Faculty of Electronics & Computer Technology & Engineering

DEVELOPMENT OF COST-EFFECTIVE ENERGY METER MONITORING SYSTEM USING IOT FOR SMARTHOME

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Bachelor of Electronics Engineering Technology (Telecommunications) with Honours

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DEVELOPMENT OF COST-EFFECTIVE ENERGY METER MONITORING SYSTEM USING IOT FOR SMARTHOME

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DEDICATION

I dedicate this thesis to my beloved mother, Zainah Binti Isa, and father, Azahari Bin Abd Wahab, who always helped me through this long process of completing this project. I also dedicate this thesis to my kind lecturers and not forgetting to my all friends for their Love, sacrifice, encouragement, and best wishes along with all hardworking. Finally, I very thankful to my respected Supervisor Ts. Eliyana Binti Ruslan who always provided support and guidance from the beginning until I successfully completed my project and thesis without any difficulties.

ABSTRACT

Electricity is an essential requirement for various purposes, including domestic, industrial, and agricultural use. However, power theft has become a significant issue, causing substantial losses for electricity. The energy meter monitoring is an electronic device equipped with an energy meter chip to measure electric energy consumption and a wireless protocol for data communication. This system will continuously monitor and keep track of the electricity consumption for verification by setting a limit on their monthly usage. The primary objective of this project was to design a smart energy meter systems that employs instantaneous power calculation. This project mainly targets university students who choose to rent a house in the nearby campus. Some students have a habit of leaving their electricity running at home even when it is not required. To reduce that problem, the monitoring system programmed in the energy meter using the application phone software will monitor the current and voltage usage, also its cost. Additionally, users have the ability to turn off any appliances that are consuming excessive power to better manage their energy consumption. This system has a potential to be expanded for whole building energy usage monitoring, which could further lead to more accurate power bill calculation.

ABSTRAK

Elektrik adalah keperluan penting untuk pelbagai tujuan, termasuk kegunaan domestik, industri dan pertanian. Walau bagaimanapun, kecurian kuasa telah menjadi isu penting, menyebabkan kerugian besar bagi elektrik. Pemantauan meter tenaga ialah peranti elektronik yang dilengkapi dengan cip meter tenaga untuk mengukur penggunaan tenaga elektrik dan protokol tanpa wayar untuk komunikasi data. Sistem ini akan terus memantau dan menjejaki penggunaan elektrik untuk pengesahan dengan menetapkan had penggunaan bulanannya. Objektif utama projek ini adalah untuk mereka bentuk sistem meter tenaga pintar yang menggunakan pengiraan kuasa serta-merta. Projek ini terutamanya menyasarkan pelajar universiti yang memilih untuk menyewa rumah di kampus berhampiran. Sesetengah pelajar mempunyai tabiat meninggalkan bekalan elektrik di rumah walaupun tidak diperlukan. Untuk mengurangkan masalah itu, sistem pemantauan yang diprogramkan dalam meter tenaga menggunakan perisian telefon aplikasi akan memantau penggunaan arus dan voltan, juga kosnya. Selain itu, pengguna mempunyai keupayaan untuk mematikan mana-mana peralatan yang menggunakan kuasa berlebihan untuk mengurus penggunaan tenaga mereka dengan lebih baik. Sistem ini berpotensi untuk dikembangkan untuk pemantauan penggunaan tenaga keseluruhan bangunan, yang seterusnya boleh membawa kepada pengiraan bil kuasa yang lebih tepat.

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CHAPTER 1

INTRODUCTION

1.1 Background

Smart homes are gaining popularity with various research article. The main component of smart homes is internet to send or received a data. New protocol is developedfor sending wireless sensor which is infrared sensor, motion sensor and sensor signal over the internet which is the IoT (Internet of Thing) [1]. An energy meter monitoring system is a tool that measure the quantity of electricity usage at residence or an electrically powered tool. Energy meter monitoring system using IoT should have microcontroller and a sensor. The sensor can be used is current sensor. The sensor will release analogue signal where microcontroller able to read then the signal will process. When energy meter applied IoT thedata automatically save in the database. Electric utilities utilize electric powered meters set up at customers premises for billing and tracking purposes.

1.2 Addressing Global Warming Through Cost-effective Energy Meter Monitoring Project

Global warming is a major environmental issue that is having significant impacts on the planet. One of the key drivers of global warming is the release of greenhouse gases, such as carbon dioxide and nitrous oxide, that blanket the Earth and trap the sun's heat. This is where an energy meter project ca be a critical intervention. By monitoring energy consumption or electrical equipment usage and detect energy waste. The energy meter project helps in minimize the carbon footprint of buildings. An energy meter project can provide valuable data can be used to better understand the impact of global warming. Energy meter monitoring plays a vital role in addressing global warming in commercial buildings. By providing real-time data, facilitating energy efficiency optimization and promoting stakeholder engagement to conserve energy and contribute to a sustainable future. Overall, a cost-effective energy meter project can be a powerful tool in the fight against global warming providing crucial energy data usage to mitigate the impact of climate change. For example, transmission line is inclined to harm during bad weather. Warmer temperature, particularly hot summer temperature can affect energy transmission. When temperature rise, the carrying capacity of transmission line drop [1]. This risk is why a few utilities closed down. Besides, by considering the energy source and its associated emissions factors, energy meter data can be used to calculate carbon footprints and identify opportunities for emission reduction.

1.3 Problem Statement

Electricity is a fundamental thing recently.As a technologies are getting develop, and modern gadgets are being create to build life easier. The unrestrained daily electricity utilization causes the monthly charge increase until the user realizes that their electric usage exceed the budget. The project is focused on student where their electricity more than their monthly budget. Students have no idea how many kWh used on daily or monthly. They use more than they estimate for charging purposes especially when they have assignment. If it exceeds their monthly budget, that will be affect the financial. When there is no control over electrical usage, it means that there are no mechanisms in place to monitor or regulate the amount of electricity being consumed. This lack of control can occur in various settings, such as in student housing or during semester breaks when houses are vacant. To address these issues, it is important to implement systems that provide control over electrical usage. This can include installing smart meters systems that allow for monitoring and regulating electricity consumption. Additionally, raising awareness among students and residents about responsible energy usage can help mitigate wasteful practices .

1.4 Project Objective

The main aim of this project is to save electricity from waste by measuring the current and cost of electricity. Specifically, the objectives are as follows:

a) To design a handphone application to observe energy usage.
b) To monitor the initial reading meter application which is linked with the hardware reading meter.
c) To construct an energy meter hardware to prevent wastage of electrical energy.

1.5 Scope of Project

The scope of this project focuses on monitoring the energy meter reading and managing the use of electricity. A system that is easily installed, controlled, and monitored from all locations. Below are a few project scopes listed based on this study:

a) The project can only be used for student rental housing with an energy consumption of not more than RM200 montly.

b) The position of the hardware built cannot be relocated to any other part of the house or office.

c) With a limit set, the consumer needs to set a new estimated limit using the handphone application.

d) This project using the Arduino software IDE which is necessary order for the Node Mcu to function.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This part covered the entire project's literature review and the project development. Additional materials for this project, such as journals, articles, and books from prior works related to the project topic internet and technology advancements have made it easier for the users to monitor their electricity usage using a Cost-effective Energy Meter Monitoring system. To educate the public about the importance of conserving energy. The Internet of Things (IoT) platform used in this project allows it to read energy consumption data and manage the data in the cloud, as well as collect and analyze real-time energy usage and will be display in handphone application.

2.2 Cost-Effective Energy Meter Monitoring Project: Understanding it relevance in the content of Environment.

The Cost-effective Energy Meter Monitoring Project holds great significance in the context of the environment. Environmental concerns such as pollution, resource depletion, and climate change necessitate the need for sustainable energy practices and efficient resource management. The project's focus on cost-effective energy meter monitoring directly addresses these concerns and contributes to a healthier environment[1]. By implementing cost-effective energy meters, the project enables continuous monitoring of energy consumption in various settings, including households, businesses, and industries. This monitoring allows for a better understanding of energy usage patterns and helps identify areas of energy wastage. By detecting inefficiencies and anomalies in energy consumption, corrective actions can be taken promptly, leading to reduced environmental impact. The project promotes the efficient use of energy resources by encouraging users to adopt energy-saving practices. With access to real-time energy consumption data provided by the energy meters, individuals and organizations can make informed decisions regarding their energy usage. This not only helps in reducing energy waste but also contributes to the conservation of natural resources and a more sustainable future[2]. Moreover, the cost-effective nature of the project makes it accessible to a wider range of users, including those with limited resources. This inclusivity ensures that energy monitoring and conservation practices can be implemented at various levels, leading to a collective effort in preserving the environment.

2.3 Cost-effective Energy Meter Monitoring Project: Understanding it relevance in the content of Global Warming.

Through a review of the literature on energy meter monitoring technologies, this section will explore the ways in which it can contribute to our understanding of global warming and inform strategies for mitigating its impacts. Research has shown that energy meter monitoring can provide valuable data on value electrical usage that are indicative of the impacts of global warming. For example, studies have used energy meter monitoring can control the electric usage been increasing over time. A set installed sensor and smart device[3]. Investigation of load profiles of residential, commercial and industrial load segments to determine load factor (LF) and loss factor (LsF) were considered in the analytical models[4].

2.4 Evolution of Electricity Meter from the Past

In the earlier years, access to electricity was limited to a privileged section of society. However, technological advancements over time aimed to fulfill the needs of people worldwide. The evolution of electricity meters is closely linked to the contributions of researchers throughout history. Initially, electricity usage in the 1870s was primarily restricted to telegraphs and arc lamps. The invention of the electric bulb by Thomas Elva Edison in 1879 revolutionized the power energy market and made it accessible to the general public. In 1888, Oliver B. Shallenberger introduced his AC ampere hour meter. This marked a significant milestone in metering technology, leading to the improved quality of life for many individuals [5].

