Smart Room Design As A Concrete Step Towards A Sustainable Smart Campus At The Institut Teknologi Sumatera

Sabhan Kanata[1], Sabar[2], Amrina Mustaqim[3], Gde KM Atmajaya[4], M. Rizky Hikmatullah[5], Muhammad Asrofi[6], Asmar[7]

[1,4,6]Electrical Engineering, Institute of Teknologi Sumatera, Lampung Selatan, 35365, Indonesia
[2]Instrumentation and Automation Engineering, Institute of Teknologi Sumatera, Lampung Selatan, 35365, Indonesia
[3]Physics Engineering, Institute of Teknologi Sumatera, Lampung Selatan, 35365, Indonesia
[5]Telecommunications Engineering, Institute of Teknologi Sumatera, Lampung Selatan, 35365, Indonesia
[7]Electrical Engineering, Bangka Belitung University, Bangka Belitung, 33172, Indonesia

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ABSTRACT

Institut Teknologi Sumatera (ITERA) is one of the new PTN campuses in Indonesia. As a campus that carries the smart-campus motto, ITERA will continue to create smart services, including saving electrical energy. One of the programs to support a sustainable campus is innovation in electrical energy management so that electrical energy efficiency can be maximized. The ITERA smart-room product called SMARTERA is one of the campus's tangible manifestations to control electrical equipment using Internet-based intelligent control of Things (IoT). The initial stage in this research is automatic control of the two most widely used electrical equipment in the campus environment, namely lights and air conditioning (AC).

Corresponding Author:

Sabhan Kanata
Electrical Engineering, Institut Teknologi Sumatera, Lampung Selatan, 35363, Indonesia
Email: sabhan.kanata@el.itera.ac.id

1. INTRODUCTION

The rapid development of digital technology has greatly helped people to get limitless services. This also happens in universities as a become of science and technology. Smart campus programs must be pushed forward so that the campus can become a pioneer in a smart technology-based environment. Currently, awareness of the utilization of energy-saving technology has not been widely applied in managing energy usage in campus environments in Indonesia [1]. Automation processes to manage frequently used electrical equipment are often considered unimportant. If this unawareness is left to continue, then the campus as a green energy pioneer can only be a symbol.

Digital technologies have been an immense boon to the educational realm, with multiple applications designed to enhance the teaching and learning experience from preschool to university levels [2]. The latest advancements in intelligent control and communication systems have brought about a situation where heterogeneous devices can form an integrated network. The integration of short-range cellular transceivers into everyday objects has enabled new forms of communication between objects and between people and objects. A concept where an object can send data over a network without the assistance of a computer device or a human is called the Internet of Things (IoT) [3].

Universities provide great opportunities to apply various smart solutions as they are considered to have a complex ecosystem. Universities have an openness to do experiments as they have multidisciplinary expertise, scientific knowledge, and innovative developments. Moreover, Universities are considered small-scale cities for the usage of smart technologies such as smart transportation, smart

buildings, smart parking, and so on [4].

The application of a smart home or smart room can increase the efficiency of electricity usage due to the increased use of electricity networks and the pattern of users or humans in the use of this electricity network. The implementation of the smart home concept may involve using technologies such as the Internet of Things (IoT) platform, computing, control, visual presentation, and communication [5].

The Institute of Technology of Sumatera (ITERA) is a new university with a mission to empower the potential in the Sumatera region and Indonesia as well as the world through excellence in education, research, and community service in the field of science, technology, art, and humanities. Programs to support the campus slogan of a smart, friendly, and forrest campus need to be continuously supported to prepare human resources that are ready to compete nationally and internationally.

Smart Room is a real manifestation of ITERA Institute of Technology's initiative as Smart Green Campus. This is aimed at creating sustainable development in the ITERA campus environment. The utilization of technology and knowledge built is the automatic control of existing electrical equipment in a room within the campus environment based on IoT. This implementation is expected to help electricity saving on the campus.

2. RESEARCH METHOD

In this study, we used applied research where applied research is done with the aim of implementing, testing, and evaluating the ability of a theory to be applied in solving practical problems [5]. This research method has several stages, which are designing SMARTERA System Architecture, creating schematic diagrams, creating flowcharts, implementing the SMARTERA monitoring and automation prototype, and testing the system.

