ABSTRACT

This project report describes the development of a cost-optimized AC/DC nanohome powered by a photovoltaic (PV) system. The design prioritizes minimizing power conversion stages while ensuring efficient power management for two DC loads and one AC load. To minimize converter usage and cost, DC appliances are strategically chosen to operate directly at the PV output voltage whenever possible, eliminating the need for dedicated DC-DC converters. A single carefully selected boost converter elevates the DC voltage from the PV panels to a higher level suitable for powering a DC load that requires a higher voltage and efficiently charging the battery storage unit. A Bidirectional Buck-Boost Converter serves two crucial functions. During periods of excess solar power generation, the bidirectional buck-boost converter operates in buck mode, stepping down the elevated PV voltage to effectively charge the battery storage unit. Conversely, when the PV system isn't generating enough power, the converter can operate in boost mode, utilizing the stored battery charge to provide DC power to the loads. The H-bridge inverter plays a vital role in transforming the DC voltage from either the battery or the boosted PV output into AC voltage to power the AC load within the nanohome. Depending on the voltage matching requirements, a transformer might be strategically used to step up the AC voltage from the inverter to meet the specific needs of the AC load. This project ensures efficient power management while keeping the system affordable for nanohome applications. It focus on affordability making this project valuable for those seeking to develop sustainable and accessible housing solutions

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ABBREVIATIONS

PV	Photovoltaic
DG	Distributed generator
DC	Direct current
AC	Alternating current
V_{in}	Input voltage
V_{out}	Output voltage
F_s	Switching frequency

CHAPTER-1

INTRODUCTION

The growing emphasis on environmental sustainability and the ever-increasing demand for efficient living solutions have fueled innovation in housing concepts. Nanohomes, compact dwellings designed with a focus on minimizing resource utilization, are emerging as a promising approach for sustainable living. Powering these nanohomes with renewable energy sources like solar power is crucial for achieving true sustainability. This project report details the design and development of a cost-effective AC/DC nanohome powered by a photovoltaic (PV) system.

The core objective of this project is to establish a reliable and efficient power management system for the electrical appliances within a nanohome, catering to both DC and AC loads. A central focus of this project is minimizing the number of power conversion stages involved in the system. This not only reduces overall system complexity but also contributes significantly cost-effectiveness. To achieve this objective, a strategic approach is adopted for connecting DC appliances. Whenever possible, DC appliances are meticulously chosen to operate directly at the voltage level provided by the PV output, eliminating the need for dedicated DC-DC converters. This direct connection approach streamlines the system and reduces the number of conversion stages, leading to significant cost savings.The system incorporates a single, carefully chosen boost converter which elevates the DC voltage from the PV panels to a higher level.The battery serves as a vital component, acting as a reservoir for surplus solar energy generated during peak sunlight hours. This stored energy can then be utilized to power the nanohome during periods of low or no solar generation, ensuring a reliable and continuous power supply. Even during extended periods without sunlight, the battery storage guarantees uninterrupted operation of essential DC appliances. A key element within the system is the multifunctional bidirectional buck-boost converter. This versatile converter serves two crucial purposes, depending on the availability of solar energy. During periods of excess solar power generation, the converter operates in buck mode. In this mode, it steps down the elevated PV voltage to effectively charge the battery storage unit, ensuring efficient utilization of the available solar energy. This approach maximizes the benefit of renewable energy by minimizing energy waste. Conversely, when the PV system isn't generating enough power, for instance during nighttime or cloudy weather, the converter can operate in boost mode. In this mode, it utilizes the stored battery charge and steps up the DC voltage to provide the necessary power to the nanohome's lower voltage DC loads that are not directly connected to the boost converter output. This ensures uninterrupted operation of these DC appliances even when the direct solar energy input is unavailable.

The final stage of power conversion involves the H-bridge inverter. This crucial component plays a vital role in transforming the DC voltage from either the battery or the boosted PV output into AC voltage. This AC voltage is then used to power the AC load within the nanohome. A step up transformer is employed to level up the voltage. This transformer can step up the AC voltage from the inverter to meet the specific needs of the AC load, ensuring compatibility and efficient power delivery.

The project prioritizes cost-effectiveness throughout the design process. This is achieved by meticulously selecting components that offer a balance between performance and cost. Furthermore, control strategies are implemented to optimize converter operation and minimize energy losses within the system. This ensures efficient power management while keeping the system affordable for nanohome applications. This project report serves as a valuable resource for researchers and developers interested in creating efficient and cost-effective DC microgrid solutions for powering nanohome applications. The detailed design approach, focus on affordability, and emphasis on renewable energy utilization make this project a significant contribution to the development of sustainable and accessible housing solutions for the future

CHAPTER-2
LITERATURE REVIEW

1) Scalable-flexible architecture and power management strategy for a rural standalone DC community grid :

This paper presents about DC community grid (DCCG) is a system that connects rooftop solar panels and battery systems in homes together to form a local power grid. This approach improves reliability and sustainability of power supply in remote locations by enabling a decentralized and plug-and-play addition or removal of homes to the grid.

2) A review of technologies, key drivers, and outstanding issues of Renewable Sustainable Energy:

This paper presents about Microgrids, self-contained power systems, are becoming commercially available due to advancements and their ability to improve grid reliability, integrate renewable energy, and provide power to remote areas. This article discusses microgrids' applications, benefits, and challenges.

3) An MPC-based power management of standalone DC microgrid with energy storage:

Renewable energy sources and load demand can cause power imbalances in standalone DC microgrids. This paper proposes a supervisory power management strategy using model predictive control to optimize power flow and stabilize voltage in such a microgrid.

4) An improved mathematical model of photovoltaic cells based on datasheet information:

This paper proposes a two-step method to model photovoltaic (PV) cells using datasheet information. It separates the model into an ideal part and a resistance part, then extracts parameters from datasheet values under different conditions. The validity of the method is verified by comparing modeled results with experimental data.

5) Adaptive Droop Control Strategy for Load Sharing and Circulating Current Minimization in Low-Voltage Standalone DC Microgrid:

Parallel-connected DC-DC converters in microgrids suffer from uneven current sharing and voltage drops. This paper proposes an adaptive droop control method using a droop index to improve current sharing and minimize circulating currents, achieving better voltage regulation.

CHAPTER-3
OBJECTIVES

This project aims to develop a cost-effective AC/DC nanohome powered by a photovoltaic (PV) system. The key objectives are:

1. Efficient Power Management: Design a system that efficiently manages power for both DC and AC loads within the nanohome.
2. Minimize Conversion Stages: Reduce the number of power conversion stages involved in the system to minimize complexity and cost.
3. Direct DC Appliance Connection: Whenever possible, connect DC appliances directly to the PV output voltage, eliminating the need for dedicated DC-DC converters.
4. Single Boost Converter: Utilize a single, strategically chosen boost converter to:
   - Elevate voltage for DC loads requiring higher voltage than the PV output.
   - Efficiently charge the battery storage unit.
5. Bidirectional Buck-Boost Converter Functionality:
   - Battery Charging: During excess solar generation, step down the PV voltage for efficient battery charging.
   - Load Powering :In scenarios with insufficient PV generation, step up the battery voltage to power loads
6. H-Bridge Inverter and AC Load Powering
   - Utilize an H-bridge inverter to transform DC voltage from the battery or boosted PV output into AC voltage to power the AC load within the nanohome. A transformer is used to adjust the AC voltage.
7. Cost-Effectiveness: Prioritize cost-effectiveness throughout the design process by selecting components that balance performance and affordability

By achieving these objectives, the project seeks to create a sustainable and affordable power management solution for AC/DC nanohomes powered by renewable solar energy.

CHAPTER- 4

PROJECT METHODOLOGY

4.1 METHODOLOGY

This chapter will cover the detailed explanation of methodology that is being used to make this project complete and working. The method is use to achieve the objective of the project that will accomplish a perfect result. The methodology is expressed as below. In order to evaluate this project, generally there are four major steps, which is planning, analysis, design and implementation

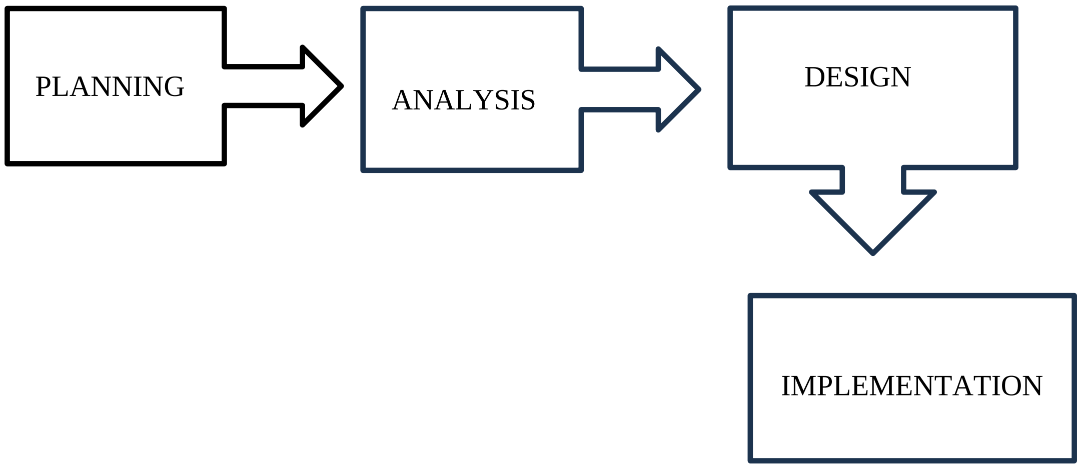

Fig 4.1 Block diagram of project methodology

The project includes various stages and the execution will contain the following stages

1. Data collection and identifying the topologies suitable for the project
2. Design stage of the topology
3. Validation of the methodology using MATLAB
4. Implementation of hardware

The study phase consists of analysing which are the most commonly used MPPT techniques and study about the intermediate converters and inverters through verification and simulation results.

