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Temperature Monitoring System Internet of Things-based Electric Cars (IoT)

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ABSTRACT

Electric cars are a means of transportation that can meet the mobility needs of the community but are still environmentally friendly because they have no air pollution or exhaust emissions. Electric cars at Ahmad Dahlan University began to be made since 2019. In the effort to develop this electric car, there are several obstacles in monitoring the tools on the electric car during the race. So this research provides an Internet of Things-Based Battery and BLDC Motor Temperature Monitoring System on the ADEV 01 Monalisa Electric Car. which is made using several components including the DS18B20 Sensor, ADEV BLDC Motor, NodeMCU ESP32, LCD (Liquid Crystal Display). This research method develops a temperature monitoring system on an Internet of Things-based electric car using the Thinger.io platform. in this study tested the effectiveness of the DS18B20 temperature sensor in monitoring the temperature of the Battery and BLDC Motor on the ADEV 01 Monalisa electric car. the tests carried out were static testing, dynamic testing, testing data transmission to the Thinger.io platform, and distance testing. The results of testing the battery and BLDC motor on the ADEV 01 Monalisa Electric Car in a static state are good because the reading error is 0.60% and 0.50%. As for testing while running, namely 0.90% and 0.86%. Testing on the Internet of Things is successfully sent with a stable and fixed delay. therefore this parameter is good for monitoring electric vehicles. Researchers conducted distance testing for the Internet of Things using Thinger.io which aims to find out how far the internet connection can send sensor readings to Thinger.io. so the results obtained that a distance of >230 meters the internet connection is disconnected and cannot send data to Thinger.io.

1. Introduction

Electric cars are a means of transportation that can meet the mobility needs of the community but are still environmentally friendly because they have no air pollution or exhaust emissions [1]. There are many negative impacts of air pollution or exhaust emissions resulting from the combustion of conventional car engines. One of them is the negative impact on human welfare and health for a clean environment.

In the face of an era that is very difficult to get a clean environment without air pollution [4]. The solution that can be recommended to the community to reduce the use of fossil-based motorized vehicles by switching to KBL or commonly called Electric Based Vehicles [5]. Electric-based vehicles have several advantages, one of which does not produce exhaust gas so it does not provide an environment full of air pollution [6]. Electric-based vehicles were first introduced by Robert Anderson from Scotland in 1832-1839, but at that time the price of fuel or called (BBM) was relatively cheap so that people used more fossil-based motors.

Conventional cars or commonly referred to as fossil-fueled vehicles are currently needed as a basic necessity for the wider community. The function of the car itself is also significant for all existing circles both from ordinary circles and from circles for livelihood searches for material wealth. The rapid manufacture of fossil-based cars is actually endangering the survival of humans on earth [11]. The more threatened pollution on planet earth. Therefore, a lot of research is carried out to develop fossil-based vehicles to switch to electric-based vehicles as in developed countries.

The first electric car named ADEV 01 Monalisa and the second electric car named ADEV 2 Supernova. In an effort to develop this electric car, several obstacles were found in monitoring the tools on the electric car during the race. Some monitoring tools that have been developed include current and voltage monitoring based on the Internet of Things and Telementri, speed monitoring on electric cars and position monitoring. in the monitoring process, it is still necessary to monitor the temperature contained in the battery and BLDC motor to minimize damage or heat spikes. The Al-Qorni team used to check the temperature manually and had to be in contact with the object. So this research provides a temperature monitoring system on batteries and BLDC motors based on the internet of things. This monitoring does not need to check manually, because it can monitor the temperature remotely as long as it is still connected to an internet connection.

This results in the process of checking the function of the tool on the electric car takes a long time and is less efficient. With this temperature parameter monitoring system, it makes it easier for the team to check the function of the tools contained in the electric car can run well or need to be repaired. Temperature monitoring on electric cars is very important in order to minimize damage to the battery and also the BLDC motor that will be used.

The function of this monitoring system is to find out that the BLDC Battery and Motor have abnormal temperatures [21]. So that researchers decided to make a temperature monitoring system on batteries and BLDC motors based on the Internet of Things using the Thinger.io platform requires an internet connection. The results of the temperature measurement test can be done in real time using a computer / smartphone as a media tool for monitoring temperature readings on batteries and BLDC motors.

