Magnetic Levitation Train

Project Proposal

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&

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Introduction

The Magnetic Levitation Train (MAGLEV) project uses the concepts of electromagnetism and electrical machinery to levitate and propel a train along a track. The previous work of Paul Friend in 2004 includes the development of a laboratory scale model train containing permanent magnets, hung above a rotating wheel. MAGLEV will prove levitation with a new and more stable rotating wheel and it will demonstrate propulsion using an oval track. The ultimate goal for MAGLEV will then be to build a levitating train that is propelled along the oval track with reasonable stability.

Project Description

Project Phases

MAGLEV will consist of three construction phases. Phase I will prove that levitation is possible using a redesign Paul Friend's wheel track. Phase II will involve construction of an oval track to design and test a linear induction motor (LIM) for propulsion. The third and final phase will consist modifying the oval track to allow for levitation as demonstrated in Phase I. Note that Phases I & II are independent and thus can be done simultaneously.

Block Diagram

The highest level system block diagram is shown in Figure 1.1. 3ø AC Power is being used to control the levitation height and train velocity.

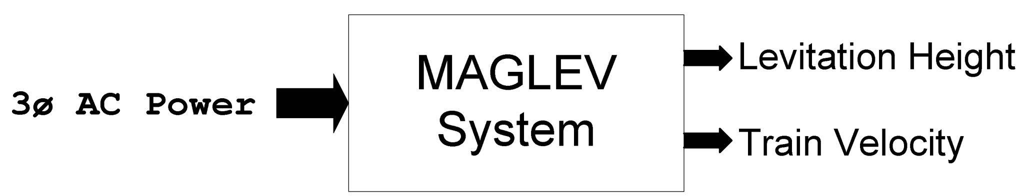

Figure 1.1 – High-Level Block Diagram

Figure 2.1 breaks the block diagram down one level. Here the 3ø AC Power is being fed into a controller, previously purchased by Dr. Anakwa. This controller allows the user to vary the frequency of the AC Power. The frequency controls how fast the train is able to move on the track. The overall MAGLEV system is made up of two subsystems: propulsion and levitation. Both Figures 1.1 & 2.1 correspond to the final construction phase (III) of MAGLEV.

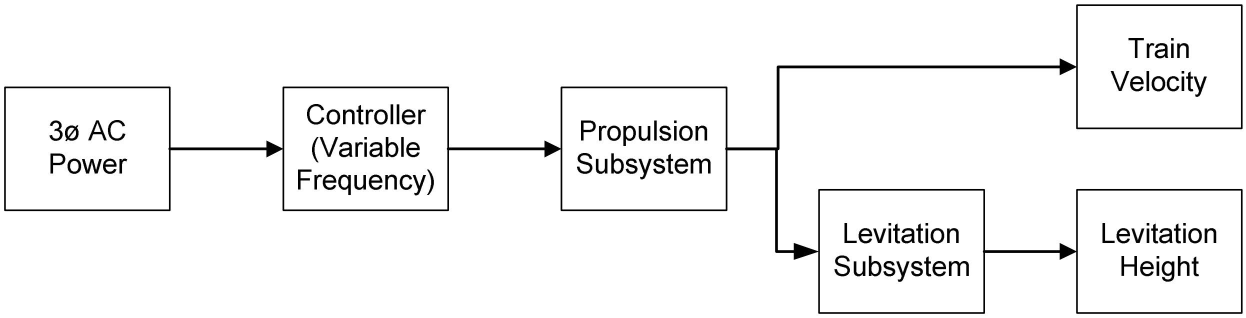

Figure 2.1 – Next Level Block Diagram

Levitation

The levitation of the train is completely dependent on the train's velocity. The faster the Halbach arrays move across the surface of the track, the higher the train levitates. Figure 2.2 describes exactly how levitation is accomplished. First, the train's velocity induces a current in the track. This current then induces a magnetic field that levitates the train. This signal is fed back through a levitation constant dependent on the properties of the Halbach Array and the track design.

