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A Project Report on

"DESIGN OF HYBRID CONVERTER FOR E VEHICLE"

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The project report has been approved as it satisfies the academic requirements in respect of Project work prescribed for the said Degree.

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DECLARATION

We, [Ms.**MEENS S (1CR16EE045),** Mr. **RAVIKANTH S M (1CR17EE409),** Ms.**SHILPA S LOLA (1CR17EE413),** Mr. **SACHIN (1CR17EE410)],** hereby declare that thereport entitled **"Title of the project"** has been carried out by us under the guidance of **Dr. AGALYA V,** Associate professor, Department of Electrical & Electronics Engineering, CMR Institute of Technology, Bengaluru, in partial fulfillment of the requirement for the degree of**BACHELOR OF ENGINEERING in ELECTRICAL & ELECTRONICS ENGINEERING**, of Visveswaraya Technological University, Belagaum during the academic year 2019-20.The work done in this report is original and it has not been submitted for any other degree in any university.

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Abstract

Many automotive companies are working in developing fuel cell powered Hybrid Electric Vehicles (HEV) because they offer a reduced emission and improves the fuel economy. The key technology for such development of fuel cell for propulsion is the power electronics. This paper reports different DC/DC converter topologies used to interface the fuel cell to the motor controllers in HEVs. The aim is to present a simple and practical boost converter topology with a coordinated control that can regulate both the output voltage and the input current simultaneously. The performance of the proposed power conditioning system is evaluated is simulation results under different dynamics.

An integral part of any modern day electric vehicle is power electronic circuits (PECs) comprising of DC-AC inverters and DC-DC converters. A DC-AC inverter supplies the high power electric motor and utility loads such as air-conditioning system, whereas a DC-DC converter supplies conventional low-power, low-voltage loads. However, the need for high power bidirectional DCDC converters in future electric vehicles has led to the development ofmany new topologies ofDC-DC converters. This paper presents an overview ofstate-of-the-art DC-DC converters used in battery electric vehicles (BEVs), hybrid electric vehicles (BEVs), and fuel cell vehicles (FCVs). Several DC-DC converters such as isolated, nonisolated, half-bridge, fuU-bridge, unidirectional and bidirectional topologies, and their applications in electric vehicles are presented.

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LIST OF ABBREVIATIONS AND SYMBOLS

EV -electric vehicle

HEV- Hybrid electric vehicle

FCEV- fuel cell electric vehicle

FCs-fuel cells

SCs-super capacitors

PV- photo voltaic

PWM- pulse width modulation

CHAPTER 1

INTRODUCTION

1.1 BREIF BACKGROUND OF THE RESEARCH:

The large number of automobiles in use around the world has caused and continues to cause serious problems of environment and human life. Air petroleum pollution, global warming, and the rapid depletion of the earth's resources are now serious problems. Electric Vehicles (EVs), Hybrid Electric Vehicles (HEVs) and Fuel Cell Electric Vehicles (FCEVs) have been typically proposed to replace conventional vehicles in the near future. Most electric and hybrid electric configurations use two energy storage devices, one with high energy storage capability, called the "main energy system" (MES), and the other with high power capability and reversibility, called the "rechargeable energy storage system" (RESS).

MES provides extended driving range, and RESS provides good acceleration and regenerative braking. Energy storage or supply devices vary their output voltage with load or state of charge and the high voltage of the DC-link create major challenges for vehicle designers when integrating energy storage / supply devices with a traction drive. DC-DC converters can be used to interface the elements in the electric power train by boosting or chopping the voltage levels. Due to the automotive constraints, the power converter structure has to be reliable, lightweight, small volume, with high efficiency, low electromagnetic interference and low current/voltage ripple.

Thus, in this chapter, a comparative study on three DC/DC converters topologies (Conventional step-up dc-dc converter, interleaved 4-channels step-up dc-dc converter with independent inductors and Full-Bridge step-up dc-dc converter) is carried out. The modeling and the control of each topology are presented. Simulations of 30KW DC/DC converter are carried out for each topology. This study takes into account the weight, volume, current and voltage ripples, Electromagnetic Interference (EMI) and the efficiency of each converter topology.

1.2 INTRODUCTION TO ELECTRIC VEHICLES:

An Electric Vehicle is a vehicle that uses a combination of different energy sources, Fuel Cells (FCs), Batteries and Supercapacitors (SCs) to power an electric drive system as shown in Fig. 1. In EV the main energy source is assisted by one or more energy storage devices. Thereby the system cost, mass, and volume can be decreased, and a significant better performance can be obtained. Two often used energy storage devices are batteries and SCS. They can be connected to the fuel cell stack in many ways. A simple configuration is to Electric Vehicles – Modelling and Simulations.

Fig1: Electric vehicle

Directly connect two devices in parallel, (FC/battery, FC/SC, or battery/SC). However, in this way the power drawn from each device cannot be controlled, but is passively determined by the impedance of the devices. The impedance depends on many parameters, e.g. temperature, state-of-charge, health, and point of operation. Each device might therefore be operated at an inappropriate condition, e.g. health and efficiency. The voltage characteristics also have to match perfectly of the two devices, and only a fraction of the range of operation of the devices can be utilized, e.g. in a fuel cell battery configuration the fuel cell must provide almost the same power all the time due to the fixed voltage of the battery, and in a battery/supercapacitor configuration only a fraction of the energy exchange capability of the supercapacitor can be used. This is again due to the nearly constant voltage of the battery. By introducing DC/DC converters one can chose the voltage variation of the devices and the power of each device can be controlled (Schaltz& Rasmussen, 2008).

In reference (Schaltz& Rasmussen, 2008), 10 cases of combining the fuel cell with the battery, SCs, or both are investigated. The system volume, mass, efficiency, and battery lifetime were compared. It is concluded that when SCs are the only energy storage device the system becomes too big and heavy. A fuel cell/battery/supercapacitors hybrid provides the longest life time of the batteries. It can be noticed that the use of high power DC/DC converters is necessary for EV power supply system. The power of the DC/DC converter depends on the characteristics of the vehicle such as top speed, acceleration

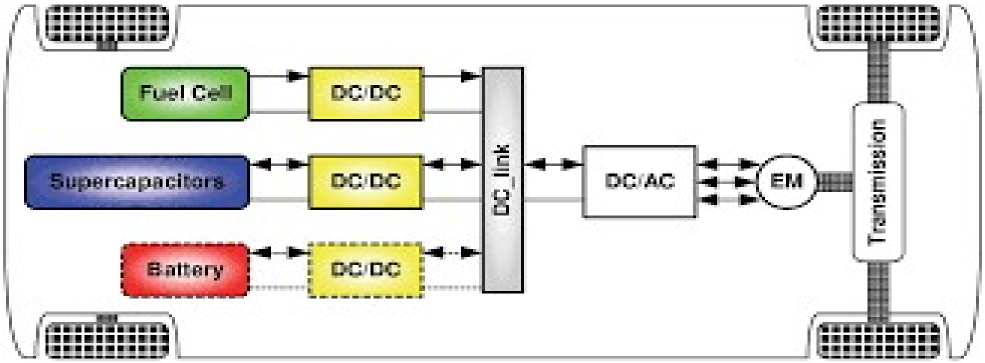


Fig2: Electric vehicle drive system

time from 0 to 100 Km/h, weight, maximum torque, and power profile (peak power, continuous power) (Büchi et al., 2006). Generally, for passenger cars, the power of the converter is more than 20 KW and it can go up to 100 KW.

1.3 DC-DC CONVERTERS FOR ELECTRIC VEHICLES

The different configurations of EV power supply show that at least one DC/DC converter is necessary to interface the FC, the Battery or the Supercapacitors module to the DC-link. In electric engineering, a DC to DC converter is a category of power converters and it is an electric circuit which converts a source of direct current (DC) from one voltage level to another, by storing the input energy temporarily and then releasing that energy to theoutput at a different voltage.

The storage may be in either magnetic field storage components (inductors, transformers) or electric field storage components (capacitors). DC/DC converters can be designed to transfer power in only one direction, from the input to the output. However, almost all DC/DC converter topologies can be made bi-directional. A bi-directional converter can move power in either direction, which is useful in applications requiring regenerative braking. The amount of power flow between the input and the output can be controlled by adjusting the duty cycle (ratio of on/off time of the switch).

Fig3: Dc-Dc converter for electric vehicle

Usually, this is done to control the output voltage, the input current, the output current, or to maintain a constant power. Transformerbased converters may provide isolation between the input and the output. The main drawbacks of switching converters include complexity, electronic noise and high cost for some topologies. Many different types of DC/DC power converters are proposed in literature (Chiu & Lin, 2006), (Fengyan et al., 2006). The most common DC/DC converters can be grouped as follows:

1.3.1 Non-isolated converters

Fig4: Non isolated converters

The non-isolated converters type is generally used where the voltage needs to be stepped up or down by a relatively small ratio (less than 4:1). And when there is no problem with the output and input having no dielectric isolation. There are five main types of converter in this non-isolated group, usually called the buck, boost, buck-boost, Cuk and charge-pump converters.

The buck converter is used for voltage step-down, while the boost converter is used for voltage step-up. The buck-boost and Cuk converters can be used for either stepdown or step-up. The charge-pump converter is used for either voltage step-up or voltage inversion, but only in relatively low power applications.

