Design thermohygrometer based on internet of things in clinical laboratory

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ABSTRACT

Clinical laboratory units must meet safety requirements such as temperature stability and room humidity because the materials and substances used are sensitive to changes in temperature and environmental conditions, so it is important to carry out routine monitoring. The purpose of this research is to design an internet of things (IoT)-based thermohygrometer that can make it easier for users to monitor temperature and humidity even though the user is outside the laboratory. This tool can also store the results of temperature and humidity measurements making it easier for the user to monitor changes in temperature and humidity that occur. The method used is descriptive exploratory with a prototype system, namely the system development process, users and the required data and results obtained through a tool that has been designed. The results of research conducted using an IoT-based thermohygrometer prototype after statistical testing, there was no significant difference between the reference thermohygrometer and the IoT-based thermohygrometer prototype and the readings from the thinkspeak web. For temperature and humidity measurements that have been carried out at the X clinical laboratory in Denpasar, it still does not meet the standards.

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1. INTRODUCTION

Measurement of air temperature and humidity is one of the important measurements to be carried out in the laboratory unit. Changes in temperature and humidity must be monitored regularly, recorded and documented in accordance with the safety requirements of the laboratory unit. According to the regulation of the minister of health of the Republic of Indonesia number 7 of 2019 concerning hospital environmental health the temperature allowed in the laboratory is 20-22 °C and the humidity allowed is 40-60% relative humidity (RH) [1]. So far, temperature and humidity checks in the X Denpasar clinical laboratory are carried out manually and operators who carry out the checks have to go in and out of the laboratory to retrieve temperature and humidity data three times a day so that these conditions can affect the values of temperature and humidity measurements and laboratory staff have difficulty monitoring temperature. and humidity in real time [2].

Previous research by Abubeker and Baskar [3], regarding an internet-based monitoring system of things on machine learning strategy for internet of things. This research focused on creating an internet-based monitoring system of things that allows checking temperature in real time. The device used is the MAX30102 and MLX90614 for measuring temperature. However, this study only reached the appearance of blood glucose and body temperature. The develop hardware use support vector machines (SVM) and K-nearest neighbors (KNN) algorithm and deployed in raspberry Pi 4B.

Based on this device this research designed measuring instruments that are capable of measuring, recording and documenting measurement results automatically without the intervention of officers and officers not having to come to the laboratory just to measure temperature and humidity. The existence of a monitoring, notification and warning maintenance system is expected to be able to overcome the problems that occur in the clinical laboratory unit X Denpasar. This tool is designed to help measure temperature and humidity, namely a thermohygrometer designed with the addition of the internet of things (IoT) [4]–[9]. IoT is a concept where we can exchange various sources of information, interact with objects around us through an internet connection that can be controlled remotely [10]–[13]. With the integration of the DHT22 sensor connected to the ESP8266 module. ESP8266 is a chip that has an internet connection that can interact with hardware and software, functions to read input/output and process data [14], [15]. When DHT22 detects temperature and humidity in the clinical laboratory room, ESP8266 will send temperature and humidity data to thingspeak.com to see the results of temperature and humidity monitoring data [14], [16], [17]. This makes it easier for users to know the temperature and humidity in the clinical laboratory room in real time and provides a time and effort efficiency effect and this tool also has an alarm feature as a reminder to carry out maintenance warnings on the device itself as well as an alarm when the laboratory room temperature exceeds a threshold value allowed.

2. METHOD

This study uses an exploratory descriptive method. Descriptive research only analyzes to the level of description, namely analyzing and presenting data systemically, so that it can be more easily understood and concluded, while exploratory research is a type of research that aims to find something new. Exploratory descriptive research aims to describe the state of a phenomenon, in this study it is not intended to test certain hypotheses but only describes what a variable, symptom or situation is [18].

The object of this research is an IoT-based thermohygrometer. The method of observation is to directly measure temperature and humidity using the tool by observing using observation guidelines. In this research, the measurement results in the form of temperature and humidity on the IoT-based thermohygrometer prototype and the readings on the think speak web will be compared with the temperature and humidity on the reference thermohygrometer. In this research using several tools, such as multimeter, solder, pliers, cutter and screwdriver. Multimeters are used to measure currents and voltages when making tools [19]. Solder is used to solder electronic components in making tools. Pliers, cutters and screwdrivers are used as tools in making tools.