The design stage include the design of the boost converter, bidirectional buck boost converter ,buck converter and H bridge inverter. This project used three major steps to implement project starting from planning, implementing and testing. All the methods used for finding and analysing data regarding the project related

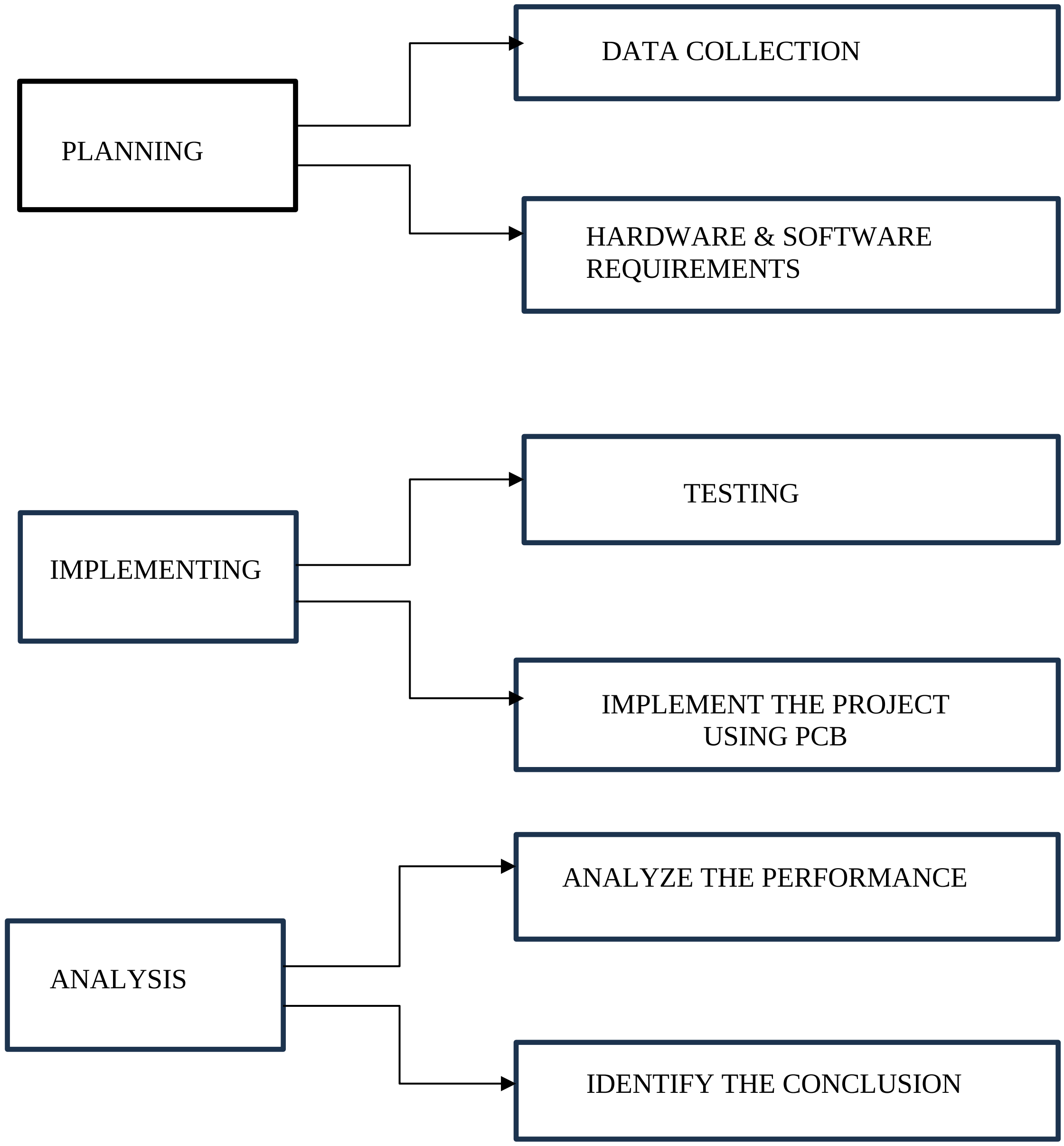

Fig 4.2 Flowchart of project methodology

CHAPTER -5

PROPOSED SYSTEM

This project proposes a cost-effective AC/DC nanohome powered by a photovoltaic (PV) system. The system prioritizes efficient power management for both DC and AC loads while minimizing the number of power conversion stages to reduce complexity and cost.

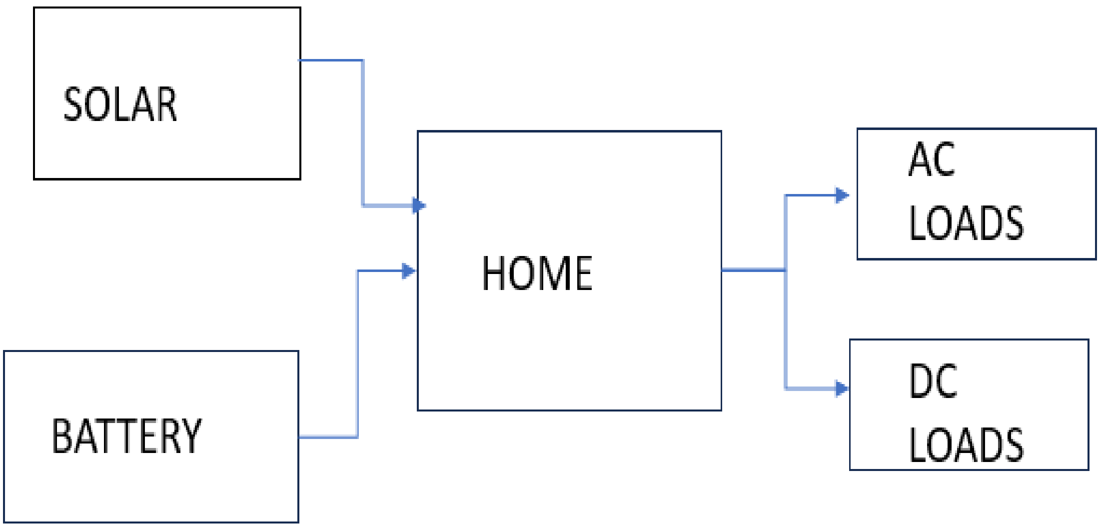

Fig 5.1 General structure

From the general structure we can understand that AC loads and DC loads can be functioned at the same time in our home solely depending on solar panels and battery. Solar Panels (PV) represents the solar panels that capture sunlight and convert it into DC electricity. Battery stores DC energy from the solar panels. DC appliances can be connected directly to the DC output from the solar panels or battery. AC appliances are connected to inverter to convert DC power to AC power for them to function.

5.1 BLOCK DIAGRAM

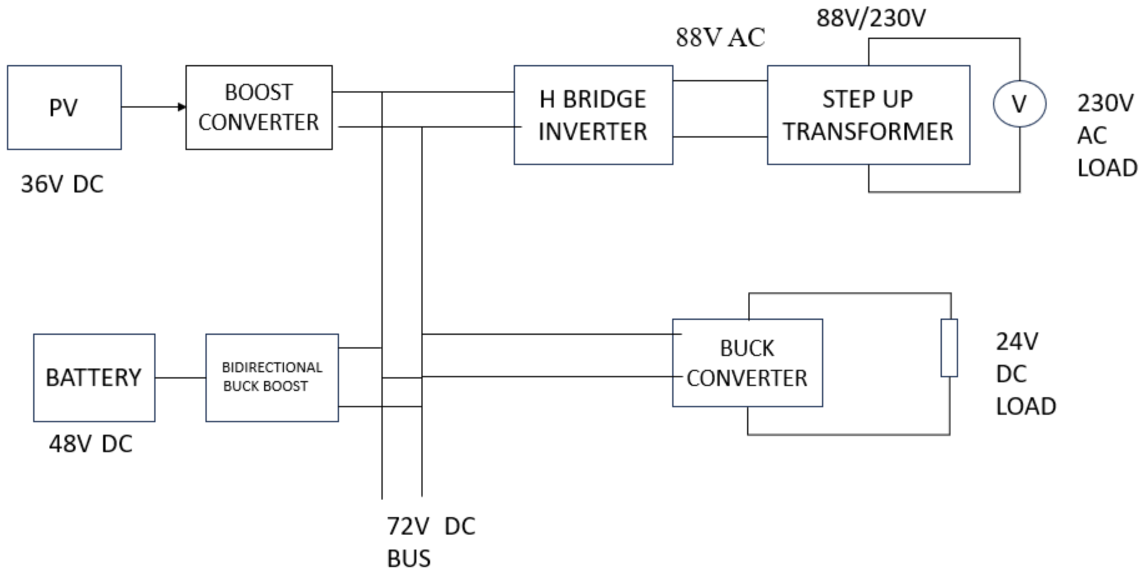

Fig 5.1.1 Block diagram

The block diagram illustrates a photovoltaic (PV) system designed to deliver power to a home, catering to both DC and AC appliances.

5.1.1 PV

PV (Photo voltaic) represents the solar panels that convert sunlight into DC electricity. It supplies DC power to the system.36V DC is the DC voltage level coming from the solar panels. Each panel is made up of numerous solar cells, the basic unit of a PV system. These cells are typically made from silicon, a semiconductor material. A solar cell has a p-n junction, formed by doping silicon with impurities to create a positive and negative layer.When sunlight strikes the solar cell, photons (light particles) are absorbed by the silicon. This absorption excites electrons in the silicon, allowing them to flow freely. This movement of electrons and holes creates an electric current.