2.5 Traditional Electrical Meter and its type

Figure 2.1 Traditional Electrical Meter [6]

Figure **2.1** show electricity meters are devices designed to measure and indicate energy consumption through readings. Traditional meters have been in use since the late 19th century[7]. They facilitate the exchange of data between electronic devices in computerized environments for electricity generation and distribution purposes. In many traditional electricity meters, aluminum discs are employed to determine power usage. Traditional electricity meters only show the quantity of electricity consumed since someone (meter reader) last read the meter[8]. Smart electricity metering enhances the accuracy, features, visibility, privacy, and security of energy consumption data, while minimizing human errors and eliminating estimated bills. These benefits contribute to a more efficient and customer-centric energy management system[9].

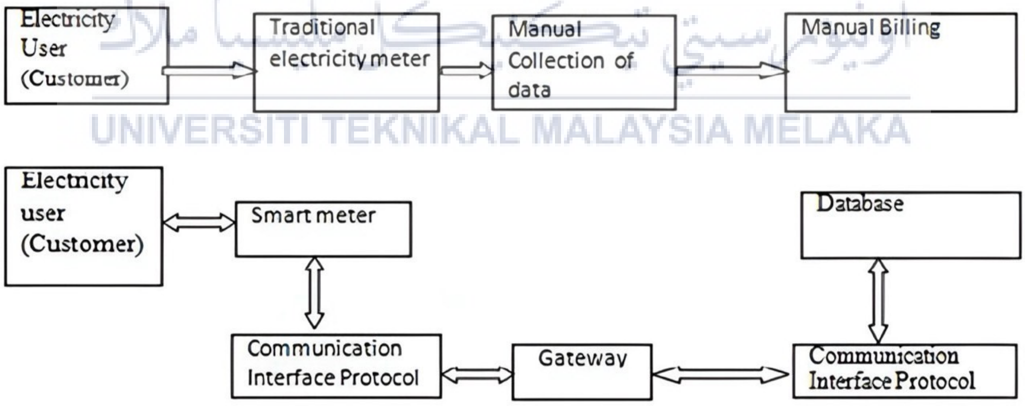

Figure 2.2 Traditional Vs Smart Electricity Metering Systems [10]

2.6 Smart Energy Meter

A smart meter system consists of various control devices and sensors that detect parameters and situations within a smart grid[11]. The system then either transfers the collected data to a central control centre or sends command signals to the devices installed in customers' homes[12]. By regularly collecting electricity consumption data from all customer devices, utility companies can efficiently manage electricity demand and response. They can also provide customers with valuable information on cost-effective methods for using their appliances[13].

Table 2.1 Comparison Traditional Meter & Smart Meter [14]

Property	Electro-Mechanical Meter	Digital Meter	Smart Meter
Accuracy	low	High	Very high
Theft detection	low	Possible at node level	Possible at network level
Communication	Manual reading	One way communication	Two way communication
Control	No	limited	full
Consumer Participation	nil	Less	high
Time Wise Reading	no	After a fix interval	according to requirement
Day to day billing info	Not possible	Not possible	Possible

Figure 2.1 shows a comparison of traditional meter & smart meter based on property, electromechanical meter, digital meter and smart meter. The comparison that we can see is accuracy, theft detection, communication, control, consumer participation, time wise reading, day to day billing info.

Furthermore, smart meters can be programmed to create schedules for operating home devices and controlling other appliances accordingly. For example, they can regulate lighting, heat water in swimming pools, manage air conditioning, and operate washing machines, among other tasks[14]. Integrating smart meters into the electricity grid allows utility companies to identify instances of electricity theft and unauthorized consumption, leading to improved power quality and distribution efficiency[15]. Therefore, in the future, smart meters will play a crucial role in monitoring the performance and energy usage characteristics of loads on the electricity distribution grid.

In Nigeria[16], the researchers emphasized the growing importance of managing electricity as a vital resource within any economy. They highlighted smart metering as a disruptive technology that has the potential to bring cost-saving benefits to both residential consumers and utility providers. Smart meters enable two-way communication between consumers and utilities, presenting numerous opportunities for both parties[17]. The research aimed to enhance the understanding of the value and significance of smart metering. It introduced smart metering and the general concept of electricity metering. The researchers proposed and implemented a design that could be compatible with various existing metering systems. The prototype developed in the study utilized GSM communication protocol to transmit consumption details to the utility, ensuring accurate billing. Moreover, the system allowed for remote connection and disconnection of consumers loads based on their priorities. The proposed design aimed to minimize the obsolescence of current electricity metering systems while reducing the implementation costs associated with smart metering[18]. Mohammad Kamrul Hasan has stated in an article "Internet of Things-Based Smart Electricity Monitoring and Control System Using Usage Data” [19]. To ensure efficient and responsible use of electricity in daily life, various existing systems for home electricity control have been explored. However, these systems have limitations such as higher error ratios and a lack of remote monitoring capabilities, as observed in the PMAS method[20]. To address these issues, this study introduces a smart monitoring and control system (SMACS) for household appliances[21]. The main objective of this system is to monitor the electricity usage of household appliances using hardware components and Internet of Things (IoT) techniques.

The prototype of the proposed system is developed using Arduino UNO, a liquid crystal display (LCD), an ACS712 current sensor module, relays, and AC sources. The data collected by the system is stored in cloud storage using ThingSpeak[22]. Additionally, a mobile application called Virtuino is used to access and visualize the data through graphical and numerical displays. The collected data is wirelessly transmitted using ZigBee technology through ZigBee Ethernet shield receivers connected to the serial port. This data is then transmitted from the Ethernet shield to the LAN using a WiFi router. The system enables remote control and monitoring of the collected data. The ZigBee Network is the development of a system that can help users be more aware of their appliances' consumption. Another focus of PMAS is storing data and monitoring[23].

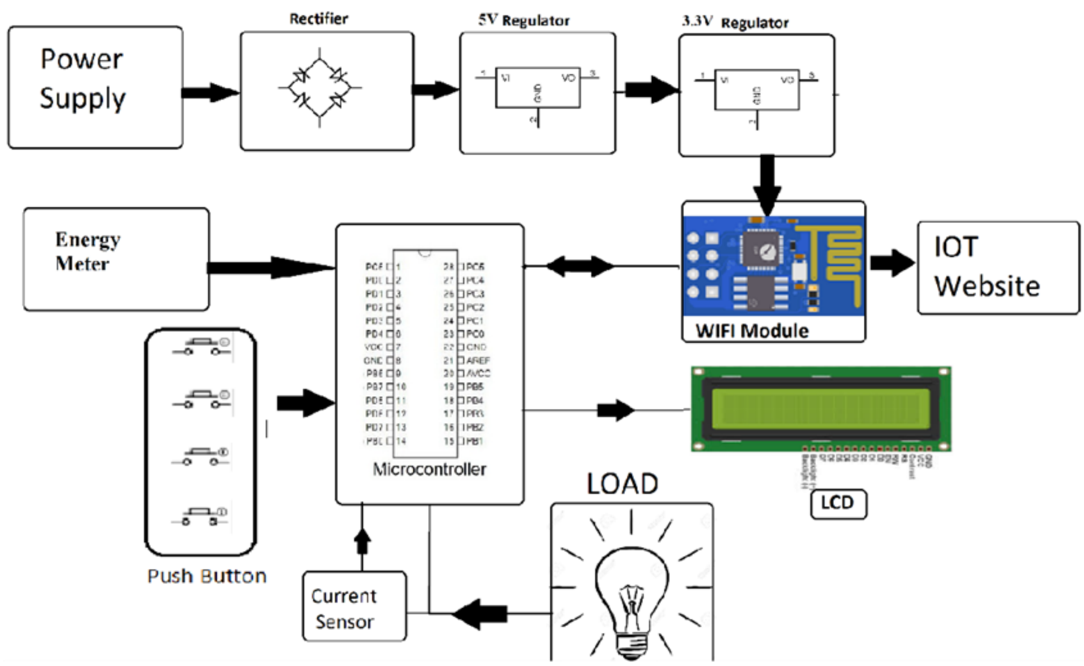

Figure 2.3 Block Diagram Smart Energy Meter

Figure 2.3 show the block diagram of the smart energy meter monitoring system which shows the connection of the equipment used. The energy meter serve as the input devices, providing data to the microcontroller. The microcontroller processes the input and coordinates the functioning of the system. The Wi-Fi Module enables connectivity to a wireless network, allowing for remote access and data transmission. Finally, the LCD Display visually presents the information and readings to the user[24].

