

Internal and External Crack Detection on Railway Track

Submitted in fulfillment of the requirements for the award of
Bachelor of Engineering degree in Mechatronics

by

Kathiravan K R (39090016)

Divakar S G (39090009)



**DEPARTMENT OF MECHATRONICS
SCHOOL OF MECHANICAL ENGINEERING**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

**Accredited with Grade "A" by NAAC | 12B Status by UGC | Approved by AICTE
JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119**

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **Kathiravan K R (39090016)**, **Divakar S G (39090009)** who have done the project work entitled “**Internal and External Crack Detection on Railway Track**” under our supervision from June 2022 to May 2023.

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Submitted for Viva Voice examination held on ____ May 2023

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DECLARATION

We **Kathiravan K R (39090016)** and **Divakar S G (39090009)** hereby declare that the Project Report entitled “**Internal and External Crack Detection on Railway Track**” done by us under the guidance of **Mr. M. Amaranth, M.E.**, is submitted in fulfillment of the requirements for the award of Bachelor of Engineering degree in Mechatronics.

1. 

2. 

DATE: ____ May 2023

PLACE: Chennai, Tamil Nadu

SIGNATURE OF THE CANDIDATE

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ABSTRACT

Railway tracks are an essential part of the transportation infrastructure, and it is crucial to ensure their safety and reliability. Heavy trains passing over railway tracks exert a considerable amount of strain and wear on the tracks, which can lead to the formation of cracks. These cracks can potentially result in fatal accidents, making it essential to have a reliable crack detection system in place. To address this issue, a fracture detection system based on Arduino has been suggested. The system uses a crack sensor to detect signals produced by cracks in the railroad rails. The signals are then processed by Arduino to identify and categorize the fractures. The system is designed to detect both internal and external cracks of all sizes and shapes. It is non-destructive and highly sensitive, making it an efficient and reliable method of detecting cracks in railway tracks. The system has been tested on model railway tracks and has demonstrated its effectiveness in identifying cracks and averting potential accidents. One of the significant advantages of the suggested system is its affordability and ease of use. The system is also highly adaptable to various environments, making it suitable for use in different settings and conditions. The system's efficiency and reliability make it suitable for both manual and automated inspection of railway tracks. The system can be easily integrated with other monitoring systems to provide a comprehensive solution for monitoring railway tracks' safety and reliability. The suggested Arduino-based fracture detection system is a solution for detecting cracks in railway tracks. The system's efficiency, affordability, and adaptability make it suitable for use in various settings, and it has the potential for broad applicability. The system can be further developed and enhanced to meet unique user requirements and improve railway transportation network safety and reliability.

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LIST OF ABBREVIATIONS

GSM	Global System for Mobile Communication
GPS	Global Positioning System
LDR	Light Dependent Resistor
IoT	Internet of Things
IR	Infrared Sensor
P-Wave	Penetration Wave

CHAPTER 1

INTRODUCTION

India has one of the largest rail networks in the world, yet manual inspection and fracture detection on these lines is a time- and labor-intensive procedure. The suggested system uses sensors and a micro-controller to provide a really inexpensive approach for detecting railway track cracks. There are currently 113,617 kilometers of track in the Indian railway network (70,598 mi). along a 63,974 km (39,752 mi) circuit with 7,083 stations. The world's fourth-largest railway network is located there. The Indian rail system is still expanding in an effort to meet the demands of the country's economy. Despite India's rapid development in rail travel, the related safety infrastructure facilities have not kept pace with it. Our facilities fall short of international norms, and as a result, there are frequent derailments that cause significant loss of priceless human lives as well as property.

Recent figures indicate that derailments account for around 60% of all rail accidents and that roughly 90% of these derailments are caused by cracks in the tracks, either as a result of natural reasons (such as excessive expansion due to heat) or as a result of antisocial elements. The frequent use of rail in India means that cracks in railway lines have been a recurring issue that requires immediate correction. Due to poor maintenance and the sporadic and manual track line monitoring that is currently being done, these cracks and other rail issues typically go undiscovered. An automated method to monitor the presence of cracks on railway lines is required due to the high frequency of trains and the unreliability of manual labor. Due to the serious consequences of this issue, this paper implements an effective and affordable solution appropriate for large-scale application by applying op-based fracture detection in railway tracks via the GSM system.

This concept is useful in various applications where problem-solving is involved. The exceptional sensitivity of this technique means that crack detection doesn't encounter any issues. Because of the system's straightforward design, installation is a breeze. According to GSM standards, a radio communications system only functions successfully if each component portion stays within predetermined parameters. This concept is useful in various applications where problem-solving is involved. The exceptional sensitivity of this technique means that crack detection doesn't encounter any issues. Because of the system's straightforward design, installation is a breeze. According to GSM standards, a radio communications system only functions successfully if each component portion stays within predetermined parameters. This concept is useful in various applications where problem-solving is involved.

The exceptional sensitivity of this technique means that crack detection doesn't encounter any issues. Because of the system's straightforward design, installation is a breeze. According to GSM standards, a radio communications system only functions successfully if each component portion stays within predetermined parameters. In order to maintain a call of acceptable quality, mobiles and base stations must send a suitable amount of power with appropriate fidelity while avoiding transmitting an excessive amount of power into the frequency channels and time slots designated for others. Similar to transmitters, receivers need to be sensitive and selective enough to pick up and demodulate a low-level signal. The essential measures needed to test GSM transceivers are outlined in this document. Additionally, it covers how GSM mobile performance is derived.

In conclusion, the GSM standard is critical to the functioning of radio communications systems. It specifies the parameters within which each component of the system must operate to maintain a call of acceptable quality. By testing transceivers and mobile performance, operators can ensure that the system is functioning correctly and providing high-quality service to users.

1.1 TYPES OF CRACK DETECTION IN METAL

1.1.1 Visual Inspection

Visual inspection, also known as visual testing, is a type of non-destructive testing (NDT) method used to assess the internal and external surfaces of a material for defects, flaws and other irregularities. It is a cost-effective and quick method of inspection that is often used in the initial stages of quality control.

Visual inspection can be performed manually or with specialized tools and devices. There are many different types of visual inspection, including: Surface Inspection: Surface inspection involves examining the surface of an object for defects and flaws, such as cracks, pits, scratches, and other irregularities. Surface inspection can be performed using a variety of tools, including microscopes, magnifying glasses, and bore scopes.

Dimensional Inspection: Dimensional inspection involves measuring the dimensions of an object to ensure that it meets the required specifications. This type of inspection can be performed using calipers, micrometer, and other types of measuring tools.

Material Identification: Material identification involves determining the material composition of an object. This can be performed by using chemical analysis techniques, such as X-ray fluorescence (XRF) spectroscopy or optical microscopy. Visual inspectors must have a keen eye and attention to detail in order to identify defects and flaws. They must also be familiar with industry standards and regulations, as well as the appropriate NDT methods for the type of material being inspected. Visual inspection can be used to detect a wide range of defects.

Cracks: Cracks are one of the most common types of defects that can be detected with visual inspection. They can occur on the surface of the object or internally, and can be caused by a variety of factors, such as fatigue, stress, or corrosion.

Porosity: Porosity is the presence of voids or pores in the material that can reduce the strength and durability of an object. It can occur as a result of the manufacturing process or from external factors, such as exposure to moisture or chemicals.

Corrosion: Corrosion is a chemical or electrochemical reaction that causes the degradation of a material. It can occur on the surface or internally, and can be caused by a variety of factors, such as exposure to moisture or chemicals.

Weld Defects: Weld defects, such as porosity, slag inclusions, and cracks, can occur during the manufacturing of welded components. These defects can reduce the strength of the weld and can lead to failures. Visual inspection is a widely used NDT method and is an important component of the quality control and quality assurance processes. It can be used to detect a wide range of defects, and can help to prevent failures and ensure that products meet the necessary standards.

1.1.2 Dye penetration inspection

Eddy current testing is a non-destructive testing method used to detect surface or near-surface defects and anomalies in conductive materials. It relies on the generation of eddy currents, which are created when a varying magnetic field is applied to a conductive material. These eddy currents generate their own magnetic fields, which interact with the original magnetic field and produce a signal that can be analyzed to identify defects. Eddy current testing is commonly used in the aerospace, automotive, power generation, and manufacturing industries, among others, to detect surface and sub-surface cracks, corrosion, and other flaws in conductive materials. It can be used on a variety of materials, including metals, alloys, and some non-metals. The basic principle of eddy current testing is that when a varying magnetic field is applied to a conductive material, it induces an electric current in the material. This electric current generates its own magnetic field, which interacts with the original magnetic field to produce a signal that can be analyzed. The strength and frequency of the

signal can provide information about the conductivity and thickness of the material, as well as the presence of defects or anomalies. To perform eddy current testing, a probe is used to apply a magnetic field to the material being tested.

The probe contains a coil of wire through which an alternating current is passed, creating the varying magnetic field. As the magnetic field passes through the material, eddy currents are induced in the conductive material. The interaction between the eddy currents and the magnetic field creates a signal that is picked up by the probe and sent to a receiver for analysis. The receiver analyzes the signal and provides information about the material being tested. If there are any defects or anomalies in the material, they will produce a change in the signal that can be detected and analyzed. The receiver can be used to display the signal in real-time, allowing the operator to identify any issues with the material immediately. Eddy current testing can be performed in a variety of ways, depending on the material being tested and the type of defect being detected. For example, surface probes can be used to detect defects on the surface of a material, while rotating probes can be used to scan the surface of a material to detect defects.

Additionally, eddy current testing can be performed with or without a contact between the probe and the material being tested. One advantage of eddy current testing is its ability to detect defects in complex shapes and sizes of conductive materials. Eddy current testing can be used to detect defects in thin or thick materials, as well as in materials with complex geometries. Additionally, eddy current testing can be used to detect defects at high speeds, making it useful for inline testing during manufacturing processes. However, eddy current testing has some limitations. It is generally limited to detecting surface and near-surface defects, and it may not be able to detect defects that are too small or too deep within the material. Additionally, eddy current testing is generally not effective on non-conductive materials. In conclusion, eddy current testing is a powerful non-destructive testing method used to detect surface and near-surface defects and anomalies in conductive materials. It is used in a wide range of industries to

ensure the safety and reliability of materials, components, and products. With its ability to detect defects in complex shapes and sizes, eddy current testing is an essential tool for modern manufacturing and maintenance.

1.1.3 Magnetic particle inspection

A non-destructive testing technique called magnetic particle inspection is used to find surface and sub-surface defects in ferromagnetic metals. This technique includes applying magnetic particles to the metal's surface, which are drawn to any flaws or cracks. The fissures are then evident when the particles are viewed under a black light. This technique works well for finding cracks in welds and other difficult-to-reach places. Magnetic particle inspection (MPI), also known as magnetic particle testing (MPT), is a non-destructive testing (NDT) method used to detect surface and shallow subsurface defects in ferromagnetic materials such as iron, nickel, and cobalt. MPI involves the application of a magnetic field to the material under test, and the subsequent detection of any discontinuities or flaws in the magnetized part using finely divided magnetic particles that are applied to the magnetized area. These particles may be visible to the naked eye or may be fluorescent, allowing for the inspection to be carried out under ultraviolet light. MPI is commonly used in the aerospace, automotive, and power generation industries to detect cracks, seams, laps, and other defects in ferromagnetic components. The principle of MPI is based on the detection of magnetic fields.

