International Journal of Latest Engineering and Management Research (IJLEMR)
ISSN: 2455-4847
www.ijlemr.com || Volume 09 – Issue 03 || March 2024 || PP. 01-08

Development of Management System for Air Conditioning of Environments

Willian Marlon Ferreira[1], Gabriel Miranda Freitas[1],
Gustavo Rafael de Souza Reis[1]
[1]*Federal Institute of Minas Gerais, Brazil*

Abstract: This paper presents the development of air conditioning control without the need for modifications to the device. The traditional remote control of this equipment was replaced by programmable control through a personal computer interacting online with microcontrolled devices that receive data from the environment and send commands to the air conditioning unit. The user can maintain a given environment at a constant temperature, regardless of the number of people or heat sources in that environment. Another possibility for using these intelligent equipment is programming opening times or automatic shutdown when there are no people in the environment.
Keywords: Air conditioning devices, environments, microcontrolled devices, programmable control.

1. INTRODUCTION

In recent years, there has been exponential growth and advancements in computing technology. There has also been an increase in the use of these technologies, even among non-technical users. Similarly, there has been a growing trend toward ubiquitous computing that integrates seamlessly into the edge environment. [5].

The Internet has continually changed the way people interact with each other and, more recently, with the advent of the Internet of Things (IoT), it has also changed the way people interact with devices. The Internet of Things can be understood as the expansion of Internet services based on the interaction between people and devices and between devices. [4].

In all environments where there is electrical and electronic equipment, whether domestic, corporate or industrial, there is always misuse of such equipment, which results in unnecessary energy expenditure for the concessionaire and consumers. [3].The growing concern about energy efficiency leads us to research ways to optimize energy consumption in facilities, with the air conditioning system being an important part of this consumption. In addition to the efficiency brought by the project, the automation of the shutdown and management system of the air conditioning system seeks to resolve problems related to the use of air conditioning remote controls, devices that are lost and suffer constant breakdowns.

The system may also undergo future expansions, such as: automated control of the lighting system; addition of window and door sensors to prevent the use of air conditioning in non-ideal conditions; and, monitoring the energy consumption of load boards, enabling load shedding in order to avoid fines for excess demand, in addition to optimizing contracted demand.

2. CONTROL SYSTEM

The management system was implemented at the Federal Institute of Minas Gerais - Campus Ipatinga, Brazil, Minas Gerais.The system is composed of electronic modules based on the Internet of Things (IoT), therefore, the system was composed of a microcontrolled module capable of connecting to the campus' information technology (IT) architecture. The module connected to the network through wireless routers, therefore, the NodeMCU module, based on the ESP8266 microcontroller, was chosen as the development platform. In Fig. 1, the module is presented, while Fig. 2 shows its pinout. The NodeMCU module is a low-cost open platform for IoT, has integrated support for WIFI networks, reduced size, and low power consumption [1]. These characteristics make NodeMCU an interesting choice for this work.

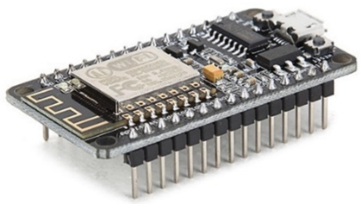

Figure 1. NodeMCU Module [2]

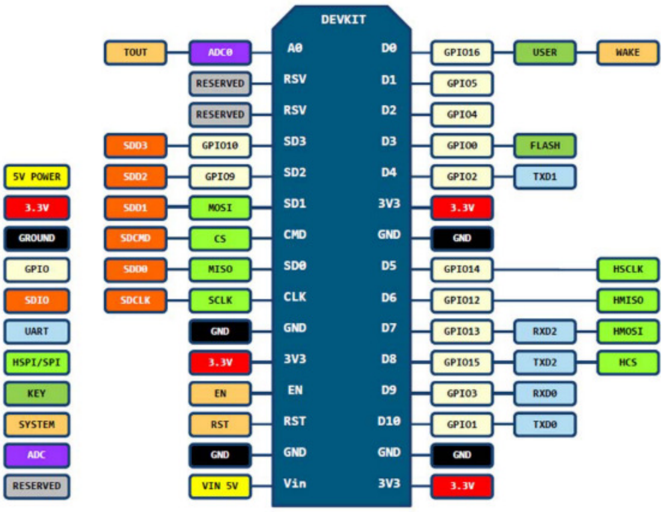

Figure 2. NodeMCU module pinout [2]

The module is available to be programmed using the IDE developed for Arduino, which facilitates and accelerates the development of IoT systems [2]. In addition to having the hardware requirements necessary for the system proposed in this work.

