IOT BASED SOLAR PANEL MONITORING SYSTEM WITH TRACKING

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This Report Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Computer Science and Engineering

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APPROVAL

This Project titled "**IoT-based Solar Panel Monitoring System with Tracking**", submitted by Nafisha Tamanna Nice, ID No: 181-15-1837 and Muftain Ahmed Joy, ID No: 181-15-1849 and Tanvir Ahmed, ID No: 181-15-1939 to the Department of Computer Science and Engineering, Daffodil International University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on 13-01-2022.

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We hereby declare that, this project has been done by us under the supervision of **Tajim Md. Niamat Ullah Akhund, Lecturer, Department of CSE** Daffodil International University. We also declare that neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma.

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ABSTRACT

As technology advances, the cost of renewable energy systems is falling, so solar panel installations are increasing massively, but most installations are in inaccessible places, as close as a roof or even a desert. So, we need a suitable surveillance system that uses wide area networks. In this document we will discuss a low-cost IoT-based solar panel monitoring system with tracking. Using sensors and microcontrollers, we can send the measured data to the Internet, which we can access from anywhere in the world, which provides us with real-time information from the solar panel at a fixed interval of 15 seconds. So, it will be very easy to monitor, detect faults and maintain the Solar Panel. We will also discuss how to gain maximum power from sun radiation. This can be achieved by rotating the solar panel with the sun all day long. The position of the sun is determined by its angle of elevation and its direction. Using Light dependent sensors and Servo motors, this process can be done. So, this paper proposes the whole methodology for monitoring and tracking solar panel.

Keyword: IOT (internet of things), Solar Panel Remote monitoring, Temperature Sensor, Light Dependent Resistor Sensor, Voltage and Current sensor, Servo Motor, NODE MCU, Arduino UNO.

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CHAPTER 1

Introduction

1.1 Introduction

Solar energy is a renewable form of energy. It's readily available on the earth. Basically, solar panel absorbs the solar power from the sun and then converts it into electricity. This solar energy has been used by people since ancient days. If we want to generate electricity through solar energy, then we must require the installation of PV cells. These cells actually do the main job by absorbing the energy from the sun and then convert it to electricity. We all know that environmental pollution is getting increased day by day. But we can reduce it by using solar energy. It's a promising way of reducing the environmental pollution. Actually, there are so many advantages of using solar energy. Its maintenance cost is very cheap, so it's quite easy to maintain. By using solar energy, less electricity bill has to be paid.

IoT (Internet of Things) has a broad application in solar power. If we use IoT in solar power, then we can see exactly what's happening with our components. We can even control them from anywhere we stay around the world. If we connect our devices to a cloud server, we can easily identify what problem has actually occurred or not. Then we can fix the problems before the entire system being disrupted. But, it would not be much easier without the help of IoT. It would be very difficult to determine the problems.

We have proposed a system that is IoT-based Solar Panel Monitoring and Tracking system. Our main objective is to gain maximum power from the sun. We already discussed that PV cells installed in the solar panel absorb the solar energy from the sun and then convert it to electricity. But, if we keep the solar panel at a fixed position and direction, it's never possible to get the optimum output. We need to make a system where the solar panel rotates with the movement of the sun. Then we will be able to get the maximum power. And in our proposed system, we will keep the solar panel that rotates with the sun position to gain maximum power. In this way, we will be able to get more than 60% higher output. This is how our tracking system will work. And we have used several sensors that are connected to Arduino via a wired connection. We also used NodeMCU for transmitting data to a cloud server. Users can read and analyze those data. This is how the monitoring system will work.

1.2 Motivation

We all know that a secure and affordable supply of energy is vital for any socio-economic development. As a country, Bangladesh is facing an acute power crisis. And now Bangladesh is trying to develop its renewable energy sources. Bangladesh doesn't have that much non-renewable energy resources. But it is fulfilled with renewable energy sources. Solar Technologies must be implemented in our country. In city areas, there is no electricity problem. But in village and hilly areas, there is acute electricity problem. We also know, almost every year some parts of our country become flooded. In those flood-affected areas, electricity becomes unavailable for infinitive days. Again, people living in the village are mostly poor. They can't afford the bills of electricity. Bangladesh is an agricultural country. Agriculture has a great contribution to the economy of Bangladesh. But in the dry season, farmers face a lot of problems in farming and irrigation. To solve these problems, solar panel installation is a must. Then it will be a promising solution to these problems people are facing till now.

1.3 Objective

i. To gain maximum power through solar panel by tracking the movement of the sun.
ii. To monitor the total system by analyzing data uploaded to the cloud server.

1.4 Feature

i. Getting Optimized Power.
ii. It's a renewable energy source.
iii. It reduces the electricity bills.
iv. It has the real-time data display system.
v. It has low maintenance cost.

vi. Monitoring Power and Voltage can be done easily.
vii. The entire system occupies less space.
viii. Even in cloudy days, some energy will be generated.

1.5 Expected Outcome

i. Solar panel with tracker will produce more electricity.
ii. In future, increased energy requirement can only be met with renewable resources of energy, such as that obtained from solar panel.
iii. People of all areas getting electricity to use.
iv. In flood-affected areas, people don't need to wait for the infinitive time to get electricity back. As solar panel can be installed on the top buildings of that particular area.
v. People using solar power instead of paying electricity bills.

1.6 Problem Statement

Our life have been made modern and sophisticated by Electricity. Nowadays it is quite impossible to think about the modern and civilized world without electricity. Bangladesh is facing a crisis of electricity. And this is a common phenomenon in our country for years after years. There are lower availability of plants and also out of monitoring. In city areas, the electricity problem is gone. But in the village areas, it's still there. People cannot afford to pay electricity bills. That's why they are not getting the electricity service and not being modernized. Even in some areas, there is no electricity at all. For this reason, students are suffering. In those areas, young children are not getting that many opportunities to get educated. Again, in the dry season farmers cannot irrigate due to a lack of electricity. So, socio-economic development is being hampered. Again, in flood-affected areas, electricity goes unavailable for months after months. In the summer season, there is also acute load shedding. These issues would be solved by using an IoT based solar monitoring and tracking system. The installation of this system is easy and maintenance cost is also less.

With this system, maximum power can be generated and people can enjoy continuous electricity service. And this system can be monitored too by analyzing the uploaded data to the cloud server.

1.7 Social Impact

The IoT (Internet of Things) has made people's lives much easier and sophisticated. We already stated about our country facing electricity problems. In these modern ages, life becomes very difficult to lead without electricity. The proposed system would solve these problems. Our system can gain maximum heat from the sun and generate electricity from this heat and irradiance. That generated electricity can be used in our homes, offices, institutions, etc. People who live below poverty and cannot afford to pay electricity bills can enjoy electricity service if they just manage to set up a solar panel. Students in the village areas can study at night also. Farmers can irrigate in the dry season also. If on the higher places or buildings solar panel can be set up, then there will be electricity service in the flood-affected areas also. Yes, it may not be possible to set up in every home in flood-affected areas. But in some of the homes, this can be set up and the family of the homes can enjoy electricity service. In educational and non-educational institutions, this system can be used too. In city areas, several companies may use this system and save the money that had to pay electricity bills. Moreover, solar energy is much more effective than power generation by burning fuel. Energy generation from the solar panel also pollutes the environment very little. Cities, villages that use electricity generated from solar panel can enjoy fresh and clean air in their region which will give a healthy life for everyone.

1.8 Report Layout

Report layout: Our proposed system’s visual presentation is comprised of a figure that clearly depicts the whole endeavor. We have divided our project report by 5 chapters. All chapters are explained in detail by a demographic depiction having a short description.

Chapter 1: INTRODUCTION

Concerning this project, Motivations, Objectives, Features, Problem Statement, Social Impact.

Chapter 2: LITERATURE REVIEW

Review previous works

Chapter 3: REQUIREMENT ANALYSIS AND METHOLOGY

Equipment analysis, System Methodology, Diagram, Algorithm

Chapter 4: RESULTS AND OUTPUT

Implement Methodology, Show the Output

Chapter 5: CONCLUSSION

Conclusion, Future work, Recommendation

Figure 1.1 Report Layout

CHAPTER 2

Literature Review

The study document [1] shows that an IoT-based remote PV solar monitoring system is developed by Suresh K. Gawre and Ankit Kekre. Their main purpose is to create a connection between all devices and sensors on a common network to allow the user to access data and control the devices if they have an internet connection. The connection between devices and sensors is made by cable or wireless. The user can control the devices from anywhere in the world. To create this system, photovoltaic solar sensors, voltage and current, temperature sensors, a GSM module and a microcontroller are needed. The system can measure temperature, voltage and solar PV values. It can send them over the Internet using a GPRS compatible modem. In case of deviation from the normal temperature, current or voltage data, the system sends an alert to the user by SMS. Users can access and view the data. This system is really wonderful energy savings and man labor. This system can be able to measure the alternating voltage and the current output by adding more sensors.