2. Methods

In this research, the focus is on determining the temperature generated from the battery and BLDC motor. This chapter describes the steps taken in the research, including system design, hardware design, and implementation of the temperature monitoring system on the Battery and BLDC Motor on ADEV 01 Monalisa to provide information to the team.

2.1. Software Design

The flowchart starts from the temperature sensor that reads from the battery, then the sensor also reads the load from the BLDC motor. After the sensor is read, the sensor will send data to the NodeMCU ESP32, then the NodeMCU ESP32 will send data to the output, namely Thinger.io, which will display temperature data requiring an internet connection that will display data to the serial monitor and I2C LCD. The flowchart and block diagram of the tool can be seen in Fig. 1 and Fig. 2.

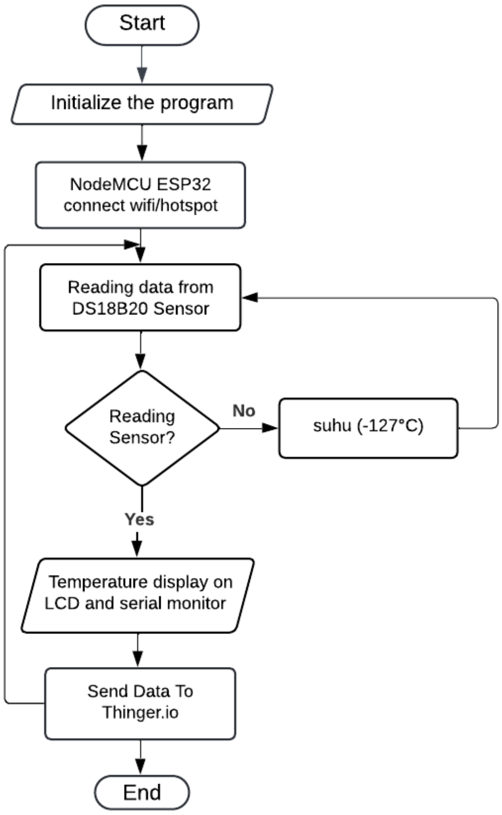

Fig. 1. Flowchart

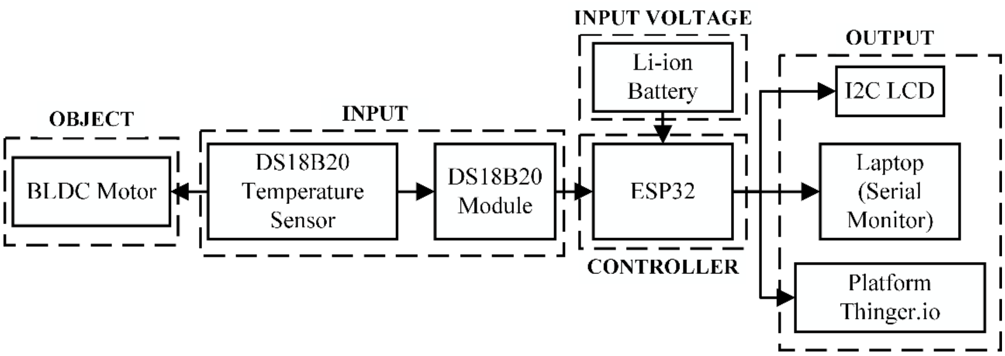

Fig. 2. Block Diagrams

2.2. Wiring Diagram

The wiring diagram is made to find out the wiring paths in the system that is made in order to minimize errors in connecting one component to another. The specifications and wiring diagram images can be seen in Table 1 and Fig. 3.

