MZUZU UNIVERSITY
FACULTY OF SCIENCE, TECHNOLOGY AND INNOVATION
DEPARTMENT OF IFORMATION AND COMMUNICATION TECHNOLOGY

DESIGN AND IMPLEMENTATION OF SOLAR POWER PLANT MONITORING SYSTEM

By

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A Systems Project Submitted in partial fulfilment of the requirements for the award of a Bachelor’s degree in Information and Communication Technology

MARCH 2021

DECLARATION

I **Felix Kumafutsa,** here by declare that the work presented in this project entitled **"Solar Power Plant Monitoring System"** is an authentic record of my own work carried out under the supervision of Mr. Namacha, Lecturer, Department of Information and Communication Technology, Mzuzu University. The work presented does not infringe any patented work and has not been submitted to any other university or anywhere else for the award of any degree or any professional diploma.

Name ***: Felix Kumafutsa*** ***Signature*** ***: _______________***

Date ***: ____ / ____ / ____***

DEDICATION

The System Project is dedicated to my parents, Mr. and Mrs. Mkhonde. I say, thank you for your moral, spiritual and financial support that you have rendered throughout my study period at Mzuzu University. The almighty God should continue blessing you.

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to the Lord Almighty God for giving me the courage, strength and ability to bring this work to a final stage.

My heartfelt gratitude should go to the following people who contributed to the successful completion of this work.

Firstly, I would like to thank my supervisor Mr. Namacha for accepting to work with me on my project idea, supervising my work, providing his expertise, guidance, suggestion, patience and motivation and ensuring that I meet his quality standards regarding any document or code produced. Secondly, I would like to thank my family and friends for providing moral, financial and psychological support which has helped me to successfully finish my work. In addition, I would like to thank the ICT Department for giving me this rare opportunity to work on my project and for providing funding to buy hardware equipment for the project. Also, I would like to the Academic Office for their efforts in ensuring that I finalize my work successfully. Lastly, I would like to thank my classmate for their support throughout the development of my project both mentally and technically.

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LIST OF ABBREVIATIONS

IoT	Internet of Things
ERD	Entity Relation Diagram
GUI	Graphical User Interface
LDR	Light Dependent Resistor
ESP	Espressif
SRS	System Requirement Specification
DDD	Detailed Design Document
LCD	Liquid Crystal Display
UML	Unified Modelling Language
UPS	Uninterruptible Power Supply
API	Application Programming Interface
GHZ	Gigahertz
GB	Gigabytes
MB	Megabytes
GSM	Groupe Speciale Mobile
URL	Uniform Resource Locator
MCU	Microcontroller Unit
GPIO	General Purpose Input/Output
ACS712	Active Current Sensor

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ABSTRACT

Due to the rapid population growth and continuous environmental degradation, electric energy produced is failing to meet the daily electricity needs of the communities. Solar energy is a clean, easily accessible and abundantly available alternative energy source in nature as compared to other renewable energy sources e.g., fossil fuels. Getting solar energy from nature is very beneficial for sustainable power generation hence the idea of converting solar energy into electrical energy using photovoltaic panels holds its place in the front row compared to other renewable sources because it does little environmental degradation [1]. But the continuous change in the relative angle of the sun with reference to the earth reduces the amount of power delivered by solar panel and using a fixed solar panel, we extract maximum energy only during 12 noon to 2 PM of the day which results in less energy efficiency of the solar power plants. Solar panels must be perpendicular with the sun in order to get maximum energy but this is not always the case because the current implementation hinders the panel from being perpendicularly oriented towards the sun. Solar trackers are needed to move the solar panels towards the sun throughout the day without need to manually calibrating them to receive maximum sunlight. The solar power plants need to be monitored in real time using a smart monitoring system to allow power plant owners to visualize the real plant operations. Hence, the need to improve the energy efficiency of solar panel by building an automated solar power plant monitoring system cannot be over-emphasized. Assumptions have been made that this monitoring system can increase the solar power plant efficiency by 25% which can enable the solar power plant to produce electric power that can serve basic electricity requirements of households for example; lighting, heating and watching TV. The system allows users to monitor parameters in the operation of the power plants in real time, allows the users to control the power consumption and also saves time [2]. The Solar power plant monitoring system is one of the IoT smart systems implemented using microcontroller (Arduino Uno), a Wi-Fi shield (ESP8266), current sensors, voltage sensors and light sensors (LDR). This project will result in the implementation of an Arduino based solar power plant monitoring system that will be able to trace the sun position and timely orient the sun at a right angle for it to get maximum sunlight. Light Dependent Resistors (LDRs) are used to sense the intensity of sunlight and hence the solar panel is adjusted accordingly to track maximum energy. The light sensors are attached to two edges of the solar panel to respond to the sun's change of position and send data to the microcontroller to instruct motors to calibrate the solar to receive maximum sun rays. The

mechanism uses a servo motor to control the movement of the solar panel. The microcontroller controls the servo motor based on signals received from the LDRs. A current transformer is connected to the circuitry to monitor the electrical power in watts (the Arduino is programmed to calculate power produced by the plant from the values provided by the current transformer). The system uses ESP8266 for real time transmission of data pertaining to the power being produced and consumed. The result of this work will be a solar power plant monitoring system that produces more energy compared to a fixed panel and that will also be able to perform monitoring activities on the solar power plant.

PART 1: PROJECT PROPOSAL

1.1 INTRODUCTION

1.1.1 Project History

Malawi is known to be a power-starved country because of the frequent power outages and shortages and this lack of power has been a real obstacle to Malawi's social and economic development [3]. This has been as a result of over-dependence on one source of electricity which is hydroelectric power source, lack of enough companies to supply electricity to the ever-growing population and lack of interest to invest in renewable energy technologies. Presently, public electricity covers only a small proportion of Malawian homes and this is not still on a consistent basis. Due to lack of constant power supply in Malawi, people have started embracing the culture of generating their own power through the use of solar systems and companies have started building huge solar power plant to sustain the energy needs of the nation. The use of fossil fuels like paraffin or petrol used in generators as a means of generating electricity is expensive making cost of living very high, especially in the rural part of the country. It also brings pollution to the environment which in turn is not safe for our health. It releases carbon dioxide which causes the greenhouse effect. This brings about the deforestation of land and also the pollution of air and water. Solar energy is gotten solely from the sun and as a result does not emit carbon dioxide which prevents the green-house effect. Nowadays solar energy is becoming one of the most reliable sources of energy as a result of its surplus and environmental friendliness. However, the operation of current of solar systems does not produce maximum power because they are arranged in a fixed array and also because these systems are not monitored in real time. Maximum energy is produced by a solar panel when it is positioned at right angle to the sun [4]. A system that tracks the sun will be able to know the position of the sun and position the solar panel at a right angle to receive maximum sunlight, and also be able to monitor solar power production, usage and distribution. Therefore, the aim of this project is to develop an Arduino based solar power plant monitoring system for energy improvement of solar panels.

1.1.2 Problem definition

Solar usage has proved to be a sustainable energy source but there are some challenges associated with current solar system installations and these include;

- Inefficient power production by fixed array solar installations
- The need to manually place the solar at a right angle to receive maximum sunlight
- Lack of monitoring of the charging of batteries that store our solar power
- Lack of monitoring of the power produced and power being consumed by different home appliances.