2.1. The ITERA Smart Room Architecture System

The ITERA Smart Room Architecture (SMARTERA) is a concept in automatic control of the two utilities as shown in Figure 1. The working principle of the SMARTERA layout is that the Relay and NodeMCU ESP8266 module will be supplied with voltage from the AC/DC power supply so that all equipment can work and function. PIR sensor can detect motion, especially coming from the man while in range (range) sensor, PIR sensor only responds to energy and passive IR rays possessed by each object detected by it [6]. PIR sensors work by capturing heat energy produced from passive infrared rays that are possessed by each object with an object temperature above 0 degrees celsius [7]. The PIR sensor will send information about the presence or absence of human movement then read by the NodeMCU ESP82766 and then send data to the server in TCP / IP format so that it can be displayed on the smartphone [8].

Likewise, the DHT11/22 sensor will send the temperature/humidity condition to the NodeMCU ESP8266 microcontroller. The DHT11 module works on serial communication and is single-wire communication. This module sends data in form of a pulse train of the specific period. Before sending data to Arduino, it needs some initialization command with a time delay. And the whole process time is about 4 ms [9]. Subsequently, the microcontroller will read both conditions and then send the data to the server in TCP/IP format so that it can be displayed on the smartphone.

Then, the microcontroller will read the commands sent to the server using TCP/IP format and then change to form a "high" and "low" logic, when the sensor is at a HIGH (1) level, digital data is sent from the DHT22 to the MCU, allowing it to process the data for display. Conversely, when the sensor is not active at a LOW (0) level, the digital data transmission is stopped and the MCU will not process it. The voltage connected to the 3.3V pin is linked to the VDD pin, whilst the GND pin is connected to the NodeMCU ESP8266 V3's GND pin. Then, the relay will be commanded to be on when it is of "high" logic and vice versa [10].
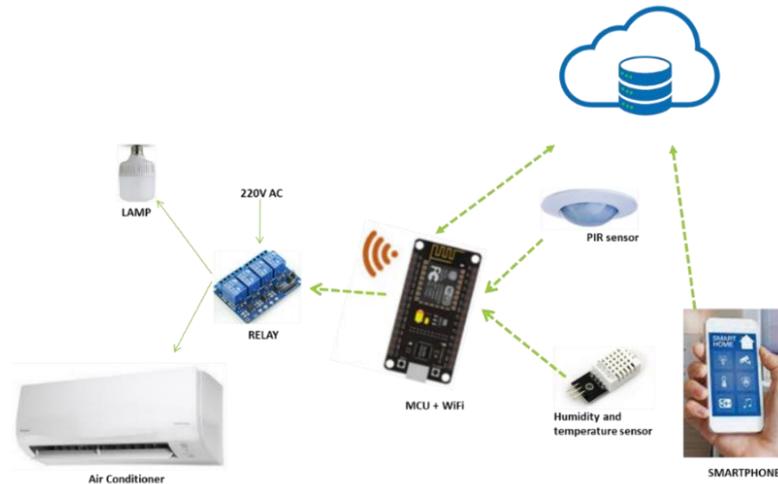
Figure 1. SMARTERA System Architecture