When a magnetic field is applied to a part, it magnetizes any ferromagnetic material within the part. Cracks or other defects in the area under inspection disrupt the magnetic field and cause the magnetic flux leakage, which can be detected by a magnetic particle inspector using the appropriate equipment and techniques. The presence of magnetic flux leakage will cause the magnetic particles to move away from the defect, creating a pattern that can be interpreted and identified. One of the key benefits of using MPI is the ability to detect flaws and defects in ferromagnetic materials that may not be visible to the naked eye. MPI can also be used to detect flaws and defects that other types of NDT methods may have missed, such as fatigue cracks in welds or stress-induced fractures. In addition, MPI is a relatively low-cost and easy-to-use NDT method,

which makes it a popular choice for many industries. However, there are also some limitations to MPI. For example, it cannot detect subsurface defects because the magnetic flux leakage is only detected on the surface of the part. It is also not suitable for non-ferromagnetic materials or for materials that have a large thickness, as the magnetic flux may not be able to penetrate the material.

1.1.4 Ultrasonic testing

A non-destructive testing technique called ultrasonic testing is used to find surface and sub-surface flaws in metals. High-frequency sound waves are used in this technique and are focused at the metal's surface. When they come into contact with a fracture or flaw, the sound waves travel through the metal and return. The size and location of the flaw are then determined by analyzing the sound waves that were reflected. This technique can be used to find cracks in forgings, castings, and welds. UT is based on the principles of sound waves that are transmitted through the material being inspected. These waves travel through the material and reflect back from the opposite surface or a defect present within the material. The time taken by the wave to travel back to the transmitter is measured and analyzed to determine the size and location of the defect.

UT equipment consists of a transducer, which is used to generate ultrasonic waves, and a receiver, which detects the reflected waves. The transducer is placed on the surface of the material being inspected, and ultrasonic waves are transmitted into the material. The waves travel through the material until they encounter a boundary or defect. At this point, some of the wave energy is reflected back to the transducer, where it is detected by the receiver. The received signals are displayed on an oscilloscope or computer screen. The signals are analyzed to determine the location and size of the defect. The signal strength and time of flight are used to determine the depth of the defect. UT is used in a wide range of industries, including aerospace, automotive, construction, and manufacturing. UT is used to detect flaws in welds, castings, forgings, and other types of components. UT is also used to measure the thickness of materials and to detect the presence of cracks, voids, and other types of defects. UT has several advantages over other NDT techniques. It is a non-destructive method that can be used to inspect parts without causing any damage. UT is also very sensitive and can detect very small defects, which may not be visible to the naked eye. UT is also fast and can be

used to inspect large areas quickly. UT has some limitations that should be considered.

The method requires access to both sides of the material being inspected, which may not always be possible. UT also requires trained technicians to perform the inspections and interpret the results. UT may not detect defects that are oriented perpendicular to the surface being inspected, and it may not be suitable for very thin materials. Ultrasonic Testing is a valuable NDT technique that is used to inspect a wide range of materials and components. UT is a non-destructive method that can detect very small defects and is fast and sensitive. Although UT has some limitations, it is still one of the most widely used NDT techniques and will continue an important role in the inspection of materials and components in the future.

1.1.5 THERMOGRAPHIC TESTING

Thermographic testing, also known as thermal imaging or infrared imaging, is a non-invasive diagnostic technique that uses infrared technology to detect and measure temperature variations on the surface of objects. This technology works by detecting the infrared radiation emitted by the surface of an object, which is directly related to its temperature. Infrared thermography can be used in a variety of fields, including medicine, building inspection, electrical and mechanical engineering, and more. The technology is used to identify areas of heat loss, moisture intrusion, structural defects, and other potential issues. In this article, we will discuss the different applications of thermographic testing and how it works. In the medical field, thermographic testing is often used to detect areas of inflammation, injury, or poor circulation in the body. The test works by detecting and measuring the infrared radiation emitted by the body's surface, which is directly related to the body's temperature.

Areas of the body with higher temperatures may indicate inflammation, while areas with lower temperatures may indicate poor circulation. Thermographic testing is used in a variety of medical applications, including the detection of breast cancer,

nerve damage, and other conditions. In the building inspection industry, thermographic testing is used to identify areas of heat loss, moisture intrusion, and structural defects. By detecting temperature variations on the surface of walls, ceilings, and other building components, thermal imaging can help identify potential problem areas before they become major issues. This can be especially useful in identifying energy inefficiencies, which can help homeowners and building managers save money on heating and cooling costs. Electrical and Mechanical Engineering: In the electrical and mechanical engineering industries, thermographic testing is used to identify hot spots and other potential issues in electrical and mechanical equipment. By detecting temperature variations on the surface of equipment, thermal imaging can help identify potential areas of failure and prevent costly downtime. This technology is particularly useful in detecting problems in high-voltage electrical equipment, such as transformers and switch gear.

Thermographic testing works by detecting and measuring the infrared radiation emitted by an object's surface. This radiation is converted into an image that displays the temperature variations on the surface of the object. The technology works best when there is a significant temperature difference between the object and its surroundings. In order to perform a thermographic test, a trained technician uses a thermal imaging camera to capture the infrared radiation emitted by the surface of the object. The camera then creates a visual image of the temperature variations on the object's surface, which can be used to identify potential issues. Thermographic testing is a valuable diagnostic tool that can help identify potential issues in a variety of fields. However, it is important to note that these tests should always be performed by trained professionals and should not be used as a substitute for other diagnostic tests or medical examinations.

1.1.6 EDDY CURRENT TESTING

Eddy current testing is a non-destructive testing method used to detect surface or near-surface defects and anomalies in conductive materials. It relies on the generation of eddy currents, which are created when a varying magnetic field is applied to a conductive material. These eddy currents generate their own magnetic fields, which interact with the original magnetic field and produce a signal that can

be analyzed to identify defects. Eddy current testing is commonly used in the aerospace, automotive, power generation, and manufacturing industries, among others, to detect surface and sub-surface cracks, corrosion, and other flaws in conductive materials. It can be used on a variety of materials, including metals, alloys, and some non-metals.

The basic principle of eddy current testing is that when a varying magnetic field is applied to a conductive material, it induces an electric current in the material. This electric current generates its own magnetic field, which interacts with the original magnetic field to produce a signal that can be analyzed. The strength and frequency of the signal can provide information about the conductivity and thickness of the material, as well as the presence of defects or anomalies. To perform eddy current testing, a probe is used to apply a magnetic field to the material being tested. The probe contains a coil of wire through which an alternating current is passed, creating the varying magnetic field. As the magnetic field passes through the material, eddy currents are induced in the conductive material.

The interaction between the eddy currents and the magnetic field creates a signal that is picked up by the probe and sent to a receiver for analysis. The receiver analyzes the signal and provides information about the material being tested. If there are any defects or anomalies in the material, they will produce a change in the signal that can be detected and analyzed. The receiver can be used to display the signal in real-time, allowing the operator to identify any issues with the material immediately. Eddy current testing can be performed in a variety of ways, depending on the material being tested and the type of defect being detected. For example, surface probes can be used to detect defects on the surface of a material, while rotating probes can be used to scan the surface of a material to detect defects. Additionally, eddy current testing can be performed with or without a contact between the probe and the material being tested. One advantage of eddy current testing is its ability to detect defects in complex shapes and sizes of conductive materials.

In conclusion, eddy current testing is a powerful non-destructive testing method used to detect surface and near-surface defects and anomalies in conductive

materials. It is used in a wide range of industries to ensure the safety and reliability of materials, components, and products. With its ability to detect defects in complex shapes and sizes, eddy current testing is an essential tool for modern manufacturing and maintenance.

1.2 CHARACTERISTICS OF RAIL STEEL

Rail steel, commonly referred to as railway track steel or rail steel, is a specific kind of steel used to make railway tracks. Some of the key traits of steel used in railway track construction include the following:

High strength: Steel used in railway tracks is a high-strength steel that can support enormous weights and endure abrasion.

Toughness: The steel is resilient to impact and wear, making it perfect for heavily loaded railway rails.

Ductility: Steel used for railway tracks has good ductility, making it possible to bend and shape it without fear of it breaking.

Resistance to wear and tear: Railway track steel has a high resistance to wear and tear due to its hardness, which makes it ideal for withstanding the abrasive effects of train wheels.

Corrosion resistance: Steel used for railroad tracks has a high corrosion resistance, which is crucial because train lines are frequently exposed to inclement weather.

Durability: The steel used in railway track construction has a long lifespan and can sustain repeated severe use, which lowers maintenance costs and increases track longevity.

CHAPTER 2

LITERATURE REVIEW

2.1 AUTOMATED CRACK DETECTION OF RAILWAY TRACK

Trains haven't been depicted as posing a serious threat, Because they don't happen as frequently as car accidents. However, when a railway disaster occurs, it often causes catastrophic injuries as well as fatalities. The majority of the time, accidents are caused by unforeseen corners and missing track lines. Therefore, the goal is to create a system that candetect these flaws before any suffering occurs. The project's main objective is to create a bot that can detect any cracks or other unpleasant flaws in railway tracks. It is based on the detection of faults in railroad tracks.

Any cracks, missing track lines, or unwelcome bends are all detected by the bot using an ultrasonic sensor. If a fault is discovered, the ultrasonic sensor notifies the Arduino UNO board, which then issues a command to the Global System for Mobile Communications (GSM) module. The GSM module then contacts the control room and transmits its location using the Global Positioning System(GPS). The buzzer then begins to buzz after the relay module is turned on.

The project's main goals are to lessen railroad risks and keep the railroad department informed of the track's current state. The techniques and necessary supplies are extremely straightforward yet with exact measurements. They are strategically positioned to create connectivity between the parts. Here, the problem detection system. uses GSM and GPS technology.

2.2 AUTOMATIC RAILWAY TRACK CRACK DETECTION USING IR SENSOR

The Indian Railways operates one of the biggest rail networks in the world and offers the most significant form of public transportation in India, as well as the most widely used and reasonably priced long-distance transportation system in the nation. The fundamental issue with a railway analysis is spotting structural flaws. If

these flaws are not addressed right away, they could result in a lot of derailments and a significant loss of life and property. Using an IR SENSOR assembly system, we are launching a project that aims to design a reliable railway crack detection scheme (RRCDs), which prevents train accidents by spotting cracks on railway tracks.