5.1.2 Boost converter

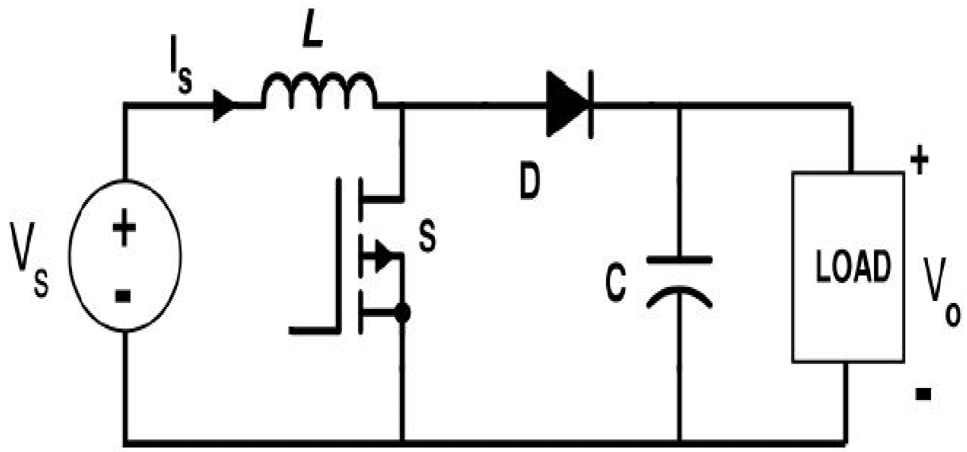

Fig 5.1.1 Circuit diagram of boost converter

A boost converter, also known as a step-up converter, is a widely used DC-to-DC power converter circuit. Its primary function is to increase the voltage of a DC input source to a higher DC output voltage. Here the boost converter is used to step up the varying voltage from the PV panel to a constant 72V DC output.

5.1.2.1 working of boost converter

When the switch (S) is turned on current flows from the input voltage source (Vin) through the inductor (L). During this time, the inductor opposes the change in current and stores energy by building up a magnetic field. The voltage across the inductor is positive at its top end and negative at its bottom end. The diode (D) is reverse-biased and does not conduct current. The capacitor (Cout) supplies current to the load (R) using the previously stored energy.When the switch (S) is turned off the inductor resists changes in current cannot suddenly stop conducting current. The diode (D) becomes forward-biased and conducts the current flowing through the inductor. This current now flows through the diode, the capacitor (Cout), and the load (R). The energy stored in the inductor's magnetic field is released to charge the capacitor (Cout) and supply the load. The voltage across the inductor is now reversed, with the top end negative and the bottom end positive. By rapidly switching the switch (S) on and off, the boost converter regulates the on-time (Ton) compared to the off-time (Toff), which is called the duty cycle (D). This duty cycle manipulation is key to achieving a higher output voltage.

5.1.3 Battery

Battery stores DC energy captured from the solar panels. 48V is the nominal voltage level of the battery. The battery serves as a vital component, acting as a reservoir for surplus solar energy generated during peak sunlight hours. This stored energy can then be utilized to power the nanohome during periods of low or no solar generation, ensuring a reliable and continuous power supply. The battery guarantees uninterrupted operation of essential DC appliances even during extended periods without sunlight.

5.1.4 Bidirectional buck boost converter

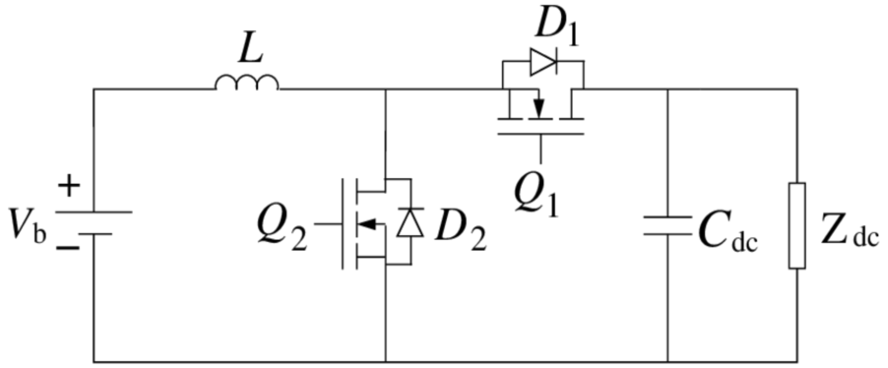

Fig 5.1.2 Circuit diagram of bidirectional buck boost converter

A Bidirectional Buck-Boost Converter manages the charging and discharging processes between the battery and the PV system. During periods of excess solar power generation, the converter operates in buck mode. It steps down the elevated PV voltage to effectively charge the battery storage unit, maximizing the benefit of renewable energy by minimizing energy waste. When the PV system isn't generating enough power (nighttime or cloudy weather), the converter can operate in boost mode. It utilizes the stored battery charge and steps up the DC voltage to provide the necessary power to the nanohome's lower voltage DC loads that are not directly connected to the boost converter output. This ensures uninterrupted operation of these DC appliances even when the direct solar energy input is unavailable.

5.1.5 Buck converter

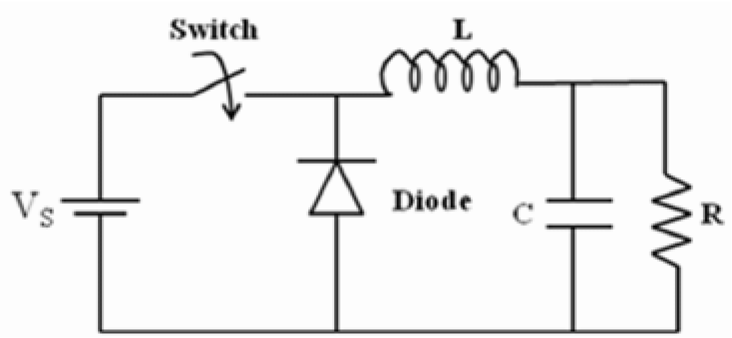

Fig 5.1.3 Circuit diagram of buck converter

A buck converter, also known as a step-down converter, is a widely used DC-to-DC power converter circuit. Its primary function is to reduce the voltage of a DC input source to a lower DC output voltage. To signify the low voltage applications a buck Converter of 24V DC Load is used. This converter reduces the voltage from 72V DC to a level suitable for the specific DC appliance requiring 24V DC to operate.

5.1.5.1 Working of buck converter

When the switch (S) is turned on, and current flows from the input voltage source (Vin) through the inductor (L). During this time, the inductor opposes the change in current and stores energy by building up a magnetic field. The voltage across the inductor is positive at its top end and negative at its bottom end. The diode (D) is reverse-biased and does not conduct current. The capacitor (Cout) supplies current to the load (R) using the previously stored energy. When The switch (S) is turned off. The inductor, which resists changes in current, cannot suddenly stop conducting current. The diode (D) becomes forward-biased and conducts the current flowing through the inductor. This current now flows through the diode, the capacitor (Cout), and the load (R). The energy stored in the inductor's magnetic field is released to charge the capacitor (Cout) and supply the load. The voltage across the inductor is now reversed, with the top end negative and the bottom end positive. By rapidly switching the transistor (S) on and off, the buck converter regulates the on-time (Ton) compared to the off-time (Toff), which is called the duty cycle (D). This duty cycle manipulation is key to achieving a lower output voltage.

5.1.6 H bridge inverter

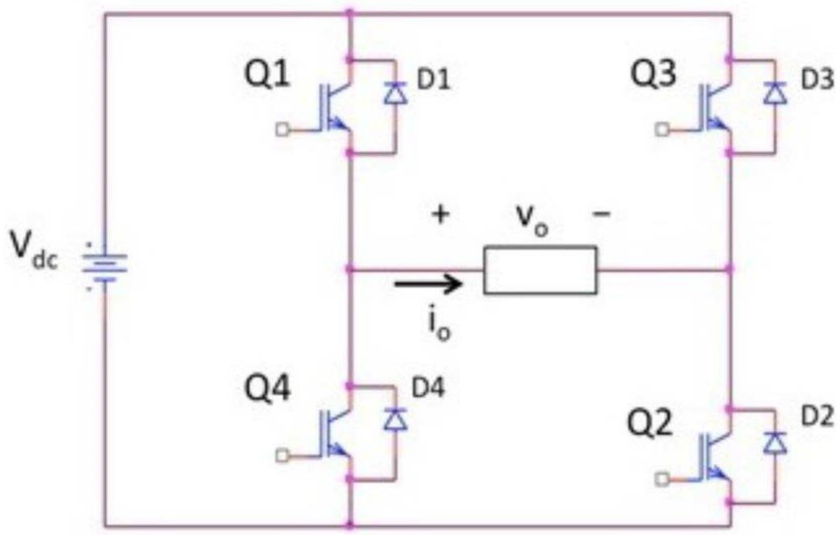

Fig 5.1.4 Circuit diagram of H bridge inverter

An H-bridge inverter, also known as a full-bridge inverter, is a power electronic circuit that converts DC electricity from a source like a battery into AC electricity. Here the H-Bridge Inverter is used to convert DC power from the bus (72V DC) into AC power for appliances that necessitate it.

5.1.6.1 Working of H bridge inverter

The H-bridge inverter operates by strategically switching the transistors (Q1-Q4) in a specific sequence. There are two main switching states that determine the direction of the current flow in the load. In forward direction Q1 and Q2 are turned ON, Q3 and Q4 are turned OFF (Refer fig 5.4.1). This configuration connects the positive terminal of the DC source (Vdc) to the top output terminal and the negative terminal to the bottom output terminal. Current flows from the positive terminal of the DC source through Q1, the load, and Q2 to the negative terminal, creating a positive half-cycle of the AC output waveform at the load. In Reverse Direction Q3 and Q4 are turned ON, Q1 and Q2 are turned OFF. In this configuration connects the positive terminal of the DC source (Vdc) to the bottom output terminal and the negative terminal to the top output terminal. Current flows from the positive terminal of the DC source through Q3, the load, and Q4 to the negative terminal, creating a negative half-cycle of the AC output waveform at the load. By rapidly switching the transistors (Q1-Q4) on and off in these complementary pairs (Q1 & Q2 or Q3 & Q4), the H-bridge inverter generates a square wave voltage waveform at the output. However, for most applications, this square wave needs further filtering to create a smoother sinusoidal AC waveform. This filtering is often achieved using passive components like inductors and capacitors.

