To Predict ▶ To Design ▶ To Perform

College of Engineering
Department of Mechanical & Industrial Engineering

ME, ECE, BE Capstone Design Programs

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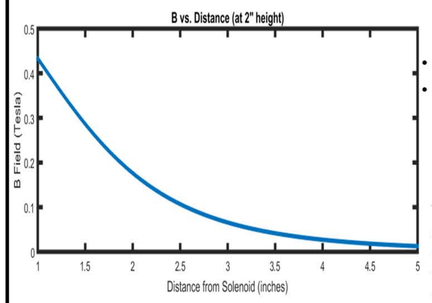
Team 28:Tiger-R.E.A.L.M.

(Real-time Electromagnetic Apparatus for Levitation and Manipulation)

Background



- An approximation formula has been used to quantify each electromagnets B filed off axis
- $B = \frac{\mu_0}{4\pi}(knI\pi a^2 l)\left(\hat{r}\frac{2cos\theta}{r^3} + \hat{\theta}\frac{sin\theta}{r^3}\right)$
- On axis approximation is characterized by Amperes Law:

$$B = \frac{\mu_0 In}{2}$$

The $\vec{B}$ field approximation formula describes how the magnetic field varies off axis of each electromagnet until termination. This behavior is shown in the adjacent figure.

Engineering Specifications

Dimensions	16.5"x9.5"x15.5"	•16.5"x9.5"x15.5"
Amperage	44A to Electromagnets	•42.2A
Levitation	<1cm fluctuations in levitating height	
"Real-Time"	<200ms response time	• 4kHz
Total Manufacturing Cost	<$2000	• $1812.13
Weight	<50 lbs	• 46 lbs
Levitating Height	5.75 in with 10A/magnet	

Constraints

Per US Patent 9061761 B2 our design is constrained to the following:

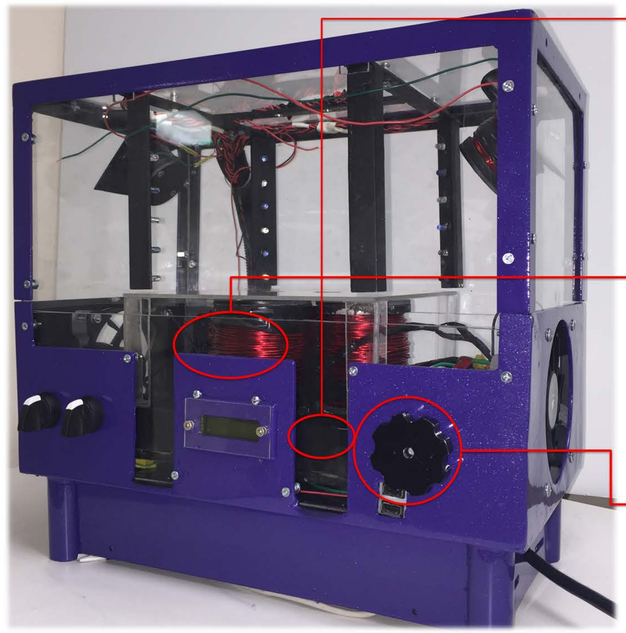
- Placement and use of Side Magnets
- Placement and use of Electromagnet(s) at bottom of base
- Four walls forming a see-thru enclosure
- Levitating magnet must incorporate a scaffold assembly
- All wiring must be isolated from the user
- All wiring must be strain relieved

Objective

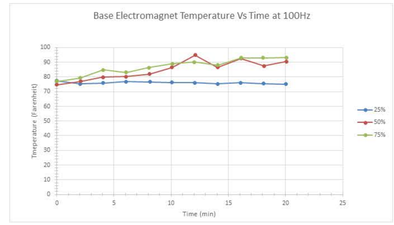
To design and manufacture a device which provides stable and repulsive magnetic levitation and allows for vertical and lateral displacement of a levitating magnet.

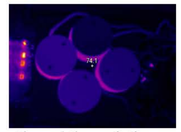
Project Summary

Tiger-R.E.A.L.M – a prototype electromagnetic manipulator, embodies the requirements of Dr. William Belisle's patent (US Patent 9061761 B2). Stable electromagnetic levitation can be used for educational demonstrations and experimentation. Interchangeable components can be used for further investigation into magnetics.



Heating and Cooling





Cooling System Design :

- Heatsink – 40 fins
- (2) CPU Fans -62.47 CFM

Base Electromagnets are cooled by forced convection, both directly and through the Heatsink. Temperature varied with time and current at various duty cycles as shown.

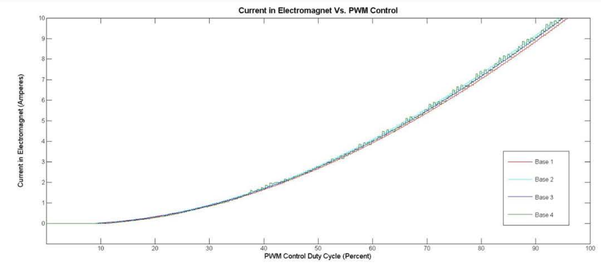
Magnetic Trapping

- A magnetic trap is created by a quadrupole arrangement of base magnets
- A saddle point is created at the center of the trap and results in a single point of stable levitation when current is fluctuated
- Fluctuating current results in variable magnetic field strength
- Variable field strength results in changing force magnitude and direction

Governing Equation:

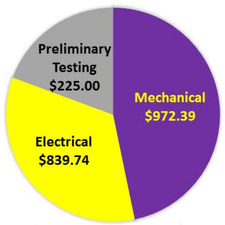
$\vec{F} = \nabla\vec{B}X\vec{M}$

Real-Time Controls



- The shape of the magnetic trap is controlled by an on board MCU
- A sensor network is used to senses the position of the levitator and adjust magnetic fields
- Users have the ability to control position directly in the vertical axis and lateral plane
- An LCD readout is used to display current per electromagnet.

Budget



Total Manufacturing Budget - $2000.00
Additional Testing Funds- $225.00
Total Expenditures - $1812.13
Total Surplus- $ 412.87

Manufacturing and Assembly

Tiger-R.E.A.L.M will be assembled and tested in phases starting in early January 2016:

- January 15 - Electromagnet construction and Electrical Subsystem procurement
- January 20 - Assembling and testing of sensory network
- February 1 – Manufacturing Start Date
- March 3- Manufacturing Completion Date
- March 18 – Cooling and Sensor Testing

August — Commencement Meeting with Project Sponsor
September — Concept Generation
October — Midterm Presentation; Began Preliminary Testing
November — Preliminary Testing Completed
December — Final Presentation
January — Manufacturing Start Date; Electromagnet Construction Completed
February
March — Electronic Wiring Complete; Manufacturing Completion Date; Cooling and Sensor Testing
April — Cooling Testing Complete; Control System Debugging
May — Final Presentation; Final Report Due

Sponsors: Dr. William Belisle

Advisors: Dr. Michael Murphy