The robotic replica has a built-in camera that transmits live movies and photos. Additionally capable of employing GPS and GSM modules to locate itself, sending SMS messages to authorities to inform them of the issue. The system also has a distance-measuring sensor that shows the distance between the railway tracks when there is a track deviation. This will prevent an unwelcome rail track discontinuity from affecting a number of trains in India. The vehicle's front sides are equipped with a single set of IR sensor modules. The cracks are detected using an IR transmitter and receiver circuit. It is appropriately fixed to the front sides of the car. The car moves along the model track when it is powered on. The rails' status is monitored by the IR sensors. The motor, LDR, and serial transmission are in their earliest stages under typical circumstances. The motor is started in the forward direction when the micro-controller receives power, and messages are sent to the micro-controller using serial communication. The moment the IR sensor detects a fracture, the vehicle stops. The GPS receiver then triangulates the car's position to obtain the Latitude and Longitude coordinates of the vehicle's position from satellites. The microprocessor transforms the Latitude and Longitude coordinates that the GPS receives into a text message. The Wi-Fi Module utilizes IOT to send text messages (Telegram APP).

2.3 ADVANCED AUTOMATIC DETECTION OF CRACKS IN RAILWAY TRACKS

In India, routinely rail transport is crucial in providing the required transit for meeting the demands of a financial sector that is expanding quickly. The world's fourth-largest railway network is currently found in India. Since the majority of actual transit is handled by the railway system, any problem with it has the possibility to substantially disrupt the financial system. There is a way to stop trains from colliding and putting the railways in risk. The methods, which often give rail transport among the unaware public an unjustified reputation for inefficiency and frequently fuel calls for immediate reforms, include the fact that a

security vehicle that travels along a railway at the head of a train failure follow-on in accident generally gets deep media exposure even when the railway is not at fault.

The objective of this paper is to support the railway control's efforts to improve and increase the surveyor equipment required through ongoing protection monitoring.

2.4 IMPLEMENTATION OF RAILWAY CRACK DETECTION AND MONITORING SYSTEM

Finding structural flaws is the challenge with the railway study discussed in this work. India's railway system is the fourth-largest in the world and is entirely manual. This is a highly laborious process that takes a lot of time and labour to inspect and find flaws in the railroad rails. Track-related problems are the main cause of derailments and service interruptions. Greater track damage has been caused by increases in axle loads, vehicle primary yaw suspension stiffness, wheel-rail conicity, and capacity.

This project intends to design an autonomous vehicle that can identify faults in railway tracks using an ultrasonic sensor and a microcontroller. The ultrasonic sensor detects the crack and objects and sends this information to the microcontroller and stops the train immediately. The microcontroller receives the supply in order to function. The microcontroller receives the programming and depending on the program, the controller will operate. A sensor that uses ultrasonic waves to monitor the railroad track will pass the waves before they reach a set distance from the locomotive. When everything is in order, the sensor provides a signal to the microcontroller that is either normal or positive. In this instance, the train will operate normally. The sensor here can detect any faults, such as cracks or other obstructions in the railway path. The microcontroller will get error signals or negative signals from it. The controller sends an error signal, and the supply to the motor driver is cut off. So the train will come to a complete halt. Buzzer will sound an alert when a malfunction is discovered and will also send the loco pilot a signal.

The data is simultaneously transmitted via the transmitter to the nearby station. The computer is attached to the receiving section of the station. Because the type of fault that happened will be displayed, recovering the fault will be simple. After the fault has been fixed, the loco pilot will manually reset the device before starting the train. The circuit explanation of the suggested system, which is given below, is all that comes before the points indicated above.

2.5 REVIEW ON RAILWAY TRACK CRACK DETECTION USING A TRANSMITTER AND RECEIVER

The whole station with an IR transmitter and receiver for measuring railroad track geometry. The purpose of railway crack inspection is to gauge rail safety. The defect information, which comprises the defect level and location data obtained by an embedded GPS receiver, can be wirelessly communicated to a railway safety management centre using a GSM module. Indian railroad has not yet attained the required levels of reliability and safety, according to international norms. Finding structural flaws is the main problem with railway studies.

This study proposes a low-cost approach to the problem of railway track crack detection utilising an IR transmitter and receiver to locate the broken track in order to save many lives. Train derailments can be avoided, and the possibility of loss of human life and economic damage can be reduced, if these inadequacies are not handled at an early stage they might lead to a number of derailments resulting in a heavy loss of life and property. This system's proposed micro-controller is the PIC16F877A. It uses high-speed, low-power CMOS FLASH/EEPROM technology. Additionally, it is a low-cost, simple-to-programmed micro-controller with only 35 instructions. Before starting the rail-way line scan, the robot is programmed to self-calibrate the IR Transmitter and Receiver. After calibration, the onboard GPS module of the robot waits for a certain amount of time before attempting to read the correct geographic place. According to the principle underlying this crack detection, the total quantity of light that reaches the IR receiver is correlated with the intensity of the crack, indicating that the crack intensity is higher when the greatest quantity of light generated by the transmitter reaches the receiver. On one side of the rails, the IR transmitter will

be fastened, and on the other, the IR receiver. When everything is working normally and there are no cracks, the light from the transmitter does not hit the receiver, therefore the set value is low. The value is increased when light from the transmitter strikes the receiver, and the amount by which it is increased will be proportional to the intensity of the incident light.

As a result, a dramatic increase in the value can be seen when light from the transmitter deviates from its course because of the existence of a fracture or a break. This shift in value suggests that the rails have a crack or another kind of structural flaw. We utilize a GPS receiver, whose purpose is to obtain the most recent latitude and longitude data, to determine the device's current location in the event that a crack is found. We use a GSM modem to transmit the information that has been received. The relevant authorities are receiving an SMS with the most recent latitude and longitude information thanks to the GSM module. The PIC16F877A micro-controller has been interfaced with the GSM and GPS modules to create the aforementioned functionality. Four wheels on the robot are propelled by two 12V batteries. The device's portability is made possible by its straightforward and practical design.

2.6 CRACK DETECTION IN RAILWAY TRACKS USING IMAGE PROCESSING

The majority of the time, railroad tracks operate in distant locations where it is impossible to constantly inspect the quality and condition of the tracks manually. This makes the detection of railroad track cracks necessary today. Using an automatic crack detection system, it is necessary to constantly check on the track's overall health. The suggested system is focused on using a MATLAB model to identify cracks in railway tracks using image processing methods.

The Gabor filter is used to measure the fracture depth. As an added benefit, we concentrate on developing a unique model that will use thermal image processing methods to forecast internal cracks. The prediction score and accuracy of the simulated model are good. Here, MATLAB 2017 is utilized to create an algorithm. The suggested framework concentrated on the implementation of a MATLAB model to identify the cracks in the railway track

using image processing methods. The Gabor filter is used to measure the fracture depth. As a bonus, we concentrated on developing a unique model that uses thermal image processing to anticipate interior fissures. In order to analyse and simulate the effective design and implementation of railway track crack detection, MATLAB 2017 is being used. The findings are then shown. The train automatically applies brakes to halt when the ultrasonic sensors, which are installed at the engines, detect an obstruction. The driver is then alerted, and the emergency brake control is activated. If this system was implemented in the railway industry, accidents could be avoided, the site of damage could be automatically reported to the control room, and as it is a fully automated system, it could be utilized in rural regions, saving time and reducing the need for human labor.

2.7 DOUBLE-PROBE ULTRASONIC DETECTION METHOD FOR CRACKS IN STEEL STRUCTURE

The double-probe penetration detection method employs two probes—one sending and one receiving—to measure the strength of the penetrating acoustic signal and identify the degree of the crack's spread within the inspected components.

The words P-wave (for the transmitted wave) and P-wave (for the penetrating wave) refer to the height of the corresponding waves. The ultrasonic pulse from the transmit probe will diffuse into the substance under test. When the wave collides with the imperfection, a portion of it is reflected by the flaw, while the remaining component continues to the receiver probe. Depending on how much of the wave is reflected, the receiving signal will be weaker than it would be in a fault-free situation. The amount of power of the signal that was obtained can be applied to assess the inside breakage propagation signal. P-wave, S-wave, or surface waves can all be used for ultrasonic testing, depending on the characteristics of the object being tested. The usage of S-waves is more appropriate in this experiment.

2.8 A NOVEL PROBE OF DC ELECTROMAGNETIC NDT BASED ON DRAG EFFECT: DESIGN AND APPLICATION IN CRACK CHARACTERIZATION OF HIGH-SPEED MOVING FERROMAGNETIC MATERIAL

A dc electromagnetic NDT based on the drag effect is used to characterise cracks in a high-speed moving magnetic substance once it was successfully built through testing while taking into account the strength and sensitivity of the detecting signal. The measurement uncertainty of a detected signal based on an interface-convolutional technique is then studied and appraised. The analysis showed that the proposed probe can effectively describe the multiple cracks at 20 m/s with a relative error and standard deviation of 10% when the fracture depth is deeper than 1.0 mm. Additionally, the degree of repeatability of the experiment improves with crack depth. Therefore, it is expected that the proposed probe will be able to detect a large number of cracks in magnetic substances that are moving rapidly, such as rotating roller bearings, transmission lines, and railroad tracks.

2.9 ULTRASONIC TESTING FOR DETERMINATION OF INTERNAL FLAWS AND DISCONTINUITIES IN METAL CASTING: A REVIEW

The determination of internal and subsurface fault detection in metal casting is greatly influenced by UT. The qualifying quality of metal-cast objects is strongly related to UT. The melting of the raw material, the pouring of the molten metal, and the solidification are all closely related to the quality of the cast item. Welding, grinding, or machining are all effective methods for fixing surface defects. However, it is believed that ultrasonic testing is more effective than x-ray at identifying internal flaws due to the harmful effects of radiation. Finding the exact location of the issue is the only restriction of using UT. Low frequency probes can only be used to analyse metal casts due to the material's density. High-frequency probes may rather regularly detect flaws inside walls.

2.10 CRACK DETECTION USING LOW-FREQUENCY ULTRASONIC WAVES CAUSED BY LOW DIRECTIVITY AND SCATTERING

The investigations demonstrated that an ultrasonic wave transmitted via a solid-contact interface comprises spectra with significantly lower frequencies in addition to the transmitted fundamental frequency component. The incident

angle affects the low-frequency component's magnitude, which will be used to design a thorough procedure that even inexperienced engineers can use to find cracks. In this study, we concentrated on angles for a novel low-frequency component approach development. Investigating low-frequency spectral properties for the angle between the transmitting and receiving transducers is the goal of this paper.

CHAPTER 3

AIM AND SCOPE OF THE PRESENT INVESTIGATION

3.1 AIM

The goal of this project is to use an Arduino and crack-detection sensor to create an effective and trustworthy crack-detecting system for railroad tracks. The system ought to be able to identify both internal and external railway track cracks and categories them according to how severe they are. The device must be highly sensitive, non-destructive, and capable of seeing cracks of all sizes and forms. The initiative also intends to make the system affordable, simple to operate, and environment-adaptive. By identifying and averting potential accidents brought on by crack development in railway tracks, the system should be suitable for both manual and automated inspection of railroad tracks. It should also be able to significantly increase the safety and dependability of railroad transportation systems. Finally, the project seeks to serve as a foundation for future system enhancements and modifications to better suit the needs of individual users.

3.2 OBJECTIVE

The objective of using crack detection sensors for internal and external crack detection in railway tracks is to ensure the safety and integrity of the tracks, as well as the trains that run on them. Specifically, the objectives of crack detection sensors are:

Early detection of cracks: The crack detection sensors are designed to identify the cracks in the tracks as soon as they occur. This enables the railway authorities to take preventive measures and carry out repairs before the cracks worsen and lead to more serious problems.

