IoT BASED POWER SAVING WATER MANAGEMENT SYSTEM

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A project report submitted in partial fulfilment of the requirements for the award of the degree of Bachelor of Electrical Engineering

Electrical Engineering
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DECLARATION

We hereby declare that this project report is based on our original work except for citations and quotations which have been duly acknowledged. We also declare that it has not been previously and concurrently submitted for any other degree or award at Bahria University or other institutions.

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APPROVAL FOR SUBMISSION

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Date : _______________________

Specially dedicated to
my beloved grandmother, mother and father
(Zainab Rashed Arshad Al Shaikh)
my beloved grandmother, mother and father
(Muhammad Usama)
my beloved grandmother, mother and father
(Talha)

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IoT BASED POWER SAVING WATER MANAGEMENT SYSTEM

ABSTRACT

The IoT Based Power Saving Water Management System uses technology to manage the water supply in residential complexes without any human intervention. The system has sensors that monitor the water level in the overhead tank and the flow rate of water in each flat. Moreover, it has solenoid valves that regulate the water supply. The water level sensor detects the water level in tank and sends the signal to controller to operate motor when the water level reaches a certain low point and stops it once the overhead tank is full. Additionally, each flat has a daily water consumption limit, and a solenoid valve shuts off the water supply once it reaches the limit to prevent wastage of water and power. If the residents want additional water above their daily allotted limit, they can request for it and will be charged per liter.

The IoT-powered water management system is accessed via web application, enabling residents to track their daily water usage and receive notifications if they approach their limit. The system's primary goal is to save water and energy by limiting water usage and reducing motor operation time. Ultimately, the IoT based power saving water management system is an innovative solution aims to, conserve water resources, and energy in residential buildings. This system also improves the efficiency in flats.

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LIST OF SYMBOLS / ABBREVIATIONS

P	Power, hp
Q	Flow Rate, L/sec
H	Total Developed Head, m
ρ	Density, kg/dm^3
η	Efficiency
T	Total Amount of Water, L
E	Energy Consumption, kWh
P	Power Rating, kW
t	Operating Time, hour
C	Cost of Electricity, Rs

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CHAPTER 1

INTRODUCTION

1.1 Background

Concern of water scarcity is growing worldwide, and increasing importance of managing water resources efficiently is very high. There is lack management of water supply in many urban areas, water supply an urban areas are managed manually, because of lack of automation in these areas wastage of water and energy is very high, and to solve this issue an IoT based water management system is being developed for flats.

The average family consumption of water in flats in Karachi depends on various factors such as family size, lifestyle, water usage habit and efficiency of water fixtures and appliances. On average, a family living in flats in Karachi may consume 1000L of water per day, this estimate includes daily activities such as cooking, bathing, washing dishes, doing laundry and general household needs. It is important to note that the larger families or families with higher water usage requirement may consume more water, while smaller families or those practising water conservation measures may consume less, means there is uneven distribution of water between families. To prevent this problem we have designed a system that supply equal amount of water for each families in flats which will be average family consumption of water, and the family who will consume above the allotted amount they will be charged on it per liter.

Karachi has been facing water supply challenges for many years and these challenges often effect both flats and other residential areas in city. The water crisis in flats in Karachi can be attributed to several factors such as: limited water resources, unequal distribution of water, aging infrastructure for water supply and distribution, population growth and urbanization in Karachi and illegal connections and water theft. To address this crisis in flats it is essential to focus on improving infrastructure of water supply and distribution and keep monitoring the real-time data of usage of water.

The main aim of proposed system is to manage and automate the water supply process, different sensors are used to detect the water level in the tank and to measure the flow of water at each flat. The motor will automatically operate to fill the tank when the water level drops below a certain level, and will automatically turn off when the tank is full. To prevent wastage of water and energy each flat will be assigned a limited amount of water e.g. 1000 liters per day. When the limit is reached the solenoid valve will automatically turn off. Residents who need extra water beyond their limit can request for additional water through an appication and they will be charged on it per liter.

The model will be operated through an IoT based Web application, and residents can monitor their daily water consumption through this app and can receive notifications when their daily limit is reached. The purpose of this project is to save water and power by preventing excessive water consumption and reducing the operating time of the motor.

The system is a progressive solution that aims to conserve water resources and power to improve efficiency of water consumption in flats. The IoT-based system for managing water usage is helping urban areas maintain a more sustainable future. By recognizing and adapting to the way people consume water, this technology has the potential to significantly reduce wasted energy and resources.

1.2 Literature Review

Recently, there has been a surge of interest in IoT-based power-saving water management systems and their potential to enhance water and electricity usage while reducing waste. These systems incorporate sensors, smart electric valves, and mobile apps to track and regulate water usage for optimal distribution and consumption efficiency. Research shows that the implementation of these systems by Xu et al. (2019) has effectively reduced water consumption.

The study examined a residential community in China to assess the effectiveness of implementing a smart water metering system to reduce water and energy consumption. These systems use IoT sensors to collect data on usage, successfully providing real-time feedback on consumption levels through a mobile app so that homeowners can monitor and control their usage. The results demonstrated an average efficiency rating of 15%.

The researchers conducted a field study on the water consumption patterns of households in a Chinese residential building. They analyzed the data collected from smart water metering systems implemented before and after installation, noticing significant changes in usage.

The study found that implementing a smart water metering system led to significant reductions in both water and energy use. As residents became more aware of their consumption patterns, they made behavioural changes resulting in more efficient utilization of water resources. Consequently, the study concludes that smart water metering systems can be effectively employed to promote conservation of water and decrease usage in residential buildings by providing real-time data to raise consumer awareness about their consumption levels. This facilitates informed decision-making and action-taking towards eliminating wasteful practices.

The article "A Review on smart water management systems using the internet of things (IoT)" by Alam, M., M.S (2020), published in the journal Water, delves into the application of IoT in managing water resources. The paper specifically focuses on how IoT technology can aid data gathering, monitoring and controlling activities of a smart water system.

The article covers the potential benefits of using IoT in smart water manageme-nt systems such as improved decision-making, increased efficiency, and reduced water waste. However, it also sheds light on obstacles and constraints while adopting IoT technologies in the water sector such as data security and privacy concerns. The article aims to provide informative insights into how IoT is used in managing water resources sustainably. Thus, it serves as a useful resource for professionals, policymakers, and researchers seeking relevant information on this subject matter.[2]

In their 2021 work titled "Smart water management systems: A review of technologies and applications," Al-Khatib conducts an exhaustive analysis of various technological tools employed in smart water management such as the Internet of Things, data analytics, sensor networks, and automation. The authors maintain a neutral tone and style to provide qualified readers with insightful information on the available technology options for smart water management systems. Throughout the article, they give a comprehensive examination of these systems' features and benefits including real-time monitoring, leak detection, demand management, and water quality testing. The article highlights the benefits of utilizing such systems, showcasing their ability to improve water resource efficiency, decrease operational expenditures and enhance decision-making capabilities. The language utilized is neutral and understandable for a competent audience who wishes to deepen their understanding of the subject matter.

The article aims to explore the challenges that hinder the implementation of a smart water management system, including data security, privacy concerns, technological limitations, and interoperability issues. It provides valuable insights into the current state of smart water management technology and applications. This resource is an essential read for researchers, experts, and decision-makers in water management systems. By understanding how these technologies can address pressing water management problems sustainably, this essay helps promote sustainable practices for managing our precious water resources.

1.3 Problem Statements

Karachi apartment residents face several challenges related to water management systems and water usage. These challenges include inconsistent water supply, excessive water consumption and lack of efficient and effective monitoring and control systems. It is therefore important to provide solutions that address these issues and improve energy efficient water management practices while ensuring fair and equitable water distribution and conservation.

- Water shortage and wastage in urban areas: In many urban areas water shortage is a significant problem due to inefficient management of water distribution and usage system. The water distribution system is manual in many areas.

- Inconsistent water supply: Flats in Karachi often experience irregular water supply and shortage of water, leading to inconvenient and uncertainty for residents. This consist makes it difficult for families to plan for their water usage effectively and can disrupt their daily routine.

- Lack of fairness in water distribution: In the absence of fair and transparent water distribution system, some families may face water shortages while others may receive an unfair advantage. This uneven distribution creates dissatisfaction and conflicts among residents.

- Unregulated and excessive water consumption pattern in residential buildings: Residential building especially flats in Karachi often experience irregular water supply and there is lack of awareness and inefficient water management system practices which leads to excessive consumption in flats. This inconsistency make it difficult for families to plan their water usage effectively and can disrupt their daily routine. This system helps prevent excessive water consumption and promote responsible water usage.

- Inefficient power usage: Inefficient consumption of electricity by water pumps and motors in residential buildings and traditional or manual water distribution system such as pumps and valves consume significant amount of energy leading to increase electricity costs and adds to the overall energy burden in flats. An IoT based power saving water management system will automatically shut off the motor when the tank is full.

- Manual Monitoring and Operation: Lack of centralized monitoring and control system for water distribution and consumption in residential building. Which leads to fail in providing a consistent and reliable supply of water. This reliance on manual monitoring methods makes it challenging to track water usage accurately, resulting in difficulties in identifying excessive consumption and implementing necessary control measure. An IoT based water management system can help in monitoring and control the water distribution and usage, and provides real-time feedback on water usage to make water distribution system more efficient and effective.

- The high cost incurred by residents who consume water less than their allotted quota due the absence of a monitoring and controlling system of water distribution and usage.

An IoT based power saving water management system aims to solve these problems by providing an automated and efficient solution for household water management systems. By implementing a water level gauge, a flow sensor and a solenoid valve, the system will automatically activate the engine when the water level falls below a certain value and close the valve when the water level limit reaches the assigned amount. . This prevents water wastage and ensures an even supply.