2.2. Schematic Diagram

The circuit design in Figure 2 illustrates the connectivity of the device to process and generate the desired output simultaneously. The researchers maximized the small space for the chosen microcontroller. With the compact circuit design, the device won't take up much space, making it easy to move. The circuit connection involves the Data OUT Pin of the PIR Sensor and DHT11 connected to the microcontroller with the ESP8266 pins. The LED has connected pins indicating the current status of the light as either ON or OFF. Each IN pin of the relay switch is connected to the pins marked D on the MCU. The Relay NO pin is connected to the electric equipment control cable while the COM pin is connected to the AC supply line. This design allows the components to work together following the desired functionality of the system as a whole. The final design itself can work in any kind of lighting set in any building. Furthermore, the researchers also designed a PCB as a realization form of the SMARTERA prototype to be installed in the ITERA General Lecture Building. The design of ITERA's PCB product is shown in Figure 2 below.
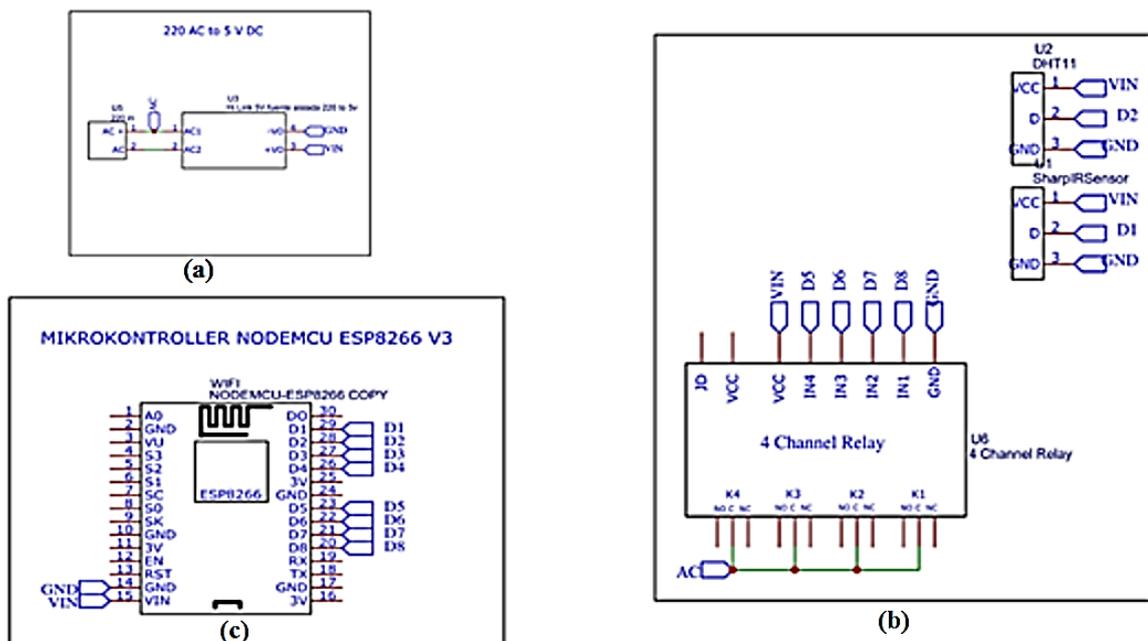

Figure 2. SMARTERA Schematic Diagram; (a) AC to DC Converter, (b) 4 Channel Relay, (c) NodeMCU ESP8266

Figure 2. (a) shows an AC to DC (Alternating Current to Direct Current) Converter which is an electronic device used to convert alternating current (AC) into direct current (DC) in the circuit. Then Figure 2. (b) shows 4 channels in which an electronic device is used to control a larger electrical load by using a small electrical signal. It has four channels or channels, each of which can control a separate electrical load. The last part figure 2. (c) explains NodeMCU ESP 8266 which is a microcontroller development board based on the ESP8266 chip. The ESP8266 is a system on a chip (SoC) integrated with a WiFi module that enables the use of wireless networks in electronics projects such as the smartera prototype.

| (a) | (b) |
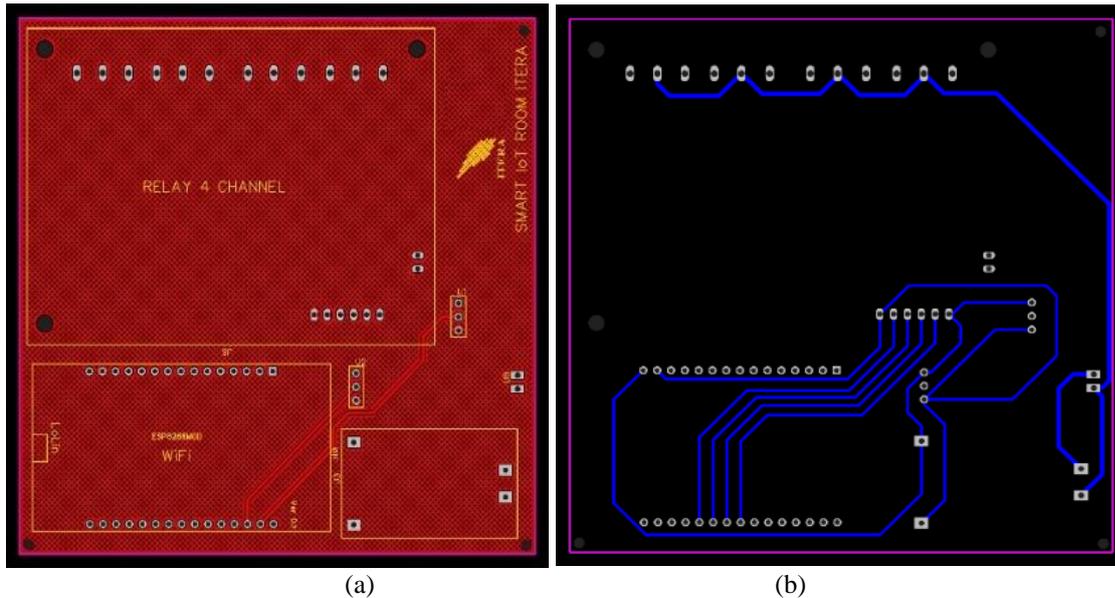
Figure 3. SMARTERA PCB Design: (a) Top view (red) (b) Bottom view (black)

