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Real Time Monitoring Small Scale Off Grid Solar System with Blynk App

Anna Malar Salvan[1]*, Mohd Fadly Abd Razak[1]*,

[1]Department of Electrical Engineering Technology, Faculty of Engineering Technology.
Universiti Tun Hussein Onn Malaysia, Muar, 84600, Pagoh, Johor, MALAYSIA

*Corresponding Author Designation

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Abstract: This research project aims to address the need for a monitoring system specifically designed for small solar grid systems. With the increasing popularity of solar panels as a practical and environmentally friendly means of generating electricity, it is crucial to ensure the effective operation and maintenance of these systems, particularly in off-grid living areas. To achieve this objective, the project focuses on developing a user-friendly monitoring system utilizing the Arduino ESP32 microcontroller and the Blynk software. The Arduino ESP32 serves as the main controller, gathering real-time data from sensors and solar panels to evaluate system performance. Key factors such as battery levels, voltage, and current are continuously monitored to provide clients with valuable insights into their small-scale grid systems. The system employs optimized data collection methods and error management systems to ensure stability and reliability. The collected data is securely transmitted to the Blynk app, enabling users to remotely monitor their solar power installations in real-time. The Blynk software offers visual representations such as measurements and graphs, facilitating data interpretation and analysis. By identifying patterns and potential issues through this monitoring system, users can make informed decisions regarding the most effective utilization of their solar power systems. The project's overarching goal is to provide individuals with an accessible means of monitoring their solar power installations. By leveraging the Arduino ESP32 microcontroller and the user-friendly Blynk software, users can effectively manage their energy consumption and contribute to the development of sustainable energy systems.

Keywords: Monitoring System, Blynk Software, Real-Time Data,

1. Introduction

The Arduino platform is an open-source electronics project building platform that simplifies programming and eliminates the need for a separate programmer. It offers a simplified C++ implementation and a convenient USB connection for loading code onto the microcontroller [1]. Arduino's standardized form factor makes it easy to use and interface with other peripherals. It has

**Corresponding author: fadly@uthm.edu.my*

gained popularity among beginners in electronics and programming due to its user-friendly features. Solar energy, derived from sunlight, is increasingly promoted as a clean and sustainable energy source [2]. Solar panels, also known as PV panels, convert sunlight into electricity through the photovoltaic effect. They find applications in various sectors, including remote power systems, telecommunications, and residential/commercial solar-powered electric systems. This project aims to design a log data system using Arduino technology to automatically monitor voltage and power sources. The collected data will be presented in a user-friendly format through the Blynk App. By comparing the system's accuracy with manual data, the project aims to ensure reliable and precise measurements with minimal margin of error.

1.1 Problem Statement

This project aims to overcome the challenges associated with effectively managing and monitoring small-scale grid systems, particularly those powered by solar electricity. The existing monitoring solutions lack real-time data collection, user-friendly interfaces, and integration with smart devices, resulting in inefficient energy utilization and system failures. To address these issues, we are developing a comprehensive monitoring system using the Arduino ESP32 microcontroller and the Blynk app. This solution enables real-time data collection from solar panels and sensors, providing users with up-to-date information on voltage, current, battery life, and power consumption. The Blynk app allows for remote visualization and analysis of system data, facilitating informed decision-making and optimization efforts. Additionally, the system offers features such as data tracking, personalized alarms, and notifications to enhance historical analysis and enable timely responses to critical situations.

1.2 Objectives

There are three main objectives for this research which are:

i. Implement data logging features in the solar operating system using the Arduino ESP32 microcontroller.
ii. Determine the voltage and current measurements for the solar system's ideal data inputs and outputs.
iii. Determine whether data collection via the Blynk App is appropriate and effective.

