Daffodil International University
Dhaka, Bangladesh

Thesis Report
On
Study on Grid Connected Solar PV System

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This thesis has been submitted to the Department of Electrical and Electronic Engineering in partial fulfillment of the requirement for the degree of Bachelor of Science in Electrical and Electronic Engineering.

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APPROVAL LETTER

This thesis report titled **"Study on Grid Connected Solar PV (Photo Voltaic) System",** submitted by MD.ImranBadsha ID: 161-33-249,Md.Nadim Mahmud ID: 161-33-256And Md.Safayet Ahmed Safu (Bakul)to the Department of Electrical and Electronic Engineering, Daffodil International University has been recognized as a partial supplement to the postgraduate science phase of electrical and electronic engineering and confirmed as its style and material. The presentation has been held on 16 July 2019.

Board of Examiners:

DECLARATION

We declare that this thesis is based on the results we receive. The work materials found by other researchers are referred by reference. This thesis is submitted to Daffodil International University for achieving BSc degree of Electrical and electronics engineering. This thesis has not been fully submitted for any degree prior to the degree.

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TABLE OF CONTENTS

LIST OF FIGURE

ABSTRACT

This paper presents the arrangement and diversions of a photovoltaic structure using trouble and watches methodology most extraordinary powerpoint following (MPPT) calculation with help converter. Furthermore, this paper deals with the arrangement and generation of a three-stage inverter in MATLAB SIMULINK condition which can be a bit of photovoltaic grid-related structures. At present, photovoltaic (PV) frameworks are playing a main job as sun based sustainable power source (RES) due to their extraordinary points of interest. This pattern is being expanded particularly in lattice associated applications due to the numerous advantages of utilizing RESs in appropriated age (DG) frameworks. This new situation forces the necessity for a successful assessment device of framework associated PV frameworks to anticipate precisely their dynamic execution under various working conditions so as to settle on an extensive choice on the plausibility of joining this innovation into the electric utility matrix. This suggests not exclusively to distinguish the qualities bends of PV modules or exhibits yet additionally the dynamic conduct of the electronic power molding framework (PCS) for associating with the utility matrix. To this point, this part talks about the full nitty-gritty displaying and the control structure of a three-stage network associated photovoltaic generator (PVG). The PV exhibit model permits anticipating high exactness the I-V and P-V bends of the PV boards/clusters. Additionally, the control plot is given the abilities of at the same time and freely managing both dynamic and responsive power trade with the electric lattice. The displaying and control of the three-stage matrix associated PVG are actualized in the MATLAB/Simulink condition and approved by trial tests.

Chapter 1

Generation of Electric Energy

1.1 Introduction

The sustainable power source is usually characterized as vitality that originates from assets that are normally recharged on a human timescale, for example, daylight, wind, storm, tide waves and geothermal. About 16% of worldwide last vitality utilization straightforwardly originates from inexhaustible assets, with 10% of all vitality from conventional biomass, mostly used for warming, and 3.4% from hydroelectricity. New inexhaustible (little hydro, modem biomass, wind, daylight based and geothermal) speak to another 3% and are growing rapidly. At the national level, at any rate, 30 nations around the globe as of now have a sustainable power source contributing over 20% of the vitality supply. National sustainable power source markets are anticipated to continue growing emphatically in the coming decade and past. The sustainable power source is accessible in various structures including Wind, Sun oriented and Biomass control. We plan to acquaint individuals with the need and advantages of using the regular wellsprings of vitality. This is essential as the World's wellsprings of oil and coal are near exhaustion with an enormous addition popular. Along these lines, it has become amazingly basic that individuals grasp the essence of safeguarding these unassuming wellsprings of vitality and make sense of how to direct vitality viably.

The integration of photovoltaic systems into the framework is turning into the most important application of PV systems today, with traditional anesthetic therapeutics gaining enthusiasm for without any assistance autonomous systems. This pattern is being fortified with many advantages of utilizing RSE in conveyed (scattered, installed or decentralized) Generation (DG) power systems [4-5]. These advantages incorporate the favorable financial and regulatory motivations established in many nations that straightforwardly affect the commercial acceptance of the lattice connected PV system. In this sense, the increasing number of conveyed PV systems carries new challenges to the operation and management of the power lattice, especially when these variable and irregular power sources comprise a significant portion of the total system generation capacity. This new approach emphasizes the requirement for compelling plan and performance evaluation instruments of network connected PV systems so innovation can be accurately estimated for their dynamic performance across various operating conditions to choose whether to incorporate the electronic utility lattice. The flow voltage (IV) properties of the modules or arrays cannot be recognized, however the dynamic behavior of the power hardware interface with the utility matrix to make the necessary change can also make the necessary transformation to yield power into valuable power and to the lattice. This PV PC is the key fixing that enables us to supply more affordable harvests from the sun and meet certain framework code prerequisites. These necessities incorporate the arrangement of a significant level of security, quality, reliability, availability, and proficiency of electrical vitality. Furthermore, present day DG applications are increasingly integrating new dynamic compensation issues and individually on the utility matrix, including current active power exchanges including voltage control, power oscillator damping, power factor modification, and separating among others, saying this pattern will increase in future DG applications.

This chapter shows a total mathematical model of a three-phase lattice connected photovoltaic generator (PVG) with a PV array and electronic power molding system based on the MATLAB/Simulink software package [8]. The proposed PV array model uses theoretical and empirical equations, including data gave by the manufacturer and meteorological data (solar radiation and cell temperature, among others) to foresee the fourth accuracy of PV panels/arrays with high accuracy. Since PV PC dissemination addresses integration issues from both the PV manufacturer and the utility

1.2 Sustainable power

The sustainable power source is ordinarily characterized as vitality that originates from assets that are normally recharged on a human timescale, for example, daylight, wind, deluge, tide waves and geothermal. About 16% of worldwide last vitality utilization legitimately originates from inexhaustible assets, with 10% of all vitality from conventional biomass, predominantly used for warming, and 3.4% from hydroelectricity. New inexhaustible (little hydro, modem biomass, wind, daylight based and geothermal) speak to another 3% and are growing rapidly. At the national level, at any rate, 30 nations around the globe as of now have a sustainable power source contributing over 20% of vitality supply. National sustainable power source markets are anticipated to continue growing emphatically in the coming decade and past. The sustainable power source is accessible in various structures including Wind, Sun oriented and Biomass control. We plan to acquaint individuals with the need and advantages of using the regular wellsprings of vitality. This is essential as the World's wellsprings of oil and coal are near exhaustion with an enormous addition popular. Along these lines, it has become amazingly basic that individuals understand the essentials of safeguarding these unassuming wellsprings of vitality and make sense of how to administer vitality successfully.

1.3 Solar Energy

Solar energy, brilliant light, and warmth from the sun is saddled utilizing a scope of regularly developing advancements, for example, solar warming, solar photovoltaics', solar warm electricity, solar engineering, and fake photosynthesis. Solar innovations are extensively portrayed as either detached solar or dynamic solar relying upon the manner in which they catch, change over and circulate solar energy. Dynamic solar procedures incorporate the utilization of photovoltaic boards and solar warm gatherers to saddle the energy. Detached solar systems incorporate arranging a structure to the Sun, choosing materials with ideal warm mass or light scattering properties, and planning spaces that normally flow air.

A solar cell, or photovoltaic cell (PV), is a gadget that changes over light into electric flow utilizing the photoelectric impact. The main solar cell was developed by Charles Fritts during the 1880s. The German industrialist Ernst Werner von Siemens was among the individuals who perceived the significance of this disclosure. In 1931, the German designer Bruno Lange built up a photograph cell utilizing silver selenide instead of copper oxide, in spite of the fact that the model selenium cells changed over under 1% of episode light into electricity. Following crafted by Russell Ohm during the 1940s, specialists Gerald Pearson, Calvin Fuller and Daryl Chapin made the silicon solar cell in 1954. These early solar cells cost 286 USD/watt and arrived at efficiencies of 4.5-6%.

Renewable energy:

Renewable vitality is usually characterized as vitality that easily falls into place from assets that are naturally filled over a human period, for example, daylight, wind, rain, tidal waves and geological conditions. About 16% of the global final vitality utilize originates from renewable assets, 10% of all vitality from conventional biomass, mainly utilized for heating, and 3.4% from hydropower.

1.4 Grid Tied Solar Electric Systems

Network Tide Solar Electronic frameworks generate electricity discreetly and with no moving parts. Sunshine falls on the solar show (blue, on the roof of the house), DC supplies electricity. That DC power is converted to 120 V in the family by the inverter's electronics cooling electricity (blue and low, on the divider). Force air system power to be supported on your electric meter and electric switchboard (reduce in the divider). Electricity is either in your mechanical assembly and lights, or in cross-sections, or in everything. All of this happens seamlessly and generally reliably. Lattice Inter Control Frameworks are for individuals who will (or will) be related to administration association electrical links ("networks") to use the framework to improve what they can create with economic power sources such as the sun or the wind. Expect

Create with renewable energy sources like sun or wind

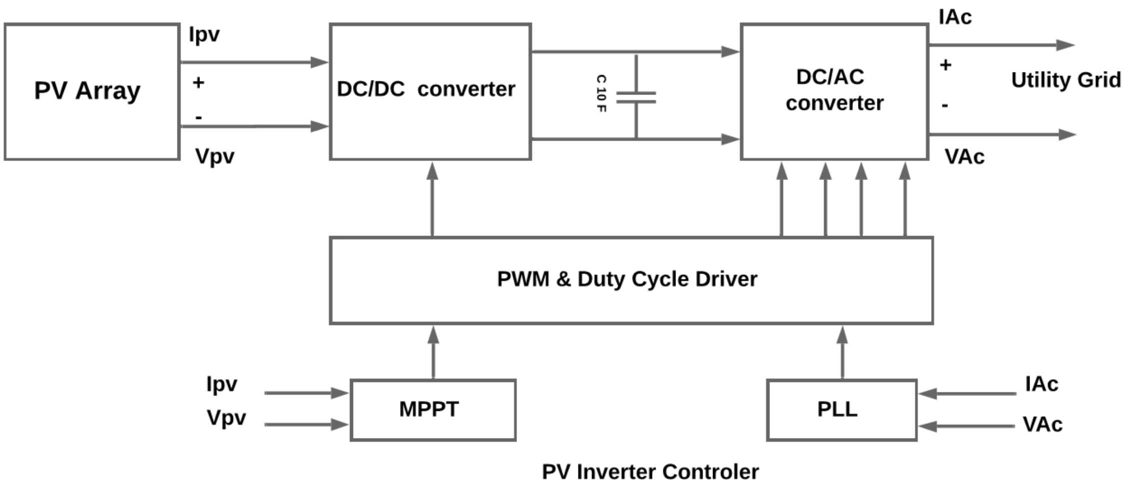


Figure 1.1: - Grid Tie Solar System

1.4.1 Parts of Grid Tie Solar System

* Solar Panel.
* Maximum Power Point Tracking (MPPT).

* DC To DC Converter.
* DC to AC Converter (Inverter).
* Utility Grid.

1.5 Objectives of the Study

The essential focal point of this undertaking is the improvement of a Grid Connected solarPV System in which dynamic and responsive forces sway exponentially with voltage and execution of this model in Ideal Power Stream and examination of the possible results of the above with those got from OPF considers without association of weight models to guarantee least debacles and age costs [4].

The main Objectives of the Study are:

- ➔ To know about grid connected Solar Photovoltaic System.
- ➔ Discuss About Grid Tie.
- ➔ Brief discuss about Solar panel and solar system
- ➔ Briefly Discuss about PVG(PhotovoltaicGenerator) Model.
- ➔ To find out favorable solutions for the problems and appropriate strategies for expansion of the business.

1.6 Solar Panel

The kind of solar panel you have probably observed on individuals' roofs are called Photovoltaic Solar Panels photograph meaning light, and voltaic meaning to do with power. As the name recommends, Photovoltaic (or PV) panels convert light straightforwardly into electrical vitality.

