International Journal For Advanced Research In Science & Technology
A peer reviewed international journal www.ijarst.in
ISSN: 2457-0362

Analyze the Energy Transfer System's performance utilizing CCCV Control for the EV Battery Charging Method

[1.]P.Ashish Naidu, [2.]P.Jagadeesh, [3.]S.Jagadeesh, [4.]V.Krishna Sai, [5.]K.V. Chandra Sekhar

[12345]Students, Department of Electrical and Electronics Engineering

Vignan's Institute of Information Technology (A), Visakhapatnam, Andhra Pradesh, India.

Abstract – EVs are more efficient than fuel-powered vehicles, producing zero emissions while reducing greenhouse gas emissions, air pollution, and meeting climate targets. Charging an electric vehicle is less expensive than filling up with gasoline or diesel for transportation. Nowadays, there is a significant demand for electric vehicles. However, due to several complexities, they are not preferable to traditional vehicles; the primary disadvantage of EVs is battery charge. To avoid negative effects and improve desired charging efficiency, it is critical to undertake an analysis of the present status of EV charging technologies and employ advanced management strategies to accelerate the adoption of EV. To attain peak performance, charging systems require a unique transformer design, control strategy, standard compatibility, and charging and discharging codes. Charging an electric vehicle battery takes longer. However, more technologies are now accessible to help them solve this challenge, such as level 1, level 2, and level 3 charging technologies. However, they are not concerned about battery life.So we decided to create a project to extend the life of an EV battery by employing the CCCV approach with a bi-directional DC-DC converter. Our invention not only extends battery life but also improves EV performance by adding an auxiliary battery to give power when the main battery is overloaded. Finally, we used MATLAB to create a software model, and we frequently had satisfactory results.

Keywords: Bidirectional DC/DC converter, New energy vehicle, Electric vehicle, CCCV mode, PID controller, PWM technique, Charging Technologies.

1.INTRODUCTION

In recent years, Electric vehicles' (EVs) quick development has had a big impact on the global transportation and energy industries. In order to fulfill the increasing demand for electric vehicles (EVs) and handle issues with range anxiety and limited infrastructure, charging stations and procedures have experienced amazing breakthroughs. These developments are crucial to this revolution.

Electric vehicle supply equipment (EVSE),[1] also referred to as charging stations, is a necessary piece of infrastructure that EV owners depend on to recharge their vehicles in a reliable and easy manner. The types of these stations differ; they might be public charging stations placed strategically in parking lots, along highways, and within cities, or they can be residential chargers installed in residences.

Manufacturers, utilities, and start-ups have worked together to create a variety of charging solutions geared to certain use cases and consumer needs. Fast-charging stations, which can produce high power outputs to quickly recharge EV batteries, have grown in popularity, solving issues about charging time and accessibility.

One of the most significant breakthroughs in recent years has been the widespread adoption of direct current (DC) fast charging [2], which enables EVs to recharge their batteries much faster than AC charging. DC fast chargers employ high-power outputs to enable rapid charging sessions, making them excellent for long-distance travel and decreasing charging time for consumers.

Furthermore, wireless charging technology has developed as an appropriate choice, eliminating the need for physical cords and interfaces. Wireless charging, which uses electromagnetic induction or resonance, allows EVs to recharge simply by parking on designated charging pads, providing significant convenience and paving the path for seamless integration with autonomous driving systems.

2.Charging Stations

Charging stations for electric cars (EVs) have advanced significantly in recent years to satisfy rising demand and handle a variety of EV adoption issues. Here is a summary of major developments: Governments, utilities, and private companies have made significant investments in developing charging infrastructure to accommodate the growing number of EVs on the road.[3] This growth involves the installation of public charging stations in large cities, highways, and workplaces,

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal www.ijarst.in
IJARST ISSN: 2457-0362

as well as the implementation of charging facilities into residential complexes and parking lots.

The implementation of rapid charging networks has been a key priority, with the goal of reducing charging times and relieving EV drivers' range anxiety. Fast charging stations, which can produce high power outputs, have becoming more common, allowing EVs to recharge quickly during long-distance trips or when time is restricted. Globally, networks such as Tesla's Supercharger, CCS (Combined Charging System), and CHAdeMO have expanded, providing fast charging to a wide range of electric vehicle.