Another Smart Solar PV remote monitoring system is proposed by the authors of [2]. The main purpose of this system is monitoring PV system state via an IoT based network for controlling it remotely. In the proposed system, Current transducers, GPRS Module, LM35 Temperature sensor, Microcontroller, RS232 interfaces and converter are required. The voltage divider is used to sense PV voltage, while PV current is detected by combining a shunt with a differential amplifier. The voltage and current of the network are detected sequentially by the potential transformer and the current transformer. A GSM or GPRS "SIM900" module is used to communicate the data logger and the server. The main role of the data logging system is to send data via a GPRS-compatible modem. As soon as the modem receives the commands, it continues to operate. This system can be used to improve energy efficiency. In the future, this system can be used to monitor the performance of a solar power plant. It can be used to track plant locations by being equipped with GPS Modules.

Mubashir Ali etal. [3] have proposed an approach based on IoT for monitoring solar power consumption. Their goal is to make a system where users can have the access to monitor the solar plants on their mobiles. It’s a very efficient approach for checking the activities of the solar plants by staying far away from them. They used ADAFRUIT cloud services to store and communicate the real-time statistics. In their proposed model, all the attached sensors sense the conditions and then Arduino keeps analyzing the data received from these sensors. For connecting to mobile, there is a WI-FI Module. After all the parameters being uploaded to the cloud server, the users can access these parameters whenever they want. In this system, 4 sensors are used to sense different factors such as voltage, current, heat and temperature, humidity and they are attached to the battery. To fetch the data from the cloud they also developed a mobile application. Then they display the real-time results to the user. For predicting future usage and electricity production from solar panels, they also planned to implement a reinforcement learning algorithm.

The authors of [4] have suggested a system for accessing solar monitoring from anywhere. They mentioned a country like India which has so many areas having no access to electricity. So. Their proposed system can be a revolutionary for the nation like India. Their main objective is analyzing any solar photovoltaic panels. The system sends the data to the clouds through the IoT platform. Photovoltaic arrays are the combination of arrays of photovoltaic cells. These photovoltaic cells play an essential role because they convert solar radiation into direct current. Analog data from DC transducers is converted to digital data using MCP3008 (A2D converter). Then this data is sent to the Raspberry PI via SPI. Here, Raspberry works as a web server and is used to transfer data to the Internet. When the data is available online, it can be used to monitor and analyze the solar configuration. This system offers a great way to transfer data. The system is so easy to install and may be able to collect all required data. The authors said their system will also help optimize charging and grow solar technology.

W Priharti et al. [5] demonstrated that their proposed system would be an excellent solution for real-time monitoring of a solar photovoltaic system. They said their system implementation is very flexible. ATmega328p is used as a microcontroller, ESP8266 is used as a wireless transceiver, and Thingspeak is used as an IoT platform to build the system. For better viewing, they also created a smartphone app. Here all the factors are recorded by the ATmega328p microcontroller. Subsequently, all data is uploaded to the Internet via the NodeMCU ESP8266 wireless transceiver. In the system, Thingspeak was used to store all data from various sensors and for monitoring. One of the main advantages of the system is that the user can monitor the output information of the photovoltaic panel from anywhere if they have an internet connection. Their system successfully collected data with excellent accuracy of 98.49%. This proves their project can have a significant role.

The study paper [6] shows that a multi-purpose poultry farm is proposed by the authors. Producing healthy poultry meat and analyzing is their main objective. We came to know that most of the time poultry farmers use medicine for the growth of the poultry unconsciously. It’s a common phenomenon for a country like Bangladesh. They inject chickens after 7 days of their birth. And when people eat meat of those injected chicken become weaker. In their proposed system, temperature sensor, gas sensor, moisture sensor, relay module, LCD Display, fan, cooler etc. are used. Sensors used in the system collect the data from the environment and then forward them to the Arduino. Arduino then sends them to the cloud server using GSM Module. All the electrical devices used in the system can be controlled via Bluetooth. There is an automated controlling for keeping the environment comfortable for the chicken. Solar and nano-hydro system will power the full system and battery will store the power as back up. Analyzing, Monitoring and controlling all can be done from any location around the world.

Solar energy monitoring system is proposed by the authors of [7]. The proposed system shows the energy consumption of solar energy online. For this reason, users can easily analyze the energy consumption. The article shows that the solar panel helps store solar energy in the battery. In addition, this battery is connected to the Arduino. There is also a connection between the Arduino and the "Raspberry pi" server via a USB cable. Raspberry sends the monitoring data to the Internet server. The data Arduino sends is displayed on a web page using RPi. Finally, those data are displayed in different forms like graphs by cloud server. These are completely visible to the user. These graphs are so helpful as they emphasize and make the data more convincing. The result shows that the efficiency of the system is about 95%. This system has future work too. It can be enhanced by using more and more results of the present system.

The authors of [8] have proposed Smart Home Automation. They have designed an IoT based smart solar house electrical system using their methods. To make the home efficient and comfortable, many components are required. For measuring temperature, light intensity, humidity, CO_2 level, one hub is created and placed in every room of the house. Various sensors keep sensing the factors and all the information is stored to the cloud. After collecting data from specific sensors, they can be used in order to control smart devices. In order to clean the PV panel, there is cover, brush, LDR sensor. After detecting light intensity, the cover with the brush move “in” each day time and “out” each night time. For data transmission, NodeMCU and ESP2866 are used. NodeMCU can analyze and give commands to the devices. This is how the system works. This system can be extended in the future and applied to a larger scale.

Manish Katyarmal etal. [9] have made a monitoring system of solar panel using IoT. In their proposed system, the main goal is to gain the optimum power output. Different sensors like voltage sensor, current sensor and other components like solar panel, WI-FI Module, LCD Monitor, Power Supply, ATmega328 are required. Data from sensors are uploaded to the internet and then an analysis goes on these data. Powerful IoT platforms like Thingspeak, Google cloud platform can exactly point out useful information and ignore unnecessary things. Information is later used for detecting faults and problems. The advantage of this system is that it keeps tracking the solar power continuously so that daily, weekly analysis becomes much easier. But we didn’t see any servo motor there. If servo motors are used in this system, then they can rotate with the movement of the sun. Then maximum power will be gained.

The study paper [10] shows that an IoT based smart irrigation system is proposed by the authors. This proposed system consists of integrated work among Hardware, Software, and IoT components. There are 2 microcontrollers in the hardware section. Here, the soil moisture sensor is also used to collect soil moisture data. Then this data is sent to the base station via NRF24L01. LDR sensor, mini water pump and Wi-Fi module are attached to Arduino UNO. Via Arduino TX and RX, the WIFI module connects to Arduino. This mini water pump is connected to NodeMCU via a transistor. The base station sends the data to the cloud station after receiving. All data is saved in a database and displayed on the Android app. When the system is activated, the mini water pump starts pumping water from the tank and also begins to irrigate. In software section, Arduino UNO IDE is installed and a mobile application is developed. One of the major advantages of this system is that it meets the goal of saving water as it has the self-intelligent capability.

Manh Duong Phung et al. [11] have made the management of solar energy in micro-grids using reliable control based on IoT. In the near future, solar energy is going to be a sustainable source of energy. It depends on various factors like weather conditions, photovoltaic (PV) panels and energy conversion. For controlling and managing, the microgrid cards are interconnected and combined with a private cloud network. The system has been verified by design, reliability for fault tolerance and self-recovery operations, resource efficiency in reliable control and IoT, and stability of reliable control systems. We have seen that the range of solar trackers, the series of modules, the maximum power, the efficiency result, test the ability of the system to follow the direction of the sun by providing set points and every day. Energy is accumulated in the fixed times of this project. Various structures of energy diversity, reduction and sustainable operation are sufficient to provide energy at lower cost. Especially for the management of rapid responses, to overcome the degradation of control performance, the investigation should be conducted during the transition process.

Mohd Saifuzzaman and others. [12] have developed a public lighting and traffic management system using the concept of Internet of Things. Their objective is to use solar cells instead of avoiding the supply of electricity for streetlight lighting. maintenance of traffic signs if the traffic light and barrier system can be installed together in this manner. In our modern life, they will discover the efficiency of energy consumption and the need of each developed and developing country necessary for all. In search of efficiency, they produced a prototype of public lighting and spoke out for an era of energy saving. The main thing here is to reduce traffic jams and obey traffic rules forcefully. Huge amount of energy close to about 30-40 % can be saved Using this methodology and obeying traffic rules for the traffic jam curse, all unwanted situations can be captured and stored through the monitoring system for use later. To improve the level of energy saving percentage if it increases people will be more benefits.

Md Sanwar Hossain et al. [13] have built an intelligent IoT-based system to monitor substation equipment. This offers a promising solution. Internet of Things is considered the key technology to establish intelligent substation through low-cost networkable microcontroller modules. This system is an alternative way to provide differential protection monitoring and control where the distance between the two sides of the equipment does not affect the performance of the system. Here using sensor, transformer / OCB oil level sensor, actuator, microcontroller, Wi-Fi module, a web server, MQTT circulate / subscribe, and control and monitoring. The search for the accuracy of the proposed model depends mainly on the performance of the prototype version in this case demonstrating the results of the experiment of the prototype system. It worked successfully on the basis of the results of the experiment during its implementation on the practical circuit. 0.1A minimum difference of the readings of two current sensors for control, otherwise the program will not be controlled.

