International Journal of Research and Review
Volume 11; Issue: 8; August 2024
Website: www.ijrrjournal.com
E-ISSN: 2349-9788; P-ISSN: 2454-2237

Research Paper

Comparison of DHT 11 and NTC Temperature Sensors Based on Internet of Things and Lora Ebyte 32 For Incubator

Muhammad Zimamul Adli[1], Euman Suratman[2], Muhammad Aditiya Firdaus[3], Fikrul Haykal Johar[4], Yandi Setia Permadi[5], Teguh Teuja Laksana[6]

[1,2,3,4,5,6]Department of Electrical Engineering, Faculty of Engineering, Nusantara Islamic University, Bandung, Indonesia

Corresponding Author: Muhammad Zimamul Adli

DOI: https://doi.org/10.52403/ijrr.20240849

ABSTRACT

Incubators require precise temperature monitoring to ensure optimal conditions for the growth and development of the organisms inside. DHT11 and NTC sensors are both widely used in temperature measurement, but have different characteristics in terms of accuracy, response time, and reliability. The use of IoT technology enables real-time and remote temperature monitoring and control, while the LoRa Ebyte 32 module is used for efficient long-range wireless communication. The results show that the NTC sensor has a higher percentage error and average error compared to DHT11, namely RE 2.4681% MEA 0.8885 and DHT11 has RE 1.5255% MEA 0.5492. From these results it can be stated that the DHT11 sensor is suitable for use in baby incubators.

Keywords: DHT11; NTC; LoRa; Inkubator; IoT

INTRODUCTION

The air quality in a baby incubator is critical to the health and development of the baby, especially for premature babies who require intensive care. Environmental conditions such as temperature and humidity must be closely monitored and maintained to ensure optimal condition [1]. However, air quality monitoring in incubators is often done manually, which can lead to inaccuracies and delays in detecting changes in conditions.

Based on data from the Maternal Perinatal Death Notification (MPDN), a maternal death recording system owned by the Ministry of Health, the number of maternal deaths in 2022 reached 4,005 and in 2023 increased to 4,129. Meanwhile, infant deaths in 2022 amounted to 20,882 and in 2023 amounted to 29,945 [2]. According to the United Nations Children's Fund (UNICEF), premature birth is the leading cause of death for children under the age of five with an estimated 15 million babies born prematurely worldwide each year [3].

In today's digitalization era, connectivity is very important, especially with more and more IoT (Internet of Things) devices connecting to LoRa (Long Range) networks [4]. LoRa technology allows IoT devices to connect to wireless networks with low power and longer range compared to Wi-Fi or Bluetooth networks [5]. The main advantage of this technology is its ability to transmit small amounts of data over very long distances, with very low power consumption, making it ideal for devices that require long periods of battery operation [6].

LoRa works by using a modulation technique known as spread spectrum modulation, which helps to reduce interference and increase the signal's resistance to interference

[7]. LoRa networks also support bi-directional communication, allowing devices to not only send data but also receive instructions or updates from a central network [8]. This makes it a highly flexible option for a wide range of IoT applications. However, LoRa's signal range is still limited and can be easily disrupted by obstacles such as building walls or large trees [9]. To overcome signal range limitations, LoRaWAN (Long Range Wide Area Network) network technology is often used, which enables the setup of a network consisting of multiple gateways [10]. These gateways act as a bridge between LoRa devices and the internet, collecting data from devices within its range and forwarding it to a central server. Thus, even though the devices may be far away from the central server, data can still be sent and received efficiently through the wide network of gateways [10].

An effective solution is to implement an automatic monitoring system based on the Internet of Things (IoT) by using certain sensors that can measure critical parameters in the incubator. The concept of IoT itself describes a network of physical devices that are connected to the internet and can communicate with each other and exchange data [11]. The use of IoT technology in this system not only improves the efficiency and accuracy of monitoring, but also ensures the safety and comfort of babies who are very vulnerable to temperature changes. In this study, we will compare the quality of temperature sensors in incubators using NTC (Negative Temperature Coefficient), DHT11 (Digital Humidity and Temperature) sensors integrated in the LoRa Ebyte E32 IoT-based system.