1.4 Aims and Objectives

1.4.1 Aims

An IoT based power saving water management system aims to address power and water related challenges faced by families living in apartments in Karachi. The Aims of the project is to:

i. Development of an IoT based water management system that automates the water supply and distribution process and reduces water and energy wastage.

ii. Save power by avoiding unnecessary motor work.

iii. To ensure equitable distribution of water, a daily water allowances of 1000 liters is set for each family, and household requiring more than the set limit, the water will provided them with charges on it per liter.

iv. Provide user-friendly platform for families to monitor and manage their daily water consumption.

v. Reduction of maintenance costs by automating the motor operation.

vi. Increase the efficiency of water distribution and utilization system.

1.4.2 Objectives

The power-saving water management system that is based on IoT technology aims to tackle the issues related to electricity and water consumption that are commonly e-ncountered by families living in Karachi flats. The main objectives of this project include: -

i) To detect the tank's water level through the use of a water level indicator. The system ensures the motor turns on automatically when the water reaches a certain point and switches off automatically when the tank is full. This process promotes efficient water management practices while preventing any unnecessary waste.

ii) To develop a solenoid valve system that closes automatically when the daily water limit is reached.

iii) To develop a web application that will provides the families real-time information of their daily water usage and families can monitor their daily water usage from this application. Also, they can request for additional water if they needed.

iv) To establish a billing system for families who exceed their daily water limit and require additional water.

Through these aims and objectives, the IoT based power saving water management system project strives to address power and water related challenges, promote responsible water usage, conserve resources and enhance the living experience for families residing in flats.

1.5 Scope of Project

The scope of the IoT based power saving water management system includes the development and implementation of a smart water management system for flats. The system will be designed that automatically operate the motor when the water level drops below a certain level and will automatically turn off when the tank is full, and will limit the amount of water usage for 1000 liters per flat per day. A solenoid valve will be used that will automatically close the supply of water once the limit is reached. If any family needs extra water beyond their limit they will be charged on it per liter. The complete system will be functioned through a web application.

The water usage system in each apartment is monitored and controlled to ensure efficient use of water. Motorized valves regulate the flow, with control available via web application. The project's objective is to provide equal water to every household, with any excess charged accordingly. It helps save both energy and water by regulating the motor only when necessary. The initiative includes hardware and software development, as well as system installation and testing for seamless integration. The system's services encompass managing water consumption in apartments to conserve energy. It can also be applied to other settings like parks and gardens. By implementing and using this system, you can save on electricity and water resources while ensuring their efficient usage, which leads to a reduction of your bills providing significant cost savings.

- Hardware Implementation: The project involves the installation and integration of hardware components such as water level indicator, solenoid valve and water flow sensor in the water supply and distribution system of each flat. These components enable automated control and monitoring of water levels, ensuring efficient operation and water and energy conservation.

- IoT Integration: The project utilizes IoT technology to connect the hardware components to a centralized system. This integration enables real-time data monitoring, remote control, and communication between the water management system and the web application to make it easy to residents to monitor their daily water usage and to communicate with admin for any queries.

- Water consumption Allocation: The system will allot a daily water limit of 1000 liters per flat to ensure fair and even distribution of water and encourage responsible usage. When the allocated amount is consumed, the system will automatically close the valve to prevent excessive usage.

- Power Optimization: The system aims to optimize power usage by automating the motor's operation based on the water's level in the tank. The motor will only run when its necessary, this will reduce energy consumption and promote power efficiency

- Extra water provision: Families who require additional water beyond their allocated limit, can request for additional water through the web application. The system will provide them with the requested water and will charge them per liter for the extra usage. This feature ensures that residents have access to additional water while discouraging wasteful consumption.

- Web Application Development: A user-friendly web application has been developed to provide residents with access to monitor their daily water consumption data, control features and additional services. The application will allow residents to monitor their water usage, set consumption goals, receive notifications and request extra water if needed.

The scope of the project does not include retrofitting existing water supply infrastructure or addressing Karachi's widespread water scarcity and distribution problems. Instead, we focus on providing efficient and easy-to-use solutions in residential environments, promoting responsible water use and addressing the specific challenges faced by families living in those homes.

1.6 Sustainable Development Goals of Project

1.6.1 Introduction

The IoT based power saving water management system project aligns with several Sustainable Development Goals (SDGs) of the United Nations, which aims to create a better world for present and future generations. In this context, we are working on a project named IoT based power saving water management system, which aim to address several of the SDGs. The IoT based water management system can help alleviate poverty which will provide equitable water distribution and reducing wastage of water. Also, this system optimize water management is residential building through an innovative IoT based technology which will ensure sustainable cities and communities, and this system promotes responsible consumption and production by setting a daily limit of 1000 liters per flat and encouraging residents to conserve water.

1.6.2 Justification

The implementation of an IoT based power saving water management system in flats aligns with several sustainable development goals that's are:

- The 1st SDG, No Poverty, is closely related to the project as it can help alleviate poverty in all its forms and dimensions by providing equitable water distribution and reducing water wastage which can be cost saving for families who do not excess the use of water. Water is a basic human right and is crucial for the health and well-being of individuals, especially for those living in poverty. This project ensures providing daily assigned quota of water. Which will help to reduce wastage of water and equitable distribution of water distribution.

- The 11th SDG, Sustainable Cities and Communities, providing as sustainable solution for managing water and energy resources in urban areas. As the cities are continue growing and becoming more densely populated, the demand for water and energy increases. By implementing an IoT based power saving water management system, we can create more efficient and sustainable cities.

- The 12th SDG, Responsible Consumption and Production, the system promotes responsible consumption of water by allotting daily limit of water for each flat implementing a payment system that enables residents to pay for extra water usage, and encouraging residents to conserve water and contributes to the sustainable development of communities by promoting production reducing the use of manual labour and enhancing the quality of life in many urban areas.

Overall, the IoT based power saving water management system aligns with several SDGs that promotes responsible consumption and production contributing to the sustainable development of communities. Also, reduce the use of manual labour and enhancing the quality of life in urban areas.

1.6.3 Mapping of Sustainable Development Goals

SDGs learning Outcomes	FYP Name	
	Mapping	SDG attainment Detail
GOAL 1: No Poverty	✓	Providing equitable water distribution and reducing water wastage, which will be cost saving.
GOAL 2: Zero Hunger		
GOAL 3: Good Health and Well-being		
GOAL 4: Quality Education		
GOAL 5: Gender Equality		
GOAL 6: Clean Water and Sanitation		
GOAL 7: Affordable and Clean Energy		
GOAL 8: Decent Work and Economic Growth		
GOAL 9: Industry, Innovation and Infrastructure		
GOAL 10: Reduced Inequality		
GOAL 11: Sustainable Cities and Communities	✓	Optimize water management in residential building.
GOAL 12: Responsible Consumption and Production	✓	Promotes responsible consumption of water by setting a daily limit.
GOAL 13: Climate Action		
GOAL 14: Life Below Water		
GOAL 15: Life on Land		
GOAL 16: Peace and Justice Strong Institutions		
GOAL 17: Partnerships to achieve the Goal		

Table 1.6: Mapping of SDGs

1.7 Environmental Aspects of Project

1.7.1 Introduction

The IoT based power saving water management system is not only aimed at improving the efficiency of water and energy usage but also focuses on addressing several environmental aspects. Water is a precious resource, an efficient management can help conserve this resource and protect the environment.

The project uses an electric valve that ensures the water is used in controlled and regulated manner, preventing the wastage of water by assigning a daily limited amount of water to each flat. When the flow of water reaches the limited amount the electric valve will automatically close and will stop the flowing of water. This system encourages residents to use water judiciously and prevents excessive usage of water which will help in conserving water resource and protect the environment. By providing additional amount of water to families who need extra water with charges per liter, the system encourages responsible use of water and prevents overuse of this resource.

Furthermore, the use of an automated motor that operates only when required ensures that the power is not wasted by using water level indicator, when the tank reaches below a certain level the motor will automatically operate and when it is full the motor will automatically shut down. This reduces the carbon footprint of the system and reduces the regular maintenance of motor making it environmentally sustainable solution. The use of an IoT based technology and web application ensures that the system is user friendly, and residents can monitor their daily usage of water and get notification when the limit is about to reach encouraging responsible water usage. All these aspects make this project environmentally conscious and promote sustainability.

1.7.2 Environmental Impact Assessment (EIA)

An environmental impact assessment (EIA) is a process of evaluating the potential environmental impacts of the project. In the case of IoT based power saving water management system, following EIA can be conducted:

i) Energy Conservation: The automatic operation of motor and solenoid valves will result in efficient use of electricity, saving power and reducing carbon emission.

ii) Water Conservation: The project aims to reducing water wastage by providing a limited amount of water to each flat in residential buildings, and closing the valve automatically when the usage exceed the assigned limit. This will result in significant reduction in wastage of water and conservation of this valuable resources.

iii) Reduction of Water Pollution: Reducing in consumption of water will reduce the amount of wastewater generated, which will reduce the pollution of water bodies and the environment.

iv) Reduction of Carbon Footprint: The implementation of IoT based power saving water management system would lead to reduction in the carbon footprint by automating the operation of motor reducing electricity consumption, which would result in lowering greenhouse gas emission.

v) Reduction in Environmental Costs: The implementation if an IoT based power saving water management system would result in reduce environmental costs related with water and energy consumption. The overall cost savings can be used to support other environmental initiatives.

In conclusion, the implementation of the IoT based power saving water management system would have a positive impact on the environment by conserving water and energy, reducing water pollution and lowering the carbon footprint of the water management system.

