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# Analysis of PID-Based Baby Incubator Humidity using Kangaroo Mode

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**ABSTRACT** The main factor that affects the parameters of the workings of humidity in the baby incubator is the sensor used to read the humidity in the room. The purpose of this study is to analyze the humidity sensor in the baby incubator using 2 humidity sensors (DHT11 and DHT22) in the different location. The manufacture of this device used an after-only design, with a comparison device of INCU Analyzer, DHT11, and DHT22 sensors. Based on the measurement, DHT11 produced a value of 46%, while DHT22 produced a value of 55.45% with BPFK standards of 50%-70%. Based on the results of measurements using the INCU Analyzer, the average error value for DHT11 is 16.05%, while DHT22 is 3.47%. Therefore, the results showed that the DHT22 sensor was more accurate to be used in baby incubators because the measurement results were under BPFK standards and produced a low error value. This can be further implemented in a baby incubator making to improve the health and safety of the babies.

**INDEX TERMS** Kangaroo, moisture, baby incubator, humidity sensor

## I. INTRODUCTION

Babies are normally born at the age of 37 weeks or more than 9 months with a weight of 3 kg. However, many mothers give birth at gestational age of below 37 weeks; these babies are usually called as premature babies [1]. Premature babies, especially those who are born under 32-34 weeks, have a distinctive physical appearance, thinner skin, and easy-to-see blood vessels [2][3]. Premature babies will quickly lose their body warmth and be hypothermic because their body warmth regulation center is not functioning properly. Their metabolism is also low and their body surface is relatively large, thus they must have been cared in an incubator to make them feel warm like in the womb [3]. Premature babies have a lower chance of survival and lower intelligence scores than babies born with normal weight. Complications that occur in premature babies include short-term and long-term complications. The short-term complications are in the form of newborn respiratory distress syndrome which often ends in mortality, while the long-term complications are in the form of blindness, deafness, paralysis, and mental retardation. For this reason, a strategy is needed to reduce premature babies mortality by providing care using a baby incubator [4][5]. Baby care in a baby incubator causes the separation between the mother and the newborn. Mothers who had premature or preterm babies are found to be less confident in taking caring of their babies compared to mothers who have term babies. In this case, the innovation in taking care of premature babies to make the babies and their mothers

closer is the Kangaroo Method of Care [5][6]. The kangaroo method of care aims to create an emotional attachment between the mother and the baby, so the mother will be confident with her ability to take care of the baby and feel capable and satisfied with her role as a mother [6][7]. Another benefit of this method is to help accelerating the health of the premature babies who are sick. Based on the results of research on the skin to skin contact, there are benefits from this technique in terms of the physiology and the behavior of babies with low birth weight [8]. This method indicates an improvement on the baby metabolic status, thermal regulation, breathing patterns, and oxygen saturation, reduces apnea and bradycardia, increases body weight and milk production, shortens hospital stays, and serves as an analgesic during painful medical procedures.

Research has been conducted by Dianesty Trisuciyan by using 808H5V6 sensor as a humidity sensor and seven segments-display. The weakness of this system is that the buzzer remains on when the switch is not turned off, so the buzzer cannot be automatic. Another weakness is that the display still used seven-segments. However, this can be used to limit and monitor the patient's temperature continuously [9]. Furthermore, a study was also conducted by Rizqy Rully Pratama who updated the display using ATmega8535 microcontroller IC so that users can easily use the device [10]. In the same year, Hari Bagus Karyadi conducted a study that also updated the view but by using the ATmega 16 microcontroller IC. The research was done

by adding an automatic temperature setting through the weight and skin temperature which is then directly measured the results. In addition, he also updated the previous research by adding humidity parameters [11]. Next research by Anjar Wahyu C created a system by making a baby incubator equipped with blue light therapy. In addition, study performed by Nur Fildzah Hidayati was done by adding kangaroo mode which aims to create an emotional attachment between the mother and her baby so that mothers will be confident with their ability to take care of the babies and feel capable and satisfied with their role as mothers. However, the drawbacks of this device are that the water area for humidity control is still not large enough so that it is not as desired and there is no air velocity control system for when the temperature stability range begins to decrease [12][13][14].

Based on the previous research that only modifies the incubator [15], the general operation of a baby incubator can be concluded. Modifications were made because they wanted to update components to be more advanced than before, such as updating the sensors, controls, and others [16][17][18]. However, it was done by still paying attention to the main parameters of a baby incubator [17][18], namely temperature and humidity [20]. However, in previous research, no research was conducted on humidity sensors. Therefore, previous research does not know whether the sensor is worthy to be used or not.

