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Bidirectional Battery Charging for Electric Vehicles

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A B S T R A C T

Electrical vehicles (EVs) are gaining popularity on a global scale, because its carbon dioxide emissions are lower than those of an IC Engine. More individuals are using electric automobiles all over the world. It is projected that EVs will play a significant role in building a more sustainable future. When an electric car is plugged in, the battery charges, preparing the energy that has been stored there for use by the propulsion system. EV battery chargers using convectional technology can only charge in one of two ways: Due to the mobility of EVs, vehicle to grid (V2G) technology has evolved. V2G technology requires a specialized electric car battery charger in order to facilitate bidirectional power flow between the battery of an electric vehicle and the power grid. In this paper, we discuss bidirectional battery chargers for electric vehicles (EVs), with an emphasis on communication options between grid, home, and vehicle. In the G2V operation mode, batteries are charged from the power grid using sinusoidal current and a unitary power factor. The ability to transfer battery power back to the power grid while in V2G operation mode improves the electrical system's stability. In the V2H operation mode, the batteries' stored energy can be used to power sites that are not linked to the power grid or houses during blackouts. The principal method of recharging batteries is to be replaced by charging stations (CSs), which heavily rely on power electronic converters. converters that can function as either rectifiers or inverters, depending on the direction of the power flow. Electric vehicles (EVs) are evolving into a sizable distributed energy resource (DER) that utilities, microgrids, and other industry service providers can use to efficiently balance grid supply and demand, offer ancillary services, produce economic benefits, and support essential energy needs during outages. The adaptability that bidirectional charging technology offers for managing and controlling power system operations.

Keywords:Electric vehicles, charging stations, bidirectional converter, Bidirectional Battery Charger, Grid-to-Vehicle (G2V), Vehicle-to-Grid (V2G), Vehicle-to-Home (V2H).

1. Introduction

In most cities, EV charging stations and parking lots with charging capabilities are becoming standard infrastructure. Internal combustion engine vehicles (ICEVs) are predicted to be replaced by electric cars (EVs) in the near future due to the urgent need to reduce greenhouse gas emissions and the ultimate depletion of fossil fuels. Additionally, the widespread usage of EVs is integrated into a more intricate situation involving microgrids and the idea of a smart grid, which poses significant difficulties for several research areas. Although the technology of batteries and Energy Storage Systems (ESSs) limits advancements in the field of electric vehicles, there are many encouraging signals of growth in this area. Given that battery chargers can be directly supplied via either a common dc connection in dc microgrids or indirectly through ac-dc converters connected to the ac mains.

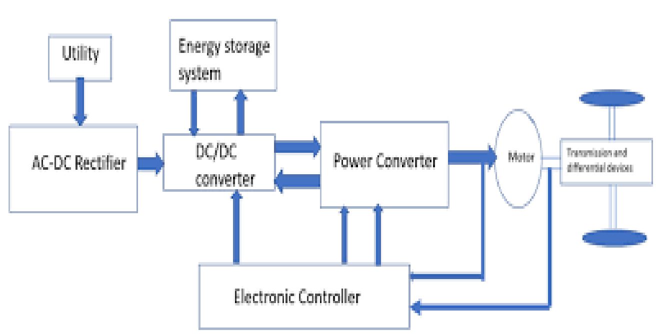

Fig. 1 Bidirectional charger Technology

To maintain the quality of the power in the power grids, the grid-to-vehicle (G2V) procedure for charging EV batteries must be regulated. However, when EVs become more common, a significant quantity of energy will be stored in their batteries, creating the possibility of an energy flow in the other way

(Vehicle-to-Grid, V2G). The interaction with EVs will be one of the main technologies in the future smart grids, enabling the power grid to run autonomously. Regarding this novel strategy, EVs can operate in addition to the G2V and V2G operation modes as voltage sources capable of supplying the electrical loads in residences with EV charging stations. This battery charger enables you to extract energy from the power grid (G2V) and return some of the battery's stored energy to the power grid (V2G).Energy can flow to or from the EV batteries (G2V and V2G) when the EV is linked to the power grid. The EV can act as a voltage source to provide the desired loads when there is no power grid or power interruptions. The system has an auxiliary energy storage system but is not designed to provide real-time energy backup. Consequently, seamless transitions between the modes are possible

