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Design and Control Level of Moisture in Baby Incubator with On-Off Method and Acquisition of Baby Weight Use Load Cell Sensor

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Abstract: *Baby incubator is one of life support for premature babies. Premature babies are babies who born faster than the birth of normal babies and usually have weight under 2500 grams. In general, the standard incubator currently only serves to maintain the appropriate room temperature conditions for babies. Another important thing that must be considered in a baby incubator is the level of humidity and monitoring the baby's weight. In this final project a baby incubator system is designed using a DHT11 sensor and a load cell sensor. DHT11 sensor is used to measure and control the required moisture level. This humidity control is done by the ON-OFF method. Humidity regulated in baby incubators is in the range of 40% -60%. While the load cell sensor is used for the acquisition of baby's weight automatically. The maximum capacity of the load sensor used is 5 kg. From the results of testing the humidity control system and the acquisition of baby weight, the ideal humidity results are in the range of 45% -55%. Humidity in that range can maintain indoor conditions and form a stable graph. For the acquisition of a baby's weight using a sensor load cell, it was found that the average error was quite good at 0.01%.*

Keywords: Baby Incubator, DHT11 Sensor, Load Cell Sensor

1. INTRODUCTION

In the medical world, baby incubator is one of the life supports for premature babies. Premature babies are babies who born faster than the birth of normal babies and usually have weight under 2500 grams. The baby incubator device serves to maintain the warmth and moisture of the baby's body, prevent respiratory infections in infants and to isolate newborns or premature babies who weigh less than 2.5 kg [1]. In general, the standard incubator currently available only serves to maintain the appropriate room temperature conditions for the baby. Another important thing that must be considered in a baby incubator is the level of humidity. According to the statistical data, measurements and calibration carried out by the Surabaya Health Facilities Security Center (BPFK) in 2006-2007, there was a tendency for problems in the humidity and Over Heat on the mattress. Thus in the baby incubator the humidity conditions must be maintained so as not to disturb and affect the performance of the incubator [2][3]. In addition to the humidity factor, monitoring baby weight is also needed. Babies with low birth weight (LBW) tend to have problems such as difficulty breathing, problems in the nervous system and organ organs are important because of the immaturity of the organ system [4][5]. Therefore, it must always be monitored the development of the baby's weight. In a previous study, Faishol Fathur Riza conducted a study by creating a temperature control system and monitoring the humidity based on ATMega8535 at a plant incubator. In testing using PI (Proportional Integral) control to control the incubator room temperature. For humidity, moisture monitoring is only done. The results obtained indicate that between temperature and humidity affect each other. If the temperature is raised then the humidity will decrease and if the temperature is lowered then the humidity will rise [6]. Laura designed the automatic temperature and humidity control system for baby incubators. This system of baby incubators will automatically turn on or turn off the fan and / or heater in accordance with the normal limits of temperature and humidity in the baby's incubator. The normal limit for the temperature of the baby incubator used is 33^oC to 35^oC. Whereas the nominal limit for air humidity in a baby's incubator is 40% to 60%. The test results show the heater will turn on if the temperature is below the 33 ° C limit. While the fan will turn on if air humidity is above 60% [7]. Joko Setiono design a temperature control design and automatic weight scales in baby incubators. The design of this system aims to obtain the design of the incubator room temperature controller with on-off control in the range of 31^0C-36^0C and the design of automatic weight scales in the range 0 kg - 5 kg [8]. Pallerla Akshay implements a web-based baby incubator system in real time to monitor baby's temperature, humidity and weight. Temperature and humidity are controlled. Models from baby incubators were simulated using LabVIEW 2011 software [9]. To complete the incubator to make it better, in this study a baby incubator was designed by reviewing the parameters of humidity and weight which are expected to facilitate the process of monitoring the development of the baby and being able to maintain the required moisture. The baby incubator tool that will be made uses a DHT11 sensor and a load cell sensor. DHT11 sensors are used to measure and control humidity levels. This humidity control is done by the on-off method. While the load cell sensor is used for the acquisition of baby's weight.

