Faculty of Electrical and Electronic Engineering Technology

DEVELOPMENT OF SMART CLAMP METER FOR ENERGY CONSUMPTION MONITORING

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Bachelor of Electrical Engineering Technology (Industrial Automation & Robotics) with Honours

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in partial fulfillment of the requirements for the degree of
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DEDICATION

First and foremost, I want to thank Allah for giving me the opportunity to finish my report. Aside from that, I dedicate all my work to my loving parents, who inspire me and remind me to be patient. To my siblings who have always helped me when I've been away from home. My family always encourages me to keep going and work harder so that I can make my parents proud. I also dedicate my dissertation to all of my friends who have helped me during the process. I will always be grateful for everything they did to help me accomplish this project. Last but not least, thanks to all of the lecturers, particularly my supervisor, who always encourages me on and asks questions about the issues I have difficulty handling.

ABSTRACT

One of the most critical issues nowadays is energy consumption problem, especially electrical energy consumption. An effective technique to monitor this energy consumption is required for effective and optimal energy usage. Electrical energy monitoring can help users be aware of their energy use. At factories, machines electrical consumption are monitored to facilitate industries to minimize cost as well as the scheduling and application of appropriate preventive maintenance. The purpose of this project is to create a remote voltage and current monitoring system, so that any irregular pattern will help user to anticipate any potential problem in electrical system and implement corrections before it gets even worse. The objectives of this project, i.e. from design, construct and test phases were achieved successfully. A project prototype that integrates ESP32 with CT Sensor, Voltage sensor, an LCD and Node MCU was built to meet the project requirements. Basically, this project extends the function of a standard clamp meter with an additional function that will turn it into a smart clamp meter. It can monitor I and V online and real-time and has a data logging capability. The data collected by the voltage and current sensors are sent to a data logging device, and can be displayed at an android using Blynk apps. A number of experiments were carried out to test functionality of the smart meter. For comparisons, a real multimeter is used to measure current and voltage of the appliances to calculate error between smart meter readings and multimeter readings. An extender is proposed in order to ensure measurements using voltage and current sensor can be carried out with safety. The results show a variation of error percentage based on different appliances. The error percentage were found to be 0% for a battery bank, 8.7% for a table fan, 11.11% for a rice cooker and 13.6% for an electric kettle. These results give opportunity for improvement of the project. As a conclusion, a smart meter to monitor electrical consumption of appliances is successfully built and has a valueable benefit to technical operators of local companies to use the product to facilitate their maintenance or troubleshooting work at production line with less effort yet highly reliable.

ABSTRAK

Salah satu isu paling kritikal yang berlaku pada hari ini ialah penggunaan tenaga, terutamanya penggunaan elektrik. Teknik yang berkesan untuk memantau penggunaan tenaga ini amat diperlukan. Di kilang-kilang, pemantauan penggunaan tenaga membantu pihak pengurusan menggunakan tenaga secara optimal melalui penjadualan dan aplikasi penyelenggaraan pencegahan yang sesuai. Tujuan projek ini adalah untuk mencipta pemantauan voltan dan arus secara jarak jauh agar sebarang profil penggunaan tenaga yang tidak normal yang menggambarkan kemungkinan kepada permasalahan boleh diperbaiki sebelum ianya menjadi lebih teruk. Objektif projek yang bermula dengan mereka bentuk, membangunkan prototaip dan menguji keberkesanannya berjaya dicapai. Prototaip yang dihasilkan menggabungkan ESP32 dengan penderia CT, penderia voltan, LCD dan Node MCU agar ianya boleh memenuhi keperluan projek. Prototaip yang dibina memberikan nilai tambah ke atas meter pengapit yang sedia ada menjadi meter pengapit bijak. Ianya mampu mengikut voltan dan arus dan mempunyai keupayaan menyimpan dan memaparkan data menggunakan aplikasi Blynk. Beberapa eksperimen dijalankan bagi menguji keberfungsian meter bijak tersebut. Bagi tujuan perbandingan, multimeter digunakan untuk mengukur arus dan voltan peralatan bagi mengira anggaran ralat antara bacaan meter bijak dan bacaan multimeter. Satu alat “extender” digunakan agar pengukuran menggunakan penderia arus dan voltan boleh dilaksanakan dengan kaedah yang selamat. Hasil eksperimen menunjukkan kepelbagaian peratusan ralat bergantung kepada jenis perkakasan yang diukur. Peratusan ralat didapati 0% untuk bank bateri, 8.7% untuk kipas meja, 11.11% untuk periuk nasi elektrik dan 13.6% untuk cerek air elektrik. Dapatan ini membuka ruang bagi menambahbaik projek. Sebagai kesimpulan, satu meter bijak bagi mengukur penggunaan tenaga elektrik peralatan telah berjaya dibangunkan dan ianya mempunyai nilai yang tinggi kepada operator teknikal di syarikat-syarikat tempatan untuk menggunakan inovasi ini membantu mereka melaksanakan penyelenggaraan atau mengenal pasti masalah di kilang mereka dengan kos yang rendah tetapi mempunyai nilai kebolehpercayaan yang tinggi.

