

ENHANCED ENERGY MANAGEMENT AND CONTROL OF SINGLE STAGE GRID CONNECTED SOLAR PV AND BES SYSTEM

Submitted in partial fulfilment of the requirements for the award of

Bachelor of Engineering Degree in
Electrical and Electronics Engineering

By

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SCHOOL OF ELECTRICAL AND ELECTRONICS ENGINEERING**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

**Accredited with Grade "A" by NAAC
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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the Bonafide work of **PRANJIT DAS** (Reg. No. 37140064) and **SUDIPTA SARKAR** (Reg. No. 37140074) who carried out the project entitled "**ENHANCED ENERGY MANAGEMENT AND CONTROL OF SINGLE STAGE GRID CONNECTED SOLAR PV AND BES SYSTEM**" under our supervision from December 2020 to April 2021.

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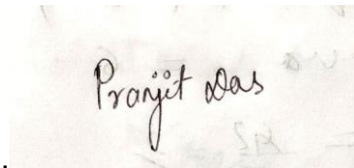
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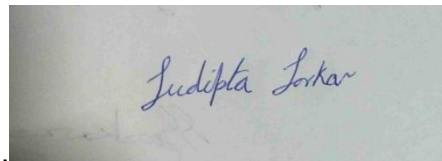
DECLARATION

We **PRANJIT DAS** (Reg. No. 37140064) and **SUDIPTA SARKAR** (Reg. No. 37140074) hereby declare that the Project Report entitled “**ENHANCED ENERGY MANAGEMENT AND CONTROL OF SINGLE STAGE GRID CONNECTED SOLAR PV AND BES SYSTEM**” done by us under the guidance of **Mrs .V. GEETHA** is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Electrical and Electronics Engineering.

1.

A photograph of a handwritten signature in black ink on a light-colored, slightly textured paper. The signature reads "Pranjit Das".

2.

A photograph of a handwritten signature in blue ink on a light-colored, slightly textured paper. The signature reads "Sudipta Sarkar".

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ABSTRACT

A photovoltaic system is a form of power system that uses photovoltaic cells to harness the full amount of solar energy. It is made up of many parts, including solar panels that absorb and transform sunlight into electricity, a solar inverter that converts direct current to alternating current, and mounting structure, cabling, and other electrical accessories. It may also provide an integrated battery solution and use a solar monitoring system to increase the overall efficiency of the system, as storage device costs are projected to fall in the future. The majority of PV systems are now grid-connected, with off-grid or stand-alone systems making up a small percentage of the market.

For real power injection, solar modules are connected to the grid through a DC-DC Converter and a Voltage Source Converter (VSC) (Called two stage conversion). In terms of performance, single stage conversion is more common, as it allows for maximum power point tracking (MPPT) of SPV and real power injection using only VSC. However, if Battery Energy Storage (BES) is needed, it must be assisted by a bidirectional DC-DC converter and VSC must be achieved by simultaneous MPPT and real power injection. MATLAB SIMULINK simulation will be used to simulate the circuit. A PIC Controller is used to execute the proposed circuit. The results of both the simulation and the hardware will be checked.

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LIST OF SYMBOLS AND ABBREVIATIONS

L	=	Inductance
C	=	Capacitance
Vs	=	Voltage Source
R	=	Resistor
I	=	Current
Vo	=	Output Voltage
S ₁ , S ₂	=	Switch
MOSFET	=	Metal Oxide Semiconductor Field Effect Transistor
I _L	=	Current across inductor
I _c	=	Current across capacitor
V _c	=	Voltage across capacitor
V _L	=	Voltage across inductor
I _D	=	Current through diode
V _{in}	=	Input voltage
mH	=	Millihenry
uF	=	Microfarad
Gnd	=	Ground
MPPT	=	Maximum power point Tracking
VSC	=	Voltage source converter
AC	=	Alternating Current
DC	=	Direct Current
SEPIC	=	Single Ended Primary Inductor Converter

CHAPTER 1

INTRODUCTION

1.1 GENERAL INTRODUCTION

PV systems are solar energy supply systems that often provide power to electrical applications or storage systems such as the grid or a battery system. Solar power energy can be used in two different ways. For starters, the incarcerated high temperature can be used as a source of solar thermal power energy, which has applications in space heating. Conversion of incident solar radiation to electrical energy, which is the most exploitable type of energy source, is an additional alternative.

1.2 PV SYSTEM INTRODUCTION

Since the grid will accumulate the power generated by the PV array, a grid-connected PV system does not need a battery. The switched DC-DC converters aid in escalating the voltage from a low battery voltage source, smoothing the path to a synchronised DC output voltage that would otherwise necessitate a large number of battery voltage sources. In general, DC-DC converters are used to increase the performance of renewable energy systems. High step-up output voltage gain, low input current and low current ripples, high output voltage and low voltage ripples, and higher performance are all factors that determine the utility of DC-DC converters. The conventional coupled inductor, switched capacitor, clamping diodes, and controlled power semiconductor unit, which is controlled by duty ratio, are used to design various DC-DC converters. The output voltage of a DC-DC converter may be increased or decreased depending on the duty ratio. The PV system's efficiency is

also determined by the PV module, which consists of multiple solar cells connected in sequence. Solar cells produce electricity from solar radiation using the photovoltaic effect.

1.3 PRINCIPLE OF PHOTOVOLTAIC EFFECT

The photovoltaic effect works on the theory that when a photon collides with the photocell's surface, an electron is displaced, which excites the outermost electron and lowers the potential barrier, allowing current to flow.

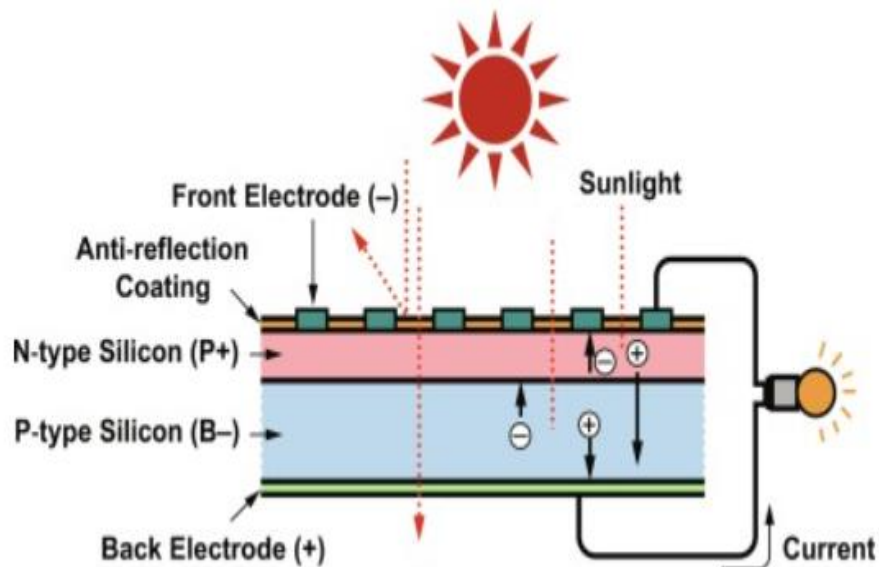


Fig.1.1: Photovoltaic effect

1.4 WORKING OF PHOTOVOLTAIC CELL

Intrinsically type semiconductors are the purest form of semiconductor and can be made of Ge (Germanium) or Si (Silicon) (Silicon). Doping is the method of introducing impurity to an intrinsic type semiconductor, and the impure form is known as an extrinsic type semiconductor. When an electronegative product, such as arsenic or phosphorus, is doped, the majority of charge carriers in the lattice are electrons. The n-type semiconductor is the name for this type of semiconductor. When an electropositive material such as Ga(Gallium) or Br(Boron) is doped, the majority of charge carriers in the lattice are holes, resulting in a p-type semiconductor. When they are joined together, they form a depletion area between them, in which no electrons or holes exist. The p side becomes positively charged and the n side becomes negatively charged due to electron hole pair attraction at the depletion region's boundary. This photon energy is sufficient to produce electron hole pairs in the depletion region as light hits in the n region and penetrates to the p-n junction. The electric field in the depletion area drives electrons and holes to the n and p sides of the depletion region, respectively. Since the concentration of electrons in the n region is so high and the concentration of holes in the p region is so low, a potential gap can grow between them. Electrons can flow from the n region to the p region through the load if we connect a load between the p and n terminals. In practise, we use a thin, heavily doped n layer, while the p layer is dense and lightly doped, resulting in a larger depletion area. Since the n layer is small, light can easily pass through it, resulting in an increase in the production of electron hole pairs.

1.5 LITERATURE SURVEY

A.K Sinha,et al., (2017) , proposes the microgrid idea, which is gaining traction as distributed generation becomes more prevalent (DG). Microgrid control techniques are a developing research subject in the field of microgrids. A significant number of survey papers concentrate on microgrid control techniques; however, a systematic survey of hierarchical control techniques based on various microgrid architectures receives little attention. In microgrids, the hierarchy of control is divided into three levels: principal, secondary, and tertiary control layers. This paper provides an overview of primary and secondary control methods for AC, DC, and hybrid AC-DC microgrids. The primary controllers cannot act if the central controller fails to operate due to a communication error. In the case of decentralised secondary control, however, a centralised controller's command is not needed to operate primary controllers. Since local controllers lack knowledge about the system's operating state, decentralised secondary control is less effective than centralised secondary control. This disadvantage can be solved by using a distributed control approach, in which local controllers communicate with one another and are well-informed about the microgrid's operating scenario.

Sonal Gaurav,et al., (2015), proposes The energy management algorithm for a PV-based microgrid with battery storage system is conceptualised. The device demonstrates how a renewable energy source, such as a PV array, can be used in conjunction with a battery in a microgrid to power local loads. This paper looks at how to operate an Energy Storage System (ESS) in a microgrid with a PV array, and how to use a DC-DC bidirectional converter to control battery charge, retain, and discharge operations based on the load's needs. The PV array, battery, and load are all simulated for a variety of scenarios, including PV supplying and charging the battery, PV supplying only the load, battery supplying the load, and PV-Battery both supplying the load. For each state, output parameters such as voltage, current, and power graphs are plotted and analysed. The Matlab-Simulink environment is used to simulate the entire paper.

Dimna Denny C,Shahin M ,et al.,(2015), proposes the notion of A bidirectional SEPIC/ZETA converter with a coupled inductor is proposed, and the output of the modified converter is validated through a comparison with a traditional converter. The SEPIC-Zeta converter with coupled inductor is a low-cost, low-component non-inverting DC-to-DC converter that can run in buck or boost mode. The size and expense of the filter capacitor are reduced because the output voltage ripple is lower than in traditional topologies. In a traditional converter, replacing individual inductors with a coupled inductor with a coupling co-efficient of 0.92 improves efficiencyIt decreases the converter's overall size and turn tension. The efficiency of output voltage is increased despite the fact that the mean value of output voltage is decreased by the addition of a coupled inductor. The system's steady-state operation is adequate for a wide range of DC bus voltage variations. When the variance is very high, however, the initial voltage and current in switches will increase, necessitating the use of high-rated switches.

V. Indira Gandhi,et al., (2017), proposes a concept of There are a variety of configurations where a DC-DC converter boosts the output voltage. Based on its switching methodology, this review paper provided a broad overview of DC-DC boost converter configurations. In order to achieve good performance, the review suggests using soft switching technique in boost converters. This paper also discusses interleaved boost converter setups, which are widely used in high step-up applications. The interleaving principle is repeatedly used to recover better efficiency and shrink the size of filters. This review paper provides a comprehensive examination of both isolated and non-isolated boost converter configurations. The importance of developing integrated power converters with multiple ports, which can regulate power flow among multiple input power sources for optimal power sharing and reliability, is also discussed. Multiport converters were found to be superior to multi-source hybrid power systems in terms of simple structure, bi-directional power flow, low power components, transformer-free operation, and centralised control.

