CHAPTER 1

INTRODUCTION

In the realm of urban infrastructure management, the Smart Waste Management project endeavors to redefine the efficiency and efficacy of waste collection processes. Much like the Manhole Cover Monitoring System with NodeMCU, this initiative seeks to address the challenges inherent in conventional waste management practices through innovative technological solutions.

Manual monitoring of waste bins is often labor-intensive and error-prone, leading to inefficiencies and delays in waste collection. Recognizing these limitations, the Smart Waste Management project harnesses the power of advanced sensor technology and automation to optimize waste collection processes.

At its core, the project aims to streamline waste collection by leveraging real-time data provided by sensors integrated into waste bins. When the fill-level of a bin surpasses a predefined threshold, an automated notification system is triggered, alerting both supervisors and workers via mobile app. This proactive approach not only enhances operational efficiency but also ensures timely waste collection, minimizing overflow and associated environmental hazards.

Central to the project's objectives is the seamless integration of monitoring devices with existing urban infrastructure. By leveraging NodeMCU technology, along with additional components such as ultrasonic sensor and OLED display, the system offers a comprehensive solution for waste management within urban environments.

Moreover, similar to the Manhole Cover Monitoring System, the Smart Waste Management project emphasizes remote accessibility. Operators and maintenance personnel can remotely monitor the status of waste bins in real-time, enabling prompt decision-making and proactive maintenance strategies.

Furthermore, the project prioritizes compatibility with databases, adhering to the regulations of waste management. By ensuring interoperability with existing infrastructure, the project aims to enhance safety, reliability, and sustainability within urban environments.

In summary, the Smart Waste Management project represents a significant advancement in waste collection and urban infrastructure management. Its integration of sensor technology, automation, and remote accessibility underscores its commitment to optimizing waste collection processes, ultimately contributing to cleaner, safer, and more sustainable cities.

1.1: Problem Statement:

In the realm of urban infrastructure management, the monitoring and maintenance of waste collection systems present significant challenges that impede operational efficiency and compromise environmental sustainability. Traditional waste collection methods rely heavily on manual inspections, leading to inefficiencies, delays, and environmental hazards. These outdated approaches pose risks to public health, exacerbate pollution, and strain municipal resources.

Manual waste collection systems are inherently prone to human error, resulting in inconsistencies, missed pickups, and overflow incidents. Inadequate monitoring and delayed response times further compound these issues, leading to unsightly and unsanitary conditions in urban areas. Additionally, the lack of real-time data hampers decision-making processes, hindering the ability to optimize waste collection routes and schedules.

Furthermore, the disjointed nature of existing waste management systems impedes seamless integration with emerging technologies and smart city initiatives. Without interoperability and data standardization, municipalities struggle to leverage the full potential of technological advancements, limiting their ability to address growing waste management challenges effectively.

Moreover, compliance with environmental regulations and sustainability goals is paramount in modern waste management practices. The absence of a comprehensive monitoring system tailored to meet these standards leaves municipalities vulnerable to regulatory penalties, public scrutiny, and environmental degradation.

In light of these challenges, there is a critical need for the implementation of a Smart Waste Management system with NodeMCU technology. This system aims to revolutionize waste collection processes by integrating advanced sensors, automation, and real-time data analytics. By leveraging these technologies, municipalities can optimize waste collection routes, reduce operational costs, and minimize environmental impact.

Figure 1.1: Waste management

Furthermore, the Smart Waste Management system offers remote accessibility and seamless integration with existing urban infrastructure, empowering municipalities to make informed decisions and respond promptly to emerging waste management challenges. Ultimately, this system represents a transformative approach to waste collection, fostering cleaner, healthier, and more sustainable urban environments for present and future generations.

1.2: Problem Scope:

The problem scope for implementing a Smart Waste Management system with NodeMCU technology encompasses several challenges and deficiencies within the current urban waste management framework. These limitations hinder operational efficiency, compromise environmental sustainability, and impede the overall management of waste collection processes.

Manual Monitoring and Human Error:

- Reliance on manual inspections for monitoring waste bins introduces a significant risk of human error.
- Manual monitoring is time-consuming and may result in delays in identifying full bins, leading to overflow incidents and environmental hazards.

Delayed Collection Response:

- The absence of real-time monitoring systems contributes to delayed response times for waste collection.
- Delays in identifying full bins pose risks to public health and the environment, especially during periods of increased waste generation.

Lack of Remote Accessibility:

- Current systems lack remote monitoring capabilities, limiting access to real-time data from different locations.
- Remote inaccessibility hampers quick decision-making and proactive response to emerging waste management challenges, increasing the likelihood of overflow incidents and environmental pollution.

Integration Challenges:

- Existing waste management systems often lack seamless integration with municipal infrastructure, complicating data flow and decision-making processes.
- The lack of integration with other urban infrastructure systems hinders interoperability and overall waste management efficiency.

