A2: HoverRail

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Use-Case

Problem:
Resources for learning about Maglev trains are either expensive, inaccessible, or lack interactivity.

Solution:
Develop an affordable, accessible, and remote-controlled Maglev train intended for train enthusiasts and beginners alike.

Areas: Signals and Systems, Circuits, Software, and Devices

Lack interactivity

Expensive

Lack interactivity

Design Requirements

Category	Goal
Levitation	0.8 inch
Propulsion (Speed Up Coils)	Create a magnetic field strong enough to propel the carrier across the track
Response Time / Communication	Signal should be sent fast enough to exhibit smooth travel between stops, not cause significant slow down
Stability	Carrier should remain visibly stable while along track
Sensing - Ultrasonic	Detect objects blocking track (min 5cm ahead, ideally carrier length ahead)
Sensing - Linear Hall Effect	Detect the magnetic fields of stops (magnets) along the sides of the track

Solution Approach

Problem 1:
Resources for learning Maglev trains are expensive or inaccessible

Problem 2:
Models lacking interactivity, users don't have control over train's movement along the track

Solution:

Our design will serve as an interactive education tool to teach fundamental properties of electromagnetics, magnetic levitation, and MagLev trains.

Ethical Considerations:

Economic Factors:
Most MagLev train sets are around $1000. Given the restraints of our budget, our project is a more affordable option

Global Factor:
Interface will be simplistic enough for universal understanding

Public Health, Safety, Welfare:
- No supercoiled magnets in our design, eliminates harm of high powered magnetic fields and harmful materials (liquid nitrogen)
- Visual disclaimer to warn people with magnetic accessories to avoid interference with the circuit which poses safety risks

Solution Approach: Changes

Problem 1:
Resources for learning Maglev trains are expensive or inaccessible

Problem 2:
Models lacking interactivity, users don't have control over train's movement along the track

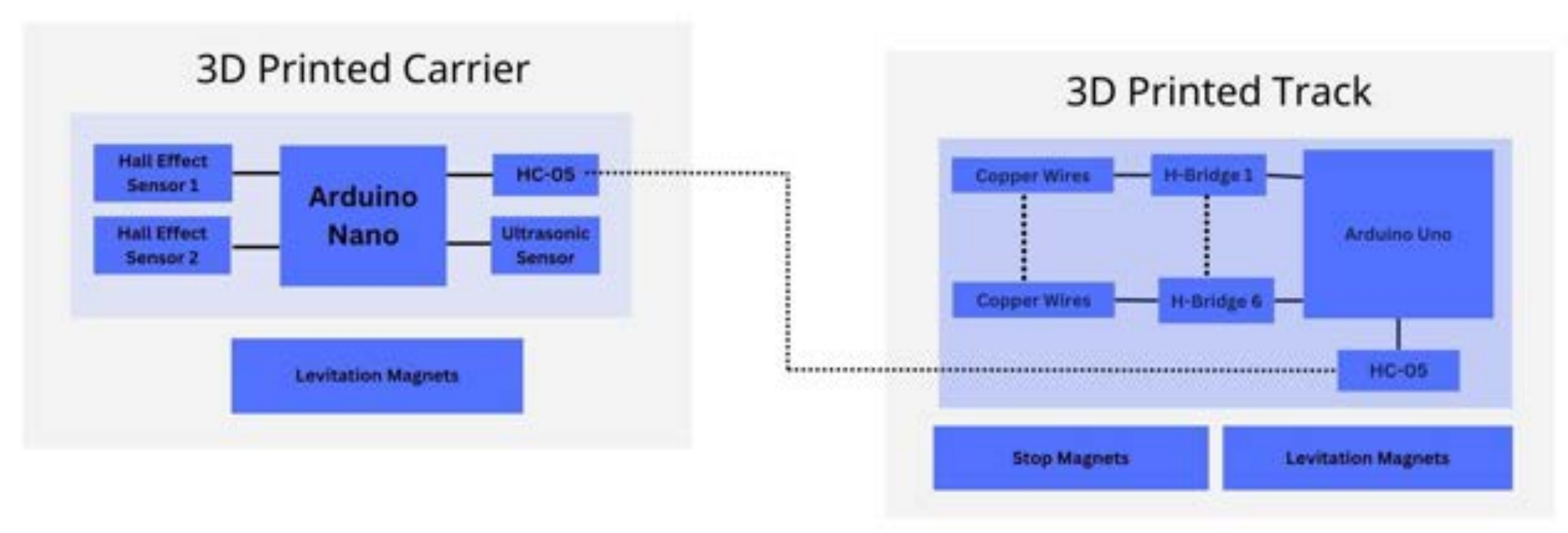
Solution:

