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Design and Implementation of Smart Multi Socket Power System for Efficient Monitoring, Control and Management of Domestic Appliances

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Abstract - The rapid growth of electrical and electronic appliances in modern households has increased the demand for intelligent, safe and efficient power distribution systems. Conventional switchboards and extension sockets provide limited control, lack monitoring features and may lead to energy wastage and safety risks. The design and implementation of a Smart Multi-Socket Power System using the ESP32 microcontroller for voice control and remote switching of domestic appliances. The system integrates multiple 6A and 16A sockets within a single unit, where each socket can be independently controlled through mobile based ON/OFF commands and voice assistance. The ESP32 acts as the central control unit, enabling wireless communication and real-time system operation through Wi-Fi. Voltage and current sensors are used to measure electrical parameters of connected appliances. The ESP32 processes these values to estimate power consumption, allowing users to monitor energy usage effectively. To enhance safety, a Miniature Circuit Breaker (MCB) is incorporated to protect against overload and short circuit conditions.

Keywords - ESP32, Smart Multi-Socket System, Home Automation, Voltage Sensor, Current Sensor, Remote Switching, Voice Control, Wi-Fi Communication, Relay Module, MCB Protection.

I. INTRODUCTION

The rapid advancement of technology and the increasing use of electrical and electronic appliances in modern households have significantly raised the demand for efficient and intelligent power distribution systems. From lighting and fans to high-power appliances such as heaters, refrigerators, and washing machines, homes today depend heavily on electricity. However, conventional switchboards and extension sockets offer only manual ON/OFF control and lack features such as remote access, real-time monitoring, and advanced safety mechanisms. This limitation often results in energy wastage, reduced efficiency, and potential electrical hazards. With the development of Internet of Things (IoT) technology, smart home automation systems have become more popular due to their ability to provide remote operation, improved convenience, and better energy management. In this context, the Smart Multi-Socket Power System is designed to enhance control and monitoring of domestic appliances using the ESP32 microcontroller.

The ESP32 provides built-in Wi-Fi capability, enabling wireless communication between the socket system and a mobile application for remote control and voice-based operation. The proposed system integrates multiple 6A and 16A sockets within a single unit, allowing users to connect both low-power and high-power appliances. Each socket can be independently controlled through a mobile application. Voltage and current sensors are incorporated to measure electrical parameters of the connected load. The ESP32 processes these readings to estimate power consumption, enabling users to monitor energy usage effectively.

To ensure safety and reliability, the system includes a Miniature Circuit Breaker (MCB) for protection against overload and short-circuit conditions. USB Type-C and Type-B ports are also included for convenient charging of electronic devices. Overall, the proposed system offers a smart, safe, and energy-efficient solution suitable for modern residential and commercial applications. To improving convenience and safety, the Smart Multi-Socket Power System plays an important role in promoting energy awareness among users. By providing real-time voltage and current monitoring, the system helps users understand how much power each appliance consumes. This encourages responsible usage of electrical devices and supports energy conservation practices. As electricity demand continues to rise, efficient monitoring and control systems become essential to reduce unnecessary power consumption and lower electricity billsThe ESP32 microcontroller is selected for this project due to its high performance, low power consumption, and built-in Wi-Fi capability. It enables seamless communication between the hardware system and mobile applications without requiring additional communication modules. The relay module connected to the ESP32 allows safe switching of high-voltage AC loads using low-voltage control signals.

This ensures proper isolation between control and power circuits.Overall, the Smart Multi-Socket Power System represents an advancement over traditional electrical distribution methods. It combines automation, monitoring, and protection into one intelligent system, contributing to safer operation, improved efficiency, and the development of smart home environments.

II. LITERATURE REVIEW

Pathak et al has gained importance in a way to create 'smart objects' with embedded sensing, actuation, computation, communication capabilities to share information and provide value-added services to an end user. Smart Home technology with IoT is greatly on the rise as it promises to provide comfort living with optimal use of resources in a secured environment. This paper proposes the design and implementation of smart switch board control system for local/remote switch control of home appliances/devices in a room through the dedicated web-based control application accessible over the internet. Using the standard Ethernet integrated with embedded controller and programmable interactive switch board, the system allows the authentic remote user to control the ON/OFF switch operation of room devices such as lights, fans, heater, cooler, mobile charger etc. as well as speed-control of fan through the graphically designed web-application with unique IP address. The current status of the room appliances is also refreshed on the remote panel following the bi-directional communication over the network.

