International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Smart Grid EV's: Bi-Directional Charging & Innovations for Electrical Vehicles. A Review

[1]Mudadla Deepak, [2]Dr. P. Ramana, [3]Ramesh Yelakala, [4]Uttarala Vamsi

[1]B. Tech Student, Department of Electrical and Electronics Engineering, GMR Institute of Technology, Vizianagaram District, A.P, India
[2] Professor, Department of Electrical and Electronics Engineering, GMR Institute of Technology, Vizianagaram District, A.P, India.
[3]B. Tech Student, Department of Electrical and Electronics Engineering, GMR Institute of Technology, Vizianagaram District, A.P, India
[4]B. Tech Student, Department of Electrical and Electronics Engineering, GMR Institute of Technology, Vizianagaram District, A.P, India

ABSTRACT

This report incorporates perspectives from the specialized edition centered on "Grid-to-Vehicle (G2V) and Vehicle-to-Grid (V2G) Technologies." Internationally, there is a pressing demand to decarbonize energy systems for a dependable and sustainable energy supply, with the objective of lessening greenhouse gas emissions and addressing global warming challenges. Electric vehicles (EVs) are recognized as an effective and eco-friendly transportation method, benefiting from refined utilization of battery energy storage. Additionally, their capability to engage with power grids expedites charging times by contributing power and regulating charging rates. This scholarly article provides a comprehensive understanding of "Grid-to-Vehicle (G2V) and Vehicle-to-Grid (V2G) Technologies." It delves into diverse facets of G2V and V2G solutions, including the management and control of vehicles capable of interfacing with the grid, systems for overseeing energy storage, the infrastructure for charging, forecasting loads in distributed systems, interfaces enabling Vehicle-to-Grid (V2G) interactions, communication standards, charging configurations, and the associated environmental and economic advantages of these technological developments.

Keywords: V2X concept, bi-directional charging topologies; communication standards; battery management system, energy storage system, ADAS, digital infotainment system.

1. INTRODUCTION

Electric vehicles (EVs) and smart grids are significant advancements in the way we think about transportation and energy distribution. These two technologies are inextricably linked, heralding a future in which intelligent and adaptive energy management meets sustainable and efficient mobility. In this introduction, we will delve into the worlds of electric vehicles and smart grids, investigating their significance, benefits, and the synergy that exists between them. Electric vehicles (EVs) are a revolutionary factor in the automotive industry and play a substantial role in promoting environmental sustainability. In contrast to traditional internal combustion engine vehicles, electric vehicles use stored electricity in rechargeable batteries for their power source. EVs are not a new concept, but recent advances in battery technology, increased environmental worries, and government assistance have fuelled their rapid growth.

In parallel with the rise of electric vehicles, smart grids have emerged as a critical infrastructure to support the adoption of clean energy technologies, including EVs. Smart grids are advanced electrical grids equipped with digital communication and control 2 technologies. They facilitate real-time monitoring, automation, and optimization of energy distribution and consumption. Smart grids are a significant departure from the conventional, one-way energy delivery system, allowing for bidirectional flow of electricity and enabling integrating eco-friendly energy sources such as solar and wind power.

Electric vehicle integration into smart grids holds enormous promise. These two technologies complement one another in a variety of ways. Electric vehicles, for example, can function as distributed energy storage systems, with their batteries acting as mobile energy reserves. Electric vehicles (EVs) can contribute surplus power to the grid during peak electricity demand, alleviating strain on the system. EVs, on the other hand, can recharge when energy demand is low, taking advantage of off-peak electricity rates. This bidirectional energy flow improves grid efficiency and helps to balance electricity supply and demand.

This thorough literature review explores the intricacies of the technologies known car-to-grid (C2G) and car-to-everything (C2X) technologies pertain to the capability of vehicles to link up and share information with the power grid and various devices. This includes considerations of their architectures, components, power electronic configurations, communication standards, and charging methods. Additionally, the document delves into the foundational principles of advanced driver assistance systems and digital infotainment systems.