Ultra-fast charging technology, capable of producing even higher power outputs, has emerged to significantly shorten charging time. Charging stations with power levels more than 350 kW have been installed, allowing EVs to gain significant range in a couple of minutes. These ultra-fast charging stations are frequently found along key transportation corridors and are compatible with next-generation EVs capable of handling higher charging speeds.

Many charging stations are now powered by renewable energy sources such as solar and wind power, resulting in cleaner and more sustainable charging alternatives. This integration reduces greenhouse gas emissions from EV charging and promotes the use of renewable energy in the power source.

Advances in smart technology have resulted in the creation of intelligent charging solutions that optimize charging schedules based on variables such as electricity pricing and renewable energy availability.[4] Smart charging stations can connect with EVs and utility networks, ensuring that electrical resources are used efficiently while reducing prices for EV owners.

Wireless charging technology for EVs is gaining popularity, providing greater comfort and ease of usage. Wireless charging pads put in parking lots or dedicated charging zones enable EVs to recharge without the use of physical cables, improving the user experience and encouraging the adoption of electric vehicles.

3.Charging Methods

In recent years, there have been considerable developments in electric vehicle (EV) charging technology, with the goal of increasing charging efficiency, reducing charging times, and improving user experience.[5] Here are some important developments:

Charging infrastructure has evolved to support higher power outputs, resulting in faster charging speeds. High-power charging stations capable of producing 350 kW or more have becoming more prevalent, allowing EVs to gain significant range in a short period of time. These stations are frequently strategically positioned alongside major highways and transit corridors to support in long-distance travel.

Liquid-cooled charging cables were designed to properly regulate the heat created during high-power charging sessions. The circulation of a coolant via the cables improves heat dissipation, allowing for more efficient and stable charging. This technique prevents charging components from overheating and guarantees that charging performance remains consistent over time.

Charging technologies have also benefited from advances in battery management systems, which monitor and control the charging process in order to improve battery performance and longevity. Advanced BMS algorithms use temperature monitoring, state-of-charge estimation, and cell balancing approaches to assure safe and efficient charging operations. These technologies serve to safeguard the battery from overcharging, overheating, and other damaging situations, extending its life and improving its reliability.

Plug-and-charge technology makes EV charging easier by allowing automatic authentication and invoicing when the car is plugged into a suitable charging station.[6] This seamless connectivity eliminates the need for RFID cards or smartphone apps, improving the user experience and lowering obstacles to electric vehicle adoption.

Battery swapping technology provides an alternative to traditional charging techniques, allowing EV users to exchange depleted batteries for fully charged ones at specially designed swapping stations. This technique has the potential to significantly cut charging times while also addressing concerns about battery condition and lifespan, especially for commercial operators of vehicles and long-haul transportation.

4. Charging Technologies Of EV:

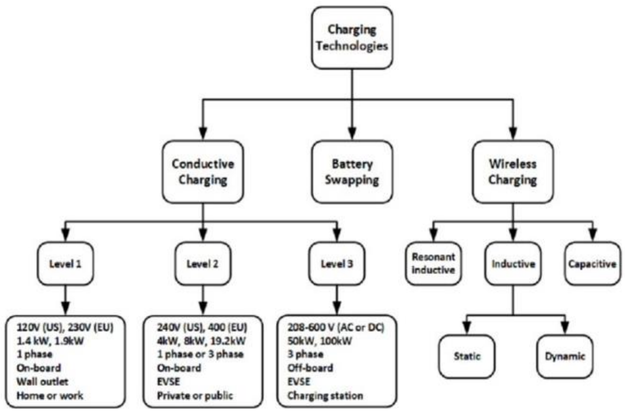


Figure-1: Electric Vehicle Charging Technologies

Types of charging technology

Different charging levels and timeframes are required during the electric vehicle charging process.

