

Design and Fabrication of Universal Charging Adapter for Electric Two Wheelers

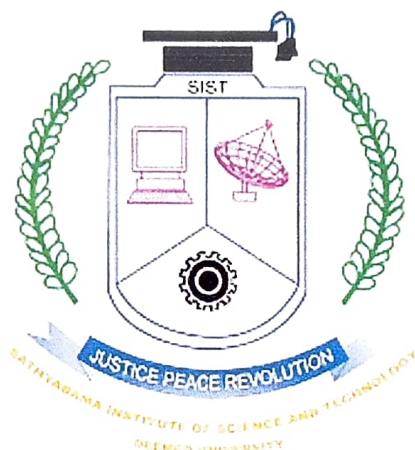
Submitted in partial fulfillment of the requirements for the award of

Bachelor of Engineering degree in
Automobile Engineering

By

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DEPARTMENT OF AUTOMOBILE ENGINEERING

SCHOOL OF MECHANICAL ENGINEERING

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with grade "A++" by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI – 600119

APRIL 2024



SATHYABAMA

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DEPARTMENT OF AUTOMOBILE ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of Ignatius Raja (Reg. No. 40860001) and Satyam Shrivastav (Reg. No. 40860703) who carried out the project entitled "Design and Fabrication of Universal Charging Adapter for Electric Two Wheelers" under our supervision from November 2023 to April 2024.

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Submitted for Viva-voce Examination held on 06.04.24

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DECLARATION

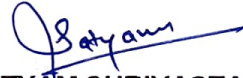
We, Ignatius Raja (Reg. No. 40860001) and Satyam Shrivastav (Reg. No. 40860703) hereby declare that the Project Report entitled "Design and Fabrication of Universal Charging Adapter for Electric Two Wheelers" done by us under the guidance of **Dr. V.K. BUPESH RAJA, ME., Ph.D.** is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Automobile Engineering.

DATE: 26.03.2024

PLACE: CHENNAI



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CANDIDATE**

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ABSTRACT

This report examines the selection and integration of two Electric Vehicle (EV) chargers, rated at 6A and 60V, to devise an innovative adapter. Its primary aim is to tackle the challenge of interchangeability in EV chargers while promoting sustainability and cost efficiency. The project endeavors to create a solution supporting the concept of using one charger for multiple EV two-wheelers, thereby reducing electronic waste and improving charging station efficiency. The report discusses the selection criteria for the chosen chargers, including compatibility, safety features, and adherence to industry standards. Through the development of a versatile adapter, this project not only meets the current demand for effective charging solutions but also aligns with broader goals of environmental consciousness and resource optimization in electric transportation.

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LIST OF ABBREVIATIONS

<i>ABS</i>	Acrylonitrile Butadiene Styrene
<i>PLA</i>	Polylactic acid
<i>TPU</i>	Thermoplastic polyurethane
<i>EV</i>	Electric Vehicle(s)

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CHAPTER 1

INTRODUCTION

1.1. BACKGROUND AND CONTEXT

The world of electric two-wheelers (e-bikes and e-scooters) is brimming with potential, but one obstacle to widespread acceptance is a lack of standardization in charging terminals. This implies that various manufacturers utilize different charging ports, which is troublesome for consumers who must rely on public charging stations or use chargers from other brands.

Here's a breakdown of the situation:

Traditionally, various regions and manufacturers have adopted different charging standards. For example, the SAE J1772 connector is common in North America, while Mennekes type 2 is popular in Europe. However, the e-two-wheeler market adds another layer of complexity. Fragmentation in the e-two-wheeler market: Unlike cars where a standard like CCS (Combined Charging System) is gaining traction, the e-two-wheeler market sees individual manufacturers like Ather Energy and Ola Electric developing their own proprietary charging connectors. This creates a situation where: Users are limited to using their brand's specific chargers or designated stations. Public charging infrastructure needs to cater to various connector types, increasing complexity and cost.

Recognizing this issue, some businesses are investigating the potential of adapters that would allow consumers to connect their e-bikes/scooters to charging stations with various connectors. However, there are issues with adapters:

Standardisation challenges: Even with adapters, the lack of a global standard adds complexity for both consumers and enterprises.

Bulkiness and inconvenience: Adding an extra adapter might be cumbersome and may not be the most user-friendly solution.

Safety: It is critical to ensure that the adapter satisfies all safety regulations and does not interfere with the charging process.

The ideal solution would be a universal charging standard for e-two-wheelers, similar to what we see in smartphones. This would eliminate the need for adapters and create a seamless charging experience for users regardless of the brand or location.

However, achieving this standardization requires collaboration between governments, manufacturers, and industry bodies. In the meantime, adapters might offer a temporary solution, but they shouldn't be seen as a long-term fix.

It's important to note that this is a rapidly evolving landscape, and future developments in technology and regulations could significantly impact the future of EV charger compatibility and standardization.

1.2. PROBLEM STATEMENT

The lack of standardized charging ports for electric two-wheelers (e-bikes and e-scooters) creates significant challenges for users and hinders the wider adoption of these vehicles. This inconsistency leads to:

- **User inconvenience:** E-bike/scooter owners are limited to using their brand's specific chargers or designated stations, restricting their flexibility and hindering long-distance travel.
- **Public infrastructure complexity:** Charging stations need to cater to various connector types, increasing cost, complexity, and maintenance needs.
- **Market fragmentation:** Proprietary charging ports stifle competition and innovation in the e-two-wheeler market.

Therefore, it is crucial to find a solution that ensures:

- **Compatibility:** E-bikes/scooters should be able to charge seamlessly across

different charging stations regardless of the manufacturer.

- **User-friendliness:** The solution should be convenient and easy to use, avoiding bulky adapters or complex procedures.
- **Cost-effectiveness:** The chosen approach should be cost-efficient for both users and infrastructure providers.

Finding a solution that addresses these challenges is critical for promoting the widespread adoption of e-two-wheelers and creating a sustainable future for electric mobility.

CHAPTER 2

LITERATURE SURVEY

Arif, et. Al. The rapid growth of Electric Vehicles (EVs) is driven by global trends including fossil fuel depletion, climate change awareness, renewable energy advancements, and EV technology improvements. With transportation contributing significantly to CO₂ emissions, EVs offer a cleaner alternative. Governments are promoting renewable energy adoption, with China and the US investing heavily in wind and solar power. Despite EV benefits, battery limitations hinder widespread acceptance, but substantial research and development investments aim to address these challenges. Countries like Australia and New Zealand are witnessing increasing EV sales and are actively transitioning towards renewable energy sources. New Zealand, in particular, aims for 100% renewable electricity by 2035, leveraging its diverse renewable energy mix to reduce fossil fuel dependence in the transportation sector, highlighting the pivotal role of EVs in achieving sustainability goals.

Ayob et. Al, The shift towards electric vehicles (EVs) is driven by concerns over energy usage, environmental pollution, and fossil fuel prices. Electricity is deemed the most suitable energy carrier for transportation due to its low emissions and availability. EVs encompass Hybrid Electric Vehicles (HEVs), Plug-in Hybrid Electric Vehicles (PHEVs), and all-electric vehicles, each with different propulsion systems and charging capabilities. HEVs can be series, parallel, or series-parallel configurations, while PHEVs offer the option to recharge from the grid for extended electric-only operation. EVs rely solely on external charging and are expected to impact electricity distribution networks. Power demand for EVs varies based on voltage, current, and battery size, with fast chargers consuming up to 100 kW. Efforts to standardize charging stations aim to facilitate widespread adoption. This study provides an overview of EV technology, battery chargers, charging stations, and standards across regions.

Brenna et. Al, The surge in Electric Vehicles (EVs) adoption stems from concerns over carbon emissions and fossil fuel depletion. By 2022, EV numbers are projected to surpass 35 million globally. However, widespread EV use strains power grids, prompting the integration of renewable energy sources (RESs) into charging infrastructure. While conductive charging dominates due to challenges with inductive methods, EV battery chargers are categorized into levels based on power ratings, enabling bidirectional power flow for grid-to-vehicle (G2V) and vehicle-to-grid (V2G) interaction. V2G holds potential for grid reliability by utilizing EVs as backup power during outages. Charging strategies like constant-current/constant-voltage (CC/CV) and pulse current are common, but research focuses on more comprehensive models. Falling costs of EV batteries and power electronics drive technological advancements, impacting charger sizing. The paper discusses on-board and off-board charger architectures, fast charging stations, and optimal charging system sizing using a genetic algorithm.