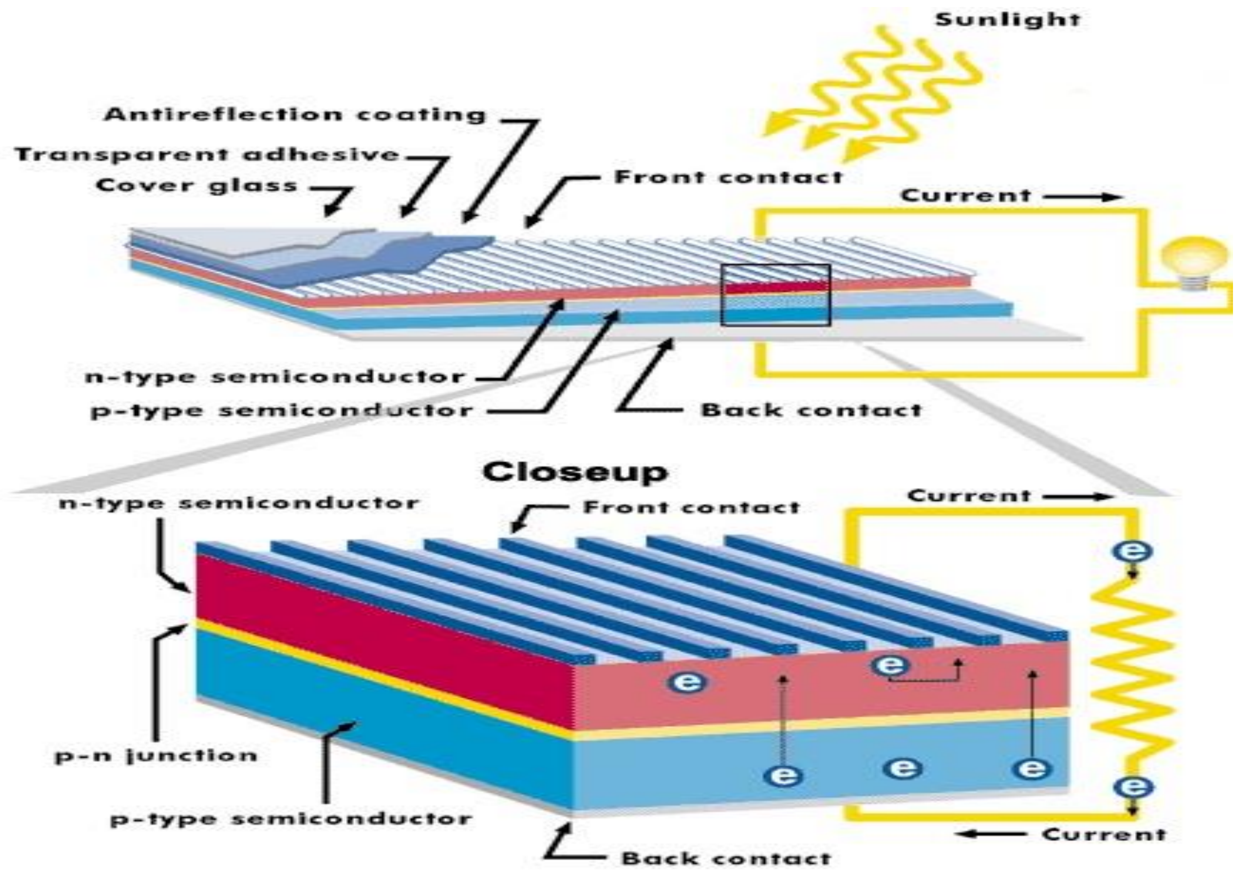


Figure 1.2: - Solar Panel

1.7Basic Principal of Solar Panel

A solar cell or photovoltaic cell is a gadget that changes over daylight straightforwardly into power by the photovoltaic impact. Photovoltaic is a technique for generating electrical power by changing over solar radiation into direct flow power utilizing specially planned p-n intersections that show the photovoltaic impact. At the point when electromagnetic irradiation falls on such an intersection, it transfers vitality to an electron in the valence band and elevates it to the conduction band thus creating an electron-opening pair. The electrons and gaps created can now act as portable charge carriers and hence current is delivered. This procedure across a p-n intersection has appeared in the figure

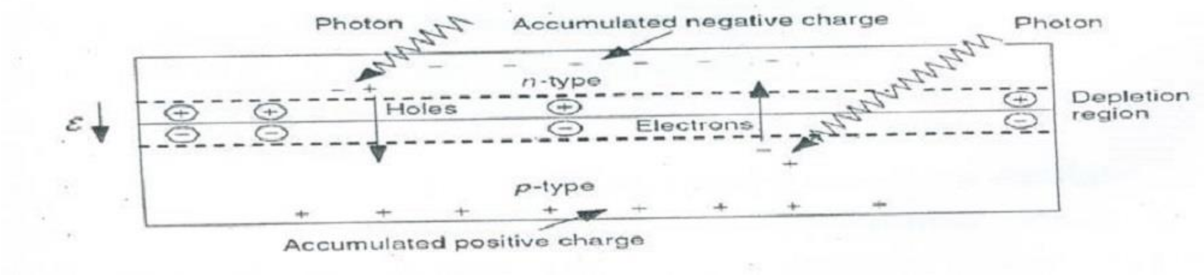


Figure 1.3: - Creation of Electron-Hole Pairs by incident electromagnetic irradiation

1.8Solar Cell

A solar cell (also called a photovoltaic cell) is an electrical gadget that converts electricity directly through the effect of photovoltaics to the power of light. It is a type of photoelectric cell (its electrical properties, for example, flow, voltage or opposition when the light is illuminated on it) that can create and promote an electric current without any addition when presented to the light, using an external voltage source. It requires an external burden.

The expression "photovoltaic" denotes "light" from Greek φ ς (Foss), and "volt" derives from a single and volt of electronic-thought process energy, derived from the last name of the Italian physicist Alessandro, the inventor of volts and batteries (electrochemical houses).). The expression "Photograph Voltaic" has been used in English since 1849. The field of invention and research is characterized by the effective use of photovoltaic cells in the delivery of light to electricity, but it is often used explicitly with the age of electricity, from daylight to houses can be depicted as photovoltaic in any event, when the source of light is truly Not daylight (lamplights, fake lights, etc.) Phone, in this case, Is sometimes used as a photograph identifier (for example infrared detector), to detect light or other electromagnetic radiation close to a symptomatic range or to estimate light energy.

1.8.1 Operation of a Photovoltaic (PV) Cell

The operation of a photovoltaic (PV) cell required

* The absorption of light, generating either electron-hole pairs or exactions.
* The separation of charge carriers of opposite types.
* The separate extraction of those carriers to an external circuit.

In contrast, a solar heat collector supplies heat by absorbing sunlight, for the purpose of generating direct heating or indirect electric power. On the other hand, "photo electrolytic cells" (photo electronic chemicals) refers to a type of photovoltaic cell (such as Edmund Beckerel and modem dye developed by sensitive solar cells), or a device that directly shares water with hydrogen and uses oxygen only solar photosynthesis.

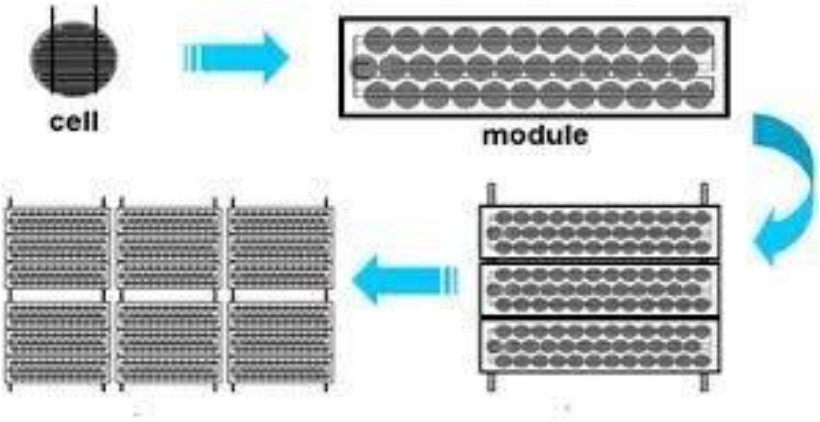


Figure 1.4: - Construction of Photovoltaic Solar Panel

1.9Modules

PV modules are sealed in an environmental protective laminate containing PV cell circuits and are the basic building block of the PV system.

1.10Array

A PV array is the complete power-generating unit, consisting of any number of PV Modules and panels.

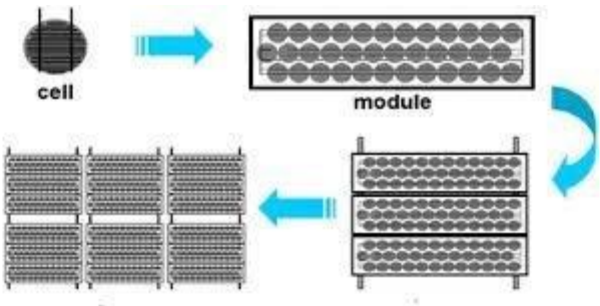


Figure 1.5: - Photovoltaic Array

Chapter 2
Evaluating MPP Using MATLAB PV Model

2.1 Introduction

A "network tie" solar structure is related to the power matrix, appearing dependent on the shock diode conditions to pull power from an appropriate PV module electric model. The straightforward model contains a photograph current, current source, a seamless diode intersection, and an arrangement barrier and includes temperature conditions. The technique of parameter extraction and model determination in Matlab appears for a typical 60 W solar board. This model is used to test a variety of greatest power points with temperature and light levels.

2.2 Photovoltaic Modules

Solar cells comprise of a P-N crossing point that is formed on the semiconductor's unstable wafer or layer. In the ambiguity, the I-V yield for the solar cells remains a nearby trademark as the normal diode. When exhibited to the light, photographs of the vitality being more vitality than the semiconductor band gap vitality are infused, creating an electronic-gap pair. These carriers are individually cleansed by the internal electric fields of the P-N crossing point and form a stream compared to the episode radiation. At the point when the cell is short-circulated, it streams into this external circuit; When opened, this current is expelled by the natural P-N crossing point diode. The properties of this diode, along these lines, decide the properties of the open-circuit voltage of the cell.

2.3 Standard Test Conditions (STC) includes of PV Module

The business standard against which all PV modules are appraised and can be looked at is called Standard Test Conditions (STC).

- Irradiance (daylight force or power), in Watts per square meter falling on a level surface. The estimation standard is 1kW per sq. m. (1,000 Watts/m2)
- Air Mass alludes to "thickness" and lucidity of the air through which the daylight goes to arrive at the modules (sun point influences this worth). The standard is 1.5.
- Cell temperature, which will vary from encompassing air temperature.

STC characterizes cell testing temperature as 25 degrees C.

Each solar display board adds 36, 72 or even 96 individual standard solar cells. In the past, cell sizes have achieved approximately 5 "square (125 mm) measurements Most utilized solar cells are made by strong film silicon, whose effectiveness is assessed at moderate to high percentages of 20 percent for polycrystalline cells, and 25 percent for mono-crystalline cells. In unadulterated use, cells are engaged with the arrangement to gather adequate voltage from 0.6V which A standard cell to inform usable voltage levels, present-day evaluation solar modules operate from a solitary cell, covered in glass plates for assurance and wiring and sandwiched between polymers.

2.4 Modeling the Solar Cell

Accordingly, the least mind-boggling uniform circuit in a solar cell is the source present in parallel to a diode. The yield of the present source is conversely related to the amount of reading inside the cell. Decides the ivy properties of the diode cells.

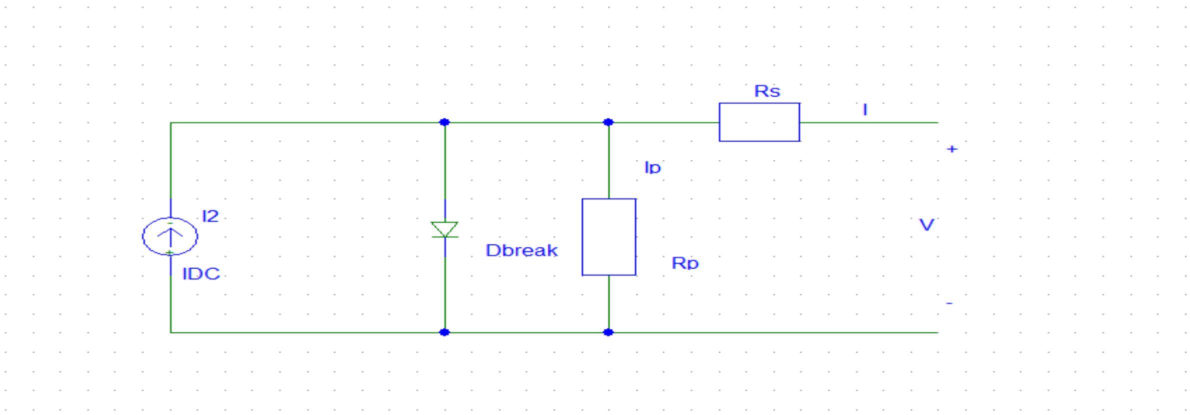


Figure 2.1: - The Circuit Diagram of the PV Model

Increasing sophistication, accuracy and complexity can be introduced to the model by adding in turn.

- Temperature dependence of the diode saturation current I0.
- Temperature dependence of the photo current IL.
- Series resistance R_s which gives a more accurate shape between the maximum power point and the open circuit voltage.
- Shunt resistance R_p, in parallel with the diode.

- Either allowing the diode quality factor n to become a variable parameter (instead of being fixed at either 1 or 2) or introducing two parallel diodes (one with A = 1, one with A = 2) with independently set saturation currents.