Table 1. Wiring diagram specifications

No	NodeMCU ESP32	Temperature Sensor	Temperature Sensor	LCD I2C
1	15	Out	Out	-
2	21	-	-	SDA
3	22	-	-	SCL
4	3.3V	Positive	Positive	-
5	5V	-	-	Positive
6	GND	Negative	Negative	Negative

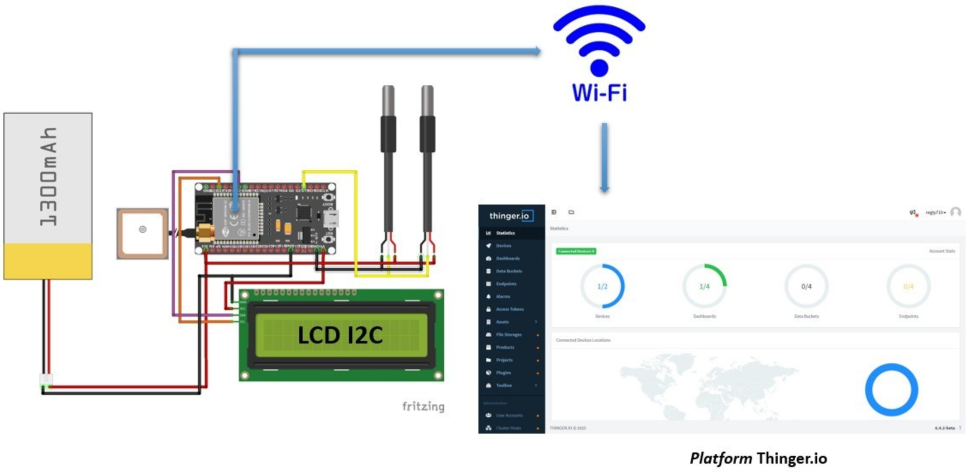

Fig. 3. Wiring Diagram

3. Results and Discussion

3.1. Hardware Implementation

The system implementation is carried out to ensure that the system created can work according to the specifications and needs of the Al-Qorni electric car team with the ADEV 01 Monalisa Car that has been designed. The implemented system includes the installation of all hardware and software developed using the Arduino IDE to process temperature sensor data and activate the LCD and send data to the Thinger.io platform in real-time. This implementation has been tested and its condition has been ensured so that the system can work properly and produce accurate data. The system implementation can be seen in the Fig. 4.

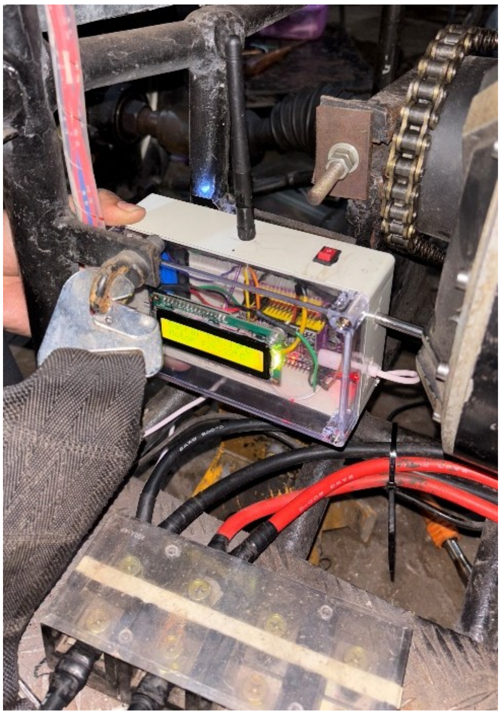

Fig. 4. Hardware implementation

3.2. Sensor Calibration Testing

The sensor calibration test conducted aims to ensure that the sensor to be used is not damaged so that it can be used to perform checks. The test results obtained by obtaining a reading error value of 0.78%. The sensor is still read properly because the results do not exceed 2. These results prove that the temperature reading on the sensor can work well and does not significantly affect performance.

So, the DS18B20 temperature sensor used does not require correction or adjustment. The test results are presented in Table 2 and also Fig. 5.