Environmental Compliance Concerns:

- Compliance with environmental regulations and sustainability goals is essential for responsible waste management.
- The absence of a dedicated monitoring system designed to meet or exceed these standards leaves municipalities vulnerable to regulatory penalties, public scrutiny, and environmental degradation.

Operational Disruptions:

- Inefficient monitoring and delayed waste collection response contribute to the potential for operational disruptions in urban waste management.
- Operational disruptions pose risks to public health and the environment, leading to unsanitary conditions and increased pollution.

Complex Facility Management:

- The disjointed nature of existing waste management systems adds complexity to overall facility management.
- Lack of integration with other municipal systems complicates data accessibility and decision-making processes, hindering efforts to optimize waste collection routes and schedules.

Risk to Public Health and Environmental Sustainability:

- The cumulative impact of manual monitoring, delayed collection response, and operational disruptions poses risks to public health and environmental sustainability.
- Timely and reliable waste collection is essential for preventing environmental pollution and ensuring the well-being of urban residents.

Addressing these challenges within the defined problem scope requires the development and implementation of a comprehensive Smart Waste Management system with NodeMCU technology. This system aims to integrate advanced sensor technology, real-time monitoring capabilities, remote accessibility, and adherence to environmental regulations to enhance the efficiency and sustainability of urban waste management processes. Ultimately, this project will contribute to cleaner, healthier, and more sustainable urban environments for present and future generations.

Figure1.2:Technologies used for smart waste management

1.3: Advantages of Implementing a Smart Waste Management System with NodeMCU:

The implementation of a Smart Waste Management system with NodeMCU technology offers a multitude of advantages, significantly transforming waste collection processes and enhancing the efficiency, safety, and sustainability of urban environments. Key advantages include:

Real-time Monitoring:

- Enables continuous and real-time monitoring of waste bin fill levels.
- Promptly detects full bins, ensuring timely waste collection and minimizing overflow incidents.

Early Fault Detection:

- Utilizes intelligent algorithms to detect anomalies in waste bin fill levels at an early stage.
- Minimizes the risk of overflow incidents and environmental hazards by addressing issues proactively.

Enhanced Public Safety:

- Reduces the risk of environmental pollution and public health hazards associated with overflowing waste bins.
- Contributes to cleaner and safer urban environments for residents and pedestrians.

Remote Accessibility:

- Facilitates remote monitoring of waste bins from various locations.
- Enables workers to respond swiftly to full bin alerts, even when not physically present on-site.

Improved Operational Efficiency:

- Streamlines waste collection processes, reducing the need for manual inspections and optimizing route planning.
- Enhances operational efficiency by providing real-time data for proactive decision-making in waste management.

Seamless Integration:

- Integrates seamlessly with existing municipal infrastructure and waste management systems.
- Ensures data accessibility, interoperability, and a cohesive approach to overall waste management.

Compliance with Environmental Regulations:

- Adheres to environmental regulations and sustainability goals governing waste management.
- Mitigates the risk of environmental damage and regulatory penalties by promoting responsible waste collection practices.

Data Logging and Analysis:

- Records and logs data related to waste bin fill levels, facilitating historical analysis and trend identification.
- Supports data-driven decision-making and optimization of waste collection schedules.

Proactive Maintenance:

- Facilitates predictive maintenance by identifying potential issues before they lead to overflow incidents or environmental hazards.
- Reduces the need for reactive and costly interventions, contributing to long-term cost savings.

Enhanced Emergency Preparedness:

- Strengthens emergency response capabilities by providing real-time information during critical situations such as waste overflow incidents.
- Enables municipalities to respond swiftly to unforeseen circumstances, minimizing the impact on public health and environmental integrity.

Environmental Sustainability:

- Contributes to environmental sustainability by optimizing waste management practices and reducing pollution.
- Supports eco-friendly initiatives aimed at promoting sustainable urban development and waste reduction.

The implementation of a Smart Waste Management system with NodeMCU technology offers a comprehensive solution to the challenges associated with waste collection in urban environments. By providing real-time monitoring, early fault detection, remote accessibility and seamless integration, the system not only enhances public safety but also promotes operational efficiency and compliance with environmental regulations, ultimately contributing to the sustainable development of urban environments.

1.4 Proposed Solution:

The proposed solution for optimizing the Smart Waste Management system with NodeMCU involves the strategic integration of Internet of Things (IoT) technologies, transitioning the system into a smart, interconnected infrastructure. By leveraging IoT capabilities, the solution offers real-time monitoring, remote accessibility, and advanced analytics, revolutionizing waste collection processes. Key components of the proposed solution include:

IoT-enabled Sensors:

A network of IoT-enabled sensors will be strategically deployed to monitor the fill levels of waste bins in real-time.