A.A. Jamali, et al., (2015), proposes Examining the suitability of various energy storage systems (ESS) and their applications in the power grid for large-scale electrical networks. A quantitative analysis of current energy sizing models that operate under unconstrained network conditions was also included in the paper. The aim was to look at the flaws in current models and make suggestions for future studies. The promise of battery storage technology has been highlighted in recent studies, and its superior performance makes it more appealing than many others. As a result of this research, it is now understood that many researchers use the same techniques for energy storage sizing for large PV plants as they do for standalone PV systems. Meanwhile, some authors have based their energy storage sizing models solely on device energy requirements, ignoring such network constraints. The findings point to the need for further research into energy storage sizing methods that take into account electrical network constraints.

Xiaotong Song, et al., (2019), proposes the idea of for the microgrid (MG), reliability is important, and it deserves more focus. The microturbine (MT), PV, ESS, and comprehensive load (CL), which is composed of hourly time-varying component, stochastic component, and controllable component, are chronologically modelled and combined with model of load shedding minimization and sequential Monte Carlo (SMC) simulation algorithm, with the goal of photovoltaics (PV) and energy storage system (ESS) dependent MG. The case studies have shown that, first and foremost, increasing PV capacity can boost probability indices while also causing SE-SAIFI, particularly when the ESS is undersized.

M. Hashem Nehrir, et al., (2019) ,proposes Increased interest in green power generation systems has been sparked by rising energy demand, rising fossil fuel costs, and the finite existence of fossil fuels, as well as the deteriorating global climate. Two of the most promising alternative energy generation technologies are wind and solar power generation. A stand-alone hybrid alternative energy system with wind, PV, FC, electrolyzer, and battery is proposed in this paper. To take full advantage of renewable energy, the system's primary power sources are wind and

PV, with the FC–electrolyzer combination serving as a backup and long-term storage system. The WECS, PV, FC, and electrolyzer, as well as the overall control and power management strategy for the proposed hybrid energy system, are discussed; the characteristics of the key components in the system, namely, the WECS, PV, FC, and electrolyzer, are given; and the overall control and power management strategy for the proposed hybrid energy system is provided.

Ming Shen, et al., (2018), proposes From a multiphysics perspective, this paper summarises battery simulation techniques. For modelling, the thermal model is often combined with the electrical model. The development of a multifunctional integrated battery management system that integrates with other onboard controls and intelligent technology to form a full concept ranging from multiphysics modelling simulation to multifunction integrated technology.

1.6 AIM

To add SEPIC dc-dc converters to the device as a source of stimulation. To assess the system's performance and to simulate a real-time scenario in order to assess the system's effectiveness, Financial update for the year, as well as a report on electricity efficiency.

1.7 SCOPE

A SEPIC (Single Ended Primary Inductor Converter) DC-DC converter with a three-phase inverter has been proposed in this project. A 5 watt solar panel and a 12V battery are used in the experimental setup. The PIC16F877 controller is used to construct the MOSFET triggering circuit.

When the solar panel voltage falls below a certain level, the battery discharges, resulting in a steady 213V through the converter's output. Additionally, MATLAB/SIMULINK was used to simulate the proposed job. PV-Sol programme was used to perform the energy storage simulation.

1.8 LIMITATION OF EXISTING SYSTEM

1. The voltage at the output is lower.
2. There is a lot of total harmonic distortion.
3. There is a lack of performance.
4. The output's initial delay.
5. As the service cycle increases, the output voltage changes as well.

1.9 ADVANTAGES AND APPLICATIONS OF PROPOSED TECHNIQUE

1. Switching frequency that is constant.
2. Excessive voltage gain
3. Constant current feedback
4. It has the ability to go up and down in voltage.
5. Extremely effective.
6. Extensive boosting potential.

CHAPTER 2

PROJECT DESCRIPTION

2.1 BLOCK DIAGRAM

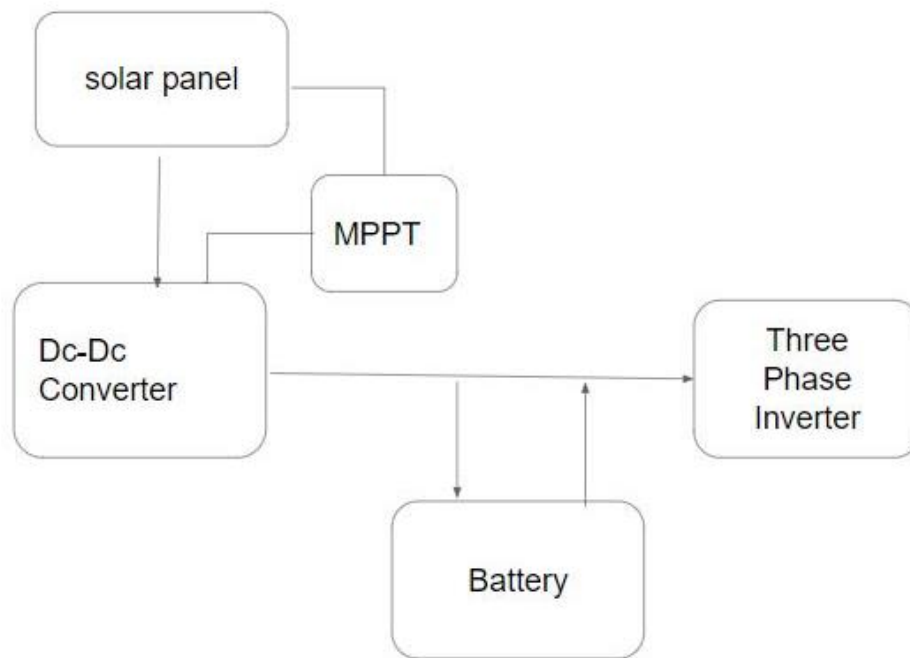


Fig 2.1: Block diagram

The fig. 2.1 MPPT is connected to a solar panel and a DC-DC converter in the proposed system. The converter is attached to a DC connection that is connected to a battery to store electricity, as well as a three phase inverter that transforms DC voltage to three phase AC voltage.

2.2 CONCEPT EXPLANATION

The voltage Boost technique with SEPIC converter in this proposed device has a high voltage gain, high power efficiency, and a constant input current. A SEPIC (Single Ended Primary Inductor Converter) DC-DC converter with a three-phase inverter is proposed in this paper. We used a 5 watt solar panel and a 12 volt battery in our test setup. The PIC16F877 controller is used to construct the Mosfet triggering circuit. When the solar panel voltage is insufficient, the battery discharges, resulting in a steady 213V through the converter's output.

Furthermore, the proposed analysis has been simulated using MATLAB/SIMULINK. PV-Sol programme was used to run the energy storage simulation.

2.3 EXISTING SYSTEM

The system has the configuration of a grid-connected SPV with a battery energy storage system in a three-phase network. SPV series, VSC, Boost DC-DC converter, battery, source, and load are all included. To meet the appropriate voltage and power ratings, the SPV string consists of a series and parallel combination of photovoltaic modules. The VSC is primarily used for real-time power injection and SPV MPP monitoring. The single-stage operation is accomplished in the case of SPV and battery storage systems by coordinating the VSC and DC-DC converter depending on the battery unit's State of Charge (SoC).

2.4 PROPOSED SYSTEM

We used a SEPIC DC-DC converter to replace the current Boost converter in the proposed configuration, which also includes a battery energy storage system and a three-phase inverter. To meet the appropriate voltage and power ratings, the device uses a series and parallel combination of photovoltaic modules. For the proposed scheme, a MATLAB simulation is run.

2.5 MODULE DESCRIPTION

The output of a single-ended primary inductor converter (SEPIC) is regulated by the service cycle of the control transistor and causes the electrical potential (voltage) at its output to be greater than or equal to that of the input.

A SEPIC is essentially a boost converter followed by a Buck-Boost converter, because it's similar to a traditional Buck-Boost converter, but with the advantages of having a non inverted output (the output has the same voltage polarity as the input), a series capacitor is used to couple energy from the input to the output (and hence can respond gracefully to the short-circuit output), and being capable of responding gracefully to the short-circuit output. SEPICs work well in situations where the battery voltage is both above and below the regulator's expected output. For example a typically Lithium Ion battery discharges from 4.2 V to 3V ,if other components require 3.3 V ,then the Sepic would be effective.

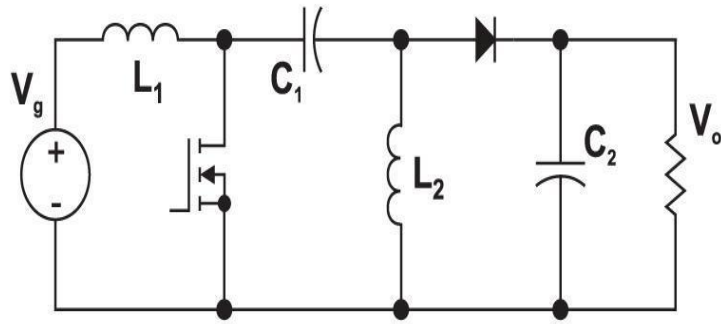


Fig 2.2 : Sepic converter

2.5.1 Methodology

As seen in the diagram below, a single ended primary inductance converter (SEPIC) is equivalent to the CUK. With no polarity reversal, the SEPIC will produce an output voltage that is either greater or less than the input voltage. These initial assumptions are made to derive the relationship between the input and output voltages:

1. All inductors are very large, with regular currents.
2. All capacitors are very wide, with a steady voltage through them.
3. The circuit is in a steady state, which means the voltage and current waveforms are normal.
4. The door is closed for DT and open for $(1-D)T$ while the job ratio is D .
5. The diode and the switch are ideal.

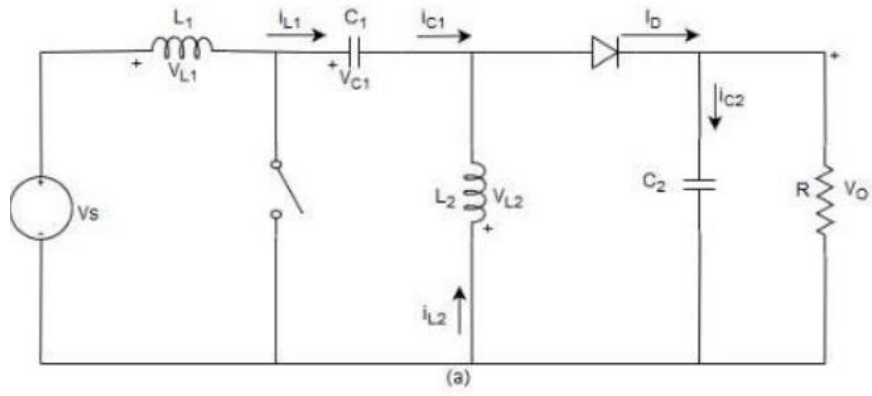


Fig 2.3 : SEPIC circuit

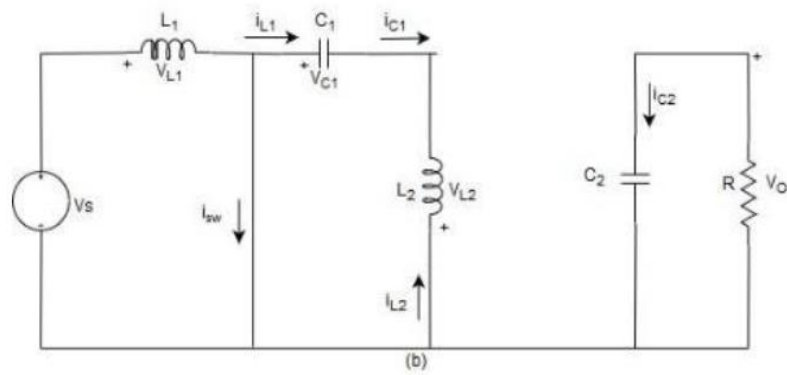


Fig 2.4 : Circuit with the switch closed and the diode off.