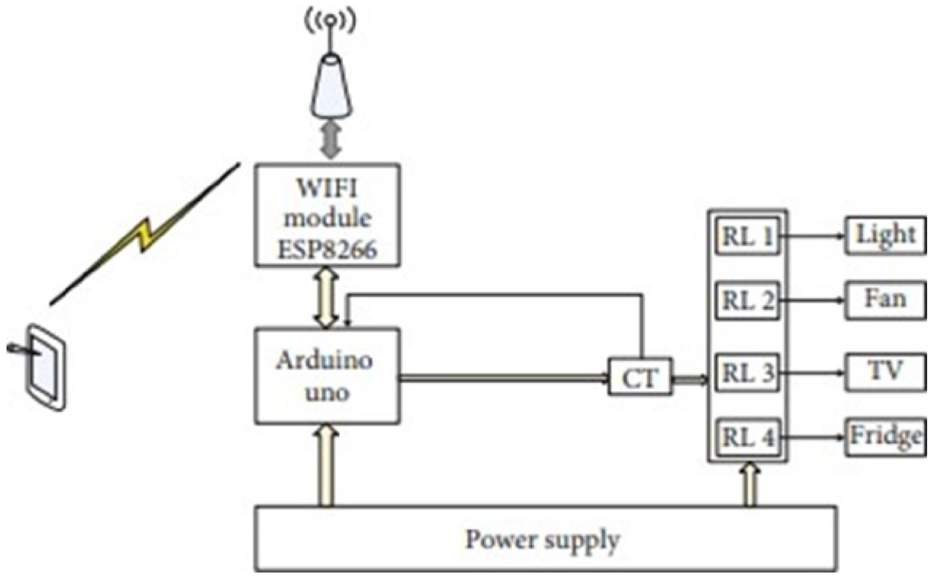

Figure 2.4 The block diagram of IoT-based control

Figure 2.4 shows the implementation involved the utilization of Arduino UNO along with the ESP 8266 Wi-Fi module and a clamp current transformer with a relay for managing appliances. For communication and home control, GSM-based communications required the introduction of a different AT command. However, a drawback of the system is the absence of a user interface for consumers to display information, necessitating the memorization of AT commands to control connected devices.

2.7 Energy Consumption

The scheme proposed in modelling an adjustable autonomous multi-agent internet of things system for elderly smart home is controlling devices within a smart home, categorizing them as active or passive and utilizing agents attached to each appliance[25]. This system is specifically tailored for elderly individuals, so its application for younger adults may require additional considerations due to differences in usage frequency. While the accuracy of detecting devices is tested, other crucial factors such as activity classification during daytime and night time and human-appliance interaction are not addressed, limiting the system's autonomy. Another system presented in [26] focuses on fulfilling the energy requirements of smart homes using renewable energy sources. The smart homes communicate with the smart grid for energy demand, and the grid supplies energy from storage or renewable systems. However, the proposed work lacks a machine learning technique to handle uncertainties associated with renewable energy sources, particularly when weather conditions are unfavorable. Autonomous smart homes require a multi-phase system, encompassing human activity classification and appliance scheduling. While existing literature offers machine learning mechanisms to improve activity classification, complete automation of all aspects within a smart home necessitates significant modifications to the existing infrastructure. Therefore, researchers should prioritize areas that provide maximum societal benefits, such as automation. In this context[27], proposes a Home Energy Management System to optimize electricity consumption costs using genetic algorithms, tested with distributed power systems and electric vehicles. However, the authors do not consider the user's comfort level in their objective functions. In situations where a home user sets a demand for electricity from a smart grid and the grid cannot meet that demand, the user's discomfort level may increase.

Table 2.2 Comparison Energy consumption

Reference	Energy Consumption	User Comfort	Advantages	Disadvantages
Smart energy coordination of autonomous residential home[26]	No	Yes	• Efficient automatic control of things for elderly people • Multi-agent architecture	• Inefficient Real-time performance • Data analytics needed
Home energy management optimization method considering potential risk cost [27]	Yes	No	• • Effective coordination and synchronization of energy systems • • Significant reduction in energy consumption cost.	• Renewable energy sources are used without considering the climate variation

How IoT is utilized to deliver energy savings. [28]	Yes	Partially satisfied	• A two-stage optimization achieved • The cost of electricity is significantly reduced	• The environmental factor are not considered • Consumer dissatisfaction increases unsatisfied electricity. demand.

2.8 Energy Wastage

It is well understood that reducing waste leads to cost savings. Investors are actively focusing on energy-saving solutions, which benefit both consumers and the energy industry[28]. With the help of the Internet of Things (IoT), the consumption of electricity by home appliances becomes a crucial aspect that requires constant monitoring. Various sensors can be installed to detect energy consumption, such as temperature sensors, weight sensors, or air pressure sensors[29]. The system offers remote control capabilities, allowing convenient actions to be performed either through a Wi-Fi connection or using bluetooth for short-distance control[30].

In Ghana[31], one of the significant contributors to energy wastage is the lack of remote access and control over appliances[32]. To address this issue, this project introduces a remote control system for electrical appliances and lighting, based on the Global System for Mobile Communication (GSM). The system offers comprehensive control over the connected interface, enabling home owners to manage appliances remotely. By utilizing a GSM Shield, the system can receive Short Message Service (SMS) commands from the homeowner's mobile phone[33], allowing an arduino microcontroller to execute actions such as turning appliances ON or OFF, such as fans, lights, air conditioners, and the main power supply. The system reads the received SMS and responds accordingly. Unlike commercially available products that rely on internet connectivity, this GSM-based system ensures true mobility and security. Home owners can control their household appliances from anywhere using their mobile phones, while unauthorized access to the appliances is prevented. An essential aspect of this system is the inclusion of security measures that notify homeowners of any intrusion through SMS alerts, utilizing GSM technology[34]. This GSM-based home appliances control system is highly recommended for implementation in every home in Ghana, as it effectively addresses the prevalent issue of energy wastage.

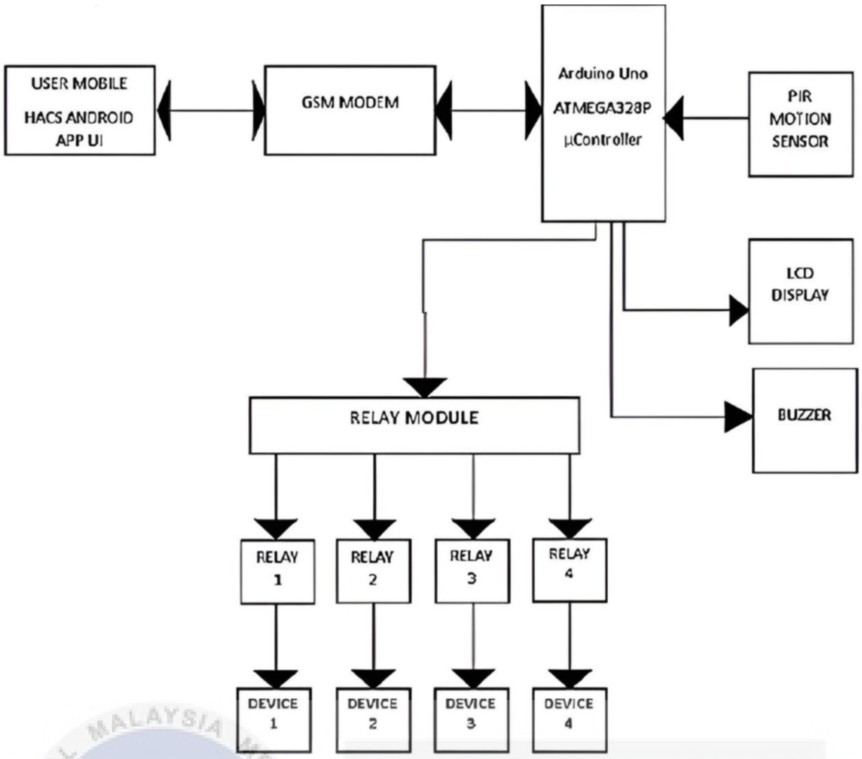

Figure 2.5 System Architecture

2.9 Energy Theft

Power theft poses a significant problem for consumers as it results in a situation where consumers are essentially benefiting from electricity without paying for it, leading to an imbalance between the demand for power in a home and the actual supply received. The emergence of IoT technology has brought about advancements that enable swift detection of power theft [35]. Through the reception of alert messages, the system can swiftly identify the source of unauthorized power loss, linking it to the energy meter and subsequently disconnecting the power supply to prevent further theft [36]. Smart meters play a crucial role in combating power theft by detecting any discrepancies or anomalies in the programmed system [37]. In the absence of an energy meter, homeowners and customers may remain oblivious to the fact that their power supply is being stolen.

However, with the implementation of an energy meter, users gain access to daily and monthly data readings, eliminating the need for extensive human labor. This user-friendly application or website serves as a platform to conveniently display the collected energy consumption data [38].

Existing methods for detecting power theft have shown vulnerabilities, making it relatively easy for thieves to bypass detection. However, this issue can be addressed by incorporating a sensor into the energy meter that promptly notifies the homeowner of any suspicious activity or tampering attempts [39]. While some systems may send power consumption data exclusively to the electrical company, neglecting to provide homeowners with this information can lead to a lack of transparency and negative user experience. It is crucial to raise awareness among users regarding their electrical consumption by implementing mechanisms that proactively alert them about their energy usage patterns.

According to article titled "IoT Based Energy Meter Reading, Theft Detection and Disconnection," this project focuses on developing and implementing an energy meter using IoT principles, with the PIC16F877A microcontroller as its core component. The main goal is to establish an automated system that minimizes human intervention in electricity maintenance tasks [40]. Through an interfacing circuit, the energy meters are connected to the PIC microcontroller, and an optocoupler sensor generates interrupts whenever the meter LED flashes. By comparing the readings obtained from both the main energy meter and sub energy meters, instances of theft can be identified. If any discrepancies are found between the values, a notification indicating theft is displayed on both the LCD display and a web page dedicated to the system. This web page can be accessed globally using the consumer number provided by the supply authorities, allowing consumers to conveniently monitor their energy usage and effectively manage power consumption. The hardware interface circuit consists of the PIC16F877A microcontroller, MAX232, LCD display, and optocoupler.