The proposed system is demonstrated in Fig. 3, and can be described through the following steps:

a) The NodeMCU module sends commands to the air conditioner via infrared signal. The commands are memorized in the NodeCMU module through a routine that records the commands used by the device's remote control;
b) The NodeMCU module performs the acquisition of the ambient temperature and humidity through the DHT 22 temperature sensor;
c) The NodeMCU module sends the temperature, humidity and status of the air conditioner to an MQTT Broker;
d) The MQTT Broker sends the received data for storage on an IoT platform on the internet;
e) System customers read temperature and humidity data through the IoT platform;
f) On the server where the MQTT Broker was installed, a client application makes it possible to change the temperature reference parameters, positioning of the air conditioning pallets and time slots in which the air conditioning system will be released for use;
g) An on/off button is positioned in the rooms so that users can control the air conditioning system.

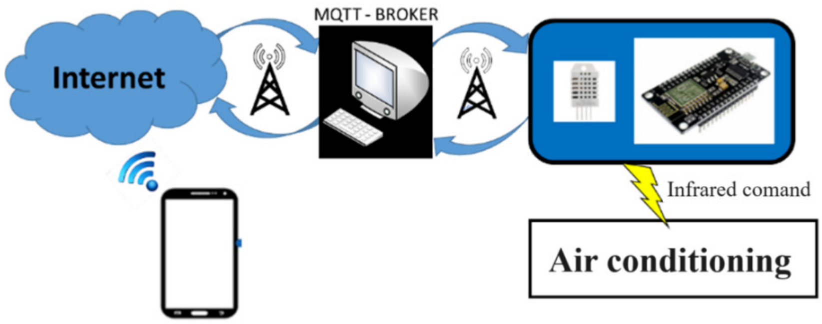

Figure 3. The proposed system

To enable the system to function, it was necessary to develop software embedded in the microcontroller, thus, the following software architecture was created:

1. Initialization:
2. Iterations: Infinite loop:
2.1. If button B1 (On/Off) is pressed;
2.1.1. Sends the command for the air conditioning to turn on;
2.1.2. If button B1 is pressed for 3 seconds, it sends the command to the air conditioning to turn off;
2.1.3. Function that sends the air conditioning condition to the MQTT broker;

2.2. Every 1 minute;

2.2.1. Reads the temperature and humidity of the room;
2.2.2. Sends temperature and humidity to the MQTT broker;
2.2.3. Requires updating air conditioning parameters: palette positioning and reference temperature; in addition to the time window settings in which the system is allowed to operate;
2.2.4. Synchronizes the microcontroller clock with the MQTT broker;

2.3. If the device remains on after the end of the set period, the system must turn off the device, this function aims at sustainable use of resources

3. RESULTS E DISCUSSION

The functions necessary for the system to function were defined, functions previously raised through the algorithm. The microcontroller system programming and hardware design necessary for a first bench test on a protoboard were carried out.

Next, reading and memorization tests for the remote control commands were carried out. In this step, all the necessary parameters to be read from the remote control were determined, in addition to saving these parameters in a non-volatile memory area of the microcontroller, the tests were carried out with the components mounted on a protoboard.

Tests were also carried out to send commands to the air conditioning unit. The functions responsible for sending commands to the air conditioning unit were tested.

Furthermore, communication tests were also carried out with the MQTT broker. At this stage, the necessary parameters to be exchanged with the MQTT broker were determined, in addition to their implementation and testing. The system demonstrated that it is capable of exchanging data with the server and feeding a database with temperature, humidity and system status data, in addition to receiving configuration files.

