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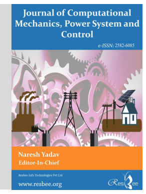

IoT Based Solar Energy Collecting as Alternative Energy Source and Monitoring System

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Abstract: With the increment utilization of the web the term Internet of Things is presented, this term encompasses a vision in which the web has the intuitive within the genuine world and has integration with day-by-day usable items. The IoT permits objects to be effectively controlled and can sense the parameters in as of now existing frameworks and systems and make numerous occupations and careers in this field of innovation. This mechanical upgrade increments productivity, exactness, and financial benefits in existing frameworks and diminishes the burden on people. This innovation has numerous applications like sun-oriented cities, keen towns, sun-oriented lights, and mechanical applications.Solar cities are urban areas that aim to meet a significant portion of their energy needs through solar power. They leverage the concept of the Internet of Things (IoT) to monitor and manage their energy consumption effectively.Solar energy has a wide range of mechanical applications such as Solar Thermal Collectors,SolarPowered Vehicles,Solar-Powered Mechanical Systems,and Solar-Powered Roads and Buildings.As we know the center on renewable vitality assets isexpanding day by day, this proposed framework will give an online show of control utilization of sun-based vitality the nodeMCU will play an imperative part in this application and resolvingour electrical issues by permitting us to analyze the vitality utilization.

Keywords: Iot, Idcol, Nodemcu, I2c, Pcb, Arduino Ide, Blynk

Nomenclature

Abbreviation	Expansion
IoT	Internet of Things
PCB	Printed Circuit Board

1. Introduction

1.1 Background

The IoT has revolutionized the way we connect with innovation and has opened up unused roads for development in different areas. One such field is the era and dissemination of clean vitality. With the rise of worldwide warming and the got to decrease carbon emanations, the request for renewable vitality sources has increased significantly. Among them, sun-based vitality is one of the foremost promising sources of renewable vitality. The utilization of sun-powered vitality has developed in notoriety in later a long time, and it has ended up being a more reasonable and viable elective to conventional vitality sources. In any case, the effectiveness and unwavering quality of sun-oriented vitality frameworks can be influenced by an assortment of variables, including climate conditions and support issues. In arrange to optimize the execution of sun-powered vitality frameworks, it is significant to have an observing framework in place that can distinguish and address these issues in an opportune way. This can be where IoT-based sun-oriented vitality collecting and observing frameworks come in. By coordinating IoT sensors and gadgets into sun-oriented vitality frameworks, it is conceivable to screen and control different angles of the framework, counting vitality generation, vitality capacity, and support. IoT-based sun-powered vitality frameworks can give real-time information on vitality generation and utilization, as well as distinguish potential support issues sometime recently that end up as major issues. In this setting, an IoT-based sun-powered vitality framework can also serve as an elective vitality source for

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family units and businesses. With the proper setup, IoT-based sun-oriented vitality frameworks can give clean, solid, and cost-effective vitality that can offer assistance decrease carbon outflows and dependence on conventional vitality sources. By and large, an IoT-based sun-oriented vitality collecting and observing framework has the potential to revolutionize the way we produce and expend vitality, making it more productive, solid, and maintainable. IoT-based sun-based vitality collecting and observing frameworks can moreover offer a few benefits in terms of taking a toll on investment funds and proficiency. For illustration, by joining sensors into sun-based boards, it is conceivable to screen and optimize their execution in real time. This will offer assistance in recognizing issues such as shading or breaking down panels, allowing for speedy repairs that can offer assistance to maximize the system's vitality yield. Also, IoT-based sun-powered vitality frameworks can be coordinated with vitality capacity arrangements, such as batteries. This may offer assistance to reduce the dependence on the control framework and guarantee that vitality is accessible indeed when the sun isn't sparkling. By utilizing vitality capacity arrangements, it is conceivable to store an overabundance of vitality created during the day and utilize it at night or amid times of tall request. Additionally, IoT-based sun-powered vitality frameworks can moreover offer assistance to diminish general vitality utilization by optimizing vitality utilization within a building or domestic. For example, savvy domestic gadgets can be coordinated into the framework, permitting programmed control of apparatuses and lighting based on energy demand and accessibility. This will offer assistance to diminish by and large vitality utilization, and encourage expanding the effectiveness of the sun-powered vitality framework. In conclusion, IoT-based sun-powered vitality collecting and observing frameworks offer a few benefits, counting fetched investment funds, expanded proficiency, and supportability. As the innovation proceeds to evolve and gotten to be more reasonable, ready to expect to see an expanding number of homes, businesses, and communities depending on IoT-based sun-based vitality frameworks as a clean and reliable alternative to conventional vitality sources. Another critical advantage of IoT-based sun-powered vitality frameworks is that they can be remotely checked and overseen, permitting more noteworthy adaptability and control. By utilizing the cloud-based program, users can get real-time data on the performance of their solar vitality framework from anyplace within the world, employing a computer or portable gadget. This will be especially useful for businesses and organizations that work in numerous areas, as they can screen and oversee their vitality utilization and costs centrally. In addition, IoT-based sun-oriented vitality frameworks can offer assistance to decrease the by and large natural effect of vitality generation. Conventional vitality sources, such as fossil powers, can have a noteworthy effect on the environment, contributing to discussion and water contamination, as well as nursery gas emanations. In contrast, solar vitality is a clean and renewable source of vitality that produces no emanations or toxins. By utilizing IoT-based sun-based vitality frameworks, ready to offer assistance to diminish our dependence on conventional vitality sources and contribute to a more maintainable future. Finally, IoT-based sun-oriented vitality systems can also offer assistance in making modern work openings within the renewable vitality division. As the request for clean vitality proceeds to develop, there's a need for skilled experts who can introduce, maintain, and work sun-oriented vitality frameworks. By contributing to IoT-based sun oriented vitality systems, able to offer assistance to form unused jobs and bolster the growth of a more feasible economy. In conclusion, IoT-based sun-based vitality collecting and observing frameworks offer various preferences, counting taken a toll reserve funds, expanded effectiveness, maintainability, and adaptability. As the innovation proceeds to create and become more available, it has the potential to play a progressively critical part in our move to a cleaner, more economically vitality future.

