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Development of an intelligent IoT-Based Monitoring System for Power Quality Application

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Abstract: A process on solar charging system where there is a solar panel, battery and the load as for charging the battery the solar charger is needed to complete the system. The problem that is occur is providing sustainability of energy and to relieving the global environmental crisis. Th power production is need for accurate solar power forecasting its crucial for grid integration when its directly connected with their accuracy. As for data loggers for PV monitoring there are some research regarding the best way to collect the data needed. As the precise and simplest way is using the data logger. There are several researches proposed that the data logger is necessary for monitoring and collecting data. The requirement also has been measured which there are several instinct levels that can reach the main goal of measurements. As for the performance and testing of its results within the accurate range, the multimeter is the base guideline to validate our measurements in this project. This standard can be defined as class B (medium accuracy) as the most ideal system and fit for our application. Among all the various connectivity fir out online monitoring system, there are several of frequency we need to address, on of it the connection to the internet and it is reliable of connection without any networking problem. There are several characteristic the best is WLAN(Wi-Fi) which suitable and fast if the bandwith application. In this project, we build a prototype which can monitor the solar panel to gain data and collect all measurements needed. PV system, monitoring is regarded as a critical feature for assessing the system's stability and performance. For collecting data with simple GUI interface that has been create. The cloud data is been store in the firebase online, which is being link to the GUI system app. Without losing any data, the system will continue collect if there any problem in the online system. As it restores all the necessary data. The real time monitoring system is been accomplish as the main objective is been achieve as for the precision of 100% as the manual data collecting.

Keywords: Collect Data, Monitoring System, GUI System

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1. Introduction

1.1 Background Study

The demand for power production by renewable energy to the electricity supply constantly increases, particularly photovoltaic (PV) solar power. In fact, to a large extent, solar energy can curb the energy crisis and global warming. Nevertheless, power generated from solar energy systems exhibits fundamentally different characteristics than conventional energy sources (e.g., fossil fuels). While power production from conventional sources can easily be matched to the given electricity demand, the availability of solar energy is primarily determined by the prevailing weather conditions and is therefore highly variable. Such high variability of solar energy poses significant challenges for integrating such renewable energy into existing power systems with the requirement of balancing supply and demand.

This work is dedicated, to creating a simple system for collecting data and monitoring system. The monitoring system has a backup for holding and collecting the data. As the data, it can be stored for 30 days. This can help in analyzing the data and comparing the data can do some research on the efficiency of solar energy. It's can reduce human error than the old monitoring system, which needs collect manual way. The system also improves the data measuring, which the system can be implemented in any solar system.

1.2 Problem Statement

Solar power energy technology is a convincing approach to providing sustainable energy and to relieving the global environmental crisis. However, the availability of solar energy is largely determined by the prevailing weather conditions and is therefore highly variable. Details information on the expected power production required accurate solar power forecasting for an efficient integration of the power system.

The correctness of PV power forecast for grid integration is crucial for grid integration where it is directly connected with their accuracy. Hence the need of precisely forecast PV data will be a key motivation of this proposed work. Such solar data can contribute to the effective forecasting and management of solar resources on the power grid specifically in Malaysia. For this respect, it is worthwhile to develop data acquisition monitoring system for solar power pertaining to the peculiarities of climate in this region. In fact, the sufficient data collection obtain from the data acquisition should help to explore the characteristics of PV forecasting models in this region.

1.3 Objectives

The main objectives for this study are;

a) To develop a prototype data acquisition system hardware for photovoltaic system monitoring and reporting.
b) To development a programming software for data acquisition system which can store and monitor parameters form PV system.
c) To integrate software and hardware for the develop data acquisition system and validate the functional performance of the prototype system.

1.4 Scope of work

For this project, the scope will be focusing on;

a) This project is solely implemented based on the prototype DAQ station for photovoltaic system.
b) There are require several important parameters form PV panel such as voltage and current.
c) The graphic user interface for the DAQ station which associate and incorporate algorithm with associate and incorporate algorithm with Android Studio.
d) A photovoltaic data acquisition system will be developed to record of PV solar power from the solar panel.

e) The DAQ that been obtained will refresh every hour to gather new data.

2. Methodology

In this chapter, the general workflow within the scope of this study is explained. Next, the methodology on the DAQ system overview, which show the combination the hardware and software which we read the measurements. The next methodology is the PV DAQ process system algorithm that show, how to the PV solar readings for the system. Outcomes of the modelling will then be validated with the data acquisition station of the solar photovoltaic system.

2.1 Project Flowchart

Figure 1 shows the general workflow proposed in this work, mainly based on the extensive analysis of the circuit design and decoding process. The flow of the work already addresses in objective 1, which we start to processing all the program which needed to work with all the component that will use. In this process we can try and error by using the stimulation based on the needed application. Finding the right component which we can integrate directly to the software that been develop.

The second stage of the work will be focused developing the program and creating GUI that can perform as expected. The GUI consists on the interface for the data monitoring with a long side proper hardware that measure the data. All the data that has been collected will go through a data logger, All the data will be collect from the solar panel that will use in this prototype. The hardware will be also program that will work on how many times its need to measure alongside all the component. The validation of the model will be carried out through solar evaluation. Such work will complete the second objective proposed in this proposal.

The final stage of the project will be focusing on the evaluation and validation of the physical model developed from the second objective. The data acquisition station (DAQ) will be developed to obtain the actual photovoltaic parameters. Then, the validation of the physical model will be compared to measurement data with respect to the efficiency of the physical model.