Table 2. Sensor Calibration Testing

NO	Sensor (°C)	Thermometer (°C)	Error Value (%)
1	33.8	33.1	0.7
2	35.0	34.2	0.8
3	36.1	35.0	1.1
4	38.7	37.4	1.3
5	39.8	38.5	1.3
6	41.7	41.1	0.6
7	43.1	42.9	0.2
8	44.8	44.7	0.1
9	45.5	45.0	0.5
10	46.2	45.0	1.2
Average	**40.47**	**39.69**	**0.78**

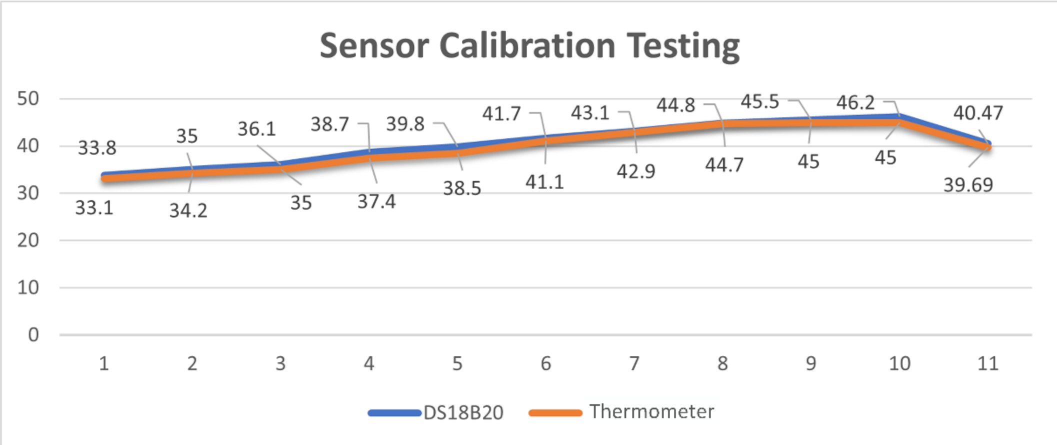

Fig. 5. Sensor calibration testing graph

3.3. Temperature Testing on Battery and BLDC Motor While the Car is Idle

Testing the DS18B20 sensor on the Battery and BLDC Motor when the car is turned on in a stationary condition aims to check whether the device to be tested is functioning properly. the test results of the reading error on the battery are 0.60% and the BLDC motor is 0.50%. the results on the battery can be seen in the Fig. 6 and Table 3 while for the BLDC motor can be seen in the Fig. 7 and Table 4.

Table 3. Testing the temperature of the battery while the car is stationary

NO	Temperature on Battery Sensor (°C)	Temperature on Thermometer (°C)	Error Value (%)
1	25.75	25.00	0.75
2	25.62	25.00	0.62
3	26.31	25.00	1.31
4	26.37	26.00	0.37
5	27.44	27.00	0.44
6	27.50	27.00	0.50
7	32.06	32.00	0.06
8	32.69	32.00	0.69
9	32.81	32.00	0.81
10	33.52	32.00	0.52
Average	**29.00**	**28.30**	**0.60**

