Journal of Computer Science and Technology Studies
ISSN: 2709-104X
DOI: 10.32996/jcsts
Journal Homepage: www.al-kindipublisher.com/index.php/jcsts

JCSTS
AL-KINDI CENTER FOR RESEARCH AND DEVELOPMENT

| RESEARCH ARTICLE

Household Electricity Utilization Monitoring System Using Microcontroller Based SCADA

I Gede Ketut Sri Budarsa[1], I Wayan Raka Ardana[2] ✉ Luh Gede Putri Suardani[3] and I Putu Muliana[4]
[1234]Politeknik Negeri Bali, Indonesia
Corresponding Author: I Wayan Raka Ardana, **E-mail**: rakawyn@pnb.ac.id

| ABSTRACT
Human needs continue to grow, making today's technology a necessity. In today's life, humans cannot be separated from electricity. In the household, the current electrical control system is still classified as conventional, namely by using a switch or still relatively manual. To overcome this, a SCADA system is needed to monitor and control household electrical appliances. In making the SCADA system uses an Arduino uno microcontroller and an ethernet shield that is connected via a switch/hub that goes directly to a computer that will be monitored on the VT-Scada software. The results of the delay test on the VT-Scada output are, on average, 1.80 seconds of delay when on and 1.90 seconds of delay when off. The results of monitoring the entire system in each room are as expected.

| KEYWORDS
SCADA, VT-Scada, Microcontroller, Arduino, Ethernet

| ARTICLE INFORMATION
ACCEPTED: 24 November 2022 **PUBLISHED:** 01 December 2022 **DOI:** 10.32996/jcsts.2022.4.2.16

1. Introduction
Currently, electricity is a basic need for humans. All equipment mostly uses electricity as its energy [Anggher, 2019]. Electricity is a basic need in everyday life because all equipment now uses electricity. Without electricity, the world would be dark because all lighting already uses electricity. Utilization of electrical energy in meeting energy needs ensures almost all sectors of life are good for households, companies and industries. In households, the system for controlling and monitoring the use of electrical energy still uses the conventional method, namely by using a standard Kwh meter and switch equipment with manual operation. The current conventional system in the use of electrical energy in households is less effective and efficient because the switching process and energy use cannot be controlled by mobile and other electrical parameters cannot be known in real time [Apriyoga, 2015].

For that, we need a system that is able to overcome the shortcomings of conventional systems. One alternative that can be used in SCADA (Supervisory Control And Data Acquisition). SCADA systems are designed to be able to control operating systems and collect and analyze field data that can be monitored in real time. SCADA is also capable of transmitting and communicating data with the use of electrical energy to a central computer for processing these data. The SCADA communication protocol is also used in industrial automation control systems as a data communication system to monitor and control industrial equipment. In making a SCADA system with a microcontroller, there are many applications that can be used, such as the App Inventor application. This system has a weakness when it uses two or more microcontrollers, and when adding more sensors, it requires rearranging the program code blocks. So in this study, the VT-Scada software was used, which uses a "tag" system in its communication via ethernet. VT-Scada makes it easy to monitor and control the use of electrical energy in a household that requires a lot of I/O on the microcontroller.

2. Methodology

2.1 SCADA System Design

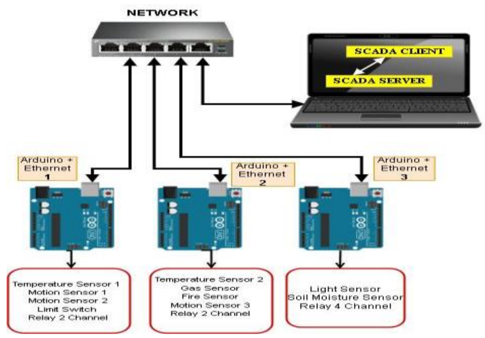

Figure 1 Scada System Design

On Arduino 1, there are several sensors used, namely temperature sensors, PIR sensors, limit switches, and relays. On Arduino 2, there are several paired sensors, namely temperature sensors, gas sensors, fire sensors, PIR sensors and relays. Arduino 3 is paired with an LDR sensor, soil moisture sensor and relay as output. So that Arduino can communicate via an ethernet network and these data can be accessed via a server, an additional Ethernet shield module is installed on the Arduino and with an additional switch/hub, these three Arduinos can connect to a server which can be accessed on the client and displayed on the HMI. The workings of the SCADA system with the Arduino microcontroller are designed as shown in Figure 2 below.

