DESIGN OF STEP-UP DC-DC BOOST CONVERTER USING SPV-MPPT ALGORITHM

A Project report submitted in partial fulfillment
of the requirements for the degree of B.Tech in Electrical Engineering

By

Diptesh Basu	***EE2017/024***	***11701617062***
Soumalya Aich	***EE2017/010***	***11701617035***
Arkaprabho Chowdhury	***EE2017/045***	***11701617070***
Sumit Patra	***EE2018/L06***	***11701618002***

………………………………………………

Under the supervision of-

MR. SARBOJIT MUKHERJEE

Assistant Professor

Department of Electrical Engineering

श्रमम् बिना न किमपि साध्यम्

RCC INSTITUTE OF INFORMATION TECHNOLOGY

CANAL SOUTH ROAD, BELIAGHATA, KOLKATA – 700 015

Maulana Abul Kalam Azad University of Technology, West Bengal

Acknowledgement

It is my great fortune that I have got opportunity to carry out this project work under the supervision of Mr. Sarbojit Mukherjee assistant professor in the Department of Electrical Engineering, RCC Institute of Information Technology (RCCIIT), Canal South road, Beliaghata, Kolkata-700015, affiliated to Maulana Abul Kalam Azad University of Technology (MAKAUT), West Bengal, India. I express my sincere thanks and deepest sense of gratitude to my guide for his constant support, unparalleled guidance and limitless encouragement.

I wish to convey my gratitude to Associate Prof. (Dr.) Debasish Mondal, HOD, Department of Electrical Engineering, RCCIIT and to the authority of RCCIIT for providing all kinds of infrastructural facility towards the research work. I would also like to convey my gratitude to all the faculty members and staffs of the Department of Electrical Engineering, RCCIIT for their whole hearted cooperation to make this work turn into reality.

DATE:

PLACE: KOLKATA

Soumalya Aich

SOUMALYA AICH

Diptesh Basu

DIPTESH BASU

Arkaprabho Chowdhury

ARKAPRABHO CHOWDHURY

Sumit Patra

SUMIT PATRA

NAME AND SIGNATURE OF STUDENTS

\

Department of Electrical Engineering
RCC INSTITUTE OF INFORMATION TECHNOLOGY
CANAL SOUTH ROAD, BELIAGHATA, KOLKATA – 700 015
Maulana Abul Kalam Azad University of Technology, West Bengal

CERTIFICATE

To Whom It May Concern

This is to certify that the project work entitled DESIGN OF ***DESIGN OF STEP-UP DC-DC BOOST CONVERTER USING MPPT ALGORITHM*** carried out by Soumalya Aich (11701617035), Diptesh Basu(11701617062), Arkaprabha Chowdhury(11701617070), Sumit Patra(11701618002) of B. Tech (EE) 8th Semester of 2021 Dept. of Electrical Engineering, RCC Institute of Information Technology (RCCIIT), Canal South Road, Beliaghata, Kolkata-700015, affiliated to Maulana Abul Kalam Azad University of Technology (MAKAUT), West Bengal, India, during the academic year 2020-21, in partial fulfillment of the requirements for the degree of Bachelor of Technology in Electrical Engineering and that this project has not submitted previously for the award of any other degree, diploma and fellowship.

Sarbojit Mukherjee
……………………………………

SIGNATURE OF GUIDE
NAME: Mr. Sarbojit Mukherjee
DESIGNATION: Asst.Professor

HoD, Dept. of EE
RCC Institute of Information Technology
Kolkata-700015
……………………………………

SIGNATURE OF HOD
NAME: Dr. Debasish Mondal,
DESIGNATION: Associate Prof,HOD

……………………………………

EXTERNAL EXAMINER

TABLE OF CONTENTS

Abstract

In this report we present a DC-DC Boost Converter based on coupled inductor with voltage multiplier cells for the purpose of getting higher voltage gain, low switch stress, ripple free output current and cost-efficient converters.

The shortage and environmental concerns of fossil fuel resources has accelerated the utilization of renewable energy sources. Power converters based on photovoltaic (PV) panels are among the most attractive energy sources. By reason of that, efficiency improvement of the systems fed by PV energy is deemed important. PVs have focused on minimize the costs and maximize the conversion efficiency. In order to maximize the efficiency of PV energy conversion systems, solar panels and arrays should be operated at maximum power points (MPP). At MPP, solar arrays generate the electric energy at maximum efficiency and minimum losses. Solar cells have variable current and voltage characteristics and MPP depends on solar irradiations and ambient temperature. So, a maximum power tracking control should be made rapidly in different temperature and solar radiation conditions. In this proposed solution, solar cell was obtained by using equivalent circuit of solar cell with Matlab / Simulink and by using this structure, a PV generator was designed which is not only used with boost dc / dc convertor but also used with MPPT (maximum power point tracking) unit. Besides due to its easy implementation, P&O (Perturb-Observe) which is the most common algorithm in PV systems, chosen the design of the MPPT.

1.Introduction

The shortage and environmental concerns of fossil fuel resources has accelerated the utilization of renewable energy sources in recent times the accelerated use and utilization of renewable sources of energy is due to the shortage and as well as the environmental concerns of fossil fuels. Power systems based on renewable sources of energy can be obtained from wind, fuel cells, and photovoltaic (PV) panels. Some of the mentioned sources feature low output voltages (PV panels and fuel cells) which need to be boosted to high voltage level for residential power systems. Therefore, power electronic converters are required in grid-connected systems to boost the output low voltage to a high voltage level [1].
Renewable energy like solar, wind, and fuel cells has gradually been recognized as a reliable and low-cost way to meet future energy demand, but raising higher demands on power electronics technology. In order to connect the grid from the renewable energy, high-step gain DC-DC converters are needed to boost lower dc voltages for feeding into grid-connected inverters. Due to renewable energy sources output voltage is low and fluctuating, front boost DC-DC converter is indispensable in grid-tied system. Clean energy such as photovoltaic, wind turbine and fuel cell, the output voltage is pretty low and fluctuate within a wide range. Thus, a front high boost DC-DC converter is necessary for grid-tied inverter to convert and deliver energy. By using passive components and semiconductor elements those are coupled inductor, filter capacitors, active switches and multiple diodes. With increasing number of coupled inductor diode-capacitor cells i.e., by using multi-cell concept, the voltage conversion ratio of proposed converter can be further increased. In addition, with the increased cell number, the voltage stress of semiconductors decrease and voltage gain increase quickly.

The conventional boost dc-dc converter has several issues such as power loss, the voltage drops across various devices, and the effects due to the inductor resistance when it tries to achieve the required voltage gain. The quality of operation and the conversion efficiency is affected by the high duty cycle of the semiconductor switch. The converter proposed in this paper has high-quality output and high gain by making a small modification in the conventional one. Another notable highlight of the proposed converter is its spike-free voltage and current waveforms. The conventional DC-DC converters (boost converter) produces large voltage ripples in multilevel converter systems. For that reason, in this paper, a new DC-DC converter topology is proposed, and the performance is analyzed. Since the proposed converter delivers high conversion efficiency, it can be selected for multilevel boost DC-DC converters. The output voltage ripples are reduced in the proposed converter. The theoretical analysis is presented in this paper, which speaks about the advantage of the proposed converter. The converter operation is analyzed and discussed in continuous conduction mode (CCM). The voltage gain of the proposed converter is higher than the conventional boost converter. The experimental result confirms the theoretical analysis. The proposed converter can be extended by connecting a greater number of voltage multiplier (VM) cells to get the desired multilevel output voltage. The proposed project work is therefore aimed to be carried out in the phases of determination of problem statement, study the scope and expected outcome, literature review, topology development, design, simulation & experimental verification (if condition permit) of laboratory prototype.

2.Review of Literature

As we know renewable sources of energy is the future of mankind, so almost each and every energy source on the planet has taken a turn towards green energy. We have prepared our project on this basis only.

Photovoltaic panel has the limitation of low single cell voltage, at the same time, those cannot be connected in series to achieve higher voltage level because of the reliability issues. This Issue of the Photovoltaic cell can be resolved by using a BOOST CONVERTER between the PV source and DC bus [2]. High voltage conversion ratio can be realized through diode-capacitor network and cascade structure. The switch-capacitor network boost technology has the advantage of high-power density and high conversion ratio. Isolated converter such as fly-back converter, push-pull converter, forward converter, bridge converters etc. overcome the above issues, where high voltage gain can be achieved by adjusting the transformer turns ratio [3].

In a PV system as shown, the DC-link capacitor provides the necessary power decoupling for single-phase inverter. The electrolytic capacitors used for power decoupling have high failure rate, the reliability of the PV unit is adversely affected. High operating temperatures and aging causes these capacitors to lose their filtering characteristics, thereby increasing the ripple at its terminals [7]. The idea of employing film capacitors instead of electrolytic type is suggested in [8]. However, film capacitors are large in volume and expensive, which makes their usage more economical only if the required capacitance for the system is significantly reduced. Reduction in the capacitor size will make the unit highly reliable but this would also result in the increase of double-line frequency ripple in the DC-link voltage. The DC-link voltage ripple resulted from the reduction of DC-link capacitor size causes third harmonic ripples in the AC grid current.

DC converters are widely used for traction motor control in electric automobiles, trolley cars, marine hoists, forklifts trucks, and mine haulers. They provide high efficiency, good acceleration control and fast dynamic response. They can be used in regenerative braking of DC motors to return energy back into the supply. This attribute results in energy savings for transportation systems with frequent steps. DC converters are used in DC voltage regulators; and also are used, with an inductor in conjunction, to generate a DC current source, specifically for the current source inverter.[24]

3.Formulation/Algorithm

The proposed DC-DC boost converter is a cascaded type coupled inductor in which the leakage energy in the leakage inductor is recycled using a passive voltage clamp, also as it is an initiative towards green energy, we have replaced the conventional DC Voltage source by a Solar panel.
The solar energy is converted to electrical energy, but to achieve high efficiency in this design we introduced a MPPT (Maximum Power Point Trace/Tracker) between the source and the converter.

