International Journal of Engineering Applied Sciences and Technology, 2022
Vol. 7, Issue 10, ISSN No. 2455-2143, Pages 144-150
Published Online February 2023 in IJEAST (http://www.ijeast.com)

ELECTRICAL ENERGY SAVINGS BY UTILIZING INTERNET-BASED AUTOMATIC MONITORING AND CONTROL OF THINGS

Jaja Kustija
Department of Electrical Engineering Education
Indonesian University of Education, Bandung, Indonesian

Irgi Surya
Department of Electrical Engineering Education
Indonesian University of Education, Bandung,
Indonesian

Diki Fahrizal
Department of Electrical Engineering Education
Indonesian University of Education, Bandung,
Indonesian

Abstract— **Utilization of modern technology is almost inseparable from the use of electrical energy. There is often the use of electrical energy that is actually not needed (wasteful), wasteful use of electrical energy results in increased costs, increased power supply, which has an impact on increasing equipment capacity, the problem of saving electrical energy has been widely discussed but saving electrical energy is easy and can be controlled automatically and can be monitored remotely still needs to be improved. Saving electrical energy can have an impact on cost savings, as well as prevent a crisis in the supply of electrical energy. According to data from the Ministry of Energy and Mineral Resources, the installed capacity of power plants for the 2018-2020 period increased by 2.34% per year. The distribution of electricity to customers in the 2018 – 2020 period has increased by 1% per year. Monitoring and controlling electrical energy can be done using controls using sensors and can be monitored and controlled remotely based on the internet of things. This study aims to design and manufacture a prototype tool that functions to monitor and control electrical loads in real time from a distance based on the internet of things and by utilizing sensors can also help turn on and turn off electrical loads as needed. The method used is through the stages of Analysis, Design, Development, Implementation, Evaluation (ADDIE). The results of the study show that the designed and manufactured tools can monitor electrical loads whether they are on or off and can turn on or turn off electric loads automatically with the help of sensors and actuators and can also be controlled remotely via smartphones, laptops, computers or tablets. Future studies are expected to be able to control electrical parameters including voltage, current, frequency, real power, reactive power, apparent power, and power factor. The expected impact of this research is that it can control electrical energy automatically easily and can control it remotely and save electricity usage.**

Keywords— **Saving electricity remotely, Automatically, Internet of things, Sensors, Controls**

I. INTRODUCTION

Consumption of electrical energy in Indonesia continues to experience a significant increase day by day, this is due to the increasing population growth and the increasing need for electrical energy used, this of course has an impact on increasing electricity rates per 1 Kwh that must be purchased by the public.

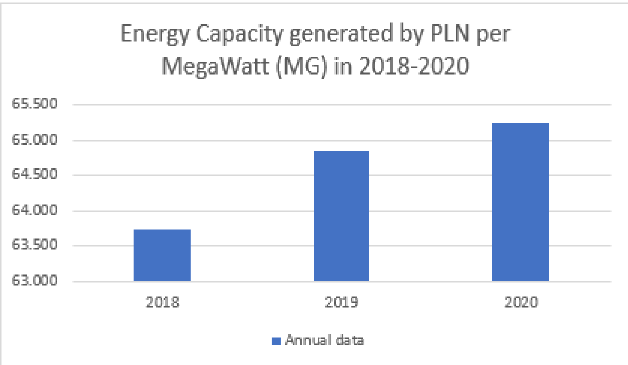

Fig. 1. Electrical capacity data

In this research, an automatic control system is designed that is a combination of sensors and monitoring of electrical loads based on the Internet of Things as a solution to save electricity[1] starting from its global architecture and then developing it into a prototype and realizing it in the form of a system that can be used as a tool to control and monitor usage. electronic devices at home in real time using the NodeMCU ESP32[2] and the AdaFruit IO server so that later users can control and monitor the use of electronic devices at home using only the smartphone they have[3]. Then this system is tested and its performance is measured both in terms of delay, server response, and the monitoring display of this system.

