

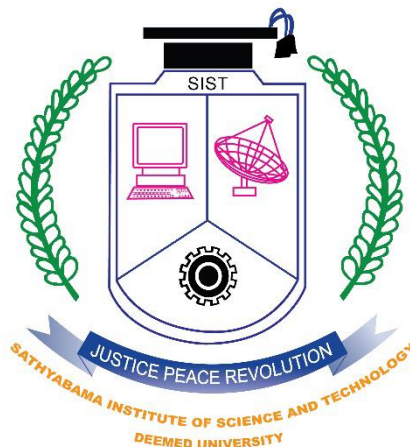
A DUAL SWITCHED COUPLED INDUCTOR BASED HIGH STEP-UP DC-DC CONVERTER FOR PHOTOVOLTAIC

Submitted in partial fulfillment of the requirements for the award of
Bachelor of engineering degree in
Electrical and Electronic Engineering

By

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

SCHOOL OF ELECTRICAL AND ELECTRONICS

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with Grade "A++" by NAAC

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APRIL 2024



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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the Bonafide work of **SHALINI E** (Reg. No. 40140032) and **ROJA S** (Reg. No. 40140029) who carried out the project entitled "**A DUAL SWITCH COUPLED INDUCTOR-BASED HIGH STEP-UP DC-DC CONVERTER FOR PHOTOVOLTAIC**" under our supervision from November 2023 to April 2024.

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DECLARATION

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DATE:

PLACE: Chennai

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ABSTRACT

In this project a dual-switch DC-DC converter with high-voltage gain for solar Photovoltaic (PV) systems. High-voltage gain is obtained by combining the coupled inductor (CI) and switched-capacitor (SC) voltage boosting techniques. Combining CI and SC techniques, the design flexibility is increased, and low voltage stresses on the semiconductor devices are achieved, which leads to the adoption of low-voltage-rating semiconductor devices with low ON-state resistance resulting in low switching and conduction losses. Unlike the conventional boost converter, thanks to the existence of leakage inductance, the output diode turns off naturally in the proposed converter, which suppresses the reverse-recovery problem and losses. Operation principle and steady-state analysis are discussed to show the advantages of the proposed DC-DC converter. To verify the operation of the proposed converter, a performance comparison is provided. Moreover, the simulation of a 200 W converter with 20 V input and 400V output is being carried out using the PLECS Block set. This project proposes a High gain DC-DC boost converter for PV applications. The High gain Boost converter topology includes only dual switches. This achieves low switching loss operation. The active diodes provide regenerative snubber protection. This project is implemented using Matlab Simulation and hardware development DSPIC30F2010 Controller.

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CHAPTER 1

INTRODUCTION

1.1 GENERAL

Renewable electricity sources and fuel cellular cars have the blessings of excessive electricity conversion efficiency and zero emissions, in addition to better levels than battery-powered cars. However, gas cells produce low voltage and high current and cannot be used directly for strength. Vehicles require an excessive DC bus voltage (e.g. 400 V). To fit the low voltage gas cells with the high voltage DC bus required for electric powered motors, a high voltage gain Boost DC-DC converter is needed to act as an electricity interface between the gasoline cells and the DC bus. Additionally, the battery percentage may be connected to the DC bus through a bidirectional DC-DC converter, which is made right into a high energy manager. In addition, the output voltage of gasoline cells drops with growing energy output. Therefore, the Boost DC- DC converter must perform at a huge voltage advantage to gas the automobile. A traditional Boost DC-DC converter has an excellent voltage benefit of $1/(1 - d)$, in which d is the obligation cycle of the active power switch. However, the high-voltage benefit is restrained through the effects of parasitic resistance and intense responsibility cycles, and the electricity voltage visible with the aid of all used semiconductors is excessive because of the output voltage. Although the three-step Boost DC-DC converter.

can reduce the output voltage to half of the output voltage, the best voltage advantage is still $1/(1 - d)$. Also, a complicated management strategy is needed to stabilize the capacitor wheel voltage seen by all the semiconductors. A switched inductor boost DC-DC converter is proposed with an excessive voltage advantage, but the go-cutting-edge power voltage continues to be equal to the output voltage. A two-level cascaded Boost DC-DC converter also has a huge voltage benefit; however, its efficiency is the product of the efficiency of each stage. Additionally, the semiconductor output stage nonetheless suffers from high voltage pressure. In, a switched Capacitor

Boost DC-DC Converter is provided with a high voltage benefit, and a low ringing voltage. A diode is positioned among the enter and output causes inside the circuit, and the corresponding ability difference between the two pulse fields in the switching frequency. This condition will limit packages due to the extra electromagnetic interference created. In addition to increasing the voltage benefit of the Boost DC-DC converter for gas cell cars and reducing its conduction and switching losses, the dv/dt ability difference between the input and the converter output ought to be 0 (i.e., impartial floor) or small. To enhance the performance of the techniques described above, an unmarried- stage wide-voltage advantage-amplitude DC-DC Boost converter is proposed in this paper. The improved voltage in all semiconductors is $1/2$ of the output voltage, the advantage voltage is two/ (1 d), that is two times that of a traditional Boost DCDC converter, and the difference is the electricity distinction between the input and output. The sector is small. In phase 2, the topology of the proposed converter is added, and the running principle is defined in segment three. In segment four, a small-signal converter version is evolved with balance analysis and fault-tolerant operation. In Section five, an experimental prototype is advanced and experimental results are presented to validate the proposed converter.

1.2 MOTIVATION FOR SELECTION OF THIS PROBLEM

The selection of a dual switched coupled inductor-based high step-up DC-DC converter for a photovoltaic project is motivated by several key factors, each contributing to the overall optimization and success of the project. One primary motivation is the need for efficient energy conversion in photovoltaic systems. Solar panels generate DC voltage, which needs to be converted to a higher voltage for practical usage or grid integration.

The high efficiency of dual switched coupled inductor-based converters ensures minimal energy loss during this conversion process, maximizing the energy harvested from solar panels and enhancing the overall system's performance. Another crucial aspect is the voltage boost capability of these converters. Photovoltaic systems often operate at lower voltages than what is required for grid connection or powering certain loads. High step-up

converters excel at boosting the voltage to the desired level, enabling seamless integration with grid-tied inverters or meeting the voltage requirements of specific applications without the need for additional components or complex circuitry. Additionally, the compact design of dual switched coupled inductor-based converters is highly advantageous for photovoltaic installations. Space efficiency is a significant consideration, especially in rooftop or space-constrained environments where every square inch matters. These converters' ability to achieve high step-up ratios while maintaining a small footprint makes them ideal for such installations, allowing for more flexible system design and deployment. Moreover, the improved performance metrics offered by these converters, such as reduced voltage ripple, input current ripple, and enhanced system stability, play a crucial role in ensuring reliable and consistent power output from solar panels. This is particularly important given the intermittent nature of solar energy, where fluctuations in environmental conditions can impact power generation. By focusing on a dual switched coupled inductor- based high step-up DC-DC converter for the photovoltaic project, the aim is to address these critical factors comprehensively, leading to a more efficient, reliable, and optimized photovoltaic system that can contribute significantly to renewable energy adoption and sustainability efforts.

1.3 OVERVIEW

Our project focuses on the design and implementation of a high Step-Up DC-DC converter tailored for photovoltaic applications, employing a dual-switch coupled inductor configuration. This specialized converter aims to efficiently elevate the low voltage output from photovoltaic panels to a higher voltage suitable for various uses, Such as charging batteries or powering devices. By leveraging the unique advantages of the dual switch coupled inductor, including higher efficiency and improved voltage conversion ratios, we aim to optimize the performance and reliability of the system. Through meticulous component selection, integration of control circuitry, and rigorous testing, our project seeks to deliver a robust solution capable of effectively harnessing solar energy for practical applications, contributing to the advancement of renewable energy technologies.

CHAPTER 2

LITERATUR REVIEW

2.1 INTRODUCTION

In recent years, photovoltaic (PV) systems have gained significant attention as a clean and sustainable energy source, contributing to the global effort to reduce carbon emissions and combat climate change. However, the intermittent nature of solar energy necessitates the development of efficient power conversion systems to maximize the utilization of solar resources. DC-DC converters play a crucial role in PV systems by efficiently transforming the low-voltage output of solar panels to higher voltages required for grid integration or battery charging. Among various DC-DC converter topologies, the high step-up converter is particularly important for PV applications. It allows for the efficient conversion of the low input voltage from solar panels to higher output voltages, facilitating grid-tie operation or battery charging. However, achieving a high step-up voltage conversion ratio while maintaining high efficiency and compactness remains a challenge in converter design. In recent years, the dual-switch coupled inductor-based topology has emerged as a promising solution for high step-up DC-DC conversion. This topology utilizes coupled inductors and two active switches to achieve a high voltage gain with reduced voltage stress on the switches, leading to improved efficiency and reliability. Additionally, it offers advantages such as reduced component count, simplified control, and decreased electromagnetic interference (EMI). Given the importance of high step-up converters in PV applications and the potential benefits of the dual-switch coupled inductor-based topology, there has been growing research interest in this area. This literature survey aims to provide an overview of existing research and developments in dual-switch coupled inductor-based high step-up DC-DC converters for photovoltaic projects. By reviewing relevant literature, identifying key challenges, and highlighting recent advancements, this survey aims to guide future research efforts towards the development of more efficient and reliable power.

2.2 MAJOR FINDINGS FROM LITERATURE SURVEY

The paper titled "Step-up switching-mode converter with high voltage gain using a switched capacitor circuit" is authored by O. Abutbul, A. Gherlitz, Y. Berkovich, and A. Ioinovici. Published in the IEEE Transactions on Circuits and Systems I, Volume 50, Issue 8, in August (2003), it introduces a novel step-up switching-mode converter configuration. This converter achieves high voltage gain by employing a switched capacitor circuit. The proposed circuit design and operation enable efficient voltage boosting, crucial for various applications requiring a higher output voltage than the input. The paper likely provides detailed analysis, circuit diagrams, experimental results, and discussions regarding the performance and advantages of the proposed converter topology. This research contributes to advancing the field of power electronics by offering a solution for efficient voltage conversion, which can find applications in diverse areas such as power supplies, renewable energy systems, and electric vehicles.

