Numerical Analysis of On-Grid Photovoltaic System and Off-Grid Wind-Turbine Asynchronous Generator Using Simulink

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A project is presented for the degree of
Bachelor of Science in Electronics & Telecommunications Engineering

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ABSTRACT

This work focuses on a program developed in stimulant of 100-kw and turbine asynchronous generator .This program simulates PV array using an equivalent circuit model including a photocurrent source, a diode, a series resistor and a shunt resistor .The PV module is the interface which converts light into electricity. Modeling this device always requires taking climate factors (irradiance and temperature) as input variables. The output can be current, voltage, energy or other variables.The common five-parameter model was selected for the present study, and solved using a novel combination technique which integrated an algebraic simultaneous calculation of the parameters at well known test prerequisites (STC) with an analytical dedication of the parameters under real running conditions. A monocrystalline photo voltaic module was simulated using MATLAB/Simulink software program at different ambient temperature and the output energy of cell was recorded. Solar Radiation and its effect on energy of module is also simulated. Simulation shows that the output energy of photo voltaic cell get decreased with reduce in sun's radiation and raising temperature also decreases the output.Additionally, this thesis also examines the operating characteristics of an off- grid wind turbine asynchronous generator . Wind energy capacity has grown rapidly as a share of worldwide electricity supply in recent years. In an isolated distribution network, a small-scale wind turbine generator is usually installed. This paper is intended to justify the fact that the intermittent power output of a small wind power capacity contributes to demand without interfering with the output power balance

APPROVAL

This is to certify that the project entitled “Numerical Analysis of On-Grid Photovoltaic System and Off-Grid Wind-Turbine Asynchronous Generator Using Simulink”, submitted to the respected matter of the faculty of Engineering for partial fulfillment of the requirement for the degree of Bachelor of Electronics and Telecommunication Engineering (ETE) under complete supervision of the undersigned.

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CERTIFIED

This certifies the project entitled “Numerical Analysis of On-Grid Photovoltaic System and Off-Grid Wind-Turbine Asynchronous Generator Using Simulink”, being submitted by Md. Tanveer Ahmmed & Md. Nazrul Islam Patoary to department of Electronics and Communication Engineering, East West University, Dhaka for the award of the degree of Bachelor of Science in Electronics and Telecommunication Engineering, is a record of a major project carried out by them. They have worked under my supervision and guidance and have fulfilled the requirements, which, to my knowledge, have reached the requisite standard for the submission of this dissertation.

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DECLARATION

We hereby declare that we carried out the work reported in this thesis in the Department of Electronics and Communications Engineering, East West University under the supervision of Zahidur Rahman. We declare that to the best of our knowledge, no part of this report has been submitted elsewhere for the award of any degree. All source of knowledge used in the report has been duly acknowledged.

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Contents

List of Figures

Chapter 1

INTRODUCTION

1.1 Motivation

The current world runs on electricity. As individuals, we depend on electrical energy to heat, cool, and light our homes; refrigerate and prepare our food; pump and purify our water; deal with sewage; and support most of our communications and entertainment. As a society, we depend on electrical energy to light our streets; control the flow of traffic on the roads, rails, and in the air; function the myriad physical and information chains that create, produce, and distribute items and services; maintain public safety, and assist assure our countrywide security. An essential element to be used in this model is the photo voltaic cell which converts photo voltaic energy into electrical energy at the atomic level. When light falls on these cells they absorb photons from the light and release electrons. If these electrons are accrued they create flow of electrons,which can be used as electricity. Hence they are also recognized as solar cells. These cells are made of semiconductor materials like silicon.[3]

1.2 Electrical energy

Electrical energy is a type of kinetic energy caused through transferring charges. The amount of energy relies upon on the speed of the expenses – the quicker they move, the extra electrical power they carry. Electric energy is easy to transmit.[7]

1.3 Electrical energy consumption statistics

Energy consumption refers to all the power used to operate an action, manufacture something or actually inhabit a building. In a fac-

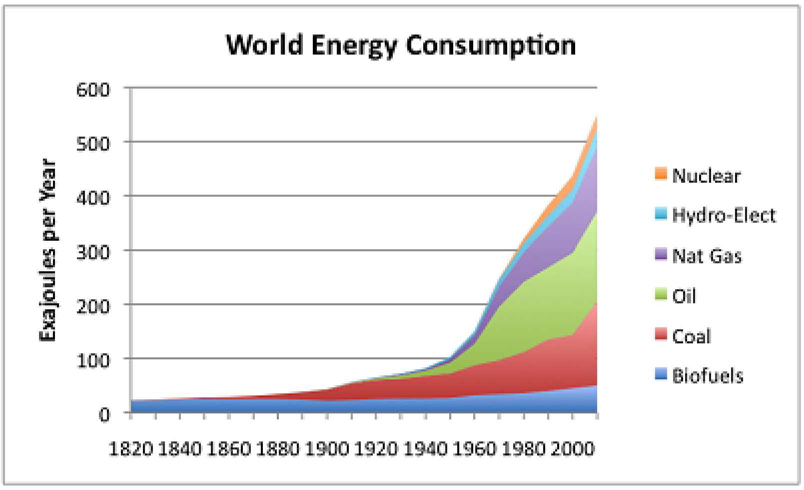


Figure 1.1: Huge increase in world energy consumption last 200 years.

tory, whole energy consumption can be measured through looking at how plenty power a production process consumes, for example,through making vehicle parts.This will include water,electricity,gas etc. This figure shows the huge increase in world energy consumption that has taken place in roughly the last 200 years. This rise in energy consumption is primarily from increased fossil fuel use

1.4 Energy generation

Electricity technology is the process of generating electric powered power from sources of primary energy. For electric utilities in the electric power industry, it is the first stage in the transport of electricity to end users, the different levels being transmission, distribution, energy storage and recovery, using the pumped-storage method.

Solar energy is the most considerable source of energy. It can be used in two ways to generate energy. It can be used to boil water and rotate turbines. Solar energy can also be used to generate electricity by using the photovoltaic effect. For this device known as the photovoltaic cell (Zghal, et al. 2012) is needed which absorbs photons from the sunlight and breaks electron pairs which make charged particle move. They can be converted into DC electrical energy through using this effect. Photovoltaic cells are made from semiconductor materials. Solar energy is available everywhere and but photovoltaic cells are very inefficient. Constructing solar plants requires massive amount of funding hence solar power electricity plants are limited. About 4% of the world's electricity is generated from solar energy. Solar Energy Solar energy is the most considerable source of energy; it is an almost inexhaustible power supply which is also environmentally friendly. Since 2010 photo voltaic energy use has been encouraged. After a few decades we will be out of all the non-renewable sources which makes us to rely on solar power (Haque, et al., 2013) more and greater as time goes by. By 2050 photo voltaic energy will be the leading energy source. Hence photo voltaic energy plants be encouraged. The only obstacle for this is the efficiency of solar energy plants. They need a very massive preliminary investment, however it is not recurring.

1.5 Objectives of this thesis

The usual objective of this thesis is to graph a Sims cape primarily based Stimulant mannequin of a silicon monocrystillaine solar module. In the section stage of the proposed work the Theory of photovoltaic solar power studied. Then the behavior of a solar cell phone is simulated in Simulink. In the third phase a MPPT is designed the usage of Simulink R, observed by way of the layout of a DC-DC converter which completes the entire design. The novel contributions of this thesis encompass the thinking to decrease the usage of non- renewable strength sources with the aid of the usage of solar energy.

Chapter 2

Theory of solar cells

2.1 Invention of solar cell

Solar energy was first commercially used by Sir Frank Shuman in 1897 to generate power through converting water into steam to run a steam engine through using dark colored pipes and mirrors. This is all mechanical energy generation. Before this happened, in 1839 the photo-voltaic effect was established by Sir Alexandre-Edmond Becquerel. The first solar cell was built through Aleksandr Stoletov in 1888 primarily based on the photoelectric impact proposed through Heinrich Hertz (Peter Gevorkian et al., 2007). In 1905 Albert Einstein introduced a paper on provider excitation due to light for which he received the Nobel Prize in Physics in 1921. Later in 1946 Russell Ohl patented the junction semiconductor solar cell. In 1954 the first photovoltaic cell was established publicly at Bell Laboratories by Daryl Chapin, Calvin Souther Fuller and Gerald Pearson.

In the early 1960's solar cells where used in area applications only because they were costly. Later, due to the invention of built-in circuits, the price decreased significantly (David Feldman et al., 2014).

2.2 Semiconductors

A semiconductor is a substance, typically a stable chemical element or compound, that can behavior electrical energy below some prerequisites however not others, making it a appropriate medium for the control of electrical current. Its conductance varies relying on the modern or voltage utilized to a manage electrode, or on the intensity of irradiation through infrared (IR), visible light, ultraviolet (UV), or X rays.[2]

The specific properties of a semiconductor rely on the impurities, or dopants, introduced to it. An N-type semiconductor contains modern mainly in the form of negatively-charged electrons, in a manner comparable to the conduction of modern in a wire. A P-type semiconductor carries modern predominantly as electron deficiencies known as holes. A gap has a positive electric powered charge, equal and opposite to the charge on an electron. In a semiconductor material, the flow of holes occurs in a path opposite to the flow of electrons.

Elemental semiconductors consist of antimony, arsenic, boron, carbon, germanium, selenium, silicon, sulfur, and tellurium. Silicon is the best-known of these, forming the basis of most integrated circuits (ICs). Common semiconductor compounds include gallium arsenide, indium antimonite, and the oxides of most metals. Of these, gallium arsenide (GaAs) is widely used in low-noise, high-gain, and weak-signal amplifying devices.

A semiconductor device can perform the characteristic of a vacuum tube having thousands of times its volume. A single built-in circuit (IC), such as a microprocessor chip, can do the work of a set of vacuum tubes that would fill a massive constructing and require its own electric powered generating plant.[4]

2.3 P-N Junction Diode

The impact of adding this extra strength supply consequences in the free electrons being in a position to go the depletion area from one aspect to the other. The behavior of the PN junction with regards to the conceivable barrier's width produces an asymmetrical conducting two terminal device, higher regarded as the PN Junction Diode.

A PN Junction Diode is one of the easiest semiconductor gadgets around, and which has the attribute of passing contemporary in solely one direction only. However, in contrast to a resistor, a diode does not behave linearly with recognize to the utilized voltage as the diode has an exponential current-voltage (I-V) relationship and therefore we cannot described its operation through truly the usage of an equation such as Ohm's law.

If a appropriate tremendous voltage (forward bias) is applied between the two ends of the PN junction, it can grant free electrons and holes with the greater energy they require to cross the junction as the width of the depletion layer around the PN junction is decreased.

By applying a poor voltage (reverse bias) effects in the free fees being pulled away from the junction resulting in the depletion layer width being increased. This has the impact of growing or reducing the nice resistance of the junction itself permitting or blocking cutting-edge waft via the diode.

Then the depletion layer widens with an expand in the application of a reverse voltage and narrows with an extend in the application of a ahead voltage. This is due to the variations in the electrical properties on the two facets of the PN junction ensuing in physical modifications taking place. One of the results produces rectification as viewed in the PN junction diodes static I-V (current-voltage) characteristics. Rectification is proven through an asymmetrical present day float when the polarity of bias voltage is altered as proven below.

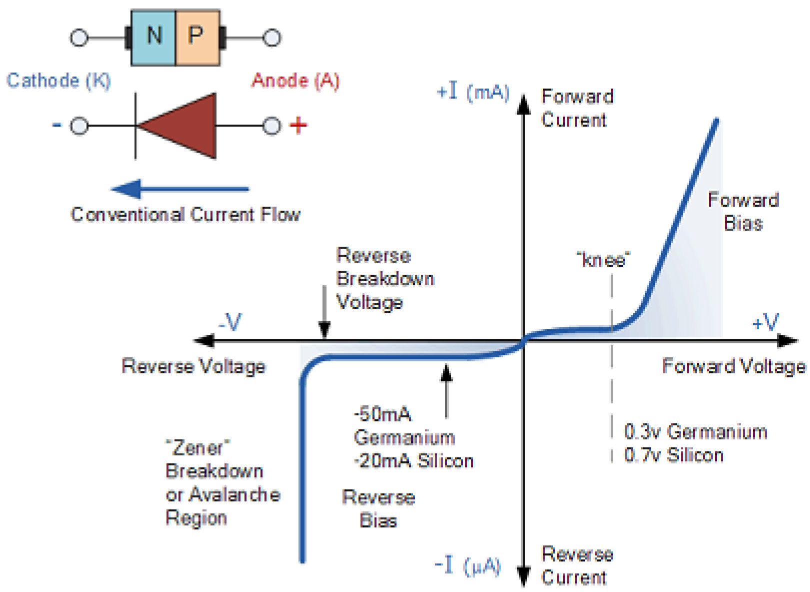


Figure 2.1: Junction Diode Symbol and Static I-V Characteristics

But earlier than we can use the PN junction as a sensible device or as a rectifying gadget we want to first off bias the junction, ie connect a voltage manageable throughout it. On the voltage axis above, "Reverse Bias" refers to an external voltage achievable which increases the practicable barrier. An exterior voltage which decreases the practicable barrier is stated to act in the "Forward Bias" direction.

There are two operating areas and three viable "biasing" prerequisites for the popular Junction Diode and these are:

1. Zero Bias – No exterior voltage possible is utilized to the PN junction diode.

2. Reverse Bias – The voltage practicable is linked negative, (-ve) to the P-type fabric and positive, (+ve) to the N-type material

throughout the diode which has the impact of Increasing the PN junction diode's width.

3. Forward Bias – The voltage potential is related positive, (+ve) to the P-type material and negative, (-ve) to the N-type material throughout the diode which has the impact of Decreasing the PN junction diodes width.

Zero Biased Junction Diode

When a diode is linked in a Zero Bias condition, no exterior workable energy is applied to the PN junction. However if the diodes terminals are shorted together, a few holes (majority carriers) in the P-type cloth with sufficient power to overcome the workable barrier will pass throughout the junction against this barrier potential. This is known as the "Forward Current" and is referenced as IF

Likewise, holes generated in the N-type cloth (minority carriers), discover this state of affairs favourable and pass across the junction in the contrary direction. This is acknowledged as the "Reverse Current" and is referenced as IR. This switch of electrons and holes back and forth across the PN junction is known as diffusion, as shown below.

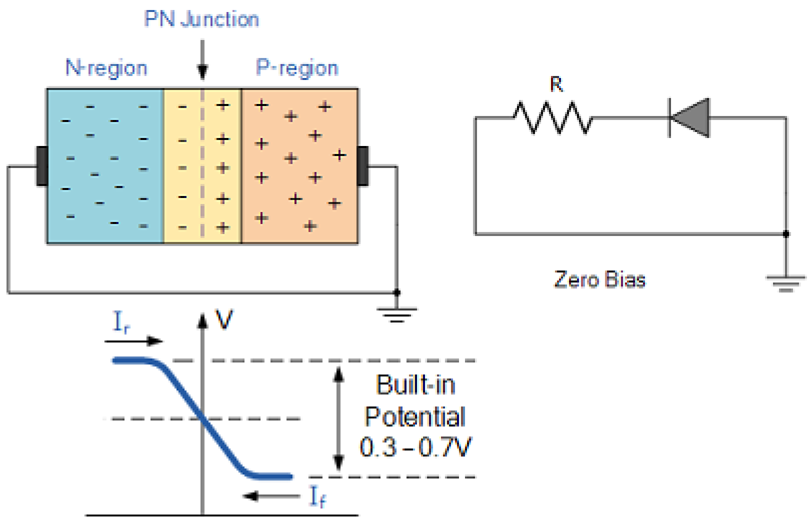


Figure 2.2: Zero Biased Junction Diode

The potential barrier that now exists discourages the diffusion of any more majority carriers throughout the junction. However, the potential barrier helps minority carriers (few free electrons in the P-region and few holes in the N-region) to flow throughout the junction.

Then an "Equilibrium" or stability will be hooked up when the majority carriers are equal and each transferring in contrary directions, so that the internet result is zero modern-day flowing in the circuit.

When this occurs the junction is stated to be in a country of "Dynamic Equilibrium".

The minority carriers are continuously generated due to thermal energy so this nation of equilibrium can be damaged by way of elevating the temperature of the PN junction inflicting an increase in the technology of minority carriers, thereby resulting in an make bigger in leakage modern-day however an electric modern-day cannot flow on account that no circuit has been connected to the PN junction.

Reverse Biased PN Junction Diode

When a diode is connected in a Reverse Bias condition, a fantastic voltage is applied to the N-type material and a negative voltage is utilized to the P-type material.

The advantageous voltage applied to the N-type material attracts electrons towards the fantastic electrode and away from the junction, whilst the holes in the P-type end are also attracted away from the junction towards the terrible electrode.

The net result is that the depletion layer grows wider due to a lack of electrons and holes and affords a excessive impedance path, nearly an insulator. The end result is that a high conceivable barrier is created for that reason stopping modern-day from flowing via the semiconductor material.

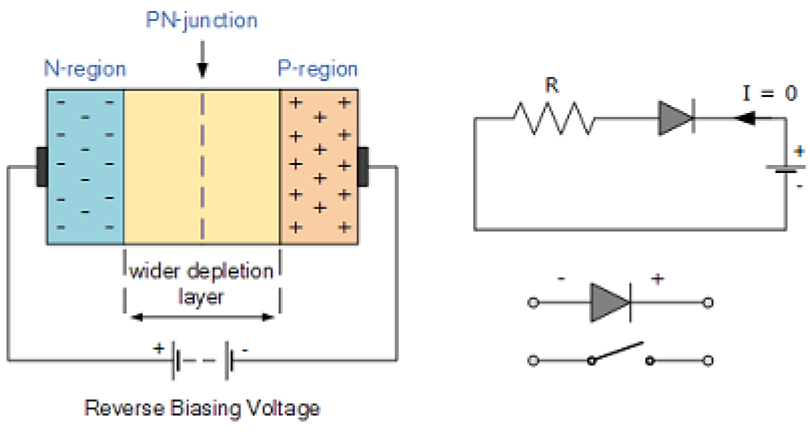


Figure 2.3: Increase in the Depletion Layer due to Reverse Bias

This circumstance represents a high resistance price to the PN junction and virtually zero modern flows via the junction diode with an increase in bias voltage. However,a very small leakage modern-day does float through the junction which can be measured in micro-amperes.

One remaining point, if the reverse bias voltage Vr applied to the diode is improved to a sufficiently high enough value, it will purpose the diode's PN junction to overheat and fail due to the avalanche impact around the junction. This may additionally purpose the diode to grow to be shorted and will result in the drift of most circuit current, and this shown as a step downward slope in the reverse static characteristics curve below.

