International Journal of Research and Development in Applied Science and Engineering (IJRDASE)
ISSN: 2454-6844

A Comprehensive Review on Wireless Charging Systems for Electric Vehicles

Neha Singh, Vani Bhargava, Dr. Hemant Ahuja,
Electrical & Electronics Engineering,
AKGEC, Ghaziabad, India,
neha2121003m@akgec.ac.in

Abstract: Because of its safety features, flexibility, and user-friendliness, wireless charging technology has emerged as a key trend in the expansion of EV power supply innovation. As a critical technical connection, interoperability has gained increasing significance alongside the march of industrialization. Interoperability in a wireless charging system refers to the ability of the output performance to fulfill particular indications when various transmitter and receiver devices are paired. This can be accomplished by matching up compatible transmitters and receivers. This article provides a summary of the current understanding on wireless power transfer for electric vehicle charging. The initial definition and description of interoperability for wireless charging systems was completed. The current interoperability standards will be investigated in the next portion of this article.

Keywords: wireless charging; interoperability; electric vehicle; magnetic coupler; compensationtopology; evaluation method.

1. Introduction:

State-run governments throughout the globe are looking for low-carbon urban regions and putting plans in place to reduce carbon dioxide emissions from both public and private automobiles in this era of anthropogenic climate change. Additionally, they are looking to move their capital cities to low-carbon metropolitan areas. Utilizing electric vehicles is seen as a way to reduce greenhouse gas emissions, enhance fuel supply, wean society off of fossil fuels, and reduce emissions from automobiles [1-2]. The late commercialization of cars like the plug-in crossover Chevrolet Volt and the Nissan Leaf [3] is evidence that the mobility revolution is progressing. The transportation industry is changing its position on autonomous cars as they become more intelligent, secure, and robust [4–9]. Owners of electric vehicles (EVs) regularly complain about the conductive or plug-in chargers now available on the market, as well as the fact that it is risky to charge an EV outdoors when exposed connections are present [10–12]. Wireless charging could be the solution to this problem. Due to its ease of use and security, wireless power transfer (WPT), which utilizes an electromagnetic field rather than a carrier medium to charge or transmit power to electric cars, is growing in popularity among industrial and scientific research groups [1–13]. WPT uses an electromagnetic field to communicate or charge electric vehicles. Electric vehicle applications using inductively coupled wireless power transfer systems have been suggested for more than 20 years [14–21]. However, the difficulties connected with supplying adequate power to these vehicles without sacrificing either safety or mobility have so far stymied the commercial development of electric cars. Although inductive coupling has basically been surpassed by the enticing reverberation coupling-based remote charging characteristic, it is anticipated that attention will be mainly directed to the fundamental barrier that prevents the implementation of an improved WPT framework for EV charging. This is due to the fact that inductive coupling has basically been outclassed by the reverberation coupling-based remote charging peculiarity. Finding the operating system that permits the most wireless power transfer with no limits on the charging infrastructure requires careful research. In contrast to the current method of cable charging, it will be necessary to continue improving wireless power transmission in order to usher in a new era of wireless charging for electric vehicles.

2. Related Work:

Due to its low rate of self-discharge and high energy density, lithium batteries, according to Hui Xiong and colleagues (2020), have replaced gasoline and diesel engines as the main power source for emission-free automobiles. Internal resistance and rate of self-discharge are two features that set apart individual cells in series battery packs used in real-world applications. These changes would reduce the battery pack's efficiency and lifespan, and they may even jeopardize the battery system's security. In order to decrease the unreliability of series battery packs, this research proposes a unique equalization approach that makes use of a fly-back converter as the system's core component. The amount of energy that is still there in a single cell is one way to gauge consistency. Simply counting the energy left behind allows one to ascertain this. A fly-back converter ensures that all of the system's batteries are charged consistently and at the same pace. All of our standards for discretion, usability, and long-term usage are met by this product. In comparison to traditional designs, the work described here offers an equalization topology that requires fewer parts and takes up less space. In light of the state of regional and global research into equilibrium topologies and the effect that consistency has on power battery pack cycle life, a novel charge-balancing bidirectional equalization architecture based on a flyback converter has been presented [21]. This was carried out because the flyback converter was used.