MATERIALS & METHODS

The proposed system is designed to monitor and measure incubator parameters such as temperature, humidity, and air quality. The main objective of our design is to compare the quality of sensor readings for advanced real-time intelligent monitoring of a baby incubator based on IoT and LoRA networks that track the temperature conditions inside the incubator. By placing sensor modules in the surrounding area and analyzing the real-time data collected and monitored on a web page by utilizing the Wi-Fi based BLYNK IoT platform, WeMos D1, dht 11 sensor, and NTC thermal sensor are used in the hardware configuration to collect data.

1.1.Hardware Component

The above-mentioned components for data collection, data transfer, data processing and analysis are used in the development of the proposed IoT-based wireless intelligent monitoring system for parameters related to baby incubators. For comparison of temperature sensor readings in the incubator, two different sensors were used in this study. The sensors were selected based on various important variables such as accuracy, calibration, power consumption, compatibility, dependability, durability and cost.

1.1.1. Temperature & Humidity Sensor (DHT11)

DHT11 is a sensor module that functions to sense the temperature and humidity of objects that have analog voltage outputs that can be further processed using a microcontroller. DHT11 sensors generally have a fairly accurate temperature and humidity reading value calibration feature. The calibration data storage is contained in the OTP program memory which is also called the calibration coefficient[12].

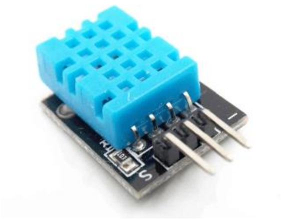

Figure 1. DHT 11

The DHT-11 sensor is a sensor package that functions to measure air temperature and humidity at the same time which includes an NTC (Negative Temperature Coefficient) type thermistor to measure temperature, a humidity sensor with resistive characteristics to changes in moisture content in the air and a chip that performs several analog to digital conversions and outputs in single-wire bi-directional format[13].

1.1.2. NTC Thermistor (*Negative Temperature Coefficient Thermistor*) sensor

Temperature sensor whose resistance decreases as the temperature increases. NTC Thermistors work based on the change in resistance of the semiconductor material as the temperature changes. When the temperature increases, the thermal energy generated increases the atomic motion within that semiconductor material, which in turn reduces the resistance and resistance of the material. This results in a change in voltage or current in the circuit to which the NTC Thermistor is connected[14].

Figure 2. NTC THERMAL

The working principle of the NTC thermistor mainly depends on the ambient temperature. Once the temperature of the thermistor increases, its resistance will decrease. For every 1 degree centigrade increase in temperature, 5% resistance will decrease.

1.1.3. LoRa

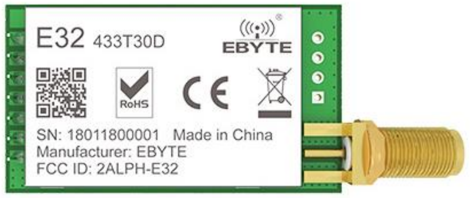

Figure 3. LoRa EBYTE 32

The working principle of LoRa is basically to convert information data into spread-spectrum signals for transmission through spread-spectrum coding. Spread spectrum modulation is a technique to spread the spectrum of information data by widening the bandwidth of information data, the resistance of the signal to noise and interference in the transmission process is improved, LoRa uses chirp modulation to modulate the original data to a high-bandwidth chirp signal, thereby realizing reliable communication in an environment with a low signal-to-noise ratio.

