Design and Build a Charging Monitoring System Power on Level Crossing Batteries with Arduino IoT Application Remote Based ESP32 Devkit 1

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Abstract. Batteries play a role in storing electrical energy reserves. In level crossing using batteries as a backup power supply. Monitoring for charging the batteries used in level crossing *real time* to show the incoming voltage and current, so there is often interference, namely the doorstop that failed to rise due to low voltage. Based on these problems, the authors design a monitoring system for the incoming voltage and current to the battery which aims to prevent interference with the doorstop caused by low voltage. This study uses an ESP 32 Devkit 1 microcontroller US a microcontroller. Voltage readings use a voltage divider circuit connected to *port* the microcontrollers, for current readings using the ACS758 sensor, Arduino IoT Remote as a remote monitoring application. The function test on the tool is carried out ten times to ensure that each sensor contained in the tools can function properly. The results of the function test are compared with the measurements read on the multimeter. The results of testing the tool, the ESP 32 Devkit 1 can send data by WIFI so that it can be read on the application. In the voltage reading there is the highest percentage of error rate of 1.6% on the digital Avometer. In the current reading there is the highest error percentage of 0.9% with a difference of 0.3 A.

Keywords: Battery · Charging · ESP 32 Devkit 1 · Arduino IoT Cloud · Current sensors · Voltage Divider Sensor

1 Introduction

Cross door crossing train fire is wrong one infrastructure train that serves as a symbol that the train will pass. Upgrade Safety The level crossing between the railway line and the road is explained that the battery is used as a backup supply when the main power supply from state power company (PLN) currently experience disturbance or extinguished. On gate level crossing fire between Tasikmalaya Station and Ciawi Station using a 12 V Basa alkaline battery 120 Ah in accordance with the provisions contained in ministerial regulation number 94 that use battery voltage 12 V for all equipment safety crossing plot. Charging used on gate level crossing battery use type charging power automatic. When battery in state empty charging power in progress use current boosts, when battery under

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normal circumstances it uses float current, and charging will automatic stop when battery in state full. Based on data There are still some disturbances from telecommunications and electricity system technical service unit 2.9 Tasikmalaya what happens to the battery is that when the battery has dropped it can't keep current so that charger or Power supplies no could light up and to do back up, besides that battery experience drop voltage that causes the doorstop to not operate properly. Besides that, battery working as backup power nor power system emergency, the use of batteries will determine the quality of the electrical system. The battery parameters include the charging system (charging) more and more big current charging on battery will cause age (lifetime) battery getting shorter (Reza, 2016). Current battery maintenance and inspection conducted by officer conducted by manual with method check voltage per battery with a multimeter and carried out periodically once a month. Care and the inspection done by manual have the drawback is the limited parameters and data that must be carried out regularly.

Based on this, it is necessary to have a system for monitoring the type of charging that takes place in the form of voltage and current parameters entering the battery which functions to avoid overheating conditions in the battery so that the voltage and current are always monitored in real time, so *real-time monitoring is needed so* that the voltage and current at the battery is always under the supervision of the officer.

1.1 Theoretical Aspect

Monitoring the voltage and current on the battery using the ESP 32 Devkit 1 microcontroller as a sensor value reader and connecting to a WiFi network. The components for compiling the microcontroller from this battery monitoring are ESP 32 Devkit 1, voltage sensor, current sensor ACS7 58, stepdown LM2596, alligator clamp cable, buzzer, LED, and LCD.

1.2 Voltage Divider Circuit

The voltage divider circuit serves to divide a large voltage into a smaller voltage using two resistors. The function of the voltage divider circuit is so that the voltage read by the microcontroller does not exceed the voltage limit that can be accepted by the microcontroller (Giyantara et al., 2019).

$$Vout = \frac{R1}{R1 + R2} Vin \tag{1}$$

where, Vin is input voltage, Vout is the output voltage of the voltage divider circuit, R1 is prisoner and R2 is prisoner.

