p-ISSN 2715-2871
e-ISSN 2714-5247

Design and Development of Voltage, Current and Frequency Monitoring on 3-Phase Electrical Panel Boxes for Audio Sound Systems Using ESP32 Based Ubidots

Arif Setiabudi
Departement of Electrical Engineering
State University Of Surabaya
Surabaya, Indonesia
arifsetiabudi123@gmail.com

Bambang Suprianto
Departement of Electrical Engineering
State University Of Surabaya
Surabaya, Indonesia
bambangsuprianto@unesa.ac.id

Parama Diptya Widayaka
Departement of Electrical Engineering
State University of Surabaya
Surabaya, Indonesia
paramawidayaka@unesa.ac.id

Rina Harimurti
Departement of Electrical Engineering
State University Of Surabaya
Surabaya, Indonesia
rinaharimurti@unesa.ac.id

***Abstract*— This research aims to design and build a monitoring system capable of measuring voltage, current, and frequency on 3-phase electrical panels for audio-sound systems. This system uses an ESP32 device as a microcontroller and Ubidots as a cloud platform for real-time data visualization and storage. Equipped with a PZEM004t as a voltage, current, and frequency sensor, this system provides accurate and real-time monitoring of electrical parameters. An analysis was carried out on the ability of this system to be accessed remotely via the network, as well as the integration of notifications via the Telegram application for direct notification of disturbances in the electrical panel. Testing was carried out by comparing this system with existing electrical panel boxes as well as through observation and assessment by five sound engineers to evaluate the system's performance in monitoring voltage, current, and frequency accurately and stably. The test results show that the system is capable of measuring and monitoring electrical parameters well, providing useful information for the maintenance and management of electrical systems, as shown by the results of the average map test error on the parameters voltage (0.4%), current (10% and frequency (0.6% and in usability testing, a percentage score of 97.5%. The implementation of this system is expected to increase the operational efficiency and reliability of the audio-sound system.**

Keywords*— *Monitoring, voltage, current, frequency, electrical system, ESP32, Ubidots, sensor, Wi-Fi, real-time, online dashboard, audio sound system, efficiency.

I. Introduction

Electrical energy is very necessary in everyday life. The stability of the electrical system is something that needs to be considered, and one of the most common ways to generate electricity is by using generators [1]. The function of this generator itself is to convert mechanical energy, or motion energy, into electrical energy. The motor connected to the generator is the main mover. Generators have limited capacity in terms of the power they can produce. If the electrical load exceeds the capacity of the generator, an overload can occur, which has the potential to damage the generator and connected equipment. Therefore, users must pay attention to the generator capacity and ensure that the electrical load remains within the specified limits. For example, disturbances such as overload current and voltage drops often occur. Damage to the generator can disrupt the electric power operating system.

Uncontrolled use of high-power electricity and electronic equipment that does not comply with regulations can cause various technical problems, including the risk of fire and equipment damage. Therefore, supervision and monitoring of electrical systems are very important in ensuring safety and good performance.

Monitoring electricity such as voltage, current, and frequency on electronic devices is actually very important but is often ignored, even though unstable electricity can affect the performance of electronic devices so that they cannot work optimally and have the potential to cause damage and shorten the life of electronic equipment [2]. Audio sound systems are an example of the use of electricity in the entertainment industry, such as on concert stages, recording studios, celebrations, and other public events that are currently held outdoors [3]. For a sound engineer, maintaining the condition of the electricity used for the sound system is very important, but to maintain voltage, current, and frequency, use a panel box that uses standard measuring instruments or analog or digital measuring instruments that are portable so that the measurement results can be known directly but cannot be monitored remotely in real-time [4].

One of the monitoring systems that has been included in several trends in recent years is the Internet of Things (IoT). IoT is a concept that refers to physical devices that can be connected to the internet so that they are able to communicate with other devices without connecting directly between devices [5]. In the IoT system, these devices are equipped with sensors, software, and internet connectivity to collect and exchange data. The basis behind IoT is to make nearby devices smart and connected in order to improve efficiency, comfort, and quality of life. By utilizing increasingly advanced networking, sensor, and computing technologies, IoT enables continuous data collection, real-time monitoring, and remote control of these devices.

By utilizing electronics, information technology, and the internet, this research will design and build a voltage, current, and frequency monitoring system on a 3-phase electrical panel box used in an audio sound system in real-time with the Internet of Things (IoT) using a platform called Ubidots based on ESP32, which can be accessed using a laptop or Android without needing to go directly to where the panel is located. The aim of this research is to help improve the quality of the audio sound system and provide a more accurate and efficient monitoring solution for the 3-phase electrical system in the audio sound system. It is hoped that the existence of this monitoring system will be able to increase the effectiveness of supervision and minimize human error, such as when measuring using portable standard measuring instruments, so that it can improve sound quality and prevent damage that may occur.

