Electromagnetic Railgun

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Abstract

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 $3km/s$).

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 $3km/s$).

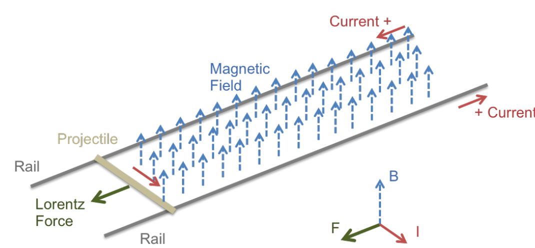
II. Potential Applications

- 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.

We notice that the direction of force is always outward as shown in $figure1$, regardless of whether the power supply is AC or DC.

We apply the magnetic field as seen in Figure 1 using a current carrying coil. The magnetic field intensity of a current carrying coil with N turns is given by the equation

$$B = \frac{\mu_0 N I_c}{2r} \tag{2}$$

Where r is the radius of the coil, B is magnetic field intensity and I_c is current passing through the coil.

As the magnetic field is perpendicular to the current carrying projectile, $Eq(1)$ simplifies to $F = I_r l B$. Substituting equation 2 into 1, we get

$$F = \frac{\mu_0 N l I_c I_r}{2r} \tag{3}$$

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*

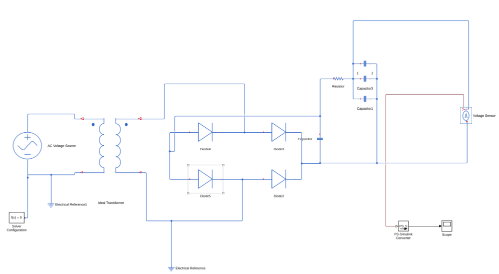
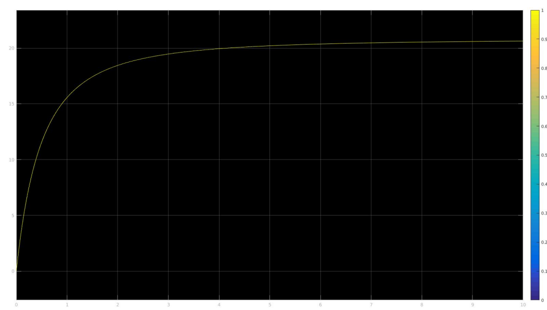
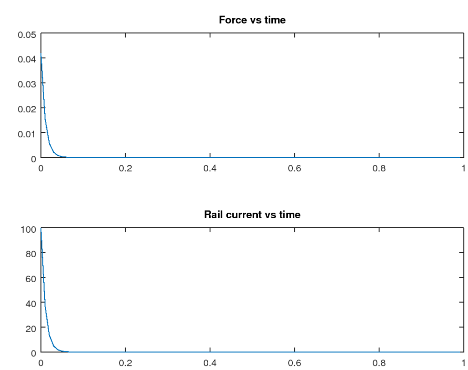


Figure 3: *Plot of voltage across capcitor bank vs time*



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