The paper titled "A bidirectional DC-DC converter for fuel cell electric vehicle driving system" by H. Chiu and L. Lin, published in the IEEE Transactions on Power Electronics, Volume 21, Issue 4, in July (2006), addresses the critical need for efficient power management in fuel cell electric vehicle (FCEV) propulsion systems. FCEVs offer a promising alternative to conventional internal combustion engine vehicles, utilizing hydrogen fuel cells to generate electricity for powering electric motors. However, integrating fuel cells with the vehicle's powertrain requires sophisticated power electronics solutions to manage the bidirectional flow of energy between the fuel cell stack, energy storage systems, and the vehicle's drivetrain. In this paper, Chiu and Lin propose a bidirectional DC-DC converter tailored specifically for FCEV driving systems. The converter facilitates efficient energy transfer between the high-voltage fuel cell stack and the low-voltage battery pack or supercapacitors, enabling seamless energy flow and optimal utilization of the available power sources. By employing bidirectional power conversion capabilities, the converter allows for regenerative braking, energy recuperation, and effective management of transient power demands during vehicle operation. The authors likely present a detailed analysis of

the converter topology, including circuit configuration, control strategy, and performance evaluation. Experimental results and simulation studies may demonstrate the effectiveness and efficiency of the proposed converter design in real-world FCEV driving scenarios. Overall, this research contributes to advancing the field of power electronics for sustainable transportation, providing insights into the development of energy-efficient solutions for fuel cell electric vehicles.

The paper titled "Optimization of fuel cell and super capacitor for fuel-cell electric vehicles" authored by Y. Wu and H. Gao was published in the IEEE Transactions on Vehicular Technology, Volume 55, Issue 6, in November (2006). This research focuses on the optimization of fuel cells and super capacitor integration in fuel-cell electric vehicles (FCEVs). FCEVs represent a promising alternative to conventional internal combustion engine vehicles, utilizing fuel cells to generate electricity for powering electric motors. Super capacitors, with their high-power density and fast charging/discharging capabilities, can complement fuel cells by providing additional power during transient driving conditions such as acceleration and regenerative braking. In this paper, Wu and Gao present a comprehensive optimization framework for the integration of fuel cells and super capacitors in FCEVs. The optimization process likely involves the determination of optimal sizing, configuration, and control strategies for both the fuel cell system and the super capacitor bank. The objective is to maximize the overall system efficiency, minimize energy losses, and enhance the vehicle's performance and driving range. The authors likely employ mathematical modeling, simulation studies, and optimization algorithms to analyze various design parameters and operating conditions. Through systematic optimization, the paper aims to identify the most suitable combination of fuel cell and super capacitor specifications to meet the dynamic power demands of FCEVs while ensuring cost- effectiveness and reliability.

This paper was presented at the Annual Conference of the IEEE Industrial Electronics Society in (2010). The authors, M. Ahmadi, E. Galvan, E. Adib, and H. Farzaneh Fard, introduce a novel fully soft-switched bi-directional converter designed specifically for hybrid electric vehicles. The paper likely includes analysis of the converter topology, control

strategies, and experimental results demonstrating its effectiveness in hybrid vehicle applications. This research contributes to the advancement of power electronics solutions for improving the efficiency and performance of hybrid electric vehicles.

This paper was published in the IET Power Electronics journal in February (2012). The authors, M. Ahmadi, M. R. Mohammadi, E. Adib, and H. Farzaneh Fard, present a family of non-isolated zero current transition bi-directional converters featuring only one auxiliary switch. The paper discusses the design, analysis, and performance evaluation of these converters, which are significant for various power electronic applications requiring bidirectional power flow. The research contributes to the advancement of converter topologies for efficient power conversion in diverse applications.

This paper was published in the Journal of Power Sources in March (2014). The authors, A. A. Fardoun, E. H. Ismail, A. J. Sabzali, and M. A. Al-Saffar, present a bidirectional converter specifically designed for high-efficiency fuel cell powertrain applications. The paper discusses the design principles, operation, and performance evaluation of the bidirectional converter, focusing on its role in optimizing power flow and improving the overall efficiency of fuel cell powertrains. This research contributes to the advancement of power electronics solutions tailored for fuel cell systems, which are crucial for the development of sustainable transportation and energy systems.

This paper was published in the IEEE Transactions on Power Electronics in March (2015). The authors, E. Jamshidpour, P. Poure, E. Gholipour, and S. Saadate, present a single-switch DC-DC converter design with fault-tolerant capability. Specifically, the converter is designed to withstand open- and short-circuit switch failures, ensuring continued operation and reliability in the presence of faults. The paper discusses converter topology, fault detection and diagnosis methods, fault-tolerant control strategies, and experimental validation of the proposed design. This research contributes to the development of robust power electronic systems capable of maintaining functionality and performance even under adverse operating conditions.

This paper was published in the IEEE Transactions on Industry Applications in the combined January/February issue of (2015). The authors, U. R. Prasanna, X. Pan, A. K.

Rathore, and K. Rajashekara, explore propulsion system architecture and power conditioning topologies specifically tailored for fuel cell vehicles (FCVs). The paper discusses various aspects of FCV powertrains, including the integration of fuel cell stacks, energy storage systems, power conditioning units, and electric propulsion systems. Additionally, it may cover topics such as control strategies, efficiency optimization, and system reliability. This research contributes to the advancement of FCV technology by addressing key challenges related to power management and system integration, ultimately promoting the adoption of clean and sustainable transportation solutions.

This paper was presented at the International Conference on Advanced Mechatronic Systems in August (2014). The authors, J. Xiao, X. Zhang, S. Wen, and D. Wang, discuss the development of a DC-DC converter for a fuel cell system. The converter is designed with real-time pulse width modulation (PWM) control, which likely enables precise regulation of the voltage output to meet the requirements of the fuel cell system. The paper may cover aspects such as converter topology, control algorithm, experimental validation, and performance analysis. This research contributes to the advancement of power electronics solutions for fuel cell applications, aiming to enhance the efficiency and reliability of fuel cell systems through effective voltage regulation.

This paper was published in the Electric Power Systems Research journal in May (2017). The authors, V. F. Piresa, D. Foitoa, and J. F. Silvab, present a single-switch hybrid DC/DC converter designed for photovoltaic (PV) applications. The converter likely offers an extended static gain, which can enhance the efficiency and performance of PV systems by optimizing power conversion from the solar panels to the load or energy storage devices. The paper may include details about the converter topology, control strategy, experimental validation, and potential applications in photovoltaic power systems. This research contributes to the advancement of power electronics solutions for renewable energy integration, supporting the development of more efficient and reliable PV systems.

The paper authored by F. M. Shahir, E. Babaei, and M. Farsadi, titled "Voltage-Lift Technique Based Non isolated Boost DC–DC Converter: Analysis and Design," was

published in 2018 in the IEEE Transactions on Power Electronics. This article, appearing in volume 33, pages 5917-5926, explores a novel design for a non-isolated boost DC-DC converter that employs a voltage-lift technique to enhance voltage conversion ratios significantly. In this study, the researchers detail a new converter topology that optimizes both the efficiency and the step-up ratio, crucial for applications requiring conversion from low to high voltage without the complexities and costs associated with isolation transformers. The paper provides a thorough analysis of the converter's operation, focusing on its distinct operational phases and the critical transitions among them. It also addresses the design parameters, including component selection and the implementation of control strategies that are Vital for achieving.

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In the 2021 IEEE Texas Power and Energy Conference (TPEC), R. Rahimi, S. Habibi, P. Shamsi, and M. Ferdowsi presented their research in a paper titled "An Interleaved High Step-Up DC-DC Converter Based on Combination of Coupled Inductor and Built-in Transformer for Photovoltaic-Grid Electric Vehicle DC Fast Charging Systems." This study introduces an advanced DC-DC converter design that integrates a coupled inductor with a built-in transformer to achieve high step-up voltage conversion, which is particularly beneficial for electric vehicle (EV) fast-charging stations powered by photovoltaic (PV)

sources. The interleaved technique employed enhances the efficiency of the converter, reduces the size of the magnetic components, and minimizes the ripple in both input and output currents. These improvements are crucial for the stability and efficiency of fast charging systems, making the technology more sustainable and viable for widespread use in grid-connected setups.

2.3 PROBLEM STATEMENTS

This project aims to address the need for efficient voltage conversion in photovoltaic (PV) systems through the development of a dual-switch coupled inductor-based high step-up DC-DC converter. The rapid growth of solar energy adoption has highlighted the importance of maximizing power extraction from PV panels, especially in scenarios where the output voltage needs to be significantly boosted for grid-tie or battery charging applications. Existing DC-DC converter topologies face limitations in achieving high step-up ratios while maintaining high efficiency and reliability. Therefore, this project proposes the exploration of a dual switch coupled inductor topology, known for its ability to achieve high voltage step-up ratios with reduced voltage stress on power switches and improved efficiency compared to traditional boost converters. By leveraging this topology, the project aims to design and optimize a converter capable of efficiently stepping up the low-voltage output from PV panels to higher voltage levels suitable for various applications. The project will involve comprehensive literature review, converter topology design, control strategy development, simulation studies, hardware prototyping, and experimental validation. Through this research endeavor, the project seeks to contribute to the advancement of power electronics solutions for renewable energy integration, particularly in PV systems, ultimately fostering the development of more efficient and sustainable energy technologies.