It was necessary to develop the system monitoring dashboard with receiving/sending data with the MQTT broker. This dashboard performed system monitoring and commands using the Node-RED development tool based on data flow for visual programming, allowing device control and monitoring through graphics and buttons.

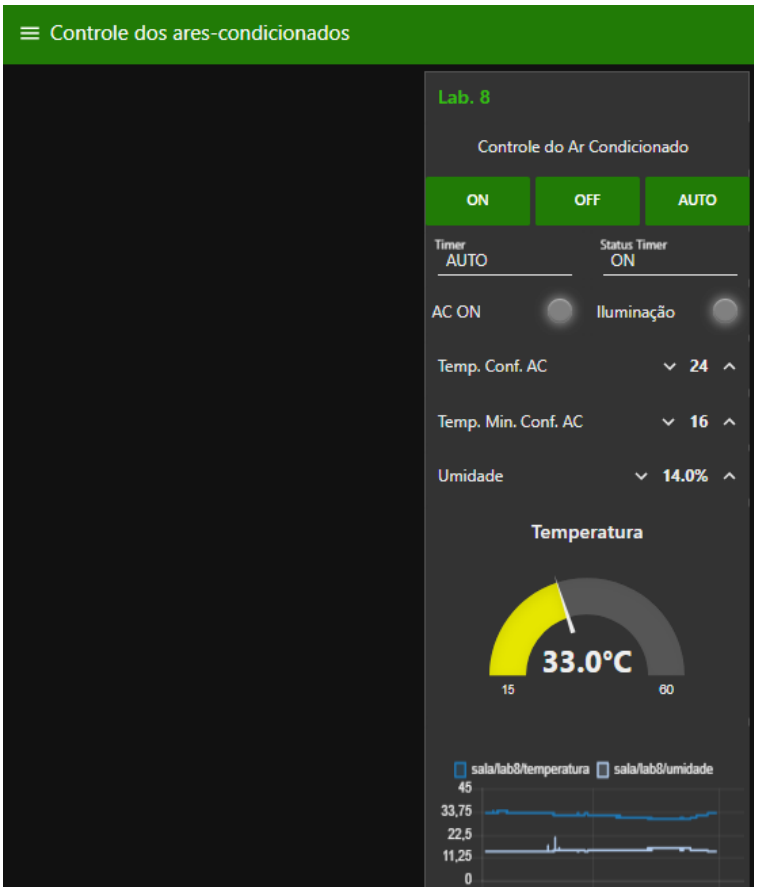

Figure 4. Monitoring and commands dashboard developed in Node-RED

After the system was assembled on a breadboard, and all tests were completed, the hardware design was carried out. The project consisted of mounting on a printed circuit board.

The power input consisted of a circuit that allowed external electrical power to be inserted onto the board that supplied electrical energy to the other circuits.

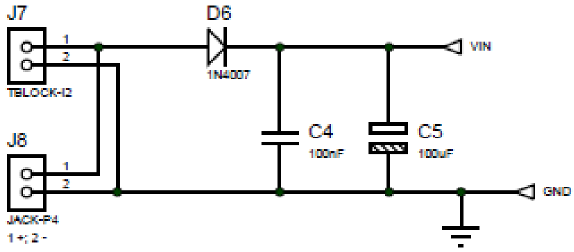

Figure 5. Power supply: 5V – 1A

The circuit to increase and/or decrease the operating temperature of the air conditioning unit consisted of digital inputs for increment and decrement that were connected externally to non-retaining buttons that were located in the classrooms. LED lights were used and sensors for doors and windows were also provided, which were not included in the initial project, but could be added in the future.