1.1.3 Objectives/Goals

The purpose of this project is

- To study the operation of solar systems
- To study the requirements for developing an automated solar power plant monitor
- To study the Arduino platform and its sensor kit to know how we can develop a system that automates solar power plant operations
- To use Arduino platform to develop an automated solar power plant monitor.
- Gain knowledge about solar energy management using IoT.

1.2 PROJECT STAKEHOLDERS

This section presents the stakeholders of the system being proposed.

1.2.1 System Personnel

1.2.1.1 Developer

The system is developed by Felix Kumafutsa.

1.2.1.2 End users

The system end users are household owners who are interested in using smart green energy. They will be using the home computer to receive data from the power plant, monitor the functionality of their power plant.

1.2.1.3 Owner

The system owners are any household solar power users who are able to purchase the required components.

1.3 AREA UNDER STUDY

1.3.1.1 Scope

The proposed system will be able to provide the following;

- Track the sun’s position and place the solar panel at a position where it can receive maximum sunlight in order to improve the production efficiency of solar power plants.
- Monitor power production over the web
- Monitor power consumption of different electrical appliances using power from our plant over the web.
- Automatically turn on and off lights to save energy.
- Aid power distribution to different appliances.

1.3.1.2 Deliverables

The following will be the system deliverables to be submitted at stated dates:

1.3.1.2.1 Project Proposal Document

This document shows the history, problem definition, objectives/goals and the scope of the proposed system. The method planned to be used is suitable and practical, and the results are likely to demonstrate productive results and shall make an original contribution.

1.3.1.2.2 System Requirements Specifications document (SRS)

The system requirements specification document will set out what the client expects and what is expected of the system which is being developed. It will also provide a mutual agreement and insurance policy between client and developer.

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1.3.1.2.3 Detailed Design Document (DDD)

Detailed Design Document describes the system requirements, operating environment, system and subsystem architecture, files and database design, input formats, output layouts, human-machine interfaces, detailed design, processing logic, and external interfaces.

1.3.1.2.4 User manual

This is a technical communication document intended to help people using the system. It shall provide direction on how to, install and operate a system once it is implemented.

1.3.1.2.5 The complete system and the system's documentation

This shall include a complete system in a fully operational physical format. It shall also be complemented with the user manual and a combination of System Requirements Specifications and Detailed Design Document.

1.3.1.2.6 Project Report

The project report will provide an overview of the system development process by presenting the project description, purpose, scope, scenarios, stakeholders, facts and opinions, requirements, solution ideas and the retrospective of the project.

1.4 PROJECT PLAN

1.4.1 Project Development

The system shall be developed within a period of approximately 10 months starting from 24 December 2019 to April 2021. The chart below shows how the activities of the project will be carried out:

ID	Task Name	Start	Finish	Duration
1	**Project Proposal**	**25/12/2019**	**17/01/2020**	**3.6w**
2	Drafting	25/12/2019	31/12/2019	1w
3	submission	07/01/2020	07/01/2020	.2w
4	Review and Editing	07/01/2020	15/01/2020	1.4w
5	presentation	17/01/2020	17/01/2020	.2w
6	**System Requirement Specification**	**20/01/2020**	**06/02/2020**	**2.8w**
7	Drafting	20/01/2020	24/01/2020	1w
8	Submission	27/01/2020	27/01/2020	.2w
9	Review and editing	28/01/2020	03/02/2020	1w
10	Presentation	06/02/2020	06/02/2020	.2w
11	**Detailed Design Documentation**	**05/03/2020**	**24/04/2020**	**7.4w**
12	Drafting	05/03/2020	25/03/2020	3w
13	Submission	10/04/2020	10/04/2020	.2w
14	Review and editing	13/04/2020	17/04/2020	1w
15	Presentations	24/04/2020	24/04/2020	.2w
16	**System Simulation**	**06/05/2020**	**16/10/2020**	**23.6w**
17	Design of simulation models	06/05/2020	27/05/2020	3.2w
18	Coding	29/05/2020	02/06/2020	.6w
19	Integration	04/06/2020	04/06/2020	.2w
20	Testing	04/06/2020	12/06/2020	1.4w
21	Presentation	16/10/2020	16/10/2020	.2w
22	**Hardware development**	**07/12/2020**	**18/03/2021**	**14.8w**
23	Component assembly and testing	07/12/2020	15/01/2021	6w
24	Hardware Design and development	18/01/2021	27/01/2021	1.6w
25	Coding	29/01/2021	01/02/2021	.4w
26	Integration	03/02/2021	03/02/2021	.2w
27	Testing	03/02/2021	18/03/2021	6.4w
28	Presentations	16/03/2021	16/03/2021	.2w
29	**Final submissions**	22/03/2021	**02/04/2021**	**2w**
30	Finalizing documentation and project report writing	22/03/2021	29/03/2021	1.2w
31	Submission	02/04/2021	02/04/2021	.2w

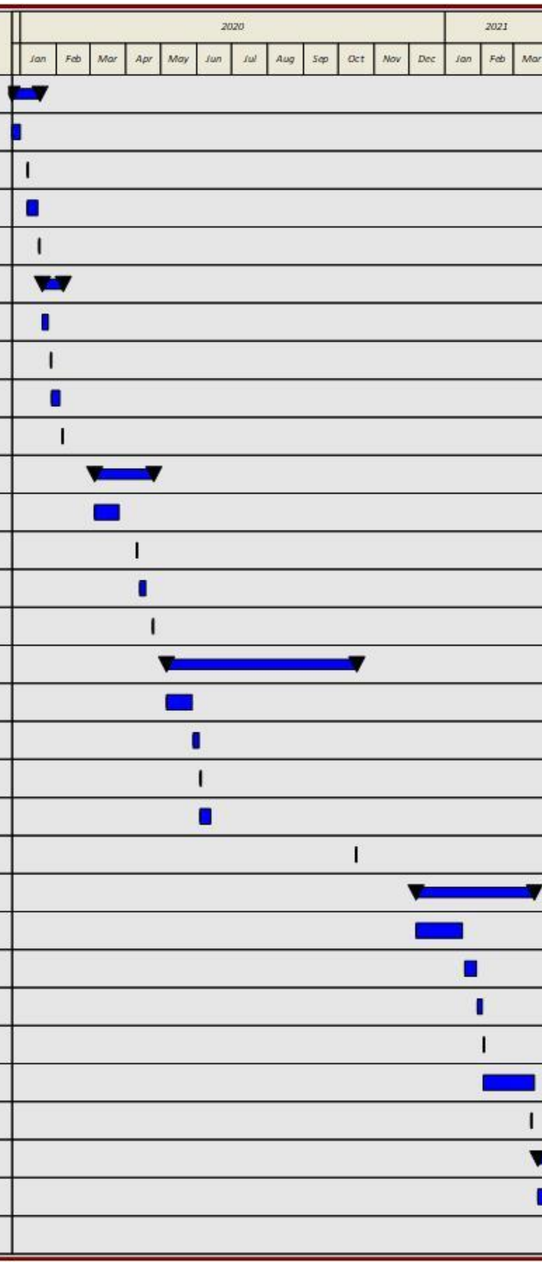

Figure 1: Project activity timing (Gannt chart). Note: most of these timings are just approximated.

