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MODELING AND SIMULATION OF A HYBRID ELECTRIC GRID FOR RELIABLITY AND POWER QUALITY ENHANCEMENT

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Master's Thesis

Supervisor

Prof. Dr. Osman Nuri UÇAN

İstanbul, 2024

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The thesis MODELING AND SIMULATION OF A HYBRID ELECTRIC GRID FOR RELIABLITY AND POWER QUALITY ENHANCEMENT prepared by YAHYA MOHAMMED JASIM AL-MASHHADANI and submitted on NOVEMBER /2023 has been accepted for the degree of Master of Science.

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I hereby declare that this thesis/dissertation meets all format and submission requirements of a master's thesis/dissertation.

Submission date of the thesis to Institute of Graduate Studies: ___/___/___

DEDICATION

To My Country Iraq. To my father and mother. To My Wife and my daughter.

To My Brothers.

ABSTRACT

MODELING AND SIMULATION OF FOR RELIABLITY AND POWER QUALITY ENHANCEMENT

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Because of necessity for reactive power in solar energy systems, this paper proposes a hybrid technique for improving the power quality of grid-connected photovoltaic (PV) panels using a fixed capacitor bank, as well as PV-integrated grid reactive compensation. A styling study for a photovoltaic -integrated electrical network system on a fixed capacitor is presented in this work. Using the software program MATLAB Simulink, the system that is suggested is simulated and evaluated. The offer system has been examined in a set of operational scenarios., such as variable photovoltaic system irradiance and variable reactive consumption power. itemized simulations and compares of the fixed capacitor instead of the absence of a fixed capacitor, as well as temperature and solar radiation's effects on photovoltaic electricity generation.

Keywords: Capacitor Bank, Renewable Energy Sources, Reactive Power Compensation, Maximum Power Point Tracing, Power Quality Enhancement.

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ABBREVIATIONS

PV	:	Photovoltaic
RES	:	Renewable Energy Sources
EMS	:	Energy Management System
V, I	:	Voltage, Current
MPPT	:	Maximum Power Point Tracking
P&O	:	Perturb and observe
PSO	:	Practical Swarm Optimization
DC	:	Direct Current
ISDM	:	Ideal Single Diode Model
SSDM	:	Simplified Single Diode Model
DDM	:	Double Diode Model
P	:	Real Power
Q	:	Reactive Power
AI	:	Artificial Intelligence

1. INTRODUCTION

1.1 INTRODUCTION

The swift expansion to industry and economic development results in an increase in the need for energy, especially given that pollution from Petroleum and oil has exacerbated climate change and warming of global issues. Hence, sun energy sources, for example, wind turbines, and hydroelectric dams, etc. is a renewable and ecologically benign source of energy. Diversifying energy sources is seen as a condition of stability and dependability for the electrical network since it minimizes reliance on fossil fuel energy sources. The PV energy source in particular has received considerable attention from the global society; Figure (1.1) depicts the total green power capacity additions from 2001 to 2027, and Figure (1.2) indicates how PV has risen from 2020 to 2022 relative with other RES [1].

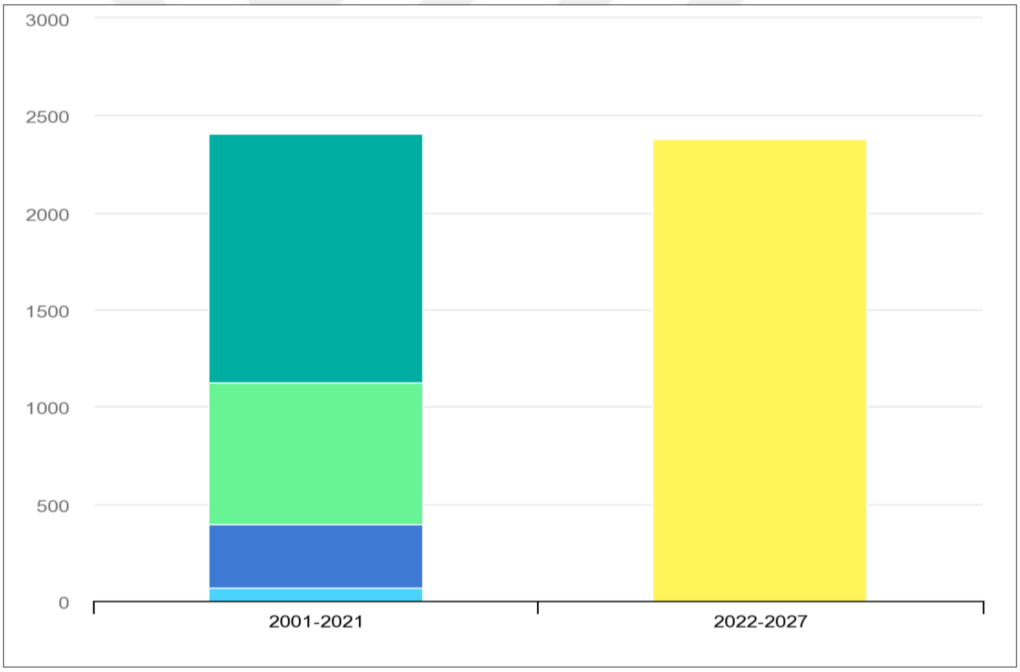


Figure 1.1: Increases in Renewable Energy Capacity, 2001-2027.

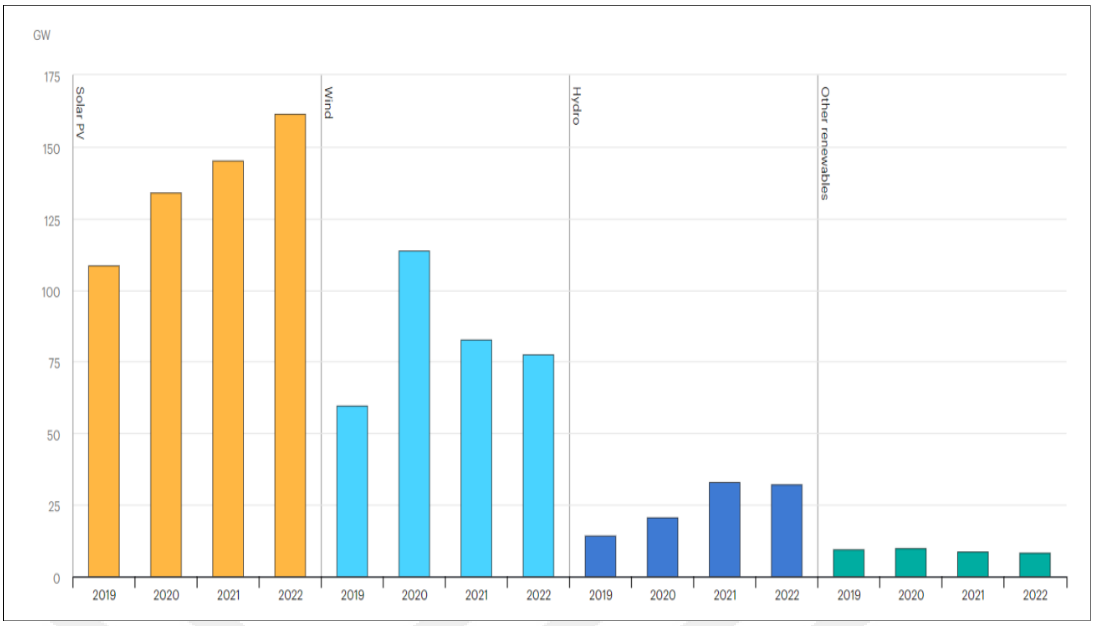


Figure 1.2: Net Additions of Renewable Capacity by Technology, 2020-2021.

The RES System is designed to function within a specific range of characteristics. However, their operation and behaviour may be impacted by disturbances. Disturbances can differ in terms of their source, length, and strength [2]. This thesis aims to analyse, assess, and elucidate the showing and behaviour of the photovoltaic (PV) hybrid grid under disruptions, such as sudden changes in load or significant fluctuations in applied radiation. MATLAB Simulink will be utilized to present the results of the PV system simulation. The current electricity generation industry Favours solar systems due to their low manufacturing cost per PV panel and ease of installation and plant management [3][4]. Connecting the photovoltaic system in series may boost the voltage of a solar power plant, while tying the panels together in parallel can increase the current rating. When creating series or parallel connections, it is needful to establish a connection between the load and the network. The two predominant ways for connecting a solar photovoltaic array to the electrical grid are single-stage connections and double-stage connections. A single-stage connection employs a grid-tied inverter with grid control circuitry to directly link the solar array system to the grid. However, this form of connection is only suitable when the end voltage of the PV array remains within the allowable range. If the final voltage of the PV system is inadequate, a two-stage connection must be utilized. A two-stage configuration utilizes a direct current setup converter to elevate the voltage of the solar system to the standard level. It also employs an electrical network-connected inverter to link the output of the setup converter to the grid. In a dual connection system, a step-down direct current converter must be utilized between the electrical net-connected inverter and the solar PV array when the PV array system voltage is very high [5][6]. Reactive power control is a crucial component of a solar grid system. Only the energy that can be effectively utilized is sent to the load from a photovoltaic (PV) system. Excess real power is distributed to the electric net; however, photovoltaic array systems do not distribute reactive power. The numbers [7], and [8]. By legal mandate, the grid is obligated to supply reactive load power if the load demands it. Reactive power on the output side can be rectified by utilizing a capacitor bank [9][10]. If the reactive power required by the load is lower than the capacity of the capacitor, the load-side power factor is leading. Conversely, if the reactive power required via the load exceeds the capacity of the capacitor bank, the load-side power factor is trailing. Below is an analysis of the organizational framework of this project: Solar PV panel array designs include LC filters to attenuate harmonics and enhance power quality. Chapter Two introduces the grid-connected inverter, DC-DC converter, and storage capacitor. In Chapter three, the text explores the procedure of modelling a multi-mode, grid-connected solar PV array. The proposed job summary is wrapped up in Chapter four. To simulate the suggested system, we will use MATLAB Simulink version 2022/b.

1.2 TYPES OF PV SYSTEMS

The primary application of PV technology was to provide the satellite in space with the necessary electrical power; the same technology is currently being developed to deliver electricity to customers. There are four types of photovoltaic (PV) systems that may be utilized[11].

a. Grid-Connected System: In this system, PV power is converted from DC to AC power via inverters., surplus electrical power is immediately or later sold to energy supply companies, and power can be purchased from the grid at night or when irradiance drops.
b. Standalone System: In this system, the photovoltaics system is not connected to the electricity net; in this situation, a battery may be utilized to store and provide power as needed.
c. PV generating systems are combined to form a hybrid system with alternative energy production devices, such wind turbines, diesel generators, and so on. PV generation has the potential to reduce conventional units' overall fuel consumption.

d. In this scenario, the PV-generated energy is stored in batteries and may be used when the irradiance lowers at night. With net-balance power, unutilized PV energy may be sold back to the power grid.

1.3 MOTIVATION

Because of environmental concerns and the fast development of technology, both industrialized and developing countries are seeking to replace fossil fuels with RES. Governments, consumers, and investors have identified photovoltaic (PV) technology as a critical technology for meeting the need for energy. The increasing usage of PV systems of all sizes, including utility- and residential-scale systems, exemplifies this. Figures 1.1 and 1.2 demonstrate how solar PV systems are being developed and implemented throughout a vast portion of the power system. Advantages of utilizing a different system:

a. By reducing increasing the reduction of fossil fuel dependence combined with the deployment of renewable energy sources, particularly intermittent ones, hybrid systems may improve the ecoefficiency of the generation of energy and energy security.
b. In the long term, hybrid systems may cut energy costs by balancing fossil fuel use with renewable generation.
c. Establishing isolated grids may assist rural locations with contemporary energy access while because minimizing the cost of connections for distribution and transmission to the central grid is necessary. Hybrid systems could contribute to more reliable access to contemporary energy sources, particularly in impoverished communities that rely on diesel generators and are susceptible to power outages due to fuel price variations.

1.4 HYBRID ENERGY SYSTEMS FACE THESE ISSUES.

a. Financial: Due to the various components necessary to produce a hybrid system, its construction is often costly[12].

b. Technical

a) Hybrid energy systems do not have a single best setup. Instead, optimization is based on factors including local renewable and non-renewable resource availability, energy infrastructure, production costs, and financial incentives. Therefore, it is important to devote sufficient time to study for each prospective project area while constructing a hybrid system. The scalability of many hybrid systems is limited by the technologies available now because they rely on dispatchable, small conventional power production facilities and/or on small storage devices to deal with intermittent renewable energy sources.

b) The technologies for generating and storing energy that may be part of a hybrid system are still at various stages of development. Investing in costly, long-term infrastructure that might be significantly upgraded soon is dangerous.

c) Market possibilities for the implementation of emerging energy technologies may arise with the advent of hybrid energy systems. If a technology, like a new fuel cell, isn't yet ready to produce energy on its own, it may still be useful as part of a hybrid system, where its less-than-ideal performance may be mitigated by the presence of other, more dependable components.

1.5 THESIS OBJECTIVE

We will concentrate on addressing the following goals in this work:

a. Conduct a complete literature study, including books, journals, and conference papers, on a hybrid electrical grid coupled to a PV system.

b. A critical analysis of the major converter topologies utilized in PV systems.

c. To progress the output efficiency of the photovoltaic system, MPPT algorithms, including P&O are implemented.

d. Propose and implement a modified boost to enhance the PV system's output and lower the current to lower the converter switches' power losses.

e. To design a hybrid system capable of ensuring a reliable power flow from the PV-designed and generating source (fuel) to the load.

f. Construction and simulations of a three-phase inverter to regulate an apparatus that upholds as stable a frequency and voltage output as feasible.

g. Compensating for reactive power in a hybrid system by installing a capacitor bank to the load.

h. analysis of the fixed capacitor bank's performance under various load and generation-side disturbances.

i. The relationship between temperature and solar radiation in the production of electrical power generated from the solar station.

1.6 METHODOLOGY

This study's methodology used a modelling and simulation technique. Each suggested model and simulation are created using MATLAB-Simulink. work circuit block to aid in the improvement of the design of a hybrid electrical system using two energy sources an electrical grid coupled with a PV system and to install a fixed capacitor bank for power quality. This study uses MPPT methodologies to examine their performance.

1.7 THESIS OUTLINE

The approach for completing the research's five chapters is laid out in Section 1.5, along with a description of how the study's goals will be reached. There will be a brief introduction to each chapter that gives a synopsis and identifies the most significant contributions. There is a summary at the end of each section.

Chapter1: provides a quick rundown on green energy, particularly the PV method, accompanied by a discussion of the thesis framework, goals, and purpose for the study.

Chapter 2: Follows the mathematical notion of the photovoltaic system cell and the electrical net-connected PV system after providing a summary of how panel array systems have evolved. This is followed by a description of the capacitor bank device and, finally, the highest power point specification-the monitoring principle (MPPT) and collection of MPPT techniques.

Chapter 3: covers the key panel array system converter topologies. This includes distinct mathematical models shown in block diagrams as converter characteristics. Similarities across converters are followed by mathematical derivations, modelling forms, and functionality definitions. Often, capacitor bank type modelling and balance of voltage between cells are performed**.**

Chapter 4: Accompanying the different scenarios given should be a description of the proposed hybrid electrical grid's performance simulation.

Chapter 5: completes the investigation and discusses future study possibilities.

2. THE ORETICAL BACKGROUND

2.1 INTRODUCTION

Hybrid energy systems have several advantages over conventional energy systems because they employ multiple energy generation, storage, and/or consumption technologies. Why restrict us to just one kind of energy production and storage when diversity is the spice of life? In such situations, hybrid energy systems are the best option, as they can provide significant performance improvements and cost savings while also being adaptable to the specific requirements of the end user[13]. Diverse varieties of RES may be able to be integrated with ESS into the microgrid due to increased reliability and security by sustaining the power flow during the shortage in RES caused by low irradiance during cloudy or nocturnal conditions, low wind speed for wind turbines, etc.

2.2 HYBRID ENERGY SYSTEM

Optimal hybrid system design for load needs must be determined by evaluations determined by system life-cycle cost and power reliability, As sight in Figure (2.1) [14].

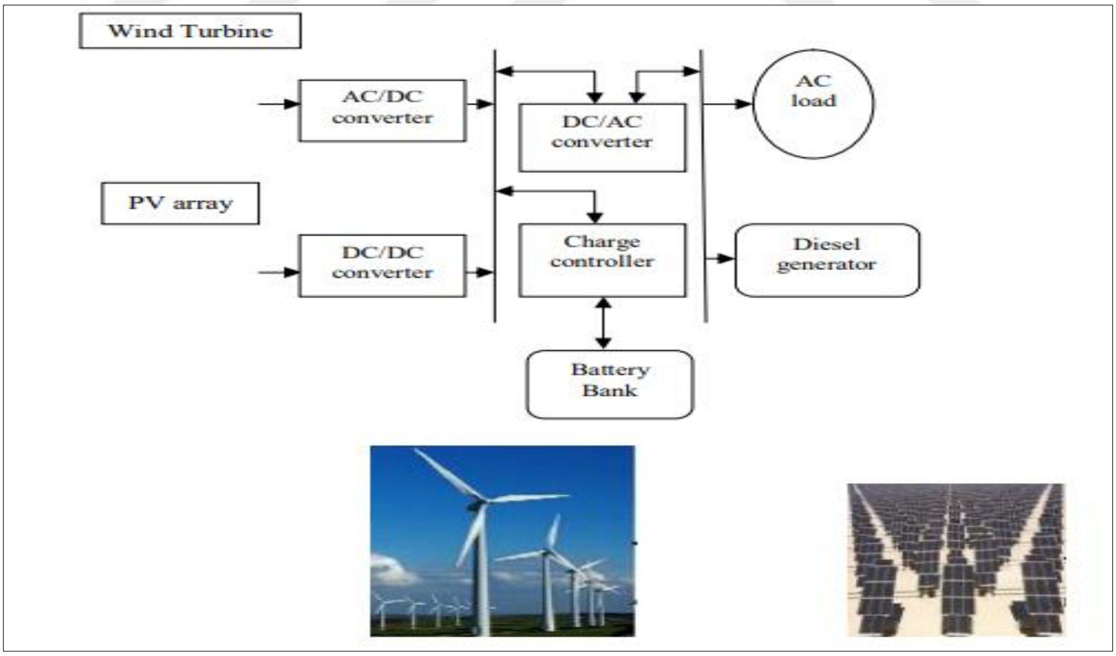


Figure 2.1: Hybrid Energy System.

2.2.1 Power Reliability Analysis

Power reliability is seen as a vital component in the development of hybrid systems. The hybrid energy system's goal should be to meet demand at the least expensive price point possible. Multiple techniques exist for testing the durability of hybrid technologies. possibility of power supply failure, The likelihood of a load failure, system efficiency, and load failure hours. There is a possibility of an insufficient power supply if the hybrid system cannot match the capacity required. When there is a period when there is a greater demand for electrical power than there is supply available, there is a risk of overloading the power system (LOLP). The SPL calculates the probability that the load will be too great for it to bear. Al-Ashwell and Mugham devised a technique for figuring out how much energy should come from Using a hybrid method, solar and wind energy based on the loss of load risk (LOLR)[14].

2.2.2 Analysis of System Expense

The system cost analysis makes use of the economic variables Levelized cost of energy, life cycle cost, and net present cost. The starting price of every system component as well as the replacement costs incurred during the project, and the cost of maintenance are all included in the net present cost. It is a popular belief that PV modules last as long as the system. By multiplying the system's annual power output by its entire annual cost, the levelized cost of energy is determined [14].

2.2.3 Optimization of Unit Size

hybrid size units RE/AE systems is a critical & crucial issue that have been widely explored. Essentially, it is a technique for estimating the size of hybrid system components to minimize system cost while ensuring system dependability. Under sizing the system components might result in a breakdown of the power supply or inadequate power provided to the load, while oversizing would increase the system cost. Size optimization may be accomplished in the following ways[14]:

a. Software equipment.
b. Probabilistic method
c. Method of graphic construction

d. Iterative strategy

e. Method of Artificial Intelligence

2.3 ENERGY MANAGEMENT SYSTEM

The impact of RES resources and ESS devices on distribution networks could have a substantial influence on the grid's performance. Integration of RES into of distribution system has positive effects, including increased dependability, a lower bus voltage profile, and decreased grid losses. In addition to the benefits, the unwarranted administration of concurrent network activities may diminish its durability. Consequently, a suitable administration schedule is essential for the effective operation of these components. One of the primary objectives of a distribution grid operator is to reduce operational expenses, thereby reducing electricity costs. In addition, reliability is an important objective in the study of power distribution grid, which play a significant role in improving system performance, particularly in reducing subscriber blackouts, and any operational program is unacceptable in modern power systems regardless of reliability indicators. accordingly sight in Figure (2.2) [15].

