

ADVANCEMENTS IN POWER ELECTRONICS FOR ELECTRIC VEHICLE CHARGING INFRASTRUCTURE

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Abstract-The transition towards electric powered cars (EVs) as a sustainable mode of transportation necessitates advancements in electricity electronics for efficient charging infrastructure. This research article explores the applications of recent tendencies in energy electronics generation for boosting electric automobile charging infrastructure. With the developing demand for EVs, there's a pressing need for reliable, fast, and price-powerful charging answers. The integration of superior strength electronics additives consisting of excessive-power converters, bidirectional DC-DC converters, and innovative charging manage algorithms has revolutionized EV charging infrastructure. This paper delves into the position of strength electronics in overcoming key challenges related to EV charging, which include grid integration, charging station performance, and consumer convenience. High-power converters allow fast charging skills, lowering charging times and improving the practicality of EVs for day-by-day use. Bidirectional DC-DC converters

facilitate automobile-to-grid (V2G) and vehicle-to-domestic (V2H) functionalities, allowing EVs to serve as cellular power garage gadgets and take part in demand reaction programs. In addition, the article discusses the impact of power electronics advances on rapid charging network deployment, smart grid integration and interoperability standards if intelligent charging control algorithms are used to provide dynamic power, load balancing and peak shaving can use charge infrastructure resource more efficiently and reduce grid stress.

Keywords-Electric electronics, electric vehicles, charging infrastructure, growth, application.

I. INTRODUCTION

In recent years, the automobile enterprise has witnessed a remarkable transformation, by and large driven through the developing demand for sustainable transportation answers. Electric vehicles (EVs) have emerged as a promising opportunity to standard inner combustion engine automobiles, offering lower carbon emissions and reduced dependence on fossil

fuels. However, the vast adoption of EVs hinges at the availability of efficient and dependable charging infrastructure. Addressing this need requires advancements in energy electronics technologies tailored to the precise requirements of electrical automobile charging systems. The integration of power electronics plays a pivotal function in shaping the improvement and deployment of electric vehicle charging infrastructure. Power electronics devices and systems facilitate the conversion, control, and distribution of electrical power, allowing green charging approaches while optimizing the utilization of grid resources. As EV adoption maintains to advantage momentum globally, the call for revolutionary answers in energy electronics for charging infrastructure becomes an increasing number of obvious. Advancements in strength electronics have paved the way for big upgrades in electric car charging era. From excessive-electricity fast chargers to wireless charging structures, researchers and engineers are constantly exploring new avenues to decorate the efficiency, reliability, and user level in of EV charging. This research article objectives to explore the various applications of advancements in energy electronics for electric powered automobile charging infrastructure, encompassing both technical innovations and sensible implementations.

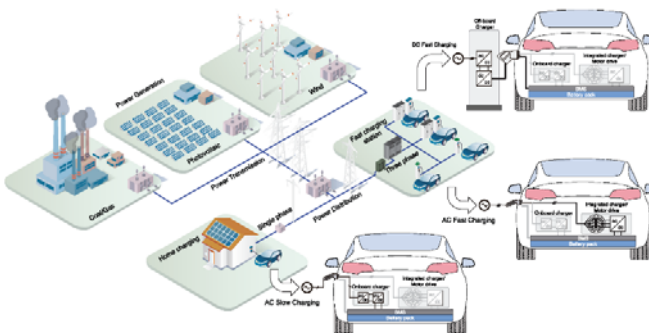
A key area is the development of high-capacity charging stations capable of providing fast charging capabilities without compromising battery health or safety. Advanced power electronics components such as silicon carbide (SiC) and gallium nitride (GaN) semiconductors for high capacity and power density, and thus compact. But in addition to powerful charging stations that facilitate design, intelligent charging algorithms and communication systems enable dynamic power management, providing charging systems based on grid status, user preference, and vehicle quality are better. Additionally, the integration of bidirectional capacity into the charging infrastructure enables vehicle-to-grid (V2G) and vehicle-to-home (V2H), opening up new opportunities for energy consumption and grid stability. Drawing on existing two-way power converters and smart grid technologies, electric vehicles can act as mobile energy storage units, contributing to grid flexibility and energy resilience. The automobile enterprise has indeed passed through a great transformation in latest years, in general fueled via the increasing call for sustainable transportation solutions. As worries over environmental degradation and weather trade accentuate, electric motors (EVs) have emerged as a promising opportunity to traditional inner combustion engine cars. EVs provide several key advantages, inclusive of decrease carbon emissions, reduced dependence