1.7.3 Environment Impact Statement (EIS)

An Environmental Impact Statement (EIS) is a detailed analysis of the potential environmental impacts of a project. In the case of the IoT based power saving water management system project, there are different potential environmental impact which are:

Positive Impact:

- Reduce excess of energy consumption by ensuring that the motor is operating only when its necessary and will turn off automatically when its full
- Reduce water consumption by limiting of water to each family per day, which will help conserve water resource.
- Reduce Greenhouse Gas emission by operating the motor only when it's needed, thereby reducing the carbon footprint of the system.
- Reduce water wastage and pollution by preventing excess water from water overflowing and pollute the surrounding.

Negative Impact:

- Energy consumption and Greenhouse Gas emission that are related to the manufacturing and installation of the system's component, which may have negative impact on environment during the production process.
- E-waste generated by the system's component at the end of the life-time may have negative impact on the environment if not disposed of properly.
- Possible water leakage due to any fault occurs in valves may cause water wastage and damage to surrounding environment.

Overall, the IoT base power saving water management system has the potential to have positive impact on environment by reducing energy consumption and conserving water. However, it is important to reduce ant negative impact by ensuring proper disposal of e-waste and addressing any issues related to the water leakage.

CHAPTER 2

DESIGN AND METHODOLOGY

2.1 Design

The IoT based power saving water management system is designed to save power and water while ensuring that’s each family gets an equal share of water per day and controlling the operation of motor. The system will be implemented on flats and will operate through a web application. The design of the system includes solenoid valve, water flow sensor, water level sensor, motor, controller and a mobile app.

Water Level Sensor: The sensor installed in the water tank to detect the water level in the tank. The sensor sends the signal to the controller to turn the motor on and off depends on the level of the water. When the water falls below a certain level, the sensor will send the signal to the controller to operate the motor, and when it the tank is full the sensor will detect the water level and sends signal to the controller to turn off the motor.

Water Flow Sensor: The flow sensor installed in the pipeline system to measure the amount of water flowing through the system. It will send the signal to microcontroller to monitor the water consumption.

Solenoid Valve: The solenoid valve installed in the pipeline system to control the flow of water. When the water consumption reaches 1000 liters the controller will send a signal to close the solenoid valve automatically.

Controller: It is the brain of the system. The central processing unit that will receive signals from the Water Level Sensor, Flow Sensor and Mobile App. It will control the motor and solenoid valve based on the input received from the sensors and app.

Motor: The motor is used to pump the water from storage tank to the roof tank. It will be turned on and off automatically depends on the level of water in the roof tank.

Web Application: Through the mobile app, user can monitor their daily usage of water and can interface with admin to request for extra water if needed. Also, it allows admin to monitor and control the daily usage of water consumed by the each family and will have access to provide additional water to family who needed extra water. Also, admin can monitor the motor operation through this appication and water level of the tank.

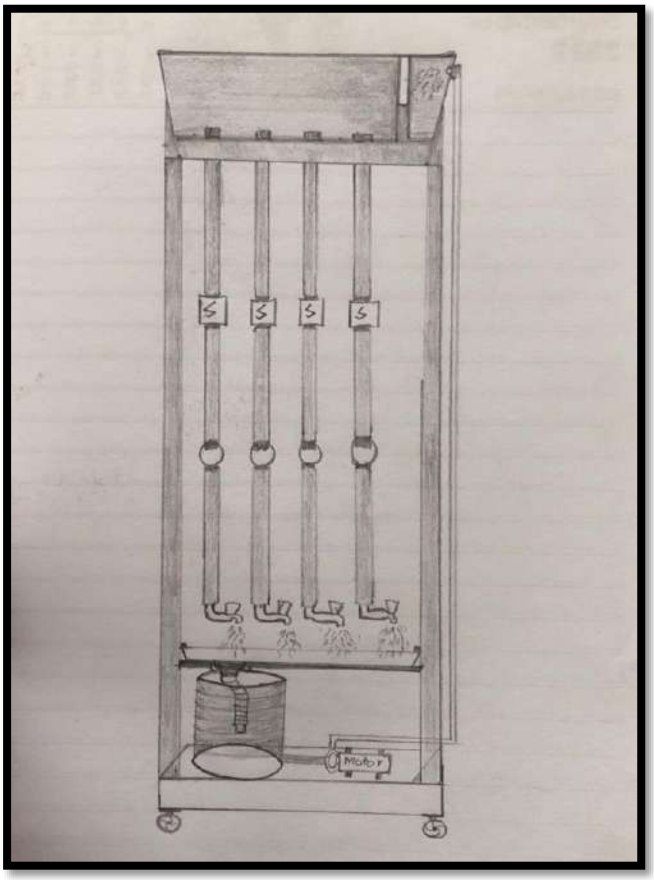

Figure 2.1: Proposed Design of Project

Figure 2.2: Blender Model of Project

2.2 Methodology

The methodology for implementing the IoT based power saving water management system involves the following steps:

i) Assessment of water needs: The first step is to assess the water needs of each family in the flats by taking the real time data of water usage of different families then calculate the average consumption of water of a family. Based on this assessment, an equal share of 1000 liters per day will be assigned to each family.

ii) Identify the requirement: The second step is to identify the requirements of the system. This includes the number of flats, the amount of water assigned to each flat, the capacity of tank and the maximum water level of the tank.

iii) Design the system: Based on the requirements, the system is designed with the necessary components such as water level sensor, water flow sensor, solenoid valve, controller, motor, and web application.

iv) Prototype development: The prototype includes the installation of hardware and software components of the system. The water level sensor, water flow sensor and solenoid valve will be installed in the water tank and pipeline system. The controller will be programmed to control the motor and solenoid valve.

v) Testing and validation: The system will be tested to ensure proper functioning of the hardware and software by testing it for different scenarios such as low water level, high water level, water flow after reaching the limit and user request for additional water. The validation will be done to check the efficiency of the system in saving water and power.

vi) Deployment: Once the system is tested and validated, it is deployed in the flats. The system is connected to the water tank, pipes and power supply.

vii) Maintenance and Monitoring: The system is monitored regularly for its performance. The system is monitored to ensure its efficient performance.

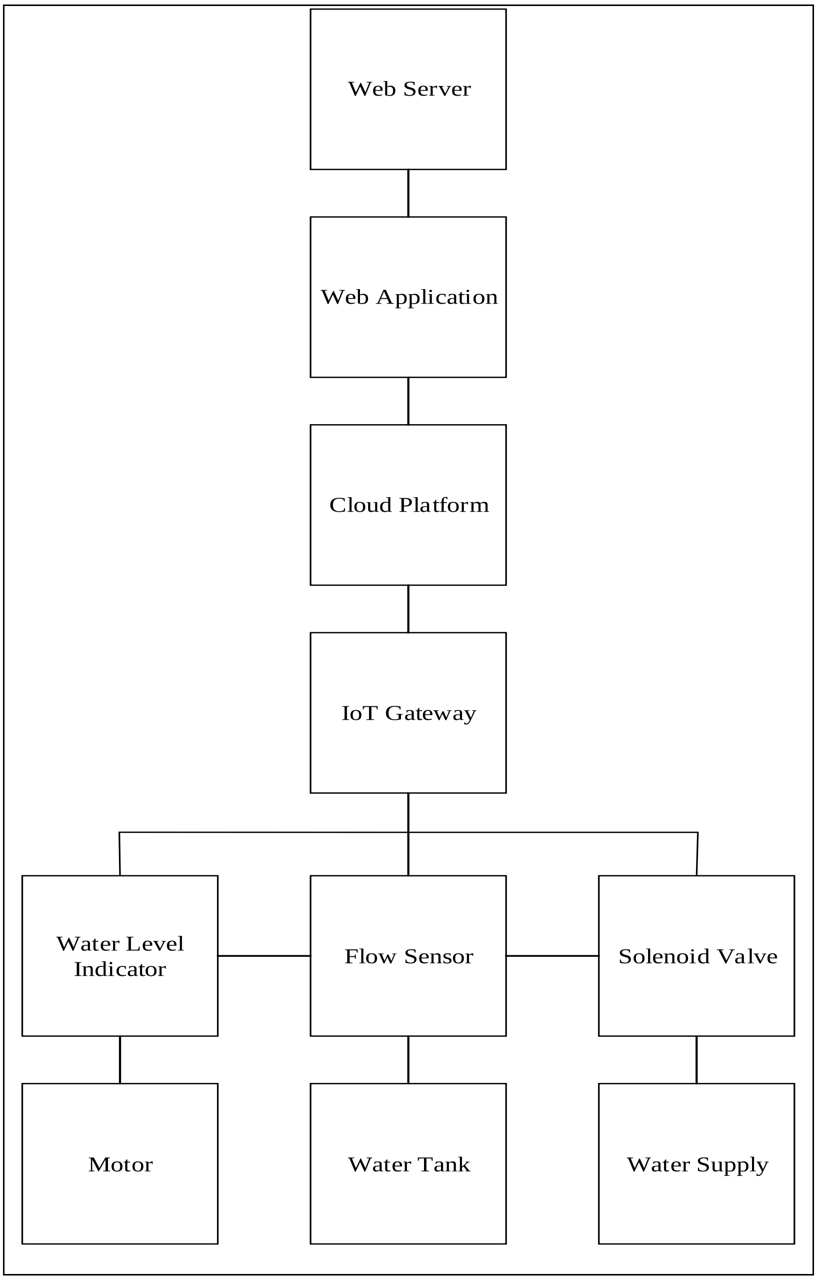

Figure 2.3: System's Block Diagram

Figure 2.4: System’s Model

CHAPTER 3

DESIGN IMPLMENTATION

3.1 Hardware

3.1.1 Water Flow Sensor

This system uses model YF-B5 of Water Flow Sensor to measure the amount of water being consumed by each flat. When water consumption reaches the assigned limit of water per day, the solenoid valve will automatically close to prevent excess usage of water.