DESIGN

Hardware design includes the overall system hardware design, power supply design, DHT11 sensor design, load cell sensor design and HX711 module, and ATMega16 microcontroller design. Software design includes software design for humidity control systems and heavy system acquisition software design.

2.1 Power Supply

In the design of this use a power supply AC 220 volt voltage source with a 24 volt power supply, a buck converter module 12 volt, and a buck converter module 5 volt. The 24 volt power supply produces a 24 VDC voltage, the 12 volt buck converter module produces 12 VDC voltage, and the 5 volt buck converter module produces a 5 VDC voltage. The power supply module with 24 Volt 10 Ampere output, is efficient enough to supply / supply all types of other electronic equipment that have a voltage equal to or below the existing voltage. In this study it was used as a supplier of ultrasonic mist makers for moisture [10]. Module 12 volt DC voltage is used to supply DC fans. Module 5 volt DC voltage is used to supply ATMega16 microcontrollers, DHT11 sensors, load cell sensors, and relays. The system power supply circuit can be seen in Figure 1.

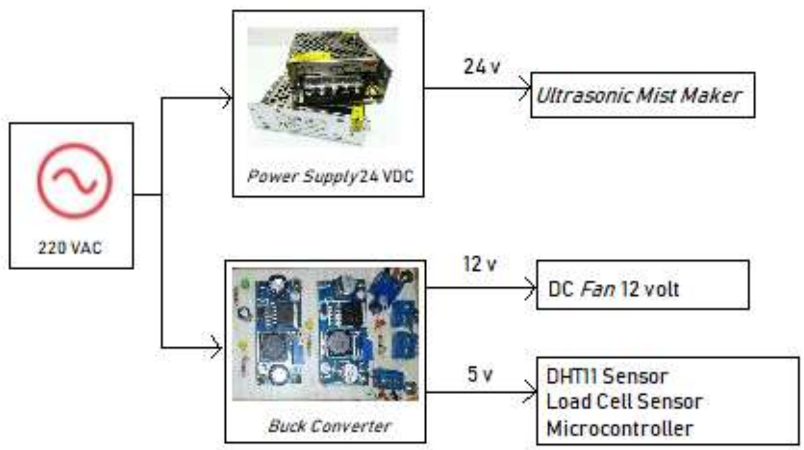


Figure 1: System Power Supply Circuit

2.2 DHT11 Sensor

DHT11 sensor serves to measure humidity and air temperature. The DHT11 sensor has 4 pins, namely VCC, Data, NC, and GND [11]. The VCC pin DHT11 sensor is connected to a 5 volt voltage source. The GND sensor DHT11 pin is connected to ground. The DATA sensor DHT11 pin is connected to pin A.6 in the ATMega16 microcontroller. NC pins not used. The series of results of designing the DHT11 sensor can be seen in Figure 2.