1. Level 1 charging uses a regular household plug and is the slowest charging technique. It has a charging speed of two to five miles per hour. Depending on the vehicle's battery capacity, a full charge can take eight to twenty hours. fig-1
2. Level 2 charging necessitates separate charge and is quicker than level 1 charging. It has a charging speed of between ten and thirty miles per hour. Depending on the vehicle's battery capacity, a full charge could take 4–8 hours.
3. Level 3 charging, sometimes referred to as DC fast charging, is the quickest charging technique and calls for specialized charging hardware. About 30 minutes is needed for charging at up to 100 miles per hour. Depending on the vehicle's battery capacity, a full charge takes less than an hour to complete.

Level 1 charging:

Electric vehicle users will find Level 1 charging to be rather convenient. entry to a covered parking area. By enabling overnight charging, you can make sure the vehicle starts up fully charged every morning.

One of the primary benefits of Level 1 charging is that it can be used with regular 120-volt household outlets, negating the need for additional equipment or modifications to the infrastructure.

Level 2 charging:

Typically found in public areas like parking lots, workplaces, and shopping centers, level 2 charging infrastructure offers a practical solution for the charging [7]. Quicker rates of charging in contrast to charging at Level 1, Level 2. greatly shortens the time needed to charge an electric car, satisfying the demands of drivers on a more constrained timetable.

DC Fast Charging Fast charging stations make long trips more feasible and appealing to customers by increasing driving range to 250 miles in just 30 minutes.

Quick Charging DC Fast charging stations' ultra-fast charging feature reduces wait times and boosts the convenience of having an electric car overall.

The car doesn't need to be physically plugged into an outlet to charge thanks to wireless technology. seamless and practical charging process.

Wireless charging systems can be installed on a range of surfaces, including parking lots and roadways, providing a range of options for effectively charging electric vehicles.

By reducing charging times even further, ultra-fast charging networks hope to increase the gas-speed competitiveness of electric vehicles relative to conventional vehicles.

5. CCCV Charging Method:

Constant Current Charging (CC):

The technique of continually charging a rechargeable battery at a constant current in order to avoid overcurrent charge circumstances is known as constant current charging.

To avoid overvoltage charge, there is a further technique that involves charging at a low,constant current or gradually changing the current.

Constant Voltage Charging (CV):

To avoid overcharging, one technique for charging is constant voltage charging. After a high beginning value, the charging current progressively drops.To avoid the rechargeable battery's temperature from becoming too high, there is another technique that involves starting low and gradually increasing the voltage.

Constant Current Constant Voltage Charging (CCCV):

One common technique for charging rechargeable batteries like lithium-ion is CCCV charging.

Depending on the voltage of the rechargeable battery, operation alternates between CV, which charges at a constant voltage, and CC charging, which charges with a constant current.

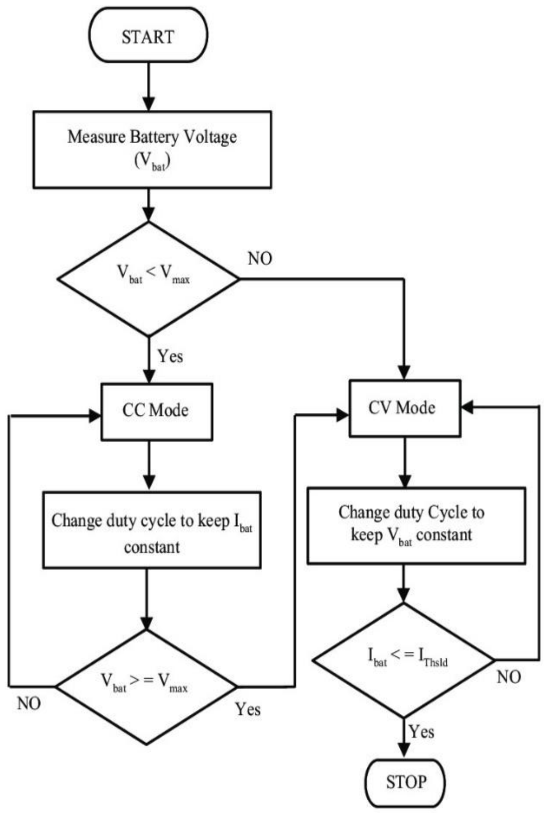


Figure-2: Flow Chart of CC-CV Method

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal www.ijarst.in
ISSN: 2457-0362

A set amount of current is supplied to the battery during the constant current charging phase, which enables it to charge rather quickly. The battery goes into the constant voltage charging phase as its voltage rises fig-2. At this point, the voltage stays constant while the charging current progressively drops. This prevents overcharging and enables the battery to operate at its maximum capacity.