In article "A Survey on IoT Based System for Smart Home Automation and Theft Control" [41]. This journal article explores the application of Internet of Things (IoT) technology in the domains of smart home automation and theft detection. Smart home automation aims to enhance user convenience and security by integrating various sensors to monitor and control objects within a three-dimensional space. These sensors can measure parameters such as temperature, humidity, pressure, light, noise, and air quality. To implement a smart home system, this project used a Raspberry Pi kit, which includes sensors such as temperature, motion, and light sensors connected to the kit for theft detection, a face recognition sensor is employed to recognize individuals, and the captured images are displayed on the user's smartphone. Access can be granted through fingerprint authentication, and live video streaming is provided for enhanced security. All of these devices are connected to the internet, enabling users to monitor and control them remotely, irrespective of time and location. The article thus presents a comprehensive overview of various aspects of home automation and theft control using IoT technology.

2.10 Comparison Of previous Project Smart Meter

Table 2.3 Comparison for previous research paper

Author	Title	Component	Featured	Method
Internet of Things-Based Smart Electricity Monitoring and Control System Using Usage Data [19].	IoT Based Energy Meter Reading	-ATMEGA328 - LDR senser -WI-FI Module -LCD display	-Scalability -More security	- Using program of language HTML. browse will receive HTML documents. -using wifi module
A new method to predict contractile force for pneumatic muscle actuators [20].	Internet of Things-Based Smart Electricity Monitoring and Control System Using Usage Data	-Arduino UNO -ACS712 current sensor module -Relays -zigbee apps	-High power -Cost-effective solution	-Transmit the data using Zigbee

An integrated system for smart-home control of appliances based on remote speech interaction [32].	GSM-Based Home Appliances Control System (HACS) for Domestic Power Users in Ghana	- PIC16F877A microcontroller -Lcd -Gsm Moderm	-Remote energy monitoring. -Consumption using Bluetooth	This project introduces a remote control system for electrical appliances and lighting, based on the Global System for Mobile Communication (GSM).
A survey on iot based system for smart home automation and theft control [41].	A Survey on IoT Based System for Smart Home Automation and Theft Control.	-Raspberry pi -Esp8266 wifi module -Temperature sensor -qToggle App	-High-speed -Cost-effectiveness	-The device is based on ESP8266 and integrates a high current switch that can be used to remotely cut off energy supply, in case of an emergency using qToggle

2.11 Summary

The focus in designing the project is based on the use of energy meters, energy consumption, energy wastage, and energy theft. These drives ensure that the energy meter is used at its most efficient and convenient for home tenants and users to monitor and control the supply and demand of electricity that flows in and out of a home.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter explains the processes and steps of development of cost-effective energy meter monitoring system using IoT for smart home. All technical parts will be starting from the explanation of block diagram and the flow chart. Besides that, the function of hardware design and development of software for the project are explained. All the flow and steps are taken from start to the end in process development. The effectiveness in implementing the cost-effective energy meter monitoring is important considering that students are on a budget. Electricity is the main supply in terms of voltage and current that will be measured using cost-effective energy meter monitoring.

3.2 Methodology

The method used to calculate the supply of electricity through the energy meter is a current meter where it will display the values. The method is studied to implement to save cost, and time and make it user-friendly. It is through programmed software and hardware design that it will be made effective. The creation of the project is shown in Figure 3.1 as a guide for this project. Then, read the electrical consumption from the loads and check whether it exceeded the limit or not. The flow chart of the project explains the entire phase of the method to meet the final goals. A flowchart is constructed to visualize the project flow, and the process is clearer and more understand. The project is split into two sections, software, and hardware.

