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Study Of Magnetic Levitation Technology

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ABSTRACT

The Aim of this paper is to investigate magnetic levitation and to design a working system capable of levitating an object from below. The system should be able to levitate an object from below, clear of an array of electromagnets without any form of support. There shouldn't be any object, structure or device assisting in levitation, on the same level of elevation as the levitating object. The control and circuit complexities should be investigated and recommendations for improving the designed system should be made.

Keywords: PID, NIB, EDS

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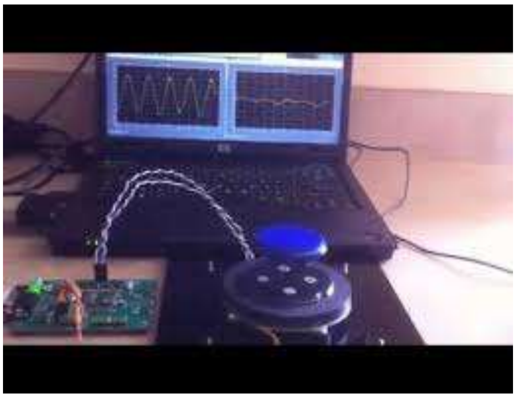
I. INTRODUCTION

Magnetic Levitation is the process of levitating an object by exploiting magnetic fields. In other words, it is overcoming the gravitational force on an object by applying a counteracting magnetic field. Either the magnetic force of repulsion or attraction can be used. In the case of magnetic attraction, the experiment is known as magnetic suspension. Using magnetic repulsion, it becomes magnetic levitation. To achieve the best result, we choose a hybrid of electromagnets and permanent neodymium magnets to provide supporting force and use PID feedback loop to control the system so we can reduce the power consumption of the system.

Nowadays, traffics in many cities around the globe becoming issues and problems that need to be resolved. As the number of population increases rapidly, private vehicles and air services are no longer able to serve as mass rapid transport anymore [1]. The number of vehicles on the road, not only contributes worsen the traffic jammed but also produces polluted environment. Therefore, the availability of transportation system to serve the public movement which is more efficient, safe, efficient and eco-friendly vehicles are imperative these days. Obviously, the new generation of this vehicle must suited to mass transportation and magnetic levitation (maglev) train is one of the best option for such transportation system [1][2]. With the development of industrial technology, many researchers have focused their work to further improve maglev technology. Maglev train uses magnetic force to levitate vehicle a short distance away from a guide as well as to propel the vehicle [3]. In comparison, conventional train uses friction between wheel and train to drive the train forward. Therefore, maglev trains tend to move more quietly as well as more smoothly that the wheeled ones. In addition, these trains can reach very high speed since there is no friction between train and the guide. Magnetic forces can be generated by using several methods such as electromagnetic and superconducting. In her research, utilized a permanent magnet and an electromagnetic field to generate levitation forces. The result of this research was then used by others as a basis for developing a stable magnetic levitation forces.

II. WORKING PRINCIPLE OF MAGNETIC LEVITTION

Magnetic fields are the result of electric current and are specified by direction and magnitude. These fields can be produced by electric charge currents moving through wires and from objects made of magnetized ferromagnetic materials. Magnetic fields produced by electrons are dependent on the particle's charge, velocity, and acceleration. When point charges move through a cylindrical wire, magnetic field lines are formed concentrically around the length of the wire. These concentric circles are strongest close to the wire and decrease in strength as the distance from the wire increases. The direction of the field around the wire is determined by the “right hand rule,” where the right hand is held above the wire with the thumb pointing in the direction of the current. The direction of the fingers wrapping around the wire describes the direction of the magnetic field produced. Due to this two magnetic field that is of permanent magnet and electromagnet object will levitate.



