ISSN 2355-3286

Sensor Design for Building Environment Monitoring System based on Blynk

Fahmy Rinanda Saputri[1], Sekar Fattima Dhaneswari[2]
[1,2] Department of Engineering Physics, Universitas Multimedia Nusantara, Tangerang, Indonesia
[1] fahmy.rinanda@umn.ac.id, [2] sekar.dhaneswari@student.umn.ac.id

Accepted on 10 June 2022
Approved on 06 July 2022

***Abstract*— A green building is a building wherein planning, construction, operation until the maintenance reduces the negative impacts, such as efficient use of energy, water, and other resources, maintaining the excellent quality of the building, and considering the quality of life of occupants. Good environmental damage in the building will affect the health, comfort and, safety of the occupants' lives. Therefore, it takes green buildings concept for buildings where people do activities in a home, an office, a school, a hospital, or a community center. To implement the green building concept, the building needs a monitoring system to monitor the quality of its environment. This research aim is to design sensor systems to monitor the building environment. The parameters monitored are temperature, humidity, illuminance, and noise intensity. The sensor system needs to the integrated with microcontroller and Blynk applications. The sensor system obtains the environment parameter. The accuracy rating for the temperature sensor is 94.41%, the humidity sensor is 93.53%, the light sensor is 91.26%, and the sound sensor is 97.13%. Blynk's warning system can make it easier for users to monitor the environment of a building.**

***Index Terms*— Blynk; green building; humidity sensor; light sensor; microcontroller; monitoring system; sensor system; sound sensor; temperature sensor.**

I. INTRODUCTION

A green building is a building wherein planning, construction, operation until the maintenance reduces the negative impacts, such as efficient use of energy, water, and other resources, maintaining the excellent quality of the building, and considering the quality of life of occupants. Good environmental damage in the building will affect the health, comfort and, safety of the occupants' lives. Currently, green building is a requirement for sustainable development. Not only applied to office buildings, but the green building also applied in campus buildings, hotels, department stores, even houses.

Green Building Council Indonesia (GBCI) has issued GREENSHIP Interior Space Version 1.0. This standard contains appropriate site development (ASD), Energy Efficiency and Conservation (EEC), Water Conservation (WAC), Material Resource and Cycle (MRC), Indoor Health and Comfort (IHC) and, Building Environment Management (BEM) criteria [1]. To meet these criteria standards, especially IHC 5, 6, and 7 and, to improve the comfort of occupants, a building environment monitoring system is needed to monitor the condition of the building and its environment.

In this paper, the sensor system able to monitor the environment parameters, such as temperature, humidity, illuminance, and noise intensity. The comfort standard for these parameters is regulated in the Standar Nasional Indonesia (SNI). Thermal comfort is regulated in SNI 03-6572-2001 [2]. The standard shows that optimal comfort in tropical areas is 22,8°C – 25.8°C. For tropical areas, relative air humidity is recommended between 40% - 50%, but for rooms where the number of people is dense such as meeting rooms, relative humidity is still allowed ranging from 55% - 60%. Based on SNI 03-6197-2000, the recommended average lighting level is set based on the room's function, for example, for kitchens in residential houses of 250 Lux, office workspaces of 350 Lux, and classrooms in educational institutions are 250 Lux [3]. In terms of noise intensity, SNI 16-7063-2004, which regulates noise control, said that the noise intensity is 88 dB(A) for the exposure time of 4 hours per day [4].

In general, buildings in Indonesia are complex buildings because there are various rooms by their functions. In this case, monitoring of environmental parameters in the building is required. In addition, it needs technology that can monitor these parameters at all times. It can solve these problems by designing a building environment monitoring system. With this system, the values of each parameter can be monitored in real-time so that occupants can know the information provided by the system. Occupants can also compare it with comfort standards according to SNI.