II. RESEARCH METODHOLOGY

In this research, researchers will design and build a voltage, current and frequency monitoring system on a 3-phase electrical panel box for an audio sound system using ESP32-based ubidots and using several processes to get the desired results. Apart from that, this research seeks to create a tool that makes it easier for users to monitor electrical parameters on panel boxes in real time or online.

A. Flowchart Software

In software design, workflows, algorithms, and the work logic of the system to be built are mapped. In addition, software design can also facilitate future development processes because library needs have been identified. The results of the software development stage are in the form of a flowchart.

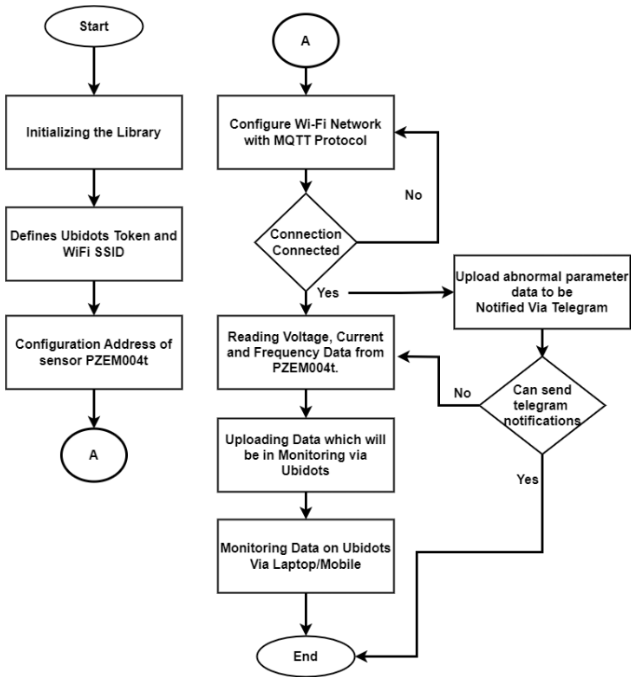


Figure 2.1 Flowchart Software Tools

B. Block Diagram

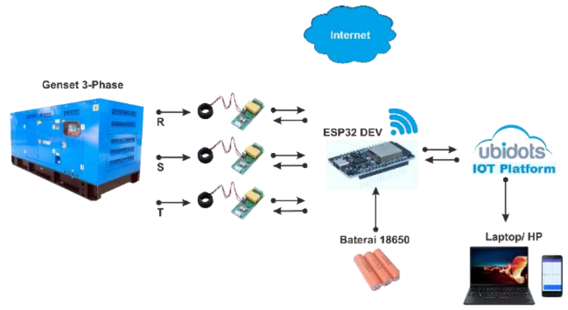


Figure 2.2 Diagram Block Tools

From the block diagram above, you can find out a little about the description of the object of this research and the following is an explanation of the function of each block:

1. Generator 3-Phase
   In this research, the voltage, current, and frequency to be measured are sourced from a 3-phase generator; in this case, the generator is the input part.

2. ESP32Board
   The microcontroller uses the ESP32 board as the main controller in the monitoring tool. The ESP32 regulates the three PZEM004t sensors so that they do not collide with each other during the process and connect to the Ubidots IoT platform via the internet.

3. PZEM-004t
   The PZEM004t Sensor Series plays a very important role in the system, with the main aim of capturing data regarding the voltage, current, and frequency parameters produced by the 3-phase generator. This circuit consists of three PZEM004t sensors connected in parallel, then connected to the Rx and Tx pins on the ESP32board.

4. Battery18650
   This 18650 battery is used as the main power source for 3-phase electricity monitoring tools. 2 18650 batteries are used, a step-up module will be added to these batteries to increase the voltage of the 18650 battery which was initially 3.7V to 5V in order to meet the needs of the PZEM004t and ESP32 microcontroller. Apart from that, this circuit is also equipped with a charger module and 5V adapter which is used to recharge the battery when the system receives power from the generator.

5. Ubidots
   Ubidots is a cloud-based IoT platform that allows users to connect, collect, process and analyze data from connected devices around the world. Ubidots offers a wide range of features and functionalities that include: Data

Collection, data visualization, Notifications and Alarms, Integration and Extensibility, Security, Data Analytics.

Introduction section covers background or motivation of the research, purpose and methods of the research, and clear contribution which is justified by concise literature review.

C. *Wiring Diagrams*

This system consists of two main parts, namely sensors and microcontrollers. The sensor consists of three PZEM004t sensors installed in parallel to read the R, S, and T power sources from the generator. Meanwhile, the microcontroller uses the ESP32 board as the main controller in the monitoring tool. The ESP32 regulates the three PZEM004t sensors so that they do not collide with each other during the process and connect to the Ubidots IoT platform via the internet. From the Ubidots platform, notifications can be sent under certain conditions. Apart from that, monitoring results can be displayed via laptops and Android devices via the Ubidots web. To keep the system running smoothly, this hardware is supplied using an 18650 battery, which is regulated like a UPS system.