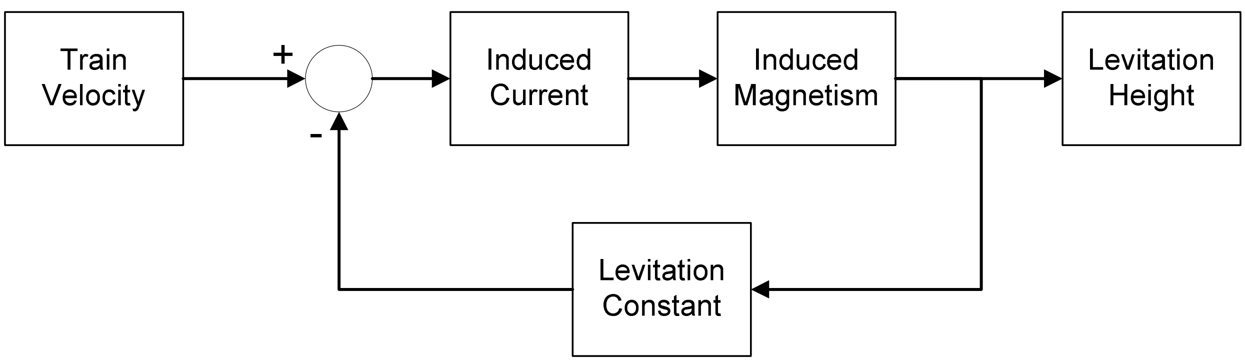

Figure 2.2 – Levitation Subsystem

Halbach Arrays. The Halbach Arrays in the train cancel the magnetic field above the magnets while strengthening the field below them. See Figure 2.3. Each array is built by placing magnets at 90 degree angles relative to each other. The current magnets in the test setup are grade 38, Neodymium-Iron-Boron (NdFeB), 12mm cube magnets.

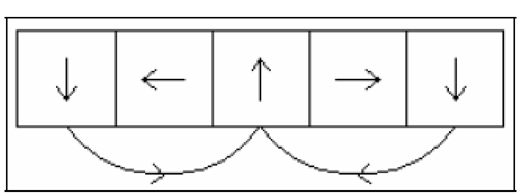

Figure 2.3 – Single Halbach Array

Track. The laminated sheets can be chemically or mechanically etched to create slots. The slots serve to separate the track into rails which act as individual inductors. As the train moves along the track, the onboard permanent magnets induce a current through each rail, which induces a magnetic field opposing the field of the permanent magnets on the train. An illustration of the copper track being used for project is shown in Figure 3.1, as simulated by Lawrence Livermore National Laboratory.

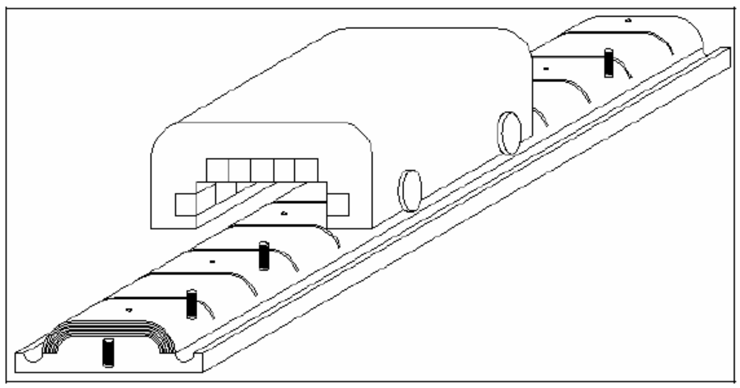

Figure 3.1 – Passive Levitation and Guidance Using Copper Sheets

Propulsion

A linear induction motor (LIM) will be used to propel the train along the track. The LIM consists of rows of magnets on the train and coils of wire along the track. The motor works by using position sensors to activate specific sets of coils along a track. These coils create magnetic fields that "push" and "pull" the train along the track. Figure 3.2 describes the propulsion system. When 3ø power is fed into the track, a sensor records the position of the train along the track and gives this data to another controller. The controller switches between coils based on this information and causes the train to move.