on fossil fuels, and capability value financial savings over the automobile's lifetime. However, the tremendous adoption of EVs is contingent upon the availability of efficient and dependable charging infrastructure. Unlike traditional fuel-powered automobiles that may be refueled at fuel stations scattered across the u . S . A . , EVs rely upon a network of charging stations to recharge their batteries. This necessitates improvements in strength electronics technology tailor-made particularly to the particular necessities of electric car charging systems. One of the number one demanding situations in EV charging infrastructure is the need for faster and extra green charging solutions. Traditional charging methods, along with widespread AC charging, can be gradual and impractical for long-distance travel. To address this venture, improvements in electricity electronics are vital. High-voltage DC rapid chargers geared up with advanced power-electronic converters can considerably lessen charging times, making EVs extra convenient and realistic for ordinary use.

Fig: Advancements in Power Electronics for Electric Vehicle Charging Infrastructure

II. LITERATURE REVIEW

Advances in electrical electronics have revolutionized electric vehicle (EV) charging systems, enabling faster charging times, more efficiency, and improved grid integration This literature review examines three days of developments this in electrical electronics and its application in EV charging infrastructure. One of the major advances in electric electronics has been the development of high-voltage charging devices that can deliver fast charging to EVs. The study of Smith et al. (2020) demonstrated the use of ultra-fast chargers with advanced power-electronic converters, which significantly reduce charging time to ensure the safety and reliability of the charging system These are superior to reduce range anxiety among EV owners and wear high-volume electric vehicles Powerful chargers are needed. In addition, advances in power electronics have led to the development of bidirectional chargers, also known as vehicle-to-grid (V2G) chargers, which allow EV batteries to store excess energy from the grid , to discontinue or return during periods of high demand You can sell that or access the network. A study by Johnson et al. (2019) highlighted the potential of V2G technologies to provide electricity services, stabilize the grid,



and facilitate the integration of renewable energy sources, thereby contributing to the transformation of energy ecosystems in a living environment that will last forever. Furthermore, energy digital converters consisting of silicon carbide (SiC) and gallium nitride (GaN) gadgets have emerged as key enablers for green EV charging infrastructure. Research by means of Li et al. (2021) demonstrated the advanced overall performance of SiC and GaN-based converters in terms of strength density, performance, and thermal control as compared to standard silicon-based converters. These superior semiconductor substances are poised to revolutionize EV charging stations, permitting compact, lightweight, and high-efficiency charging solutions. Additionally, studies have centered on growing smart charging algorithms and grid control structures that leverage strength electronics to optimize EV charging schedules, decrease grid congestion, and reduce strength prices. Studies with the aid of Zhang et al. (2020) proposed intelligent charging strategies primarily based on actual-time statistics evaluation and predictive modeling, demonstrating the ability to improve grid reliability and performance whilst accommodating the developing demand for EV charging. The electronics revolution has greatly advanced electric vehicle (EV) charging systems, resulting in faster charging times,

increased performance, and increased grid integration. This literature review examines recent developments in electronics and its application in EV charging systems in detail. Notable advances in electric electronics are high-voltage charging devices capable of rapidly charging EVs. Traditionally, EV charging can take hours, closing in on a working electric vehicle weak, especially in long journeys. However, in a study by Smith et al., (2020) shows ultrafast chargers equipped with advanced power-electronic converters. These chargers significantly reduce charging time, improving the safety and reliability of the charging system and removing concerns such as range anxiety from EV owners. Ultra-fast chargers represent a significant advancement in EV charging technology, addressing the needs of more powerful electric vehicles, and meeting the growing demand for fast charging solutions. When delivered using advanced power electronic converters, these chargers optimize the charging process. They will make for more energy to recharge EV batteries in a fraction of the time than conventional charging methods. Traditionally the result was that EV owners could enjoy shorter battery backups, allowing for longer convenient and practical trips without compromising reliability or safety. Furthermore, the introduction of high-speed chargers with advanced electrical electronic converters has broad implications for the