Brenna, Morris, and their coworkers (2020) researched and showed a variety of electric vehicle (EV) charging techniques as part of their study. In this study, both existing and underdeveloped EV charging systems' converter topologies, power levels, power flow orientations, and charging control algorithms are examined. It is highlighted that quick charging maintains lithium-ion batteries' great charging efficiency while also extending their lifespan. Common pricing techniques are a topic that this book also examines. We concentrate on the architecture of battery charging stations for electric cars in the first part of our investigation. This article covers the best charger topologies for charging electric vehicles at various phases, including startup, intermediate, and advanced charging. When the phrase "onboard charger" is used, a combination of level 1 and level 2 charger topologies is often intended [22].

According to Mohana Rao, M. Rama, and (2020), hybrid electric vehicles (HEVs) are a popular kind of cutting-edge technology since they increase a vehicle's overall fuel efficiency while lowering emissions. The hybrid electric vehicle (HEV) is propelled by an electric motor that is powered by a bidirectional flyback converter. The converter's ability to provide steady voltages enhances the vehicle's viability and efficiency. In hybrid electric cars, the battery pack and the drive dc connection may run at different voltages. To enhance volumetric efficiency, the batteries are charged at a lower voltage while the DC connection is charged at a greater voltage. As a result, it's essential to utilize direct current (DC) to connect the drive and the batteries. This interface must be able to provide electricity to outside generators, motors, and grids in order for batteries to operate. According to the study's findings, the Multi-Purpose Plug (MPP) interface for electric and hybrid cars should be a four-phase bidirectional flyback DC-DC converter. Since the converter can work both ways, it may be used to charge the battery from a wall outlet and while it is also being charged from another source. There are many phases, so many batteries may be connected in parallel. A rather simple hysteresis control is used to regulate the converter. The four converters are running continuously at a 75% duty cycle, which considerably minimizes the ripple current in the capacitor since they are working in a 90° phase. The snubber is no longer necessary since contemporary transformers are more efficient. Investigating how Li-ion batteries achieve charge equilibrium is the aim of this work. Every battery pack or module includes a fundamental adjustment mechanism since lithium-ion batteries are so sensitive to series connections. This is the condition regardless of whether the battery pack or module is a separate item. The issue was resolved by using an active battery balancing system that included a fly-back converter. The issue at hand and one potential solution are briefly explained in the first section of the paper before moving on to replication testing to confirm the method. A high-level overview of the design, focusing on the subsystems and initial component choices, is also included in the report [23].

This research was carried out by Avinash V. Shrivastav and his associates in 2020 to better assess the potential of the Indian market for the construction of an EV and CS infrastructure. The transmission and distribution of electricity in India, as well as market procedures pertaining to energy allocation and the energy mix, have all improved as a consequence of more privatization, regulatory reform, and the growth of distributed and renewable power generation in the electrical market. As a consequence, there is now more distributed and renewable power being produced. This article looks closely at whether or not electric automobiles are financially viable in the present energy market. Electric vehicle adoption will accelerate with the implementation of five important technologies: vehicle-to-grid charging, on-road charging, contactless charging, smart charging, and solar electric car charging. Smart charging will also have an impact. These developments might not only have a big influence on the transportation industry but also improve the grid and speed up the adoption of renewable energy sources. For new technology to be quickly and broadly adopted, appropriate business models and standards must be in place. You are suggested to purchase an electric car in India. As infrastructure, technology, and energy sources continue to move in this direction, the usage of electric vehicles (EVs) might increase [24].