2. LITERATURE REVIEW

V2G services can either draw power from or decrease demand on electric vehicles connected to suitable charging stations. The prediction of vehicle connections relies on automated machine learning. Enhancements in the Improved stability and reduced harmonic distortion in the output current of a V2G inverter are achieved through the application of a model predictive control system featuring an enhanced active voltage vector region. Present developments are directed towards improving Advanced Driver Assistance Systems (ADAS) devices with the objective of increasing driver comfort and safety by raising awareness of the surroundings. Analysing the configurations of structures, components, power electronics, communication methods, and charging strategies in V2G and V2H technologies is crucial for understanding the pros and cons of their unique charging setups. The conventional electric grid due to their G2VandV2G charging and discharging capabilities causes several problems and focus on exploring and reviewing the issues that the integration of EVs poses for electrical networks. Moreover, there exists an opportunity to thoroughly investigate G2V and V2G controls, tackle challenges, scrutinize operational aspects, and incorporate emerging technologies to enhance the seamless collaboration between grids and electric vehicles (EVs). This involves exploring the potential for efficient bidirectional charging and discharging capabilities.

3. Solid State Batteries and Regenerative Braking

Many characteristics of electric vehicles resemble those of conventional gasoline-powered cars, including common elements like seats, tires, and steering wheels. However, the pivotal factor distinguishing them is the battery, which significantly shapes the widespread acceptance of electric vehicles (EVs). Current research in the automotive industry is primarily focused on advancing battery technology, with a notable emphasis on exploring "solid-state" batteries. These alternatives to lithium-ion batteries hold the promise of enhancing vehicle range, minimizing charging times, and eliminating the potential risk of battery overheating.

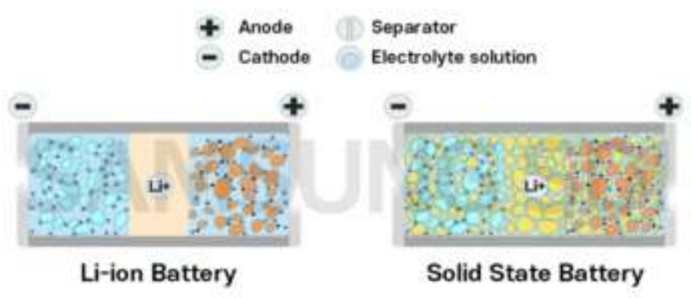

Figure 1: General structure of battery

3.1. Regenerative driving and electric vehicles

There has been a notable increase in attention towards electric vehicles (EVs) as a practical alternative to traditional vehicles that run on internal combustion engines, which are fueled by limited fossil resources. This heightened interest primarily arises from apprehensions regarding the environmental and economic impacts associated with utilizing fossil-derived oil as a fuel in vehicles equipped with internal combustion engines (ICEs).

Thanks to advancements in battery technology and the impressive efficiency of electric motors, electric vehicles (EVs) have emerged as a practical solution for long-distance travel. In plug-in EVs, a rechargeable battery system is employed, and it can be charged using standard power outlets.

3.1. BLDC regenerative stopping

Regenerative braking operates by reversing the current within the motor-battery circuit during deceleration, enabling the motor to function as a generator and directing the current flow back into the supply battery. The power circuit outlined in Figure 2 is compatible with a switching strategy. Integrating switching in conjunction with pulse-width modulation (PWM) provides a straightforward and effective approach to achieving efficient braking control.

