Electromagnetic Catapult

Mr.S Jayakumar[1] , Aditya Singh[2], Anish Bhattacharyya[3], Piyush Ojha[4]
[1, 2] Dept of Computer Science Engineering
[1, 2] SRM Institute of Science and Technology Chennai, India

Abstract- *The Rocket engines system that we use today waste a lot of energy. The total energy is distributed into many forms (heat, sound, light, etc.), to reach the desired speed for the projectile which uses lot of energy. The main focus of the project is to minimize the waste of energy while reducing the distribution of energy. Electromagnetic Projectile System(EPS) efficiently decreases the energy loss which cause the projectile to cover larger distances. The proposed system works electrically rather than mechanically which overcome a lot of problems as caused in mechanical model.*

Keywords- Electromagnet, Projectile,coilgun,rail

I. INTRODUCTION

In its simplest kind, the coil gun is Associate in Nursing magnetic force Accelerator whose propulsive force is thanks to the interaction between 2 concentrical coils: a stationary driver, and a moving driven coil. The force is enticing if the currents flow within the same direction in each coils, and repulsive once they flow in opposite directions. Additional sensible than one drive coilis the use of a longitudinal array of coils to create a gun barrel that guides the moving coil hooked up to the projectile. For a one-way current within the moving coil, the current in every drive coil should modification sign at the moment that the driven coil crosses its sheet, to forestall reversal of the thrust. to attain this sign modification, the excitation current must oscillate synchronously with the passage of the driven coil. The oscillatory circuit is tuned approximately to the frequency reminiscent of the transit time between 2 ordered drive coils. Synchronization may be accomplished, in essence, by optical sensors that trigger the drive coil switches.

II. LITERATURE SURVEY

Previous developers have delineate the induction acceleration of single conducting rings [1,2,3,4], and of multiple-coil arrangements [1,5,6]. These acceleration schemes imply that a moving coil (or coils) is driven by a packet of energy travelling on the barrel; paper [7] describes the way to inject current into the moving coils by utilizing mechanical brushes. Another approach, used by Driga, Weldon and Woodson [8], and by Elliott [9], is to design the coil-gun as a linear induction motor, based on the model for standard electrical machines. within the latter, the barrel is worked up by rotating machine, either by employing a special variable-frequency generator, or by employing a group of constant-frequency generators. Despite the excitation issues, this methodology has the advantage that it may be used as a theoretical model even for a travelling packet of energy arrangement. The coil gun delineated during this paper, known as the Linear Induction Launcher (LIL), differs from alternative ideas in this it is designed to be swimmingly accelerated by a travelling electromagnetic wave-packet employing a capacitance power source in associate uncommon switch theme. additionally, typical of induction launcher systems [8,9], it doesn't need contacts or guides to feed and support the projectile, and has no want for actual synchronization between the projectile and also the traveling magnetic wave.

III. ARCHITECTURE OF THE PROPORSED MODEL

The electromagnetic catapult can be designed by the following components:

1. 1 meter barrel
2. 14 mm projectile diameter
3. <52 projectile mass.
4. <5 cm length
5. Multiple capacitors
6. 400m/s muzzle velocity

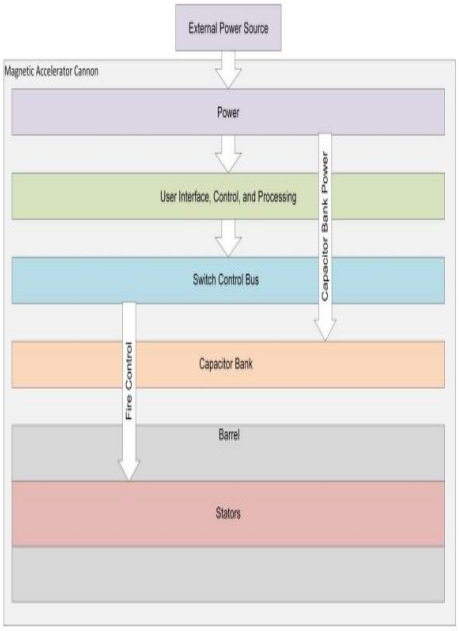


Figure 1 M.A.C System Block Diagram

Each of the project members brings a unique set of interests and knowledge, including electromagnetic fields, microelectronics, power systems and embedded systems. This project will both engage and cultivate those skills. Figure 1 depicts the initial top level system block diagram for the Magnetic Accelerator Cannon. The project documentation which follows will go into depth into how the EMC will be the foundation for the next generation of launch technology systems.