5.1.7 Step up transformer

A step-up transformer, as the name suggests, is a passive electrical device that increases the voltage of an AC (alternating current) electrical signal. It achieves this by utilizing the principles of electromagnetism and Faraday's law of induction. The Step-Up Transformer elevates the AC voltage level from the inverter to meet the specific operating voltage of the AC appliances connected to the system.

Overall, the system prioritizes cost-effectiveness by allowing DC appliances to connect directly and using a single inverter to handle AC conversion. This proposed system offers a cost-effective and efficient solution for powering a nanohome with a combination of DC and AC loads using renewable solar energy. By minimizing conversion stages and prioritizing cost-effective components, the system promotes sustainability and affordability for future housing solutions.

CHAPTER-6
SIMULATION

Simulations were performed using MATLAB to characterize the behaviour of the system. MATLAB stands for MATrix LABoratory is a proprietary multi paradigm programming language and numeric computing environment. It includes an additional package called Simulink by which we can perform graphical multi-domain simulation and model based design for dynamic and embedded systems

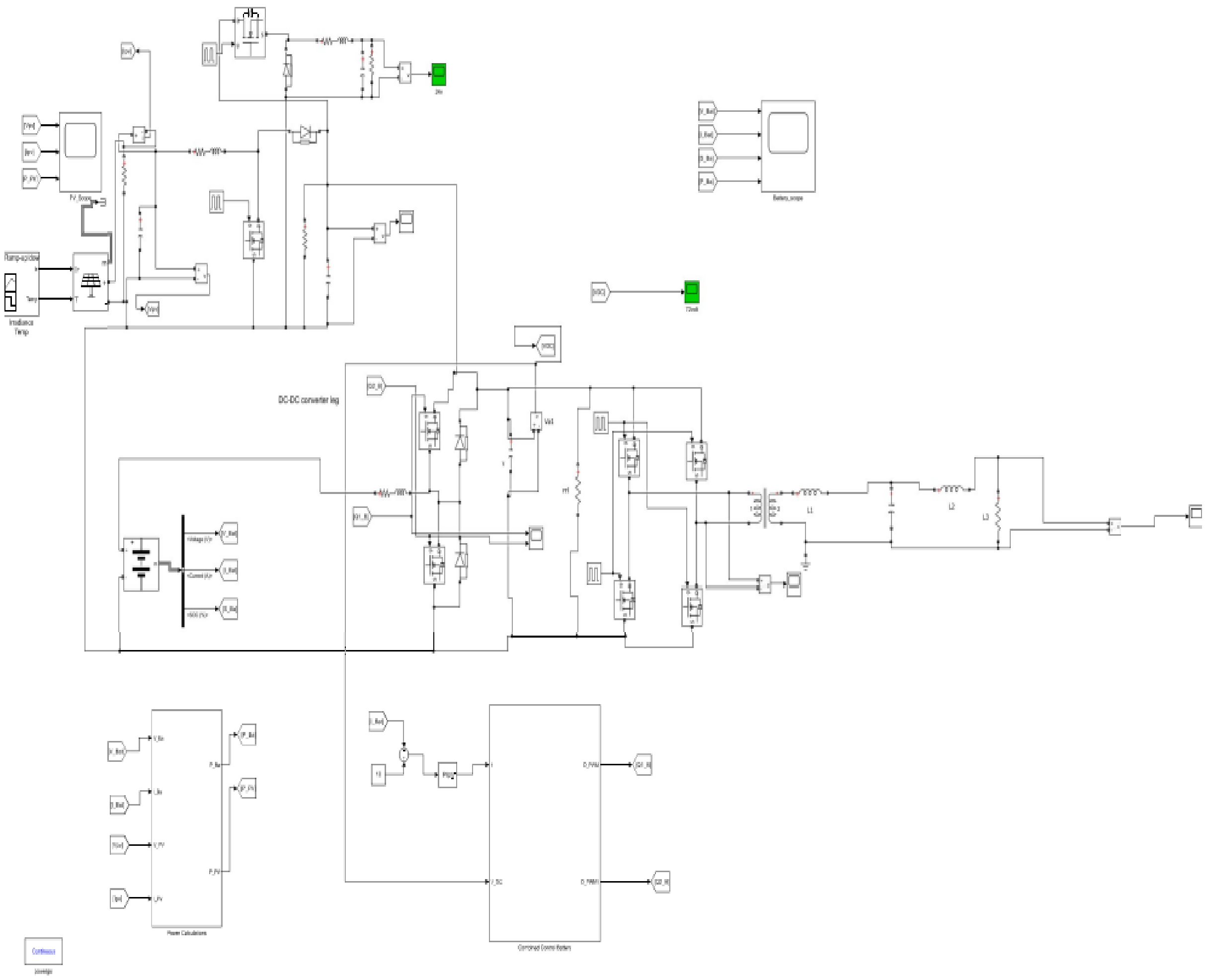

Fig 6.1 Simulink model of entire system

The simulation is done with the below set conditions:

TIME	PV	BATTERY
0-1 sec	ON	CHARGING
1-2 sec	OFF	DISCHARGING

Table 6.1 Simulation conditions

The individual converters and inverter Simulink model,simulation parameters and simulation output is given below

6.1 SIMULATION OF BOOST CONVERTER

6.1.1 Simulink model of boost converter

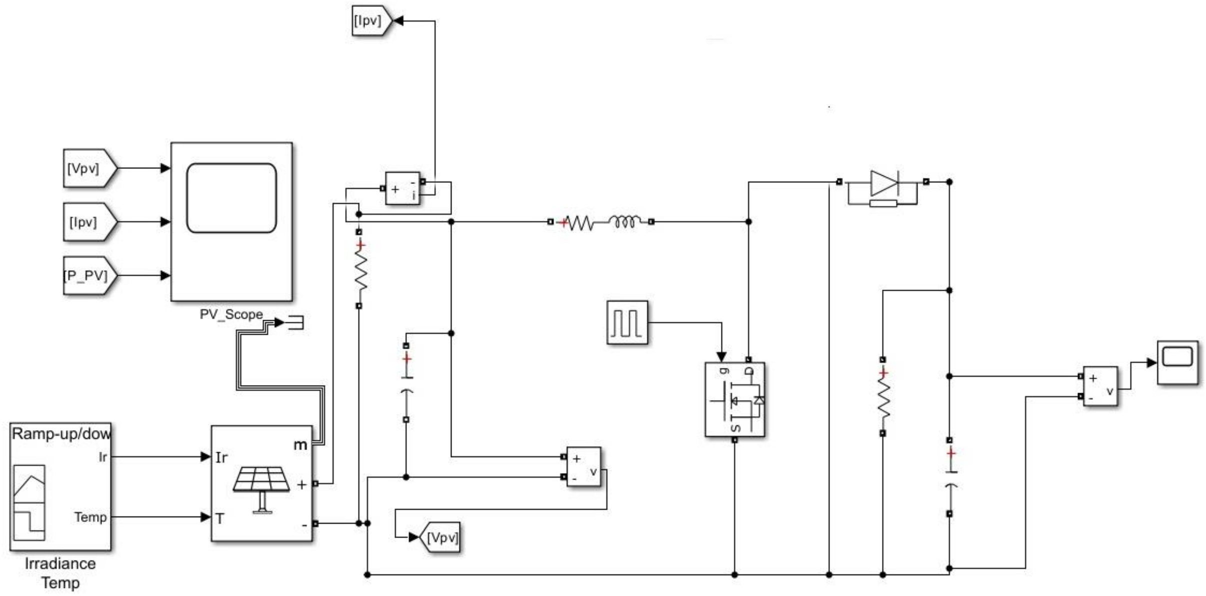

Fig 6.1.1 Simulink model of boost converter

6.1.2 Simulation Parameters

Input voltage	36V
Output Voltage	72V
Switching Frequency	5KHz
L	3mH
C_1	4.7µF
C_2	0.94F

