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An Analysis Of Electric Energy Monitoring And Protection Based On Smart Interface Systems

Mardi Sijabat[1], Muhammad Erpandi Dalimunthe[2], Rahmaniar[3]
Universitas Pembangunan Panca Budi, Medan, North Sumatera, Indonesia[1,2,3]

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Electrical Energy,
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ABSTRACT

This research aims to analyze an electrical energy monitoring and protection system based on a smart interface system. In the current digital era, the need for systems that are more efficient, reliable and easily accessible is very high, especially in terms of electrical energy management and protection. Smart interface systems offer solutions to improve monitoring and protection capabilities through the use of advanced technology and automation. Research methods include the development and implementation of a smart interface system consisting of advanced sensors, wireless communication modules, and web-based monitoring software. This system is designed to detect various electrical parameters such as voltage, current and frequency in real-time, and provide automatic protection responses when anomalies or disturbances occur. The research results show that the smart interface system is able to increase the reliability and efficiency of monitoring and protection of electrical energy. This system successfully detects and responds to disturbances quickly, reduces the risk of equipment damage, and minimizes operational downtime. In addition, the intuitive user interface makes it easier for operators to monitor and manage electrical energy systems. The implementation of a smart interface system for monitoring and protecting electrical energy provides many benefits, including increased operational efficiency, system reliability and ease of management. This research contributes to the development of more advanced and reliable monitoring and protection technology, as well as providing recommendations for wider application in various industries that depend on complex electrical energy systems.

Corresponding Author:
Mardi Sijabat
Universitas Pembangunan Panca Budi, Medan, North Sumatera, Indonesia
Boysaragi272@gmail.com

INTRODUCTION

In the Industrial Revolution 4.0, electrical power is the most important need to support human life today to meet daily needs, both household and industrial. Monitoring and protection is one of the management methods in the use of electrical energy in an industry. It is not enough just to use The kWh meter is only provided by PLN, because the kWh meter from PLN is only tasked with monitoring the amount of overall electrical energy usage, so it is necessary to periodically control the use of industrial machines, by turning off machines that are not in use.

For better electricity management in industry, electronic devices are needed that can monitor electrical energy consumption at any time. In realizing electrical energy monitoring devices, the author conducted research by studying real-time electrical energy consumption monitoring tools with the AVR Atmega 16 microcontroller with Visual Studio software.

Where the Analysis Tool is designed to obtain information related to Real Power (Watt), Apperent Power (VA), Voltage RMS (V), Cuttent RMS (A) in real time which can be accessed by computer. Measuring power usage is usually done with an analog kWh meter for each plan and takes a long time because of the remote locations. This system consists of hardware and software that are connected to each other so that the information obtained can be directly accessed at the same time.

The development of energy monitoring and protection needs to be carried out in order to meet energy needs and sustain life, therefore a tool is needed that can capture temperature differences into electrical energy for generating thermoelectric generators. The need for electrical energy cannot be separated from the needs of living things in carrying out daily activities.

This has the impact that along with very rapid growth in the field of technology, energy needs will also increase, however, not all energy sources currently used can be renewed so that as time goes by, these fossil fuel sources will run out. For example, non-renewable energy is conventional energy. Conventional Energy is energy that is available in quantity limited. One of the most widely used examples of conventional energy is fossil energy. (Muhammad Ady Pradana, 2020). In today's technological developments, various alternative and new renewable energies have been launched to reduce the impact of global warming. However, the availability of new renewable energy sources in Indonesia is still not utilized optimally.

This research was carried out based on the use of new renewable energy sources, especially geothermal energy to produce electrical energy, namely using a thermoelectric generator (TEG) as an alternative energy source. The thermoelectric generator can convert temperature differences into electrical quantities directly, but TEG still has several shortcomings, namely having low efficiency value, namely 10%. Things that reduce efficiency are that the heat convected in the TEG is not absorbed completely and the cooling system is not perfect so that the TEG cannot work optimally. This is what underlies this research, namely designing a heat insulation system to maximize the work of the TEG module.

Electrical energy is not only a basic need for households, but is also the backbone for industry and other important sectors. Therefore, the reliability of the electrical energy distribution and protection system is a crucial aspect in ensuring the continuity and stability of the electricity supply.

Rapid technological developments have made it possible to create more sophisticated and efficient monitoring and protection systems. One of the latest innovations is the use of a smart interface system in monitoring and protecting electrical energy. The system integrates sensor technology, wireless communication modules and web-based software to provide real-time monitoring and automatic response to disturbances or anomalies in the electrical

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system.

