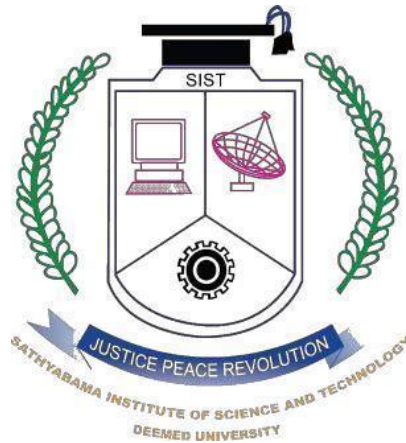


Monitoring and Detection of Manhole Using IoT

Submitted in partial fulfilment of the requirements for the award of
Bachelor of Engineering degree in Electronics and Communication
Engineering

By

Febi Shafrin G.S (39130129)



**DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
SCHOOL OF ELECTRICAL AND ELECTRONICS**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
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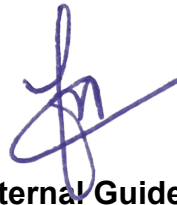
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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **Febi Shafrin G.S** (Reg. No. 39130129) who carried out the project entitled "**MONITORING AND DETECTION OF MANHOLE USING IoT**" under our supervision from January 2023 to April 2023.

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Internal Guide

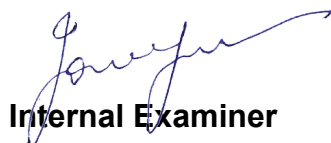
Ms F.V.Jayasudha

A handwritten signature in black ink, appearing to be 'T. Ravi', with the date '15/4/2023' written below it.

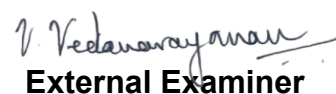
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DECLARATION

Myself, **Febi Shafrin G.S** (Reg. No. 39130129) who carried out the project entitled **“MONITORING AND DETECTION OF MANHOLE USING IoT”** done by us under the guidance of **Ms F.V.JAYASUDHA** is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Electronics and Communication Engineering.

DATE : 19-04-2023

PLACE: CHENNAI

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I would like to express my sincere and deep sense of gratitude and thanks to our project guide **Ms F.V.Jayasudha** for her valuable guidance, suggestions, and constant encouragement paved way for the successful completion of our project work.

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ABSTRACT

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 a message 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. Nowadays, accidents due to broken and missing manhole covers are quite frequent. Manholes are not monitored properly in developing countries. These accidents can lead to serious injuries and also death. Hence, here we propose a system to overcome this problem. We have included an array of sensors for complete monitoring of the manhole cover so that such accidents can be prevented. This project includes a gas cover to monitor the gas emitted from the sewage systems so that toxicity can be monitored, the internal temperature is also monitored if a check for a change in the temperature as the property of manhole change with temperature which could need to crack formation, a tilt sensor is introduced to indicate whether the manhole can tilt. Also, a float sensor is used to indicate when the water level goes beyond a certain level, in case of any alert due to any of the parameters we send a Mail to an authority Mail id.

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LIST OF ABBREVIATIONS

S.NO	ABBREVIATION	EXPANSION
3	ADC	Analog to Digital Convertor
5	AIC	Ampere Interrupting Capacity
6	FPAA	Field Programmable Analog Array
2	GSM	Global System for Mobile Communication
1	LED	Light Emitting Diode
4	PRNG	Pseudo Random Number Generator

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 its cleanliness. If the sewage maintenance is not proper, ground water gets contaminated causing infectious diseases. Blockages drains during monsoon season, causing 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, their exact location. It mainly acknowledges in the field of alerting the people about the gas explosion, increase in the water level and the temperature level. It uses IoT to make the drainage monitoring system in a highly automotive by using sensor for detecting and sending alerts through GSM and GPS module 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 cross 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 automatic message. Maintenance of manholes manually is tedious and dangerous due to the poor environmental conditions inside, so the main focus of this project is to provide a system which monitors water level, atmospheric temperature, water flow and toxic gases. If drainage gets blocked and sewage water overflows, it is sensed by the sensors and a message is sent to the municipality. It is, therefore, dangerous to go inside the manholes for inspection of its current state. To solve all the problems related to underground sanitation, a remote alarm system is necessary for transmitting data collected by the sensors set inside the manhole to the managing station. This includes components such as controller, memory, transceiver and battery to supply power. Manhole detection and monitoring system using IOT it is a very useful system to all of us by this we detect manhole condition in this system.

We used the different components like water flow sensor ,gas sensor , temperature and humidity sensor . This project overcome the demerit of paper by detecting drainage water flow speed rate by installing water flow rate sensor at the intersection of nodes when there is a blockage in a particular road there is variation in the flow of drainage in water which when across the seat value will display the alerts in the managing station by the system. we protect the health of municipality working staff. In this system we use different components this components is very high output and input components and very efficiency component buy this components and this system we detect any problem occur in manhole without any man. For a clean and healthy environment, many Indian cities have an underground drainage system that is controlled by the Municipal Corporation. The water in the drainage system is occasionally mixed with pure water due to poo upkeep Infections and diseases can be spread through the drainage system. Because of climate change, drainage is affected throughout the year, and the environment is dynamic, people's daily lives are disrupted. To fix all drainage system concerns and to send Blynk notifications to the municipal corporation informing them of the state of the drainage system so that officials can take the necessary steps to restore the drainage system. A gas sensor was used to detect the gas produced within the bio-waste drainage system, preventing it from escaping. The pressure inside the drainage system produced an explosion.

The purpose of this design is to track the drainage system using the sensor. When the sewage system is obstructed, water overflows, or the drainage lid is removed, sensors monitor the drainage and send the data to a nearby municipal corporation official via integrated Wi-Fi, where the water overflow and gas value are presented live in the cloud for later examination. The Blynk Server also provides the drainage's GPS location. The sewage system exhibits instability and uncertainty due to multivariable, nonlinear, temporal variation, and random treatment processes. This model's purpose is to create a low-cost, customizable solution for detecting obstructions and stinky or foul-smelling gases. 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 system and the city's municipal corporation must maintain its cleanliness. If the sewage maintenance is not proper, ground water gets contaminated causing infectious diseases. Blockages in drains during monsoon season, causes 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, their exact location. It mainly acknowledges in the field of alerting the people about the gas explosion, increase in the water level and the temperature level. It uses IoT to make the drainage monitoring system in a highly automotive by using sensor for detecting and sending alerts GSM module 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 cross the set value will display the alert in the managing station. 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 over flow of the drainage water and alerting the same to the managing station through automatic message. Maintenance of manholes manually is tedious and dangerous due to the poor environmental conditions inside so, the main focus of this project is to provide a system which monitors water level, atmospheric temperature, water flow and toxic gases. If drainage gets blocked and sewage water overflows, it is sensed by the sensors and message is sent to the municipal. It is, therefore dangerous to go inside the manholes for inspection of its current state. To solve all the problems related to underground sanitation, a remote alarm system is necessary for transmitting data collected by the sensors set inside the manhole to the managing station. This includes components such as controller, memory, transceiver and battery to supply power. In this paper, we propose a cheap and unique manhole intrusion detection system that notifies security teams of four various stages of vandalizing the telecommunication infrastructure in order to reduce copper cable theft. The contributions of this paper are summarized as follows:

- A new flowchart representing the new algorithm for implementing an intrusion detection system.
- Due to the inclusion of three different additional sensors, the proposed system performs timely or early-stage intrusion.

detection. The response time is improved since the first alert is sent to the response team early before the actual cutting of the cable.

- The system first immediately notifies the rapid response team upon

detecting vibrations caused by the tools during cutting of the manhole lid. A vibration sensor is utilized to detect vibrations caused by the cutting tools.

- The rapid response team is alerted if the manhole lid is opened. An ultrasonic sensor detects the opening up of the manhole lid.

- The security team is then alerted when an access into the manhole has been detected before vandalism of the cable itself. Human movement in the manhole is detected by a passive infrared (PIR) sensor. The proposed system notifies the security team in time before the actual cutting of the telecommunication cables.

- Finally, if the cable is cut, another notification is sent to the security team. Cable loop break is detected by a current sensor.

- The sensors are connected to the Arduino-Uno which sends notifications at every stage of vandalism via the GSM SIM 800 L module. An LCD for local display of the notifications is also utilized in our system. Urban cities have been attracting people to live in. Due to the growth of the population, cities utilities and resources are suffering from the rising number of utilities failure and resources consumption. Modern governments normally monitor these utilities and resources to overcome the population growth effect by using new monitoring technologies.

Monitoring and controlling the city utilities, resources and the services using the new monitoring technologies is a strategy named “Smart City”. To clear this point, smart city can be defined as mentioned “ Smart City is a city which functions in a sustainable and intelligent way, by integrating all its infrastructures and services into a cohesive whole and using intelligent devices for monitoring and control, to ensure sustainability and efficiency”. Smart City has many branches from the sensing technology viewpoint as shown in Fig 1:1.

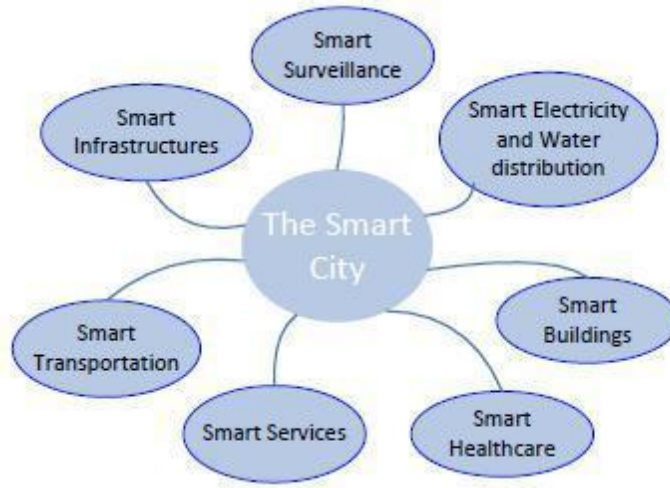


Fig: 1.1 Smart City

Due to the huge developments in the communication systems technologies and the internet, the goal now in the smart city concept is to connect the infrastructures and the services via the internet cloud.

Smart city communication based on internet of things (IoT) cloud is still in the early stages; it is starting to appear in several smart city applications. For example, smart healthcare using wearable medical devices connected to the internet is starting to spread very fast and extending from monitoring patients to being used for monitoring the human health in daily life from several perspectives. When monitoring devices are connected to the cloud, they are called IoT devices. This connection adds more challenges to the monitoring system design like security, privacy, big data, and more.

As reported in [1], smart infrastructures are one of the smart city fields for which applications are required. Infrastructures include underground utilities, which are considered as the vein for any city because most of these infrastructures are commonly used by the people like electrical, water/sewer, natural gas systems, etc. These utilities are designed to be accessed and monitored via a room called “manhole”. Manholes are composed of many structures. One of these structures is the manhole cover . MC is like a door between two different environments: Upper ground and underground environment. As manhole locations can be found all over the cities, MC structure can be affected, and its failure affects the safety, security and the economy of the cities.

Generally, monitoring utilities have two types: automatic and manual. Automatic type means that no human effort has to be done to monitor these utilities; however, the monitoring system is designed to send the data via wireless or wired systems. The other type is manual monitoring, which is based on a human effort to go to the utility location for monitoring regardless of the technologies used to monitor. Automated monitoring systems cost less and are very fast in comparison to the manual ones. However, they are still in the early stages because of several challenges. It is noteworthy that monitoring systems based on IoT cloud which is used for Smart city applications are called nowadays “IoT device”. The IoT device for monitoring MC normally needs to be placed beneath the MC to prevent any harm to pedestrians or the traffic and is connected to the base station then to the cloud. Information is then transferred to the organisation that is concerned about the manhole cover and the utilities under it.

The IoT based automated MC monitoring system is composed mainly of Sensors, Data Acquisition system (DAQ), Control Unit (CU), Communication unit, and Power unit as shown in Figure 1.2. Based on the study done by the researcher, power consumption is one of the main challenges for designing the IoT based automated MC monitoring system. An analogue to digital converter (ADC) found in the DAQ unit is the circuit with the highest power consumption which needs to be redesigned to reduce the amount of power consumed.

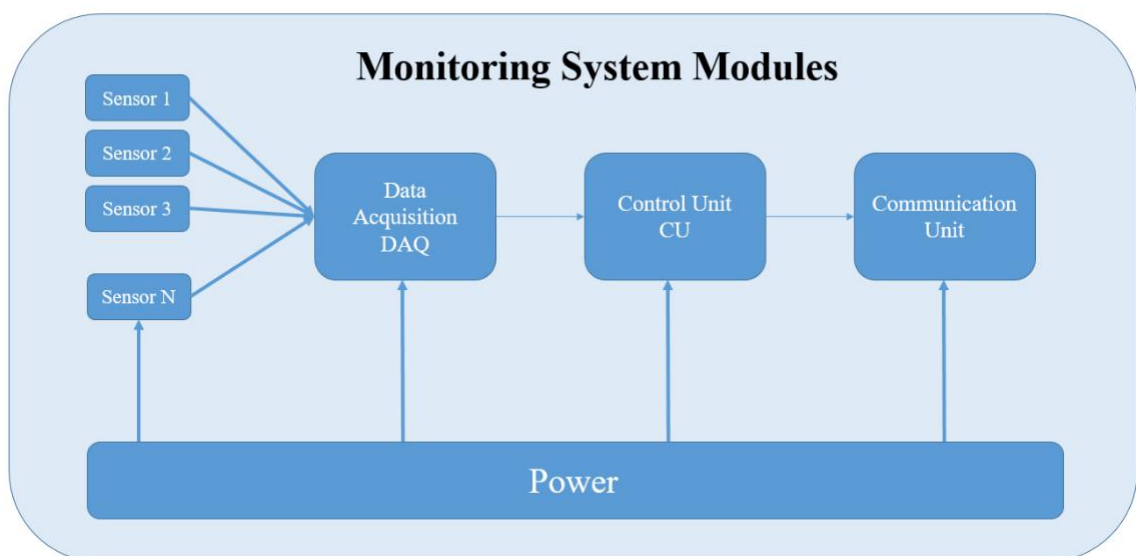


Fig 1.2 IoT device based automated MC monitoring system

While most of the designs of IoT devices is based on digital circuit design techniques because it is robust to noise and easy to program, analogue circuit design can be considered as another route to overcome the same challenges with significant result especially for power consumption and security .