Schematik diagram

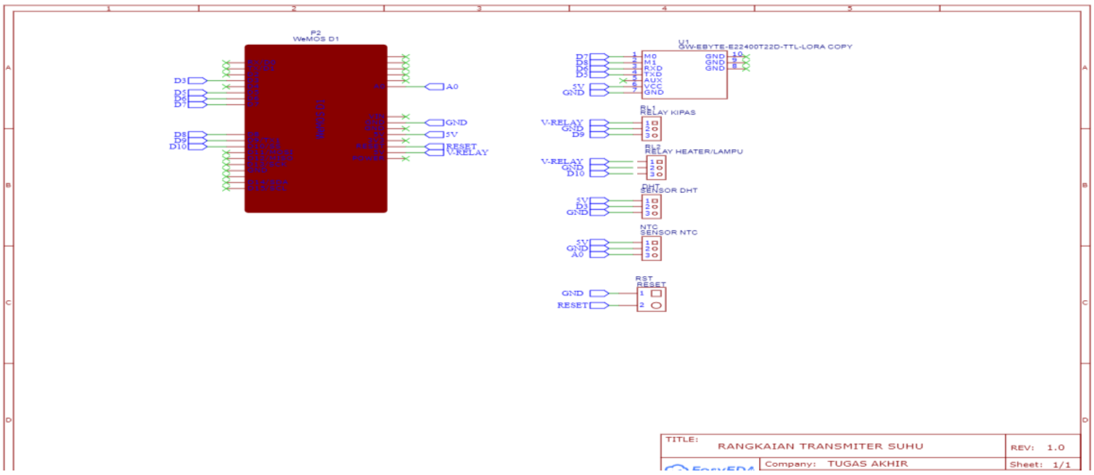

Figure 4. SCHEMA TX

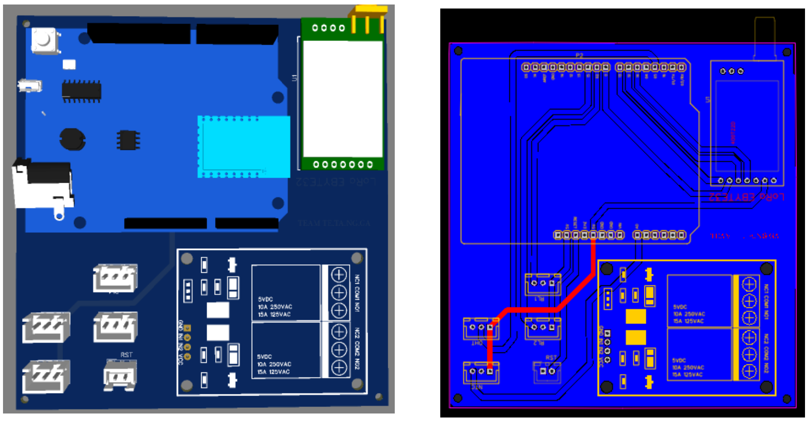

Figure 5. 3D PCB

METHODS

In this research we use experimental methods based on quantitative methods to determine the difference in reading values from DHT11 sensors and NTC sensors to get optimal results and determine the error value of sensor readings.

1. Data Collection: Take temperature measurements using DHT11 sensor and NTC sensor under the same conditions. Use a calibration thermometer as a reference value.
2. Data Processing: Calculate the MAE, RMSE, and RE values for each sensor based on the collected data.
3. Analysis: Compare the MAE, RMSE, and RE values for both sensors to determine which sensor is more accurate

RESULT

The experiment was conducted at 'Midwife Hj. Dewi Apriani Bandung City Indonesia' in June 2024. When the circuit is powered up by connecting the pins to the corresponding slots, all the sensors i.e. DHT 11 temperature sensor and NTC Are initialized then take readings of the ambient temperature and then send the measurement results to the oled screen via the loRa communication line then Oled displays the measurement results on its screen.

Sensor data collection and storage-based timeframes depend on factors such as the application, sensor type, and desired level of analysis. Real-time monitoring requires short intervals, while long-term trend analysis may require longer intervals. Thus, in this work the data from sensors is collected for different time slots such as every minute and every 1 minute regularly at 'Midwife Hj. Dewi Apriani Kota bandung indonesia June 2024, and provides meaningful analysis.

Dht 11 Sensor Measurement Result

DHT 11 sensor readings were taken for one hour and recorded every 1 minute. The results of the DHT 11 sensor readings are shown in the following table

Table 1. Measured DHT11

Time[menit]	Temp (°C)	Temp ref	Time[menit]	Temp (°C)	Temp ref
00:00	36.5	36	00:31	36.7	36
00:01	36.6	36	00:32	36.5	36
00:02	36.5	36	00:33	36.6	36
00:03	36.5	36	00:34	36.5	36
00:04	36.7	36	00:35	36.5	36
00:05	36.5	36	00:36	36.6	36
00:06	36.6	36	00:37	36.5	36
00:07	36.5	36	00:38	36.5	36
00:08	36.5	36	00:39	36.6	36
00:09	36.6	36	00:40	36.5	36
00:10	36.5	36	00:41	36.7	36

00:11	36.7	36	00:42	36.5	36
00:12	36.5	36	00:43	36.6	36
00:13	36.6	36	00:44	36.5	36
00:14	36.5	36	00:45	36.5	36
00:15	36.5	36	00:46	36.6	36
00:16	36.6	36	00:47	36.5	36
00:17	36.5	36	00:48	36.5	36
00:18	36.5	36	00:49	36.6	36
00:19	36.6	36	00:50	36.5	36
00:20	36.5	36	00:51	36.7	36
00:21	36.7	36	00:52	36.5	36
00:22	36.5	36	00:53	36.6	36
00:23	36.6	36	00:54	36.5	36
00:24	36.5	36	00:55	36.5	36
00:25	36.5	36	00:56	36.6	36
00:26	36.6	36	00:57	36.5	36
00:27	36.5	36	00:58	36.5	36
00:28	36.5	36	00:59	36.6	36
00:29	36.6	36	01:00	36.5	36
00:30	36.5	36			