Our design will serve as an interactive education tool to teach fundamental properties of electromagnetics, magnetic levitation, and MagLev trains.

Changes:

- Our system's capabilities will be fixed once the track has started to propel
- Our system will not allow changes to speed
- Our system does not have slopes or turns
- We will send a notification when there is an obstruction

Solution Approach: Block Diagram



Final Solution

1. Constant propulsion
2. Carrier makes a stop
3. Carrier detects an obstruction

Carrier - 2cm circle magnets - no spacing

Track - 2.5cm rectangle magnets - no spacing

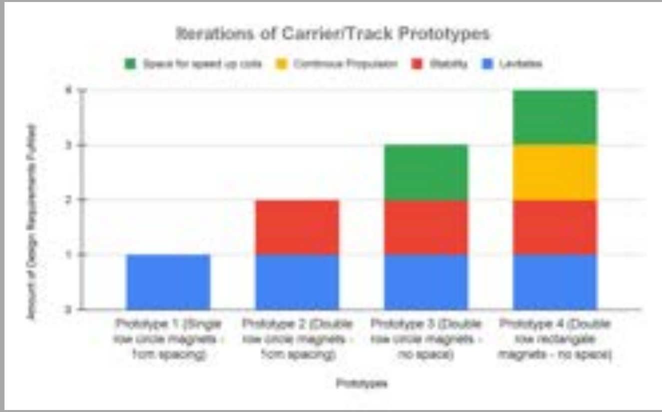
Carrier, Carrier Circuit, Speed Up Coils w/ H-Bridge, and Track

Test, Verification and Validation

Category	Goal	Testing Plans	Results and Design Tradeoffs
Levitation	0.8 inch	Manually verify our carrier's height above the track	1.1 in (2.6 cm) of levitation (w/ the rectangle double magnet track)
Propulsion (Speed Up Coils)	Create a magnetic field strong enough to propel the carrier across the track	1. Calculating using Magnetic Field formula 2. Linear Hall Effect Sensor to compare coils 3. Visually testing smoothness of carrier moving along track	Propels the carrier at 12 Milli-tesla (Magnetic field of the coil)
Response Time / Communication	Signal should be sent fast enough to exhibit smooth travel between stops, not cause significant slow down	Measure the time it takes from signal dispatch to the actual stopping by logging in to the Arduino terminal.	50ms delay
Stability	Carrier should remain visibly stable while along track	Manually verify that the track remains stable through levitation and propulsion	Track (2 rows of rectangle magnets) and Carrier(Circle magnets) are visibly stable
Sensing - Ultrasonic	Detect objects blocking track (min 5cm ahead, ideally carrier length ahead)	Test each possible output with LED circuit	Accurately detects objects within 2cm of the track (95% of error)
Sensing - Linear Hall Effect	Detect the magnetic fields of stops (magnets) along the sides of the track	Test each possible output with LED circuit	Detects magnets within 1.5 cm of the linear hall effect

Testing, Verification, and Validation: Results

Results and Design Tradeoffs
1.1 in (2.6 cm) of levitation (w/ the rectangle double magnet track)
Propels the carrier at 12 Milli-teslas (Magnetic field of the coil)
50ms delay
Track (2 rows of rectangle magnets) and Carrier(Circle magnets) are visibly stable
Accurately detects objects within 2cm of the track (95% of error)
Detects magnets within 1.5 cm of the linear hall effect



