

Rail and Coil Gun Based Levitating Hybrid Train

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Abstract

Hybrid train is a train which is a hybrid of the concept ideas of coil gun, rail gun, halbach array, magnetic levitation etc. Theoretically this train could achieve the fastest Speed an object could reach respect to its mass. This train could surpass sound barrier and could even be made to go to speed exceeding mach 3. But due to travel safety a certain speed limit can be implemented in these train. These trains use less amount of electricity. These trains need electricity only to excite the train moving forward so the other winding loops can be switched off. The concept of coil gun is used to accelerate ions in LHC to do various scientific experiment in the LHC the atoms are accelerated very much closer to the speed of light (299,792,458 m/s). But due to the increase in mass the Einstein equation states that the greater the mass the more energy need to be applied to achieve certain speed. Thus, we can control the speed of the train to a speed at which even the severe accident leads to the least injury. This train could be the future of our humanity and has the highest safety measures a train could have.

Keywords: Rail-gun, Coil-gun, eddy current based Magnetic levitation, Halbach array, Eddy current based projectile system.

INTRODUCTION

Rail Gun

A railgun is a linear motor device, typically designed as a weapon, that uses electromagnetic force to launch high velocity projectiles. The projectile normally does not contain explosives, instead relying on the projectile's high speed, mass, and kinetic energy to inflict damage.

The railgun uses a pair of parallel conductors (rails), along which a sliding armature is accelerated by the electromagnetic effects of a current that flows down one rail, into the armature and then back along the other rail. It is based on principles similar to those of the homopolar motor.

As of 2020, railguns have been researched as weapons utilizing electromagnetic forces to impart a very high kinetic energy to a projectile (e.g., APFSDS) rather than using conventional propellants

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(Refer Figure 1). While explosive-powered military guns cannot readily achieve a muzzle velocity of more than ≈ 2 km/s, railguns can readily exceed 3 km/s. For a similar projectile, the range of railguns may exceed that of conventional guns. The destructive force of a projectile depends on its kinetic energy and mass at the point of impact and due to the potentially high velocity of a railgun-launched projectile, their destructive force may be much greater than conventionally launched projectiles of the same size. The absence of explosive propellants or warheads to store and handle, as well as the low cost of projectiles compared to conventional weaponry, come as additional advantages.

Basics of Rail gun

The railgun in its simplest form differs from a traditional electric motor in that no use is made of additional field windings (or permanent magnets). This basic configuration is formed by a single loop of current and thus requires high currents (e.g., of order one million amperes) to produce sufficient accelerations (and muzzle velocities) [1]. A relatively common variant of this configuration is the *augmented railgun* in which the driving current is channeled through additional pairs of parallel conductors, arranged to increase ('augment') the magnetic field experienced by the moving armature. These arrangements reduce the current required for a given acceleration. In electric motor terminology, augmented railguns are usually series-wound configurations.

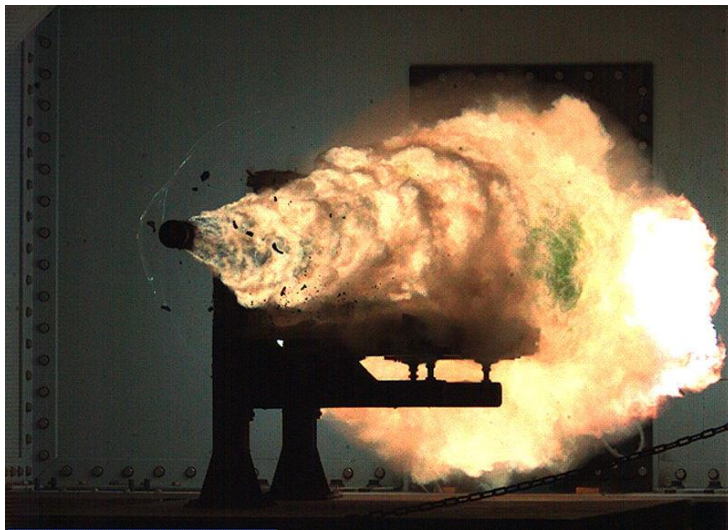


Figure 1. Projectile being fired from a coil gun.

Some railguns also use strong neodymium magnets with the field perpendicular to the current flow to increase the force on the projectile as depicted in Figure 2.