To find out the average error between the value measured by the sensor and the reference value can be known by the following equation.

$$MAE = \frac{1}{n}\sum_{i=1}^{n} |Tmeasured, i - Treference, i|$$

MAE = 0.5492

To find out the square root of the average square error can be found with the equation below

$$RMS = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(Tmeasured, i - Treference, i)^2}$$

RMS = 0.5532

To find out the relative error to the reference value expressed in percent can be found with the following equation

$$RE = \frac{|Tmeasured,i - Treference,i|}{Treference,i} \text{ X } 100\%$$

RE = 1.5255 %

NTC sensor measurement result

NTC sensor readings were taken for one hour and recorded every 1 minute. The results of the NTC sensor readings are shown in the following table

Table 2. Measured NTC

Time[menit]	Temp (°C)	Temp ref	Time[menit]	Temp (°C)	Temp ref
00:00	36.5	36	00:31	36.7	36
00:01	35.8	36	00:32	34.9	36
00:02	37.2	36	00:33	37.0	36
00:03	34.9	36	00:34	35.5	36
00:04	36.1	36	00:35	36.6	36
00:05	37.5	36	00:36	35.0	36
00:06	35.3	36	00:37	37.2	36
00:07	36.9	36	00:38	35.3	36
00:08	34.7	36	00:39	36.9	36
00:09	37.1	36	00:40	34.7	36
00:10	35.6	36	00:41	37.1	36
00:11	36.8	36	00:42	35.6	36
00:12	34.8	36	00:43	36.8	36
00:13	37.3	36	00:44	34.8	36
00:14	35.4	36	00:45	37.3	36
00:15	36.7	36	00:46	35.4	36
00:16	34.9	36	00:47	36.7	36

00:17	37.0	36	00:48	34.9	36
00:18	35.5	36	00:49	37.0	36
00:19	36.6	36	00:50	35.5	36
00:20	35.0	36	00:51	36.6	36
00:21	37.2	36	00:52	35.0	36
00:22	35.3	36	00:53	37.2	36
00:23	36.9	36	00:54	35.3	36
00:24	34.7	36	00:55	36.9	36
00:25	37.1	36	00:56	34.7	36
00:26	35.6	36	00:57	37.1	36
00:27	36.8	36	00:58	35.6	36
00:28	34.8	36	00:59	36.8	36
00:29	37.3	36	01:00	34.8	36
00:30	35.4	36			

To find out the average error between the value measured by the sensor and the reference value can be known by the following equation.

$$MAE = \frac{1}{n}\sum_{i=1}^{n} |Tmeasured, i - Treference, i|$$

MAE = 0.8885

To find out the square root of the average square error can be found with the equation below

$$\text{RMS} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(Tmeasured, i - Treference, i)^2}$$

RMS = 0.9440

To find out the relative error to the reference value expressed in percent can be found with the following equation

$$RE = \frac{|Tmeasured,i - Treference,i|}{Treference,i} \text{ X } 100\%$$

RE = 2.4681 %

LoRa Ebyte 32 measurement result

The results of measuring the distance of data transmission using Lora are shown in the following table.