From this point of view, the research is focusing on designing a low-power, secured ADC based on analogue circuit design techniques to be used in the DAQ unit for the IoT based automated MC monitoring system. The research uses the off-shelf components and a design using a printed circuit board (PCB) for the sake of simplicity and to achieve an optimum design with acceptable low cost.

The main reason that makes an ADC circuit the unit which consumes more power is using a high sampling rate as it will be shown later. The sampling rate for a traditional ADC is based on the bandwidth of the signal which is for the DAQ unit the sensors signal bandwidth. Based on the study done by the researcher as will be, the sensors' signal can reach 5 MHz frequency range. The minimum required sampling rate for the traditional ADC is at least double the signal bandwidth (Nyquist Shannon sampling theorem).

On the other hand, an IoT device designer needs to take all the design challenges into his/her considerations. There are several challenges besides the power consumption which must be considered like security, huge data, and cost, etc. Several techniques have been addressed to optimise these challenges. However, the compressive sensing technique is more attractive because of its basic design which has the ability to reduce the power consumption and the amount of data at the same time.

Compressive Sensing theory introduced in 2002 claims that sampling rate of the ADC can be reduced to less than the Nyquist Shannon rate if the signal has a sparse representation in one of the known domains like the frequency domain. Fortunately, most of the sensor signals are sparse in some domains like the frequency domain [5]. The sparse representation means that the signal is sparse in a specific domain if most of its values in this domain are equal to zero. Another advantage of reducing the sampling rate is the reduction of the memory size because the number of bits needed to represent the analogue signal will be reduced.

Compressive Sensing based ADC is called Analogue to Information Converter (AIC). The reason for this name is that CS is targeting the information in the signal more than its bandwidth. As for sparse signals, the information content is less than the bandwidth; the ADC sampling rate requirement will be reduced in comparison without reducing the sensor signal bandwidth. AIC has several architectures like Random Demodulation (RD), Random Modulator Pre-Integrator (RMPI), Xampling... etc. This research will focus on RD only because of its simplicity.

The central part of most of the AIC architecture is the random number generator (RNG). RNG has to generate random $(-1, 1)$ or $(0, 1)$ sequence with a rate equal to or more than Nyquist Shannon rate. Most of the RNG used in AIC is a pseudorandom generator (PRNG) designed by linear shift register (LFSR) technique. LFSR is a very well-known digital circuit that generates PRNG. However, this digital circuit is found in the analogue front end of the AIC, which means isolation is required between the analogue and digital parts to prevent crosstalk and noise. Another disadvantage of using LFSR in AIC analogue front end is the security factor. While LFSR generates random signals, it suffers from the lack of security. This point is very important from the IoT device design viewpoint and motivated several researchers to develop the CS to make it acceptable from the security point of view.

However, most of these efforts were based on digital circuit design by developing or replacing LFSR with more complex digital design and mainly based on digital chaotic oscillator design. Chaotic oscillators can be presented in an analogue and digital manner. Because chaotic oscillators are based on differential equations that model the dynamic behaviour of the oscillators, an analogue hardware implementation for chaotic oscillators consumes less power than digital hardware implementation as will be shown later in this research. Furthermore, analogue circuit design becomes more attractive from the power consumption point of view through merging the analogue circuit design with other fields like neuroscience and biology. This point was highly motivating to study and investigate the ability to design low power analogue chaotic oscillator to replace LFSR taking into consideration the security issue.

As a starting point of the research, an analogue Chua circuit chaotic oscillator will be tested in AIC framework as it is considered as the basic circuit to implement chaos theory. The motivation for using the Chua circuit is the simplicity with few numbers of components required. Chua circuit is one of the mostly used circuits in communication applications for encryption and is used to generate random numbers in some applications .

The chaotic sequence has been studied before in the CS theory and shows good performance for signal reconstruction. However, implementing the analogue chaotic circuit in AIC framework has not been performed until now to the knowledge of the author. This has motivated the researcher to study the use of the analogue chaotic oscillator circuit to identify the hardware limitations and the design trade-off.

The proposed systems are based on coupling oscillators. The coupling oscillators concept is starting to get more attention from the scientists as it can be used in several fields like neuroscience, neuromorphic engineering and analogue circuit design. Generally, a chaotic oscillators design starts from modelling the chaotic system in differential equations form to model the dynamic behaviour. In this research, another circuit design technique will be presented which is the waveshaping technique.

The waveshaping technique is well known for design relaxation oscillators. This technique is based on studying the effect of charging and discharging the energy storage elements in the presence of the resistors and/or diodes to reshape the input signals. The technique is very easy to understand and does not require extensive differential equation analysis as in the traditional chaotic oscillator design and analysis.

The relaxation oscillator circuit design can be implemented by means of transistors or opamp. The Opamp Schmitt trigger-based relaxation oscillator will be used for implementing the proposed systems. The two main motivations to use opamp Schmitt trigger are:

- 1- The simplicity of the design.

2- Schmitt trigger is one of the main blocks for designing field programmable analogue array (FPAA), which gives the advantage of controlling the analogue design by programming. This point is more important when the hardware implementation of the compressive sensing is based on FPAA, which has been done before and still promising for more development especially after applying the neuromorphic engineering concept on analogue design as will be shown later.

In this thesis, two modifications are presented for an opamp Schmitt trigger. These modifications mimic the effect of coupling oscillators between two biological oscillators which leads to chaotic behaviour which is the main target of the design.

PSpice software was used for simulating the analogue Chua circuit and the proposed systems. Hence, the output of the PSpice will be fed to Random Demodulation based AIC framework implanted in Matlab software. Besides the simulation, hardware implementation takes place by using the Texas Instrument Analog System Lab Kit which shows the simplicity of designing the proposed systems.

The proposed systems are simulated based on: a) the range of the temperature found beneath MC (-30°C – 60°C), and b) the presence and the absence of the noise. The proposed systems are also validated by comparing them with a Jerk chaotic oscillator using two opamps which has the same number of the active elements. The validation results show the good performance of the proposed systems from the power consumption and the signal reconstruction viewpoints especially the second proposed system.

The proposed systems can be found in the same PCB or IC with using only two opamps. This point is very attractive from the security perspective because of the fewer resources required. Because the study uses off the shelf components, it is expected to develop for what is now called open source hardware to be used for the IoT hardware design.

CHAPTER 2

LITERATURE SURVEY

2.1 Interfaces from Literature Survey

In 2012 ,The design space of wireless sensor networks, Wireless Communications, Author: Romer, K. Mattern , In the recent past, wireless sensor networks have found their way into a wide variety of applications and systems with vastly varying requirements and characteristics.As a consequence, it is becoming increasingly difficult to discuss typical requirements regarding hardware issues and software support. This is particularly problematic in a multidisciplinary research area such as wireless sensor networks, where close collaboration between users, application domain experts, hardware designers, and software developers is needed to implement efficient systems. In this paper we discuss the consequences of this fact with regard to the design space of wireless sensor networks by considering its various dimensions. We justify our view by demonstrating that specific existing applications occupy different points in the design space.

In the year 2011 ,Towards the Implementation of IoT for Environmental Condition Monitoring in Home, Author: Kelly S.D.T, Suryadevara, N.K, Mukhopadhyay S.C ,In this paper, we have reported an effective implementation for Internet of Things used for monitoring regular domestic conditions by means of low cost ubiquitous sensing system. The description about the integrated network architecture and the interconnecting mechanisms for reliable measurement of parameters by smart sensors and transmission of data via internet is being presented. The longitudinal learning system was able to provide self-control mechanism for better operations of the devices in monitoring stage. The framework of the monitoring system is based on combination of pervasive distributed sensing units, information system for data aggregation, reasoning and context awareness. Results are encouraging as the reliability of sensing information transmission through the proposed integrated network architecture is 97%. The prototype was tested to generate realtime graphical information rather than a test bed scenario

In the year 2013, Monitoring Smart City Applications using Raspberry PI Based on IoT, Authors: Prof. S A. Shaikh¹, Suvarna A. Sonawane, the Smart city is the development goal to monitor the quality of resource in the city to improve good management and faster development of the city required necessity is to upgrade healthy and safe cities that delivering real time services and latest facility to implement the concept of smart city use IoT concept by which easy wireless communication is possible. The system consist of sensors, collect different types of data from sensors and transfer to the Raspberry Pi3 controller. The acquired output from the controller is sent to the control room through the E- mail and also display on the personal computer.

In the year 2015 ,Manhole Detection and Monitoring System Using IOT, Authors: Mr. Mane Harshavardhan, Mr. Nimbaler, Chougule Pushpraj Babaso , Mr. Ghatage Abhishek Dundappa, Ms. Saundatte M .G Manhole detection and monitoring system using IOT it is a very useful system to all of us by this we detect manhole condition in this system. We used the different components like water flow sensor ,gas sensor , temperature and humidity sensor . This project overcome the demerit of paper by detecting drainage water flow speed rate by installing water flow rate sensor at the intersection of nodes when there is a blockage in a particular road there is variation in the flow of drainage in water which when across the seat value will display the alerts in the managing station by the system. we protect the health of municipality working staff. In this system we use different components this components is very high output and input components and very efficiency component buy this components and this system we detect any problem occur in manhole without any man. In our manhole detection and monitoring system project we have detect the flow of water, toxic gases, sense the humidity and temperature in the manhole and they send the IOT message to municipal corporation. In this system we have also reduce the work of man power and easy to handle situation. In previous system man had to go inside the drainage system and clean the garbage but in the new system the work has been made easier and safe by reducing those things.

In the year 2009, Manhole cover monitoring system over IOT, Authors: Wesam Moneer Rasheed, Raed Abdull, Development of smart cities and implementation of automated manhole covers has gained much importance in previous years. A number of incidents occur regarding the safety and security of people due to the

issues of manhole cover (MC). Uncovered holes pose a great challenge to citizens and can cause safety hazards to underground structures. To prevent accidents from manhole-cover an intelligent manhole cover management system has been introduced as a basic platform in smart cities. Developing cities usually do not focus on opened manhole covers and are not monitored properly. These manholes can be a great threat to lives and assets in a number of ways. Manholes can be filled with some toxic and hazardous materials and underground structures can get affected from these materials. Systems need to be developed to monitor the lids of manhole covers to avoid accidents. Developments are made to replace traditional and manual methods with IoT based automated monitoring systems. The issue of poorly managed and stolen gas well covers is becoming an alarming situation in different countries. The existing manhole cover systems are found to be covering single monitoring parameters, have immature technology and contain inefficient analysis capabilities to find and eradicate issues regarding manhole covers and security.

The traditional methods of manhole cover protection and monitoring cannot cope with the challenges of increasing population and underground infrastructures, therefore, there is a need to develop more automatic systems of monitoring. To detect the issues regarding manholes, a system with Global Positioning system (GPS) has been developed based on ultrasonic sensors and accelerometers to detect manholes accurately. For monitoring of the road, the sensor-based system detects the vehicles and provides data to cloud system continuously. This system helps drivers to avoid manhole on the road and provide them with alarming alerts. The sensor based system also provides useful data to Highway Maintenance Department in a smart city. This proposed method employs accelerometer and ultrasonic sensors. The data obtained from sensors is processed and analysed through Honey Bee optimization algorithms. This system can also provide information of any accident occurred on the road to save other vehicles from its effects. A survey report showed that in India, nearly 50% of the roads are damaged because of manholes and can cause dangerous impacts on humans and vehicles. The sensor-based systems are seen to be more fast and liable modes of manhole detection.

In the year 2006, Development and Test of Manhole Cover Monitoring Device Using LoRa and Accelerometer. Authors: He-sheng Zhang; Lei Li; Xuan Liu, The monitoring device is installed under the manhole cover, three key problems, how to

measure the tilt angle or state of resources °. For the second problem, long range (LoRa) is adopted. A 433-MHz whip antenna is designed to overcome the shield of manhole cover and the absorption of electromagnetic waves of the earth. The field tests show that the effective communication distance has been extended more than 700 m by using the whip antenna. In addition, the parameter spreading factor (SF) and bandwidth (BW) are configured. For the third problem, sleep mode is used and input output (IO) pin is configured.