1.4.2 Project budget

The project budget will include the following:

ITEM/ COMPONENT	QUANTITY	COST (MWK)
Arduino UNO	1	22 500
LDR	4	4 500
WIFI shield (ESP8266)	1	18 000
Current sensor	1	13 500
10k Resistor	4	5 000
9 volts battery	1	5 000
Servo motor	2	18 000
Solar panel (10 watts)	1	10 000
Breadboard	4	4 500
Energy meter	1	9 000
2x16 LCD	1	4000
Jumper wire	20	4 000
Internet	-----	10 000
Stationary	-----	10 000
	Total	137 500

Table 1: Project budget

1.5 DESCRIPTION OF COMPONENTS

This section presents the different components for the proposed system and their descriptions.

ITEM/ COMPONENT	DESCRIPTION
Arduino UNO	Microcontroller board for controlling the whole system
LDR	Sensors for sensing sunlight intensity
WIFI shield (ESP8266)	A module to allow us to transfer data to the internet
Current sensor	A sensor for detecting amount of current passing through the circuits
10k Resistor	For controlling current passing through, the circuits
9 volts battery	For powering the Arduino board
Servo motor	Motors that help in automated rotating of the solar panel
Solar panel (10 watts)	For generating the energy
Breadboard	Board for making circuitry of the system
Energy meter	Meter used to measure amount of power used
Jumper wire	Wires for making connections
2 x 16 LCD	Liquid Crystal Display which is a 2 by 16 character display module

Table 2: description of components.

PART 2: SYSTEM REQUIREMENTS SPECIFICATION

2.1 SYSTEM OVERVIEW

The following is a presentation of the system modelling using Unified Modeling language. We use UML Use Case Diagrams to depict the usage scenarios of the system starting with the current implementation and then the proposed system. Figure 1 shows the use case for the current solar system installations and figure 2 shows the use case diagram for the proposed system.

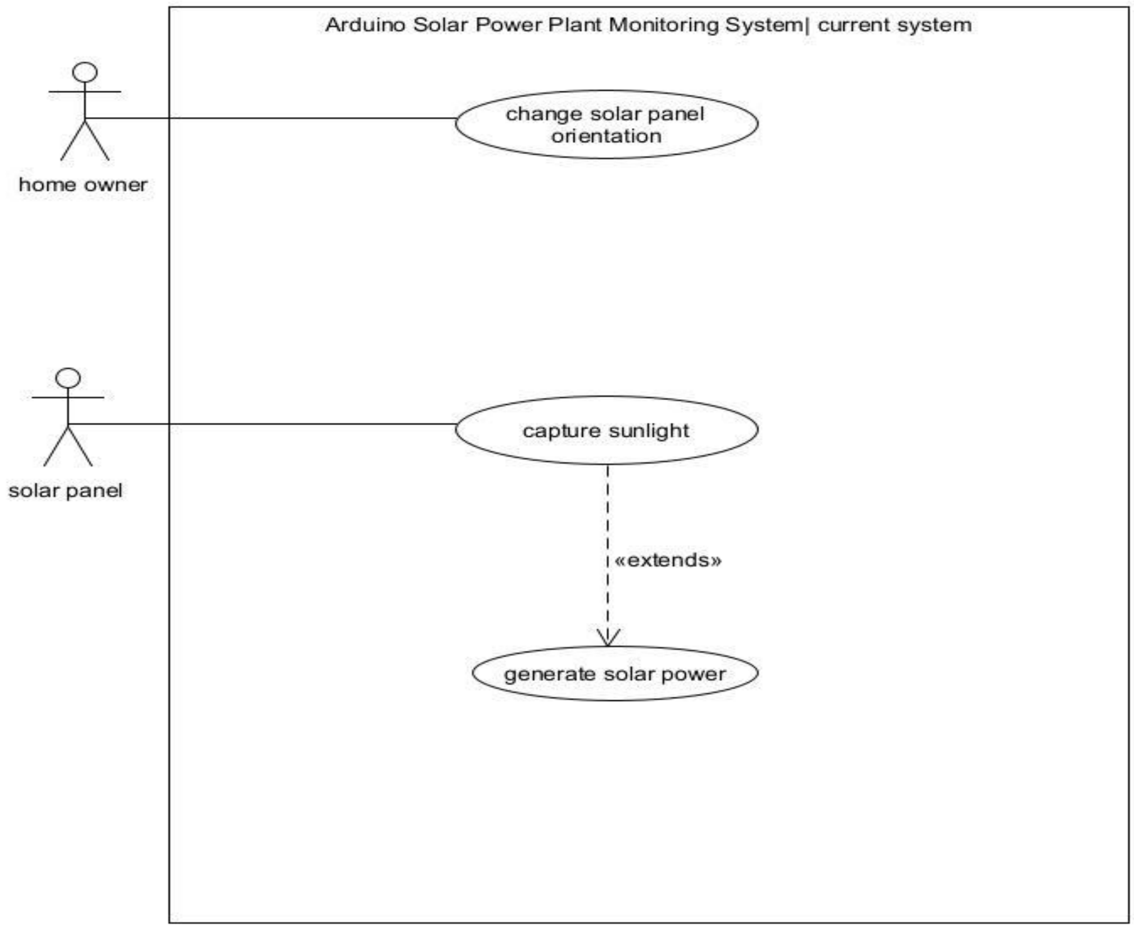

Figure 2. use case diagram for current system

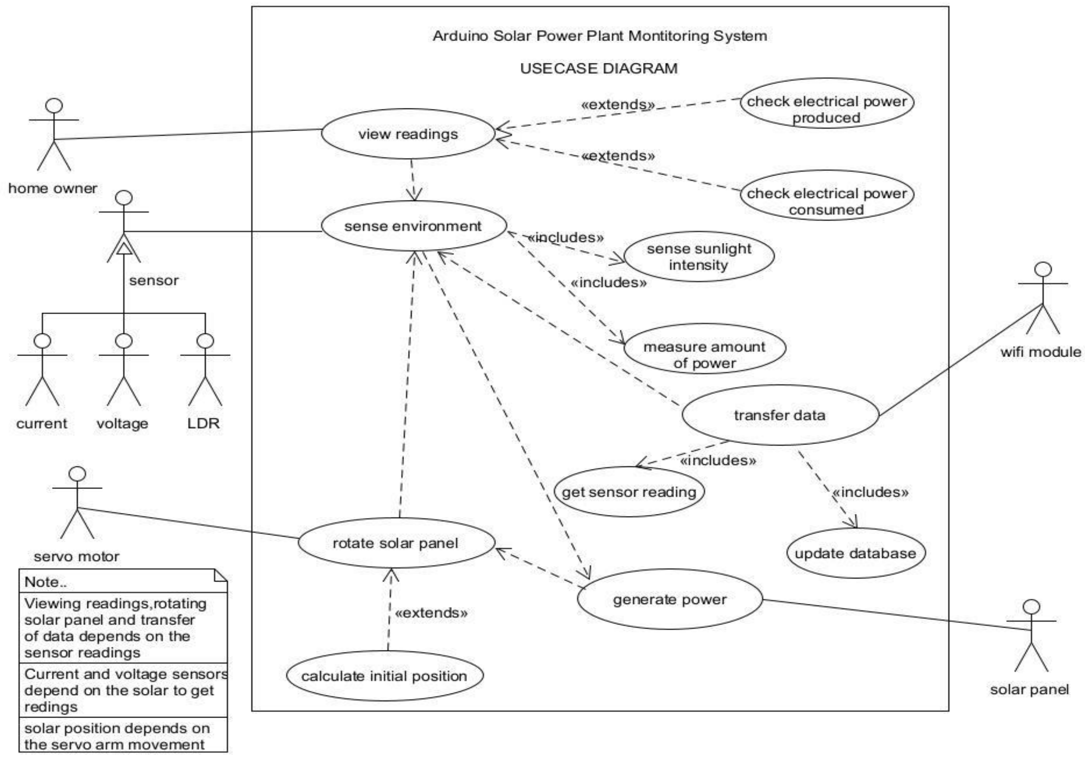

Figure 3. use case diagram for proposed system.