Chandwadkar et. Al, The global Electric Vehicle (EV) market is gaining momentum, driven by advancements in battery technology and charging systems. EVs offer zero emissions, quiet operation, and fast acceleration. However, challenges such as cost, limited range, and charging infrastructure persist. Society of Automotive Engineers (SAE) standards classify AC charging stations into Level 1 and Level 2, utilizing 120V/230V and poly-phase 240V sources respectively. Unofficially, Level 3 DC charging stations provide high-voltage DC directly to EV batteries for rapid charging. Onboard and off-board chargers differ in power levels and complexity, with off-board chargers handling higher power transfer and requiring more sophisticated Battery Management Systems (BMS). Power electronics converters are crucial in EVs, facilitating functions from charging to driving electric motors. AC-DC, DC-DC, and DC-AC converters are utilized. Battery charging methods vary, categorized as fast or slow chargers based on power rating and location. As EV technology advances, optimizing charging systems and infrastructure remains pivotal for widespread adoption.

Jettanesan et. Al, The rise in transportation demands coupled with dwindling oil and natural gas resources has led to environmental pollution and high fuel costs. In response, electric vehicles (EVs) are gaining popularity due to their pollution-

free operation and ability to be powered by renewable energy sources. While EVs offer environmental benefits, they face limitations such as restricted range and prolonged charging times for large energy storage systems. Traditional EV battery chargers typically employ dual-stage DC/DC and DC/AC converters, resulting in complexity and inefficiency. To address these issues, novel single-stage chargers have been proposed. Various research explores different charger topologies and control strategies, aiming to optimize efficiency and performance. This paper introduces a charger for electric motorcycles, utilizing a buck converter with constant current and voltage techniques to convert AC residential supply to DC for efficient and controlled charging.

Shivanand et. Al, India aims to have 15% of its vehicles electric within five years, aligning with global efforts to reduce fossil fuel dependency. While global electric vehicle (EV) sales exceeded 4 million, India sold only 2,000 EVs in 2017. The government incentivizes EV adoption through schemes like FAME, supporting pilot projects and charging infrastructure development. Energy Efficiency Services Limited (EESL) has ordered 10,000 EVs to promote adoption. However, challenges persist, particularly in charging infrastructure. Limited standardization, range anxiety, and high costs hinder deployment. Despite low initial investment for AC slow charging infrastructure, growth remains sluggish. India lacks a comprehensive charging network, with few stations installed by EV manufacturers. Scaling up infrastructure requires sustained government, utility, and manufacturer support. Addressing these challenges is crucial for India's ambitious EV goals.

CHAPTER 3

AIM AND SCOPE

3.1. AIM OF THE PROJECT

The project aims to address the issue of interchangeability in Electric Vehicle (EV) chargers by developing an innovative adapter that can accommodate two EV chargers rated at 6A and 60V. This solution seeks to promote sustainability and cost efficiency by enabling the use of one charger for multiple EV two-wheelers, thereby reducing electronic waste and enhancing charging station efficiency. The project prioritizes criteria such as compatibility, safety features, and adherence to industry standards in the selection of chargers. Through this initiative, the project aims to provide an effective charging solution that aligns with environmental consciousness and resource optimization in electric transportation.

3.2. SCOPE OF THE PROJECT

The scope of this project encompasses the selection, integration, and development of an innovative adapter for two Electric Vehicle (EV) chargers rated at 6A and 60V. The primary focus is on addressing the challenge of interchangeability in EV chargers while emphasizing sustainability and cost efficiency. The project aims to facilitate the use of one charger for multiple EV two-wheelers, thus reducing electronic waste and enhancing charging station efficiency. Key aspects within the scope include evaluating compatibility, safety features, and adherence to industry standards during the selection process. By creating a versatile adapter, the project aims to fulfill the demand for effective charging solutions while contributing to broader objectives of environmental consciousness and resource optimization in electric transportation.

CHAPTER 4

MATERIALS AND EXPERIMENTAL METHOD

4.1. OVERVIEW OF EV CHARGER REQUIREMENTS

Developing an adapter for EV two-wheeler chargers required a careful selection of the targetchargers. Here's a breakdown of key criteria that were considered:

4.1.1. Technical Specifications:

- **Input and Output Voltage & Current:** The adapter needs to be compatible with a range of input voltages (usually household AC) and be able to handle the output voltage and current required by different e-two-wheelers. Focus on chargers with a common voltage range (e.g., 48V or higher) to maximize adapter applicability.
- **Connector Type:** This is the most crucial factor. Select chargers with the most prevalent connector types in your target market. Consider researching popular e-two-wheeler brands and their respective connector styles (e.g., SAE J1772, proprietary connectors).
- **Charging Protocols:** Different chargers might utilize varying communication protocols to manage charging parameters with the e-two-wheeler. Ideally, choose chargers with a common protocol (if applicable) or focus on chargers with a simple charging mode that doesn't require complex communication.

4.1.2. Safety and Reliability:

- **Safety Certifications:** Ensure the chosen chargers possess relevant safety certifications for your region. This guarantees the charger meets safety standards forelectrical components and charging processes.
- **Brand Reputation:** Opt for chargers from reputable brands known for their quality and reliability. This minimizes the risk of malfunctions or compatibility

issues that could impact adapter functionality.

4.1.3 Practical Considerations:

- **Availability and Cost:** Choose chargers that are readily available and cost-effective to acquire. This ensures the adapter development process is feasible and the final product remains affordable for consumers.
- **Physical Size and Design:** Consider the physical size and design of the chargers. Ideally, choose chargers that are compact and lightweight for easier integration with the adapter and user portability.

4.2. CRITERIA FOR CHARGER SELECTION

It was extremely important to select the right set of chargers to proceed with our idea of project in order to ensure efficient charging, safety and convenience. Here's a breakdown of key criteria considered when selecting the EV two-wheeler chargers:

- **Connector Type:** This is paramount. Ensure the charger's connector matches the port on your e-two-wheeler. Common types include SAE J1772 (North America), Mennekes type 2 (Europe), and various proprietary connectors used by specific manufacturers. Mismatched connectors can damage your battery or prevent charging altogether.
- **Battery Voltage:** Chargers are designed for specific voltage ranges. Match the charger's output voltage to your e-two-wheeler's battery voltage (e.g., 48V, 72V). Using an incompatible voltage can damage the battery.
- **Output Current:** This determines charging speed. Higher output current (amps) translates to faster charging, but also requires a compatible circuit and might be more expensive. Choose an output current that meets your needs. Consider your typical riding distance and how often you need to recharge.
- **Charging Levels:** EV chargers are categorized by levels based on power output and charging speed. Level 1 chargers (typically 120V) are slowest, while

Level 3 chargers (DC fast chargers) offer the fastest charging but are less common for home use. Consider Level 2 chargers (240V) for a good balance between speed and convenience for home charging.

- **Cost:** Selecting two chargers that were relatively affordable to avoid shortage of funds in case of failure was extremely crucial. This enabled us to keep funds for contingency.

4.3. COMPARISON OF AVAILABLE CHARGER OPTIONS

The EV two-wheeler market is huge, and its charging can be confusing due to the lack of a universal standard. Here's a breakdown of the available options that we found in Chennai:

4.3.1. *Ampere Magnus:*



Fig. 4.1. Charging Pin of Ampere Magnus

The Ampere Magnus is an electric scooter that comes in two variants, the LT and the EX. The EX has a longer range of 121 km on a single charge and a top speed of 50 km/h. It's priced around Rs 1.04 lakh. Both variants are known for their comfortable ride and come in a variety of colors. It is a good choice for riders looking for an affordable, practical electric scooter for commuting. Fig. 4.1. displays the charging pin of the charger used to charge this EV two-wheeler.

4.3.2. Ampere Primus:



Fig. 4.2. Charging Pin of Ampere Primus

The Ampere Primus is a performance-focused electric scooter with a claimed range of 107 km and a top speed of 77 km/h. It boasts a powerful motor and a long list of features for its price tag of Rs 1.46 lakh. This includes a 3kWh battery, ergonomic seating, a 22L boot space, and smartphone connectivity. It's a good option for riders seeking a feature-rich electric scooter with a sporty edge. Fig. 4.2. displays the charging pin of the charger used to charge this EV two-wheeler.

4.3.3. Ampere Reo Li Plus:

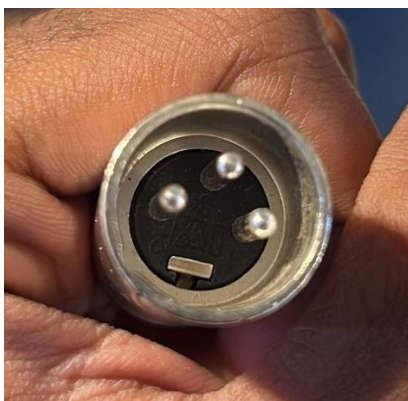


Fig. 4.3. Charging Pin of Ampere Reo Li Plus

The Ampere Reo Li Plus is a perfect electric scooter for riders on a budget. With a price tag around Rs 70,000, it's a low-cost option for zipping around

town. You won't be speeding away at high velocity though, as its top speed is 25 kmph. This also means you can ride the Reo Li Plus without a license, making it even more accessible. Despite the slower speed, the Reo Li Plus offers a claimed range of 70 kilometers on a single charge, enough for most daily commutes. Fig. 4.3. displays the charging pin of the charger used to charge this EV two-wheeler.