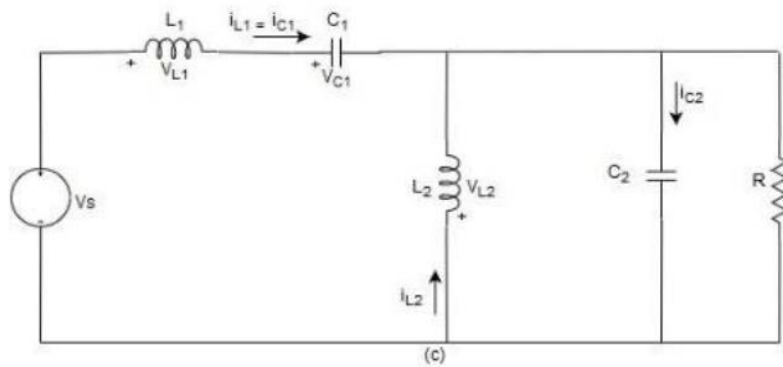


Fig 2.5 : Circuit with the switch open and diode on.

2.5.1.1 Continuous mode

If the current through the inductor L_1 never falls to 0, the SEPIC is said to be in continuous - conduction mode (continuous mode). The average voltage around the capacitor C_1 (V_{C1}) is equal to the input voltage (V_{in}) during steady state action of a SEPIC. The average current through capacitor C_1 (I_{C1}) is zero since it blocks direct current (DC), leaving inductor L_2 as the only source of load current. As a result, the average current through the inductor L_2 (I_{L2}) is the same as the average load current, and therefore the input voltage has little effect.

When switch S_1 is turned on, current I_{L1} increases in the positive direction while current I_{L2} increases in the negative direction. (It reduces mathematically due to the arrow direction) The energy used to raise the current I_{L1} is derived from the input source. Since S_1 is closed for a limited time and the instantaneous voltage V_{C1} is close to V_{in} , the voltage V_{L2} is close to $-V_{in}$. As a result, the capacitor C_1 provides the energy required to increase the magnitude of the current in I_{L2} , thus enhancing the amount of energy contained in L_2 . The simplest way to imagine this is to consider the circuit's bias voltages in a DC state, then close S_1 .

■

CHAPTER 3

SIMULATION CIRCUIT AND RESULT

3.1 SIMULATION CIRCUIT

The project's simulation was carried out in MATLAB Simulink. Three-phase voltage waveforms were successfully achieved. The Simulation circuit diagram is shown in fig. 3.1.

1. MPPT receives input from the solar panel.
2. The MPPT's output is fed into the converter's feed.
3. The converter's output is fed into a three-phase inverter and a BES (Battery Energy Storage) device.
4. A bidirectional transformer in the BES device charges and discharges the battery.
5. The battery's SoC is determined by the battery controller.
6. The three-phase inverter's output is attached to the feedback circuit, which triggers the inverter's MOSFETs.

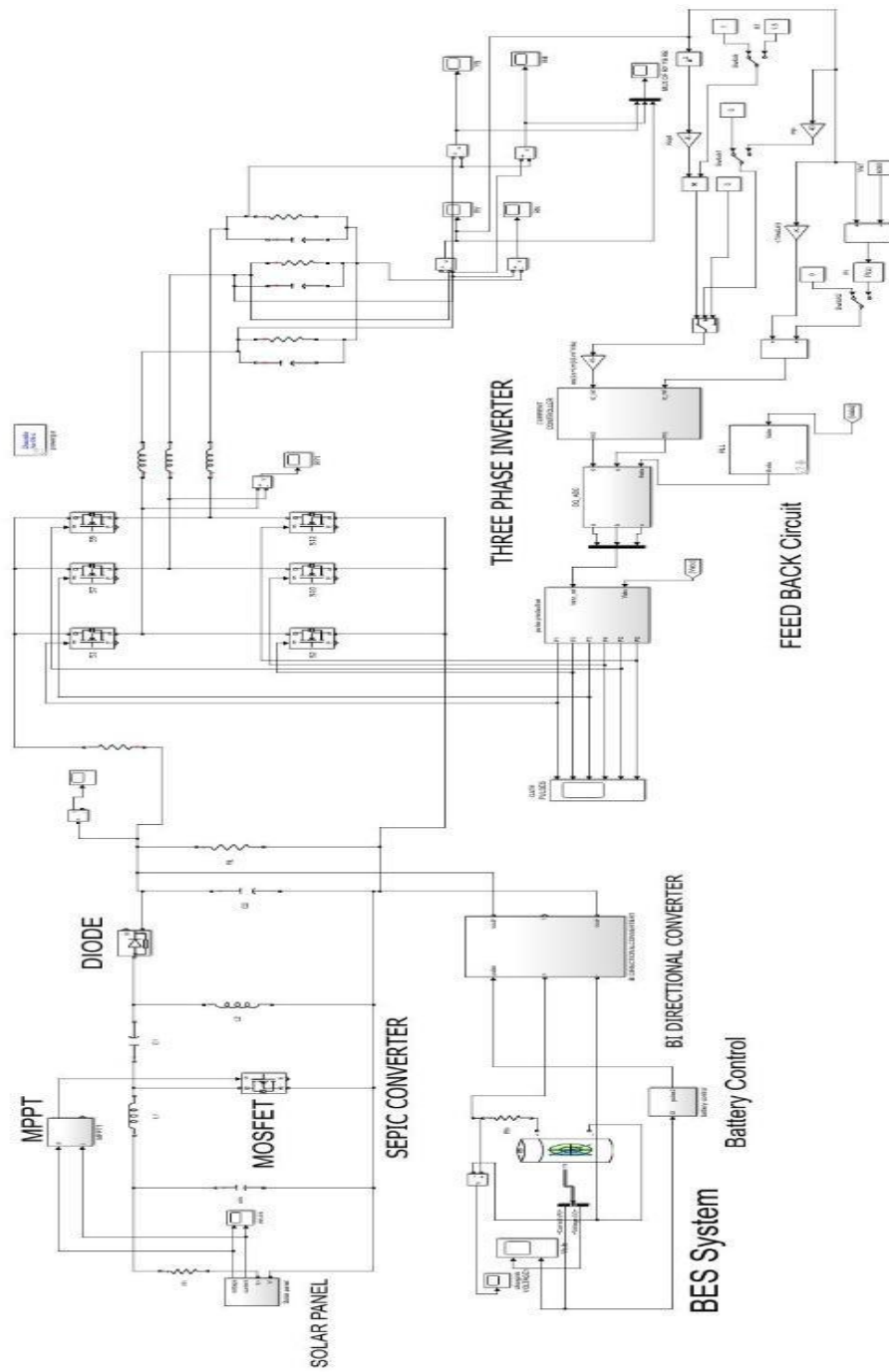


Fig 3.1 : Simulation Circuit diagram of sepic converter

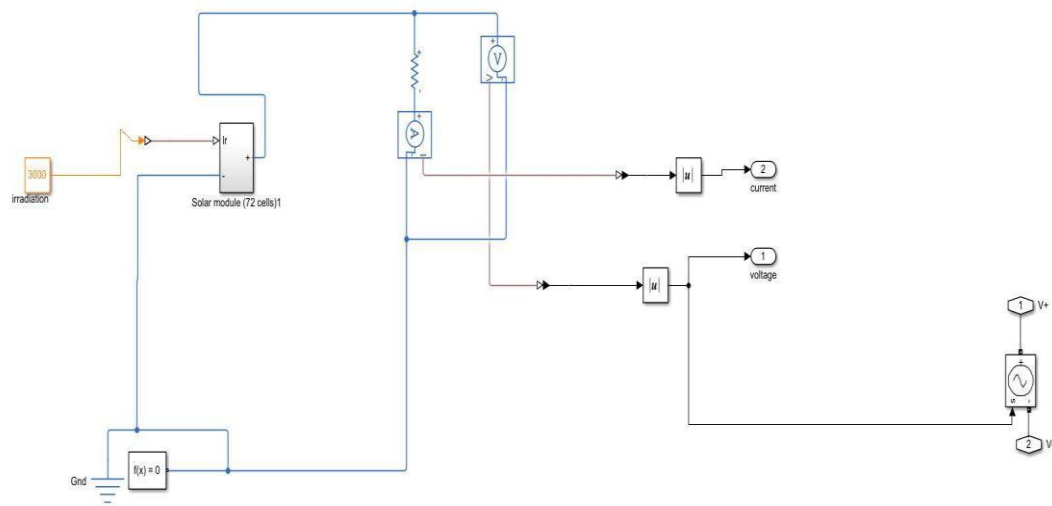


Fig 3.2 : Simulation circuit diagram for Solar panel.

In the fig. 3.2 The solar panel has 72 cells, and the 'A' determines the current, while $|u|$ is an absolute determining feature that takes the current's floor value. The voltage is measured by the 'V' and fed to $|u|$, which calculates the voltage's floor value.

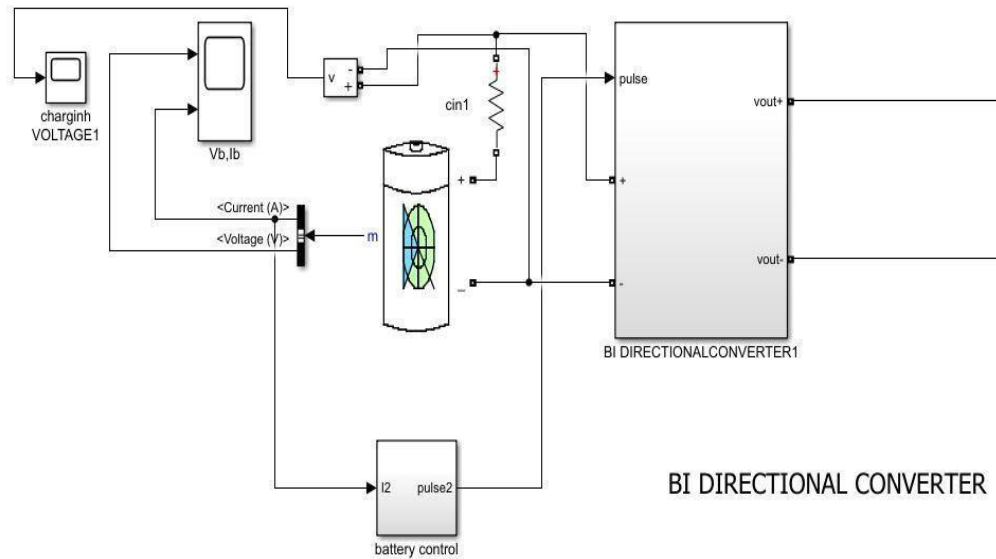


Fig 3.3 : Simulation circuit diagram for BES system

Fig. 3.3 depicts a circuit diagram for a battery energy storage device simulation. It is made up of a bidirectional converter and a battery controller. The battery is charged and discharged by the bidirectional converter. The State of Charge of the battery is determined by the battery power.

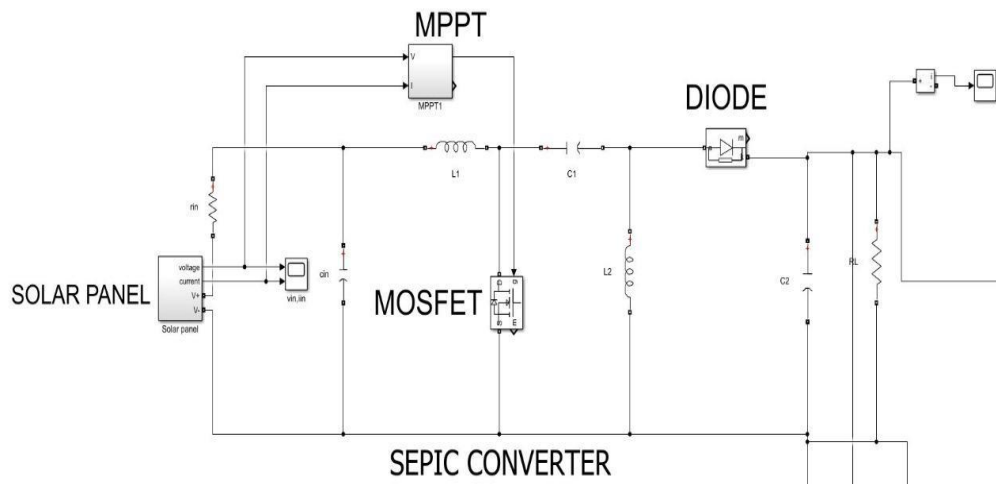


Fig 3.4 : Simulation circuit diagram of Converter

The fig. 3.4 shows Solar panel and Maximum Power Point Tracking are wired to a SEPIC converter, which comprises an inductor L1, a MOSFET, a capacitor C1, a diode D1, an inducer L2, and a load resistor RL.