These sensors will wirelessly transmit data to a centralized monitoring system, providing immediate insights into waste collection status.

Centralized Monitoring System:

Empowered by edge computing, the centralized monitoring system will process and analyze incoming sensor data in real-time.

This system will offer real-time insights into waste bin fill levels, enabling proactive decision-making and efficient waste collection scheduling.

User-Friendly Dashboard:

A user-friendly dashboard accessible remotely via web interfaces or mobile applications will provide stakeholders with comprehensive insights into waste collection processes.

The dashboard will display real-time data, alerts, and predictive analytics, empowering workers and supervisors to monitor the system and take proactive measures.

Seamless Integration:

The solution will prioritize seamless integration with existing municipal infrastructure, including waste management systems and urban networks.

This integration will ensure interoperability and data exchange, facilitating a cohesive approach to waste management and infrastructure maintenance.

Scalability:

Designed for scalability, the solution will accommodate future growth and expansion of waste collection infrastructure.

By implementing this IoT-based solution, municipalities can enhance public safety, improve operational efficiency, and optimize waste management processes. The proposed solution aims to address the challenges associated with manual monitoring, delayed collection response, and inefficient waste management, ultimately contributing to cleaner, safer, and more sustainable urban environments.

1.5 Aim and Objectives

Aim:

The aim of this project is to revolutionize waste collection processes through the implementation of a Smart Waste Management system with NodeMCU technology. Using Internet of Things (IoT) capabilities, the aim is to transition traditional waste collection methods into a smart, interconnected infrastructure. This innovative system aims to offer real-time monitoring, remote accessibility, and advanced analytics, thereby enhancing operational efficiency, improving public safety, and promoting environmental sustainability in urban environments. Through strategic integration of IoT-enabled sensors, centralized monitoring systems, user-friendly dashboards, seamless integration with existing infrastructure, and scalability considerations, the aim is to optimize waste collection processes, minimize operational costs, and mitigate environmental risks. Ultimately, the aim of this project is to contribute to cleaner, safer, and more sustainable cities by revolutionizing waste management practices and ensuring the efficient utilization of resources.

Objectives:

The objectives of implementing a Smart Waste Management system with NodeMCU technology are as follows:

Continuous Public Safety:

- Ensure the safety of residents and pedestrians by effectively managing waste collection processes and minimizing environmental hazards such as overflowing bins or litter accumulation.

Real-time Monitoring:

- Implement a continuous and real-time monitoring system for waste bin fill levels to promptly detect full bins and facilitate timely waste collection interventions.

Swift Intervention through Early Fault Detection:

- Utilize intelligent algorithms to achieve early fault detection in waste collection processes, enabling immediate corrective actions and minimizing the risk of environmental pollution or public health hazards.

Operational Efficiency Enhancement:

- Streamline waste collection processes and reduce reliance on manual inspections to improve overall operational efficiency and resource utilization.

Remote Accessibility:

- Enable operators and waste management personnel to monitor waste bin fill levels remotely, facilitating quick responses and interventions regardless of physical location.

Integration with Municipal Infrastructure:

- Seamlessly integrate the waste management system with existing municipal infrastructure and waste collection networks to enhance data accessibility and interoperability.

Adherence to Safety Standards:

- Ensure strict adherence to safety standards and regulations governing waste management practices, mitigating the risk of environmental contamination and ensuring a safe urban environment.

Data-driven Decision Making:

- Facilitate data logging and analysis to support data-driven decision-making for the optimization of waste collection routes, schedules, and resource allocation.

Proactive Maintenance:

- Implement predictive maintenance strategies by identifying potential issues such as imminent bin overflow before they escalate into major waste management challenges, reducing the need for reactive and costly interventions.

Environmental Sustainability:

- Contribute to environmental sustainability by optimizing waste management practices, minimizing waste generation, and supporting eco-friendly initiatives in urban development.

By achieving these objectives, the Smart Waste Management system with NodeMCU aims to create a comprehensive, technologically advanced solution that enhances public safety, improves operational efficiency, and contributes to the sustainable development of urban environments.

CHAPTER 2

Literature Survey

The adoption of a Smart Waste Management system with NodeMCU, integrated with Internet of Things (IoT) technologies, has become a focal point in waste management literature. Researchers have extensively explored avenues to enhance the efficiency and sustainability of waste management processes through continuous monitoring facilitated by IoT-enabled sensors. These sensors play a crucial role in acquiring real-time data on critical parameters such as waste bin fill levels, enabling proactive measures to optimize waste collection routes and schedules while minimizing environmental impact.

In the domain of sensor technology, literature emphasizes the diverse array of sensors utilized in IoT-based waste management systems. Research endeavors have focused on evaluating the accuracy, reliability, and suitability of these sensors for monitoring waste collection processes. Various sensor types, including ultrasonic sensors, infrared sensors, and weight sensors, are examined to determine their effectiveness in accurately measuring waste bin fill levels and detecting overflow conditions.