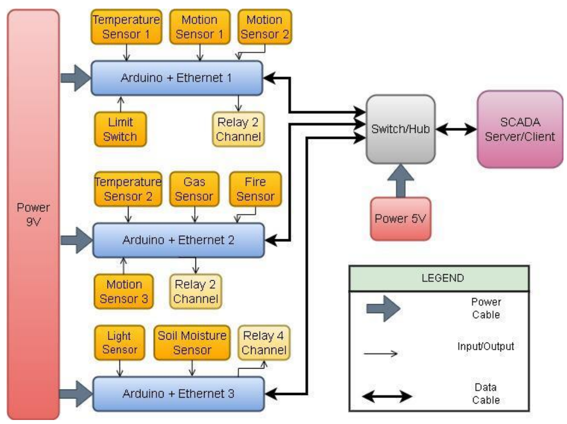

Figure 2 System Block Diagram

The work sequence of the system in Figure 2 begins with providing a voltage supply to 3 Arduinos of 9 Volts. Arduino will work with input data from the output of sensors that have been connected to the Arduino analog input pins. After the data from the sensors is obtained, the data is immediately sent to the server via an ethernet network using a switch/hub so that the three Arduinos can connect to the server. The switch/hub is also given 5V power so that it can work according to its function. After connecting to the server, the data can be accessed via the client's computer.

2.2 Home Installation Design

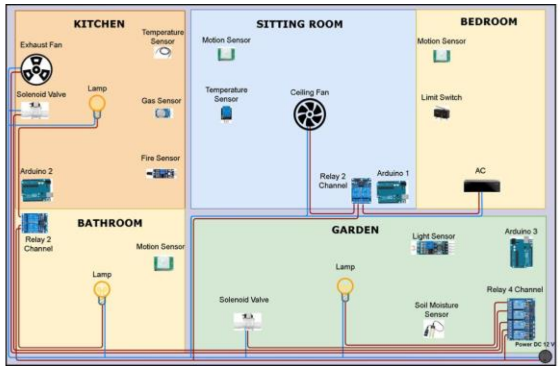

Figure 3 House Installation Design

The prototype in Figure 3 illustrates the design of the equipment installation, namely the living room; there are 2 sensors, namely a PIR sensor and a temperature sensor. The PIR sensor detects people in the room. When the PIR sensor detects people, the HMI display indicator light will be ON. In the living room, there is also a temperature sensor to find out the room temperature; if the temperature is above 30℃then the ceiling fan will turn on, and the HMI display indicator will be ON. Vice versa, when the temperature is below 30℃ then, the ceiling fan will turn off automatically, and the HMI display indicator will be OFF. In the bedroom, when the bedroom door is opened, the limit switch sensor will be detected ON, and the AC will be ON immediately. While in the bedroom, the PIR sensor will also detect people who are in the bedroom, which keeps the AC running even though the door is closed. In the kitchen room, there are several sensors that are used to control electrical equipment, namely the temperature sensor. When the kitchen temperature is over 30℃then, the exhaust fan in the kitchen will be ON, and when the kitchen temperature is below 30℃ then, the exhaust fan will turn off. Likewise, the gas sensor in the kitchen detects a gas leak, if there is a gas leak, the exhaust fan will turn ON, and the lights and other electrical equipment will automatically turn off. When a gas leak is not detected, the lights/kitchen electrical equipment will turn on again. If a fire occurs, the fire sensor will detect the fire and give an ON signal to the attached solenoid valve and buzzer. Vice versa, if the fire is extinguished, the solenoid valve and buzzer will stop working. In the bathroom, there is 1 PIR sensor which functions to turn on/off the lights automatically if someone is in the bathroom or not. In the park, LDR sensors and soil moisture sensors are installed, which function to control garden lights and solenoid valves in the park. During the day, the garden lights will be OFF, and if it is dark, the garden lights will be ON. When the soil moisture sensor detects dry soil, the solenoid valve will continue to be ON to open water. If the soil in the garden is damp and wet, the solenoid valve will be off.

