DE-40(DEE)

YEAR 2022

NUST COLLEGE OF

ELECTRICAL AND MECHANICAL ENGINEERING

Maximum Power Point Tracking

Solar Charge Controller

A PROJECT REPORT

DE-40 (DEE)

Submitted by

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BACHELORS

IN

ELECTRICAL ENGINEERING

YEAR 2022

PROJECT SUPERVISOR

Dr. Usman Ali

NUST COLLEGE OF

ELECTRICAL AND MECHANICAL ENGINEERING

PESHAWAR ROAD, RAWALPINDI

DEDICATION

We dedicate this effort to our parents, who have always supported us financially and emotionally and provided for all of our needs while we worked on this project. They taught us that even the most daunting of tasks can be completed successfully if they are tackled step by step with self-assurance and courage.

It is also dedicated to our teachers and specially our supervisor Dr Usman ali and all the technical staff who really helped us for the completion of this project.

We would also like to dedicate this project to college of electrical and mechanical engineer, my significant second home and all the friends who lead us through the valley of darkness with light of hope and support.

CERTIFICATE OF APPROVAL

It is to certify that the project "**MAXIMUM POWER POINT TRACKING SOLAR CHARGE CONTROLLER**" was done by **Muhammad Mazhar Khan, Ahmad Jahanzaib and Shazeb Anwar** under the supervision of **Dr. Usman Ali.**

This project is submitted to **Department of Electrical Engineering**, College of Electrical and Mechanical Engineering (Peshawar Road Rawalpindi), National University of Sciences and Technology, Pakistan in partial fulfilment of requirements for the degree of Bachelors of Engineering in Electrical engineering.

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DECLARATION

If any section of this Project Thesis is used in an application for another degree or qualification, we hereby certify that it has not been used for such purpose. If any plagiarism is discovered, we will be held entirely liable for any disciplinary measures taken against us, up to and including the revocation of our degree, depending on the gravity of the proved crime.

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ACKNOWLEDGEMENTS

We would like to express our gratitude to our supervisor, Dr. Usman Ali, for providing me with the opportunity to work on this fantastic project on a Maximum Power Point Tracking Solar Charge Controller. This project allowed us to conduct a significant amount of research, and I learned a great deal from my supervisor.

My friends and family have been a huge help in getting this project finished on time, so a big thank you to them as well.

ABSTRACT

Due to rising energy demands and the depletion of non-renewable resources, solar energy has become increasingly popular in recent years. Due to environmental circumstances such as sun irradiation and temperature that might affect solar energy production, it is impossible to predict how much power will be generated. Consequently, to serve as a standby power source, a battery is permanently connected between the load and the solar panel. Because solar cells generate higher power when exposed to more sunlight, the risk of battery damage increases as sunlight increases. MPPT is a method for maximising the output of a photovoltaic module while minimising the risk of overcharging the battery. MPPT charge controllers are designed to preserve and monitor the battery.

Boundary limitations and a dynamic perturbation step-size are employed to reduce the oscillation's impact on the MPP. Ropp, sinusoidal, and ramp irradiance tests are used to evaluate the proposed P&O against the conventional and adaptive P&O. A 10-hour irradiance and temperature profile is used to evaluate the findings. A buck-boost converter is utilised to accomplish the MPPT efficiency (MPPT) calculation, which serves as a benchmark for the procedure. On average, all tests showed an increase of two percentage points in MPPT for the proposed P&O system. It also doesn't need any new hardware; just a few lines of extra software code must be added to the regular P&O MPPT control.

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CHAPTER 1: INTRODUCTION

1.1. Introduction

Most Pakistanis live in rural areas without access to the national grid transmission line. The current electric networks are incapable of meeting the needs of the impoverished. As a result, the ideal alternative is to use renewable energy sources, such as solar panels and wind turbines. They offer a few advantages, such as being pollution-free and low-maintenance; they also have a few disadvantages, such as a high manufacturing cost and an inefficient energy conversion rate An effective solar charge controller may lower the total cost of ownership of a solar power system since solar panels have a relatively poor conversion efficiency at this time. The charge controller of a solar power system is the brains of the system, and its primary function is to safeguard the rechargeable battery

1.2. What is Charge Controller

Voltage or current control is the primary function of a solar charge controller, which is used to charge the battery and prevent overcharging of the electric cells. The solar panels' output voltage and current are directed to the electric cell using this device. Electric cells may be harmed by overcharging if there is no restriction on the voltage output of 12V boards and panels. Devices typically need between 14 and 14.5 volts to be fully charged. There are a wide range of features, prices, and dimensions for solar charge controllers to choose from. Charge controllers might be as little as 4.5A and as high as 60 to 80A.

1.3. Types of solar Charge Controller

Most solar power systems nowadays employ one of two popular kinds of charge controllers.

1. Pulse width modulation (PWM) and
2. Maximum power point tracking (MPPT).

To avoid overheating, both the charging rate and battery temperature are monitored to ensure that the battery is not overcharged.

1.4 Pulse Width Modulation (PWM) ChargeController

PWM charge controllers are the most efficient way to maintain a constant voltage battery charge by altering the duty ratio of a switches (MOSFET). In a PWM charge controller, the power from the solar panel tapers depending on the battery's state and recharging demands. The PWM algorithm gradually decreases the charging current to minimise heating and gassing of the battery, while charging continues to deliver the greatest amount of energy to the battery in the quickest time.. As a result, the array's voltage will be reduced to levels comparable to those of a rechargeable battery. The following are some benefits of a PWM system:

- Higher charging efficiency
- Longer battery life
- Reduced battery over heating
- Minimizes stress on the battery
- Ability to de-sulfate a battery

DC to DC transformers do not exist in the PWM world. It's a switch, and it links the solar panel and batteries through PWM. As soon as you shut the switch, the voltages on the panel and battery will be approximately equal.

Initial charge voltage will be about 13 volts, assuming 0.5 volts of voltage loss via the cable and controller. In order to boost the voltage, the battery's charge level must rise. The PWM controller will begin disconnecting and reconnecting the panel to avoid overcharging when the absorption voltage has been achieved. PWM charge controller is an acronym for pulse width modulation.

1.5. Maximum Power Point Tracking

Maximum Power Point Tracking (MPPT) is the most sophisticated solar charge controller currently on the market (MPPT). It's more advanced and more pricey, though. Over the

PWM charger controller, it offers various benefits. Using it at a lower temperature increases its efficiency by 30 to 40%. A synchronous buck converter circuit serves as the foundation for the MPPT's operation. It reduces the greater solar panel voltage to the battery's charging voltage

For optimal power collection from the solar panel, it will alter its input voltage, and this power will be transformed to provide the fluctuating voltage requirements of battery + load. It will be. Generally speaking, MPPT controllers outperform PWM controllers in colder climates, but both controllers perform about the same in warmer climates.

Charge controllers that use the MPPT charge controller may convert electricity from higher voltages to lower voltages. Because the output voltage is less than the input voltage and the output current is greater than the input current, the product P=VI stays constant regardless of the difference in the voltage and current values.. As a result, a charge controller ought to be able to choose the best current voltage point on the current voltage curve: the Maximum Power Point—in order to get the most out of a solar panel. An MPPT is just what you need for this purpose. A PWM controller's input voltage is always the same as the output voltage of the battery it's linked to. As a result, in the vast majority of situations, the solar panel is not operated at its Maximum Power Point.

The monitoring of maximum power points is normally done electronically - in the form of a digital record. Panel output is compared to the battery's voltage via a charge controller. It then determines what the optimal power output from the panel is for charging the battery. For optimum battery power, it takes this and transforms it to a voltage that is as close to its ideal as possible. In terms of conversion efficiency, current MPPTs typically achieve a figure between 93% and 97%. Power increases by 20% to 45% in the winter and 10% to 15% during the summer. Weather, temperature, and other conditions may have a significant impact on the amount of energy you get out of your battery. Under the following circumstances, MPPTs work best:

At this time of year, when the additional electricity is required the most, it's winter and/or overcast days

Solar panels are more efficient in cold weather, but without an MPPT you're wasting a lot of that energy. Cold weather is more common in winter, when daylight hours are fewer and batteries need to be recharged more than any other time of year.

When your battery's state of charge is low, an MPPT will draw more current from it, which is when the additional power is most required. Having both of these things is possible.

Cable lengths above 100 feet may result in significant voltage drop and power loss while charging a 12-volt battery, thus it's important to utilise extra-large wire. Depending on the scope of the project, this might be prohibitively costly. There is less power loss when you connect four 12 volt panels in series for 48 volts, and the controller will transform that voltage level to 12 volts at the battery.

CHAPTER 2: LITERATURE REVIEW

2.1. Background

One of South Asia's most populous nations, Pakistan accounts for 2.56 percent of the world's overall population. International commerce and energy corridors are projected to be established in the country in the near future because of its strategic position. It is thus imperative that the energy supply of Pakistan be sufficient to fulfil both the country's immediate and long-term requirements, as well as those of the region and the world at large. There was a 26.82 percent gap between the amount of power needed and the amount that was available throughout history. Load shedding (power outage) is a common occurrence in both urban and rural regions, resulting in power outages of between 13 and 14 hours in urban areas and 16 and 19 hours in rural areas. As a consequence, numerous entrepreneurs and manufacturers have invested and relocated their firms to neighbouring nations. As a result, immediate and long-term solutions are needed to address the current energy crisis. There is a summary of Pakistan's current energy resources in this article Oil (38 percent), hydro (32 percent), natural gas (27 percent), and coal (3 percent) make up the majority of indigenous energy sources.