Vanessa Lee and Fahmy Rinanda S. researched about the design of monitoring system for laboratory. They can monitor the condition of illumination using LDR sensor and microcontroller in laboratory through the website in real-time using Blogger and an Internet of Things (IoT) platform [5]. Bimo et al. researched the design of sensor systems using Arduino Uno boards. Data acquisition testing is conducted separately for each sensor. The method compares the results of the data taken by the sensors and their respective measuring instruments under different conditions. So it is known the measurement error [6]. Research from M. Dwisnanto Putro et al. used LDR sensors for light intensity readings in various rooms in a house. However, the results had varying degrees of accuracy ranging from 70.6% to 99.6% after comparison with a luxmeter [7]. In addition, Wanto uses AT89S52 microcontrollers from ATMEL as a data processing system. This microcontroller has 8-bit input/output terminals, 8 KB flash memory, 256 BYTES OF RAM [8] [9]. Meanwhile, Ahmed H. H. Imam uses NodeMCU as a controller where the control has been equipped esp8266 as a communication module with a WIFI internet connection. No longer needed components of communication module devices separately [10].

In this study, a microcontroller is using the WeMos D1 Mini. The sensors used are the DHT22 sensor for temperature and humidity, the BH1750 sensor for the lighting level, and the KY-038 sensor for noise intensity. These sensors will be used as a medium to monitor environmental parameters that want to know their value at all times. The sensors used will record the data obtained. It also will give notify on the device used as a monitoring tool of the parameters above. If in a condition where the data obtained by the sensor exceeds the standard set, then there will be a warning through a notification on the phone using the Blynk application. After knowing the environmental conditions in a building, it will be information for the occupants.

II. Green Building Theory

Green Building is a practice in the series of green buildings, which create structures from a building and use environmentally responsible processes and use efficient material sources throughout the building creation cycle. From placement to design, construction, operation, maintenance, renovation, and deconstruction. This practice expands and reduces design issues classic buildings in terms of economy, utility, durability, and comfort [11].

Green buildings are designed to reduce the overall impact from the environment of a building to human health and the environment in three ways, namely:

- Use electrical energy and water efficiently,
- maintain the health of building users and improve the work performance of employees,
- reduce waste disposal, pollution, and environmental degradation.

III. Tools And Materials For Research

A sensor is a tool that receives a stimulus and responds with an electrical signal. Stimulus is the quantity, properties, or conditions received and converted to electrical signals. There are two types of sensors, active sensors, and passive sensors. Active sensors require an additional source of energy to work. Passive sensors do not require additional energy sources to work and directly emit electrical signals to respond to stimuli. The input and output relationships can be represented by a mathematical equation, the transfer function. Under ideal conditions, the transfer function is stable both graphically, in value, and equations. In general, the transfer function can be written as follows [12]:

$$y = a + bx \tag{1}$$

The value a is intercepting, and b is sensor sensitivity. Not all transfer functions are linear, but they can also be polynomial, logarithmic, or exponential. Sensors have several characteristics, namely sensitivity, span, accuracy, threshold, nonlinearity, saturation, resolution, saturation, repeatability.

A. *Temperature Sensor*

A temperature sensor is a component that can convert the amount of heat into an electric magnitude so that it can detect the symptoms of temperature changes in a particular object. The temperature sensor measures the amount of heat/cold energy produced by an object, allowing us to know or detect the symptoms of these temperature changes in the form of analog and digital outputs. There are four types of temperature sensors: thermocouple, thermistor, Resistant Temperature Detector (RTD), and temperature sensor IC.

A DHT22 sensor is a sensor that can provide input of temperature and humidity data from a surrounding environment. The DHT22 sensor outputs a calibrated digital signal. These sensors use digital signal collection and technology to sense moisture to ensure the stability and reliability of DHT22 sensors. For its sensing element used to sense input from the outside environment connected with a single chip of an 8-bit computer [13].

B. *Humidity Sensor*

Humidity sensors are electronic components used to assist in the measurement of moisture contained in the air. Types of humidity sensors include a capacitive sensor, electrical conductivity sensor, thermal conductivity sensor, optical hygrometer, and oscillating hygrometer. A moisture sensor uses a capacitive sensor. In this sensor, a dielectric between capacitor plates is made of hygroscopic material that can absorb water molecules. The constant of dielectric material varies according to the amount of moist vapor absorbed. It will convert the capacitance that can be measured and converted into a relative moisture value.