COMPONENTS

A. PID controller

A proportional integral derivative controller (PID controller) is a generic control loop feedback mechanism widely used in industrial control systems. Generally speaking, a PID controller calculates the "error" value as the difference between a measured process variable and a desired value. The controller attempts to minimize the error by adjusting the control inputs. In the absence of an explicit function between the inputs and the outputs, PID controllers are the best controllers.The PID controller calculation involves three separate parameters: the proportional, the integral and derivative values, denoted P, I, and D. The proportional value determines the reaction to the current error, the integral value determines the reaction based on the sum of recent errors, and the derivative value determines the reaction based on the rate at which the error has been changing.

By tuning the three constants in the PID controller, the controller can provide control action designed for specific process requirements. The response of the controller can be described in terms of the responsiveness of the controller to an error, the degree to which the controller overshoots the set point and the degree of system oscillation.

B. Electromagnets

The electromagnets are steel bolts with thin copper wire wound around them. Two circular pieces of wooden hardboard are bolted to each end. The coil itself is wrapped in masking tape .The coil has a dc resistance of 22 ohms.

C. Ratiometric Linear Hall Effect Sensors

The Hall Effect Sensors are linear output devices which sense the strength and polarity of nearby magnetic fields. Their part no. is UGN3503u. The sensor itself comes in a small three pin IC package. Its supply voltage is 4.5V - 6V and the supply current required is 53mm 78mm 24mm Coil Hardboard collars Steel Bolt approximately 9mA – 14mA. It outputs a quiescent voltage of 2.4V – 3V depending on the supply voltage. The sensor sensitivity is dependent on the supply voltage, but it is generally in the range of 1.4mV/G.

D. LME675 High Output Current Operational Amplifier

LME675 is used to drive the electromagnets since we need to put a maximum of 1.2 amps through it at a voltage of 22 volts. However, this op-amp requires a open-loop gain of at least 10 to stabilize. So we make our control voltage between 0V and 2.2V.

III. OPERATION OF MAGNETIC LEVITATION TECHNOLOGY

Keeping one end of the test magnet steady, the other end was brought into proximity of the Hall Effect sensor which was attached to the electromagnet.

The Hall Effect sensor is placed on the centre axis of the electromagnet. It is noted that the circuit is sensitive to the orientation of the electromagnet, i.e. which way round it is connected. If the electromagnet is connected the wrong way, then an approaching south pole for example, will cause the circuit to produce a north pole from the electromagnet. This would be contrary to the intended operation of the circuit and it would enter an unwanted mode.

If the electromagnet pairs were too far from each other,the bar magnet would easily fall in between. If they were too close, then as lightly weaker part of the magnetic field of the bar magnet would be exposed to the Hall Effect Sensors. The result is that the electromagnets do not get enough current, and the bar magnet will drop. The system is less sensitive to the distance between electromagnets in a group repelling the same magnetic pole. If the Hall Effect Sensors were properly positioned on the surface of the electromagnet, then levitation of one of the magnetic poles of the bar magnet could still be achieved.

Repulsive and attractive force between these magnetic fields i.n some configurations, the train can be levitated only by repulsive force. In the early stages of maglev development at the Miyazaki test track, a purely repulsive system was used instead of the later repulsive and attractive EDS system. The magnetic field is produced either by superconducting magnets (as in JR–Maglev) or by an array of permanent magnets .

The repulsive and attractive force in the track is created by an in wires or other conducting strips in the track. A major advantage of EDS maglev systems is that they are dynamically stable – changes in distance between the track and the magnets creates strong forces to return the system to its original position . In addition, the attractive force varies in the opposite manner, providing the same adjustment effects. No active feedback control is needed

