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Design of IoT-Based Analog kWh Meter Monitoring

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Abstract – The PLN officer in charge of recording kWh meters is sometimes unable to photograph them because men discovered that the houses were unoccupied and their fences were locked. Due to these circumstances, the calculation of the current month's electricity consumption is equated with the previous month, and customers can be harmed. The purpose of this research is to take a physical photo of the kWh meter showing the electrical power consumption and send it to WhatsApp. Firstly, it needs to set the timer on the DS3231, which determines the date for activating the esp32-cam to take kWh meter pictures and upload them to the server. Next, esp8255 downloads those photos from the server. Finally, esp8255 sends them to the WhatsApp application. In this study, the results were obtained in the form of an Internet of Things (IoT)-based smart home device system. The WhatsApp application is a notification media, taking pictures of analog kWh meters in 3–5 seconds with throughput, reliability, and availability values of 189 bps, 96%, and 95.97%, respectively.

Keywords: Espcam-32, Esp8255, kWh Meter, Whatsapp, IoT.

I. INTRODUCTION

PLN collects the use of electrical energy information on the KWh meter by bringing in field officers to directly record the monthly use of electrical energy manually [1]. The activity of recording the amount of energy consumed by PLN users is obtained by taking pictures of kWh meters. In cases where there is a KWh meter that is not reached by the officer, the electrical energy provider concludes and draws the average value of daily electrical energy use in the previous month. This greatly impacts consumers, as their monthly electricity bills may be higher than usual. Research on monitoring the use of electrical power has been accomplished by many previous researchers. The use of android-based smartphones is used to determine the amount of electricity consumed by electronic equipment [2]. In addition, monitoring electrical power in real time, protecting and limiting the use of electrical energy in rooms with a current of 2 A is also the research focus [3]. Meanwhile, the use of the Internet of Things in monitoring has also been widely applied. Monitoring kWh meters by measuring the amount of current, voltage and energy sent in the form of text messages to WhatsApp as one of the Internet of Things (IoT) applications has been carried out [4]. The application of IoT is also carried out in monitoring the amount of energy needed through multi-parameter readings of electricity by PZEM-004T, the main controller of Android, and data transmission to the cloud using ESP8266 [5]. The increasing number of boarding houses used by students, laborers, office workers and other communities is a solution for residents who do not have housing. The owners of these boarding houses generally charge the same electricity bill for each room, even though electricity consumption is different from one room occupant to another. IoT utilization is applied to the above conditions by using the ESP8266 nodemcu microcontroller, PZEM-004T module, 5V relay module, 20x4 LCD and DS3231 RTC [6]. The rent payment system makes it easier for tenants paying off their obligations without meeting landlord face to face. This convenience can be implemented using IoT [7].

This research utilizes the website interface and WhatsApp application to provide information to the homeowner through sending images on his WhatsApp account. Thus, a system is needed that can support the achievement of efficiency and effectiveness in the implementation of kWh meter monitoring. To solve the problem, image notifications via email and telegram were replaced by using the WhatsApp application. The WhatsApp application was chosen because it is the most

widely used application in Indonesia. Therefore, the notification in this study uses the WhatsApp application. Later, a notification in the form of a picture of power consumption on the kWh meter will be sent to the homeowner.

II. BASIC OF THEORY

The esp32-cam microcontroller is an integrated microcontroller that can work independently. In addition to WiFi and Bluetooth connectivity, the module also has an integrated camera and a microSD slot for storage. This Esp-32 Cam module can be used to capture images as well as a wifi module for data transmission [8].

Figure 1. Esp32-cam

Features of the Esp-32 Cam module are:

- Module of Ultra-small 802.11b/g/n Wifi + BT / BLE SoC
- Low-power dual-core 32-bit CPU for application processors
- Up to 240MHz, up to 600 DMIPS
- Built-in 520 KB SRAM, external 4M PSRAM
- Supports interfaces such as UART / SPI / I2C/ PWM / ADC/DAC
- Supports OV2640 dan OV7670 cameras with built-in flash
- Support for WiFI image uploads
- Supports TF card
- Supports multiple sleep modes
- Embedded Lwip and FreeRTOS

Eps32-cam module programming can use arduino IDE [9].