The use of electrical power in a building depends on usage. The more equipment used, the greater the power used, which can cause excessive current load. In order to carry out better electricity management in household cases, an electronic device is needed that can monitor the use of electrical energy in electrical devices that are considered quite wasteful such as electric rice cookers, dispensers, refrigerators, televisions, washing machines. There is a need for a monitoring tool that can calculate the power used. This tool processes current and voltage to find out how much power is released. \

This monitoring application was created using Microsoft Visual Studio software. Microsoft Visual Studio is an Integrated Development Environment created by Microsoft Corporation. Microsoft Visual Studio can be used to develop applications in native code (in the form of Microsoft Intermediate Language on top of the .NET Framework) [3]. This application was created using the Visual Basic programming language[4]. Programming languages are commands or instructions that are understood by computers to perform certain tasks. Apart from that, it is also referred to as a means for producing Windows-based application programs [5]. This application can save data in Excel and this application will also display a graph of the measured parameter values [6].

Literature Review

Electric Power Distribution System

The distribution system is one part of the electric power system, starting from the power source or power generator to the consumers. In the current era where the need for electric power is increasing, a system for distributing electric power from generators to consumers that has high reliability is needed.

According to the voltage value, distribution systems can be divided into two types, namely:

1. Medium / Primary Voltage Distribution System
   The primary distribution network is the electric power network that distributes electrical power from sub-transmission substations to distribution substations. This network is a medium voltage network or primary voltage network (Abdul Kadir, 2006). Medium voltage distribution channels are divided into 2 parts, namely main channels and branch channels.
2. Low / Secondary Voltage Distribution System The secondary distribution system is used to distribute
   Electric power from distribution substations to consumer loads. In the secondary distribution system, the most widely used channel form is the radial system. This system can use insulated cables or conductors without insulation. This system is usually called a low voltage system which will be directly connected to consumers/users of electric power using the following equipment:
   a. Sharing Connection Device (PHB) on distribution transformers,
   b. Low voltage mains (secondary distribution lines).
   c. Customer Service Line (SLP)
   d. Limiting devices and power meters (KWh meters) as well fuse or safety device

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for customers.

In Indonesia, in this case PT. PLN uses the system voltage 220/380 Volts. The secondary distribution system functions as a distributor of electric power from distribution substations (distribution substations) to load centers (electric power consumers). The voltage standard for the secondary distribution network is 220/380V.

Reactive Power Consumption in Customers

PT. PLN (Persero) has 6 groups of customers in accordance with the Presidential Regulation of the Republic of Indonesia Number 8 of 2011 concerning Electricity Tariffs Provided by the State Electricity Company (Persero), namely household, industrial, business, social, government office and PJU customers, as well as traction. For customers of PT. PLN (Persero) with the industrial group, excess use of reactive power (kVARh) with an average power factor (Cos φ) of less than 0.85 will be subject to a fee for excess use of reactive energy or a penalty. The use of reactive power (kVARh) by industrial customers cannot be avoided because electric machines and other equipment that use coils such as electric motors generate reactive power when working. If reactive power consumption exceeds the limit determined by PLN, customers will be charged for excess reactive power usage or a penalty.

This is stated in the Regulation of the Minister of Energy and Mineral Resources of the Republic of Indonesia Number 9 of 2011 concerning Provisions for the Implementation of Tariffs for Electricity Provided by the State Electricity Company (Persero) Article 3, namely:

1. In the event that the average power factor per month is less than 0.85 (eighty-five percent), then several tariff categories are subject to a fee for excess reactive power usage (kVArh).
2. The excess reactive power usage fee as intended in the previous paragraph applies if the kVArh usage recorded in 1 (one) month is higher than 0.62 (sixty two per hundred) of the total kWh in the month concerned, so that the power factor (Cos φ) an average of less than 0.85 (eighty five percent).

Linked Research

In this era of globalization, a teacher's accuracy in choosing learning media is a major factor in helping students understand a concept. Media is a component of learning resources or physical vehicles that contain instructional material in the student environment that can stimulate students to learn. On the other hand, the National Education Association defines media as forms of communication, both printed and audio-visual, and their equipment. Thus, media can be manipulated, seen, heard and read.

Computers are a form of learning media. The existence of computers can help teachers explain learning material more optimally to students. This is because computers can display material visually, audio and even audio-visually. Computer simulations provide dynamic, interactive and individual learning opportunities. With simulation, complex work environments can be structured to resemble the real world.