One of the methods used in measuring the current of this current sensor circuit is the resistive method (Giyaantara et al., 2019).

$$Isensor = \frac{Vfc}{Rs} \tag{2}$$

where, Vfc is the output voltage of the rectifier circuit, isensor is current measured on sensor and RS is reference prisoner

2 Method

2.1 Block Diagram

The block diagram is an explanation of the flow chart of the work of a system that is created. The start of the workflow from input to output in accordance with what has been planned from the work system of the tool (Fig. 1).

2.2 Communication Diagram

Based on the image of the communication block, it can be seen that the monitoring tool is installed on two different LEVEL CROSSINGs, this system can be used if the ESP 32 Devkit 1 which is on the *monitoring charger* is connected to the router. Then enter the *Service Set Identifier* (SSID) and *password* from *the router* in the Arduino code so that the ESP 32 Devkit 1 can connect to the internet. If the ESP 32 Devkit 1 has been connected to a router, monitoring can be done with a Wifi frequency strength of 2.4 Ghz. The data displayed on the LCD *charger* monitoring will be sent using the ESP 32 Devkit 1 on the *Arduino* IoT *Remote application*. As long as the *cellphone* and ESP 32 Devkit 1 are still connected to the internet, every 5 s the data will change according to the voltage and current that is read.

2.3 Schematic Diagram

The design of this battery voltage monitoring uses an ESP 32 Devkit 1 Microcontroller which has the function of processing and running programs from a circuit. The overall circuit of the battery voltage and current monitoring design can be seen in Fig. 2.

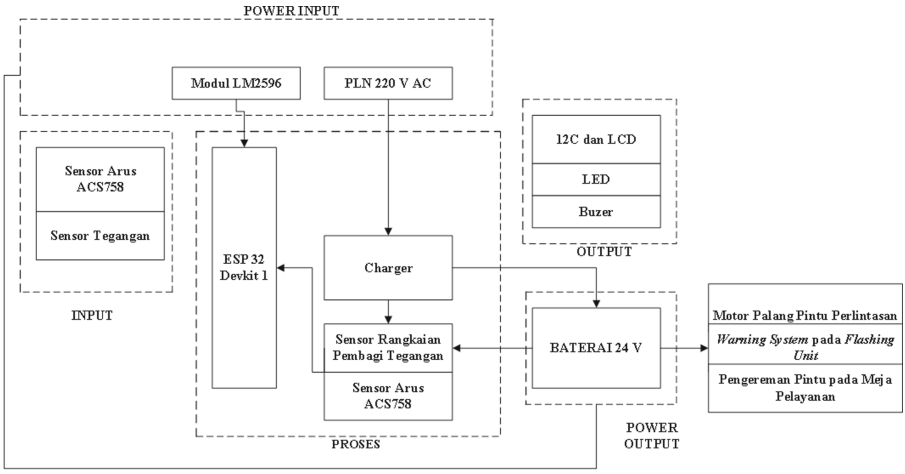

Fig. 1. Block Diagram

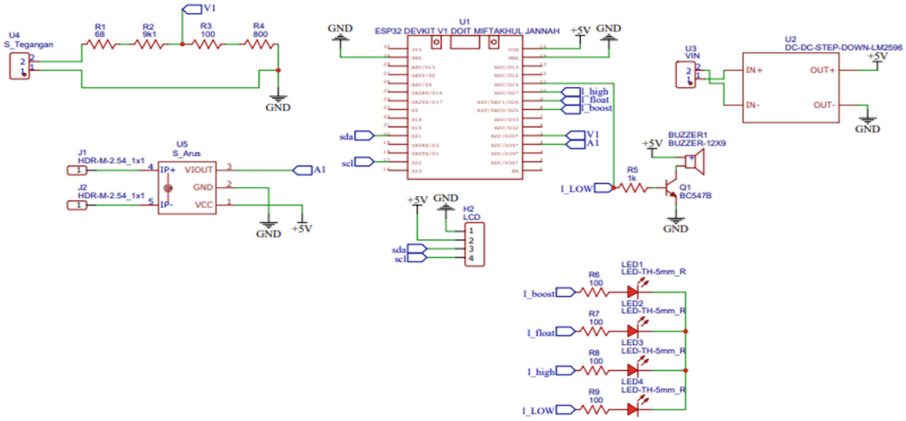

Fig. 2. Schematic Diagram

2.4 Design Results

The results of the design are divided into 2 stages, namely hardware design and software design.