2.3 Arduino circuit

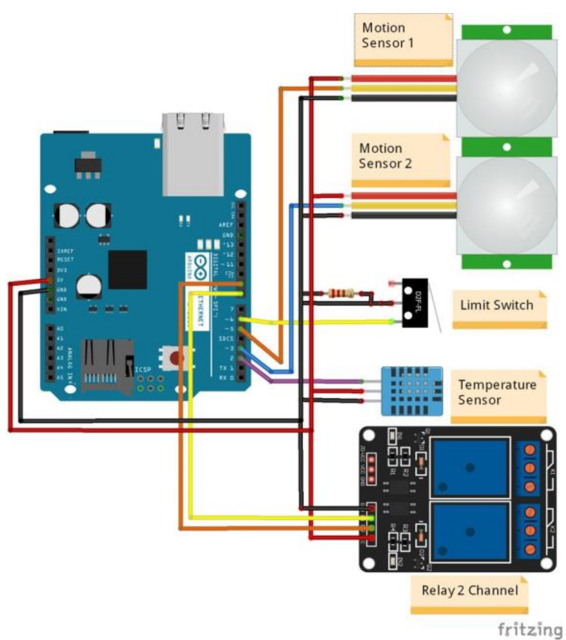

Figure 4 Arduino 1 circuit

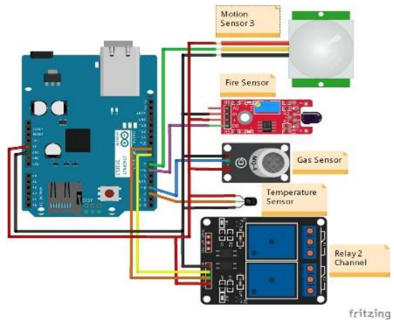

Figure 5 Arduino 2 circuit

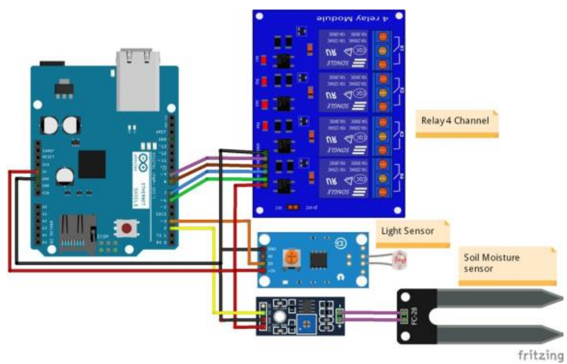

Figure 6 Arduino circuit 3

3. Results and Discussion

3.1 Hardware Assembly

At the Arduino assembly stage, with sensors installed in every room, the sensors will be connected to each predefined Arduino; Installation of sensors using JST port cables to make it easier to assemble. The board used to put the Arduino in position uses an acrylic board to make it look cleaner and neater. Giving color to each room will look more attractive

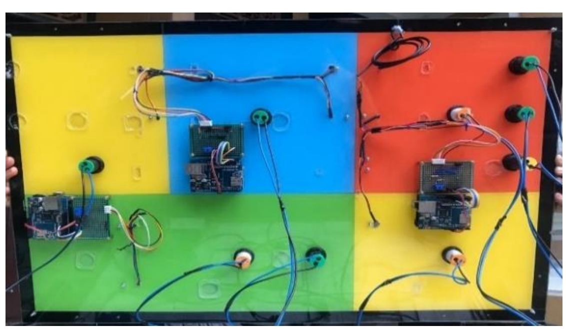

Figure 7 Sensor Placement Assembly and Arduino

Predetermined positioning of switches/hubs and relays; After placing these tools into the appropriate position, wire the relay to the load of the electrical equipment and attach the data cable to be connected to the Arduino microcontroller. A DC power supply of 9 volts with a maximum current of 2A is connected to the Arduino port, as shown in Figure 7. The control of equipment indicator lights uses a DC relay.

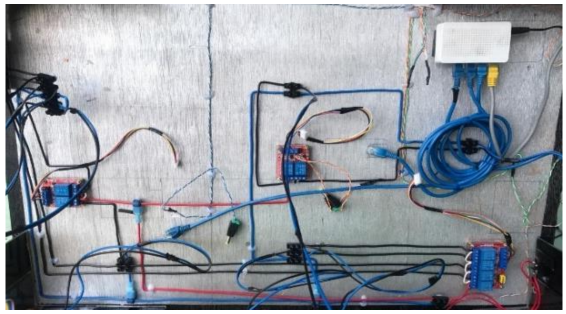

Figure 8. Overall Assembly of Tools

3.2 System Testing

SCADA System Testing is carried out to ensure that the system can monitor and retrieve data in real time according to the function and work of the prototype tool. Tests in this study were divided into tests on each input/output using Matrikon OPC software, SCADA system testing on VTScada software, delay testing on output electrical loads and testing on prototype work. The test results are as in table 1.