1.2 Problem Statement

The issue explanation is that conventional vitality sources are not feasible and harm the environment. As a result, there's a thought to develop alternative vitality sources that are renewable and eco-friendly. Sun-powered vitality could be a promising alternative, but its effectiveness and unwavering quality depend on different components such as climate conditions, area, and support. Besides, there's a need for successful observing frameworks for sun oriented vitality era, which can lead to imperfect execution and support issues. This issue is compounded by the reality that numerous sun-oriented vitality frameworks are found in farther or hard-to-reach ranges, making it troublesome to screen their execution. To address these issues, an IoT-based sun-oriented vitality collecting and checking framework can be created. Such a framework would utilize sensors and networks to screen and optimize the execution of the sun-based vitality era, as well as give real-time information on vitality era, utilization, and capacity. This would empower the effective and successful administration of sun-oriented vitality frameworks, moving forward their unwavering quality, effectiveness, and by and large supportability. Framework Advancement Company Restricted (IDCOL) stores activities and programs that make utilization of different sorts of renewable assets as a portion of its mission to advance elective vitality sources. IDCOL bolsters the government's objective of creating 5% of the nation's add-up to power from renewable sources by 2015 and 10% of the nation's add-up to power from renewable sources by 2021 by giving beginning appropriations, concessionary credits, and capacity advancement bolster. The mission of IDCOL is to guarantee the sector's long-term money-related and financial practicality with a canter on commercialization [1].

1.3 Objectives of the Research Project/Thesis

The objective to incite this extent is to present a moo-fetched IOT-based sun-powered control era framework that can effectively be open and controlled with genuine-time information era through innovative improvements. This extensionisn't as it were for private ranges but this innovation can moreover utilized in industries and workplaces to induce economic vitality and with parcels of effectiveness. This extend will spare common assets and will permit us to play our portion in sparing our soil from contaminations which are produced by warm control stations. This venture has four capacities one is to produce a proficient control era without much misfortune and the rest is to pick up genuine time data of the control era, making the system last long, and to coordinate diverse advances to create a progress framework. This innovation will be sensible and anybody can manage this innovation effortlessly without any trouble of working it. The scope of this extension is to make the idealized IOT based sun based control era framework that can easily deliver sufficient control to meet the conclusion required of the customers, to create our clients fulfill with the long-enduring execution and simple to utilize and oversee framework with genuine-time information era, Which can be advantageous for the customers to form check and adjust of their control utilization encourage the framework ought to moreover decrease the billings and the costs the customers which they used to donate to their power suppliers. This extension will spare the common resources and energy leading to supportability and superior soil. This extent can effortlessly be worked without any issues to comprehend.

1.4 Why Do We Choose This Project

There are several reasons why one might choose to undertake a project focused on IoT-based solar energy collection and monitoring:

1. Natural concerns: The utilization of elective vitality sources, such as sun-based vitality, can offer assistance to diminish the dependence on non-renewable sources of vitality and decrease the natural effect of conventional vitality-era strategies.
2. Cost-effectiveness: In the long run, sun-powered vitality is regularly cheaper than conventional vitality sources, which can make it a more cost-effective alternative for both people and organizations.
3. Versatility: IoT-based checking frameworks can be easily scaled to meet the wants of different-sized ventures, making it a perfect alternative for both little and large-scale sun-based vitality ventures.
4. Inaccessible observing and control: IoT-based observing frameworks can be utilized to remotely screen and control sun-oriented vitality frameworks, which can be especially valuable for farther or hard-to-reach areas.
5. Instructive purposes: This extension can be a great opportunity for understudies or people to memorize approximately IoT-based checking frameworks and renewable vitality advances, making a difference to create abilities that are in the tall request within the cutting-edge work showcase.

By and large, the venture can be a great opportunity to investigate inventive arrangements to meet the vitality needs of communities while too lessening the natural effect of conventional vitality-era strategies.

1.5 Features

IoT has the potential to revolutionize the way we produce and utilize vitality. One range where IoT can make an enormous effect is in sun-oriented vitality collection and checking frameworks. Here are a few highlights of an IoT-based sun-powered vitality collecting and observing framework:

1. Sun-powered Board Observing: IoT gadgets can be utilized to screen the execution of personal sun-powered boards in a sun-based cluster. This could offer assistance in identifying any issues with person boards that will influence the general proficiency of the framework.
2. Vitality Capacity Checking: With the utilization of IoT gadgets, the status of the vitality capacity framework such as batteries can be observed. This data can be utilized to optimize the charging and releasing of the batteries to maximize their life expectancy.

3. Real-time Execution Observing: With IoT, real-time execution checking can be accomplished, and information can be collected from different components of the sun-based vitality framework. This information can be utilized to distinguish issues sometime recently they gotten to be major issues.
4. Farther Checking: The framework can be checked remotely through the web, which permits further administration and support.
5. Prescient Support: The information collected by IoT gadgets can be utilized to anticipate when support is required. This may offer assistance to decrease downtime and amplify the life of the sun-oriented vitality framework.
6. Vitality Administration: IoT can be utilized to optimize the vitality utilization of a building. By checking the vitality utilization, it is conceivable to distinguish regions where energy can be spared and decrease vitality costs.
7. Vitality Analytics: By analyzing the information collected by IoT gadgets, it is conceivable to pick up experiences into the performance of the sun-powered vitality framework. This may offer assistance in distinguishing ranges for advancement and optimizing the framework for the most extreme effectiveness.
8. Vitality Exchanging: An IoT-based sun-based vitality framework can be associated with a local energy showcase or a virtual control plant to exchange vitality when there's an overabundance era.

1.6 Business Goal

The trade objective of an IoT-based sun-based vitality collecting and observing framework is to supply a maintainable, cost-effective, and adaptable elective to conventional vitality sources while guaranteeing solid and effective execution. The framework points to advancing natural maintainability, diminishing vitality generation costs, optimizing operational proficiency, empowering data-driven choice-making, and offering a competitive advantage. By leveraging real-time checking, prescient support, and progressed analytics, the framework can offer assistance to businesses and people to optimize their vitality utilization and diminish their carbon impression. Eventually, the objective is to empower the far-reaching selection of renewable vitality sources, such as sun-oriented vitality, and quicken the move to a more economical and strong vitality framework.

1.7 Working strategy

The working procedure of an IoT-based sun-based vitality collecting and observing framework includes utilizing IoT sensors to gather real-time information on sun-based vitality era, utilization, and capacity. The information is transmitted to a cloud-based stage, where it is analyzed utilizing progressed analytics to screen and optimize the execution of sun-oriented vitality frameworks. The framework leverages prescient analytics to estimate vitality requests, alter vitality generation and capacity appropriately, and decrease vitality wastage. Furthermore, the framework gives real-time observing and prescient support, empowering fast distinguishing proof and resolution of issues that will affect execution. The data is displayed in a user-friendly dashboard, permitting clients to imagine and analyze key measurements such as vitality utilization, era, and capacity. This advances data-driven choice-making, making a difference for clients to optimize their vitality utilization, decrease costs, and advance natural supportability.