Electric Vehicle are charged via the CCCV method since it has a number of benefits. Firstly, in comparison to other techniques, it enables faster loading.[8] Second, by avoiding overcharging, it contributes to longer battery life. Lastly, it guarantees a steady and dependable charging procedure, which is critical to an electric vehicle's overall effectiveness and performance.

Benefits of the CCCV Approach:

Improved battery performance can be attained by optimizing the charging process with the use of the CCCV (Constant Current Constant Voltage) approach. By supplying a constant current during the initial charging phase and subsequently switching to a constant voltage, the CCCV method provides efficient and successful battery charging.

Longer battery life: The CCCV technique contributes to a longer battery's total lifespan. The CCCV approach reduces the possibility of overcharging or undercharging, which can cause battery degeneration, by closely monitoring the charging process. By doing this, the battery's life and capacity are extended.

Constant Current, Constant Voltage, or CCCV, is the widely accepted technique for charging lithium-ion batteries, the type of batteries found in the majority of modern products. This is due to a few factors:

Faster charging: The CCCV approach enables a higher current to be supplied to the battery during the early stage (Constant Current), which results in faster charging periods.

Safer charging: Constant Voltage is used when the battery reaches a specific voltage level. By doing this, overcharging is avoided, which may harm the battery and perhaps pose a safety risk.

Versatility: The CCCV approach is not limited to lithium-ion batteries; it may also be utilized with nickel-metal hydride batteries.

Efficiency: To top off the battery without wasting energy, the CCCV approach maximizes current flow in the first stage before switching to voltage regulation.

All things considered, the CCCV technique offers a fair mix of efficiency, safety, and speed while charging different types of rechargeable batteries.

The CCCV method's objective-One technique for charging electric vehicles (EVs) is the Constant Current Constant Voltage (CCCV) method. This entails giving the battery a steady current until it reaches a particular voltage, and then continuing to provide it a constant voltage until it is fully charged. The battery's longevity and safety are guaranteed, and the charging procedure is optimized with this method.

6.Traditional Charging Process:

As the traditional technique is the most efficient approach for charging stations, and the cccv methodology has been used in recent years, the hardware equipment will be implemented using the classic method.

The CC and CV stages of CC-CV charging algorithms work in concert with one another in some way, with the significant electrochemical polarization potential at the CV stage effectively compensating for the capacity loss caused by the high electrochemical polarization potential in the CC stage. Because of its superiority over both the single CC charge and the single CV charge, the CC-CV charging approach has been selected as a standard by which to compare the effectiveness of other battery charging techniques.

The major difficulty in using the traditional CC-CV charging method is determining the appropriate constant voltage at the CV stage and constant current at the CC stage fig-3. The battery capacity and the amount of charging current in the CC mode determine how long the battery will take to charge completely when using the CC-CV charging technique. Under the CC mode, battery life and charge efficiency often rise as charging current falls. Furthermore, microcontrollers are not needed for batteries charged by the CC-CV algorithm; instead, just a voltage sensor, current sensor, and temperature sensor are needed. As such, the CC-CV charging methodology is easy to use.