The armature may be an integral part of the projectile, but it may also be configured to accelerate a separate, electrically isolated or non-conducting projectile [2]. Solid, metallic sliding conductors are often the preferred form of railgun armature but plasma or 'hybrid' armatures can also be used. A plasma armature is formed by an arc of ionized gas that is used to push a solid, non-conducting payload in a similar manner to the propellant gas pressure in a conventional gun. A hybrid armature uses a pair of plasma contacts to interface a metallic armature to the gun rails. Solid armatures may also 'transition' into hybrid armatures, typically after a particular velocity threshold is exceeded. The high current required to power a railgun can be provided by various power supply technologies, such as capacitors, pulse generators and disc generators.

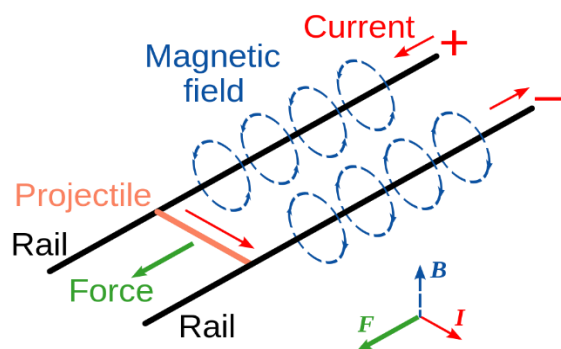


Figure 2. Working of rail gun.

Coil Gun

A coil gun, also known as a Gauss rifle, is a type of mass driver consisting of one or more coils used as electromagnets in the configuration of linear motor that accelerate a ferromagnetic or conducting projectile to high velocity. In almost all coil gun configurations, the coils and the gun barrel are arranged on a common axis. A coil gun is not a rifle as the barrel is smoothbore (not rifled). The name "Gauss" is in reference to Carl Friedrich Gauss, who formulated mathematical descriptions of the magnetic effect used by magnetic accelerator cannons [3].

Coil guns generally consist of one or more coils arranged along a barrel, so the path of the accelerating projectile lies along the central axis of the coils. The coils are switched on and off in a precisely timed sequence, causing the projectile to be accelerated quickly along the barrel via magnetic forces. The circuit diagram represented the structural consistency of the Miniature Coil Gun in Figure 3.

