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# Magnetic Levitation Train Controlled Using IOT

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***Abstract:*** **-- Magnetic Levitation is a technology that has been experimented with intensely over the past couple decades. It wasn't until the last ten years when scientists began to develop systems that would use magnetic levitation as a means of transport. This paper outlines the methods behind magnetic levitation, as well as the technologies implemented using the levitation. The implementation of a large-scale transportation system using magnetic levitation has huge social as well as economical effects.**
**Magnetic levitation, maglev or magnetic suspension is a method by which an object is suspended with no support other than magnetic fields. The electromagnetic force is used to counteract the effects of gravitational and any other acceleration. The physics behind it is to simply provide a magnetic force which must be equal and opposite of the gravitational force on the object. The two forces cancel and the object remains suspended. The two primary issues involved in magnetic levitation are lifting forces and stability. In this model, polarities are varied using arduino, which is interfaced with IOT. Magnetic levitation is used for maglev trains, contactless melting, and magnetic bearings and for product display purposes.**

***Keywords*****:-- levitation, magnetic bearings, maglev trains, contactless melting.**

## I. INTRODUCTION

Magnetism has been a part of the earth since the beginning. It is due to the magnetism of the earth that the world spins and thus creates things like gravity. The magnetism is created by the processes within the core of the earth. The earth's iron-ore core has a natural spinning motion to it inside which creates a natural magnetic force that is held constant over the earth. This creates magnetic forces that turn the earth into a large bar magnet. The creation of North and South poles on the earth are due to this field. Maglev systems are becoming a popular application around the globe. Magnetic levitation related to faraday's law and Lenz's law. Its working principle is that when a current flow through the coil then induces a magnetic field.

Maglev trains are popular in transportation stations in big countries like Germany, China, Japan and the United States of America due to the demand for high-speed transportation, as the general public transportation services become more congested with increase of population. Maglev trains are magnetically levitated trains that traverse in a very high speed, with only electricity being its main source of energy. The train propels forward without any friction from moving mechanical parts. It has many advantages with minor drawbacks. Maglev has been a long standing dream of railway engineers for the past century. These engineers envisioned a train that could float above its tracks. They saw the enormous potential for a train like this. The vision of Maglev began in the beginning of the 20th century with two scientists. In 1904, Robert Goddard, who was a college freshman at the time, wrote a paper proposing a form of frictionless travel by raising train cars off the rail by using electromagnetic repulsion roadbeds. He said the train would travel at super-fast speeds. In 1910, Emile Bachelet applied for a patent on a rail car which for levitation would use alternating current electromagnets and for propulsion would use solenoids at intervals along a roadbed. Bachelet's dreams couldn't be realized because this concept uses too much power for conventional magnets. In the early 1920s, a German scientist named Hermann Kemper pioneered in work in attractive-mode Maglev. He received a patent for magnetically levitating trains. Kemper continued to research and pursue his concept through the 1930s and 1940s and established the basic design for practical, attractive mode Maglev in a 1953 article. In 1969 two Americans Gordon Danby and James Powell, were granted a patent on their design of a magnetically levitated train. This was the first patent for a design of this kind of train. This was around the same time that Germany and Japan were both getting very interested in Maglev technology. In 1970, both countries start investing money into researching maglev. In that same year the United State Federal Railroad Administration studied high-speed ground transportation. The creation of magnetic forces is the basis of all magnetic levitation. The creation of a magnetic field can be caused by a number of things. The first thing that it can be caused by is a permanent magnet. These magnets are a solid material in which there is an induced North and South pole. These will be described further a little later. The second way that an magnetic field can be created is through an electric field changing linearly with time. The third and final way to create a magnetic field is through the use of direct current.

There are two basic principles in dealing with the concept of magnetic levitation. The first law that is applied was created by Michael Faraday. This is commonly known as Faraday's Law. This law states that if there is a change in the magnetic field on a coil of wire, there is seen a change in voltage. The direction of the forces created by Faraday's Law was discovered by a man named Heinrich Lenz. His theory states that "the emf induced in an electric circuit always acts in such a direction that the current it drives around the circuit opposes the change in the magnetic flux which produces the emf." In other words, this is stating that if there was a current that was created in a coil of wires, then the magnetic field that is being produced will be perpendicular the current direction.