2.2 SYSTEM REQUIREMENTS

2.2.1 Functional Requirements

This section describes the software requirements discovered during the analysis of all the requirements obtained from the users of the system. Each of the requirements represent unambiguous, standalone, testable and verifiable statements. Table 1 shows functional requirements and their description.

Req. #	Requirement	Description
1.	Tracking the sun's position	With the help of light detecting resistors the system will be able to trace the position of the sun and place the solar panel at a position where it can trap maximum

		sunlight.
2.	Monitoring of power production in real time	The system will allow real time transferring of data through the Wi-Fi module (ESP8266).
3.	Monitoring of power consumption in real time	The system will allow real time users to monitor the amount of power produced and being used by different appliances connected to the grid. This will be possible anywhere around the globe even when the user is travelling.

Table 3. functional requirements

2.2.2 Interface Requirements

There is no any other external system that will be interacting with the solar power plant monitor at the moment apart from the sensor composition of the system itself. But for optimization and appropriateness, it might be interfaced to a Smart UPS (uninterruptable power supply) system in the future. The Smart UPS system will be able to shift power source, thus switching to the solar power use when mains electricity is down (blackouts or low voltages) and vice versa. It might also be extended to work on android phones, which will enable the system to be controlled remotely with unlimited mobility.

2.2.3 Non-Functional Requirements

2.2.3.1 System-related non-functional requirements

2.2.3.1.1 Performance

i. Time

The system will update the sensor reading visualization platform in real time. The speed will depend on the system performance of the machine being used and the signal strength of the WIFI network used.

ii. Space

Minimum of 200MB space shall be required.

2.2.3.1.2 Operational Environment

i. Hardware platform

Any device with 2GB of memory or higher

ii. Software platform

Arduino Solar Power Plant Monitoring system will run both on the web using an API that will be sending sensor data to ThingSpeak.io (an open-source platform for IoT analytics) and on the desktop using the computer's serial monitor and the microcontroller (Arduino Uno).

iii. External software interoperability

Arduino Solar Power Plant Monitoring system will run on all software platforms say windows, Linux, apple, android and many more. The Arduino Uno is compatible to any of these operating systems

2.2.3.1.3 General characteristics

i. Reliability

The system is expected to perform effectively on all machines with not less than 2 GB of memory and processing power of at least 1.2 GHZ. The WIFI module used allows saving of energy by going into sleep mode and continuously checks for connection to make sure it is persistent. The system will still work under stress or with some minor faults.

ii. Correctness and accuracy of data

The system will provide correct and much accurate readings, and make necessary calculations on the sensor readings to update the user on the power production of their power plant. The correctness and accuracy of the data will also help in controlling some physical and mechanical functionalities of the system.

iii. Security

The system will be deployed in a safe and secure place to prevent thieves from stealing our equipment and the website login credentials will be private.

iv. Safety

The system presents a friendly platform to the user and safe execution environment since it has a simple user interface that targets novice users since IoT is just emerging an emerging technology.

v. Portability

The system will be able to run on any machine and system generated data will be available anywhere around the globe.

vi. Modifiability and extendibility

It will be possible to expand the system and/or make improvements. Arduino Solar Power Plant Monitoring system might be extended to work on an Android phone for remote controlling. The features of the system can also be extended to allow the system be able to shift household power source from main lines to solar power lines when there is black out and it can also be extended to include a GSM based metering system so that people will be able to buy electricity units from our power plant. In the future the system can also be integrated with LoRa technology to enhance the width of coverage provided by our Wi-Fi module. This will enable large company implementation of the system to be able to monitor the systems installed from large sites that are far apart.

2.2.3.2 User-related non-functional requirements

2.2.3.2.1 Skills level

The users of the system shall be required to possess basic computer skills to successfully use the system like be able to open a web browser etc.

2.2.3.2.2 Training

The users of the system will be trained for them to fully interact with the system. They will also be oriented on how to use all the controls provided by the user interface.

PART 3: DETAILED DESIGN DOCUMENT

3.1 INTRODUCTION

This section presents the architectural, data and graphical interface designs of the system.

3.2 CONSTRAINTS

3.2.1 Hardware

The battery used to power Arduino Uno MCU has to be strong and rechargeable to save costs of buying batteries. The costs of system installation may be high for large solar power plants (running power cables, high precision sensors and buying large servo motors).

3.2.2 Software

The system will require a better platform that will be able to withstand failures and, in the case, where the platform used is of lower specification, the system's functionality might be affected negatively. Adding to the software constraint the system will also require a persistent internet connection to the WIFI network being used.

3.3 ARCHITECTURAL AND COMPONENT DESIGN

This part depicts the entities of the system that interact with each other and their relationships as shown in the figures bellow.