4.3.4. Ampere Zeal:



Fig. 4.4. Charging Pin of Ampere Zeal

Ampere offers two electric scooters under the Zeal name: the Zeal and the Zeal EX. The standard Zeal prioritizes affordability with a range of around 75 kilometers and a more basic feature set. It's a good choice for budget-minded riders who need a dependable electric scooter for short trips. Fig. 4.4. displays the charging pin of the charger used to charge this EV two-wheeler.

4.3.5. Ather 450x:



Fig. 4.5. Charging Pin of Ather 450x

The Ather 450X is a high-performance electric scooter known for its speed and range. It boasts zippy acceleration and a top speed of 90 km/h, making it ideal for navigating city traffic. With a claimed range of 115 kilometers on a single charge (depending on variant), the 450X offers peace of mind for daily commutes. Adding to its appeal is a touchscreen instrument cluster for a tech-forward riding experience. It displays everything from your speed and battery life to turn-by-turn navigation powered by Google Maps. Bluetooth and Wi-Fi connectivity keep you connected while you ride. The sleek, modern design of the Ather 450X isn't an afterthought either. It comes in a variety of colors, so you can choose the one that best reflects your style. Fig. 4.5. displays the charging pin of the charger used to charge this EV two-wheeler.

4.3.6. Bajaj Chetak:



Fig. 4.6. Charging Pin of Bajaj Chetak

The Bajaj Chetak is the electric reincarnation of a legendary Indian scooter, offering a familiar and comfortable ride for your daily commute. It trades neck-breaking speed for practicality, designed to effortlessly navigate city streets. With a classic design that pays homage to its past, the Chetak is a modern take on a beloved symbol. Plus, it boasts a range of up to 127 kilometers on a single charge, letting you conquer your daily errands and commutes with ease. Fig. 4.6. displays the charging pin of the charger used to charge this EV two-wheeler.

4.3.7. Ola S1 Pro:



Fig. 4.7. Charging Pin of Ola S1 Pro

Ola's S1 Pro electric scooter isn't just about getting from point A to B, it's an adrenaline rush on two wheels. It catapults you from 0 to 40 kmph in a staggering 2.6 seconds, reaching a top speed of 120 kmph. With that kind of power, highway cruising becomes effortless. But hold on, there's more! The S1 Pro boasts an impressive, certified range of 195 kilometers, so you can explore further and farther without worrying about range anxiety. Fig. 4.7. displays the charging pin of the charger used to charge this EV two-wheeler.

4.3.8. TVS iQube:

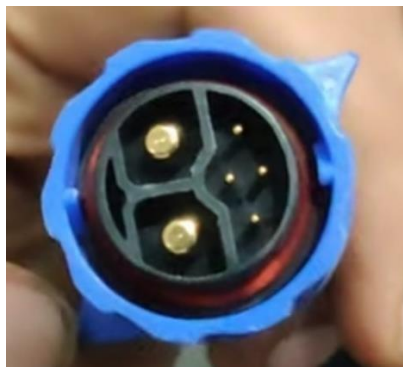


Fig. 4.8. Charging Pin of TVS iQube

The TVS iQube caters to everyday riders seeking a balance between performance and practicality. It's a dependable option for navigating city environments. The iQube comes in three variants, each offering a different

range and features to suit your needs and budget. While it won't win any drag races, the iQube provides a smooth ride with enough zip to handle city traffic. The most powerful variant boasts an impressive, claimed range of 145 kilometerson a single charge. Fig. 4.8. displays the charging pin of the charger used to charge this EV two-wheeler.

The above chargers are compared based on the following factors:

- No. of pins
- No. of communication pin
- Input Voltage
- Input Current
- Output Voltage
- Output Current
- Charger Cost

Table 4.1. Comparison of EV Two-Wheeler Chargers Available in Chennai

Name Of Bike	No. Of Pins	No. of Commu- nication Pins	Input Voltage (V)	Input Current (A)	Output Voltage (V)	Output Current (A)	Cost Of Charger (₹)
Ampere Magnus	6	4	170-280	4	67	7.5	7500
Ampere Primus	6	4	180-290	5	57	15	8000
Ampere Reo Li Plus	3	-	180-260	4	67	7.5	5000
Ampere Zeal	3	-	170-280	4	67	7.5	4000
Ather 450x	9	6	190-230	5	59	12	7500
Bajaj Chetak	3	-	150-220	5	72	6	5300
Ola S1Pro	6	4	100-240	6	72	8	15000
TVS iQUBE	6	4	110-240	8	60	10	7000

Table 4.1 notes the important factors we studied to select the chargers. After careful consideration, based on the available options, their specifications and their cost we decided to fabricate an adapter for Amper Reo Li Plus and Ampere Zeal

since they were few of the most common chargers available and used in multiple other two wheelers along with the feasibility and affordability of their chargers taken into account.

4.4. AVAILABLE SHELL MATERIALS

4.4.1. Acrylonitrile Butadiene Styrene (ABS):

Pros:

- Affordable and readily available.
- Offers good impact resistance and mechanical strength.
- Can be easily molded into various shapes for different charger designs.
- Can be flame retardant with additives (check for FR-ABS specifically).

Cons:

- Not as scratch resistant as some other options.
- Can become brittle over time, especially in extreme temperatures.
- May not be the most aesthetically pleasing option.

4.4.2. Polycarbonate (PC):

Pros:

- Excellent impact resistance and durability.
- More scratch-resistant than ABS.
- Offers good dimensional stability and heat resistance.
- Can be flame retardant (look for FR-PC).
- Provides a clear or translucent finish for aesthetics.

Cons:

- Generally, more expensive than ABS.
- Can be more challenging to mold into complex shapes.

4.4.3. Polypropylene (PP):

Pros:

- Lightweight and cost-effective option.
- Offers good chemical resistance and electrical insulation.
- Can be flame retardant (check for FR-PP).

Cons:

- Lower impact resistance compared to ABS or PC.
- Can have a lower melting point, limiting heat tolerance.
- Not as rigid as other options might require additional structural support.

4.4.4. Thermoplastic Elastomer (TPE):

Pros:

- Offers excellent flexibility and shock absorption.
- Provides a good grip and comfortable feel.
- Flame retardant options are available.

Cons:

- Generally, more expensive than ABS or PP.
- Might not be as aesthetically pleasing as other materials.
- May show wear and tear more easily due to its flexibility.

4.4.5. Metal (Aluminum):

Pros:

- Excellent heat dissipation, ideal for high-power chargers.
- Very durable and long-lasting.
- Provides a sleek and premium aesthetic.

Cons:

- Most expensive option on this list.
- Heavier compared to plastic materials.

4.4.6. Thermoplastic Elastomer (TPU):

Pros:

- Flexibility and Grip: Provides a comfortable and non-slip grip, especially beneficial for handheld chargers.
- Impact Resistance: Absorbs shocks and impacts, offering some protection for the charger in case of drops.
- Flame Retardant Options: Look for specifically flame-retardant TPU (FR-TPU) for added safety.

Cons:

- Heat Resistance: While some TPU blends offer improved heat tolerance, it's generally not as heat resistant as ABS or PC. This might limit its suitability for high-power chargers that generate significant heat.
- Durability: TPU can show wear and tear more easily compared to rigid plastics.
- Cost: TPU can be more expensive than ABS or PP.

4.4.7. PLA (Polylactic Acid):

Pros:

- Environmentally Friendly: PLA is a bioplastic derived from renewable resources.
- Lightweight: The lightest option on this list.
- Customization: Can be 3D printed for unique or personalized designs (not massproduction).

Cons:

- Not Heat Resistant: PLA has a very low melting point, making it unsuitable for applications involving heat generation from the charger.
- Brittle: PLA is more susceptible to cracking or breaking compared to other options.

