Demonstration of Electromagnetic Phenomenon for Point Object Launching

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Abstract - Electromagnetic engineering plays an important role in study of three dimensional real time applications. Electromagnetic phenomenon has wide range of applications like power grids, submarines, broadcasting, RADAR & satellites. This paper reviews application area in electromagnetic rail gun & also demonstrates electromagnetism in launch of object of rail gun projectile. Design details of control mechanism to interface electromagnetic system with microcontroller & wireless module discussed.

Key Words*: *EMRG, Projectile launching, Rail gun design

1. INTRODUCTION

At the early start of 19th century development of electromagnetic rail gun started. But it gained popularity during World War II as a weapon to target enemies. Now a day's rail gun considered as future space vehicle. Construction of large models of EMRG (Electromagnetic Rail Gun) is complicated & tedious job. Hence plenty of demonstrations has implanted in small sizes of EMRG. Its point form energy considerations are taken in account as design parameters. Main design aspects are pair of parallel rail tracks, projectile, coil gun capacitor banks, charging circuits, & DC power source. [1]

Such electromagnetic assembly usually controlled by electrical power assemblies [2]. Here interfacing of EMRG with microcontroller represented & operated it with RF trans- receiver module.

Power required for controlling of EMRG is small, as it operates only on +5 V dc supply. Transmitted DC pulses encoded using HT12D encoder circuit. Pulses received at receiver end decoded using decoder pair & transferred to MCU unit. According to command set from transmitter MCU unit provides pulses to EMRG unit. Relay acts as isolators in between EMRG unit & MCU. Wireless RF module unit has isolation in between controlling transmitter & operational receiver.

1.1 Principle of operation:-

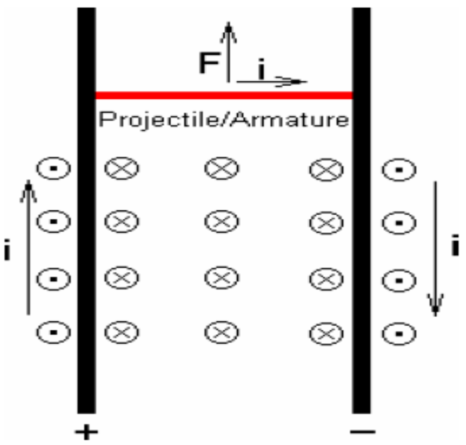

Fig. 1 Basic principle of EMRG

Due to the Faradays law of electromagnetic induction, magnetism produced in electric bars or rail. This magnetism results in a force.

$$F = NBIL \qquad [1]$$

The application can be understood with the help of Biot-Savart law &, Laplace or Lorentz force equation.

$$B = \frac{\mu I}{2\pi d} ln \frac{d-r}{r} \qquad [2]$$

$$\vec{F} = i\vec{W}\ X\ \vec{B} \qquad [3]$$

$$\vec{F} = q[\vec{E} + (\ \vec{v}\ X\ \vec{B}) \qquad [4]$$

Here F is the force on projectile; B is magnetic field density with u as permittivity of magnetic material.

1.2 Launch of projectile:-

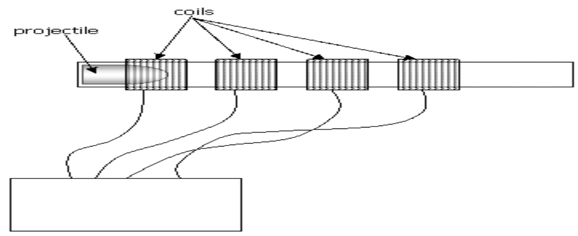

Fig. 2 Launch of projectile with EMRG

In many of the large scale experiments projectile tried to launch in space in vertical direction. As our projectile size is considerably small, we tried to launch the projectile in linear or horizontal direction. Launching task is the operation of driving current through electric bars. It is essential to use heavy power supply. Some laboratory experiments achieved high speed launching due to large energy supplying power supplies. Ian R. McNab archived muzzle velocity of 2-3 km/s for more than 8MJ energies. Theoretically it can be extended up to 7.5 Km/s for 10GJ of energy for space vehicle launching. Due to increase in theoretical muzzle velocity and range, rail gun has advantageous over chemical propellant based methods. [3]

2. Design Considerations:-

It is found that for the production of uniform magnetic field, solid wires should be preferred. Air filled within the rails makes magnetic field non-uniform. Projectile accelerates more in certain direction due to concentrated uniform magnetic field. [4]

Rail gun has structure of two conducting rails fitted with armature which completed the circuit. Current carrying capacity of the rail bars chosen should be high. It is because current in bars results in force acting on projectile in the field. In order to develop dense magnetic field in armature high permeability magnetic material should be selected. Rail should not make contact with armature but keep them at short distance. Armature should be solid. [3, 6]

In order to design power supply for EMRG, it should provide high current. For actuation of coils, the current pulses are generated on which actuator relays operated. It is not possible to design power supply which will provide high current. Hence capacitor banks are designed. Capacitors store large amount of energy in the form of electric field & discharges in form of current which is high in accordance with value of capacitors used.

