Faculty of Electrical and Electronic Engineering Technology

DEVELOPMENT OF REAL-TIME ENERGY BILLING SYSTEM

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Bachelor of Electrical Engineering Technology (Industrial Power) with Honours

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DEVELOPMENT OF REAL-TIME ENERGY BILLING SYSTEM

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Student Name : HADIRAH BINTI ZAHARUDDIN

Date : 25/1/2023

APPROVAL

I approve that this Bachelor Degree Project 1 (PSM1) report entitled "Development of Real Time Energyg Billing System" is sufficient for submission.

Signature :

Supervisor Name : Ts. Dr. MOHD HATTA BIN JOPRI

Date : 25/1/2023

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I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electrical Engineering Technology (Industrial Power) with Honours.

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Date : 25/1/2023

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Co-Supervisor Name (if any) : MUSTAFA BIN MANAP

Date : 25/1/2023

DEDICATION

To my beloved mother, Afrizah Zainal Abidin, and father, Zaharuddin Ismail

and

My dearest family, Hazim, Syafiqah, Nabihah, Najihah and Hakim

My Supervisor, Ts. Dr. Mohd Hatta Jopri

My Senior, Tan Kim Loong

ABSTRACT

Real Time energy billing system in a residential place is a system that can help with money management in electricity of a household and at the same time saving the energy. This system does not only simplify the billing system of a consumer to a utility company, but it is also able to track how much money that is being utilised in the household on a daily basis by creating a load profile log of a certain household. The advantage of this metering system is able to enhance efficiency of power usage and concurrently lowering its operation cost by lowering the manpower for energy meter reading. Incidentally, the system supports the movement of a greener earth by lessening paper bill receipt that is being handed to utility company customer every month. Besides, this energy monitoring system is able to collect large amount of data and monitoring it in real time. This real-time, large number of sampled data for efficient analysis. The User Interface (UI) is designed using Blynk application and built using Arduino IDE C++ programming language. Blynk app is used as a consumer platform in for real time monitoring, data acquisition, energy analysis and load profiling of a household. The system provides a better perception and a finer analysis in power quality data. The expected result shall be an energy monitoring platform that shows Voltage RMS, Current RMS, power, power usage and shows a daily profile of a system.

ABSTRAK

Sistem meter tenaga pada masa sebenar di tempat kediaman adalah sistem yang boleh membantu pengurusan wang tenaga elektrik isi rumah dan pada masa yang sama menjimatkan tenaga. Sistem ini bukan sahaja memudahkan Sistem meter tenaga pengguna kepada syarikat utiliti, tetapi ia juga dapat mengesan jumlah wang yang digunakan dalam isi rumah setiap hari dengan mencipta log profil beban isi rumah tertentu. Kelebihan sistem pemeteran ini mampu meningkatkan kecekapan penggunaan kuasa dan pada masa yang sama menurunkan kos operasinya dengan menurunkan tenaga kerja untuk bacaan meter tenaga. Secara kebetulan, sistem ini menyokong pergerakan bumi yang lebih hijau dengan mengurangkan resit bil kertas yang diserahkan kepada pelanggan syarikat utiliti setiap bulan. Selain itu, sistem pemantauan tenaga ini mampu mengumpul sejumlah besar data dan memantaunya dalam masa nyata. Ini masa nyata, bilangan besar data sampel untuk analisis yang cekap. Antara Muka Pengguna (UI) direka menggunakan aplikasi Blynk dan dibina menggunakan bahasa pengaturcaraan Arduino IDE C++. Aplikasi Blynk digunakan sebagai platform pengguna untuk pemantauan masa nyata, pemerolehan data, analisis tenaga dan profil beban isi rumah. Sistem ini membangunkan sistem pemantauan tenaga masa nyata dan akan memberikan persepsi yang lebih baik dan analisis yang lebih telus dalam data kualiti kuasa. Hasil yang dijangkakan ialah platform pemantauan tenaga yang menunjukkan Voltan RMS, RMS Semasa, kuasa, penggunaan kuasa dan menunjukkan profil beban harian

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δ	-	Voltage angle

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V	-	Voltage

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CHAPTER 1

INTRODUCTION

1.1 Background

Electricity demand in Malaysia has been escalating for the past decades and is expected to be further increasing in the future. This is in parallel with the speedy industrialization, development of urban areas and especially with the nation's growing populations [1]–[3]. A study reveals that commercial and residential buildings takes up to 48% of Malaysia's overall electricity demand [2] . In a common Malaysian household, the average number of utilized electrical household equipment are about 20 to 30 equipment. [3]. Energy wastage tends to occur mainly with the user's negligent of leaving the unused electrical equipment, such as hair dryer, rice cooker, air conditioner, water heater and oven switched on for the whole day. [4] Even though the equipment is certified with 5 stars energy efficiency label, this misbehavior consumes a large amount of energy at the end of the month.