4.5. COMPARATIVE STUDY BETWEEN ABS, PLA AND TPU

Table 4.2. Comparison of TPU, ABS and PLA for Material Selection

Type of Property	TPU	ABS	PLA
Chemical Structure	TPU is composed of alternating flexible segments (polyols) and rigid segments (diisocyanates).	ABS is a terpolymer made from three monomers: Acrylonitrile, Butadiene, and Styrene.	PLA is composed of repeating units of lactic acid, a renewable resource derived from plant sugars.
Mechanical Properties	• Flexible and elastic. • High elongation at break (ability to stretch before breaking). • Excellent abrasion resistance. • Good tear strength.	• More rigid and stiff compared to TPU. • Lower elongation at break. • Moderate to high impact resistance. • Good toughness.	• Limited elasticity • Lower elongation at break compared to TPU. • Moderate impact resistance • Moderate toughness

Hardness	It is available in a wide range of hardness levels, from very soft to relatively rigid	Generally, has a harder and more rigid feel compared to TPU.	Moderate hardness, making it suitable for a variety of applications.
Temperature Resistance	Exhibits good flexibility and performance over a broad temperature range, typically between -40°C to 120°C.	Can withstand lower temperatures compared to TPU but may experience deformation or warping at higher temperatures (above 80°C).	Glass transition temperature around 60-65°C, limiting its use in high-temperature environments.
Chemical Resistance	Generally, has good resistance to oils, greases, and chemicals.	Moderate resistance to chemicals but may be affected by some solvents.	Decent resistance, but it can degrade when exposed to certain solvents and acids.
Processing and Manufacturing	Easily processed using common thermoplastic processing methods such as injection molding, extrusion, and 3D printing.	Suitable for injection molding, extrusion, and 3D printing as well, making it widely used in various manufacturing processes.	Easily processed using common techniques such as injection molding, extrusion, and thermoforming.
Cost	Generally, more expensive than ABS.	Known for its cost-effectiveness.	Cost-effective compared to some other biodegradable polymers,
3D Printing	Known for its compatibility with flexible filament 3D printing. It is often used to create flexible and elastic objects.	Commonly used in 3D printing, providing good layer adhesion and a smooth surface finish.	Widely used in 3D printing due to its ease of printing, low warping, and biodegradability
Applications	Applications requiring flexibility, such as shoe soles, automotive components, medical devices, phone cases, and flexible hoses.	Widely used in automotive components, electronic housings, toys, consumer goods, and 3D printing.	Biodegradable packaging, disposable tableware, medical implants, textile fibers.

After reviewing the materials and their properties thoroughly using the above Table 2 and identifying the materials accessible in our laboratory facility for 3D printing, we decided to perform test prints using PLA and final print using TPU for the added advantage of flexibility.

4.6. STRUCTURAL ANALYSIS OF PLA AND TPU

This study presents a comparative structural analysis of an Electric Vehicle (EV) charger adapter utilizing two different materials: Polylactic Acid (PLA) and ThermoplasticPolyurethane (TPU). The analysis aims to evaluate the adapter's performance in terms of total deformation, equivalent strain, and shear stress under typical loading conditions. FiniteElement Analysis (FEA) simulations were conducted using ANSYS software to simulate the mechanical behavior of the adapter. Results from the analysis provide insights into the comparative performance of PLA and TPU materials, aiding in material selection for adapter shell.

1. PLA Material:

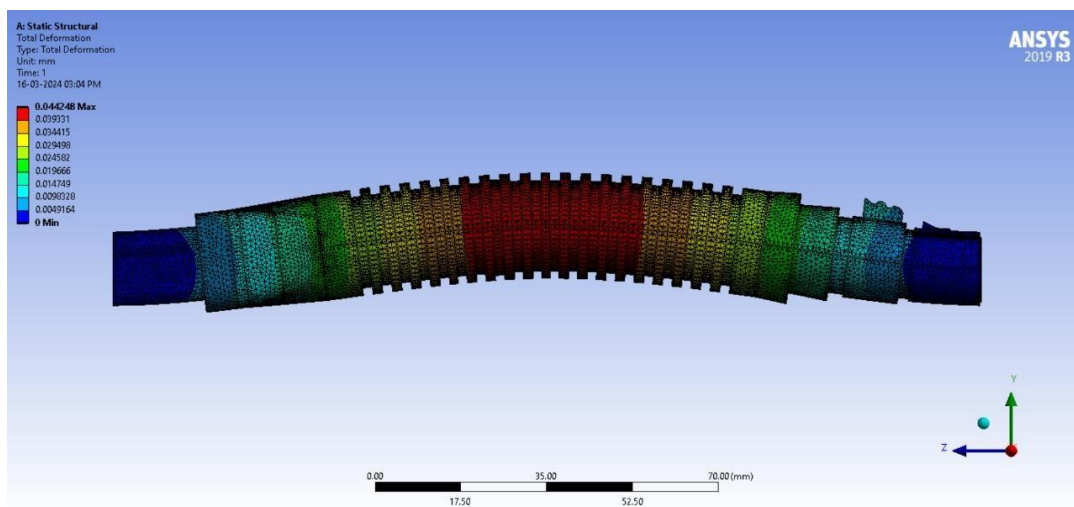


Fig. 4.9. Total Deformation on PLA Shell

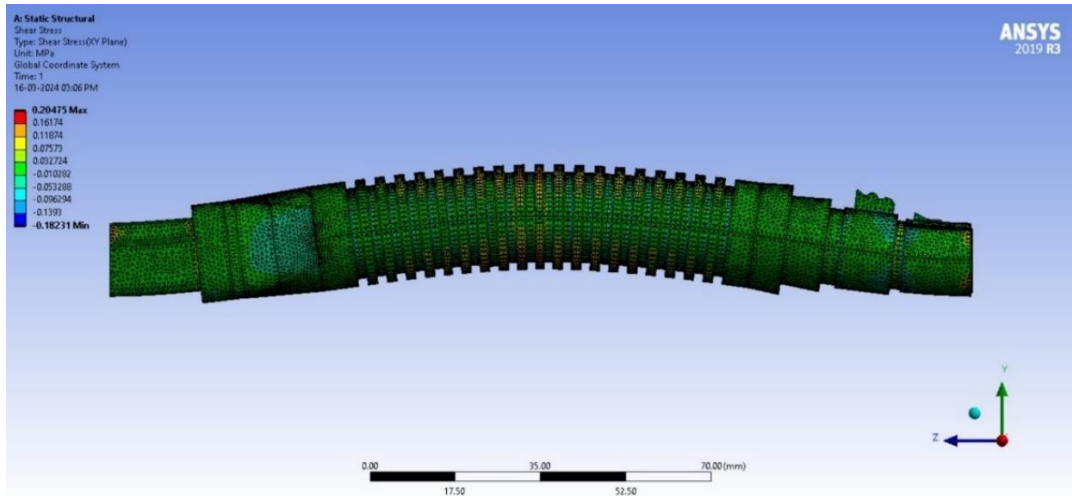


Fig. 4.10. Shear Stress on PLA Shell

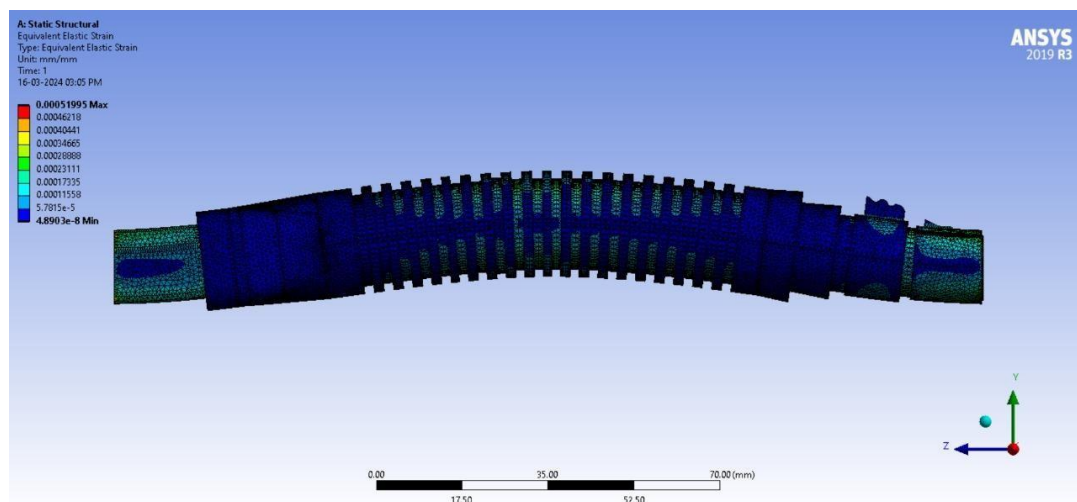


Fig. 4.11. Equivalent Elastic Strain on PLA Shell

Figures 4.9, 4.10 and 4.11 are the results derived from the analysis performed on PLA material. The shell underwent a force of 25N considering the usual formula:

$$F = m \times a$$

The mass of the adapter is nearly 300 grams and when attached to the charger, the adapter could face a weight of up to 700-1000 grams. Considering the total weight of the adapter to be nearly 1kg when attached to the charger and

including another 1.5 kg weight to consider any additional mass when handled by a human while removing or attaching the adapter that could act upon the adapter. So, a safe mass of about 2.5kg is considered and 9.8m/s^2 acceleration due to gravity is taken into justification.