Table 6.1.1 Simulation Parameters of boost converter

6.1.3 Irradience and Temperature input to PV

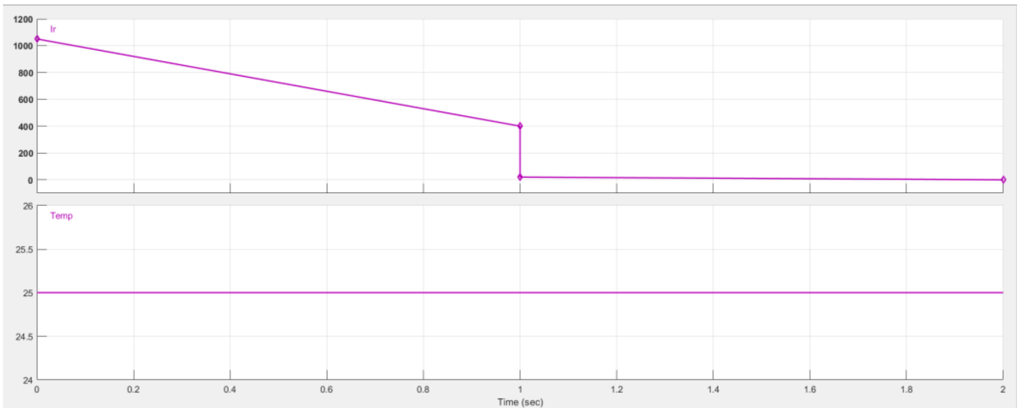

Fig6.1.2 Irradiance and temperature input

6.1.4 Simulation output

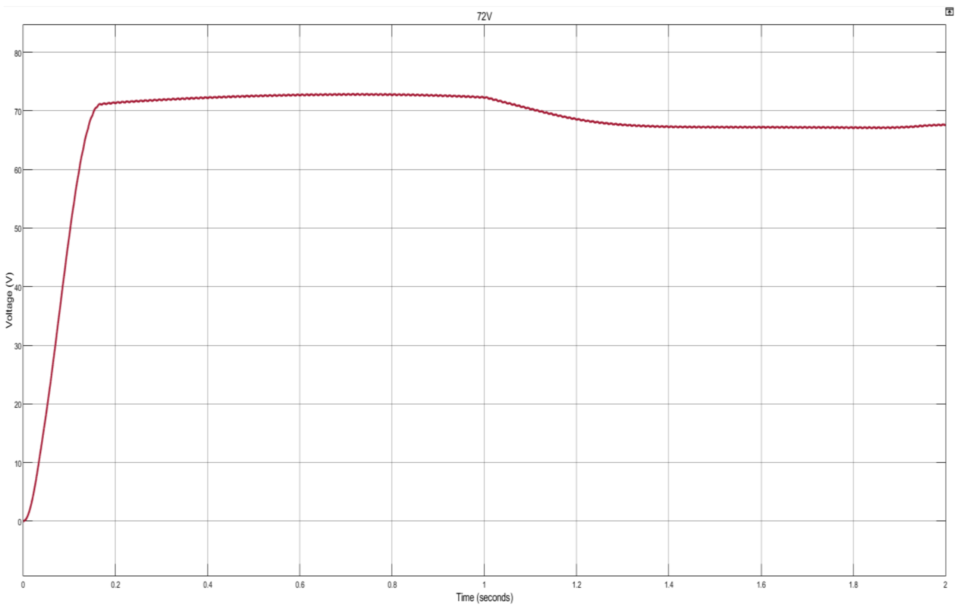

Fig 6.1.3 Simulation output of boost converter

6.2 SIMULATION OF BUCK CONVERTER

6.2.1 Simulink model of buck converter

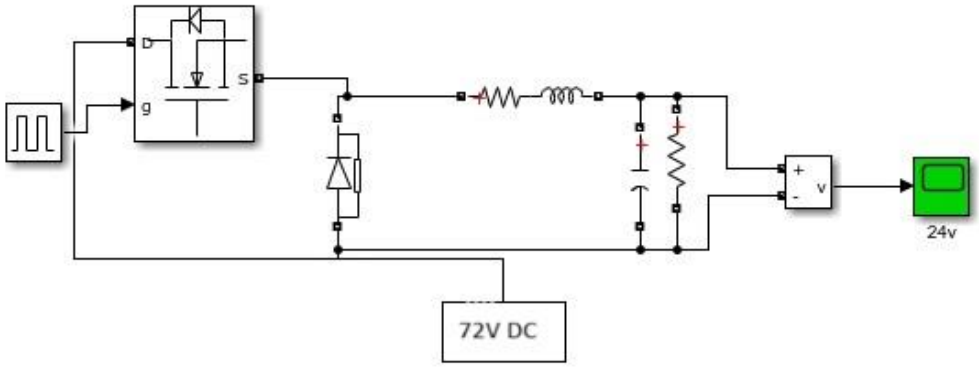

Fig 6.2.1 Simulink model of buck converter

6.2.2 Simulation Parameters

Input Voltage	72V
Output voltage	24V
Switching Frequency	5KHz
L	5mH
C	4.7µF

Table 6.2.1 Simulation Parameters of Buck converter

6.2.3 Simulation Output

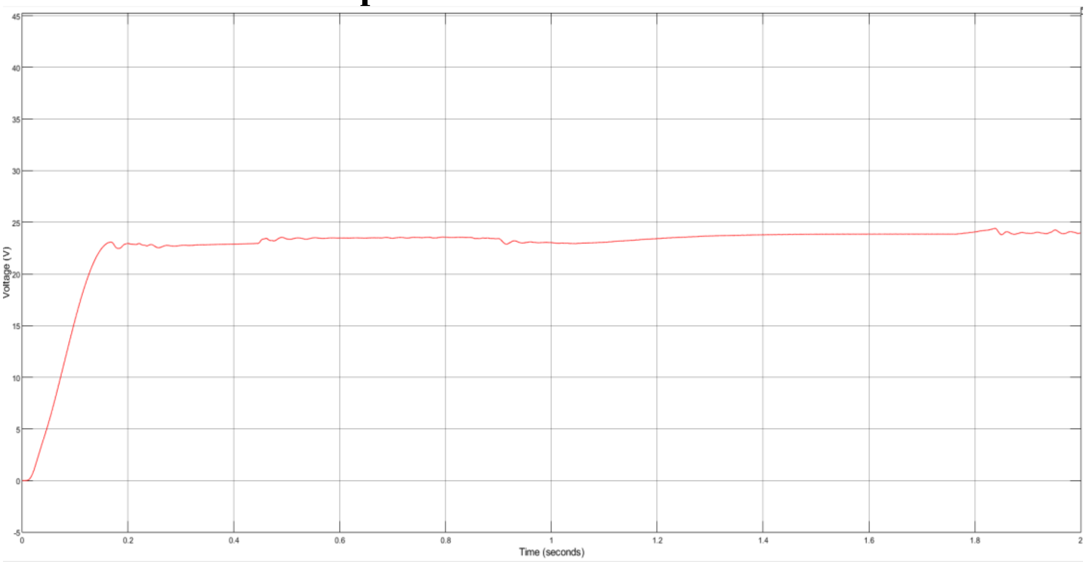

Fig 6.2.2 Simulation output of Buck converter

6.3 SIMULATION OF BIDIRECTIONAL BUCK BOOST CONVERTER

6.3.1 Simulink block of bidirectional buck boost converter

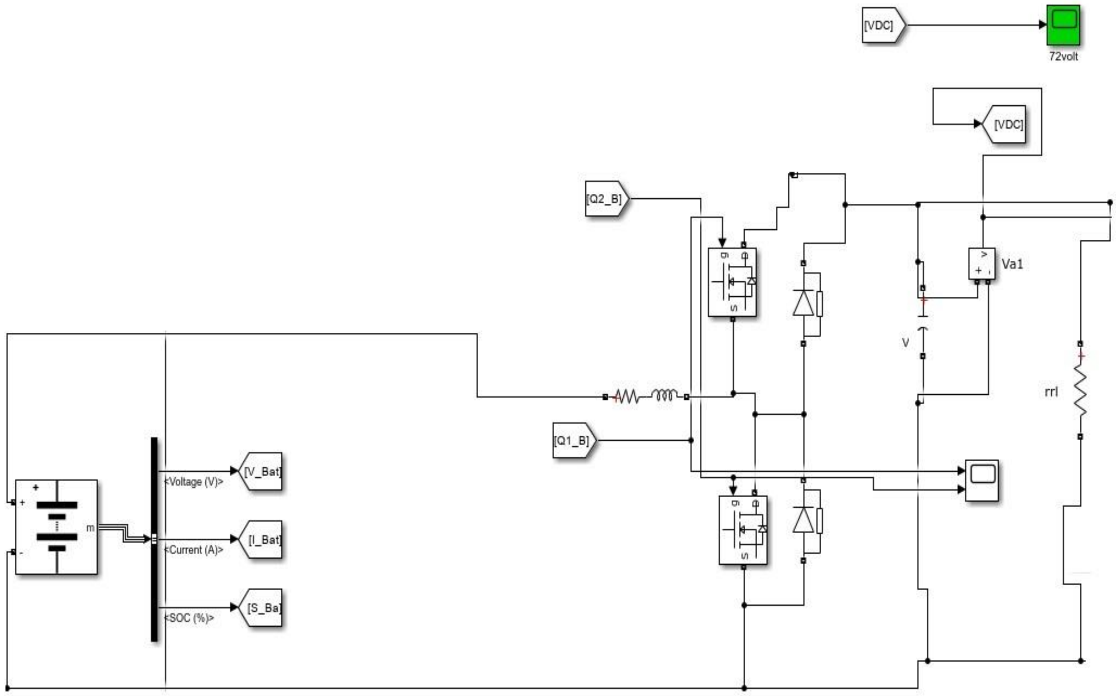

Fig 6.3.1 Simulink model of bidirectional buck boost converter

6.3.2 Simulation parameters

	Buck mode	Boost mode
Input voltage	72V	48V
output voltage	48V	72V
Switching frequency	5KHz	5KHz
L	3mH	3mH
C	0.094F	0.094F

