SMART HOUSE UTILITY METER USING IOT

An Undergraduate CAPSTONE Project

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A CAPSTONE Project submitted to the Faculty of Engineering, American International University - Bangladesh (AIUB) in partial fulfillment of the requirements for the degree of Bachelor of Science in their mentioned respective programs.

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DECLARATION

This is to certify that this research is our original work. No part of this work has been submitted elsewhere partially or fully for the award of any other degree or diploma. Any material reproduced in this research has been properly acknowledged.

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APPROVAL

The CAPSTONE Research titled **IoT BASED SMART MULTIFUNCTIONAL UTILITY METER AND MANAGEMENT SYSTEM** has been submitted to the following respected members of the Board of Examiners of the Faculty of Engineering in partial fulfillment of the requirements for the degree of Bachelor of Science in the respective programs mentioned below on **January 2023** by the following students and has been accepted as satisfactory.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

The rapid increase in the use of smart home technology has resulted in a need for reliable and accurate utility meters. This paper presents an IoT-based Smart Home Utility Meter (SHUM) system that provides real-time monitoring and control of energy usage in a home environment. The SHUM system is composed of an embedded sensing module, a mobile application, and a cloud-based platform. The sensing module is based on a low-power microcontroller unit (MCU) capable of measuring current and voltage, and transmitting data to the cloud platform using Wi-Fi. The mobile application provides users with a graphical interface for monitoring and controlling energy usage, as well as setting up alarms and notifications. The cloud platform provides the ability to store and analyze data, as well as provide remote access for users. The SHUM system has been evaluated for accuracy and reliability in a real-world setting. The results show that the system is capable of providing reliable and accurate energy monitoring and control. The system also provides an energy-efficient solution for smart home owners, as it can be easily integrated into existing home automation systems. This paper presents the design and implementation of the SHUM system as an effective and efficient solution for energy monitoring and control in a home environment. First, it enables consumers to pay their utility bills in one go. This will reduce the time and money spent on paying multiple bills. The main focus of this research is to reduce the burden on the consumers. Second, it makes the process of purchasing and accounting for water, gas, and electricity much simpler and easier. Consumers can now purchase bundles of these utilities and have a unified payment system. Additionally, this system can help in reducing energy consumption. By tracking the usage of electricity, gas, and water, and sending notifications to the consumers, they can be aware of their consumption patterns and be more mindful of how much energy they are using. Finally, this research can be used to create a better and more efficient system for measuring and billing for utilities. The prototype can be further developed to include more features and capabilities, such as real-time monitoring of usage and automated billing.

CHAPTER 1

INTRODUCTION

1.1. Overture

The IoT (Internet of Things) is a network of interconnected sensors, processors, and digital devices that may communicate with one another via the internet to exchange and send data using UIDs, which are supplied to each object unique identifiers [1]. The focus on automating these institutions has changed significantly with the expansion of diverse corporate establishments and societies. Additionally, everyone is looking for an electrical control system that is more trustworthy due to the growing traffic congestion in cities. For increased energy savings and quick resolution, a user-friendly web application and mobile-based monitoring and control system connected to IoT cloud servers were introduced. Electric power quality is the extent to which the frequency, waveform, power, and voltage are validated to establish the criteria. The high-power quality of the system is created by a consistent AC supply voltage that stays within the necessary range. The growing frequency is also close to the frequency's rated value, which is a sine wave or other smooth waveform of the curve [2]. The caliber of the electricity flowing from the source and if the load connected to the outlet is compatible with it. The phrase relates to electrical power and describes how well an electric load can operate. The gas level is monitored using a gas flow sensor. The gas is automatically booked using this notice, which is also done through IoT, when the level surpasses a certain threshold value and is sent to the distributor [3]. Real-time monitoring of water quality and level is often used for water management. Real-time water level monitoring may significantly decrease water loss from tank overflow. The water management system may help in the identification of water leaks in a smart home by monitoring water levels throughout the day. For a more intelligent world, an intelligent water management system is essential. Given the recent development of the IoT for smart cities, the high cost of intelligent water management systems is a major factor in the low adoption of these systems.

1.2. Significance of the Project / Project Work

Smart metering makes greater use of utility data by doing away with traditional, manual analog meter readings. Utility firms may gather, examine, and communicate utility use data more effectively as a result of current metering systems. Smart meters work by promptly and precisely calculating a customer's utility use. This automated technique of consumption information may be seen by both energy users and utility providers. Gas, electric, and water utilities often use smart meters, which enable more accurate meter readings, more accurate utility pricing, and better two-way data interchange between utility providers and customers. One of the most crucial advantages of a utility metering system is the chance to position a utility company as an energy partner rather than merely a service provider. Customers' satisfaction with utility service will be considerably increased if real-time energy consumption data is made available to them in clear forms and helps them change their use patterns to conform to their environmental and cost-saving objectives. Real-time energy use data for each customer is provided through smart meters.

1.3. Engineering Problem Statement

It is essential to have a theoretical grasp of the fundamental components of microcontrollers, electrical systems, and electronics in order to construct this IoT-based entire utility smart metering for homes. While working on this research, there are several competing concerns to consider. Numerous computations in mathematics are required. Here, a comprehensive articulation of several engineering fundamentals is required [11]. To finish the job, specialized engineering skills must be used.

1.4. Objective of this Work

The research 's goal is to plan and construct a system that will control all home bills for gas, electricity, and water consumption. That suggests that in the event of a power outage, trustworthy data may be used to quickly educate customers about what is occurring, what is causing the outage, where it is, and when their utility is predicted to be operational again. The many elements that may affect how the dielectric characteristics change will be thoroughly examined [12].

1.4.1. Primary Objectives

- Creating unique utility metering systems;
- Integrating all utility metering systems on the platform;
- Creating unique utility metering systems;
- Integrating all utility metering systems on the platform;
- Building a server to link users to the IoT system's webpage

1.4.2. Secondary Objectives

- To use a data acquisition system to store the real-time data.
- Creating a portable mobile application for payments and utilities status monitoring.
- Establish a single point of payment for all of their utilities [11].

1.5.Comparison With Traditional Method

- As part of the research , a smart utility meter model and an app for all utility management systems will be unveiled.
- The mechanism is easier to understand.
- A smart utility meter that combines water, gas, and electricity will be available.
- A monthly package will be available, allowing you to pay all of your utility bills at once [12].

1.6. Organization of Book Chapters

The following chapters of this book are structured as follows

Chapter 2 Literature Review and Detailed Analysis

This chapter covers the research 's historical context as well as many associated studies and publications. The research requires the required crucial specialized technical skills. There has been discussion regarding the status of technology today.

Chapter 3 Project Management

This chapter of the book goes into great length on research cost analysis, schedule management, S.W.O.T. analysis, P.E.S.T. analysis, individual accountabilities, interdisciplinary components management, and research lifecycle.

Chapter 4 Methodology and Modeling

This chapter's technique and modeling are its primary goals. The simulation, block diagram, and simulation modeling are the main topics of this chapter. The software and hardware implementation sections of this chapter are separated.

Chapter 5 Implementation of Research

This chapter describes the operation of each component in our research, their significance, and how they function. All of the linkages are briefly covered in this chapter. Software-based creations are also included in this chapter.

Chapter 6 Result Analysis and Critical Design Review

In this chapter, the simulation's results have been examined. This chapter also briefly discusses the hardware implementation and its causes. We have also developed a visual depiction of the Internet of Things' monitoring utilities management system using Thing Speak. The aims of the research are to purchase gas, water, and electricity package deals and pay utility bills from home using an app, it can be inferred from the contents of this chapter. Additionally, users have the option of checking their package balance.

Chapter 7 Conclusion

We have covered the research 's overall conclusions in this chapter. This article has also covered research financing. The goal of the work is to create a utility management system app that will allow users to save time. The prototype incorporates Internet of Things (IoT) technology, enabling us to manage the whole procedure through the app.

CHAPTER 2

LITERATURE REVIEW WITH IN-DEPTH INVESTIGATION

2.1. Introduction

Bangladesh is now a developing nation. Bangladesh has made progress in all areas. A smart all-in-one utility meter and management system is one of them. Prior until recently, each house's electricity, gas, and water meters required separate payments. With the development of the smart all-in-one utility meter, it is no longer necessary to see and pay bills for current gas and water meters individually. Numerous different meters are used in the current measuring system to gather energy, water, and gas for end customers. Every meter monitors the parameter every day, and an LCD screen attached to the meter shows the data. The power of the meter determines the rate at which the screen's data is updated. Data from the measurement system is gathered by looking at the individual meters strewn around. Utility Management Systems (UMS) support the management of all facets of the electricity, gas, and water resources' businesses, from payments to customer service. Resources like electricity, water, and gas are included in this. Electric, gas, water, sewage, and waste management corporations' benefit from utility management systems to manage all element of their business, from invoicing to customer service. For the utilities that your business has chosen, the Utility Management System compiles thorough usage data. Many businesses also submeter using the Utility Management System. Included are significant hotel loads including those for the restaurant, laundry, and refrigerator. It is a multi-story building, and each floor's electric, gas, and water use may result in separate monthly utility bills.

The main objective of the research is to reduce the burden associated with creating a unified utility payment system. Customers will be able to pay for all of their utilities using a single, integrated payment system. A smart meter that is based on the whole utility system will be constructed with the help of certain sensors. They'll link everything together with an app that lets users pay bills and check on utility status at any time. Consumers will find it more convenient. We would need an energy meter, a water flow meter, and a gas meter repeatedly to measure the electricity, water flow rate, and gas volume. Users may make forecasts about their monthly expenses or how many units to buy by consulting the historical data in this manner. By logging in, they may view their daily use and pay their invoices.

2.2. Related Research Works

The study created a meter based on the total utility system, in sum. With the assistance of utility meter providers, commercial electricity, water, and gas meter prototypes were designed, built, and tested utilizing three. There is a load connected to each meter. The use of energy, water, and gas is shown in real-time on the meter LCD. The meter has a distinct network address, and the utility service providers may remotely configure it to scan the three utility consumptions at any desired frequency. Customers will find it simple to pay their bills and understand their financial condition. By creating a prepaid system that allows users to recharge once and access the whole utility, they can make that system better. Consumers' lives will be made simpler by the system [4].

In this research, it is suggested to design, construct, and test an integrated IoT-based smart utility meter that tracks energy, water, and gas usage. The meter has a distinct network address, and the utility service providers may remotely configure it to scan the three utility consumptions at any desired frequency. Users may access the meter via a computer or a mobile device. Google Map markers that show the usage of each utility and whether the meter is attached or removed are used to show the meter's status [5].

This was done in order to increase the present gas meter's metering accuracy. Here, a meme sensor was utilized. A smart electronic metering device that has been tried out and utilized in a number of Internet of Things (IoT) systems is the proposed MEMS-based gas meter. The sensor offers excellent range, accuracy, and sensitivity. Although they built the gas meter to measure energy, the suggested method may also be used in other contexts. Just a few examples include oil, petrochemicals, healthcare, environmental protection, and industrial automation control. Utilities have traditionally utilized or hired traditional meter readers to gather time- and money-consuming data on natural gas use. The burden on customers should be lessened as a result of adopting this meter. By creating the whole utility infrastructure, they may create this meter [6].

In summary, the adoption of this invention's IOT intelligent gas meter and its control system enables the management of a gas supplier's business network through network k and the sharing of user resources over the internet. Since the computer management system can control gas meter data and relay usage data from gas meter terminals to the management system for gathering terminal application data, the gas user no longer needs to pay a bill at a conventional service center. The protective range of this is not limited to the aforementioned apps, and each of them is a premium application with universal protection [7].

A study titled "IOT based Electrical Device Surveillance and Control System" was published by a group of students from the University School of Information, Communication, and Technology (USICT). An

IOT-based surveillance and control system for electrical devices is covered in this article. Since lighting appliances consume a significant amount of energy, increasing efficiency and swiftly identifying errors are crucial tasks. Two different model strategies are used in this research, depending on the kind of application. When all appliances are connected to a single Wi-Fi network, IEEE 802.11 wireless technology is used in restricted areas or small spaces. In the second model, when the number of appliances grows only in one direction, like a streetlight pole, wired design is used to eliminate range difficulties. The only purpose of this Internet of Things (IoT)-based device surveillance and control system is to monitor the condition of electrical equipment and manage its on/off functionality from a central location. The system is designed to provide effective interior and outdoor lighting. By providing central management over the appliances, it both significantly reduces the amount of electricity used and improves system efficiency by sending out a warning signal in the case of a failure. The user is given a user-friendly and easily accessible platform through the graphical App-based mobile controlling platform. This technology might be developed into a self-operating, energy-efficient streetlight control system. The main objectives of the study are to monitor and correct power quality factors in order to achieve excellent power quality. To safeguard electric appliances, this research continuously checks voltage lead, voltage lag, and voltage interruption while enhancing power quality. In our research, an ARDUINO microcontroller continuously monitors the properties of the power line and activates the appropriate compensation circuits to guarantee good power quality. Additionally, a platform for the Internet of Things [IoT] is used to monitor the research. From any location on the earth, the user may now assess the power quality. According to the current lag's voltage and current leads' voltage situations, the research adds an auxiliary capacitor load and an inductive load to perform automatic power factor adjustment. The load is automatically segregated when there is a frequent or extended power loss. In the case of a power loss, backup power is employed. A specific URL and an Internet of Things platform are used to monitor the power factor [8].

This study presents an automated remote meter reading system based on GSM. This paper may be used to get readings as needed, saving meter readers from having to visit every customer to gather consumption statistics and hand out bill slips. The meter values may be monitored and recorded using a microcontroller. There is no need to dispatch a utility worker to shut off the client connection in the event of a defaulting customer. With a brief message, the utility may disconnect and restore the consumer connection. Service (SMS), Additionally, a consumer may request a simple SMS to verify the status of their usage. In this system, GSM is used to send energy meter values. Despite the fact that water is often the cheapest utility commodity and service in the nation [9].

The YF-S201 water flow sensor makes it simple to build a water management system. The monitoring and control mechanism used in the prototype implementation allows internet-based data collecting and employs CoAP. The system tackles new issues in the water industry, such as the requirement for simple billing and a study of water supply vs use to raise awareness of water waste and promote conservation. A pinwheel sensor that is placed within the waterline is used to measure the volume of water transported. The ATmega1280 microcontroller was used in the construction of the Arduino development board. The microcontroller employs the SPI synchronous serial data protocol to interface with peripheral devices. The Hall Effect flow meter is used; it features a rotor fashioned like a little fan or propeller that is placed in the flow of the liquid. The flow of water pushing the rotor's fans causes it to rotate as it rushes through the flow sensor. The rotor's shaft is connected to the Hall Effect sensor. The serial window of the Arduino displays the water flow values as the water passes through the sensor connected to a digital pin, and the data are also transferred to the cloud using ThingSpeak. An open data platform is offered by Thing Speak. Sensors or boards like Arduino are used to collect the data [10].

2.2.1. Earlier Research

Its current Smart All-in-One Utility Meter and Management System has a distinguished past [14]. In Hunstville, Alabama, Ted Paraskevakos created computerized fire safety, security, and medical alarm systems while he was employed by Boeing. It could scan utility meters as well. A lack of historical context may sometimes result in misconceptions about how things came to be, so let's take a closer look at the winding path that took us here [15]. So In this fashion, Mr. Paraskevakos authorized patents in the US in 1974. Three years later, he established Metretek, Inc., which three years later unveiled the first automated, commercially available remote meter reading and load control system. It has always been necessary to find a mechanism to balance electricity production and consumption. Traditional gas and electric meters assess overall usage but do not reveal when energy is consumed. Smart meters, on the other hand, expand site-specific data, giving customers and providers useful data on energy usage. Although they may not have automated readings, interval and time-of-use meters have traditionally been placed to monitor commercial and industrial users. By the end of 2008, there were 39 million smart meter users in Europe, according to Berg Insight [16]. According to Pike Research, the number of smart meters in use globally reached 17.4 million units in the first quarter of 2011. The smallest city in the world will incur costs of $7 billion in 2012, according to Vision Gain. Since January 2018, the European Union has installed more than 99 million energy meters, and an additional 24 million are anticipated by the end of 2020 [17]. According to European Report's DG Energy, the installed base of 266 million smart meters would cost $ 18.8 billion in 2020 and € 40.7 billion in 2030. Globally, 665 million smart meters were created in 2017 [16]. Revenue is anticipated to rise from $12.8 billion in 2017 to $ 20 billion by 2022. Smart meters in the south of England and the Midlands link through a cellular network; thus, they perform poorly where there is limited phone service [17]. The remedy was introduced as of March 2017; however, it hasn't worked. Customers having smart meters placed might expect to save an average of £ 11 a year on their energy expenses, significantly less than what was first anticipated, according to research by a select committee in the United Kingdom. The cost statement from 2016 was going to be analyzed in 2019, and average savings were going to be compared.

Utility meters were subsequently developed, although initially it was designed for fire safety, security, and medical alert systems. He then established a method for managing and reading meters. Build energy, gas, and water meters gradually so that they may be developed in succession. built a smart meter reading gradually to take it all together [19]. Later, the meter was changed to make the smart meter simpler; at first, the smart meter just provided power ratings and alarms. Later, the house's water, gas, and electricity were all managed by a utility management system. There are electricity, water, and gas circuits for determining consumption rates. info from the app meter. One Watt, 0.5 liters of water, and 0.625 liters of gas are produced in one meter's pulse [18]. This research focuses on the design, development, and testing of IoT-based smart device meters. The meter simultaneously measures gas, water, and electricity. The data is subsequently sent to a cloud-based service, where it is continually processed. Customers and service workers may link the meter to the internet for monitoring and management needs.

