MPPT BASED SOLAR BUCK BOOST INVERTER

SENIOR DESIGN PROJECT REPORT
B.E Electronics Specialization

Prepared by

Asadullah Qureshi 9659
Hassan Azeem 9865
Saif-ur-Rehman 9970

Project Advisor

Lecturer
Mam Tooba Hai

College of Engineering

Karachi Institute of Economics and Technology
Karachi

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Starting with the name of Allah, who is the most beneficent and pitiful. All the praises and thanks be to Allah without whom we can do nothing, we will not be able to get succeed in our goal to get this project done without his help.

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Finally, I'd want to thank all of my friends, parents, and Lab Engineers who have patiently offered various sorts of support in order for this project to be completed.

ABSTRACT

Nowadays electricity becomes the major need. If we look our surroundings we found our economy relies on electricity, including industrial Sector. The electricity plays a vital role to run Industries. There are many ways of generating Electricity like Hydropower stations are there which generates electricity through water. Second one is Wind Energy Systems from which electricity is generated through wind. The Plants of Wind Energy systems are installed in a Wide and open area. We see in last decade there is a boom in solar energy for the generation of electricity which is cheaper and can be installed easily.

Let's Talk about how solar systems generates Electricity? Solar panels have millions of solar cells which converts the sunlight into electricity to run our household appliances. Solar panels are also known as photovoltaic cells. We are also making Solar-based project using MPPT technique.

In this project we have designed and developed MPPT (maximum power point tracking) frequency ranging from 20Hz to 80Hz and inverter using Microcontroller which converts DC input to AC output e.g. 12 volts DC voltage to 220 AC voltages approx. with the frequency of 50Hz.

Solar panels are connected with MPPT which generates the P.W.M. signal (usually Square Wave)which is connected as a input to the controller which gives the 4 sinusoidal waves which then connects with the inverter to gain the real output of 220V.we are using ATMEGA 32 as a microcontroller which is used for the pulse generation. The input of Atmega 32 will the output of MPPT, and then the H-Bridges connected at the output pins of the controller. The H-bridge circuit consist of Mosfet driver combinations which produces the output in the form square wave pulses which

will become the input of the Transformer that converts DC square pulse into Ac sinusoidal pulses output. The transformer that we have used in our project is basically center taped transformer three input pins at the primary side and two output pins at the secondary side.

KEYWORDS

Solar panel

M.P.P.T

Microcontroller

DC Batteries

Center taped Transformer

Shottkey diode

MOSFETS/IGBTS

Sine Wave

Square Wave

Inductor & Capacitor

LC filter

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PROJECT OBJECTIVES

Motivation:

The amount of sunshine that is typically available in Pakistan has the capacity to supply a sizable portion of the nation's electrical needs. The use of solar panels is growing over time, particularly in many rural regions. However, one major drawback is that these panels still struggle to efficiently and effectively employ the sunlight that they are able to capture. The best option is solar energy because it can power entire grids and has no pollution or health risks. Even though solar energy has so many benefits, it is still not being used as broadly as it should be. The efficiency of solar energy remains a major worry, and there are also significant unknowns regarding how it will function in overcast weather. We therefore sought to create an MPPT solar charge controller with all of these considerations in mind, so that it could modify charging rates based on the battery's charge level to enable charging closer to the battery's maximum capacity and monitor battery temperature to prevent overheating. An MPPT controller is better suited for colder climates since it can draw more power from the solar array because PV array voltage can be higher than battery voltage. A MPPT solar charge controller for PV panels offers a number of benefits that may potentially increase their utilization to their maximum capacity. In order to operate AC appliances that function on pure sinusoidal wave rather than modified sine wave, the output voltage of 12V must also be changed into 220V, which must be pure sinusoidal wave.

Aim:

This work aims to design a High Efficient Maximum Power Point Tracking (MPPT) Solar Inverter. A converter is designed in the system to boost the power from the photovoltaic panel. It is aimed to decrease the maintenance cost. A microcontroller is introduced for tracking the P and O Algorithm used for tracking the maximum power point. The duty cycle for the operation of the convertor is optimally adjusted by using MPPT controller. There is a MPPT charge controller to charge the battery as well as fed to inverter which runs the load. Inverters are used to change DC input voltage from batteries or solar panels into AC voltage, which creates a pure sinusoidal output to power AC loads.

Objective:

Our main objectives are as follow:

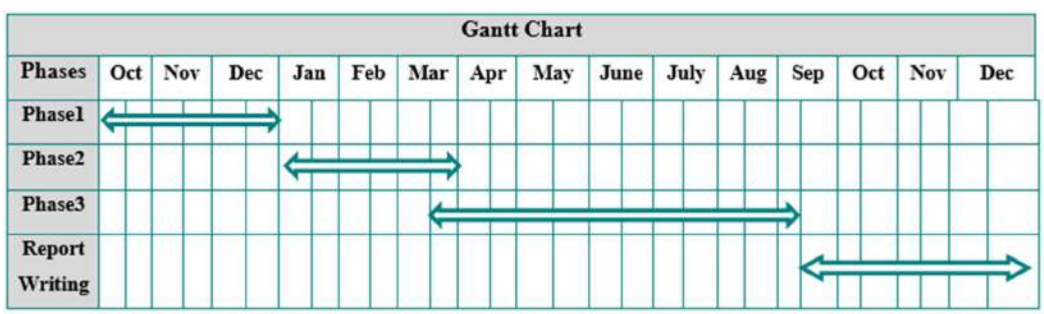
- To draw the current out of PV panel at maximum power point.
- To protect battery from overcharging and over-discharging.
- To achieve the above targets MPPT charge controller is constructed.
- To obtain inverter with maximum achievable efficiency.
- Try to achieve the pure sinusoidal wave.

The main objective of this project is to construct a solar inverter based on MPPT that will get the most power possible from solar panels to charge the battery and run low-voltage DC appliances. It will then invert that 12V DC to 220V AC and build a 200W pure sine wave inverter as a domestic solution to run our AC appliances as well.

Market or Industry adaptability/applications:

Our Project solar inverter has a vast applications in industries and market. Nowadays as the cost per unit of electricity is rising day by day and due to load shedding peoples are facing many difficulties. Therefore a large amount of people are moving to solar power as well as whole industries, school and colleges are installing MPPT based solar inverter to make their lives easy and get rid of these electric bills and failures.

Gantt Chart



We conduct all of the component-related research in phase 1; this includes work on panels, sensors, microcontrollers, mosfet drivers, and converters. We simulate the MPPT and Inverter in phase 2. Phase 3 involves creating the project's real hardware on a PCB board. We finish our project's final report in the last stage.

CHAPTER 1

1. INTRODUCTION

Alternating current and direct current are two forms of electrical power (DC). The voltage level of alternating current may be ramped up or down using transformers, whereas the voltage level of direct current can be stored in batteries. The majority of today's electrical equipment are built around AC/DC power conversion. To power such devices, DC electricity from storage batteries must be converted to AC power. In practice, a power inverter is converting DC to AC. The inverters available in the market are Pure and Modified sine wave inverters. Although the improved sine wave is quite similar with square- wave, it uses less energy. It generates a large number of harmonics, which damages the electronics and shortens their lifespan. The pure sine-wave inverter, on other hand, boosting power proficiency usage and the life of Household appliances. It also minimizes auditory and electrical noise in loud equipment such as televisions and fluorescent lights, as well as allowing inductive loads such as fans to run quicker and quieter.

MPPT, payload controller-based method for mining the concentrated available power in a solar PV panels under particular conditions. The Peak voltages PV module is the highest power or peak power voltage. The intensity influenced by solar radiation, higher temperature, and temperature of PV panels. When measured at 25 degrees temperature, PV panels provides optimum power about 17V.

How does M.P.P.T works?

The MPPT's main purpose is actually harvesting the upmost available power from the PV module by allowing it to function at the most efficient power level possible (high power point).

The MPPT evaluates the output of the PV module, compares it to the power of the battery, and determines the best power a PV module can deliver to charge the battery. It then translates that best power to the best power available for the current battery. Additionally, a DC load that is connected directly to the battery can receive power from it.

The following conditions are favorable for MPPT performance: chilly weather, foggy or cloudy days: PV modules typically operate best in low light, and MPPT is used to obtain the most energy feasible.

How does Inverter works?

The output of MPPT is fed to inverter circuit. In inverter circuit, the high frequency PWM is generated and is used to control the low voltage MOSFET's bridge circuit. Now the 12v dc and the output of low voltage Mosfet driver is feed into the H-Bridge circuit from which we get the pure sinew wave 220V/50Hz at the output.

1.1. Project scope

The aim of the project revolves around drawing the current at maximum power from Solar Panel. Solar Panel's power generated is dependent upon solar irradiance, temperature of panel and load characteristics. The Solar Charge Controller's function is to regulate the charges supplied to the battery during its charging and safeguard it from excessive charging and excessive discharging. MPPT based Solar Charge Controller serves the purpose of charging the battery at maximum power output.

If the battery is directly connected to the Solar Panel, the Solar Panel will keep charging the battery and does not know when the battery is fully charged. Actually, 12V battery attached with solar plate directly, if its wattage is less than 5 watts. For Solar panels of wattage greater than 5 watts, there is required a solar charge controller. The battery can be protected by either disconnecting the battery from panel when it is fully charged or by using Solar Charge Controller.

Solar Panels provide power at day time, when there is ample amount of sunlight to produce power. But as soon as the sun starts setting the solar irradiance received from Sun to solar panel starts decreasing. At this point of time the role of batteries plays a Key role as backup source of Solar Panel. Batteries, at day time gets charged and at night time provide power backup. The MPPT Controller charges the batteries. The desired output power ranges from 240W-700W. But our design might be limited to the mentioned level of power output.

The 12V from controller is then fed to the inverter, that generates the high frequency PWM and which is then converted to 220V through H-Bridge. This is high voltages are used to run the AC appliances.

1.2. Key Objectives

- Pure sinusoidal wave
- Photovoltaic inverter with maximum power point tracking
- Algorithm efficiency
- Implementation of chosen Algorithm
- Sensors Efficiency
- User Friendly
- Low cost

1.3. JUSTIFICATION OF THE PROJECT

• Because they are sensitive to harmonic disturbances, several products, including laser printers, laptop computers, digital clocks, and medical equipment, need a low harmonic power source.

- Because outages of power are common in the country, power backup systems are employed when electricity is switched from the grid to generators and vice versa.

CHAPTER 2

2. DESIGN, OBJECTIVES, ISSUE AND THEIR ANALYSIS:

2.1. Design objective:

The main goal of this project is to employ a solar inverter to power household loads. Photovoltaic (PV) cells use solar energy to create electricity. During the day, this energy is stored in batteries for use whenever it is needed. A solar-powered inverter transforms a PV module's direct current (DC) output into utility-frequency alternating current (AC), which can then be used by a local, off-grid electrical network or supplied into a commercial electrical grid.

2.2. Issue:

Solar energy is one of the most importance renewable energy sources. But there has been encountered a problem with Solar system that the solar irradiance is not constant all the time. The efficiency of the power transferred from PV cells depends on the sunlight, shading, and temperature of panel and load's electrical characteristics. The sunlight, shading, and temperature of panel depend on the weather conditions which keep on changing every instant. Because of this, the electrical properties of the load are always changing, which causes the maximum power point to fluctuate based on the power of the panel at hand. The process of tracking MPP on a PV panel's I-V curve is known as MPP tracking.

PV panels do not provide us constant voltages that's why need of converters is necessary to get constant output. Usually Buck-Boost dc-dc converter causes reverse polarity of voltages at output. This inverted output causes complexity in feedback circuit and we may need an inverting operational amplifier for feedback purpose. Normally in Buck Boost Converters we need to attach a filter to minimize input current ripples. These current ripples cause the lower efficiency of power at load side. There is electrical stress on components in buck-boost converters which may cause over heating of components or may short circuit occur.

2.3. Analysis:

To overcome the problem the MPPT technique is used in which solar charge controller is connected between the solar panel and the battery. Because the solar charge controller being developed is based on MPPT, consumers benefit from MPPT is that no power is lost because electricity is provided at optimum efficiency.

A large amount of power generated at the specific peak hours of sunlight, though after peak hours sunlight received reduces but it is backed up by batteries which have been charged by solar panels during day time. The battery may be harmed by overcharging or over draining if it is connected directly to a solar panel, therefore managing the charge of the panel is crucial. Between the solar panel and the battery, a solar charge controller is utilized to avoid over charging, that will prevent our battery health.

CHAPTER 3

3. DESIGN SPECIFICATIONS

3.1. Literature review:

The utilization of non-conventional energy sources has gained attention in Recent decades due to the exponential decay of traditional energy sources. Examples include Solar, Geothermal, Ocean, Wind, and Biomass energy and they are all gaining importance for industry increasingly. Although, it's a renewable energy source is sunlight on the planet because of its environmentally beneficial practices and infinity in nature effectiveness of this due to two factors, energy source is quite low.

Firstly, the output power of a solar PV panel is significantly lower than its price, and secondly, that electricity fluctuates constantly because of solar radiation and temperature are continually fluctuating but by monitoring the functioning maximum power point, solar PV modules at a specific time and by using there are several MPPT methods. By tracking the maximum power point, we may raise the PV system's effectiveness, the module's maximum output power. Despite the fact that there are several MPPT techniques, including the incremental conductance approach, the "P and O" method, and the Peak Power Tracking Method Based on Voltage and Current.

3.2. Solar Energy

Solar energy which ranges from irradiance or sunlight to thermal energy or heat, is the most powerful and pure energy source on the earth. This energy is considered a renewable source of energy. It is continuously accessible and used everyplace within the world. Solar power never runs out, unlike other energy sources. As long as there's the sun, humans are going to be able to use solar power, which suggests we have got a minimum of five billion years before the sun dies, as foreseen by the scientists.