Table 6.3.1 Simulation parameter of bidirectional buck boost converter

6.3.3 Simulation output

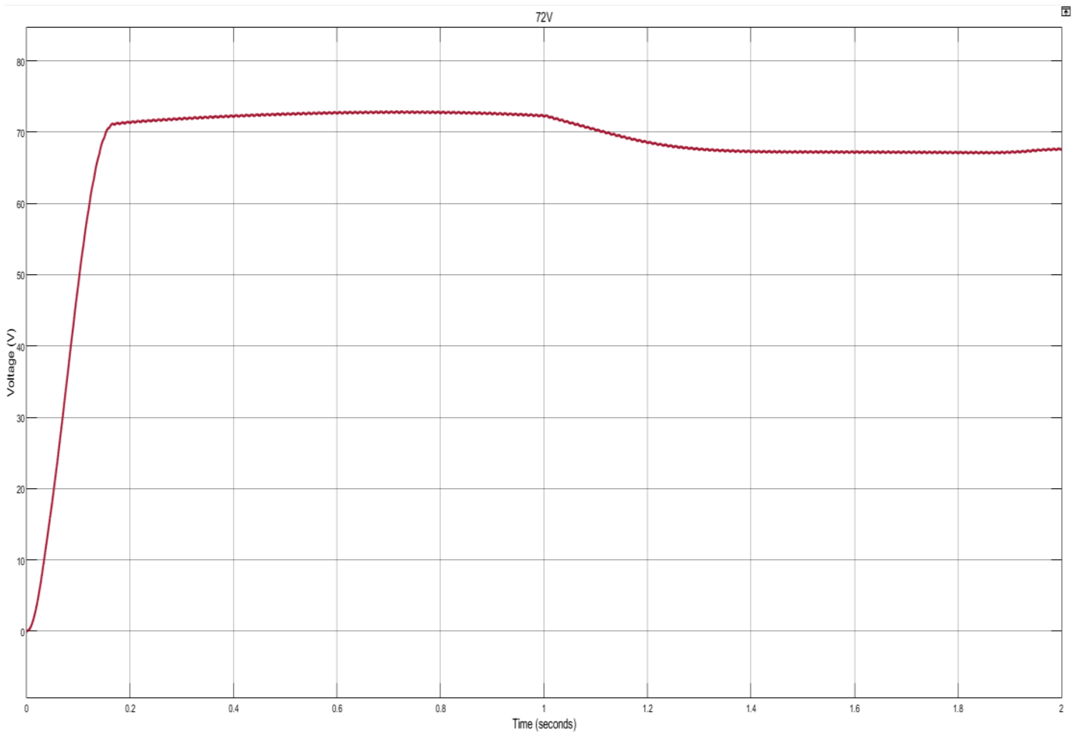

Fig 6.3.2 Simulation output of bidirectional buck boost converter

6.4 SIMULATION OF H BRIDGE INVERTER

6.4.1 Simulink block of H bridge inverter and step up transformer

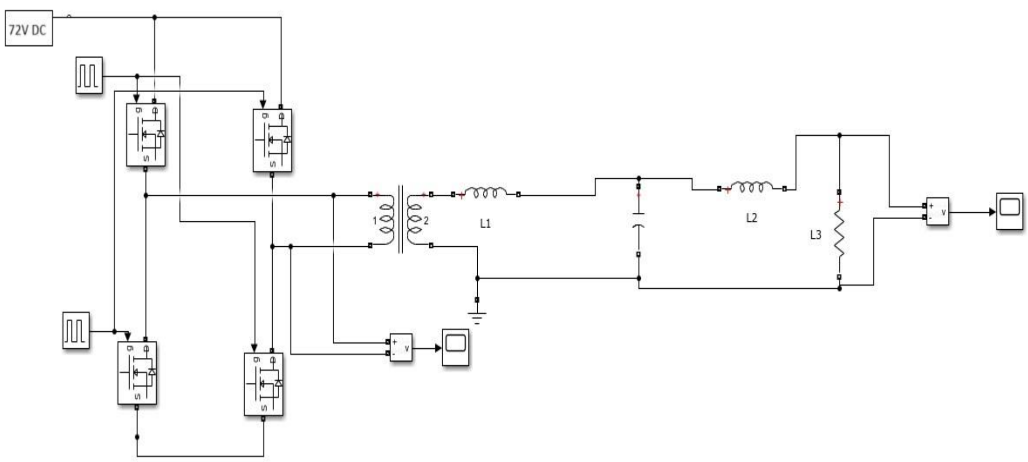

Fig 6.4.1 Simulink block of H bridge and step up transformer

6.4.2 Simulation parameters

Input voltage	72V DC
Output voltage	230V AC
Frequency	50Hz
Step up transformer rating	88/230V ,1kVA 50 Hz
L_1	15mH
L_2	15mH
C	500μF

Table 6.4.1 Simulation parameters of H bridge inverter and step up transformer

6.4.3 Simulation output

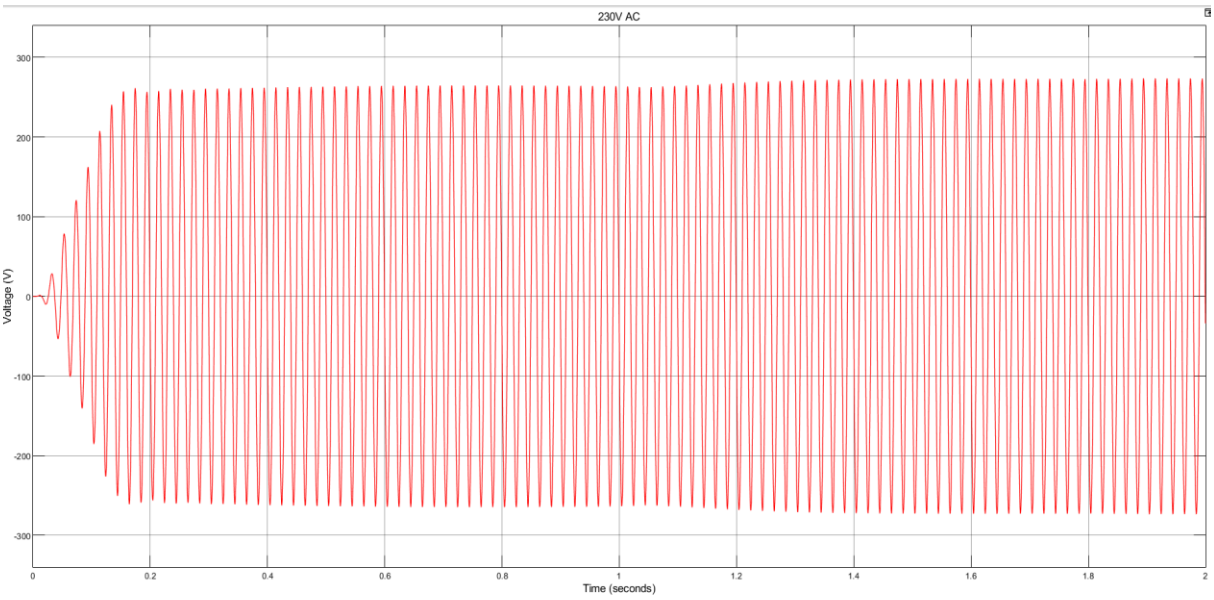

Fig 6.4.2 Simulation output of H bridge inverter with step up transformer

CHAPTER-7

HARDWARE

We have scaled down the voltage values while implementing the hardware prototype

7.1 CIRCUIT DIAGRAM

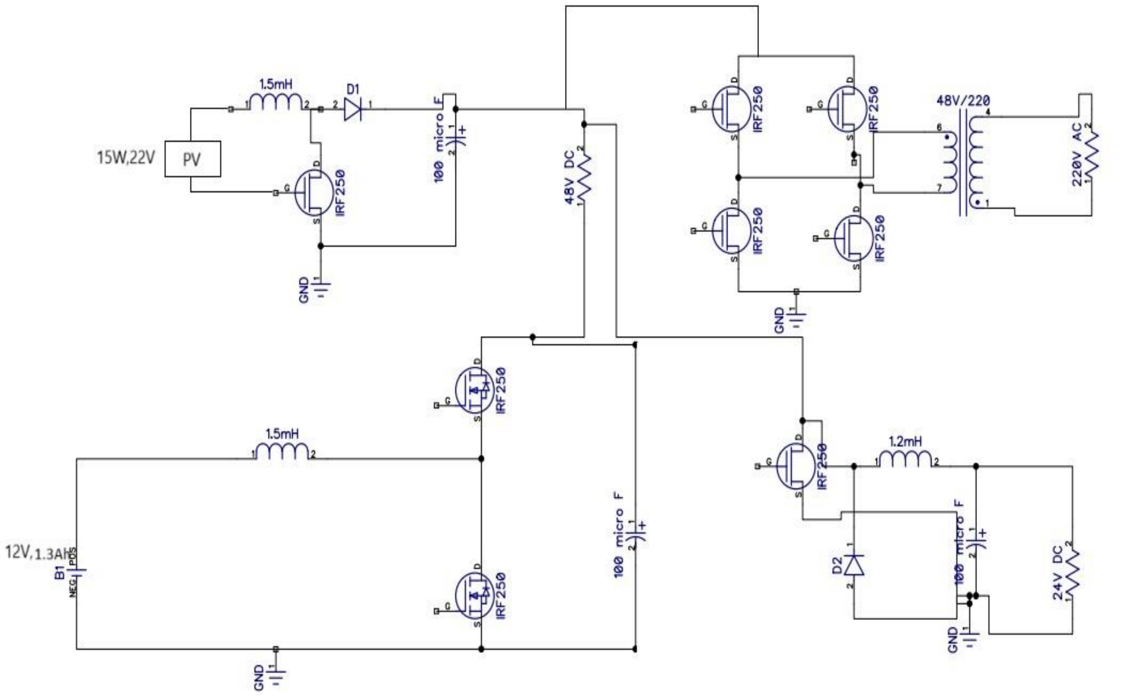

Fig 7.1 circuit diagram

From the circuit diagram we can understand that a 15W, 22V solar panel is connected with boost converter. The boost converter step up the voltage to 48V,a 48V DC fan is connected as the load to get the output. A 12V battery is connected with a bidirectional buck boost converter from the output of the boost converter which charges the battery in buck mode while the PV is ON and discharges in boost mode while PV is OFF. A buck converter is also connected from the 48V DC bus which provides an output voltage of 24V to portray low voltage applications. A 24V DC fan is connected at the output of the buck converter. For AC loads an H bridge inverter is connected with a step up transformer. A 220V AC fan is connected as load to get the output.We are experimenting different scenarios where PV is ON/OFF or battery is charging/discharging with the help mode selecting switches. This system is controlled and pulses to the converter and inverter switches according to the selected mode are given by ATMEGA 16 controller

7.2 HARDWARE COMPONENTS

7.2.1 Solar panel

Fig 7.2.1 Solar panel

Solar panels are used to convert light from the sun, which is composed of particles of energy called "photons", into electricity that can be used to power electrical loads. Solar panels are comprised of several individual solar cells which are themselves composed of layers of silicon, phosphorous (which provides the negative charge), and boron (which provides the positive charge). Solar panels absorb the photons and in doing so initiate an electric current. The resulting energy generated from photons striking the surface of the solar panel allows electrons to be knocked out of their atomic orbits and released into the electric field generated by the solar cells which pull these free electrons into a directional current. This entire process is known as the Photovoltaic Effect. Here we are using a solar panel of the below mentioned specification.