3.1 Photovoltaic Cell:

As a result of environmental concerns, global warming caused by the emission of greenhouse gases, limited fossil fuel resources, and the hazards of nuclear energy, electrical generation systems powered by renewable energy resources have gathered so much attention as an alternative to conventional power plants [20], [21]. The energy produced by photovoltaic (PV) solar cells can be considered as the most important and essential renewable energy resource due to the affluence and sustainability of solar energy. These advantages have led to the rapid growth of installed capacity of solar power plants, which had reached at least 177 GW by the end of 2014 [22]. For instance, in Germany, with more than 1.5 million PV systems distributed all over the country, the energy policy is to approve an energy plan that intends to a 20% reduction in greenhouse gas emission before 2020 and attains a total installed PV capacity of 200 GW by 2050 [23]. Photovoltaic cells convert the sunlight into electricity directly [4]. Two categories of PV cells are used in most of today's commercial PV modules: crystalline silicon and thin film.
The crystalline silicon category, called first-generation PV, includes monocrystalline and multi-crystalline PV cells, which are the most efficient of the mainstream PV technologies. These cells produce electricity via crystalline silicon semiconductor material derived from highly refined poly-silicon feedstock. Mono-crystalline cells, made of single silicon crystals, are more efficient than multi crystalline cells but are more expensive to manufacture [5].
The thin-film category, called second-generation PV, includes PV cells that produce electricity via extremely thin layers of semiconductor material made of amorphous silicon (a-Si), copper indium diselenide (CIS), copper indium gallium diselenide (CIGS), or cadmium telluride (CdTe).
A single PV cell can be represented by a current source in parallel with a diode, a series resistance, and a shunt leakage resistance as shown in Fig. 1.1. The photo-generated current (I_g) is proportional to the solar insolation to which it is exposed. [6]

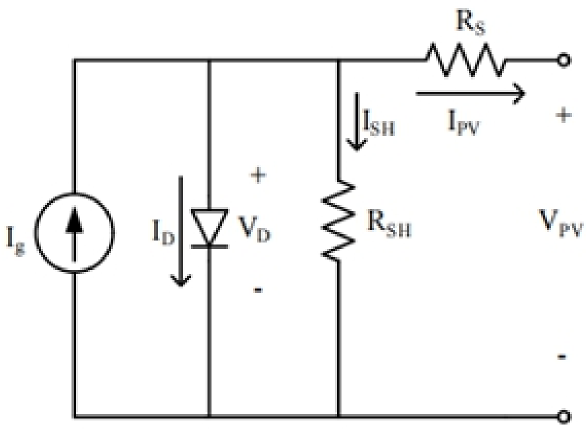


Figure 1. Electrical Equivalent of Single PV Cell

3.2 Maximum Power Point Tracking:

The production of electric power with the renewable energy is essential to meet the increasing future demand and decreasing generation resources. Among various renewable sources, the most popular are solar and wind generating plants. Due to the omnipresence of solar energy, its applicability is higher. The photovoltaic (PV) cells convert the radiations from the sun into electricity. A single cell cannot generate sufficient electricity. Therefore, these cells are connected with each other to form PV panels [new]. The electricity produced by these panels depends on the intensity of radiation falling on the panel and temperature of surroundings. The irradiance is fluctuating in nature and never remain constant. The V-I characteristics of PV panels are non-linear, and P-V characteristics show that for a particular irradiance only single maximum power point (MPP) exists. The variation in irradiance and temperature changes the value of current and voltage respectively. The operating point of PV panel depends on the load characteristics. The point at which load curve intersects the IV curve is the operating point of the system. The MPP vary with the variations in irradiance and temperature. The operating point also shifts according to changing climatic conditions. Thus, the operating point is not always the MPP but at some other point. If the system operating point deviates from the MPP there are more losses. Due to changing climatic conditions, the efficiency of PV system is not optimum [18][19].

Solar energy is freely available, abundant and sustainable in nature throughout the year and other resources are depleting. Solar energy is being converted to various forms such as heat, electricity etc. Solar panel has Photovoltaic (PV) arrays which directly converts light into electricity. The best PV cell has an efficiency of up to 30%. Hence output power is small for input that it takes. Therefore, panel is required to operate at its maximum power point (MPP) to achieve high efficiency. The output characteristics of PV module depends on the solar irradiance, temperature and output voltage of PV module. As the PV cell has nonlinear Current – Voltage (IV) and Power – Voltage (PV) characteristics, it is necessary to design a control circuit or algorithm so that the cell is tuned to operate at MPP irrespective of the load connected and external parameters variations such as illumination and temperature. The panel output characteristics are nonlinear in nature; therefore, it is necessary to model and simulate for use in PV system applications. In order to improve the output efficiency of PV system, a novel variable step size perturbation and observation P&O method is proposed to track the maximum power point of PV system.

The solar cell has the nonlinear output characteristics which are called IV and PV characteristics. These characteristics are the functions of illumination, temperature and output voltage of the PV module. So, the curve is nonlinear. Therefore, it is necessary to make the cell operate at its maximum power point so that it can be used for various PV system applications. Also, the nature of these curves determines the efficiency of the panel.

There are three important factors that determine the efficiency- Panel efficiency, converter efficiency and efficiency of MPPT algorithm. It is not easy to improve the efficiency of the panel and converter circuit. The best possible way to improve the overall efficiency is to design an efficient algorithm for tracking maximum power. Also, energy generated through the photovoltaic effect cannot be directly used for powering most electronic circuits.

Maximum Power Point Tracking is electronic tracking - usually digital. The charge controller looks at the output of the panels and compares it to the battery voltage. It then figures out what is the best power that the panel can put out to charge the battery. It takes this and converts it to best voltage to get maximum AMPS into the battery. So, our design helps in meeting the required power/Voltage be it anytime of the year and maintains optimum power supply.

MPPT's are most effective under these conditions:

Winter, and/or cloudy or hazy days - when the extra power is needed the most.

- Cold weather - solar panels work better at cold temperatures, but without an MPPT you are losing most of that. Cold weather is most likely in winter - the time when sun hours are low and you need the power to recharge batteries the most.
- Low battery charge - the lower the state of charge in your battery, the more current an MPPT puts into them - another time when the extra power is needed the most. You can have both of these conditions at the same time.
- Long wire runs - If you are charging a 12-volt battery, and your panels are 100 feet away, the voltage drop and power loss can be considerable unless you use very large wire. That can be very expensive. But if you have four 12-volt panels wired in series for 48 volts, the power loss is much less, and the controller will convert that high voltage to 12 volts at the battery. That also means that if you have a high voltage panel setup feeding the controller, you can use much smaller wire.

At different sun conditions, the short-circuit current Ig varies, which gives different I-V curves for different solar irradiation conditions. Fig. below shows the I-V curve at different irradiation conditions of sun. The maximum solar irradiation 1000 W/m2, the sun condition is said to be 1.0 sun.

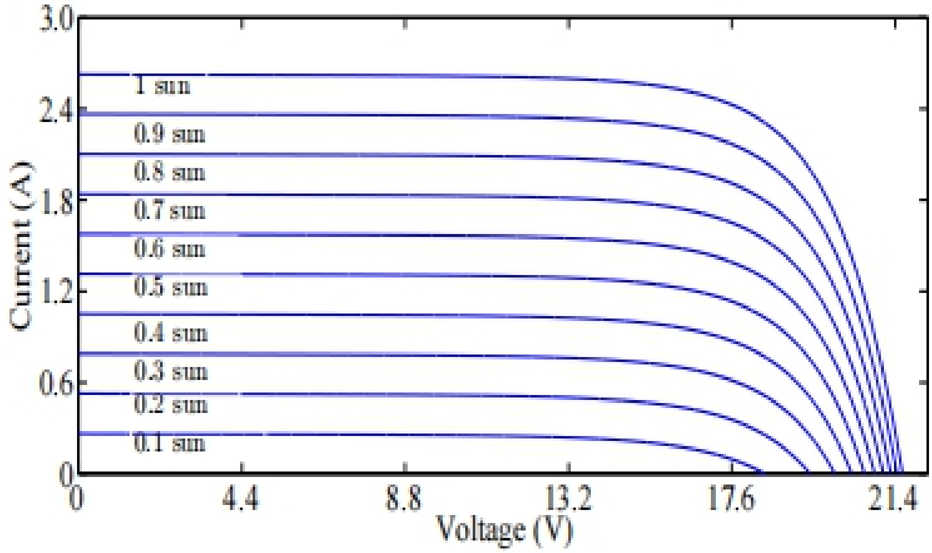


Figure 2. Solar Cell I-V Curve in Varying Sunlight

4.Implementation Details

If the output power is plotted with the output voltage for a given sun condition, a particular combination of voltage and current results in the maximum power [6].