Table 1. Test Results on the Matrix

No	ID items	Score	Status	Success
1	led1	false	Active	Succeed
2	led2	false	Active	Succeed
3	Limit1	false	Active	Succeed
4	PIR1	false	Active	Succeed
5	PIR2	false	Active	Succeed
6	temperature1	28	Active	Succeed
7	Fire	false	Active	Succeed
8	Gas	true	Active	Succeed
9	Led3	false	Active	Succeed
10	Led4	false	Active	Succeed
11	PIR3	false	Active	Succeed
12	temperature2	27.5	Active	Succeed
13	LDR	false	Active	Succeed
14	led5	false	Active	Succeed
15	Led6	false	Active	Succeed
16	led7	false	Active	Succeed

From the results of the input/output test using the OPC matrix above, all items were successfully connected to Arduino according to their work function. Each sensor can detect input from the outside, while the output can be monitored and controlled through the SCADA system. The quality of all input/output readings results in the prototype being able to operate properly. The date and time are clearly visible on the OPC Matrix display, and the status of all items is shown as all active. So testing on all input/output items on SCADA hardware is in good condition.

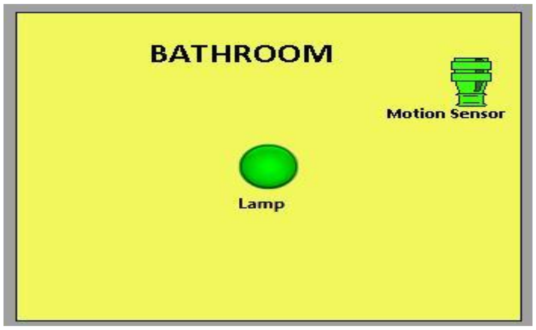

Figure 10. Example of a Limit Switch ON

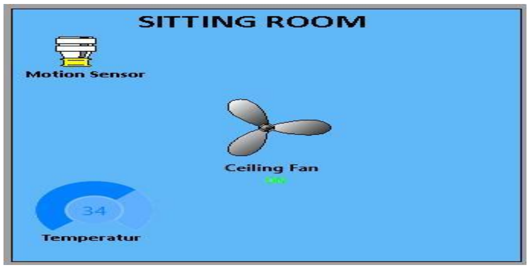

Figure 11. Example for Living Room Temperature >30℃

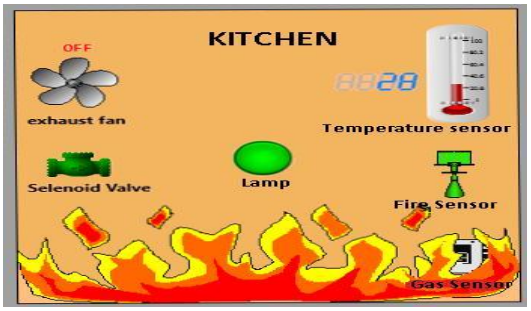

Figure 12. Example Display During a Fire

Figure 13 Display of the ON state of the PIR sensor

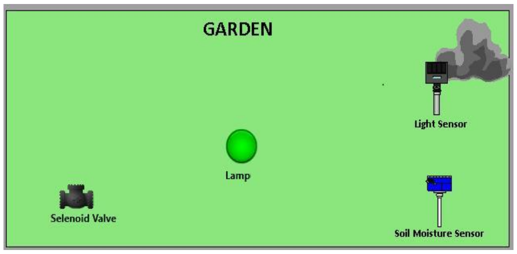

Figure 14 Appearance when it's cloudy and wet

Table 2 Delay Test Results at VTScada Output

No	Output name	Time Relays		Feedback VTScada	Remark
		ON	**OFF**		
1	Ceiling Fans	2.75	3.15	displayed	Good
2	air conditioning	2.62	3.01	displayed	Good
3	Exhaust Fan	2.37	2.65	displayed	Good
4	Kitchen Solenoid Valves	2.30	1.78	displayed	Good
5	Kitchen Lamp	2.11	2.96	displayed	Good
6	bathroom lamp	1.91	2.15	displayed	Good
7	Garden Solenoid Valves	1.85	2.05	displayed	Good
8	Garden lamps	2.76	2.31	displayed	Good

In the results of the delay test at the VTScada output, the average delay time that occurs when the electric load is ON is around 1.80 seconds (ON delay), while the OFF delay when the electricity load is OFF is around 1.90 seconds. This is influenced by the number of I/O tags in the VTScada software so that the data traffic received and sent in the system has a high frequency. The average ON delay that occurs is 2.33 seconds, and the OFF delay is 2.50 seconds.