2. Background of the Study

IoT could be a quickly developing arrangement of interconnected gadgets, permitting a run of inventive applications. One such application is the utilization of IoT in sun-based vitality collection, which offers various benefits as an elective vitality source. With the worldwide thrust toward economic vitality sources, sun-oriented vitality has ended up a progressively prevalent choice due to its wealth, openness, and cost-effectiveness. In any case, there are still impediments to sun-based vitality collection, such as its dependence on climate conditions and its intermittency. The utilization of IoT in sun-powered vitality collection and checking can offer assistance to address these impediments and make strides the in general effectiveness and adequacy of sun-based vitality frameworks. IoT-based sun-based vitality frameworks can screen and collect information on vitality era, climate conditions, and vitality utilization, permitting real-time alterations to optimize vitality collection and utilization. This checking framework can moreover distinguish potential issues and give prescient support to anticipate framework disappointments. Furthermore, IoT can empower inaccessible get-to and control sun-based vitality frameworks, making it less demanding to oversee and keep up with them from any place. The potential benefits of IoT-based sun-based vitality collection and checking frameworks are various, including decreased vitality costs, expanded vitality efficiency, and decreased natural effects. As such, there's a developing intrigued in research and improvement of IoT-based sun-based vitality frameworks, with various ventures and activities now underway around the world. IDCOL stores activities and programs that make utilization of different sorts of renewable assets as a portion of its mission to advance elective vitality sources. IDCOL bolsters the government's objective of creating 5% of the nation's add-up to power from renewable sources by 2015 and 10% of the nation's add-up to power from renewable sources by 2021 by giving beginning appropriations, concessionary credits, and capacity improvement bolster. The mission of IDCOL is to guarantee the sector's long-term budgetary and financial reasonability with a center on commercialization [1]. Sun-powered vitality is accessible all over the world and can offer assistance to decrease dependence on imported vitality.

2.1 Existing Work

In 2019, P. Jayalakshmi and P. Santhosh Kumar [2] implemented an IoT-based framework for observing and controlling sun-based vitality. This framework comprised of sensors to a degree different parameters of the sun-oriented board and a microcontroller to prepare the information. The framework also incorporated a versatile application that permits clients to screen and control the sun-oriented panel.

In 2018, M. U. Hassan, *et al.* [3] executed an IoT-based sun-powered vitality observing and control framework that employments sensors to degree different parameters of the sun-based board and a microcontroller to prepare the information. The frame work moreover incorporated a portable application for observing and control.

In 2019, S. B. Gadakh, *et al.,*[4]presented an IoT-based sun-based vitality observing framework utilized by Arduino. The framework incorporated sensors to degree different parameters of the sun-oriented board, an Arduino for preparing the information, and a versatile application for checking and control.

In 2018, D. R. Dhamak and N. M. Patil, [5] used an IoT-based framework for checking and overseeing sun-oriented control. The frame work employments sensors to degree different parameters of the sun-oriented board and a microcontroller to prepare the information. The framework too incorporates a web application for observing and control.

In 2020, S. S. Sahu, *et al.,* [6] devised an IoT-based sun-oriented board checking and control framework that employments sensors to degree different parameters of the sun-based board and a microcontroller to prepare the information. The framework also incorporated a versatile application for checking and control.

2.2 Comparison Table

Table 2.3 *Comparison Table*

Existing Project	Project Features				
	Voltage Meter	Current meter	Power Meter	Budget	Mobile Apps
P. Jayalakshmi and P. Santhosh Kumar [2]	Yes	Yes	No	High	No
M. U. Hassan, *et al.* [3]	Yes	Yes	No	High	Yes
S. B. Gadakh, *et al.,* [4]	No	No	No	High	No
D. R. Dhamak and N. M. Patil, [5]	Yes	Yes	No	High	No
S. S. Sahu, *et al.,* [6]	Yes	Yes	No	High	No
Proposed System	Yes	Yes	Yes	Low	Yes

3. Methodology

The strategy for an IoT-based sun-oriented vitality collecting and observing framework includes planning and sending sensors to gather information on vitality era, utilization, and capacity. This information is transmitted to a cloud-based stage for investigation and optimization, which may incorporate machine learning calculations modeling, and recreation. The framework is at that point overseen and controlled to optimize vitality execution and diminish costs, with announcing and visualization instruments to screen vitality execution in real time. Customary calibration and support of the sensors and equipment components are vital, and integration with other frameworks can make strides generally execution and effectiveness. At last, a cost-benefit analysis should be conducted to assess the financial achievability and potential benefits of the framework, considering establishment, upkeep, and operation costs, as well as potential vitality investment funds, fetched diminishments, and natural benefits. The strategy must also consider security measures to ensure against cyber dangers and unauthorized get to to the information.

3.1 System Architecture

The sunlight directly falls on the solar panel and then the electricity is provided and stored in a battery the Arduino processor analyses the power, capacity, energy, energy cost, and other criteria and displays the result through the Blynk application. Finally, the data are stored in the database. The flow process is represented in the system architecture Fig. 1.

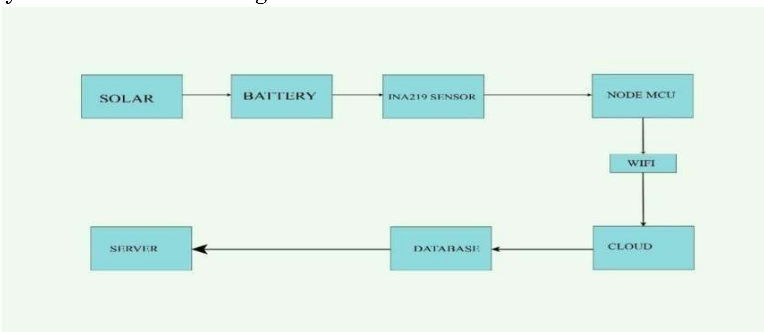

Fig. 1. *System Architecture*

3.2 Required Components and Software

Table. 3.2 represents the required components and software for the project.

Table. *3.2 Required Component and Software*

Hardware	Software
ESP8266 Node MCU **1.3" IIC OLED Display** **INA219 Current Sensor** **Solar Panel** **Battery** **DC-DC Buck Converter Step-Down Module** **DC Fan** **DC LED Bulb** **PCB Prototyping Board** **Cable** **Android Smart Phone** **PC**	Arduino IDE, C/C++, Blynk Apps

3.3 Description of the Software

3.3.1 Arduino IDE

The Arduino Coordinates Improvement Environment (IDE) is an open-source computer program application utilized to type in and transfer code to Arduino sheets. The IDE incorporates a code editor with highlights such as sentence structure highlighting, auto-complete, and mistake discovery, making it simple for clients to compose, test, and investigate code for Arduino sheets. The IDE also incorporates a serial screen that permits clients to communicate with the board, see information, and investigate code in genuine time. The Arduino IDE underpins an extent of programming dialects, counting C and C++, and it is consistent with different working frameworks, such as Windows, Mac, and Linux. The Arduino IDE may be a prevalent choice among hobbyists, understudies, and experts who need to make and program microcontroller-based ventures.