For the reason for this test, a model of moderation unpredictability was utilized. The model included temperature reliance of the inundation current of the photon current K and diode IO. The advancement of the rupees was incorporated, yet no restriction. The diode quality factor set was utilized in the Salt Shunt diode to give the best curve adjustment. This model is a streaming adaptation of the two diode models displayed by the bovine and the monitor. The circuit chart for the solar seal will appear in the figure above.

The conditions which portray the I-V qualities of the cell are

I= IL-Io(eq(V+IRs)/nkT-1) -----------(I)

I_L= $I_{L(T1)}$ (1+K_0(T-T1)) --------------------(11)

$I_{L(Tl)}$ = G*$I_{SC(Tl,nom}$/G(nom) --------------------(III)

K_o = ($I_{sc(T2)}$-$I_{sc(Tl)}$))/(T2-T1) --------------------(IV)

I0= I0(T1) *(T/T1)3/n * e-qVg/nk*(1/T-l/Tl) ------------(V)

I0(T1) = Isc(T1)/(eqVoc(T1)/nKT1-1) -----------------(VI)

Rs = -dV/dI_{voc}-1/Xv------------------------(VII)

Xv = I0(T1) *q/nkT1*eqVoc(T1)/nkT1-------------(VIII)

Where,

I_L = Photo Current
1_0=Diode Saturation Current
R_s =Series Resistance
R_p = Shunt Resistance
n = Diode Quality Factor
K= Boltzmann's Constant
I_{sc} =Short Circuit Current
v_g = Bandgap Voltage
V_{oc} = Open Circuit Voltage
q = Charge of Electron
T = Temperature
G= Irradiation

All the constants in the above equation can be controlled by the manufacturer's rating of the PV array and then by the distributed or measured I-V bend of the array. As a general example, the Solar "Rusa" 60 twofold array model will be utilized to illustrate and validate. Photograph current IL (An) is straightforwardly proportional to radiation G (WM-2). At the point when the cell runs low, trivial current streams into the diode. So the balance coherence (III) is set in the equation with the goal that the rated short circuit is provided under the current Isc rated irradiation (typically 1 sun = 1000Wm · 2). For "Riusa", Tk = 25 ° C (298 K) in the sun at Isk = 3.8 A, therefore, IL (T1) = 3.8 A/bright.

The relationship between the photograph current and the temperature is linear (Acon, II), and with the change of temperature the photograph current changes, and the change in 3.92A (3%) is taken note. "Riusa", IL varies from 3.80 to 25 to 75 ° C. At the point when the room isn't illuminated, the relation between the terminal voltage of the cell and the. The flow is given by the equation in stun. At the point when the cell is circulated and illuminated, the photograph current streams totally into the diode. The I-v application is offset by the current generated IL (acne I) from the yield.

At the point when the cell isn't illuminated, the relation between the terminal voltage and the flow of the cell is given by the equation in the stun. At the point when the cell is open-propagated and illuminated, the photograph current streams superbly into the diode. The photogenerated current from the wellspring of the I-V bend is offset by the IL (Akon I). At this temperature (eqn VI), the value of saturation current 10 to 25 ° C is calculated utilizing open-circuit voltage and short-circuit current. An estimate from the obscure "normative coefficient" n must be made. Green states that it takes a value somewhere in the range of 1 and 2, turns out to be more like one at higher flows, increases to two at lower flows. A value of 1.3 is prescribed as normal in normal operation and may be utilized initially by turning fittings until a more accurate value is estimated. The impact of the variance of the normative cause is found in the "Riesa" model, with higher values softening the knee in the bend. The relationship of temperature to 10 is intricate, yet fortunately, there are no variables that should be evaluated (eqn V). The nonstop resistance of the panel V = Voc has a large impact on the optical curvature of the IV bend, as found in the figure (eqn VII) and (eqn VIII) recognizing (eqn I), evaluating V = Voc and. As far as this, reorder. Utilizing the values obtained from the manufacturer's bend from "Rusa", a value of the total panel arrangement resistance = 8m calc was calculated.

2.5 MATLAB Model of the PV Module

Solar "Riusa", a standard 60 W PV module, was picked for display. The module contains 36 arrangements connected to polycrystalline cells. The key features have appeared in Table in The model were evaluated utilizing Matlab. The model parameters are evaluated while performing the equations recorded in the past segment utilizing the above data focuses contained in the content. The present I is then evaluated utilizing these parameters and the variables voltage, fuel, and temperature. In the event that one of the information variables is a vector, at that point, the yield variable (current) is also a vector. The consideration of arrangement resistance in the model illuminates the present iterative equation (see Eqn. I). A straightforward reiteration procedure initially looked to change over just for positive flows. The Newton Raphson strategy utilized is a lot faster and changes over it to both positive and negative flows.

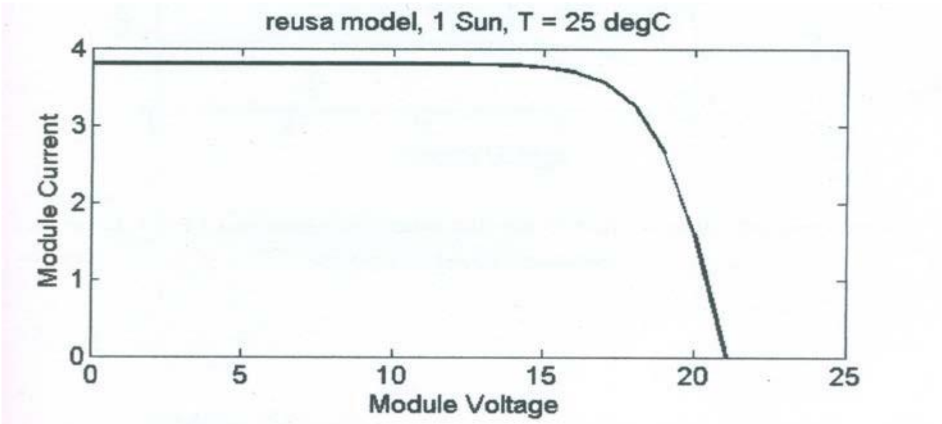


Figure 3.2 V-I Characteristics Curve of Solar Cell at Constant Temperature and Irradiation

At Temperature	T	25	C
Open Circuit Voltage	V_{OC}	21.0	V
Short Circuit Current	I_{SC}	3.74	A
Voltage, Max Power	V_m	17	V
Current, Max Power	I_m	3.52	A
Maximum Power	P_m	59.84	W

Table 2.1:-The key specifications of the Solar "reusa" PV panel.

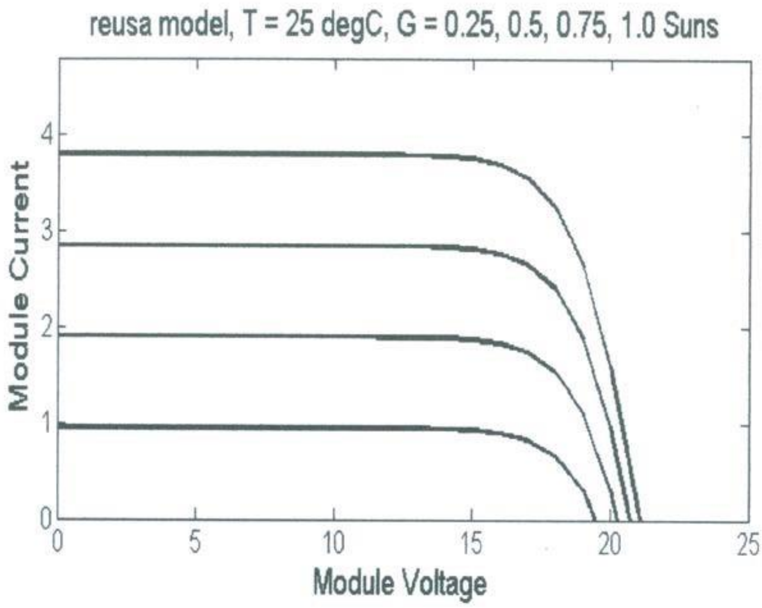
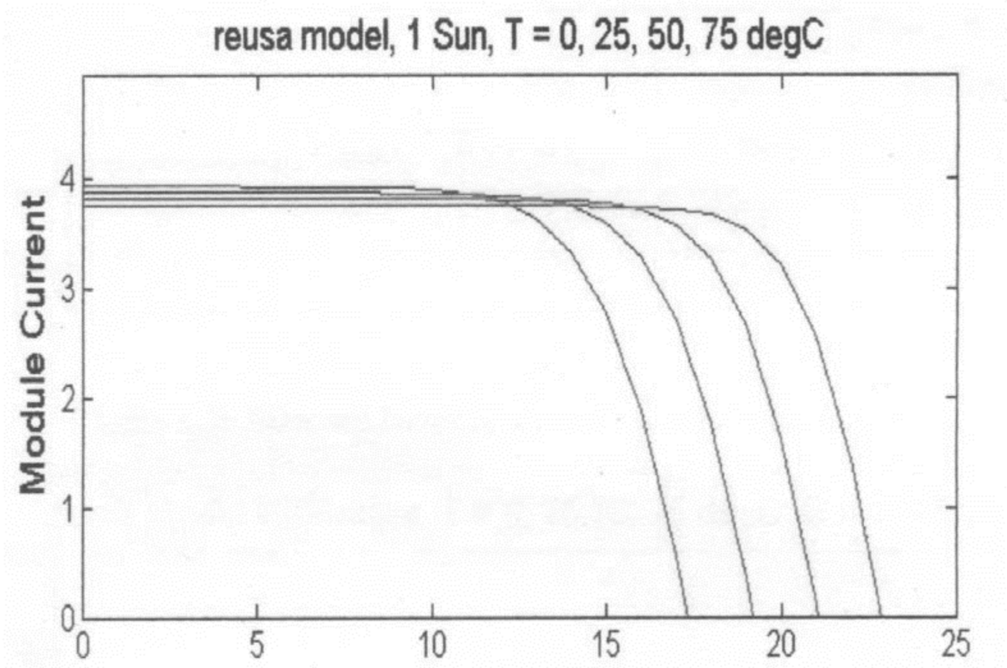
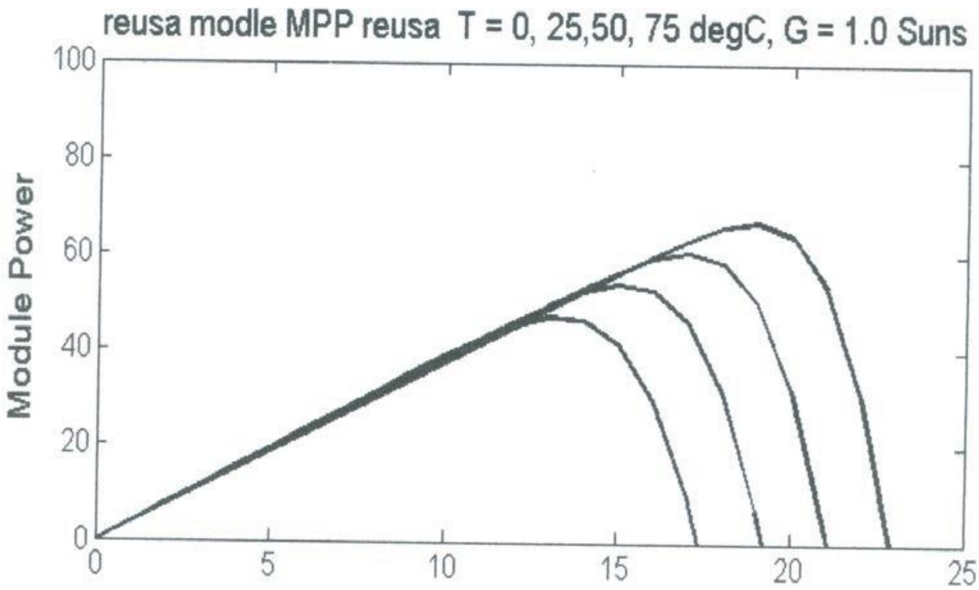


Figure 3.3 V-I Characteristics Curve of Solar Cell at Constant Temperature and Various Value of Irradiation.



