SEVEN
publicações acadêmicas

Development of a didactic kit with the ESP32 microcontroller

https://doi.org/10.56238/Connexpemultidisdevolpfut-164

Beatriz Correia Santos
University of the State of Amazonas, Brazil
ORCID: https://orcid.org/0000-0001-9613-2208
E-mail: santosbea13@gmail.com

Jessamine Maria de Lima Azevedo
University of the State of Amazonas, Brazil
ORCID: https://orcid.org/0000-0002-2975-0329
E-mail: jessaminelima@gmail.com

Israel Gondres Torné
University of the State of Amazonas, Brazil
ORCID: https://orcid.org/0000-0002-1267-1878
E-mail: itorne@uea.edu.br

Victor Norton Lima
University of the State of Amazonas, Brazil
ORCID: https://orcid.org/0009-0008-8914-2887
E-mail: vnla.lic18@uea.edu.br

Fabio de Sousa Cardoso
University of the State of Amazonas, Brazil
ORCID: https://orcid.org/0000-0001-7705-7169
E-mail: fcardoso@uea.edu.br

Andre Luiz Printes
University of the State of Amazonas, Brazil
ORCID: https://orcid.org/ 0000-0001-7915-283X
E-mail: aprintes@uea.edu.br

ABSTRACT
Microcontroller-based kits are used for the development of different projects and in different areas of knowledge. The main objective of this project is to develop a didactic kit that can help teachers in the classroom, and make programming practice more accessible to students, as well as obtaining more knowledge about the ESP32 microcontroller and the various peripherals (sensors and actuators). that will be present in the kit, overcoming the difficulties that exist in the execution of practices inside and outside the classroom.

Keywords: Didactic kit, ESP32, Microcontroller.

1 INTRODUCTION

Nowadays electronics and microelectronics are around the increasingly modern society. Industry 4.0 is a great example of the modernization of manufacturing processes improving efficiency and productivity, and from this perspective the current world requires that professionals in training leave universities with new competencies and skills increasingly refined, not only in theory, but mainly in practice (FARERI et al., 2020). The understanding of microcontrollers now needs to be improved in terms of knowledge and skills, especially in the area of Electrical and Electronic Engineering, as cited by BAZZO and PEREIRA:

"Preparing professionals who work with competence in the numerous areas of Engineering is a task that requires courses that contemplate a consistent set of knowledge that enable them to do so. Well-founded theoretical disciplines, internships in the labor market and practical classes are essential to achieve these purposes" (BAZZO & PEREIRA, 2006)

Today, there are development kits like the Arduino UNO based on the ATmega328P microcontroller that is widely used in practices. However, other more updated microcontrollers with more features have been emerging, such as the ESP32 that in addition to the low cost and low power consumption, has Wi-Fi and Bluetooth integrated (ESPRESSIF., 2022), which enables a range of new applications in this way to develop a didactic kit based on this microcontroller allows many advantages.

2 THEORETICAL FRAMEWORK

For a successful approach to the project it is also necessary to deepen the theoretical and conceptual knowledge about some elements that will soon be used in the development of the research, in this case as the Esp32 microcontroller; the Altium Designer layout technique; Peripherals; MPU 6050 sensor and BMP280 sensor; Buzzer; LED; temporary switch; relay; potentiometer and other didactic elements. These will be exposed to continuation.

The ESP32 microcontroller will be the main device for the board of the didactic kit to be developed, and it is up to it to control all the processes according to the programming made by the students. This microcontroller is an integrated circuit chip developed by the company Espressif, which has Wi-Fi and Bluetooth connectivity, presents a system with Dual Core processor with very low power consumption, showing robustness, versatility and reliability in a wide variety of applications and power scenarios (ESPRESSIF, 2022), making the construction of systems such as the Internet of Things (IoT) much simpler and compact.

