PROJECT REPORT

ON

INTEGRATING MPPT AND BOOST CONVERTER WITH PV INVERTER FOR EFFICIENCY

B .TECH 6th SEMESTER ELECTRICAL ENGINEERING

Submitted by

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DECLARATION

We hereby certify that the work which is being presented in this project report entitled "Integrating MPPT and boost converter with PV inverter for efficiency maximization in MATLAB", in partial fulfillment of requirements for the 6th semester of degree of BACHELOR OF TECHNOLOGY in ELECTRICAL ENGINEERING, submitted to the Department of Electrical Engineering, Faculty of Engineering and Technology, J.C. Bose University of Science and Technology, YMCA, Faridabad, Haryana-121006 is an authentic record of our work carried out during period from JAN 2025to MAY 2025, under the supervision of Dr Shakuntla . We have not submitted the matter presented in this project report to any other University/Institute for the award of B.Tech. or any degree or diploma .

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CERTIFICATE

This is to certify that the project entitled "Integrating MPPT and boost converter with PV inverter for efficiency maximization in MATLAB" submitted to Department of Electrical Engineering, Faculty of Engineering and Technology, J.C. Bose University of Science and Technology, YMCA, Faridabad, Haryana-121006 by Dr Shakuntla in partial fulfilment of the requirement for the 6^{th} semester of degree of BACHELOR OF TECHNOLOGY in ELECTRICAL ENGINEERING, is a bonafide work carried out by them under my supervision and guidance. This project work comprises of original work and has not been submitted anywhere else for any other degree to the best of my knowledge.

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ACKNOWLEDGEMENT

We extend our sincerest gratitude to Dr Shakuntla for her invaluable guidance, steadfast support, and mentorship throughout the entirety of the “Integrating MPPT and boost converter with PV inverter for efficiency maximizatio in MATLAB”. Dr Shakuntla's profound expertise, meticulous feedback, and unwavering dedication were pivotal in shaping the trajectory and ultimate success of the endeavor.

Additionally, our appreciation is extended to JC BOSE UST for their provision of essential resources, conducive facilities, and enabling opportunities that greatly facilitated the seamless execution of the project.

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OBJECTIVE :

The primary objective of applying Maximum Power Point Tracking (MPPT) in a grid-tied inverter system is to ensure that the maximum possible power is consistently extracted from the photovoltaic (PV) array under varying environmental conditions such as solar irradiance and temperature. MPPT algorithms dynamically adjust the operating point of the PV system so that it matches the maximum power point (MPP) of the solar panels, thereby improving the overall energy harvesting efficiency and performance of the grid-connected solar power system.

1.Optimize Energy Harvesting: Solar irradiance and temperature fluctuate throughout the day, directly impacting the output characteristics of PV modules. MPPT ensures that the inverter adjusts its input parameters to extract the maximum available power at any given time, regardless of external conditions.

2. Improve Efficiency of Power Conversion: By continuously tracking and maintaining the operation of the PV system at the MPP, MPPT algorithms maximize the efficiency of DC-to-AC power conversion in the inverter, minimizing energy losses.

3. Enhance System Performance and ROI: Maximizing power extraction translates to more kilowatt-hours (kWh) sent to the grid. This increases the system's yield and improves the return on investment (ROI) for both residential and commercial grid-tied solar installations.

4. Ensure Compliance with Grid Standards: Grid-tied inverters must operate within strict voltage and frequency boundaries. MPPT helps the inverter maintain optimal power delivery without violating grid constraints, ensuring stable and reliable integration with the utility network.

5. Facilitate Real-Time Control and Monitoring: MPPT is often integrated with advanced digital controllers that enable real-time monitoring and diagnostics of system performance. This contributes to predictive maintenance and minimizes downtime.

6. Adapt to Partial Shading and Non-Uniform Conditions: In cases of partial shading, dust accumulation, or non-uniform illumination, MPPT algorithms can identify local maxima and attempt to find the global MPP, thus minimizing energy loss due to mismatch conditions in PV arrays.

The primary objective of this project is to design, develop, and implement a Maximum Power Point Tracking (MPPT) system using the Incremental Conductance (IC) algorithm integrated with a grid-tied inverter, in order to maximize the energy extraction from a photovoltaic (PV) array and ensure efficient, stable, and synchronized delivery of electrical power to the utility grid.

This project aims to address the critical challenge of power optimization in PV systems, which is often hindered by continuously changing environmental conditions such as solar irradiance, ambient temperature, and partial shading. These factors significantly influence the output voltage and current characteristics of PV modules, thereby affecting their ability to operate at the Maximum Power Point (MPP). Failure to track the MPP accurately leads to substantial energy losses and reduces the overall efficiency of the solar power system.

To overcome this limitation, the project focuses on the Incremental Conductance MPPT algorithm, known for its superior precision and adaptability in real-time conditions. Unlike conventional methods such as Perturb and Observe (P&O), the IC method compares the incremental and instantaneous conductance of the PV array to accurately identify the MPP and dynamically adjust the operating point, thus minimizing power loss and steady-state oscillations.

The implementation will be carried out in a grid-tied configuration, where the inverter converts the DC power generated by the PV array into AC power and injects it into the utility grid. In this context, the project also aims to ensure efficient DC-to-AC power conversion with minimum harmonic distortion, grid synchronization, including phase matching and voltage level compatibility.

By achieving these objectives, the project contributes to the development of a more intelligent, efficient, and sustainable grid-connected solar energy system, capable of supporting the global transition toward cleaner energy sources and decentralized power generation.

ABSTRACT :-

The growing demand for clean and sustainable energy has led to increased reliance on photovoltaic (PV) systems as a key source of renewable power. However, the efficiency of solar energy conversion is significantly influenced by external environmental conditions such as solar irradiance and temperature, which cause continuous fluctuations in the output characteristics of PV panels. To address this challenge, Maximum Power Point Tracking (MPPT) techniques are implemented to ensure that the PV system consistently operates at its optimal power point. This project focuses on the design and implementation of the Incremental Conductance (IC) MPPT algorithm in a grid-tied inverter system, with the objective of maximizing energy extraction and improving system performance.

The Incremental Conductance method is chosen for its superior accuracy and dynamic response under rapidly changing environmental conditions. Unlike conventional MPPT techniques, such as Perturb and Observe (P&O), the IC algorithm calculates the derivative of the PV power with respect to voltage to determine the direction toward the Maximum Power Point (MPP). By comparing the incremental conductance (dI/dV) with the instantaneous conductance (I/V), the algorithm accurately tracks the MPP and reduces steady-state oscillations, resulting in higher tracking efficiency and better stability.

In this project, the IC algorithm is integrated into the control system of a grid-connected inverter, which converts the DC output of the PV array into AC power compatible with the utility grid. The implementation ensures seamless synchronization with the grid while maintaining real-time MPPT operation. The system is simulated and tested under various irradiance and temperature profiles to evaluate its performance. Key metrics such as power tracking efficiency, convergence speed, and grid compliance are analyzed to validate the effectiveness of the IC method.

The results demonstrate that the Incremental Conductance MPPT algorithm provides reliable and efficient tracking of the maximum power point, even under rapidly changing weather conditions. Its integration with a grid-tied inverter contributes to optimal energy utilization, reduced power losses, and enhanced overall system efficiency.