Module Voltage

Figure 2.4: - V-I Characteristics Curve of Solar Cell at Constant Irradiation and Various Value of Temperature

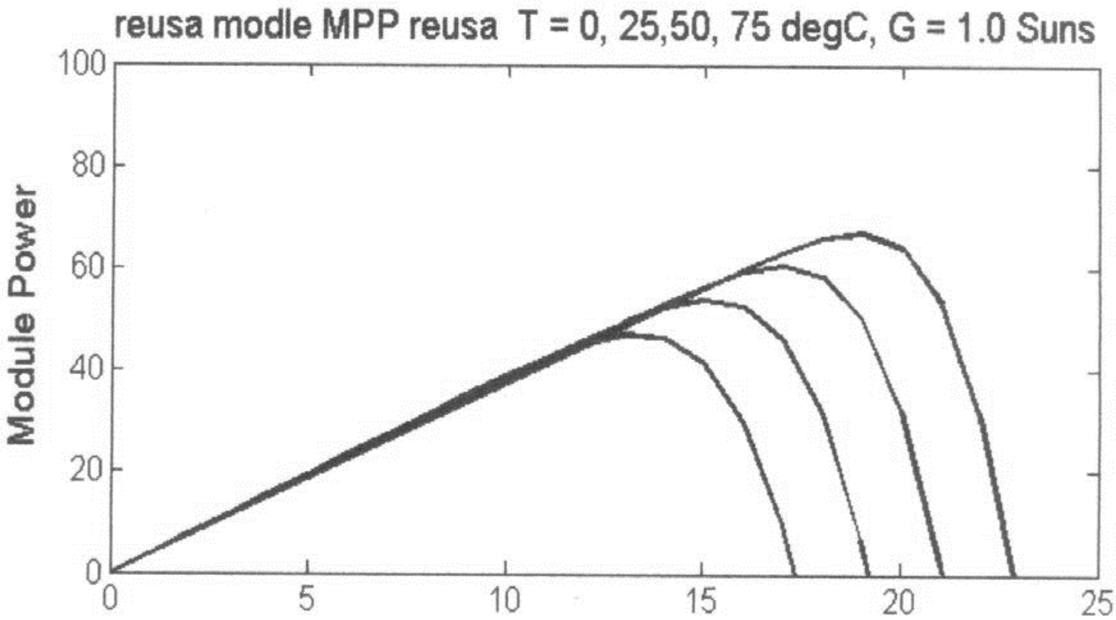


Module Voltage

Figure 2.5: - V-P Characteristics Curve of Solar Cell at Constant Temperature and Various Value of Irradiation

Serial No.	Temperature	Sun	Voltage	Current	Power Max.
01	25	0.25	16	0.8999	14.3978
02	25	0.50	17	1.7869	29.6971
03	25	0.75	17	2.6569	45.1681
04	25	1	17	3.5200	59.9000

Table 2.2:- Constant Temperature and Various Value of Sun

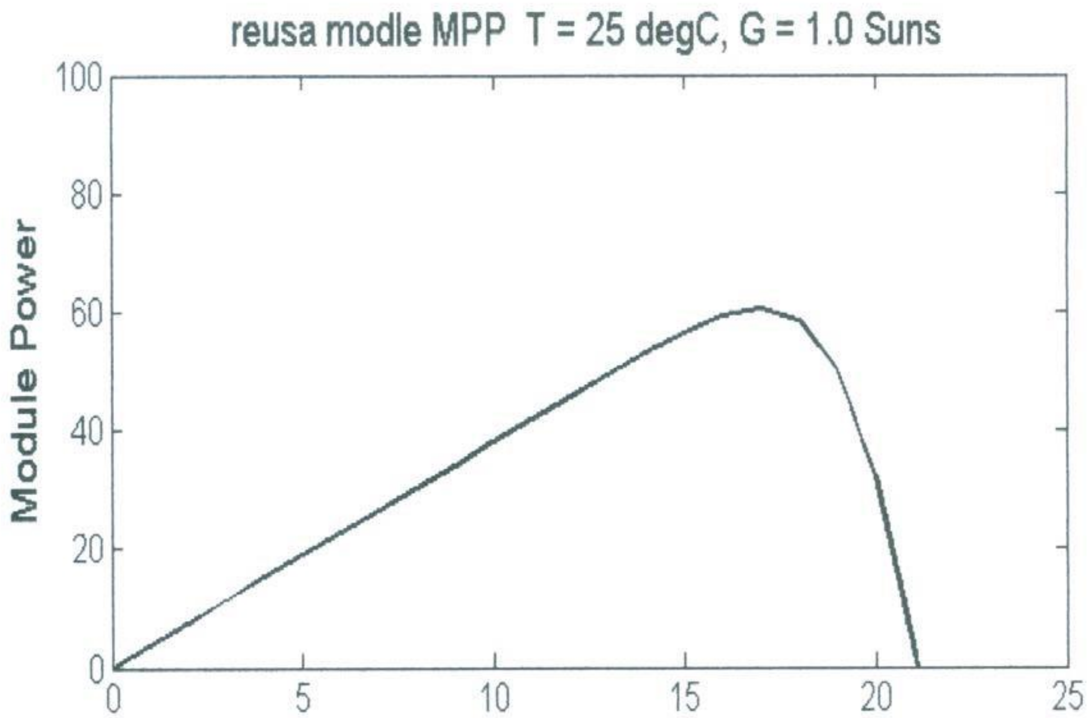


Module Voltage

Figure 2.6: - V-P Characteristics Curve of Solar Cell at Constant Irradiation and Various Value of Temperature

Serial No.	Temperature	Sun	Voltage	Current	Power Max.
01	0	1	19	3.5210	66.8993
02	25	1	17	3.5200	59.9000
03	50	1	15	3.5909	53.8631
04	75	1	13	3.6221	47.0875

Table 2.3: - Constant Sun and Various Value of Temperature



Module Voltage

Figure 2.7: - V-P Characteristics Curve of Solar Cell at Constant Irradiation and Temperature

Serial No.	Temperature	Sun	Voltage	Current	Power Max.
01	25	1	17	3.5200	59.9000

Table 2.4: Constant Sun and Temperature

Chapter 3

Evaluating MPPT Converter Topologies

3.1 Introduction

The maximum power point tracker (MPPT) topology is compared to the Bock versus and the immediate association with a constant voltage load. Because of the high effectiveness and high yield voltage, the But converter is the most suitable and most regularly utilized for photovoltaic systems.

3.2 Maximum Power Point Tracker (MPPT)

So as to adapt to the electrical operating states of the generator, it is necessary to utilize an MPPT that comprises of a power segment and a control segment. The power area is usually a DC/DC converter where the control segment can be worked by rationale or analog gadgets. Various strategies have been proposed to drive the AC or DC trouble in the MPP. These strategies are based on the control of the PV module yield voltage or current according to the reference voltage or current signal, which is constant or got from the characteristics of the PV generator. One contrast of these systems is that the immediate DC/DC converter obligation cycle is utilized as the control parameter and the derivative DP/D1 is forced to zero, where P is the PV yield power and the obligation cycle, so just a control loop is in the figure. As required as illustrated

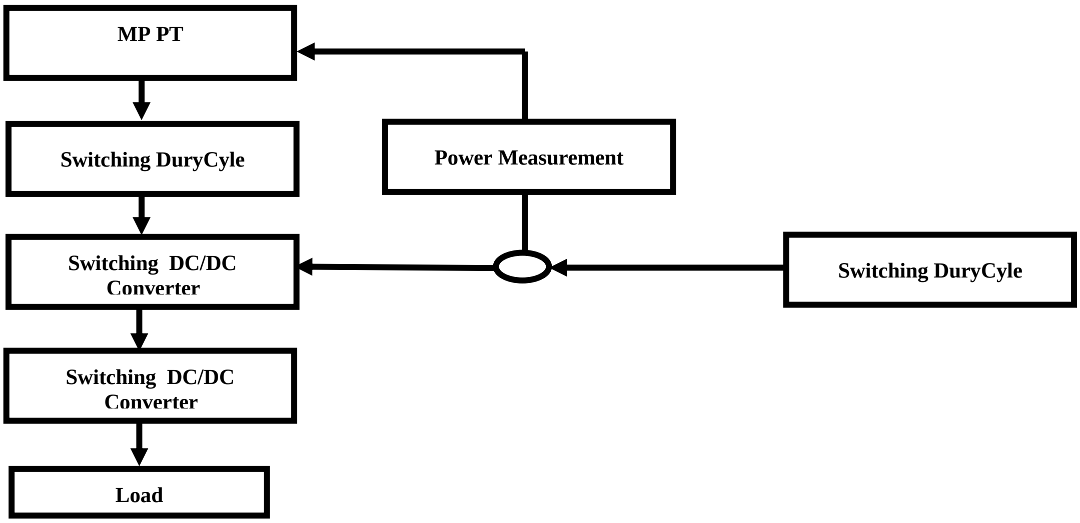


Figure 3.1: - Block Diagram of the MPPT Control

Depending on the result of the comparison the duty cycle is changed accordingly and the process is repeated until the maximum power point has been reached.

3.3 Methods of Maximum Power Point Tracking

The maximum power is reached by adjusting its obligation cycle with the DC/DC converter. Presently the inquiry arises as to how to separate the obligation cycle and in which heading the maximum capacity is reached. Regardless of whether manual tracking or automatic tracking?

Manual tracking is absurd so automatic tracking is favored for manual tracking. Automated tracking can be finished utilizing various algorithms.

- ✓ Perturb and observe.
- ✓ Incremental Conductance
- ✓ Parasitic Capacitance
- ✓ Voltage Based Maximum Power Tracking
- ✓ Current Based Maximum Power Tracking

3.3.1 Perturb and Observe Method

With this algorithm, a little irony is introduced to the system. The power of the module changes due to this error. If the power increases due to knocking, then the tension will continue in that direction. At the next instant, the peak energy decreases as it reaches, and therefore, the net is reversed.

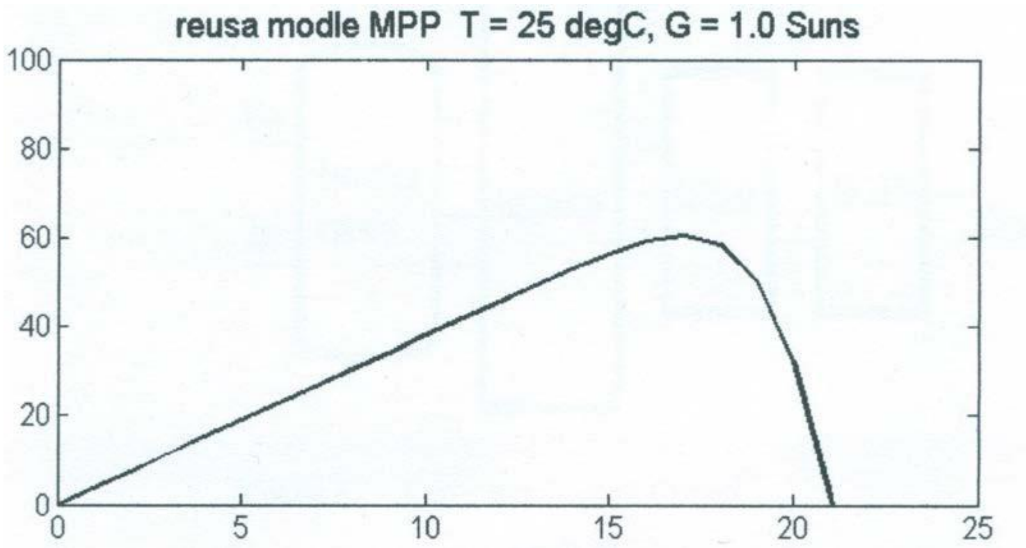


Figure 3.2: - Perturb and observe Method.

At steady-state, the algorithm is around the most elevated direct C toward keeping the power variation small, the size of the porthole is kept exceptionally small. The algorithm is created so that it sets a reference voltage of the module relative to the maximum voltage of the module. At that point, a microcontroller works by moving the operating purpose of the module to that particular voltage level. It is seen that because of this distinction a portion of the misfortunes fails to track the power are rapidly changing atmospheric conditions. Yet at the same time, this algorithm is popular and basic.

3.4 Converter control circuit

The system control circuit shown in figure -14 is based on the PIC Microcontroller. The control circuit consists of:

- √ Interface circuits which contain sensors and signal Conditioners connected to the microcontroller A/D converter
- √ PIC 16F877 microcontroller
- √ Quadruple differential line driver
- √ IC driver for the power GTOs.

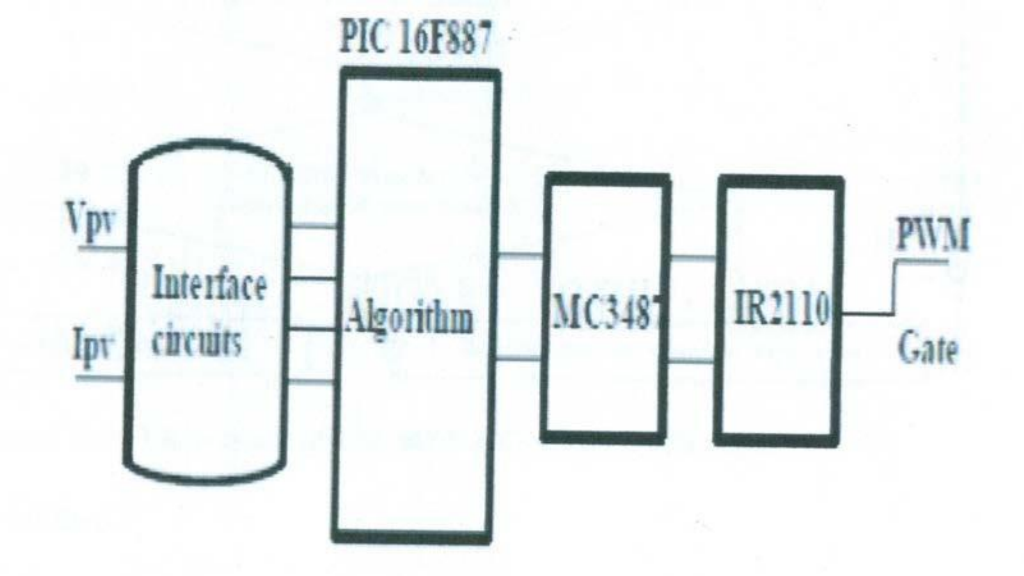


Figure 3.3: - Converter Control Circuit.