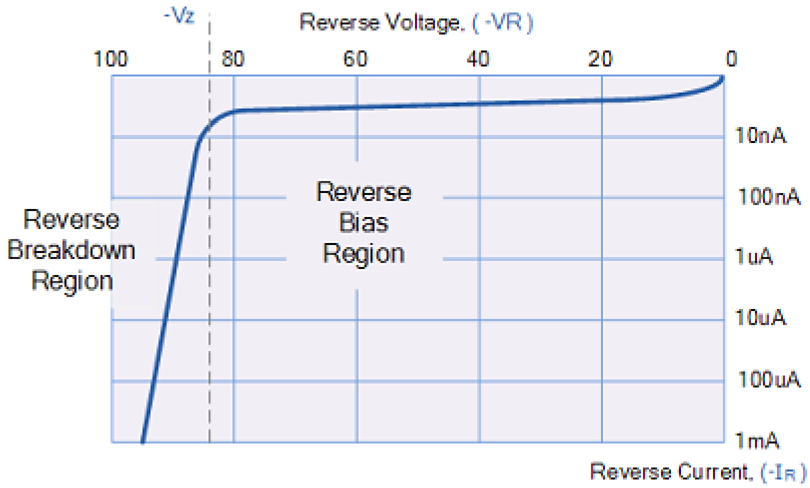


Figure 2.4: Reverse Characteristics Curve for a Junction Diode

Sometimes this avalanche impact has realistic purposes in voltage stabilizing circuits where a collection limiting resistor is used with the diode to restriction this reverse breakdown cutting-edge to a preset most value thereby producing a fixed voltage output throughout the diode. These kinds of diodes are regularly recognized as Zener Diodes..

Forward Biased PN Junction Diode

When a diode is connected in a Forward Bias condition, a poor voltage is utilized to the N-type fabric and a fine voltage is applied to the P-type material. If this exterior voltage turns into higher than the price of the potential barrier, approx. 0.7 volts for silicon and 0.3 volts for germanium, the plausible boundaries opposition will be overcome and current will start to flow.

This is due to the fact the terrible voltage pushes or repels electrons towards the junction giving them the strength to move over and mix with the holes being pushed in the contrary course closer to the junction by the high-quality voltage. These consequences in a characteristics curve of zero modern-day flowing up to this voltage point, known as the “knee” on the static curves and then a high modern flow thru the diode with little enlarge in the external voltage as proven below.

The application of a forward biasing voltage on the junction diode consequences in the depletion layer becoming very skinny and slim

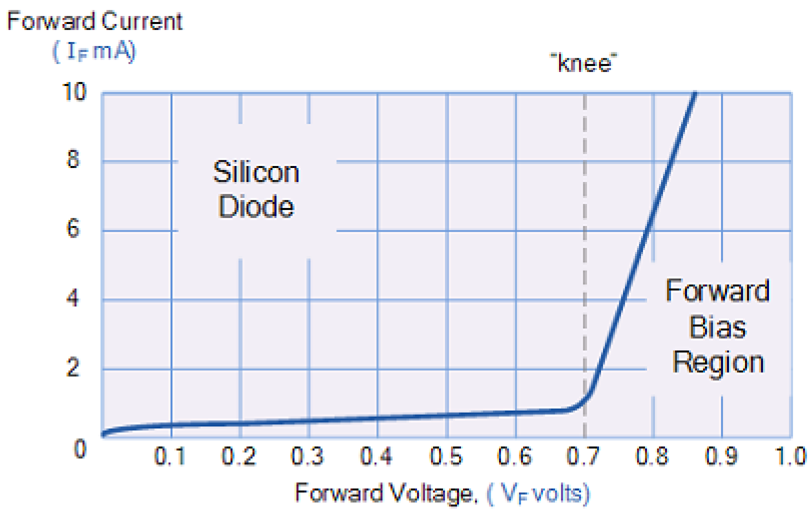


Figure 2.5: Forward Characteristics Curve for a Junction Diode

which represents a low impedance route through the junction thereby allowing high currents to flow. The factor at which this surprising expand in cutting-edge takes area is represented on the static I-V characteristics curve above as the "knee" point.

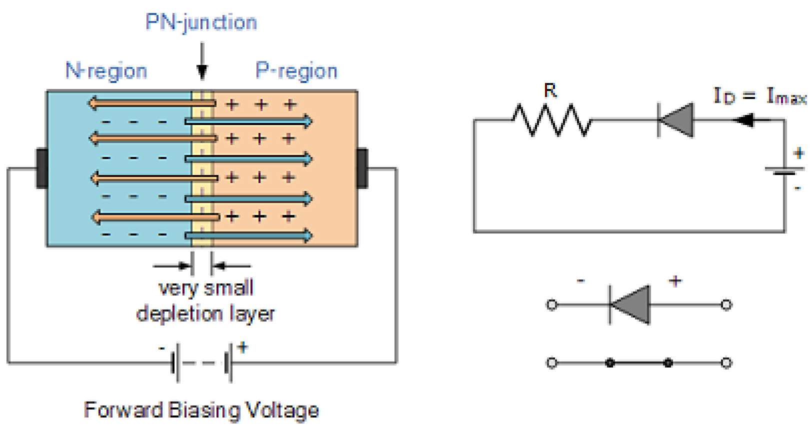


Figure 2.6: Reduction in the Depletion Layer due to Forward Bias

This condition represents the low resistance route thru the PN junction allowing very massive currents to drift thru the diode with solely a small enlarges in bias voltage. The actual plausible difference across the junction or diode is stored regular with the aid of the motion of the depletion layer at about 0.3v for germanium and about 0.7v for silicon junction diodes.

Since the diode can conduct "infinite" modern-day above this knee point as it successfully turns into a short circuit, therefore resistors are used in series with the diode to limit its modern-day flow. Exceeding its maximum ahead present day specification motives the machine to dissipate more energy in the structure of warmth than it used to be designed for ensuing in a very rapid failure of the device.[9]

2.4 Modeling of the solar cell

n 1981 V.Cordes and K. P. Maass published a paper which discussed photovoltaic Power (Cordes et al., 1981) and proposed to use solar energy for telecommunication systems. In 1988 the convention on solar cells (Kerschen et al.,1988) [26] named with the aid of Photovoltaic Specialists Conference, 1988" contained a massive body of research on solar cells and the photovoltaic effect. In 2000 at the Eighth International IEEE convention on Power Electronics and Variable velocity Drivers (Lloyd et al., 2000) , a Simulink mannequin of a PV cell has been posted which gives a targeted view of the cell. In 2002 a theoretical evaluation of PV systems is provided in IEEE Transactions on Energy Conversation 2002" which gives a wide variety of related papers (Masoum et al., 2002).[1]

2.5 Modeling photovoltaic systems

Growing pastime in renewable strength sources has brought about the photovoltaic (PV) strength market to expand rapidly, particularly in the place of disbursed generation. For this reason, designers need a bendy and reliable tool to accurately predict the electrical power produced from PV arrays of various sizes. A mobile is defined as the semiconductor system that converts sunlight into electricity. A PV module refers to a quantity of cells connected in series and in a PV array, modules are related in collection and in parallel. Most of the mathematical fashions developed are primarily based on current-voltage relationships that end result from simplifications to the double-diode model proposed by using Chan & Phang (1987). The current-voltage relationship for the single-diode mannequin assumes that one lumped diode mechanism is sufficient to describe the traits of the PV cell. This current-voltage relationship is the foundation for the mathematical fashions developed via Desoto et al. (2006) and Jain & Kapoor (2004). Further simplification to the current-voltage relationship is made with the aid of assuming the shunt resistance is infinite, hence forming the groundwork for the four parameter mathematical model. Numerous methods have been developed to remedy this unique model. Khezzar et al. (2009) developed three techniques for solving the model. Chenni et al. (2007) developed a simplified specific method by means of assuming that the photocurrent (Iirr) is equal to the short-circuit current (ISC). Zhou et al. (2007) delivered the concept of a Fill Factor (F F) to remedy for the most power-output (PMax).Rajapakse & Muthumuni (2009) developed a model based totally on the currentvoltage relationship for the single diode in EMTDC/PSCAD. Campbell (2007) developed a circuit-based, piecewise linear PV device model, which is suitable-for use with converters in transient and dynamic digital simulation software. King (1997) developed a mannequin to reproduce the V-I curve using three important points: short-circuit, open-circuit, and most electricity point stipulations on the curve. To improve accuracy, King et al. (2004) improved the model to encompass two extra points along the V-I curve. However, the method requires, in addition to the popular parameters such as the collection resistance (RS) and shunt resistance (RP), empirically determined coefficients that are furnished through the Sandia National Laboratory. The mannequin proposed by King et al. (2004) is best for cases where the PV array will be operating at prerequisites different than the most strength point.The U.S. Department of Energy (DOE) supported recent development of the Solar Advisor Model (SAM). SAM affords three picks for module performance models: the Sandia Performance Model proposed by way of King et al. (2004), the 5 parameter model popularized by using Desoto et al. (2006) and a single-point efficiency model. The single-point affectivity mannequin is used for analysis the place the parameters required by way of other fashions are not available. Cameron et al. (2008) completed a study comparing the three performance models reachable in SAM with two-other DOE-sponsored models:PVWATTS is a simulation software developed through the National Renewable Energy Laboratory and PVMOD is a simulation software developed via the Sandia National Laboratory. Both packages can be found on the respective laboratory website. The find out about compared the estimated outcomes with actual measured consequences from a PV array; all had been found to agree with minimal deviation from the measured values. For this study, the modified current-voltage relationship used to be solved using a technique primarily based on the 5 parameter model since it solely requires statistics provided by means of the manufacturer and has been shown to agree properly with measured results. In this study, a modified current-voltage relationship for a single photo voltaic cell is elevated to a PV module and ultimately to a PV array. The 5 parameter model given by means of Desoto et al. (2006) uses the current-voltage relationship for a single solar mobile phone and only includes cells or modules in series. This paper presents a amendment to this technique to account for each sequence and parallel connections. Detailed current-voltage output features are developed for a cell, a module and a string of modules connected in series and in parallel. This cell-to-module-to-array mannequin makes the similarities and variations of the equal circuits and current-voltage relationships clear. Manufacturers normally furnish the following operational records on PV panels: the open-circuit voltage (VOC); the short-circuit present day (ISC); the maximum strength factor contemporary (IMP) and voltage (VMP); and the temperature coefficients of open-circuit voltage and short-circuit present day (PT and aT , respectively). This operational fact is required to resolve the improved five parameter dedication method. The mannequin expected V-I curves, P-V curves, most energy point, short-circuit current, and open-circuit voltage conditions across a vary of irradiation tiers and cell phone temperatures are used for assessment with the experimental records provided with the aid of the manufacturer. The proposed mannequin can be applied for PV arrays of any size and is suitable for software in simulation packages such as EMTDC/PSCAD and Mat Lab/Stimulant. A series of experiments had been carried out outside for different configurations of a PV array to validate the accuracy of the model. The experiments revealed consistency between experimental and model predicted results for V-I and P-V curves for every configuration.

2.6 SIMULINK based modeling of circuits and systems

Circuits and structures in usual can be modeled at a number of ranges of abstraction (Saraju et al., 2015). The abstractions allow a divide-and-conquer mechanism to deal with giant and complicated circuit and system design and simulation. The modeling is additionally possible in a behavioral trend as properly as structural fashion. Behavioral simulation and modeling is faster, however does not seize any structural small print and subsequently synthesizing circuits or structures out of behavioral models is a very tough task. On the other hand, structural modeling captures the shape of the circuits and systems and as a result can be taken to a degree at which they can be constructed as a true entity. However, it can be difficult to acquire at description of a circuit and system besides following some kind of hierarchical mechanism.

SIMULINKR has been explored for nanoelectronic circuit modeling in (Joshi et al., 2015), (Shital et al., 2015). In this work, it is endorsed that Simulink or Sims cape primarily based modeling can allow high pace simulation of circuits and systems. It can be performed the use of very minimal computational assets as compared to the case of a SPICE. SIMULINK models do not require any fab data; rather they count on first precept models published in the physics/semiconductor literature. A particular case study of a grapheme based nanoelectronic system, a 45nm based totally LC- VCO has been presented. In 2001 Geoffrey Walker proposed a Maximum Power Point Tracking (MPPT) converter topology using MATLAB pv fashions (Geoffrey et al., 2001). Based on this research Francisco modeled a photovoltaic module the usage of MATLABR (Francisco et al., 2005). Later an article which proposed a Simulink mannequin of photo voltaic photovoltaic cells in the International journal of Renewable Energy Research" gave a whole mannequin of a solar telephone the usage of Simulink R. Based on that research an article was published in the International Journal of Engineering Sciences and Research Technology" which gave a model of solar photovoltaic arrays for battery charging functions the use of Simulink (P.Sathya et al. 2013). This article is a precise example mannequin of a solar cell charger using Simulink.

2.4 PV power output dependence on module operating temperature

The essential position of the working temperature in relation to the electrical efficiency of a photovoltaic (PV) device, be it a easy module, a PV/thermal collector or a building-integrated photovoltaic (BIPV) array, is well hooked up and documented, as can be considered from the interest it has obtained with the aid of the scientific community. There are many correlations expressing Tc, the PV phone temperature, as a feature of weather variables such as ambient temperature, Ta, local wind speed, Vw, and solar radiation flux/irradiance, I(t), with fabric and system-dependent houses as parameters, e.g., glazing-cover Transmittance plate absorptance α , etc. An equally massive wide variety of correlations expressing the temperature dependence of the pv modules electrical efficiency ηc, can additionally be retrieved, even though many of them expect the acquainted linear form, differing solely in the numerical values of the relevant parameters which, as expected, are fabric and device dependent. With regard to the applicable weather variables, and qualitatively speaking, it used to be discovered that the PV cell phone temperature upward jab over the ambient is extremely sensitive to wind speed, less to wind direction, and virtually insensitive to the atmospheric temperature. On the different hand, it needless to say relies upon strongly on the impinging irradiation, i.e. the photo voltaic radiation flux on the phone or module. From the mathematical point of view, the correlations for the PV operating temperature are both explicit in form, as a consequence giving Tc directly, or they are implicit, i.e. they involve variables which themselves depend on Tc. In this last case, an new release manner is vital for the relevant calculation. Most of the correlations generally encompass a reference nation and the corresponding values of the pertinent variables. The electrical overall performance is notably influenced by the type of PV used. A typical PV module converts 6-20% of the incident photo voltaic radiation into electricity, depending upon the kind of solar cells and climatic conditions. The rest of the incident solar radiation is transformed into heat, which significantly increases the temperature of the PV module and reduces the PV effectively of the module. This warmth can be extracted by using flowing water/air under the PV module the usage of thermal collector, called, photovoltaic thermal (PVT) collectors. In practice, only a-Si and crystalline Si have been found in the literature on PVT. The higher affectivity of crystalline Si will result in a greater electrical efficiency and a higher electrical-to-thermal ratio of the PVT than in the case of a-Si. Tripanagnostopoulos et al. presents experimental measurements on PVT-liquid and PVT-air collectors for both a-Si and c-Si. He finds that at zero reduced temperature, for his PVT liquid collector, the affectivity of his c-Si prototype is 55% and his a-Si prototype 60%, whilst for his PVT air collector the c-Si prototype is 38% and the a-Si prototype 45%.However, the electrical performance for the c-Si modules is 12% and for the a-Si it is 6%. A higher thermal yield was once additionally observed for a-Si via Ji et al. However, in different experiments a decrease thermal efficiency used to be observed for a-Si than for c-Si, Affolter et al. and Platz et al. Zondag et al.compared a conventional PV module, an unglazed PVT module and a glazed PVT module. The average annual electrical effectivity used to be located to be 7.2%, 7.6% and 6.6%, respectively. Show calculated the electrical overall performance of a thermosyphon PVT collector with the PV at the excessive end and at the low quit of the absorber. For the colder low end, he found a 3% higher electrical efficiency. Naveed et al.examined a PVT air system in which PV was once related to an unglazed transpired collector. It was found that a temperature discount of 3-9 degree Celsius resulted in an expanded electrical performance, permitting a reductionin PV place from 25 to 23 m2. Krauter and Ochs and Krauter have developed an unglazed integrated solar domestic system, in which a PV laminate is related to a triangular water tank. The tank serves to cool the pv by means of an extended heat capacity.Typically,at high irradiance a pvtemperature discount of about 20C is suggested relative to a traditional solar home system, which leadsto a 9-12% expand in electrical yield, relying on the stratification.

Chapter 3

Wind Turbine

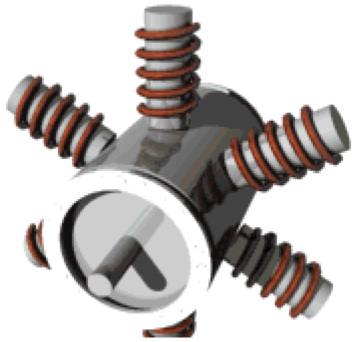
3.1 Wind-Turbine asynchronous

An induction generator or asynchronous generator is a type of alternating current (AC) electrical generator that uses the principles of induction motors to produce electric power. Induction turbines function by means of automatically turning their rotors quicker than synchronous speed. An everyday AC induction motor normally can be used as a generator, without any interior modifications. Induction generators are useful in functions such as mini hydro energy plants, wind turbines, or in decreasing high-pressure fuel streams to lower pressure, because they can get better energy with pretty easy controls.

An induction generator typically draws its excitation energy from an electrical grid. Because of this, induction turbines cannot typically a de-energized distribution system. Sometimes, however, they are self-excited through using phase-correcting capacitors.[6]

3.2 Asynchronous Turbine Generator operation

Most wind mills in the world use a so-called three phase asynchronous (cage wound) generator, additionally known as an induction generator to generate alternating current. This type of generator is no longer widely used backyard the wind turbine enterprise and in small hydropower units, however the world has a lot of journey in dealing with it anyway. The image illustrates the basic ideas in the asynchronous generator, lots comparable with the synchronous generator before. In reality, solely the rotor section appears different. two two two two two The curious factor about this kind of generator is that it was sincerely at the start designed as an electric motor. In fact, one 1/3 of the world's electricity consumption is used for strolling induction motors riding equipment in factories, pumps, fans, compressors, elevators and different purposes where you want to convert electrical energy to mechanical energy. two One cause for selecting this type of generator is that it is very dependable and tends to be comparatively inexpensive. The generator also has some mechanical homes which are useful for wind turbines, like the generator slip and a positive overload capability.