Solar power is often utilized in a range of ways victimizing photovoltaic, we are able to generate electricity or heat (solar thermal). In rural areas where people have no access to water we can use solar power and distil water in areas with a scarcity of potable water.

On the other hand, its primary drawback is that this type of energy does not last throughout the day. Because of the atmosphere, only a portion of the solar energy directed at the planet reaches its surface, according to estimates. One bad thing about solar power is that existing technology only uses the power of this power to its full potential. While there are multiple PV panels technology options, 30% of electricity converted from solar energy by PV panels.

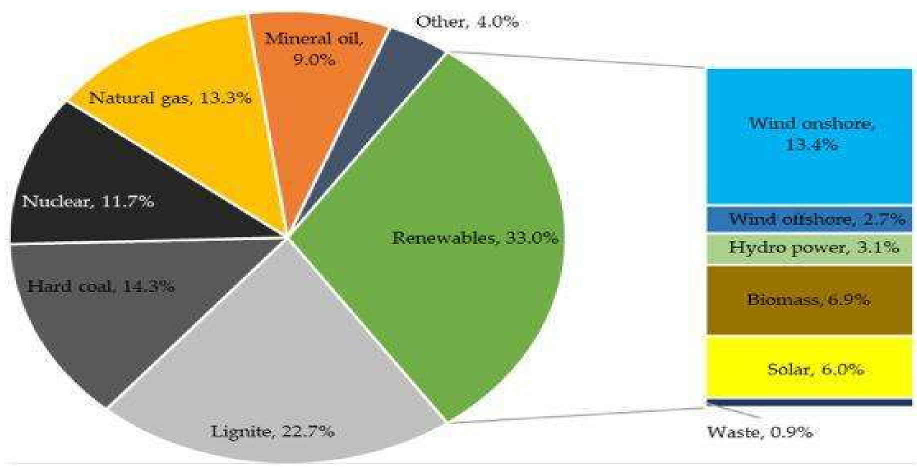


Figure 3.1.

There are several types of solar panels or solar plates, each utilizing different materials and technologies to convert sunlight into electricity. Here are the most common types:

3.2.1. Mono Crystalline Silicon Panel:

The cells we often refer to as silicon. Nowadays, these solar panels are the most frequently used solar panels in rooftop solar panel systems.
The biggest disadvantage of such types of solar cells is the cost. Such a method of manufacturing complex, because mono-crystalline solar cells require more silicon. The high price of each panel in comparison to other solar panels in our review is covered by these last facts. Nevertheless, due to the shortage in deficiencies and the cell structure, such types of solar panels are much popular and well performing, averaging 11 to 16 percent efficiency. These panels operate better and have been more successful because of their increased efficiency level and longer-lasting silicon technology panels have been demonstrated. The lifespan of these displays is anticipated to be at least 25 years. Furthermore, certain products have been demonstrated to endure up until the greater price being justified by the saved energy costs that they have experienced over the previous 50 years.

Panels produce throughout their long lifetimes. Another advantage of this is that because the panels are so efficient, the consumer will get the most watts per square foot of panel utilizing them. This makes these panels a worthwhile investment choice when space is a concern, very efficient mono-crystalline solar panels delicate, and handling during shipping and installation must be taken care of.
This project is carried out using these panels. As compared the cost and efficiency with polycrystalline these panels make the viable option for the project.

3.2.2. POLYCRYSTALLINE SILICON PANEL:

It is used for household installations nowadays due to its low cost and high efficiency. In order to achieve the best results, melted silicon is spread and cooled in a rectangular shape throughout this molding process. The block is subsequently sliced into little solar cells in the same way that the monocrystalline was. By name suggested, that ingot forms up of many crystals that resemble glass fragments as a result of the manufacturing process. This method is quick and simple to utilize. As a result, in comparison to monocrystalline silicon cells, these varieties of silicon cells are less expensive to produce. Efficiency is polycrystalline solar panels' major drawback. The sunlight energy that strikes their surface varies from 10 to 14 percent. For these, compared to the effectiveness when monocrystalline counterparts are considered, the price of solar panels decreases energy loss where two nearby objects separate or fuse crystals. Similar to monocrystalline panels, polycrystalline panels also perform poorly at low light levels or shadow. Most of the market consists of these panels in solar panel manufacturing for the last ten years.

3.2.3. Copper indium gallium selenide:

3.2.3.1. Thin film panel for CIGS

One of the most modern and effective energy generation technologies is thin-film solar technology that has been developed so far for the solar industry. Various versions of these photovoltaic (PV) modules are available depending on the materials used to make them. Copper indium gallium selenide (CIGS) technology, more commonly used CIGS Solar Panel is a class of thin film modules using CIGS as the main semiconductor material for absorbent layer. Large-scale installations, building-integrated photovoltaic (BIPV), photovoltaic roofs, thin-film flexible solar panels and other applications are popular thanks to this technology. Photovoltaic effect is used by thin-film CIGS solar panels to generate energy like other photovoltaic modules.

Absorbing photons from incoming sunlight and the creation of electrons flowing from the n side to the p side of the junction in the absorber layer, CIGS solar cell is made by CIGS and cadmium sulphide (CdS) as an absorber to generate electricity. CIGS panels are superior then silicon because unlike silicon, its efficiency is not affected by increases in temperature, making them perfect for hot climates like Central Florida. Using very little adjustments, the efficiency of CIGS panels increased from 10% to 15% by the National Renewable Energy Laboratory and set a new peak of 19.9%. Because of the adequate performance of solar panels, future production will likely increase significantly. Due to their triviality, these panels are often quite expensive and as a result they are difficult to install, they will not be responsible for the project.

3.3. Charge Controllers

An electrical device which is used to connect the battery to a set of solar panels is known as Solar Charge Controller also referred to as a solar regulator. The main purpose of this regulator is to control the charging process of the battery whether it is charged appropriately or not overcharged. For many years DC–coupled solar charge controllers are employed for all small off-grid power solar systems.

Charge controllers are typically used in off-grid mode to monitor. It protects the energy produced by managing the solar output voltages on batteries. Since batteries require a certain number of charging current standards and density in each category, voltage power regulation is critical to battery charging. To lengthen battery life and performance, various charging techniques are important.

The controller has a number of responsibilities. Controllers changes the input voltage as per the requirement of the output voltage needed by the battery. Either the Standard or MPPT case directors might be used for that, using a controller when a solar panel's input power is greater than its output voltage a battery in this case, the controller will gradually reduce the voltage while the constant panel output is maintained. Consequently, the total power produced by the panels will be diminished. Utilizing the MPPT charge control techniques, such as the highly high computation power outages caused by microcontrollers might happen at any time. In this case, the voltage will be tested again while maintaining power. Lowering the voltage while raising the battery's potential is what the MPPT charging controller does continuity. As a result, energy efficiency increases and solar energy is dissipated less in the atmosphere.

Charge controllers utilizes two different technologies:

1. PWM (Pulse Width Modulation)
2. MPPT (Maximum Power Point Tracking)

PWM draws current from the panel at a slight voltage premium above that of the battery, in contrast to MPPT controller, which draws current from the panel at the maximum power voltage (Vmp). As a result, MPPT charge controllers are advised.

3.3.1. MAXIMUM POWER POINT TRACKING

The PV panel's current is pulled using the MPPT method, which operates at maximum power voltage (Vmp). PV panels are used to their full potential at any given time.

Maximum voltage power (Vmp) of the panel determines the maximum power point. The amount of solar radiation that a PV panel receives and its temperature determine the maximum power voltage (Vmp), which is constantly changing. The weather might also shift, causing this change. The controller monitors the Vmp and drains power at its peak before stepping down the PV voltage to the battery volts. The power of the PV panel may be increased in this manner by increasing the current while the voltage is stepped down.

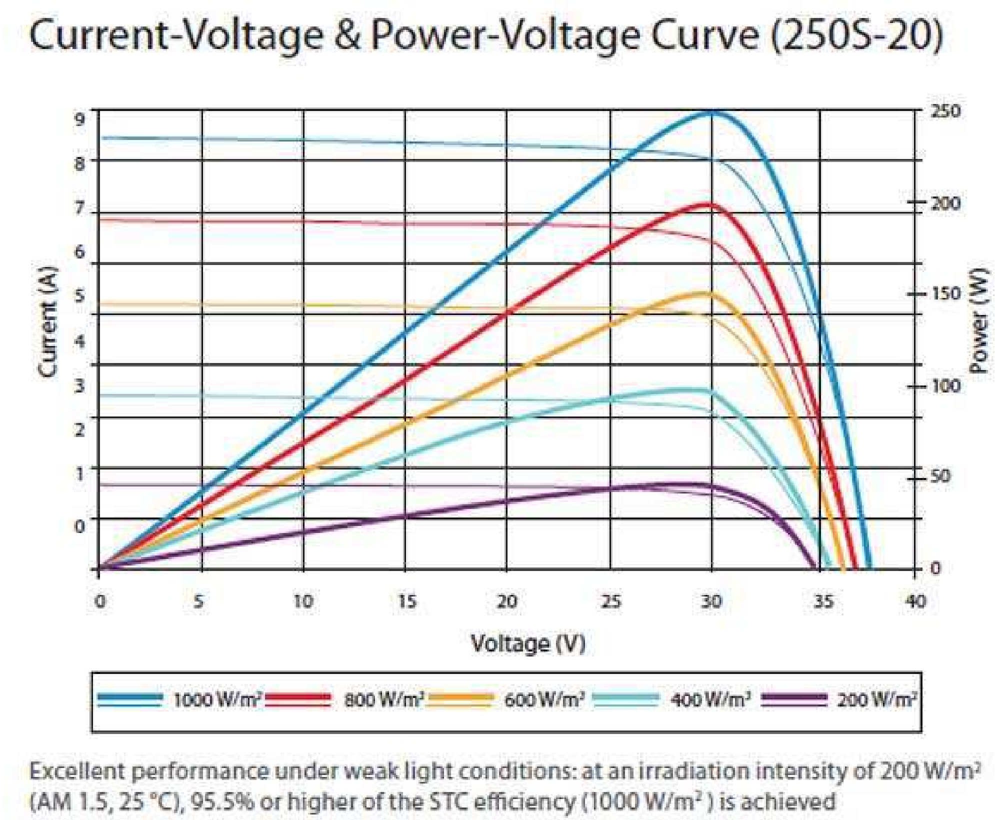


FIGURE 3.2

3.3.1.1. The MPPT solar charge controller's functioning:

The MPPT technology is used for the maximum extraction of power. It is used in PV systems and also in wind turbines. The MPPT Charge Controller is a DC-DC converter with a microcontroller to regulate and control the unregulated voltage of a PV panel to the desired level of voltage. PV panels operate on a wide range of voltages. The main function of MPPT is to charge the battery at maximum power voltage and protect it from overcharging and disconnecting the load to prevent the over discharging when the battery reaches its cut off voltage.

The MPPT charge controller operates over a wide range of voltages. It senses the power received from PV panels at any specific time, then it tracks the maximum power voltage for the power available at any specific point. As the weather condition is not constant all the time, it affects the irradiance received due to which maximum power voltage keeps on changing. The MPPT draws the current by adjusting the Solar panel voltage equivalent to maximum power volts as per the power produced by the panel at that very instant. Then it bucks down the voltage to the battery voltages to charge it. Meanwhile, the current increases due to the decrease in the voltage to keep the power of the panel the same.

The decision of perturbation of voltage of panel for finding the MPP is taken by the microcontroller. Microcontroller uses the algorithm to decide whether to increase the voltage of the panel or decrease it to reach MPP. Microcontroller senses the voltage and current using the sensors.

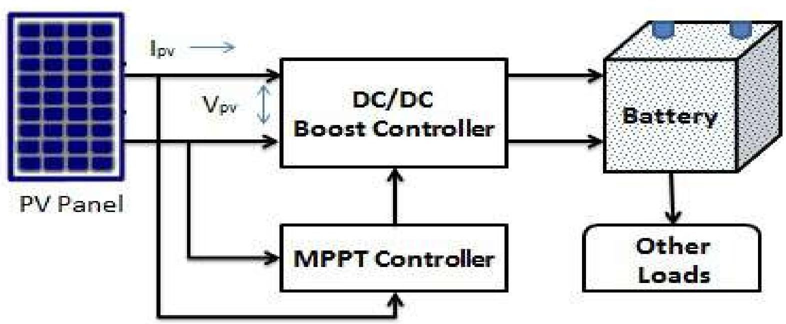


FIGURE 3.3

3.4. DC-DC Regulator

The DC power of the panel is affected by the amount of light, the time of day, and the panel's temperature. Battery capacity depends on the load connected to it. It is critically important that the panel current strength is compatible with required battery charge components at any time to ensure a good battery charge. To increase or reduce input panel power to required battery level, a DC-DC Driver is required. When power is transferred from input to output via a power switch, inductor, capacitor or diode, these regulators are known to change controllers. Different DC to DC controller types can be created by editing these sections. This substitution is possible in any case.

The switches might be passive or active. The idle switch is usually a diode used often as in passive switches, whereas active switches are a certain type of MOSFET transistors. MOSFET transistors work well and are a faster technique for managing frequency and cycle function ON and OFF for "switch" time using pulse width modulation (PWM) signal. The higher the duty cycle, the greater the input-to output power transmission. The benefits of PWM include digital continuity of the signal transmission from source, analog-to-digital reduction or perhaps elimination signal conversion is required. It has no effect on digital signals. Unless the outside noise is strong enough to either change the signal, as much from outside noise one to zero, or the opposite.

These regulators do not produce electricity, they operate with different sources of electricity. The variation in Voltage levels impacts the Current levels, ensuring that an equal amount of power is maintained. The current and voltage are directly proportional, which means that increase in current will decrease the voltage which is sense in the buck mode. The voltage rises as the current increases in boost mode diminishes.

