Closed Loop Magnetic Levitation Control of a Rotary Inductrack System

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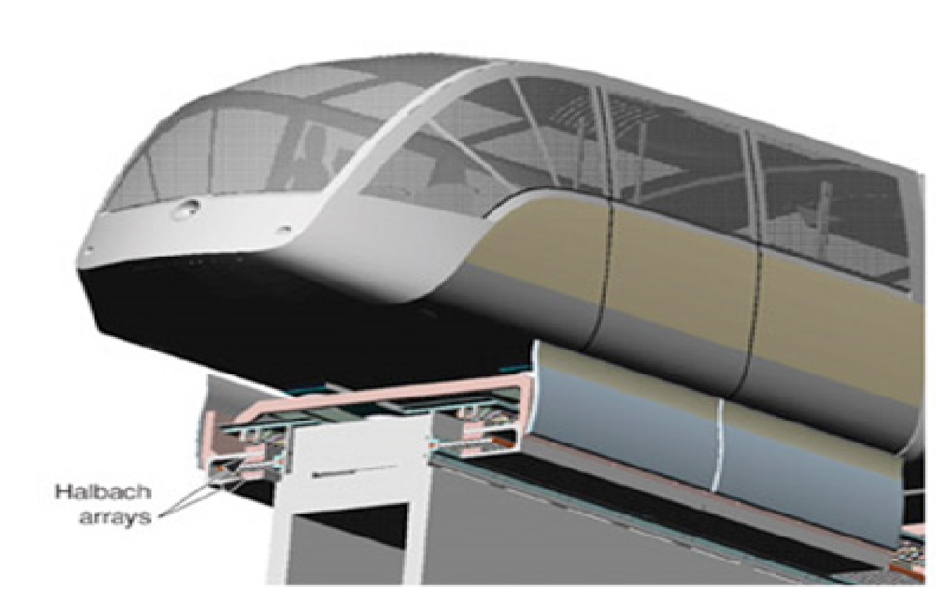
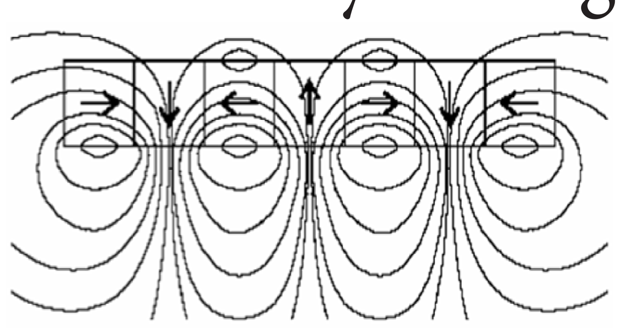


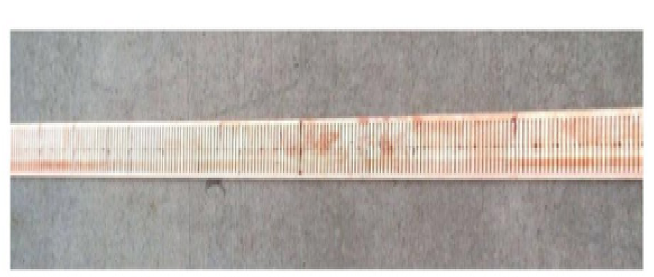
Abstract

There are currently bullet trains that are using magnetic levitation to travel more efficiently for long distances than planes or regular trains. These trains work by inducing a current in the track from an on-board generator in the train. This method of producing levitation is not very energy efficient. A permanent magnet will be used to induce a current in the inductrack instead of the generator to improve efficiency.This project is a continuation of a project done last year. There will be an FPGA added to control the system autonomously. A circuit is designed to control the motor speed by using a pulse width modulation (PWM) signal generated by an FPGA. The user will input a desired levitation height into the FPGA which will be converted to a velocity from a look-up table. This is the required motor velocity to reach the levitation height set by the user.

