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AIP Conf. Proc. 2169, 030002 (2019)
https://doi.org/10.1063/1.5132652

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The Assembling of Electrical Socket for Electricity Usage Monitor and Electronic Device Control with ESP8266 Microcontroller Basis

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Abstract. Electrical socket to monitor the electricity usage and control the electronic control based on ESP8266 microcontroller was successfully made. This tool was assisted by PZEM-004T module to monitor electrical power consumption. Electricity consumption monitoring and electronic device controlling were carried out through Android application. This electrical socket assembling was necessary to minimize the excessive electric use. Assembling of electrical socket starts with making an electronic circuit design, casing design, and Android applications that are continuing with the component manufacturing process. The measurement result of electrical energy was done by using a device made with energy meter showed measurement errors with an average error of 5.31%

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INTRODUCTION

Indonesia's electricity demand is growing rapidly, driven by robust economic growth combined with unprecedented urbanization and industrialization [1]. Nowadays, Indonesia is facing energy scarcity and still struggling with finding new energy resources. No other ways the employee have to use the currently available energy wisely. However, wasteful behavior in energy use is still often seen in public sectors like government/private buildings, schools/campuses, hospital, and others [2]. Overuse of energy has caused many environmental and economic crises. Home appliances consume high energy. Energy consumption by home appliances is considered as one of the most critical areas for the attention to the researchers [3]. Major electrical wastages in household appliances can be considerably reduced with proper monitoring and control [4].

An energy monitoring device integrating with the concept of the Internet of Things allows their measured data to be monitored and retrieved at any locations where internet is available [5]. The Internet of Things (IoT) is a concept created to define the technological revolution of the devices used in day-today connected to the global Internet network [6]. Several studies which have been conducted related to monitoring and control of electronic device with the concept of Internet of Things [2], [5], [7-17].

According to various studies of electronic device monitoring and control using the Internet of Things concept, the parameters measured are current, voltage, and power consumed by electronic devices. Monitoring and control of electronic devices can be further developed in terms of automation and ease of use. Therefore, ESP8266-based Power Socket for Monitoring and Controlling Electronic Devices needs to be made. The device will be manufactured using a relay module to control electronic devices, PZEM-004T to monitor electricity consumption, and is based on ESP8266 - a microcontroller integrated with a WiFi chip [7]. ESP8266 is used because of its small size and according to needs. There is some research by utilizing the Internet of Things using ESP8266 [8], [18-31]. The objectives of this research are to acquire the assembling electrical socket which could connect to internet

The 8th National Physics Seminar 2019
AIP Conf. Proc. 2169, 030002-1–030002-7; https://doi.org/10.1063/1.5132652
Published by AIP Publishing. 978-0-7354-1916-2/$30.00

through Wi-Fi, the assembling electrical socket control system through Android application, and present observation result of electricity consumption for each electrical socket in Android application.

METHOD

There were two types of designs to make the Electrical Sockets for Electronic Devices Monitor and Control, there are hardware and software design. Hardware design included case series design and circuit design. Software design included logic design of device's workflow and Android application designs.

FIGURE 1. 3D Design Tool

Figure 1 was a 3D design tool that has been made. There were three main materials for the design of the circuit cover, which were the black box, electrical socket, and over plug. The main cover box, used a X2 type of black component box with dimension of 12 centimeters long, 6 centimeters wide, and 4 centimeters high. An electrical socket, size of 5 centimeters, was placed in a hole that has been made in the component box, which would later be used for electronic power supply. The part which was used for the over plug was the foot section, that would be placed at the bottom of the black box to connect to the State Electricity Company (PLN) power source. The required materials, electronic components, and requirement software which is needed to build this system describe in Tab. 1 and Tab. 2.