C. Light Sensor

A light sensor is an electronic component that can provide changes in electrical magnitude when receiving and sensing changes in light intensity in the environment. Components include light sensors, namely LDR, photovoltaic, photoconductive, photodiode, phototransistor, and optocoupler.

The BH1750 sensor is a sensor for measuring the value of ambient light. This sensor allows detecting a wide range with high resolution (1-65535 Lux). The BH1750 sensor uses an I²C interface, has a response that approaches the human eye, can convert illumination to digital signals, and uses only a tiny amount of power [14] [15].

D. Sound Sensor

Sound sensors are electronic components that can change the size of the sound becomes the amount of electricity. The sound sensor works based on the magnitude/small force of the sound wave that hits the sensor membrane causing the sensor membrane to move up and down. Behind this membrane is a small coil that flows magnetic waves due to the movement of the sensor membrane. The speed of motion of the coil affects the strength/weakness of the electric waves it generates .

The sound that disturbs human activity is called noise. So KY-038 sensor will measure the noise in this research. The KY-038 sensor is the microphone sensor used for the Arduino. The sensor has three main components on its circuit board. The first component is a sensor located in front of the module to measure the physical state of the environment and transmit data in the form of analog signals to the second component, the amplifier. The amplifier serves to amplify the analog signal by the potentiometer that has been determined from the beginning. The third component is a comparator that turns off the LED if the signal obtained is below the specified value [16].

E. Sound Sensor

MCU (Microcontroller Unit) is an electronic component or IC (Integrated Circuit) with computer-like properties, such as centralized processing units, memory codes, memory data, and ports for input/output. Microcontrollers have a small shape and are relatively cheap so that they can be integrated into various parts. Microcontrollers are programmed through software programs that can write, read, and delete content from microcontrollers [17].

The WeMos D1 Mini is a board based on an open-source electronic microcontroller whose main component is an ESP-8266EX micro-8266EX chip. Microcontroller can be programmed using a computer. The chip has a function to embed the microcontroller program to read the input, then the input will be processed, and after processing, the input will produce output. In WeMos D1 Mini, there is already a wireless network module, so it no longer requires additional wireless network module components [18].

F. Blynk

Blynk is Internet of Things (IoT) platform that allows user to build the apps to control certain devices over the internet. It provides dashboard by which user can create graphic interface using different widgets. It also displays and stores the data from the sensor. Blynk provides libraries for hardware platforms like Arduino, ESP8266, Raspberry Pi, SparkFun, WeMos D1 Mini, etc. There are three main components in the Blynk, app, server, and libraries. The app is used to create the interface. The server is for communication between app and hardware. Then, libraries enable for hardware communications with the server using commands [19].

IV. Working Of The System

The sensor systems consist of the DHT22 sensor, BH1750 sensor, KY-038 sensor, WeMos D1 Mini, mobile phone and, Blynk. Fig. 1 is the block diagram of the building environment monitoring system.