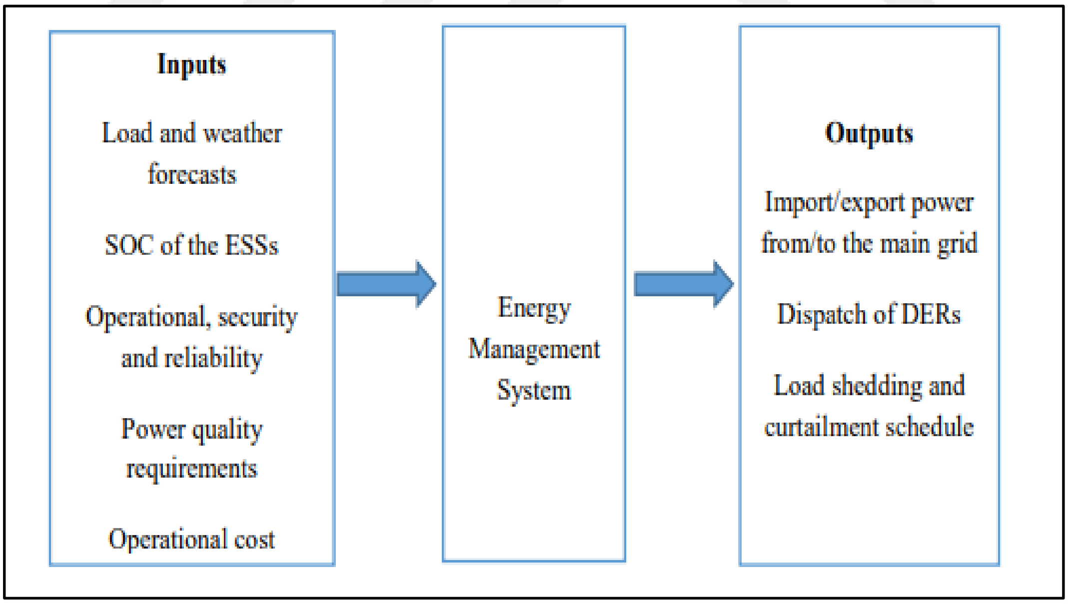


Figure 2.2: Energy Management System Input and Output Information.

2.3.1 Benefit from Energy Management Programs

In addition to aiding in the mitigation of global issues caused by carbon emissions, energy management programs also assist businesses. Having energy management software in place helps in controlling a company's budget and reducing the risk connected with energy price rises, which may affect a company's capacity to function. Monitoring electricity expenses and energy efficiency enables businesses to budget more effectively and obtain a deeper understanding of their entire operating costs. According to Energy Star, a 10% reduction in energy use may enhance net operating income by 1.5%. Energy monitoring and management not only contributes to a company's bottom line via lower use and consumption, but it may also minimize a company's dependency on supply networks that are often unstable. Energy management systems may also assist businesses in saving expenses through competitive procurement[16].

2.3.2 The Challenges of Energy Management

Energy management has its own unique difficulties. Such examples include:

a. Insufficient data integrity, analysis, and transparent benchmarks: Conventional building management systems and meters that gather data through manual energy audits do not give data that reveals patterns of inefficient energy use. Using an energy management system makes it simpler and easier to obtain and use more information on energy usage. A robust energy management system delivers frequent, trustworthy, and personalized energy data automatically.
b. Faulty systems, improper settings, and badly maintained equipment are the result of rarely scheduled inspections. Unanticipated equipment failure necessitates reactive maintenance, which may entail difficulties and unanticipated costs. In contrast, intelligent energy systems promptly notify you of device failure and energy waste. They give you real-time data on energy use and allow you to establish energy KPIs for consistent outcomes. With a proactive maintenance approach that includes routine and preventive maintenance schedules, equipment is routinely maintained and has longer lifespans.
c. Failure to prepare for energy upgrades: in-depth energy data enables you to make intelligent judgments on energy retrofits or upgrade activities that result in cost savings and a positive return on investment.

2.4 ENERGY PRODUCING SOLAR PANELS

The photovoltaic (PV) cell relies on a P-N junction technology on radiation and temperature for its operation and is composed of semiconducting materials such as monocrystalline or polycrystalline silicon. Now, silicon holds the greatest significance in the solar cell sector., despite not being the material from which cells can be made. The photoelectric cell comprises a voltage sources, diode, resistance in series, and resistance in shunt on a global scale. Photovoltaic cells are divided into four distinct categories [17].

a. A single-diode model that is ideal (ISDM) is straightforward, efficient, and needs a little simulation time [18].
b. The Single Diode Model (SDM) contains RS, RSH, IO, and IPV.
c. The Simple Single Diode Model (SSDM) reduces the complexity of the Simplified Diode Model (SDM).
d. Double Diode Models (DDMs) It enhances the model's precision, although it is not often used due to its complexity. The conversion of energy in a photovoltaic (PV) system step that explain how this happens: The absorption of solar energy (photons) produces electrons, or electronic holes. The gadget then separates electrons and holes in the subsequent stage. The final step is the collection of electrical charges at the edges of the photoelectric cell.

2.4.1 Modelling of PV

A multitude of photovoltaic cells that may be arranged in either series or parallel configurations to create a solar cell module. Unit size efficiency as demonstrated by the equations, the modules may be interconnected either in parallel or series to create the array 2.3 [19]. This arrangement allows them to generate the necessary amount of energy. The series connection is responsible for collecting the voltage, while the parallel connection is designed to accumulate current. The equations that express the PV voltage and current are as follows:

$$I_{PV} = \sum_{i=1}^{M_p} I_i \,; \quad M_p \text{ parallel branches} \tag{2.1}$$

$$V_{oc} = \sum_{i=1}^{M_S} V_i \,; \quad M_S \text{ branches ofseries} \tag{2.2}$$

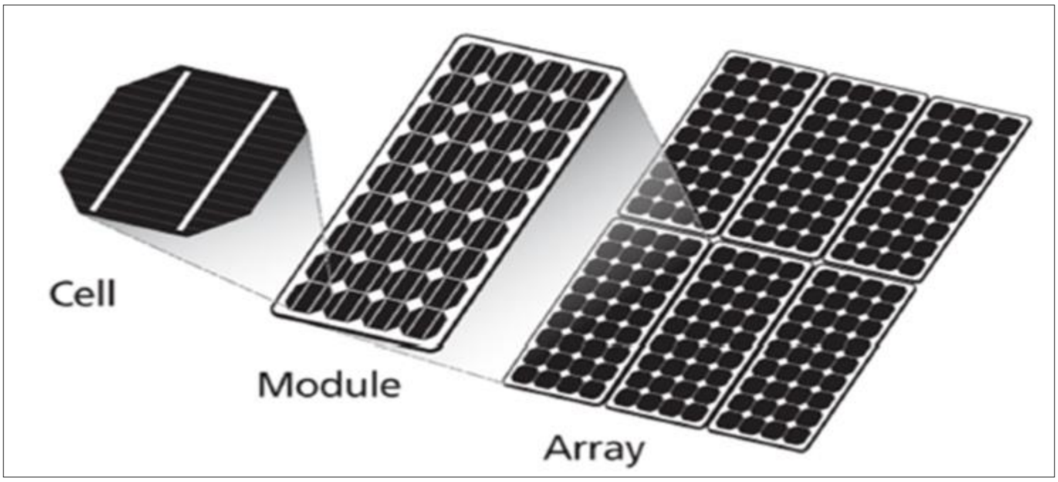


Figure 2.3: PV Array System Creation.

2.4.2 PV System Classification

a. Centralized Type: In this configuration, cells are interconnected in rows to provide high voltage. Next, these successive rows are linked to the parallel rows through as demonstrated in Figure 2.4, diodes to produce the required high energy magnitude, which is generally used in PV farms with a large number of solar panels[20].

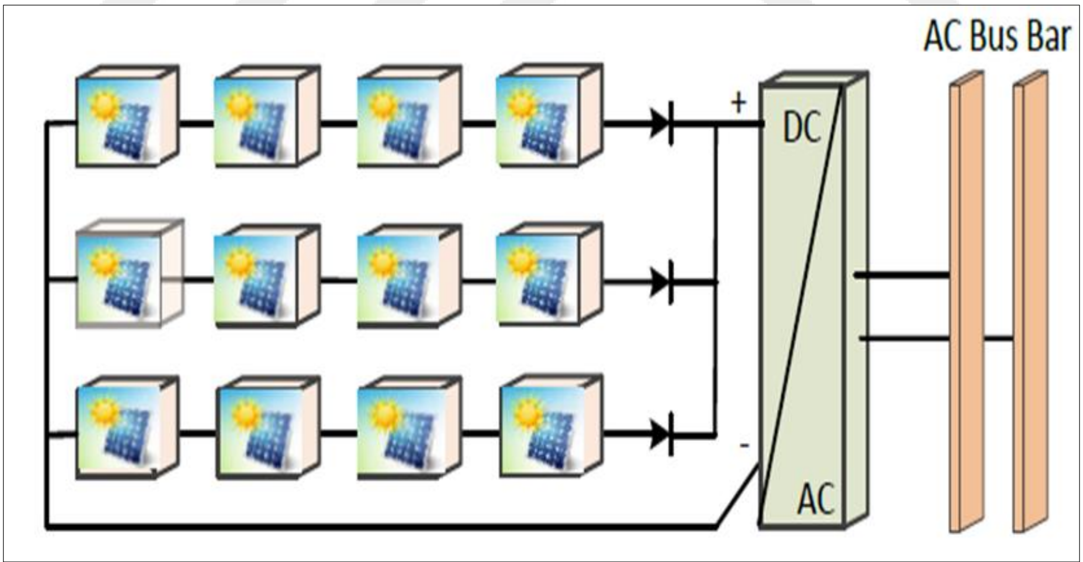


Figure 2.4: Centralized PV System.

Due to the inverter's direct connection to the leading network, this kind of inverter incurs significant losses when one of the panels crosses the darkened period. As well as the lack of autonomy of the connection between cells, such as when a defect in one of the cells or its passage into the shade occurs, it will affect all other cells, thereby affecting the generation and increasing the temperature of the cells, which causes damage or shortens their lives.

b. String PV System: In this form, cells are linked to each row sequentially, but there is no connection between rows. As illustrated in Figure (2.5)[20], each row is segregated from the next and linked to the leading grid through the inverter. This system may be enhanced by adding more chains and inverters. Due to the separation of the chains, this kind has fewer losses than the preceding type, which is one of its benefits. Each chain is distinct from the others and is linked to the leading network independently of the others. This decreases losses when a fault occurs in one of the cells of the same chain, since only one string will be affected.

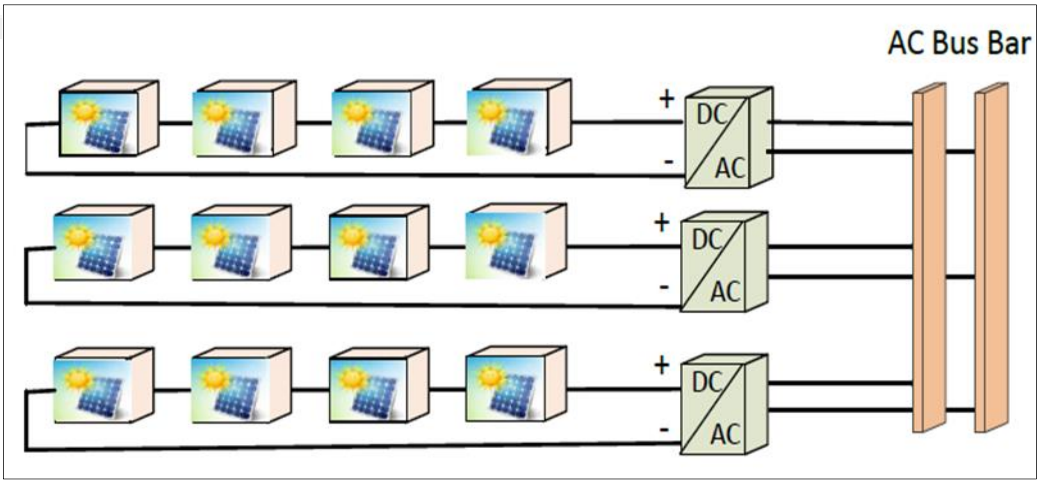


Figure 2.5: String PV System.

c. Multi-String Type: This variety resembles the earlier variety in that each chain is connected independently from the other chains, each chain is added to the converter from After connecting each converter from direct current to direct current, the inverter is connected, and each converter is connected to an alternate current inverter is finally connected to the guiding network, as shown in Figure (2.6). Due to its ability to generate the necessary voltage, this both are extremely efficient in terms of direct current to direct current conversion. And resistant to power fluctuations. voltage. The output voltage of each chain is therefore unaffected by a defect in one chain. One of the compartments experiences the night-time or atmospheric variations.

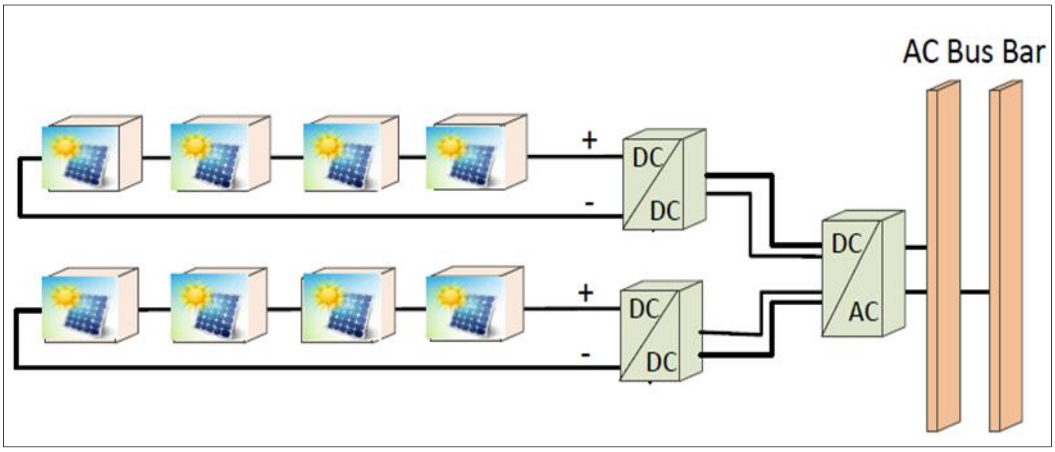


Figure 2.6: PV System with Multiple Strings.

d. The module-integrated type is the most recent and sophisticated form, with the least amount of loss compared to all prior generations. Each board is independently linked to a subnetwork through a direct current to alternate current adaptor. As indicated in Figure 2.7, the subnetworks are linked to the leading network. Therefore, this kind has limited use direct current to alternate current converters are used with several solar cells despite their expensive development (inverter per cell).

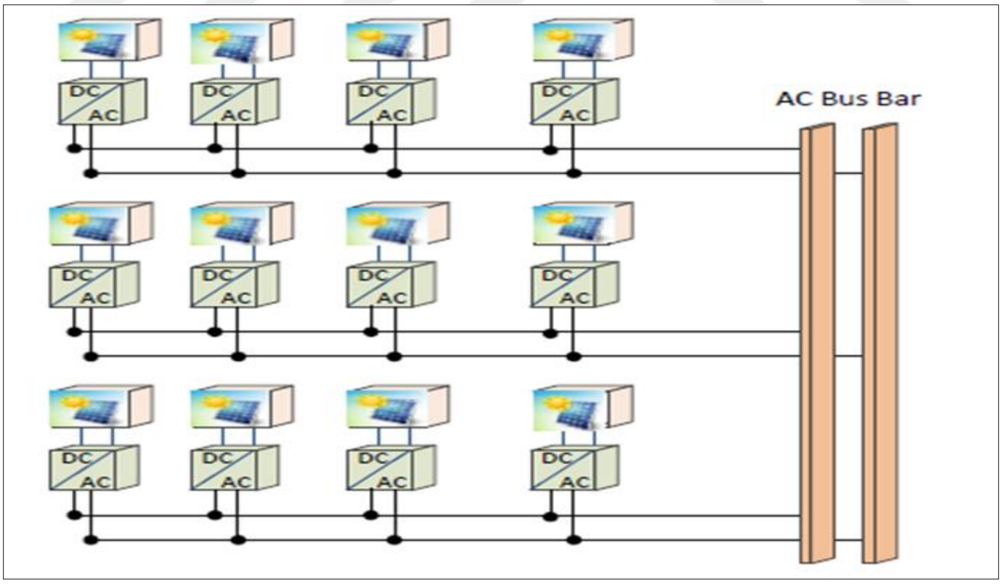


Figure 2.7: Module Integrated PV System.

2.4.3 Ideal PV Cell Model

Photovoltaic (PV) devices convert sunlight to direct current (DC) by utilizing the photovoltaic effect. P and N semiconducting materials are incorporated into the PV cells. Thus, a PV cell can be considered a diode in practice. The photovoltaic effect occurs when a connection generates currents after absorbing light. To create enough voltage and power, most PV modules will include numerous solar cells linked either parallelly or in series. To produce enough power for a meaningful contribution, a system called an array is built from of multiple individual solar modules that are bonded together on a single plane. Figure (2.8) illustrates The inverter is connected once each converter is connected from direct current to direct current [21].

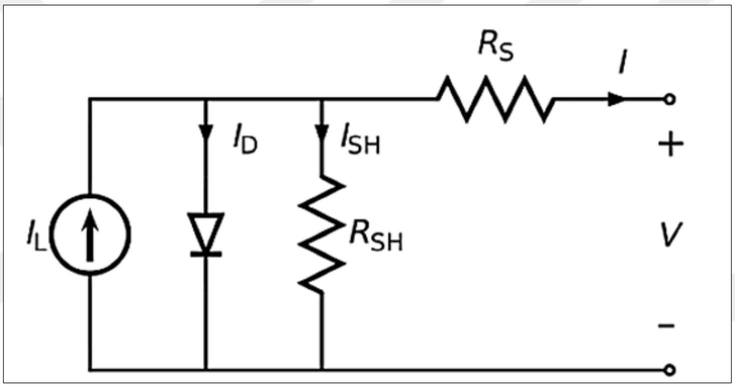


Figure 2.8: Circuit Diagram of PV-Cell.

The panel's output's load current of solar -Cell able to represent by the following equation:

$$I= IL\text{-}ID\text{-}ISH \quad (2.3)$$

$$I = I_L - I_0 * [\exp\left(\frac{q\,V_D}{nkT} - 1\right) - \frac{V_D}{R_{SH}}] \quad (2.4)$$

IL represents the current flowing through the photovoltaic (PV) system in Amperes (A), ID represents the current flowing through the diode in Amperes (A), ISH represents the shunt current flowing through the resistor in Amperes (A), VD represents the voltage across the diode in Volts (V), I0 represents the reverse saturation current of the diode in Amperes (A), k represents the Boltzmann constant, which equals 1.38X10-23 Joules per Kelvin (J/K); Q, which stands for electron charge, and T, which stands for cell temperature in Kelvin (K), Rs denotes the resistance in series, & RSH stands for parallel resistance (shunt). The power output of a solar cell is represented by the given equation.

$$Ppv = V \times I \tag{2.5}$$

The PV cell output current is represented by (I) (Amp.), (V) is the PV cell voltage (volt), and (Ppv) is the wattage of a solar cell. Due to resistor losses, the V and I characteristics in the solar cell differ from the actual.

$$I = I_L - I_0 * \left[\exp\left(\frac{q V_D}{nkT} - 1\right) - \frac{V_D}{R_{SH}}\right] \tag{2.6}$$

2.4.4 Modelling the PV Array

In this concept, a collection of photovoltaic cells is linked as an array to cells parallel or series connectivity. on the series, a rise at voltage and a corresponding raise in current are related. As seen in Figure (2.9)[21], This model augments the analogous circuit both parallel and series resistance.

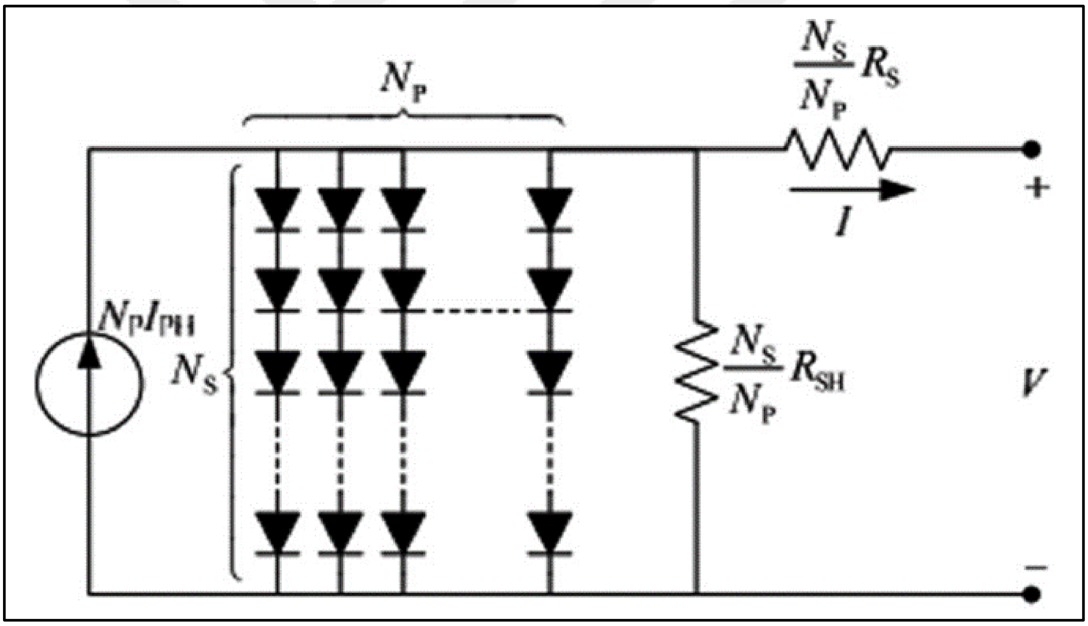


Figure 2.9: Modelling the Array.

