is also a product offered by Barry Controls, but these systems can be very complex. To this point, active vibration control systems created by Barry Controls have been highly specialized and time-consuming to develop.

The goal of this project was to develop an active vibration control system that is less specialized, costly, and time-intensive to install. The team aimed to develop a system in an application space new to Barry Controls and applicable to other areas. While designing and evaluating this system, the team provided insight to Barry Controls on the overall process with a fresh, new perspective on active vibration control.

What Is Active Control?

Active vibration control uses a mixture of passive vibration and actuators to create a force that is equal and opposite to the vibration force, such that the two forces cancel each other out and mitigate the vibration

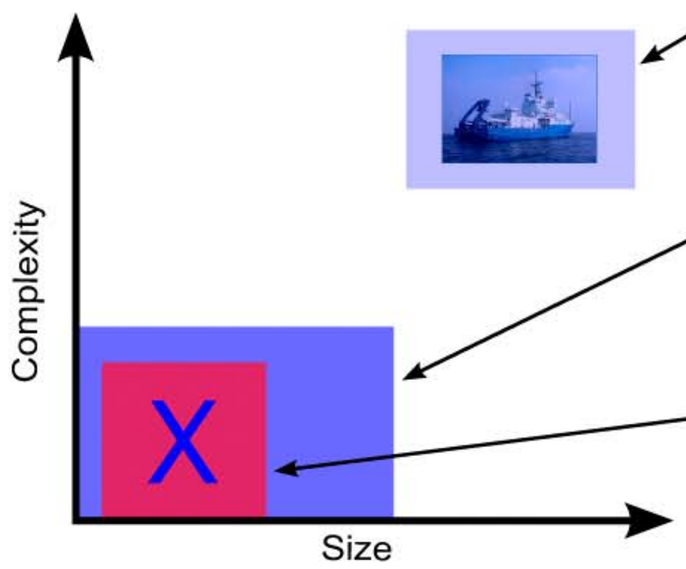


Shock mounts or other passive isolation mounts provide initial isolation across the targeted frequency range and provide damping.

Sensors such as accelerometers provide feedback to the control system regarding the success of the active control

Actuators provide opposing force at 180 degrees out of phase of the target vibrations so as to cancel them out via superposition

Considerations and Requirements



Barry Controls' current active control systems:

- Large
- Complex (many actuation points)
- Expensive
- Time-intensive

Barry Controls' goals and requirements for new designs:

- Broadly applicable to multiple markets
- Reduced complexity enough to reduce necessary analysis
- Lower cost

SCOPE team requirements for project:

- Moderately small and accessible
  - Equipment must be large relative to active system
- Simple enough to ensure project feasibility
  - Consistent vibration frequencies
  - Less required analysis than typical Barry Controls project
- Significant potential impact and demand

Project Focus

Based on these requirements, the team chose to focus on the application area of **construction equipment**. Specifically, the team chose to develop an active control system for an **electric breaker**.

Project Impact

Overexposure to vibration leads to hand-arm vibration syndrome (HAVS), a condition that can include significant nerve damage. Vibration control in construction equipment will protect workers and increase productivity for construction companies.

System Diagram

Amplifier

- Amplifies signal from controller to run actuator

Actuator

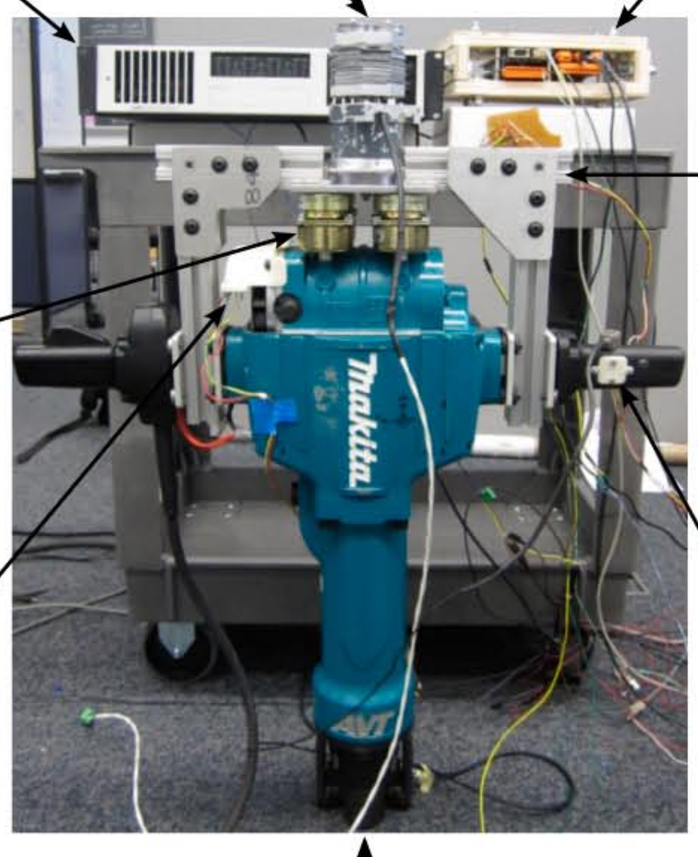
- Target natural frequency ~ 12Hz
- Controlled vibration in the vertical direction by modifying end-caps, springs, and mass