Accurate detection: The crack detection sensors are designed to accurately detect the cracks in the tracks, including those that may be difficult to detect visually or through manual inspections. This ensures that even the smallest cracks are detected and addressed promptly.

Efficient monitoring: The crack detection sensors enable efficient monitoring of the tracks, reducing the need for manual inspections and saving time and resources. This also ensures that the tracks are monitored more frequently and consistently, reducing the risk of accidents caused by undetected cracks.

Improved safety: By detecting and addressing cracks in the tracks promptly, the crack detection sensors help to improve the safety of the railway system, reducing the risk of accidents and ensuring that passengers and freight can be transported safely and efficiently.

Overall, the objective of using crack detection sensors for internal and external crack detection in railway tracks is to improve the safety, efficiency, and reliability of the railway system, and to reduce the risk of accidents and delays caused by undetected track defects.

3.3 PROBLEM DEFINITION

The problem addressed in the paper is the need for an accurate and efficient system for detecting cracks in railway tracks, both internally and externally, using crack detection sensors. The traditional methods of manual inspection and visual inspection are time-consuming, labor-intensive, and can be prone to errors, leading to undetected cracks that can compromise the safety of the railway system. Therefore, the paper aims to develop and implement a system that uses crack detection sensors to monitor the tracks continuously and detect any cracks as soon as they occur, enabling timely repairs and maintenance. The system aims to improve the safety, reliability, and efficiency of the railway system by detecting and addressing track defects promptly, reducing the risk of accidents and minimizing disruptions to train services.

3.4 FUTURE SCOPE

There is a lot of room for future advancements and modifications in the suggested fracture detection system for railway tracks using Arduino and a crack detection sensor. The following are some potential future project scopes:

- Machine learning integration: Automatic crack detection and categorization using machine learning techniques can enhance the crack detection system. This can decrease the need for manual intervention and increase the system's accuracy.
- Wireless connectivity: The system has the option of being modified to include wireless connectivity, allowing for remote system monitoring and control. This can be helpful for keeping an eye on railroad tracks in distant or inclement weather places.
- Real-time tracking: The system can be improved further to offer real-time tracking of railroad tracks, allowing for the early identification and prevention of any mishaps.
- Integration with other sensors: System expansion to include additional sensors such as temperature, humidity, and vibration sensors is possible. This can give us more details on the state of the railroad tracks and make the crack detection system more precise.

The proposed crack detection system is a promising technology for raising the safety and dependability of railway transportation systems since it provides a substantial amount of room for future upgrades and modifications.

CHAPTER 4

EXPERIMENTAL SETUP AND METHODOLOGY

4.1 EXPERIMENTAL SETUP

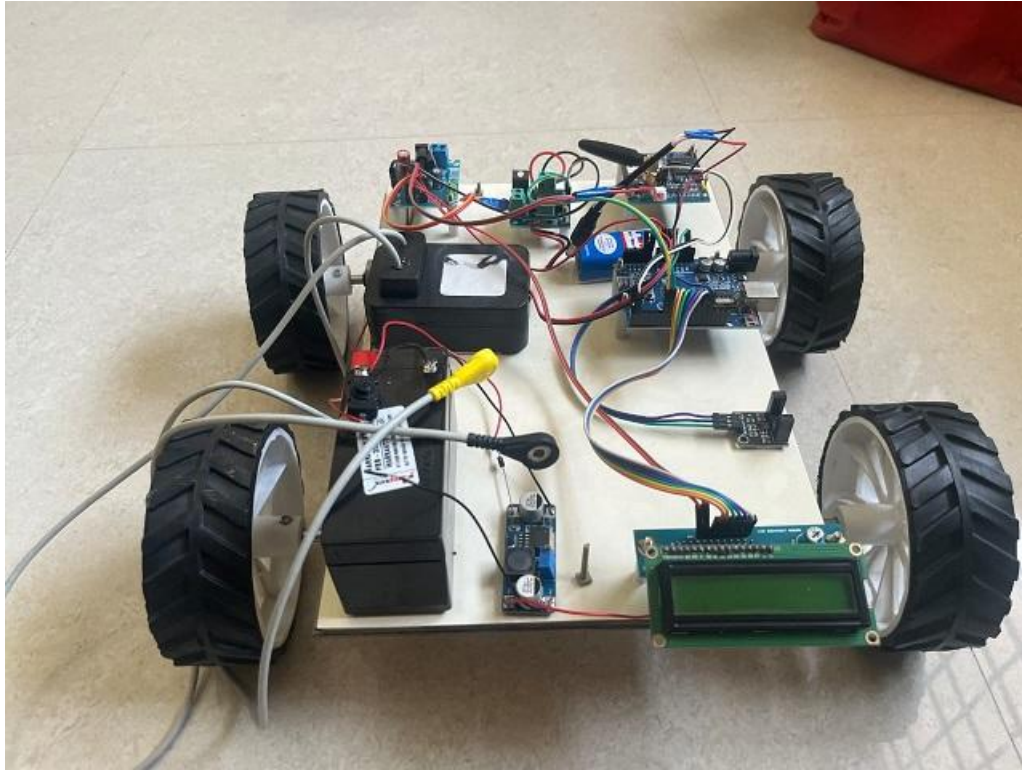


Fig 4.1: Experimental setup

4.2 METHODOLOGY

This method illustrates how sensors can identify a damaged rail line and transmit the problem through SMS to the closest control tower. In this section, we combine the information from two different sensors: an infrared (IR) sensor and a CD (crack detection) sensor. The target is communicated with by CD waves emitted by the CD sensor, which then echo back to the device. If the object is broken, it may take more or less time for the reflected signal to go back to its source.

In order to determine the range of the test, we can use the formula: $\text{test range} = (\text{high-level time} \times \text{sound velocity } (340\text{M/S}) / 2)$. The IR detector is activated primarily by incident light. Both tools are required to adhere to specific norms. Once the

threshold is reached, the check is halted, and the GPS coordinates of the malfunctioning track are transmitted through GSM modulation to the base station. Typically, CD rail check can only be performed at speeds between 20 and 30 mph, limiting its use to testing multiple tracks at once. Furthermore, many of the most important flaws that may emerge in the track head may be very hard to detect with the currently available diagnostic equipment. For modest inspection speeds, the need to couple the transducer and track with liquid or dry coupling components is an argument in favour of classical NDT. Two different CD sensor provisions can be found in the project. components installed on polar opposite sides of the vehicle. If there is a break in the transmission line, this gadget will activate or deactivate the GSM transmission.

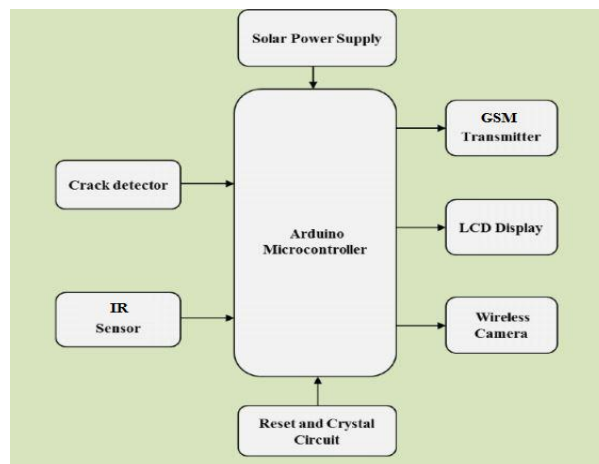


Fig 4.2: Block diagram

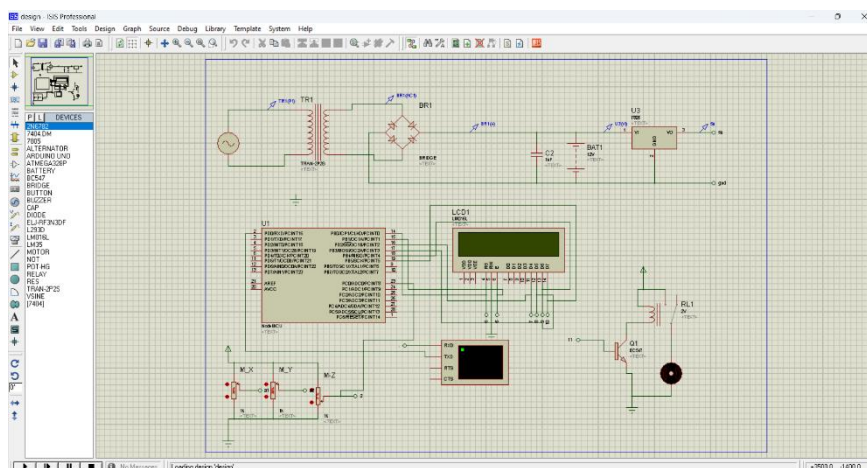


Fig 4.3: Circuit diagram

4.3 MATERIALS AND COMPONENTS

4.3.1 Arduino UNO

Open-source microcontroller board referred to as the Arduino Uno has been created by Arduino cc and initially became available in 2010. It is built around the ATmega328P microprocessor from Microchip. A variety of expansion cards (shields) and other circuits can be interfaced with using the board's collection of digital and analogue input/output (I/O) pins. PWM can be generated using six of the board's fourteen digital I/O pins, six of its digital I/O pins, and six of its analogue I/O pins. It may be programmed using the Arduino Integrated Development Environment (IDE) and type B USB connections. In addition to the voltage range of 7 to 20 volts, it may also be powered by a USB cable or an external 9-volt battery. It has many similarities to the Arduino and Leonardo nano models. The hardware reference design is available for download on the Arduino website under the terms of a Creative Commons Attribution Share-Alike 2.5 licence. Extra layout and production files are included for various hardware revisions. It was decided to use the Italian word "uno," which translates to "one," to indicate that the Arduino Software is now widely available. The first Arduino board that use USB is known as the Uno board. It and the Arduino IDE's version 1.0 served as the basis for further iterations of Arduino. New code may be uploaded to the board's ATmega328 without the use of a third-party hardware programmer thanks to the boot-loader that is presently preinstalled on it.

The Uno stands out from all other boards in that it hyperlinks using the first-generation STK500 protocol but does not use the FTDI USB-to-serial driver chip. Instead, an Atmega16U2 (or Atmega8U2 up to version R2)-based USB-to-serial converter is employed. The popular Arduino Uno microcontroller board is used frequently for electronic project prototype and construction. Depending on the ATmega328P microcontroller chip, it is designed to be simple to use even by individuals with little to no programming or electronics abilities. The Arduino Uno board contains a USB connector for power and programming, as well as 14 digital input and output (I/O) pins and 6 analogue input pins. Additionally, it contains a 16 MHz quartz crystal oscillator that gives the microcontroller accurate timing. The Arduino Uno's adaptability with an assortment of sensors,

modules, and components is one of its differentiating qualities, making it an ideal platform for curiosity and prototyping. It may be used for developing many other projects, including robotics, interactive art exhibits, home automation systems, and much more.