In Summary, the paper made a meter based on overall utility system. Commercial electricity, water, and gas meters prototypes were conceived, constructed, and tested using three with the help of utility meter suppliers. Each meter has a load attached to it. On the meter LCD, consumption of electricity, water, and gas is presented in real time. The meter has a unique network address and can be remotely programmed to scan the three utility consumptions at any desired frequency that the utility service providers can specify.it will easy for consumers to pay the bill and identify the situation of the expenses. They can improve that system by make a prepaid system where consumers can recharge for once and can use the whole utility. The system will make life easier for consumers [17].

The design, development, and testing of an integrated IoT-based smart utility meter that monitors power, water, and gas use is proposed in this study. The meter has a unique network address and can be remotely programmed to scan the three utility consumptions at any desired frequency that the utility service providers can specify. The meter can be accessed by end users via a computer or a mobile phone. The status of the meter is displayed using Google Map markers, which reflect the consumption of each utility and whether the meter is connected or detached [18].

This have made to improve the metering accuracy of current gas meter. Here they used meme sensor. The suggested MEMS-based gas meter is a smart electronic metering device that has been tested and used in a variety of Internet of Things (IoT) systems. The sensor has a high sensitivity, accuracy, and range ratio. Despite the fact that they designed the gas meter to measure energy, the proposed technique can be applied to other areas as well. Oil, petrochemicals, medical treatment, environmental protection, and industrial automation control are just a few examples. Traditional meter readers have been used or contracted by utilities to collect natural gas usage data, which is costly and time consuming. By using this meter, the burden of consumers should be reduced. They can develop this meter by making the whole utility system [19].

In Summary, the business network of a gas supplier can be managed via network, and user resources may be shared over the internet, thanks to the adoption of this invention's IOT intelligent gas meter and its control system. As a result, the gas user does not need to pay a bill at a regular service center, and the computer management system may regulate gas meter data and feedback use data from gas meter terminals to the management system for acquiring terminal application data. The protective range of this is not restricted to the applications listed above, and all of the applications listed above are premium applications that are not limited to themselves [20].

2.3. Validity and Accuracy of Existing Solution

Thanks to Internet of Things (IoT) technology, data on the use of energy, water, and gas by appliances in residential units can now be gathered more often. However, meters are still unique and are set up in diverse locations across homes or flats. This study proposes the design, development, and testing of an integrated IoT-based smart utility meter that tracks energy, water, and gas usage. The meter has a specific network address, and it may be remotely configured to scan the three utility consumptions at any frequency decided upon by the utility service providers. The integration of three utility meters into one, mobile device access to the proposed meter while showing meter status on a Google Map, and the utility's ability to access the meter to alter the rate during peak demand are, in short, the main contributions of this study.

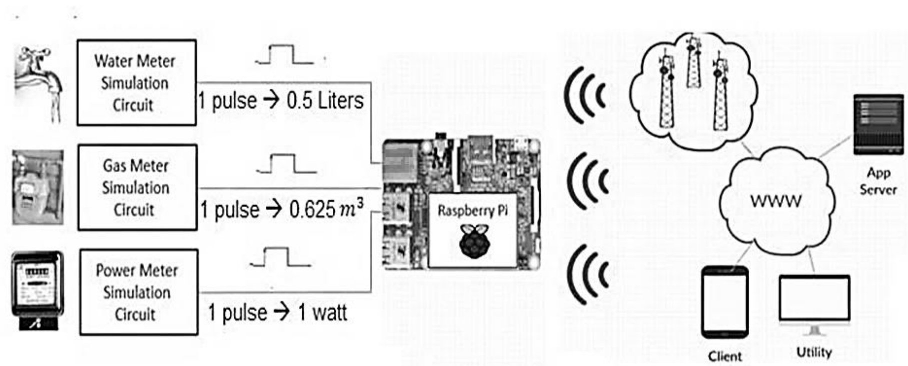


Figure 2.1: Block Diagram of System Hardware Architecture [20].

Figure 2.1 shows that deception by the user or employee might lead to the destruction of the electrical board. In certain locations, cameras are used to collect readings, but the system is sophisticated and not particularly user-friendly. This study suggests a wireless system for smart power meters and billing systems based on the Internet of Things to handle all of these problems (IoT). An automatic relay mechanism is used to turn off or disconnect the energy meter and load from the supply mains when a client doesn't pay his bill within the allotted period. With the help of a buzzer and LEDs, the user's payment of the bill is signaled [21].

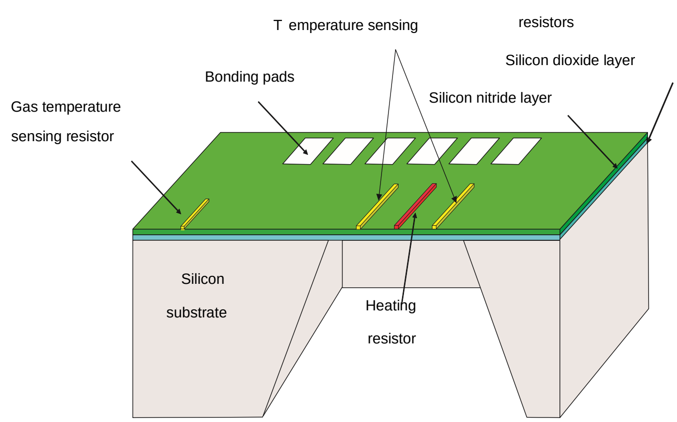


Figure 2.2: Principle and structure of a MEMS thermal flow sensor.

In this Figure 2.2, an Android-based automated water billing (AWB) system was developed. The AWB system is intended to employ a low-cost water flow meter that calculates bills based on each customer's water use by measuring the flow rate of water moving through their supply pipe.

2.4.Wide Range or Conflicting Research Works

The client may control their water consumption in this way without paying extra money. The user is given a deadline to pay the bill; if it is not met, the provider will cut off the water supply. The Andiron Studio-designed Water Bill Management Application (WBM-App) delivers users their invoices and reminders about their payment deadlines.

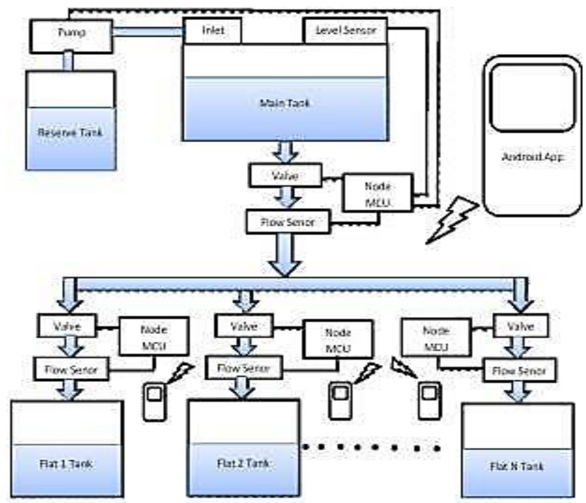


Figure 2.3: Block Diagram of Android-based Automatic Water Billing System [21].

Using the suggested manner, water billing will be accurate and timely. This performs better than earlier systems in terms of cost and manpower. This is a practical method of controlling water costs [20].

In this Figure 2.3, it was shown that various gases had distinctive effects on how a MEMS sensor reads data. They propose a novel method to adjust for the errors introduced by various natural gas types on the sensor's reading based on a thorough analysis of the MEMS thermal gas flow sensor's operating principle. The suggested solution takes into account the relationship between the calorific value and physical properties of natural gases by first measuring the physical property of the gas that is being metered in order to derive the composition correction coefficient, which will then be used to correct the meter's reading errors [19].

Applications for industrial control, energy management, and smart homes have already made use of the suggested technology. Field testing, deployments in the real world, and simulation results all support the accuracy and efficiency of the recommended approach [18].

2.5. Critical Engineering Specialist Knowledge

We were able to develop an app for all home utility management systems as well as an IoT-based smart utility meter. We have separate sensors for gas, water, and electricity. Nodemcu is linked to the sensors. And from the Arduino, NODEMCU will transmit data to the server. Data may be predicted via nodemcu, which also has MATLAB and Excel forecasting capabilities. The website allows us to see all the data. Thankfully, an alarm system exists. So that customers may contribute some money and cover the month, a message will be sent to their phone and a notice will be posted on their website when the balance drops. For this, individuals may foresee their monthly debt and deliberately purchase the bundle. Any hardware board, including Raspberry Pi, Arduino, and others, may be used to create the physical hardware item. Each board has unique benefits and drawbacks, therefore extensive knowledge about those microcontrollers is needed as well as the specific programing language author needs to learn to carry out this research. Although they nearly have the same functional design, they differ in terms of features, price, and processing speed. By introducing these hardware boards, the functionality of internet-connected devices technology has advanced significantly. The support for various technologies as a communication medium is introduced after the development of wireless technology and the benefits of Wi-Fi Networks on automation are discussed. Each of these technologies has its own specifications and operating efficiency. Hence authors should have knowledge about those network implementations.

2.6.Stakeholders From Research Literature

Our key objective is to provide the utility system a solid management system. The lives of our customers will be made considerably simpler as a result. They can effortlessly control their daily spending and keep an eye on their utility condition at all times. They were spared from having to pay for various utilities at various times. Through an app, people may conveniently pay their utility bills from home.

2.7. Summary

A Smart All-in-One Utility Meter and Management System is becoming more and more necessary. The idea, which was subsequently expanded by several studies and the efforts of dreamers, has made it feasible to use smart utility meters and even to control them. With the assistance of utility meter providers, commercial electricity, water, and gas meter prototypes were designed, built, and tested utilizing three. There is a load connected to each meter. The use of energy, water, and gas is shown in real-time on the meter LCD. The meter has a distinct network address, and the utility service providers may remotely configure it to scan the three utility consumptions at any desired frequency. Customers will find it simple to pay their bills and understand their financial condition [21]. By creating a prepaid system that allows users to recharge once and access the whole utility, they can make that system better. Customers' lives will be made simpler by the system. Close real-time monitoring of energy use is possible thanks to smart meters. This enables energy providers to levy various use charges based on the day and season. Real-time information on gas and gas use may be provided via smart meters with a display located outside the living rooms. This enables energy providers to levy various use charges based on the day and season. Additionally, it facilitates the development of precise cash-flow models using his resources. Because smart meters may be read remotely, resources are used more efficiently [21]. Smart meters provide advantages for consumers. In addition, smart display meters outside of houses may give real-time information on gas and electricity usage, helping individuals to better manage their energy use and minimize their debt. Limited credit, which is a significant cause of customer complaints, will no longer be available [20]. This is crucial for achieving the advantages of smart meters in terms of product reduction, since millions of consumers only raise a tiny percentage of the savings benefits. Additionally, smart water meters may provide clients detailed and timely information about their water use as well as early warning of any local water breaches.

CHAPTER 3

PROJECT MANAGEMENT

3.1. Introduction

Bangladesh is a developing country currently. In every industry, Bangladesh has made advancements. An intelligent integrated utility meter and management system are one of them. A few days ago, each house's power, gas, and water meters required separate payments. The smart all-in-one utility meter has made it unnecessary for present gas and water meters to appear and be paid for individually. Electricity, water, and gas are collected for end customers via a variety of meters under the current measurement system. Each meter takes a daily reading of the parameter and shows the information on the LCD screen that is attached to the meter. Reducing the burden of creating a single utility payment system is the research 's main objective. Clients will be able to pay for all of their utilities through a single, integrated system that is being developed. A smart meter built on the foundation of the entire utility system will be made possible with the help of a few sensors. All of this will be connected through an app that allows users to pay bills and keep track of their utility status at any time. Customers' lives will be made simpler by it. We would require a water flow meter, a gas meter, and an energy meter several times to measure the electricity, water flow rate, and gas volume. Users can make predictions about how much they will pay or how many units they will buy by looking at the historical data in this way. They can check-in, view their daily activities, and pay their bills on the internet. This chapter includes several significant subjects. project management is one of them. A project 's success or failure is guaranteed by the project management element. The cost analysis and social demand of a particular project can be determined by some project management techniques. Furthermore, project management guarantees that the specific project is completed on time and by the appropriate timetable. This chapter also includes schedule management, P.E.S.T. analysis, and S.W.O.T. analysis for this project. The entire project cost will also be shown in this chapter. Each project participant will have their level of accountability set. Another crucial matter that will be examined is the management of timetables.

3.2. S.W.O.T. Analysis of the Research

The S.W.O.T analysis is the process to determine the internal strength and the weakness of a research. By the analysis, external opportunities and threats of the project are also determined. The analysis is an internal analysis based on the survey, simulation, and internet acknowledgment.

3.2.1. Strengths

- This research is a combination of water, gas, and electricity, people do not have to go to different places to pay the bill. Bills can be paid through the app and website online.
- This research is echo-friendly so there are no threats to the environment.
- This research is of low cost and the components of this research are less expensive and easy to acquire.
- Track prior uses so that the users can take appropriate action.
- Track their activities remotely.
- Everything in this research is controlled automatically so there is no chance of human error.
- This research is easy to use so users can easily use the website and apps.
- Research accuracy is an important factor. As we used three sensors to collect data and send it to Arduino which ensures a high accuracy level that everything works perfectly.

3.2.2. Weaknesses

- The system might get complex User may find it difficult to comprehend the entire system.
- A 15-second maximum synchronous time limit for data logging to the server.
- Due to WIFI connectivity, two separate microcontrollers are utilized, which could raise the cost.
- The system may experience serial communication issues due to voltage fluctuations, which results in missing data.

3.2.3. Opportunities

Smart utility meter based on the Internet of Things is being utilized all over the world. However, because we are a developing country, education and financing are required to improve smart technology practices. For example, if the government launches an Internet of Things (IoT) based smart all-in-one utility meter and management system, people of our country will be benefitted because people would be able to purchase a combinational package of household utilities and pay the bills online. And if the government helps us, we would develop our app professionally and we would add more banks for the payment. So that, it becomes easier to use.

3.2.4. Threats

1. Data Theft: Hackers can access the personal data stored in the smart utility meters, such as energy consumption patterns and financial information, and use it for malicious purposes.
2. Data Tampering: Hackers can also modify or delete the data stored in the meters, resulting in incorrect billing and unreliable data.
3. Unauthorized Access: Attackers can gain access to the meters without permission, allowing them to control the energy supply without authorization.
4. System Vulnerabilities: Outdated software and firmware can create security vulnerabilities that attackers can exploit, allowing them to gain control of the meters.
5. Denial of Service Attacks: Attackers can send a flood of traffic to the smart utility meters, resulting in a denial of service and preventing legitimate users from accessing the meters.

3.3. Schedule Management

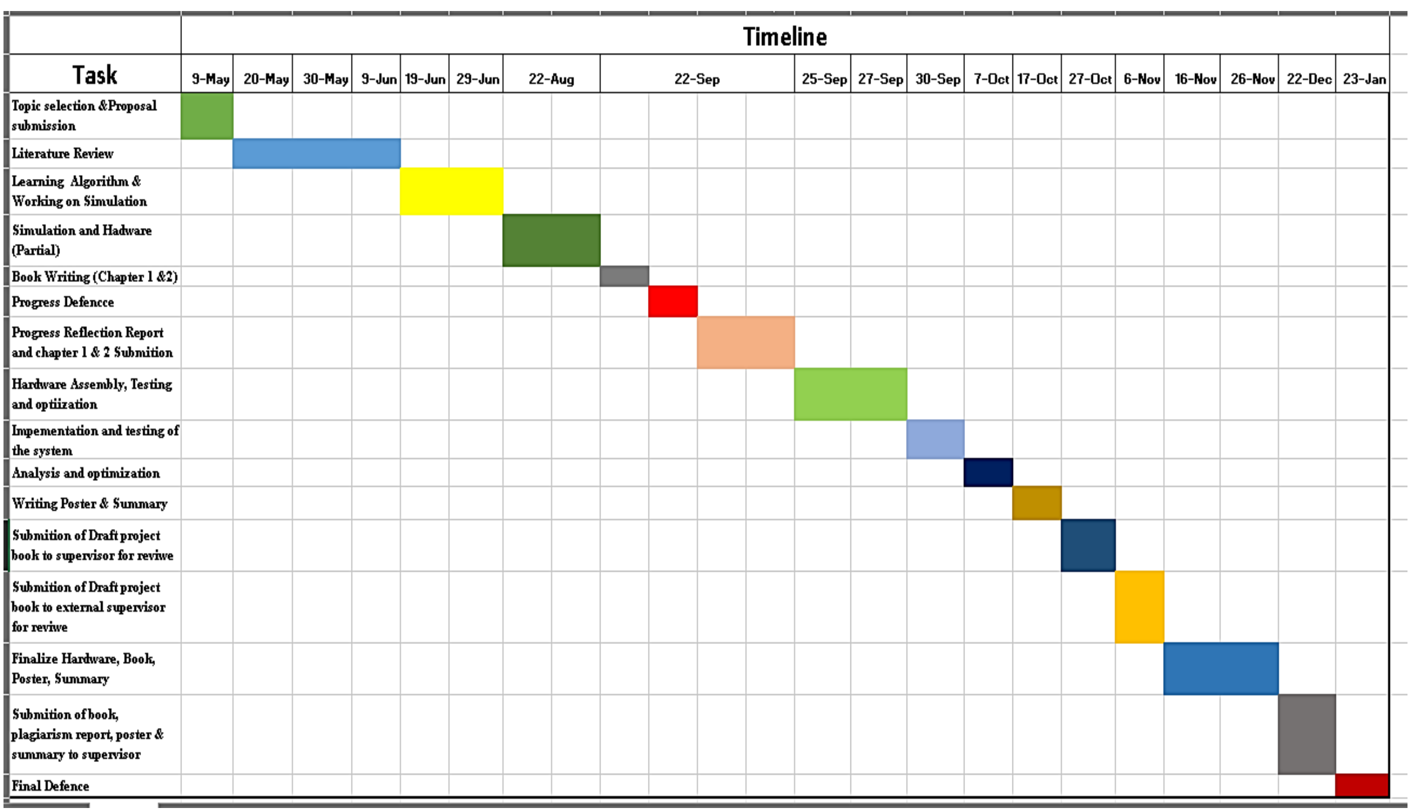


Figure 3.1 Project Management

There were some tasks which had individual submission deadlines The tasks were scheduled and distributed among all the members. There was regular communication with the research supervisor and everything was completed as per the time given by supervisor. We were able to collaborate effectively and efficiently by using a shared document to track all the tasks and deadlines. Everyone was held accountable for their individual tasks, and the supervisor was able to follow up with each member to ensure everything was completed on time. We also had regular meetings to check in on progress, discuss any issues, and brainstorm solutions. Additionally, we used an online platform to share documents and communicate any updates.