The acceptance of electric cars (EVs) as a more environmentally friendly mode of transportation has grown during the last ten years. Despite this, EVs have not been generally adopted because to worries about their limited driving range, high purchasing costs, and a lack of public charging stations. In 2020, Rahul Kumar and company will still be active. Owners of electric vehicles that have range anxiety benefit from the opportunity to charge their vehicles at home or at the office. In order to conduct this research, a battery-powered electric vehicle (BEV) onboard charger will be created, used, and put on display. This charger provides reactive power to the grid in addition to enabling V2G (vehicle-to-grid) energy transmission. An alternating current to direct current (AC-DC) network converter system with three stages powers the on-board power supply. Direct power control (DPC) and space vector tweak (SVM) are the technologies in charge of individually regulating the receptive power stream and the charging current. AC-DC matrix converters are an advantageous technology for electric vehicle chargers because of their numerous benefits, including the support of reactive power and the flow of power in both directions. While maintaining the sinusoidal input current on the direct current (DC) side, it provides exact voltage and current control. SVM [25] adds low-order harmonics to the incoming current despite the fact that they little affect how much reactive power the converter generates.

Jeremy Brandis and several others. Additionally, the new transformer has a preset duty cycle of 75%, as stated in Al (2020), therefore the snubber is no longer required. Investigating how Li-ion batteries achieve charge equilibrium is the aim of this work. Since Li-ion batteries are very sensitive to connections in series, every battery pack and module needs to include an internal balancing mechanism to function properly. By employing a fly-back converter for battery balancing, this problem was satisfactorily resolved. Part 1 begins with a discussion of the problem and a proposal for a solution before going on to the mock exams that evaluate the effectiveness of the cure. Second, the paper gives a general overview of the design, concentrating on the first component choice and the subsystems. This category of potential solutions includes both hardware and software options. This project's ultimate goal is to construct and exhibit an active balancing cell system based on a fly-back converter. The battery pack's logical design avoids overloading of the cell with the greatest voltage by distributing the extra capacity to other cells [26].

In 2020, Oleksandr Korch and his colleagues will present a study on a predecessor to isolated grid inverters. This study establishes a benchmark for classifying the various results. Thirty alternative topologies' primary benefits and drawbacks were compared and analyzed. The ability of an inverter that is not linked to a network to function with a variety of input power and output voltage levels determines how flexible it is. These inverters have the capability of being utilized to produce electricity continuously. It maintains sinusoidal input current while accurately modifying voltage and current on the direct current (DC) side. On the AC side, it adjusts the input current sinusoidally. SVM [25] adds low-order harmonics to the incoming current despite the fact that they little affect how much reactive power the converter generates.

According to research by Andrej Brandis and colleagues (2020), the new transformer operates at a fixed duty cycle of 75%, which renders the snubber unnecessary. Investigating how Li-ion batteries achieve charge equilibrium is the aim of this work. Since Li-ion batteries are very sensitive to connections in series, every battery pack and module needs to include an internal balancing mechanism to function properly. The issue was resolved by using an active battery balancing system that included a fly-back converter. Part 1 begins with a discussion of the problem and a proposal for a solution before going on to the mock exams that evaluate the effectiveness of the cure. Second, the paper gives a general overview of the design, concentrating on the first component choice and the subsystems. This category of potential solutions includes both hardware and software options. This project's ultimate goal is to construct and exhibit an active balancing cell system based on a fly-back converter. The battery pack's logical design avoids overloading of the cell with the greatest voltage by distributing the extra capacity to other cells [26].

In 2020, Oleksandr Korch and his colleagues will present a study on a predecessor to isolated grid inverters. This study establishes a benchmark for classifying the various results. Thirty alternative topologies' primary benefits and drawbacks were compared and analyzed. The ability of an inverter that is not linked to a network to function with a variety of input power and output voltage levels determines how flexible it is. Among other things, these inverters may be used to provide steady energy. When local PV is inadequate to completely charge electric cars, the BES is designed to start charging in accordance with the recommended management plan. This is what is anticipated to occur when redundant PV power is available, the network is inactive, such as at night, or local PV power is inaccessible. The combined use of solar power plants, battery energy storage systems, and electric car charging stations leads to a more trustworthy and stable electrical grid. An ANSYS Twin Developer replica was created, along with a warm model of the electric vehicle charging station, taking the suggested multiport converter and SiC companion into account. This was accomplished after carefully assessing the benefits and drawbacks of each of the many modes of functioning. According to the findings of the simulation, the efficiency of the PV-to-EV mode, PV-to-BES mode, and BES-to-EV mode all rises by 5.67%, 4.46%, and 6.10%, respectively, under the stated operating circumstances. Since electric automobiles that operate in similar conditions have access to silicon-based charging infrastructure, this possibility may be increased [29].