An easy-to-learn programming language based on C++ is used for developing programmes for the Arduino Uno. For developing and uploading code to the board, the integrated development environment for Arduino (IDE) offers a user-friendly interface. Online libraries and examples are widely available, making it simple to get begun and learn. The Arduino Uno is a strong and adaptable tool for anyone interested in discovering more about programming and electronics, in general. It's an excellent selection for both novice and experienced users because to its straightforwardness, low cost, and ability to adapt.



Fig 4.4: Arduino Uno

4.3.2 Ultrasonic Sensor

Ultrasonic transducers and ultrasonic sensors are devices that emit or detect ultrasound energy. They can be classified into three major categories: transceivers, receivers, and transmitters. Transceivers are equipment that can send and receive ultrasounds, as opposed to transmitters and receivers that change electrical signals into ultrasonic and inversely. In many automated manufacturing and processing facilities, ultrasonicsensors can identify targets in motion and determine their distance from the sensor. Sensors can produce an

analogue output proportional to distance or an on-or-off digital output for sensing the movement of objects. As a component of a web guiding system, they are able to detect the material's edge. To help drivers reverse into parking spaces, ultrasonic sensors are frequently employed in automobiles as parking sensors. They are also being tested for a number of other automotive applications, including helping autonomous UAVs navigate and using ultrasonic person detection. Ultrasonic sensors can be used in situations where photoelectric sensors may not be since they sense sound rather than light. For applications where photoelectric failure due to target translucence, such as clear object recognition and liquid level measurement, ultrasound is a fantastic alternative.

Additionally, ultrasonic sensors are unaffected by target colour or reflectivity and can function dependably in conditions with high levels of glare. To find dangerous situations that produce ultrasonic sounds, such as high-pressure gas or liquid leaks, passive ultrasonic sensors may be utilized. These technologies reduce sounds from the transducer (microphone) to a range that is audible to humans. Commercially available ultrasonic cleaning equipment uses high-power ultrasonic emitters. A stainless steel pan with a solvent inside is attached with an ultrasonic transducer (frequently water or isopropanol). The transducer receives an electrical square wave, which generates sound in the solvent that is powerful enough to create cavitation. Numerous cleaning applications have involved the use of ultrasonic technology. Ultrasonic gun cleaning is one that has gained a fair bit of attention during the past ten years. An ultrasonic sensor is a device that uses high-frequency sound waves to detect the distance and presence of objects in its vicinity. These sound waves are inaudible to humans as they operate in the ultrasonic range of frequencies, which is above 20 kHz. Ultrasonic sensors work by emitting a high-frequency sound wave from a transmitter and then detecting the reflected sound waves from an object using a receiver. The time taken for the sound wave to travel to the object and back to the receiver is measured, and this information is used to calculate the distance to the object. The range of ultrasonic sensors can vary from a few centimeters to several meters, depending on the design and specifications of the sensor. They can also operate in various environments, including air, water, and solids, making them versatile for a range of applications.

One of the most common applications of ultrasonic sensors is in distance measurement and obstacle detection. They are often used in robotics and automation for collision avoidance and to ensure accurate positioning of objects. They can also be used for level sensing in tanks and silos, as well as in flow measurement in pipes. Ultrasonic sensors are also used in medical applications, such as imaging and diagnostics. They are used in ultrasound machines to create images of internal organs and tissues, and can also be used for therapeutic purposes, such as breaking up kidney stones. In conclusion, ultrasonic sensors are versatile devices that use high-frequency sound waves to detect the presence and distance of objects. They have a wide range of applications, including distance measurement, obstacle detection, level sensing, and medical imaging. Their ability to operate in various environments and their accuracy make them an essential component in many industrial and scientific settings.



Fig 4.5:Ultrasonic sensor

4.3.3 DC Motor

An electric motor known as a geared DC motor utilises a gearbox to slow down the output shaft's speed and increase its torque. The DC motor unit and the gearbox make up the motor's two main parts. The gearbox lowers the output shaft's speed and boosts torque while the DC motor transforms electrical power into mechanical energy. Due to their straightforward design, low price, and excellent efficiency, direct current (DC) motors are widely employed in an array of applications. A rotor and a stator make up the motor. The moving component of the motor is the rotor, while the stationary component is the stator. The shaft, armature, and commutator constitute the rotor. The armature is a coil of wire that is wrapped around the shaft,

and the commutator is a set of contacts that connect the armature to the power source. When a current flows through the armature, a magnetic field is created, which causes the rotor to rotate. The direction of rotation depends on the direction of the current flow.

DC motors are available in various sizes and power ratings, and can be used in a wide range of applications, including robotics, industrial automation, and automotive systems. However, DC motors have some limitations. They tend to operate at high speeds and low torques, which may not be suitable for some applications. To overcome this limitation, a gearbox is used to reduce the speed of the output shaft and increase the torque. The gearbox consists of a series of gears that mesh together to transmit power from the motor to the output shaft. The gears are arranged in different configurations, such as spur gears, helical gears, and planetary gears, depending on the application requirements. Spur gears are the simplest type of gear and consist of a cylindrical toothed wheel that meshes with another gear to transmit power. They are commonly used in low-speed applications, such as electric drills and screwdrivers. Helical gears are similar to spur gears but have angled teeth that mesh together. They provide smoother operation and are more efficient than spur gears. They are commonly used in high-speed applications, such as machine tools and printing presses. Planetary gears are a complex arrangement of gears that provide high torque and speed reduction. They consist of a sun gear, planet gears, and a ring gear. The sun gear is located at the center of the gearbox and meshes with the planet gears, which are mounted on a carrier. The carrier rotates around the sun gear and meshes with the ring gear to transmit power to the output shaft. The selection of the gearbox configuration depends on the application requirements, such as torque, speed, and efficiency. The torque and speed of the output shaft can be calculated using the following formulas:

$$\text{Torque} = \text{Power} / \text{Speed}$$

$$\text{Speed} = \text{Voltage} / (\text{Current} \times \text{Resistance})$$

Where power is the electrical power supplied to the motor, voltage is the supply voltage, current is the motor current, and resistance is the motor resistance.

The efficiency of the gearbox can be calculated using the following formula:

$$\text{Efficiency} = \text{Output Power} / \text{Input Power}$$

Where output power is the mechanical power delivered to the output shaft, and input power is the electrical power supplied to the motor.

In conclusion, a geared DC motor is a type of electric motor that uses a gearbox to reduce the speed and increase the torque of the output shaft. The selection of the gearbox configuration depends on the application requirements, such as torque, speed, and efficiency. The torque and speed of the output shaft can be calculated using the formulas mentioned above, and the efficiency of the gearbox can be calculated using the efficiency formula. Geared DC motors are widely used in various applications, including robotics, industrial automation, and automotive systems.



Fig 4.6: DC motor

4.3.4 IR Sensor

A passive infrared detector (PIR sensor) is a gadget that detects the infrared (IR) light produced by something in its field of observation. They are used most frequently in PIR-based motion detectors. PIR sensors, which are often used in independent illumination and safety alarm systems, are able to detect general movement but not determine the nature of the object that moved. For that, a camera with an IR sensor is required. The abbreviation for "PIR" or, less frequently, "PID," which means "passive infrared detector," is widely used to refer to PIR sensors. Because PIR devices do not emit energy to detect objects, they are considered as passive devices. The identification of infrared radiation (radiant heat) that emits or reflects from objects is the only way of operation.

The ambient temperature and surface characteristics of whatever is in front of the sensor have an impact on the quantity of infrared light that impinges on it over time. The temperature at that location in the sensor's field of vision will shift from ambient to body temperature when an item, like a human, passes in front of a background, like a wall, and then return to normal. The sensor converts the resulting variation in the entering infrared light into an alteration in its output voltage in order to trigger the detection. Moving objects in relation to the backdrop, as well as objects with similar surface features but distinct infrared emission patterns, all possess the potential to trigger the detector. PIRs can be used for a variety of reasons and come in a variety of configurations. The most common kinds have numerous Fresnel lenses or segments of mirror, a field of view that is less than 180 degrees, and a successful distance of around 10 metres (30 feet). There are types that are frequently intended to be installed on a ceiling and have wider viewing angles, including 360°. Some larger PIRs are made of single-segment mirrors and can detect shifts in infrared light from up to 30 metres (100 feet) away. Furthermore, some PIRs involve changeable orientation mirrors that offer coverage that is either large (110° wide) or extremely small (like a "curtain"), or they have on their own adjustable parts that let you "sculpt" the coverage. A sensor that detects the existence of an object by sending and receiving infrared light is known as an infrared (IR) sensor. A form of electromagnetic radiation known as infrared radiation is invisible to the human eye and has a wavelength that is longer than visible light.

IR sensors are effective for a wide range of applications since they operate on the idea of non-contact detection. An emitter that creates infrared radiation and a receiver that monitors the reflected radiation compose an IR sensor in most cases. The receiver measures the radiation's power, and the presence or missing an object is inferred from this data. IR sensors come in passive and active varieties. Safety devices and motion detectors frequently use passive IR sensors to identify heat emissions from targets that move. Active IR sensors are excellent for measuring distance and detecting objects since they produce their own infrared light and pick up reflected radiation. IR sensors are used in many different industries and professions. They are frequently used in robotics and automation for collision avoidance and obstacle identification. The remote

controllers for televisions, cooling systems, and other electronic gadgets also make use of them. IR sensors are utilized in automobile applications for automatic illumination and rain-sensing wipers.

IR sensors have applications in the medical industry for non-invasive blood flow and body temperature monitoring. They are also utilized in air quality monitoring and gas detection systems. The capacity of IR sensors to operate effectively in dimly lit and dark areas is one of their benefits. Additionally, they are less susceptible to interference from other radiation sources, like as sunlight, which makes them more trustworthy in some applications. However, climatic factors like fog or rain may have an impact on IR sensors. IR sensors are adaptable gadgets that use non-contact infrared radiation detection to detect the movement of objects. They have numerous uses in the sectors of automation, robotics, cars, medicine, and environmental monitoring. They are an essential element in many industrial and scientific contexts due to their dependability and ability to function in situations with limited light.



Fig 4.7: IR sensor

4.3.5 L293d Motor Drive

A triple half-H driver featuring high current is the L293D. It is designed to deliver bidirectional drive currents of up to 600 mA at voltages from 4.5 V to 36 V. Including bipolar and dc stepping motors, solenoids, relays, and other devices, both items are made to drive inductive loads in positive-supply applications. TTL is compatible with all inputs. A full totem pole driving circuit with a pseudo-Darlington source and a Darlington transistor sink exists in each output. Drivers are turned on in pairs; for instance, 1,2EN turns on drivers 1 and 2, while 3,4EN turns on drivers 3 and 4. The linked drivers are activated and their outputs are

active and in phase with their inputs when an enable input is high. These drivers are off and the results are in the high-impedance state when the enable input is low. Each set of drivers creates a full-H (or bridge) reversible drive with the right data inputs, which is ideal for solenoid or motor applications.