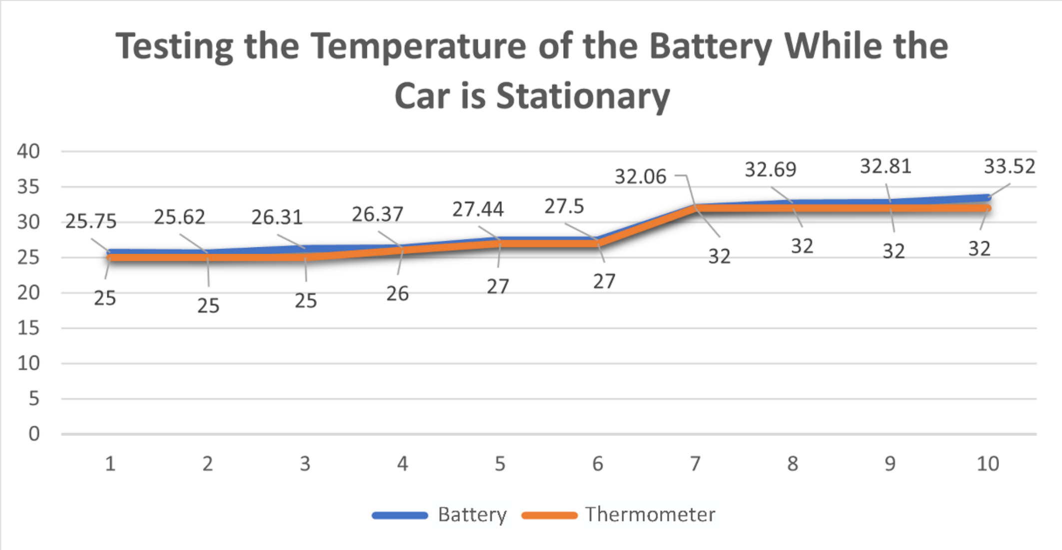

Fig. 6. Battery temperature test graph while the car is stationary

Table 4. BLDC Motor Test Results when the car is stationary

NO	Temperature on Battery Sensor (°C)	Temperature on Thermometer (°C)	Error Value (%)
1	26.69	26.00	0.69
2	25.69	25.00	0.69
3	25.81	25.00	0.81
4	25.87	25.00	0.87
5	25.94	25.00	0.94
6	26.12	26.00	0.12
7	27.19	27.00	0.19
8	33.31	33.00	0.31
9	35.31	35.00	0.31
10	38.12	38.00	0.12
Average	**29.00**	**28.50**	**0.50**

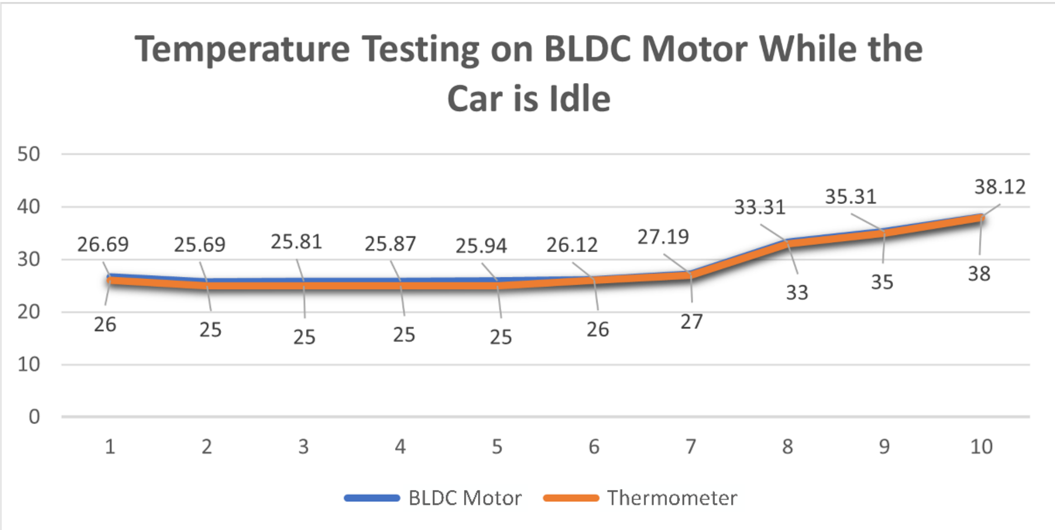

Fig. 7. BLDC motor temperature test graph when the car is stationary

3.4. Temperature Testing on Battery and BLDC Motor While the Car is Running

Testing the DS18B20 sensor on the Battery and BLDC Motor while the car is running aims to determine whether the battery is functioning and does not overheat if it is to be used in heavy activities such as during a race. the test results of the reading error on the battery are 0.92% and the BLDC motor is 0.86%. the results on the battery can be seen in Fig. 8 and Table 5 while for the BLDC motor can be seen in Fig. 9 and Table 6.

Table 5. Battery temperature testing while the car is running

NO	Temperature on Battery Sensor (°C)	Temperature on Thermometer (°C)	Error Value (%)
1	31.62	31.00	0.62
2	31.69	31.00	0.69
3	36.81	36.00	0.81
4	36.94	36.00	0.94
5	38.12	37.00	1.12
6	40.45	40.00	0.45
7	40.94	40.00	0.94
8	41.88	41.00	0.88
9	42.06	41.00	1.06
10	42.77	42.00	0.77
Average	**38.32**	**37.4**	**0.92**