Islam et al has Current energy management system calls for reliability and reduction between power supply and demand gaps. As huge development is being made in Smart Grid & Smart Metering systems, other electric switches and components requires upgrade too. This calls for the need of introducing smart switching technology. This paper represents ‘Smart Switch Board’ which is the smarter version of the traditional switch boards. It is an IoT based switching device which enables it to be controlled via apps from smart devices and this feature would become very useful for the old and handicapped persons. Besides, smart switch meter can be used to control smaller areas if it is connected with the router. In that case, it will function via router’s ip address which will make the system more secured. Again, physical contact is not required to operate it and due to the usage of electronics, ac/dc power conversion is required which ensure reliability and safety from fire accidents.

Teemu Outinen et al has investigate what kind of exchange electricity control methods could be made for heating with Legrand's existing smart components. The goal was also to find alternative solutions for how it could be implemented with components already available on the market, utilizing the current SLY wiring or Legrand's smart components. In the theoretical part, the participants got to know the components of Legrand, what they could be implemented with and what kind of development opportunities they had. The smart switchboard, exchange electricity and electricity exchange were also the subject of investigation. The possible future power fee for electricity was also a concern when writing the thesis.

Sharifah Azzila Roslan et al had Smart Switch used Internet of Things based (IoT) system and used Blynk to connect the software and the hardware. Significantly, Smart Switch lets the consumer to control the condition of fan and lamp switches remotely without manually pressed the conventional switch on the wall. Electrical consumer tend to forget to turn off their electrical appliance switches specifically the fan and the lamp which will lead to waste of electrical consumption in their household. The Smart Switch's main objective is to prevent electrical waste and facilitate controlling the switches of the lamp and fan remotely wherever the consumer is. In addition, Smart Switch can track the condition of the switches either is still turn on or off. It allows the consumer not in the particular connection range to have access to deal with the switch. Smartphones and electrical appliances in the home need to be connected to Wi-Fi. Therefore, the user can control the lights and a fan via a smartphone without using conventional wall switches.

Peter Holcsik et al had handling short-time short-circuits without causing equipment failure is the management of the reclose function integrated into smart switchboard which is described in this article. Due to the cost of the application, the optimal placement of such equipment must be well-planned. During the planning of the placement optimization of a low-voltage electricity network quality, the increase of the consumer supply security must be considered along with the best economic utilization. The research presented in this article aims to introduce a new special decision support methodology calculated with these variables. The management of smart switchboard (SSB) tool installation into low voltage (LV) network was investigated. The selection of the placement nodes is based on the complex investigation of the network characteristics. Investigation is performed by empiric analysis. This method can support the power companies to make the optimal decision.

Siwanatthakul Chaiyason et al had management and operation of an electrical switchboard originally was processed by an inspector so only tangible malfunctions could be identified while other intangible ones that can cause severe damages to the switchboard were overlooked. To solve this serious deprivation, this investigation, therefore, implemented an intranet sensors system in the electrical switchboard to create a new channel of communication via smart devices to operate and access it remotely, which will eventually lead to increased safety and efficiency of managing electrical switchboards, as well as manufacturing reliability and stability. All these will also increase competitiveness in business. The findings of this research indicate that the application could solve the deprivation by signaling all security malfunctions, both tangible and intangible, remotely via smartphones and laptops in the real-time operating system, which helps reduce severe damages to the switchboard, on-site inspection, and loss of service time to fix malfunctions and human and related risks, as well as increase manufacturing reliability and stability of the operation.

Farah Khaliq Baloch et al had The Internet of Things (IoT) has ushered in an era of transformative innovation, revolutionizing the way we interact with our surroundings. In the context of home automation, the IoT-Based Smart Switch with Touch Control project represents a leap forward in convenience and efficiency. This research explores the development and implementation of a switch board devoid of mechanical components, relying instead on touch sensors and advanced microcontroller technology. The aim is to create a touch-operated switchboard, of standard size and uncompromising reliability, with the potential to revolutionize everyday living. The research delves into the methodology, key components, beneficiaries, and the constraints involved in this innovative project. Moreover, it provides a detailed account of the project's first evaluation task and the technology used, including the PZEM Power Module, ESP8266 NodeMCU, and Home Assistant. This research illuminates the potential of IoT in simplifying and enhancing the lives of not only the technologically inclined but also senior citizens and the middle class, who may have been previously unable to afford high-cost switch boards with advanced functionality.

