A Project Report
on

Charger for Electric Bike

by

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A Project Report submitted to the
DEPARTMENT OF ELECTRICAL ENGINEERING
in partial fulfillment of the requirements for the degree of
BACHELORS OF SCIENCE IN ELECTRICAL ENGINEERING

Faculty of Engineering
Capital University of Science & Technology,
Islamabad
July, 2023

DECLARATION

It is declared that this is an original piece of our own work, except where otherwise acknowledged in text and references. This work has not been submitted in any form for another degree or diploma at any university or other institution for tertiary education and shall not be submitted by me in future for obtaining any degree from this or any other University or Institution.

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CERTIFICATE OF APPROVAL

It is certified that the project titled "Charger for Electric Bike" carried out by Alishba Tahir Registration No. BEE193007, Muhammad Yahya Satti Registration No. BEE193026, under the supervision of Dr. Muhammad Ashraf, Capital University of Science & Technology, Islamabad, is fully adequate, in scope and in quality, as a final year project for the degree of BS Electrical Engineering.

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ABSTRACT

Globally, research and development into electric vehicles (EVs) is revitalizing owing to the need to lower CO_2 emissions and improve fuel efficiency. The objective of this project is to help the fight against global warming and offer a more affordable form of transportation. The goal of this project, which focuses on the design, modelling, and manufacture of an electric bike charger, is to provide a more cost-effective means of transportation while supporting efforts to counteract global warming. To determine the battery and charger specifications, a thorough analysis of the literature is used as part of the technique. An AC input filter, AC/DC converter, and DC/DC converter are all parts of the charger system, which is controlled by a charger control system. The prototype managed to charge the battery to an astonishing 60 volts using a 10 amp charging current, despite earlier hopes for 20 amps being constrained by the battery's capacity. As a consequence, a 700-watt charger that demonstrates cost-effectiveness. The project is in line with Sustainable Development Goals (SDGs) for access to cheap, renewable energy, fair employment opportunities and economic growth, as well as for infrastructure, industry, and innovation. Two important recommendations are made: increased investment in R&D to spur innovation in renewable energy and energy efficiency; and the requirement for comprehensive policy frameworks and regulations that encourage sustainable practices and technologies, including tax incentives and emissions standards. When these actions are taken, they will help to reduce global warming and open the door to a more sustainable future.

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LIST OF ACRONYMS/ABBREVIATIONS

PHEV	Plug-in-Hybrid Electric Vehicle
BEV	Battery Electric Vehicle
AC	Alternating Current
DC	Direct Current
PBS	Pakistan Bureau of Statistics
HEV	Electric Hybrid Vehicles
EVSE	Electric Vehicle Supply Equipment
SAC	Standardization Administration of China
BMS	Battery Measurement System
SoC	State of Charger

Chapter 1

INTRODUCTION

The purpose of the project is to provide electric charging stations prototype for bikes would encourage customers to opt for electric bikes when there are places to charge them at different points throughout the city. A prototype for electric bike will be designed and simulated as well as fabricated.

1.1 Overview

Global warming is putting the Earth in great peril. Pakistan is one of the countries most affected by global warming [2]. The goal of this project is to devise a strategy that will aid in the reduction of global warming by providing an electric bike charging station.

1.2 Project Idea

The Earth is in grave danger as a result of global warming. One of the nations most impacted by global warming is Pakistan. To bridge the market gap between bikes and vehicles, this initiative proposes to build an electric bike charging station. The availability of electric bike charging stations may encourage users to convert to electric bikes because the price of bicycles in Pakistan is higher. Islamabad doesn't have any charging stations at the moment. The purpose of this project is to come up with a plan that will enable the provision of an electric bike charging station, which will contribute to the mitigation of global warming. Pakistan is a third-world country, The number of customers buying bikes is more than those of cars. Therefore, the market gap between bikes and cars is significant. According to the data taken from the Pakistan Bureau of Statistics (PBS) from the year 2015 to 2018, the gap between the bikes and cars market is increasing. Purchasing a vehicle is more expensive than buying a bike. This is the reason more people purchase motorcycles than cars. By providing bike electric charging stations, consumers would be more likely to choose electric bikes. When various locations throughout the city have charging stations for them. Unfortunately, there are presently no electric bike charging facilities in Islamabad.

1.3 Purpose of the Project

The project scope is to deliver a charging station prototype for electric bikes. Bikes are more commonly purchased than cars in Pakistan. Yet there is still no charging stations currently available in Islamabad for electric bikes.

1.4 Project Specifications

The specifications of this project are:

1.4.1 Charger Specifications

The electric bike charger features a maximum charging current of 10 amps, an output voltage of 70 volts, and a power rating of 700 watts.

Table 1. 1: Charger Specifications

Maximum Charging Current	10 amps
Output voltage	70 volts
Power rating	700 watts

1.4.2 Battery Specifications (of one cell)

The EV bike battery has a capacity of 6000mAh, assuring electric bike users a lengthy and stable power supply. With a voltage of 3.2V, this battery has enough energy to efficiently run the bike's motor. The discharge cut-off voltage of 2.0V ensures that the battery is protected from over-discharge, extending its lifespan. Plus, the charge restricted voltage of 3.65±0.03V guarantees a safe and regulated charging procedure, minimizing any battery damage when charging. Standard charge and discharge currents of 0.2 C add to the battery's safety and stability by providing a steady and balanced flow of energy in and out of the battery.

Table 1. 2: Battery Specifications

Nominal Capacity	6000mAh
Nominal Voltage	3.2V
Discharge Cut-off Voltage	2.0V
Charge Limited Voltage	3.65±0.03V

Standard Charge Current	0.2 C
Standard Discharge Current	0.2 C

1.5 Project Plan

The project is divided into two parts. Part I of the project deals with gathering information for the project, in the literature review. Part II deals with the software simulation of the project and proper hardware built for the project.

1.5.1 Project Milestones

Every project function as well as its timeframe for part 1 are listed in the project table:

Table 1. 3: Project Plan Part 1

S#	Tasks	Duration	Resource Person
1	Literature Review	08 Weeks	Alishba, Yahya
2	Visiting Existing Charging Stations	02 Weeks	Alishba, Yahya
3	Testing Existing Charging Circuits	06 Weeks	Alishba, Yahya
4	Finalizing the Specifications for Our Charger	01 Week	Alishba, Yahya

Every project function as well as its timeframe for part 2 are listed in the project table:

Table 1. 4: Project Plan Part 2

S#	Tasks	Duration	Resource Person
1	Mathematical Calculations and Software Design and Simulations	02 Weeks	Alishba, Yahya
2	Hardware Design and Fabrication	05 Weeks	Alishba, Yahya
3	Testing and Debugging	03 Weeks	Alishba, Yahya
4	Report Writing	08 Weeks	Alishba, Yahya

1.5.2 Project Timeline

Each task with timeframes for part 1 are provided below.

Table 1. 5: Project Timeline for Part 1

S#	Weeks	1	2	3	4	5	6	7	8
1	Literature Review	🟧	🟧	🟧	🟧	🟧	🟧	🟧	🟧
2	Visiting Existing Charging Stations			🟨	🟨				
3	Testing Existing Charging Circuits			🟩	🟩	🟩	🟩	🟩	🟩
4	Finalizing the Specifications for Our Charger								🟪

Each task with timeframes for part 2 are provided below.

Table 1. 6: Project Timeline for Part 2

S#	Weeks	1	2	3	4	5	6	7	8
1	Mathematical Calculations and Software Design and Simulations	🟥	🟥						
2	Hardware Design and Fabrication			🟫	🟫	🟫	🟫	🟫	
3	Testing and Debugging						■	■	■
4	Report Writing	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩

1.6 Applications of the Project

There are many applications of this project some of these applications are given below:

1.6.1 Urban Transportation Centers

By strategically placing electric motorcycle chargers in urban transportation hubs like bus stops, railway stations, and open parking lots, commuters can easily charge their electric motorcycles while traveling, promoting environmentally responsible transportation choices. This effort not only promotes the use of electric bikes, but it also decreases dependency on fossil fuels, resulting in a cleaner and greener environment. Besides that, the easy accessibility of these chargers assures that commuters may pick electric motorbikes as a dependable method of transportation without fear of running out of battery power.

1.6.2 Adventure Tourism Locations

Adventure tourism locations have constructed charging facilities for electric motorcycles to accommodate thrill-seekers exploring isolated places. By expanding the range as well as the accessibility of electric motorcycles during outdoor leisure activities, these chargers offer a dependable power supply.

1.6.3 Sustainable Development Goals (SDG)

This project targets one SDG goal. The goals is:

Table 1. 7: List of Targeted Sustainable Development Goals

S#	Targeted SDGs	SDG No.	Implementation Detail
1	Climate Action	SDG#13	Electric bikes have the potential for quick climate action by decarbonizing society and transportation. By incorporating biking into their climate action plans, tactics, education, along with awareness-raising, organizations at all levels can take action.

Figure 1. 1: SDG 13

1.7 Report Organization

The first chapter of the report examines as well as answers issues such as, what is the project? What are its requirements? And how may it be useful? The second chapter emphasizes on research that has already been done on this topic. It also goes through some of the project's positioning & navigation technology. This chapter also goes into depth on other initiatives that were comparable to this one and their technology. Furthermore, this chapter analyses the shortcomings of previous studies.

The third chapter of the report emphasizes project hardware as well as software design plus implementation. The fourth chapter of the report goes into depth on the tools as well as processes used to complete the project one by one. The chapter initially addresses all of the tools but also strategies used for project hardware modeling before focusing on software tools and processes. The fifth chapter of the report addresses the project's outcomes. The chapter initially describes the project's hardware but also then its software outcomes. The last chapter discusses the project's completion.

1.8 Summary

The project's overview and the project's timeline are provided in this chapter. This chapter also covers project idea, project applications, and project specifications.

Chapter 2

LITERATURE REVIEW

Global warming is endangering the planet severely. Pakistan is one of the nations most impacted by global warming. Working on a strategy that will aid in assisting in lowering global warming is the idea behind this initiative. The goal of this project is to create an electric car charger that can speed up charging compared to a regular charger. But an electric bike prototype will be created, both physically and virtually. The goal of this project is to develop a strategy that will allow for the installation of an electric bike charging station, which will help to reduce global warming. Islamabad currently lacks any infrastructure for charging electric bikes.

2.1 Background

Electric cars, also known as electric vehicles (EVs), are vehicles that are powered by electricity rather than gasoline or diesel fuel. Unlike traditional gasoline-powered cars, which produce emissions and contribute to air pollution, electric cars produce zero emissions and are a much cleaner and more sustainable form of transportation.

The history of electric cars dates back to the early 19th century, when inventors first began experimenting with the use of electricity as a means of powering vehicles. The first electric car ever made was the Electrobat, developed by William Morrison in the United States in 1891. It was a four-wheeled vehicle that could reach a top speed of 14 mph and had a range of about 30 miles on a single charge [1].

Figure 2. 1: First Electric Car [1]

Despite the early success of electric cars, they faced a number of challenges over the years. One of the biggest challenges was the limited range of the batteries, which meant that drivers had to frequently stop to recharge their vehicles. In addition, the batteries used in these early electric cars were heavy and expensive, making them less practical for widespread use.

As a result, the development of the internal combustion engine led to the rise of gasoline-powered cars, which were able to travel further and faster than electric cars. This led to a decline in the popularity of electric cars, and they were largely replaced by gasoline-powered vehicles.

However, in recent years, there has been a renewed interest in electric cars due to concerns about air pollution and climate change. Advances in battery technology and the increasing availability of charging stations have made electric cars a more viable option for many people, and they are becoming an increasingly popular choice for those looking for a more sustainable and eco-friendly form of transportation.

2.2 Global Warming

The extreme heat and destructive floods of this year serve as a stark warning that natural disasters brought on by climate change have the potential to seriously hamper Pakistan's development goals and efforts to fight poverty. More than 8 million people have been left homeless and over 1,700 individuals have died as a result of these calamities. There have been significant losses and damages totaling more than $30 billion to infrastructure, assets, crops, and animals. According to the Country Climate and Development Report (CCDR) for Pakistan published by the World Bank Group, the nation needs to make fundamental changes to its development trajectory and policies. These changes will call for sizable investments in people-centric climate adaptation and resilience, which will necessitate international assistance [2].

“The recent flooding and humanitarian crisis provide a wake-up call for urgent action to prevent further devastation to the people of Pakistan and its economy due to climate change,” said Martin Raiser, World Bank Vice President for South Asia. “Accelerated climate actions can protect the economy from shocks and secure more sustainable and inclusive growth in Pakistan.” [2].

According to the CCDR, Pakistan's GDP is expected to decrease by at least 18 to 20% by 2050 due to the hazards of catastrophic climate-related events, environmental deterioration, and air pollution combined. This will halt efforts to reduce poverty and advance economic growth. [1]

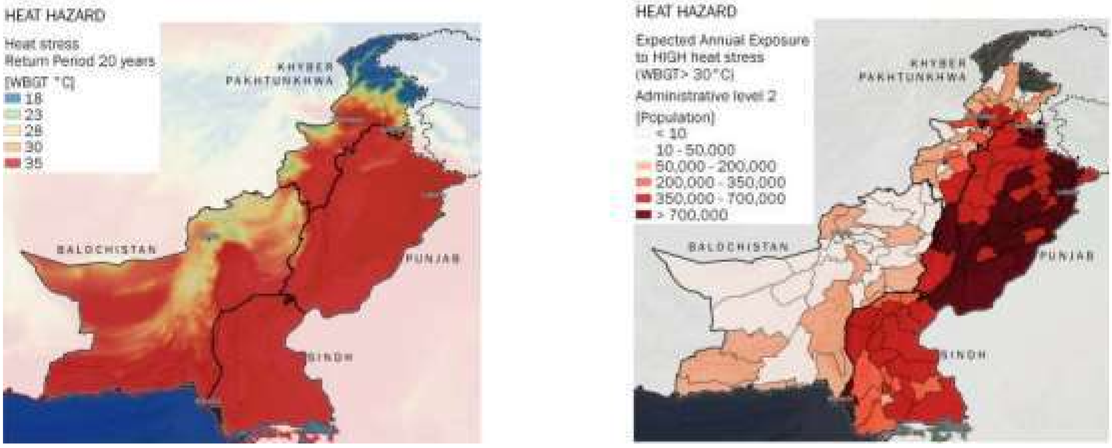


Figure 2. 2: Heat Hazard (left) and Population Exposure (right) [2]

Pakistan is seeing a marked rise in the frequency and severity of droughts, which is related to the intense heat. Regarding the danger of drought, it comes up at number 43. Food security is significantly impacted by droughts, which regularly call for aid operations in vulnerable areas around the nation. When yearly precipitation fell by 24.4 percent less than projected, 3 million people in Sindh and 1.8 million in Balochistan had moderate to severe droughts in January 2019. Even though the issue has been for a while, it has recently gotten worse. Prior to this, from 1999 to 2001, a series of droughts caused crop failure, widespread hunger, and livestock starvation, resulting in damages of US$247 million. According to climate projections, Pakistani droughts are predicted to become more frequent and severe [2].

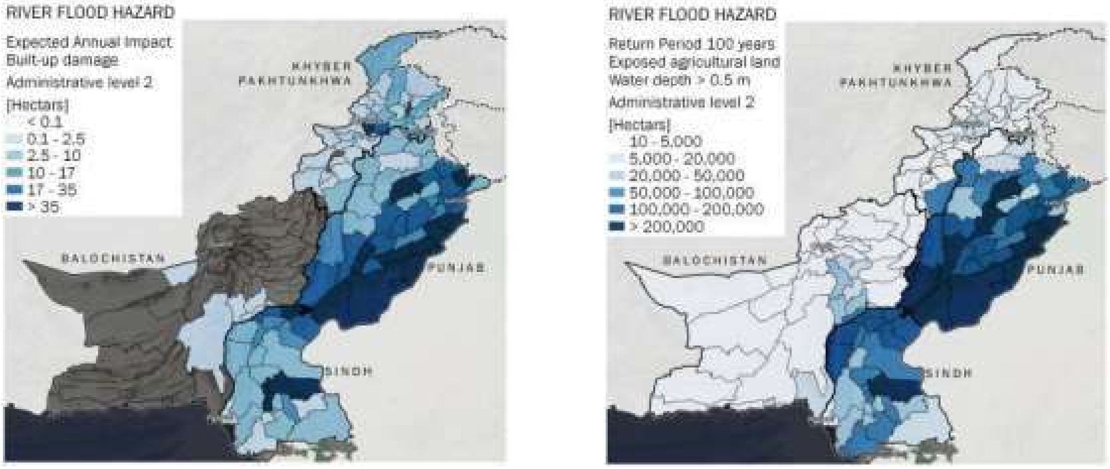


Figure 2. 3: Expected Annual Impact of Floods on Built-up Assets (left) and on Agricultural Land (right) [2]

In KP, Gilgit-Baltistan, and Azad Kashmir, major economic losses can be attributed to landslides in the northern highlands and monsoon floods that are exacerbated by glacial melt due to high temperatures and earthquakes. Nine landslides between 1900 and 2020 are estimated to have caused damages totaling roughly US$18 million and affected close to 30,000 people [2].

2.3 Electric Vehicle (EV) Research and Development

Electric vehicle (EV) research and development are reviving globally due to the requirement for reducing CO_2 emissions and enhancing fuel economy. These automobiles can take the place of ones that run on petrol. Due to their low power consumption and lack of local emissions, electric cars really provide a wonderful way to reduce the environmental impact of transportation and reduce energy reliance.

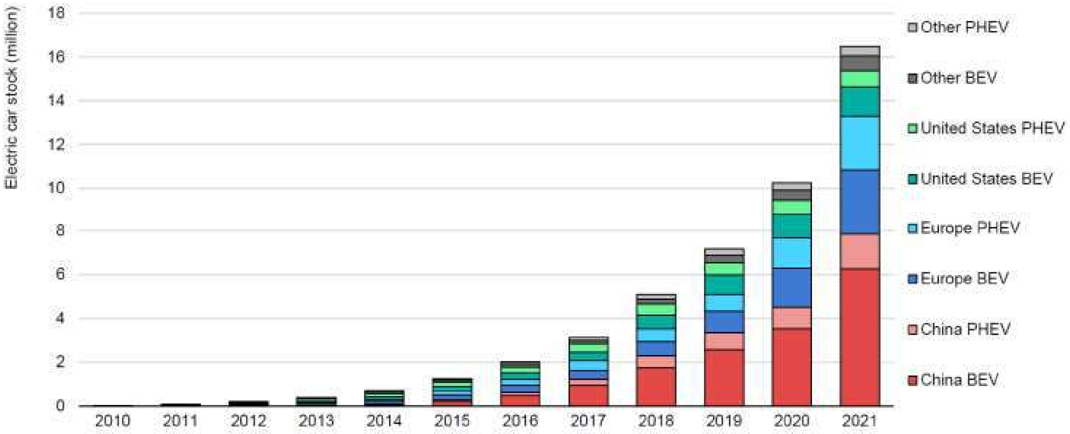


Figure 2. 4: Worldwide fleet of electric vehicles during 2010 until 2021 [3]

As shown in Figure 3, markets for electric cars and the number of them on the road have been expanding excessively since 2010. The number of EVs in use globally topped 5.1 million in 2018, more than double the record-breaking number of new registrations in 2017. The global EV fleet, including light cars, reached 7.5 million units by the end of 2019.

The worldwide EV fleet reached 10 million units in 2020, an increase of 43% from 2019. Particularly, battery electric cars made up two-thirds of the stock and all new electric car registrations (BEVs).

EV sales reached a record level in 2021. The total number of EVs on the road now stands at more than 16.5 million, nearly doubling from 3.6 million to 6.6 million.

Following a period of stagnation, sales in China climbed three times more than in 2020, reaching 3.3 million, and by two thirds year over year in Europe, reaching 2.3 million. China and Europe accounted for more than 85% of all EV sales globally in 2021, more than doubling from 2020 to reach 630,000 EVs, with the United States coming in second with 10% [3].

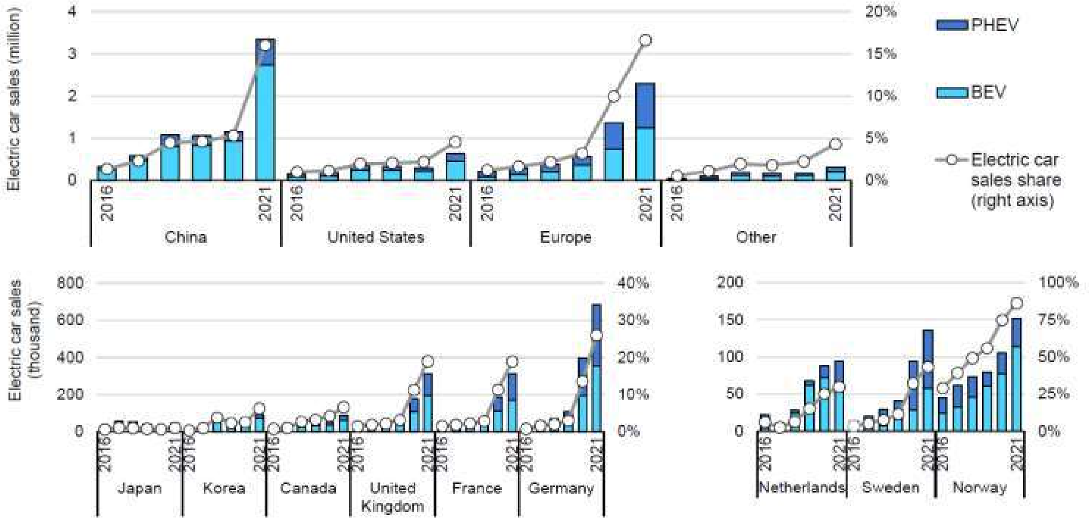


Figure 2. 5: Global electric vehicle sales as well as market share from 2016 to 2021 [3]

From this vantage point, Figures 3 and 4 show the global EV fleet from 2010 to 2021 and the global EV sales and market share from 2016 to 2021, respectively.

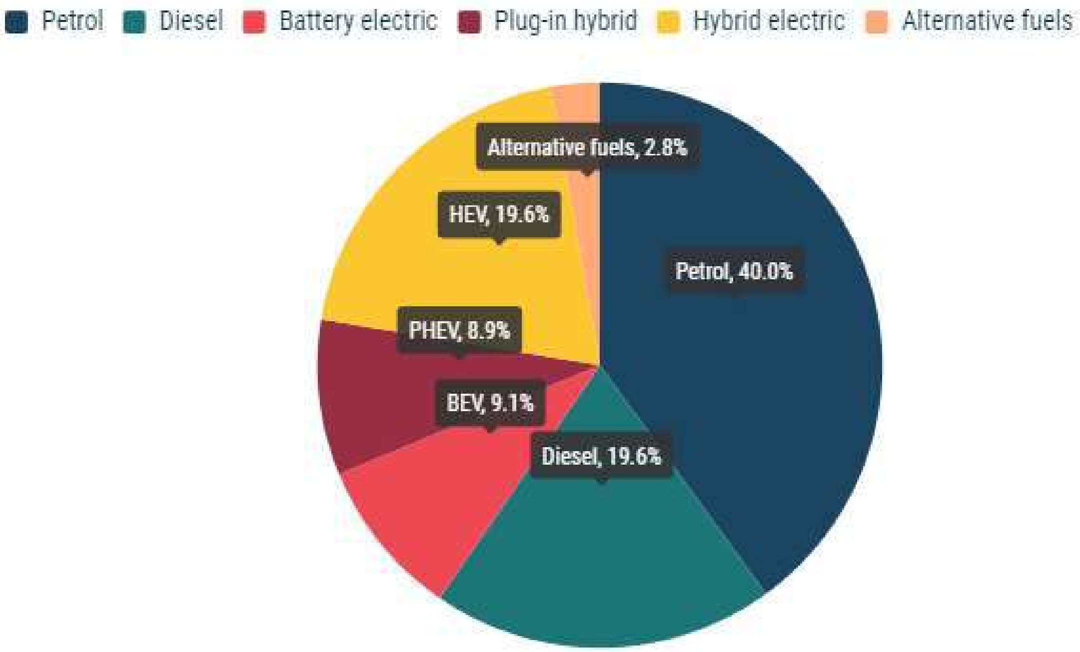


Figure 2. 6: 2018 to 2021, market share of new automobiles in the EU by fuel type [4]

The fact that EVs are becoming increasingly popular in Europe as a whole is one of the main conclusions drawn from the data supplied by the European Automobile

Manufacturers Association (ACEA). Figure 5 depicts the yearly increase in new passenger car registrations in the EU from 2018 to 2021, broken down by engine type. However, new EV registrations in the European Union climbed from 5.9% (2019) to 37.6%. (2021) [4].

Simultaneously, observe a broad decline in the sales of diesel engines (from 55.6% to 40.0%) and petrol engines (from 36.7% to 19.6%).

The Earth is in grave danger as a result of global warming. One of the nations most impacted by global warming is Pakistan. The purpose of this project is to come up with a plan that will enable the provision of an electric bike charging station, which will contribute to the mitigation of global warming. Pakistan is a third-world country. The number of customers buying bikes is more than those of cars. Therefore, the market gap between bikes and cars is significant.

The GDP of Pakistan in 2021 was around $1,538. While the annual growth in 2021 was around 13.12%. The cost of bikes is less than the cost of buying a car. Therefore, the majority of citizens buy a bike as compared to a car. Providing electric charging stations for bikes would encourage customers to opt for electric bikes when there are places to charge them at different points throughout the city [5].

