# SMART CITIES MANHOLE COVER MANAGEMENT SYSTEM BASED ON IOT EDGE COMPUTING

**A PROJECT REPORT**

***Submitted by***


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***in partial fulfillment for the award of the degree***

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***in***

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INTERNAL EXAMINER EXTERNAL EXAMINER

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## ABSTRACT

A smart city is the future goal to have cleaner and better for the society. Smart underground infrastructure is an important feature to be considered while implementing a smart city. Drainage system monitoring plays a vital role in keeping the city clean and healthy. Since manual monitoring is incompetent, this leads to slow handling of problems in drainage and consumes more time to solve. To mitigate all these issues, the system using a wireless sensor network, consisting of sensor nodes is designed. The system also provides a real-time alert to the relevant authorities, enabling them to take immediate action The proposed system is low cost, low maintenance Internet of Things (IoT) devices, and artificial intelligence algorithms based real-time which alerts the managing station through an email/message when any manhole crosses its threshold values and to check whether a manhole cap is open or closed. This system reduces the death risk of manual scavengers who clean the underground drainage and also benefits the public.


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## LIST OF ABBREVIATION

| | |
|---|---|
| **IOT** | Internet Of Things |
| **GSM** | Global System For Mobile Communication |
| **AI** | Artificial Intelligence |
| **ML** | Machine Learning |
| **AVR** | Alf And Vegard's Risc Processor |
| **IR** | Infrared |
| **DHT11** | Digital Humidity And Temperature |
| **LCD** | Liquid-Crystal Display |
| **HVAC** | Heating, Ventilation, And Air Conditioning |
| **AC** | Alternating Current |
| **DC** | Direct Current. |
| **IDE** | Integrated Development Environment |

# CHAPTER 1
# INTRODUCTION

An integral part of any drainage system is the access points into it when it comes to cleaning, clearing, and inspection. Metropolitan cities have adopted underground drainage systems, and the city's municipal corporation must maintain cleanliness. If the sewage maintenance is not proper, groundwater gets contaminated causing infectious diseases. Blockages in drains during monsoon season cause problems in the routine of the public. Hence, there should be a facility in the city's corporation, which alerts the officials about blockages in sewers, and their exact location. It mainly acknowledges in the field of alerting the people about gas explosions on, increases in the water level and temperature level. It uses IoT to make the drainage monitoring system in a highly automotive by using sensors for detecting and sending alerts through GSM to the authorities. This project overcomes the demerits by detecting drainage water blockage by installing water flow rate sensors at the intersection of nodes. When there is a blockage in a particular node, there is variation in the flow of drainage water which when crosses the set value will display the alert in the managing station. Also, other demerits are solved by detecting temperature variations inside the manhole and alerting the same to the managing station. Also, flow rate sensors are used to detect the overflow of the drainage water and alerting the same to the managing station through automatic messages.

## 1.1 PROJECT OBJECTIVES

The project's primary objective is to develop a system that can monitor manhole covers in real-time. The system should be able to detect and measure parameters such as liquid flow, object presence, and liquid level in the manhole. Additionally, the project aims to develop a system that can trigger alerts in case of any issues with the manhole cover. This includes generating SMS alerts to

concerned authorities and an audible alert through a buzzer. The platform should provide a user interface for authorized personnel to monitor and control the system. The project also aims to integrate IoT edge computing into the Smart Cities Manhole Cover Management System. This includes using an Arduino board to process data collected by the sensors, triggering alerts, and communicating with other components of the system.

Furthermore, the project aims to design the Smart Cities Manhole Cover Management System with future scalability in mind. This includes exploring the potential for AI and ML integration, cloud integration, and block chain integration. The system should be designed in a way that enables easy integration with these technologies in the future. The overall project objectives are to develop a comprehensive system that can monitor and manage manhole covers in real time, reduce downtime, improve efficiency, and prevent accidents. The system should be scalable, easy to use, and provide remote monitoring and control capabilities.

## 1.2. EMBEDDED SYSTEM IMPLEMENTATION

An embedded system is one kind of a computer system mainly designed to perform several tasks like to access, process, and store and also control the data in various electronics-based systems. Embedded systems are a combination of hardware and software where software is usually known as firmware that is embedded into the hardware. One of its most important characteristics of these systems is, it gives the o/p within the time limits. Embedded systems support to make the work more perfect and convenient. So, we frequently use embedded systems in simple and complex devices too. The applications of embedded systems mainly involve in our real life for several devices like microwave, calculators, TV remote control, home security and neighbourhood traffic control systems, etc.

**Bringing software and hardware together for embedded system:**

To make software to work with embedded systems we need to bring software and hardware together .for this purpose we need to burn our source code into microprocessor or microcontroller which is a hardware component and which takes care of all operations to be done by embedded system according to our code.

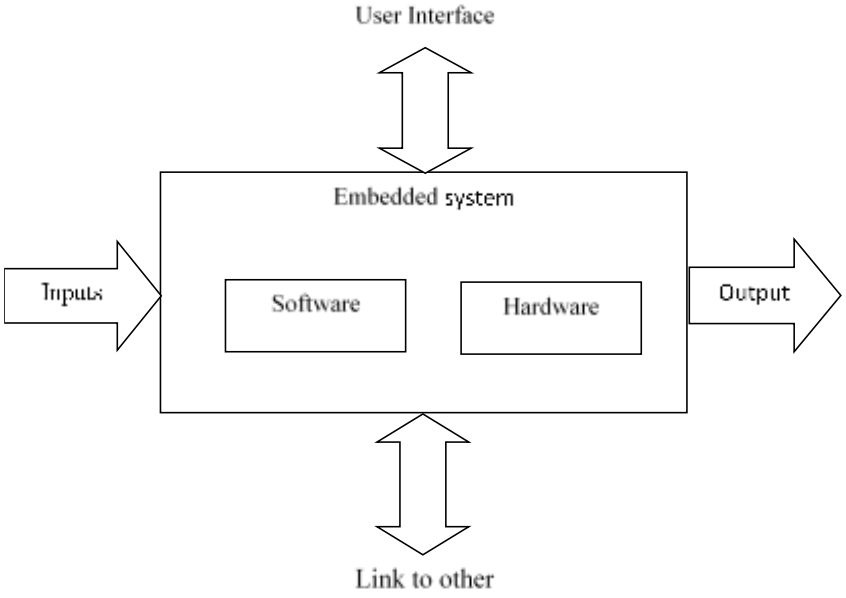



***Fig 1.1: Overview of Embedded System***

Generally we write source codes for embedded systems in assembly language, but the processors run only executable files. The process of converting the source code representation of your embedded software into an executable binary image involves three distinct steps:

→ Each of the source files must be compiled or assembled into an object file.

→ All of the object files that result from the first step must be linked together to produce a single object file, called the re-locatable program.

→ Physical memory addresses must be assigned to the relative offsets within the re-locatable program in a process called relocation.

### 1.2.1 Implementation Flow:

**Stage 1:**

Considering the problems of existing methods and giving solution to that problem by considering the basic requirements for our proposed system

**Stage 2:**

Considering the hardware requirement for the proposed system

For this we need to select the below components:

1. Microcontroller
2. Inputs for the proposed system ( sensors, drivers etc..,)
3. Outputs (Buzzer , loads..)

**Stage 3:**

After considering hardware requirements, now we need to check out the software requirements. Based on the microcontroller we select there exists different software for coding, compiling, debugging. we need to write source code for that proposed system based on our requirements and compile, debug the code in that software . After completing all the requirements of software and hardware we need to bring both together to work our system. For this we need to burn our source code into microcontroller, after burning our source code to microcontroller then connect all input and output modules as per our requirement.

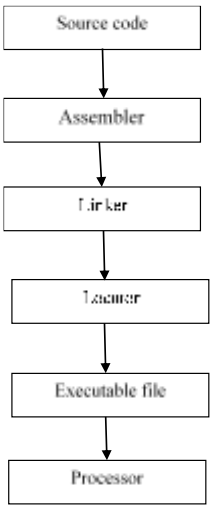



**Fig 1.2: Flow of burning source code to processor**

# CHAPTER 2
# LITERATURE SURVEY

## [1]. Xinru Fu ‘Manhole Cover Intelligent Detection And Management System’ Journal of Atlantis Press , 2016

This paper presents the design and implementation of manhole cover system. In order to avoid the risks that imperfect manhole cover and feature to bring, this paper, aiming at the existing problem of manhole cover, proposed a detectable and maintainable regionalization covers intelligent security management system. Many sensors set up in the manhole cover to real-time monitor its situation, Through MCU?RF Wireless Data Communication Module and upper computer to understand and control manhole cover, this system could monitor the city manhole cover in real time and give an alarm automatically. There is no double that it could improve the management ability of the manhole cover and greatly enhance the safety of people’s travel.

**[2]. N Nataraja; R Amruthavarshini; N L Chaitra; K Jyothi; N Krupaa; S S M Saqquaf 'Secure Manhole Monitoring System Employing Sensors and GSM Techniques' Published in: 2018 3rd IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT)**

In this paper implementation of Opening of manholes due to breakage of manhole cover, manhole explosions are major threat in recent days. Manhole cover opening leads to accidental fall of vehicles, pedestrians leading to accidents or loss of life. Manhole opening detection and alerting is mainly based on detecting the manholes which are opened due to overflow of sewage / rain water during heavy rainfall and alerting. When a manhole opening is detected either due to overflow of sewage water, increase in pressure or temperature, it leads to the breakage of the manhole lids. To avoid such incidents even before it could affect the public, an alerting system is built wherein the buzzer alerts the surrounding and sends the sensed data to the managing authorities using GSM techniques. So, they can take precautionary action to close the manhole considering public safety.

**[3]. Dr.T.Menakadevi , Akash.M , Dilip kumar.B , Kannan.M , Chandra Mohan.S 'IOT BASED AUTOMATED MANHOLE DETECTION'published in International Research Journal of Engineering and Technology (IRJET) , 2021**

A smart city is the future goal to have cleaner and better amenities for the society. Smart underground infrastructure is an important feature to be considered while implementing a smart city. Drainage system monitoring plays a vital role in keeping the city clean and healthy. Since manual monitoring is incompetent, this leads to slow handling of problems in drainage and consumes more time to solve. To mitigate all these issues, the system using a wireless sensor network, consisting of sensor nodes is designed. The proposed system is low cost, low maintenance IoT based real time which alerts the managing station through an email when any manhole crosses its threshold values. This system reduces the death risk of manual scavengers who clean the underground drainage and also benefits the public.

[4]. **Amit Mankotia, Anil Kumar Shukla 'IOT based manhole detection and monitoring system using Arduino' Department of ECE, ASET, Amity University Uttar Pradesh, Noida, India. Published in science direct, 2022.**

contamination of fresh water due to problem in sewage drainage system is of concern. In observation most of the manhole's lids were not in the settled emplacement. As most of the manhole's lids are in the damaged condition. Because of the damaged manholes, there are chances of occurrence of accidents on the road. These damaged manholes will be hazard to the personal safety. The goal of this project is to create an effective accident-avoidance system by avoiding open manholes in large cities. Sensors such as tilt sensors are used to identify rifts and damage to manhole lids, and the information obtained is then sent to the authorities of the municipal corporation department and the councillor of the local region, who will find the manhole location. The supervision and the maintenance are done through the Internet of Things. The working and implementation of this project will be very useful to the society.

[5]. **S. Sundararajan; R. Santhana Krishnan; B. Sumathi; D. Rachel; N. Iswarya; K. Manju** 'Solar **based Manhole Surveillance System (SMSS)**' **Published in: 6th International Conference on Intelligent Computing and Control Systems (ICICCS), 2022.**

Proper maintenance and periodical monitoring of manholes will help us to maintain good hygiene in the society. Improper maintenance will lead to loss of life, the spread of disease in the community and a lot more issues. A lot of sewers lost their lives while encountering poisonous gases during the process of cleaning and this death rate seems to be increasing every year. In addition to this manhole lid is kept open which also leads to a lot of accidents. To bring a better solution to these existing issues, this research work has proposed a system named Solar based Manhole Surveillance System (SMSS). The proposed SMMS system will monitor the gases inside the manhole and forwards an alert message to the municipality via a cloud server. Similarly, the level of sewage is closely observed and that information will be passed to the municipality and the nearby public. The unwanted movement of the manhole lid is identified and that information will be passed to the municipality. In addition to this, the whole system is operated with the support of a solar power supply which reduces the usage of electricity to a huge extent.

**[6]. Varun Krishna Nallamothu; Saahith Medidi; Swetha Priyanka Jannu 'IOT BASED MANHOLE DETECTION AND MONITORING SYSTEM '(2022)**

A Drainage Monitoring System Plays significant amount of role to keeping towns and cities healthy and clean. Most of the manholes are open without any observations that cause accidents. In India many cities adopted emptying underground system because it is vital. All the man-holes don't seem to be in a position of secure. Many man-holes were in broken condition. With these broken man-holes, there were some probabilities of incidence to accidents within the roads. As result, emptying standing will be checked on daily basis. Irregular inspections may cause overflow, clog emptying systems, and compliments will be payed. So manual monitoring was incompetent and leads for handling slow with issues while emptying it may consume more time. After going research with these issues, we've built an IoT based man-hole system that monitors temp, gases, water level. These broken manholes are threat to public safety.