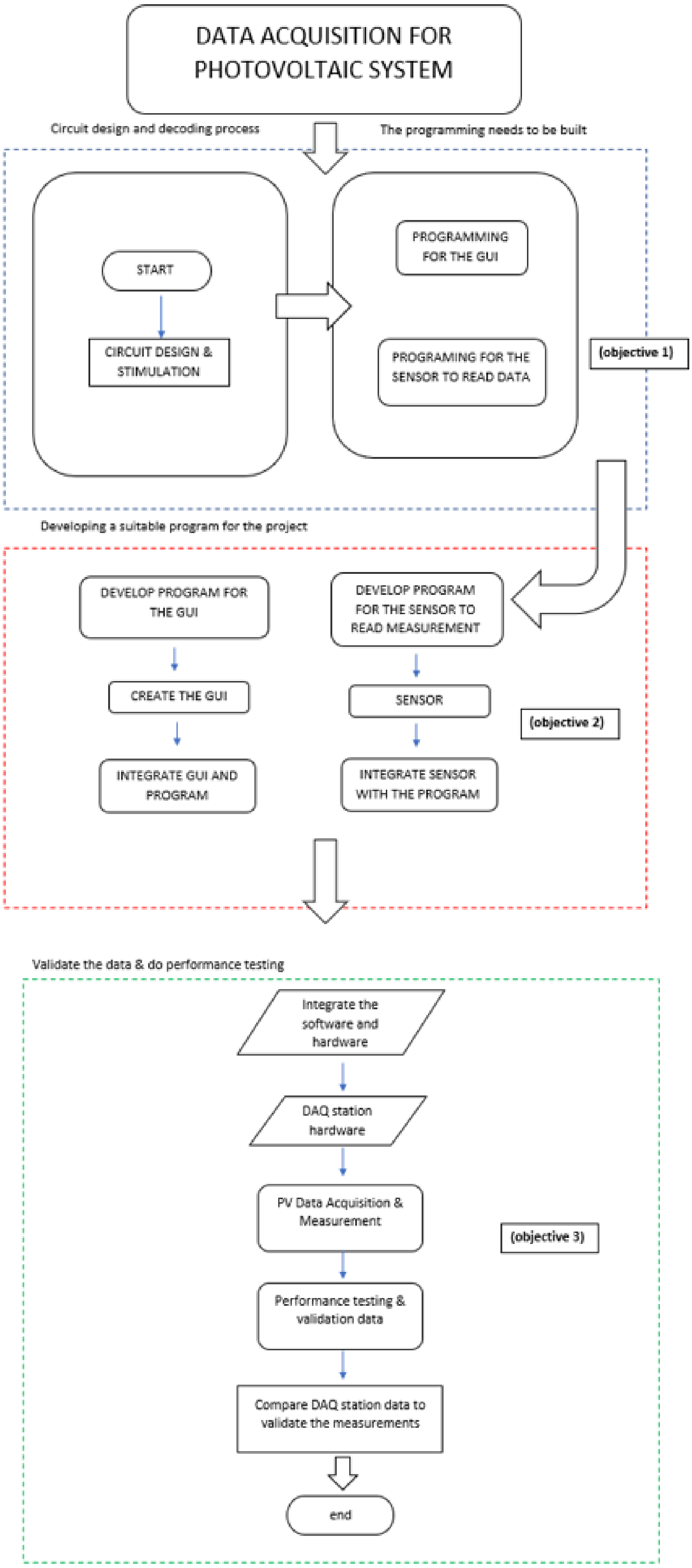

Figure 1: Block Diagram

2.2 Block Diagram of DAQ System

This segment is show on how the prototype works, as shown in Figure 2. The system starts from the monitoring, which their GUI that help to monitor. The GUI will be connected to the internet, and there the data storage in the cloud. All the PV data that has been collected will go to the data logger, which it collects directly and been store for the data analysis if needed. After the data logger collect the data, it will send the data by using the connection that connected to the internet, the data will be access by the GUI.

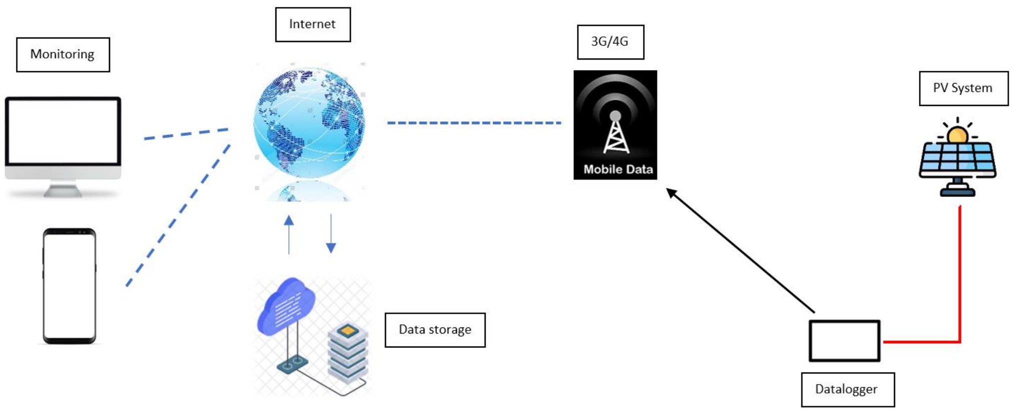

Figure 2: Block Diagram DAQ System

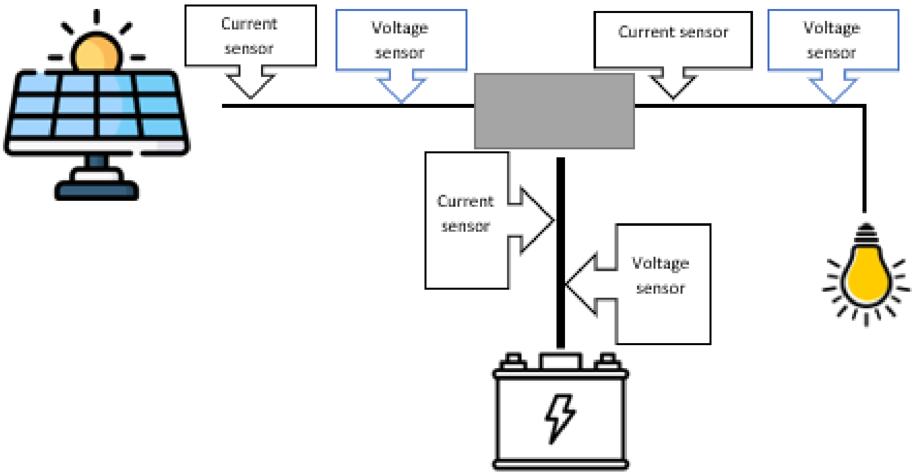

Figure 3: Block Diagram Sensor

In Figure 3, it shows where sensor it going to located, the sensor is for collecting all the data needed, which is current sensor, voltage sensor and temperature sensor. Every type of sensor will record and see the measured data in the GUI which the user can access from a remote location.

