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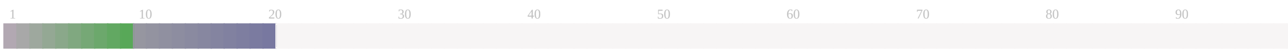

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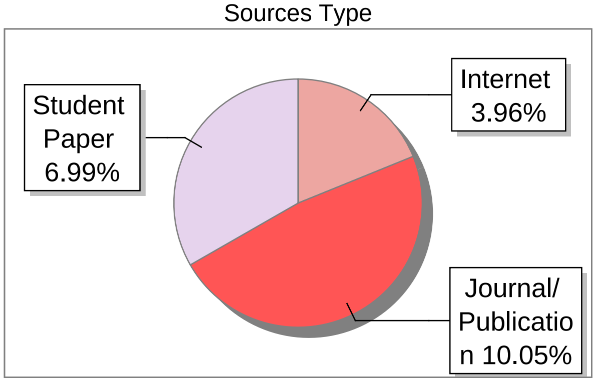

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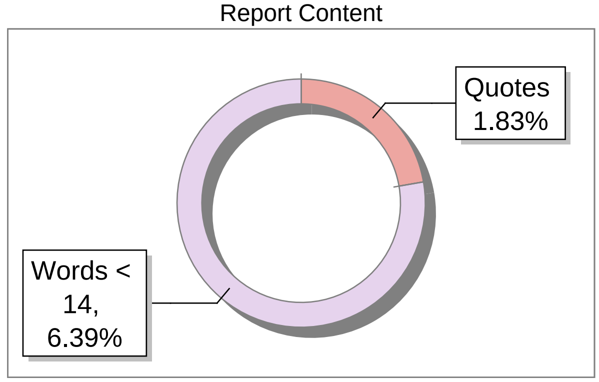

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Visvesvaraya Technological University

Belagavi

A Mini Project Report

on

“Small scale power generation using MATLAB Simulink “

Submitted by

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In partial fulfilment for the award of the

degree of

BACHELOR OF ENGINEERING

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

NEW HORIZON
COLLEGE OF ENGINEERING
New Horizon Knowledge Park, Ring Road, Marathalli
Autonomous College Permanently Affiliated to VTU, Approved by AICTE & UGC
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Bengaluru – 560 103

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

CERTIFICATE

Certified that the Mini project entitled "Small scale power generation using MATLAB SIMULINK"is carried out by Ms.Bhoomika S Kulkarni bearing USN: 1NH23EC031 and Ms. C Hitha Amrutha bearing USN: 1NH23EC035, bonafide students of NHCE, Bengaluru in partial fulfilment for the award of Bachelor of Engineering in Electronics and Communication of the Visvesvaraya Technological University, Belagavi during the year 2024-25. It is certified that all corrections and suggestions indicated for Internal Assessment have been incorporated in the report deposited in the department library. The mini project report has been approved as it satisfies the academic requirements in respect of the mini project work prescribed for the said degree.

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Bhoomika S Kulkarni(1NH23EC031)

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ABSTRACT

- Solar power generation has emerged to become a sustainable and efficient alternative to conventional energy sources. The use of MATLAB/Simulink for modelling and simulating solar power systems provides a tool for understanding the behavior of solar photovoltaic (PV) systems under various environmental conditions. This Mini project explores the simulation of solar power generation modeling systems using MATLAB/Simulink, including of key components such as solar panels, maximum inverters, and energy storage systems. The performance irradiance and temperature the power point tracking (MPPT), of solar PV systems under varying conditions is analyzed, and the optimization of system efficiency is discussed. Additionally, the paper investigates the integration of solar power into grid- connected systems, highlighting challenges related to power quality and stability. The results demonstrate the potential of MATLAB/Simulink in enhancing the design and optimization of solar power systems, contributing to their efficient deployment in small-scale and large-scale applications. Despite its advantages, the paper also outlines some limitations, including the simplification of real-world conditions, computational complexity. Future real-world data, improving the accuracy the accuracy of component models, and research directions include incorporating more detailed of storage and inverter models, and conducting economic feasibility studies to further enhance the practical applications of solar power systems.