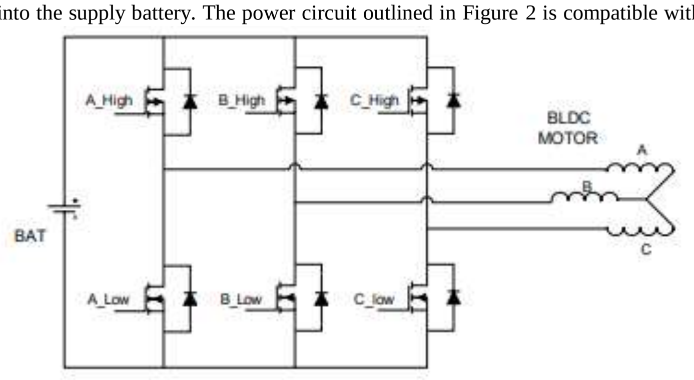

Figure 2: Power Inverter Circuit

4. Development and Implementation of EVs

4.1. Introduction

The importance of electric vehicles (EVs) lies in their emission-free operation and efficient energy utilization. The operation of electric cars depends on a varied array of battery cells, requiring a strong battery management system (BMS) to guarantee efficient power distribution. The selected battery for an electric vehicle should not only ensure long-lasting energy but also provide substantial power. Lead-acid, lithium-ion, and metal hydride are the commonly used types of traction batteries, with lithium-ion being the favoured option due to its superior benefits and performance. Generally, the battery capacity of electric vehicles falls within the range of 30 to 100 KWH or potentially even surpassing this limit.

The choices made by the battery management system (BMS) are influenced by various factors, including the battery's charging and discharging rates, estimated state of charge, estimated state of health, cell voltage, temperature, current, and other pertinent parameters.

4.2 Battery Management System (BMS)

The battery management system (BMS) is indispensable for electric vehicles as it protects batteries from being excessively charged or discharged, preventing potential damage. Excessive charging or discharging raises the temperature, diminishing the battery's lifespan and potentially impacting users. Additionally, the BMS plays a key role in maximizing the energy stored in the vehicle, thereby enhancing its overall range.

4.2.1 Battery management system is essential for following reasons

1. Ensure the safety and reliability of the battery.

2. Monitor and assess the battery's condition.

3. Regulate the state of charge.

4. Sustain cell balance and supervise operational temperature.

5. Control the utilization of regenerative energy.

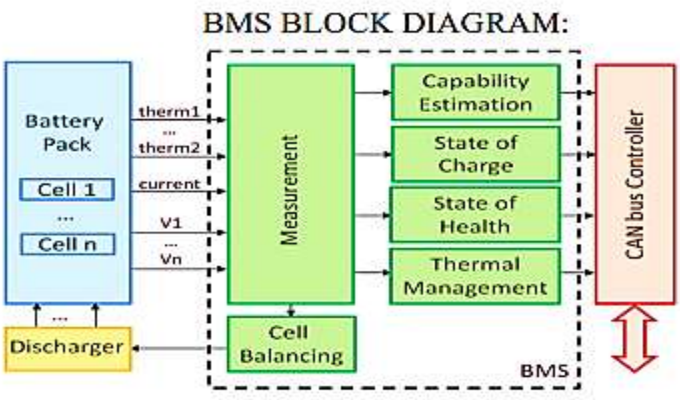

Figure 3: BMS Block Diagram

4.3 Implementation of EVs

Spotlights some of the merits that can be employed to rationalize the development and embrace of electric vehicles (EVs). Attaining mechanical motion in an EV demands the meticulous coordination of diverse components. Apart from the evident benefits of electric vehicles, high-performance EVs have the potential to surpass their internal combustion engine (ICE) counterparts in the foreseeable future. Advanced technology can effectively address the constraints of electric vehicles, positioning the EV as the preferred vehicle of the future. Electric vehicles offer substantial advantages, including swift driving response, decreased driving and maintenance expenses, robust torque and power, exceptional safety features, a single-speed transmission, effective traction control, and a range of speed capabilities and power ratings.

5. Digital Infotainment System

5.1 Infotainment system

Infotainment systems in electric vehicles offer an engaging and connected environment for both drivers and passengers. These systems typically feature touchscreen displays, navigation, music and media playback, as well as seamless integration with smartphones for hands-free calls and app connectivity. Furthermore, they can offer insights into energy consumption, locate charging stations, and seamlessly integrate with vehicle diagnostics, providing a comprehensive user experience. The field of vehicle systems has experienced rapid growth in recent years, attracting significant forensic attention. Previous research primarily focused on on-board systems like event data recorders within the electronic control unit or manufacturer-based infotainment systems. In contrast, modern vehicles are equipped with infotainment systems that connect to mobile devices like Android Auto and Apple CarPlay. This connectivity allows vehicles to communicate with iPhones and external networks, expanding the range of services available to drivers. Consequently, vehicles store a diverse set of data, including valuable information for forensic analyses.