2.3 Software Development

The official IDE for Android is Android Studio. It's optimized for Android development to save you time and ensure that your apps run well on all Android-powered devices. Using Android Studio to creating the GUI needed for this project with a simple interface which can directly communicate with the firebase database system show in Figure 2.4. Apply Changes in Android Studio allows you to deploy code and resource changes to your running app in certain situations, without resuming the current activity and without having to relaunch your app. Small, incremental changes may be deployed and tested without requiring a full restart because of this control over how much of your program is restarted. This is good for our developing the necessary change if needed as to implement or build new features in the GUI.

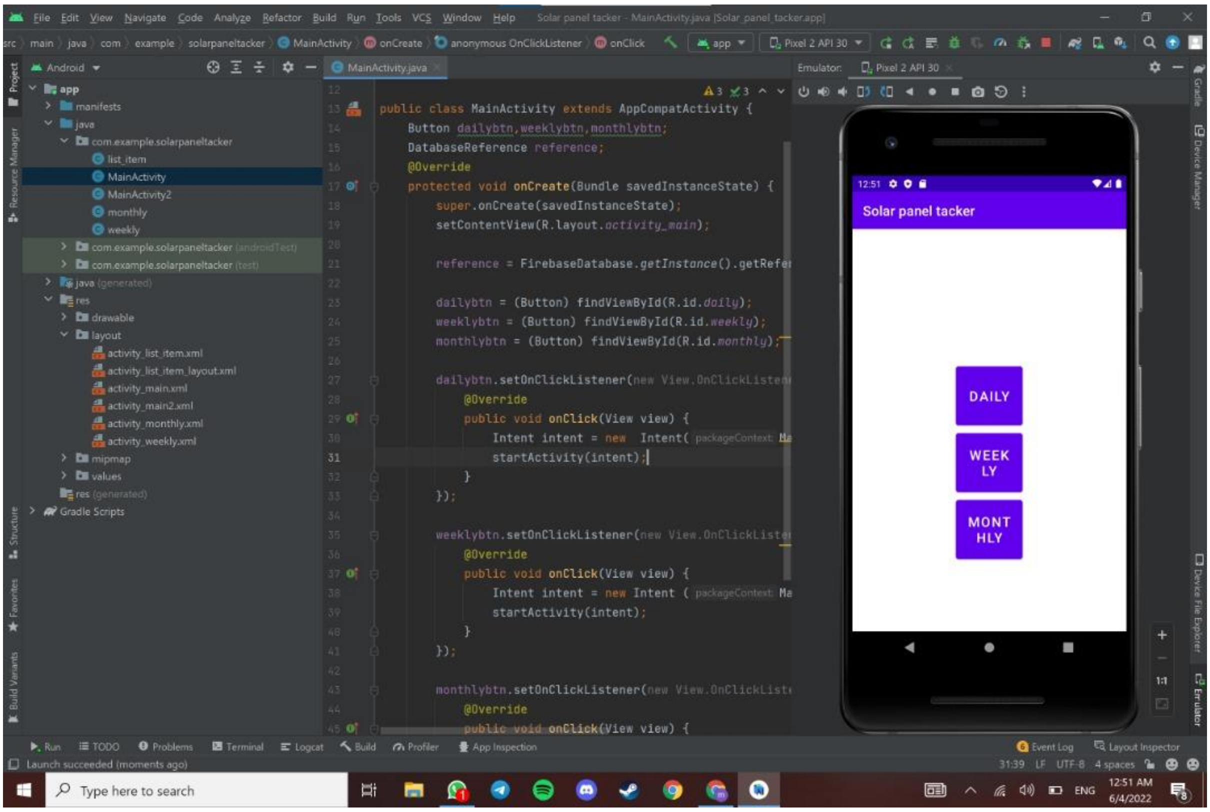

Figure 4: Android Studio GUI Development

2.4 Hardware Development

2.4.1 Load used in the project

From the solar panel the voltage will go to the battery which it either can charge or maintain by trickle charge the battery, the trickle charge is to maintain the voltage capacity and to prevent the battery to gone flat. After that from the battery it will go through the load. The load that we are using is the lamp which is 12 V of lamp. This lamp is not dimmable lamp, if there any voltage that drops under 5 V the lamp will start blinking because there is not enough voltage to maintain the steady output. The lamp we put is beside the solar charger which we can easily monitor the system charging and can see the output load in Figure 5.

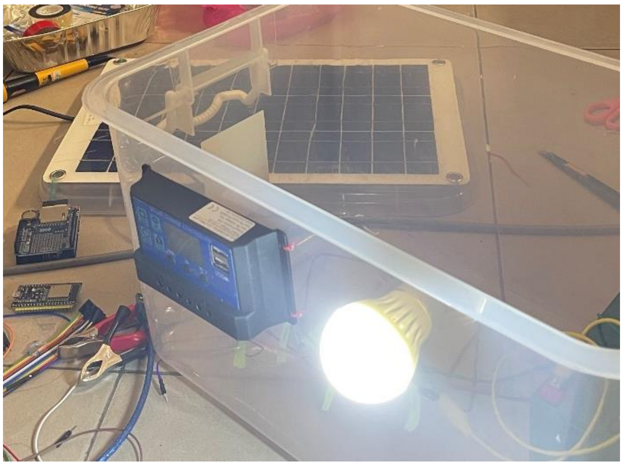

Figure 5: Load Used In This Project

2.4.2 Electronic device circuit

The electronic device circuit is developed using breadboard. The components used in hardware development is shown in Figure 6. The components used in the hardware development included ESP-WROOM-32 microcontroller Arduino, voltage sensor current sensor and solar panel. There are total 6 sensor that being used. This sensor is being used for monitoring each system of the solar panel charging system. Basically, this system we just implement the sensor to the system which we can monitor the system.