The authors of this paper [14] have worked on Solar PV Environment. Their system is comprised of a data logger with eight analog input. There is an A 2 D (Analog to Digital converter) which is of 16 bits. Required components for this system are Arduino UNO, ADC Board, Temperature and Irradiance sensor, etc. Initial investigation of MPPT efficiency of the system is done by the proposed system. For this investigation, sensor readings from different sensors are needed. If this project is extended in the future, then another alternative for Arduino UNO has to be replaced. Because for larger research and handling complex data Arduino UNO is not that much able. The author used Raspberry Pi in their proposed system. But there will be much more data in the development of the solar panel system around the globe. And we all know Raspberry Pi does not have the required real-time clock to acquire the data. So it's a major fact to keep in mind in their proposed system.

Anand Nayyar et al. [15] made smart farming of smart IoT-based sensors into a stick for real-time temperature and humidity monitoring using Arduino, cloud computing and solar technology. Real-time data on soil moisture, ambient temperature based on IoT. Use of wireless sensor network (WSN) technologies, Cloud Computing, Big Data Analytics, Communication protocols, Communication protocols Today, the agricultural sector is also adopting IoT technology. Farmers can increase food production by 70% by 2050, as described by IoT experts, is considered the key component of smart agriculture using precise sensors and smart equipment. It Reduce the cost rate to a noticeable level of IoT productions and in turn will increase profitability and sustainability. Fully focused on increasing the sensors on this key to retrieve more data, especially regarding pest control, which is why the integration of the GPS module in this IoT key to improve this agriculture.

Mr. S. Karthik etal. [16] have made Solar Panel Fault Monitoring and Control using IoT. It is a versatile solution because micro-controller-based system is also cost-effective that's why it does not requires any extra sensor circuits for voltage and current. The purpose of light dependent resistor, for increasing incident light intensity the resistance of a photoresistor decreases with as well as in other words it exhibits photoconductivity. Using Arduino Uno for pins connection. Using LDR sensor PANEL to outcome without defect and with defect result for Fault Monitoring and Control system. When there are more than hundreds of a PV panel as there will be some difficulties in real environment. For maximum benefit and efficiency gain in real environment, need to the condition of photovoltaic panels improvement continuously.

Padma Nyoman Crisnapati and others. [17] built a hydroponic management and monitoring system. The target of the hydroponic management and monitoring system which can be carried out automatically using this sensor and implanted as artificial intelligence. In this system, evaporation from the sun or the process of photosynthesis of plants, water will be used continuously and is only reduced. By adding the total load in watts obtained by calculating the power consumption used in the system and each hour the total power is calculated in units of Watt / hour. No need to worry for new farmers about the value that should be brought to his sowing medium which already contains the pH and PPM value by the automatic adjustment. NFT hydroponics tools such as nutrient levels, pH levels of nutrients, temperature, EC and PPM levels of nutrients and nutrients, the data of which will help the user to qualify for the agricultural systems.

S.R. Jino Ramson et al. [18] developed an IoT-based container level monitoring system. They developed this for solid waste management. The goal of an autonomous and intelligent IoT system has been developed in this project for solid waste management. Wireless access point units (WAPUs) using smart cities are equipped with wireless access point units to provide data connectivity to users and power management units that use the panel solar to store energy in the battery specially designed by Texas Instruments to efficiently extract the energy generated. The intelligent graphical user interface maps each bin to a color code taking into account the BLMU measurement and the maximum vacuum level of the bins. BLMU is programmed not to collect solid waste from the shorter root. For better improvement, to assess the shortest route of the trucks, it is appropriate to collect the solid waste in the graphical user interface through the IoT-based container-level monitoring system which includes the integration of a route optimization algorithm.

This study paper [19] shows the research and integration of the health monitoring system of photovoltaic solar panels based on IoT. IoT-based photovoltaic solar panel in the health monitoring system, the implementation of the technology helps reducing the fatigue of the solar panel and could be easily identified when a fatigue condition occurs on the photovoltaic panel for successful implementation. Which explains and shows the methodological integration process of the proposal. All information is contained in Google Cloud. Due to the temperature of the environment, when it increases with the temperature of the photovoltaic panel also increases, and in this way, when the ambient temperature decreases with the temperature of the photovoltaic panel, it also decreases, but it operates over a fixed time interval.

This study document [20] shows development of an ecological gamma radioactivity monitoring system based on the IoT. To identify the source and intensity of radiation, we can utilize a spectrometer. For the weakest radiations, these constraints are vital when evaluating the propagation of radio-active particles. Using monitoring devices and dashboards, analysis of measurement results can find out whether there is any radioactive particles. The data analysis capability of the radiation monitoring station is not the fastest speed. To improve, the data analysis speed should be faster than the previous one in the radiation monitoring station.

The authors of [21] realized the IoT in photovoltaic systems. In this article, we learned that solar power is the biggest attraction among the renewable energy resources used for electrification. For the control of system energy requirements (PV) cause you can convert from light energy from the sun is into this electricity. Internet of things in a photovoltaic system, there are few new features such as continuous monitoring, efficient operational efficiency, rapid and immediate response to failures, reusable energy system and many other things.

Study paper [22] shows research on a low-cost solar PV cells in monitoring system which is developed on the basis of IOT for online display and performance improvement. IOT performance based on stable power. Developing solar panel monitoring system on photovoltaic (PV) can decrease greenhouse gas emission and ozone layer depletion and also save natural fossil fuels. By using LABVIEW software developed a virtually reliable solar PV monitoring system that has three layers. Sensors are lower layer, transmit are middle layer and upper layer works on store real-time data, easier access, and data visualization. The main advantage is that to determine optimal performance for better maintenance of solar PV and low amount of installment cost.

Chin Kim Gan etal. [23] have made IoT-based electricity energy monitoring systems. This paper shows IoT-enabled devices which can communicate many other digital energy meters through the Modbus protocol. Climate change negative effects and excessive use of fossil fuels resource are so much crucial aspects. So, the master of challenge is that the energy audit of process is the collection of energy consumption aspects. Based on information it is important it can be integrated into existing energy management systems for optimized results. Digital power meter equipped with Modbus, TCP / IP for the ability to communicate through the development protocol of industrial devices. By developing this project, it is possible to monitor the electricity consumption of each building of the faculty. It can monitor voltage, current with associated power factors. And the important thing is that all data is stored in the virtual cloud server. So, this paper developed and energy monitoring solution that is cost-efficient and energy savings.

The authors of [24] have implemented intelligent monitoring using AWS. This document shows the implementation of IoT-based system that monitors several constraints of the solar panel. Three items are included which are temperature and output voltage with current. Today, IoT is used for the activation, discovery, storage, and processing of data. A solar panel monitoring system is implemented with the help of NodeMCU ESP8266. There is also temperature sensor (LM35), current sensor (ACS712) if we want to monitor output current. These values of sensors were collected by ESP8266 and sent AWS cloud platform Through MQTT. This solar panel is very efficient because nowadays converts only 16% of the energy obtained into electricity, but now using better types of equipment they get 55% efficiency. But the disadvantage is installment cost is so high. So solar panel monitoring system AWS these project opens up so many opportunities for smart management of the resource. It’s important for harvesting and renewable energy.

The research paper [25] shows an IoT-based Environment monitoring system. The paper presents IoT based solar monitoring system developed for agricultural purposes because temperature, humidity, light intensity, air pressure are indices that were continuously monitored. It also presents an IoT-based framework that excellently monitors the transformation in an environment using sensors, microcontrollers, and IoT-based technology. For developing an Environment monitoring system, we use the IoT, big data cause for implementing here we need a large data set for programming, used machine learning language. So, the project was made from low-cost components that are available everywhere and also monitored several environments. This system is flexible and scalable. So, after testing all the functions in this project in the different conditions its appearances a great degree and reliability.

The research paper [26] proposed monitoring system of an IoT-based solar energy. This proposed system declares that solar panel can generate electricity from sun radiation. If we use solar energy, pollution will be reduced. For making solar panel monitoring system using an Arduino, using sensors for current-voltage measurement, LCD for showing voltage and current. And this project equipments and installment cost is not that much high and detect the error very easily and solve it instantly. So, the objective of this system is to gain maximums power generation using sun radiation and solar panel..

The authors of this paper [27] suggested a monitoring system of solar power plants using the IoT platform Arduino and Thingspeak. The objective of this project is to determine common minor scale instillations along the budget friendly and operative monitoring system. People utilized the monitor system because their maintenance expenses are greatly condensed. This designed system used the Arduino UNO controller, light intensity monitoring using LDR sensor, voltage dividing principle, for current measurement using

ACS712 current sensor, and used the LM35 for the temperature sensor. The development of this project used an integrated development environment. Programming language based on (IDE) C and C ++. The main advantages of this project equipment are the very economical costs. The installation process and finding any kind of problem is very simple and its interface is very simple for people to use it very easily. So, in one sentence, this project will facilitate preventive maintenance, historical analysis of plant failures as well as real-time monitoring.