1.3.2 Isolated converters

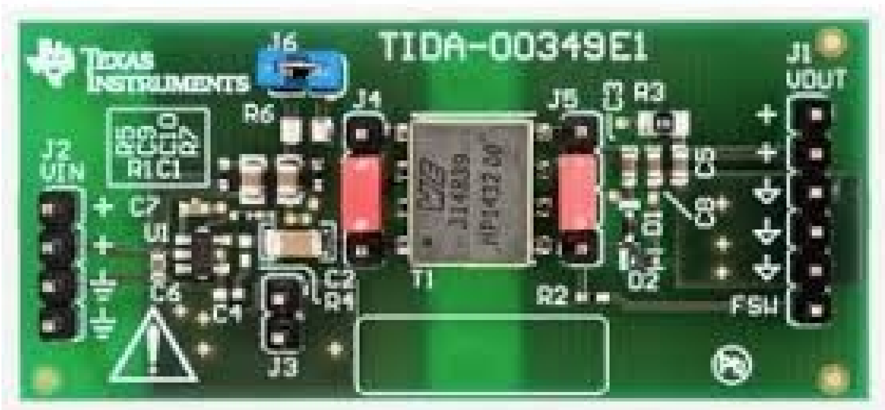


Fig5: Isolated converters

Usually, in this type of converters a high frequency transformer is used. In the applications where the output needs to be completely isolated from the input, an isolated converter is necessary. There are many types of converters in this group such as Half-Bridge, FullBridge, Fly-back, Forward and Push-Pull DC/DC converters (Garcia et al., 2005), (Cacciato et al., 2004). All of these converters can be used as bi-directional converters and the ratio of stepping down or stepping up the voltage is high.

1.4 THE ELECTRIC VEHICAL CONVERTER REQUIREMENTS

In case of interfacing the Fuel Cell, the DC/DC converter is used to boost the Fuel Cell voltage and to regulate the DC-link voltage. However, a reversible DC/DC converter is needed to interface the SCs module. A wide variety of DC-DC converters topologies, including structures with direct energy conversion, structures with intermediate storage components (with or without transformer coupling), have been published (Lachichi& Schofield, 2006), (Yu & Lai, 2008), (Bouhalli et al., 2008). However some design considerations are essential for automotive applications:

- Light weight,
- High efficiency,
- Small volume,
- Low electromagnetic interference,
- Low current ripple drawn from the Fuel Cell or the battery,
- The step up function of the converter,
- Control of the DC/DC converter power flow subject to the wide voltage variation on the converter input.

Each converter topology has its advantages and its drawbacks. For example, The DC/DC boost converter does not meet the criteria of electrical isolation. Moreover, the large variance in magnitude between the input and output imposes severe stresses on the switch and this topology suffers from high current and voltage ripples and also big volume and weight.

A basic interleaved multichannel DC/DC converter topology permits to reduce the input and output current and voltage ripples, to reduce the volume and weight of the inductors and to increase the efficiency. These structures, however, can not work efficiently when a high voltage step-up ratio is required since the duty cycle is limited by circuit impedance leading to a maximum step-up ratio of approximately 4. Hence, two series connected step-up converters would be required to achieve the specific voltage gain of the application specification. A full-bridge DC/DC converter is the most frequently implemented circuit configuration for fuel-cell power conditioning when electrical isolation is required. The full bridge DC/DC converter is suitable for high-power transmission because switch voltage and current are not high. It has small input and output current and voltage ripples. The fullbridge topology is a favorite for zero voltage switching (ZVS) pulse width modulation (PWM) techniques.

CHAPTER 2

LITERATURE REVIEW

2.1 BRIEFABOUT THE LETERATURE REVIEW

In 1997, Honda Motors released a hybrid two-wheeler concept in the Tokyo motor show with the key goals of a 60% reduction in CO2 emission and 2.5 times better fuel-efficiency. In this system, a water-cooled 49 cc gasoline engine packed with a DC brushless electric motor for driving the rear wheel. The gasoline engine delivers power for high-speed performance and for hill climbing while the electric motor is engaged for low-speed cruising.

Biona (2007) conducted an analysis to investigate the fuel use and emission reduction potential of incorporating hybrid systems to two stroke powered vehicles. Carbureted and direct injection two stroke engine hybrid systems were investigated and compared with the impact of shifting to four stroke engines. Results showed that hybridized two stroke powered systems would be able to provide far better environmental and fuel reduction benefits than the shift to new four stroke vehicles. He recommended that the development of such technology specifically for two stroke vehicles be seriously pursued.

In India, two-wheelers play a vital role in fulfilling personal transportation, especially in urban areas due to their maneuverability and affordability. They contribute to nearly two-third of the vehicle population in 45 India. The high fuel consumption and emission contribution of two-wheelers in urban areas needs to receive more attention in order to improve the nearterm sustainability of energy and urban air quality in the future. Therefore, the implementation of plug-in hybrid technology for two-wheelers will result in reduction of greenhouse gas emission and petroleum oil independency to a large extent.

The plug-in concept is implemented in certain concept cars and two-wheelers in the market in a limited way. Following are the important conclusions drawn from the above literature review: Modeling, simulation, sizing and selection of powertain components for the plug-in hybrid electric two-wheeler are based on all-electric range, driving style and battery type. There is a need for development of optimum control strategy for plug-in hybrid electric two-wheeler to manage the energy and power between hub motor with battry pack and IC engine. Estimation of correct battery type, battery energy capacity and its mass for different all-electric range may vary based on driving cycle. Economic and emission reduction analysis will help the commercialisation of plug-in hybrid electri two-wheelers. The above factors from the literature survey clearly show the available scope for the present work.

2.2 BASIC PRINCIPLE OF INVERTER

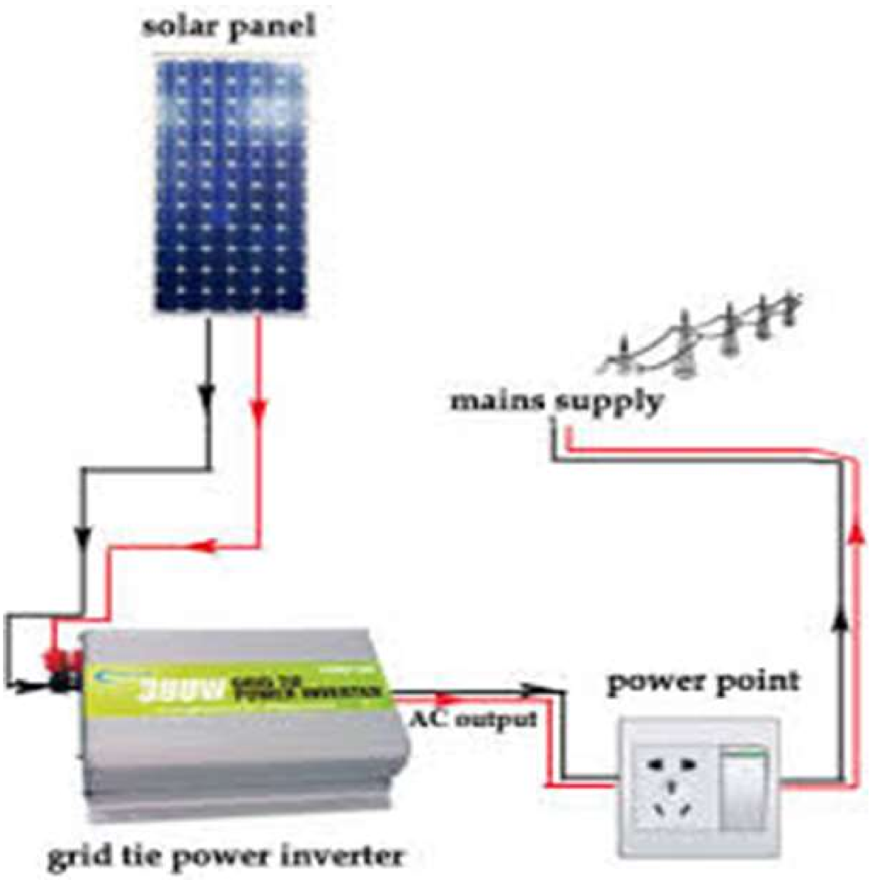


Fig6: Circuit of solar inverter

A solar inverter, or PV inverter, converts the variable direct current (DC) output of a photovoltaic (PV) solar panel into a utility frequency alternating current (AC) that can be fed into a commercial electrical grid or used by a local, off-grid electrical network.

It is a critical component in a photovoltaic system, allowing the use of ordinary commercial appliances. Solar inverters have special functions adapted for use with photovoltaic arrays, including maximum power point tracking and anti-islanding protection

2.3 NEED OF SOLAR INVERTER

There are two types of sources for electrical power generation. One is conventional and other is non- conventional. Today to generate most of electrical power conventional sources like coal, gas, nuclear power generators are used. Some of conventional source are polluted the environment to generate the electricity. And nuclear energy is not much preferable because of its harmful radiation effect on the mankind. After some of ten years conventional sources will not sufficient enough to fulfill the requirements of the mankind. So some of the electrical power should be generated by non-conventional energy sources like solar, wind .With the continuously reducing the cost of PV power generation and the further intensification of energy crisis, PV power generation technology obtains more and more application.

Fig7: Solar inverter

Conventionally, there are two ways in which electrical power is transmitted. Direct current (DC) comes from a source of constant voltage and is suited to short-range or device level transmission. Alternating current (AC) power consists of a sinusoidal voltage source in which a continuously changing voltage (and current) can be used to employ magnetic components. Long distance electrical transmission favors AC power, since the voltage can be boosted easily with the use of transformers. By boosting the voltage, less current is needed to deliver a given amount of power to a load, reducing the resistive loss through conductors.