The Table 4.3 below provides information on the type and magnitude of force applied on the adapter:

Table 4.3. Load on PLA Material

Object Name	Fixed Support	Force
State	Fully Defined	
Scope		
Scoping Method	Geometry Selection	
Geometry	3 Faces	14 Faces
Definition		
Type	Fixed Support	Force
Suppressed	No	
Define By		Vector
Magnitude		25. N (ramped)
Direction		Defined

The below Table 4.4 finally displays the results from the analysis:

Table 4.4. Results from PLA Material

Object Name	Total Deformation	Equivalent Elastic Strain	Shear Stress
State	Solved		
Scope			
Scoping Method	Geometry Selection		
Geometry	All Bodies		
Definition			
Type	Total Deformation	Equivalent Elastic Strain	Shear Stress
By	Time		
Display Time	Last		
Calculate Time History	Yes		
Identifier			
Suppressed	No		
Orientation			XY Plane
Coordinate System			Global Coordinate System
Results			
Minimum	0. mm	4.8903e-008 mm/mm	-0.18231 MPa
Maximum	4.4248e-002 mm	5.1995e-004 mm/mm	0.20475 MPa
Average	2.4359e-002 mm	6.8442e-005 mm/mm	-8.2065e-005 MPa
Minimum Occurs On	Solid		
Maximum Occurs On	Solid		
Information			
Time	1. s		
Load Step	1		
Substep	1		
Iteration Number	1		
Integration Point Results			
Display Option		Averaged	
Average Across Bodies		No	

The Results section shows the minimum, maximum, and average values of the total deformation, equivalent elastic strain, and shear stress. It also shows the location where the minimum and maximum values occurred. The table shows that the model deformed a maximum of 0.44248 millimeters. The equivalent elastic strain was a maximum of 5.1995e-004 mm/mm. The shear stress was a maximum of 0.20475 MPa. The minimum values were 0 mm, 4.8903e-008 mm/mm, and -0.18231 MPa, respectively. The average values were 2.4359e-002 mm, 6.8442e-005 mm/mm, and -8.2065e-005 MPa, respectively.

2. TPU Material:

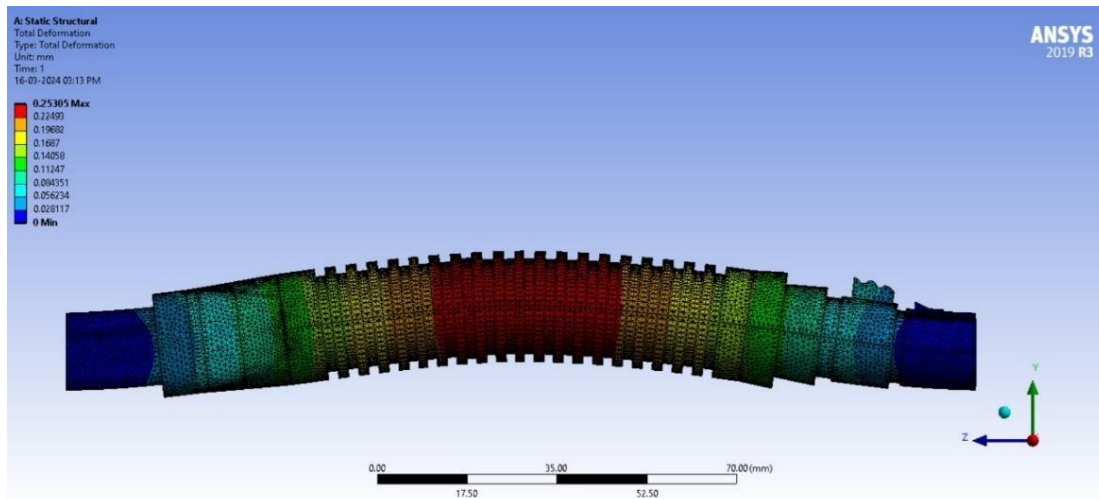


Fig. 4.12. Total Deformation on TPU Shell

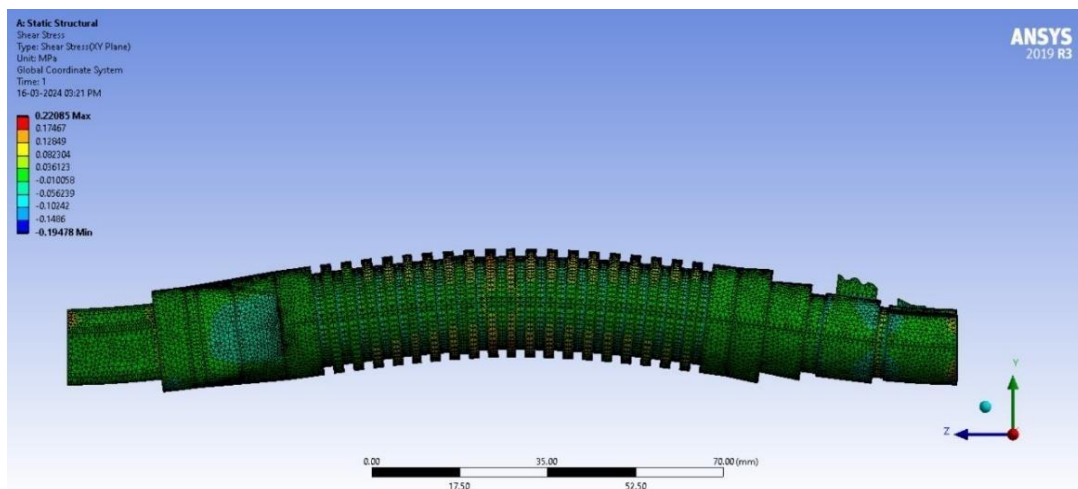


Fig. 4.13. Shear Stress on TPU Shell

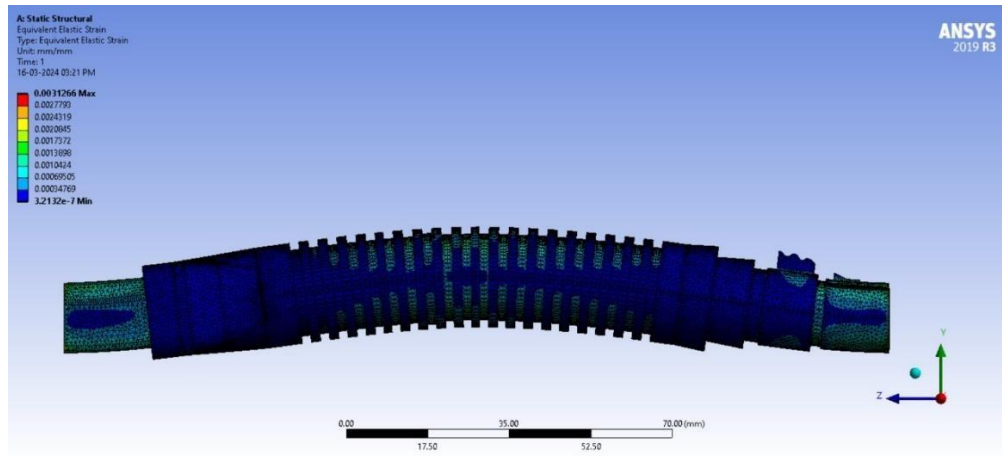


Fig. 4.14. Equivalent Elastic Strain on TPU Shell

Figures 4.12, 4.13 and 4.14 are the results derived from the analysis performed on TPU material. The shell underwent a force of 25N considering the same calculation that was used on PLA Material.

The Table 4.5 below provides information on the type and magnitude of force applied on the adapter:

Table 4.5. Load on TPU Material

Object Name	Fixed Support	Force
State	Fully Defined	
Scope		
Scoping Method	Geometry Selection	
Geometry	3 Faces	14 Faces
Definition		
Type	Fixed Support	Force
Suppressed	No	
Define By		Vector
Magnitude		25. N (ramped)
Direction		Defined

Overall, the total deformation of the scope is equal to the total deformation of the object. The total deformation of the shell is somewhere between 0 mm and 0.25305 mm. The equivalent elastic strain is between 0 mm/mm and 3.1266e-003 mm/mm. The shear stress is between -0.19478 MPa and 0.22085 MPa.

Here's a more detailed explanation of the results:

Total Deformation: This is the amount that the object has deformed under the applied load. The table shows that the maximum total deformation is 0.25305 mm. This means that the object has deformed by a quarter of a millimeter at its most deformed point.

Equivalent Elastic Strain: This is a measure of the strain (or deformation) that an object experiences under load, relative to a perfectly elastic material. The table shows that the maximum equivalent elastic strain is 3.1266e-003 mm/mm.

