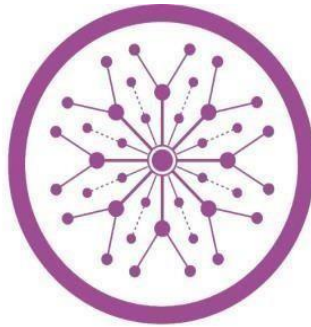


Comparative Study and Simulative Analysis of Electric Vehicle Fleet Integration in AC Microgrids



SUPERIOR UNIVERSITY

B.Sc. ELECTRICAL ENGINEERING

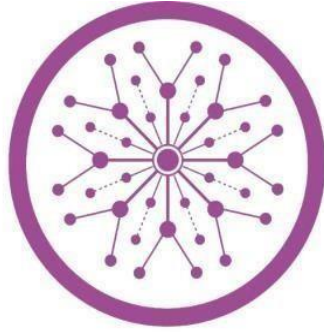
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**Comparative Study and Simulative Analysis of
Electric Vehicle Fleet Integration in AC Microgrids**

A thesis submitted to fulfillment of the requirements for the Degree of
Bachelors of Science in Electrical Engineering

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DECLARATION

This thesis is a presentation of my original research work. Wherever contributions of others are involved, every effort is made to indicate this clearly, with due reference to the literature, and acknowledgement of collaborative research and discussions. I also declare that this work is the result of my own investigations, except where identified by references and free from plagiarism of the work of others.

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DEDICATION

I would like to dedicate this thesis to our Prophet Hazrat Muhammad (S.A.W) and to my beloved family, teachers and friends.

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LIST OF ACRONYMS

BMS	Battery Management Systems
CCM	Charging Capacity Model
G2V	Grid to Vehicle
LLC	Inductor Inductor Capacitor
MCU	Microcontroller Unit
MG	Micro Grid
OVP	Over-Voltage Protection
PFC	Power factor correction
SCP	Short-Circuit Protection
THD	Total harmonic distortion
V2G	Vehicle to Grid

ABSTRACT

In the world of modern electric biking, an electric bike charger is a necessary component. Its significance comes from its crucial part in supplying the rising need for environmentally friendly transportation. Electric vehicles (EVs) are the prominent choice in the transportation sector to decrease the consumption of fossil fuels as well as greenhouse gases (GHG) productions. Microgrid operations especially hybrids AC/DC pave progressive development in the electrical vehicle by using renewable resources providing penetration of direct current (DC) into alternating current (AC). Power flow in AC, DC, and Hybrid-microgrid was made with the help of an isolated bidirectional battery charger with the potential of 1.5kW of 120 V. The proposed battery charger circuit was designed into two-stage conversion AC-DC and DC-DC. AC-DC conversion was done with the help of an inverter, while the rectifier was used for DC-DC conversion. Four switches operating at a High-frequency PI controller were used to maintain the output of 120V DC for battery charging while two controllers were used in the proposed battery charger circuit for battery power discharge system. Conduction losses were measured for comparative analysis of EV integration and future interventions. The mathematical equation and datasheet of IGBT were analysed by using MATLAB/SIMULINK software.

Keywords: Electric bike charger, environmentally friendly, BMS, Energy efficiency.

CHAPTER NO 1

INTRODUCTION

1.1 Background and Motivation

Approximately 60% of total air pollution is caused by the carbon, nitrogen oxide emissions from conventional power houses and vehicles resulting in the massively adverse impact of traditional energy production and transportation on the climate [1], [2], [3]. Dominantly, the transportation sector depends on crude oil products (i.e. petrol, diesel, etc.) with CNG and LPG being cheaper alternatives available in some countries that make up around 95% of existing transport network. This results in greenhouse gas emissions creating air pollution and other environmental hazards [4], [5]. Additionally, these conventional resources are also very costly and are depleting at a high rate due to their extensive utilization. For the generation purpose it is the basic need to burn the fossil fuels but as mentioned that they are not environment friendly, and this situation is responsible in climate change [6], [7], [8].

Considering the hazardous environmental impact of the traditional fossil fuels based automobiles and power plants, researchers are working on the development of electric vehicles (EVs) and implementation of renewable resources (RRs) for power generation. These RRs can also be implemented through microgrids to overcome the inherent complexities of large transmission networks and can provide ready to supply source for EV charging stations at the required locations. These microgrid are responsible for supplying the power to the local areas [9], [10], [11], [12], [13]. The advantages of the microgrid are as follows;

- Enhancement of the local reliability,
- Feeder losses reduction,
- Provide support to the local voltage,
- Correction of the sag voltage,
- Provide Uninterruptable supply.

Microgrids (MGs) have two operational modes, namely, islanded and grid connected modes and the main component to be controlled is the inverter in any MG. The primary focus of any MG is to provide assistance in optimizing the power system in an economical manner and the necessary control features of the MGs are discussed in [14], [15], [16], [17], [18]. The aim of incorporating electric vehicles (EVs) in the existing transport networks emphasizes the implementation of RR based MGs to facilitate local power generation without increasing hazardous Now-a-days, electric vehicle becomes very popular

among the government and public sector. The main reason for popularity among the other renewable resources are follows

- Easiness
- Clean source of energy
- Cleanness

V2G mode is more stable source of renewable energy because it does not affect by climate change. It is also a clean source of energy because it is free from carbon oxides emission. In comparison to fossil fuel the cost of EV is less so it is considered as economical solution.

Electric vehicles are considered as environment friendly due to zero emission. The maintenance of the inside components of EV's is also very easy. There is one problem according to the cost. The manufacturer must limit the capacity of the battery. If you want a higher pack of the battery, then the cost of the battery increased. The range of the EV's is increased but as well as cost also increased. The most expensive component of the EV's is battery.

The range of the EV's keep small due to their cost. People needs cars to travel to home or offices and their range is short. So, people want to charge their batteries once and it's a common to charge the EV's at night. EV's owner need a solution to charge and discharge their batteries according to their practice. emissions.

Researchers are designing various mechanisms to improve the climatic conditions by reducing various hazardous emissions. One foremost prospect is to facilitate the use of EVs that will not only provide cleaner alternate to the commonly available fossil fuel burning vehicles besides, they can also provide a mechanism for possible energy storage [19], [20]. The environmental and economic benefits along-with the various facilitating policies made by governments globally, the EVs are becoming very popular among the private investors [21], [22], [23]. However, the EV's also have some drawbacks like initial price, the short distance covered, battery charging time and lack of the infrastructure for the charging of vehicles are the major reasons for currently lower share of the EVs in global transport network. Besides, in the currently implemented power system, the EV's charging result in over-loading of the transformers. Therefore, for increasing the share of EVs in the transport network, the current and future enhancement of the cleaner power generation should also be considered at the planning stage [24], [25], [26].

EV's charging, might be the reason behind the over-loading of the transformer of the distribution system which are already present. Therefore, at the planning stage for the EV's use it must be kept in mind to keep the capacity of the Electric Grid according to the characteristic of the EV's. The charging property of the EV's batteries can cause problems for the load structures of EV's. The switching time of the EV's on time and off time also effect on the EV's load. So, these are the two hot topics for the research.

The combined structure for fleet of EVs is commonly examined in scale of hours. For the calculation of Electric Grid studies, the perfect model of battery is the basic requirement. The property of the EV's integration in/off time in contrast to the charging of the battery has more significant effect on the combined property of the load in case of fleet of EV's. The size and other constraint of the Electric grid are influenced by the time period of the EV's connection to the grid. The EV's load profile also effected by the temperature and the initial charging status of the battery.

The EV's also have some drawbacks like initial price, the short distance covered and lack of the infrastructure for the charging of the EV's. Due to these drawbacks the market share of the EV's is low. A model of the EV by the car company Nissan is made which has ability to cover the distance of 250 km and the reduction in annual cost of the battery is fourteen percent.

Besides, the combined structure for fleet of EVs are examined in scale of hours. For the future calculation of Electric Grid studies, the precise model of battery is the basic requirement with the consideration of EVs integration in ON/OFF time. The size and other constraint of the Electric grid will be influenced by the period of the EVs connection to the grid as [27], [28], [29]. The prominent contributions made by the researchers in the field of EV development and deployment are presented in the next section with the consideration of various significant EV parameters.

1.2 Problem Statement

With the increasing penetration of EVs in the global transportation network, the national grids are facing rise in their load demand, fluctuations in supply voltage, increasing losses in the power electronic circuitry and deteriorating power quality due to increase in harmonics. Therefore, it is necessary to analyse the connectivity of fleet of EV in the AC, DC, and Hybrid microgrid (HMG). It can help in reducing the load on traditional electric grids, decline in hazardous emissions and increase the charger efficiency. Thus, improving the charging time of EVs and paving the way of their better integration in the global transport networks.

1.3 Objectives

- Development of control techniques for the charging and discharging of Electric Vehicles.
- Simulate the Charging/Discharging of EV in AC microgrid.
- Analyse the performance of EV in AC microgrid.
- Calculate the conduction losses during charging and discharging phases.

1.4 Overview of EV Chargers

Battery chargers can be constructed by different ways. It depends on the type of the battery and the source which used. In the literature review there are two types of topologies used for the charging of the battery. One is called single stage and the other is known as 2 stage converters as shown in fig 1-1. For the low power rating single stage topology is used. The rating is low so that why no need for galvanic isolation like transformer is needed in this type. These types of chargers for battery are known as non-isolated battery chargers. They are 1-phase.

They are controlled by a single controller. The function of the controller is to perform the process of rectification such as AC-DC conversion and power factor correction is also done in this. For the charging of the battery DC-DC conversion is required.

The cost of these chargers is very low. The weight and size of these chargers is also small. These chargers are designed for a power rating such as (<250). They are not applicable for high power rating because the problem of the isolation. In addition to the ripples are also present in output DC voltage which is used to charge the battery.

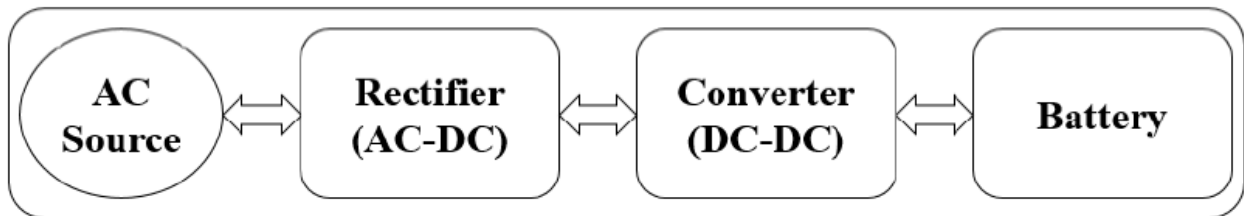


Figure 1.1. Block diagram of traditional bi-directional charger

This other type, which is known as two-stage is used for the high-power rating. The power rating is high, so the problem of galvanic isolation occurs in this type and that's why high frequency transformer is required as shown in fig 1-2. It is also very important to provide protection in faulty condition also this transformer works as voltage conversion such as for buck operation and for the boost operation according to the charging and discharging mode. So, this is the reason to call these chargers isolated chargers. It is available in single phase as well as three phases.

