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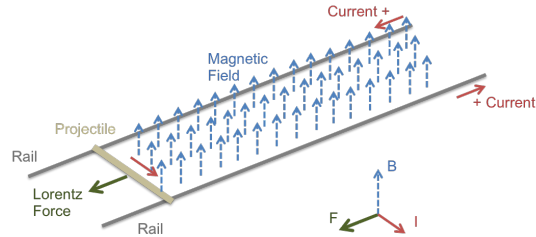
$$\vec{F} = I_r \vec{l} \times \vec{B} \tag{1}$$

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

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

1

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 $F = I_r lB$. Substituting equation 2 into 1, we get

$$F = \frac{\mu_0 N l I_c I_r}{2r} \qquad (3)$$

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.

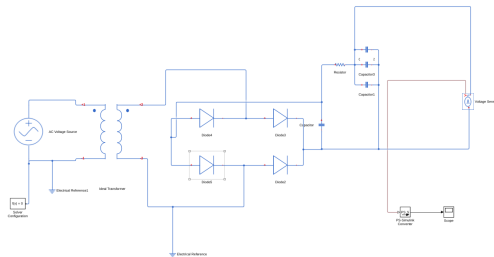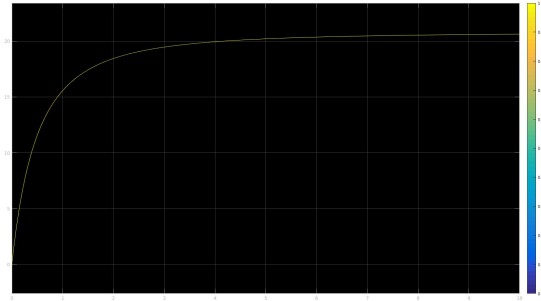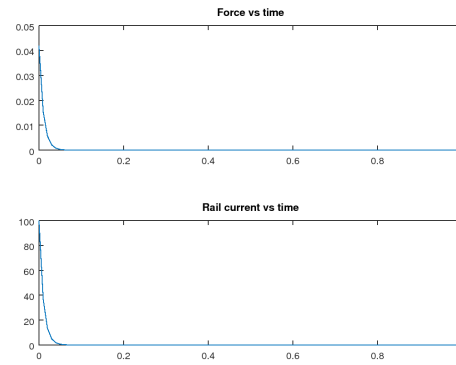**Figure 2:** *Circuit Diagram of simulated charging circuit*

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. ARCHITECTURE

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
- Graphite rod (as projectile)

Structure Description

The steel scales serve as rails. The graphite rod is chosen as projectile as it is conducting but not ferromagnetic. If we use a projectile made of ferromagnetic material, it will get attracted back by the strong magnetic field. The permanent magnets provide strong magnetic field perpendicular to the plane of the rails. The capacitors are charged with the DC output of the rectifier with input from the variable auto-transformer. The charged capacitor provides high amounts of instantaneous current when connected to the rails. Current flows through the graphite rod (projectile) and it moves and it experiences a force according to the principle in equation (1).

VI. Testing the Prototype

VII. Bibliography

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- electronics-course.com/ripple-counter.
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