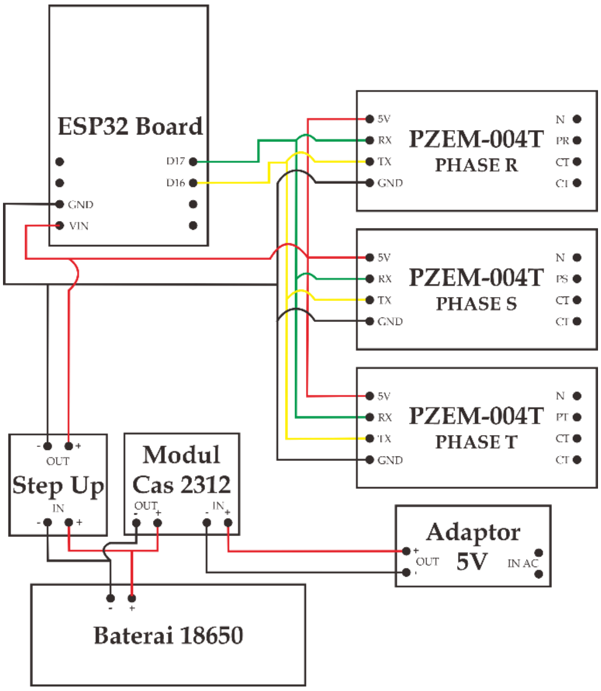


Figure 2.3 Wiring Diagram Tools

The PZEM004t Sensor Series plays a very important role in the system, with the main aim of capturing data regarding the voltage, current, and frequency parameters produced by the 3-phase generator. This circuit consists of three PZEM004t sensors connected in parallel, then connected to the Rx and Tx pins on the ESP32 board. Apart from that, this circuit also requires a stable voltage flow provided by the power supply circuit. With this arrangement, the PZEM004t Sensor series is able to accurately and efficiently measure and monitor voltage, current, and frequency signals produced by a 3-phase generator.

D. *Hardware Manufacturing*

In this research, hardware was designed that aims to monitor 3-phase electricity from a generator that will be used in an audio sound system at outdoor events.

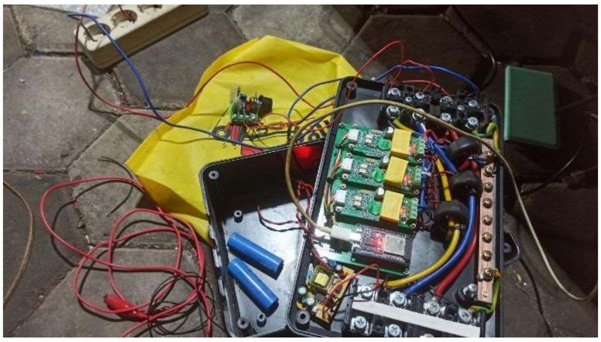


Figure 2.4 Hardware assembly

E. *Software Manufacturing*

1. *Ubidots Account Creation*

A 3-phase electrical monitoring system program has been designed to connect the ESP32 to the Ubidots IoT platform. The first step in this process is to ensure that the device has a stable internet connection. After that, users have to open a browser and access the ubidots website to create a new account using a valid email address.

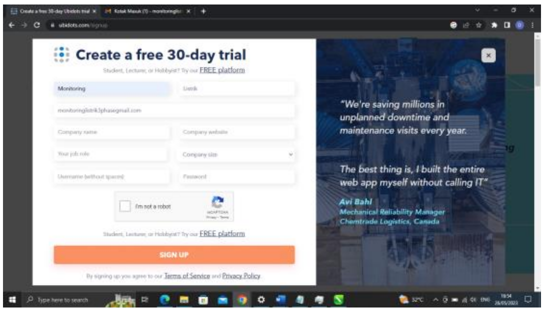


Figure 2.5 Ubidots account registration

After successfully creating a Ubidots account using a valid email address, the next step is to log in to the account. After logging in, users will be directed to the main Ubidots dashboard. Here, they will be able to see the various options and features provided by the platform, such as device creation and management, variable creation and management, and data visualization creation. After successfully creating a Ubidots account using a valid email address, the next step is to log in to the account. After logging in, users will be directed to the main Ubidots dashboard. Here, they will be able to see the various options and features provided by the platform, such as device creation and management, variable creation and management, and data visualization creation.

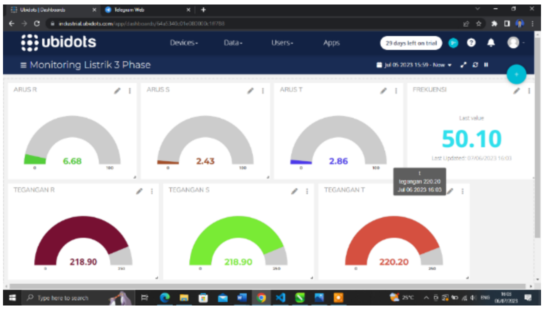


Figure 2.6 Dashboard Ubidots

2. *Telegram Bot Creation*
The aim of this system is to provide notifications directly via the Telegram platform when abnormal parameters are detected. To start implementing the system, the first step was to create a Telegram bot called "3 Phase Electricity Monitoring" using the Bot Father service.