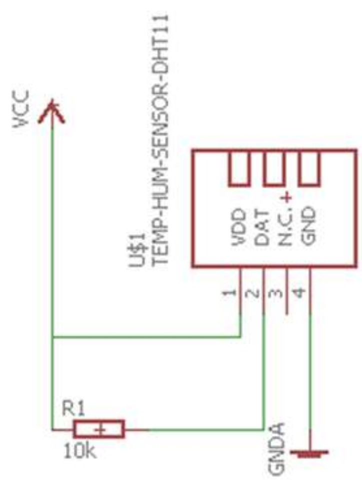


Figure 2: DHT11 Sensor Circuit

2.3 Load Cell Sensor and Module HX711

Load cell is a device used as a transducer to get an electrical signal and the result is directly proportional to the force to be measured. This sensor has a change in conductor resistance so that it can measure the voltage of the wire that converts mechanical stress into an electrical signal [12]. Changes in delivery prisoners may change due to changes in cross section length and area. The weighing sensor has a mechanical work method. Load cell has the principle of pressure using a strain gauge as a sensing (sensor). HX711 as a type of load cell This module functions as an output signal amplifier that comes from a load cell and this module converts analog data into digital data, or commonly heard, namely Analog Digital Converter (ADC) [13]. This load cell sensor has 4 color cables, namely red (R), black (B), green (G), and white (W). Red and black cables have a function as input. Green and white cables serve as output. The four cables contained in the load cell sensor are connected to pins E +, E-, A +, and A- on the HX711 module. The HX711 signal amplifier module has 8 pins which are divided into 2 sides. The first side consists of pins E +, E-, A +, and A-. The second side consists of VCC, SCK, DT, and GND pins. The four cables contained in the load cell sensor are connected to the first side of the HX711 module. The red cable is connected to pin E +, the black cable is connected to pin E-, the green cable is connected to pin A +, and the white cable is connected to pin A-. The second side of the HX711 module is connected to the ATMega16 microcontroller pin. The VCC pin on the HX711 module is connected to a 5 volt voltage source, the DT pin on the HX711 module is connected with ATM A16 microcontroller pin, the SCK pin on the HX711 module is connected with ATMega16 pin B.6, and the GND pin on the HX711 module is connected to ground. The design of the load cell sensor and the HX711 module can be seen in Figure 3.

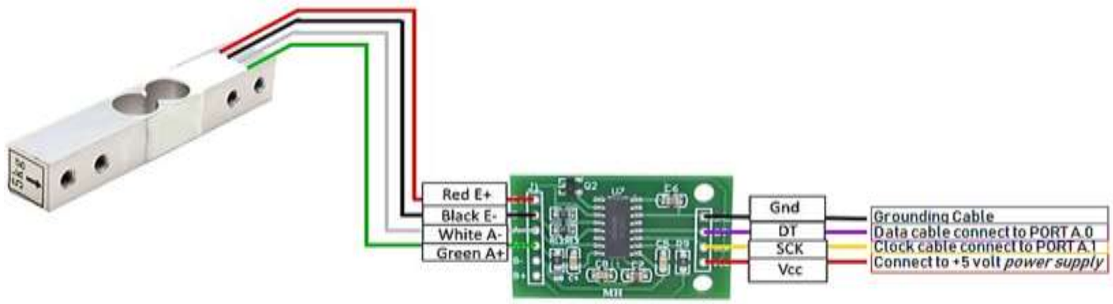


Figure 3: Load Cell Sensor with HX711 Module

2.4 Microcontroller ATMega16

AVR is an 8-bit Complementary Metal Oxide Semiconductor (CMOS) series made by Atmel based on Reduced Instruction Set Computer (RISC) [14]. In general, AVR microcontrollers can be grouped into 5 groups, namely the Attiny, AT90Sxx, ATMega, AVRXMega, and UC3 AVR32 families. One of the microcontrollers that is often used is ATMega 16. ATMega 16 has a throughput of close to 1 Millions Instruction Per Second (MIPS) per MHz, thus making power consumption low against the speed of the command execution process. ATMega16 microcontroller is used to control humidity, read DHT11 sensors and load cells, and to process sensor reading data. In general, the distribution of pins in the ATMega16 microcontroller can be seen in Figure 4.