2. Convertible Battery Chargers

Various types of convertible battery chargers are:

a. Vehicle-to-Grid (V2G)

b. Grid-to-Vehicle (G2V)

c. Vehicle-to-Home (V2H)

a. Grid-to-Vehicle (G2V),

The full-bridge AC-DC bidirectional converter functions as an active rectifier with sinusoidal current and a unitary power factor in this mode. As a buck converter, the reversible DC-DC converter works. The fundamental idea behind vehicle-to-grid electricity is that while they are parked, EVs power the grid. The EVs can be a fuel cell, hybrid, or battery-electric vehicle that is connected to the grid. Each vehicle must possess the three necessary components for V2G. An electrical energy flow connection to the grid . Communication requires either control or a logical relationship. utilising grid operators Precision metering within the car. A grid operator must assume that there are always enough parked cars that could be plugged in to arrange the dispatch of power. At least 90% of personal automobiles are parked, even during peak traffic times, because the average personal vehicle is only on the road for 4-5% of the day. Rarely have the technologies needed for V2G systems been integrated. When these technologies are used in tandem on a big scale, unexpected technical challenges can occur, but there might also be unanticipated positive spill overs and synergies. The communication and grid regulation systems necessary to manage dispatch, recharge, and regulation up and down are likely to be crucial for the diffusion of V2G technology. Due to the smaller scale of generation from each vehicle, compatibility issues with current systems built on huge generation units may arise.

b. Vehicle-to-Home (V2H)

The full-bridge ACDC bidirectional converter creates a sine-wave voltage with the necessary amplitude and frequency to power the household loads when operating in V2H mode. Like in the V2G operation mode, the reversible DC-DC converter functions as a boost converter to keep the DC link voltage at an appropriate amplitude for the full-bridge AC-DC bidirectional converter's proper operation. The power immersed by the loads varies over time, the power from the traction batteries must follow this load variation, for the DC connection voltage regulation. since the full-bridge AC-DC. The only voltage that a bidirectional converter can be modified for is the output voltage. The frequency and amplitude of the DC connection are controlled. Similar to vehicle-to-grid (V2G), vehicle-to-house (V2H) uses energy locally to power a home rather than supplying it to the electrical grid. This makes it possible for the EV to perform similarly to a typical home battery system, which helps to boost self-sufficiency, particularly when combined with rooftop solar. The capacity to offer backup power in the event of a blackout is another advantage of V2H. It instructs the bidirectional EV charger to discharge in an identical proportion in order to balance out any grid power used. Similar to how smart EV chargers operate, when the system notices energy being exported from a rooftop solar array, it diverts this to charge the EV.

c. Vehicle-to-Grid (V2G)

Due to the high cost of the supporting technologies to individual PEV owners, V2G technology has attracted interest from the government, power utilities, and EV owners. The deployment of the V2G concept is favoured by the way EV drivers now drive. The average amount of time a personal vehicle spends on the road, according to the vehicle travel trend, is less than 10% of a day. These cars won't just be driving about; they'll also be parked in garages or lots. As a result, these EVs can be used for V2G deployment by being linked to the power grid. Energy resources, power utilities, system operators, aggregators, bidirectional battery charging facilities, communication facilities, intelligent metering, and battery management are just a few of the crucial components that make up the V2G concept's architecture. Figure 1 shows the V2G components. Information and orders can be sent thanks to communication between the individual EV and the power grid operator. Power flow for the V2G idea can be either unidirectional or bidirectional depending on the needs of the power utility. The term "unidirectional V2G" describes a power flow that only goes in one direction, from the power grid to the EV. To manage and set limits on the charging time, location, and power flow during an EV charging event, unidirectional V2G requires the involvement of grid operators. More technological and financial advantages are provided by bidirectional V2G. The advantage of using vehicle batteries as grid storage versus stationary storage is that the storage is essentially paid for by the owner of the vehicle with little to no upfront cost; utilities pay for access to the storage that is already there. V2G commercialisation, however, won't happen for a few years since automakers will keep an eye on the effect on battery life before deciding whether or not to integrate the required power and communications technology into the vehicles at the factory. The operation of the electrical system may be controlled and managed more easily thanks to bidirectional V2G technology.