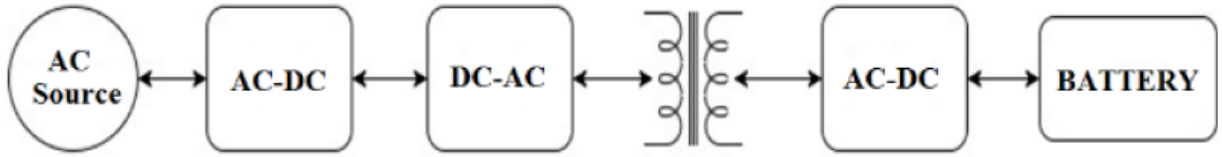


Figure 1.2. Block diagram of isolated battery charger

In this type the 2 controller is used. one controller perform the process of rectification such as from AC-DC with power factor correction. A DC link capacitor is also used which is controlled by another controller and performs the conversion process like DC-DC. This conversion is used to attain the DC voltage at the output terminal. They are both types single-phase and 3-phase. The selection process is done according to the power rating.

These are also used for the unidirectional as well as bidirectional depending on the condition of the circuit. For rectification process of single phase mostly diode topology is used and for bi-direction H-bridge is used. Single phase bi-directional. This is shown in fig 1-3.

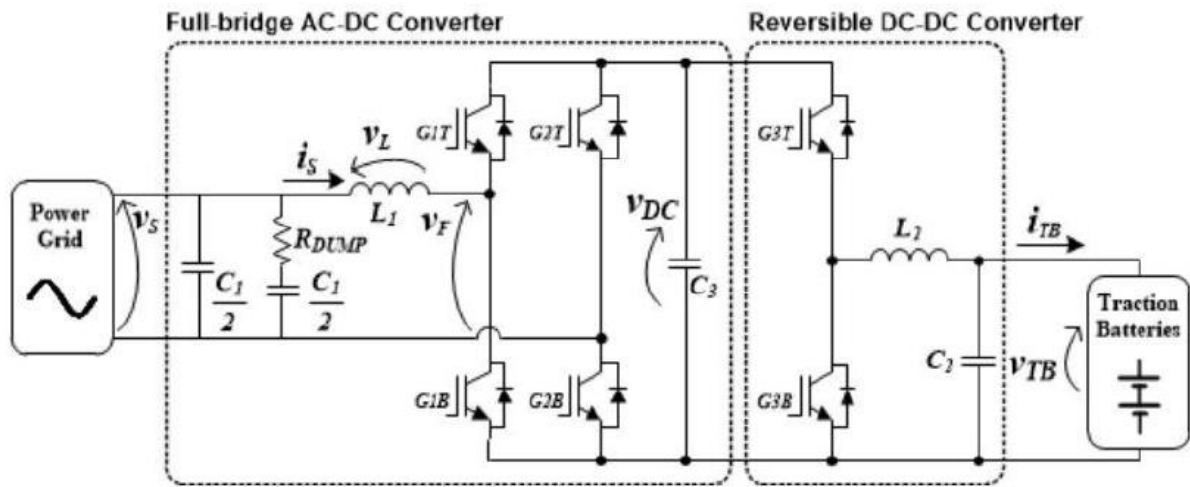


Figure 1.3. Block diagram of bi-directional single-phase battery charger[26]

The proposed 1-phase or 3-phase, whether it is isolated or non-isolated battery charger it has at least one of the following drawbacks.

1.5 Thesis Organization

Chapter 1 is the introduction of the EV's and the Microgrid. Literature review of the Electric Vehicles are presented in the Chapter 2. The integration of EV's into the Grid is discussed in the chapter 2. The Methodology for charging from the Grid and discharging to the Grid is discussed in the chapter 3. In the

chapter 3 controllers for charging and discharging are discussed. Charging and discharging techniques for the AC, DC and hybrid microgrid is discussed. The results of the simulation for AC, DC and hybrid microgrid is shown and discussed in the chapter 4. The conduction losses and their comparison in AC, DC and hybrid microgrid also presented in the chapter 4. The conclusion and discussion in the chapter 5.the future work is in the chapter 6 and the references are at the end of the chapter 6.

CHAPTER NO 2

LITERATURE REVIEW

2.1 Introduction:

The industrial revolution started in the nineteenth century with the incorporation of steam powered stations due to excessive availability of the coal and lack of knowledge about their environmental impact. The industrialists at the time developed steam powered cars [30], but they were inefficient due to the requirement of large and heavy components used in the car [31]. In addition, this was time taking processes [32]. These steam cars had many other disadvantages like, slow operation of the engine, excessive vibrations and lesser control on driving [33]. However, the people started working on other possible technologies to make more fuel-efficient vehicles.

The continued efforts of the researchers yielded fossil fuels based vehicles which were more efficient than steam power cars and had better operational features that made cars are the most commonly source of transportation [34], [35]. These fossil fuels were much cheaper and efficient at the time and the climatic conditions were better so, the world did not pay attention to the forth coming issue of their depletion and the generated pollution at that time [36].

During last two to three decades, an alarming situation arose around the world known as global warming that caused severe changes in weather patterns and an increase in natural disasters like, excessive rains, floods in some areas and impactful droughts in other areas [37], [38]. The researchers concluded that excessive use of fossil fuels for increasing power demand and transportation has altered the global ecological balance due to an extensive increase in emissions of hazardous GHGs [39], [40]. These factors motivated researchers to develop various cleaner alternatives for the necessary power generation and transportation [41].

Now-a-days, share of EVs in the transportation system is increasing significantly (from 0.1% in 2014) due to various technological improvements. [42]. According the recent surveys, the fossil fuel dependency of the transport sector reduced to 95% due to gradual increase in the number of EVs and this trend is increasing continuously [43]. This trend is also encouraged by many governments, like in EU strict penalties are enforced on breaching the fixed limit of CO₂ emissions [44]. The issue of EV

charging is also addressed by the developers and the prominent topologies for the purpose are discussed in the next sub-sections.

The function of the single stage controller is to perform the process of rectification such as AC-DC conversion and power factor correction is also done during this conversation. For the fast charging of the battery, DC-DC conversion is also required. The size and weight of these charger are small due to lesser components and their costs are also lesser than the two stage chargers. However, the charging time of these chargers are not very appreciable due to the low power rating.

2.2 G2V Charging Topology:

EVs require an external source for the charging of the batteries and traditionally it has been the electric supply from the electric grid to serve the purpose. The charger used for the purpose is a rectifier since the conventional grids supply only AC power to the consumers and it requires conversation to DC for charging the batteries [45].

To improve the charging time at the EV charging stations, an extra DC-DC converter is now implemented for more efficient conversation and fast charging. These chargers can be on or off board, depending on the level of charging and current status of the battery [46].

With the aim of improving the mobility of the EVs their weight must be kept in check and structures were to be made more compact. But the on-board chargers have issues like lower power rating and their traditional designs are not supportive for facilitating fast charging. On the other hand, the off-board chargers are normally situated at locations, where size if the charger is secondary thus, DC-DC converters are easily added to support the fast charging of EVs [47], [48].

The G2V operation works with the power transferred from the grid used to charge the EV through a BUCK converter and the working mechanism of this type of charger is presented in figure 2-1.

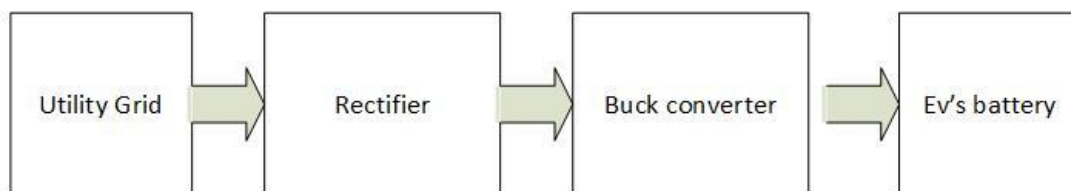


Figure 2.1. Block Diagram in G2V Operation

2.3 V2G Charging Topology:

In contrast to the G2V topology, in the V2G mechanism the power flows between EV-batteries and electric grid. This V2G topology facilitates the power flow from the EVs to the grid or other utilities so they actually start behaving as a source as well [42]. This mechanism also improves the load management of the utility as the EVs can be charged during the off-peak hours for the travelling or storage purposes. These charged EVs can also be used as a local power supplier during the peak hours [49], [50], [51].

The V2G topology can have following three categories,

- vehicle-vehicle (V2V),
- vehicle -building (V2B) or vehicle-home (V2H) and
- the vehicle-grid(V2G).

The charge stored in the batteries of EVs is used to supply the backup power in all the above-mentioned categories which helps in load sharing for the electric grid during the peak load hours. This also solves an important issue of EV charging as well, since the EV charging has been considered as an additional load on the already fully/ over loaded electric grids in various countries. Besides, this concept can also be enhanced commercially is a properly business model is implemented where both the consumers and suppliers can benefit. Thus, proper scheduling of EV charging can provide important technical and financial benefits [52], [53], [54].

The operational process of V2G is reversed as the battery of EV supplies its energy to the grid or some other consumer(s) through a BOOST converter and its operational mechanism is presented in figure 2-2.

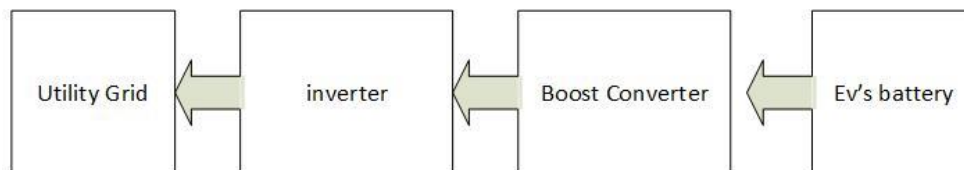


Figure 2-2. Block Diagram in V2G Operation

2.4 Charging Levels:

The international electromechanical commission (IEC) and the society of the automotive engineer (SAE), have developed international standards for the charging of EVs that are overviewed in the table given below [55], [56], [57], [58]:

Table 2.1: International standards for the charging of EVs

Sr.	Power Level type	Level 1	Level 2	Level 3
1	Grid Voltage	120 V _{AC} (US) 230 V _{AC} (EU)	240 V _{AC} (US) 400 V _{AC} (EU)	208-600 V _{AC} or V _{DC}
2	Power range	≤3.7kW	3.7-22kW	>50kW
3	Approximately charging time	11-36 hours	1-6 hours	0.2-1 hours
4	Charger topology	On-board	On-board	Off board
5	Grid supply type	1-phase	1-phase or 3-phase	3-phase
6	Charging type	Slow charge	Semi-fast charge	Fast charge
7	Battery capacity	15-50kW	15-50kW	15-50kW

The diffusion of EVs into smart grid has gone through a great progress, facilitating two-way flow of electric power. The EVs charged during the off-peak hours, supply power during the peak hours for various purposes mentioned in the section 2.2. More benefits from the EV's batteries can be retrieved by more enhancement in the equipment thus emphasizing the development of an efficient bidirectional charger [59].