Hence, the photoelectric cell's characteristic of equation is:

$$I=(I_{PV} - I_C - I_D - I_{Sh}) \tag{2.7}$$

$$I_s = \frac{V_P+R_S I_P}{R_{SH}} \tag{2.8}$$

$$I_{PV} = [I_S + K_O(T - T_{nom})] \frac{G}{G_{no}} \tag{2.9}$$

When the short circuit current (I_S) occurs, the optimal value is between the range of 250 to 1000 W / m2. T_NO denotes the optimal temperature of the cell, which is 250 degrees. G_NO denotes the optimal radiation received by the cell, which is 1000 w/m2. (T) indicates the current temperature in the atmosphere. (G) refers to the specific level of radiation, whether it is precise or real. K_O represents a constant value of 3mA/0C, signifying a 3mA rise in short circuit current (I) and a 10 C increase from the surrounding temperature. R_s represents the resistance in series of the module, whereas (R-Sh) represents the resistance in parallel. Figure 2.10 illustrates the current-voltage (I-V) behaviour of a photovoltaic (PV) array configuration.

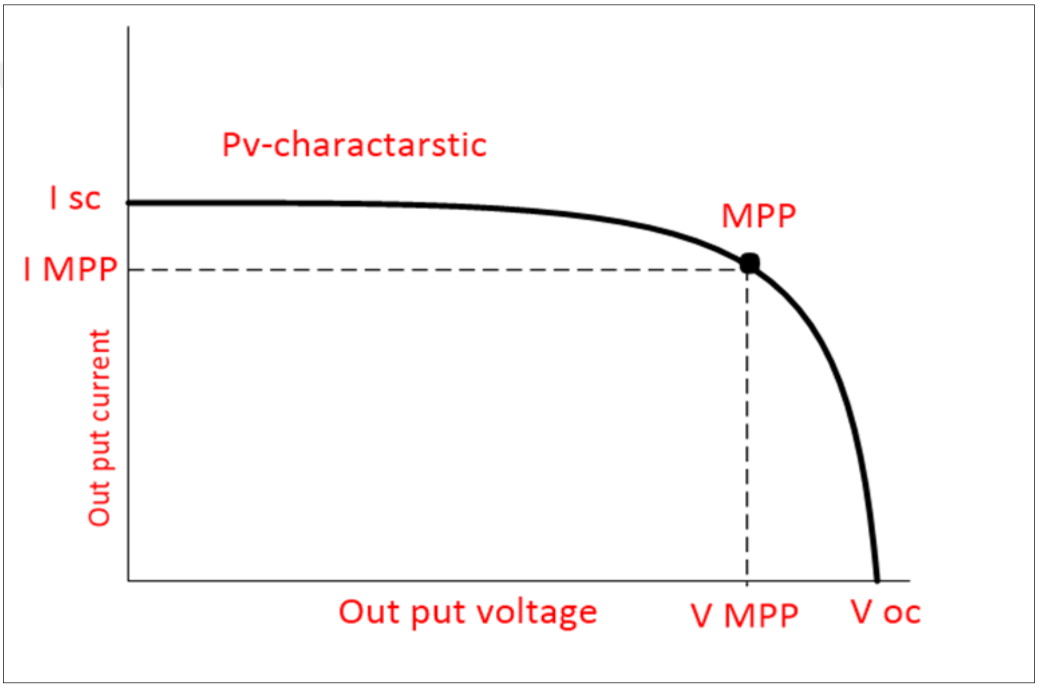


Figure 2.10: Module PV Array I-V Characteristics.

2.5 THE CAPACITOR

Capacity, from which capacitance is derived, denotes the ability to store or retain something. To put it simply, a capacitor is a device that can store electrical energy. Unlike water, which can be kept in almost infinite reservoirs like ponds, lakes, containers, and our seas, our choices for storing electrical energy are rather limited. To convert electrical energy into chemical energy for a battery, our only choice is a roundabout one. There is a plethora of uses for this energy storage and release phenomena in electronic circuits. Although capacitors come in a variety of sizes and configurations, they always perform the same function: storing electrical charge. We won't go into the specifics of any one capacitor, but instead cover the fundamentals of how they work.

2.5.1 What Exactly Is a Capacitor

A capacitor can store both positive and negative electric charge. This charge results in a difference in potential between the terminals. Similarly, to batteries, capacitors operate. Its diameters range from tiny crystals used in electronic circuits to massive ones used in power circuits for power factor optimization. As seen in Figure (2.11) [22].

Figure 2.11: Capacitor.

2.5.2 The Capacitor's Construction

In a capacitor, two parallel conductors are separated from one another by an insulator. This insulation prevents charge/current from traveling between the conductive plates, keeping it localized to the plates themselves. Beads, discs, and cylinders may be created from flat plates of varying forms such as rectangle, square, and circular while still retaining the same level of insulation. The capacitance of these devices is what determines their size. The accompanying image is the simplest, most intuitive capacitor schematic possible. The dielectric medium in the shown capacitor is air, but in practice, insulating material is utilized that can keep the charge on the plates. Materials might range from clay and paper to plastic and gasoline. A voltage source is required to charge the capacitor, and current will flow steadily into it until it is completely charged. When fully charged, a battery may be used as a voltage generator. The accompanying picture also shows a small, cylinder-shaped capacitor. It's important to realize, however, that capacitors come in a variety of sizes, ranging from minuscule to gigantic. Most capacitors these days have multilayer designs, which enable us to store more charge in each space. Bipolar capacitors are compatible with both direct current and alternating current, whereas unipolar capacitors can only handle direct current. The capacitor is well-sealed on the outside to prevent the infiltration of moisture. Capacity, voltage, and polarity are all clearly marked on the housing of each capacitor. It may keep working even after being subjected to mechanical stress. As seen in Figure (2.12).

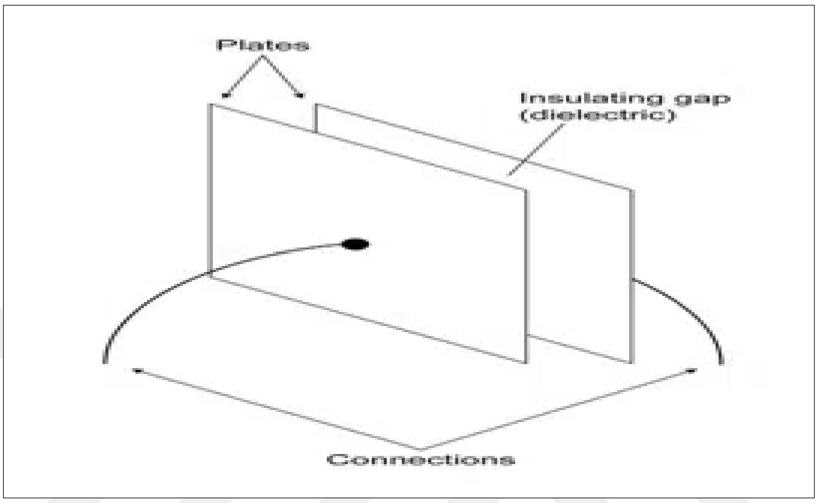


Figure 2.12: Capacitor Graphical, in Most Basic Form.

2.5.3 The Basic Capacitor Circuit

The below of image (2.13) depicts a simple circuit for illustrating capacitor charging and discharging. When the switch is moved toward the positive battery terminal, positive charges build up on the capacitor's positive plate, and negative charges build up on the negative plate. This procedure is repeated until the voltage of the capacitor matches that of the battery. After the switch is the resistance is now linked the battery is open-circuited because the positive plate is connected to the negative plate. across the capacitor. As a voltage source, resistance discharges a capacitor.

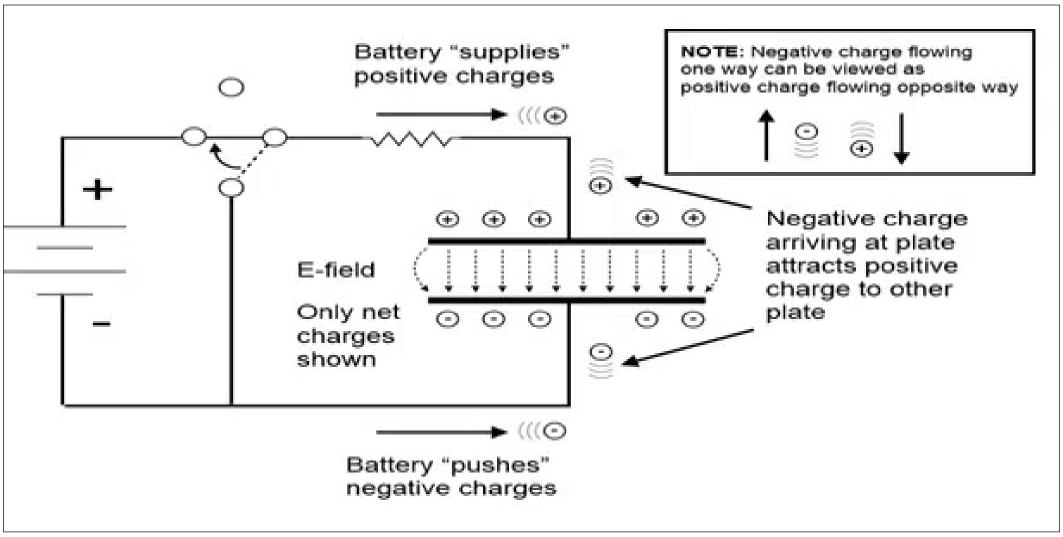


Figure 2.13: Circuit Diagram.

2.5.4 Symbol for Capacitor

Capacitors are referred to in a different of ways depending on the country and standard; we've included the most common ones here, As seen in Figure (2.14).

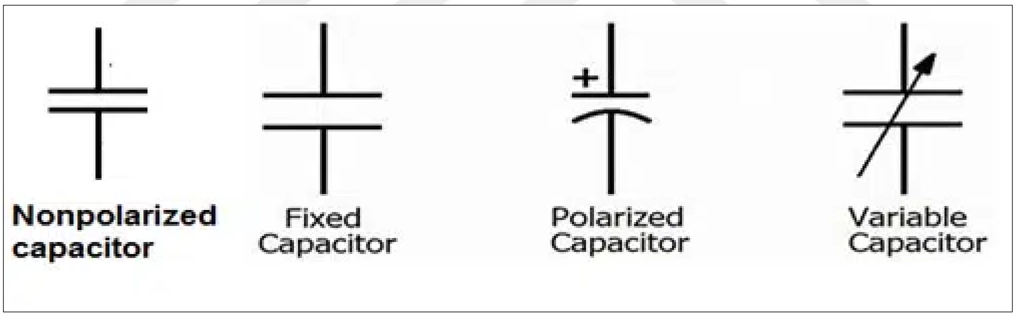


Figure 2.14: Capacitor Symbols.

2.5.5 The Capacitor's Operating Theory

When a conductor is coupled to a voltage source, it is well known that Q charge is transferred to the conductor. Since charges are proportional to voltage, this relationship can be expressed as Q-V. Must establish the relationship between charge (Q) and (V).

$Q=C\times V$, C are conductor capacitance.

$C=Q/V$, the magnitude of C is affected by several factors, which are listed below.

a. Zone of plates and conductors. The amount of charge accumulated on a plate increases in proportion to its surface area.

b. ii. Space between the plates. When the separation between the plates widens, the capacitance drops because either the permittivity, the magnetic force, or the charge binding strength declines.

c. A dielectric substance. The capacitance value might be increased by using a material with a high permittivity. Air is thought to have a relative permittivity of 1, whereas glass/ceramic is thought to have a relative permittivity of greater than 7.

These materials are of paramount importance while building a capacitor. This may be expressed mathematically as[22]:

$$C = \frac{\delta\, A}{d} \tag{2.10}$$

Were,

a. C= Capacitance (F)
b. δ = dielectric permittivity (absolute)
c. A= Plate area overlap in (M^2)
d. d = distance amidst plates (M)

2.5.6 Capacitor Expression Mathematically

The formula for power stored in a capacitor be found below.: Q = CV and W = $CV^2/2$. The Capacitor Formula are another name for this. Capacitance Could be produced by connected ingredient in (series and parallel), as shown in Figure (2.15), where Cp and Cs are the parallel and serial capacitances, respectively.

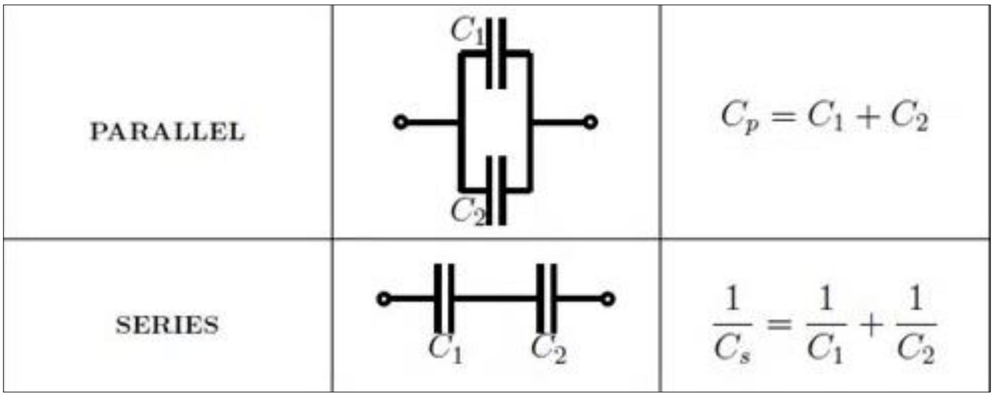


Figure 2.15: The Series and Parallel Capacitor.

2.5.7 Measurement of Capacitance

Michael Faraday, a famous scientist, inspired the naming of the Farad, the SI unit for capacitance. coulomb on volt is equivalent to one Farad.

2.5.8 Capacitor Applications

In practically every discipline of electronics, capacitors play a crucial function, and power circuits are no exception according to the application, we may employ several capacitors part for various purposes.

a. Ceramic capacitors are favoured for use in filters, oscillators, and tuned circuits because of their excellent dielectric characteristics. Because the lengths of An RC constant time can be used to calculate the charging and discharging times, and capacitors can be utilized as timing devices.
b. Capacitors may be used to couple, block, or bypass radio frequency signals.
c. In addition, capacitors serve as a standardizing component in a wide range of wave generators, frequency converters/inverters, and other high-switching-frequency applications.
d. Voltage is divided and multiplied using capacitors.
e. As a retention mechanism Even if the power source is interrupted, capacitors can retain their voltage/value.
f. Capacitors are utilized in snubber circuits to safeguard various power electronic components.
g. To filter out unwanted sounds, capacitors are crucial. This is where a film capacitor shines the brightest.
h. In all A/D converters, the capacitor plays a key role. This purpose may be served by electrolytic capacitors.
i. High ignition voltage is provided by capacitors in a variety of ignition methods.
j. Power factor enhancement, achieved by installing a capacitor in a power system, extends the life of the switchgear and boosts the system's active power.

k. In the case that the primary battery fails, capacitors are used to offer a supplementary source of direct current power (Emergency supply) for activation.

l. Single-phase ac motors also make use of capacitors, but in a different capacity: as phase splitters. Electrolytic capacitors made of aluminium are the best choice here.

3. MODELLING OF THE PROPOSED SYSTEM

3.1 THE PROPOSED SYSTEM CONFIGURATION

Figure (3.1) depicts the Photovoltaic grid-connected system recommended by this research; the system's primary energy source is PV system. To mitigate inefficiencies, a step-up (boost) converter from direct current to direct current is utilized until increase the DC V_{out} and decrease the current of direct I_{out} of a PV solar system. LCL filter in solar PV-side inverter is used in conjunction with P&O techniques to achieve MPPT in PV-solar systems. The three-phase grid is a backup power source that is utilized when the primary power source is interrupted or insufficient. Three circuit breakers are used to incorporate the fixed capacitor into the three-phase grid to provide reactive power compensation.

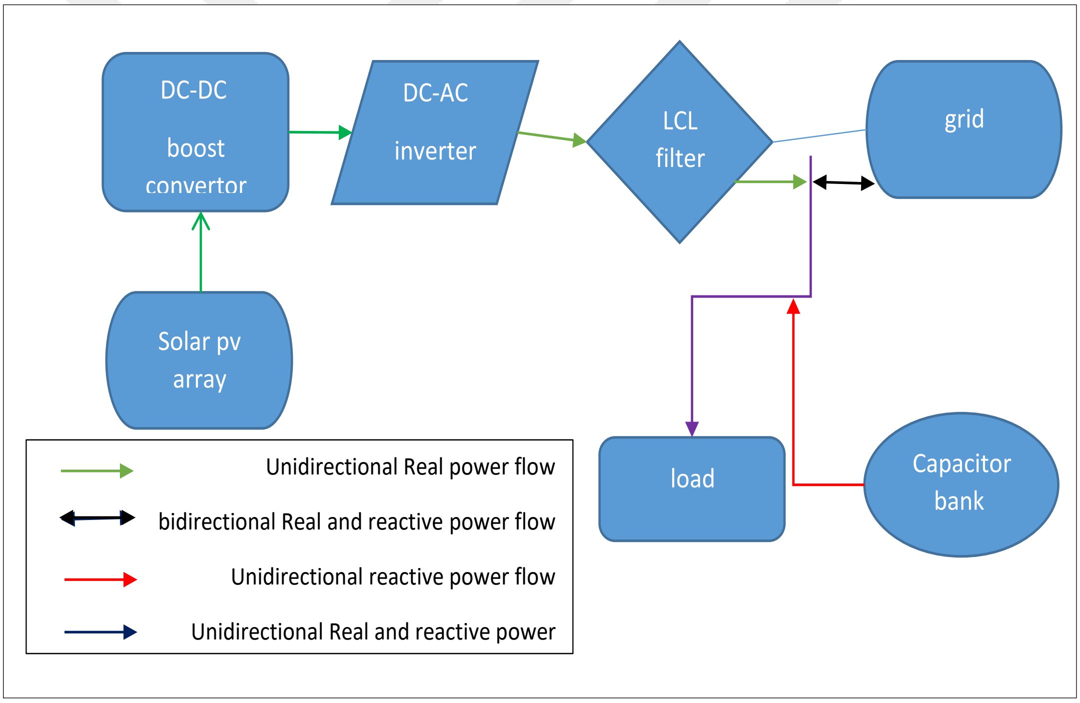


Figure 3.1: Grid Connected System with Fixed Capacitor.

In addition to P&O MPPT algorithm technology techniques are used to assure optimum functioning of the PV system. This is a crucial part of the project. In addition to PV and a fixed capacitor bank, this system will also include an EMS designed to reduce grid imports and offset reactive power needs. With the MATALB Simulink program/2022/b the entire suggested system is constructed, as seen in look 3.2.

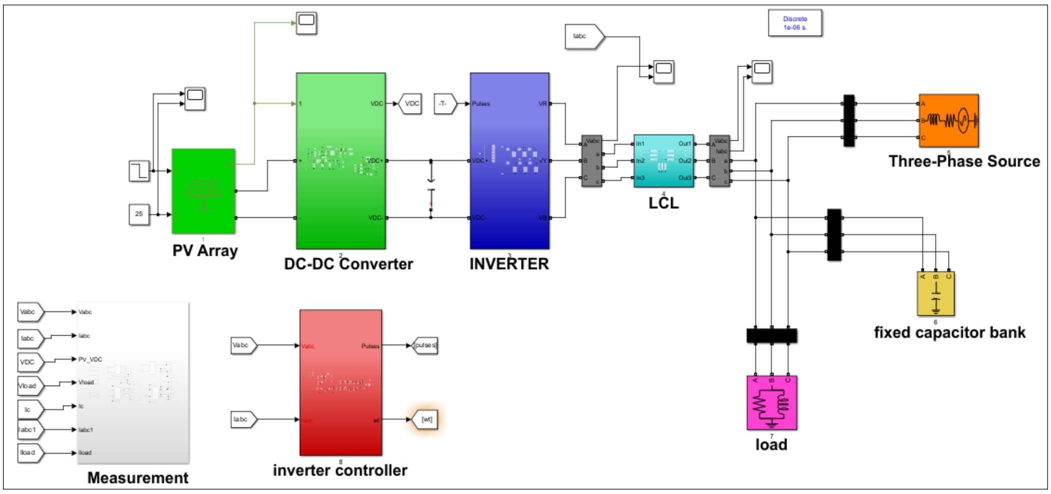


Figure 3.2: the MATLAB is Used to Run the System.