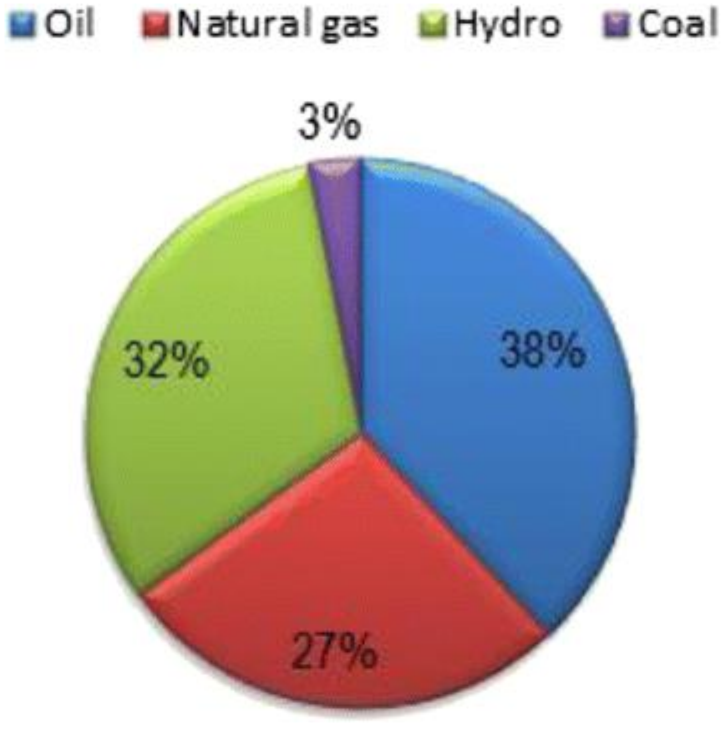

Figure 1 Flowchart of Pakistan's indigenous energy resources

For Pakistan's present and future home and industrial energy needs, full-scale production from various energy sources would be required to make major contributions toward supply chain sustainability. As a result of the country's reliance on foreign oil to maintain its current energy mix and the fast decline of local gas assets, current energy production places a heavy financial strain on the country's economy. In Pakistan, the installed electricity capacity is 22,797 MW, as reported by Pakistan's Board of Investment (BIP). To meet peak demand of 17,000 to 21,000 MW, current daily output is between 12,000 and 13,000 megawatts (MW). As seen in Figure 2, the average yearly demand for energy is rising by 8–10 percent per year.

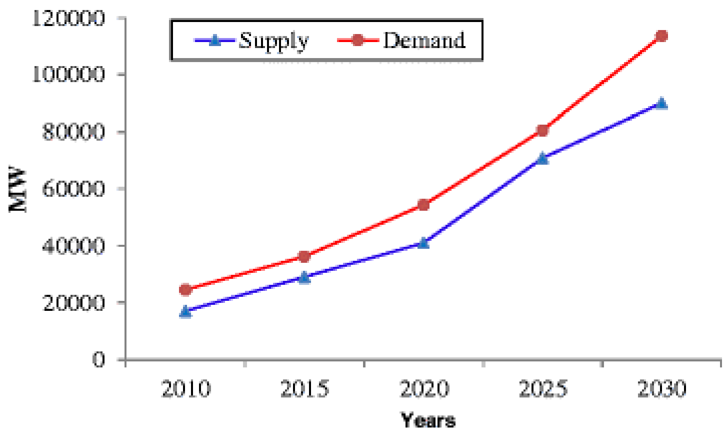

Figure 2 Annual demand of electricity of Pakistan

There is a big economic burden on the nation because of the severe deficit and hardship caused by oil imports. Diverse governmental and international entities, such as ADB and the World Bank, have made various attempts to stabilise the energy situation. ADB and the World Bank There have been little attempts by the government to deal with the issues of energy security, global warming, and long-term development that they have raised. A key national priority should be the quest for alternative fuel sources that are more sustainable and renewable while less attention is paid to boosting domestic fossil fuel-based energy generation (gas, coal, and oil).

2.2. Solar energy

One of the most abundant renewable energy sources is solar. It is dependable and can produce a large quantity of energy without causing harm to the environment. In rural and urban regions alike, photovoltaic (PV) cells and solar thermal implementation of the convention are often used to harvest solar energy for a variety of purposes. Using photovoltaics (PV), you may generate power from the sun's rays.

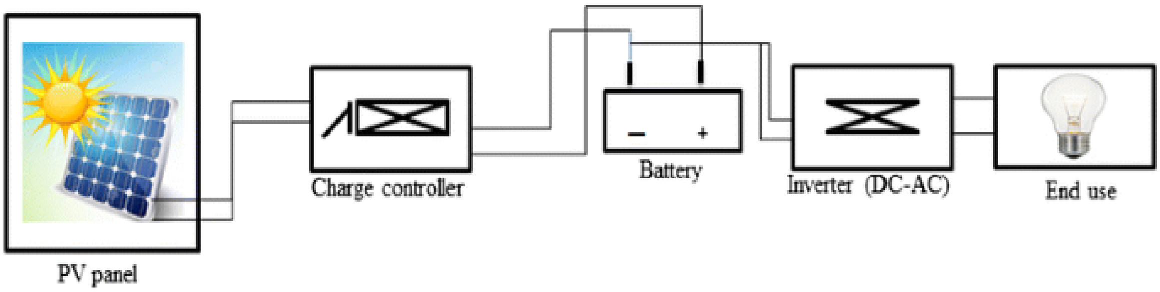

Figure 3 Solar Pv System

2.3. Photovoltaic Effect in Solar Cells

Solar panels transform solar energy into electrical energy that can be used by the end user in order to better comprehend the photovoltaic impact and make an informed choice on the most costly component of this project. An absorbent substance, such as silicon or another semiconductor, is used to make the photovoltaic cell. The band gap of every semiconductor is unique. When the lowest level of conduction band energy Ec is compared to valence band Ev's greatest level of energization Ev, it's termed band gap energy (Eg). The band gap between the valence and conduction bands may be crossed by electrons with sufficient input energy. The solar cells' direct current is generated by these electrons. Variations in the quantity of energy contained in photons or packets of solar energy correlate to variations in the solar spectrum. When the photon energy meets the semiconductor band gap, these photons are absorbed by the semiconductor material itself. Therefore, photons with greater energy levels than Eg are absorbed, but their surplus energy is reflected or wasted in the form of heat (wasted energy), whereas photons with lower energies than Eg are not able to be absorbed at all.

All that matters is to choose the right semiconductor material with the best band gap energy for solar radiation in order to maximise efficiency. All of sunlight's wavelengths can be absorbed by a single semiconductor, but no one semiconductor has a band gap wide enough to cover the whole spectrum. Solar cells that operate over the whole visible spectrum of light have previously been developed, but they are still prohibitively expensive for the average customer.

2.4 Challenges of Photovoltaic Technology

2.4.1 Efficiency of the PV Cell

Because of this, the rated output power of each PV cell varies with the surrounding meteorological conditions. Greater PV output current is a consequence of increased photon voltage striking the electron hole of the cell, which results in an increase in the PV array's generation power. Due to the increased band gap of the PV semiconductor at higher operating temperatures, open circuit voltage of PV cells lowers, resulting in a loss in efficiency. When input irradiation is absorbed, the mobility of PV electrons becomes less valent, resulting in a decreased energy loss. But the PV cell has a single operating point known as the maximum power point (MPP), and this point changes with the weather.

2.4.2. Stability of PV generation

The variability in PV output power due to passing clouds is regarded a key concern when designing a grid-connected PV system. The PV system may be affected by a number of factors, including a spike in voltage and voltage oscillations. There are several factors that impact the stability and dependability of PV power production, particularly in large-scale PV generating. When it comes to traditional power systems, this kind of problem doesn't occur very often, thus the ability to regulate the energy flow across a hybrid power system is critical for optimising PV production for distribution. As a result of passing clouds, the PV output power fluctuation is a serious challenge when constructing a grid-connected PV system The PV system may be affected by a number of factors, including a spike in voltage and voltage oscillation. There are several factors that impact the stability and dependability of PV power production, particularly in large-scale PV generating. Conventional power systems seldom have this problem, thus managing the energy flow via a hybrid power system so that the PV production may be adjusted for the utility grid is crucial for this system.

2.4.3 Partial shading condition

This maximum power point (MPP) is unique to each PV array, and it is determined by the amount of solar irradiation and temperature. However, if trees or dust are shading part of the PV array, multiple MPPs will be generated by the array. As a consequence, several PV power values will be created at the same time since each PV module will produce its MPP. As a result, worldwide PV power production is expected to decline in the future. In this situation, a hotspot on the PV module may form due to a sudden shift in PV voltage, which might cause damage to the PV system.

2.4.4 Mismatch of PV load

Similarly, the voltage output of a PV array is influenced by the amount of load it is carrying. Lower or greater than expected power production from a PV array may cause voltage drops or rises in the PV system, lowering or increasing PV generation's efficiency. Large-scale PV plants may also cause harm to grid-connected PV systems when they disconnect due to a problem.

2.4.5 Lifespan of an Installed PV Module

According to the majority of PV manufacturing firms, a PV module's lifetime is generally 20 years and its output is at least 80% of its rated power. The climatic conditions in which a PV system is built have a significant impact in reducing its life expectancy by roughly 0.2 percent every year, according to many studies. It's because of the fast fluctuations in PV voltage that occur as a result of quickly changing weather.

2.5 Radiation

Because of the strength of solar radiation or irradiance, solar panels operate better in the middle of the day than in the morning or at night. The electromagnetic radiation (EM) released by the sun is known as solar radiation. To measure insolation, you measure the quantity of energy that reaches a certain surface during a specified period of time. Electricity may be measured in several ways, the most common of which are kilowatt-hours (kWh/(m2day)) or watts per square metre (W/m2). The average amount of solar irradiance from the sun on Earth's surface is 1368 W/m2 due to the planet's distance from the sun.