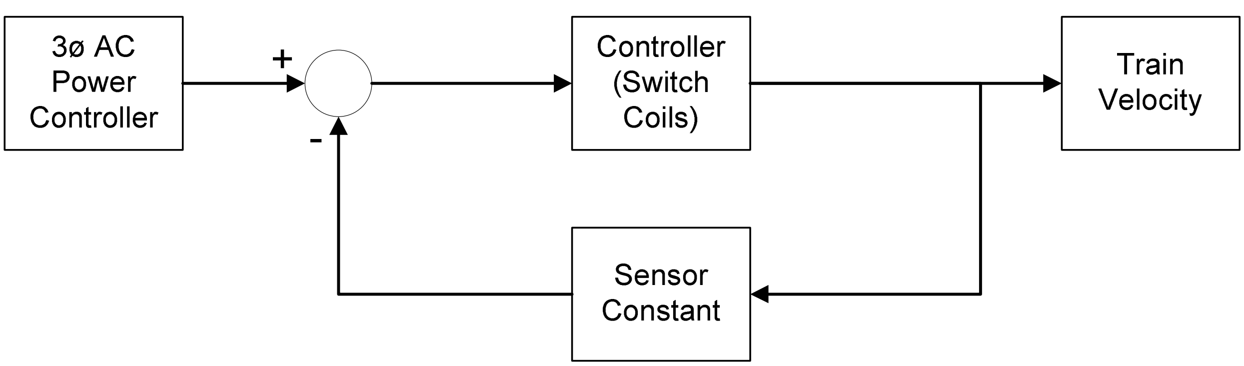

Figure 3.2 – Propulsion Subsystem Block Diagram

Project Schedule

	Dusty Funk	Kyle Getsla
Week 1	Propulsion Design	Levitation Design
Week 2	Propulsion Simulation & Trials	Levitation Simulation & Trials
Week 3-6	Oval Track Construction (LIM)	Wheel Track Construction
Week 7-8	Oval Track Testing	Wheel Track Testing
Week 9	Catch-Up Week & Combine Designs	Catch-Up Week & Combine Designs
Week 10-11	Modify Oval Track to Combine Levitation & Propulsion	Modify Oval Track to Combine Levitation & Propulsion
Week 12-14	Prepare Presentation and Final Report	Prepare Presentation and Final Report

Figure 4.1 – Project Division & Schedule

As shown in Figure 4.1, the first eight weeks will involve mostly independent work. Dusty will be modeling the propulsion of a train by using a linear induction motor (LIM) in conjunction with an oval track. Kyle will be modeling the levitation of a train using a stationary train above a spinning wheel track. Weeks 9-11 will involve combining both models. At this point, the work will be done together. Unlike the wheel track, there is no pre-built model to guide the construction of the oval track; therefore, there will be much more collaboration on the oval track design than the wheel track.

Standards

Since the concepts and parameters for the MAGLEV train are still being developed for real-world use, there is no official set of standards for this project. However, the Low-Speed Urban Maglev Program run by General Atomics has established a list of standards as a goal for their project (see Figure 4.2). We will use their standards as a reference throughout our project's development.

Max. Speed	160 km/hr	Max Jerk	2.5 m/s^3
Throughput	12000/hr/direction	Inside Noise Level	< 67 dB
Max Acceleration	1.6 m/s^2	DC Mag. Field in Car	< 5 Gauss
Min Curve Radius	18.3 m (60 ft.)	Availability	> 99.99%
Max Grade	10%	Ride Quality	ISO 2631 (1987)

Figure 4.2 – Suggested Standards

Patents

Below is a list of the patents we have researched to this point, sorted by date. This list can be thought of as a basic timeline of previous MAGLEV concepts.