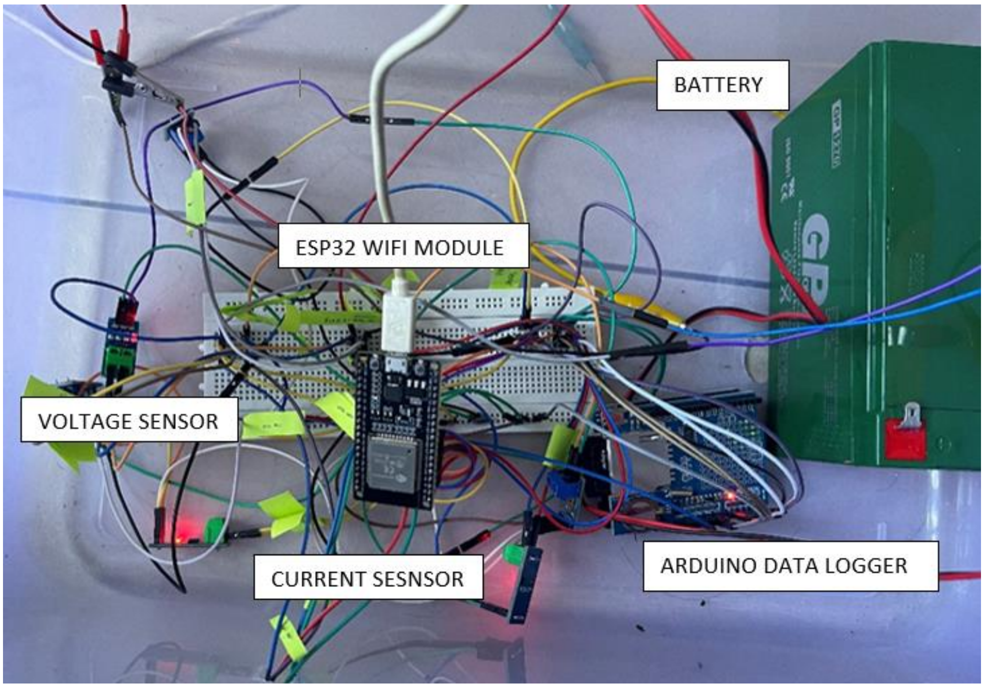

Figure 6: Electronic device circuit

2.4.3 Complete Hardware

Therefore, the hardware development is complete by combine the load of the project and the electronic devices. Figure 7 shows the complete hardware of the IoT-based power quality monitoring system. The electronic device for this project were inserted in the plastic box and the lip container we put the solar panel.

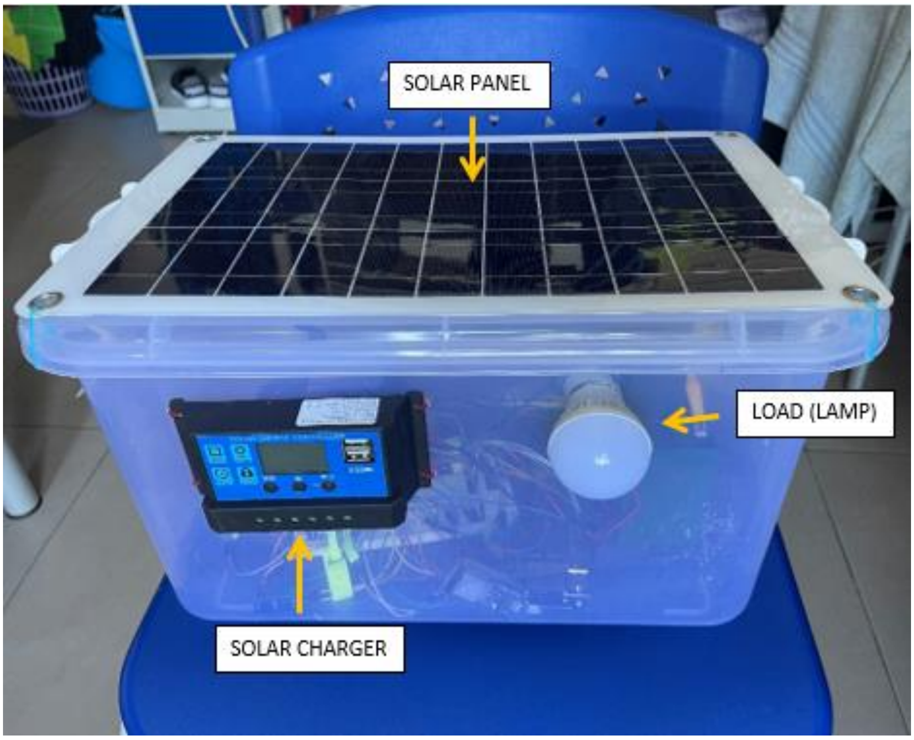

Figure 7: The complete hardware

3. Results

For the overall results this project is more focused on developing a simple prototype which can make it easy to show the implemented system monitoring system, in any electrical charging system.

3.1 Overall results

The firebase system offers real-time database and backend services. The service offers an API that allows application data to be synced and saved in the Firebase cloud. The library can integrate with Android, iOS, JavaScript, Java, Swift, and Node.js apps. The database is also accessible through REST API and is compatible with numerous JavaScript Frameworks, including AngularJS, React, Ember.js, and Backbone.js. Realtime database developers can safeguard data by enforcing security requirements imposed by the application needed. Cloud Fire store, the next generation of Firebase Realtime Database. The wifi module helps to connect to the firebase system. As shown in Figure 8.

Figure 8: ESP-32 Wifi & Bluetooth Development Board

As this firebase real-time database, it can communicate with the wifi module that can directly connect with the fire base real-time monitoring. This process can help us to read the measurements live and directly. The wifi module help it connect by using Arduino and data logger as the time stamp, for when the time is recorded. The coding that upload the data to firebase system.