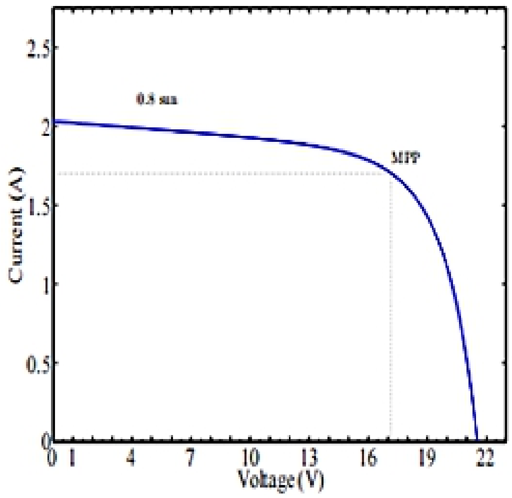


Figure 3.1 I-V Curve Solar Panel Production

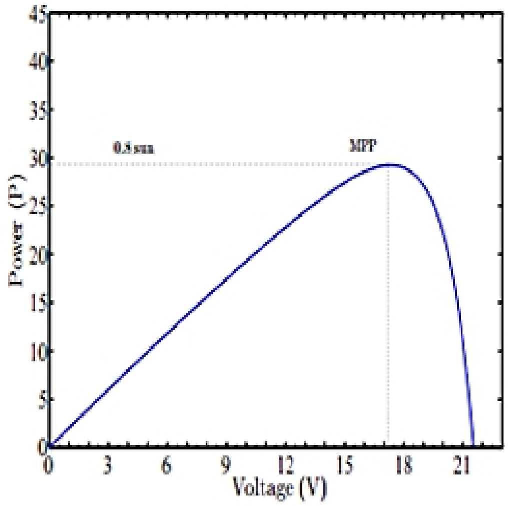


Figure 3.2 P-V Characteristics Curve For MPPT

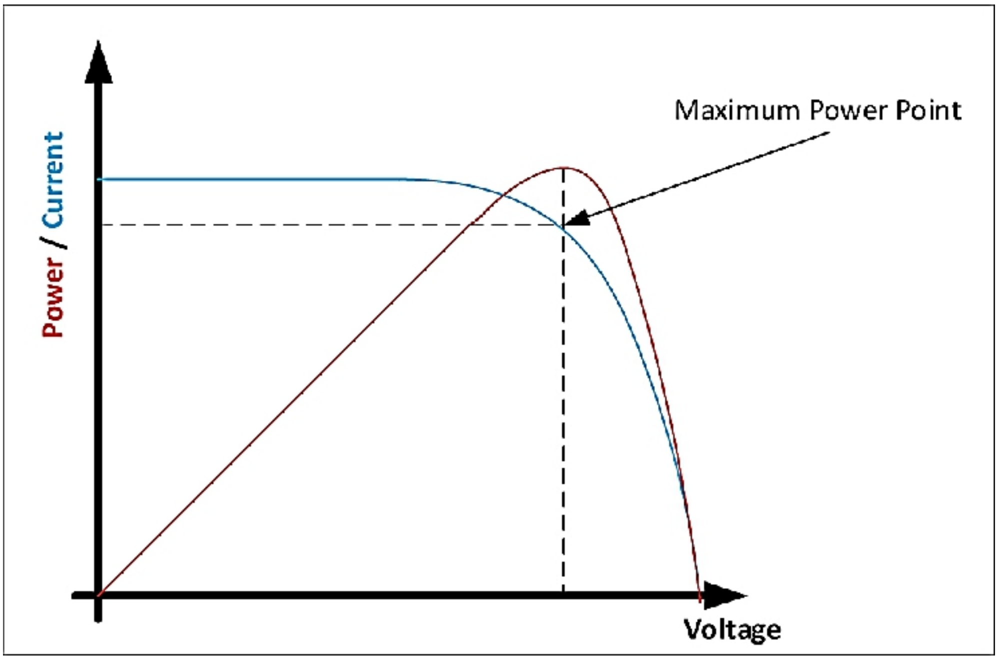


Figure 3.3 Maximum Power Point of a PV Array

It is observed from given figure that the maximum power is 29.18 W. The voltage corresponding to 29.18 W is 17.1 V. The current corresponding to 17.1 V on the I-V curve is 1.70 A. Hence, the MPP on the I-V curve is at coordinates (17.1, 1.70). Observing the location of MPP, it can be inferred that the MPP lies on the knee of the I-V curve.

Photovoltaics (PV) is one of the emerging solar technologies. As the price of the PV systems are high, extraction of the maximum available energy is necessary for early payback. The power conditioning unit converts the DC input power into AC output power and also make the PV system operate at the MPP in order to maximize the output power. The PV power conditioning units (PCU) are categorized based on the number of power stages. The PCU can use a single-stage or a two-stage topology. The future technology primarily focuses on the two-stage topology, where a DC-DC converter is connected in between the PV modules and the DC-AC inverter.

Solar Power Conditioning unit (PCU) is an integrated system consisting of a solar charge controller, inverter and a Grid charger. It provides the facility to charge the battery bank through either a Solar or Grid/DG set. The PCU continuously monitors the state of battery voltage, solar power output and the load. Due to constant usage of power, if the battery voltage goes below a set level, the PCU will automatically transfer the load to the Grid/DG power and also charge simultaneously. The PCU always gives preference to the solar power and will use Grid/DG power only when the solar power / battery charger is unable to meet the load requirement.

Benefits of a Solar PCU:

1. Can Run without a Solar Panel

You can power a solar PCU with or without a solar panel. You can either use it as a standard inverter without needing to bother about using solar power. And whenever you feel solar power would be more beneficial, all you need to do is install a solar panel.

2. Easy to Install and Economical

Solar PCUs are easy to install, affordable, and can also help reduce your electricity bills. It thus ensures that the user gets double the benefit.

3. Standalone Operation

Compared to a solar inverter, the solar PCU can run with or without Grid Power. The Solar PCUs can be used without connection with Grid. So, while inverters can be used only with Grid, PCUs work with grid too.

4. In-depth Information Display

When using a solar inverter, you will have limited access to information. Whereas, when it comes to a solar PCU, you have access to detailed information such as charging status, remedial actions required, load level, battery level, etc.

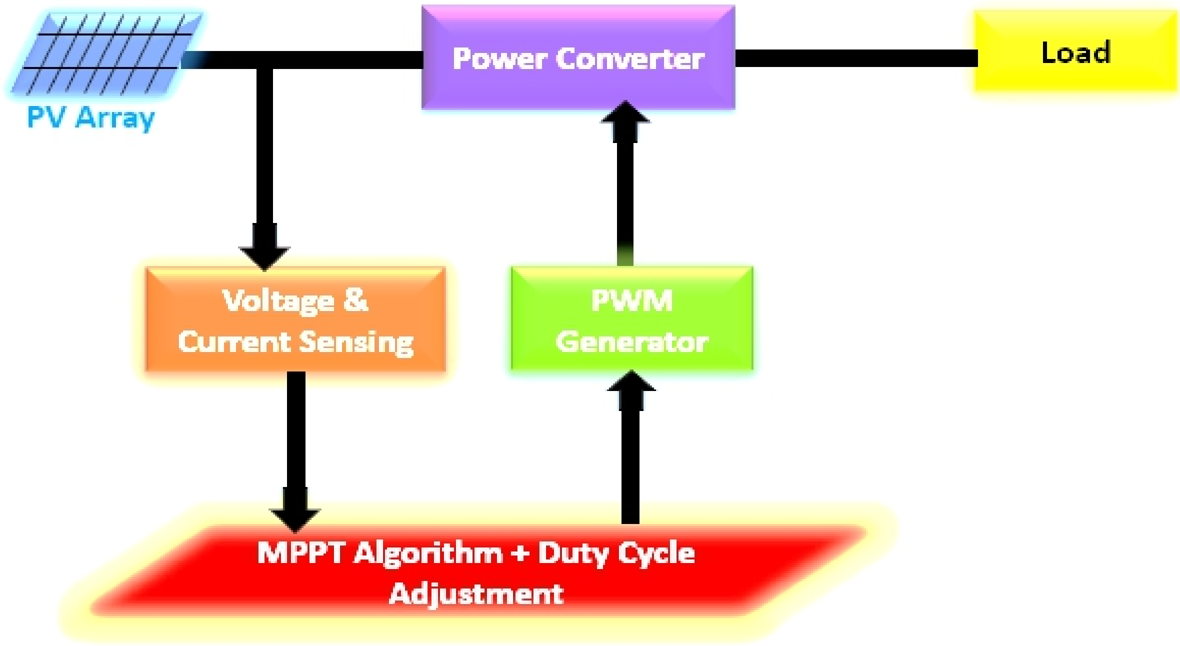


Figure 4. Implementation Strategy (Block Diagram)

4.1 DC-DC Boost Converter:

The role of the DC-DC boost converter is to boost the PV source voltage in order to extract maximum power from the PV array. Fig. 1.8 shows the circuit diagram of a DC-DC boost converter. A DC-DC boost converter consists of an inductor L, a diode D, a controllable switch Q (a MOSFET or IGBT), and a filter capacitor C. The switch is switched at a high frequency with a certain duty cycle. During the on-period the voltage across switch, VSW will be equal to the input DC voltage V_{in}. When the switch is OFF the inductor current follows through the diode which makes V_{sw} equal to V_0 . At steady state the average voltage across the inductor must be zero and the equation will be

$$V_{in}t_{on} + (V_{in} - V_0)t_{off} = 0 \quad (1)$$

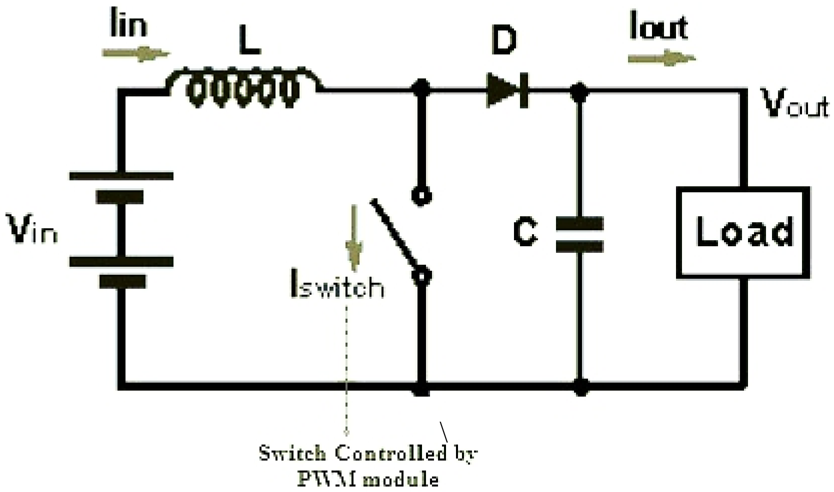


Figure 5. Boost Converter

A Boost converter is utilized as the voltage increment instrument in the circuit known as the 'Joule thief', which is a circuit topology utilized with low power battery applications, and is purposed at the capacity of a lift converter to 'take' the leftover energy in a battery. The energy remaining would somehow or another be squandered since the low voltage of an almost exhausted battery makes it's anything but a heap. The excess energy would some way or another stay undiscovered in light of the fact that numerous applications don't permit sufficient current to move through a heap when voltage corrupts. This happens as batteries are debased, and is an attribute of a typical battery. [16][17].

There is a scope of employments for a DC-DC support converter. Explorers need to convey such gadgets at the point when they need to bring gadgets from home and the inventory of current in a far-off country contrasts from that which is available at their home Sometimes only a plug converter is required, but in other cases, plugging electronics directly into the power supply could damage the devices. A boost converter provides a bridge to allow travellers to access electricity safely. Such devices are also used with systems that require high voltage, ranging from theatrical
lighting to scientific apparatus. The boost converter may in some cases be wired directly into the
electrical supply because of a permanent requirement. In different occasions, it becomes important to connect the gadget as required, particularly on account of voyaging hardware like that utilized by groups on the shows. Similarly, as with other electrical gadgets, it is fitting to assess a lift converter before use to affirm it is inacceptable working condition and to check for any issues that may disable functionality or safety. [4]

In our proposed project we have planned a dc-dc boost converter with the MMPT algorithm to keep up with undeniable level out [put paying little heed to the climate or some other state of being.