The adoption of AC power has created a trend where most devices adapt AC power from an outlet into DC power for use by the device. However, AC power is not always available and the need for mobility and simplicity has given batteries an advantage in portable power. Thus, for portable AC power, inverters are needed. Inverters take a DC voltage from a battery or a solar panel as input, and convert it into an AC voltage output.

2.4 BASIC PRINCIPLE OF CONVERTER

The key principle that drives the boost converter is the tendency of an inductor to resist changes in current by creating and destroying a magnetic field. In a boost converter, the output voltage is always higher than the input voltage. Converters and inverters are electrical devices that convert current. Converters convert the voltage of an electric device, usually alternating current (AC) to direct current (DC). On the other hand, inverters convert direct current (DC) to alternating current (AC).

2.5 NEED OF CONVERTER

It is a type of converter that works very efficient. It helps to change one level/voltage of DC into another level/voltage of DC.

You may for example have solar power system to charge a battery of 12V battery but your Arduino processor and I2C or RS232 IC for communication monitoring of the solar powerplant on a mobile telephone or 3G data link needs only 3.5V. Instead of using a resistor to consume the energy difference the DC/DC converter converts the one source to the other more efficiently.

- DC/DC converters are used for the following reasons:
- To step down the voltage from a high voltage source to a lower voltage,
- To match the loads to the power supply,
- To isolate the primary and secondary circuits

2.6 BUCK CONVERTER

A Buck converter is a switch mode DC to DC converter in which the output voltage can be transformed to a level less than or greater than the input voltage. The magnitude of output voltage depends on the duty cycle of the switch.It is also called as step up/step down converter.

Fig8: Buck converter

2.7 BOOST CONVERTER

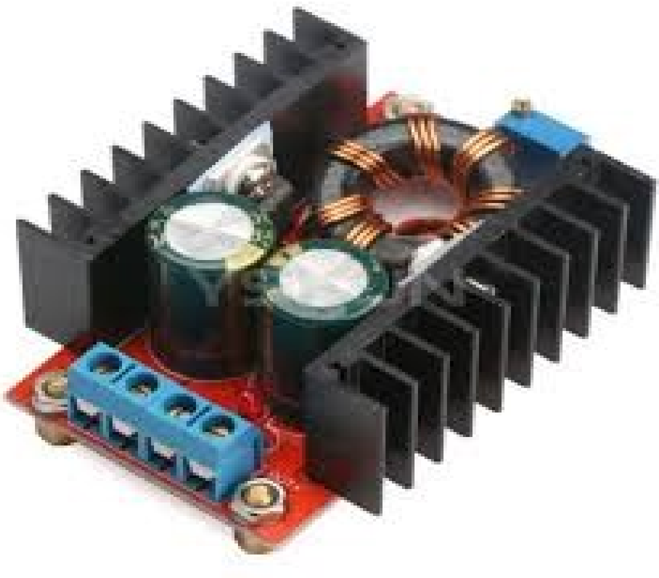


Fig9: Boost converter

A Boost converter is a switch mode DC to DC converter in which the output voltage is greater than the input voltage. It is also called as step up converter. The name step up converter comes from the fact that analogous to step up transformer the input voltage is stepped up to a level greater than the input voltage

2.8 BUCK BOOST CONVERTER

The buck boost converter is a DC to DC converter. The output voltage of the DC to DC converter is less than or greater than the input voltage. The output voltage of the magnitude depends on the duty cycle. These converters are also known as the step up and step down transformers and these names are coming from the analogous step up and step down transformer. The input voltages are step-up/down to some level of more than or less than the input voltage. By using the low conversion energy, the input power is equal to the output power. The following expression shows the low of a conversion.

Input power (Pin) = Output power (Pout).

For the step up mode, the input voltage is less than the output voltage (Vin <Vout). It shows that the output current is less than the input current. Hence the buck booster is a step up mode.

Vin <Vout and Iin>Iout

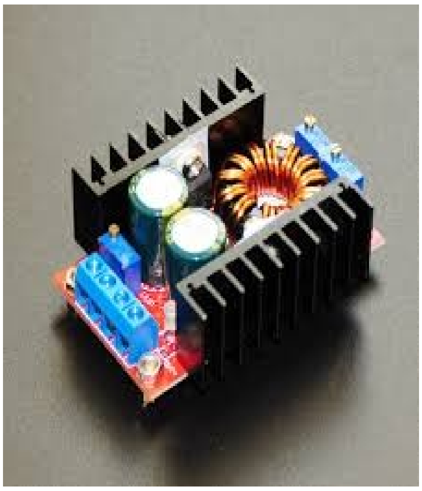


Fig10: Buck boost converter

In the step down mode the input voltage is greater than the output voltage (Vin >Vout). It follows that the output current is greater the input current. Hence the buck boost converter is a step down mode.

It is a type of DC to DC converter and it has a magnitude of output voltage. It may be more or less than equal to the input voltage magnitude. The buck boost converter is equal to the fly back circuit and single inductor is used in the place of the transformer. There are two types of converters in the buck boost converter that are buck converter and the other one is boost converter. These converters can produce the range of output voltage than the input voltage. The following diagram shows the basic buck boost converter.

CHAPTER 3

PROPOSED MODEL WITH THEORITICAL BACKGROUND

3.1 HYBRID CONVERTER ARCHITECTURE

The hybrid converter has been particularly used which replaces other types of converters used earlier. This hybrid converter can be applied to Nanogrid architectures. This Nanogrid architecture is a small type of architecture designed to interface with power system grid particularly residential electrical system [2]. There can be two types of interfacing. They are either conventional energy resources or non-conventional energy sources. This Nanogrid system can be connected to both dc loads as well as ac loads. This hybrid converter is suitable for use in compact systems where more complex circuits are avoided. For example the hybrid converter can be used to power an fan and a led lamp. As already stated above, here two loads can be used. So fan uses ac power and led lamp uses dc power. Hence we can simultaneously use both loads.

The fig shows the schematic of hybrid converter based architecture where the input is a single dc source and the output obtained is both dc output and ac output simultaneously. The major advantage compared to the dc – dc converter and dc – ac converter is a single converter performs both the converters operation and hence the complexity of the entire operation is minimized. This type of hybrid converter is mainly connected to non-conventional energy sources particularly smarter residential system which provides clean energy.

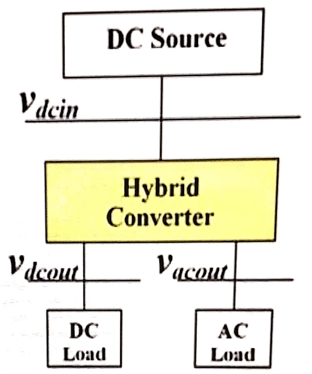


Fig11: Hybrid converter architecture

3.2 PROPOSED MODEL

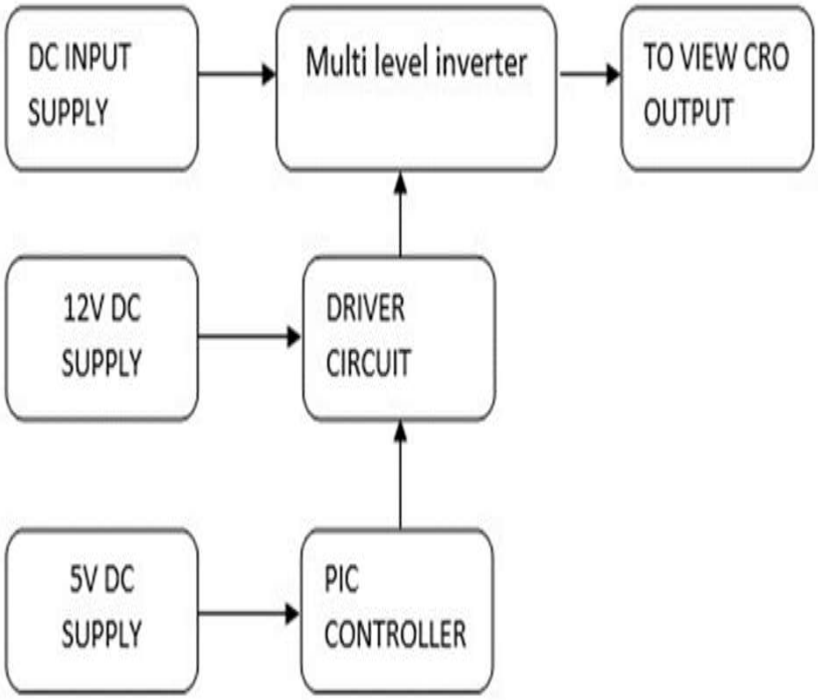


Fig12: proposed model of hybrid converter

Input supply: - AC charger for E Vehicle

Driver circuit: -It can be used to amplify the 5V pulses to 12V for using transistor technology and provided isolations for using opto coupler. It has two functions

Amplification and isolation

Multilevelinverter:The multi-level inverter is to synthesize a near sinusoidal voltage from several levels of dc voltage.

3.3 WORKING PRINCIPLE OF BUCK BOOST CONVERTER

The working operation of the DC to DC converter is the inductor in the input resistance has the unexpected variation in the input current. If the switch is ON then the inductor feed the energy from the input and it stores the energy of magnetic energy. If the switch is closed it discharges the energy. The output circuit of the capacitor is assumed as high sufficient than the time constant of an RC circuit is high on the output stage. The huge time constant is comparedwith the switching period and make sure that the steady state is a constant output voltage Vo(t) = Vo(constant) and present at the load terminal.