The Sun Founder L293D is a monolithic integrated, 4-channel, high voltage, and high current driver. It simply means that you can use DC motors and power supply of up to 16 Volts with the L293D chip, which is additionally referred to as a type of H- Bridge. Although the chip is able to deliver an aggregate current of 600mA per channel, those are some rather big motors. A voltage can frequently be sent across a load in either direction to an output, such as a motor, using an electrical circuit known as an H-Bridge. Robotics and other motor control applications frequently use the L293D, a well-liked H-bridge motor driver IC (integrated circuit). The IC is made to provide bidirectional current flow to the motor coils, which can be utilized for controlling the direction and speed of DC motors or stepper motors. Four half-H bridges on the L293D chip can be set up to regulate two DC motors or one stepper motor.

A control signal from a microcontroller or other logic circuit can be used to independently migrate on and off each half-H bridge's two transistors. The L293D is appropriate for a variety of motors since it can manage a maximum current of 600mA per channel and a voltage range of 4.5V to 36V. Additionally, it contains integrated flyback diodes that guard the chip against voltage spikes caused by the motor coils. The L293D's ability to control the motor speed via PWM (pulse width modulation) signals is one of its major characteristics. The average voltage applied to the motor can be adjusted by changing the PWM signal's duty cycle, allowing smooth and accurate speed control. Robotics projects including mobile robots, robot arms, and motorised vehicles frequently use the L293D. It is also used in various industrial and home automation applications, such as controlling gates, doors, and other moving parts. In addition to its motor control capabilities, the L293D can also be used as a general-purpose switch for other types of loads, such as LEDs, solenoids, and relays. This makes it a versatile component for various electronics projects.

The L293D is available in a variety of package types, including DIP (dual in-line package) and surface-mount packages. It is a cost-effective and reliable solution for motor control applications and is widely used by hobbyists and professionals alike. The L293D is a versatile motor driver IC that allows for precise control of DC motors and stepper motors. Its ability to handle high current and voltage ranges, as well as its built-in flyback diodes and PWM control capabilities, make it a popular choice for robotics and motor control projects. Its versatility also extends to other types of loads, making it a useful component for various electronics projects.



Fig4.8: L293d motor drive module

4.3.6 GSM Module

The Global System for Mobile Communications (GSM) standard was developed by the European Telecommunications Standards Institute (ETSI) to establish the protocols for digital cellular networks of the second generation (2G) used by mobile devices such as smartphones and tablets. The GSM trademark is owned by the GSM Association. Another name for GSM is the Full Rate voice codec. In Finland, it was first used in December 1991. By the middle of the 2010s, it had over 90% of the market share and was in use in more than 193 nations and territories, making it the de facto standard for mobile communications. Second-generation (2G) cellular networks have taken the place of first-generation (1G) analogue networks.

The GSM standard was the first to define a digital, circuit-switched network intended for full duplex voice transmission. The scope of this grew over time to encompass data communications, initially via circuit-switched transport, then via packet data transmission via General Packet Radio Service (GPRS), and lastly via Enhanced Data Rates for GSM Evolution (EDGE). Later, the 3GPP produced the third generation (3G) UMTS standards as well as the fourth generation (4G) LTE Advanced and the fifth generation (5G) standards, which are separate from the ETSI GSM standard. Due to the network's widespread use in Europe, all mobile phones were briefly referred to as "GSM" in France, the Netherlands, Bulgaria, and Belgium. In Belgium, it is still widely used today. In the late 2010s, many carriers all around the world began to decommission their GSM networks. A GSM (Global System for Mobile Communications) module is a hardware device that allows devices to connect to a mobile network and communicate via cellular technology.

GSM modules contain a SIM card slot, allowing devices to access mobile networks and communicate wirelessly over voice, SMS, and data services. GSM modules can be used for a variety of applications, including remote monitoring, data transfer, and location tracking. They are commonly used in Internet of Things (IoT) devices, such as smart home appliances, security systems, and vehicle tracking systems. GSM modules are designed to be easily integrated into electronic devices and can be connected to microcontrollers, microprocessors, or other embedded systems. They can communicate with devices through serial communication protocols, such as UART, SPI, or I2C. GSM modules operate on various frequencies and standards, depending on the region and network provider. They support various data transfer rates, such as GPRS (General Packet Radio Service), EDGE (Enhanced Data rates for GSM Evolution), and HSPA (High-Speed Packet Access), allowing for high-speed data transfer. One of the key advantages of using GSM modules is their ability to operate over long distances, as they are not limited by Wi-Fi or Bluetooth range. They can also be used in areas without Wi-Fi or Ethernet connectivity, making them useful for remote monitoring and control. GSM modules also offer reliable and secure communication, as they use encryption algorithms to protect data transmission.

They can also be used for two-way communication, allowing devices to send and receive data, making them useful for applications such as tracking and remote control. In conclusion, GSM modules are a versatile and reliable solution for wireless communication and data transfer in various applications. They offer long-range connectivity, reliable communication, and secure data transfer, making them useful for IoT devices, remote monitoring, and location tracking systems. Their ease of integration and compatibility with different microcontrollers and communication protocols make them an essential component in many electronic devices.



Fig 4.9: GSM module

4.3.7 GPS Module

The Global Positioning System (GPS), previously Navistar GPS, is a satellite-based radio navigation system that is owned and operated by the US government. Given an unobstructed line of sight to four or more GPS satellites, it is one of the global navigation satellite systems (GNSS) that can locate a GPS receiver anywhere on or near the Earth. Additionally, the time is provided. The usage of these technologies does not necessitate the transmission of any data by the user, nor do they require Internet or phone coverage to function, even if they can increase the use of GPS locating data. It offers vital global locating capabilities to users in the military, government, and commercial sectors.

Although the United States government invented, oversees, and maintains the GPS system, anybody with a GPS receiver is allowed to use it. The GPS project was started in 1973 by the American Department of Defence. The first experimental spacecraft was launched in 1978, and the full 24 satellite constellation began operations in 1993. President Ronald Reagan signed an executive order enabling civilian usage, which had previously only been accessible to the US military, in the wake of the Korean Air Lines Flight 007 tragedy. Due to technical improvements and growing demands placed on the present system (OCX), efforts are now being undertaken to upgrade the GPS and incorporate the upcoming generation of GPS Block IIIA satellites and Next Generation Operational Control System. Through a programme called Selective Availability, the US government started lowering GPS location accuracy in the early 1990s. In 1999, during the Kargil War, the government blocked or restricted the Indian military's access to the system thanks to this programme. However, on May 1, 2000, this practise was banned thanks to a statute that President Bill Clinton signed into effect. As a result, several nations have created new regional or worldwide satellite navigation systems.

The Russian Global Navigation Satellite System (GLONASS), which was created concurrently with GPS, did not entirely cover the globe. When GPS and GLONASS reception are combined, there are more satellites accessible, allowing for quicker location fixes and greater precision down to two metres (6.6 feet). In order to identify a device's position, speed, and time, a GPS (Global Positioning System) module is a device that receives signals from GPS satellites. Numerous applications, including navigation systems, vehicle tracking systems, and location-based services, make extensive use of GPS units. GPS modules consist of a GPS receiver and an antenna. The receiver processes the signals from GPS satellites and calculates the device's location and speed using triangulation techniques. The antenna is used to receive the signals from the GPS satellites and must be positioned in a clear line of sight to the sky for optimal performance. GPS modules can be interfaced with a microcontroller or other embedded systems using various communication protocols, such as UART, SPI, or I2C. The GPS module can provide location and speed data to the microcontroller, allowing for various applications such as navigation, tracking,

and geofencing. One of the key advantages of using a GPS module is its ability to provide accurate and precise location information. GPS modules can provide location information with an accuracy of a few meters or less, depending on the number and quality of satellites in view. GPS modules can also provide real-time tracking information, allowing for the monitoring of moving vehicles, ships, or other mobile assets. This makes GPS modules useful in various applications such as logistics, transportation, and fleet management. GPS modules can also provide time synchronization, which is useful for applications such as network synchronization, data logging, and time-stamping. GPS modules use highly accurate atomic clocks to provide precise time information, making them an essential component in various timing applications. In addition to the GPS module's primary function of location tracking and navigation, some GPS modules also include additional features such as altitude measurement, velocity estimation, and distance calculation.

These features make GPS modules a versatile and powerful tool for various applications. GPS modules are an essential component in various location-based applications. They provide accurate and precise location information, real-time tracking capabilities, and time synchronization features. Their ease of integration with microcontrollers and other embedded systems make them a versatile tool for various projects, from navigation systems to logistics and fleet management applications.



Fig 4.10: GPS module

4.3.8 LCD DISPLAY

A 16x2 LCD (Liquid Crystal Display) is a popular alphanumeric display module that is widely used in electronic projects, industrial equipment, and consumer electronics. It consists of a controller, driver, and character generator. The controller receives data from a microcontroller or other device and converts it into signals that the driver uses to control the display. The character generator provides the characters that can be displayed on the LCD. The 16x2 LCD display has a resolution of 16 characters per line and two lines, for a total of 32 characters. The characters can be letters, numbers, symbols, or other custom characters defined by the user.

The display is usually backlit, making it easy to read in low-light conditions. The LCD module is typically connected to a microcontroller or other device using a set of pins. The specific pinout can vary depending on the manufacturer, but common pins include power (VCC and GND), data (RS, RW, and EN), and backlight (BL). The power pins supply power to the LCD module, while the data pins are used to send commands and data to the module. The backlight pin controls the backlight of the display. To use a 16x2 LCD module in a project, you need to initialize the module and send commands to it. The initialization process usually involves setting the mode, function, and display settings of the module. The mode determines whether the module is in command mode or data mode. The function sets the number of lines and the font size. The display settings control the display on/off, cursor on/off, and cursor blink on/off. After the initialization process, you can start sending data to the module. The data can be text or custom characters that you have defined. To send data to the module, you need to select the data mode, set the cursor position, and then send the data. The cursor position determines where the data is displayed on the module. There are many applications for 16x2 LCD modules, including digital clocks, temperature displays, and message displays. The modules are also used in industrial equipment, such as control panels and data loggers. The versatility and ease of use of the 16x2 LCD module make it a popular choice for hobbyists and professionals alike. When designing a project with a 16x2 LCD module, it is important to consider the power requirements of the module.

The module typically requires a 5V power supply, and the backlight can draw a significant amount of power. It is also important to consider the readability of the display in different lighting conditions. In bright sunlight, the display may be difficult to read, and in low-light conditions, the backlight may be necessary. In summary, a 16x2 LCD module is a widely-used display module that can display 16 characters per line and two lines, for a total of 32 characters. It consists of a controller, driver, and character generator. The module is typically connected to a microcontroller or other device using a set of pins. To use the module, you need to initialize it and send commands and data to it. The module has many applications in various fields, including electronic projects, industrial equipment, and consumer electronics. When designing a project with a 16x2 LCD module, it is important to consider the power requirements and readability of the display.



