Design and Construction of Electromagnetic Braking System

A report submitted to the Department of Mechanical, Sonargaon University of Bangladesh in partial fulfillment of the requirements for the Award of Degree of Bachelor of Science in Mechanical Engineering

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15 January, 2025

Letter of Transmittal

To

The Supervisor

Department of Mechanical Engineering.

Sonargaon University of Bangladesh

Subject: Submission of Project Report.

Dear Sir,

We are pleased to submit the project report on "**Electromagnetic Braking System ".** It was a great pleasure to work on such an important topic. This project has been done as per instruction of your supervision and according to the requirements of the Sonargaon University.

We expect that the project will be accepted by the concerned authority we will remain happy to further explanation that you may feel necessary in this regard.

Thank You

Sincerely yours,

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DECLARATION

We do hereby solemnly declare that, the work presented here in this project report has been carried out by us and has not been previously submitted to any University/ Organization for award of any degree or certificate

We hereby ensure that the works that has been prevented here does not breach any existing copyright.

We further undertake to indemnify the university against any loss or damage arising from breach of the foregoing obligation.

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ACKNOWLEDGEMENT

First, we started in the name of almighty Allah. This thesis is accomplished under the supervision of **Nahiyan Chowdhury**, Lecturer, Department of Mechanical, Sonargaon University. It is a great pleasure to acknowledge our profound gratitude and respect to our supervisor for this consistent guidance, encouragement, helpful suggestion, constructive criticism and endless patience through the progress of this work. The successful completion of this thesis would not have been possible without his persistent motivation and continuous guidance.

The author are also grateful to **Md. Mostafa Hossain**, Head of the Department of Mechanical Engineering and all respect teachers of the Mechanical Engineering Department for their co-operation and significant help for completing the thesis work successfully.

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ABSTRACT

In this paper we have develop the electromagnetic braking system. Braking System should ensure the safety and comfort of the passenger, driver and other road user. The brake must be strong enough to stop the vehicle during emergency within shortest distance. The conventional braking system are bulky and power to weight ratio is low. Electromagnetic braking system is high-tech braking system find its use in small & heavy vehicle like car, jeep, truck, busses etc. This paper represent about minimizing the brake failure in order to avoid the accident. It also reduces the maintenance of braking system. The effectiveness of brake should remain constant. The proper cooling of brake gives anti fade character and efficient operation of brake. Proper lubrication and maintenance must be done to operate brake safe, effective and progressive with minimum fatigue to driver. This system provides better response time for emergency situations and in general keeps the friction brake working longer and safer.

Table of Contents

Letter of Transmittal ..... **Error! Bookmark not defined.**

Student's Declaration ..... **Error! Bookmark not defined.** i

Supervisor's Certification iii

Abstract ..... **Error! Bookmark not defined.**

Acknowledgments ..... **Error! Bookmark not defined.**

List of Figures viii

Chapter 1. Introduction 1

1.1 Introduction 1

1.2 History 1

1.3 Types of Braking System 2

1.3.1 Electromagnetic Brake System 2

1.3.2 Frictional Brake System 3

1.3.3 Hydrolic Break System 3

1.4 Significance and Scope 3

1.5 Electromagnet 4

1.6 Electromagnetism 4

1.7 Magnetic Effect of Current 4

1.8 Objective 4

Chapter 2. Literature Review 5

2.2 Literature Survey 5

2.3 Summary 6

Chapter 3. Research Methodology 7
3.1 Methodology 7
3.2 Block Diagram 7
3.3 Circuit Diagram 8
3.4 Working Principle 8
3.5 Project Hardware Image 9
3.6 Required Instrument and Software 9
3.7 Battery 10
3.8 Voltage Regulator 11
3.9 Relay 12
3.10 Motor 15
3.11 Wheel 16
3.12 Push Button 17
3.13 Electromagnetic Brake 17
3.14 Proteus Software 19

Chapter 4. Result and Discussion 20
4.1 Result 20
4.2 Advantages 20
4.3 Limitations 21
4.4 Application 21
4.5 Hydraulic Brake vs Electromagnetic Brake 22
4.6 Discussion 22

Chapter 5. Conclusion 23
5.1 Conclusion 23
5.2 Future Scope of Study 23

References 24

List of Figures

Figure 3.1 Block Diagram..... 7

Figure 3.2 Circuit Diagram of Our System 8

Figure 3.3 Project Hardware Image..... 9

Figure 3.4 12V Battery 10

Figure 3.5 5V Regulator IC 11

Figure 3.6 Relay..... 12

Figure 3.7 Relay Module. 13

Figure 3.8 Mains voltage connections. 13

Figure 3.9 Relay voltage connections..... 14

Figure 3.10 DC Motor..... 15

Figure 3.11 Wheel..... 16

Figure 3.12 Push Switch 17

Figure 3.13 Electromagnetic Break 18

Figure 3.14 Proteus Software Interface 19

Chapter 1. Introduction

1.1 Introduction

Electromagnetic brakes (also called electro-mechanical brakes or EM brakes) slow or stop motion using electromagnetic force to apply mechanical resistance (friction). The original name was "electro-mechanical brakes" but over the years the name changed to "electromagnetic brakes", referring to their actuation method. Since becoming popular in the mid-20th century especially in trains and trams, the variety of applications and brake designs has increased dramatically, but the basic operation remains the same. Electromagnetic brakes are the brakes working on the electric power & magnetic power. They works on the principle of electromagnetism.