Communication protocols serve as essential components in establishing robust connections between IoT-enabled sensors and centralized monitoring systems. Literature extensively examines different communication protocols, with wireless technologies such as LoRaWAN, Zigbee, and RFID emerging as prominent choices. Evaluating the strengths and limitations of these protocols is critical in ensuring seamless and reliable data transmission, particularly in the context of waste management operations.

Addressing security and privacy concerns is paramount in the development of IoT systems for waste management. The literature survey delves into the implementation of robust security measures to protect sensitive waste management data. Encryption techniques, authentication mechanisms, and secure data transmission protocols are explored to safeguard the system against potential cyber threats and privacy breaches.

Integration with existing municipal infrastructure emerges as a key consideration, as highlighted in the literature. Compatibility with Geographic Information Systems (GIS) and Waste Management Systems (WMS) is emphasized to facilitate seamless data exchange and interoperability. Understanding the integration of IoT-based solutions with these existing systems enhances the feasibility and effectiveness of waste management technologies in urban settings.

Real-world case studies and implementations offer valuable insights into the practical challenges and lessons learned from deploying IoT-based waste management systems in urban environments. Analyzing these cases provides a deeper understanding of the system's performance, its impact on waste collection operations, and opportunities for optimization.

Recent trends in literature demonstrate a growing interest in edge computing for faster data processing and decision-making. Furthermore, the integration of artificial intelligence (AI) for advanced analytics is gaining momentum, enabling predictive maintenance and optimization of waste collection processes. The exploration of emerging technologies such as 5G networks underscores the commitment to technological innovation in waste management practices.

In conclusion, the comprehensive literature survey highlights a concerted effort to develop sophisticated and technologically advanced solutions for optimizing waste management processes. The exploration of IoT-enabled sensors, communication protocols, data security, integration with existing infrastructure, and real-world case studies provides valuable insights into the current state of research in this domain. The continuous evolution of these technologies underscores the ongoing commitment to revolutionize waste management systems and promote environmental sustainability.

CHAPTER 3

Methodology

The methodology for implementing a Manhole Cover Monitoring System with NodeMCU, leveraging Internet of Things (IoT) technologies, adopts a systematic approach tailored to the unique demands of urban infrastructure management. It commences with a meticulous needs assessment, engaging municipal authorities and urban planners to identify critical requirements and operational challenges pertaining to manhole cover monitoring and water level detection in urban environments. Subsequently, both functional and technical prerequisites for the system are clearly defined, encompassing essential aspects such as real-time monitoring, remote accessibility, integration with existing infrastructure, and adherence to safety standards.

Selection of appropriate IoT-enabled sensors constitutes a pivotal step, where factors like accuracy, reliability, and power consumption are carefully evaluated to ensure compatibility with the monitoring requirements of waste management.

Development of the centralized monitoring system entails the incorporation of edge computing for local data processing, thereby minimizing latency and ensuring timely access to critical information. An intuitive user interface accessible through web applications or mobile devices is meticulously designed, featuring real-time monitoring, immediate alerts, and insightful visualization of historical data.

Integration with existing municipal infrastructure, such as Geographic Information Systems (GIS) and utility networks, is carefully addressed to ensure interoperability and cohesive data exchange. Rigorous testing of the entire system, including sensor functionality, data transmission, and central monitoring system performance, is conducted in controlled environments before deployment. Training programs are then conducted for municipal personnel and maintenance crews to ensure effective utilization and management of the monitoring system.

Deployment is undertaken in a phased approach, starting with critical areas, followed by continuous monitoring and evaluation post-implementation. A proactive maintenance schedule is established to address regular updates, patches, and sensor calibration, ensuring the sustained performance of the system over time. Moreover, the incorporation of data analytics enables predictive maintenance, and optimization of urban infrastructure management. Continuous evaluation and adaptation of the monitoring system ensure its effectiveness, efficiency, and alignment with evolving urban infrastructure needs.