CHAPTER 1

INTRODUCTION

- Solar power generation is a critical component of the renewable energy transition ,providing an environmentally friendly and sustainable alternative to traditional fossil fuels. With the growing global demand for clean energy, solar the photovoltaic (PV) systems have gained widespread adoption in both residential and commercial applications. Solar power generation systems convert sunlight into electrical energy through the use of solar panels, and their efficiency largely depends on environmental factors such as sunlight intensity, temperature, and the overall system configuration.
- .MATLAB and Simulink, developed by MathWorks, are widely used tools in the field of renewable energy for modeling, simulation, and optimization of solar power systems. MATLAB, with its extensive range of functions and toolboxes, allows for the numerical analysis and visualization of solar power generation. Simulink, an add-on product to MATLAB, provides a graphical environment for simulating dynamic systems using block diagrams, making it ideal for modeling complex solar energy systems that involve interconnected components, such as PV modules, power electronics, energy storage systems, and control strategies.
- .Using MATLAB/Simulink, researchers and engineers can simulate solar power generation systems under varying environmental conditions, enabling the analysis of performance metrics such as efficiency, power output, and system stability. These simulations can model solar panels' electrical characteristics, design maximum power point tracking (MPPT) algorithms, optimize energy storage solutions (such as batteries), and simulate grid integration for hybrid or standalone solar power systems.
- One of the key benefits of using MATLAB/Simulink is the ability to model complex interactions between various system components and their real-time behavior. Simulations can be run for different geographical locations with varying irradiance levels, as well as under different weather conditions, to predict the system's performance accurately. This flexibility allows for the testing of different configurations and the optimization of systems for maximum efficiency.
- Moreover, MATLAB/Simulink provides the capability to perform both small-scale and large-scale simulations. For instance, simulations of small rooftop systems or large solar farms can be conducted, ensuring that various aspects of system design, such as power generation, grid synchronization, and storage, are thoroughly analyzed before real-world implementation.
- Despite its many advantages, the simulation of solar power systems using MATLAB/Simulink does have limitations, such as the simplification of real-world conditions (like shading and environmental changes), the computational complexity

of large-scale simulations, and the accuracy of component models. These limitations highlight the need for continuous improvement in the modeling and simulation of solar power systems, as well as the integration of real-world data for more accurate predictions.

• In this paper, we explore the use of MATLAB/Simulink for the modeling and simulation of solar power generation systems. We will cover the basic principles of solar power generation, the components involved, and the capabilities of MATLAB/Simulink in simulating these systems. Additionally, we will discuss the advantages and limitations of using MATLAB/Simulink in solar power applications, while emphasizing the role of these tools in optimizing the design and performance of solar energy systems.

CHAPTER 2

LITERATURE SURVEY

Title of the paper	**Author & Year of Publication**	**Outcome**	**Limitation**
Power Electronics	N. Patel and S. Gupta (May 2018)	This paper provides a method for modeling and simulating a solar photovoltaic (PV) system using MATLAB/Simulink.	Consists of very basic information regarding solar power generation..
IEEE Trans. on Sustainable Energy	M. S. A. Hossain and S. K. Bhowmick, (October 2019.)	This paper focuses on the simulation of solar power generation systems, both standalone and grid-connected, using MATLAB/Simulink..	Shading is a major factor affecting solar power generation, but its effects haven't been included in this paper
Language Models are Few-Shot Learners	J. K. Vázquez, C. Sánchez, and A. García (January 2017)	This paper emphasizes the design of the solar system and the control strategies for integrating solar power with the electrical grid.	This paper assumes ideal or average solar irradiance and weather conditions, which do not capture the variability that is commonly observed in real world conditions.