2.5 Conduction Losses:

The power dissipation of a switch while conducting can be written as in (2.1),

$$P_{con}(t) = V_{on}(t)I_{sw}(t) \quad (2.1)$$

where V_{on} and I_{sw} are the On state voltages current respectively [50] while the IGBT voltage for the ON state can be obtained as in (2.2),

$$V_{on}(t) = V_{ceo} + R_{on} I_{sw}(t) \quad (2.2)$$

The average value of the power loss for IGBT can be calculated using (2.3) in-terms of time period T and in-terms of frequency f using (2-4),

$$P_{avg. cond} = \frac{1}{T} \int_0^t [V_{ce}(t) * I_{ce}(t) dt] \quad (2.3)$$

$$P_{avg} = f \int_0^t [P(t) dt] \quad (2.4)$$

The following three steps should be followed to calculate the overall power loss for the operational cycle of IGBT,

- The device in ON-state.
- The device is conducting.
- The device in OFF-state.

$$P_{avg}(IGBT) = P_{on} + P_{cond} + P_{off} \quad (2.5)$$

However, the conduction losses are independent of the switching frequency and depend on the duty cycle.

2.6 Switching Losses:

The switching losses should also be considered for making the charger circuitry more precise and reliable and they can be calculated using following steps,

$$P_{sw}(IGBT) = (E_{on} + E_{off}) f_{sw} \quad (2.6)$$

$$P_{sw}(IGBT) = \frac{[(E_{on} + E_{off}) * I_{pk} * f_{sw} * V_{dc}]}{\pi * I_{nom} * V_{nom}} \quad (2.7)$$

Thus the total switching losses of the IGBT can be found using,

$$P_{avg.IGBT}(total) = P_{cond}(IGBT) + P_{sw}(IGBT) \quad (2.8)$$

2.7 Diode Losses:

The diode losses can be calculate using equations (2.9) to (2.11),

$$P_{avg}(diode) = P_{cond}(diode) + P_{rec}(diode) \quad (2.9)$$

$$P_{cond}(diode) = 0.5 \left(V_{d0} * \frac{I_{pk}}{\pi} + R_d * \frac{(I_{pk})^2}{4} \right) - m * \cos\phi \left(V_{d0} * \frac{I_{pk}}{8} + R_d * (I_{pk})^2 / 3\pi \right) \quad (2.10)$$

$$P_{rec.}(diode) = E_{rec} * f_{sw} \quad (2.11)$$

2.8 Total Losses:

The overall total of the conduction losses can be calculated using (2.12),

$$P_{avg}(diode) = P_{rec}(diode) + P_{cond}(diode) \quad (2.12)$$

CHAPTER NO.3

SIMULATION AND RESULTS

Battery chargers can be constructed by different ways. It depends on the type of the battery and the source which used. In the literature review there are two types of topologies used for the charging of the battery. One is called single stage and other is known as 2 stage converters as shown in fig 3-1. For the low power rating single stage topology is used. The rating is low so that why no need for galvanic isolation like transformer is needed in this type. These types of chargers for battery are known as non-isolated battery chargers and they have single phase operation.

3.1 Proposed system:

The constructed battery charger has the capacity to charge and discharge the battery. The constructed battery charger is made up of single-phase AC source. It is responsible for both operation such as V2G and G2V operation. The construction of the proposed system is discussed in this section.

3.2 Construction for AC grid:

The proposed charger is composed of single-phase AC Grid which is connected by a rectifier which is connected to a DC-link bus capacitor followed by a high frequency transformer. The Primary winding of the transformer is connected by four switches and output is connected by a full bridge which further connected by a battery. The circuit diagram of the proposed system is shown in the fig 3-1.

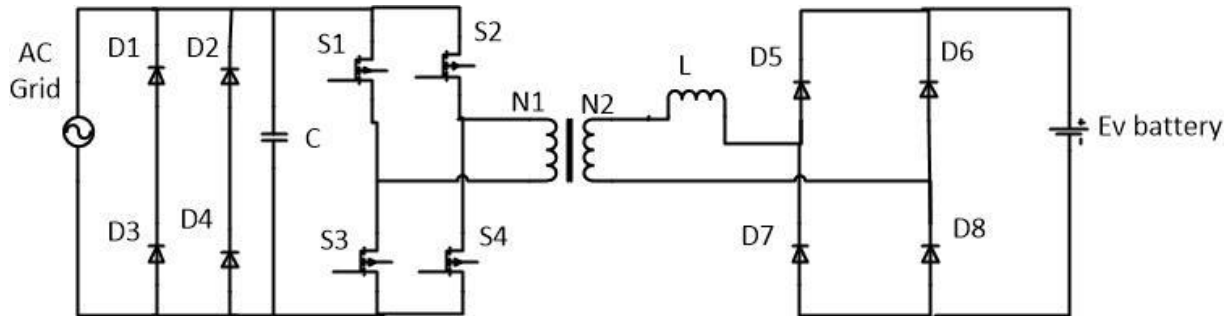


Figure 3.1. battery charger V2G operation diagram in AC grid

In grid connected mode of operation, generally LCL filter is used. This LCL filter is used because it has more advantages than the LC filter and L filter. The L_g is the grid side inductor while the L_i is the inverter side inductor. The L_i always smaller than the L_g . The capacitor is used to remove the harmonics. The bridge is used as rectifier when it is in charging mode of operation, and it is used as inverter when it is used in discharging mode of operation.

3.3 Charging and Discharging Mode:

3.4.1 Charging Mode (G2V):

An isolated circuit is used in the proposed system. There are two stages in the charging mode in the proposed topology such as for conversion of AC-DC and for conversion of DC-DC. For conversion of AC-DC full wave rectifier is responsible which alter the AC voltage into the DC voltage by a link capacitor which is DC. This is shown in the fig 3-2.

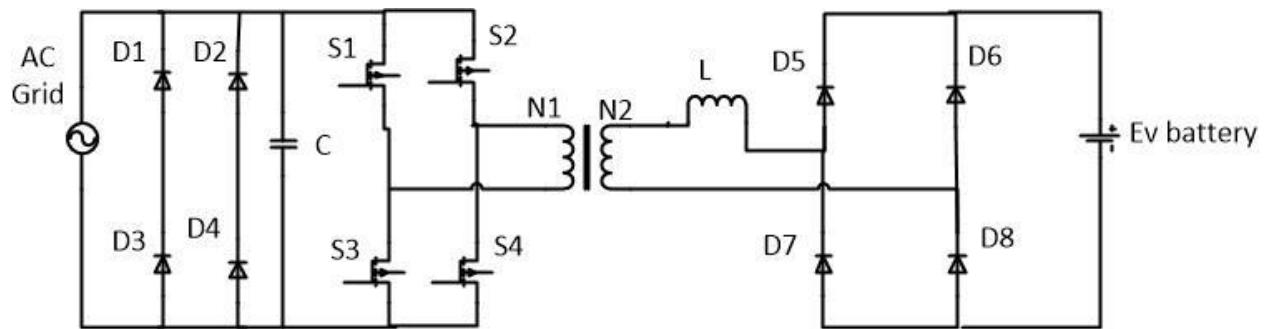


Figure 3.2. Proposed Charger in Case of Charging

The conversion of DC-DC, the capacitor is used as DC-link capacitor provide a DC voltage which is constant. The high frequency transformer is connected with four switches which act as inverter. This converts the AC voltage into DC voltage through the PI controller.

The transformer is centrally tap and it bucks the AC voltage while operating in charging mode. If some fault occurs, it provides isolation. It protects the battery from the fault current from the source side. The buck voltage then applied to the full bridge act as diode which convert the AC voltage into DC voltage to charge the battery as shown in the fig. the required output is attain by the PI controller.

3.4.2 Discharging Mode (V2G):

In discharging mode, for conversion of DC-DC the battery voltage applies across the full-bridge which alters the DC voltage into AC voltage which is connected by a HF transformer which is centrally tap. Now this transformer works as boost and it boost the AC voltages. It also provides the isolation. The constant voltage is maintained by a PI controller. Then DC voltage is converted into AC voltage to provide the supply to the grid. This is constant and pure sinusoidal and controlled by PR controller. The circuit diagram is shown in the fig 3-3.

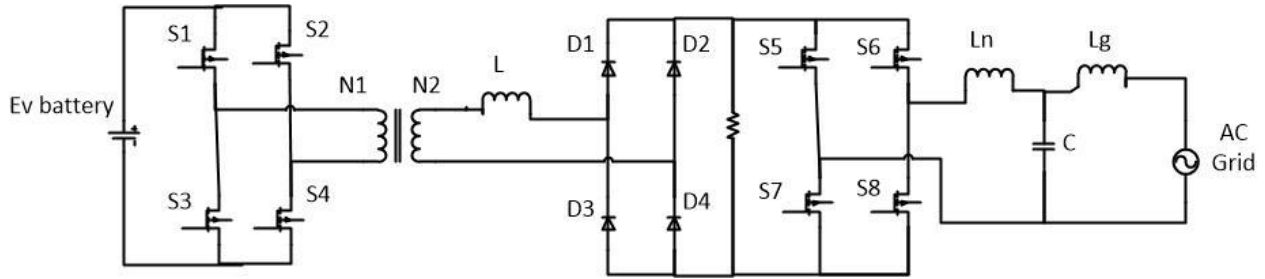


Figure 3.3. Proposed System in Case of Discharging

3.4 Simulation:

A 1.5 KW isolated battery charger with voltage of 120V is constructed and simulation is done in Simulink/ MATLAB. The proposed battery charged by single-phase AC source, DC source and hybrid, while the constructed charger has ability to discharge the battery when there is power is required. The battery charger works at nominal frequency i.e. 50 HZ, while the switching frequency of the proposed battery is 20000 HZ. The input single phase supply for AC source is 220 V. It is same in the case of DC and Hybrid-microgrid. The output voltage of the battery is 120 V. The parameters of the proposed battery charger are given in table 3-1. Each value is given from the simulation which is done in the MATLAB/Simulink. By using this value, the results can be achieved.

Table 3.1. Parameters

Sr.no	Parameters	Values
1	Source side inductor L_i	400e-6
2	Source side capacitor	100e-3
3	Inverter side inductor L_g	100e-3
4	DC link bus capacitor	500e-6
5	Transformer Primary winding	220 V
6	Transformer Secondary winding 2	120 V
7	Output capacitor	100e-3

3.5 AC Grid:

3.5.1 Charging Mode (G2V):

In the charging Mode while operating in AC grid the battery is charged by the input supply voltage of 220 V AC. PI controller is used to maintain the output voltage of 120 V DC with the help of the proper

The SOC in the G2V mode is shown in the fig which shows the increment behaviour which means that battery is in charging mode as shown in the fig 3.5. The output voltage of the proposed battery is shown in the fig 3.6.