BLOCK DIAGRAM:-

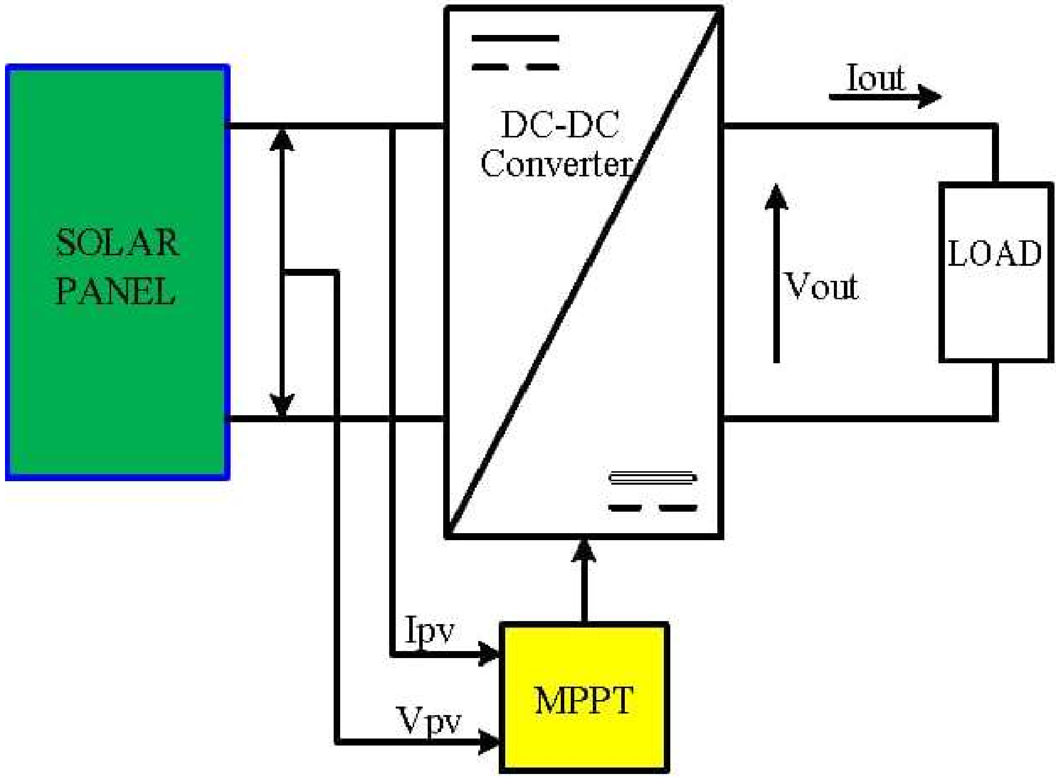


Figure 1

The system consists of a solar panel, a DC-DC converter, an MPPT control block, and a grid-tied inverter. The solar panel generates variable DC power depending on sunlight. The MPPT block (using the Incremental Conductance algorithm) continuously monitors the panel's voltage and current to find the Maximum Power Point (MPP).The MPPT output controls the DC-DC converter (usually a boost converter), adjusting its duty cycle to keep the panel operating at the MPP. The regulated DC power is fed into the grid-tied inverter, which converts it into AC power synchronized with the utility grid. This setup ensures maximum power extraction from the solar panel and efficient delivery of electricity to the grid

STIMULATION DIAGRAM:

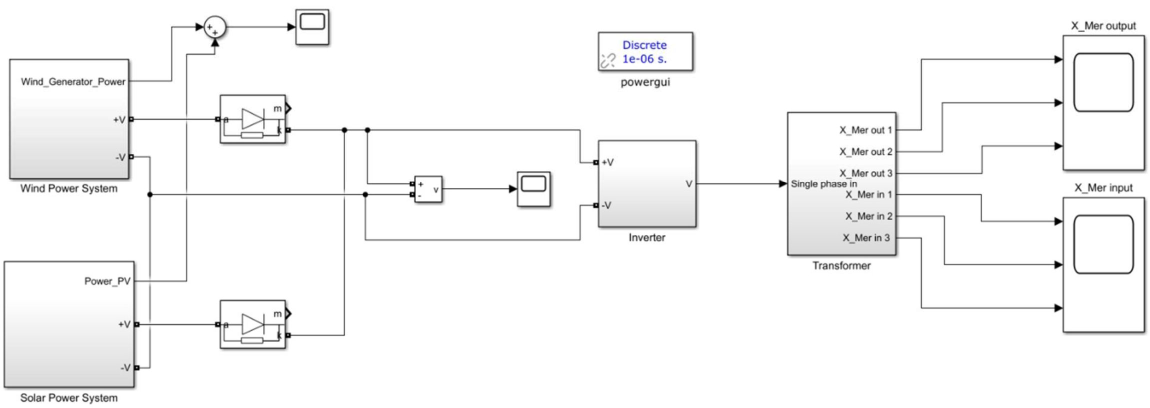


Figure 2

Solar power system:

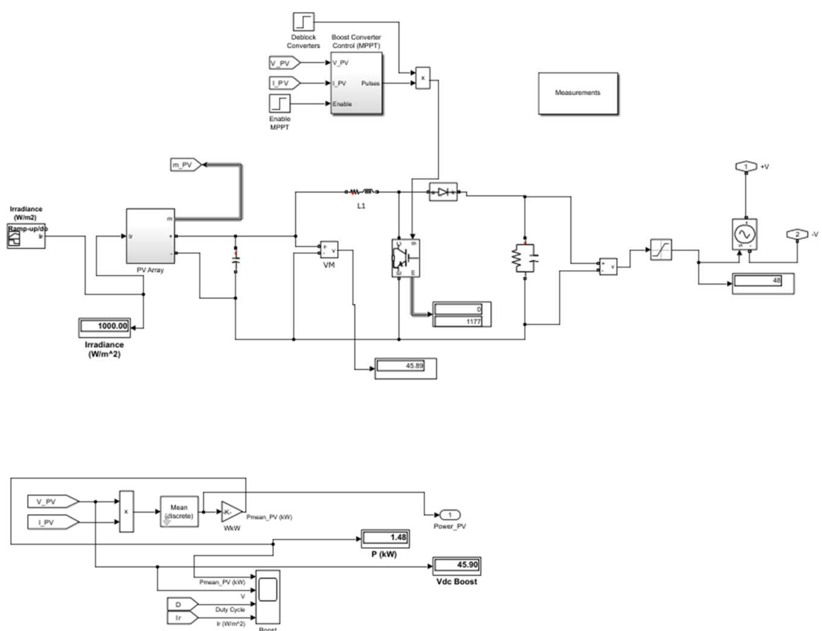


Figure 3

The Solar Power Subsystem in an MPPT and boost converter integration project represents the photovoltaic (PV) panel that converts sunlight into electrical energy. This subsystem typically includes a solar cell or array model that simulates the I-V and P-V characteristics of real PV panels under varying irradiance and temperature conditions. It provides the raw DC voltage and current as output, which varies with environmental conditions. This output is then fed into the MPPT algorithm to determine the optimal operating point and into the boost converter to regulate the voltage. The Solar Power Subsystem is the primary energy source of the system and plays a critical role in demonstrating the impact of MPPT and power conversion on overall efficiency

PV array subsystem :