## 2.1.PROBLEM IDENTIFICATION AND FORMULATION

### PROBLEM IDENTIFICATION:

- Need Internet access.
- All of the maintains data won't be stored in the current system.
- There is no flow sensor to detect the flow of Manhole water.

### FORMULATION:

- No need of Internet access.
- Edge computing can store the manhole maintenance data.
- Flow of water can be detected, Blockage of water also detected by flow sensor.
- Corporate environmental sensors within manholes to monitor temperature, humidity, and gas levels, enabling data collection for analysis and facilitating informed decision-making for environmental management.

# CHAPTER 3
# SYSTEM ANALYSIS

## 3.1. EXISTING SYSTEM

Today's manhole systems is not high-tech. So whenever there is blockage it is difficult to figure out the exact location of the blockage. Also, early alerts of the blockage are not received. Hence detection and repairing of the blockage become time consuming. It becomes very inconvenient to handle the situation when pipes are blocked completely and garbage cleaning. Due to such failure of drainage line and overflow of garbage people face a lot of problems. The existing system also lacks real-time data and insights that could be useful in optimizing city services such as traffic management, waste management, and public safety. With the IoT Edge-Computing-based system, city officials can use the data collected by the sensors to monitor and improve city services.

## 3.2. PROPOSED SYSTEM

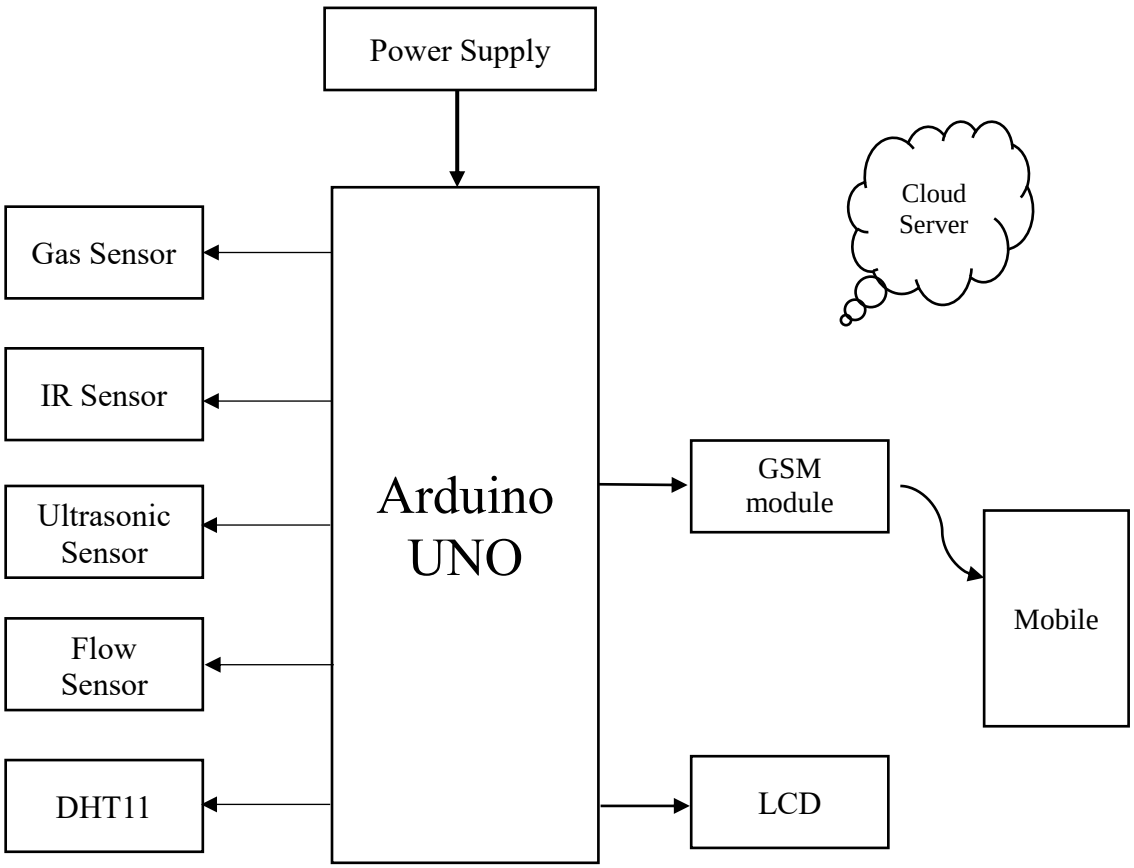
In the proposed method, development of IoT based drainage and manhole monitoring system is designed. This system monitors temperature, manhole lid position whether it will opened or close. Maximum levels are set and sensors keep monitoring the changing conditions. As the levels reach a maximum set point the sensors detect and send the signal to controller, where it commands the IoT network to generate alerts to the "Municipal Corporation". Gas sensor will monitor the toxic gases, Flow sensor will detect the Flow rate of the manhole water, hence the water flow blockage is also easily detected. DHT11 sensor will monitor the Temperature and humidity. If any of the sensor data increases greater than the threshold value then GSM (Global System for Mobile Communication) will send the message to Municipal Corporation and the buzzer will give alerts.

In This proposed solution user doesn't need to have internet access in his device to get updates from this manhole Monitoring & detection system

# CHAPTER 4

# SYSTEM DESIGN

## 4.1. BLOCK DIAGRAM




## 4.2. BLOCK DIAGRAM DESCRIPTION

The Smart Cities Manhole Cover Management System based on IoT edge computing is a comprehensive system designed to monitor and manage manhole covers in real-time. The system is made up of various components that work together seamlessly to detect and measure different parameters such as the flow of water, Whether the lead open/close using IR sensor, water level , and harmful gases . The data collected by the sensors is processed by an Arduino board, which acts as the central controller for the system. The Arduino board is responsible for analysing the data, triggering alerts, and communicating with other components of the system. In case of any issues with the manhole cover, a GSM module is used to send SMS alerts to concerned authorities, and a buzzer is used to generate an audible alert. The system is connected to a cloud-based platform, which enables remote monitoring and control of the system.

# CHAPTER 5
# SYSTEM REQUIREMENT

## 5.1. REQUIREMENT SPECIFICATION

The requirements specification is a technical specification of requirements for the software products. It is the first step in the requirements analysis process it lists the requirements of a particular software system and hardware system including functional, performance and requirements. The requirements also provide usage scenarios from a user, an operational and an administrative perspective. The purpose of software requirements specification is to provide a detailed overview of the software project, its parameters and goals. This describes the project target doctor and the patient interface, hardware and software requirements. It defines how the patient, doctor see the system and its functionality.

## 5.2. HARDWARE REQUIREMENTS

### 5.2.1. MICROCONTROLLER

#### 5.2.1.1. Introduction To Arduino UNO

→ **Arduino Uno** is a microcontroller board developed by Arduino.cc which is an open-source electronics platform mainly based on AVR microcontroller Atmega328.

→ First Arduino project was started in Interaction Design Institute Ivrea in 2003 by David Cuartielles and Massimo Banzi with the intention of providing a cheap and flexible way to students and professional for controlling a number of devices in the real world.

→ The current version of Arduino Uno comes with USB interface, 6 analog input pins, 14 I/O digital ports that are used to connect with external electronic circuits. Out of 14 I/O ports, 6 pins can be used for PWM output.

→ It allows the designers to control and sense the external electronic devices in the real world

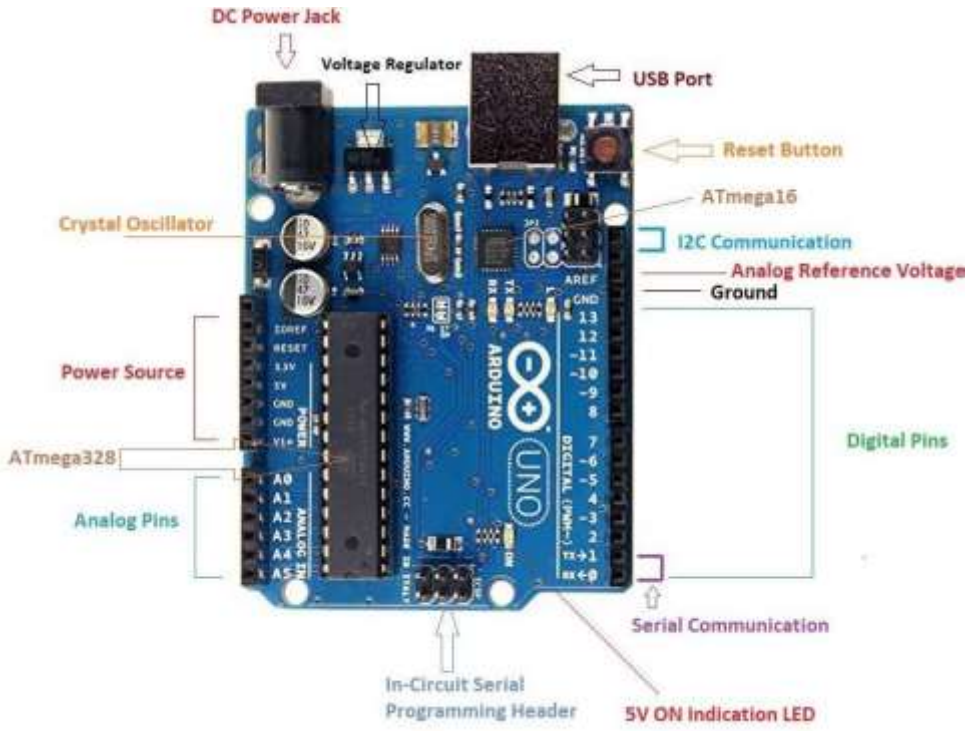



***Fig 5.1: Arduino UNO***

→ This board comes with all the features required to run the controller and can be directly connected to the computer through USB cable that is used to transfer the code to the controller using IDE (Integrated Development Environment) software, mainly developed to program Arduino. IDE is equally compatible with Windows, MAC or Linux Systems, however, Windows is preferable to use. Programming languages like C and C++ are used in IDE.

→ Apart from USB, battery or AC to DC adopter can also be used to power the board.

- → Arduino Uno boards are quite similar to other boards in Arduino family in terms of use and functionality, however, Uno boards don't come with FTDI USB to Serial driver chip.
- → There are many versions of Uno boards available, however, Arduino Nano V3 and Arduino Uno are the most official versions that come with Atmega328 8-bit AVR Atmel microcontroller where RAM memory is 32KB.
- → When nature and functionality of the task go complex, Mirco SD card can be added in the boards to make them store more information.
- → The software used for Arduino devices is called IDE (Integrated Development Environment) which is free to use and required some basic skills to learn it. It can be programmed using C and C++ language.

In the Smart Cities Manhole Cover Management System based on IoT edge computing, an Arduino board is used to process data collected by the sensors. The board is responsible for triggering alerts and communicating with other components of the system. The Arduino board is connected to sensors such as flow sensors, IR sensors, and ultrasonic sensors that collect data on liquid flow, object presence, and liquid level in the manhole.

The data collected by the sensors is then processed by the Arduino board, which triggers alerts if any issues are detected with the manhole cover. The Arduino board communicates with other components of the system, such as the GSM module, which is responsible for sending SMS alerts to concerned authorities. The use of Arduino in the Smart Cities Manhole Cover Management System enables real-time data processing, reduces latency, and improves the overall efficiency and effectiveness of the system.

Overall, Arduino plays a critical role in the Smart Cities Manhole Cover Management System, enabling the system to collect, process, and communicate

data in real-time. Its versatility, ease of use, and affordability make it an ideal choice for IoT-based projects such as this one.

Some people get confused between **Microcontroller and Arduino**. While former is just an on system 40 pin chip that comes with a built-in microprocessor and later is a board that comes with the microcontroller in the base of the board, bootloader and allows easy access to input-output pins and makes uploading or burning of the program very easy.