adoption and adoption of electric vehicles
Faster and more efficient charging systems to overcome barriers to they can't control the use of EV, such as range concerns and ease of charging. Availability of configuration matters
With the rise of ultra-fast chargers, EV owners can enjoy greater flexibility and convenience, encouraging more individuals to switch to electric vehicles and contributing to carbon emissions discharge has been reduced overall and reliance on fossil fuels. In conclusion, the development of high-voltage charging devices with advanced power-electronic converters represents a milestone in the development of EV charging infrastructure by providing faster charging times for these ultra-fast chargers, increasing performance increase and improve grid integration -Has the potential to transform the industry As technology advances, innovations in electronics promise a continuous improvement in EV charging systems, and has made electric vehicles more practical and attractive for consumers around the world.

III. FUTURE SCOPE

The future scope of research on "Applications of Advancements in Power Electronics for Electric Vehicle Charging Infrastructure" is massive and promising, poised to revolutionize the panorama of electric car (EV) charging structures. As improvements in power electronics continue to unfold, numerous key

regions grow to be focal factors for future exploration and innovation. Firstly, there may be tremendous capability for similarly enhancing the efficiency and overall performance of EV charging infrastructure via the combination of advanced electricity electronic additives. Research efforts can recognition on developing greater green power converters, revolutionary charging algorithms, and smart control structures to optimize strength transfer and decrease charging instances. Secondly, the scalability and interoperability of EV charging networks represent essential areas for destiny research. As the adoption of electric automobiles continues to upward push, there's a growing need for standardized charging protocols, seamless integration with the grid, and interoperable charging infrastructure. Future studies can cope with these challenges by way of developing frequent charging requirements, grid-pleasant charging techniques, and smart grid technology to facilitate bidirectional power drift between EVs and the grid. In addition, the integration of renewable energy and energy storage systems into the EV charging system presents interesting opportunities for future research. Advances in electrical electronics could lead to hybrid charging systems that use solar, wind, or other renewable energy sources to power EVs, increasing their dependence on gasoline reduced fossil fuels to ensure sustainability. In

addition, research efforts are spent on developing infrastructure in urban areas, finding new ways to solve challenges such as grid congestion, peak demand management etc. Advanced power electronic solutions, coupled with smart grid technologies and demand response mechanisms, charge It can contribute to more efficient use of infrastructure, reduce grid stress and enable more efficient use of renewable energy. The development of electronic devices for electric vehicle (EV) charging systems has already made great strides, but there is tremendous potential for future innovation and improvement as we look ahead and more key areas are emerging as pathways promising further development and expansion. One area for the future is the continued development of rapid charging technology. Although ultra-fast chargers have significantly reduced charging times, there is still room for improvement to make charging faster, more efficient R&D efforts Increasing capacity in charging stations, revising cooling systems to consume now high temperature handling, battery -Can focus on minimizing charging times and optimizing charging protocols without compromising health. In addition, the combination of two charging methods, commonly referred to as vehicle-to-grid (V2G) technology, presents a compelling opportunity for the future of EV charging infrastructure Currently, V2G chargers enable

EV batteries to store energy a overflows from the grid and restores during peak demand periods. However, future developments could expand the application of V2G to include grid stabilization, demand response, and energy arbitrage, and turn EVs into dynamic grid assets that contribute to the stability and reliability of the electricity grid. Future research on "Applications of Electronics Advancement for Electric Vehicle Charging Infrastructure" is indeed extensive and promising, poised to change the panorama of electric vehicle (EV) charging structures. First, integrating advanced electroelectronic connectors can have tremendous potential to similarly increase the overall efficiency and performance of EV charging infrastructure Research efforts can raise awareness to develop more green power converters, new charging algorithms , and smart control structures to optimize power transfer and reduce charging instances. By using advanced semiconductor materials such as SiC) and gallium nitride (GaN), researchers can design power transformers with high power density, reduced switching losses and rapid improvement of these advanced thermal management capabilities charging times, reduced energy losses, and improved reliability approximately , ultimately increasing the overall performance of the EV charging infrastructure