1) Hardware Design (Hardware)
   The arrangement of hardware components is adjusted based on the schematic diagram that has been made so that the program is as planned.
2) Software Design (Software)
   The software design uses Arduino IDE software which is useful for programming Arduino ATMega so that it can make data commands. NodeMCU ESP8266 to receive and send data to Thingspeak which is processed in graphical form and can be displayed in real time.

2.5 Measurement Formula

1) Voltage Measurement
   To see the level of error from each battery can be calculated using the formula using

$$\%error = \frac{Rated\ Detection\ Voltage\ -\ Rated\ Avometer}{Rated\ Avometer} \times 100\% \tag{3}$$

2) Current Measurement
   To calculate the percentage error of the current sensor reading, use

$$\%error = \frac{Rated\ Detection\ -\ Rated\ Amperemeter}{Rated\ Amperemeter} \times 100\% \tag{4}$$

2.6 Testing Tool

The test results are used to determine the certainty of the success of making the tool. Tool testing can be done as follows:

a. Voltage Sensor Reading Test
Testing the voltage sensor readings is by comparing the values read with a multimeter. This reading test is carried out on battery 1 to battery 6. The suitability of voltage readings from the voltage sensor and from the multimeter is based on the calibration of each programming.
b. Current Sensor Reading Test
Testing the current sensor readings is the display of the current value from the battery on the LCD. The current sensor test is to check the current from one battery at a time. If the battery has no load, then the current detected is small.
c. Data Communication Functional Test
Functional tests carried out on the software used on smartphones through ThingSpeak tested the ability of this system to receive data from all sensors, display data from sensors and provide real-time information or notifications.

3 Results and Discussion

3.1 Current Sensor Reading Test

This test aims to determine the reading of the incoming current during the charging process using the ACS758 sensor. The results of the above test show that the ACS758 sensor is functioning properly.

Table 1. Test Results 1 of Current Sensor

Test to	**Time (WIB)**		**Rated Current (Amperes)**			**Error**
	Date	O'clock	Ampere Detector (A)	Application (A)	Multimeter (A)	
1	25/06/2022	08:06:15	1.17	1.17	1.21	0.09%
2	25/06/2022	08:06:30	1.17	1.17	1.21	0.09%
3	25/06/2022	08:06:45	1.18	1.18	1.21	0.09%
4	25/06/2022	08:07:00	1.21	1.21	1.21	0.08%
5	25/06/2022	08:07:15	1.19	1.19	1.20	0.06%
6	25/06/2022	08:07:30	1.20	1.20	1.21	0.08%
7	25/06/2022	08:07:45	1.21	1.21	1.21	0.00%
8	25/06/2022	08:08:00	1.21	1.21	1.21	0.08%
9	25/06/2022	08:08:15	1.19	1.19	1.21	0.05%
10	25/06/2022	08:08:30	1.18	1.18	1.20	0.07%
Average			1.19	1.19	1.21	0.05%