The basis of maglev trains mechanisms are magnetic levitation. This is achieved with the principal of repulsion and attraction between two magnetic poles. When two magnets have the same poles, it will repel with each other and when it has different poles, the result would be otherwise. Maglev can create frictionless, efficient, far-out-sounding technologies. Maglev systems offer a number of advantages over conventional trains that use steel wheels on steel rails. The motion of the maglev train is based on the magnetism and magnetic fields. This magnetic field is produced by using high powered electromagnets. By using magnetic fields, the maglev train can be levitated above its track. Wheels and moving parts are eliminated on the maglev train, allowing it to move on air without friction. A method of supporting and transporting objects or vehicles which is based on the physical property that the force between two magnetized bodies is inversely proportional to their distance. By using this magnetic force to counterbalance the gravitational pull, a stable and contactless suspension between a magnet (magnetic body) and a fixed guide way (magnetized body) may be obtained. In magnetic levitation (Maglev), also known as magnetic suspension, this basic principle is used to suspend (or levitate) vehicles. Magnetic levitation means "to rise and float in air". The Maglev systems made possible by the use of electromagnets and magnetic fields. The basic principle behind maglev that if two magnets are placed together in a certain way there will be a strong Magnetic attraction and the two magnets will clamp together. This is called "attraction". If one of those magnets is flipped over then there will be a strong magnetic repulsion and the magnets will push each other apart. This is called "repulsion".

The study of magnetic levitation is provided as follows:
Section 2 states the Types of magnetic levitation
Section 3 states the Simple Electromagnetic Train
Section 4 deals with Magnetic Levitation
Section 5 comprised of Magnetic Levitation Train By Changing Polarities of Electromagnet.

## II TYPES OF MAGNETIC LEVITATION

Although the concepts of magnetic levitation are all the same, the way that those concepts are brought about can vary. These options are controlled and changed depending on the type of application that is necessary.

***Permanent Magnets:***

The first type of levitation is the implementation through permanent magnets. These magnets are made of a material that creates a north and a south pole on them. This can be seen in Figure

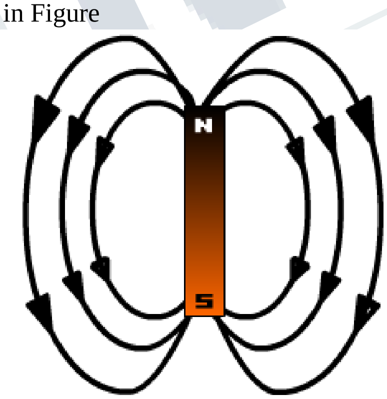


***Fig 1: Permanent Magnet Fields***

The formal definition of a permanent magnet is "a material that retains its magnetic properties after and external magnetic field is removed." The whole idea behind permanent magnets is that like ends will repel and opposite ends will attract. Permanent magnets require very little if any maintenance. These magnets do not require cryogens or a large power supply for operation. The magnetic field is measured vertically within the bore of the magnet. The main disadvantages of a permanent magnet are the cost of the magnet itself when put into large scale systems. Another disadvantage is the varying changes in the magnetic field. The ability to control a constant magnetic force from a

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permanent magnet is an on-going problem in the application of these types of magnets. Different applications that use these types of magnets can be found in a number of different areas. Examples of these applications are compasses, DC motor drives, clocks, hearing aids, microphones, speedometers, and many more.

***Electromagnetic Magnets***:

The basic idea behind an electromagnet is extremely simple. By running electric current through a wire, you can create a magnetic field. When this wire is coiled around a magnetic material (i.e. metal), a current is passed through this wire. In doing this, the electric current will magnetize the metallic core.
This can be seen in Figure.

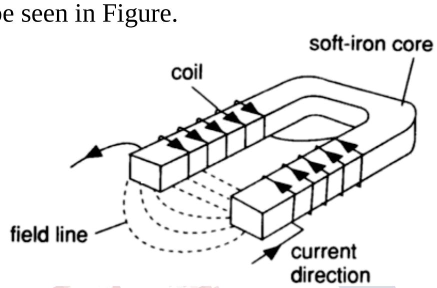


***Fig 2: Electromagnet***

By using this simple principle, you can create all sorts of things including motors, solenoids, heads for hard disks, speakers, and so on. An electromagnet is one that uses the same type of principles as the permanent magnet but only on a temporary scale. This means that only when the current is flowing is there going to be an induced magnet. This type of magnet is an improvement to the permanent magnet because it allows somebody to select when and for how long the magnetic field lasts. It also gives a person control over how strong the magnet will be depending on the amount of current that is passed through the wire.