There are two different types of working principles in the buck boost converter.

- Buck converter.
- Boost converter.

3.3.1 BUCK CONVERTER WORKING

The following diagram shows the working operation of the buck converter. In the buck converter first transistor is turned ON and second transistor is switched OFF due to high square wave frequency. If the gate terminal of the first transistor is more than the current pass through the magnetic field, charging C, and it supplies the load. The D1 is the Schottky diode and it is turned OFF due to the positive voltage to the cathode.

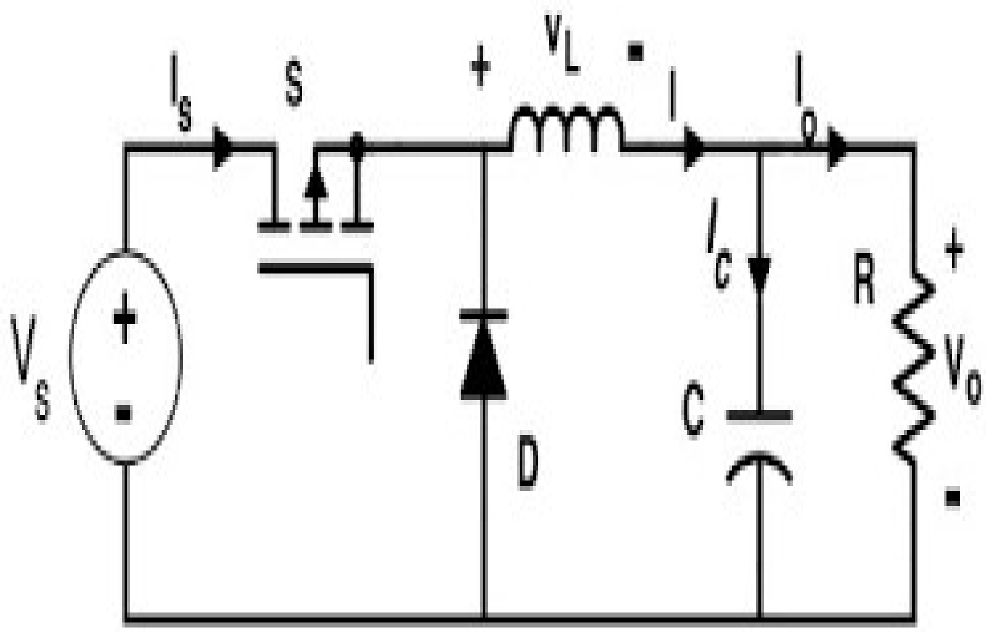


Fig13: buck converter working

The inductor L is the initial source of current. If the first transistor is OFF by using the control unit then the current flow in the buck operation. The magnetic field of the inductor is collapsed and the back e.m.f is generated collapsing field turn around the polarity of the voltage across the inductor. The current flows in the diode D2, the load and the D1 diode will be turned ON.

The discharge of the inductor L decreases with the help of the current. During the first transistor is in one state the charge of the accumulator in the capacitor. The current flows through the load and during the off period keeping Vout reasonably. Hence it keeps the minimum ripple amplitude and Vout closes to the value of Vs.

3.3.2 BOOST CONVERTER WORKING

In this converter the first transistor is switched ON continually and for the second transistor the square wave of high frequency is applied to the gate terminal. The second transistor is in conducting when the on state and the input current flow from the inductor L through the second transistor. The negative terminal charging up the magnetic field around the inductor. The D2 diode cannot conduct because the anode is on the potential ground by highly conducting the second transistor.

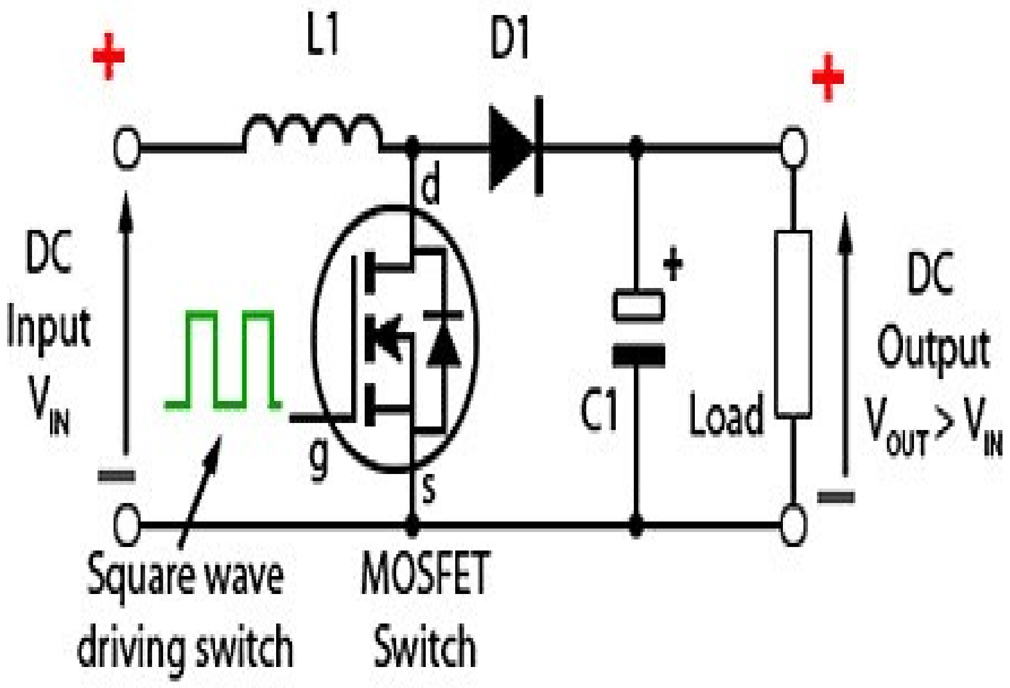


Fig14: boost converter working

By charging the capacitor C the load is applied to the entire circuit in the ON State and it can construct earlier oscillator cycles. During the ON period the capacitor C can discharge regularly and the amount of high ripple frequency on the output voltage. The approximate potential difference is given by the equation below.

$$VS + VL$$

During the OFF period of second transistor the inductor L is charged and the capacitor C is discharged. The inductor L can produce the back e.m.f and the values are depending up on the rate of change of current of the second transistor switch. The amount of inductance the coil can occupy. Hence the back e.m.f can produce any different voltage through a wide range and determined by the design of the circuit. Hence the polarity of voltage across the inductor L has reversed now.

The input voltage gives the output voltage and atleast equal to or higher than the input voltage. The diode D2 is in forward biased and the current applied to the load current and it recharges the capacitors to VS + VL and it is ready for the second transistor.

3.4MODES OF BUCK BOOST CONVERTER

There are two different types of modes in the buck boost converter. The following are the two different types of buck boost converters.

- Continuous conduction mode.
- Discontinuous conduction mode.

Continuous Conduction Mode: In the continuous conduction mode the current from end to end of inductor never goes to zero. Hence the inductor partially discharges earlier than the switching cycle.

Discontinuous Conduction Mode: In this mode the current through the inductor goes to zero. Hence the inductor will totally discharge at the end of switching cycles.

Applications of Buck boost converter

- It is used in the self regulating power supplies.
- It has consumer electronics.
- It is used in the Battery power systems.
- Adaptive control applications.
- Power amplifier applications.

Advantages of Buck Boost Converter

- It gives higher output voltage.
- duct cycle.
- Low voltage on MOSFETs
- Low operation.

CHAPTER 4

DESIGN AND PROCESS

4.1 DESIGN OF BATTERY

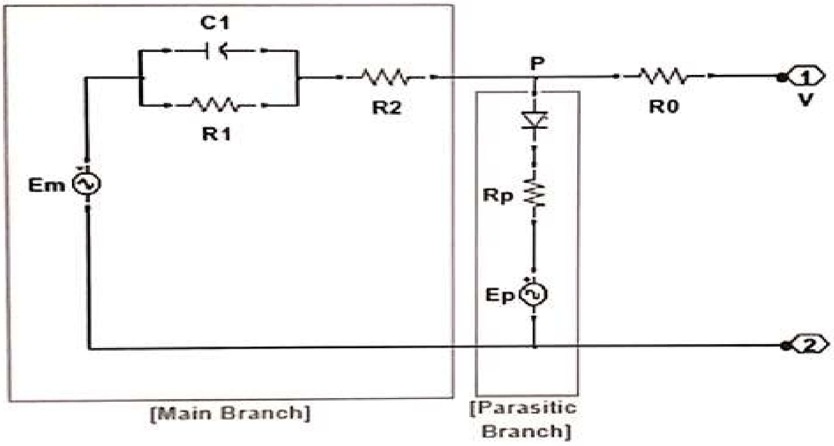


Fig15: equivalent circuit of battery

A physical system lead-acid battery model was created. The battery model was designed to accept inputs for current and ambient temperature, as shown in Figure. The outputs were voltage, SOC, and electrolyte temperature.

The structure did not model the internal chemistry of the lead-acid battery directly; the equivalent circuit empirically approximated the behavior seen at the battery terminals. The structure consisted of two main parts: a main branch which approximated the battery dynamics under most conditions, and a parasitic branch which accounted for the battery behavior at the end of a charge.