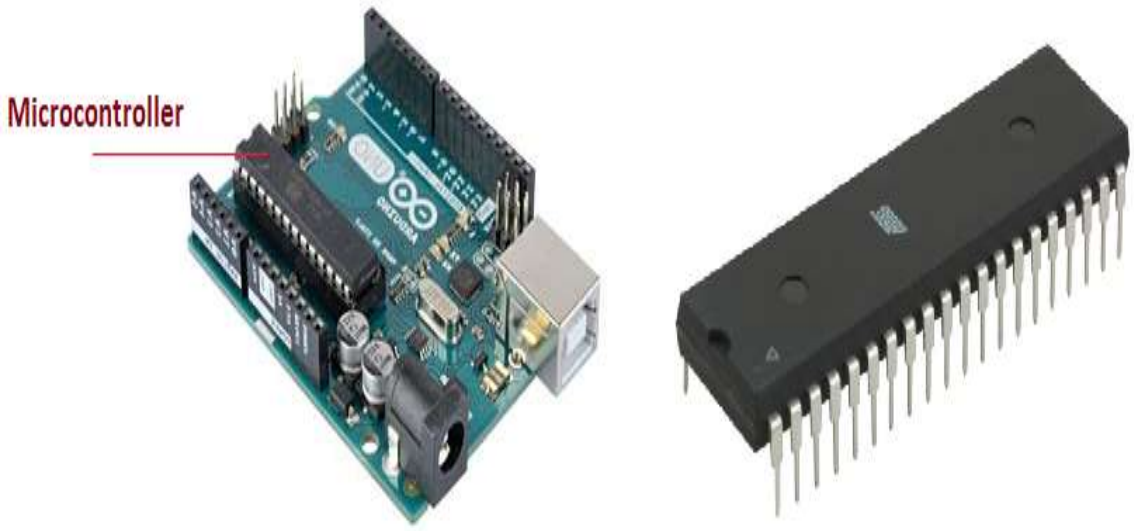



***Fig 5.2: Arduino board & ATmega328P MC***

## Arduino Pinout

- Arduino Uno is based on AVR microcontroller called Atmega328. This controller comes with 2KB SRAM, 32KB of flash memory, 1KB of EEPROM. Arduino Board comes with 14 digital pins and 6 analog pins. ON-chip ADC is used to sample these pins. A 16 MHz frequency crystal oscillator is equipped on the board. Following figure shows the pinout of the Arduino Uno Board.

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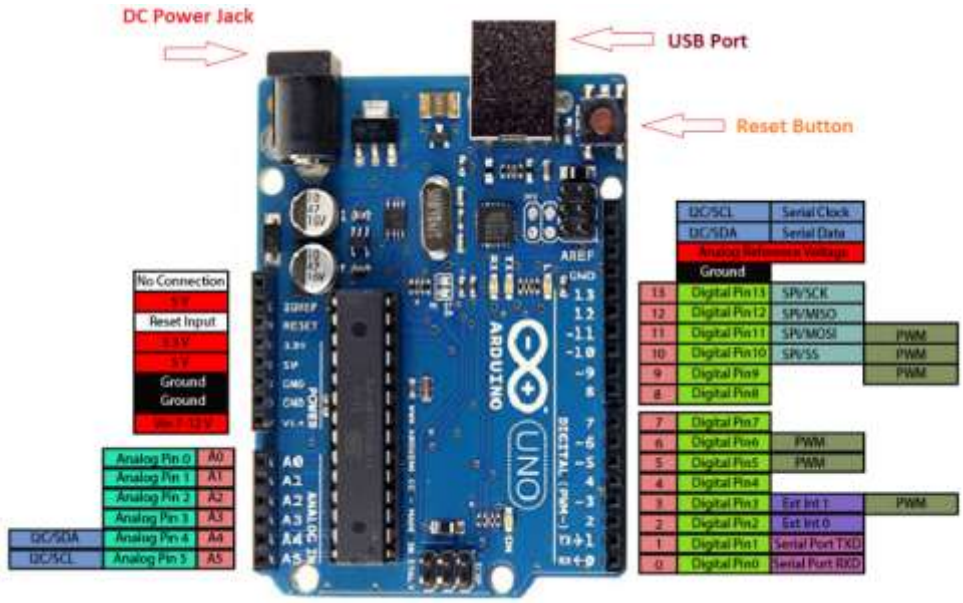



*Fig 5.3: Arduino Pinout*

### 5.2.1.2. Pin Description

There are several I/O digital and analog pins placed on the board which operates at 5V. These pins come with standard operating ratings ranging between 20mA to 40mA. Internal pull-up resistors are used in the board that limits the current exceeding from the given operating conditions. However, too much increase in current makes these resisters useless and damages the device.

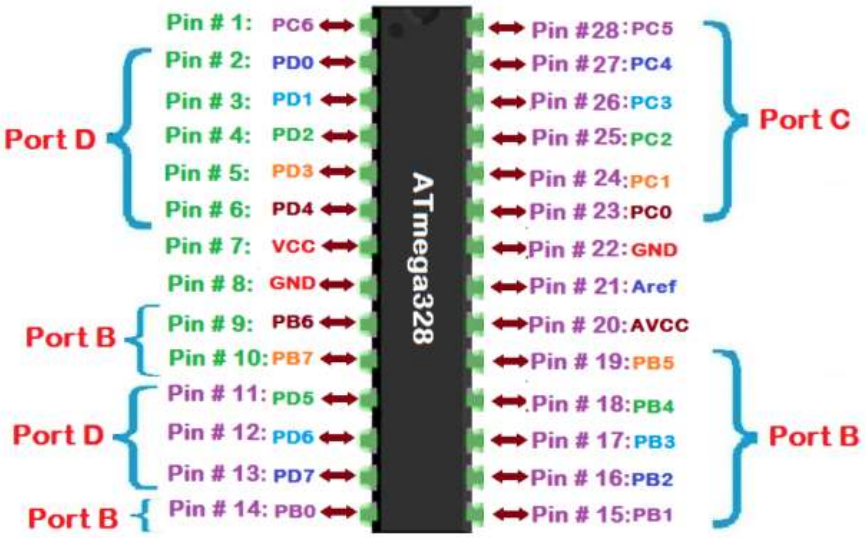



**Fig 5.4: Atmega328 Microcontroller pin Diagram**

**LED:** Arduino Uno comes with built-in LED which is connected through pin 13. Providing HIGH value to the pin will turn it ON and LOW will turn it OFF.

**Vin:** It is the input voltage provided to the Arduino Board. It is different than 5 V supplied through a USB port. This pin is used to supply voltage. If a voltage is provided through power jack, it can be accessed through this pin.

**5V:** This board comes with the ability to provide voltage regulation. 5V pin is used to provide output-regulated voltage. The board is powered up using three ways i.e. USB, Vin pin of the board, or DC power jack.

**GND:** These are ground pins. More than one ground pins are provided on the board which can be used as per requirement.

**Reset:** This pin is incorporated on the board which resets the program running on the board. Instead of a physical reset on the board, IDE comes with a feature of resetting the board through programming.

**IOREF:** This pin is very useful for providing voltage reference to the board. A shield is used to read the voltage across this pin which the selects the proper power source.

**PWM:** PWM is provided by 3, 5, 6,9,10, 11pins. These pins are configured to provide 8-bit output PWM.

**SPI:** It is known as Serial Peripheral Interface. Four pins 10(SS), 11(MOSI), 12(MISO), 13(SCK) provide SPI communication with the help of SPI library.

**AREF:** It is called Analog Reference. This pin is used for providing a reference voltage to the analog inputs.

**TWI:** It is called Two-wire Interface. TWI communication is accessed through Wire Library. A4 and A5 pins are used for this purpose.

**Serial Communication:** Serial communication is carried out through two pins called Pin 0 (Rx) and Pin 1 (Tx). Rx pin is used to receive data while Tx pin is used to transmit data.

**External Interrupts:** Pin 2 and 3 are used for providing external interrupts. An interrupt is called by providing LOW or changing value.

5.2.1.3. **Arduino Uno Technical Specifications**

| | |
|---|---|
| **Microcontroller** | ATmega328P – 8 bit AVR family microcontroller |
| **Operating Voltage** | 5V |
| **Recommended Input Voltage** | 7-12V |
| **Input Voltage Limits** | 6-20V |
| **Analog Input Pins** | 6 (A0 – A5) |
| **Digital I/O Pins** | 14 (Out of which 6 provide PWM output) |
| **DC Current on I/O Pins** | 40 mA |
| **DC Current on 3.3V Pin** | 50 mA |
| **Flash Memory** | 32 KB (0.5 KB is used for Bootloader) |
| **SRAM** | 2 KB |
| **EEPROM** | 1 KB |
| **Frequency (Clock Speed)** | 16Hz |

### 5.2.2. MQ2 SENSOR

The **gas sensor module** consists of a steel exoskeleton under which a sensing element is housed. This sensing element is subjected to current through connecting leads. This current is known as heating current through it, the gases coming close to the sensing element get ionized and are absorbed by the sensing element. This changes the resistance of the sensing element which alters the value of the current going out of it.


*Fig 5.5:MQ2 Sensor*

The MQ2 sensor is a gas sensor that can detect different types of gases such as smoke, propane, methane, and carbon monoxide. It is a popular sensor used in various electronic projects and is especially useful in detecting gas leaks and fires. In the Smart Cities Manhole Cover Management System based on IoT edge computing, the MQ2 sensor can be used to detect the presence of toxic gases in the manhole. Toxic gases can pose a threat to workers who may need to enter the manhole for maintenance or repairs.The MQ2 sensor can be connected to the Arduino board in the Smart Cities Manhole Cover Management System and can be used to trigger an alert in case of any toxic gas presence in the manhole. This alert can be in the form of an audible alarm, an SMS alert sent to concerned authorities, or both.

The use of the MQ2 sensor in the Smart Cities Manhole Cover Management System improves the safety of workers and reduces the risk of accidents. It also ensures that any toxic gas presence is detected in real-time, allowing prompt action to be taken to prevent any harm.


*Fig 5.6: Various Parts of a Gas Sensor*

Fig 5.6 shows externals of a standard gas sensor module: a steel mesh, copper clamping ring and connecting leads. The top part is a stainless steel mesh which takes care of the following:

1. Filtering out the suspended particles so that only gaseous elements are able to pass to insides of the sensor.
2. Protecting the insides of the sensor.
3. Exhibits an anti-explosion network that keeps the sensor module intact at high temperatures and gas pressures.

The top of the gas sensor is removed off to see the internals parts of the sensor: sensing element and connection wiring. The hexapod structure is constituted by the sensing element and six connecting legs that extend beyond the Bakelite base.

***Fig 5.7: Hexapod Structure inside a Gas Sensor***

The hollow sensing element which is made up from Aluminum Oxide based ceramic and has a coating of tin oxide. Using a ceramic substrate increases the heating efficiency and tin oxide, being sensitive towards adsorbing desired gas' components (in this case methane and its products) suffices as sensing coating.

The leads responsible for heating the sensing element are connected through Nickel-Chromium, well known conductive alloy. Leads responsible for output signals are connected using platinum wires which convey small changes in the current that passes through the sensing element. The platinum wires are

connected to the body of the sensing element while Nickel-Chromium wires pass through its hollow structure.

While other wires are attached to the outer body of the element, Nickel-Chromium wires are placed inside the element in a spring shaped. Image 5 shows coiled part of the wire which **is** placed on the inside of the hollow ceramic.

**MQ2 sensor has a sensitivity range of 300-10,000 ppm for propane and a sensitivity range of 200-10,000 ppm for methane. The sensitivity range for smoke and carbon monoxide is in the range of a few hundred parts per million (ppm).**

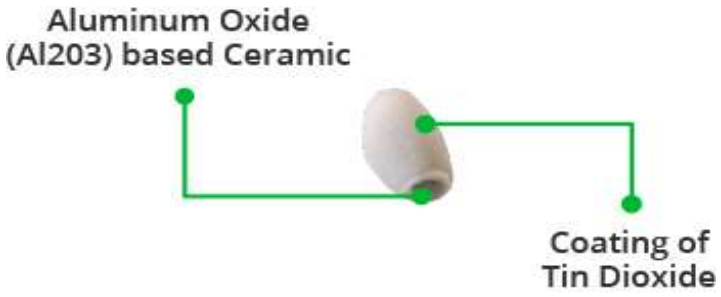



***Fig 5.8: Closer Look at the Ceramic Element***

The ceramic with tin dioxide on the top coating that has good adsorbing property Fig 5.8 . Any gas to be monitored has specific temperature at which it ionizes. The task of the sensor is to work at the desired temperature so that gas molecules get ionized. Through Nickel-chromium wire, the ceramic region of the sensing element is subjected to heating current. The heat is radiated by the element in the nearby region where gases interact with it and get ionized. Once, ionized, they are absorbed by the tin dioxide. Adsorbed molecules change the resistance of the tin dioxide layer. This changes the current flowing through the sensing element and is conveyed through the output leading to the unit that controls the working of the gas sensor**.**

### 5.2.3. IR SENSOR

An IR (infrared) sensor is a device that can detect infrared radiation in its surrounding environment. It is a popular sensor used in various electronic projects due to its low cost and versatility.


***Fig 5.9: IR Sensor***

IR sensor can also be used in the Smart Cities Manhole Cover Management System to detect the presence of the manhole lead. The manhole lead is a metallic plate that covers the manhole and is used to secure the manhole cover.

The IR sensor can be installed on the underside of the manhole cover and can detect the presence of the manhole lead when it comes in close proximity to the sensor. This can be done by setting up the IR sensor to detect a specific wavelength of light that is reflected off the metallic surface of the manhole lead. can be used to trigger an alert in case the manhole lead is missing or damaged. This alert can be in the form of an audible alarm, an SMS alert sent to concerned authorities, or both. The system ensures that any missing or damaged manhole lead is detected in real-time, allowing prompt action to be taken to repair or replace it. This improves the safety of pedestrians and drivers, reducing the risk of accidents caused by open manhole covers.