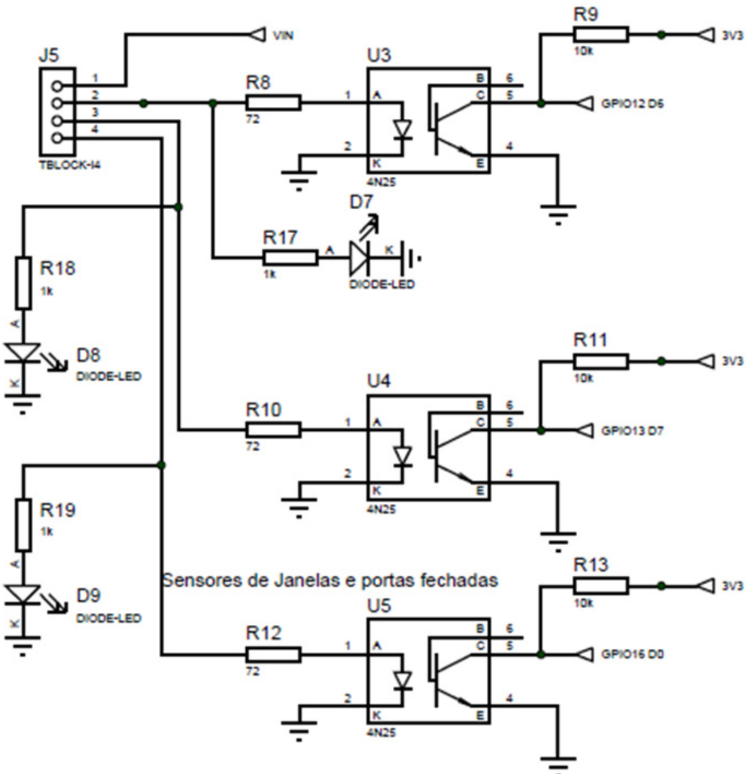

Figure 6. Temperature increase/decrement circuit

The sensor used to acquire temperature and humidity data is shown below, it is a model called “DHT 11” and it will be attached directly to the board.

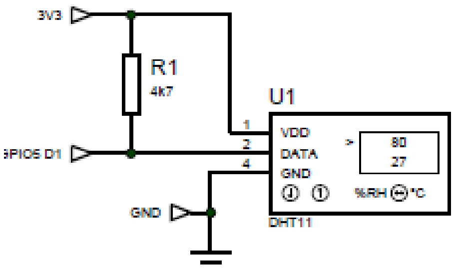

Figure 7. DHT 11 temperature and humidity sensor

The following circuit demonstrates the infrared receiver used to detect the activation signal carried out by the individual control of the air conditioning unit.

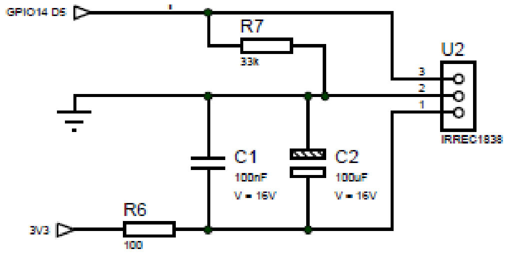

Figure 8. Infrared receiver

The circuit that transmitted the air conditioning activation code consisted of an infrared LED that sent the signal previously saved in the program.

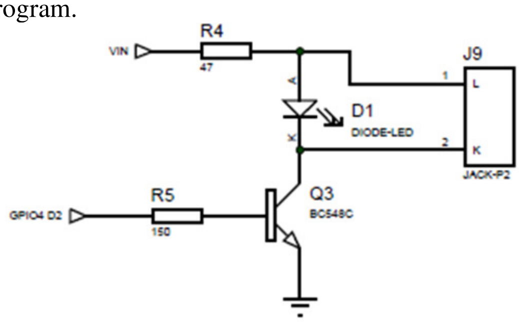

Figure 9. Infrared LED

The following circuit consisted of a discrete relay output to interrupt the air conditioning unit's power supply circuit. An LED was also used for signaling to indicate when the relay was activated.