Table 3 Test Results on the Entire System

No	Steps	Condition	Success
1	Powering 9V on all three arduinos	Normal	Succeed
2	Gives a Switch/Hub power of 5V	Normal	Succeed
3	Data cable installation on arduino and laptop	Normal	Succeed
4	Check the LED on the Switch/Hub	Normal	Succeed
5	Open Arduino OPC Server	Normal	Succeed
6	Open the OPC Matrix	Normal	Succeed
7	Open VTScada Software	Normal	Succeed
8	Provides 220V AC power to the pilot indicator light	Abnormal	Has not succeeded

From the results of testing the entire system, it can be seen that the system can work properly before providing power to the 220V AC indicator light. When supplying 220V AC power to the pilot, the indicator light can jam the system. The solution to the jammed system that was created was to replace the 220V AC pilot indicator light with a 12V DC pilot indicator light. So using 220V AC voltage at the load output will make the system crash.

4. Conclusion

From the results of testing and analysis of the installation monitoring system for the utilization of household electrical energy using a microcontroller-based SCADA, the following conclusions can be drawn:

1. The microcontroller-based SCADA monitoring system can be an alternative in monitoring, controlling and utilizing electrical energy in households with very small delays and can be done in real time.
2. Every input/output connected to the three Arduinos can be monitored, such as item ID, sensor value data that can be read and written, installation quality, time and status through the OPC Matrix.
3. Each room can control its output load by providing logic that is made in the form of tags that can be designed and monitored directly through the VTScada software. The appearance of the VTScada software matches the appearance of the prototype tool made.
4. The delay that occurs in the SCADA system is caused by a large number of input/output tags used, which causes delays in data transfer in the VTScada software. If more input/output tags are used, the longer the delay that will occur in the SCADA system. On the other hand, if there are fewer input/output tags used, the delay that occurs in the SCADA system will be faster.
5. The system can work normally using 12V DC on the wiring in the relay. If using 220V AC, then the system will crash and stop working.
6. Overall shows that the system can work properly and has been running according to the expected design.

Funding: This research received no external funding.
Conflicts of Interest: The authors declare no conflict of interest.
Publisher's Note: All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers.

References

[1] Anggher D P, Feby A and Bengawan (2019). Sistem Monitoring Beban Listrik Berbasis Arduino NODEMCU ESP8266, *Jurnal AMPERE, 4*(1)
[2] Apriyoga, I,M.T, Eddy SM (2015). Implementasi sistem scada pada rumah hunian menggunakan android berbasis Arduino*, Artikel ilmiah Prodi Teknik Elektro, 7(*1)
[3] Artono B, and Rakhmad G P (2018). Penerapan Internet of Things (IoT) Untuk Kontrol Lampu Menggunakan Arduino Berbasis Web, *Jurnal Teknologi Informatika dan Terapan, .5(*1)
[4] Haris I and Dedy H (2017). Monitoring system refrigerasi pada cold storage berbasis SCADA, Seminar Nasional Sains dan Teknologi, Fakultas Teknik Universitas Muhammadiyah Jakarta
[5] I Gusti P M E, Ida A D G and Lie J (2017). Monitoring Penggunaan daya listrik sebagai implementasi Internet of Things Berbasis Wireless Sensor Network, *Tekologi Elektro, 16(3)*
[6] Kurniawan E, Cucu S, Dedy T (2013). Sistem Penerangan Rumah Otomatis Dengan Sensor Cahaya Berbasis Mikrokontroler, *Jurnal Coding Sistem Komputer Universitas Tanjungpura, 01(2*) Hal 1-10
[7] Muslihudin M, Willy R, Taufiq, A A and Fery S (2018). Implementasi Aplikasi Rumah Pintar Berbasis Android dengan Arduino Microcontroller, *Jurnal Keteknikan dan Sains (JUTEKS), 1(1)*
[8] Raden F D F W, Dadan N B and Edi R (2019). Sistem Kendali dan Pemantauan Lampu Penerangan dan Keamanan di Area Kampus Berbasis SCADA, *Prosiding Industrial Research Workshop and National Seminar, 10(1)*
[9] Sri M. S (2018). Internet of Things (IoT) pada prototipe penditeksi kebocoran gas berbasis MQ-2 dan SIM800L, *Jurnal Teknik Universitas Muhammadiyah Tanggerang, 7(2*) hlm.67-72
[10] Wahyu D and Akhmad, A (2017). Rancang Bangun Sistem Pengairan Tanaman Menggunakan Sensor Kelembapan Tanah, *Jurlan Teknologi Elektro Universitas Mercu Buana*