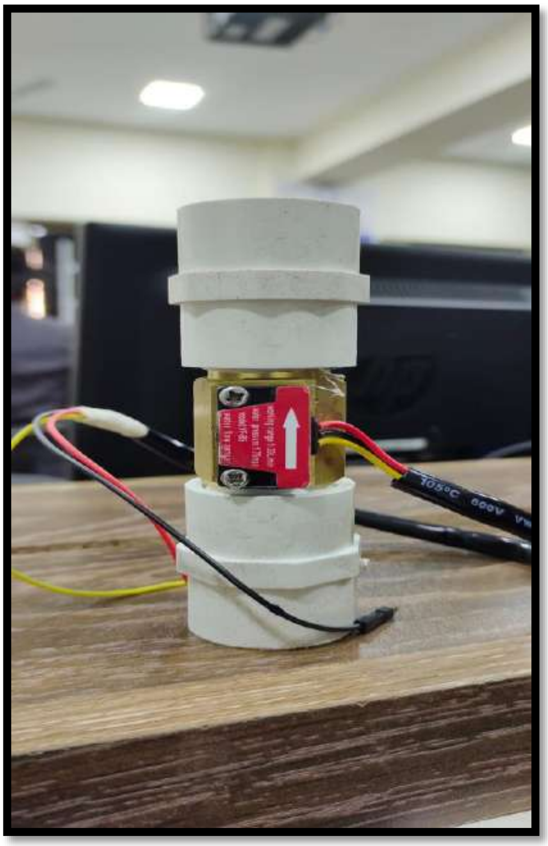

Figure 3.1: Water Flow Sensor

This sensor flows 1-30L/M with water pressure of 1.75mpa.

3.1.2 Solenoid Valve

This system uses a solenoid valve to control the flow of water. When the water consumption reaches 1000L/day the flow sensor will send the signal to microcontroller to turn off the valve. This valve is connected to IoT device that will allow the admin to provide water to families who need additional water.

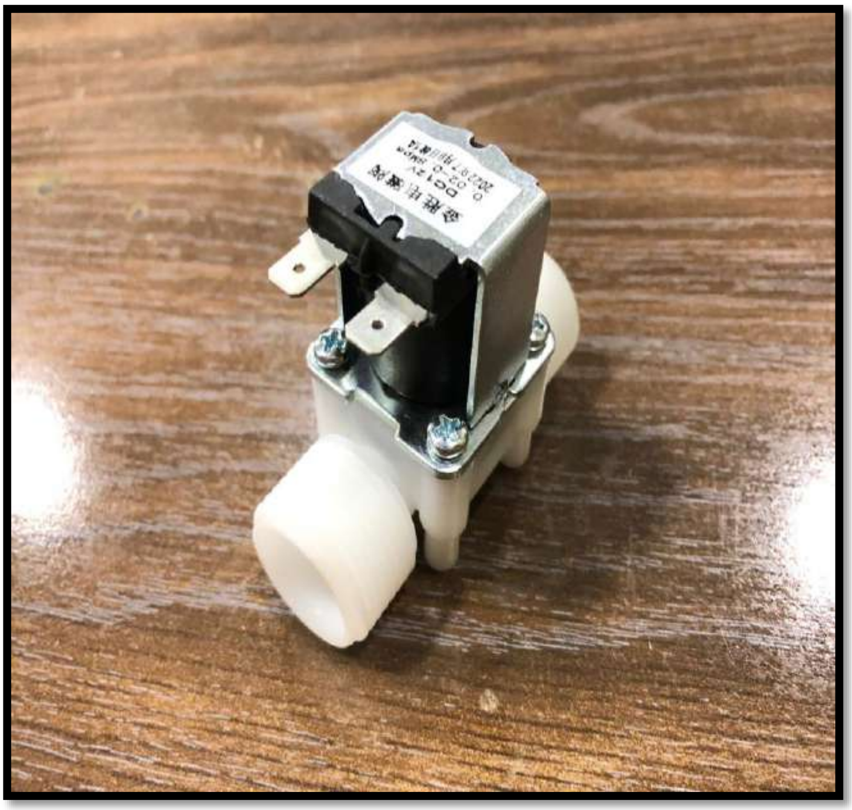

Figure 3.2(a): DC Solenoid valve

A DC Solenoid valve is an electromechanical device that allow or block flow of water through it in a system using direct current (DC) power.

Water pressure of this valve is 0.02-0.8Mpa and can operate on DC 12V

Figure 3.2(b): AC Solenoid valve

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An AC solenoid is an electromagnetic device that allows or block the flow of water through it in a system using direct current (DC) power.

The operating pressure of this valve is from 0kg/cm^2 to 10 kg/cm^2 and can operate on AC 220V

Response time of AC solenoid valve is faster and effective than response time of DC solenoid valve and m

3.1.3 Water Level Sensor

This system uses a Waterproof Ultrasonic Sensor to detect the level of water in the overhead tank, when the tank is below a certain level the sensor sends the signal to controller to operate the motor, and when the tank is full the sensor sends the signal to controller to turn the motor off.

Figure 3.3(a): Ultrasonic Water Level Sensor

JSN-SR04T used in this system.

Range of this sensor is 20cm-400cm.

Compatible with both 3.3V and 5V.

It has four pins: VCC, GND, TRIG(RX), ECHO(TX)

Figure 3.3(b): Ultrasonic Water Level Sensor Implementation

3.1.4 Motor

Motor plays crucial role in pumping water from the underground tank to overhead tank to supply water to the flats. Once the motor is activated, its starts pumping water from lower tank to the overhead tank. The motor continues to operate until the desired water level in the tank is reached which will be detected by water level sensor.

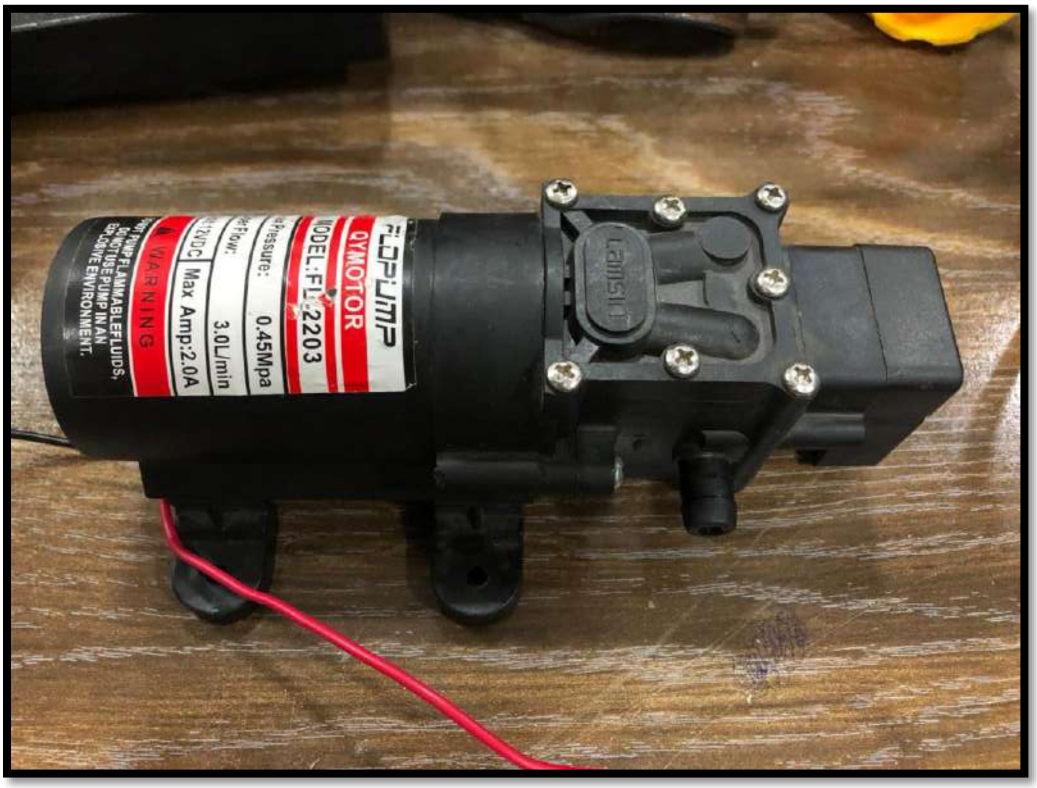

Figure 3.4: Motor

Model No. FL-2203

Max Pressure of this motor is 0.45Mpa and flows 3.0L/min

Operates at DC 12V.

3.1.5 Controller

In our IoT based power saving water management system project, the controller's function is to monitor and control the operation of various components such as motor and solenoid valve, ensuring efficient water and power usage, and managing the system's behaviour.