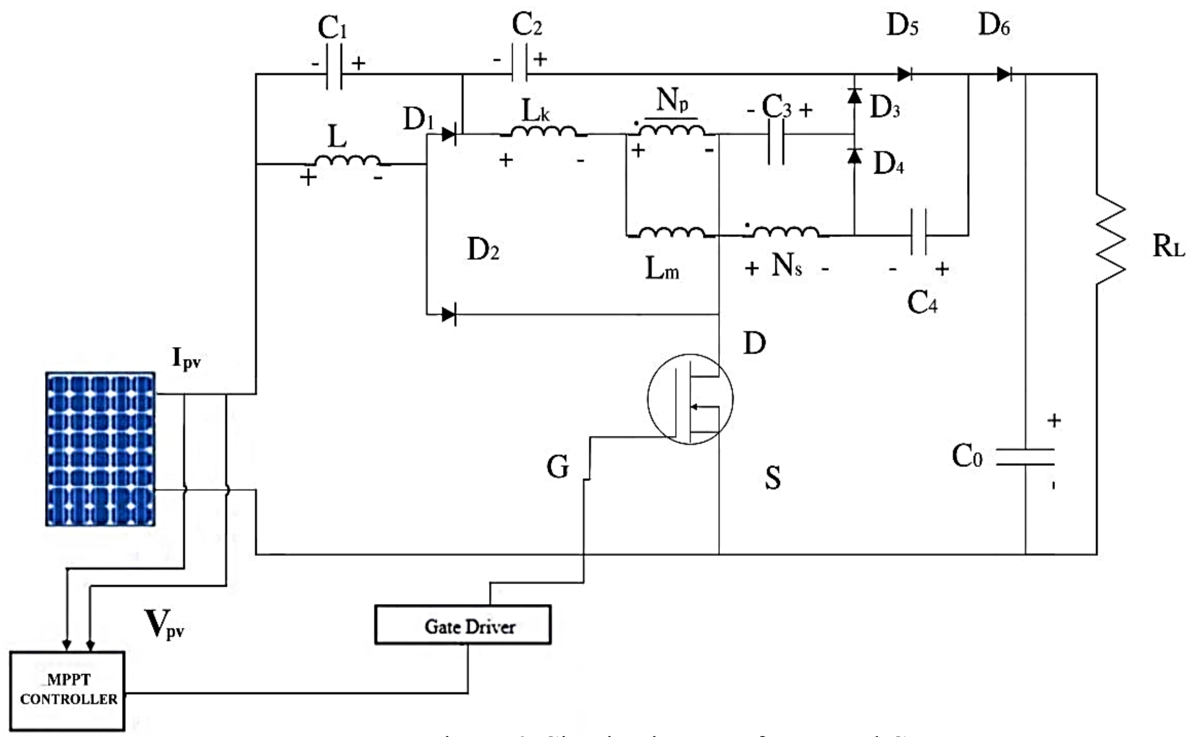


Figure 6. Circuit Diagram of Proposed Converter

4.2 Working Principle Of Boost Converter:

1. <u>(0<t<DT) (Turn ON mode)</u>

When the switch is closed diodes D2,D5 and D1,D3.D4,D6 are in forward biased and reversed biased respectively. In this time interval L,Lk are charged by the input source and store some energy. Capacitor C4 is charged by the secondary side current of the coupled inductor and the energy is stored in the capacitors C1 and C2. Initially capacitors C1,C2 and C4 are charged as

because before closing the switch inductors deliver some amount of energy. After closing the switch polarity of capacitors gets reversed and acts as a voltage source for the remaining circuit. For that reason, the output capacitor provides energy to the load. This mode ends by turning the switch S off.

During Mode 1, the switch is on and the input DC source charges inductor,by applying KVL,getting equations

$$V_L = V_1 \qquad (1)$$

$$\left(L\,\frac{di_L}{dt}\right)DT = V_1DT \qquad (2)$$

By applying KCL, getting equations

$$I_L + I_{C_1} + I_{C_4} = I_1 \quad \textbf{(3)}$$

$$\left(L\frac{di_L}{dt}\right)DT + \left(C_1\frac{dV_L}{dt}\right)DT + \left(C_4\frac{dV_1}{dt}\right)DT = I_1 \quad \textbf{(4)}$$

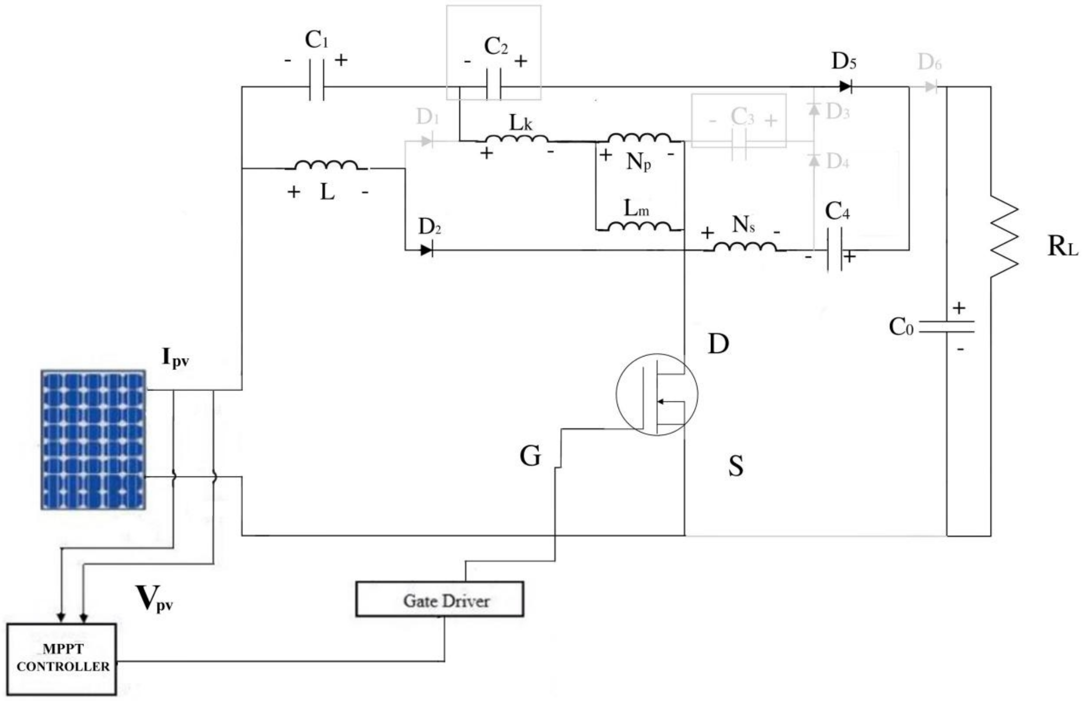


Figure 7.1 Circuit Diagram During Turn ON Mode

2. DT<t<T (Turn OFF mode):

When the switch is open diodes D1,D3,D6 and D2,D4,D5 are in forward biased and reversed biased respectively. The leakage inductor current is decreased manually and demagnetized to capacitor C2 through diode D3. The secondary side current of the coupled inductor flows through diode D6 and charges the output capacitor. Capacitors C3 and C4 are discharged to capacitor C2 and the output capacitor, respectively. This mode ends when diode S is turned off.

The voltage across inductor L in Modes 2

$$V_L = -V_{C_1} \quad \textbf{(5)}$$

$$\left(L\frac{di_L}{dt}\right)(1-D)T = -V_{C_1} \quad \textbf{(6)}$$

By applying KCL at node, getting equation

$$I_L(1-D)T = C_4\frac{dV_1}{dt}(1-D)T + C_0\frac{dV_1}{dt}(1-D)T + \frac{V_0}{R_L}(1-D)T \quad (7)$$

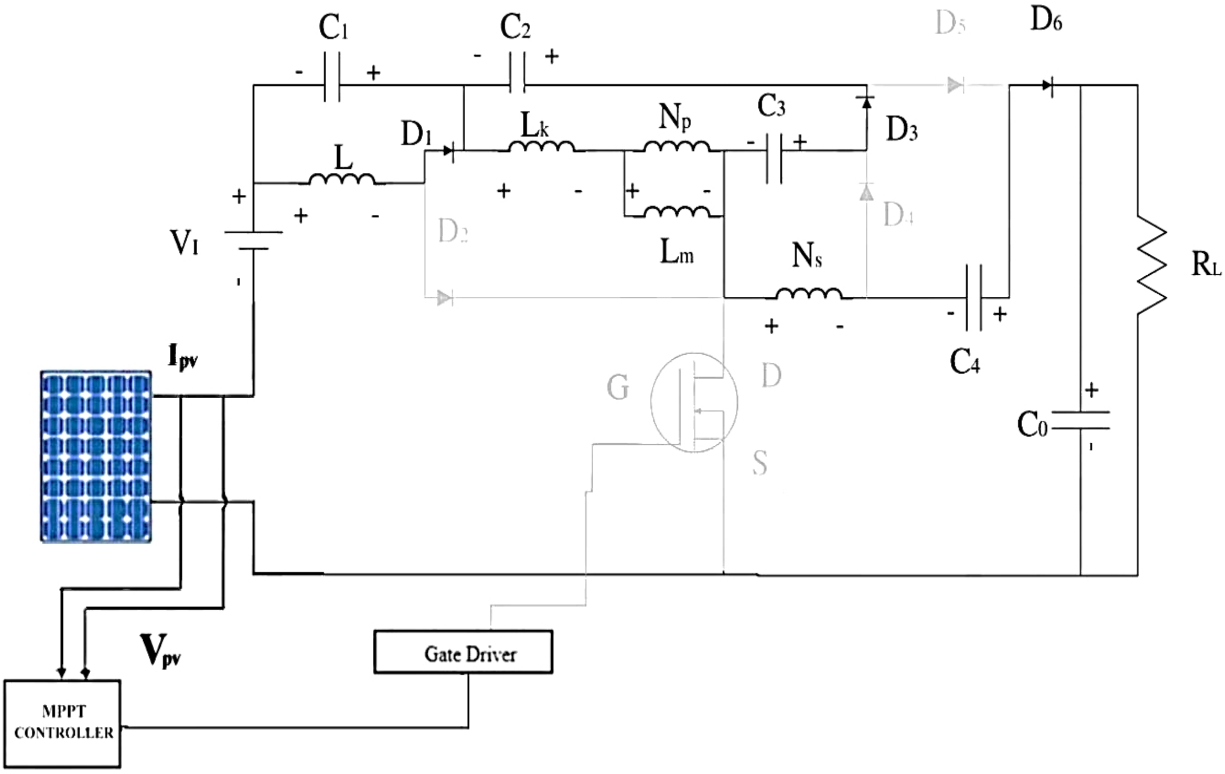


Figure 7.2 Circuit Diagram During Turn OFF Mode

4.3 Working Principle Of Maximum Power Point Tracking:

To reap greatest force from the PV board an accuse regulator of MPPT capacity is proposed in this paper. The two general classes of MPPT procedures are the circuitous methods and direct strategies. Roundabout procedures incorporate the fixed voltage, open circuit voltage and short out current strategies. In this sort of following, straightforward suspicion and intermittent assessment of the MPPT are made with simple estimations. For instance, the fixed voltage strategy just changes the working voltage of the sun-oriented PV module at various seasons with the supposition of higher MPP voltages in winter and lower MPP voltages in summer at a similar illumination level. This technique isn't exact a direct result of the changing of light and temperature level inside a similar season. [9]