The development of printed circuit boards (PCI) needs attention because it is essential a good knowledge of layout techniques, in addition to mastering the functionalities of the circuits that will constitute the electrical scheme. With this, one must observe all the layout techniques, from the material chosen to develop the board to the proper positioning of the components among other important aspects, and so the Altium Designer was chosen. Altium Designer offers a unified design environment, empowering engineers with a single view of all aspects of the Printed Circuit Board (PCI) design process, from schematic to PCI layout and design documentation (ALTIUM LIMITED, 2022).

Peripherals are devices that help the processor to perform the operations, usually those of input/output and external storage of a data processing system, other than the central processing unit (SAWAYA, 1999).

The MPU-6050 is a sensor that contains an accelerometer and a gyroscope on a single chip. Both the accelerometer and gyroscope contain 3 axes that can capture x, y, and z with 16-bit analog-to-digital conversion hardware for each channel. The Mpu-6050 uses I2C for communication, which is a multi-master, multi-slave, single-terminated, low-speed serial computer bus, but very useful because it uses only two wires: SCL (clock) and SDA (data) lines (TDK ELECTRONICS, 2013).

The BMP280 is a barometric pressure sensor absolutely designed for mobile applications. The sensor module is housed in a package with a metal cover. Its small dimensions and low power consumption allow it to be implemented in battery-powered devices such as mobile phones, GPS modules or watches. It will be used together with ESP32 to verify its variables (SENSOR, 2015).

The buzzer or doorbell is often used as sound markers, it can be mechanical, electromechanical or piezoelectric. It consists of a coil attached to a diaphragm, when an electric current passes through the coil moving the diaphragm back and forth so as to make the air vibrate, resulting in sound. The doorbell is used as an indicator that the process is complete or an error occurs on a device (SAWAYA, 1999).

Leds or light-emitting diode will also be used, which "is one that emits visible or invisible (infrared) light when energized" (BOYLESTAD, 2013).

A push button is a temporary or non-disruptive switch that causes only a temporary change in the state of an electrical circuit when the switch is physically triggered. A spring-loaded mechanism returns the key to its default position shortly thereafter, restoring the circuit to its original state (BARRETT; PACK, 2012).

The relay is an "electromagnetic device operated by currents in one or more windings of an electromagnet, whose operation causes, in an electrical circuit, sudden changes" (SAWAYA, 1999), serving to turn on or off devices.

According to Sawaya (1999), the potentiometer is a "device that controls the electrical power supplied to a consumer device", that is, it is a device that uses the variation of its resistance.

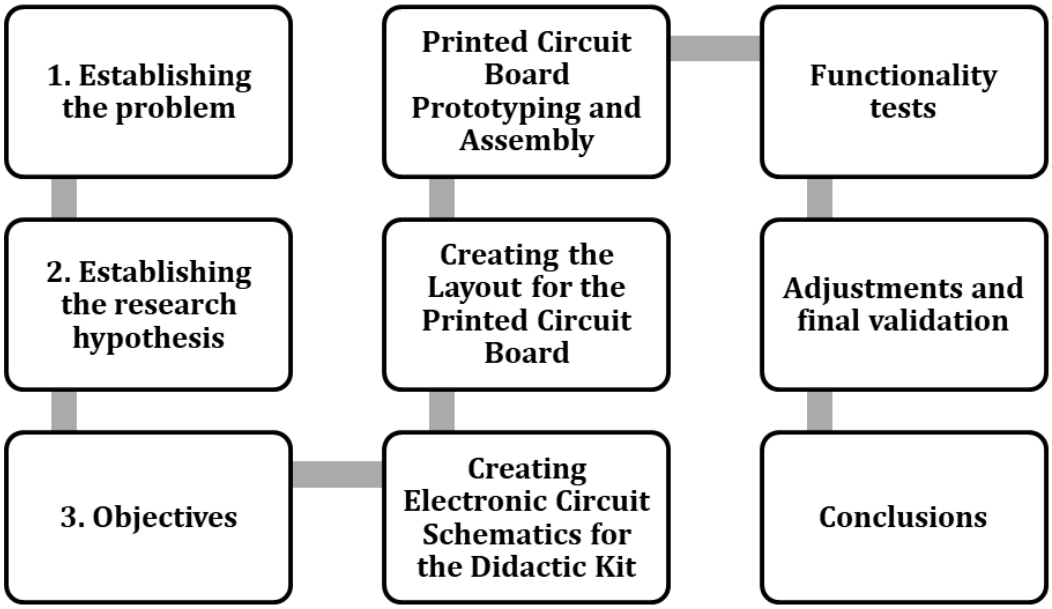
Second, Barbosa and Cardoso (2020), the constant improvement of technology, through the combination of computer systems, microprocessors and communication networks, allows the application of learning strategies that have become crucial for the preparation and performance of engineers. Thus, the use of didactic kits offers a way to encourage the contact and familiarization of students with the use of technologies.