TABLE 1. The required materials

No	Material Type	Description
1	X2 Component Box	Used as the main container for putting all electronic materials and components
2	Round Electrical Socket	Used as an electrical socket for all electronic equipment to be controlled and monitored
3	EU Over Plug	Used as a link between a device made with AC power source
4	ESP8266-01	Data processor and controller of connected modules
5	AC-DC 5V Module	Power Source for all electronic components
6	PZEM-004T	To read the voltage, current, and power from the electronic device
7	Relay	For condition control of electronic device
8	LED	For Indicator of the tool
9	AMS1117 Regulator	Drop 5V voltage to 3,3V
10	3,9 KΩ Resistor	As a resistor in a relay circuit
11	PC817 Optocoupler	As a relay circuit controller
12	BC548 Optocoupler	As a relay circuit controller
13	100uF & 10nF Capacitor	As a voltage stabilizer

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TABLE 2. Software requirements

No	*Software* Name	Version	Function
1	Google Chrome	73.0.3683.86	Open the Firebase Realtime Database console page
2	Arduino IDE	1.8.5	Source code compiler and uploader to ESP8266-01
3	Android Studio	3.3.1	To create an android application

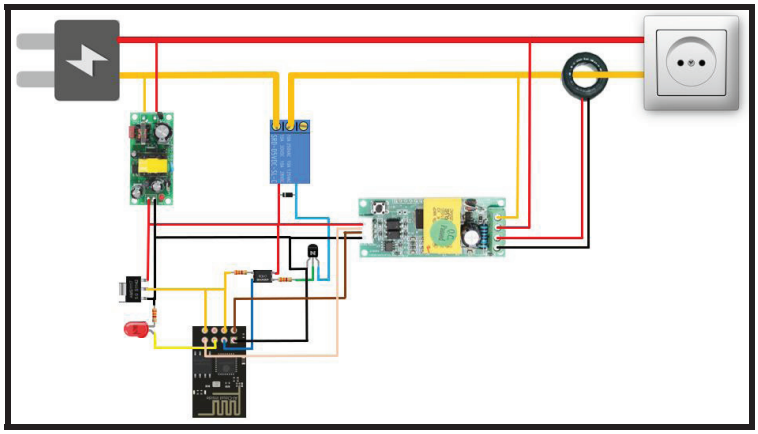

FIGURE 2. Electronic Circuit

Figure 2 shows an electronic circuit design of developed device. There was a power supply module with an output voltage of 5V which functioned as a DC voltage source for all electronic components used. The regulator functioned to lower the power supply output to 3.3V so that it could be used as a voltage source of ESP8266-01. ESP8266 was used as the main processor of all existing input and output components. One of the input components was the PZEM-004T module which was used as a voltage reader and AC current consumed by electronic devices. PZEM-004T used a type of serial communication to transmit data to the microcontroller, then the PZEM-004T module RXTX pin was connected to the TXRX ESP8266-01 pin. Meanwhile the relay was an output component that was used to connect and disconnect electrical lines connected to electronic devices.

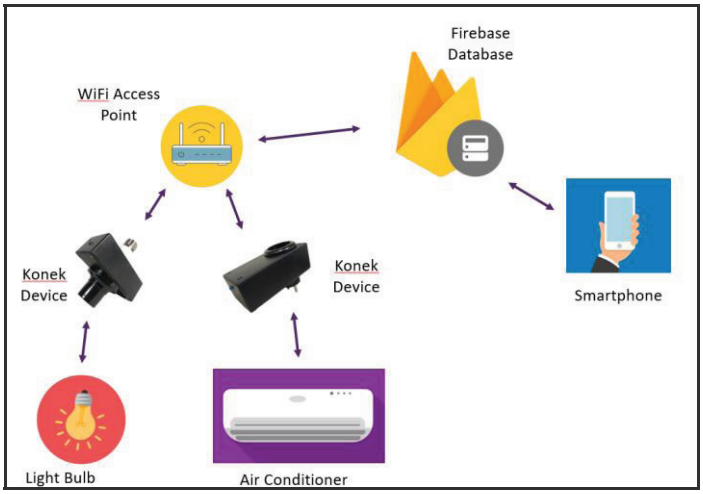

FIGURE 3. System Workflow

System workflow design can be seen in Fig. 3. Electronic devices which were connected to this device could be controlled through an Android application, if the device was connected to an access point which had internet access. The connected device would start the connection with the Firebase real-time database. When the tool has

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successfully connected to the database, the results of monitoring electricity consumption would be sent by the device to the database. In addition to sending monitoring results, the tool would also read the On / Off switch sent by the Android application. The Android application could display the results of monitoring electricity consumption by retrieving data in the database that has been sent by the device.

The prototype simulation phase was the stage of doing a simulation or trial for the device that has been made. The aim was to get information about the shortcomings from the solutions provided. The simulation directly tested the tool.