In the year 2004, Thermodynamic Analysis of Explosive Events in Manholes and Electrical Vaults, Authors : W.Z.Black, Robert E.Snograss, Bryan P.Walsh . A computer code is used to simulate the conditions that exist during a manhole event consisting of an electrical fault and a gas explosion. When energy is generated within the structure, pressures can reach levels sufficient to propel the cover from its frame . The code quantifies the effects of the event and provides guidelines for the design of safety devices that can minimize the potential danger of the event. Differences between chemically-driven and electrically-driven events are shown to require different design criteria for cover restraint systems. Devices designed to restrain the cover must be able to withstand explosive forces and react in sufficient time to reduce internally generated pressures.

In the year 2008, Manhole explosion and its root causes, Author: Glen Bertini .The phrase “manhole events” is a euphemism for fires and explosions that occur in utility manholes in urban areas. All fires and explosions require three elements: fuel, oxygen (or another oxidizer), and an ignition source. Further, the fuel and oxygen must be within a specified range of concentrations to support combustion. Figure 1 lists most of the significant compounds (flammable or not) that are likely to be encountered in a manhole environment and, where applicable, their upper and lower explosive limits (UELs and LELs, respectively).

In the year 2015, Secure Manhole Monitoring system Employing sensor and GSM Techniques, Author: N Nataraja; R Amruthavarshini; N L Chaitra; K Jyothi; N Krupaa; S S M Saquaf . Nowadays manhole problems in the populated cities is the major issues. 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. In 2016 Sugato Ghosh; Indranil Das; Deepanjana Adak; Nillohit Mukherjee; Raghunath Bhattacharyya worked on "Development of selective and sensitive gas sensors for manhole gas detection". Loss of life of the workers inside manhole is a common problem for many parts of the world. To resolve this issue a portable, low cost, simple manhole gas detection unit has been designed and developed which is capable to detect the poisonous gases like carbon monoxide, hydrogen sulfide, and explosive gas like methane within a minute and raise alarm if the concentration of any gas is beyond the threshold limit.

CHAPTER 3

AIM AND SCOPE

3.1 Aim of the Project

The aim of the project is to have cleaner cities and intelligent management of drainage in the city. , Detection of drainage water level and blockages in the drainage, Checking water flow rate continuously, as well as sending automatic mail, display on the monitor if the water level is outside of an expected normal range, The main objective is to obtain an effective low-cost and flexible solution for condition monitoring and infrastructure management in the city, Sensing the temperature and leakage of gas and updating it in real time through IoT. This research aims to investigate and design a low-power IoT-based manhole cover monitoring system to be used for smart city applications taking into consideration the IoT device design requirements and challenges. Critically surveying the existing problems and researches for the Manhole Cover and its monitoring systems . The results and analysis from this survey are used to identify and list the main challenges for designing automated MC monitoring system from the Smart city and IoT point of view . Investigating Compressive sensing and the analogue circuit design techniques to reduce the power consumption for IoT -based manhole cover monitoring system . Developing an improved performance technique suitable for reducing the power consumption of the IoT -based manhole cover monitoring system. Validating the developed technique using simulation results and hardware implementation and examining the power consumption and the thermal effect of the signal reconstruction for the proposed systems, based on the range of the temperature found beneath the manhole cover.

3.2 Scope of the Project

Today's drainage system 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. Due to the failure of the drainage line people face a lot of problems. A new method combined with multi-view matching and feature extraction

technique is developed to detect manhole covers on the streets using close-range images combined with IMU and LINDAR data. The covers are an important target on the road traffic as same as transport signs, traffic lights and zebra crossing but with more unified shapes. However, the different shoot angle and distance, ground material, complex street scene especially its shadow, and cars in the road have a great impact on the cover detection rate. The paper introduces a new method in edge detection and feature extraction in order to overcome these difficulties and greatly improve the detection rate.

CHAPTER – 4

METHODOLOGY AND ALGORITHMS USED

4.1 Existing Methodology

In the previous model we have used GSM and GPS. The location of the manhole shall be updated on map. This feature of the system can be further used by various GPS navigation software apps such as google map and WAZE to show the missing manhole road to prevent accidents . The localization requires the system to get the coordinates of the missing manhole via the GSM/ GPS module and update the location on a Map on the IOT platform.

Detecting a struck in the manhole pipe, due to blockage of sludge in a pipe. It is also necessary to alert the concerned authorities in case of opened/ displaced/ breakage of manhole lids for necessary and immediate action. This enables to maintain a safe and user-friendly environment. To monitor water level in manhole sensors are to be deployed which will detect and transmit necessary data for immediate attention to clear the clogs well before it over flows.

4.2 Proposed Methodology

It is a very useful system to all of us because this system detects and monitors the manhole situation. The system used different components like Arduino UNO, DHT11 sensor, MQ4 gas sensor, Wi-Fi module ESP8266 LCD display.

In this system we used a different sensor, if any problem occurs in band holder centuries since this problem and send the information to the microcontroller and Microcontroller is given information and by Wi-Fi module this is for information said to the authorized person. A new automated system is presented to solve the aforementioned shortcomings. The manhole is monitored by sensors in the proposed system, and data is automatically updated on a remote server. The microcontroller Arduino Mega interfaced with the several types of sensors (flow, level, temperature, and gas sensors). When the various sensors hit the threshold level, the microcontroller receives an indicator of that value and sensor is being sent to the microcontroller. Furthermore, Arduino Mega then sends the signal and location of the manhole to the municipal corporation

through Alert and the officials could easily locate which manhole is having the problem and could take appropriate steps. Also, Arduino Mega updates the live values of all the sensors. We have included an array of sensors for complete monitoring of the manhole cover so that such accidents can be prevented. This project includes a gas cover to monitor the gas emitted from the sewage systems so that toxicity can be monitored, the internal temperature is also monitored if a check for a change in the temperature as the property of manhole change with temperature which could need to crack formation, a tilt sensor is introduced to indicate whether the manhole can tilt.

4.3 Difference Between Existing and Proposed Methodology

The practical square outline portrays the observation of sewer vent in underground waste framework. Any blockages, ascend in temperature, blast because of poisonous gases, flood, sewer vent cover left open is distinguished by the sensors. The signs from the sensors are taken care of to the regulator, which is modified to produce alarms. In this we use sensors to distinguish blockage, floods, and gases. The sensors will distinguish the obstructing inside the seepage framework and will give data about the area and further moves will be made by the civil. There are some other systems already available which can be classified as two types. Send the output to the user via text message through GSM. Send the output to the user via web or mobile application using internet. The following are some of the disadvantages of the existing method For sending the output of the sensors which are used in the manhole detection system via text message to the user, then we need to initialize the user's mobile number previously. But we cannot be sure that the user always has the registered mobile number. When we consider the second method, it always needs a router and Internet access on both device side and user side. This will increase the initialization and maintenance cost of this system. If the user does not have internet access in his mobile, then he cannot get the updates of the manhole detection system. This is the main drawback of this system.

4.4 Advantages of Proposed Methodology

In our project we have overcome these drawbacks in both existing systems. We are creating an edge network instead of the internet. We have constructed the manhole detection system through attaching an array of sensors like tilt sensor, Gas sensor, Float sensor, etc. and also attach an esp8266 with this

system. We have programmed this esp8266 as an access point which provides its own network without the internet. If the user is present in this area, the manhole detection system automatically sends the sensor's data to the user via web or mobile application alert messages without internet. The following are some of the key advantages of the proposed method: In this proposed method, there is no need to spend money on the internet. Whole system is working like a local network by edge computing. The user can use any device to get the updates from the system. Not limited to using only registered devices. The user doesn't need to have internet access in his device to get updates from this manhole detection system.

CHAPTER 5

IMPLEMENTATION DETAILS

5.1 Block Diagram

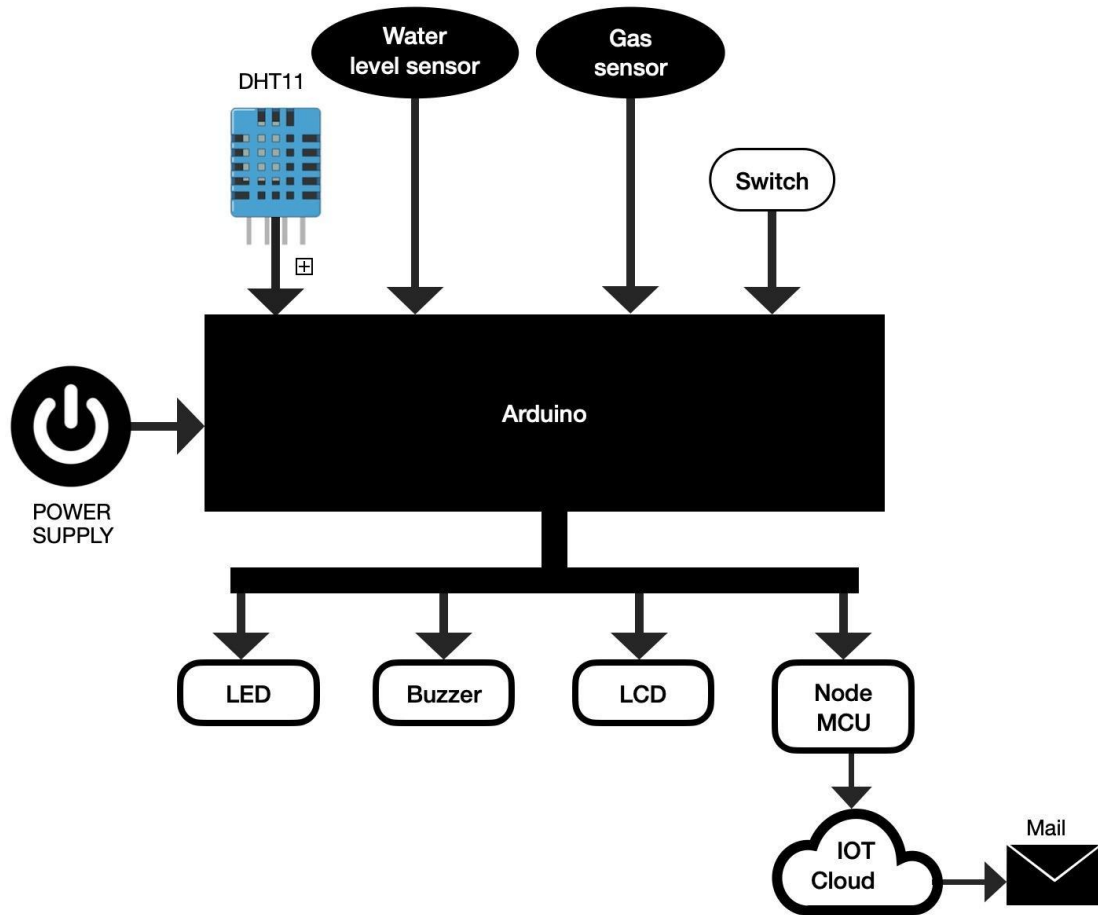


Fig 5.1 Block Diagram

5.2 Working

An underground drainage monitoring system will not only help in maintaining the proper health and safety of the city but also in reducing the work of government personnel. Various types of sensors (flow, level, temperature and gas sensors) are interfaced with microcontroller Arduino Uno in order to make the system smart. When the respective sensors reach the threshold level, the indication of that respective value and sensor is being sent to the microcontroller. Furthermore, Arduino Uno then sends the signal and location of the manhole to the municipal corporation through GSM and GPS and the officials could easily locate which manhole is having the problem and could take appropriate steps. Also, Arduino Uno updates the live values of all the sensors in the manholes falling under the respective area using IoT. A message will also be displayed on

the LCD. Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs – light on a sensor, a finger on a button, or a Twitter message – and turn it into an output – activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino programming language (based on Wiring), and the Arduino Software, based on Processing.

Over the years Arduino has been the brain of thousands of projects, from everyday objects to complex scientific instruments. A worldwide community of makers – students, hobbyists, artists, programmers, and professionals – has gathered around this open-source platform, their contributions have added up to an incredible amount of accessible knowledge that can be of great help to novices and experts alike.

LCD screen is an electronic display module and finds a wide range of applications. A 16x2 LCD display is a very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on. A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in a 5x7 pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD.

Node MCU is an open-source platform based on ESP8266 which can connect objects and let data transfer using the Wi-Fi protocol. In addition, by providing some of the most important features of microcontrollers such as GPIO, PWM, ADC, and etc, it can solve many of the project's needs alone. The general DHT11 is a low-cost digital sensor for sensing temperature and humidity. This sensor can

be easily interfaced with any micro-controller such as Arduino, Raspberry Pi etc... to measure humidity and temperature instantaneously. DHT11 humidity and temperature sensor is available as a sensor and as a module. The difference between this sensor and module is the pull-up resistor and a power-on LED. DHT11 is a relative humidity sensor. To measure the surrounding air this sensor uses a thermistor and a capacitive humidity sensor.

The water level sensor is a device that measures the liquid level in a fixed container that is too high or too low. According to the method of measuring the liquid level, it can be divided into two types: contact type and non-contact type. The input type water level transmitter we call is a contact measurement, which converts the height of the liquid level into an electrical signal for output. It is currently a widely used water level transmitter.

Gas sensors are devices that help us understand the amount of gas in the environment and the natural state of its movement. Gas sensors reveal the amount of gas in the environment and the nature of the gas composition with electrical signals and can provide its change

The parameters that should be considered when creating gas sensors are as follows: the type of gas that needs to be detected, its concentration, and the environment in which the gas is located. MWCNT gas adsorption occurs in the outer region where the gas molecule is connected to the sensor together with the van der Waals force. The electrical charge flow in the gas sensor differs from the binding of the molecule. With this differentiation, gas sensor resistance is determined to differ .