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IoT	-	Internet of Thing
CT Sensor	-	Current Transformers Sensor

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CHAPTER 1

INTRODUCTION

1.1 Background

Nowadays, innovation creates and develops swiftly. Innovations have the potential to improve people's lives and create a more sustainable and inclusive society. A few years ago, tracking functions involving human contact were tested in control systems. The most recent technological advance, the Internet of Things (IoT), has enhanced consumer standards of living and may reduce needless daily spending. Understanding the IoT basics will help in discussing the implementation.

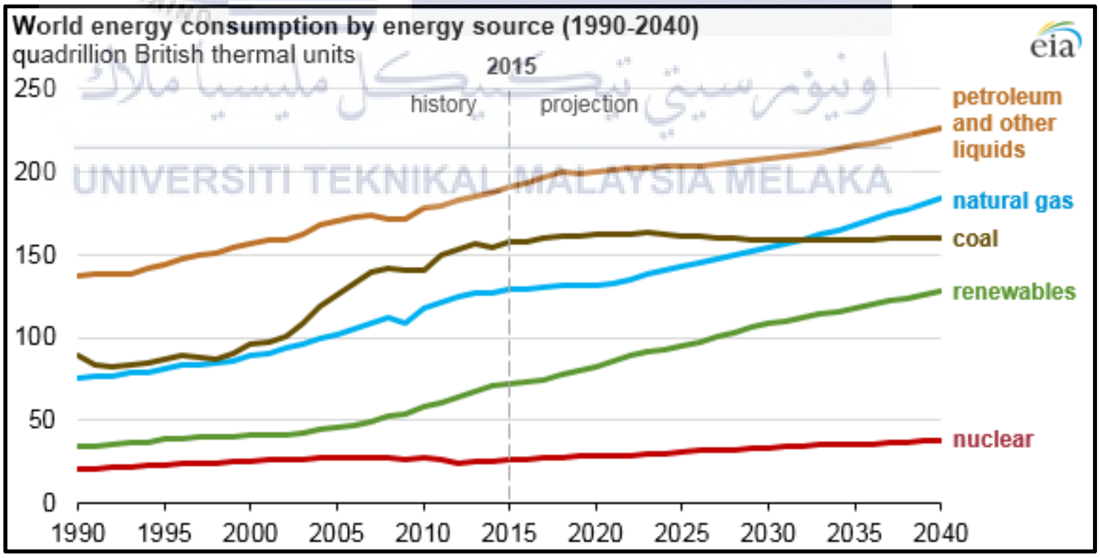

Figure 1.1: World energy consumption by energy source (EIA)

The main source of electricity is from non-renewable energy. As we all know the power plant use a non-renewable energy such as coal, oil, and neutral gas, nuclear to power up and produce electricity. Based on The U.S. Energy Information Administration, graph shown in figure 1 shown that Demand of non-renewable energy is higher than renewable energy due to demand of electricity usage.

It is essential to evaluate energy usage because it has operational costs. High-tech new services and goods may need to have their energy use assessed. Monitoring energy use may be beneficial in a variety of ways for industrial processes. It may aid in the appropriate scheduling and monitoring of preventative maintenance and energy consumption. Preventive maintenance may assist the home in managing its energy use.

For this project, it may be possible to modify a clamp meter, a test tool that combines a simple digital multimeter and a current sensor and connect it to a microcontroller to monitor energy usage online using the Internet of Things concept.

Predictive assessment and advanced methods may be used to analyze, collect, and examine the data in order to provide useful information in the form of reports, charts, and graphs. As a consequence, this real-time data analysis may aid utilities ecosystem firms in gaining important information about tracking energy use.

The initial concept for the energy monitoring system was triggered by expensive prices and problems with the current equipment. This is an effect of the pricey equipment and kind of microcontroller that was used. Despite the fact that certain items could seem cheap, the whole cost is substantial. Important components of this project are current transformers, a sensor for detecting alternating current, a voltage sensor module for measuring AC voltage, and a microcontroller for tracking all inputs and outputs from the system.

1.2 Problem Statement

A local Small Medium Enterprise (SME) company, represented by a technician has come to meet with FTKEE researchers for a consultation. He came to get views and opinions from FTKEE researchers on the current problem that he was having with an induction motor used as a conveyor belt in one food packaging factory. It can be observed that the technician was able to describe technical problems that he was facing verbally, however no proper, and sufficient data were present to support his claims. Good data collection will lead to sufficient analysis, and the analysis findings will help the technician to make decisions on what are the steps need to be taken to solve the current problem.

In large manufacturing industries, Distributed Control System is used to assist the company management to run the production line. As we know, this system has a very comprehensive connectivity to all the production line machines and equipment, however the cost of a complete DCS is very high. Most of local SMEs could not afford such technology, and our developed prototype in this project could help to facilitate them in conducting online monitoring at an affordable price.