As for the real time monitoring system can be monitor by using the GUI apps and the firebase system. The real monitoring provides the continuous stream of relevant and current data which can immediately read and collect stored data. This way it can be more quickly routed and its better than the old way on collecting data. Generally, real time monitoring software display is a lot of relevant data, the data we gain can be used for display expected data range and formats as numerical line graphs, bar graphs, pie charts or percentages. As we see in Figure 9, Figure 10 and Figure 11. The Wifi module we can overwrite the system by resetting the module and the measurements on that time will be measure.

Figure 9: Real Time Monitoring from Solar Panel

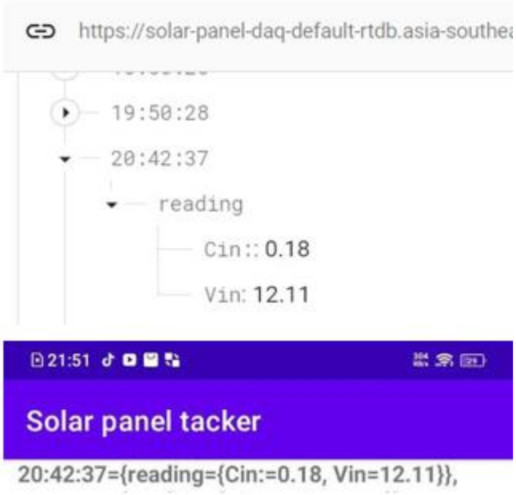

Figure 10: Real Time Monitoring from Battery

Figure 11: Real Time Monitoring from Load (Lamp)

The next objective is to monitor the data that has been collected for 24 hours and analyze the measured data online. For this purpose, all the data will be collect throughout the day, which we collect data for 24 hours. This is the results that we collected with load is connected for 24 hours, and the place what time we put indoor and outdoor.

Based on 24 hours this project measurement voltage and current every hour the increase of measurements when we put the solar panel outdoor which there is sunlight. We can also see the results which is indoor where there are some voltage from the solar panel this is because the voltage come from the lighting in the room, where we can see around 00:50:28 the voltage is drop because there is no light in the room. The data all has been collected to the online database in Figure 12.

Figure 12: Online Firebase Data Measurements Load is ON

The Solar Reading Voltage and Current when system is connected in more specific analysis data and easy to see the measurements data readings.

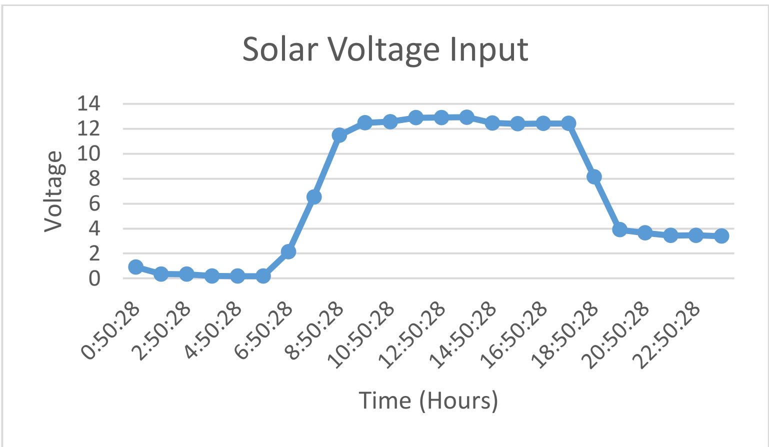

Figure 13: Solar Graph Show Much Voltage Gain from The Solar Panel

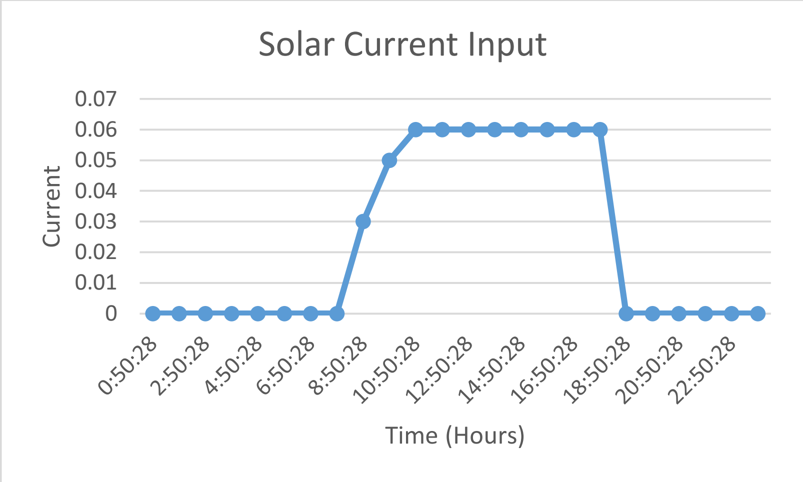

Figure 14: Solar Graph Show Much Current Gain from The Solar Panel

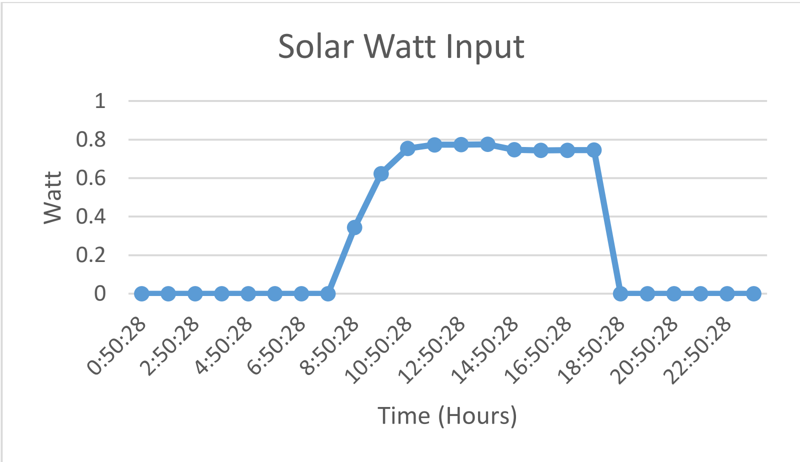

Figure 15: Solar Graph Watt Input Gain from Solar Panel

The data that has been collected for 24 hours of monitoring which has been collected. This measurement is when load is connected. We also can see the different of the voltage and current in Figure 13 and Figure 14 which in the indoor the solar panel does not produce voltage more than 10 V and 0A of current which is not charging the battery. When we put the prototype outdoor, we can see the solar charge for 10 hours because the voltage is above 10 V which is enough voltage to charge the battery. In Figure 15 we can see the power input from the solar panel, which the higher peak when the sunlight directly into the solar panel.