### 5.2.4. ULTRASONIC SENSOR

An ultrasonic sensor transmit ultrasonic waves into the air and detects reflected waves from an object. There are many applications for ultrasonic sensors, such as in intrusion alarm systems, automatic door openers and backup sensors for automobiles.

Accompanied by the rapid development of information processing technology, new fields of application, such as factory automation equipment and car electronics, are increasing and should continue to do so. Using its unique piezoelectric ceramics manufacturing technology developed over many years, Murata has developed various types of ultrasonic sensors which are compact and yet have very high performance. The information contained in this catalog will help you to make effective use of our ultrasonic sensors.


***Fig 5.10: Ultrasonic Sensor***

The ultrasonic sensor can be placed at the top of the manhole and pointed downwards towards the water level. When the sensor emits sound waves, they travel down to the water level and bounce back up to the sensor. The time taken for the sound waves to travel to the water level and back up to the sensor can be used to calculate the distance between the sensor and the water level, which can then be used to determine the water level. The ultrasonic sensor can be connected to the Arduino board in the Smart Cities Manhole Cover Management System and can be used to trigger an alert in case of high water levels inside the manhole.

This alert can be in the form of an audible alarm, an SMS alert sent to concerned authorities, or both.

The use of an ultrasonic sensor to measure the water level in the Smart Cities Manhole Cover Management System ensures that the water level inside the manhole is monitored in real-time, allowing prompt action to be taken to prevent flooding and damage to the manhole and surrounding areas. It also improves the safety of workers and reduces the risk of accidents.

**HC-SR04 Ultrasonic Sensor - Working**

As shown above the HC-SR04 Ultrasonic (US) sensor is a 4 pin module, whose pin names are Vcc, Trigger, Echo and Ground respectively. This sensor is a very popular sensor used in many applications where measuring distance or sensing objects are required. The module has two eyes like projects in the front which forms the Ultrasonic transmitter and Receiver. The sensor works with the simple high school formula that

**Distance = Speed × Time**

The Ultrasonic transmitter transmits an ultrasonic wave, this wave travels in air and when it gets objected by any material it gets reflected back toward the sensor this reflected wave is observed by the Ultrasonic receiver module as shown in the picture below


***Fig 5.11: HC-SR04 Ultrasonic Sensor - Working***

Now, to calculate the distance using the above formulae, we should know the Speed and time. Since we are using the Ultrasonic wave we know the universal speed of US wave at room conditions which is 330m/s. The circuitry inbuilt on the module will calculate the time taken for the US wave to come back and turns on the echo pin high for that same particular amount of time, this way we can also know the time taken. Now simply calculate the distance using a microcontroller or microprocessor.

### 5.2.5. FLOW SENSOR

A flow sensor (more commonly referred to as a "flow meter") is an electronic device that measures or regulates the flow rate of liquids and gasses within pipes and tubes. Flow sensors are generally connected to gauges to render their measurements, but they can also be connected to computers and digital interfaces. They are commonly used in HVAC systems, medical devices, chemical factories, and septic systems. Flow sensors are able to detect leaks, blockages, pipe bursts, and changes in liquid concentration due to contamination or pollution.


***Fig 5.12: Flow Sensor***

Flow sensors can be divided into two groups: contact and non-contact flow sensors. Contact flow sensors are used in applications where the liquid or gas measured is not expected to become clogged in the pipe when it comes into contact with the sensor's moving parts. In contrast, non-contact flow sensors have no moving parts, and they are generally used when the liquid or gas (generally a food product) being monitored would be otherwise contaminated or physically altered by coming into contact with moving parts.

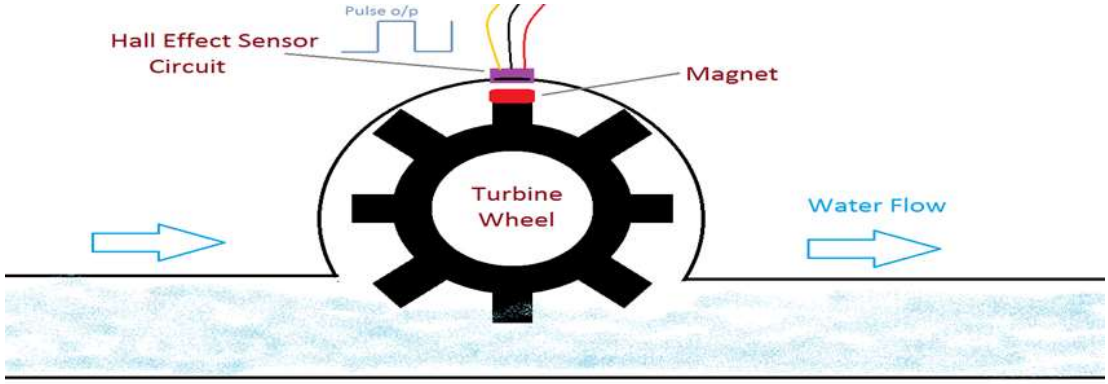



***Fig 5.13: Working Of Flow Sensor***

A flow sensor is a device that is used to measure the rate of flow of a fluid in a pipeline or channel. A flow sensor can be used to detect the flow of sewage water inside the manhole. The flow sensor can be installed in the pipeline that leads to the manhole and can be connected to the Arduino board in the Smart Cities Manhole Cover Management System. The flow sensor can measure the rate of flow of the sewage water inside the pipeline and can send this data to the Arduino board.

The Arduino board can then analyze this data to determine the flow of sewage water inside the manhole. If the flow rate is above a certain threshold, it can trigger an alert in the form of an audible alarm, an SMS alert sent to concerned authorities, or both.

### 5.2.6. **GSM MODULE**

GPRS Modules are one of the commonly used communication modules in embedded systems. A GPRS Module is used to enable communication between a microcontroller (or a microprocessor) and the GPRS Network. Here, GSM stands for Global System for Mobile Communication and GPRS stands for General Packet Radio Service.

A GPRS MODEM comprises of a GPRS Module along with some other components like communication interface (like Serial Communication – RS-232), power supply and some indicators. With the help of this communication interface, we can connect the GSM GPRS Module on the GPRS MODEM with an external computer (or a microcontroller).

GPRS Modules allow microcontrollers to have a wireless communication with other devices and instruments. Such wireless connectivity of microcontroller opens up to wide range of applications like Home Automation, Home Security Systems, Disaster Management, Medical Assistance, Vehicle Tracking, Online Banking, E – Commerce etc. to name some.

***Fig 5.14: GSM Module***

The GSM module can be connected to the Arduino board in the Smart Cities Manhole Cover Management System and can be programmed to send SMS alerts to the phone numbers of concerned authorities in case of any anomalies detected by the sensors. This can include alerts for high water levels, low manhole cover pressure, or any other issues that require immediate attention.

The use of a GSM module in the Smart Cities Manhole Cover Management System ensures that concerned authorities are immediately notified of any issues detected by the sensors. This allows prompt action to be taken to resolve the issue before any major damage occurs. It also ensures that the system is always monitored, even when concerned authorities are not physically present at the location.

GPRS or General Packet Radio Service is an extension of the GSM Network. GPRS is an integrated part of the GSM Network which provides an efficient way to transfer data with the same resources as GSM Network.

**Execution Command**:

These commands perform an operation like send an SMS, retrieving information about battery charging status etc. They read the non – variable subparameters that are affected by the GSM Module.

Syntax of Execution Commands: ATCMD1<CR>

Example for Execution Commands: AT+CMGS=<number><CR> <text message> <CTRL-Z> (Sends text message to the number).

**Information Responses and Final Codes**

After sending the AT Commands to the GSM GPRS Module, we have look for the response. For example, if we send the command as AT+CGMI<CR> to the GSM Module, then the response would be as follows.

<CR><LF>Apple<CR><LF>

<CR><LF>OK<CR><LF>

Here, <CR> is Carriage Return and <LF>is Line Feed.

In a HyperTerminal, if you entered AT+CGMI<CR>, the response will look something like this.

AT+CGMI <– Command entered

Apple <– Information Response

OK <– Final Code

The syntax of the information response and final command is as follows:

<Carriage Return><Line Feed> <Information Response / Final Result Code> <Carriage Return><Line Feed>

<CR><LF><Response><CR><LF>

**Frequently used AT Commands**

In this list, you can find out some of the most commonly used AT Commands. For a complete list of AT Commands and their definitions, it is advised to refer

the manufacturer data. The <Carriage Return> or <CR> is denoted by this symbol ↲.

***To check the communication between the GSM Module and the host (Computer)***

AT ↲

OK

***To make a voice call***

ATD6380607370; ↲

***To answer or receive an incoming call***

ATA ↲

***To redial the last number***

ATDL ↲

***To disconnect a call***

ATH ↲

***To set the message mode to text mode***

AT+CMGF=1 ↲

OK

***To send a text message***

AT+CMGS=”6380607370” ↲

Message

### 5.2.7. LCD

LCD (Liquid Crystal Display) is the innovation utilized in scratch pad shows and other littler PCs. Like innovation for light-producing diode (LED) and gas-plasma, LCDs permit presentations to be a lot more slender than innovation for cathode beam tube (CRT). LCDs expend considerably less power than LED shows and gas shows since they work as opposed to emanating it on the guideline of blocking light.

A LCD is either made with a uninvolved lattice or a showcase network for dynamic framework show. Likewise alluded to as a meager film transistor (TFT) show is the dynamic framework LCD. The uninvolved LCD lattice has a matrix of conductors at every crossing point of the network with pixels. Two conductors on the lattice send a current to control the light for any pixel. A functioning framework has a transistor situated at every pixel crossing point, requiring less current to control the luminance of a pixel.

A 16x2 LCD show is an essential module that is generally utilized in various gadgets and circuits. These modules more than seven sections and other multi fragment LEDs are liked. The reasons being: LCDs are affordable; effectively programmable; have no restriction of showing exceptional and even custom characters (not at all like in seven fragments), movements, etc.