This research aims to design, manufacture, control, and evaluate a prototype that can make a system able to control electrical loads and can monitor in real time[4] and can even be controlled remotely using the internet. [5]The method used is through the Analysis, Design, Development, Implementation, Evaluation (ADDIE) approach, namely by studying the literature[6] to analyze the research object, then design and develop the design results and implement the design results and then implement them on the research object[7][8], all suggestions for improvement are used as an evaluation for improving this system[9]. The novelty of this research is to help users control and monitor electrical loads in real time and without the need to use applications or software that must be downloaded first[10], users only need to Entering the AdaFruit website is of course much easier and more flexible in use[11], unlike in previous studies that have been carried out, users must first download a software or application and this system is also equipped with the use of sensors so that this system can work with more ef isien[12].

The internet of things is a concept in which objects or objects are embedded with technologies such as sensors and software with the aim of communicating, controlling, connecting and exchanging data through other devices as long as they are still connected to the internet[11][13]. The Internet of Thing is a concept where an object has the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction[14]. The development of IoT can be seen starting from the level of convergence of wireless technology, microelectromechanical (MEMS), internet, and QR (Quick Responses) Code. IoT is also often identified with RFID (Radio Frequency Identification) as a method of communication[15]. In the development of the internet of things, many modernize electronic equipment that still has a conventional system, which is converted into an embedded system[16] a program with a certain algorithm to be controlled, monitored, or monitored remotely[17].

NodeMCU is an open source IoT platform[18]. It consists of hardware in the form of the ESP32 on-chip system made by Esperessif System[19]. NodeMCU can be analogous to an Arduino board connected to ESP32[20][21]. The ESP32 microcontroller is made by a company called Espressif Systems. One of the advantages possessed by the ESP32 is that it already has Wi-Fi and Bluetooth in it, so it will be very easy for us when we learn to create an IoT system that requires a wireless connection[15][22]. The ESP32 microcontroller has the advantage of being a low-cost, low-power system with a WiFi module that is integrated with the microcontroller chip and has Bluetooth with dual mode and power-saving features making it more flexible[23].

Adafruit IO is a provider of MQTT server services for Internet of Things[24], this service can be used to make NodeMCU ESP32 controllable remotely by using subscribe and publish facilities. Without the need to use other applications or software, users only need to access the available websites. The advantage of Adafruit IO is that users are not charged when creating an account and using it as a server to be connected to NodeMCU ESP32[25].

II. METHODS

The research method used is Analysis, Design, Development, Implementation, Evaluation (ADDIE). The ADDIE research method is often used in research to produce industrial products or appropriate technological tools[26]. This study aims to create a system that can control electrical loads and can monitor them in real time and can even be controlled remotely using the internet, this system provides ease of use and flexibility in operating time because the user only needs to open the existing Adafruit server. on the website without the need to download the application first [27].

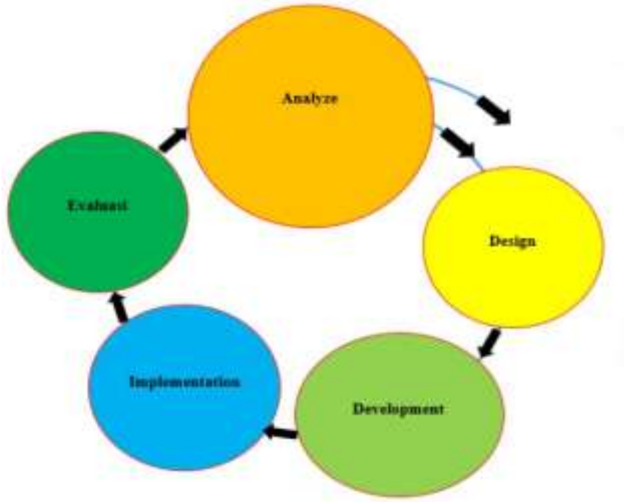

Fig. 2. Research methods

Based on Figure 1, the research procedure is explained, the steps carried out in this study went through several stages, including:

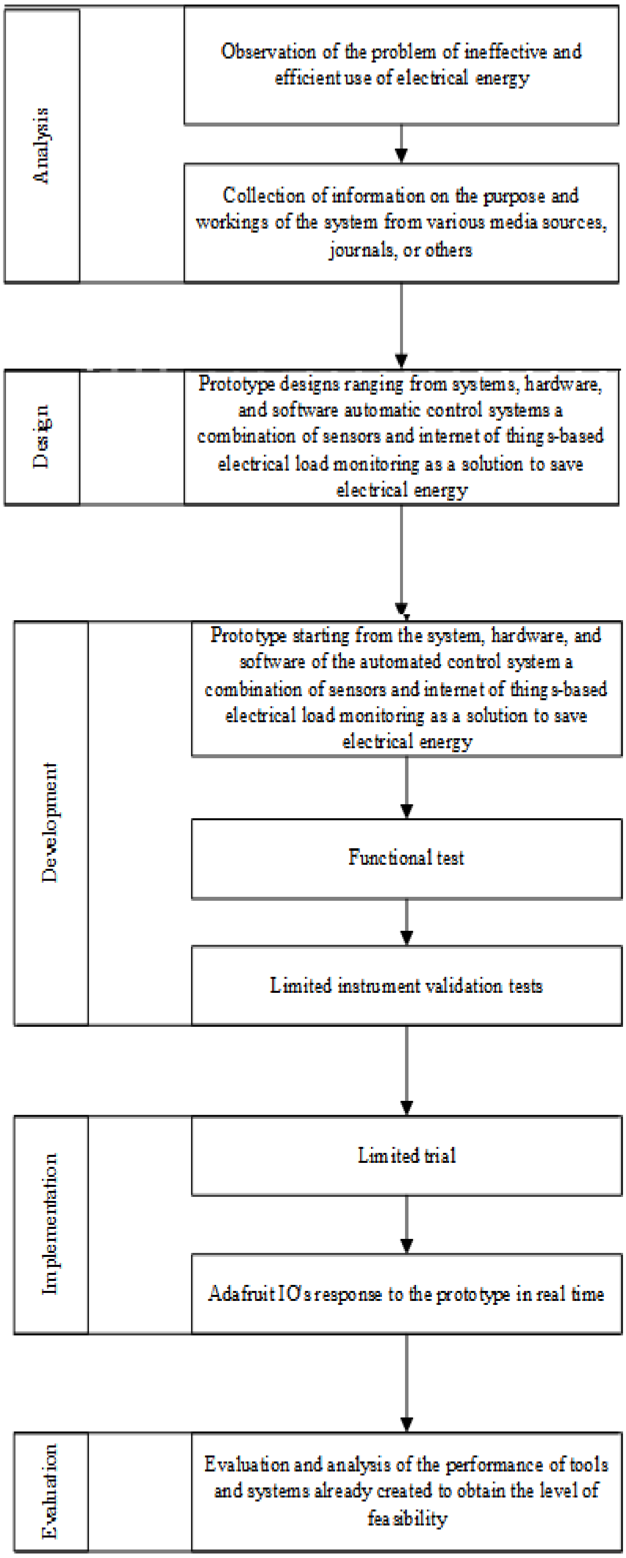

Fig. 3. Research procedure

In case of two-dimensional image, after a DWT transform, the image is divided into four corners, upper left corner of the original image, lower left corner of the vertical details, upper right corner of the horizontal details, lower right corner of the component of the original image detail (high frequency). You can then continue to the low frequency components of the same upper left corner of the 2nd, 3rd inferior wavelet transform.

III. RESULTS AND DISCUSSION

A. System Architecture

Fig. 4. Arcitekture of Systems

Based on Figure 3 it can be seen that the architecture of this system consists of 3 main parts namely, users, internet and servers, as well as electronic devices at home. Users can use their smartphone to directly control and monitor connected electronic devices in real time by simply logging in to the Adafruit IO server which can be accessed via the website without the need to download the application first on the smartphone, the internet and the server are the link between the user and the devices. electronics which will later be monitored and can be controlled remotely.

Sensors as a tool to increase the efficiency of using electric loads:

1. An LDR (Light Dependent Resistor) sensor is used to turn on and turn off the light based on the intensity of the light.
2. For the electric load of the water heater type, the DHT11 sensor is used by making low temperature and high temperature settings to be able to turn on and off the water heater.
3. For the electric load of the air conditioner (AC) type, a thermostat type temperature sensor is used by making low room temperature settings and high room temperature settings to be able to turn on and turn off the air conditioner (AC).
4. For an electric load of the water pump type, a water level sensor is used by making settings on the sensor for low water level and high water level so that the water pump can turn on and off.