The literature survey highlights various research studies related to smart power distribution and home automation systems that integrate modern technologies for efficient energy management. Several studies emphasize the importance of intelligent control systems in reducing energy wastage and improving electrical safety in residential environments. Research on IoT-based smart socket systems demonstrates the effectiveness of wireless communication and mobile-based control for remote operation of domestic appliances.

III. DESCRIPTION OF THE EXISTING SYSTEM

In recent years, IoT-based home automation systems have been developed to provide remote control of household electrical appliances. The commonly used existing system is based on Node MCU (ESP8266) along with relay modules for switching electrical loads. These systems allow users to control appliances such as lights and fans through a mobile application using Wi-Fi connectivity.

In the existing system, the AC mains supply is converted into 5V DC using a transformer-based power supply circuit consisting of a transformer, rectifier, filter capacitor, and voltage regulator. This regulated DC supply is used to power the Node MCU and relay modules. The Node MCU connects to a Wi-Fi network and communicates with a mobile application like Blynk. When a user sends an ON/OFF command through the application, the signal is transmitted over the internet to the microcontroller.

The Node MCU processes the received signal and sends a control output to the relay module. The relay, which acts as an electrically operated switch, controls the high-voltage AC load using a low-voltage control signal. When the relay is activated, the connected appliance turns ON; when deactivated, the appliance turns OFF. This allows remote operation of electrical devices from anywhere. Although the existing system provides basic remote switching functionality, it has several limitations.

Fig.1. Existing system of smart switch board

Energy consumption data is generally not available, making it difficult for users to track power usage. Additionally, many existing systems support only limited load capacity and do not integrate both 6A and 16A sockets within a single compact unit. Safety features in existing systems are also minimal, often limited to basic relay isolation and simple circuit protection. Advanced protection mechanisms such as integrated MCB protection and structured multi-socket design are not commonly included. Furthermore, some systems depend heavily on internet availability, which may reduce reliability during network failure.

IV. PROPOSED SYSTEM

The proposed system is a Smart Multi-Socket Power System designed to provide intelligent control, monitoring, and protection for domestic electrical appliances. Unlike conventional switchboards, this system integrates both hardware and software to enable remote switching, voltage and current monitoring, and enhanced safety features within a single compact unit. The system is built around the ESP32 microcontroller, which serves as the central control unit. The ESP32 is chosen for its built-in Wi-Fi capability, fast processing speed, and low power consumption. It enables wireless communication between the multi-socket system and a mobile application, allowing users to control appliances from anywhere.

The proposed system includes multiple 6A and 16A sockets, enabling connection of both low-power and high-power appliances. Each socket is connected to a relay module, which allows independent ON/OFF control through mobile commands or voice-based instructions. When a command is sent from the mobile application, the ESP32 processes the signal and activates the corresponding relay, thereby switching the selected socket. To improve energy awareness and monitoring, voltage and current sensors are integrated into the system. These sensors continuously measure the electrical parameters of connected loads. The ESP32 reads the sensor data and calculates power consumption, which can be displayed in the mobile application. This helps users track energy usage and reduce unnecessary power consumption.

For safety purposes, the system incorporates a Miniature Circuit Breaker (MCB) to protect against overload and short-circuit conditions. Proper isolation between control and power circuits ensures safe operation. Additionally, USB Type-C and Type-B ports are included to provide direct charging facilities for electronic devices. Overall, the proposed system enhances convenience, safety, and energy efficiency by combining remote control, real-time monitoring, multi-socket integration, and protection mechanisms in a single smart unit. It is suitable for modern smart homes, offices, and commercial environments.