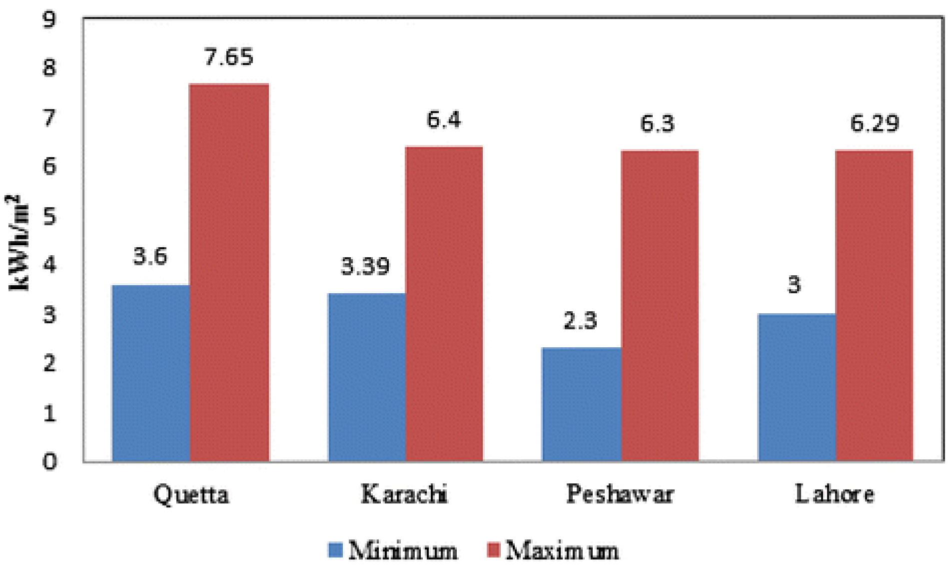

Figure 4 Maximum and Minimum range of solar radiation in Pakistan

In order to compensate for reduced levels of solar irradiation, a few techniques exist for improving the performance of solar panels. Direct approaches, such as sun tracking and light concentration, as well as indirect ways, such as the one discussed in this project and using an MPPT charge controller, are all possibilities. In order to reduce the angle of incidence between solar panels and the sun, solar tracking is used. To put it another way, this technique assures that the solar panels are always facing the sun. By installing the solar panels on a single or double axis mounting mechanism, which is regulated by the intensity of sunshine, this may be done. With the use of mirrors or lenses, solar panels are able to receive more sunlight, resulting in a greater quantity of energy being generated.

In an on-grid or off-grid situation, such as charging a battery bank, MPPT is an indirect means of improving the efficiency of the solar panels. MPPT charge controllers optimise the output voltage of the solar panel to meet the required-state voltage level of the batteries. Because of this, the output current of the panel may be adjusted to keep its power level constant. For example to maintain the same level of power, the MPPT charge controller will lower its output voltage and increase its output current in order to decrease the PV output voltage and keep the same amount of power.

Chapter 3: Methodology

3.1 Objectives

Our main research objective is to reduce the MPPT's price. MPPT (Maximum Power Point Tracking) is a recently developed technique that enables for incredibly fast MPP collection in the controller. Charges the battery to full capacity in a matter of minutes using a four-stage controller. According to the testing findings, the new charge controller tracks the MPP more quickly than the commonly used controllers. Charge controllers based on this design provide a low steady-state oscillation error and a good MPPT accuracy.

3.2. MPPT techniques

Because a solar panel's MPP varies with irradiance and temperature, MPPT algorithms are necessary for PV applications. This means that a solar panel's maximum power output cannot be achieved without MPPT algorithms.

A slew of strategies for tracking down the MPP have been devised and made public in the last several decades. The number of sensors required, their complexity, cost, speed of convergence, maintenance of the efficacy range, correction for changes in radiation and/or temperature, and the hardware required to implement the popularity are just some of the differences between these approaches that need to be taken into account.

Conventional MPPT techniques exist. We've compiled a list of seven of the most notable. Among them are the following:

1 Constant Voltage method

2. Open Circuit Voltage method

3. Short Circuit Current method

4. Perturb and Observe method

5. Incremental Conductance method

6. Temperature method

3.2.1. Constant Voltage Method

The constant voltage approach is the most basic MPPT algorithm. As the name suggests, this technique uses the open circuit voltage to calculate a constant voltage value. The operating voltage is reported in the literature as a range of acceptable estimations, generally between 73% and 80%. [30] Figure 15 assumes a constant voltage of 76% of the VOC.

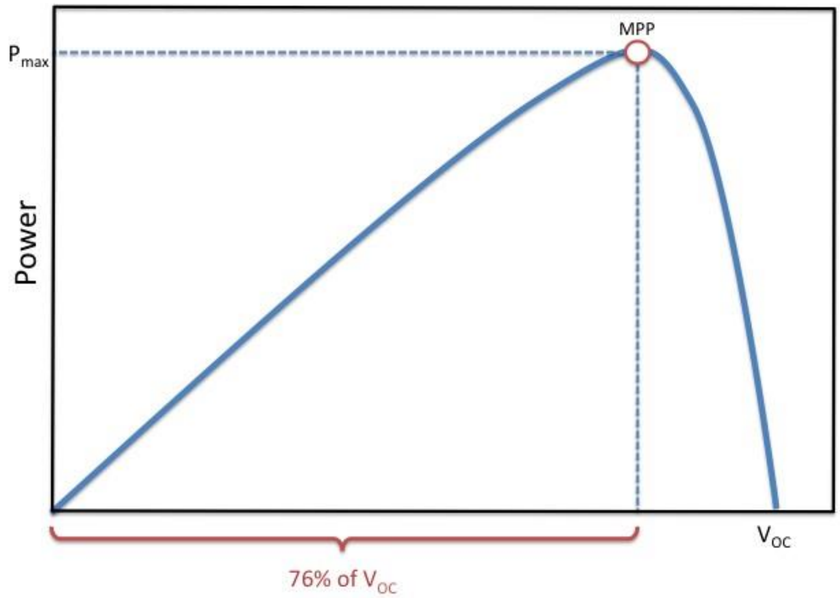

figure 5 The constant Voltage Method for MPPT

To calculate the open circuit voltage, the system reduces the PV current to zero for a brief period of time. Once it obtains this number, it can compute, depending on the set ratio, what the voltage level should be, and the system may begin moving toward that point .'s The system may be set to wait a certain period of time before isolating the source and doing the computation a second time. To put it another way, this approach is fundamentally less effective than either the perturb-and-observe or the proposed control algorithm. In order to estimate VOC, the current must be set to zero. This results in significant losses in efficiency due of lost energy. Because the peak power is not constantly at 76 percent, it is impossible to correctly predict where it will be. This method's key benefit is its simplicity and reduced processing requirements.

3.2.2 Incremental Conductance Method

The incremental conductance approach is a more involved but generally more accurate process. This technique is based on comparing the voltage-dependent power differentiation to zero and determining whether it is greater or lesser than zero, as shown in Figure.

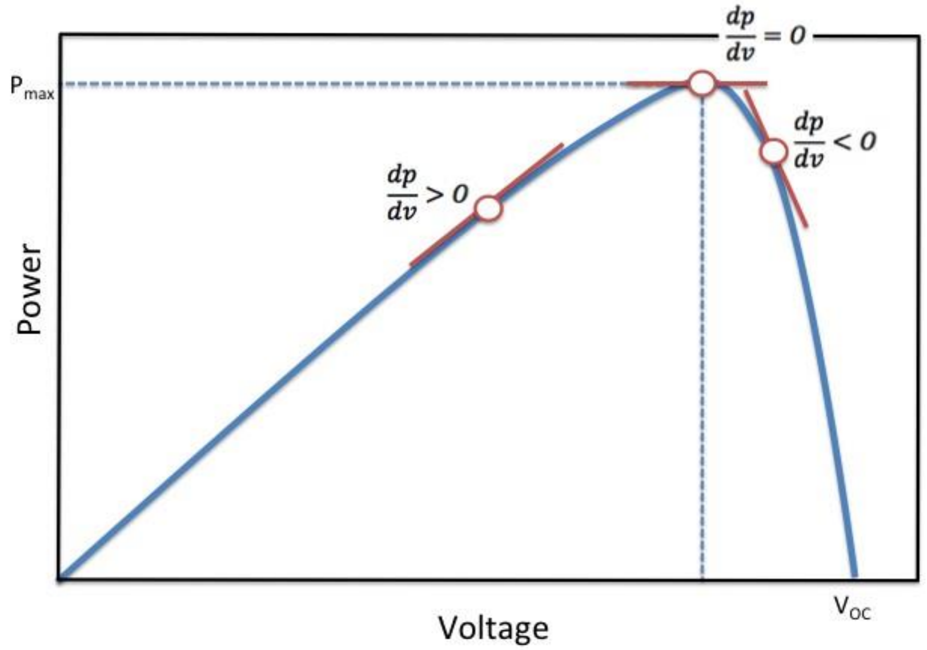

Figure 6 The Incremental Conductance Method for MPPT

Rewriting a zero-power differential in terms of conductance simplifies this problem. It is the same as the incremental conductance, except the sign is reversed.

$$-\frac{I}{V} = \frac{dI}{dV}$$

This equation (and each of the two inequalities that could arise) corresponds to the three regions referenced in Figure 14, one of which being the point where $dP/dV = 0$. Algorithm continues to raise voltage until maximum power point is reached if incremental conductance is higher than instantaneous conductance If you use incremental conductance instead of perturb and observe, you can get a precise figure for the system's maximum power point, and it will stay there until the environment changes. In our project, we employed the perturb and observe strategy, which we'll detail in the next section.

3.3 Perturb and observe

This is one of the most common strategies of a long-standing tradition. If an increase in voltage leads in a rise in power, this signals that the maximum power zone has been reached; if the power declines, the voltage must be adjusted to match the MPP. This is the standard P&O method. TLB converter duty cycle d and duty cycle variation d are presented in Figure 11 in P&O flowchart. New P&O is based on a PPV-to-PMPP comparison in the newer P&O. This means that in order to match the MPP, either lower or higher VPV is used. Figure depicts the P&O flowchart we've come up with so far. To put it another way, the enhanced P&O technique provides less room for error.