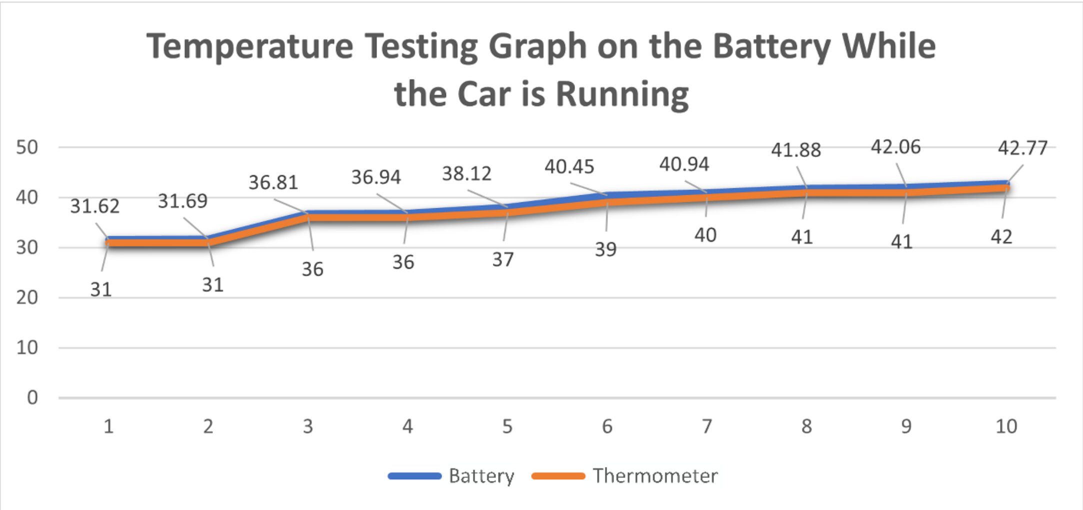

Fig. 8. Temperature Testing Graph on the battery while the car is running

Table 6. Temperature testing while the car is running

NO	Temperature on Battery Sensor (°C)	Temperature on Thermometer (°C)	Error Value (%)
1	31.69	31.00	0.69
2	31.81	31.00	0.81
3	38.75	38.00	0.75
4	38.94	38.00	0.94
5	39.07	38.00	1.07
6	46.65	46.00	0.65
7	49.45	49.00	0.45
8	53.66	53.00	0.66
9	56.66	55.00	1.66
10	58.96	58.00	0.96
Average	**44.56**	**43.7**	**0.86**

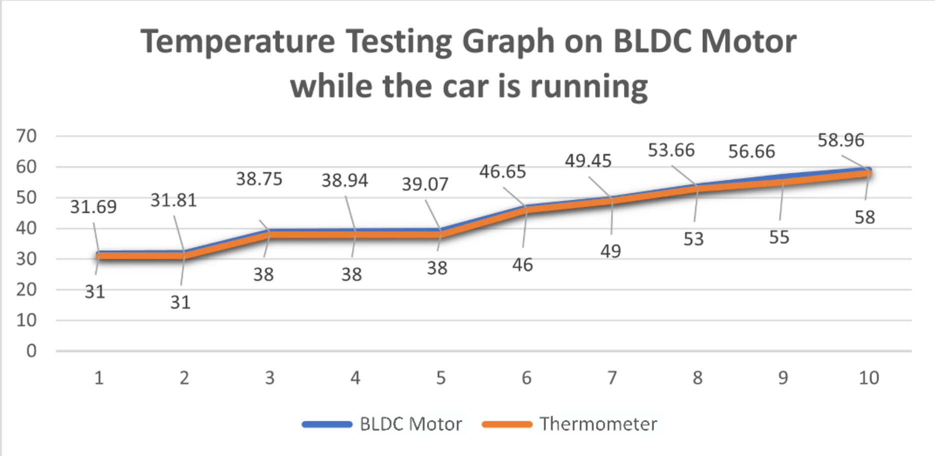

Fig. 9. Temperature Testing Graph on BLDC Motor while the car is running

3.5. Temperature Testing on BLDC Batteries and Motors Using Internet of Things Thinger.io

Battery and BLDC Motor Testing using Thinger.io aims to determine how accurate data transmission is via the Internet of Things Thinger.io by comparing the delay in each experiment. The test that has been carried out has obtained quite good and very stable results which get a delay of 5.00 seconds. The delay obtained from Thinger.io is very stable and the results remain the same, because the settings on Thinger i.o are made for sending and reading temperatures every 5.00 seconds. During the temperature test, the device used with an internet connection is still close and can reach a good internet connection without any connection obstacles so that the sending and reading of temperatures are in accordance with the settings, namely 5.00 seconds. the results on the battery can be seen in Fig. 10 and Table 7 while for the BLDC motor can be seen in Fig. 11 and Table 8.