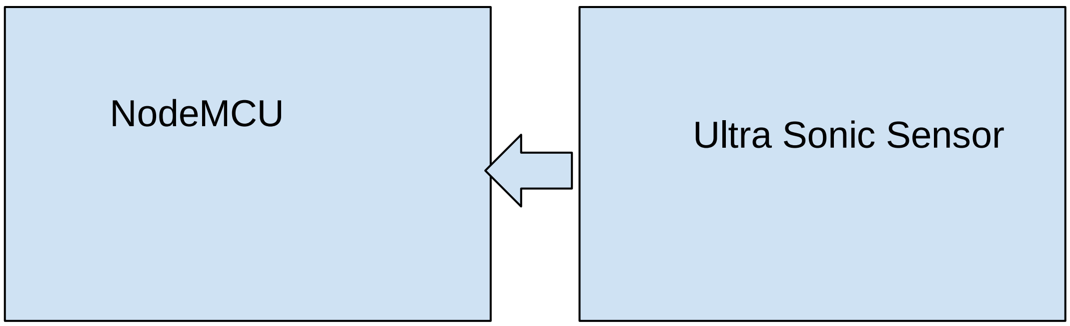


Figure 3.1: Block Diagram of the Smart waste management

3.1 NodeMCU (ESP8266)

The NodeMCU ESP8266 is a powerful and versatile platform designed for Internet of Things (IoT) development. It is a cost-effective Wi-Fi microchip known for its capability to enable wireless communication in IoT applications. NodeMCU, on the other hand, is an open-source firmware and development kit that simplifies the process of prototyping and programming the ESP8266, built-in Wi-Fi connectivity, the NodeMCU ESP8266 allows devices to connect to the internet wirelessly, making it suitable for a wide range of IoT projects. One notable feature is its support for the Lua scripting language, providing a high-level programming environment for developers. Additionally, it is compatible with the Arduino IDE, allowing those familiar with Arduino to use the NodeMCU platform. Equipped with General Purpose Input/Output (GPIO) pins, the ESP8266 facilitates interfacing with various electronic components, making it ideal for applications such as home automation and sensor networks. It has garnered significant community support, resulting in an extensive collection of libraries and documentation, making it a popular choice for rapid IoT prototyping and development.

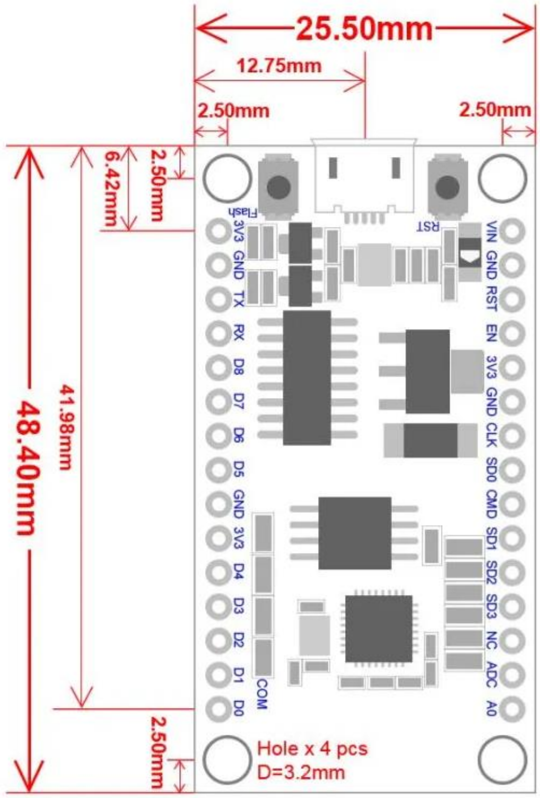


Figure 3.2 NodeMCU 2D View

NodeMCU Specification:

The NodeMCU development board is based on the ESP8266 microcontroller, and different versions of NodeMCU boards may have slight variations in specifications. As of my knowledge cutoff in January 2022, here are the general specifications for the NodeMCU ESP8266 development board:

1. Microcontroller: ESP8266 Wi-Fi microcontroller with 32-bit architecture.

2. Processor: Tensilica L106 32-bit microcontroller.

3. Clock Frequency: Typically operates at 80 MHz.

4. Flash Memory:

- Built-in Flash memory for program storage.
- Common configurations include 4MB or 16MB of Flash memory.

5. RAM: Typically equipped with 80 KB of RAM.

6. Wireless Connectivity:

- Integrated Wi-Fi (802.11 b/g/n) for wireless communication.
- Supports Station, SoftAP, and SoftAP + Station modes.

7. GPIO Pins: Multiple General Purpose Input/Output (GPIO) pins for interfacing with sensors, actuators, and other electronic components.

8. Analog Pins: Analog-to-digital converter (ADC) pins for reading analog sensor values.

9. USB-to-Serial Converter: Built-in USB-to-Serial converter for programming and debugging.

10. Operating Voltage: Typically operates at 3.3V (Note: It is crucial to connect external components accordingly to avoid damage).