Table 3. Measured LoRA

Distance [m]	Result
100	DELIVERED
200	DELIVERED
300	DELIVERED
400	DELIVERED
500	DELIVERED
600	NOT DELIVERED

Graphic measured DHT11

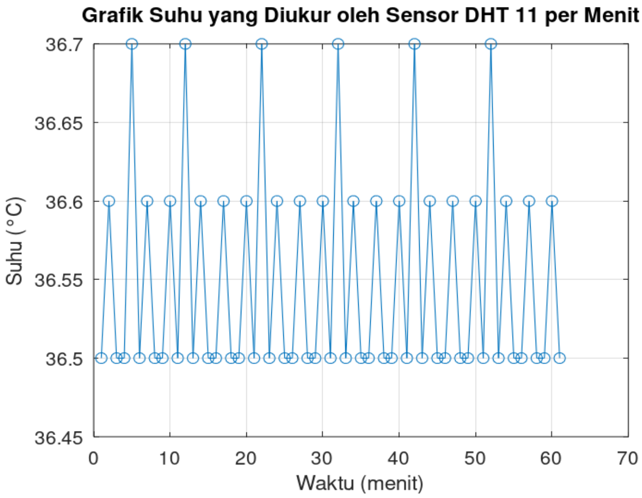

Figure 6. Graph measured DHT11

Graphic measured NTC

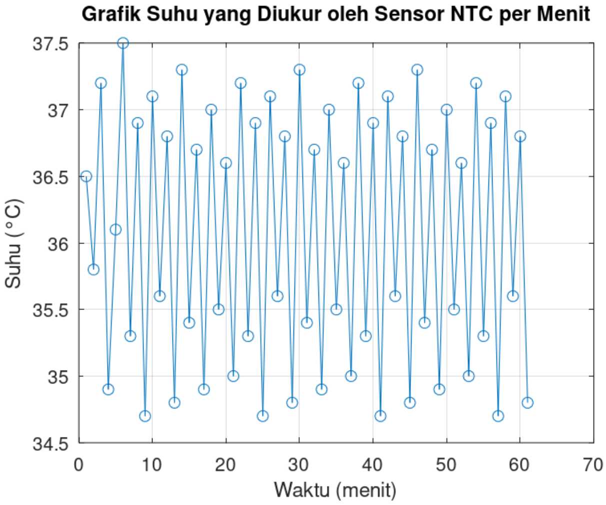

Figure 7. Graph measured NTC

Comparison Graph Measured DHT, NTC, Ref

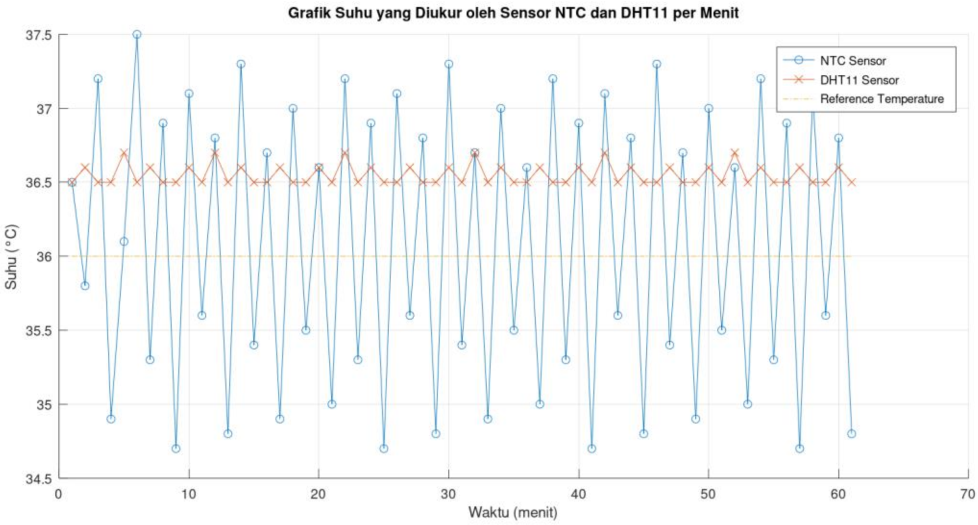

Figure 8. Graph comparison

CONCLUSION

Based on the test results and analysis calculations, it can be concluded that the percentage of high error values obtained on the NTC sensor reading is 2.4681%, while the percentage of low error values obtained on the NTC 11 sensor reading is 1.5255%. then the average DHT 11 sensor error of 0.5492 is smaller than the average NTC error of 0.8885 or a difference of 0.3. From these results it can be stated that the DHT11 sensor is suitable for use because it is more stable during measurement and based on the calculation of the percentage of error value, because the percentage level of error value is below 2%.

Declaration by Authors

Acknowledgement: None
Source of Funding: None

Conflict of Interest: The authors declare no conflict of interest.

REFERENCES

1. K. C.. Raju, “SMART INFANT INCUBATOR MONITORING,” *IJCRT.ORG*, no. March, 2024.
2. M. Sjahid Latief and L. Destian, “Evaluasi Dan Outcome Terapi Penggunaan Antibiotik

Profilaksis Pada Pasien Sectio Caesarea Di Rumah Sakit Muhammadiyah Taman Puring Jakarta," *Indones. J. Heal. Sci.*, vol. 4, no. 1, pp. 28–39, 2024, doi: 10.54957/ijhs.v4i1.732.

