BRADLEY
University

Department of Electrical and Computer Engineering
Senior Capstone Project
Active Suspension System

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Introduction

The primary goal of the Active Suspension System Senior Design Team (ASSSDT) will be to design an active system capable of eliminating most of the vertical motion imparted to the supported platform by the disturbance input. The ultimate use for such a system is most commonly to reduce the effect of disturbances imparted to a moving vehicle by rough terrain to provide a gentle ride for passengers. For this single actuator response arrangement, the lower platform of the system will provide an oscillating vertical motion and the linear actuator will extend or retract as necessary to ensure the upper platform maintains the desired position specified by the user. The linear actuator will be controlled by an optically-coupled H-bridge module connected to an Atmega128 Microcontroller which permits the control algorithms to be coded using Embedded C.

Subsystem level Functional Requirements

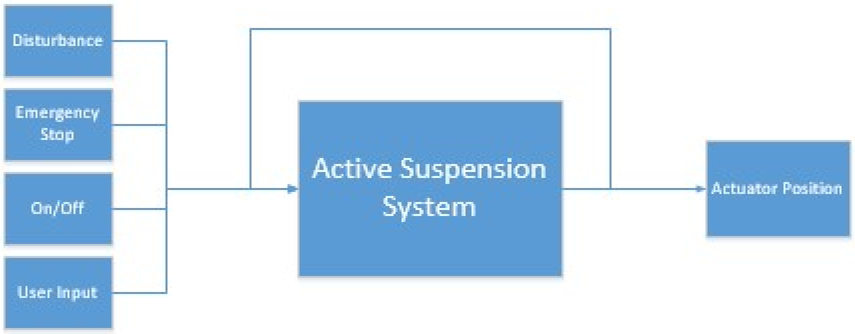

Figure 3.1: Active Suspension System Block Diagram

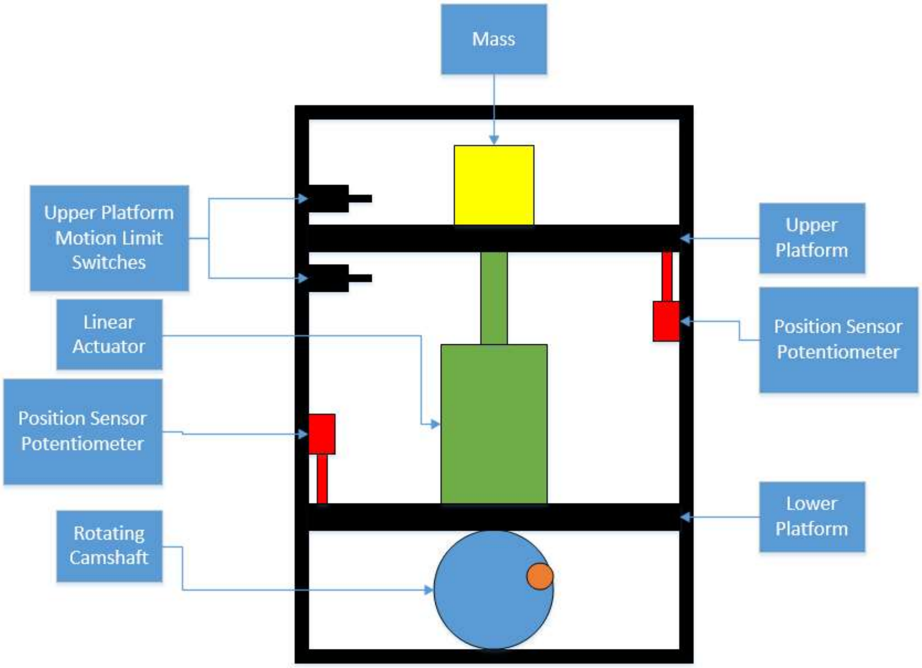

Figure 3.2: Active Suspension System

Subsystem Functional Descriptions

Hardware

Upper and Lower Platform

The system controller implemented with the Atmega128 microcontroller will ensure that the upper platform's vertical motion will be maintained at (or near) the desired position specified by the user. The lower platform will oscillate in the vertical direction and will be controlled by a three-phase AC induction motor connected to a camshaft as shown in figure 3.2. The lower platform oscillation frequency will be controlled by the three-phase AC variable-frequency drive (VFD) used to control the speed of the AC induction motor. It should be noted, however, that the lower platform motion will not provide true sinusoidal vertical motion because the VFD operates in a "constant torque" mode and not in a "constant speed" mode. Therefore, since the AC motor will not provide a constant rotational velocity, the lower platform's vertical motion will approximate sinusoidal motion, but will in fact be slightly distorted.

Potentiometer