3.2 PV SYSTEM DEVELOPMENT

Connected in parallel or series, an infinite number of PV-modules generate the required voltage and current. Using a user-defined type at the MATLAB PV system (or panel), this project has generated an estimated total of (100kW) of electrical power. The maximum power per panel is 213.15 watts, while the photovoltaic system's overall power output is around 100 kilowatts[23]. The total number of PV panels may be calculated using the calculation below.

$$N = \frac{Total\ generated\ power\ (watt)}{Maximum\ power\ for\ each\ array\ (watt)} \quad (3.1)$$

$$N = \frac{100\ kW}{213.15\ \ W} = 470\ \text{array panel} \quad (3.2)$$

Photovoltaic power farms are comprised of Integrated parallel and series panels and positioned on a certain manner to make the necessary current & voltage for the design procedure. The score of (Np) and (Ns) show series and parallel digit arrays, and they can be articulated in the format shown below.:

$$\text{N} = \text{Np} \times \text{Ns} \quad (3.3)$$

Ns is 10, by employ of equation in (3.2), the overall in number of parallel panels Np are[23]:

$$N_p = \frac{470}{10} = 47\ array \quad (3.4)$$

The suggested can be calculated by using the following equations PV solar system's voltage, current, and power output [23]:

$VPV = Ns \times Vmppt = 10 \times 29 = 290V$

$IPV = Np \times Imppt = 47 \times 7.35 = 345.45\ A$

$PPV = VPV \times IPV = 290 \times 345.45 = 100.181\ KW$

Figure 3.3 depicts the (V, I) characteristics selected curve for the PV model at a constant 25°C and varying irradiances of 1000, 500, and 100 (W/m2) adding to the highest output power. The maximal power output of the solar array is 8.90 kW at 100 W/m2 while (25°C), 50.74 kW at (500) W/m2 and 25°C, and 100.22 kW at 1000 W/m2 and (25°C).

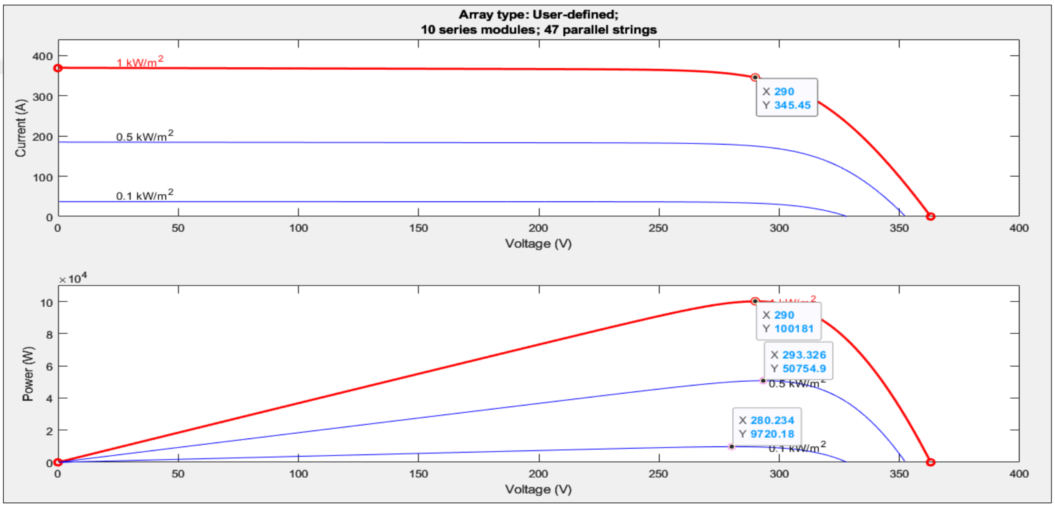


Figure 3.3: The P-V and I-V Features of the Examined Solar PV System are Impacted by Alter Irradiances.

Figure 3.4 displays the Solar PV system's power-voltage and current-voltage characteristics that is being taken into consideration for various temperatures. The solar array's peak output is 104.085 kW at 15°C and (1000) W/m2, 100.184 kW at 25°C and (1000) W/m2, and 91.838 kW at 45°C and (1000) W/m2, respectively.

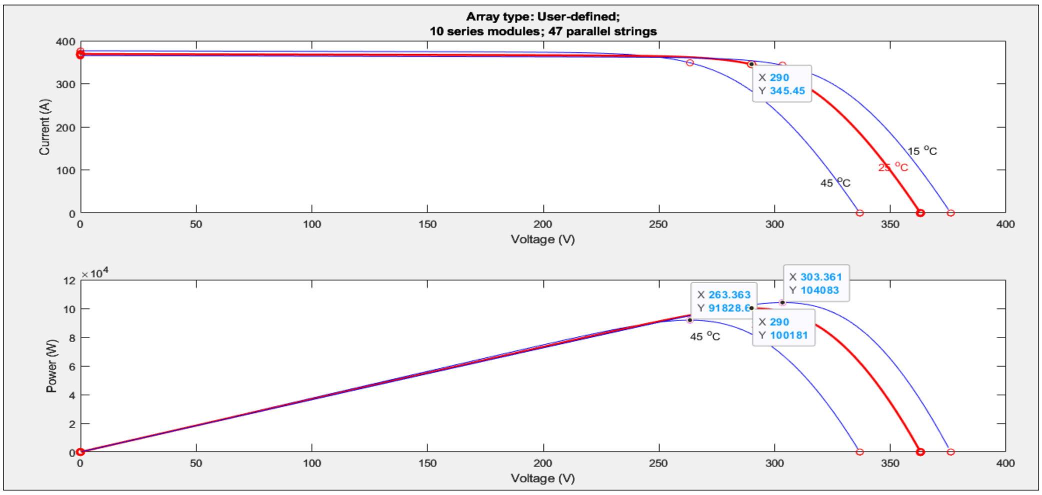


Figure 3.4: The Temperature has an Impact on the P-V and I-V Properties of the PV Array being Studied.

Table 3.1: The Proposed PV Generator System's Technical Specifications are Shown.

Parameters	**Value**	**Unit**
Whole of Series Panel	10	-
Whole of Parallel Panel	47	-
Whole of Panel	470	-
The Voltage (V) of solar System by (MPPT)	290	V
The Current (I) of the PV System by (MPPT)	345.45	I
Overall Rated Power	100.18	KW

3.3 EFFICIENCY OF SOLAR PANELS

When solar panels are positioned perpendicular to the sun's rays, they are most effective at converting solar energy into electricity. Trackers are used to reorient solar panels consequently that they are directly aligned together the sun's rays for maximum energy production. Figure 3.5 depicts how a tracking system increases the duration of maximum power.

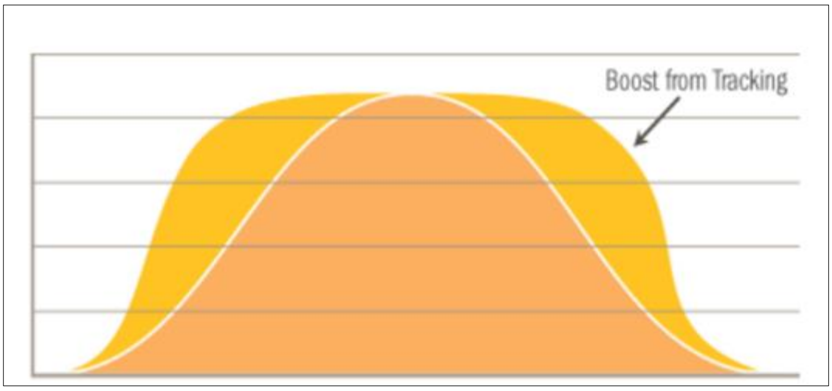


Figure 3.5: Daily Power Production Compared to Fix Mount [24].

The utilization of trackers in PV systems is prevalent, with dual and single axis trackers being the most often employed varieties, as seen in Figure 3.6[24]. The single axis is employed for measuring the azimuth angle, whilst the dual axis is utilized for tracking both the elevation and azimuth axes.

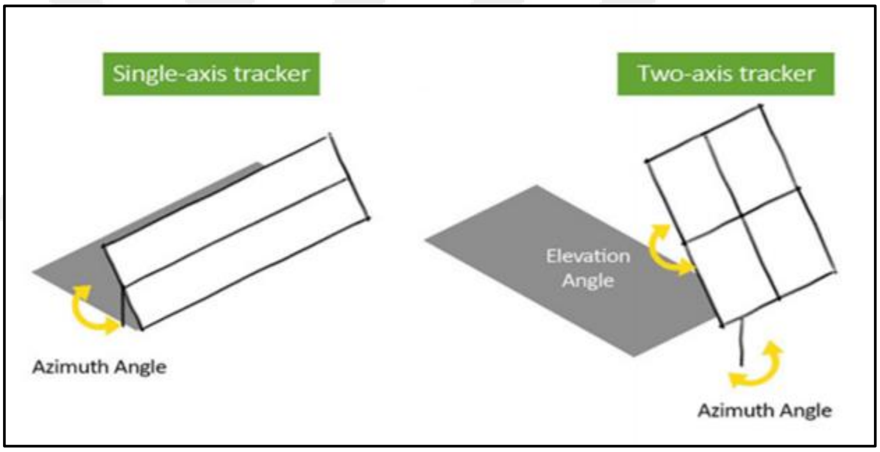


Figure 3.6: Single and Dual Axis Trackers.

3.4 MAXIMUM POWER POINT TRACKING (MPPT)

A direct current to direct current converter is frequently used in conjunction with the MPPT technique to maximize the power output of solar panels in a solar system. The method known as Maximum Power Point Tracking (MPPT) is used to modify a solar panel's output power. array in adaptability to shifting array configurations and operating conditions. Figure 3.7 depicts the relationship between the output power and voltage for the (P&O) technique, which is a commonly used MPPT algorithm in PV systems. The curve above illustrates the photovoltaic (PV) array's Maximum Power Point (MPP), also known as the P-V curve in the Perturb and Observe (P&O) technique. The array is operating non-uniformly when power fluctuations are seen, and the operational voltage of the array is orientated in a certain direction. The operational point is situated to the left of the maximum power point (MPP) when there is a positive relationship (dP/dV>0) between the change in voltage and the change in power. the 25th number. A greater operating voltage must be used to reach the Maximum Power Point (MPP). When the voltage perturbation is counterclockwise to the power change (dP/dV), The Maximum Power Point (MPP) is to the right of the point of operation. In this case, lowering the operating voltage will get you closer to the MPP. The perturb and observe (P&O) method is used periodically after the photovoltaic (PV) array reaches its maximum power point (MPP), which causes it to oscillate steadily about its MPP.The text that the user has written is [26].

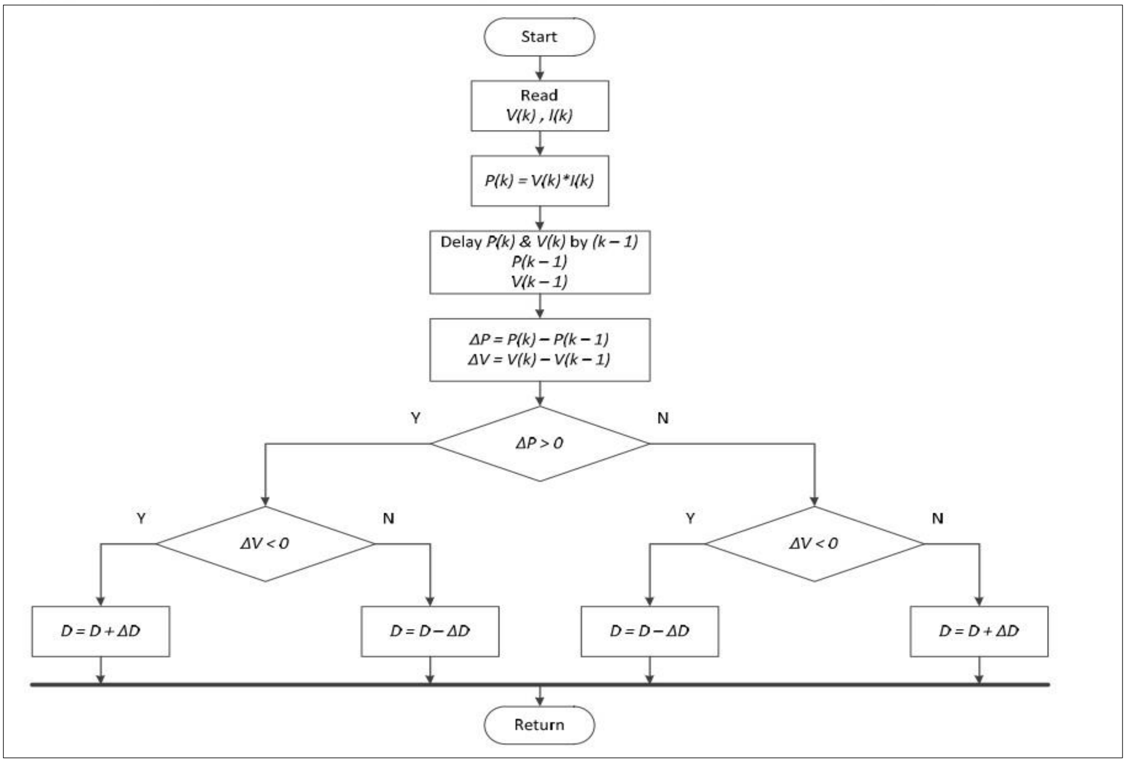


Figure 3.7: The P&O MPPT Method Flow Diagram [26].

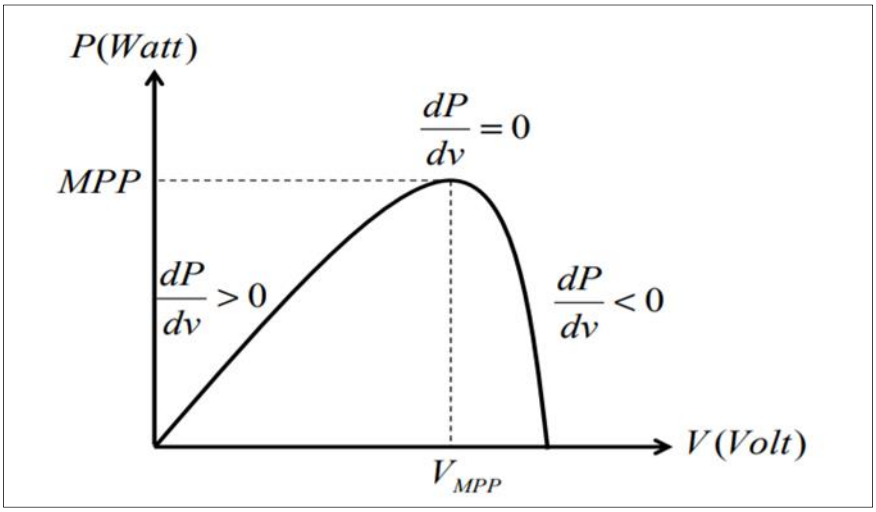


Figure 3.8: Operating Point Variations Based on MPPT [25].

The incremental MPPT technique assumes shown in Figure 3.8, which states that the gradient of the P and V curve = 0 which the MPP, the mean positive point of operation are directly to the going away of the MPP., and the negative mean the operation point are to the right. incremental flowchart method and incremental conditions is shown in Figure 3.9. which incremental MPPT approach has the advantage over the P&O algorithm of being able to calculate and identify the exact PV module operating voltage perturbation direction. Theoretically, perturbation phenomena that often occur around the MPPT may be avoided if the MPP is determined using the judgment conditions ($\triangle I/\Delta V = - I/V$ and $\triangle I = 0$) of the technique of incremental.

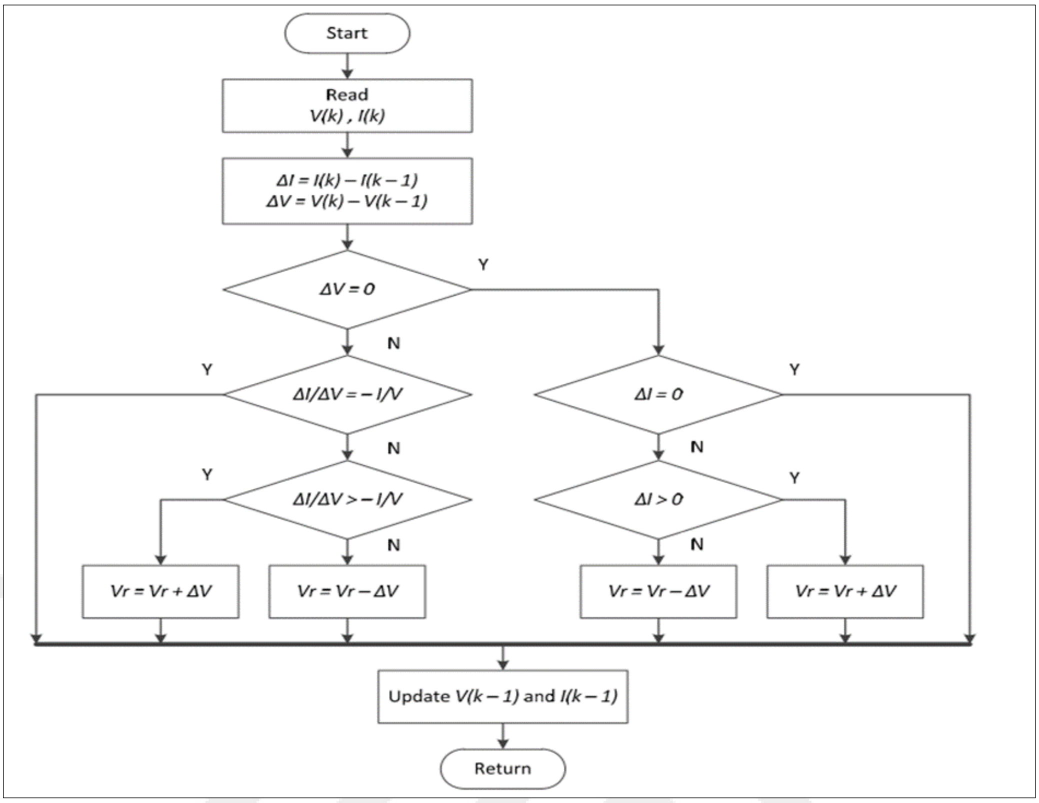


Figure 3.9: Flow Chart of the Incremental MPPT Technique [26].

Due to its straightforward implementation, quick computing speeds, and ability to discover the MPP regardless of outside influences, the PSO technique has a lot of potential. Additionally, compared to It can carry out more haphazard searches than other evolutionary algorithms, such as the Genetic Algorithm. Unlike normal systems, which cause the duty cycle to be disrupted by a consistent amount, the PSO algorithm updates the duty cycle based on particle velocity rather than having it fixed. The rapid convergence and straightforward implementation of the PSO distinguished it from other global optimization approaches. Thus, researchers investigating the application of PSO with MPPT in PV systems have started to give it a growing amount of attention. Utilizing In the last swarming example, PSO modeled a "flock," or swarm, of many cooperative "birds," or in this case, particles, working together. Every single swarm particle has a fitness value, which it uses to decide how far it will travel, and which has an objective function mapping it. and its own velocity. Each particle shares the knowledge it has learned during its individual search activities. Both the finest particle in the area (G best), which is recorded as the greatest position of the flock, and the optimal solution determined by the particle individually (P best), which is retained as the particle's best location, both affect where a particle is placed. This method causes each particle to move in a different direction and at a different speed until they finally move in the direction of the ideal position or a location near to the global optimum. The particle swarm employs this strategy to move toward the ideal spot. The PSO MPPT algorithm's flowchart is seen in Figure 3.10.

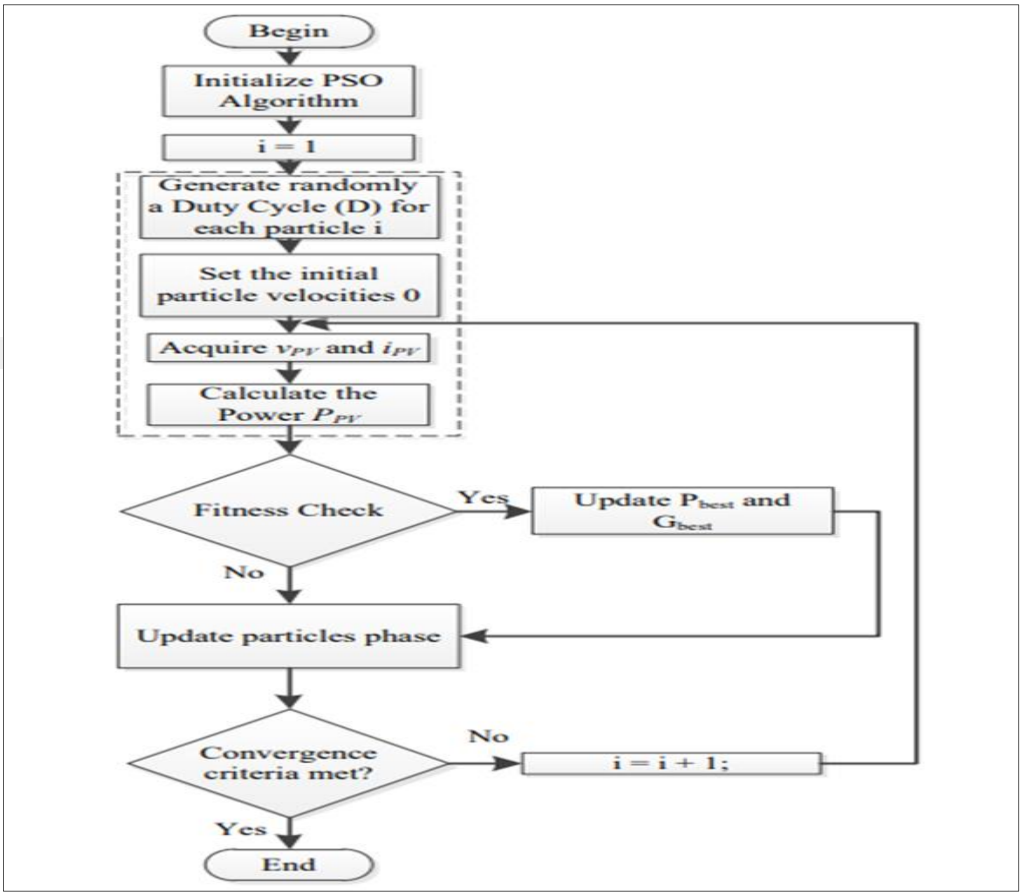


Figure 3.10: Flow Chart of the PSO MPPT Technique [27].