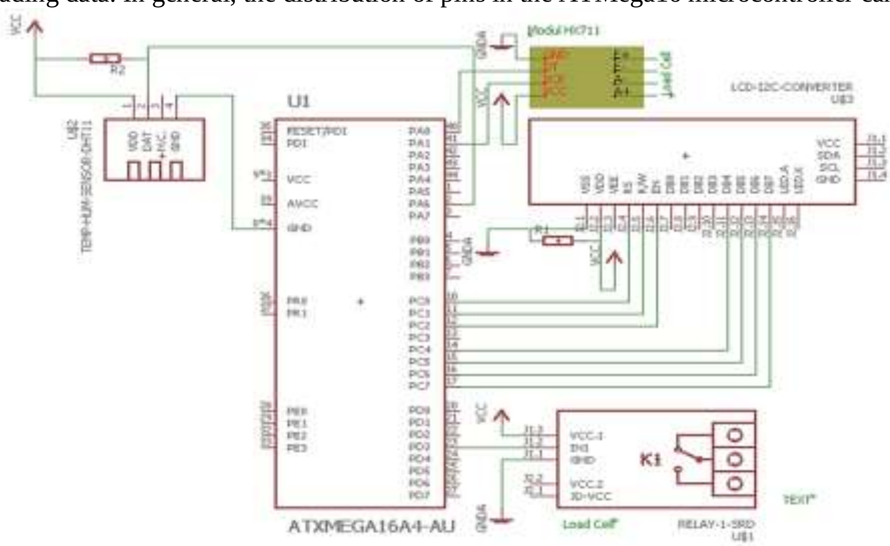


Figure 4: ATMega16 Microcontroller Circuits

2.5 The Humidity Control System Uses The On-Off Method

The on-off method in designing a humidity control system uses 1 normally open relay with an "active low" condition. Low active condition is a condition where a circuit will die if given logic 1 and the circuit will be active if given logic 0. Following is the flow diagram of the work of the humidity control system using the on-off method shown in Figure 5.

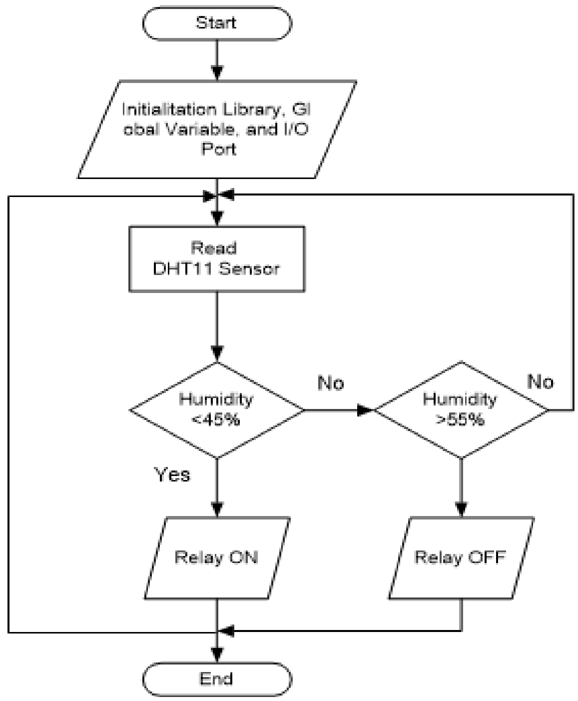


Figure 5: ATMega16 Microcontroller Circuits

The stages of the moisture control system flow diagram are described in the following explanation:

1. Start.
2. Initialize libraries, global variables, and I / O ports.
3. Compare the humidity values read by the DHT11 sensor with the humidity that has been set.
4. If the humidity is less than the bottom set point, the relay will be on and the mist maker will light up. The system will then loop to stage 3 and re-read the DHT11 sensor.
5. If the humidity is more than the upper set point, the relay will be off (inactive) and the mist maker will stop operating. The system will then loop to stage 3 and re-read the DHT11 sensor.
6. If the humidity is in a state of hysteresis which is between the lower set point and the upper set point, the relay follows the last condition of the sensor reading. The system will loop to stage 3 and re-read the DHT11 sensor.

2.6 Design of Heavy Acquisition Algorithms

Designing a heavy acquisition system algorithm includes input to be processed, processing input data, and the final output. The flow chart of the work on the baby weight acquisition system is shown in Figure 6.