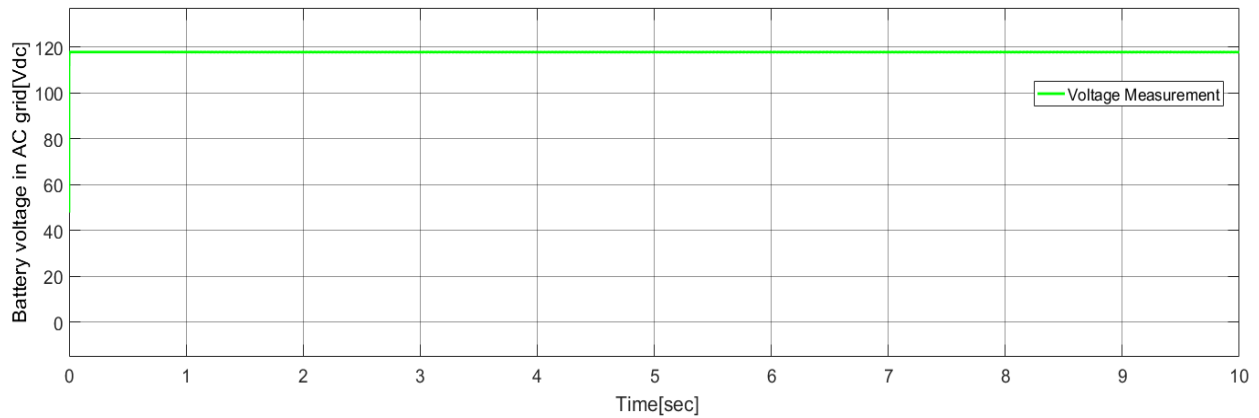


Figure 3.5. Battery voltage in AC grid

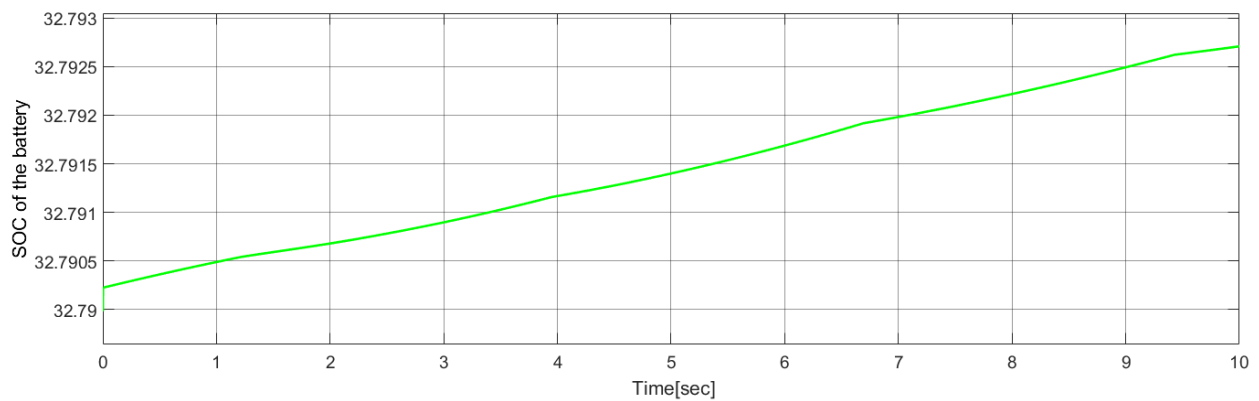


Figure 3.6. SOC of the battery in G2V mode

3.5.2 Discharging Mode (V2G):

In the discharging mode while operating in AC grid, battery is discharged and supply 220 AC Voltage to the grid. Fig. 3.7 shows the simulation diagram for grid to vehicle (V2G) system performed in MATLAB (Simulink).

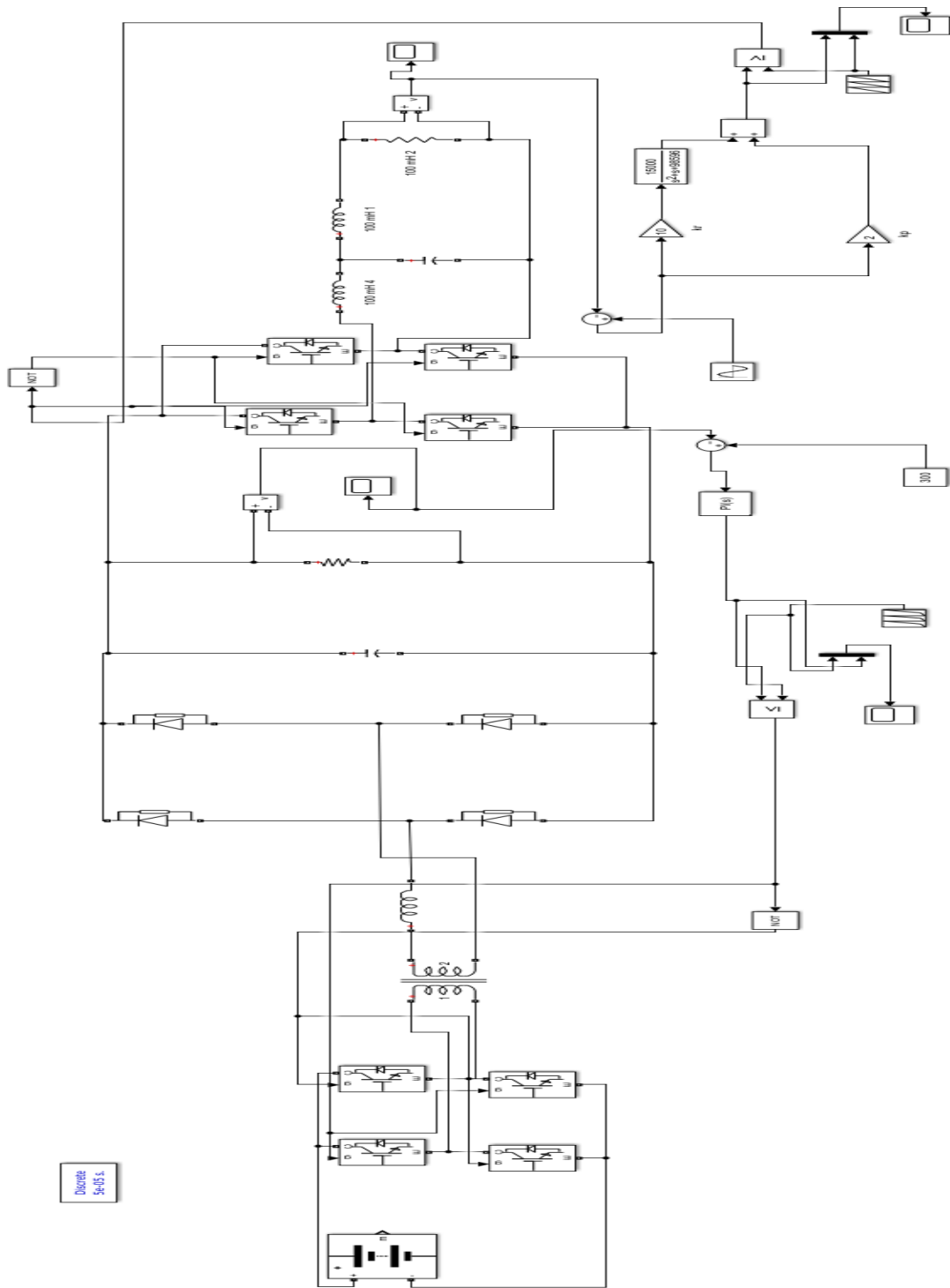


Figure 3.7. Simulation Diagram for G2V (Charging State)

The PI and PR controller are used to main 220 AC Voltage. This is shown in the fig 3.8. The SOC in the V2G mode is decreasing which means that the battery is discharging and supplying power to the grid as shown in the fig 3.9.

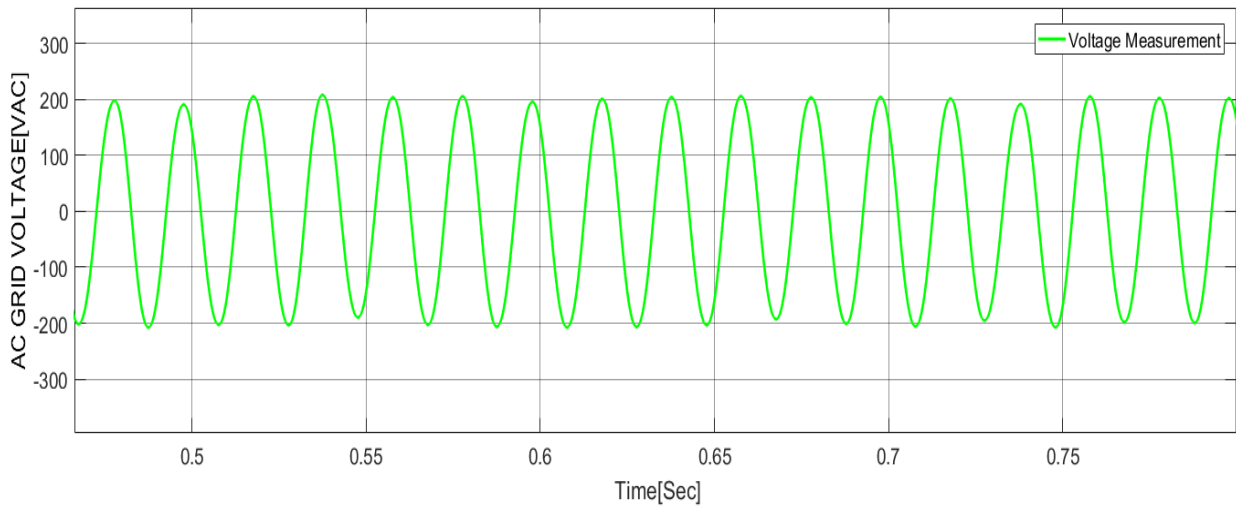


Figure 3.8. Grid Voltage

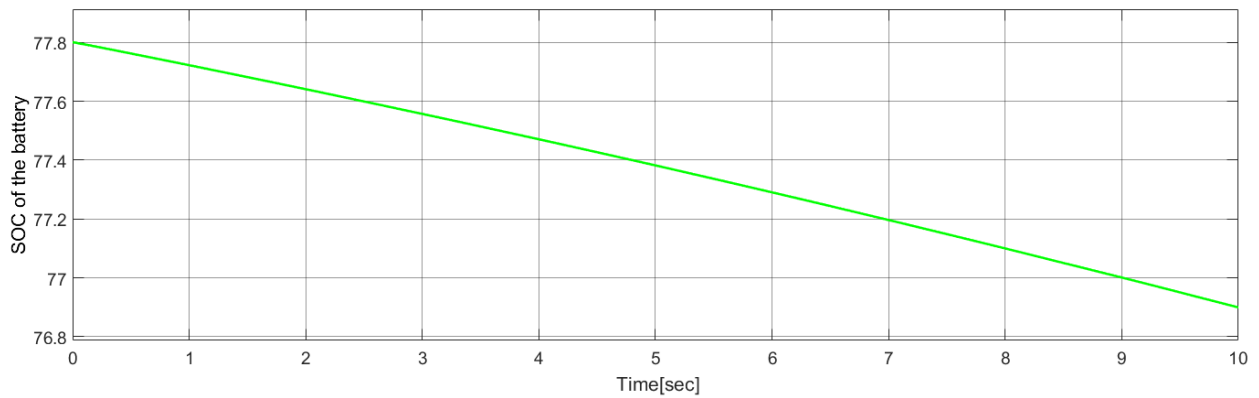


Figure 3.9. Percentage SOC in V2G mode

3.5.3 THD In Grid Connected Mode:

The THD in grid connected mode is allowed 5%. The proposed system has the THD of 2.37% as shown in the fig 3.10.