Overall, this strategy worked very well and enabled us to complete our research on time. It also helped us to stay organized and on track, which allowed us to maximize our productivity and achieve the best possible results.

3.4. Cost Analysis

The necessary components to implement this research has been listed with estimated cost in table 3.1. Estimation of the cost has been taken from websites of various manufactures and sellers. The total estimated cost for the research is Four Thousand Six Hundred and Sixty-one taka. Hopefully, the research can be implemented within the budget and will not exceed that.

Table 3.1 Express and component list for the prototype.

PRODUCT NAME	QUANTITY	PRICE
1 CHANNEL 5V RELAY BOARD MODULE	**2**	**180 Taka**
16X2 LCD MODULE DISPLAY	**1**	**375 Taka**
6A125VAC TOGGLE SWITCH	**3**	**255 Taka**
12V 2A AC ADAPTER	**1**	**599 Taka**
SCREW TERMINAL BLOCK CONNECTOR 1PER	**3**	**60 Taka**
JUMPER WIRE SET	**4**	**360 Taka**
RESISTORS	**20**	**100 Taka**
ARDUINO UNO	**1**	**1200 Taka**
PUSH BUTTON SWITCH 4 PIN	**3**	**21 Taka**
YF-S201 HALL EFFECT WATER FLOW SENSOR	**1**	**480 Taka**
ZMCT103C CURRENT SENSOR	**1**	**250 Taka**
ZMPT101B VOLTAGE SENSOR	**1**	**180 Taka**
NODEMCU ESP8266	**1**	**500 Taka**
BREAD BOARD	**1**	**150 Taka**
POTENTIOMETER	**1**	**75 Taka**
TOTAL		**4661 Taka**

$$Standard\ Deviation\ =\ Square\ root\ of\ \left(\frac{(Sum\ of\ (x\ -\ mean)^2)}{(Number\ of\ values\ -\ 1)}\right)$$

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}.$$

$$\sigma^2 = \frac{\Sigma(x_i - \mu)^2}{N}$$

$$= \frac{(180 - 590.375)^2 + \ldots + (4661 - 590.375)^2}{16}$$

$$= \frac{18932155.75}{16}$$

$$= 1183259.734375$$

$$\sigma = \sqrt{1183259.734375}$$

$$= 1087.7774286935$$

3.5. P.E.S.T. Analysis

PEST analysis is a measurement tool for assessing markets for a specific business over a specific period. Political, economic Social, and Technological (PEST) variables are acronyms for Political, economic Social, and Technological factors. A comparable concept is SWOT analysis (Strength, Weakness, Opportunities, and Threats).

3.5.1. Political Analysis

We would like to analyze the political implications of this initiative. The smart billing system of household utilities through the Internet of Things (IoT) is necessary to build a smart city. The IoT-based concept is used so that the service provider and customer can continuously monitor the consumption of power (in watts), water usage (in liter), and gas usage (in kg). If it reaches the minimum amount, it would alert the users to recharge or buy a combinational pack through the smartphone. In this method, the

Arduino processor is used to monitor and control the entire system model. The implementation of IoT will help better management, conservation of energy, and also in doing away with the unnecessary hassles over incorrect billing. Further, the IoT will be able to incorporate transparently seamlessly several different devices.

3.5.2. Economic Analysis

This prototype is environmentally friendly and economical to make. In residential areas, the consumption of electricity is usually monitored with an electromechanical system which consists of a rotating disk to track the usage. Each month, a utility company employee must manually inspect and record the readings and then the total bill is calculated in a central system. This traditional metering has a few problems: it requires lots of labor, has potential for human error, and doesn't allow customers to see their bills and how it is related to their usage. The meter can be individually programmed with a network address, allowing service providers to set a certain frequency to read the three utility consumptions. Homeowners can also access their meter from a personal phone.

3.5.3. Social Analysis

By using the prototype consumers will be benefitted by a huge margin. Students like us will be able to save time by paying the bills online. Also, elderly people can save their time and money as well by buying combinational packages of household utilities.

3.5.4. Technological Analysis

In this rapidly expanding world, the survival of the fittest is the only way to survive. As a result, because it is an Internet of Things (IoT)-based all-in-one utility with sensors, its acceptability is dependent on how frequently it is updated in terms of technology. Technology such as sensors was utilized to the greatest extent feasibly. It may be improved over time since additional sensors, more banks, and payment methods can be added and further research can be done regarding the technical improvement of the prototype as time goes on.

3.6. Professional Responsibilities

Professional engineering responsibilities have been followed by every member individually to solve the research.

3.6.1. Norms of Engineering Practice

The engineering standards we must abide by are listed below:

- Engineers shall place a high priority on public welfare, health, and safety.
- Engineers shall only make public remarks that are unbiased and accurate.
- Engineers shall exclusively provide services in their areas of expertise.
- Engineers shall not allow the falsification of their credentials or the credentials of their collaborators.
- Engineers shall conflict all of interest-known or hypothetical-that could affect or seen to affect a person's judgement or caliber of their services must be disclosed.
- Engineer shall refuse to provide a present or any significant consideration to land a job. They are prohibited from paying a commission, percentage, or brokerage charge in exchange for labor.

Every technical best practice and regulation is adhered to in this research.

3.6.2. Individual Responsibilities

All the team members participated equally in executing the project. Every member of the group financially contributed an equal amount of money for this research cost. The individual performance of each member is given below:

Table 3.2 Accountabilities of Member.

Name of The Member	Contribution
Rashedul Hasan Shohag	➢ Calibrating simulation analyzing findings and result using proteus software. ➢ Writing chapter 1-1.4 And chapter 6 and chapter 7.3.2-7.6 of the book. ➢ Literature Review. ➢ Designing block diagram ➢ Mobile Application developing in MIT App Inventor. ➢ Coding part of Node MCU

MD.EMON HOSSEN	➢ Calibrating simulation analyzing findings and result using proteus software. ➢ Writing chapter 1.5-1.8 And chapter 3 of the book. ➢ Analyzing project feasibility conducting necessary survey. ➢ Identifying and listing project components. ➢ Mobile Application developing in MIT App Inventor. ➢ Formatting of the research Book.
SHAHRUKH ISLAM	➢ Combining tasks and maintaining overall Co-ordination. ➢ Writing chapter 2.4-2.8And chapter 5 and chapter 7.7-7.8 of the book. ➢ Hardware implementation ➢ Thing speak server developing ➢ Writing book abstract ➢ IoT frameworks and architecture development.
SABBIR HOSSAIN KHAN	➢ Writing chapter 2.1-2.3 And chapter 4 and chapter 7.1-7.3.1 of the book. ➢ Poster Preparing ➢ preparing Gantt chart using MS word ➢ Hardware implementation. ➢ Real time data acquisition for calibration and verification ➢ Thing speak server developing

3.7. Management principles and economic models

To accomplish this chapter, first, we need knowledge about the whole research management. In the software part, we used proteus software. The proteus software is essential for the simulation component, which also tests suitable of the sensors. Arduino Uno has been used instead of Raspberry Pie to reduce the cost of this research. For electricity we have used a voltage sensor and current sensor, for water we used a water flow sensor, as the gas sensor is costly and not easily available, so we have used the potentiometer instead of the gas sensor which will exactly work like the gas sensor. The sensors are connected with Arduino. The NodeMCU ESP8266 wifi module is also connected with Arduino. Which will take data from Arduino and pass it to the ThingSpeak server with the help of ESP8266. We used ThingSpeak as the cloud storage. For the user interface, we used the Blynk platform, which is easily accessible. In this platform, we can easily design the user interface and display the data in the GUI. We also used the motion sensor, which is used to detect human presence.

The whole research has been divided into five parts.

1. Circuit Design
2. Proteus Simulation
3. Arduino Programming
4. Blynk Interface Design
5. NodeMCU Programming

We used the circuit designing software Proteus to design the circuit simulation and check the compatibility of the sensors. We used Arduino IDE to code the Arduino Uno. We used Blynk platform to design the user interface. We used the NodeMCU ESP8266 module to connect the Arduino board and ThingSpeak server.

In this research, we successfully monitored the electricity, water and gas usage. We also successfully designed the user interface and connected it with ThingSpeak server. The motion sensor was also used to detect the human presence in a room. The research was successfully tested and all the sensors were working as expected.

3.8. Summary

In this chapter, the total research management has been discussed. The S.W.O.T and P.E.S.T analysis are very important for research, which has been discussed briefly here. In the cost analysis section, we discussed the component price for implementing the hardware setup. Also, the responsibility of every group member has been discussed here.

CHAPTER 4

METHODOLOGY AND MODELING

4.1. Introduction

This chapter contains an explanation of the research ’s working principle and modelling. The methodology of the all-in-one smart meter and management system was identified using individual flowcharts. Hardware implementation and 3D design modelling are the two main parts of this chapter. Energy, water, and gas consumption by devices in residential units can now be collected more regularly thanks to the Internet of Things (IoT) technology. Each meter regularly takes a parameter reading and displays the data on an LCD screen that is mounted to the meter. Consumption of electricity, water, and gas are displayed in real-time on the meter LCD [21]. Automated results were displayed on the service's website and compared with the actual values displayed on the meter LCD screens. Depending on the capabilities of the meters, the rate at which the screen changes will vary. The individual meters that are dispersed over various areas are inspected to collect data for the metering system. The collected data is transmitted to the energy center for processing, billing, and monitoring the operation of the meters. This chapter has explained how all the hardware implementation is done in the system block diagram section.

4.2. Block Diagram and Working Principle

The detailed block diagram of the research is shown below, along with an explanation and a description of each component that we used in the research.

4.2.1. Block Diagram

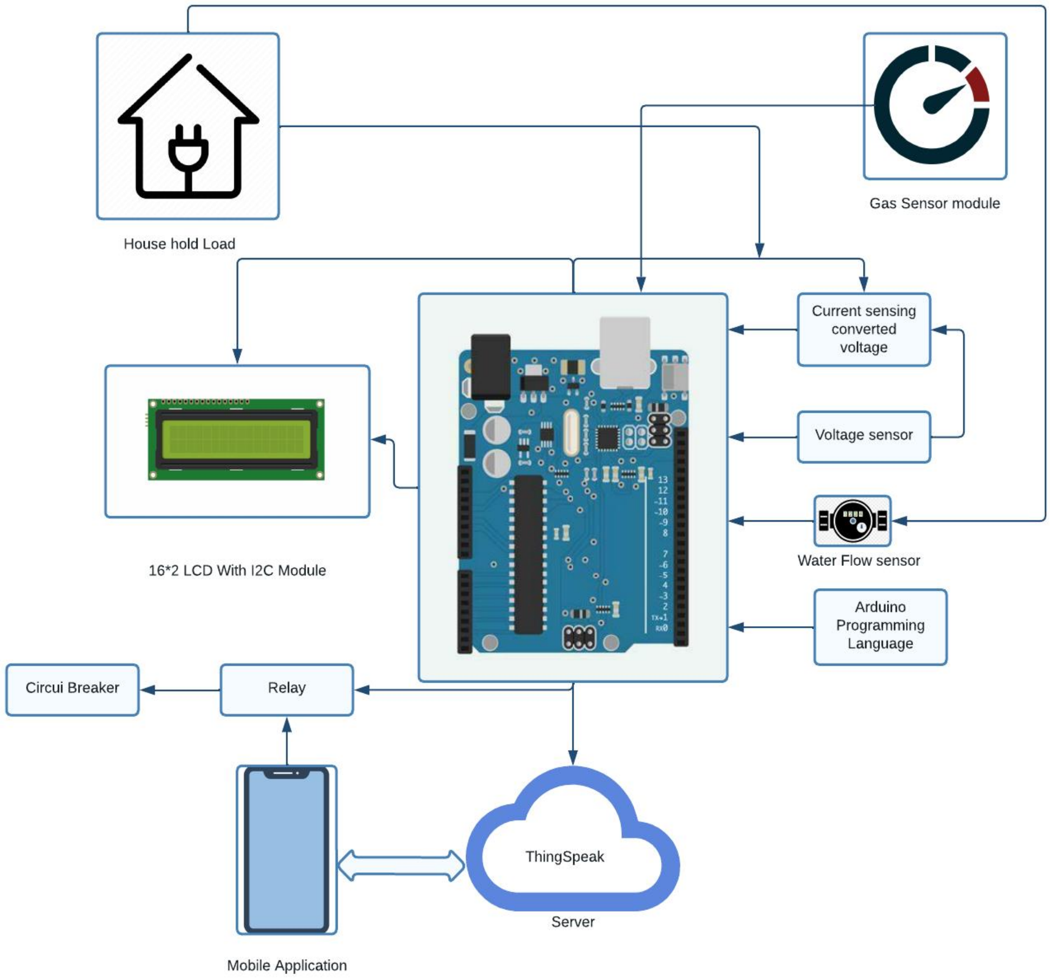


Figure 4.1: System Block Diagram

Figure 4.1 shows the process flow in which Arduino, a processing unit, is used. Several edge sensors, such as a water flow sensor and a voltage sensor, are connected to the Arduino, the process starts by connecting the edge sensors to the Arduino. The Arduino collects the data from the edge sensors, processes it, and displays it on an LCD display. It is then connected to a Thingspeak module, which stores the processed data and sends it to an MIT App Inventor and a mobile application. Finally, a relay is used to take data from the internet and break out the circuit. The Block diagram described the research 's process. Block diagrams are special diagrams showing a process or workflow. Another way to think of a flowchart is as a graphical representation of a methodical approach to problem-solving. The meter is based on the overall utility system. Commercial electricity, water, and gas meter prototypes were conceived, constructed, and tested using three with the help of utility meter suppliers. The design, development, and testing of an integrated IoT-based smart utility meter that monitors power, water, and gas use are proposed in this study. Each meter has a load attached to it. On the meter LCD, the consumption of electricity, water, and gas are presented in real-time. The block diagram shows the phases with arrows between the boxes. This is due to consumers' ability to monitor and control their consumption and utility y meet the supply-demand with variable tariffs. Two separate flowcharts were created to break down the complicated process. The Hall Effect sensor is connected to the shaft of the rotor. The water flow readings, as the water flows through the sensor taken from the digital pin of Arduino are displayed on the serial window of Arduino, and also the readings are sent to the cloud through thing speak. ThingSpeak provides a platform an open data. The data is are taken from the sensors or boards like Arduino. A flowchart for the block diagram and data collection system was created to better understand the research methodology. The LED display is connected to the input of the Arduino. The energy meter, Water flow sensor, and Gas sensor are connected to the input of the Arduino. All the sensors collect data and show it on the LED display. It will power on and enter the start-up process. LED should light up for half a second or less, and when it turns off it means the boot process has been completed. Data analytic and visualization techniques are used to extract bill information and display consumption on a dashboard in a graphic format. We use the KR-SR0087 and ZMPT101B sensors to measure voltage and current for the energy meter. I want to take a slightly different approach to detect mains electricity. It uses a dedicated single-phase AC voltage sensor module ZMPT101B. We used my trusty digital AC volt and current meter (AC230V/100A) module for the AC input voltage measurements. And we used the YF-S201 sensor for the water flow sensor. This is a YF-S201 Water Flow meter Measurement Sensor with 1-30Leter/min Flow Rate in black color. This sensor sits in line with your water line and contains a pinwheel sensor to measure how much liquid has moved through it. An integrated magnetic hall-effect sensor outputs an electrical pulse with every revolution. The hall-effect sensor is sealed from the water pipe and allows the sensor to stay safe and dry. We will combine the three and create a "smart meter" using NodeMCU and Arduino. The advantage of NodeMCU is that it will communicate data coming to the server, where it will be displayed visually or mathematically using Thinkspeak. We can also preserve the functionality of application development and notification capability through MIT APP INVENTOR. MIT App Inventor is a web application integrated development environment originally provided by Google and now maintained by the Massachusetts Institute of Technology (MIT). It allows newcomers to computer programming to create application software (apps) for two operating systems.

4.3.Modeling

3D with the proper architecture of the proposed prototype model are given. Every aspect of the hardware and software of this model has been highlighted. People can easily view their utility bills by using our prototype. This has facilitated the movement of people. The country is improving and the country is saving a lot of money. Our hardware is similar to this prototype. According to the simulation, the hardware is 85 percent similar. We are Fusion 360 cad software and we were used to creating this 2D and3D model. Fusion 360 has built-in capabilities to do 3D modeling, simulation, and documentation. It can manage manufacturing processes such as machining, milling, turning, and additive manufacturing. The model has the same dimension as the hardware we constructed. Here we designed prototypes in 2D and 3D. The three various viewpoints of our model are shown here: front view, side view, and top view. Here we see the 10.5-inch length and 13.5-inch width side view. Also has Arduino in the top view and display in the front view. I can see the sensor and power input in the back view. We shall witness a smart meter and management system in this research. To create a utility smart meter, we utilized a display, three sensors (water, gas, and current), an Arduino, a wifi sensor, and other components. Written our research (IoT). To operate Arduino, we wrote code. The hardware was created with the simulation in mind. The sensors track how much water, gas, and energy we consume. The display will display it. And by using Arduino and a wifi sensor, users will be able to purchase their bills and shipments through the MIT App inventor. It will cut expenditures and greatly enhance our nation. Time will be saved for everyone. We used the Arduino IDE to write our code. We wrote a code to read the sensors and display the readings. We also wrote code to check the internet connection, and finally, to connect to our app. The Arduino IDE is a powerful tool that allows us to write our code and debug it quickly.