2.4 EXISTING BLOCK DIAGRAM AND EXPLANATION

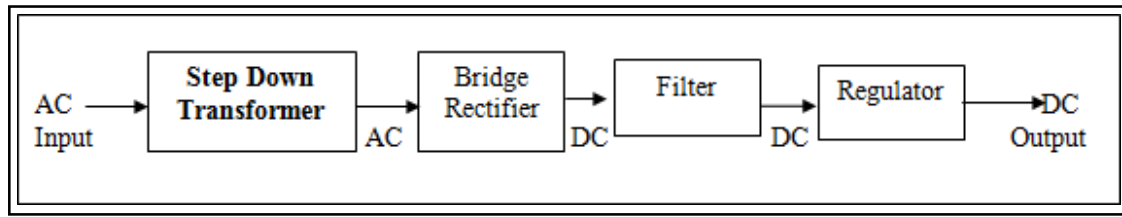


Fig 2.1 Existing Block diagram

Fig 2.1 shows a high voltage advantage DC-DC converter is presented in this test. The proposed converter is just like a two-section intermittent enhance converter at enter side even as having a voltage multiplier based on the Dickson charge pump the output sides. This converter gives non-stop input modern, which makes it more appropriate for the renewing included resources, including solar panels to a 400 V DC bus, Similarly, the converter can draw energy from one supply or two impartial assets.

Additionally, the usage of a voltage multiplier gives a bias for capability scores, which doubtlessly results in degradation. Converter design and element choice are mentioned in detail with the assist of simulation consequences. A hardware prototype of the proposed converter with $V_{in}=20V$ and $V_{out}=400V$ evolved to validate the analytical effects.

2.5 DISADVANTAGE OF EXISTING SYSTEM

2.3.1 Maximum power loss.

2.3.2 Still the goal and modern-day of circles

2.6 STANDARD

The IEEE Standard **adapted for this project** are IEEE 1547 - 2018 and IEEE 936- 1987.

IEEE 1547 2018: IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces:

IEEE 936-1987: IEEE Guide for Self-Commutated Converters.

2.6.1 TERMINOLOGY

IEEE 1547-2018 is a standard developed by the Institute of Electrical and Electronics Engineers (IEEE) for interconnecting distributed energy resources (DERS) with electrical power systems. This standard specifies the technical requirements for interconnections and interoperability of DERS, including renewable energy sources such as solar and more wind, with the electric power grid. The standard also addresses safety, power quality, and grid support functions of DERS. IEEE 1547-2018 provides a framework for utilities, of the regulators, and manufacturers to ensure that DERS can be integrated safely and reliably into the electric power system, which is crucial for the ongoing growth of renewable energy and the transition towards a more sustainable energy future. *IEEE 936-1987* is a guide for self-commutated electronic power converters. It provides guidance on the design, testing, and operation of these converters, which use components within the converter that can accomplish commutation. The standard was published by the IEEE in 1987 and it can be available for download from various libraries and online resources. This tutorial is intended for self-commutated electronic power converters, or converters whose internal need can components do commutation. In converters using turn-off-capable switching elements like transistors or gate-turn-off thyristors.

2.7 CONSTARINTS

Cost: The cost of the hybrid energy source-based Landsman converter system can be a significant constraint. It involves multiple components such as solar panels, wind turbines, batteries, inverters, and controllers. The cost of these components can be high, especially for high-capacity systems.

Space: The space required for installing the hybrid energy source system can also be a constraint. The system involves multiple components, and these components require adequate space for installation.

Scalability: The *hybrid* energy source-based Landsman converter system should be scalable, which means it should be able to accommodate additional components and

energy sources as the *energy* demand increases. The design should be flexible enough to integrate new components into the existing system.

Efficiency: The efficiency *of* the system is another constraint. The system should be designed to maximize energy conversion efficiency and minimize energy loss.

TRADE-OFFS:

Reliability vs. Cost: The reliability of the hybrid energy source-based Landsman converter system can be improved by using high-quality components, redundant systems, and backup power sources. However, these measures can increase the cost of the system.

Energy Storage vs. Efficiency: The system can be designed to store excess energy in batteries for use during periods of low energy production. However, energy storage can reduce the overall efficiency of the system due to energy conversion losses.

Energy Source Diversity vs. Complexity: The Landsman converter system can be designed to incorporate multiple energy sources such as solar, wind, and hydro. However, incorporating multiple energy sources can increase the complexity of the system, leading to higher installation and maintenance costs.

AC/DC Conversion vs. Energy Loss: The hybrid energy source-based Landsman converter system involves the conversion of energy from AC to DC and **vice versa**. The conversion process can lead to energy losses, which can reduce the overall efficiency of the system. However, the conversion process is necessary to integrate the different energy sources into the microgrid.

CHAPTER 3

AIM AND SCOPE OF THE PRESENT INVESTIGATION

3.1 INTRODUCTION

The primary aim of this investigation is to design, simulate, and prototype a dual-switch coupled inductor-based high step-up DC-DC converter tailored for photovoltaic (PV) applications. The project endeavors to address the pressing need for efficient voltage conversion in PV systems, particularly in scenarios where the output voltage must be substantially increased to meet grid-tie or battery charging requirements. The investigation seeks to explore the utilization of the dual switch coupled inductor topology, renowned for its capacity to achieve remarkable voltage step-up ratios while mitigating voltage stress on power switches and enhancing overall converter efficiency compared to conventional boost converters. The scope of this investigation encompasses a comprehensive literature review to understand existing research and identify key challenges and opportunities in high step-up DC-DC converter design for PV systems. Subsequently, the investigation will involve the design and optimization of the converter topology, development of a robust control strategy to ensure precise voltage regulation, simulation studies to evaluate performance under various operating conditions, hardware prototyping for experimental validation, and performance analysis to assess efficiency, reliability, and suitability for real-world PV applications. Through this investigation, we aim to contribute to the advancement of power electronics solutions for renewable energy integration, facilitating the development of more efficient and sustainable PV systems capable of maximizing power extraction and enhancing overall energy conversion efficiency.

3.2 OBJECTIVE

The aim of this project is to design, develop, and validate a dual-switch coupled inductor-based high step-up DC-DC converter tailored specifically for photovoltaic (PV) applications. The project seeks to address the critical need for efficient voltage conversion in PV systems, particularly in scenarios where the output voltage must be substantially

increased for grid-tie or battery charging purposes.

3.3 SCOPE OF THIS PROJECT

The scope of the project encompasses a comprehensive literature review to understand existing research and identify the limitations of conventional boost converters in achieving high step-up ratios while maintaining efficiency. Specific objectives include designing and optimizing a dual switch coupled inductor topology capable of achieving remarkable voltage step-up ratios with improved efficiency and reliability. Additionally, the project aims to develop a robust control strategy to ensure precise voltage regulation and dynamic response under varying operating conditions. Simulation studies will be conducted to evaluate the performance of the designed converter topology and control strategy, followed by hardware prototyping for experimental validation. Through this project, we aim to contribute to the advancement of power electronics solutions for renewable energy integration, fostering the development of more efficient and sustainable PV systems capable of maximizing power extraction and enhancing overall energy conversion efficiency.

3.4 METHODOLOGY

The development of the dual-switch coupled inductor-based high step-up DC-DC converter for photovoltaic applications involves several key steps. Firstly, a comprehensive literature review is conducted to understand existing research and identify design considerations, challenges, and opportunities. Following this, the converter topology is designed, considering factors such as component selection, efficiency, and voltage conversion ratio. A robust control strategy is then developed to regulate the output voltage accurately under various conditions, employing techniques such as pulse width modulation (PWM) and maximum power point tracking (MPPT). Simulation studies are conducted using tools like MATLAB/Simulink or LTspice to assess the converter's performance across different operating conditions. Subsequently, a hardware prototype is fabricated, and experimental validation is carried out to evaluate key performance metrics such as efficiency, voltage regulation, and reliability. Any observed limitations or issues are addressed through iterative

design improvements. Comprehensive documentation is prepared, summarizing the methodology, design process, simulation results, experimental setup, and performance analysis. Through this methodology, the project aims to develop an efficient and reliable converter solution tailored for photovoltaic applications, contributing to the advancement of renewable energy integration technologies. issues are addressed through iterative design improvements. Comprehensive documentation is prepared, summarizing the methodology, design process, simulation results, experimental setup, and performance analysis. Through this methodology, the project aims to develop an efficient and reliable converter solution tailored for photovoltaic applications, contributing to the advancement of renewable energy integration technologies.

3.5 PROPOSED BLOCK DIAGRAM AND EXPLANATION

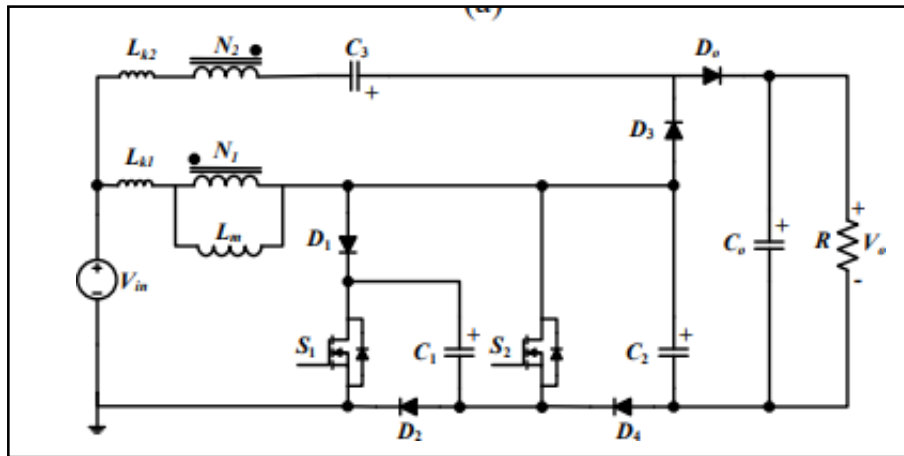


Fig 3.1 proposed Block diagram

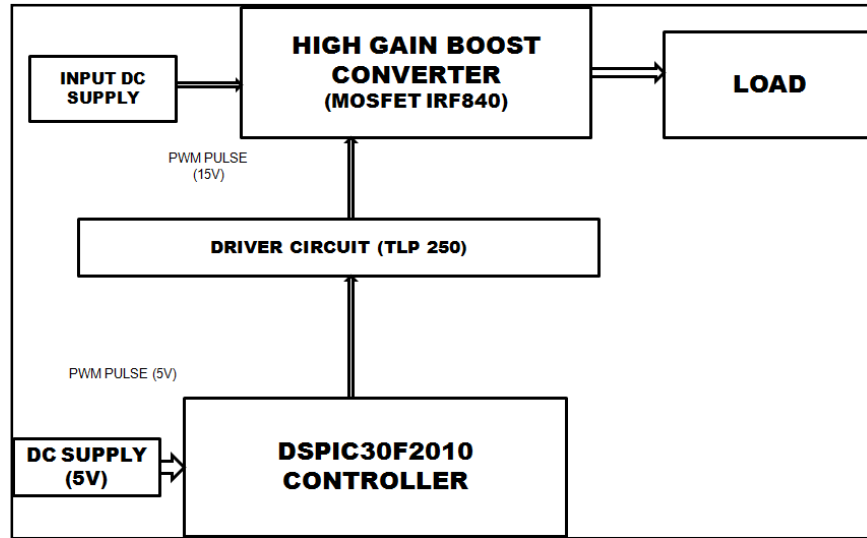


Fig 3.2 proposed circuit diagram

The proposed system involves connecting PV arrays to the DC bus via a boost converter to imitate DC sources. An AC bus connects to a DFIG wind generation system to simulate AC sources. Energy storage is achieved by linking a bidirectional DC/DC converter battery to the DC bus. Finally, a variable DC and AC load are connected to their respective DC and AC buses to imitate various loads as shown in Figure 3.1 and Figure 3.2.