Block Diagram

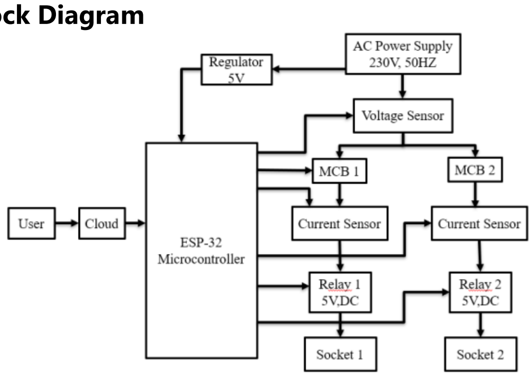

Fig.2. Block Diagram of the Proposed System

Flow Chart

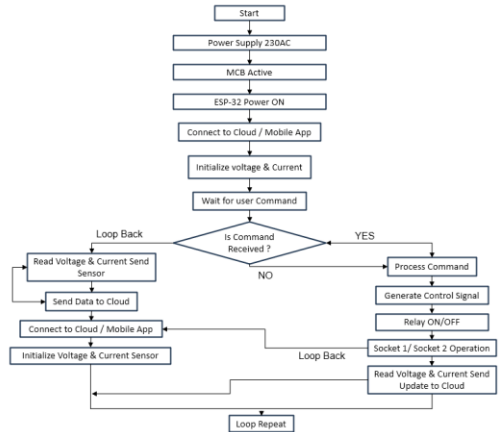

Fig.3. Flow Chart of Proposed System

Hardware Implementation

The hardware implementation of the Smart Multi-Socket Power System is designed to ensure safe and efficient operation of domestic appliances. The system receives 230V AC mains supply through a Miniature Circuit Breaker (MCB), which provides protection against overload and short-circuit conditions. The AC supply is distributed to the sockets through relay contacts for controlled switching. The ESP32 microcontroller acts as the central control unit of the system. It is powered directly through its USB input and manages wireless communication, sensor data processing, and switching operations. The ESP32 connects to a Wi-Fi network to receive commands from a mobile application for remote and voice-based control of the sockets.

Voltage and current sensors are connected to monitor the electrical parameters of the connected loads. These sensors continuously measure the supply voltage and load current, and the ESP32 reads these values to estimate power consumption. The monitored data can be transmitted to the mobile application for real-time observation. A relay module is interfaced with the ESP32 to independently control the 6A and 16A sockets. The relay functions as an electrically operated switch, allowing the low-voltage control signal from the ESP32 to safely switch high-voltage AC appliances. When an ON or OFF command is received, the ESP32 activates or deactivates the corresponding relay, thereby controlling the selected socket. USB Type-C and

Type-B ports are also incorporated to provide direct charging capability.

Proper isolation between the control circuit and the high-voltage AC section is maintained to ensure safety. Adequate wiring, earthing, and protective components are used to enhance system reliability. Overall, the hardware implementation integrates control, monitoring, protection, and multi-socket functionality into a compact and efficient smart power distribution unit.

Hardware Components:

ESP32 microcontroller: The ESP32 microcontroller is the main control unit of the system. It features built-in Wi-Fi capability, which allows wireless communication with a mobile application for remote and voice-based control. The ESP32 processes the data received from voltage and current sensors and controls the relay module accordingly.

Fig.4. ESP32 microcontroller

Relay module: A relay module is used to switch the connected 6A and 16A sockets. The relay acts as an electrically operated switch that allows low-voltage control signals from the ESP32 to safely control high-voltage AC appliances. Each socket is connected to a dedicated relay channel for independent control.

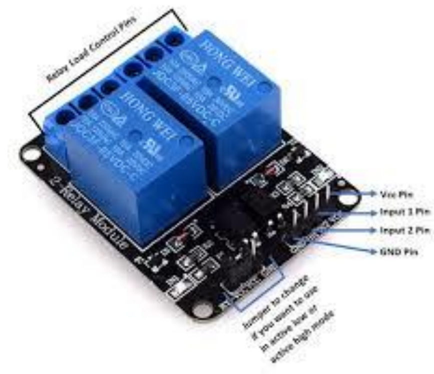

Fig.5. Relay module

Miniature Circuit Breaker: The system includes a Miniature Circuit Breaker (MCB) at the input stage to provide protection against overload and short-circuit conditions. This ensures safety by automatically disconnecting the supply when abnormal current levels are detected.

Fig.6. Miniature Circuit Breaker

Voltage sensor: The voltage sensor module is

Fig.7. Voltage sensor

used to measure the AC supply voltage applied to the connected appliances. It works by reducing the high AC voltage to a lower, safe level that can be read by the ESP32 microcontroller. The module typically consists of a voltage divider network or isolation circuit that scales down the input voltage.

Current sensor: The current sensor module is used to measure the load current drawn by the connected appliances. In this project, a sensor such as the ACS712 can be used. The current sensor works based on the Hall Effect principle, where the magnetic field generated by the flowing current is converted into a proportional voltage output.