Fig. 2. *Arduino IDE*

3.3.2 C/C++

C/C++ are prevalent programming dialects utilized for creating a wide extend of applications, counting working frameworks, implanted frameworks, and video recreations. C could be a low-level programming dialect that gives coordinated access to framework assets and memory, making it fast and productive. C++ may be a higher-level dialect that builds on the beat of C, giving object-oriented programming highlights and deliberations. Both dialects are commonly used in computer science instruction and industry. They are too cross-platform dialects, which suggests that code composed in C or C++ can be compiled and run on diverse platforms, including Windows, Linux, and Mac OS. C/C++ remains a basic instrument for program advancement and framework programming. C/C++ could be a popular choice for programming IoT (Web of Things) gadgets. Due to their effective execution and low-level control, C/C++ is well-suited for resource-constrained IoT gadgets that have to work with restricted memory and handling control. C/C++ can be utilized to type in code for different IoT gadgets, such as sensors, doors, and edge gadgets. Moreover, numerous IoT stages, such as Arduino and Raspberry Pi, bolster C/C++ programming, making it simpler for engineers to form and program IoT gadgets. C/C++ libraries and systems, such as the Paho MQTT library and the Contiki working framework, give advance bolster for IoT advancement in C/C++. In general, C/C++ proceeds to be an imperative programming dialect for IoT development.

3.3.3 Blynk

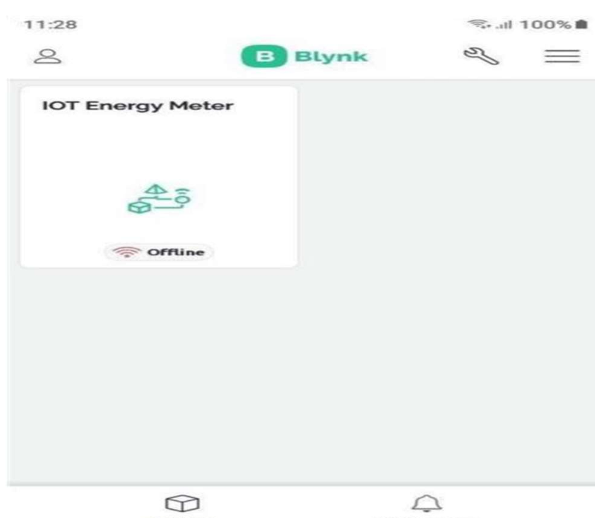

Fig. 3. *Blynk*

Blynk is a mobile app advancement stage that empowers users to make and control IoT gadgets employing a smart phone or tablet. It enables different communication conventions, such as Bluetooth, Wi-Fi, and Ethernet to display results on the screens for monitoring. Blynk is the adaptable and extensible stage that can be utilized with an assortment of equipment and program stages, including Arduino, Raspberry Pi, ESP8266, and Node.js. It gives a cloud-based server that enables inaccessible get to and control of IoT gadgets, making it less demanding for clients to screen and control their gadgets from any place within the world.

3.4 Budget

The overall budget for the project and its components are represented in Table 3.5.

Table 3.5 *Budget*

S.N	Components Name	Quantity	Price (TK)
1	ESP8266 Node MCU	1	420
2	1.3" IIC OLED Display	1	600
3	INA219 Current Sensor	1	800
4	Solar Panel	1	1000
5	Battery	1	850
6	DC-DC Buck Converter Step-Down Module	1	200
7	PCB Prototyping Board	1	50
8	Cable	2	200
9	DC Fan	2	200
10	DC LED Bulb	2	100
11	Other		200
		Total	4620

3.5 Block Diagram of Proposed System

The microcontroller is connected to solar panels to trap sunlight to produce electricity. The battery stores the electricity. The Blynk app displays the information in the PC and mobile application. Finally, it is connected to the external devices. Fig. 4. represents the overall block diagram of the proposed system.

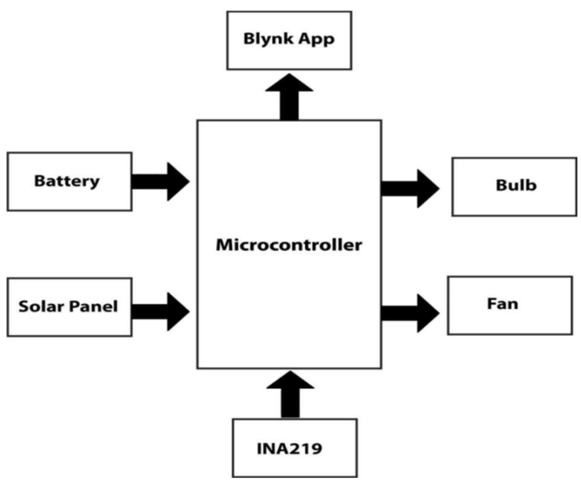

Fig. 4. *Block diagram of Proposed System*

3.6 Activity Diagram

The flow process of the monitoring system is represented in the activity diagram Fig.5.

3.7 Use Case Diagram

This IoT based based solar energy collector requires two users. To measure the voltage, current, power, capacity, and energy cost of the energy source we need systems. To monitor the displayed energy information through PC and mobile applications we need users. This is represented in the use case diagram Fig.6.