B. The Block Diagram Of How The System Works

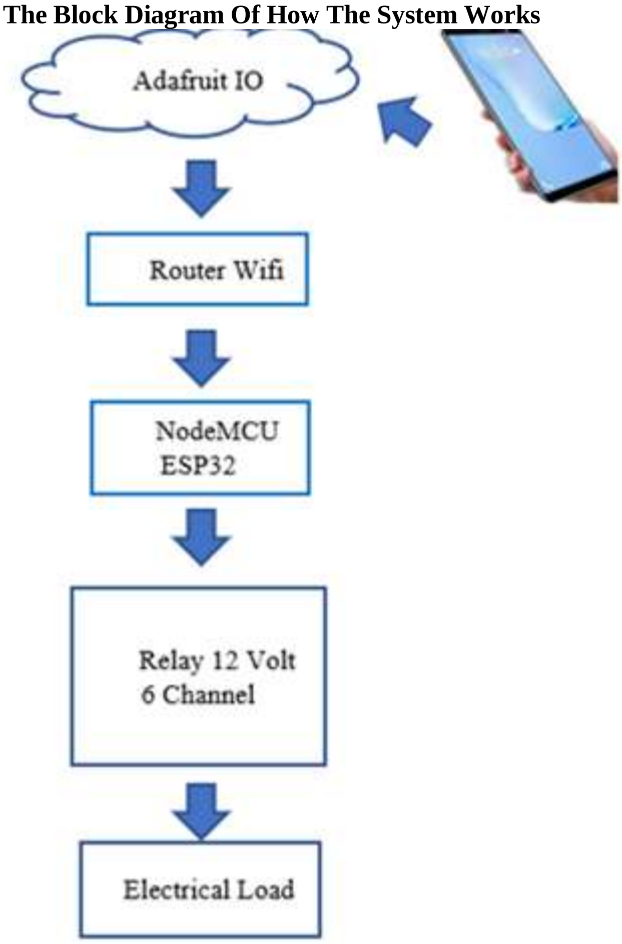

Fig. 5. The Block Diagram

Based on Figure 4 it can be seen how the system works, Adafruit IO is the server used in this system, users can access Adafruit IO using their smartphone by simply opening the Adafruit IO website, later users who already have an account will directly enter the Adafruit IO website. NodeMCU ESP32 must be connected to the wifi or internet network installed in the user's home to be able to control and monitor the use of electronic devices installed in the user's home.

C. Block Diagram Of The Prototype Chain

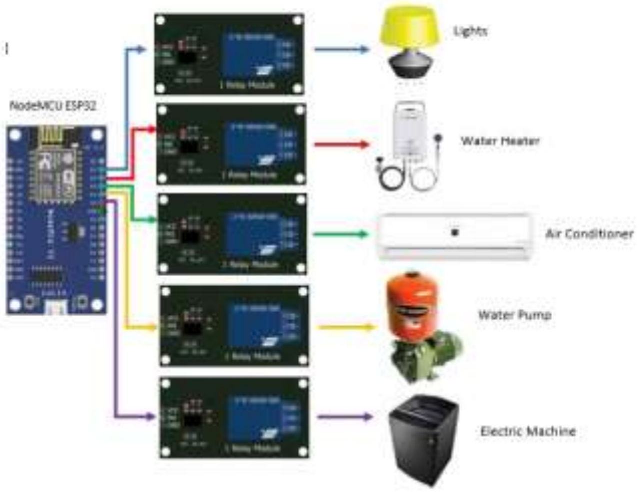

Fig. 6. Block Diagram of The Prototype

Based on figure 5, the description of this prototype uses five relays for experimentation and for relay inputs connected to the pins on the NodeMCU ESP32. Then the output on the relay is connected to the electrical load, which can later be controlled according to the programming results uploaded to NodeMCU ESP32.

D. Adafruit Io Account Settings With Nodemcu Esp32

AdaFruit IO is a website-based flatfoam company engaged in the manufacture of open source hardware and also provides a server that can be connected to NodeMCU ESP32 to be able to control it remotely. Using Adafruit IO, users do not need to download applications or other supporting software. open the available website, the steps that must be taken to be able to set up NodeMCU ESP32 with the AdaFruit IO server can be seen in figure 6.