The Cage rotor

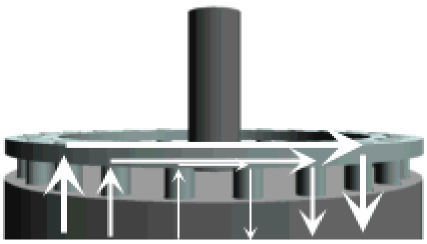
The key component of the asynchronous generator is the cage rotor (it used to be called a squirrel cage rotor however after it grew to become politically fallacious to work out your domestic rodents in a treadmill, we solely have this much less charming name). two two two two It is the rotor that makes the asynchronous generator specific from the synchronous generator. The rotor consists of a number of copper or aluminum bars which are connected electrically by way of aluminum stop rings, as you see in the picture. In the picture is proven how the rotor is supplied with an "iron" core, the use of a stack of skinny insulated steel laminations, with holes punched for the conducting aluminum bars. The rotor is placed in the middle of the stator, which in this case, once again, is a 4-pole stator which is at once related to the three phases of the electrical grid.

Motor operation

When the modern is connected, the laptop will begin turning like a motor at a speed which is just slightly below the synchronous velocity of the rotating magnetic area from the stator.If we look at the rotor bars from the preceding picture, there is a magnetic discipline which strikes relative to the rotor. This induces a very strong modern in the rotor bars which offer very little resistance to the current, because they are short circuited through the cease rings. The rotor then develops its very own magnetic poles, which in flip emerge as dragged along by the electromagnetic force from the rotating magnetic discipline in the stator.

Generator operation

If we manually crank this rotor round at exactly the synchronous speed of the generator, e.g. 1500 rpm, as we noticed for the 4-pole synchronous generator on the previous web page nothing will happen. Since the magnetic subject rotates at precisely the equal pace as the rotor, there will be no induction phenomena in the rotor and it will not interact with the stator. two two If pace is elevated above 1500 rpm then the rotor moves faster than the rotating magnetic subject from the stator, which skill that as soon as again the stator induces a sturdy modern-day in the rotor. The harder is cranked the rotor, the more strength will be transferred as an electromagnetic pressure to the stator, and in turn transformed to electricity which is fed into the electrical grid.



Generator slip

The speed of the asynchronous generator will fluctuate with the turning pressure (moment, or torque) utilized to it. In practice, the distinction between the rotational velocity at height strength and at idle is very small, about 1%. This distinction in per cent of the synchronous speed, is referred to as the generator's slip. Thus a 4-pole generator will run idle at 1500 rpm if it is connected to a grid with a 50 Hz current. If the generator is producing at its maximum power, it will be strolling at 1515 rpm. two two two two two two It is a very beneficial mechanical property that the generator will make bigger or decrease its pace barely if the torque varies. This capability that there will be less tear and put on the gearbox, because of lower peak torque. This is one of the most vital motives for the usage of an asynchronous generator alternatively than a synchronous generator on a wind turbine which is immediately connected to the electrical grid.

Grid connection required

On the page about the synchronous generator we showed that it may want to run as a generator except connection to the public grid. An asynchronous generator is different, because it requires the stator to be magnetized from the grid earlier than it works. two two However, an asynchronous generator in a stand on my own machine can be used if it is furnished with capacitors which provide the indispensable magnetization current. It also requires that there be some eminence in the rotor iron, i.e. some leftover magnetism to start the turbine. Otherwise a battery and strength electronics will be needed, or a small diesel generator to begin the system.

Wind Turbine Performance and Design

The wind has been used to power sailing ships for many centuries. On land, wind Turbines date returned to the center of the seventh century A.D. The earliest recorded English wind turbine dates from A.D. 1191. The first corn-grinding wind turbine was built in The Netherlands in 1439. Denmark was the first United States to use wind turbines for the technology of electricity. In 1890, a wind turbine with a diameter of 23 meters was used for that purpose. By 1910, various hundred gadgets with a capacity of 5 to 25 kW were in operation in Denmark [21].A robust interest in renewable strength sources began in the mid Seventies when concerns about the environmental effects of fossil power sources coincided with the OPEC oil embargoes. Wind turbine science has matured for the duration of the closing 25 years and is today a generic technology.

Turbine

Wind turbines generate power by converting the kinetic energy in the air into rotating mechanical power. The most common wind turbine is of the horizontal-axis propeller type with two or three blades mounted on the top of a tower. The number of blades on a wind turbine is not an easy design choice. Two blades cost less than three blades, but two-bladed wind turbines must operate at higher rotational speeds than three-bladed wind turbines. As a result, the individual blades in a two bladed wind turbine need to be lighter and stiffer and are therefore more expensive. The power of the wind in an area, A, perpendicular to the wind direction is given by the formula p=1/2ρ A ....(1) Where P is the power, ρ is the air density and v is the wind speed. The fraction of the wind captured by means of a wind turbine is given by way of a factor, Cp, called the strength coefficient.

The value of the power coefficient has a theoretical Betz restriction of 59.3%.The format of wind turbines is governed by the need to face up to mechanical loads. Most wind power sites trip high wind speeds solely during a few hours per 12 months and some shape of strength law is necessary if a design is to be economical. The aerodynamic layout can be regulated either with the aid of designing the blades to go into an aerodynamic stall above a certain wind velocity or by designing the blades as feathered in order to spill the unwanted power. The first approach is known as stall-regulation; the second method is known as pitch-control. One advantage of stall-regulation is the simplified mechanical design which permits the blades to be connected rigidly to the hub. In addition, stall-regulation will no longer allow strength excursions from gusty winds to omit through the drive train. The risks are the technical difficulties of aerodynamic stall design, the need for a rotor brake, motor driven begin and greater aerodynamic noise.

Fixed-speed Wind Turbines

The generator in fixed-speed wind mills is of the induction type connected at once to the grid. Synchronous generators have been used in some early prototypes but the induction machine has been more broadly adopted due to the fact of decrease cost, improved environmental durability and a ideal mechanical compatibility with speedy wind variations. The generator together with a gearbox is positioned in a nacelle on the pinnacle of the tower. The feature of the gearbox is to exchange the low rotational velocity of the turbine to a excessive rotational pace on the generator side. The rotational pace of an induction generator is usually 1000 or 1500 rpm. The turbine speed is dependent on the rotor diameter, for example a 200 kW turbine has a rotational velocity of approximately 50 rpm, while the rotational velocity of a 1 zero kW turbines is approximately 30 rpm. Figure 2.2 illustrates the essential components in a fixed-speed wind turbine. A fixed-speed wind turbine is designed to gain maximum affectivity at one wind speed that will give the most suitable tip pace to wind speed ratio for the rotor airfoil. In order to capture extra energy, some fixed-speed wind mills have two different rotational speeds. This can be completed either through two mills or by means of one generator with two windings.[5]

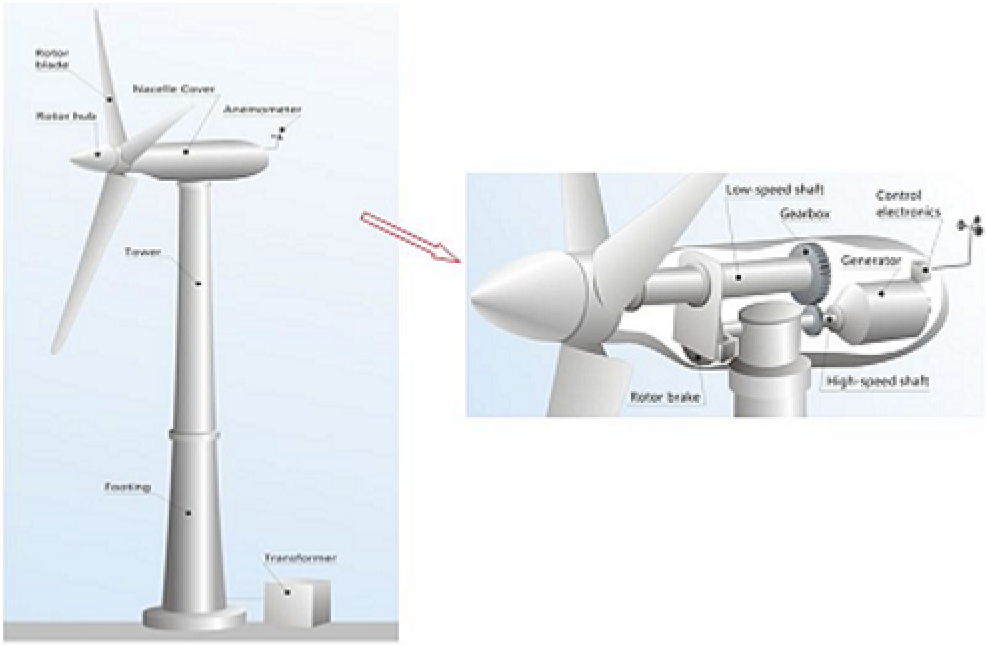


Figure 3.1: Schematic figure of a typical fixed-speed wind turbine illustrating the major components

3.3 Impact on Environment

Impact of Land

The land use influence of wind electricity amenities varies extensively depending on the site: wind turbines positioned in flat areas normally uses extra land than these positioned in hilly areas. However, wind turbines do no longer occupy all of this land; they should be spaced approximately 5 to 10 rotor diameters apart (a rotor diameter is the diameter of the wind turbine blades). Thus, the generators themselves and the surrounding infrastructure (including roads and transmission lines) occupy a small component of the total area of a wind facility.

A survey by the National Renewable Energy Laboratory of giant wind amenities in the United States found that they use between 30 and 141 acres per megawatt of energy output capacity (a regular new utility-scale wind turbine is about 2 megawatts). However, much less than 1 acre per megawatt is disturbed permanently and less than 3.5 acres per megawatt are disturbed briefly at some stage in building. The remainder of the land can be used for a range of other productive purposes, which includes livestock grazing, agriculture, highways, and hiking trails. Alternatively, wind services can be sited on brown fields (abandoned or underused industrial land) or other business and industrial locations, which significantly reduces concerns about land use.

Offshore wind facilities require large amounts of house due to the fact the generators and blades are higher than their land-based counterparts. Depending on their location, such offshore installations might also compete with a range of different ocean activities, such as fishing, recreational activities, sand and gravel extraction, oil and gas extraction, navigation, and aquaculture. Employing first-class practices in planning and sitting can assist reduce potential land use affects of offshore and land-based wind tasks.

Figure 3.2: Land based Wind-Turbine

Impact of Wildlife and Habitat

The affect of wind generators on wildlife, most incredibly on birds and bats, has been extensively file and studied. A recent National Wind Coordinating Committee (NWCC) evaluate of peer-reviewed lookup determined proof of fowl and bat deaths from collisions with wind generators and due to adjustments in air pressure triggered by the spinning turbines, as well as from habitat disruption. The NWCC concluded that these affects are rather low and do not pose a risk to species populations.

Additionally, lookup into natural world behavior and advances in wind turbine technological know-how have helped to decrease hen and bat deaths. For example, wildlife biologists have determined that bats are most active when wind speeds are low. Using this information, the Bats and Wind Energy Cooperative concluded that maintaining wind generators motionless at some point of instances of low wind speeds may want to limit bat deaths by means of extra than 1/2 without appreciably affecting strength manufacturing. Other wildlife influences can be mitigated through higher sitting of wind turbines. The U.S. Fish and Wildlife Services has played a management function in this effort with the aid of convening an advisory crew which includes representatives from industry, nation and tribal governments, and nonprofit agencies that made complete tips on terrific wind farm sitting and nice management practices .

Offshore wind mills can have comparable impacts on marine birds, however as with onshore wind turbines, the fowl deaths related with offshore wind are minimal. Wind farms positioned offshore will additionally impact fish and other marine wildlife. Some studies advocate that mills may also honestly enlarge fish populations with the aid of performing as artificial reefs. The affect will vary from web site to site, and consequently acceptable lookup and monitoring systems are wanted for every offshore wind facility.

Figure 3.3: Wildlife Impacts of Wind Energy

Impact of Public Health and Community

Sound and visible impact are the two principal public health and neighborhood issues related with working wind turbines. Most of the sound generated through wind mills is aerodynamic, brought on through the motion of turbine blades via the air. There is additionally mechanical sound generated by way of the turbine itself. Overall sound levels rely on turbine design and wind speed.

Some human beings living close to wind amenities have complained about sound and vibration issues, however enterprise and government-sponsored research in Canada and Australia have observed that these issues do no longer adversely influence public health. However, it is necessary for wind turbine builders to take these neighborhood worries critically by following "good neighbor" high-quality practices for sitting mills and initiating open speak with affected neighborhood members. Additionally, technological advances, such as minimizing blade floor imperfections and the use of sound-absorbent materials can decrease wind turbine noise.

Under certain lighting fixtures conditions, wind generators can create an effect recognized as shadow flicker. This annoyance can be minimized with cautious sitting, planting trees or putting in window awnings, or curtailing wind turbine operations when positive lighting fixtures conditions exist.

The Federal Aviation Administration (FAA) requires that massive wind turbines, like all buildings over 200 ft high, have white or red lights for aviation safety. However, the FAA currently decided that as lengthy as there are no gaps in lights increased than a half-mile, it is not necessary to mild every tower in a multi-turbine wind project. Daytime lighting fixtures are pointless as long as the generators are painted white.

When it comes to aesthetics, wind generators can elicit robust reactions. To some people, they are sleek sculptures; to others, they are eyesores that compromise the herbal landscape. Whether a neighborhood is inclined to be given an altered skyline in return for cleaner strength have to be decided in an open public dialogue.[8]

Chapter 4

Results and Discussions

Component	Value
Irradiance	1000 W/mˆ2
PWM switching frequency (Hz)	5000
Resistance (Ohms) :	0.001

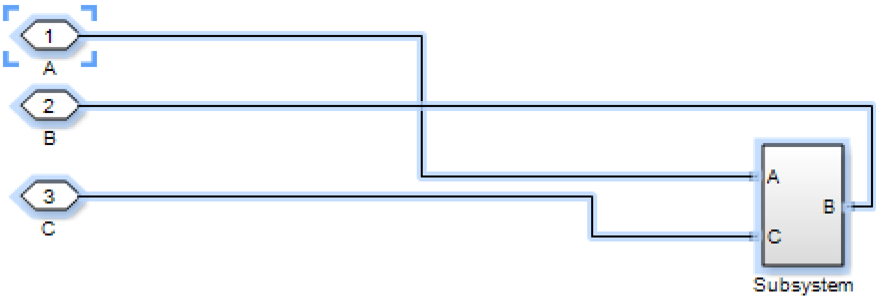


Figure 4.1: Utility grid subsystem for Model Of Solar Cell

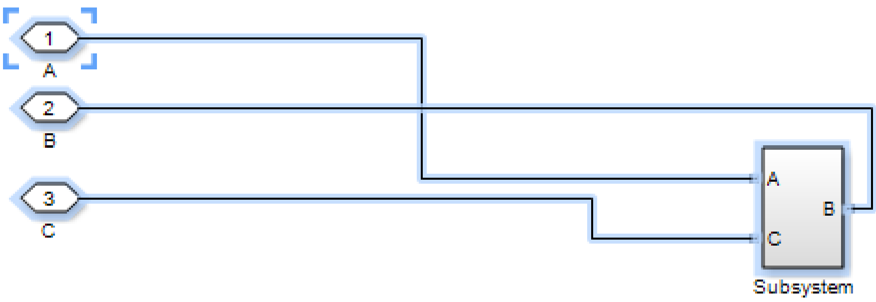


Figure 4.2: Utility grid implementation for Model Of Solar Cell

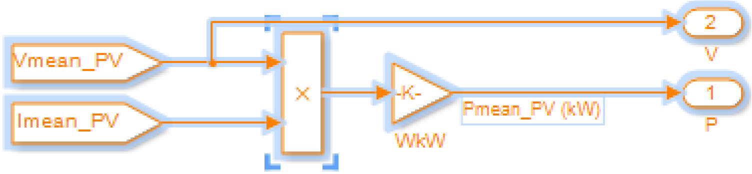


Figure 4.3: Pmean subsystem for Model Of Solar Cell

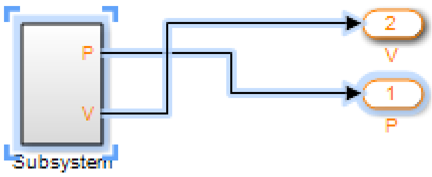


Figure 4.4: Pmean implementation for Model Of Solar Cell

additional block fig 2
additional block fig 3
A 100-kW PV array is connected to a 25-kV grid via a DC-DC boost converter and a three-phase three-level Voltage Source Converter (VSC). Maximum Power Point Tracking (MPPT) is implemented in the boost converter by means of a Simulink model using the 'Incremental Conductance + Integral Regulator' technique.

Another example (see power_PVarray_grid_avg model) uses average models for the DC_DCand VSC converters. In this average model the MPPT controller is based on the 'Perturb and Observe' technique

Graphs with change of temperature

For 20°C

The effect of Constant 1000 Irradiance and 20°C temperature,we can see in the above figure Pmean becomes stable at 100 kW and Vmean becomes stable at 250v.The duty cycle is 0.5second Here we can see the Vref-Vmean curve start with 0 to 600 with difference 100 it stables at 500.the Mod.Index stables at 0.85s. Here in the graph Vsc(vehicle stability control) is not stable at 0 to 0.2 second it get stables at 0.3(time) second

Here in the graph the power is stables at 100 kW from 0.5 In this graph we can see voltage(Va) -2×10^4 to 2×10^4 and Current we can see (Ia) stability is from time 0.4. **For 50** The effect of Constant 1000

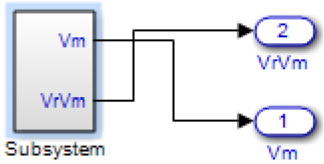


Figure 4.5: Vref-Vmean subsystem for Model Of Solar Cell

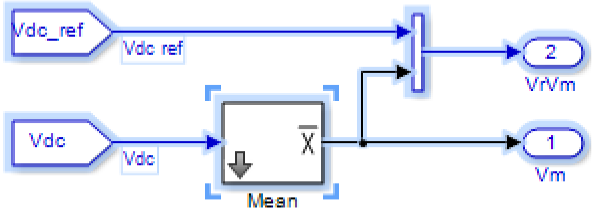


Figure 4.6: implementation Vref-Vmean for Model Of Solar Cell

Irradiance and 50°C temperature we can see Pmean stables at 90 kW and Vmean stables at 250v

Here we can see the Vref-Vmean curve start with 0 to 600 with difference 100 it stables at 500.the Mod.Index stables at 0.85s.

