Design of Controller for Electrical Vehicle to Grid Power

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Abstract. This paper prescribed the design of controller for electrical vehicle to Grid power, by using this controller improve the power requirement of grid and reactive power compensation capability. Bidirectional converter is very helpful during on peak load demand. During off peak load demand grid will supply the power to the battery and charge the battery. During on peak load demand excess power of battery will supply to the grid. The concept aggregator is depicted in the figure 2. (Aggregator collects the power from all electrical vehicle first then it supply to the grid). This modern electrical vehicle technology proposed the distribution generation Methodology. All the control strategies of modern electrical vehicle to grid is proposed like smart charging or discharging of batteries during off peak load demand and On peak load demand respectively. V2G controller allow the active power it act as an ancillary services to grid. Electrical vehicle controller has ability to exchange the active or reactive power capability. Simulation of bidirectional AC/DC and DC/DC controller and their control circuit are analyzed by using matlab Simulink software.

Keyword: V2G Bidirectional Controller, Smart Charging and Discharging.

1. Introduction
At the beginning the electric vehicle had unidirectional power flows i.e. (from power grid to electric vehicle). In1980s the electric vehicle charging on power grid create influence due to charging demand coincide with overall maximum power demand. Due to penetration of electric vehicle in power grid and are growing every day. Thus it is very necessary to manage their maximum power demand. [2]

Nowadays the electric vehicle has bidirectional power flows i.e. (from electric vehicle to power grid and power grid to electric vehicle). The V2G pay a vital role in bidirectional power flow and accomplish its peak load demand [3,6,9].

The V2G controller utilize bidirectional AC/DC and DC/DC converter operation. During off peak load demand converter take the power from grid and charge the battery and during on peak load demand, the excess power of battery will supply to the grid. [4] Obviously the electrical vehicles are new load to the grid, will increase the demand but it is also beneficial due to the excess power of battery supply to the grid as an ancillary services.[5]

The electrical vehicle consumer also have the benefits to supply the battery power to grid since grid operator will gives cash back to the consumers while it supply the power to grid. When electrical vehicles consumer take the power from grid it will pay the money for the electricity.[10,11,12]

The thermal power plant, Diesel engine and petrol engine vehicle will increase carbon dioxide emission and results in environmental pollution which result in change of climate. It increase global warming effect. Thus it is necessary to displace the diesel and petrol engine vehicle by electric vehicle. [7][8]. The concept of aggregator is purposed because single electrical cannot be communicated with power grid control centre. The power grid control centre communicate with Aggregator about on/off peak load demand, then aggregator will communicate with electric vehicle.

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about the peak load demand. According to state of charge (SOC) of battery electric vehicle supply or receive the power from power grid control centre. Electric vehicle SOC monitoring is purposed by matlab Simulink. The objective of this paper is to provide the excess power of battery to power grid with help of aggregator and it will supply to power grid.[13]

2. Literature Survey

Diyun Wu, Chunhua Liu, [1] has given about coordination control on V2G a system, V2G system is integrated with conventional energy sources like wind, solar power, photovoltaic power etc. Furthermore, a complex AC grid including power grid and gradable vehicles gathering veneer are settled. ShuangGao [2] have executed the V2G controller Cite to Advanced control strategy of batterylike advanced charging/discharging. The control algorithms is utilized to control system parameter variation like load, frequency regulation, system frequency regulation. It also improve the power, frequency quality. QiangSun ,Shancanfu collage of engineering and technology Tianjin Agriculture Universityhas given about the bidirectional converter of V2GWhich adopt the technology of charging or discharging of electrical vehicle, it is considering robustness of PR controller for v2g application. [15]A Sgarbossa,[4]. Introduced bidirectional AC/DC and DC/DC converters. The AC/DC converter exchange active or reactive power with phase displacement of +−10 degree. When grid voltage update again excess power of battery is furnished to grid by setting the duty cycle through PR controller. G. Lacey dept.has given about choice of capacitor and inductor sizing in DC/DC converter side voltage fluctuation, voltage variation can be stabilized by increasing the size of capacitor. Choice of inductor should be properly otherwise high current transient resemble in device whichever causes aging of device. In case the inductor size decline then ripple current appear at the output.[16,17,18]shiruizhong[2] has introduced about V2G Fast charging need high current and high voltage. It arranged three phase bidirectional AC/DC converter in series with DC/DC converter is connected by DC link. The DC link voltage, frequency fluctuation, Duty cycle of DC/DC converter are stabilized by control system mechanism (control system include DQ and ABC voltage, current frames and PI converter). AC/DC converter utilize PWM techniques.[19] Hoang Vu Nguyen[14]presented active power decoupling circuit and APD circuit is used to absorb power ripple by dc link capacitor. In this paper single AC/DC converter, hybrid DC/DC converter, half bridge DC/DC converter, bidirectional DC/DC converter, isolated low voltage battery charger are utilized. When electrical vehicle is in running position then traction battery (HV) charge low voltage battery (LVB).