The purpose of this study is to analyze previous research by analyzing the humidity in the baby incubator by comparing the humidity measurements using 2 sensors, namely DHT11 and DHT22 sensors [21][22][23]. This research is expected to obtain the factors which affect the measurement of the sensor.

## II. MATERIALS AND METHODS

### A. EXPERIMENTAL SETUP

This study used the after-only design method because the temperature and humidity data collection was compared using a comparison device (INCUB II).

#### 1.) MATERIALS AND DEVICE

In this study, DHT11 and DHT22 sensors were used for humidity sensors. In this case, 5 LM35 sensors were used for temperature sensors, while skin sensors used thermistors. A microcontroller is a value processor monitored by sensors. The DC fan functions as humidity in the chamber which receives command from the microcontroller. The heater functions as a heater in the chamber which receives command from the microcontroller. The thermostat functions as a safety device, where if the temperature is overheated, the thermostat will disconnect the heater. In addition, when the temperature is overheated, the buzzer will sound.

#### 2.) EXPERIMENT

The DHT11 and DHT22 sensors collected the data for 10 minutes with the incubator temperature setting at 32°C-37°C and the influence of the room temperature was 27.2°C.

Temperature data collection during kangaroo mode was also carried out for 10 minutes with the incubator temperature setting at 32°C-37°C and the influence of room temperature was 27.2°C.

### B. THE DIAGRAM BLOCK

FIGURE 1 shows the block diagram of a baby incubator. When the device is turned on, the voltage will be lowered and rectified by the power supply to +5 VDC, +12 VDC, and Ground will be used to supply the entire circuit. The room temperature will be read by 5 LM35 sensors that have function as analog data, which will be read by pins A0, A1, A2, A3, and A4. A0 is the PID control, while A1, A2, A3, A6 are the temperature monitoring displayed on the LCD. The room temperature control circuit requires AC voltage to run the heater and SSR. The SSR output is the AC voltage connected to the heater. The skin temperature connected to pin A5 will process the data read from the thermistor sensor in the form of analog data and will further be displayed on the LCD.

The humidity sensor using the DHT22 and DHT11 sensors requires an input voltage of +5 VDC and ground. The output of the DHT 22 sensor is in the form of digital data connected to digital pin 2, while the output of the DHT 11 sensor is in the form of digital data connected to digital pin 3 that will be read and displayed on the LCD. When the humidity reading by DHT22 is less than 70%RH, then the fan will turn on. However, when the humidity is more than 70%RH, then the fan will turn off. The temperature setting can be done by pressing the push button which is connected to digital pins 11, 12, 13 in the form of the Up, Down, and OK buttons. The thermostat functions to cut off the heater work if the temperature in the chamber has been met. The buzzer sounds after the heater is disconnected or not working.

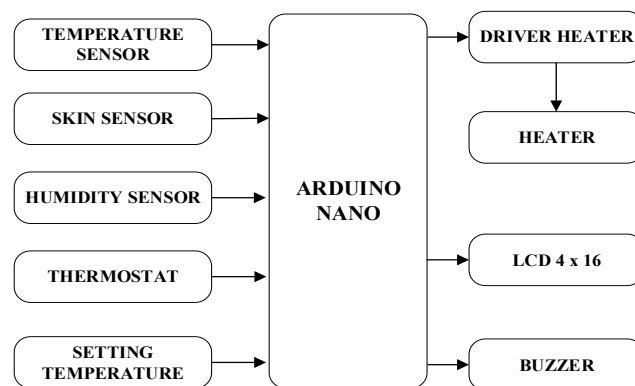


Figure 1. The Diagram Block of Baby Incubator

### C. THE FLOWCHART

FIGURE 2 is the flow diagram of the device. During START, the process is initialized and the user selects a mode. If the user opens the chamber door, then kangaroo mode is in progress. However, when the user does not open the chamber door, air mode is in progress. In this case, the

room temperature sensors used are 5 LM35, 2 humidity sensors of DHT11 and DHT22, skin sensors of thermistors. Then, the process of measuring the temperature and humidity in the chamber will occur. The room temperature sensor will activate the heater. If the temperature is too high, the heater will turn off and when the temperature is less than the setting, the heater will work. The temperature and humidity measurements will be further displayed on the LCD. At the END, the device will stop operating.