These brakes are an excellent replacement on the convectional brakes due to their many advantages. The reason for implementing this brake in automobiles is to reduce wear in brakes as it frictionless. Electromagnetic brakes are of today's automobiles. The working principle of this system is that when the magnetic flux passes through and perpendicular to the rotating wheel the eddy current flows opposite to the rotating wheel/rotor direction. This eddy current trying to stop the rotating wheel or rotor. This results in the rotating wheel or rotor comes to rest/ neutral.

1.2 History

It is found that electromagnetic brakes can develop a negative power which represents nearly twice the maximum power output of a typical engine, and at least three times the braking power of an exhaust brake. These performance of electromagnetic brakes make them much more competitive candidate for alternative retardation equipment compared with other retarders. By using by using the electromagnetic brakes are supplementary retardation equipment, the friction brakes can be used less frequently, and therefore practically never reach high temperatures. The brake linings would last considerably longer before requiring

maintenance and the potentially “brake fade” problem could be avoided. In research conducted by a truck manufacturer, it was proved that the electromagnetic brake assumed 80% of the duty which would otherwise have been demanded of the regular service brake. furthermore the electromagnetic brakes prevents the danger that can arise from the prolonged use of brake beyond their capability to dissipate heat. This is most likely to occur while a vehicle descending a long gradient at high speed. Ina study with a vehicle with 5 axles and weighting 40 tones powered by a powered by an engine of 310 BHP travelling down a gradient of 6% at a steady speed between 35 and 40 mph, it can be calculated that the braking power necessary to maintain this speed to the order of 450 HP. The brakes, therefore, would have to absorb 300 HP, meaning that each brake in the 5 axels must absorb 30 HP, that a friction brake can normally absorb with self-destruction.

The magnetic brake is well suited to such conditions since it will independently absorb more than 300 HP. It therefore can exceed the requirements of continuous uninterrupted braking, leaving the friction brakes cool and ready for emergency braking in total safety. The installation of an electromagnetic brake is not very difficult if there is enough space between the gearbox and the rear axle. If did not need a subsidiary cooling system. It relay on the efficiency of engine components for its use, so do exhaust and hydro-kinetic brakes. The exhaust brake is an on/off device and hydro-kinetic brakes have very complex control system. The electromagnetic brake control system is an electric switching system which gives it superior controllability.

1.3 Types of Braking Systems

1.3.1 Electromagnetic Brake System: A rising style of brake system, electromagnetic brakes use an electric motor that is included in the automobile which help the vehicle come to a stop. These types of brakes are in most hybrid vehicles and use an electric motor to charge the batteries and regenerative brakes. On occasion, some buses will use it as a secondary retarder brake.

1.3.2 Frictional Brake System: A frictional brake system is found in many automobiles. They are service brakes, and typically found in two forms; pads and shoes. As the name implies, these brakes use friction to stop the automobile from moving. They typically include a rotating device with a stationary pad and a rotating weather surface. On most band brakes the shoe will constrict and rub against the outside of the rotating drum, alternatively on a drum brake, a rotating drum with shoes will expand and rub against the inside of the drum.

1.3.3 Hydraulic Brake System: A hydraulic brake system is composed of a master cylinder that is fed by a reservoir of hydraulic braking fluid. This is connected by an assortment of metal pipes and rubber fittings which are attached to the cylinders of the wheels. The wheels contain two opposite pistons which are located on the band or drum brakes which pressure to push the pistons apart forcing the brake pads into the cylinders, thus causing the wheel to stop moving.

1.4 Significances and Scope

The following are the significances:

1. Electromagnetic brakes satisfy all the energy requirements of braking without the use of

friction. They have better heat dissipation capability to avoid problems that friction brakes faces times.

2. They can also be used as a supplementary retardation equipment in addition to the regular friction brakes on heavy vehicles.

3. These brakes' component cost is less so these brakes are cheap.

4. They can be used as an alternative method for the future crisis of the crude oils.

1.5 Electromagnet:

An electric current can be used for making temporary magnets known as electromagnets. An electromagnet works on the Magnetic effect of current. It has been found that if a soft iron rod called core is placed inside a solenoid, then the strength of the magnetic field becomes very large because the iron ore is magnetized by induction.