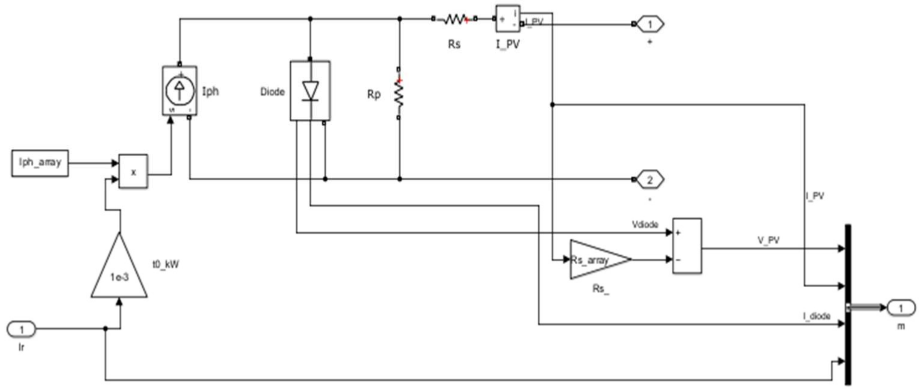


Figure 4

The PV Array Subsystem models the electrical behavior of a photovoltaic panel or a group of panels connected in series and parallel. It simulates how the array responds to different levels of solar irradiance and temperature, producing a DC output voltage and current that varies with these conditions. The subsystem uses mathematical equations to represent the non-linear I-V and P-V characteristics of real solar cells. This output is used by the MPPT algorithm to track the maximum power point and by the boost converter to regulate voltage. Overall, the PV Array Subsystem serves as the heart of the solar generation system, providing the variable input power that drives the rest of the model.

Boost control converter subsystem:

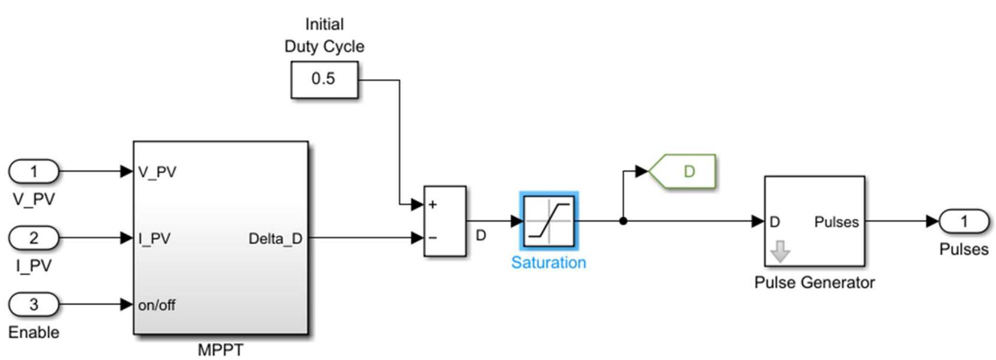


Figure 5

The Boost Control Converter Subsystem is responsible for stepping up the variable DC voltage from the PV array to a higher, more stable DC voltage suitable for the load or grid connection. It consists of components like an inductor, switch (typically a MOSFET), diode, and output capacitor, forming a boost converter circuit. This subsystem operates based on the duty cycle signal generated by the MPPT algorithm, which controls the switching of the MOSFET. By adjusting the on and off times of the switch, the boost converter regulates the output voltage to ensure efficient power transfer while maintaining the

PV array at its maximum power point. This subsystem is crucial for voltage regulation and overall energy efficiency in the system

<u>Wind power system:</u>

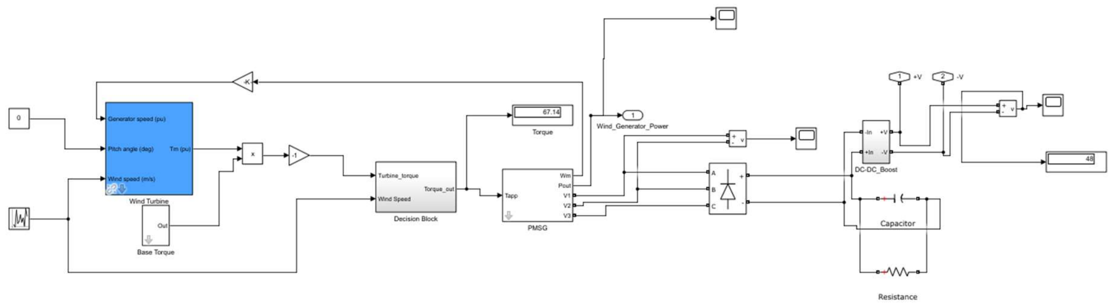


Figure 6

The Wind Power System subsystem models the generation of electrical power from wind energy, typically using a wind turbine connected to a permanent magnet synchronous generator (PMSG) or similar type. This subsystem converts the kinetic energy of the wind into mechanical energy through the turbine blades, which is then transformed into electrical energy by the generator. The output is often variable-frequency AC, which is rectified into DC for compatibility with the rest of the system. In hybrid renewable energy systems, the wind power subsystem complements the solar PV system by providing additional power, especially during low-sunlight periods. It enhances the reliability and stability of the overall energy generation by harnessing wind energy in varying environmental conditions.

DC-DC boost converter subsystem in wind power system :

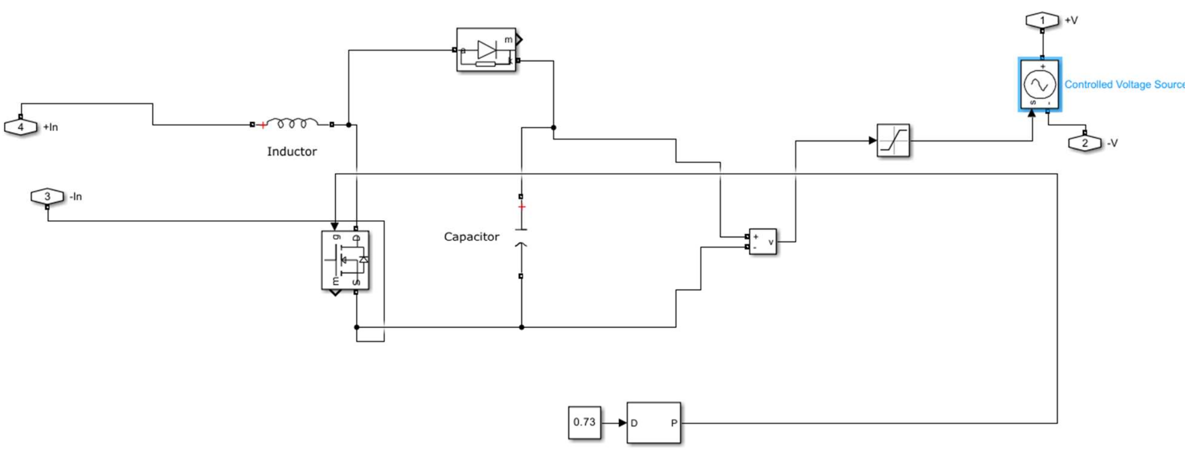


Figure 7

Figure : The DC-DC Boost Converter Subsystem in the Wind Power System is designed to regulate and increase the variable DC voltage output from the wind turbine's rectifier to a stable, higher DC voltage level suitable for storage or load use. After the AC output of the wind generator is rectified to DC, this voltage can still fluctuate depending on wind speed. The boost converter ensures a consistent voltage by adjusting the duty cycle of its switching device (typically a MOSFET), controlled either by a fixed logic or an MPPT algorithm tailored for wind. The converter uses an inductor, diode, switch, and output capacitor to transfer and store energy efficiently. This subsystem is essential for maintaining power quality and optimizing energy transfer from the wind source.