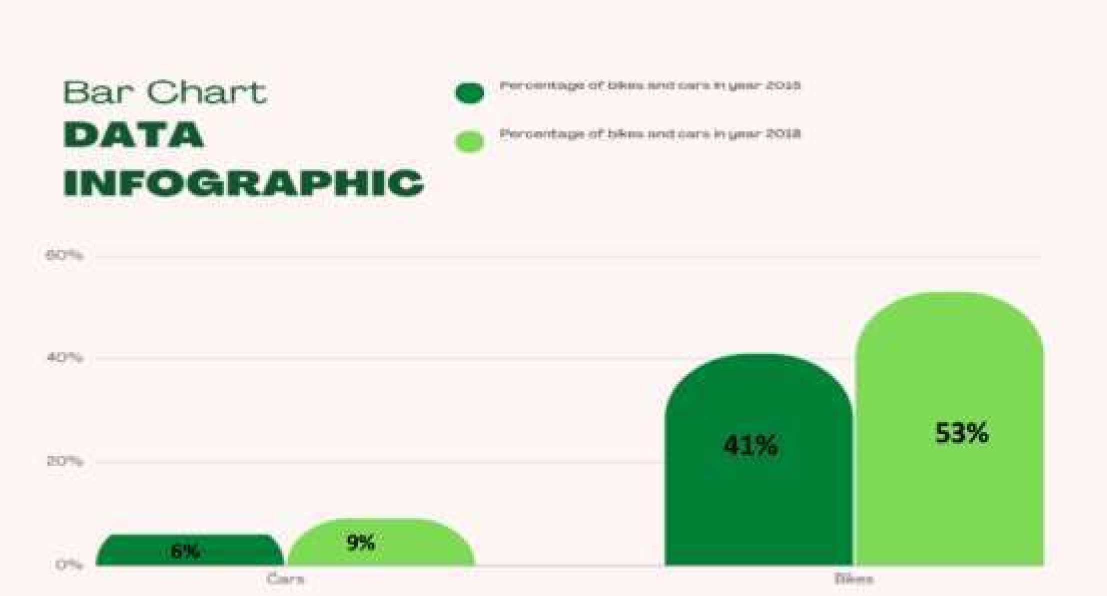


Figure 2. 7: Percentage of bikes and cars in year 2015 and 2018 [6]

According to the data taken from the Pakistan Bureau of Statistics (PBS) from the year 2015 to 2018, the gap between the bikes and cars market is increasing. Purchasing a vehicle is more expensive than buying a bike. Because of this, more people purchase motorcycles than cars. By providing bike electric charging stations, consumers would be more likely to choose electric bikes. When various locations throughout the city have charging stations for them. Unfortunately, there are presently no electric bike charging facilities in Islamabad [6].

Figure 2. 8: World Bank Stats [5]

The number of EV on road is increasing day by day. However, the gap between the EV cars and available charging stations is huge [7].

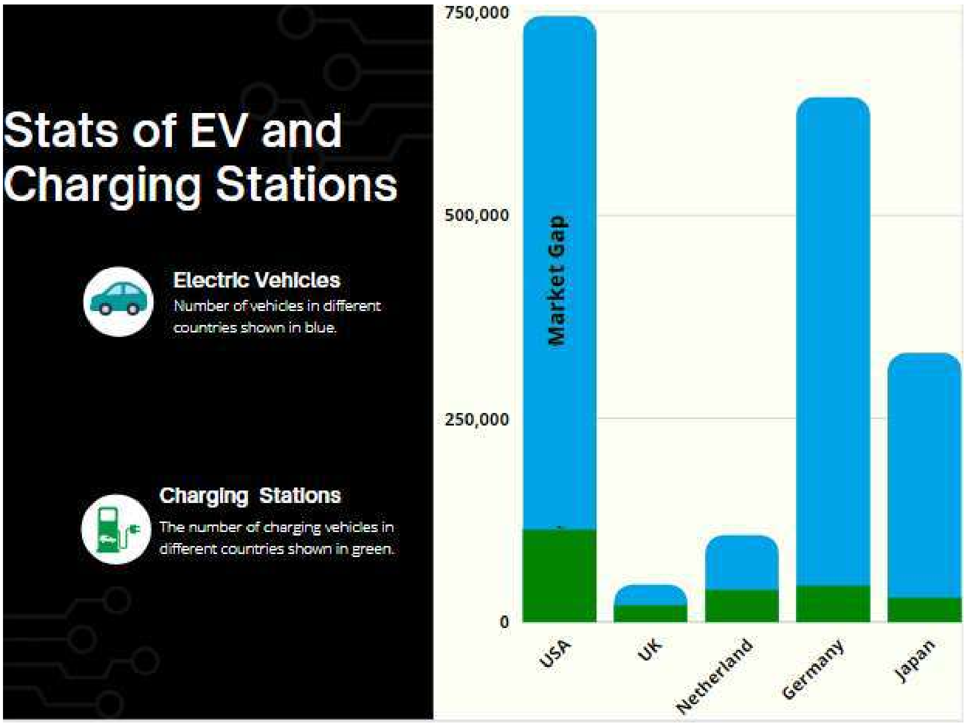


Figure 2. 9: Market gap between EVs and Charging Stations [7]

2.4 Electric Bikes

Jolta Electric Pvt Ltd is Pakistan's first approved electric vehicle (EV) company, with a mission to electrify the country's automobile industry for a more sustainable future. Jolta Electric focuses on fulfilling requirements for electrifying the industry, and is an EV technology provider, having designed key components of electric vehicle kits for various types of vehicles. With five years of product design, development, and manufacturing experience in China, Jolta Electric's eBikes offer a superior riding experience through their line of electric motorcycles. Their people are motivated by innovation and driven by passion, guided by integrity, and measured by results.

Jolta Electric has played a significant role in shaping EV policy in Pakistan and is the only authorized EV manufacturer in the country, with years of research experience in the EV and renewable energy industry [8].

For this project, three different electric bikes were looked at, given below is the table comparison of them [8]:

Table 2. 1: Comparison between Bikes

Bike	JOLTA JE-125L	JOLTA JE-70D SE	JOLTA JES-49L
Type of Battery	Lithium Ion	Dry EV GEL.	Lithium Ion
Distance	Up to 110KM	Up to 80KM	Up to 80KM
Top Speed	70-75 KM/H	55 KM/H	55 KM/H
Charging Time	2.5 Hours	Over Night	2.5 Hours

2.4.1 Calculations of Honda CD-70

Let’s assume if a person use a normal conventional bike and he has to travel for 80km per day.

Fuel Average of Honda CD-70 = 60km for l liter

Petrol for Month = 80km*30 Days

= 2400km.

Petrol price in Pakistan = Rs. 250.50 for l liter

Total Liters Consumes in a Month will be = 30 liters

Cost of 30 liters = 30*250.20 = Rs. 7515

2.4.2 Calculations of Jolta EV Bike.

Unit Consumption of EV Bike = 1.5 unit for 80km
Unit Consumption for Month = 1.5* 30 = 45 Units
1 Unit price in Pakistan (Domestic) = 9.68Rs.
Cost of 45 units = 45*9.68 = 435Rs.

So it is concluded that EV bike is 94.3% cost saving with respect to the conventional bike.

2.4.3 Bike Selected

The bike selected for this project is Jolta JES-49L using table 2.1 .

2.5 Batteries

All the data collected on batteries is given below:

2.5.1 Different Types of Batteries

A battery is a grouping of one or more cells that store electrical energy for use in powering electrical equipment.

There are two kinds of electrochemical cells and batteries. Although there are other additional classes, these are the most important [9]:

- Primary (non-rechargeable)
- Secondary (rechargeable)

2.5.1.1 Primary Batteries

A main battery is an efficient way to power portable gadgets and devices. Primary batteries cannot be recharged [9].

Table 2. 2: Battery Characteristics [8]

Battery Type	Characteristics
Alkaline (Zn/Alkaline/MnO2)	Extremely popular, low cost, and great performance.
Magnesium (Mg/MnO2)	Large capacity and long shelf life.
Mercury (Zn/HgO)	Very high capacity, as well as long shelf life.
Lithium/Solid Cathode	High energy density, low temperature performance, and extended shelf life.

Lithium/Soluble Cathode	High energy density, high performance, and a wide temperature range.
Lithium/Solid Electrolyte	Low power consumption, incredibly extended shelf life.
Silver/Zinc (Zn/Ag2O)	Highest capacity, most expensive, flat discharge.
Zinc – Carbon	Abundant, low-cost, and available in a range of sizes

2.5.1.2 Secondary Batteries

The major benefit of these batteries is that they can be recharged and reused. As a result, the other term: rechargeable batteries [9].

Secondary batteries are often more expensive than primary batteries. However, because they are rechargeable, they may have a longer lifespan.

Used for two purposes:

- Energy storage systems
- Uses where the battery is charged and discharged as a main battery

Secondary batteries are used in the initial application to deliver and store energy for devices such as:

- Power Supplies That Aren't Interrupted (UPS)
- Electric Hybrid Vehicles (HEV)

Rechargeable batteries are also useful for portable devices such as:

- Mobile phones
- Laptop computers
- Electric vehicles

Other significant types of rechargeable batteries are as follows:

- Nickel-Cadmium Batteries: One of the oldest types of batteries accessible today. They have a lengthy lifespan and are also dependable and strong.
- Nickel - Metal Hydride Batteries: These are a new form of battery that is a more advanced variant of Nickel - Hydrogen Electrode Batteries. Useful in aeronautical applications (satellites).

2.5.2 Wet and Dry Battery:

A wet cell battery has an aqueous electrolyte inside of it. The lead-acid battery is the most typical type of wet cell.

A paste electrolyte, containing just enough moisture to for the current to pass, is used in a dry cell. Dry cell batteries are now a common feature in cars as they are thought to be environmentally favorable. Since they don't emit acid vapors and there isn't a risk of acid leaking or spilling (liquid) [10].

Table 2. 3: Wet and Dry Battery Comparison [10]

	Wet Cell Battery	**Dry Cell Battery**
Electrolyte	Liquid electrolyte	Paste electrolyte
Directional Usage	Typically can be used only in upright direction. Other orientations may result in acid spilling	Can be operated in any orientation without spilling
Emission	Can produce gases that are harmful to health.	Typically does not emit gases
Weight	Heavier	Relatively lighter
Maintenance	Electrolyte level needs to be periodically checked & maintained	No regular maintenance required
Resistance to cold	Lesser resistance to cold weather	Greater resistance to cold weather
Cost	Inexpensive	Slightly Expensive

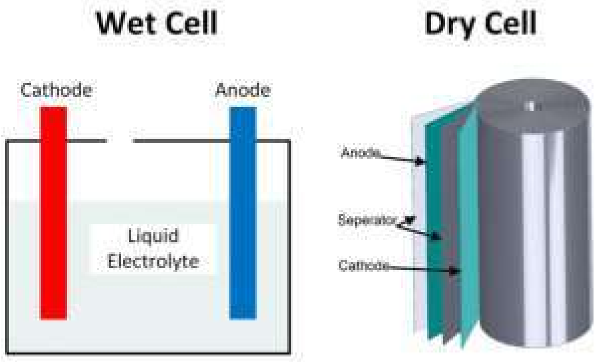


Figure 1: Wet and Dry Battery [10]

2.5.3 Battery Specifications

Three different batteries are compared below to select one for the project:

Table 2. 4: Comparison of Batteries

Parameter	Battery 1 (48V100Ah)	Battery 2 (60V50Ah)	Battery 3 (60V20Ah)
Type of Battery	Lithium iron phosphate battery	Lithium-Nickel-Manganese-Cobalt-Oxide	Lithium-Nickel-Manganese-Cobalt-Oxide PVC Pack.
Dimensions (Width*Depth*Height)	442mm*425mm*178mm	400mmX300X70mm	200 mm x 170 mm x 140 mm
Energy	5120Wh	2960Wh	1200Wh
Weight (Approximate)	43.0 kg	14.0 kg	7.25 kg
Rate of Charging (Voltage /Current)	V = 56V I = ≤100A	V = 67V I = 20A	V = 29.4V I = 5.0 A
Rate of Discharging	I =>100A and <150A V=60V	I = 50A V= 43 V	V = I = 40A
Recommended charging current and time	30A(0.3C) for 3.5 hours		
Calendar life	At 25°C >10 Years	At 25°C >5 Years	At 25°C >5 Years
Dimensions (Width*Depth*Height)	442mm*425mm*178mm	400mmX300X70mm	200 mm x 170 mm x 140 mm
Energy	5120Wh	2960Wh	1200Wh
Weight (Approximate)	43.0 kg	14.0 kg	7.25 kg
Rate of Charging (Voltage /Current)	V = 56V I = ≤100A	V = 67V I = 20A	V = 29.4V I = 5.0 A
Rate of Discharging	I =>100A and <150A V=60V	I = 50A V= 43 V	V = I = 40A
Recommended charging current and time	30A(0.3C) for 3.5 hours		
Calendar life	At 25°C >10 Years	At 25°C >5 Years	At 25°C >5 Years

2.5.4 Battery Selection:

The battery selected for this project is Lithium-Nickel-Manganese-Cobalt-Oxide 60V 50Ah using table 2.4.

2.6 Electric Vehicles Chargers

As the world moves towards cleaner energy solutions, electric vehicles have become a crucial part of the transition. The widespread adoption of EVs, however, depends on the availability of reliable and convenient charging solutions. Electric cars have become an important component of the shift as the globe works towards better energy options. However, the broad acceptance of EVs is dependent on the accessibility of dependable and simple charging methods.

2.6.1 SAE J1772-Three Levels of EV Charging

The three EV charging levels are Level 1, Level 2, as well as Level 3. DC Fast Charging and (Tesla) Supercharging comprise Level 3. More power is provided to the car when the charge level is greater, hastening the charging process. Because each EV can receive a different amount of electricity from the EVSE, various EVs charge at varying speeds on each level [11].

Charging Level	Specifications
AC Level 1	EV includes an on-board charger
	AC Single-phase Supply from a household outlet: • 120 V @ 12 A ⇒ 1.44 KW • 120 V @ 16 A ⇒ 1.92 KW
	Estimated charge-time for 1.92 KW: • PHEV: 7 h (State of charge 0% to 100%) • BEV: 17 h (State of charge 20% to 100%) *
AC Level 2	EV includes an on-board charger
	208–240 V AC Single-phase
	Supply from residential installation or EVSE
	Charging power up to 19.2 KW (Typically: 7.2 KW)
	Charging current up to 80 A (Typically: 30 A)
	Estimated charge-time for 3.3 KW: • PHEV: 3 h (SOC 0% to full) • BEV: 7 h (SOC 20% to full)
	Estimated charge-time for 7 KW: • PHEV: 1.5 h (State of Charge 0% to full) • BEV: 3.5 h (State of Charge 20% to full)

DC Level 1	Charging power up to 80 KW (Typically 50 KW)
	Charging current up to 80 A (Typically 50 A)
	Estimated charge-time for 50 KW: • PHEV: 10 min (State of Charge 0% to 80%) • BEV: 20 min (State of Charge 20% to 80%)
DC Level 2	EVSE output voltage: 50–1000 V DC
	Charging power up to 400 KW (Typically: 50 KW)
	Charging current up to 400 A (Typically: 50 A)
	Estimated charge-time for 100 KW: • BEV: < 10 min (State of Charge 20% to 80%)

* Battery capacity for BEVs is estimated to be 25 KWh, compared to 5–15 KWh for PHEVs.

The level of charging used for motorcycles depends on the specific motorcycle and it's charging requirements. Level 1 or Level 2 charging is more commonly used for motorcycles.

2.6.2 IEC 61851-1 Charging Modes

The electric vehicle conductive charging system - General requirements is an international standard (IEC 61851-1) that provides the specifications for electric vehicle (EV) conductive charging systems. It outlines the general requirements for the design, construction, and performance of AC and DC charging systems for electric vehicles [12].

This standard covers the following areas:

- Safety requirements for electric vehicle conductive charging systems.
- Requirements for the electrical installation and protection of the charging station.
- Requirements for the charging process and communication between the charging station and the electric vehicle.
- Requirements for interoperability between different charging systems and electric vehicles.
- Test procedures for verifying compliance with the standard.

The objective of this standard is to ensure the safe and reliable operation of electric vehicle conductive charging systems and to promote interoperability between different charging systems and electric vehicles [12].

The charging modes are as follows:

- **Mode 1** employs a basic household socket and has limited safety features, resulting in it being deemed as dangerous.
- **Mode 2** utilizes a standard domestic socket with added control and protection features, making it safer than Mode 1 but with a lower charging capacity.
- **Mode 3** is the prevalent charging mode and uses specialized AC charging stations with a power range of 3.7 kW to 43 kW that are well-controlled and protected.
- **Mode 4** utilizes public DC charging stations that provide direct DC voltage to the battery, bypassing the on-board charger.

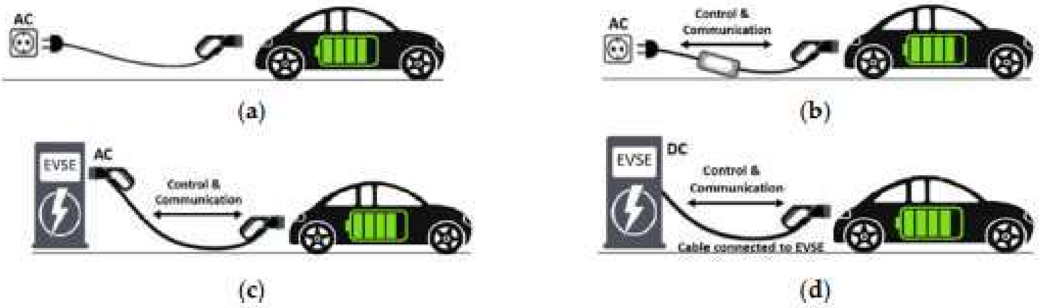


Figure 2. 10: Charging Modes: (a) Mode 1; (b) Mode 2; (c) Mode 3; (d) Mode 4 [12]

According to IEC 61851-1, the international standard for electric vehicle conductive charging systems, electric motorbikes can be charged using Mode 3 (AC Charging) and Mode 4 (DC Charging).

Mode 3 AC Charging involves charging the electric motorbike using a controlled and protected dedicated AC charging station. The charging station provides AC power to the motorbike, and the on-board charger within the motorbike converts the AC power to DC power to charge the battery.

Mode 4 DC Charging involves charging the electric motorbike directly with DC power through a public DC fast charging station. This mode of charging is typically faster than Mode 3 AC Charging, but it is less common for electric motorbikes due to the limited availability of public DC fast charging stations and the higher cost of the equipment required.

It is important to note that not all electric motorbikes may be compatible with both Mode 3 and Mode 4 charging, so it is recommended to check the specifications of the specific model of motorbike before choosing a charging mode.

2.6.3 China GB Standards

The China GB Standards for electric vehicles (EVs) are a set of national standards that regulate the design, manufacturing, and performance of electric vehicles in China. These standards are developed by the Standardization Administration of China (SAC) and serve to ensure the quality, safety, and reliability of EVs in the Chinese market.

The China GB Standards for EVs cover various aspects of electric vehicle design and performance, such as battery technology, charging systems, and safety requirements. Some of the relevant China GB Standards for EVs include [13]:

- GB/T 31467-2015 Technical Requirements for Electric Bicycles
- GB/T 31468-2015 Performance Requirements for Electric Bicycles
- GB/T 27930-2015 Technical Requirements for Electric Cars
- GB/T 27931-2015 Performance Requirements for Electric Cars
- GB/T 27932-2015 Technical Requirements for Electric Buses
- GB/T 27933-2015 Performance Requirements for Electric Buses

Adherence to these standards is mandatory for electric vehicles manufactured and sold in China, and they play a significant role in ensuring the quality, safety, and reliability of EVs in the country.

2.7 Related Technologies

There are several technologies that are related to electric bikes, including:

2.7.1 Wireless Chargers

There is no need for a charging wire while charging an EV; the car may be charged simply by parking in a designated place.

The steering functions automatically in combination with the navigation system's screen marking the parking place and providing instructions on driving forward or reverse. The driver may park the car in the desired spot simply by using the accelerator, brakes, or shift in accordance with the instructions [14].

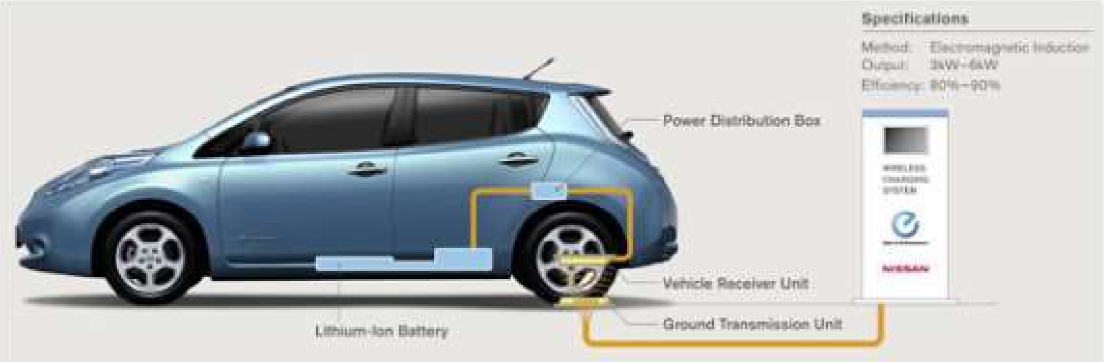


Figure 2. 11: Wireless Charger [14]

2.7.2 Combined Solar Inverter and EV Charger

A solar inverter and electric vehicle charger that can be charged straight from rooftop solar is a recent technological advancement. A creative approach that removes the need for a separate EV charger, additional cabling, and prospective electrical improvements is to integrate a charger with a solar inverter. The inverter must be located near or in a garage, which is the sole drawback.

SolarEdge is the first solar inverter producer to create a hybrid solar inverter and EV charger that can charge at a rate of up to 7.4kW from solar power alone or from solar power and the grid simultaneously. This is perfect for anyone who want smart home automation and want to add solar as well as an Electric charger at the exact same time [15].

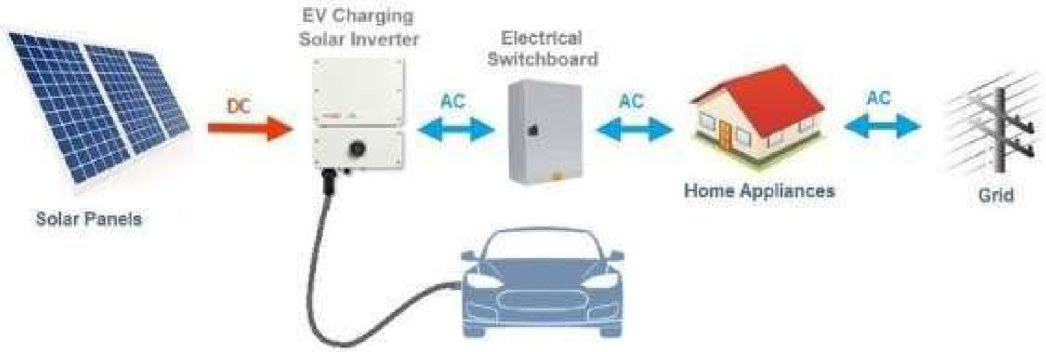


Figure 2. 12: Solar Charger [15]

2.8 Related Projects

Many similar tasks may be accomplished using this framework. Some comparable projects are listed below. Some initiatives differ in terms of technology, while others vary in scope. The projects and technologies are discussed further below.

2.8.1 Presenting Plug-in Evs, Smart Charging, as well as Grid Support

Plug-in electric cars (PEVs) are becoming more popular in California as a result of increased social awareness of their environmental benefits, improved battery technology, and appealing federal, state, and municipal government incentives. Because the average U.S. driver spends less than an hour per day in personal cars and drives an average of 37 miles per day, PEVs may be employed as a unique and vital type of energy storage. Solar photovoltaic (PV) power throughout the day is suitable for charging PEVs, assisting California in meeting its 2050 renewable objective of lowering greenhouse gas emissions by 50% below 1990 levels [16].

Electric vehicle success requires vehicle-to-grid and vehicle-to-building technologies (PEVs). PEVs may discharge energy into the grid or support building loads via vehicle-to-grid and vehicle-to-building, reducing peak loads and related energy expenditures. Grid services can be used to remove extra energy during periods of over-generation or to supply energy back to the grid during times of high demand. The capacity to aggregate and regulate several PEVs for a coordinated response is the difficulty with PEVs delivering grid services [16].

This project created and demonstrated improved charging infrastructure supporting smart charging, vehicle-to-grid and vehicle-to-building communications, grid functions, as well as cost recovery validation.

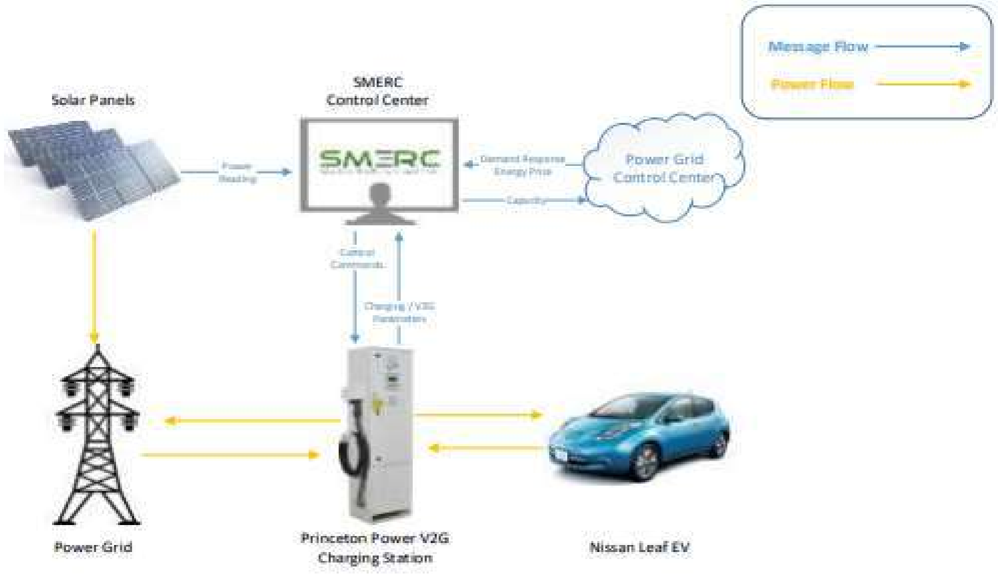


Figure 2. 13: Princeton Power Vehicle to Grid System Design [16]

EV Chargers with smart charging, vehicle-to-grid, vehicle-to-building, and grid-service technology capabilities provide economic benefits to fleet owners under SCE grid service [16].

2.9 Related Studies/Research

There have been several previous experiments linked to electric bikes chargers. Some initiatives differ in terms of technology, while others differ in scope. The projects and innovations are discussed further below.

