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Smart Distribution Board Using Blynk

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Abstract

The Smart Distribution Board features an LCD for real-time monitoring of voltage, current, and power consumption, enhancing safety and efficiency in electrical distribution. It includes a microcontroller (Arduino), ZMPT101B voltage sensor, ACS712 current sensor, 16x2 LCD display, and a servo motor for resetting the RCCB after tripping. Integrated with the Blynk platform, the system allows remote monitoring and control via smartphone. Voltage and current sensors continuously measure parameters displayed on the LCD. Upon detecting an overcurrent, the servo motor resets the RCCB after a delay, restoring electrical supply once the fault clears. Users benefit from real-time status monitoring, trip notifications, and remote RCCB control through Blynk. This system leverages IoT capabilities to provide efficient management of electrical parameters and ensures prompt response to faults, improving overall reliability and user convenience in monitoring and controlling electrical distribution.

1. Introduction

Modern electrical power systems now integrate administration, control, design, and operation, linking customers to centralized power plants through extensive transmission and distribution networks. Driven by climate concerns, governments are developing smart cities using advanced technologies to enhance living standards, address environmental issues, and reduce carbon dioxide emissions [1]. A power system delivers electrical energy to end-users, with the distribution system (DS) providing energy at required voltage levels between substations and customers. The main DS operates at higher voltages (11kV, 6.6kV, 3.3kV), while the secondary DS runs at 415V or 230V. Operational losses occur throughout generation, transmission, and distribution [2].

The electrical industry benefits from integrating the Internet of Things (IoT) into power systems, leading to intelligent and efficient power production, transmission, distribution, and consumption. IoT enables real-time monitoring and autonomous decision-making within smart grids, significantly enhancing the performance of these smart nodes and overall system efficiency [3]. A distribution panel board (DPB) is crucial in electrical distribution, linking power feeds to branch circuits and housing circuit breakers for safety. It protects against overloads and short circuits. Advances in ICT and electronics are transforming traditional DPBs by integrating intelligent electronic features and enhanced safeguards [4].

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1.1 Problem statement

A smart distribution board, serving as the central hub for managing electrical circuits, can face various complex issues requiring meticulous examination. Power supply problems necessitate a comprehensive assessment of the main supply, including voltage stability checks and identifying tripped circuit breakers or fuses. Persistent issues mandate engaging a licensed electrician for an in-depth inspection. Communication interruptions, often caused by wireless protocols like Wi-Fi or Zigbee, require evaluating network proximity, physical barriers, and interference, alongside ensuring firmware and software are up to date. Malfunctioning sensors or equipment necessitate methodical testing, checking for loose connections and cable integrity, and replacing or repairing faulty components. Overloading or circuit abnormalities demand careful load redistribution and understanding circuit capacities, with a certified electrician conducting thorough diagnostics if needed. Configuration issues, despite appearing simple, significantly impact performance and require precise setting reviews and manufacturer consultation. Physical damage needs a visual inspection to identify and replace damaged components, maintaining structural integrity. Addressing interference from other electrical equipment involves relocating devices, implementing shielding, or consulting experts for comprehensive resolution.

1.2 Objective

This project aims to build a smart distribution board with three primary objectives. Firstly, the project seeks to design a system that enables real-time monitoring of current and power consumption via the Blynk platform. This will provide users with immediate access to crucial electrical data, enhancing the management of their power usage. Secondly, the system will be constructed to allow users to remotely turn on residual current circuit breakers using a smartphone connected to Blynk, adding a layer of convenience and safety by enabling remote control over the electrical system. Lastly, the project will evaluate the maximum performance of the smart distribution board to ensure it meets the necessary standards of efficiency, reliability, and safety. By achieving these objectives, the project aims to create a robust and user-friendly smart distribution board that integrates modern technology for improved electrical management and safety.

2. Literature review

A distribution board divides electrical power into smaller circuits, each protected by fuses or circuit breakers to prevent electrical hazards like shocks and fires. Typically equipped with a residual current protection device, fuses, and a main circuit breaker, it includes grounding devices and manages multiple power sources. Crucial for home safety, it shields against overloads and shorts, isolating faulty circuits without affecting the entire system. Serving as a central hub in buildings, it connects lighting, outlets, and appliances with individual circuit breakers for each cable. Unlike a central switch, it features separate switches for each circuit, ensuring efficient and safe electrical distribution.[5] The Internet of Things (IoT) is a transformative concept in the IT sector, combining "Internet" and "things." The Internet is a vast global network of interconnected networks using TCP/IP, facilitating global communication through diverse technologies like electrical, wireless, and optical networks across private, public, academic, business, and government sectors.[6] RCCBs monitor circuit currents for imbalances or residual currents to prevent electrical hazards by tripping and cutting off power. Unlike RCCBs, pure RCDs lack overcurrent protection, termed as GFCIs in North America and RCBOs in Europe and Australia, where overcurrent protection is integrated.[7]