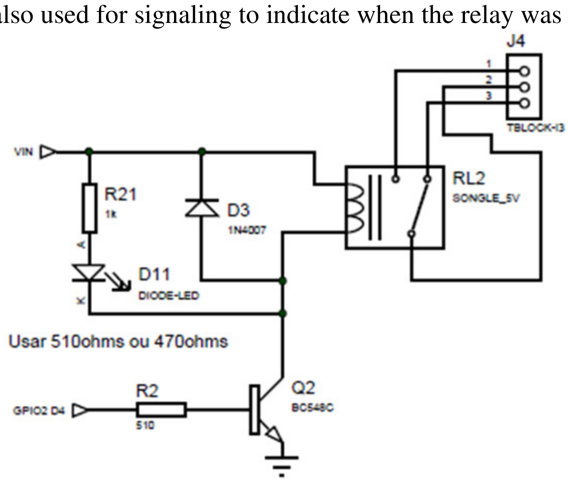

Figure 10. Relay output for the air conditioning

A circuit for detecting ambient lighting was foreseen in the project. This circuit will not be used in the initial project, but may be added to the system in the future.

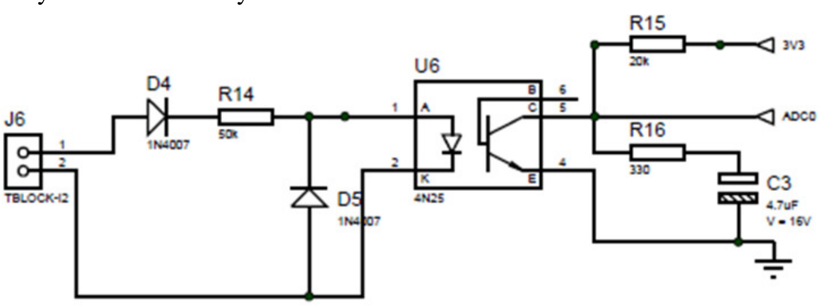

Figure 11. Digital input for ambient lighting detection

Just as in the circuit for detecting ambient lighting, a relay output was included in the project to activate the lighting. This circuit will not be connected externally in the initial project, but may be added to the system in the future.

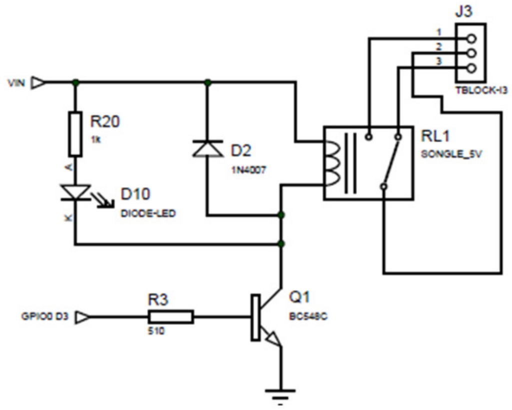

Figure 12. Relay output for lighting activation

The project also has a circuit with a fault indicator LED that can be used flexibly, both for system failures and to indicate activation outside the permitted time range.

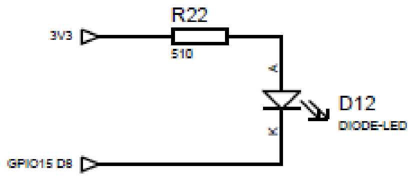

Figure 13. Fault indicator LED and/or Timer OFF

The pinout for fitting the microcontroller is demonstrated below, the range of pins called "J1" and "J10" are internally connected and allow the use of different microcontroller models.

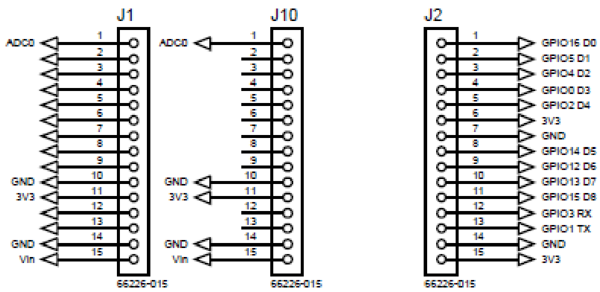

Figure 14. Pinout for fitting the microcontroller

Figure 15 shows the three-dimensional model of the final printed circuit board that was sent for manufacturing.