2.9.1 Electric Vehicle Charging Systems: Comprehensive Review

The paper "Electric Vehicle Charging Systems: Comprehensive Review" is a comprehensive examination of the state of electric vehicle (EV) charging systems. It covers the various charging technologies and infrastructure, including charging stations, charging networks, and charging equipment. The authors provide an overview of the various business models that have emerged for EV charging, including public charging, home charging, and workplace charging [3].

The authors also examine the challenges and opportunities of EV charging systems. The challenges discussed include issues related to cost, reliability, and safety. The authors also highlight the need for standardization and interoperability between different charging systems to ensure seamless and convenient charging experiences for EV drivers.

The paper also provides an overview of the current state-of-the-art and future trends in EV charging systems. It covers advancements in charging technology, such as fast charging and wireless charging, as well as the integration of renewable energy sources in charging systems [3].

In conclusion, the authors state that while there are still challenges to be addressed, the growth of EV adoption and advancements in charging technology are creating a bright future for the EV industry. They believe that the development of efficient and convenient charging systems will be a key factor in the widespread adoption of EVs. While there are still issues to be solved, the authors believe that the increase of EV usage and developments in charging technologies are producing an encouraging outlook for the EV sector.

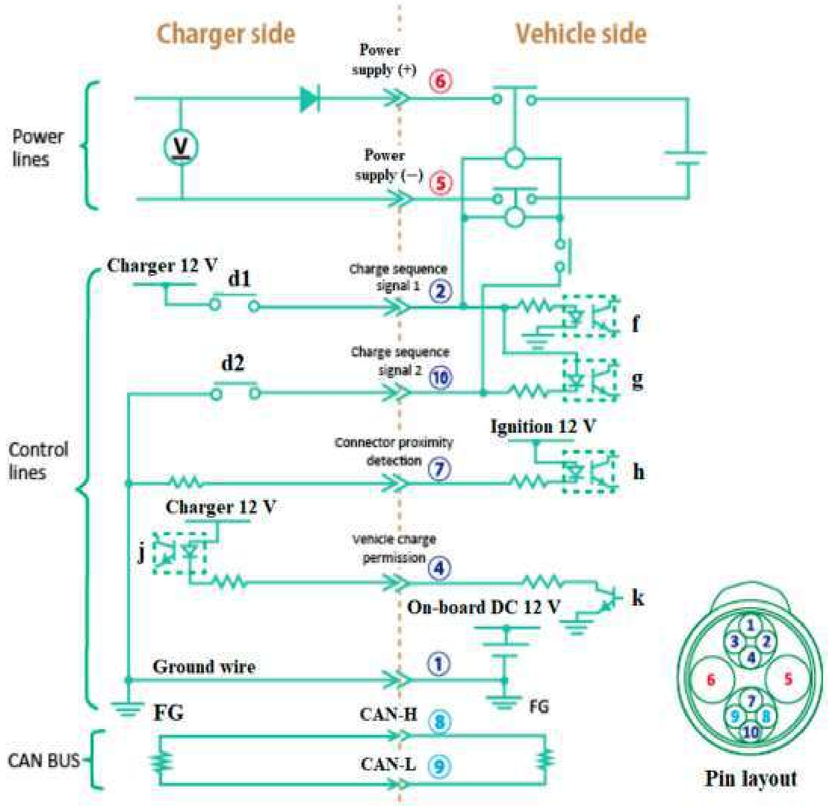


Figure 2. 14: CHAdeMO sequence circuit and pin layout [3]

2.9.2 Sustainable E-Bike Charging Station

The paper titled "Sustainable E-Bike Charging Station That Enables AC, DC and Wireless Charging from Solar Energy" by Gautham Ram Chandra Mouli and Peter Van Duijsen presents a design for a sustainable electric bike charging station that is capable of providing AC, DC, and wireless charging using solar energy [17].

The authors begin by discussing the challenges and limitations of existing electric bike charging systems, including the limited availability of charging infrastructure and the slow charging speeds of some technologies. They then describe their design for a sustainable charging station that is capable of providing AC, DC, and wireless charging using solar panels and advanced power management technologies.

It is crucial to charge electric vehicles using sustainable power sources, such as solar or wind energy if they are to be really sustainable. This study looks at the construction of an e-bike charging station powered by solar energy that can wirelessly, AC, and DC charge e-bikes. The charging station features inbuilt battery storage that makes it possible for it to operate both on and off the grid [17].

Without using an AC charging converter, DC charging uses the solar panels' DC electricity to directly charge the e-bike battery. For wireless charging, the e-bike may be charged via inductive power transfer using the kickstand of the bike as the receiver and a specifically made tile as the transmitter at the charging station, which offers the user the greatest level of convenience.

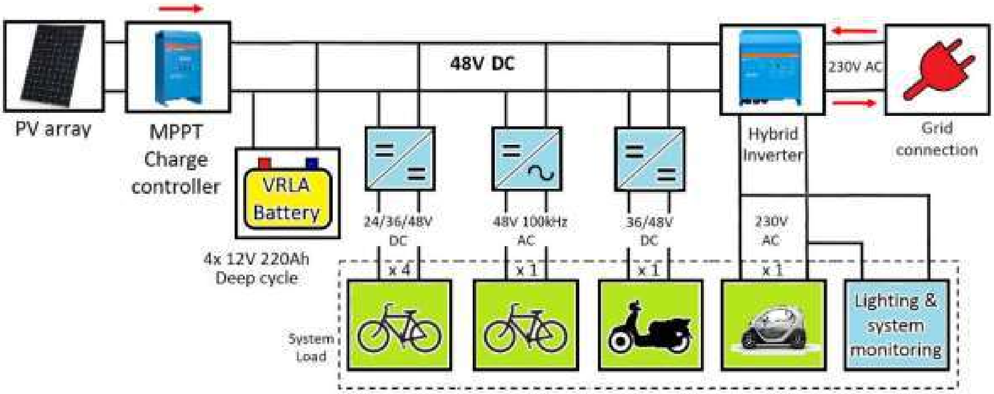


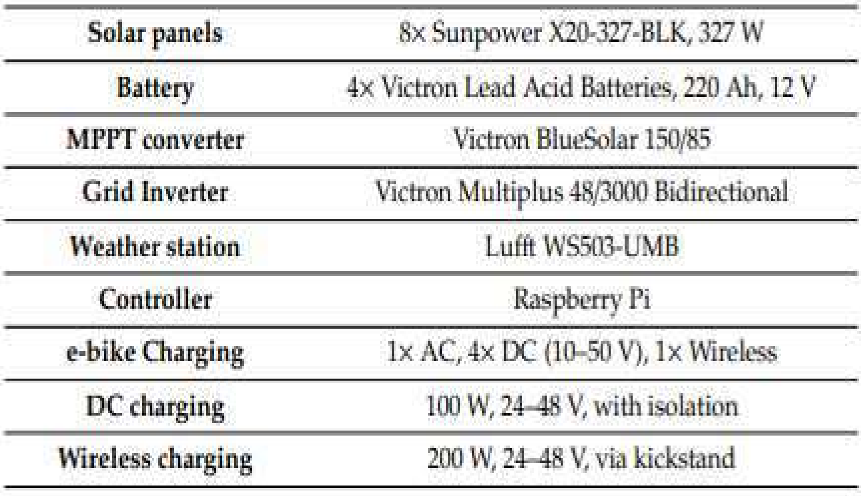
Figure 2. 15: Schematic of the solar e-bike station with 48 V DC interconnection that facilities power exchange between the solar panels, e-bike chargers, and the AC grid [17].

The charging station is designed to be compact and portable, allowing it to be easily installed in a variety of locations. It also incorporates a number of advanced features, such as a user-friendly interface and a built-in power management system, to provide a convenient and efficient charging experience for electric bike riders.

The authors also discuss the potential benefits of their charging station, including its ability to provide fast and convenient charging for electric bike riders, and its use of renewable energy sources to reduce carbon emissions. They conclude that their charging station represents a significant advance in electric bike charging technology, and could be an important step towards a more sustainable and environmentally-friendly transportation system.

In summary, this paper presents an innovative design for a sustainable electric bike charging station that is capable of providing AC, DC, and wireless charging using solar energy. The authors provide a detailed description of the design and its key features, and discuss the potential benefits and challenges of implementing such a charging station. This study describes a unique concept for a solar-powered electric bike charging station. The researchers describe the design and major features in-depth broad terms, as well as the possible benefits and obstacles of installing and with the value of a charging station. Overall, the study contributes significantly to the field of electric car charging technology. [17]

Table 2. 5: Specifications of the solar e-bike charging station [17]



Solar panels	8× Sunpower X20-327-BLK, 327 W
Battery	4× Victron Lead Acid Batteries, 220 Ah, 12 V
MPPT converter	Victron BlueSolar 150/85
Grid Inverter	Victron Multiplus 48/3000 Bidirectional
Weather station	Lufft WS503-UMB
Controller	Raspberry Pi
e-bike Charging	1× AC, 4× DC (10–50 V), 1× Wireless
DC charging	100 W, 24–48 V, with isolation
Wireless charging	200 W, 24–48 V, via kickstand

2.10 Limitations and Bottlenecks of the Existing Work

The following are some of the obstacles we ran through while working on our project:

- Not having the lithium-ion battery that can support charging current of 20Amps
- Fly Back Converter has advantages like it gives better Isolation, Voltage Regulation, High Efficiency and Design Flexibility. It was used instead of Buck Converter.
- Due to the high cost of the necessary equipment, a working prototype of a car charging station was unable to be constructed.

2.11 Problem Statement

Global warming is a serious threat to the planet, and Pakistan is one of the nations most impacted by its unfavorable effects. This project attempts to solve the dearth of electric bike charging infrastructure in Islamabad, Pakistan, in order to battle this urgent problem. Designing, simulating and building a prototype for electric bike chargers that will be placed strategically across the city is the aim of the project. The initiative aims to encourage consumers to select environmentally friendly mobility alternatives and lessen their dependency on conventional motorcycles that increase greenhouse gas emissions by offering convenient and effective charging facilities for electric bikes. The objective is to support SDG 13 (Climate Action) by providing a viable solution to reduce global warming and close the gap between bikes and vehicles in the market, eventually encouraging the use of electric bikes as a more environmentally friendly method of transportation in Pakistan.

2.12 Summary

This chapter provided a full description of the work. It explains all of the technologies that are relevant to the project, such as various positioning technologies. The second section of the presentation addresses all previous similar initiatives as well as research and connected studies to our project. It concludes by discussing the limits of earlier attempts.

Chapter 3

PROJECT DESIGN AND IMPLEMENTATION

The project is divided into two parts: the hardware design and the software modelling design. This chapter discusses both of these designs as well as their implementation processes.

3.1 Proposed Design Methodology

The general block diagram that is followed to complete this project is given below:

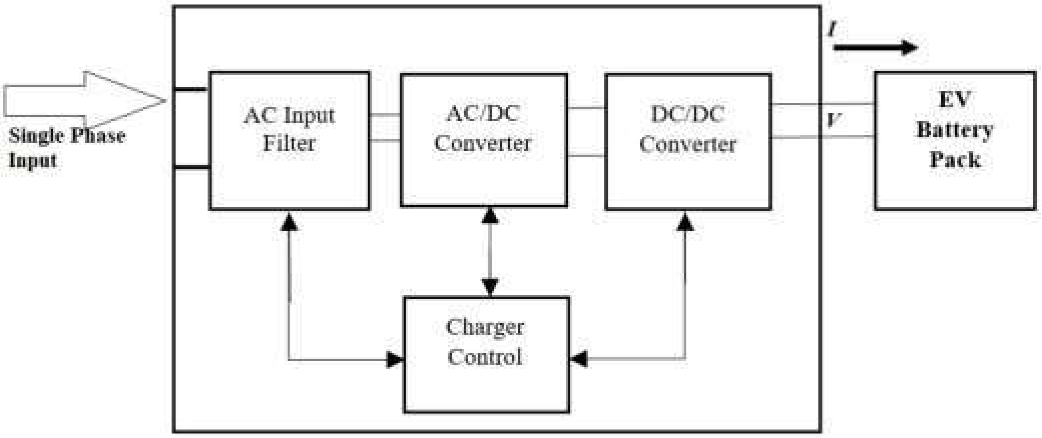


Figure 3. 1: Block diagram of the project

The above block diagram shows that an AC input filter is used in EV battery chargers to improve the quality of the input AC voltage waveform, and reduce harmonic content. The output from AC input converter enters AC/DC converter. The work of an AC/DC converter in an EV battery charger is to convert incoming AC power into DC power, which can be used to charge the battery. The output of AC/DC converter is given as an input to a DC/DC converter, also known as a fly back converter, which is a voltage regulator that is used to convert a higher voltage DC input into a lower voltage DC output. In an EV battery charger, the DC/DC converter is used to step down the voltage of the rectified DC power from the AC/DC converter to a level that is appropriate for charging the battery. Through all of this process there will also be a charger control system that will regulate the entire process. And an LCD that shows the State of Charge of the system. The charger control system monitors voltage, as well as current to ensure that the charging procedure is effective but also reliable. The LCD display shows the Status of Charge in real time, allowing customers to readily keep track of the battery's charging condition.

3.2 Analysis Procedure

The project is analyzed using several methods. The Arduino Nano will be used to implement some ADC pin settings and other crucial qualities, even if a number of technologies may be used to generate this project.

3.2.1 Critical Analysis

After researching for this project, the following specifications were selected:

- Jolta JES-49L is selected for EV bike using table 2.1 because it has good mileage as well as the charging time which is convenient if a person for example needs to come to CUST University from their home.
- The battery selected is 60V and 50Ah from table 3.1

Table 3. 1: Battery Selection

Parameter	Battery 2 (60V50Ah)
Type of Battery	Lithium-Nickel-Manganese-Cobalt-Oxide
Dimensions (Width*Depth*Height)	400mmX300X70mm
Energy	2960Wh
Weight (Approximate)	14.0 kg
Rate of Charging (Voltage /Current)	V = 67V I = 20A
Rate of Discharging	I = 50A V= 43 V
Calendar life	At 25°C >5 Years

- Charger of mode 3 is selected as Mode 3 charging is widely used for charging EVs and PHEVs, including electric motorcycles, as it provides a convenient and flexible way to charge the vehicle while parked.

3.3 Design of the Project Hardware

Two main hardware design components may be split into an electric bike charger:

1. **Charging Unit:** This component of the charger is in charge of providing electricity to the battery of the electric bike. It consists of the following elements:
   a. **Power Supply:** The power supply transforms the alternating current (AC) electricity from the electrical grid into the necessary voltage and

current for charging the electric bike. Transformers, rectifiers, and voltage regulators may be included in it.

   b. **Charging Control Module:** This component controls the charging procedure and makes sure that the battery of the electric bike receives electricity securely and effectively. It connects with the bike's onboard charging system, keeps track of battery data, and regulates charging voltage and current.

2. **<u>User Interface and Control Panel:</u>** This section of the charger focuses on the user experience and offers the tools and data required for charging. It has the following elements:

   a. **Display:** The charger has a display panel or screen that shows data about the charging status and battery level. Users may keep an eye on how the charging process is going.

   b. **Safety measures:** Incorporating safety measures into charger will protect users from electrical risks and assure their security. These features might consist of emergency stop buttons, overcurrent protection, temperature monitoring, and ground fault prevention.

3.4 Design of the Project Software/Algorithm

By separating the software design into these two key components, it is simpler to concentrate on the particular features related to charging control and user interaction, guaranteeing that users of electric bikes will have a well-thought-out and user-friendly charging experience. The software design of an electric bike charger may be broken down into two main categories:

- **<u>Charging Controlling Software:</u>** This component of the software architecture is in charge of overseeing the charging procedure and making sure that electricity is transferred to the electric bike's battery safely and effectively. It consists of the following elements:
  - **Charging Management** Algorithm: Based on the battery's specs and charging needs, this algorithm controls the charging current and voltage. It makes sure the battery is charged within safe ranges, avoids

    overcharging or undercharging, and maximizes the effectiveness of the charging procedure.
  - **State of Charge (SoC) Inspection:** During the charging process, the software keeps track of the battery's state of charge. It monitors the battery's energy level and modifies the charging settings as necessary. This aids in figuring out when to cease charging once the battery is fully charged and when to switch from constant current to constant voltage charging.
  - **Safety Checks as well as Fault Handling:** During the charging process, the software has safety checks to keep an eye on vital variables, including temperature, current, and voltage. The charging process may be stopped, the current reduced, or warnings and error messages may be sent if any aberrant values or defects are found. These steps are done to safeguard the battery and maintain user safety.
- **User Interface Software:** This section of the software design focuses on offering a user-friendly interface for users to interact with the charger. The following elements make it up:
  - **Display and Information Presentation:** The software displays pertinent information on a display or user interface, enabling users to keep track of the charging status, battery level, charging time, and other pertinent information. Users can utilize this information to remain up to date on how the billing process is going.
  - **User Input and Control:** Users may interact with the charger via buttons, or other input devices such as a potentiometer. Within the given parameters, users may start the charging process, choose charging choices and manage the charging settings.

3.5 Implementation Procedure

There are various phases in the process of creating an electric bike charger. First, create the electrical circuitry for the charger while taking the appropriate voltage and current standards into account depending on the needs of the electric bike's battery. Purchase the essential parts, such as charging connections, transformers, rectifiers, and voltage regulators. Make sure that the connections and insulation are correct when you assemble the parts in accordance with the design. To govern the charging process, keep track of battery characteristics, and assure safety, develop the charging control algorithm and software. Include safety precautions like temperature monitoring and overcurrent prevention. Check the charger's operation and security features, and make any necessary corrections and calibrations. Finally, execute extensive testing to confirm the charger's functionality, including compliance with charging standards and compatibility with various electric bike models.

3.5.1 Driver IC

The driver IC IR2104 is used to drive the gate of power MOSFETs due to the following reasons:

- **Gate Voltage Level:** To completely switch on and achieve low on-resistance (R_{ds} (on)), power MOSFETs normally need a greater gate voltage. By using a bootstrap method, the IR2104 driver IC delivers an appropriate gate voltage level for the power MOSFET. Because it produces a larger gate drive voltage than the input supply voltage, the MOSFET is switched on completely and effectively.
- **Gate Drive Capability:** Power MOSFETs feature capacitive gates, which require a lot of current to fast charge and discharge. This is known as the gate drive capability. The IR2104 driver IC is built to deliver enough gate drive current, allowing for quick switching rates and lowering switching losses. It can source and sink large peak output currents, assuring the power of MOSFET's efficient and dependable functioning.

Requirements to drive the gate of power MOSFET:

- **Gate Voltage:** To achieve complete turn-on and minimal on-resistance, the driver should supply a gate voltage greater than the power MOSFET's threshold voltage.
- **Gate Drive Current:** The driver must be able to source and sink enough current to quickly charge and discharge the power MOSFET's gate capacitance, enabling faster switching rates and reducing power losses.

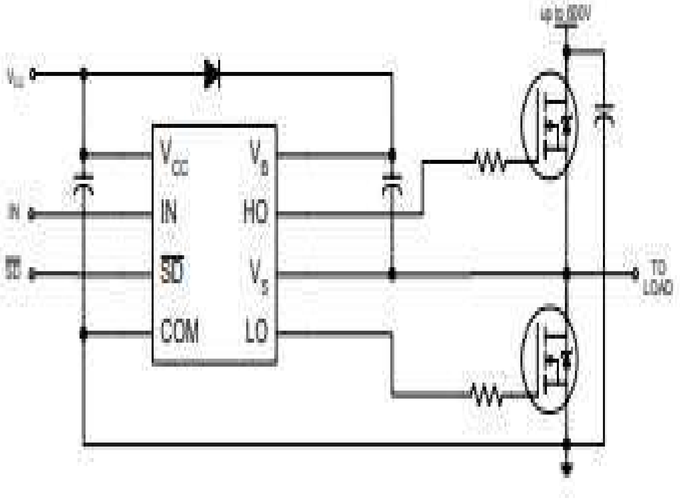


Figure 3. 2: IR2104 Typical Connection

3.5.2 DC to DC converter

Due to its many benefits, the flyback converter is frequently utilized to create electric bike chargers. The flyback converter, which first ensures safety and protection, offers galvanic isolation between the input and output. When working with high-voltage charging systems, this is essential. The flyback converter also provides high voltage conversion ratios, enabling effective step-up or step-down voltage conversions as necessary for charging the batteries of electric bikes. It is an economical solution with straightforward design and management. In addition, the flyback converter offers superb regulation, allowing for exact control of the charging process. It is appropriate for many charging scenarios due to its capacity to handle wide input voltage ranges and high-frequency operation.

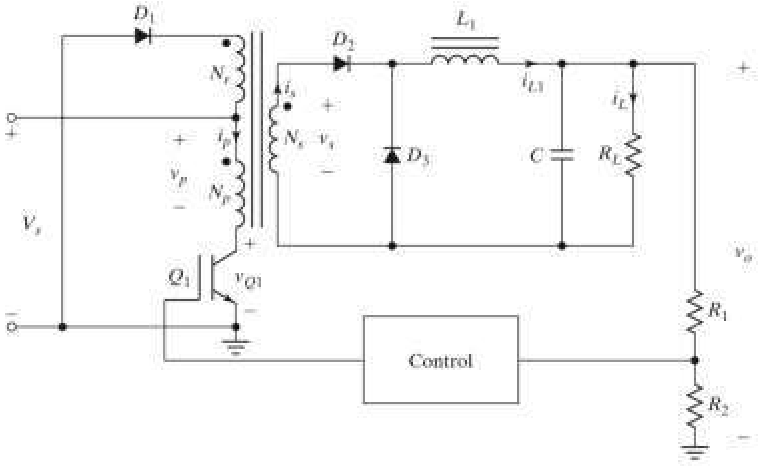


Figure 3. 3: Fly back DC to DC Converter

3.6 Details of Simulations / Mathematical Modeling

The electric bike charger circuit begins with the AC input and is followed by a 6A fuse for overcurrent safety. The AC input is then converted to DC using a bridge rectifier, and capacitors are utilized to smooth the output voltage. The circuit has a floating plus ground output, with the float voltage used to control the gate. This is important because N-channel MOSFETs require a larger VGS voltage than the drain-to-source voltage to switch on completely. To do this, a certain topology is used to supply the necessary voltage to the MOSFET. The high and low sides are also driven by an IR2104 MOSFET driver, which accepts a single input and outputs the necessary information. The circuit's PWM (Pulse Width Modulation) control, which enables accurate voltage management, is combined with an Arduino Nano. The Arduino Software (IDE) makes it simple to develop code and upload it to the board when not connected to the internet. To precisely measure the current passing through the circuit, the AC712 current sensor is used. The AC712 current sensor's advanced signal processing technologies provide precise and consistent readings.This complete design takes into account EMI reduction, gate driver needs, MOSFET driving, and current monitoring to provide efficient and regulated charging of the electric bike's battery.

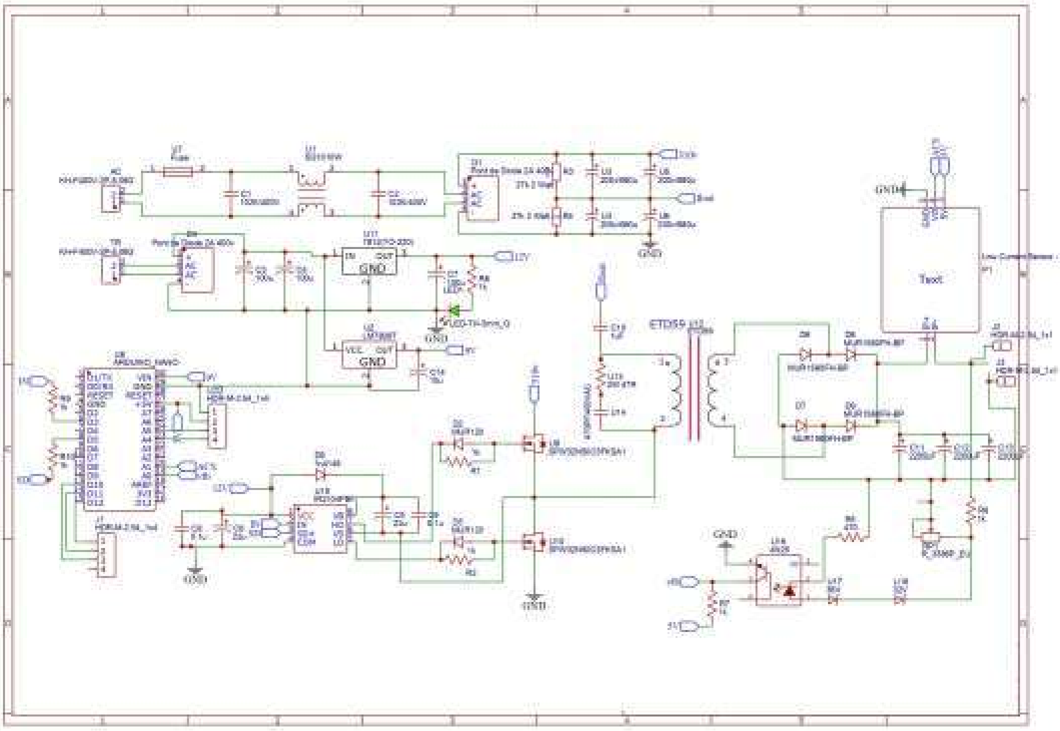


Figure 3. 4: Schematic of Battery Charger

3.6.1 Calculations for the Charger for Electric Bike

Following is the calculations:

3.6.1.1 Finding Values for LC filter for Buck Converter

$$V_s = 300\,V$$

$$V_a = 60\,V$$

$$\Delta V = 20\,mV$$

$$P.t.P\,ripple = 0.8\,A$$

$$f = 25kHz$$

$$\Delta I = 0.8\,A$$

a. Duty Cycle "k"

$$V_a = k\,V_s \qquad \text{(Eq. 3.6.1.1.1)}$$

$$k = \frac{V_a}{V_s} \qquad \text{(Eq 3.6.1.1.2)}$$

$$k = \frac{60}{300}$$

$$k = 0.2$$

$$k = 0.2 \times 100$$

$$k = 20\,\%$$

b. Filter Inductance "L"

$$\Delta I = \frac{V_a\,(V_s - V_a)}{f\,L\,V_s} \qquad \text{(Eq. 3.6.1.1.3)}$$

$$L = \frac{V_a\,(V_s - V_a)}{f \times \Delta I \times V_s} \qquad \text{(Eq. 3.6.1.1.4)}$$

$$L = 0.0024$$

$$L = 2400\,u\,H$$

c. Filter Capacitor "C"

$$\Delta V_c = V_c - V_c(t = 0) \qquad \text{(Eq. 3.6.1.1.5)}$$

$$\Delta V_c = \frac{1}{C}\int_0^{\frac{T}{2}} \frac{\Delta I}{4}\,dt \qquad \text{(Eq. 3.6.1.1.6)}$$

$$\Delta V_c = \frac{\Delta I}{8 \times f \times C} \qquad \text{(Eq. 3.6.1.1.7)}$$

$$C = \frac{\Delta I}{8 \times f \times \Delta V_c} \qquad \text{(Eq. 3.6.1.1.8)}$$

$$C = 200\,u\,F$$

d. The Critical Values of “L” and “C”

$$L_c = \frac{(1-k)\,R}{2f}$$ **(Eq. 3.6.1.1.9)**

$$L_c = 0.384\,uH$$

$$C_c = \frac{(1-k)}{16 \times L \times f^2}$$ **(Eq. 3.6.1.1.10)**

$$C_c = 0.03333\,uF$$

3.6.1.2 Inductor Coil Calculation for Buck Converter:

L= 2400uH

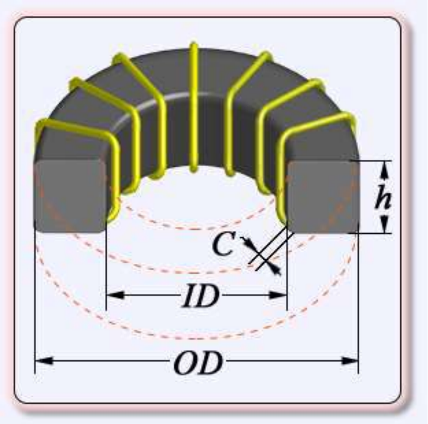


Figure 3. 5: Inductor Coil for Buck Converter

Outer Diameter = 22mm

Inner Diameter = 11mm

Height of ring = 5mm

Ur = 3000

AWG (12) = 2.05mm

Inductance Factor of the Ring A = 1386

Number of turns= 33

Required Length of the wire = 1.02m

For reasons discussed in Chapter 4, the DC to DC converter was switched from Buck Converter to Fly Back Converter.