AWG	Radius (inches)	Turns	Amps (A)	Magnetic Field (Teslas)
24	0.25	100	5.1	**0.00116192**
18	0.75	102	5.1	**0.00510339**
24	0.25	400	3.2	**0.0046477**
30	0.75	600	0.5	**0.00294313**
32	0.75	700	0.23	**0.00157948**
24	0.75	396	2.5	**0.00971235**
22	0.75	230	5.1	**0.01150766**

Project Management

Emanuel

- Constructing Speed up Coils from Copper Wire
- Adjusting Copper Wire to optimize magnetic field produced
- Stopping and starting system via bluetooth
- Areas: Semiconductors, Circuits

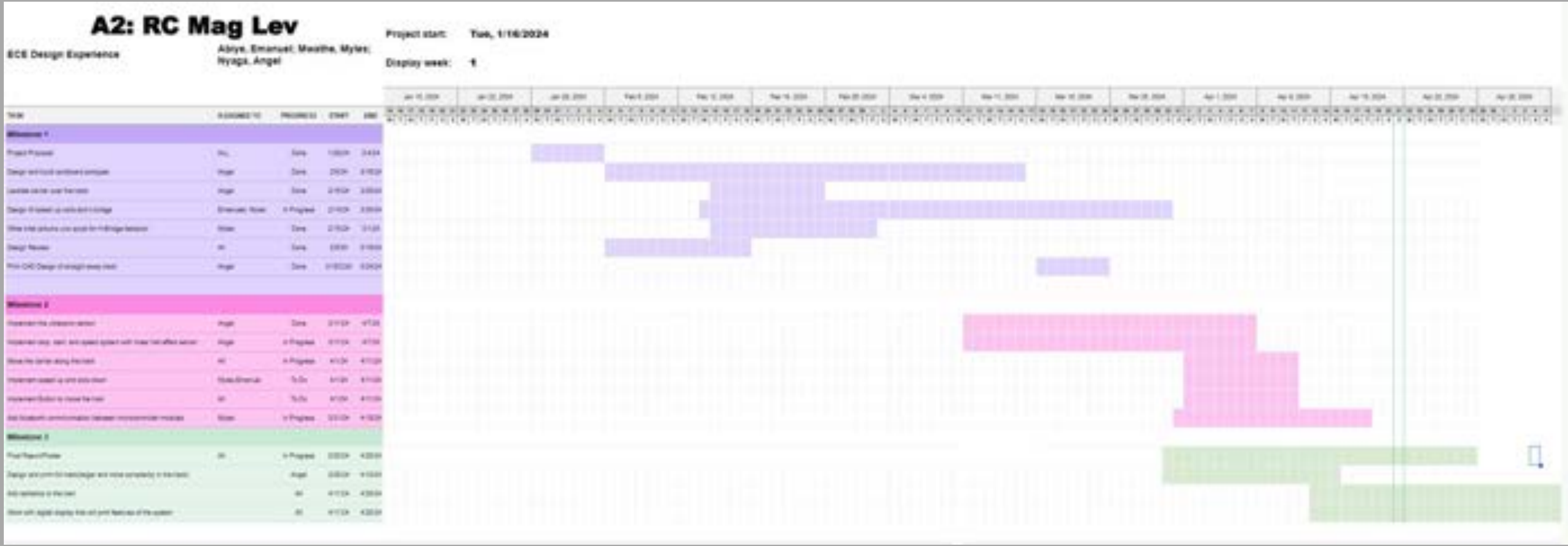
Myles

- Constructing H-Bridge circuit to programmatically change current polarity
- Constructing Speed up Coils from Copper Wire
- Develop code to allow communication between carrier and track (HC-05)
- Areas: Semiconductors, Circuits, Software

Angel

- Create prototypes of track and carrier design to optimize magnetic fields
- Develop code to allow ultrasonic sensing
- Develop code to allow linear hall effect sensing
- Area: Semiconductors, Circuits, Software

Project Management: Schedule



Lesson Learned

- Slopes and curves are difficult to implement
- Magnets shape and its effect on design
- Magnets and levitation is unstable
- Multiple Stops
- User interface
- CAD design is challenging without prior experience