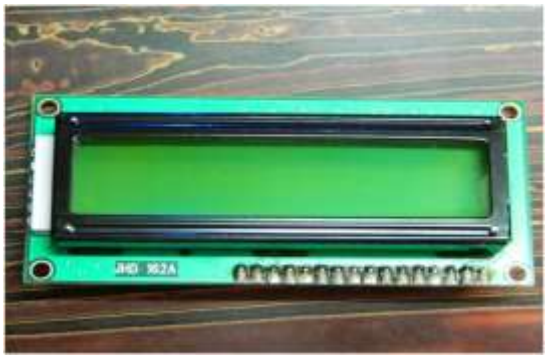


*Fig 5.15: LCD – Front View*

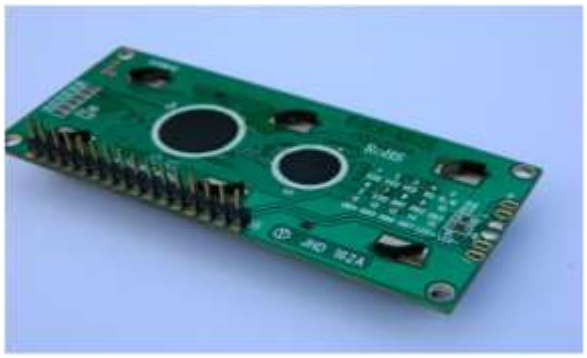


*Fig 5.16: LCD – Back View*

## Pin Diagram:

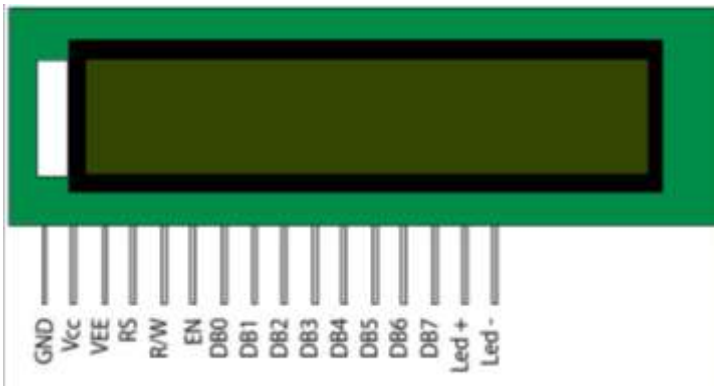



***Fig 5.17: Pin Diagram***

## Pin Description:

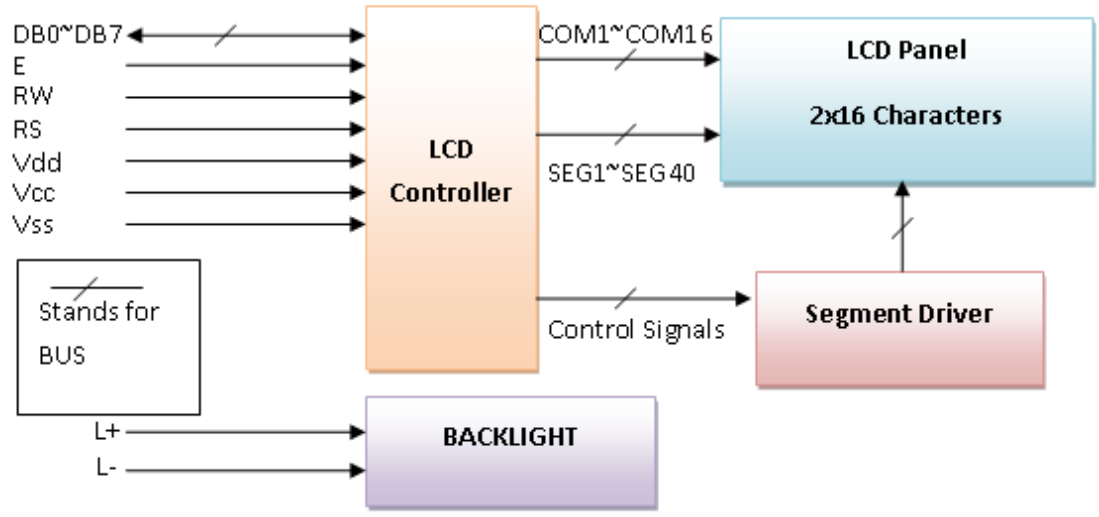
| Pin No | Function | Name |
|---|---|---|
| 1 | Ground (0V) | Ground |
| 2 | Supply voltage; 5V (4.7V – 5.3V) | Vcc |
| 3 | Contrast adjustment; through a variable resistor | $V_{EE}$ |
| 4 | Selects command register when low; and data register when high | Register Select |
| 5 | Low to write to the register; High to read from the register | Read/write |
| 6 | Sends data to data pins when a high to low pulse is given | Enable |
| 7 | 8-bit data pins | DB0 |
| 8 | | DB1 |
| 9 | | DB2 |
| 10 | | DB3 |
| 11 | | DB4 |
| 12 | | DB5 |
| 13 | | DB6 |
| 14 | | DB7 |
| 15 | Backlight $V_{CC}$ (5V) | Led+ |
| 16 | Backlight Ground (0V) | Led- |

**Data/Signals/Execution of LCD**

Now that was all about the signals and the hardware. Let us come to data, signals and execution.

Two types of signals are accepted by LCD, one is data and one is control. The LCD module recognizes these signals from the RS pin status. By pulling the R / W pin high, data can now also be read from the LCD display. Once the E pin has been pulsed, the LCD display reads and executes data at the falling edge of the pulse, the same for the transmission case.

It takes 39-43µS for the LCD display to place a character or execute a command. It takes 1.53ms to 1.64ms except for clearing display and searching for cursor to the home position.




Any attempt to send data before this interval may result in failure in some devices to read data or execute the current data. Some devices compensate for the speed by storing some temporary registers with incoming data.

There are two RAMs for LCD displays, namely DDRAM and CGRAM. DDRAM registers the position in which the character would be displayed in the ASCII chart. Each DDRAM byte represents every single position on the display of the LCD.

The DDRAM information is read by the LCD controller and displayed on the LCD screen. CGRAM enables users to define their personalized characters. Address space is reserved for users for the first 16 ASCII characters.

Users can easily display their custom characters on the LCD screen after CGRAM has been set up to display characters.

**Control and display commands**

| **Instruction** | **Instruction Code** | | | | | | | | | | **Instruction Code Description** | **Execution time** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | RS | R/W | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 | | |
| Read Data From RAM | 1 | 1 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | Read data from internal RAM | 1.53-1.64ms |
| Write data to RAM | 1 | 0 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | Write data into internal RAM (DDRAM/CG RAM) | 1.53-1.64ms |
| Busy flag & Address | 0 | 1 | BF | AC6 | AC5 | AC4 | AC3 | AC2 | AC1 | AC0 | Busy flag (BF: 1→ LCD Busy) and contents of address counter in bits AC6-AC0. | 39 µs |
| Set DDRAM Address | 0 | 0 | 1 | AC6 | AC5 | AC4 | AC3 | AC2 | AC1 | AC0 | Set DDRAM address in address counter. | 39 µs |
| Set CGRAM Address | 0 | 0 | 0 | 1 | AC5 | AC4 | AC3 | AC2 | AC1 | AC0 | Set CGRAM Address in address counter. | 39 µs |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Function Set | 0 | 0 | 0 | 0 | 1 | DL | N | F | X | X | Set interface data length (DL: 4bit/8bit), Numbers of display line (N: 1-line/2-line) display font type (F:0→ 5×8 dots, F:1→ 5×11 dots) | 39 μs |
| Cursor or Display Shift | 0 | 0 | 0 | 0 | 0 | 1 | S/C | R/L | X | X | Set cursor moving and display shift control bit, and the direction without changing DDRAM data | 39 μs |
| Display & Cursor On/Off | 0 | 0 | 0 | 0 | 0 | 0 | 1 | D | C | B | Set Display(D),Cursor(C) and cursor blink(b) on/off control | 39 μs |
| Entry Mode Set | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | I/D | SH | Assign cursor moving direction and enable shift entire display. | 0μs |
| Return Home | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | X | Set DDRAM Address to “00H” from AC and return cursor to its original position if shifted. | 43μs |
| Clear Display | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | Write “20H” to DDRAM and set DDRAM Address to “00H” from AC | 43μs |

### 5.2.8. DHT11 SENSOR

The DHT11 is a basic, low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed). It's fairly simple to use, but requires careful timing to grab data. The only real downside of this sensor is you can only get new data from it once every 2 seconds.

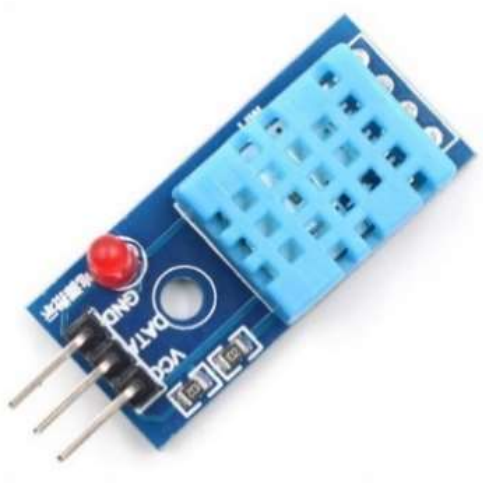



***Fig 5.18: DHT11 Sensor***

**Technical Specifications:**

| **Item** | Measurement Range | Humidity Accuracy | Temperature Accuracy | **Resolution** | **Package** |
|---|---|---|---|---|---|
| **DHT11** | 20-90%RH<br>0-50$^0$C | **±5%RH** | **±2$^0$C** | 1 | 4 Pin Single Row |

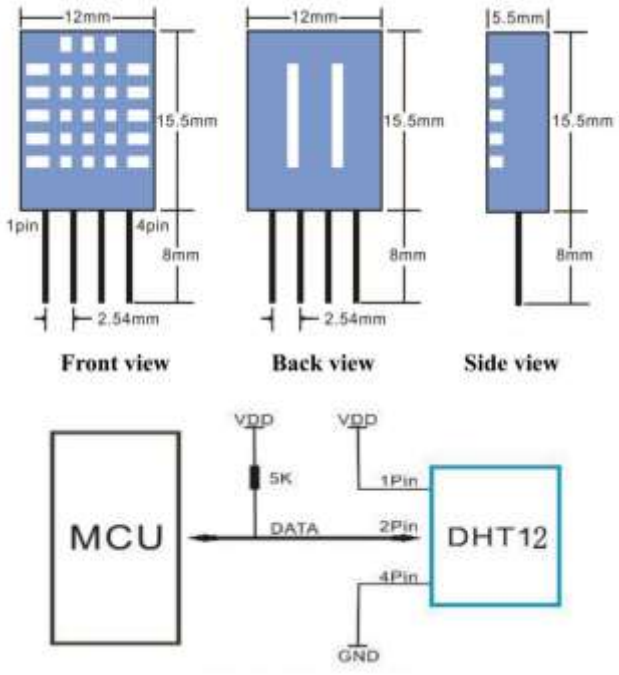
In the Smart Cities Manhole Cover Management System based on IoT edge computing, the DHT11 sensor can be used to monitor the temperature and

humidity inside the manhole. Extreme temperatures and humidity levels can pose a risk to workers who may need to enter the manhole for maintenance or repairs. The DHT11 sensor can be connected to the Arduino board in the Smart Cities Manhole Cover Management System and can be used to trigger an alert in case of extreme temperature or humidity levels inside the manhole. This alert can be in the form of an audible alarm, an SMS alert sent to concerned authorities, or both.

The use of the DHT11 sensor in the Smart Cities Manhole Cover Management System ensures that temperature and humidity levels inside the manhole are monitored in real-time, allowing prompt action to be taken to prevent any harm. It also improves the safety of workers and reduces the risk of accidents.

**Power and Pin:**

DHT11's power supply is 3-5.5V DC. When power is supplied to the sensor, do not send any instruction to the sensor in within one second in order to pass the unstable status. One Capacitor valued 100nF can be added between VDD and GND for power filtering.



### 5.2.9. BUZZER

A buzzer or beeper is an audio signalling device, which may be mechanical, electromechanical, or piezoelectric. Typical uses of buzzers and beepers include alarm devices, timers and confirmation of user input such as a mouse click or keystroke. Buzzer is an integrated structure of electronic transducers, DC power supply, widely used in computers, printers, copiers, alarms, electronic toys, automotive electronic equipment, telephones, timers and other electronic products for sound devices. Active buzzer 5V Rated power can be directly connected to a continuous sound, this section dedicated sensor expansion module and the board in combination, can complete a simple circuit design, to "plug and play.

***Fig 5.19: Buzzer***

Audio indicator, a buzzer is a basic audio device that generates a sound from an incoming electrical signal. Buzzers come in two primary forms — piezo buzzers and magnetic buzzers. The buzzer is a sounding device that can convert audio signals into sound signals. It is usually powered by DC voltage. It is widely used in alarms, computers, printers and other electronic products as sound devices.

**Buzzer Pin Configuration**

| Pin Number | Pin Name | Description |
|---|---|---|
| 1 | Positive | Identified by (+) symbol or longer terminal lead. Can be powered by 5V DC |
| 2 | Negative | Identified by short terminal lead. Typically connected to the ground of the circuit |

### 5.2.10. POWER SUPPLY

**Rectifier:**

A **rectifier** is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. The process is known as *rectification*, since it "straightens" the direction of current

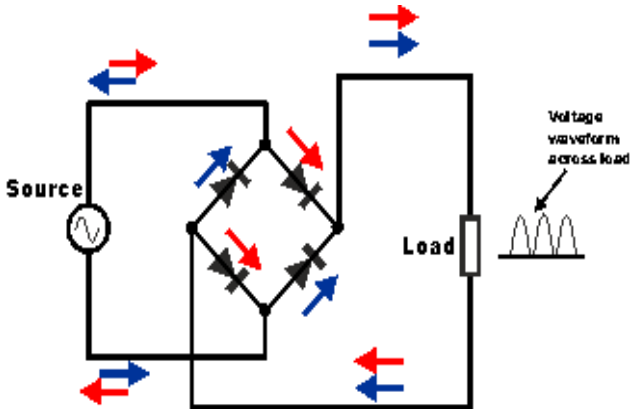



***Fig 5.20: Circuit of rectifier***

. Rectifiers have many uses, but are often found to serve as components of DC power supplies and direct power transmission systems with high voltage. Rectification can be used in roles other than direct current generation for use as a power source.

## 5.3. SOFTWARE REQUIREMENT

**Embedded System Software:**

The embedded system software is written to perform a specific function. It is typically written in a high level format and then compiled down to provide code that can be lodged within a non-volatile memory within the hardware. An embedded system software is designed to keep in view of the three limits:

- Availability of system memory
- Availability of processor's speed
- When the system runs continuously, there is a need to limit power dissipation for events like stop, run and wake up.

### 5.3.1. Arduino IDE:

**Arduino IDE** where IDE stands for Integrated Development Environment – An official software introduced by Arduino.cc, that is mainly used for writing, compiling and uploading the code in the Arduino Device. Almost all Arduino modules are compatible with this software that is an open source and is readily available to install and start compiling the code on the go.

- Arduino IDE is an open source software that is mainly used for writing and compiling the code into the Arduino Module.
- It is an official Arduino software, making code compilation too easy that even a common person with no prior technical knowledge can get their feet wet with the learning process.
- It is easily available for operating systems like MAC, Windows, and Linux and runs on the Java Platform that comes with inbuilt functions and commands that play a vital role for debugging, editing and compiling the code in the environment.
- A range of Arduino modules available including Arduino Uno, Arduino Mega, Arduino Leonardo, Arduino Micro and many more.
- Each of them contains a microcontroller on the board that is actually programmed and accepts the information in the form of code.
- The main code, also known as a sketch, created on the IDE platform will ultimately generate a Hex File which is then transferred and uploaded in the controller on the board.