We used Autodesk Fusion 360 to create the 3D model of our prototype. It is a powerful CAD software that enables us to create realistic models. We used it to create our model with the help of 3D printing. We used the 3D printer to create our prototype. 3D printing is an excellent way to manufacture a prototype quickly and efficiently. We also used Autodesk Inventor to create our prototype. Inventor is a powerful 3D computer-aided engineering software. It enables us to create 3D objects from scratch. We used it to create our prototype from the 3D model. We used Inventor to create our prototype because it provides us with the ability to design complex objects with precision and accuracy.

Finally, we used MIT App Inventor to create our app. App Inventor is a powerful, open-source software that enables us to create apps quickly and easily. We used it to create our app. With the help of App

Inventor, we created our app to facilitate the purchase of utility bills and shipment tracking. In conclusion, our research is an effort to create a prototype model that can track and monitor utility bills in an efficient manner. We used Fusion 360, Arduino IDE, Autodesk Inventor, and MIT App Inventor to create our 3D model, write code, and create our app. We believe that our prototype will be beneficial for the entire country, as it will save time and money for everyone.

4.3.1. Working Principle

To finish installing a smart meter for homes utilizing the table. A few liters of water were submerged in water that was true to the voltage of the water service provider, the water sensor, and the metering system. Automated results were displayed on the service's website and compared with the actual values displayed on the meter LCD screens [22]. The next step would be to connect the meter to the utility provider's system. This could be done by connecting the meter to the utility's communication infrastructure or by using a wireless connection. Once the connection is made, the utility provider can control the meter remotely and access data from it. The data can then be used to determine the amount of energy being consumed by the customer. This data can be used to send out bills, provide usage information, and to detect potential problems. Finally, the customer can access their smart meter data online and can use it to monitor their usage and make changes to their usage patterns. As a result, this is the property where we will connect a full tank system to the water pipeline. A smart water management system as such is a dire need for a smarter planet. One of the main reasons for the low adoption of the smart water management system is its high cost. The creation, testing, and integration of a smart utility meter that tracks how much gas, water, and electricity is used. Electric uses include conjuring power for the electricity sensor, as we used to say. The utility service provider can connect or disconnect any of the utilities, if the customer fails to pay the bills, depending on the rules and regulations of the contract between the provider and the customer. Utilizing any exact act as the gas sensor gave the meter's voltage potential additionally, it will provide us the voltage signals for the heart's hourly meaning. The utility and consumers will save about 20-30% compared with existing metering techniques. This is due to consumers' ability to monitor and control their consumption and utility to meet the supply and demand with variable tariffs. The mobile application listens to the server through the internet. The Block diagram described the research 's process. Block diagrams are special diagrams showing a process or workflow. Another way to think of a flowchart is as a graphical representation of a methodical approach to problem-solving. The block diagram shows the phases with arrows between the boxes. Two separate flowcharts were created to break down the complicated process. A flowchart for the block diagram and data collection system was created to better understand the research approach.

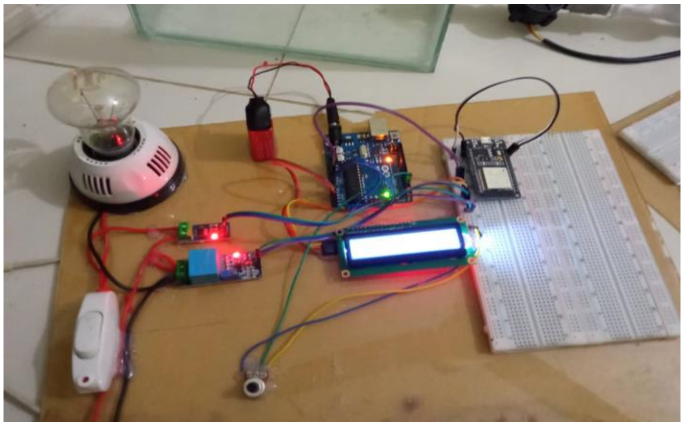


Figure 4.2 : The all-in-one utility metering

For server, by implementing the simulation model and in hardware that allows for measurement or control of the physical characteristics of all practical data connecting different sensors. Furthermore, those data are logged into the thing speak server as proceed to the inclusion.

The sensor was used to collect information from the sensors. Arduino received the information after. Next Arduino transmitted information to the ThingSpeak website using the ESP8266 WI-FI module. The data on the MIT app inverter website is accessible for monitoring and observation.

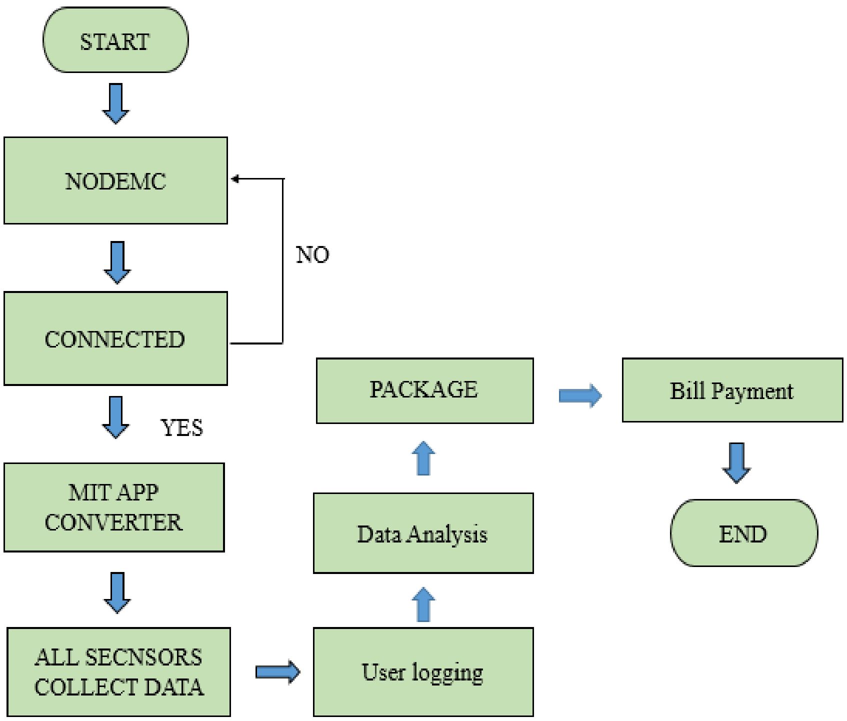


Figure 4.3: Research Work Flowchart.

This flowchart is a process for using the NodeMCU, a low-cost IoT platform, to collect sensor data, log user information, package the data, and then analyze it before finally producing a bill for payment. The process starts by connecting the NodeMCU to the MIT App Converter. Then all the sensors attached to it will collect the data. This data is then logged in a user log. After that, the data is packaged and analyzed. Lastly, a bill is generated for payment and the process is complete.

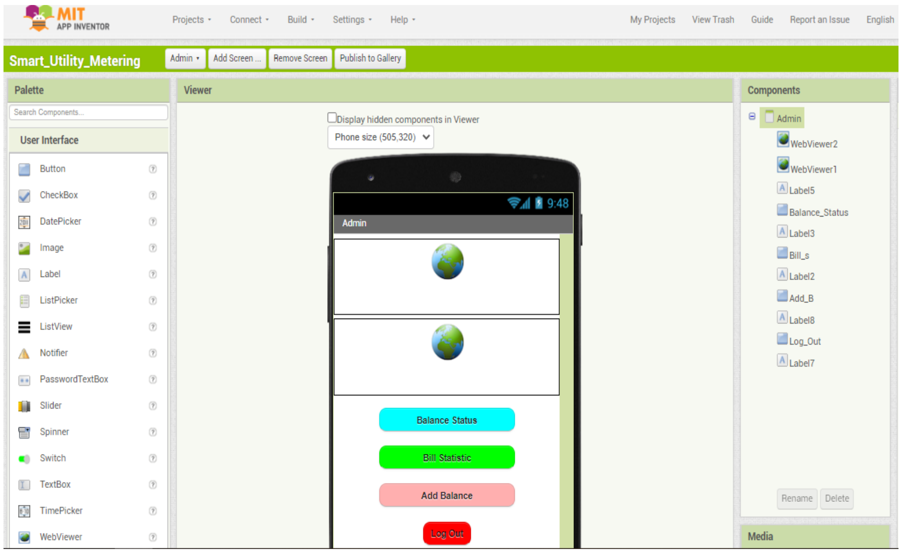


Figure 4.4: MIT App invertor

MIT App Inventor is an online software development platform, developed by the Massachusetts Institute of Technology (MIT). It was created to provide a way for anyone, regardless of experience or technical background, to create mobile apps. Using App Inventor, users can create their own Android apps, no coding required. App Inventor is a graphical block-building environment, providing a simple and intuitive way to build apps for Android devices. Blocks can be dragged and dropped together to create an app, and the user can easily see the results of their work on their device. App Inventor also supports the use of standard Android components, allowing users to use existing components or create their own.

App Inventor provides a suite of tools and resources to help users design, test, and deploy their apps. These tools include a visual designer, debugging tools, a block editor, a code editor, and a project system. It also provides access to a wide range of libraries, tutorials, and sample projects. App Inventor is designed to help people of all ages and backgrounds create apps. It is particularly well-suited for use in educational settings, such as in high school or college classes. It can also be used by individuals to create their own apps for personal use or for professional distribution. App Inventor is an excellent choice for anyone who wants to create an Android app without having to learn a programming language. It is easy to use, and it provides a wide range of features and resources to help users create the apps of their dreams.

4.4. Summary

This chapter focuses on methodology and modeling. This chapter goes into depth about the organizational structure of the research. This chapter contains key information about block diagrams and flowcharts. The energy server processes information from the meter, which measures the consumption of energy, water, and gas. Through a Wi-Fi connection, homeowners and utility workers can access the meter anytime, anywhere. On the Google map, the meter status is displayed in color; green means it's up and running, while red means it's not. An experimental prototype was created. The main objective of this chapter was to describe the research approach and operational procedures. Three-dimensional models of the vehicle were prepared, demonstrating views from different sides. This chapter also describes the software needs of the research.

CHAPTER 5

IMPLEMENTATION

5.1. Introduction

This chapter mainly focused on how we implement our whole research, the software we use, and how the sensor or components are implemented. This research was completed by preparing the designs and simulating them with the necessary software. First of all, in the simulation part, we did the individual simulation (electricity, water, gas) after that add them through a processor unit and run the simulation. We got our desired output. After completing the simulation part we are supposed to do hardware implementation. We have to use some sensors such as a water sensor, current and voltage sensor, and potentiometer for gas which will provide voltage signal same as a gas sensor. This chapter goes through all of the components that will be used in our research in great depth. The research 's software-based implementation will also be discussed briefly.

5.2. Required Tools and Components

Proteus software was used for simulating the research. Fusion 360 software was used to create the prototype. The model has the same dimension as the hardware constructed. The three various viewpoints of our model were the front view, side view, and top view. The server was created by using ThingSpeak, and also by using the MIT app inverter an app was made where we can show all time running data and also recharge through mobile banking. The software was chosen to make sure that all of the components were functional. While some models could not be located, they were replaced with standardized models.

5.3. Implemented Models

Fundamental components were selected to develop a system that is effective and less complex. With explanations, the description of a few key components was given. The first component is the user interface, which is the part of the system that the user interacts with. This is important because it needs to be intuitive and easy to use. The user interface needs to be designed to allow the user to easily find what they are looking for and navigate the system with minimal effort. It should also be aesthetically pleasing, so the user feels comfortable using it.

The second component is the data model, which is the structure of the data that is stored in the system. This is important because it needs to be designed so that the data is organized in a logical and efficient manner, so that it can be easily accessed and used. It should also be designed to protect the data from corruption or loss. The third component is the application logic, which is the code that runs the system. This includes the logic for how the user interacts with the system, as well as the logic for the business processes. This needs to be designed to be efficient and effective, so that the system runs quickly and reliably. This also needs to be designed to be secure, so that the data is protected from unauthorized access. The fourth component is the database, which is the storage mechanism for the data. This is important because it needs to be designed to store the data in a secure and efficient manner. It should also be designed to protect the data from corruption or loss. The fifth component is the network, which is the means of communication between the system and the user. This is important because it needs to be designed to be reliable and secure, so that the data is protected from unauthorized access. The sixth component is the security, which is the set of controls for protecting the system from malicious or unauthorized access. This includes measures such as encryption, authentication, and authorization.

Finally, the seventh component is the system maintenance, which is the process of monitoring, updating, and repairing the system. This is important because it needs to be designed to ensure that the system is running reliably and securely. These seven components make up the foundation of a system. When they are combined together in an effective manner, they can create a system that is reliable, secure, and efficient. Each component needs to be designed and implemented in a way that meets the requirements of the system. By taking the time to design and implement these components properly, a system can be created that is effective and less complex.

5.3.1. Hardware Model

The model also includes a graphical user interface which allows the user to visualize the generated and consumed power. The user can also select the type of load, such as inductive, resistive, or capacitive, and the amount of power being generated. The graphical user interface also shows the total energy consumed and the energy efficiency of the model. This can be used to evaluate the performance of the system and compare it with other similar models.

The generated power can also be monitored in terms of voltage, current, and power factor. The power factor is the ratio between real power and apparent power and it is used to measure the efficiency of the system. The authors have also included a power factor meter which can be used to measure the power factor of the system. This can be used to identify areas of improvement in order to increase the efficiency and reduce power wastage.

The model also includes a power converter which can be used to convert the generated power into other forms of energy such as electricity, heat, or fuel. This can be used to power various applications such as heating and cooling systems, electrical motors, and other appliances. The authors have also included an energy storage system which can store the generated power for future use. This can help to reduce the cost of energy and ensure that the system remains efficient.

Arduino UNO

The Arduino Uno was used to accomplish the both software and hardware-based exercise. It's simple to write code and equally to post it on the board. The principle programming languages are C++ and C. For this research, code was written in the C++ programming language. All modules can work together.

Arduino UNO is a microcontroller board based on the ATmega328P microcontroller. It is one of the most popular boards in the Arduino family and is designed for beginners and experienced makers alike. The board has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header, and a reset button. It can be powered directly from the USB connection or with an external power source.

The board contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. Arduino UNO has an on-board USB port for programming, as well as a power jack for connecting an external power source. The board also has an ICSP header for connecting to external programming hardware. The board can be programmed using the Arduino IDE, which is a cross-platform software development environment. It supports a wide range of programming languages, including C/C++, Java, and Python. The board can be programmed with sketches, which are special programs written in the Arduino language. Sketches can be uploaded to the Arduino board via USB or serial port.

Arduino UNO is a powerful and flexible platform for creating interactive projects. It can be used for a variety of robotics and electronics applications, such as home automation, environmental monitoring, and 3D printing. It is also a great board for learning how to program and use microcontrollers.

Figure 5.1: Arduino Uno

Serial LCD module display I2C Address. 0x3F Backlight which was (White character on blue background) Supply voltage was 5V, Size was 82x35x18 mm Come with IIC interface, which can be connected by DuPont Line. Serial LCD modules are used in a variety of applications, from industrial instrumentation to consumer electronics. They provide a way to display information in an easy to read format that is also cost effective.

Serial LCD modules can be used to display text, graphics, and/or data in a variety of formats. The most common of these is the character LCD (or text LCD) which is used in many consumer products. These displays are typically used to display text and/or simple graphics. They are limited to displaying a certain number of characters, usually 8, 16, or 20 characters per line. Serial LCD modules come in a variety of sizes and resolutions. The most common resolutions are 128x64, 128x32, and 64x32. These sizes allow for a variety of display configurations, including single line, multi-line, and graphic displays. Some LCD modules also come with a built-in backlight for better visibility in low-light conditions.

Serial LCD modules use various types of interfaces to communicate with the microcontroller or host device. The most common of these are SPI, I2C, and UART interfaces. Depending on the module, these interfaces can be used for both data and control commands. Serial LCD modules are used in a variety of applications, from instrumentation to consumer electronics. They provide a cost-effective, easy-to-read way to display information. They are also relatively easy to interface with using a variety of microcontroller and host devices. Serial LCD modules can be used to display text, graphics, and/or data in a variety of formats, and they come in a variety of sizes and resolutions.

Figure 5.2: Serial LCD module Display

Voltage sensor

The name of that sensor was ZMPT101B which was able to indicate how much voltage was passed into the single-phase line. By that sensor, it measures the accurate AC voltage with a voltage transformer. Its rated input was 10V, supply voltage 5V. A voltage sensor is a device used to measure the electrical potential difference between two points in an electrical or electronic circuit. Voltage sensors provide a direct measurement of the voltage present in a circuit and are used in a wide range of applications, from basic electrical testing to complex engineering systems.

Figure 5.3: Voltage sensor

Figure 5.3 Voltage sensors can be used to detect changes in the voltage level, such as a sudden drop or increase in voltage, as well as to measure the average voltage level in a circuit. Voltage sensors come in a variety of shapes and sizes, and can be used in both analog and digital circuits. They can be used in combination with other types of sensors, such as current sensors, to provide a more comprehensive picture of the electrical activity in a circuit.