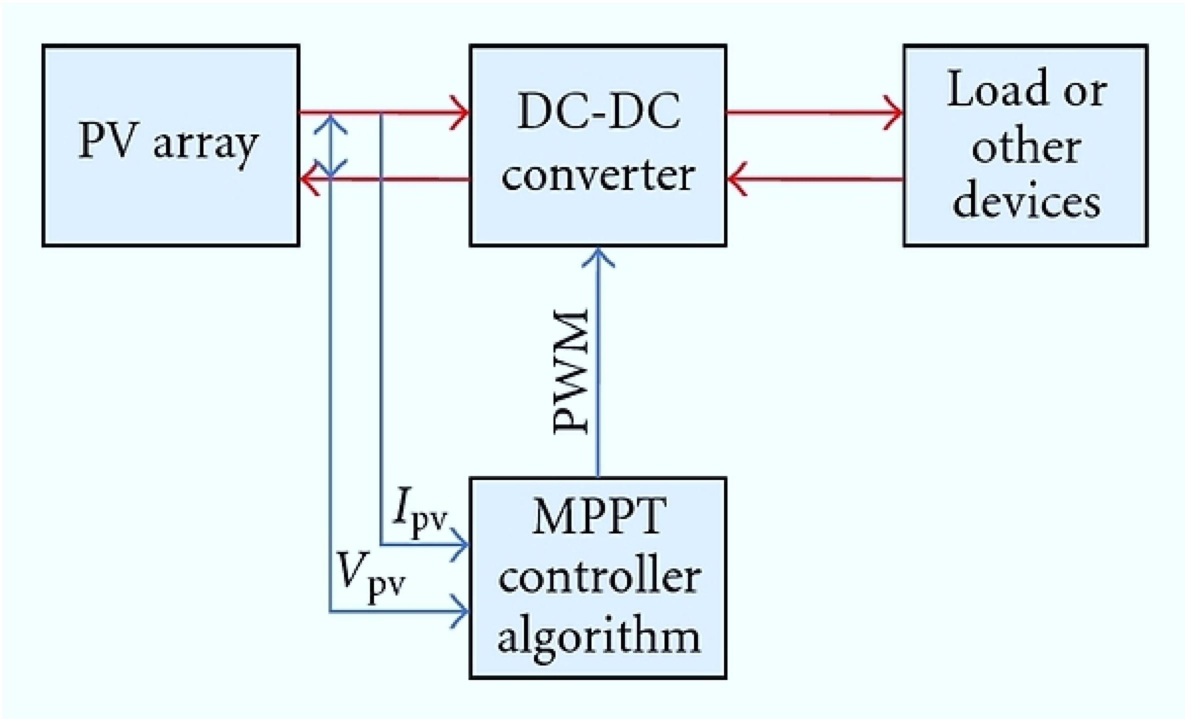


Figure 8. Working Principle of MPPT Controller Algorithm

Another most normal backhanded MPPT procedure is the open circuit voltage (OV) strategy. In this technique, it is expected to be that:

$$V_{MMP} = k * V_{OC}$$

Where k is a constant and its value for crystalline silicon is usually to be around 0.7 to 0.8. This technique is simple and is easier to implement compared to other techniques.

However, the constant k is just an approximation Leading to reduced efficiency, and each time the system needs to find the new open circuit voltage (Vout) when the illumination condition changes. To find the new open circuit voltage, each time the load connected to the PV module must be disconnected causing power loss. Direct MPPT methods measure the current and voltage or power and thus are more accurate and have faster response than the indirect methods. Perturb and observe (P&O) is one of the direct MPPT techniques, which is used here with some modifications.

4.4 Perturb and observe algorithm (P&O):

The most commonly used MPPT algorithm is P&O method. This algorithm uses simple feedback arrangement and little measured parameters. In this approach, the module voltage is periodically given a perturbation and the corresponding output power is compared with that at the previous perturbing cycle. In this algorithm a slight perturbation is introduce to the system. This perturbation causes the power of the solar module various. If the power increases due to the perturbation, then the perturbation is continued in the same direction. After the peak power is reached the power at the MPP is zero and next instant decreases and hence after that the perturbation reverses. When the stable condition is arrived, the algorithm oscillates around the peak power point. In order to maintain the power variation small, the perturbation size is remaining very small. The technique is advanced in such a style that it sets a reference voltage of the module corresponding to the peak voltage of the module. A PI controller then acts to transfer the operating point of the module to that particular voltage level. It is observed some power loss due to this perturbation also the fails to track the maximum power under fast changing atmospheric conditions. But remain this technique is very popular and simple.

Typically, P&O method is used for tracking the MPP. In this technique, a minor perturbation is introduced to, cause the power variation of the PV module. The PV output power is periodically measured and compared with the previous power. If the output power increases, the same process is continued otherwise perturbation is reversed. In this algorithm perturbation is provided to the PV module or the array voltage. The PV module voltage is increased or decreased to check whether the power is increased or decreased. When an increase in voltage leads to an increase in power, this means the operating point of the PV module is on the left of the MPP [10]. Hence further perturbation is required towards the right to reach MPP. Conversely, if an increase in voltage leads to a decrease in power, this means the operating point of the PV module is on the right of the MPP and hence further perturbation towards the left is required to reach MPP. The flow chart of the adopted P&O algorithm for the charge controller is given in Fig. 5. When the MPPT charge controller is connected between the PV module and battery, it measures the PV and battery voltages. After measuring the battery voltage, it determines whether the battery is fully charged or not. If the battery is fully charged (12.6 V at the battery terminal) it stops charging to prevent battery over charging.

If the battery is not fully charged, it starts charging by activating the DC/DC converter. The micro-controller will then calculate the existing power $\boldsymbol{P_{new}}$ at the output by measuring the voltage and current, and compare this calculated power to the previous measured power $\boldsymbol{P_{Old}}$. If $\boldsymbol{P_{new}}$ is greater than $\boldsymbol{P_{Old}}$, the PWM duty cycle is increased to extract maximum power from the PV panel. If $\boldsymbol{P_{new}}$ is less than $\boldsymbol{P_{Old}}$, the duty cycle is reduced to ensure the system to move back to the previous maximum power. This MPPT algorithm is simple, easy to implement, and low cost with high accuracy [10,11,12]

