Electromagnetic Railgun

Aravind Ganesh
ee16tech11026@iith.ac.in

Siva Kumar
Project advisor
ksiva@iith.ac.in

Adithya Hosapate
ee16btech11040@iith.ac.in

Anand N Warrier
ee16btech11042@iith.ac.in

Deep Diwani
ee16tech11006@iith.ac.in

December 4, 2017

Abstract

In this project, we have designed a prototype of a railgun. As this project is only for educational purposes, we have limited ourselves to low power levels of around 100V and 10 Amperes. We hope this project serves as a proof of concept. This prototype can be further developed and deployed in a multitude of applications.

I. Introduction

A railgun is a device that uses electromagnetic force to launch high velocity projectiles, by means of a sliding armature that is accelerated along a pair of conductive rails. Railguns rely on electromagnetic force to propel a projectile at very high velocities(more than $3km/s$).

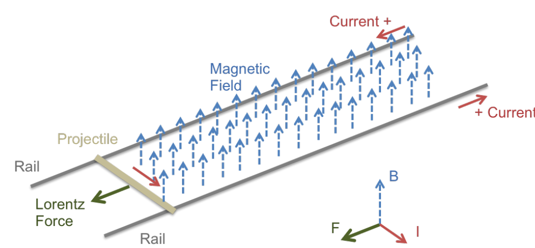
II. Potential Applications

- Railguns are being researched as weapons that would use neither explosives nor propellant.The absence of explosive propellants or warheads to store and handle conventional weaponry come as additional advantages.
- In addition to military applications, NASA has proposed to use a railgun to launch wedge-shaped aircraft with scramjets to high-altitude at Mach 10, where they will then fire a small payload into orbit using conventional rocket propulsion.
- Railguns can potentially be used to aid mining, as a substitute for dynamite for clearing tunnels.

III. Principle

The magnetic force on a current carrying conductor can be modelled by the equation.

Figure 1: *Working principle of railgun*



$$\vec{F} = I_r\vec{l} \times \vec{B} \tag{1}$$

Where F is force, B is magnetic field and I_r is current passing through the rails.

As we are using permanent magnets to supply an external magnetic field, we restrict our power supply to DC only.

We apply the magnetic field as seen in Figure 1 using strong permanent magnets. The magnetic field intensity of a magnet is given by $\vec{B}$

As the magnetic field is perpendicular to the current carrying projectile, $Eq(1)$ simplifies to

$$|\vec{F}| = I_r l|\vec{B}|$$

IV. Approach

We began by deciding the architecture of our gun. After brainstorming many different setups, we settled on

- A set of 2 parallel rails
- A cylindrical graphite rod, which is conducting yet non-ferromagnetic.
- Strong Permanent magnets to generate an external magnetic field
- A capacitor bank in order to deliver high currents in a short amount of time to the rails.

Current progress

We began by designing the Capacitor bank charging circuit, using simulink (A MATLAB simulation software).

A detailed schematic of the circuit can be found below in Figure 1.

Figure 2 shows the voltage vs time plot of the charging capacitors.

Figure 2: *Circuit Diagram of simulated charging circuit*

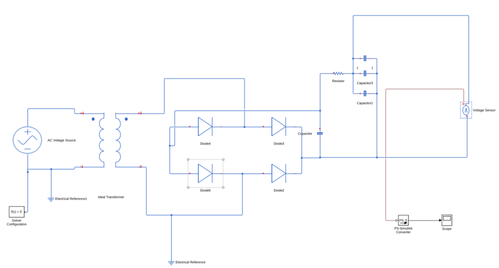
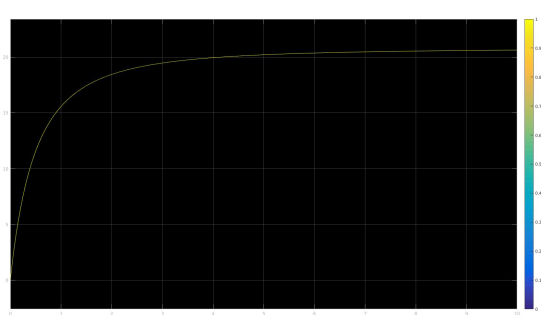
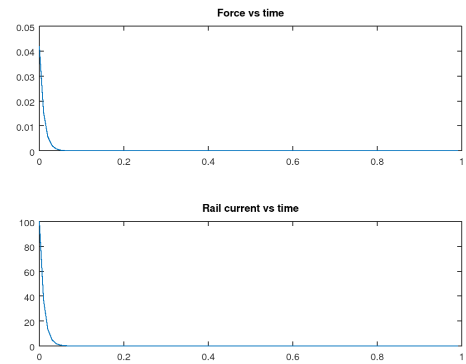


Figure 3: *Plot of voltage across capcitor bank vs time*



We ran calculations using a matlab script and plotted the force on the projetile vs time along with the rail current vs time.(Figure 3)

Figure 4: *Plots of rail current vs time and force vs time*



The script and all other code used in this project can be found in the project github repository. **https://github.com/AravindGanesh/IDP-Sem3**

V. Components

- Capacitors - 2.2mF (as power source for the rails)
- Variable Auto-Transformer
- Fullwave bridge Rectifier (uncontrolled)
- Power MOSFET - IR740 (for switching)
- Strong Neodymium Magnets
- High power resistors
-
- Steel scales as rails

Testing the Prototype

VI. Bibliography

- https://www.allaboutcircuits.com.
- electronics-course.com/ripple-counter.
- https://www.eecs.tufts.edu/ dsculley/tutorial