Nowadays, there are many types of software that can be used as a medium to simulate or visualize physics materials, including; PSIM Simulation, PHET Simulation, easy

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java/javascript Simulation (Ejs), GeoGebra and Visual Basic For Application on Excel spreadsheets. However, each media has different advantages and disadvantages, these differences can be in the form of improvements to previous media. One software that is quite easy to operate and is quite popular among teachers and students is spreadsheets in Microsoft Excel. This program is able to process data in the form of numbers and present it in graphical form. Apart from being easy to operate, this program can be found on every computer because it is installed from the start, which allows users to know and understand how to operate this application.

The potential of spreadsheets in physics learning includes the ability to visualize, simulate and animate physical phenomena with the display of numbers and dynamic graphs. Simulations using spreadsheet media are very effective in helping students learn, because these simulations do not only display graphic drawings that are formed but are the same as conducting experiments in a laboratory. Spreadsheets with Visual Basic for application in Excel are very helpful in learning, besides that macro programs are very helpful in seeing the effects of input data. The goal is to provide students with better alternative tools that can be used to improve their understanding of concepts that are otherwise abstract to the average student.

In learning physics, especially in electricity, many students still have difficulty understanding the subject. Moreover, teachers have difficulty explaining the subject of electricity. This is due to the inadequacy of interesting learning media to explain the material. Even though learning media is very influential in helping teachers in explaining learning, especially electrical material. Therefore, taking into account the ease of operation and the ability of the Excel spreadsheet visual basic application to simulate as well as the need for interesting learning media, through this research a Visual Basic for Application Spreadsheet Excel Simulation will be created on the Three Phase Electric Motor Concept which can be used as a learning medium.

METHOD

The increase in basic electricity tariffs in households and small industries can be due to lack of management in using electrical equipment. The use of electrical equipment that is used over time can increase the value of electrical power and even the resulting costs can be quite large. Monitoring electricity use is a process that allows a user of electricity facilities to monitor and manage electricity use.

The use of electrical power in a building depends on usage. The more equipment used, the greater the power used, which can cause excessive current load. In order to carry out better electricity management in household cases, an electronic device is needed that can monitor the use of electrical energy in electrical devices that are considered quite wasteful such as electric rice cookers, dispensers, refrigerators, televisions, washing machines. It is necessary to have a monitoring tool that can calculate the power used. This tool processes current and voltage to find out how much power is released.

This application was created using a programming language *Visual Basic*.

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Programming languages are commands or instructions that are understood by computers to perform certain tasks. Apart from that, it is also referred to as a means for producing Windows-based application programs. This application can save data in Excel and this application will alLso display a graph of the measured parameter values.

The research was carried out by designing a single-phase electrical power usage monitoring system*visualstudio*. In Figure 3 you can see the block diagram of the system being created. A 220 Volt power source is connected to a single phase load (in this study a lamp load is used). A current sensor and voltage sensor are installed on the load to read the current and voltage values flowing to the load. The sensor reading results are processed using an Arduino Uno and then the data is displayed on the computer in graphic form using Visual Studio. Apart from graphs, measurement data can also be viewed using Microsoft Excel

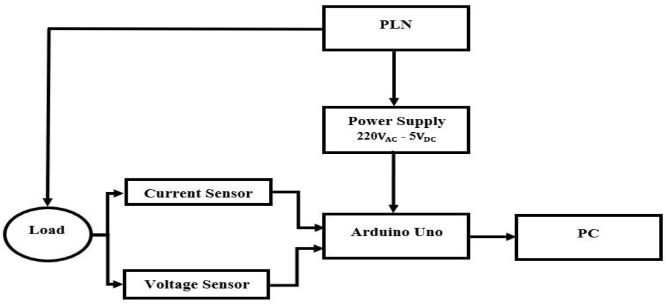

Figure 1. Block diagram of a single-phase electric power usage monitoring system

Where as*Flow chart*which serves as a reference in making*program listings* and contains the instructions for the program to be created which can be seen in Figure 2.

Figure 2. Monitoring system flowchart

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RESULTS

The system created is tested on a simple single phase electrical system, namely there is a source and a load tone. In the test, the electricity source used was 220 volts and the load used was a lamp as seen in Figure 5.