Vsc model graph

Here in the graph Vsc(vehicle stability control) is not stable at 0 to 0.2 second it get stables at 0.3(time) second Here in the graph the power is stables at 90 kW from 0.4

Grid model graph for 50

In this graph we can see voltage(Va) -2×10^4 to 2×10^4 and Current we can see (Ia) stability is from time -3 to 3 and current start from -2

For 100

The effect of Constant 1000 Irradiance and 50°C temperature we can see Pmean stables at 54kW and Vmean stables at 200v Here we can see the Vref-Vmean curve start with 0 to 600 with difference 1000 it stables at 500.the Mod.Index stables at 0.85s. Here in the graph Vsc(vehicle stability control) is not stable at 0 to 0.2 second it get stables at 0.3(time) second

Grid model graph for 50

In this graph we can see voltage(Va) -2×10^4 to 2×10^4 and Current we can see (Ia) stability is from time -3 to 3 and current start from -2

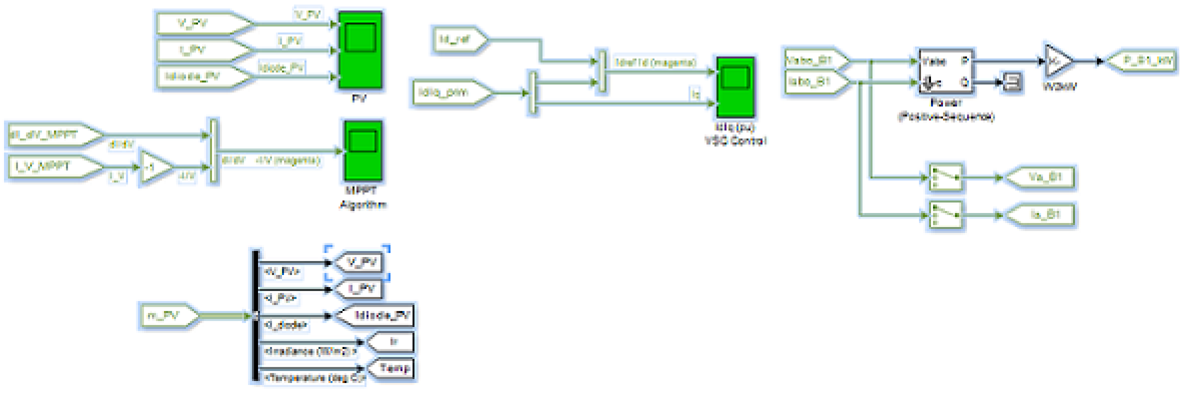


Figure 4.7: additional block fig 1 for Model Of Solar Cell

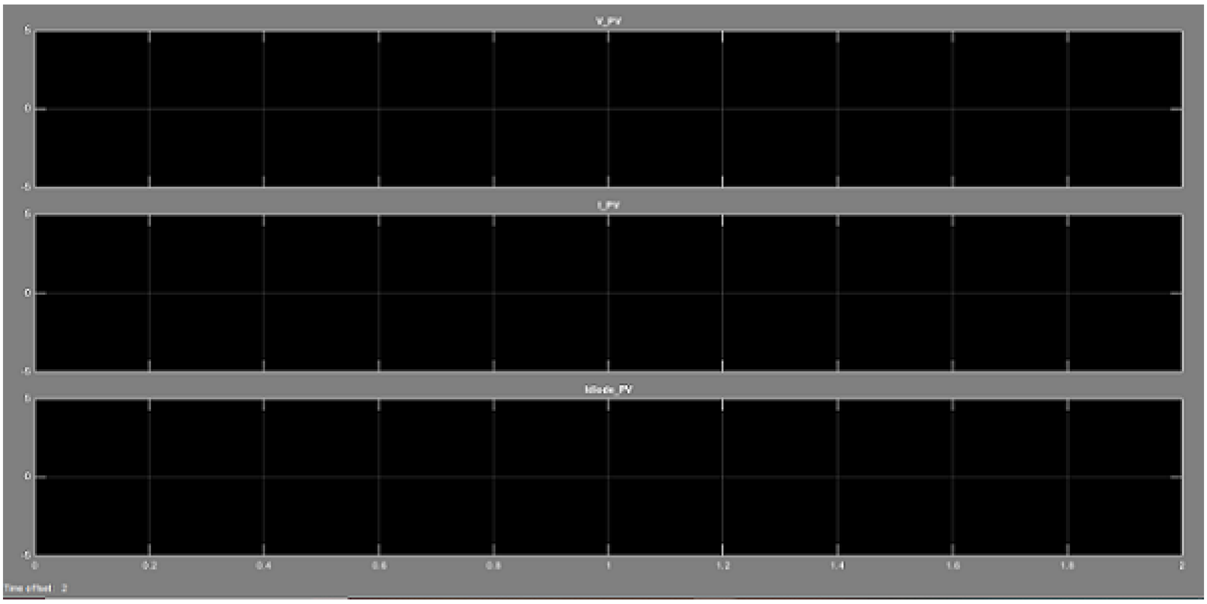


Figure 4.8: Additional block of PV array solar cell

For 100

The effect of Constant 1000 Irradiance and 50°C temperature we can see Pmean stables at 54kW and Vmean stables at 200v Here we can see the Vref-Vmean curve start with 0 to 600 with difference 1000 it stables at 500.the Mod.Index stables at 0.85s.

Here in the graph the power is stables at 71 kW from 0.4 In this graph we can see voltage(Va) -2×10^4 to 2×10^4 and Current we can see (Ia) stability is from time -4 to 4 and current start from 0.4

For wind turbine

For speed 10 Scope 1:

The motor stability is for Vabc is 0.5 and Labc Sec.load stable is at 0.3 The frequency (Hz) is 60 to 60.1 **Scope 2:**

Here the power of wind turbine 190-230 Kw,psec .load is 200KW

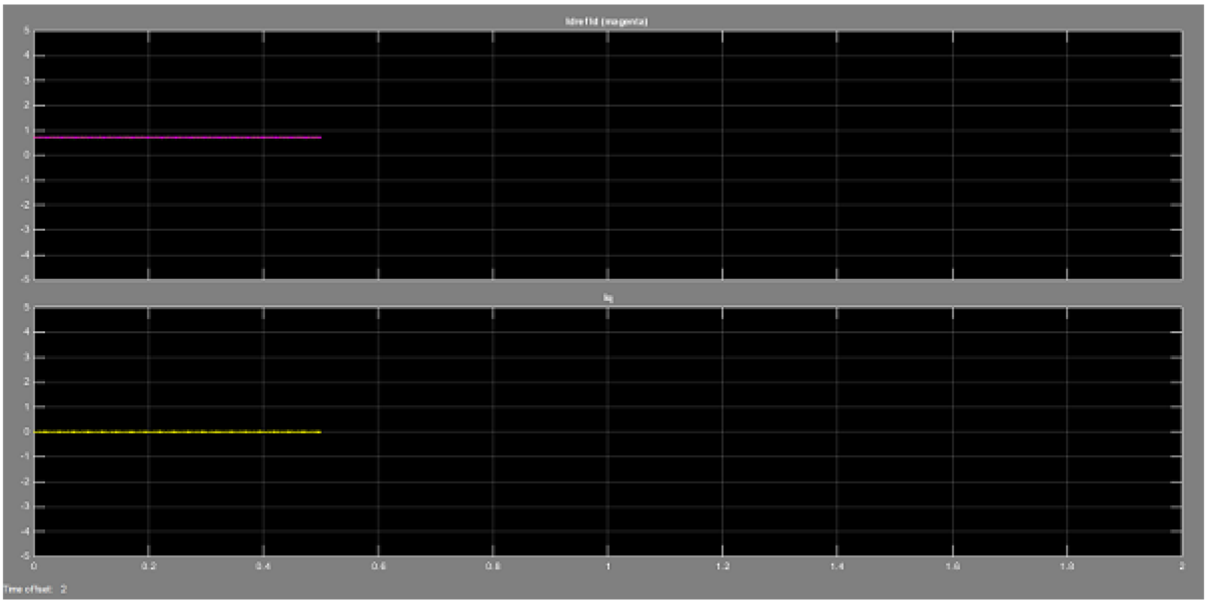


Figure 4.9: Additional block of PV array solar cell

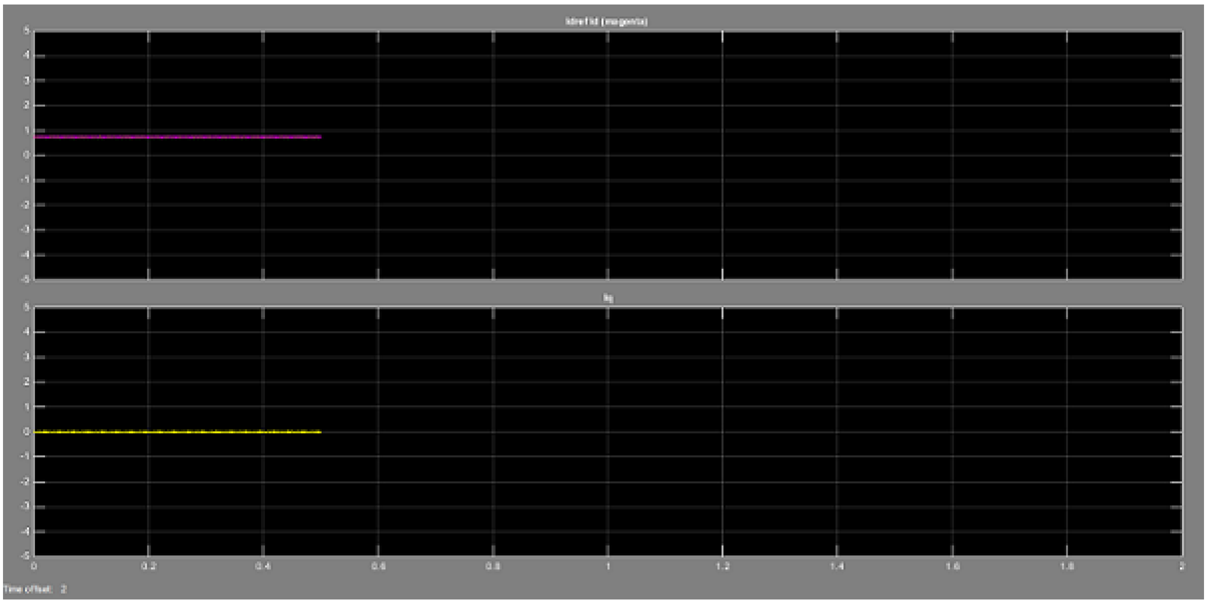
For 20

Scope 1

The motor stability is for Vabc is 0.5 and Labc Sec.load stable is at 0.3 The frequency (Hz) is 60 to 60.1

Scope 2 Here the power of wind turbine 190-230 Kw,psec .load is 200KW **For 50 Scope 1** The motor stability is for Vabc is 2.8 and Labc Sec.load stable is at 2.8 The frequency (Hz) is 60 to 120

Scope 2



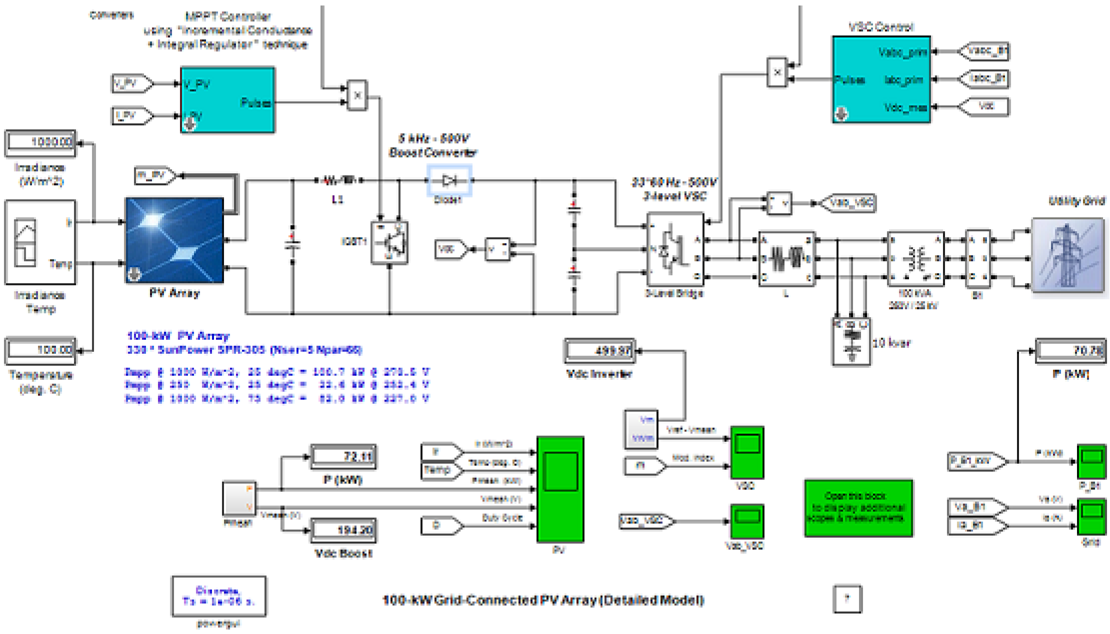


Figure 4.10: 100kW Grid-Connected PV Array (Detailed Model Of Solar Cell)

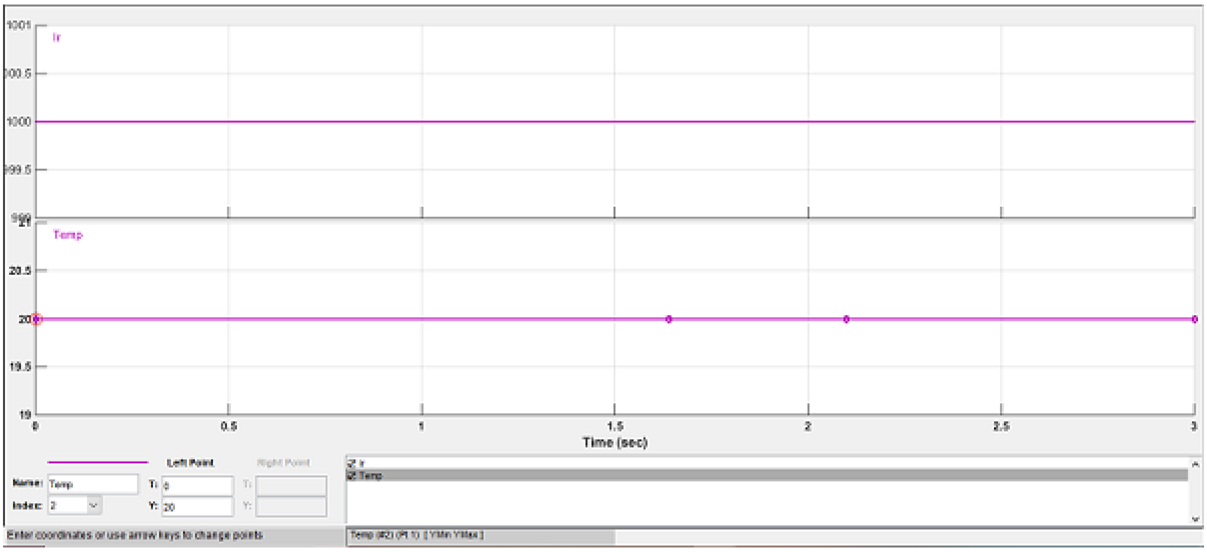


Figure 4.11: Fixed with 1000Ir and 20°C temperature

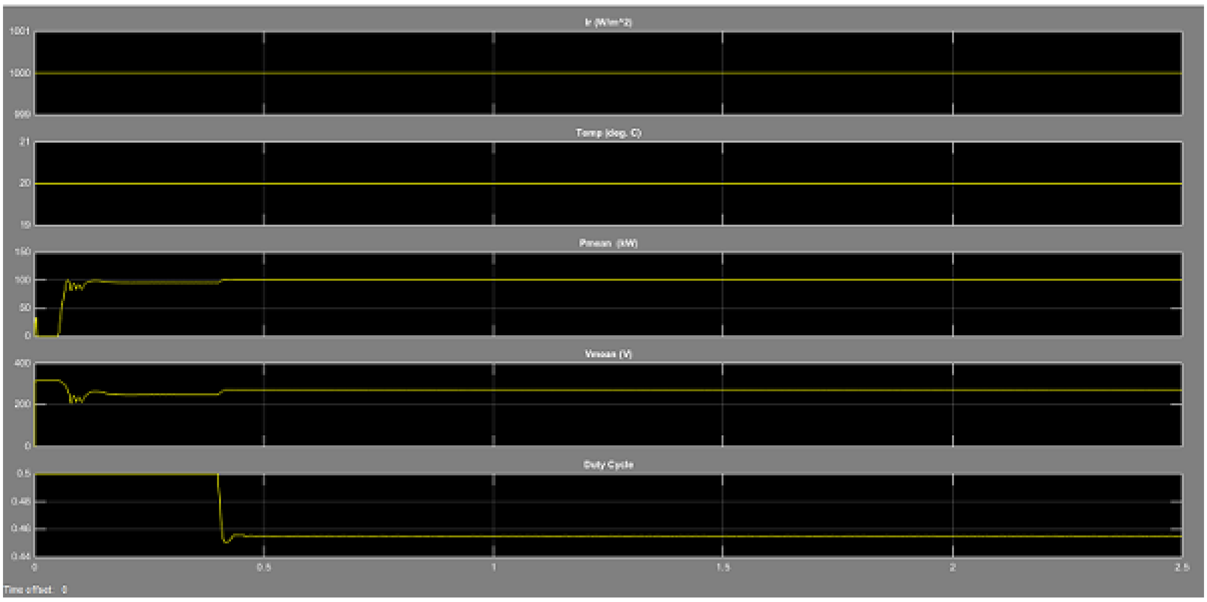


Figure 4.12: The Curves for pv graph with Constant irradiance and Various Temperature