A switch responds to an external force to mechanically change an electric signal. Switches are used to turn electric circuits ON and OFF and to switch electric circuits. In electrical engineering, a switch is an electrical component that can disconnect or connect the conducting path in an electrical circuit, interrupting the electric current or diverting it from one conductor to another. The most common type of switch is an electromechanical device consisting of one or more sets of movable electrical contacts connected to external circuits. When a pair of contacts

is touching current can pass between them, while when the contacts are separated no current can flow. An audio signaling device like a beeper or buzzer may be electromechanical or piezoelectric or mechanical. The main function of this is to convert the signal from audio to sound. Generally, it is powered through DC voltage and used in timers, alarm devices, printers, alarms, computers, etc. Based on the various designs, it can generate different sounds like alarm, music, bell & siren. LED lighting products produce light up to 90% more efficiently than incandescent light bulbs. How do they work? An electrical current passes through a microchip, which illuminates the tiny light sources we call LEDs and the result is visible light. To prevent performance issues, the heat LEDs produce is absorbed into a heat sink. LEDs are semiconductor light sources that combine a P-type semiconductor with an N-type semiconductor . Applying a sufficient forward voltage will cause the electrons and holes to recombine at the P-N junction, releasing energy in the form of light. Compared with conventional light sources that first convert electrical energy into heat, and then into light, LEDs convert electrical energy directly into light, delivering efficient light generation with little-wasted electricity. The Arduino Integrated Development Environment - or Arduino Software contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuino hardware to upload programs and communicate with them.

5.3 Manhole Cover and its failure's impact



Fig 5.2 MC materials

MC, as mentioned before, is like a door between two different environments. Each environment affects the MC structure and this effect differs according to the MC material types. Generally, MC can be fabricated from several materials like cast iron or composite like fibre reinforced plastics and other materials as shown in Figure . The type mostly used all over the world and found intensively in the roads is the cast iron.

Besides, any MC design has to follow the country's specifications. For example, in the UK, BSI British Standards is the UK's national standards organisation that produces standards and information of products that promote and share best practice. The code which begins with "BS EN 124" is the code for gully tops and manhole tops for vehicular and pedestrian areas. Based on the location of manhole it is classified into several classes as shown in Figure The type that will be considered in this study mainly is Group 4 which includes carriage and roads (heavy duty) which is called BS EN124 Class D400.

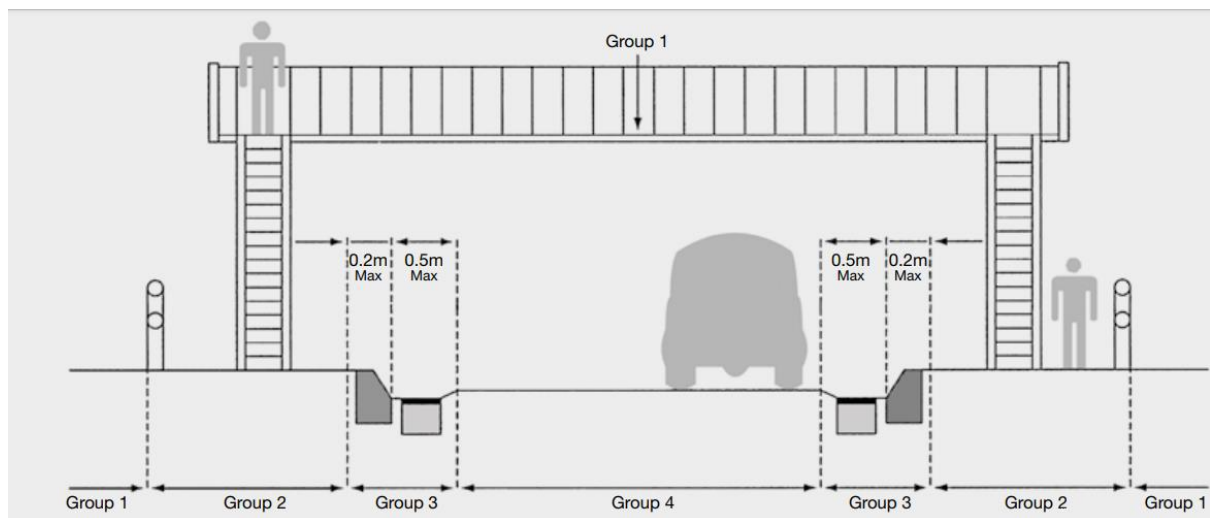


Fig 5.3 British Standard BS EN124 Specs

MCs are mainly located on the road. This location makes it attached to the pedestrians and any failure of its structure harms people, especially motorbikes and bikes riders. The Motorcycle Action Group (MAG) has mentioned on its website several problems of the MC structure. MC structure defects can cause injuries and accidents. The UK government reported the statistical release for the road casualties for 10 years as shown in Figure . For 10 years the motorcycle accidents

approximately did not change in comparison with the car accidents that have been rapidly reduced within the same period, while the cyclist accidents have slightly risen in the same period. Accident sources are several, one of them is the MC structure failure. Automating the monitoring of MC will contribute in fast warning about any MC failure or defects that cause accidents which will improve the safety and security of people. Metallic MC especially the cast iron is very valuable. This makes it very attractive to be stolen. This makes the pedestrians more prone to fall into manholes, which causes injuries and lets the underground utilities be more susceptible to be facing any terrorist attack, besides the cost of replacing the MC. In [9] it is reported that MC is one of the common metal thefts that cost millions of pounds every year besides the harm of underground utilities like electrical cables and national heritage. On the other hand, the work in mentioned that WRC (Water Research Centre) found that many Manhole Covers in the UK have failed and caused hazards which cost almost 40 million pounds.

Chart RAS45013: Reported killed or seriously injured (KSI) road casualties by road users, rolling four quarter totals: GB Q1 2003 – Q1 2012

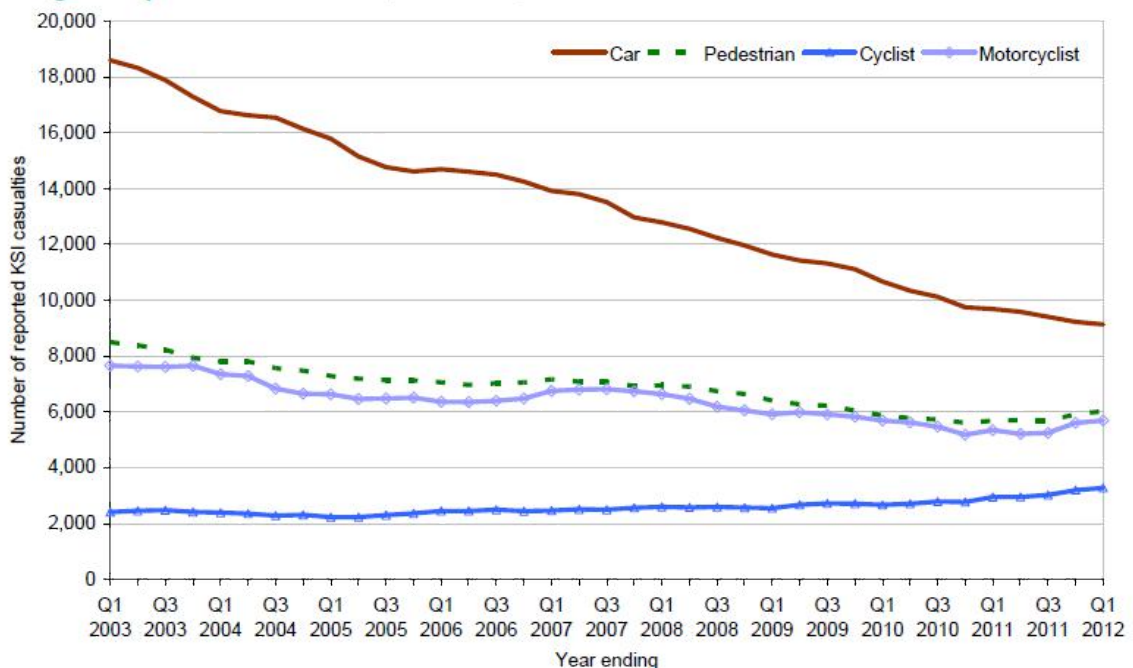


Fig 5.4 Injured road casualties by road users in the UK

5.4 MC Classifications Issues

The available monitoring systems for MC are not all automated and the automated types are not monitoring all the MC issues. Most of the current monitoring systems monitor one or few of MC issues and are based on partial classification or

study. The partial study of the MC issues has limited capabilities to address the wider automation problems, and this leads to a high probability of inaccurate monitoring. For example, in , authors designed an automated monitoring system that monitors the security of the MC by monitoring the tilting of the MC; this system is very sufficient but the data from their proposed system can be misleading because MC structure can be tilted because of several sources like the soil moving or traffic pressure and not only because of unauthorised intrusion. Another example is in , where authors used high-resolution images to identify the location of the MC and their methods detect only 40% of MC while their study was not concerned about the MC structural degradation issue which may affect their results. It can be concluded that the reasons for the surge to find an IoT based automated monitoring system for MC can be summarised as follows: • Reducing any delay that can happen after any failure of the MC that may harm pedestrians or traffic. • Reducing the cost of using labours and protect the labours from being harmed from the harsh environment beneath the MC. • Integrating with other infrastructures within a smart city based on IoT. To reach an IoT based automated MC monitoring system, the MC issues and the current monitoring systems used for these issues have to be addressed first. The target of this section and the chapter is to assign the manual monitoring methods that need to be replaced by the automated methods to reach an IoT based automated system.

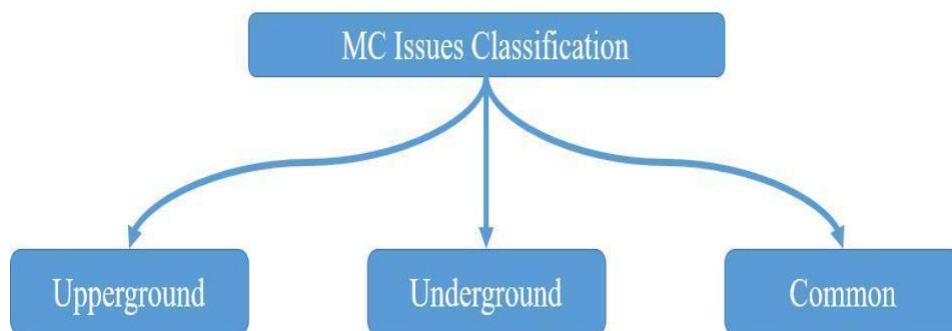


Fig 5.5 MC Issues Classification

MC issues are caused by the ambient underground or upperground environments. Some of these issues are common in both environments. For this reason, the classification is branching to three main branches: Upper ground, Underground and Common, as shown in Figure One of the contributions of this study is that it shows

most of the issues and the current monitoring MC systems, which have not been gathered before in one reference. This classification can be used by the government, industry and researchers to develop in several fields like smart city, Internet of Things, underground monitoring and much more. Most of the references used in this chapter are from companies' websites. These kinds of references may not explain in detail the monitoring systems used for marketing reasons. This makes it difficult to gather all of the information. However, by comparing and reading from different resources, complete classification based on the criteria mentioned before (environment effect-based classification) is suggested. Before starting the MC issues classification, first, the definition of "MC issue" has to be cleared. MC issue can be defined as "the issue which causes MC structure failure, or it is the issue resulting from the MC structure itself". As the classification is based on the environmental effect as mentioned before, MC issues can be classified into three types: a) Upper ground MC Issues: MC issues based on the effect of the upperground environment only, b- Underground MC issues: MC issues based on the effect of the underground environment only, and c- Common MC Issues: which are common between the upperground environment and underground environment effects. However, the influence of each environment on the MC structure may differ. MC issues classifications based on the type of the environment. It is shown that each type of environmental effect on the MC structure is responsible for three kinds of MC issues. The available monitoring techniques for the upperground MC issues, underground MC issues, and the common MC issues are summarised in Figure below. Based on upperground effect, three main issues are highlighted: security, detection and skid resistance.

The security issue is the only issue for which automated monitoring system is used based on several techniques: mechanical, fibre optics, magnetic sensor, infra-red (IR) sensor, closed circuit television, and accelerometer sensors. The first five techniques are summarised and their functionality is detailed above. Accelerometer sensor is used for measuring the tilting of the MC as mentioned above. MC detection is one of the main issues for MC in some countries like Taiwan which uses buried MC. However, this issue is still monitored by manual techniques like radio-frequency identification (RFID), digital camera, or mobile laser scanning. Because of the high population and the increase of transportation vehicles, MC structure failure has increased and has affected society. The need for using an automated system for

monitoring structure degradation is becoming one of the modern societies' demands. Skid resistance is one of the main reasons for most of the bikes and motorbikes accidents. However, this issue is still monitored by using a manual system like Pendulum scale. The average of decreasing the percentage of the skid resistance of MC can reach less than half in 12 months. As for the upperground environment effect on the MC structure, three main issues are found based on the type of underground utility found beneath the MC, namely stray/contact, explosion and noise. The stray takes place normally if there is no isolation between the cables and the MC. Isolation may be not working, which also generates the stray voltage leading to the contact voltage. One company has mentioned that it designed and fabricated an automated system for the stray/contact issue. However, no technical data has been known for this system . Explosion issue mainly takes place with the gas or electric utilities. For the electric utility, some companies like ABB has used some automated monitoring systems as mentioned above. For the gas utility, the manual monitoring system is still used till now. Noise or sound coming from MC has been accounted to be an issue, however, this issue is very rare and it is monitored manually only based on the claims of the people . Some of MC issues can take place from either upperground or underground, and they are classified as the common issues, these include corrosion, structure degradation and misalignment/moving. Corrosion issue is the first one, it has increased because of acidic environment found in the sewer utility or if the MC is found near to the sea coast. Corrosion issue is still monitored manually by the digital camera and by human inspection . 26 Structure degradation is one of the main issues for MC.