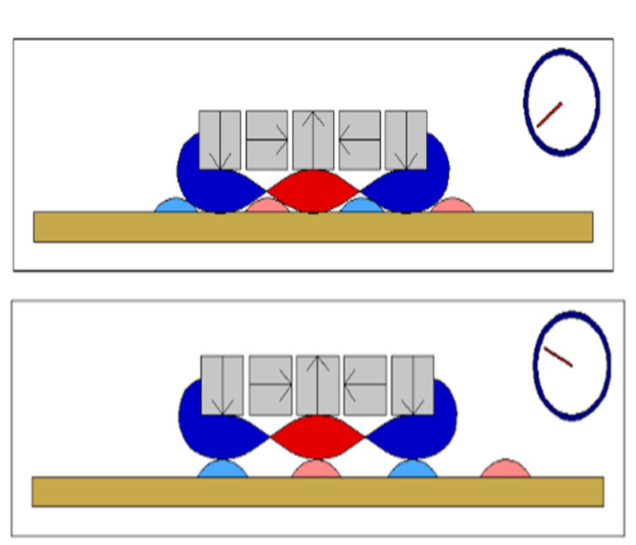
Hallbach Array of Magnets



Copper Inductrack



Magnetic Field Interaction



Force Equations

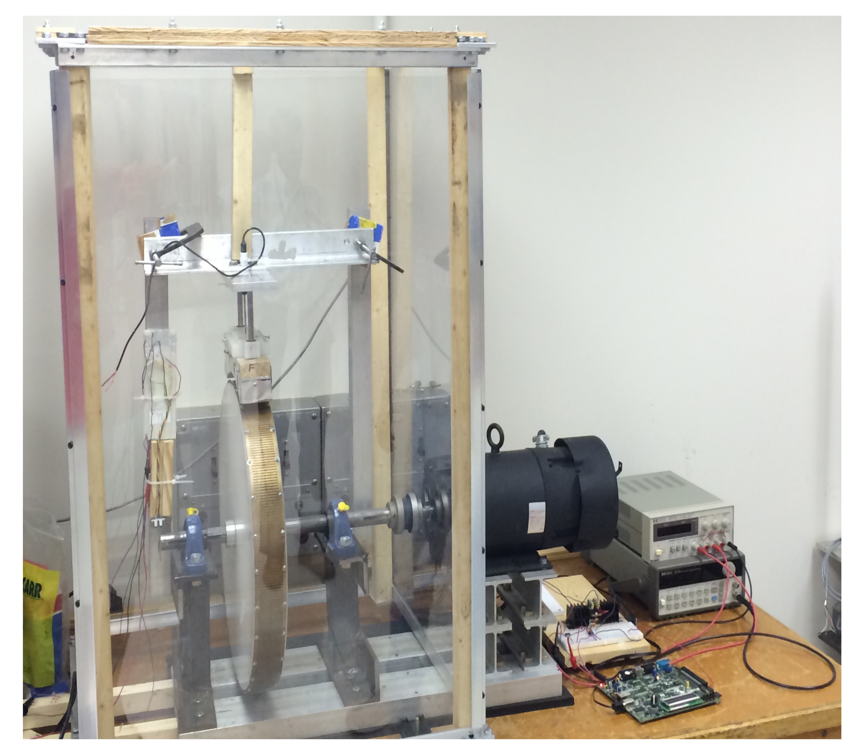
Vertical Force:

$$F_y(\omega_e, y) = \frac{B_0^2 wA}{2kLd_c}\left[\frac{1}{1+\left(R/\omega_e L\right)^2}\right]e^{-2ky} \quad [N]$$