CHAPTER 3

SYSTEM REQUIREMENTS

SOFTWARE SPECIFICATIONS:

1. Software Requirements

Platform: MATLAB Simulink (R2021b or later recommended)

Toolboxes: Simulink

Hardware Requirements

Processor: Intel i5/i7 or equivalent

RAM: Minimum 8 GB (16 GB recommended for larger simulations)

Storage: Minimum 10 GB of free space

Operating System: Windows 10/11, macOS, or Linux

Functional requirements:

1.Environmental Inputs: Irradiation and temperature

2.Boost converter

3.Inverter

4.Passive filter

5.Scope for simulation output

6.Battery storage system

Chapter 4

SYSTEM DESIGN

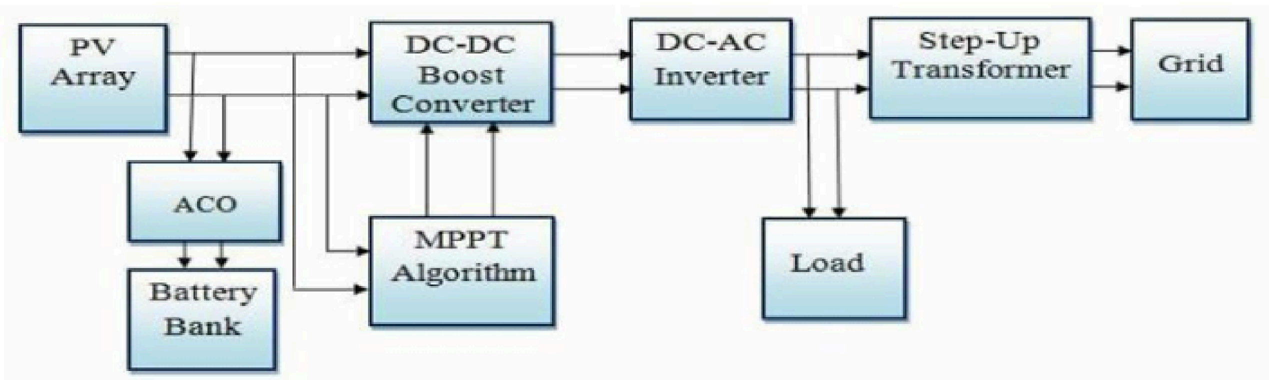
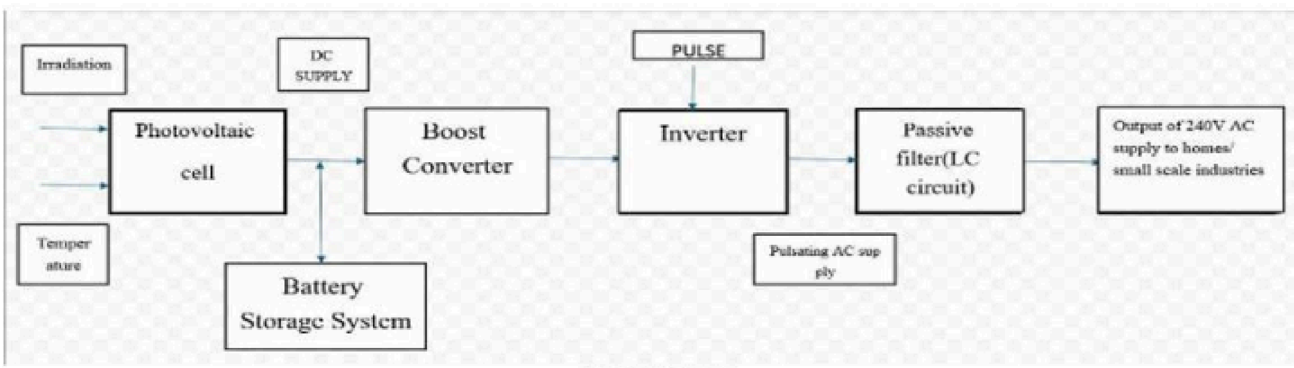