2. Materials and Methods

2.1 Materials

In this project, the materials used include the Arduino ESP32 microcontroller and the Blynk software [3]. The Arduino ESP32 serves as the main controller for the monitoring system, while the Blynk software facilitates data visualization and analysis. To conduct the study, various sensors are utilized to collect real-time data from the solar panels and other relevant factors such as battery levels, voltage, and current. These sensors are connected to the Arduino ESP32, which gathers and processes the data [4]. The data collection process involves implementing optimized methods to ensure accuracy and reliability. Error management systems are also implemented to enhance the stability and dependability of the system. The collected data is securely transmitted to the Blynk app, which allows users to remotely monitor their solar power installations in real-time. The app provides visual representations such as measurements and graphs to aid in data interpretation and analysis. To validate the accuracy of the system, manual data collection is performed as a benchmark for comparison with the data obtained through the automated monitoring system. This allows for the assessment of the system's performance and the margin of error.

2.2 System Block Diagram

Figure 1 shows the details of the system block diagram. The system block diagram is made up of several parts that cooperate to monitor and manage a small grid system. The ESP32 microcontroller, which acts as the main control component, is at the system's core [5]. Data from different sensors, including a voltage sensor and a current sensor linked to the solar panel and battery, respectively, are gathered by the ESP32. To check the efficiency of the solar panel and battery, these sensors measure the voltage and current data. The Solar Charge Controller, which controls the battery's charge in accordance with the solar energy received, is then contacted by the ESP32 after processing this data. The Solar Charge Controller enables effective and secure charging while guarding against overcharging or battery discharge. Additionally, the ESP32 interfaces to the Blynk app, allowing for real-time system monitoring and control through a smartphone or tablet. The Blynk app gives controls to monitor system parameters and make necessary modifications, as well as a user-friendly interface for visualizing the data from the sensors [6]. The combination of the solar panel, solar charge controller, battery, voltage sensor, current sensor, ESP32 microcontroller, and Blynk software is shown in this system block diagram, enabling quick and easy monitoring of the tiny grid system.