2.1 Review on Related Previous Studies

The reviewed articles provide a comprehensive analysis of smart distribution board technology, highlighting its numerous benefits and promising future applications worldwide. The research discusses the development of a smart distribution board, as mentioned in [8], included high-speed CT metering sensor and non-intrusive load monitoring (NILM) for appliance identification and grid demand management. The contributes to the implementation of a smart distribution board are highlighted in [9]. Designed for domestic energy management, emphasizing user-friendliness, simplicity, and cost-effectiveness. It addresses the control of home appliances and energy allotment. Next, [10] highlight to focuses on historical consumption and energy management in residential settings. Using a priority model for energy management in non-smart grid networks. Additionally, design of an IoT- enabled low-voltage distribution panel board are highlighted in [11], that integrated with intelligent capacities and machine learning techniques and focusing on displaying significant information such as voltage, current, and power component. Lastly, in[12] focusing how to develop and design cost-effective smart distribution board.

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3. Methodology

A project's execution has a big impact on its capacity to meet its objectives. Meticulous planning is required from the outset to guarantee the success of this endeavour. For both software and hardware components, this chapter explains the planning, designing, and development process as well as the overall procedure. This sophisticated smart distribution board project demonstrates how a project may be finished all at once by going through the steps step-by-step, starting with planning and ending with execution.

3.1.1 System block diagram

Smart distribution board are made possible with a few core components. The block diagram shown in Figure 1 shows the sensor voltage, current and power are main element to measure:

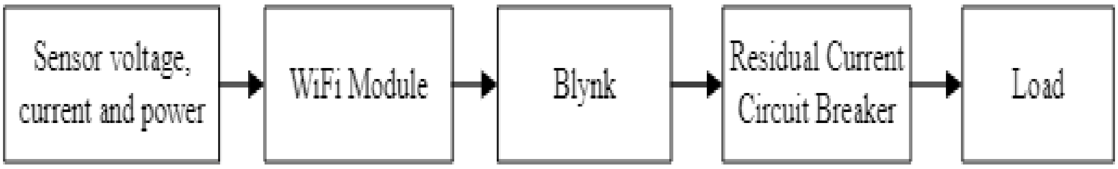

Figure 1: System block diagram

Figure 1 shows blynk used to updated real-time monitoring of voltage, current and power consumption by user smartphone . Blynk will sent a notification thought apps to the user while short circuit or circuit in trip condition. Residual current circuit breaker (RCCB) will turn OFF when short circuit or trip user can turn ON back the RCCB using smartphone that connected to the Blynk. The servo motor will be mounted on the side of RCCB to trigger the breaker. The circuit back to normal when the RCCB triggered ON.

3.1.2 Flowchart system

Figure 2 shows a flow chart system designed based on logical operations.