Next measurements are the battery that we measure which is Voltage, Current and Watt when load is connected.

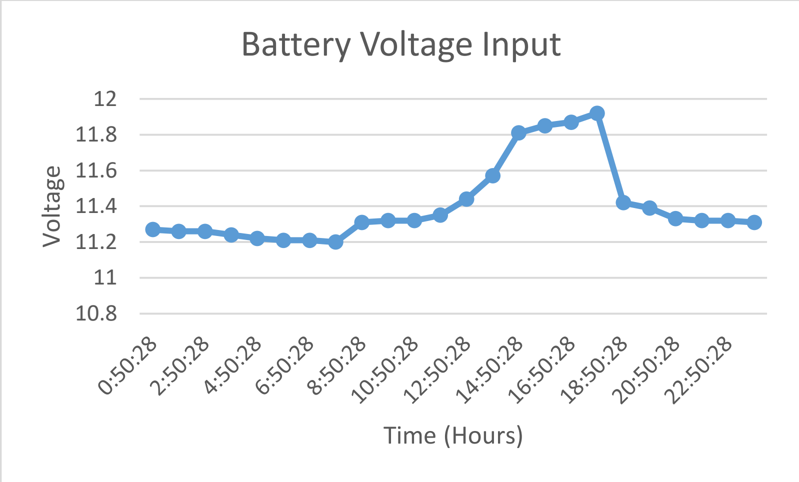

Figure 16: Battery Graph Voltage When Load Is Connected

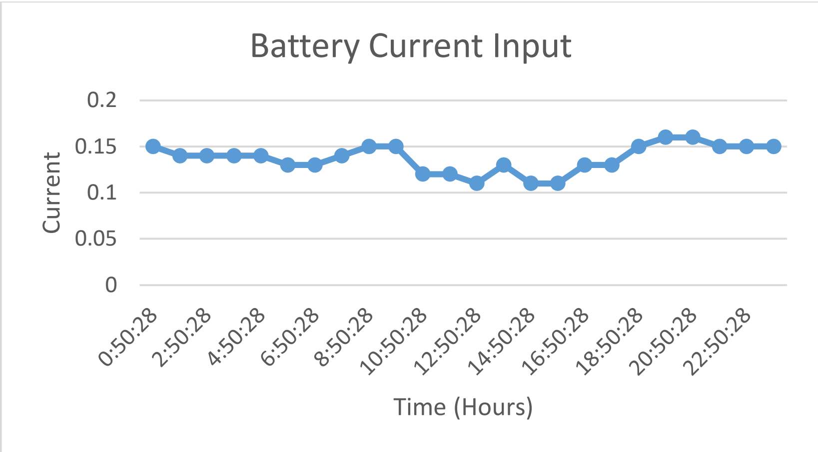

Figure 17: Battery Graph Current When Load Is Connected

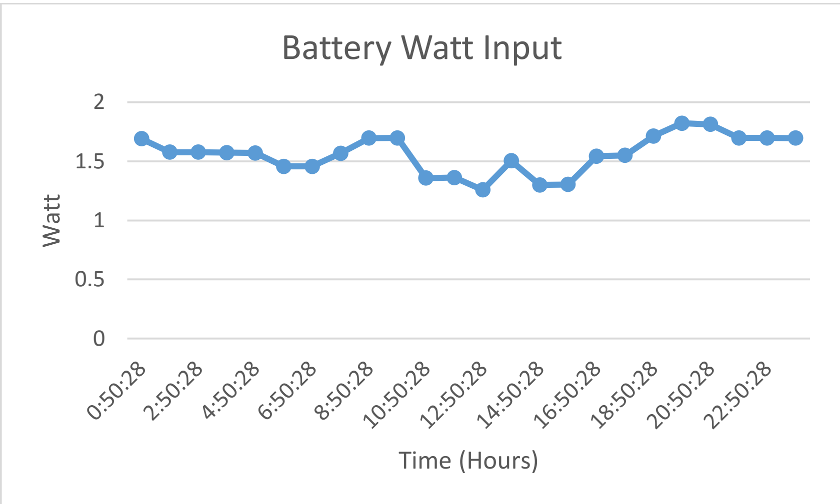

Figure 18: Battery Graph Watt When Load Is Connected

The voltage is start charging and how much battery is depleted during the indoor measurements when load is connected. This can be seen in the Figure 16 and Figure 17. Same as the power of the battery, we can see different charge of current due to the output is not constant can be cause by the load or the solar panel.