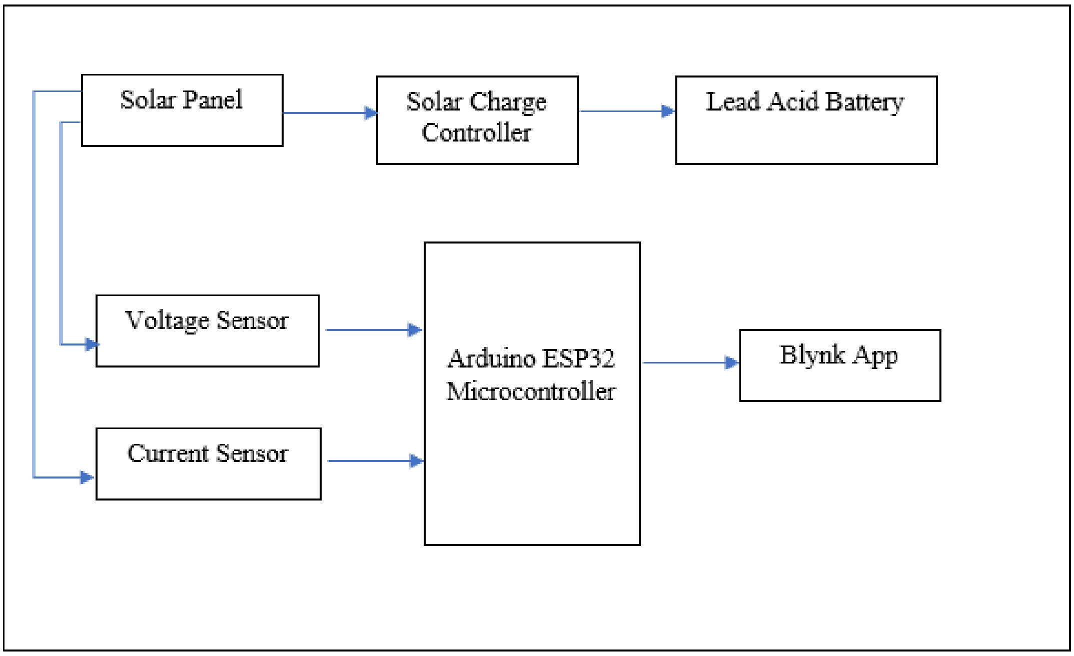

Figure 1: Block Diagram of the project

2.3 System Flowchart

For Figure 2, a rounded box at the top of the flowchart represents the system's start. Initializing the system is the first phase, which involves making sure all required parts are installed and prepared for use. To communicate with outside devices, the system next establishes a connection to a Wi-Fi network. It establishes contact with the Blynk app, which acts as the monitoring interface in real time. The system extracts information about the functioning of the small-scale grid system by reading the voltage and current values from the solar panel and battery sensors [7]. The Blynk app then receives these updates and offers a user-friendly interface for users to monitor the system in real-time. Through the app, users can interact with the system, access the data shown, and change any necessary system settings or parameters. After waiting for a specific period, the system resumes the data gathering and updating procedure. This cycle repeats until the system is manually halted, as shown by the rounded box at the flowchart's conclusion. This flowchart gives a clear picture of how the system works while highlighting the continuous data update cycle made possible by the Arduino ESP32 and Blynk software.