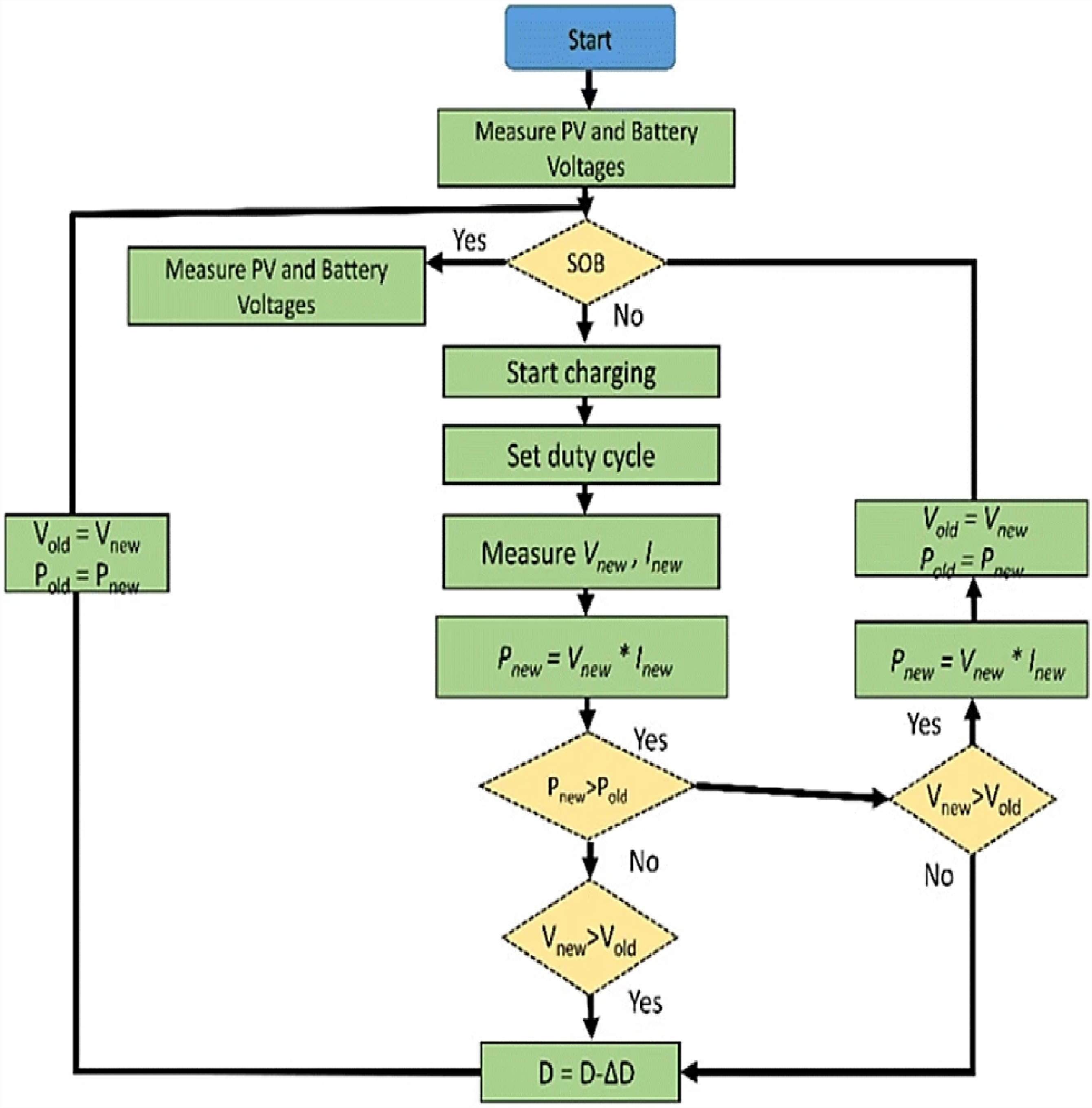
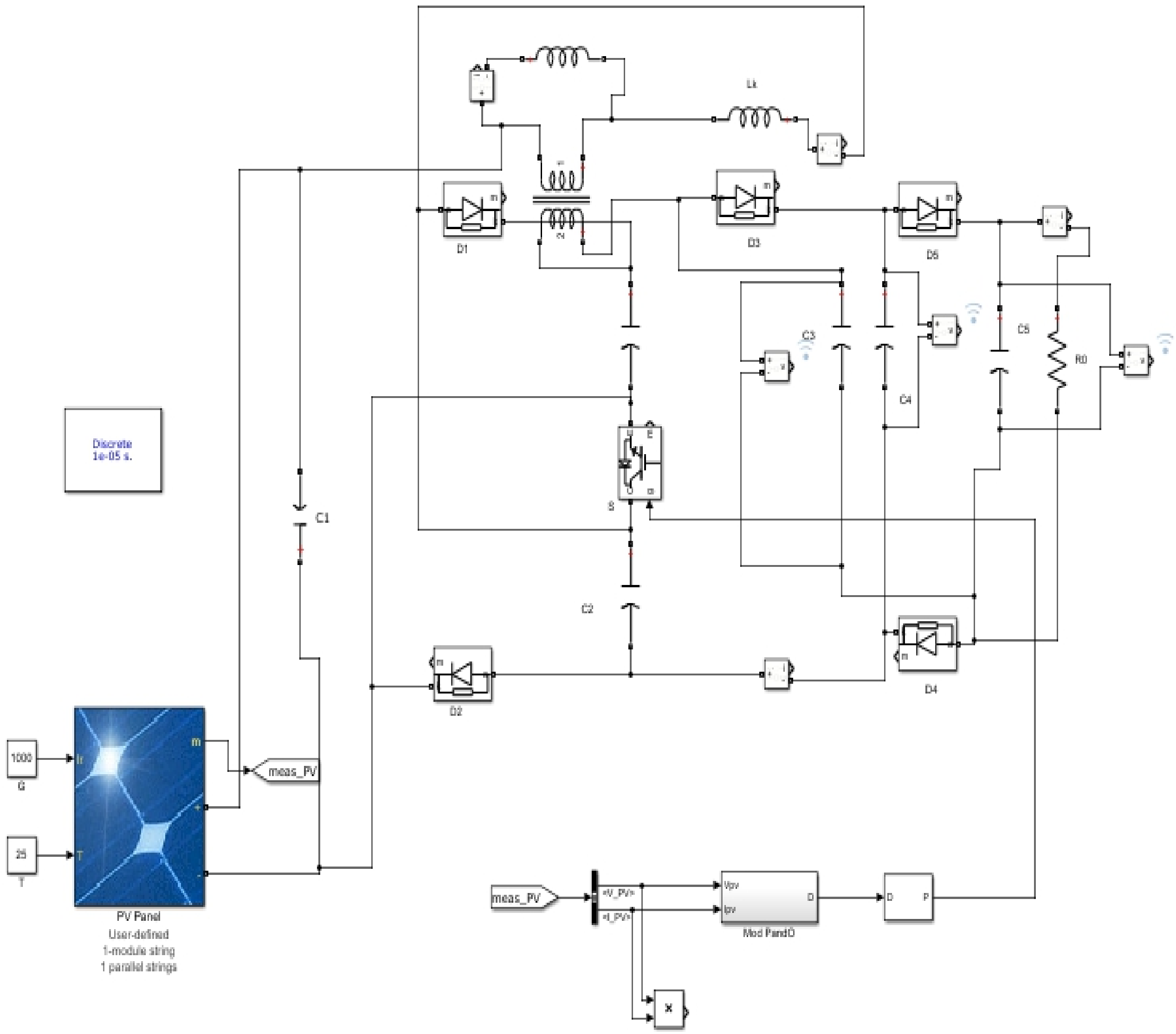


Figure 9. Flow Chart For MPPT Algorithm

5.Software Implementation of Problem

The implementation of this problem was done using MATLAB SOFTWARE



5.1 Datasheet for Simulation Results

COMPONENTS	VALUES
Capacitor(C1)	1000µF
Capacitors(C2-C4)	300µF
Capacitor(C5)	350µF
Resistor(R)	300Ω
Leakage Inductor (Lk)	2µH
Inductor(L)	400µH
Turns Ratio(n)	3
Switching Frequency	5KHz
PV Array	✓ Max. Power: 160(W) ✓ Open Ckt. Voltage: 48(V) ✓ Voltage at Max. Power Point: 48(V) ✓ Short Ckt. Current: 5(A) ✓ Cells Per Module: 36(Nell)

Table 1. Datasheet for Simulation Results

6.Sample Output

6.1 Output Voltage(V) & Current(I) vs Time(sec) Graph

- As shown in the fig. output voltage is nearly equals to 230V at the time of steady state whereas output current is 0.75A. To analyse output waveforms, we have defined two different states those are Transient State and Steady State. In order to get fast response (Damping Factor(ζ) is nearly equals to 1) all, the closed loop poles are real in nature for that reason Time Constant (Tcritically) decreases hence Settling Time for the system (Ts) also decreases.

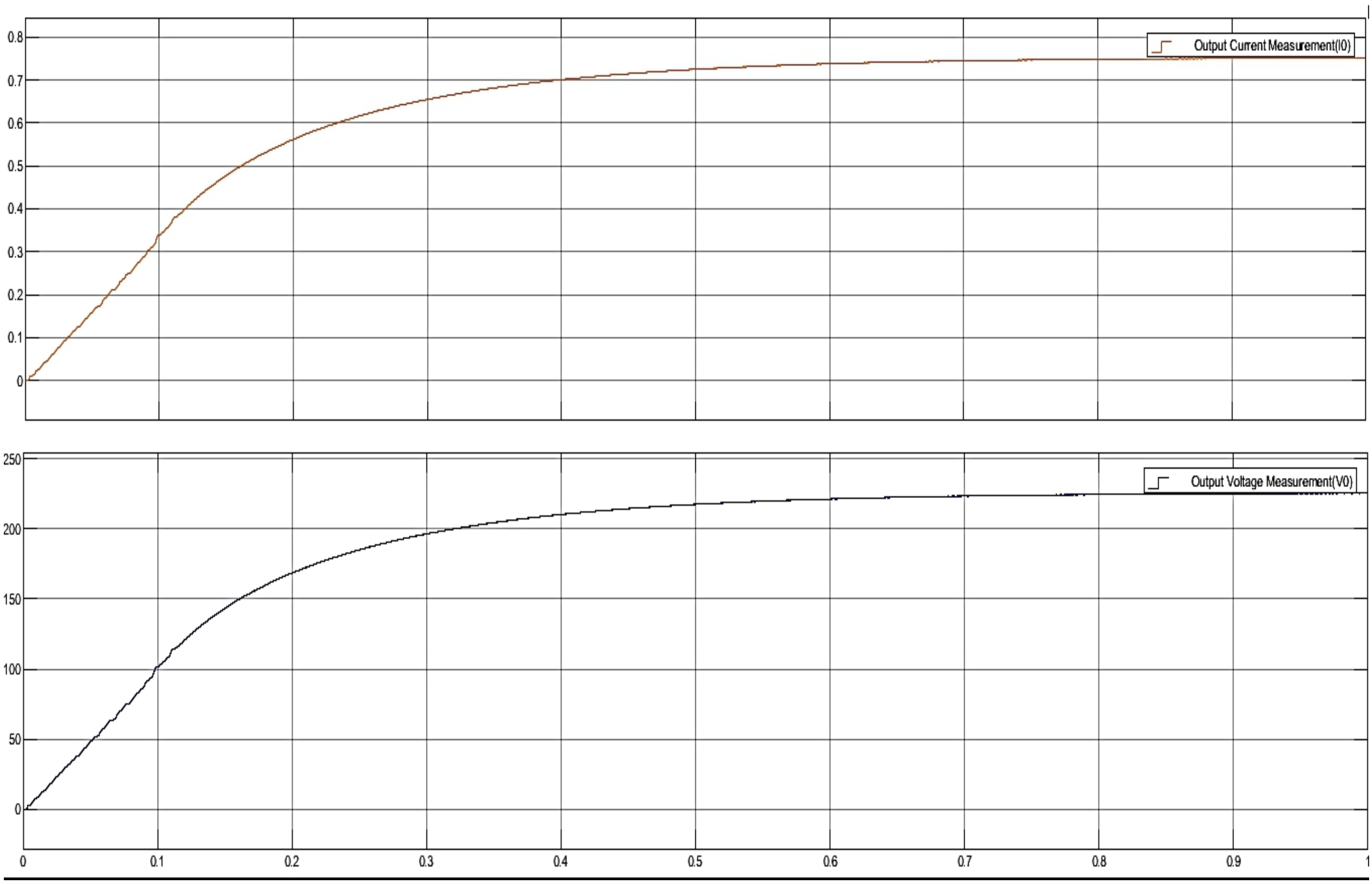


Figure 10.1 Output Current Waveform
Figure 10.2 Output Voltage Waveform

6.2 Input & Output Power vs Time Graph

- The power quality injected into the grid and the performance of the converter system depend on the quality of the input power control. As shown in the fig. output power for the PV panel has the undershoot and there are multiple maxima which makes the closed loop system unstable by the addition of unexpected Imaginary Poles in the system (Roots are Complex Conjugate in nature) and the system becomes Undamped. In order to overcome such dubious situation, we have integrated MPPT technique and as a result the input power for the buck-boost converter has a smooth characteristic at the time of both steady state as well as Transient State.