3.6.1.3 Calculations for Fly Back

Step 1: Determine the Fly back Voltage

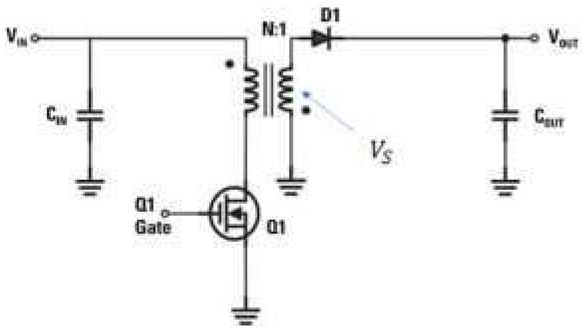


Figure 3. 6: Fly Back

$$V_S = V_{out} + V_{D1} \text{ ...... } \textbf{(Eq. 3.6.1.3.1)}$$

$$\frac{Np}{Ns} = \frac{Vfly}{VS} \text{ .... } \textbf{(Eq. 3.6.1.3.2)}$$

Step 2: Determine the Duty Cycle

$$D = \frac{Vfly}{Vin + Vfly} \text{ .... } \textbf{(Eq. 3.6.1.3.3)}$$

Step 3: Determine Ls and Lp

$$Ls < \frac{Vs(1 - Dmax)}{2Iout\ fmax} \text{ .... } \textbf{(Eq. 3.6.1.3.4)}$$

$$Lp = \left(\frac{Np}{Ns}\right)^2 \text{Ls .... } \textbf{(Eq. 3.6.1.3.5)}$$

Step 4: Determine Peak Currents

$$Is(pk) = \frac{2Iout}{1 - D} \text{ .... } \textbf{(Eq. 3.6.1.3.6)}$$

$$Ip(pk) = \frac{Ns}{Np} Is(pk) \text{ .... } \textbf{(Eq. 3.6.1.3.7)}$$

3.6.1.4 Calculations for Fly Back Inductor Coil

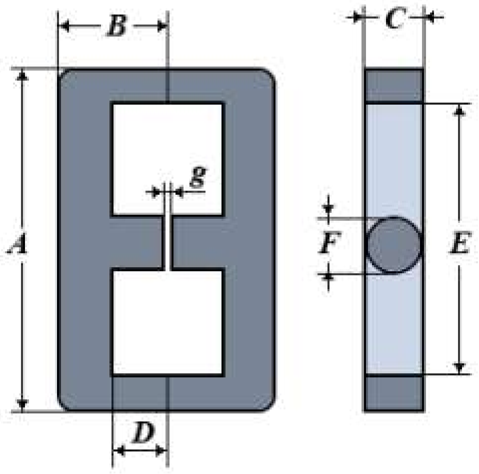
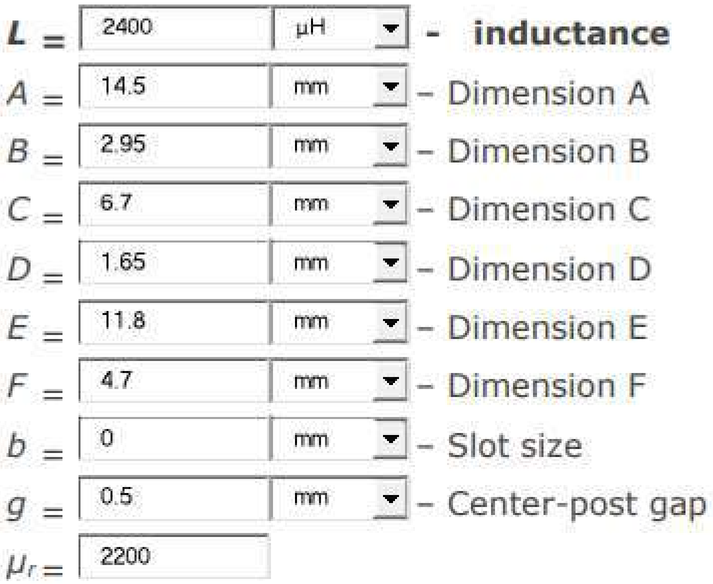


Figure 3. 7: Calculations for Fly Back Inductor Coil



L = 2400 µH - inductance

A = 14.5 mm - Dimension A

B = 2.95 mm - Dimension B

C = 6.7 mm - Dimension C

D = 1.65 mm - Dimension D

E = 11.8 mm - Dimension E

F = 4.7 mm - Dimension F

b = 0 mm - Slot size

g = 0.5 mm - Center-post gap

μ_r = 2200

Figure 3. 8: Values of Dimensions

$$\text{Number of turns } N = 32$$

$$\text{Effective magnetic path length: } Ie = 336.096\ mm$$

$$\text{Effective cross-sectional area: } Ae = 388.144\ mm^2$$

$$\text{Effective core volume: } Ve = 130453.606\ mm^3$$

$$\text{Peak current limited by the core saturation: } Ip = 1.5526\ A$$

3.6.1.5 Finding the Performance parameters of a Flyback Converter:

$$Vo = 24\,v\,,\ R = 0.8\,ohms\ k = 50\%\,,\ Fsw = 31khz$$

$$\text{Voltage drop of Transistors } Vt = 1.2V$$

$$\text{Voltage drop of Diode } Vt = 0.7V$$

$$\text{Turn Ratio of Transformer } a = \frac{Ns}{Np} = 0.25$$

a. **Output Power**

$$Po = Vo \cdot Io \ \ldots\ldots\ldots\ldots\ldots \ \textbf{(Eq. 3.6.1.4.1)}$$

$$Po = 24 \times 30$$

$$Po = 730W$$

b. **Secondary Voltage**

$$V2 = Vo + Vd \ \ldots\ldots\ldots\ldots\ldots \ \textbf{(Eq. 3.6.1.4.2)}$$

$$V2 = 24.7$$

c. Primary Voltage

$$V1 = \frac{V2}{a} \text{ .... } (\textbf{Eq. 3.6.1.4.3})$$

$$V1 = 98.8V$$

d. The Input Voltage

$$Vs = V1 + Vt \text{ .... } (\textbf{Eq. 3.6.1.4.4})$$

$$Vs = 100V$$

e. Input power

$$Pi = \frac{Vs}{Is} \text{ .... } (\textbf{Eq. 3.6.1.4.4})$$

$$Pi = 1.2Ia + VdIo + Po \text{ .... } (\textbf{Eq. 3.6.1.4.5})$$

Substituting $Ia = Is$ gives

$$Is(100 - 1.2) = 0.7 \times 30 + 720$$

$$Is = \frac{741}{98.8}$$

$$Is = 7.5A$$

f. Efficiency

$$Pi = Vs \times Is \text{ .... } (\textbf{Eq. 3.6.1.4.6})$$

$$Pi = 750W$$

$$n = \frac{7.5}{750} = 96.0\%$$

g. Average transistor Current

$$Ia = Is = 7.5A$$

h. The peak transistor current

$$Ip = \frac{2Ia}{K} \text{ .... } (\textbf{Eq. 3.6.1.4.7})$$

$$Ip = 2 \times \frac{7.5}{0.5}$$

$$Ip = 30A$$

i. The RMS Transistor Current

$$Ir = \frac{\sqrt{k}}{3Ip} \text{ .... } (\textbf{Eq. 3.6.1.4.8})$$

$Ir = 12.25A$ For 50% duty cycle

j. Open circuit Transistor voltage

$$Voc = Vs + \frac{V2}{a} \text{ .... (Eq. 3.6.1.4.9)}$$

$$Voc = 198.8V$$

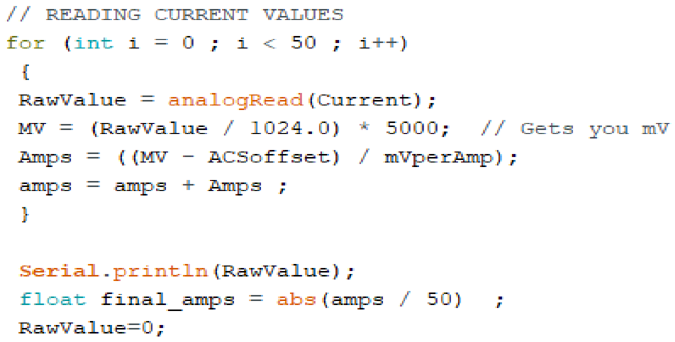
k. The Primary Magnetizing Inductor

$$Lp = \frac{Vsk}{f \times Ip} \text{ .... (Eq. 3.6.1.4.10)}$$

$$Lp = 1.67mH$$

3.6.2 State of Charge

The state of charge (SoC) of a rechargeable battery is the proportion of the total quantity of electrical energy it has available at any one time. It stands for the amount of power that may be used to run a machine or system. As it defines the amount of leftover energy that is usable, SoC is an essential measure for controlling and predicting the battery's performance. Users can comprehend the battery's capacity and adjust their usage by evaluating and tracking the SoC. In a variety of applications, including electric cars, renewable energy systems, as well as portable electronic gadgets, it offers efficient energy management, avoids overcharging or over-discharging, and also enables battery life improvement.



```
// READING CURRENT VALUES
for (int i = 0 ; i < 50 ; i++)
 {
 RawValue = analogRead(Current);
 MV = (RawValue / 1024.0) * 5000;  // Gets you mV
 Amps = ((MV - ACSoffset) / mVperAmp);
 amps = amps + Amps ;
 }

 Serial.println(RawValue);
 float final_amps = abs(amps / 50)   ;
 RawValue=0;
```

Figure 3. 9: Code for State of Charge

3.6.3 Battery Measurement System

A specialized combination of tools, gadgets, and algorithms called a battery measurement system (BMS) is used to track and examine the functionality and state of a battery. It generally consists of sensors, data collecting systems, and also software algorithms that gather and process a variety of metrics, including voltage, current, temperature, as well as state of charge (SoC), in order to offer thorough details about the battery's condition and activity. BMSs are often used in a variety of applications, including portable electronic gadgets, renewable energy systems, and electric cars. A BMS allows for effective and secure battery operation, precise SoC estimate, and defense from overcharging or over-discharging, and can potentially lengthen battery life by continually monitoring battery conditions.

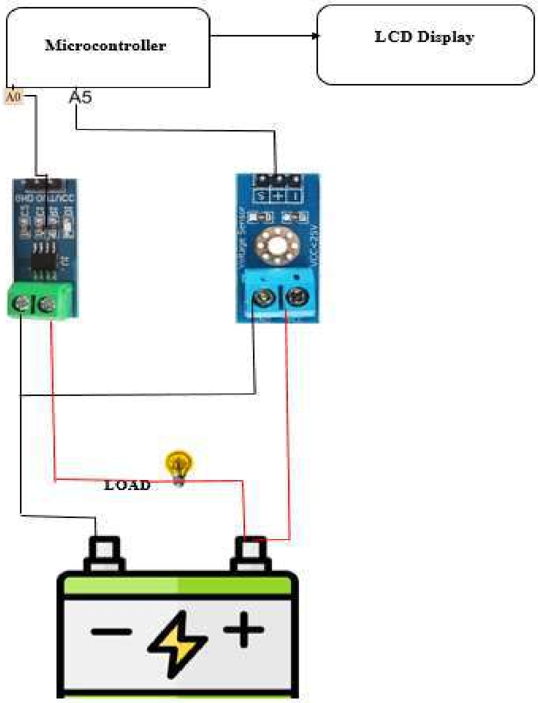


Figure 3. 10: Block Diagram of Battery Measurement System

3.7 Details of Final Working Prototype

We have created a charger that can recharge the batteries used in bicycles and electric cars (EVs). The highest voltage that our charger can handle is 60 volts. It has customizable settings through a probe and can give a variable current range of 1 to 10 amps. The charger has an LCD display that shows real-time data such battery voltage, charging progress, output current, and the current limit that the user has selected. Our charger also includes a number of safety precautions, such as a 10-amp fuse and a series board at the start of the charging circuit that effectively caps the input power.

3.8 Summary

This chapter shows the methodologies that have been adopted for the software designing. Project software designing along with block diagrams and functions pictures are include.

Chapter 4

TOOLS AND TECHNIQUES

In this chapter, is discussing in detail all the tools used in your work. This includes hardware, software and simulation tools.

4.1 Hardware Tools

Hardware tools used in this project are:

4.1.1 Buck Converter

A Buck converter, also known as a step-down converter, is a type of DC-DC converter that converts a higher voltage level into a lower voltage level. It works by switching a high voltage input on and off using a switch (typically a transistor), and then filtering the resulting waveform to obtain a lower voltage output.

The basic operation of a Buck converter involves four main components: an input voltage source, a power switch, an inductor, and a diode. When the switch is closed, the inductor stores energy from the input voltage source. When the switch is opened, the stored energy in the inductor is transferred to the output load through the diode. This process repeats itself continuously, resulting in a steady output voltage that is lower than the input voltage [18].

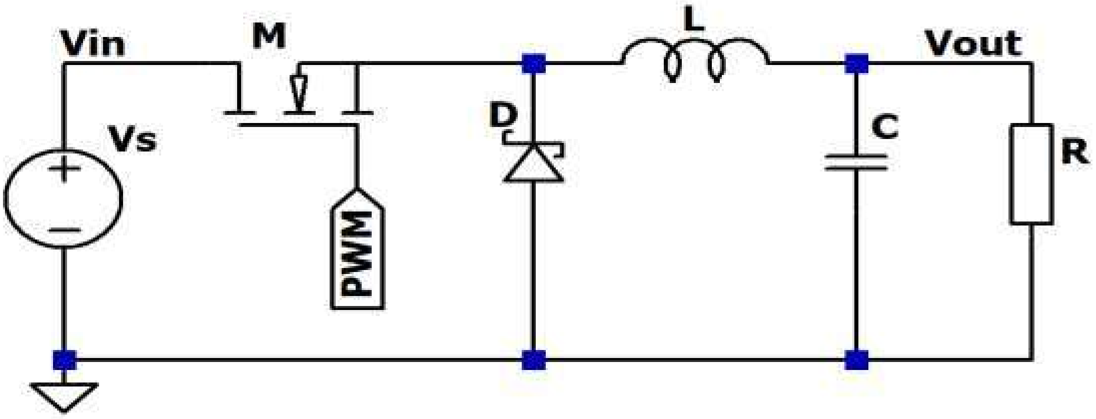


Figure 4. 1: Buck Converter

Buck converters are commonly used in a variety of applications, such as in power supplies for electronic devices, battery charging circuits, and LED drivers. They offer high efficiency, low cost, and small size, making them an attractive choice for many designers. However, they are also sensitive to variations in input voltage and load conditions, and require careful design and tuning to ensure optimal performance.

There are several types of DC-DC converters, and each has its own unique characteristics and applications. Here are some of the key differences between Buck converters and other common types of DC-DC converters [19]:

- **Buck Converter vs Boost Converter:**

  The table below shows the difference between buck converter and boost converter.

Table 4. 1: Buck converter vs Boost converter

Buck Converter	Boost Converter
A Buck converter steps down the input voltage	A Boost converter steps up the input voltage.
A Buck converter uses an inductor to store energy and a diode to transfer the energy to the output.	A Boost converter uses an inductor and a switch to transfer energy to the output.
Buck converter applications : mobile devices, LED lighting, automotive electronics, solar power systems, industrial automation etc.	A Boost converter is often used in applications where the input voltage is lower than the required output voltage, such as in battery-powered devices.

- **Buck Converter vs Buck-Boost Converter:**

  The table below shows the difference between buck converter and buck-boost converter.

Table 4. 2: Buck converter vs Buck-Boost converter

Buck Converter	Buck Boost Converter
A Buck converter steps down the input voltage.	A Buck-Boost converter can step down or step up the input voltage.
A Buck converter uses an inductor to store energy and a diode to transfer the energy to the output.	A Buck-Boost converter uses an inductor and a switch to transfer energy to the output, and can reverse the polarity of the output voltage.
Buck converter applications : mobile devices, LED lighting, automotive electronics, solar power systems, industrial automation etc.	A Buck-Boost converter is often used in applications where the input voltage can vary widely, such as in automotive and solar power systems.

- **Buck Converter vs Forward Converter:**

  The table below shows the difference between buck converter and forward converter.

Table 4. 3: Buck converter vs Forward converter

Buck Converter	Forward Converter
A Buck converter uses a single inductor to store and transfer energy	A Forward converter uses a transformer to store and transfer energy.
A Buck converter typically provides a single output.	A Forward converter can provide multiple isolated outputs.
Buck converter applications : mobile devices, LED lighting, automotive electronics, solar power systems, industrial automation etc.	A Forward converter is often used in high-power applications, such as in industrial and telecom power supplies.

4.1.2 Fly Back Convertor

A common form of DC-DC converter used for voltage conversion in power electronics applications is the fly-back converter. A transformer is used in this switching power supply design to store and move energy between the input and output sides. A fly-back converter's fundamental operation entails the storage of energy during the "on" period when the input voltage is applied in the magnetic field of the transformer. The energy that has been stored is released to the output side during the "off" period when the input voltage is shut off. The word "fly-back" refers to the discontinuous method in which this energy is transferred. A power switch (often a MOSFET), a diode, a transformer, an energy storage capacitor, and control circuitry are the main parts of a fly-back converter. The control circuitry controls the power switch's switching to control the output voltage. Fly-back converters provide benefits, including the capacity to recover energy during the fly-back cycle, galvanic isolation among both input and output, voltage step-up and step-down capability, multiple output capability, as well as high efficiency. They are often utilized in low- to medium-power electronic systems, battery chargers, LED drivers, and power supplies [20].

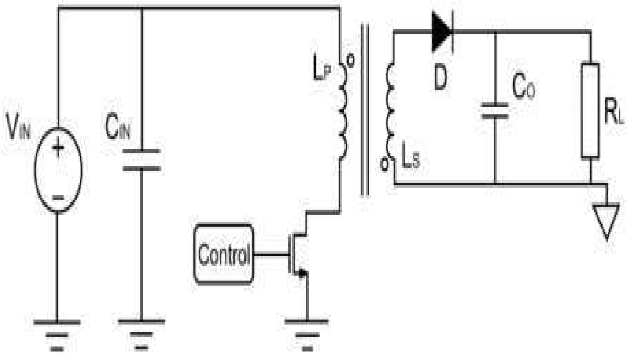


Figure 4. 2: Fly-back Converter Schematic [20]

Fly-back converters have the same fundamental components as the majority of other switching converter topologies, but what sets them apart is their linked inductor, which separates the converter's input from its output. The two signal semi-periods of a fly-back converter, T_{ON} also T_{OFF}, are identified after (and regulated by) the switching states of the MOSFET.

The MOSFET is in the on state throughout T_{ON}, thus current flows through the primary inductor from the input to linearly charge the linked inductor. The connected inductor starts to demagnetize through the diode when the MOSFET is in the off state (T_{OFF}). The load is powered by the inductor's current, which also charges the output capacitor [20].

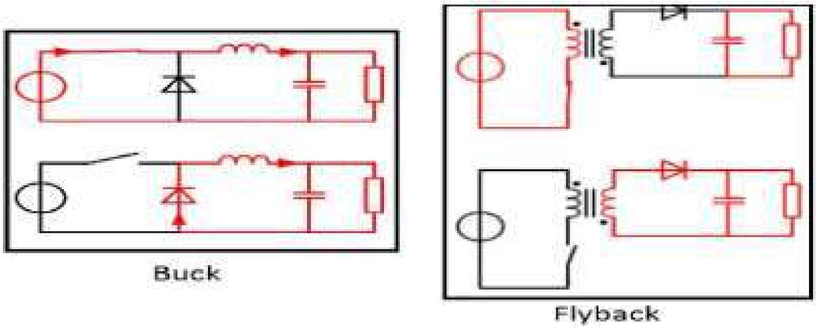
4.1.2.1 Reasons for working with Fly Back Converter instead of Buck Converter

Reasons for working with Fly Back Converter instead of Buck Converter:

- **Isolation:** Galvanic isolation is a feature of a flyback converter that prevents a direct electrical connection from existing between the input and output sides. This isolation provides increased safety since it improves the separation of delicate electronics in the charging system and helps prevent electrical shocks.
- **Voltage Regulations:** Better voltage control is possible with flyback converters, because of their transformer-based construction. Regardless of changes in input voltage, the transformer enables stepped-up or stepped-down voltage conversion, making it simpler to produce the necessary output voltage for charging the electric bike's battery.
- **High Efficiency:** Because flyback converters can recover energy throughout the flyback cycle, they may operate at high-efficiency levels. When compared to buck converters, the energy accumulated in the transformer during the

switching phase is released during the flyback phase, improving energy efficiency, particularly at bigger input-output voltage differences.

- **Design Freedom:** When compared to buck converters, flyback converters offer greater design freedom. They are appropriate for many circumstances involving the charging of electric bikes since they can handle a broad range of input voltages and output power levels. Flyback converters may also deliver various output voltages concurrently, enabling the charge of numerous battery packs or the powering of supplementary motorcycle electronics.



Buck

Flyback

Figure 4. 3: Buck vs. Flyback

1.1.3 Current Sensor Module

A device that measures as well detects the electric current flowing across a circuit is called a current sensor module. It comprises a current sensor component that incorporates extra circuitry for signal processing and output. The current sensor component may be based on the Hall Effect, shunt resistor, or current transformers, among other theories. For monitoring, controlling, and protecting functions, the module is made to deliver exact and accurate readings of current. It often has characteristics such as a broad measuring range, little burden voltage, low insertion loss, and good linearity. Analog or digital current sensor modules are available, with output possibilities including voltage, current, or digital interfaces like I2C or SPI. Power management, renewable energy sources, electric cars, industrial automation, and robotics are just a few of the areas where they are used. With benefits like non-invasive measurement, high accuracy, quick response, and low power consumption, alongside electrical isolation among the measured current and the sensing circuit, these modules ensure secure and trustworthy current monitoring in a variety of electrical and electronic systems [21].

1.1.3.1 ACS712 Current Sensor Module

The ACS712 Current Sensor Module is one form of current sensor module specifically designed to measure and detect electric current using the ACS712 integrated circuit. Because of its Hall Effect foundation, it can precisely measure both AC and DC currents. A current sensor chip, signal processing hardware, and output amplification make up the ACS712 module. It is intended to give users a non-intrusive, isolated way to measure current in a circuit without having to interrupt it. Common properties of the module include a broad current measuring range, good linearity, a small offset, and low noise. It is offered in several current rating choices, enabling customers to choose the ideal module by their unique application needs. The ACS712 module typically produces an analog voltage output that is inversely proportional to the measured current. For additional processing or monitoring, this analog output is readily interfaced with microcontrollers, analog-to-digital converters (ADCs), or other electronic devices. Applications for the ACS712 Current Sensor Module include industrial automation, robotics, motor control, energy management, and power monitoring. It is a popular option for precisely measuring current in a variety of electrical and electronic systems because of its small size, simplicity of use, and dependable performance [22].

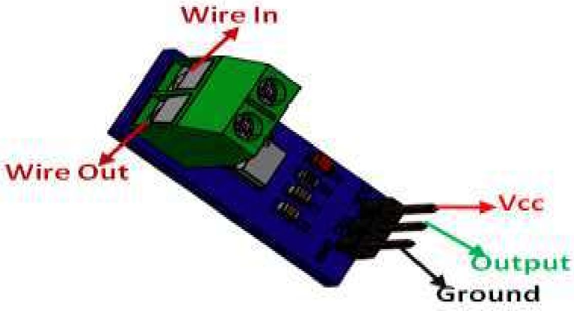


Figure 4. 4: ACS712 Current Sensor Module [22]

Table 4. 4: ACS712 Pin Description [22]

Pin No.	Pin Name	Description
1	Vcc	The input voltage for common applications is +5V.
2	Output	Analog voltage outputs that are proportional to current.
3	Ground	It is connected to the circuit's ground.