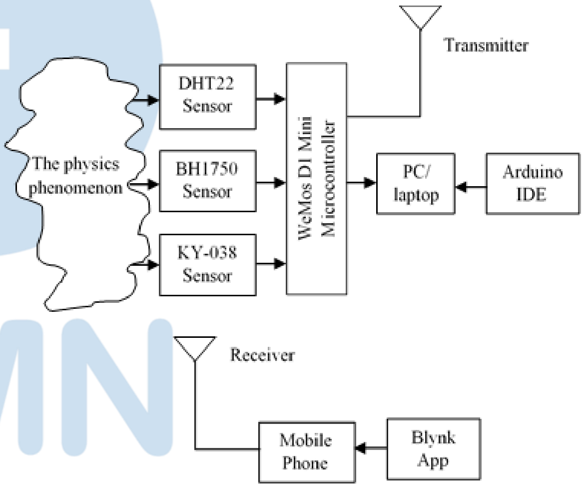

Fig. 1. Block diagram of building environment monitoring system

The sensors will sense the environment parameters. A DHT22 sensor is a sensor that can provide input of temperature and humidity data from a surrounding environment. The BH1750 sensor is a sensor for measuring the value of ambient light. Then, the KY-038 sensor is the microphone sensor used for this microcontroller. The WeMos D1 Mini is a board based on an open-source electronic microcontroller whose main component is an ESP-8266EX micro-8266EX chip. It will process the data from the sensor. The process need the program in Arduino IDE. Then, the output will be displayed on serial monitor Arduino IDE and also on mobile phone with the Blynk applications. Some notifications also can be set, so the alarm will work on if the value of parameters is trimmer and more than standards. The standards also can be set to allow the SNI.

Fig. 2 displays the system flowcharts. Start with set parameters, in this research, is temperature, humidity, illuminance, and sound intensity. This parameter would be input for the sensors. If the value match with the range of standard, this value will be displayed in Blynk applications. However, if the data do not match the standard range, Blynk will alarm and notify the user, so the user will know if the environment does not appropriate the standard.

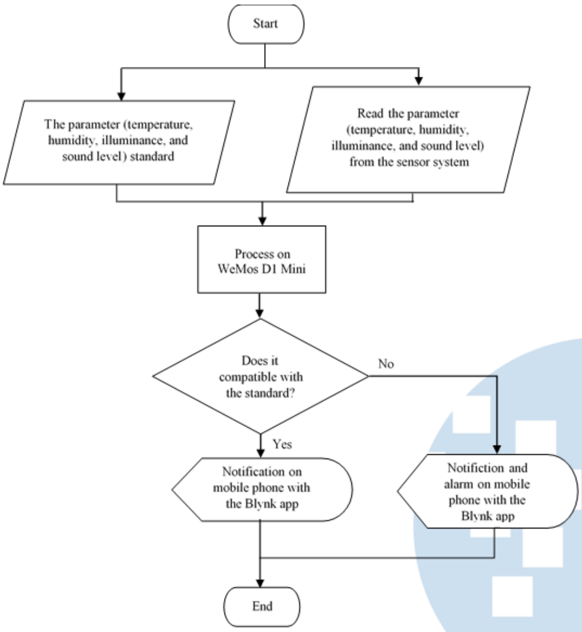

Fig. 2. Building environment monitoring system flowchart

For the entire sensor system consisting of a DHT22 sensor, the BH1750, and ky-038 sensors, will all be connected to the WeMos D1 Mini. Here is Fig. 3, which shows the complete hardware of the sensor system consisting of KY-038 sensor (number 1), DHT22 sensor (number 2), BH1750 sensor (number 3), and WeMos D1 Mini (number 4).

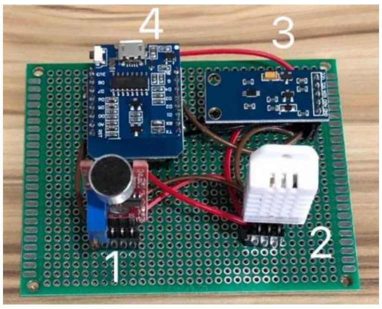

Fig. 3. System wiring

In using this sensor system, these steps must be taken:

1. Place the sensor system by working in a stable state and away from the noise.
2. Add input voltage to turn on the system.
3. The light indicator will turn on if it is connected to the voltage source.
4. Open the Blynk app on the mobile phone and make sure it has a stable internet connection.
5. Then press the start sign, and the program will run.
6. If the device is already connected via Wi-Fi, it will appear as 'Connected' on the Blynk app.
7. Data from the sensor will be displayed in this application located on the mobile phone.

Before this system is implemented in a building, it will be compared with the Environment Meter DT-8820 as a calibrator. There are thirty data of the temperature and humidity, illuminance, and sound intensity. The accuracy, precision, and error are analyzed based on the data.

