Railway Track Defect Monitoring Based on IoT

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Abstract -One of the most economical and energy-efficient means of transit is rail. A reliable and safe train operation depends on regular railway track heath inspections. The safe operation of train transportation is seriously threatened by postponed inquiries and issue findings. The conventional technique of physically scrutinizing the train track using a railway cart is both inefficient and prone to mistakes and biasness. Automating inspection is essential to prevent disasters and save countless lives, especially in areas with a high rate of train accidents. In order to improve the current railway carriage system and solve the aforementioned problems, this study creates an Internet of Things (IoT)-based automated railway track defect detection method. In order to prevent mishaps, fishplate joint monitoring is crucial in the train communication system. Derailments of trains from the track are typically the cause of rail mishaps. Losing track alignment because of loose fishplates is one of the main causes of train accidents. In order to guarantee train safety and security, it is necessary to watch rail alignment and fishplate bolt location. An IOT-based real-time railway fishplate surveillance device is suggested in this article. Every fishplate is monitored for position and vibration by the planned system, which also notifies local stations, incoming train drivers, and a central railway tracking centre if any bolts become loose.This device uses IOT connectivity and can function in locations with at least 2G cellular coverage. With the aid of sensors, an embedded system locates the flaw position and issues a warning as soon as a defect is found. Comparatively, the suggested method is much less expensive. Additionally, the findings of a simulation-based warning accuracy test for the system demonstrate high accuracy, demonstrating its efficacy. The likelihood and frequency of accidents are anticipated to be greatly decreased by this system.

Keywords: Arduino UNO BoardArduino UNO Board, ATmega328 Microcontroller, Internet of Things (IOT), ESP8266 NODEMCU Wi-Fi Dev kit, Tilt Sensor, Optical position Sensor, Vibration Sensor, Buzzer.

I. INTRODUCTION

One of the main forms of transit is the rail system. Both the scope of rail transportation and the number of trains is ever growing with the increasing necessity of transportation for people and products. With this increase, railroad mishaps have gained significant attention. According to statistics made public by the Indian Railway Department of Transportation, derailments caused nearly 67572 train accidents nationwide between 1975 and 2019 that resulted in 140 fatalities and 6172 injuries. Therefore, ensuring safety and security is essential to improving the dependability of the rail transportation system. The inspection of fishplates is one of the key safeguards for the safety of the railways.One of the most popular kinds of rail connectors is rail fishplate, also known as rail joint bars. A fishplate, which can be a tiny copper or nickel-plated plate, is frequently used in train transit simulations to keep alignment and electrical continuity. When the device is bolted into position, the top and bottom sides of the device wedge themselves between the top and bottom of the rail. Fishplate detachment on a railroad can result in a serious mishap and many fatalities. Therefore, keeping an eye on railroad fishplates is essential for maintaining track alignment and preventing derailing.But physically inspecting each and every fishplate of the railway system on a daily basis would take a lot of time and money. So, an automatic system which can check the state of the fishplates frequently can decreased the number of mishaps due to derailment.

II. LITERATURESURVEY

a) *IoT-Based Automated Crack and Object Identifier Vehicle for Railway System.* (2022)

Author name : Tareq Anwar Shikdar, Fahad Bin Ayub, Sekh Faisal & Md. Moontasir Rashid

This study focuses on the fracture and object detection of train tracks in order to ensure secure rail transit in Bangladesh and to lessen derailments that result from track cracks. The "Crack and object Identifier Vehicle," an IoT-based solar-powered automated crack and object detection vehicle, is suggested to find train line fractures and give the station master the locations. As the car inspects the rail lines using an image processing technique with an ESP32 CAM as well as an IR sensor, an ultrasonic sensor, and NPN proximity sensors, it looks for cracks and other elements that could lead to rail line derailments.A specialized application is created to watch the train tracks and send the authority the coordinates of the location of any cracks and objects discovered. Additionally, the location's details are sent via SMS to the station manager using GSM and GPS devices. In this study, an automated fissure and object identifier vehicle is suggested for locating fractures and obstructions in the railway track. This vehicle can assist in reducing rail mishaps, particularly in nations with inadequate rail infrastructure.

b) *Railway Track-Crack Detection System by using Arduino Microcontroller (2021)*