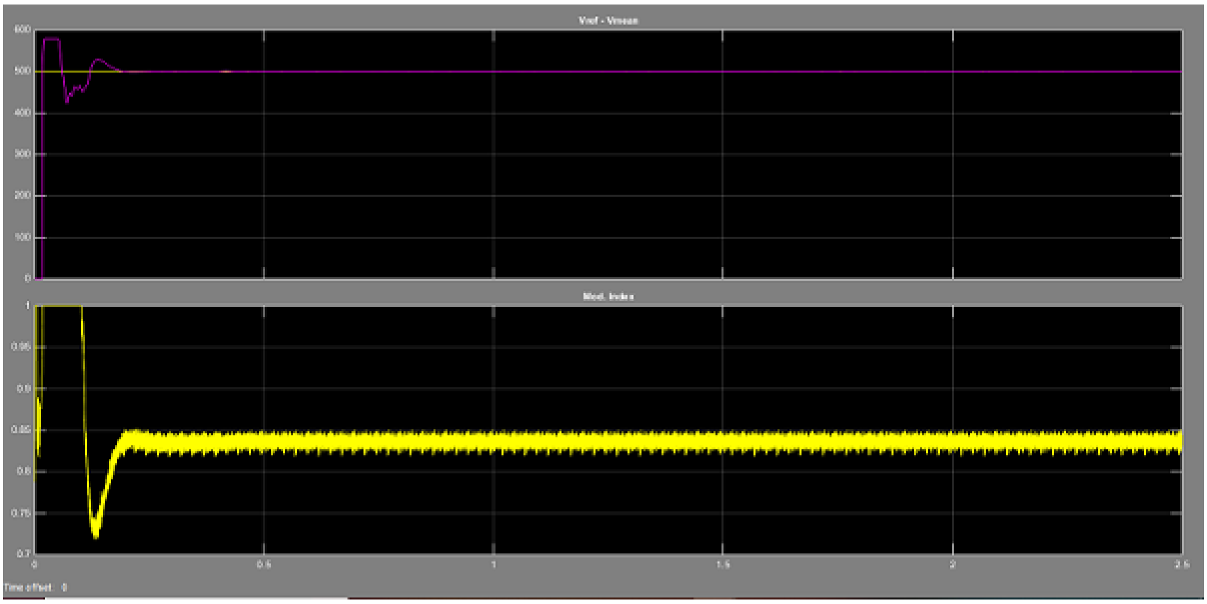


Figure 4.13: Vsc graph for Constant irradiance and 20°C Temperature

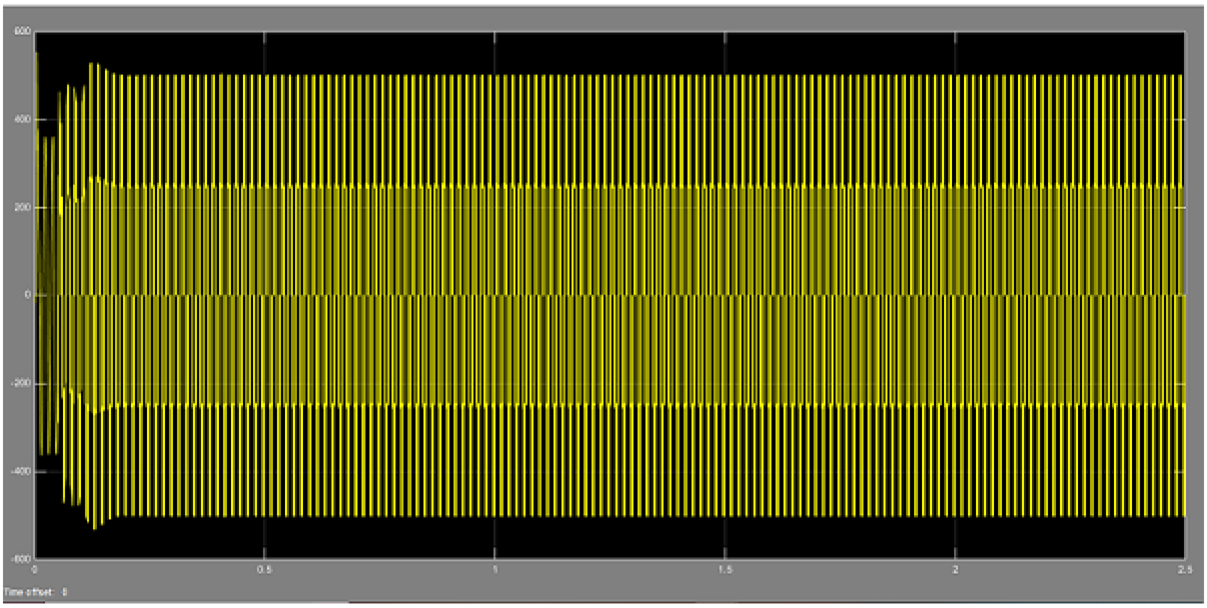


Figure 4.14: Vab_Vsc Model graph Constant irradiance and 20°C Temperature

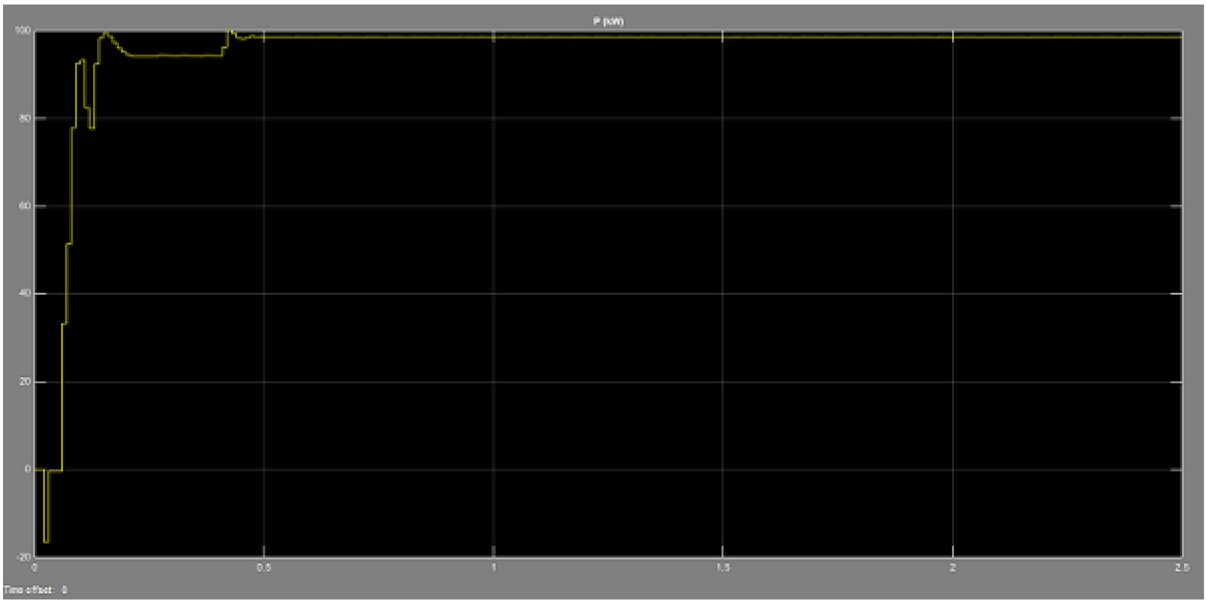


Figure 4.15: P_b1 Model graph for Constant irradiance and 20°C Temperature

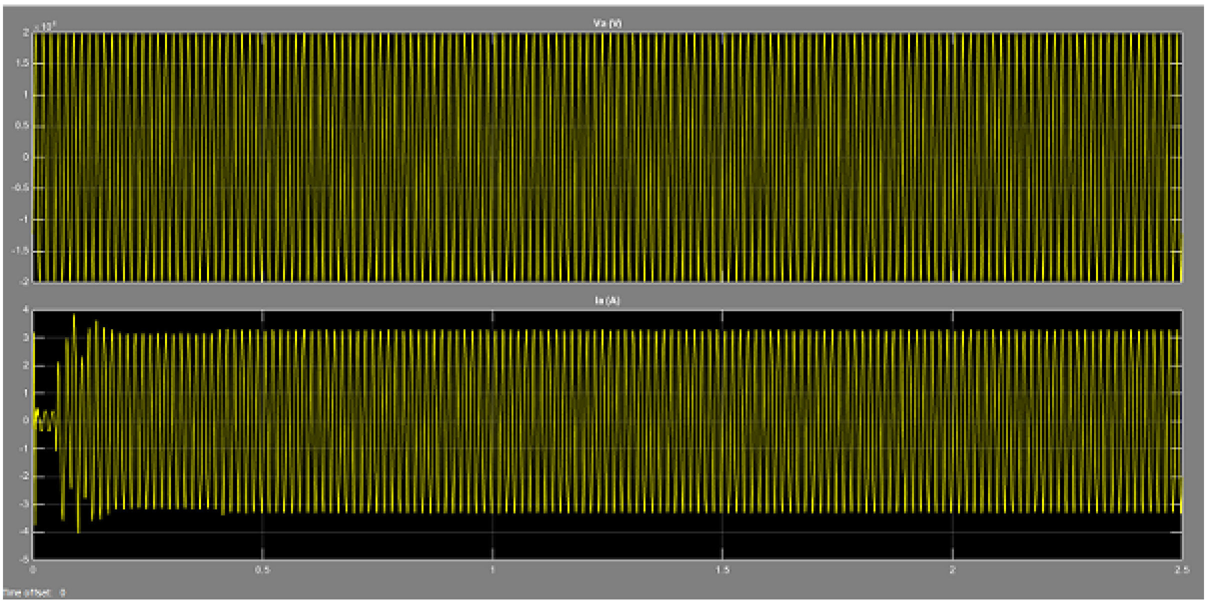


Figure 4.16: Main solar cell graph for Constant irradiance and 20°C Temperature

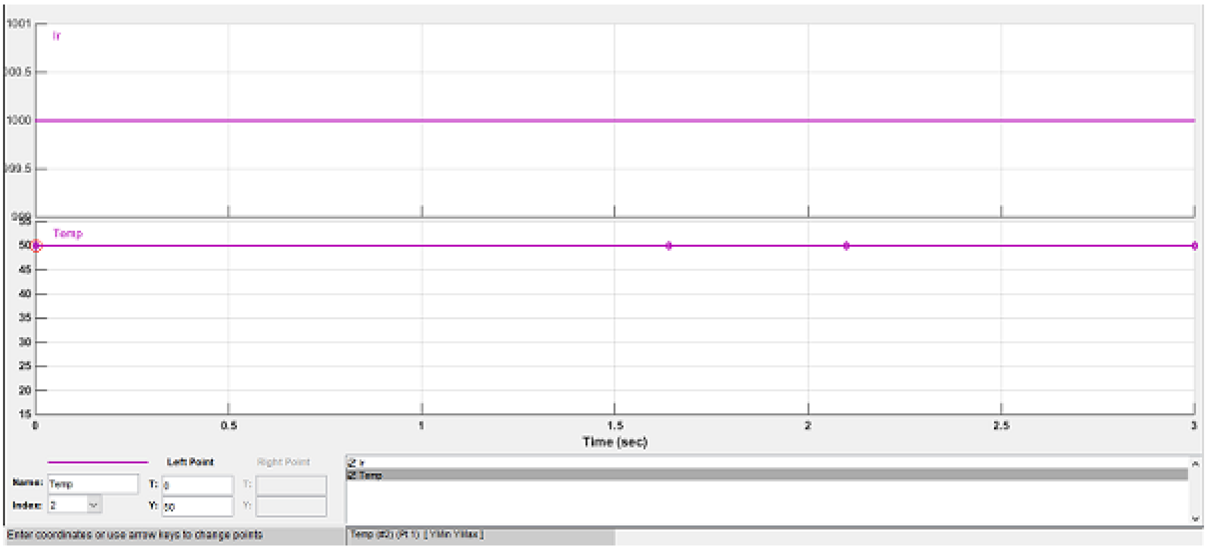


Figure 4.17: Fixed with Ir=1000 w/m^2 and 50°C temperature

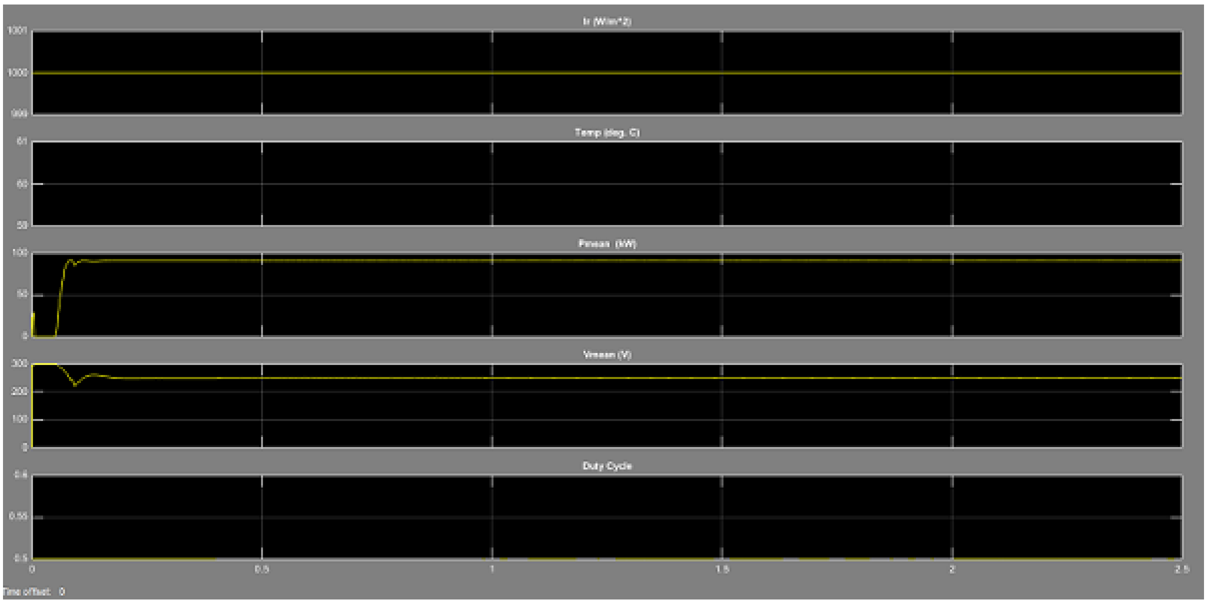


Figure 4.18: The Pv Curves for Constant irradiance and Various Temperature

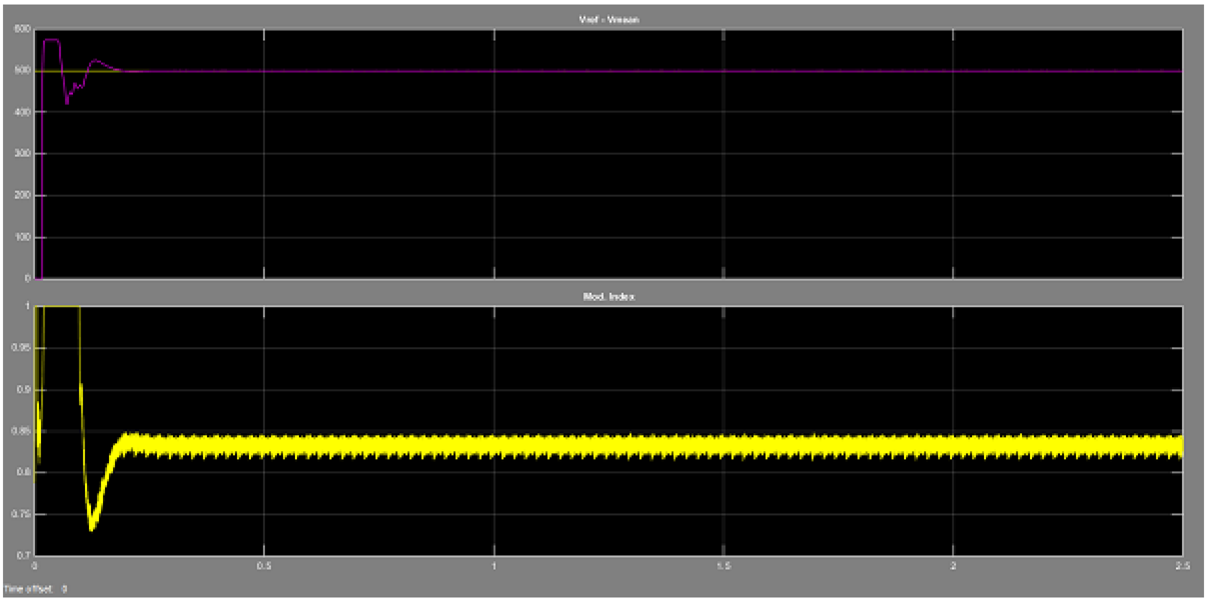


Figure 4.19: Vsc Model graph for Constant irradiance and 50°C Temperature

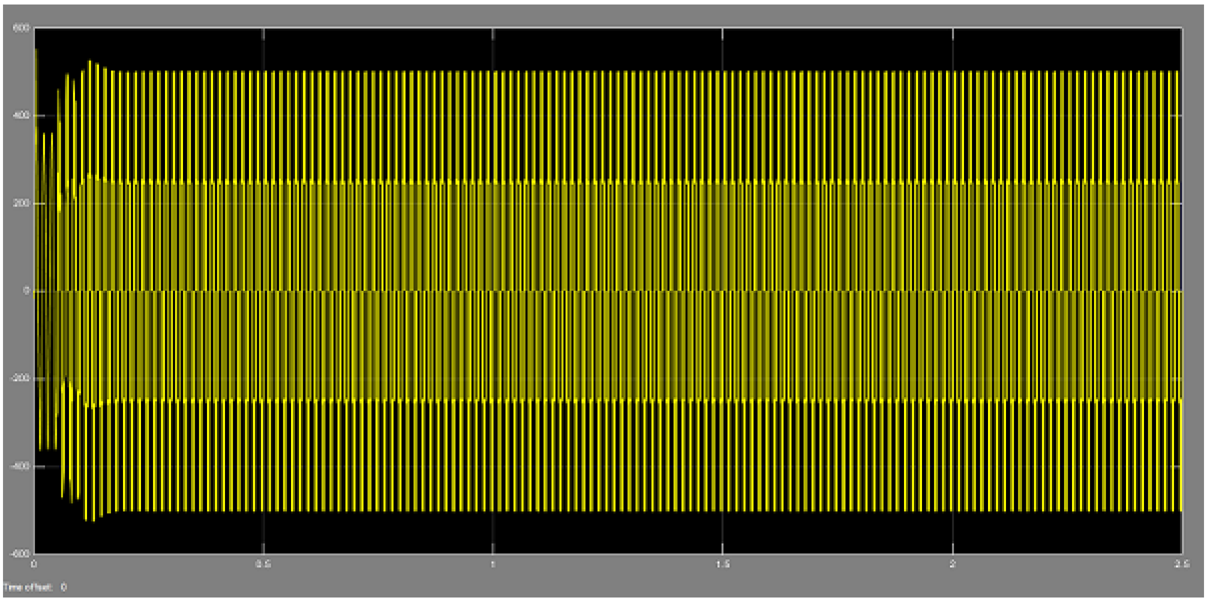


Figure 4.20: Vab_Vsc Model graph Constant irradiance and 50°C Temperature

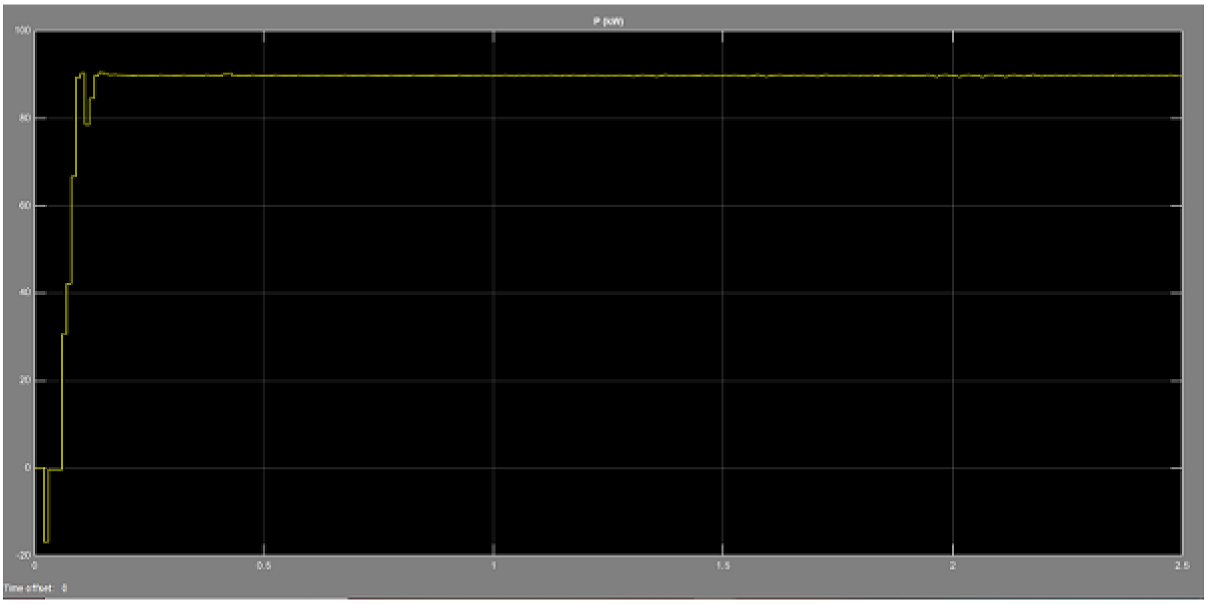


Figure 4.21: P_b1 Model graph for Constant irradiance and 50°C Temperature

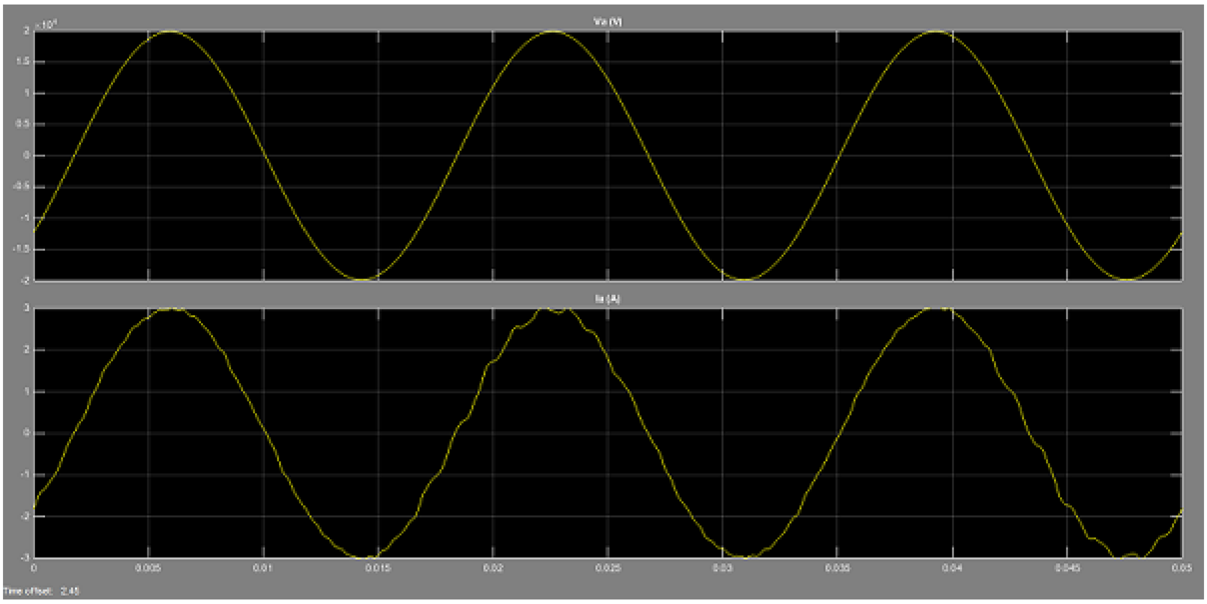