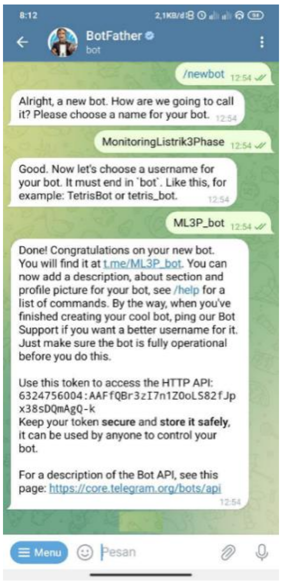
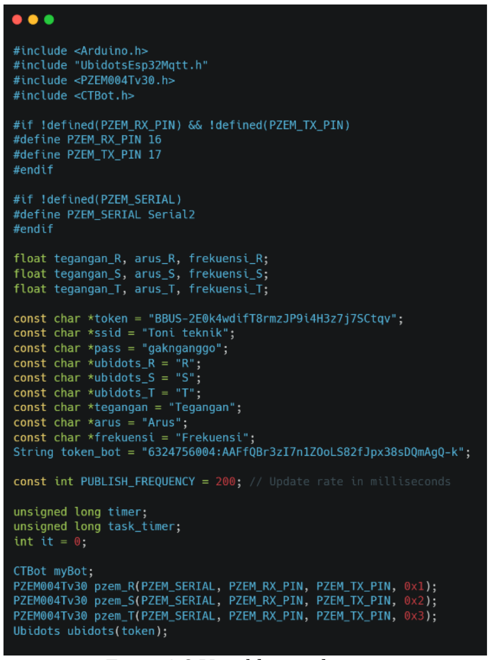


Figure 2.7 Create a telegram bot with “Bot father”

3. *Program Code Creation*
In the designed monitoring system, software development follows a series of structured stages. First of all, software creation is done by writing code using the C++ programming language and using the Visual Studio Code (VSCode) application, whose functions have been expanded through the PlatformIO extension. Communication between PlatformIO and the laptop is usually done via a USB Type C cable to ensure fast and reliable data transfer. Next, there are three key stages in the process of creating this software. The first stage is creating an account on the Ubidots platform, which is a platform for managing sensor data and visualizing data online. Then, the second stage involves creating a Telegram bot whose function is to provide notifications to users based on data collected by the monitoring system. The final stage is creating lines of program code that regulate the interaction between the hardware and software that have been developed. Before the program can be uploaded to the ESP32 microcontroller board, an important step that must be taken is the compilation or build process using the VSCode application. This process aims to check for possible errors in the program code before the program is uploaded to the ESP32 board. By carrying out this build process, errors or bugs in the program can be detected and corrected before the final implementation is carried out on the target hardware.



```
#include <Arduino.h>
#include "UbidotsEsp32Mqtt.h"
#include <PZEM004Tv30.h>
#include <CTBot.h>

#if !defined(PZEM_RX_PIN) && !defined(PZEM_TX_PIN)
#define PZEM_RX_PIN 16
#define PZEM_TX_PIN 17
#endif

#if !defined(PZEM_SERIAL)
#define PZEM_SERIAL Serial2
#endif

float tegangan_R, arus_R, frekuensi_R;
float tegangan_S, arus_S, frekuensi_S;
float tegangan_T, arus_T, frekuensi_T;

const char *token = "BBUS-2E0k4wdifT8rmzJP9i4H3z7j7SCtqv";
const char *ssid = "Toni teknik";
const char *pass = "gaknganggo";
const char *ubidots_R = "R";
const char *ubidots_S = "S";
const char *ubidots_T = "T";
const char *tegangan = "Tegangan";
const char *arus = "Arus";
const char *frekuensi = "Frekuensi";
String token_bot = "6324756004:AAFfQBr3zI7n1Z0oLS82fJpx38sDQmAgQ-k";

const int PUBLISH_FREQUENCY = 200; // Update rate in milliseconds

unsigned long timer;
unsigned long task_timer;
int it = 0;

CTBot myBot;
PZEM004Tv30 pzem_R(PZEM_SERIAL, PZEM_RX_PIN, PZEM_TX_PIN, 0x1);
PZEM004Tv30 pzem_S(PZEM_SERIAL, PZEM_RX_PIN, PZEM_TX_PIN, 0x2);
PZEM004Tv30 pzem_T(PZEM_SERIAL, PZEM_RX_PIN, PZEM_TX_PIN, 0x3);
Ubidots ubidots(token);
```

