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## **V2V Charging System in Electric Bike**

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### **ABSTRACT**

This research investigates the application of a Vehicle-to-Vehicle (V2V) charging system for e-bikes, concentrating on the development and assessment of a Split-Pi converter. In order to encourage the widespread use of electric bicycles as a sustainable form of transportation in urban areas, effective charging techniques are essential. An innovative and practical way to increase the range of electric bicycles is to allow them to charge one another while they are moving. This is made possible by the proposed V2V charging system. An essential part of the V2V system, the Split-Pi converter is designed and analyzed in this research. The converter's capacity to effectively transfer power between electric bicycles is proved through simulations and results from experiments. The research presented here tackles the issues related to the infrastructure for charging electric bicycles and adds to the continuing efforts to create sustainable transportation alternatives. The results in this study highlight the viability of vehicle-to-vehicle (V2V) charging systems for electric bicycles, as well as how important they are for encouraging eco-friendly urban mobility and having the ability to increase range and decrease the need for a large infrastructure for charging. In order to integrate the V2V charging technology with current electric bicycle systems and put it into practice, more research is needed to develop and improve it.

**Keywords:** Split-Pi Converter, Electric Bicycles, V2V Charging, Urban Mobility, Sustainable Transportation.

### **1 Introduction**

Due largely to their affordability and low environmental impact, e-bikes are becoming a more and more well-liked form of sustainable mobility in cities. However, reliable and practical charging options present a significant obstacle to the widespread use of electric motorcycles. The flexibility and convenience of using an electric bike are limited by the need for power outlets, even if traditional plug-in chargers are readily available. Vehicle-to-vehicle (V2V) charging systems have surfaced as a creative solution to address this issue and increase the use and range of electric motorcycles. Electric bikes can now charge one another while traveling thanks to V2V technology, which does away with the requirement for infrastructure for fixed charging.

This strategy might completely change the way electric bike transportation works, making it more sustainable and useful for city dwellers. This study focuses on the design and assessment of a Split-PI converter, an essential part of the electric bike V2V charging system. During V2V

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charging, the Split-PI converter serves as a mediator to enable effective power transmission between electric bikes. This study intends to offer important insights into the viability and usefulness of V2V charging in the context of electric motorcycles by analyzing its design and functionality. The format of this document is as follows: In Section II, the literature on V2V technologies and electric bike charging techniques will be reviewed, with an emphasis on the gaps that our research seeks to fill. The methodology will be covered in full in Section III, along with the Split-PI converter's design and implementation as well as the techniques employed for performance assessment.

The results of the investigation will be presented in Section IV, and the consequences and potential roadblocks of installing V2V charging systems in electric bikes will be thoroughly discussed and analyzed in Section V.

**2 Literature Review**

Electric bikes, or "e-bikes," are becoming more and more well-known and are being acknowledged as a sustainable mode of transportation for urban travel. As an economical and environmentally friendly mode of transportation, e-bikes are becoming more and more popular. Finding effective charging techniques is a significant hurdle, though, as traditional plug-in chargers are limited in their usefulness by the need for power outlets.

Vehicle-to-vehicle (V2V) charging systems have become a viable remedy for this problem. By allowing electric bikes to share power while in use, V2V charging reduces the requirement for fixed charging infrastructure and increases user convenience for e-bike owners. The development of V2V charging systems for electric bikes and the function of the split-PI converter can be better understood by looking through the literature that has already been written in this area.

Studies on electric bike charging techniques have exposed the accessibility and user-friendliness shortcomings of conventional plug-in chargers. Power outlets are frequently needed by users, and having to plug in and wait for the battery to charge can be annoying, particularly in crowded areas. Alternative solution exploration has been prompted by the need for faster and more flexible charging choices.

The automobile industry has given V2V technology a great deal of attention, with an emphasis on electric cars (EVs). Research in this field has shown that it is feasible to transfer power wirelessly between cars, providing a potential way to increase the driving range of EVs. The development of comparable systems for electric bikes can benefit from knowledge gained from the use of V2V technology in the automotive industry.

However, there is a paucity of performance evaluation and real-world application in the existing research on V2V charging systems for electric bikes. In order to close this gap, the current study is concentrated on developing and assessing the split-PI converter, which is an essential part of V2V charging systems for electric bikes. The objective of this project is to enhance the development of sustainable and effective urban mobility solutions, specifically for



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electric bikes, by filling in the existing gaps and expanding on the present understanding of V2V technology and electric bike charging.

### **3 Methodology**

This section explains the approach used to examine the Split-Pi converter's design and evaluation, as well as the V2V charging system in electric motorcycles. Our goal is to provide a thorough and comprehensible explanation of our study methodology and the experimental techniques we employed.