RESULT AND DISCUSION

The implementation of Android applications has been made based on the system design. The initial page of the application is a login page. After the user logged in, a dashboard page would appear showing a device that has been integrated with the user account. Users could determine the condition of the device through the dashboard page by pressing the power button. In addition, users could see the information about the device by pressing one of the device's names to go to the details page. On the details page of the device, there was a history button to display the history of electricity usage.

To change the configuration of the device, the user must enter the details page of the device, then pressed one of the available modes, then a dialog would appear so that users could fill-in the desired configuration. Each tool could only activate one configuration mode or not at all, if there was no mode activated, then no automation system was carried out, the user could only turn on or turn off the switch by pressing the power button.

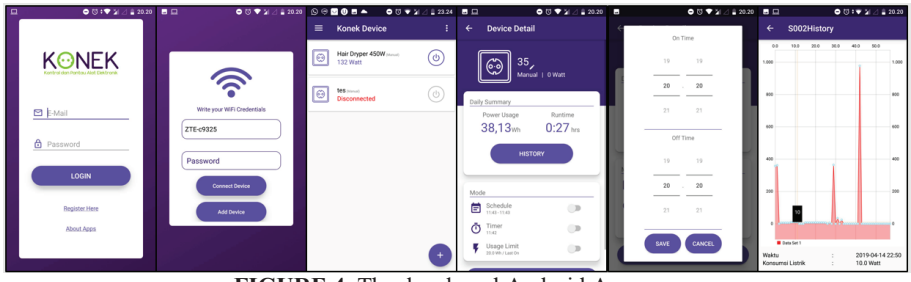

FIGURE 4. The developed Android Apps

The users could also add a new device by pressing the '+' button on the dashboard page. Users would be directed to the add device page to add a new device to the user's account. On this page, the user needed to fill in the SSID and password which would be used to connect to the internet. After that the user must add the device token by manually filling it or using the camera to scan the QR code on the device.

TABLE 3. The measurement results of electricity usage monitoring

No	Device Name	Power Measurement Result		Power difference (Watt)	Error (%)
		Developed device (Watt)	Digital Power Meter (Watt)		
1	Hit Mat	5	5.2	0.2	3.85%
2	Phone Charger	6	6.6	0.6	9.09%
3	nVc LED	8	8.7	0.7	8.05%
4	Solder	25	26.2	1.2	4.58%
5	Full Speed Fan	41	42.4	1.4	3.30%
6	Fan	35	37.1	2.1	5.66%
7	Laptop Charger	53	56	3	5.36%
8	Iron	370	383.5	13.5	3.52%
9	Full Speed Hair Dryer	1,037	1,085	48	4.42%
10	Hair Dryer	132	139.3	7.3	5.24%
		Error Average			5.31%

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TABLE 4. Electronic Device control test result

No	Mode	Configuration	Condition	Switch Status
1	Manual	-	On Button Pressed	ON
2	Manual	-	Off Button Pressed	OFF
3	Schedule	13:00 - 20:00	Current Time = 12:00	OFF
4	Schedule	13:00 - 20:00	Current Time = 14:00	ON
5	Timer	00:10	Duration of use = 00:04	ON
6	Timer	00:10	Duration of use = 00:11	OFF
7	Usage Limit	50 Wh/day	Total Usage = 30Wh	ON
8	Usage Limit	50 Wh/day	Total Usage = 60Wh	OFF

The trial was carried out so that the implementation could be in line with the expected goals. There are the functionality of electricity usage monitoring and control of electronic devices through the developed application. The electricity usage monitoring was carried out by comparing the developed device results to the digital power meter. Table 3 shows the measurement results. It can be seen that the average error measurement is 5.31%. Meanwhile the results of electronic device control through an Android application were described in Tab. 4.

CONCLUSION

The electrical socket to monitor the electricity usage and control the electronic control based on ESP8266 microcontroller was successfully made. According the results, it could be concluded that all the functionality of the device could work properly. The result of electricity usage monitoring was not far different from the power meter. The control of electronic devices could be done without any problems.

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ACKNOWLEDGMENT

This research was funded by Hibah Penelitian Terapan Unggulan Perguruan Tinggi (PTUPT) Direktorat Jendral Penguatan Riset dan Pengembangan Kemenristekdikti Republik Indonesia under contract number of 3/E1/KP.PTNBH/2019 in 29 March 2019.