3.5.1 SOLAR PANEL

Through photovoltaic cells solar panels capture sunlight and convert solar energy into electrical energy. Then it can generate relatively low voltage output. Through high gain Boost converter low voltage from the solar panel as input and boost into a higher voltage level suitable for the load operation. The boost converter involves switching the current through inductor and capacitor storing energy and delivering it to the load.



Fig 3.3 solar panel

3.5.2 LOAD

The load receives the boosted voltage from the high gain boost converter and operates using this increased capacitor.

3.5.3 DRIVER CIRCUIT

The driver circuit ensures the proper switching of the power switches in the light.

3.5.4 DSPIC30F2010 CONTROLLER

DSPIC30F2010 is a micro controller based digital signal processing. This DSP chip acts as the controller for the entire system. It provides intelligence, monitor system parameters.

3.5.5 DESIGN OF DC-DC CONVERTER

A dual-switched coupled inductor (DSCI) based high step-up DC-DC converter is a sophisticated power electronics circuit designed to efficiently boost the low voltage output from photovoltaic (PV) panels to higher voltage levels suitable for various applications. In this converter topology, two switches are used with coupled inductors to achieve significant voltage step-up ratios. Figure 3.5 shows the DC-DC converter's circuit diagram. By considering the four modes shown, its operation can be analyzed.

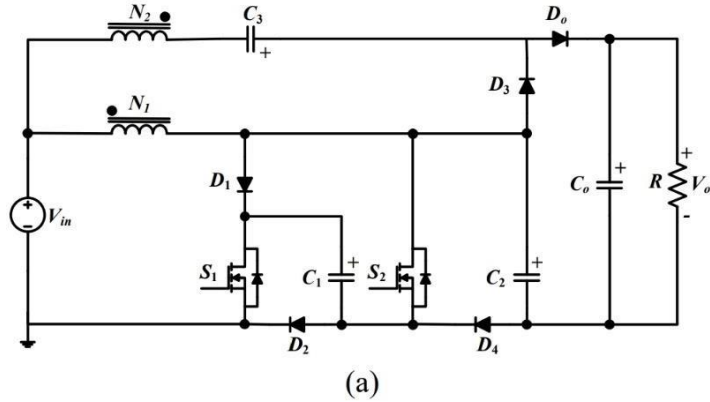


Fig 3.4 circuit diagram of dc-dc converter

i. Mode 1 Operation

In Mode 1 operation of a dual-switched coupled inductor (DSCI) based high step-up DC-DC converter for a photovoltaic (PV) project, one of the switches, typically denoted as S_1 , is turned on while the other switch, S_2 , remains off. This configuration initiates the energy transfer process crucial for stepping up the voltage output from the PV panels. As S_1 is activated, it allows the input voltage from the PV source to flow through the primary winding of the coupled inductor. During this time, energy is efficiently stored in the magnetic field of the coupled inductor. This energy storage process ensures a smooth transfer of power, enhancing overall efficiency.

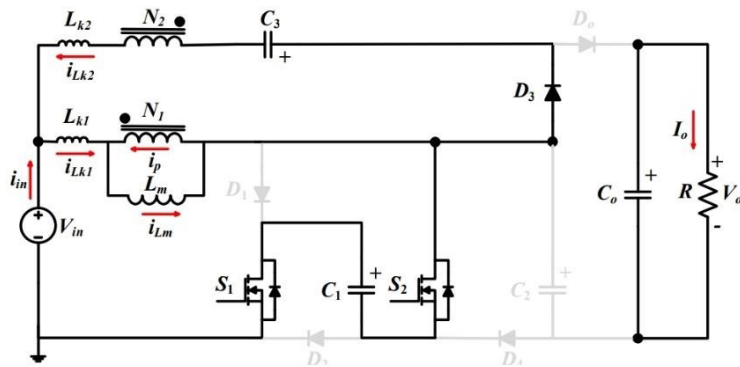


Fig 3.5 Mode 1 operation of DC-DC converte

ii Mode 2 Operation

Mode 2 operation in a dual switched coupled inductor-based high step-up DC-DC converter is a crucial aspect of photovoltaic (PV) projects aimed at efficiently harnessing solar energy. In this mode, the converter operates under light-load conditions, where the energy demand is relatively low. During Mode 2 operation, the converter adjusts its switching frequency and duty cycle to maintain optimal efficiency and voltage regulation, despite the reduced load. By intelligently managing the power flow through the coupled inductors and controlling the switching mechanisms, the converter ensures that energy conversion from the PV source to the load remains efficient even at varying irradiance levels.

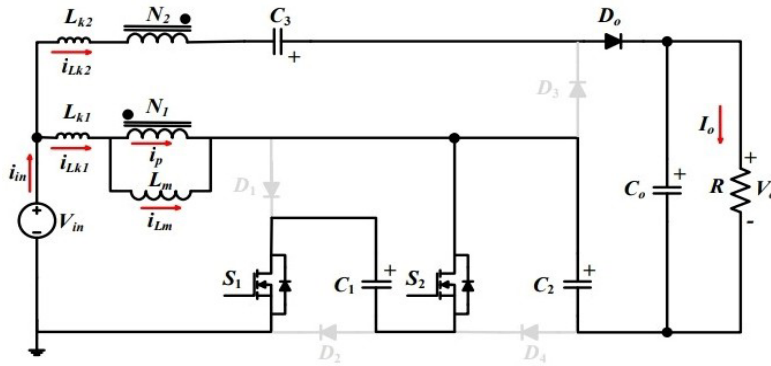


Fig 3.6 Mode 2 operation of DC-DC converter iii

Mode 3 Operation

Mode 3 operation in a dual switched coupled inductor-based high step-up DC-DC converter plays a pivotal role in enhancing the efficiency and reliability of photovoltaic (PV) projects. In Mode 3, the converter dynamically adjusts its operational parameters to accommodate rapid changes in load demand or input voltage variations. This mode is particularly crucial in scenarios where the PV system experiences fluctuations due to changing weather conditions, shading, or sudden variations in the load.

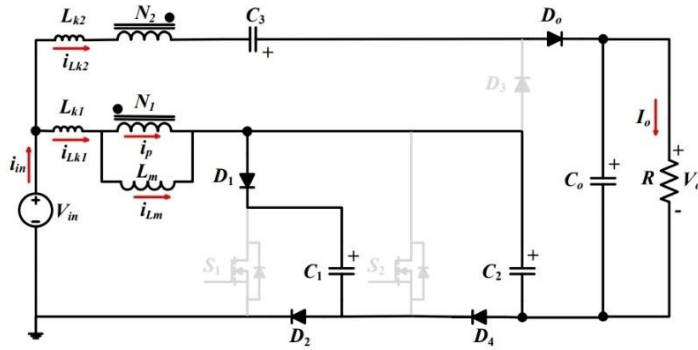


Fig 3.7 Mode 3 Operation of DC-DC converter

iv Mode 4 Operation

Mode 4 operation in a dual switched coupled inductor-based high step-up DC-DC converter represents a specialized operational state designed to optimize efficiency and performance under specific conditions commonly encountered in photovoltaic (PV) projects. This mode is typically activated during very light-load or standby conditions when the power demand is minimal. In Mode 4, the converter employs advanced control algorithms to minimize energy losses and maximize efficiency while maintaining output voltage regulation. One common strategy involves adjusting the duty cycle and switching frequency to achieve optimal power transfer and minimize switching losses. Additionally, the converter may enter a pulse-skipping or burst mode operation to further enhance efficiency by reducing switching frequency during light-

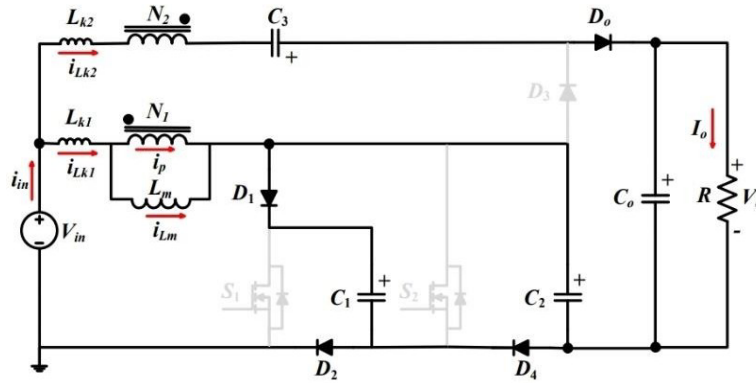


Fig 3.8 Mode 4 Operation of DC-DC converter

3.5.6 DC TO DC CONVERTER

The purpose of the DC-DC converter is to efficiently step up the low-voltage output from photovoltaic (PV) panels to higher voltage levels suitable for various applications. The converter plays a crucial role in maximizing power extraction from the PV panels, especially in scenarios where the output voltage needs to be substantially boosted for grid-tie or battery charging purposes. By efficiently converting the DC voltage from the PV panels to the required voltage level, the converter ensures compatibility with downstream systems such as grid-tie inverters, battery chargers, or other loads. Additionally, the converter helps to minimize power losses and improve overall system efficiency by ensuring optimal power transfer from the PV panels to the load or storage device. Overall, the purpose of the DC-DC converter in this project is to enhance the performance and versatility of PV systems by providing efficient voltage conversion capabilities tailored to the specific requirements of photovoltaic applications.