***Superconductive Magnets:***

The ideas presented behind superconductive magnets are the same principles that are at work in an MRI. Superconductive magnets are the most common of all the magnets, and are sometimes called cryomagnets. The idea behind the superconducting magnets is that there is a material which presents no electrical resistivity to electrical current. Once a current has been fed into the coils of this material, it will indefinitely flow without requiring the input of any additional current. The way that a material is able to have such a low resistivity to current is that it is brought to very low temperatures. The temperatures that are commonly found in superconducting magnets are around -258oC. This is done by immersing the coils that are holding the current into liquid Helium; this also helps in maintaining a homogenous magnetic field over time. The advantage to the superconducting magnet is that they don't require constant power from a source to keep up the value of the current in the coils. Although a disadvantage is that they require an expensive cryogen such as helium to operate correctly. The magnetic field is in the direction of the long axis of the cylinder or bore of the magnet. Since the resistance in the coils can cause the current to decay, cryogens reduce the resistance to almost zero, which will help maintain a homogenous magnetic field over time.

## III SIMPLE ELECTROMAGNETIC TRAIN

Electricity and magnetism are linked in a way that scientists do not completely understand. Each can create the other. If a copper wire is wrapped into coils and run an electrical current through it, a magnetic field will be created. If a permanent magnet is rotated inside a coil of copper wire, an electrical current will be created.

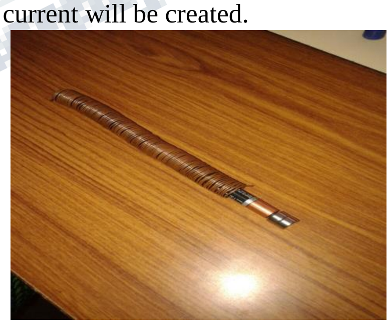

***Fig 3: electromagnetic train setup***

In this model, the neodymium magnets are placed on the ends of the battery create a bar magnet with a north pole and a south pole. When this train is placed inside the coils, it causes an electrical current to flow through the copper wire, which creates a magnetic field in the section of wire coils right around the train car. If current is passed through a coil, it generates a magnetic field inside the coil like the figure given below.

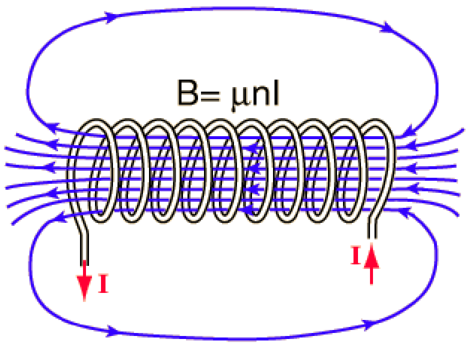


*Fig 4: field inside the coil*

The trick in this model is that the magnets are made of a conducting material and they connect the battery terminals to the copper wire, so the battery, magnets and copper wire make a circuit that generates a magnet field just in the vicinity of the battery.

The geometry means the two magnets are automatically at the ends of the generated magnetic field, where the field is divergent, so a force is exerted on the magnets. The magnets have been carefully aligned so the force on both magnets points in the same direction, and the result is that the magnets and battery move. But as they move, the magnetic field moves with them and you get a constant motion.

If two magnets are flipped round at the ends of the battery, then the battery and magnets would move in the reverse direction. If only one magnet is flipped the two magnets would then be pulling/pushing in opposite directions and the battery wouldn't move. In this model, the battery experiences two forces which are pull force and push force which is shown in the figure.

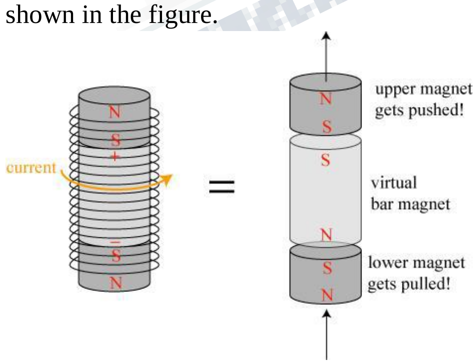


*Fig 5: battery and magnet setup*

Due to these forces, the battery tends to move. Thus this is about simple electromagnetic train and its working.