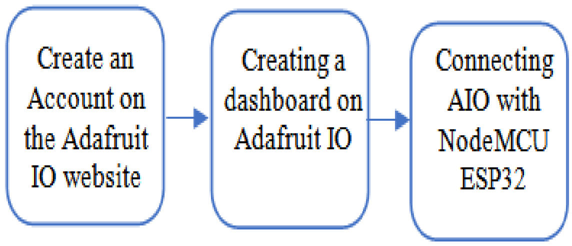

Fig. 7. Setting Adafruit IO

E. Control And Monitoring

International Journal of Engineering Applied Sciences and Technology, 2022
Vol. 7, Issue 10, ISSN No. 2455-2143, Pages 144-150
Published Online February 2023 in IJEAST (http://www.ijeast.com)

Fig. 8. Display User Condition Off

Fig. 9. Display User Condition On

Based on Figure 7, you can see the shape of the Adafruit display which is already connected to the NodeMCU ESP32, there are switches that can function to control electronic equipment, the red color is marked with the equipment in the off position, while if the equipment is on or working, the color will change to green can be seen in Figure 8.

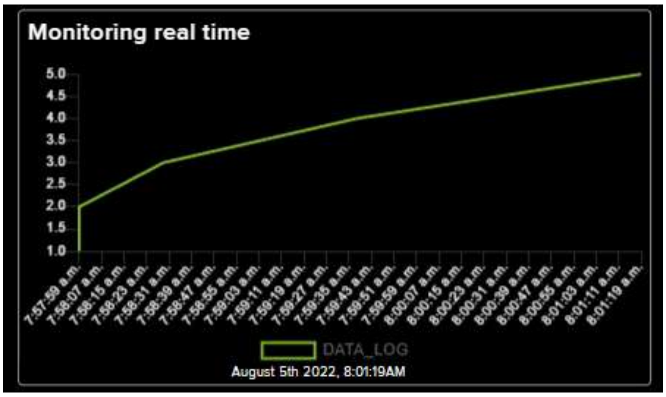

Fig. 10. Display Monitoring

Based on Figure 9 it can be seen from the monitoring display contained in Adafruit IO, users can monitor in real time data on the use of electronic devices that are being used or not being used. The monitoring chart above shows the vertical line for the number of devices that are on or in use or not, while the horizontal line shows the time the electronic devices are being used per unit of time. There are also operational dates and hours for the use of electronic devices that are on or in use. Later users can find out directly which electronic devices are on or in use and which are off or not in use, users can also directly control electronic devices remotely as long as the user is connected to the internet. This minimizes the use of electronic devices that are not in use but are still on or on or users who forget to turn off their electronic devices at home. Of course this really helps users in increasing the efficiency of using electrical energy due to electronic devices that are not being used but are on or lit so that electrical energy is wasted.

F. Trial Systems And Tools

System testing is carried out by making a prototype using 6 lamps each connected to the Adafruit IO system and connected to the NodeMCU ESP32 as a microcontroller that can connect to the user's wifi and smartphone, this test measures the delay between the user, server and installed electronic equipment. also measures the server response on the monitoring display displayed on the Adafruit IO server with a certain internet speed range. Can be seen in table 1.

Table -1 Tests on the system measure wifi internet speed, user internet speed and delays that occur

Speed of Internet Wifi (MBPS)	**Speed of Internet User (MBPS)**	**Delays (S)**
21-30	11-15	0.6
11-20	6-10	0.8
0- 10	0-5	1

Based on table 1, it can be seen that there is a significant influence between wifi internet speed, user internet speed, and the delay that occurs. In the range of 0-10 MBPS wifi internet speed and user internet speed are installed in the range of 0-5 MBPS then the delay that occurs is 1 second, in the range 11-20 wifi speed and user internet speed are installed in the range of 6-10 MBPS then the delay that occurs ie 0.8 seconds, and in the range 21-30 wifi internet speed and user internet speed are installed in the 11-15 MBPS range, the delay that occurs is 0.6 seconds, meaning that wifi internet speed and user internet speed are directly proportional to the delay in this system, the more the higher the wifi internet speed and the user's internet speed the smaller the delay that occurs in this system.