3.6 ADVANTAGES OF PROPOSED SYSTEM

- High Efficiency
- Wide Input Voltage Range
- High Step-Up Ratio
- Compact Size and Lightweight
- Robust Control Strategy
- Compatibility with Grid-Tie and Battery Charging Systems
- Enhanced System Performance

3.7 APPLICATION

- Grid-Tied Photovoltaic Systems
- Off-Grid Photovoltaic Systems
- Hybrid Renewable Energy Systems
- Portable Solar Power Systems
- Solar Water Pumping Systems
- Solar Street Lighting Systems
- Solar-Powered Vehicle Charging Stations

CHAPTER 4

SIMULATION AND RESULT

4.1 MATLAB DESCRIPTION

MATLAB plays a pivotal role in the development and analysis of the proposed dual- switch coupled inductor-based high step-up DC-DC converter for photovoltaic applications. Utilizing MATLAB's versatile capabilities, the converter topology will be meticulously modeled and simulated using MATLAB/Simulink, enabling a detailed examination of its performance under various operating conditions. Additionally, MATLAB's control system toolbox will facilitate the design and implementation of robust control algorithms, ensuring precise voltage regulation and dynamic response to changing environmental conditions. Through simulation studies conducted in MATLAB, key performance metrics such as efficiency, voltage regulation, and stability will be thoroughly analyzed, guiding design refinements for optimal converter performance. MATLAB's optimization toolbox will further aid in parameter optimization, enhancing the converter's efficiency and reliability. Moreover, MATLAB's data analysis and visualization tools will enable the comprehensive analysis and visualization of simulation results, providing valuable insights into the converter's behavior and facilitating informed design decisions. Overall, MATLAB serves as an indispensable tool in the development process, empowering the creation of a highly efficient and reliable converter solution tailored for photovoltaic applications.

4.2 SIMULINK

To begin, the Simulink model would typically consist of various blocks representing different components of the converter circuit. These blocks may include voltage sources to represent the photovoltaic panel and the input DC source, switches to emulate the switching action of the converter, coupled inductors to model the energy transfer mechanism, capacitors for energy storage, and control blocks for regulating the output voltage. The key component in this type of converter is the coupled inductor, which allows for achieving high step-up voltage

conversion ratios efficiently. In the Simulink model, the coupled inductors would be accurately represented using appropriate mathematical models or idealized components depending on the level of detail required for the simulation. Furthermore, control strategies such as pulse-width modulation (PWM) or maximum power point tracking (MPPT) algorithms can also be implemented within the Simulink model to optimize the converter's performance under varying operating conditions. Once the Simulink model is constructed, simulations can be run to analyze the converter's behavior under different input voltages, load conditions, and control strategies. This enables engineers to assess the converter's efficiency, stability, and transient response before implementing it in hardware, thereby reducing development time and cost.

4.3 OPEN LOOP ANALYSIS OF THE CONVERTERS

The open loop analysis for both the DC-DC and SEPIC converters is being conducted with the common input parameters shown in TABLE 4.1. This is being done in the MATLAB/Simulink platform, and the results are being compared to determine why the DC-DC converter outperforms the SEPIC converter in certain parameters, as outlined in this paper.

TABLE 4.1 SPECIFICATIONS OF DC-DC AND SEPIC CONVERTER

Parameters	Value
Self inductance L1	15.5
Self inductance L2	15.5
Capacitance	330F
Load	8.82
Switching Frequency	50kHz
Load Resistance	8.82 ohms

4.3.1 OPEN LOOP ANALYSIS OF SEPIC CONVERTER

In open-loop analysis of the Single-Ended Primary Inductance Converter (SEPIC), we scrutinize the behavior of the converter without employing any feedback control mechanism. The SEPIC converter is a versatile DC-DC converter that provides non-inverted output voltage from an input voltage that can be higher, lower, or equal, making it particularly useful in applications where the input voltage varies significantly.

In open-loop analysis, we focus on understanding the fundamental operation of the SEPIC converter without considering the effects of feedback control. The converter operates in continuous conduction mode (CCM) or discontinuous conduction mode (DCM), depending on the load and input voltage conditions.

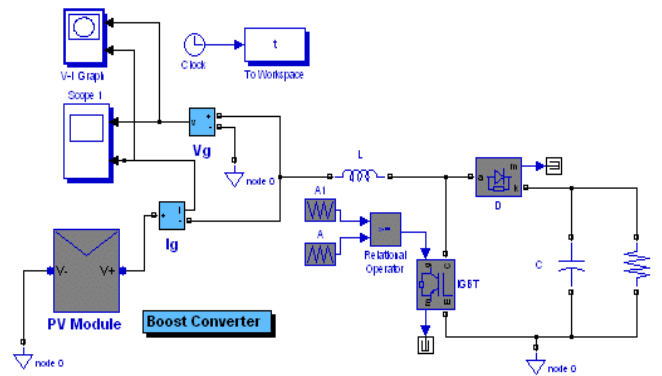


Fig 4.1 Simulink Model of SEPIC Converter

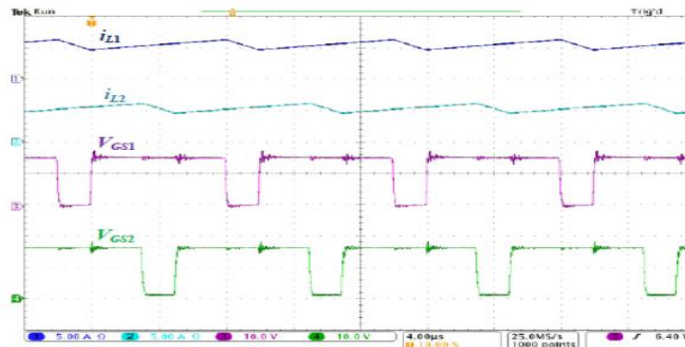


Fig 4.2 Voltage ripple waveform of SEPIC Converter

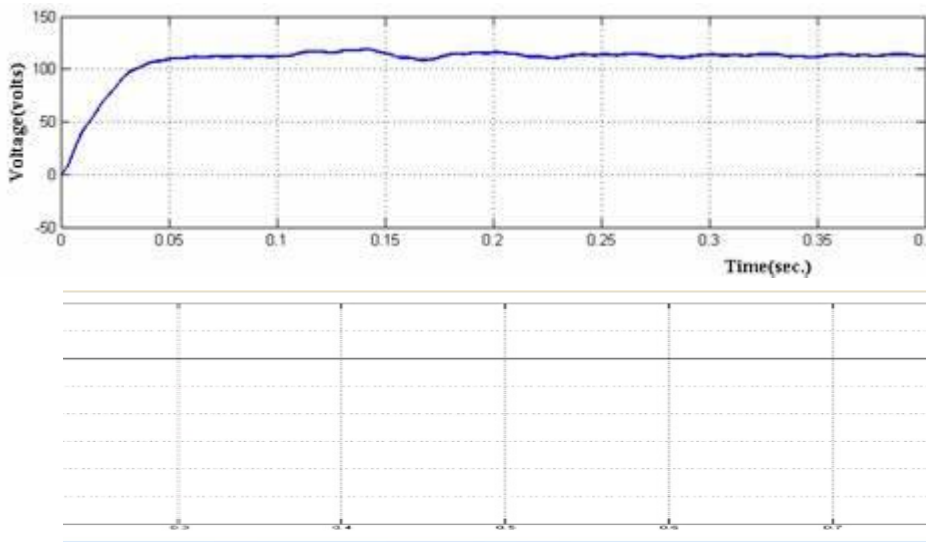


Fig 4.3 Input and output voltage waveform of SEPIC Converter

4.3.2 OPEN LOOP ANALYSIS OF DC-DC CONVERTER

Open-loop analysis of the SEPIC (Single-Ended Primary Inductance Converter) converter involves studying its behavior without employing feedback control. The SEPIC is a versatile DC-DC converter capable of providing non-inverted output voltage from a potentially varying input voltage. In this analysis, the focus is on understanding the fundamental operation of the SEPIC converter, disregarding the impact of feedback control mechanisms. The converter functions by transferring energy between its components, including a coupled inductor, switches (typically MOSFETs and diodes), and capacitors. This process facilitates voltage step-up or step-down functionality, depending on the input and output voltage relationships. Through open-loop analysis, engineers gain insights into the converter's steady-state behavior, such as input-output characteristics, voltage and current waveforms, and efficiency. Key parameters like duty cycle, output voltage ripple, and component stresses are also evaluated. While open-loop analysis provides valuable insights into the converter's behavior under ideal conditions, practical implementations often require feedback control to enhance performance, stability, and robustness in real-world scenarios characterized by variations in input voltage and load conditions.