The battery equivalent circuit represented one cell of the battery. The output voltage was multiplied by six, the number of series cells, to model a 12 volt automotive battery. In Figure 3, the number of series cells was entered into the Gain block with parameter value “ns.” The voltage multiplication by six assumed that each cell behaved identically. Figure 4 shows the electrical circuit diagram containing elements that were used to create the battery circuit equations. Each equivalent circuit element was based on nonlinear equations. The nonlinear equations included parameters and states. The parameters of the equations were dependent on empirically determined constants. The states included electrolyte temperature, stored charge, and circuit node voltages and currents. The equations were as follows,

Main Branch Voltage

The emf value was assumed to be constant when the battery was fully charged. The emf varied with temperature and state of charge (SOC).

Em =Em0 – KE273 + ɵ (1 - SOC)

Where, Em -was the open-circuit voltage (EMF) in volts θ -was electrolyte temperature in °C SOC- was battery state of charge.

Main Branch Resistance

The resistance was assumed constant at all temperatures, and varied with state of charge.

R0=R00[1+ A0 1 – SOC]

Where,

$R0$ - was a resistance in Ohms R00- was the value of R0 at SOC=1 in Ohms A0 - was a constant

Main Branch Capacitance

The time constant modeled a voltage delay when battery current changed.

C1=

τ 1 R1

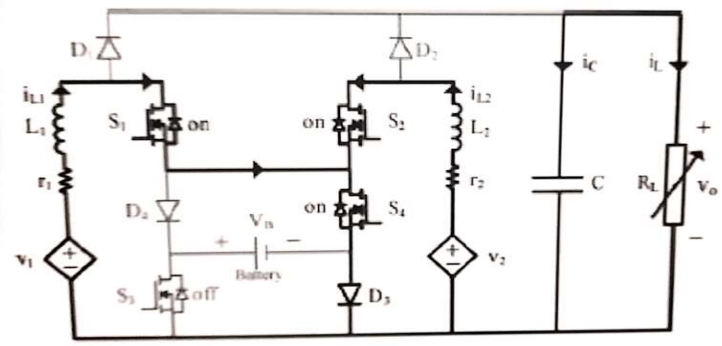
After the battery discharge parameters were fully Optimized, then the charge curves were optimized. However, while some parameters primarily affected the battery charging condition, other parameters affected both the discharge and charge. Consequently, both discharge and charge test data and parameters were used in the final optimization.

4.2 DESIGN OF THREE INPUT BOOST CONVERTER

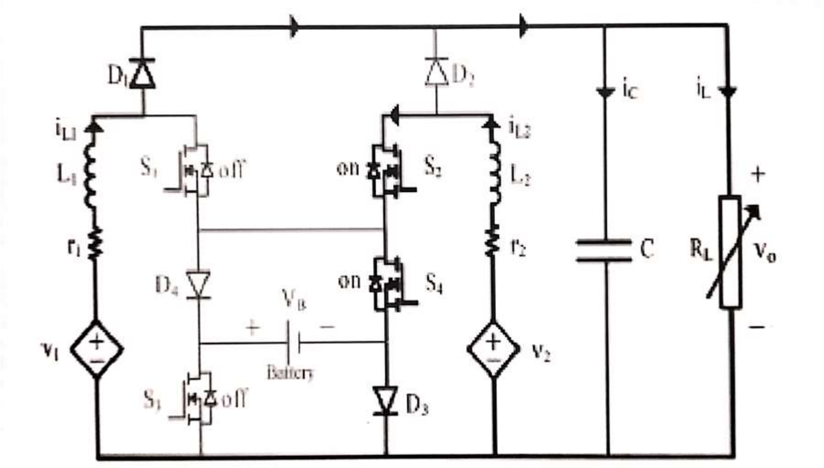
The system is applicable for DC loads. Control strategy has been considered to achieve permanent power supply to the load via the photovoltaic/battery or wind based on the power available from the sun. Supplying the output load, charging or discharging the battery can be made by the PV and the wind power sources individually or simultaneously. Depending on utilization state of the battery, three different power operation modes are defined for the converter either charging or discharging action to be taken place

4.3Modes of Operation

4.3.1 First Power Operation Mode



(a)



(b)

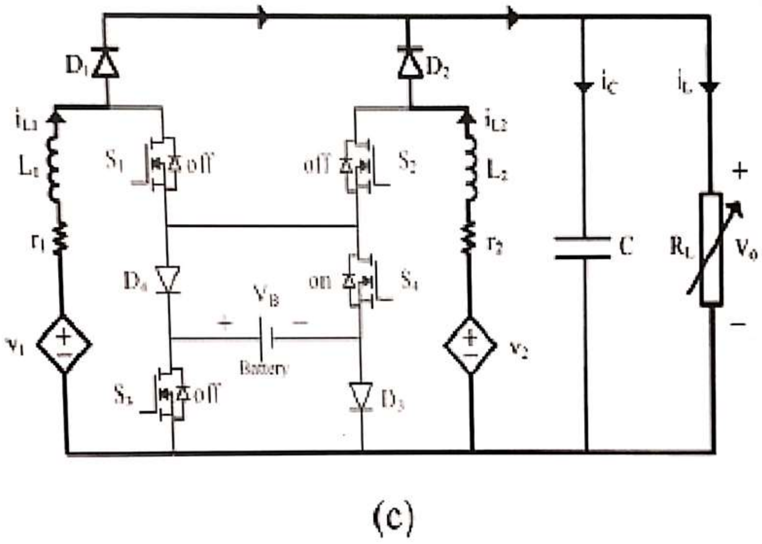


Fig16: first operating modes

In this operation mode, two input power sources $V1$ and $V2$are responsible for supplying the load, and battery charging is not done. This operation mode is considered as the basic operation mode of the converter. As clearly seen from the converter structure, there are two options to conduct input power sources currents IL1andIL2 without passing through the battery; path 1:S4 − D3, path 2:S3−D4. In this operation mode, the first path is chosen; therefore, switch S3 is turned OFF while switch S4is turned ON entirely in the switching period. Thus, three different switching states of the converter are achieved in one switching period.

Switching state 1 (0 < t <D1T): At t = 0, switches S1and S2are turned ON and inductors L1 and L2are charged with voltages across V1 and V2 respectively.
Switching state 2 (D1T< t <D2T): At t =D1T, switch S1 is turned OFF, while switch is S2still ON. Therefore, inductor L1 is discharged with voltage across V1−V0into the output load and the capacitor through diode D1, while inductor L2 is still charged by voltage across V2. Switching state 3 (D2T < t < T): At t = D2T, switch S2is also turned OFF and inductor L2is discharged with voltage acrossV2−V0as like as inductor $L1$. By applying voltage–second and current–second balance theory to the converter, following equations are obtained: signals of the four switches
L1=D1T V1-R1iL1 +1 – D1T(V1-R1iL1- V0)
L2=D2TV2-R2iL2 +1 – D2T(V2-R2iL2- V0)
C= 1-D1TiL1 + 1- D1TiL2