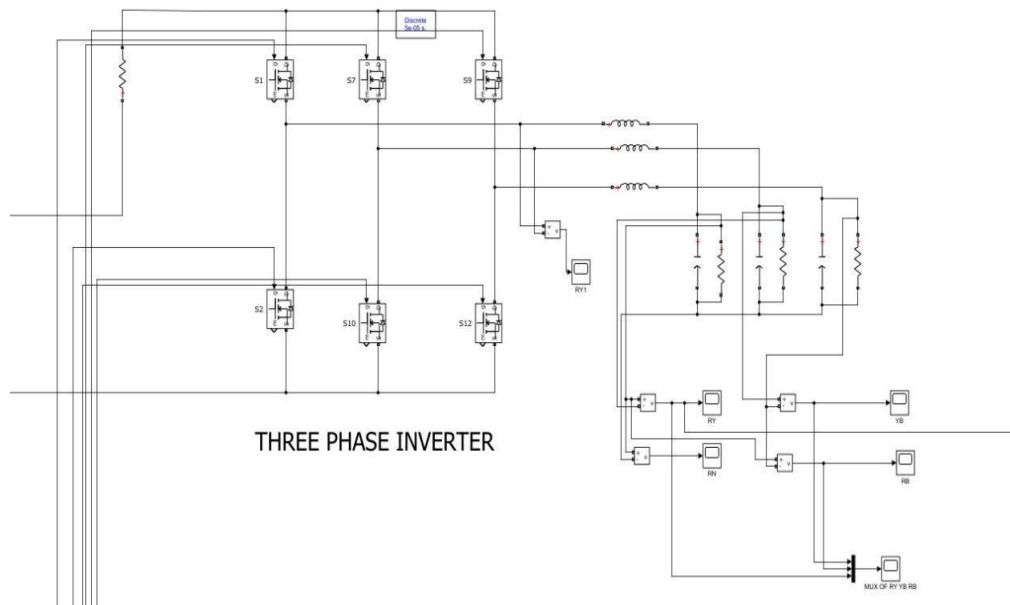


Fig 3.5 : Simulation circuit diagram for Three phase inverter

Fig. 3.5 represents circuit diagram for simulation each three-phase leg of a three-phase inverter is made up of two MOSFETs and is fed with a fixed dc current. The feedback circuit delivers the MOSFET signal pulse.

3.2 OUTPUT PARAMETERS OR SIMULATION RESULTS

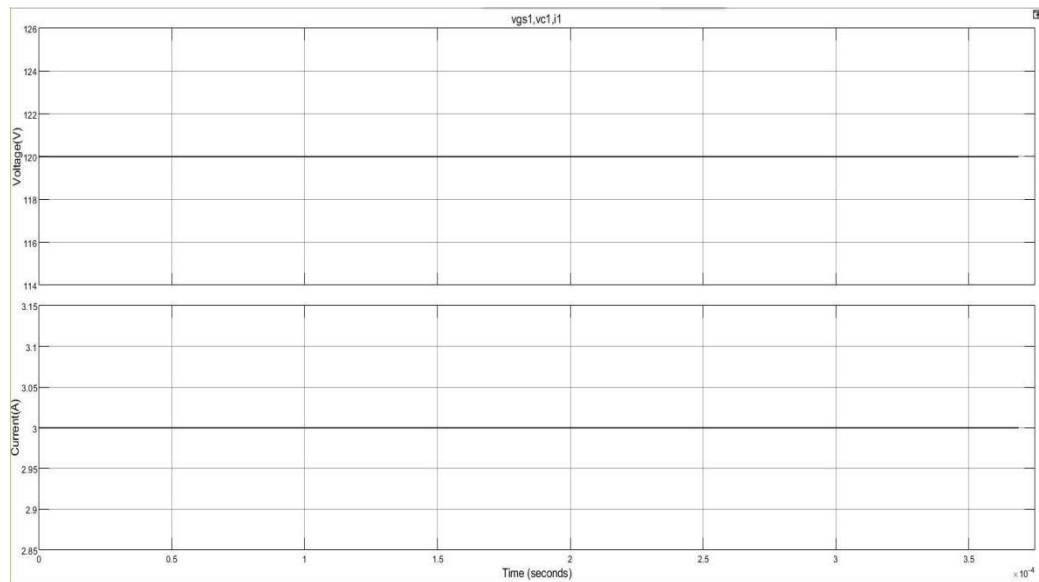


Fig 3.6 : Solar Output Voltage and Current graph

Fig. 3.6 shows the output parameters of Solar Panel which gives the output voltage of 120 Volt and output current of 3 Amp.

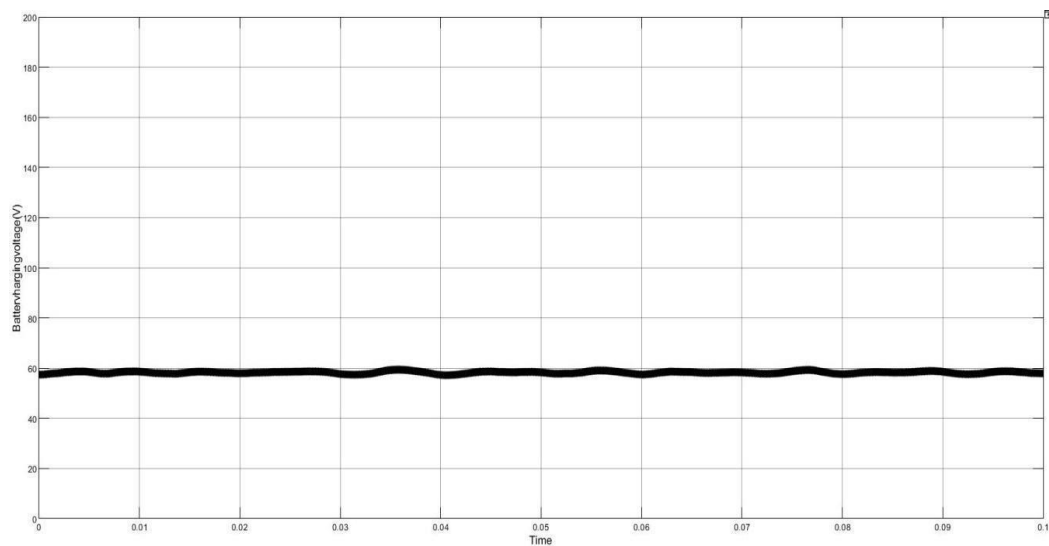


Fig 3.7 : Battery charging voltage

Fig 3.7 shows the battery charging voltage of the Battery Energy Storage system which gives the voltage of 60 Volt.

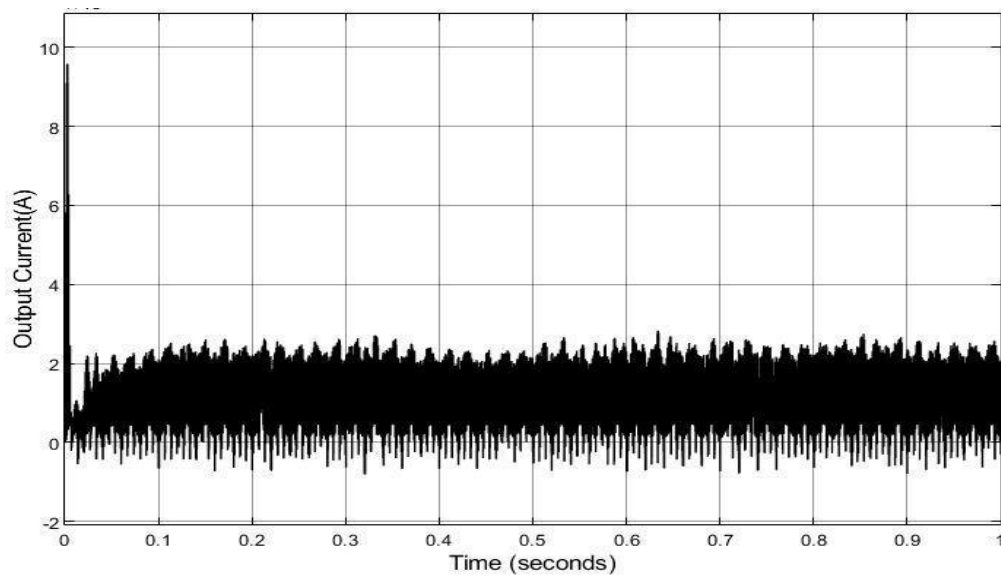


Fig 3.8 : Output current of the converter.

Fig. 3.8 shows the graph of Output current Versus Time of the converter which gives the output current of approximate 3 Amp.

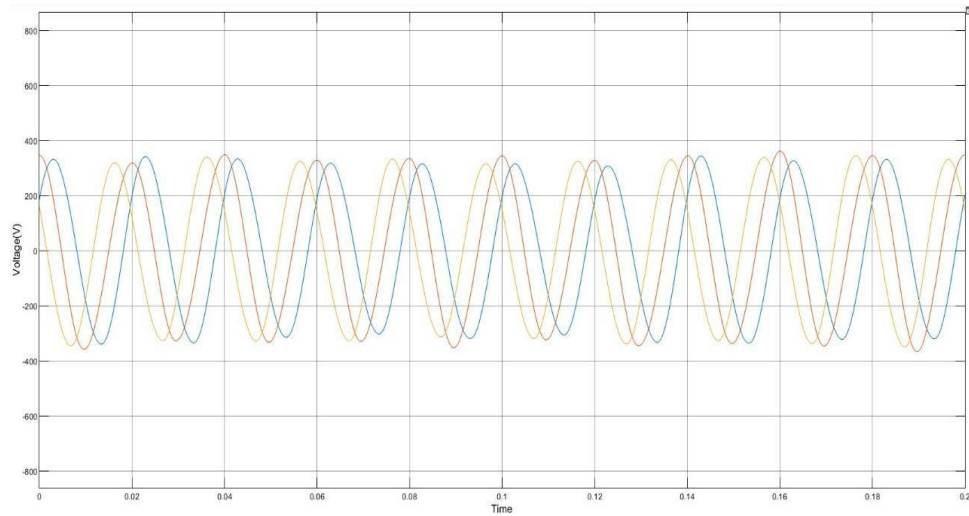


Fig 3.9 : Three Phase Output Voltage

The graph shown in the fig. 3.9 is Three phase output voltage Versus time graph which gives the Three phase output voltage of 380 Volt.