1.6 Electromagnetism:

Electromagnetism is one of the four fundamental interactions in nature. The other three are the strong interaction, the weak interaction and gravitation. Electromagnetism is the force that causes the interaction between electrically charged particles; the areas in which this happens are called electromagnetic fields.

1.7 Magnetic Effect of Current:

The term "Magnetic effect of current" means that "a current flowing in a wire produces a magnetic field around it". The magnetic effect of current was discovered by Oersted in 1820. Oersted found that a wire carrying a current was able to deflect a magnetic needle.

1.8 Objectives

The objectives of this project are:

- To design and construct an **Electromagnetic Braking System**.
- To test the performance of the system.

Chapter 2. Literature Review

2.1 Literature Survey

Stephen Z:- Oldakowski, Bedford, Ohio A magnetic brake provides braking or locking capability and is remotely controlled by electric power. The magnetic brake comprises a rotatable shaft and a brake disc mounted on the shaft. A nonrotating core housing assembly located around the shaft includes a permanent magnet and a bipolar solenoid. A magnetic armature adjacent to the core housing assembly is capable of movement toward the core housing assembly and toward and into engagement with a brake disc to prevent rotation of the shaft. A spring urges the armature away from the core housing assembly and into engagement with the brake disc. The brake does not use any electric power to maintain the brake in the set mode with the rotating shaft fully locked or in the released mode with the rotating shaft fully released. The permanent magnet is of sufficient strength to hold the armature against urging of the spring until an opposite polarity is supplied by the solenoid.

Karl Erny: - Holzhausem an elevator drive has a brake device with compression springs to actuate brake levers, and brake linings on a brake drum creating a braking force. A sensor is provided to detect the movement of a brake magnet armature tappet. A bracket is attached to the brake magnet tappet on one end and a distance piece carrying the sensor housing is arranged on the other end. A restoring lug is attached to the existing mechanical indicator. A monitor evaluates the sensor signal and turns off the elevator drive in the event of dangerous operational states via a safety circuit. The system allows the state of the brake device to be monitored. The more the brake linings wear off due to abrasion, the smaller the distance between the armature and the brake magnet housing. If the armature is in contact with the brake magnet housing, the braking ability of the brake linings is completely void.

Hung-Chi Wu :- 958-2, Ghung Shan Rd., Tao Yuan, Taiwan This invention relates to an adjustable magnetic brake and in particular to one including an aluminum fan, a magnetic conducting ring enclosing the aluminum fan, a permanent magnet disposed within the aluminum fan, a fixing seat for keeping the permanent magnet in position, a sliding seat mounted in the fixing seat and provided with a bearing, a housing, bolts provided on one side of the fixing seat and extending out of the housing, a mounting plate connected with the bolts and a wire connected with the mounting plate such that when the wire is pulled outwards, the permanent magnet will be moved outwards.

Jae-WoongLee:- Seoul, Rep .of Korea Disclose disamagnetic brake system for a vehicle. comprising: a plurality of brake disk solenoids for generating the magnetic force; a plurality of brake pad solenoids for generating the magnetic force; a braking sensor for detecting whether a brake pedal is applied; a wheel speed sensor for detecting wheel speed; a magnetic polarity sensor for detecting magnetic polarity of the brake disk solenoids; and a control unit for controlling the brake pad solenoids using signals from the braking sensor. The wheel

speed sensor and the magnetic polarity sensor.

2.3 Summary

The above discussion gives an idea about the Braking System. The automatic Electromagnetic Braking System in the situation are described in detail. From this we also got the direction of work of the project.

Chapter 3. Research Methodology

3.1 Methodology

Our used methodology for the project:

- Electromagnetic Braking System and designing a block diagram & circuit diagram to know which components need to construct it.
- Setting all components in a PCB board & soldering. Then assembling the whole block in a board and finally run the system & checking.
- To take necessary notes from the project for future improvements.

3.2 Block Diagram

The way of whole project works is generated electromagnetic power to stop the wheel. Here we use power source, voltage regulator, pedal, relay, motor, wheel, electromagnetic break etc. All are in layout in below block diagram.