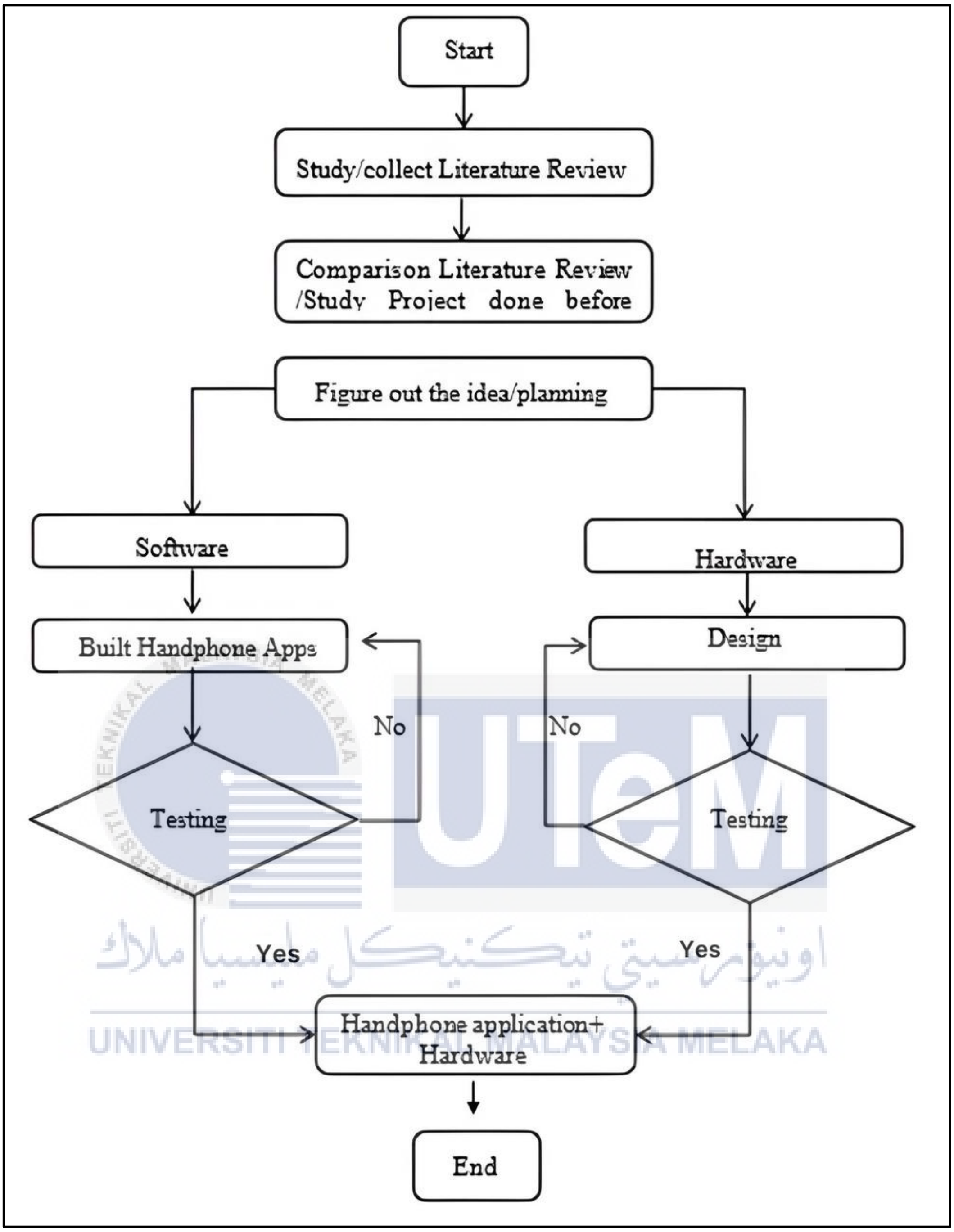

Figure 3.1 Project Flow Chart

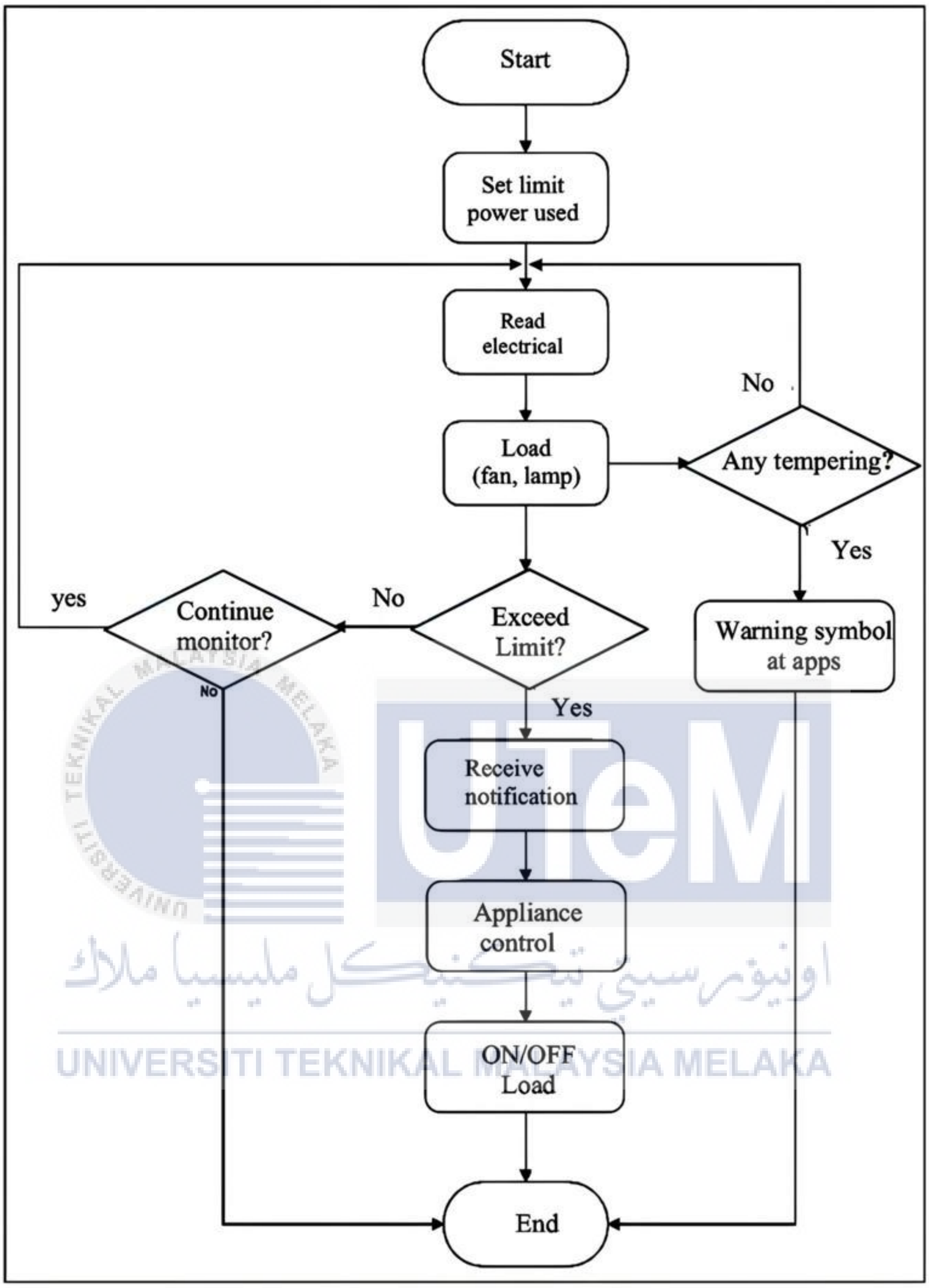

Figure 3.2 Flow chart Project

3.2.1 Experimental setup

The meter collects data continuously, which is then presented in the application software. This enables the display of usage data on a daily and monthly basis, as well as the monitoring of electricity costs. The system includes a programmed feature that helps tenants or home owners estimate and control their power usage, notifying them when they exceed the set limit. By implementing this feature, users can become more efficient in managing their energy consumption at home. The circuit design of the system, illustrated in Figure 3.3 show the connection of each component to the Node Mcu Esp8266.

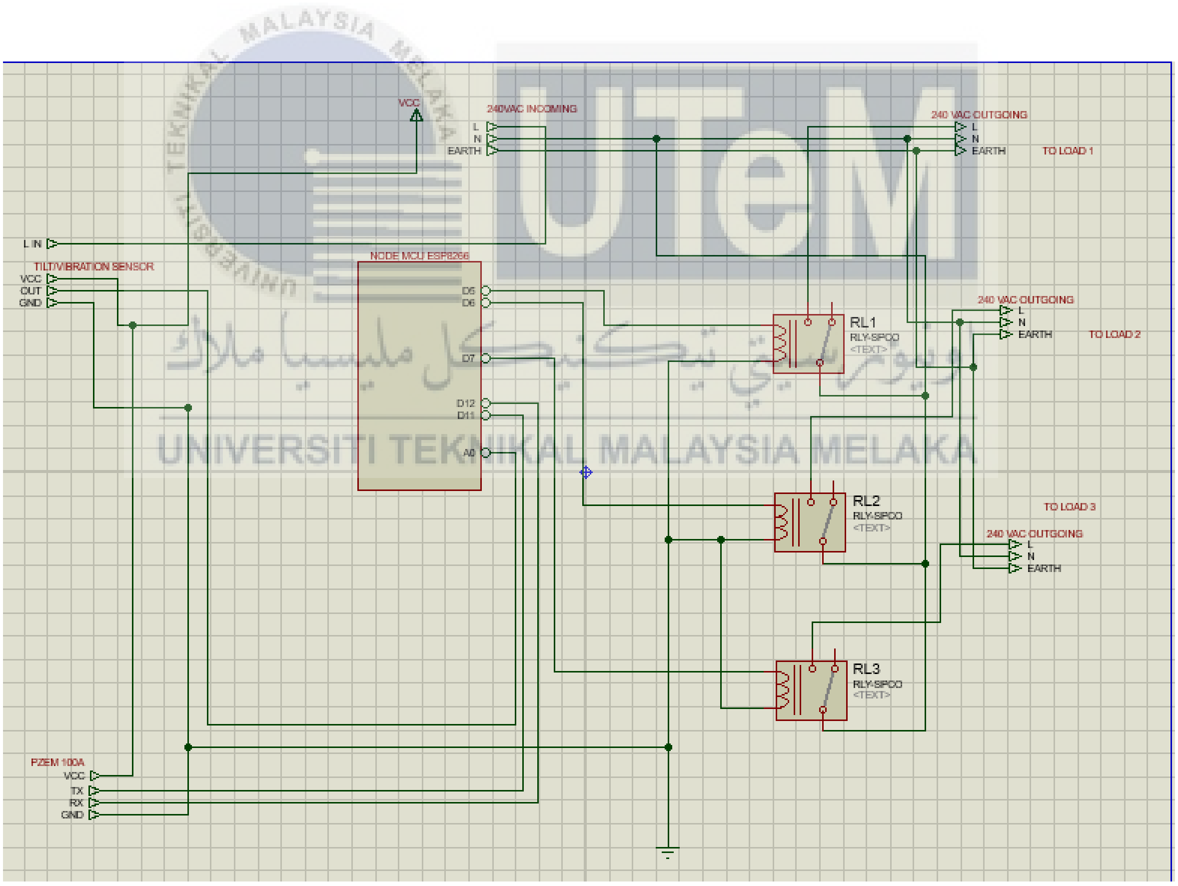

Figure 3.3 Circuit Design Cost-Effective Energy Meter

3.2.1.1 Parameter

A parametric approach for cost-effective energy monitoring consists of several steps. First, the system using a current sensor to detect energy consumption. A wireless communication link is established between the user and the energy meter using the Esp 8266 Wi-Fi module. Users can access comprehensive information about power consumption. With this app, users can avoid unpleasant surprises when they receive monthly electricity bills. Through daily, weekly, and monthly usage reports, users can stay informed and have one less thing to worry about. In addition, users are given the ability to analyze their budget energy consumption.

3.2.1.2 Hardware Component

There are a few components used to ensure that the hardware can carry out its functions. There are Esp8266 Node Mcu, Relay and Pzem-004T 100 Ampere. Node Mcu Esp8266 is a Microcontroller which can control the flow of current in the hardware system. The current, power, energy, frequency and power factor will be measured by the Pzem-004T 100 Ampere. The Pzem-004T sensor is utilized to measure the current flow, offering a broad range of coverage and enhanced accuracy compared to other sensors available in the market. The Pzem-004T meter is suitable for assessing power, energy, voltage and current level.

3.2.1.3 Node Mcu Esp 8266

Figure 3.4 Node Mcu Esp 8266

The NodeMCU, incorporating the ESP8266 module, has become linked in the IoT to its cost-effectiveness, user-friendly design, and adaptability across a range of applications. It finds extensive use in prototyping, amateur projects, and is even employed in certain commercial IoT products. This system makes use of this Wi-Fi module to link the software handphone application using MIT Invertor which will lead to improved functionality for the programmed.

3.2.1.4 Pzem-004T 100 Ampere

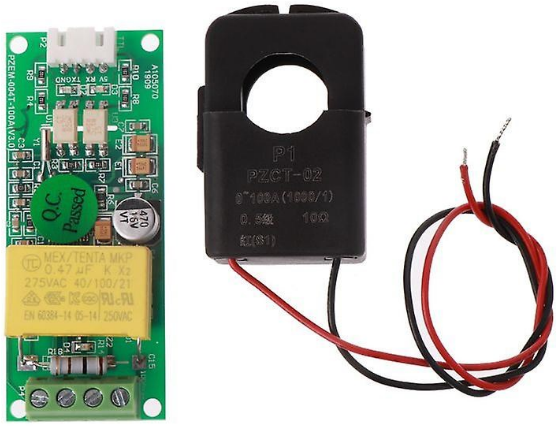

Figure 3.5 Pzem-004T 100 Ampere

The PZEM-004T multi-function AC power monitor is widely used in projects involving electrical consumption measurement. It can measure four interconnected electrical parameters: voltage, current, power, and energy. This compact PZEM-004T circuit is particularly effective for measuring AC (RMS) voltage, current, and power in single-phase setups. It seamlessly integrates with Arduino and other hardware through the provided code library.

3.2.1.5 Vibration Sensor Sw-240

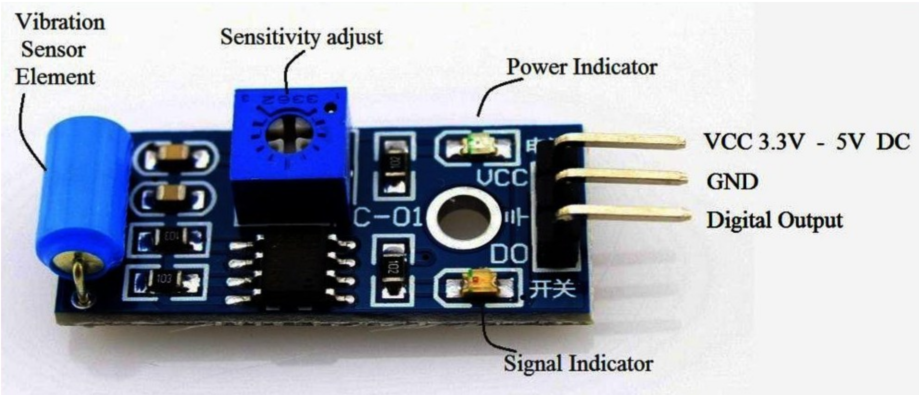

Figure 3.6 Vibration Sensor Sw-420

The SW-420 vibration sensor module is an affordable device that includes the SW-420 sensor and LM393 comparator. It incorporates an SW-420 Vibration Sensor, a 10K potentiometer for adjusting sensitivity, and an LM393 comparator that generates a stable digital output. The LM393 comparator utilizes a preset to detect vibrations in the environment and retains its state accordingly. If vibrations are detected, it outputs a logic high signal; otherwise, it stays in its default logic low state. This module provides a convenient and user-friendly interface for various applications and commercial uses. It support 3.3V-5V power . The DO pin will be LOW when there is no vibration, and indicator LED will lit up.