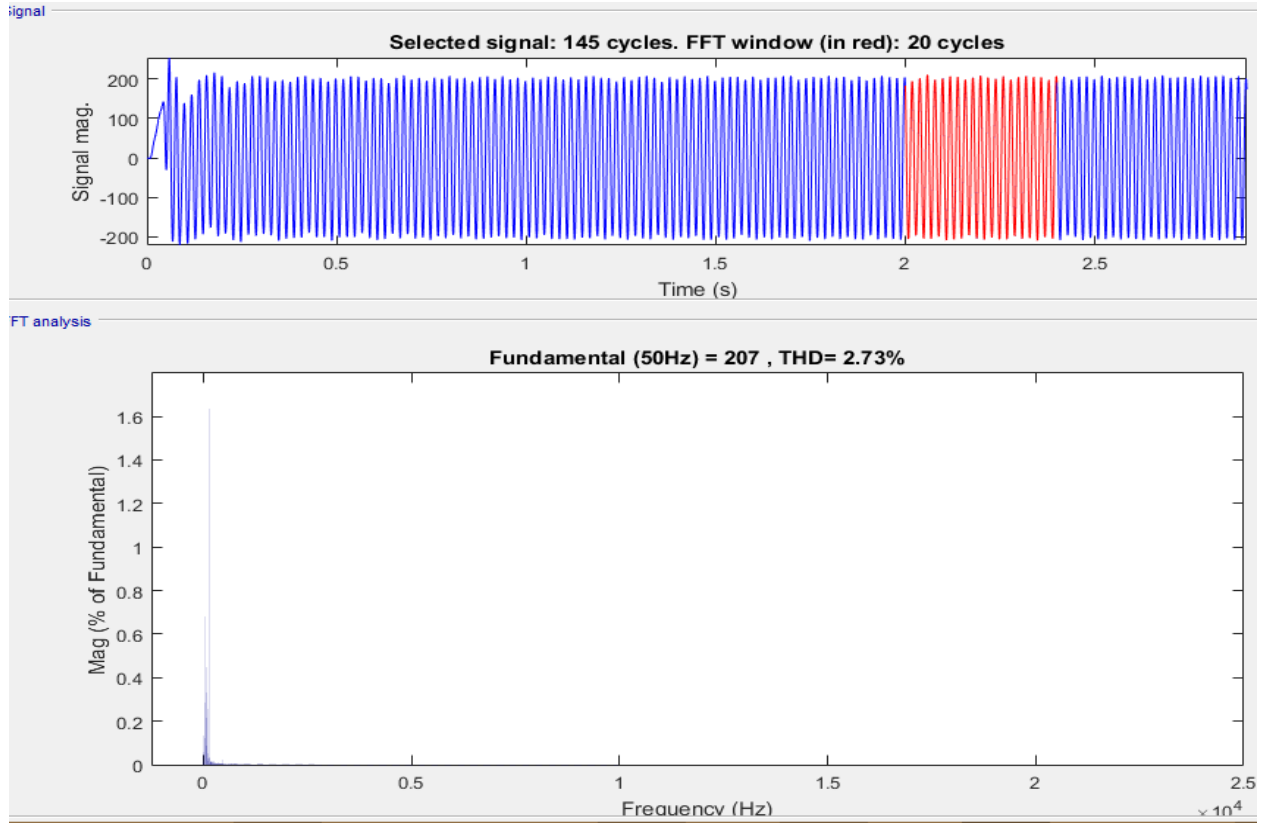


Figure 3.10. THD in case of Grid connected mode

CHAPTER NO. 4

HARDWARE DESIGN

The project aims to explore the dynamic interactions between electric vehicle (EV) fleets and alternating current (AC) microgrids. With the increasing adoption of EVs and the growing emphasis on renewable energy sources, integrating EVs into microgrids presents both opportunities and challenges for energy management and distribution.

4.1 Introduction

The integration of electric vehicle (EV) fleets into alternating current (AC) microgrids represents a pivotal development in modern energy systems. As the transition to renewable energy sources accelerates, and electric vehicles become more prevalent, understanding their impact on microgrid stability and efficiency is critical. This project focuses on a comparative study and simulative analysis to evaluate the feasibility, benefits, and challenges of incorporating EV fleets into AC microgrids.

Microgrids, which are localized grids that can operate independently or in conjunction with the main power grid, offer enhanced reliability and sustainability by integrating distributed energy resources (DERs) like solar panels, wind turbines, and battery storage systems. The addition of EV fleets introduces a new layer of complexity, as these vehicles can act both as energy consumers and potential energy suppliers through vehicle-to-grid (V2G) technology

This study employs various simulation tools and hardware components to model different scenarios of EV integration, examining factors such as load balancing, peak shaving, energy storage, and power quality. By conducting a comparative analysis, the project aims to identify optimal strategies for managing the bidirectional flow of energy between EVs and microgrids, ensuring a stable and efficient energy system

4.2 Hardware Details

The hardware design of the project involves a detailed configuration of various components to facilitate effective simulation and analysis. Here's an overview of the key elements and their arrangement within the hardware design

4.2.1 Diode

A diode is a semiconductor device that allows current to flow in one direction only, exhibiting high resistance to current in the opposite direction. Diodes are fundamental components in electronic circuits and have a wide range of applications. Here are a few descriptions of different types of diodes.

Key Characteristics of Diodes:

- **Forward Voltage Drop:** The voltage drop across the diode when it is conducting current in the forward direction, typically around 0.7V for silicon diodes and 0.3V for Schottky diodes.
- **Reverse Breakdown Voltage:** The voltage at which the diode starts to conduct in reverse, leading to a sharp increase in reverse current.
- **Current Rating:** The maximum current that the diode can safely conduct in the forward direction.
- **Switching Speed:** The time it takes for the diode to switch from conducting to non-conducting state and vice versa.

Diodes are crucial in designing and building various electronic circuits, serving functions such as rectification, voltage regulation, signal modulation, and light emission.

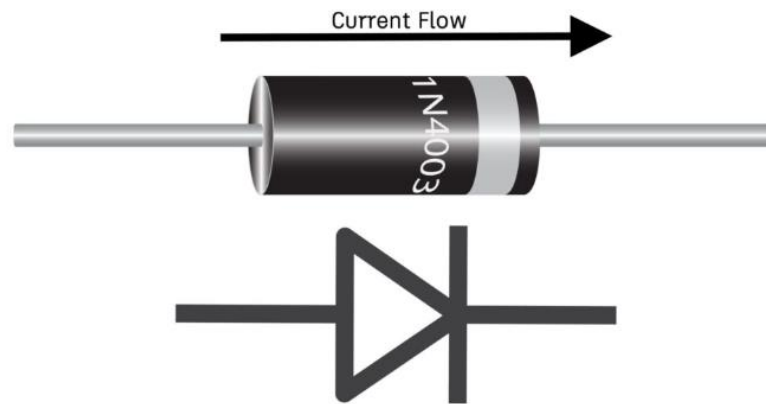


Figure 4.1: Diode

4.2.2 Transformer

A step-down transformer is a key component in power supply systems used to reduce high voltage levels to lower, usable levels for various applications. Here are a few details about step-down transformers:

A step-down transformer decreases the voltage from a higher level to a lower level while increasing the current. It operates on the principle of electromagnetic induction, where alternating current (AC) in the primary coil generates a magnetic field that induces a voltage in the secondary coil

A step-down transformer is crucial in ensuring that electronic devices and systems receive the appropriate voltage levels, enhancing safety and efficiency in power distribution.

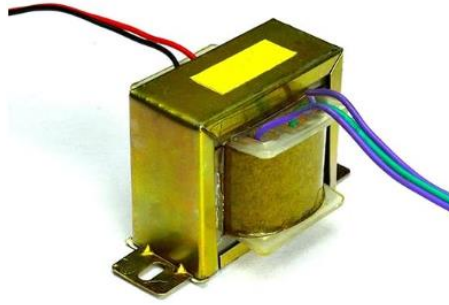


Figure 4.2: Transformer

4.2.3 Features of the Hardware

Feature of the hardware is given below:

- Wide operating input range (from 110V to 230V) 480W rated power and constant voltage output
- High Efficiency Up to 93%
- Short-Circuit Protection (SCP) (Auto Restart Mode)
- Over-Voltage Protection (OVP)
- Over-Load Protection



Figure 4.3. Project Circuit Design

4.2.4 Short-Circuit Protection

Short-circuit protection is a critical aspect of electrical system design, aimed at preventing damage and ensuring safety when an unintended low-resistance connection occurs, leading to excessive current flow. Here are some key details about short-circuit protection:

Purpose

- **Safety:** Protects people from electrical hazards such as electric shock and fire.

- **Equipment Protection:** Prevents damage to electrical components and wiring.
- **System Integrity:** Maintains the stability and reliability of the electrical system.

Protection Principles

- **Current Limiting:** Devices like current-limiting fuses reduce the peak current by interrupting the circuit quickly, limiting the let-through energy.
- **Time-Current Characteristics:** Circuit breakers and fuses are designed to trip faster as the current increases, balancing between protection and avoiding nuisance tripping.
- **Selective Coordination:** Ensures that only the closest protective device to the fault trips, maintaining power to unaffected parts of the system.

By incorporating short-circuit protection, electrical systems can prevent catastrophic failures, enhance safety, and ensure the longevity and reliability of electrical infrastructure.



Figure 4.4: Short Circuit Protection

4.2.5 Over-Voltage Protection

Over-voltage protection is essential to safeguard electrical and electronic systems from damage caused by excessive voltage levels. Here are key details about over-voltage protection:

Purpose

- **Safety:** Prevents electrical hazards such as fires and electric shocks.
- **Equipment Protection:** Protects sensitive electronic components and devices from damage due to voltage spikes.
- **System Integrity:** Ensures the reliable operation of electrical systems by preventing over-voltage conditions from causing malfunctions or failures.

Protection Principles

- **Clamping:** Limits the voltage to a specific level by absorbing or redirecting excess energy. Common in surge protectors and TVS diodes.
- **Shunting:** Diverts excess voltage away from sensitive components to ground. Used in devices like GDTs and MOVs.
- **Regulation:** Maintains a constant voltage level to ensure stable operation of electronic devices. Achieved using voltage regulators



Figure 4.5: Overvoltage Protection

Over-voltage protection is vital for preventing damage to electrical and electronic systems due to excessive voltage levels. By implementing devices such as surge protectors, TVS diodes, GDTs, voltage regulators, and crowbar circuits, systems can be safeguarded against voltage spikes, ensuring safety, equipment longevity, and reliable operation.