3.4.1. BUCK-BOOST CONVERTER

A buck-boost converter is a DC-DC converter that can output either a higher or a lower voltage than its input voltage. It is also known as an inverting buck-boost converter because it can also invert the polarity of the output voltage.

The buck-boost converter is similar to the buck converter in that it uses a switch, an inductor, and a diode to regulate the output voltage. However, in the buck-boost converter, the inductor is connected between the input and the output, and the switch is connected in parallel with the inductor.

During the switch-on period, the inductor stores energy from the input voltage, and during the switch-off period, the inductor releases energy to the output. The output voltage is regulated by adjusting the duty cycle of the switch, which controls the amount of time the switch is on and off.

The buck-boost converter is commonly used in applications where the input voltage may vary widely, such as in battery-powered devices, solar-powered systems, and LED lighting. The ability to both step up and step down the input voltage makes it an ideal solution for these applications.

However, the buck-boost converter has some limitations, such as reduced efficiency at high input and output voltage ratios and increased complexity compared to other DC-DC converter topologies. Nonetheless, it remains a popular and useful solution for many applications.

3.5. MICROCONTROLLER

Microcontroller is a very important part of PMCC and tracking tasks, MPPT and other charging algorithms, as well as the ability to send and receive data wirelessly. It is responsible for reading many monitoring circuits and Sensors are used to monitor peak power. The microcontrollers input and output ports must match each of the selected sensors. The Computer programming language is Microcontrollers should be reliable and simple to use. Other Advantages Low cost, low power consumption, small footprint and fast clock features would be the specifications speed.

3.6. ATMEGA 32

The ATmega32 microcontroller can be used in a buck-boost inverter to control various functions of the circuit. The microcontroller can be used to implement the maximum power point tracking (MPPT) algorithm to extract maximum power from the solar panel by adjusting the duty cycle of the switching device.

The microcontroller can also be used to implement various control algorithms such as pulse-width modulation (PWM) for regulating the output voltage and current of the buck-boost inverter. Additionally, the microcontroller can be used to monitor various parameters of the inverter such as the input voltage, output voltage, output current, and temperature.

Furthermore, the ATmega32 microcontroller can be used to implement various communication protocols such as UART, SPI, or I2C to communicate with other devices in the system such as a display, sensors, or a remote monitoring system.

In summary, the ATmega32 microcontroller is a versatile and powerful tool that can be used to implement various functions and algorithms in a buck-boost inverter, allowing for efficient and effective control and monitoring of the system.

3.7. MPPT Algorithms

The launch of solar panels, which has been working on solar energy for years for many purposes, doesn't work well enough to be considered profitable. In case of a power outage, there are several stages of capturing solar energy. Advances in the material of solar cells and integration improves overall system performance, but there are also additional features which can save money. This research focuses on the efficiency that can be achieved by the use of a charge controller with excellent performance, particularly called MPPT. The PV list shows a constant current and Voltage graph (IV) under normal conditions. A place with Curve IV and more accessible energy that can be collected can be used to calculate power. There are a number of things that go into building a PV list that works well and efficiently establishes maximum peak point. IV curve fluctuates because of changes in nature of the environment, especially the increase in panel temperature and the level the irradiance and power point being in a varying position. As a result, the file The MPPT algorithm will not need to be fixed and always follow the PowerPoint. Although temperatures, pollution, radiation and other factors can affect the quantity with the power drawn from the cells, the system cannot operate at a constant voltage to get more energy. Frequency of charge administrators following the point, it has been shown that the amount of electrical power is greater to increase the efficiency of the system about 30% more than charge administrators who do not employ MPPT. Also, in the absence of a charge controller, the voltage of a battery charger will change as it passes through many charging points, which may cause it to malfunction. Take into account the case where the purpose of the plan is to charge a 12V battery but maximum power point here is on a 15V panel to keep everything the same. The power of the panel, if it is connected directly to the battery, will increase to 12 volts and an IV graph will be formed; this clearly indicates that it is not functional and operating below the high power point. Load control keeps the panel going instead of wasting this energy. Work on MPP without stopping using it. DC to DC converters adjust for variations in the required electrical power. This minimizes significant losses and allows the system to take advantage of the important energy of the solar system.

There are several common strategies to gain maximum power. Depending on the tracking technique they use, these iterative strategies propose various levels of complexity. The most popular techniques are the Incremental Conductance Method, the Fixed Voltage Method, and the Perturb and Observe Method.

3.7.1. Perturb and Observe Method

P&O is the MPPT Algorithm that is most frequently utilized. This strategy functions as a feedback system with a few track able parameters. This method compares the current power to periodic measurements of the PV output power. The same procedure is carried out if output power rises; otherwise, the discomfort is reversed. This algorithm supplies distortion to the voltage of the PV module or array. To control the increase or reduction in power, the PV module's voltage raises or drops. The power increases as the voltage rises. In other words, the left side of the solar panel has the highest power point, and vice versa.

When steady state reached the algorithm oscillates around MPP. The size should remain very small in perturbation to keep the power variation low. The strategy is complex enough to provide a reference voltage for the module that corresponds to the voltage's maximum value. A PI controller then transfers the system's operational point to that specific voltage level and module. Because of this inconvenience, significant power was lost. Also, struggles to maintain maximum strength rapidly changing weather conditions.

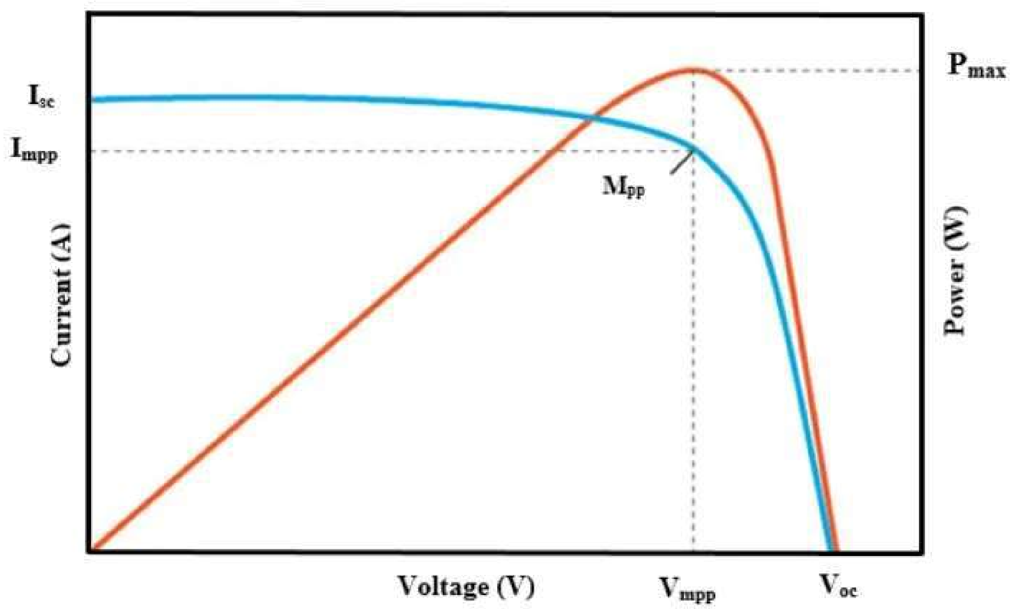


FIGURE 3.4

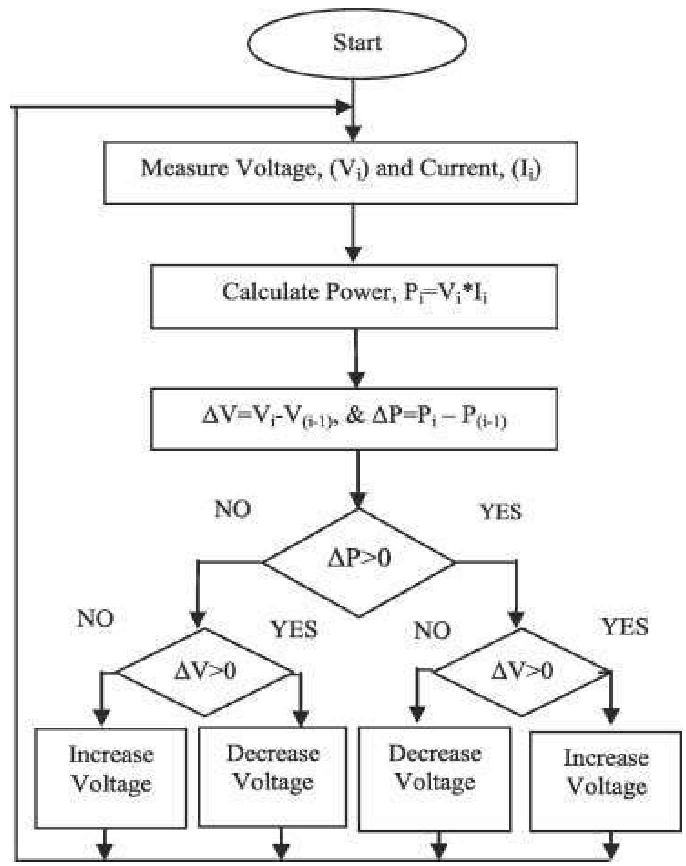


FIGURE 3.5

3.8. LCD

The liquid crystal display is included in the design to display various mathematical values as well as any system status signals that may arise; improvement facilitates human interaction and makes use of the system easier. Charge controller current and voltage, as well as temperatures of various elements of the system, should be displayed on this screen. The user should be able to monitor the battery charging status, as well as alerts or notifications that may appear in settings. Liquid crystal displays are more common in battery-powered electronic devices because they use less electricity. These pixels turn on and off depending on the electric field implanted. The LCD screen to be used in this project will be a microcontroller compatible. LCD screens come in a wide variety of sizes, shapes, and colors from ultra-small print to full-color touch screens screen capabilities.

3.8.1. Segmented LCD

These screens are referred as alphanumeric (numbers & Alphabets) displays. Segment LCDs are made of two ITO glasses and in between there is a twisted nematic fluid , also known as static displays or glass-only displays. A segment display with one pin for each segment is referred to as a static display. Alphanumeric displays are LCD screens that are separated from one another. Due to fourteen segments in a separate display that may be changed to produce additional alphanumeric characters, they are shown in this way. One is low power usage, one of the benefits of alphanumeric LCD displays. Another advantage of the method is its simplicity and usability. Regrettably, there isn't much latitude, and there is a limit on the amount of characters that can be shown.

FIGURE 3.6

3.8.2. Character LCD

LCD characters, also known as Dot Matrix characters, can create their own character alphabets using a list of pixels on screens. The number of possible characters which is displayed on this type of LCD is usually expressed in terms of line size. 16x2 LCD, for example, you can display sixteen characters per line and have two lines. Each letter typically consists of 5 × 7 pixels and allows for a large variation in the type of signals that can be generated. Dot Matrix can be used to generate numbers, letters in various languages and various other things. Whether to display the characters apart from split LCD, LCD characters can be a useful option. It is similar to having a separate screen; LCD characters are easy to insert and require very little power, especially when compared to a graphic display. This is true and also it is less expensive than other large-scale color panels. In Evil only text is locked, but you can add more integrations like photos, thumbnails or click menus.

3.8.3. Graphical LCD

A graphical display uses an array in the same manner as character LCDs do, but the grouping of pixels on the screen is much larger and each pixel is independently accessible. As a result, the user may program. Any kind of visual or text may be used, and it can be placed wherever on the screen. The versatility of design provided by graphical LCDs makes their incorporation advantageous because of a wider interface, more text, more images and logos, etc. Because the LCD will use more electricity due to its increased size. Another drawback is that most electronic devices are easier to build than controller circuits that are augmented by presently installed controller chips. Furthermore, the programming necessary is more difficult.

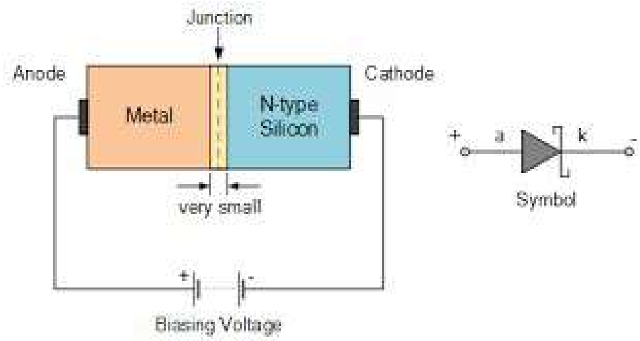
FIGURE 3.7

3.9. Sensors

A sensor is a device that senses input from the physical environment and responds to it by transforming it into digital data. E.g. heat, humidity light, heat, movement, pressure etc. can be our sensing in outs. Output comes in the form of digital displays act as actuators. To achieve the desired system function, the charge controller's sensor performance was crucial. The system uses these sensors to monitor and communicate with the microcontroller. The MPPT controller is designed to keep an eye on the high power point of a PV solar panel at all times in order to maximize energy output. Unfortunately, a variety of factors influence energy output. Temperature, weather conditions, overcast or clear skies, light intensity, and other natural elements all have an impact on solar panel performance. The amount of varying watts of power that a solar panel can produce at any particular time is used to quantify this variability in performance. The MPPT charging control is then used to determine the current and output (V) of the panel in real time (A), which defines the system's overall output power. The MPPT controller's implementation of voltage and current sensors are thus critical characteristics that will allow it to perform tracking. Another location where these senses will play a function in the current power and battery availability. In addition to these sensors, the system will include a temperature sensor and an irradiance sensor. Which enables users to keep track of the various temperature and light intensity that affects Solar panel output power. Both of these senses will be used for PMCC development and will supply crucial information to the user, but they can also be ascribed to other programs such as solar energy research generating.

