Control of Halbach Array Magnetic Levitation System Height

Functional Requirements List and Performance Specifications

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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.

This year, all of the parameters will be recalculated. This will lead to a new experimental set up, including the magnets, Halbach array, Maglev device, wheel, and motor. A 5 by 5 Halbach array will be used for initial testing. A new device will then be made and testing will be completed with a 5 by 13 Halbach array.

System Block Diagram:

The overall system block diagram is shown in figure 1.

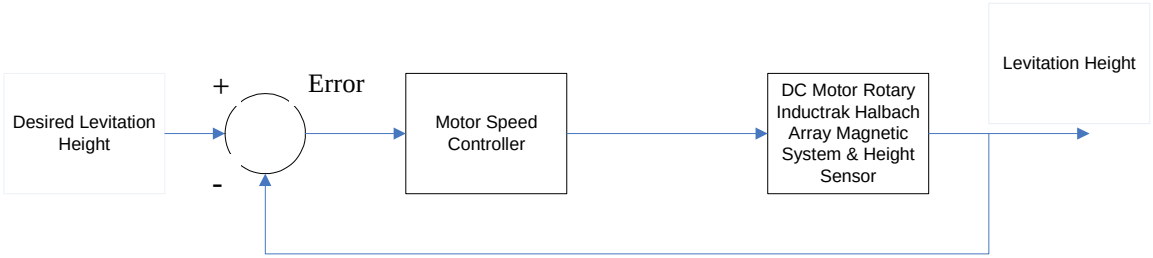

Figure 1: High level overall system block diagram

The first goal of the project will be to demonstrate levitation. Once successful levitation is demonstrated, a closed loop control system will be implemented as shown in figure 1. The measured levitation height from the displacement sensor will be compared to a desired levitation height that is entered by the user. The desired and actual levitation heights will be compared, and 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, driving the Inductrack. The motor's speed will be adjusted by this signal, causing the track velocity to change, thereby adjusting the levitation height.

Functional Requirements:

Rotary Wheel Requirements:

- A new wheel shall be fabricated with a radius of 9 inches.
- A new aluminum Inductrack shall be fabricated with 4 to 5 mm conducting strips with 0.5 mm spacing between the strips.

Maglev Device Requirements:

- Two new devices shall be fabricated out of balsa wood to house the Halbach arrays.
- The device shall have a breakpoint levitation velocity of less than 30 m/s, corresponding to a motor speed of 1253 RPM.

Halbach Array Requirements:

- 6 mm cube magnets shall be used to create the Halbach arrays.
- Each magnet shall have peak strength of 1.21 Tesla.
- A Halbach array of 5 by 5 magnets shall be constructed using 6mm cube magnets.
    - The length of the Halbach array shall be 34 mm.
    - The width of the Halbach array shall be 34 mm.
    - The total area under the Halbach array shall be 1156 mm^2.
    - The wavelength of the Halbach array shall be 28 mm.
    - The Halbach array peak strength shall be 0.80595 Tesla.
- Another Halbach array of 5 by 13 shall be constructed.
    - The length of the Halbach array shall be 90 mm.
    - The width of the Halbach array shall be 34 mm.
    - The total area under the Halbach array shall be 3060 mm^2.
    - The wavelength of the Halbach array shall be 28 mm.
    - The Halbach array peak strength shall be 0.80595 Tesla.

Motor Requirements:

- For initial testing, the Reliance motor model 437698-KW shall be used.
    - The motor shall have 1/3 horsepower.
    - The motor shall be rated at 1725 RPM.
    - The rated current of the motor shall be 3 amps armature current and 0.4 amp field current.
    - The rated voltage of the motor shall be 115 volts.
- For further testing and set up with closed loop control, the D&D ES-10E-33 DC motor shall be used.
    - The motor shall have peak horsepower of 17 horsepower and continuous horsepower of 8 horsepower.
    - The motor shall be a 48VDC Separately Excited Motor.
    - The motor shall be rated at 3000 RPM.

Performance Specifications

- The controller to be used has yet to be determined.
- The maximum overshoot of the system shall be <10%.
- The steady state error shall be less than 0.2 cm.
- The rise time shall be less than 13.9 ms.
- The settling time shall be less than 55.6 ms.

References:

[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.