4.2.6 Overload Protection

Overload protection is a critical aspect of electrical system design, aimed at preventing damage and ensuring safety when a circuit or device draws more current than it is designed to handle. Here are key details about overload protection:

Purpose

- **Safety:** Prevents electrical hazards such as overheating, fires, and electric shocks.
- **Equipment Protection:** Protects electrical components and wiring from damage due to excessive current.
- **System Integrity:** Ensures the reliable and efficient operation of electrical systems by preventing overload conditions from causing malfunctions or failures.

Protection Principles

- **Time-Current Characteristics:** Overload protection devices are designed to trip faster as the current increases, balancing between protection and avoiding nuisance tripping. This characteristic ensures that temporary current surges do not cause unnecessary interruptions while providing protection against sustained overload conditions.
- **Inverse Time Delay:** The trip time decreases as the current increases, providing faster protection for higher overloads and allowing for short-term inrush currents that are typical in motor startups.

Overload protection is essential for preventing damage to electrical systems and ensuring safety. By implementing devices such as fuses, circuit breakers, and overload relays, systems can be protected from excessive current conditions, maintaining safety, equipment longevity, and reliable operation. Proper selection, coordination, and maintenance of these protective devices are crucial for effective overload protection.



Figure 4.6: Overload Protection

4.2.7 Capacitor

A capacitor stores electrical energy in an electric field when voltage is applied across its terminals. It consists of two conductive plates separated by an insulating material called the dielectric.

Capacitors are fundamental components in electronic circuits, playing crucial roles in various applications across industries such as telecommunications, automotive, consumer electronics, and power electronics. Understanding their characteristics and selecting the appropriate type is essential for designing efficient and reliable electronic systems.



Figure 4.7. Capacitor

4.3 System Specification

The details of the system specification in mentioned in table 4.1. It provides the range and values of different input and output parameters of the design circuit.

Table 4.1. System Specification

PARAMETER	SPECIFICATION
Input Voltage Range	110 V to 230 V AC
Output Voltage Range	60 V to 72 V $\pm 1.5\%$ DC
Output current	10 A $\pm 1.5\%$
Nominal Conditions	Input: 220Vac Output: 60Vdc, 10A

Expected efficiency	> 93 %
---------------------	--------

4.4 Test Prerequisites:

4.4.1 Voltage and Current Requirements

Table 4.2: Voltage and Current Requirements

Parameter	Specifications
Input Voltage	90-264 VAC
Input Frequency	50-60 Hz
Output Voltage	71.4 V
Output Current	10A

Required Equipment:

- Multimeter (current): Fluke 287C
- Multimeter (voltage): Fluke 287C
- AC Source: Chroma MODEL 61605
- E-Load: Chroma 631202
- Oscilloscope: Tektronix DPO3054
- Electrical Thermography: Fluke TiS65

Dimensions:

The board dimensions are 190 mm (length) * 105 mm (width) * 43 mm (height).

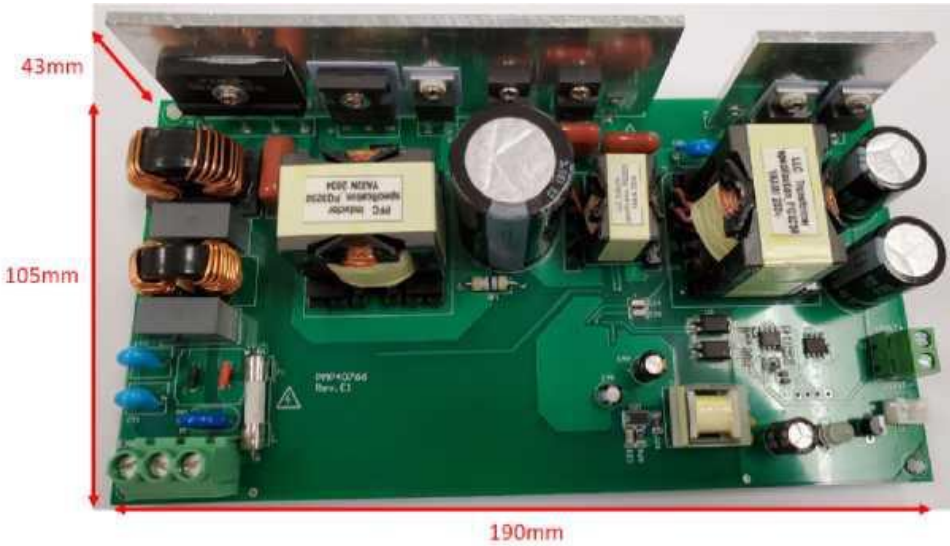


Figure 4.8: Project Board

Table 4.3. List of Components

Designator	Qty	Value	Part Number	Manufacturer	Package
C1	1	1uF	ECQ-E2W105KH	Panasonic	DIP
C34, C35		33nF 630V	MKS4J023302E00KSSD	WIMA	DIP
C2, C3, C4, C5	4	470 uF	ESK477M063AL4EA	KEMET	
C6	1	220pF 1000V	GRM31A7U3A221JW31 D	Murata	1206
C7	1	330nF 630Vdc	R60334-630-N	NISSEI- ARCOTRONICS	
C9, C13, C16, C22, C41, C43, C44, C45, C47	9	1nF	06031nF		0603
C10	1	33nF 1000V	R60QI2330AAL0K	Kemet	DIP
C11, C15, C39	3	220uF 35Vd 0.1uF	CD110-35V220	JIANGHAI, Kemet	r3.5mm, DIP
C12, C46	2	100nF	1206100nF		1206
C14	1	100nF	0603100nF		0603
C17	1	10uF	120610uF		1206
C18	1	330pF	0603 330pF		0603
C19, C36	2	10pF	0603 10pF		0603
C20	1	5pF 1000V	MC1206N4R7C102CT	MULTICOMP	1206
C21, C56	2	1uF	1206 1uF		1206
C23	1	2.2uF	0805 2.2uF		0805
C24	1	470nF	0603 470nF		0603
C25	1	470nF	0805 470nF		0805
C26	1	10uF	080510uF		0805
C27	1	10uF > 15V	1206 10uF 25V		1206

C28, C61, C62, C70, C81, C82,	9	NS			
D14, D17, D21, D22, J2, Q5, Q13, Q14	8	NS			
R7, R17, R19, R20, R24, R29, R45,	8	NS			
R57, R60, R64, R76, R78, R80,	8	NS			
R115, R116, R117, U5	8	NS			
C29, C31	2	TF684	TF684K2Y10BL270D9R	CARLI	DIP

Table4.4: List of Components

Designator	Qty	Value	Part Number	Manufacturer	Package
C30	1	180uF 450Vdc	ELG187M450AS3A A	KEMET	DIP
C32, C33	2	22nF > 400V	C1206V223KCRACT	KEMET	1206
C37, C38	2	680pF	0603 680pF		0603
C40	1	100nF 100 V OMD	VJ1206Y104KB BAT 4X	Vishay	1206
C42	1	10nF	060310nF		0603
C48, C49	9	1uF	GRM32DC72A475KE 01L	Murata	1206
C59, C64, C65, C66,	7	1uF	GRM32DC72A475KE 01L	Murata	1207

C52, C53, C60	3	47pF	0603 47pF		0603
C60	1	2.2nF	0603 2.2nF		0603
CY1, CY3	2	2n2 CY	DE1E3RA222MN4AN 01F	Murata	
D1, D8, D18	3	2454084, RS1J	RS1J	ON SEMICONDUCTOR	DO- 214AC
D2, D16	2	Green	SML-D12P8WT86C	ROHM	0603
D3	1	1494941	TL431AIDBZTG4	TEXAS INSTRUMENTS	SOT-23-3
D4, D6,	5	24532 69RL	1N4148WS	ON SEMICONDUCTOR	SOD- 323F
D5, D7, D13, D15	4	1843674	B160	DIODES	DO- 214AC
D11, D12	2	15V	BZX84C18LT1G	ON SEMICONDUCTOR	SOT-23-3
D19	1	QH08 TZ600	QH08TZ600	POWER INTEGRATIONS	TO- 220AC
D20	1	GBU8J	GBU8J	On Semiconductor	GBU8L
D23, D24	2	WSGC10DH	WSGC10DH	ZOWIE	
F1	1	5A / 300VAC	SS-5H-5A-APH	EATON BUSSMANN SERIES	
HS1	1	HS1	HS1	Monolithic Power Systems	
J1	1	400A 16A	MKDSN2,5/3-5.08	PHOENIX CONTACT	
J3	1	250V 2.5A	RAPC322X	Schurter	Screw
J4	1	200- FLE10 801GDV	FLE-108-01-G-DV	Samtec	SMD
L1	1		005-L1	PROELEC	EF20
L2	1	330u	7447065	Würth Elektronik	25x10

Table 4.5. Components Temperature Specifications

Component	Temp. (°C)
D1 Rectifier Bridge	99
Q1 PFC MOSFET	93.1
D5 PFC Diode	87.9
L4 PFC Choke	60
Q4	90.5
Q7, Q8 LLC MOSFETs	82.3
L5 LLC Inductor	77.9
T1 LLC Transformer	53.9
D11, D12 LLC Rectifier Diodes	54.5

4.5 Why PCB Use in EV Bike Charger:

Printed Circuit Boards (PCBs) are used in Electric Vehicle (EV) bike chargers for several reasons, which contribute to the overall functionality, reliability, and efficiency of the chargers.

- i. **Compact and Efficient Design:**
 - **Space Efficiency:** PCBs allow for the compact arrangement of electronic components. This is essential in EV bike chargers, where space is often limited.
 - **High Density:** PCBs support high-density component placement, which is crucial for creating powerful yet small-sized chargers.
- ii. **Reliability and Durability:**
 - **Robust Connections:** The use of copper tracks in PCBs ensures reliable and stable electrical connections, reducing the risk of loose connections that can occur with traditional wiring.
 - **Heat Dissipation:** PCBs are designed to manage heat effectively, often incorporating heat sinks and thermal vias to prevent overheating of components, which is vital for the safety and longevity of the charger.
- iii. **Manufacturing and Assembly:**
 - **Automation:** PCBs are compatible with automated manufacturing processes, ensuring consistent quality and reducing human error.
 - **Cost-Effective Production:** Mass production of PCBs is cost-effective, which helps in reducing the overall cost of EV bike chargers.

iv. **Circuit Integrity:**

- **Reduced Noise and Interference:** PCBs are designed to minimize electrical noise and electromagnetic interference, which is critical for the stable operation of the charger.
- **Complex Circuitry:** PCBs can support complex circuitry required for functions like power management, voltage regulation, and communication with the EV's battery management system (BMS).

v. **Safety and Compliance:**

- **Standardization:** PCBs can be designed to meet various safety and industry standards, ensuring that the chargers are compliant with regulatory requirements.
- **Protective Layers:** PCBs can include protective coatings and layers to shield the electronic components from environmental factors such as moisture, dust, and chemicals.

vi. **Customization and Scalability:**

- **Custom Designs:** PCBs can be customized for specific charger designs, allowing manufacturers to create unique products tailored to different EV bike models.
- **Scalability:** The design and production process of PCBs can be scaled up efficiently to meet increasing demand without compromising quality.