There are two potentiometers vertically-mounted onto the system. One of the potentiometers is connected to the upper platform and the other potentiometer is connected to the lower platform. The potentiometers will be used to measure the instantaneous position of the respective platforms. When a control algorithm is applied to the active system, the lower potentiometer will indicate a much larger change in position than the upper potentiometer during normal operation.

Limit Switches

There are two limit switches connected to the system. The switches are included in the system design to guarantee an upper and lower bound of motion in the event of a controller malfunction during development or due to a component failure after the system design is complete. When activated, both relays will switch to their normally open positions and the all system motors will stop. Note that the linear actuator has an internal brake that will also be activated to lock it in place. However, the AC induction motor is not equipped with a brake, so it will simply settle to its lowest position once it is turned off.

Linear Actuator

The linear actuator will be driven by an optically-coupled H-bridge module connected to an Atmega128 Microcontroller used to apply the control algorithms. The actuator will extend and retract to compensate for lower platform movements based on the output of the potentiometer used as the upper position sensor. The upper platform will maintain the position specified by the user input while the rotating camshaft continues to provide disturbances to the lower platform.

Rotating Camshaft

The rotating camshaft will rotate at all times during system operation unless the emergency stop is activated. The lower platform is oscillated by the rotating camshaft and will simulate the rough terrain alluded to in the introduction.

Basic System Electrical Hardware

The white control box contains the connections to all subsystems on the apparatus. This includes two LM317 voltage regulators set to 12 volts and 3.3 volts, one LM7815 voltage regulator set to 15 volts, and one LM7805 voltage regulator set to 5 volts. There are two MY2N-D2 power relays connected to the emergency stop button which can be used deactivate the linear actuator motor and the AC induction camshaft motor in an emergency. An optically-coupled MSK 4227 H-bridge connected to an Atmega128 Microcontroller is used to control the direction and positon of the linear actuator motor as required to maintain the desired upper platform position.