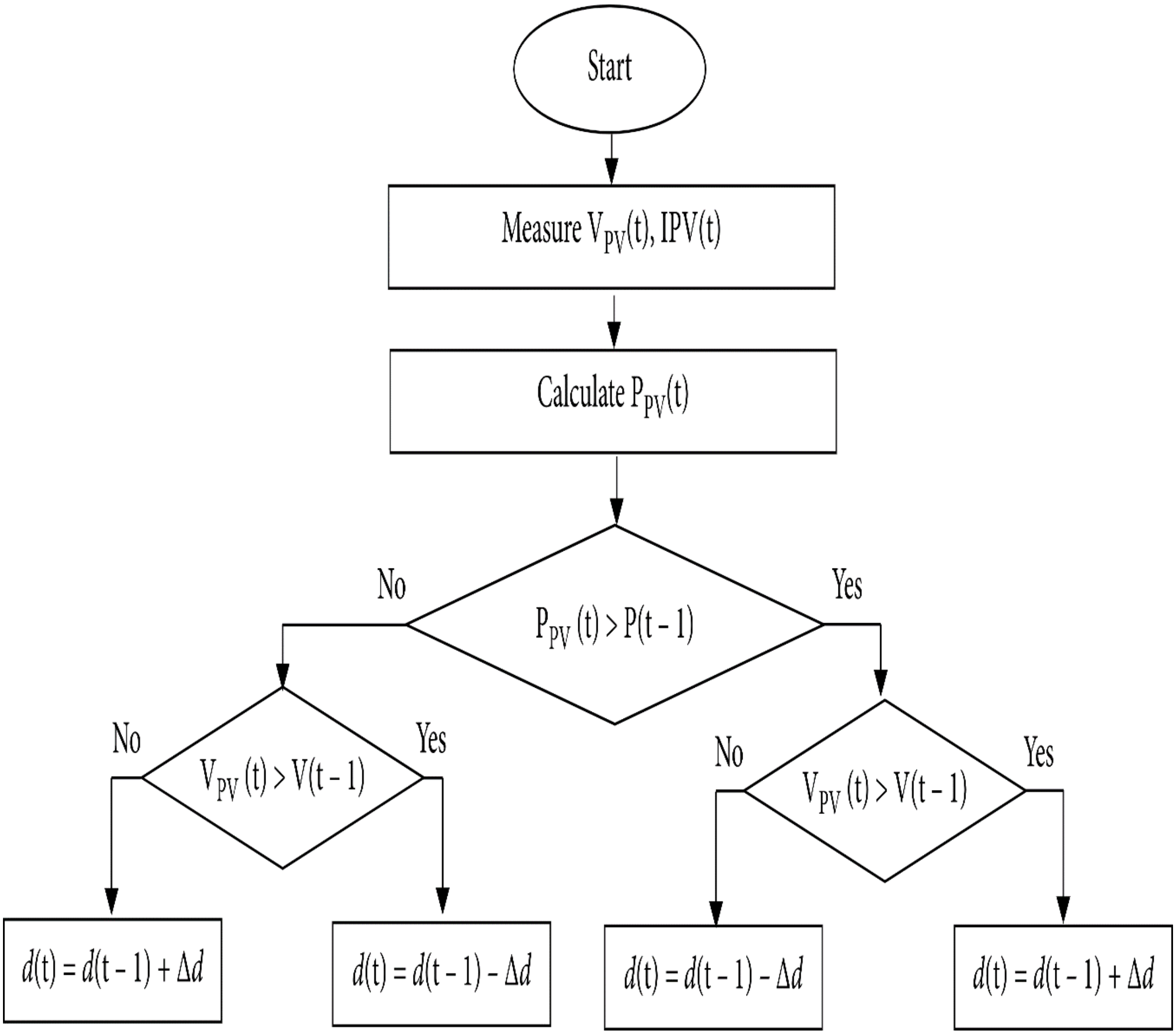

Figure 7 Flowchart of the P&O algorithm.

The P&O approach is frequently referred to as hill-climbing, however the two terms refer to the same thing. The duty cycle of the power converter and the operating voltage of the Dc link between the PV array and the power converter are both affected by hill-climbing. Changes in the DC connection between PV arrays and power converters may be referred to as Hill-climbing or Hill-climbing, depending on how they affect duty cycles.

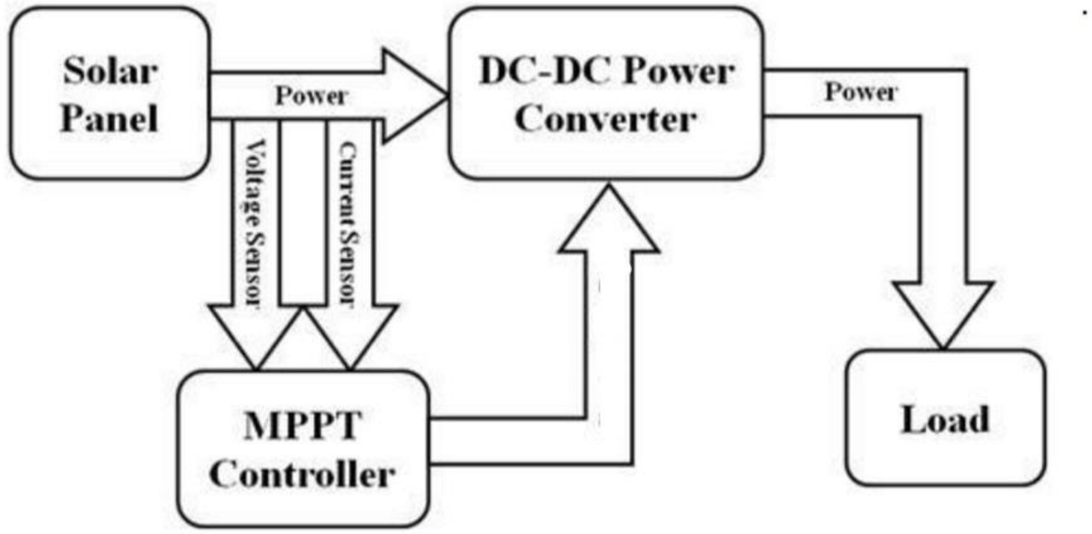

Figure 8 Block diagram

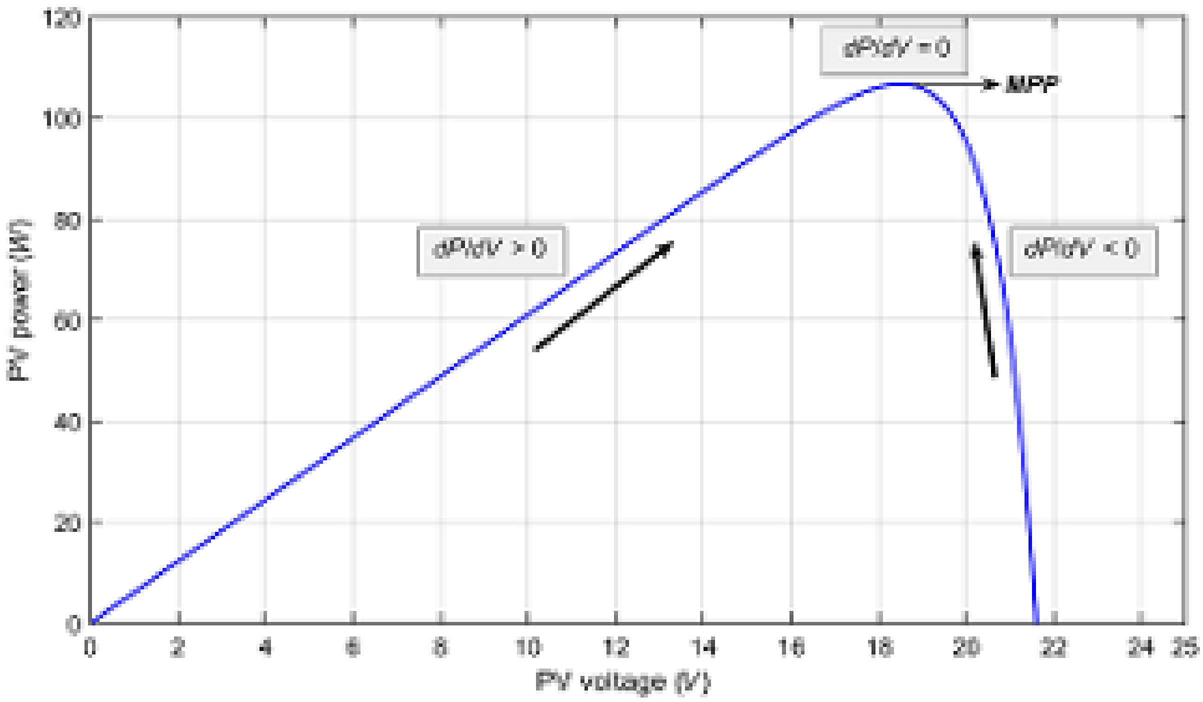

Figure 9 Power graph

3.3.1 Benefits of using the P&O method

- This algorithm's brevity
- Execution simplicity
- It has a lower implementation cost than other options.
- To put it simply, it is more precise than other methods.

3.3.2 Limitations of using P&O method

Because of this, the MPP cannot be accurately determined. The output power oscillates about the MPP during steady-state operation..

If the voltage is far from MPP, this approach will take a long time to discover it;

In any event, the voltage output of the PV will have multiple peaks and the P&O will be unable to identify them and discover the true peak if there is any shade on any of the panels (since they are connected in series and parallel).

CHAPTER 4 SOFTWARE

4.1. Software

We have made a prototype of our project using different software and after implementing on software we implemented it on hardware. Following is the software we used to implement our project:

- PROTEUS
- ARDUINO IDE

Proteus was used for the simulation work. We made the circuit on proteus and used the components which we were intended to use in our hardware work. Proteus is actually a tool used for the electronic design automation. Proteus is a software developed by Lab Center Electronics for the simulation electronic devices and Circuits. Proteus can be used for the designing of the circuit and also for the creation of PCB layout structure.

Following is the way how to add a library in proteus:

- First, download the library you want to install in proteus.
- Unzip the file and copy the library file.
- If you are using Proteus 8 professional, then go to C:\ProgramData\Labcenter Electronics\Proteus 8 Professional\LIBRARY
- Paste the file in Library folder and then restart the software.

This is how each library is added in to the proteus. Hence Proteus was the main and primary tool for our project. We have made our first attempt by making our project on proteus. we have made many changes as for our desired result and to make changes on proteus is very simpler and easy. once our project was fully working then we proceed to our hardware section.