Fig.8. Current Sensor

USB Type-B & C: USB Type-B and USB Type-C ports to provide convenient and direct charging facilities for electronic devices. These ports allow users to charge smartphones, tablets, power banks, and other low-power gadgets without requiring separate external adapters.

Fig.9. USB Type-B & C

Indication lamp: The indication lamp is used to visually display the operating status of the Smart Multi-Socket Power System. It helps the user easily identify whether the system or a particular socket is powered ON or OFF. The indication lamp is typically an LED connected to the control circuit or across the output line of each socket.

Fig.10. Indication lamp

6 & 16A socket: 6A and 16A sockets to support different types of domestic electrical appliances. The 6A socket is designed for low-power devices such as lights, fans, chargers, televisions, and small electronic equipment. It is suitable for loads that require lower current capacity and ensures safe operation for everyday household appliances.

Fig.11. 6&16A Socket

Working of Proposed System

The proposed Smart Multi-Socket Power System operates by integrating wireless control, switching mechanisms, and electrical parameter monitoring into a single unit. When the system is powered, the 230V AC mains supply is provided through the Miniature Circuit Breaker (MCB), which ensures protection against overload and short-circuit conditions. The supply is then distributed to the 6A and 16A sockets through relay contacts. The ESP32 microcontroller acts as the central control unit of the system. Once powered, it connects to a Wi-Fi network and establishes communication with the mobile application. The user can send ON or OFF commands through the mobile app or voice control interface. When a command is received, the ESP32 processes the signal and activates the corresponding relay. The relay then switches the selected socket ON or OFF by controlling the live AC line connected to the appliance.

At the same time, the voltage sensor measures the supply voltage and the current sensor measures the load current drawn by the connected appliance. These sensor readings are continuously monitored by the ESP32. Using the measured voltage and current values, the microcontroller calculates the power consumption and updates the information to the user interface for real-time monitoring. The system continues to operate in a loop, allowing continuous monitoring and control. If any abnormal condition such as overload occurs, the MCB automatically disconnects the supply to ensure safety. Thus, the proposed system provides intelligent switching, real-time monitoring, and enhanced protection in a compact smart multi-socket unit suitable for modern applications.

Discreption of The Proposed System

The operation of the proposed Smart Multi-Socket Power System begins when the 230V AC mains supply is provided to the system through the Miniature Circuit Breaker (MCB). The MCB ensures protection by disconnecting the supply in case of overload or short-circuit conditions. Once powered, the ESP32 microcontroller initializes and connects to the available Wi-Fi network to enable communication with the mobile application. After successful connection, the system enters standby mode, waiting for user commands. The user can control the 6A and 16A sockets through a mobile application or voice command. When an ON or OFF command is sent, the ESP32 receives the signal via Wi-Fi, processes it, and sends a control signal to the corresponding relay module. The relay then switches the connected appliance by controlling the live AC supply line. Simultaneously, the voltage sensor monitors the supply voltage and the current sensor measures the load current flowing through the appliance. The ESP32 continuously reads these sensor values and calculates the power consumption. This data can be viewed in the mobile interface for real-time monitoring. The system operates continuously in this manner, allowing independent control and monitoring of each socket. In case of any abnormal current flow, the MCB provides automatic protection, ensuring safe and reliable operation of the entire system.

V. RESULTS AND DISCUSSIONS

The Smart Multi-Socket Power System was successfully designed and implemented to provide remote control and monitoring of domestic appliances. The ESP32 microcontroller established stable Wi-Fi communication with the mobile application, enabling smooth and real-time ON/OFF control of both 6A and 16A sockets. The relay module responded quickly to user commands, and the switching operation was completed within a short response time. The voltage and current sensors accurately measured the electrical parameters of connected appliances. The ESP32 processed these values and calculated power consumption effectively. The monitored data was displayed on the mobile interface, allowing users to observe real-time electrical conditions. The system demonstrated reliable performance under normal household load conditions.