The authors of [28] have suggested a solar tracker with an IoT monitoring. This study paper describes the utility of solar power technology which is derived from sunlight and is also used in many traditional machines and other supplies. This system is the very efficient method for improving the working of a solar panel by tracking and tracking the sunlight. Light dependent resistors are used to sense sunlight. To rotate the solar panel with respect to the sun movement we use servo motor. In the methodology, the process of the two-axis solar tracker is first explained and this project is also separated into two parts. The first one is about software development and the second one is about hardware development.

The study paper [29] describes plant damaging prediction system. This project aims for sustainable agricultural development. This system is used with several soil diseases where the software architecture can handle different models of plant diseases. There are three types of module methodology composed which is hardware module, software module, and agricultural module. Monitoring plant disease forecasting used six sensors where the most important station is solar-powered. Solar radiation can handle visible plant diseases. Implementing this project. there used power types of equipment and expensive microcontroller and battery. Though the development cost is so expensive the result of project implementation is accurate and effective. So, I based plant diseases monitoring system diseases find so fast and accurate.

The authors of [30] have developed a low-power solar panel monitoring system. This document shows low-cost solar energy systems that have been developed in the smart city to reduce pollution. Energy management scheme for Smart City based on IoT technology with LoRaWAN. Acquisition and analysis of sensor signals. There are four types of sensors used: current sensors, voltage sensors, solar radiation sensors, and temperature sensors. The entire system is controlled from the headquarters via LoRaWAN. Here the main advantages are that the cost of the equipment is very low. and it's easy to use. The role is a new development direction to provide alternative electricity in the smart city.

CHAPTER 3

Requirement Analysis and Methodology

3.1 Requirement Analysis

3.1.1 Solar panel

A solar panel is a combination of solar cells. Solar energy exists with the sun. The solar panel is a component of the photovoltaic (PV) system used to convert sun radiation. It's made up of particles of energy called protons, and electricity can be used to power electrical charges. Installed solar panel at home it helps to protect harmful emission of greenhouse gases and reduce global warming and also decrease reliance of fossil fuels.

Figure 3.1.1 Solar panel

3.1.2 Arduino Uno

Arduino UNO is a microcontroller based on the ATmega328P microprocessor. In 2010, the Microchip ATmega328P microcontroller developed by Arduino.cc. This Arduino has 14 digital input output pins having 6 PWM (Pulse Width Modulation) pins, 6 analog pins, 16MHz ceramic resonator, power plug, USB connection, connection ICSP and a reset button. Basically, it contains each and everything to support the microcontroller. It is connected to our computer via a USB cable and starts up with the AC / DC adapter or battery

Figure 3.1.2 Arduino Uno

Technical specification of Arduino Uno:

- It operates at 5 volts
- Input voltage range: 7 to 12 volts (Recommended)
- Number of PWM pins: 6
- Number of Digital Pins: 14
- Number of Analog pins: 6
- SRAM: 2KB
- EEPROM: 1KB
- Built In LED: 13

3.1.3 Servo Motor

Figure 3.1.3 Servo Motor

A rotary actuator allowing exact control of the pointed position, speed and acceleration of the servo motor. A sensor is connected to the positioning process and consists of a suitable motor. Servomotor control Speed and motor position signal based on a response Maximum initial servo loop speed. Most servo systems need location control and speed control, control is usually provided by including a position loop-in cascade or series with a speed loop.

3.1.4 Temperature sensor LM35

LM35 is temperature sensor its output an analog sensor, it is a temperature sensor of integrated circuit. This sensor output voltage is linearly relative to the Celsius temperature. The advantages of LM35 temperature sensor it requires no external calibration.

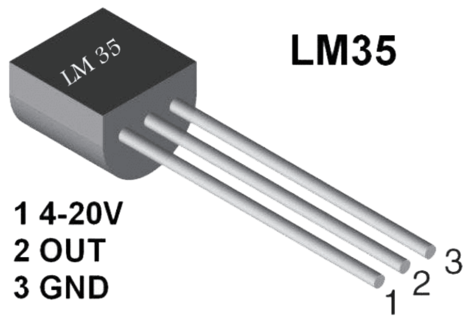


Figure 3.1.4 Temperature sensor LM35

LM35 Temperature Sensor Feature:

- Calibrated directly in Celsius
- Operate from 4V to 30V.
- Low self-heating
- Suitable for remote applications.

3.1.5 LDR (Radiation)

LDR (Light Dependent Sensor) or photoresistors are used in electrical circuit design. LDR sensor detects the presence or level of light. LDR sensors are used in different kinds of applications to identify the light intensity. There are two types of LDR or Photoresistor sensors

- Intrinsic photoresistors: Its use semiconductor materials including silicon of un-doped type.
- Extrinsic photoresistors***:*** Factory-made from semiconductor of materials incapacitated with layers.

Figure 3.1.5 LDR (Radiation)

LDR or Photoresistor specification:

- Max power dissipation: 200mW
- Max Voltage: 200V
- Peek Wavelength: 600nm
- Min. resistance: 1.8k Ω
- Max. resistance: 4.5k Ω

3.1.6 Breadboard

A breadboard is a manufacturing base for the prototyping of microchip technology. Basically, the breadboard is derived into two parts bread and board. Mainly its used to cut the bread into pieces so it's called breadboard. A breadboard is a temporary circuit that is used for testing and tries out for an idea. The board is not soldering required and it's easy to replace components and change connections. There are many sockets arranged on this breadboard. Wires and other components are pushed straight to the holes.

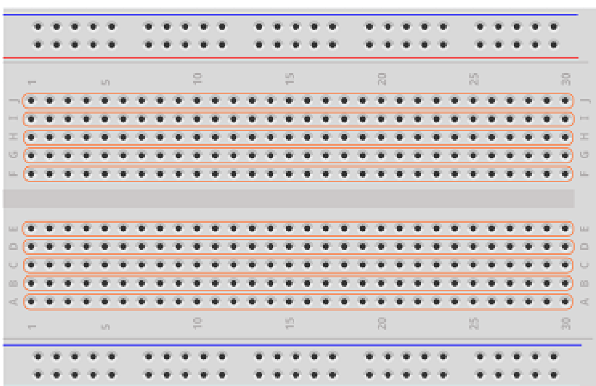


Figure 3.1.6 Breadboard

Specification and Features of a breadboard:

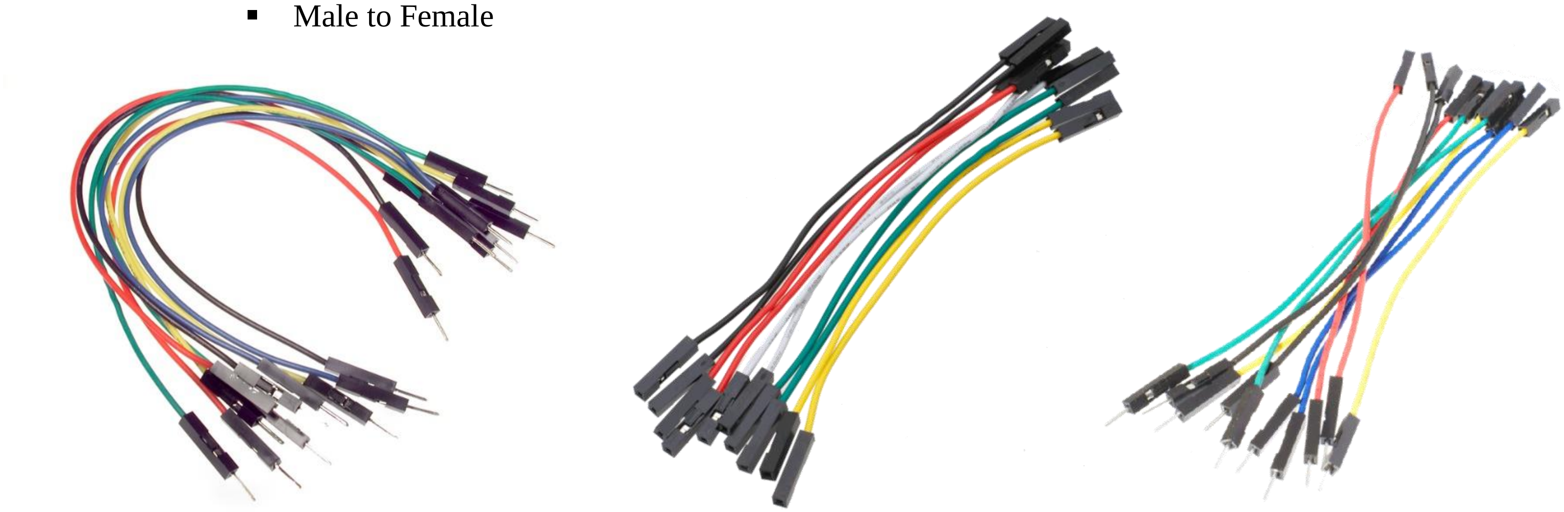
- Distribution Tiles are two
- Wire Dimensions is 21-26 AWG wire
- Tie Points 200.