11. Programming Interface: Programmable using the Arduino IDE, Lua scripting language, or other compatible frameworks.

12. Voltage Regulator: Onboard voltage regulator for stable operation.

13. Reset Button: Reset button for restarting the board.

14. Dimensions: Standard NodeMCU boards often have dimensions around 49mm x 24mm.

15. Power Consumption: Low power consumption, making it suitable for battery-operated applications.

16. Community Support: Active community support with extensive documentation and libraries.

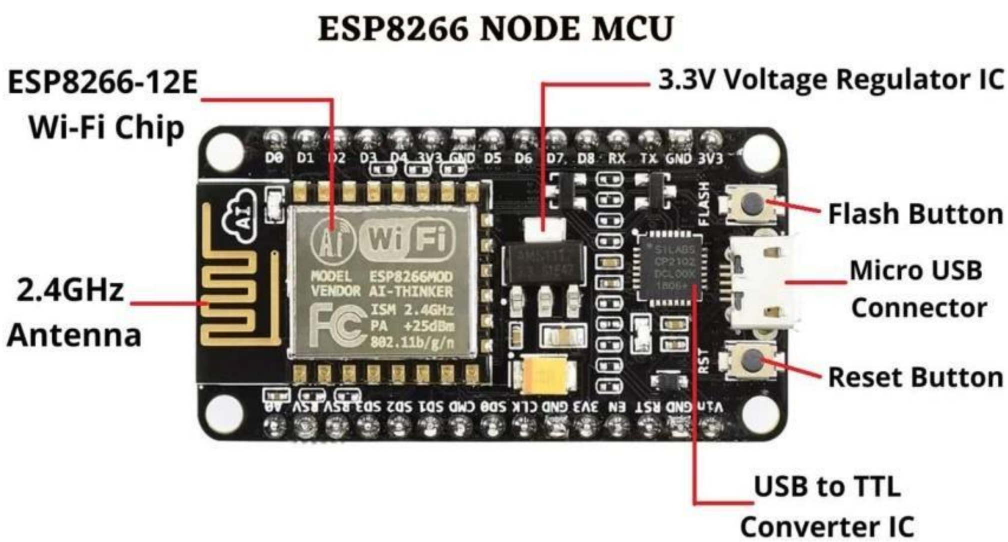


Figure 3.3: NodeMCU Parts

The NodeMCU ESP8266 development board typically has GPIO (General Purpose Input/Output) pins that can be used for various purposes, including interfacing with sensors, actuators, and other electronic components. Below is a common pinout configuration for the NodeMCU development board

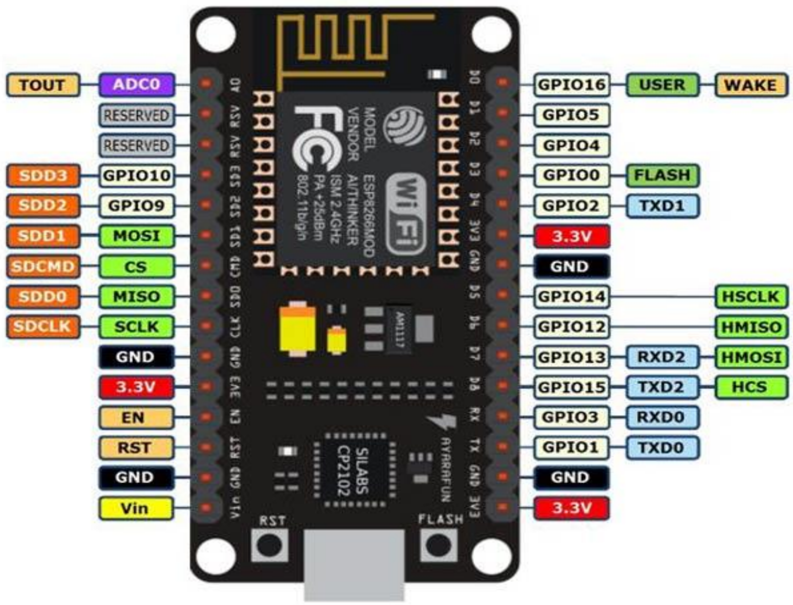


Figure 3.4: NodeMCU ESP8266 Pinout

ADC | A0 | GPIO16
EN | Enable | GPIO14
D0 | GPIO16 | GPIO12
D1 | GPIO5 | GPIO13
D2 | GPIO4 | GPIO15
D3 | GPIO0 | GPIO2
D4 | GPIO2 | GPIO9
D5 | GPIO14 | GPIO10
D6 | GPIO12 | GPIO3
D7 | GPIO13 | GPIO1
D8 | GPIO15 | TX (GPIO1)
D9 | GPIO3 (RX) | RX (GPIO3)
D10 | GPIO1 (TX) | D11 (MOSI)
D11 | MOSI | D12 (MISO)

D12 | MISO | D13 (SCK

ADC: Analog-to-Digital Converter pin for reading analog sensor values.

EN (Enable): Enable pin.

D0-D8: Digital GPIO pins.

D9 (RX) and D10 (TX): Serial communication pins for programming and debugging.

D11 (MOSI), D12 (MISO), D13 (SCK): Pins used for SPI communication.

D14 (SDA) and D15 (SCL): Pins used for I2C communication.