3.3.1 USE CASE DIAGRAM

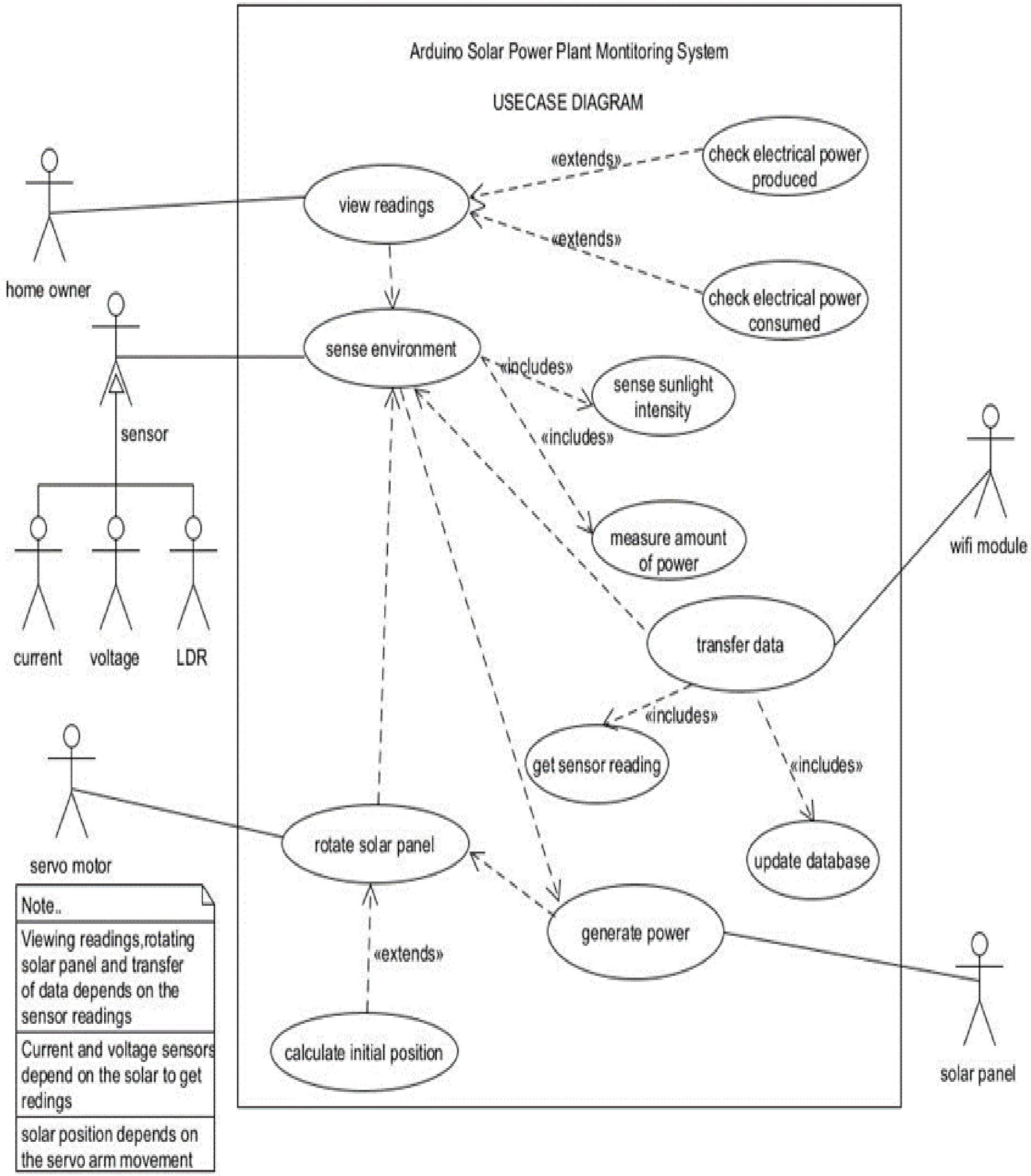

Figure 4: Use case diagram for the system being developed.

3.3.1.1 PROCESS ANALYSIS

USE CASE NAME: sense environment

ATTRIBUTES: sensorReading, calculatedPower

PRE-CONDITION: proper pin usage should be declared.

PRE-CONDITION: Wi-Fi Connection must be established and connection to database.

POST-CONDITION: voltage and current sensors get readings and send to the Arduino.

POST-CONDITION: Arduino transfers data to ESP (Wi-Fi module) that later update our database remotely.

ALGORITHM

X: getSensorReadings

return sensorReadings

voltage := voltageReading

current := currentReading

power := voltage * current

transferReadings(voltage,current)

USE CASE NAME: Automate Lighting

ATTRIBUTES: sensorReading, lightIntensityThreshold.

PRE-CONDITION: proper pin usage should be declared.

PRE-CONDITION: LDR3 should be operational

POST-CONDITION: LDR3 gets readings and send to the Arduino.

POST-CONDITION: Arduino checks against the lightIntensityThreshold and automatically turn lights on and off depending on the light intensity value.

ALGORITHM

Y: getSensorReadings

return sensorReadings

turnOnLights(lightIntensity)

turnOffLights(lightIntensity)

USE CASE NAME: view readings

ATTRIBUTES: url, sensorReading, calculatedPower

PRE-CONDITION: system user opens a web browser and inputs the system webpage address(url).

PRE-CONDITION: system continuously gets sensorReadings and calculates the amount of power.

POST-CONDITION: web page displays all the readings.

ALGORITHM

W: view readings

return sensorReadings, calculated power

getReadings()

displayReadings()

USE CASE NAME: rotate solar

ATTRIBUTES: lightIntensity, initialPosition

PRE-CONDITION: LDR gets the amount of sunlight.

PRE-CONDITION: initialPosition of servo arm is defined.

POST-CONDITION: LDR1 and LDR2 gets amount of sunlight and send to Arduino. Arduino calculates the difference between light intensities from LDR 1 and LDR2 then it transmits the data to ESP8266-01 (Wi-Fi module) which updates our database.

POST-CONDITION: Arduino transfers data to ESP8266-01 (Wi-Fi module) that later update our database remotely

ALGORITHM

Z: rotateSolarPanel

```
Return initialPosition
    R1 := analog reading of LDR 1
    R2 := analog reading of LDR 2
    diff1 := R1 – R2
    diff2 := R2 – R1
 if ((diff1 <= error) || (diff2 <= error))
        do nothing
 else if (R1 > R2)
         initialPosition := --initialPosition
 else if (R1<R2)
        initialPosition := ++initialPosition
```

3.3.2 SEQUENCE DIAGRAM

The figure below shows how different components interact through the messages they send to each other. These components include both the software components and the hardware components.

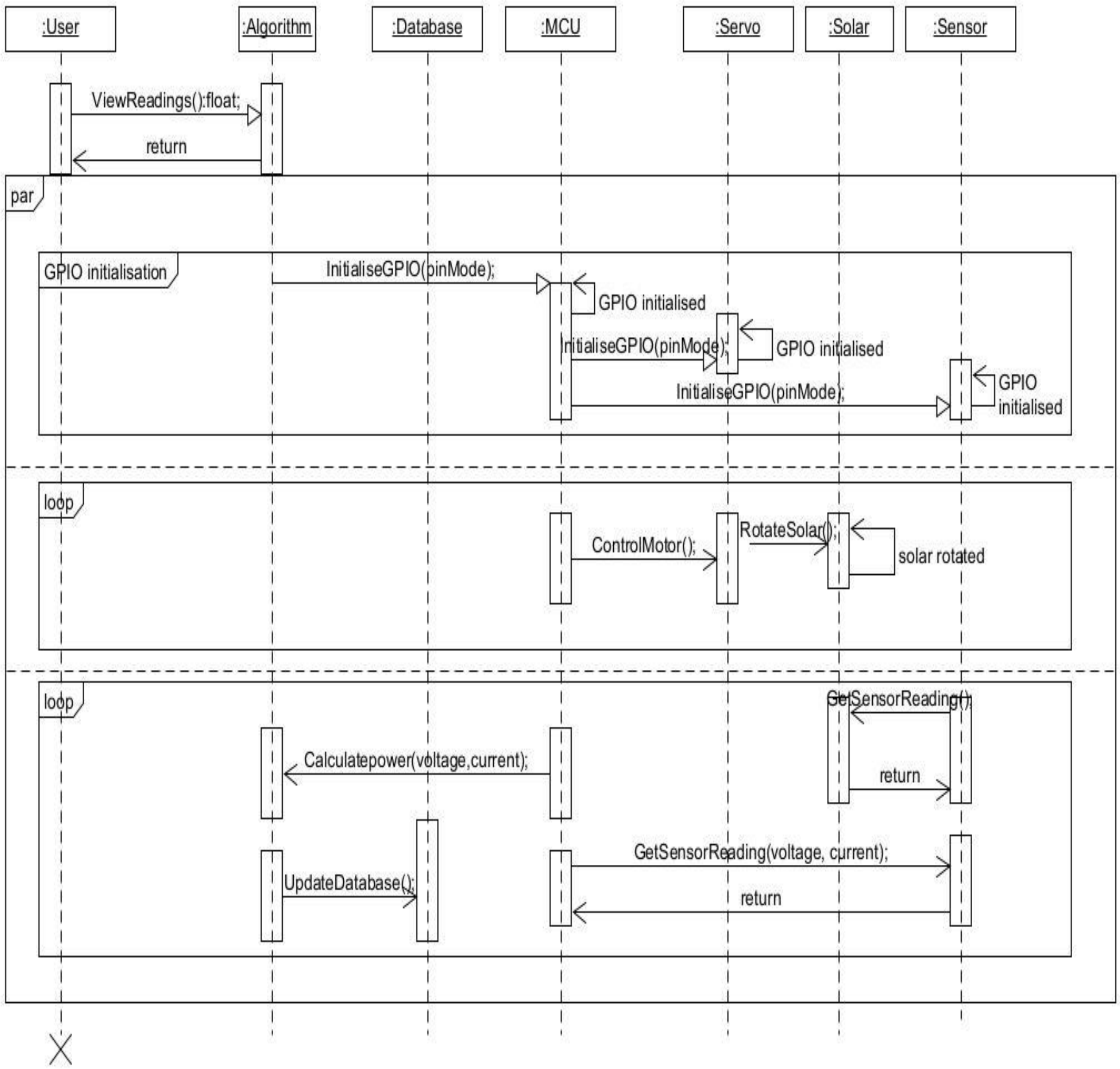

Figure 5: Sequence diagram for the system.