- Resisting Voltage is 1,000V AC
- Tie points within IC are 630
- Isolation Resistance is DC500V or 500MΩ
- Measurement is 6.5*4.4*0.3 inch
- Rating is 5Amps
- ABS plastic through color legend
- ABS heat Distortion Temperature is 183° F (84° C) Hole .

3.1.7 Connecting Wire

Probable the maximum common breadboarding wire is easy solid core wire. that is generally bought in spools of various lengths and plenty of exclusive colorings. The generally encouraging size for wire associated with breadboarding is 22awg or 0.64 mm. There are three types of wires such as

- Male to Male.
- Female to female
- Male to Female



Male to male Female to Female Male to Female

Figure 3.1.7 Connecting wires

3.1.8 Voltage Sensor

This sensor is used for calculating the voltage deliver. This sensor can decide both the AC/DC voltage level. This voltage sensor can determine the switches, an audible signal, a current signal, analog voltage signal, and many others.

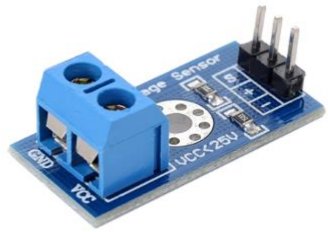


Figure 3.1.8 Voltage sensor

Specification of Voltage Sensor Module range:

- Voltage detection Range:0-25
- Analog voltage resulation:0.00489
- Length:28mm
- Width:14mm
- Height:13mm
- Weight:4gm
- Dimention:4 *3*2 cm

3.1.9 Lithium Battery

Lithium battery is advanced battery technology. Lithium batteries are small in size and batteries are capable of having very high voltage. High power of unit volume and charge storage per unit mass. Lithium batteries can be used for many kinds of materials as electrodes. Mostly it is found on laptops and cellphones. . They've one of the highest power densities of any battery generation these days (one hundred-265 Wh/kg or 250-670 Wh/L).


Figure 3.1.9 Lithium Battery

3.1.10 ACS 712 Current sensor

The ACS712 current sensor is an advanced Hall effect linear sensor with 2.1 kVRMS voltage isolation and built-in low resistance current conductor. Technical phrases aside, it truly ranks fourth as a modern sensor that uses its conductor to calculate and measure the amount of sharpness performed. It can be easily installed by users.

Figure 3.1.10 Current sensor

Features of ACS 712 Current sensor:

- Bandwith:80kHz
- Output Sensitivity:66 to 185 mV/A
- Conductor resistance:1.2m Ω
- Output errors: 1.5% at TA=25%
- Voltage: Stable
- zero magnetic hysteresis

3.1.11 NodeMCU ESP 8266

NodeMCU is open source firmware for Espressif's ESP8266 WiFi SOC and uses a flash module-based SPIFFS recording device. , but the mission is now supported by the network and the firmware can now be run on any ESP module. It is Wi-Fi supported, so it can upload all the data to a cloud server. It can be used in Arduino IDE of we modify some necessary fields.

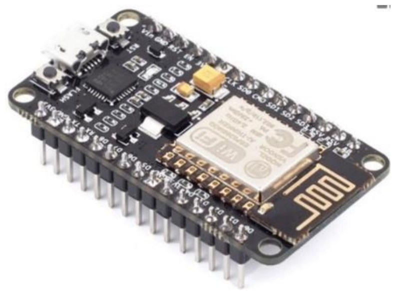


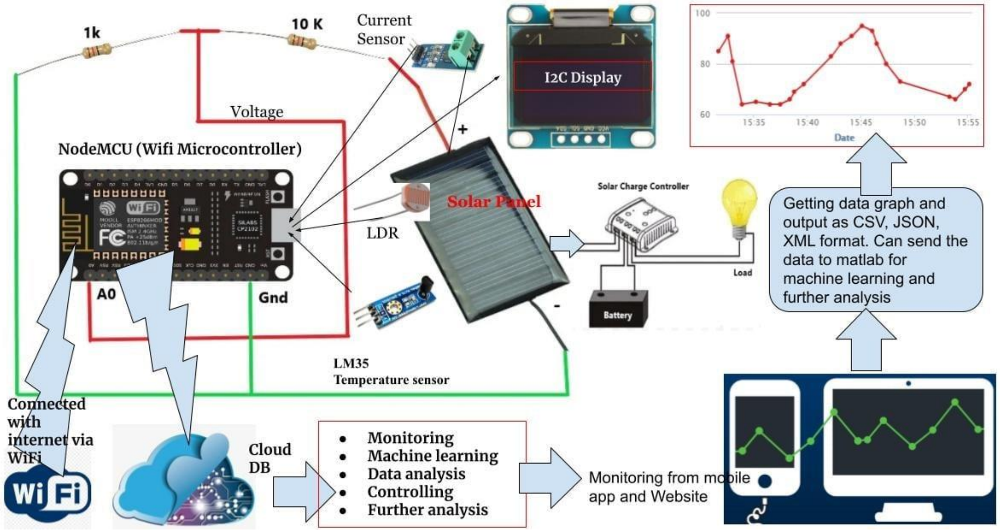
Figure 3.1.11 NodeMCU ESP 8266

NodeMCU ESP8266 Specifications & Features:

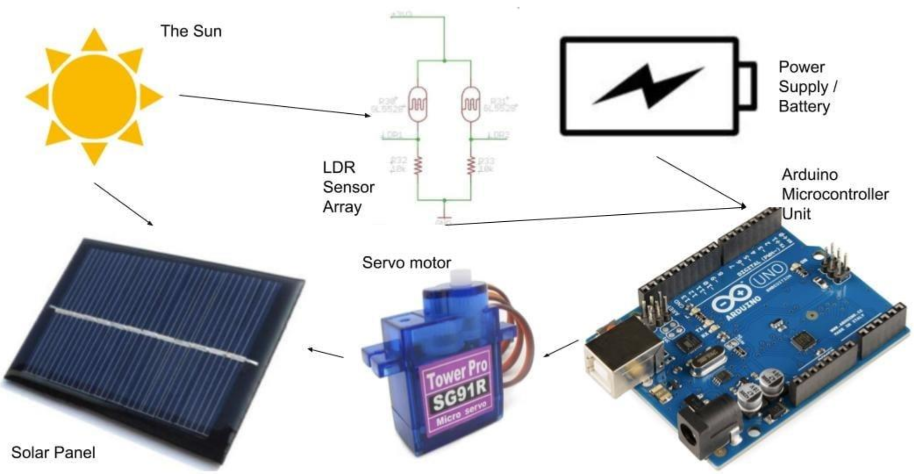
- Tensilica 32-bit RISC microcontroller
- 3.3v operating system
- Input voltage: 7-12V
- 16 digital input/output pins
- 1 analog input pins
- 1 UARTs
- 1 SPIs
- 1 12Cs
- Flash memory: 4MB
- SRAM: 64 KB
- Clock speed: 80MHz
- PCB Antenna
- Small size module
- USB-TTL based on CP2102

3.2 Methodology

3.2.1 System Architecture



Solar Panel Monitoring



Solar Panel Tracking

Figure 3.2.1: System Architecture

The above diagram shows the system architecture of our proposed IoT-based Solar Panel Monitoring and Tracking System. We have utilized several modules to complete our project. There is a battery to power up the system. When we turn on the battery, the system gets the required power. Here, we used NodeMCU module to link devices and allow data transmission via Wi-Fi network. NodeMCU is a framework that is built on ESP8266. Sunlight falls on the solar panel. There are four sensors to sense the factors. All analog sensors are connected to the analog pins of Arduino UNO. LDR sensor is used to detect the level of light. If the sunshine is higher, the resistance will be lower and vice-versa. Based on the quality of resistance, Arduino can understand in which direction the sun is giving more sunshine. Then this information is sent to the Arduino. Based on this, Arduino keeps operating the servo motor. Servo motor keeps rotating the solar panel where the sunshine and heat is higher. To sense this heat, we used another sensor which is Temperature Sensor LM35. The voltage sensor is used to calculate and determine the supply of voltage. The current sensor is used to detect the incoming current and convert it to a measurable output voltage. This is how solar panel gets the maximum power. And this tracking system does the job of generating optimum power.

NodeMCU also sends the data to an analytical IoT-based platform named "Thingspeak". That platform helps to gather, evaluate and display real-time data from connected devices. For further analysis if needed, data can be sent to MatLab. By analyzing the data user can monitor the system.