Figure 3. (a) provides information about smartera PCB design from the top View and Figure 3. (b) explains PCB design from the bottom view.

2.3. Flowchart Design

The stages of this system are detailed in the flowchart diagram as shown in Figure 4 below. Figure 4 provides information about the logic of the system can be seen in the flowchart Figure 4. The system work starts when the equipment is turned on and then immediately initializes the air conditioner and lamp. In the next step, the system will control the temperature, and humidity and detect the presence of humans in the room. Furthermore, it works for the measurement target in the room. If there is a measurement error, the system will be calibrated to avoid larger errors.

The procedures carried out in this study were carried out in several stages, as follows: (1) Simulation of design outcomes. This step is to ensure the wiring process, sensors, and connections to the IoT are in line with the desired output, (2) Laboratory scale testing phase. At this stage, researchers will conduct experiments on the laboratory scale prototype to ensure the hardware device runs according to the simulation results, (3) Limited space testing phase. The prototype that has been tested in the laboratory will be tested in the field (small scale) to observe the response in a limited environment, (4) the multi-room scale testing phase. The prototype that has been tested in the laboratory will be tested in the field (multi-room scale) to observe the response in a wider environment.
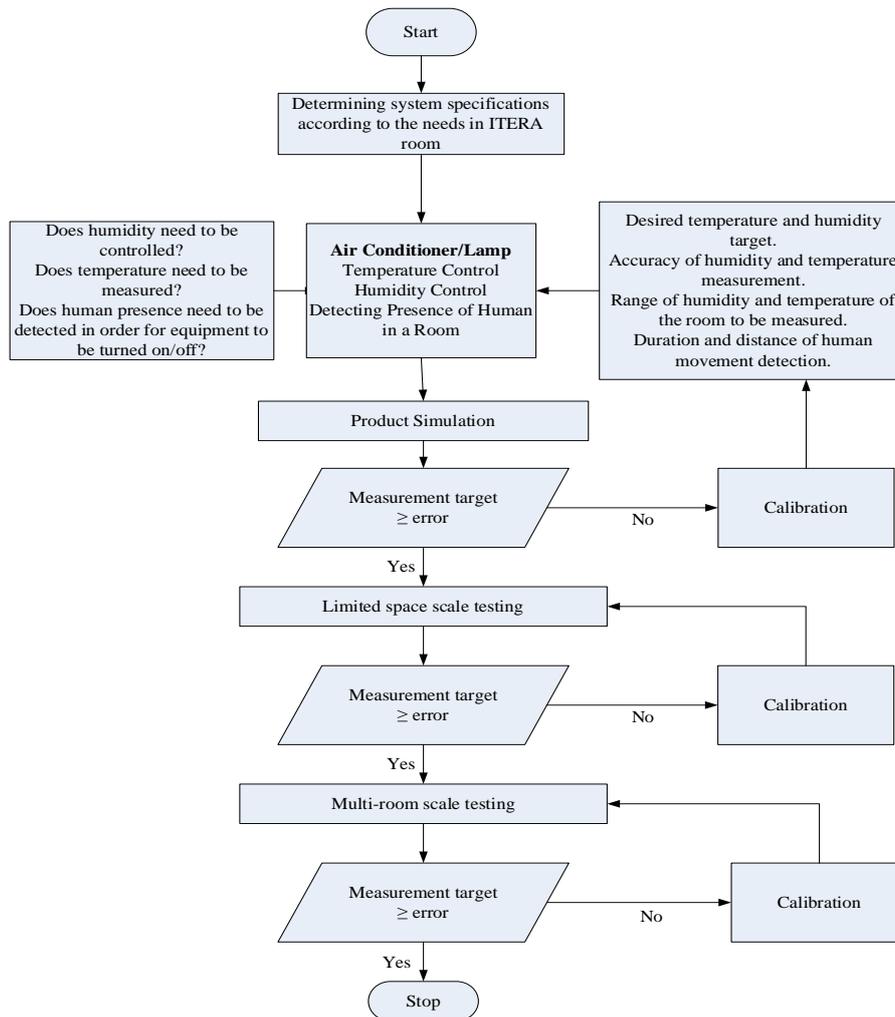
Figure 4. SMARTERA Flowchart Diagram