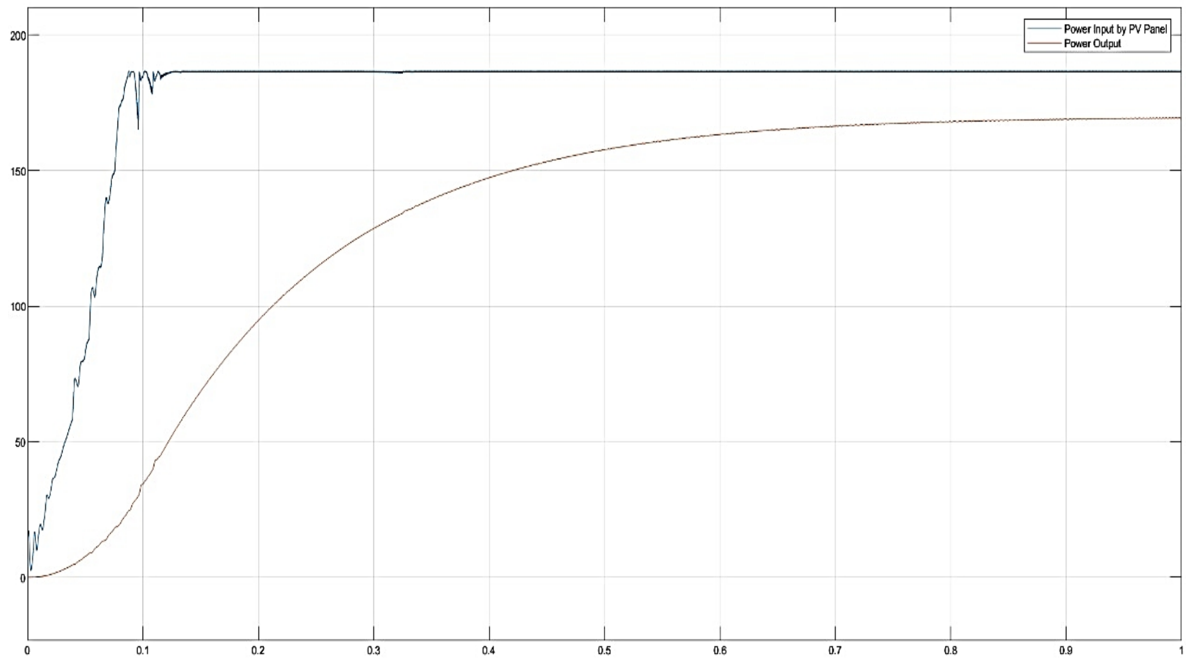


Figure 11. Power Input & Output Characteristics

6.3. Capacitor Voltages(V) vs Time(sec) Graph

- Capacitor voltage characteristics are depicted at the time of Steady State. As shown in the fig. output voltage is nearly equals to 230V at the time of steady state whereas input voltage for the buck-boost converter is 48V. A voltmeter is connected across the load side (Capacitor) in order to get output voltage from the system.

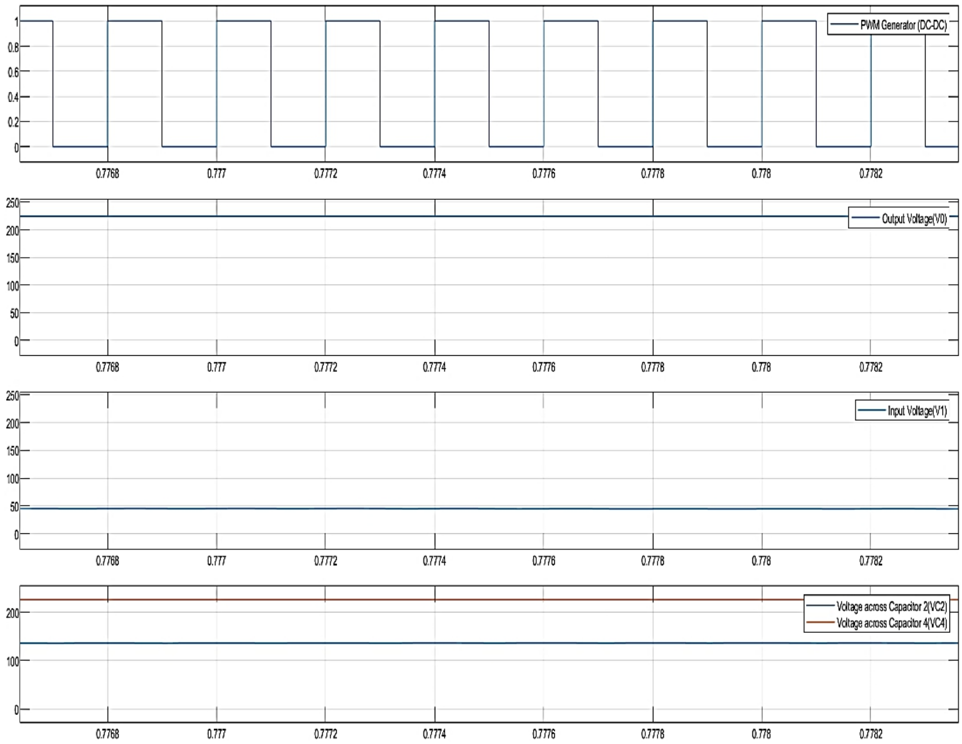


Figure 12. Capacitor Voltage Characteristics at the Time of Steady State

6.4 Leakage Inductor current vs Time Graph

- The leakage currents are dependent on gate triggering pulse for the converter. At the instant the gate pulse is applied to IGBT switch, the current is at its peak. The occurrence of this peak current depends on the forming characteristics of gate pulse and the internal resistance of the source of voltage.

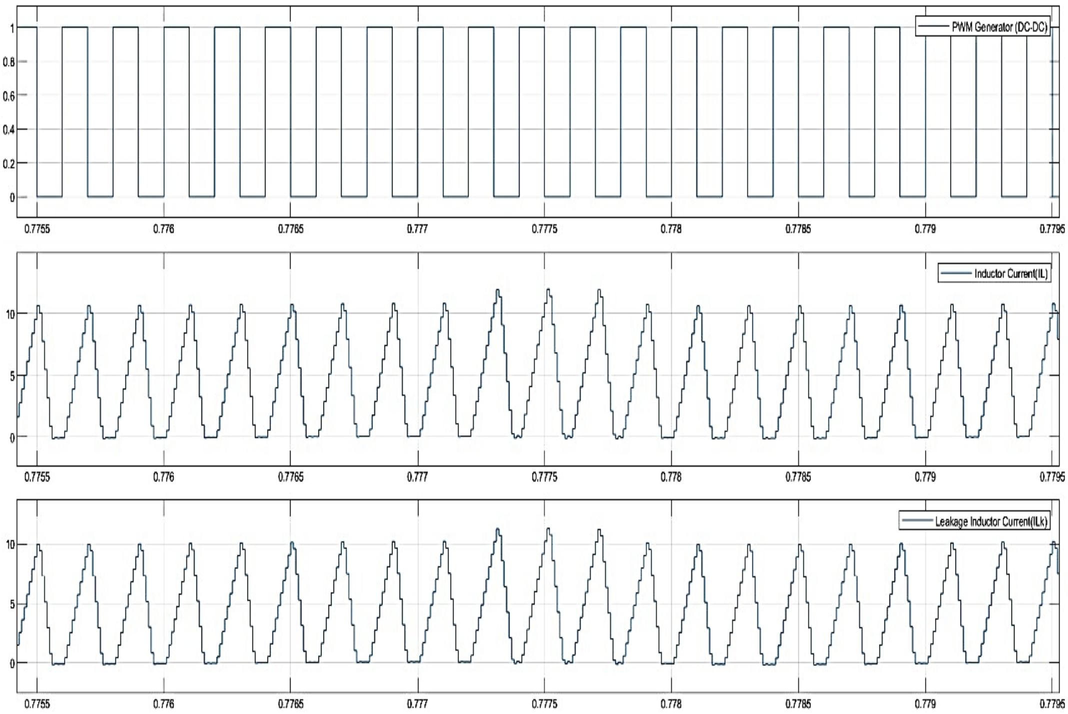


Figure 13. Inductor Current Characteristics

6.5 Transformer Primary & Secondary Side Current(I) vs Time

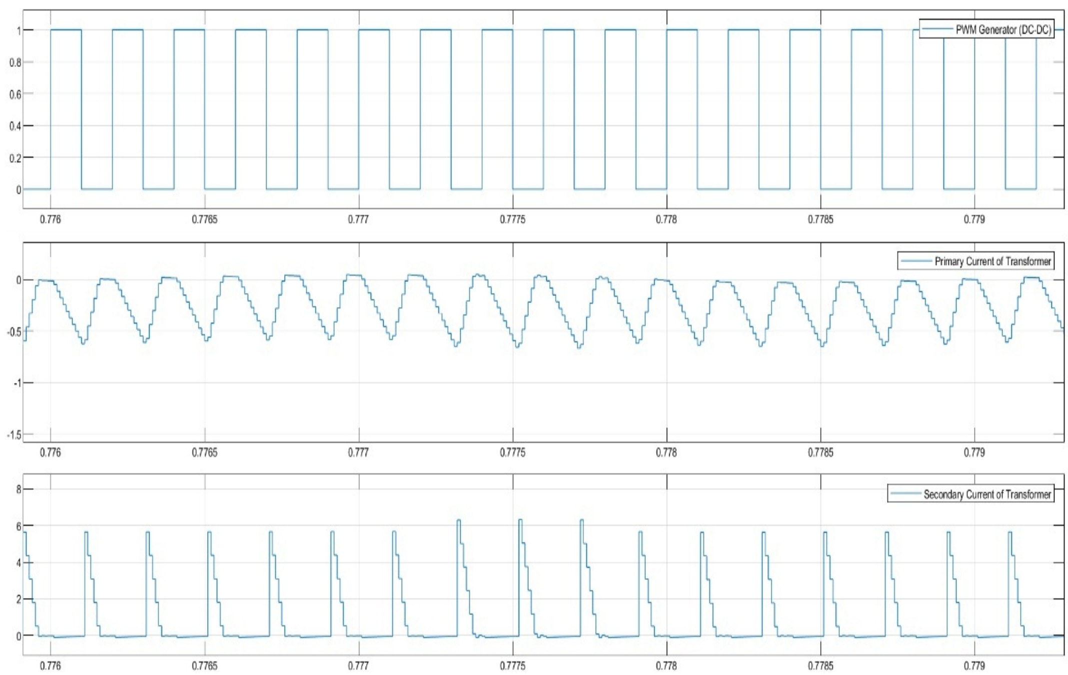


Figure 14. Transformer's Primary & Secondary Side Current Characteristics

6.6 Diode Currents(I) vs Time (Sec)

- Diodes are performed switching and digital logic operations. Whenever diodes are in Forward Biased mode ideally it can be considered as short circuit, the voltage across the diodes have some finite value but ideally current is zero, when diodes are in Reverse Biased mode ideally it can be considered as open circuit, the voltage across the diodes is zero and current have some finite value, as shown in the fig. the current is at its peak when they are operated in Forward Biased mode and when there is no peak current available that means they are operated in Reversed Biased mode.

