INTEGRATED ELECTRICITY METER AND COST CALCULATOR

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Dedicated in thankful appreciation to my parents, siblings, colleagues and friends for the support, encouragement and understanding

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ABSTRACT

This project report describes the development of an electric meter with integrated circuit to display household monthly electricity usage. Unlike the conventional meters, this project also tries to integrate an electricity cost calculator into the same device. So the meter could display two information on its screen; amount of electricity usage (kwh) and the amount of bill (RM). The cost calculations are based on the pricing and electricity tariffs rates provided by Tenaga Nasional Berhad (TNB). It is built to educate people to a better manage the usage of energy. By showing the amount of bill of current use and appropriate indicator and monitoring element, the household will be trained to use energy in economically. This project uses PIC18F4553 microcontroller as a processor to execute programming code and instruction for the output and input peripheral. The main component of this energy meter is ACS758 50A Current Sensor that detects the current flow in a circuit as a compulsory element to calculate energy. This product can be considered as green technology product and helps the environment in the long run.

ABSTRAK

Laporan projek ini menerangkan tentang pembangunan meter elektrik dengan litar bersepadu untuk memaparkan jumlah penggunaan elektrik bulanan isi rumah. Tidak seperti meter konvensional yang lain, projek ini menggabungkan pengiraan kos elektrik ke dalam peranti yang sama. Jadi, meter ini boleh memaparkan dua maklumat pada skrin iaitu jumlah penggunaan elektrik (kwh) dan jumlah bil (RM). Pengiraan kos adalah berdasarkan harga dan tarif kadar elektrik mengikut yang ditentukan oleh Tenaga Nasional Berhad (TNB). Ia dibangunkan untuk mendidik orang ramai supaya menguruskan penggunaan elektrik dengan baik. Dengan menunjukkan jumlah bil penggunaan semasa dan penunjuk yang sesuai serta elemen pengawal, pengguna akan dilatih untuk menggunakan tenaga dengan berhemah. Projek ini akan menggunakan PIC18F4553 mikropengawal sebagai pemproses untuk melaksanakan kod pengaturcaraan dan arahan kepada keluaran dan masukan. Komponen utama projek ini ialah ACS758 50A pengesan arus yang mengesan arus yang mengalir dalam litar sebagai elemen utama pengiraan tenaga. Produk ini boleh dianggap sebagai produk teknologi hijau dan membantu alam sekitar dalam jangka masa panjang.

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PIC	-	Programmable Integrated Circuit
LCD	-	Liquid Crystal Display
LED	-	Light Emitting Diode
PIC	-	Peripheral Interface Controller
ADC	-	Analog to Digital Converter
DC	-	Direct Current
AC	-	Alternate Current
PCB	-	Printed Circuit Board
IC	-	Integrated Circuit
TNB	-	Tenaga Nasional Malaysia
kWh	-	Kilowatt Hour
RM	-	Ringgit Malaysia

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CHAPTER I

INTRODUCTION

1.1 Introduction

Power or energy crisis has always been a critical agenda to the world. Practicing good power management is needed to control massive usage of electrical energy in industrial, commercial, public and everyday household uses. Since energy has become the prime contributor to the rapid growth of the Malaysian economy [1], the utility management emerge as an important thing in order to ensure that the utility is not burden to the public especially to pay the rate of electricity bills. People are trying to reduce the cost of electricity bills in several ways as they start to concern about the uncontrollable electricity usages. A research in UK found that the regular monitoring of energy patterns can indicate areas of unnecessary consumption while the reporting of power usage can provide savings of up to 20 percent [2].

The awareness of managing power consumption brings us to an idea to develop a device that could can monitor the usage of the electricity and educate people in using the energy. Calculating kilowatt-hour energy doesn't give a special function to the energy meter as the current product did, unless the total cost of the amount usage is shown as one of the parameter in managing the power consumption. Expanding the idea, the product would also be installed with an appropriate indicator and some controlling elements where users have the ability to set when the system will warn them.

Basically, the development of this project includes hardware and software elements in an integrated circuit in order to display monthly electricity usage. Unlike the conventional meters, this project tries to integrate an electricity cost calculator into the same device. The outputs being displayed will be electricity usage in kilowatt-hour (kWh) and amount of current usage in Malaysia Ringgit (RM).

The system acquires the amount of current used and converts it into amount cost using a microcontroller. The cost calculations are based on the pricing and electricity tariffs rates provided by the national utility provider in Malaysia, which is Tenaga Nasional Berhad (TNB). Both of the parameters will be used in a controlling element where the user can set up a certain electricity usage amount and an indicator will be activated once the usage exceeds it.