3.5 MODELING OF DC-TO-DC BOOST CONVERTER

Solar array output voltage is increased to 600 V using a unidirectional boost converter. The voltage of output is assumed to be twice the voltage of input to decrease high-current circuit losses. This converter was built with the MPPT algorithm in mind, which allows for maximum power extraction from a PV system. Figure 3.11 depicts the one-way boost converter.

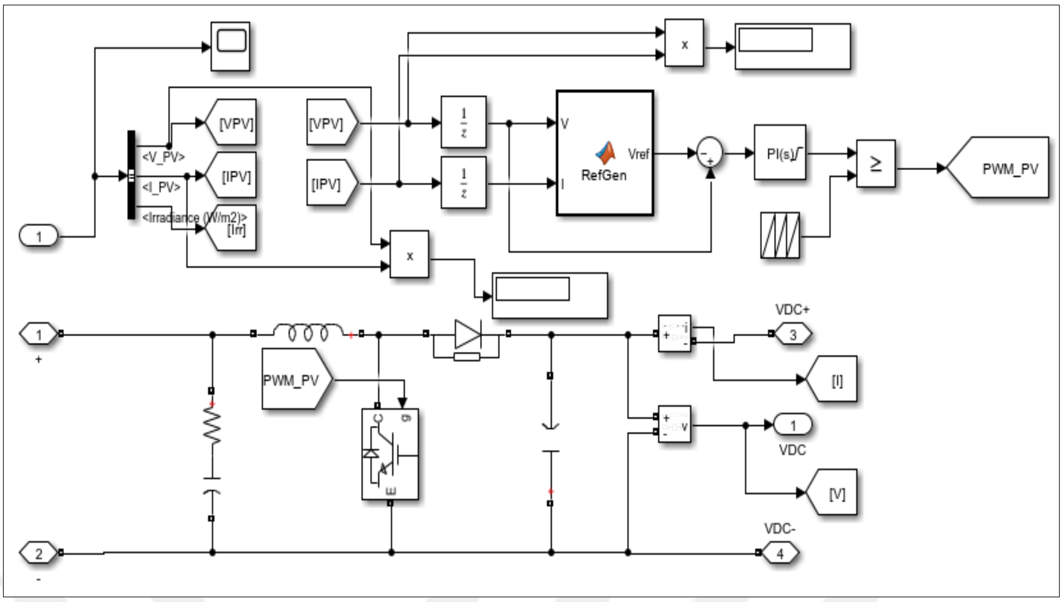


Figure 3.11: Boost Converter by Utilizing MATLAB Simulink Program.

Table 3.2: Specifications of Boost Converter.

Parameters	Value	Unit
Inductor	1.23 m	H
Capacitor	4132 µ	F
Inductor resistance assumed	0.001 m	Ω
Input Capacitor assumed	1000 µ	F

The design of the dc-dc increase converter is impacted by the solar PV array's voltage and power ratings as well as the output voltage required by the grid-connected inverter. Solar photovoltaic systems are typically tested at 290 volts and 100.180 kilowatts. The output voltage or DC link voltage of the grid-connected inverter needs to be at least 600 V. In a photovoltaic system for electrical network integration, this equation is utilized to create the upper inductor and capacitor of the DC-DC converter [28].

$$Ioutmax = \frac{P}{Vout} \tag{3.5}$$

$$\Delta IL = 00.7 \times Ioutmax \times \frac{Vout}{Vin} \tag{3.6}$$

$$\Delta V_{out} = 0.007 \times Vout \tag{3.7}$$

$$L = \frac{Vin \times (Vout - Vin)}{\Delta IL \times Fs \times Vout} \tag{3.8}$$

$$C = \frac{Ioutmax \times (1 - Vin/Vout)}{\Delta Vout \times Fs} \tag{3.9}$$

The variable Vin in a direct current to direct current step-up converter denotes the photovoltaic (PV) system's voltage under typical test settings. The filter inductor is represented by the variable L, the filter capacitor by the variable C, and the power rating of the photovoltaic system under typical test conditions is indicated by the variable P. The maximum current that can flow through a boost converter while converting direct current to direct current is known as the "I outmax." The output voltage, ripple inductor current, and ripple output voltage of a DC-DC step-up converter are represented by the symbols IL, Vout, and Vout, respectively. The maximum output current of a direct current to direct current step-up converter is,

$$Ioutmax = \frac{100.180 \times 1000}{600} = 166.966\ A \tag{3.10}$$

An A direct-current to direct-current boost converter's ripple inductor current is,

$$\Delta IL = 0.07 \times 166.96 \frac{600}{290} = 24.18\ A \tag{3.11}$$

What is the direct-current to direct-current step-up converter's ripple inductance voltage

$$\Delta Vout=0.007 \times 600 = 4.2\ v \tag{3.12}$$

The Direct-current to Direct-current Step-Up Converter's calculated inductor value is,

$$L = \frac{290 \times (600 - 290)}{24.18 \times 5000 \times 600} = 1.23\ mH \tag{3.13}$$

The capacitor's calculated rate It is found in the step-up converter from direct current to direct current.

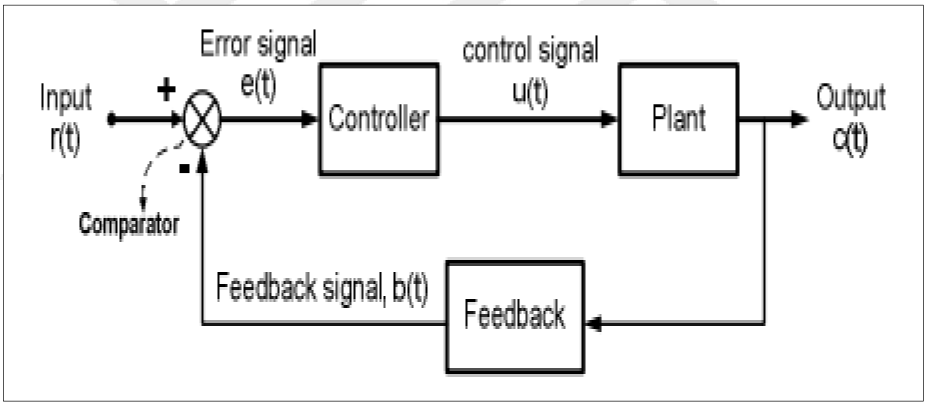
$$C = \frac{166.96 \times (1 - 290/600)}{4.2 * 5000} = 4132 \mu F \tag{3.14}$$

3.6 INVERTER CONTROL

This work suggests an inverter control based on the two primary relationships.

Are voltage controller loop and current controller loop the droop controls strategy is shown in Figure 3.12. To modulate the inverter's Reference values must be used to modify voltage, frequency, active and reactive power [29].

current controller loop**:** - The direct and lateral grid currents are managed by the current control circuits., Id and Iq, thereby allowing the active and reactive powers to be regulated [30][31]**.** voltage controller loop**: -** Modulation is needed to change the inverter switches' on and off times while maintaining a constant DC input voltage to produce an inverter output voltage that is under control. Pulse width modulation, commonly known as PWM, is the prevailing modulation technique used for inverters. The references are [31], and [32]. As seen in Figure 3.12, this is a control system that relies on both its input signal and output response to determine its control action.



.

Figure 3.12: A closed-Loop Control the System's Block Diagram [33].

phase locked loop(PLL)**: -** The solar energy system's phase-locked loop-linked inverter is an essential component of the device because it enables dependable grid connection through quick and accurate phase detection and locking [31].

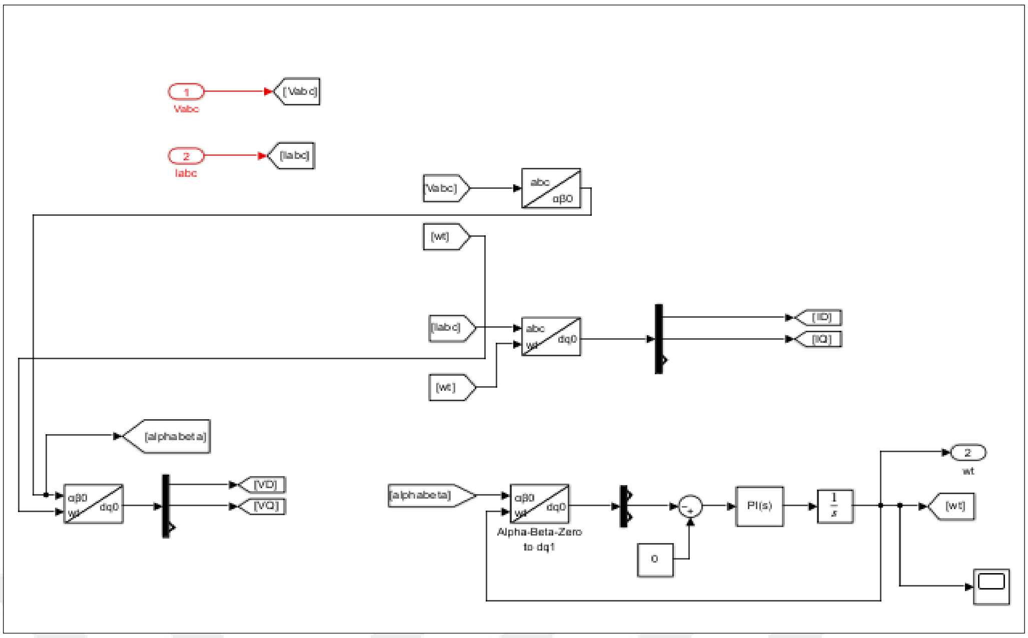


Figure 3.13: Phase Locked Loop Design.

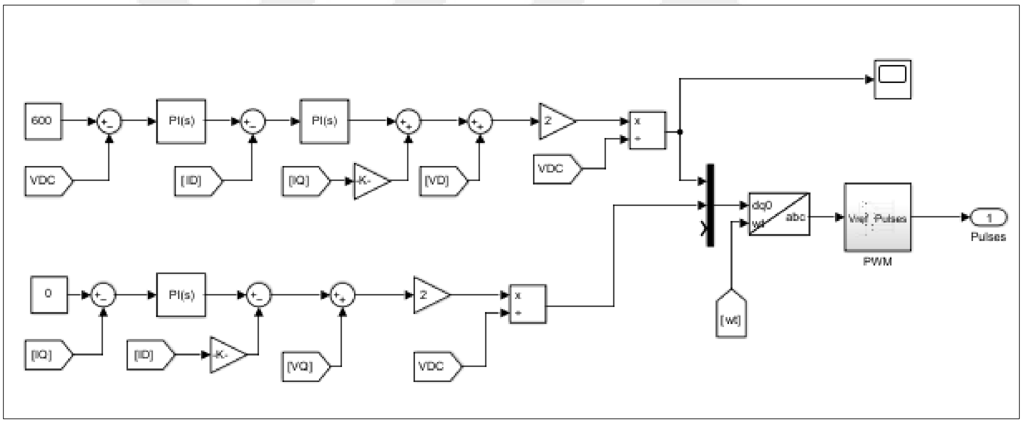


Figure 3.14: Design the Voltage Controller Loop and Current Controller Loop.

3.7 HARMONIC FILTER DESIGN

The fundamental goal of utilizing an LC filter should reduce the current and voltage waveforms' harmonic since it causes distortions and output power losses. Although there are many varieties L-Filters, LC-Filters, and LCL-Filters are the three general categories of filters. Every category has distinct traits. Based on these features, you may select the type of filter. Figure 3.15 displays the three types of filters. LC and LCL filters are designed for huge power, while L-filters are made for low power and only include one series inductor. Instead of making an LCL filter, the goal is to make an LC filter. in this work is to address issues with the high cost and additional space needed for LCL owing to the usage of two inductors. The LC-filter is extensively used due to its simplicity and inexpensive cost. As previously mentioned, the LC filter is less expensive, more effective, and smaller than the LCL filter [34].

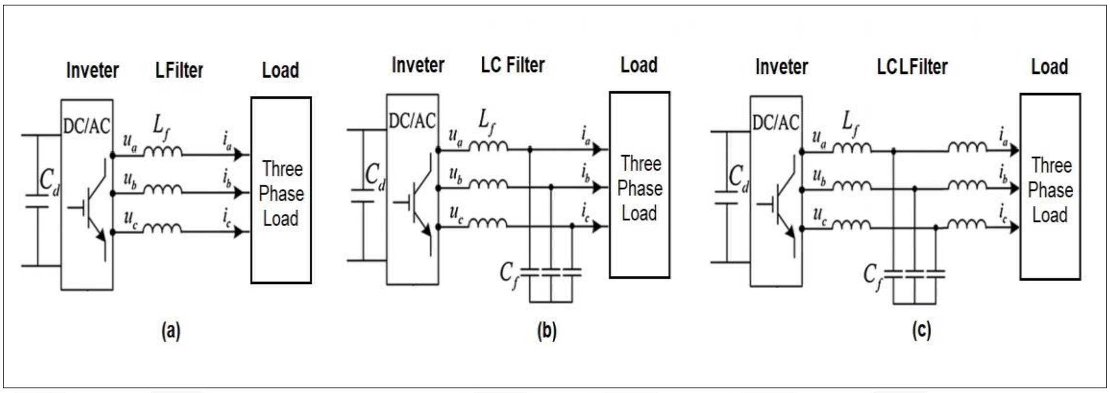


Figure 3.15: Three Types of Filters [34].

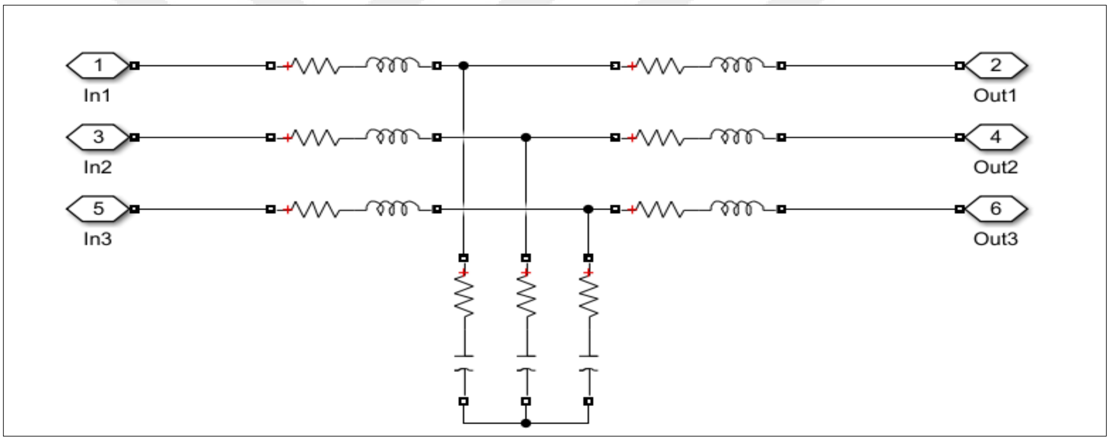


Figure 3.16: MATLAB-Created Harmonic Filters.

The grid-connected inverter's harmonic filter is now fully constructed. The user only typed the letter "A" in their text. Considering the solar power ratings, inverter switching frequency, dc-link voltage, grid voltage, and grid frequency, a harmonic filter is built for the grid-connected inverter. The construction of a grid-connected inverter's harmonic LCL filter follows a particular mathematical procedure [3.8] [3.18].

$$\omega g = 2 \times \pi \times Fg \tag{3.15}$$

$$Zb = \frac{Vg^2}{(p/3)} \tag{3.16}$$

$$Cb = \frac{1}{Wg} \times Zb \tag{3.17}$$

$$Imax = P \times \frac{\sqrt{2}}{3} \times Vg \times 0.9 \quad (3.18)$$

$$\Delta Imax = \frac{10}{100} \times Imax \quad (3.19)$$

$$L1 = \frac{Vout}{6 \times Fsw \times \Delta Imax} \quad (3.20)$$

$$Cg = 0.05 \times Cb \quad (3.21)$$

$$L2 = \frac{\sqrt{1}}{0.2^2} + \frac{1}{Cg} \times (2\pi \times Fsw^2) \quad (3.22)$$

$$\omega res = \frac{\sqrt{1L1 + L2}}{L1 \times L2 \times Cg} \quad (3.23)$$

$$\omega min = 10 \times Fg \quad (3.24)$$

$$\omega max = 0.5 \times Fsw \quad (3.25)$$

It stands for grid frequency (fg). Phase grid voltage (Vg), angular frequency (g) of the grid (in radians), phase harmonic impedance filter (Zb), and primary filter capacitance (Cb) are all related terms. Imax stands for the harmonic filter MC rating, Imax for the filter inductor's harmonic filter MC ripple, L1 for the receiving side and L2 for the output of side, Cg for the harmonic filter capacitor, and res for the resonance harmonic. periodic filter The minimum frequency limit filter harmonic is denoted by min, and the maximum by max, both in radians. The grid of the angular frequency system is established by,

$\omega g = 2\pi \times 50 = 314.1593\, rad/sec$

The harmonic filter's per impedance is given by.

$$Zb = \frac{230^2}{100.180 \times \frac{1000}{3}} = 1.5770$$

The harmonic filter's basal capacitance is given by:

$$Cb = \frac{1}{314.1593 \times 1.5870} = 0.002\mu F$$

The harmonic filter's maximum current rating is determined by,

$$Imax = \frac{100.180 \times 1000 \times \sqrt{2}}{3 \times 230 \times 0.9} = 227.7317A$$

The formula denotes the maximal ripple inductor of the harmonic filter.

$$\Delta Imax = \frac{10}{100} \times 227.7317 = 22.7732A$$

The following formula describes the harmonic filter's input side filter inductor.

$$L1 = \frac{600}{6 \times 10000 \times 22.7732} = 500\ \mu H$$

The harmonic filter's filter capacitor is given by.

$$Cg = 0.05 \times 0.002 = 100.29\ \mu F$$

The harmonic filter's exterior filter inductor is given by:

$$L2 = \frac{\sqrt{1}/0.2^2}{100.29 \times 10^{-6} \times (2 \times \pi \times 10000)^2} = 15\mu H$$

3.8 DESIGN OF FIXED CAPACITOR BANK RATINGS

The load side's demand for reactive power determines the fixed capacitor bank's reactive power rating. For reactive power correction, a capacitor bank with an 85 kVA reactive power rating is employed in this study.

3.9 SYSTEM FOR ENERGY MANAGEMENT PROPOSED

The hybrid power system necessitates an approach to managing power to supply the necessary flow of power to satisfy capacity demand. The power management strategy's main goal is to make hybrid power systems operate better. The primary objective of a power management strategy is at keep supply and demand in balance. In the event that P-pv is unavailable, imported power will be drawn from the power grid; otherwise, the gird will continue to serve as a reserve or standby, as this management intends to reduce reliance on traditional generation units and rely solely on renewable energy resources [35].

4. SIMULATION AND RESULTS

4.1 INTRODUCTION

The MATLAB/Simulink Figure shows how the proposed system is put into practice (4.1). The system uses a layout of 47 rows, each with 10 user-defined photovoltaic panels, to produce an output power of 100 kW and a current density of 1000 amperes per square meter. To connect the solar system and DC bus, the voltage of the solar system must be raised to 600 V, which is the voltage of the DC bus. This can be done with a DC-DC boost converter. A solar grid system that features a fixed capacitor bank and the capacity to modify reactive power based on application. We tested the suggested arrangement under various real-world conditions, such as varying irradiance levels, reactive power Q correction in a photovoltaic network system with a static fixed capacitor bank C, and fluctuating temperature levels.