Most voltage sensors contain an integrated circuit, or IC, which is a small chip that contains a number of transistors and other components that can be used to measure voltage. The voltage sensor is connected to the circuit via two or more leads, and the voltage is measured by the IC. The IC also contains a reference voltage, which is used to calculate the voltage level in the circuit. Voltage sensors can be used to measure AC or DC voltages. AC voltage sensors are typically used for measuring the alternating current in an electrical circuit, while DC voltage sensors are used to measure the direct current in a circuit. Voltage sensors can also be used to measure the voltage level of a battery or other power source.

Voltage sensors are used in a wide range of applications, including automotive systems, industrial automation, consumer electronics, and medical equipment. They are used to measure the voltage of power supplies, motor controllers, inverters, and other components. They can also be used to measure the voltage of a variety of sensors, such as temperature, pressure, and humidity sensors. Voltage sensors can be used to provide an accurate measurement of voltage in a variety of applications, and are an essential component of any electrical system. They provide a convenient and reliable way to monitor the voltage levels in a circuit, and can be used to detect changes in voltage levels and to monitor the average voltage level of a circuit.

Current sensor

ZMCT103C was the current sensor that was able to indicate how much current was passed into the single-phase line. Its rated input is 1-2 mA. It’s converting the AC to DC. A current sensor is a device that measures the current in an electric circuit. It is also known as a current transducer, current probe, or current transformer. Current sensors are used in a variety of applications, from measuring DC currents in automobiles to AC currents in power plants. They are also used in industrial automation, robotics, and renewable energy systems.

Current sensors work by detecting the magnetic field created by the current flowing through a conductor. This magnetic field is then transformed into an electrical signal, which can be measured and used for various purposes. The signal is usually in the form of a voltage, which can then be used to control a device or system. Current sensors are typically used to measure current in AC and DC circuits. They can also be used to measure high current and low current levels. In addition, they can also be used to detect current overloads, ground faults, and other dangerous conditions. Current sensors can be either active or passive. Active sensors use a power source, such as a battery, to power a circuit. Passive sensors, on the other hand, rely on the magnetic field produced by the current itself to generate a signal.

Current sensors are available in a variety of shapes and sizes. The most common type is the hall-effect sensor, which uses a magnetic field to detect current. Other types of current sensors include Rogowski coils, current transformers, and fluxgate sensors. Current sensors are used in a wide range of industries, from automotive to energy production. They can help to ensure the safety of electrical systems, protect devices from overloads, and detect faults. Current sensors are also used in robotics and other systems, where they can help to provide feedback for control and automation. Current sensors are essential components in the modern world. They help to ensure the safe and efficient operation of electrical systems, protect devices from overloads and faults, and provide feedback for control and automation. They are used in a variety of industries, from automotive to energy production, and are a crucial part of many modern systems.

Figure 5.4: Current sensor

Gas sensor

Potentiometer was used which will work the same as a gas sensor Figure 5.5. The gas sensor provides a voltage signal, here potentiometer also can provide a 0 to 5V voltage signal. This demo sensor will capable of giving the desired output. A gas sensor is a device used to detect the presence of gases in an environment, typically as part of a safety system. These devices are used in a variety of applications, including household appliances, industrial process control, and environmental monitoring. Gas sensors typically consist of a sensing element, a transducer, and a control unit.

Figure 5.5: Potentiometer

The sensing element is typically a chemical material that interacts with the gas to be detected, causing a change in electrical resistance, voltage, or current. The transducer converts this change in electrical property into a signal that can be read by the control unit. Depending on the application, the control unit may simply display the value of the gas concentration, or it may trigger an alarm in the presence of unsafe levels of the gas. Gas sensors can detect a wide range of gases, including oxygen, carbon dioxide, sulfur dioxide, nitrogen dioxide, ammonia, hydrogen, and volatile organic compounds. They are designed to be highly sensitive to the gas they are designed to detect, while remaining insensitive to other environmental factors such as humidity and temperature.

Gas sensors come in a variety of shapes and sizes, including handheld devices, portable devices, and fixed-location sensors. Portable gas sensors are used for spot-checking for hazardous gases in the environment, while fixed-location sensors are often used for continuous monitoring. Gas sensors are used in a variety of industries, including healthcare, oil and gas, manufacturing, and food safety. They are used to detect poisonous gases in the environment, to monitor for hazardous levels of flammable gases in the workplace, and to detect food spoilage. They are also used in automotive exhaust systems to measure the concentration of pollutants. Gas sensors are an important part of any safety system, as they help to detect dangerous levels of gases in the environment. They play an important role in protecting people, animals, and the environment from the adverse effects of hazardous gases.

Water flow sensor

Its model was YF-S201 and the Sensor Type was Hall effect. Its Working Voltage was 5 to 18V DC (min tested working voltage 4.5V) Max current draw was 15mA at 5V. Output Type was 5V TTL. Working

Flow Rate was 1 to 30 Liters/Minute. The Working Temperature range was -25 to +80℃. A water flow sensor is an electronic device used to measure the amount of water that passes through a pipe or other space. It can be used in a variety of applications, from monitoring water usage in a home, to measuring the flow of a river or to detect leaks in a system.

Water flow sensors are typically composed of a flow meter, transducer, controller, and display. The flow meter detects the amount of water passing through the pipe, and the transducer converts this into a measurable signal. The controller then interprets this signal and sends the appropriate information to the display, which can be a digital readout or a graph. Water flow sensors are available in a variety of styles, including mechanical, electromagnetic, and ultrasonic. Mechanical sensors work by using a paddle wheel or turbine to measure the amount of water passing through the pipe. Electromagnetic sensors use a magnetic field to measure the velocity of the water, while ultrasonic sensors emit sound waves that reflect off of objects and measure the distance traveled by the waves.

Water flow sensors are used in a variety of applications, such as monitoring water consumption in a home, measuring the flow of a river, and detecting leaks in a system. In addition, they can be used to control valves, pumps, and other systems, as well as to measure the temperature and pressure of the water. Water flow sensors are typically easy to install and maintain, and are available in a variety of sizes and styles. They are also relatively inexpensive, and can be used for both commercial and residential applications. In addition, they are highly reliable, and can be used for long-term monitoring.

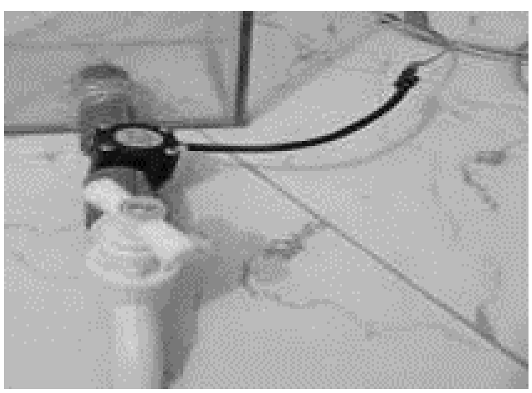


Figure 5.6: Water flow sensor

Other than this there are switches, relay, terminal block collector, 12V 2A AC adapter, push button switch, jumper cable, etc. used. This box is the heart of the research. Here are some sensors that were used for sensing current, voltage, and water. There is a processor unit which Senses and helps to give the desired Output.

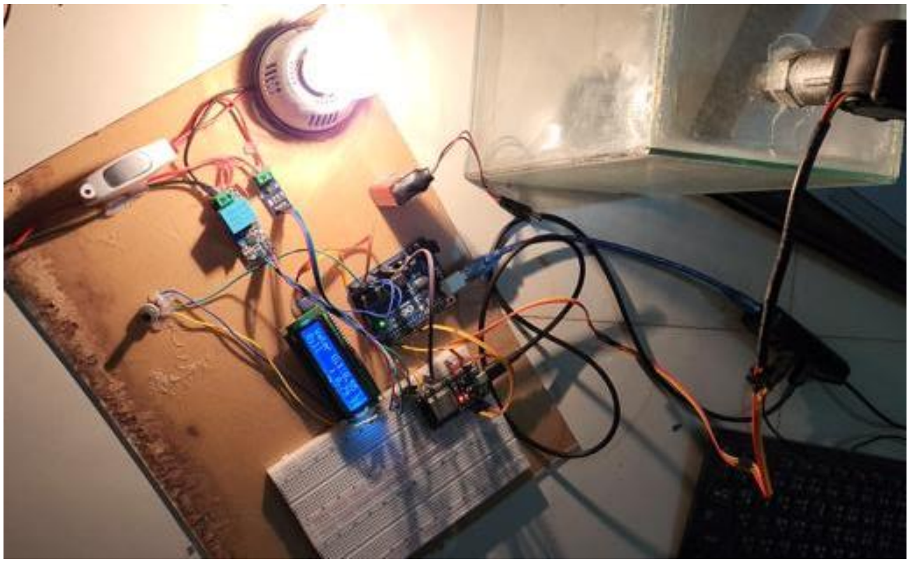


Figure 5.7: Hardware

For electricity here two 100W bulbs were used, which consumed power is 2KW. Besides, the water sensor provides a voltage signal that signals converted to the metering system. Two bulbs are parallel to the main power flow. The bulb is also in a series connection. The voltage sensor contains 4 sets of pins on the Arduino side and 2 sets of pins on the power electrical side. When measuring voltage in parallel so we are parallelly connected to two wires. Also, for measuring current in series phase line and current in series setup. Here also have the current sensor which has 3 pins. It senses the current, converting through the IC ACS712. This IC converts the current in terms of voltage. The voltage goes through the Arduino. The voltage sensor senses the voltage and indicates how much voltage is passed into the single-phase line. here also have a relay that will act as a switch or we can use it for Isolation. RTC module is used to calculate time, we calculate kwh by this. I2C is used for reducing the PINs. We also used the gov't rate per unit cost to get the best output result in the server or app.

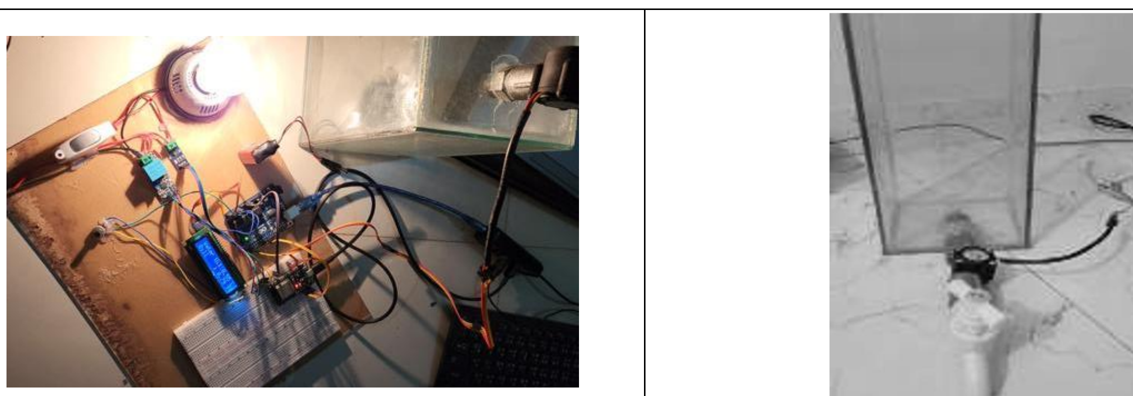


Figure 5.8: Hardware setup.

5.4. Summary

The hardware and software implementation of our research are covered throughout the chapter. This chapter discusses all of the components used in our research, how they operate, how significant they are, and so on. This chapter discusses all of the connections in detail. This chapter also includes examples of software-based work.

CHAPTER 6

RESULTS ANALYSIS & CRITICAL DESIGN REVIEW

6.1. Introduction

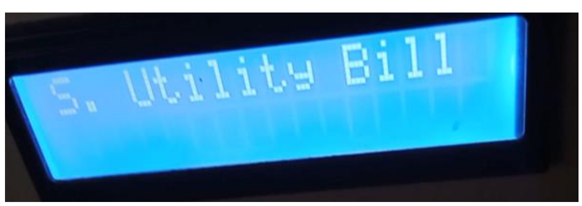
In this research, the authors have generated a system where users will pay utility bills online using an app; consumers can stay at home and spend their payments while saving time. In our app, there is a package system application. A theoretical grasp of fundamental electronics, electrical, and microcontroller elements is required for constructing an IoT-based complete utility smart metering for households. While working on this research, there were several contradictory difficulties. A variety of mathematical computations are required. The design, development, and testing of an integrated IoT-based smart utility meter that monitors power, Water land gas use is proposed in this study. The meter has a unique network address and can be remotely programmed to scan the three utility consumptions at any desired frequency that the service providers can specify. A holistic articulation of many fundamental engineering concepts is required in this case. To complete the research, specialized engineering is analyzed. The most appealing feature of this system is its ease of setup and lack of complexity. In this chapter, all the results of the research are going to be discussed. The result is going to analysis in four different aspects. Predictive analytics is an advanced technique in predictive analytics that allow one to search for patterns in the data and confirm them at the same time. Flowed by Prescriptive analytics essentially, authors predict multiple futures and allow companies to assess a number of possible outcomes based on their actions. Then Diagnostic analytics to see why specific behavior is observed can look at a combination of variables. Analyze results and conclude. After testing the model in simulation and getting results, the results need to be analyzed in order to conclude, and this is where the statistical model typically comes into the picture to weigh the evidence that we have collected to see if an implemented model that authors have formulated in order to answer the question of interest is true or false.

6.2. Results Analysis

The authors analyzed the model through a cumulative simulated platform and then developed prototype hardware to analyze it practically. After verifying the model in a simulated environment, they implemented it into a prototype and analyzed the data to see if the system was working. As they developed energy meters, water flow meters, and gas meters, they analyzed electricity, rate of water flow, and volume of gas. NodeMCU was used to send the data directly to the server, which was then presented graphically or numerically on ThinkSpeak. Creating an application and notification feature with MIT APP INVENTOR, users can log in to the website to check their daily uses and pay their bills. They can also transfer the data to excel and use MATLAB to predict future data. To compare the simulated and hardware results, this analysis section is divided into two sections. The first section deals with the simulated results and the second section deals with the hardware results. The authors concluded that their proposed system was reliable and valid and could be used in many applications.

6.2.1. Hardware Results

In the hardware section, we have used a 16X2 Liquide Cristal Display (LCD), which shows all the results with a duration of 3 seconds so that the consumers can track their current uses and the balance they have left with. As we have coded in Arduino ide to show the system's title as "Smart Utility Billing System" in short S. Utility Bill that we can spot in figure 6.1 (A), this title stays on screen for about 3 seconds so that the user can recognize the Sentence. After that, that user can see how much he spent on electricity from these utility meter systems. We can see users till now used 2.25 units, and the corresponding bill 18.04 taka, which is shown in figure 6.1 B. Onward, the gas uses 2.09 KG they are being shown in the figure 6.1 C. Figure 6.1 D shows us how much consumer uses water and its corresponding unit and bill. In the last figure, 6.1 E shows how much users spend from their deposited taka and how much they are left with it also mansion current balance level. Therefore, this system can maintain the accurate utility bills of consumers and the system is efficient to handle the billing system of any type of utility. The hardware system is smart and user-friendly, and it can handle any type of billing system easily. So, this system is efficient for economical and convenient billing system.

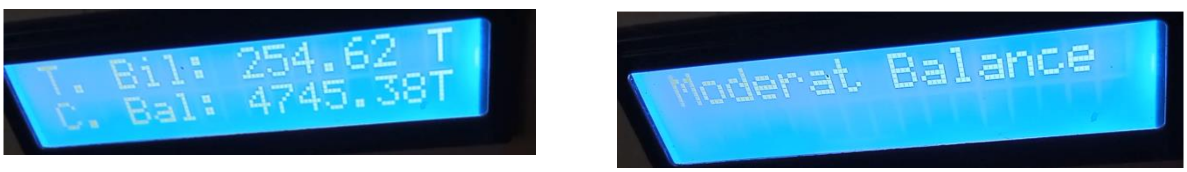


(A)

(B)

(C)

(D)



(E)

Figure 6.1: Output Result in LCD monitor from The Hardware.

Figure 6.2 shows that Serial communications have been established between the hardware and Arduino ide, which is an easy and flexible way for the Arduino board to interact with the computer and other devices. It is also a debugging tool for testing concepts or communicating directly with the Arduino board. Using the serial communication, we have sent the data to NODE MCU from Arduino for internet connectivity. As the Arduino Uno does not have any wifi capability, sending those data to the ESP8266 microcontroller is made posible to send those data to the thingspeak server. Figure 6.2 explains how to send and receive information using this capability.

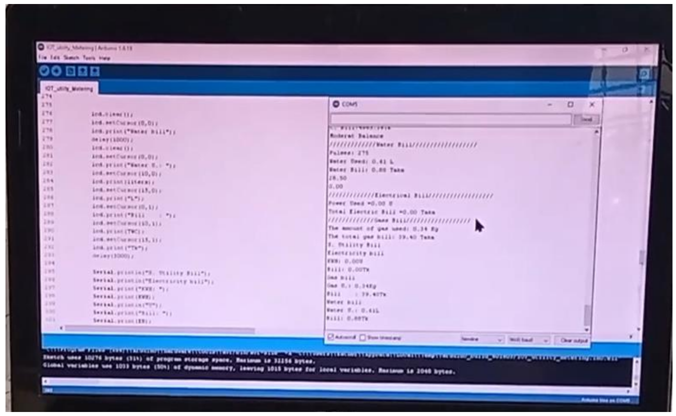


Figure 6.2: Serial connectivity between hardwires.

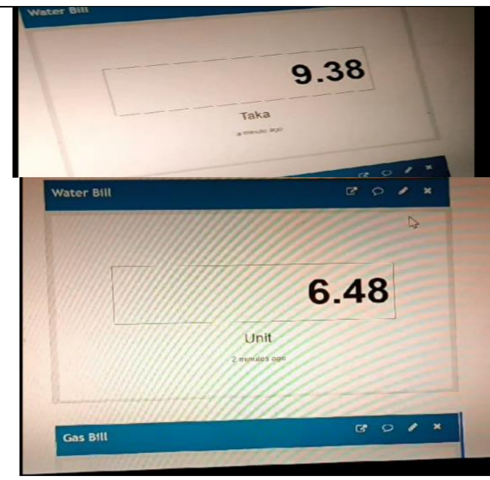


Figure 6.3: Real time water data collction.