Several materials are used for the manufacture of tools, such as NodeMCU, DHT22 sensor, thin-film-translator (TFT) screen, adapter, buzzer, and other electronic components. NodeMCU is a microcontroller component used in the manufacture of tools [4], [20]–[26]. The DHT22 sensor is used to read temperature and humidity [27]. The TFT screen is used to display the reading results. Adapter is used to convert AC voltage to DC. Buzzer is an alarm that will sound as a sign that there is a shortage/excess of temperature and humidity, besides that this buzzer also functions as a reminder for maintenance every 30 days. Liquid crystal display (LCD) and other electronic components as additives used in the manufacture of tools. In addition to the TFT screen, the reading of the temperature and humidity results on this tool can also be accessed via the thinkspeak web. The data that can be seen is in the form of numbers and graphs of changes in temperature and humidity readings. In addition, from this website the reading results can also be downloaded according to user needs.

The assembly of the equipment was carried out in June 2022 and the data collection time at the Denpasar X clinical laboratory was taken in September-October 2022. The data from the temperature and humidity test results from the prototype tool and the thinkspeak web are compared with the temperature and humidity from the manufacturer’s tool. Data analysis in this study used the Wilcoxon test.

3. RESULTS AND DISCUSSION

Making this tool using NodeMCU as a microcontroller. This microcontroller helps so that the results of temperature and humidity readings are not only seen from the screen on the device, but can be monitored via the thinkspeak web and the readings displayed on the web are in the form of numbers and graphic. This tool is added with a buzzer as a marker of temperature/humidity that is over the limit and this tool is also given a maintenance warning that will run every 30 days, so that on the web there will be no excess data. Figures 1-5 are the tools that have been designed and the results on the thinkspeak web.

The components used to make this tool are simple, but are expected to work optimally. The components used to compose this tool are NodeMCU, DHT22 sensor, TFT screen, active buzzer, stepdown module, battery, battery indicator, on/off switch, diode, and adapter. The circuit schematic of these components can be seen in Figure 6.