Structure degradation is one of the main issues for MC. However, this issue is still monitored by manual techniques like vacuum tester or digital camera . Movement of the MC structure can happen because of the pressure of the transportation vehicles or moving the soil. In both cases monitoring the movement of the MC is done manually. To conclude this section, MC issues have been classified based on the type of the environment that affects the MC structure. The classification divides the issues into three categories: Upper ground environment effects, Underground environment effects and common issues that can be based on the upperground environment or the underground effects. The classification identifies also the type of current monitoring systems used to monitor these issues. In the next section, discussion and analysis based on this classification will be done to identify the

challenges and the requirement for designing IoT based automated MC monitoring system.

5.5 Discussion and analysis of MC classification issues

This section discusses and analyses the MC classification issues explained in the previous section and the available monitoring systems for MC to design an IoT based automated monitoring system for MC. Most of the MC issues are monitored manually and some monitoring systems are based on a recording camera to capture an image of the MC attached to the regular inspection report . Regular manual inspection is mainly based on underground utilities and may take from several times per month to several times per year. However, long time without inspection and monitoring can result in sudden MC failure or stealing which badly affects society and could cause several unwanted hazardous effects. To evaluate the overall monitoring systems to assign the need to design an IoT based automated monitoring system for MC, the analysis will be presented in this section. Based on the previous section, the available automated MC monitoring systems cover only 30% of the MC issues found. Table and Figure identify the automated systems used for MC issues and the percentage of these automated systems to the manual ones respectively. Besides, from the survey, and by addressing and analysing the effect of each underground environmental utilities on the health of the MC structure, it is found that Water/Sewer underground utilities are the utility mostly affecting the MC structure by causing most MC issues. Figure represents the percentages of the MC issues caused by the different types of underground utilities based on this survey. Using automated systems to monitor the MC issues is needed for the safety and security of the society. However, designing an IoT based automated MC monitoring system faces several challenges and needs to be reliable to the smart city and IoT concepts, which are used by modern governments to protect the society. From the study done by the researcher, there are mainly four big challenges facing the design of the IoT based automated MC monitoring system: power consumption, platform cost, data security and memory size required to store the information. The power consumption challenge is very essential because the automated system lifetime is mainly based on the battery lifetime. Replacing the battery several times during the MC lifetime is not reliable or sufficient from the cost point of view. This point is very critical, especially that the maximum number of MC issues that are monitored automatically in one system is only two issues and the lifetime is about only one year. Reducing the power

consumption has debatable aspects . However, as the IoT based automated cast iron MC monitoring system is not found until now, the sensor type selection needs to be addressed first because using active sensors may affect the power consumption of the monitoring system.

According to several references like, the DAQ module needs to be activated more than any module of the wireless monitoring system regardless of the concept of the monitoring strategy (Trigger- Driven or Scheduled-Driven) and by using some types of active sensors, the power consumption will increase more . However, because of the different types of underground utilities, it can be concluded that the IoT based automated MC monitoring system is not universal and depends on the type of underground utilities.

Generally, several techniques had been developed by several researchers to reduce power consumption. Selected examples of these techniques used to reduce the power consumption are shown. However, power consumption is still one of the biggest challenges for designing automated monitoring systems.

In addition to these techniques, analogue circuit design starts to attract the researchers for low power consumption applications. Merging analogue circuit design with other fields like neuroscience, opens a new route for designing low power IoT device especially with the development in Machine Learning algorithms .Another challenge is the cost of the monitoring system platform itself. By entering the smart city (SC) and IoT era, monitoring systems need to be of low cost and suitable to be controlled and managed via the internet. From the survey, available MC monitoring systems from one side and smart city and IoT from the other side were not mentioned in any reference before now, to the knowledge of the author. This opens a new research field to investigate. Besides that, some of the monitoring systems used in several applications including some current automated MC monitoring, off-shelf monitoring systems hardware platform like Imote2, Wasp mote (which is called also motes) and by using open source software cloud, controlling these motes via internet is used and has become more easy and reliable [69]. However, the cost of these modules is still high. On the other hand, a new hardware technology is spreading very fast, which is open source hardware like Beaglebone, Raspberry Pi [70]. These systems are very promising and proved suitable to be used in several smart cities

and IoT applications, because of the low cost and the ease with which they can be programmed. However, open source hardware suffers from the high power consumption with respect to the off shelf motes mentioned before .

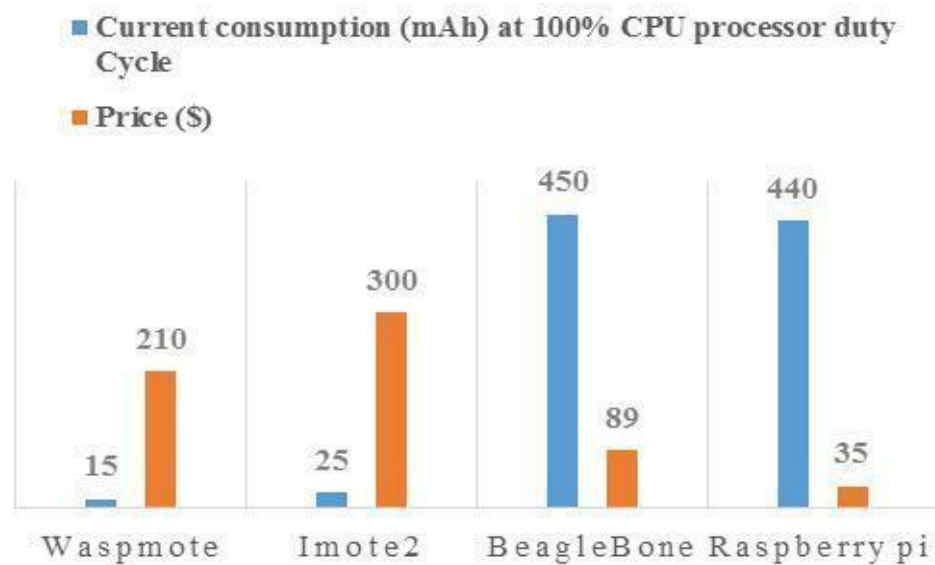


Fig 5.6 Current consumption and price for off shelf mote and open source hardware

Fig 5.5 shows examples of the current consumption and price of selected motes and open source hardware. Open source hardware opens a new gate for research in several monitoring applications like IoT based automated MC monitoring system by redesigning it to be less power consuming and to be used for smart city and IoT applications. Another challenge facing the design of the IoT based automated monitoring systems is the security. IoT based monitoring systems can be wired like supervisory control and data acquisition or wireless like wireless sensor network nodes (WSNN). Wired monitoring systems have the advantage of the security over the wireless systems. However, wired systems are very expensive if compared with the wireless systems. This problem leads to looking further to design WSNN with a high security system. Also, in the internet of things (IoT) era which is based on connecting or communicating all the monitoring systems under the internet cloud, even wired monitoring systems like SCADA will face the security issues in internet security. In some studies, the combination of the two methods (SCADA and WSNN) takes place to get the advantages of both systems. However, this concludes that both systems will be facing mainly the same security issues, but they differ in the cost which makes

WSNN monitoring systems replace the wired monitoring system in the future for monitoring most of the city utilities.

Another challenge for a secured IoT device design is the power consumption. The tradeoffs between the power consumption and the security has become a hot spot for the current IoT device designs for several applications. Moreover, hardware design is more demanding as it consumes less power if compared to software-based security system.

While most of the current design for the secured IoT devices is based on digital circuit design, It is clear that this system will have to include the underground MC issues monitoring techniques, common MC issues and has the ability to attach other sensing techniques for underground MC issues based on the type of the utility beneath the MC. Most of the automated monitoring systems for underground utilities, use the MC as a holder to monitor these utilities. This means that the design of an IoT based automated monitoring system for MC should also be able to attach more sensors that can be used to monitor the underground utilities. This will need more care in the design as it will be more complex and therefore more power consumption is expected. To conclude, this section analyses the proposed classification of the MC issues and shows the gap area in the research for the design of an IoT based automated monitoring system for MC.

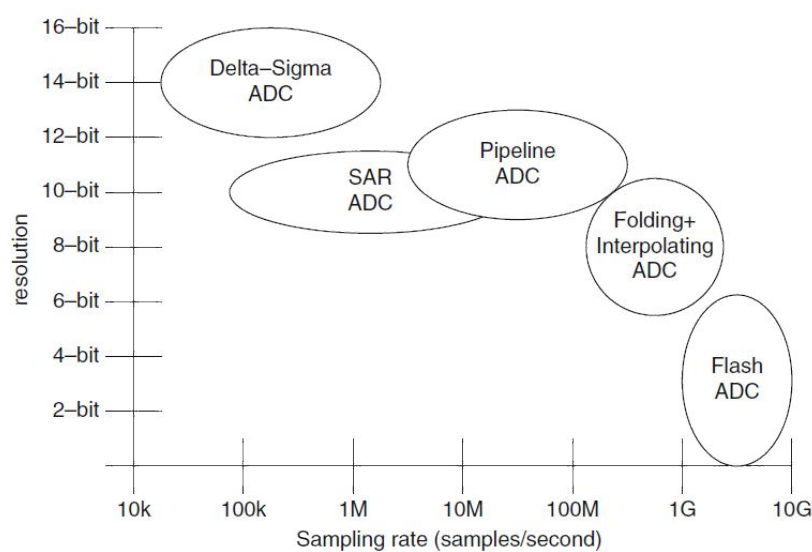


Fig 5.7 ADC Architectures

5.6 Power consumption challenge

Designing an IoT based automated MC monitoring system faces several challenges as shown before. The present research focuses on reducing the power consumption of the system. However, the IoT device designer needs to take into consideration all the previous challenges. As shown also, active sensors and DAQ are the main parts that consume more power in the system. To be more focused, this research will consider reducing the power consumption of the DAQ module by reducing the power of the most consuming circuit in the DAQ which is ADC. The first step to reduce the ADC power consumption is to identify the sensors types to determine the required bandwidth and the power required for the ADC to work. For this reason, the next section will propose a study to identify the sensors types required for the IoT based automated MC monitoring system. This will help to assign the power requirements for the DAQ.

A DAQ module consists mainly of

- i) Sensor Signal conditioning circuit: which reads the variation of the sensor signal based on its function.
- ii) A multiplexer (MUX): MUX is one of the most sensitive parts in the design of the DAQ system. It is important for accurate sampling of multi-input channels. A MUX typically consists of several switches connecting all of the input channels to the output end of the MUX.
- iii) Amplifier: is mainly a Programmable Gain Amplifier (PGA), Low Noise Amplifier (LNA), or Charge Amplifier.
- iv) Filter: to activate the essential bandwidth of interest. The filter mainly is Low Pass Filter.
- v) Analogue to digital converter (ADC): to transfer the analogue signal into the digital domain which converts the analogue signal to a digital value. ADC function is to deliver the processed analogue signal to the CU module to process and store.

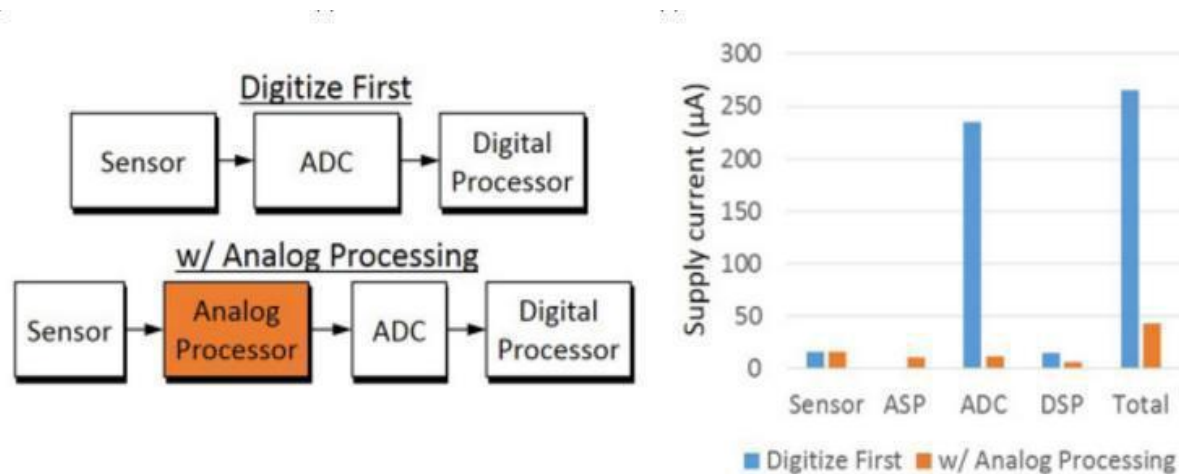


Figure 5.8 Comparison of the dominant power consumers and a sensor system

The ADC is the circuit which consumes the most power in the DAQ module. This is because it needs to sample the sensor signal at least double its bandwidth (Nyquist Shannon theorem). By increasing the bandwidth of the sensor signal, the sampling rate increases. For the purposes of designing an IoT based automated MC monitoring system, reducing the sampling rate is one of the main targets to reduce the power consumption in the DAQ module.