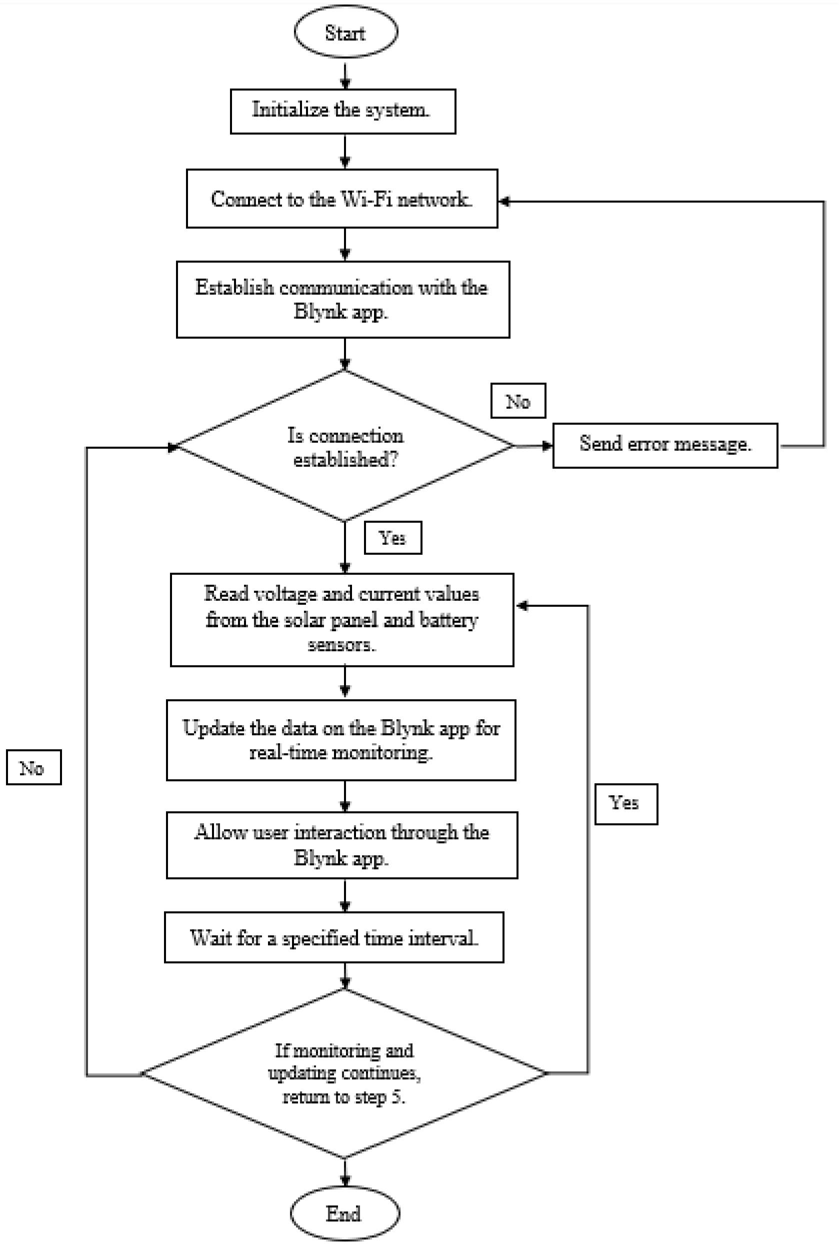

Figure 2: Flowchart of the project

2.3 Limitation of project

The project has certain limitations that should be considered. Firstly, the monitoring system developed is primarily focused on small-scale grid systems and may not be easily scalable or suitable for larger or more complex grid setups. Compatibility with different types of solar panels, sensors, or peripheral devices may also pose challenges [8]. While efforts are made to optimize data collection and minimize errors, there may still be a margin of error in the measurements obtained by the system. Additionally, users may require some level of familiarity with the Arduino platform and the Blynk app, which could pose a learning curve for those who are not familiar with these technologies. Lastly, the implementation cost of the system, including the Arduino microcontroller and additional sensors, should be taken, potentially limiting accessibility for users with budget constraints. Considering these limitations, ongoing improvements and addressing these concerns can lead to a more robust and effective monitoring solution for small-scale grid systems.

3. Results and Discussion

The implementation and operation of the Real-time Monitoring System for Small-Scale Grid Systems will be described in this chapter. In this section, the actual results of the monitoring system will be presented in more detail, along with supporting data to validate the findings obtained during the testing phase.

3.1 Results

Figure 3 illustrates the interface of the Blynk app displaying the live voltage and current readings in real-time. Users can track and analyze the electric activity of the system using the gauge in numerical that represents the voltage and current values in Figure 3.

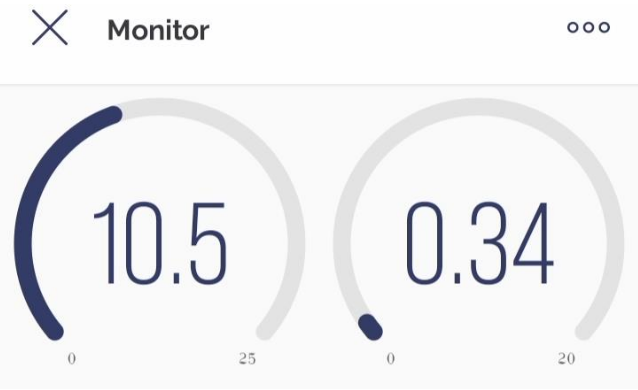

Figure 3: Monitoring Live voltage and current result in gauge

Figure 4 illustrates the interface of the Blynk app displaying the live voltage and current readings in real-time. Users can track and analyze the electric activity of the system using the graph that represents the voltage and current values in Figure 4. The voltage and current measurements are often displayed on a line graph in the Blynk app's visually appealing and user-friendly display. Users can see any changes or trends in electrical values by viewing the voltage and current values plotted against time on the graph.

Figure 4: Monitoring Live voltage and current result in graph

Figure 5 displays the voltage and current data over a period of a day. Users can analyze long-term trends and patterns in the electrical parameters over this longer time by examining the gauge's thorough summary of how the voltage and current values change over the duration of a whole day.

Figure 5: Reading of voltage and current for 1 day in gauge

Figure 6 displays the voltage and current data over a period of a day. Users can analyze long-term trends and patterns in the electrical parameters over this longer time by examining the graph's thorough summary of how the voltage and current values change over the duration of a whole day.