Figure 2.8 Variable initialization

The line of program code for making 3-phase electricity monitoring has several parts, including:Initializing Variables shows the required library declaration and the process of initializing the variables needed to connect to the internet via a WiFi network, along with the variables used to connect to the Ubidots web and Telegram bot."Void Setup" has a function that aims to start all the processes involved in the tool, including connecting to the internet network to send data to the Ubidots server and also the Telegram bot server. This program code is important in keeping electricity monitoring running smoothly and can send the necessary data to the Ubiquitous platform server and Telegram bot for further processing and analysis."Void Loop" has the task of taking data from the pzem sensor in the form of voltage, current, and frequency from each phase and sending the data to the ubidots server, as well as arranging sending telegram bot notifications according to the conditions in each phase when experiencing abnormal conditions and sending values according to the abnormal conditions. both voltage, current, and frequency values

p-ISSN 2715-2871
e-ISSN 2714-5247

III. RESULTS AND DISCUSSION

In the next stage, after completing the process of making the electrical circuit, hardware, and software for the 3-phase monitoring system, testing is carried out to ensure optimal performance. This testing covers all hardware and software components that are assembled comprehensively, with the aim of ensuring that the system can function harmoniously and produce accurate results. This testing process aims to demonstrate the system's ability to monitor 3-phase electricity with a high level of brightness and accuracy. The results of this experiment provide important information and understanding regarding the performance of the system that has been created, and these results become a reference in optimizing the 3-phase electricity monitoring system as a whole.Keep your text and graphic files separate until after the text has been formatted and styled. Do not use hard tabs, and limit use of hard returns to only one return at the end of a paragraph. Do not add any kind of pagination anywhere in the paper. Do not number text heads-the template will do that for you.

FIGURE 3.1 THE PROCESS OF INSTALLING TOOLS ON THE GENERATOR

During this process, the neutral cable is installed, as are the R, S, and T phases from the generator to the electric flow input of the 3-phase electricity monitoring device. Apart from that, the output cable for the 3-phase electrical monitoring device was also installed into the existing audio-sound system electrical panel box.

Figure 3.2 Data Monitoring Process on Ubidots Web

A. *MAPE testing*

According to M. Azman Maricar [6], this is a calculation used to calculate the average percentage of absolute error. MAPE testing involves comparing the values predicted by the monitoring system with the actual values of voltage, current and frequency on the 3-phase electrical panel box. By comparing predicted values with actual values, MAPE measures the magnitude of the average error in percentage of the actual value. The smaller the MAPE value, the higher the level of accuracy of the monitoring system.

Testing of the monitoring system has been carried out in a series of sequential stages, which have been explained and carried out within a testing time of 1 hour. The following are the measurement values for voltage, current, and frequency of the 3 phases, with detailed calculations and terms used as follows:

Ref : Reference is the actual value. Used in 3-phase electrical panel boxes

Monitor : Is the value obtained from the monitoring system that has been created

Dif : Differential is a value that measures the difference between the reference value and the monitor value.
This difference is calculated using the formula:
Dif =ABS (x Monitor – x Ref)

Error : Is the percentage error from comparing the two tools. The formula for calculating errors is as follows:

$$\text{Error x} = \frac{x\ Dif}{\text{x Ref}} \qquad (1)$$

Table 3.1 Variable data phase R

Tegangan				Arus				Frekuensi			
V.Ref	V.Monitor	V.dif	e V	I. Ref	I.Monitor	I.dif	e I	f.Ref	f.Monitor	f.dif	e f
240	239,1	0,9	0,38%	**0,5**	0,605	0,11	0%	50	50	0	0,0%
235	238,2	3,2	1,36%	**0,5**	0,508	0,01	1,60%	50	50	0	0,0%
235	235,2	0,2	0,09%	**0,5**	0,508	0,01	1,60%	50	49,9	0,1	0,2%
235	234,9	0,1	0,04%	**0,5**	0,507	0,01	1,40%	50	50	0	0,0%
235	238,5	3,5	1,49%	**0,5**	0,508	0,01	1,60%	50	49,9	0,1	0,2%
235	236,2	1,2	0,51%	**0,5**	0,509	0,01	1,80%	51	49,9	1,1	2,2%
235	235,6	0,6	0,26%	**0,5**	0,507	0,01	1,40%	49	50	1	2,0%
235	234,2	0,8	0,34%	**0,5**	0,506	0,01	1,20%	50	50	0	0,0%
235	235,6	0,6	0,26%	**0,5**	0,502	0,00	0,40%	50	50	0	0,0%
235	234,7	0,3	0,13%	**0,5**	0,505	0,01	1,00%	49	50	1	2,0%
235	234,8	0,2	0,09%	**0,5**	0,508	0,01	1,60%	50	50	0	0,0%
233	237,1	4,1	1,76%	**0,5**	0,504	0,00	0,80%	49	50	1	2,0%
235	233,7	1,3	0,55%	**0,5**	0,505	0,01	1,00%	50	49,9	0,1	0,2%
233	234,1	1,1	0,47%	**0,5**	0,506	0,01	1,20%	50	49,9	0,1	0,2%
235	238,7	3,7	1,57%	**0,5**	0,507	0,01	1,40%	50	49,9	0,1	0,2%