REFERENCES

1. M. A. McNeil, N. Karali, and V. Letschert, “Forecasting Indonesia’s electricity load through 2030 and peak demand reductions from appliance and lighting efficiency,” *Energy for Sustainable Development* ***49***, pp. 65–77, Apr. (2019).
2. R. Linda, L. Susanti, and H. R. Zadry, “Intervention Selection to the Awareness of Energy-Saving Behavior in the Public Sector,” *MATEC Web of Conferences* ***248***, p. 03002 (2018).
3. J. JeyaPadmini and K. R. Kashwan, “Effective Power Utilization and Conservation in Smart Homes Using loT,” pp. 5 (2015).
4. R. T. Mathew, S. Thattat, K. V. Anirudh, V. P. K. Adithya, and G. Prasad, “Intelligent Energy Meter with Home Automation,” in *2018 3rd International Conference for Convergence in Technology (I2CT)*, Pune, pp. 1–4 (2018).
5. S. Wasoontarajaroen, K. Pawasan, and V. Chamnanphrai, “Development of an IoT device for monitoring electrical energy consumption,” in *2017 9th International Conference on Information Technology and Electrical Engineering (ICITEE)*, Phuket, pp. 1–4 (2017).
6. G. Marques and R. Pitarma, “System for monitoring and control energy consumptions,” in *2017 12th Iberian Conference on Information Systems and Technologies (CISTI)*, Lisbon, Portugal, pp. 1–5 (2017).
7. H. Aamer, R. Mumtaz, H. Anwar, and S. Poslad, “A Very Low Cost, Open, Wireless, Internet of Things (IoT) Air Quality Monitoring Platform,” in *2018 15th International Conference on Smart Cities: Improving Quality of Life Using ICT & IoT (HONET-ICT)*, Islamabad, pp. 102–106 (2018).