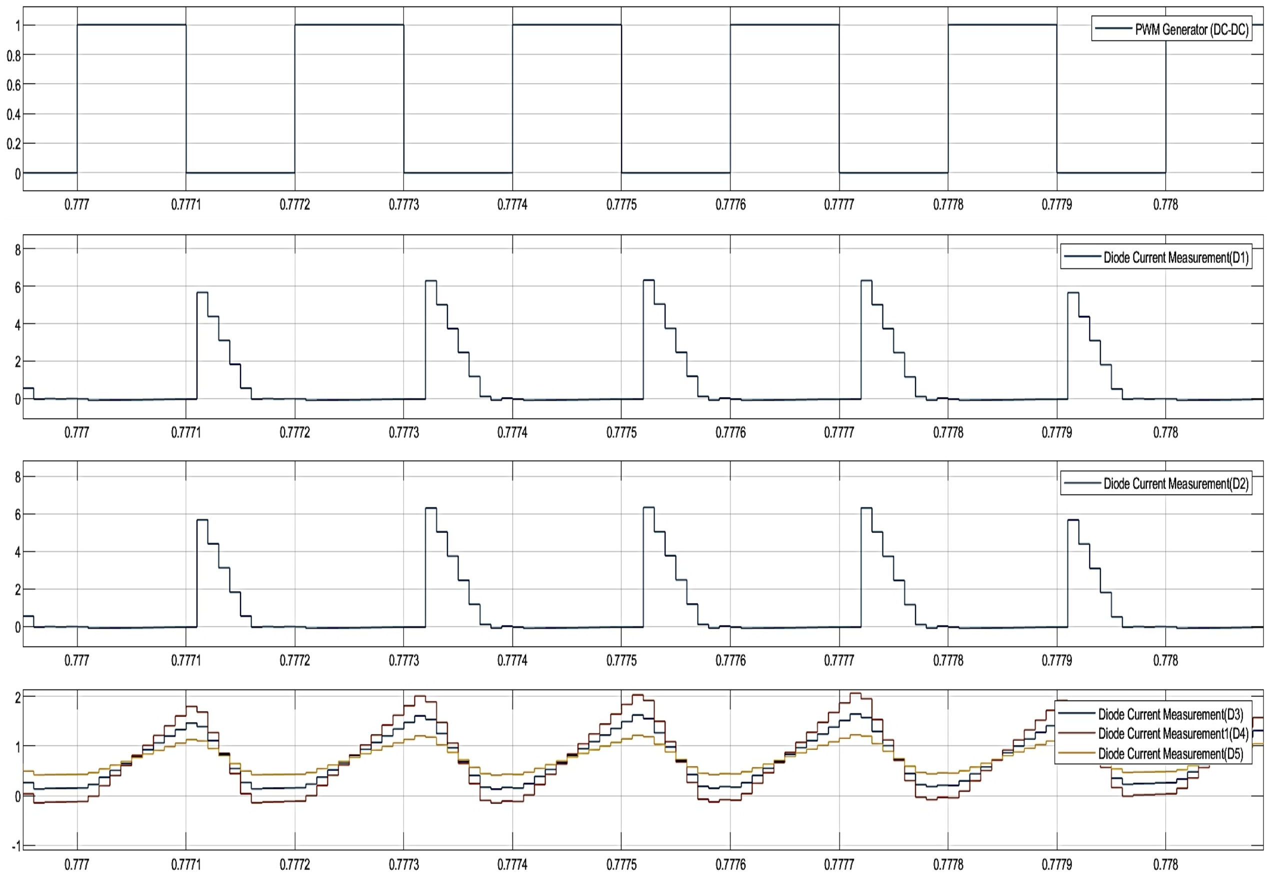


Figure 15.1 Gate Triggering Pulse
Figure 15.2 Diode D1 Current Characteristics
Figure 15.3 Diode D2 Current Characteristics
Figure 15.4 Diodes D3,D4,D5 Current Characteristics

7.Conclusion

In this paper, a High Gain Step-Up DC-DC converter with SPV-MPPT Controller is proposed. The first stage of the converter is integrated with PV Array. The second stage is a high step-up converter with voltage multiplier cells. The output of the first stage and the input source together are the input of the second stage. To track the MPP of PV module, Conventional P&O and MPPT algorithms have been used. Besides, the blocking voltage across the main IGBT switch is reduced in this structure with voltage clamp circuit. Thus, a low on-resistance (RDS-on) switch could be used which decreases conduction loss. The steady-state analysis of the proposed converter is presented in the paper. Finally, the buck boost converter is designed and simulated using MATLAB/SIMULINK.

The future scope for this project can be the design of circuit in micro grid system and use of step up boost converter in electric vehicle charging stations.

8.Reference

1) A. E. Khosroshahi, L. Wang, H. Dadashzadeh, H. Ardi, A. Farakhor, and A. M. Shotorbani, "A Two-Stage Coupled-Inductor-Based Cascaded DC-DC Converter with a High Voltage Gain," *2019 IEEE Can. Conf. Electr. Comput. Eng. CCECE 2019*, pp. 1–5, 2019, doi: 10.1109/CCECE.2019.8861768.
2) M. Sahoo and S. Kumar K, "High gain step up DC-DC converter for DC micro-grid application," *2014 7th Int.Conf. Inf. Autom. Sustain. "Sharpening Futur. with Sustain. Technol. ICIAfS 2014*, 2014, doi: 10.1109/ICIAFS.2014.7069600.
3) A. Ghosh, "Nonlinear Modeling and Bi / ureations in Switehed Power-Faetor-Correetion Boost Regulator," no. I, pp. 517–522, 2013.
4) C. Honsberg and S. Bowden, "Pv cdrom," 2012. [Online].
Available: http://www.pveducation.org/pvcdrom/solar-cell-operation/solar-cell-structure
5) S. Price, "2008 solar technologies market report," 2010. [Online].
Available: http://www1.eere.energy.gov/solar/pdfs/46025.pdf
6) A MAXIMUM POWER POINT TRACKING TECHNIQUE FOR SINGLE-PHASE PHOTOVOLTAIC SYSTEMS WITH REDUCED DC-LINK CAPACITOR by Sindhu Krishna Yarlagadda December 2012
7) A. Lahyani, P. Venet, G. Grellet, and P.-J. Viverge, "Failure prediction of electrolytic capacitor during operation of a switchmode power supply," Power Electronics, IEEE Transactions on, vol. 13, no. 6, pp. 1199 –1207, nov. 1998.
8) A. Testa and S. De Caro, "Active voltage ripple compensation in pv systems for domestic uses," Industrial Electronics (ISIE), 2010 IEEE International Symposium on, pp. 2193 –2198, jul. 2010.
9) https://pcmp.springeropen.com/articles/10.1186/s41601-018-0099-8
10) Dabra, V., Paliwal, K. K., Sharma, P., & Kumar, N. (2017). Optimization of photovoltaic power system: A comparative study. Protection and Control of Modern Power Systems, 2(1), 3.
11) Kumari, J. S., Babu, D. C. S., & Babu, A. K. (2012). Design and analysis of P&O and IP&O MPPT techniques for photovoltaic system. International Journal of Modern Engineering Research, 2(4), 2174–2180.
12) Sera, D., Teodorescu, R., Hantschel, J., & Knoll, M. (2008). Optimized maximum power point tracker for fast changing environmental conditions. In Industrial Electronics, 2008. ISIE 2008. IEEE International Symposium on (pp. 2401-2407). IEEE.
13) Carl Nelson & Jim Williams, "Linear Technology, LT1070 Design Manual", 1986
14) Marty Brown, "Practical Switching Power Supply Design", New York: Academic Press, Inc., 1990
15) Irving M. Gottlieb, "Power Supplies, Switching Regulators, Inverters, & Converters", New York: McGraw-Hill, 1993
16) F. Schimpf and L. Norum, "Effective use of fifilm capacitors in single-phase pv-inverters by active power decoupling," IECON 2010 - 36th Annual Confer ence on IEEE Industrial Electronics Society, pp. 2784 –2789, nov. 2010.
17) Hwang, P. Lehn, and M. Winkelnkemper, "Control of grid connected ac-dc converters with minimized dc link capacitance under unbalanced grid volt age condition," Power Electronics and Applications, 2007 European Conference on, pp. 1 –10, sept. 2007.
18) Y. Hu, J. Zhang, J. Wu, W. Cao, G. Y. Tian, and J. L. Kirtley, "Efficiency Improvement of Non-Uniformly-Aged PV Arrays," IEEE Transactions on Power Electronics, vol. 32, no. 2, pp. 1124–1137, 2017.
19) H. Bounechba, A. Bouzid, H. Snani, and A. Lashab, "Real time simulation of MPPT algorithms for PV energy system," International
Journal of Electrical Power and Energy Systems, vol. 83, pp. 67–78, 2016
20) O. M. Toledo, D. Oliveira Filho, and A. S. A. C. Diniz, "Distributed photovoltaic generation and energy storage systems: A review," Renewable Sustainable Energy Rev., vol. 14, pp. 506–511, 2010.
21) M. Bragard, N. Soltau, S. Thomas, and R. W. De Doncker, "The balance of renewable sources and user demands in grids: Power electronics for modular battery energy storage systems," IEEE Trans. Power Electron., vol. 25, no. 12, pp. 3049–3056, Dec. 2010.
22) G. Masson, M. Latour, and D. Biancardi, "Global market outlook for photovoltaics until 2016," Eur. Photovoltaic Ind. Assoc., Brussels, Belgium, vol. 5, 2012
new) P. Goli and W. Shireen, "PV powered smart charging station for PHEVs," Renewable Energy, vol. 66, pp. 280–287, 2014.
23) H. Wirth and K. Schneider, "Recent facts about photovoltaics in Germany," Version as of Dec 25, 2015, Division Director Photovoltaic Modules, Systems, and Reliability, Fraunhofer ISE, 2013.