4.3.2 Second Power Operation Mode

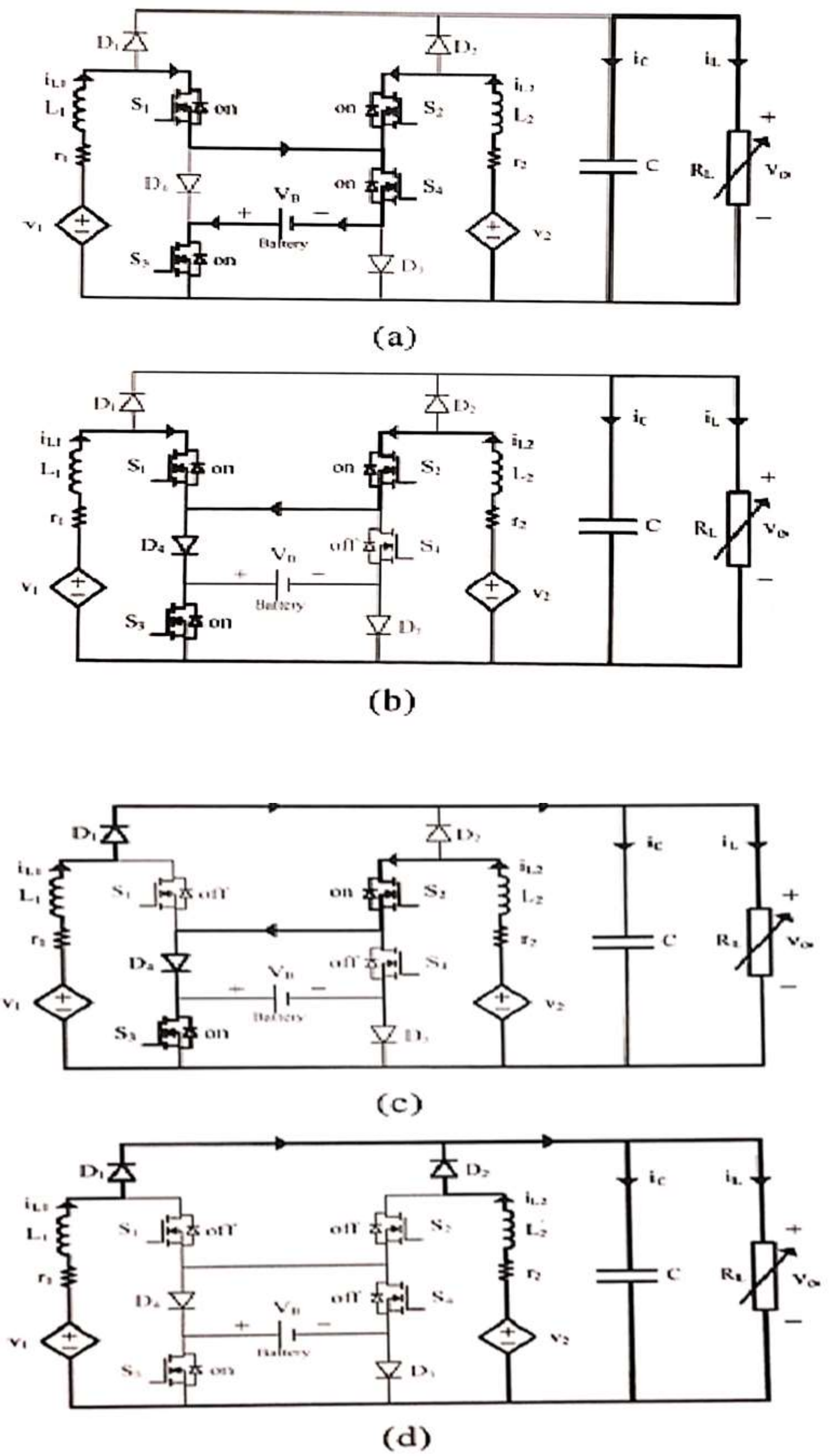


Fig17: second operating mode

In this operation mode, two input power sourcesV1 and V2along with the battery are responsible for supplying the load. Therefore, discharging state ofthe battery should be provided in this operation mode. Referring to the converter topology, when switches S3and S4are turned ON simultaneously, currentsIL1 and IL2are conducted through the path of switch S4.Switch S3which results in battery discharging. However, discharging operations of the battery can only last until switches S3and S2are conducting. As a result, the maximum discharge power of the battery depends on duty ratios of D1 and D2as well as currents IL1andIL2.

Therefore, in order to acquire a desired maximum discharging power of the battery, the input power sources should be designed in proper current and voltage values. This can be made by changing the state of only one of switches S3and S4before switches S1andS2 are turned OFF. In this paper, duty ratio D4is controlled to regulate the discharging power of the battery. Regarding the facts that when S4is turned ON, it results in passing the currents of input power sources through the battery; hence, the battery discharge mode is started, and its turn-OFF state starts conducting through diode D4and stops discharging the battery.

Switching state 1 (0 < t <D4T): At t = 0, switch S1 and S4are turned ON, so inductors L1and *L*2 are charged with voltages across V1 and V2, respectively .

Switching state 2(D4T < t < D1T): At t = D4T switch S4 is turned OFF, while switches *S*1and *S*2 are still ON. Therefore, inductors L1 and L2are charged with voltages across V1 and V2 respectively.

Switching state 3 (D1 T< t < D2T): At t = D1T, switch S1 is turned OFF, so inductor L1 is discharged with voltage across V1−V0while inductor L2 is still charged with voltages across V2.

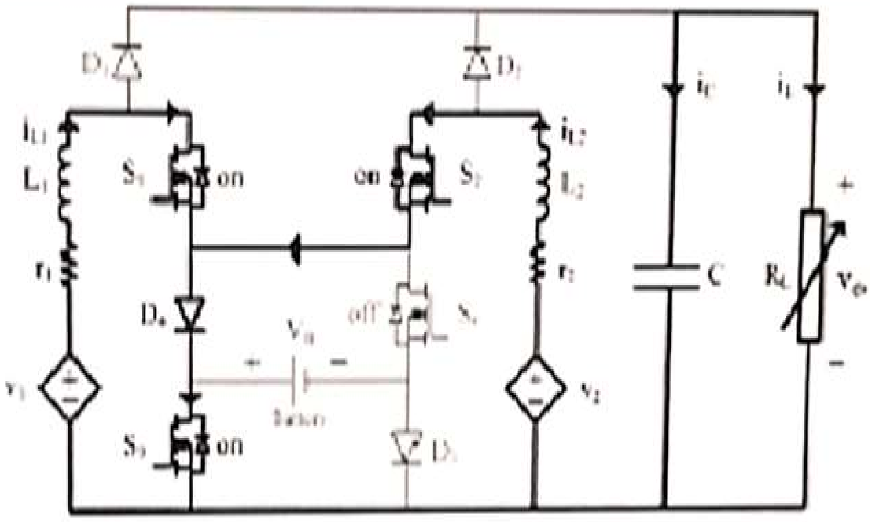
Switching state 4 (D2T < t < T): At t = D2T, switch S2is also turned OFF and inductors L1 and L2are discharged with voltage across V1−V0 and V2−V0 respectively. By applying voltage–second and current–second balance theory to the converter, following equations are obtained.

L1=D4T V1-R1iL1 + 1- D4 T(V1-R1iL1-V0)

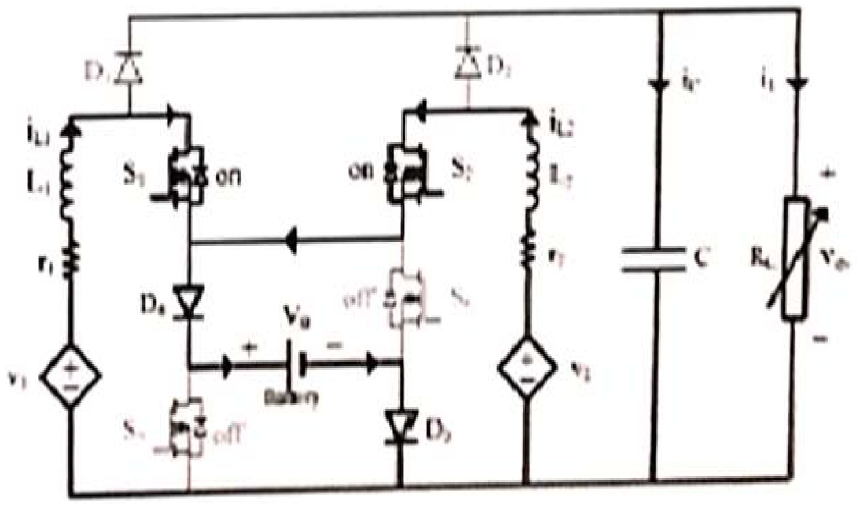
L2=D3TV2-R2iL1 + 1- D1 T(V2-R2iL2-V0)

C= 1- D1TiL1 + 1- D1 TiL2

4.3.3 Third Power Operation Mode



(a)



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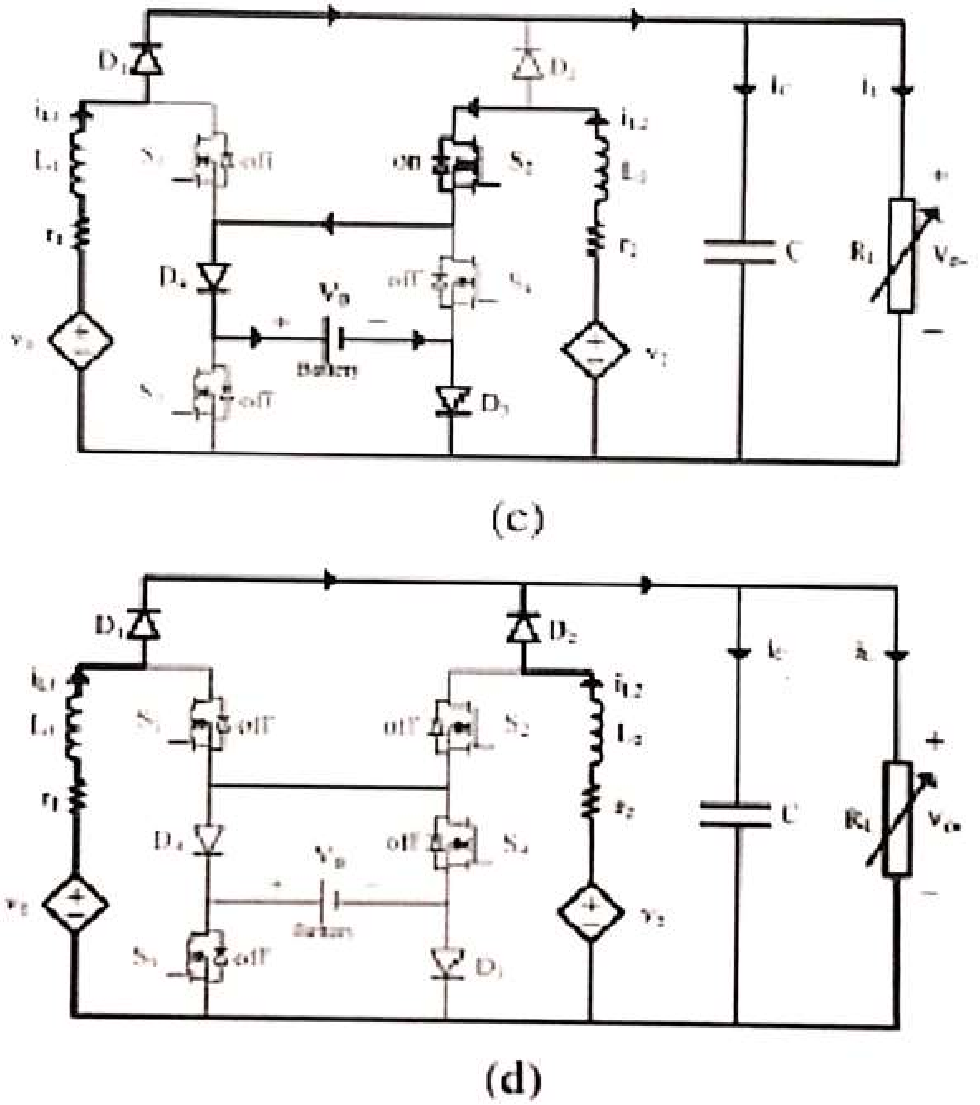