3.10. Schottky Diodes

Only majority carriers are compatible with the Schottky diode. As opposed to other types of diodes, there are no minority carriers, and as a result, there is no reverse leakage current. Conduction-band electrons are significantly concentrated in the metal area, whereas doping levels in the n-type semiconductor region are relatively low. The higher energy electrons in the n area are introduced into the metal region when forward-biased, where they quickly release their surplus energy. There is a very quick reaction to a change in bias since there aren't any minority carriers like in a traditional rectifier diode. Most of the Schottky's uses take advantage of its quick switching ability. It may be utilized to shorten switching times in various digital circuits and high-frequency applications.



3.10.1. MBR 40100 PT

A Schottky rectifier diode, has tin plated leads with solder able terminals, and polarity markings on the body. It has high temperature epoxy encapsulation and have long reliability. Majority carrier conduction at a metal silicon junction protecting against overvoltage used in situations requiring low forward voltage drop, high frequency operation and polarity protection. It has a high current capability with low power.

It is used in Power switching supplies, Freewheeling Diodes, converters and for the purpose of Reverse battery protection.

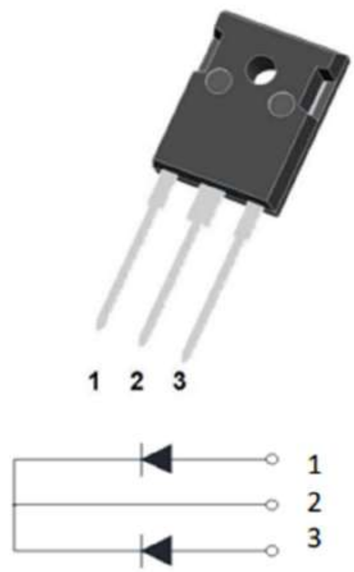


FIGURE 3.8

1. Anode
2. Cathode
3. Anode

3.11. MOSFET DRIVERS

A MOSFET driver, a type of power amplifier, accepts a low-power input from a controller IC in order to drive the gate of a high-power transistor, such as an Insulated-Gate Bipolar Transistor (IGBT) or power MOSFET. The MOSFET power and thermal efficiency are increased due to the reduction of switching time between the gates ON/OFF phases caused by the high-current drive applied to the MOSFET gate. MOSFET drivers are useful for MOSFET operation because of this.

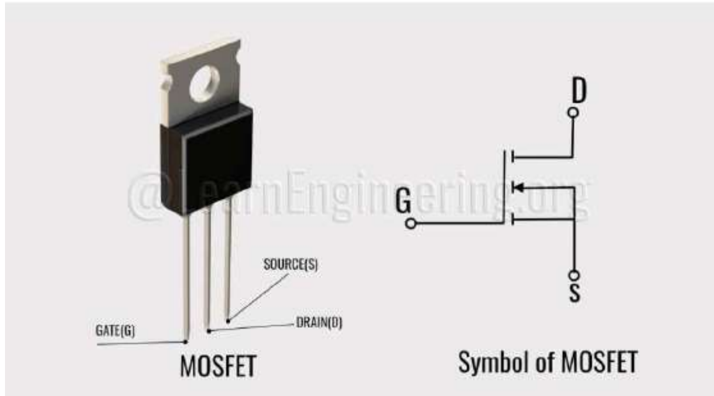


FIGURE 3.9

3.11.1. IRFB4115 MOSFET

The N-channel MOSFET IRFB4115 has a low Rds value of 9.3m and a high drain current of 104A. Consequently 5V to drive microcontrollers is rather popular. If the MOSFET must be entirely switched on, a driver circuit is required. The IRFZ44N is noted for its high drain current and quick switching speed. It also has a low Rds value, which will help to increase the effectiveness of the switching circuit. The MOSFET will turn on even at a low gate voltage of 3V, but the maximum drain current won't be reached until a gate voltage of 10V is applied.

3.12. INVERTER

An inverter is an electronic device that converts DC (direct current) power into AC (alternating current) power. Inverters are used in a wide range of applications, from simple household appliances to complex industrial systems, where AC power is required to operate various types of electrical equipment.

Inverters typically consist of a power electronic circuit that converts DC power from a battery, solar panel, or other DC source to a high-frequency AC waveform. The output waveform of an inverter can be either a sine wave, a modified sine wave, or a square wave, depending on the application.

Inverters are used in a variety of applications, including solar power systems, backup power systems, electric vehicles, and industrial motor drives. In addition to converting DC to AC power, inverters can also provide various control functions such as voltage and frequency regulation, overload protection, and communication with other devices in the system.

In summary, inverters are essential components in many modern electrical systems, providing a reliable and efficient way to convert DC power to AC power for a wide range of applications.

3.12.1. CLASSIFICATION OF INVERTERS

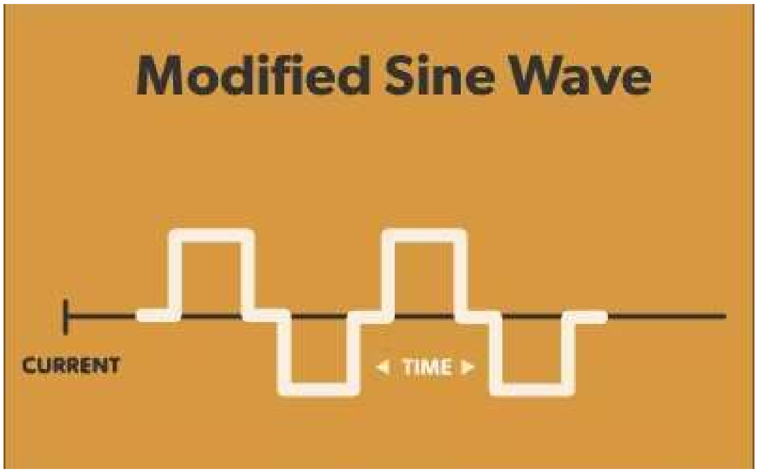
There are two types of inverter that are commonly used in market today:

- Modified sine wave
- Pure sine wave

In these types of inverter the output varies, resulting in different levels of efficiency and distortion, which can have a variety of effects on electrical devices.

3.12.1.1. Modified Sine Wave

Although it has a "stepping" appearance and is formed more like a sine wave, it has the appearance of a square wave. The waveform is simple to create since it only requires switching between 3 values at predefined frequencies, doing away with the more intricate electronics needed to create a pure sine wave. As a result, it offers a low-cost and simple solution for powering AC-powered devices. However, not all gadgets can run on a modified sine wave, and sensitive items like computers and medical equipment requires a pure sine output. These inverters closely resemble sinusoidal wave having low harmonics to avoid causing problems with household equipment. The disadvantage of this inverter is its peak voltages changes with battery volts.



3.12.1.2. Pure Sine-Wave:

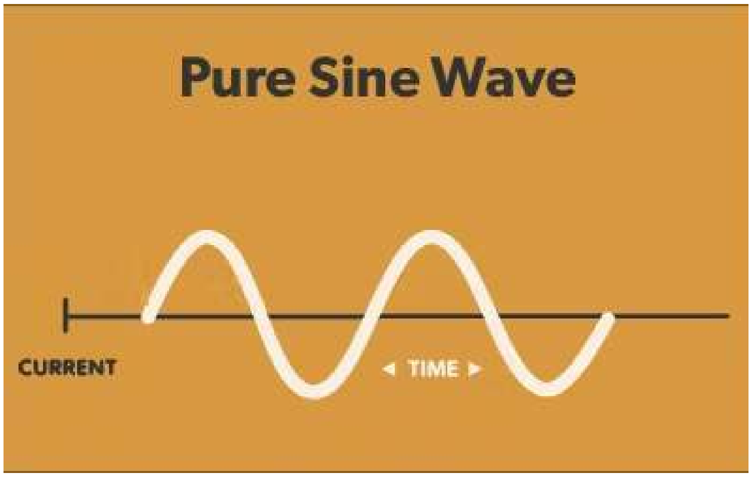
A pure sine wave inverter is an electronic device that converts DC (direct current) power from a battery or other DC source to a clean and stable AC (alternating current) sine wave. Unlike modified sine wave or square wave inverters, which produce an output waveform that is not a true sine wave, a pure sine wave inverter produces a waveform that is identical to the AC power that is supplied by the grid.

The advantages of using a pure sine wave inverter include higher efficiency, less audible and electrical noise, and improved performance of sensitive electronic equipment such as computers, audio systems, and medical equipment. It also ensures compatibility with any AC-powered device and allows for clean and efficient power transfer.

Pure sine wave inverters are widely used in a variety of applications, including RVs, boats, off-grid solar systems, and emergency backup power systems. They come in various sizes and power ratings, from small portable units to larger inverters that can power entire homes or buildings.

However, pure sine wave inverters are typically more expensive than modified sine wave or square wave inverters. They also require more complex electronic circuits to produce a clean output waveform, which can increase the size and weight of the inverter.

In summary, a pure sine wave inverter is a reliable and efficient way to convert DC power to AC power for a wide range of applications, providing a stable and clean power output that is suitable for use with sensitive electronic equipment.



3.13. PWM Techniques for pure sine wave Inverter

When the duty cycle of a PWM signal is altered, voltages across the load take on the appearance of an AC signal in a particular pattern to the load. When the signal is run through a low pass filter, it produces a pure sine wave. To create waveforms with variable PWM signal duty cycle, a digital microcontroller and analogue components are used. Sine wave pulses produced by one of the two topologies are insufficient to regulate the output of the inverter.

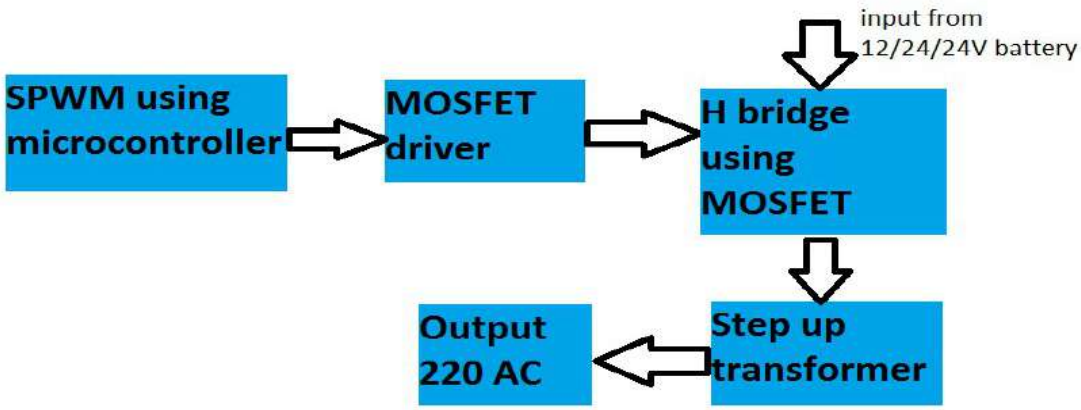


FIGURE. 3.10

The signal production of control signals organized in H-bridge form that is used for switching purpose and converts DC to AC.

3.13.1. PWM➔ pulse Width Modulation:

An effective technique for controlling a CPU's analog to digital outputs is PWM. It is referred as pulse duration modulation (PDM). The frequency of the trailing pulses varies while the leading edge of the carrier pulse is constant.
Electronics today frequently employ PWM signals. Some of them are as follows:

Less Power Consumption - Since switching devices are virtually always off (low current = low electricity), switched circuits use less power (low voltage drop means low power). Power inverters, motor drivers, Class D audio power amplifiers, and switched-mode power supplies are some of the circuits that benefit from this capability. These circuits typically use semi-analogue methods (ramps and comparators) rather than digital ones, but the advantages remain the same.

Simple to Create — Producing PWM signals is easy. Many modern microcontrollers come with PWM hardware, which may be used in the background without interfering with code execution and requires little attention from the CPU. PWM signals can also be generated directly from a comparator by just passing the carrier and modulating signals through it.

If pulse width modulation is combined with the appropriate filtering, it can be used as a digital to analogue converter. PWM signals can be utilized for digital-to-analogue conversion because the duty cycle of a PWM signal can be dependably controlled by simple counting operations.

The suggested PWM method must possess the ensuing qualities.

• If the DC supply voltage is properly utilized, a significant voltage gain is feasible.

A voltage control system's voltage control linearity is a phrase used to define how linear it is.

• To reduce the harmonic content of output currents, the low order harmonic has a small amplitude.

• Low switching loss inverter switches.

• Provide sufficient time for the control system and inverter switches to operate properly.

Sine wave inverters use PWM techniques in a number of different ways. Some of the methods that are most frequently used are as follows: The simplest method for producing a PWM signal is a single- or two-level PWM. Figure shows the 2-level PWM signal that is produced when a comparator is used with these two signals as inputs. It is the most popular and commonly applied method (PWM).