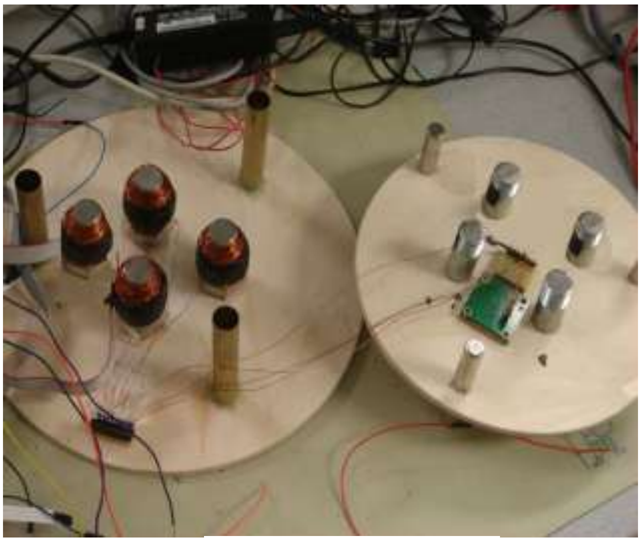


Fig. Neodymium Electromagnet

IV. APPLICATION

The Maglev Train analysis focuses on three system aspects: cost, speed, and reliability. These performance metrics were chosen because they are the basic characteristics of a train system. Speed is the most common standard used to compare transportation systems and is directly related to the time needed to travel. For the Maglev, speed is an extremely appealing attribute since it can travel over a hundred miles per hour faster than the current high speed rail in the Northeast Corridor. The measure for speed is in miles per hour. Lastly, reliability is the most crucial parameter because knowledge of a transportation system's safety is the determining factor whether or not the system is viable. Passenger safety requires transportation reliability, which is paramount to all other system aspects.

A)EDS Electro Dynamic Suspension
In Electro dynamic suspension (EDS), both the guideway and the train exert a magnetic field, and the train is levitated by the repulsive and attractive force between these magnetic fields. In some configurations, the train can be levitated only by repulsive force. In the early stages of maglev development at the Miyazaki test track, a purely repulsive system was used instead of the later repulsive and attractive EDS system. The magnetic field is produced either by superconducting magnet by an array of permanent magnet.

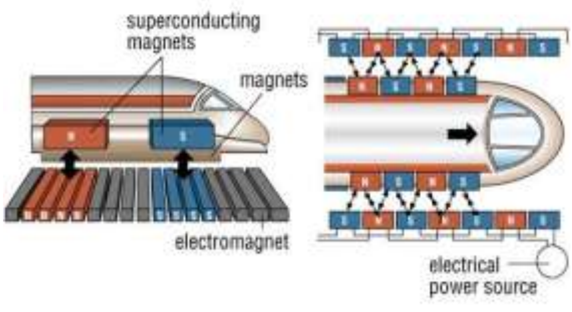


Fig Electromagnetic repulsive levitation

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V. ADVANTAGE

1) The foremost advantage of maglev trains is the fact that it doesn't have moving parts as conventional trains do, and therefore, the wear and tear of parts is minimal, and that reduces the maintenance cost by a significant extent.

2) More importantly, there is no physical contact between the train and track, so there is no rolling resistance. While electromagnetic drag and air friction do exist, that doesn't hinder their ability to clock a speed in excess of 200 mph.

3) Absence of wheels also comes as a boon, as you don't have to deal with deafening noise that is likely to come with them.

4) Maglevs also boast of being environment friendly, as they don't resort to internal combustion engines.

VI. DISADVANTAGES

1)Impact Although the tracks could be elevated, there would still be the addition of guideways crossing great amounts of land.

2)Energy Consumption Larger train cars are tougher to levitate and require quite a bit more energy, making them less efficient.
3)Safety While the MagLev can be safer overall, any infrequent accidents that do occur are likely to be more catastrophic due to the elevated guideways and incredible speeds

VII. CONCLUSION

India has the most complex, widespread rail network which is now bogged down by congestion. Maglev provides the flexibility to equip existing steel tracks with magnetic levitation (based on EDS) and propulsion system. This will help in operating both maglev and conventional trains on same track. The possible incorporation of both steel track and maglev guideway is hinted in figure. By this we can replace the conventional trains with maglev trains in phased manner.

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