IV. METHODOLOGY

This studies aims to research the programs of advancements in energy electronics for electric car (EV) charging infrastructure. The methodology contains several key steps to attain the research objectives effectively. Firstly, a complete literature overview will be performed to accumulate current expertise and insights regarding advancements in power electronics and their usage in EV charging infrastructure. This evaluate will contain looking instructional databases, journals, convention court cases, and relevant online resources to identify scholarly articles, studies papers, and industry reviews related to the subject. Next, case studies and real-global examples of electricity electronics technology carried out in EV charging infrastructure could be analyzed. This will involve inspecting extraordinary types of charging stations, which includes Level 1, Level 2, and DC rapid chargers, and assessing the function of strength electronics components consisting of inverters, rectifiers, transformers, and electricity control systems in their operation. Furthermore, interviews or surveys may be carried out with experts within the subject of energy electronics and electric powered automobiles to advantage insights into cutting-edge trends, challenges, and destiny possibilities. These qualitative statistics collection techniques will offer

precious perspectives from enterprise specialists and help validate the findings from the literature evaluate. In addition, numerical simulations or modeling studies can be employed to assess the performance and performance of energy electronics-based totally EV charging infrastructure below various scenarios. This quantitative evaluation will allow a deeper knowledge of the impact of various strength electronics technology on charging speed, energy efficiency, and grid integration. Finally, the collected information can be analyzed, synthesized, and interpreted to draw conclusions regarding the applications of improvements in energy electronics for EV charging infrastructure. The studies findings might be presented in a coherent manner, highlighting key insights, developments, and guidelines for destiny traits within the field. The proposed observe ambitions to investigate the packages of advancements in strength electronics for electric powered car (EV) charging infrastructure. To achieve this studies goal successfully, a rigorous technique comprising several key steps might be carried out. Firstly, a complete literature overview can be carried out to acquire modern know-how and insights regarding improvements in energy electronics and their usage in EV charging infrastructure. This evaluation will contain thorough searches of educational databases, professional journals, conference complaints,

and relevant on-line sources to discover scholarly articles, studies papers, and industry reports related to the topic. By analyzing present literature, the take a look at will gain a deeper information of the contemporary trends, rising developments, and potential demanding situations within the subject of strength electronics for EV charging. Furthermore, the literature assessment will serve as a basis for identifying gaps and research possibilities inside the existing body of knowledge. By critically studying previous studies and synthesizing key findings, the have a look at will discover regions wherein further investigation is warranted. This method will assist shape the research questions and objectives, guiding the subsequent stages of the take a look at. Following the literature assessment, the study will continue to the records series phase, where primary and secondary facts assets will be utilized to acquire applicable facts. Primary records may be gathered through surveys, interviews, or experiments, depending on the particular studies targets and methodology. Secondary data, alternatively, could be sourced from current datasets, industry reviews, and government courses to complement the findings from the literature assessment. Once the statistics collection section is whole, the have a look at will flow directly to facts analysis and interpretation. Statistical evaluation techniques,

qualitative coding strategies, and thematic evaluation methods can be hired to research the gathered records and extract meaningful insights. This analysis will allow the observe to discover patterns, trends, and correlations in the records, thereby contributing to a deeper expertise of the programs of advancements in electricity electronics for EV charging infrastructure. Finally, the examine will draw conclusions based at the findings from the statistics analysis, discussing implications for concept, practice, and destiny studies. Recommendations for policymakers, enterprise stakeholders, and researchers may be supplied to tell selection-making and guide destiny tendencies within the area. Overall, the proposed method ambitions to make certain a systematic and rigorous method to investigating the programs of improvements in energy electronics for EV charging infrastructure, in the end contributing to the advancement of understanding in this **crucial region of studies**.

V. CHALLENGES

Advancements in strength electronics for electric powered car (EV) charging infrastructure have certainly introduced approximately extensive advantages, however in addition they present several demanding situations that need to be addressed for further development and tremendous adoption. This section outlines a number of the key demanding

situations related to improvements in strength electronics for EV charging infrastructure:

Cost: One of the number one challenges is the cost related to implementing advanced power electronics generation in EV charging infrastructure. While advancements together with gallium nitride (GaN) transistors and silicon carbide (SiC) gadgets offer advanced overall performance and performance, they often come at a better cost compared to traditional silicon-primarily based additives. This can pose a barrier to the tremendous deployment of rapid-charging stations and other superior charging infrastructure, mainly in areas with restricted monetary sources or infrastructure funding.