6.V2x Concept & Advanced Driver Assistance System (ADAS)

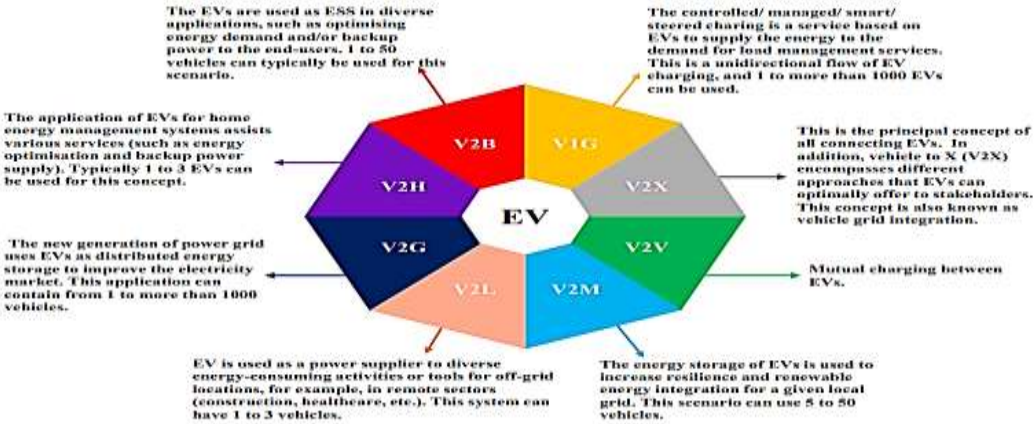

Figure 4: Different concepts of V2

6.2. Advanced Driver Assistance System (ADAS)

Advanced driver assistance systems, also known as ADAS, are critical to increasing the safety and convenience of electric vehicles (EVs). These systems make use of a variety of gadgets to provide intelligent features.

6.3. Methodology

The procedure is outlined in Figure 6. At the outset, images taken by the vehicle camera are subjected to processing through the VMS object recognition module. Following this, the VMS section is standardized through tasks like image cropping, perspective and angle adjustments, and colour modification. These adjustments prepare the image for the ensuing stage of text extraction. Finally, the text extracted is transformed into audio through the utilization of a cloud-based "text to speech" service.

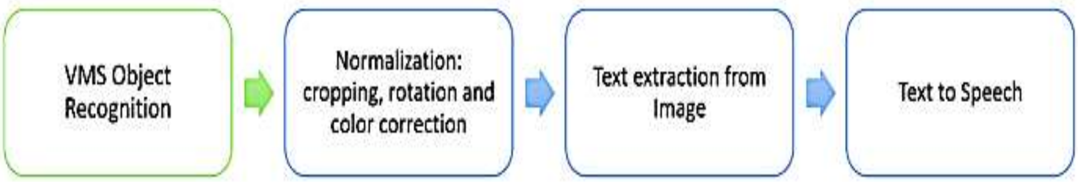

Figure 5: Processing procedures.