Authors : N L Bhojwani, A S Ansari, S SJirge&M B Baviskar

The simplest and most practical form of long-distance and suburban traffic as well as passenger transit in India is provided by railroads. In India, the train network handles almost 80% of all transportation. Rail track crossings and unidentified cracks in rail tracks are the primary causes of accidents that occur on railways. About 60% of mishaps occur at railroad crossings and are caused by a crack in the tracks, costing commuters their lives and their money.This project discusses a Railway track crack detection using sensors and is a dynamic approach that combines the use of GPS tracking system and GSM module to send alert messages and the geographical coordinate of location. As a result, there is a need for new technology that will be reliable, effective, and stable for both crack detection in railway track as well as object detection. This device's operations are managed and coordinated by an Arduino Microcontroller.

c) *A Survey on Crack Detection Technique in Railway Track (2018)*

Authors : Maneesh Kumar M.; Muthu S. Murali; M. Saranya; S. Arun; R.P. Jayakrishnan.

As you may already be aware, the majority of people use rail transportation because it is a quick and affordable mode of transportation. Due to some minor failures such as track failures, obstacles and improper maintenances causes accidents. It is possible to conduct thorough rail inspections to make it safe. For improved security and inspections, a crack detection system must be effective. But it requires skilled people stroll through the route for inspection. It requires much effort. A visual inspection system (VIS) is proposed as a solution to these problems. We suggest a visual fracture identification system that offers more precise results than other systems currently in use.It makes the processes smooth and quick. A digital scan line camera is used by this device to record the images. VIS offers improved functionality and clarity depending on the capturing instrument. Using the Otsu technique for analysis, the picture contrast can be improved, and any cracks in the track are then found. To reduce the chance of accidents, this technology instantly detects cracks and generates the necessary warnings to the closest station. While it is in operation, this device doesn't interfere with the operation of the railway.

III. PROPOSEDSYSTEM

The proposed system's schematic layout, in which the proposed gadget is connected to a railroad fishplate, is shown in the above figure. Information about the state of the fishplate is gathered by the gadget and sent via IOT module to a cellular base station. Information is transmitted from the base station to the central control

center, a nearby stop, and a nearby train. (if necessary).

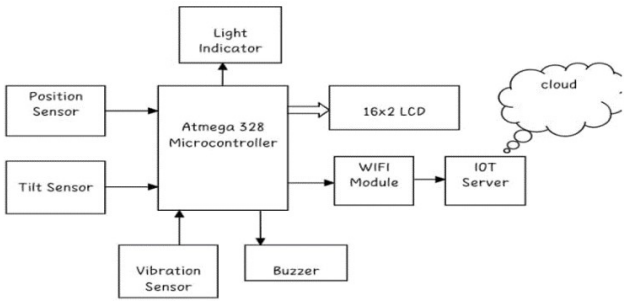


Fig 1 Proposed block diagram

The total process is divided into four different tasks,

1. Position Detection by Sensor:

The location of the bolts holding the fishplates to the rail is detected by the suggested method. The devices use appropriate sensors, piezoelectric sensors, load sensors, etc. to measure vibration on railroad lines. The microprocessor used in this instance, an Arduino Uno, processes the sensor data.

2. Data Processing by Embedded System:

This microprocessor processes the data obtained from the sensors, continuously analyses the information, and shows the most recent measurement in an LCD module so that the user can see the location of the fishplate at the moment. This microprocessor can keep an eye on more than five railroad fishplates simultaneously in this case. Each fishplate has a distinct address, making it simple to identify a defective plate.

3. IOT Communication to a Remote Server:

If the microcontroller detects a data error, it transmits the information right away to the server—which is located with the train department—via a WIFI Modem. It will be simpler for officials to locate the damaged fishplate with the help of the area number and plate location. If there is a chance of an accident, this information is relayed to the adjacent train conductor.

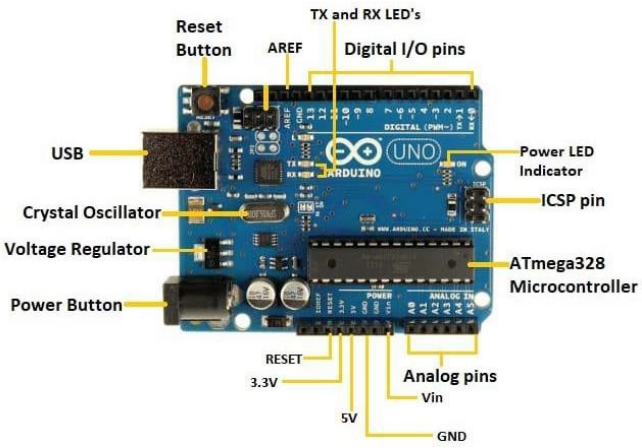
4. Warning System:

A buzzer that emits a caution sound is used to issue a notice in an emergency scenario so that officials can focus on the problem first.