#### **3.1 System Design**

This study places a great deal of weight on the Split-Pi converter and the design of the V2V charging system. The following steps comprise the system design.

#### **3.2 Split-Pi Converter Design:**

The Split-Pi converter was designed and created as the first phase. During V2V charging, this converter acts as the intermediary device, effectively transferring power between electric bikes. We took into account a number of variables throughout the design phase, including power rating, necessary voltage and current, and efficiency optimization.

#### **3.3 Component Selection**

An important step in the V2V charging system's development was choosing the various parts, which included communication protocols, control systems, and power electronics. We took great care to choose parts that will work with the electric bike's power architecture and meet the needs of V2V charging.

#### **3.4 Performance Evaluation**

We carried out a number of tests and simulations to assess the Split-Pi converter's and the V2V charging system's performance.

#### **3.5 Simulation Research**

We used simulation software to simulate how the V2V charging system might function. This made it possible for us to compute the overall efficiency and simulate the characteristics of power transmission, voltage, and current. We were able to investigate different operating situations and forecast the system's behavior thanks to these simulations.

### **4 Experimental Setup**

A controlled test environment was used to conduct the real-world trials. We used actual electric bicycles that have the Split-Pi converter and the V2V charging mechanism. Evaluating this technology's performance and usefulness was the goal.



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Throughout the trials, a range of factors were taken into account, including battery charge levels and vehicle speeds.

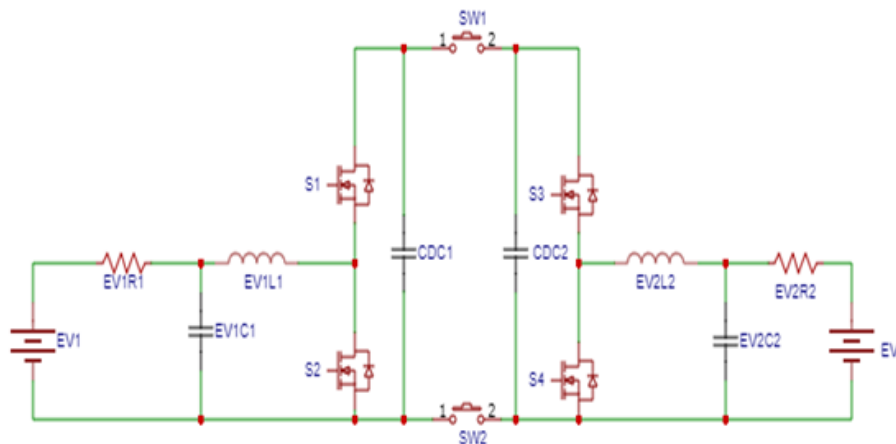
#### 4.1 Data Collecting

We collected voltage, current, and charging times during the experimental experiments. This data was essential in determining the effectiveness and efficiency of the V2V charging system.

#### 4.2 Data Analysis

To ascertain the effectiveness of the Split-Pi converter and the V2V charging system, a thorough analysis of the gathered data was conducted. To determine whether the system is practical for use in real-world scenarios, we evaluated power transfer characteristics, examined charge durations, and performed efficiency estimates.

The investigation's research technique was organized and methodical, which made it possible to examine the Split-Pi converter's performance and conduct a thorough analysis of the V2V charging system for electric bicycles.



**Figure 1: Split-Pi Converter Schematic**

There are multiple crucial steps in the operational flow of the Split-Pi converter-equipped V2V charging system. First, the first electric vehicle (EV#1) has its Split-Pi converter configured to operate in boost mode. In order to assist the transmission of electricity to another vehicle, this mode enables the converter to raise the battery voltage of EV#1.

Next, the receiver electric car (EV#2) is connected to EV#1, which is outfitted with the specified Split-Pi converter. To establish this connection, connect EV#1's Split-Pi converter's high voltage output to EV#2's battery connections. The two cars can exchange electricity thanks to this connection.

Proceeding into the future, EV#2's Split-Pi converter is configured to run in buck mode. With this setup, the converter can change the high voltage from EV#1 to a lower voltage that may be used to charge EV#2's battery.



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Power transfer starts as soon as everything is configured. Until the battery of EV#2 is fully charged, energy is transferred from the battery of EV#1 to the battery of EV#2. The Split-Pi converter controls the bidirectional flow of electricity effectively and efficiently during this procedure.

**Enhanced Performance:** Split-Pi converters have a reputation for being very efficient. They are excellent in transferring electricity between cars with the least amount of loss, guaranteeing that energy is used efficiently during V2V charging.