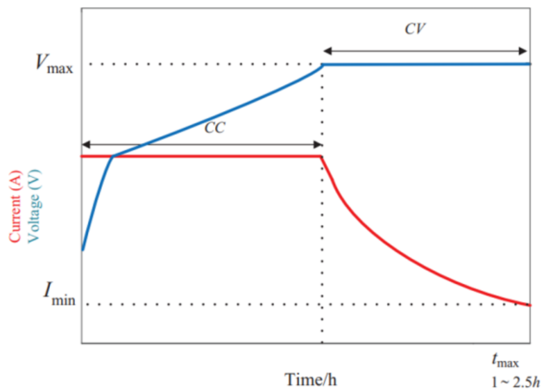


Figure-3:CC-CV Charging Method

IJARST
International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
www.ijarst.in
ISSN: 2457-0362

7.Bidirectional DC DC Converter

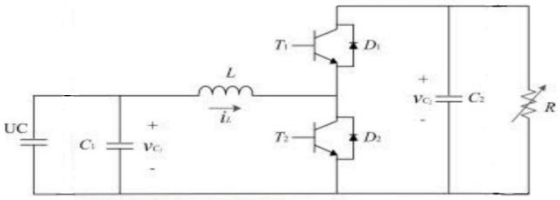


Figure-4: Block Diagram of Bidirectional DC DC Converter

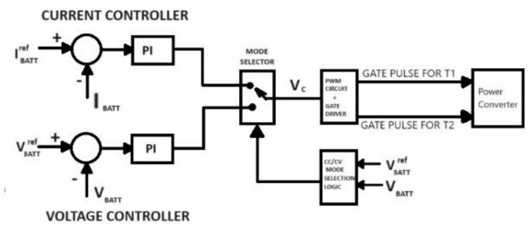


Figure-5: Control Block for Bidirectional DC-DC Converter

A bidirectional DC-DC converter is an important component of electric vehicle (EV) charging and energy management systems. Unlike standard unidirectional converters, which only allow electricity to flow in one direction (from input to output or vice versa), bidirectional converters allow energy to flow in both directions, allowing the vehicle's battery to be charged and discharged simultaneously.

Bidirectional dc-dc converters are critical components of traction systems in hybrid electric vehicles fig-4, fig-5. [9] The use of a bi-directional dc-dc converter fed dc motor drive dedicated to electric vehicle (EV) applications allows for appropriate regulation of both driving and regenerative braking operations, which can contribute to a significant boost in total drive system efficiency. Many bidirectional dc-dc converter topologies have recently been published, including soft switching techniques used to improve transfer efficiency.

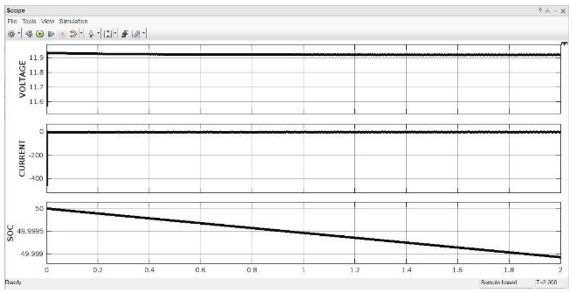
Many modern applications, including automobiles servers, and renewable energy systems, may depend heavily on a bidirectional coordinate current (DC)/DC converter. Most low-voltage bidirectional DC/DC converters are not isolated. Currently available bidirectional converter designs and products all use the hard-switching synchronous buck architecture. This research compares the transition-mode totem-pole zero-voltage-switching (ZVS) architecture to the hard-switching synchronous buck topology using an automobile 48-V/12-V bidirectional converter as an example.

8.Components

S.No	Components
1.	Mosfet
2.	Inductor
3.	Capacitor
4.	Current Sensor
5.	Micro Controller
6.	Battery
7.	Constant DC Supply
8.	CRO

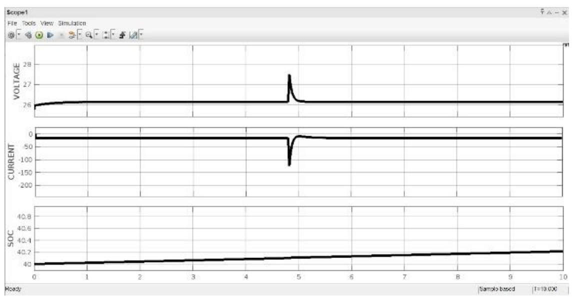
9.Matlab Graphs

A) Bidirectional DC DC Converter Graph



The bidirectional graph(A) shows that, The graph in the model depicts battery voltage (Vbat) on the y-axis and time (s) on the x-axis. The battery voltage starts at 11.92 V and gradually lowers over time. The current (Ibat) is set to zero, maintaining a steady current. The state of charge (soc) is also represented on the graph, and it begins at 50% before gradually declining, reflecting the pattern of battery voltage.