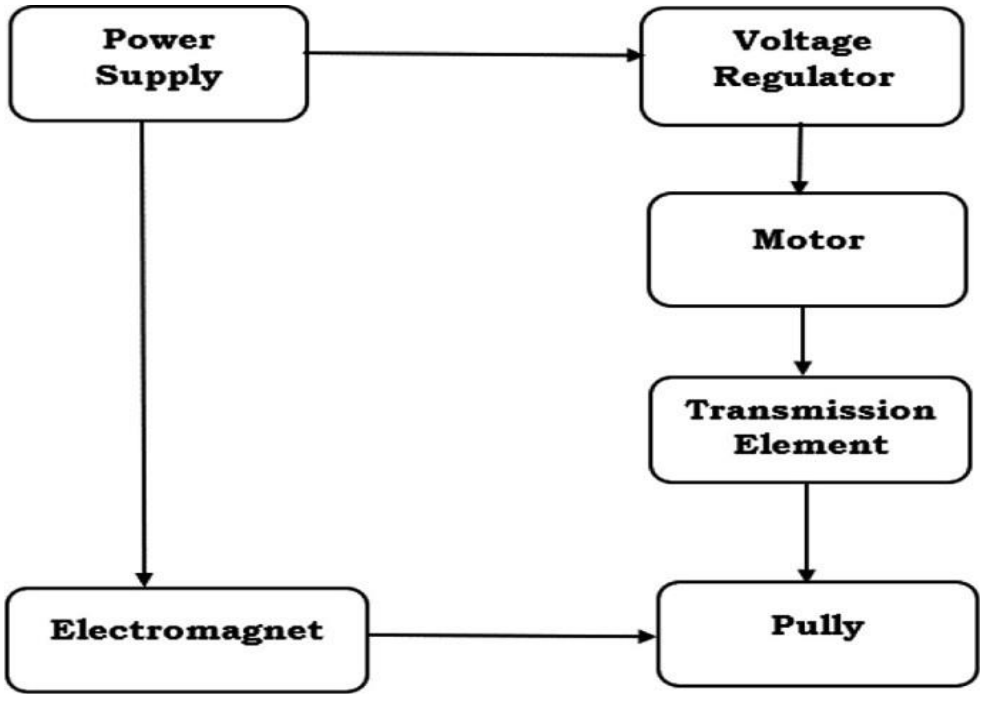


Figure 3.1: Block Diagram

3.3 Circuit Diagram

The schematic diagram here is representing the electrical circuit and the components of the project. Here we have used standardized symbols and lines.

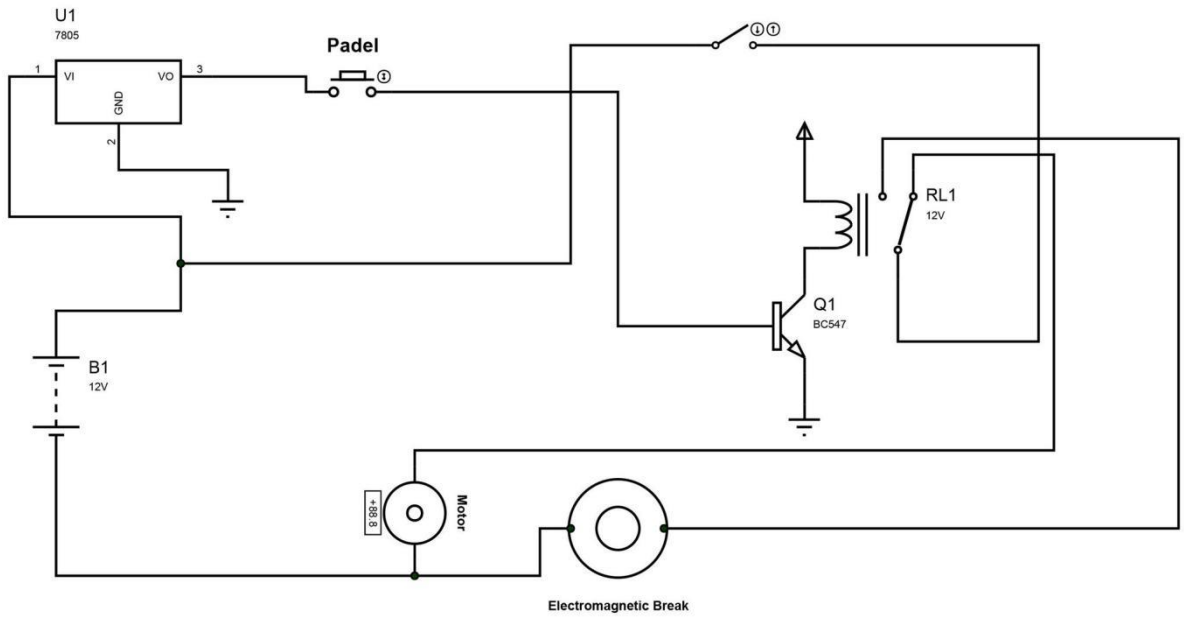


Figure 3.2: Electromagnetic Braking System

3.4 Working Principle

The main power source of our system is a powerful 12 volt battery. Once the system is switched on and connected to the battery, the system is ready to work. After that pressing a switch will turn the relay on and the motor will start and the wheel will continue to spin. Then when the brake pedal or push switch is pressed, the relay turns off the connection to the motor and the electromagnet brakes stops the wheel. This is the main function of our system.