Decision block subsystem:

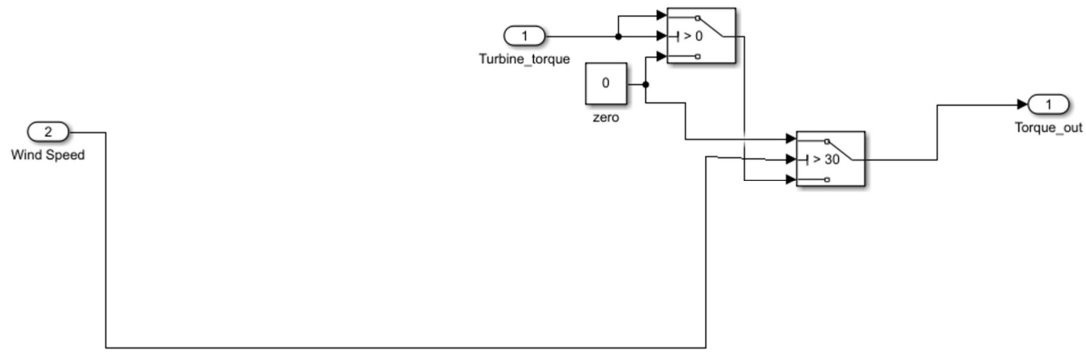


Figure 8

The Decision Block Subsystem plays a critical role in managing power flow between multiple energy sources, such as solar and wind, in a hybrid renewable energy system. Its primary function is to monitor the output parameters (like voltage, current, or power) from the solar and wind systems and determine which source should supply power to the load or battery at a given moment. Based on predefined conditions or thresholds—such as available irradiance, wind speed, or power output—it activates or prioritizes one source over the other, or allows both to work simultaneously. This intelligent switching or selection ensures optimal energy utilization, system reliability, and continuous power delivery, making the Decision Block Subsystem a key component for efficient hybrid energy management.

Inverter system:

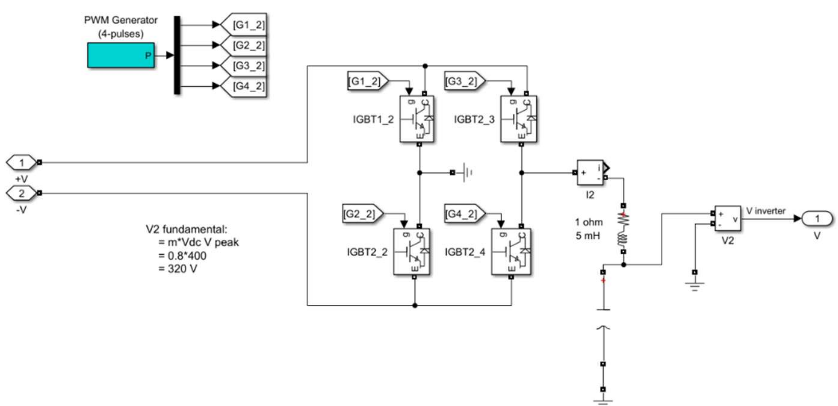


Figure 9

The Inverter System subsystem is responsible for converting the regulated DC voltage, obtained from the boost converters of the solar and wind systems, into AC voltage suitable for powering AC loads or for grid integration. It typically consists of power electronic switches (like IGBTs or MOSFETs) arranged in a bridge configuration and controlled using PWM (Pulse Width Modulation) techniques to generate a sinusoidal AC output. The inverter ensures the output voltage has the correct amplitude, frequency, and phase, matching the requirements of the connected load or the grid. In hybrid renewable systems, the inverter also helps in synchronizing multiple sources and maintaining power quality. This subsystem is essential for delivering usable AC power from DC renewable sources.

Transformer system:

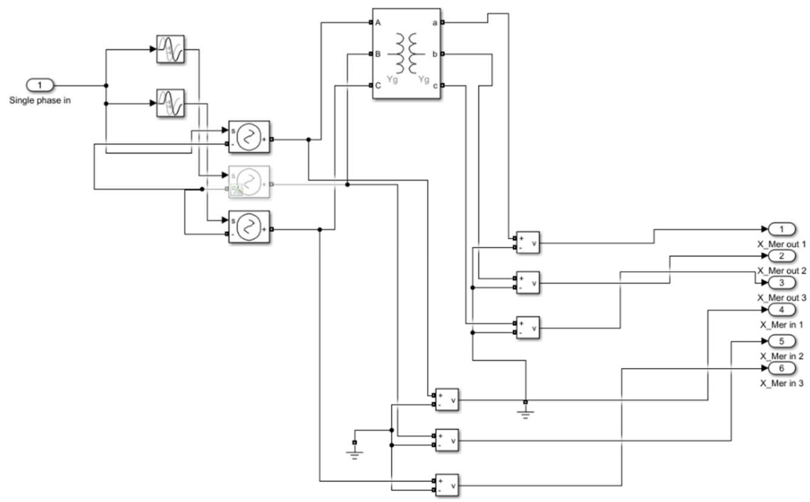


Figure 10

The Transformer System subsystem is used to step up or step down the AC voltage output from the inverter to match the voltage level required by the load or for grid connection. It typically consists of a two-winding transformer model that operates based on electromagnetic induction, transferring electrical energy between its primary and secondary coils. In renewable energy systems, this transformer ensures safe and efficient voltage matching, provides isolation between the inverter and the load or grid, and helps in reducing transmission losses when power needs to be delivered over longer distances. The Transformer System is crucial for voltage regulation, electrical isolation, and enhancing the overall stability and safety of the power system.

LITERATURE :-

The integration of photovoltaic (PV) arrays with the power grid has been extensively studied, driven by the global shift toward sustainable energy solutions. The mppt algorithm emphasizes the critical role of control strategies and optimization algorithms in ensuring efficient energy harvesting and stable grid interaction. Main objectives of grid integration are as follow:

1. Photovoltaic Systems and Grid Integration : PV systems have been widely recognized for their potential to meet global energy demands sustainably. Studies highlight the challenges posed by their intermittent nature due to environmental variations such as irradiance and temperature. Researchers have focused on improving the reliability and efficiency of grid-connected PV systems through advanced power electronics and robust control techniques.

2. Maximum Power Point Tracking (MPPT) Algorithms: MPPT algorithms are pivotal in optimizing the performance of PV systems. Techniques such as Perturb and Observe (P&O), Incremental Conductance (INC), and Fuzzy Logicbased MPPT have been analysed for their efficiency and adaptability. According to T. Esram and P.L. Chapman (2007), MPPT ensures that the PV array operates at its maximum power output, irrespective of external conditions, making it a cornerstone of modern PV system design.

3. PI Controllers in Grid Integration: Proportional-Integral (PI) controllers have been extensively used in grid-connected PV systems for their simplicity and effectiveness in maintaining stability. Researchers like B. Singh et al. (2011) have demonstrated that PI controllers ensure smooth voltage regulation and synchronization with the grid, reducing harmonic distortions and enhancing overall system reliability.

4. Hybrid Control Systems: The combination of MPPT algorithms with PI controllers has been explored in recent studies as an effective hybrid approach. Research has shown that this integration enhances the adaptability of PV systems to dynamic grid conditions and improves energy utilization efficiency.