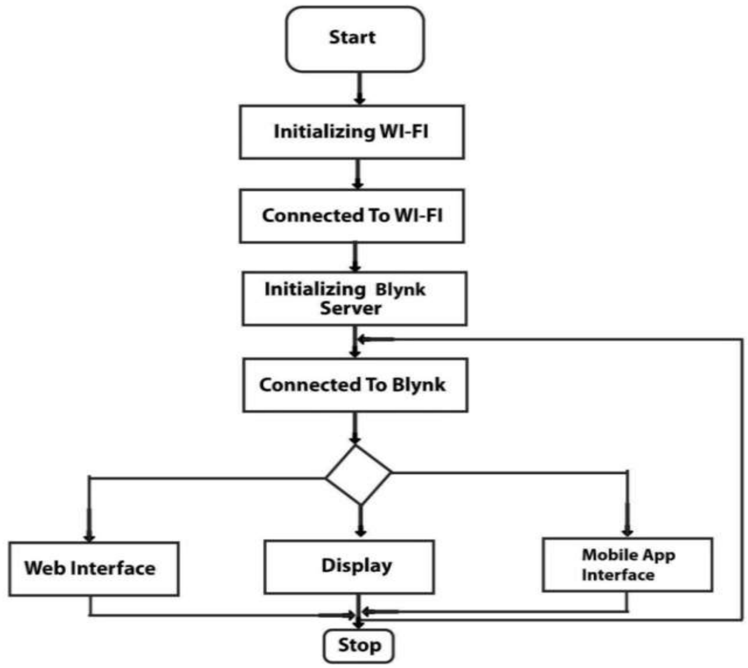

Fig.5. *Activity Diagram*

3.8 Circuit Diagram

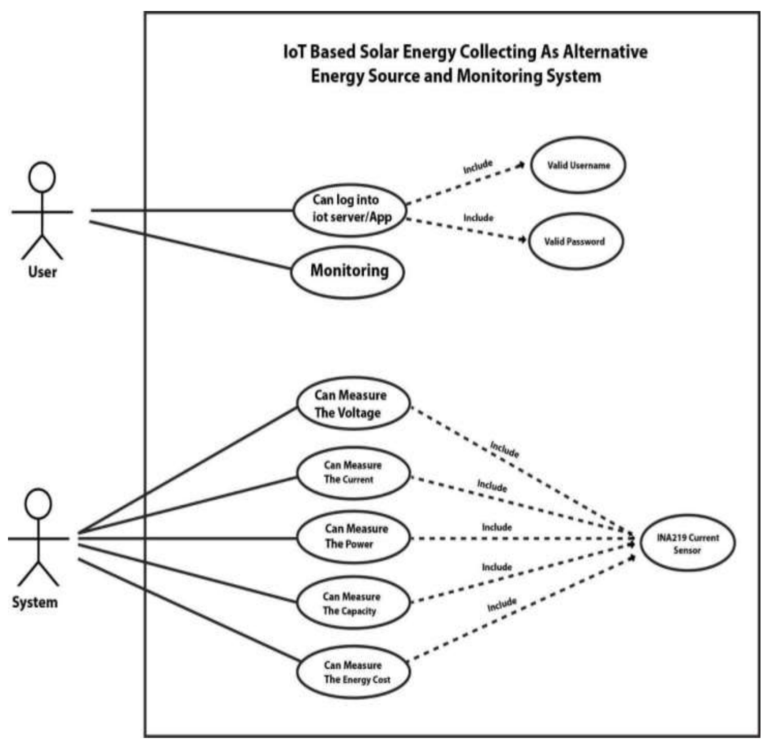

Fig.6. *Use Case Diagram*

The real-time project was performed with the circuit connection (Fig.7.) and Fig. 8. Screen shot shows the entire project.

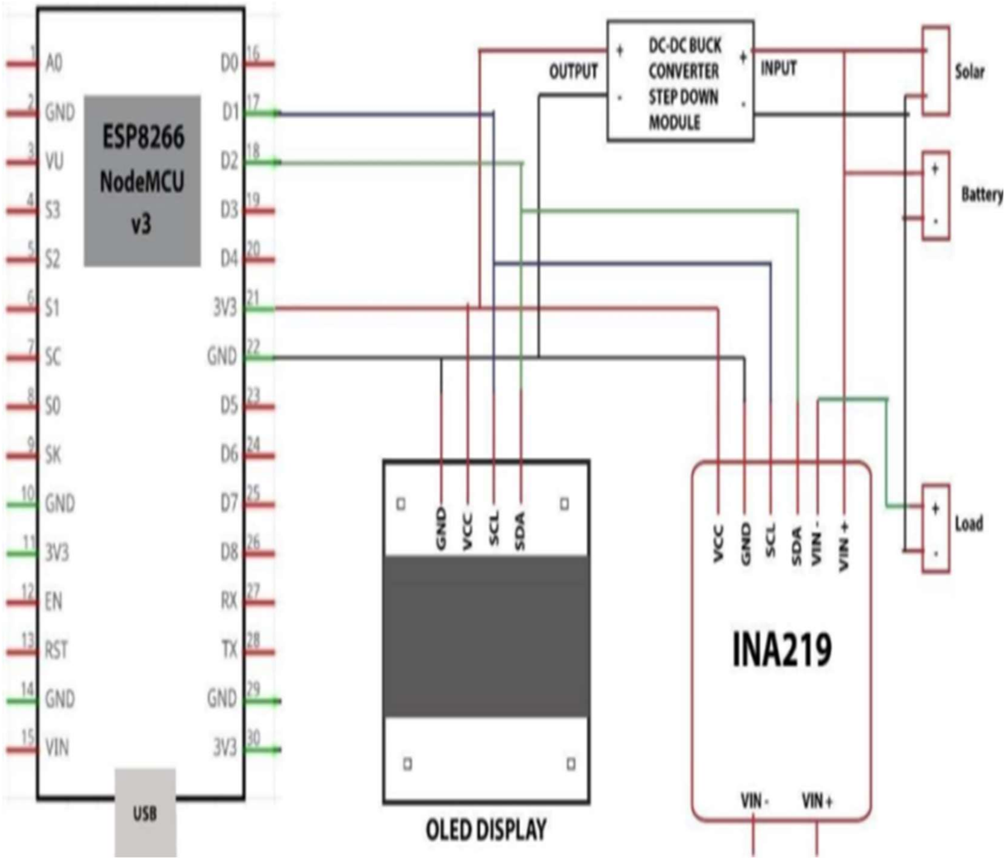

Fig.7. *Circuit Diagram*

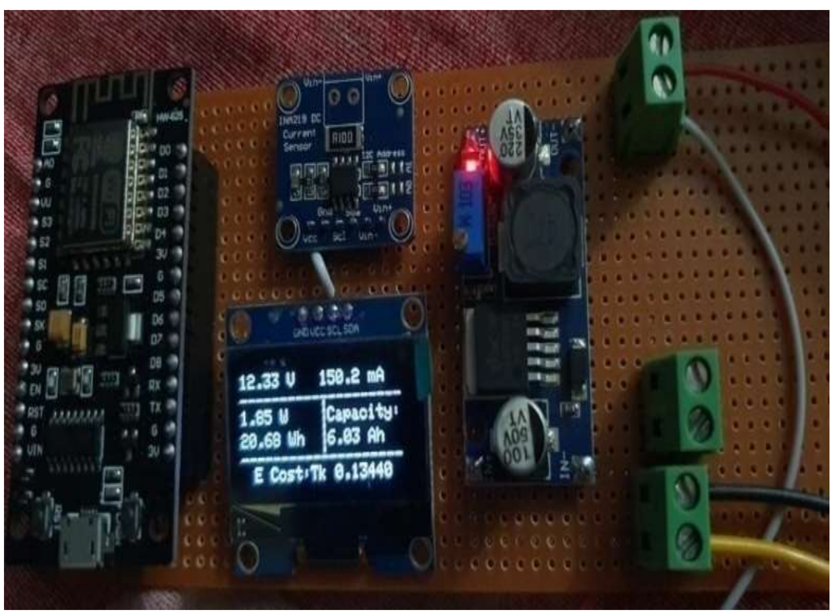

Fig.8. *Project Screenshot*

3.9 Gantt Chart

The Gantt chart Fig.9. represents the activities that are performed for the project.