Shear Stress: This is the type of stress that tends to cause the layers of material to slide relative to each other. The table shows that the maximum shear stress is 0.22085 MPa.

It is important to note that these are just the results of a computer simulation. The actual behavior of the object under load could be different.

The below Table 4.6 finally displays the results from the analysis:

Table 4.6. Results from TPU Material

Object Name	Total Deformation	Equivalent Elastic Strain	Shear Stress
State	Solved		
Scope			
Scoping Method	Geometry Selection		
Geometry	All Bodies		
Definition			
Type	Total Deformation	Equivalent Elastic Strain	Shear Stress
By	Time		
Display Time	Last		
Calculate Time History	Yes		
Identifier			
Suppressed	No		
Orientation			XY Plane
Coordinate System			Global Coordinate System
Results			
Minimum	0. mm	3.2132e-007 mm/mm	-0.19478 MPa
Maximum	0.25305 mm	3.1266e-003 mm/mm	0.22085 MPa
Average	0.13909 mm	3.9652e-004 mm/mm	-8.7691e-005 MPa
Minimum Occurs On	Solid		
Maximum Occurs On	Solid		
Information			
Time	1. s		
Load Step	1		
Substep	1		
Iteration Number	1		
Integration Point Results			
Display Option		Averaged	
Average Across Bodies		No	

4.7. COMPATIBILITY CONSIDERATIONS

Supported Connector types:

Our adapter is made especially to fit T-pin and XLR connectors, which are frequently found in bicycle charging systems. To make sure consumers understand the compatible connector types, this constraint should be made apparent to them.

XLR Compatibility:

XLR connectors, which are frequently used in electric bike charging systems, are entirely compatible with the adaptor. Because of this compatibility, users whose bikes have XLR connectors can easily attach their chargers to the adaptor.

T-pin Compatibility:

In a similar vein, T-pin connections, another popular connector type in bike charging systems, are compatible with the adaptor. Customers who ride bikes with T-pin connectors may depend on the adaptor to work seamlessly when charging.

Limited Compatibility Scope:

It's vital to remember that our adapter's unique design may prevent it from working with other connector types that are frequently seen in bike chargers. Before utilising the adapter, users should make sure that their bike chargers use T-pin or XLR connectors.

User Awareness:

We highlight how important it is to let consumers know about the adapter's constrained compatibility. It is imperative to offer customers with comprehensive documentation and labelling that fully explains the supported connector types and any possible constraints.

Potential Compatibility Factors:

Although our adapter is now compatible with XLR and T-pin connectors, it may support more connector types in later versions or upgrades. We'll keep an eye on market developments and customer input to evaluate prospective improvements and make sure our goods satisfy changing compatibility requirements.

Compatibility Considerations

Currently, there are no specific government safety regulations for e-bike charger adapters in India. However, there are general safety guidelines and standards that your adapter should ideally follow to ensure user safety. These are set by agencies like the Automotive Research Association of India (ARAI) and the Bureau of Indian Standards (BIS).

The following are some things to consider about with the e-bike charging adapter safety.

Technical specifications:

- Verifying that the voltage and amperage ratings of the current e-bike batteries are compatible.
- To manage the current without overheating, use cables of the proper thickness and types.

Manufacturing:

- The adapter housing is made from good quality and shock-resistant materials.
- Use safety features like overload and short-circuit protection and appropriate circuit design.

Testing and Certification:

Although it's not yet required, having adapter tested and certified by BIS to meet the AIS (Automotive Industry Standards) requirements for chargers for e-bikes. This will show that safety procedures are followed, which could boost customer confidence in your goods.

4.8. COMPONENT DETAILS AND THEIR INTERACTIONS

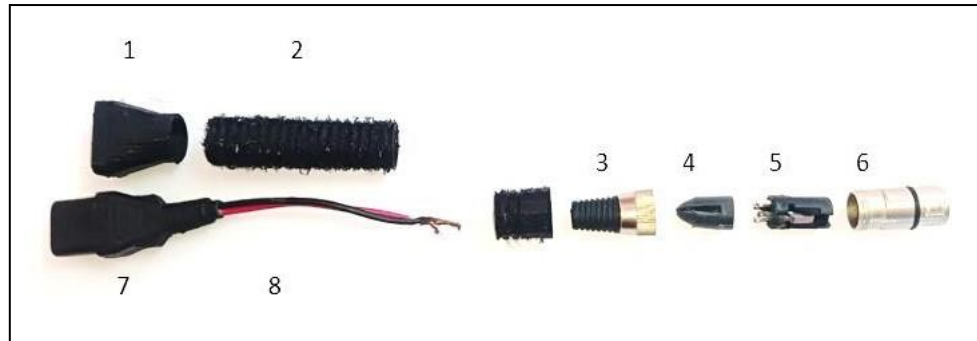


Fig. 4.15. Components of the Adapter

Each of the parts from the above fig. 4.15 are mentioned below:

1. Connector External shell
2. Middle External shell
3. Adjusting screw
4. Wire tensioner
5. Electrical pin holder
6. XLR connector
7. T-Pin connector
8. Cable for inside connections

External Shell: The external shell of the adapter acts as a shield, preventing physical harm and environmental factors from entering and damaging its internal components. It ensures endurance and dependability in a range of operating circumstances by offering structural integrity and enhancing the adapter's overall resilience.

Middle External Shell: The middle shell of the adapter acts as a shield, preventing physical harm and environmental factors from entering and damaging its internal components. It ensures endurance and dependability in a range of operating circumstances by offering structural integrity and enhancing the adapter's overall resilience.

Adjustment Screw: The adapter's internal parts can be fine-tuned by using this mechanical component to modify the tension or alignment. Through accurate adjustment of the screw, users may ensure correct connector alignment and seamless operation while using the adapter, hence optimising its performance and functionality.

Wire tensioner: Mechanism to regulate and control the tension of internal wires in the adapter is called a wire tensioner. In order to avoid damage, kinking, or tangling during operation, it makes sure that the cables are correctly fastened and kept at the ideal tension. The internal wiring system of the adapter is made more dependable and long-lasting by this component.

Electrical Pin Holder: In order to create connections between the adapter and external devices, like bike chargers, electrical pins or terminals are placed within this electrical pin holder. The adapter and connected devices may establish dependable electrical contact and power transmission thanks to the stable and secure mounting position it offers for the pins.

XLR Connector: Professional, electric motorcycles audio and lighting equipment, and other devices frequently use the XLR connector type of electrical connector. It has several round pins grouped inside a sturdy shell to provide a safe and dependable connection for power and signal transmission. Because of its dependability and suitability for high-current applications, the XLR connector is frequently used in bicycle charging systems.

T-Pin Connector: Another kind of electrical connector frequently found in electric bike charging systems is the T-Pin connector. It has a pin arrangement that looks like the letter "T," with two or more pins positioned inside a small

housing perpendicular to one another. Because of its simplicity, usability, and compatibility with a range of charging configurations, the T-Pin connector is preferred.

Cable for Inside Connections: The term "wire for internal connections" describes the insulated electrical wires that are used to link the adapter's internal parts, including terminals, pins, and connectors. These cables enable power and electrical signals to be transferred between the various components of the adapter, guaranteeing optimal operation. To ensure safety in electrical systems, minimize interference, and preserve signal integrity, high-quality cables with sufficient insulation are necessary.

4.9. ILLUSTRATION OF SYSTEM ARCHITECTURE

The adapter's protective covering is provided by the outer shell. For the internal parts, including the wire connections, the middle outer shell provides flexibility and extra protection. Adjusting the interior parts is made possible via the adjusting screw. Internal wire tension is maintained and controlled by the wire tensioner. The electrical pins needed to make connections are kept in the electrical pin holder. E-bike charger connectivity is made possible by the XLR and T-Pin connectors. Internal cables allow different ends of the adaptor to be connected to one another. Figure 4.16 and 4.17 below is the complete system and its architecture.



Fig. 4.16. Adapter from Top View



Fig. 4.17. Both Ends of the Adapter

CHAPTER 5

RESULTS AND DISCUSSION

5.1. DESIGN CONCEPT AND SPECIFICATIONS

The adapter's design was inspired by a straightforward yet successful concept giving bike owners an easy-to-use and affordable way to charge their bikes with a single charger. We set out to create an adapter that would allow consumers to use their current chargers for their bikes, considering the cost and inconvenience of needing to buy extra bikes or chargers. Our motivation came from the aim to advance accessibility, affordability, and sustainability within the electric two-wheeler industry.

Our objective was for a design that would work seamlessly with current bike charging systems and be universally compatible with a large variety of charger models and bike kinds. Inspired by this idea, we meticulously developed an adaptor that helps bike owners maximize their investment in electric mobility while also streamlining the charging procedure. In the end, the innovative and inclusive spirit that inspires our design ultimately opens the door to a more user-friendly and sustainable method of bike charging.