Choosing the ADC architecture is one of the solutions to reduce the power consumption. Several architectures have been designed to achieve optimal power consumption for different sampling rate and resolution (resolution indicates the number of the discrete values it can produce over the range of the analogue values). However, the selection of the type of an ADC architecture will be cleared after choosing the sensor type in the next section. On the other hand, an ADC architecture is not the only optimum solution to reduce the power consumption for designing low-power IoT based automated MC monitoring system. It is mentioned in that one of the new approaches to reduce the power consumption of sensor nodes in IoT is to add analogue processing before the ADC.

Compressive Sensing (CS) based hardware implementation is called analogue to information converter. AIC is already following the approach of using an analogue preprocessor before the ADC as mentioned. CS concept takes place if the original signal is sparse in one domain like frequency or time which is the case for most of the sensor signals. While CS or AIC can improve the reduction of ADC power consumption, it reduces also the size of the data. However, as mentioned before, IoT device designer needs to take all the IoT device design challenges into consideration especially if the IoT devices need to be located in harsh or difficult to reach

environments. Because the heart of the AIC is the pseudorandom generator (PRNG), this attracted researchers to use it at the same time for the data security. The traditional hardware designs for AIC used the digital linear feedback shift register (LFSR) for generating PRNG. However, LFSR is not recommended for security. Hence, researchers started to replace LFSR with another digital PRNG with more security capability. Most of these efforts are done by using digital circuit design. Digital hardware implementations add more complexity for the AIC which consumes more power. This point will be discussed in more details in the next chapter. From this point of view, the present research focuses on studying the use of AIC to design a low-power secured IoT based automated MC monitoring system. The study extends to enhance the AIC circuit design by replacing the digital part in the AIC analogue front end to make this part pure analogue for power consumption issue and to overcome any need of isolation between digital and analogue circuits as will be shown later. This study is expected to contribute to monitoring MC, monitoring underground utilities and extends to contribute in several fields used in smart city concepts and develop in the design of IoT devices.

To conclude, this section focuses on power consumption as the main challenge to design a secured IoT based automated MC monitoring system. It was shown in this section that the ADC circuit is the main circuit consuming more power. Compressive sensing theory is targeting reducing the power consumption of the ADC by reducing the sampling rate which is the main reason for increasing the power consumption for the ADC. Hence, this study will focus on developing CS based ADC which is called analogue to information converter .

5.7 Types of Sensors needed for IoT based automated Manhole Cover Monitoring System

Before proceeding in the ADC design, sensor types need to be identified first. This section is very important for designing the required ADC. However, several challenges were found to identify the sensor types for an IoT based automated Manhole Cover monitoring system. The first challenge is that not all the available monitoring systems are automated; hence, the type that can be used for automated systems should be identified. The second challenge is that an issue like skid resistance has special kind of monitoring which is the pendulum. This kind of monitoring is very rare, and it also does not use an electronic circuit to monitor but uses a mechanical ruler and the user has to read it. This means an intensive study

needs to identify the type of sensor that can be used to replace this manual method and to be efficient.

While the sensor design is not the aim of this study, the selection of the sensor type is very essential to identify the required bandwidth for the system. Hence the ADC requirement will be determined, and to be specific the sampling rate for the ADC will be identified.

From the survey in this chapter, it can be observed that the IoT based automated Manhole cover monitoring system is not universal, but it depends on the underground utility beneath the Manhole Cover. In other words, IoT based automated monitoring system for the Manhole cover is a multisensor monitoring system which has the ability to add more sensors based on the underground utility type.

Based on this observation, the Manhole Cover issues and the monitoring system can be divided into two branches: the first one is fixed which includes the upperground and the common issues, while the second branch includes the underground issues. The physical phenomenon to be measured by each branch needs to be recognized to identify the sensor type. By observation of the MC issues classifications, the physical phenomenon that needs to be monitored can be classified as shown in Figure 2-11 to four different classes which are: orientation, structure degradation, electrification and explosion. To be more specific about sensor type selection, the physical phenomenon can be classified into two categories: first for upperground and common issues; the second is for the underground utility type. For each class, one or more sensors can be used to monitor the related MC issues.

It has to be mentioned that two issues have been omitted from the study in this section from the Manhole Cover issues. The first one is the detection phenomenon, because generally most of the automated monitoring systems need to send information including the location or system identification. Hence, it has to be found in the design by several ways like adding the location to the information content. The other issue is the noise or, in other words, sound phenomenon. The noise issue as mentioned before is rare and also depends on several aspects like the design of the Manhole Cover or sometimes results from the structure degradation which needs to be monitored.

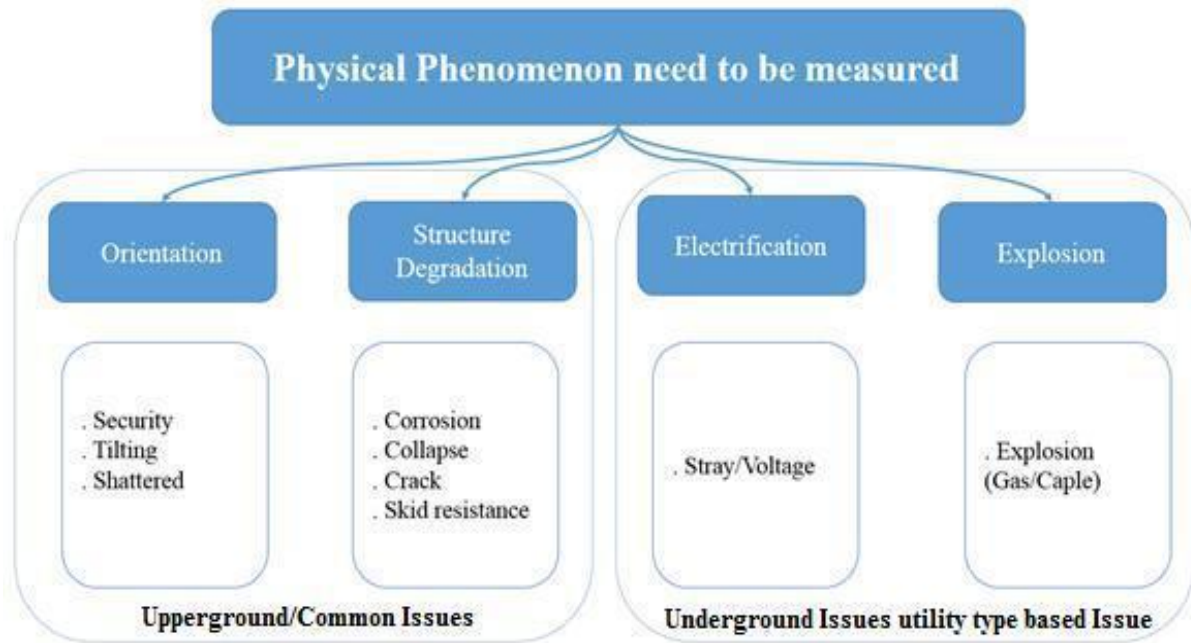


Fig 5.9 Physical phenomenon needed to be measured

Sensor type selection was very challenging and required to study the sensing techniques from several fields like civil engineering and aerospace. Besides, the selection of the sensor type needs to satisfy the need for low power consumption for the sensors. Based on the survey done by the researcher and by the investigation from several references, shows the sensor type selection for IoT based automated Manhole Cover monitoring system.

It is shown that the maximum sensor bandwidth is 5 MHz for the PZT which required at least 10 MHz for sampling (it has to be mentioned that inauthors use the PZT sensor with sampling rate 100MHz to avoid noise).

To conclude, this section presents the sensor selection required for the IoT based automated Manhole Cover monitoring system. The selection was based on the available techniques for the automated system besides the sensing techniques from other fields like civil engineering. The target of this section is to identify the maximum sensor bandwidth needed for IoT based automated Manhole Cover monitoring which shows the minimum sampling rate required for traditional ADC.

5.8 Thesis Contributions

This research proposed a new detailed classification for manhole cover issues and the current monitoring systems. The proposed classification covers the influence of the environment found beneath or above the manhole cover. This classification is recommended to be used by the modern governments which seek the development of their societies from the smart city point of view. Furthermore, the classification shows the lack of using the automated monitoring systems for manhole cover and how much damages and losses can be avoided by changing the monitoring systems from manual to automated systems.

This research studies for the first time replacing complex digital pseudorandom number generator (PRNG) found in the analogue information converter (AIC) analogue front end, for the sake of the power consumption and the security. This study leads to the use of analogue chaotic oscillators, which exhibits more enhancement for the AIC analogue frontend design from the perspective of power consumption and security compared with digital design.

The research proposed the use of the waveshape design concept to design analogue chaotic oscillators without the need to start by complex differential equations which describe the behavior of the dynamic systems of the chaotic oscillators. In this research, the waveshaping design concept was thus used to design analogue chaotic oscillators based on coupling oscillators found in neuroscience, with few steps which can be widely used for neuromorphic oscillators design.

This research proposed a new vision for design by using an opamp Schmitt trigger which mimic biological oscillators. Furthermore, as an opamp Schmitt trigger is one of the main blocks of the field programmable analogue array (FPAA), the proposed vision can be easily implemented and re-programmed which gives more richness to using an opamp Schmitt trigger.

This research proposed two low-power analogue chaotic oscillators using 2 opamps Schmitt trigger based on coupling oscillators. The proposed systems design offers an innovative analytical and methodological approach based on contributions 3

and 4. The design of the proposed systems combines between new vision of analogue chaotic oscillator design based on neuromorphic engineering with hardware implementation and software simulation. The proposed systems are implemented to replace the traditional digital PRNG found in the AIC analogue frontend. The proposed systems have been implemented and simulated under the temperature range found beneath the manhole cover. The validation takes place by comparing the proposed systems with another 2 opamps based Jerk chaotic oscillators. The validation proved the good performance of the proposed systems, especially the second system from the power consumption and the security point of view. The validation extends to compare between the output chaotic sequence from the proposed systems and the random sequence based on numerical algorithm that can be implemented using digital circuit. This comparison shows the ability of the proposed systems to reconstruct the original signal more accurately than the numerical algorithm in the absence and the presence of the noise.

As the proposed systems were implemented using off the shelf components, it is expected that the proposed systems will enhance the IoT device based on open source hardware from the power consumption point of view which is the main disadvantage found in these devices. Furthermore, the proposed systems developed an IoT device based on open source hardware using neuromorphic engineering which is still in its early stage and is expected to be widely used in the near future.

CHAPTER 6

RESULTS AND DISCUSSION

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs – light on a sensor, a finger on a button, or a Twitter message – and turn it into an output – activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino programming language (based on Wiring), and the Arduino Software (IDE), based on Processing.

Over the years Arduino has been the brain of thousands of projects, from everyday objects to complex scientific instruments. A worldwide community of makers – students, hobbyists, artists, programmers, and professionals – has gathered around this open-source platform, their contributions have added up to an incredible amount of accessible knowledge that can be of great help to novices and experts alike.

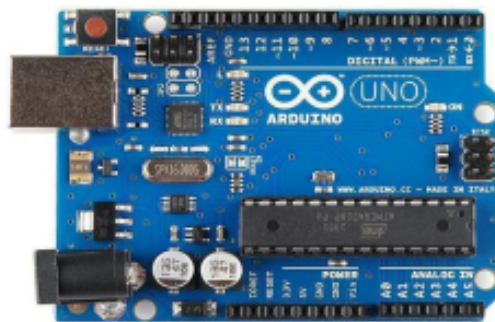


Fig 6.1 Arduino

LCD screen is an electronic display module and finds a wide range of applications. A 16x2 LCD display is a very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on. A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in a 5x7 pixel matrix. This LCD

has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD.



Fig 6.2 LCD Display

DHT11 is a low-cost digital sensor for sensing temperature and humidity. This sensor can be easily interfaced with any micro-controller such as Arduino, Raspberry Pi etc... to measure humidity and temperature instantaneously. DHT11 humidity and temperature sensor is available as a sensor and as a module. The difference between this sensor and module is the pull-up resistor and a power-on LED. DHT11 is a relative humidity sensor. To measure the surrounding air this sensor uses a thermistor and a capacitive humidity sensor.



Fig 6.3 DHT11 Sensor

The water level sensor is a device that measures the liquid level in a fixed container that is too high or too low. According to the method of measuring the liquid level, it can be divided into two types: contact type and non-contact type. The input type water level transmitter we call is a contact measurement, which converts the height of the liquid level into an electrical signal for output. It is currently a widely used water level transmitter.



Fig 6.4 Water Level Sensor

Gas sensors are devices that help us understand the amount of gas in the environment and the natural state of its movement. Gas sensors reveal the amount of gas in the environment and the nature of the gas composition with electrical signals and can provide its change

The parameters that should be considered when creating gas sensors are as follows: the type of gas that needs to be detected, its concentration, and the environment in which the gas is located. MWCNT gas adsorption occurs in the outer region where the gas molecule is connected to the sensor together with the van der Waals force. The electrical charge flow in the gas sensor differs from the binding of the molecule. With this differentiation, gas sensor resistance is determined to differ .