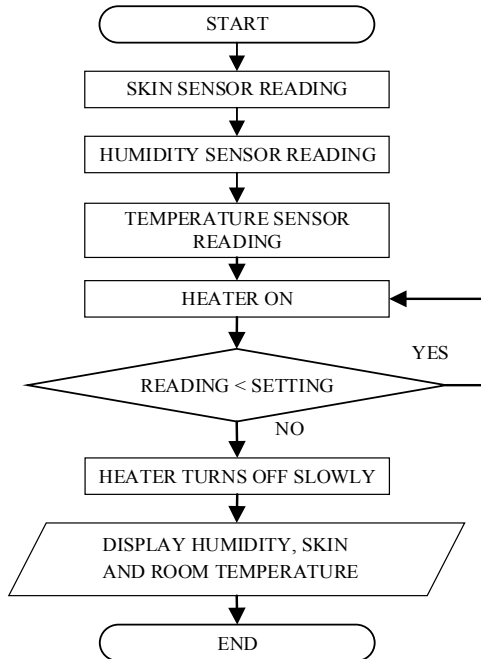


Figure 2. The Flowchart of Baby Incubator

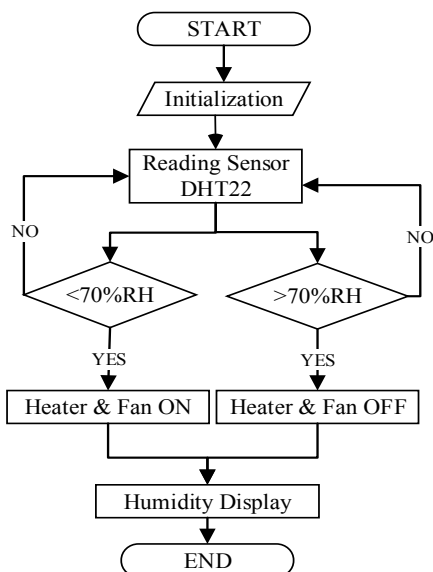


Figure 3. The Flowchart of Humidity Control

FIGURE 3 shows the DHT22 sensor that acts as the humidity sensor. The output of the DHT22 sensor goes [Homepage: jeeemi.org](http://Homepage: jeeemi.org)

directly to the microcontroller Digital PIN and gives command. If the humidity read on the sensor is below 70%RH, then the heater and humidity will turn on. However, if the humidity read on the sensor is above 70%RH, then the heater and fan will turn off. In addition, the humidity value is displayed on the display in the form of a character LCD. The calculated humidity value is displayed on the LCD using the DHT22 sensor. In this case, the sensor calculations were compared to the DHT11 sensor data collection.

### III. RESULTS

#### a) Results of microcontroller design

FIGURE 4 is the result of the front view of the baby incubator. The author used an LCD for a readable display on the device. Push buttons are used for device settings. The heater indicator for the heater marker is off or on. Furthermore, there is a buzzer test to check if the buzzer is still working or not. FIGURE 5 is the result of a baby incubator made. On the inside of the chamber, there were 5 LM35 sensors consisting of 1 LM35 sensor as the PID control which is located in the middle and 4 for measurement of room temperature which is located in the right and left corners. Inside the left side of the chamber, there are DHT22 and DHT11 sensors for measuring the humidity of the baby incubator chamber. On the front, there is a skin sensor to measure the body temperature on the skin.

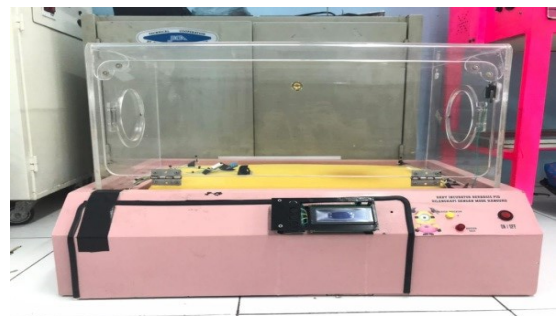


Figure 4. Baby Incubator

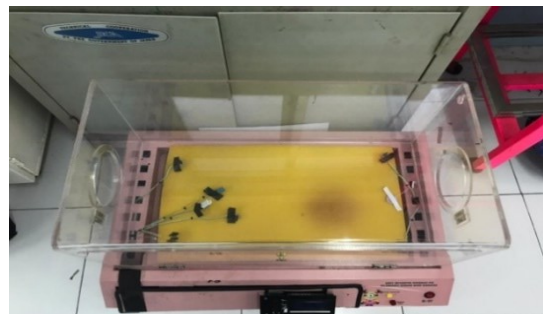


Figure 5. Sensor Point of Baby Incubator

## b) The measurement of humidity

**TABLE 1.**  
Humidity Measurement Data Using Dht11

Temperature Setting (°C)	DHT11 (%Rh)	INCUII (%Rh)	Error (%)
32 °C	43.00 %	50.23 %	16.81%
33 °C	44.00 %	51.32 %	16.64%
34 °C	49.00 %	55.69 %	13.65%
35 °C	49.00 %	56.13 %	14.55%
36 °C	48.00 %	55.58 %	15.79%
37 °C	44.00 %	52.29 %	18.84%
Average			16.05%