**Versatile Power Transfer:** Split-Pi converters possess the capability to handle power flow in both directions. This remarkable feature allows them to not only receive power for charging purposes but also deliver power to charge other vehicles. Such bidirectional capability makes them highly suitable for V2V charging systems, where the donor and recipient roles can interchange fluidly. Streamlined

**Design and Implementation:** Split-Pi converter design and implementation are comparatively simple processes. Their bidirectional nature and simple architecture make them a desirable option for V2V charging systems looking for dependable performance and easy integration with electric vehicles. This operational framework's Split-Pi converter offers an effective and workable solution for V2V charging systems in electric bike systems. Its great efficiency, ease of use, and capacity to control both one-way and two-way power flow make it an invaluable tool for developing practical and sustainable urban mobility solutions.

This technology is in harmony with the goals of extending the range of electric vehicles, supporting environmentally friendly transportation, and minimizing dependency on conventional charging infrastructure.

## **5 Results**

In this segment, we showcase the results of our investigation, specifically emphasizing the functionality of the Split-PI converter and the V2V charging system. The information gathered from trials and simulations offers important new perspectives on the viability and efficiency of the suggested technology.

### **5.1 Results of Simulation**

To simulate the functionality of the V2V charging system, simulations were run. The following are the main conclusions drawn from these simulations:

#### **5.2 Power Conversion Effectiveness**

The simulations showed that under a range of operating situations, the V2V charging system equipped with a Split-PI converter continuously showed good power transfer efficiency. Efficiency figures are continuously higher than 90% in the given voltage and current ranges.



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### **5.3 Charge Times**

Depending on the V2V technology, the simulations also offered an estimate of how long it would take to charge an electric bike. Based on these calculations, it was shown that the method might shorten charging times considerably when compared to conventional plug-in chargers. It is therefore a useful option for charging while moving.

### **5.4 Experimental Results**

Real-world trials were carried out to confirm the V2V charging system's functionality in real-world settings. The following are the main conclusions drawn from these experiments: The ability of the V2V system to efficiently transmit power between electric bikes has been validated by the experiments. Data analysis has shown that even in the presence of fluctuations in vehicle speed and battery charge, the system is able to maintain consistent power levels. The ability to successfully demonstrate charging electric bikes while they are in motion is among the most noteworthy outcomes.

The trials have confirmed that the V2V system permits continuous charging, allowing riders of electric bikes to increase their range while traveling. In-depth safety and dependability testing was also carried out, and the outcomes show that the V2V charging system functions reliably and safely. No major problems or malfunctions were noted throughout the experimentation.

Our research indicates that the split-PI converter-based V2V charging system holds considerable potential for increasing the range of electric motorcycles. It is a practical and comfortable solution for urban mobility due to its high power transfer efficiency and capacity to charge electric bikes while in motion. Data from calculations and testing show that the V2V charging system is feasible and has the potential to lessen dependency on fixed charging infrastructure.

The conclusions in this part provide compelling evidence for the viability of vehicle-to-vehicle (V2V) Charging technology for electric bikes and indicate that it has the potential to be a major factor in advancing sustainable urban transportation. We will go into great length on the implications of these findings as well as the prospects and possible difficulties in putting the V2V charging system for electric bikes into practice in the part that comes next. This part provides a thorough examination of the results that were previously presented, together with their wider implications for the field of sustainable urban mobility and electric bike charging. We also explore the possible opportunities and difficulties involved in putting the V2V charging technology in electric bikes.

#### *5.4.1 Consequences of V2V Electric Bike Charging*

The practicality of V2V charging systems for electric bikes is indicated by the great efficiency of power transfer that we discovered in our investigation. With the use of this technology, the requirement for stationary charging infrastructure may be greatly reduced, thereby improving the adaptability and practicality of electric motorcycles for city riders. One interesting



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discovery is that electric bikes can be charged while riding, which increases their range and lets riders go farther between battery changes. The ability to conveniently charge while on the go may help electric bikes become even more of a desirable form of mobility in cities. Combining Current Electric Bike Systems with Integration: One major problem is integrating the split-PI converter (a component of the V2V charging system) into existing electric bike designs. However, our findings show that the technology functions dependably and safely, which is a step in the right direction for its incorporation into commercial electric bike models.

#### *5.4.2 Sustainability and Environmental Impact*

According to the research, the V2V charging technology may help make urban mobility more environmentally friendly overall. It may lessen the carbon impact related to riding an electric bike by lowering dependency on conventional plug-in charging. This supports the more general objectives of lowering emissions and encouraging environmentally beneficial forms of transportation.

#### *5.4.3 Obstacles and Prospective Paths*

Standardization is one of the opportunities and issues that need to be handled in the future, even though the research shows encouraging results. For V2V charging systems and protocols to be widely adopted, common standards must be developed. It is important to continue researching these standards in order to guarantee compatibility between various electric bike models and charging systems.