4.2. Circuit diagram

After adding all the libraries to the proteus, we then started making the circuit. Following is the circuit diagram of our project that we made in the proteus

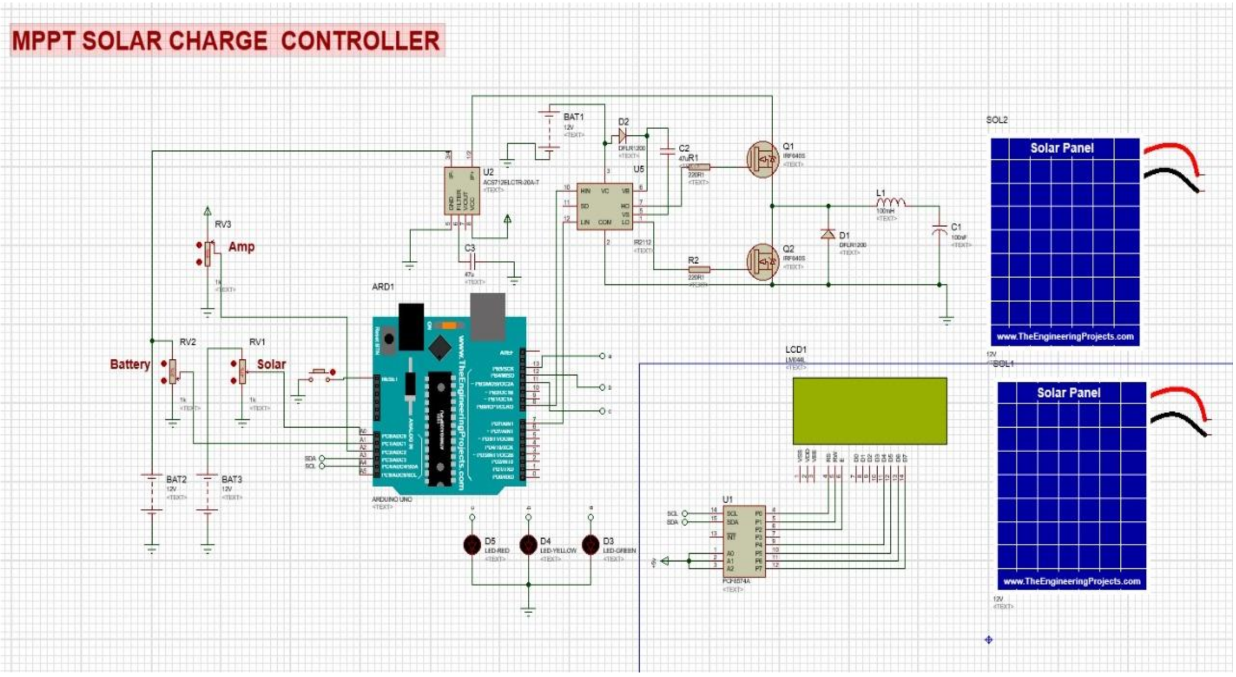

Figure 10 Proteus circuit

Here first of all, we have used an Arduino UNO. We have used Arduino UNO because it was cheap than another Arduino and was able to complete our requirements. We have connected different components like ACS712, IR2112,PCF8574 and another components. The circuit above is fully working according to our desired result. We also used potentiometer to change the current and voltage that is coming from the solar panel. Despite of fully working the above circuit is the cheapest circuit that can be made and then can easily be implemented on large scale for our daily usage purpose.

4.1.2 Arduino UNO

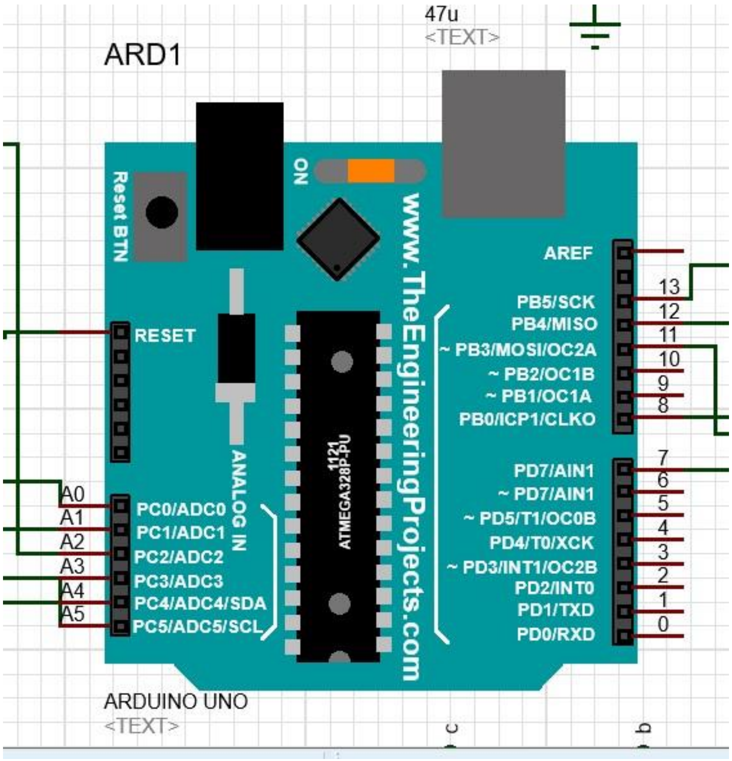

Figure 11 Arduino UNO

- In Italy, "UNO" means "one" and refers to the Arduino UNO board, which uses the Atmega328 microprocessor as its core.
- Software for developing and compiling code, as well as for uploading it to Arduino boards (named Arduino IDE), is available for free download from the official site of Arduino.
- Input voltage ranges from 7V to 12V, while the operational voltage is 5V. "
- Arduino UNO's maximum current rating is 40mA, thus if the load exceeds this current level, you might damage your Arduino board.
- A crystal oscillator of 16 MHz serves as the device's primary source of power. "
- Using the Arduino UNO's 14 digital pins, you may connect to any one of them.

Hence in short Arduino UNO was able to fulfill our requirement in a pretty way.

4.1.3 Buck Converter

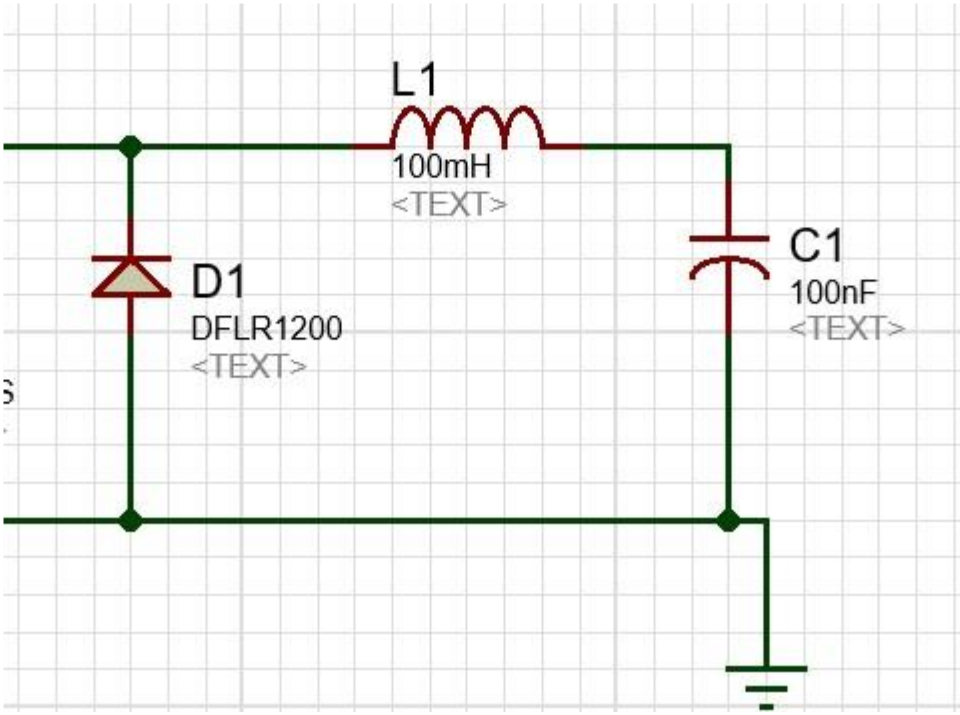

Figure 12 Buck Converter

A 50W solar panel provides the power supply and a 12V lead-acid battery is used as the load. A buck converter is defined as a device that converts alternating current into direct current,

1.Inductor

2.Capacitor

3.Diode

in our case the value of inductor is 100 microhenry, the value of capacitor is 100nanoFarad and we have used DFLR1200 as a diode. Buck Converter is playing the vital and very important role in our project.

4.1.4 ACS712

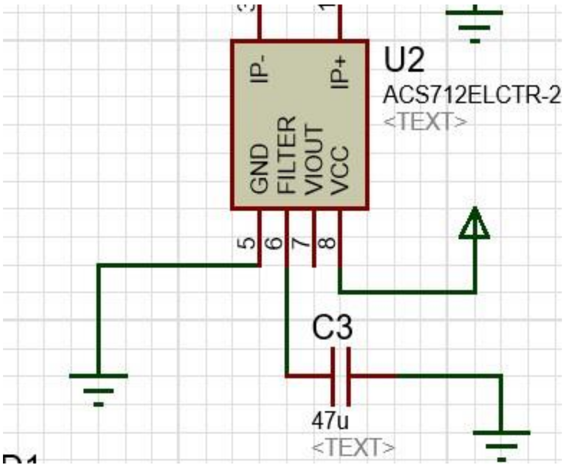

Figure 13 ACS712

linear current sensor featuring 2.1kVRMS voltage separation and integrated low-resistance current conductor are provided by the ACS712. As far as terminology goes, it's just an electrical conductor used to determine the amount of applied electrical power.