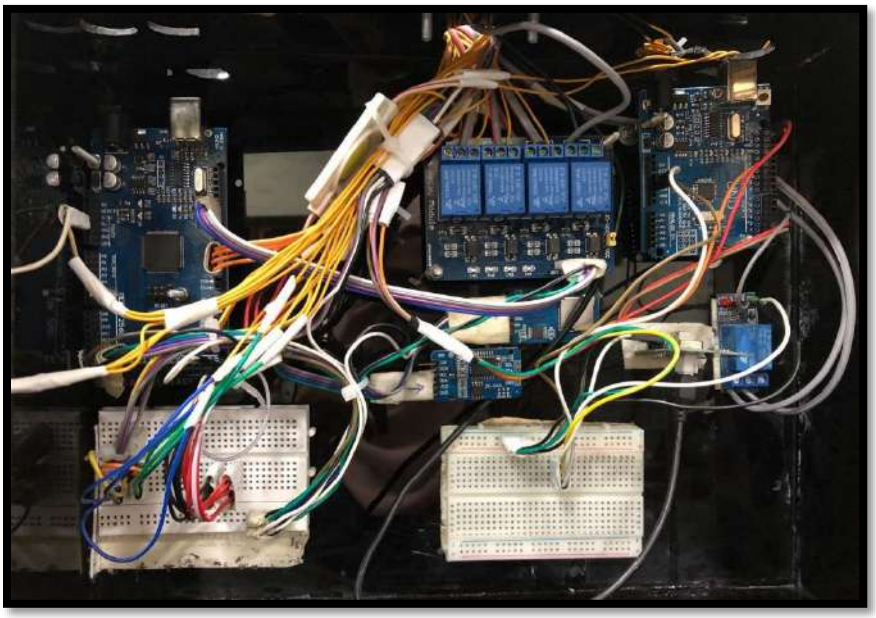

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Figure 3.5: Controller

The controller implemented using a microcontroller (Arduino), plays a crucial role in the following aspects:

Sensor Integration:

The controller interface with sensors such as the water level sensor and water flow sensor. It reads the data from the sensor to determine the current water level in the overhead tank and flow rate of water, which helps in making decisions and performing appropriate actions.

Decision Making:

Based on the data of the sensors, the controller applies predefined logic and decisions-making algorithms to determine the necessary action. It analyses the water level to decide when to activate the motor and analyse the total amount of water pumped to the flat to open or close the solenoid valves.

Motor Control:

The controller controls the operation of the motor that pumps the water to overhead tank. It activates the motor when the water level falls below a certain level, ensuring an adequate supply. Similarly, it deactivates the motor once the desired water level is reached, preventing excessive pumping and energy waste

Valve Control:

The controller controls the opening and closing operation of solenoid valve, which controls the flow of water to each flat. The controller automatically closes the solenoid valve when a flat reaches its allotted 1000 liters of water per day, preventing over consumption of water. If a family needs extra water, the controller can open the valve and keep track of the additional water consumed for billing purposes.

Communication:

The controller establishes communication with the web application and cloud infrastructure to enable remote monitoring and control. The controller receive commands and updates from the web application, while also transmitting data such as water level readings and system status.

Data Processing:

The controller processes the sensor data and performs necessary calculations or conversions, it calculates the flow rate of water at each flat and calculates the total water consumed by each flat. Also, if additional water provided to family the controller calculates the additional amount of water consumed by the family and surplus charges on it.

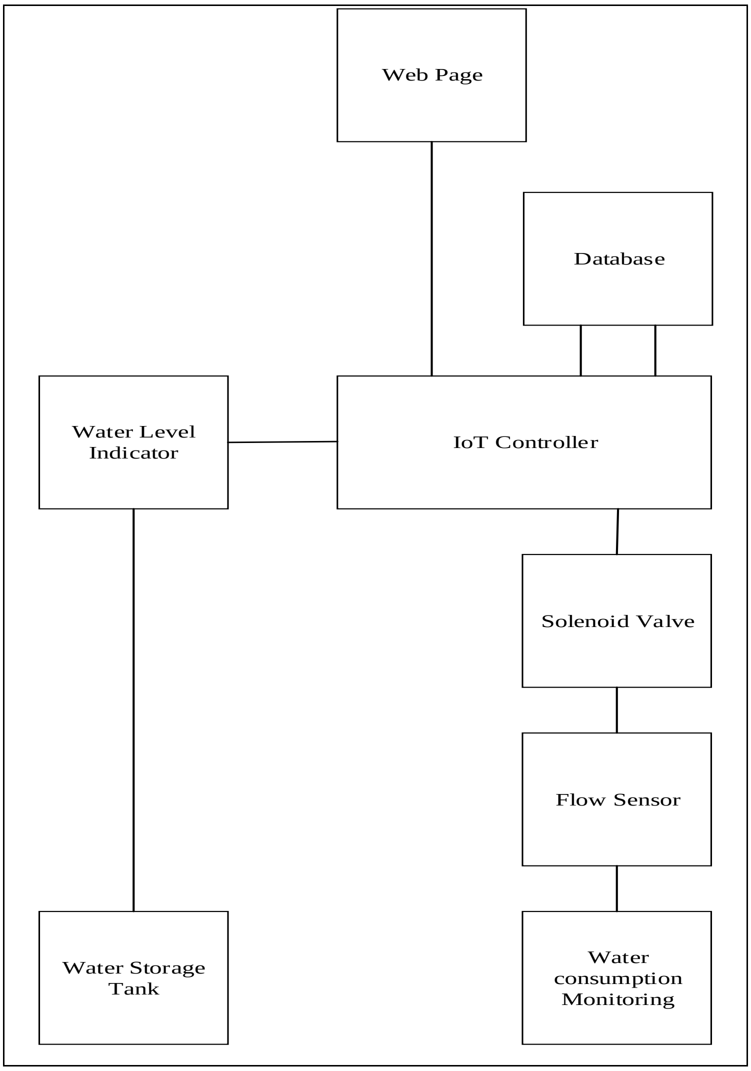

Figure 3.6: Design Implementation Block Diagram

Overall, the controller serves as the central component that controls the operation of sensors, actuators, and communication interface in our IoT based power system water management system. It ensures efficient water distribution, accurate consumption tracking and timely motor and valve control to promote water and energy savings.

3.2 Software

The software part of IoT based power saving water management system involves developing the necessary code and components to enable communication, control and data management. Here are some software aspects to consider:

Web Application:

- A user-friendly web database (ThingSpeak) for residents to monitor their water consumption, set preferences and receive notification.
- Implement user authentication and authorization mechanism to ensure secure access to the system via Firebase.
- Enable real-time data visualization, displaying water level in the overhead tank, daily usage of water and additional charges for extra water consumption.

Backend Development:

- Design the backend system responsible for receiving data from sensors, processing it, and controlling the motor and solenoid valves.
- Implement algorithms and logic to determine when to activate and deactivate the operation of motor and close the solenoid valve based on the water level in the overhead tank and daily consumption limits.

Data Management:

- Set up a database to store the historical data, including water consumption, user preferences, authorizations, authentications and system configurations.
- Implement data storage and analysis functionalities to generate insights on water usage patterns and trends.
- Ensure data integrity and implement backup and recovery mechanisms to prevent data loss.

IoT Device Integration:

- Establishment of communication protocol between the microcontroller and the backend system via ESP8266.
- Define message formats and payload structure for transmitting sensor data, control commands and system status updates.
- Implement data parsing and handling routines on the microcontroller to transmit and receive data from the backend.

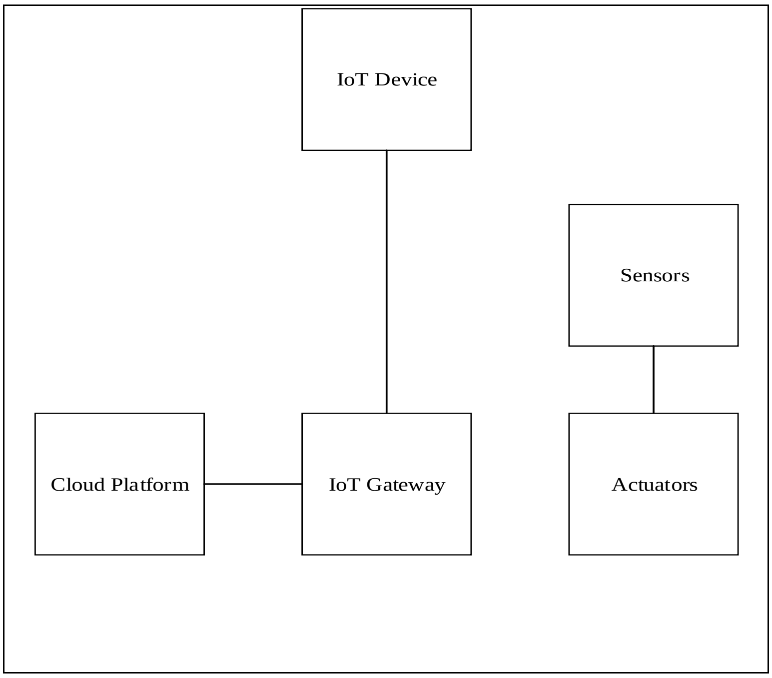

Figure 3.7: IoT Block Diagram

3.3 Calculations

To calculate the cost of electricity for a motor, we have to know the power rating of the motor and the duration for which it operates:

Energy consumption (kWh) = Power Rating (kW) × Operating Time (hr) (3.1)

Cost of electricity in a month excluding any additional charges or taxes that may be applicable to electricity bills:

Cost of Electricity (Rs) = Energy Consumption (kWh) × Unit Rate × 30 (3.2)

1 unit = 1 kWh (3.3)

Example 1

A building of 70 flats, and height of the building is 49 meters. The motor that pumps the water to overhead tank, is of 25hp operates for 2.5 hours per day, considering that the commercial rate of electricity per unit is 60 Rs.

To demonstrate the total liters of water pumping to the overhead tank per day, we can calculate it from following equation:

$$P\ in\ hp = \frac{Q \times H \times \rho}{75\ \times \eta} \tag{3.4}$$

Where:

P = power, (hp).

Q = flow rate, (L/sec).

H = Total developed head, (m).

ρ = density, (kg/dm^3).

η = Efficiency

Density of water (ρ) = 1 kg/dm^3

Assume the efficiency of motor (η) = 1.