5. Renewable Energy and Smart Grids: The advent of smart grids has provided new opportunities for integrating renewable energy , intelligent grid systems, combined with advanced control techniques, allow for better demand-side management and seamless integration of distributed energy resources like PV arrays

To overcome these challenges and maximize energy extraction, Maximum Power Point Tracking (MPPT) techniques have become a critical part of PV system design. In particular, grid-tied PV systems—which are directly connected to the utility grid—rely heavily on MPPT algorithms to optimize energy flow, ensure grid compatibility, and support broader energy distribution objectives such as net metering and grid stability. In today's context of smart grids and growing penetration of distributed renewable sources, accurate and dynamic MPPT methods are essential not only for maximizing power output but also for ensuring economic viability, system reliability, and regulatory compliance. Among various MPPT strategies, the Incremental Conductance (IC) algorithm is regarded as one of the most effective, especially under rapidly changing environmental conditions.

By continuously comparing the instantaneous conductance (I/V) with the incremental conductance (dI/dV), the IC algorithm accurately determines the direction in which the operating voltage should be adjusted to reach and maintain the MPP.

Unlike simpler methods such as Perturb and Observe (P&O), which can be misled by transient changes in irradiance and may oscillate around the MPP, the IC method offers greater precision, faster convergence, and lower steady-state error. This makes it ideal for real-time applications in grid-tied inverters, where stable and efficient power delivery is essential.

COMPONENTS :-

Wind turbine block : is used to simulate the mechanical power generation of a wind turbine based on wind speed input. It models the aerodynamic behaviour of the turbine and outputs mechanical torque and rotor speed, which can be fed into a generator model like a DFIG or PMSG. Key parameters such as blade radius, air density, and power coefficient define the turbine's performance. This block helps in analysing wind energy systems and integrating them with power electronics and grid models in renewable energy simulations.

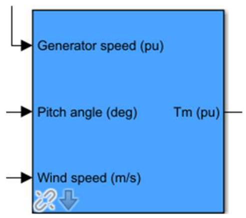


Figure 11

Decision block : is typically used within the State flow environment to model decision-making logic based on conditions and events. It allows you to define how a system should behave depending on various inputs, often used in control systems, automation, and embedded applications. The block evaluates logical conditions and determines which path or action to take next. It is essential for implementing if-else, switch-case, or event-driven logic and is often used in MPPT algorithms, fault detection, or controller switching in renewable energy systems.

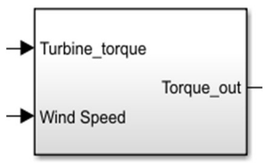


Figure 12

PMSG :

Figure 13

is used to model a synchronous generator with permanent magnets. It converts mechanical power (from a wind turbine, for example) into electrical power without requiring an external excitation system.

Inputs: Mechanical torque and shaft speed

Outputs: Three-phase AC electrical output

Applications: Wind turbines (Type-4), marine generators, and electric vehicles

UNIVERSAL : The Universal Bridge block in MATLAB/Simulink is a flexible and widely used component from the Simscape Electrical library, designed to model various power electronic converters such as rectifiers, inverters, and choppers. It can be configured with different types of semiconductor devices like diodes, thyristors, IGBTs, or MOSFETs, and supports both single-phase and three-phase topologies. The block receives gating signals to control the switching of the power devices and facilitates the conversion between AC and DC power. It is commonly used in renewable energy applications, such as grid-tied PV systems, where it functions as the inverter that converts DC power from solar panels into AC power for grid integration. Its versatility makes it essential for simulating and analyzing power conversion in modern electrical systems.

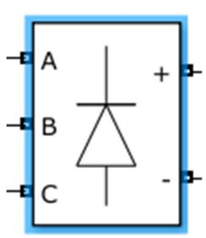


Figure 14

SATURATION BLOCK The Saturation block in MATLAB/Simulink is used to limit a signal within a specified upper and lower bound. It ensures that the output of a system does not exceed defined physical or safety constraints, which is especially important in control systems where variables like voltage, current, or speed must stay within safe operating limits. When the input signal goes beyond the set limits, the block "saturates" the output to the nearest bound. This block is essential in power electronics, MPPT algorithms, and motor control applications to prevent unrealistic or damaging signal values, ensuring more stable and reliable simulations

Figure 15

PWM GENERATOR BLOCK : The PWM Generator block in MATLAB/Simulink is used to produce pulse-width modulated (PWM) signals, which are essential for controlling power electronic devices like IGBTs and MOSFETs in converters and inverters. The block generates a PWM signal by comparing a reference signal (usually from a controller or MPPT algorithm) with a carrier waveform, typically a sawtooth or triangular wave. The duty cycle of the output determines how long the switch stays on during each cycle, thereby controlling the output voltage or current of a DC-DC converter or inverter. This block is crucial in applications such as solar PV systems, motor drives, and power management circuits, enabling precise control of power flow and system performance.

Figure 16

CONTROLLED VOLTAGE SOURCE :

The Controlled PWM Voltage block represents a pulse-width modulated (PWM) voltage source. It is possible to model electrical or physical signal input ports by setting the Modeling option parameter to either between

output low states:

Figure 17

MOSFET : The MOSFET (Metal-Oxide-Semiconductor Field-Effect Transistor) block in MATLAB/Simulink is a key component used to simulate switching behavior in power electronic circuits. It acts as a controlled switch that can rapidly turn on and off in response to a gate signal, allowing efficient control of voltage and current in converters, inverters, and other electronic systems. MOSFETs are widely used in DC-DC converters and PWM-based circuits due to their high switching speed and low conduction losses. In Simulink, the MOSFET block accurately models both the electrical and thermal characteristics, making it ideal for analyzing performance, efficiency, and thermal stress in renewable energy and power electronics simulations.

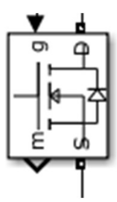


Figure 18

DC-DC BOOST CONVERTER:

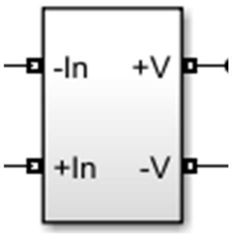


Figure 19

The D-Boost Converter (also known simply as a boost converter) in MATLAB/Simulink is modeled using basic power electronic components such as an inductor, diode, switch (typically a MOSFET or IGBT), and a capacitor. It is a type of DC-DC converter that steps up a lower input DC voltage to a higher output DC voltage. The switching of the MOSFET is controlled using a PWM signal, often generated by an MPPT controller in renewable energy applications like solar PV systems. In Simulink, this converter is essential for regulating the PV panel output to a suitable level for further processing, such as feeding into an inverter or battery system. The boost converter's behavior can be analyzed in terms of efficiency, response to dynamic loads, and interaction with control algorithms within the simulation environment**.**

CONTROLLED CURRENT SOURCE:-

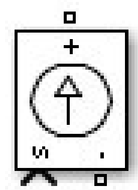


Figure 20

The Controlled Current Source block converts the Simulink input signal into an equivalent current source. The generated current is driven by the input signal of the block. It can be initialized with a specific AC or DC current. If there is a need to start the simulation in steady state, the block input must be connected to a signal starting as a sinusoidal or DC waveform corresponding to the initial values.