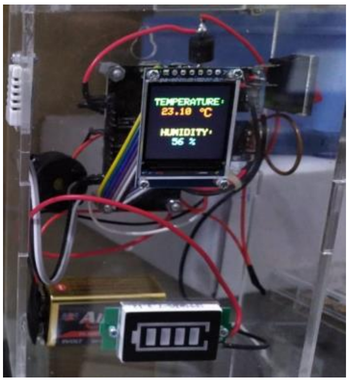

Figure 1. IoT based thermohygrometer telemetry tool

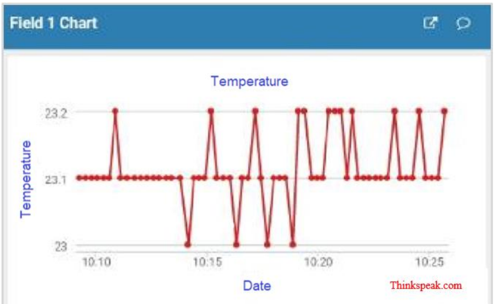

Figure 2. Temperature chart

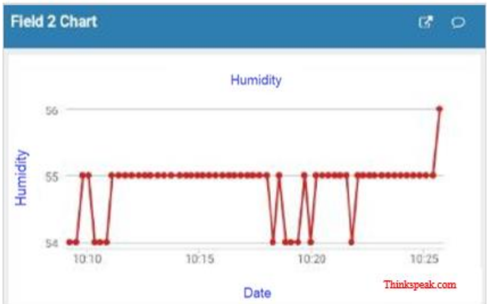

Figure 3. Humidity chart

Figure 4. Temperature result

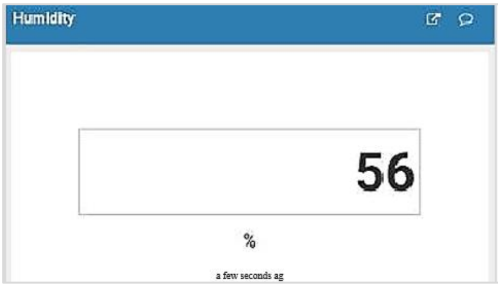

Figure 5. Humidity result

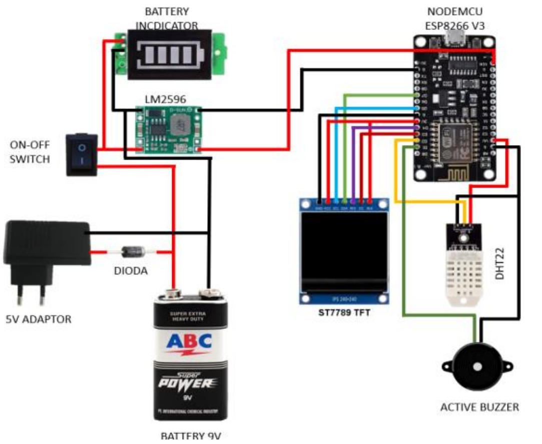

Figure 6. Wiring diagram of IoT based thermohygrometer

This tool has two sources, the first is electricity from State Electricity Company (PLN). When the tool is connected to PLN electricity which is connected to the adapter, the adapter will convert the AC current to DC. Then forwarded to the switch, in this state the battery becomes a backup so that when the power goes out the tool will still be able to live. Second, when the switch is turned on, the 9 v battery serves as a backup power source for the tool and this battery is also added with a battery indicator so it will not run out of power. The switch will connect the power source to the 5 v stepdown module. Then stepdown will lower the voltage to 5 v and send it to all components. The NodeMCU will initialize the DHT22, TFT display, and WiFi. The NodeMCU will connect to the destination WiFi service set identifier (SSID). Then the TFT screen will display the connection status with WiFi. Furthermore, DHT22 will read the temperature and humidity around the room. Then sent to the NodeMCU for processing. The NodeMCU will also send data to thingspeak for further display on the thinkspeak web dashboard. When the data sent by DHT 22 has a temperature value of ≤20 °C and ≥22 °C, the TFT screen will display the status of the temperature rising or falling and the buzzer will sound, then if the humidity is ≤40% and ≥60% then the TFT screen will display the status of the humidity rising or falling. and the buzzer will sound. Figure 7 are block diagrams of an IoT-based thermohygrometer.

This tool was tested at the X clinical laboratory in Denpasar and compared with an analog thermometer. This test was carried out for 1 month, from September 16, 2022-October 14, 2022. Table 1 is the result of measuring analog thermohygrometers, IoT-based thermohygrometers and thinkspeak web at clinical laboratory X in Denpasar.

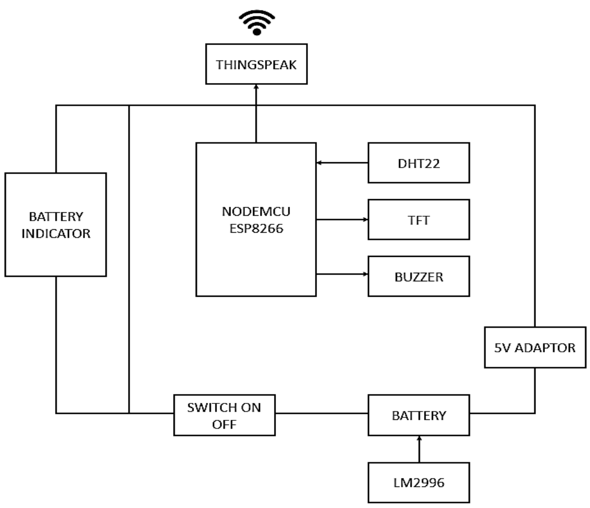

Figure 7. Block diagram of IoT based thermohygrometer

Table 1. Measurement result at the Denpasar X clinic laboratory

No.	Date	Thermohygrometer		IoT thermohygrometer prototype		Thinkspeak web	
		Temperature (°C)	Humidity (%)	Temperature (°C)	Humidity (%)	Temperature (°C)	Humidity (%)
1	16-9-2022	23	57	22.2	60	23.4	60
2	19-9-2022	23	57	23.4	58	23.5	58
3	20-9-2022	24	66	23.6	64	23.1	66
4	21-9-2022	25	59	24.5	59	24.9	58
5	22-9-2022	23	58	23.7	57	23.2	57
6	23-9-2022	23	58	23.3	53	22.9	60
7	26-9-2022	23	59	23.1	59	23.1	55
8	27-9-2022	23	59	23.1	56	23.2	56
9	28-9-2022	23	60	23.1	56	23.1	59
10	29-9-2022	23	57	23.4	58	23.4	56
11	30-9-2022	23	57	23.4	50	23.4	55
12	3-10-2022	23	57	23.7	56	22.7	55
13	4-10-2022	24	57	24.1	58	23.2	56
14	6-10-2022	23	57	23.5	58	23.5	58
15	7-10-2022	22	58	22.2	57	22.2	57
16	10-10-2022	24	58	23.6	56	23.9	56
17	11-10-2022	23	59	23.5	60	23.5	59
18	12-10-2022	23	56	23.9	57	23.2	58
19	13-10-2022	23	57	24.2	58	23.1	57
20	14-10-2022	24	60	23.7	58	23.6	58