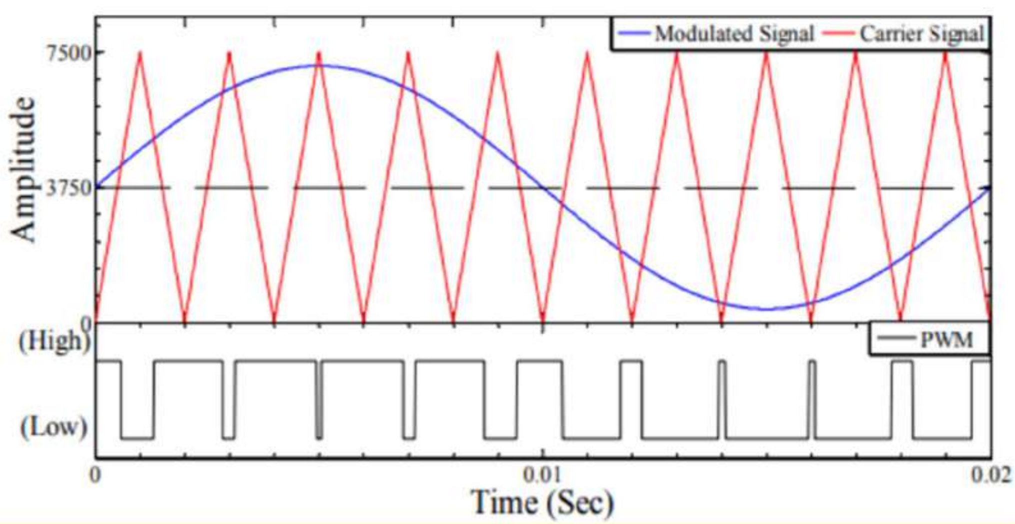


FIGURE 3.11

Multilevel PWM: By using many pulses during each half-cycle of the output voltage, the harmonic content can be considerably reduced. Each level of multiphase PWM is available, and when the PWM level is increased, each level yields better results. The three, five, seven, and nine level PWM types are the most prevalent. Depending on factors like inverter cost and output quality, you can choose a different PWM level. A three level PWM is frequently used to balance the cost and quality of inverters.

The diagram shows a PWM with three different levels. When comparing the 3-level PWM to the 2-level PWM, the harmonics figure reveals that there are no higher level harmonics of significant importance. This demonstrates how much closer to the intended sine wave the 3-Level signal is. On the other hand, compared to the 2-Level design, the amplitude of the voltage at the primary frequency is significantly smaller. This is explained by the fact that additional frequencies—which are not harmonics of the 50Hz signal—are formed as the signal flips from one polarity to the other and back.

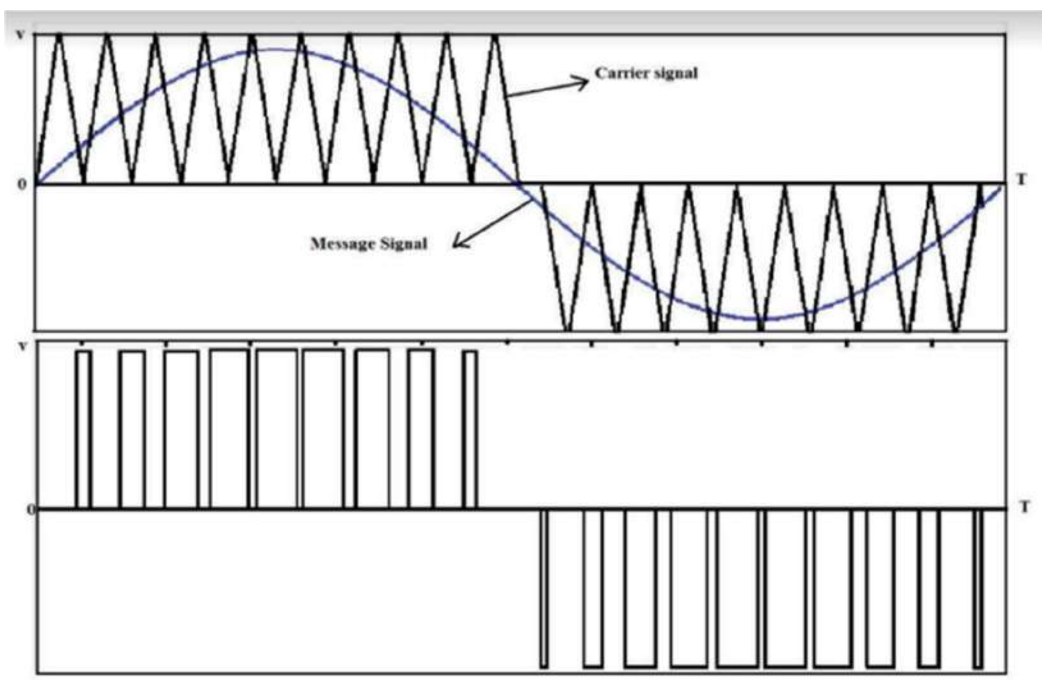


FIG 3.12

PWM is a method that is usually utilized in electronic power converters and motors to either do complex DC/AC conversion or to power alternating current (AC) devices with a conveniently available direct current (DC) source. The duty cycle of the PWM signal can be altered to either control the speed of motors that would otherwise only run at their maximum speed or off, or to supply a precise DC voltage across the load that appears to the load as an AC signal. To create a pattern in which the duty cycle of a PWM signal swings, one can utilize basic analogue components, a digital microcontroller, or specialized PWM integrated circuits.

3.13.2. H- Bridge Configuration

Inverters are devices that convert alternating electricity to direct current. Thyristors like SCR and TRIAC can be utilized for this. Single phase inverters, like the Diode rectifier, require two thyristors (SCRs).

Based on the kind of connection between semiconductor devices, inverters are classified into three types:

(i) Series inverter (ii) Parallel inverter (iii) Bridge inverter

Single Phase Series Inverter: The elements L and C are in series with the load resistance R in a series inverter. R can also be in parallel with C when it comes to load resistance. L and C have values that result in an underdamped circuit.

Single Phase Parallel Inverter: This inverter is referred regarded as a parallel inverter because, when operating, capacitor C is linked in parallel with the load via the transformer.

Single Phase Bridge Inverter: In DC-AC conversion, bridge circuits are often employed. Furthermore, with a bridge circuit, an output transformer is not required.

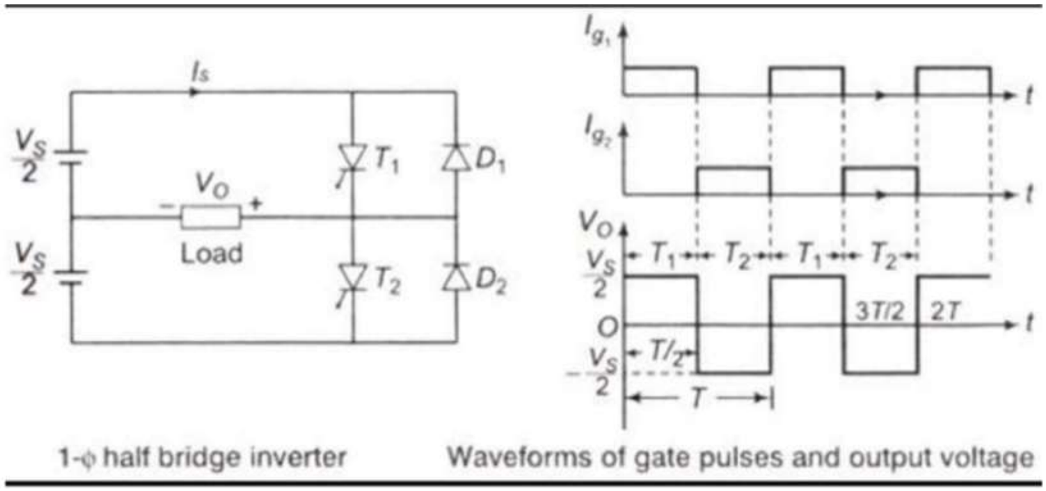


FIGURE 3.13

Four switches make up the H-Bridge circuit as depicted in Figure: high side left, high side right, low side left, and low side right. To acquire voltages across the load, you can use one of four switch settings. The table below summarizes these places. All other alternatives are ruled out because they would result in a short circuit to earth, which might damage the gadget or deplete the power source quickly.

TABLE 3-1

High Side Left	High Side Right	Low Side Left	Low Side Right	Voltage Across Load
On	Off	Off	On	Positive
Off	On	On	Off	Negative
On	On	Off	Off	Zero Potential
Off	Off	On	On	Zero Potential

An H- Bridge's switches could be mechanical or solid-state transistors. Several factors influence which switch is best to utilize. On the plus side, P-Channel MOSFETs are simpler to use, but the "on" resistance and power loss are reduced by using all N-Channel MOSFETs with a FET driver. All N-Channel MOSFETs need a driver because a high-side N-Channel MOSFET needs a voltage greater than the switching voltage to turn on (in the case of a power inverter, 12V). Most people use driver circuits, which charge an external capacitor to provide extra potential, to address this issue.

3.13.3. Filter

An analogue low pass filter is used to remove the majority of the high frequency components from a PWM signal before converting it to a digital-analog (D/A) signal. The diagram below depicts this. The low-pass filter's bandwidth mostly determines the bandwidth of the digital-to-analog converter.

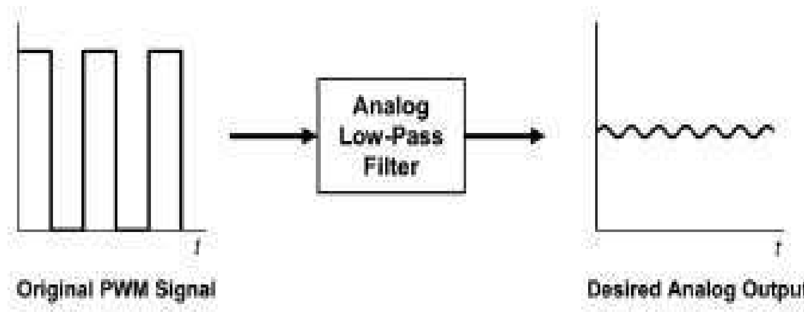


FIGURE 3-14

Filters are categorized according on how well they perform. One of them is active filters, which are produced by op-amps. Unbiased filters (composed solely of resistors, inductors, and capacitors). Impedance loading is a problem with passive filters because the impedances surrounding the filter can change its properties. This issue is solved by using active filters. Passive filters are less expensive and easy to build.

The gain bandwidth of the op-amps must be taken into account when utilizing active filters. The gain bandwidth denotes the highest frequency that the op-amp can effectively handle when used in a closed-loop circuit with an acceptable signal input. Active low-pass filters muffle input signal components with higher frequencies because the op-amp cannot handle frequencies above the gain bandwidth. The expense of employing a separate DAC chip may eventually be less expensive than buying costlier op-amps with the necessary gain bandwidth to handle these frequencies.

Gain bandwidth is a less significant issue with passive filters. Impedance is always passive's biggest drawback. The filter's upstream and downstream impedances determine its performance characteristics. The DSP's PWM output will be upstream of the filter in the PWM/DAC application. This source has a low output impedance, therefore it won't have much of an impact on the filter. A low-cost voltage follower op-amp can be used to supply a high-impedance input in the downstream direction. Since it is used after the low-pass filter, the op-gain amp's bandwidth is not crucial.

Filters can also be divided into

Filters of the first order that are linear and time-invariant. The equation

(Vout/vin= 1/ (Ts+1)) is the first order filter's continuous-time domain transfer function

"Seconds" are used to express the time constant. It is feasible to construct it with only a resistor and a capacitor.

- Time-invariant linear filters of the second order. (Vout/vin=ωn2/ (s2+2ζωn+ωn2));

CHAPTER 4

Implementation and Development

4. Methodology

The first step is to use any standard technique to get the PV panel's maximum power. The PV panel's output voltages can reach up to 24 V on a fully sunny day. To feed it to the inverter circuit, we require a steady 12V at the solar charge controller's output. To step down the power to 12V, we are utilizing a buck converter.

The block diagram illustrates the introduction of an MPPT charge controller, which will increase system efficiency. An MPPT charge controller is installed between them to make sure the battery receives the most power possible from the PV module.

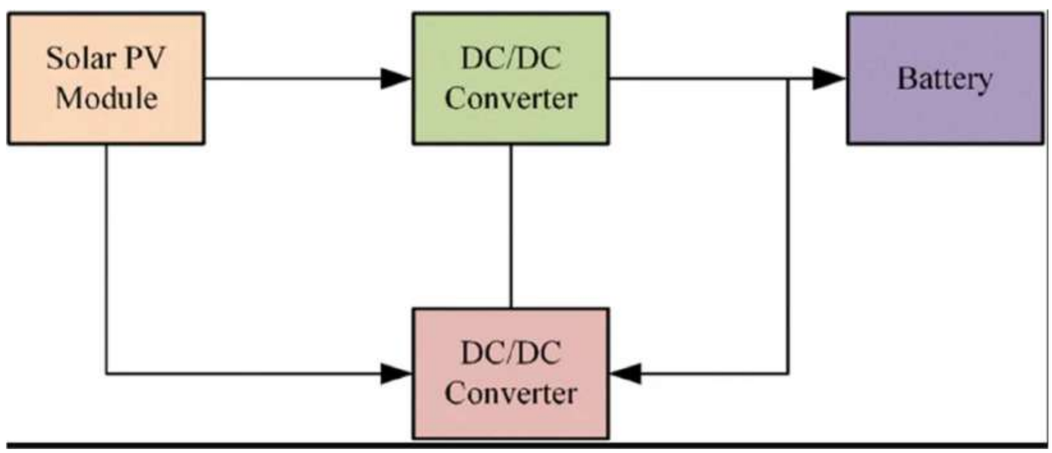


Figure 4-1

4.1. Tracking by Perturb and Observe Algorithm

As a standard algorithm, we used Perturb & Observe. In this sort of tracking, the MPPT is approximated on a regular basis using simple data and fundamental assumptions. For instance, the fixed voltage technique merely modifies the solar PV module's operating voltage over time, assuming that MPP voltages will be higher in winter and lower in summer while the irradiance level remains constant. This method is imprecise due to the fluctuating irradiance and temperature levels within a single season.

Due to its simplicity of usage, this method is extensively employed. In this technique, a slight disturbance is produced in order to change the PV module's power output. On a regular basis, the PV output power is checked and contrasted with the prior power. The same process is applied if the output power rises; otherwise, the perturbation is reversed. To assess if the power has increased or decreased, the PV module voltage is adjusted.