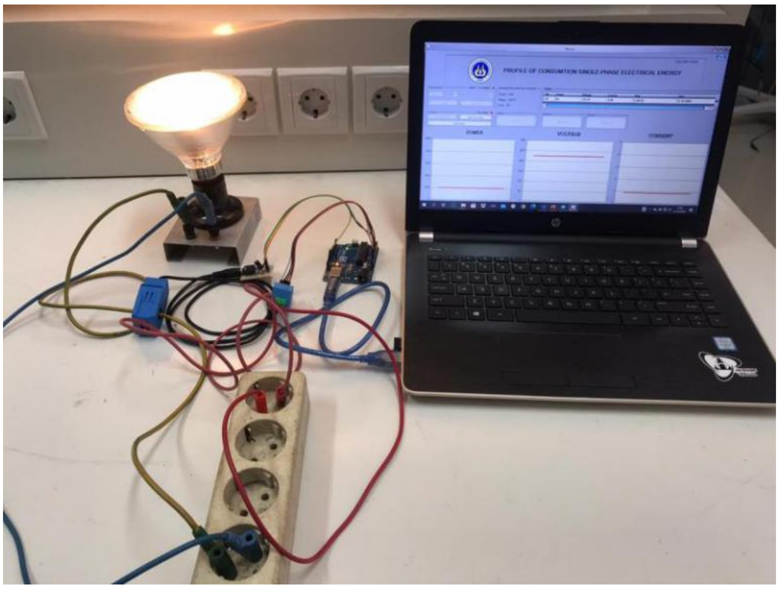

Figure 3. Testing Visual Basic Monitoring System

Figure 4 is a display form of monitoring electrical power usage in the form of a usage graph*interfaces*visualstudio. On the monitoring display there are graphs of current, voltage and power from electrical power usage. The graph that appears will change according to changes in the value of the electrical load used.

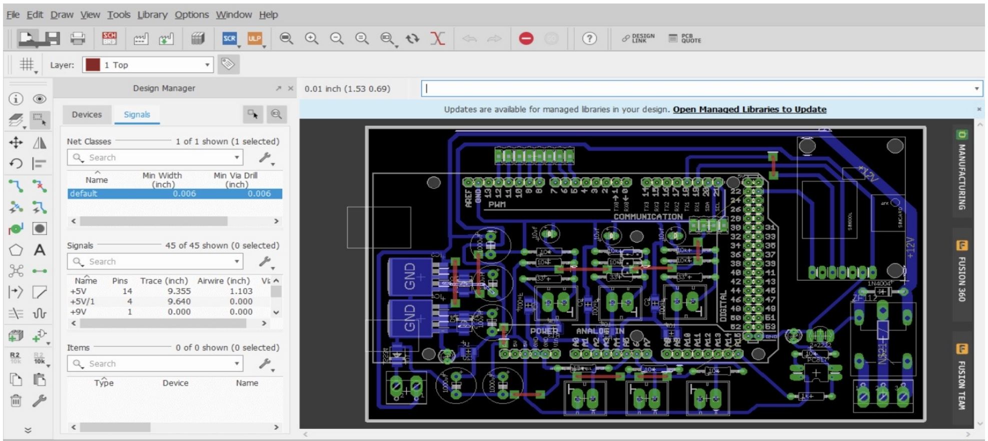

Figure 4. Monitor application display using Visual Studio

Apart from using the monitoring display, measurement data can also be viewed using Microsoft Excel. The measured current and voltage values are also automatically saved in Excel data as shown in Figure 5.

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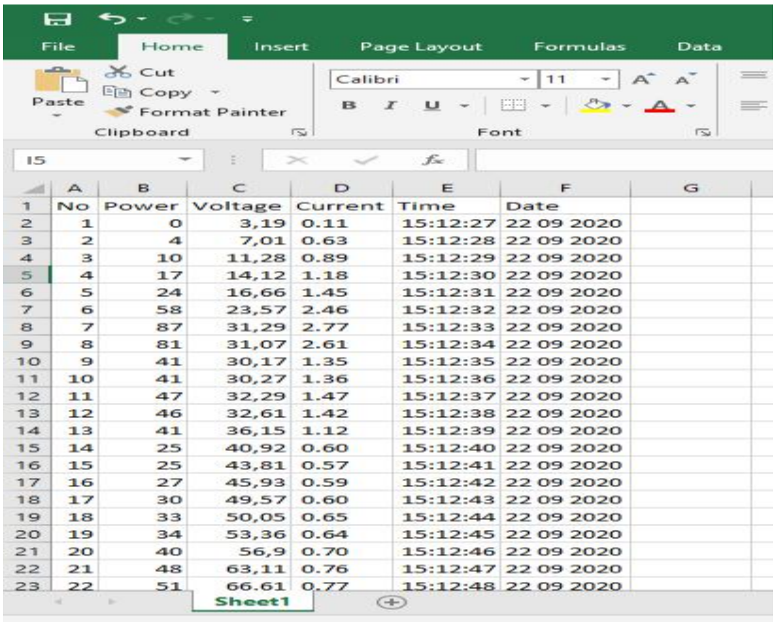