Figure 4.22: Main solar cell graph for Constant irradiance and 20°C Temperature

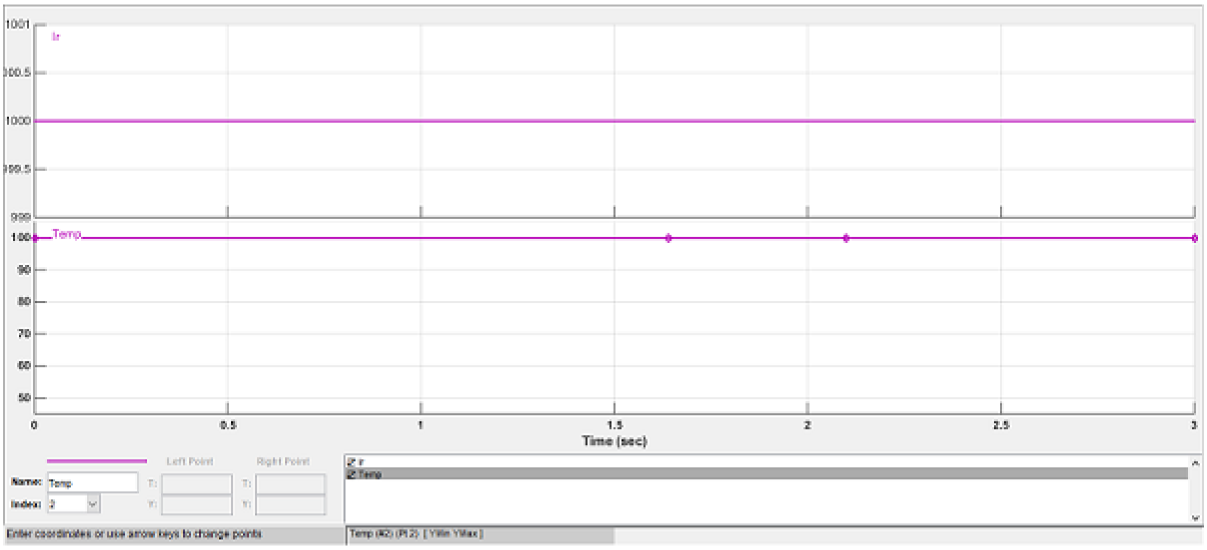


Figure 4.23: Fixed with 1000Ir and 100°C temperature

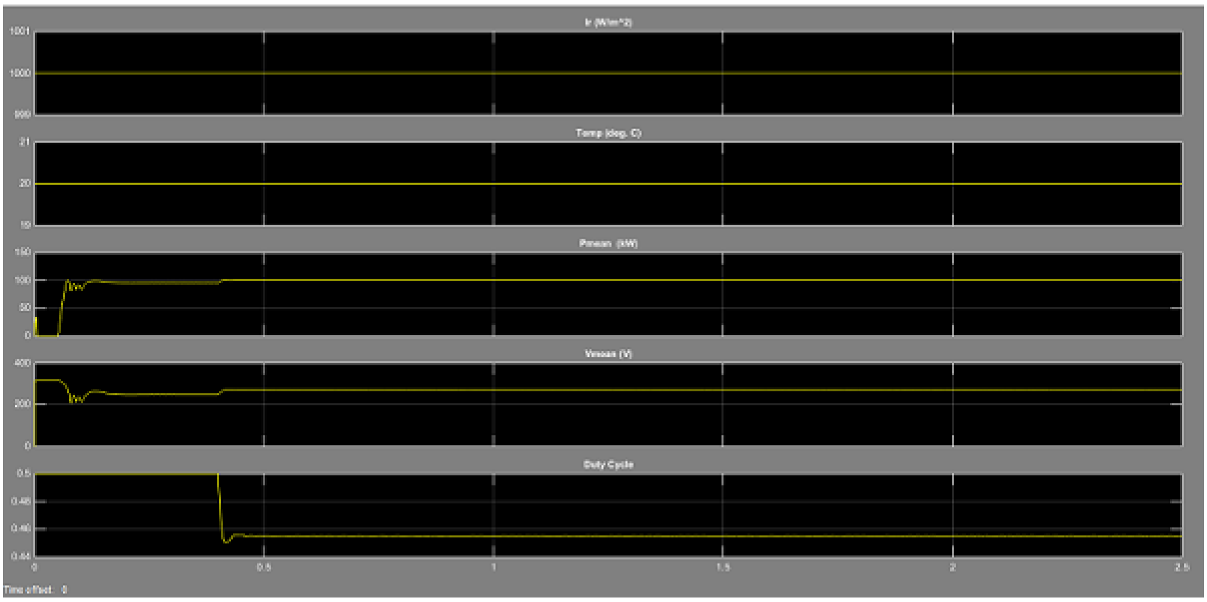


Figure 4.24: The Pv Curves for Constant irradiance and Various Temperature

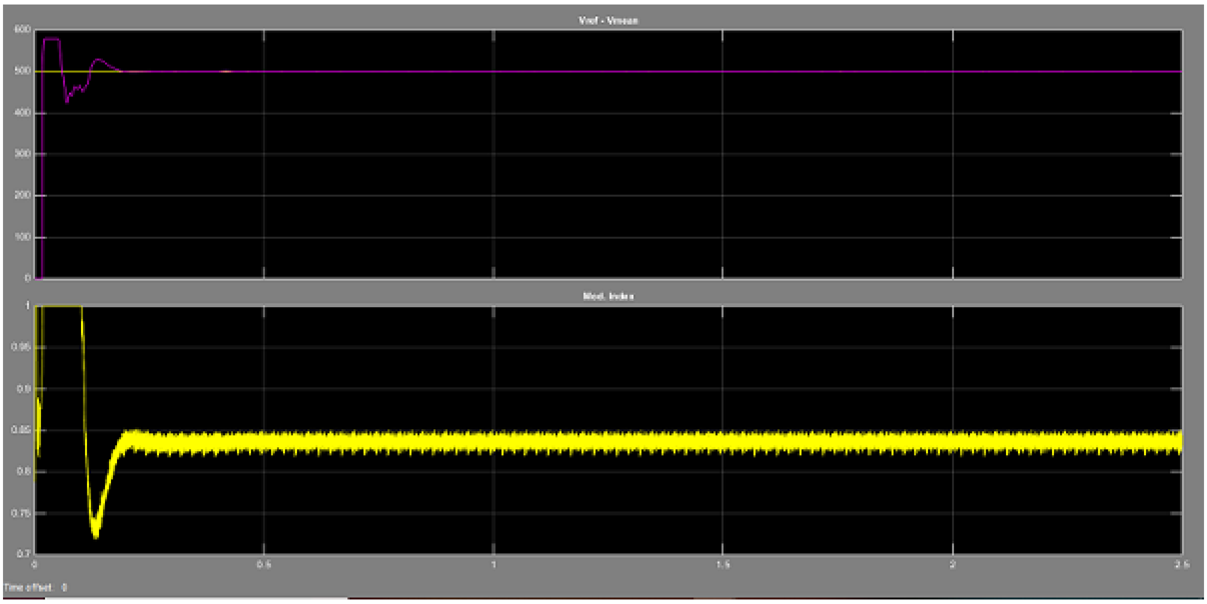


Figure 4.25: Vsc Model graph for Constant irradiance and 100°C Temperature

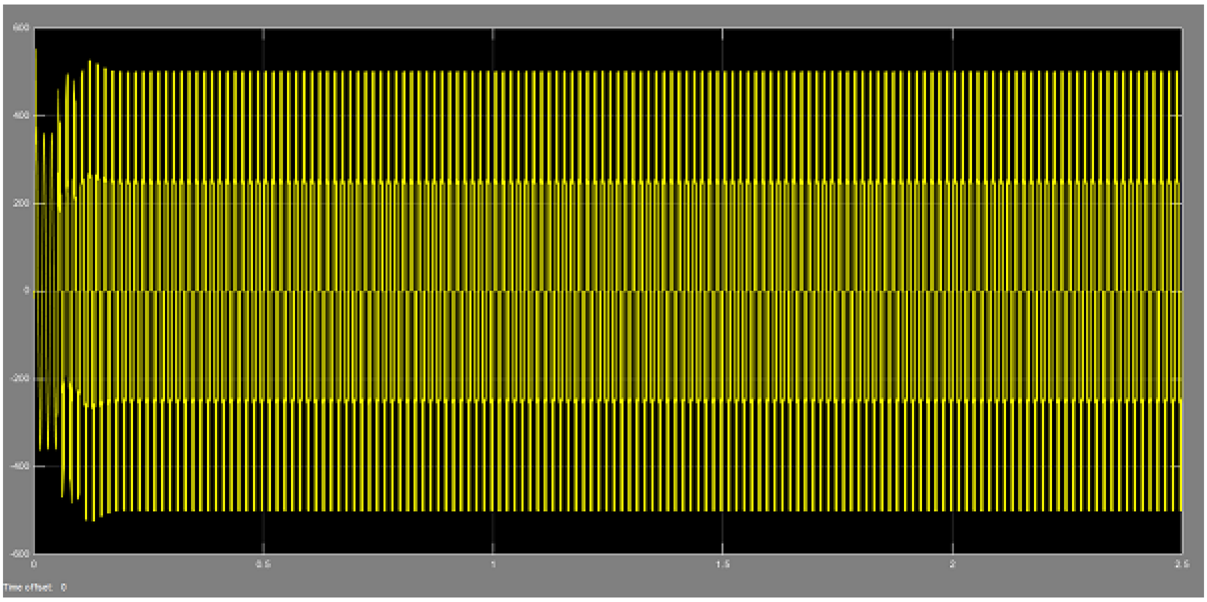


Figure 4.26: Vab_Vsc Model graph Constant irradiance and 100°C Temperature

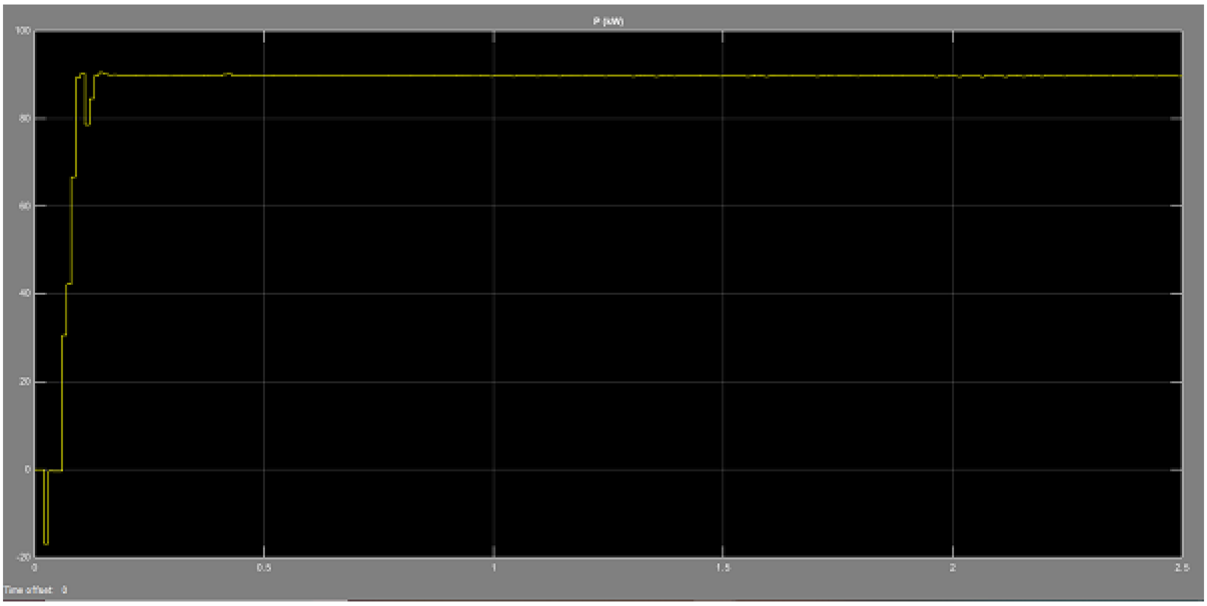


Figure 4.27: P_b1 Model graph for Constant irradiance and 100°C Temperature

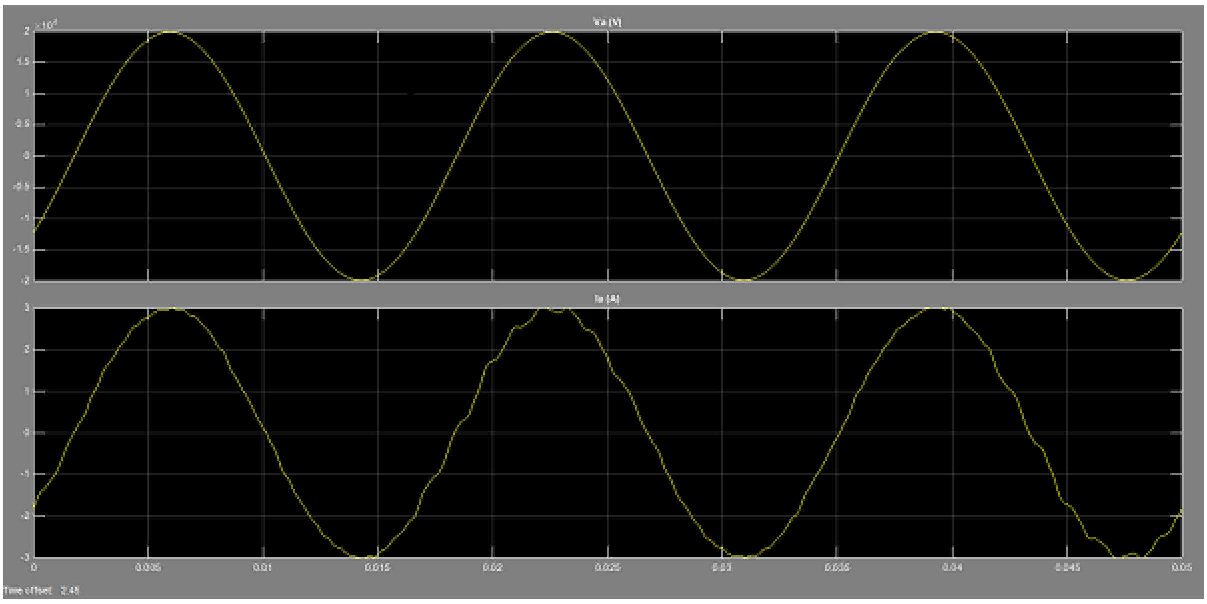


Figure 4.28: Main solar cell graph for Constant irradiance and 20°C Temperature

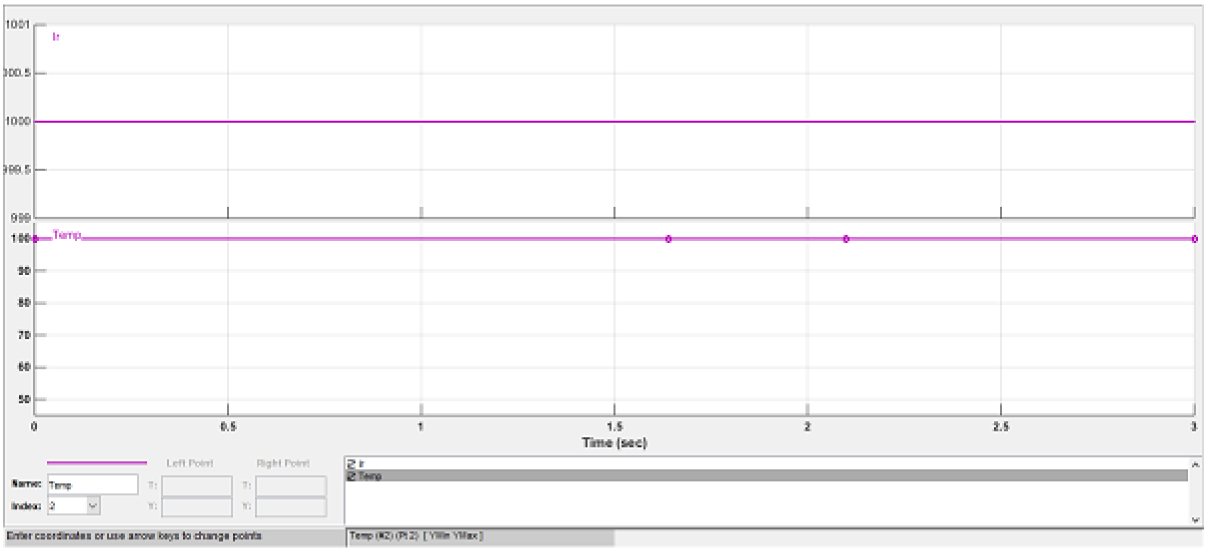


Figure 4.29: Fixed with 1000Ir and 100°C temperature

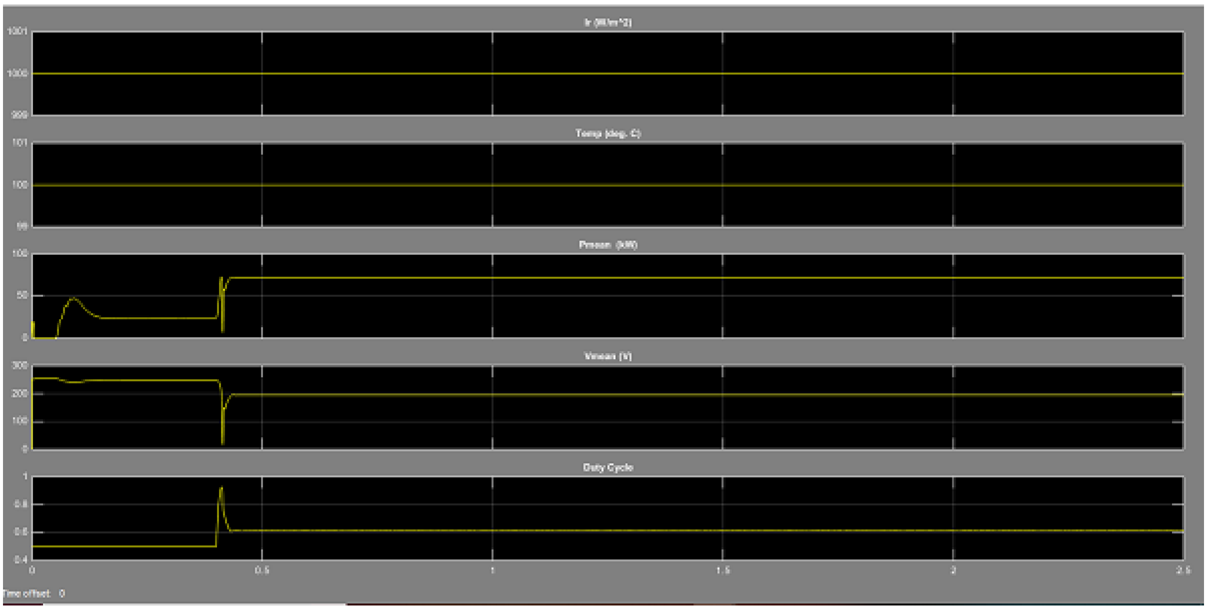


Figure 4.30: The Pv Curves for Constant irradiance and Various Temperature

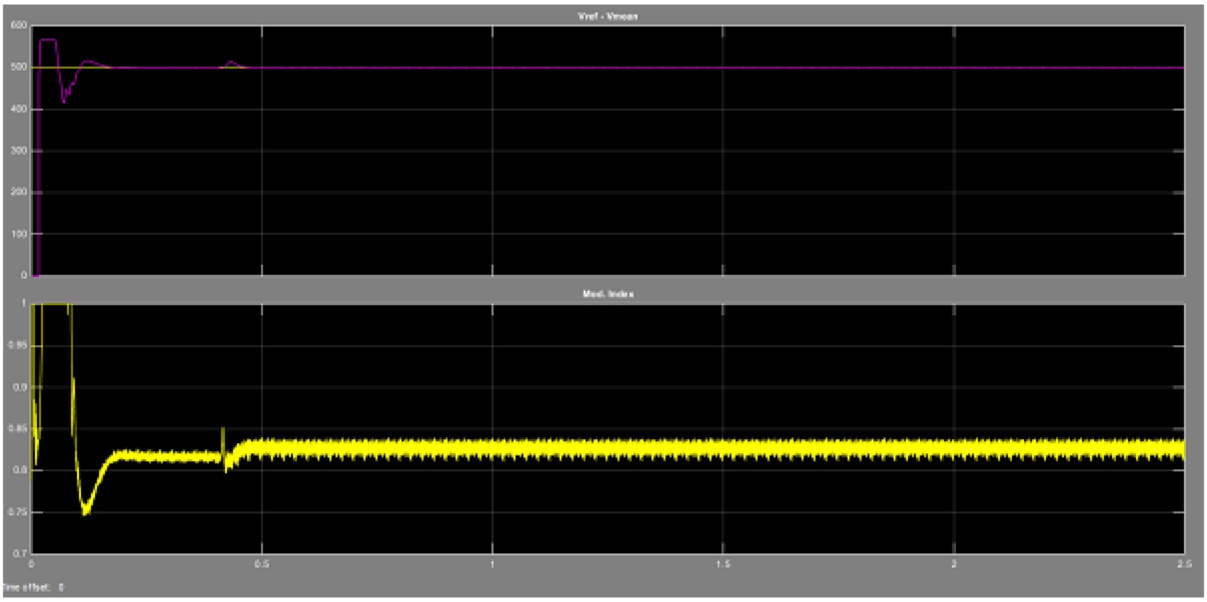


Figure 4.31: Vsc Model graph for Constant irradiance and 100°C Temperature