**TABLE 2.**  
Humidity Measurement Data Using Dht22

Temperature Setting (°C)	DHT22 (%Rh)	INCUII (%Rh)	Error (%)
32 °C	52.13%	50.23 %	3.64%
33 °C	53.57%	51.32 %	4.2%
34 °C	57.41%	55.69 %	3%
35 °C	57.79%	56.13 %	2.87%
36 °C	57.49%	55.58 %	3.32%
37 °C	54.36%	52.29 %	3.8%
Average			3.47%

The measurement of DHT11 (TABLE 1) with INCUII was done at chamber temperature setting conditions of 32°C to 37°C. The error value in measuring humidity using the DHT11 sensor is relatively high with a value of 16.05%.

There are data on the measurements results of DHT22 (TABLE 2) with INCUII at room temperature setting conditions of 32°C to 37°C. The error value in humidity measurement using the DHT11 sensor is relatively low with a value of 3.47%.

## c) Measurement Graph of DHT11 and DHT22

FIGURE 6 is the measurement of DHT11 and DHT22 data compared to INCUII.

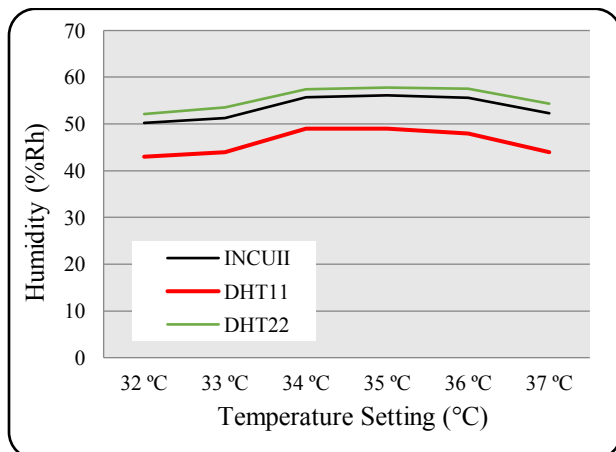


Figure 6. Comparison between DHT11 and DHT22 with INCUII

## IV. DISCUSSION

TABLE 1 shows the results of measurement using the DHT11 sensor which was set according to the room temperature of 32°C-37°C. Then, the results were compared to INCUII Analyzer. In this case, the comparison was done on the error value obtained between the DHT11 and INCUII Analyzer data. The error value is the difference in the mean of each data. Likewise, TABLE 2 shows the results of measurement using the DHT22 sensor which was set according to the room temperature of 32°C-37°C. Then, the results were compared to the INCUII Analyzer and an error value was generated.

The results of the DHT11 measurement were compared to the measurements of INCUII Analyzer at a temperature setting of 32°C-37°C which produces an average error value of 16.05%. DHT22 compared the INCUII Analyzer at a temperature setting of 32°C-37°C resulted in an average error value of 3.47%. The error value of DHT11 is very high compared to DHT22 [24] [18].

Therefore, DHT22 is more feasible to be used than DHT11, seen from the average error value on DHT11 which is quite high. The cause might be due to the poor sensor condition or environmental conditions during the sensor measurement. In addition, the characteristics of DHT22 are also better than the characteristics of DHT11 [25][24] [5].

Therefore, related to the purpose of this measurement, it can be seen that it is better to use a DHT22 humidity sensor when making a baby incubator because it produces a better accuracy level than DHT11 [23]. However, future research is also recommended to use a humidity sensor that has a smaller error value than DHT22, thus the sensor has high accuracy. Furthermore, the purpose of this research can be implemented to the public to increase knowledge about the right accuracy of humidity sensor for baby incubators [26][27].

## V. CONCLUSION

This study aims to find out which sensor is more accurate to be used in baby incubators and able to guarantee the safety and health of babies [27]. The recommended sensor obtained for the baby incubator is the DHT22 sensor because it has a fairly low error value [25] when the measurement data were compared with INCUII. For further research, it is recommended to use a sensor that has a lower error value than the DHT22 sensor.

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