This project aims at building a simple prototype that extends function of a conventional clamp meter. The extended feature is its connectivity to the internet, making the electrical load monitoring easier and more convenient and at the same time will assist the technician with meaningful set of data which enables proper analysis during troubleshooting.

The extraction of data necessary to evaluate electric consumption, such as current and voltage, is made possible by the use of clamp meters. The data may also be monitored more often and effectively with the use of IoT. Thus, utilizing this technique has benefits that increase productivity and efficiency, which are difficult to obtain when extracting data manually.

The followings are the expected features of the project prototype: -

1. Ability to extract the data, which is voltage, current without break the circuit and exposed to high current.
2. To improve the real time data extraction by using IoT. More data can be collected compared to manual data recording. In manual data recording, the operator can only take one reading in a time interval of two to three seconds. With the help of technology, one data can be recorded in a very short time e.g. 1 milliseconds. This means automation realizes high data acquisition rate.
3. Limitation of exposure to danger during extraction of data.
4. To improve the efficiency and accuracy of data extraction using clamp meters and avoid human errors.
5. To improve the real time data extraction by using IoT and Blynk apps for monitoring.
6. With this technology, an operator does not need to be on site all the time to keep an eye on the clamp meter's display to see the current and voltage of their machines in real time. This initiative also will make users more aware of current

and voltage consumption, as well as assist in the daily monitoring of electricity power usage.

1.3 Project Objective

This project has a few objectives to develop a smart clamp meter for energy consumption monitoring. The following are the objectives:

1. To design and develop a GUI system that can monitor electrical energy consumption.
2. To save the monitored data online or can be view in offline mode.
3. To test the accuracy and reliability of the developed prototype.

1.4 Scope of Project

The main objective of this project will be to integrate a clamp meter with an IoT (Internet of Things) system so that the system can track power consumption regularly. In this project, hardware and software development will be merged. To develop the prototype with the necessary hardware parts, products like voltage module (VM) sensors and current transformer (CT) sensors may be used. In addition, an Arduino can automate the current tracking process, which will monitor the entire amount of energy consumed. Additionally, a liquid crystal display, or LCD, was included to show the clamp meter load's measuring capabilities. The variables that may be observed are current and voltage. The data is then delivered toward a smartphone via the Blynk application after the parameters may be communicated to an Arduino using a Wi-Fi module or an ESP32.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The existing systems that were employed for study and improved upon from the last research article will be the subject of the literature review. It will be concerned with and focused to the development of Arduino, which is chosen, and the Internet of Things (IoT). The research paper based on prior research that is relevant to this project, as well as a range of publications and journals that are relevant to this project, will then be discussed. The articles may concentrate on the techniques and tools used in everyday home and business operations, such as the clam meter and energy monitoring.

2.2 Clamp meter overview

Figure 2.1: Clamp meter

An electrical test device that combines with a basic digital multi-meter and has a current sensor is referred to as a clamp meter in figure 2.1. This tool is used to measure electrical data, including current and voltage. An electric meter with an adjustable jaw allows users to tighten a cable, wire, or other conductor across an electric circuit at any location. The current would then be monitored without being paused or disconnected after that. The magnetic field created by current may be detected, magnified, and measured as it passes through the conductor thanks to the ferrite iron hard jaw underneath its plastic mount. (Fluke Corporation, 2020)

2.2.1 Way clamp work

Once transformed into a value, an AC current may be read when the clamp meter's current transformer detects the presence of magnetic fluctuations. The interaction between current and the total vector current flow via the probe and through all of the conductors is what operates the clamp meter. Conductors may be clamped with the mouth to measure their current. When the couple wire passing between the jaws detects the current flowing through, the clamp meter operates. The secondary winding, which is linked across the meter's input shunt, may be likened to the iron core of a power transformer in this case. The meter's input will supply less current because of the disparity between the number of secondary windings wrapped around the core and the number of main windings wrapped around the core.

2.3 Overview of Existing Project

It will be emphasized and analyzed for this part based on earlier research. It will demonstrate how the project was used and developed based on the previous project in order to achieve the main objectives of the project. This will assist in determining the most effective way to enhance the use of smart meters for energy consumption monitoring in production and daily life. Based on the current project, it may also be possible to gain a deeper understanding of the issues and potential users for this project.

2.3.1 Energy consumption monitoring in smart home system

For this research, the researcher main objective is to find an alternative way to build a well-structured way that can be used on monitoring the energy consumption. They believe by having this system can help in tracking electricity used inside the household. For this research they focus on measuring the units of electricity that flow on appliance using the current sensor ACS712 and how it works. The data than collected by Thingspeak channel through either HTTP or web socket protocol via Node MCU from the data extraction sensed by ACS712. The Android application makes a GET/POST request to the database to collect data for processing. From the data it will predicts the electricity units with high accuracy and precision during data processing. It will automatically calculate the cost for energy consumption to the current date. This will help the consumer to monitor the status on the daily basis and help them to reduce the consumption to preserve electricity.