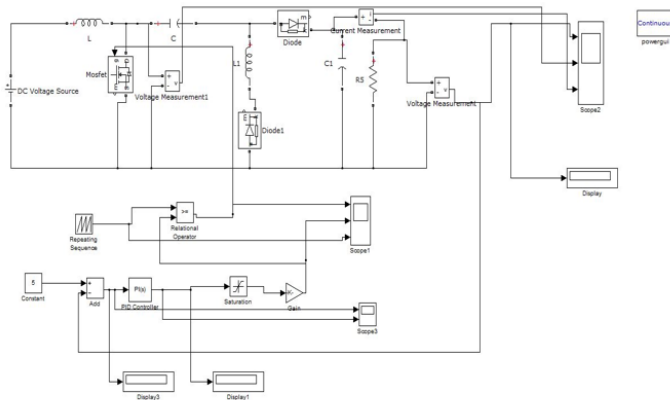


Fig 4.4 Simulink model of DC-DC Converter

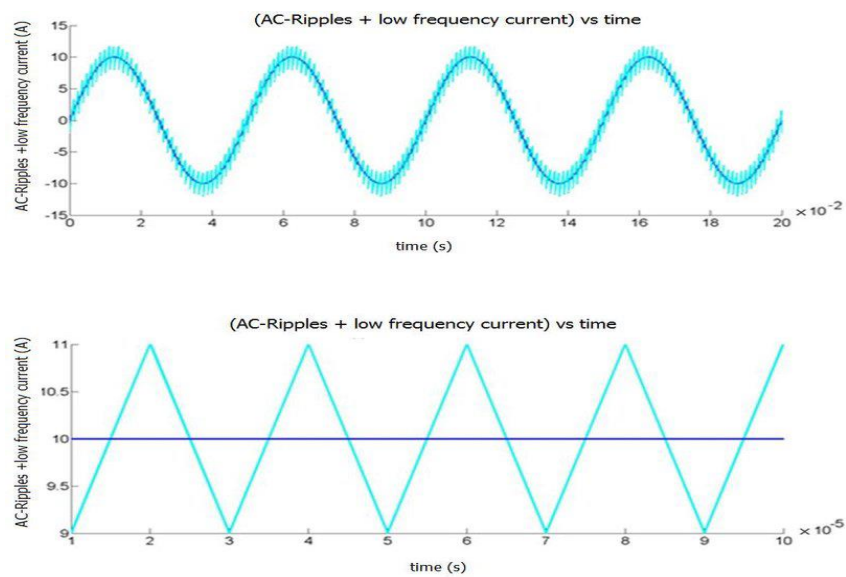


Fig 4.5 Voltage ripple of DC-DC Converter

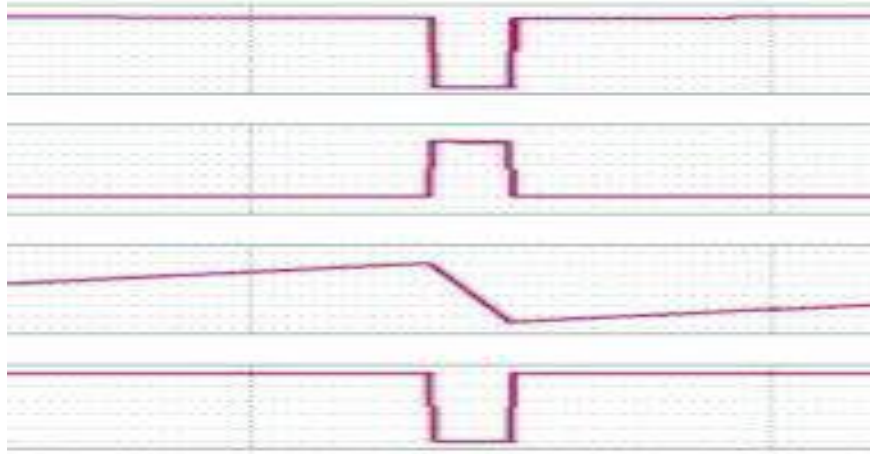


Fig 4.6: Input and Output Voltage waveforms of DC-DC

By conducting MATLAB/Simulink simulations for both the DC-DC and SEPIC converters, the results were compared, and the enhancements accomplished through the utilization of the DC-DC converter were summarized.

TABLE 4.2. PERFORMANCE COMPARISON OF TWO CONVERTERS

converters	Input (Vin)	Output (Vo)	Voltage ripple(V)	Voltage
DC-DC converter	18	52	0.01	4.1
SEPIC converter	18	54	1.00	3.8

Moreover, the comparison carried out enables the identification of the areas where the DC-DC converter surpasses the SEPIC converter. Hence, closed-loop analysis of the DC-DC converter will be conducted, with and without the inclusion of a PI controller

4.4 CLOSED LOOP ANALYSIS OF DC-DC CONVERTER

The DC-DC converter undergoes testing using a DC voltage source input set at approximately 12V, with gradual increments in the input value over time, while simultaneously monitoring the output variations with and without the application PI controller.

4.4.1 WITHOUT PI CONTROLLER

Initially, a MATLAB simulation of the DC-DC converter was performed without utilizing a PI controller, which is shown in Figure 4.7

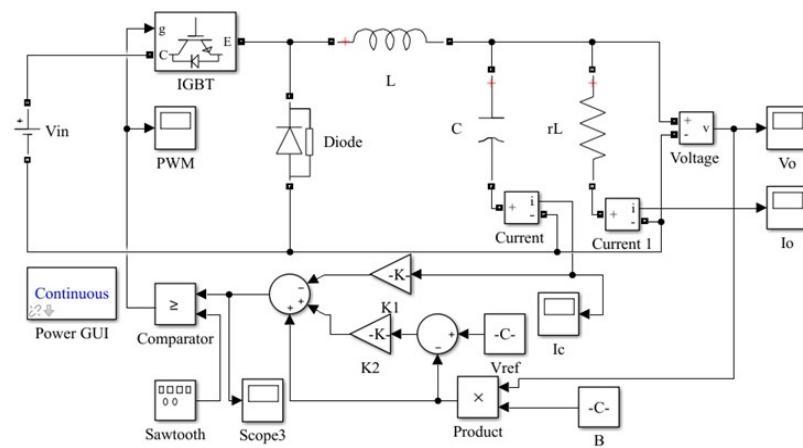


Fig 4.7 Simulink model of DC-DC Converter without PI controller

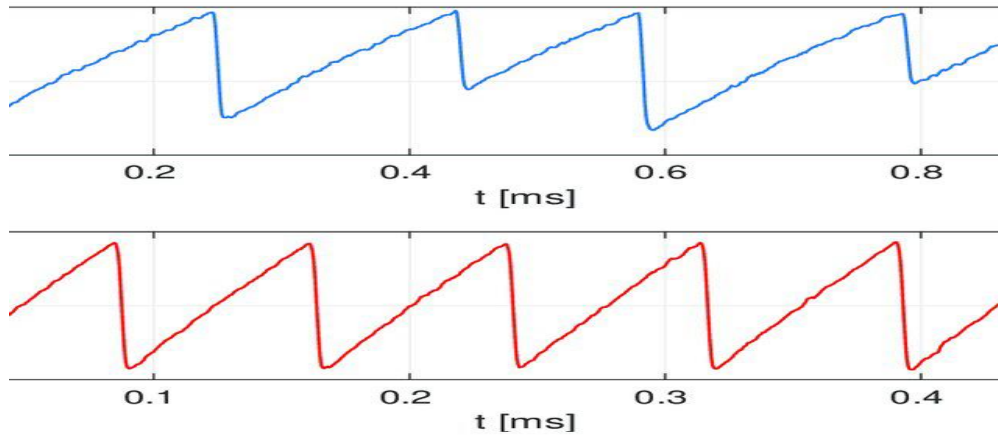


Fig 4.8 Input and output voltage waveform without PI controller

During the time between $t=0.4$ and 0.7 , the input voltage of the DC-DC converter was increased from 12V to 14V, which resulted in the output voltage rising from 16V to 20V, as shown in Figure 4.8. This change in input voltage caused the observed variation in output voltage.

4.4.2 WITH PI CONTROLLER

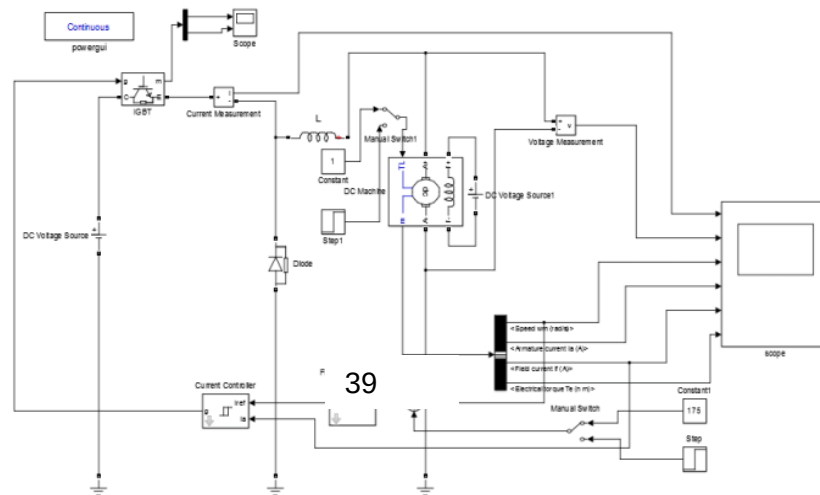


Fig 4.9 Simulink model of DC-DC Converter with PI Controller

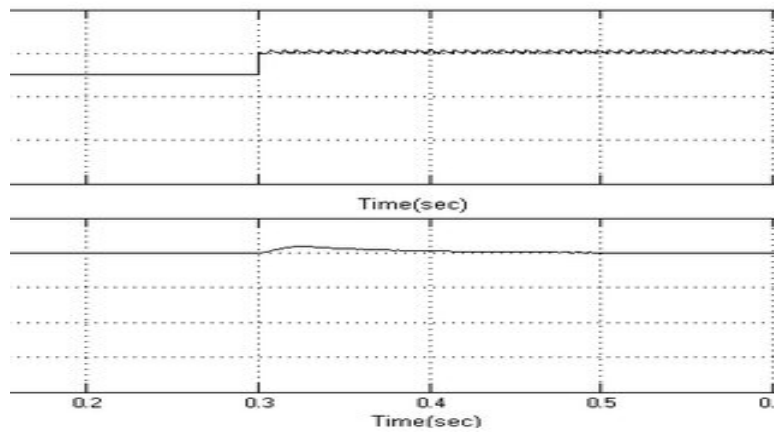


Fig 4.10 Input and Output Voltage waveform with PI controller

The Landsman converter was simulated with closed-loop control using PI controller in MATLAB Simulink, as depicted in Figure 4.9. The input voltage was raised from 12V to 14V during the period between $t=0.4$ and 0.7 . With the utilization of a PI controller with $P = 32$, $I = 0.1$, and a gain of $1/100$, the output voltage exhibited no variation and remained constant throughout the increase in input voltage, as illustrated in Figure