B) CC-CV Graph



The CCCV graph(B) shows the battery voltage (Vbat), current (Ibat), and soc on the y-axis, and time on the x-axis.The graph most likely reflects the CCCV technology. A constant current area followed by a constant voltage region indicates a CCCV control method. In the constant current

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal www.ijarst.in
IJARST ISSN: 2457-0362

area, the converter would provide a continuous current to the battery. When the battery voltage reaches a certain point, the converter switches to constant voltage mode, controlling the voltage to avoid overcharging.

References:

[1] K. Fauziah *et al.*, "Design of AC Electric Vehicle Supply Equipment based on Safety Standard," *2021 3rd International Conference on High Voltage Engineering and Power Systems (ICHVEPS)*, Bandung, Indonesia,2021, pp. 425-430, doi: 10.1109/ICHVEPS53178.2021.9600963.

[2] Q. Deng, S. Tripathy, D. Tylavsky, T. Stowers and J. Loehr, "Demand Modeling of a dc Fast Charging Station," *2018 North American Power Symposium (NAPS)*, Fargo, ND, USA, 2018, pp. 1-6, doi: 10.1109/NAPS.2018.8600618.

[3] P. Aji, D. A. Renata, A. Larasati and Riza, "Development of Electric Vehicle Charging Station Management System in Urban Areas," *2020 International Conference on Technology and Policy in Energy and Electric Power (ICT-PEP)*, Bandung, Indonesia, 2020, pp. 199-203, doi: 10.1109/ICT-PEP50916.2020.9249838.

[4] Riza *et al.*, "A Design of Smart Charging Architecture for Battery Electric Vehicles," *2023 IEEE PES Innovative Smart Grid Technologies Europe (ISGT EUROPE)*, Grenoble, France, 2023, pp. 1-5, doi: 10.1109/ISGTEUROPE56780.2023.10408308.

[5] A. B. Malla and H. Myneni, "Analysis of Different Charging methods of Batteries for EV Applications with Charge Equalization," *2023 IEEE IAS Global Conference on Renewable Energy and Hydrogen Technologies (GlobConHT)*, Male, Maldives, 2023, pp. 1-6, doi:10.1109/GlobConHT56829.2023.10087758.

[6] J. Yusuf, S. Ula and A. S. M. Jahid Hasan, "Analyses and Applications of Plug-in Electric Vehicle Charging Stations' User Behavior in a Large University Campus Community," *2020 International Conference on Smart Grids and Energy Systems (SGES)*, Perth, Australia, 2020, pp. 928-933, doi: 10.1109/SGES51519.2020.00170.

[7] A. Almaghrebi, S. Shom, F. Al Juheshi, K. James and M. Alahmad, "Analysis of User Charging Behavior at Public Charging Stations," *2019 IEEE Transportation Electrification Conference and Expo (ITEC)*, Detroit, MI, USA, 2019, pp. 1-6, doi: 10.1109/ITEC.2019.8790534.

[8] N. Sivakumar, S. C. Raja, M. Saravanan and S. A. E. Xavier, "Analysis the performance of Energy Transfer System (ETS) for EV battery charging method using non-isolated SEPIC converter-based CCCV control," 2023 9th International Conference on Electrical Energy Systems (ICEES), Chennai, India, 2023, pp. 377-381, doi: 10.1109/ICEES57979.2023.10110262.

[9] N. A. Al-Obaidi, R. A. Abbas and H. F. Khazaal, "A Review of Non-Isolated Bidirectional DC-DC Converters for Hybrid Energy Storage System," *2022 5th International Conference on Engineering Technology and its Applications (IICETA)*, Al-Najaf, Iraq, 2022, pp. 248-253, doi: 10.1109/IICETA54559.2022.9888704.