3. RESULTS AND DISCUSSION

3.1. Prototype Realization

The SMARTERA product of ITERA Smart Room is a tangible manifestation of campus for controlling electrical equipment using intelligent control-based Internet of Things (IoT) control. The initial stage of this research is automatic control of two most commonly used electrical appliances in the campus environment, namely lamps and air conditioning (AC). The researcher will conduct 3 test stages, namely laboratory scale, limited room scale, and multi-room scale. In the process of testing the three test stages, the researcher will validate the accuracy of the input parameters, process, and output.

The results of the product in the research produced the design of the SMARTERA Chasing Smart Room ITERA which will later be installed in the room to be tested. The picture of the product SMARTERA is shown in Figure 5 below.
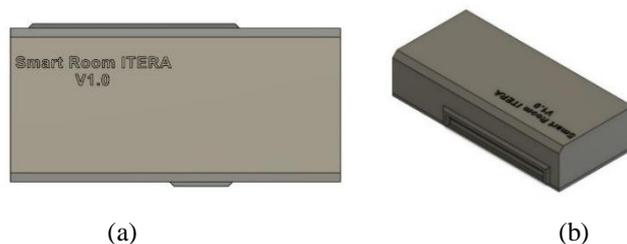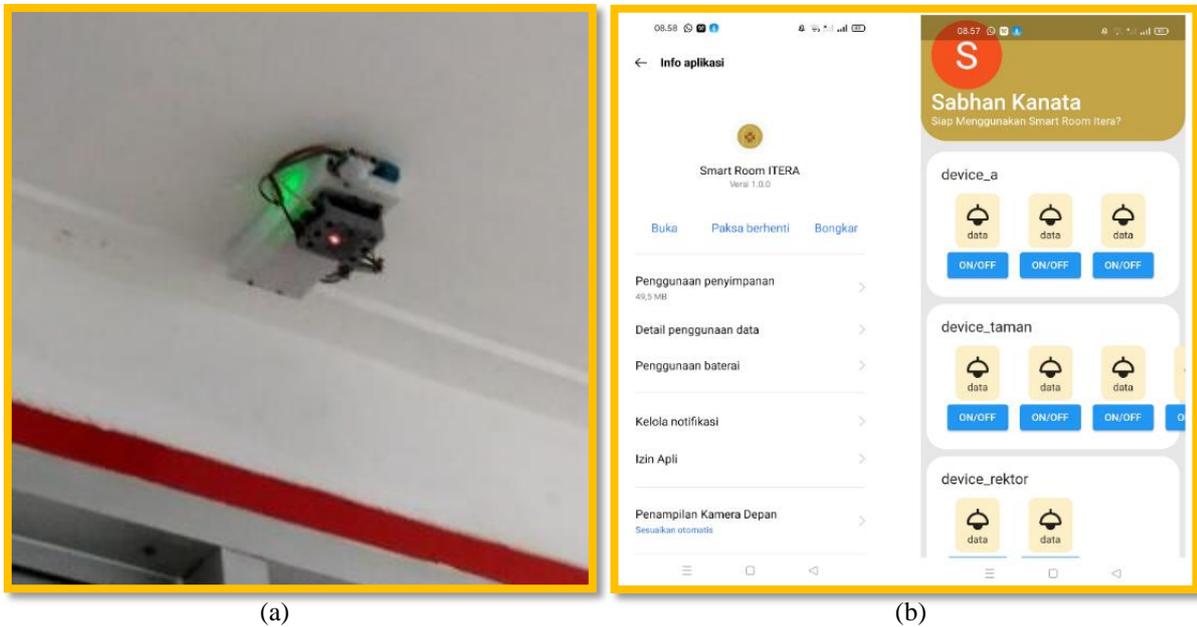

(a)   (b)

Figure 5. SMARTERA Casing of Products (a) Top view; (b) Bottom view

Figure 5 shows the design of easing Smart Room ITERA will be used as cover and protect the system. Figure 5 (a) is the view from the top and figure 5 (b) is the view from the bottom.