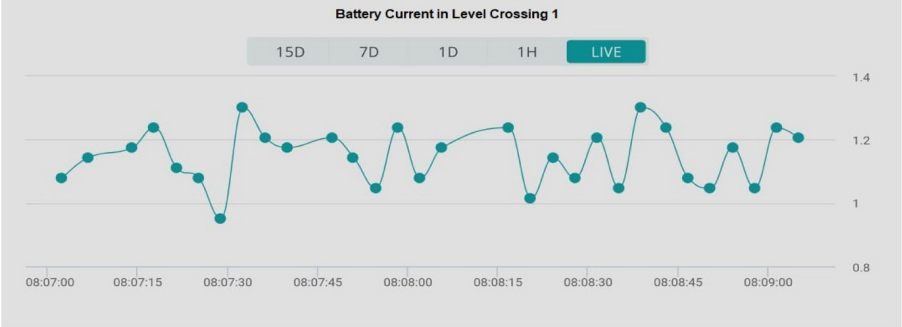

Fig. 3. Draw Flow Graph on Application

Table 2. Current Sensor Testing

Test to	Time		Rated Current (Amperes)			Error
	Date	O'clock (WIB)	Ampere Detector (A)	Application (A)	Avometer (A)	
1	25/06/2022	08:06:15	1.11	1.11	1.21	0.08%
2	25/06/2022	08:06:30	1.11	1.11	1.21	0.08%
3	25/06/2022	08:06:45	1.12	1.12	1.21	0.07%
4	25/06/2022	08:07:00	1.12	1.12	1.21	0.07%
5	25/06/2022	08:07:15	1.12	1.12	1.20	0.07%
6	25/06/2022	08:07:30	1.11	1.11	1.21	0.07%
7	25/06/2022	08:07:45	1.12	1.12	1.21	0.07%
8	25/06/2022	08:08:00	1.11	1.11	1.21	0.08%
9	25/06/2022	08:08:15	1.12	1.12	1.21	0.07%
10	25/06/2022	08:08:30	1.12	1.12	1.20	0.06%
Average			1.12	1.12	1.20	0.06%

a. Current Sensor Testing
Based on Table 1 of the current test data above, the results of the above test show that the ACS758 sensor can be used for current measurement. The average current measurement in Fig. 3 is 1.18 A, there is a difference between the measurement results of the sensor and the Avometer with the highest error rate of 0.09%.

b. Current Sensor Testing
Based on Table 2 of the current test data above, the results from the above test show that the ACS758 sensor is functioning properly, there is a difference between the measurement results of the sensor and the Avometer with the highest error rate of 0.09% based on in Fig. 4.

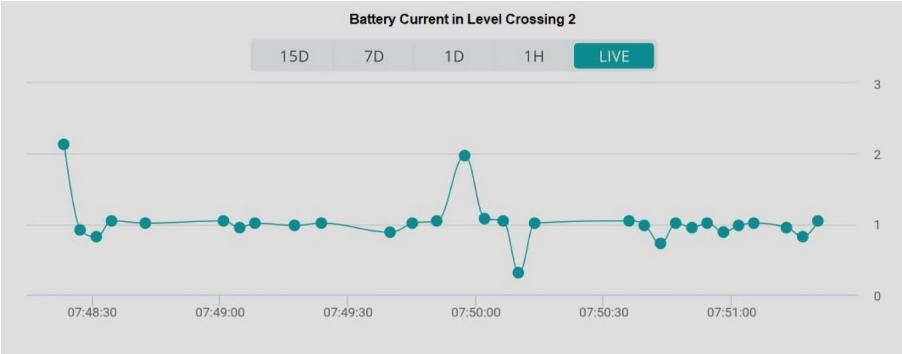

Fig. 4. Draw Flow Graph on Application

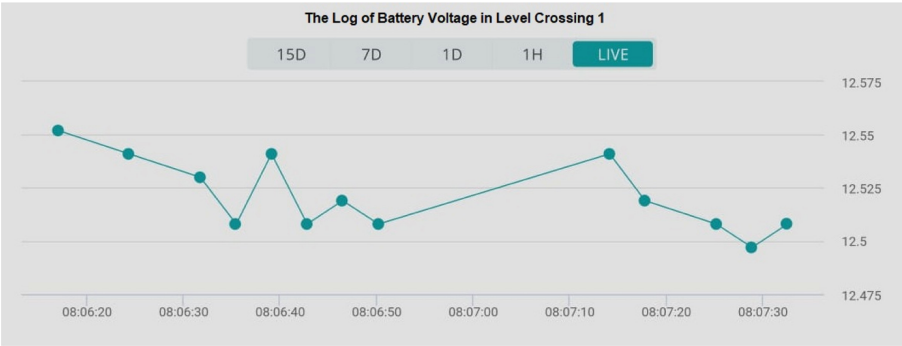

Fig. 5. Draw Voltage Graph on Application

3.2 Voltage Sensor Reading Test

This test can be carried out with the aim of knowing the results of voltage readings and using a voltage divider circuit. The tested battery includes a 12 V battery. The results of the voltage reading test are as follows:

a. Voltage Sensor Testing
   Figure 5 is a voltage graph found in the *Arduino IoT Remote application*
   Based on the test data in Table 3, the results of the voltage readings read by the microcontroller are almost the same as measurements using the Avometer. So it can be said that the voltage reading is functioning properly. The highest error rate is 1.6%, so it can be said that the voltage reading is functioning properly.