Projectile must fit tightly into the barrel. Material selection for projectile & barrel depends on the strength & life of the EMRG. Assembly should be assembled tightly to reduce mechanical & high current magnetizing & hysteresis losses. [6]

2.1 Proposed Demonstration design:-

Proposed demonstration system based on the prototype design of electromagnetic rail gun for launch of point mass projectile. For producing strong electromagnetism instead of capacitor banks, 18 V battery power supply selected. For avoiding sudden discharge of battery, three series connected 6V / 4.5 AH lead acid rechargeable batteries connected in series.

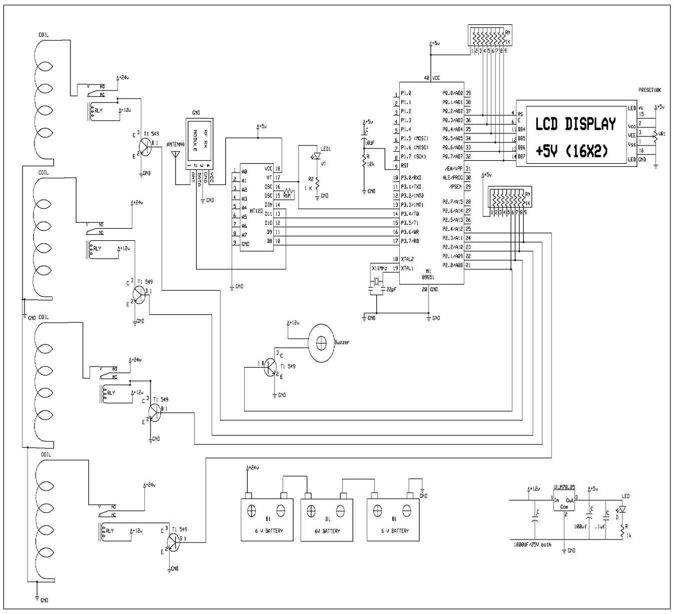

Fig. 3 Circuit diagram of Tx unit in EMRG

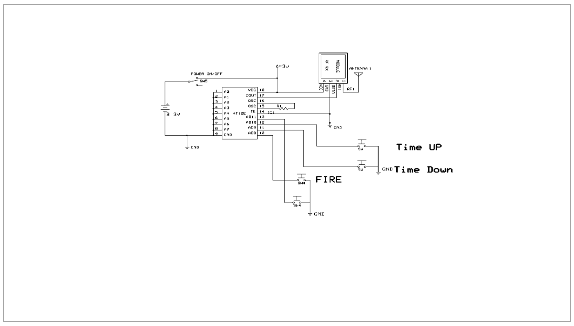

Fig. 4 Circuit diagram of Rx unit in EMRG

Control mechanism of the rail gun operated from AT89S52 microcontroller. Benefit of using such basic microcontroller is its available software & firmware support. It is programmed by using Keil uvision4 IDE & Proload downloader.

Four copper coils of having 250 number turns on each coil wounded PVC bore material. For better operation we use a 16 SWG wire for making the coils. It has current carrying capacity of 18 A & only 1 Ω resistance. Projectile used for launching is of capsule size & of iron material. It is of 50 gram small weight, 0.5 projectile diameters. Efficient distance travelled by this consideration with muzzle velocity is 60 feet. Launch of projectile done through 50 cm length PVC tube.

Fig.5 Designed coli unit for demonstration

Electromagnetic types of relays are used as contactors & driving mechanism. These relays also provide isolation between electromagnetic functioning rail gun unit & control unit.
As effective distance covered by this demonstration is small, a wireless module operating on 433 MHz used for operation. This is interfaced with MCU unit with HT12D decoder unit at receiver side. Same Encoder & Transmitter module interfaced with switches to perform firing & timing up-down operation.

Design cost of such system is larger but it is effective option for operation with RF module interface. Such system can be used in automation without human presence.

3. CONCLUSIONS

Electromagnetism has large influence on rail gun mechanism. Designed prototype model works well for point launch of object up to 60 feet distance only. Increase of distance & muzzle velocity is possible with considerable changes in conductivity of coil material. Low Powered EMRG can be controlled & operated by using MCU unit & wireless devices. In future electromagnetic systems can be efficiently interfaced with WSN networks & launching from any space module is possible.

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REFERENCES

[1] M. R. Palmer and A. E. Dabiri, "Electromagnetic space launch: A re-evaluation in light of current technology and launch needs and feasibility of a near-term demonstration," *IEEE Trans. Magn.*, vol. 25, pp. 393–399, Jan. 1989.
[2] B. Turman, "Long range naval coilgun technology," Presentation to NSWL, Dahlgren, VA, Feb. 21, 2001.
[3] I. R. McNab and G. A. Kemeny, "Electromagnetic projectile launcher with combination plasma /conductor armature," U.S. Patent 4 467 696, Aug. 28, 1984.
[4] W. A. Jacobs, "Magnetic launch Assist-NASA's Vision for the Future" *IEEE Trans. Magn.*, Vol. 37, pp. 55-57, Jan. 2001.

[5] Salami, S.O, Green O.O, Philips D.A "Design and Simulation of a Rail Gun using Microcontroller" IJRITT Volume: 01 Issue: 07 November – 2015
6] Scott Harmon "A Look into Railgun Physics and Design" Senior Honors Thesis April 2011
7] Uma Mukherji "Electromagnetic field theory & wave propagation" Narosa Publication, 2006

BIOGRAPHIES

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