4.6 Project Results:

Figure 4.9 presents the G2V (silver color casing) and V2G (camel color casing) modules developed for hardware implementation.



Figure 4.9. Project Module

Figure 4.10 presents the lab-based testing of G2V module where the output DC voltages appearing are 73.8V as required by the charger of EV.

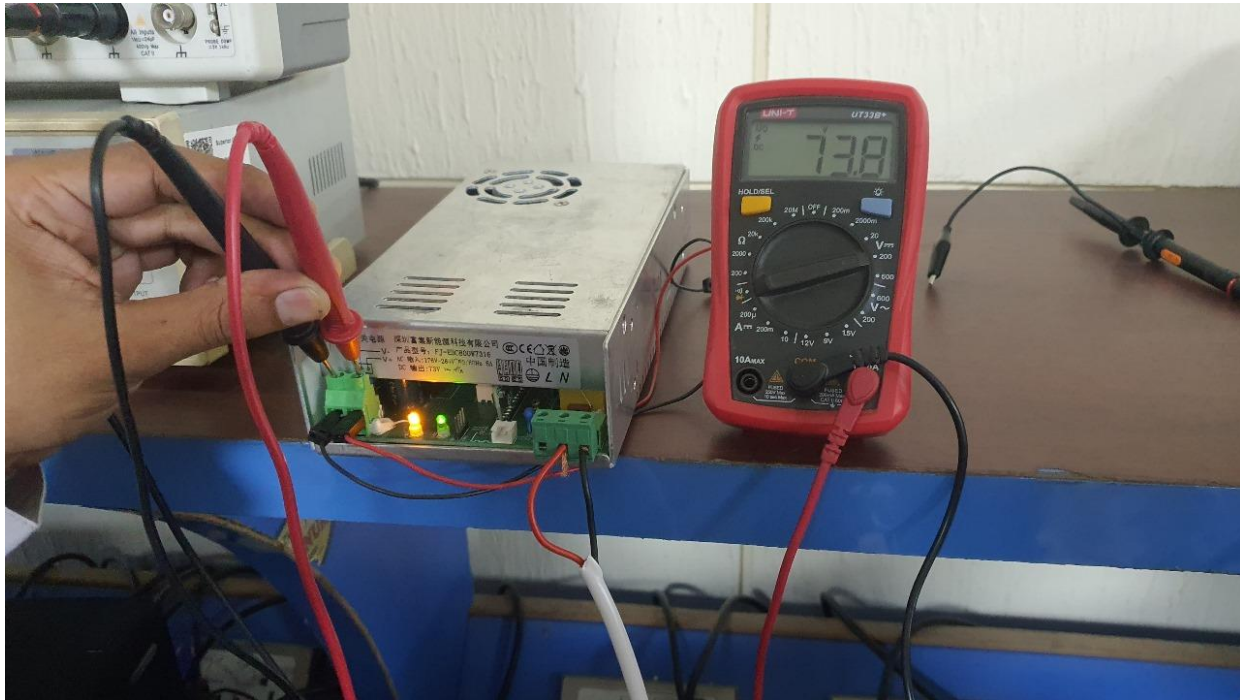


Figure 4.10. G2V (DC Output voltage)

Figure 4.11 presents the lab-based testing of G2V module where the output DC voltages are appearing as a straight line.

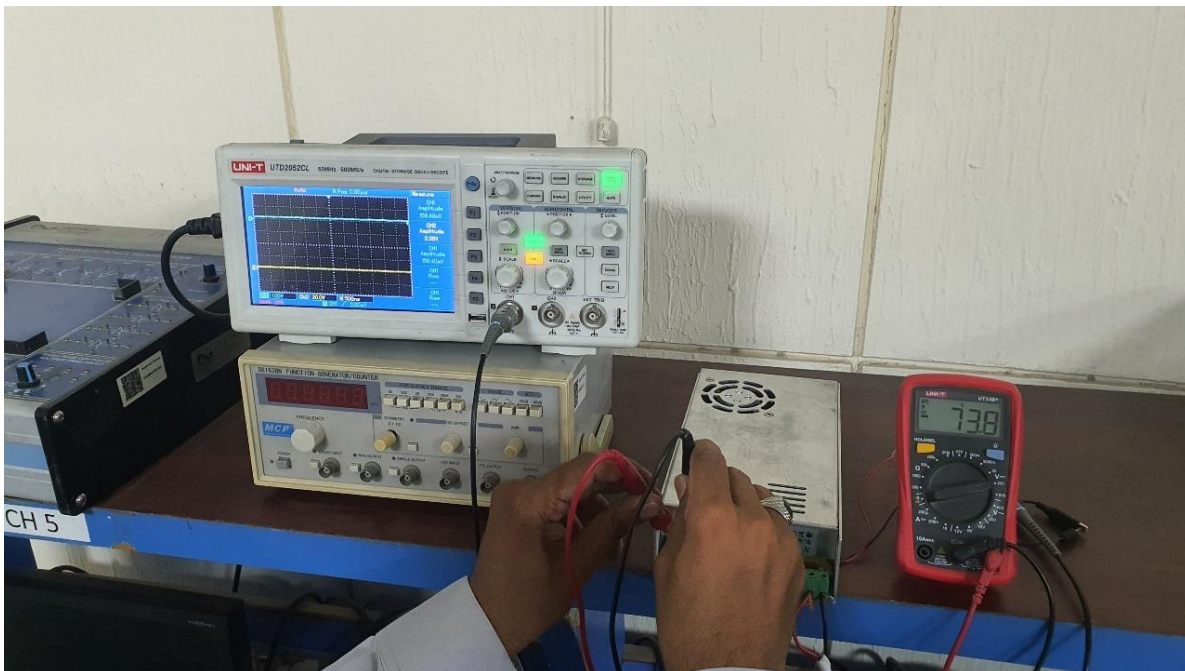


Figure 4.11. G2V (DC Output)

Figure 4.12 presents the lab testing of the V2G module, where the output voltages are 213 V AC, as

measured through the DMM.



Figure 4.12. V2G (AC Output voltages)

Figure 4.13 presents the lab testing of the V2G module, where the output voltages are appearing as a pure sinewave, as depicted by the CRO.

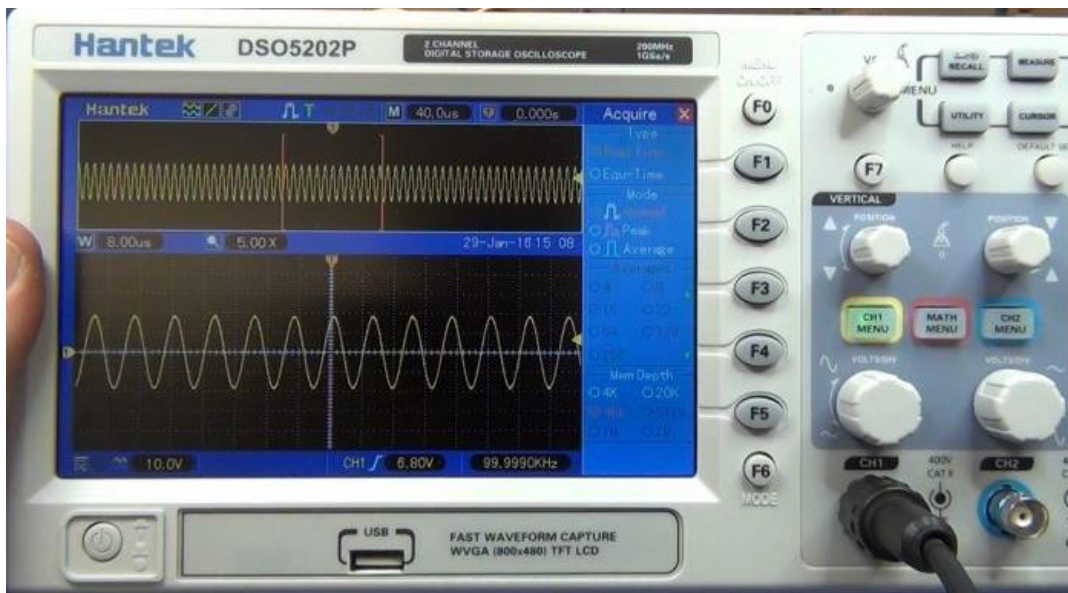


Figure 4.13. V2G (AC Voltage)

CHAPTER NO. 5

BUSINESS DESCRIPTION

5.1 Form of Business

The form of our business will be Sole Ownership

5.1.1 Team/Organizational Structure

All business starts from a low scale and after some time starts growing. Similarly, we will start our business on a small scale by providing a service in the integration of EVs with AC Microgrids and trying to market them all over the world. After some time, our business will start to grow and will surely make a reasonable profit. The following are the positions that will be assigned to the members of the company.

- Faisal Shahzad will be the Owner of the company
- Tanveer Hussain will be the Director of the company.
- Usama Tanveer will manage the company and marketing.

This organizational structure and team composition provide the necessary framework and expertise to carry out the business of conducting comparative studies and simulative analyses of electric vehicle fleet integration in AC microgrids effectively. Each department and team play a vital role in contributing to the success of the company's projects and initiatives.

5.1.2 Vision

Our vision is to pioneer sustainable mobility solutions, optimizing the integration of electric vehicle fleets into AC microgrids, driving the evolution towards cleaner, more resilient energy ecosystems, and fostering economic growth while reducing environmental impact.

5.1.3 Mission

Our mission is to lead the transformation of transportation and energy systems towards sustainability, efficiency, and resilience through innovative research, advanced technology, and collaborative partnerships. We are committed to conducting rigorous comparative studies and simulative analyses to optimize the integration of electric vehicle fleets into AC microgrids, maximizing their potential as dynamic assets for grid stability and renewable energy utilization. We strive to empower communities, businesses, and governments to embrace clean energy solutions, driving economic growth, job creation, and environmental stewardship. Our mission is rooted in a dedication to continuous learning,

exploration, and innovation, as we work towards a future where electric vehicles and renewable energy sources play a central role in building a more sustainable and prosperous world for all.

5.1.4 Goal and Objective

The primary goal of this project is to improve the level of services and efficiency of the system in parallel with the scalability and strength of the model. Later on, incorporating the power of artificial intelligence, the project aims to augment the capabilities of V2G and G2V communication. The main goals will be the:

- Establish leadership in sustainable mobility solutions.
- Expand market presence and reach.
- Drive technological advancement.
- Prioritize customer satisfaction and retention

Objectives

- Conduct comprehensive studies and simulative analyses.
- Develop innovative hardware and software solutions.
- Optimize grid performance through advanced analytics.
- Ensure regulatory compliance

5.2 Industry and Marketing Analysis

5.2.1 Industry Analysis:

Few points if the industry analysis is given below:

Growing Demand: The electric vehicle (EV) market is experiencing rapid growth globally, driven by increasing environmental concerns, government incentives, and technological advancements.

Microgrid Adoption: Microgrids are gaining traction as decentralized energy solutions, offering resilience, flexibility, and integration with renewable energy sources.