Table 3. Voltage Tests on 12 V Batteries

Test to	Time		Rated Voltage (Volt)			Error
	Date	O'clock (WIB	Voltage Detector (V)	Application (V)	Avometer (V)	
1	25/06/2022	08:06:15	12.5	12.5	12.3	1.6%
2	25/06/2022	08:06:30	12.5	12.5	12.4	0.8%
3	25/06/2022	08:06:45	12.5	12.5	12.4	1.6%
4	25/06/2022	08:07:00	12.4	12.4	12.3	0.8%
5	25/06/2022	08:07:15	12.4	12.4	12.3	0.8%
6	25/06/2022	08:07:30	12.5	12.5	12.4	0.8%
7	25/06/2022	08:07:45	12.5	12.5	12.3	0.8%
8	25/06/2022	08:08:00	12.4	12.4	12.3	0.8%
9	25/06/2022	08:08:15	12.5	12.5	12.3	1.6%
10	25/06/2022	08:08:30	12.4	12.4	12.3	0.8%
Average			12.4	12.4	12.3	1.2%

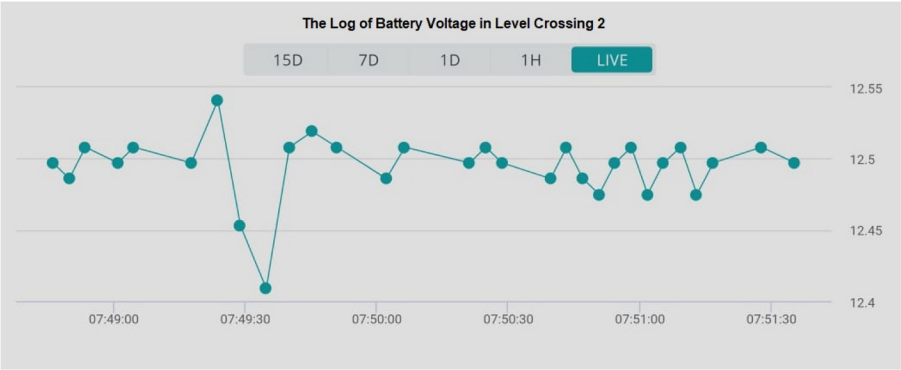

Fig. 6. Draw Voltage Graph on Application

b. Voltage Sensor Testing 2

In the Fig. 6, above is an image of the voltage graph displayed on the Arduino IoT Remote application.

Based on the test data table above, the results of the voltage readings read by the microcontroller are almost the same as measurements using the Avometer. So, it can be said that the voltage reading is functioning properly. The highest error rate is 0.8%, so it can be said that the voltage reading is working fine (Table 4).

Table 4. Test Results on 12 V Battery with Voltage Detector

Test to	Time		Rated Voltage (Volt)			Error
	Date	O'clock	Voltage Detector	Application	Avometer	
1	28/07/2022	10.00	12.5	12.5	12.4	0.8%
2	28/07/2022	10.01	12.3	12.3	12.4	0.8%
3	28/07/2022	10.02	12.3	12.3	12.4	0.8%
4	28/07/2022	10.03	12.5	12.5	12.5	0%
5	28/07/2022	10.04	12.5	12.5	12.5	0%
6	30/07/2022	15.00	12.4	12.4	12.4	0%
7	30/07/2022	15.01	12.4	12.4	12.3	0.8%
8	30/07/2022	15.02	12.5	12.5	12.5	0%
9	30/07/2022	15.03	12.4	12.4	12.4	0%
10	30/07/2022	15.04	12.6	12.6	12.6	0%
Average						0%

3.3 Testing on 2 Level Crossing

Overall testing is done by assembling all components into one and then trying to communicate from the tool. This test aims to determine whether all components that have been included in programming code can work as expected or even inversely. And also, whether the communication of two *devices placed* on 2 different level crossing can function properly or inversely. The first monitoring tool is placed on the level crossing battery *charger simulation at the Bandung Station Workshop* using a 12 V battery. While the second monitoring tool is placed on the level crossing 206 Nagrek with a 24 V battery.