Mutual inductance is based on the distances between coils. Therefore, the position of the projectile and the currents induced determine the amount of force which the projectile experiences. The thesis uses “Inductance Calculations” by Frederick W. Grover to solve for the mutual inductances between coils using the current filament method. This method and book is described in the following sections and is a primary driving method to solve for the force between filaments of the stators and projectile.

The average efficiency that was achieved in the coilgun designed was 30% without recovering the energy in the coils after one current cycle. With recovering the magnetic energy left over in the coils the efficiencies were brought up to an average of 65%. This analysis showed insight into the types of efficiencies that could be seen In the EMC The topic on time switching was investigated by the lab as well. Performance profiles were developed for the coilguns built to determine switch and timing errors. The errors induced into the system were in the scale of micro-seconds. Errors at this scale provided a negligible effect on the performance in the low speed gun, 400m/s, and a small deviation from mean velocity in the high-speed gun, 2.5 km/s.

This equation is the general formula for inductance depending if you have pitch, n, given or number of turns, N, given

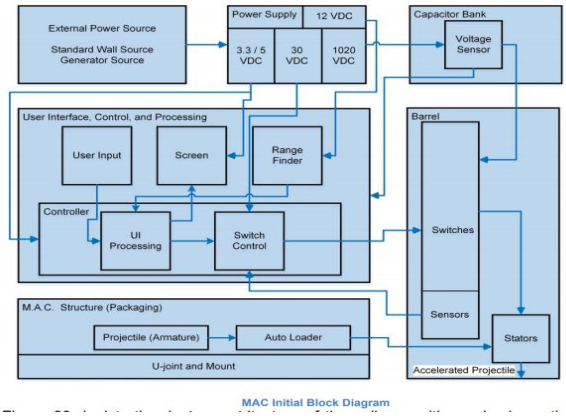
$$L = 0.002\pi^2 a\left(\frac{2a}{b}\right)N^2K$$

Variables used to determine the Inductance of a single layer coil

Variable	Description	Unit
L	Inductance	uH
a	Coil radius	cm
b	Coil length	cm
n	Winding density	Turns/cm
N	Number of turns	-

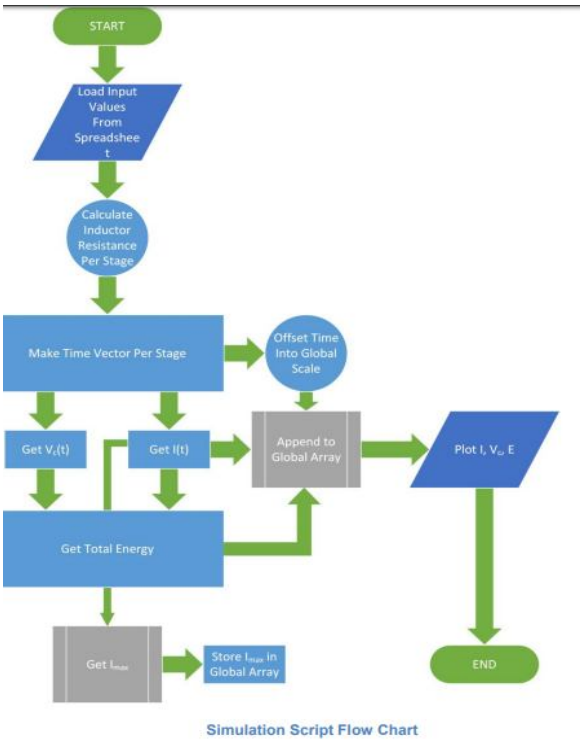
III. PROPOSED ALGORITHM(S)