NodeMCU is an IoT platform that is open source and also includes the ESP 12 module, and runs on the esp8266 firmware which makes NodeMCU a microcontroller that has been equipped with a Wifi module in it [1].

Features of NodeMCU Esp8266 V3 are

- *Microcontroller* : Tensilica 32 bit
- Flash Memory : 4 KB
- Operating voltage : 3.3 V
- Input voltage : 7 – 12 V
- Digital I/O : 16
- Analog Input : 1 (10 Bit)
- Interface UART : 1
- Interface SPI : 1
- Interface I2C : 1

Figure 2. Esp 8266 microcontroller

The RTC DS3231 Module is a module that functions as an RTC (real-time clock). The interface to access this module is i2c or two wires (SDA and SCL). The input VCC can be supplied using voltages between 2.3V and 5.5V and has a battery backup. It has an integrated crystal, two programmed time alarms, and an output pin of 32,768 kHz to ensure higher accuracy. RTC is a device that can receive and store real-time data in the form of time decryption, such as days, dates, months, and years. RTC DS3231 is automatically able to store all data on time, day, date, month, and year, up to the difference in months that have 30 or 31 days [10].

Figure 3. RTC DS3231 module

This step down is an integrated module that uses the lm2956 ic which functions to reduce dc to dc power

Figure 4. Step down lm 2956

A relay module is a board that is so designed and composed of one or several relay components that it is used as an intermediary microcontroller to control electronic devices that require a large voltage source or AC [11]. The relay consists of a coil and contacts. A coil is a coil of wire that gets an electric current, while a contact is a kind of switch whose movement depends on the presence or absence of electric current in the coil. Contacts are classified into two types: normally open (initial condition before activation open) and normally closed (initial condition before activation closed).

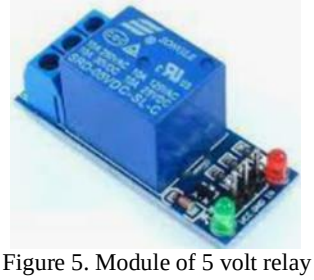

Figure 5. Module of 5 volt relay

Twilio, whose category includes Cloud Communications Platform Services (CpaaS), is a cloud communication platform. integrating and improving the function of exchanging information between two or more users across various channels in the form of voice telephone, SMS, chat, MMS, video, and programmatic conferencing servicesross various channels in the form of

voice telephone, SMS, chat, MMS, video, and programmatic conferencing services. This Twilio was able to do it. [12].

WhatsApp Messenger is a messaging app that allows users to communicate with one another over the internet by sharing files, text, voice, video, or location.The application uses the user's mobile phone number. The security possessed by this application uses end-to-end encryption. In which the entire data of WhatsApp messenger users is encrypted so that only the sender and recipient of the message can read it.

Wireshark is a tool intended for analyzing network data packets. Wireshark is also called a network packet analyzer, which functions to capture network packets and tries to display all the information in the package in as much detail as possible. A network packet analyzer is a tool to check what is really happening inside the network, both wired and wireless. With Wireshark, everything is greatly facilitated in terms of monitoring and analyzing packets passing through the network. [13].

IoT is the concept of using information technology to continuously connect all activities in the real world to the internet. Conventional IoT systems link two or more nodes that communicate with each other by detecting specific variables. The nodes can be machines, equipment, and other physical objects with network sensors and actuators that exchange data with each other. [14]. The data transmitted include temperature, presence, light density, current, voltage, traffic intensity and others [15] in the form of data, voice, images, video or multimedia. The information is used as input to carry out activities according to the desired performance.

III. METHOD AND DESIGN

The method used in this study is device design consisting of hardware and software designs.