HARDWARE DESCRIPTION

a) ARDUNIO UNO BOARD

An example of an ATmega328-based microprocessor device is the Arduino Uno, which is named after the Italian word for one, uno. A power port, six analogue inputs, a crystal oscillator operating at 16 MHz, a USB on link, a RST switch, and ICSP header pins are all present on this board. It also has 14 digital I/O pins.The microprocessor device can be connected to a computer to perform all of these functions. This board's power source can be provided by a battery, a USB cable, or a to DC



converter.

Fig 2 Arduino uno board

Features:

- ✓ It's a simple USB link. This makes interface with USB and acts like a serial device.
- ✓ The chip on the device inserts into a USB socket and functions as a virtual serial connection on your computer. The benefit of this configuration is that USB enables connection with contemporary computers and makes it convenient. Serial transmission is a very simple protocol that has stood the proof of time.
- ✓ The ATmega328 processor, the centre of the microcontroller, is easily accessible. More hardware features, such as timers, internal interrupts, PWM pins, and different sleep modes, are present.
- ✓ It is an open source design and there is an advantage of being open source is that it has a large community of people using and troubleshooting it. Developers can easily debug projects using this option.
- ✓ It is a 16 MHz clock which is fast enough for most applications.
- ✓ It is very convenient to manage power inside it and it had a feature of built-in voltage regulation. Without using any additional power, the board can also be charged straight from a USB port. A 12 volt external power source can be connected, and the board's regulators will regulate it to 5 and 3.3 volts.
- ✓ It has 13 digital ports and 6 analogue wires. These ports enable additional hardware connections to the Arduino Uno board. These wires are used as ports to increase the Arduino Uno's capacity to interface with the outside world. Simply insert the sockets for the electrical gadgets and sensors into each of these connections.
- ✓ If the chip becomes defective and can no longer be used by your computer, you must re-boot install it using the ICSP, which serves as a port.
- ✓ It has a 32 KB flash cache that is used to store the code.

Characteristics:

Power Supply :A USB cable or an external power source is used to provide electricity to the Arduino Uno device. The most common external power source is a DC converter, but batteries are also used. The Arduino Uno board's power connector is used to connect the power adaptor to the Arduino board. Similarly, the battery is attached to the Vin pin and the GND port of the POWER connection. The recommended working voltage range will be 6 volts to 12 volts.

Input &Output: 14 digital ports on the Arduino uno chip can be used for input and output. For this, the methods pin Mode (), digital write (), and digital read () are utilised.

PWM Pins (3, 5, 6, 9, 10, & 11): By recording the function analogue Write, this port provides an 8-bit PWM output. ().

SPI Pins (Pin-10 (SS), Pin-11 (MOSI), Pin-12 (MISO), Pin-13 (SCK): The SPI protocol is used with these ports.

LED (Pin-13): Pin 13 is linked to the built-in LED. (Digital pin). The LED is off whenever the pin has a HIGH value, and on whenever the pin has a low value.

I2C (SCL) Pin-4 (SDA) & Pin-5: With the aid of the Wire library, it enables contact using the Two Wire Interface.

AREF (Reference Voltage): The analogue inputs with the function analogue Reference require a reference voltage. ().

Reset Pin: This pin is used to restart the microprocessor, which causes the programme to begin at stage one.

Memory: This Atmega328 Arduino microprocessor has 32 KB of flash memory, 2 KB of SRAM, and 1 KB of EEPROM for code storage.

APPLICATIONS

The applications of Arduino board include the following

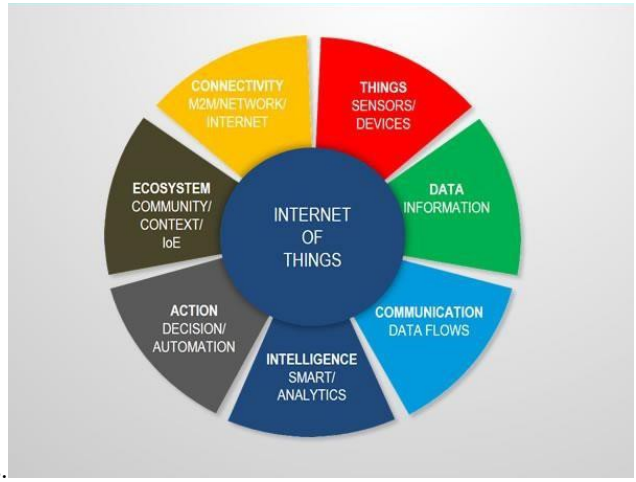
- ✓ It is utilised for testing and Do-It-Yourself tasks.
- ✓ It is utilised to create programmes for code-based management,
- ✓ Automated systems, such as tank level controllers,
- ✓ New circuit designing.

b) INTERNET OF THINGS(IOT)

The Internet of Things (IoT) is a network of connected computing devices, mechanical and digital tools, items, animals, or people that can exchange data over a network without the need for human-to-human or human-to-computer contact.