Ensuring that future professionals in the field have the ability to design and build technological systems that meet the connectivity and interaction needs brought about by IoT is critical. The biggest obstacle for Computer Science is to create scalable and engaging educational strategies capable of providing an innovative curriculum that adequately follows technological evolution (SABO et al., 2020, p. 511).

The expansion of experimental activities in the school environment offers the teacher the possibility of innovating in their pedagogical approaches and, simultaneously, providing students with new ways of understanding and learning the fundamental concepts of electronics (SOUZA, 2020).

3 METHODOLOGY

The development of the hardware begins from the reading and interpretation of the objectives of the developed kit, such as the identification of the peripherals to be used, in order to elaborate the architecture of the hardware. After choosing the peripherals, studies of the circuits were carried out with the aid of reading the data sheets of each component. The following is the analytical structure of the methodology followed.



3.1 ESTABLISHMENT OF THE PROBLEM

The use of kit with microcontrollers is a current trend that aims to increase in the trainees new skills and abilities increasingly refined, not only in theory, but mainly in practice due to the technological development in the environment of industry 4.0. The use of other microcontrollers with greater possibilities and a problem of high importance and timeliness.

3.2 ESTABLISHMENT OF THE RESEARCH HYPOTHESIS

In view of the problem expressed, it was planted as an affirmative hypothesis of the research: it is possible to develop a didactic kit using the ESP32 microcontroller as the main device for the didactic kit board.

3.3 GOALS

General: Development of a didactic kit using the ESP32 microcontroller as the main device for the board of this Kit.

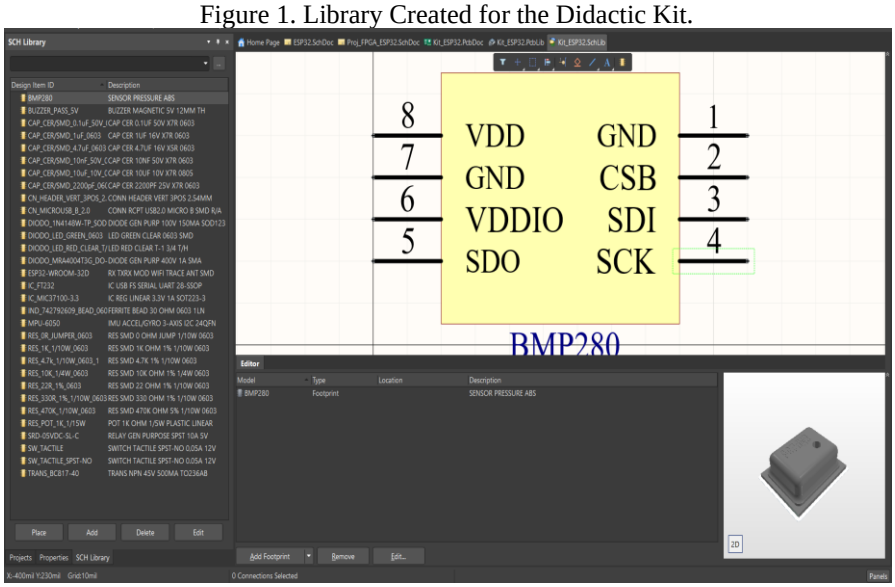
Specific: Create the methodological conceptual bases necessary to develop the kit starting from the selected microcontroller; creation of Schematics of Electronic Circuits of the Didactic Kit; creation

of the Layout for the Printed Circuit Board; Develop the prototyping, test and validate the developed kit.