## IV MAGNETIC LEVITATION

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. In the past, magnetic levitation was attempted by using permanent magnets. Attempts were made to find the correct arrangement of permanent magnets to levitate another smaller magnet, or to suspend a magnet or some other object made of a ferrous material.

This is a simple magnetic levitation circuit which suspends objects a set distance below an electromagnet. The physics behind it is to simply provide a magnetic force which equal and opposite of the gravitational force on the object. The two forces cancel and the object remains suspended. Practically this is done by a circuit which reduces electromagnet force when an object gets to close, and increases it when the object is out of range. The infrared magnetic levitator circuit is shown below.

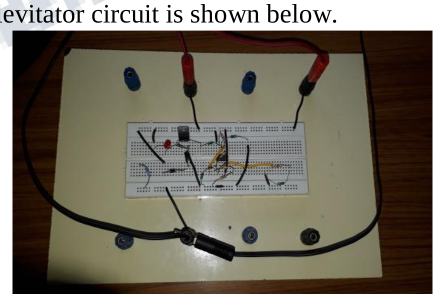

*Fig 6: Magnetic levitator circuit*

This circuit works by comparing the signals from the sensors with the first op-amp and sending out a voltage proportional to the difference or "error". The error signal is then sent through a compensation network which acts a high-pass filter, allowing quick changes in error to pass easier than slow changes. This is required to stabilize the control loop, and without it objects would just flutter close to the electromagnet due to the system being unstable. The signal is then amplified to its original amplitude, since the

 

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compensation network attenuated it, and finally drives the TIP122 Darlington transistor, which controls the electromagnet current. The extra diodes around the transistor are to prevent damage to the transistor. The signal diode on the base prevents reverse biasing the base, which is damaging, while the two 1N4001's give a path for the magnetizing current to flow when the electromagnet turns off. The optical components used aren't too critical, as long as their wavelengths match up ok, and the detection/emission angles aren't too narrow. The IR LEDs are TIL38, which are 940nm peak, have 15 degree spread, 35mW and 100mA max. The detectors are PT204-6B, which are IR phototransistors. The setup is as follows.

***Fig 7: magnetic levitator setup***

The top detector is a reference detector and the bottom one senses when an object is in levitating position. The object detector must be level with the IR LED. The reference detector must see the IR diode at all times, even when levitating an object. The electromagnet should have maximum 15 ohms of resistance, any more and it will not be able to lift anything. Too little resistance and the transistor will have problems regulating electromagnet current and will also dissipate more heat. When constructing an electromagnet there are two things to remember. Magnetic force is proportional to the number of turns and current. So when using copper wire the magnetic force is roughly proportional to the square of the power dissipated in it, for all practical use. In this model 70 meters of 0.45mm magnet wire is used as coil. The coil can be wound on almost any ferrous metal rod if you're not concerned with efficiency. Remember that keeping the surface area of the face small will keep the object centered better. Constructing the circuit correctly is easiest if built in two parts; part 1 with the detectors and first op-amp to make sure the output swings when an object is put in the beam, and then part 2 with the rest. This way it will be much easier to troubleshoot. Thus, this is about simple magnetic levitation and its working.

## V MAGNETIC LEVITATION TRAIN BY CHANGING POLARITIES OF ELCTROMAGNET

This concept has already found commercial application in maglev trains. Maglev is an acronym for magnetic levitation, and is most commonly used when referring to trains. Maglev is desirable in such an application because of the low maintenance for the track networks, and the low friction track that it provides. Because many trains gain their energy from sources not on the actual train, the energy requirements of the system become less stringent. Therefore, even though, it takes a considerable amount of energy to levitate the train, the energy can be feasibly obtained and transferred to the train.

While permanent magnets produce a good and sometimes very strong static magnetic field, in some applications the strength of this magnetic field is still too weak or we need to be able to control the amount of magnetic flux that is present. So in order to produce a much stronger and more controllable magnetic field we need to use electricity. By using coils of wire wrapped or wound around a soft magnetic material such as an iron core we can produce very strong electromagnets for use in many different types of electrical applications. This use of coils of wire produces a relationship between electricity and magnetism that gives us another form of magnetism called Electromagnetism.

Electromagnetism is produced when an electrical current flows through a simple conductor such as a length of wire or cable, and as current passes along the whole of the conductor then a magnetic field is created along the whole of the conductor. The small magnetic field created around the conductor has a definite direction with both the “North” and “South” poles produced being determined by the direction of the electrical current flowing through the conductor.