T1	Wire In	Wire that requires to be attached to measure current is connected.
T2	Wire Out	The output of analog voltage according to the observed current.

These ACS712 modules have a measurement range of +5A to -5A, +20A to -20A, and +30A to -30A for AC or DC current. Since precision must be sacrificed for larger range modules, it is important to choose the appropriate range for your project. Due to the fact that this module generates analogue voltage (0–5V) dependent on the current passing through the wire, it is extremely simple to connect it to any microcontroller. [23]

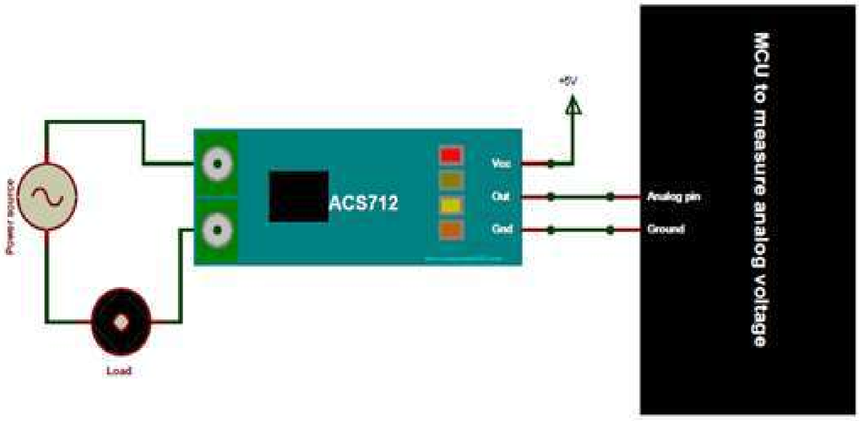


Figure 4. 5: Interface the ACS712 Module with Microcontrollers [23]

Connect the analog output pin of the ACS712 module to any of the analog input pins (A0-A7) on an Arduino Nano to interface the device. Reading the analog voltage from the ACS712 module and converting it to a digital value may be done using the Arduino's included ADC (analog-to-digital converter) functionalities. This digital value may then be used in your Arduino code for additional computations or control logic [23].

1.1.4 Arduino Nano

The ATmega328P microcontroller chip serves as the foundation for the small and adaptable Arduino Nano microcontroller board. One of the most well-known members of the Arduino family, it provides a wide range of features for embedded system development and prototyping. The Nano board is distinguished by its tiny form factor, which makes it perfect for applications with limited space. It has SPI

(Serial Peripheral Interface), and I2C (Inter-Integrated Circuit) interfaces for connecting to other devices and sensors, as well as digital input/output pins, analog inputs, PWM (Pulse Width Modulation) pins, UART (Universal Asynchronous Receiver-Transmitter) communication capabilities, plus digital input/output and PWM pins. The Arduino Software (IDE), which enables users to create and upload code quickly to control multiple components and interact with the real environment, may be used to program the Arduino Nano. Its compatibility for a wide variety of libraries and shields enables quick development and increases its functionality. The Arduino Nano is frequently used in projects including robotics, automation, the Internet of Things (IoT), sensor interfacing, and educational objectives thanks to its low cost, simplicity of use, and wide variety of applications [24].

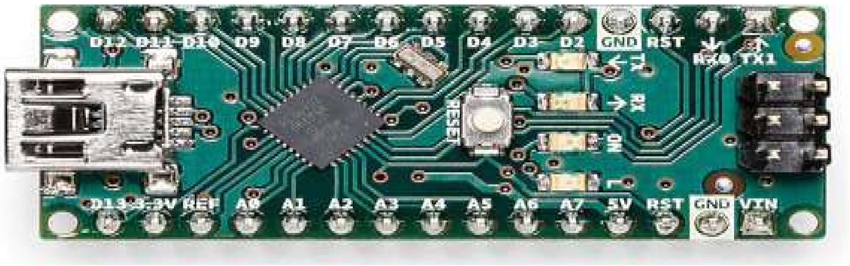


Figure 4. 6: Arduino Nano [24]

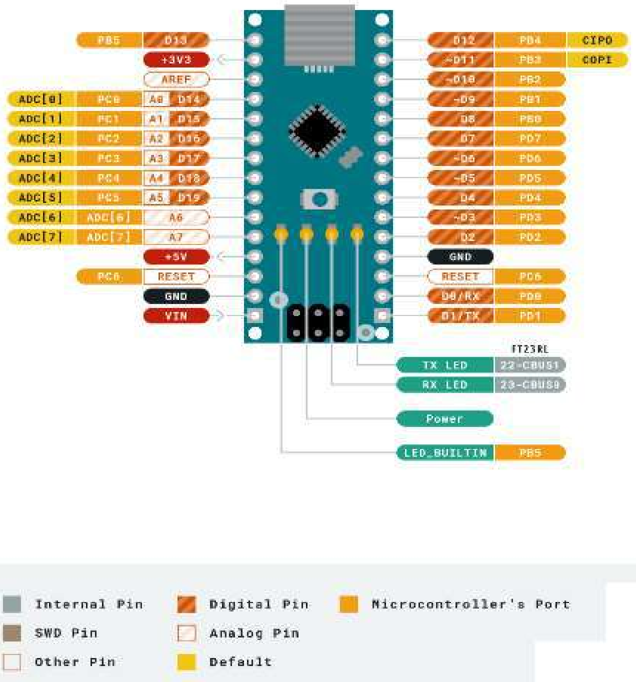


Figure 4. 7: Arduino Nano Pins [24]

The ATmega328P microcontroller processor, which powers the Arduino Nano, runs at 16 MHz and has 32KB of flash memory and 2KB of SRAM. It has 8 analog input pins, 6 PWM pins, and 14 digital I/O pins. UART, SPI, and I2C communication protocols are supported by the board. It can be supplied through a USB or an external power source with a voltage range of 7 to 12 volts, and it contains a voltage regulator and a USB interface for programming and power. The 18mm x 45mm Arduino Nano comes in a variety of variations, including the Nano 33 series, with extra features, including BLE connection and improved processing power [24].

Below is a table of Arduino Nano technical specifications:

Table 4. 5: Arduino Nano Technical Specifications [24]

Arduino Nano Technical Specification	
Microcontroller	ATmega328
Architecture	AVR
Operating Voltage	5V
Flash Memory	32 KB of which 2 KB used by bootloader
SRAM	2KB
Clock Speed	16 MHz
Analog (Pins)	8
EEPROM	1 KB
DC Current per I/O Pins	40 mA (I/O Pins)
Input Voltage	7-12V
Digital I/O Pins	22 (6 PWM)
PWM Output	6
Power Consumption	19mA

1.1.5 Integrated Circuit

A small integrated circuit, or IC, is a collection of electronic components, including transistors, resistors, capacitors, and diodes, that are all mounted on a single semiconductor chip. The IC may execute a variety of tasks or electrical circuits thanks to the interconnection of the components through an intricate network of metal traces on the chip. Through the use of semiconductor production processes, it is possible to integrate millions or even billions of electronic parts into a single integrated circuit (IC). They may be divided into three separate categories: mixed-signal ICs, which integrate digital and analog circuitry, and digital ICs, which carry out logic operations. Analog ICs handle continuous signals. Modern electronics heavily rely on integrated circuits (ICs), which are used in a wide range of products, including computers, cellphones, televisions, automotive electronics, medical equipment, communication systems, and much more. Compared to conventional discrete electronic components, they have benefits, including smaller sizes, enhanced performance, decreased power consumption, and cheaper production costs. The growth and development of IC technology have greatly aided in the miniaturization and expansion of electronic device capability, revolutionizing a variety of sectors and influencing our current digital world [25].

Figure 4. 8: Integrated Circuit [25]

1.1.5.1 IR2104 Integrated Circuit

The IR2104 is an integrated circuit (IC) made primarily for high and low-side power MOSFET driving in switching-intensive applications. It is frequently employed in motor control and power electronics circuits. Two separate high- and low-side gate drivers, each competent in providing a high peak output current, are included in the IR2104 IC. With the help of this function, MOSFET switching may be done quickly and with the least amount of power loss. To guard against unusual operating situations, the IC has protective features, including overcurrent shutdown, undervoltage lockout, and heat shutdown. Input and output pins are also provided on the IR2104 for synchronization, enabling exact control of the switching frequency. This IC is frequently used in situations where precise control and effective switching of power MOSFETs are necessary, such as switch-mode power supply, motor drives, and inverters. Its small and integrated design makes it easier to construct circuits, boosts performance, and raises the overall dependability of the system [26].

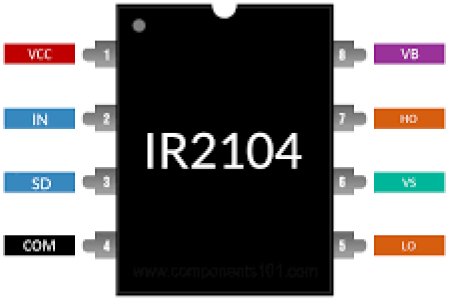


Figure 4. 9: IR2104 Integrated Circuit [26]

The IR2104(S) is a high voltage, high-speed power MOSFET and IGBT driver with dependent high and low side referenced output channels. Monolithic structure is made possible by proprietary HVIC and latch-immune CMOS technology. The conventional CMOS or LSTTL output is compatible with the logic input down to 3.3V [26].

A high pulse current buffer stage with little driver cross-conduction is a characteristic of the output drivers. An N-channel power MOSFET or IGBT with a high-side configuration that runs from 10 to 600 volts can be driven via the floating channel. Output drivers have a high pulse current buffer stage with less driver cross-conduction. The floating channel can drive an N-channel power MOSFET or IGBT with a high-side arrangement that operates between 10 and 600 volts [26].

Table 4. 6: Parameters of IR2104 [26]

Parameters	IR2104
Voltage Class	600V
VCC UVLO (On)	8.9 V
VCC UVLO (Off)	8.2 V
Turn On Propagation Delay	680 ns
Turn Off Propagation Delay	150 ns
Output Current (Sink)	0.36 A
Output Current (Source)	0.21 A
Isolation Type	Functional levelshift

Input Vcc min	10 V
Input Vcc max	20 V
Channels	2

1.1.6 Capacitors

An electronic component known as a capacitor stores and releases electrical energy. It is made up of two conductive plates that are spaced apart by a dielectric substance. An electric field forms in the dielectric when a voltage is applied across the capacitor, creating a potential difference between the plates. An electrostatic charge is a sort of energy that is stored in this electric field. Electronic circuits frequently employ capacitors for a number of functions, including energy storage, filtering, coupling, and timing. They occur in a variety of forms, such as tantalum, ceramic, electrolytic, and film capacitors, each having unique properties and uses. The amount of charge that a capacitor can hold per unit of voltage is determined by its capacitance, which is expressed in farads (F). They also have additional characteristics that determine how well they operate in certain circuit applications, including voltage rating, tolerance, and equivalent series resistance (ESR). Smoothing out voltage fluctuations, blocking direct current (DC), passing alternating current (AC), and storing energy to be released when necessary are all important functions of capacitors. They are crucial parts of many electronic systems, including power supply, amplifiers, filters, oscillators, and many other devices due to their capacity to store and release electrical energy [27].

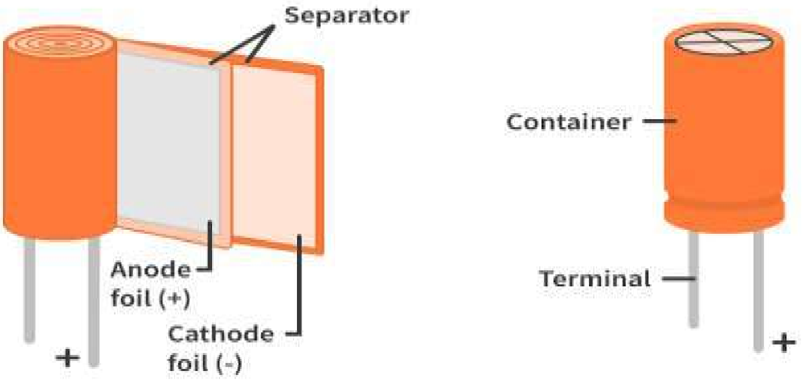


Figure 4. 10: Capacitors [27]

1.1.7 Diodes

An electrical component with two terminals called a diode permits current to flow in one direction while blocking it in the other. It is made of a p-n junction and is made of semiconductor materials, usually silicon or germanium. A material with an excess of positive charge carriers (holes) is used to dope the p-side of the diode, while a substance with an excess of negative charge carriers (electrons) is used to dope the n-side. The diode conducts current freely, enabling electrons to go from the n-side to the p-side, when a voltage is applied across it in the forward bias direction, with the positive terminal connected to the p-side and the negative terminal connected to the n-side. Forward bias is the operational area in question. Due to the depletion area generated at the p-n junction, the diode stops current flow when the voltage is applied in the opposite bias direction, providing a high resistance channel. Reverse bias refers to this area of operation. Electronics used for diodes include signal demodulation, rectification, voltage clamping, voltage control, and protection from reverse current flow [28].

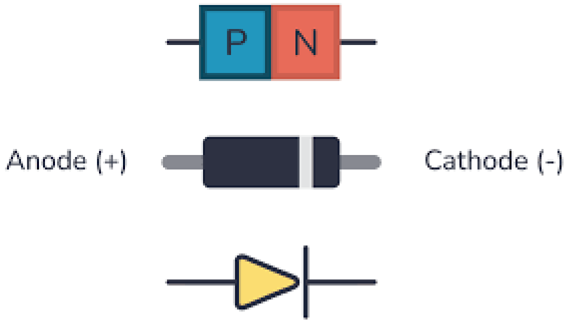


Figure 4. 11: Diode [28]

MUR1560G - MUR1560G 15A 600V Ultra-Fast Recovery Diode

Features

- Peak Repet. Reverse Voltage (Vrrm): 600V
- Max. DC Reverse Voltage (Vdc): 600V
- Average Rectified Current (Io): 15.0A
- Maximum Reverse Current (Ir): 100µA
- Maximum Power Dissipation (Pd): 100W
- Maximum Forward Voltage (Vf): 1.05V

Figure 4. 12: MUR1560G Diode [28]

1.1.8 Resistors

An electrical component known as a resistor works to counter the passage of electric current in a circuit. It is intended to have a certain resistance value expressed in ohms (Ω). Typically, high-resistivity materials like carbon, metal, or metal oxide coatings are used to make resistors. They are coupled to other components in series or parallel and have two terminals to regulate the voltage or current flow in a circuit. According to Ohm's Law (V = I R), when a voltage is put across a resistor, a voltage drop proportionate to the current flowing through it results. The magnitude of this voltage drop is determined by the resistance value. Resistors are used in many different ways in electronics, including controlling the amount of current that flows, dividing the voltage, providing biasing for electronic circuits, reducing the amplitude of signals, and establishing the gain or time constant of amplifiers and filters. They can be found in a variety of shapes, including through-hole, surface-mount, and variable resistors (potentiometers). To meet the needs of various circuits, resistors are offered in a wide range of resistance levels and power ratings [29].

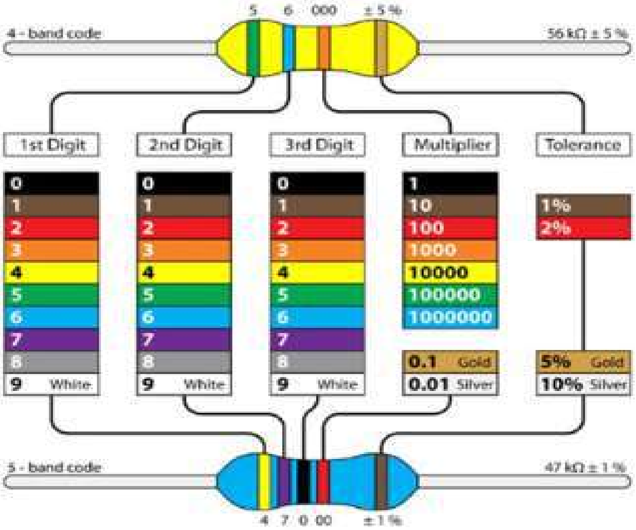


Figure 4. 13: Resistors [29]

1.1.9 LCD

Liquid Crystal Display is referred to as LCD. It is a flat-panel display technology that generates visual output using liquid crystals. A layer of liquid crystals is placed between two transparent electrodes, polarizing filters, and two transparent electrodes in LCDs. The LCD display module operates within a voltage range of 4.7V to 5.3V. It has a low current consumption of 1mA when the backlight is not activated. This alphanumeric LCD module is capable of displaying both alphabets and numbers. It consists of two rows, with each row capable of displaying up to 16 characters. Each character is built using a 5x8 pixel box, allowing for clear and legible text. The module can function in both 8-bit and 4-bit mode, providing flexibility in interfacing with microcontrollers or other control systems. One of the notable features of this LCD module is its ability to display custom-generated characters. This means that users can define and display their own character patterns within the 5x8 pixel grid, offering a degree of customization and versatility in visual representation. The module can be programmed to show special symbols, logos, or unique characters that suit the specific requirements of the application. This feature allows for enhanced visual representation and personalization in applications such as embedded systems, user interfaces, and various electronic devices [30].

Figure 4. 14: LCD [30]

1.1.10 Voltage Regulator

Regardless of changes to its input voltage or load circumstances, a voltage regulator generates an output voltage with a predetermined magnitude that is constant.

1.1.10.1 Voltage Regulator (7812)

The 7812 is a well-liked integrated circuit that regulates positive voltage and delivers a steady output voltage of +12 volts. Even if the input voltage swings or fluctuates, it can accept input voltages of more than 12 volts (usually up to 35 volts) and yet provide a steady output value of +12 volts. The 7812 is frequently used in electronic circuits that need a reliable voltage source, such as audio amplifiers, power supplies, and other applications that need for a regulated +12V power supply [31].

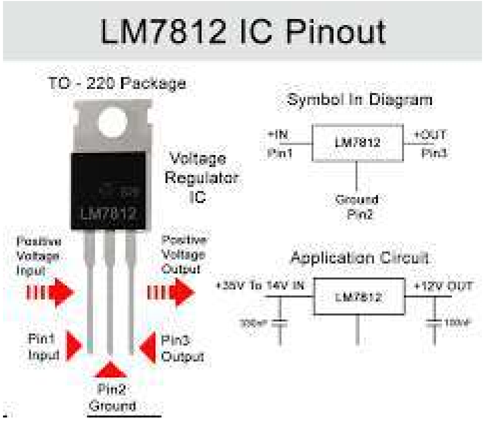


Figure 4. 15: Voltage Regulator (7812) [31]

1.1.10.2 Voltage Regulator (7805)

The voltage regulator (7805) delivers a fixed, controlled output voltage of +5 volts and is another popular positive voltage regulator IC. It accepts an input voltage of more than 5 volts (usually up to 35 volts) and keeps a steady output value of +5 volts, just like the 7812. The 7805 is widely used in many electronic devices and projects, including sensors, digital circuits, microcontrollers, and other things that need a consistent and dependable +5V power supply. Due to its accessibility and simplicity, it is a preferred option for many professionals and enthusiasts [32].

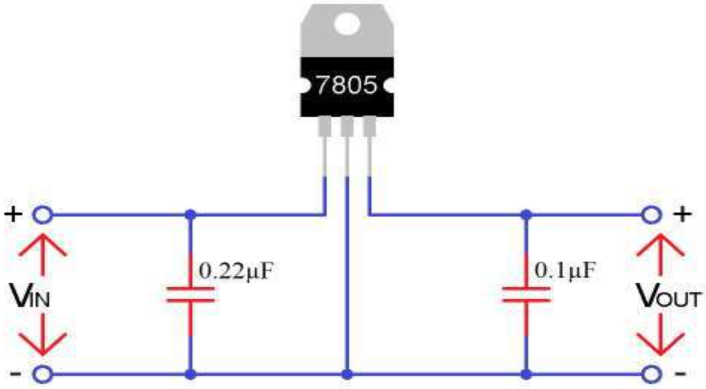


Figure 4. 16: Voltage Regulator (7805) [32]

1.1.11 IRF470 Power MOSFET

A Power MOSFET, or Metal-Oxide-Semiconductor Field-Effect Transistor, is the IRF470. It is a kind of electrical component used in high-power devices such power supply, amplifiers, and motor control. A power MOSFET produced by International

Rectifier, which is now a division of Infineon Technologies, is particularly referred to as the IRF470. This MOSFET is built to effectively withstand high current and voltage levels. With its low on-resistance, there are fewer power losses and more efficiency. The IRF470 is frequently utilized in several industrial as well as automotive sectors where high-power switching needs to be fulfilled due to its durable design and high-performance features [33].

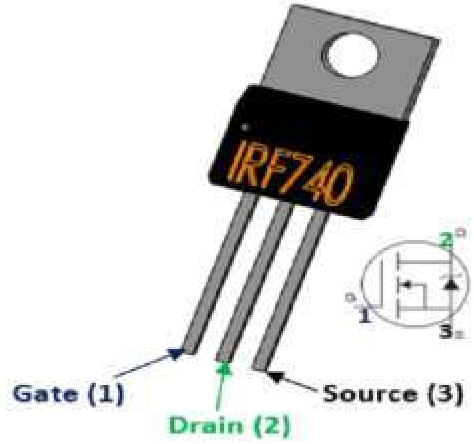


Figure 4. 17: IRF470 Power MOSFET [33]

1.2 Software and Simulation Tools

Software work done on this project is given below:

1.2.3 Multisim

The National Instruments (NI) created the software program Multisim to make it easier to build, simulate, and analyze electrical circuits. Users may build circuits utilizing a huge library of electronic components and simulate their behavior in a virtual environment. Users of Multisim may carry out several studies, including DC, AC, and transient analysis, to assess the performance of circuits, ensure the integrity of signals, and confirm the functioning of designs. Users may visualize circuit responses, evaluate voltage and current levels, and troubleshoot any problems using the software's interactive simulation features. In fields including education, research, and development, the multisim is frequently used to educate and study electronics, prototype circuit designs, and improve performance before physical implementation. For thorough circuit design and analysis, it provides an easy user interface, cutting-edge simulation features, and seamless connection with other products. Engineers, students, and electronics hobbyists can use Multisim to speed up the design process, reduce mistakes, and acquire an understanding of circuit behavior in a virtual setting [34].

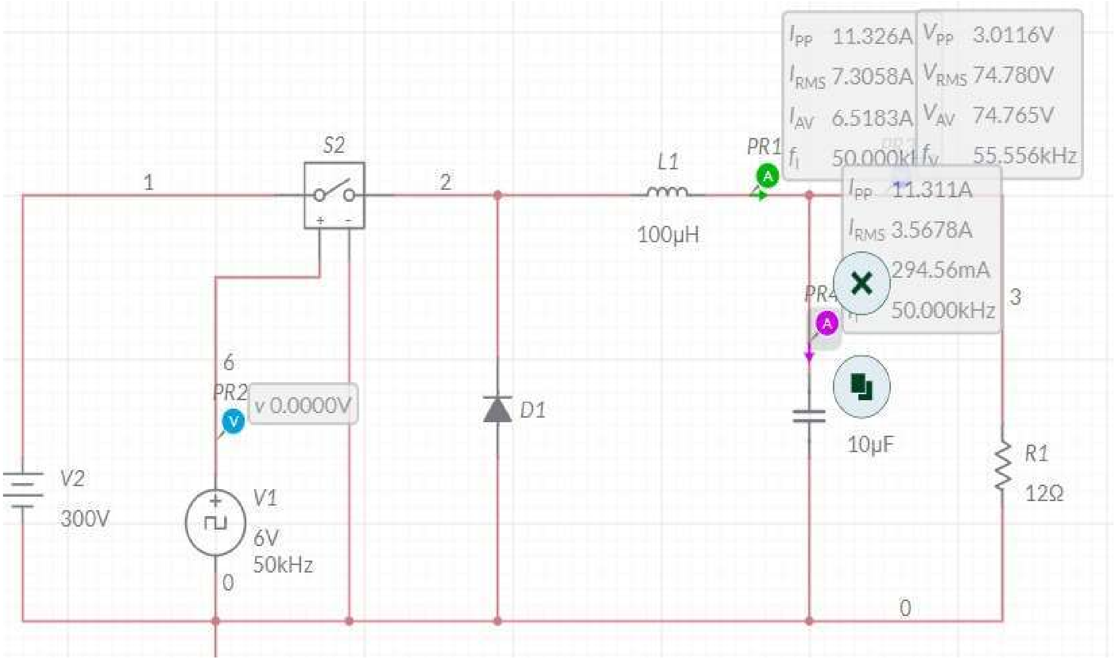


Figure 4. 18: Simulation in Miltisim

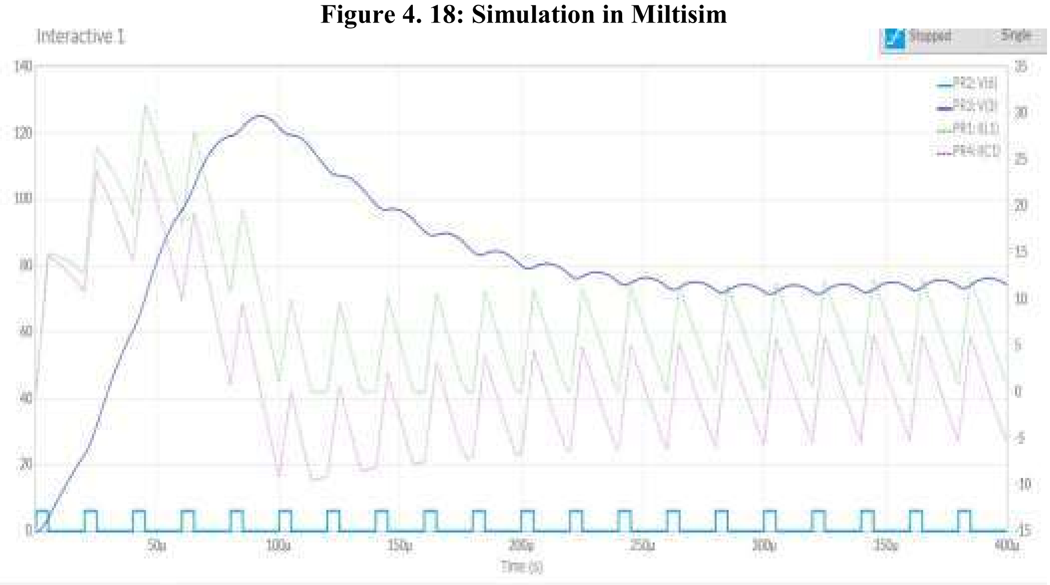


Figure 4. 19: Output in Miltisim

1.2.4 Proteus

Proteus is a piece of software created by Labcenter Electronics that provides a complete answer for PCB (Printed Circuit Board) layout, simulation, and electrical circuit design. Engineers, students, and electronics hobbyists may build and test circuits on a virtual platform before physically fabricating them. ISIS, for circuit design and simulation, and ARES, for PCB layout design, are the two core components that makeup Proteus. ISIS enables users to build circuits using a large component library, simulate component behavior, and examine circuit characteristics like voltage, current, as well as signal integrity. Users may design and layout PCBs using ARES, as well as place components and route traces [35].