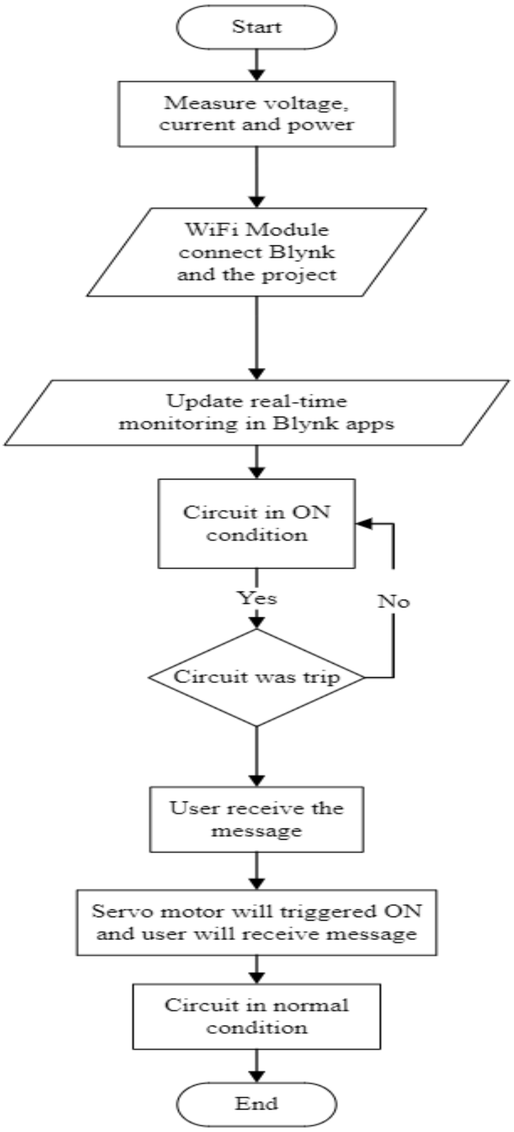

Figure 2: Flowchart system

Figure 2 flowchart illustrates the operation of a smart distribution board system, starting with the initialization of the microcontroller and sensors to prepare them for active monitoring. The system continuously monitors voltage and current levels using integrated sensors, capturing crucial electrical parameters. These readings are then displayed in real-time on an LCD screen, allowing for easy observation of electrical conditions. The system actively checks for any anomalies, such as overcurrent conditions, which may indicate potential electrical faults. Upon detecting such a fault, the Residual Current Circuit Breaker (RCCB) trips to disconnect the power supply, preventing further issues. After a predefined delay, a servo motor automatically resets the RCCB, restoring power once it is safe to do so. The system also integrates with the Blynk platform, enabling remote monitoring and control. Users can receive notifications, check the status, and manually reset the RCCB via a smartphone application, ensuring enhanced safety and operational efficiency. The flowchart effectively outlines the process from initialization to continuous monitoring and fault management, emphasizing the importance of real-time data display and remote control in modern electrical distribution systems.

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3.2 Circuit diagram

The circuit is a guide for the wiring of the electronic components. Figure 3 shows the Arduino Uno circuit diagram.

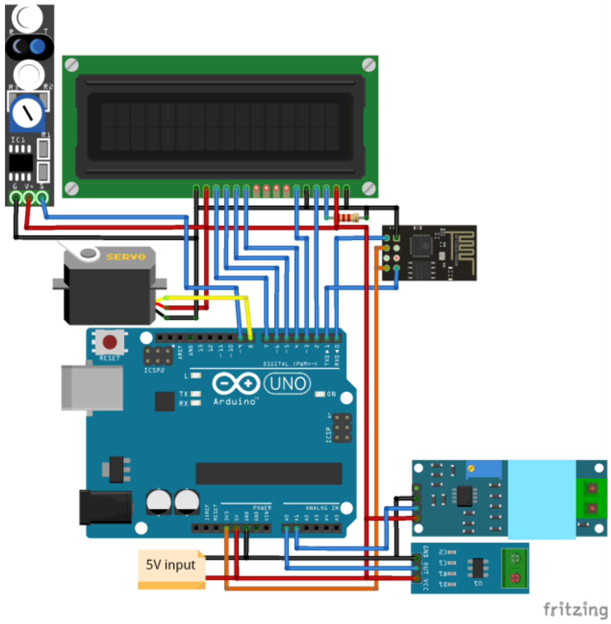


Figure 3 : Circuit diagram

Figure 3 show the smart distribution board setup involves integrating various sensors and components with an ESP8266 microcontroller to monitor and manage electrical parameters effectively. The ESP8266 serves as the core controller, collecting real-time data from a ZMPT101B voltage sensor and an ACS712 current sensor, which measure the AC voltage and current, respectively. This data is then displayed on an LCD to monitoring. Additionally, the system includes a servo motor connected to the ESP8266, which is used to reset the Residual Current Circuit Breaker (RCCB) in case of a trip. The RCCB is equipped with an tracker sensor that provides a signal to the ESP8266, indicating the RCCB toggle status. This signal is crucial for detecting when the RCCB has tripped and needs to be reset. The servo motor's PWM signal from the ESP8266 allows it to move to a specific position to reset the RCCB automatically.