Fig 4.11: LCD Display

4.3.9 12 BOOST CONVERTER

A 12V boost converter is a type of electrical circuit that raises the output voltage from a 12V DC input voltage. Due to the fact that they step up the input voltage to a greater output voltage, boost converters are sometimes referred to as step-up converters. An inductor and a switching transistor are the two major parts of a boost converter that perform its fundamental function. The inductor is responsible for storing energy when the transistor is on, and releasing it when the transistor is off. This results in a higher voltage output, which can be regulated using additional components such as a feedback control loop. To understand how a

boost converter works, it is important to understand the basic operation of an inductor. An inductor is a passive component that, when a current passes through it, stores energy in a magnetic field. The magnetic field collapses when the current stops flowing, releasing the accumulated energy back into the circuit. In a boost converter, a pulse width modulation (PWM) signal generally controls the switching transistor. The PWM signal operates at a high frequency, often in the tens or hundreds of kilohertz range, turning the transistor on and off. Current passes through the inductor when the transistor is turned on, storing energy in the magnetic field. The inductor releases its stored energy into the output capacitor and load when the transistor is switched off. The duty cycle of the PWM signal controls the boost converter's output voltage. The duty cycle is the proportion of the overall PWM signal duration that the transistor is turned on for. The output voltage rises with increasing duty cycle while falling with decreasing duty cycle.

One important consideration when designing a boost converter is the choice of components. The inductor should be chosen to store enough energy to meet the output voltage and current requirements, while the switching transistor should be chosen to handle the input voltage and current. Capacitors and diodes are also commonly used in boost converter circuits to filter the output voltage and prevent reverse current flow. Another important consideration is the efficiency of the boost converter. Boost converters are typically less efficient than buck converters, which step down the input voltage to a lower output voltage. This is because the boost converter must store and release energy, which results in energy losses due to heat and other factors. To improve efficiency, it is important to choose high-quality components and optimize the design of the circuit. In summary, a 12V boost converter is an electronic circuit that steps up the input voltage to a higher output voltage using an inductor and switching transistor. The output voltage is controlled by a PWM signal, and additional components such as capacitors and diodes are used to filter the output voltage and prevent reverse current flow. When designing a boost converter, it is important to choose high-quality components and optimize the design for efficiency.



Fig 4.12: Boost Converter

4.3.10 POWER SUPPLY MODULE

A DC-DC 12V to 3.3V 5V 12V Power Module Multi Output Voltage Converter is a device that can convert a 12V DC input voltage to multiple output voltages, including 3.3V, 5V, and 12V DC output voltages. This module is commonly used in electronic devices that require multiple voltage levels, such as microcontrollers, sensors, and other digital circuits. The DC-DC 12V to 3.3V 5V 12V Power Module Multi Output Voltage Converter is a type of switching power supply, which uses a high-frequency switching circuit to convert the input voltage to the desired output voltage. The module contains a switching regulator that can efficiently convert the input voltage to the desired output voltage while maintaining high efficiency and low power dissipation. The module typically consists of a transformer, switching regulator, control circuitry, and output filtering components. The transformer is used to step down the input voltage to a lower voltage, which is then rectified and filtered to produce a DC voltage. The switching regulator controls the output voltage by adjusting the duty cycle of the high-frequency switching circuit. The control circuitry is responsible for regulating the output voltage and protecting the module from overvoltage, overcurrent, and short-circuit conditions. The DC-DC 12V to 3.3V 5V 12V Power Module Multi Output Voltage Converter can be used in a wide range of applications, including industrial automation, medical equipment, robotics, and other electronic devices.

The module's multiple output voltages allow it to power multiple devices simultaneously, making it a versatile solution for many applications. The 3.3V output voltage is commonly used to power microcontrollers, sensors, and other digital circuits. The 5V output voltage is commonly used to power logic circuits, such as TTL and CMOS devices. The 12V output voltage is commonly used to power motors, relays, and other electromechanical devices. One of the main advantages of the DC-DC 12V to 3.3V 5V 12V Power Module Multi Output Voltage Converter is its high efficiency. The switching regulator can convert the input voltage to the desired output voltage with minimal power dissipation, resulting in high efficiency and low heat dissipation. This makes the module an excellent choice for battery-powered applications, where power efficiency is critical. Another advantage of the DC-DC 12V to 3.3V 5V 12V Power Module Multi Output Voltage Converter is its compact size. The module's small form factor allows it to be easily integrated into a wide range of electronic devices, making it an ideal solution for space-constrained applications. The module also provides excellent voltage regulation, ensuring that the output voltage remains stable and within a specified range. This makes it an excellent choice for applications that require precise voltage control, such as medical equipment and instrumentation.

When selecting a DC-DC 12V to 3.3V 5V 12V Power Module Multi Output Voltage Converter, it is important to consider the module's specifications, including its input voltage range, output voltage range, output current capacity, and efficiency. It is also important to consider the module's protection features, such as overvoltage, overcurrent, and short-circuit protection, which can help protect the module and the connected devices from damage. In conclusion, the DC-DC 12V to 3.3V 5V 12V Power Module Multi Output Voltage Converter is a versatile and efficient solution for powering multiple electronic devices simultaneously. Its multiple output voltages, high efficiency, and compact size make it an excellent choice for a wide range of applications, including industrial automation, medical equipment, and robotics.



Fig 4.13: Power supply module

4.3.11 SOLAR PANNEL

A device that transforms sunlight into energy is a solar panel, sometimes referred to as a photovoltaic (PV) panel. A bigger solar panel is created by connecting a lot of little solar cells together. Semiconducting materials, such as silicon, are layered inside the cells to create an electric current by absorbing sunlight. Homes and businesses frequently employ solar panels as a sustainable energy source to supply power. Other spacecraft, including satellites, are also powered by them. When photons, or light particles, strike the solar cells, the process of turning sunlight into energy starts. A current is produced when an electron flow results from the photons' knocking electrons out of their atoms. This is known as the photo voltaic effect. Solar panels are designed to absorb as much sunlight as possible, so they are often placed in areas with high levels of solar radiation, such as deserts or on rooftops. They are also designed to be durable, so they can withstand harsh weather conditions.

Solar panels come in two basic varieties: mono-crystalline and poly-crystalline. Poly crystalline panels are created from numerous silicon crystals, while mono crystalline panels are created from a single silicon crystal. Although mono crystalline panels are more costly, they are more effective at converting sunlight into energy. Despite being less effective, poly-crystalline panels are more

cheap. Depending on the available area and the desired output, solar panels can be mounted on the ground or on a roof. Typically, the frames on which the panels are attached are fastened to the surface by bolts or screws. The direct current (DC) produced by the panels is then changed into alternating current (AC), which may be used by homes and businesses, by connecting the frame to an inverter. The size and efficiency of the solar panel, the quantity of sunshine it gets, and the temperature of the surroundings are just a few of the variables that affect how much power is produced by a solar panel. Solar panels should be positioned in regions that are shaded or have adequate air circulation since they are most effective when they are cool. Solar energy can help lessen reliance on fossil fuels since it is clean and renewable. They do not produce any emissions or pollutants, and they require very little maintenance.

However, they do have some drawbacks, including the cost of installation and the fact that they only produce electricity during daylight hours. Despite these drawbacks, the use of solar panels is increasing around the world, as governments and individuals seek to reduce their carbon footprint and adopt more sustainable energy sources. Many countries offer incentives and subsidies for the installation of solar panels, and advancements in technology are making them more efficient and affordable. In conclusion, solar panels are a key component of the renewable energy sector, and their use is likely to continue to grow in the coming years. They offer a clean and sustainable source of electricity that can help reduce carbon emissions and combat climate change. While they do have some limitations, the benefits of solar panels make them a valuable investment for individuals and businesses alike.



Fig 4.14: Solar panel

4.4 PROGRAM CODE

```
#include <LiquidCrystal.h>

LiquidCrystal lcd(8,9,10,11,12,13);

void sendmsgs()
{
  Serial.println("AT+CMGF=1");
  delay(1000);
  Serial.println("AT+CMGS=\"+919787887901\\r\"");
  delay(1000);
  Serial.println("External Crack Detected");
  delay(1000);
  Serial.println("https://www.latlong.net/c/?lat=12.8713&long=80.2224");
  delay(1000);
  Serial.println((char)26);
  delay(4000);
}

int count =0;

void setup()
{
  lcd.begin(16, 2);
  lcd.setCursor(0, 1);lcd.print("Smart Railway");
  delay(1500);
  lcd.clear();
  Serial.begin(9600);
  pinMode(6,OUTPUT);pinMode(7,OUTPUT);
```

```
digitalWrite(6,1);digitalWrite(7,1);  
}
```

```
void loop()  
{  
  int Cr=analogRead(A0);  
  lcd.setCursor(0,0);lcd.print("LCD :");lcd.print(Cr);
```

```
  int Cr1=analogRead(A1);  
  lcd.setCursor(0,1);lcd.print("OCD :");lcd.print(Cr1);
```

```
  if(Cr<900)  
  {  
    digitalWrite(6,0);digitalWrite(7,0);  
    Serial.println("AT+CMGF=1");  
    delay(1000);  
    Serial.println("AT+CMGS=\"" +919787887901"\"r");  
    delay(1000);  
    Serial.println("Internal Crack Detected");  
    delay(1000);  
    Serial.println("https://www.latlong.net/c/?lat=12.8713&long=80.2224");  
    delay(3000);  
    Serial.println((char)26);  
    delay(4000);  
    digitalWrite(6,1);digitalWrite(7,1);  
  }
```

```
if(Cr1<900)
{
    count =count+1;
    lcd.setCursor(14,1);lcd.print(count);
    if(count>10)
    {
        digitalWrite(6,0);digitalWrite(7,0);
        sendmsgs();
        count =0;
        digitalWrite(6,1);digitalWrite(7,1);
    }
    delay(500);
}
delay(1000);
lcd.clear();
}
```

RESULTS AND DISCUSSION

5.1 RESULTS

The suggested fracture detection system for railroad tracks that uses an Arduino and a crack detection sensor has been successfully tested on actual railroad tracks. The outcomes of the tests demonstrate that the system is capable of identifying and categorizing interior and external railway track cracks according to their severity. The technology is highly sensitive, non-destructive, and capable of spotting cracks of all sizes and forms. The system's crack-detecting sensor is a piezoelectric sensor, which produces an electrical signal in response to mechanical stress. Arduino is then used to process the signal produced by the sensor, and an algorithm is used to find and categorize the cracks. The system uses a set of predetermined thresholds to distinguish between sound and broken railroad rails. The technology was put to the test on model railroad lines, and the outcomes were compared to expert eye examinations. The findings demonstrate that the system is capable of accurately classifying cracks based on their severity and detecting fissures that are invisible to the unaided eye. The system's exceptional sensitivity is demonstrated by the fact that it can also find cracks that optical inspections miss.