3.2.2 Flow Chart

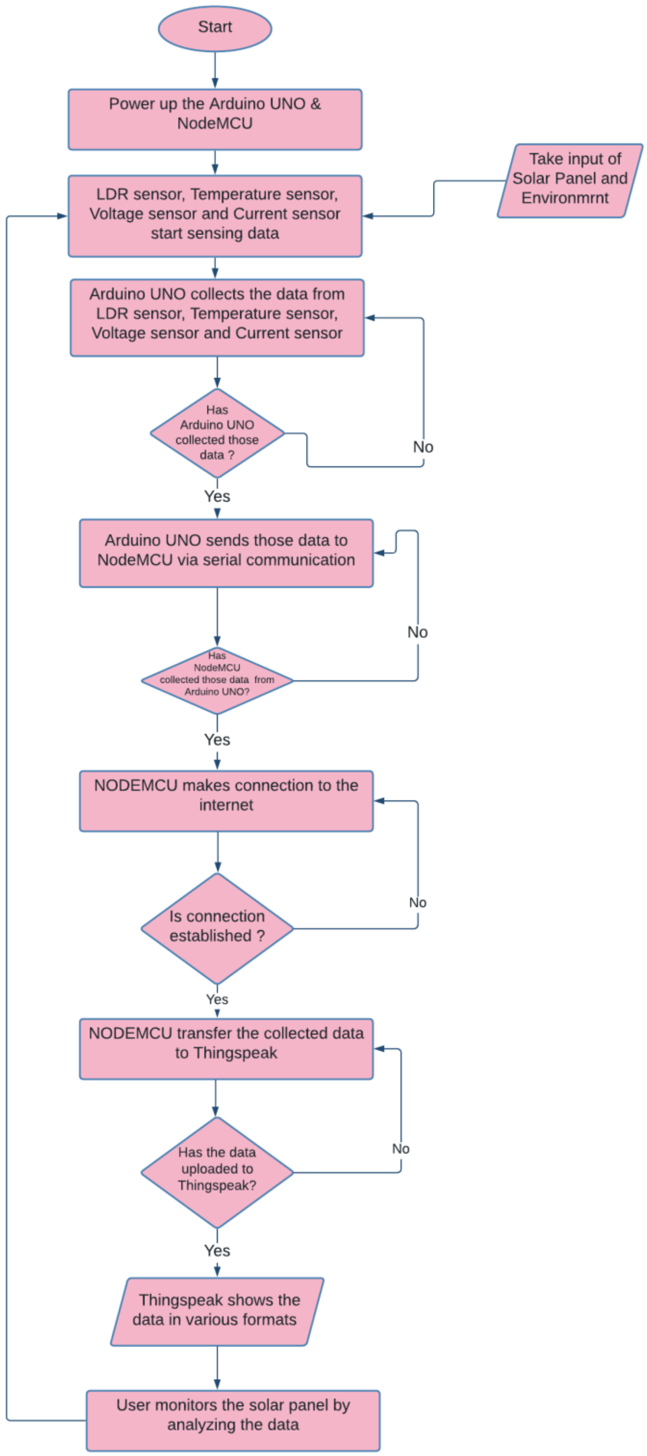


Figure 3.2.2: Solar Panel Monitoring Flow Chart

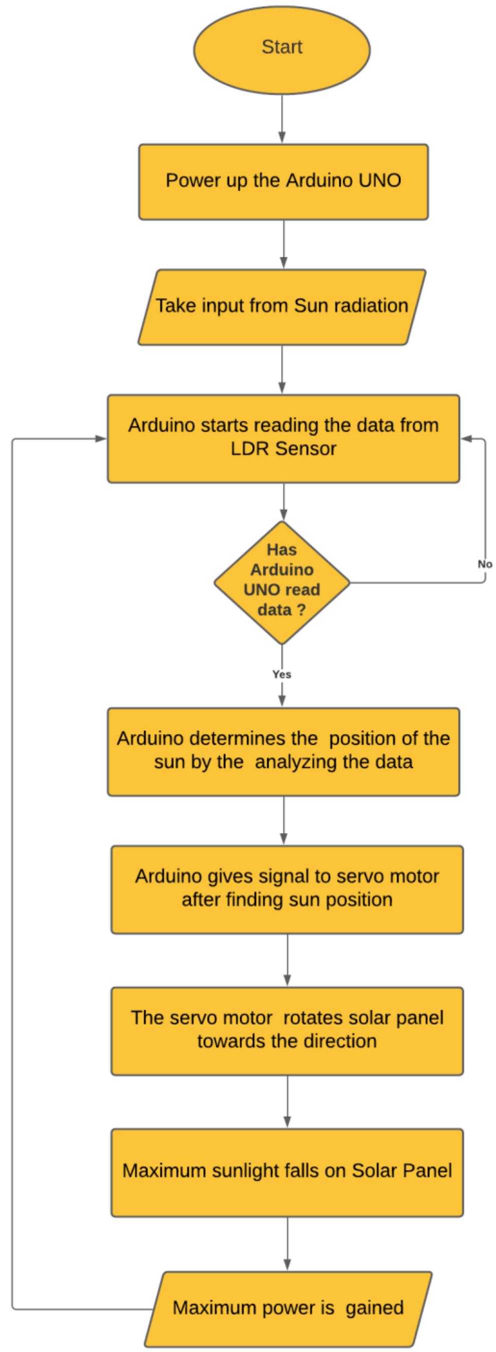


Figure 3.2.3: Solar Tracking Flow Chart

3.2.3 Algorithm

Solar Panel Monitoring System: -

Step1 – Start.

Step2 – We will power the Arduino and NodeMCU by turning on the battery.

Step3 – LDR sensor, Temperature sensor, Voltage sensor and Current sensor start sensing data.

Step4 – Arduino UNO collects the data from LDR sensor, Temperature sensor, Voltage sensor and Current sensor.

Step5 – Arduino UNO sends those data to NodeMCU via serial communication.

Step6 – NODEMCU make a connection to the internet and transfer the collected data to Thingspeak.

Step7 – Thingspeak shows the data in various formats.

Step8 – User monitors the solar panel by analyzing the data.

Step9 – Again we will go back to Step3 and then continue the whole process accordingly.

Solar Panel Tracking System: -

Step1 - Start.

Step2 – We will power the Arduino from the battery.

Step3 – Arduino starts reading the data from LDR Sensor.

Step4 – Arduino determines the position of the sun by the analyzing the data.

Step5 – Arduino gives signal to servo motor after finding sun position.

Step6 – The servo motor rotates solar panel towards the direction.

Step7 – We will gain the maximum power

Step8 – Again we will go back to step3 and continue to read the data of the LDR sensor and the solar panel will move accordingly.

CHAPTER 4

Output Results Analysis and Discussion

4.1 Output Results Analysis

In our experiments, we conducted a total of 1000 tests of Solar Panel Monitoring. During the testing of Solar Panel Monitoring, we measured 4 different factors. Also, we conducted a total of 1000 tests for solar tracking. 500 without solar tracker, and 500 with solar tracker. From the 500 tests, we have got 92% power gain with the solar tracker. While power gain from remaining 500 tests without solar tracker is just 50%. During the testing of the solar tracker, we also measured other factors associated with the solar tracker.

Factors measured: -

1. Temperature
2. Radiation
3. Voltage
4. Current
5. Movement of the servo motor
6. Solar Panel Movement (SPM)

Temperature sensing observed is 90%. LDR sensing observed is 97%. Voltage and Current sensing observed are 94 and 96% sequentially. Movement of the servo motor observed is 95%. SPM observed is 93%. It came to our observation that the solar panel works best facing south. Because this time the sun moved in the direction of east to west.

When the sun Radiation was highest, the best performance was observed. And the hours were between 8a.m. till 1p.m. We took the measurements from such a place where nothing was blocking maximum sunlight from reaching the solar panel. During this time Current and Voltage measurement showed the best value also.

Features	Outcome
Temperature Sensing	90%
LDR Sensing	97%
Voltage Sensing	94%
Current Sensing	96%
Movement of the servo motor	95%
SPM	90%
Power Gain with Tracking	92%
Power Gain without Tracking	50%

Fig. 4.1 Output Results Analysis

4.2 Features Statistical Analysis

In this chapter, we will mainly discuss on result analysis, features and how we have succeeded in doing these tasks.

Our first feature is temperature sensing. We have used a temperature sensor LM35 to sense the temperature from the environment. It will help to understand how is the weather condition. 90% of the times, it is able to give the data properly.

We have used LDR sensor to understand where the sun is actually giving more heat. Through this Arduino can easily understand where to turn the solar panel in which direction. We have seen that 97% times LDR gives data accurately. It is one of the main features because it plays a vital role to gain maximum output.

To gain maximum output from sun radiation, we needed to keep the solar panel rotating. Depending on the LDR data we saw that, servo motor was working well. 95 times out of 100 times, it kept moving. Also, it kept moving the solar panel almost 90% times in the direction of maximum sun radiation.

Again, generation of current from sun radiation is also our main feature. We have seen that power generation rate from the sun radiation is 96%. That means it is able to convert sunlight to current effectively.

Voltage measuring is also a feature of our proposed system. Our sensor can measure the voltage of the solar panel with an accuracy rate of 94%.