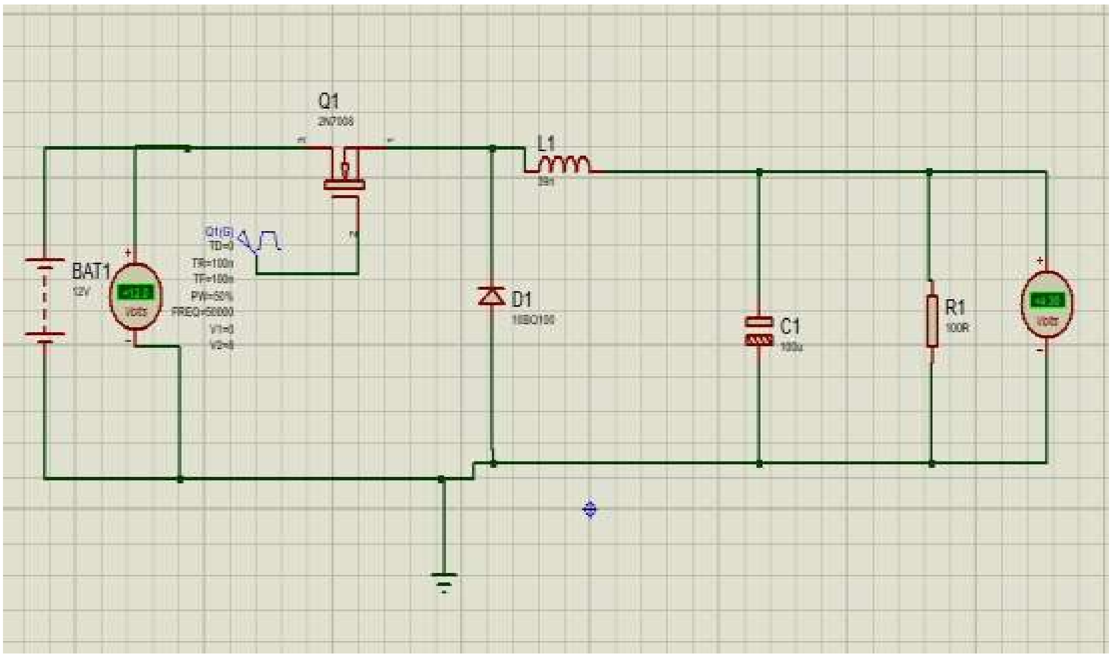


Figure 4. 20: Simulation in Proteus

1.2.5 EasyEDA

EasyEDA is a cloud-based electronic design automation (EDA) software program that enables users to create electrical circuits and PCB (Printed Circuit Board) layouts as well as stimulate them and work together on them. It offers a web-based platform that enables engineers, amateurs, and students to produce circuit designs of a professional caliber without requiring difficult installation or configuration. Users of EasyEDA may quickly drag and drop various components, such as resistors, capacitors, ICs, and more, onto the canvas to build circuits. With functions including schematic capture, PCB layout creation, simulation, and 3D visualization, the program has an intuitive user interface. Users may run SPICE simulations on their circuits to check design functionality and analyze their behavior. Apart from that, EasyEDA offers collaboration tools that let users discuss and collaborate in real-time on projects with team members. The program also provides connections with well-known PCB manufacturing services, which makes it simpler to translate designs into actual PCBs.

EasyEDA provides an easy-to-use platform for circuit design and PCB layout that is appropriate for a wide variety of users, from novices to seasoned engineers [36].

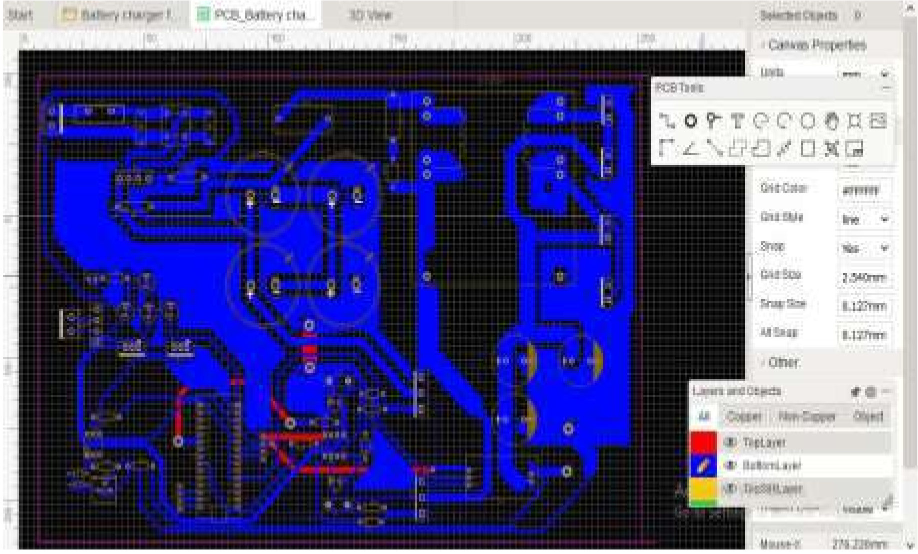


Figure 4. 21: PCB of Battery Charger using EasyEDA

Figure 4. 22: 3D view of PCB using EasyEDA

1.2.6 Arduino

A text editor for coding, a message box, a text terminal, a toolbar with buttons for necessary activities, and a number of menus (IDE) are all included with the Arduino software. The Arduino Software (IDE) makes it simple to develop code and upload it to the board when not connected to the internet. It is recommended for people who have a weak or no internet connection. This program is compatible with any Arduino board. The Arduino IDE presently comes in two types: IDE 1 and IDE 2. It permits communication and software upload by establishing a connection with the Arduino hardware [37].

Figure 4. 23: Arduino

1.2.6.1 Writing Sketches

Drawings may be made by programmers using the Arduino IDE. Text editors are used to generate and save these visuals as files. In the editor, you may search for and replace text as well as copy and paste text. The message area offers feedback and highlights exporting and storing issues. Detailed error messages and other information are sent to the terminal by the Arduino software (IDE). The bottom right window corner shows the configured board and serial port. The toolbar buttons may be used to validate and upload programmers, create, open, and save drawings, activate the serial monitor, and more. More commands are available through the five menus File, Edit, Sketch, Tools, and Help. Contextual menus only display options that are pertinent to the currently being carried out assignment [37]

1.3 Summary

The equipment, devices, parts, and software utilized to execute and accomplish our project are covered in this chapter. Go over each component in depth before introducing the software that will be utilized in this project. In our project, Proteus and Arduino were utilized. Before using a software program, verify and test how well it functions since every software program has a unique working principle. This includes software, hardware, simulation tools, and other components that we used in our project.

Chapter 5

PROJECT RESULTS AND EVALUATION

All hardware results are shown below. All of the outcomes are shown in photos. These outputs serve as the basis for evaluation.

5.1 Presentation of the Findings

The project results related complete description are given below:

5.1.1 Hardware Results

In order to enhance the waveform quality and lower harmonic content of the input AC voltage, an AC input filter is utilized in EV battery chargers. The AC/DC converter receives the output from the AC input converter. An AC/DC converter in an EV battery charger transforms incoming AC power into DC power so that the battery may be charged. A fly back converter, also known as a DC/DC converter, is a voltage regulator that transforms a higher DC input into a lower DC output by using the output of an AC/DC converter as an input. The DC/DC converter in an EV battery charger is used to reduce the rectified DC power voltage from the AC/DC converter to a level that is suitable for charging the battery. A charger control system will be there during the entire procedure to regulate it all and an LCD that displays the system's State of Charge.

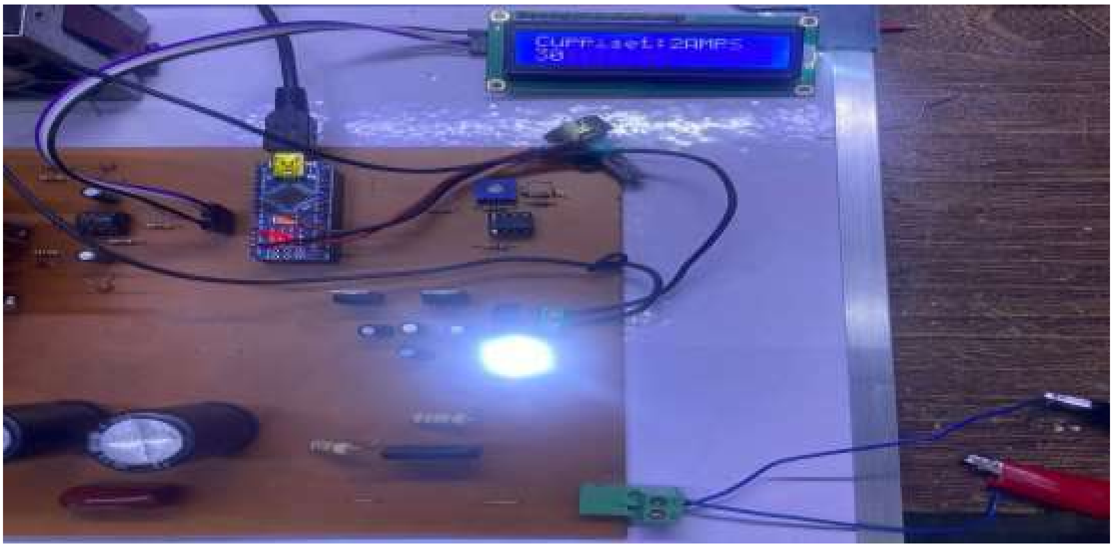


Figure 5. 1: Hardware Result P1

In the electric bike charger circuit, a 6A fuse for overcurrent protection comes after the AC input. The AC input is then converted to DC using a bridge rectifier, and capacitors are employed to smooth the output voltage. The circuit output is floating plus ground, and the float voltage controls the gate. This is essential because in order to properly switch on, N-channel MOSFETs require a larger VGS voltage than the drain-to-source voltage. To do this, a certain topology is used to supply the appropriate voltage to the MOSFET. The high and low sides are additionally driven by an IR2104 MOSFET driver, which accepts a single input and outputs the needed data. The circuit's PWM (Pulse Width Modulation) control, which enables accurate voltage regulation, is utilized in combination with an Arduino Nano. To accurately gauge the current moving across the circuit, an AC712 current sensor is employed. With the help of this thorough design, which also takes into account EMI reduction, gate driver needs, MOSFET driving, and current monitoring, the battery of the electric bike will be charged efficiently and under control.

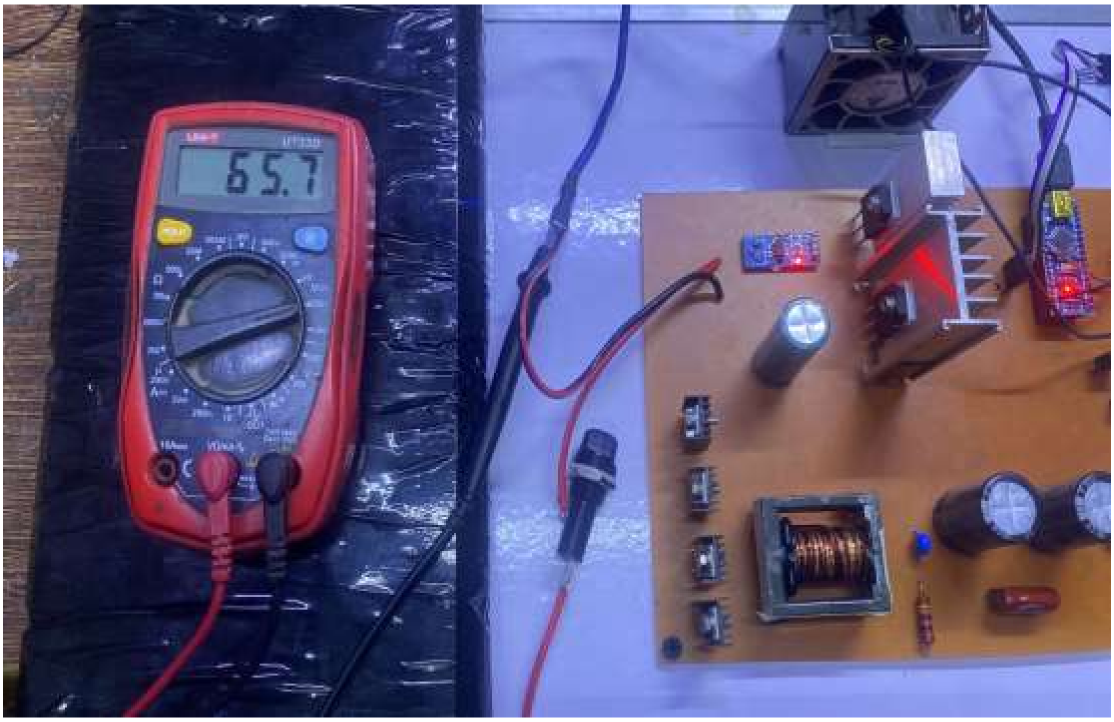


Figure 5. 2: Hardware Result P2

In the electric bike charger circuit, a 6A fuse for overcurrent protection comes after the AC input. The AC input is then converted to DC using a bridge rectifier, and capacitors are employed to smooth the output voltage. The circuit output is floating plus ground, and the float voltage controls the gate. This is essential because in order

to properly switch on, N-channel MOSFETs require a larger VGS voltage than the drain-to-source voltage. To do this, a certain topology is used to supply the appropriate voltage to the MOSFET. The high and low sides are additionally driven by an IR2104 MOSFET driver, which accepts a single input and outputs the needed data.

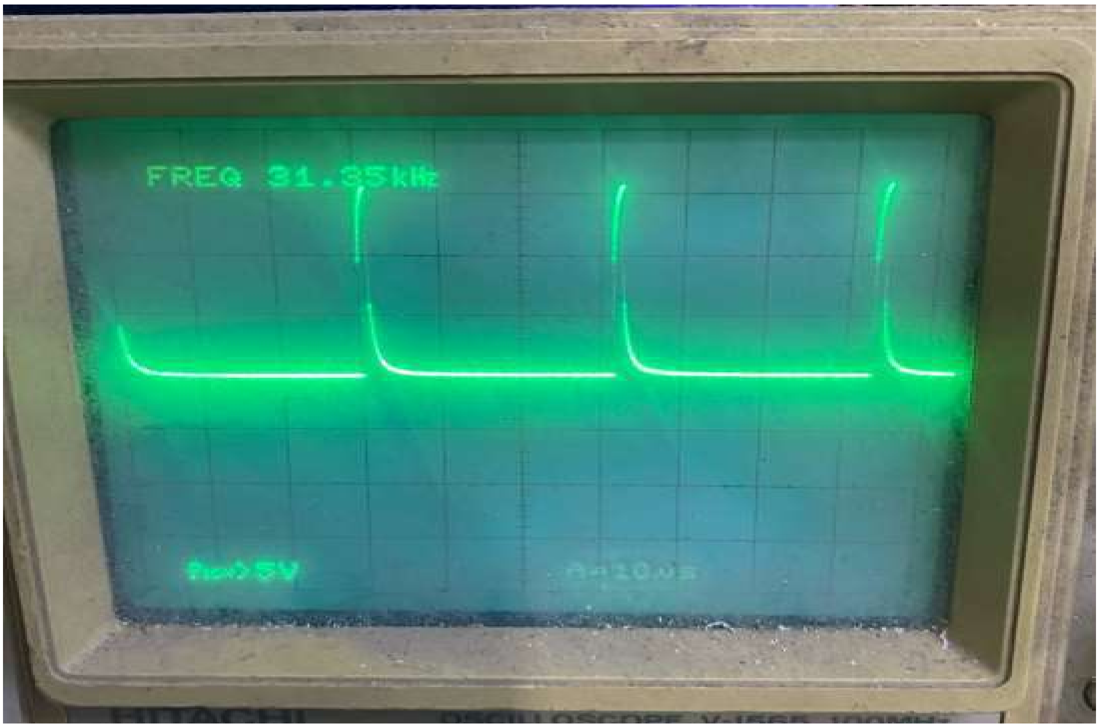


Figure 5. 3: Wave forms of IC

Below is the picture of the high side output of IC:

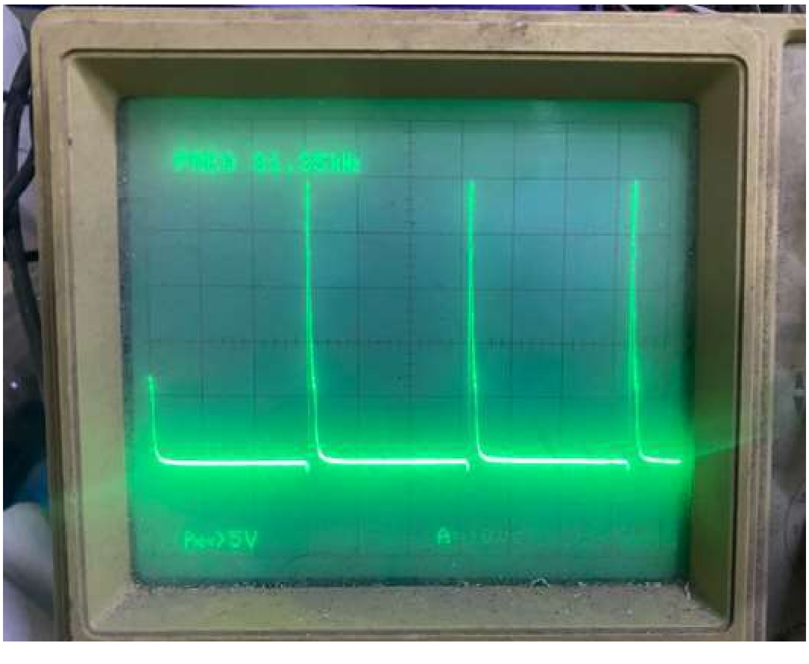


Figure 5. 4: Gate Driver High Side Output

Below is the picture of the low side output of IC:

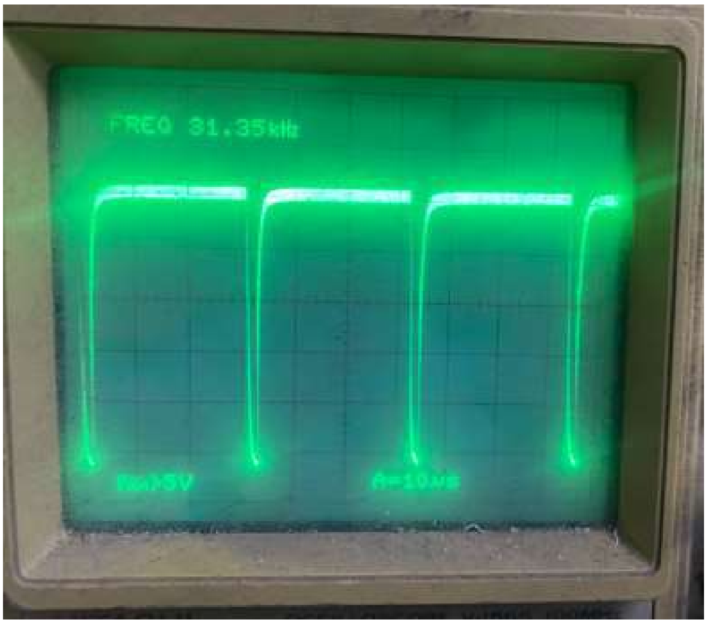


Figure 5. 5: Gate Drive Low Side Output

5.1.2 Software

A 6A fuse for overcurrent protection comes after the AC input in the electric bike charger circuit. A bridge rectifier is then used to convert the AC input to DC, and capacitors are used to smooth the output voltage. The circuit output is floating plus ground, and the gate is controlled by the float voltage. This is significant because N-channel MOSFETs need a higher VGS voltage than the drain-to-source voltage in order to fully switch on. To do this, a certain topology is employed to provide the MOSFET with the required voltage. An IR2104 MOSFET driver, which takes a single input and outputs the required data, is also used to drive the high and low sides. An Arduino Nano is used in conjunction with the circuit's PWM (Pulse Width Modulation) control, which permits precise voltage regulation. The Arduino Software (IDE) makes it simple to develop code and upload it to the board when not connected to the internet. The AC712 current sensor is used to properly measure the current flowing through the circuit. The battery of the electric bike will be charged effectively and in a controlled manner thanks to this comprehensive design, which also considers EMI reduction, gate driver requirements, MOSFET driving, and current monitoring. The powerful signal processing methods used by the AC712 current sensor also guarantee precise and dependable results. This makes it possible to precisely monitor the current levels, allowing for effective power management and averting any potential harm to the battery or electronics of the electric bike.

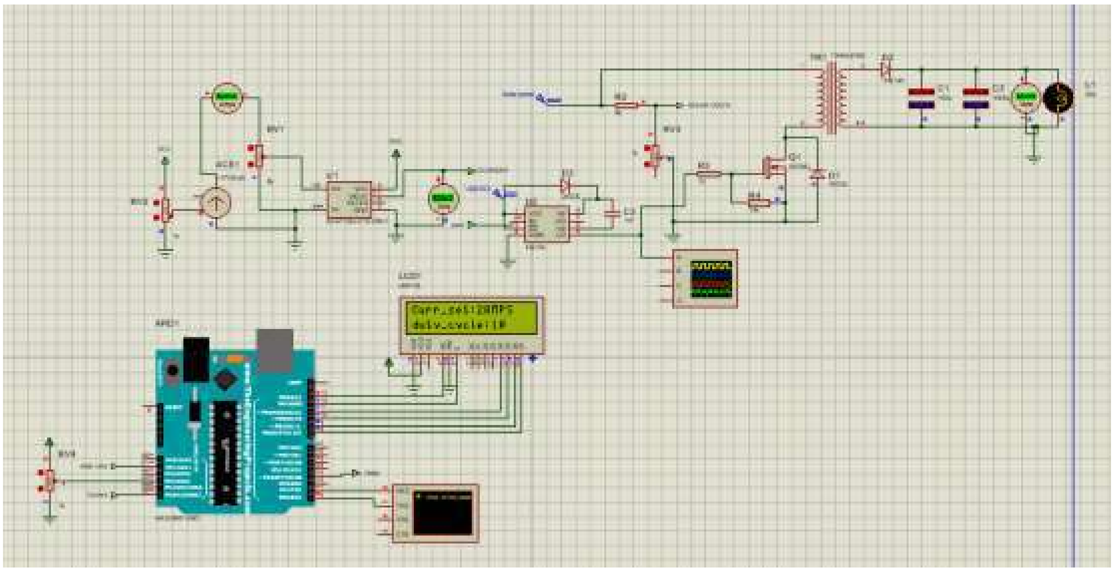


Figure 5. 6: Software Result

Table 5. 1: Software Testing Results

Conditions	**Testing**
Current Sensor	Before installing the current sensor on the project we have first attached the current sensor on board and connected it to the Arduino and with the help of Arduino IDE Software we have seen the result of current sensor on the LCD screen.
Voltage Sensor	Later another sensor was integrated with previous one and both of the results were displayed on screen by the help of Arduino IDE software
Pins Condition Test	Now different conditions were implemented by programming in Arduino IDE software and results were observed over the screen
LCD Test	The LCD was first tested by printing the “Hello Word” on it by programming at Arduino software latter sensors were attached to see the proper results

5.2 Discussion on the Findings

The prototype was the height of engineering prowess, able to give a 60-volt battery life with a determined 10A charging current. Our initial goals, however, were more ambitious: we wanted to give a battery the glorious rush of 20 amps. Unfortunately, our battery's limits were readily obvious when it was unable to endure the powerful stream of 20A. This failure did not prevent us from continuing, and we eventually created a charger with a prestigious 1200 watt power rating. Unfortunately, the siren song of budgetary restraints rang true, and we wisely chose to take a detour down a different road where efficiency meets pragmatism. As a result, a charger with a 700 watt rating was born, encapsulating our dedication to both cost-effectiveness and the pursuit of technological excellence.

5.2.1 Comparison with Initial Project Specifications

The comparison with intimal project specifications and the specifications in the final prototype are given below. Furthermore, in 5.2.2 the reasons for the short coming to actually archiving the initial project specifications and the change to final prototype specifications are also explained.

Below is the comparison with initial project specifications:

Table 5. 2: Comparison with Initial Project Specifications

S #	Initial Project Specification	Final Prototype Specification
1	Maximum Charging current 20Amps	Maximum Charging current 10Amps
2	Power Rating 1200 Watts	Power Rating 700Watts
3	Buck Converter	Flyback Converter

5.2.2 Reasoning for Short Comings

The reasons for short comings are:

1. We do not have the lithium-ion battery that can support charging current of 20Amps
2. The expense of making 1200watts is more as compared to 800watts
3. Because Fly Back Converter has the following advantages it gives better Isolation, Voltage Regulation, High Efficiency and Design Flexibility.