Table 3.2 Variable data phase S

Tegangan				Arus				Frekuensi			
V.Ref	V.Monitor	V.dif	e V	I. Ref	I.Monitor	I.dif	e I	f.Ref	f.Monitor	f.dif	e f
235	237,3	2,3	1,0%	**3,5**	3,55	0,0522	1,5%	50	50	0	0%
235	238	3	1,3%	**1**	1,006	0,006	0,6%	50	50	0	0%
235	235	0	0,0%	**6,5**	6,541	0,041	0,6%	50	49,9	0,1	0%
235	234,7	0,3	0,1%	**9**	9,039	0,039	0,4%	50	50	0	0%
235	235,5	0,5	0,2%	**7,7**	7,757	0,057	0,7%	50	49,9	0,1	0%
235	235,8	0,8	0,3%	**7,5**	7,609	0,109	1,5%	51	49,9	1,1	2%
234	235,4	1,4	0,6%	**8**	8,042	0,042	0,5%	49	50	1	2%
235	234,1	0,9	0,4%	**9,5**	9,507	0,007	0,1%	50	50	0	0%
235	235,8	0,8	0,3%	**7**	6,943	0,057	0,8%	50	50	0	0%
234	234,2	0,2	0,1%	**9**	9,055	0,055	0,6%	49	50	1	2%
234	234,6	0,6	0,3%	**9**	8,867	0,133	1,5%	50	50	0	0%
234	236,6	2,6	1,1%	**5,5**	5,556	0,056	1,0%	49	50	1	2%
234	233,9	0,1	0,0%	**9,5**	9,459	0,041	0,4%	50	49,9	0,1	0%
234	233,8	0,2	0,1%	**10**	10,195	0,195	2,0%	50	49,9	0,1	0%
240	238,6	1,4	0,6%	**2**	1,989	0,011	0,5%	50	49,9	0,1	0%

Table 3.3 Variable data phase T

Tegangan				Arus				Frekuensi			
V.Ref	V.Monitor	V.dif	e V	I. Ref	I.Monitor	I.dif	e I	f.Ref	f.Monitor	f.dif	e f
240	238,3	1,7	0,71%	**1**	1,017	0,017	2%	50	50	0	0%
234	233,6	0,4	0,17%	**2**	1,99	0,01	1%	50	50	0	0%
234	233,7	0,3	0,13%	**2**	1,998	0,002	0%	50	49,9	0,1	0%
235	236,3	1,3	0,55%	**1,5**	1,482	0,018	1%	50	50	0	0%
234	234,3	0,3	0,13%	**2**	1,987	0,013	1%	50	49,9	0,1	0%
234	233,9	0,1	0,04%	**2**	1,973	0,027	1%	51	49,9	1,1	2%
234	235,6	1,6	0,68%	**1,5**	1,508	0,008	1%	49	50	1	2%
235	234,5	0,5	0,21%	**2**	2,027	0,027	1%	50	50	0	0%
235	235,1	0,1	0,04%	**2**	1,973	0,027	1%	50	50	0	0%
237	235,6	1,4	0,59%	**2**	2,021	0,021	1%	49	50	1	2%
235	235,2	0,2	0,09%	**2,5**	2,51	0,01	0%	50	50	0	0%
234	234,5	0,5	0,21%	**2**	1,988	0,012	1%	49	50	1	2%
235	234,7	0,3	0,13%	**1,5**	1,507	0,007	0%	50	49,9	0,1	0%
235	236,9	1,9	0,80%	**1,5**	1,501	0,001	0%	50	49,9	0,1	0%
237	237	0	0,00%	**0**	0,071	0,071	0%	50	49,9	0,1	0%

Table 3.4 Interpretasi Mape

p-ISSN 2715-2871
e-ISSN 2714-5247

NO.	Percentage MAPE	Interpretasi
1	≤ 10 %	Very Accurate
2	10%- 20%	Good
3	20%- 50%	Quite accurate
4	>50%	Not accurate

From the results of the MAPE analysis, it can be concluded that the relative error level of the model or system being researched is good. This indicates that the system has a high level of prediction accuracy, as seen from the average test results in the table below.

Table 3.5 Overall average results

Voltage	Current	Frequency
0,4%	10%	0,6%

B. Telegram Notifications

This 3-phase electricity monitoring device has been programmed to send notifications via bot in the Telegram application when electricity conditions show abnormalities. This abnormal condition is determined by several parameters, such as the difference in electric current between the R, S, and T phases, which exceeds 8A; the frequency, which is outside the 50–60 Hz range; and the voltage, which is below 180V or above 240V. Notification or warning when electrical conditions reach abnormal values or are outside a predetermined range. This allows users to immediately respond and resolve problems that may arise in a 3-phase electrical system.