3.4 CREATION OF SCHEMATICS OF ELECTRONIC CIRCUITS OF THE DIDACTIC KIT.

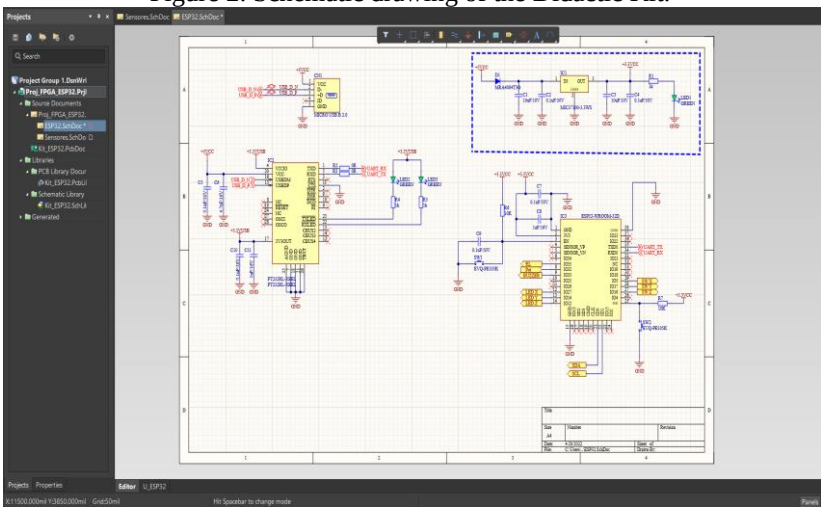
The elaboration of schematics is the most important step, because it is from it that the specifications of the components to be used were made. In this way, the creation of the library of components was initiated (Figure 1), and again it turns to the study of the data sheets of each component to be created, and then the schematic of the component, along with its footprint, associated with its 3D model, is made. After the creation of the components, the development of the electrical scheme was finally done (Figure 2).

Figure 1. Library Created for the Didactic Kit.



Source: Own Author

Figure 2. Schematic drawing of the Didactic Kit.