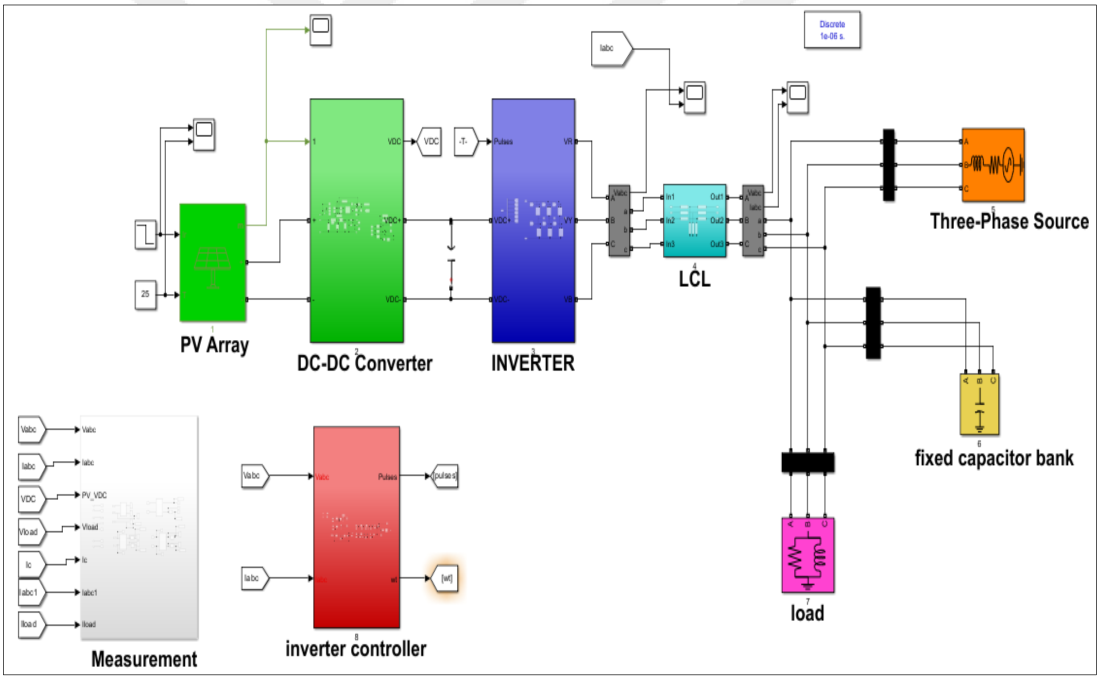


Figure 4.1: Suggested Structure.

4.2 PV SOLAR SYSTEM

Photovoltaic systems convert sunlight into direct electricity by use of the photovoltaic effect. In order to produce enough voltage and power, multiple solar cells must be connected in parallel or series. 34 is the number. A step-up transformer from direct current to direct current is needed to obtain the necessary DC bus voltage (V). A PV solar system's power generation is optimized by the MPPT algorithm. Using different control tactics or approaches can improve the electricity generation of solar systems. This work employs three Maximum Power Point Tracking (MPPT) techniques, namely perturb, and observe (P&O). The architecture of the boost converter and photovoltaic (PV) system with maximum power point tracking (MPPT) is shown in Figure 4.2.

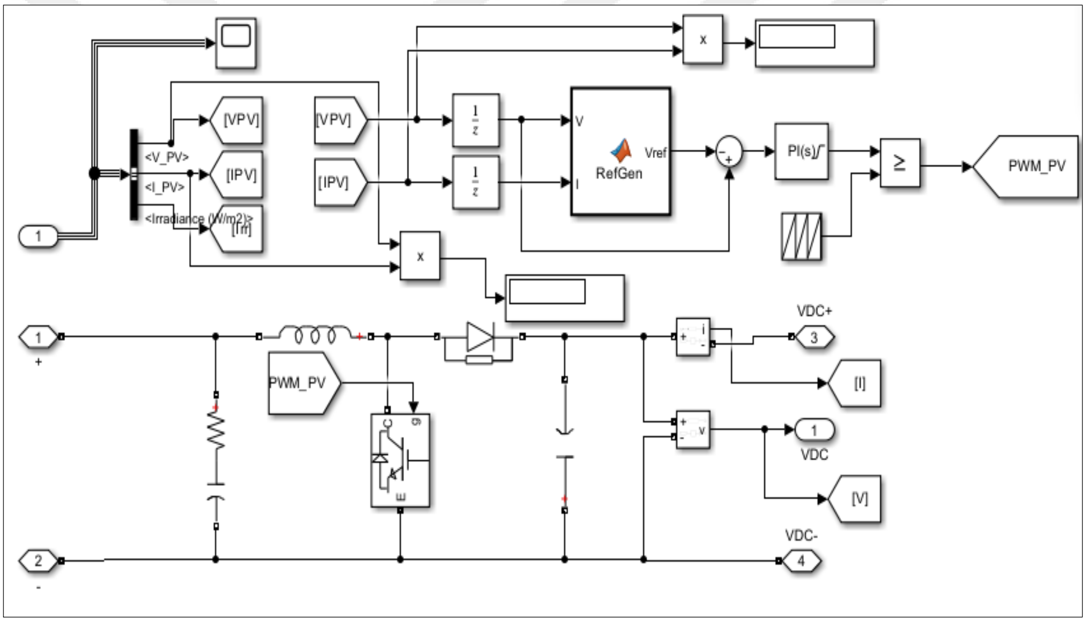


Figure 4.2: PV System Together Boost Converter & MPPT Simulation Employ the MATLAB.

As seen in Figure (4.3), the suggested input irradiation varies from 500 to 1000 A/m2, assuming that the temperature remains constant during the simulation period.

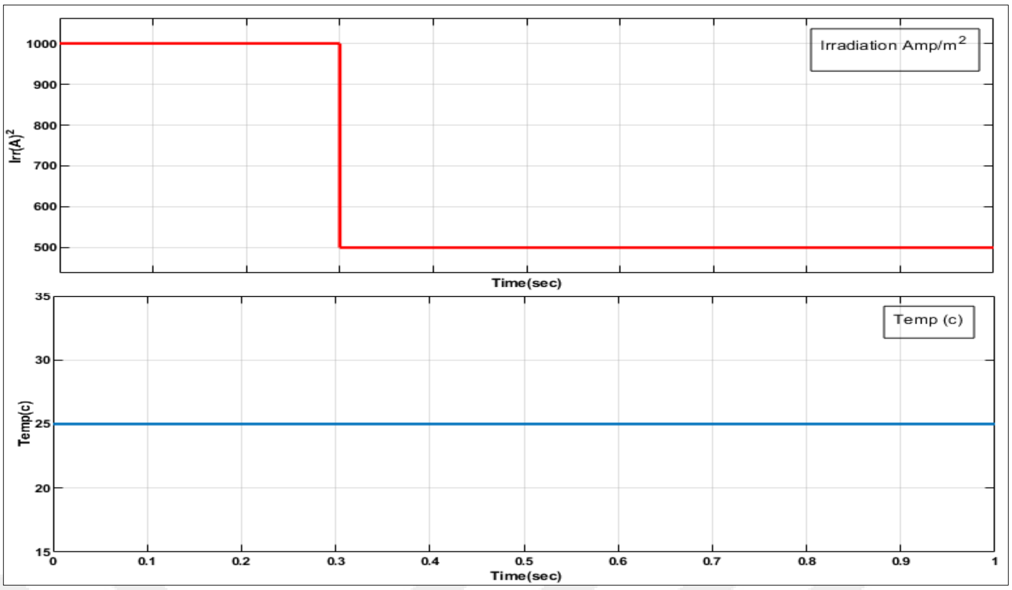


Figure 4.3: Temperature and Irradiation were Encouraged.

Accordingly, by MATLAB, the (I, V) and (P, V) choice specification panel (user-defined) is shown at Figure (4.3), in situation at 500 A/m2 (which t= 0 to t =1 sec. as shown in look (4.4)) the generated power is about 107.989 watt.

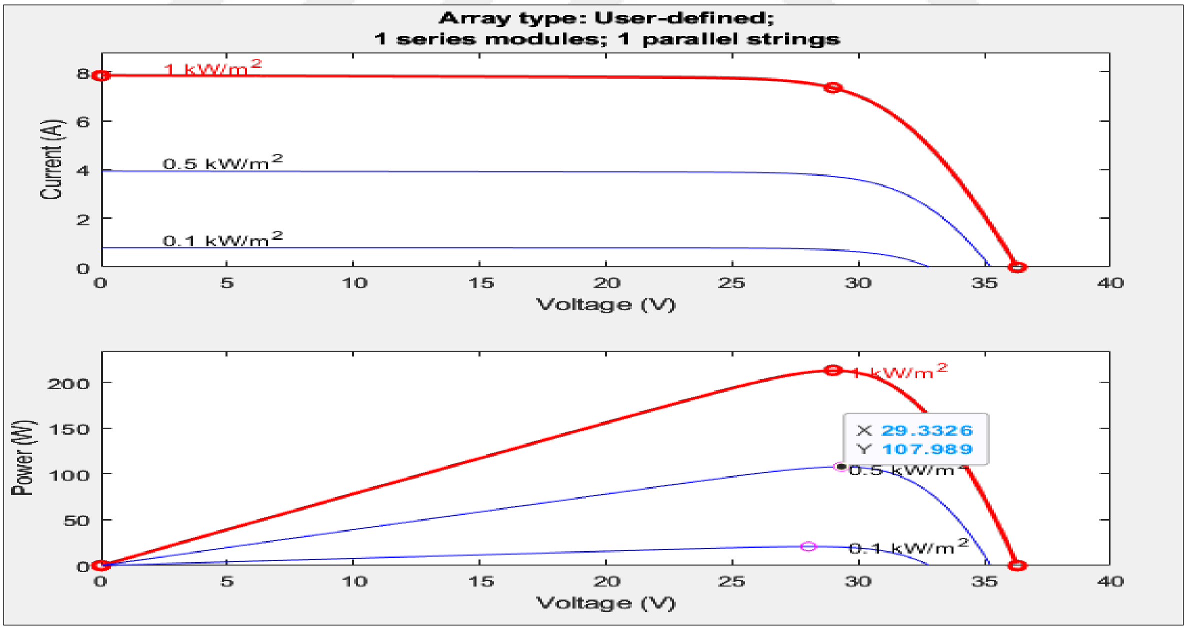


Figure 4.4: Features to User-Defined Panel Using (I,V) and (P,V).

Figure (4.5) depicts the (V I) and (VP) properties of a given material. PV power was generated. that the irradiation is 500 A/m2, the produced power is approximately 50,754

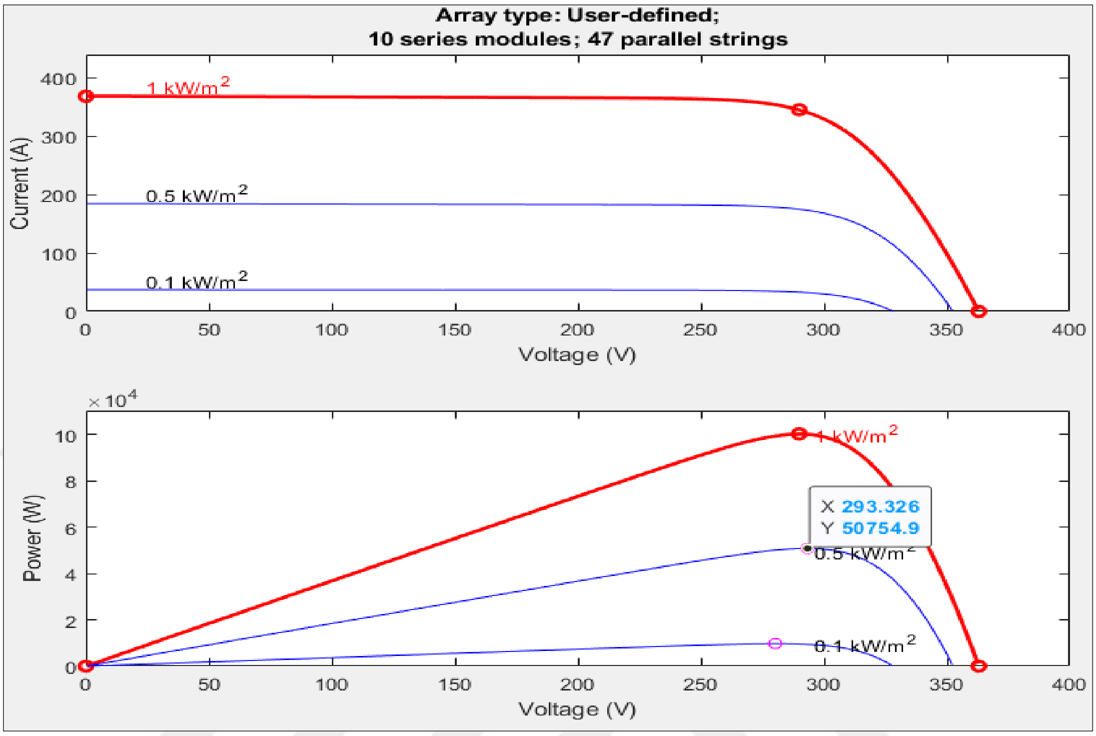


Figure 4.5: The I.V and P.V Parameters of the Entire Solar PV System.

Figure 4.6 shows the photovoltaic (PV) system's voltage (V) and current (I). A photovoltaic system's voltage is directly correlated with its constant temperature of 25 °C during this study. There is a direct correlation between the current and irradiance: the output current increases as the irradiance increases and vice versa. As shown in Figure (4.7), the output photovoltaic power multiplies the output voltage (V) and current (I).

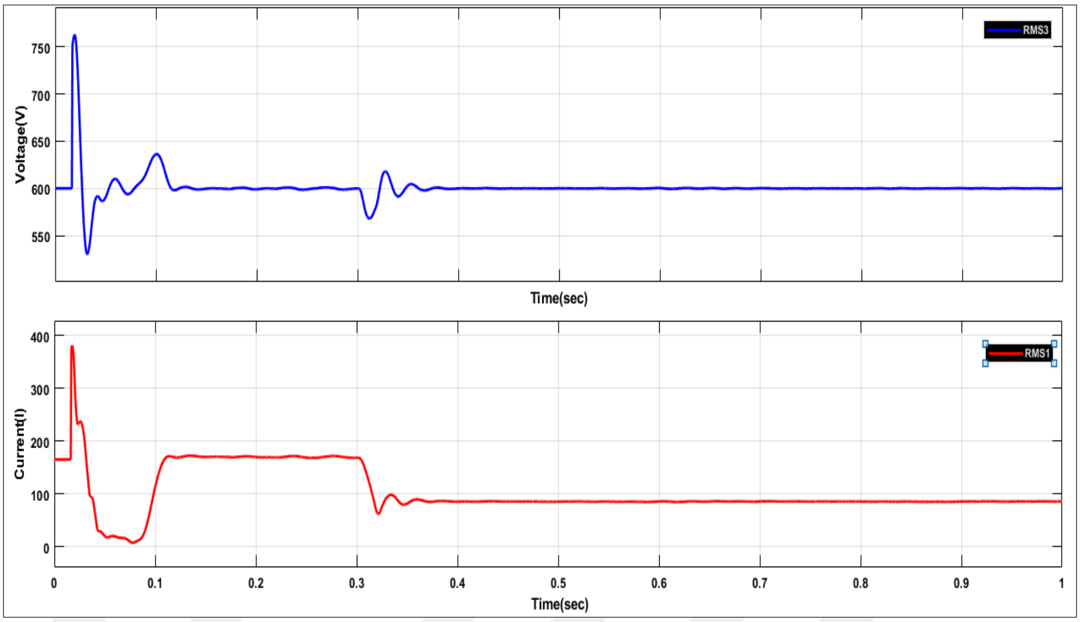


Figure 4.6: Output Voltage and Current of a PV System.

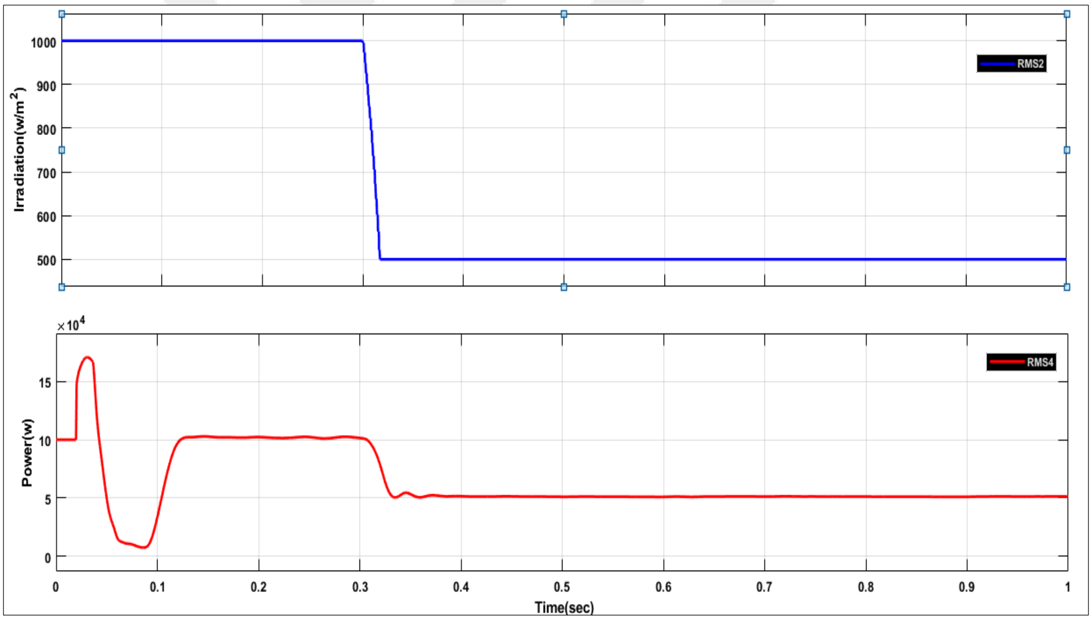


Figure 4.7: PV Structure Output Power.

4.2 MPPT WITH P&O TECHNIQUE

The solar panel's peak power production while applying the Perturb and Observe (P&O) technique. An approximate output power of 50.754 kW is obtained using the P&O approach, but with some distortion. This is the P&O algorithm shown in Figure 4.8. One can calculate the photovoltaic system's efficiency using the following formula.:

$$\eta_{P\&O} \frac{Actual\ Maximum\ outpout\ Power}{Maximum\ rated\ power} \times 100\% \qquad (4.1)$$

$= \ 49480/50754 \times 100\%$

$\eta_{P\&O} = 97.4 \ \ \%$

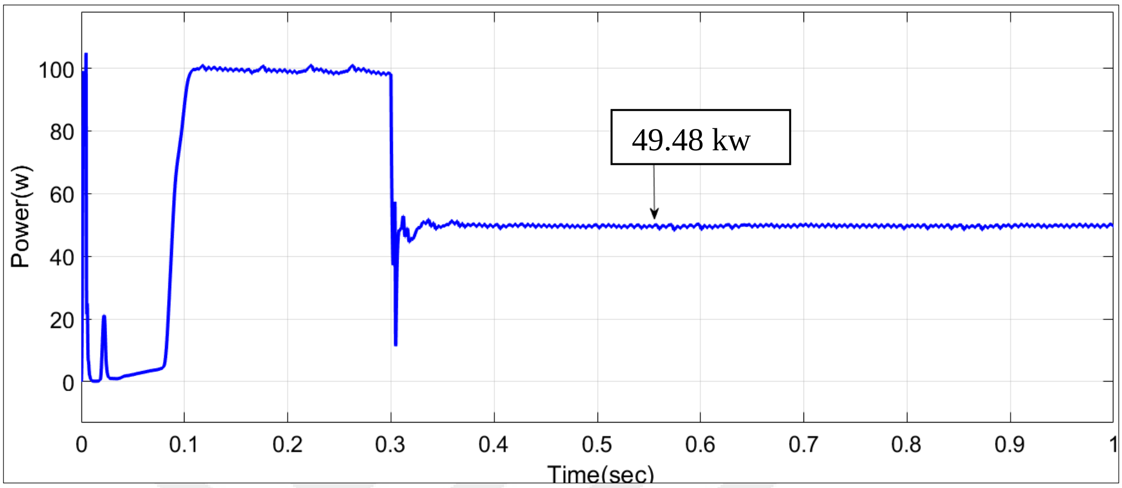


Figure 4.8: Efficiency and Output Power of MPPT at Irradiation of 500 W/m2.

4.3 THE EFFECT OF TEMPERATURE AND SOLAR RADIATION ON ELECTRIC POWER GENERATION

Under that circumstance, in 0.2,0.4,0.6 seconds, the temperature changes at 45,25,15 with constant irradiation at 1000 w/m2 Figure 4.9,4.10 depicts the PV output (V, I) and real power.

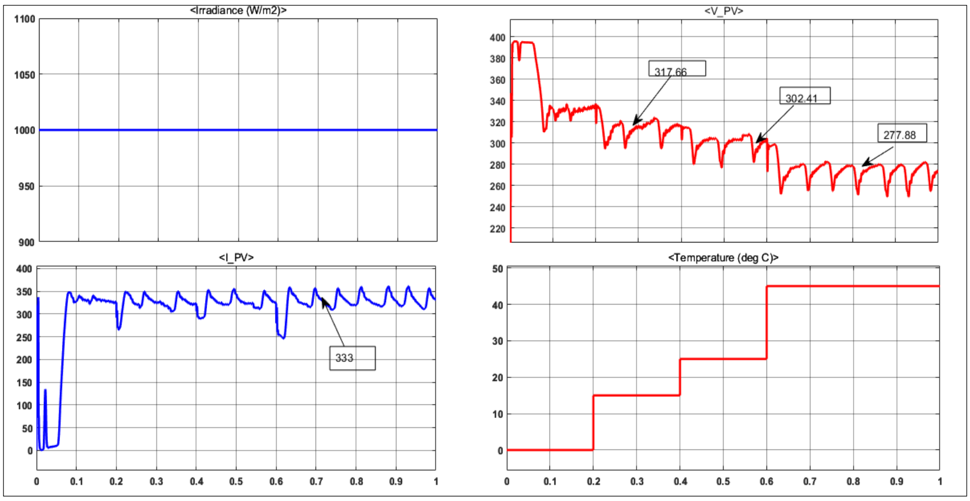


Figure 4.9: PV System Output (V, I) Under Various Temperature.