1.2 Backgrounds of Problem

As the electrical energy consumption is proportional to the usage of electricity, the higher usage of electricity leads to the higher bill costing. The uncontrolled daily electricity consumption causes the monthly electricity bill to hike up without realizing that it exceeds the household budget. In addition, the household cannot control the usage of electricity because there is no indicator or measurement that can tell them the amount cost of current usage.

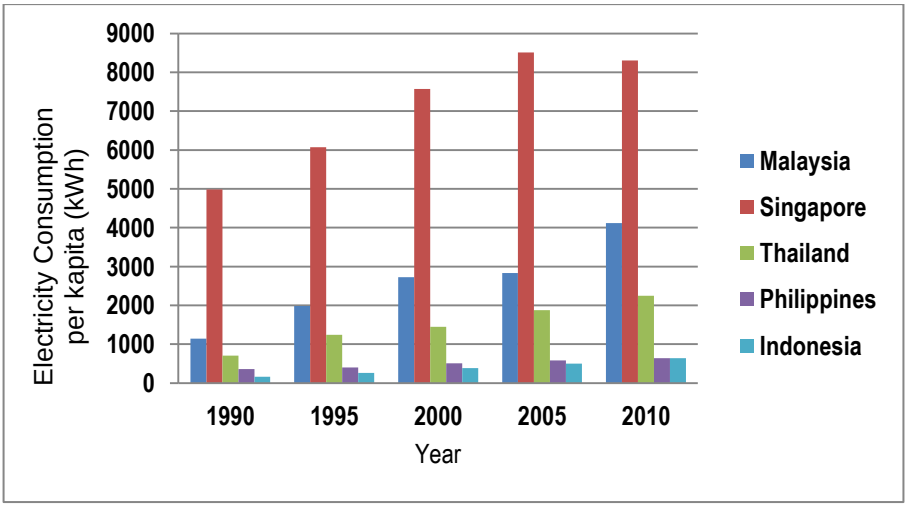

Figure 1.3: Electricity Consumption per kapita in ASEAN [3]

Moreover, according to the data from World Bank Indicators [3] as shown in Figure 1.1, the electricity consumption in Malaysia is becoming of an interest nowadays given the fact that the Malaysia's electricity consumption per capita is the second highest among the five ASEAN founding nation.

Other than that, the currently assembled electricity energy meter by electrical energy providers will only shows the current electrical consumption in terms of kWh rather than showing the cost of energy that has been spent. Psychologically, the conventional system applied would not affect the trend of electrical consumption, but it might function accordingly if the meter displays the pricing information. It is because many households could not understand the readings in kWh instead of in RM. Real-time pricing in energy meter gives a real cost-controlling opportunity to the users in practicing a good power management.

Some products that already manufactured such as 'Plug-in Electricity Monitor' as in Figure 1.2 can measure the amount of usage, however the reading taken directly using a specific plug and socket for electric tools installed on the plug. It does not measure the overall of the electricity usage.

Figure 1.4: Portable electricity energy meter in market

Hence, this Integrated Electricity Cost Calculator Meter project is developed to provide monitoring function to the user about the usage and spending of the electricity.

1.3 Objectives

The objectives of this project are:

1. To develop and design a device that integrates a meter display cost calculator in a single device.

2. To design a product with control settings and indicators and simple for household to use.

1.4 Scope of Work

The scope of this project is basically producing a device that is detachable from the single phase digital main electricity meter. The device should be able to calculate the energy consumed by the household and convert it into cost in Malaysian Ringgit. Both consumptions in kWh and RM will be shown in an LCD display. The cost calculations are based on the pricing and electricity tariffs rates effective from 1st June 2011 for residential consumer provided by the national utility provider in Malaysia, which is Tenaga Nasional Berhad (TNB). According to the TNB tariff booklet, there are four types of meter reading calculated for residential consumer [4]. This project is focused on the normal meter reading (N type) which is an actual reading billing of the consumer.

The design and development of the project uses PIC microcontroller to integrate the input from electricity supply and loads with the output of LCD display and indicator.

1.5 Importance of Study

Continuous researches in this area have been conducted for many years since the emerging technology leads the world of innovation. Since Malaysia is practicing the Energy Efficient (EE) model under the Ministry of Energy, Green Technology and Water [5] [6], the application and implementation towards the idea in this Integrated Electricity Cost Calculator Meter has indirectly supports the efforts where the energy savings being one of the element of the product. This project could be considered as green technology and helps the environment in the long run besides achieving its objective in educating people in practicing good power management and solve the burden of electricity bill increment.