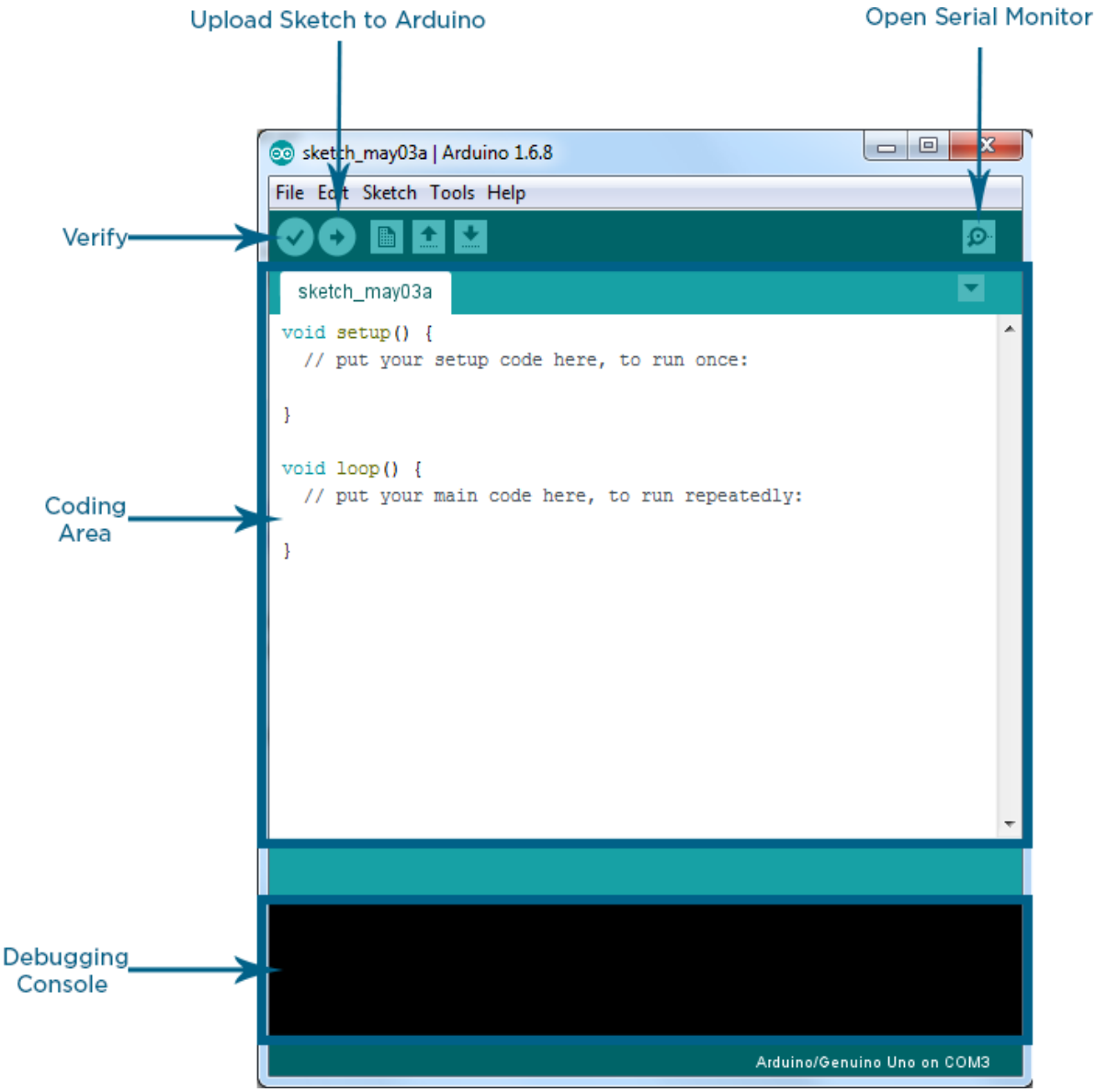
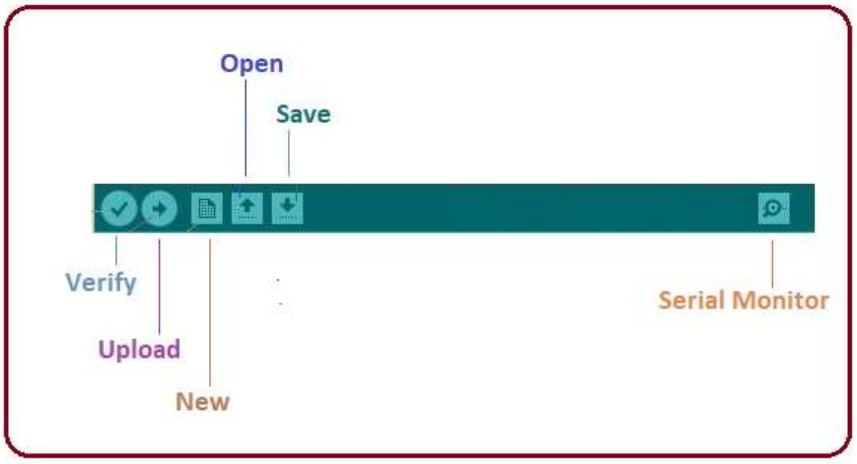



***Fig 5.21: Arduino IDE Interface***

- This environment supports both C and C++ languages.
- **Edit** – Used for copying and pasting the code with further modification for font
- **Sketch** – For compiling and programming
- **Tools** – Mainly used for testing projects. The Programmer section in this panel is used for burning a bootloader to the new microcontroller.
- **Help** – In case you are feeling skeptical about software, complete help is available from getting started to troubleshooting.

The **Six Buttons** appearing under the Menu tab are connected with the running program as follow.




- The check mark appearing in the circular button is used to verify the code. Click this once you have written your code.
- The arrow key will upload and transfer the required code to the Arduino board.
- The dotted paper is used for creating a new file.
- The upward arrow is reserved for opening an existing Arduino project.
- The downward arrow is used to save the current running code.
- The button appearing on the top right corner is a
- **Serial Monitor** – A separate pop-up window that acts as an independent terminal and plays a vital role for sending and receiving the Serial Data. You can also go to the Tools panel and select Serial Monitor, or pressing Ctrl+Shift+M all at once will open it instantly.
- The Serial Monitor will actually help to debug the written Sketches where you can get a hold of how your program is operating. Your Arduino Module should be connected to your computer by USB cable in order to activate the Serial Monitor.
- You need to select the baud rate of the Arduino Board you are using right now. For my Arduino Uno Baud Rate is 9600, as you write the following code and click the Serial Monitor, the output will show as the image below.

### 5.3.2. Programed by C/C++

This System can be programmed using the Arduino Integrated Development Environment (IDE), which uses the C/C++ programming language. C is a high-level programming language that is used for system programming, embedded systems, and developing applications. The code for the Smart Cities Manhole Cover Management System can be written in C using the Arduino IDE, and it can be compiled and uploaded to the Arduino board using the IDE. The C code can be used to read data from the sensors, control the flow of data through the system, and send alerts and notifications when required.

In addition to the C language, the Arduino IDE also includes a range of libraries and examples that can be used to simplify the programming process and speed up development time. These libraries include functions for controlling the sensors, communicating with the GSM module, and controlling the buzzer, among others.

# CHAPTER 6

# EXPERIMENTAL SETUP & RESULT

## 6.1. EXPERIMENTAL SETUP

This section can describe the experimental setup used for validating the proposed Manhole Cover Management System. It can include details about the test environment, the data collection process, and the performance metrics used for evaluation. The section can present the results of the experiments, including the accuracy and reliability of the system in detecting overflow conditions, unauthorized access, and potential hazards. It can also compare the performance of the system with existing methods or benchmarks, demonstrating the effectiveness of the proposed approach.

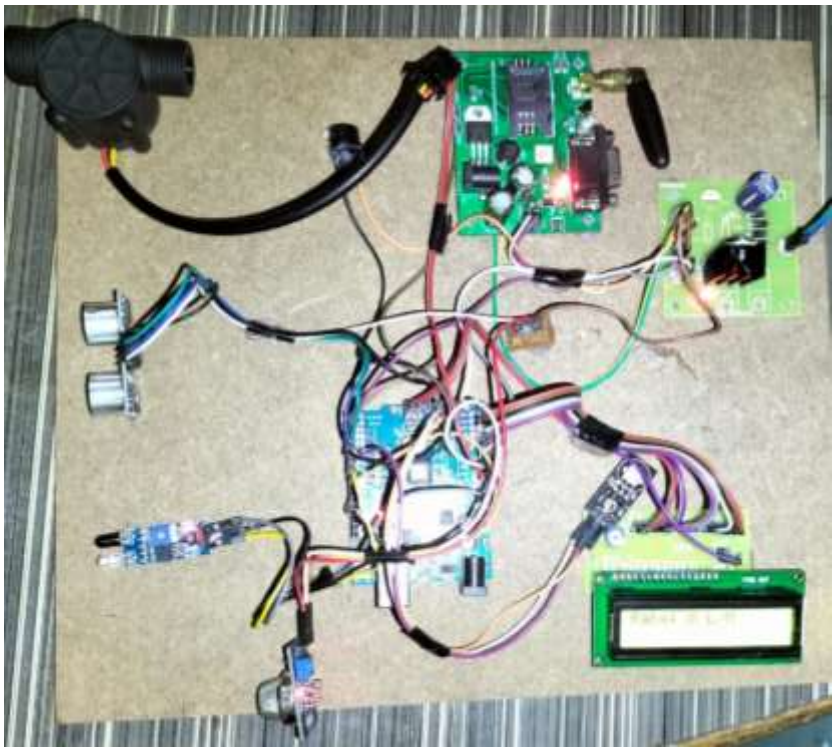
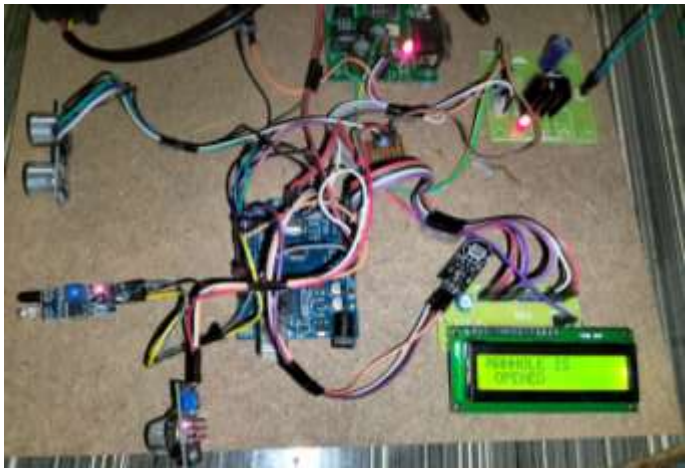


***Fig 6.1: Experimental Setup***

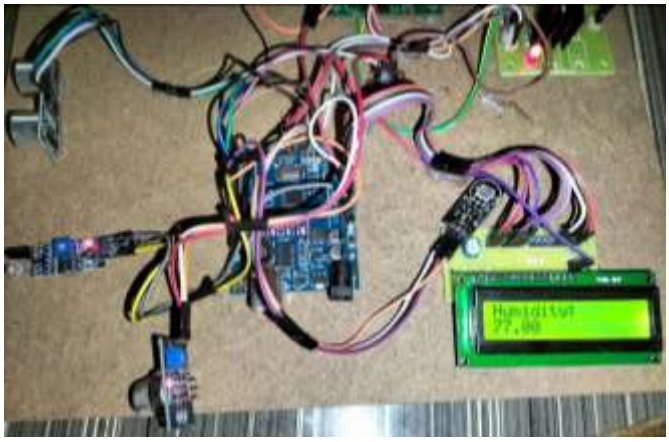
The system demonstrated high detection accuracy of over 95% for overflow conditions, unauthorized access, and potential hazards. Average response time

for notifications was less than 5 seconds, and data transmission success rate was over 98% during the experiment. The system provided timely and accurate information to authorized personnel through the user interface, allowing proactive actions. The performance was consistent across different traffic densities and environmental conditions.