3.3.3 ACTIVITY DIAGRAM

The activity diagram shows the behavioral patterns among the different system components and it also shows different processes of the system. It shows the starting and ending of different processes in the systems operation, some processes run in concurrency while others run consecutively. Two swim lanes distinguish the system process perspective and the user process perspective.

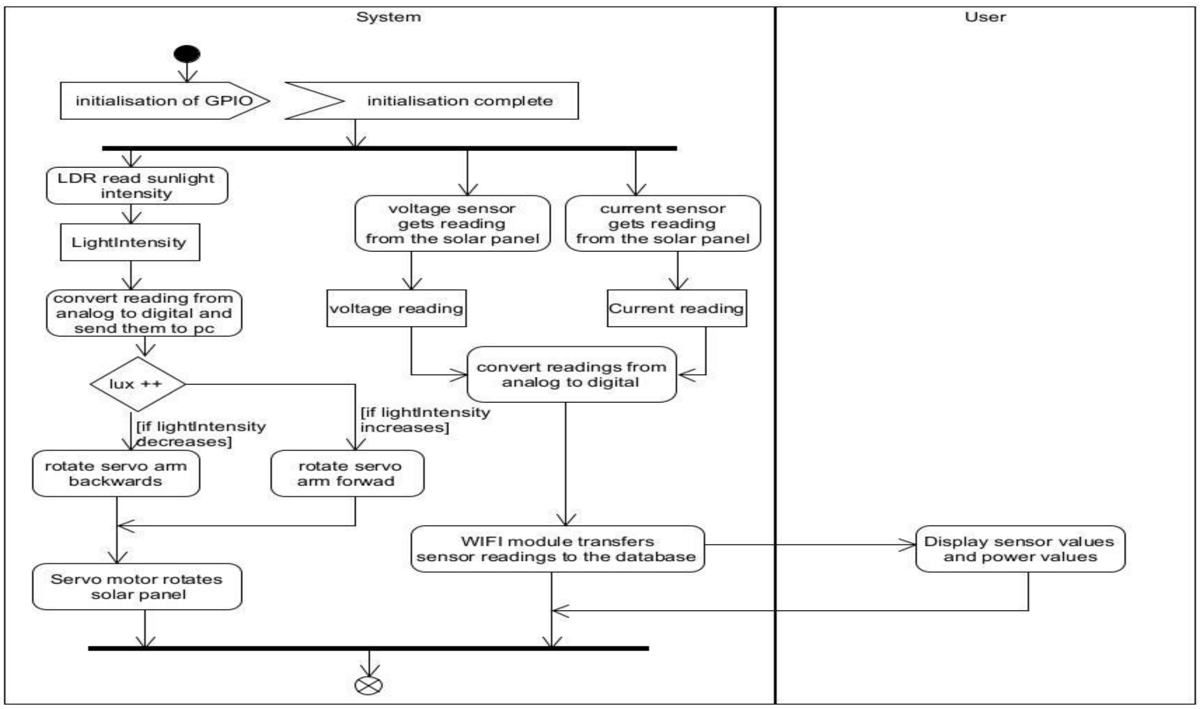

Figure 6: Activity diagram for the system being developed.

3.3.4 CLASS DIAGRAM

The class diagram shows the structure of the system from as a composition of different classes containing objects in them. It also shows how different classes are related to one another and also how objects in the one class relate to each other and how they relate to objects from another class. The type of communication is message passing that enable the objects to synchronize with each other.

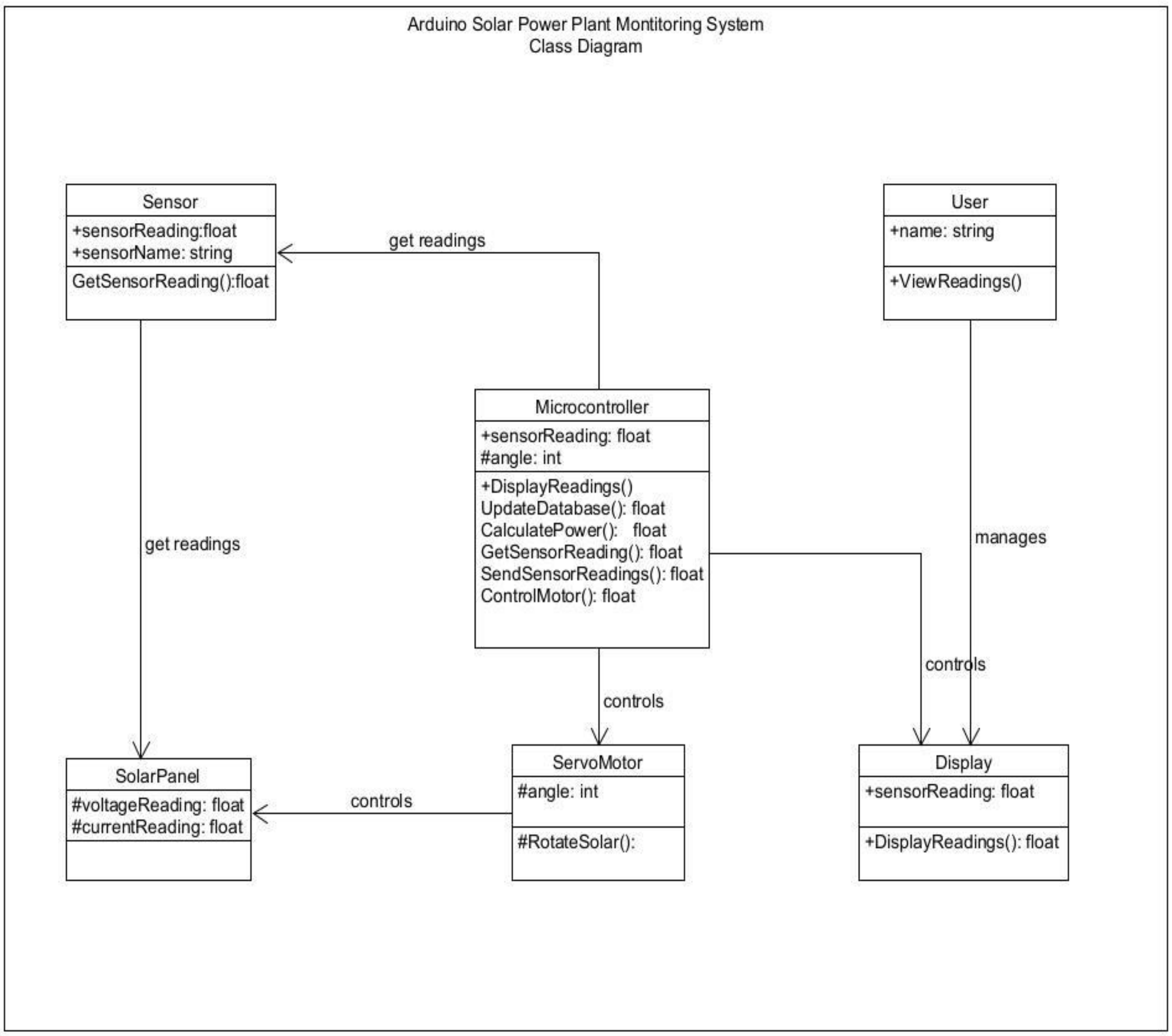

Figure 7: Class diagram for the system being developed.