The operational point has drifted toward the MPP, and the operating voltage has been perturbed in the same manner, if the PV array's operating voltage is disturbed in an unusually given direction and the power drained from the PV array increases. The operating voltage perturbation should be reversed if the operative point has moved away from the MPP. This is possible even if the amount of electricity drawn from the PV array drops.

We detected a slight interruption from this strategy. The solar module's power varies as a result of this interruption. The perturbation will continue in the same direction if the influence of the disturbance on power grows. Power drops off immediately after the peak power is reached, reaching zero at the MPP.

The flowchart is mentioned below:

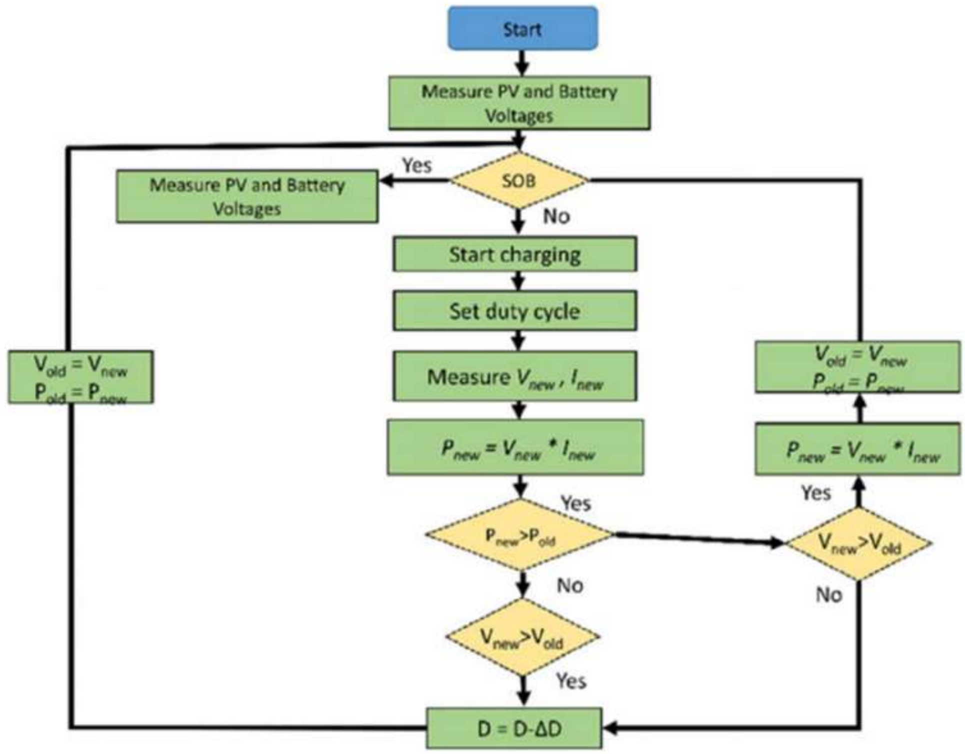


Figure 4-2

We measured the optimum power comes from solar panels also battery voltages by this charge controller once it's connected between them. It makes sure the charging of the battery and prevents it from overcharging.

We identified that the controller stopped battery overcharging when battery is charged up to 12 volts. The DC/DC converter is turned on to begin charging the battery if it isn't fully charged. The microcontroller then compared the voltage and current readings to determine the current power (Pnew) at the output, the power was determined using Pold, the prior power. To get the most out of the PV panel, we increased the PWM duty cycle when Pnew was greater than Pold (Pnew > Pold).

The duty cycle decreased when Pnew was bigger than Pold (Pnew > Pold) to make sure the system resumes operating at its peak power. This M.P.P.T optimization method is basic, straightforward, inexpensive, and precise.

We calculate the change in power (delta p) by subtracting P (new) P from P (old) P. (old). When delta p was more than zero (delta p>0). We measured the voltage change (Delta V). Delta V is less than zero, so (delta V). The duty cycle was then reduced. As a result, the output power increased.

We determine change in power (delta p) by taking the difference of P (new) P (old). Then, we measured the change in voltage (Delta V). As delta p was greater than zero (delta p>0) and delta V was also greater than zero (delta V>0). We increased the duty cycle. The output power increased.

When delta p was less than zero (delta p>0) and delta V was also less than zero (delta V>0). So, we increased the duty cycle. Thus, the output power decreased.

4.2.Step 1(Using the perturb and observe algorithm for tracking)

4.2.1. Case 1

We determine the power change (delta p) by deducting P (new) P from P (old) (old). If delta p is greater than 0 (delta p>0). After then, the voltage change must be measured (Delta V). Whenever the Delta V value is less than zero (delta V0). The duty cycle must then be reduced. As a result, the output power is boosted. Figure following depicts the entire scenario:

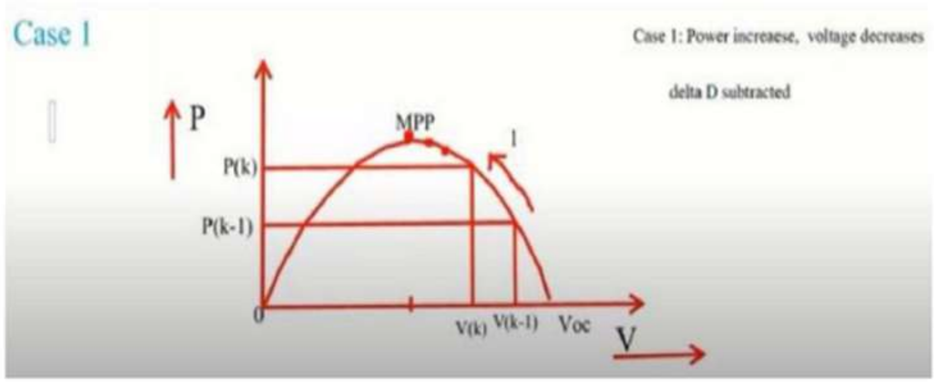


Figure 4-3

4.2.2. Case 2

We calculate the change in power (delta p) by subtracting P (new) P from P (old) (old). The voltage change must then be measured (Delta V). When both delta V and delta p are greater than zero (delta V>0), then the duty cycle must then be increased. As a result, the output power is boosted. Figure following depicts the entire scenario:

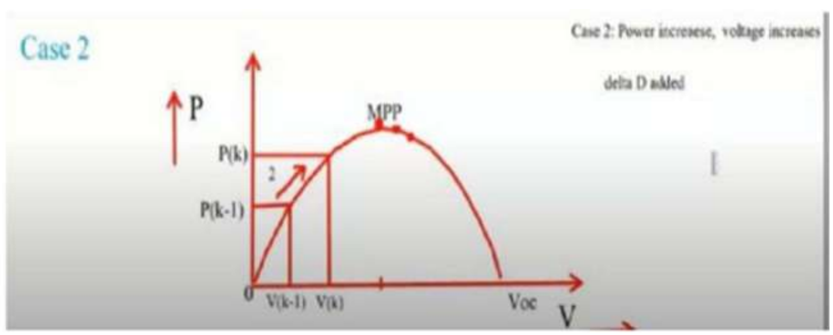


Figure 4-4

4.2.3. Case 3

We calculate the change in power (delta p) by subtracting P (new) P from P (old) (old). Then we must calculate the voltage change (Delta V). If delta V and delta p are both greater than zero (delta p>0). The duty cycle must then be increased. As a result, the output power is reduced. Figure following depicts the entire scenario:

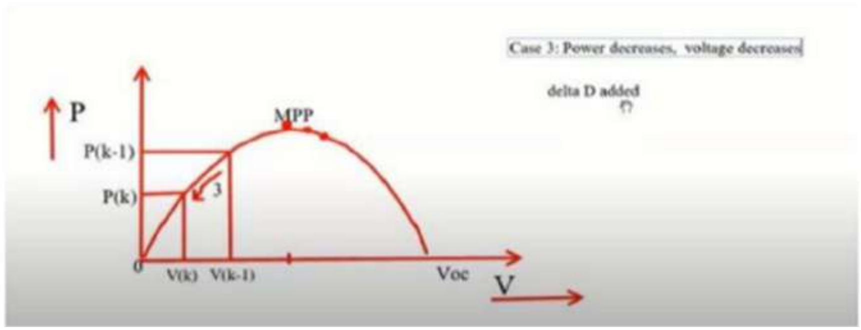


Figure 4-5

4.2.4. Case 4

We calculate the change in power (delta p) by subtracting P (new) P from P (old) (old). Then we must calculate the voltage change (Delta V). Whenever delta p exceeds zero while delta V is less than zero (delta p>0), the duty cycle must then be reduced. As a result, the output power is reduced. Figure following depicts the entire scenario:

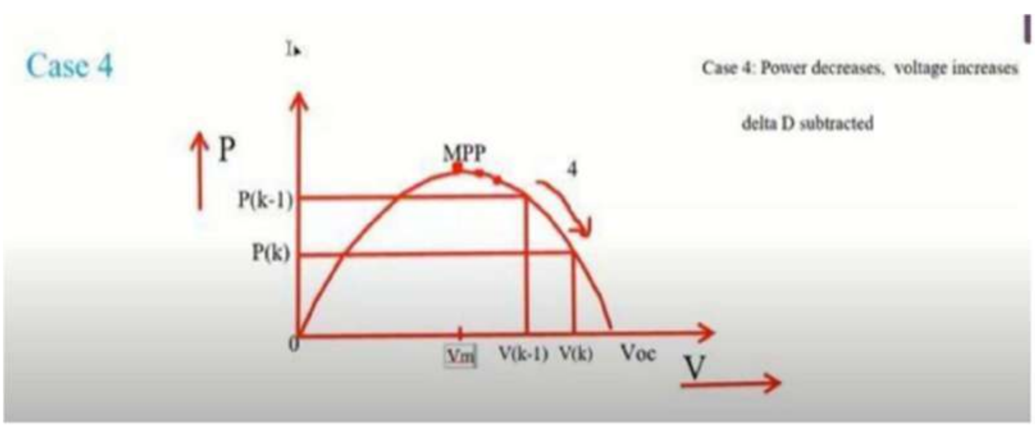


Figure 4-6

CHAPTER 5

5. MPPT Calculations and Observations

5.1.1. To find Duty Cycle:

$$Max\ Duty\ Cycle = \frac{\text{Vout}}{\text{Vin(max)x}\,\eta}$$

Input range: 9 to 30 v output

Value: 16V

Pout: 300 watt

D = $Duty\ Cycle = \frac{t1}{T}$

$$D = \frac{\text{Ton}}{\text{Total Time(Ton + Toff)}}$$

D = 0.5

5.1.2. To Find Inductance and Capacitance:

For L:

L = [(Vout + VD) (1-Dmin) T] / 2x Lout (min) Henry

Vd = 0.37, Dmin = 0.48, Iout = 0.5, T= 33.33e-6 s

By putting these values in above formula we will get:

L=25.598mH

For C:

C = ΔIo/8 fs ΔV

ΔIo = 9.749e-3 A, ΔV= 48.5 V, fs= 20e3 Hz

C= 0.8375 nF

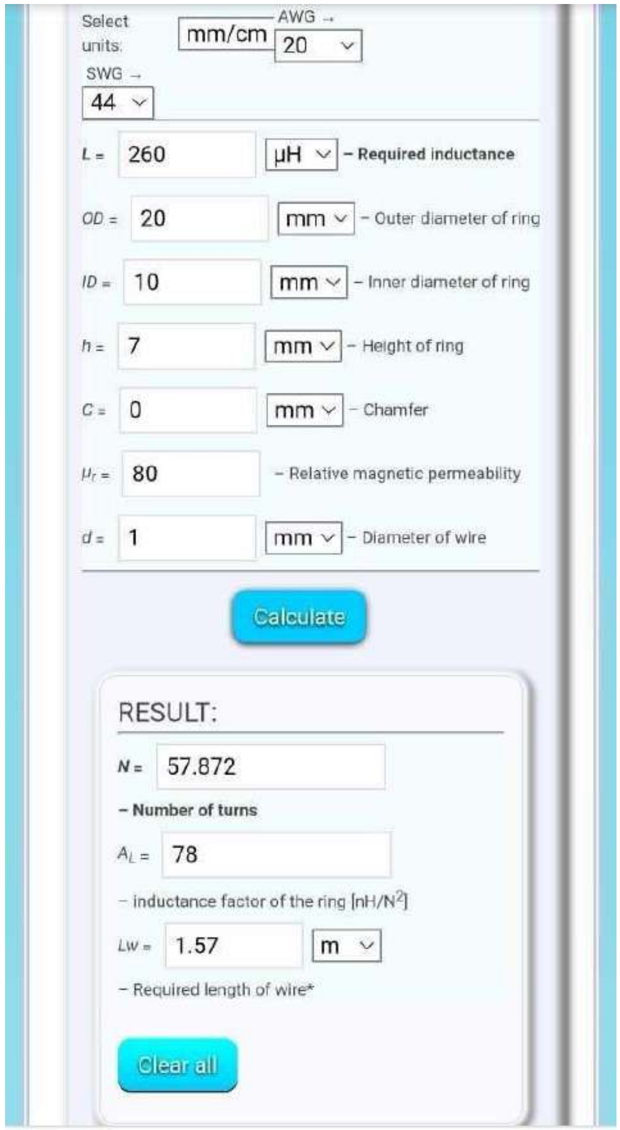
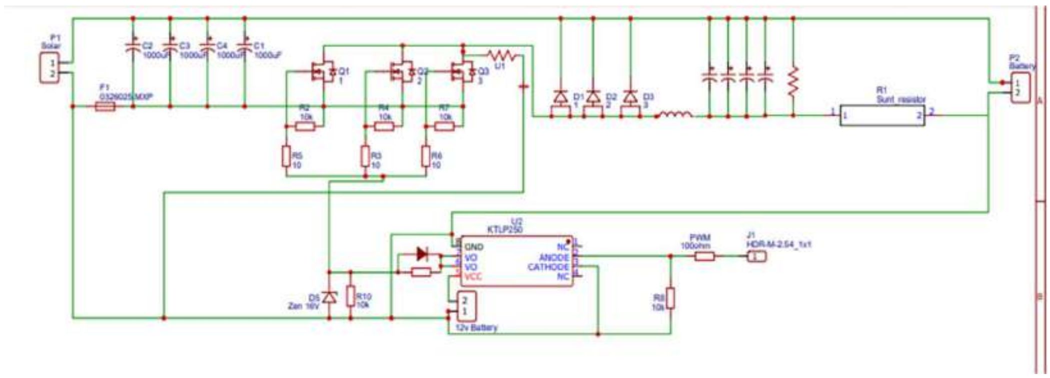