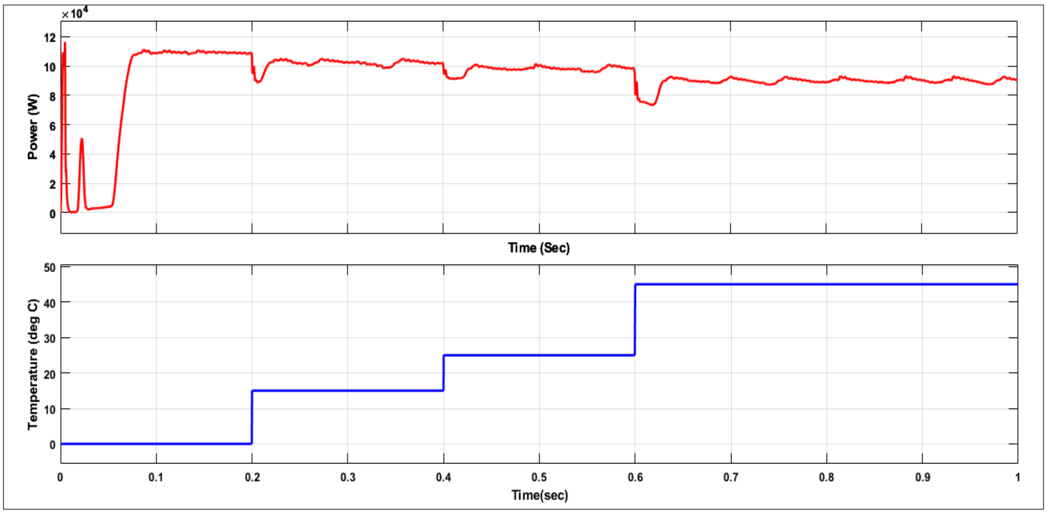


Figure 4.10: PV System Output (Power) Under Various Temperature.

Under that circumstance, in 0.2,0.4,0.6 seconds, the solar irradiance changes at 1000,500,100 w/m2 with constant temperature Figure 4.11,4.12 depicts the PV output (V, I) and real power.

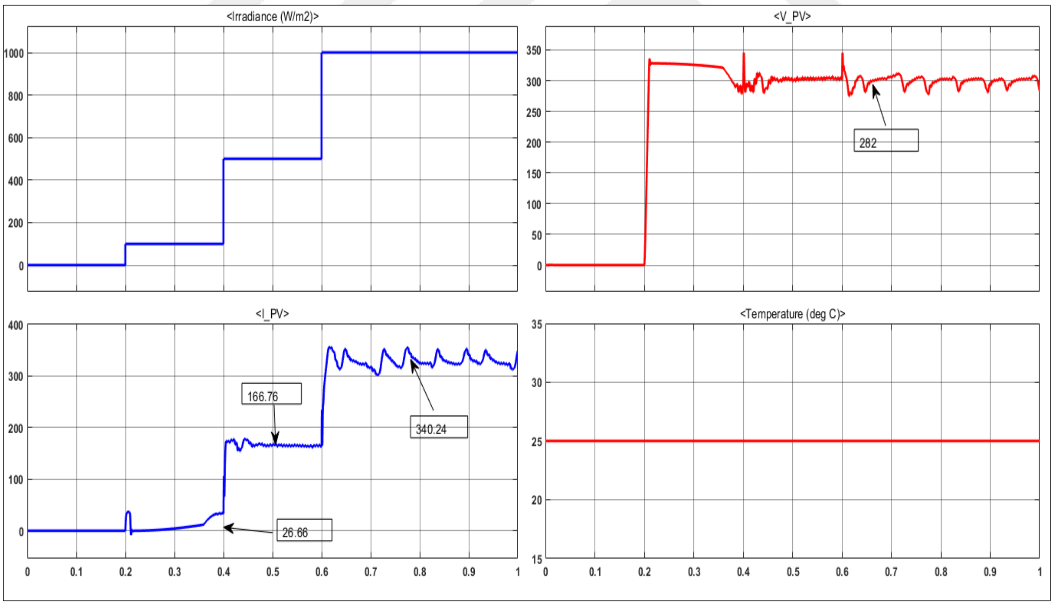


Figure 4.11: PV System Output (V, I) Under Various Irradiation.

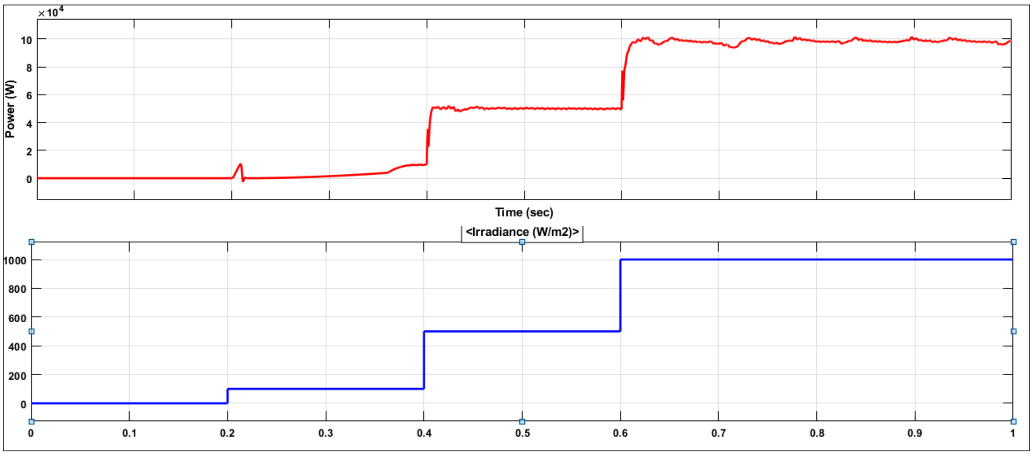


Figure 4.12: PV System Output (Power) Under Various Irradiation.

4.4 BOOST CONVERTER OUTPUT

Reducing the output is the primary goal of the direct current to direct current converter. In order to lower short circuit current and system losses, increase the output voltage. Simulink software is used for DC-DC boost converter research, as shown in Figure 4.13.

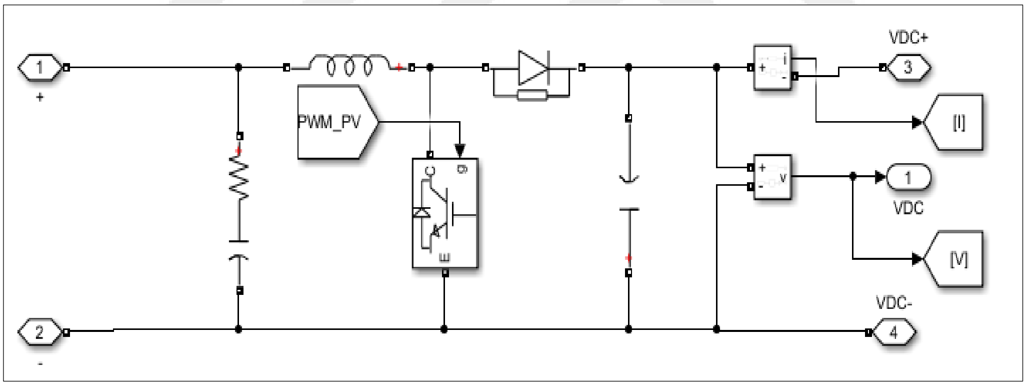


Figure 4.13: MATLAB Program is Used to Model a Boost Converter.

Figure (4.14) depicts the Vo of the boost converter, which remained stable at 600 V throughout the copying.

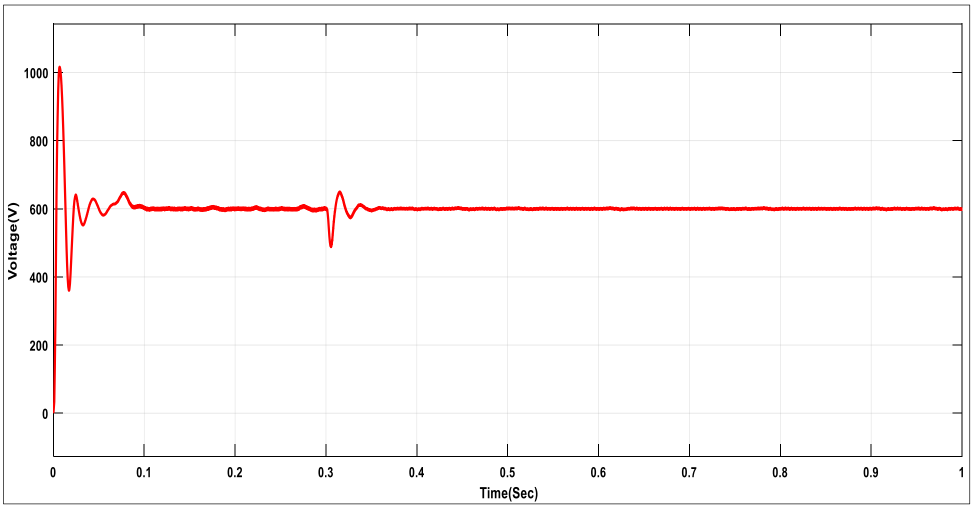


Figure 4.14: Voltage Product by the Boost Converter.

4.5 OUTPUT VOLTAGE AND CURRENT

By minimizing harmonics and making the output as sinusoidal as possible, an LC filter can be used to optimize the output V & I waveforms. The produce three phase V and I inverter is depicted in the figure. (Before to the LC filter) Fig (4.15).

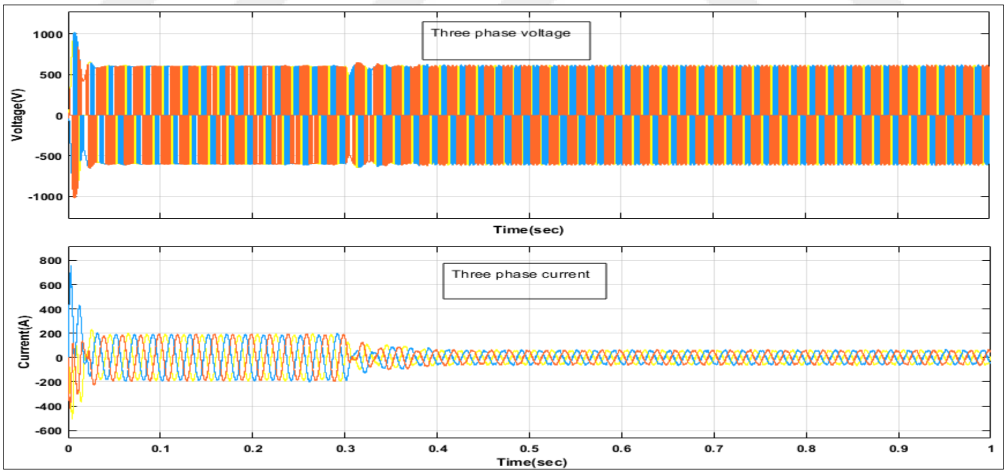


Figure 4.15: 3ph Voltage & Current at Load Aspect (Before Process Filter).

There is less total harmonic distortion (THD) than 5%, which is in accordance with IEEE standard 519. For systems with voltages less than 1 kV, THD should be less than 5% [31], output V and I at load demand (after filter) for 2014. They are depicted in Figure (4.16).

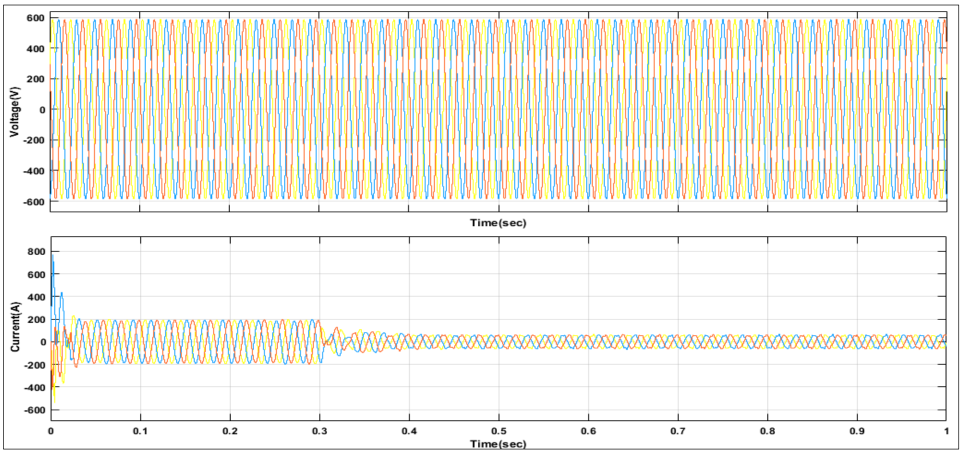


Figure 4.16: 3ph V and I at Load Side (After Process Filter).

4.6 RESULT AND SIMULATION OF THE PV INTEGRATED GRID SYSTEM THAT PROVIDES LOCAL LOAD.

Under this circumstance, the P at load is 80 kW and the Q is 85 kvar. In 0.3 seconds, the PV irradiance shift from 1000 w/m2 to 500 w/m2. In 0.3 Second, Figure 4.17 depicts the solar inverter current, and link direct current voltage in Figure 4.18. The PV structure's highest power is 97.17 kW at 1000 W/m2 and 49.48 kW at 500 W/m2. Figure 4.19 depicts the reactive and real power of the solar PV inverter.

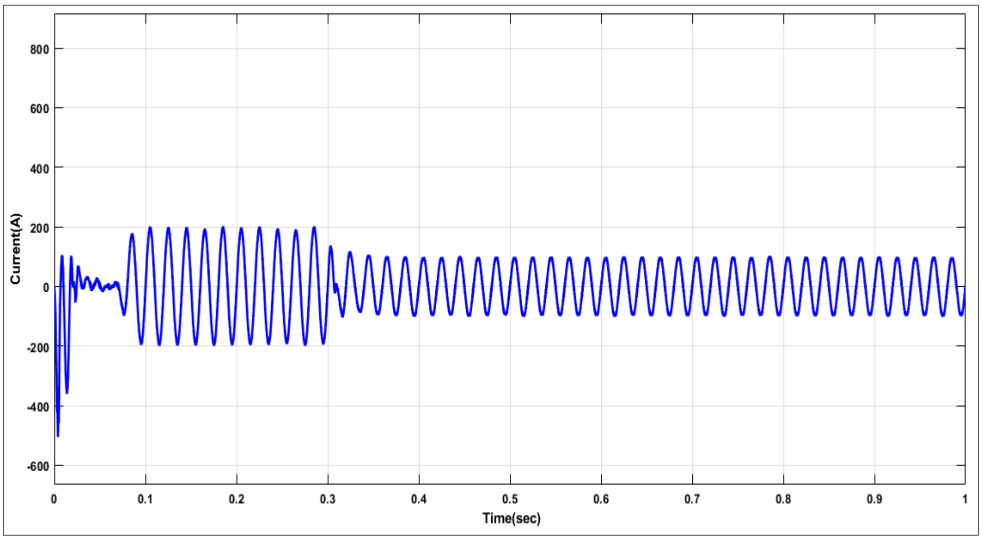


Figure 4.17: PV Inverter (Current).

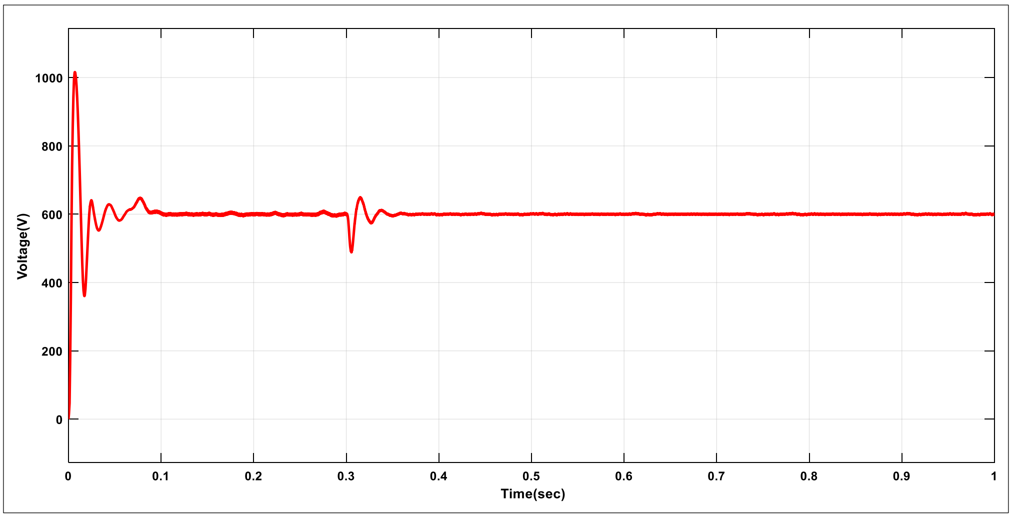


Figure 4.18: PV Inverter (Dc Link Voltage).

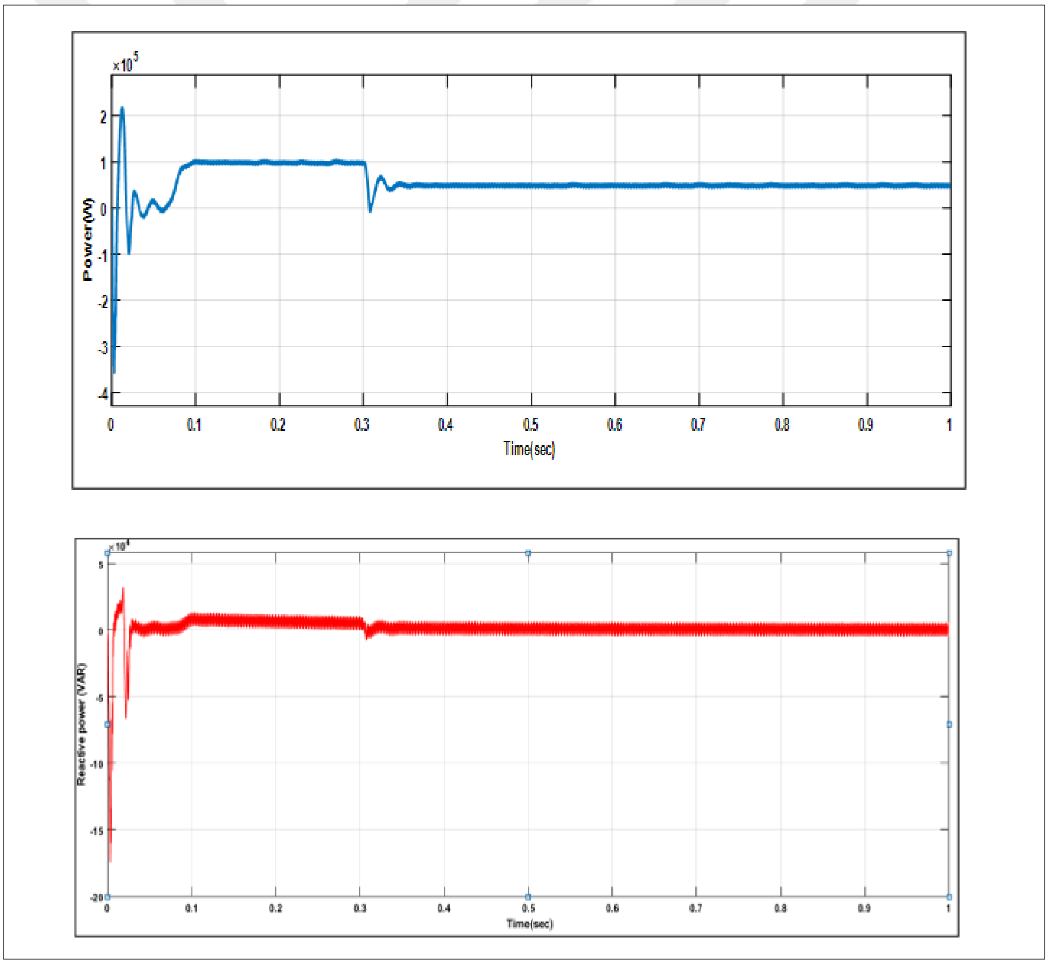


Figure 4.19: PV Inverter (P and Q).

The Q of the grid is 85. kvar. while P is 30 KW The grid's apparent power is shown in Fig.4.20.