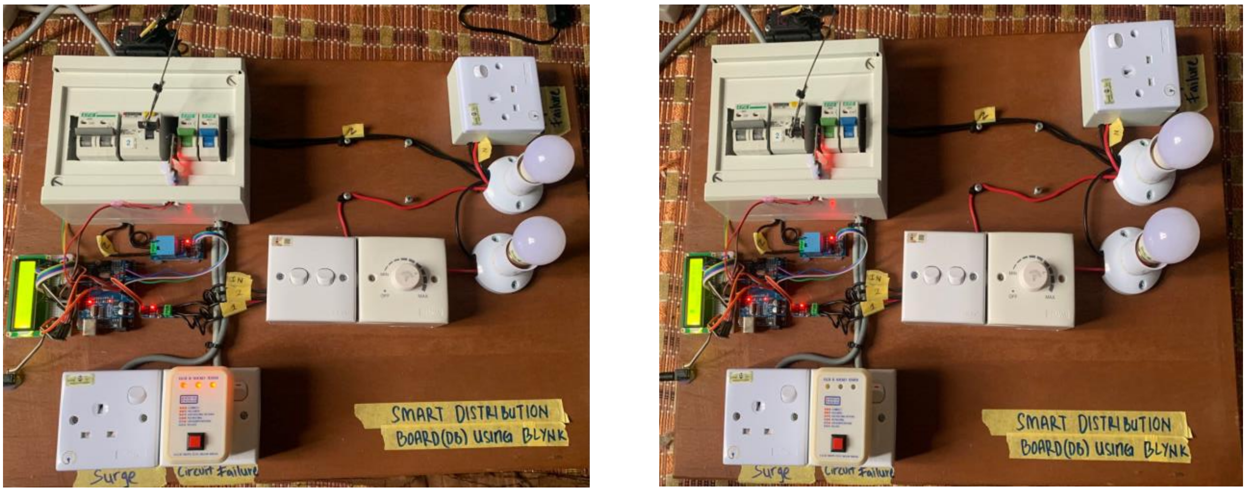
The smart distribution board uses the Blynk platform to keep users informed about system status and any issues. When the RCCB trips due to a fault, tracker sensor will detect the position off RCCB toggle and sent signal about the condition, which then sends a notification through Blynk. If the servo motor is unable to reset the RCCB because of a persistent fault, the system alerts the user to ensure quick action. This setup ensures effective monitoring and management of electrical safety in homes settings.

4. Result

After the connections have been verified, the prototype can be turned on as shown in Figure 4 below.

Figure 4 : Prototype demonstrate

The system is able to work properly and RCCB can be turn on by servo motor MG996R that able to support RCCB , there is no failure that show visible smoke or alarming smell due to wrong circuit connection after turned ON. The system proceed to circuit failure test using socket trip tester. Figure 5 below shows the before and after circuit failure trip test condition.



(a) **(b)**

Figure 5 : Circuit failure trip test (a) Before trip test; (b) After trip test

When the socket trip test button is pressed, the Residual Current Circuit Breaker (RCCB) detects an imbalance in current or earth leakage, causing it to trigger and turn off the power. This safety mechanism prevents potential electrical hazards by disconnecting the circuit when a fault is detected.

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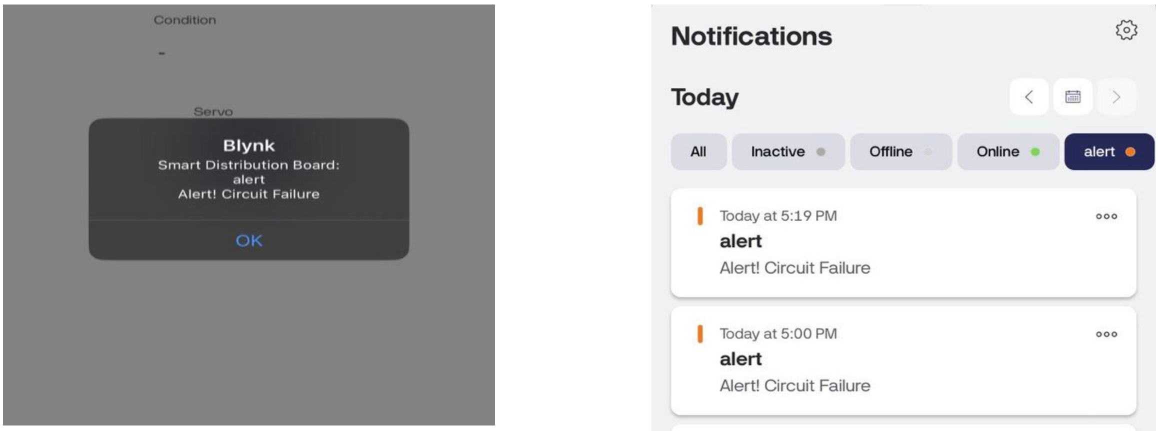
Figure 6 below shows the after trip test condition notification on Blynk apps.