3.3.5 GRAPHICAL USER INTERFACE

The following diagram presents different the simulation of different hardware components in Proteus simulation software. The presentation of the solar panel uses the solar panel library from www.theengineeringprojects.com and its tracking mechanism is presented by the rotation of the servo motor, and this rotation is as a result of the differences between the readings of LDR1 and LDR2. The automated lighting system uses the readings of LDR3 and automatic switching off of electric lights is done with the aid of a relay and its library is provided by Groove. Electrical power sensing mechanism uses an ACS712 current sensor library from AdaFruit. The data transmission part is simulated using a Node MCU Esp8266 WIFI module because there is no library available for ESP8266-01 and a virtual terminal to transfer data for viewing simulation data and lastly an LM16 16x2 character display module is used to view the simulation data locally.

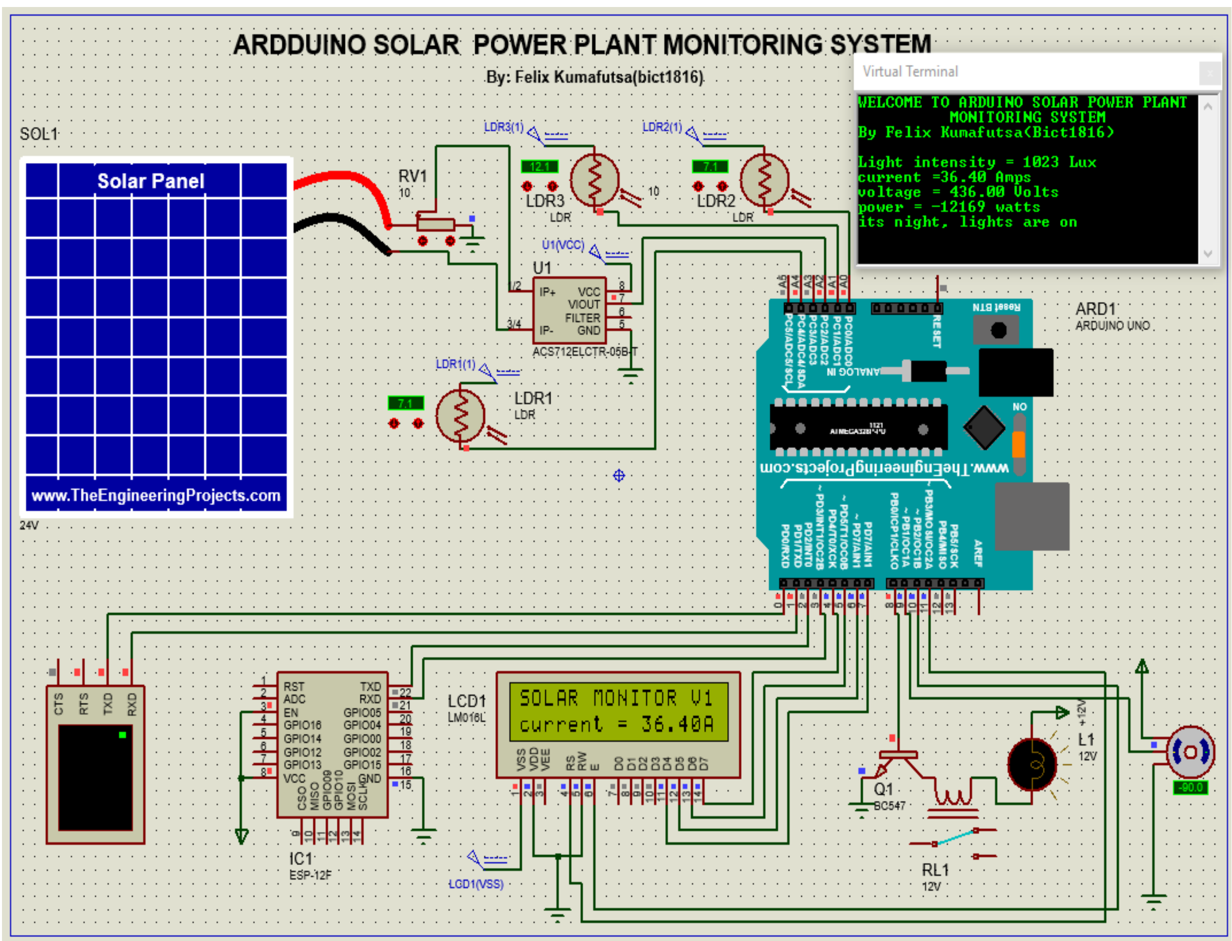

Figure 8: GUI for proteus simulation software.

Below is the web visualization interface from thingSpeak IoT analytics platform. It shows the readings of voltage, current, and power in chart format and they are visualized in real time. It also shows a google maps location of the system.