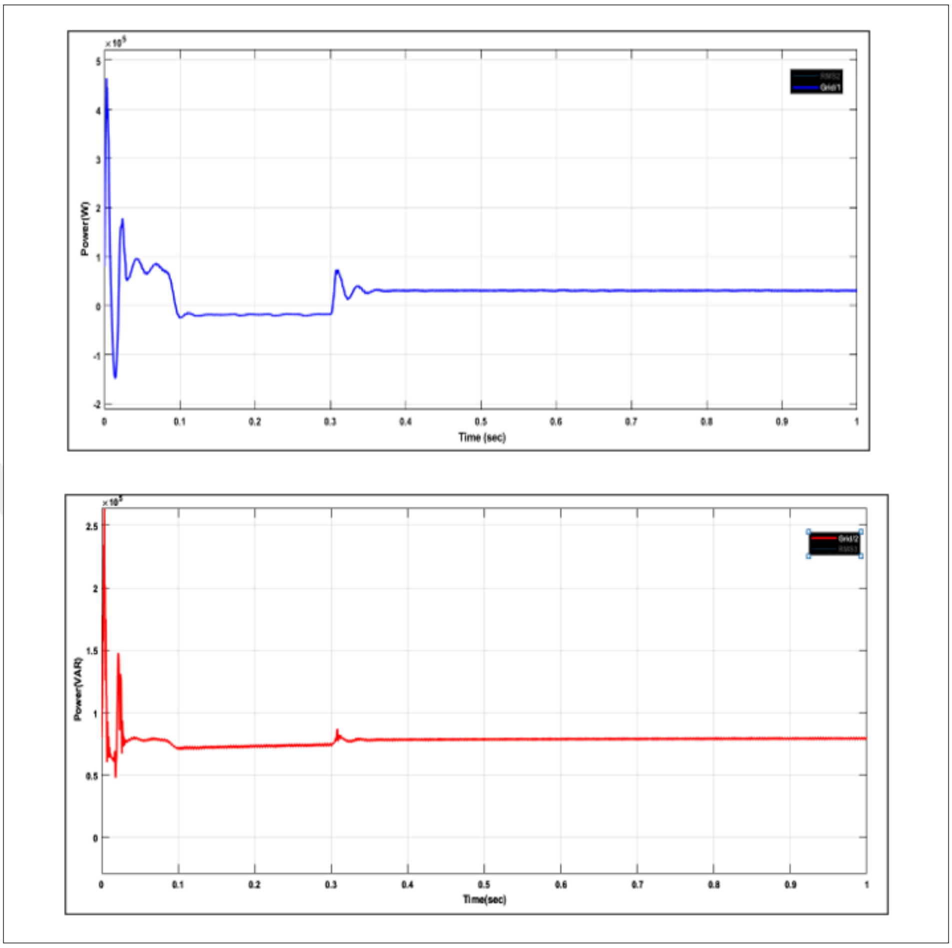


Figure 4.20: Grid Active and Reactive Power.

The load's Q equal 85 KVAR, but its P is 80 kW. Figure 4.21 displays the load's reactive Q power and active power P.

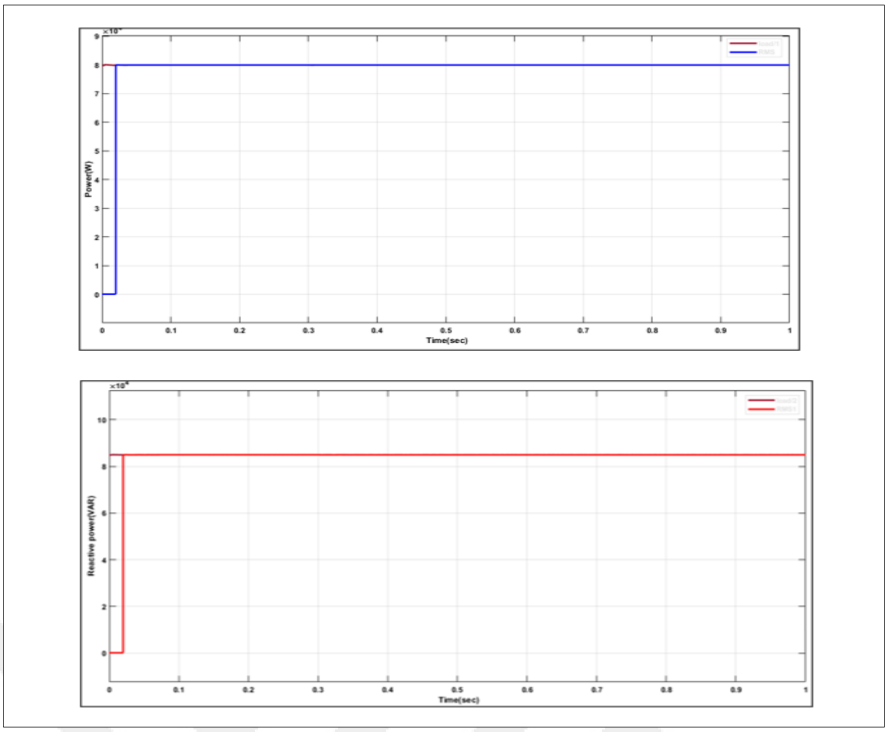


Figure 4.21: Reactive Q and Active Power P Must be Loaded.

4.7 A GRID - INTEGRATED SYSTEM WITH A FIXED CAPACITOR BANK IS A RESULT OF THE PV ARRAY.

down that circumstance, the actual power load is 80 kW and Q is 85 kvar. In 0.3 seconds, the photovoltaic irradiance difference at 1000 w/m2 to 500 w/m2. In 0.3 seconds, Figure 4.22 depicts the PV current of inverter, and link DC voltage in Figure 4.23. at maximum power of PV panels is 97.17 kW at 1000 W/m2 and 49.48 kW at 500 W/m2 in Figure 4.24 reproduce P and Q of the photovoltaic inverter in Fig 4.25.

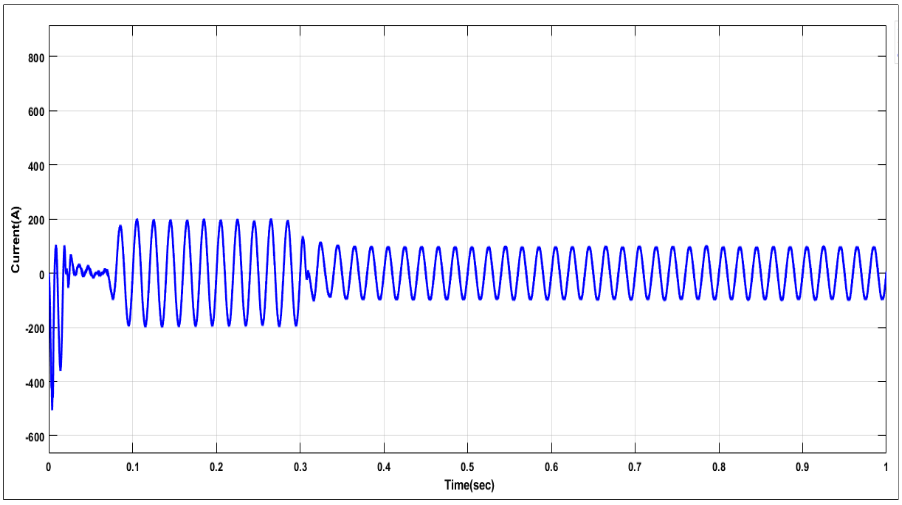


Figure 4.22: Reactive Q and Active Power P Must be Loaded.

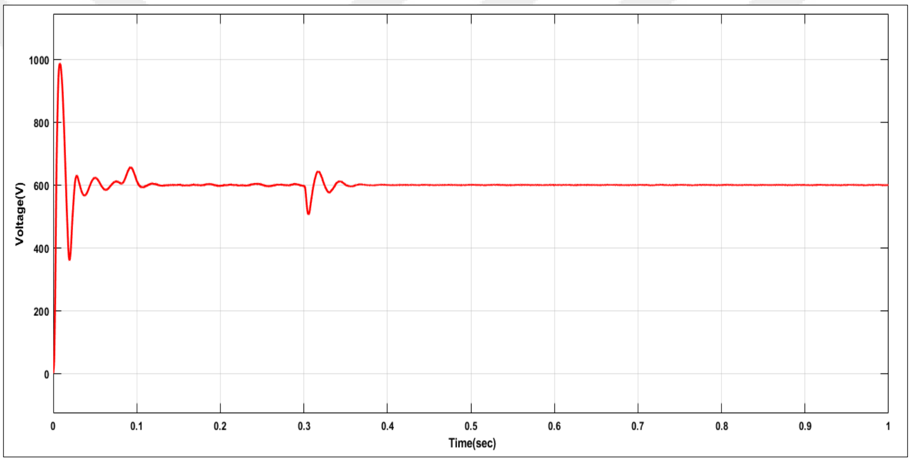


Figure 4.23: (Dc Link Voltage) PV Inverter.

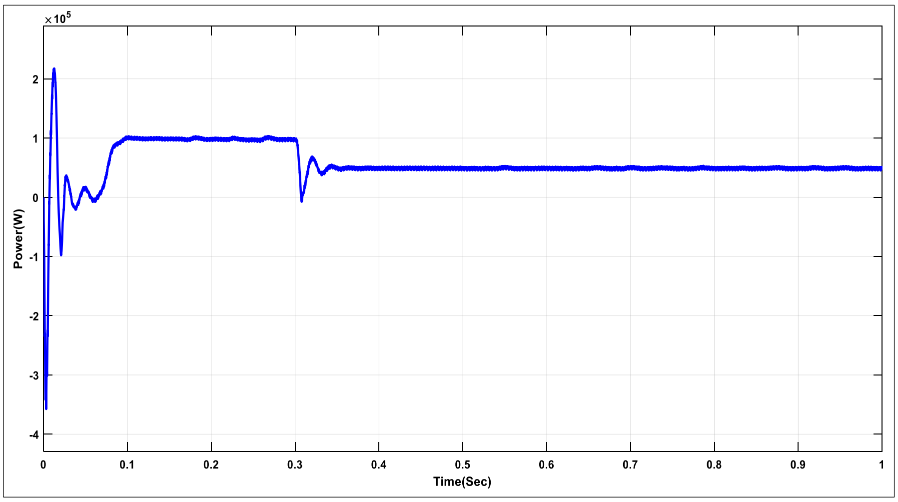


Figure 4.24: PV Inverter (P Power).

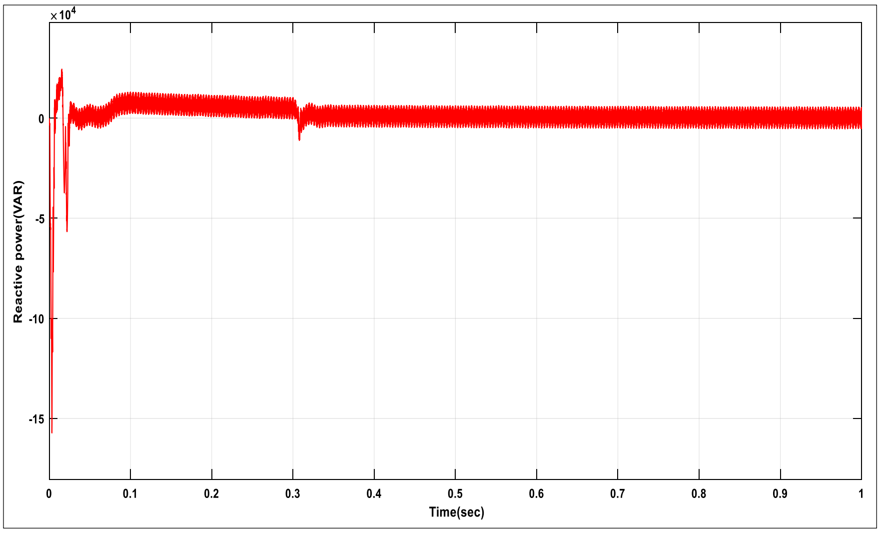


Figure 4.25: PV Inverter (Q Power).

The network (Q) and (P) are produce in Fig.4.26 and Fig.4.27. The grid (P) power is around 30. The (Q) at the grid is 1. kvar.

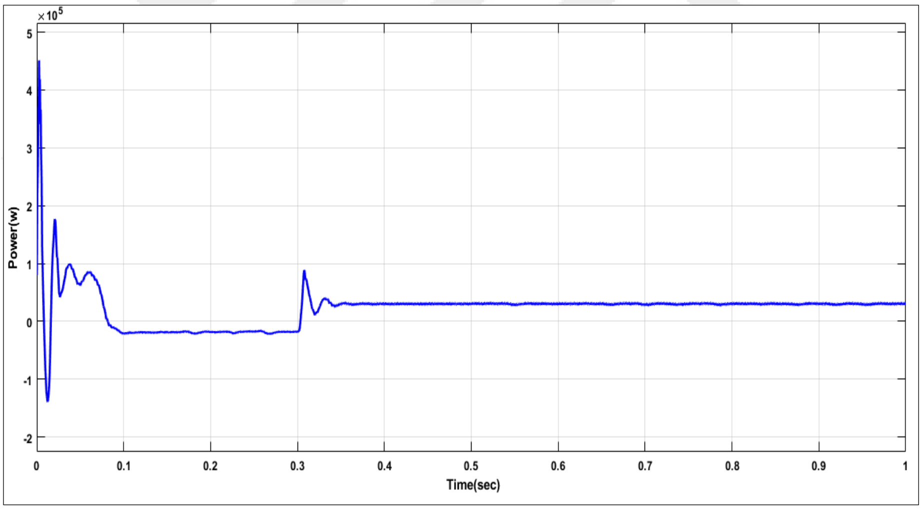


Figure 4.26: The Grid of Electricity (P).

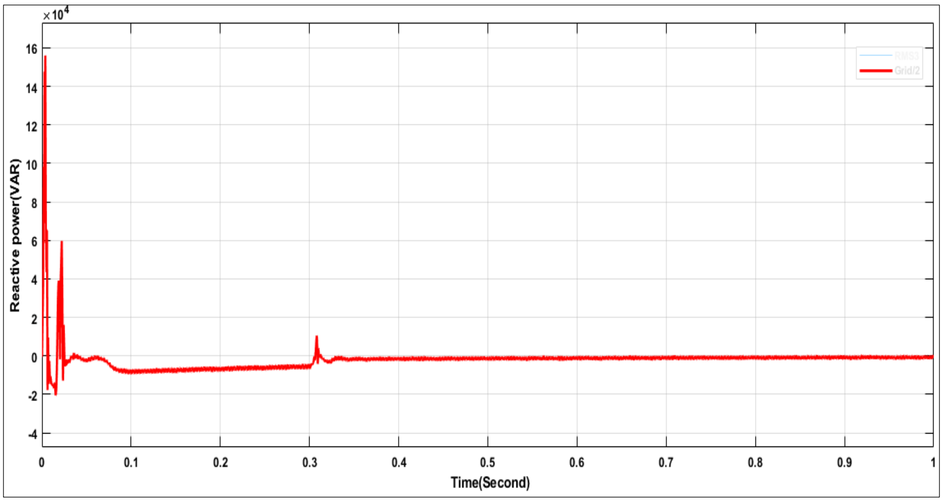


Figure 4.27: Electricity Grids (Reactive Power).

The capacitor bank reactive power is almost 127 Kvar As shown in the Fig.4.28. the load real power is 80 Kw and reactive power is 85 Kvar As shown in the Fig.4.29 and Fig.4.30.

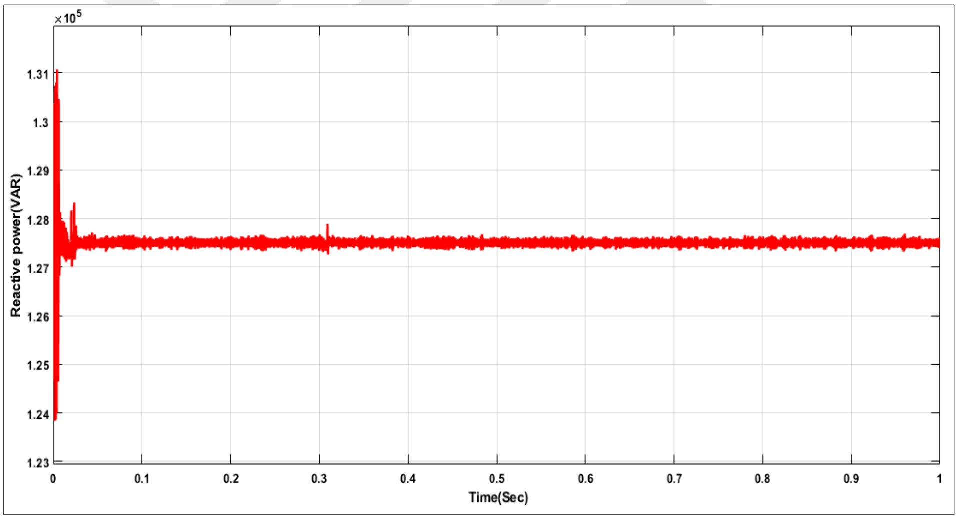


Figure 4.28: Specifications of Boost Converter.

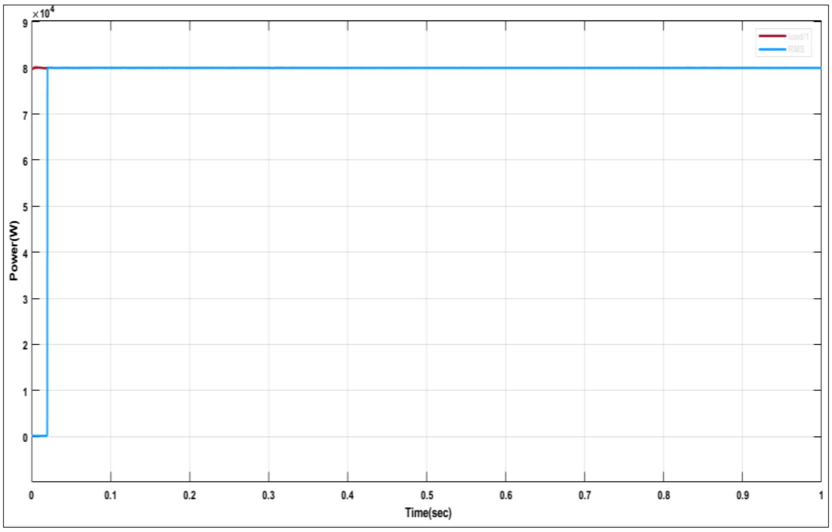


Figure 4.29: The Load (Real Power).

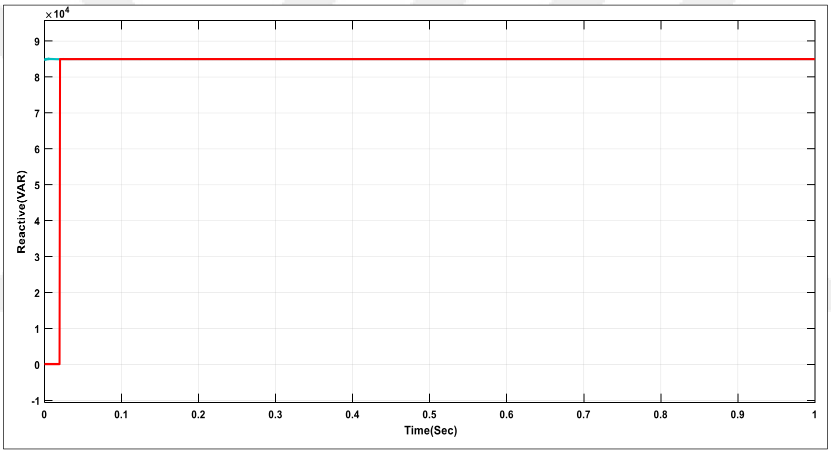


Figure 4.30: The Load (Reactive Power).

5. CONCLUSION AND FUTURE WORK

5.1 CONCLUSION

This study illustrates how to counterbalance (Q) in a grid using a set capacitor bank connected solar photovoltaic array. This dissertation examines the construction of photovoltaic (PV) systems, direct current to direct current boost converters, and electrical grid-connected inverters. The complete model of MATLAB Simulink is used to model the intended system. Tests have been conducted on the grid-connected photovoltaic solar array system under various operating conditions, both with and without fixed capacitors for (Q) power correction.

a. status 1: Evaluation of the grid-connected photovoltaic array technology without a fixed bank under different operating circumstances.
b. Status: 2 The electrically linked photovoltaic solar array system with a fixed bank has been assessed for (Q) power compensation under various operating situations.
c. Simulation results indicate that the electrically linked solar power photovoltaic system's reactive power is efficiently and dynamism adjusted by a fixed capacitor bank C according to the supply side's reactive power Q demand.
d. - Maximum power point monitoring algorithms have been suggested in this work (P&O) for maximizing the PV system's power output.
e. - Simulation results indicate that voltage is influenced by variations in temperature while electric current is affected by solar energy.
f. A simulation of the proposed system, which consists of a connected grid, was performed using the MATLAB Simulink program. Solar PV array three-phase inverter based on voltage controller loop and current controller loop control strategy, which represent by constant voltage and frequency during load changes and alter the apparent power (P, Q) utilizing reference values to control the inverter's voltage and frequency.

5.2 FUTURE WORKS

The issues that need more investigation are:

a. Create technically and economically viable equipment to compensate for (Q) in the power system.

b. To improve system efficacy, It is essential to build a The current MPPT algorithm uses artificial neural networks (ANN) and fuzzy logic.

c. The economic aspects of the design system and their energy management must be evaluated.

d. A wind turbine can be combined with other renewable energy sources to help satisfy energy demand.

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