IGBT:

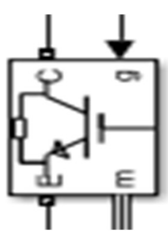


Figure 21

The IGBT (Insulated Gate Bipolar Transistor) block in MATLAB/Simulink models a semiconductor device widely used in power electronics for switching and amplification. Combining the high input impedance of a MOSFET with the high current and low saturation voltage capabilities of a bipolar transistor, the IGBT is ideal for high-power applications like inverters, motor drives, and renewable energy systems. In Simulink, the IGBT block simulates the device's switching behaviour, including turn-on and turn-off times, losses, and conduction characteristics. It plays a crucial role in controlling power flow efficiently and reliably in converters and grid-tied inverter systems

INVERTER

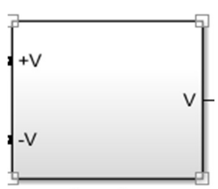


Figure 22

The Inverter block in MATLAB/Simulink is used to convert direct current (DC) from sources like solar panels or batteries into alternating current (AC) suitable for powering loads or feeding into the utility grid. It typically uses power electronic switches such as IGBTs or MOSFETs controlled by PWM signals to generate a sinusoidal AC output with the desired frequency and voltage. In renewable energy systems, the inverter ensures efficient power conversion while maintaining synchronization with the grid, controlling power quality, and meeting grid standards. This block is essential for simulating the operation and performance of grid-tied or standalone AC power systems.

TRANSFORMER

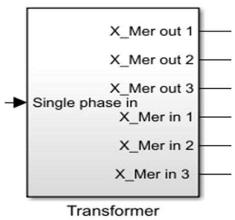


Figure 23

The Transformer block in MATLAB/Simulink models an electrical transformer used to step up or step down AC voltages in power systems. It simulates the magnetic coupling between primary and secondary windings, allowing voltage transformation while maintaining power balance (ignoring losses in ideal models). Transformers are essential components for matching voltage levels between generation sources, transmission lines, and loads. In renewable energy and grid-connected systems, the transformer block helps analyze voltage regulation, isolation, and power flow, playing a key role in integrating distributed energy resources with the utility grid.

CONSTANT BLOCK :-

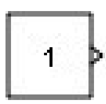


Figure 24

The Constant block generates a real or complex constant value signal. This block is used to provide a constant signal input. The block generates scalar, vector, or matrix output, depending on dimensionality of the Constant value parameter and setting of the Interpret vector parameters as 1-D parameter.The output of the block has the same dimensions and elements as the Constant value parameter.

SCOPE :-

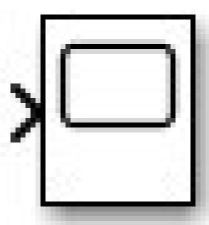
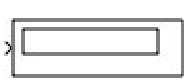


Figure 25

Scope block is a visualization tool used to display and analyze simulation results in real time or post simulation. During simulation, the scope block continuously plots signals in real time as they are computed by simulation model, after simulation, the scope block retains the plotted signals, allowing users to review and analyze simulation results. The scope block can display multiple signals simultaneously which enables the comparison and correlation between different variables and system responses . so , the scope block serves as a valuable tool for visualizing , analyzing , and validating simulation results .

DISPLAY:-



The Display block connects to a signal in the model and displays its value during simulation. Its possible to edit the parameters of the Display block during simulation. The Display block can display complex, vector, and 2-D matrix signals.

Figure 26

BUS SELECTOR :-

Figure 27

The Bus Selector block extracts the elements that are selected by name from the input bus hierarchy. The block can output the selected elements separately or in a new virtual bus. When the block outputs the selected elements separately, each selected element corresponds to an output port. When the block outputs a new virtual bus, the block has one output port for the virtual bus that contains each selected element.

While multiple elements can have the same name in different locations in the bus hierarchy, each element has a unique fully qualified name that the Bus Selector block uses.

GAIN:

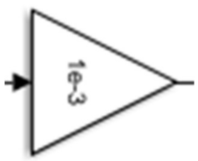


Figure 28

the Gain block is used to scale or adjust signals—typically the duty cycle signal generated by the MPPT algorithm—before applying it to the PWM control or pulse generation circuit. It ensures that the calculated duty cycle (often a normalized value between 0 and 1) is properly scaled to match the requirements of the Pulse Generator or the switching control logic. This helps maintain correct switching behaviour of the boost converter, allowing it to efficiently adjust the output voltage in real time and track the maximum power point of the solar panel.

DIODE :- Diode block plays a key role in the boost converter circuit by allowing current to flow only in one direction—from the inductor to the output—while preventing reverse current flow. When the switch (MOSFET) is turned off, the energy stored in the inductor is released through the diode to the output capacitor and load. This unidirectional behaviour is essential for proper voltage boosting and maintaining continuous power flow, contributing to efficient energy conversion and stable operation of the MPPT-controlled system.

Figure 29

PRODUCT:-

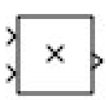


Figure 30

The Product block outputs the result of multiplying two inputs: two scalars, a scalar and a non scalar, or two non scalars that have the same dimensions.

PULSE GENERATOR : the Pulse Generation block is responsible for creating the PWM signal that controls the switching of the boost converter's MOSFET. It uses the duty cycle value calculated by the MPPT algorithm to modulate the width of the pulses, effectively regulating the on-off timing of the switch. This dynamic control enables the converter to adjust the output voltage in real-time, ensuring the solar panel operates at its maximum power point for optimal energy efficiency.

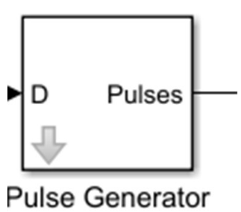


Figure 31

EXPECTED RESULTS;-

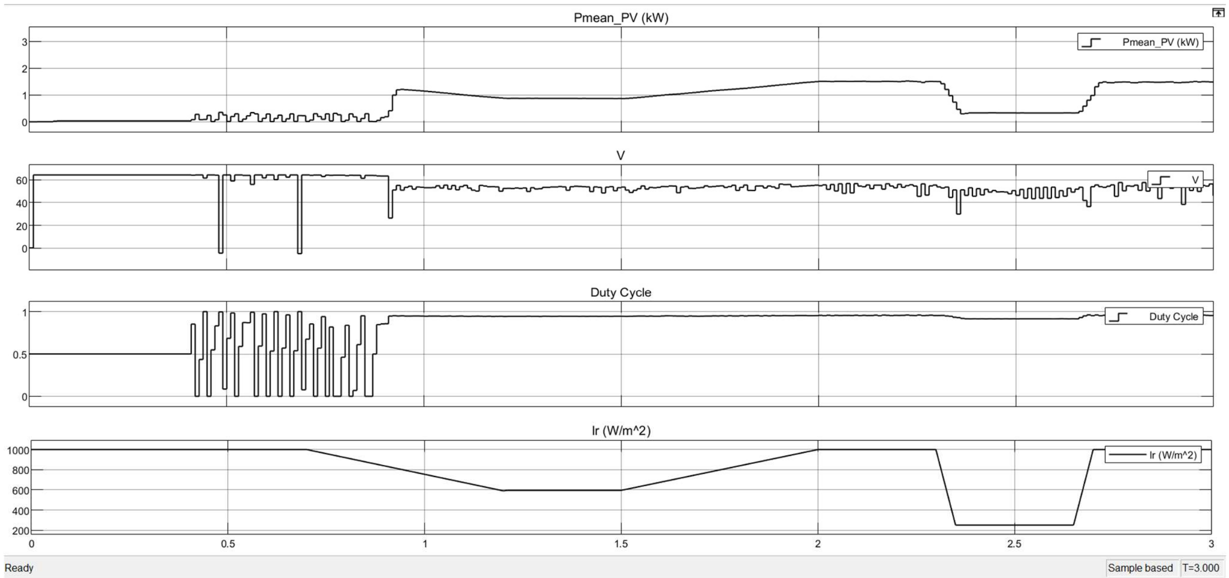


Figure 32

Figure-32 : illustrates the core operation of your MPPT-boost converter system under varying irradiance conditions. The bottom plot shows the solar irradiance (Ir), which changes over time. Correspondingly, the PV voltage (V) and the mean PV power (Pmean_PV) fluctuate. Notice how the duty cycle of the boost converter adjusts in response to these changes, particularly when the irradiance drops and then recovers. The MPPT algorithm is actively changing the duty cycle to ensure the PV system operates at its maximum power point for each irradiance level.