1.6 Thesis Outline

This report consist of 5 different chapters. The first chapter for this report is introduction. In introduction, it will have a few of sub-topics, which are problem statement, objectives, scope of project, and the importance of the study. Basically this chapter is an overview of the project where the idea being generated from problem statement followed by managing the entire basis scope of the project. Second chapter for this report is literature review. In this chapter it also divided into a few of sub chapters that will explain the study of electrical energy meter, calculation involve and suitable component for the project. The third chapter is methodology part. This part will explain about some of the guidelines for this project and also clearly mentioned steps that should be taken for this project. It show the step to achieve the main objective in this thesis. The fourth chapter is the result and discussion. This part will describe about the results and findings obtained and also discussing the matter related for this project. The last chapter is conclusion and recommendation. In this part, it will conclude whether this project achieve the objective and some recommendation for future improvement.

CHAPTER II

LITERATURE REVIEW

2.1 Energy Meter

Electricity energy meter is a device that measures the amount of electrical energy consumed by a residence, business, or an electrically powered device where it is typically calibrated in billing units of kilowatt-hours (kWh). It is operate by continuously measuring the instantaneous voltage and current and finding the product of these to get the instantaneous electrical power (watts) which is then integrated against time to get the energy used [7]. There are two types of supply voltage from electrical energy provider, single-phase and three-phase supply. A single-phase meter measures usage from a 240 volt supply through two wires, and a 3-phase meter is supplied with 415 volts through four wires. Since this Integrated Electricity Cost Calculator Meter designed for residential consumer, the single phase input with the lower current rate is being used rather than three phase input.

The electricity energy meters fall into two basic categories, electromechanical and electronic meter. Electromechanical meter is an analog type meter that operates by counting the revolutions of a non-magnetic metal disc which is made to rotate at a speed proportional to the power passing through the meter, while the electronic meter is a digital type meter that operates the input of loads, voltage, current and instantaneous time to a digital signal processing system and convert the energy to the pulse signal form [8]. Since the digital meter is more accurate and efficient than the

analog meter, this type of meter is being considered to be used in this project. Moreover, the way to process the input is more easier using digital approach were it can be read directly to microcontroller unit and absolutely easy to analyze data.

Figure 2.2: Single phase Digital Energy Meter

Single phase digital energy meter as shown in Figure 2.1 is example of common digital energy meter that being used by household user in Malaysia. In Malaysia, there are four companies that was assigned by electrical energy provider to provide energy meter for household use. There are Smart Meter Technologies Sdn Bhd (SMT), Malaysian Intellligence Meters Sdn Bhd (MIM), Krizik Malaysia Sdn Bhd (KMSB) and MISA Sdn Bhd (MISA). These four companies are responsible to produce a digital meter with energy calculation that based on the TNB tariff rates.

As the research area of this project involve the calculation of energy, this project needs to get advises and guidelines from one of the energy meter provider to get a clear way and method on how to measure input and calculate energy with higher accuracy as what they are doing.

2.2 Recent Research Project

There are several research project conducted related to this system where the electricity energy meter was developed digitally using several types of digital signal processor or microcontroller. The development of these products in research market shows the variety of system with different way of integrating digital energy meter based on the function and application involve.

Sudin et. al [9] presented the Digital Household Energy Meter where this product consist of a digital electrical pricing system which composed of a communication system that upload usage data from the meter to a central computer for data processing. The display panel is using computer interfaces developed using Visual Basic software that connected via RS-232 communication cable to MK-6 Genius, a type of digital energy meter. The idea implement seem to be similar with the development of this Electricity Cost Calculator Meter device, but it is no hardware produce because the simulation of the amount cost are calculate internally using software interfaces.

Eng, (2011) produced a device called Cost Monitoring Digital Power Meter [10] which is calculating the electrical energy and convert into cost. It is uses the PIC 16F877A microcontroller as the main component used to interface the input and output. Input of the system is voltage from the supply, current from the load, and instantaneous time, while the output is LCD display and LED indicator. The 240 volts AC Voltage is being reduced using step down transformer. The measurement of this device is using Energy Meter Chip that integrates the voltage and current together before the outputs of the integrated circuit goes to the PIC microcontroller and produce the output in the form of pulses. The PIC Microcontroller was programmed using appropriate programming language to give the instruction of calculating the energy and cost and also controlling the output display and indicator. However, this system has a problem where the calculating value is not accurate as the real energy meter did. Observing the problem founds that the transformer used in this system resulting the high percentage of loss voltage while the input is being stepped down. Thus, the linearity of actual input and the reference voltage would not be as accurate as what should it be.