Measurement system is applied in this research to obtain the accuracy, precision, and error calculation based on the temperature, humidity, illuminance and noise data measurement. There are thirty measurement data for each variable. The data is taken every two seconds real-time. Fig. 4, 5, 6, and 7 show the real-time data of temperature, humidity, illuminance, and noise level. This graph shows a comparison of data from sensor systems and Environment Meter. Based on the that data, the accuracy, precision, and error can be calculated.

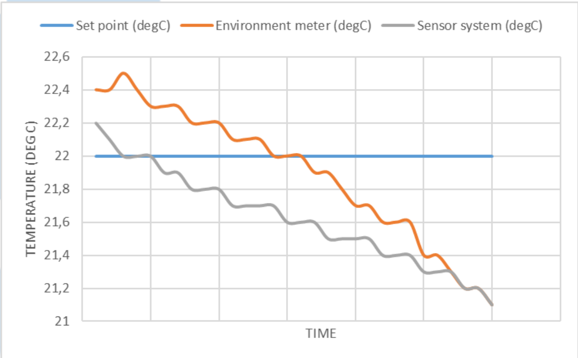

Fig. 4. Graph of temperature measurement

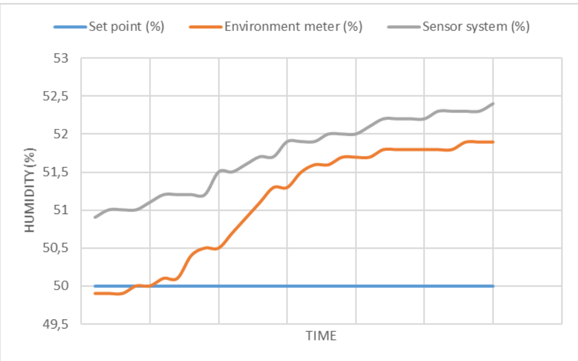

Fig. 5. Graph of humidity measurement

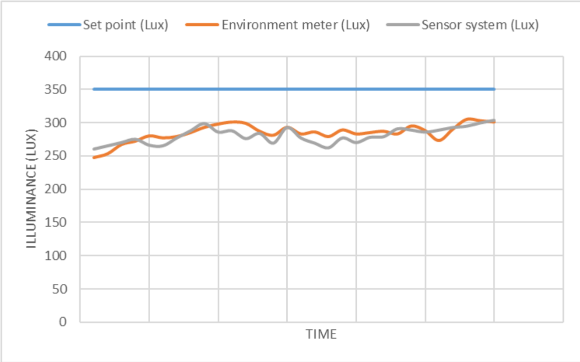

Fig. 6. Graph of illuminance measurement

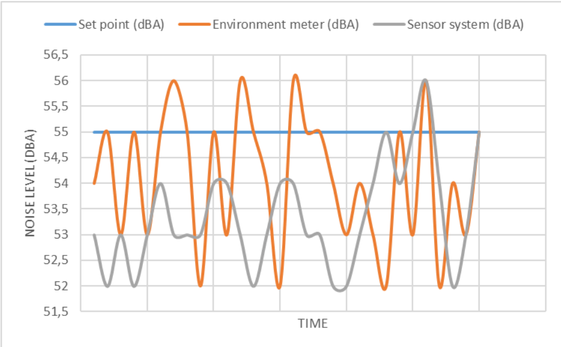

Fig. 7. Graph of the noise level measurement

Table 1. results from the accuracy, precision, and error calculation based on the temperature data measurement. When compared to the results, it is obtained that the accuracy and precision of the sensor system in measuring the temperature is higher compared to the environment meter measuring instrument. So the error is also more minor compared to the environment meter. The results are that the accuracy rating for the temperature sensor is 94.41%. The precision and error of the sensor system are 96.06% and 5.59%. It shows in the Table 1.

TABLE I. ACCURACY, PRECISION, AND ERROR CALCULATION RESULTS IN TEMPERATURE MEASUREMENT

Accuracy (%)		Precision (%)		Error (%)	
Environment M.	**Sensor System**	**Environment M.**	**Sensor System**	**Environment M.**	**Sensor System**
93.91	94.41	94.37	96.06	6.09	5.59

Then, the result of the calculation on humidity data measurement shows in Table 2. The sensor system has a higher accuracy and precision value but lower error when compared to the environment meter. Accuracy, precision, and error of humidity sensor is 93.53%, 97.12%, and 6.47%.