For monitoring the solar panel all the measured data are sent to the server 'ThingSpeak'. The accuracy of server data and server graph was 94% and 98%. So, users can have a great overview what is exactly happening in the solar panel. After a regular interval, the data is updated. So, depending on the data we can analyze and monitor the solar panel efficiently.

While using solar tracker, the power gain rate is up to 92%. But without using solar tracker the rate was only 50%. Because, if the solar panel doesn't rotate then it can not get the maximum radiation all time when the sun is in the east or west. But using tracking system, the solar panel keeps rotating automatically in the right direction where sun gives the maximum temperature. So, we have seen that tracking system gives maximum power gain.

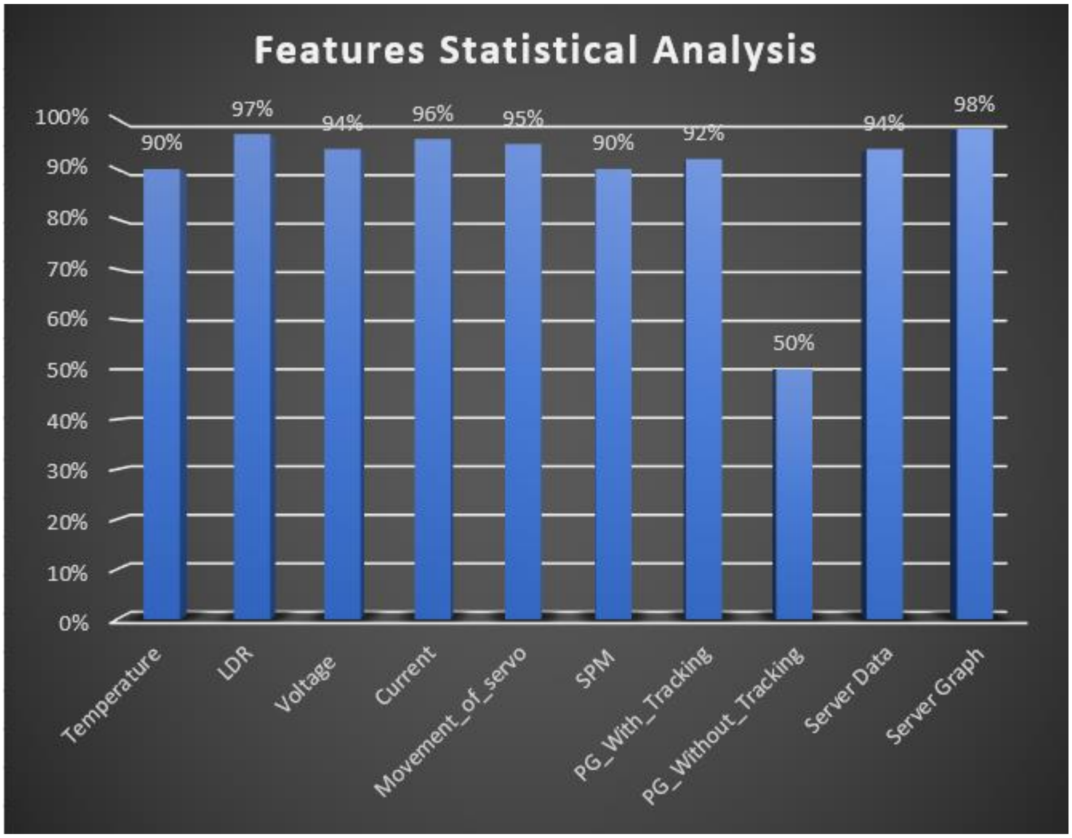


Fig. 4.2 Features Statistical Analysis

4.3 Limitation

- We need a power supply to power up both the microcontrollers.
- In rainy days, there is a chance of damaging the components if there is no waterproof case.
- It can not produce much power in cloudy and foggy weather.

4.4 The Output of This Project

In this chapter we will show outputs of this project. Through this we have presented the latest work of the project and some pictures of the output of our project. We proposed the Monitoring and Tracking system of solar panel in order to obtain the maximum power and remote monitoring from anywhere.

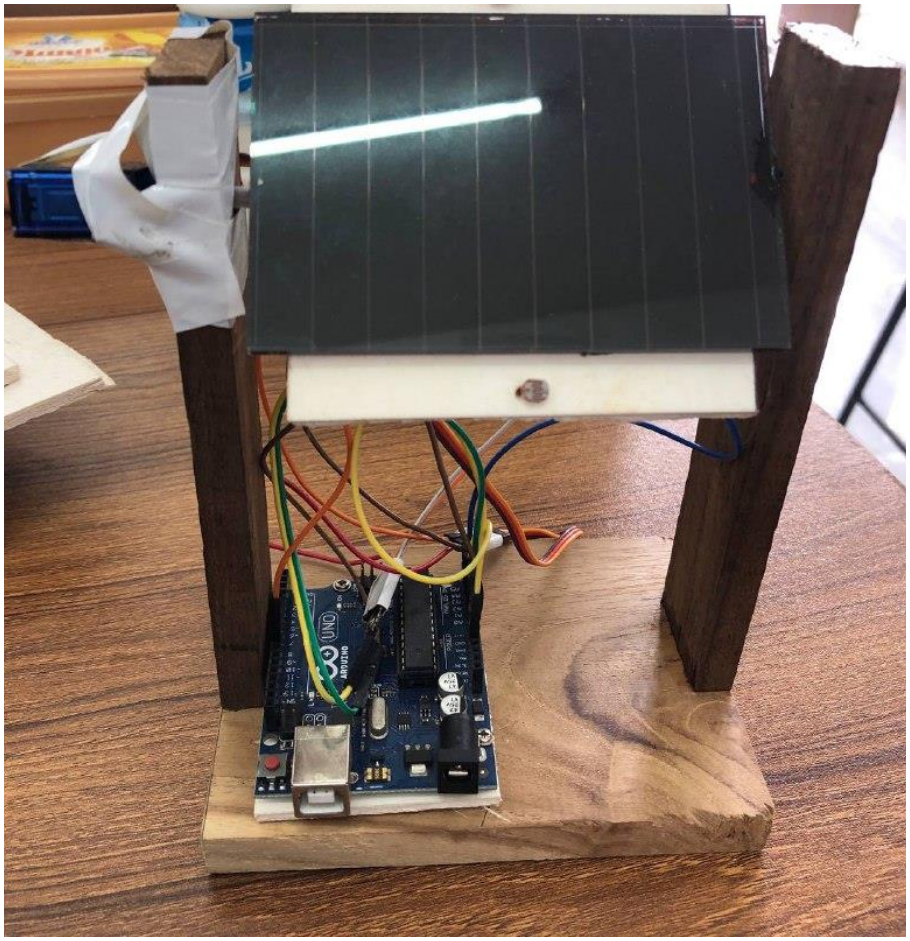


Fig 4.4.1 Output Solar Tracker

This is the output picture of our Solar Panel Tracking system. Here we have used Arduino UNO, 2 LDR, Jumper wires, Solar panel, USB cable, Servo motor to make the system. Sun radiation falls on the solar panel and 2 LDR sense the radiation value. Depending on this value, Arduino UNO operates the servo motor. Then servo motor keeps rotating the solar panel in the direction where the sun is giving maximum heat.

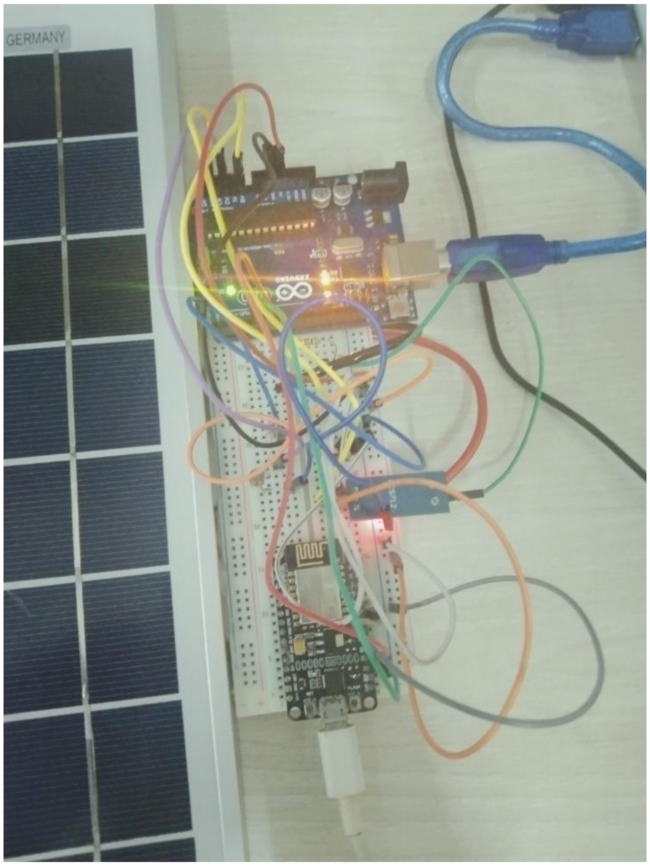


Fig 4.4.2 Output of Solar Panel Monitoring

Fig 4.4.3 Solar Panel

We have used Arduino UNO, NodeMCU, LDR Sensor, ACS712 Current sensor, LM35 Temperature sensor, jumper wire, USB Cable, Resistance, Solar panel, Breadboard.