A. Hardware Design

Hardware design is how to use existing components and systems as part of producing an IoT-based analog kWh meter monitoring tool. The LM 2956 module serves to lower the supply voltage by 5 volts. This module also supplies other modules. The esp8255 microcontroller will monitor the specified alarm date (through the program) via the DS3231 timer IC. If it matches the date, then the esp8255 will trigger the relay module to activate the esp32cam microcontroller.

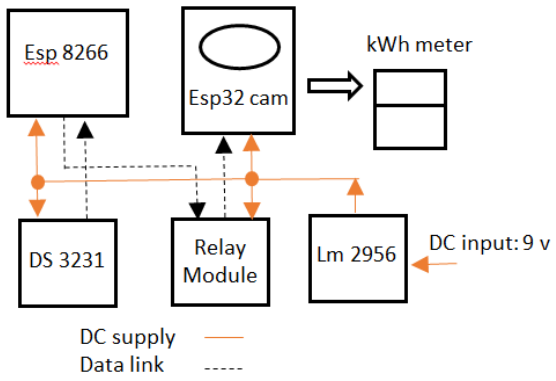

Figure 6. Hardware diagram block

The eps32-cam microcontroller is used to take a physical picture of the power consumption figures on an analog kWh meter through its camera, which is then sent to the Twilio server via the HTTP protocol. After 5 minutes, eps8266 will activate the server to send a notification of the current month's used kWh image data to the property owner via WhatsApp messaging, indicating that it is time to send a photo of the kWh meter to the electrical energy provider, in this case, PLN. The complete range of this equipment can be seen in Figure 7 below.

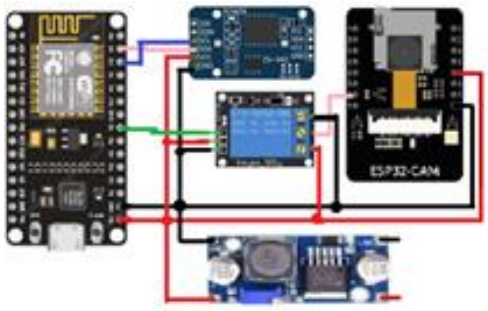

Figure 7. Overall circuit

B. Software Design

The first step of the software design process is that esp32-cam will analyze the ports connected to it as well as the esp826. Next, esp8266 will check the date on the DS3231 timer to see if it is the same as the set date; if it is, it will activate esp32-cam to take a photo of the kWh meter. Afterward, the photo is uploaded to the website. After the photo is saved on the website, esp8266 will download the image from the website. In the next step, the website will send a photo of the kWh meter to the WhatsApp application. Figure 8 depicts a software design flowchart.

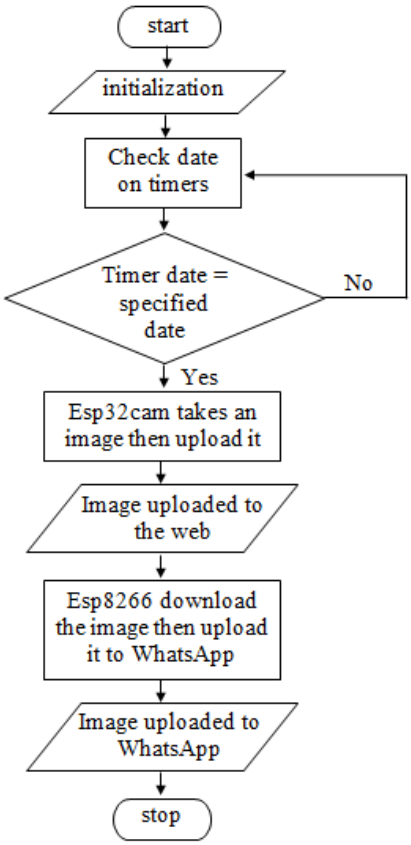

Figure 8. Software design flowchart

IV. RESULTS AND DISCUSSION

The parameters that support the design of the kWh meter monitoring hardware and software will be discussed in this section.

