Active Control of Structures Using Electromagnetic Damping

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ABSTRACT

The main goal of this project is to develop an active vibration control system to dampen a vibrating structural frame. A Piezo electric accelerometer is used to measure the vibration. The acquired data is then used to implement a proportional-derivative (PD) control loop that dampens the system using magnetic forces.

INTRODUCTION

There are many sources of vibration capable of exciting structural systems, such as bridges and buildings, to a resonance point. It is then very important to understand the dynamic characteristics of these systems to prevent failure due to uncontrolled movement. Resonance is reached when a dynamic force affecting a structure has a frequency equal to one of the natural frequencies of the system being disturbed. Whenever this occurs, the result is a building oscillating with a bigger amplitude every cycle and consequently a disastrous event. To face this problem, the team in this project aimed to design an active damping system using an electromagnetic damper.

METHODOLOGY

The complete control system consists of the following equipment:

- **Signal Generator: BK Precision 4070A.**
- **NI Signal Conditioner Chassis SCXI-1001 with modules SCXI-1530, 1124, & 1325**
- **PCB Piezo electric accelerometer (model 353B34)**
- **E-core Electro magnet**
- **SAP2000 (Software)**
- **LabVIEW 8.2(Software)**

First, the accelerometer was installed on the steel frame. The following step consisted of understanding the dynamic characteristics of the structure. For this purpose, the frame's dimensions were measured and modeled in SAP2000 to obtain the natural period of vibration. The system was then put into vibration using a signal generator which sends a repetitive current through a coil and creates a magnetic field which excites the frame near its resonance frequency. Finally, a proportional derivative (PD) control algorithm was implemented using LabVIEW 8.2 with the SCXI chassis to create a magnetic field strong enough to reduce the amplitude of the vibration.

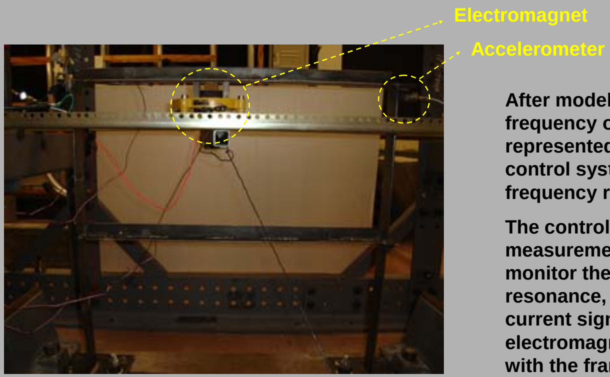

Fig.1 Structural Frame

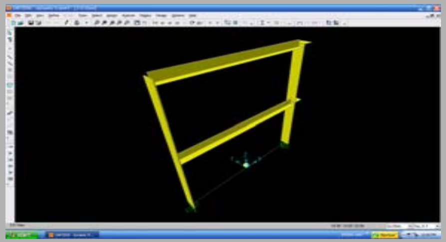

Fig.2 SAP 2000 Simulation

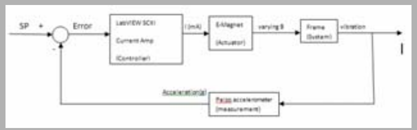

Fig.3 Control System's Block Diagram

Fig.4 NI Signal Conditioner SCXI-1001

Fig.5 Current drive circuitry

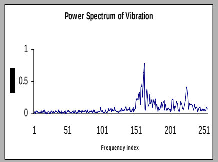

Fig.6 FFT Spectrum Analysis (No damping)

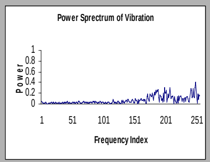

Fig.7 Power spectrum with active control

DISCUSSION OF RESULTS

After modeling the frame in SAP 2000, the Natural frequency of the frame was found to be 11.4 Hz. This value represented a very important design parameter for the control system since it characterized the dynamic force frequency required to excite the frame into resonance.

The control loop was designed as shown in Figure 3. The measurement signal from the accelerometer was used to monitor the vibration of the frame. Once the frame reached resonance, the output signal from the controller drove a current signal through an interface and finally to the electromagnet. The magnetic force generated, interacted with the frame as a damping force that attenuated the frame's vibration.

Although the vibration was not totally controlled, the active control system significantly dampened the structure by 50% (Figure 6) in comparison with the case when no control was applied (Figure 7).

CONCLUSION

An active structural control system with a proportional derivative (PD) control loop has been implemented and tested. The preliminary results have demonstrated the effectiveness of the active control system in structural vibration attenuation. Future work will be focused on controller tuning for optimal performance with various types of excitation sources.

ACKNOWLEDGEMENTS

Financial support was provided through the UHD Scholars Academy with funding by the U.S. Army Research Office (Award No. W911NF-04-1-0024). Special thanks to faculty advisors Dr. Alberto Gomez-Rivas and Dr. Weining Feng for their guidance. This research was possible through support from the UHD Department of Engineering Technology.

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