Figure 6: Reading of voltage and current for 1 day in graph

3.2 Data Analysis

This research has been conducted with 4 different scenarios. When the login is successful and Wi-Fi is established in the first scenario, the system can then move on to take voltage and current values. The relevant data will be accessible via the Blynk app, which will then show it to the user and provide real-time monitoring of voltage and current measurements. The system is unable to take voltage and current readings if the login attempt fails in the second case even though there is a Wi-Fi connection. Without the user's authentication, the Blynk app did not have access to the necessary data. As a result, it is impossible to display the voltage and current data. The system drops its capacity to retrieve voltage and current readings even if the login is successful and the Wi-Fi connection is severed in the third situation. As a result, the Blynk app will not be able to get real-time data from the system. Therefore, the app is unable to show the voltage and current readings. The fourth situation, in which the login attempt is failed, and the Wi-Fi connection is severed, restricts access to the system while the Wi-Fi disconnection inhibits data retrieval. As a result of the lack of authentication and a data connection, the Blynk app is unable to monitor or display voltage and current readings. In conclusion, the Blynk app can monitor and display voltage and current readings when Wi-Fi is connected, and a successful login has been made. Conversely, when Wi-Fi is disconnected or a failed login attempt has been made, the app is unable to access the necessary data, making it impossible to monitor and display the readings in real-time.

Table 1: Data Analysis for monitoring solar System with Blynk App

No	Condition 1	Condition 2	Outcome
1	Login successful	Wi-Fi connected	• The system can proceed to take voltage and current readings
2	Login unsuccessful	Wi-Fi connected	• The system cannot proceed to take voltage and current readings
3	Login successful	Wi-Fi disconnected	• The system is unable to retrieve voltage and current readings
4	Login unsuccessful	Wi-Fi disconnected	• The login attempt fails, and the system cannot retrieve voltage and current readings

In this study, Figure 7 shows the voltage measurements were taken both manually and through the Blynk app at three different time points during the day which is at 9 AM, 12 PM, and 5 PM. The manual measurements involved recording the voltage readings using traditional measuring instruments which is clamp device, while the Blynk app provided a digital interface to monitor and collect data wirelessly. A comparison was made between the voltage readings obtained manually and through the Blynk app. At 9 AM, the manual measurement indicated a voltage of 5.58V, while the Blynk app displayed a slightly lower reading of 5.55V. Similarly, at 12 PM, the manual measurement recorded a voltage of 12.28V, whereas the Blynk app showed a slightly higher reading of 12.30V. Finally, at 5 PM, the manual measurement resulted in a voltage of 9.38V, while the Blynk app indicated a voltage reading of 9.40V. Overall, the voltage readings obtained manually and through the Blynk app were found to be in close agreement, with only slight variations between them.

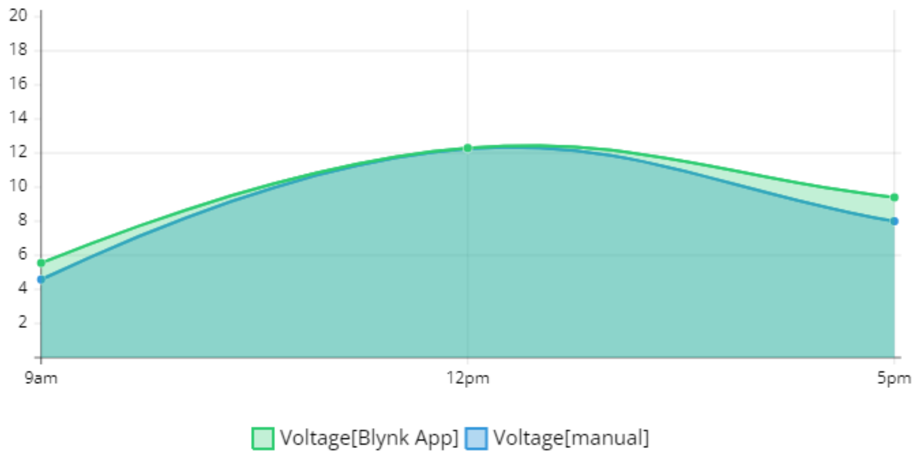

Figure 7: Comparison of manual data and data using Blynk App for voltage

The Figure 8 shows the comparing of the current readings obtained manually and through the Blynk app at the same three time points which 9 AM, 12 PM, and 5 PM. Manual measurements were taken using conventional current measuring devices, while the Blynk app provided a digital platform to monitor and collect current data remotely. At 9 AM, the manual measurement indicated a current of 0.2A, while the Blynk app displayed a slightly lower value of 0.19A. Similarly, at 12 PM, the manual measurement recorded a current of 0.32A, whereas the Blynk app showed a slightly higher reading of