Figure 6.3 shows the real time data accusation and calibration for water system modeling, as our designed model give us same output that relay system dose there for it met the requirements. Our system is able to handle huge amount of data and compute them in real time. The system is designed with an open architecture, which enable us to modify and enhance it as needed. The system offers various features such as data visualization and real time analysis, to help us identify any potential problems and take corrective actions in a timely manner. Furthermore, it has a predictive analysis capability that can help us forecast the system's performance. In addition, the system is also equipped with a self-learning algorithm to improve the accuracy and performance of the model. All of these features make it a reliable and powerful system for water system modeling.

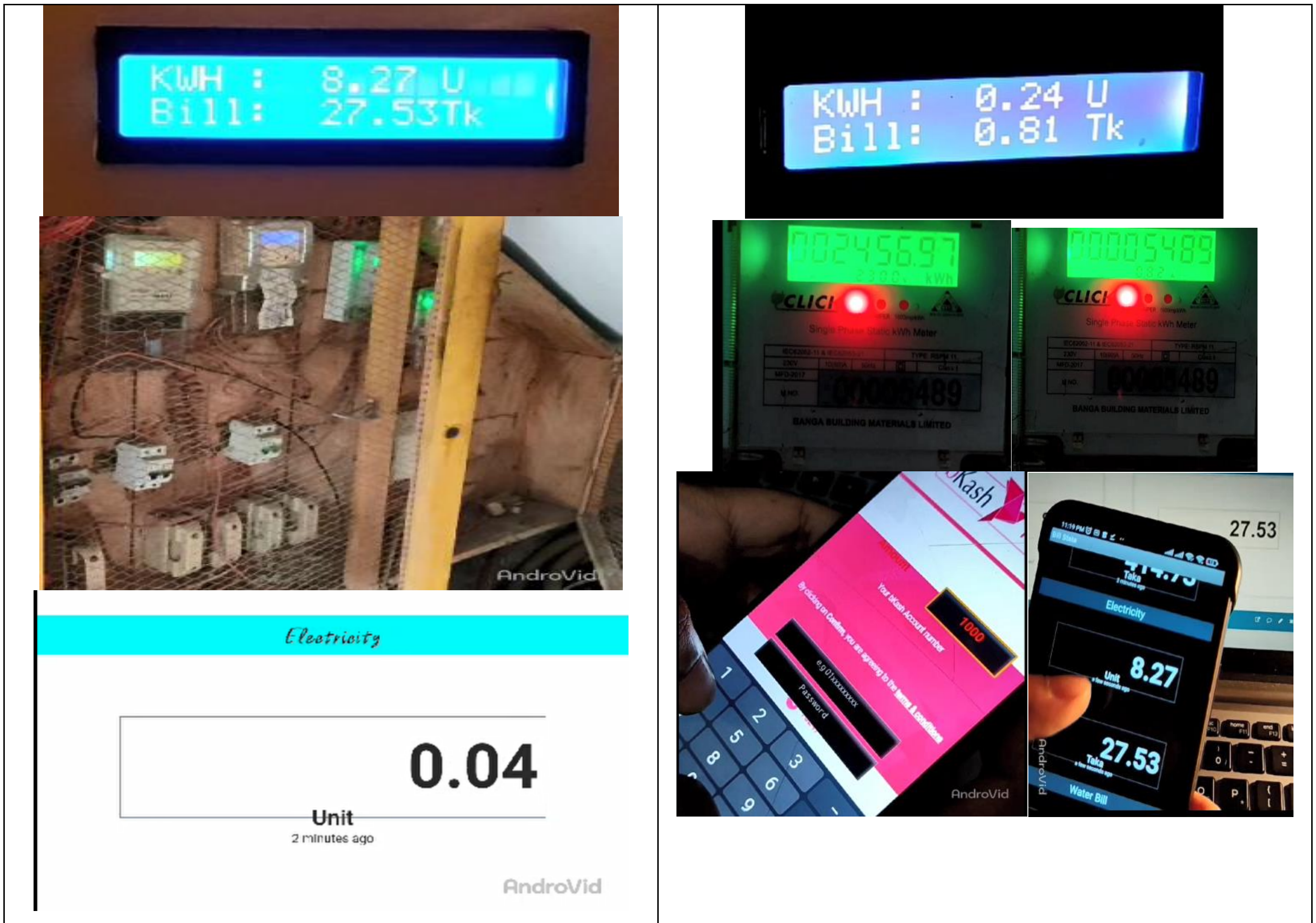


Figure 6.4: Real time Electrical unit data collction.

Figure 6.4 depicts the consumption of electricity using our suggested meter and the actual meter that we previously had in our home. This meter displays 8.27 units, which cost 27.53 taka for a two-day power bill. After finishing the two-day data analysis, we did calibrations to validate our system in real life. We operated the system for about an hour, and the bill was.24, as shown in our recommended design.

We also obtained the same result from the real meter. Following that, we sent a check of our stuff with the server and our mobile apps to ensure that everything was as intended. We may also use a smartphone application to make Bkash payments using the Bkash payment gateway.

This result shows us the output monitor, which provides all the output results in one platform used by the consumer. In the serial monitor, let us start with the water bill. It can be seen in the pulse coming from the sensor in the processing unit that the water has consumed 6.48 liters so far, and the corresponding bill is almost 10 takas. The water bill is 9.37 taka, and we can see the line voltage and current since we are not using electricity; thus, the consumed current is zero; consequently, the electric unit and cost are both zero. As the first deposited 5000 taka, the total consumption is 29 takas; therefore, current balance is 4971 takas. Moving on, the gas bill is quite low since we are using a gas stove for cooking. The gas consumption is 0.34 cubic meters, and the bill is 3.4 taka. The total consumption is 32.4 taka; thus, the current balance is 4938.6 takas.

Furthermore, the internet bill is also low because we are not using internet services. The internet usage is 0 GB, and the bill is 0 taka. The total consumption is 32.4 taka; therefore, the current balance is 4938.6 takas. Lastly, the total consumption of all the utility bills is 32.4 taka, and the current balance is 4938.6 taka. The serial monitor provides us the real time data of all the utility bills and their corresponding costs in one platform. This is extremely helpful for the consumers to keep track of the usage and the bill amount. The per-unit water bill cost as far as the WASA is 14.46 Tk pre-unit (1,000 liters) . Secondly, the per unit LPG gas price is 116 taka and the following table 6.1 shows the set prices for different amounts of LPG for March.

Table 6.1 Set prices for different amount of LPG

Amount (in kilograms)	Price (in Taka)
5	637
15	1,738
16	1,854
20	2,318
22	2,549
25	2,897
30	3,476
33	3,824
35	4,055
45	5,215

Lastly, the electricity tariff rate was assigned as far as the Dhaka Power Distribution Company (DPDC). The authors made the system generic as the uses of electricity differ, and it falls into a particular part. It will automatically charge the corresponding unit cost. The following table 6.2 shows the tariff rate of electricity according to DPDC.

Table 6.2 Tariff rate of electricity according to DPDC only for Residential

Customer category and slab	New Tariff Per Unit Rate (Tk)	Service charge (Tk/Month)	Demand charge (Tk/KWH/Month)
Life Line: 1-50 Units	3.33	1-phase 10.00 3-phase 30.00	15.00
a. First step: From 00 to 76 units	3.80		
b. Second step: From 76 to 200 units	5.14		
c. Third step: From 201 to 300 units	5.36		
d. Fourth step: from 301 to 400 units	5.63		
e. Fifth step: From 401 to 500 units	8.70		
f. Sixth step: From 501 to 600 units	9.98		

6.2.2. ThinkSpeak Result

The results of the research can be observed through Thing Speak. Thing Speak is used to store data publicly to allow access to the mobile app. After successfully implementing all the hardware, authors broadcast all these data into the thing speak server shown in the figures below. Here the first six graphs of figure 6.5 demonstrate all individual household bills that have been used for gas, electricity, and water usage; here, see specific uses on a specific day by selecting a single data on this graph. Field chart one logged the data for the electric unit used; field chart 2 shows the bill in Taka. Followed by those two-chart field charts three and four show the use of unit and consumption taka for water. Last two graphs in figure 6.5 log the value for the gas bill and their unit. Figure 6.6 shows the deposited balance from the mobile applications and the current balance calculated into the processing unit, Adriano, in this case. From the field chart, eight users can track how much they deposited last time or any day from the previous month or year. It gives a view. Also shown for field chart 7, which represents how many balance levels the user is left with. If the balance falls between 500, it shows the red mark, and if it got into a well handsome value, it shows in the green level region. At least from the peak data analysis, figure 6.7 gives us the numeric value of each use bill, the deposit, and the current balance.

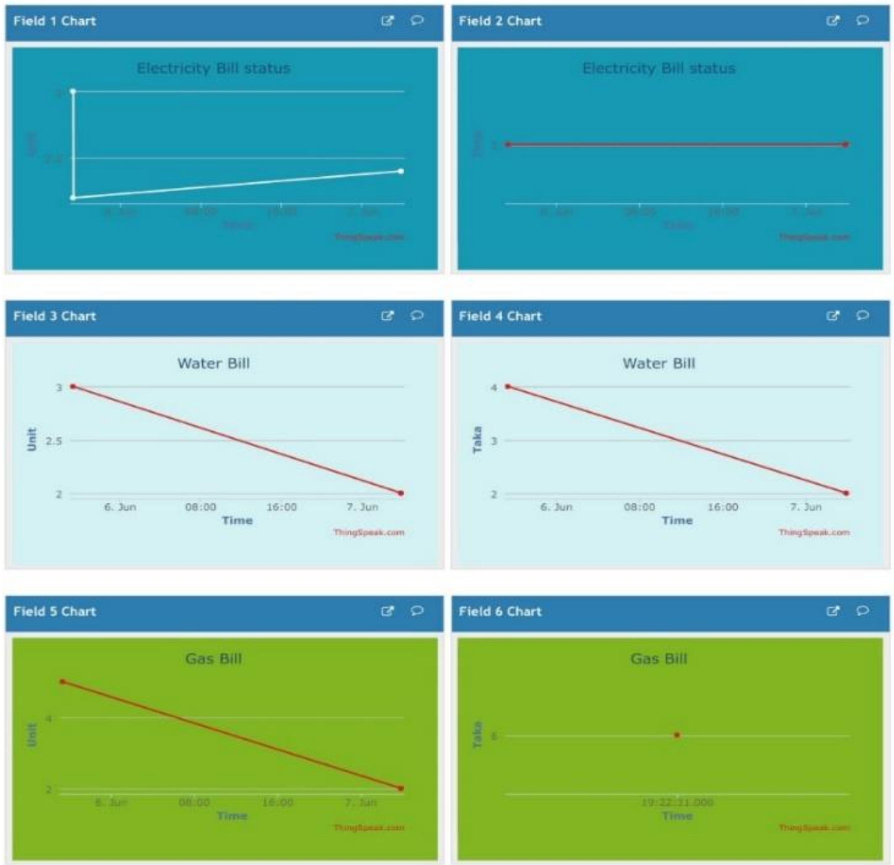


Figure 6.5: Individual unit and costing data logged into ThingSpeak.

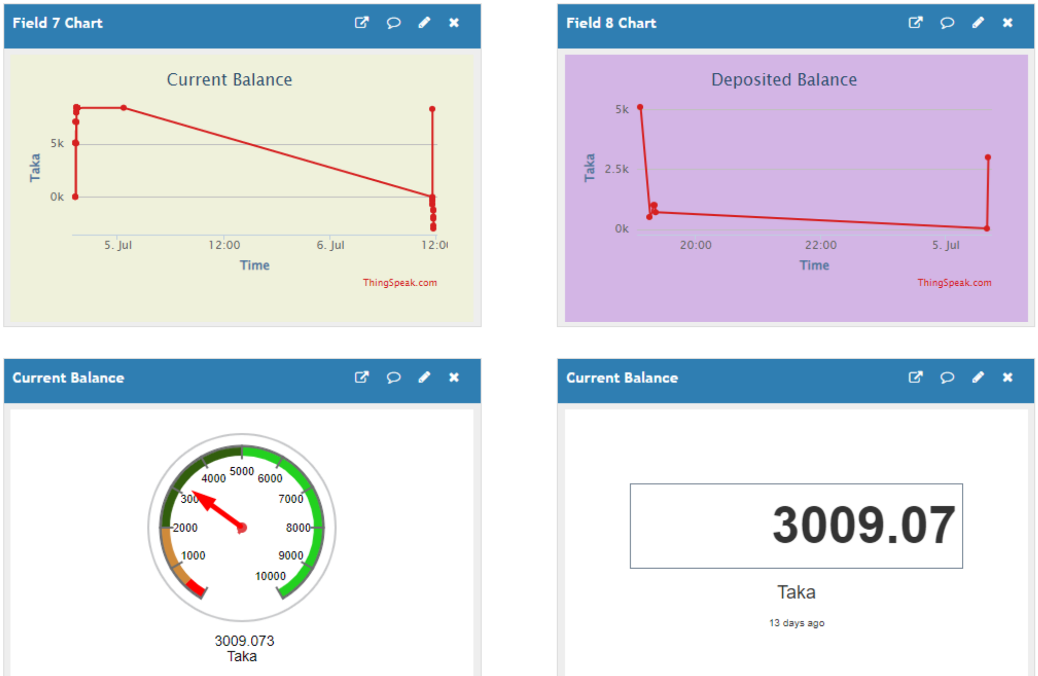


Figure 6.6: Deposited and current balance data.

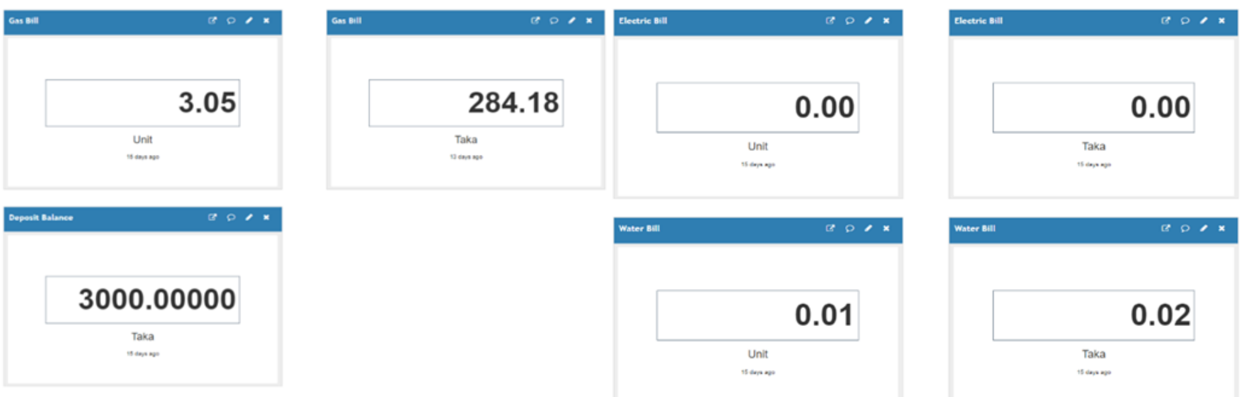


Figure 6.7: All measurements show numerically.

6.2.3. Mobile Application

A homepage was created using the MIT App Inventor, and four buttons were designed inside the page to show the status, bill statics, balance, and about page. All of these buttons lead to different pages designed inside the app. Inside the mobile application, we can observe all graphical data and numerical data as far as the thing speaks server. We can deposit the amount through the BKASH getaway and purchase the package for the whole month.