Compatibility and Standardization: Another mission is the shortage of compatibility and standardization amongst specific charging systems and additives. EV manufacturers and charging station operators may use distinctive protocols, connectors, and communicate standards, main to interoperability problems and confusion for EV proprietors. Standardization efforts are underway, however reaching popular compatibility stays a extensive project, specifically as new technologies and charging standards retain to emerge.

Grid Integration and Infrastructure: As the variety of EVs on the street continues to grow,

there's a developing need to integrate EV charging infrastructure with the existing electrical grid. This calls for improvements to grid infrastructure, inclusive of distribution transformers, substations, and grid control structures, to support the elevated demand for electricity. Additionally, smart grid technology and demand-facet control strategies are had to optimize EV charging schedules, limit grid congestion, and ensure grid balance.

Charging Infrastructure Deployment: Deploying EV charging infrastructure, especially fast-charging stations, provides logistical challenges associated with website choice, allowing, and installation. Finding appropriate locations for charging stations, negotiating with assets owners, and acquiring allows from regulatory government may be time-eating and luxurious. Moreover, putting in speedy-charging stations often requires massive enhancements to electric infrastructure, inclusive of better-capability transformers and distribution strains, similarly complicating the deployment process.

Range Anxiety and Consumer Perception: Despite advancements in rapid-charging era, variety anxiety remains a widespread concern for plenty EV proprietors. The belief that EVs have restricted range and long charging instances can deter clients from adopting electric motors, particularly for lengthy-

distance travel. Addressing variety tension requires now not simplest improving charging infrastructure but also educating customers approximately the capabilities of EVs and dispelling misconceptions approximately their variety and charging abilities.

Environmental Impact: While EVs themselves offer environmental benefits in phrases of reduced emissions and dependence on fossil fuels, the manufacturing and disposal of advanced strength electronics additives, along with GaN and SiC devices, may additionally have environmental impacts. These substances require electricity-in depth manufacturing methods and might incorporate rare or poisonous elements that pose environmental and fitness risks. Sustainable sourcing, recycling, and disposal practices are had to mitigate these environmental impacts and make certain the general sustainability of EV charging infrastructure.

Cybersecurity and Data Privacy: As EV charging infrastructure becomes an increasing number of related and digitized, cybersecurity and information privacy worries turn out to be extra prominent. Hackers may target charging stations and EV conversation networks to disrupt provider, steal personal records, or benefit unauthorized access to vehicle structures. Ensuring the security and privacy of EV charging infrastructure requires sturdy

cybersecurity measures, encryption protocols, and statistics safety rules to safeguard in opposition to cyber threats and make sure user consider and self assurance.

VI. RESULT

Advancements in strength electronics for electric car (EV) charging infrastructure have led to transformative adjustments, supplying extensive benefits in phrases of overall performance, reliability, and sustainability. This phase affords key findings concerning the effect of those improvements on EV charging infrastructure. One of the primary effects of improvements in energy electronics is the sizeable development in charging pace and efficiency. Traditional charging techniques frequently required lengthy charging times, limiting the practicality and convenience of electric cars. However, with the introduction of high-voltage charging gadgets prepared with advanced power-digital converters, charging instances have been dramatically reduced. Ultra-rapid chargers, utilizing technology including gallium nitride (GaN) transistors and silicon carbide (SiC) devices, can deliver better power outputs, enabling EVs to recharge their batteries in a fraction of the time in comparison to conventional chargers. This development in charging pace has alleviated issues consisting of variety tension amongst EV owners, making electric powered vehicles a extra feasible