First we will calculate flow rate (Q) from following equation:

$$Q = \frac{\text{P in hp} \times 75}{\text{H} \times \rho} \tag{3.5}$$

Q = $\frac{25hp \times 75}{49}$

Q = 38.265 L/sec

To convert it in L/hr:

Q = 38.265 × 3600

Q = 137755.102 L/hr

To know the total amount of water in liters following to the overheard tank daily, we will multiply the flow rate with total working hours of motor in a day:

T = Q × 2.5

Where:

T = Total amount of water flowing in the overhead tank in a day, (L)

T = 137755.102 × 2.5

T = 344387.755 L

In this building we have 70 flats, if we divide total amount of water (T) with 70, we can approximate the average use of water of a flat in a day:

344387.755 / 70 = 4919.8 L

If we allot each flat 1000 L of water per day, which is average family consumption of water, we can reduce the operating time of motor, from which we can save the power and water as well.

To calculate the effect in electricity cost between if we operate the motor of 25hp for 2.5 hour and if we operate it for an hour. First, we have to calculate the cost of electricity for a motor running for 2.5 hours in a month, then calculate the cost of electricity for a motor running for an hour in a month, and then measure the difference between them. Using formula (3.1) and (3.2):

First, we have to calculate the Energy consumption of motor using equation (3.1):

$E = P \times t$

Where:

E = Energy Consumption, (kWh).

P = Power Rating, (kW).

t = Operating time, (hour)

Convert the power rating of motor from hp to kW:

1hp = 0.7457 Kw.

25hp × 0.7457 = 18.6425 kW

$E = 18.6425 \times 2.5$

$E = 46.606$ kWh

Now, to calculate the cost of electricity in a month, we use equation (3.2):

$C = E \times \text{unit rate} \times 30$

Where:

C = Cost of Electricity, (Rs).

E = Energy consumption, (kWh).

$C = 46.606 \times 60 \times 30$

$C = 83890.8$ Rs

If we run the motor for an hour, the cost of electricity will reduce to:

E = 18.6425 × 1

E = 18.6425 kWh

C = 18.6425 × 60 × 30

C = 33556.5 Rs

Difference between the cost of electricity is

83890.8 - 33556.5 = 50.333.8 Rs

Number of electricity units that we can save:

46.606 - 18.6425 = 27.9635 units per day

For a month, we can save:

27.9635 × 30 = 838.905 units

We can save 838.905 of electricity units per month if we reduce the running time of motor, and this is possible by allotting the specific amount of water to each flat that average family can consume, and by exceeding the allotted limit the family will be responsible for their usage and will be charged for extra water consumption.

By implementing the features such as efficient motor operation, optimal water distribution, automatic valve control and user awareness and accountability, the IoT based power saving water management system helps conserve both water and energy resources, promoting sustainability and reducing wastage in residential settings.

Example 2

A 15hp of motor in a building working for 4 hours in a day to fulfil the building residents demand. Managing the water distribution system by allotting each family limited amount of water reduces the operating time of motor to 2.5 hours. Calculate how much in can conserve power and cost of electricity in a month if we manages the water distribution system.

First, we have to calculate the Energy consumption of motor using equation (3.1):

When motor runs for 4 hours:

$E = P \times t$

Where:

E = Energy Consumption, (kWh).

P = Power Rating, (kW).

t = Operating time, (hour)

Convert the power rating of motor from hp to kW:

1hp = 0.7457 Kw.

15hp × 0.7457 = 11.1855kW

$E = 11.1855 \times 4$

$E = 44.474$ kWh

Now, to calculate the cost of electricity in a month, we use equation (3.2):

$C = E \times \text{unit rate} \times 30$

Where:

C = Cost of Electricity, (Rs).

E = Energy consumption, (kWh).

$C = 44.474 \times 60 \times 30$

C = 80053.2 Rs

If we run the motor for 2.5 hours, the cost of electricity will reduce to:

E = 11.1855 × 2.5

E = 27.96 kWh

C = 11.1855 × 60 × 30

C = 20133.9 Rs

Difference between the costs of electricity is:

80053.2 - 20133.9 = 59.919.3 Rs

Number of electricity units that we can save:

44.474 – 27.96 = 16.514 units per day

For a month, we can save:

16.514 × 30 = 495.905 units

CHAPTER 4

RESULTS AND DISCUSSIONS

The IoT based power saving water management system aims to efficiently manage water consumption in flats by implementing automated control system using water level sensor, water flow sensors and solenoid valves. This system ensures that each flat receives equal amount of water which will be allotted by the admin, the valves will automatically shut off once the limit is reached and if any family requires extra water, it can be provided with additional charges on it. Additionally, this system controls the operation of motor by turning it off once the tank is full and will turn the motor on when water reached below a certain level. The system is controlled through a web application allowing residents to monitor their water usage and send request for additional water if they needed.

4.1 Results

Water Consumption Monitoring

The data collected by flow sensors and water level indicators enables real-time monitoring of water consumption in each flat. With the system's IoT based application, residents can easily monitor their daily water consumption through the web application, providing residents with insight into their daily usage of water. This transparency promotes awareness and encourages resident responsible water consumption practice by reducing water wastage and conserving energy.

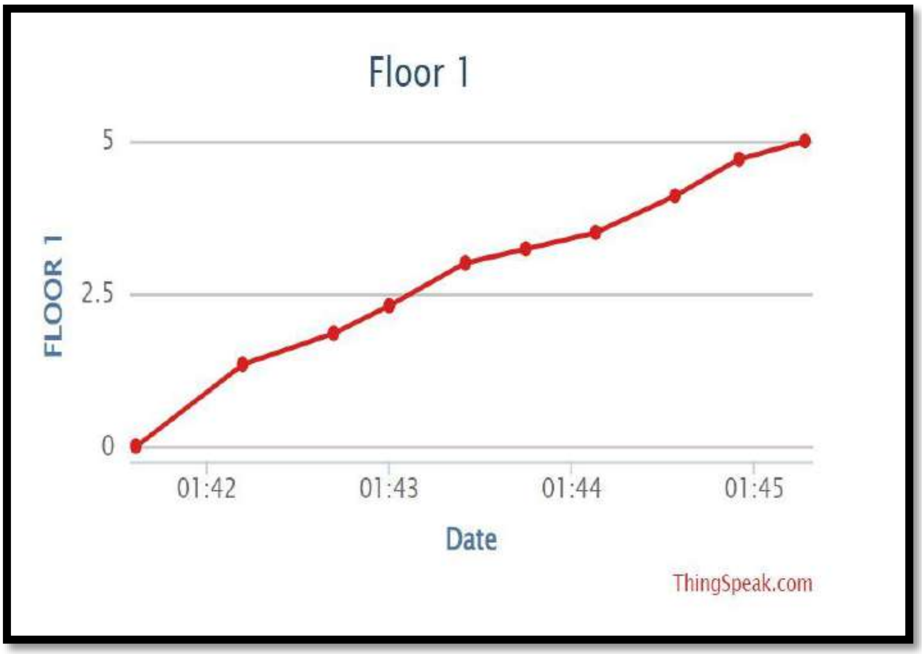

Figure 4.1(a): Floor 1 Data Web Chart

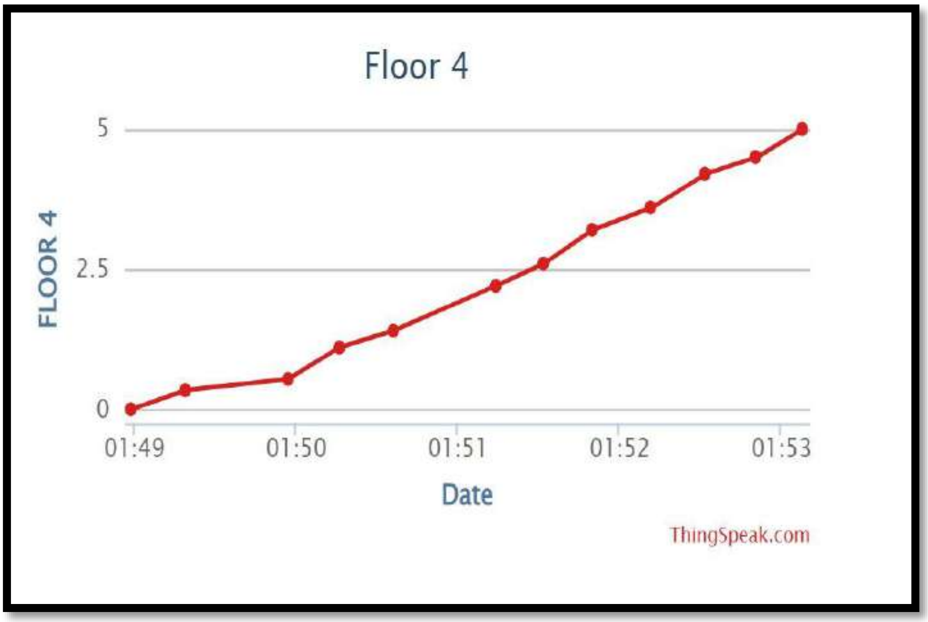

Figure 4.1(b): Floor 4 Data Web Chart

Automatic Motor Control

The IoT based power saving water management system has ability to automatic control the motor operation based on the level of water, which will significantly reduce unnecessary water and energy consumption. The system prevents the motor from running for extended periods or when water is not required by activating the motor operation only when water reaches below a certain level, and will automatically deactivate when the tank is full. This prevents the overflow of water and unnecessary operation of motor, contributing to a greener and more sustainable approach of water management.

Water Limit Enforcement

The system promotes efficient water usage by setting a daily limit of water for each flat per day, once the limit is reached the solenoid valve will automatically close preventing further water flow. This feature encourages residents to be conscientious of their water consumption and find ways it maximize their usage within the given limit. Also, it helps in reducing water wastage due to either over consumption of water or over flow of water.

Additional Water Provision

The IoT based power saving water management system provides the flexibility to provide additional water to residents who require it beyond the predetermined limit. Also, this feature encourages responsible consumption of water and discourages excessive water usage by charging for additional water usage. The implementation of this billing system can also generate revenue to cover the costs associated with providing additional water.