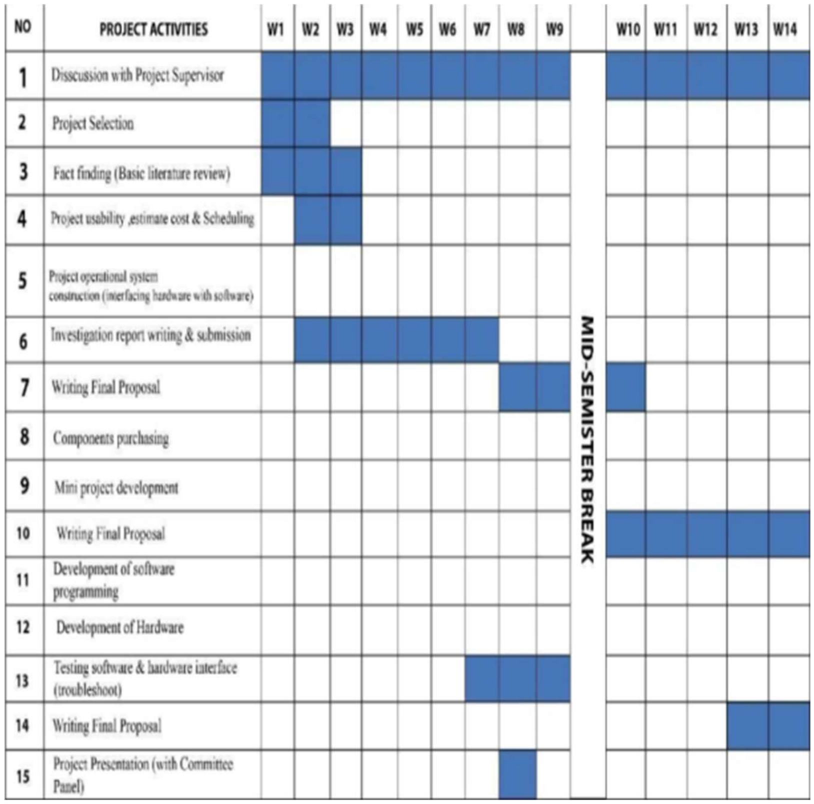

Fig.9. *Gantt Chart*

3.10 Software Design

3.10.1 Web Application Design

Blynk could be a stage that permits clients to create custom Web of Things (IoT) applications for controlling equipment and gadgets employing a versatile app or a web interface. The Blynk stage comprises a portable app, a cloud-based server, and a library of computer program components for different equipment stages.

Whereas Blynk was initially planned for portable gadgets, they have moreover discharged a web-based form of their stage called Blynk Web Dashboard. From that, clients can make and oversee IoT applications from a web browser, without requiring to utilize a portable gadget. Blynk Web Dashboard offers similar usefulness to the versatile app form, counting the capacity to form custom interfacing, include widgets and controls, and interface to a wide extent of equipment gadgets. It too permits clients to screen and control their gadgets remotely, see real-time information, and get alarms and notices. Generally, Blynk Web Dashboard offers a helpful way for clients to oversee their IoT ventures from a web browser and gives an extra alternative for those who favor employing a computer over a portable gadget.

3.10.2 Mobile Application Design

With the Blynk mobile app, users can create custom interfaces and add widgets and controls to control and monitor their IoT devices. The app offers a wide range of pre-built widgets, including buttons, sliders, graphs, displays, and more, which can be easily configured to interact with various hardware components. Users can also create custom notifications and alerts based on the data received from their devices. For example, they can set up notifications to alert them when a certain condition is met, such as when the temperature in a room exceeds a certain threshold. In addition, the Blynk mobile app provides access to a community of developers and enthusiasts who share their projects and ideas with other users. This allows users to learn from others, collaborate on projects, and get help and support when needed. Overall, the Blynk mobile app provides a user-friendly and intuitive platform for developing and managing IoT applications from a mobile device.

4. Result

The IoT-based solar energy collecting and monitoring system is still in progress, and no final results are available yet. However, once completed, the system is expected to provide several benefits, including reduced reliance on non-renewable energy sources, cost savings, and a more sustainable energy usage pattern. The real-time data on energy production and consumption provided by the monitoring system can be used to optimize energy usage and reduce wastage, resulting in cost savings and a more sustainable energy usage pattern. Additionally, the IoT-based live streaming feature will provide users with remote access to energy production data and the ability to control the system from anywhere, enabling efficient energy management and control from remote locations. Fig.10. shows the total number of installed solar home systems in Bangladesh from 2003 to 2018.

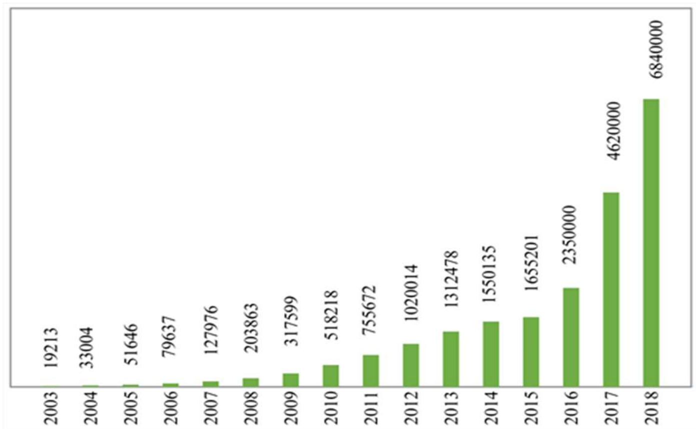

Fig.10. *Total number of installed solar home systems in Bangladesh from 2003 to 2018 [6]*

4.1Web Application Result

On PC, the web application result will be displayed. Detailed information such as voltage, power, capacity, cost, current, energy, and other details. Fig.11. shows the details information on the web application.

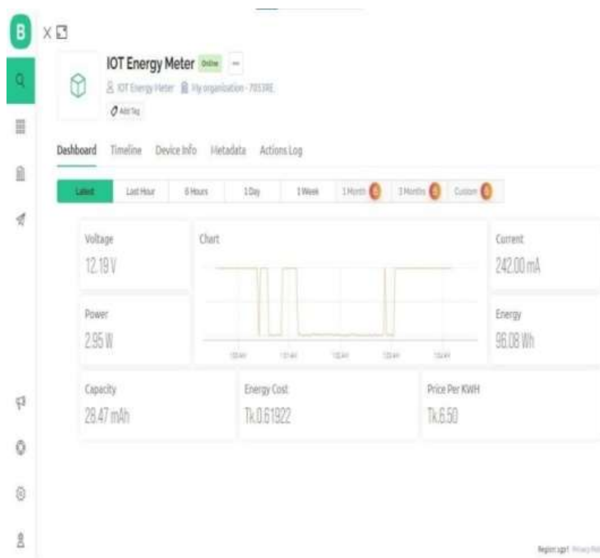

Fig.11. *Web Application Result*

4.2 Mobile Application

The energy meter displays the information on the mobile screen that shows voltage, power, current, capacity, cost, and other details. Fig.12. shows the details of the mobile application result.