Figure1.Existing System



Block diagram

Figure2.Proposed system block diagram

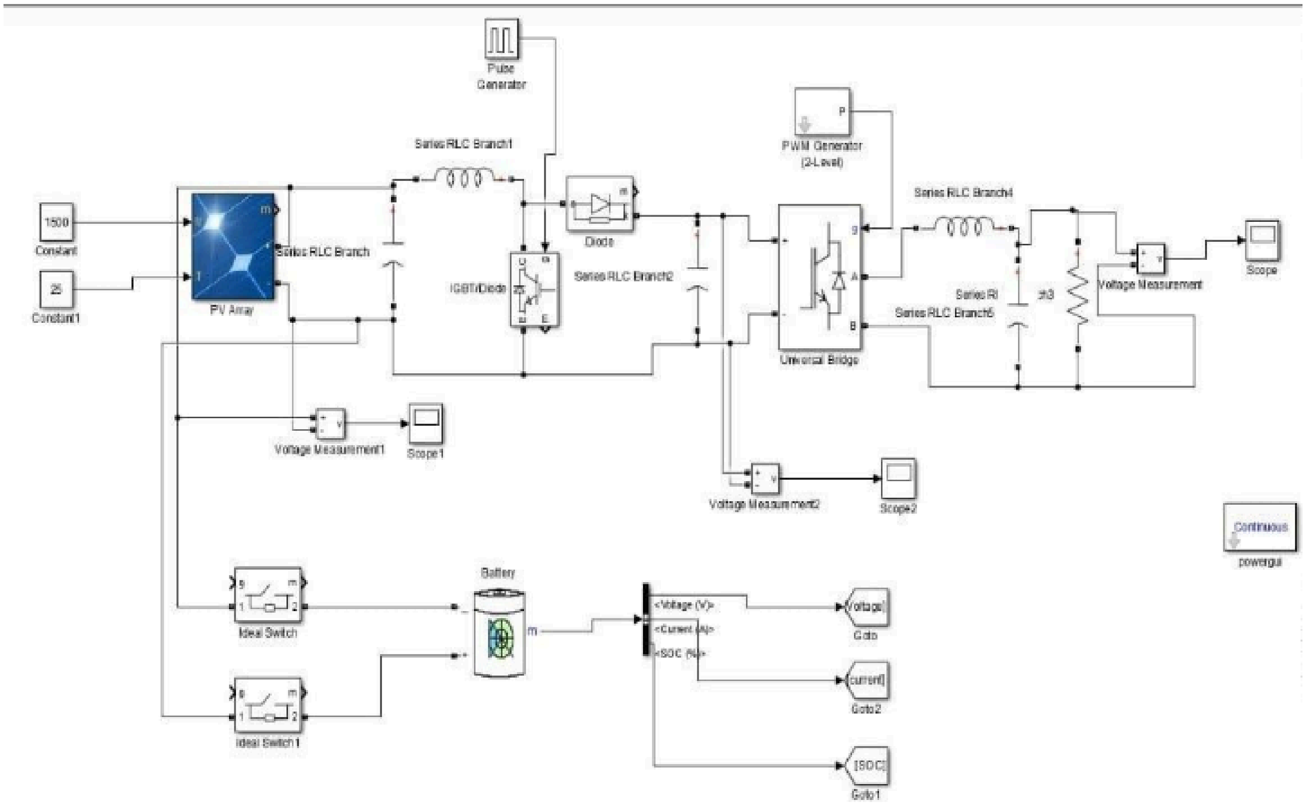


Figure 3:simulink model

Main Components and Their Roles

1. PV Array:

Constant blocks input irradiance (1500 W/m²) and temperature (25°C).

Produces DC power based on solar energy input.

2. DC-DC Converter Stage:

Composed of:

IGBT/Diode pair (DC chopper),

Pulse Generator to control the switching,

Series RLC Branches acting as filters/energy transfer elements.

Purpose: To boost or regulate the PV output voltage.

3. Battery and Switches:

Battery block is connected via two Ideal Switches.

It allows:

Charging from the PV (when excess power is available).

Discharging to load or inverter (when PV output is low).

Goto blocks for voltage, current, and state of charge (SOC) monitor battery output.

4. Voltage Measurements and Scopes:

Several Voltage Measurement blocks were placed at strategic locations to monitor system behavior.

PV output (Scope1)

Inverter input (Scope2)

Load side (final Scope)

5. Inverter (Universal Bridge):

Converts the DC power from the PV/Battery to AC.

Controlled via a PWM Generator (2-Level).

Output is fed through filter circuit components (Series RLC Branch4 and Branch5) to smooth the AC waveform.

6. Load:

Represented as a resistive load (Series R with RLC Branches).

Receives AC power from the inverter.