Convergence of EVs and Microgrids: The integration of EV fleets into AC microgrids presents new opportunities for grid optimization, demand management, and renewable energy utilization

5.2.2 Market Analysis:

- **Target Segments:** Focus on key segments such as commercial fleets, public transportation, logistics, and utilities that are embracing electric vehicles and seeking grid-integrated solutions.

- **Geographic Focus:** Prioritize markets with supportive regulatory frameworks, high EV adoption rates, and significant renewable energy penetration, such as North America, Europe, and Asia-Pacific.
- **Competitive Landscape:** Competitors include established players in the EV charging infrastructure, microgrid management, and energy analytics sectors, as well as emerging startups offering innovative solutions in grid integration and optimization.

5.2.3 Marketing Strategy:

- **Differentiation:** Highlight unique features such as advanced simulation capabilities, grid optimization algorithms, and customizable solutions tailored to specific customer needs.
- **Thought Leadership:** Establish the company as a thought leader through industry publications, research reports, and participation in conferences and forums focused on sustainable mobility and energy.
- **Partnerships and Alliances:** Forge strategic partnerships with EV manufacturers, energy utilities, technology providers, and research institutions to enhance product offerings, expand market reach, and leverage complementary expertise.
- **Customer Engagement:** Engage with potential customers through targeted marketing campaigns, demonstrations, and workshops showcasing the benefits of electric vehicle fleet integration in AC microgrids.
- **Regulatory Compliance:** Ensure compliance with relevant regulations, standards, and certifications related to electric vehicle charging infrastructure, microgrid operation, and data privacy to build trust and credibility in the market.
- **Customer Support and Training:** Provide comprehensive customer support, training, and ongoing maintenance services to ensure smooth implementation and operation of grid-integrated EV solutions.
- **Market Expansion:** Explore opportunities for market expansion in emerging regions and niche segments, while continuously monitoring market trends, customer feedback, and competitor activities to adapt marketing strategies accordingly.

5.3 Competitive Analysis:

Competitor A: A well-established player in the electric vehicle charging infrastructure market, offering a range of hardware and software solutions for EV fleet management. They have a strong presence in key markets and extensive experience in grid integration.

Competitor B: Specializes in microgrid management systems and energy analytics software. While not specifically focused on electric vehicle integration, they offer robust grid optimization solutions that could potentially be adapted for EV fleet management.

Competitor C: An emerging startup with innovative technologies for dynamic grid balancing and demand response. They are gaining traction in the market with their agile approach and focus on renewable energy integration.

Competitor D: A multinational energy company with expertise in renewable energy generation and distribution. They offer comprehensive solutions for microgrid deployment, including grid-connected electric vehicle charging stations.

Competitor E: A research institution collaborating with government agencies and industry partners on projects related to electric vehicle grid integration. They provide consulting services and technology transfer opportunities for companies seeking to enter the market.

Key Factors of Competitive Analysis:

- **Product Portfolio:** Assess the range and depth of offerings, including hardware, software, and services, tailored for electric vehicle fleet integration in AC microgrids.
- **Technological Differentiation:** Evaluate the unique features, capabilities, and performance of each competitor's solutions, particularly in terms of grid optimization, demand management, and renewable energy integration.
- **Market Presence:** Analyze market share, geographic reach, customer base, and brand reputation to understand competitive positioning and market penetration.
- **Partnerships and Collaborations:** Identify strategic alliances, joint ventures, and research partnerships that enhance competitive advantages and enable access to new markets or technologies.

- **Customer Satisfaction:** Gather feedback from customers and industry experts to assess satisfaction levels, quality of service, and overall customer experience with each competitor.
- **Pricing and Value Proposition:** Compare pricing models, value-added services, and return on investment (ROI) offered by competitors to evaluate their competitiveness and perceived value in the market.
- **Regulatory Compliance and Certification:** Verify compliance with relevant regulations, standards, and certifications, ensuring adherence to industry best practices and mitigating regulatory risks.
- **Future Outlook and Innovation:** Anticipate future trends, technological advancements, and disruptive innovations that could impact the competitive landscape, positioning the company to adapt and thrive in a rapidly evolving market

5.4 SWOT Analysis:

SWOT Analysis for Electric Vehicle Fleet Integration in AC Microgrids:

i. **Strengths:**

- **Innovative Technology:** Advanced simulation methodologies and optimization algorithms for seamless integration of electric vehicle fleets into AC microgrids.
- **Expertise and Experience:** Team of research scientists, engineers, and data analysts with deep knowledge and experience in electric vehicles, microgrid management, and energy analytics.
- **Strategic Partnerships:** Collaborations with key stakeholders including EV manufacturers, utilities, and research institutions, enhancing product offerings and market reach.
- **Regulatory Compliance:** Strong adherence to regulatory standards and certifications, ensuring trust, credibility, and compliance with industry best practices.

ii. **Weaknesses:**

- **Market Awareness:** Limited awareness and visibility in certain markets or segments, requiring targeted marketing efforts to increase brand recognition and market penetration.

- **Dependency on External Factors:** Vulnerability to external factors such as regulatory changes, technological disruptions, and market dynamics impacting demand for electric vehicles and microgrid solutions.
- **Resource Constraints:** Limited resources for research and development, marketing, and expansion efforts, necessitating efficient allocation and prioritization of investments.

iii. **Opportunities:**

- **Growing EV Market:** Rapid expansion of the electric vehicle market globally, presenting opportunities for offering grid-integrated solutions and services to support EV fleet management and charging infrastructure.
- **Emerging Technologies:** Advancements in renewable energy, energy storage, and smart grid technologies creating opportunities for innovation and differentiation in microgrid integration and optimization.
- **Government Initiatives:** Supportive policies, incentives, and funding for renewable energy and electric vehicle adoption, fostering a conducive regulatory environment for market expansion and growth.
- **Partnership Opportunities:** Potential collaborations with emerging startups, technology providers, and research institutions to leverage complementary expertise and drive innovation in electric vehicle fleet integration.

iv. **Threats:**

- **Competitive Landscape:** Intense competition from established players and emerging startups offering similar solutions in electric vehicle integration, microgrid management, and energy analytics.
- **Technological Disruptions:** Risks associated with rapid technological advancements, evolving standards, and disruptive innovations impacting the competitive landscape and market dynamics.
- **Regulatory Changes:** Changes in regulations, policies, and standards governing electric vehicle charging infrastructure, microgrid operation, and energy markets, posing compliance challenges and regulatory risks.
- **Economic Uncertainty:** Economic downturns, fluctuations in energy prices, and geopolitical instability affecting investment decisions, market demand, and customer willingness to adopt grid-integrated electric vehicle solutions.

The SWOT analysis provides valuable insights into the internal strengths and weaknesses of the company, as well as external opportunities and threats in the market landscape. By leveraging strengths, addressing weaknesses, capitalizing on opportunities, and mitigating threats, the company can develop effective strategies to achieve its objectives and sustain competitive advantage in the industry.

5.5 Financial Plan

5.5.1 Resources Required:

The resources are required:

- All the basic resources are required to start a business (i.e. Machinery, electronic equipment, a proper place etc.)
- Accessories.
- Human resources.
- Electricity (etc.)

Table 5.1. Initial Budget Expenses

Sr. No	Capital Nature Expenses	Amount(PKR)
1	Laptop (70000 x 1)	70000/-
2	Equipment (40000 x 1)	40000/-
Revenue Nature Expenses		
3	Internet (4000 x 12)	48000/-
4	Misc. Expenses (1,500 x 12)	18,000/-
5	Electricity (10,000 x 12)	100,000/-
6	Purchase of Raw Material (10,000 x 10)	100,000/-
Total: Initial Expenses (Budgeted)		328,000/-

Table 5.2. Statement of Comprehensive Income (Budged)

Sr. No		1 st Year	2 nd Year	3 rd Year	4 th Year	5 th Year
1	Revenue	328,000/- (w-1)	360,000/- (w-2)	410,000/- (w-1)	430,000/- (w-1)	470,000/- (w-1)
2	Cost of Production	(80,000) (w-2)	(100,000) (w-1)	(130,000) (w-2)	(170,000) (w-2)	(200,000) (w-2)

3	Other Operating Expenses	(100,000) (w-3)	(100,000)	(105,000)	(111,000)	(135,000)
4	Depreciation	(5,000) (w-4)	(5,000)	(5,000)	(5,000)	(5,000)
5	Misc.	(4000)	4000	4000	4000	4000
6	Marketing Expenses	(8000)	(16000)	(16000)	(20000)	(20000)
7	Profit before Commission	30,000/-	40,000/-	60,200/-	89,800/-	110,400/-
8	Commission	(13,000) (w-5)	(18,000) (w-2)	(25,000) (w-3)	(35,000) (w-3)	(46000)(W-3)
9	Profit After Commission	40,000/-	50,000/-	60,000/-	70,000/-	80,000/-

By creating a comprehensive financial plan, the company can effectively allocate resources, monitor financial performance, and make informed decisions to achieve its objectives and drive success in the electric vehicle fleet integration market.

5.6 Conclusion:

In this chapter, the total business strategy is portrayed exhaustively alongside the five-year monetary arrangement. The undertaking's qualities and different highlights are additionally portrayed exhaustively. The design is to make it simple to peruse and comprehend the financial worth and social remains of this venture.

CHAPTER NO. 6

CONCLUSION AND FUTURE WORK

6.1 Conclusion:

In conclusion, the comparative study and simulative analysis of electric vehicle fleet integration in AC microgrids represent a critical step towards advancing sustainable mobility and energy solutions. Through innovative technologies, strategic partnerships, and rigorous research, our company is poised to lead the transformation towards a cleaner, more efficient transportation infrastructure. By optimizing grid performance, promoting renewable energy integration, and fostering economic growth, we are committed to creating a brighter, more sustainable future for generations to come.

6.2 Future Works:

Looking ahead, there are several avenues for future work and expansion:

- i. **Enhanced Simulation Capabilities:** Continuously improve and refine simulation methodologies, algorithms, and software platforms to address evolving market needs and technological advancements.
- ii. **Market Expansion:** Explore opportunities to expand into new geographic regions and industry sectors, leveraging partnerships, market insights, and customer feedback to tailor solutions for diverse markets.
- iii. **Product Development:** Invest in research and development initiatives to innovate new products and services, such as advanced grid optimization tools, real-time monitoring systems, and predictive analytics for electric vehicle fleet management.
- iv. **Policy Advocacy:** Advocate for supportive policies, incentives, and regulatory frameworks that promote electric vehicle adoption, microgrid deployment, and renewable energy integration at local, national, and international levels.
- v. **Community Engagement:** Engage with stakeholders, communities, and grassroots organizations to raise awareness, promote education, and empower individuals to participate in the transition towards sustainable energy systems.
- vi. **Sustainability Initiatives:** Integrate sustainability practices into all aspects of the business, from supply chain management to operations, reducing environmental impact and demonstrating corporate responsibility.

- vii. **Partnership Development:** Foster strategic partnerships with industry leaders, technology providers, academia, and government agencies to drive collaboration, innovation, and collective impact in the clean energy space.

By continuing to innovate, collaborate, and adapt to emerging trends and opportunities, our company can remain at the forefront of sustainable mobility and energy solutions, driving positive change and making a meaningful impact on a global scale.

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