The first conceptual design was made using free hand sketch as shown in figure 5.1 below:

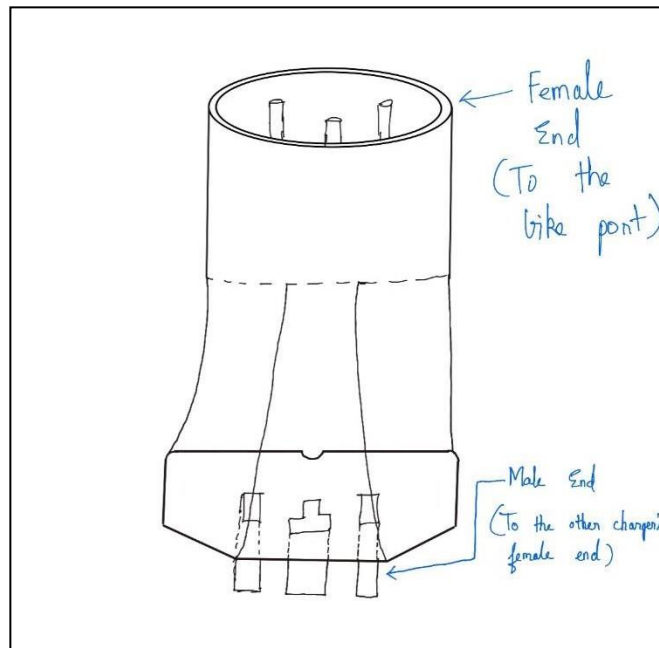


Fig. 5.1. Adapter Concept Sketch

Once the conceptual design and chargers were finalized, CAD Model was created and the figure 5.2 below shows the same:

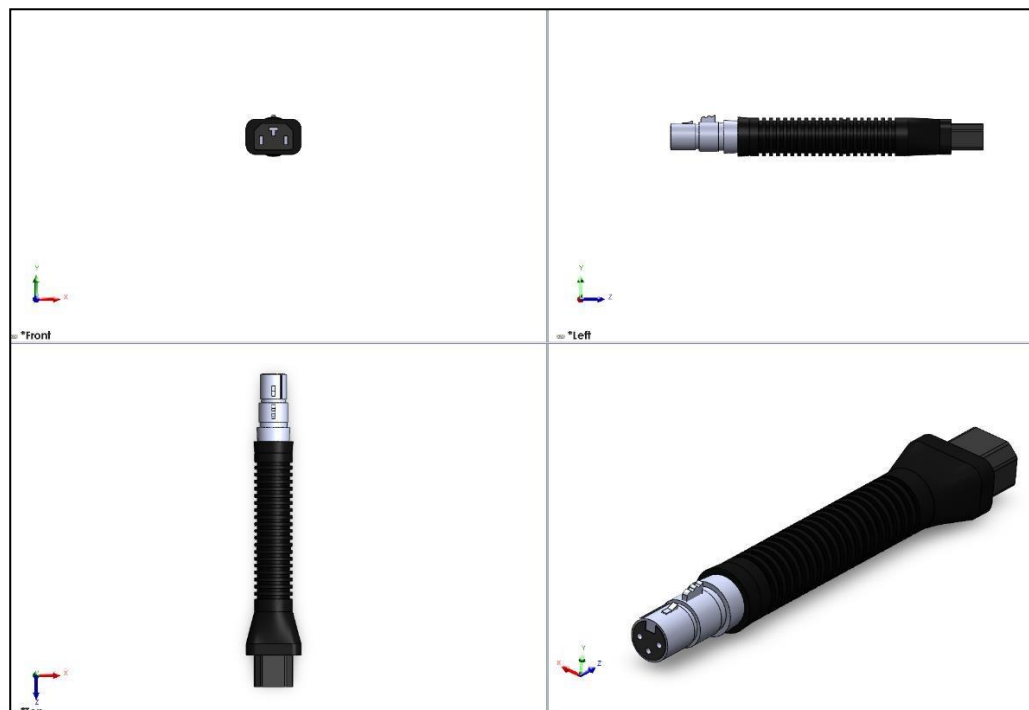


Fig. 5.2. FV, TV, SV, and Isometric View of the Adapter

The below figure 5.3 displays the dimensional specification of the adapter:

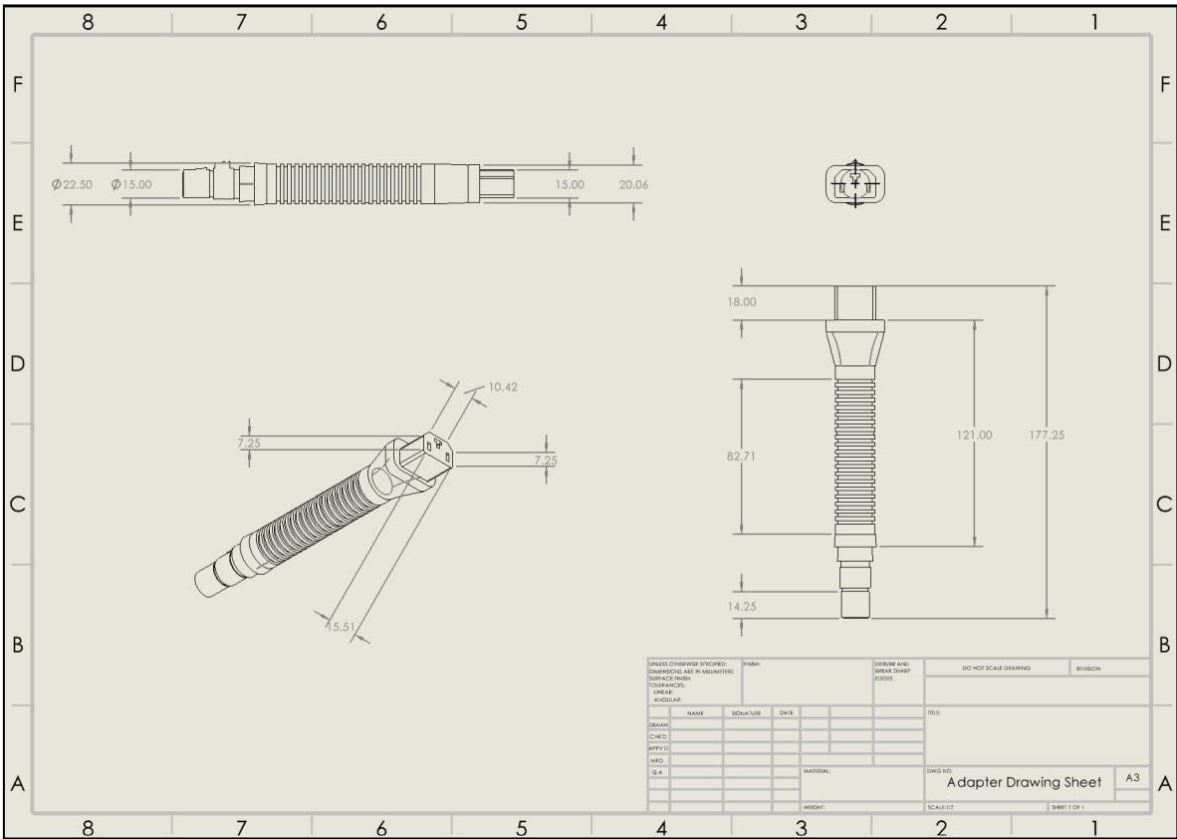


Fig. 5.3. Dimensional Specification of the Adapter

5.2. PROTOTYPE DEVELOPMENT PROCESS

5.2.1. Determine the Requirements:

Describing the project's goals, mentioning the necessity of cost-effectiveness, sustainability, and interchangeability in EV charging options. Based on compliance with industry standards and compatibility with electric two-wheelers, verifying the specifications and ratings needed for the EV chargers.

5.2.2. *Selecting a Charger*

Examine the EV chargers that are currently on the market and determine whether they meet the needs that have been established. To support a range of electric two-wheelers, select two EV chargers with complementing characteristics, such as a 60V charger and a 6A charger.

5.2.3. *Evaluation of Safety and Compliance:*

Making that the chosen EV chargers abide by all applicable safety requirements the charging of electric vehicles. the chargers have all the necessary safety short circuit protection, and overcurrent protection.

5.2.4. *Engineering and Design of Adapters:*

Doing the technical and design for creating a thorough plan for combining the two EV chargers into a single, multipurpose adaptor. To maximize usability and functionality, taking into account elements like form factor, heat dissipation, and user interface throughout the design phase.

5.2.5. *Integration of Parts:*

Taking the chosen EV chargers apart so we can see the inside parts and circuitry. Determining which common components and interfaces the adapter's design can incorporate to ensure smooth operation with electric two-wheelers.