Fig.12. *Mobile Application Result*

4.3 Testing Report

Based on the testing performed on the IoT-based sun-powered vitality collecting and checking framework, the taking after comes about were:

1. Sun-oriented board: The sun-powered board was able to produce control as anticipated and charge the battery amid sunshine hours. The sum of control produced was influenced by variables such as cloud cover and the point of the board.
2. Battery: The battery was able to store the control created by the sun-oriented board and give control to the framework when there was no daylight. The battery capacity and release rate were checked utilizing the INA219 sensor.
3. ESP8266 Node MCU: The ESP8266 Node MCU microcontroller was able to effectively interface to the Wi-Fi organize and communicate with the Blynk app to send real-time information.
4. INA219 sensor: The INA219 sensor was able to precisely degree the battery voltage, current, and control utilization.
5. Blynk app: The Blynk app was able to show real-time information from the framework, such as the battery voltage and control utilization.
6. Fan and bulb: The fan and bulb were able to turn on and off based on the control accessibility from the battery.

In general, the framework was able to effectively collect sun-oriented vitality and store it within the battery for utilization afterward. The real-time checking of the system's execution gives important bits of knowledge into its proficiency and viability in creating and utilizing elective vitality.

4.3.1 Testing Report Table

Table 4.2 represents the testing report of the charging battery, energy collection, monitoring, and Blynk.

Table 4.2 *Testing Report Table*

Test	Description	Result
Solar charging battery	Test the solar panel's ability to charge the battery	YES
Batteries collecting energy	Test the battery's ability to store energy	YES
INA219 monitoring	Test the INA219's ability to measure voltage, current, power, and energy consumption	YES
Nodemcu connects Blynk and Display	Test the nodemcu's ability to connect to the Blynk app and transmit data	YES
Fan and bulb running	Test the fan and bulb's ability to operate using the stored energy	YES

4.4 Discussion

The usage of IoT-based sun-based vitality collection and checking frameworks has noteworthy benefits for the vitality division. It gives an elective and feasible vitality source that can offer assistance to diminish reliance on conventional fossil fuels. Furthermore, the utilization of IoT innovation permits real-time observation and optimization of the vitality collection preparation, which increases effectiveness and diminishes costs. One of the essential focal points of IoT-based sun-based vitality frameworks is their capacity to gather and analyze information. This permits the optimization of vitality collection by altering parameters such as the point of the boards and the amount of vitality put away within the battery. The framework can also identify any flaws or anomalies, empowering fast upkeep and repair.

Another advantage is the adaptability of these frameworks. The measured plan of the components permits for simple integration into the existing framework and empowers the expansion of more boards and sensors as required. This makes it conceivable to form vitality frameworks that are customized to meet particular needs and can be adjusted to changing circumstances. IoT-based sun-oriented vitality frameworks have a positive effect on the environment. They are a clean and renewable vitality source that does not emanate hurtful gasses into the environment. They too offer assistance to decrease the carbon impression of buildings and organizations, making them an economical and mindful choice for vitality generation. In general, IoT-based sun-based vitality collection and observing frameworks give a productive and feasible elective vitality source with various benefits for the environment and the economy.

4.5 Scope of Improvement

Whereas IoT-based sun-oriented vitality collection and checking frameworks have noteworthy benefits, there's still room for advancement in their plan and execution.

One range for advancement is the unwavering quality and toughness of the components. The sun-oriented boards and sensors must be able to resist unforgiving natural conditions such as extraordinary temperatures and climate conditions. Furthermore, the remote organization must be steady and secure to guarantee ceaseless and precise information transmission. Another range for enhancement is the integration of vitality capacity frameworks. Whereas sun-oriented vitality frameworks can produce power during the day, they require vitality capacity frameworks to supply power at night or amid periods of moo daylight. Moving forward the productivity and capacity of vitality capacity frameworks can make sun-oriented vitality frameworks more solid and viable. The taking toll of IoT-based sun-oriented vitality frameworks can also be an obstruction to their far-reaching appropriation. Whereas the toll of sun-powered boards has diminished over a long time, the toll of sensors and controllers remains generally tall. Finding ways to diminish the toll of components without compromising their usefulness can offer assistance to make sun-based vitality frameworks more available to a broader run of buyers. At long last, more inquiryis required to optimize the execution and effectiveness of IoT-based sun-powered vitality frameworks. This incorporates creating calculations and prescient models to optimize vitality collection and capacity, as well as examining the effect of natural variables on framework execution.

5. Conclusion

IoT-based sun-based vitality collection and observing frameworks offer an economical and proficient elective to conventional vitality sources. The capacity to gather and analyze real-time information gives various benefits, including expanded proficiency, diminished costs, and moved forward unwavering quality. The versatility of these frameworks too permits for simple integration into existing foundations and customization to meet specific needs. Be that as it may, there's still room for advancement within the plan and execution of these frameworks. Moving forward the unwavering quality and strength of components, coordination vitality capacity frameworks, diminishing the taken toll of components, and optimizing execution through an inquiry about are all regions for advancement. Despite these challenges, the move towards renewable vitality sources such as sun-based vitality is imperative for an economical future. IoT-based sun-powered vitality collection and checking frameworks play a critical part in this move and offer various benefits for both the environment and the economy. As innovation proceeds to development, ready to anticipate to see indeed more noteworthy advancements in IoT-based sun oriented vitality frameworks. These frameworks have the potential to revolutionize the vitality division and contribute to a more economical and affluent future for all.

5.1 Future Work

Future work in IoT-based sun-oriented vitality collection and checking frameworks:

1. Integration of AI and ML calculations to optimize vitality collection and utilization designs.

2. Improvement of progressed vitality capacity frameworks to overcome restrictions of current advances.
3. Investigate the long-term natural and social impacts of sun-oriented vitality frameworks.
4. More noteworthy collaboration between partners to advance the advancement and selection of maintainable vitality sources.
5. Moving forward the versatility and versatility of IoT-based sun-oriented vitality frameworks.
6. Creating measured and adaptable frameworks that can be effortlessly designed and reconfigured as required.
7. Progressing the unwavering quality and toughness of sun-oriented boards, inverters, and other framework components.
8. Creating more productive and cost-effective sun-oriented cell advances.
9. Expanding the utilization of IoT sensors and other checking instruments to make strides in framework execution and productivity.
10. Creating unused commerce models that incentivize the appropriation of renewable vitality sources and advance vitality preservation.

These ranges of future work are fundamental for the proceeded development and improvement of IoT-based sun-powered vitality collection and observing frameworks. By tending to these challenges, able to make a more economically vitality future that benefits both the environment and society as an entire.

Compliance with Ethical Standards

Conflicts of interest: Authors declared that they have no conflict of interest.