3.5 Project Hardware Image



Figure 3.3: Project Hardware Image

3.6 Required instrument and Software

Hardware

- Battery / Power Source
- Regulator
- Push Switch
- Relay
- Motor
- Wheel
- Electromagnetic Break

3.7 12v Battery

A twelve-volt battery has six single cells in series producing a fully charged output voltage of 12.6 volts. A battery cell consists of two lead plates a positive plate covered with a paste of lead dioxide and a negative made of sponge lead, with an insulating material (separator) in between.

Quick Details

- Nominal Capacity: 200AH
- rechargeable 12v dc battery pack: 1PCS/CTN (according to the actual situation)
- Production Capacity: rechargeable 12v dc battery pack:50000PCS/Month
- Factory space: 6000m2
- Maintenance Type: Free
- Voltage: 12V



Figure 3.4 : 12V Battery

3.8 5V Regulator IC

Voltage sources in a circuit may have fluctuations resulting in not providing fixed voltage outputs. A voltage regulator IC maintains the output voltage at a constant value. 7805 IC, a member of 78xx series of fixed linear voltage regulators used to maintain such fluctuations, is a popular voltage regulator integrated circuit (IC). The xx in 78xx indicates the output voltage it provides. 7805 IC provides +5 volts regulated power supply with provisions to add a heat sink.

7805 IC Rating

- Input voltage range 7V- 35V
- Current rating Ic = 1A
- Output voltage range VMax=5.2V ,VMin=4.8V

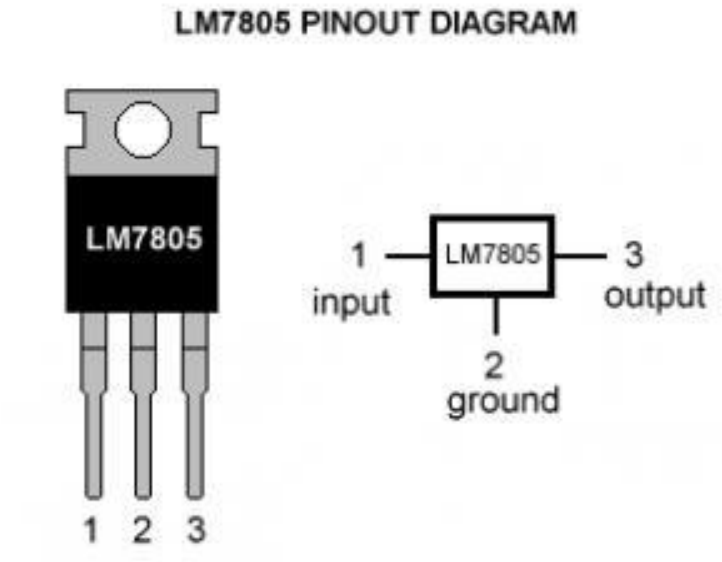


Fig.3.5: 5V Regulator IC

3.9 Relay:

A relay is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a separate low-power signal, or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits as amplifiers: they repeated the signal coming in from one circuit and re-transmitted it on another circuit. Relays were used extensively in telephone exchanges and early computers to perform logical operations.

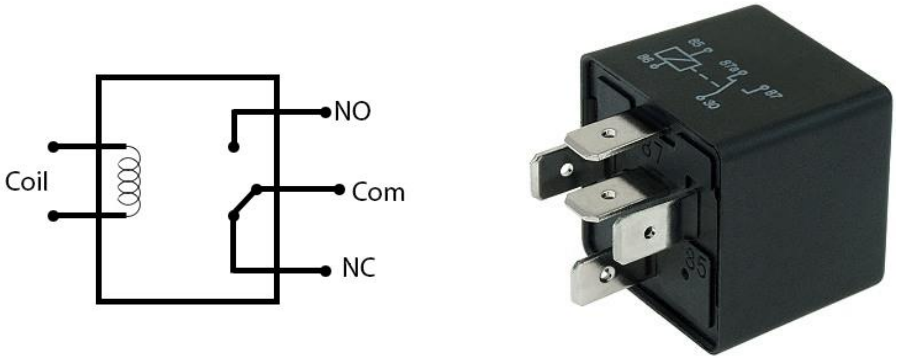


Figure 3.6: Relay

A type of relay that can handle the high power required to directly control an electric motor or other loads is called a contactor. Solid-state relays control power circuits with no moving parts, instead using a semiconductor device to perform switching. Relays with calibrated operating characteristics and sometimes multiple operating coils are used to protect electrical circuits from overload or faults; in modern electric power systems these functions are performed by digital instruments still called "protective relays".

Magnetic latching relays require one pulse of coil power to move their contacts in one direction, and another, redirected pulse to move them back. Repeated pulses from the same input have no effect. Magnetic latching relays are useful in applications where interrupted power should not be able to transition the contacts.magnetic latching relays can have either single or dual coils. On a single coil device, the relay will operate in one direction when power is applied with one polarity, and will reset when the polarity is reversed. On a dual coil device, when polarized voltage is applied to the reset coil the contacts will transition. AC

controlled magnetic latch relays have single coils that employ steering diodes to differentiate between operate and reset commands.