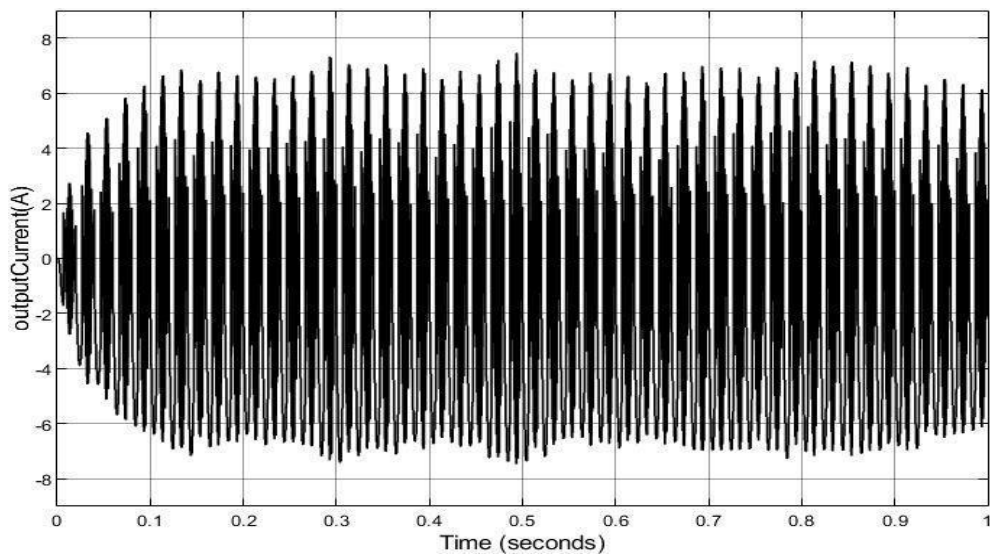


Fig 3.10 : Output Current of three phase inverter

The Fig. 3.10 is the Output current of Three phase inverter which gives the output current of approximate 6 Amps.

TABLE 3.1 : Simulation Results

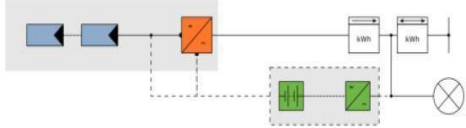
SL. No.	Parameters	Values
1.	Solar Output Voltage	120 Volt
2.	Solar Output Current	3 Amp
3.	Battery Charging Voltage	60 Volt
4.	Output Current of the converter	3 Amp
5.	Three phase output voltage	380 Volt
6.	Three phase output current	6 Amp

3.3 PV SOL SIMULATION

3.3.1 SYSTEM TYPE AND CLIMATE DATA

System Type, Climate and Grid

Type of System
Grid-connected PV System with Electrical Appliances and Battery Systems



Type of Design
 ☐ Use 3D Design

Time step of simulation
☒ 1 Hour (faster simulation)
☐ 1 Minute (more precise simulation)

Climate Data

Country		Location	
India		Madras (1991-2010)	
Latitude	13° 0' 0" (13°)	Annual sum of global irradiation	1926 kWh/m ²
Longitude	80° 10' 58" (80.18°)	Annual Average Temperature	28.2 °C
Time zone	UTC+5.5		
Time Period	1991 - 2010		

AC Mains

 Enter

Voltage (N-L1)	230 V
Number of Phases	1-phase
cos φ	0.8
Maximum Feed-in Power Clipping	No

Fig 3.11 : Location and System type Data

Since the average irradiance in the PV module varies depending on the region, the performance of the PV system is distance-dependent. Grid-tied, grid/hybrid, and off-grid solar PV and storage systems are the three major groups. They all have benefits and drawbacks, and that all depends on the customer's actual energy supply and what they want to bring out of the scheme.

3.3.2 CONSUMPTION OF VARIOUS LOADS

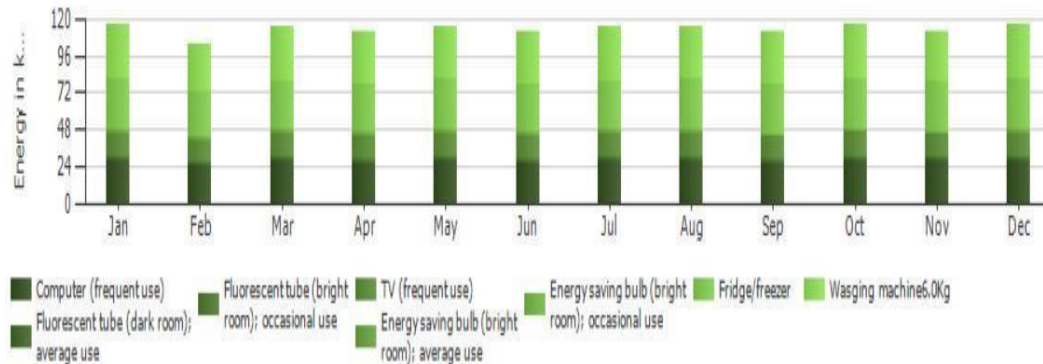


Fig 3.12 : Consumption of Various Load

The fig. 3.12 shows the total energy intake of different loads over the course of a year KiloWattHour is the unit of measurement for energy ratings. Similar shades reflect different types of loads and their rates of use. This graph depicts household loads such as computers, televisions, fluorescent tubes, refrigerators, washing machines, and so on. The consumption may also apply to the number of hours the load is turned on or the frequency at which it is switched on.

3.3.3 DEGRADATION OF PV MODULE

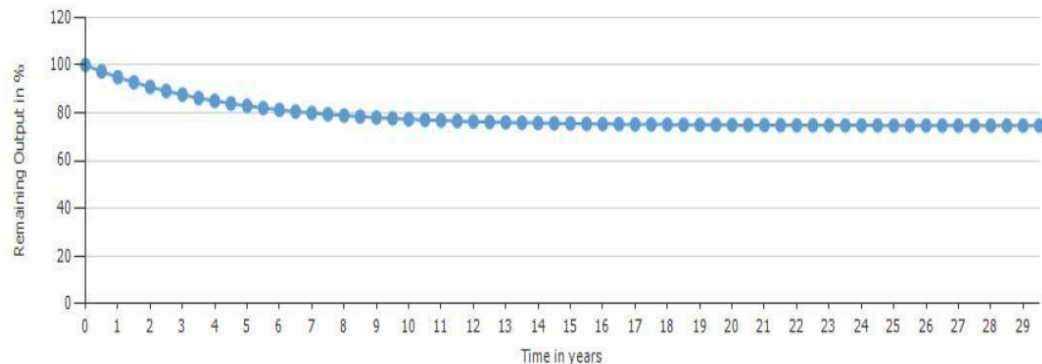


Fig 3.13 : PV Module Degradation

The fig. 3.13 depicts that the deterioration of PV modules over time Solar panels all fail with time, resulting in less energy being generated from the same amount of sunlight. A number of external factors (such as weather) break down the plates, reducing their ability to generate electricity.

3.3.4 CABLE PROPERTIES

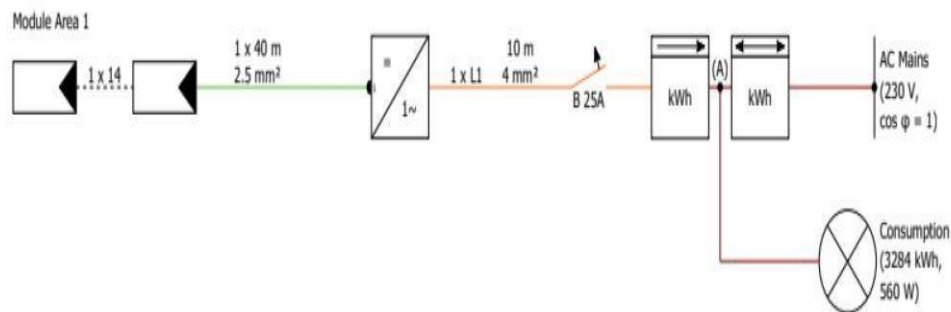


Fig 3.14 : Cable Connection

Unlike Fig. 3.14, cable failure applies to the amount of power lost over the cable's duration. The green wire represents the dc string section, the orange wire represents the AC, and the red wire represents the AC Mains cord. We will figure out how much money we've lost. AC cable consumes 0.66 percent of total power (26.5W), DC string lines consume 0.58 percent of total power (25W), and inverters consume 1.18 percent of total power (52W).

3.3.5 SCHEMATIC DIAGRAM

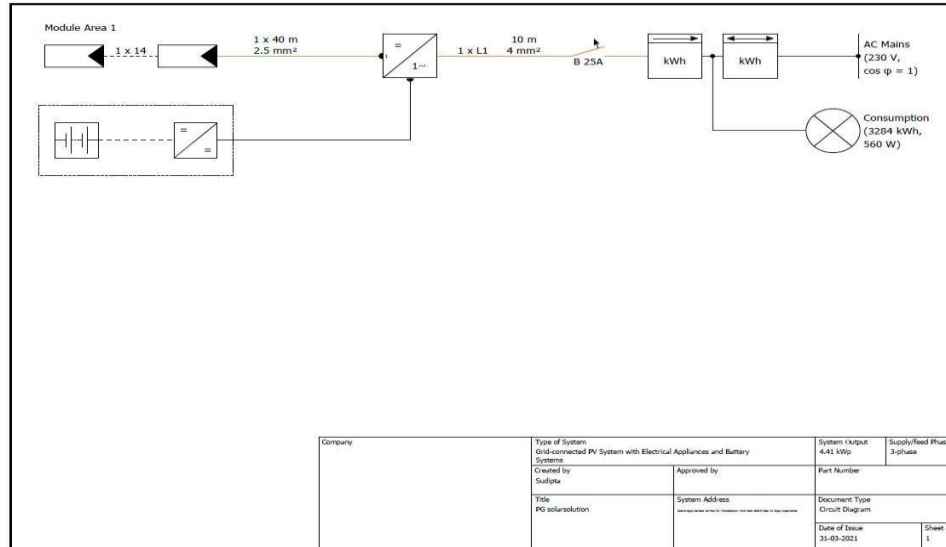


Fig 3.15 : Plan

The fig. 3.15 shows schematic circuit diagram and other technical sketches and plans. For voltage surge safety, a 25A circuit breaker is included in the AC main portion. We use 4mm² thick and 10m long wire for AC cable and 2.5mm² thick and 40m long wire for DC cable, which can be modified according to site specifications.

3.3.6 PRODUCTION FORECAST WITH CONSUMPTION

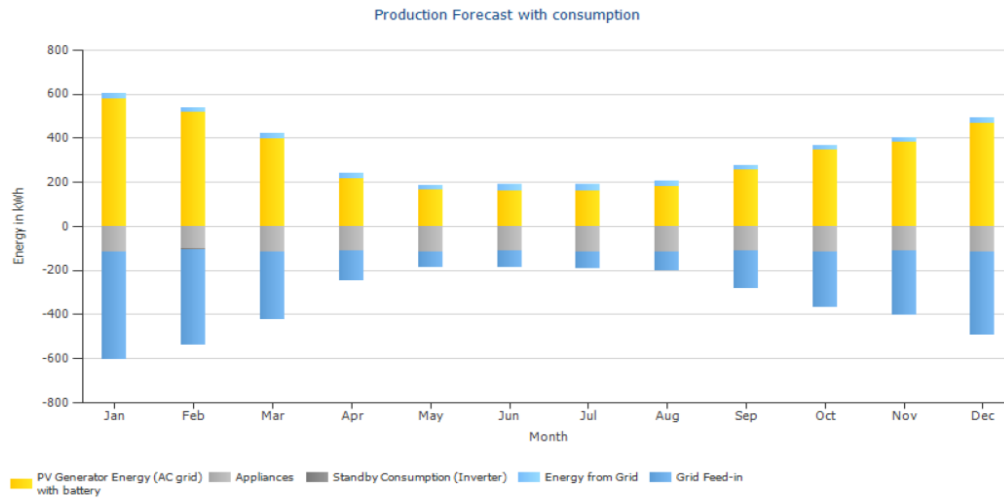


Fig 3.16 : Production forecast with consumption

The fig. 3.16 represents In a year, we produce and consume a certain amount of energy. If the PV system produces so much electricity, it is pumped into the grid. PV provided electricity with battery (yellow), Appliance (grey), Standby usage (dark grey), Energy from Grid (light blue), Grid feed are all depicted in different colours (blue).