Fig 6.5 Gas Sensor

A switch responds to an external force to mechanically change an electric signal. Switches are used to turn electric circuits ON and OFF and to switch electric circuits. In electrical engineering, a switch is an electrical component that can disconnect or connect the conducting path in an electrical circuit, interrupting the electric current or diverting it from one conductor to another. The most common type of switch is an electromechanical device consisting of one or more sets of movable electrical contacts connected to external circuits. When a pair of

contacts is touching current can pass between them, while when the contacts are separated no current can flow.



Fig 6.6 Switch

An audio signaling device like a beeper or buzzer may be electromechanical or piezoelectric or mechanical. The main function of this is to convert the signal from audio to sound. Generally, it is powered through DC voltage and used in timers, alarm devices, printers, alarms, computers, etc. Based on the various designs, it can generate different sounds like alarm, music, bell & siren.

The pin configuration of the buzzer is shown below. It includes two pins namely positive and negative. The positive terminal of this is represented with the '+' symbol or a longer terminal. This terminal is powered through 6 Volts whereas the negative terminal is represented with the '-' symbol or short terminal and it is connected to the GND terminal.



Fig 6.7 Buzzer

LED stands for light emitting diode. LED lighting products produce light up to 90% more efficiently than incandescent light bulbs. How do they work? An

electrical current passes through a microchip, which illuminates the tiny light sources we call LEDs and the result is visible light. To prevent performance issues, the heat LEDs produce is absorbed into a heat sink. LEDs are semiconductor light sources that combine a P-type semiconductor (larger hole concentration) with an N-type semiconductor (larger electron concentration). Applying a sufficient forward voltage will cause the electrons and holes to recombine at the P-N junction, releasing energy in the form of light. Compared with conventional light sources that first convert electrical energy into heat, and then into light, LEDs convert electrical energy directly into light, delivering efficient light generation with little-wasted electricity.



Fig 6.8 Light Emitting Diode

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuino hardware to upload programs and communicate with them.



Fig 6.9 Arduino IDE

The extension of the C programming language is known as embedded C. It is generally utilized for creating microcontroller-based applications. Talking about the extension it is I/O fixed-point arithmetic operations, hardware addressing, accessing address spaces, and more. This is majorly used to develop microcontroller-based applications. It generates the .hex files. It has specified resources like RAM and ROM.

The level of optimization is high. In embedded C language, it is not easy to make changes in the program. In an embedded C language program, bug fixing is difficult.

This system detects the blockages and water level in the manhole. It also monitors the continuous water flow rate. With the help of sensors temperature, humidity and gas leakage can be identified. The system also informs whether the manhole lid is open or closed by using the ultrasonic sensor. When a particular sensor reaches the respective threshold level, then that respective value of the sensor will be sent to the microcontroller. Microcontrollers update the live values of all the sensors using IoT. If any problem arises in the manhole, the sensor senses it and sends that information to the microcontroller. Furthermore, the microcontroller sends the signal and the exact location of the manhole through IoT to the managing station. Then, an automatic mail is. This alerts the person-in-charge to take the required actions regarding the problem occurring inside the manhole. In this chapter, MC types and issues have been highlighted and a new classification of these issues has been presented in view of the available monitoring systems. The outcome of this classification shows that 70% of the monitoring systems for the Manhole cover is based on manual technique. With the increasing failure of the Manhole Cover because of various issues and the effect of this failure on the society from the security, safety, and economy sides, the need to design an IoT based automated Manhole Cover monitoring system has increased.

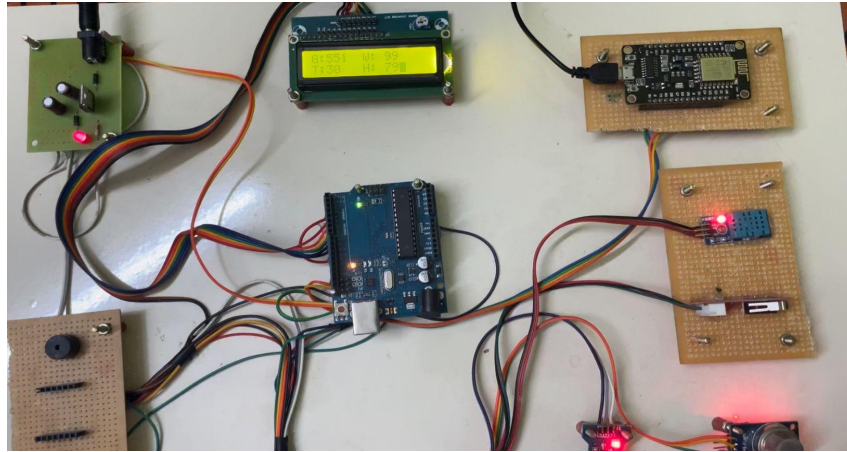


Fig 6.10 Experimental Setup

In order to protect the sewage worker from death we have come up with the solution called IOT based underground drainage monitoring system which helps in monitoring hazardous gases present in sewage & helps to alert the sewage workers whenever the gas level crosses the specified limit. It also displays the value of gas level in the smart phone through the app. It also helps to decide whether it is safe for the worker to work in the environment or not.. The proposed methodology is based on IoT, which helps in monitoring the hazardous gases present in sewage. Whenever the gas level crosses the threshold value, the sewage workers are alerted through a buzzer indicating whether it is safe for the worker to work or not through an app in the smartphone. This system helps in saving the life of sewage workers.



Fig 6.11 Display values

Link the device (Hardware) to the power supply. Initially, the LCD shows the flow rate and the system's environmental state, with or without dangerous gases. If the ultrasonic sensor is triggered, the buzzer will be activated and the sound and GPS position and the notification will be transmitted to the registry phone. If there is a wave, the wave sensor is sensed and the flow rate is reflected on the LCD.

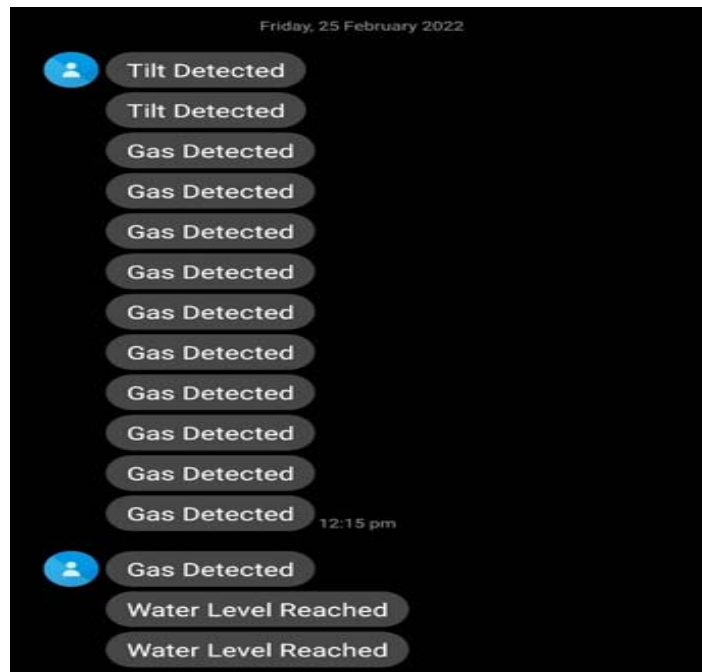


Fig 6.12 Output as an SMS

An ionic app is developed to display the amount of gas levels individually to the sewage workers. When the gas level crosses the threshold value, the buzzer makes a sound alerting the sewage worker. This system prevents the death of sewage workers. Below two cases are mentioned for the clear understanding of the working of ionic application. In case 1 all the gas levels are below the threshold values so buzzer will not make sound & led does not glow. In case 2, the Carbonmonoxide gas is above the threshold value so buzzer makes a sound & led glows indicating it is not safe for the sewage worker to work over there. By following this method the death of sewage workers can be avoided.

CHAPTER 7

CONCLUSION AND FUTURE SCOPE

7.1 CONCLUSION

The main aim in this research is to investigate and design a low-power IoT-based manhole cover monitoring system to be used for smart city applications taking into consideration the IoT device design requirements and challenges. To reach this aim and based on investigation done by this research, compressive sensing was studied as it was proved from other applications its ability to reduce the power consumption for IoT device by reducing the sampling rate of the used ADC.

As a first step in this research, MC types and issues have been investigated deeply. Based on this investigation, a new detailed classification of manhole cover issues with the current monitoring systems is proposed. This classification presents good guidance for the modern governments to identify the main requirements to improve the safety and the security for their societies. Also, this classification gives a new vision for the researchers who work in the smart city's underground and road monitoring applications. It was concluded from this classification and investigation that analogue to digital converter found in DAQ module is the main source for consuming power for the MC automated monitoring system. In this research, a low power automated MC monitoring system with IoT device design requirements was the target to be suitable for Smart City's application.

Compressive sensing framework proved in several applications its ability to reduce the power consumption for monitoring systems by using low sampling rate ADC. The CS based ADC is named analogue to information converter (AIC). The AIC has become more attractive to the IoT device designers because the heart of the AIC is a pseudorandom number generator (PRNG) which can be used for the data security. However, most of the current PRNG circuit found in the AIC circuit design is implemented by digital circuit which has drawbacks which are: a) power consumption, b) using the digital PRNG at AIC analogue frontend mainly required isolation between the analogue part and the digital part by using separate power supplies and separate grounds. The present research focused on using an analogue PRNG to overcome the digital PRNG issues for AIC.

In this research, two analogue chaotic oscillators are proposed by using one of the main blocks of the FPAA (FPAA proved its ability to implement CS signal reconstruction algorithms with low-power consumption) which is the opamp Schmitt trigger. The heart of the two proposed systems is two new modifications of the opamp Schmitt trigger to mimic biological oscillators.

The proposed systems are based on coupling oscillators, which are inspired by the neuroscience field. While this research is not the first research which studies the coupling oscillator, but it is the first that introduces the waveshaping technique to design coupling chaotic oscillator without the need of using differential equations for modelling. This point opens a new route for designing chaotic oscillators based on relaxation oscillators. Furthermore, the proposed systems can both be implemented on the same PCB using only 2 opamps with switches to act as selectors for the RC coupling network and the connected nodes. This point is very attractive which gives the proposed system the richness to design secured DAQ module with two or more different chaotic sequence with low-power consumption. Furthermore, this type of connection is very suitable for the FPAA design, which is based on a switching capacitor design concept.

The two proposed systems have been introduced and studied from the power consumption and signal recovery points of view at the range of the temperatures found beneath the manhole cover (-30°, 25°C 60°). The two proposed systems show a good performance from a power consumption point of view as they can be used for at least 21.8 years using the Li-Ion battery. This achievement is suitable for monitoring manhole cover structure that has a lifetime which can reach up to 25 years, while the current automated MC monitoring systems have a lifetime of maximum 3-5 years.

From the signal reconstruction point of view, the proposed systems show good performance of the signal recovery which can reach 0.00000179 average square error in the absence of noise. In the presence of noise and by comparing the proposed systems to PRNG sequence generated from the algorithm and fitted to the AIC, the proposed system 1 improves the signal reconstruction by 6.094 % and the proposed system 2 improves the signal reconstruction by 17.831%. This

achievement is very significant from a security point of view, as it is shown before that signal reconstructing in the presence of noise is used to assess communication system security.

Finally, the research used off the shelf components which is very interesting in the IoT device design based on open source hardware which mainly suffers from the high-power consumption issue. The merging between the open source hardware and the neuroscience is still in the early steps, which makes this research helpful in the development in such applications. It is expected that this research develops several smart city's applications like underground and road monitoring.

7.2 FUTURE SCOPE

Full implementation of the system and attaching it to manhole cover with testing is one of the main future work targets . The effect of the opamps internal circuit with different technologies and design on the proposed systems opens a new route for more improvement of the system, especially from the power consumption point of view. Studying the same design concept in radio frequency range to reduce the power consumption of the communication module for the IoT device design.Using diodes in the coupling of the proposed systems will be studied to investigate their effects on the performance of the proposed systems.