A. Esp32-cam Testing

This test aims to find out exactly on the specified date esp32-cam took a picture of the kWh meter and then uploaded to the server, in which the capacity of the image taken averaged 40 kb.

Figure 9. Esp32-cam result

B. Throughput Testing

Throughput is the ability of a network to transmit measurable data in bits per second (bps) [7].

$$Throughput = \frac{\text{the amount of data sent}}{\text{delivery time}} \quad \text{..... (1)}$$

The Wireshark window display provides information about the time, source and destination IP addresses, protocols used in the sending process, data length, and data condition info.

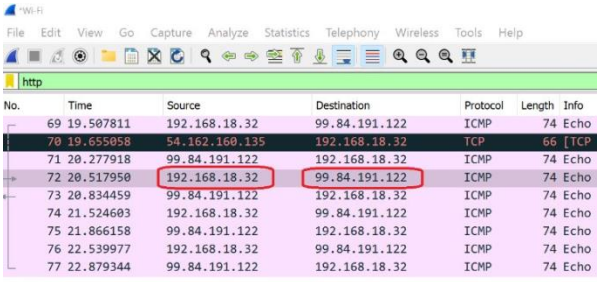

Figure 10 . Wireshark window

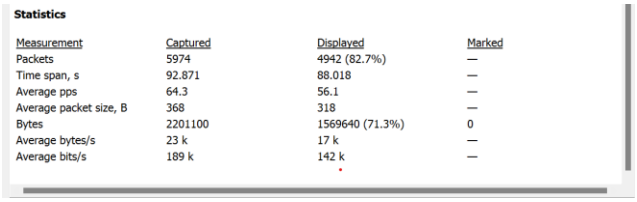

Figure 11. Statistical capture property

Meanwhile, the throughput value was obtained at 189 bps using equation (1) and the statistical capture property data in figure 11 above.

C. Availability and Reliability Testing

The author measures availability and reliability by sending information from esp8255 to the WhatsApp messenger application. Messages are sent 25 times at random times during the testing. The system performed well in the test, with availability and reliability values of 96% and 95.97%, respectively.

Table 1. Reliability and Availability Testing

Number of data sent	Number of successfull packets sent	Number of failed packets sent	Availability (%)	Reliability (%)
25	24	1	96	95.97

D. Uploading of the Resulting Image to Mobile Phone

The process of uploading images to the WhatsApp application indicates that the process of sending data from the web server to the homeowner's cellphone has been successfully transmitted and taken 3-5 seconds. Figure 12 below displays the received kWh meter image message.

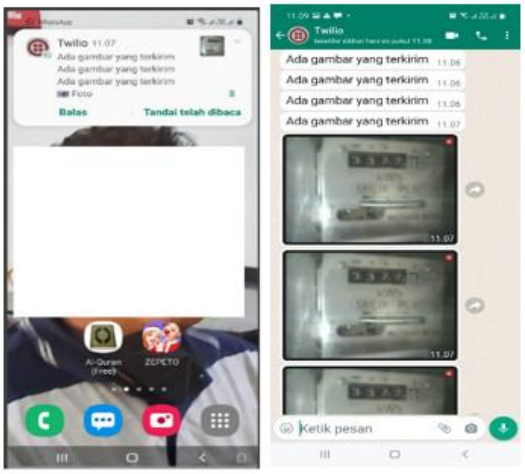

Figure 12. The images appear on WhatsApp application

The realization design of the overall of the tool can be seen in the following figure 13.

Figure 13. The tool realization design

V. CONCLUSION

The designed system can function as desired, in which the kWh meter image can be sent to the homeowner's WhatsApp with an average kWh meter image capacity of 40 kb in an interval of 3-5 seconds. This equipment is able to produce a throughput of 189 bps with a reliability of 96% and an availability of 95.97%. In the future, photo data can be directly converted into text. Then, the kWh photo data and text can be sent simultaneously to WhatsApp customers and electricity providers, in this case PLN, so that there is no more human intervention in reporting power consumption at home.

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