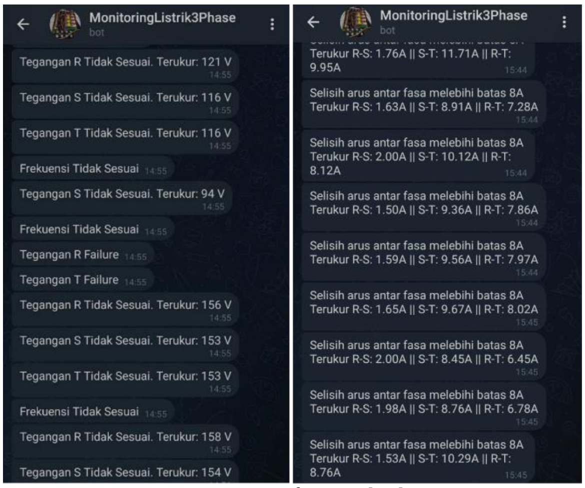


Figure 3.3 Notification display

C. Usability Testing

Usability testing is an observation and assessment process that aims to assess the user's level of comfort and satisfaction with using a product, website, or application effectively. In this test, users representing the target audience will be asked to complete a series of tasks relevant to the product. The goal is to identify potential issues in design or functionality that might hinder the user experience. Observations and assessments of user interactions with products are carried out, either through direct supervision or screen recordings, to collect data that can be used to improve product design, identify usage trends, and gain a gain a deeper understanding of user needs.


Figure 3.4 Observation and Assessment Process

According to Nielsen [7], in his article "Introduction to Usability," to find usability problems in an application, it is enough to involve the participation of five users in the testing process. This usability test involved the participation of five sound engineers, or respondents, as observation subjects. Respondents are used to using audio-sound system devices and have the ability to analyze and collect the necessary information.

To measure the level of usability of this system, equation 2 is used as a calculation tool. The usability percentage value is calculated based on the average of aspects such as learnability (ease in learning the system), flexibility (flexibility in using the system), effectiveness (effectiveness in achieving usage goals), and attitude (the user's attitude towards the system). By using this equation, a calculation value for the usability percentage of the system being tested can be obtained.

Table 3.6 Learnability Aspect

Code	Statement
P1	This 3-phase electrical monitoring device is easy to learn and use.
P2	This 3-phase electrical monitoring device is very helpful in using audio sound systems.

Table 3.7 Flexibility Aspect

Code	Statement
P3	This 3-phase electricity monitoring device is easy to activate.
P4	This 3-phase electricity monitoring device can provide automatic notification of abnormal conditions from anywhere.

Table 3.8 Efectivyness Aspect

p-ISSN 2715-2871
e-ISSN 2714-5247

Code	Statement
P5	This 3-phase electricity monitoring device does not require a long time to provide notifications when electricity conditions are abnormal.
P6	Users can easily and quickly respond to the data provided by the system to take necessary actions.
P7	This system can help users save time and energy by monitoring electricity.
P8	With this 3-phase electrical monitoring device, electrical safety can be increased.

Table 3.9 Attitude Aspect

Code	Statement
P9	This 3-phase electricity monitoring device is interesting.
P10	The visual composition of 3-phase electrical monitoring via the Ubidots web is good.
P11	I would suggest other users use this 3-phase electrical monitoring device in audio-sound systems.

Data results from usability testing can be found in the table below. This table describes the number of respondents for each answer in each question, the associated weight, and the percentage of each answer. Statements (P) in the table have been categorized according to relevant aspects.

To measure the results of the data obtained, a Likert scale was used. The Likert scale is a measurement method that is often used in behavioral research and surveys. This scale has response levels that respondents can choose to indicate their level of suitability or satisfaction with the questions asked.

Tabble 3.10 Likert Scale Answer Level

No.	Answer	Mention
1	Very Dissatisfied	STP
2	Not satisfied	TP
3	Neutral	N
4	Satisfied	P
5	Very Satisfied	SPS

Table 3.11 Usability testing results

P	Jawaban					Bobot	%
	STP	TP	B	SP	SPS		
Aspek Learnibility							
P1	0	0	0	1	4	24	96
P2	0	0	0	0	5	25	100
Aspek Flexibility							
P3	0	0	0	0	5	25	100
P4	0	0	1	1	3	22	88
Aspek Efectiveness							
P5	0	0	0	0	5	25	100
P6	0	0	0	1	4	24	96
P7	0	0	0	0	5	25	100
P8	0	0	0	1	4	24	96
Aspek Attitude							
P9	0	0	0	0	5	25	100
P10	0	0	0	0	5	25	100
P11	0	0	0	0	5	25	100

The learnability aspect refers to the user's ease in using the 3-phase electricity monitoring device. Overall, respondents' understanding of the use of the device was very satisfactory. The flexibility aspect relates to the availability of features in the system for users. In general, respondents' understanding of 3-phase electricity monitoring devices is satisfied. The effectiveness aspect concerns the success of achieving the objectives of using monitoring devices, and overall, respondents' understanding of this aspect is very good. The attitude aspect reflects the level of user satisfaction with the 3-phase electricity monitoring device. This device attracts users' interest because it can be accessed via mobile devices, and overall, the attitude towards this device is very satisfying.