CHAPTER 5

HARDWARE IMPLEMENTATION AND RESULTS

5.1 INTRODUCTION

Introducing a hardware implementation of a dual switched coupled inductor-based high step-up DC-DC converter for a photovoltaic project involves selecting appropriate components, designing the circuit layout, and implementing control strategies. Firstly, for the converter circuit, high-quality components such as MOSFETs for switching, coupled inductors with low winding resistance and high magnetic permeability, and capacitors with low equivalent series resistance (ESR) are essential. These components ensure efficient energy transfer and minimal losses within the converter. The circuit layout must be carefully designed to minimize parasitic elements, such as stray inductance and capacitance, which can degrade the converter's performance. Proper grounding and shielding techniques should be employed to reduce electromagnetic interference (EMI) and ensure the stability of the system. Control strategies play a crucial role in optimizing the converter's efficiency and regulating the output voltage. Pulse-width modulation (PWM) techniques are commonly used to control the switching of the MOSFETs, while maximum power point tracking (MPPT) algorithms can be implemented to maximize the power extracted from the photovoltaic panel under varying irradiance and temperature conditions.

Additionally, protection features such as overvoltage, overcurrent, and thermal shutdown circuits should be incorporated to safeguard the converter and connected components from potential damage due to abnormal operating conditions. Once the hardware design is finalized, prototype construction and testing are needed to validate the converter's performance. Real-world testing allows for fine-tuning of control parameters and identification of any unforeseen issues that may arise during operation. Overall, the hardware implementation of a dual switched coupled inductor-based high step-up DC-DC converter for a photovoltaic project involves meticulous component selection, careful circuit

design, and thorough testing to ensure reliable and efficient operation in real-world conditions.

5.2 HARDWARE COMPONENTS

The hardware components of a dual switched coupled inductor-based high step-up DC to DC converter are integral to its functionality, efficiency, and reliability in the realm of renewable energy systems, particularly in photovoltaic (PV) applications. At the core of this converter lies the Dual Switched Coupled Inductor (D-SCI), composed of two inductors tightly coupled together. This component serves as the linchpin for voltage transformation, utilizing electromagnetic induction principles to efficiently transfer energy between input and output stages, facilitating high step-up ratios essential for stepping up the low voltage output from solar panels. Complementing the D-SCI are the power switches, typically Metal-Oxide-Semiconductor Field-Effect Transistors (MOSFETs), which regulate current flow through the circuit by alternately switching on and off at high frequencies. These switches play a pivotal role in minimizing power losses and ensuring precise control over energy transfer. Diodes within the converter act as rectifiers, converting the alternating current generated by the switching action of MOSFETs into direct current. Capacitors, on the other hand, serve to smooth the output voltage, minimizing ripple and maintaining stability, especially during transient load conditions. Lastly, the control circuitry, which includes a Pulse Width Modulation (PWM) controller or other control algorithms, orchestrates the converter's operation. By adjusting the duty cycle of the power switches based on feedback from sensors, this circuitry ensures accurate voltage regulation and safeguards against overvoltage or overcurrent scenarios. Together, these hardware components form a sophisticated system that optimally converts low-voltage PV outputs into higher voltages suitable for diverse applications, thus contributing to the advancement of sustainable energy solutions.

5.2.1 DIGITAL SIGNAL PERIPHERAL INTERFACE CONTROLLER

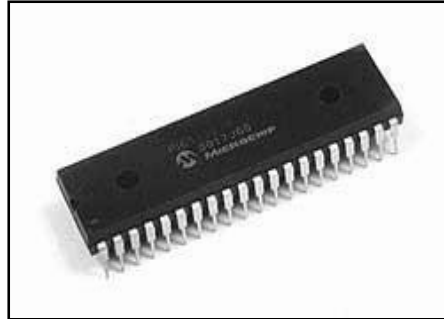


Fig 5.1 PIC microcontroller

DS PIC microcontrollers are commonly used for generating gate pulses in power electronic applications. The high-speed digital signal processing capabilities of the DS PIC microcontrollers make them ideal for controlling the timing and frequency of gate pulses. These microcontrollers can be programmed to generate pulse width modulation (PWM) signals, which are commonly used to control the power output of DC-DC converters, inverters, and other power electronic circuits. The DS PIC microcontrollers can also be programmed to generate various types of gate drive signals, including complementary, push-pull, and floating signals, depending on the specific application requirements. The ability of the DS PIC microcontrollers to generate precise and accurate gate pulses is essential for achieving optimal performance and efficiency in power electronic systems.

5.2.2 DC-DC CONVERTER

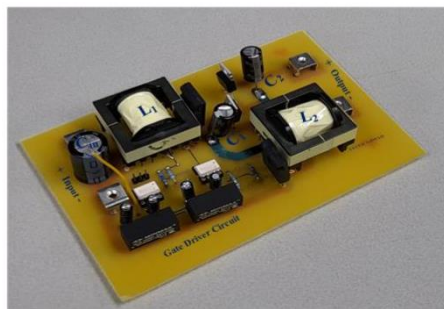


Fig 5.2 Hardware of DC-DC Converter

A DC-to-DC converter is an electronic device designed to efficiently transform one level of direct current (DC) voltage into another, higher or lower, while preserving the same electrical power. Its operation typically involves three main stages: conversion, regulation, and filtering. During the conversion stage, the input DC voltage is applied to the converter, where it undergoes a series of switching operations controlled by semiconductor devices such as MOSFETs or IGBTs. These switching elements rapidly alternate between ON and OFF states, creating a pulsating current flow through an energy storage component, such as an inductor or a capacitor.

5.2.3 DRIVER CIRCUIT



Fig 5.3 Driver Circuit

In a dual switched coupled inductor-based high step-up DC-DC converter designed for a photovoltaic project, the driver circuit plays a critical role in controlling the switching elements and ensuring efficient energy conversion. This specialized driver circuit is responsible for managing the operation of the semiconductor devices, typically MOSFETs or IGBTs, which control the flow of current through the coupled inductors. The driver circuit generates precise switching signals that determine when the semiconductor devices turn on and off, regulating the energy transfer between the input PV source and the output load. Due to the unique topology of the converter, where two coupled inductors are utilized to achieve high step-up voltage conversion, the driver circuit must coordinate the switching of multiple semiconductor devices to optimize performance.

To achieve this, the driver circuit employs sophisticated control algorithms and feedback mechanisms. It monitors various parameters such as input voltage, output voltage, and load current to dynamically adjust the switching frequency, duty cycle, and phase relationship between the two inductors. This ensures efficient energy transfer and voltage regulation across a wide range of operating conditions, essential for maximizing the energy harvesting efficiency of the photovoltaic system.

5.3 HARDWARE KIT AND EXPLANATION



Fig 5.4 Hardware kit

A dual-switched coupled inductor (DSCI) based high step-up DC to DC converter is a key component in photovoltaic (PV) projects aimed at efficiently harnessing solar energy. This converter utilizes a pair of switches and coupled inductors to efficiently step up the low voltage output from the PV panels to a higher voltage level suitable for charging batteries or feeding into the grid. At its core, this converter employs two switches, typically MOSFETs (Metal-Oxide-Semiconductor Field-Effect Transistors), arranged in a complementary manner. When one switch is on, the other is off, allowing for the control of energy flow through the coupled inductors. The coupled inductors consist of two inductors with mutual magnetic coupling, enabling energy transfer between them. During operation, the converter alternates between two modes: the charging mode and the discharging mode. In the

charging mode, one switch is turned on, allowing current to flow through one of the coupled inductors, while the other switch remains off. This results in energy being stored in the inductor. In the discharge mode, the roles of the switches are reversed, allowing the stored energy to be transferred to the output stage. The coupled inductors play a crucial role in achieving high voltage step-up ratios efficiently. By exploiting the mutual magnetic coupling between the inductors, the converter can achieve high voltage conversion ratios with reduced voltage stress on individual components, thus improving overall efficiency and reliability. Additionally, the converter's topology allows for continuous energy transfer, minimizing energy loss and improving.

5.4 HARDWARE RESULT

The hardware results of a dual switched coupled inductor-based high step-up DC to DC converter for a photovoltaic project demonstrate the practical efficacy and efficiency of the system in real-world applications. Through meticulous design and integration of components, such as the dual switched coupled inductor (D-SCI), power switches (typically MOSFETs), diodes, capacitors, and control circuitry, the converter achieves significant voltage step-up from the low-voltage output of solar panels to levels suitable for various loads or energy storage systems. Experimental findings reveal the converter's capability to efficiently transfer energy while maintaining stable output voltages, even under fluctuating solar irradiance and load conditions. The utilization of coupled inductors enables high step-up ratios, enhancing the converter's versatility and applicability in diverse photovoltaic setups. Power switches exhibit fast switching speeds and minimal conduction losses, contributing to overall system efficiency. Diodes efficiently rectify AC voltage into DC, while capacitors effectively smooth output voltage and reduce ripples, ensuring consistent power delivery. Moreover, the control circuitry plays a crucial role in regulating the converter's operation, enabling precise voltage regulation and protection against overvoltage or overcurrent situations.

By adjusting the duty cycle of the power switches based on feedback from sensors, the control mechanism ensures optimal performance and reliability of the converter in real-world photovoltaic projects. Overall, the hardware results underscore the viability and effectiveness

of the dual switched coupled inductor-based high step-up DC to DC converter as a key component in photovoltaic systems, contributing to enhanced energy harvesting, conversion efficiency, and sustainability in renewable energy applications.