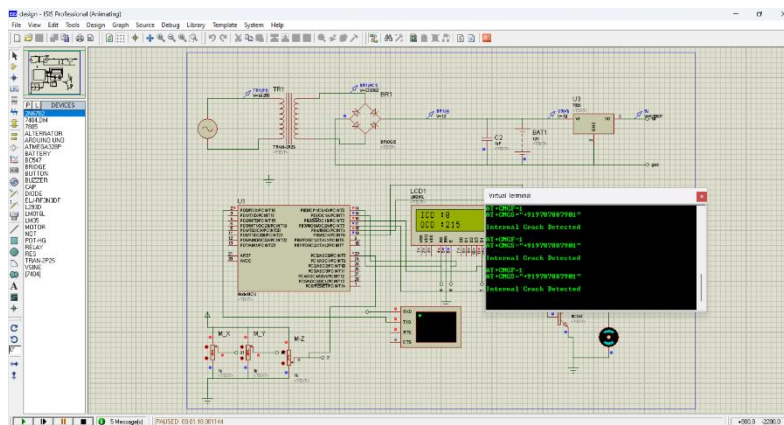


Fig 5.1: Simulation result of the circuit

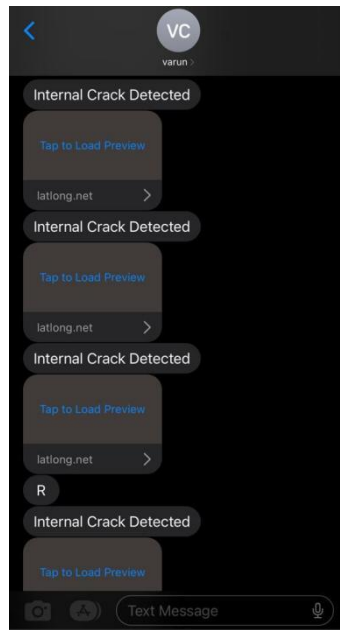


Fig 5.2: SMS Received From the Robot

5.2 DISCUSSION

This system is affordable, simple to use, and environment-adaptive thanks to the usage of Arduino in it. The system is simple to install on already-existing railway tracks, and it is simple to transfer the data it collects to a computer or cloud-based service for analysis and monitoring.

Overall, the suggested fracture detection system for railway tracks, which makes use of an Arduino and a crack detection sensor, is a potential technological advancement for raising the security and dependability of rail transportation networks. After tests on actual railway lines, the system has proven to be functional, and there is a lot of room for future enhancements and modifications.

CHAPTER – 6

SUMMARY AND CONCLUSION

6.1 SUMMARY

The system has been successfully implemented and tested on simulation software and model railway tracks, and the results show that the system is highly accurate and sensitive, capable of detecting cracks that are not visible to the naked eye. After several tests we found that this system has quick response time and lower power usage. This model is included with solar pannel for auto battery recharge so, there will not be any power shortage. This model is made environmental friendly so, there will not be any harm for the The Eco-system and any livingthings. use of Arduino in the system makes it cost-effective, easy to use, and adaptable to different environments. The system has significant potential for future improvements and adaptations, including integration with machine learning, wireless connectivity, real-time monitoring, integration with maintenance systems, and integration with other sensors.

In summary, the proposed crack detection system is a promising technology for enhancing the safety and reliability of railway transportation systems. The system can significantly improve the detection and prevention of potential accidents caused by crack development in railway tracks and has the potential to be widely implemented and further developed to meet specific user needs.

6.2 CONCLUSION

If there are surface flaws or obstacles, the approach can find them. The suggested method has numerous advantages over current detection methods, such as reduced overhead and energy savings, a reliable detection system that doesn't require human involvement, and quicker analysis times. The major advantages of this model is, it is very compact and easy to carry multiple places. It has high response time so the work can be done faster.

By employing this prototype to prevent railway collisions and derailments, many lives can be saved. Also, it is useful for testing equipment on trains by putting it through its paces. You can observe the system failure and position failure in action since information about your current location is sent to your phone's default number. The outcome demonstrates that this cutting-edge technology will further enhance the effectiveness of train infrastructure safety features. Incorporating these features into a running system can reduce accidents by as much as 70 percent. This vehicle makes it easy to do tests in places where humans would struggle, such as shallow coalmines, mountainous locations, Higher region bridges, and regions with thick and deep forests. If the vehicle's sensors identify fractures or irregularities during railway inspections, an SMS will be delivered automatically to a specified mobile number. This will ensure the railway lines are managed and controlled in a reliable manner, ensuring their continued good condition.

REFERENCE

- [1] *"Automated Crack Detection of Railway Track"* Aniket Chakraborty¹, Shyamsundar Banerjee¹, Soutrik Karmakar¹, Koushik Das¹, Susmita Das²
- [2] *"Automatic Railway Track Crack Detection Using IR Sensor"* Dr Nanda Kishore, Asst. Professor Ruhejadhav J2Aishwarya K S V, Pallavi M
- [3] *"Advanced Automatic Detection of Cracks in Railway Tracks"* B. S. Sathish; P. Ganesan; A. Ranganayakulu; Sanjay S. Dola; S. Jagan Mohan Rao
- [4] *"Implementation Of Railway Crack Detection And Monitoring System"* V. Elanangai
- [5] *"Review on railway track crack detection using a transmitter and receiver"* Rakesh V. Pise¹, Parag D. Nikhar², Prof. Avinash H. Shelar³
- [6] *"Crack Detection in Railway Tracks using Image Processing"* Mr Balasubramanian S¹, Pooja Rajagopal², S. Smrithi³, Yaashine Sree M
- [7] *"Double-Probe Ultrasonic Detection Method for Cracks in Steel Structure"* Xin Chen, Zhi Ye *, Jun Yuan Xia, Jie Xiu Wang and Bo Hai Ji
- [8] *"A Novel Probe of DC Electromagnetic NDT Based on Drag Effect: Design and Application in Crack Characterization of High-Speed Moving Ferromagnetic Material"* Fei Yuan, Yating Yu, Member, IEEE, Wei Wang, and Guiyun Tian
- [9] *"Ultrasonic Testing For Determination Internal Flaws And Discontinuities In Metal Casting: A Review"* Chirag Jadav ^{1,2*} and Shailesh Patel³
- [10] *"Crack Detection Using Low-frequency Ultrasonic Waves Caused by Low Directivity and Scattering"* Shingo Onodera, Yuji Kato and Toshihiko Sugiura, School of Integrated Design Engineering, Keio University, Japan
- [11] X. Hu, J. Lu, Y. Zhang, S. Tan, B. Li and J. Zhang, "Research on Delamination Failure of Insulator in Electromagnetic Rail Launcher," in IEEE Transactions on Plasma Science, vol. 50, no. 12, pp. 4987-4995, Dec. 2022.
- [12] H. Li et al., "Dynamic Rail Near-Surface Inspection of Multiphysical Coupled Electromagnetic and Thermography Sensing System," in IEEE Transactions on Instrumentation and Measurement, vol. 72, pp. 1-13, 2023, Art no. 3501613.
- [13] Y. Zhou, "Image Recognition Algorithm of Complex Cracks in Metro Tunnel based on Neural Network," 2022 IEEE 2nd International Conference on Electronic Technology, Communication and Information (ICETCI), Changchun, China, 2022, pp. 1109-1119.

- [14] Z. Sun, J. Lu and J. Sun, "Ultrasonic System Design of Multi-Machine Parallel Processing Suitable for Online Flaw Detection of Railway Wheels," 2022 IEEE 13th Annual Information Technology, Electronics and Mobile Communication Conference (IEMCON), Vancouver, BC, Canada, 2022, pp. 0331-0337.
- [15] X. Liao, B. Zhang and S. Wu, "Monitoring of Ground Deformation Along Shenzhen Metro System with Sentinel-1A SAR Imagery," IGARSS 2022 - 2022 IEEE International Geoscience and Remote Sensing Symposium, Kuala Lumpur, Malaysia, 2022, pp. 2943-2946.
- [16] E. Y. Puzina, I. A. Khudonogov and E. Y. Dulsky, "Zonal Peculiarities of Operating Traction Rolling Stock's Electrical Machines at the East Siberian Rail Road," 2022 International Conference on Industrial Engineering, Applications and Manufacturing (ICIEAM), Sochi, Russian Federation, 2022, pp. 456-460.
- [17] L. U. Daura and G. Y. Tian, "Characterization of Angular RCF Cracks in a Railway Using Modified Topology of WPT-Based Eddy Current Testing," in IEEE Transactions on Industrial Informatics, 2022.
- [18] R. Paul, N. M, N. Sagar, V. Nair and Y. Ps, "A Swarm-based AI Aided Wheel Bot System to Detect Cracks in Railway Tracks," 2022 Sixth International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), Dharan, Nepal, 2022, pp. 678-685.
- [19] Y. Chang, Q. Hao, X. Hu, X. Zhang and Y. Shen, "Rail Fatigue Crack Classification by WSCNN-GRU using Acoustic Emission," 2022 41st Chinese Control Conference (CCC), Hefei, China, 2022, pp. 3901-3906.
- [20] S. -M. Xue, S. Zhou, X. Wang, X. -H. Zeng and Z. -Q. Liu, "Microstructure coarsening of high-temperature Sn-Pb solder joint in IGBT modules of high-speed trains," 2022 23rd International Conference on Electronic Packaging Technology (ICEPT), Dalian, China, 2022, pp. 1-4.
- [21] S. Rakshit, S. BS and E. F. S. S, "Railway Track Fault Detection using Deep Neural Networks," 2022 IEEE 6th Conference on Information and Communication Technology (CICT), Gwalior, India, 2022, pp. 1-5.
- [22] S. Meng, S. Kuang, Z. Ma and Y. Wu, "MtlrNet: An Effective Deep Multitask Learning Architecture for Rail Crack Detection," in IEEE Transactions on Instrumentation and Measurement, vol. 71, pp. 1-10, 2022, Art no. 5014210.
- [23] Y. Li, Z. Liu, Y. Zheng, X. Guo, W. Yuan and P. Zhao, "Transverse Crack Detection of Rail Base Considering Wedge-Like Structure and Using a Bulk-Wave

Electromagnetic Acoustic Transducer," in IEEE Transactions on Instrumentation and Measurement, vol. 71, pp. 1-9, 2022, Art no. 6002009.

[24] X. Ni, H. Liu, Z. Ma, C. Wang and J. Liu, "Detection for Rail Surface Defects via Partitioned Edge Feature," in IEEE Transactions on Intelligent Transportation Systems, vol. 23, no. 6, pp. 5806-5822, June 2022.

[25] Y. Song, L. Huang, P. Xu and M. Wan, "Real-Time Rail Fault Diagnosis Based on Vibration Signal Analysis and Second-Order Sinusoidal Model," in IEEE Sensors Journal, vol. 22, no. 4, pp. 3382-3396, 15 Feb.15, 2022.

ANNEXURE

- Submitted the 1st review paper titled “INTERNAL AND EXTERNAL CRACK DETECTION ON RAILWAY TRACK -A SYSTEMATIC LITERATURE REVIEW” for ICRDME-2023 on 2nd February 2023.
- Presented the 1st paper in ICRDME-2023 on 3rd March 2023.
- 1ST paper under scrutiny for Journal publication.
- Submitted the 2nd research paper titled “INTERNAL AND EXTERNAL CRACK DETECTION ON RAILWAY TRACK” for ICDTM sastra on 28th February 2023.
- Presented the 2nd paper in ICDTM sastra on 7th April 2023.
- 2nd paper under scrutiny for Journal publication