Table 7. Battery temperature testing using Thinger.io.

NO	Temperature (°C)	Thinger.Io (°C)	Delay (S)
1	31.19	31.19	5
2	36.94	36.94	5
3	39.06	39.06	5
4	39.38	39.38	5
5	39.63	39.63	5
6	40.36	40.36	5
7	40.50	40.50	5
8	45.36	45.36	5
9	45.44	45.44	5
10	49.38	49.38	5
Average	**40.72**	**40.72**	**5**

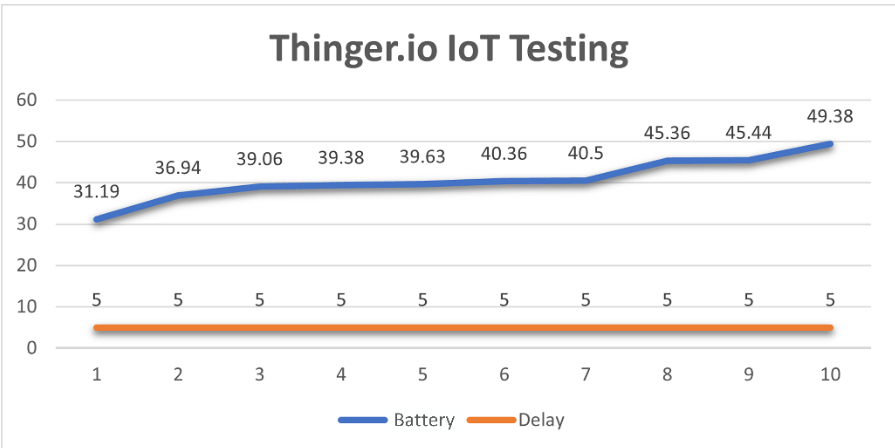

Fig. 10. Thinger.io Delay Graph

Table 8. BLDC Motor temperature testing using Thinger.io.

NO	Temperature (°C)	Thinger.Io (°C)	Delay (S)
1	36.88	36.88	5
2	39.19	39.19	5
3	39.38	39.38	5
4	39.94	39.94	5
5	42.74	42.74	5
6	44.07	44.07	5
7	45.37	45.37	5
8	45.88	45.88	5
9	46.39	46.39	5
10	57.25	57.25	5
Rata -rata	**43.70**	**43.70**	**5**

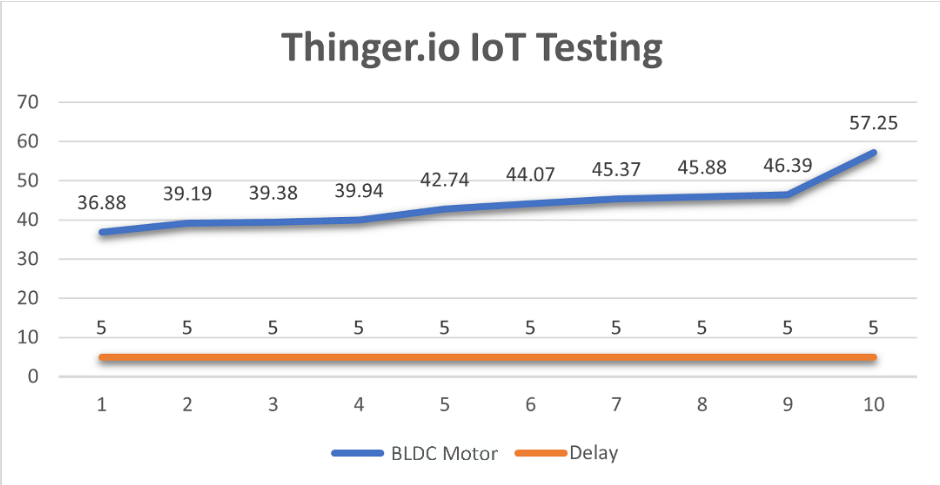

Fig. 11. Thinger.io Delay Graph.