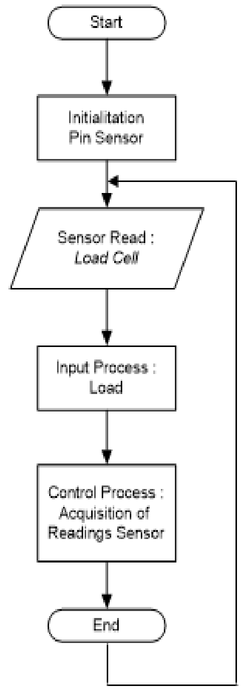


Figure 6: Heavy Acquisition System Flow Chart

The stages of the baby weight acquisition system flow diagram are described in the following explanation:

1. Initialize the load cell sensor pin.
2. The load cell sensor detects the weight of the load.
3. The weight reading results are displayed on the LCD.
4. The system will loop again after steps 1-3 have been completed.

3. RESULTS AND ANALYSIS

In this section, tests in this study included testing of heavy humidity and acquisition control systems in baby incubators.

3.1 DHT11 Sensor Test

Testing the DHT11 sensor is done by comparing the air humidity read by the sensor through a microcontroller with air humidity read by a digital thermohygrometer. The following is the result of measuring and reading the DHT11 sensor with a digital thermohygrometer. shown in Table 1.

Table 1: Common information sharing pathways used in the peri-urban dairy sub-value chain

No	Humidity (%RH)		|*Error*|	|%*Error*|
	Thermohygro Digital	DHT11		
1	34	34	0	0
2	42	39	1	2,4
3	46	44	2	4,3
4	52	52	0	0
5	60	58	2	3,3
Mean			1	2%

Based on Table 1, it can be seen that five times the data retrieval of DHT11 sensor reading with a digital thermohygrometer obtained humidity with an average error of 1 and an average error percentage of 2%. The biggest error was found in the 3rd and 5th tests which had an error of 2 and followed by the 2nd test which had an error of 1. In the 1st and 4th tests there was no error. The error can be caused by differences in sampling time and differences in sensor readings with the thermohygrometer and the effect of laying between DHT11 sensors and thermohygrometer. Based on the above tests it can be concluded that the sensor readings to detect the amount of air humidity can read changes according to changes that occur in the digital thermohygrometer. Based on Table 1 it can be graphed the relationship between the DHT11 sensor humidity data and a digital thermohygrometer. The graph can be seen in Figure 7.

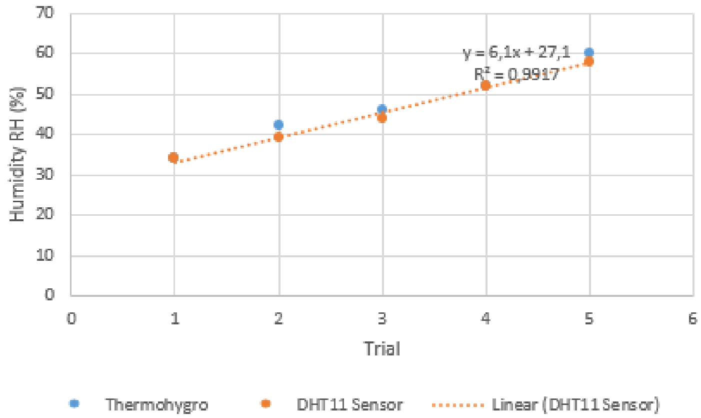


Figure 7: Comparison chart of DHT sensor humidity readings with thermohygro digital

Based on Figure 6, humidity reading between the DHT11 sensor and the digital thermohygrometer forms a linear curve with R2 of 0.9917, where R2 is a regression and can show the accuracy of the measurement tools made at 99.17%.

3.2 Load Cell Sensor Test

Testing of load cell sensors is done by looking at the relationship between sensor output voltage and mass. This test is conducted to determine the linearity of the system. The relationship of sensor load cell to mass is presented in Table 2.