3.5 MPPT Control Technique & Software Designs

To create a steady yield voltage, a voltage foundation control structure is utilized. In this control structure, the yield voltage will be estimated and contrasted, and a reference voltage and differential value will be utilized to generate the PWM signal. Any adjustment of the yield voltage will move the advancement of the obligation cycle to the PWM signal. A microcontroller is utilized to generate bunches of PWM signals. The PIC16F877 microcontroller was picked because of the general dynamic estimation of advanced converters, comparators, and PWM generators. PIC16F877 When powered by the 20 MHz clock cycle, the PWM signal with recuperation 20 kHz may be created. The voltage control module is planned and loaded on a PIC 16F877 microcontroller as appeared in the diagram of the control stream diagram.

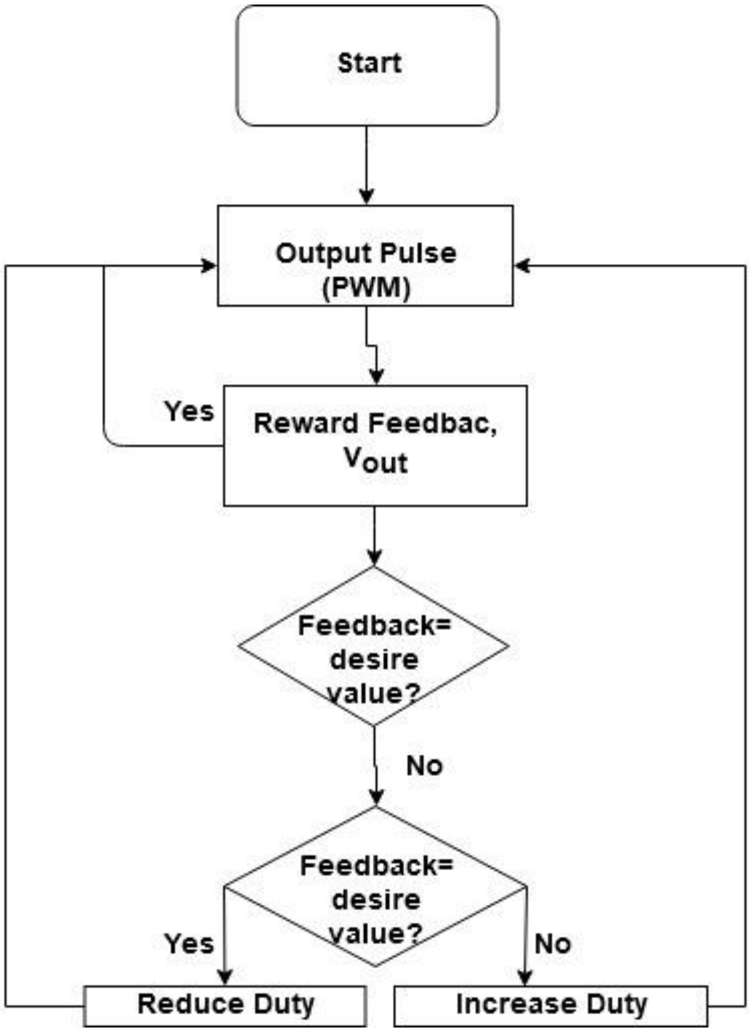


Figure 3.4: -Flowchart of the MPPT Control Technique.

3.6 External level control

The external level control, which is described in the form of simplification in the left part of Figure 8, is responsible for determining the active and reactive power exchange between the PV generator and the utility electrical system. This control technique is designed to perform two main control goals, voltage control mode (VCM) only for reactive power compensation energy and active power control mode (APCM) for dynamic active power exchange between PV arrays and electric power systems. For this purpose, the instantaneous voltage across the PCC is calculated by assigning a well-rotated reference frame. As a result, the instantaneous values of the three-phase AC bus voltage are converted to D-Q components, VDs and VQs, respectively. Since the D-axis is always compatible with the instantaneous voltage vector Vm, the current element on the D-axis of the VSI contributes to the instantaneous active energy P while the current component of the Q-axis represents the instantaneous reactive power Q. Thus, in order to achieve active and reactive power control of a deck bridge, it is necessary to provide a decoupled control strategy for ID and IQ. Thus, the only VD used to calculate the current reference signal is the result required for the active and reactive power flow of the desired PV output. Additionally, instant real output currents of the PV system, ID and IQ are obtained and used for medium level control.

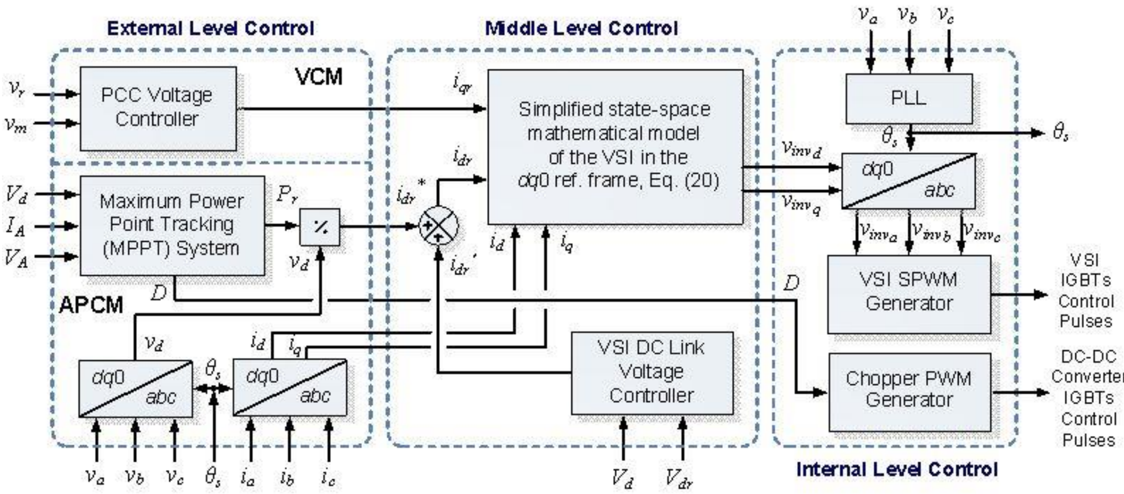


Figure 8.The multi-level control scheme for the three-phase grid-connected PV generator

In many modern power grids with high integration of inter-component renewable-based distribution generation, voltage control is becoming an essential task in the distribution phase. Since inverter-interfaced sources are deployed to control the voltage at each inverter's common connection, PVG can easily perform this control operation and participate in controlling the voltage of the grid. To this end, a control loop at the external level is the VCM, also known as Automatic Voltage Regulation (AVR). It controls (supports and controls) voltage on the PCC through the modulation of the reactive element of the ICT, the

IQ output. Since only the reactive power is exchanged with the grid in this control mode, there is no need for a PV array or any other external power source. In fact, this reactive power is produced locally only by the inverter and can be controlled simultaneously and independently of the active power produced by the PV array. The design of the rotating frame's control loop employs a standard proportional-integral (PI) compensator with an anti-windup system. This control mode removes the constant state voltage offset through the PI compensator. A voltage regulation drop is included to change the ratio of the PV inverter (PCC) to the terminal voltage compensating current. Thus, the Drop-featured PI regulator becomes a common phase-lag compensator.

The main purpose of the grid-connected solar photovoltaic generating system is to exchange with the electronic utility grid the maximum available power for a given atmospheric condition, independently of the reactive power produced by the inverter. In this way, the APCM allows to dynamically regulate the active power flow in combination with the active power exchanged by the inverter with the maximum instantaneous power produced by the PV array; Meeting these requirements in practice is very difficult and will increase the complexity and cost of applying for DG. It requires sensitivity to the precise information of its characteristic curve, compounded by room temperature and solar radiation. What's more, PV parameters change over time, making it difficult for real-time forecasting.

Many MPPT methods have been reported in the literature. These methods can be classified into three main categories: search table method, calculation method (neural network, fuzzy logic, etc.) and hill climbing methods [22 - 25]. These vary in the degree of sophistication, processing time, and memory requirements. Among them, mountain climbing methods are indirect methods with a good combination of flexibility, precision and simplicity. They are efficient and robust for tracking MPPs of solar photovoltaic systems and have the added benefit of control flexibility and ease of application with different types of PV arrays. The energy efficiency of these techniques depends on the control algorithm which tracks the MPP by measuring the amount of some array.

The easiest MPPT using climbing methods is the "Partitulation and Observation" (P&O) method. This MPPT technique uses a simple structure and a few measurable variables to apply a recursive method that allows the matching of loads with the output impedance of the PV array by adjusting the DV-DC converter duty cycle periodically. This MPPT algorithm continuously parturbs, ie increases or decreases, the output voltage of the PC array driven by the duty cycle D of DC-DC boost converter and compares the actual output power with the previous lifting sample mentioned in Fig. 9. The strength is increasing, the flexibility will continue in the same direction in the following cycle, otherwise, the curved side will reverse. This means that the PV output voltage is split at each MPPT repeat cycle cat sample interval, while maintaining the VSI DC bus voltage at all times through torque medium level control. Thus, when the optimum power is reached for precise operating conditions, the P&O algorithm will track the MPP (climb to the PV array output power curve) and then stabilize at this point but there will be a slight twitch around it. The output power measured at each iteration step is assigned as a reference power signal PR and then converted directly to the current reference IDR for mid-level control.

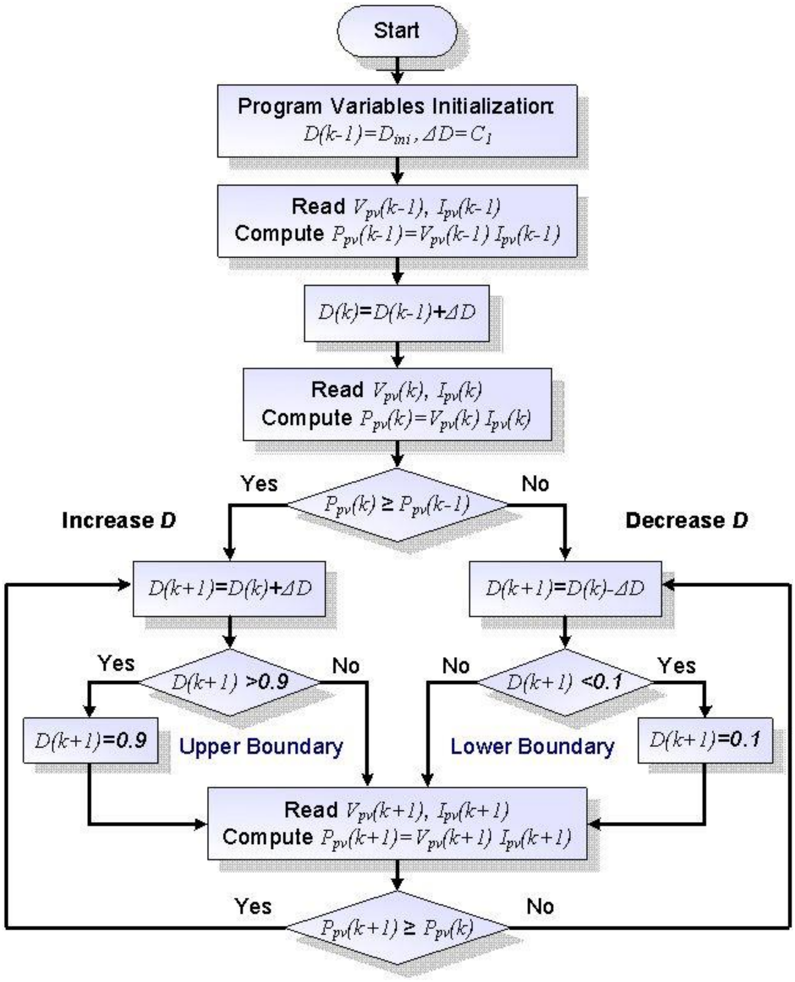


Figure 9. Flowchart for the P&O MPPT algorithm

3.7 Middle-level control

Medium-level control creates the expected output to dynamically track the reference values set by the external level, especially the actual active and reactive power exchange between the PV VSI and the AC system. This level of control, which is depicted in the middle of

Figure 8, is based on the linearization of the state-space mathematical model of the PV system in the D-Q reference frame described in Eq (20).