IV.CONCLUSION

This study aims to design, manufacture, control, and evaluate a prototype that can make a system able to control electrical loads and can monitor in real time and can even be controlled remotely based on IoT and using the simple and inexpensive NodeMCU ESP32 microcontroller. Yet efficient. To save energy and can be controlled remotely. To design this system using the NodeMCU ESP32 microcontroller as a control and local materials that are cheap and easy to get. Our target is to design the system in such a way that its components prevent the wastage of electrical energy. The whole system operates automatically. So it does not require experts to operate it. This design has a lot of room for future research and development. This tool is expected to be able to solve problems related to energy regulation and saving electricity. Although in this project there are still many shortcomings that must be investigated in the future.

V. REFERENCE

[1] J. Kustija, K. S. Nur Adillawati, and D. Fauziah, "Smart home system to support Bandung smart city programme," Pertanika J. Sci. Technol., vol. 25, no. S, pp. 77–88, 2017.

[2] M. A. Rahman, "Remote monitoring of heart rate and ECG signal using ESP32," Proceedings - 2021 4th International Conference on Advanced Electronic Materials, Computers and Software Engineering, AEMCSE 2021. pp. 604–610, 2021. doi: 10.1109/AEMCSE51986.2021.00127.

[3] J. Kustija and N. Dwi Jayanto, "IoT Implementation for Development of Remote Laboratory (Case Study on Microscope Practice)," Reka Elkomika, vol. 3, no. 1, pp. 20–29, 2022.

[4] I. Surya and J. Kustija, "Implementation of the Electricity Load Monitoring Trainer and Internet of Things-based Power Factor Improvement," Int. J. Sci. Res. Publ., vol. 12, no. 11, pp. 206–215, 2022, doi: 10.29322/IJSRP.12.11.2022.p13127.

[5] J. Kustija and Purnawan, "Solutions To Overcome Inequality in Laboratory Facilities and Laboratory Sharing in Similar Institutions Remote Laboratory Based," J. Eng. Sci. Technol., vol. 17, no. 3, pp. 1792–1809, 2022.

[6] J. Kustija and F. Andika, "Control - Monitoring System Of Oxygen Level, Ph, Temperature And Feeding in Pond Based on Iot," REKA ELKOMIKA J. Pengabdi. Kpd. Masy., vol. 2, no. 1, pp. 1–10, 2021, doi: 10.26760/rekaelkomika.v2i1.1-10.

[7] J. Kustija, I. Surya, and D. Fahrizal, "Design of automated power factor monitoring and repair tool for industry in real time based on Internet of Things," Int. J. Sci. Technol. Res. Arch., vol. 02, no. 03, pp. 0–7, 2022, doi: https://doi.org/10.53771/ijstra.2022.3.2.0106.

[8] I. Surya and J. Kustija, "Dashboard for Industrial Load Control and Remote Power Factor Correction Based on Adafruit ' s MQTT," Bul. Ilm. Sarj. Tek. Elektro, vol. 5, no. 1, pp. 76–85, 2023, doi: 10.12928/biste.v5i1.7494.

[9] T. Vince, "IoT implementation in remote measuring laboratory VMLab analyses," J. Univers. Comput. Sci., vol. 26, no. 11, pp. 1402–1421, 2020, [Online]. Available: https://api.elsevier.com/content/abstract/scopus_id/85100700929

[10] N. D. Jayanto and J. Kustija, "Remote desktop system in IoT and HTML 5-based virtual laboratory for HMI (Human Machine Interface) practicum and hydraulic simulation," IOP Conf. Ser. Mater. Sci. Eng., vol. 830, no. 4, 2020, doi: 10.1088/1757-899X/830/4/042052.

[11] P. W. Rusimamto, "Implementation of arduino pro mini and ESP32 cam for temperature monitoring on automatic thermogun IoT-based," Indones. J. Electr. Eng. Comput. Sci., vol. 23, no. 3, pp. 1366–1375, 2021, doi: 10.11591/ijeecs.v23.i3.pp1366-1375.

[12] J. Kustija, A. Ana, and N. D. W. I. Jayanto, "Web-based and thinvnc remote laboratory implementation to support students skills in mechatronics course to face the industrial revolution 4.0," J. Eng. Sci. Technol., vol. 16, no. 2, pp. 1800–1813, 2021.