Based on Table 5, the test data from the voltage readings read by the voltage detector is almost the same as the measurement using the Avometer which is placed on Level Crossing 1, namely at the Sintel Bandung Workshop. The voltage readings on the monitoring tool and application also have the appropriate value. So it can be said that the voltage reading is functioning properly. The highest error rate is 1.74%, so it can be said that the voltage reading is functioning properly. In accordance with the maintenance guidelines on the level crossing battery, which is a minimum of 11.5–13.8 V DC.

Based on Table 6, the test data from the voltage readings read by the voltage detector is almost the same as the measurement using the Avometer which is placed on the level crossing 206 Nagrek. Voltage readings on monitoring devices and applications also have appropriate values. So, it can be said that the voltage reading is functioning properly. The highest *error* rate is 1.53%, so it can be said that the voltage reading is functioning properly. In accordance with the maintenance guidelines on the level crossing battery, which is a minimum of 11.5–13.8 V DC.

Based on Table 7, the test data of the current reading results read by the current detector is almost the same as the measurement using a Multimeter. Voltage readings on monitoring devices and applications also have appropriate values. So, it can be said

Table 5. Data of Level Crossing 1 on 12 V Batteries

Test to	Time		Rated Voltage (Volt)			Error
	Date	O'clock (WIB)	Voltage Detector (V)	Application (V)	Avometer (V)	
1	28/06/2022	13:04:00	12.64	12.64	12.86	1.74%
2	28/06/2022	13:04:05	12.65	12.65	12.86	1.66%
3	28/06/2022	13:04:10	12.65	12.65	12.87	1.73%
4	28/06/2022	13:04:15	12.7	12.7	12.86	1.25%
5	28/06/2022	13:04:20	12.65	12.65	12.86	1.66%
6	28/06/2022	13:04:25	12.67	12.67	12.85	1.42%
7	28/06/2022	13:04:30	12.66	12.66	12.87	1.66%
8	28/06/2022	13:04:35	12.7	12.7	12.87	1.25%
9	28/06/2022	13:04:40	12.67	12.67	12.86	1.49%
10	28/06/2022	13:04:45	12.67	12.67	12.87	1.57%
Average			12.66	12.66	12.86	1.57%

Table 6. Data of level crossing 2 on 24 V Batteries

Test to	Time		Rated Voltage (Volt)			Error
	Date	O'clock	Voltage Detector (V)	Application (V)	Avometer (V)	
1	28/06/2022	13:04:00	24.74	24.74	25.12	1.53%
2	28/06/2022	13:04:05	24.75	24.75	25.12	1.49%
3	28/06/2022	13:04:10	24.75	24.75	25.12	1.49%
4	28/06/2022	13:04:15	25.45	25.45	25.36	0.95%
5	28/06/2022	13:04:20	25.67	25.67	25.98	1.20%
6	28/06/2022	13:04:25	26.14	26.14	26.54	1.53%
7	28/06/2022	13:04:30	26.65	26.65	26.87	0.82%
8	28/06/2022	13:04:35	26.79	26.79	27.12	1.23%
9	28/06/2022	13:04:40	27.18	27.18	27.35	0.62%
10	28/06/2022	13:04:45	27.52	27.52	27.65	0.47%
Average			25.93	25.93	26.22	1.11%

that the current reading works well. The highest *error rate is* 1.97%, so it can be said that the voltage reading is functioning properly. The current sensor test is conducted to determine the current reading using the ACS7 58 sensor. The results below are testing the current sensor readings.