Fig18: third operating mode

In this operation mode, two input power sources V1 and V2 are responsible for supplying the load while the battery charging performance is accomplished. Therefore, the charging state of the battery should be provided in this operation mode. Referring to the converter topology, when switches S3and S4are turned OFF, by turning ON switches S1 andS2currents IL1and IL2are conducted through the path of diodeD4,the battery and diodeD3.Therefore, the condition of battery charging is provided. However, the charging operation of the battery can only last until switches S1 and S2 are conducting. As a result, the maximum charge power of the battery depends on duty ratios D1 and D2 in order to acquire a desired maximum charge power of the battery, the input power sources should be designed in proper current and voltage values. On the other hand, regulating the charging power of the battery below the P max bat.ch can be made by changing the state.

of only one of switches S3 and S4 before switches S1 and S2 are turned OFF. Switching state 1 (0 < t <D3T): At t = 0, switches S1,S2and S3are turned ON, so inductors L1 and L2 are charged with voltages across V1andV2, respectively.

Switching state 2 (D3T < t < D1T): At t = D3T, switch S3 is turned OFF while switches S1and S2are still ON (according to the assumption). Therefore, inductors $L1$ and L2 are charged with voltages across V1−VB and V2−VB , respectively . Switching state 3 (d1 T < t < d2 T): At t = D1T, switch S1is turned OFF, so inductor L2 is discharged with voltage across V1 − V0 , while inductor L1 is still charged with voltage across V2−VB.

Switching state 4 (D2T< t < T): At t = D2T, switch S2 is also turned OFF and inductor L2 as like as L1 is discharged with voltage across V2−V0

L1= D3T V1- R1iL1 +1 – D4 T(V1 -R1IL1-V0)
L1= D1T V2- R2iL2 +1 – D1T(V2 -R2iL2-V0)
C= 1- D1 TiL1+ 1- D1 TiL2

CHAPTER 5

RESULTS AND DISCUSSION

This chapter presents a pulse width modulation (PWM) technique for the minimization of leakage current in the grid connected/ stand-alone transformer-less Photo-Voltaic (PV) Cascaded Multi-Level Inverter (CMLI). The proposed PWM technique is integrated with MPPT algorithm and is applied to the five-level CMLI.

Further, using the proposed PWM technique the high frequency voltage transitions in the terminal and common mode voltages are minimized. Thus, the proposed PWM technique minimizes the leakage current of the PV array and EMI filter requirement in the system without addition of any extra switches. Further, this paper also presents the analysis for the terminal voltage across the PV array and common mode voltage of the inverter based on switching function.

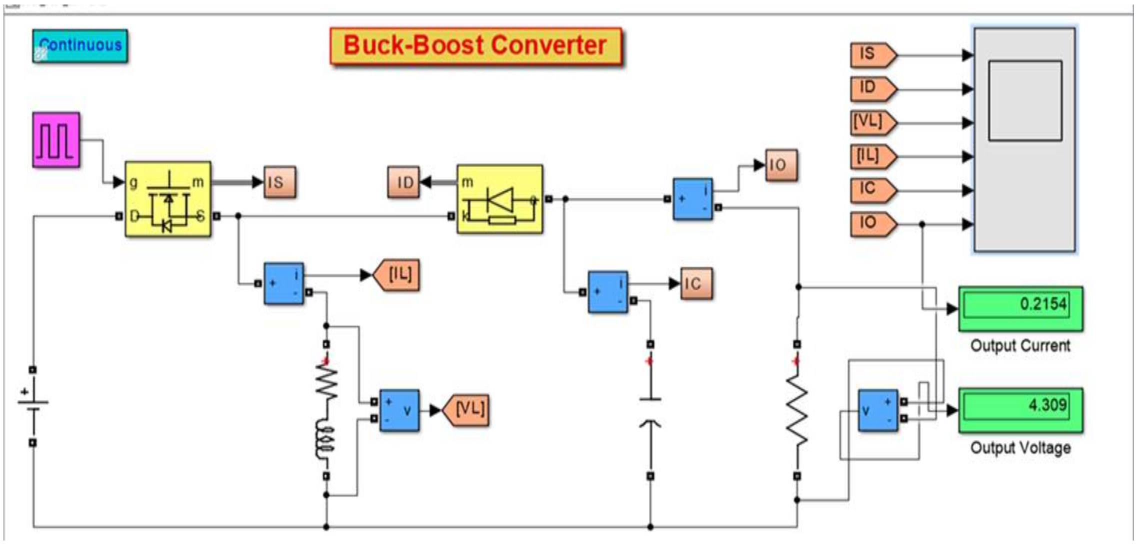

Fig19: Simulink diagram

Using the given analysis the effect of PWM technique can be analysed, as it directly links the switching function with the common mode voltage and leakage current. Also, the proposed PWM technique requires reduced number of carrier waves compared to the conventional sinusoidal pulse width modulation technique (SPWM) for the given CMLI. Complete details of the working principle and analysis with the support of simulation and experimental results of the proposed PWM technique are presented in this chapter.

The proposed way of the efficient integration of RES is illustrated in Fig.1. With this respect only one inverter is used in DC-AC conversion for interfacing the stand-alone or grid-connected consumer (Gaiceanu, et al., 2007b). By its control, the inverter can ensure the efficient operation and the accomplishment of the energy quality requirements related to the harmonics level. The hybrid system can ensure two operation modes: the normal one, and the emergency one (as backup system).

The Battery Power Conditioning Systemconsists of a battery pack and a DC-DC power converter. The NiMH battery produces a variable DC power. The battery pack has as main task to deliver the critical load power.