To achieve active and reactive power control of a deck bridge, it is necessary to provide a decoupled current control strategy for ID and IQ. Inspection alone. (20) shows a cross-coupling of both components of the PV VSI output current through V ω Therefore, an appropriate control signal has to be generated. To this end, it is proposed to use two control signals x1 and x2, derived from the assumption of zero derivatives of currents in the upper part (AC side) of (20). In this way, the use of two conventional PI controllers with an appropriate response to the components of the VSI output current removes a cross-coupling effect at a steady state. EQ. (23) also shows additional connections of the ID and IQ derivatives with the DC voltage VD. To reduce the impact of VD, the DC bus voltage in this issue needs to be kept constant. This problem is solved by using the DC bus voltage through the PI controller to remove the constant-voltage variations of the DC bus. This DC bus voltage control is acquired by forcing a small active power exchange with the electric grid to compensate for VSI switching losses and transformers through the contribution of the correction signal IDR *.

3.8 Internal level control

The internal level provides dynamic control of information signals to the DC-DC and DC-AC converters. This control level, which is delineated in the correct part of Fig. 8, is liable for generating the exchanging signals for the twelve valves of the three-level VSI, according to the control mode (PWM) and kinds of valves utilized (IGBTs). This level is mainly made out of a three-phase three-level sinusoidal PWM generator for the VSI IGBTs and a two-level PWM generator for the single IGBT of the lift DC-DC converter. Furthermore, it incorporates a line synchronization module, which comprises mainly of a phase-locked loop (PLL). This circuit is a feedback control system used to automatically synchronize the converter exchanging beats with the positive succession segments of the AC voltage vector at the PCC. This is achieved by utilizing the phase θs of the converse coordinate transformation from DQ to ABC segments.

Chapter 4

Grid Tie Inverter Design

4.1 Introduction

The DC to AC converter is known as an inverter. Electric power is usually circulated and utilized through alternating flows. Be that as it may, a few kinds of electrical manufacturing and storage gadgets straightforwardly produce flow, examples are PV modules and batteries. An inverter is an electronic gadget that changes over DC to AC, consolidating DC power from these generators for use with ordinary AC appliances, and/or with existing electrical frameworks. Photovoltaic generation is usually interfaced to the framework transport via a PWM inverter that comprises of a switch signal comparing the ideal sinusoidal yield (i.e., a modulated signal or control signal) with a high-recurrence triangular wave (carrier signal). The purpose of crossing point of the correction signal and the carrier signal are the focuses where the GTO or theorists of the inverter change to my turn.

4.2 Phase-Locked Loop

A phase-lock loop or phase-lock loop (PLL) is a control structure that creates a yield signal whose phase is characterized by the phase of an information signal. There are a couple of particular sorts, however, like an electronic circuit comprising of variable repeating oscillators and a phase detector, this isn't easy to do in the primary picture. The oscillator creates an irregular sign. The phase detector changes the phase of the sign and the occasional marking of the information to the blanket and keeping the office integrated. The arrival of the yield signal to the information signal for the relation is known as the investigate loop because the yield is 'contribution' around the information forming a loop.

Lockstep prescribes keeping additional data and yield scenes as well as data and yield recurrence equivalent. Therefore, in spite of the synchronizing sign,

A phase-lock loop can pursue any data iteration or it can create retrieval that many of the data iterations of These features are utilized individually for blending PC clock synchronization, demodulation, and iteration.

They can be utilized to move a mark, recover a mark from an energizing correspondence channel, create constant redundancies on the results of the information (reiteration association), or propagate consummately structured clock bits to advanced rationale circuits, for example, microprocessors. Since an integrated circuit can give a total phase-locked loop building block, the technique is generally utilized in modem electronic gadgets, with yield frequencies ranging from a small range to several GHz.

4.3 Three-Phase PWM Inverter

A three-stage yield is gotten from the arrangement of six transistors and six diodes. Two kinds of control signs can be applied to the transistor: 180° conductivity or 120° conduction. 180° conduction switches have better use and are the favored strategy. We consider a 180° conductivity inverter for the matrix tie solar system. Depict the capacity of the Bello Grid Tie Inverter. The yield voltage relies upon the exchanging pace of the waveform's recurrence switches and can, along these lines, fluctuate over a wide range. In this method of activity, each switch is driven for 180 °. Along these lines, three switches are on at some random minute. When S1 is on, the terminal is connected to the positive terminal of the information DC source. So also, if S4 is turned on, the terminal gets connected to the negative terminal of an info DC source. There are six potential methods of activity of a cycle, and every mode is of 60 spans, and the translation of every mode is as per the following: The terminals an and c are connected to the positive terminal of the info DC source and b is connected to the negative terminal of the DC source.

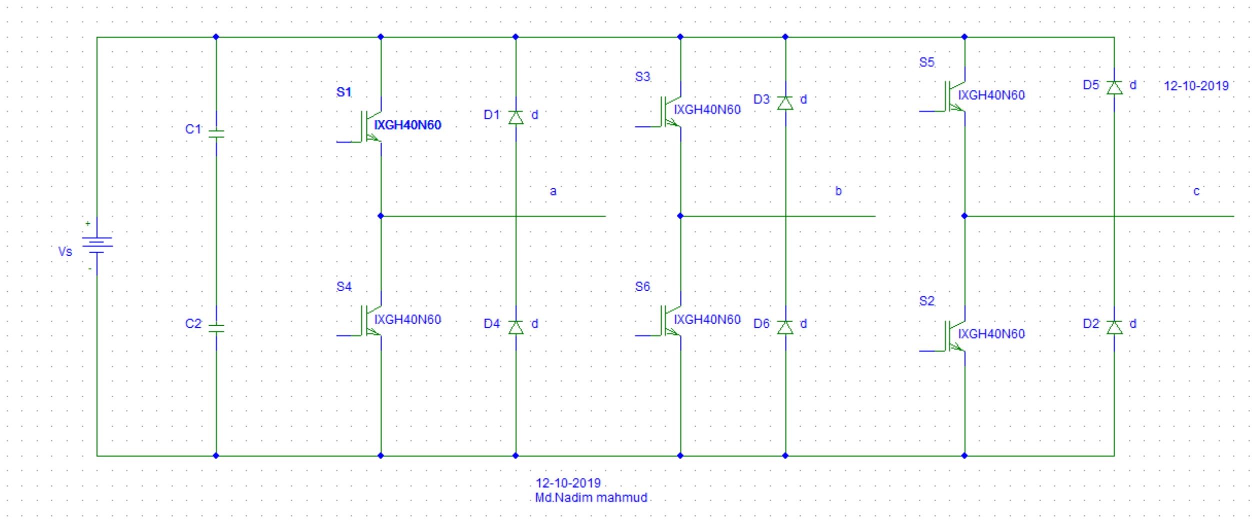


Figure 4.1: -Configuration of a Three-Phase DC-AC Inverter

4.4 180-Degree Conduction with Star Connected Resistive Load

The configuration of the three-phase inverter with star connected resistive load is shown in Figure 4.2. The following convention is followed:

√ A current leaving a node point a, b or c and entering the neutral point n is assumed to be positive.
√ All three resistances are equal, $R_a=R_b, =R_c=R$.

In this method of activity, each switch conducts for 180°. Consequently, at any moment of time three switches stay on. When S1 is on, the terminal gets connected to the positive terminal of the information DC source. Also, when S4 is on, terminal a gets connected to the negative terminal of information DC source. There are six potential methods of activity in a cycle and every mode is of 60° span and the clarification of every mode is as per the following:

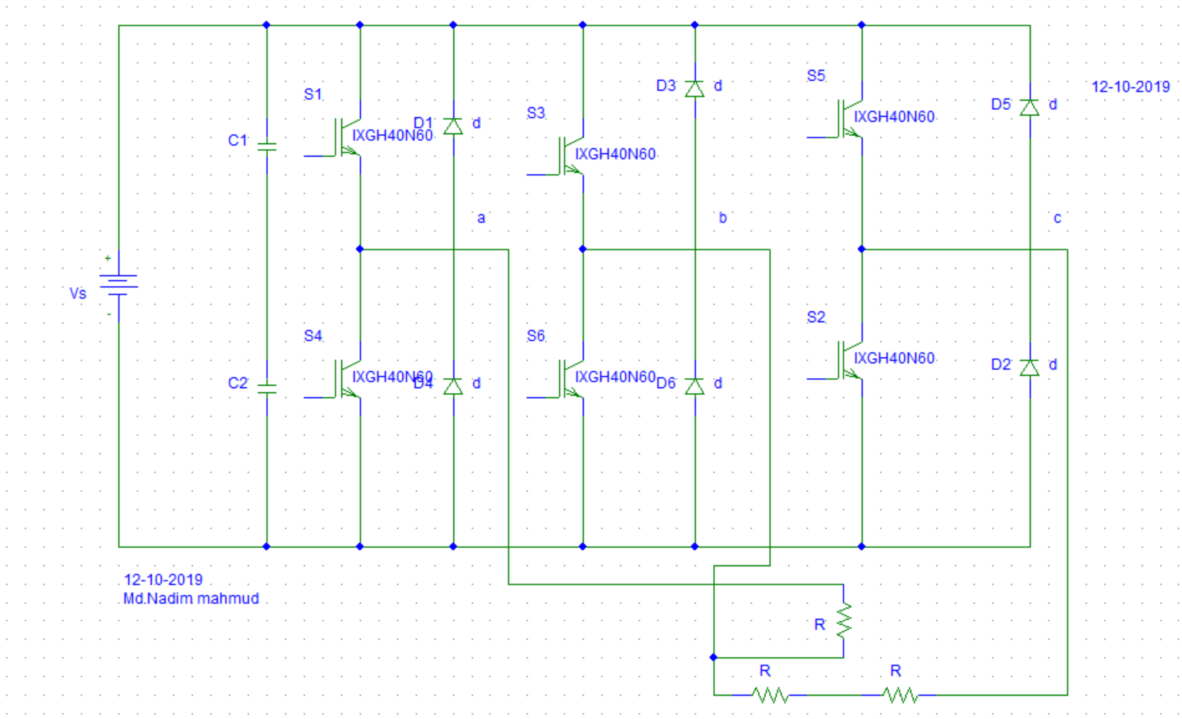


Figure 4.2: Three-Phase DC-AC Inverter with Star Connect Resistive Load

Mode 1: In this mode the switches S**5**, S**6,** and S**1** are turned on for time interval

O≤*wt*≤π/**3.**As a

Aftereffect of this the terminals an and c are connected to the positive terminal of the information DC source and the terminal b is connected to the negative terminal of the DC source. The present course through Ra, R, and R has appeared in Figure 5.2a and the proportionate circuit has appeared in Figure 5.2b. The comparable obstruction of the circuit appeared in Figure 4.2b is:

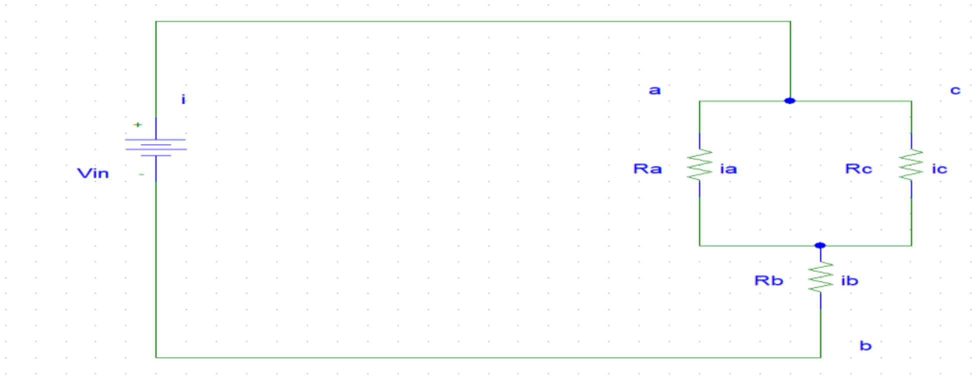
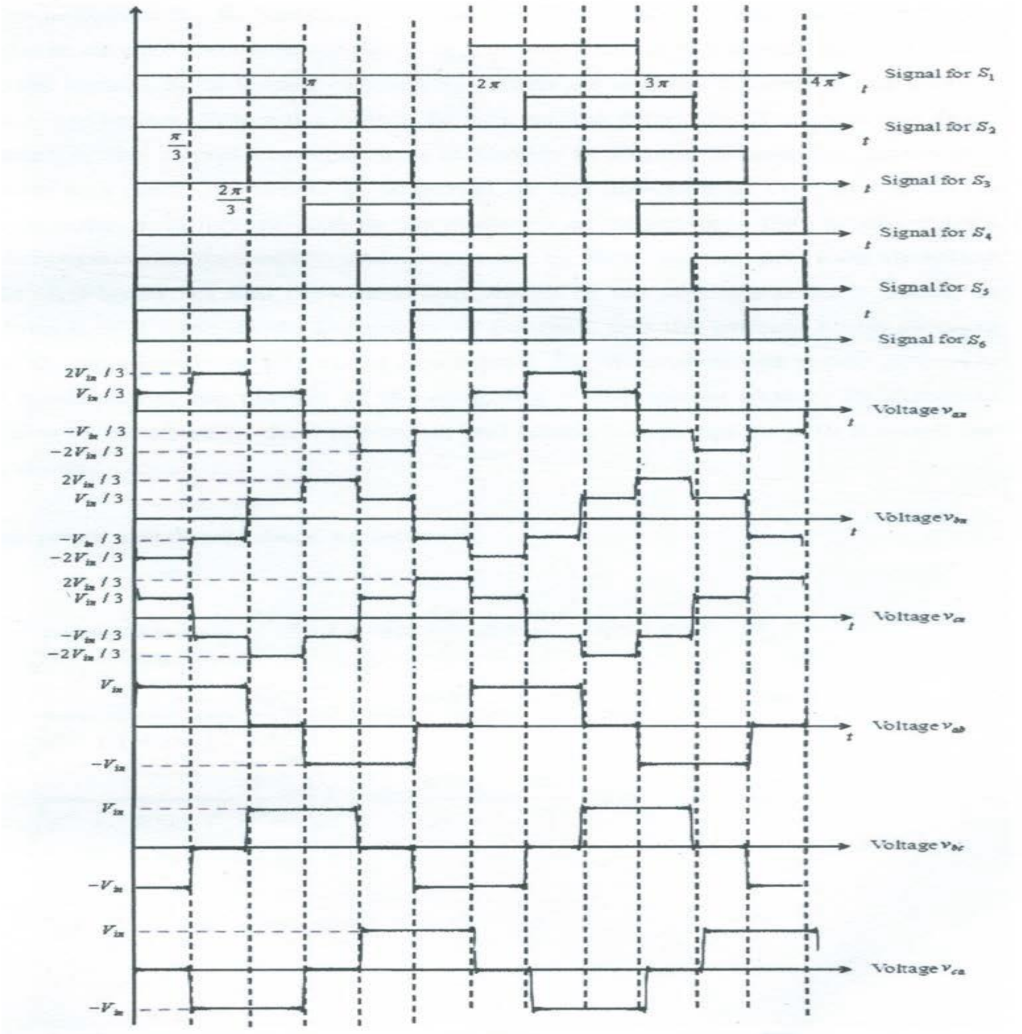


Figure 4.2 (a): - Equivalent Circuit in Mode 1



in mode 1 the switches S5, S4, and S1 are turned on. The mode past to display 1 was mode 6 and in mode 6 the switches S4, S5, and S6 were on. In the progress from mode 6 to mode I the switch 84 is killed and 8) turned on and the present I alters its course (friendly stage). At the point when switch 84 was on, the course of current was from guide n toward point the circuit design has appeared in Figure 7a and the identical circuit has appeared in Figure 7b. At the point when 8) is turned on the bearing of current ought to be from indicating a point n. Be that as it may, because of the nearness of inductance, the current can't alter its course immediately and keeps on streaming the past way through diode D) (Figure 7c) and the proportional circuit of the arrangement has appeared in Figure 7d. Once ia= 0, the diode D1 stops to direct and the present beginnings moving through S1 as demonstrated as of now in Figure 3a and Figure 3b. At whatever point one mode gets over and the following mode begins, the current of the active stage can't alter its course quickly because of the nearness of the inductance and henceforth finishes its way through the freewheeling diode.

4.5 Three Phase Inverter Simulink by MATLAB

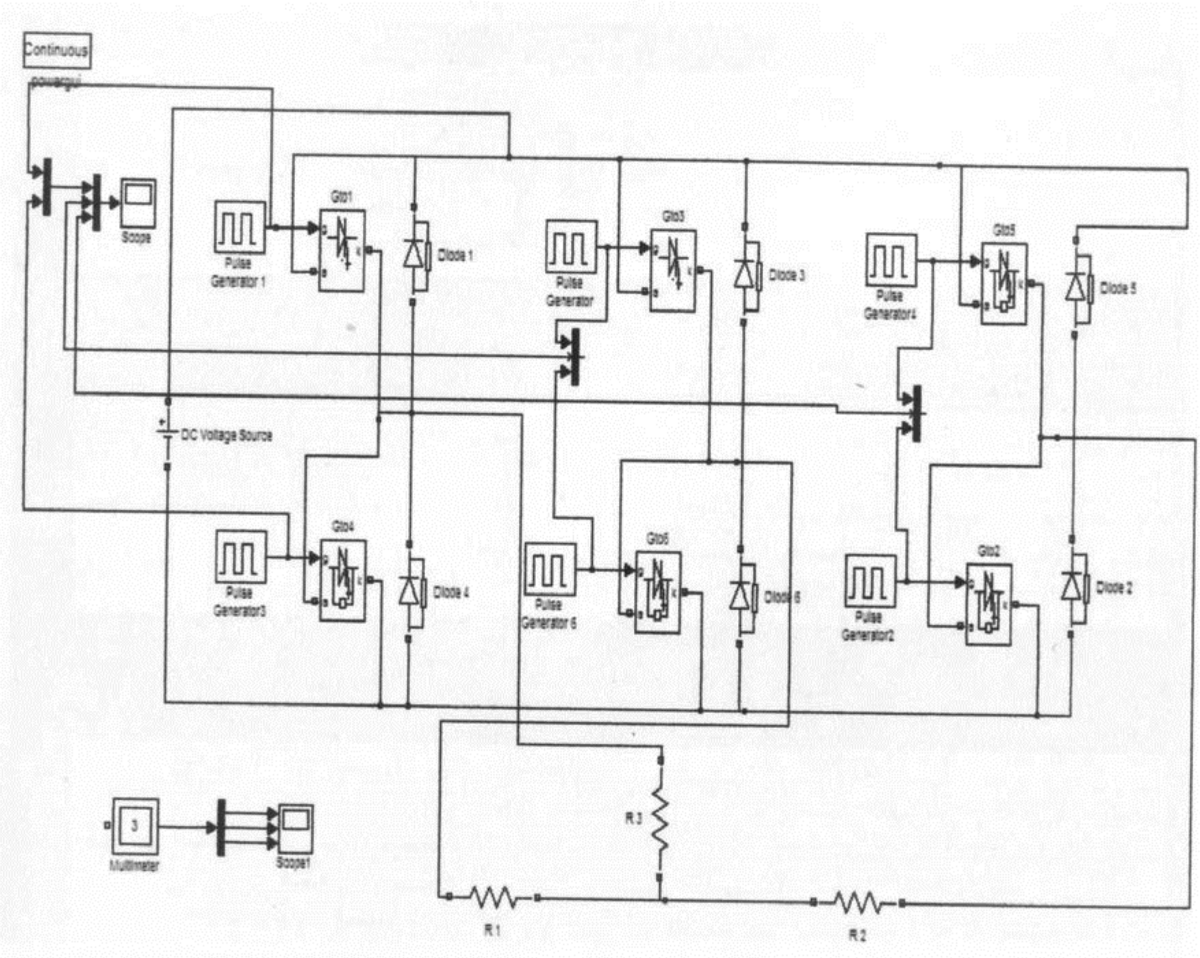


Figure 4.5: - Three Phase Inverter Simulink by MATLAB

4.6 Three Phase Inverter Simulink Output Waveform by MATLAB

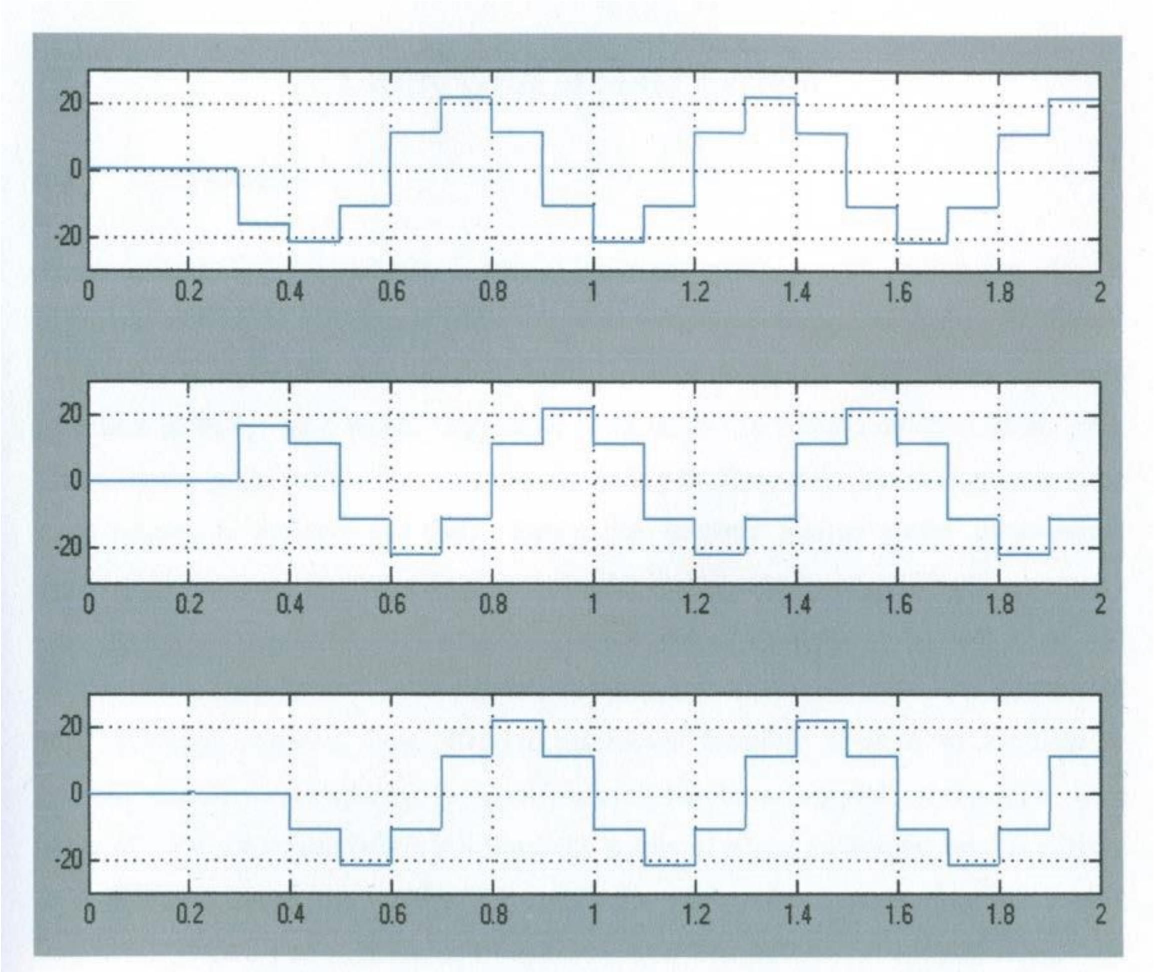


Figure 4.6: Three Phase Inverter Simulink Output Waveform by MATLAB

Chapter 5

Utility Grid of Solar System

5.1 Introduction

Photovoltaic (PV) solar power is one of the environmentally friendly power vitality sources that can assume a significant job in the program of diminishing ozone harming substance outflows. In spite of the fact that PV innovation is costly, it is getting solid support through different motivating force programs around the world. Accordingly, huge scale solar ranches are being connected to the matrix. Worldwide transmission lattices are as of now confronting the test of coordinating such huge scale sustainable systems and solar ranches because of their constrained power transmission limit. Arrangement pay and different Flexible AC Transmission System (FACTS) gadgets are being proposed to expand the accessible power move limits/limits of existing transmission lines. In outrageous cases, new lines may be built at a significant expense. Financially savvy systems should be investigated to build a stockpiling limit. Novel research on evening utilization of a PV solar ranch (when it is typically lethargic) has been accounted for where a calculating gadget is utilized as a PV solar firm static compensator for voltage control, along these lines improving system effectiveness and expanding network availability to neighboring solar. Ranch It is realized that voltage control is at transitory security Color can improve the power transmission line, for example, the quantity of static burden Santa Facts connected gadgets. The compensatory and stable compensator is utilized worldwide to improve the transmission limit. This venture introduces an extravagant evening time utilization of a PV solar firm whereby the solar ranch inverter is utilized as a static compensator for managing the voltage to improve the power transmission capacities medium-term. In any event, during the day, the solar homestead still goes about as a fixed compensator while giving genuine power yield and voltage control is given utilizing its leftover inverter MVA limit (left after what is required for genuine power age). These daytime voltage controls are additionally appeared to expand strength and power to move restricts generously.

5.2 Theory of Synchronizing

When turning off an electrical switch between two powerful pieces of the power system, it is essential to alter the voltages on the two sides of the electrical switch before closing down.

perhaps. To be appropriately synchronized, three distinct parts of voltage over the electrical switch must be intently checked. The three parts of voltage are called synchronizing factors and are:

- ✓ The voltage magnitudes
- ✓ The frequency of the voltages
- ✓ The phase Sequence

5.3 Synchronizing Method

Modem power plants for the most part use synchronizers naturally. The significance of synchronizing can't be exaggerated. All system administrators need to comprehend the hypothesis and practice of synchronizing. On the off chance that two power systems are synchronized through an open electrical switch and the synchronizing procedure isn't performed appropriately, the nearby planetary group can be seriously harmed.