From the test, then a statistical test was carried out starting with a descriptive test to get an idea of the size of the concentration and distribution of each variable, namely temperature and humidity. At the minimum value temperature variable on the thermohygrometer, the prototype thermohygrometer IoT and the web thinkspeak is 22 °C. While the maximum temperature value on the thermohygrometer is 25 °C, while the prototype IoT thermohygrometer is 24.5 °C and on the thinkspeak web it is 24.9 °C. The average temperature value on the thermohygrometer is 23.25 °C, while the prototype IoT thermohygrometer is 23.46 °C and on the thinkspeak web is 23.305 °C.

Figure 8 is a garph shows the results of temperature measurements for 20 days in the clinical laboratory. The square legend shows the results of temperature measurements on the reference thermohygrometer used in clinical laboratories [1]. The triangle legend shows the results of temperature measurements on the IoT thermohygrometer prototype and the round legend shows the results of temperature measurements on the thinkspeak web. Referring to the regulation of the minister of health regarding temperature regulations in laboratories that are allowed, the temperature in clinical laboratories still does not meet these regulations. It can be seen from the measurement results that there are still many temperature measurements above 22 °C.

Figure 9 is a graph shows the results of measuring humidity for 20 days in the clinical laboratory. In measuring humidity, it was found that the value exceeded the regulatory limit by 66% RH on the thermohygrometer, 64% RH on the prototype of the IoT design tool and 66% RH on the thinkspeak web. The square legend shows the results of humidity measurements on a reference thermohygrometer used in a clinical laboratory. The triangle legend shows the results of humidity measurements on the IoT thermohygrometer prototype and the round legend shows the results of humidity measurements on the thinkspeak web.

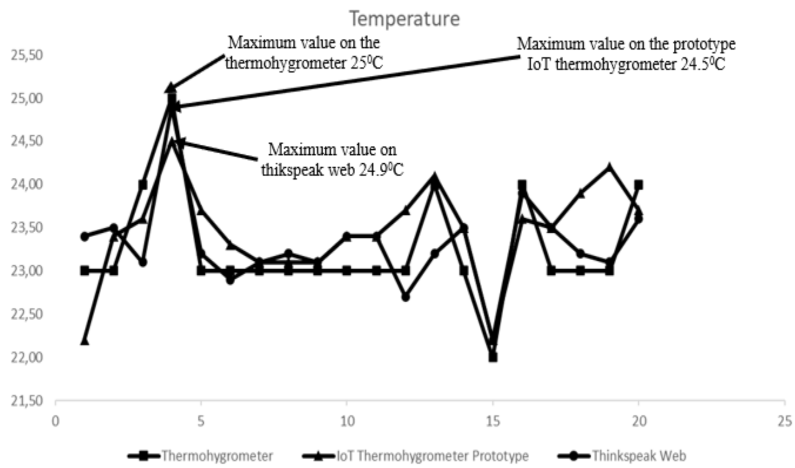

Figure 8. Temperature chart between thermohygrometer: IoT thermohygrometer and thinkspeak web

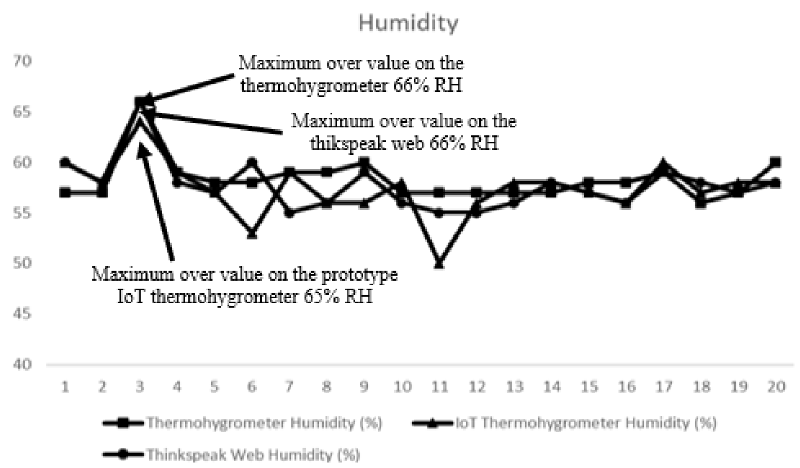

Figure 9. Humidity chart between thermohygrometer, IoT thermohygrometer and thinkspeak web