Human participants: The conducted research follows the ethical standards and the authors ensured that they have not conducted any studies with human participants or animals.

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Appendix:

```
#define BLYNK_PRINT Serial

#define BLYNK_DEVICE_NAME "IOT Energy Meter"

#include <ESP8266WiFi.h>
#include <SoftwareSerial.h>
#define BLYNK_AUTH_TOKEN "6zmICzLhWSMdcF7_kILvHr9Ft3xzWUGq"
charauth[]="6zmICzLhWSMdcF7_kILvHr9Ft3xzWUGq";charssid[]="mobilewifi";
charpass[]="abcd1234efgh";
#include <SPI.h>
#include <Wire.h>
/*****************************************************************************/
#define SCREEN_WIDTH 128 // OLED display width, in pixels
#define SCREEN_HEIGHT 64 // OLED display height, in pixels
#define OLED_RESET     -1 // Reset pin # (or -1 if sharing Arduino reset pin)
#define SCREEN_ADDRESS 0x3C ///< See datasheet for Address; 0x3D for 128x64, 0x3C for 128x32
// Declaration for an SH1106 display connected to I2C (SDA, SCL pins)
Adafruit_SH1106G display = Adafruit_SH1106G(SCREEN_WIDTH, SCREEN_HEIGHT, &Wire, OLED_RESET);
Adafruit_INA219 ina219;
unsignedlongpreviousMillis=0;
unsignedlong interval =2000;
floatshuntvoltage=0.00;
floatbusvoltage=0.00;
float current =0.00;floatloadvoltage=0.00;
float energyPrice = 6.50;
float power = 0.00;float capacity = 0.00;
```

```
voidsetup()
{
Serial.begin(9600);
while(!Serial){
// will pause Zero, Leonardo, etc until serial console opens
delay(1);
}
uint32_tcurrentFrequency;
Serial.begin(9600);
// initialize OLED display
display.begin(0x3c, true);
display.clearDisplay();
display.print("IoT Energy Meter");
display.display();
//Start Blynk 2.0
Blynk.begin(auth, ssid, pass);
// Initialize the INA219.
// By default the initialization will use the largest range (32V, 2A).  However
// you can call a setCalibration function to change this range (see comments).
if(! ina219.begin()){
Serial.println("Failed to find INA219 chip");
while(1){
        a.delay(10);
}
}
// To use a slightly lower 32V, 1A range (higher precision on amps):
//ina219.setCalibration_32V_1A();
// Or to use a lower 16V, 400mA range (higher precision on volts and amps):
//ina219.setCalibration_16V_400mA();
Serial.println("IoT Energy Meter with INA219 ...");
}
voidloop()
{
Blynk.run();
}
void ina219values(){
shuntvoltage= ina219.getShuntVoltage_mV();
busvoltage= ina219.getBusVoltage_V();
current = ina219.getCurrent_mA();
current =abs(current);
loadvoltage=busvoltage+(shuntvoltage/1000);
power =loadvoltage* current;
energy = energy + power /3600;//Wh
capacity = capacity + current /1000;
energyDifference= energy -energyPrevious;
energyPrevious= energy;
energyCost=energyCost+(energyPrice/1000*energyDifference);
// Send data to blynk
Blynk.virtualWrite(V7, current);
Blynk.virtualWrite(V5, String("Tk.")+ String(energyPrice));
// nothing connected? set all to 0, otherwise they float around 0.
   if(loadvoltage<1)loadvoltage=0;
   if(current <1)
   {
   current =0;
   power =0;
   //energy = 0;
   //capacity = 0;
```

```
//energyCost=0;
}
Serial.print("Bus Voltage:   ");Serial.print(busvoltage);Serial.println(" V");
Serial.print("Shunt Voltage: ");Serial.print(shuntvoltage);Serial.println(" mV");
Serial.print("Load Voltage:  ");Serial.print(loadvoltage);Serial.println(" V");
Serial.print("Current:       ");Serial.print(current);Serial.println(" mA");
Serial.print("Power:         ");Serial.print(power);Serial.println(" mW");
Serial.print("Energy:        ");Serial.print(energy);Serial.println(" Wh");
Serial.print("Capacity:      ");Serial.print(capacity);Serial.println(" Ah");
Serial.print("Energy Cost:   ");Serial.print("Tk. ");Serial.println(energyCost);
Serial.println("-------------------------");
}
voiddisplaydata(){
display.clearDisplay();
display.setTextColor(SH110X_WHITE);
display.setTextSize(1);
// VOLTAGE
Blynk.virtualWrite(V0, String(loadvoltage, 2)+ String(" V"));
display.setCursor(0, 5);display.print(loadvoltage, 2);
display.print(" V");
// CURRENT
if(current >1000){
Blynk.virtualWrite(V1, String((current /1000), 2)+ String(" A"));
display.setCursor(60, 5);
}
else
{
Blynk.virtualWrite(V1, String(current, 2)+ String(" mA"));display.setCursor(60, 5);display.print(current, 1);
display.println(" mA");
display.setCursor(0, 15);display.println("--------------------");}
display.setCursor(60, 20);
display.setCursor(60, 36);display.print("|");
display.setCursor(60, 40);
display.print("|");
display.setCursor(0, 46);
display.print("--------------------");
// POWER
if(power >1000){
Blynk.virtualWrite(V2, String((power /1000), 2)+ String(" W"));
display.setCursor(0, 24);
display.print(String((power /1000), 2));
display.println(" W");
}
else{
Blynk.virtualWrite(V2, String(power, 2)+ String(" mW"));
display.setCursor(0, 24);
display.print(power, 2);
display.println(" mW");
}
//Energy Comsumption
if(energy >1000){
Blynk.virtualWrite(V3, String((energy /1000), 2)+ String(" kWh"));
display.setCursor(0, 36);display.print((energy /1000), 2);
display.println(" kWh");
}
else{
```

```
Blynk.virtualWrite(V3, String(energy, 2)+ String(" Wh"));
display.setCursor(0, 36);
display.print(energy, 2);
display.println(" Wh");
}
// CAPACITY
if(capacity >1000){
Blynk.virtualWrite(V4, String((capacity /1000), 2)+ String(" Ah"));
display.setCursor(65, 24);
display.println("Capacity:");
display.setCursor(65, 36);
display.print((capacity /1000), 2);
display.println(" Ah");

}
else
{
Blynk.virtualWrite(V4, String((capacity), 2)+ String(" mAh"));
display.setCursor(65, 24);
display.println("Capacity:");
display.setCursor(65, 36);
display.print(capacity, 2);
display.println(" Ah");

}
// ENERGY COST
Blynk.virtualWrite(V6, String("Tk.")+ String(energyCost, 5));
display.setCursor(10, 54);
display.print("E Cost:Tk ");
display.println(energyCost, 5);
display.display();
}
```