The relay module is the one in the figure below.

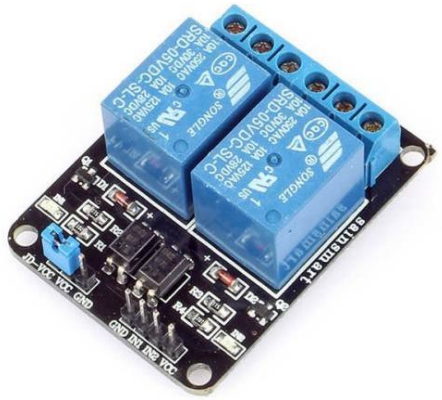


Figure 3.7: Relay Module.

This module has two channels (those blue cubes). There are other varieties with one, four and eight channels.

Mains voltage connections.

In relation to mains voltage, relays have 3 possible connections:

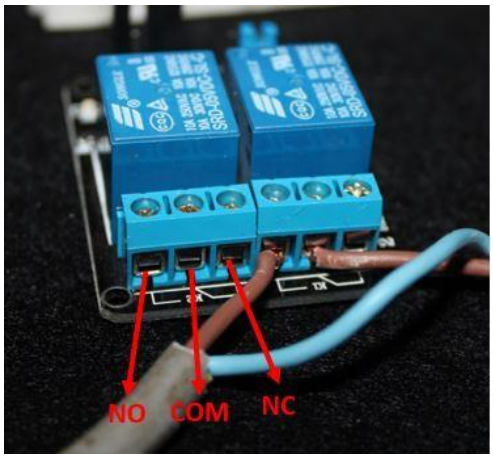


Figure. 3.8 : Mains voltage connections.

- **COM**: common pin
- **NO (Normally Open):** there is no contact between the common pin and the normally open pin. So, when you trigger the relay, it connects to the COM pin and supply is provided to a load
- **NC (Normally Closed):** there is contact between the common pin and the normally closed pin. There is always connection between the COM and NC pins, even when the relay is turned off. When you trigger the relay, the circuit is opened and there is no supply provided to a load.

Pin wiring

The connections between the relay module and the Arduino are really simple:

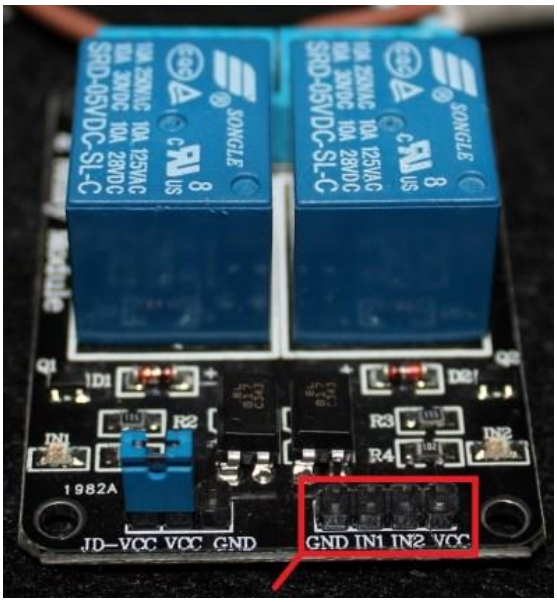


Figure 3.9: Relay voltage connections.

- **GND**: goes to ground
- **IN1**: controls the first relay (it will be connected to an Arduino digital pin)
- **IN2**: controls the second relay (it should be connected to an Arduino digital pin if you are using this second relay. Otherwise, you don't need to connect it)
- **VCC**: goes to 5V

3.10 DC Motor

A DC motor is any motor within a class of electrical machines whereby direct current electrical power is converted into mechanical power. A 12v DC motor is small and inexpensive, yet powerful enough to be used for many applications.

Specification:

- Voltage: 12V DC
- Gear ratio: 1/31
- No-load speed: 200 RPM
- Rated Speed: 140 RPM
- Rated torque: 10 kg.cm
- Rated current: 2.5 Amp
- Length of Motor (including spindle): 106 mm/4.17″
- Diameter: 37 mm/1.45″
- Shaft length: 21 mm/0.82″
- Shaft diameter: 6 mm/0.24″



Figure 3.10: DC Gear Motor

3.11 Wheel

A wheel is a circular component that is intended to rotate on an axle bearing. The wheel is one of the key components of the wheel and axle which is one of the six simple machines. Wheels, in conjunction with axles, allow heavy objects to be moved easily facilitating movement or transportation while supporting a load, or performing labor in machines. Wheels are also used for other purposes, such as a ship's wheel, steering wheel, potter's wheel, and flywheel.