3.3.7 ENERGY FLOW DIAGRAM

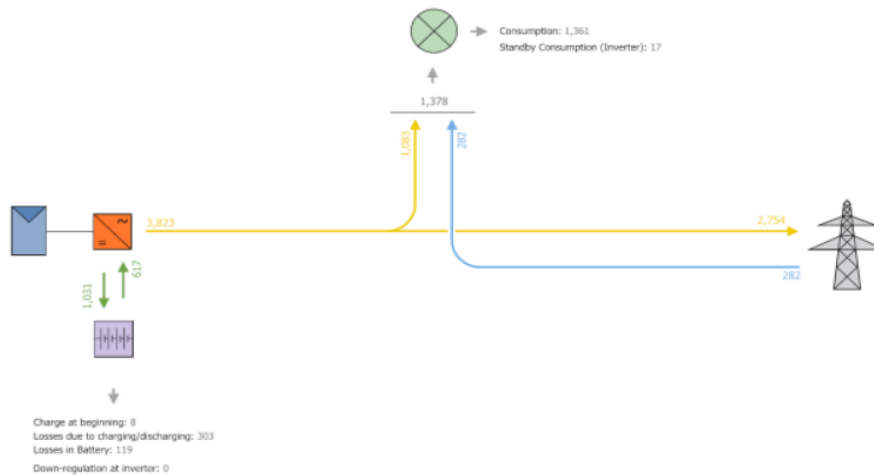


Fig 3.17 : Energy flow diagram

The fig. 3.17 depicts The energy distribution diagram provides a simple picture of the system's balance sheet energy flows. PV generates a total of 3832KWh of energy. It uses 1031 kilowatts for battery charging and 1033 kilowatts for consumption, and it provides 617 kilowatts to the grid, which feeds 282 kilowatts to appliances.

3.3.8 PV MODULE RESULTS

Module Area	
PV Generator Output	5.4 kWp
PV Generator Surface	35.7 m ²
Global Radiation at the Module	1075.3 kWh/m ²
PV Generator Energy (AC grid)	3822.7 kWh/Year
Spec. Annual Yield	707.9 kWh/kWp
Performance Ratio (PR)	65.8 %

Fig 3.18 : Results per module Area

The fig. 3.18 shows the solar PV module's surface area In a surface area of 35.7 m², the PV produces 5.4 kWp. The module's global radiation is 1075.3 kWh/m², the PV system's energy produced is 3822.7 kWh/year, and the system's output ratio is 65.8%.

3.3.9 USES OF PV ENERGY

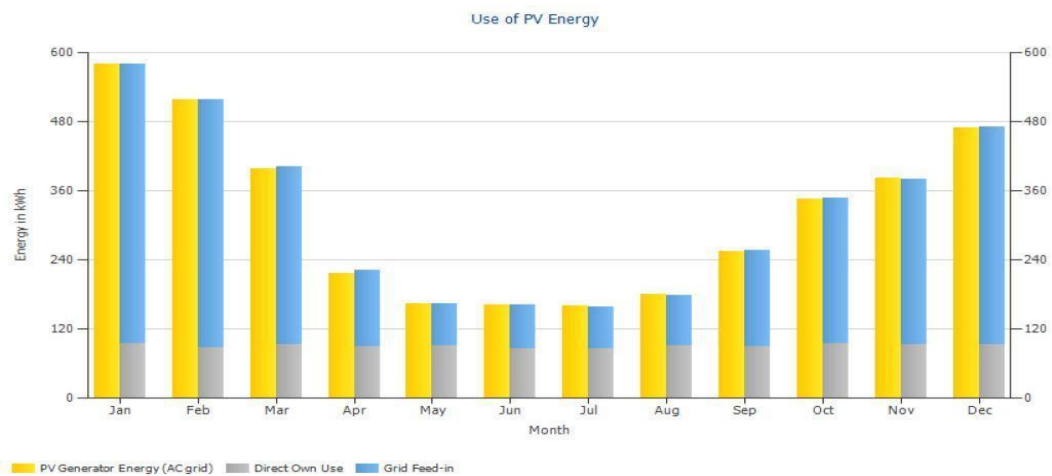


Fig 3.19 : Use of PV Energy.

The fig. 3.19 shows In a year, solar PV electricity is distributed in the form of PV generator energy (AC Grid), direct own consumption, and grid feed-in. PV generation is strong in January, as seen in the graph above. PV output was 590 KWh in January, grid feeding was 472 KWh, and the remaining electricity was used for personal consumption. PV production is poor in the month of June. PV output was 145 KWh in June, grid feeding was 70 KWh, and the remaining electricity was used for personal use.

3.3.10 COVERAGE OF TOTAL CONSUMPTION

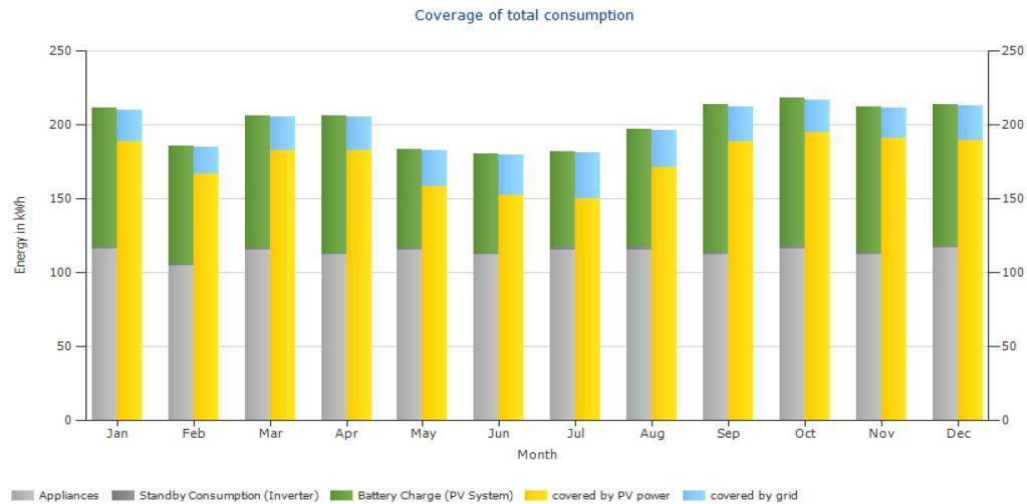


Fig 3.20: Coverage of total consumption

The fig. 3.20 depicts the cumulative coverage of intake over the course of a year. It depicts the electricity used by appliances, inverters (standby), battery charge, and PV power and grid. PV covers were 180 KWh, battery charging was 110 KWh, and grid capacity was 20 KWh in March. Electric appliances receive more than 70% of their power from solar panels, 29% from batteries, and 2% from the grid. We also recognise that the PV device generates excess electricity.

3.3.11 PRODUCTION FORECAST PER INVERTER

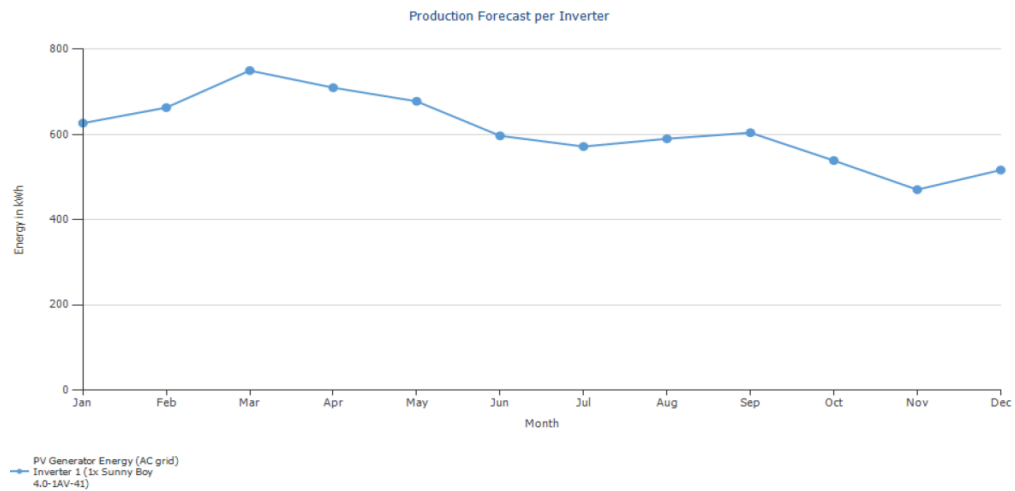


Fig 3.21 : Production Forecast per Inverter

Fig. 3.21 represent the annual energy output of two inverters in the machine. Here is a 4KW inverter with a 110 percent sizing scale. In our method, the inverter efficiency is 97 percent.

3.3.12 PERFORMANCE RATIO PER INVERTER

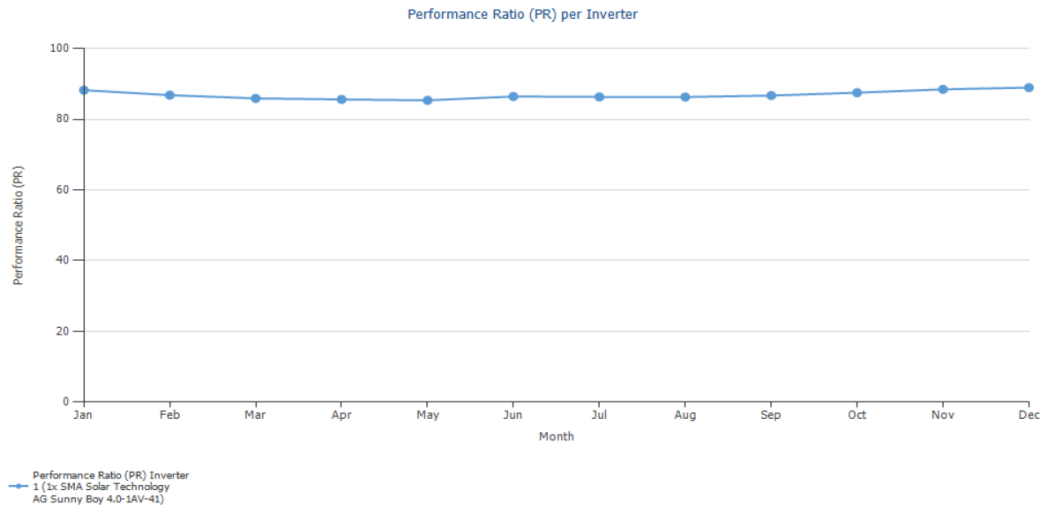


Fig 3.22 : Performance Ratio per inverter

Fig. 3.22 depicts the performance ratio of the inverter in a year. The performance in 1 year is between 90% to 86%.

3.3.13 IRRADIANCE PER MODULE

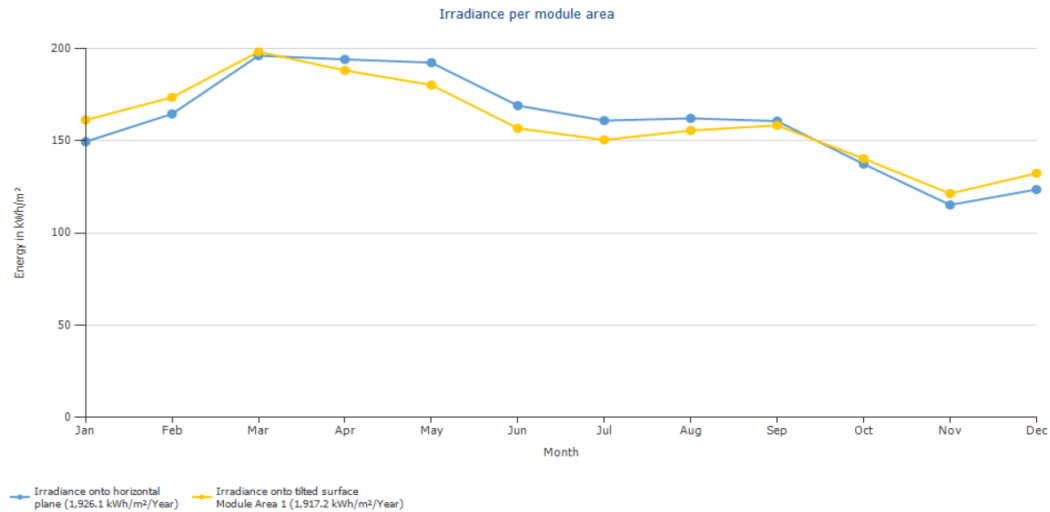


Fig 3.23 : Irradiance per module

Fig. 3.23 demonstrates The irradiance per Module area is represented by the energy emitted in Kw/m2 of two lines, one representing irradiance on a horizontal plane and the other representing irradiance on a tilted surface module area. The irradiance in modules is heavy from February to May, about 160 to 200 KWh/m2, and low from September to January, around 150 to 110 KWh/m2. It can be increased by using a dual tracking system in modules to collect more irradiance, but this will increase the mounting cost.