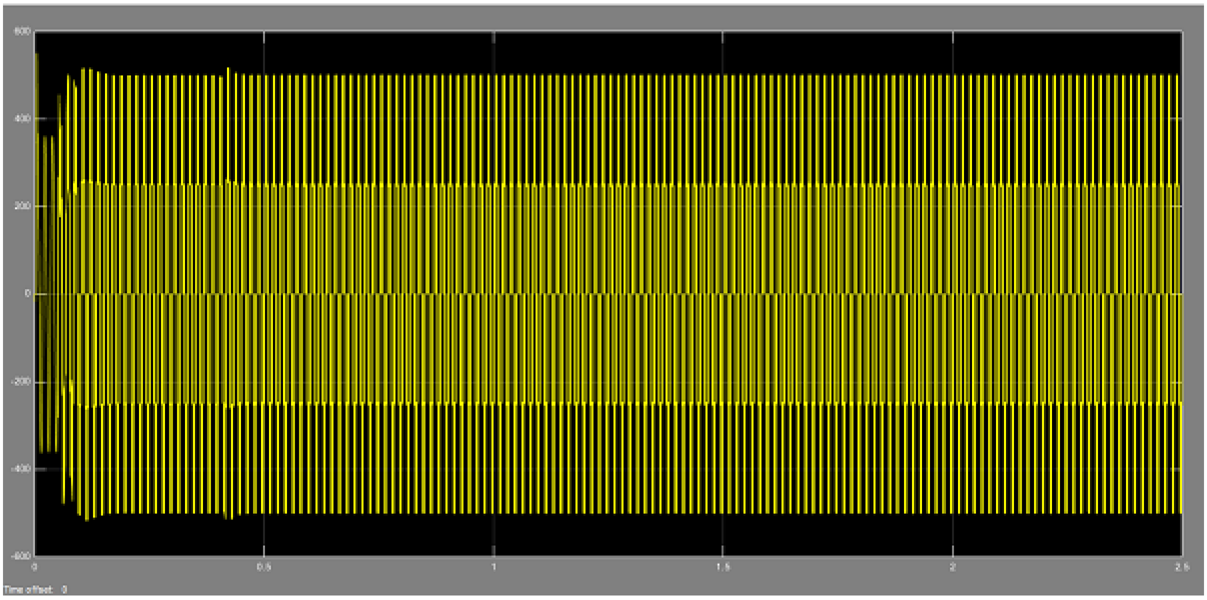


Figure 4.32: Vab_Vsc Model graph Constant irradiance and 100°C Temperature

Figure 4.33: P_b1 Model graph for Constant irradiance and 100°C Temperature

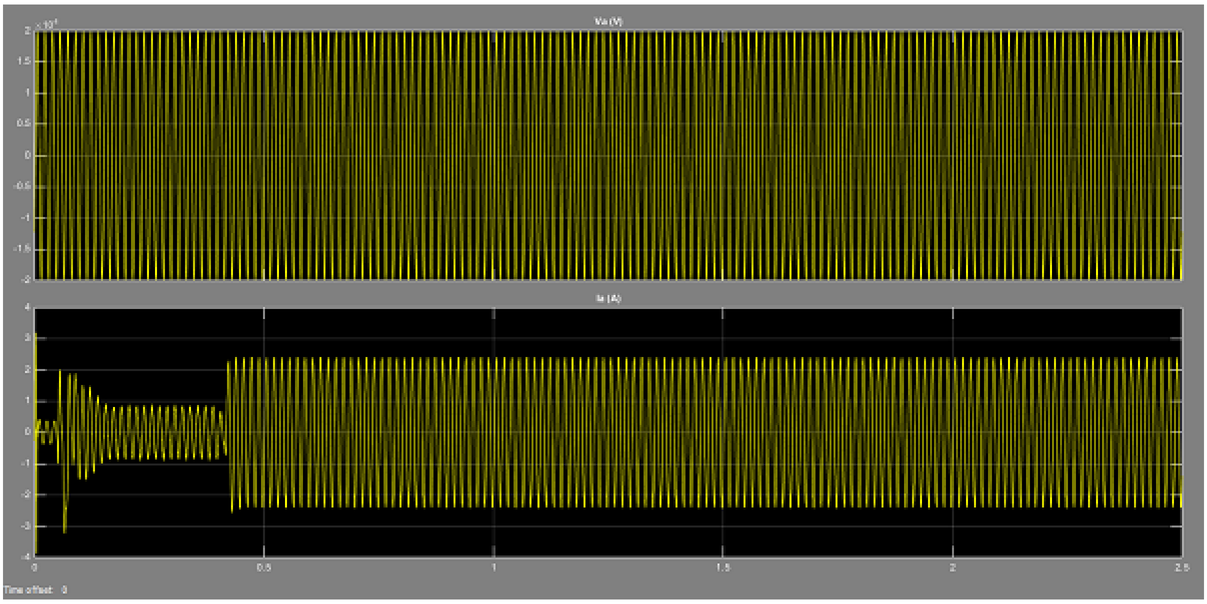


Figure 4.34: Main solar cell graph for Constant irradiance and 100°C Temperature

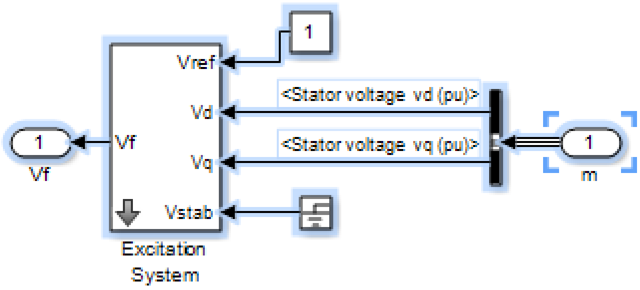


Figure 4.35: Excitation subsystem for modelling of Wind-Turbine Asynchronous Generator

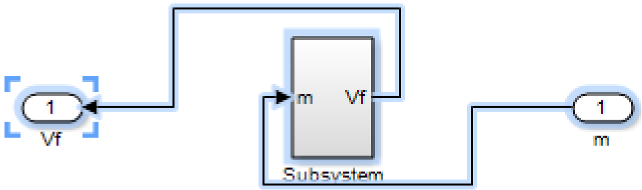


Figure 4.36: Excitation for modelling of Wind-Turbine Asynchronous Generator

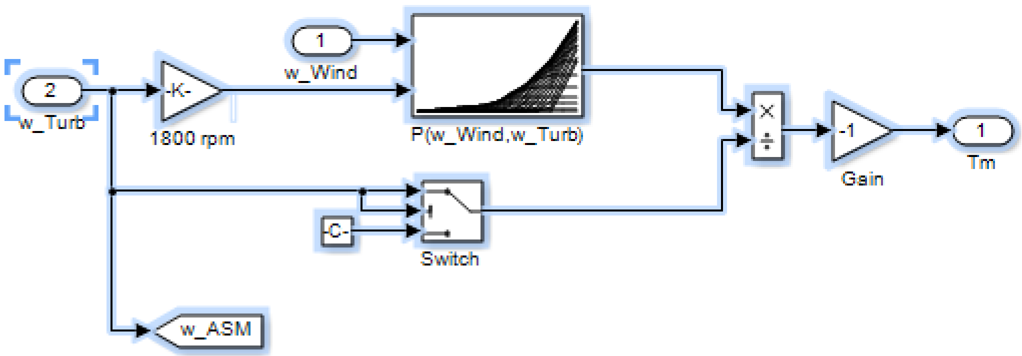


Figure 4.37: wind turbine subsystem for modelling of Wind-Turbine Asynchronous Generator

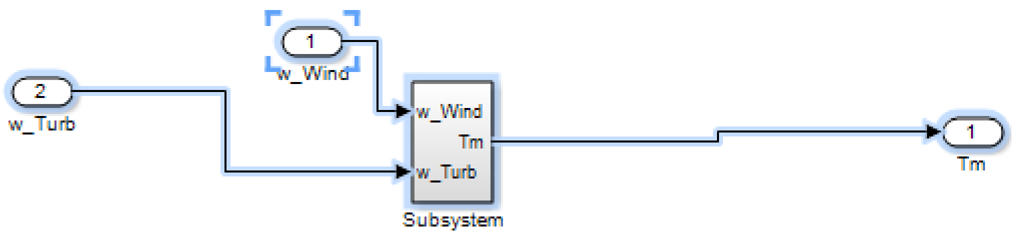


Figure 4.38: additional subsystem for modelling of Wind-Turbine Asynchronous Generator

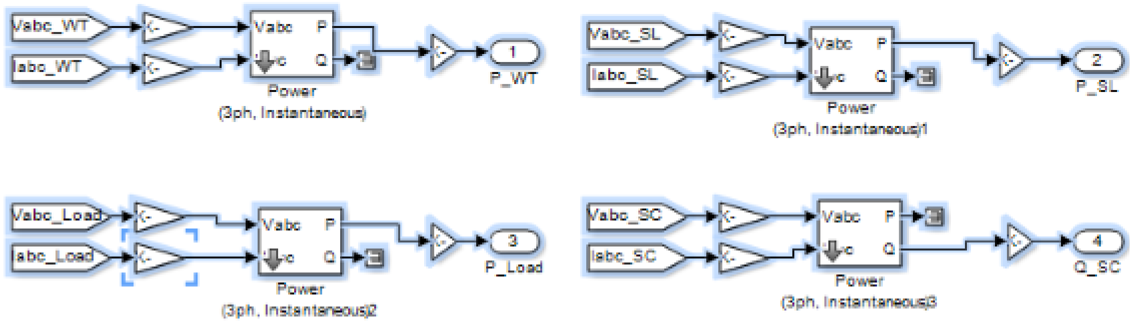


Figure 4.39: power compution subsystem for modelling of Wind-Turbine Asynchronous Generator

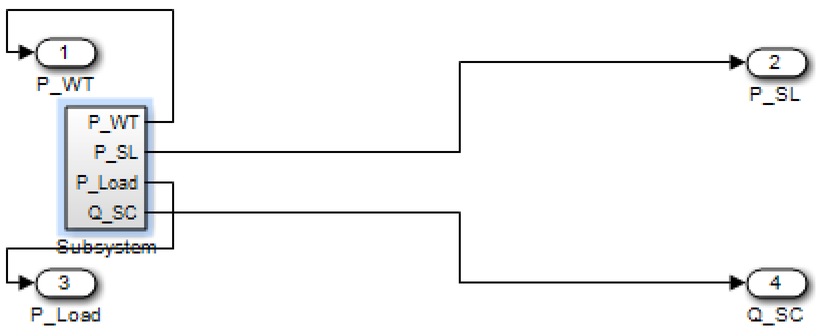


Figure 4.40: implementation of power compution for for modelling of Wind-Turbine Asynchronous Generator