Analog sensors keep sensing the data and then these values are sent to NodeMCU from Arduino UNO via serial communication. Then these data are uploaded to a cloud server "Thingspeak" for monitoring. User can visualize the real-time data in different graphs and widgets. They can also export the data in various format. This is how we can monitor our solar panel.

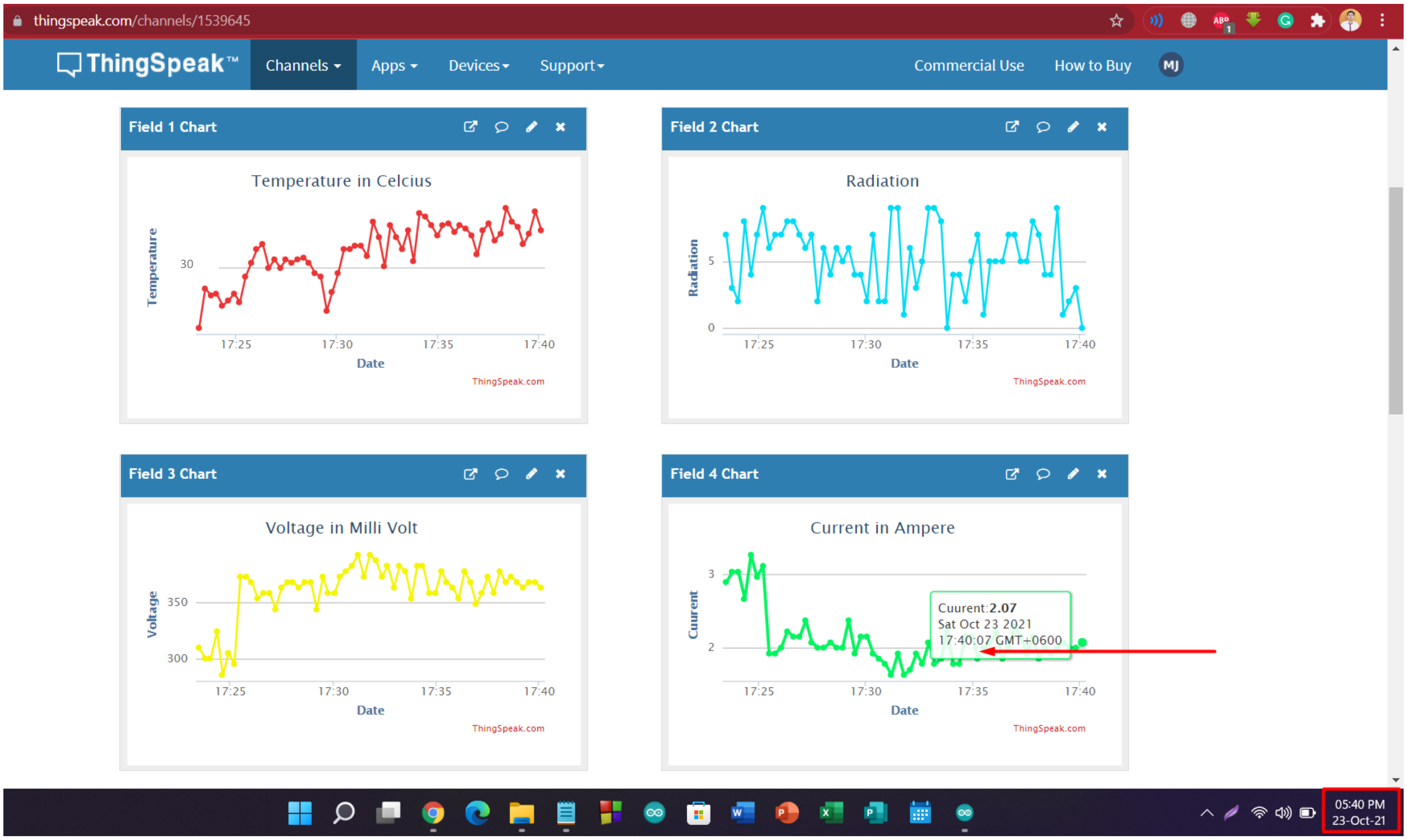


Fig 4.4.4 Real time visualization on Thingspeak Channel

NodeMCU makes a connection the internet and sends all the data to the cloud server “Thingspeak”. We have to give SSID and password of the connected wifi. We needed to create a channel on Thingspeak. Then by using the WriteAPI key and Channel ID we can send the data to our created channel. We also need toset in which fileds which sensed data will be uploaded. In each channel we can have at most 8 fileds. There is a lot of visaualizations methods and exporting features on the thingspeak server.

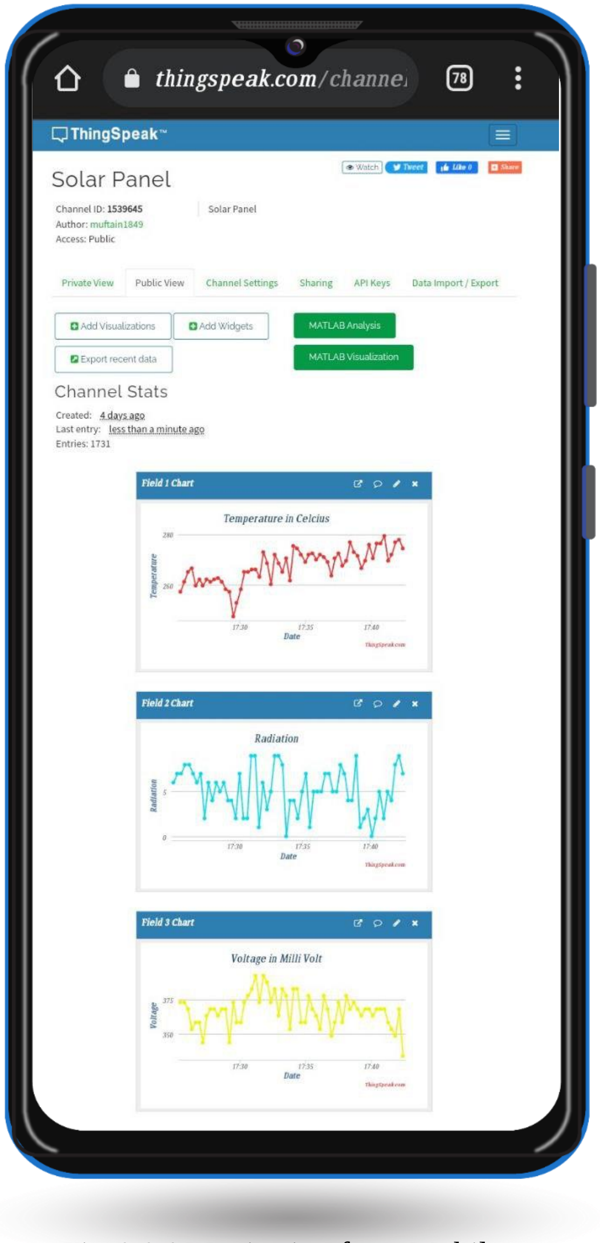


Fig 4.4.4 Monitoring from Mobile

We can also monitor our solar panel by using smartphones. We just need to connect to our Channel. Then we can monitor each and everything of the solar panel.

CHAPTER 5

Future Plan and Conclusions

5.1 Future Plan

We know that Arduino UNO operates at 5 volts and NodeMCU operates at 3.3 volts. So, we need external power supply for the system for its operation. We can solve this problem if we utilize the power generated by solar panel. Also, if we control the servo motor more efficiently, it can track the sun for better power generation. Moreover, by using various Machine Learning algorithms and model we can make system smart enough in taking decision about data and performance. Inclusion of Modern devices and sensors will make this system more efficient.

5.2 Conclusion

We know that conventional sources of electricity generation are decreasing. Now everyone badly needs renewable sources like solar and wind energy. The abundant and pollution less solar energy is a good alternative source of energy. So, we need an easy, effective, up-to-date monitoring system that can provide data to the user whenever and wherever needed. And IoT is the best solution for the monitoring of the solar panel.

In this project we have basically showed how we can get the most out of the sun through solar tracking and how we can monitor the whole system using Smartphone or PC. Flexibility of our system is its own uniqueness, presence of several sensors, measuring voltage, current, radiation and temperature and corresponding output of solar panel etc.

Using two microcontrollers to send the sensed data to the server 'ThingSpeak' for analysis. After each interval all the data is updated to the server. Users can easily monitor everything. Another thing is, there are so many solar panels having no monitoring system. If this low-cost monitoring system can be added to those solar panel, then monitoring and power generation will be more efficient and easier. Also, the tracking system plays a vital role of generating much power. Depending on the LDR value, servo motor keeps rotating the solar panel in the way where sun is providing maximum heat. Overall, this IoT based monitoring and tracking system of solar panel is very effective.

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