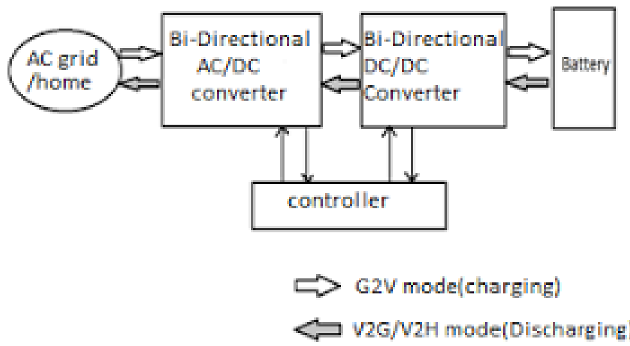

Fig. 2 Charging Topologies of V2G, G2V and V2H

3. Descriptions of System

Possible range anxiety in electric vehicles due to inadequate charging infrastructure and lengthy charge periods. Standard AC Level 1 (2 kW) or Level 2 (>For EV parking lots, there are typically two major structures: a scattered structure and a centralised structure. Each EV charger in the distributed structure is modularized, which means each charger has a complete AC-DC, DCDC converter. A centralised system only requires one higher power level ACDC converter because it only has one port for interacting with the AC microgrid. And the high power AC-DC converter is linked to the DC-DC converter-based chargers. In comparison to the scattered structure, the centralised structure has greater benefits, including fewer switching devices, easier system control, centralised administration of the bidirectional power flow, and other features.

a.EV Charging Stations

EV offers electric medium-to-heavy commercial vehicles in an effort to lessen the environmental impact of transportation. The organisation, which is devoted to maintaining a dependable EV charging infrastructure, concentrates its efforts on providing a variety of EV charging stations appropriate for a number of locations. "Range anxiety" is one of the biggest obstacles to adoption, but the promise of quick, dependable, safe, and most crucially, convenient charging infrastructure with straightforward accessibility will help reduce concern. Range anxiety is the worry that long-haul deliveries would take longer to complete since the driver will need to stop for many hours to recharge rather than just a few minutes as with a diesel truck. To reach net zero goals, the DC fast charging network must be strategically expanded quickly. The utility companies' strategies to mitigate the pressure on power grids caused by the rapid expansion of electric vehicles (EVs) are another element that would have a significant impact on the quick growth of the EV landscape. To understand the future capacity restrictions and modifications required to sustain and maintain safe, economical, and efficient supply to the new EV charging network, utility generation and local distribution centres must coordinate their efforts.