Power Flow Summary

1. PV Array generates DC electricity.

2. DC-DC converter regulates voltage.

3. Depending on the needs of the system, either energy is stored in the Battery or retrieved from it.

4. Regulated DC is fed to the Inverter.

5. Inverter produces AC power for the Load.

6. Measurements are taken at various stages to monitor and control system behavior.

CHAPTER 5

RESULT

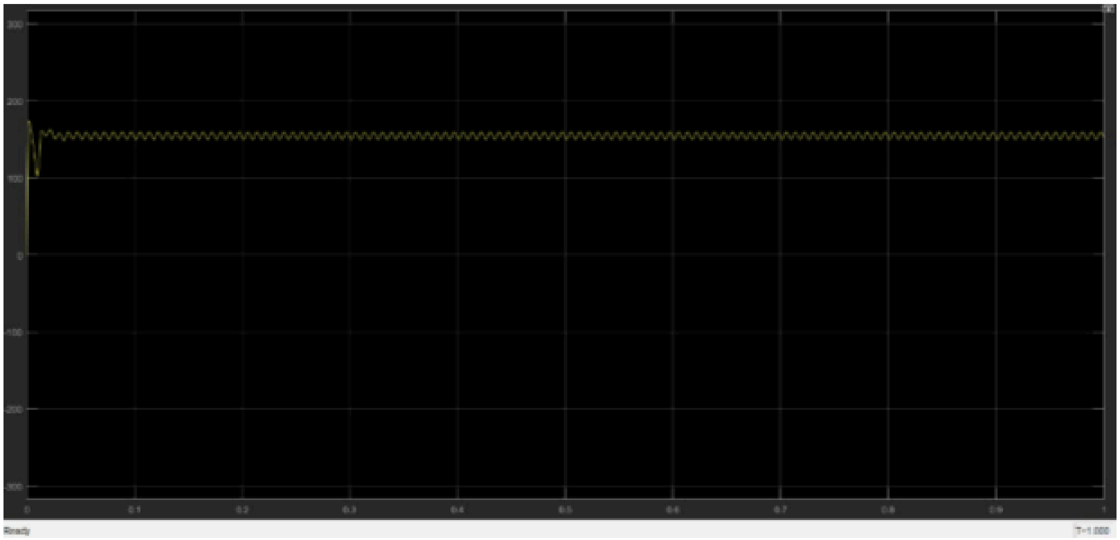


Figure 4:scope1

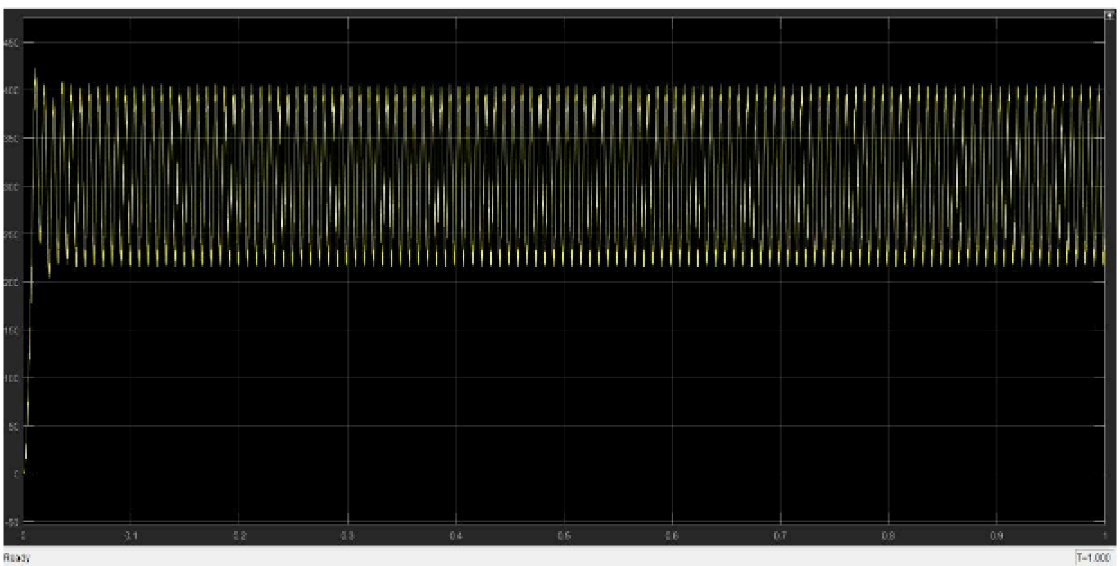


Figure 5 :scope2

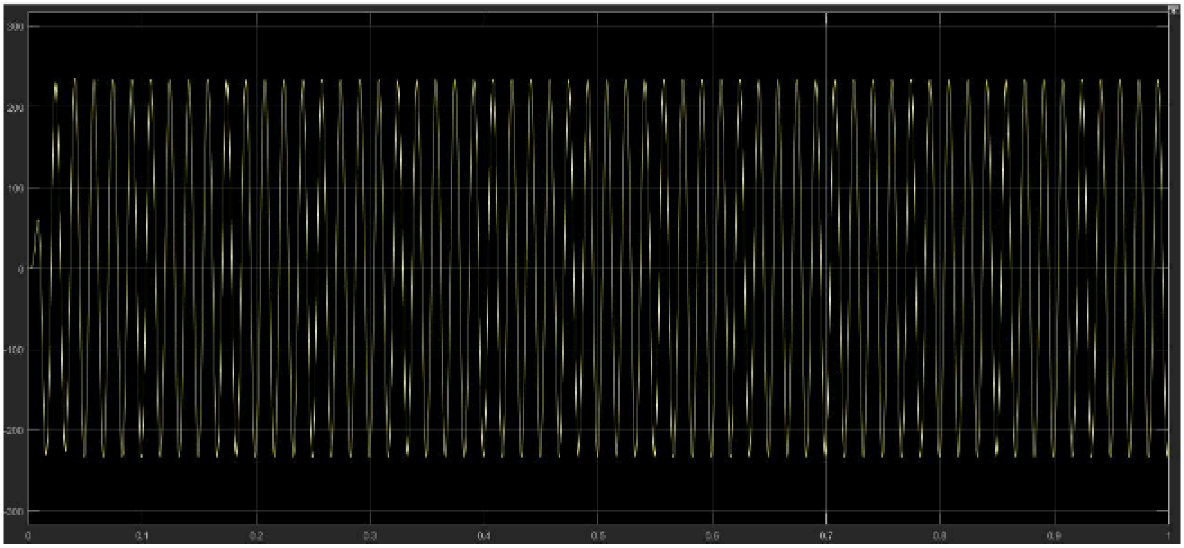


Figure 6:Scope 3

1) 1st Plot: PV Output Voltage (Scope1)

Description: This is the voltage output of the PV panel after the initial transients are passed.

Observation:

Starts from 0, rises sharply.

Stabilizes around ~150V DC.

(a) A relatively high initial overshoot and oscillation because of the startup transient of the converter or inverter step-up circuit.

Conclusion: After initial upheavals, PV array is delivering stable DC voltage.

2) 2^{nd} Waveform: (Scope 2) Inverter Input Voltage or DC-Link Voltage

Description: Most likely displays the DC-link voltage prior to the inverter input and following the boost converter.

Note:

Around 300–400V DC, the voltage stabilizes.

includes high-frequency ripples caused by switching.

In conclusion, the boost converter is raising the PV voltage to the inverter's necessary level, which is normally about 350V for 230V AC RMS output.

3) 3rd Waveform : Grid or Load Voltage (3-Phase AC Output)

Description: Probably the 3-phase output voltage waveform measured at the load or grid side.

Observation:

Sinewave at ±230V peak (RMS ~ 230V), symmetrical on 3 phases.

There are some small PWM switching ripples from the inverter.

Conclusion: The inverter is working fine by providing stable 3-phase AC output voltage to the grid/load.