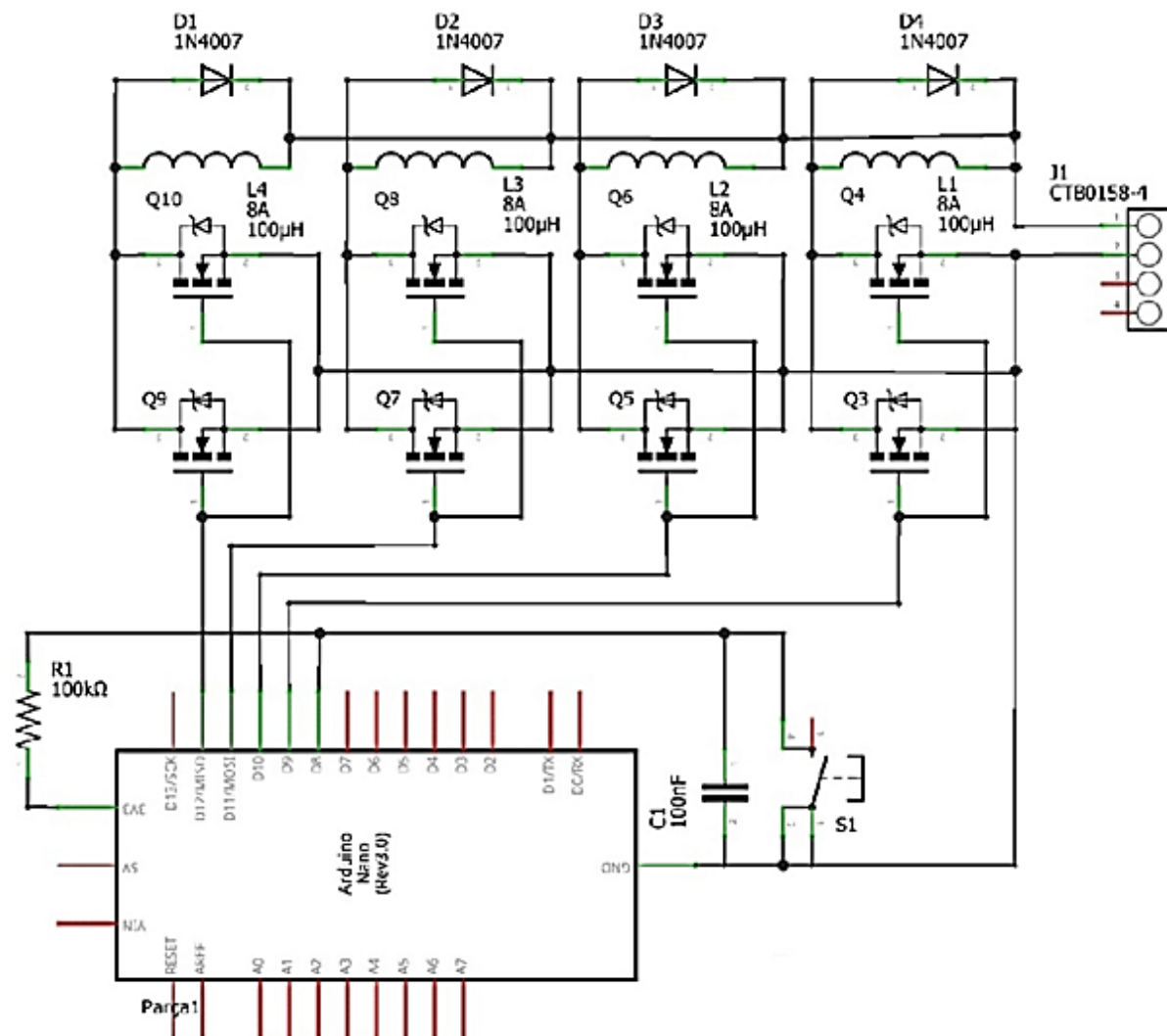


Figure 3. Circuit diagram for miniature coil gun.

Coil guns are distinct from railguns, as the direction of acceleration in a railgun is at right angles to the central axis of the current loop formed by the conducting rails [4]. In addition, railguns usually require the use of sliding contacts to pass a large current through the projectile or sabot, but coilguns do not necessarily require sliding contacts as presented in Figure 4.

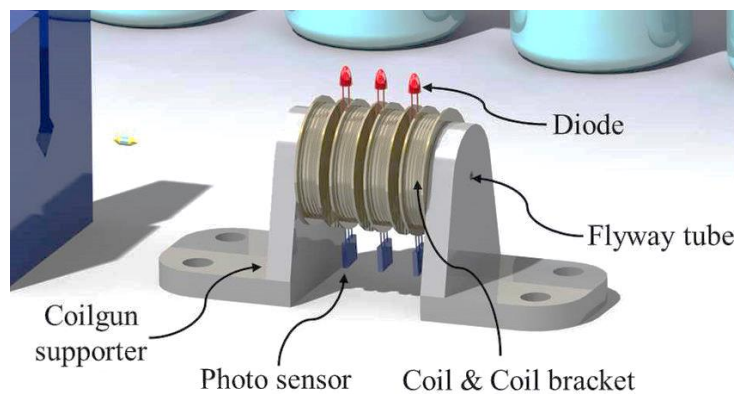


Figure 4. Miniature coil gun model.

While some simple coil gun concepts can use ferromagnetic projectiles or even permanent magnet projectiles, most designs for high velocities actually incorporate a coupled coil as part of the projectile.

Levitation-Halbach Array

A Halbach array is a special arrangement of permanent magnets that augments the magnetic field on one side of the array while cancelling the field to near zero on the other side. This is achieved by having a spatially rotating pattern of magnetization [5].

The rotating pattern of permanent magnets (on the front face; on the left, up, right, down) can be continued indefinitely and have the same effect. The effect of this arrangement is roughly similar to many horseshoe magnets placed adjacent to each other, with similar poles touching.

The principle was first invented by James (Jim) M. Winey of Magnepan in 1970, for the ideal case of continuously rotating magnetization, induced by a one-sided stripe-shaped coil.

The effect was also discovered by John C. Mallinson in 1973, and these "one-sided flux" structures were initially described by him as a "curiosity", although at the time he recognized from this discovery the potential for significant improvements in magnetic tape technology [6].