TABLE II. ACCURACY, PRECISION, AND ERROR CALCULATION RESULTS IN HUMIDITY MEASUREMENT

Accuracy (%)		Precision (%)		Error (%)	
Environment M.	**Sensor System**	**Environment M.**	**Sensor System**	**Environment M.**	**Sensor System**
93.21	93.53	95.51	97.12	6.79	6.47

Also in Table 3 is for the result of illuminance measurement using light sensor. Environment meters are capable of measuring illumination with higher accuracy and precision than sensor systems. The light sensor obtained 91.26% in accuracy, 84.49% in precision, and 8.74% in error.

TABLE III. ACCURACY, PRECISION, AND ERROR CALCULATION RESULTS IN ILLUMINANCE MEASUREMENT

Accuracy (%)		Precision (%)		Error (%)	
Environment M.	**Sensor System**	**Environment M.**	**Sensor System**	**Environment M.**	**Sensor System**
93.32	91.26	84.50	84.49	6.68	8.74

Based on Table 4, in measuring noise intensity, the sensor system has a higher precision level than the environment meter. However, the accuracy level is lower than the environment meter, so the error is higher than the environment meter. The sound sensor obtains 97.13% in accuracy, 94.08% in precision, and 2.87% in error.

TABLE IV. ACCURACY, PRECISION, AND ERROR CALCULATION RESULTS IN NOISE MEASUREMENT

Accuracy (%)		Precision (%)		Error (%)	
Environment M.	**Sensor System**	**Environment M.**	**Sensor System**	**Environment M.**	**Sensor System**
94.08	97.13	92.04	94.08	5.92	2.87

Many things that affect the sensor system obtain a level of accuracy, poor precision compared to the environment meter, such as systematic errors and even random errors. The error can be minimized for further research related.

After the accuracy is obtained, the data will be transmitted over WiFi (Wireless Fidelity) via the ESP8266 module on the WeMos D1 Mini port. Fig. 4 shows the interfaces of Blynk that are already connected with the system sensor and the interface of alarm and notification if the data do not compatible with the standard range that has been set.

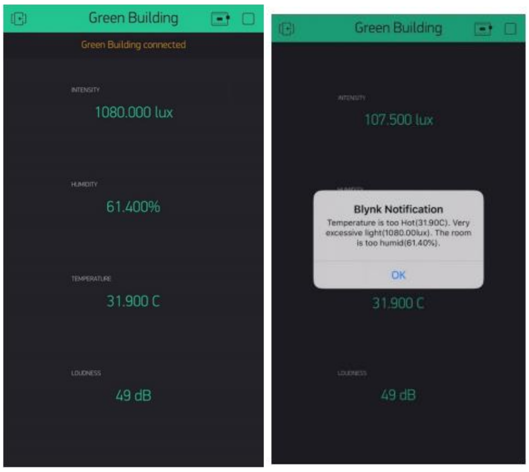

Fig. 8. Screen display of Blynk app on mobile phone and the notification

V. Conclusion

This research has designed the sensor system for building an environment monitoring system. The sensor system obtains the environment parameter. The accuracy rating for the temperature sensor is 94.41%, the humidity sensor is 93.53%, the light sensor is 91.26%, and the sound sensor is 97.13%. Blynk's warning system can make it easier for users to monitor the environment of a building. The parameter information which is sensed by the sensor system can be displayed on mobile phones using the Blynk application. In addition, Blynk's warning system can make it easier for users to monitor the environment of a building.

Acknowledgment

The authors would like to thanks Universitas Multimedia for supporting the facilities for research. So this research can complete well.

References

[1] G. B. C. Indonesia, Greenship Interior Space Version 1.0, Jakarta: Green Building Council Indonesia, 2012.