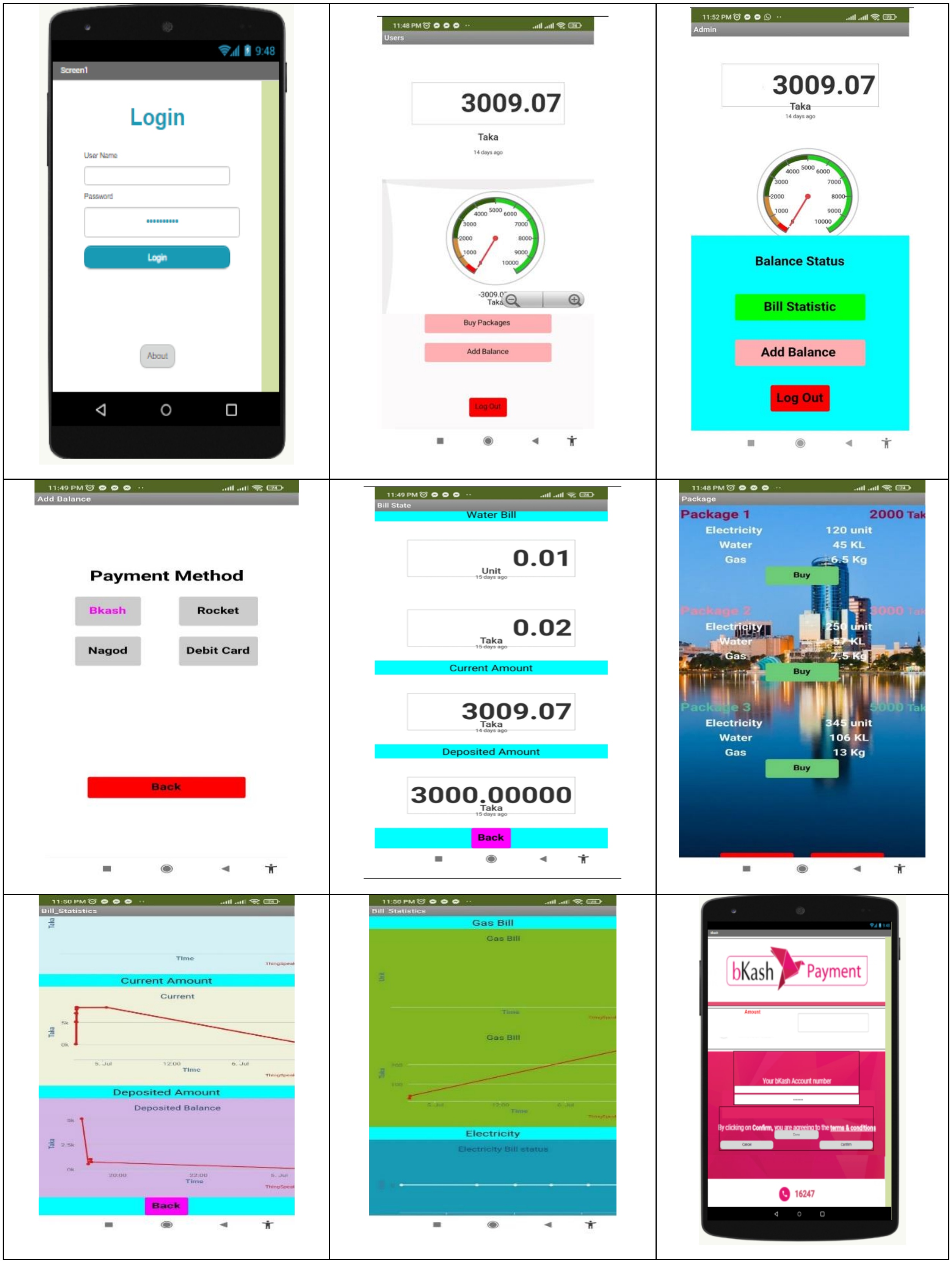

Screen1
Login
User Name
Password
Login
About
Users
3009.07
Taka
14 days ago
Buy Packages
Add Balance
Log Out
Admin
Balance Status
Bill Statistic
Add Balance
Log Out
Add Balance
Payment Method
Bkash
Rocket
Nagod
Debit Card
Back
Bill State
Water Bill
0.01
Unit
0.02
Taka
Current Amount
3009.07
Deposited Amount
3000.00000
Back
Package
Package 1
2000 Tak
Electricity
120 unit
Water
45 KL
Gas
6.5 Kg
Buy
Package 2
3000 Tak
250 unit
67 KL
7.5 Kg
Package 3
5000 Tak
345 unit
106 KL
13 Kg
Bill_Statistics
Current Amount
Deposited Amount
Deposited Balance
Back
Bill Statistics
Gas Bill
Electricity
Electricity Bill status
bKash Payment
Your bKash Account number
16247

Figure 6.8: Result from Mobile Application.

6.3. Comparison of Results

This IoT-based utility metering and control system is exclusively used to monitor householders' power and monitor functionality from a central remote location. The designed system works efficiently in the simulation model and in practical. In the case of the simulation model, the authors could not make the IoT portions as proteus simulations do not support IoT for implementing or simulating any wi-fi connectivity model. Although wi-fi connectivity was not possible in the simulation model, the authors analyze individual power consumptions like electricity, gas, and water. In the case of hardware implementations, we followed the exact connections and modules that we had implemented in simulations while we were measuring all the data that we got from the simulations, and from the hardware, we got almost similar output; however, Wi-Fi connectivity being possible in case of hardware that's why authors can upload all data to the Internet server and further to the mobile applications which are developed in MIT app inventor platform. That also makes two-way communications between the mobile applications and CPU, which makes it possible to deposit balance to the CPU from the mobile application.

Tablet 6.3: Collected data of 24 days of utility uses.

Electric Bill (KWH)	Electric Bill (TAKA)	Gas Bill (UNIT)	Gas Bill (Taka)	Water Bill (UNIT)	Water Bill (Taka)	Total Bill (Taka)
0.36	1.8	2.18	32.7	6.85	61.65	96.15
8.79	43.95	1.87	28.05	0.15	1.35	73.35
8.97	44.85	2.15	32.25	9.79	88.11	165.21
4.72	23.6	4.32	64.8	7.66	68.94	157.34
1.42	7.1	3.36	50.4	5.28	47.52	105.02
2.2	11	4.79	71.85	2.6	23.4	106.25
7.65	38.25	4.62	69.3	5.07	45.63	153.18
5.83	29.15	1.7	25.5	5.57	50.13	104.78
0.62	3.1	1.68	25.2	1.81	16.29	44.59
9.15	45.75	3.01	45.15	6.45	58.05	148.95
7.19	35.95	4.35	65.25	8.29	74.61	175.81
3.4	17	3.91	58.65	0.9	8.1	83.75
6.65	33.25	3.2	48	7.32	65.88	147.13
6.49	32.45	2.5	37.5	8.32	74.88	144.83
5	25	0.96	14.4	0.54	4.86	44.26

3.73	18.65	0.56	8.4	8.1	72.9	99.95
6.71	33.55	0.7	10.5	1.85	16.65	60.7
0.35	1.75	3.22	48.3	4.39	39.51	89.56
6.14	30.7	4.92	73.8	7.09	63.81	168.31
8.71	43.55	3.19	47.85	0.69	6.21	97.61
7.29	36.45	3.5	52.5	6.25	56.25	145.2
3.99	19.95	1.24	18.6	2.03	18.27	56.82
9.55	47.75	2.62	39.3	7.47	67.23	154.28
0.91	4.55	1.41	21.15	3.5	31.5	57.2
1.93	9.65	2.78	41.7	1.4	12.6	63.95
9.9	49.5	4.88	73.2	8.37	75.33	198.03

6.4. Summary

This chapter focused on the result analysis and the various aspect of the research like input data, output data, data visualization, simulation & more. The research encapsulates three sophisticated platforms and their use. The various reasons and logic behind using the Proteus Simulation platform, Arduino IDE, ThingSpeak, and MIT App Inventor were discussed in the chapter, including the specific functions and procedure.

CHAPTER 7

CONCLUSION

7.1. Summary of Findings

The primary aim of this work is to make it easy for people to pay all their household bills at once. Now our country is progressing in all directions. This work aims to make a smart utility meter model. So that people can easily pay bills together and management the system. No need to pay another bill through the line. What we have done is use sensors for each object. So that it is easy for us to manage it. And I can see what the bill is. That's why I made a smart meter. And in addition, we have integrated Internet of Things (IoT) technology in the prototype, which will allow us to control the whole process inside the smart utility meter. A framework was needed to create utility meters. Because it helps us pay all the bills together. The sensors are connected to the IoT module in the manner specified by the software with the assistance of the “ThingSpeak" website. The model proposed by us is a model which can be scaled up to a more significant size for utility meter purposes for the benefit of the overall development of our country. The intended design was achieved through simulation and hardware implementation and was now ready for implementation. Therefore, it can be concluded from all the results of the simulation model that the proposed device would be effective for development in a country like Bangladesh. Which will significantly affect the overall economic growth of our country. Life would be much easier for us if our research was implemented in practice.

7.2. Novelty of the work

Utility meter is new technology. Which will make the people of our country aware and better. People will save time. Most importantly, people can pay all bills at once and buy bills through packages. Many more things are new in this research. Which will help people move and reduce costs. We first give it a shape through simulation. The hardware is 85/90 % similar to making a smart utility meter. Then update the data through the sensor (IoT) and transfer the data to the MIT app. Through which user can buy, and pay my bills. In this research, we used a lot of things including different sensors. Which helped us to do the job. Maybe no one thought of this before the research I did. A report came out in 2018, IoT Best Utility Smart Meter [5]. We have updated with this. IoT Utility Smart Meter and Management System. Finally, we can say one thing. That is our research will help the country to move forward.

7.3. Cultural and Societal Factors and Impacts

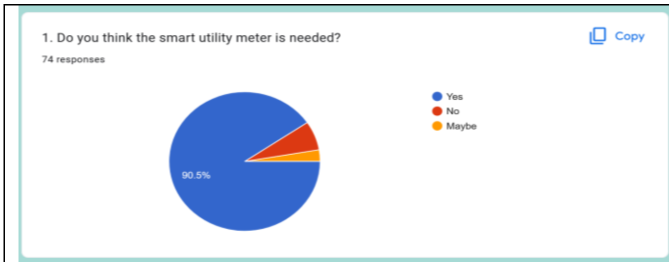
Society and the nation's economy will both be affected in different ways by this endeavor. The research will have a wide range of major repercussions, aside from the global economy and commercial trends. Society will be introduced to a high current utility meter technology that will assure a number of conveniences and comforts for the users when this research, which is a meter with modern technology, successfully completes large-scale implementation. That is why we provide bill-paying services.

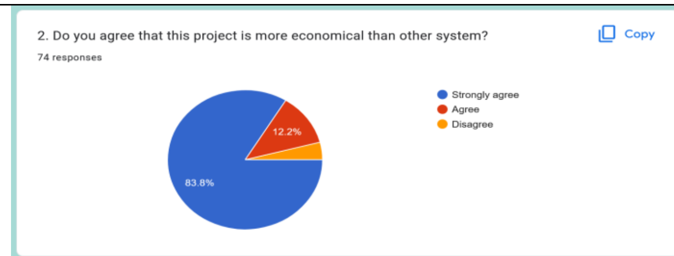
7.3.1. Cultural and Societal Factors Considered in Design

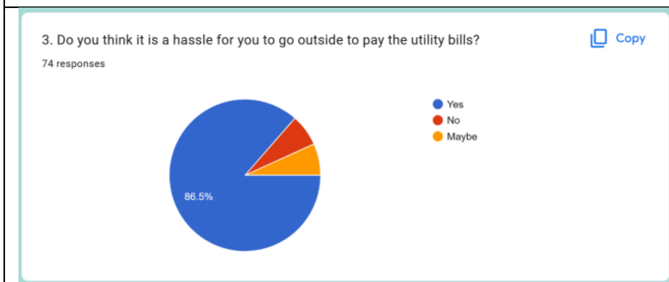
The utility smart meter and management system research is new. It will help our country progress. Because our country it will save money and time. Socially it is very beneficial. You can see how much gas, water, and the electricity you are using at the utility meter and pay the bill. We have also brought new ones with it. Such as management systems. We have put a package through which they can buy and use the package together. We have also brought new ones with it. Such as management systems. We have put a package through which they can buy and use the package together. And you can pay bills at home through Bikash, Nagad, and Sohoj. So, you can pay all these bills at one time sitting at home. You can also buy packages if you want. We have engineered it. Also called simulation, prototype, and hardware. It is 80% similar to each. So, it can be reconciled.

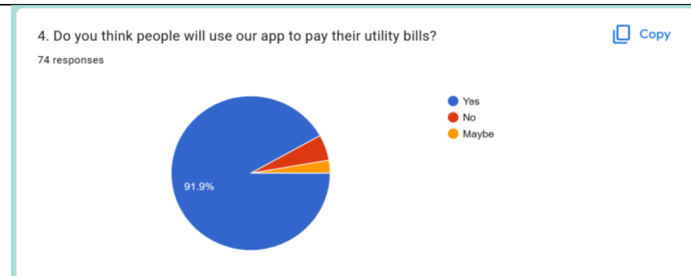
7.3.2. Cultural and Societal Impacts of the Proposed Design

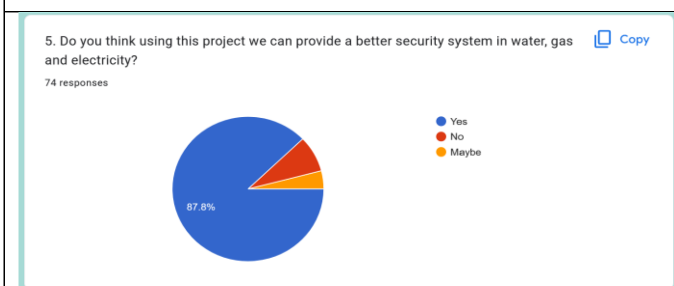
The population is now growing faster than ever. Residential areas and enterprises require much power for this reason. Several solutions have previously been developed to conserve energy from household electric meter devices. The energy meter gadget has historically been designed to fit into the consumers' Premises. Humans recorded the consumption rate and updated it in the system. This program Was heavily reliant on the operator. In order to capture the data, the operator soaked it at the users' locations. Information. It is a pretty challenging procedure. The suggested technique is utilized to prevent this situation. Automatically calculate the current consumption rate. The research will comfort the people who pay their utility bills manually. Besides, people can pay their utility bills from home. People can also check their balance and recharge packages for all utility bills. This research will be very much helpful for people and society. Some survey works were conducted and attributed to these. This technique is employed to get the most recent Utilizing IoT, and users receive alarm messages and consumption value. The meter has a unique network address and can be remotely programmed to scan the three utility consumptions at any desired frequency that the service providers can specify. It will be easy for consumers to pay the bill and identify the situation of the expenses. They can improve that system by making a prepaid system where consumers can recharge for once and can use the full utility. The system will make life easier for consumers. The designed technology in this research also significantly impacts the global health industry.

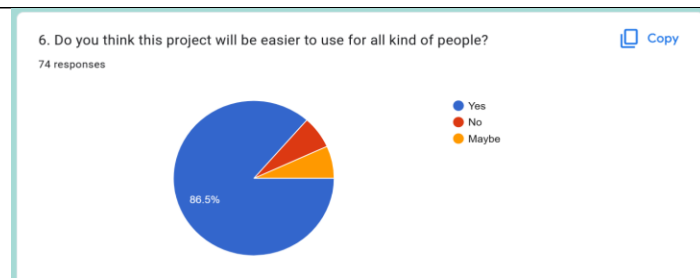


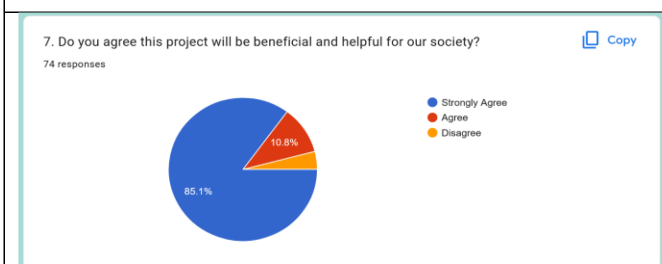


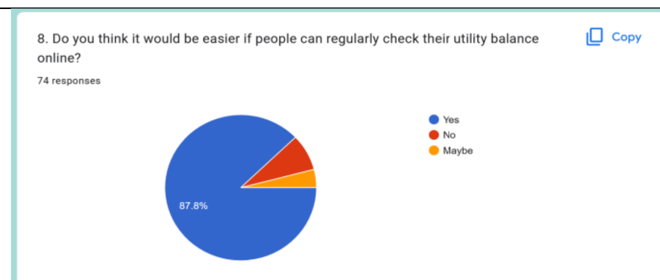












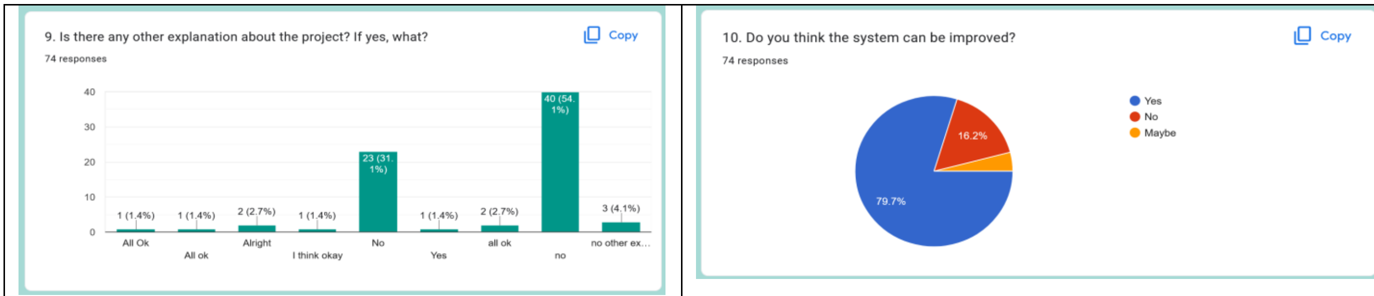


Figure 7.1: Survey Analysis from the patients.

7.4.Proposed Professional Engineering Solution

For developing this IoT-based total utility smart metering for households, individual utility metering systems have been designed, combining all systems into a single platform. It was simulated in an artificial environment to verify the model into precious. A Database architected has been developed to store the real-time data through a data acquisition system, and by those data, a future analysis has been performed. The author has been developing a mobile application using advanced block coding, which is cons traced on java-script. Various mathematical calculations are needed. A systemic formulation of different fundamental things of engineering is necessary here. Specialized engineering knowledge has to be applied to complete the research.

7.5. Limitations of the Work

A research has its own set of limitations. This research is not an exception to the rule. As a developing research ,

it will have some limitations. Nothing is perfect in this universe, particularly as technology advances. In this research, an IoT based smart all-in-one utility meter and management system based was designed and there are some limitations such as.

- The system might get complex User may find it difficult to comprehend the entire system.
- A 15-second maximum synchronous time limit for data logging to the server.
- Due to WIFI connectivity, two separate microcontrollers are utilized, which could raise the cost.
- The system may experience serial communication issues due to voltage fluctuations, which results in missing data.