Richard F Post
Inductrack Magnet Configuration
U.S. Patent 6,633,217 B2
October 14, 2003

Howard T Coffey
Propulsion and Stabilization for Magnetically Levitated Vehicles
U.S. Patent 5,222,436
June 29, 2003

Richard F Post
Laminated Track Design for Inductrack Maglev System
U.S. Patent Pending US 2003/0112105 A1
June 19, 2003

Karl J Lamb, Toby Merrill, Scott D Gossage, Michael T Sparks, Michael S Barrett
Apparatus, Systems and Methods for Levitating and Moving Objects
U.S. Patent 6,510,799
January 28, 2003

Richard F Post
Magnetic Levitation System for Moving Objects
U.S. Patent 5,722,326
March 3, 1998

Howard T Coffey
Magnetic Levitation Configuration Incorperating Levitation, Guidance and Linear Synchronous Motor
U.S. Patent 5,253,592
October 19, 1993

Enrico Levi, Zivan Zabar
Air Cored, Linear Induction Motor for Magnetically Levitated Systems
U.S. Patent 5,270,593
November 10, 1992

Equipment List

Vendor – Gaussboys, www.gaussboys.com
The NdFeB magnets are nickel plated, and grade N38.
40 – Block #05 - 12mm Cube Magnets $0.36/each $14.40 total
40 – Block #12 - 6mm Cube Magnets $2.25/each $90.00 total

These magnets are already present and do not require purchasing at this time.

Vendor – Engineering Concepts, http://www.engconcepts.net/
Other types of magnets can be used to vary Halbach designs.

10 – 4-Sided, Pyramid, N38 Magnets. 10mm base side length, 10mm tall, & 6mm sides on top.
Price: 10-29 for $0.85 each ($8.50 total for 10)

Vendor – Newark, www.newark.com
A hall-effect chip will be needed to construct a gaussmeter.
- Part # - 31K6639 – HALL EFFECT IC PACKAGE/CASE: 3-SIP;
PRODUCT DESCRIPTION: RATIOMETRIC LINEAR
Price: $0.977 ea

We will order at least 3 due to low cost and potential human errors.

Vendor – McMaster-Carr, www.mcmaster.com
Alloy 110 copper sheets are corrosion resistant, very ductile, and conductive. They are used for general purposes and electrical purposes. The copper has been recommended by LLNL for the wheel track. Possible purchases include:

- Part # - 8963K32 - 12" x 12", 0.021" $7.14/each
- Part # - 8963K52 - 12" x 48", 0.021" $12.50/each
- Part # - 8963K232 - 12" x 48", 0.021" $25.00/each
- Part # - 8963K72 - 36" x 48", 0.021" $54.55/each
- Part # - 8963K12 - 36" x 96", 0.021" $100.00/each

Alloy 1100 Aluminum is "commercially pure." It has the highest thermal and electric conductivity. The aluminum sheets may also be used for track material, and would provide an interesting comparison to copper. Possible purchases include:

- Part# - 88685K11 – 12" x 12", 0.032" $3.28/each
- Part# - 88685K14 – 12" x 24", 0.032" $5.73/each
- Part# - 88685K17 – 24" x 24", 0.032" $11.45/each
- Part# - 88685K21 – 24" x 36", 0.032" $17.19/each
- Part# - 88685K24 – 36" x 48", 0.032" $30.54/each
- Part# - 88685K27 – 36" x 96", 0.032" $48.91/each

Wood
Once the wheel track and corresponding train(s) has been designed, wood and wood fasteners will need to be purchased for construction.

LIM
We are still researching the LIM at this time. Currently, we are looking for 3-phase copper cables, an iron core, and some switches (possibly IGBTs – Insulated Gate Bipolar Transistors). Baldor Electric may be able to donate some of these materials.

Bradley University
An 80515 microcontoller can control part of the oval track for the LIM. Also, the standard electrical engineering lab equipment will be used for the majority of the testing.

Bibliography

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