No	Power	Voltage	Current	Time	Date
1	0	3,19	0.11	15:12:27	22 09 2020
2	4	7,01	0.63	15:12:28	22 09 2020
3	10	11,28	0.89	15:12:29	22 09 2020
4	17	14,12	1.18	15:12:30	22 09 2020
5	24	16,66	1.45	15:12:31	22 09 2020
6	58	23,57	2.46	15:12:32	22 09 2020
7	87	31,29	2.77	15:12:33	22 09 2020
8	81	31,07	2.61	15:12:34	22 09 2020
9	41	30,17	1.35	15:12:35	22 09 2020
10	41	30,27	1.36	15:12:36	22 09 2020
11	47	32,29	1.47	15:12:37	22 09 2020
12	46	32,61	1.42	15:12:38	22 09 2020
13	41	36,15	1.12	15:12:39	22 09 2020
14	25	40,92	0.60	15:12:40	22 09 2020
15	25	43,81	0.57	15:12:41	22 09 2020
16	27	45,93	0.59	15:12:42	22 09 2020
17	30	49,57	0.60	15:12:43	22 09 2020
18	33	50,05	0.65	15:12:44	22 09 2020
19	34	53,36	0.64	15:12:45	22 09 2020
20	40	56,9	0.70	15:12:46	22 09 2020
21	48	63,11	0.76	15:12:47	22 09 2020
22	51	66.61	0.77	15:12:48	22 09 2020

Figure 5. Measurement data in excel form

If you look at the table data, when the voltage and current are greater, the power produced will also be greater. In this way, the rates that will be paid will automatically increase. However, when the current and voltage increase smaller, the power produced is also smaller. The appearance of measured data can help electric power users to manage their use of electric power with the aim of efficiency and savings. Thus, the funds that will be spent as compensation for the use of electrical power will decrease. Testing the current sensor circuit aims to find out whether the circuit is working properly. Figure 8 is the result of testing the current sensor using a serial monitor in the Arduino IDE application.

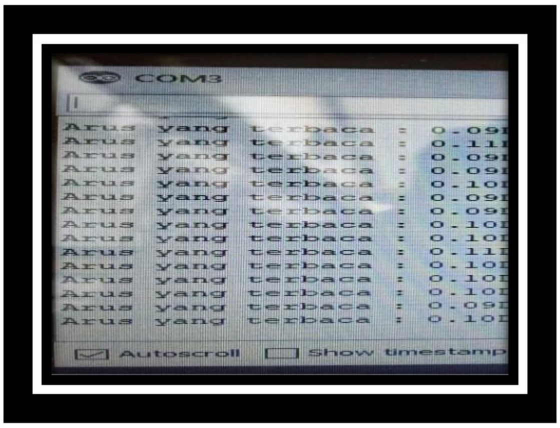

Figure 6. Current sensor test results

Testing the voltage sensor circuit is carried out by connecting pin L on the sensor to the load phase and pin N on the sensor to the neutral part of the load.

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Figure 7. Voltage sensor test results

Figure 7 shows voltage sensor reading data using a serial monitor in the Arduino IDE application. Based on the tests carried out, the single-phase electrical power usage monitoring system created can run well. Interface created using Visual Studio can display current, voltage and power values in the form of graphs well and the measured data can also be viewed using Microsoft Excel. In this way, users are expected to be able to make savings and efficiency in the use of electrical energy.

CONCLUSION

Research on Smart Interface System-Based Electrical Energy Monitoring and Protection Analysis has produced several main findings which can be summarized as follows: Implementation of a smart interface system significantly increases the reliability of the electrical energy protection system. This system is able to monitor the condition of the electricity network in real-time and provide a faster and more precise protection response compared to conventional protection systems. The smart interface system successfully provides real-time monitoring that enables early identification of potential interference and damage. This enables faster corrective action, thereby reducing operational downtime and preventing greater damage. By using a smart interface system, protection against electrical energy becomes more optimal. This system is able to coordinate various protection devices automatically, improving response to disturbances, and ensuring a more stable and reliable continuity of electricity supply. Implementation of a smart interface system has been proven to reduce the number of electrical disturbances and equipment damage. This reduction not only increases operational efficiency but also reduces maintenance and repair costs, and minimizes risks to work safety. The use of a smart interface system has a positive economic and operational impact. Increased efficiency and reduced downtime contribute to increased productivity and operational cost savings. In addition, increasing the reliability of electricity supply also supports more consistent and safe operations.

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