Rated power : 15 W

Open Circuit Voltage : 22 V

Short Circuit Current : 0.870 A

Voltage at Maximum Power : 18 V

Current at Maximum Power : 0.84 A

7.2.2 Battery

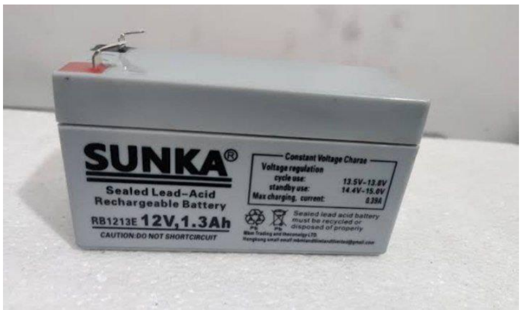

Fig 7.2.2 Battery

Batteries are a collection of one or more cells whose chemical reactions create a flow of electrons in a circuit. All batteries are made up of three basic components: an anode (the '-' side), a cathode (the '+' side), and some kind of electrolyte (a substance that chemically reacts with the anode and cathode). Here we use a battery of the following specification for experimental study.

Rated Voltage: -12V

Rated Amp-hr: -1.3 Ah

Type: Lead acid

7.2.3 Atmega 16 controller

Fig 7.2.3 ATMEGA 16

ATMEGA 16 microcontroller is one of the popular controllers in AVR series. With its features and purchase cost, it became one of favorite controller for both hobbyists and engineers. ATMEGA16 programming is similar to any other AVR controller. It is particularly a clone to ATMEGA 32 except for the memory. Although it has only half the memory of ATMEGA 32, it is still more than enough to satisfy most embedded system. ATMEGA 16 has also sleep modes. The modes can be triggered at desired times to save power. With various sleep modes on board ATMEGA 16 can work on mobile embedded systems. ATMEGA16 has 32 programmable Input/output pins, with them ATMEGA16 can interface many peripherals easily. ATMEGA 16 has also programmable Watchdog Timer with Separate On-chip Oscillator. With this Watchdog timer to reset under error the controller can be used on applications were human interference in minimal.

7.2.4 Power supply unit

The power supply unit is the most inevitable part of the hardware set up. The block diagram of power supply unit has been illustrated in Fig.8.4. Any sections of the hardware cannot be activated without the source of power. A proper power source which will be apt for a particular requirement. All the electronic components starting from diode to Intel IC's only work with a DC supply ranging from 0 - +5V to 0 - +12V. The cheapest and commonly available energy source of 230V-50Hz and stepping down, rectifying, filtering and regulating the voltage has been utilized. This will be dealt briefly in the forth-coming sections. The procedure of converting the ac supply to the required components is as follows. The 230V AC is first stepped down to 15V AC and 5V AC using a step down transformer with multiple secondary.Here the 15V AC is for the converter and inverter boards whereas the 5V AC supply is fed to the controller board. Then the AC supply is being changed into DC supply by implementing a rectifier. The unwanted signals which are called as harmonics is being eliminated using capacitor filter. The dc supply is then fed into a voltage regulator and is converted to regulated DC supply. Then it is again filters and fed to power to the converter, inverter switches and to the ATMEGA 16 controller

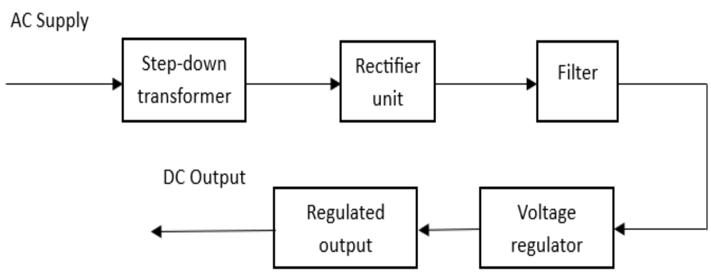

Fig 7.2.4 Block diagram of power supply unit

The main components include:

7.2.4.1 Bridge rectifier

Fig 7.2.5 Bridge rectifier

The ac input from the main supply is stepped down using a step down transformer. The stepped down AC voltage is converted into dc voltage using a diode bridge rectifier. The diode bridge rectifier consists of four diodes arranged in two legs. The diodes are connected to the stepped down AC voltage. For positive half cycle of the ac voltage, the diodes D1 and D4 are forward biased . For negative half cycles diodes D2 and D3 are forward biased. Thus dc voltage is produced to provide input supply to the DC-DC Converter

7.2.4.2 Voltage regulators

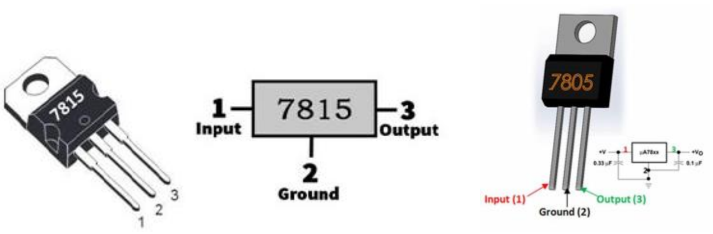

Fig 7.2.6 Voltage regulators 7815 & 7805

Both regulators are widely used in various electronic circuits to provide stable and regulated DC voltages. The “78” indicates that it is a positive voltage regulator. “05” indicates output voltage of 5V and “15” indicates output voltage of 15V in 7805 and 7815 regulators respectively

7.2.5 Driver circuit

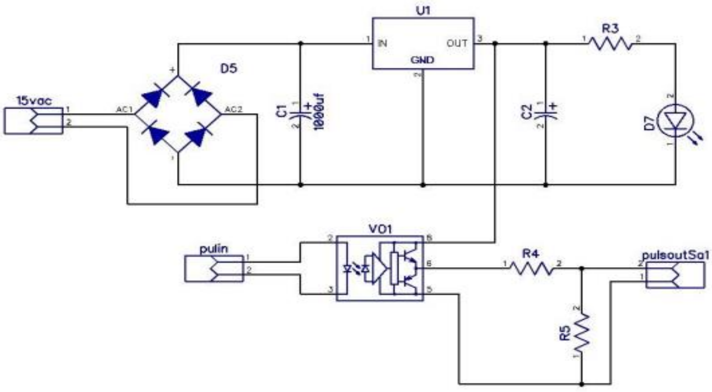

Fig 7.2.7 circuit diagram of driver circuit

It is used to provide 9 to 20 volts to switch the MOSFET Switches of the converter. Also it has an optocoupler for isolating purpose. So damage to MOSFET is prevented. The driver circuit forms the most important part of the hardware unit. The 15V output from the transformer is rectified using a bridge rectifier which is then filtered using a capacitor and regulated using a voltage regulator and again filtered using a capacitor and fed to the driver IC which also receives the signal from the Arduino which is also amplifies to provide the pulse for the MOSFET.

7.2.6 TLP 250 Driver IC

Fig 7.2.8 TLP250 driver IC

Supply Voltage Vcc – 15V – 30V

Input Current If ON – 7-10mA

Input Voltage Vf off – 0 – 0.8V

The pin mode diagram of TLP250 is shown in Fig. 8.9. The pulse from ATMEGA 16 is given to the second pin, third pin is connected to the ground of ATMEGA16, fifth pin is connected to the ground, VCC is applied to the eighth pin.

7.2.7 Inductors and capacitors

Capacitors and inductors are passive electronic components that store and release energy in electrical circuits, but they do so in different ways. Capacitors store energy in an electric field between two conductive plates separated by a dielectric material. Inductors store energy in a magnetic field generated by a coil of wire when current flows through it.They are used in applications such as filtering, energy storage, impedance matching, signal coupling, and inductive loads in electronic circuit

7.2.8 Diodes

Diodes are fundamental electronic components that conduct current in one direction while blocking it in the opposite direction. They are typically made from semiconductor materials such as silicon or germanium and have two terminals: an anode (positive terminal) and a cathode (negative terminal).

7.2.9 Resistors

It ensures proper current flow,voltage regulation and component protection

7.2.10 Transformers

- 230V/15V/6V step down transformer: Used to step down the 230V AC supply to 15V and 6V using multiple secondary tappings
- 48V/220V step up transformer: Used to step up the H bridge inverter output to 220V

7.2.11 Mosfet switch (IRFP250N)

Fig 7.2.9 IRFP250N

Metal Oxide Semiconductor Field Effect Transistor is the most popular and widely used type of field effect transistor MOSFETs are either NMOS (n-channel) or PMOS (p-channel) transistors, which are fabricated as individually packaged discrete components for high power applications as well as by the hundreds of millions inside a single chip IC.