Conservation of energy is a very important concept in the development of electromagnetic launch systems. The typical launch system uses expendable chemical energy converted into kinetic energy to achieve the goals of the system. On the other hand electromagnetic systems utilize recoverable electrical energy converted into kinetic energy to achieve the goals of the system. The use of electric energy reduces the need for costly chemical materials. The chemical method has to take into account the losses incurred by thermal energy, and friction in the barrel in chemical systems. The thesis discusses two different electrical launch systems; the railgun and the coilgun. Each has its positives and negatives. For the purpose of this project the coilgun description and design process was analyzed to learn lessons and concepts. As in most electrical systems the main propulsion forces are due to magnetic fields which are created by stator coils. The principle force in a coilgun is dependent on the current in the stator, the current induced in the armature (projectile), and the mutual inductance between the stator and armature .



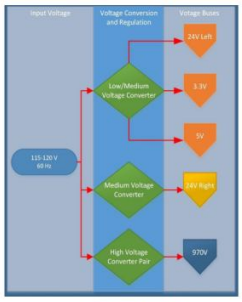
MAC Initial Block Diagram

Mutual inductance is based on the distances between coils. Therefore, the position of the projectile and the currents induced determine the amount of force which the projectile experiences. The thesis uses "Inductance Calculations" by Frederick W. Grover to solve for the mutual inductances between coils using the current filament method. This method and book is described in the following sections and is a primary driving method to



Simulation Script Flow Chart

solve for the force between filaments of the stators and projectile. Approximately 30% efficiency can be achieved between energy storage to coil excitation. Batteries, capacitors, frequency generators, and other generators were investigated to determine the most efficient source to be used in the gun. For the purposes of this project the primary focus was done on the capacitor investigation of the thesis. Capacitors can hold a lot of energy and have been proven to be ideal components for pulsed power applications and this project.



Power System Block Diagram

IV. CONCLUSION

The proposed is a great leap forward from the current systems with a greater accuracy and speed that could not have been achieved earlier. The system can be modified more with new technologies and its efficiency can be increased in the near future with more research and modifications for the same. Thus, it is a small step towards automated future with more interesting things to be developed in near automated future.

V. FUTURE ENHANCEMENT

The proposed system can be utilized in future travel , where a train could be launched with the EMC and further even rockets and aircraft could be launched applying the same concept. Various sensors could be applied on the current system so that its accuracy and efficiency could be further improved and taken to the next level. EMC could be proven to be very useful in various places as it has a very simple concept and the working is not very complex.

REFERENCES

[1] Keshtkar, A., Gharib, L., Abbasi, M.: Comparison between conventional railgun and two-turn railgun by 3D-FEM. In: 2012 16th International Symposium on Electromagnetic Launch Technology (EML), May 15-19, pp. 1–5 (2012)

[2] Guo, L., Guo, N., Wang, S., Qiu, J., Zhu, J.G., Guo, Y., Wang, Y.: Optimization for ca-pacitor-driven coilgun based on equivalent circuit model and genetic algorithm. In: Ener-gy Conversion Congress and Exposition, ECCE 2009, September 20-24, pp. 234–239. IEEE (2009)

[3] Yamori, A., Ono, Y., Sasaki, S.: Development of a plasma armature railgun with two distributed power supplies. In: 2004 12th Symposium on Electromagnetic Launch Technology, May 25-28, pp. 149–154 (2005)

[4] Kaye, R.J.: Operational requirements and issues for coilgun electromagnetic launchers. IEEE Transactions on Magnetics 41(1), 194–199 (2005)
[5] T. Březina and R. Jabloński (eds.), Mechatronics Electromagnetic Coil Gun – Construction and Basic Simulation (2016)