3.3.14 TEMPERATURE PER MODULE

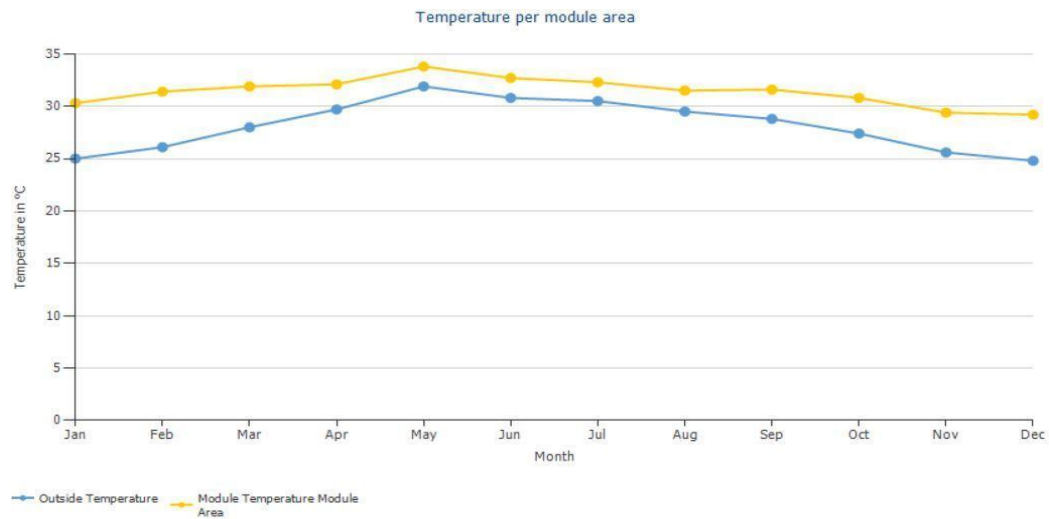


Fig 3.24 : Temperature per module area

The fig. 3.24 represents a year's worth of temperature per module region. The temperature is 0°C, and the outside temperature is represented by the blue line, while the module temperature is represented by the yellow line. The temperature inside the module is still higher than the temperature outside. In Thoraipakkam, Chennai, a PV study is carried out. 80.2362° E, 12.9416° N The average annual temperature is 27.90°C.

3.3.15 STATE OF CHARGE

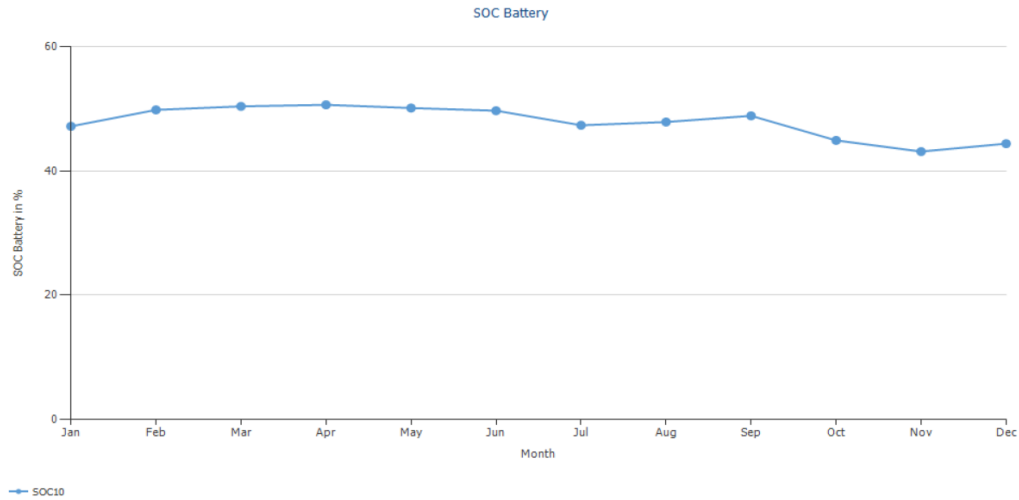


Fig 3.25 : SoC

The state of charge of an electric battery is the amount of charge it has in relation to its power. The State of Charge of the Battery in Percentage as seen in Fig.3.25. Due to environmental conditions, State of Charge declines from June to August and September to January, as seen in the graph.

3.3.16 CASH BALANCE

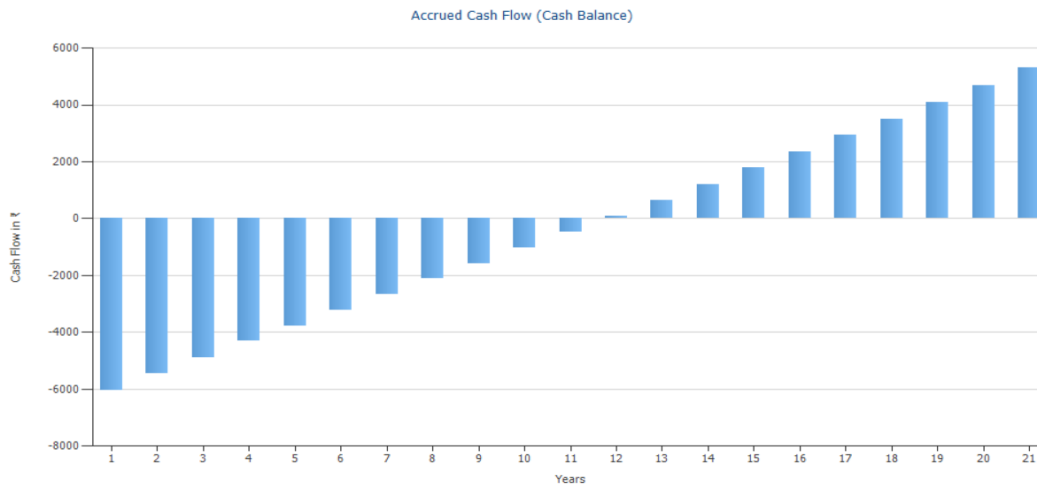


Fig 3.26 : Accrued Cash flow

The fig 3.26 shows Accrued cash flow for the current and future years. This indicates the system's balanced energy rate, which is 8.23 Rs/kWh. And, after 12 years of effective service, this machine would yield a net return of Rs5,500/-, which is a strong return as compared to our capital investment.

3.3.17 DEVELOPMENT OF ENERGY

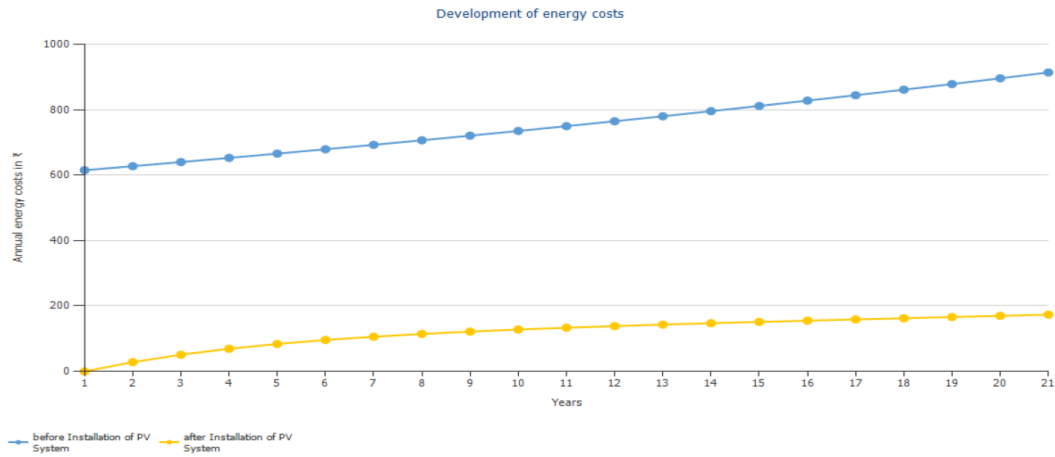


Fig 3.27 : Development of energy cost

The fig. 3.27 shows the cost of power prior to the implementation of a PV system and during the installation of a PV system. The average cost of electricity is decreased by more than 55 percent after the PV system is installed, compared to the cost before the PV system was installed.

CHAPTER 4

HARDWARE DESCRIPTION

4.1 COMPONENTS

4.1.1 Solar Panel

A solar cell is an electrical system that converts solar energy into electricity through the photovoltaic effect. The photovoltaic effect is a phenomena that occurs when light is exposed to a substrate and produces voltage or current. When sunlight is absorbed, the electrons in the valence band gain enough energy to leap into the conduction band and become free. These strongly excited electrons disperse and are transported into another substrate with the aid of built-in potential until they meet the junction. Electromotive force (emf) is produced as a result of this action, which transforms a certain amount of light energy into electric energy.

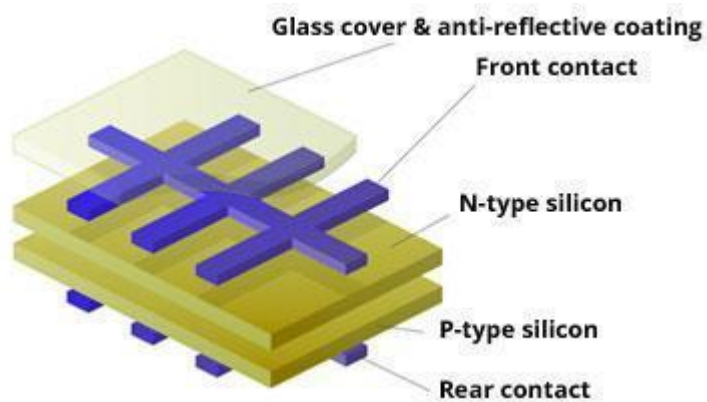


Fig 4.1 : Photovoltaic Cell

The layers in a solar cell are constructed in such a way that one layer is able to waste electrons while the other is ready to receive them. To build a solar cell, N-type and P-type silicon layers are used. Though there are electrons ready to travel, there is a lack of energy, which can only be achieved by solar energy. As light drop, electrons begin to pass in the same direction, resulting in the generation of electricity. There is a surge of electric current through an external circuit while metal contacts are connected on two ends. The collected DC current is converted to AC using an inverter, allowing it to be used at home.

Solar panels are critical to the effective use of renewable energy. This solar panels are an environmentalist's dream because they can generate unlimited electricity from the sun while emitting no radiation or carbon dioxide. Different forms of solar panels are now available on the market all over the world to expand reliance on solar energy.