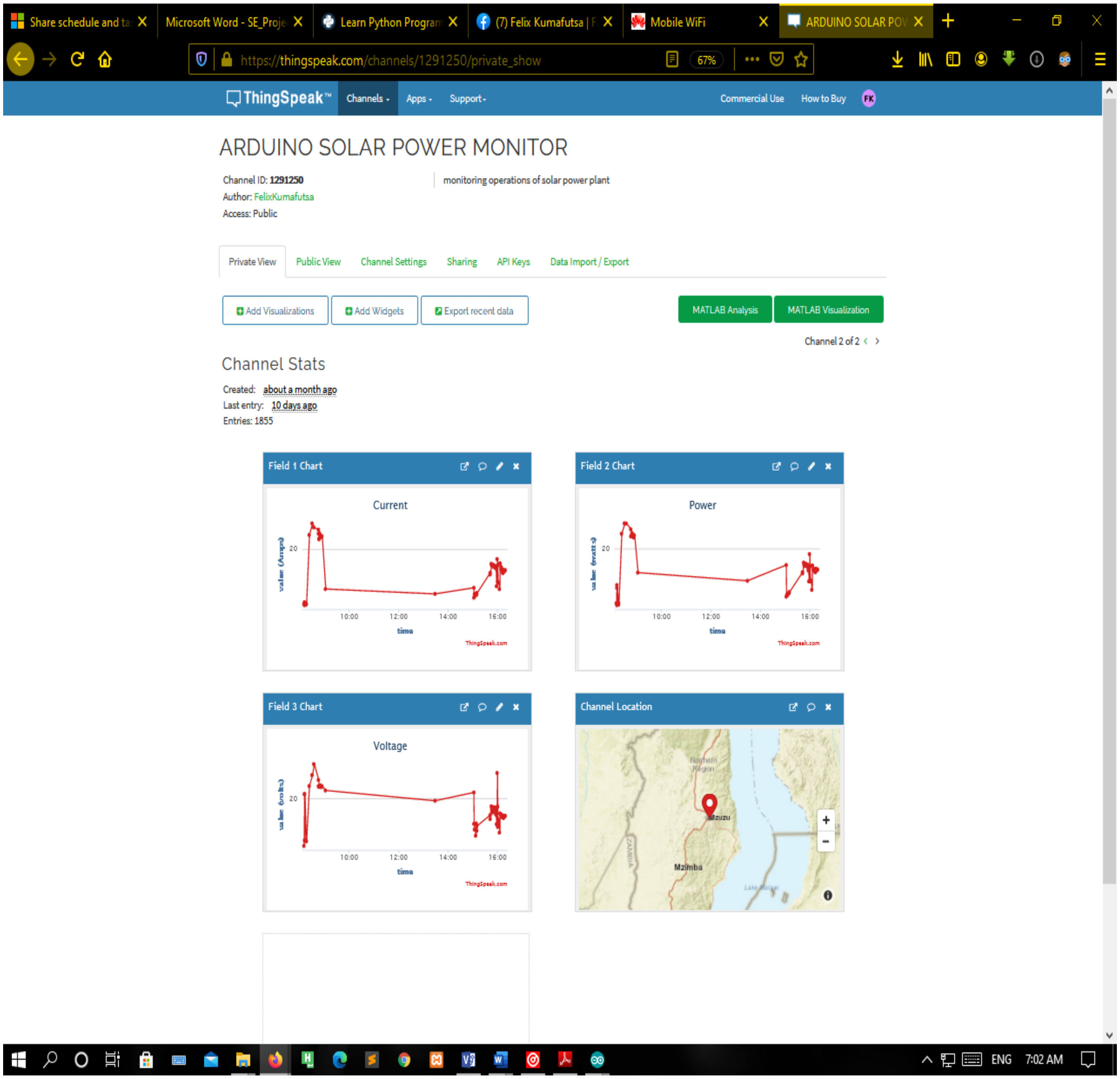

Figure 9: Web interface from ThingSpeak IoT analytics platform.

3.4 DATA ARCHITECTURE

This section presents the data models of the system being developed.

3.4.1 ENTITY RELATION DIAGRAM

This shows the entities that the system is comprised of and the different relationships between the system entities.

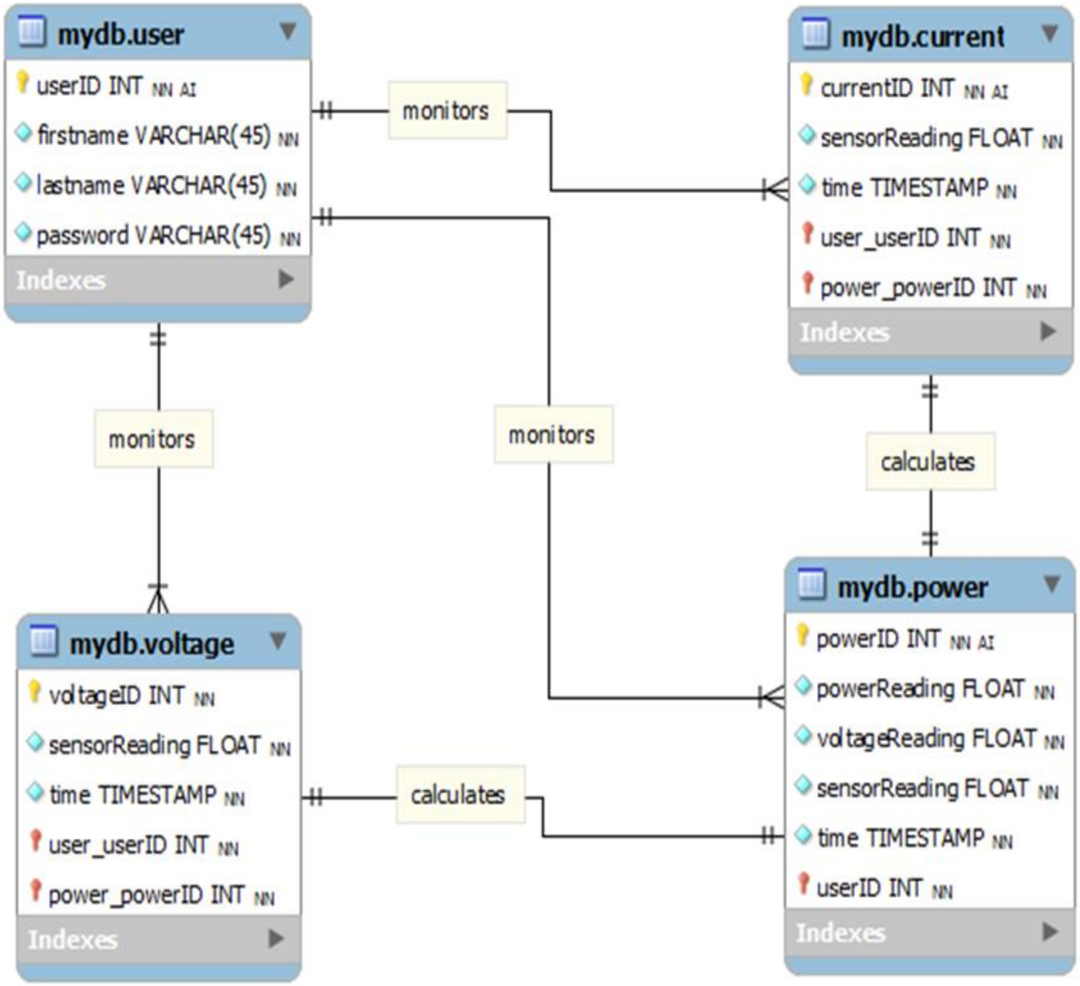

Figure 10: Entity relation diagram for the system being developed.

3.4.2 DATA DICTIONARY AND DATABASE SCHEMA

This section starts with the presentation of the data dictionary of the system and the follows the database schema showing different tables of the database.

COLUMN	DATA TYPE	DESCRIPTION	VALIDATION
id	INT (11)	A unique identification for each sensor reading	Numeric characters
time	TIME	Time of sending and reading system data	Numeric characters
sensorsReading	FLOAT (10)	Values give from different sensors	Numeric characters

Table 4: Data dictionary

Below are different tables from our database schema.

FIELD	**DATA TYPE**	**DEFAULT**	**COMMENTS**
id	INT (11)	NOT NULL	primary
time	TIME	NOT NULL	
currentReading	FLOAT (10)	NOT NULL	

Table 5: current reading table

FIELD	**DATA TYPE**	**DEFAULT**	**COMMENTS**
id	INT (11)	NOT NULL	primary
time	TIME	NOT NULL	
voltageReading	FLOAT (10)	NOT NULL	

Table 6: voltage reading table

FIELD	DATA TYPE	DEFAULT	COMMENTS
id	INT (11)	NOT NULL	primary
time	TIME	NOT NULL	
powerReading	FLOAT (10)	NOT NULL	

Table 7: power reading table

FIELD	DATA TYPE	DEFAULT	COMMENTS
id	INT (11)	NOT NULL	primary
time	TIME	NOT NULL	
lightIntensityReading	FLOAT (10)	NOT NULL	

Table 8: light intensity reading table

3.5 QUALITY ASSURANCE

The system analyst will ensure functionality and usability of the system by following the procedure below

i. Connect the hardware correctly
ii. Connect the battery to the motor driver correctly
iii. Place the solar power plant components on the site
iv. Start the server and open web page to display the readings
v. Vary the intensity of light to see how the system responds to changes in its environment

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