Therefore, it is necessary to establish a relationship between current flowing through the conductor and the resultant magnetic field produced around it by this flow of current allowing us to define the relationship that exists

 

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between Electricity and Magnetism in the form of Electromagnetism.

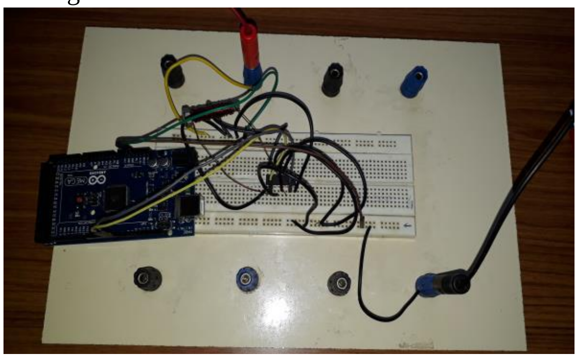

*Fig 8: arduino connection with electromagnet*

The main aim of this project is to levitate a train using a permanent magnet as a track and electromagnets to a train. The principle is same as magnetic levitation like poles repel and unlike poles attract when these like poles repel due to that repulsion the object will be levitated. In this model we are linking the electromagnet to an Arduino. When we link the electromagnet direct to Arduino due to switching on and off there may be a back emf which causes damage to the Arduino. In order to overcome that, a h bridge relay is used which helps not only for the electromagnet in order to get rid of damage but also in changing the polarity of an electromagnet. L293DNE which is a 16 pin h bridge, to which 3 and 6 are connected to a electromagnet and 1,8,16 are given to the supply and 4, 5, 12, 13 pins are grounded. 2, 7 pins are connected to the Arduino. After connecting to it programming the Arduino such that if both the pins are high then is comes on. If one is high and the other is low, then also it is on. After swapping this may reverse the polarities of electromagnet. When we place an electromagnet on the track it should automatically change the polarities according to the poles and should levitate. Due to stronger repulsive force, the train will move forward. Maglev trains are modern trains that leverage electromagnets. These trains are faster, quieter, smoother, and more efficient than their wheeled counter parts.

In this model, main purpose of arduino is to vary the polarities. This arduino is interfaced with IOT, so we can have the ability to vary the polarities by processing its IP address from banywhere. So IOT is greatly used to enjoy the advantage of magnetic trains from any place. Maglev usages from view point of engineering science can be categorized and summarized as follows:  transportation engineering (magnetically levitated trains, flying cars, or personal rapid transit (PRT), etc.),  environmental engineering (small and huge wind turbines: at home, office, industry, etc.),  aerospace engineering (spacecraft, rocket, etc.),  military weapons engineering (rocket, gun, etc.),  nuclear engineering (the centrifuge of nuclear reactor),  civil engineering including building facilities and air conditioning systems (magnetic bearing, elevator, lift, fan, compressor, chiller, pump, gas pump, geothermal heat pumps, etc.),  biomedical engineering (heart pump, etc.),  chemical engineering (analyzing foods and beverages, etc.),  electrical engineering (magnet, etc.),  architectural engineering and interior design engineering including household and administrative appliances (lamp, chair, sofa, bed, washing machine, room, toys (train, levitating spacemen over the space ship, etc.),  automotive engineering (car, etc.)  advertising engineering (levitating everything considered inside or above various frames can be selected).

## VI. CONCLUSION:

Maglev trains are more environmentally friendly than other types of trains. In terms of energy consumption maglev trains are slightly better off than conventional trains. As there is no wheel friction with the ground, the resistive force gradually increases in the air friction. Thus the energy efficiency difference between a MAGLEV train and a conventional train is of very small margin. Non-contacting characteristic is the main feature of Maglev, Which is concentrated on high-speed operation and environmental acceptability. There are certain areas, which require further attention such as braking at high-speeds in case of power failure. Overall, the sustainability of Maglev is very positive. Although the relative costs of constructing Maglev trains are still expensive, there are many other positive factors that overshadow this. Maglev will contribute more to our society and our planet than it takes away. Considering everything Maglev has to offer, the transportation of our future and our children's future is on very capable tracks. They have proven to be faster than traditional railway systems that use metal wheels, rails and are slowed by friction.

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