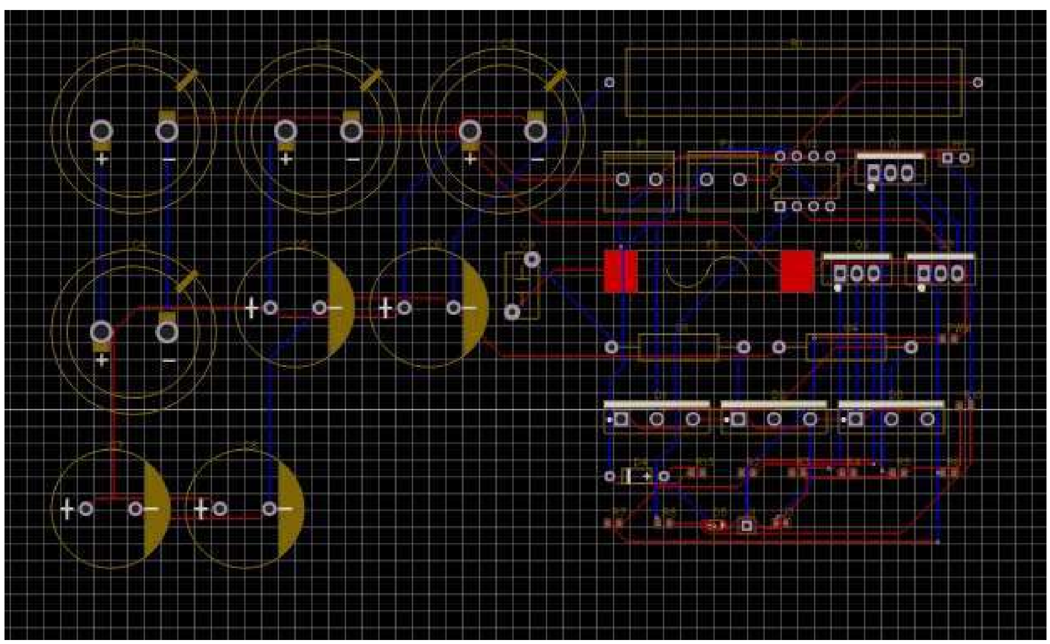
Figure 5.1 Mppt Inductance and core selection

5.2. MPPT Schematic and PCB layout:

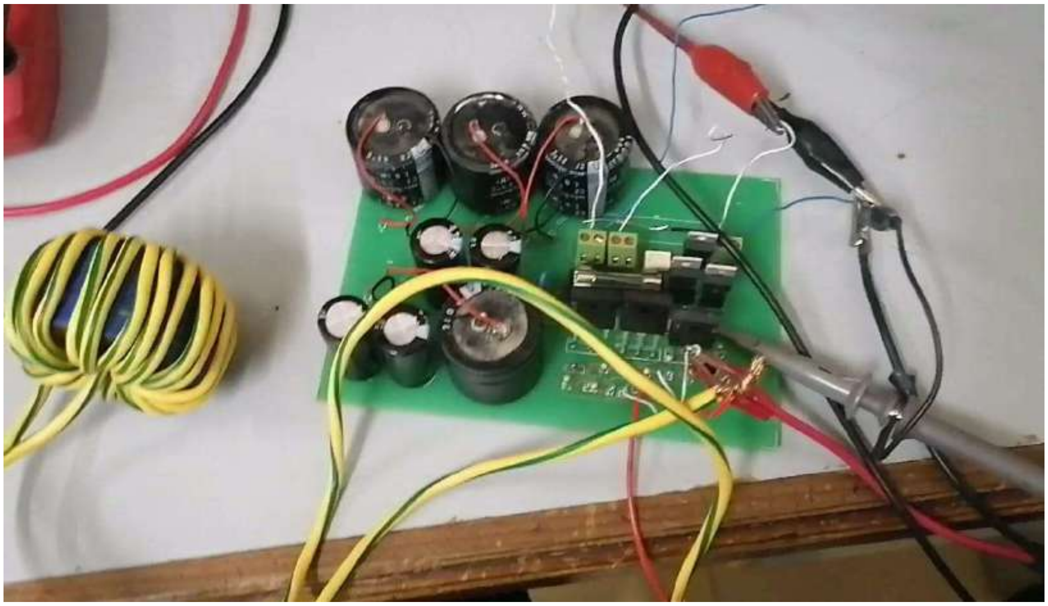
5.2.1. MPPT schematic:



5.2.2. PCB layout:



5.3. Hardware Implementation of MPPT:



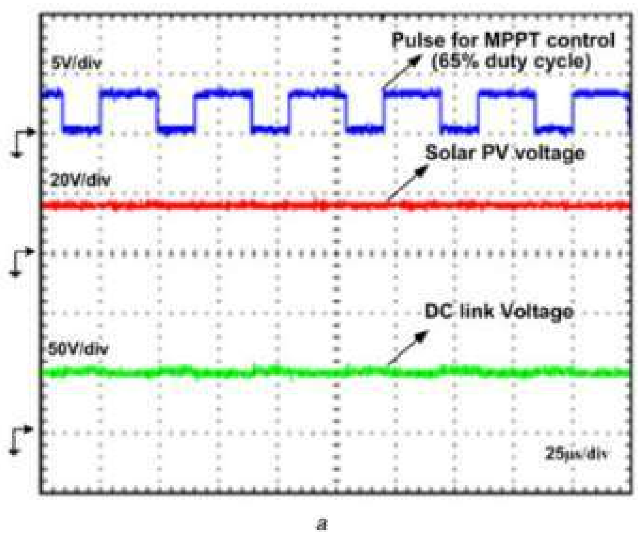


Figure 5-1

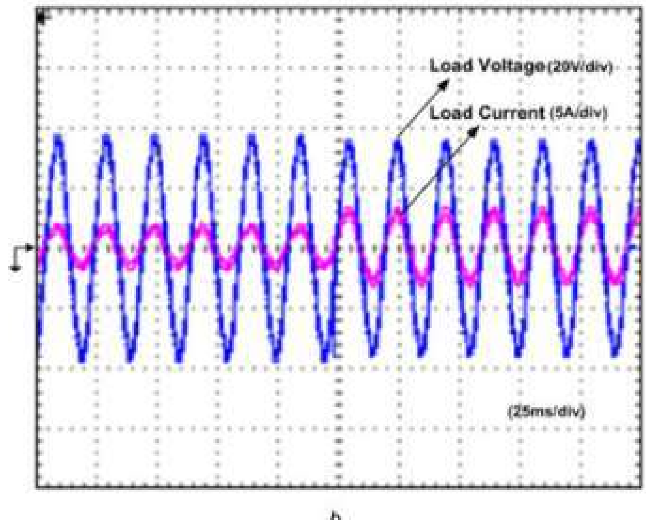


Figure 5-2

5.4. Inverter Calculations And Observations:

Formula to calculate the frequency:

The timing capacitance and timing resistance determine the frequency of PWM.

Pin 5 is linked to ground, while the timing capacitor (CT) is connected to pin 5. Between pin 6 and ground, the timing resistor (RT) is connected. The dead time is determined by the resistance between pins 5 and 7 (RD) (and also slightly affects the frequency).

The following relationship links frequency to RT, CT, and RD:

$$f = \frac{1}{\mathrm{Ct}\,(0.7\mathrm{Rt} + 3\mathrm{Rd})}$$

$$f = \frac{1}{10^{-9}[0.7(3.3k) + 3(3k)]}$$

$$f = 100\ KHz$$

f is in Hz, with RT and RD in Ω and CT in F. Where RD is 3k, RT is 3.3k, and CT is 1nf.

The typical range of RD values is 10Ω to 47Ω. The usable range of values (as indicated by the SG3525 makers) is 0Ω to 500Ω.

The RT must be between 2kΩ and 150kΩ. CT must be in the 1nF (code 102) to 0.2µF range (code 224). The frequency of the oscillator is around 45 kHz. Before the driver stage, there is a flip-flop, which causes our output signals to have frequencies half that of the oscillator frequency determined using the formula above.

High Frequency Transformer:

I/p voltage = 12 v , i/p current = 26 A

Output voltage = 240v o/p current = 1A

Frequency = 100 KHz η = 98%

Regulation = α = 0.5%

Operating Flux Density = 0.05 Tesla

Core Material Ferrite (N97)

Window Utilization Factor = 0.4

Temperature Goal = 30 ℃

Max Duty Ratio = 0.5, Single Winding (u) = 1

1) **Select Wire Ratio:**

$$Rac = \text{Rdc}$$

$$\frac{Rac}{Rdc} = 1$$

2) **Skin Depth(Ɛ) :**

$$\varepsilon = \frac{6.62}{\sqrt{f}}$$

$$\varepsilon = \frac{6.62}{\sqrt{100{,}000}} = 0.0209\ cm$$

3) **Wire Diameter (D_{Awg}**

$$D_{Awg} = 2(\varepsilon)$$

$$D_{Awg} = 0.04186$$

4) **Find Bare wire Area (A_w) =**

$$A_w = \frac{\pi(D_{Awg})}{4}$$

$$A_w = 0.00137\ cm^2$$

5) Transformer Output Power:

$$Pout = VI$$

6) Secondary Apparent Power (Pts):

$$P_{ts} = 311\ watt$$

7) Total Apparent Power (Pt):

$$P_t = P_{in} + P_o$$

$$P_{in} = \left[\frac{P_o}{\eta}\right]$$

$$P_{in} = 317.34\ watt$$

$$P_{tin} = 317.34\ watt$$

$$P_{Total\ Apparent} = 628.34$$

8) Electrical Condition (K_e):

$$K_e = 0.145(kf)^2(f)^2(B_{in})^2(10^{-4})$$

$$K_e = 5800$$

9) Core Geometry(K_g):

$$K_g = \frac{P_t}{2K_e(\alpha)}$$

$K_g = 0.10833\ cm^2$ (On bare wire Area method)

Normal wire = 0.78, Normal Value = 0.1462455 cm

PQ 32/20 , PQ – 3220 core based

10) Core Selection :

Core Area (A_e) = 169 mm^2 = 0.000169 cm^2

Area Product (A_p) = 1.374 cm^2

Mean Length turn = 6.6 cm

Core Mass Weight = 42 gram

Surface Area (A_t) = 36.3 cm^2

Window Area (w_a) = 0.808 cm^2

Core: 44020 EE

11) Primary Turns using Faraday's Law :

$$N_p = \frac{V_p(10^4)}{K_f B_{ac} f A_c}$$

$$N_p = 10\ turns$$

$$Verify\ B_{max} = 0.04838 \quad Tesla$$

Hence we are in safe range, our core will not heat up.

$$Turns \propto \frac{1}{B_{max}}$$

12) Current Density using Window Utilization factor,

(K_u) = 0.29

$$J = \frac{P_t}{K_f K_u B_{ac} f A_p}$$

$$J = 788.46\ \frac{Amp}{cm^2} \qquad Current\ Density\ in\ complete\ winding$$

The window utilization factor (Ku) is the amount of copper that appears in the window area of the transformer or inductor.