4.2 Discussion

Power Saving

The automated motor control function in this project contributes to energy saving by reducing runtime of motor and minimizing unnecessary power consumption. This function aligns with sustainable practises and helps reduce the carbon footprint associated with water management system in flat. The system optimizes power usage by leveraging IoT based technology resulting in cost saving for residents and a more environmentally friendly solution.

The IoT based power saving water management system can contribute to power savings in several ways:

1. Efficient Motor Operation: By using water level indicator that will sense the level of water in overhead tank and sends the signals to controller. This feature will automate the operation of motor, the system ensures that the motor only operates when the water level reaches below a certain level and will stop operate when the overhead tank is full. This prevents unnecessary and prolonged motor operation, resulting in energy saving.

2. Optimal Water Distribution: By allotting a fixed amount of water (1000 L/day) to each flat, the system promotes efficient water distribution and consumption. Users become aware of their daily usage of water and are encouraged to manage their water consumption within the allotted limit. This reduces the water wastage, in turn, minimizes the operating time of motor, leading to power savings.

3. Automatic Valve Control: The system’s automatic valve control feature plays a vital role in preventing excess water usage. Once a flat reaches its allotted daily limit of water, the solenoid valve automatically closes, stopping the supply of water reducing the chances of accidental overconsumption and optimizing energy usage.

4. User Awareness and Accountability: The web application interface allows users to monitor their daily water consumption in real-time. The system encourages users to be more mindful of their water consumption habit by providing information about their usage and any additional charges for exceeding the daily limit. This awareness can lead to more responsible water usage and contribute to energy conservation.

By combining these features, the IoT based power saving water management system helps conserve both power and water resources, promoting sustainability and reducing wastage in residential settings.

Water Conservation and Efficiency

The IoT based power saving water management system plays a crucial role in conserving water by ensuring that each flat is receiving their daily allotted quota of water and discourages the wastage of water. The residents become aware of their usage patterns and are encouraged to adopt water-saving habits by setting a daily limited amount of water and providing daily consumption data. The system's transparency and control empower individuals to actively participate in conserving resources.

Revenue Generation

The provision of additional water beyond the daily limit with charges per liter gives us an opportunity to generate revenue. This revenue can be used to maintain and enhance the water management system to ensure it continued efficiency and effectiveness. This system encourages residents to limit their water usage to the allocated amount reducing the wastage of water and the strain on water resources promoting the responsible consumption.

Scalability and Future Enhancement

The IoT based nature of the system allows for scalability to support larger residential complexes or additional features. For example, integration with weather data or smart irrigation systems can optimize water usage based on external factor. Further improvement could include real-time alerts for leak detection or predictive analytics to identify the usage pattern of water and suggest conservation measures.

The IoT based power saving water management system provides an effective solution for controlling and monitoring water consumption is flats. The system promotes water conservation, minimize power consumption and encourages responsible usage among residents by implementing automation, web based control and billing mechanism. With its scalability and potential for future enhancements, this system holds great promise for creating sustainable power saving water management practices in residential complexes.

The implementation of IoT based power saving water management system can successfully bring significant benefits which include water conservation by supplying limited amount of water allotted to each flat, reduces electric and water bills by allocate a fixed amount of water so residents will be more conscious of their water usage and reduce the running time of motor that it will turn off once the tank is full, efficient water management by automatic operation of motor and easily monitor their daily water usage, additional revenue by charging for additional water and have positive impact on environment by reducing water wastage and conserving energy.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

The IoT based power saving water management system developed for flats offers an effective solution for water and energy conservation and efficient usage of natural resources. The motor will operate automatically when water reaches below a certain level and will stop operate when the tank is full by implementing the water level indicator, and prevent excessive usage of water and energy and reduce wastage of water by implementing water flow sensor and solenoid valve. The allocation of specific amount of water for each flat helps in setting a reasonable limit for consumption and encourages water conservation among the residents.

The implementation of IoT technology allows monitoring and control of water management system through a web application. This enables residents to have a real-time data of their daily water usage and helps them make informed decisions about their daily consumption of water. Additionally, this system has ability to provide extra water beyond their allocated limit with charges on it per liter ensures that families who require additional water can access it while maintaining fairness in resource distribution.

This IoT based power saving water management system can effectively manage water and power consumption in flats and reduce wastage of natural resources and energy. The automatic motor and valve operation ensure that the water and power is used efficiently and not wasted. Assigning the daily limit of water to each family especially who lives in flats encourages people to use water wisely and not exceed their daily allotted limit as they will be charged on extra water consumption. Providing extra water with some charges per liter can help recover the cost of additional motor running and also discourages excessive water usage. The web-based application of the system is user-friendly and convenient where residents can monitor their daily usage of water and request for additional water if they needed.

5.2 Recommendation

The IoT based water management system can be improved by incorporating features like real-time water level monitoring in lower tank and leak detection to ensure efficient water usage and avoid wastage. This system can be scaled up to implement it in larger communities like apartments, housing complexes and office building. The system can be made more cost-effective by using solar-powered motors and valves to reduce electricity consumption. Also, can be integrated with rainwater harvesting systems to ensure a sustainable water supply. Regular maintenance and cleaning of the components are necessary to ensure it smooth functioning and longevity. In conclusion, the IoT based power saving water management system is a promising solution.

The IoT based power saving water management system has potential to bring several benefits and promote efficient water and power usage. To enhance the system here are some recommendations:

1. Scaling Up: The project can be scaled up to cover the larger communities like apartments, housing complexes and office building. The system can be customized to meet the water needs of different types of households.

2. Integration with Smart Home System: The Smart water management system can integrate with smart home system to enable more comprehensive control over water usage. For example, users could receive notifications when they leave taps running or control water-related appliances remotely to minimize wastage.

3. Leakage Detection: By integrating leakage detection sensors or algorithms into the system we can identify and notify users about any leaks or abnormal water flow. Quick detection and repair of leaks can prevent water waste and minimize the load on the motor.

4. Water Quality Monitoring: consider implementing water quality sensors to ensure the supplied water meets the required standards. This enables early detection of any water quality issues and prompts necessary actions, such as filtration or treatment, to ensure safe usage.

5. Energy Efficiency Consideration: Explore energy-efficient motor options, such as using variable speed drives or energy-saving pumps. Additionally, consider renewable energy sources like solar power system for powering the system, this reduces the environmental impact.

By implementing these recommendations, the IoT based power saving water management system can effectively conserve water, optimize power usage, promote sustainability and provide a user friendly experience for residents.

REFERENCES

Journal Papers:

[1] Liu, Xiaojun, et al. "Impact of different policy instruments on diffusing energy consumption monitoring technology in public buildings: evidence from Xi’an, China." *Journal of Cleaner Production* 251 (2020): 119693.

[2] Garg, Disha, and Mansaf Alam. "Deep learning and IoT for agricultural applications." *Internet of Things (IoT) Concepts and Applications* (2020): 273-284.

APPENDICES

APPENDIX A: Arduino Sketch

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <SPI.h>
#include <EEPROM.h>
#include <RTClib.h>
#include <SD.h>
#include <SoftwareSerial.h>
#define RX 12 // TX of esp8266 in connected with Arduino pin 2
#define TX 13 // RX of esp8266 in connected with Arduino pin 3
String WIFI_SSID = "Dreleaqua";// WIFI NAME
String WIFI_PASS = "dreleaqua"; // WIFI PASSWORD
String API = "JT8JL40DU5LOZYH9";// Write API KEY
String HOST = "api.thingspeak.com";
String PORT = "80";
int countTrueCommand;
int countTimeCommand;
boolean found = false;
SoftwareSerial esp8266(RX,TX);


LiquidCrystal_I2C lcd1(0x27, 20, 4);  // Set the LCD I2C address
and size
```

```
LiquidCrystal_I2C lcd2(0x26, 20, 4);  // Set the LCD I2C address and size
LiquidCrystal_I2C lcd3(0x25, 20, 4);  // Set the LCD I2C address and size
LiquidCrystal_I2C lcd4(0x23, 20, 4);  // Set the LCD I2C address and size

const int flowPin1 = 2;   // YF-B5 flow sensor connected to digital pin 2
const int flowPin2 = 3;   // YF-B5 flow sensor connected to digital pin 3


int relayPins1 = 8;
int relayPins2 = 9;

const int chipSelect = 53;  // SD card CS pin
unsigned int flowFactor = 5;   // Adjust this based on your calibration

volatile unsigned long previousMillis1 = 0;  // Previous time for volume calculation
volatile unsigned long previousMillis2 = 0;  // Previous time for volume calculation

volatile unsigned long totalMillis1 = 0;  // Total elapsed time
volatile unsigned long totalMillis2 = 0;  // Total elapsed time

volatile double totalFlow1 = 0.0;  // Total flow count
volatile double totalFlow2 = 0.0;  // Total flow count

volatile unsigned int PulseCount1 = 0;  // Flow pulse count
```

```
volatile unsigned int PulseCount2 = 0;  // Flow pulse count

volatile float extrawater1 = 0;
volatile float extrawater2 = 0;

volatile float charges1 = 0;
volatile float charges2 = 0;

const char floor1Name = "Floor 1"; //for filename of floor 1
const char floor2Name = "Floor 4"; //for filename of floor 4

RTC_DS3231 rtc;  // RTC object

void sendCommand(String command, int maxTime, char
readReplay[]);

void setup()
{

  Serial.begin(9600);
  esp8266.begin(9600);
  sendCommand("AT",5,"OK");
  sendCommand("AT+CWMODE=1",5,"OK");

sendCommand("AT+CWJAP=\""+WIFI_SSID+"\",\""+WIFI_PASS+"\"",20,
"OK");