- Drain-Source Voltage (Vds) – 200V
- Gate-Source Voltage(Vgs) - ±20V

7.2.12 AC and DC loads

Fig 7.2.10 48V DC ,24V DC and 220V AC fans

These loads are connected to verify the output of the hardware implementation

7.3 DESIGN OF HARDWARE

7.3.1 Boost converter

Input voltage V_{in}= 22V

Output voltage V_o= 48V

Input power P_{in} = 15W

Switching frequency F_s = 3.125KHz

Duty ratio D=(V_o-V_{in})/ V_o

del I = 0.2*I_0= 0.062A

Inductance=(V_{in}*D)/(F_s*del I) ≈ 1.5mH

Capacitance ≥ I_o/(F_s*del V_o) = 100µF

7.3.2 Buck converter

Input voltage V_{in}= 48V

Output voltage V_o= 24V

Input power P_{in} = 15W

Switching frequency F_s = 3.125KHz

Duty ratio D=V_o/ V_{in}= 0.5

del I = 0.2*I_0= 0.062A

Inductance= V_{in}*(1-D)/(F_s*del I) ≈ 1.2mH

Capacitance ≥ $I_o/(F_s*del\ V_o)$ = 100µF

7.3.3 Bidirectional buck boost converter

Inductance=(V_{in}*D)/(F_s*del I) ≈ 1.5mH

$I_o$bat = 0.5*1.3Ah = 0.65A

Capacitance ≥ $I_o$bat/(F_s*del $V_o$bat) ≈ 220µF

7.4 MODE SELECTION

To portray different scenarios where PV is ON/OFF or battery is charging/discharging is done with the help of mode selecting switches.The conditions in different modes are given below

MODE	PV	BATTERY	INVERTER
O	ON	CHARGING	ON
1	ON	DISCHARGING	ON
2	OFF	DISCHARGING	ON
3	ON	CHARGING	OFF

Table 7.4.1 Mode selection conditions

The pulses are given to the sitches operating in each mode with help of ATMEGA 16 controller.

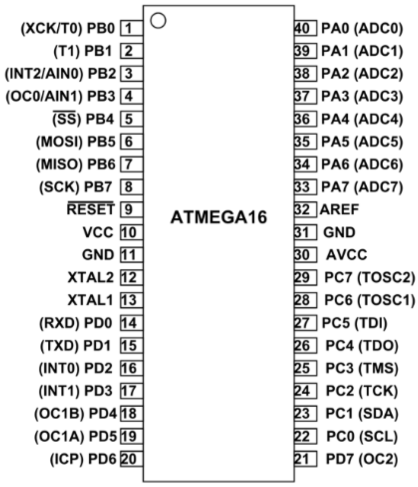

Fig 7.4.1 pinout diagram of ATMEGA 16

The input from the mode selecting switches are given to port D. The converter switches are controlled by port B and the inverter switches are controlled by port A. Pulses given to each switches with respect to the selected modes are listed below

	PORTD		PORTA									PORTB								
Mode	S1	S0					S3	S2	S4	S1						S4	S3	S2	S1	
0	0	0	0	0	0	0	0	0	1	1	0x03	0	0	0	0	1	0	1	1	0x0B
			0	0	0	0	1	1	0	0	0x0C	0	0	0	0	0	0	0	0	0x00
1	0	1	0	0	0	0	0	0	1	1	0x03	0	0	0	0	1	1	0	1	0x0D
			0	0	0	0	1	1	0	0	0x0C	0	0	0	0	0	0	0	0	0x00
2	1	0	0	0	0	0	0	0	1	1	0x03	0	0	0	0	1	1	0	0	0x0C
			0	0	0	0	1	1	0	0	0x0C	0	0	0	0	0	0	0	0	0x00
3	1	1	0	0	0	0	0	0	0	0	0x00	0	0	0	0	1	0	1	1	0x0B
			0	0	0	0	0	0	0	0	0x00	0	0	0	0	0	0	0	0	0x00

Table 7.4.2 Switch selection

Where the S1,S2,S3,S4 of port B corresponds to switches of boost converter ,buck switch of bidirectional buck boost converter, boost switch of bidirectional buck boost converter and buck converter respectively.S1,S2,S3,S4 switches of port A are the four switches of H bridge inverter where S1 & S4 and S2 & S3 works at the same time

CHAPTER-8

HARDWARE RESULT AND DISCUSSIONS

8.1 HARDWARE IMPLEMENTATION

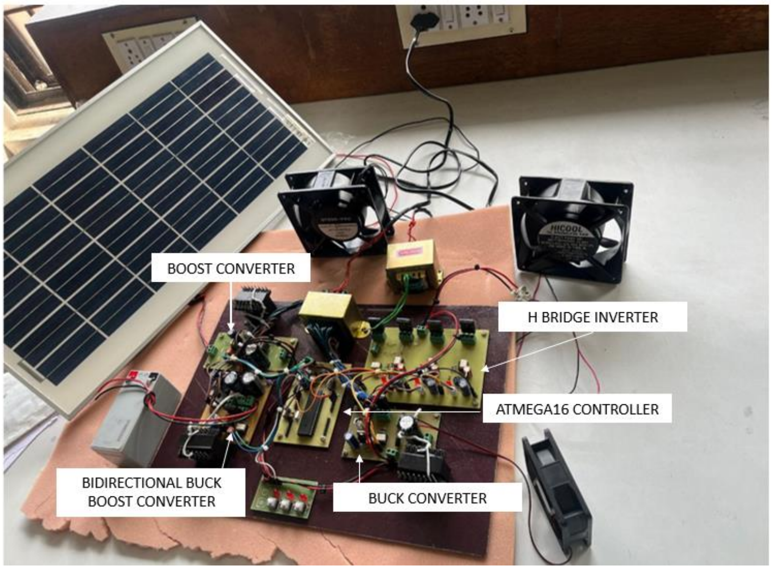

Fig 8.1 Hardware setup

This is the final Hardware setup. It mainly consists of five PCB modules

- Boost converter
- Bidirectional buck boost converter
- H bridge inverter
- Buck converter
- ATMEGA 16 controller board

Solar module is used for the power generation and a battery to charge when the PV is ON and discharge in the absence of PV. Two DC fans and one AC fan is connected to verify the output

8.2 HARDWARE RESULTS

MODE	48V DC FAN	24V DC FAN	220V AC FAN
0	ON	ON	ON
1	ON	ON	ON
2	ON	ON	ON
3	ON	ON	OFF

Table 8.2.1 Hardware results

From the hardware results it is shown that all the loads works in all conditions except in mode 3 where AC fan doesn't work. This is to show that when the PV output is low only DC load will function. This

CHAPTER-9
CONCLUSION

This project has culminated in the successful design, analysis, and potential implementation of a cost-effective AC/DC nanohome powered by a photovoltaic (PV) system. The proposed system caters to the power requirements of both DC and AC appliances, prioritizing efficiency and affordability throughout its operation. A key aspect of this design is its emphasis on cost-effectiveness. By enabling direct connection of DC appliances to the system's DC output, the need for additional converters is significantly reduced. This not only simplifies the system's structure but also translates to lower overall costs. Furthermore, the system utilizes a single inverter to manage AC power conversion for AC loads. This eliminates the requirement for multiple inverters, further contributing to cost saving. The overall design presented in this report offers a promising solution for powering nano-homes with a combination of DC and AC appliances. By maximizing the utilization of solar energy through a photovoltaic system and incorporating cost-effective measures, this system presents a sustainable and economical approach to domestic power generation. Future advancements in renewable energy technologies and component miniaturization can further enhance the system's efficiency, scalability, and affordability, making it an even more attractive option for sustainable nano-living solutions.

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APPENDIX

Program of ATMEGA 16 controller:

```
#include <avr/io.h>
#include <avr/interrupt.h>
int Total_Ovf1=0,Total_Ovf2=0;
int SW;
void timer0_init()
{
 TCCR0|=(1<<CS01);
 TCNT0=0;
 TIMSK|=(1<<TOIE0);
 sei();
 Total_Ovf1=0;
}
ISR(TIMER0_OVF_vect)//Inverter Pulse 50Hz
{
 if(SW == 0x03)//Mode 3
 {
  PORTA=0x00;
 }
 else// Mode 0, Mode 1, Mode 2
 {
  Total_Ovf1++;
  if(Total_Ovf1<=39)//10ms
  {
   PORTA=0x03;
  }
  else if(Total_Ovf1>=40 && Total_Ovf1<=78)//10ms
  {
   PORTA=0x0C;
   if(Total_Ovf1>=78)
   Total_Ovf1=0;
  }
  else
  {
   Total_Ovf1=0;
  }
 }
}
void timer2_init()
{
 TCCR2|=(1<<CS20);
 TCNT2=0;
 TIMSK|=(1<<TOIE2);
 sei();
 Total_Ovf2=0;
}
```

```
ISR(TIMER2_OVF_vect)
{
 //Mode 0
 if(SW == 0x00)
 {
  Total_Ovf2++;
  if(Total_Ovf2<=5)
  {
   PORTB=0x0B;
  }
  else if(Total_Ovf2>5 && Total_Ovf2<=10)
  {
   PORTB=0x00;
   if(Total_Ovf2>=10)
   Total_Ovf2 = 0;
  }
  else
  {
   Total_Ovf2=0;
  }
 }
 //Mode 1
 else if(SW == 0x01)
 {
  Total_Ovf2++;
  if(Total_Ovf2<=5)
  {
   PORTB=0x0D;
  }
  else if(Total_Ovf2>5 && Total_Ovf2<=10)
  {
   PORTB=0x00;
   if(Total_Ovf2>=10)
   Total_Ovf2 = 0;
  }
  else
  {
   Total_Ovf2=0;
  }
 }
 //Mode 2
 else if(SW == 0x02)
 {
  Total_Ovf2++;
  if(Total_Ovf2<=5)
  {
   PORTB=0x0C;
  }
  else if(Total_Ovf2>5 && Total_Ovf2<=10)
  {
   PORTB=0x00;
   if(Total_Ovf2>=10)
   Total_Ovf2 = 0;
```

```
  }
  else
  {
   Total_Ovf2=0;
  }
 }
 //Mode 3
 else if(SW == 0x03)
 {
  Total_Ovf2++;
  if(Total_Ovf2<=5)
  {
   PORTB=0x0B;
  }
  else if(Total_Ovf2>5 && Total_Ovf2<=10)
  {
   PORTB=0x00;
   if(Total_Ovf2>=10)
   Total_Ovf2 = 0;
  }
  else
  {
   Total_Ovf2=0;
  }
 }
}
int main(void)
{
 DDRB = 0xFF;
 DDRD = 0x00;
 DDRA = 0xFF;
 timer0_init();
 timer2_init();
 while(1)
 {
  SW = PIND & 0x03;
```

C