By using formula (1) to assess the level of feasibility of use, it is found that overall, the percentage level of feasibility of 3-phase electricity monitoring devices is explained in the calculation results as follows:

$$Usability\ \% = \frac{98+94+98+100}{4} x\ 100\% \qquad (2)$$

$$Usability \quad = 97{,}5\ \%$$

From the usability test results, which reached a percentage level of 97.5%, it can be concluded that this 3-phase electrical monitoring tool has received high acceptance from users, including sound engineers. Thus, this tool can be classified as very feasible or very suitable in the feasibility category based on the percentage that has been measured.

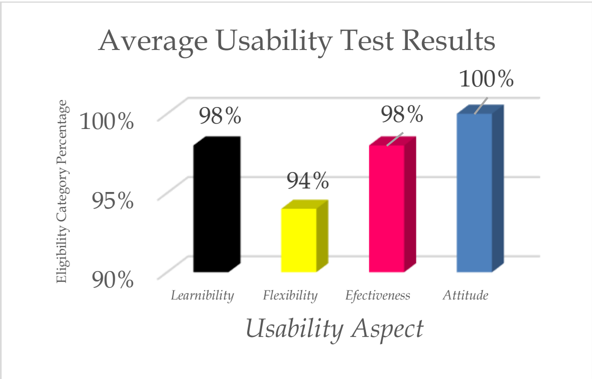


Figure 3.5 Average Usability Test Results

IV. CONCLUSION

After conducting relevant research, the author has reached the following conclusions In this research, we successfully developed an IoT-based device for monitoring voltage, current, and frequency using the ESP32, which is integrated into a 3-phase electrical panel box for an audio sound system. This device facilitates efficient, real-time monitoring of electrical conditions. The analysis of the monitoring system revealed that our system supports remote access via IoT through the Ubidots platform, providing users with the flexibility to monitor electrical conditions from various locations. The research also detailed the test results of the monitoring device, demonstrating its excellent performance in tracking voltage, current, and frequency parameters using ESP32-based IoT technology. Additionally, we developed a notification system that alerts users about disturbances in voltage, current, and frequency within the 3-phase electrical panel boxes for audio sound systems via the Telegram platform, allowing for prompt user responses to detected issues.

This device offers sound engineers the capability to obtain more accurate and detailed measurements of voltage, current, and frequency for Phases R, S, and T on 3-phase electric generators, compared to traditional analog needle-based measuring instruments, which often present readability issues. During the use of this tool, we encountered problems with data transmission to the Ubidots server, particularly experiencing delays when internet connectivity was unstable. Therefore, ensuring a stable and reliable internet connection is crucial for optimal device performance.

References

[1] F. A. Iskandarianto *et al.*, "Rancang Bangun Sistem Monitoring Tegangan, Arus, Dan Frekuensi Keluaran Generator 3 Fasa Pada Modul Mini Power Plant Departemen Teknik Instrumentas," *J. Nas. Apl. Mekatronika, Otomasi dan Robot Ind.*, vol. 1, no. 2, pp. 3–8, 2020, doi: 10.12962/j27213560.v1i2.7687.

[2] O. Zebua and N. Soedjarwantoa, "Monitoring Stabilitas Tegangan Jangka Pendek Pada Jaringan Distribusi Tegangan Rendah," 2017, pp. 31–36.

[3] H. A. Putra, "Penguat audio kelas d full proteksi dengan arduino mega 2560+esp8266 dan monitoring praktis tanpa kabel skripsi," 2023.

[4] A. J. Asgar, G. B. Putra, and T. H. Budianto, "RANCANG BANGUN ALAT PEMANTAU TEGANGAN, ARUS DAN DAYA PADA PANEL HUBUNG BAGI (PHB) BERBASIS ARDUINO DAN BLYNK," in *Prosiding Seminar Nasional Penelitian & Pengabdian Pada Masyarakat*, 2019.

[5] Y. Setiawan, H. Tanudjaja, and S. Octaviani, "Penggunaan Internet of Things (IoT) untuk Pemantauan dan Pengendalian Sistem Hidroponik," *TESLA J. Tek. Elektro*, vol. 20, no. 2, p. 175, 2018, doi: 10.24912/tesla.v20i2.2994.

[6] M. M. Azman, "Analisa perbandingan nilai akurasi moving average dan exponential smoothing untuk sistem peramalan pendapatan pada perusahaan XYZ," *J. Sist. dan Inform.*, vol. 13, no. 2, pp. 36–45, 2019.

[7] R. D. R. Dako and W. Ridwan, "Pengujian karakteristik Functional Suitability dan Performance Efficiency tesadaptif.net," *Jambura J. Electr. Electron. Eng.*, vol. 3, no. 2, pp. 66–71, 2021, doi: 10.37905/jjeee.v3i2.10787.