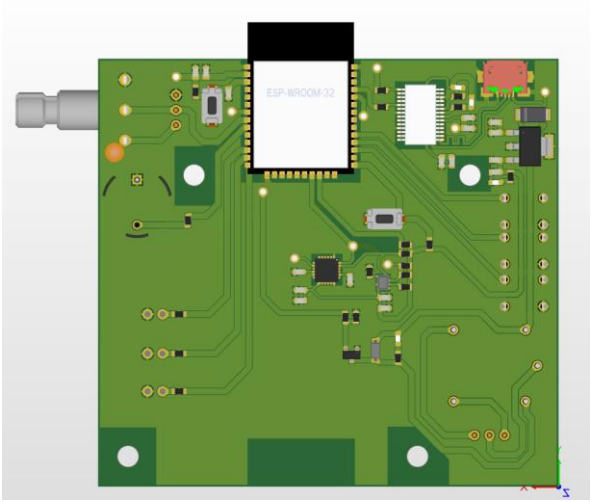


Source: Own Author

3.5 CREATING THE LAYOUT FOR THE PRINTED CIRCUIT BOARD

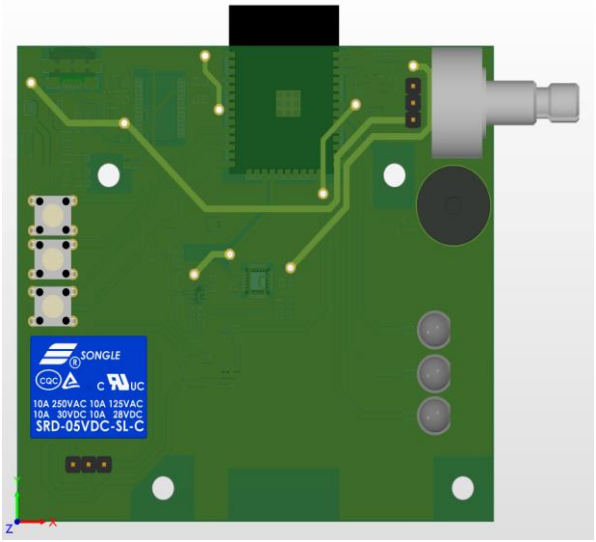
After the development of the electrical scheme was given to the development of the layout, which is given by placement, that is, the distribution of the circuits on the board, positioning them according to the need. Then the sizing of the tracks, the routing of the components, and the positioning of the silks of the components are done. An important step to note is in relation to the mechanical part that will be integrated into the developed hardware. And finally, one should pay attention to the grounding mesh throughout the board.

Figure 3. Layout of the Didactic Kit (Botton Vision)



Source: Own Author

Figure 4. Layout of the Didactic Kit (Top View)



Source: Own Author

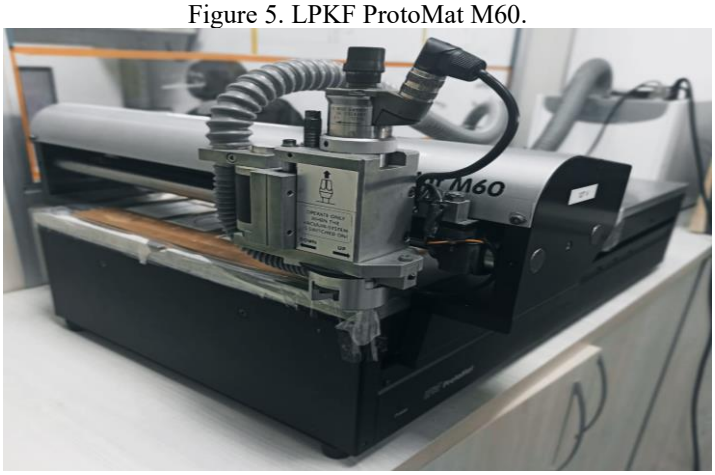
4 RESULTS AND DISCUSSIONS

4.1 PROTOTYPING AND ASSEMBLY OF THE PRINTED CIRCUIT BOARD

The prototyping of printed circuit boards is an important step in the process of developing an electronic project, as this is an important process in the development of electronic devices, allowing developers to test and validate their ideas quickly and economically.

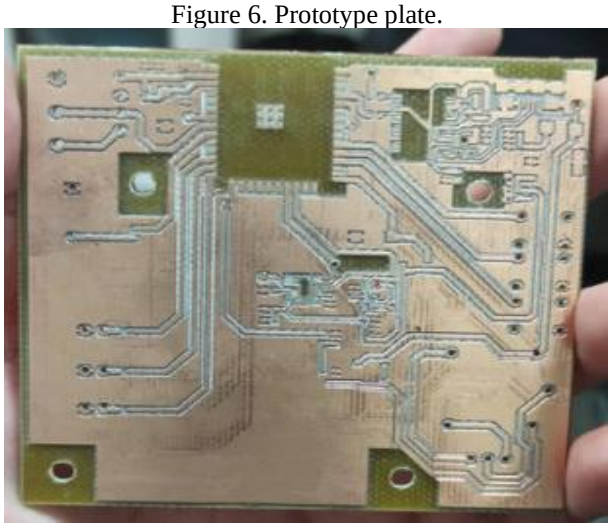
Therefore, after the completion of the development of the didactic kit, PCI prototyping was performed in the LPKF ProtoMat M60 prototyper (Figure 5). In order to send

Figure 5. LPKF ProtoMat M60.