3.6. Remote Testing Using the Internet of Things with Thinger.io

Distance testing using the Internet of Things on Thinger.io aims to determine how far the temperature monitoring is sent to Thinger.io. With this distance testing, the team can prepare the distance between cars during the race so that it can be monitored remotely using an internet connection. This test gets stable results up to a distance of 130 meters using Speedtest to measure internet connection speed. However, when entering a distance of 140 meters, data transmission to Thinger.io starts to slow down to 5.9 seconds, but the delivery is still successful and can be read on Thinger.io. After a distance of 130 meters, the resulting delay is slower but still successfully sent. When testing at a distance of 230 meters, the delivery is not read and the internet connection is lost so that Thinger.io requires a reconnect. So the result of this test is that Thinger.io cannot send data with a distance> 230 meters. The test results are presented in Table 9 and also Fig. 12.

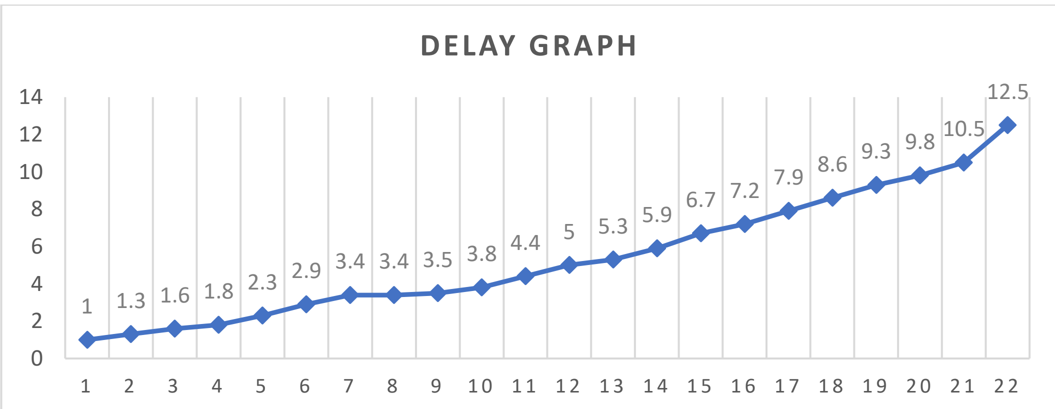

Fig. 12. Thinger.io Delay Graph

Table 9. Distance Testing using Thinger.io

NO	Distance (M)	WIFI Network Speed (Mbps)	Delay (S)	Shipping Status
1	10	15.1	1.0	Connected
2	20	14.8	1.3	Connected
3	30	14.3	1.6	Connected
4	40	13.9	1.8	Connected
5	50	13.2	2.3	Connected
6	60	12.8	2.9	Connected
7	70	12.4	3.4	Connected
8	80	12.1	3.4	Connected
9	90	11.4	3.5	Connected
10	100	10.3	3.8	Connected
11	110	9.8	4.4	Connected
12	120	8.7	5.0	Connected
13	130	8.2	5.3	Connected
14	140	7.3	5.9	Connected
15	150	6.8	6.7	Connected
16	160	5.9	7.2	Connected
17	170	5.3	7.9	Connected
18	180	4.1	8.6	Connected
19	190	3.6	9.3	Connected
20	200	3.3	9.8	Connected
21	210	2.6	10.5	Connected
22	220	1.3	12.5	Connected
23	**230**	**-**	**-**	**Not Connected**

4. Conclusion

This designed system produces a DS18B20 temperature sensor that has good accuracy in temperature measurement with a reading error of 0.78% for sensor calibration testing. Static testing of reading errors reached 0.60% and 0.50%. Dynamic testing reached 0.92% and 0.86% compared to the reference thermometer. These results are said to be reasonable because they are not above 2. This system successfully sends and displays temperature results on the Thinger.io platform. And the results of the distance test, namely sending data via the Thinger.io platform, cannot send temperature data more than 230 meters away.

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