These objects can communicate and share data thanks to a network of tangible objects, including machines, cars, household appliances, and other things that are equipped with electronics, software, sensors, actuators, and network connectivity. Each object has an integrated processing system that makes it individually recognizable, but they can all work together within the current Internet infrastructure. By 2020, the IoT is expected to contain about 30 billion items, according to experts. Additionally, it is predicted that by 2020, the IoT industry will be worth $7.1 trillion globally. A more direct integration of the physical world into computer-based systems is made possible by the Internet of Things (IoT), which also reduces the need for human intervention while improving efficiency, accuracy, and economic benefit. IoT becomes a member of

the broader category of cyber-physical systems when it is enhanced with sensors and actuators. This category also includes smart networks, virtual power plants, smart homes, intelligent transit systems, and smart communities. In the context of the Internet of Things, "things" can refer to a wide range of gadgets, including heart-monitoring implants, biochip transponders on farm animals, cameras streaming live feeds of wild animals in coastal waters, cars with built-in sensors, DNA analysis devices for monitoring environmental, food, and pathogen contamination, or field operation gadgets that help firefighters in search and rescue operations. Consider "things" as a "inextricable mixture of hardware, software, data, and service," according to legal experts. Utilizing a variety of current technologies, these devices gather valuable data



And then independently transfer it to other devices.

Fig 3IOT Characteristics

There are 7 crucial Internet of Things characteristics:

Connectivity.There isn't much more to be said about this. Devices and instruments require connections to things, each other, controllers, processes, "the Internet," or another network, among other things.

Things. Anything that can be identified or linked is intended to be linked. Tagged animals and domestic equipment to sensors. Sensors may be built into gadgets or affixed to other objects or devices.

Data. The Internet of Things is held together by data, which also serves as the foundation for insight and action.

Communication. Devices link so that they can exchange data, which can then be analysed.

Intelligence. The element of intellect found in IoT devices' sensing skills and the information learned from data analytics (also artificial intelligence).

Action. As a result of intellect. This can involve human action, action based on deliberations about phenomena (for example, choices regarding climate change), and automation, which is frequently the most crucial component.

Ecosystem. The place of the Internet of Things from a perspective of other technologies, communities, goals and the picture in which the Internet of Things fits.

APPLICATION

Helping the aged and disabled is one of the main uses of the smart house. These house automation systems make special accommodations for a user's impairments using assistive technology. Users who are blind or have mobility issues can benefit from voice control, and hearing-impaired users who wear Cochlear implants can immediately link warning systems to their devices. They can also have extra safety measures installed. Sensors that keep an eye out for medical crises like falls or seizures can be one of these characteristics. This application of smart home technology can give people more independence and a better quality of life.

c) *PROGRAMMING*

You can use the Arduino to programme the Arduino Uno by selecting it from the Tools > Board menu. (According to the microcontroller on your board). See the manual and lessons for more information. The bootloader that arrives preburned on the Arduino Uno's ATmega328 enables you to transfer new code to it without the need for an external hardware driver. It communicates using the original STK500 protocol you can also bypass the bootloader and programme the microcontroller through the ICSP (In -Circuit Serial Programming) header; The ATmega16U2 (or 8U2 in the rev1 and rev2 boards) firmware source code is available. The ATmega16U2 /8U2 is equipped with a DFU boot loader, which can be enabled by:

- Resetting the 8U2 after attaching the copper jumper on the bottom of Rev1 PCBs.
- The 8U2/16U2 HWB line is pulled to earth by a resistor on Rev2 or later devices, making it simpler to enter DFU mode.