Control Board

- Custom control board (FPGA/DSP)
- Processes tachometer and accelerometer readings
- Outputs signal to actuator

Passive Mounts

- Connect breaker to yoke
- Two models of cup mounts attached in series
  - Natural frequency 20-45 Hz
  - Attached to top of breaker
- Bushing style mounts
  - Natural frequency 19-28 Hz
  - Attached to sides of breaker



Yoke

- 1.5" 8020 frame
- Connected to breaker via top surface and handles
- Transmits actuator vibration to handles
- Supports breaker system

Tachometer (IR Sensors)

- Detects fan rotation to determine motor speed
- Allows controller to operate as a feed-forward system

Accelerometer

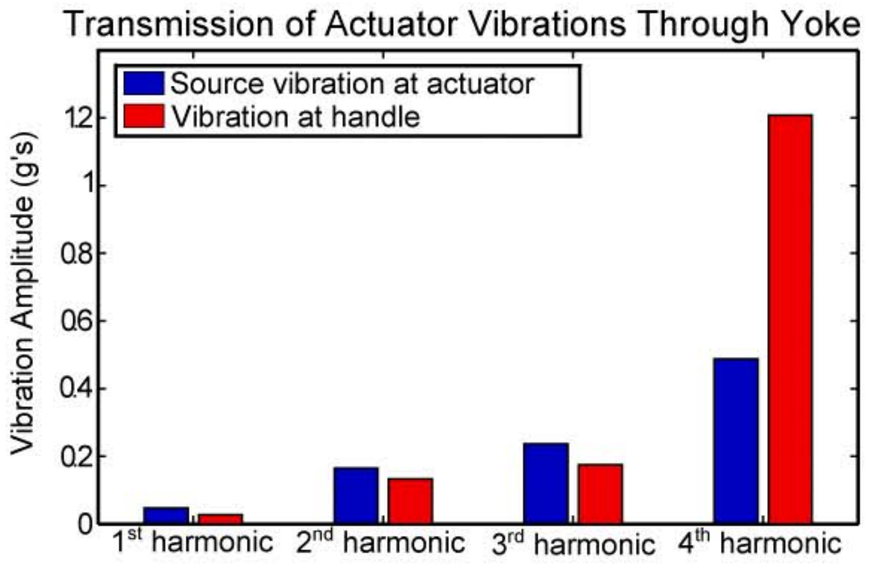
- 8 mV/g sensitivity
- Fixed to handle of breaker
- Provides feedback to controller system

Breaker

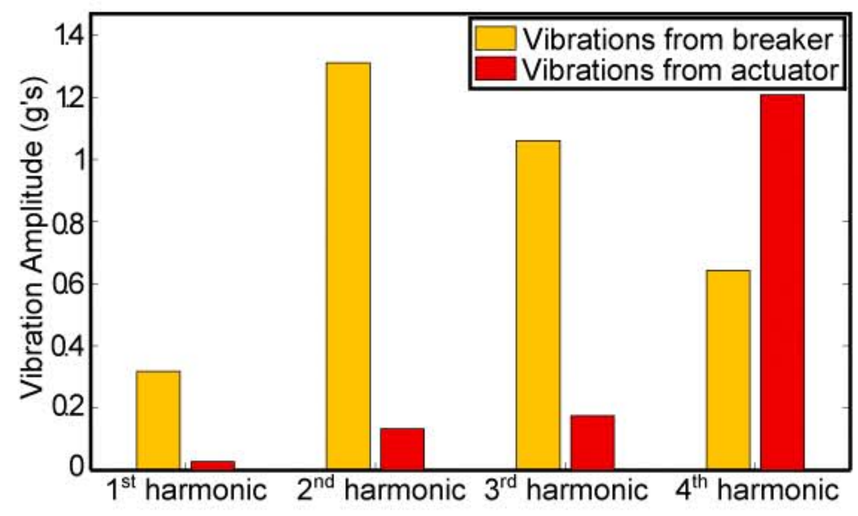
- Makita HM1810
- Operates at 1,100 BPM
- Weight: 70.6 lbs
- Cost: $1400

Results and Conclusions

Yoke: Vibrations are effectively transmitted from the actuator to both handles with little energy lost



Actuator Strength: The vibrations produced by the actuator at low frequencies are significantly weaker than the corresponding breaker vibrations.



Conclusions: More powerful, small, and low cost linear actuators need to be developed before small scale active vibration control will be feasible. However, the concept of controlling vibration at multiple locations using a single actuator has potential and could be applied to many different systems including other construction equipment, handle-bar equipment such as motorcycles or similarly sized machinery with single-axis vibration