5.3.1 Synchronizing Two Islands

It is expected from the outset to see that the two islands will be connected together utilizing the open electrical switch appeared in Figure 5.1. The two islands, since they are independent electrical systems, will have various frequencies, so each of the three of the synchronizing factors must be checked to ensure that the open electrical switch is inside satisfactory points of confinement.

The two island system administrators need to modify the generator MW yield levels (or alter the island load sum) on either of the islands to accomplish the ideal consistency in recurrence and stage points. Voltage control hardware (reactors, capacitors, and so on.) can likewise be utilized varying to change the voltage length inside satisfactory levels.

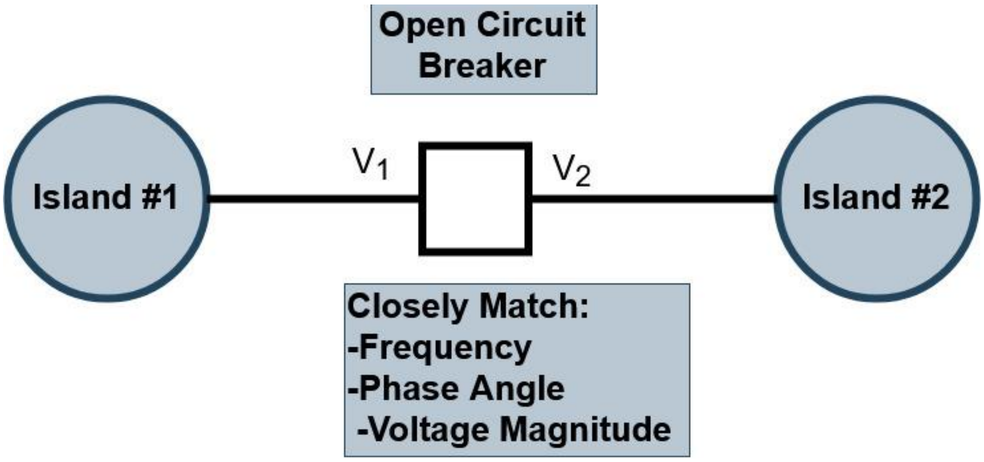


Figure 5.1: -Synchronizing Two Islands

5.3.2 Establishing the Second Tie

After the main transmission line is shut by interfacing the two islands, the frequencies will be the equivalent in the two locales. Along these lines, one of the three synchronizing factors (recurrence) is never again a factor. Notwithstanding, as shown in Figure 5.2, the other two synchronizing factors should at present be watched. Prior to shutting the second electrical switch, age, as well as voltage control apparatuses, can be utilized to guarantee that the distinction in the edge and voltage of the scene is inside adequate points of confinement. This procedure ought to be simpler than closing down the transmission line first as a factor of recurrence use.

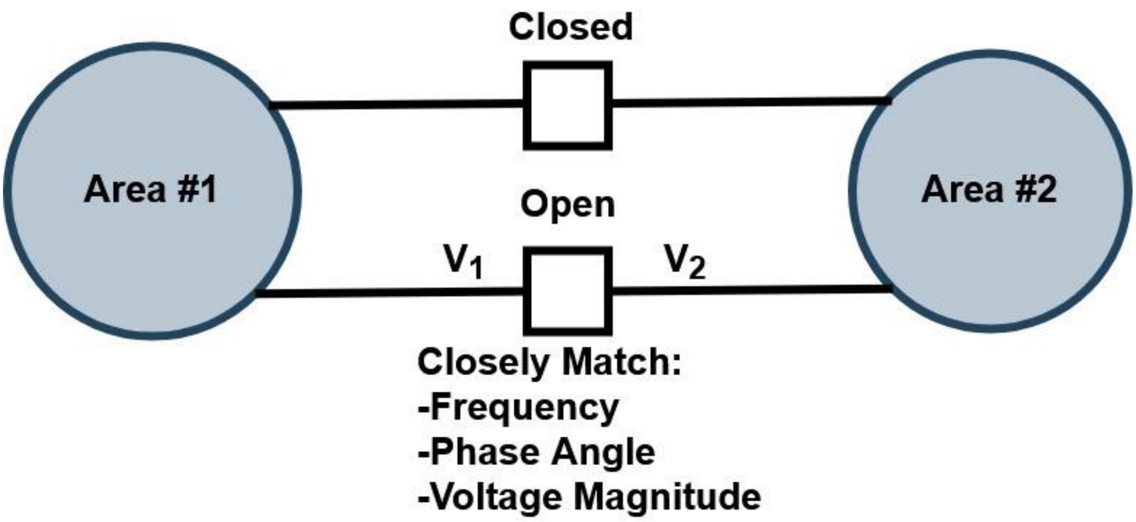


Figure 5.2: -Establishing the Second Transmission Tie

5.4 Synchronizing Measuring Equipment

5.4.1 Synchro scope

A synchroscope is a straightforward bit of gear that is utilized to screen three synchronizing factors. An essential synchroscope (envisioned in Figure 5.3) inputs voltage waveforms from the two sides of the open electrical switch. On the off chance that the voltage waveforms are at a similar recurrence, the synchroscope doesn't turn. In the event that the wavelengths of the voltage are at various frequencies, at that point the synchroscope recurrence is corresponding to the distinction. The synchroscope needle consistently indicates the voltage stage edge distinction.

A synchroscope is a manual gadget with the goal that an administrator must take a gander at the "scope" to guarantee that they turn off the electrical switch at the opportune time. The synchroscope is typically over the eye level on the "match up the board". The sink board likewise has two voltmeters so the voltage can be looked at at the same time.

The synchroscope in Figure 5.3 mirrors a slight voltage length with a stage edge of about 35f and a steady synchroscope ° The synchroscope record is the equivalent on either side of the electrical switch, demonstrating the recurrence

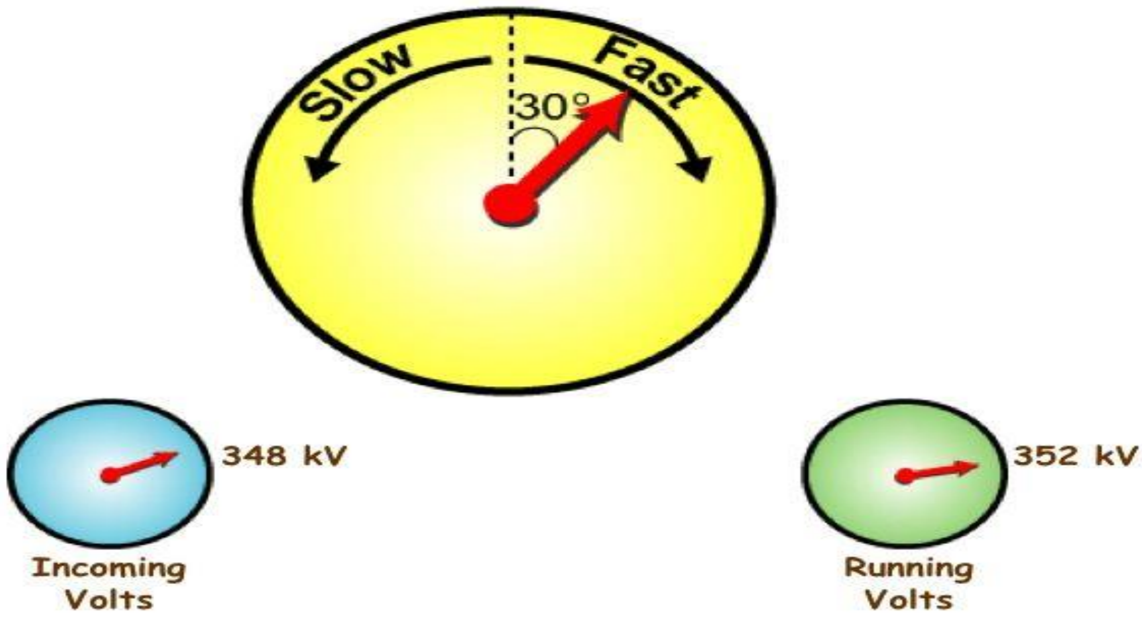


Figure 5.3: -Synchro scope in a Synch Panel

5.5 Photovoltaic Systems Monitoring

Monitoring and control of photovoltaic systems are essential for reliable functioning and the maximum yield of any solar electric system. The simplest monitoring of an inverter can be performed by reading values on display - display (usually LCD) is part of almost every grid-connected inverter. Values like PV array power, AC grid power, PV array current are usually available.

5.6 Electric Switchboard

An electric switchboard is a device that conducts electricity from one source to another. It is an assembly of panels, each containing switches that allow for power redirection The US National Electrical Code (NEC) defines a switchboard as a large single panel, frame or assembly of panels whose faces, back, or both, switches, current and other protective devices. , Bus and generally instruments. The role of the switchboard is to split the main currents provided on the switchboard into smaller currents for further expansion and to provide switching, current protection and metering for these different currents. Generally, switchboards distribute power to transformers, to panel boards, to control equipment, and finally to system loads.

The operator is protected from electrical control by a safety switch and fuse. For power supply on switchboards, the electronic generator can also control the frequency coming from the generator or the bank, especially the AC power and load sharing control, and the frequency and possibly a synchoscope displaying gauges. The amount of power to go to a switchboard should always be equal to the power going out of load.

Inside the switchboard, the bus bars have a bank, copper or aluminum strip, to which the switchboard is attached. These carry large currents through the switchboard and are supported by an insulator. Bare bus bars are common, but many bars are now fitted with an insulating cover on the bar, leaving only the connection points open.

Modern switchboards are metallic and constructed of "dead front"; No energized parts are accessible when the cover and panels are closed. Previously, open switchboards were made with switches, and other devices were fitted to panels made of slate, granite or ebony asbestos boards. The metal enclosure of the switchboard is enclosed on the ground of the earth to protect personnel. Large switchboards can have free-standing floor-mounted enclosures with the provision of incoming connections at the top or bottom of the enclosure. A switchboard may have a bus bar or bus drain for source connection and a large circuit fed from a board. A switchboard may include a metering or control buggy separate from the power distribution conductors.

5.7 Distribution Board

A distribution board (or panel board) is a component of a power supply system that divides an electric power feed into subsidiary circuits, while providing a protective fuse or circuit breaker for each circuit in a common enclosure. Typically, the main switch and recent boards will also include one or more 'residential-current devices (RCDs) or residential current breakers, including overcurrent protection (RCBO).

5.8 Busbar

In the distribution of electric power, a busbar (usually spelled repeatedly, or sometimes incorrectly or repeatedly, with which the word bus is a contraction of the Latin omnibus - means a switchboard, which is a strip or bar of copper, brass or aluminum). Conducts electricity between boards, substations, battery banks or other electrical appliances. Its main purpose is to conduct electricity, not to act as a structural member.

5.9 Electricity Meter

An electric meter or power meter is a device that measures the amount of electrical energy used by a home, business or electric powered device.
Power meters are usually calibrated in billing units, the most common being the kilowatt-hour [kWh]. Periodic lessons on power meters establish the billing cycle and power used during a cycle.

In settings when energy is stored over a certain period of time, meters can measure demand, maximizing the use of power at certain intervals. "Daytime" metering allows electric rates to change over a day, recording usage during high-cost periods and during off-peak, low-cost, periods. Also, in some areas, the meter has a relay for load shedding to respond to demand during peak load periods.

Chapter 6
Conclusion and Recommendations

6.1 Conclusion

The global power portfolio has worked together to reduce the barriers to entry into the market and expand their contribution to PV systems, increasing the efficiency of solar cells, reducing the cost of PV systems, increasing government incentive programs and many other factors over the past decade. The time could not have come at a better time to provide a clear solution to meet the ever-increasing demand for increasing economic potential. However, the price paid for tapping into the free resource is due to its intrinsic nature and the problems discovered when integrating the resource into electric power systems. Problems continue to escalate as a large percentage of the generation is coming from renewable sources. In an attempt to help alleviate some of the problems produced by the PV system without installing additional equipment along with the feeder, this thesis presents a solution by modifying the inverter's controls to eliminate problems. Additional control features designed, modeled and analyzed in the Matlab simulation environment are voltage control, frequency response and remote curtailment and ramping capabilities. If we use this photo-voltaic system in a company like the textile industry, garment factory, it will come back as a power plant and the photovoltaic system can be used for power plants as well as for our electricity.

6.2 Recommendations for Further Research

The following points are worthy of further investigation:

- The proposed operating strategies can be implemented developing an experimental prototype.
- The results of simulation studies can be applied in the practical generation and security analysis of a grid system in which one or more Photovoltaic generation are embedded.

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