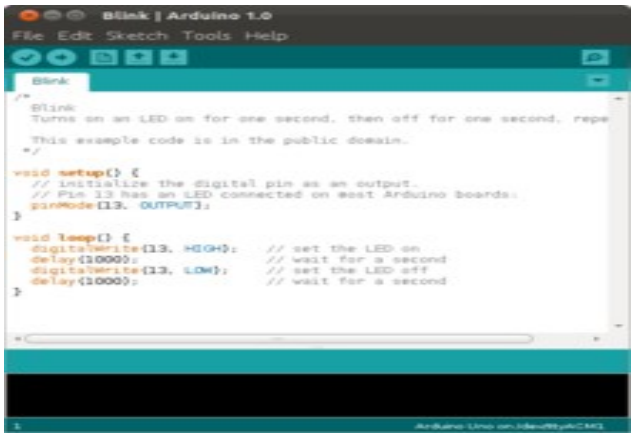


Fig 4 Arduino software

Developer(s)	Arduino Software
Stable release	1.0.5 / May 15, 2013
Preview release	1.5.4 Beta / September 10, 2013
Written in	Java, C and C++
Operating system	Cross-platform
Type	Integrated development environment
License	LGPL or GPL license
Website	arduino.cc

d) *ESP8266 NODEMCU WIFI DEVKIT*

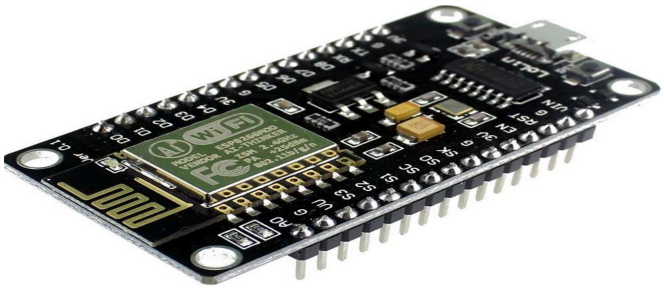


Fig 5 NodeMCU Board

The microcontroller known as the ESP8266 was created by Espressif Systems. The ESP8266 is a self-contained Wi-Fi networking system that can execute standalone programmes and serves as a gateway between Wi-Fi and pre-existing microcontrollers. This gadget includes a built-in USB connection as well as a wide range of pin-outs. Similar to Arduino, you can easily flash the NodeMCU devkit by connecting it to your PC with a microUSBconnection. Additionally, it is right away breadboard compatible.

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e) LCD Display

Liquid crystal, or LCD, is an output device with a constrained viewing range. Because it is more affordable to use and performs better with alphabets than a 7-segment LED monitor, LCD was chosen as the output device. There are many different types of LCDs available today, but for our purpose we need one with two lines and 16 characters per line, which receives data from the microcontroller and shows it. It has a supply voltage Vcc (+5v), a GND, 3 control lines, 8 data lines, and 8 data lines. By displaying the remaining card balance, this makes the entire device user-friendly. This also shows which card is in use right now.The LCD has gained broad adoption in recent years, substituting LED's. This is due to the following reasons:

- ✓ The falling cost of LCDs.
- ✓ The capacity to show numerical data, symbols, and images. In comparison, LEDs can only display a limited amount of characters and numbers.
- ✓ Including a refreshing driver in the LCD, which frees up the CPU from having to update the display.the Led, on the other hand, needs to be updated by the CPU in order to keep showing the info.

Fig 6 – 16x2 LCD Screen

LCD Pin Descriptions

VCC, VSS and VEE
VEE is used to regulate LCD sharpness while VCC and VSS supply +5v and ground, respectively.
RS, Register Select
Inside the LCD, there are two crucial sensors. The following RS code was used for their pick. The instruction command code register is chosen if RS=0, enabling the user to send commands like "clear display," "cursor at home," etc.In the event that RS is 1, the data register is chosen, enabling the user to send data to be shown on the LCD.
R/W Read/Write
The user can read from the LCD or record information there using R/W input.
R/W = 1 for reading and 0 for writing.
E, ENABLE
The LCD latches data that is present on its data lines using the enable bit. For the LCD to latch in the data present at the data pins, a high to low pulse must be applied to this port when data is provided to the data pins. This pulsation needs to be at least 450 ns broad.
D0-D7
The 8-bit data ports D0-D7 are used to communicate with the LCD and receive data from its internal registers.

The chart below lists the LCD command numbers.4. While setting RS=1, we transmit the ASCII codes for the letters A-Z, a-z, and digits 0-9 to these ports in order to show letters and numbers.