Recently in Malaysia, Energy and Natural Resources Minister announced the new tariff rates. This new tariff is said not to burden domestic consumers based on the Incentive-Based Regulation (IBR) [5]. The main Electric Utility companies across Malaysia namely, Tenaga Nasional Berhad (TNB) for peninsular Malaysia, Sabah Electricity for Sabah and Sarawak Energy for Sarawak are responsible in setting respective tariffs for each company according to Malaysian's Energy Commission's IBR [6].

1.2 Problem Statement

The utilization of electricity corresponds to the use of power. The longer the utilization of power elicits higher bill of costs at the end of every cycle and unmonitored power consumption will result in overspending [4]–[7]. The conventional energy meter is designed to display kilowatt-hour, which is the quantity of electricity that is being utilized by the consumer over a period of time. [8]–[10] The data is then individually inspected by meter readers from the energy provider companies. Monitoring consumer's energy consumption at real time can't be accessed using this method. This method is not only prone to human error but also time consuming and labour consuming[11]–[13]. The data from the conventional meter and method might not be precise and accurate. [5] Therefore, the limitations of conventional meters are the key drives of this project.

1.3 Project Objective

The objectives of this project are :

a) To design a real time energy billing system using real-time data acquisition with IoT technology

b) To develop and integrate real time measurement.

c) To analyze the performance of the system.

1.4 Scope of Project

Project's scopes help to establish its boundaries within the precise objectives, due dates, and project deliverables that is aimed for. Project goals and objectives can be met without running late or having to work too hard by having to define the scope of project. The scope of this project are as follows:

1) Energy meter for single phase residential purposes only
2) Maximum load of 160W
3) Arduino IDE software as programming platform
4) Autocad as designing tool and Utimaker cura
5) Blynk app for IoT Energy monitoring, billing monitoring and load profile monitoring

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

As a mean to make this project a successful project, several research and studies has been done from multiple sources, this includes scholarly books, article journals, research papers, dissertations and credible internet sources that is related to this project. This chapter highlights the difference between prepaid and postpaid payment, overview of the past projects, IoT in this energy meter system, how data is being stored in this energy meter and some key components needed for this energy meter.

2.2 Prepaid versus postpaid System

Fundamentally, there are three options for paying a service. Before the service provider performs the service, after its execution and payment in between the service execution. For utility companies like waterworks, gas or heating, the typical model for payments is post-paid method which consumers are charged upon the usage of the services at the end of billing cycle [10]. However, in recent years, the demand for pre-paid energy meter has been increasing with the trend of rental accommodation such as vacation homes, Airbnb, homestays , short property rental and sublets or sublease. Some developing countries have made the move to attain sustainability in the power sector through this pre-paid energy meter system [11].This method may help consumers managing their power consumption at the same time their financial condition. Consumer may budget in advance for how much electricity they planned to use or are authorized to use using a pre-paid system. Table below shows the comparison between pre-paid and conventional postpaid system

Table 2.1 Prepaid system versus conventional postpaid system

Pre-paid system	Conventional Post-paid system
Payment before usage	Payment after usage
Self-administered	Administration under utility company
Consumers pay by themselves, not needing meter readers to come	Workers from utility company will come and read meters
Reducing man labor and cost effective	More workers and not cost effective

2.3 Energy Monitoring

Monitoring of energy system are now commonly used in monitoring energy consumption in industrial plants and buildings. The residential unit consists of many private households, flats and living quarters do not necessarily have any energy monitoring device excluding the energy meter that is only accessible by the utility company. According to a research, a wastage over 41% of the total energy consumption has been done by these residential energy consumers [12]. The change of the parameters such as voltage, power factor, current could have led to the wastage and thus needed to be monitored. The key to conserving energy is understanding the basics of how energy is being utilized, monitored, and regulated over the period of billing cycle. Research also shows that consumers who are being informed by their energy consumption may better understand and make better judgements in reducing their household's electricity consumption [13].

2.3.1 Energy

Energy in physic means the ability to perform work, in other word it is the measure of work that has been done, that is required for a period of time. Energy has the SI unit of Joule or (J), while work has the SI unit of Watt or (W) and both are very closely related to Power (P) as it is the energy converted over a period of time. [14]

Energy = Frequency(Distance)

Power = Energy / time

Energy consumed is measured in kilowatt hour or (kWh). Energy is Power (P) times the time that energy is being consumed and is divided into 1000 or mathematically, it is shown as below:

$$E\left(\frac{kWh}{Day}\right)\frac{kWh}{Day} = \frac{P(W)xt\left(\frac{h}{day}\right)}{1000\left(\frac{W}{kW}\right)} \quad \text{Equation 1}$$

2.3.2 Load Profile

With advancement of smart grids, an abundant of consumer's data that is being connected to the grid has been collected. This data is finer or in other word, a fine-grained energy data. This data is considered to be very valuable as it carries information such as cumulative energy consumption of consumers. With load profile, utility companies can manage to study, analyze and perfectly predict energy consumptions for the future and on which part of the day energy can be efficiently used.[16] This is also an effort in saving energy. Load Profile is essentially an electrical load versus time graph. It is often segmented hourly in a span of 24 hours. Some load profiles even segment its result half hourly. [17]