It's important to note that GPIO pins labeled as "D" (Digital) are typically used for general-purpose digital input/output. Additionally, GPIO pins labeled as "A" (Analog) can be used as analog inputs with the ADC. GPIO pins 6, 7, 8, 9, 10, and 11 have additional functions, so it's advised to refer to the specific NodeMCU documentation for detailed information on pin functionality and capabilities.

3.2 Ultrasonic Sensor

3.2.1 Introduction:

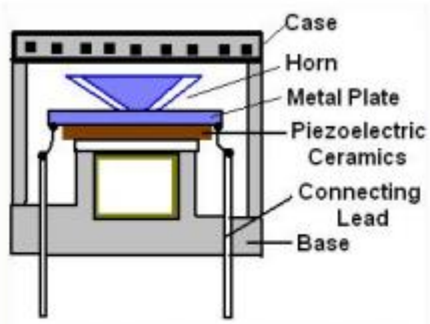
Ultrasonic is an excellent way of figuring out what's in the immediate vicinity of your Arduino. The basics of using ultrasound are like this: you shoot out a sound, wait to hear it echo back, and if you have your timing right, you'll know if anything is out there and how far away it is. This is called echolocation and it's how bats and dolphins find objects in the dark and underwater, though they use lower frequencies than you can use with your Arduino.

HC-SR04 Ultrasonic Sensor is a very affordable proximity/distance sensor that has been used mainly for object avoidance in various robotics projects. It has also been used in turret applications, water level sensing, and even as a parking sensor. This module is the second generation of the popular HC-SR04 Low Cost Ultrasonic Sensor. Unlike the first generation HC-SR04 that can only operate between 4.8V~5V DC, this new version has wider input voltage

range, allow it to work with controller operates on 3.3V.HC-SR04 ultrasonic sensor provides a very low-cost and easy method of distance measurement. It measures distance using sonar, an ultrasonic (well above human hearing) pulse (~40KHz) is transmitted from the unit and distance-to-target is determined by measuring the time required for the echo return. This sensor offers excellent range accuracy and stable readings in an easy-to-use package. An on board 2.54mm pitch pin header allows the sensor to be plugged into a solderless breadboard for easy prototyping

3.2.2. Sensor Element Construction

Piezoelectric crystals are used for sensor elements. Piezoelectric crystals will oscillate at high frequencies when electric energy is applied to it. The Piezoelectric crystals will generate electrical signal when ultrasound wave hit the sensor surface in reverse.



Construction of Ultrasonic Sensors

3.2.3. Module Specification

Electrical Parameters	Value
Operating Voltage	3.3Vdc ~ 5Vdc
Quiescent Current	<2mA
Operating Current	15mA
Operating Frequency	40KHz
Operating Range & Accuracy	2cm ~ 400cm (1in ~ 13ft) ± 3mm
Sensitivity	-65dB min
Sound Pressure	112dB
Effective Angle	15°
Connector	4-pins header with 2.54mm pitch
Dimension	45mm x 20mm x 15mm
Weight	9g