Table 7. Data of Level Crossing 1 on 12 V Batteries

Test to	Time		Rated Current (Amperes)			Error
	Date	O'clock	Ampere Detector (A)	Application (A)	Multimeter (A)	
1	28/06/2022	13:04:00	3.59	3.59	3.61	1.97%
2	28/06/2022	13:04:05	3.59	3.59	3.63	1.11%
3	28/06/2022	13:04:10	3.58	3.58	3.63	1.39%
4	28/06/2022	13:04:15	3.58	3.58	3.62	1.11%
5	28/06/2022	13:04:20	3.59	3.59	3.62	0.83%
6	28/06/2022	13:04:25	3.65	3.65	3.71	1.64%
7	28/06/2022	13:04:30	3.72	3.72	3.79	1.88%
8	28/06/2022	13:04:35	3.72	3.72	3.77	1.34%
9	28/06/2022	13:04:40	3.72	3.72	3.77	1.34%
10	28/06/2022	13:04:45	3.69	3.69	3.73	1.08%
Average			3.64	3.64	3.68	1.09%

Table 8. Data of Level Crossing 2 on 24 V Batteries

Test to	Time		Rated Current (Amperes)			Error
	Date	O'clock	Ampere Detector (A)	Application (A)	Multimeter (A)	
1	28/06/2022	13:04:00	6.92	6.92	6.94	0.55%
2	28/06/2022	13:04:05	6.92	6.92	6.94	0.55%
3	28/06/2022	13:04:10	6.92	6.92	6.94	0.55%
4	28/06/2022	13:04:15	6.92	6.92	6.96	0.57%
5	28/06/2022	13:04:20	6.91	6.91	6.95	0.57%
6	28/06/2022	13:04:25	6.89	6.89	6.92	0.43%
7	28/06/2022	13:04:30	6.90	6.90	6.93	0.43%
8	28/06/2022	13:04:35	6.89	6.89	6.93	0.58%
9	28/06/2022	13:04:40	6.89	6.89	6.93	0.58%
10	28/06/2022	13:04:45	6.88	6.88	6.93	0.72%
Average			6.90	6.90	6.93	0.43%

Based on Table 8, the test data of the current reading results read by the current detector is almost the same as the measurement using a multimeter. Voltage readings on monitoring devices and applications also have appropriate values. So it can be said that

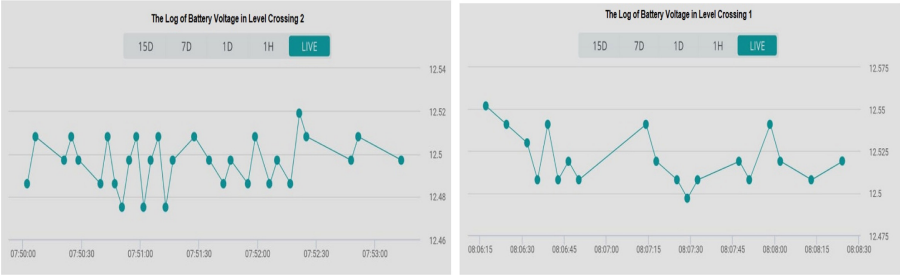

Fig. 7. Realtime Monitoring

the current reading works well. The highest *error* rate is 0.72%, so it can be said that the voltage reading is functioning properly.

3.4 Data Communication Test

This battery monitoring uses IoT *(Internet of Things)* to make it easier for the field team to monitor the battery voltage. Running a tool definitely requires testing to get the required data results. There are various websites for IoT (Internet of Things), here using *Arduino IoT Remote* for the monitoring process. The following are the testing stages of IoT *(Internet of Things).*

3.5 Battery Parameters

In the picture below is a display of real-time monitoring of battery voltage and current. Make sure ESP 32 Devkit 1 is connected to wifi, automatically monitored data from sensors will be displayed on this web. There is a graphical display of voltage and current measurements from the battery (Fig. 7).