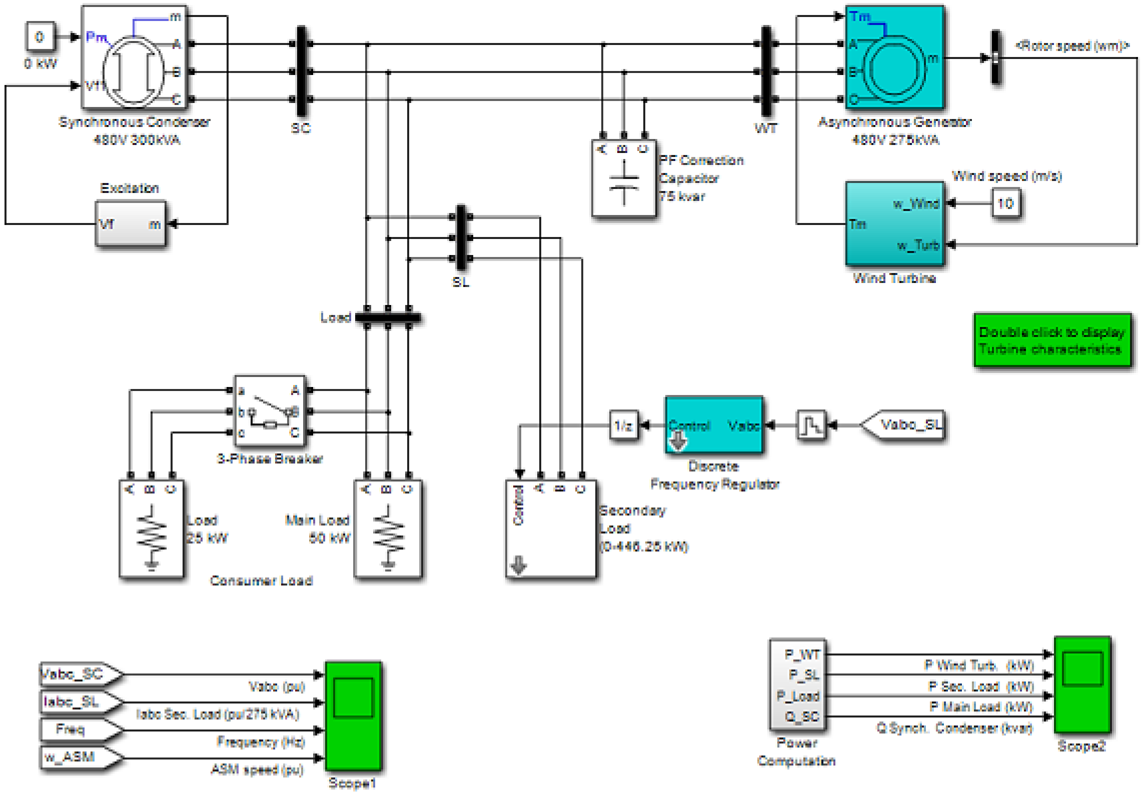


Figure 4.41: Wind-Turbine Asynchronous Generator in Isolated Network

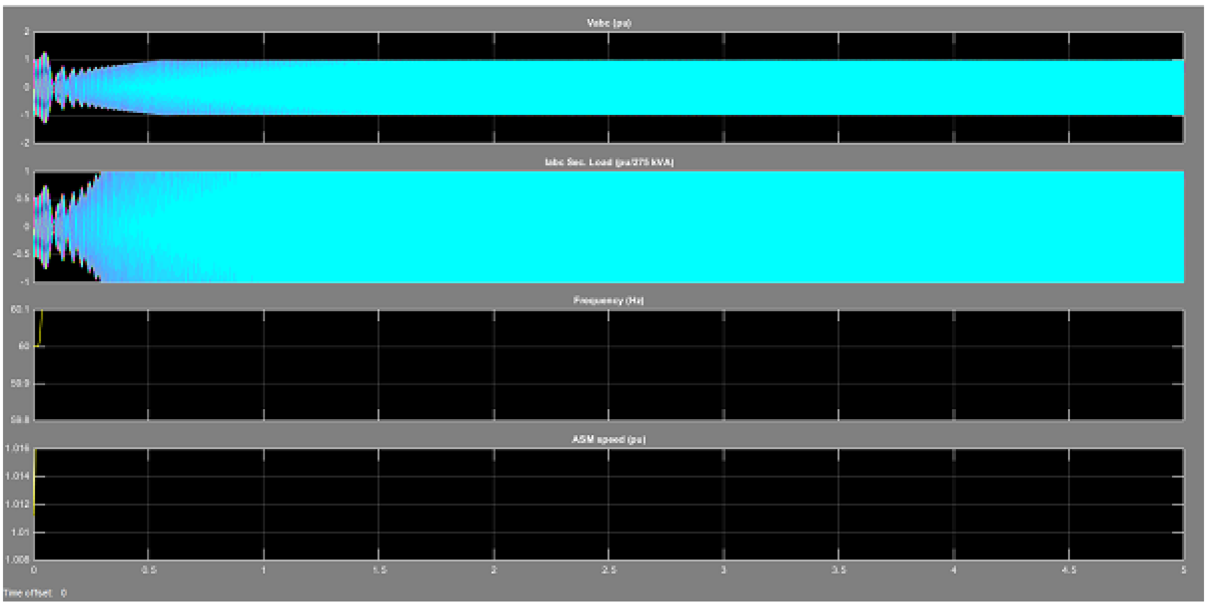


Figure 4.42: graph for Wind-speed 10 m/s Asynchronous Generator

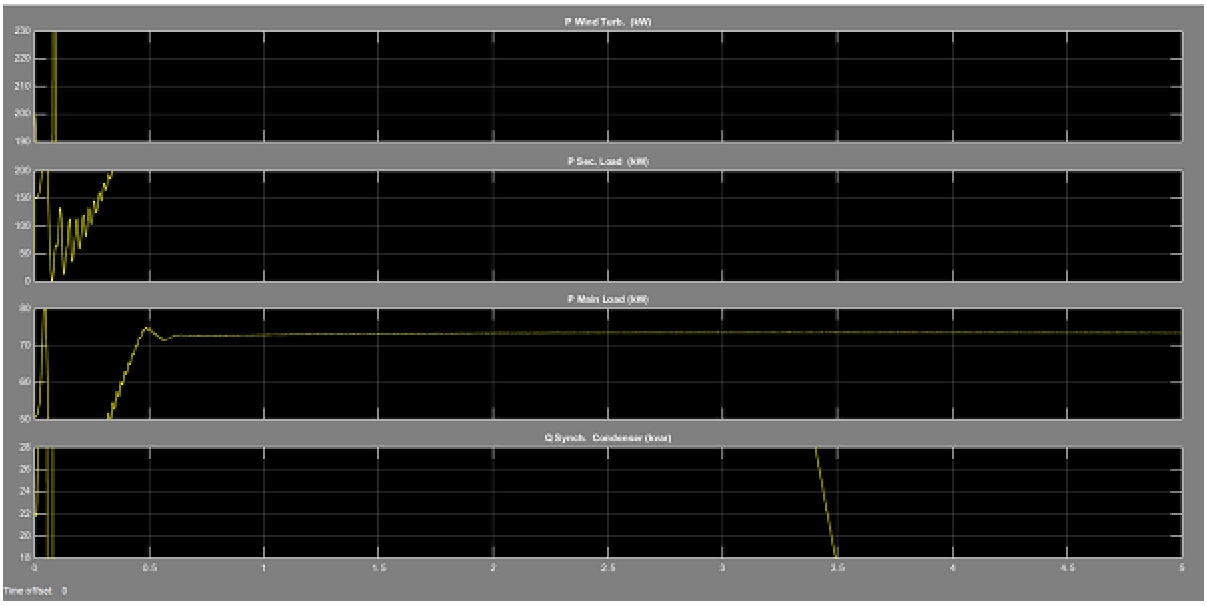


Figure 4.43: graph for Wind-speed 10 m/s Asynchronous Generator

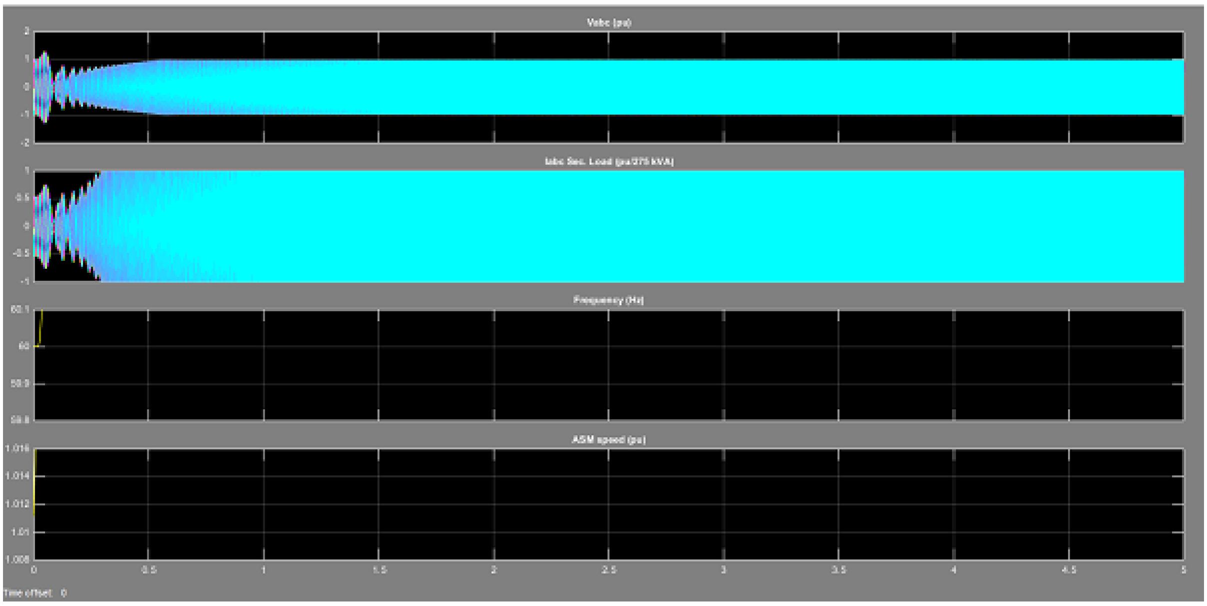


Figure 4.44: graph for Wind-speed 20 m/s Asynchronous Generator

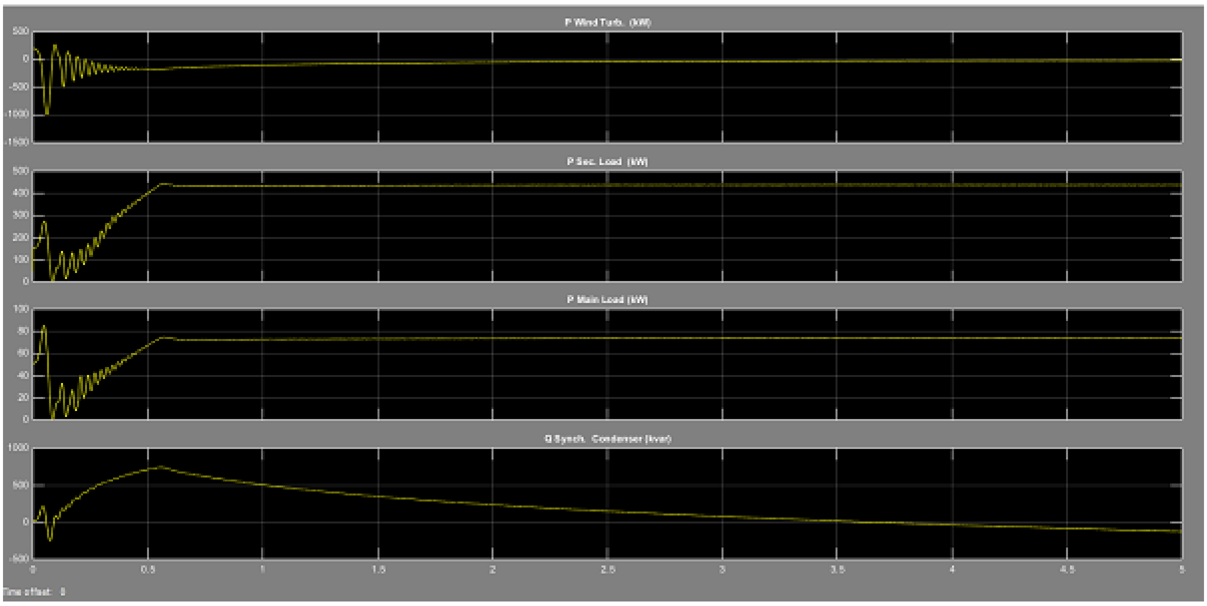


Figure 4.45: graph for Wind-speed 20 m/s Asynchronous Generator

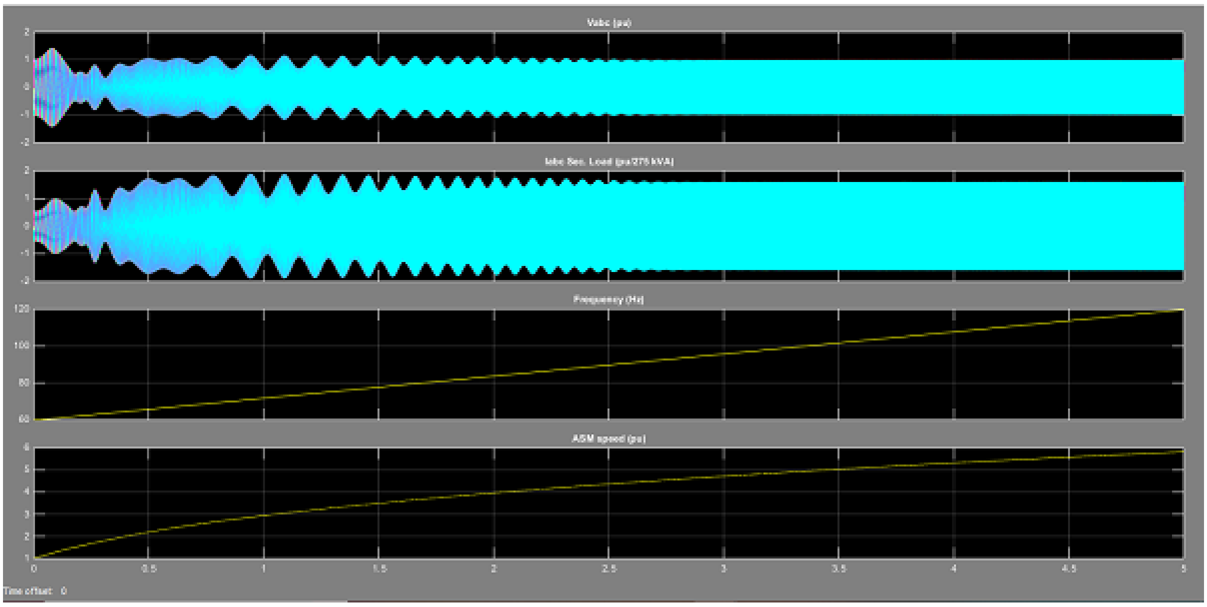


Figure 4.46: graph for Wind-speed 50 m/s Asynchronous Generator

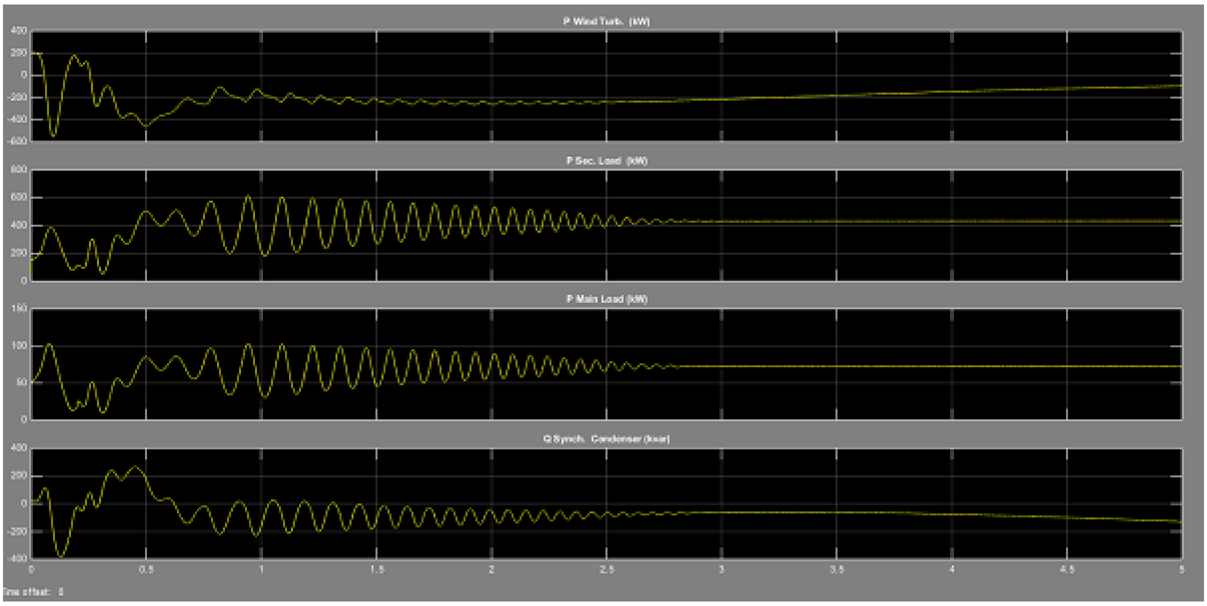


Figure 4.47: graph for Wind-speed 50 m/s Asynchronous Generator

Chapter 5

Conclusion

We can agree with wind turbine is more effect for green energy sources. Firstly, both wind turbines and solar panels are able to produce green power that can be stored and used in a household. Unlike fossil fuel burn, these green technologies don't produce waste or any greenhouse gas emissions; they are 100% clean and environmentally friendly. These solar panels and wind turbines are capable of producing big amounts of clean energy, and because of this fact, they are considered the best choice when switching on renewable resources. These devices are the best when you decide to lower the carbon footprint of your home i.e. to lower the quantity of fumes that are produced by your house and released into the atmosphere. The ideal scenario would be when fossil fuels are no longer used to power our planet, we use only green energy, and this way in just a few years our climate problems might disappear very quickly. Secondly, If you don't know what to choose between solar energy or wind turbines, simply check your area climate conditions. If you live in a windy area, you will be able to produce enough quantities of electricity with the help of your wind turbine. If you live in an area where wind is almost absent, you need to think seriously to purchase a solar panel system for the roof or for ground use. If you choose solar energy, you need to know that your area must receive direct exposure to the sun regularly; otherwise you will not be able to produce enough electricity to cover your needs. In this case a wind turbine system can be ideal, even if there is little wind in your living area. There are several wind turbine systems that work very well on slower winds. Also, your wind turbine can produce electricity even at night, unlike the solar panels that work only in daylight. Other important information to know is that the energy stored by solar panels in a solar battery system, is depleted very quick when your appliances that use electricity are used, so if you are able to produce enough solar energy even if you store it in a solar battery system you will remain without energy during the night. A wind turbine can produce energy non-stop so it can be a better choice. Some home wind turbine systems are also much cheaper if compared with solar panel systems. In Conclusion, The total costs with the purchase and the install of a wind turbine at home can be quite high. The prices for these devices are quite high at this moment just because they are still not very popular among homeowners and the manufacturers and the installation experts have not enough time at disposal to discover and develop these devices with less expensive materials. Having a wind turbine installed in your yard or on your roof can be quite expensive. But in the final, it will worth the price because you will suddenly discover how easy is to produce your own energy at home and you will receive lower energy bills from the utility companies.

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