5.3 Limitations of the Working Prototype

The problems in our project that have been noticed are a result of certain restrictions. First off, our initial specs were hampered by the lack of a sufficient lithium-ion battery that could handle a 20 amp charging current. Despite our best efforts, we were unable to find a battery that could be included into the prototype. Second, a thorough cost study showed a significant difference between the costs involved in producing a charger with a power rating of 1200 watts and the more affordable choice of 700 watts. A strategic choice was made to put cost effectiveness ahead of overall functionality and performance of the charger due to the large cost difference. By choosing a 700-watt rating, we were able to strike the perfect mix between power delivery and manufacturing costs, balancing our goals with real-world needs while pursuing technological excellence.

5.4 Attainment of Sustainable Development Goals

The project aligns with Sustainable Development Goals (SDGs) related Climate Action. Electric bikes have the potential for quick climate action by decarbonizing society and transportation. By incorporating biking into their climate action plans, tactics, education, along with awareness-raising, organizations at all levels can take action.

5.5 Summary

This chapter's objective was to show the project's development across its whole life cycle. The chapter illustrates the results of every stage of the project along with how each result relates to the creation of the following project phase. This is documented using screenshots and other images that either represent the results or are connected to the results stated at the particular step.

Chapter 6

CONCULSION

In conclusion, the imminent threat of global warming poses a grave danger to our planet, prompting scientists and engineers worldwide to invest considerable efforts in finding solutions. Pakistan, as one of the countries most affected by this crisis, has recognized the urgency of taking action. This project aims to contribute to the collective effort by designing an electric vehicle charger that significantly reduces charging time compared to conventional chargers. The proposed methodology involves an extensive literature review to finalize battery and charger specifications, followed by the implementation of an AC input filter, AC/DC converter, and DC/DC converter, all regulated by a charger control system. The project will culminate in the design of the electric car charger, accompanied by simulation results for comprehensive analysis. While challenges were encountered in the prototype phase, including the unavailability of a lithium-ion battery capable of handling the desired charging current, and cost considerations leading to the selection of an 700 watt rating over 1200 watts, these setbacks did not hinder our commitment to pursuing environmentally-friendly solutions. By addressing these limitations, we strive to make meaningful progress in mitigating the adverse effects of global warming and safeguarding our planet for future generations. In addition to the aforementioned efforts, two key recommendations emerge as vital steps in addressing the global warming crisis. Firstly, there is a need for comprehensive policy frameworks and regulations that incentivize the adoption of sustainable practices and technologies. This can include offering tax incentives for renewable energy projects, imposing stricter emissions standards, and establishing carbon pricing mechanisms. Such measures would create a conducive environment for the widespread adoption of clean energy solutions and encourage businesses and individuals to reduce their carbon footprint. Secondly, increased investment in research and development is crucial to drive innovation in renewable energy and energy efficiency. Governments and private sectors should allocate more resources to support groundbreaking research, development, and deployment of clean technologies.

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APPENDICES

Appendix – A

Pakistan District Level Climate Risk and Hazard Assessment Classification

Table 1: Pakistan District Level Climate Risk

Rank	No.	Province	District	Flood Risk	Landslide Risk	Earthquake Risk	Tsunami Risk	Cyclone Risk	Drought Risk	Avalanche	GLOF Risk	PDMA Policy	Total
1	S7	Sindh	Karachi	4	1	5	5	5	5	1	1	5	30
2	A9	A.J.K	Hattian	5	5	5	–	2	3	4	1	5	25
3	A5	A.J.K	Muzaffarabad	5	5	5	–	2	3	5	5	5	25
4	K5	Khyber Pakhtunkhawa	Charsadda	5	3	5	–	2	3	5	1	5	23
5	K21	Khyber Pakhtunkhawa	Shangla	5	4	5	–	2	4	5	5	3	23
6	K20	Khyber Pakhtunkhawa	Sawat	5	5	4	–	2	2	5	5	5	23
7	K18	Khyber Pakhtunkhawa	Nowshera	5	3	5	–	2	3	4	1	5	23
8	A8	A.J.K	Sudhnoti	5	5	5	–	2	5	1	1	1	23
9	A7	A.J.K	Poonzh	5	5	5	–	2	5	1	1	1	23
10	A10	A.J.K	Haveli	5	5	5	–	2	5	5	1	1	23
11	A1	A.J.K	Bagh	5	5	5	–	2	5	5	1	1	23
12	K16	Khyber Pakhtunkhawa	Mansehra	4	5	4	–	2	1	4	5	5	21
13	S4	Sindh	Hyderabad	5	1	4	–	4	5	1	1	1	20
14	S22	Sindh	Thatta	4	1	2	3	4	1	1	1	5	20
15	S20	Sindh	Tando Muhammad Khan	5	1	4	–	4	5	1	1	1	20
16	S2	Sindh	Dadu	5	1	2	–	2	5	1	1	5	20
17	S15	Sindh	Qamber and Shahdadkot	5	1	3	–	2	4	1	1	5	20
18	S1	Sindh	Badin	4	1	3	–	5	2	1	1	5	20
19	P30	Punjab	Rawalpindi	4	5	5	–	2	3	1	1	1	20
20	K4	Khyber Pakhtunkhawa	Buner	5	4	4	–	2	4	4	1	1	20
21	F1	FATA	Bajaur Agenzy	3	3	5	–	2	2	5	1	5	20
22	B3	Balochistan	Bolan	4	3	3	–	2	3	1	1	5	20
23	A6	A.J.K	Neelum	4	4	4	–	1	2	4	4	5	20
24	A3	A.J.K	Kotli	4	3	5	–	2	5	1	1	1	20
25	S19	Sindh	Tando Allahyar	4	1	4	–	4	5	1	1	1	19
26	K19	Khyber Pakhtunkhawa	Peshawar	5	3	5	–	2	3	4	1	1	19

Table 2: Pakistan District Level Classification

Rank	No.	Province	District	Flood Risk	Landslide Risk	Earthquake Risk	Tsunami Risk	Cyclone Risk	Drought Risk	Avalanche	GLOF Risk	PDMA Policy	Total
27	F4	FATA	Mohmand Agency	3	4	4	–	1	2	3	1	5	19
28	B7	Balochistan	Jaffarabad	5	1	3	–	2	3	1	1	5	18
29	S11	Sindh	Matiari	5	1	4	–	2	5	1	1	1	18
30	P33	Punjab	Sheikhupura	5	2	4	–	2	4	1	1	1	18
31	K24	Khyber Pakhtunkhawa	Upper Dir	4	5	4	–	2	2	4	5	1	18
32	K22	Khyber Pakhtunkhawa	Swabi	5	3	5	–	2	2	5	1	1	18
33	K2	Khyber Pakhtunkhawa	Bannu	4	2	5	–	2	4	1	1	1	18
34	K1	Khyber Pakhtunkhawa	Abbottabad	3	5	5	–	2	2	5	1	1	18
35	F2	FATA	Khyber Agenzy	3	4	3	–	1	2	3	1	5	18
36	B20	Balochistan	Nasirabad	5	1	3	–	2	2	1	1	5	18
37	A4	A.J.K	Mirpur	3	3	4	–	2	5	1	1	1	18
38	S8	Sindh	Kashmore	5	1	3	–	2	5	1	1	1	17
39	S6	Sindh	Jamshoro	5	1	2	–	3	5	1	1	1	17
40	S5	Sindh	Jacobabad	5	1	3	–	2	5	1	1	1	17
41	S17	Sindh	Shikarpur	5	1	3	–	2	5	1	1	1	17
42	S14	Sindh	Nawabshah	5	1	2	–	3	5	1	1	1	17
43	S13	Sindh	Naushahro Feroze	5	1	3	–	2	5	1	1	1	17
44	S12	Sindh	Mirpur Khas	4	1	3	–	4	4	1	1	1	17
45	P28	Punjab	Rahim Tar Khan	5	1	3	–	2	5	1	1	1	17
46	P22	Punjab	Multan	4	1	4	–	2	5	1	1	1	17
47	K7	Khyber Pakhtunkhawa	D. I. Khan	5	1	2	–	2	2	1	1	5	17
48	K3	Khyber Pakhtunkhawa	Batagram	3	4	4	–	2	3	4	5	1	17
49	K17	Khyber Pakhtunkhawa	Mardan	5	3	5	–	2	1	5	1	1	17
50	K14	Khyber Pakhtunkhawa	Lower Dir	4	4	5	–	2	1	5	1	1	17
51	B24	Balochistan	Quetta	3	1	5	–	2	5	1	1	1	17
52	S9	Sindh	Khairpur	5	1	2	–	2	5	1	1	1	16
53	S3	Sindh	Ghotki	5	1	2	–	2	5	1	1	1	16
54	S18	Sindh	Sukkur	5	1	2	–	2	5	1	1	1	16
55	P9	Punjab	Gujranwala	5	2	4	–	2	2	1	1	1	16
56	P26	Punjab	Okara	3	1	5	–	2	4	1	1	1	16
57	P24	Punjab	Nankana Sahib	3	2	4	–	2	4	1	1	1	16
58	P23	Punjab	Muzaffargarh	5	1	3	–	2	4	1	1	1	16
59	P21	Punjab	Mianwali	4	4	3	–	2	2	1	1	1	16
60	P10	Punjab	Gujrat	5	2	5	–	2	1	1	1	1	16
61	K9	Khyber Pakhtunkhawa	Haripur	3	5	4	–	2	1	4	1	1	16

Table 3: Pakistan District Level Hazard Assessment Classification

Rank	No.	Province	District	Flood Risk	Landslide Risk	Earthquake Risk	Tsunami Risk	Cyclone Risk	Drought Risk	Avalanche	GLOF Risk	PDMA Policy	Total
62	K8	Khyber Pakhtunkhawa	Hangu	3	3	4	–	2	3	1	1	1	16
63	K15	Khyber Pakhtunkhawa	Malakand	4	3	5	–	2	1	4	1	1	16
64	I1	Capital Territory	Islamabad	2	3	5	–	2	3	1	1	1	16
65	F6	FATA	Orakzai Agency	2	4	3	–	2	4	1	1	1	16
66	B8	Balochistan	Jhal Magsi	4	1	2	–	2	2	1	1	5	16
67	A2	A.J.K	Bhimber	4	2	3	–	2	4	1	1	1	16
68	S21	Sindh	Tharparkar	3	1	2	–	4	4	1	1	1	15
69	S10	Sindh	Larkana	5	1	2	–	2	4	1	1	1	15
70	P8	Punjab	Faisalabad	3	1	4	–	2	4	1	1	1	15
71	P35	Punjab	Toba Tek Singh	3	1	4	–	2	4	1	1	1	15
72	P34	Punjab	Sialkot	5	1	5	–	2	1	1	1	1	15
73	P31	Punjab	Sahiwal	3	1	4	–	2	4	1	1	1	15
74	P25	Punjab	Narowal	5	1	5	–	2	1	1	1	1	15
75	P12	Punjab	Jhang	5	1	3	–	2	3	1	1	1	15
76	K23	Khyber Pakhtunkhawa	Tank	4	1	3	–	2	4	1	1	1	15
77	B25	Balochistan	Sibi	3	1	2	–	1	3	1	1	5	15
78	B17	Balochistan	Loralai	3	2	3	–	2	4	1	1	1	15
79	P7	Punjab	D. G. Khan	5	1	2	–	2	3	1	1	1	14
80	P32	Punjab	Sargodha	4	2	3	–	2	2	1	1	1	14
81	P29	Punjab	Rajanpur	5	1	2	–	2	3	1	1	1	14
82	P19	Punjab	Lodhran	3	1	3	–	2	4	1	1	1	14
83	P18	Punjab	Leiah	5	1	2	–	2	3	1	1	1	14
84	P16	Punjab	Khushab	4	2	3	–	2	2	1	1	1	14
85	P15	Punjab	Khanewal	3	1	3	–	2	4	1	1	1	14
86	P14	Punjab	Kasur	3	1	4	–	2	3	1	1	1	14
87	P13	Punjab	Jhelum	3	2	4	–	2	2	1	1	1	14
88	F12	FATA	FR Peshawar	2	3	3	–	2	3	1	1	1	14
89	B14	Balochistan	Killa Saifullah	3	3	3	–	1	3	1	1	1	14
90	B10	Balochistan	Kech	3	1	1	–	4	4	1	1	1	14
91	S23	Sindh	Umerkot	3	1	2	–	3	3	1	1	1	13
92	S16	Sindh	Sanghar	4	1	2	–	3	2	1	1	1	13
93	P6	Punjab	Chiniot	3	1	3	–	2	3	1	1	1	13
94	P36	Punjab	Vehari	3	1	3	–	2	3	1	1	1	13
95	P27	Punjab	Pakpattan	3	1	3	–	2	3	1	1	1	13
96	P20	Punjab	Mandi Bahauddin	3	1	4	–	2	2	1	1	1	13
97	P17	Punjab	Lahore	3	1	4	–	2	2	1	1	1	13
98	K12	Khyber Pakhtunkhawa	Kohistan	3	4	3	–	1	1	4	4	1	13
99	K11	Khyber Pakhtunkhawa	Kohat	3	2	3	–	2	2	1	1	1	13
100	F7	FATA	South Waziristan Agency	2	2	2	–	1	1	1	1	5	13

Table 4: Hazard Assessment at the District Level in Pakistan

Rank	No.	Province	District	Flood Risk	Landslide Risk	Earthquake Risk	Tsunam iRisk	Cyclone Risk	Drought Risk	Avalanche	GLOF Risk	PDMA Policy	Total
101	P2	Punjab	Bahawalnagar	3	1	2	–	2	3	1	1	1	12
102	P11	Punjab	Hafizabad	3	1	3	–	2	2	1	1	1	12
103	K6	Khyber Pakhtunkhawa	Chitral	3	4	2	–	1	1	2	3	1	12
104	F9	FATA	FR D. I. Khan	1	1	2	–	1	2	1	1	5	12
105	B9	Balochistan	Kalat	3	3	3	–	1	1	1	1	1	12
106	B23	Balochistan	Pishin	2	1	4	–	1	3	1	1	1	12
107	B1	Balochistan	Awaran	2	1	1	–	3	4	1	1	1	12
108	P3	Punjab	Bahawalpur	2	1	2	–	2	3	1	1	1	11
109	K13	Khyber Pakhtunkhawa	Lakki Marwat	3	1	3	–	2	1	1	1	1	11
112	F10	FATA	FR Kohat	2	3	3	–	1	1	1	1	1	11
113	B29	Balochistan	Harnai	3	1	2	–	1	3	1	1	1	11
114	B2	Balochistan	Barkhan	3	1	3	–	1	2	1	1	1	11
115	B18	Balochistan	Mastung	2	2	3	–	1	2	1	1	1	11
116	B13	Balocistan	Killa Abdullah	3	1	3	–	1	2	1	1	1	11
117	B12	Balochistan	Khuzdar	3	1	1	–	1	4	1	1	1	11
118	P5	Punjab	Chakwal	2	1	3	–	1	2	1	1	1	10
119	P1	Punjab	Attock	2	2	3	–	1	1	1	1	1	10
124	F8	FATA	FR Bannu	1	2	2	–	1	1	1	1	3	10
125	F5	FATA	North Waziristan Agency	2	2	2	–	1	2	1	1	1	10
126	F3	FATA	Kurrum Agency	3	2	2	–	1	1	2	1	1	10
127	B6	Balochistan	Gwadar	1	1	2	1	3	1	1	1	1	10
128	B16	Balochistan	Lasbela	2	1	1	1	3	1	1	1	1	10
129	B27	Balochistan	Ziarat	1	1	4	–	1	1	1	1	1	9
130	P4	Punjab	Bhakkar	3	1	2	–	1	1	1	1	1	9
131	K10	Khyber Pakhtunkhawa	Karak	2	2	2	–	1	1	1	1	1	9
133	B15	Balochistan	Kohlu	2	2	2	–	1	1	1	1	1	9
134	F13	FATA	FR Tank	1	1	1	–	1	1	1	1	3	8
135	B4	Balochistan	Chagai	2	1	1	–	1	2	1	1	1	8
136	B28	Balochistan	Washuk	2	1	2	–	1	1	1	1	1	8
137	B26	Balochistan	Zhob	2	1	2	–	1	1	1	1	1	8
138	B22	Balochistan	Panjgur	1	1	1	–	1	3	1	1	1	8
139	B21	Balochistan	Nushki	2	1	2	–	1	1	1	1	1	8
140	B11	Balochistan	Kharan	2	1	2	–	1	1	1	1	1	8
141	F11	FATA	FR Lakki Marwat	1	1	2	–	1	1	1	1	1	7
142	B5	Balochistan	Dera Bugti	1	1	2	–	1	1	1	1	1	7
143	B30	Balochistan	Sherani	1	1	2	–	1	1	1	1	1	7
144	B19	Balochistan	Musakhel	1	1	2	–	1	1	1	1	1	7
145	D1	Disputed Area	Disputed Area	–	3	–	–	–	–	–	–	1	4

Scoring Key	Very High	High	Medium	Low	Very Low	NonHazard
	5	4	3	2	1	–

***FATA = Federally Administered Tribal Area, GLOF = glacial lake outburst flood, PDMA = Provincial Disaster Management Authority.**

****Source: Government of Pakistan, Ministry of Climate Change. 2012. National Disaster Management Plan. Islamabad: National Disaster Management Authority. p. 31. [38]**

Appendix – B

Code:

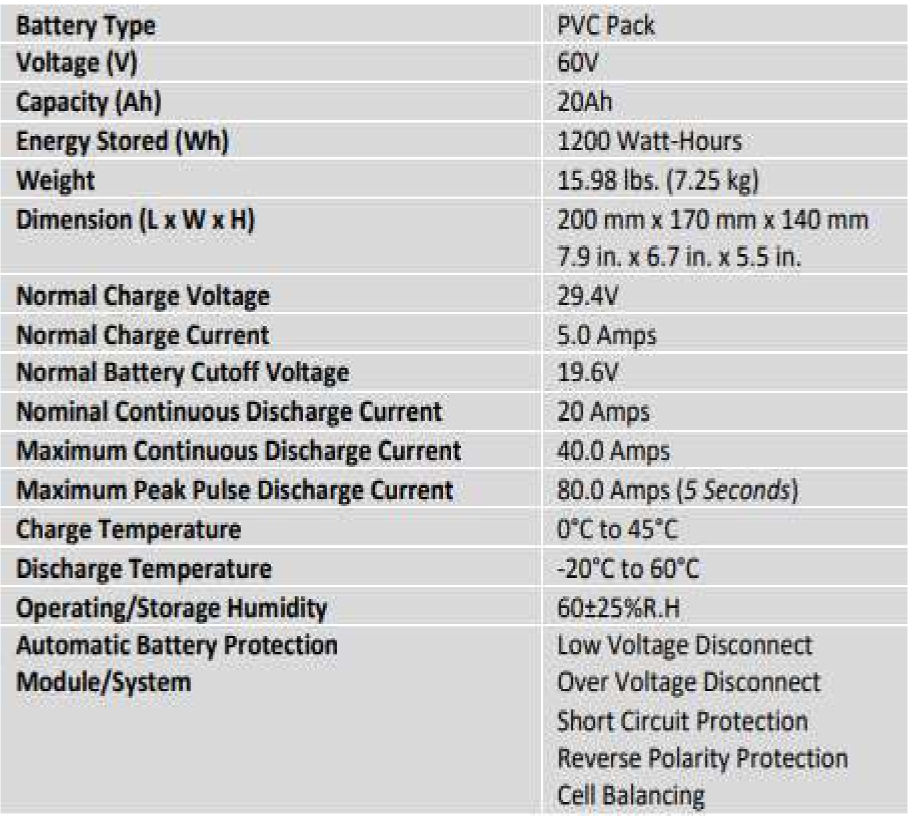
```
#include <Wire.h>
// include the library code:
#include <LiquidCrystal.h>
// initialize the library by associating any needed LCD interface pin
// with the arduino pin number it is connected to
const int rs = 13, en = 12, d4 = 11, d5 = 10, d6 = 9, d7 = 8;
LiquidCrystal lcd(rs, en, d4, d5, d6, d7);

const int fanPin = 3;
int sd = 5;
int volt_pin = A0;
int pot = A3;
float battery_volt,avgvolt,read_volt,volt,volt1,avg_volt,volt3,old_amps,read_bat = 0;
const int Current = A5;
int mVperAmp =145 ; // use 100 for 20A Module and 66 for 30A Module
int RawValue= 0 ;
int ACSoffset = 2500 ;
double MV = 0 ;
double Amps = 0;
double amps = 0;
int old_dutycycle = 0;
void setup(void)
{
  pinMode(Current,INPUT);
  pinMode(volt_pin,INPUT);
  pinMode(pot,INPUT);
  lcd.begin(16,2);
  lcd.setCursor(0,0);
  lcd.print("Battery Charger");
  lcd.setCursor(0,1);
```

```
  lcd.print("Calibrating..");
  pinMode(sd,OUTPUT);
  digitalWrite(sd,HIGH);
  TCCR2B = (TCCR2B & 0b11111000)|0x02;   // timer 2 on pin 3 generates 31khz
  analogWrite(fanPin,160); // 5-
  Serial.begin(9600);
  lcd.clear();
}
int dc = 10;
float out_volt=0;
float bat_per = 0;
void loop(void)
{
int read_pot = analogRead(pot);
int curr_req = map(read_pot,0,1024,0,5);
lcd.setCursor(0,0);lcd.print("Curr_set:");lcd.print(curr_req);lcd.print("AMPS");
// READING CURRENT VALUES
for (int i = 0 ; i < 50 ; i++)
 {
 RawValue = analogRead(Current);
 MV = (RawValue / 1024.0) * 5000;  // Gets you mV
 Amps = ((MV - ACSoffset) / mVperAmp);
 amps = amps + Amps ;
 }
 Serial.println(RawValue);
 float final_amps = abs(amps / 50)  ;
 RawValue=0;
// if(final_amps > 0.4)
// {
// lcd.clear();lcd.print("Charging Battery.");
// if(final_amps < curr_req)
// {
//  if(dc<15)
```

```
//  {
//  dc++ ;
//  }
// }
// else
// {
//  if(dc>7)
//  {
//  dc-- ;
//  }
// }
// delay(1000);lcd.clear();
// }
//  else
// {
//  final_amps = 0;
// }
  lcd.setCursor(0,1);lcd.print("duty_cycle:");lcd.print(dc);
   delay(100);lcd.clear();
   lcd.setCursor(0,0);lcd.print("CURR:"); lcd.print(final_amps,1); lcd.print(" AMPS");
// lcd.setCursor(0,1);lcd.print(avg_volt);lcd.print(" V");
// lcd.setCursor(10,1);lcd.print(int(bat_per*100));lcd.print("%");
// volt=0;
// avg_volt = 0;
// final_amps=0; amps=0;
 delay(100);
// lcd.clear();
}
```

Appendix – C

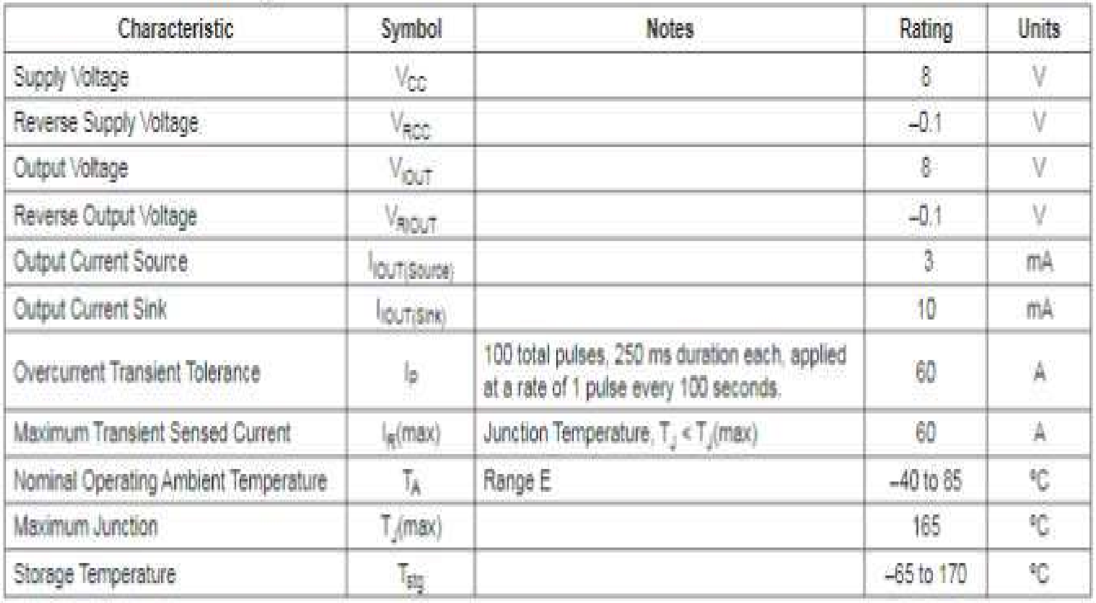
Battery Data-Sheet:



Battery Type	PVC Pack
Voltage (V)	60V
Capacity (Ah)	20Ah
Energy Stored (Wh)	1200 Watt-Hours
Weight	15.98 lbs. (7.25 kg)
Dimension (L x W x H)	200 mm x 170 mm x 140 mm 7.9 in. x 6.7 in. x 5.5 in.
Normal Charge Voltage	29.4V
Normal Charge Current	5.0 Amps
Normal Battery Cutoff Voltage	19.6V
Nominal Continuous Discharge Current	20 Amps
Maximum Continuous Discharge Current	40.0 Amps
Maximum Peak Pulse Discharge Current	80.0 Amps (*5 Seconds*)
Charge Temperature	0°C to 45°C
Discharge Temperature	-20°C to 60°C
Operating/Storage Humidity	60±25%R.H
Automatic Battery Protection Module/System	Low Voltage Disconnect Over Voltage Disconnect Short Circuit Protection Reverse Polarity Protection Cell Balancing