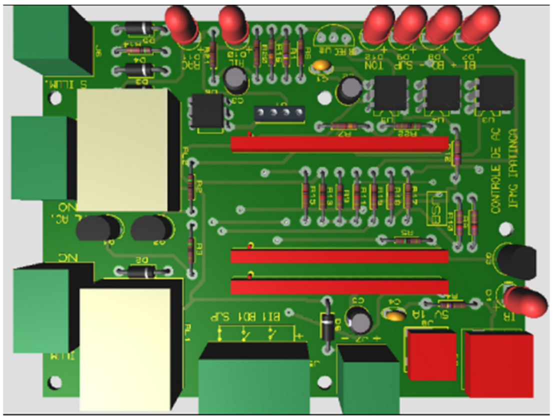

Figure 15. 3D board model

Figures 16, 17, 18 and 19 are images of the final prototype that was installed in the electronics laboratory at IFMG Campus Ipatinga and is in operation.

Figure 16. Printed circuit board after assembling the components

Figure 17. Final prototype assembled in a plastic box

Figure 18. Buttons installed in the laboratory for user activation

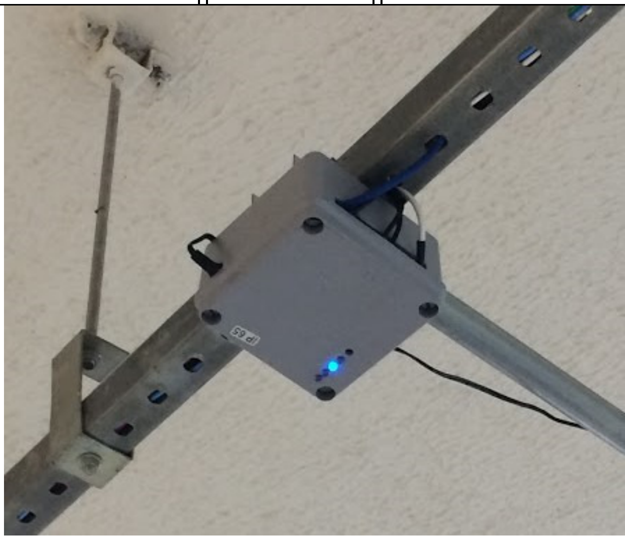

Figure 19. Final prototype in operation installed on an electrical track on the laboratory ceiling

4. CONCLUSION

The product, the object of this research, is management equipment for the air conditioning system at IFMG Campus Ipatinga. This equipment makes it possible to previously adjust the times available for turning on air conditioning units, in addition to automatically turning them off outside of permitted hours. It allows the user of the room/laboratory, through 2 buttons installed next to the lighting switch, to turn the device on and off within the permitted times, in addition to increasing or decreasing the temperature.

REFERENCES

[1] S. Tonage, S. Yemul, R. Jare, e V. Patki, “IoT based home automation system using NodeMCU ESP8266 module”, Int. J. Adv. Res. Dev., 2018.

[2] Handson Technology, “ESP8266 NodeMCUWiFi Devkit User Manual V1.2”, 2018. [Online]. Available at: http://www.handsontec.com/pdf_learn/esp8266-V10.pdf. [Accessed: 02-out-2018].

[3] F. Junior, S. Rabelo, P. Cardoso, "Sistema de Controle para Equipamentos Elétricos Domésticos". Available at: http://livrozilla.com/doc/772071/sistema-de-controle-para-equipamentos-el%C3%A9tricos [Accessed: 01-nov-2018].

[4] T. Ribeiro, S. Oliveira, "Projeto de um Gateway para Automação Residencial", Revista de Engenharia e Pesquisa Aplicada, Volume 1, Número 1, 2016. Available at: https://www.researchgate.net/publication/318961985_Projeto_de_um_Gateway_para_Automacao_Residencial [Accessed: 01-nov-2018].

[5] K. Attarde, S. Khan, K. Upadhayay, D. Shetye, A. Ansari, "Home Automation Using WiFi (Atmega 328P), International Journal of Advance Research in Engineering, Science & Technology. Volume 3, Issue 4, April-2016. Available at: https://www.irjet.net/archives/V2/i6/IRJET-V2I6133.pdf. [Accessed: 01-nov-2018].