Humidity in the laboratory room does not meet the requirements allowed by the minister of health regulations regarding humidity regulations in the laboratory that are allowed [1]. This can be seen from the results of measurements in the clinical laboratory when testing took place, on the 20^{th} it passed the threshold value then proceed with descriptive testing. Table 2 shows the results of the descriptive test.

Table 2. Description test result

Variable	Minimum	Maximum	Average	Deviation standard
Thermohygrometer temperature	22.0 °C	25.0 °C	23.25 °C	0.63867
Thermohygrometer humidity	56.0%	66.0%	58.3%	2.12999
Temperature IoT thermohygrometer prototype	22.2 °C	24.5 °C	23.46 °C	0.56419
Humidity IoT thermohygrometer prototype	50.0%	64.0%	57.4%	2.77963
Temperature thinkspeak web	22.2 °C	24.9 °C	23.305 °C	0.51756
Humidity thinkspeak web	55.0%	66.0%	57.7%	2.49420

Inferential testing to see the difference in temperature and humidity of each tool is preceded by an assumption test, namely, normality test to see the distribution of data in each variable. Based on the test results obtained results where the normal distribution appears at the temperature of the IoT thermohygrometer prototype of 0.112 (>0,05). While the other variables are not normally distributed, so that the analysis of differences uses a non-parametric test, namely the Wilcoxon test. Table 3 shows the results of the normality test.

Table 3. Normality test result

Variable	Statistic	df	Sig.
Temperature thermohygrometer	0.727	20	0.000
Humidity thermohygrometer	0.706	20	0.000
Temperature IoT thermohygrometer prototype	0.923	20	0.112
Humidity IoT thermohygrometer prototype	0.903	20	0.047
Temperature thinkspeak web	0.867	20	0.010
Humidity thinkspeak web	0.816	20	0.002

Based on the results on Table 4 of the Wilcoxon test, the following results were obtained: i) the temperature of the IoT thermohygometer prototype with a reference device shows no significant difference with the sig value of 0.082 (>0.05). This means that the average temperature on the IoT thermohygrometer prototype with a thermohygrometer is not significantly different; ii) the temperature on the thinkspeak web with the reference tool shows no significant difference with the sig value of 0.245 (>0.05). This means that the average temperature on the thinkspeak web with a thermohygrometer is not significantly different; iii) the humidity of the IoT thermohygometer prototype with the reference device shows no significant difference with the sig value of 0.149 (>0.05). This means that the average humidity in the IoT thermohygrometer prototype and the thermohygrometer is not significantly different; and iv) the humidity on the thinkspeak web with the reference tool shows that there is no significant difference with the value of sig. of 0.163 (>0.05). This means that the average humidity on the thinkspeak web with a thermohygrometer is not significantly different.

Table 4. Wilcoxon test result

Parameter	Temperature IoT thermohygrometer prototype-temperature thermohygrometer	Temperature thinkspeak web-temperature thermohygrometer	Humidity IOT thermohygrometer prototype-humidity thermohygrometer	Humidity thinkspeak web-humidity thermohygrometer
Z	-1.741^{b}	-1.163^{b}	-1.445^{c}	-1.396^{c}
Asymp. Sig. (2-tailed)	0.082	0.245	0.149	0.163

4. CONCLUSION

The conclusions obtained from the research that has been carried out are: the prototype IoT-based thermohygrometer telemetry tool is designed using NodeMCU as the main component and this tool uses DC power as a source. This tool also has a buzzer as an alarm if the temperature or humidity of the laboratory room is not appropriate and as a reminder for maintenance on the tool or memory on the thinkspeak web. From the results of testing at the Denpasar X clinical laboratory, the temperature and humidity still exceed the standard limits allowed by the regulation of the minister of health.

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