13) Input Current (I_{in}):

$$I_{in} = \frac{P_o}{V_{in}\eta} \quad I_{in}$$

$$= 26.44\ Amp$$

14) Primary Base Area $Awp_{(B)}$:

$$Awp_{(B)} = \frac{I_{in}\sqrt{D_{max}}}{J}$$

$$Awp = 0.0237\ cm^2$$

15) No. of primary strands (Snp):

$$\frac{Awp(B)}{Selected\ wire\ size\ Area}$$

$$Use = 19\ Strands \qquad For\ Primary\ winding$$

16) Primary Resistance / cm :

$$\frac{\mu\Omega}{cm} = 1345$$

New resistance = $\frac{1345}{19}$= 70.78 $\frac{\mu\Omega}{c}$

$$R_p = MLT(N_p)(\frac{\mu\Omega}{cm})(10^{-6})$$

$$R_p = 8.875\ m\Omega \qquad Total\ primary\ Resistance$$

17) Primary copper loss (P_p):

$$Pp = Ip2Rp\ Pp$$

$$= 6.204\ watt$$

18) Secondary Turns:

$$N_s = \frac{N_p \times V_s}{V_{in}}$$

$$N_s = 260.46$$

$$N_s = 260\ turns\ in\ secondary$$

19) Secondary wire Bare Area:

$$A_{ws} = \frac{I_o\sqrt{D_{max}}}{J}$$

$$A_{ws} = 8.96 \times 10^{-4} cm^2$$

20) Strands in secondary:

$$S_{ns} = \frac{A_{ws}}{\#26\ B_{ac} area}$$

Secondary strand = 1

21) Resistance per (cm):

$$\frac{\frac{\mu\Omega}{cm}}{strands} = \frac{1345\ \frac{\mu\Omega}{cm}}{1}$$

$$\frac{\mu\Omega}{cm} = 1345\ \frac{\mu\Omega}{cm} \qquad Resistance\ for\ Secondary\ winding$$

22) Resistance for secondary :

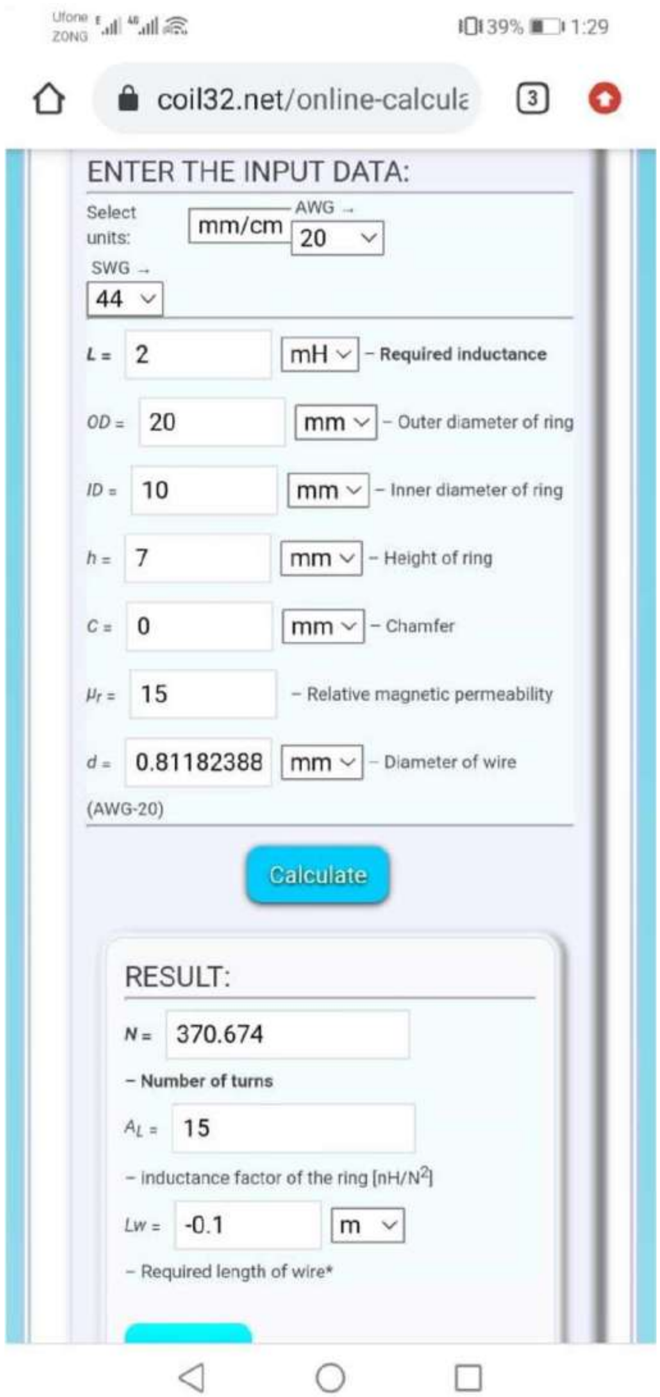
$$R_s = MLT(N_s)(\frac{\mu\Omega}{cm})(10^{-6})$$

$$R_s = 8.877\ m\Omega$$

23) Power loss in secondary winding:

$$P_s = I_{s2} \times R_s$$

$$P_s = 8.877 \times 10^{-3}\ watt$$



Inverter and core selection

Hardware Execution of Inverter:

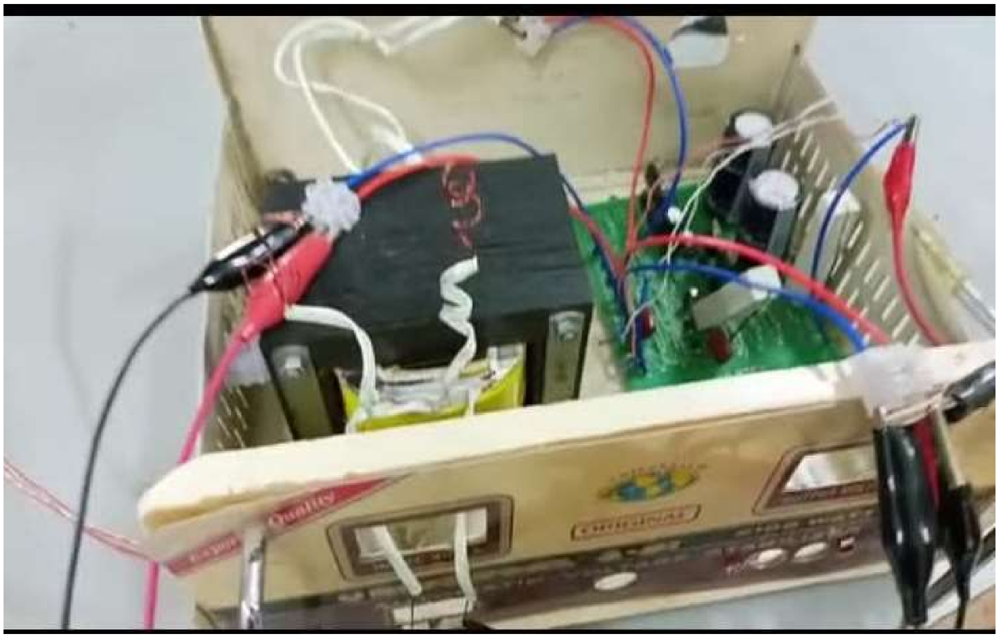


TABLE 5-1

Solar I/p & O/p	MPPT Input and Output Volts	Inverter AC Output
9.97v/16v	16v/30v	190V
11.65v/16.5v	16.5/30v	200V
14.35v/17v	17/30.5v	205V

Inverter Pcb Schematic:

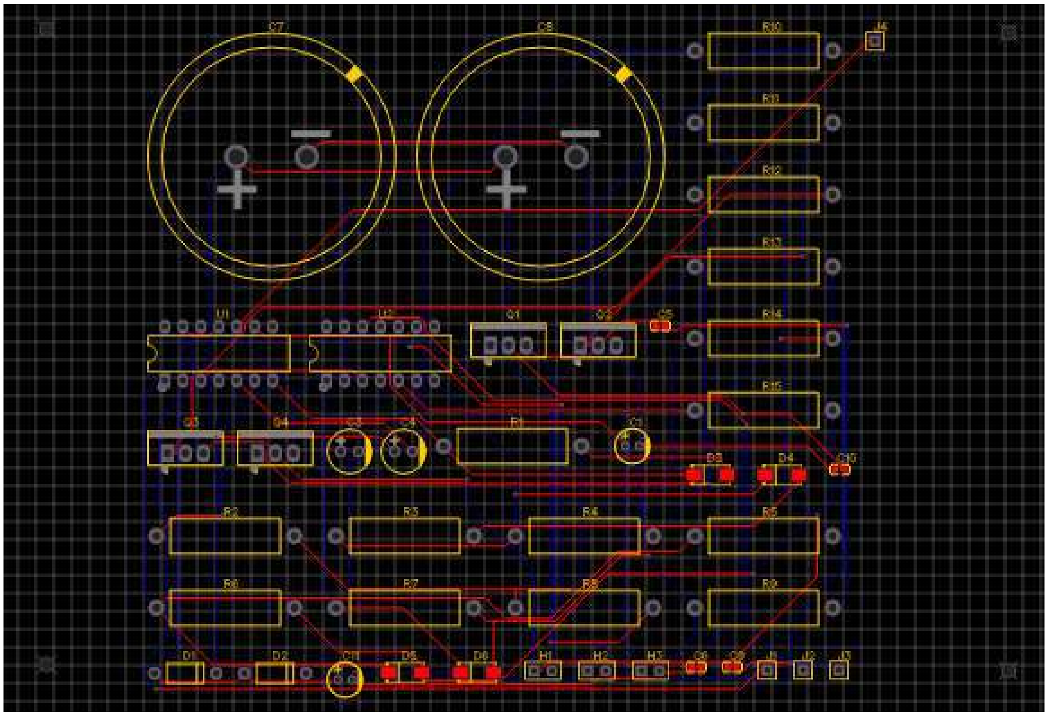


Figure 5-5

Inverter Schematic:

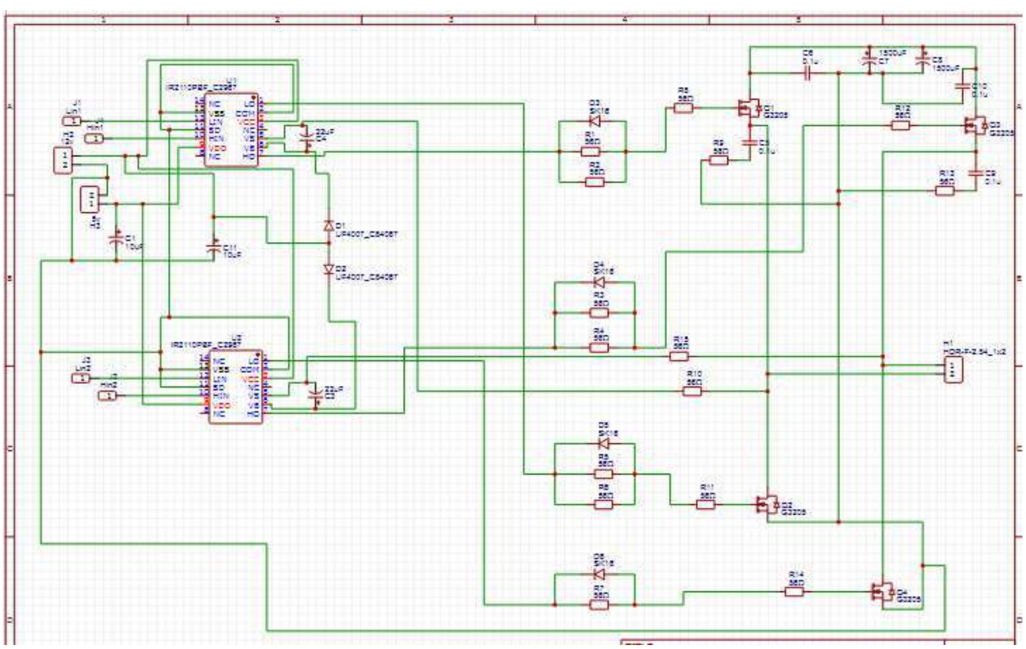


Figure 5-6 (calculations & explanation)

CHAPTER 6

6. Prototype cost

Sr. #	ITEM: Specification / Description	Quantity	Amount
1	PCB Designing	4	10000
2	Soldering Iron	1	500
3	Transformer	1	10000
4	Inductor	1	5000
5	Solder wire	1	300
6	Power Capacitors	10	1,000
7	Zener Diode	4	200
8	Microcontroller 32 Mega	1	1200
9	Soldering Paste	1	100
10	Resistors	20	100
11	Multimeter	1	1500
12	MBR40100PT	6	600
13	Heat Sinks	15	450
14	DC Bulb	1	150
15	Bread Board	2	400
16	Cap 3300uF /50V	8	800
17	Cap 1000uF /200V	8	640
18	Connectors	10	150
19	Shunt Wire	2	100

20	Structure	2	1200
21	DC Fuse 35A	2	120
22	IRFB4415	6	560
23	Jumper Wire		150
24	4148 Diode	3	100
25	TLP250IC	3	270
26	Power Resistors	8	400
27	Power Supply	1	3000

CHAPTER 7

7.1. CONCLUSION

A Maximum Power Point Tracking (MPPT) based buck-boost inverter is a power electronic circuit that is used to convert the DC power generated by renewable energy sources such as solar panels to AC power. The main function of the MPPT is to track the maximum power point of the solar panel and adjust the voltage and current to ensure maximum power output. The buck-boost inverter is used to convert the DC voltage to the required AC voltage for the grid.

The project's primary objective—to design and construct a functional DC-AC sine wave inverter with maximum power point tracking (MPPT) that could effectively supply 200W of electricity utilizing three levels of PWM—was successful. To operate the MOSFET switches placed in an H-Bridge, a number of signals were produced. The goal was to filter the bridge output to create a pure sine wave, then modulate the bridge with a two-level PWM to create a three-level PWM. This project is a great place to start if you want to build a self-regulating power supply for a variety of general-purpose high-power applications.

In conclusion MPPT based Buck-Boost Inverter is an efficient solution for converting the DC power generated by renewable energy sources into AC power for the grid. It allows for maximum power extraction from the solar panel and improves the overall efficiency of the system. It is suitable for use in a wide range of applications. However, it may have a higher cost and more complex design compared to traditional inverters.

This technology has significant potential for reducing our reliance on fossil fuels and helping to mitigate climate change.

7.2. RECOMMENDATIONS

One possible improvement is the implementation of a feedback system that gives the microcontroller a view of the output across the load so that the signals regulating the system can be altered in accordance with predetermined programming parameters. As various loads are connected and disconnected, the system's output and efficiency will change. The system must be able to adapt to variations in load and battery levels in order to run at 220Vrms and 50Hz. Installing a voltage booster at the bridge input is one suggestion for minimizing the impact of battery voltage drop on output.

7.3. REFERENCES

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[2] Hiwale, A., M. Patil, and H. Vinchurkar, an Efficient MPPT Solar Charge Controller. International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, 2014. 3: p. 10505-10511.

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[4] Trishan Esram and Patrick L. Chapman, "Comparison of Photovoltaic Array Maximum Power Point Tracking Techniques", IEEE Transactions on Energy Conversion, vol. 22, no.2, June, 2007.

[5] Ali Chermitti, Omar Boukli-Hacene, Bencherif Mohamed "Improvement of the "Perturb and Observe" MPPT Algorithm in a Phot'ovoltaic System under Rapidly Changing Climatic Conditions" International Journal of Computer Applications (0975 – 8887) Volume 56– No.12, October 2012