4.1.5 IR2112

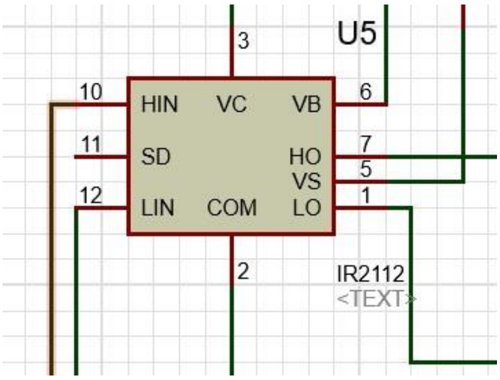

Figure 14 IR2112

With separate high and low side reference output channels, the IR2112(S) provides high voltage and high frequency power MOSFET and IGBT driver functionality. Monolithic construction may be achieved using proprietary HVIC and latch-free CMOS technology. Down to 3.3V logic inputs are compatible with typical CMOS and LSTTL outputs .

4.1.6 LED Indicators

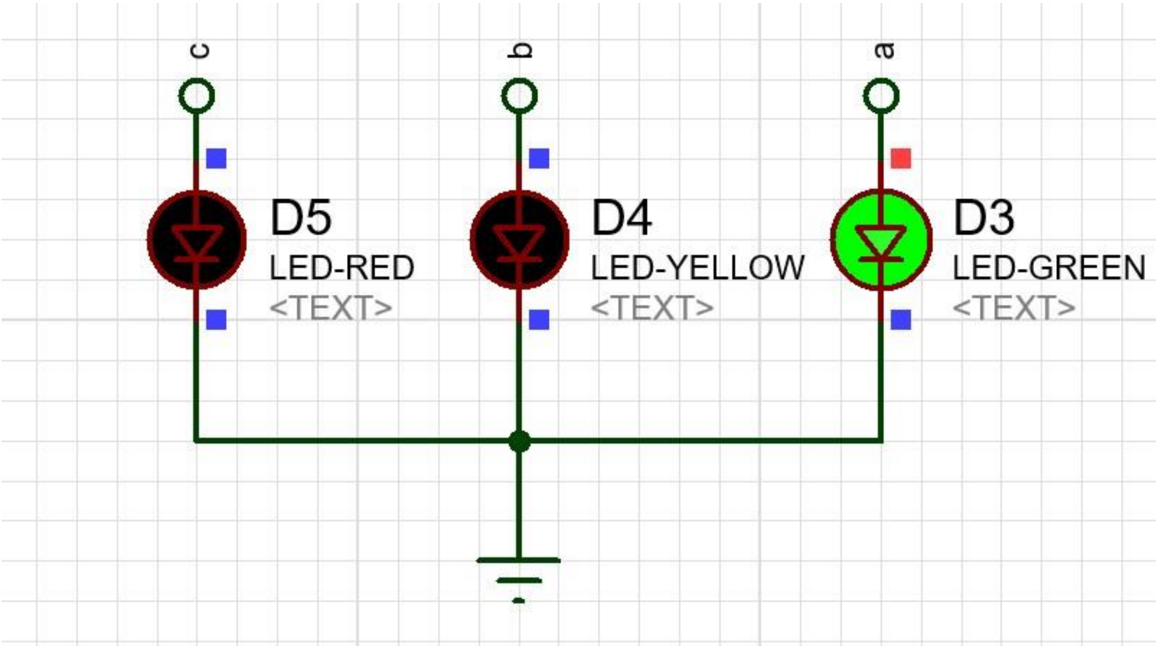

Figure 15 LED Indicators

It was decided to employ three LED indicators. When the solar panel is not generating any more electricity, the LED-RED indicates that the device is in the off (or "off") state. LED-YELLOW indicates that the solar panel is transferring the maximum amount of current and voltage to the battery, which is known as the BULK state; LED-GREEN indicates that the battery is fully charged and in a float state, which means that the battery voltage is maintained at its maximum capacity.

4.1.7 Proteus Display

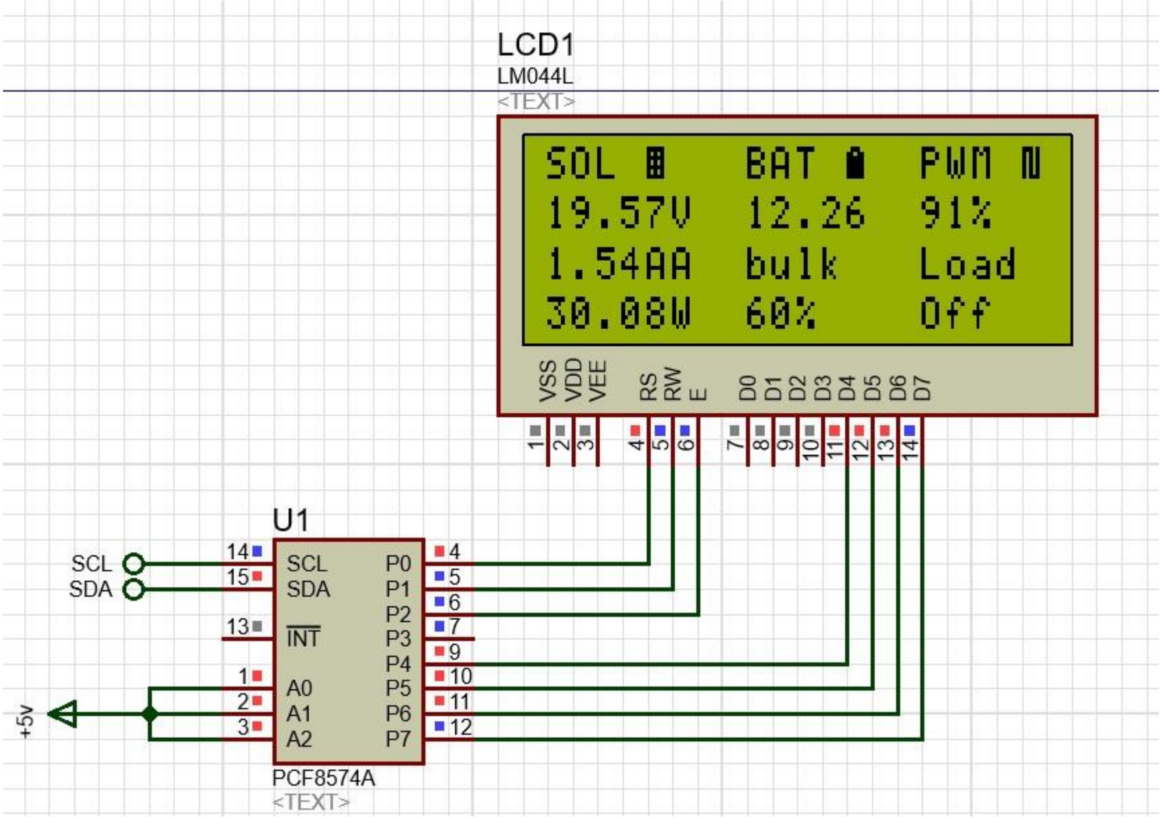

Figure 16 Proteus Display

We have used the Display of 16x4, the first column is showing sign of solar panel as SOL with icon below that is solar panel's voltage and then solar panel's current and at the last of first column there is a power that we are getting from solar Panel.

In the second column first there vis sign of Battery as BAT with icon then in the second row of second column there are voltage that are being transferred to the battery then the state of battery and in the last row of second column it is showing that how much battery is being charged.

in the last column first we have a sign of pulse width module as PWM with icon and then in the second row of third column duty cycles are being displayed .then at the last display is giving us information about load rather the load is connected or Not.

CHAPTER 5: HARDWARE

5.1 Solar Panel

To conduct the project's testing and implementation, the most costly component was the solar panel. As a result, finding a low-cost module with a high power rating was critical to the overall project's efficiency and cost effectiveness. Charge controller systems must be evaluated in settings when the solar panels' efficiency and power output exceed the battery charging requirements. The panel should also be strong enough to offer a rapid charge, so that the battery charging time may be reduced in different operating states and weather circumstances. Efficiency is the most important consideration when choosing a PV panel.

Figure 17 Solar Panel

5.2 Current Sensor

We utilized an ACS712 current sensor. The current sensor has a 30A rating. This is a current sensor that uses the hall effect to compute the current in the circuit. The capacitor is used to determine the current in this sensor. This current sensor is available in three different ranges: 30A, 20A, and 5A. We utilized a sensor with a 30A rating. This sensor can measure both AC and DC. Following is the picture of current sensor used.

Figure 18 Current sensor

Characteristics of Current Sensor

1) The following are some of the characteristics of the ACS712 sensor that lead us to choose it:
2) At a temperature of 25 degrees, this sensor has a tolerance of 1.5 percent inaccuracy.
3) It has an 80KHz bandwidth.
4) It has a signal route with minimal noise. As a result, noise interference is kept to a minimum.

Working

Sensors primarily function in two ways. They either use direct or indirect sensing to measure. Indirect sensing is applied in the instance of ACS712. Because it is a hall effect current sensor, when current is delivered through it, the hall effect sensor detects it and produces a magnetic field. The voltage signal produced by that magnetic field is proportional to the magnetic field. It produces a 0-5V analogue output signal. After certain computations, the voltage signal is utilised to calculate the current. While the current sensor is attached to the Arduino when there is no current flowing, the sensor outputs 2.5V, which implies there is no current flowing. The output voltage rises from 2.5V when the current exceeds in one direction. The voltage drops from 2.5V when the current is increased in the other way. This sensor can measure both AC and DC in this manner.

Connection diagram for the current sensor.