Table 2: Relationship between mass and voltage

No	Mass (gram)	mV (voltage)
1	50 gram	0,10
2	100 gram	0,17
3	200 gram	0,26
4	500 gram	0,37
5	1000 gram	0,50

Based on Table 2, it can be seen that the heavier the load is given, the greater the output voltage. The detected load will be directly proportional to the sensor output voltage, this is due to a change in the resistance of the sensor so that when the weight increases, the voltage is also greater. Data from the test results of the heavy load cell sensor on the output voltage can be presented in the graph as shown in Figure 8.

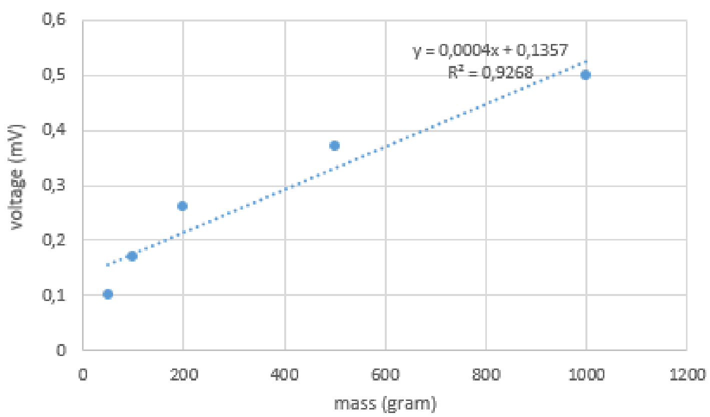


Figure 8: Graph of relation of mass to sensor load cell output voltage

Based on Figure 8, The relationship between mass and output voltage in the sensor load cell forms a linear curve with R2 of 0.9268 where R2 is a regression and can show the accuracy of the measurement tools made at 92.68%.

3.3 Testing and Analysis of Response of Humidity Control Systems

Tests are carried out in several ranges, namely the range 40% -50%, range 45% -55%, and range 50% -60%. The test results range 40% -50% can be seen in Figure 9, testing the range 45% -55% in Figure 10, and testing the range of 50% -60% in Figure 11.

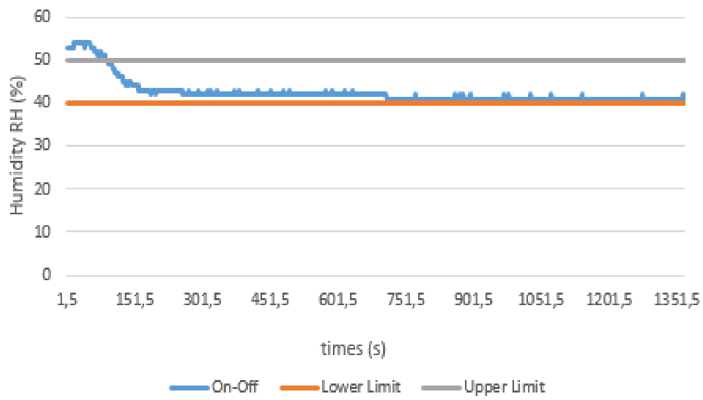


Figure 9: Testing the humidity control system range 40% -50%

Based on Figure 9 the tested range is 40% -50%. The initial moisture read by the DHT11 sensor is 53%. When the system starts controlling, the humidity rises to 54% then drops to 41%. However, moisture does not reach the set point under humidity.