According to Chakraborty, Sajib, et al. (2019), the aim of this article is to examine the various DC converter designs that might be used in BEVs and PHEVs (Programmable Hybrid Electric Vehicles). Each converter design's output power, component count, switching frequency, electromagnetic interference (EMI), losses, efficiency, effectiveness, and cost are all examined. This research (FCHARs) also looks at the development of AC-DC and DC converter systems for quick charging stations, as well as the benefits and drawbacks of employing both types of converters. This paper presents the first in-depth investigation of DC-DC converter topologies for BEV and PHEV power trains. Additionally, a forecast of prospective new study areas is provided in this publication. When choosing a DC converter for a battery electric vehicle (BEV) or a plug-in hybrid electric vehicle (PHEV), it is critical to consider the yield power, component count, exchange recurrence, and electromagnetic interference (EMI). The knowledge in this article on how to choose passive components (such as capacitors and inductors) to best fulfill certain power train needs may be useful to both the manufacturers of Power Hardware Converters (PE) and the designers of vehicles [30].

According to Nayak, Parthasarathy, and (2019)'s findings, the power converter places a limit on the amount of energy that can be stored in an electric car's battery. Power transmission in both directions, efficiency, and power factor correction (PFC) are just a few of the aspects that highlight how important it is to choose the proper converter design. A fly-back-based clamp circuit for an isolated single-stage AC-DC converter is shown in this article. This circuit may be used to recharge the batteries in the charging systems for electric vehicles. On the side that deals with alternating current (AC), it has a full-span inverter (FB), and on the side that deals with direct current (DC), it has a half-span cycloconverter (HB). Soft-switched unipolar pulse width modulation may be helpful for communication between the grid and vehicles (G2V) as well as between the grid and vehicles (V2G). The converter cannot operate as designed unless the filter and leakage inductors of the high-frequency transformer are linked to a clamp circuit. In this work, we propose a fly-back regenerative clamp circuit and a universal power factor correction (UPWM) to charge the batteries of electric automobiles while they are in the G2V mode for a single-stage bidirectional AC/DC converter. When in G2V mode, any AC-powered device will show a zero-battery indication (also known as ZCS). 31].

N. Sujitha and colleagues (2019) claim that there has lately been an upsurge in research into alternate energy sources that might be used to recharge the batteries of electric automobiles. Due to the intermittent nature of their production, renewable energy installations that are connected to the grid are required to charge the batteries in electric automobiles. In this research project, we propose a photovoltaic-powered battery charger for electric vehicles (EVs) that is also interoperable with the public power grid. The technique that has been described allows the battery of the electric automobile to be continually charged regardless of how much sunlight is available. The essential Sepic converter is replaced with a Line commutated converter in the suggested bidirectional charging system setup. This converter works as a bidirectional ac-dc converter. The results of this study suggest that photovoltaic (PV) panels must be installed in a position that is apart from the vehicle in order to recharge the batteries of an electric automobile. The major objective of this research is to determine if it is feasible to continually recharge radiation-free the batteries of electric vehicles [32].

Tao Haijun and a few more people. According to et al. (2019), a two-stage onboard charger, which is usual in electric cars, requires a DC/DC converter to operate effectively. Current full-bridge soft-switching DC/DC converters with phase shifts waste energy, struggle with secondary voltage swings, and need a lot of effort to commutate the trailing leg. The findings of this research indicate that a DC/DC converter requires both simultaneous rectification and two clamp diodes. The clamping diodes on the secondary side of the transformer provide power for the commutation of the trailing leg. These diodes also lessen fluctuations in secondary side voltage. Synchronous rectification is one method that might be used to lower switching device losses. In this article, we examine the operation, effectiveness, and energy consumption of a DC/DC converter. It has been shown that the sensitive switch may be managed over a wide load range and that the optional side of the transformer operates with a lower voltage motivation than in a conventional DC/DC converter. To get beyond the significant obstacle to speedy charging of vehicle-mounted batteries, all of these elements are required. Our research focuses on the two-stage OBC phase-shifted full-bridge soft-switching DC/DC converter architecture that has been suggested for use in EVs. Clamping diodes are installed across the output of the secondary rectifier to stop voltage oscillation [33].