Advantages of Solar Powered Systems

1. Renewable Energy Source: Solar energy is abundant and sustainable.

2. Environmentally Friendly: Reduces greenhouse gas emissions and pollution.

3. Low Operating Costs: Minimal maintenance and no fuel costs after installation.

4. Energy Independence: Reduces reliance on grid electricity or fossil fuels.

5. Scalability: Suitable for small-scale and large-scale installations.

6. Incentives: The government also offers subsidies and tax exemptions for the adoption of solar power.

Drawbacks of Solar Powered Systems

1. High Installation Costs: Installation and setup costs can be very expensive.

2. Weather Dependent: Performance is influenced by cloudy days and nighttime.

3. Energy Storage Requirement: This increases the cost and maintenance of batteries.

4. Space Requirements: A large area may be required to generate significant amounts of energy.

5. The efficiency is limited by solar panels.

6. End of the life may pose environmental concerns for the disposal or recycling of panels.

CHAPTER 6

CONCLUSION FUTURE AND ENHANCEMENT

Solar power generation is an integral part of the global shift to traditional towards renewable energy, offering an emvironmentally sustainable alternative to traditional fossil fuels. MATLAB and Simulink provide an invaluable platform for modeling, simulating, and optimizing solar power systems, enabling researchers, engineers, and system designers to analyze solar photovoltaic (PV) systems under various conditions. The combination of MATLAB's computational power and Simulink's graphical simulation capabilities allows for the effective modeling of solar systems, including PV arrays, maximum power point tracking(MPPT) algorithms, inverters, and energy storage systems. These tools have proven to be essential in evaluating the performance, efficiency, and feasibility of solar power systems, both for small-scale and large-scale applications.

Simulation results using MATLAB/Simulink can offer deep insights into system performance under diverse environmental conditions, optimizing the configuration of solar power systems to meet specific energy demands. By simulating various scenarios, such as grid integration, energy storage management, and different irradiance and temperature conditions, the tools enable better design, implementation, and operational strategies. Additionally, MATLAB/Simulink into system performance under analyzing and improving the efficiency plays a crucial role in of solar power generation systems, facilitating their broader adoption Future The future in b oth residential of Solar and commercial markets. Power generation of s olar power generation using MATLAB/Simulink holds significant potential for improvement. Several key areas can be enhanced to make the simulations more accurate, practical, and efficient:

Future of Solar Power generation

The future of solar power generation using MATLAB/Simulink holds significant potential for improvement. Several key areas can be enhanced to make the simulations more accurate, practical, and efficient:

1.Incorporating Real-World Environmental Data:

Future research should focus on integrating real-time data from weather stations, satellites, and geographic information systems (GIS) to account for dynamic environmental factors such as varying irradiance levels, cloud cover, and temperature fluctuations. This would help in developing more accurate predictions for solar power output under different seasonal and geographical conditions.

2.Advanced Energy Storage and Battery Modeling:

There is a need for more detailed and realistic modeling of energy storage systems, particularly batteries, which are crucial for off-grid and hybrid solar applications. Future enhancements could include the simulation of battery aging, efficiency losses, and temperature impacts over time, which would improve the accuracy of long-term performance predictions.

3.Improved Shading and Partial Shading Models:

Shading due to buildings, trees, and other obstacles can significantly reduce the output of solar power systems. Incorporating more advanced shading models, including partial shading effects and their impact on system efficiency, will improve the accuracy of simulations and make them more applicable to real-world environments.

4.Advanced Grid Integration and Smart Grid Systems

As solar power systems become more widespread, the integration with the power grid needs to be optimized for stability, load balancing, and power quality. Future work should focus on improving grid integration models, including the simulation of energy management systems, voltage regulation, and frequency control for large-scale solar power plants

Future Enhancement:

The future development of the solar-powered system involves improvement through technology and integration. Some of the significant enhancements include the following:

1. Efficiency Upgrade: Advanced photovoltaic material development, such as perovskite solar cells and tandem cells, can increase energy conversion efficiency rates.

2. Energy Storage Integration: Solar systems coupled with next-generation energy storage solutions,including solid-state and lithium-sulfur batteries, will help supply power consistently.

3. Smart Grids and IoT: Solar systems to be integrated into smart grids with IoT-enabled monitoring for optimized energy management and predictive maintenance.

4. Cost Reduction: Scale up production and refine manufacturing processes to make solar power more affordable and accessible.

5. Flexible and Lightweight Panels: Flexible, thin-film solar panels for diverse applications such as portable electronics and building-integrated photovoltaics.

6. Hybrid Systems: Solar energy combined with other renewable energy sources, such as wind or hydro, to ensure both reliability and efficiency.All these will allow solar-powered systems to take a central place in fulfilling global energy requirements sustainably.

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