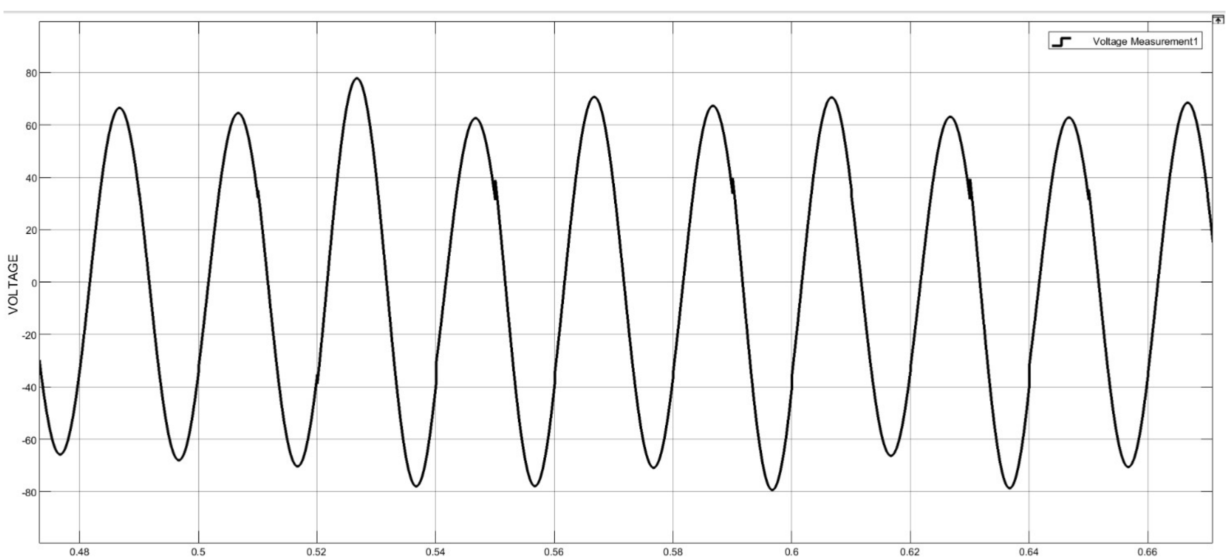


Figure 33

Figure-33: presents a single-phase voltage waveform, possibly at the output of an inverter stage after the DC boosted by the converter. The sinusoidal nature indicates AC power, and the variations in amplitude might be due to load changes or the control strategy of the inverter.

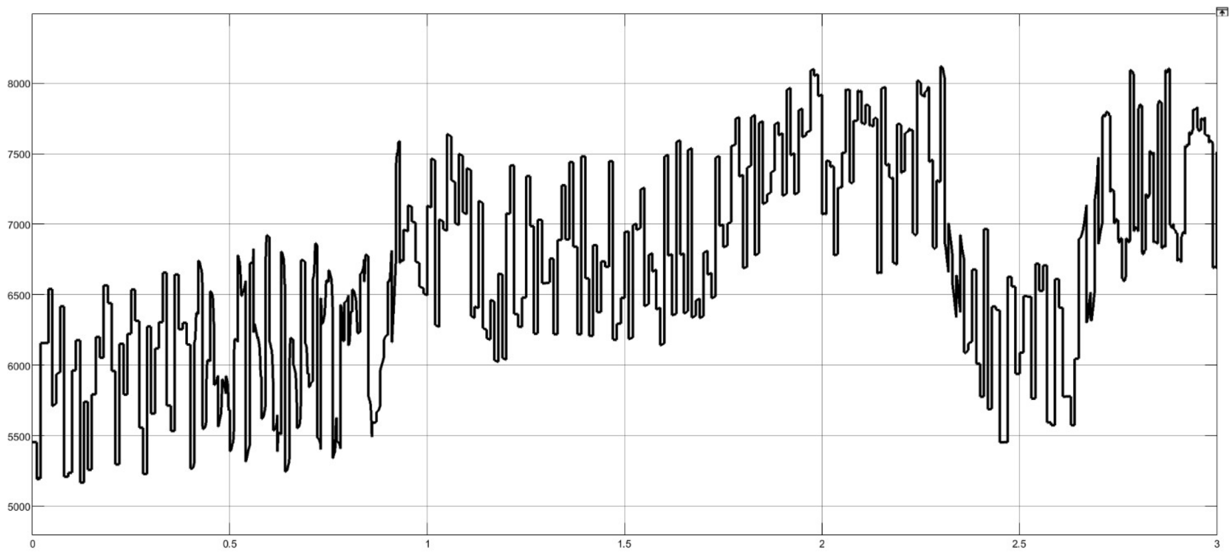


Figure 34

Figure -34 : Represents the fluctuating nature of the waveform suggests it could be the instantaneous power output, possibly showing the ripple component or variations due to the switching of the converter and inverter stages, as well as changes in the input power from the PV array.