[2] B. S. Nasional, SNI 03-6572-2001 Tata Cara Perencanaan Sistem Ventilasi dan Pengkondisian Udara pada Bangunan Gedung, Jakarta: BSN, 2001.

[3] B. S. Nasional, SNI 03-6197-2000 Konservasi Energi pada Sistem Pencahayaan, Jakarta: BSN, 2000.

[4] B. S. Nasional, SNI 16-7063-2004 Nilai Ambang Batas Iklim Kerja (Panas), Kebisingan, Getaran Lengan-Lengan dan Radiasi Sinar Ultra Ungu di Tempat Kerja, Jakarta: BSN, 2004.

[5] V. Lee and F. R. Saputri, "Website-Based Lighting Monitoring System Design in a Laboratory of Universitas Multimedia Nusantara," in 2021 2nd International Conference On Smart Cities, Automation & Intelligent Computing Systems (ICON-SONICS), Tangerang, 2021.

[6] B. A. Pamungkas, A. F. Rochim and E. D. Widianto, "Perancangan Jaringan Sensor Terdistribusi untuk Pengaturan Suhu, Kelembaban, dan Intensitas Cahaya," Jurnal Teknologi dan Sistem Komputer, vol. I, no. 2, pp. 42-48, 2013.

[7] M. D. Putro and F. D. Kambey, "Sistem Pengaturan Pencahayaan Ruangan Berbasis Android pada Rumah Pintar," Jurnal Nasional Teknik Elektro, vol. 5, no. 3, p. 297–307, 2016.

[8] Wanto and P. S. Priambodo, "Rancang Bangun Pengukur Intensitas Cahaya Tampak Berbasis Mikrokontroler," Universitas Indonesia Library, Depok, 2008.

[9] A. Corporation, 8-bit Microcontroller with 8K Bytes In-System Programmable Flash AT89S52, Atmel, 2001.

[10] A. H. H. Imam, "A Simple Smart Home Based on IoT Using NodeMCU and Blynk," UMS Library, Surakarta, 2019.

[11] U. G. B. Council, LEED Reference Guide for Green Building Design and Construction with Global ACPs, Washington DC: U.S. Green Building Council, 2009.

[12] J. Fraden, Handbook of Modern Sensors: Physics, Designs, and Applications Fourth Edition, San Diego: Springer, 2010.

[13] T. Liu, "Aosong Electronics Co.,Ltd," [Online]. Available: https://www.sparkfun.com/datasheets/Sensors/Temperature/DHT22.pdf. [Accessed 10 June 2022].

[14] M. Rawashdeh, "Instructables Circuits," [Online]. Available: https://www.instructables.com/BH1750-Digital-Light-Sensor/. [Accessed 10 June 2022].

[15] L. ROHM Co., "BH1721FVC Digital 16bit Serial Output Type Ambient Light Sensor IC," ROHM. Co.,Ltd., 2015. [Online]. Available: https://fscdn.rohm.com/en/products/databook/datasheet/ic/sensor/light/bh1721fvc_spec-e.pdf. [Accessed 10 June 2022].

[16] ElectroPeak, "How to Use KY-037 Sound Detection Sensor with Arduino," 2019. [Online]. Available: https://create.arduino.cc/projecthub/electropeak/how-to-use-ky-037-sound-detection-sensor-with-arduino-a757a7. [Accessed 10 June 2022].

[17] Yudhaniristo, "Prototipe Alat Monitoring Radioaktivitas Lingkungan, Cuaca dan Kualitas Udara Secara Online dan Periodik Berbasis Arduino (Studi Kasus: BATAN Puspitek Serpong)," Universitas Islam Negeri Syarif Hidayatullah, Jakarta, 2014.

[18] R. Thiara, "Design and Implementation of IoT based Remote Monitoring System at Electrical Engineering Laboratory in President University," President University, Cikarang, 2019.

[19] H. Durani, M. Sheth, M. Vaghasia and S. Kotech, "Smart Automated Home Application using IoT with Blynk App," in 2018 Second International Conference on Inventive Communication and Computational Technologies (ICICCT), Coimbatore, 2018.