Source: Own Author

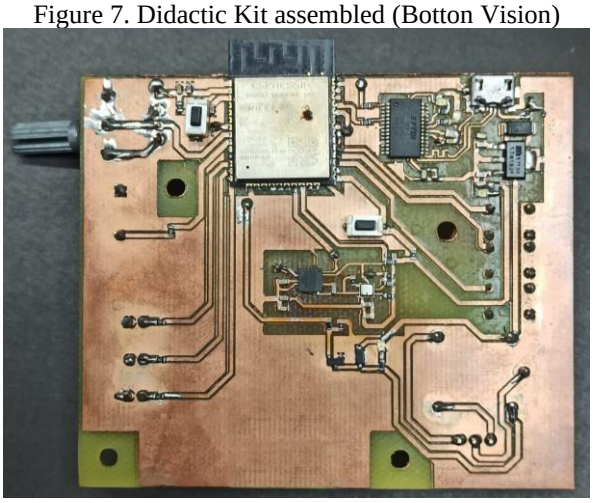
Figure 6. Prototype plate.



Source: Own Author

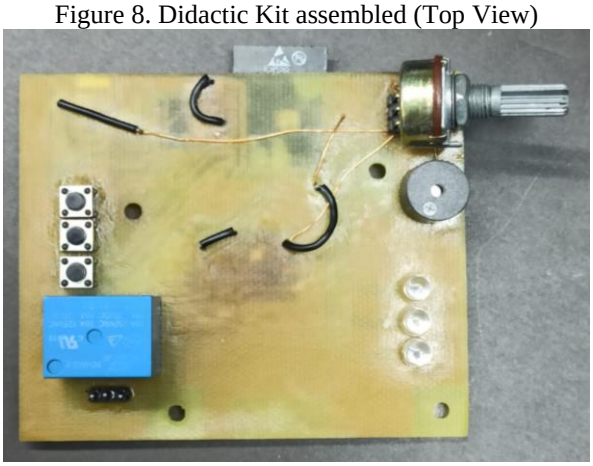
After the prototyping of the plate, the assembly and tests were made according to the schematic (Figure 7, Figure 8).

Figure 7. Didactic Kit assembled (Botton Vision)



Source: Own Author

Figure 8. Didactic Kit assembled (Top View)



Source: Own Author

After assembling a printed circuit board (PCI), it was important to perform some tests to verify that everything is working properly. Some of the basic tests that can be performed include:

Visual test: A visual inspection of the board where it was possible to identify problems such as broken trails, cold welds, incorrect connections, among others.

Continuity test: This test was done using a multimeter to check if there is continuity in the tracks of the board and if there are no short circuits.

Power test: It has been verified that the board is receiving the supply voltage correctly to ensure its proper functioning. This test was done by measuring the voltage at the power points of the board.

In this way, the proper functioning of the plate was ensured. In addition, this practice has also helped to identify errors in the board assembly process, allowing you to correct them before they become larger problems.

5 CONCLUSIONS

The overall objective was satisfactorily fulfilled by obtaining and positively testing the kit using the previously signaled elements and peripherals. The same can be used in the teaching of preaching, thus contributing to the development of practical skills in undergraduate students.

The process of development in stages according to the planed methodology made it possible to obtain the planned results satisfactorily. This research may be continued aiming at the use of other components existing in the market and that enable the continuous improvement and/or development of a kit with greater potential.

The tests developed allowed to guarantee both the correct functioning of the kit and the detection and solution of the errors inherent to this type of process and with this develop skills in the work team guarantee a successful continuity of the project.

In addition, a feature that can be incorporated in the future is the analysis generated after the student uses the kit, in order to evaluate whether the results obtained are satisfactory and meet the expectations at the time of learning. This could provide valuable insights to enhance the project and ensure that it meets the learning needs of users.

REFERENCES

FARERI, S. et al. Estimating Industry 4.0 impact on job profiles and skills using text mining. Computers in Industry, v. 118, p. 103222, 2020.

DE OLIVEIRA, Sérgio. Internet of Things with ESP8266, Arduino and Raspberry PI. Novatec Publishing, 2017.

BAZZO, Walter Anthony; PEREIRA, Luiz Teixeira do Vale. Introduction to engineering. 1st Ed. Florianópolis: Editora da UFSC, 2006.