0.33A. Finally, at 5 PM, the manual measurement yielded a current of 0.22A, while the Blynk app indicated a current reading of 0.21A. The comparison between the manual and Blynk app measurements revealed a consistent pattern of close agreement, with only minor differences observed between the two methods.

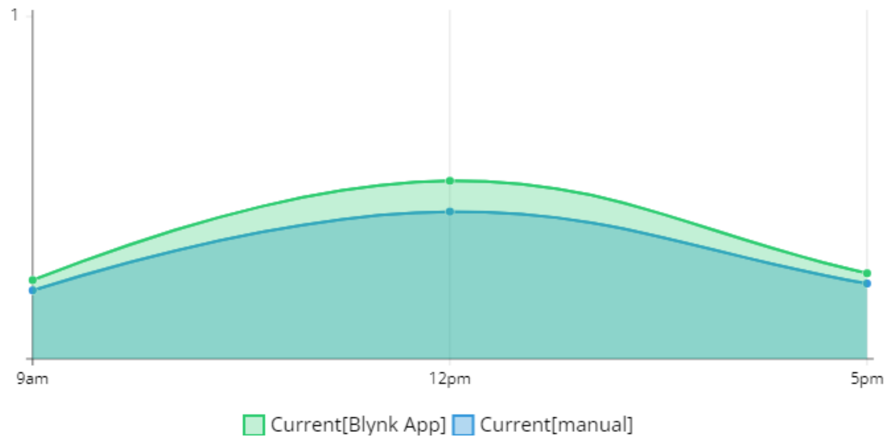

Figure 8: Comparison of manual data and data using Blynk App for current

3.3 Discussion

The prototype has produced the expected outcome based on the analysis of the data obtained through the Blynk app and the readings of voltage and current. The prototype connects to the Blynk app successfully, enabling the monitoring and display of voltage and current readings. The prototype successfully receives and processes the data because all the hardware components are linked. The data of esp32 and sensor are effectively shown on the Blynk app, proving that the prototype is working as planned and accomplishing its goals.

Overall, the analysis of the many scenarios demonstrates the connection between the lead acid battery's condition, the load, and the Blynk app's capacity to track and display voltage and current values. The Blynk app can efficiently capture and display changes in voltage and current that occur in real-time when the battery is connected, and the load is turned on. The Blynk app, however, is unable to access voltage and current information if the battery is disconnected or the load is turned off because there is no power supply or current flow. These observations highlight how crucial it is to have a working power source and a working load for the Blynk app to accurately monitor and display the data.

Conclusion

In conclusion, it is feasible to imply that the project Real-time Monitoring Small-Scale Grid System using Arduino ESP32, and Blynk App has succeeded in achieving its goal of creating a complete monitoring system. The project has made real-time data collecting from the solar panel, battery, voltage sensor, and current sensor possible by utilizing the capabilities of the ESP32 microcontroller. A practical and user-friendly user interface for monitoring and managing the system has been made possible by the integration with the Blynk app [9]. Various steps were made throughout the project, such as configuring the hardware, creating wireless connectivity, and putting the required software functionalities into place. The project's outcomes show that a dependable and effective monitoring solution for small-scale grid systems has been successfully implemented. Users can improve the system's performance, guarantee its stability, and efficiently manage energy resources with the ability to monitor and adjust in real-time. Overall, the project has demonstrated the viability and efficacy of utilizing an Arduino ESP32 and the Blynk app for real-time monitoring, providing a viable option for small-scale grid systems in terms of effectiveness, practicality, and sustainability.

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