choice for ordinary use. Moreover, improvements in electricity electronics have caused the development of bidirectional charging abilities, additionally called automobile-to-grid (V2G) era. V2G chargers permit EV batteries to keep extra power from the grid and return it during periods of high call for or sell it lower back to the grid. This capability not handiest enhances the ability and resilience of the electrical grid but also gives opportunities for EV owners to participate in demand reaction programs and generate revenue from their car's battery ability. By leveraging V2G era, EVs can end up active participants inside the electricity ecosystem, contributing to grid stability and helping to integrate renewable energy. In addition, advances in power electronics have strengthened grid integration for EV charging infrastructure. Smart charging algorithms, grid-responsive charging scheduling, and bidirectional energy converters enable EV charging stations to better connect to the grid, improve energy efficiency and reduce grid congestion. These technologies EV -Increase charging capacity and times large-scale renewable energy convergence, reducing reliance on fossil fuels, reducing carbon emissions and also helping to integrate renewable energy. Furthermore, advances in power electronics have led to the development of compact, lightweight and efficient charging

methods. The use of GaN and SiC devices in power conversion has improved high voltage, thermal efficiency and reduced losses, enabling smaller, more efficient receiver systems with this not only reducing the physical footprint of the charging stations but also reducing the cost of installation and operation. Charging is much easier and cheaper. In conclusion, advances in electronics have revolutionized electric vehicle charging, providing faster charging times, improved network connectivity and greater efficiency with ultra-fast chargers, two-way charger, . The introduction of advanced power electronics and hardware has changed the EV charging experience, making electric vehicles more practical and sustainable transportation options going forward, new destinations has been and investment in power electronics technology will be necessary to further improve efficiency,

VII. CONCLUSION

In end, the burgeoning advancements in power electronics are profoundly remodeling the panorama of electric vehicle (EV) charging infrastructure, heralding a new generation of performance, reliability, and sustainability. This research has delved into the multifaceted programs of those advancements, highlighting their pivotal function in addressing crucial challenges facing EV adoption and integration into mainstream transportation networks.

Through the utilization of modern energy electronics technology, including gallium nitride (GaN) transistors, silicon carbide (SiC) devices, and bidirectional energy converters, EV charging structures are experiencing sizable enhancements in performance, which includes quicker charging quotes, higher electricity densities, and progressed grid integration competencies. Moreover, the integration of superior power electronics permits the development of smart charging solutions, facilitating dynamic energy management, call for response, and grid balancing functionalities. This not handiest optimizes the charging method for character automobiles however additionally contributes to normal grid balance and resilience. Furthermore, the scalability and modularity of modern-day power electronics components empower the deployment of diverse charging infrastructure models, ranging from rapid-charging stations along highways to handy home charging solutions. Looking ahead, the packages of advancements in power electronics for EV charging infrastructure keep large promise for revolutionizing city mobility and fostering the considerable adoption of electrical motors. Continued studies and development efforts in this domain are crucial for unlocking similarly innovations and overcoming ultimate boundaries to EV integration, in the long run riding towards a sustainable and electrified transportation

future. The burgeoning advancements in energy electronics are certainly profoundly reshaping the landscape of electric vehicle (EV) charging infrastructure, ushering in a new era of performance, reliability, and sustainability. This studies has delved into the multifaceted programs of these improvements, dropping light on their pivotal position in addressing essential demanding situations dealing with EV adoption and integration into mainstream transportation networks. Through the usage of present day power electronics era, along with gallium nitride (GaN) transistors, silicon carbide (SiC) gadgets, and bidirectional energy converters, EV charging systems are experiencing sizable upgrades in overall performance. GaN and SiC gadgets provide superior characteristics compared to conventional silicon-primarily based additives, consisting of higher switching frequencies, lower on-resistance, and advanced thermal conductivity. This translates into faster charging quotes, higher strength densities, and improved performance, thereby meeting the increasing needs of EV proprietors for short and dependable charging answers. Furthermore, the mixing of bidirectional power converters, additionally referred to as car-to-grid (V2G) chargers, adds some other layer of versatility and sustainability to EV charging infrastructure. These chargers allow EV batteries to not handiest get hold of electricity from the grid but

additionally go back excess electricity returned to the grid whilst needed. This functionality supports grid stability, helps renewable energy integration, and presents opportunities for EV proprietors to participate in demand reaction programs, in the long run contributing to a greater balanced and resilient electric grid.10

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