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APPENDIX

SOURCE CODE

```
#include <LiquidCrystal.h>
#include <dht.h>
#include <dht.h> // Include library
#define dht11_sensor 4 // Defines pin number to which the sensor is connected
dht DHT; // Creates a DHT object

#include <SoftwareSerial.h>
SoftwareSerial mySerial(18, 19);
#include <LiquidCrystal.h>
const int rs = 5, en = 6, d4 = 7, d5 = 8, d6 = 9, d7 = 10;
LiquidCrystal lcd(rs, en, d4, d5, d6, d7);

int emergency =0;
void setup() {
  Serial.begin(115200);
  mySerial.begin(115200);
  pinMode(dht11_sensor,INPUT);
  pinMode(2,INPUT);
  pinMode(12,OUTPUT);
  attachInterrupt(digitalPinToInterrupt(2), change, LOW);
  digitalWrite(12,HIGH);delay(500);
  digitalWrite(12,LOW);delay(500);
  lcd.begin(16, 2);
  lcd.setCursor(2, 0);
  lcd.print("Man hole");
  delay(1000);

}

void loop() {
```

```

int gas = analogRead(A2);
int water = analogRead(A0);
int readData = DHT.read11(dht11_sensor);
int t = DHT.temperature; // Read temperature
int h = DHT.humidity; // Read humidity
//int emergency !=!digitalRead(2);
lcd.clear();
lcd.setCursor(0, 0);lcd.print("G:");lcd.setCursor(2, 0);lcd.print(gas);
lcd.setCursor(7, 0);lcd.print("W:");lcd.setCursor(10, 0);lcd.print(water);
lcd.setCursor(0, 1);lcd.print("T:");lcd.setCursor(2, 1);lcd.print(t);
lcd.setCursor(7, 1);lcd.print("H:");lcd.setCursor(10, 1);lcd.print(h);

if (gas > 600)
{
  lcd.clear();
  lcd.setCursor(3, 0);lcd.print("Gas Alert!!!");
  digitalWrite(12,HIGH);delay(200);digitalWrite(12,LOW);delay(200);
  digitalWrite(12,HIGH);delay(200);digitalWrite(12,LOW);delay(200);
  digitalWrite(12,HIGH);delay(200);digitalWrite(12,LOW);delay(200);
}
else if (water > 600)
{
  lcd.clear();
  lcd.setCursor(2, 0);lcd.print("Water Alert!!!");
  digitalWrite(12,HIGH);delay(200);digitalWrite(12,LOW);delay(200);
  digitalWrite(12,HIGH);delay(200);digitalWrite(12,LOW);delay(200);
  digitalWrite(12,HIGH);delay(200);digitalWrite(12,LOW);delay(200);
}
else if (t > 60)
{
  lcd.clear();
  lcd.setCursor(3, 1);lcd.print("Temp Alert");
  digitalWrite(12,HIGH);delay(200);digitalWrite(12,LOW);delay(200);
  digitalWrite(12,HIGH);delay(200);digitalWrite(12,LOW);delay(200);
  digitalWrite(12,HIGH);delay(200);digitalWrite(12,LOW);delay(200);
}

```

```

}
else if (h > 100)
{
  lcd.clear();
  lcd.setCursor(3, 1);lcd.print("Humidity Alert");
  digitalWrite(12,HIGH);delay(200);digitalWrite(12,LOW);delay(200);
  digitalWrite(12,HIGH);delay(200);digitalWrite(12,LOW);delay(200);
  digitalWrite(12,HIGH);delay(200);digitalWrite(12,LOW);delay(200);
}
else if (emergency == 1)
{
  lcd.clear();
  lcd.setCursor(0, 0);lcd.print("Emergency Alert!!!");
  digitalWrite(12,HIGH);delay(200);digitalWrite(12,LOW);delay(200);
  digitalWrite(12,HIGH);delay(200);digitalWrite(12,LOW);delay(200);
  digitalWrite(12,HIGH);delay(200);digitalWrite(12,LOW);delay(200);
}

Serial.print(gas);Serial.print(",");
Serial.print(water);Serial.print(",");
Serial.print(t);Serial.print(",");
Serial.print(h);Serial.print(",");
Serial.print(emergency);Serial.println(",");

mySerial.print(gas);mySerial.print(",");
mySerial.print(water);mySerial.print(",");
mySerial.print(t);mySerial.print(",");
mySerial.print(h);mySerial.print(",");
mySerial.print(emergency);mySerial.println(",");
delay(5000);
emergency = 0;
}
void change()
{
  emergency =1;

```

```

}
#include <SoftwareSerial.h>
SoftwareSerial mySerial(14, 12);
#include "Ubidots.h"
const char* UBIDOTS_TOKEN = "BBFF-QCgEcvVo1DxgpKSaxyjHFDYfAxWgJ3"; //
Put here your Ubidots TOKEN
const char* WIFI_SSID = "Febisiphone";    // Put here your Wi-Fi SSID
const char* WIFI_PASS = "febishaf";      // Put here your Wi-Fi password

Ubidots ubidots(UBIDOTS_TOKEN, UBI_HTTP);

int firstVal, secondVal, thirdVal, fourthVal, fifthVal;
int j=0;
int b=0;
void setup() {
  Serial.begin(115200);
  mySerial.begin(115200);
  ubidots.wifiConnect(WIFI_SSID, WIFI_PASS);
  delay(500);
}

void loop() {
  if (mySerial.available() > 0)
  {
    String a = mySerial.readString();
    Serial.println(a);
    delay(50);
    for (int i = 0; i < a.length(); i++)
    {
      if (a.substring(i, i+1) == ",")
      {
        j++;
        if (j==1)
        {
          firstVal = a.substring(0, i).toInt();

```

```

    Serial.print("first : ");
    Serial.println(firstVal);
    ubidots.add("Gas", firstVal);
    b=i;
}
else if (j==2)
{
    secondVal = a.substring(b+1, i).toInt();
    Serial.print("Second : ");
    Serial.println(secondVal);
    ubidots.add("Water Level", secondVal);
    b=i;
}
else if (j==3)
{
    thirdVal = a.substring(b+1, i).toInt();
    Serial.print("Third : ");
    Serial.println(thirdVal);
    ubidots.add("Temperature", thirdVal);
    b=i;
}
else if (j==4)
{
    fourthVal = a.substring(b+1, i).toInt();
    Serial.print("Fourth : ");
    Serial.println(fourthVal);
    ubidots.add("Humidity", fourthVal);
    b=i;
}
else if (j==5)
{
    fifthVal = a.substring(b+1, i).toInt();
    Serial.print("Fifth : ");
    Serial.println(fifthVal);
    ubidots.add("Emergency", fifthVal);

```

```

        b=0;
        j=0;
    }
}

}

    bool bufferSent = false;
    bufferSent = ubidots.send(); // Will send data to a device label that matches
the device Id

    if (bufferSent) {
        Serial.println("Values sent by the device");
    }
}
}

```

B. RESEARCH PAPER

MONITORING AND DETECTION OF MANHOLES USING IOT

- Febi Shafrin GS
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ABSTRACT

The objective of a smart city is to provide society with amenities that are cleaner and better. While creating a smart city, intelligent subsurface infrastructure is an essential component to take into account. Monitoring the drainage systems is essential for maintaining the city's cleanliness and wellness. Because human monitoring is ineffective, drainage issues are handled slowly and take longer to fix. The system, which uses a wireless sensor network made up of sensor nodes, is created to address all of these problems. The suggested system warns the managing station via message whenever any manhole crosses its threshold values. It is low cost, low maintenance, and Internet of Things based. With the use of this method, the danger of death for manual scavengers who clean the subterranean drains and appropriately in emerging nations. Accidents like these can result in fatalities as well as severe injuries. As a result, we offer a system here to combat this problem.

I. INTRODUCTION:

Any drainage system's access points are a crucial component when it comes to maintenance, inspection, and cleaning. Metropolitan areas now have subsurface drainage systems, and the municipal corporation is responsible for keeping the area clean. Inappropriate sewage maintenance can contaminate ground water and lead to dangerous diseases. Drain blockages during the monsoon season disrupt people's daily activities. Thus, the city corporation should have a facility that notifies the authorities of sewer obstructions and their precise position. It primarily recognises in the area of warning the public about gas explosions, rises in water levels, and changes in temperature. The drainage monitoring system in a highly automated vehicle is made using IoT by using sensors for providing authorities alerts via GSM and GPS devices. By putting water flow rate sensors at the intersection of nodes, this initiative corrects the flaws by identifying drainage water blockages. When there is a blockage in a particular node, the drainage water flow changes, and when it exceeds

the preset value, the managing station will display an alert. Detection also resolves other flaws. temperature changes inside the manhole and informing the management station to the same. Moreover, flow rate sensors are employed to identify drainage water overflows and send an automatic warning to the managing station. Manhole maintenance is laborious and requires power.

II. LITERATURE SURVEY:

A) Wireless sensor network design space; wireless communications Romer, K. Mattern, author (2004) Wireless sensor networks have recently made their way into a wide range of applications and systems.

B) Approaching IoT Adoption for Home Environmental Condition Monitoring Kelly SDT, Suryadevara NK, and Mukhopadhyay SC are the authors (2013) In this article, we have reported an efficiency.

C) Using Raspberry PI to monitor smart city applications utilizing IOT

Authors: Prof. S A.Shaikh 1, Suvarna A. Sonawane (2017) Description:It is necessary to upgrade healthy and safe cities that provide real-time services and cutting-edge facilities to implement the concept of smart city use. The goal of smart city development is to monitor the quality of resources in the city to improve good management and accelerate city development. IoT idea that makes

simple wireless communication possible. The system is made up of sensors, which gather various forms of data and transmit it to the Raspberry Pi3 controller. The control room receives the acquired output from the controller via email, and a personal computer also displays it.

D)The design space of wireless sensor networks, Wireless Communications Author: Romer, K. Mattern, Description: Wireless sensor networks have recently been included into a wide range of systems and applications with a wide range of needs and characteristics. As a result, it is getting harder to talk about standard requirements for hardware problems and software assistance. This is particularly challenging in a multidisciplinary study field like wireless sensor networks, where effective system implementation necessitates tight cooperation between users, application domain specialists, hardware designers, and software developers. We analyze this fact's different dimensions in this study as we discuss the implications for the wireless sensor network design space. We support our position by illustrating how particular existing applications occupy various locations inside the design space.

E) Towards the Implementation of IoT for Environmental Condition Monitoring in Homes Author: Kelly S.D.T,Suryadevara,N.K,Mukhopadhyay S.C Description: In this research,

we present an efficient Internet of Things implementation that uses a low-cost ubiquitous sensor technology to monitor typical residential circumstances. It is described how the integrated network architecture and connecting mechanisms work to ensure accurate parameter measurement by smart sensors and data transmission over the internet. The self-control mechanism for the devices in the monitoring stage was made possible by the longitudinal learning system. The monitoring system's structure is built on a scenario that combines pervasive distributed sensing units with an information system for data aggregation, context awareness, and reasoning. The dependability of sensing information transfer over the suggested integrated network architecture is 97%, which is a promising result. Real-time graphical information was generated by the prototype and tested.

F) Monitoring Smart City Applications using Raspberry PI Based on IOT Authors: Prof. S A.Shaikh 1, Suvarna A. Sonawane. Description: In order to implement the concept of a smart city, one must first upgrade healthy and safe cities that deliver real-time services and the most up-to-date facilities, as well as the Internet of Things (IoT) concept, which makes simple wireless communication possible. The goal of the smart city is to monitor the quality of resources in

the city to improve good management and speed up the development of the city. The system is made up of sensors that gather various kinds of data. The control room receives the controller's obtained output via email and can also view it on a personal computer.

III. EXISTING SYSTEM

We used GPS and GSM in the prior model. The map's depiction of the manhole's location must be corrected. Other GPS navigation software apps, including WAZE and Google Map, can also use this system capability to display the missing manhole road to avoid accidents. In order to localise, the system needs to use the GSM/GPS module to obtain the coordinates of the missing manhole and update the location on a map on the IOT platform.

IV. PROPOSED SYSTEM

We may all benefit greatly from this system because it recognises and keeps an eye on the manhole issue. The system made use of many parts, including an Arduino UNO, a DHT11 sensor, a MQ4 gas sensor, and an LCD display with an ESP8266 Wi-Fi module.

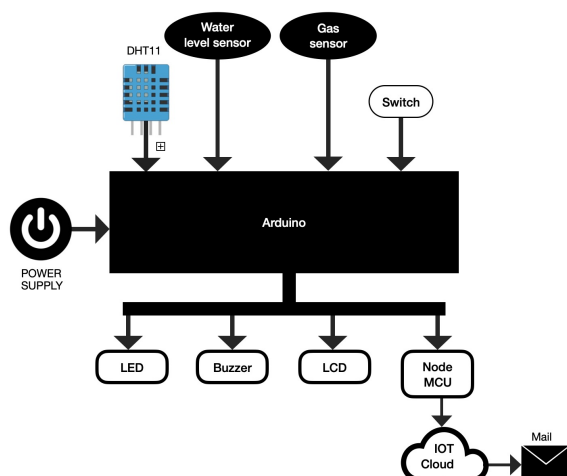
We employed a new sensor in this system, and if the band holder experiences any issues, it will send information about the issue to the microcontroller, which will then pass it along to the Wi-Fi module, which

will then communicate the information to the appropriate party.

V. DIFFERENCE BETWEEN EXISTING AND PROPOSED SYSTEM

The actual square contour shows the sewage vent as it is found in the subsurface waste framework. The sensors can identify any obstructions, temperature increases, explosions caused by hazardous gases, floods, and open sewage vent covers. The regulator, which has been modified to produce alarms, receives the signals from the sensors. To differentiate between blockages, floods, and gases in this, we employ sensors. The sensors will identify the obstructions within the seepage framework, provide information about the area, and allow the civil to make further moves. There are currently some additional systems that fall into one of two categories. Deliver the output to the user via a GSM text message, then the user will receive the output on the web.

VI. BLOCK DIAGRAM



VII. CONCLUSION

Via the Internet of Things, a sensor unit detects and automatically updates the real-time values of physical factors such as temperature, humidity, water level and flow rate, blockages, and whether the manhole cover is open or closed. The system becomes automated and smart as a result. In a developing nation, the installation of Wireless Sensor Networks (WSN) aids in the creation of smart cities. The design of environmental monitoring systems, which aid in the monitoring of volcanic activity, flood detectors, and other systems, can also benefit from the use of this WSN. This project can be used to monitor and manage systems in agricultural fields or other environmental fields with a minor update to the implementation. Infrastructure for smart communication and management of traffic signals, street lights, and transport systems may be updated in the future for Smart Cities.

VIII. REFERENCE

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