3. Conclusion:

Wireless recharging is a way for self-charging electric automobiles as well as a significant trend in the field of electric vehicle development. Wireless recharging may be accomplished through the use of inductive charging pads. In order to achieve the connection of different technological channels, it is very required to conduct research into the interoperability of wireless charging. The most recent research findings on standards, interoperability analysis, and interoperability assessment of electric vehicle (EV) wireless charging techniques are described in this article. These data were gathered from a variety of sources.

References

[1]. Dragos Niculae, Mihai Iordache, et all, ―A Review of Electric Vehicles Charging Technologies Stationary and Dynamic‖, 11th International Symposium on Advanced Topics in Electrical Engineering (ATEE), 2019.

[2]. Sesha Gopal Selvakumar, ―Electric and Hybrid Vehicles – A Comprehensive Overview‖, IEEE 2nd International Conference On Electrical Power and Energy Systems (ICEPES), 2021.

[3]. Karthika M S, Sheik Mohammed S, ―A Review on Optimal Energy Management Strategies for Electric Vehicles‖, Third International Conference on Intelligent Computing Instrumentation and Control Technologies (ICICICT), 2022.

[4]. Daisy Ranawat, M P R Prasad, ―A Review on Electric Vehicles with perspective of Battery Management System‖, International Conference on Electrical, Electronics, Communication, Computer, and Optimization Techniques (ICEECCOT), 2018.

[5]. Muniprakash T, Vinoth Kumar K, ―A review on optimization techniques of battery charging in electric vehicles‖, 2nd International Conference on Artificial Intelligence and Signal Processing (AISP), 2022.

[6]. Anurag M. Lulhe, Tanuja N. Date, ―A technology review paper for drives used in electrical vehicle (EV) & hybrid electrical vehicles (HEV)‖, International Conference on Control, Instrumentation, Communication and Computational Technologies (ICCICCT), 2015.

[7]. Ali Emadi, Young Joo Lee, ―Power Electronics and Motor Drives in Electric, Hybrid Electric, and Plug-In Hybrid Electric Vehicles‖, IEEE Transactions on Industrial Electronics (Volume: 55, Issue: 6, June 2008)

[8]. Hao Ma, Yuan Tan, ―An integrated design of power converters for electric vehicles‖, IEEE 26th International Symposium on Industrial Electronics (ISIE), 2017.

[9]. Tengxin Wang, Hui Wang, ―An integrated topology for battery charging and motor driving in electrical