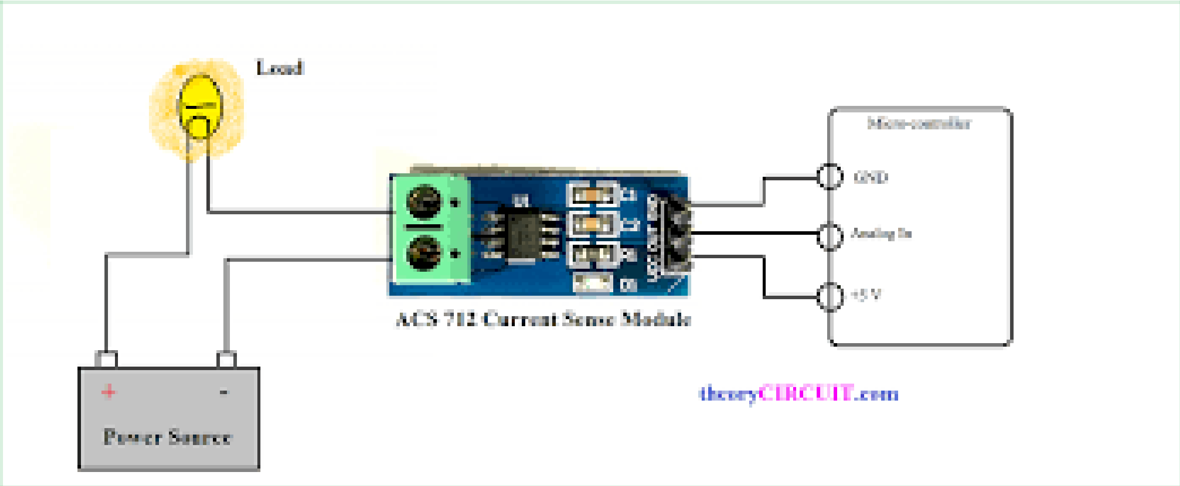

Figure 19 Connections of current sensor

5.3. MOSFET

In electronics, the MOSFET (Metal Oxide Semiconductor Field Effect Transistor) transistor is used for switching and signal amplification, among other functions. In order to make the device as small as possible, a MOSFET must be built on a single chip, either as a core or as an integrated circuit. Switching in electronics was transformed when MOSFETs were introduced.

Figure 20 MOSFET

Working of MOSFET

As the name suggests, a MOSFET device's principal function is to allow users to control the flow of current or voltage between the source and drain terminals. In this gadget, the MOS capacitor acts as a kind of switch, and this is how it works. In a MOSFET, the MOS capacitor is the most important part.

Gate voltages may be applied to the semiconductor surface behind an oxide layer between the source and drain terminals to change it from p-type (negative) to n-type (positive). When the positive gate voltage is provided with an electrostatic repulsion, the holes under the oxide layer are pushed down with the substrate.

The depletion region is populated with atoms coupled to the acceptors by bound negative charges. In order to get access to electrons, we need to create a channel. Additionally, the positive voltage pulls electrons from the n+ drain and source regions into the channel as well. As long as a voltage is applied between the drain and source, electrons flow freely between the source and drain, and the gate voltage governs the current. A hole channel will form under the oxide layer if we apply a reverse bias instead of a positive potential.

5.4. Inductor

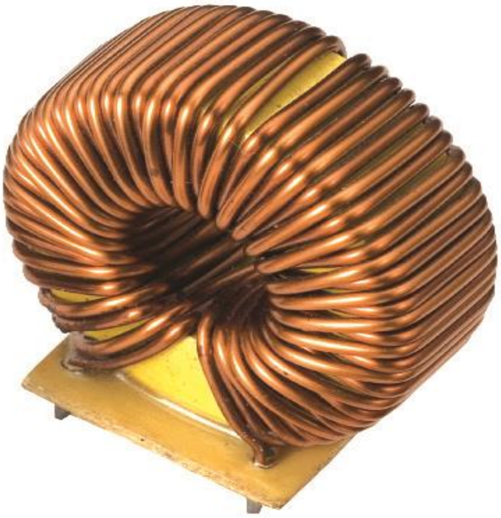

Figure 21 Inductor

Working of Inductor

Inductors can be used for two primary functions.

Signal Management

An inductor's coils can be utilized to store energy. The frequency of the current going through the inductor determines its function. That example, higher frequency signals will flow more slowly than lower frequency signals, and vice versa. This function specifies that AC current is blocked and DC current is passed. As a result, it may be used to suppress AC signals.

Energy Storage

Magnetic energy is stored in an inductor, a device. Electromagnetism in a coil generates a magnetic field, which in turn generates an electric current. As a result, the coil may store energy in a form of magnetism. Using inductance, coils give a way of storing energy.

5.5. Arduino UNO

With the Arduino UNO, it's easy to get started in the worlds of electronics and coding. This board is a great way to get started in the world of Arduino.

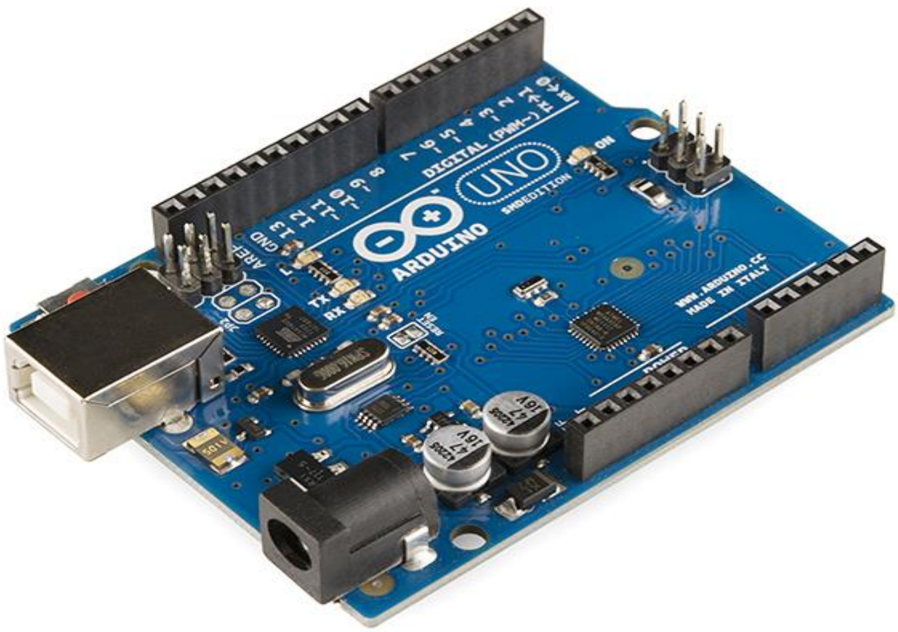

Figure 22 Arduino UNO

Characteristics of Arduino

Following are the characteristics of Arduino UNO

- Its operating voltage is 5V.
- Its input voltage is 7-12V.
- Its clock speed is 16MHz.
- Its DC current per input output pin is 20mA.
- Its flash memory is 256KB.

5.6. I/O Expander

Figure 23 I/O Expander

The PCF8574 is an 8-bit I/O expander for the two-line bidirectional bus (I2C) that works between 2.5 and 5.5 V VCC.   A general-purpose remote I/O extension is provided for most microcontroller families by using the I2C interface (serial clock, SCL, and serial data, SDA, pins).

The interrupt input of a microcontroller may be connected to the PCF8574's open-drain output (INT). When using the input mode, an interrupt is generated by any rising or falling edge of the port inputs. In the long run, tiv, INT is still relevant and useful. As soon as data is restored to its original state or another port is used, the interrupt circuit is reset and restarted, thereby allowing the system to resume normal operations.

5.7 Buck Converter

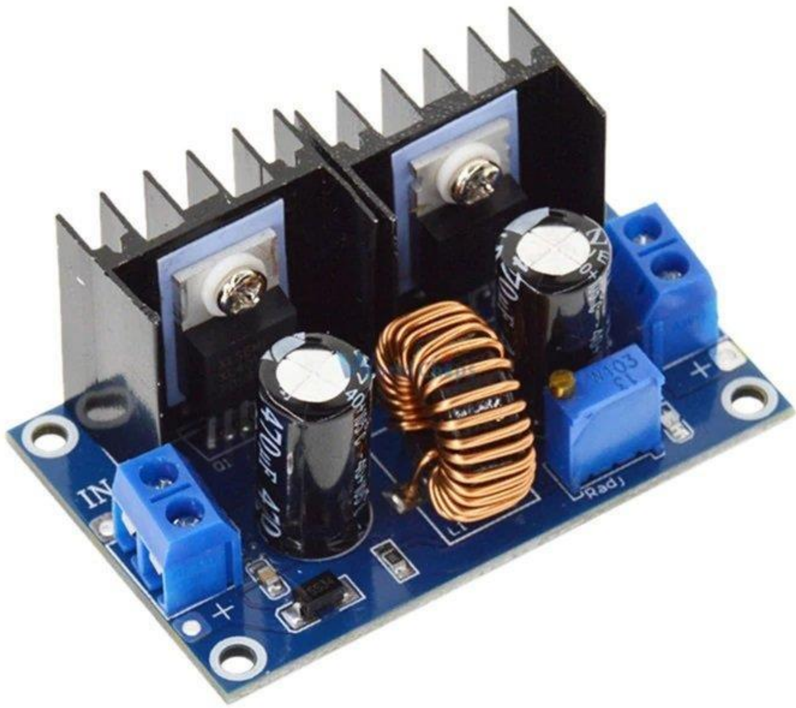

Figure 24 Buck converter

Using a high frequency, the switching transistor in the Buck Converter alternates between turning on and turning off the input and the output. Continuous output is maintained by using inductor L's power saved during on times of the switching transistor in order to maintain a constant output during off periods of the transistor In the context of the circuit, a Flywheel Circuit is a term for this. To explain this, consider a mechanical flywheel, which rotates smoothly (and produces energy) when fed regular pulses of energy separated at regular intervals.

One of the most common types of converters is the buck converter, which accepts DC power directly from a battery or other DC power source. As an alternative, a rectifier/reservoir capacitor circuit might be used to create DC from the AC mains (line). Reconductor circuit AC input may come directly from the AC mains supply, or through a step-down transformer frequency reduction.

5.8 Battery

Powerful equipment could be powered even when there was no sunlight or when more power is required than the solar arrays can provide at a particular moment thanks to the PMCC batteries. Ideally, the battery bank should have a substantial energy capacity, operate at 12V, and offer a sufficient current to accommodate heavy power demands. It's important to keep the overall system weight low, but it's more important to keep battery weight low. The battery bank should be long-lasting and inexpensive.