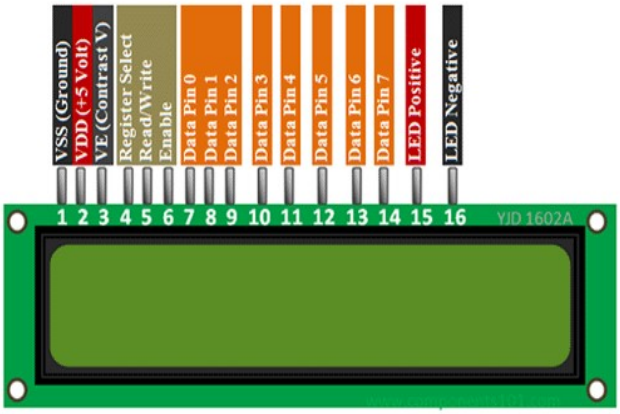

Fig 7 LCD Pin Description

16×2 LCD Module Pin Out Diagram

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The chart below lists the LCD command numbers.4. While setting RS=1, we transmit the ASCII codes for the letters A-Z, a-z, and digits 0-9 to these ports in order to show letters and numbers.

Pin1 (Vss): The LCD module's ground port.

Pin2 (Vic): Power is supplied to the LCD screen via this port (+5V supply)

Pin3 (VEE): Adjustment screw in contrast. To accomplish this, attach the slider pin to the VEE pin after joining the ends of a 10K potentiometer to ground and +5V. The contrast is determined by the voltage at the VEE port. The typical value ranges from 0.4 to 0.9V.

Pin4 (RS): Select password registration. The command register and data register are the JHD162A's two registers. At the RS pin, logic HIGH chooses the data register while logic LOW picks the instruction register. The input will be handled as data to show on the LCD screen if the RS pin is made HIGH and an input is fed to the data lines (DB0 to DB7). The RS pin will be regarded as an instruction if we set it to LOW and send an input to the data lines. (A command to be written to LCD controller – like positioning cursor or clear screen or scroll).

Pin5(R/W): Write/Read options. To switch between read and write modes, use this wire. The read mode is activated by logic HIGH at this pin, and the write mode is activated by logic LOW at this pin.

Pin6 (E): The LCD panel is activated using this pin. This pin's HIGH to LOW indication activates the gadget.

Pin7 (DB0) to Pin14 (DB7): These markers are for statistics. Through these wires, the LCD panel receives the instructions and data.

Pin15 (LED+): Anode for the LED backlight. A 560 ohm resistor needs to be attached in series with this port when running on 5V. *The 3.3V source on the Arduino board can be used to power the backlight LED in applications built on the microcontroller.*

Pin16 (LED-): LED's cathode for the backlight.

Read this document to learn more about the JHD162A LCD module's port functions: a 16x2 LCD and an 8051 microprocessor are interfaced. Below is a wiring design for connecting an LCD to an Arduino to display a text message.

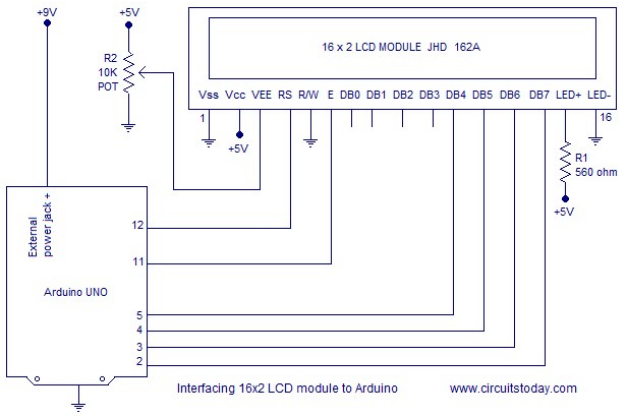

Fig 8 LCD Pin Description

IV.RESULTS

The LCD and cloud are used to send the detecting information. Each sensor uses a microprocessor to collect data, which it then sends to a Wi-Fi development kit.

Fig 9Vibration Sensor

Fig 10Tilt Sensor

Fig 11Position Sensor

V.CONCLUSIONS

An IoT-based real-time automated system that can watch the state of the rail fishplates and transmit warnings to the control centre has been demonstrated in this project. This system will enable the responsible authority to take quick action to prevent serious accidents. The suggested system is very straightforward, inexpensive, and easy to apply. About 92% of true positive results and 97% of true negative results were produced by this method. Compared to other techniques, this accuracy is quite good. The efficacy of the entire system has been assessed by physically simulating the track and examining the responses, despite the fact that the actual system has not been applied in any real track. So, rather than demonstrating a real system application, this endeavour displayed a hypothetical outcome. The system's success has been very encouraging.

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