vehicle‖, IEEE Conference on Energy Internet and Energy System Integration (EI2), 2017.
[10]. K. Sankaraditya Vikas, B. Raviteja Reddy, ―Controller for Charging Electric Vehicles at Workplaces using Solar Energy‖, International Conference on Communication and Signal Processing (ICCSP), 2019.
[11]. K. Vijayakumar, ―Solar Charging Infrastructure for E-vehicles - A Review‖, International Conference on Advance Computing and Innovative Technologies in Engineering (ICACITE), 2021.
[12]. Soham Bhadra, Priyodeep Mukhopadhyay, ―Design and Development of Solar Power Hybrid Electric Vehicles Charging Station‖, IEEE 1st International Conference for Convergence in Engineering (ICCE), 2020.
[13]. C. Mi, M. A. Masrur, and D. W. Gao, ―Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives‖, John Wiley & Sons, 2011.
[14]. S. G. Wirasingha and A. Emadi, ―Classification and review of control strategies for plug-in hybrid electric vehicles,‖ Vehicular Technology, IEEE Transactions on, vol. 60, no. 1, pp. 111–122, 2011.
[15]. P. Javagar; V. Surendar, K. Jayakumar, ―Solar Charging Power Station for Electric Vehicle‖, International Conference on Sustainable Computing and Data Communication Systems (ICSCDS), 2022.
[16]. Pavitra Shukl, Bhim Singh, ―Electric Vehicle Charging Station for Solar PV Based Grid Interactive System‖, 9th IEEE International Conference on Power Systems (ICPS), 2021.
[17]. Alexander Balakhontsev, Oleksandr Beshta,‖ A Review of Topologies of Quick Charging Stations for Electric Vehicles‖, IEEE International Conference on Modern Electrical and Energy Systems (MEES), 2021.
[18]. Ahteshamul Haque, V S Bharath Kurukuru, ―Decision-Making Approach for Smart Charging of Electric Vehicles‖, IEEE Transportation Electrification Conference (ITEC-India), 2021.
[19]. Samir M. Shariff, Mohammad Saad Alam, ―System Design and Realization of a Solar-Powered Electric Vehicle Charging Station‖, IEEE Systems Journal (Volume: 14, Issue: 2, June 2020).
[20]. Hengbing Zhao, Andrew Burke, ―An intelligent solar powered battery buffered EV charging station with solar electricity forecasting and EV charging load projection functions‖, IEEE International Electric Vehicle Conference (IEVC), 2014.
[21]. Hui Xiong, Dawei Song, Fengdong Shi, ―Novel voltage equalisation circuit of the lithium battery pack based on bidirectional flyback converter‖ IET Power Electronics 2020.
[22]. Morris Brenna, Federica Foiadelli, Carola Leone, ―Electric Vehicles Charging Technology Review and Optimal Size Estimation‖ Journal of Electrical Engineering & Technology 2020.
[23]. M.Rama Mohana Rao &Ch.Rambabu, ―A Novel Multiphase Bidirectional Fly-Back Converter Topology Is Applied To Induction Motor Drive‖ International Journal of Electronics Signals and Systems 2020.
[24]. Avinash V. Shrivastav, Sajidhussain S. Khan, Rahul K. Gupta, ―Case study on infrastructure of EV charging station‖ JETIR 2020.
[25]. Rahul Kumar, Bhim Singh, ―Matrix Converter Based Single Stage Bidirectional On-Board EV Charger with Reactive Power Support‖ IEEE 2020.
[26]. Andrej Brandis, Denis Pelin, DanijelTopić, ―Active Li-ion Battery Charge Balancing System Based on Flyback Converter‖ IEEE 2020.
[27]. Oleksandr Korkh, Andrei Blinov, Dmitri Vinnikov and Andrii Chub, ―Review of Isolated Matrix Inverters: Topologies, Modulation Methods and Applications‖ Energies 2020.
[28]. Pham Ngoc Thang, Vo Thanh Vinh and Nguyen The Vinh, ―A Flexible DC-DC Converter for the Battery - DC Bus Renewable Energy System‖ International Energy Journal 2020.
[29]. Zhang, Yibin, Jiangbiao He, and Dan M. Ionel. "Modeling and Control of a Multiport Converter based EV Charging Station with PV and Battery." IEEE Transportation Electrification Conference and Expo (ITEC). IEEE, 2019.
[30]. Sajib Chakraborty, Hai-Nam Vu, Mohammed Mahedi Hasan. ―DC-DC Converter Topologies for Electric Vehicles, Plug-in Hybrid Electric Vehicles and Fast Charging Stations: State of the Art and Future Trends‖ Energies 2019.
[31]. Parthasarathy Nayak and Kaushik Rajasheka, ―Single-stage Bi-directional Matrix Converter with Regenerative Flyback Clamp Circuit for EV Battery Charging‖ IEEE 2019.
[32]. N. Sujitha, S. Krithiga, ―Grid tied PV-Electric Vehicle Battery Charger using Bidirectional Converter‖ International Journal Of Renewable Energy Research 2019.
[33]. Haijun Tao, Guopeng Zhang, and Zheng Zheng, ―Onboard Charging DC/DC Converter of Electric Vehicle Based on Synchronous Rectification and Characteristic Analysis‖ Journal of Advanced Transportation 2019.