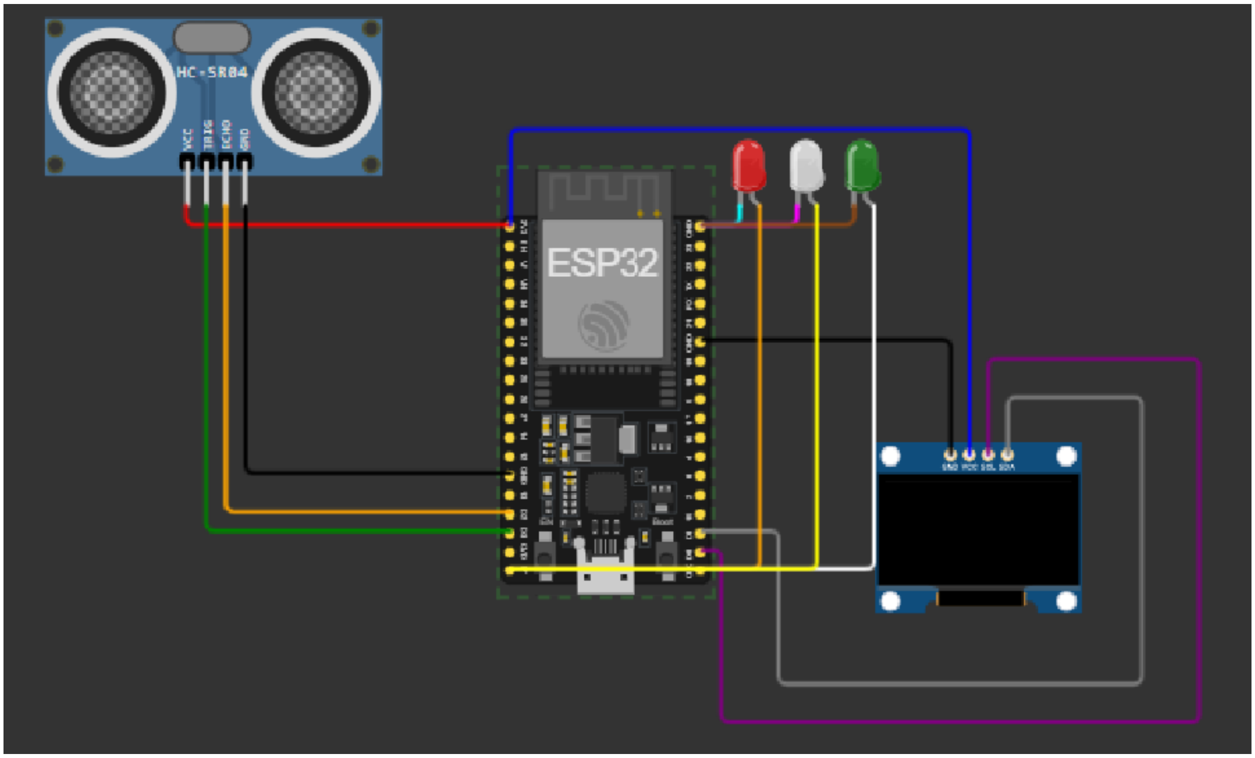
3.2.4. Hardware Information

VCC	3.3v ~ 5V
TRIG	Triggering Input Pin. 10uS TTL Pulses
ECHO	TTL Logic Output Pin. Proportional to distance
GND	Ground Pin

CHAPTER 4

Design and Coding

4.1 Circuit Diagram



4.1.1 Working

1. **Initialization (setup)**
   - The NodeMCU initializes serial communication at a baud rate of 115200 to print the distance to the Serial Monitor.
   - The trigPin is set to output mode to send pulses, and echoPin is set to input mode to receive the echo.
   - The LEDs are also set to output mode.
2. **Measuring Distance (loop)**
   - **Triggering the Pulse**:
     - The trigPin is set LOW for 2 microseconds to clear any previous state.
     - Then, it is set HIGH for 10 microseconds, which sends an ultrasonic burst from the sensor.
     - The trigPin is set LOW again, signaling the end of the pulse.

- **Receiving the Echo**:
    - The echoPin listens for the pulse to bounce back from an object.
    - The function pulseIn(echoPin, HIGH) measures the time (in microseconds) the pulse takes to return. This is stored as duration.
- **Calculating Distance**:
    - The distance to the object is calculated using the formula: distance=(duration×0.034)/2
    - The factor 0.034 converts the speed of sound (in cm/μs), and dividing by 2 accounts for the fact that the pulse travels to the object and back.

3. **Lighting Up LEDs Based on Distance**:
    - If the measured distance is greater than 8 cm, the **Green LED** turns on, indicating that the dustbin is not full. The message “I AM HUNGRY” is displayed on the OLED.
    - If the distance is between 5 cm and 8 cm, the **White LED** turns on, indicating a moderate range. The message “I AM NOT SO FULL” is displayed on the OLED.
    - If the distance is 5 cm or less, the **Red LED** turns on, indicating the dustbin is full. The message “I AM FULL” is displayed on the OLED.
    - After emptying the dustbin, the message “THANK YOU” is displayed on the OLED.

4. **Delay**:
    - A short delay of 100 milliseconds is added before repeating the process.

CHAPTER 5

Results and Conclusion

Result

The system successfully measures the distance between the ultrasonic sensor and an object (in this case, the trash level inside a dustbin) using the NodeMCU microcontroller. Based on the distance, the system accurately determines the level of the trash in the bin and appropriately lights up the corresponding LEDs:

Green LED turns on if the distance is greater than 8 cm, indicating that the bin is mostly empty.
White LED turns on when the distance is between 5 cm and 8 cm, indicating that the bin is moderately full.
Red LED turns on when the distance is 5 cm or less, signaling that the bin is full.

Messages are also correctly displayed on the OLED screen corresponding to each state:
"I AM HUNGRY" when the bin is mostly empty.
"I AM NOT SO FULL" when the bin is in the moderate range.
"I AM FULL" when the bin is full.
After the bin is emptied, "THANK YOU" is displayed.

Conclusion:

The system effectively implements an automated trash monitoring system using an ultrasonic sensor, NodeMCU, LEDs, and an OLED display. This setup provides a simple, efficient, and low-cost solution for managing waste levels in a bin. It can help reduce human effort in checking bins manually and ensure timely emptying of full bins, promoting a cleaner environment. Additionally, the system's quick response and clear visual feedback through LEDs and the OLED make it user-friendly.

We included an integrating app with a notification system (e.g., via Wi-Fi) to alert users remotely when bins are full. Overall, the system demonstrates the practical application of an ultrasonic sensor in a real-world problem, enhancing efficiency in waste management.