3.2.1.6 Relay Module

Figure 3.7 Relay Module

Figure 3.7 is an electrically operated switch is essentially a relay, relays require only a small amount of current to operate. They feature input terminals for control signals and contact terminals. The core component of a relay is an electromagnet. Relays are particularly useful for controlling high-power circuits. In our system, we primarily utilize solid-state relays due to their favorable characteristics. We connect the supply devices to the Arduino Uno microcontroller and energy meter using relays. In case of meter tampering, relays are employed to disconnect the load supply, ensuring the integrity of the metering system.

3.2.1.7 Energy Kwh Meter

Figure 3.8 Energy Kwh Meter

Figure 3.9 is a component that use in Hardware part. Energy watt meter can measure electrical power consumption. It can measure a variety of electrical parameter from current, voltage to resistance continually. In this project , a single-phase energy meter had chosen that can meet a requirement such as accuracy, voltage reading and current range also the cost.

3.3 Limitation of proposed methodology

The limitation is that it can only support households within a limited range. It is not a portable meter where its position can be moved from one place to another. The data will be stored in a cloud that has limited storage and will be saved in history in the apps. It can be easy for consumers to know the limitation of electrical. The cost-effective energy meter monitoring system is only to calculate the electricity and control appliance and the data will relate initial reading with apps.

3.4 Summary

This chapter presents the proposed methodology to develop a new, effective, and integrated approach to estimating the supply of electricity to homes. The primary focus of the proposed methodology is on reaching the expected outcome of measuring and calculating the amount of electricity supply and demand in a household. The methods that are applied, the output is aimed to be effective and convenient. The accuracy in recording the data received from the meter and making sure that it can accommodate a household. In summary, the implementation of the cost-effective energy meter monitoring using IoT, microcontroller Arduino is practical when all hardware and software component are correctly interconnected and meet the specified requirements. Careful attention will be given to addressing any encountered errors or challenges so as to achieve the project's objectives successfully. Discovering suitable methodologies for gathering required data has been one of the most challenging aspects of executing cost-effective energy meter monitoring.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This section outlines the outcomes and analysis of creating a monitoring system for smart energy meters using IoT, specifically designed for student rental houses. Employing the Node Mcu & Esp8266 Wi-Fi module connected to the Mit Invertor application, the smart energy meter is employed to establish a methodology for estimating the current electric consumption rate and associated costs, which users can monitor. As part of the project's scope, the results will be recorded, and graphs will be generated to conclude this report. The viability of an Internet of Things (IoT) system monitoring approach for power consumption was confirmed through a case study, and the study was successfully executed.

4.2 Software Application Design

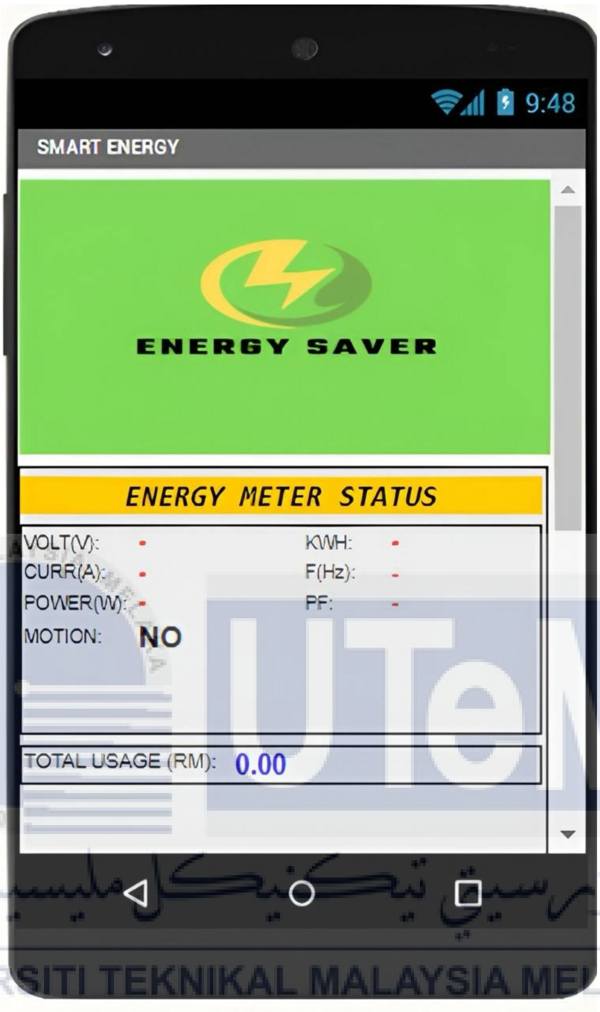

Figure 4.1 Design application using Mit Invertor

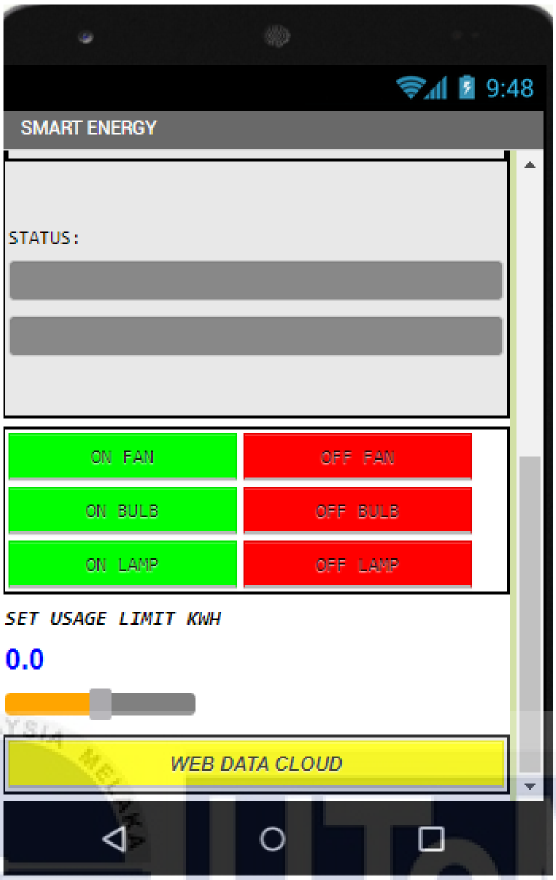

Figure 4.2 Design application using Mit Invertor

4.3 Results and Analysis

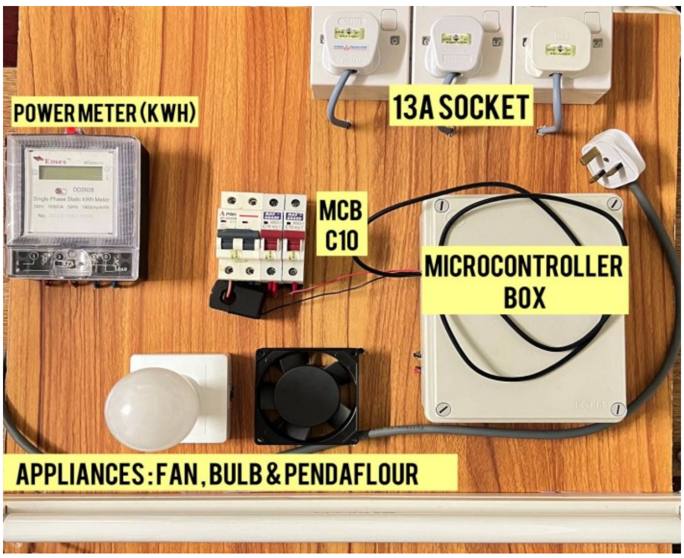

Figure 4.3 Energy Meter Monitoring System prototypes Design

Table 4.1 The data when the Fan on for 1 day

APPLIANCE ON	TIME (HOUR)	POWER (KWH)	CURRENT	TOTAL BILL (RM)
FAN	8AM	0.125	0.155	0.01
	9AM	0.135	0.145	0.012
	10AM	0.148	0.145	0.012
	11AM	0.165	0.154	0.013
	12PM	0.185	0.191	0.016
	1PM	0.288	0.211	0.017
	2PM	0.288	0.211	0.018
	3PM	0.292	0.318	0.019
	4PM	0.299	0.425	0.021
	5PM	0.321	0.468	0.025
	6PM	0.357	0.552	0.028
	7PM	0.387	0.552	0.032
	8PM	0.425	0.468	0.04
	9PM	0.463	0.628	0.045
	10PM	0.463	0.765	0.05
	11PM	0.466	0.812	0.06
	12AM	0.471	0.812	0.07