Figure 3.11: Wheel

3.12 Push Button

A push-button (also spelled push-button) or simply button is a simple switch mechanism to control some aspect of a machine or a process. Buttons are typically made out of hard material, usually plastic or metal. The surface is usually flat or shaped to accommodate the human finger or hand, so as to be easily depressed or pushed. Buttons are most often biased switches, although many un-biased buttons (due to their physical nature) still require a spring to return to their un-pushed state.



Figure 3.12: Push Switch

3.13 Electromagnetic Brake

Electromagnetic brakes (also called electro-mechanical brakes or EM brakes) slow or stop motion using electromagnetic force to apply mechanical resistance (friction). They were originally called "electro-mechanical brakes," but over the years the name changed to "electromagnetic brakes", referring to their actuation method. Since becoming popular in the mid-20th century, especially in trains and trams, the variety of applications and brake designs has increased dramatically, but the basic operation remains the same.

Application

In locomotives, a mechanical linkage transmits torque to an electromagnetic braking component. Trams and trains use electromagnetic track brakes where the braking element is pressed by magnetic force to the rail. They are distinguished from *mechanical* track brakes, where the braking element is mechanically pressed on the rail.

Electric motors in industrial and robotic applications also employ electromagnetic brakes. Recent design innovations have led to the application of electromagnetic brakes to aircraft applications. In this application, a combination motor/generator is used first as a motor to spin the tires up to speed prior to touchdown, thus reducing wear on the tires, and then as a generator to provide regenerative braking.



Figure 3.13: Electromagnetic Break

3.14 Proteus Software

The Proteus Design Suite is a proprietary software tool suite used primarily for electronic design automation. The software is used mainly by electronics design engineers and technicians to create schematics and electronics prints for manufacturing printed circuit boards. The first version of what is now the Proteus Design Suite was called PC-B and was written by the company chairman, John Jameson, for DOS in 1988. Schematic Capture support followed in 1990 with a port to the Windows environment shortly thereafter. Mixed mode SPICE Simulation was first integrated into Proteus in 1996 and micro-controller simulation then arrived in Proteus in 1998. Shape based auto routing was added in 2002 and 2006 saw another major product update with 3D Board Visualization. More recently, a dedicated IDE for simulation was added in 2011 and MCAD import/export was included in 2015. Support for high speed design was added in 2017. Feature led product releases are typically biannual, while maintenance-based service packs are released as required.

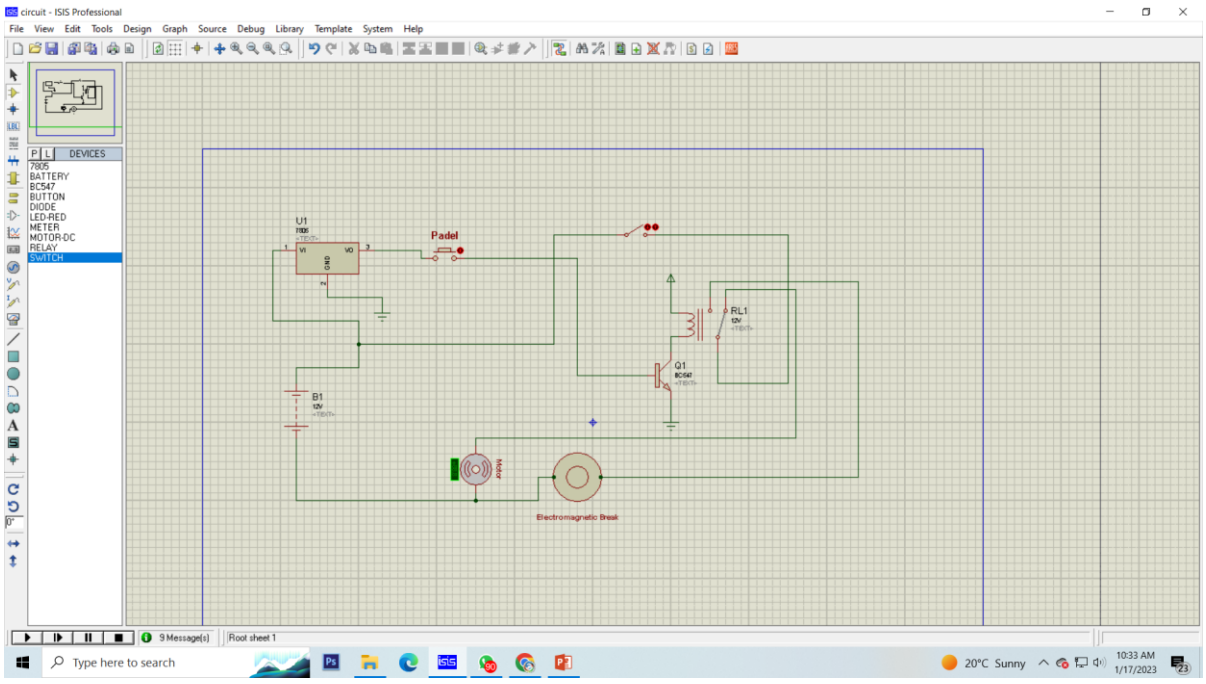


Figure 3.14: Proteus Software Interface

Chapter 4. Result and Discussion

4.1 Result

After making our project we observe it very careful. It works as we desire. Our project give output perfectly and all equipment are work perfectly. We check how much it works and we get perfect output from this project.