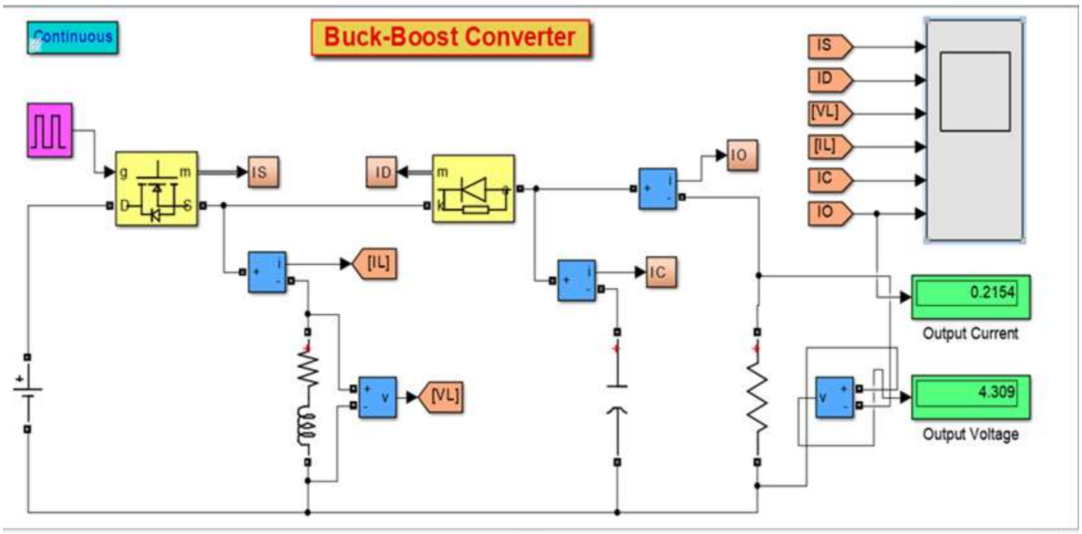

Fig20: stepdown buck boost converter simulation

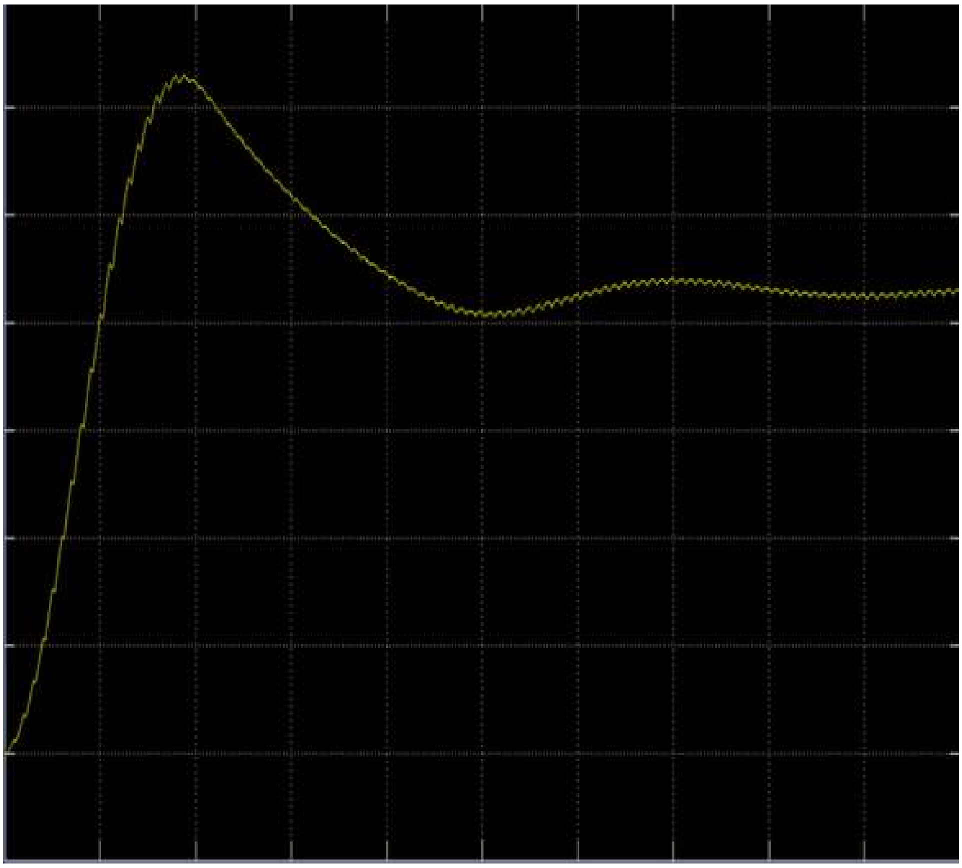

Fig21: Step down buck boost graph

By using the implemented Simulink model , the output voltage and the output power have been obtained .

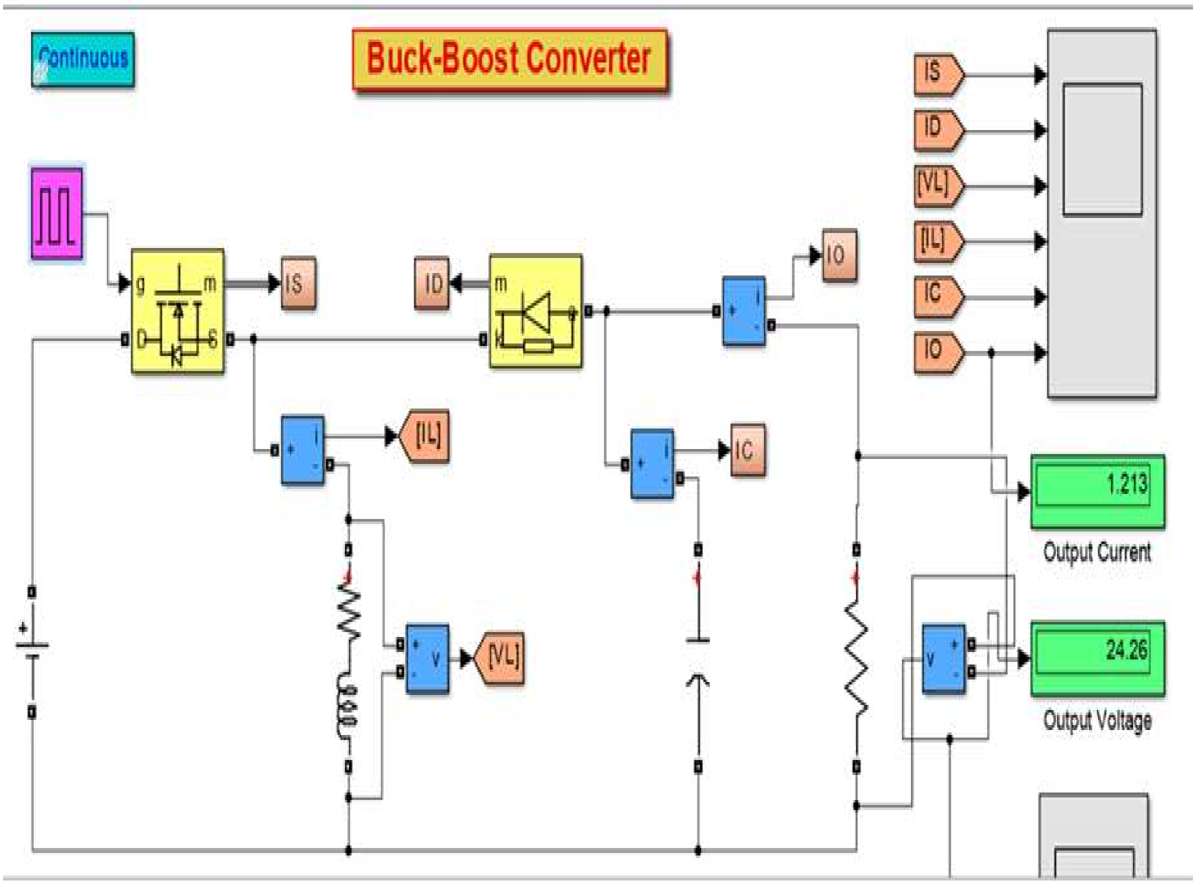

Fig22: step up buck boost simulation

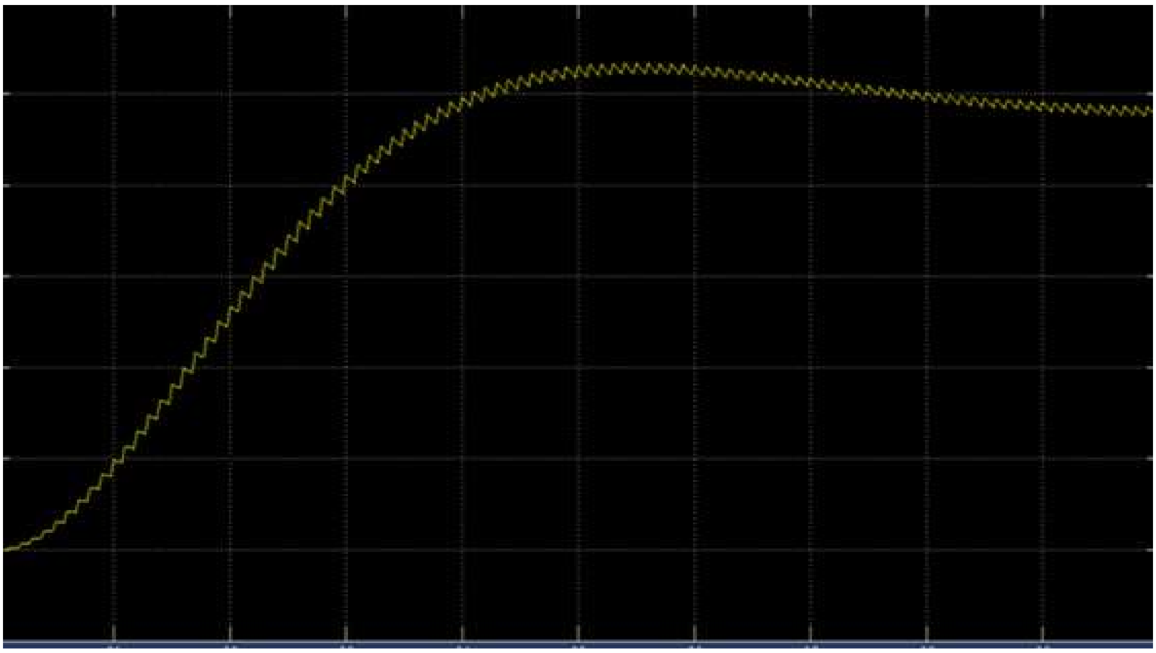

Fig23: step up buck boost simulated graph

By using the implemented Simulink model , the output voltage and the output power have been obtained .

CHAPTER 6
CONCLUSION AND FUTURE DIRECTIONS

6.1 CONCLUSION

Renewable energy sources conjointly referred to as non-conventional approach of energy area unit ceaselessly replenished by natural processes. With the merits of flexibility, the proposed three input converter shows excellent performance and potential for various applications including communication systems, satellite, radar systems. In comparison with the conventional method of hybridizing three input sources with three-boost cells the proposed converter can economize in the number of inductors, makes use of low-voltage batteries or super capacitors, works in high-stable-margin operating points and gain access to high-voltage boost factor. the battery can be charged and discharged through the both power sources individually and simultaneously.

Three input boost converter advantages are Simple structure, lowpower components, centralized control, no need to transformer, low weight, high-stability working point, independent operation of input power sources, and high level of boosting.

This chapter presents a multi-functional control for the DC/DC converters utilized in the Fuel cell powered electric vehicles. The controller of the DC/DC converter, which is comprised of two cascaded loops with a low computational complexity, is utilized to boost and regulate the output DC voltage and, at the same time, to protect the coil from overcurrent. The current controller method is insensitive to the parameter variation of the circuit, because it is adaptive in nature.

This is an absolute necessity for systems such as electric vehicles, since many parametric values can be changed with the loading level and temperature. Also, the simulation results shows that the proposed control scheme offers a robust coordination between the different functions of the DC/DC converter.

6.2 FUTURE DIRECTIONS

In this thesis work a new and fast response high step up converter topologies to generate high voltage gain from photovoltaic system integrate with grid application have been proposed. Coordinated hybrid converter (DC-DC-AC) can be developed & tested.

To validate the compatibility with other Inverter topologies (single phase / three phase).

Can be extended to develop control strategy to withstand LVRT in grid application.

Hybrid Maximum Power Point Tracking methods can be used to track the optimum point during varying environmental conditions.Coordinate controller may be developed to operate the overall PV integrated grid system.

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