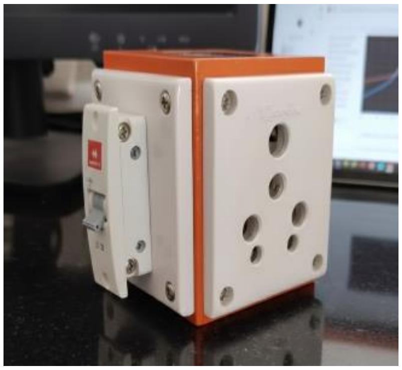

Fig.12.Design and Implementation of Smart Multi socket Power System for Efficient Monitoring, Control and Management of Domestic Appliances

The inclusion of the Miniature Circuit Breaker (MCB) provided effective protection against overload and short-circuit scenarios. During testing, the MCB successfully disconnected the supply when abnormal current conditions were simulated, ensuring safety. Overall, the proposed system performed efficiently in terms of remote control, monitoring accuracy, response time, and safety.The integration of multiple socket ratings (6A and 16A), USB effective, and efficient solution for smart home power management applications.

charging ports, and monitoring features enhanced its practicality. The system proved to be a reliable, cost-

V. CONCLUSIONS

The Smart Multi-Socket Power System was successfully designed and implemented to provide intelligent control, monitoring, and protection of domestic electrical appliances. The system effectively integrates the ESP32 microcontroller, relay module, voltage and current sensors, and protective components into a single compact unit. The ESP32 enabled reliable Wi-Fi connectivity, allowing users to control appliances remotely through a mobile application and voice commands with minimal delay. The system demonstrated stable and accurate measurement of voltage and current parameters. By processing these values, the ESP32 was able to estimate power consumption, helping users monitor their electricity usage and promote energy efficiency. The independent control of 6A and 16A sockets increased flexibility, allowing the system to handle both low-power and high-power appliances effectively.

The inclusion of a Miniature Circuit Breaker (MCB) enhanced system safety by protecting against overload and short-circuit conditions. Proper isolation between control and power circuits ensured safe operation under normal working conditions. The addition of USB Type-C and Type-B ports further improved convenience by enabling direct charging of electronic devices. Overall, the proposed system provides a reliable, cost-effective, and user-friendly solution for smart home applications. It enhances convenience, improves electrical safety, supports energy awareness, and represents a practical step toward advanced home automation and intelligent power management systems.

REFERENCES

1. Agbehadji I. E, Millham R. C, Fong S. J, Jung J. J, Bui K. H. N, & Abayomi A, (2019), “multi-stage steering convention for energy improvement in remote sensor in systems administration. In Worldwide Conference on Soft Computing and Data Science (pp. 223-238)”-Springer.
2. Al-Hubaishi M, Çeken C, & Al-Shaikhli A, (2019), “A novel energy-aware routing mechanism for SDN-enabled WSAN”-International Journal of Communication Systems, 32(17), e3724.
3. Elorbany, C. B. a. S. B., 2021. A Smart Socket Equipped With IoT Technologies for Energy Management of Electrical Appliances. Sakarya University Journal of Computer and Information Sciences, 4(3), pp. 347-353.
4. Gligoric et al., "Smartdev: IoT Product based Passport for Circular Economy depend on Printed Sensors and Unique Item-Level Identifiers," Sensors, vol. 19, no. 3, 2019.
5. B. Huang He. Intelligent design of buildings based on Niagara technology [J]. Neijiang Science and Technology. 2020,41(09):24-25.
6. Li Miao, Fan Guochang, Shi Yuyang, Pan Haofei, Wang Deming. Design and research of WiFi smart socket based on WeChat platform[J].

Science and Technology Perspectives. 2020(26):87-88.
7. Pereira, R. I,Jucá, S. C., & Carvalho, P. C. (2019). IoT embedded systems network and sensors signal conditioning applied to decentralized photovoltaic plants. Measurement, 142, 195-212.
8. Ren Yuanlin. Intelligent monitoring system for building environment based on multi-source data fusion[J]. Journal of Heilongjiang Engineering College. 2022, 36(6): 35-40.
9. Singh, R. R., Yash, S. M., Shubham, S. C., Indragandhi, V., Vijayakumar, V., Saravanan, P., & Subramaniyaswamy, V. (2020). IoT embedded cloud-based intelligent power quality monitoring system for industrial drive application. Future Generation Computer Systems, 112, 884-898.
10. Wang Chunwu, Lu Xinyue, Zhang Xinzhi, Liu Beng, Liu Chunling. An intelligent cloud environment monitoring system based on ESP8266 [J]. Journal of Jilin Normal University (Natural Science Edition).2021, 42(04):74-79.
11. Wang Hongyu. Design and implementation of WiFi-based smart home monitoring system under OneNET cloud platform[D]. Inner Mongolia University.2021.
12. ZigBee Intrusion Detection System for IoT using Secure and Efficient Data CollectionFal Sadikin, Ton van Deursen, Sandeep Kumar December 2020Page 100306.