4 Conclusion

From this research, some conclusions can be drawn as follows:

1. The making of charging monitoring on this battery uses an acrylic-based protector as a place for placing components. Voltage and current measurements are controlled using the ESP 32 Devkit 1 which is useful as a microcontroller and WiFi connection. Using a voltage divider sensor to read the voltage value, the ACS758 sensor is used as a current reader. The results of the sensor readings will be displayed on the LCD.
2. Monitoring on battery using ESP 32 Devkit 1 to send data to *Arduino IoT Remote application.* Data readings from the voltage and current sensors will be sent via ESP 32 Devkit 1, then the data is displayed on the *Arduino IoT Remote application* which can be monitored in *real time.*

3. Monitoring the voltage and current on this battery uses 2 12 V batteries arranged in series. Using the LM259 *step down module to lower the voltage on the battery so that the microcontroller can read the voltage on the battery.* Then the voltage sensor and current sensor read the value from the battery and then display it on the LCD and the Arduino IoT Cloud application.
4. The test results from monitoring the battery, namely the reading of the voltage, the percentage of the highest error rate from the voltage reading, is 1.6%. In testing the current reading, the percentage of the highest error rate is 0.9%, with a difference of 0.3 A between charging monitoring and the Avometer.

Bibliography

Arifin, N., Lubis, RS, & Gapy, M. (2019). Design and Build of 1 Phase Power Meter Prototype Based on Atmega328P Microcontroller. *Journal of Scientific Works in Electrical Engineering*, *4* (1), 13–22.

Arsana, IM, Pd, S., Machinery, DT, Machinery, T., Engineering, F., & Surabaya, UN (2021). *AUTOMOTIVE BATTERY CHARGER DESIGN Muhammad Jazuli Asfan D3 Mechanical Engineering, Faculty of Engineering, State University of Surabaya. 06*, 105–109.

Giyantara, A., Ramadhani, R., & Wulandari, R. (2019). *Full Wave Rectifier Circuit Analysis with Capacitor Filters, Voltage Dividers, Buffers and Differential Amplifiers on Current Sensors Full Wave Rectifier Circuit Analysis with Capacitor Filters, Voltage Dividers, Buffers and Differential Amplifiers on Senso . July*, 1–9.

Hamdani, R., Puspita, IH, & Wildan, BDRW (2019). Making a Motor Vehicle Security System Based on Radio Frequency Identification (Rfid). *Indept .*, *8* (2), 56–63.

Hudan, Ivan Safril, RT (2019). Design and Build of Electrical Power Monitoring System in Boarding Rooms Based on Internet of Things (IOT). *Journal of Electrical Engineering*, *08* (01), 91–99.

Handarly, D., & Lianda, J. (2018). IoT (Internet of Thing)-Based Electrical Power Monitoring System. *JEECAE (Journal of Electrical, Electronics, Control, and Automotive Engineering)* , *3* (2), 205–208. https://doi.org/10.32486/jeecae.v3i2.241

Manan Mehta. (2015). *ESP 8266 : A BREAKTHROUGH IN WIRELESS SENSOR NETWORKS WIRELESS SENSOR NETWORKS AND* .

Mukhlisin, AA, Suhanto, S., & Moonlight, LS (2019). Design and Build Control and Monitoring of Uninterruptible Power Supply (Ups) Battery Using Hybrid Energy With Internet Of Thing (IOT) Concept. *Proceedings of SNITP …* , 1–7. http://ejournal.poltekbangsby.ac.id/index.php/SNITP/article/view/404

Nirwan, S., & MS, H. (2020). Application Design for Prototype Monitoring System for Electrical Energy Consumption in Electronic Equipment Based on Pzem-004T. *Informatics Engineering*, *12* (2), 22–28.

Nurmuslimah, S., Saidatin, N., & Bagus, P. (2020). *A Design Remote Control System to Feed Bird Using ESP8266* . 81–90. https://doi.org/10.36079/laminntang.ijortas-0202.128

Pangestu, AD, Ardianto, F., & Alfaresi, B. (2019). Arduino Nodemcu Esp8266 Based Electrical Load Monitoring System. *Ampere Journal* , *4* (1), 187. https://doi.org/10.31851/ampere.v4i1.2745

Pratama, MB, Murti, MA, & Kurniawan, E. (2019). *Monitoring System on Uninterruptible Power Supply Based on Internet of Things.* 710–714.