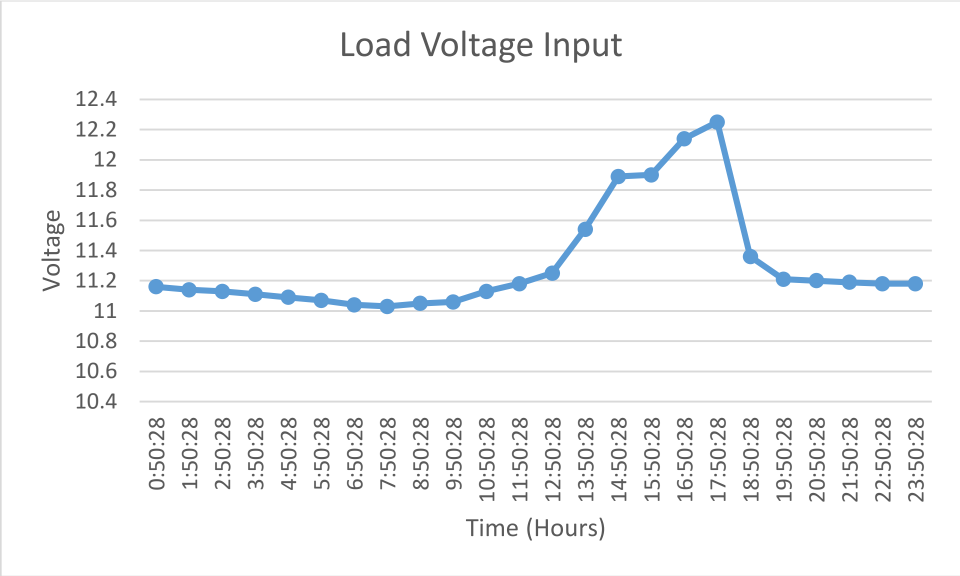

Figure 19: Load Graph Voltage When Load Is Connected

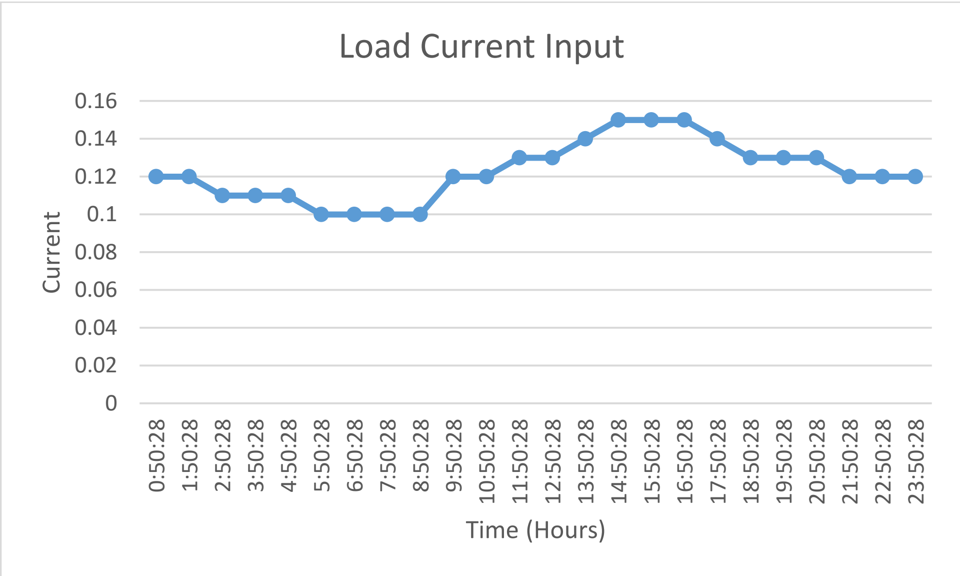

Figure 20: Load Graph Current When Load Is Connected

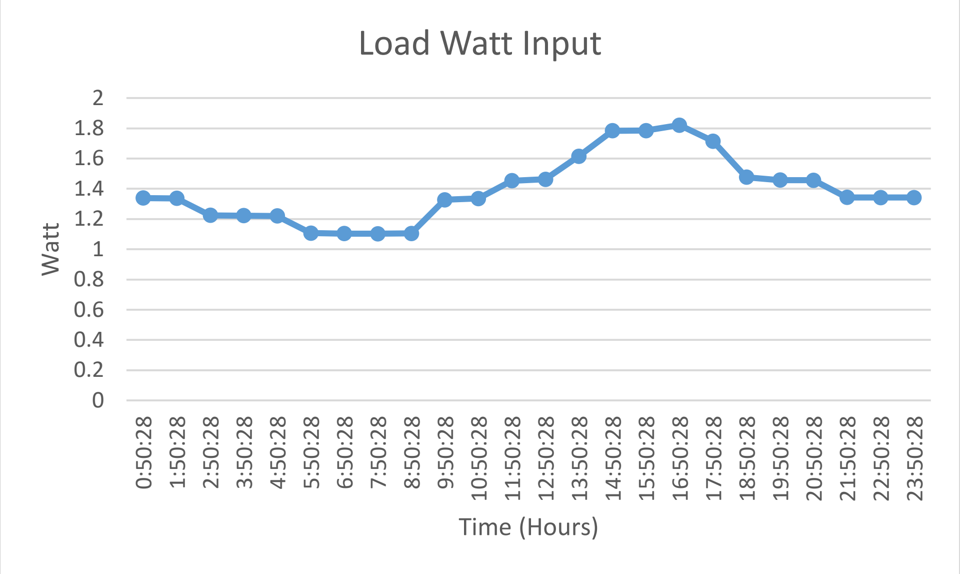

Figure 21: Load Graph Watt When Load Is Connected

The load for load lamp, with the load is connected for 24 hours. As we can see in the Figure 19 there an increase 12:50 pm to 5:50 pm because the solar panel is charging the battery, and the battery is in full of charging capacity. We can see the different in the graph of Figure 20, where the sudden spike in the graph is in the same when the battery is start charging.