7.6. Future Scopes

This research may undergo multiple additional phases to improve comfort, service, cost, and maintenance. There can be a more sophisticated alarming system designed when the balance will go down, a message will come to their phone, and a notification will come to their website so that people can add some money and cover the month. However, authors are developed some of the alarm features. Convolutional Neural Networking algorithms, Deep Learning, Artificial Intelligence, Augmented Reality, Three-dimensional Printing, Cinematic Rendering, and Digital Twin Technology techniques can improve precision, and people can predict next month's balance buy the package knowingly. Besides the Arduino microcontroller used to design the system, a sophisticated high-performance-based comptroller can be used to design an energy meter that will more accurately detect electrical, gas, and water energy use and gives additional information. The primary benefit of the smart meter is that it notifies us through message when our energy use exceeds the absolute limit.

7.7. Standard Requirements and Ethical Concerns

There were several ethical concerns with the research that needed to be taken into consideration when carrying out the research work.

7.7.1. Related Code of Ethics and Standard Requirements

This research corresponds with all applicable laws and ethical standards for engineers. This research has both hardware and software components, and it has no negative impacts. We had been able to accomplish the research 's goals. The proper reference was used to complete this research . All efforts were made to avoid plagiarism. When running the simulation and writing the code, strictly ethical standards were followed. All principles of ethics were properly maintained. Depending on the research s, each will have a separate code of ethics with varied areas of concern, but the five areas that firms commonly focus on are honesty, morality, professional competence, secrecy, and professional behavior. This research will fill up the criteria of the IEEE Code of ethics and many other standards. No animals were harmed while doing the research s.

7.7.2. Health and Safety

Health and safety define the quality of a research . this research is the safest. It was created by following some criteria so that no harmful issues have occurred. The research is completed on time and within the budget so that no financial problems arise. Some components will be used for protecting the device. Healthiness and safety guidelines and methodology were implemented perfectly before the research started.

7.7.3. Economy, Environment and Sustainability

Before doing the research , some steps should need to be considered so accurately like environmental impacts, economics, and also how sustainable the research is. These research s will fill all the impacts so accurately. Because there were no fuel or carbon emissions, it was both health & environmentally friendly. The research is made by thinking of all kinds of a user as it is completed at a low cost. So it is economical and also beneficial. In this prototype design, all the functions worked accurately. This also follows as the ability to satisfy one's own needs without affecting the ability of future generations to satisfy their own needs. As there were no emissions or other important things so this research turned out more sustainable.

7.8. Conclusion

An IoT-based all-in-one utility meter and management system have been developed. all of the research goals have been achieved. Despite various constraints, the research was completed. The research 's innovative features were evaluated. To determine the future scopes and make recommendations for developments, the final implications were examined. The Internet of Things (IoT) is also used to transport data parameters to the cloud, with ThingSpeak serving as the platform. As a result, the system's power consumption, maintenance, and complexity have all been minimized. The results of the research , surveys, and other analyses all lead to the large-scale manufacturing of this smart utility meter in addition to a management system that is crucial in the modern world. This research can be used in many different contexts, such as electrical fields, Desco, DPDC, WASA, and on a larger scale, such as smart metering in households. This might bring about a complete change in the world's economy, environment, and billing system

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Appendix A

Datasheet of the ICs used

Arduino Uno

Table 1 Data sheet of Arduino Uno

Ref.	Description	Ref.	Description
X1	Power jack 2.1x5.5mm	U1	SPX1117M3-L-5 Regulator
X2	USB B Connector	U3	ATMEGA16U2 Module
PC1	EEE-1EA470WP 25V SMD Capacitor	U5	LMV358LIST-A.9 IC
PC2	EEE-1EA470WP 25V SMD Capacitor	F1	Chip Capacitor, High Density
D1	CGRA4007-G Rectifier	ICSP	Pin header connector (through hole 6)
J-ZU4	ATMEGA328P Module	ICSP1	Pin header connector (through hole 6)
Y1	ECS-160-20-4X-DU Oscillator		

Figure 1 Arduino Uno

ZMCT103C CURRENT TRANSFORMER

Table 2: Data Sheet of current sensor

model	ZMCT103C
input current	0-10A（50Ω）
Rated output current	5mA at input 5A
turns ratio	1000:1
phase angle error	≤15′ (input 5A， sampling resistor 50Ω）
Accuracy class	0.2
Permissible error	-0.2%≤f≤+0.2% (input 5A， sampling resistor50Ω）

isolation voltage	4500V
installation	PCB mounting（Pin Length>3mm）
operating temperature	-40℃~+85℃

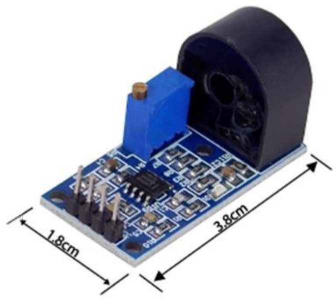

Figure 2 Current sensor

ZMPT101B VOLTAGE TRANSFORMER

Table 3: Data sheet of voltage sensor.

Model	ZMPT101B
Rated input current	2mA
Rated output current	2mA
turns ratio	1000:1000
phase angle error	≤20′ （input 2mA， sampling resistor 100Ω）
operating range	**0~1000V 0~10mA（sampling resistor 100Ω）**
linearity	≤0.2%(20%dot~120%dot)
Permissible error	-0.3%≤ f ≤+0.2%（input 2mA， sampling resistor 100Ω）
isolation voltage	4000V
application	voltage and power measurement
Encapsulation	Epoxy
installation	PCB mounting（Pin Length>3mm）
Operating temperature	-40℃~+60℃
Case Material	**ABS (Note: ABS CASE is NOT available for wave-soldering)**

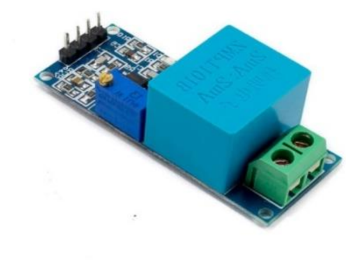

Figure 3: Voltage sensor

NodeMCU:

Table 4: Data sheet of NodeMCU

Microcontroller	**ESP8266 32 bit**
Size	**49mmx26mm**
Pin spacing	**0.9’’**
Clock speed	**80 Mhz**
USB to serial	**CP2102**
Operation voltage	**3.3v**
Input voltage	**4.5v-10v**

Figure 4: NodeMCU ESP8266

YF-S201 WATER FLOW SENSOR

Table 5: Data sheet of water flow sensor

parameters:apply	to automatic gas water heater
1. the minimum Rated working voltage	DC 5V-24V
2. Maximum working current	15 mA (DC 5V)
3. Operating voltage range	DC 5 to 18 V

4. Load capacity	≤ 10 mA (DC 5V)
5. Operating temperature range	≤ 80 ° C
6. Use humidity range of	35% ~ 90% RH (or frost)
7,allows pressure	or less1.75Mpa pressure

Figure 5: Water flow sensor

Appendix B

Code

```
#include<math.h>
#include <Adafruit_GFX.h>
 #include <SimpleTimer.h>
#include <Wire.h>
#include <SPI.h>
#include <LiquidCrystal_I2C.h>
#include<SoftwareSerial.h>
#include <ArduinoJson.h>
#define SAMPLES 300
#define ACS_Pin A1

SimpleTimer timer;
LiquidCrystal_I2C lcd(0x27,16,2);
SoftwareSerial nodemcu(5, 6);

/////////////Water Billing///////////////
#define FLOWSENSORPIN 2
volatile uint16_t pulses = 0;
volatile uint8_t lastflowpinstate;
volatile uint32_t lastflowratetimer = 0;
volatile float flowrate;
float WUP = 14.46;
float TWC = 0;
float WK = 0;

SIGNAL(TIMER0_COMPA_vect) {
uint8_t x = digitalRead(FLOWSENSORPIN);
```

```
  if (x == lastflowpinstate) {
    lastflowratetimer++;
    return;
  }
  if (x == HIGH) {

    pulses++;
  }
  lastflowpinstate = x;
  flowrate = 1000.0;
  flowrate /= lastflowratetimer;
  lastflowratetimer = 0;
}

void useInterrupt(boolean v) {
  if (v) {
    OCR0A = 0xAF;
    TIMSK0 |= _BV(OCIE0A);
  } else {
    TIMSK0 &= ~_BV(OCIE0A);
  }
}

////////////////////////Electric Bill//////////////////////

//****************Voltage*********************************

        int decimalPrecision = 2;
       // decimal places for all values shown in LED Display & Serial Monitor
        int VoltageAnalogInputPin = A2;
        float voltageSampleRead  = 0;
   /* to read the value of a sample in analog including voltageOffset1 */
```

```
        float voltageLastSample  = 0;
  /* to count time for each sample. Technically 1 milli second 1 sample is taken */
        float voltageSampleSum   = 0;
    /* accumulation of sample readings */
        float voltageSampleCount = 0;
      /* to count number of sample. */
        float voltageMean ;
   /* to calculate the average value from all samples, in analog values*/
        float RMSVoltageMean ;
    /* square roof of voltageMean without offset value, in analog value*/
        float adjustRMSVoltageMean;
        float FinalRMSVoltage;
/* final voltage value with offset value*/

        float voltageOffset1 =0.00 ;
        float voltageOffset2 = 0.00;

//----------------------------Current------------------------------------
        float High_peak,Low_peak;
        float Amps_Peak_Peak, Amps_RMS;

//&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&Bill
Parameter&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&

        float poweru = 0;                        /* Power used by the consuer*/
        float KWH    = 0;                        /* Total ussed unit*/
        float EUP    = 8;                       /* Per unit price of electricity */
        float EB     = 0;                       /* Total Electrical Bill*/


            /* 1.1 - Phase Angle Offset*/
```

```
        float currentOffsetRead =0;
        float currentOffsetLastSample =0;
        float currentOffsetSampleCount=0;
        float voltageOffsetRead =0;
        float voltageOffsetLastSample =0;
        float voltageOffsetSampleCount=0;

///////////////////////////////////Gas////////////////////////////////
       int Gin = A0;
       float gasfv =0;
       float gv =0;
       float GU =0;
       float GC =0;
       float GUP = 115;

////////////////////////////////////////////////////////////////////////
      float TotalBi =0;
      float NetBa =0;
      float Cbalance = 5000;
      int lamp = 6;
      int buzzer = 7;

//////////////////////Tranfer Variable////////////////////////////////
     float KWH_N;
     float EB_N;
     float GU_N;
     float GC_N;
     float liters_N;
     float TWC_N;
     float TotalBi_N;
     float NetBa_N;
void setup()
```

```
{
  Wire.begin();
  Serial.begin(9600);
  nodemcu.begin(9600);
  //Serial.print("Smart Billing!");
  lcd.begin();
  lcd.backlight();

  pinMode(FLOWSENSORPIN, INPUT);
  digitalWrite(FLOWSENSORPIN, HIGH);
  lastflowpinstate = digitalRead(FLOWSENSORPIN);
  useInterrupt(true);

  pinMode(lamp, OUTPUT);
  pinMode(buzzer, OUTPUT);
  pinMode(Gin, INPUT);



  pinMode(ACS_Pin,INPUT);



}

void loop()
{
 float liters = pulses;

//KWH=1;
//EB=2;
//GU=3;
//GC=4;
//liters=5.0;
```

```
//TWC=6;
//TotalBi=7;
//NetBa=8;



////////////////Water Billing///////////////////
 //Serial.println("//////////////Water Bill///////////////////");
  //Serial.print("Pulses: ");
  //Serial.println(pulses, DEC);

  liters /= 7.5;
  liters /= 60.0;
  WK = liters /10;
  TWC =TWC+ WK * WUP;

  //Serial.print("Water Used: ");
  //Serial.print(liters);
  //Serial.println(" L");
  liters = liters + WK*10;
  lcd.setCursor(0, 1);
  lcd.print("Water used: ");
  lcd.print(liters);

  //Serial.print("Water Bill: ");
  //Serial.print(TWC);
  //Serial.println(" Taka");

  delay(100);

/////////////////////////////////Electric Billing System //////////////////////////
```

```
//************************Voltage**********************************

 // if(micros() >= voltageLastSample + 1000 )                                    /* every 0.2
milli second taking 1 reading */
    //    {
          voltageSampleRead     =     (analogRead(VoltageAnalogInputPin)-     512)+     voltageOffset1;
/* read the sample value including offset value*/
          voltageSampleSum = voltageSampleSum + sq(voltageSampleRead) ;
   /* accumulate total analog values for each sample readings*/

          voltageSampleCount = voltageSampleCount + 1;
  /* to move on to the next following count */
      //    voltageLastSample = micros() ;
    /* to reset the time again so that next cycle can start again*/
      //   }

     //  if(voltageSampleCount == 1000)
  /* after 4000 count or 800 milli seconds (0.8 second), do the calculation and display value*/
       //  {
          voltageMean = voltageSampleSum/voltageSampleCount;
      /* calculate average value of all sample readings taken*/
          RMSVoltageMean = (sqrt(voltageMean))*1.5;
  // The value X 1.5 means the ratio towards the module amplification.
          adjustRMSVoltageMean = RMSVoltageMean + voltageOffset2;
       /* square root of the average value including offset value
*/
   /* square root of the average value*/
          FinalRMSVoltage = RMSVoltageMean + voltageOffset2;
  /* this is the final RMS voltage*/
          if(FinalRMSVoltage <= 10)
  /* to eliminate any possible ghost value*/
          {FinalRMSVoltage = 0;}
```

```
//          lcd.setCursor ( 0, 0 );
//          lcd.print("RMS");
//          lcd.setCursor ( 0, 1);
//          lcd.print("Voltages = ");
//          lcd.print(FinalRMSVoltage,decimalPrecision);
          //Serial.println(FinalRMSVoltage,decimalPrecision);
          voltageSampleSum =0;
      /* to reset accumulate sample values for the next cycle */
          voltageSampleCount=0;
      /* to reset number of sample for the next cycle */
        // }

//----------------------------Current------------------------------------------
  read_Amps();
  Amps_RMS = Amps_Peak_Peak*0.3536*0.06;     //Now we have the peak to peak value normally the formula requires only multiplying times 0.3536

      if(Amps_RMS < 0.2)
        {Amps_RMS =0;}
  //Serial.println(Amps_RMS);
  ////Serial.print("\t");
  ////Serial.println(Amps_Peak_Peak);
  delay(200);



    poweru = Amps_RMS * FinalRMSVoltage;
    KWH = ((KWH + (poweru * (0.1/60/60/1000))*1000)*0.05)+10+45;

   // KWH = KWH + (random(0.8,0.95) * (2.05/60/60/1000))*1000;
    if(KWH < 75)
        {EB = KWH*3.33;}
    else if(75< KWH < 200)
```

```
        {EB = KWH*5.14;}
    else if(200< KWH < 300)
        {EB = KWH*5.36;}
    else if(300< KWH < 400)
        {EB = KWH*5.63;}
   else if(400< KWH < 600)
        {EB = KWH*8.70;}
     else if(600< KWH)
     {EB = KWH*9.89;}


//          //Serial.println("/////////////Electrical Bill/////////////////");
//          //Serial.print("Power Used =");
//          //Serial.print(KWH);                              /* display current value in LCD in first row  */
//          //Serial.println(" U    ");
//          //Serial.print("Total Electric Bill =");
//          //Serial.print(EB);                               /* display current value in LCD in first row  */
//          //Serial.println(" Taka");


///////////////////////////////////////////////////////Gas Bill ////////////////////////////////////////////////////////////////////

          gasfv = analogRead(Gin)*5.0/1023;   //domestic LPG cylinders pressure avagrage 800 KPa and
flow rate around 2 Kg/H
          gv = gasfv/100;  // The amount of gas pass in that moment
          GU = GU + gv;           // the total amount of gas
          GC = GU * GUP;         // the total gas price

//           //Serial.println("/////////////Gass Bill/////////////////");
//           //Serial.print("The amount of gas used: ");
//           //Serial.print(GU);
//           //Serial.println(" Kg");
```

```
//          //Serial.print("The total gas bill: ");
//          //Serial.print(GC);
//          //Serial.println(" Taka");


/////////////////////////////////Total Utiity Bill /////////////////////////////////////
//
//         lcd.clear();
//         lcd.setCursor(0,0);
//         lcd.print("S. Utility Bill");
//         delay(2000);
//
//         lcd.clear();
//         lcd.setCursor(0,0);
//         lcd.print("Electricity bill");
//         delay(2000);
//         lcd.clear();
//         lcd.setCursor(0,0);
//         lcd.print("KWH : ");
//         lcd.setCursor(7,0);
//         lcd.print(KWH);
//         lcd.setCursor(12,0);
//         lcd.print("U");
//         lcd.setCursor(0,1);
//         lcd.print("Bill: ");
//         lcd.setCursor(7,1);
//         lcd.print(EB);
//         lcd.setCursor(12,1);
//         lcd.print("Tk");
//         delay(3000);
//
//
```

```
//          lcd.clear();
//          lcd.setCursor(0,0);
//          lcd.print("Gas bill");
//          delay(1000);
//          lcd.clear();
//          lcd.setCursor(0,0);
//          lcd.print("Gas U.: ");
//          lcd.setCursor(9,0);
//          lcd.print(GU);
//          lcd.setCursor(14,0);
//          lcd.print("Kg");
//          lcd.setCursor(0,1);
//          lcd.print("Bill  : ");
//          lcd.setCursor(9,1);
//          lcd.print(GC);
//          lcd.setCursor(14,1);
//          lcd.print("Tk");
//          delay(3000);
//            lcd.print(liters);
//          lcd.setCursor(15,0);
//          lcd.print("L");
//          lcd.setCursor(0,1);
//          lcd.print("Bill    : ");
//          lcd.setCursor(10,1);
//          lcd.print(TWC);
//          lcd.setCursor(15,1);
//          lcd.print("Tk");
//          delay(3000);
//          //Serial.println("S. Utility Bill");
//          //Serial.println("Electricity bill");
//          //Serial.print("KWH: ");
```

Appendix C

iThenticate Plagiarism Report

All Chapters.pdf

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