Three states of the battery may be utilised to decide the charging method to be employed: charged, discharged, or dead. The battery and solar array used to power the system eventually established the quantitative value for each of the thresholds, but the program was able to verify and respond to the following situations as they arose:

- An off state should be used when the solar panel is not generating enough power to keep the battery safe from being discharged back into it.

- It was in the bulk stage that the MPPT algorithms came into play most prominently. In this case, the battery's maximum power point was identified and the battery was charged in accordance with it.

- The controller entered the float state when the battery voltage was high enough and the battery was near to being completely charged. We wanted to maintain a constant voltage level while compensating for self-discharge.

5.9 Hardware circuit

The project was also implemented on hardware. A fully working prototype of the project was designed. The hardware circuit is shown below.

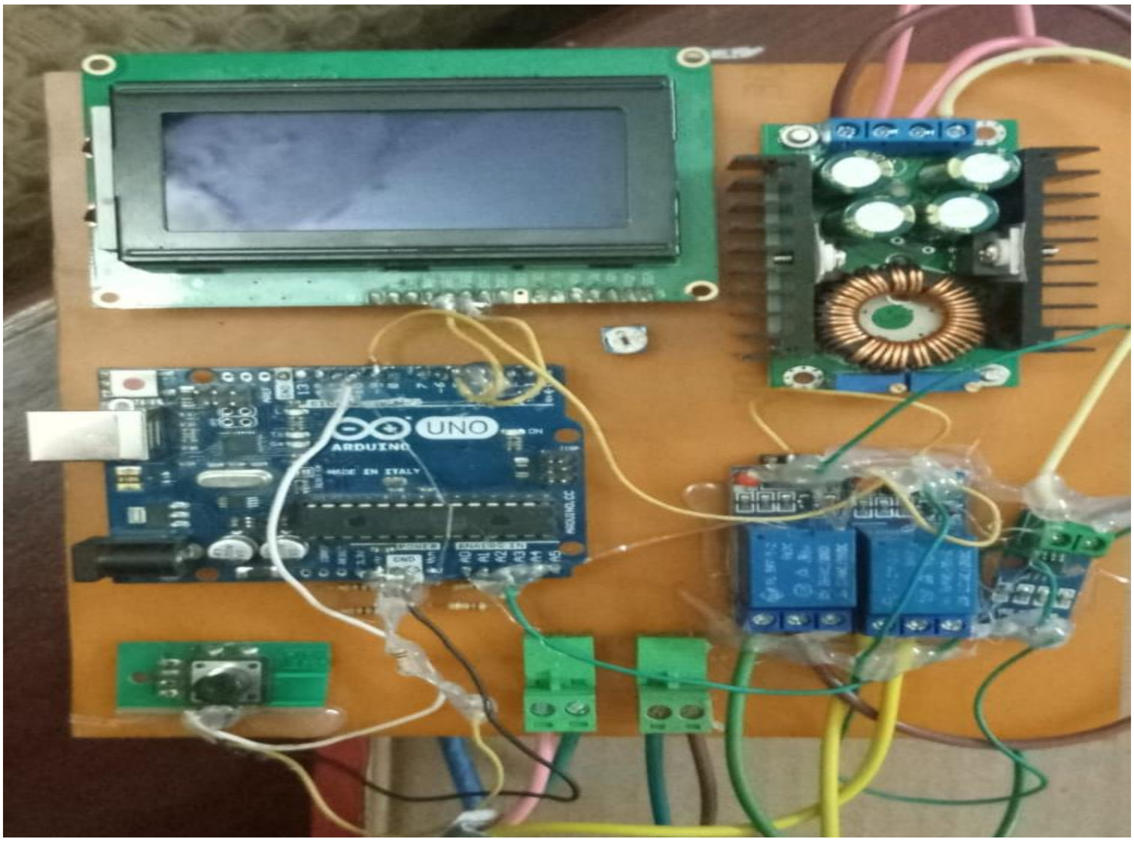

Figure 25 Hardware circuit

Chapter 6: Results and discussions

6.1. Results

The results of the hardware and the app are shown below:

6.1.1. When battery is 0% charged

Figure 26 when battery is 0% charged

These are the results when our battery is zero percent charged ,no power is being generated by solar panel and duty cycle is 0, the icon of battery is empty.

6.1.2. When battery is 60% Charged

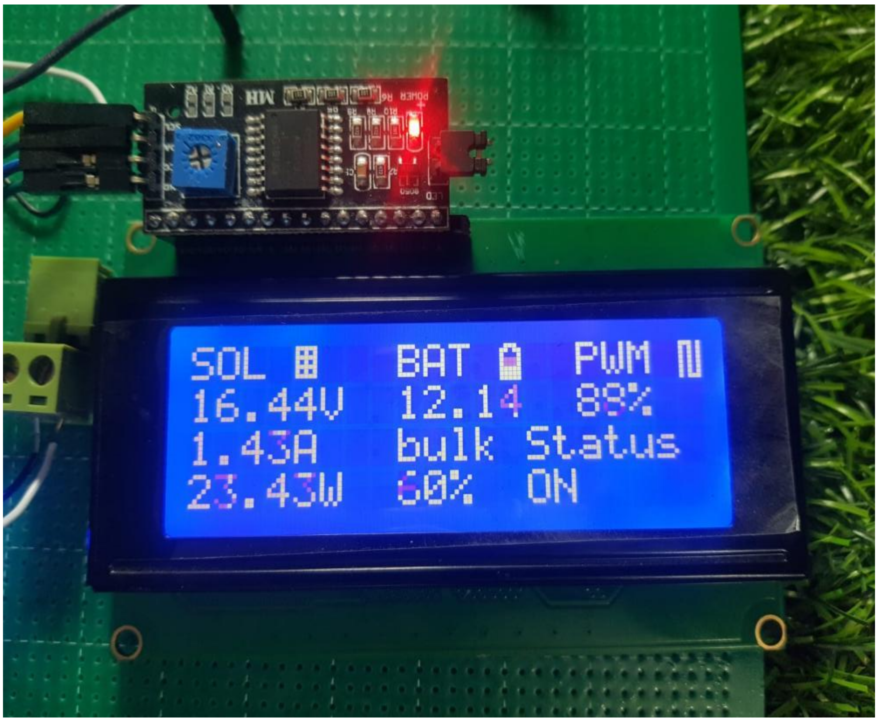

Figure 7 when Baterry is 60% charged

Now solar panel is providing the 23.43W power and battery is under charging condition in bulk state (i.e maximum of current and voltage is transferred to the battery).it can also be seen by the battery icon while the duty cycle is 89% at present stae

6.2. Discussions

Here are some of the discussions regarding the challenges and future work of the project.

6.2.1. Challenges and solutions

The cost of solar PV panels is higher than the cost of solar thermal panels. There are certain incentives and subsidies available to assist you pay for solar thermal panels, but when you utilise MPPT in addition you obtain most of the electricity and your monthly expenses are cut to some healthy level despite pricey installation.

To show off your solar PV panels, you'll need a large enough roof area. The MPPT isn't the only factor that increases with panel size: Even if the MPPT affects a great deal, the more panels there are, the more electricity they will generate.

If your house or company has a mostly north or east-facing roof, or if towering buildings and/or trees block the sun throughout the day, solar PV panels may not be a practical green energy alternative. Even if you utilise the greatest MPPT, you won't be able to generate the maximum amount of electricity this way either.

6.3. Future suggestions

Thermal Power Plants (Nuclear Coal, Petroleum, etc.) and Hydro (Water) Power Plants are well-known methods for producing energy, however they are non-renewable sources that are also harmful to human and environmental health.

There are other charge controllers, like as PWM, that may be used, but their low efficiency prevents users from fully using them. This necessitates the creation of novel, low-cost, and efficient MPPT algorithms in order to achieve near-perfect efficiency

Here are a few that might be used in future study papers:

1. MPPT operating APP: With the use of smartphones, an application for running MPPT may be made available at any time over the Internet.

2. DC-DC running loads: DC can be obtained straight from the MPPT and used to operate a DC load. DC loads assist to reduce power consumption.

3. Energy Management: When these algorithms are built, there is a requirement to manage energy.

4. Hybrid of MPPT with mechanical tracking will give more efficiency, project can be extended in this direction.

A system that can directly power a DC or AC load would be even more helpful. To provide a regulated DC signal, an extra DC-DC converter would be required. To provide an AC signal, an inverter is required. If the AC signal is to be connected to the grid, the signal's frequency must be synchronized with the grids, and the voltage must be limited to no more than the grid voltage.

Chapter 7: Conclusion

In order to solve environmental and energy issues, the usage of solar energy is critical. Domestic solar power output has been boosted by the development of MPPT algorithms, which have made solar panels more efficient over time. Different kinds of control methods, circuits, and applications may all be taken into consideration when choosing an MPPT method for a certain application in grid-connected or stand-alone mode of operation. Many modern hybrid MPPT approaches have been discussed in this study, along with their advantages for mismatched situations such as partial shade, non-uniform PV panel temperatures, and dust impacts.

The P&O method was utilized in this project for its simplicity and efficacy. It was investigated for its performance and dynamic MPPT efficiency.

A rudimentary model of the PV system was created for testing reasons. The power converter was replaced with a regulated current source in this variant. This allowed for lengthy enough runs to determine the dynamic MPPT efficiency.

The hill-climbing algorithms were modified to follow the MPP even under changing irradiation and adjust the increase in the reference voltage to the operational point, as the MPP voltage does not vary linearly.

The improved P&O's performance was investigated, and it was discovered that the modified hill climbing algorithms perform better.

The perturb & observe (P&O) technique was chosen and successfully implemented on software and hardware. The load was effectively maintained at 12 V thanks to the buck converter.
A renewable energy system, such as the one used here, may be used in both residential and industrial settings. A controlled AC output voltage that tracks the input mains utility voltage in phase and amplitude at hundreds to thousands of watts is often provided by such a system. As a result, a system like this may be quickly installed with no worry about modifying a house or business's electrical wiring to take advantage of solar ene

CHAPTER 8: REFERENCES

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