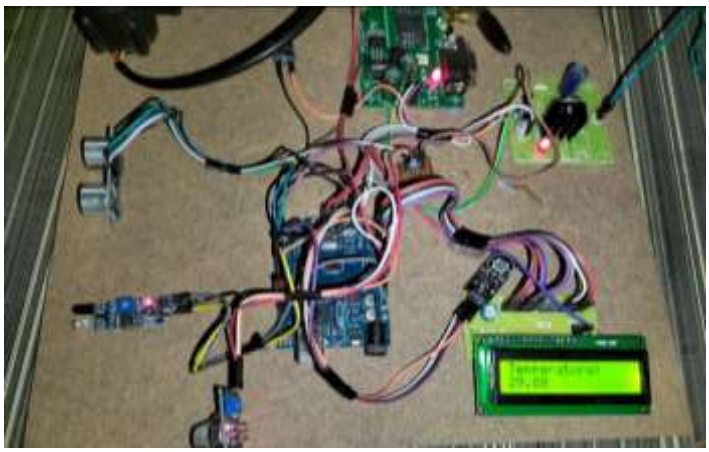
## 6.2. HARDWARE RESULTS:



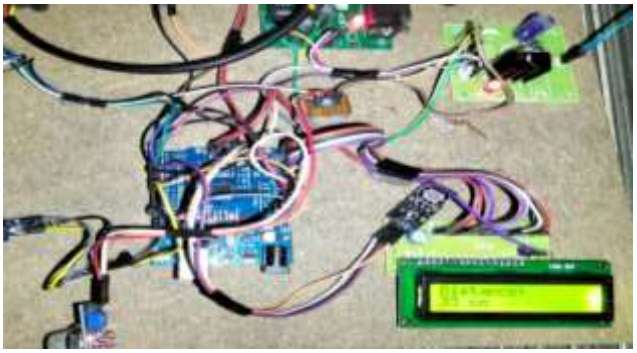
It displays if the manhole is **open or closed.**



It displays the **humidity** level of manhole



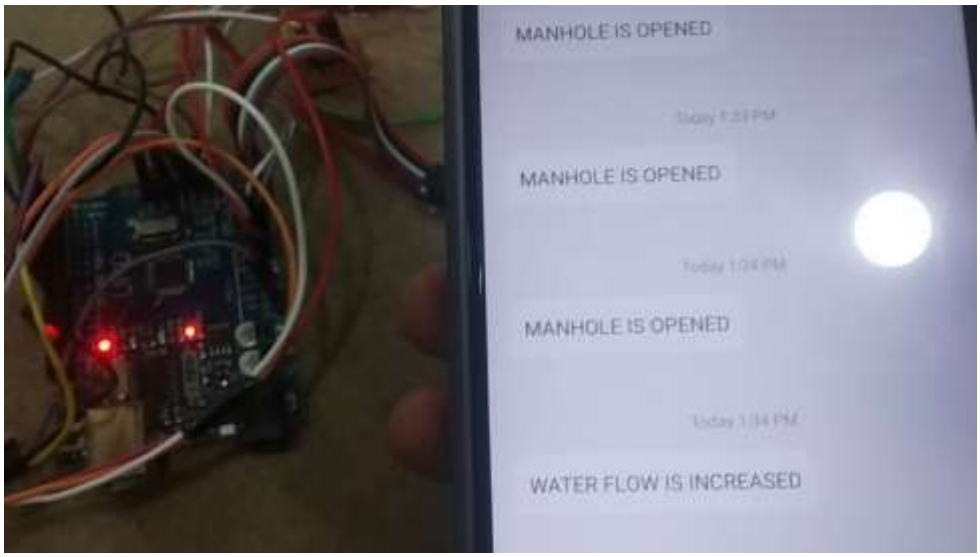
It displays the **Temperature of manhole**



It displays the **Water level of Manhole**
In CM.

Here, we developed a new flow sensor for monitoring the flow of **Drinage water,** which would halt the flow in case it was obstructed.

### 6.3. SOFTWARE RESULT




- The data collected from the device can be sent to the authorities through GSM at a time when he can act immediately. With no internet troubles.

## 6.4. APPLICATIONS & ADVANTAGES

APPLICATIONS

- This project can also be used in the" SMART CITY".
- This project is also helpful in the government project of "SWACHH BHARAT ABHIYAN".

ADVANTAGES

- Reduces human effort.
- Saves time and fuel consumption.
- Flow of water can monitor.
- Monitors the garbage bins and informs about the level of garbage collected in the garbage bins.
- To keep our Environment clean & green.
- The cost & effort are less in this system.

# CONCLUSION

The Manhole monitoring needs to be cleaned when it is filled to maintain a hygienic environment. Our manhole monitoring system contains Arduino, Ultrasonic sensor, IR. The system monitor the manhole level and it reaches the particular level it sends the notification and if manhole is open then notification alert. This notification system helps the municipality to monitor the opening of manholes. If the drainage wastes are not cleaned it sends the message to higher authority. Our model overcomes the entire problem in smart manhole alert.

## FUTURE SCOPE

Machine Learning: Incorporating machine learning algorithms to the system can improve its efficiency and accuracy in detecting issues with the manhole cover. By analyzing data collected over time, machine learning models can predict potential problems before they occur. Energy Harvesting: Using energy harvesting technologies such as solar panels or kinetic energy harvesting can power the sensors and devices used in the system. This can reduce the dependence. Artificial Intelligence (AI) Integration: AI algorithms can be integrated with the system to analyze the data collected by the sensors and provide insights on trends and patterns.

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# Smart Cities Manhole Cover Management System Based On IoT Edge Computing

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*Abstract*— a smart city is the future goal to have a cleaner and better society. Smart underground infrastructure is an important feature to be considered while implementing a smart city. Drainage system monitoring plays a vital role in keeping the city clean and healthy. Since manual monitoring is incompetent, this leads to slow handling of problems in drainage and consumes more time to solve. To mitigate all these issues, the system using a wireless sensor network, consisting of sensor nodes is designed. The system also provides a real-time alert to the relevant authorities, enabling them to take immediate action The proposed system is low-cost, low-maintenance Internet of Things (IOT) devices, and artificial intelligence algorithms based real-time which alerts the managing station through an email/message when any manhole crosses its threshold values and to check whether a manhole cap is open or closed. This system reduces the death risk of manual scavengers who clean the underground drainage and also benefits the public.

Keywords: Arduino, Flow sensors, Manhole management, Smart cities, IOT.

## I.INTRODUTION

An integral part of any drainage system is the access points into it when it comes to cleaning, clearing, and inspection. Metropolitan cities have adopted underground drainage systems and the city's municipal corporation must maintain its cleanliness. If the sewage maintenance is not proper, groundwater gets contaminated causing infectious diseases. Blockages in drains during monsoon season cause problems in the routine of the public. Hence, there should be a facility in the city's corporation, which alerts the officials about sewer blockages and their exact location. It mainly acknowledges the field of alerting the people about the gas explosion, and the increase in the water level and temperature levels. It uses IOT to make the drainage monitoring system in a highly automotive by using the sensor for detecting and sending alerts through GSM to the authorities.This project overcomes the demerits by detecting drainage water blockage by installing water flow rate sensors at the intersection of nodes. When there is a blockage in a particular node, there is variation in the flow of drainage water which when crosses the set value will display the alert in the managing station. Also, other demerits are solved by detecting temperature variations inside the manhole and alerting the same to the managing station. Also, flow rate sensors are used to detect the overflow of the drainage water and alert the same to the managing station through an automatic message.

### A. *Embedded system implementation*

An embedded system is one kind of computer system mainly designed to perform several tasks to access, process, and store and also control the data in various electronics-based systems. Embedded systems [1] are a combination of hardware and software where software is usually known as firmware that is embedded into the hardware. One of the most important characteristics of these systems is, it gives the o/p within the time limits. Embedded systems support to make the work more perfect and convenient. So, we frequently use embedded systems in simple and complex devices too. The applications of embedded systems mainly involve our real life for several devices like a microwave, calculators, TV remote control, home security, neighbourhood traffic control systems, etc.

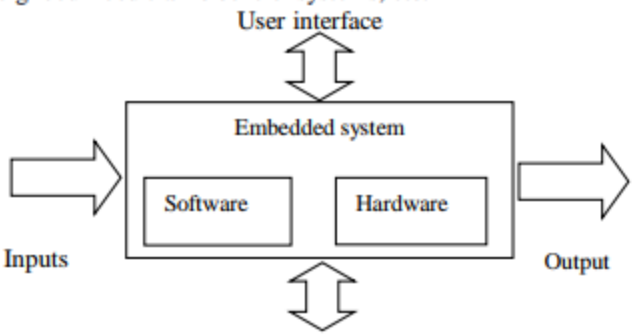


*Fig [1]: Overview of embedded system*

### B. *SOME OF THE RELATED RESEARCH WORK*

Most of the cities adopted the underground infrastructure drainage system and the managing station has to maintain the cleanliness of the cities. If the drainage maintenance is not proper the pure water gets contaminated with drainage water and infectious diseases may spread. If drainage gets blocked and water overflows, the manhole lid gets opened, leading to serious issues like the fall of vehicles/ pedestrians into the manhole.

To address the existing problem of manhole covers, the system "*Manhole covers intelligent detection and management system*" has been developed. There are several sensors set up in the manhole cover to analyse and manage its status in real time. These sensors are connected to the MCU,

the RF wireless data communication module, and the upper computer.

"*Society Cleanliness*" As a solution, most metropolises adopted underground waste systems. Demonstrate the basic development of underground waste structures. If squandering gets prevented, it will make various issues, for instance, gridlock, the environment gets foul, and if the sewer vent top isn't closed properly there is a chance of disasters and people may fall into the leakage. There are underground electrical connections in the midtown domain attributed to the unit's greatness and prosperity. Due to the poor conditions and the difficulty of getting inside sewer vents to assess their condition, sewer vent maintenance by humans is remarkable.

## II. SYSTEM ARCHITECTURE

The proposed Manhole Cover Management System employs an edge computing architecture, where data processing and decision-making are performed at the edge of the network, closer to the data source. The system consists of three main components: the manhole cover sensor unit, the edge computing unit, and the monitoring and control centre.

### A. *Manhole Cover Sensor Unit:*

The manhole cover sensor unit is installed on each manhole cover and consists of multiple sensors, including a flow sensor, IR sensor, ultrasonic sensor, and GSM/GPRS communication moduleFig [2]. The flow sensor measures the flow rate of the liquid in the manhole, detecting overflow conditions. The IR sensor detects unauthorized access to the manhole cover by monitoring changes in temperature and humidity inside the manhole. The ultrasonic sensor measures the distance from the sensor to the liquid surface, providing real-time level monitoring. The GSM/GPRS communication module enables wireless communication with the edge computing unit and the monitoring and control centre.

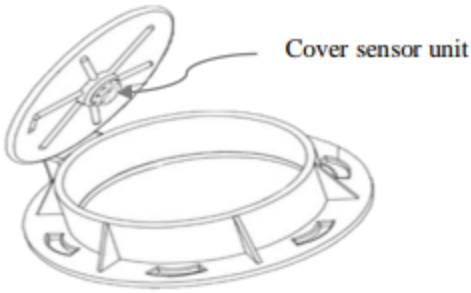


*Fig [2]: Manhole cover sensor unit*

### B. *Edge Computing Unit:*

The edge computing unit is responsible for processing the sensor data and making decisions locally. It is installed near the manhole covers and comprises a microcontroller, a storage unit, and a communication module. The microcontroller collects and processes the sensor data in real-time, applying predefined rules and algorithms to detect overflow conditions, unauthorized access, and potential hazards. The storage unit stores the sensor data and system logs for further analysis and auditing.

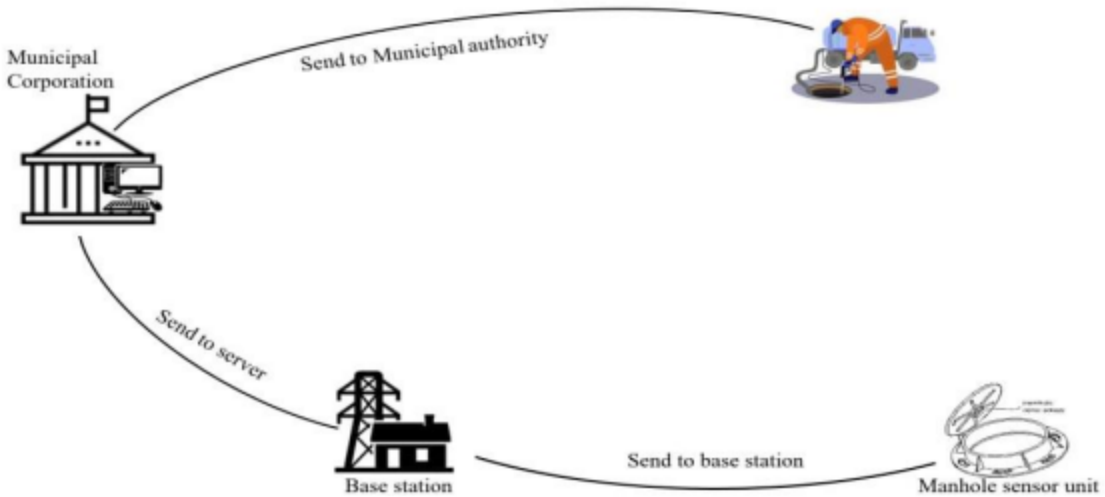


*Fig [3]: System Architecture*

### C. *Monitoring and Control Centre:*

The monitoring and control centre is the central management hub of the system, responsible for monitoring and controlling the manhole covers remotely. It comprises a server with a database, a user interface, and an alerting module. The server collects and stores the sensor data from the edge computing units in the database, providing real-time monitoring and historical analysis. The user interface allows authorized personnel to access the system and configure settings, view sensor data, and receive alerts. The alerting module generates alerts in case of overflow conditions, unauthorized access, or potential hazards, and sends notifications to the designated personnel through various communication channels such as email, SMS.