[13] A. Sumardiono, S. Rahmat, E. Alimudin, and N. A. Ilahi, "Sistem Kontrol-Monitoring Suhu dan Kadar Oksigen pada Kolam Budidaya Ikan Lele," JTERA (Jurnal Teknol. Rekayasa), vol. 5, no. 2, p. 231, 2020, doi: 10.31544/jtera.v5.i2.2020.231-236.

[14] G. Ilieva, "IoT in Distance Learning during the COVID-19 Pandemic," TEM J., vol. 9, no. 4, pp. 1669–1674, 2020, doi: 10.18421/TEM94-45.

[15] F. Jonathan, "Prototype of Home Power Monitoring Tool for Electrical Outlet Using ESP32," 8th International Conference on ICT for Smart Society: Digital Twin for Smart Society, ICISS 2021 - Proceeding. 2021. doi: 10.1109/ICISS53185.2021.9533189.

[16] Z. Chen, "Real time object detection, tracking, and distance and motion estimation based on deep learning: Application to smart mobility," 2019 8th International Conference on Emerging Security Technologies, EST 2019. 2019. doi: 10.1109/EST.2019.8806222.

[17] S. Anand, "Study and design of smart embedded system for remote health monitoring using internet of things," Lecture Notes in Electrical Engineering, vol. 511. pp. 409–414, 2019. doi: 10.1007/978-981-13-0776-8_37.

[18] A. Škraba, "Prototype of Group Heart Rate Monitoring with ESP32," 2019 8th Mediterranean Conference on Embedded Computing, MECO 2019 - Proceedings. 2019. doi: 10.1109/MECO.2019.8760150.

[19] N. A. Afifie, "Evaluation Method of Mesh Protocol over ESP32 and ESP8266," Baghdad Sci. J., vol. 18, no. 4, pp. 1397–1405, 2021, doi: 10.21123/bsj.2021.18.4(Suppl.).1397.

[20] P. Megantoro, "IoT-based weather station with air quality measurement using ESP32 for environmental aerial condition study," Telkomnika (Telecommunication Comput. Electron. Control., vol. 19, no. 4, pp. 1316–1325, 2021, doi: 10.12928/TELKOMNIKA.v19i4.18990.

[21] N. Nikolov, "Research of Secure Communication of Esp32 IoT Embedded System to.NET Core Cloud Structure using MQTTS SSL/TLS," 2019 28th International Scientific Conference Electronics, ET

2019 - Proceedings. 2019. doi: 10.1109/ET.2019.8878636.

[22] Y. H. Lin, "Novel smart home system architecture facilitated with distributed and embedded flexible edge analytics in demand-side management," Int. Trans. Electr. Energy Syst., vol. 29, no. 6, 2019, doi: 10.1002/2050-7038.12014.

[23] R. B. Salikhov, "Internet of things (IoT) security alarms on ESP32-CAM," Journal of Physics: Conference Series, vol. 2096, no. 1. 2021. doi: 10.1088/1742-6596/2096/1/012109.

[24] N. Fujii and N. Koike, "IoT remote group experiments in the cyber laboratory: A FPGA-based remote laboratory in the hybrid cloud," Proc. - 2017 Int. Conf. Cyberworlds, CW 2017 - Coop. with Eurographics Assoc. Int. Fed. Inf. Process. ACM SIGGRAPH, vol. 2017-Janua, pp. 162–165, 2017, doi: 10.1109/CW.2017.29.

[25] M. Babiuch, "Creating a Mobile Application with the ESP32 Azure IoT Development Board Using a Cloud Platform," 2021 22nd International Carpathian Control Conference, ICCC 2021. 2021. doi: 10.1109/ICCC51557.2021.9454607.

[26] S. Budijono, "Smart Temperature Monitoring System Using ESP32 and DS18B20," IOP Conference Series: Earth and Environmental Science, vol. 794, no. 1. 2021. doi: 10.1088/1755-1315/794/1/012125.

[27] P. MacHeso, "Design of Standalone Asynchronous ESP32 Web-Server for Temperature and Humidity Monitoring," 2021 7th International Conference on Advanced Computing and Communication Systems, ICACCS 2021. pp. 635–638, 2021. doi: 10.1109/ICACCS51430.2021.9441845.