- Firstly, when we press switch on then the project will be run,
- Then a switch will work to start the motor
- When we press the pedal then relay will cut off the motor connection.
- Supply the current in electromagnet break.
- When it it magnetized then wheel will be stop.

4.2 Advantages

There are many advantages of our system because of its accuracy. Some of the advantages are pointed out below:

- Problems of wear and tear is negligible
- Potential hazard of tire burst due to excess temperature is prevented
- Individual wheel braking is possible.
- As heat generation is less due to shared efforts by both the brakes, hence brakes remains cooler.
- Functioning of EM brakes is similar in all climates, i.e. no need for special changes in hot or cold climates like in case of disc brakes.
- Maintenance cost is very less
- Changing of parts due to wear and tear is less.
- Easier integration with anti-lock, traction system
- “Brake fade” effect is negligible, hence can be used for long hauls in trucks and other heavy vehicle.
- Simple construction.

4.3 Limitations

Though this project has many advantages but it has some limitations as well and they are listed below:

- Electromagnetic braking system doesn't function well on lower RPMs as the Eddy current generated is of low power.
- Large amount of electricity is needed for heavy braking, hence the battery life is reduced
- Due to low speed limitation EM braking cannot be used as an independent system.
- System can be bulky in-case of vehicles needed larger braking force.

4.4 Application

The application areas for this system in this modern and practical world are huge and some of these are given below:

- Railways
- Coaches
- Roller coasters and other theme park rides
- Industrial lifts
- Heavy duty trucks
- Automobiles
- It can be applied to aeronautic application
- Slowing down a airplane on carrier ship

4.5 Hydraulic Brake vs Electromagnetic Brake

	Hydraulic Brake	Electromagnetic Brake
Operating Principle	When the brake pedal is pressed, it creates pressure in the hydraulic fluid, which forces the brake pads or shoes against the rotor or drum, creating friction and slowing or stopping the vehicle	An electric current is passed through a coil, creating a magnetic field that attracts a ferromagnetic rotor or armature, pressing it against a brake drum or disc.
Performance	Hydraulic brakes are good for heavy-duty applications because they can handle high braking forces and dissipate heat well	Electromagnetic brakes are fast and responsive, and are often used in applications that require precise control
Maintenance	Hydraulic brakes are easier to adjust than electromagnetic brakes	Electromagnetic brakes are inexpensive to buy and maintain
Advantages	Capable of generating significant stopping power, especially in heavy-duty applications.	Braking force can be easily modulated by adjusting the current.

4.6 Discussion

While working on our project, we did face some difficulties as it is a very complex system but the end results, we came up with were quite satisfactory. We have put the whole system through several tasks to validate our work and also have taken necessary notes for future improvements. Some future recommendations that we have involves improvement in system design and wiring, adding features for more efficient.

Chapter 5. Conclusion

5.1 Conclusion

The Electromagnetic braking system is found to be more reliable as compared to other braking systems. In addition, it is found that electromagnetic brakes make up approximately 80% of all of the power applied brake applications. Electromagnetic brakes have been used as supplementary retardation equipment in addition to the regular friction of the brakes. This enhanced braking system not only helps in effective braking but also helps in avoiding the accidents and reducing the frequency of accidents to a minimum. Furthermore the electromagnetic brakes prevent the danger that can arise from the prolonged use of brake beyond their capability to dissipate heat. ABS usage can be neglected by simply using a micro controlled electromagnetic disk brake system. For the brake distribution of the electromagnetic braking system, the abrasion, noise, harmful friction dust, and the risk of thermal failure in braking system were reduced obviously. These electromagnetic brakes can be used in wet conditions which eliminate the anti-skidding equipment, and cost of these brake are cheaper than the other types. The concept designed by us is just a prototype and needs to be developed more. It can not only be used in the field of automotives but also in the field of aeronautics. Hence the electromagnetic braking system can be a better technological revolution in the future application.

5.2 Future Scope of Study

As we have already discussed about the limitations of this system so definitely there's room for improvement and thus we have lots of future scope of work available to us for this system. Some of these are listed below:

- Braking system can be done depending on the speed and add some sensors. So that the accident will be reduced.
- Depending on the sensor, the automatic brake system can be done without pressing the pedal.

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