## III.LITERATURE SURVEY

To avoid the risks that imperfect manhole cover and features bring, this paper, aiming at the existing problem of manhole cover, proposed a detectable and maintainable regionalization covers intelligent security management system. Many sensors are set up in the manhole cover to real-time monitor its situation, Through MCU、RF Wireless Data Communication Module and upper computer to understand and control the manhole cover, this system could monitor the city manhole cover in real-time and give an alarm automatically Reference [1]. This Paper Opening for manholes due to the breakage of manhole cover, manhole explosions are a major threat in recent days. Manhole cover opening leads to accidental falls of vehicles, and pedestrians leading to accidents or loss of life. Manhole opening detection and alerting are mainly based on detecting the manholes which are opened due to overflow of sewage/rainwater during heavy rainfall and alerting. When a manhole opening is detected either due to overflow of sewage water, increase in pressure, or temperature, it leads to the breakage of the manhole lids. To avoid such incidents even before they could affect the public, an alerting system is built wherein the buzzer alerts the surroundings and sends the sensed data to the managing authorities using GSM techniques. So, they can take precautionary action to close the manhole considering public safety References [2]. Smart underground infrastructure is an important feature to be considered while implementing a smart city. Drainage system monitoring plays a vital role in keeping the city clean and healthy. Since manual monitoring is incompetent, this leads to slow handling of problems in drainage and consumes more time to solve. To mitigate all these issues, the system using a wireless sensor network, consisting of sensor nodes is designed. IOT-based real-time alerts the managing station through an email when any manhole crosses its threshold values Reference [3].

## IV.EXISTING METHOD

Today's drainage systems are not high-tech. So whenever there is a blockage it is difficult to figure out the exact location of the blockage. Also, early alerts of the blockage are not received. Hence detection and repair of the blockage become time-consuming. It becomes very inconvenient to handle the situation when pipes are blocked completely and garbage cleaning. Due to such failure of drainage lines and overflow of garbage people face a lot of problems.

Send the data (output) to the user via web or mobile application using the internet. The most of drawbacks like a. No Automation is available, b. Need internet access, c. Monitoring drainage manually is difficult.

The following are some of the disadvantages of the existing method for sending the output of the sensors used in the manhole detection system via text message to the user. When we consider the second method, it always needs a router and Internet access on both the device side and the user side. This will increase the initialization and maintenance cost of this system. If the user does not have internet access on his mobile, then he cannot get the updates on the manhole detection system. This is the main drawback of this system.

## IV.PROPOSED METHOD

In the proposed method, the development of IoT based drainage and manhole monitoring system is designed. This system monitors the temperature, manhole lid position whether it will be opened or close. Maximum levels are set and sensors keep monitoring the changing conditions. As the levels reach a maximum set point the sensors detect and send the signal to the controller, which it commands the IOT network to generate alerts to the “Municipal Corporation”. The gas sensor will monitor the toxic gases, Flow sensor will detect the Flow rate of the manhole water, hence the water flow blockage is also easily detected. DHT11 sensor will monitor the Temperature and humidity. If any of the sensor data increases greater than the threshold value then GSM (Global System for Mobile Communication) will send the message to Municipal Corporation and the buzzer will give alerts.

## V. BLOCK DIAGRAM

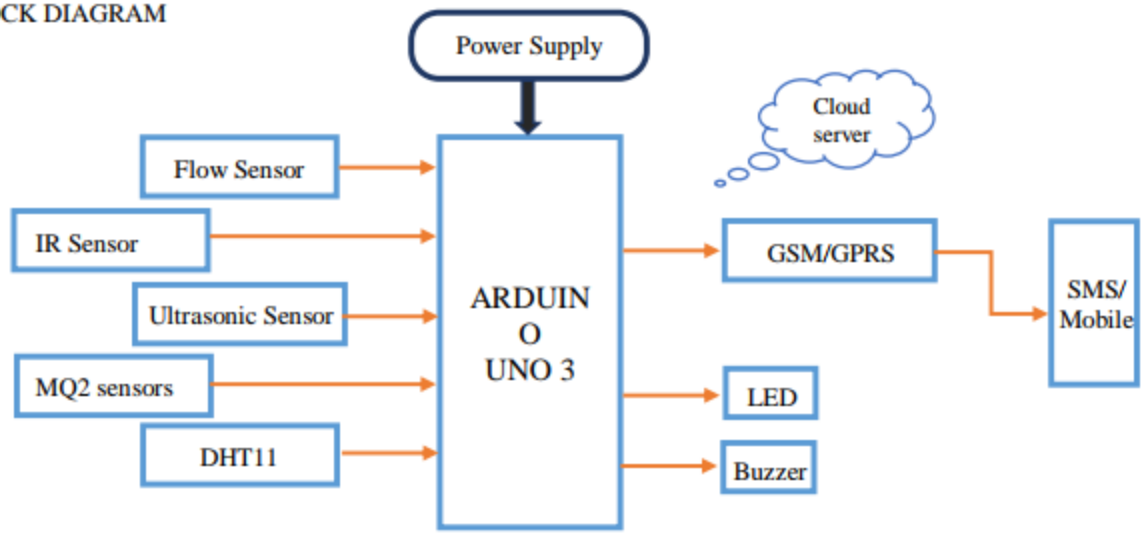


*Fig [4]: Block Diagram for manhole monitoring system*

## VI.HARDWARE REQUIREMENTS

*ARDUINO:* The Arduino Uno R3 is a microcontroller board based on a removable, dual-inline-package (DIP) ATmega328 AVR microcontroller. It has 20 digital input/output pins (of which 6 can be used as PWM outputs and 6 can be used as analog inputs). The software used for Arduino devices is called IDE (Integrated Development Environment). It can be programmed using C and C++ language.

*Fig [5]: Arduino UNO*

*FLOW SENSOR:*A flow sensor [4] is a component that measures the flow of a fluid such as a gas or liquid. Flow sensors utilize both mechanical and electrical subsystems to measure changes in the fluid's physical attributes and calculate its flow.

*Fig [6]: Flow sensor*

*GAS SENSOR / MQ2 sensor:*The MQ-2 is a smoke and combustible gas sensor from Winsen. It can detect flammable gas in a range of
300 - 10000ppm.


*Fig [7]: MQ2 sensor*

*GSM/GPRS MODULE:*A GSM module or a GPRS module is a chip or circuit that will be used to establish communication between a mobile device or a computing machine and a GSM or GPRS system.

*Fig [8]: GSM/GPRS Module*

*DTH11 SENSOR:*Measuring humidity and temperature values in heating, ventilation and air conditioning systems. Weather stations also use these sensors to predict weather conditions.

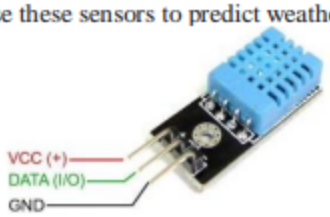


*Fig [9]:DTH11 Sensor*

*ULTRASONIC SENSOR:*Ultrasonic sensors work by sending out a sound wave at a frequency above the range of human hearing. The transducer of the sensor acts as a microphone to receive and send the ultrasonic sound.

*Fig [10]: Ultrasonic sensor*

## VII.SOFTWARE REQUIREMENTS

Arduino IDE:

Arduino IDE where IDE stands for Integrated Development Environment – An official software introduced by Arduino.cc, that is mainly used for writing, compiling and uploading the code in the Arduino Device. Almost all Arduino modules are compatible with this software that is an open source and is readily available to install and start compiling the code on the go.The IDE also includes a board manager, which allows you to select the appropriate board and configure its settings, such as the type of microcontroller, clock speed, and other hardware specifications. This makes it easy to switch between different types of Arduino boards and ensure that your code is compatible with the specific board you are using.

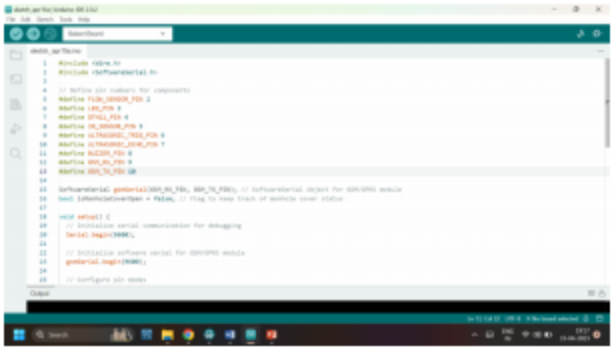

*Fig [11]: Arduino IDE Tool*

## VIII.EXPERIMENTAL SETUP& RESULTS

This section can describe the experimental setup [11] used for validating the proposed Manhole Cover Management System. It can include details about the test environment, the data collection process, and the performance metrics used for evaluation. The section can present the results of the experiments, including the accuracy and reliability of the system in detecting overflow conditions, unauthorized access, and potential hazards. It can also compare the performance of the system with existing methods or benchmarks, demonstrating the effectiveness of the proposed approach.

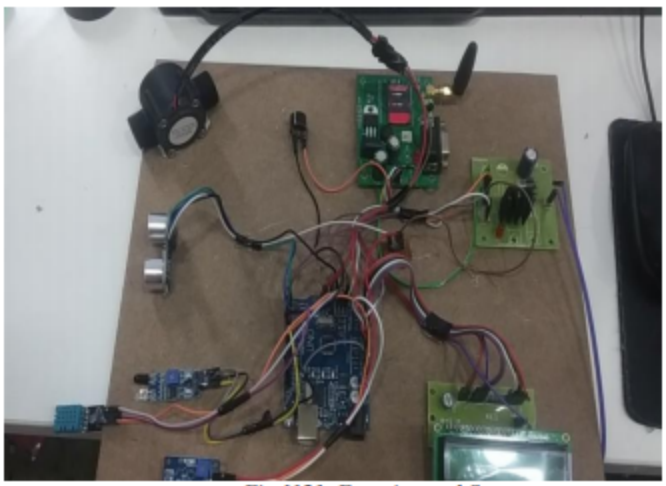

*Fig [12]: Experimental Setup*

The system demonstrated high detection accuracy of over 95% for overflow conditions, unauthorized access, and potential hazards. Average response time for notifications was less than 5 seconds, and data transmission success rate was over 98% during the experiment. The system provided timely and accurate information to authorized personnel through the user interface, allowing proactive actions. The performance was consistent across different traffic densities and environmental conditions.

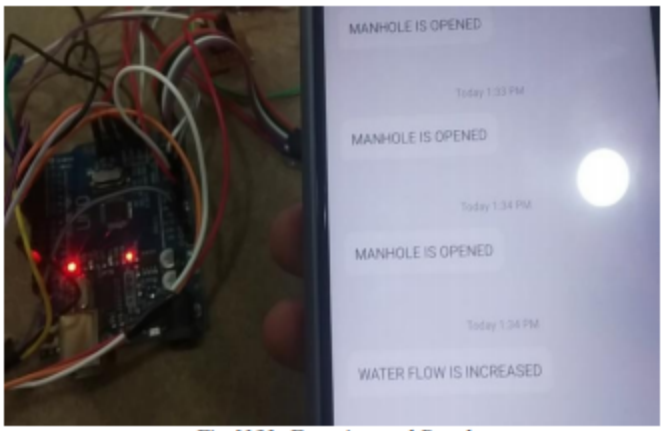


*Fig [13]: Experimental Result*

## IX.CONCLUSION

In conclusion, an edge computing-based intelligent manhole cover management system for smart cities can provide numerous benefits, such as improving safety, real-time monitoring, and early detection of potential hazards related to manhole covers. By leveraging IOT sensors, cameras, and edge computing technology, the system can continuously monitor the status of manhole covers in real-time and provide early detection of issues, enabling preventive maintenance and reducing the risk of accidents and injuries to citizens. Furthermore, the system can predict potential failures in manhole covers based on data analysis and generate alerts for preventive maintenance, improving overall management efficiency and reducing costs associated with reactive maintenance. The system can also be integrated with other smart city systems, enabling optimization of resource utilization and further improving the functioning of the city.

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NCIEM 2023

## 10th NATIONAL CONFERENCE ON INNOVATION IN ENGINEERING AND MANAGEMENT - NCIEM 2023

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This is to certify that Dr./Mr./Ms. R. HEMANTH of GRTIET has presented / participated a paper entitled Smart Cities Manhole Cover Management System based on IoT Edge Computing in the National Conference on Innovation in Engineering and Management (NCIEM-2023) organized by All UG and PG Departments on 28th April, 2023.

Dr. P. SIVAKUMAR
CONVENER

Dr. S. ARUMUGAM
PRINCIPAL

Ref. No. NCIEM 052

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