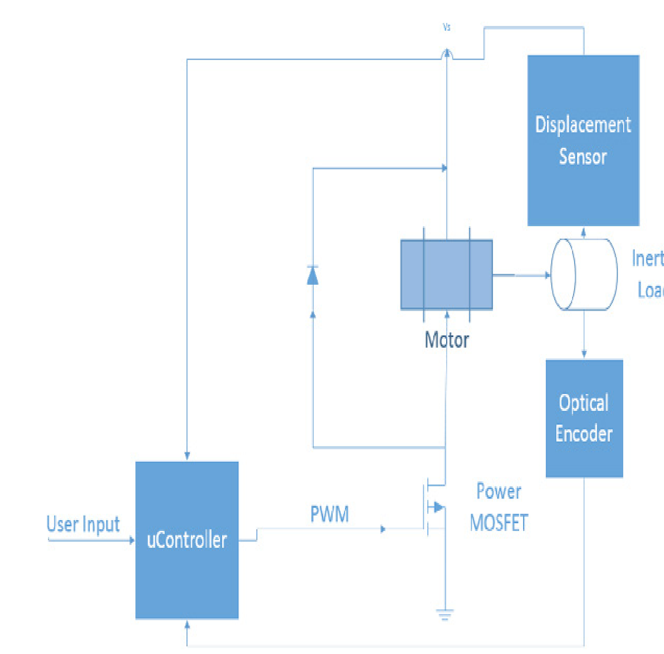
Drag Force:

$$F_x(\omega_e, y) = \frac{B_0^2 wA}{2kLd_c}\left[\frac{R/\omega_e L}{1+\left(R/\omega_e L\right)^2}\right]e^{-2ky} \quad [N]$$