(a) **(b)**

Figure 6 : Notification at Blynk app (a) Pop-up notification; (b) Blynk data cloud

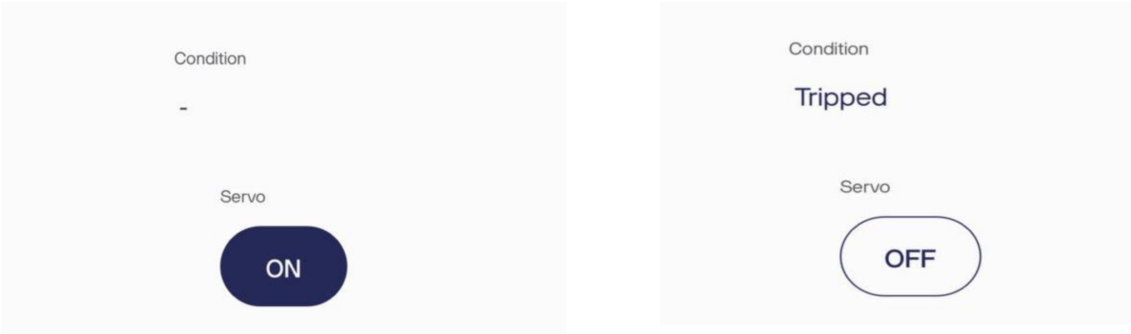
When trip happen Blynk will sent pop-up notification says "Alert! Circuit Failure"to the user smart phone when the RCCB cannot be turn ON back until the failure have been remove. This test also similar with equipment failure test. The history of failure will be save in Blynk cloud as reference to the smart distribution board user. Figure 7 below shows the before and after surge trip test condition.

(a) **(b)**

Figure 7 : Surge trip test (a) Before trip test; (b) After trip test

When trip happen tracker sensor notice the position of RCCB toggle and say "Tripped" on interface that set up in Blynk. On this situation the notification of "Alert! Circuit Failure" will not pop-up because surge happen just a moment then the RCCB can be turn ON back as usual.

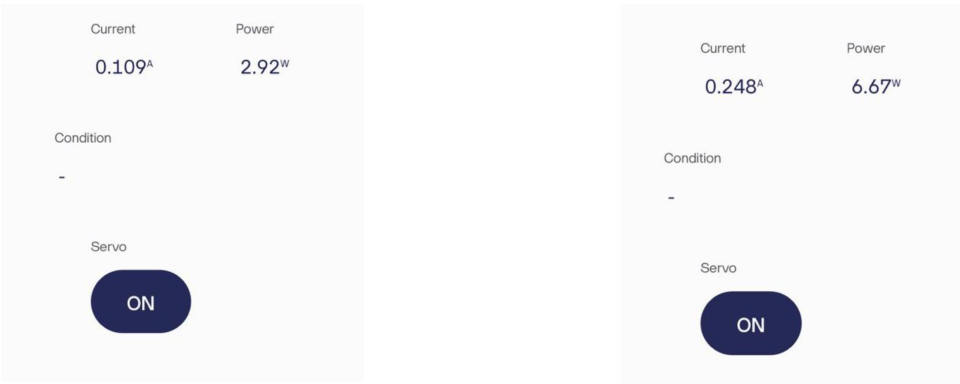
Figure 8 below shows the Blynk interface after trip test condition.



(a) **(b)**

Figure 8 : Interface at Blynk app (a) Before surge happen; (b) After surge happen

When a trip occurs, the tracker sensor detects the RCCB toggle's position and reports "Tripped" on the Blynk interface. In this situation, the notification "Alert! Circuit Failure" does not appear because the surge causing the trip is momentary, and the RCCB can be reset to the ON position as usual. This quick reset prevents prolonged downtime and the need for alerts, ensuring that any transient fault does not trigger unnecessary alarms. Consequently, users can swiftly address minor disturbances without facing undue notifications, maintaining system stability and operational efficiency. This setup enhances the monitoring system's responsiveness and accuracy in managing electrical faults. Figure 9 show the real-time monitoring for current, power for two led bulb.



(a) **(b)**

Figure 9 : Real-time monitoring (a) one LED bulb; (b) two LED blub

In figure 9(a) show, with one LED bulb, the current is 0.109 A, and the power is 2.92 W meanwhile in figure 9(b) show, with two LED bulbs, the current is 0.248 A, and the power is 6.67 W. The power increases proportionally with the number of LED bulbs, reflecting higher energy consumption.

5. Conclusion

The smart distribution board project effectively integrates advanced technology to enhance electrical safety and management in residential and industrial settings. It achieves real-time monitoring of current and power consumption via the Blynk platform, providing users with remote access to detailed electrical data. The system includes a feature to remotely reset the Residual Current Circuit Breaker (RCCB) through a smartphone, facilitated by a servo motor and controlled by the ESP8266 microcontroller, ensuring quick response to faults without the need for physical intervention. This project also evaluates and confirms the board's robustness and reliability under various conditions, proving its capability to handle complex electrical loads efficiently. Overall, the smart distribution board offers a comprehensive solution that combines safety, convenience, and energy management, empowering users to monitor and control their electrical systems effectively, leading to enhanced operational safety and potential energy savings.

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