  // Initialize SD card
  if (SD.begin(chipSelect)) {
  Serial.println("SD card initialized successfully!");
} else {
```

```
  Serial.println("SD card initialization failed!");
  while (1);
}

  // Initialize RTC
  if (rtc.begin())
   {
  Serial.println("RTC initialized successfully!");
}
  else
{
  Serial.println("RTC initialization failed!");
  while (1);
}
  //RTC to be set
  rtc.adjust(DateTime(F(DATE), F(TIME)));


  lcd1.begin(20, 4);  // Initialize the LCD
  lcd1.backlight();  // Turn on the backlight
  lcd1.setCursor(0, 1);
  lcd1.print("Final Year Project");
  lcd1.setCursor(0, 3);
  lcd1.print("    Floor 4");

  lcd2.begin(20, 4);  // Initialize the LCD
  lcd2.backlight();  // Turn on the backlight
  lcd2.setCursor(0, 1);
  lcd2.print("Final Year Project");
  lcd2.setCursor(0, 3);
  lcd2.print("    Floor 1");
```

```
  lcd3.begin(20, 4);  // Initialize the LCD
  lcd3.backlight();  // Turn on the backlight
  lcd3.setCursor(0, 1);
  lcd3.print("Final Year Project");
  lcd3.setCursor(0, 3);
  lcd3.print("    FLOOR 4");

  lcd4.begin(20, 4);  // Initialize the LCD
  lcd4.backlight();  // Turn on the backlight
  lcd4.setCursor(0, 1);
  lcd4.print("Final Year Project");
  lcd4.setCursor(0, 3);
  lcd4.print("    Floor 1");



  pinMode(flowPin1, INPUT);
  pinMode(flowPin2, INPUT);

  pinMode(relayPins1, OUTPUT);
  pinMode(relayPins2, OUTPUT);



  attachInterrupt(digitalPinToInterrupt(flowPin1), pulseCount1,
FALLING);
  attachInterrupt(digitalPinToInterrupt(flowPin2), pulseCount2,
FALLING);



  EEPROM.get(0, totalFlow1); // Get totalFlow from EEPROM
  EEPROM.get(1, totalFlow2); // Get totalFlow from EEPROM

}
```

```
void loop()
{

int Floor1 = totalFlow1;
int Floor4 = totalFlow2;

 String                                             getData="GET
/update?api_key="+API+"&field1="+Floor1+"&field2="+Floor4 ;
 sendCommand("AT+CIPMUX=1",5,"OK");
 sendCommand("AT+CIPSTART=0,\"TCP\",\""+HOST+"\","+
PORT,15,"OK");
 sendCommand("AT+CIPSEND=0,"
+String(getData.length()+4),4,">");
 esp8266.println(getData);
 delay(1000);
 countTrueCommand++;
 sendCommand("AT+CIPCLOSE=0",5,"OK");

                       //FLOOR 1
  unsigned long currentMillis1 = millis();
  unsigned    long    elapsedMillis1    =    currentMillis1    -
previousMillis1;
  previousMillis1 = currentMillis1;

  // Calculate flow rate
  float flowRate1 = (1000.0 / elapsedMillis1) * PulseCount1 /
flowFactor;  // Flow rate in L/min

  // Calculate total flow
  totalMillis1 += elapsedMillis1;
  totalFlow1   += (flowRate1 / 60.0) * (elapsedMillis1 / 1000.0);
```

```
// Reset pulse count
PulseCount1 = 0;

// Display flow rate and total flow on the LCD
lcd1.clear();
lcd1.setCursor(0, 0);
lcd1.print("   Floor 1");
lcd1.setCursor(0, 1);
lcd1.print("FLOWRATE =");
lcd1.print(flowRate1, 2);
lcd1.print("L/min");
lcd1.setCursor(0, 2);
lcd1.print("TOTAL=");
lcd1.print(totalFlow1, 2);
lcd1.print(" L");

// Store totalFlow in EEPROM
EEPROM.put(0, totalFlow1);

//relay operation for automatic closing of solenoid valve
 if (totalFlow1 > 5.0)
  {
    digitalWrite(relayPins1, LOW);  // Turn OFF the relay
  }
  else
  {
    digitalWrite(relayPins1, HIGH);  // Turn ON the relay
  }

                              //FLOOR 2
```

```
  unsigned long currentMillis2 = millis();
  unsigned    long    elapsedMillis2    =    currentMillis2    -
previousMillis2;
  previousMillis2 = currentMillis2;

  // Calculate flow rate in L/min
  float flowRate2 = (1000.0 / elapsedMillis2) * PulseCount2 /
flowFactor;

  // Calculate total flow
  totalMillis2 += elapsedMillis2;
  totalFlow2   += (flowRate2 / 60.0) * (elapsedMillis2 / 1000.0);

  // Reset pulse count
  PulseCount2 = 0;

  // Display flow rate and total flow on the LCD
  lcd2.clear();
  lcd2.setCursor(0, 0);
  lcd2.print("    Floor 4");
  lcd2.setCursor(0, 1);
  lcd2.print("FLOWRATE =");
  lcd2.print(flowRate2, 2);
  lcd2.print("L/min");
  lcd2.setCursor(0, 2);
  lcd2.print("TOTAL=");
  lcd2.print(totalFlow2, 2);
  lcd2.print(" L");

  // Store totalFlow in EEPROM
  EEPROM.put(1, totalFlow2);
```

```
  //relay operation for automatic closing of solenoid valve
   if (totalFlow2 > 5.0)
    {
      digitalWrite(relayPins2, LOW);  // Turn off the relay
    }
    else
    {
      digitalWrite(relayPins2, HIGH);  // Turn on the relay
    }

  //when relay is opened again on request than surplus amount
of water and it charges
  extrawater1 = totalFlow1 - 3.0 ;
  charges1  = extrawater1 * 5.0;
  lcd3.clear();
  lcd3.setCursor(0, 0);
  lcd3.print("   Floor 1");
  lcd3.setCursor(0, 1);
  lcd3.print("Extra water=");
  lcd3.print(extrawater1, 2);
  lcd3.print(" L");
  lcd3.setCursor(0, 2);
  lcd3.print("Charges=");
  lcd3.print(charges1, 2);
  lcd3.print(" Rs");

  //when relay is opened again on request than surplus amount
of water and it charges
  extrawater2 = totalFlow2 - 3.0;
  charges2  = extrawater2 * 5.0 ;

  lcd4.clear();
```

```
  lcd4.setCursor(0, 0);
  lcd4.print("   Floor 4");
  lcd4.setCursor(0, 1);
  lcd4.print("Extra water=");
  lcd4.print(extrawater2, 2);
  lcd4.print(" L");
  lcd4.setCursor(0, 2);
  lcd4.print("Charges=");
  lcd4.print(charges2, 2);
  lcd4.print(" Rs");

  //log data for floors
  logData1(floor1Name, totalFlow1);
  logData2(floor2Name, totalFlow2);

  delay(1000);  // Update once per second
}

void pulseCount1()
{
  PulseCount1++; // Increment flow pulse count for Floor 1
}

void pulseCount2()
 {
  PulseCount2++; // Increment flow pulse count for Floor 2
}

void sendCommand(String command, int maxTime, char readReplay[])
//commands for esp8266 connectivity.
{
  Serial.print(countTrueCommand);
```

```
  Serial.print(". at command => ");
  Serial.print(command);
  Serial.print(" ");
  while(countTimeCommand < (maxTime*1))
  {
    esp8266.println(command); //at+cipsend
    if(esp8266.find(readReplay)) //ok
    {
      found = true;
      break;
    }
    countTimeCommand++;
  }
  if(found == true)
  {
    Serial.println("OK");
    countTrueCommand++;
    countTimeCommand = 0;
  }
  if(found == false)
  {
    Serial.println("Fail");
    countTrueCommand = 0;
    countTimeCommand = 0;
  }
  found = false;
 }

 void logData1(const char* floor1Name, float totalFlow1) //data
logging for floor1
  {
  // Create the file name based on the floor name
```

```
  String fileName = String(floor1Name) + ".txt";

  // Open the file in append mode
  File dataFile = SD.open(fileName, FILE_WRITE);

  if (dataFile)
  {
    DateTime now = rtc.now();

    // Write the timestamp and totalFlow to the file
    dataFile.print(now.day(), DEC);
    dataFile.print('/');
    dataFile.print(now.month(), DEC);
    dataFile.print('/');
    dataFile.print(now.year(), DEC);
    dataFile.print(' ');
    dataFile.print(now.hour(), DEC);
    dataFile.print(':');
    dataFile.print(now.minute(), DEC);
    dataFile.print(' ');
    dataFile.println(totalFlow1, 2);

    // Close the file
    dataFile.close();
  }
  else
  {
    Serial.println("Error opening file");
  }}

void logData2(const char* floor2Name, float totalFlow2) //data
logging for floor1
```

```
{
  // Create the file name based on the floor name
  String fileName = String(floor2Name) + ".txt";

  // Open the file in append mode
  File dataFile = SD.open(fileName, FILE_WRITE);

  if (dataFile)
  {
    DateTime now = rtc.now();

    // Write the timestamp and totalFlow to the file
    dataFile.print(now.day(), DEC);
    dataFile.print('/');
    dataFile.print(now.month(), DEC);
    dataFile.print('/');
    dataFile.print(now.year(), DEC);
    dataFile.print(' ');
    dataFile.print(now.hour(), DEC);
    dataFile.print(':');
    dataFile.print(now.minute(), DEC);
    dataFile.print(' ');
    dataFile.println(totalFlow2, 2);

    // Close the file
    dataFile.close();
  }
  else
  {
    Serial.println("Error opening file");
  }
}
```