Magnetic Levitation using Eddy Current

Relative Motion between Conductors and Magnets

If one moves a base made of a very good electrical conductor such as copper, aluminum or silver close to a magnet, an (eddy) current will be induced in the conductor that will oppose the changes in the field and create an opposite field that will repel the magnet (Lenz's law). At a sufficiently high rate of movement, a suspended magnet will levitate on the metal, or vice versa with suspended metal [7]. Litz wire made of wire thinner than the skin depth for the frequencies seen by the metal works much more efficiently than solid conductors. Figure 5 coils can be used to keep something aligned.

An especially technologically interesting case of this comes when one uses a Halbach array instead of a single pole permanent magnet, as this almost doubles the field strength, which in turn almost doubles the strength of the eddy currents. The net effect is to more than triple the lift force. Using two opposed Halbach arrays increases the field even further [8].

Halbach arrays are also well-suited to magnetic levitation and stabilization of gyroscopes and electric motor and generator spindles.

Oscillating Electromagnetic Fields

Aluminum foil floating above the induction cooktop thanks to eddy currents induced in it.

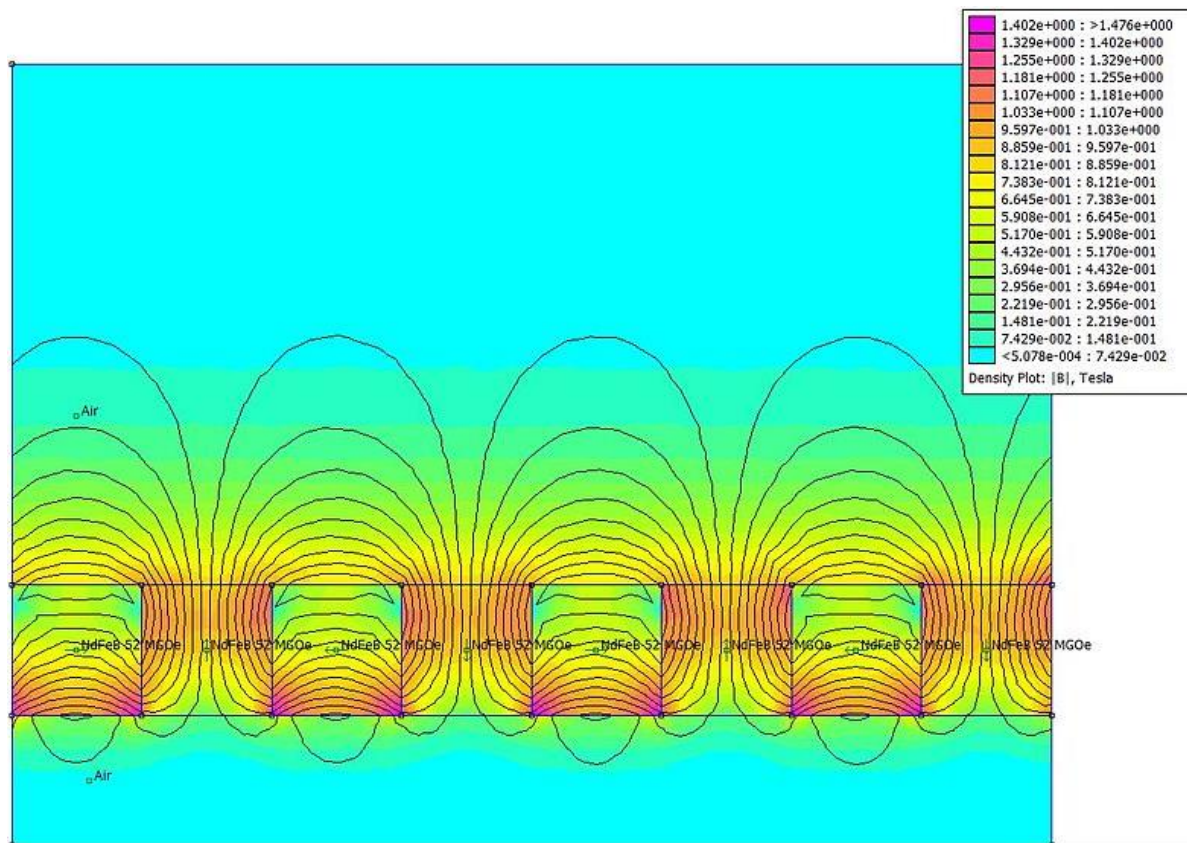


Figure 5. Flux diagram of Halbach array.