ESPRESSIF. (SHANGHAI). ESP32. 2022. Available at: https://www.espressif.com/en/products/socs/esp32. Accessed: 24 Apr. 2022.

ALTIUM LIMITED. Altium Designer: Easy, Powerful, Modern. [S. l.], 2022. Available at: https://www.altium.com/altium-designer. Accessed: 24 Apr. 2022.

CID, A. S.; CORREA, T. Venturino: analysis of pressure variation in a Venturi's tube using Arduino and pressure sensor. Revista Brasileira de Ensino de Física, v. 41, n. 3, 2019.

SENSOR, BMP280. BMP280 Digital Sensor" datasheet, Bosch. BST-BMP280-DS001-11, 2015.

BOYLESTAD, Robert L. Electronic devices and circuit theory. 11. ed. São Paulo: Pearson Education do Brasil, 2013. ISBN 978-85-64574-21-2.

INTERNATIONAL INFORMATION AND ENGINEERING TECHNOLOGY ASSOCIATION. Water Level Detection System Based on Ultrasonic Sensors HC-SR04 and ESP8266-12 Modules with Telegram and Buzzer Communication Media. Instrumentation Mesure Métrologie, ano 2019, v. 18, n. 3, p. 305-309, 25 maio 2019. DOI https://doi.org/10.18280/i2m.180311. Disponível em: http://iieta.org/journals/i2m. Acesso em: 24 abr. 2022.

MOMOT, Mikhail; BIKTIMIROV, Artur. Algorithm of Controlling Servo Drives by Means of Atmega 8 Microcontroller. In: Applied Mechanics and Materials. Trans Tech Publications Ltd, 2014. p. 596-599.

BARRETT, Steven F.; PACK, Daniel J. Atmel AVR Microcontroller Primer Programming and Interfacing. 2. ed. [S. l.]: SYNTHESIS LECTURES ON DIGITAL CIRCUITS AND SYSTEMS, 2012. 100 p. ISBN 9781608459582.

SAWAYA, Marcia Regina. Dictionary of Informatics and Internet. 3. ed. São Paulo: Nobel, 1999. 545 p. ISBN 85-213-1099-4.

NO ELECTRONICS. Datasheet: MPU-6000/MPU-6050 Product Specification. Invensense, 2013.

BARBOSA, Gabriel Nogueira; CARDOSO, Lucas Pimenta. Development of a didactic bench for the disciplines of control systems with plant identification and pid controller design via computer simulation. 2020. Final Paper (Bachelor in Electrical Engineering) - SCHOOL OF ENGINEERING, PONTIFICAL CATHOLIC UNIVERSITY OF GOIÁS, Goiânia, 2020. Available in: https://repositorio.pucgoias.edu.br/jspui/bitstream/123456789/810/1/TCC2_ELETRICA-%202020-2-Gabriel-Lucas_orientadorMarcosSousa_VersaoFinal.pdf. Access in: 29 mar. 2023.

SABO, Paulo Henrique et al. Low-cost hardware platform for teaching concepts in the Internet of Things. IBERIAN JOURNAL OF INFORMATION SYSTEMS AND TECHNOLOGIES, [s. l.], ed.

E28, p. 510-519, 2020. Available at: https://www.proquest.com/openview/60892cd66c950ed2797a06376ffde885/1?pq-origsite=gscholar&cbl=1006393#. Access in: 29 mar. 2023.

SOUZA, Gilmar Alves de. Experimental electricity kit – A tool that facilitates the teaching and learning process in physics. Advisor: Profª. Dr. Fernanda Carla Lima Ferreira. 2020. 102 p. Master's Thesis (Master in Physics Teaching) - INSTITUTE OF EXACT SCIENCES, FEDERAL UNIVERSITY OF THE SOUTH AND SOUTHEAST OF PARA, Marabá - PA, 2020. Available at: http://repositorio.unifesspa.edu.br/handle/123456789/1263. Access in: 29 mar. 2023.