5.2.6. *Integration of Electrical Systems:*

To ensure correct connections and compatibility with the power requirements of electric vehicles, integrating the electrical circuits of the two chargers into the adapter. Installing safeguards against electrical risks, such as surge protection devices, grounding, and insulation.

5.2.7. Design of Prototypes:

Based on the completed design and integration strategy, constructing an adapter prototype. Evaluating the adapter's functions, safety, and suitability for a variety of electric two-wheelers by conducting extensive testing and validation.

5.3. TESTING AND ITERATIVE REFINEMENT

The adapter underwent a rigorous testing regimen employing precise methodologies and instrumentation, notably employing a multimeter to meticulously evaluate its efficiency and performance. These meticulous tests have yielded exceptionally positive outcomes, affirming the adapter's capability to consistently and accurately transmit the requisite power output. Notably, the adapter has demonstrated commendable efficacy in facilitating the concurrent charging of two bicycles from a singular power source, a testament to its operational prowess.

Our testing methodologies rigorously scrutinized the adapter across diverse scenarios, ensuring its capacity to sustainably deliver the requisite power output. Impressively, the adapter not only met but surpassed our stringent criteria, consistently demonstrating its ability to fulfill operational demands. These favorable outcomes unequivocally underscore the adapter's seamless integration within our charging infrastructure, instilling confidence in its reliability and performance. Moreover, the affirmative results obtained from these assessments validate the adapter's suitability for real-world applications, positioning it as a dependable solution for cyclists seeking expedient and efficacious charging solutions.

Preparation for the testing process entailed meticulous calibration of the multimeter to measure direct current (DC) voltage, aligning it with the anticipated output of the adapter. Stringent safety protocols were diligently adhered to, encompassing the utilization of appropriate protective attire and the establishment of a well-ventilated workspace to mitigate any potential hazards.

The testing procedure commenced with the methodical connection of the multimeter's probes to the adapter's terminals, ensuring secure and stable contact to obviate any discrepancies in readings. Upon activation of the adapter's charging circuitry, meticulous attention was directed towards monitoring the multimeter's display screen, which served as a barometer of the voltage output. Critical observations were made to ascertain the stability and accuracy of the voltage reading, with particular emphasis placed on ensuring conformity with predetermined parameters. Throughout the testing regimen, meticulous records were meticulously maintained, encapsulating the intricacies of the setup, procedure, and resultant observations.

Following the completion of testing iterations, comprehensive analysis was conducted on the recorded voltage readings, benchmarking them against established standards to evaluate the adapter's performance. Any anomalies or deviations were meticulously noted and scrutinized to discern their implications. It is imperative to underscore that the testing process was conducted iteratively, with repeated evaluations undertaken to ascertain the consistency and reliability of results. This iterative approach facilitated the identification of any variances or inconsistencies, thereby enhancing the robustness of our assessments.

Ultimately, the comprehensive documentation of the testing process, inclusive of setup particulars, procedural intricacies, and analytical findings, serves as a repository of invaluable insights. This documentation not only provides a comprehensive record of the testing endeavors but also furnishes a foundational framework for future reference and potential troubleshooting endeavors.

The measure of current and voltage received from the multimeter with and without the adapter set-up is mentioned below in Table 5.1:

Table 5.1. Voltage and Current Reading using Multimeter

Power	Without Adapter		With Adapter	
	Voltage (V)	Current (A)	Voltage (V)	Current (A)
5A Switch	66.1	0.04	65.9	0.02
15A Switch	67.7	0.06	67.2	0.05

The test was carried out in an efficient manner and the set-up of the test is shown in the fig. 5.4 below:

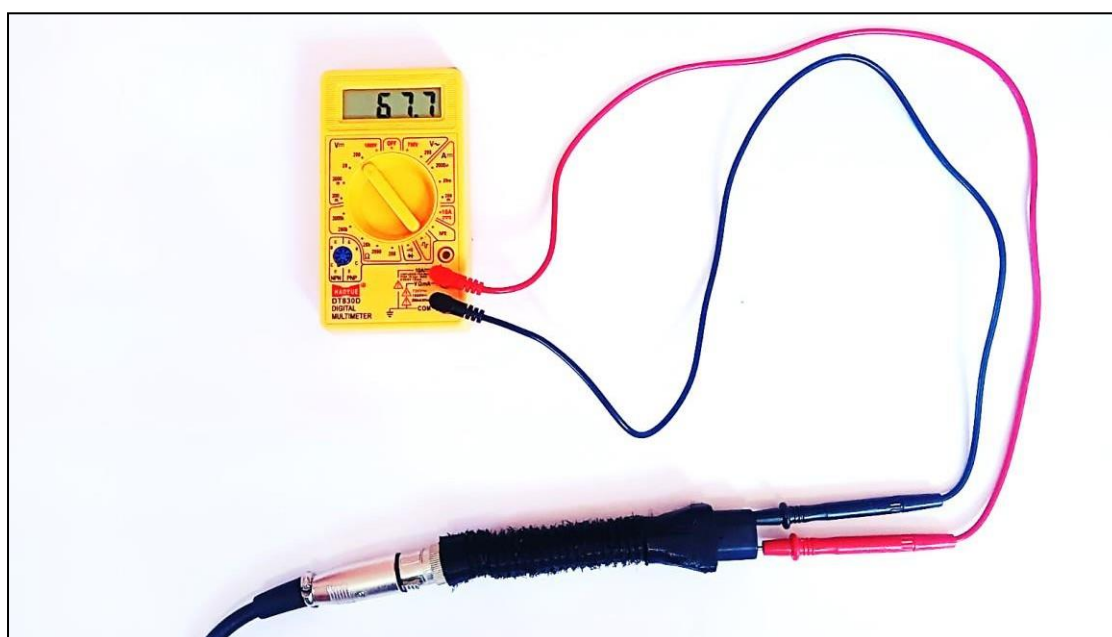


Fig. 5.4. Testing using Multimeter

CHAPTER 6

CONCLUSION

6.1. SUMMARY OF RESEARCH

This project focuses on addressing the challenge of interchangeability in Electric Vehicle (EV) chargers by developing an innovative adapter that supports the use of one charger for multiple EV two-wheelers. The primary goal is to promote sustainability and cost efficiency while reducing electronic waste and improving charging station efficiency.

The project specifically examines the selection and integration of two EV chargers rated at 6A and 60V. These chargers are chosen based on criteria such as compatibility, safety features, and adherence to industry standards. By carefully considering these factors, the project aims to ensure that the selected chargers meet the requirements for effective and safe charging.

The development of a versatile adapter is central to the project's objectives. This adapter will enable the connection of different EV two-wheelers to the chosen chargers, thereby allowing for flexibility and compatibility across various models. By creating a solution that supports multiple vehicles with one charger, the project not only addresses the immediate need for effective charging solutions but also contributes to broader goals of environmental consciousness and resource optimization in electric transportation.

Overall, this project represents a proactive approach to tackling challenges in EV charging infrastructure. By leveraging innovation and technology, the project aims to create a sustainable and efficient solution that benefits both users and the environment. Through careful selection, integration, and development, the project seeks to pave the way for a more accessible and environmentally friendly future in electric transportation.

6.2. RECOMMENDATIONS FOR FURTHER RESEARCH

For future research in this area, several recommendations can be considered to further enhance EV charging infrastructure and sustainability efforts:

- **Adapter Performance Optimization:** Investigate methods to optimize the performance of the adapter, such as improving efficiency, reducing charging time, and enhancing compatibility with a wider range of EV models.
- **Standardization and Compatibility:** Explore opportunities for standardization in EV charger connectors and protocols to improve interoperability and compatibility across different EV brands and models. This could involve collaboration with industry stakeholders to establish common standards and protocols.
- **Smart Charging Solutions:** Research smart charging technologies and algorithms to enable dynamic charging management, load balancing, and integration with renewable energy sources. This could include the development of intelligent charging systems that optimize charging schedules based on grid demand, energy prices, and user preferences.
- **Battery Technology Advancements:** Investigate advancements in battery technology, such as higher energy density, faster charging rates, and improved longevity, to enhance the overall efficiency and performance of EV charging systems.
- **Environmental Impact Assessment:** Evaluate the environmental impact of EV charging infrastructure, including life cycle assessments of chargers, adapters, and batteries. This could involve analyzing factors such as energy consumption, greenhouse gas emissions, and resource usage to identify opportunities for further sustainability improvements.

By pursuing these avenues of research, researchers can contribute to the ongoing development and improvement of EV charging infrastructure, driving forward the adoption of electric vehicles and supporting global efforts to mitigate climate change and reduce dependence on fossil fuels.

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PHASE 2 PROJECT REPORT

by Ignatius Raja

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