Conclusion

Integrating state-of-the-art technologies addresses a spectrum of operational challenges in electric vehicles (EVs), positioning them effectively for the future of the transportation system. When connected to the Distribution System Operator (DSO), the EV's battery facilitates bidirectional power flow. However, the bidirectional capability of Vehicle-to-Grid (V2G) is limited by the operational constraints of the battery in terms of charging and discharging. Despite being envisioned as in the envisioned future of electric vehicles (EVs), incorporating Vehicle-to-Grid (V2G) encounters diverse challenging scenarios that negatively impact the voltage and power of the utility grid during overload periods. Charging devices featuring 20-based power electronic converters play a crucial role in improving the performance of electric vehicles connected to the grid. However, their effectiveness may be compromised without proper control, leading to challenges. State-of-the-art Grid-to-Vehicle (G2V) and Vehicle-to-Grid (V2G) technologies enable bidirectional power transfer. This study thoroughly explores the impacts of G2V and V2G, with a focus on opportunities, strategic advancements, implementation, control mechanisms, challenges, and the integration of innovative technologies. The main focus of the article is on exploring potential advancements in electric vehicle (EV) technology, seamless integration between EVs and grids, and effective bidirectional charging and discharging capabilities. The article also examines the control structures of both EVs and grids and discusses the associated challenges, benefits, complexities, and drawbacks related to integrating modern EVs. The paper concludes by highlighting the achieved outcomes through an improved Grid-to-Vehicle (G2V) and Vehicle-to-Grid (V2G) technology, enabling rapid bidirectional energy transfer. The analysis delves into the challenges, advantages, and intricacies associated with EV integration. In the subsequent section, crucial recommendations are provided to guide the future research direction of V2G technology:

1.Create a strategic blueprint for Vehicle-to-Grid (V2G), broaden the groundwork of V2G research, and take into account supplementary hardware and operational elements in the progression of Smart Grids (SG).

2. Explore reactive, dynamic, and steady-state behaviors, encompassing capacity estimations, V2G modeling, and other pertinent research areas.

3. Promote the active engagement of EV users in the V2G system, recognizing the societal impacts of incorporating electric transportation, particularly the V2G system.

4. Design efficient charging scheduling methods tailored for V2G applications to optimize overall system performance.

5. Undertake further research to establish a comprehensive economic rationale for smart chargers. Although utilizing distributed Energy Storage Systems (ESSs) such as EVs to absorb surplus Renewable Energy (RE) offers apparent financial benefits, this aspect requires additional scrutiny.

References

1. Ota, Y.; Taniguchi, H.; Baba, J.; Yokoyama, A. Implementation of autonomous distributed V2G to electric vehicle and DC charging system. Electric Power Systems.

2. Winkler-Goldstein, R.; Rastetter, A. Power to Gas: The Ultimate Advancement for the Hydrogen Economy.

3. Xueqin, L.; Fuzhen, H.; Gang, L.; Rongfu, Q. The technological challenges of fuel cells and their application in vehicles. In Proceedings of the 2009 IEEE 6th International Power Electronics and Motion Control Conference, Wuhan, China.

4. Bossel, U. Is a Hydrogen Economy Logical? Proceedings.

5. White, C.D.; Zhang, K.M. Employing Vehicle-to-Grid Technology for Frequency Regulation and Peak-Load Reduction. Journal of Power Sources 2011.

6. Kisacikoglu, M.C.; Ozpineci, B.; Tolbert, L.M. Evaluation of EV/PHEV Bidirectional Charger for V2G Reactive Power Operation. IEEE Transactions on Power Electronics.

7. Kikusato, H.; Mori, K.; Yoshizawa, S.; Fujimoto, Y.; Asano, H.; Hayashi, Y.; Kawashima, A.; Inagaki, S.; Suzuki, T. Management of Electric Vehicle Charge–Discharge for Maximizing Photovoltaic Utilization through Coordination Between Home and Grid Energy Management Systems.

8. Arias, N.B.; Hashemi, S.; Andersen, P.B.; Træholt, C.; Romero, R. Distribution System Services Offered by Electric Vehicles: Recent Status, Challenges, and Future Prospects.

9. Shaukat, N.; Khan, B.; Ali, S.M.; Mehmood, C.A.; Khan, J.; Farid, U.; Majid, M.; Anwar, S.M.; Jawad, M.; Ullah, Z. An overview of electric vehicle transportation in the smart grid system. Renewable and Sustainable Energy Reviews.

10. European Environment Agency. Electric Vehicles in Europe. European Environmental Agency; Report No 20/2016; Publications Office of the European Union: Brussels, Belgium.