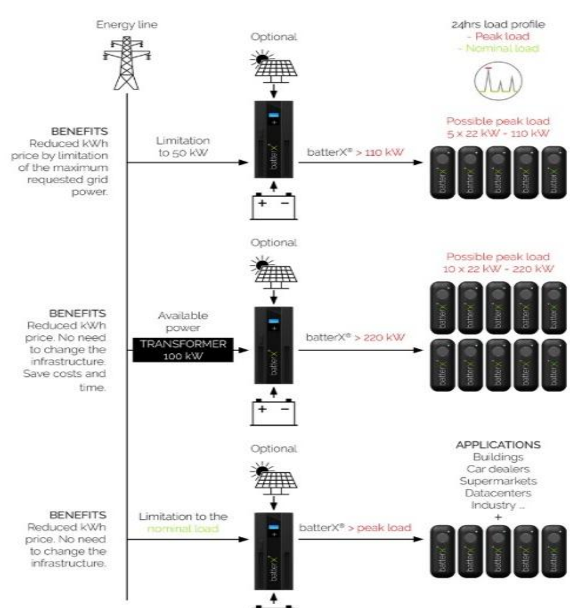

Fig. 3 Energy provided from charging station

b.EV Battery Storage

Use Energy storage solutions are required more and more urgently as the use of electric vehicles spreads, in order to extend their range. The rate at which we can create a more sustainable transportation industry will surely be impacted by the advancement of more effective battery technologies. The most recent information from businesses engaged in the development and production of EV battery storage systems to power automobiles, bicycles, buses, and even trains is provided by Innovation News Network. When the grid is already producing the most electricity and when the value and price of electricity are low or relatively low and passenger vehicles are not needed or used, some EVs will need to charge during the day and even during peak demand times. There are two main options if EV charging takes place in areas of the grid that do not have the capacity "head-room" to handle the additional power needs. To expand the necessary capacity, the utility may do a few things. First, it could build more generating, transmission, and distribution (GT&D) infrastructure. Installing distributed energy resources (DERs), such as distributed generation and storage, is the second option. The DER capacity must be placed electrically downstream from congestion sites to supply the additional local on-peak demand in order to have the desired effect.

4. Comparison between bidirectional charging and smart charging

Any method of EV charging in which the charging duration and rate may be managed by a "smart" device as opposed to a manual on/off switch is referred to as smart charging. Data links are used between the EV and the charger to accomplish this. Think about smart EV charging applications, which let you use your smartphone to manage how long your EV is charged. With smart charging, automobiles can be plugged in but do not need to be actively charging at all times. Instead, depending on the nation and the energy operator, individual EV owners or energy firms can choose when it is most cost- and demand-effective to charge electricity. Customers might occasionally gain financially from this. Consider the several energy firms. Several energy providers, for instance, might provide lower rates for charging at odd times. This lessens the possibility of situations in which a sizable number of EV owners charge simultaneously, overloading the power system.

5. Benefits of bidirectional charging

There are two benefits. First off, bidirectional charging and V2G enable building energy management systems to be upgraded and made smarter without having to be completely rebuilt, saving on costly expenditure. Secondly, bidirectional charging lowers the cost of operating the electricity. now ready to style your paper; benefits of bidirectional charging.

The Operational electricity expenses are decreased through bidirectional charging. A viable option for controlling brief local surges in electricity use is bidirectional charging. A crucial step to increase the amount of electricity provided by renewable sources in the system.

There is a constant flow of electricity. We waste it if we generate it but don't use it or keep it. With the use of V2G and EV batteries, we are able to store excess renewable energy in car batteries and then draw on it when we need it, such as to handle a brief increase on a windless night.

No more overloaded electrical grids. The grid won't get overloaded if more people rely on the electricity stored in EVs during periods of high demand. Take this as a case study. We frequently notice grid overload during abrupt temperature drops in the winter. In such circumstances, the sudden increase in energy demand severely weakens the system, resulting in local overload and energy shortages.

Finally, the energy industry and energy utilities must support bidirectional charging for it to succeed and even exist. However, it's just a matter of time before the majority of utilities invest in controlling renewable energy using the V2G technology, given the present environmental concerns and how it can protect the grid and other electrical facilities.

6. Conclusion

The bidirectional EV battery charger with direct current control approach for V2G operation is presented in this paper. Electric vehicles and the grid would be able to communicate in both directions, allowing for both power injection into the system and battery charging. As a result, the electrical grid's frequency and voltage control are stabilized and power demands, particularly during peak hours, are met. The potential for discharging and returning the EV battery's excess energy to residential houses or buildings, or to the power grid, has been explored through the three discharging operations: Vehicle to Home V2H, Vehicle to Grid V2G, and Vehicle to Building V2B.

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