3. Methodology

![Fig. 1. Power Circuit](image-url)
3.1 Method - Distribution Generation
It is a Small Generators or conventional energies like wind, solar energy V2G etc. of 2-45 MW and Output power located at various points in rural and urban area etc. This paper present V2G controller and deal with power circuit of AC/DC, DC/DC converters and their control strategies. The Single Phase Controlled AC/DC converter operate as inverter/ controlled rectifier while DC/DC converter operate as a Buck / Boost converter depending on SOC of battery is shown in fig. 1. It utilize lithium ion battery of 24 volts and 180 Ah capacity. When the battery SOC (state of charge) less than 50% Grid will supply the power to the battery and charge the battery. When SOC is greater than 95% then battery will provides the power to aggregator up to 90% of SOC. Modern electrical like Electrical Vehicle like car bike are connected to grid such that during on peak load demand it supplies the excess power to the grid. During low power load demand it will takes the power from power grid and charge the battery.

In AC/DC converter side source filter as LC low pass filter which attenuate the higher order harmonics. V2G charger can exchange active power or absorb the reactive power and maintain unity power factor which lies between (-π/2 to +π/2). During charging mode it take the active power but in discharging mode it provides active power.

In DC/DC converter side LC low pass dc filter is utilized where choice of inductor size such that it reduces the ripple current at output. Capacitor is size such that it stabilize the voltage, frequency fluctuation. Where capacitor ESR (equivalent series resistance) is 0.01 ohm. Buck mode duty cycle ratio consist of 21% while boost mode duty ratio consist of 97%. According to state of charge of battery, the duty cycle is provided by controller. Here DC/DC converter switching frequency consist of 10 kHz while AC/DC converter consist of 20 KHz.

3.2 Aggregator

![Fig.2. Aggregator](image)

According to the characteristics of aggregator single electrical vehicle power rating is usually 10-15 KW. The concept of aggregator comes in picture due to the grid driver is not capable to commune with each electrical vehicle controller shown in fig 2. V2G supplies the power to grid and improves frequency regulation during on peak and off peak loads demand.
3.3 V2G Controller Strategies

In electrical vehicle to grid, SOC (state of charge) of battery plays the vital role in the alert charging /discharging. It plays Role in the energy distribution between gradable vehicles and Power grid. In the concept of battery technology. Battery Voltage drop aggressively. Thus SOC (state of charge) Reach 20%. So to keep the battery in healthy condition and to increase the battery life. The State of charge (SOC) kept more than 50% in V2G Systems. If SOC is more than 80% it supplies the power to the Grid. If it is less than 50% than it takes the power and charge the battery.

In another word if battery voltage is greater than 22 volts, then battery will supply the power to the Grid up to 19 volts. If the battery voltage is less than 24 volts then grid will supply the power to battery and charge the battery. The depending on SOC condition firing angle of AC/DC and DC/DC converter is updated. The Fig (3) and Fig (4) shows the firing angle control of AC/DC and DC/DC converters respectively. In control circuit if and if else loop condition is employed.

4. Simulation and Results

Fig. 3. control circuit of AC/DC converter

Fig. 4. control circuit of DC/DC converter

Fig. 5. Charging of battery

Fig. 6. Dc-link voltage during charging
| Parameters                          | their values  |
|------------------------------------|---------------|
| Dc Voltage (v_1)                   | 24 volts      |
| AC Supply voltage (V)              | 230volts      |
| I/p filter (Inductor) (L1)         | 0.8mH         |
| I / p filter Capacitor (C1)        | 10 uF         |
| DC Inductor (L2)                   | 0.82Mh        |
| DC capacitor (C3)                  | 1250uF        |
| DC Resistance                     | 0.1 ohm       |
| DC link capacitor                 | 1250uF        |
| ESR of dc link                    | 0.01 ohm      |

Table 1 Parameters of Simulation.

To validate the controller based electrical vehicle power to grid or V2G bidirectional charger is design by Matlab /Simulation software. All the component and battery, semiconductor device is taken from the SimPowerSystem /Power Electronics Library. The control circuit of power circuit is shown above fig 3 and fig 4. Where firing angle of V2G or G2V controller is controlled.

Instantaneous firing is used for controlled rectifier in AC/DC converter, low pass filter is used in the grid side to reduce the harmonics and switching losses. LC type DC filter is used in battery side which help to rectify harmonics, source voltage fluctuation, signal interference. The load are 180 Ah capacity of lithium-ion battery with nominal voltage of 24 volts dc. Front side converter has single phase supply 230 volts (50Hz). The charging voltage of battery during low power demand is depicted in fig 5. While the discharging voltage of battery during maximum power demand is shown in fig 7. DC-Link voltage during charging and discharging operation is shown in fig 6 and fig respectively. The Matlab Simulink parameter is shown in table 1.

![Fig.7. Discharging of Battery](image1)

![Fig.8. Dc-link voltage during discharging operation](image2)
5. Conclusion
In this paper, Controller for Electrical vehicle to grid power is presented. Where the storing device is Li-ion battery. It charge or discharge the battery to provide the excess power of battery to power grid and help in power load management. The power circuit and control circuit for V2G operation are analyzed effectively by using MatlabSimulink.

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