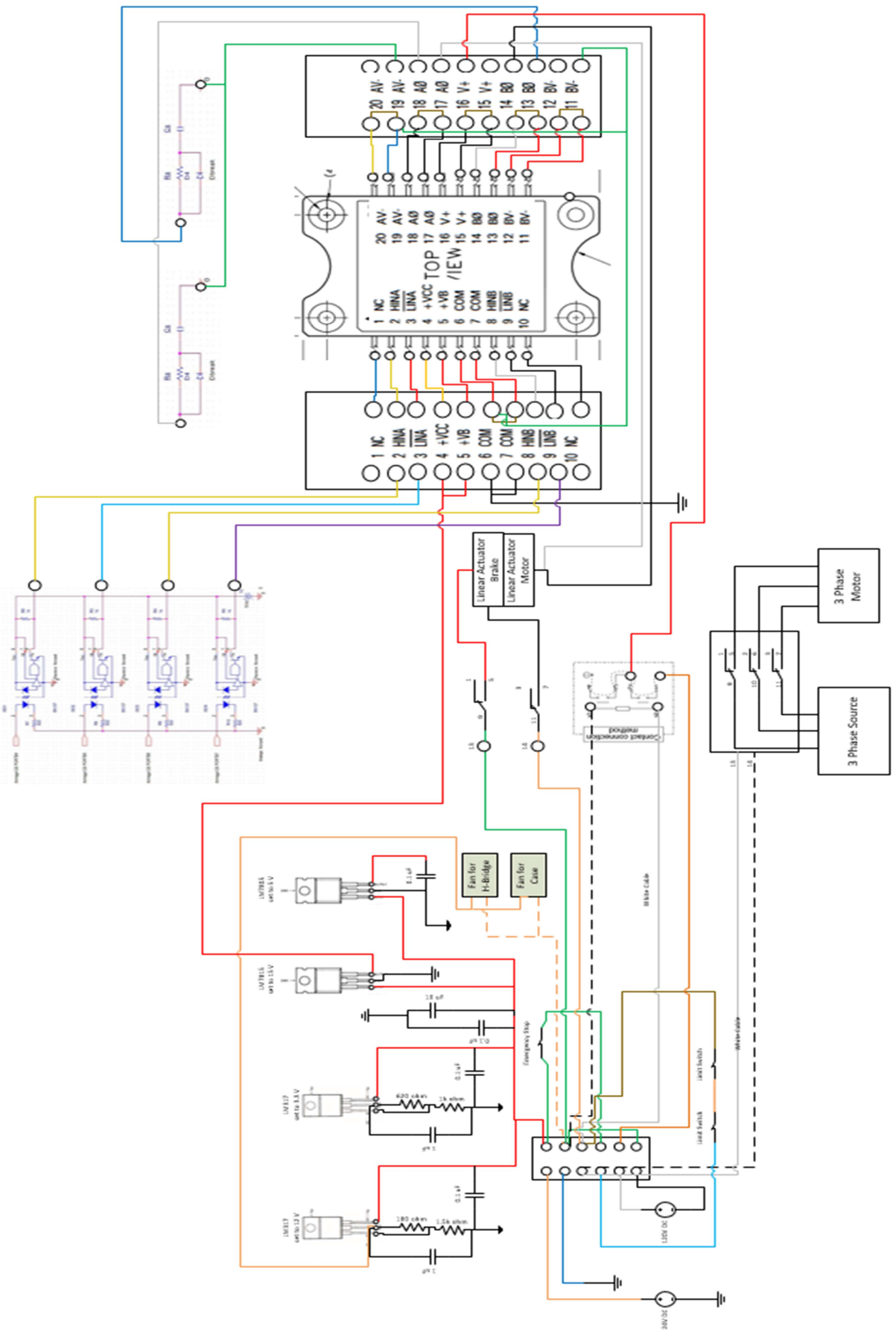

Figure 5.1: Schematic Diagram

Test Circuit

An additional H-Bridge needs to be constructed for initial software testing and purposes to ensure the basic Atmega128 Microcontroller software was reliable and fully functional before it is connected to the optically-coupled MSK 4227 H-bridge on the actual active suspension system apparatus. This is considered imperative because the team has only one of the MSK 4227 H-bridges on hand, and replacement is very expensive. The additional H-bridge will utilize (4) STP22NS25Z N-channel MOSFETs and Avago HCPL-3120 optocouplers. The process of designing and troubleshooting the additional H-bridge will also be a very valuable experience because it helps the team better understand the operation of the H-bridge and the software required to effectively control DC motors connected to the system.

Modeling and Control

Atmega128 Board:

The Atmega128 Microcontroller will control the H-Bridge, which in turn will control the direction and speed of the linear actuator. Various controller algorithms will be implemented on the Atmega128 Microcontroller board to control platform motion.

Control System

An s-domain model of the linear actuator will be developed in Simulink to simulate normal operation. Inputs to the control system will be an Atmega128 PWM signal and the position detected by the upper platform sensor will be used as the feedback component. A bang-bang controller algorithm will be implemented to verify system functionality. Once functional, the team will design a digital feedback controller algorithm to control the linear actuator.

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