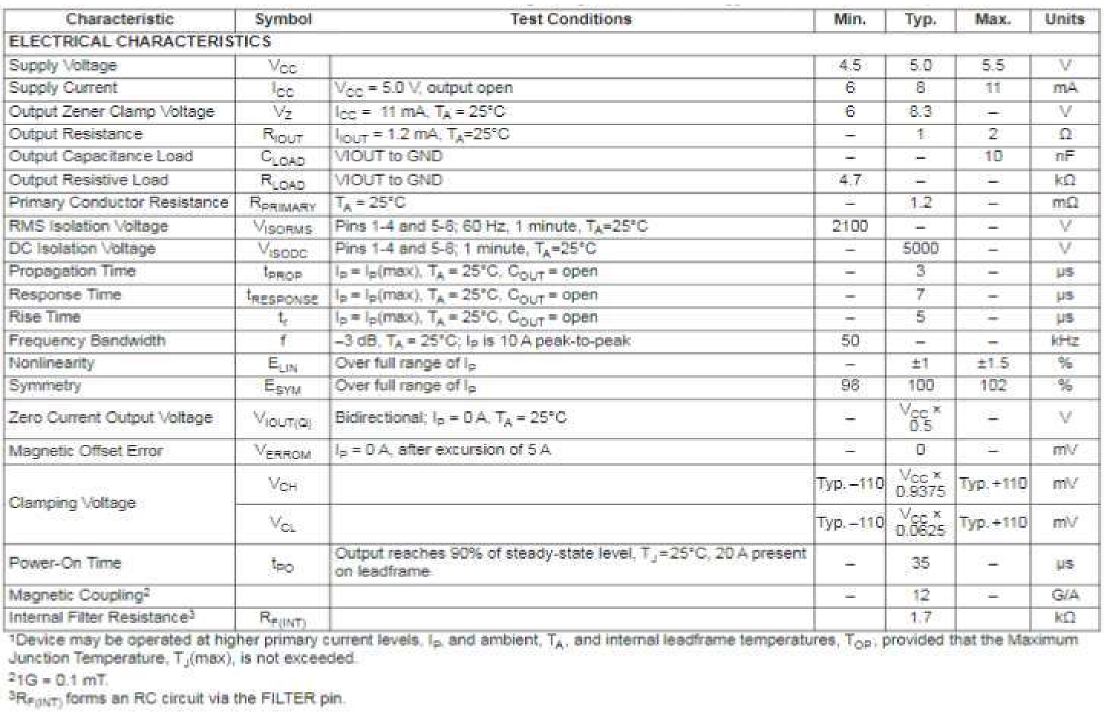
Figure 2: Battery Data-Sheet

ACS712 Datasheet:



Characteristic	Symbol	Notes	Rating	Units
Supply Voltage	V_{CC}		8	V
Reverse Supply Voltage	V_{RCC}		–0.1	V
Output Voltage	V_{IOUT}		8	V
Reverse Output Voltage	V_{RIOUT}		–0.1	V
Output Current Source	$I_{IOUT(Source)}$		3	mA
Output Current Sink	$I_{IOUT(Sink)}$		10	mA
Overcurrent Transient Tolerance	I_P	100 total pulses, 250 ms duration each, applied at a rate of 1 pulse every 100 seconds.	60	A
Maximum Transient Sensed Current	$I_R(max)$	Junction Temperature, $T_J < T_J(max)$	60	A
Nominal Operating Ambient Temperature	T_A	Range E	–40 to 85	°C
Maximum Junction	$T_J(max)$		165	°C
Storage Temperature	T_{stg}		–65 to 170	°C

Figure 3: ACS712 Absolute Maximum Ratings



Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
ELECTRICAL CHARACTERISTICS						
Supply Voltage	V_{CC}		4.5	5.0	5.5	V
Supply Current	I_{CC}	V_{CC} = 5.0 V, output open	6	8	11	mA
Output Zener Clamp Voltage	V_Z	I_{CC} = 11 mA, T_A = 25°C	6	8.3	–	V
Output Resistance	R_{IOUT}	I_{IOUT} = 1.2 mA, T_A=25°C	–	1	2	Ω
Output Capacitance Load	C_{LOAD}	VIOUT to GND	–	–	10	nF
Output Resistive Load	R_{LOAD}	VIOUT to GND	4.7	–	–	kΩ
Primary Conductor Resistance	$R_{PRIMARY}$	T_A = 25°C	–	1.2	–	mΩ
RMS Isolation Voltage	V_{ISORMS}	Pins 1-4 and 5-8; 60 Hz, 1 minute, T_A=25°C	2100	–	–	V
DC Isolation Voltage	V_{ISODC}	Pins 1-4 and 5-8; 1 minute, T_A=25°C	–	5000	–	V
Propagation Time	t_{PROP}	I_P = I_P(max), T_A = 25°C, C_{OUT} = open	–	3	–	μs
Response Time	$t_{RESPONSE}$	I_P = I_P(max), T_A = 25°C, C_{OUT} = open	–	7	–	μs
Rise Time	t_r	I_P = I_P(max), T_A = 25°C, C_{OUT} = open	–	5	–	μs
Frequency Bandwidth	f	–3 dB, T_A = 25°C; I_P is 10 A peak-to-peak	50	–	–	kHz
Nonlinearity	E_{LIN}	Over full range of I_P	–	±1	±1.5	%
Symmetry	E_{SYM}	Over full range of I_P	98	100	102	%
Zero Current Output Voltage	$V_{IOUT(Q)}$	Bidirectional; I_P = 0 A, T_A = 25°C	–	V_{CC} × 0.5	–	V
Magnetic Offset Error	V_{ERROM}	I_P = 0 A, after excursion of 5 A	–	0	–	mV
Clamping Voltage	V_{CH}		Typ. –110	V_{CC} × 0.9375	Typ. +110	mV
	V_{CL}		Typ. –110	V_{CC} × 0.0625	Typ. +110	mV
Power-On Time	t_{PO}	Output reaches 90% of steady-state level, T_J=25°C, 20 A present on leadframe	–	35	–	μs
Magnetic Coupling[2]			–	12	–	G/A
Internal Filter Resistance[3]	$R_{F(INT)}$			1.7		kΩ

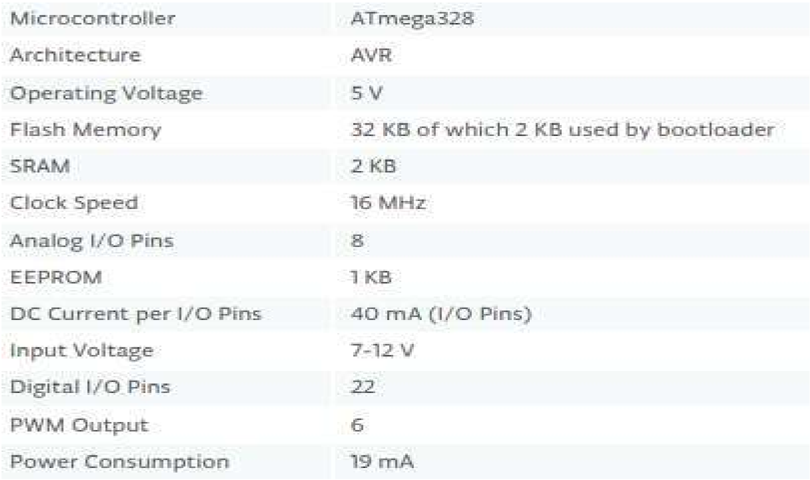
[1] Device may be operated at higher primary current levels, I_P, and ambient, T_A, and internal leadframe temperatures, T_{OP}, provided that the Maximum Junction Temperature, T_J(max), is not exceeded.

[2] 1G = 0.1 mT.

[3] $R_{F(INT)}$ forms an RC circuit via the FILTER pin.

Figure 4: ACS712 Common Operating Characteristics

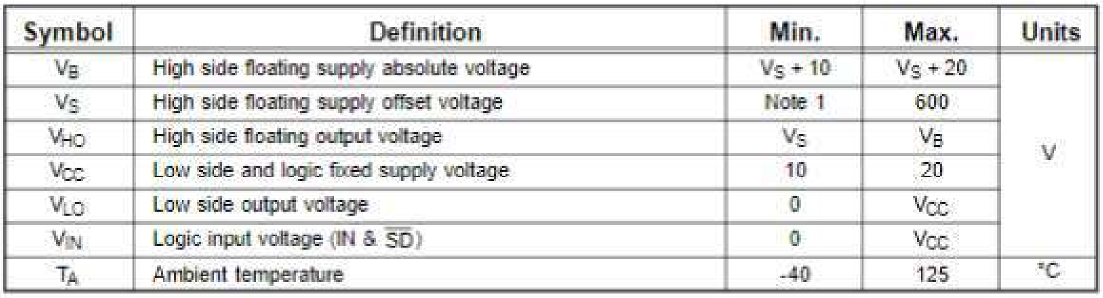
Arduino Nano:



Microcontroller	ATmega328
Architecture	AVR
Operating Voltage	5 V
Flash Memory	32 KB of which 2 KB used by bootloader
SRAM	2 KB
Clock Speed	16 MHz
Analog I/O Pins	8
EEPROM	1 KB
DC Current per I/O Pins	40 mA (I/O Pins)
Input Voltage	7-12 V
Digital I/O Pins	22
PWM Output	6
Power Consumption	19 mA

Figure 5: Arduino Nano DataSheet

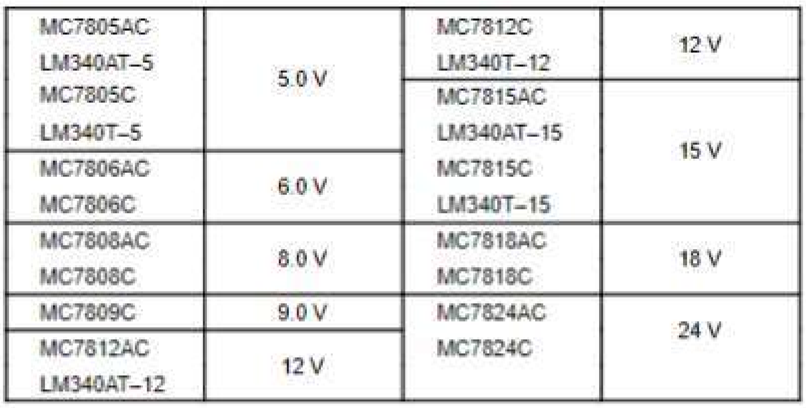
IR2104 Integrated Circuit:



Symbol	Definition	Min.	Max.	Units
V_B	High side floating supply absolute voltage	V_S + 10	V_S + 20	V
V_S	High side floating supply offset voltage	Note 1	600	
V_{HO}	High side floating output voltage	V_S	V_B	
V_{CC}	Low side and logic fixed supply voltage	10	20	
V_{LO}	Low side output voltage	0	V_{CC}	
V_{IN}	Logic input voltage (IN & $\overline{SD}$)	0	V_{CC}	
T_A	Ambient temperature	-40	125	°C

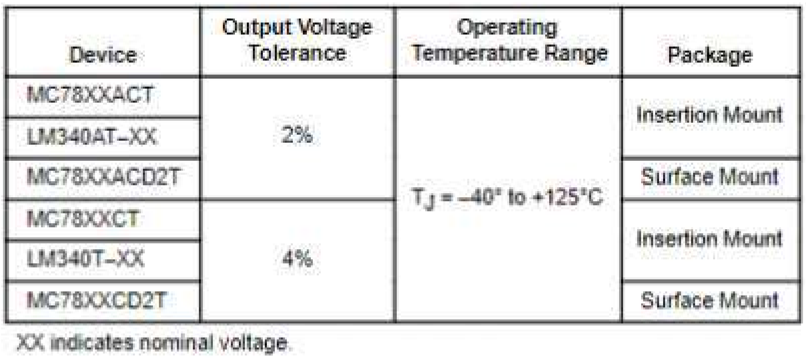
Figure 6: IR2104 Recommended Operating Conditions

Voltage Regulator (7812)



MC7805AC	5.0 V	MC7812C	12 V
LM340AT–5		LM340T–12	
MC7805C		MC7815AC	15 V
LM340T–5		LM340AT–15	
MC7806AC	6.0 V	MC7815C	
MC7806C		LM340T–15	
MC7808AC	8.0 V	MC7818AC	18 V
MC7808C		MC7818C	
MC7809C	9.0 V	MC7824AC	24 V
MC7812AC	12 V	MC7824C	
LM340AT–12			

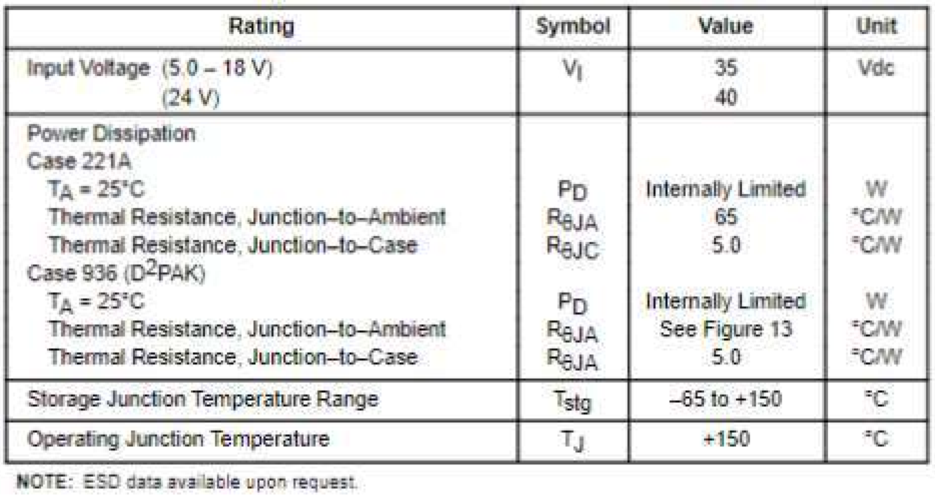
Figure 7: 7812 Device Type/Nominal Output Voltage



Device	Output Voltage Tolerance	Operating Temperature Range	Package
MC78XXACT	2%	T_J = –40° to +125°C	Insertion Mount
LM340AT–XX			
MC78XXACD2T			Surface Mount
MC78XXCT	4%		Insertion Mount
LM340T–XX			
MC78XXCD2T			Surface Mount

XX indicates nominal voltage.

Figure 8: 7812 Ordering Information

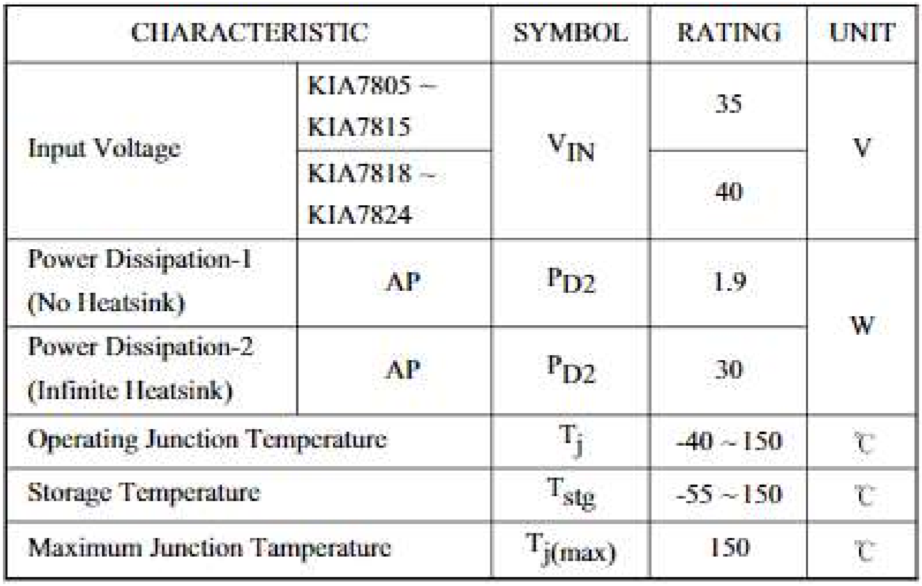


Rating	Symbol	Value	Unit
Input Voltage (5.0 – 18 V) (24 V)	V_I	35 40	Vdc
Power Dissipation Case 221A T_A = 25°C Thermal Resistance, Junction–to–Ambient Thermal Resistance, Junction–to–Case Case 936 (D^{2}PAK) T_A = 25°C Thermal Resistance, Junction–to–Ambient Thermal Resistance, Junction–to–Case	 P_D $R_{\theta JA}$ $R_{\theta JC}$ P_D $R_{\theta JA}$ $R_{\theta JA}$	 Internally Limited 65 5.0 Internally Limited See Figure 13 5.0	 W °C/W °C/W W °C/W °C/W
Storage Junction Temperature Range	T_{stg}	–65 to +150	°C
Operating Junction Temperature	T_J	+150	°C

NOTE: ESD data available upon request.

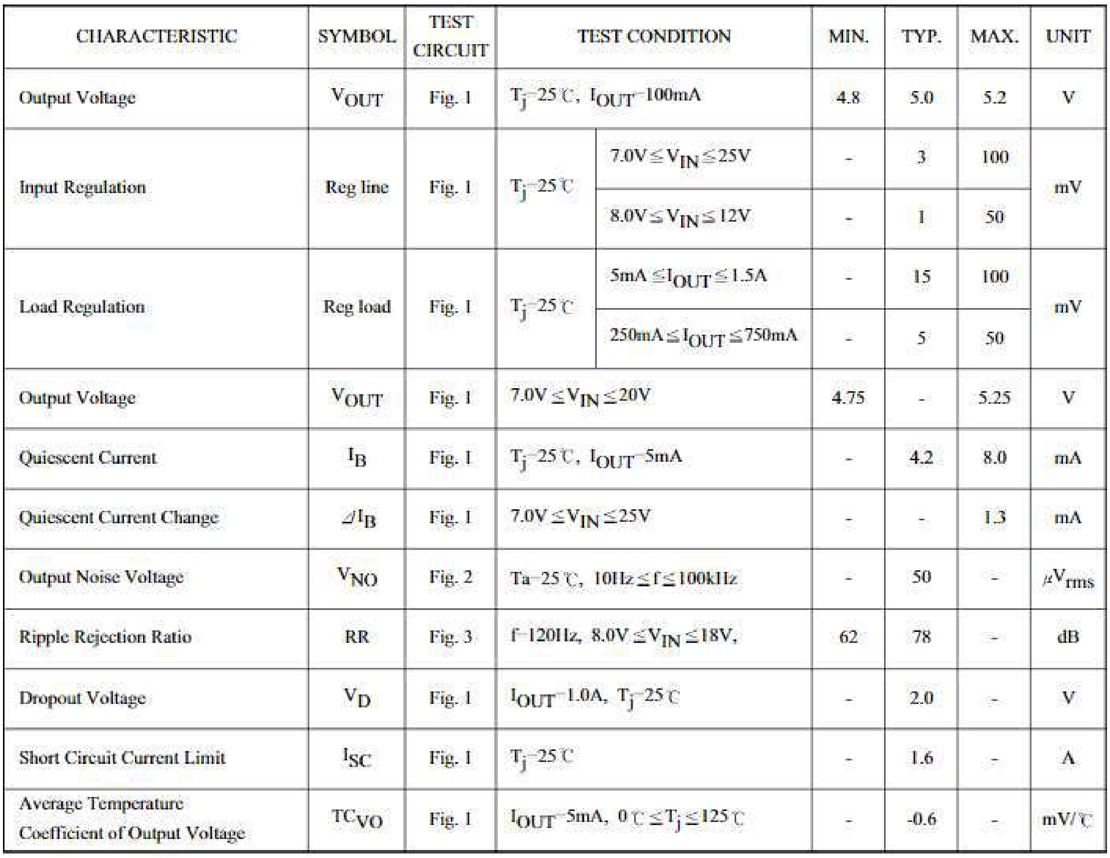
Figure 9: 7812 Maximum Ratings

Voltage Regulator (7805):



CHARACTERISTIC		SYMBOL	RATING	UNIT
Input Voltage	KIA7805 ~ KIA7815	V_{IN}	35	V
	KIA7818 ~ KIA7824		40	
Power Dissipation-1 (No Heatsink)	AP	P_{D2}	1.9	W
Power Dissipation-2 (Infinite Heatsink)	AP	P_{D2}	30	
Operating Junction Temperature		T_j	-40 ~ 150	℃
Storage Temperature		T_{stg}	-55 ~ 150	℃
Maximum Junction Tamperature		$T_{j(max)}$	150	℃

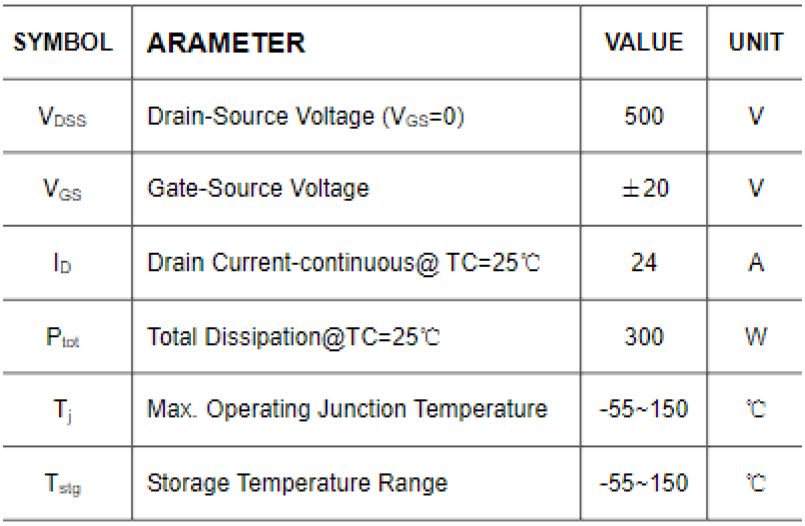
Figure 10: 7805 Maximum Rating



CHARACTERISTIC	SYMBOL	TEST CIRCUIT	TEST CONDITION		MIN.	TYP.	MAX.	UNIT
Output Voltage	V_{OUT}	Fig. 1	T_j=25℃, I_{OUT}=100mA		4.8	5.0	5.2	V
Input Regulation	Reg line	Fig. 1	T_j=25℃	7.0V ≤ V_{IN} ≤ 25V	-	3	100	mV
				8.0V ≤ V_{IN} ≤ 12V	-	1	50	
Load Regulation	Reg load	Fig. 1	T_j=25℃	5mA ≤ I_{OUT} ≤ 1.5A	-	15	100	mV
				250mA ≤ I_{OUT} ≤ 750mA	-	5	50	
Output Voltage	V_{OUT}	Fig. 1	7.0V ≤ V_{IN} ≤ 20V		4.75	-	5.25	V
Quiescent Current	I_B	Fig. 1	T_j=25℃, I_{OUT}=5mA		-	4.2	8.0	mA
Quiescent Current Change	ΔI_B	Fig. 1	7.0V ≤ V_{IN} ≤ 25V		-	-	1.3	mA
Output Noise Voltage	V_{NO}	Fig. 2	Ta=25℃, 10Hz ≤ f ≤ 100kHz		-	50	-	μV_{rms}
Ripple Rejection Ratio	RR	Fig. 3	f=120Hz, 8.0V ≤ V_{IN} ≤ 18V,		62	78	-	dB
Dropout Voltage	V_D	Fig. 1	I_{OUT}=1.0A, T_j=25℃		-	2.0	-	V
Short Circuit Current Limit	I_{SC}	Fig. 1	T_j=25℃		-	1.6	-	A
Average Temperature Coefficient of Output Voltage	TC_{VO}	Fig. 1	I_{OUT}=5mA, 0℃ ≤ T_j ≤ 125℃		-	-0.6	-	mV/℃

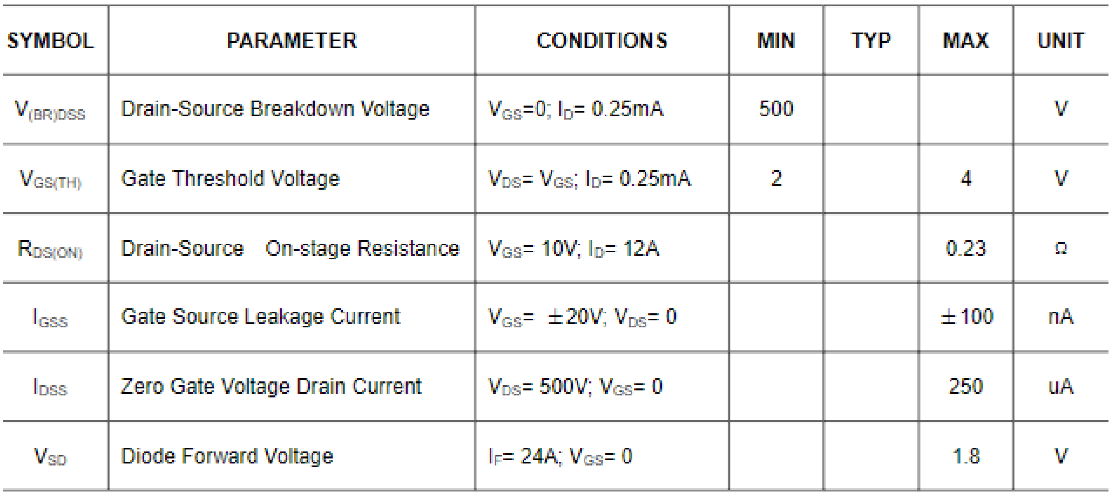
Figure 11: 7805 Electrical Characteristics

IRF470 Power MOSFET:



SYMBOL	ARAMETER	VALUE	UNIT
V_{DSS}	Drain-Source Voltage (V_{GS}=0)	500	V
V_{GS}	Gate-Source Voltage	±20	V
I_D	Drain Current-continuous@ TC=25℃	24	A
P_{tot}	Total Dissipation@TC=25℃	300	W
T_j	Max. Operating Junction Temperature	-55~150	℃
T_{stg}	Storage Temperature Range	-55~150	℃

Figure 12: IRF470 Absolute Maximum Ratings



SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	V_{GS}=0; I_D= 0.25mA	500			V
$V_{GS(TH)}$	Gate Threshold Voltage	V_{DS}= V_{GS}; I_D= 0.25mA	2		4	V
$R_{DS(ON)}$	Drain-Source On-stage Resistance	V_{GS}= 10V; I_D= 12A			0.23	Ω
I_{GSS}	Gate Source Leakage Current	V_{GS}= ±20V; V_{DS}= 0			±100	nA
I_{DSS}	Zero Gate Voltage Drain Current	V_{DS}= 500V; V_{GS}= 0			250	uA
V_{SD}	Diode Forward Voltage	I_F= 24A; V_{GS}= 0			1.8	V

Figure 13: IRF470 Electrical Characteristics