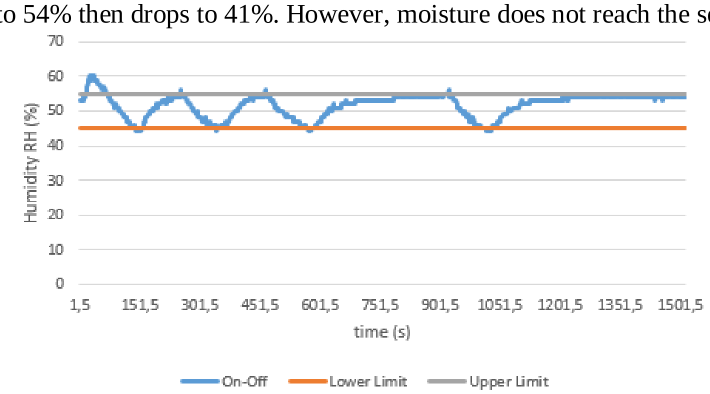
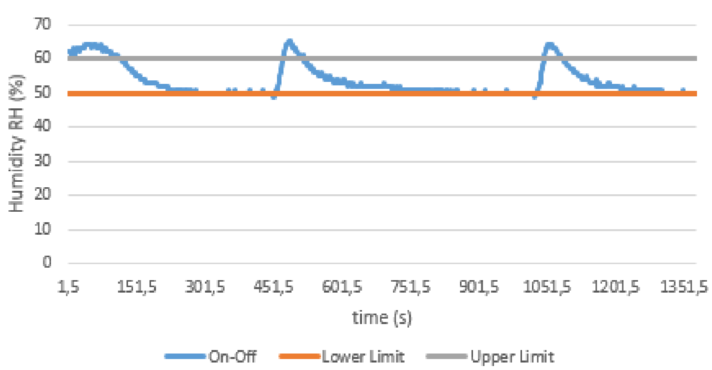


Figure 10: Testing the humidity control system range 45% -55%

Based on Figure 10 the range tested is 45% -55%. The initial humidity during testing is 53%. When the system is turned on, humidity increases up to 60% and then decreases. Humidity managed to drop until it passed the set point below 45%. When humidity is at 44%, the relay will automatically activate and turn on the ultrasonic mist maker to increase the amount of moisture. Humidity increased and reached a set point of 55% in the 4,175 minutes. At 56% humidity, the relay will act off and the ultrasonic mist maker will stop removing the mist.



Based on Figure 11 Tests are carried out in the range of 50% -60%. Humidity at the start of the test was 62%. When the system is turned on, humidity increases to reach 64% and then decreases. Humidity managed to fall to a set point below 50%. When the humidity is at 49%, the relay will turn on and turn on the ultrasonic mist maker to add moisture. When the humidity has reached the upper set point of 60%, the moisture does not immediately go down but experiences overshoot of up to 65%.

3.4 Heavy Acquisition System Testing

This test is done by comparing the weight of the load measured by the sensor with the weight of a fixed load. Weight still uses 5 pieces of weights with varying load variations. The results of the mass comparison measured by the sensor load cell with a fixed mass mass can be seen in Table 3.

Table 3: Soil Humidity Sensor Test Results

No	Load Weight Readable Sensor (gram)	Fixed Weight (gram)	*Error*	*Error (%)*
1	49	50	1	0,02
2	98	100	2	0,02
3	200	200	0	0
4	503	500	3	0,006
5	1004	1000	4	0,004
Mean			1	0,01

From the test results it can be seen that the load has a weight with a small average error rate of 0.01%. The error rate is caused by an offset voltage (noise voltage) and noise when measuring.

4. CONCLUSION

Based on the results of humidity testing with a set point of 40% -50%, set point 45% -55%, and set point 50% -60%, then the most ideal condition and can maintain a stable humidity is humidity in the range of 45% -55% . At 40% -50% humidity, humidity cannot reach the bottom set point. At 50% -60% humidity, humidity can reach the bottom set point and upper set point, but after reaching the set point the humidity is overshooted. Humidity is 45% -55%, moisture reaches an ideal state and is able to maintain moisture without overshoot. The humidity control besides the on off method can be tried using other control methods such as PID, Fuzzy, and so on.

Load cell sensors that are used to detect baby weight can be used. This can be explained by testing that has been carried out using 5 pieces of weights. The weight of 50 gram weights can be read by a 49 gram sensor. The weight of a 100 gram weighing scale, read by a 98 gram sensor. Weight 200 grams, read by a 200 gram sensor. Weight of 500 grams, read by a 503 sensor. The weight of a 1000 gram weighing scale, read by a 1004 gram sensor.

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