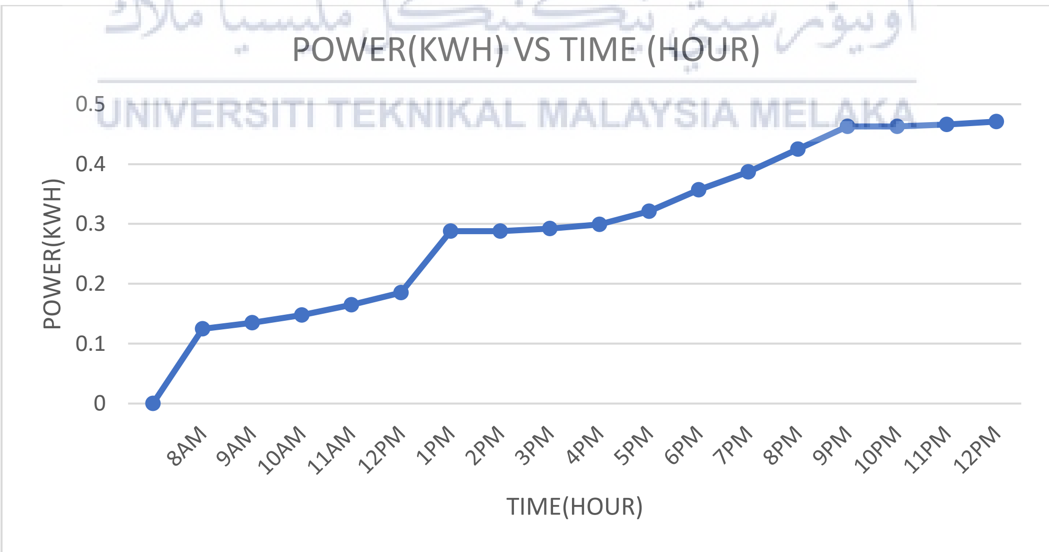

Figure 4.4 The graph Power Versus Timer for 1 day

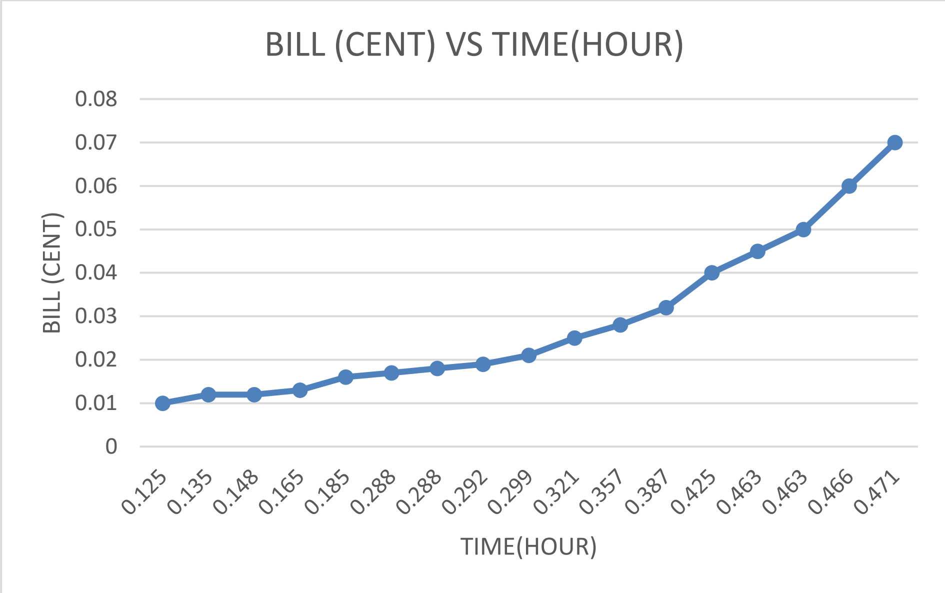

Figure 4.5 The graph Bill Versus Timer for 1 day

Figure 4.3, show the prototype of Smart Energy Meter using Iot which use a microcontroller Node Mcu to control the system and connect with Mit Invertor application to control the appliance and power consumption. In Table 4.1, give the data when the fan is on. The table presents data corresponding to hours when the appliance is active, providing details such as current, power in watts, power in kilowatt-hours, and the corresponding bill reading. The graphical representations in Figure 4.4 and Figure 4.5 are generated from this data. Figure 4.4 illustrates a direct correlation between power consumption and the duration of operation, indicating an increase in power usage over time. Meanwhile, Figure 4.5 demonstrates that higher power consumption results in an elevated billing amount.

Table 4.2 The data when the Fan and Bulb on for 1 day

APPLIANCE ON	TIME (HOUR)	POWER (KWH)	CURRENT	TOTAL BILL (RM)
FAN AND BULB	8AM	0.125	0.155	0.011
	9AM	0.155	0.165	0.013
	10AM	0.160	0.188	0.014
	11AM	0.165	0.190	0.015
	12PM	0.170	0.195	0.016
	1PM	0.205	0.211	0.017
	2PM	0.215	0.213	0.018
	3PM	0.222	0.318	0.020
	4PM	0.244	0.425	0.025
	5PM	0.260	0.468	0.030
	6PM	0.352	0.552	0.035
	7PM	0.370	0.552	0.042
	8PM	0.395	0.640	0.045
	9PM	0.442	0.652	0.055
	10PM	0.480	0.718	0.050
	11PM	0.554	0.821	0.070
	12AM	0.585	0.912	0.090

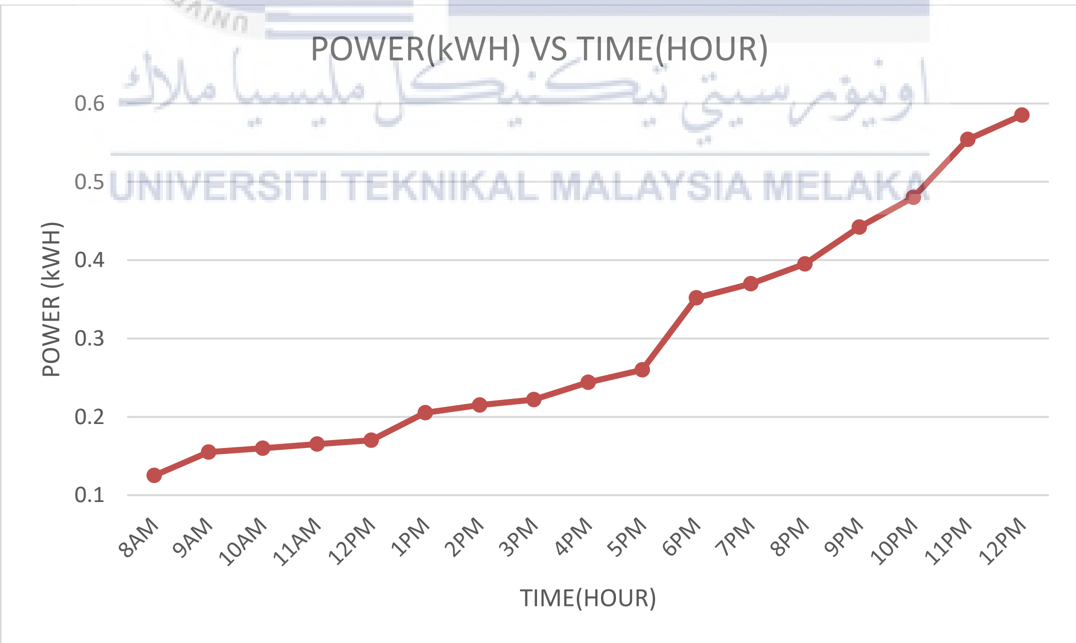

Figure 4.6 The graph Power versus Timer for 1 day

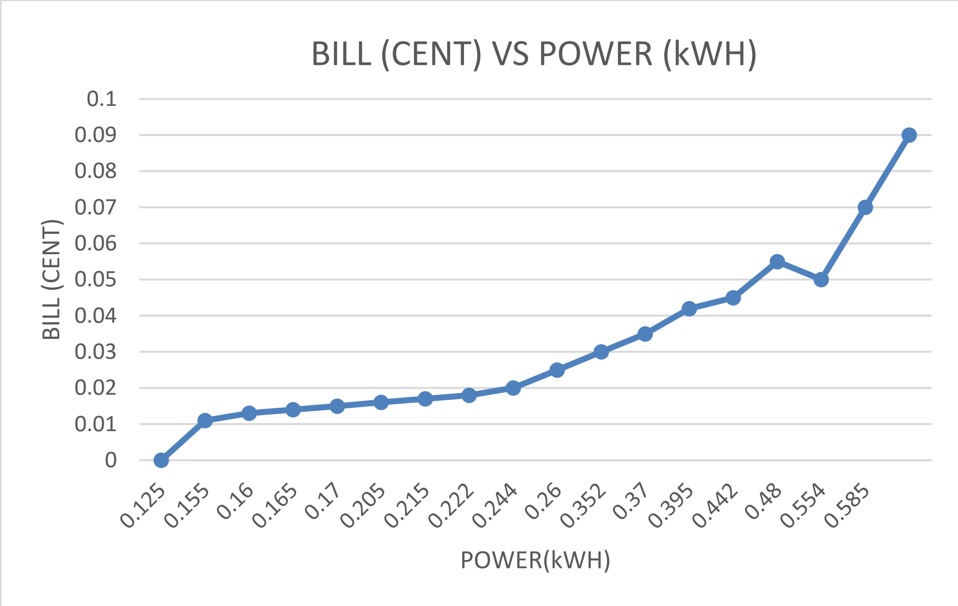

Figure 4.7 The graph Bill versus Power for 1 day

In Table 4.2 , the highest power usage observed around midnight. This suggests a peak in energy demand during the late evening hours. The current column follows a similar trend, reflecting the correlation between power consumption and the electric current flowing through the system.

Notably, from Figure 4.6 at 5 PM to 12 AM, there is a consistent and elevated level of power and current usage, indicating sustained demand during the evening hours. The fluctuations observed in power consumption from 5 PM to 6 PM, followed by an increase from 6 PM to 7 PM, may suggest specific activities or appliances contributing to variability in energy consumption during these early evening hours.