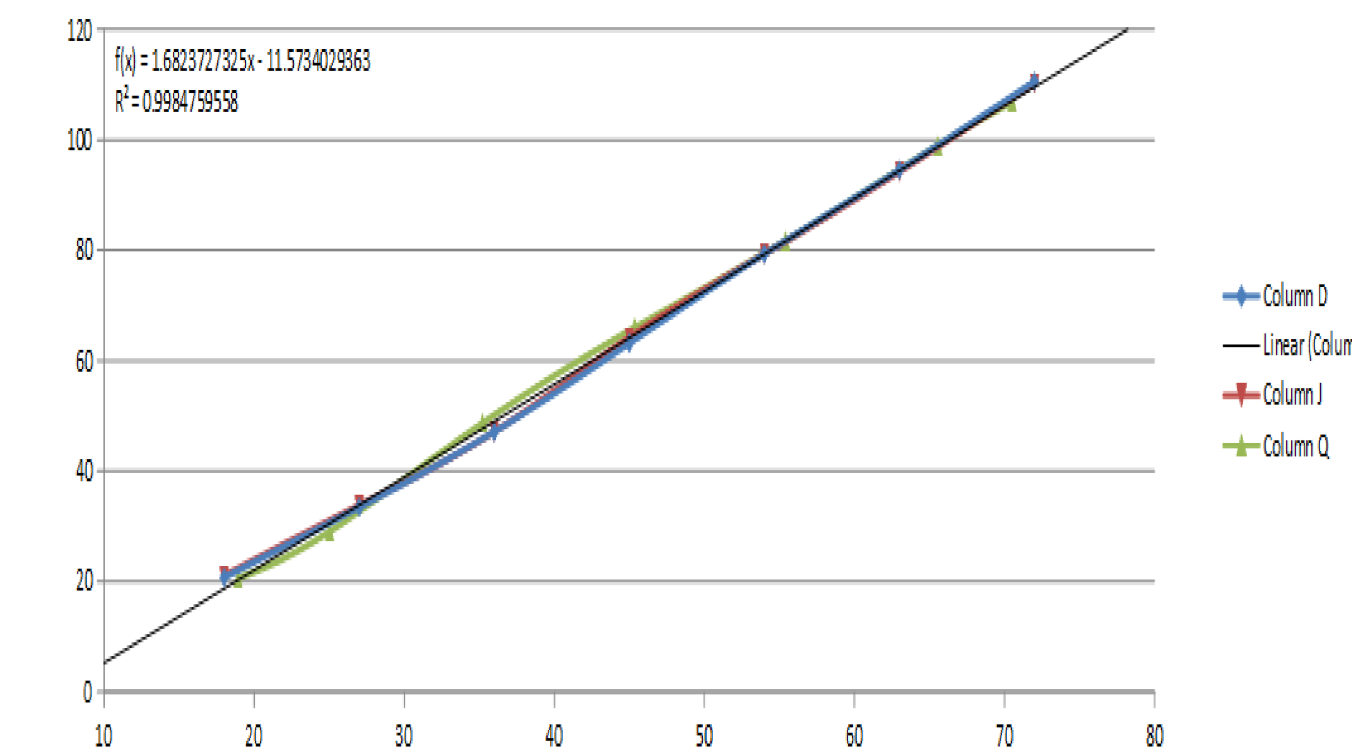
System



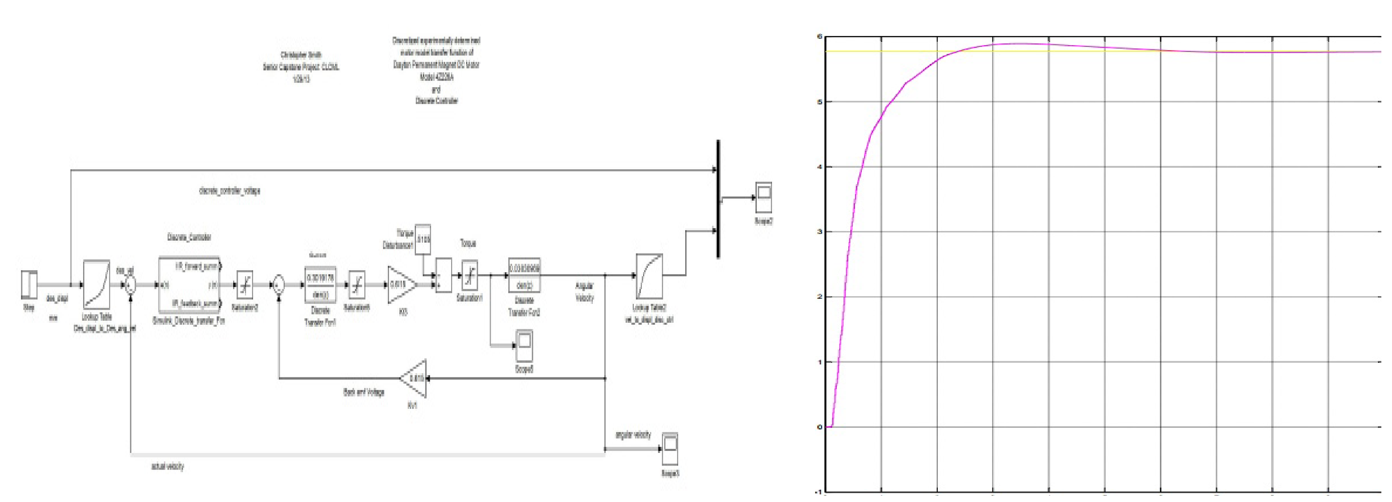
High Level Block Diagram



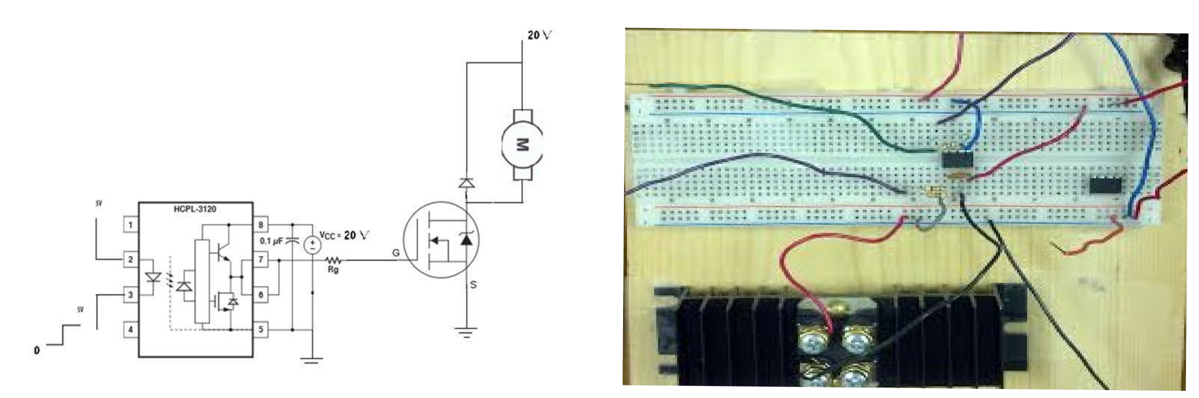
Speed Vs. Duty Cycle Results



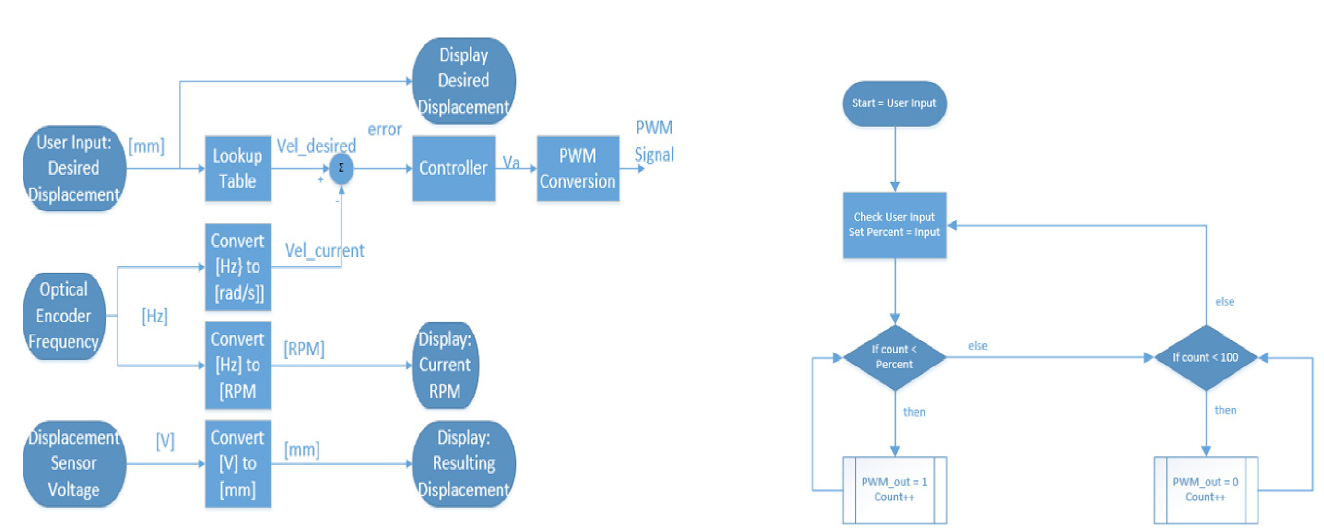
Simulink Discrete Simulation



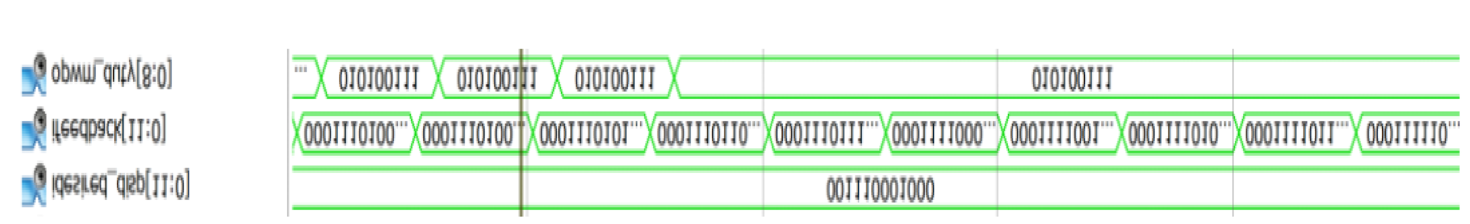
Analog Circuit



Controller Flowcharts



Controller Results



Analog Circuit Results

Conclusion

An FPGA board was selected for closed loop control of rotary inductrack magnetic levitation system height. The user will input a desired levitation height into the FPGA which will be converted to a desired velocity. The error between the actual velocity and desired velocity is used by a discrete PID controller to generate a PWM signal. This signal drives the power electronics which control the motor speed. All of the subsystems have been tested and are working correctly. The FPGA will be integrated into the system during the remainder of the semester.

References

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- Paul Friend. Senior Project. Magnetic Levitation Technology 1. Final Report, May 2004.
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