A conductor can be levitated above an electromagnet (or vice versa) with an alternating current flowing through it. This causes any regular conductor to behave like a diamagnet, due to the eddy currents generated in the conductor. Since the eddy currents create their own fields which oppose the magnetic field, the conductive object is repelled from the electromagnet, and most of the field lines of the magnetic field will no longer penetrate the conductive object [9, 10].

This effect requires non-ferromagnetic but highly conductive materials like aluminum or copper, as the ferromagnetic ones are also strongly attracted to the electromagnet (although at high frequencies the field can still be expelled) and tend to have a higher resistivity giving lower eddy currents. Again, litz wire gives the best results.

Hybrid Train

Hybrid Train is a hybrid of the concepts of rail gun, coil gun, magnetic levitation etc. At the beginning when the train is stationary in the railway station, in order to excite the train to move forward a rail gun mechanism is used at the bottom of the train. When the bottom rails are energized the train moves forward after achieving certain velocity the rail gun mechanism is ended and coil gun mechanism is implemented it has series of loops which get energized at proper time when the train leaves the coil A coil B get energized to attract the train this process is repeated again and again with each coil. Theoretically this train has the capacity to break the sound barrier and could travel really fast. In order to reduce the friction the concept of levitation is used. Levitation can be achieved either by rotating the halback array magnets really fast or applying AC voltage to the surrounding of the train.

Components

- Train body
- Rail gun rails

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- Coils of coil gun
 - Container of the system
 - Levitating Coils

Train body

Train body is made up of thick conductor with retractable wheels. The inner area can be made with shock absorbers in order to protect the passengers or the packages. The train body should be highly aerodynamic so that it experience low air resistance while traveling.

Rail Gun Rails

Rail gun rails are laid in the bottom of the train. The rail gun is used to excite the train to move the train from the stationary position. After attaining certain speed the railing is vanished. Proper computation should be made to understand when a certain train with the different range of weight would attain the required velocity. And the railing is also used at the end to slow down the train to attain its stationary position. This railing is powered by a high current supply which can be acquired from charging super capacitors.

Coils of Coil Gun

Coils are built surrounding the train housing with proper spacing when a coil excites the train is attracted to that coil when the train comes out of the first coil an IR sensor is kept at the nozzle of the coil to know that the train has come out, then the first coil shuts down then the next coil is excited thus the train gets excited to the next coil this step happens again and again. This mechanism has the ability to make the train break the sound barrier and go to enormous speed.

Container of the System

Container of the system is the housing which built in order to hold the entire train and the coil structures. The entire system is compressed into a tube which has the capacity to run the world's fastest train ever created by the humanity.

Levitating Coils

The concept of levitation can be performed using two methods. The first method is to rotate an halback array magnets with the help of high-speed motors but it may increase the weight of the train thus reducing the speed of the train. Another method is to add coils surrounding the housing and supply it with high voltage AC the AC voltage induces eddy current in the train and make it levitate. But there is a possibility that it might mess with the other magnetic field lines. Proper calculations should be made to implement the levitating coils to the housing of the train.

Advantages

- Low electricity consumption comparing other electric and maglev trains.
- Could achieve the fastest speed.
- Travelling time is reduced drastically.
- Very safe mode of travel.
- Even in case of power failure or track breakage accident won't happen because the power won't be applied to the coils so no accidents.

Disadvantage

- High implementation cost
 - High calculations should made.
 - Takes lots area.
 - Power supply should be uniform to make it run.
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Future scope

Our project will be a miniature model of the hybrid train we would try to do the calculations for the miniature version of the train.

The future scope of the project is to implement it as a new type of transport in the world of transportation. Its fast and safe people would try to adapt to this new type transportation soon.

In order to make the miniature model to a real-life train model proper calculations and proper funding is necessary to make it work any countries are coming up with its own concept of trains and this is my idea on how we could make an train which has ability to beat most of the other trains in the world in the competition of fast travel.

CONCLUSION

If this technology could be implemented in massive scale by manufacturing industrial grade materials, it would revolutionize the transportation industry. People will be able to travel a long distance within a short duration of time and in a cheapest way possible. This transportation network is wide spread across our nation we could travel from Kanyakumari to Jammu and Kashmir within few hours. This land mode of transportation has a high chance of competing with the air-based travel. Hence it can achieve a huge amount of speed that other land-based travel could highly lack.

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