8. S. K. S. Gunturi and M. S. K. Reddy, "IoT Based Domestic Energy Monitoring Device," in *2018 3rd International Conference for Convergence in Technology (I2CT)*, Pune, pp. 1–4 (2018).
9. S. Thakare, A. Shriyan, V. Thale, P. Yasarp, and K. Unni, "Implementation of an energy monitoring and control device based on IoT," in *2016 IEEE Annual India Conference (INDICON)*, Bangalore, India, pp. 1–6 (2016).
10. T. H. Nasution, M. Hanafi, K. Tanjung, and K. Fahmi, "Integrated Smart Plug Design," *MATEC Web of Conferences* ***220***, p. 05001, (2018).
11. A. H. Shajahan and A. Anand, "Data acquisition and control using Arduino-Android platform: Smart plug," in *2013 International Conference on Energy Efficient Technologies for Sustainability*, Nagercoil, pp. 241–244 (2013).
12. S. Zhai, Z. Wang, X. Yan, and G. He, "Appliance Flexibility Analysis Considering User Behavior in Home Energy Management System Using Smart Plugs," *IEEE Transactions on Industrial Electronics* ***66(2)***, pp. 1391–1401, Feb. (2019).
13. E. Al-Hassan, H. Shareef, Md. M. Islam, A. Wahyudie, and A. A. Abdrabou, "Improved Smart Power Socket for Monitoring and Controlling Electrical Home Appliances," *IEEE Access* ***6***, pp. 49292–49305, (2018).
14. Ó. Blanco-Novoa, T. Fernández-Caramés, P. Fraga-Lamas, and L. Castedo, "An Electricity Price-Aware Open-Source Smart Socket for the Internet of Energy," *Sensors* ***17(3)***, pp. 643, Mar. (2017).
15. C. Keles, A. Karabiber, M. Akcin, A. Kaygusuz, B. B. Alagoz, and O. Gul, *International Journal of Electrical Power & Energy Systems* ***64***, pp. 679–688, Jan. (2015).
16. A. N. Santos, M. A. A. Macabuhay, and J. N. De Leon, "Smart Household Socket with Power Monitoring & Control Using Android Application," in *2017 9th IEEE-GCC Conference and Exhibition (GCCCE)*, Manama, Bahrain, pp. 1–9 (2017).
17. A. Singaravelan and M. Kowsalya, "Design and Implementation of Standby Power Saving Smart Socket with Wireless Sensor Network," *Procedia Computer Science* ***92***, pp. 305–310 (2016).
18. M. C. Abeledo, F. Bruschetti, G. Aguilera, P. Iriso, M. Marsicano, and A. Lacapmesure, "Remote monitoring of elderly or partially disabled people living in their homes through the measurement of environmental variables," in *2016 IEEE Congreso Argentino de Ciencias de la Informática y Desarrollos de Investigación (CACIDI)*, Buenos Aires, Argentina, pp. 1–5 (2016).
19. M. A. Abouelela and M. M. Abouelela, "Wireless communication role in Home Energy Management system (HEMS)," in *2015 23rd Telecommunications Forum Telfor (TELFOR)*, Belgrade, Serbia, pp. 204–207 (2015).
20. A. Adriansyah and A. W. Dani, "Design of Small Smart Home system based on Arduino," in *2014 Electrical Power, Electronics, Communicatons, Control and Informatics Seminar (EECCIS)*, Malang, Indonesia, pp. 121–125 (2014).
21. D. Anggraini, N. Effendy, M. Ihsan Al Hafiz, and D. Ojeda Luviano, "Research and Development of a Power Monitoring System for the Sustainable Energy Management System Implementation at Green School, Bali, Indonesia," *E3S Web of Conferences* ***43***, p. 01021, (2018).
22. Arvandy and Y. Bandung, "Design of Secure IoT Platform for Smart Home System," in *2018 5th International Conference on Information Technology, Computer, and Electrical Engineering (ICITACEE)*, Semarang, pp. 114–119 (2018).
23. P. Barsocchi, E. Ferro, F. Palumbo, and F. Potorti, "Smart meter led probe for real-time appliance load monitoring," in *IEEE SENSORS 2014 Proceedings*, Valencia, Spain, pp. 1451–1454 (2014).
24. N. Burford, R. Jones, S. Reynolds, and D. Rodley, "Macro Micro Studio: A Prototype Energy Autonomous Laboratory," *Sustainability* ***8(6)***, pp. 500, May (2016).
25. S. D. Dalvi, D. Chandrababu, and V. Kumar, *International Journal of Ambient Energy* ***37(4)***, pp. 348–353, Jul. (2016).
26. D. J. R. Enriquez, M. L. G. Villanueva, S. M. G. Dumlao, and R. S. J. Reyes, "Wireless power consumption monitoring and analysis system using Winter's forecasting method," in *TENCON 2015 - 2015 IEEE Region 10 Conference*, Macao, pp. 1–6 (2015).
27. R. W. Fransiska, E. M. P. Septia, W. K. Vessabhu, W. Frans, W. Abednego, and Hendro, "Electrical power measurement using Arduino Uno microcontroller and LabVIEW," in *2013 3rd International Conference on Instrumentation, Communications, Information Technology and Biomedical Engineering (ICICI-BME)*, Bandung, Indonesia, pp. 226–229 (2013).
28. I. Froiz-Míguez, T. Fernández-Caramés, P. Fraga-Lamas, and L. Castedo, "Design, Implementation and Practical Evaluation of an IoT Home Automation System for Fog Computing Applications Based on MQTT and ZigBee-WiFi Sensor Nodes," *Sensors* ***18(8)***, pp. 2660, Aug. (2018).

29 September 2023 11:16:22

29. D. Hernández-Rojas, T. Fernández-Caramés, P. Fraga-Lamas, and C. Escudero, "A Plug-and-Play Human-Centered Virtual TEDS Architecture for the Web of Things," *Sensors* ***18(7)***, pp. 2052, Jun. (2018).
30. C.-J. Huang, J.-T. Hsiao, C.-Y. Deng, and K.-W. Hu, "An Intelligent Renewables-based Power Scheduling System for Internet of Energy," in *2018 10th International Conference on Knowledge and Smart Technology (KST)*, Chiang Mai, pp. 176–181 (2018).
31. Y. Ji, Y. Yang, and Z. Huo, "Design of Security Protection System for Smart Home Based on Web," in *Proceedings of the 2nd International Conference on Computer Science and Application Engineering - CSAE '18*, Hohhot, China, pp. 1–6 (2018).

29 September 2023 11:16:22