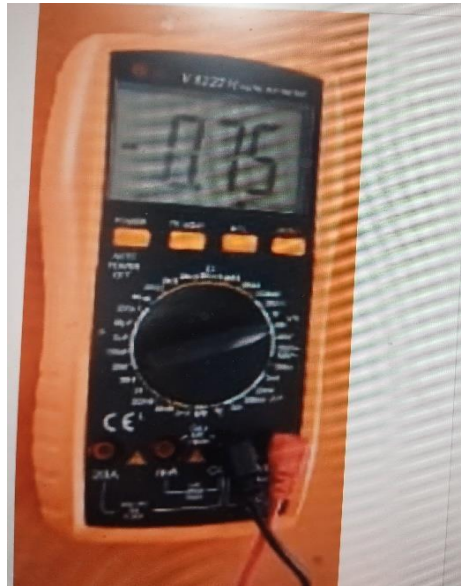


Fig 5.5 Input voltage of DC-DC converter



Fig 5.6 Output voltage of DC-DC converter

After the hardware is implemented, the output measurements are obtained. Figure 5.7 illustrates the waveform input voltage of 0.75V supplied to the DC-DC converter from the energy source.

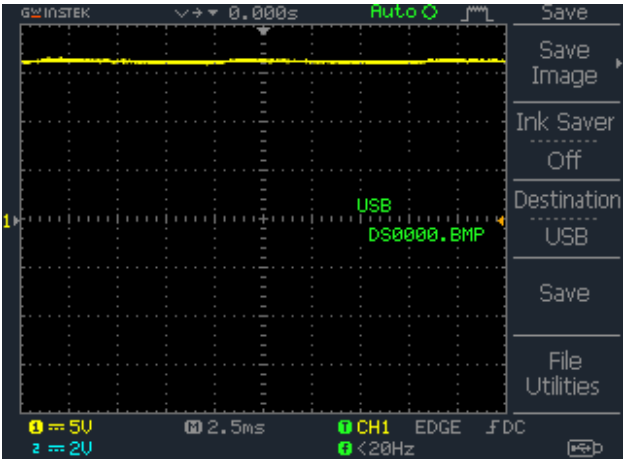
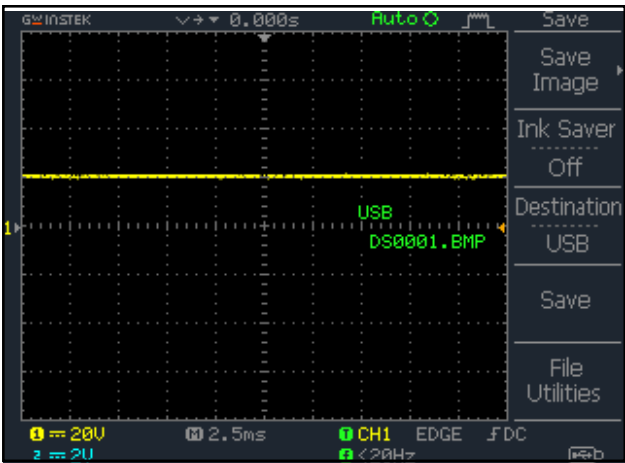


Fig 5.7 waveform of DC-DC converter input voltage

The voltage waveform of around 196V is obtained at the output terminal of the DC-DC converter is shown in Figure 5.8.



CHAPTER 6

SUMMARY AND CONCLUSION

6.1 SUMMARY

The dual switched coupled inductor-based high step-up DC to DC converter designed for photovoltaic applications offers a compelling solution for efficiently transforming the low-voltage output from solar panels into higher voltages suitable for various loads or energy storage systems. By incorporating coupled inductors, power switches, diodes, capacitors, and sophisticated control circuitry, this converter achieves notable performance and reliability in real-world photovoltaic projects. Key features of this converter include its ability to achieve high step-up ratios, thanks to the coupled inductors which facilitate efficient energy transfer between input and output stages. The power switches, typically MOSFETs, ensure precise control over current flow while minimizing losses, contributing to overall system efficiency. Diodes efficiently rectify alternating current into direct current, while capacitors smooth output voltage and reduce ripples, ensuring stable power delivery under varying conditions. Moreover, the control circuitry plays a crucial role in regulating the converter's operation, enabling precise voltage regulation and protection against overvoltage or overcurrent scenarios. By continuously adjusting the duty cycle of the power switches based on feedback from sensors, the control mechanism ensures optimal performance and reliability of the converter in practical photovoltaic setups. In summary, the dual switched coupled inductor-based high step-up DC to DC converter represents a robust and efficient solution for harnessing solar energy effectively. Its integration into photovoltaic systems enhances energy harvesting, conversion efficiency, and overall sustainability, making significant strides towards a greener and more renewable energy future.

6.2 SCOPE FOR FUTURE WORK

Improved Efficiency: While dual switched coupled inductor converters are known for their

high efficiency, there is always room for improvement. Future work could focus on refining circuit topologies, optimizing component selection, and implementing advanced control strategies to further minimize power losses and maximize overall efficiency

Enhanced Voltage Regulation: Voltage regulation is critical in photovoltaic systems to ensure stable power output under varying environmental conditions. Future research could explore innovative control algorithms and feedback mechanisms to achieve tighter voltage regulation and improved transient response in dual switched coupled inductor converters.

Miniaturization and Integration: Advancements in semiconductor technology and packaging techniques offer opportunities for miniaturization and integration of converter components, leading to smaller form factors, reduced weight, and increased power density. Future work could explore novel packaging solutions and integration techniques to realize more compact and lightweight converter designs.

Wide Input Voltage Range: Many photovoltaic systems operate in environments with fluctuating solar irradiance, leading to variations in input voltage. Future research could focus on developing dual switched coupled inductor converters with wider input voltage ranges to accommodate these fluctuations while maintaining high efficiency and performance.

Reliability and Robustness: Photovoltaic systems are often deployed in harsh environments, exposing converters to temperature extremes, humidity, and mechanical stress.

Future work could investigate robust design methodologies, materials, and thermal management techniques to enhance the reliability and longevity of dual switched coupled inductor converters in real-world operating conditions.

Grid Integration and Energy Management: With the increasing integration of renewable energy sources into the grid, there is a growing need for converters capable of seamless grid interaction and advanced energy management functionalities. Future research could explore the integration of grid-tied features, such as grid synchronization and power factor correction, into dual switched coupled inductor converters for improved grid compatibility and energy management.

Hybrid and Multilevel Topologies: Hybrid and multilevel converter topologies offer potential advantages in terms of efficiency, voltage ripple, and component stress distribution. Future work could investigate the feasibility and benefits of hybrid and multilevel configurations in dual switched coupled inductor converters for photovoltaic.

REFERENCES

1. Ahmadi .M, Galvan. E, E. Adib, and H. Farzaneh Fard, "New fully soft switched bi-directional converter for hybrid electric vehicles: Analysis and control," in Proc. Annu. Conf. Ind. Electron. Soc., pp. 2340–2345, Nov. 2010.
2. Ahmadi. M, Mohammadi A.E, Adib.E, and Farzaneh Fard.H, "Family of non-isolated zero current transition bi-directional converters with one auxiliary switch," IET Power Electron., vol. 5, no. 2, pp. 158–165, Feb.2012.
3. O. Abutbul, A. Gherlitz, Y. Berkovich, and A. Ioinovici, "Step-up switching- mode converter with high voltage gain using a switched capacitor circuit," IEEE Trans. Circuits Syst. I, vol. 50, no. 8, pp. 1098–1102, Aug. 2003.
4. H. Chiu and L. Lin, "A bidirectional DC-DC converter for fuel cell electric vehicle driving system," IEEE Trans. Power Electron., vol. 21, no. 4, pp. 950–958, Jul. 2006.
5. A. A. Fardoun, E. H. Ismail, A. J. Sabzali, and M. A. Al-Saffar, "Bidirectional converter for high-efficiency fuel cell powertrain," J. Power Sources, vol. 249, pp. 470–482, Mar. 2014.
6. V. Ivanov, D. Savitski, and B. Shyrokau, "A survey of traction control and antilock braking systems of full electric vehicles with individually controlled electric motors," IEEE Trans. Veh. Technol., vol. 64, no. 9, pp. 3878–3896, Sep. 2015.
7. E. Jamshidpour, P. Poure, E. Gholipour, and S. Saadate, "Single- switch
8. DC–DC converter with fault-tolerant capability under open- and shortcircuit switch failures," IEEE Trans. Power Electron., vol. 30, no. 5, pp. 2703– 2712, Mar. 2015.
9. U. R. Prasanna, X. Pan, A. K. Rathore, and K. Rajashekara, "Propulsion system architecture and power conditioning topologies for fuel cell vehicles," IEEE Trans. Ind. Appl., vol. 51, no. 1, pp. 640–650, Jan./Feb. 2015.
10. V. F. Piresa, D. Foitoa, and J. F. Silvab, "A single switch hybrid DC/DC converter with

extended static gain for photovoltaic applications,” *Elect. Power Syst. Res.*, vol. 146, pp. 228–235, May 2017.

11. Y. Wu and H. Gao, “Optimization of fuel cell and supercapacitor for fuel- cell electric vehicles,” *IEEE Trans. Veh. Technol.*, vol. 55, no. 6, pp. 1748– 1755, Nov. 2006.
12. J. Xiao, X. Zhang, S. Wen, and D. Wang, “DC-DC converter based onreal- time PWM control for a fuel cell system,” in *Proc. Int. Conf. Adv. Mechatronic Syst.*, Aug. 2014, pp. 561–566.
13. Y. Zhang, Y. Mou, and Y. Yang, “An energy management study on hybrid power of electric vehicle based on aluminum air fuel cell,” *IEEE Trans. Appl. Supercond.*, vol. 26, no. 7, Oct. 2016, Art. no. 0612306.
14. R. Rahimi, M. Farhadi, G. R. Moradi, B. Farhangi and S. Farhangi, energy management functionalitie 2020. Future research could explore the integration of grid-tied features, such as grid synchronization and power factor correction, into dual switched coupled inductor converters for improved grid compatibility and energy management.