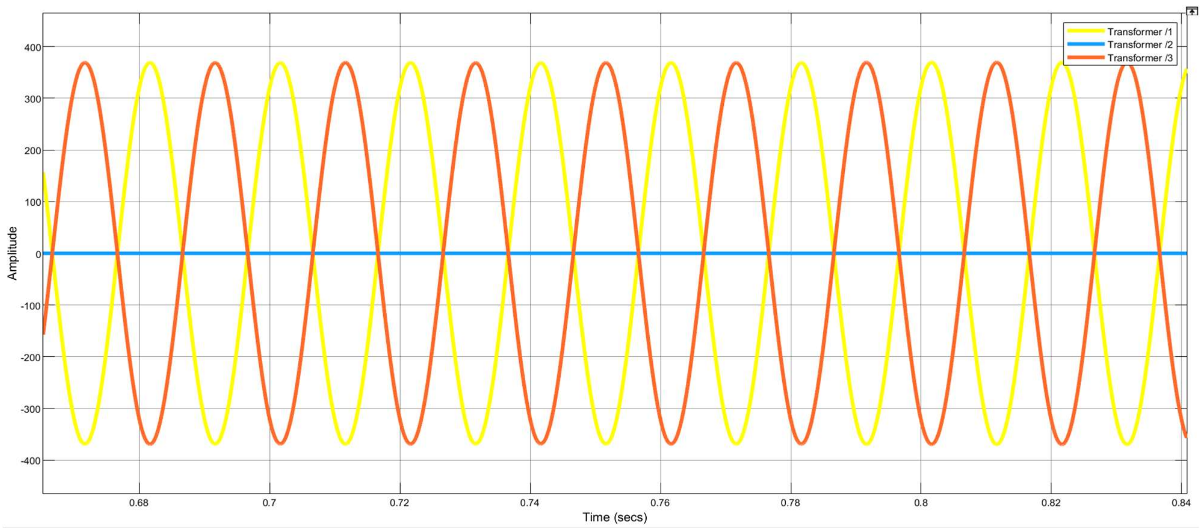


Figure 35

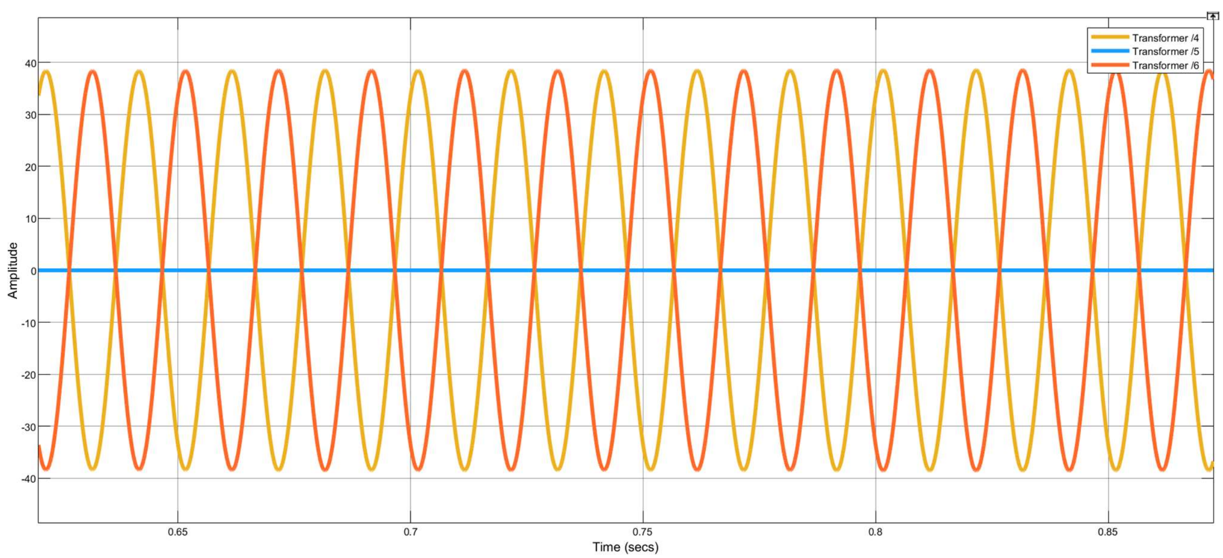


Figure 36

Fig-35 and Fig-36 appear to show the output waveforms of three-phase transformers at different points in your system. In Image 2, the transformer outputs (Transformer 1, 2, and 3) exhibit balanced sinusoidal waveforms with a significant amplitude. Image 3 also shows balanced sinusoidal waveforms (Transformer 4, 5, and 6), but with a much smaller amplitude compared to Image 2. These graphs likely represent different voltage or current levels at various stages after the boost converter and potentially an inverter stage if you're interfacing with a grid or AC load.

ADVANTAGES :-

A. Enhanced System Performance and Control:

Optimal Impedance Matching: The MPPT algorithm dynamically adjusts the operating point of the PV array to ensure the impedance seen by the array matches its internal impedance at the MPP. This maximizes power transfer to the boost converter.

Reduced Power Losses: By operating closer to the MPP, the system minimizes the power wasted due to operating at non-optimal voltage and current levels of the PV array.

Stable Output Voltage: The boost converter, with proper control, provides a stable and regulated DC output voltage suitable for various loads or battery charging, despite variations in the PV input.

Fast Response to Environmental Changes: Advanced MPPT algorithms implemented in MATLAB can quickly track rapid changes in irradiance (e.g., due to passing clouds), ensuring the system remains close to the MPP.

Potential for Advanced Control Strategies: MATLAB facilitates the implementation of sophisticated MPPT techniques like Incremental Conductance, Perturb & Observe with adaptive step size, or even AI-based methods, which can offer improved tracking efficiency and robustness compared to simpler algorithms.

B. Benefits Specific to MATLAB Simulation:

Detailed Component Modeling: MATLAB allows for the creation of detailed models of PV panels (including temperature effects, non-linear I-V curves), boost converter components (inductor saturation, MOSFET characteristics, diode voltage drop), and MPPT algorithms. This leads to more realistic simulation result.

C. System-Level Advantages:

Wider Range of Applications: The boosted and regulated DC output allows the PV system to be used with a wider variety of DC loads or to efficiently charge batteries with higher voltage requirements than the PV array itself might directly provide.

D. Potential for Grid-Tied Inverters:

The stable DC output from the boost converter is a crucial intermediate stage for connecting a grid-tied inverter, ensuring efficient and stable AC power injection into the grid.

Scalability and Flexibility: MATLAB simulations can help in analyzing the performance of larger PV systems with multiple panels and boost converters controlled by a central MPPT or distributed MPPTs.

By including these additional advantages in your project report, you can provide a more comprehensive picture of the benefits of integrating MPPT and a boost converter for maximizing the efficiency of a PV system using MATLAB as a powerful simulation and design tool.

DISADVANTAGES:-

A. Increased System Complexity and Cost:

More Components: Integrating an MPPT controller adds to the overall component count compared to a simple direct connection of the PV panel to the load. This includes the microcontroller or dedicated MPPT IC, sensing circuitry (voltage and current sensors), and potentially more complex gate driving circuitry for the boost converter.

Increased System Cost: The additional components and the more sophisticated control circuitry lead to a higher initial system cost.

More Complex Control Design: Designing and implementing an effective MPPT algorithm and the associated control for the boost converter requires a deeper understanding of power electronics and control theory. This can increase development time and effort.

B. Potential for Losses and Reduced Reliability:

Switching Losses in the Boost Converter: The switching action of the MOSFET and diode in the boost converter introduces switching losses, which can reduce the overall system efficiency, especially at high switching frequencies.

Increased Component Stress: The switching components in the boost converter are subjected to voltage and current stresses, which can potentially reduce their lifespan and the overall system reliability if not properly designed and protected.

Potential for Instability: Improperly designed or tuned control loops for the MPPT and boost converter can lead to system instability, oscillations, and reduced efficiency.

C. Challenges Specific to MATLAB Simulation:

Model Complexity and Accuracy Trade-off: Creating highly accurate models of all components (PV panel, boost converter semiconductors, inductor, capacitor) can be complex and computationally intensive in MATLAB. Simplifications might be necessary, potentially affecting the accuracy of the simulation results.

Simulation Time: Simulating complex power electronic circuits with detailed models and sophisticated MPPT algorithms can be time-consuming, especially for long simulation periods needed to analyze dynamic behavior.

D. MPPT Algorithm Limitations:

Local Maxima Tracking: Some simpler MPPT algorithms (like Perturb & Observe) can get trapped at local power maxima under partial shading conditions, failing to find the true global maximum power point.

Oscillations Around MPP: Many MPPT algorithms inherently involve some level of oscillation around the MPP, leading to slight power losses. The size and frequency of these oscillations need to be carefully managed.

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