Control of Halbach Array Magnetic Levitation System Height

Functional Description and Complete System Block Diagram

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Introduction:

This project will demonstrate magnetic levitation using a rotary inductrack and a device with Halbach array magnets. The project is an extension of projects completed in previous years, building on Paul Friend's 2004 project and Glenn Zomchek's 2007 project. These projects were able to show successful levitation, but only to a maximum height of 0.45 mm. These projects and their findings will be used to start this year's project.

Description:

Research on the previous years' projects will be done to see what improvements can be made. Improvements could include a larger diameter wheel, a larger array of magnets on the train device, or a motor that is rated at a higher RPM. These variables will be researched to find out which ones will have the greatest desired effect of increasing levitation height. This task will involve becoming familiar with many levitation equations and using previous projects' results to make modifications. Calculation of force needed to levitate the Halbach array magnet system based on the Halbach array magnet system's mass and calculation of theoretical levitation height based on the track size, speed of the track, and size of the array of magnets will be made. Once all of the components are chosen, a new Halbach array magnet system, Inductrack wheel, and support structure will need to be fabricated for a test bench. These structures will be similar to set ups used in previous projects, shown in figures 1 and 2.

Figure 1: Photo of Inductrack wheel used in previous project

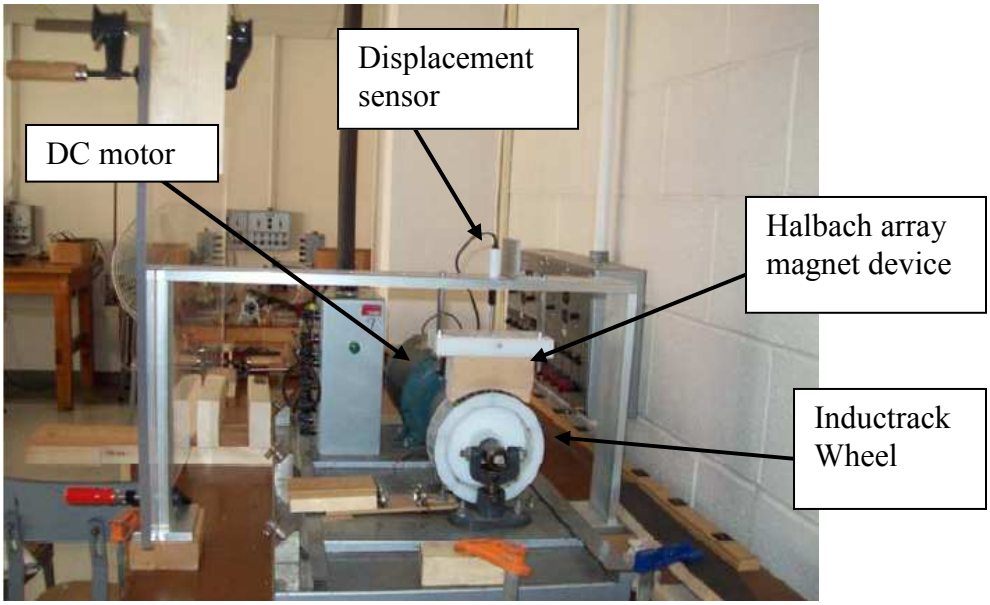

Figure 2: Photo of previous project's complete set up, with Halbach array magnet system, track, motor, and displacement sensor

The Halbach array will be suspended with a small gap above the track. A force sensor will be used to measure the force generated by levitation. A displacement sensor will be used to measure the levitation height. The levitation height and force will be measured manner and compared to the theoretical values. The previous projects were able to demonstrate levitation, but the goal of this project is to levitate the train to a height of 2.0 cm.

System Block Diagram:

The overall system block diagram is shown in figure 3.

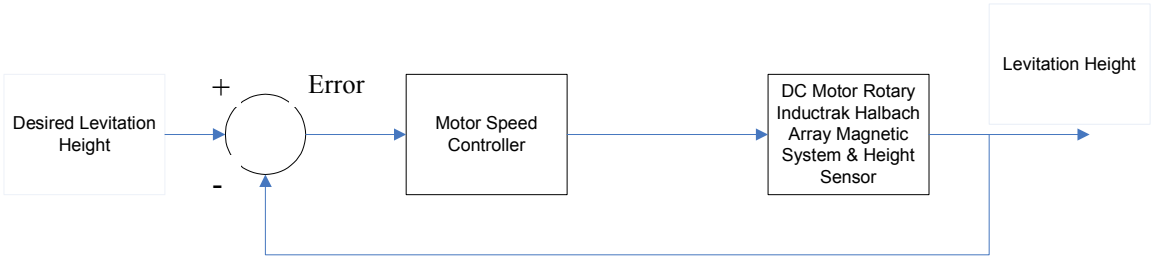

Figure 3: High level overall system block diagram

Once successful levitation is demonstrated, a closed loop control system will be implemented as shown in figure 3. The measured levitation height from the displacement sensors will be compared to a desired levitation height that is entered by the user. The desired and actual levitation heights will be compared. The motor speed controller block will use the difference between these signals and adjust the speed of the motor to achieve desired levitation height. The output from the motor speed controller block will be sent to the DC motor, Inductrack, Halbach array magnetic system, and height sensor block. The motor's speed will be adjusted by this signal, causing the track velocity to change, thus adjusting the levitation height.

Goals:

- Improve upon system used in previous years
- Demonstrate successful levitation
- Design and implement closed loop control of levitation height

Conclusion:

The first goal of the project is to improve upon the system that has been used in previous years. This will allow a greater levitation height to be obtained. Once the new system is working, a controller to control the levitation height will be designed. The work done by both Paul Friend and Glenn Zomchek will be an immense amount of help to the project as a whole.

Works Consulted:

[1] Glenn Zomchek. Senior Project. “Redesign of a Rotary Inductrack for Magnetic Levitation Train Demonstration.” Final Report, 2007.

[2] Paul Friend. Senior Project. Magnetic Levitation Technology 1. Final Report, 2004.

[3] Post, Richard F., Ryutov, Dmitri D., “The Inductrack Approach to Magnetic Levitation,” Lawrence Livermore National Laboratory.

[4] Post, Richard F., Ryutov, Dmitri D., “The Inductrack: A Simpler Approach to Magnetic Levitaiton,” Lawrence Livermore National Laboratory.

[5] Post, Richard F., Sam Gurol, and Bob Baldi. "The General Atomics Low Speed Urban Maglev Technology Development Program." Lawrence Livermore National Laboratory and General Atomics.