In conclusion, this analysis highlights the significance of considering the time of day when evaluating energy usage patterns. The data suggests that the late evening, around midnight, represents a critical period of heightened energy demand. Understanding these patterns can guide strategic decisions for optimizing energy efficiency, reducing costs, and potentially identifying opportunities for load management or the integration of renewable energy sources during periods of lower demand. Besides, from Figure 4.7 show, when more appliances are used, the more power consumption will produce and will increase the bill for every minutes usage.

4.4 Analysis Data for 1 Weeks

Table 4.3 The data for 1 weeks

DAYS	DAYLIGHT POWER (KWH) USAGE OF FAN	NIGHT POWER (KWH) USAGE OF FAN & LAMP
MONDAY	7.225	10.120
TUESDAY	7.668	10.650
WEDNESDAY	7.985	11.550
THURSDAY	8.557	12.520
FRIDAY	9.225	13.650
SATURDAY	9.555	15.857
SUNDAY	9.832	18.215

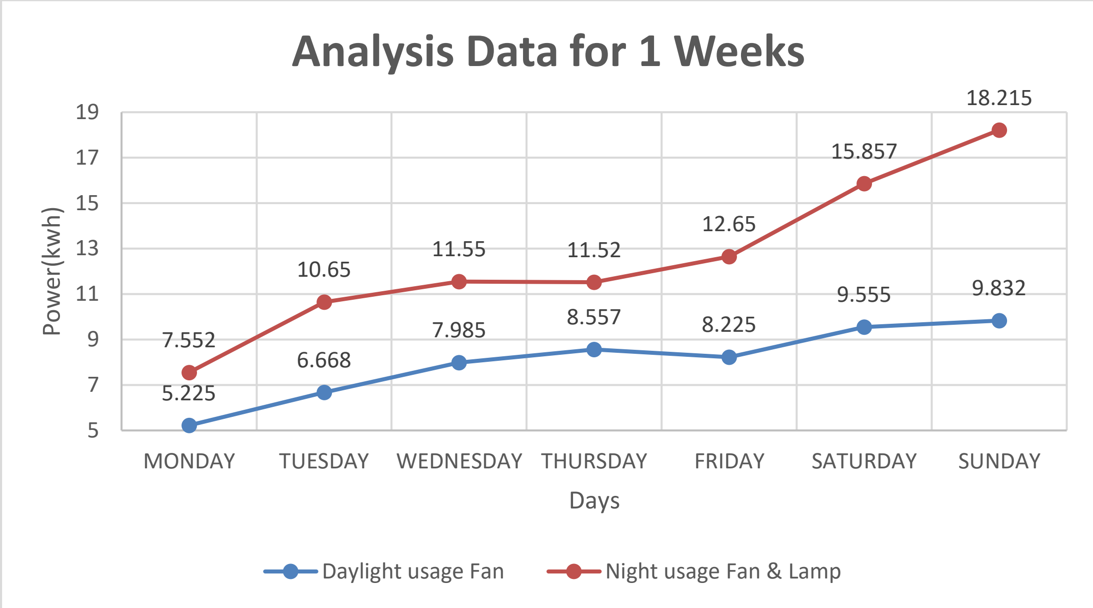

Figure 4.8 Analysis Data for 1 Weeks

The table presents a comprehensive overview of energy consumption patterns throughout a week, dividing the information into two categories: "Daylight Power (kWh) using Fan" and "Night Power (kWh) using Fan and Lamp." Each row corresponds to a specific day, starting from Monday and concluding with Sunday. The "Daylight Power" column indicates the energy consumed during daylight hours when only the fan is operational, with values range from 5.225 kWh on Monday to 9.832 kWh on Sunday. Conversely, the "Night Power" column represents energy consumption during the night, considering both the fan and a lamp in operation. This consumption varies from 5.552 kWh on Monday to 18.215 kWh on Sunday. Analyzing this table provides insights into the daily fluctuations in energy requirements, facilitating the identification of trends and informing decisions related to energy management. For instance, it highlights potential peak usage periods and the impact of additional appliances, such as a lamp, on overall power consumption during nighttime hours.

4.5 Analysis Web Data Cloud User from Application & ThinkSpeak

Figure 4.9 Data Analysis for Voltage (Vrms) vs Time

Figure 4.10 Data Analysis for Total (RM) Versus Time

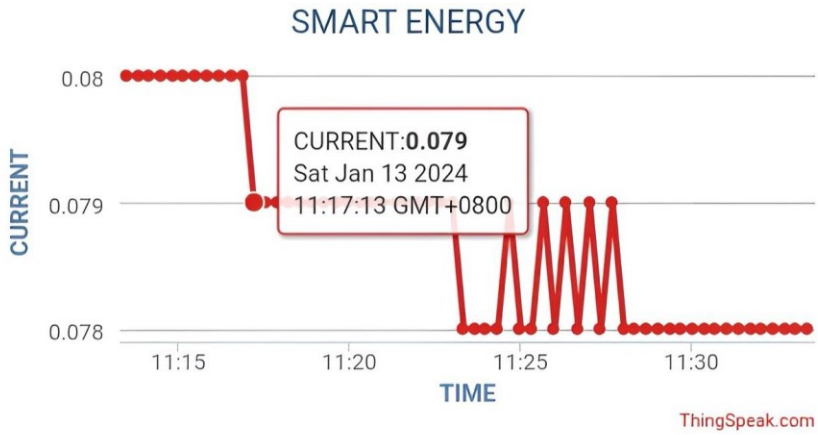

Figure 4.11 Data Analysis for Current versus Time

From the graph is represent data run for 1 days. In order to analyze the overall power consumption of users in the experimental. Figure 4.9 illustrates a substantial surge in electricity consumption for fan during specific time a days intervals, such as from 12:00 pm to 12:15 pm. During periods of increased power consumption, the voltage of the appliances also increased due to their activation. Notably, from the cloud data at 12:17 pm, the voltage reached 246.60 Vrms.

Moving on to Figure 4.7, an analysis of users' electricity consumption behavior indicates that the total (RM) is a fan is on. Consequently, when the fan is on, the total Rm of consumption electricity will increase. the power-increasing time is taken as a key factor. according to the statistics of the users electricity consumption, it is found that the users electricity consumption is randomly used and the change of electricity consumption information varies from daily. Users exhibit a significant spike in power consumption around 12:15 pm and the current increase when all the fan is on at the same time. Statistical analysis of electricity consumption data for 1 days that found when the electricity consumption of users increases, all the effect on energy will increase.

4.6 Summary

This chapter explains the results and analysis found throughout the implementation of the smart energy meter project. In light of these observations, specific data was extracted and meticulously analyzed to discern variations in output over time. Additionally, attention was given to scrutinizing applications functioning as Internet of Things (IoT) systems, capable of managing electricity usage from inadvertently neglected appliances, which could lead to a spike in power consumption.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Overall, the main focus of the project's design is on the use of an energy meter, energy consumption and built application can control the energy consumption. These drives ensure that the energy meter is utilised to monitor and control the supply and demand of electricity that flows in and out of a home in the most efficient and convenient manner for home tenants and users.

It outlines the recommended methodology for developing a new, effective, and integrated approach to calculate electricity supply to houses. The proposed methodology's major goal is to achieve the intended result of measuring and estimating the quantity of energy supply and demand in a household. The methods used, as well as the results, are intended to be effective and convenient. The accuracy with which the data collected from the meter is recorded and ensured that it can accommodate a home.

Moreover, it explains the results and analyses discovered during the deployment of the smart energy meter project. Various things were noted during the completion of this project, including input voltage and received output. Based on the observation, some data is retrieved and carefully evaluated, allowing the difference in output to be seen from time to time. Besides, insights have been gathered on IoT applications that can manage electricity usage from devices that were inadvertently left on, leading to an increase in power demand.

5.2 Potential for Commercialization

The commercial potential for a cost-effective energy meter monitoring project is significant in today's landscape, marked by a growing emphasis on energy efficiency and sustainability. The demand for affordable solutions that enable individuals and businesses to monitor and optimize their energy consumption is on the rise. A cost-effective energy meter monitoring system not only addresses this demand but also positions itself as a cost-effective tool for users looking to reduce their energy expenses. With the increasing prevalence of regulations and standards promoting energy conservation, the system aligns with compliance requirements, adding to its market appeal. Moreover, the integration of smart home technologies enhances its attractiveness, as users seek seamless solutions for managing their homes. The data collected by the system presents opportunities for additional services, such as analytics and insights, creating added value for users. By effectively communicating the benefits and affordability of the solution, coupled with ongoing marketing and educational initiatives, the cost-effective energy meter monitoring project holds strong potential for successful commercialization.

5.3 Future Works

For future improvements, accuracy and the data could be improved in the future and here ere are some potential future developments:

i) Explore advancements in hardware design for energy meters that could further.

ii) Add more appliance with high Watt to get reading more better .

iii)Include study to find a better and accurate value of load and loss factor.

iv)Make improvements so that the project can be connected also to IOS.

v) Add a button in the application to set days can we use to control energy specially for rent house or homestay.

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APPENDICES

Appendix A Gantt Chart For Psm 1

PROJECT ACTIVITY /TASK	WEEK													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Project Briefing	X													
Research project	X													
Background, Problemstatement & Objective		X	X											
Identify component			X											
Make project proposal			X	X	X									
Project flow chart					X									
Methodology					X		X							
Review report								X	X					
Submit 1st draftreport										X	X			
Submit report												X	X	
Presentation														X