4.1.1.1 Polycrystalline Solar Panels

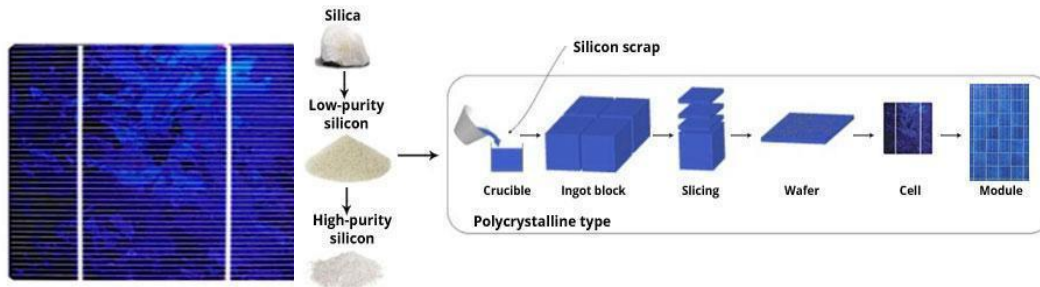


Fig 4.2 : Polycrystalline solar panel (manufacturing)

Polycrystalline solar panels hit the market for the first time in 1981. It became one of the best choices for obtaining renewable energy since its launch. It is now a standard style that is suitable for residential use. Multicrystalline, Multi-Silicon, and Ribbon are some of the most popular names for them on the market. Polycrystalline solar panels are constructed from silicon offcuts that are moulded together to shape blocks, resulting in a cell of multiple pure crystal pieces. The solar cells in the panel work together to collect energy from the sun and then aid in the conversion process. When we look at individual solar cell crystals, we can see that they are not precisely matched. Many losses occur at the joints as a result of the misalignment, rendering this solar panel less effective. Polycrystalline panels have an average productivity of 12-16 percent. It usually takes the shape of a blue solar panel with square cells. This panel has the benefit of having very little empty space. The majority of them produce low-cost panels with a 25-year warranty. Using a solar panel mount, polycrystalline solar panels can be mounted on building roofs, rooftops, or standalone facilities. It can be mounted using any of the three major types of solar panel mounts: pole mounts, roof-ground mounts, and flush mounts. Place the panel in such a way that it receives the most direct sunlight when it is mounted.

4.1.1.2 Monocrystalline Solar Panels

The safest choice is monocrystalline solar panels. They are among the most reliable, long-lasting, and energy-efficient solar panels available. The solar panels are made up of single silicon crystal modules, and are more costly than polycrystalline and thin-film panels. Monocrystalline solar panels are usually black or iridescent blue in colour, with rounded end solar cells, and are suitable for both domestic and industrial use. They are now often referred to as 'Mono Silicon' or 'Single Silicon' in the marketplace.

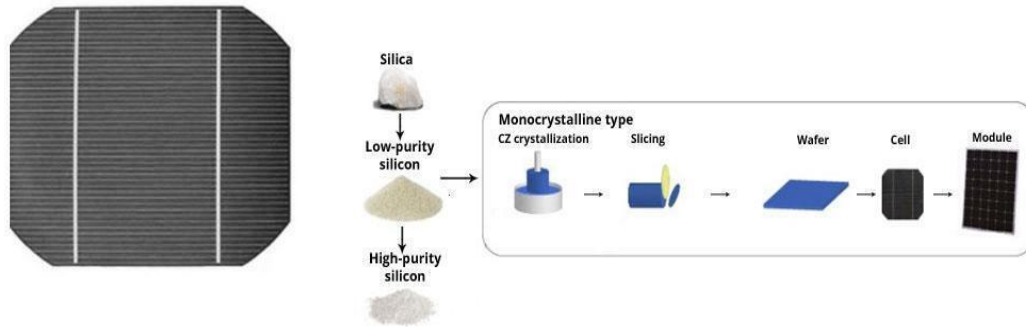


Fig 4.3 : Monocrystalline solar panel (manufacturing)

Each solar cell is oriented in one direction, which is one of the solar panels' features. This solar panels can be incredibly effective when the sun shines at the right angles because of this element. Many monocrystalline solar panel manufacturers already produce solar panels with efficiencies of 15-20%. As compared to polycrystalline solar panels, there is a significant amount of available space and a limited footprint. The best qualities of these panels are higher wattage per square foot, longevity, lower maintenance costs, more power per square metre, and a long lifespan.

Vikram Solar (INDIA) is currently the most successful monocrystalline solar panel maker in the world. They usually produce panels that are 19.5 percent effective. Suntech Power, Adani Power, Transform Solar, Sanyo, and Suniva are some of the most well-known manufacturers. Almost all of these companies have a 25-year warranty and recommend rigid mounting after construction.

4.2 HARDWARE CIRCUIT

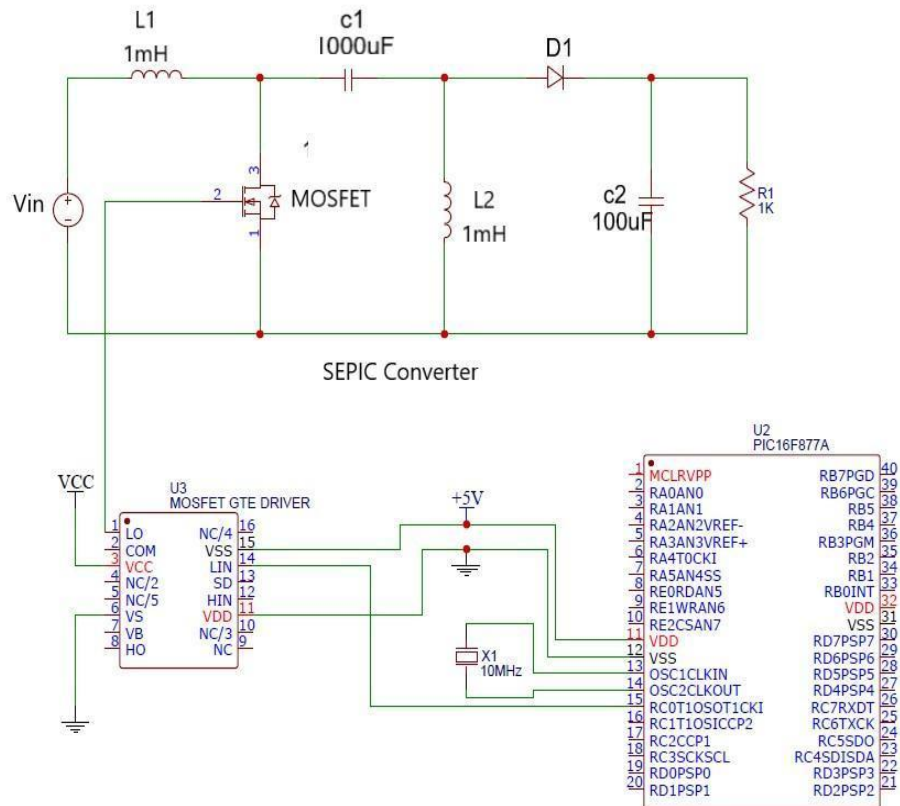


Fig. 4.4 : Hardware Circuit diagram of System.

The fig. 4.4 shows Sepic converter, MOSFET driver, and PIC16F877A controller circuit diagram. V_{in} is fed to a Sepic converter, which consists of two 1000uF and 100uF capacitors, two 1mH inductors, one 1k resistor, and a MOSFET. The MOSFET gate is triggered with the aid of a MOSFET gate driver, and the PIC16F877A controller provides the trigger pulse.

4.2.1 Hardware Circuit Photocopy

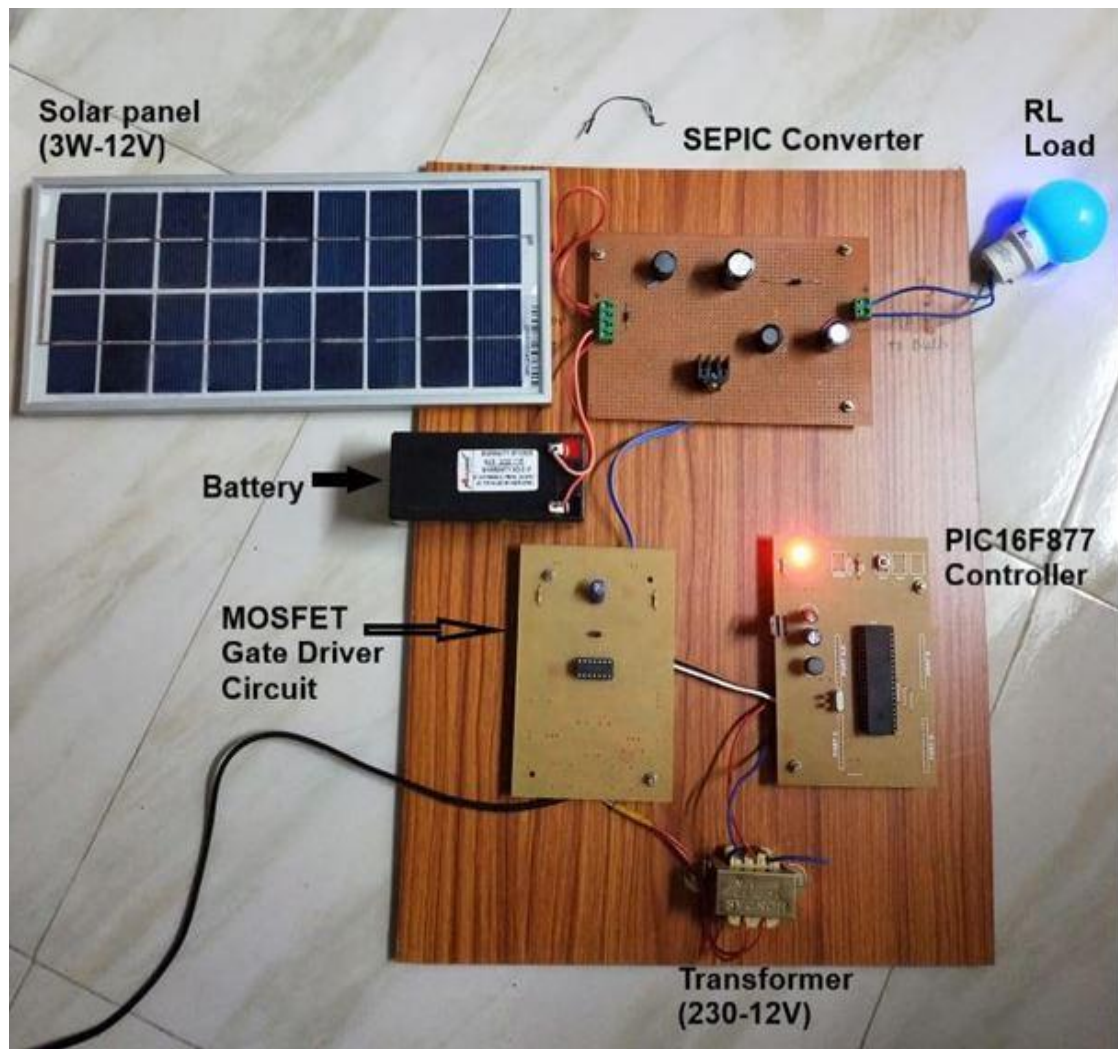


Fig 4.5 : Photocopy of Hardware Circuit

TABLE 4.1 Experimental Output Results

Sr.no	Parameters	Value
1	Solar output voltage	(3-12)V
2	Battery voltage	12V
3	Sepic converter output voltage	213V
4	Open circuit voltage of Solar panel	11.25
5	Short circuit Current of Solar panel	0.41A
6	Peak Power of solar panel	3W

CHAPTER-5

CONCLUSION AND FUTURE SCOPE

5.1 CONCLUSION

A SEPIC (Single Ended Primary Inductor Converter) DC-DC converter with a three-phase inverter has been proposed in this project. We used a 5 watt solar panel and a 12 volt battery in our test setup. The PIC16F877 controller is used to construct the MOSFET triggering circuit.

When the solar panel voltage is insufficient, the battery discharges, resulting in a steady 213V through the converter's output. Furthermore, the proposed analysis has been simulated using MATLAB/SIMULINK. PV-Sol programme was used to run the energy storage simulation. The proposed Sepic style converter has a high voltage gain and reliability, according to the results. Sepic converter can be used for solar PV and BES systems, according to our findings.

5.2 FUTURE SCOPE

This concept can be seen in hybrid green energy projects for both residential and commercial purposes. This definition allows for a variety of research situations. Since energy management is mainly concerned with the production and use of energy, there is a lot of room for growth in this area in the future.

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