3. Rokom, "Agar Ibu dan Bayi Selamat," 2024. [Online]. Available: https://sehatnegeriku.kemkes.go.id/baca/blog/20240125/3944849/agar-ibu-dan-bayi-selamat/
4. L. Jose, E. B. P, M. Sandesh, M. A. P, and C. M. Sankaranarayan, "Smart Incubator Using IoT," vol. 5, no. 5, 2024.
5. M. A. Afandi, F. K. Purnomo, R. A. Rochmanto, and S. I. Purnama, "Monitoring and Controlling Temperature Egg Incubator Prototype Based LoRa Communication," *Elinvo (Electronics, Informatics, Vocat. Educ.*, vol. 7, no. 2, pp. 119–126, 2023, doi: 10.21831/elinvo.v7i2.53664.
6. P. Hai-Phong, V.-K. Duong, T.-K. Tran, V.-D. Vo, and H.-H. Hoang, "A Low Power – Long Range IoT Development Board based on LoRa Technology," *Hue Univ. J. Sci. Tech. Technol.*, vol. 131, no. 2B, pp. 5–14, 2022, doi: 10.26459/hueunijtt.v131i2b.6795.
7. H. Mroue, A. Nasser, B. Parrein, S. Hamrioui, E. Mona-Cruz, and G. Rouyer, "Analytical and Simulation study for LoRa Modulation," *2018 25th Int. Conf. Telecommun. ICT 2018*, pp. 655–659, 2018, doi: 10.1109/ICT.2018.8464879.
8. S. Setiowati, R. Riandini, V. A. Sari, I. L. Purwanti, and N. Andriansyah, "LoRa Communication in the Service Level Monitoring Satu Duit Bogor Bridge," *JITCE (Journal Inf. Technol. Comput. Eng.*, vol. 7, no. 01, pp. 19–28, 2023, doi: 10.25077/jitce.7.01.19-28.2023.
9. T. Keser, D. Blažević, and D. Nožica, "Lora Communication Maintenance and Signal Propagation Evaluation in Obstacle-Dense Industrial Environments: a Wood Processing Application," *Adv. Eng. Lett.*, vol. 2, no. 1, pp. 28–40, 2023, doi: 10.46793/adeletters.2023.2.1.5.
10. C. Kaewta, C. Savithi, and E. Naenudorn, "An optimization of multiple gateway location selection in long range wide area network networks," *Indones. J. Electr. Eng. Comput. Sci.*, vol. 30, no. 2, pp. 1011–1020, 2023, doi: 10.11591/ijeecs. v30.i2. pp1011-1020.
11. R. Qamar and B. A. Zardari, "An Analysis of the Internet of Everything," *Mesopotamian J. CyberSecurity*, vol. 2023, no. April, pp. 85–92, 2023, doi: 10.58496/MJCS/2023/013.
12. A. Y. Rangan, Amelia Yusnita, and Muhammad Awaludin, "Sistem Monitoring berbasis Internet of things pada Suhu dan Kelembaban Udara di Laboratorium Kimia XYZ," *J. E-Komtek*, vol. 4, no. 2, pp. 168–183, 2020, doi: 10.37339/e-komtek. v4i2.404.
13. T. Suryana, "Menampilkan Informasi Cuaca Suhu , Kelembaban Udara , dan Kelembaban Tanah Menggunakan Sensor DHT11 dan Soil Moisture Abstraks Pembahasan Sensor DHT11," *Tek. Inform. Univ. Komput. Indones.*, 2021.
14. E. Rimbawan, E. Susanto, A. Kusnayat, L. Cell, S. S. Juicer, and S. Slow, "Implementasi Sistem Keamanan Suhu dan Massa Beban pada Smart Slow Juicer dengan NTC Thermistor dan Load Cell," vol. 11, no. 1, pp. 483–487, 2024.

How to cite this article: Muhammad Zimamul Adli, Euman Suratman, Muhammad Aditiya Firdaus, Fikrul Haykal Johar, Yandi Setia Permadi, Teguh Teuja Laksana. Comparison of DHT 11 and NTC temperature sensors based on internet of things and Lora Ebyte 32 for incubator. *International Journal of Research and Review*. 2024; 11(8): 462-469. DOI: *https://doi.org/10.52403/ijrr.20240849*

******