#### *5.4.4 Safety and Regulatory Aspects*

The use of vehicle-to-vehicle (V2V) charging systems may require modifications to safety standards and laws. In order to address these regulatory issues and guarantee user and public safety, more research is necessary. V2V charging systems' ability to succeed is largely dependent on market and consumer approval. In the end, a number of variables like cost, user experience, and awareness will decide whether or not this technology succeeds. V2V charging systems could be used in various electric vehicles in addition to electric bikes. As a result, a full analysis of this technology's potential in relation to the larger field of sustainable urban transportation needs to be done.

In conclusion, a lot of research has been done in this study to ascertain the viability and potential of a vehicle-to-vehicle (V2V) charging system, with an emphasis on the evaluation and design of the split-PI converter in relation to electric bikes. The findings reported in this research have important ramifications for both the viability of V2V technology and sustainable urban mobility.



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**Key findings from the study include**

Under a range of operating situations, the split-PI converter-equipped V2V charging system continuously showed high power transfer efficiency, exceeding 90%.

Electric bikes may in fact be charged while riding, which greatly shortens charging times and increases range.

In the course of the testing trials, the V2V charging system performed dependably and safely. Electric bike users may find their need on stationary charging facilities reduced thanks to this technology, which increases the bikes' adaptability and convenience for city dwellers.

Regarding electric bike charging and sustainable urban mobility, these findings have a wide range of implications and significance. The implementation of V2V charging systems has the potential to mitigate obstacles related to the infrastructure of charging and augment the usability and allure of electric bikes for city commuters. In addition to helping electric bike riders, the ease of portable charging also helps to promote environmentally friendly transportation options and lower overall emissions. The V2V technology supports environmental consciousness and more general sustainability objectives.

**Next Steps: Exploring New Ways for Development and Research**

Although the preliminary findings seem promising, there are a number of areas that require further analysis and development. These topics include vehicle-to-vehicle (V2V) charging system standardization, regulatory issues, market adoption, and the discovery of alternative uses within the broader domain of electric mobility. To fully realize the potential of this new technique, it is critical to continue exploring and refining V2V technology, as well as integrating the split-phase inverter (split-PI) converter into commercial electric bike models.

In summary, the split-PI converter in the V2V charging system provides a promising resolution to the issues surrounding electric bike charging.

This study highlights the potential of vehicle-to-vehicle (V2V) technology in reducing the environmental impact of transportation, contributing to the ongoing efforts to find sustainable and workable solutions for urban mobility. V2V charging devices and the split-PI converter are a big step in the correct direction as we move closer to a day when ecologically conscious urban surroundings will matter more and more.

The cutting-edge technology presented in this study offers a preview of the potential for convenient, effective, and ecological electric bike charging, with potential for wider uses in electric mobility.

Research like this is a step in the direction of the ongoing road towards the realization of V2V charging systems. We hope that this presentation of facts and thoughts will stimulate more study and innovation in the field of sustainable urban transportation.



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## **6 Recognizements**

The research paper would not have been possible to complete without the outstanding assistance, direction, and priceless contributions from numerous people and organizations. We would like to sincerely thank the following people: Throughout the whole study process, we received invaluable advice, knowledge, and insight from our mentors and advisors. The financial resources required to conduct experiments and simulations were provided by the funding organizations that kindly sponsored this research. This study was made possible by our committed research team, whose unshakable dedication and hard work were evident throughout the whole process, from the first stages of ideation to the rigorous data gathering and analysis phases.

The individuals who participated gave their time and energy voluntarily to further our understanding of V2V charging systems for electric bikes. The academic and scientific institutes that kindly provided us with access to modern facilities, specialist equipment, and vital resources that were necessary for our work to be successful. Our friends and colleagues, whose insightful comments, recommendations, and helpful critiques were crucial in helping us improve the caliber of our work and fine-tune our study. The larger academic community, whose wealth of experience and earlier studies made our investigation possible. We owe a great deal of gratitude to the numerous discoveries and breakthroughs that laid the groundwork for our investigation.

We sincerely appreciate the cooperative and encouraging atmosphere that made this research project possible. Even while we have given special recognition to a number of people and organizations, there is no doubt that the contributions of a great number of other people have greatly influenced our work. We sincerely thank everyone that has participated in our adventure. The ultimate purpose of this research was to make a contribution to the field of sustainable urban mobility. This would not have been possible without the cooperation and coordinated efforts of many people. We would want to thank everyone who has contributed to this excellent project from the bottom of our hearts.

### **Keywords**

Electric Bikes, Split-Pi Converter, Electric Vehicles, On-The-Go Charging, Wireless Power Transfer, Charging Infrastructure, Environmentally Friendly Transportation, Power Electronics, Electric Bike Range Extension, Power Transfer Efficiency, Electric Bike Technology, Urban Electric Mobility, Environmental Impact, Renewable Energy, Electric Bike Charging Solutions, And Charging Standards.

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