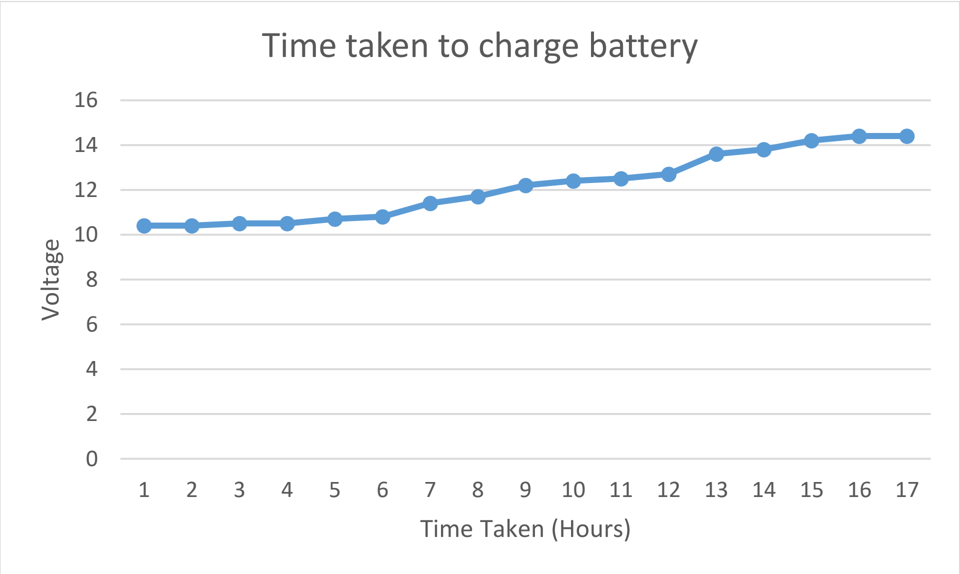

Figure 22: Line Graph Time Taken to Charge Battery

Referring to the Figure 22, the total time taken to charge battery is 16 hours. Starting from 10.4 volts, the battery will be charged up to 14.4 V. In this project the battery used is 12.0 V Battery GP Rechargeable sealed lead acid. This process charges the battery starts from 8:50 am to 5:50 pm. The value of the battery that was successfully charged on the first day was 12.5 V. The next day the battery was connected to charge to get a full charge to 14.4 V.

When the process of charging the battery takes place, the whole process has been controlled by the solar charger controller. A solar charge controller prevents overcharging of the battery by limiting the voltage and current flowing from the solar panel to the battery. In this project, the value that has been set to prevent from over charging is 14.4 V. Therefore, after the battery is fully charged, the solar charge controller will not allow voltage to flow to the battery. At 1:50 pm, the solar panel provides a lot of voltage and current to charge the battery. This is because, solar panels are the largest source of energy to be stored in the battery.

As for the effectiveness of current and voltage measurements, the effectiveness of current and voltage measurement can be test by using the multimeter to make sure the accuracy of this measurements. This measurement can be confirming by the multimeter.

Figure 23: Measurement That Show in The Gui System

Figure 24: Measurements That Validate by Using Multimeters

The data that has been measured is 8.14 V in the firebase data base system in Figure 22. The firebase data system will also communicate with the GUI which as we see in Figure 23 is show the GUI also show the same measurements. As we can validate that the firebase system is communicate with the GUI that we create. For validating our project measurements, we use 2 multimeters to validate the readings as shown in Figure 24 the multimeter measurements gain similar reading for the voltage. If we take the average of 2 readings of the multimeter. We will get 8.135V and if we compare the reading in the project which we gain 8.14 V. For the accuracy we 99.871 % as the readings from our project and by using the multimeters.

In the firebase features system, we can monitor the real time monitoring system with any other electronic device which are connected to the internet. As the firebase use a web base cloud monitoring this system can be useful for our project. As long the system is connected to internet. We can access it through anywhere and anytime. As we can see in the Figure 25 which we are using the generic website. Its only need the email and password access accounts to see the data.

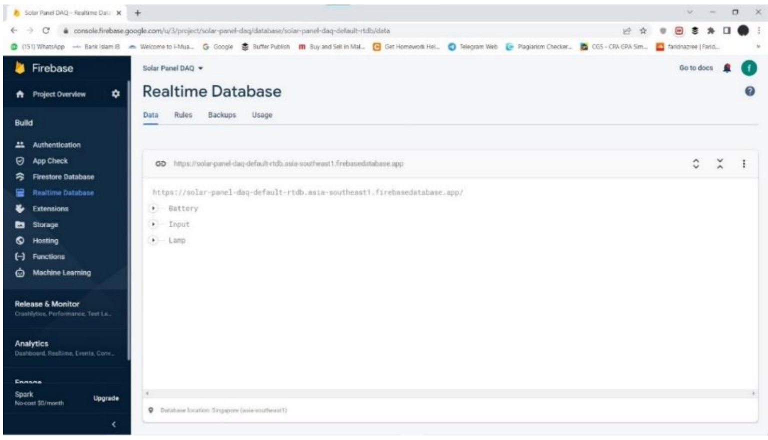

Figure 25: The Firebase Website That We Can See the Recorded Measurements

Features of this GUI system we can monitor it, without using firebase website, as the GUI is automatic connect to the firebase data system as we see in Figure 26. In the user interface has 3 buttons, which is batter, input and lamp in Figure 27. The system can be easily monitoring the system without any problem in Figure 28, Figure 29 and Figure 30. As this system has their own designated app, it also helps to read and gain data with a simple user interface.

Figure 26: GUI Application for Android

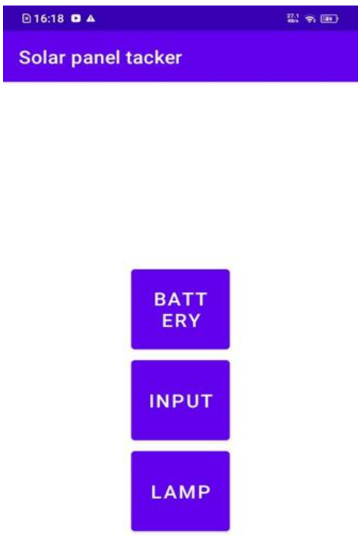

Figure 27: GUI Main Interface When Opening the Application

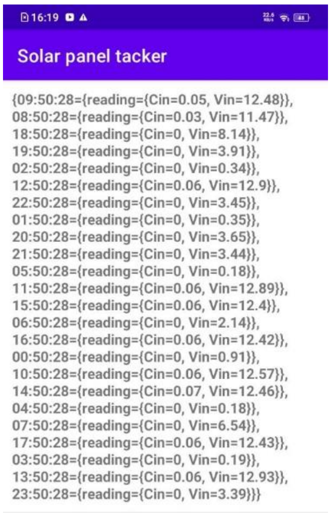

Figure 28: Solar Panel Reading from The GUI Application

4. Conclusion

The main objective for the purpose project is to data monitoring system has great potential and can be a new form of system monitoring. As we can set what parameter to monitor, this system can easily implement in many electrical systems. This project provided a monitoring system with designated application which can help to gain measurements with consistent time and accuracy of the measurements. The database that we choose to collect and monitor the system is firebase which easily accessible that only needed to connect to the internet. The project also has a backup data which we are using data logger as backup to collect data if there any problem to the internet, the data will be recorded in the small SD card storage.

Acknowledgement

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