| (a) | (b) |

Figure 6. (a) Implementation of SMARTERA in the ITERA lecture room (b) Display of the SMARTERA Application from a smartphone

Figure 6 (a) provides information on the prototype which had been applied in the ITERA lecture room. The system has the function to control and regulate the usage of lights and AC automatically based on IoT in the room that will be tested. Figure 6 (b) describes the interface display via smartphone such as picture 6 (b). Then the function of SMARTERA provides information that the lecture room could be controlled and monitored with this SMARTERA application System. So, users can easily control the temperature and monitor the room from a remote location with the aim of efficiency of electrical energy.

3.2. System Testing

First, we test the system on the power supply device which serves as the resource provider for SMARTERA devices. Therefore, an electrical power supply is necessary to convert the current. Testing the power supply circuit serves to convert 220V AC voltage to DC voltage. The SMARTERA prototype is fitted with an IC specifically designed as a voltage regulator to deliver a stable 12-volt output voltage. The circuit is tested using a multimeter. The scale used to measure voltage is attained by connecting the VCC circuit with the positive cable. The test results are indicated in Table 1 below.

Table 1. Supply Testing

IC	Input PLN	Output (Vdc)
SMARTERA	220 Volt	11,54 volt

Next, sensor testing is carried out to find out the output voltage of the PIR sensor when it is in logic 1 and 0. This testing is also required to find out the output voltage value of the passive infrared (PIR) sensor when it detects human movement and when it does not detect human movement. The way to carry out this testing is for the sensor should get an input voltage of 5 Vdc. Then measure the input and output voltage of the sensor using a voltmeter. From Table 2, the PIR sensor testing was obtained.

Table 2. PIR Sensor Testing

No	Sensor	V_{in}	V_{out}	Logic
1	Motion detected	5,00	3,31	1
2	No Motion detected	5,00	0	0

The same was done to the DHT11/22 sensors to check their condition. To check the level of error, a comparison was done between the temperature readings and the room's standard thermomet [11,12]. The results of the experiment, done 5 times, are shown in table 3 below.

Table 3. Temperature Sensor Testing

No	Sensor DHT11 (^{0}C)	Thermometer (^{0}C)	Error (^{0}C)
1	23,5	24,5	1
2	24,8	25,5	0,7
3	25,3	26,3	1
4	25,7	26,5	0,8
5	25,9	26,6	0,7

The system testing includes verifying the PIR, temperature, and microcontroller along with its electronic devices running properly. The main purpose of this system testing is to ensure the components mounted on the device can run and function properly as well as the dashboard display. This sensor testing also aims to determine the good or bad settings of the infrared sensor sensitivity. This sensor is located above the room door and so on. The mechanism of system testing is illustrated in figure 8 below.

Figure 8. Testing the SMARTERA device system

After making sure that all components are in good condition, the overall system testing is conducted. We turn on the electrical switch of the room, then electricity provides voltage to the microcontroller and runs the program on the SMARTERA device that will be executed. The program runs the PIR and Temperature sensors to detect movement and room temperature. Microcontroller program to run the PIR sensor to detect the motion of objects passing by. As for the PIR sensor in the classroom, it has functions to turn on the lights. The relay will be active if the PIR sensor is given the motion when the lights will turn on simultaneously as an active SMARTERA system. When there is no movement in the classroom, the lights will be off. When an object enters the classroom, the sensor detects the movement of the object, and the SMARTERA device will re-initialize the program. The next step SMARTERA runs the program to turn on the lights. Furthermore, temperature of the sensors reaches the set points of the system setting, while the AC will turn on according to the program that has been set in the SMARTERA device.

4. CONCLUSION

This research has the purpose to create and test a control and monitoring system for room temperature, light as well as the presence of humans based on the Internet of Things using the NodeMCU ESP8266 microcontroller and the SMARTERA application. The core of the system made is based on detecting the room temperature threshold with a DHT11 sensor and identifying light and dark conditions and the system after that detects the presence of a human in a room. Then from these two conditions, the Node MCU as a processor will instruct the relay to turn on or turn off the AC and the light according to the conditions required. Furthermore, all parameters will be sent and displayed on the SMARTERA application in real time. This prototype system has worked well and can be further developed to include more controllable parameters for smart room and automation industry.

Acknowledgments

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