THREE PHASE BI-DIRECTIONAL ELECTRIC VEHICLE BATTERY CHARGER WITH G2V AND V2G TECHNOLOGIES

Bandela Reshma[1] Dr Md Mujahid Irfan[2]

[1]M. Tech Student, Department of Electrical Electronics Engineering , SR University Ananthasagar, Hasanparthy,Warangal, Telangana 506371

[2]Associate Professor, Department of Electrical Electronics Engineering, SR University Ananthasagar, Hasanparthy, Warangal, Telangana 506371

Abstract *The development of vehicle to grid & grid to vehicle technologies has been aided by the rise in electric vehicle mobility is examined in this article. A buck converter and a boost converter built on semiconductors make up a bidirectional charger. Electric vehicle batteries and the grid can exchange electricity in both directions. Peak load cutting, load levelling, voltage regulation, and increased power system stability are made possible as a result. We created an OBC charger for (EVs), aiming to use technologies such as (V2G), (G2V), and (V2L). Using current i.e., sinusoidal and UPF in the grid-to-vehicle mode we can charge our batteries. The capacity to return battery energy to the power grid during V2G system enhances the stability of the electrical system. In case of V2L system during power breakdowns or to power loads in remote areas that are not connected to the power grid. This study presented the architecture of BBC for (EVs) applications. Several factors are to be taken when determining the Filters on the AC side are believed to boost the three operating modes performance. Also contain different topology & results of different simulation models.*

1. INTRODUCTION

Electric vehicles (EVs) are being seen as a crucial technology for lowering pollution levels in the transportation industry. In addition, initiatives aimed at promoting the use of EVs across the globe are leading to an exponential growth in the percentage of EVs. Due to their short driving range, electric vehicles require regular recharging while on the road, making this a major worry. Moreover, one of the major concerns about EV use is the accompanying high cost and the limitation in terms of battery life. Therefore, in order to establish sufficient charging stations for electric vehicles, there is a great deal of study into the use of renewable energy for this purpose. Here, electric vehicle charging stations are making use of sources such as solar photovoltaic arrays, wind turbines, and fuel cell stacks.

Consequently, it is crucial to use dispersed energy resources in a hybrid manner that complements the unpredictability of each in order to meet the power demand while also improving environmental circumstances. Additionally, a big issue presently is the charging of electric vehicles using appropriate control algorithms.

Furthermore, a concentrate by the EU observed that street transportation was liable for over 70% of CO2 discharges in the transportation area, and that the business in general was liable for roughly 28% of all emanations. To relieve the development of CO2 and other ozone harming substances in the air, authorities in most of industrialized countries are pushing for the reception of EVs. Specifically, they advocate for proficient and harmless to the ecosystem transportation by means of different projects, generally as tax cuts, purchasing appropriations, or other interesting arrangements, such free open stopping or roadway utilization. Electric vehicles have many advantages over ordinary vehicles:

1. Zero emissions: Both carbon dioxide (CO2) and nitrogen dioxide (NO2) are not released into the atmosphere by these vehicles. The production methods are also usually better for the environment, even if making batteries has a negative effect on carbon footprint.
2. Simplicity: There are fewer moving parts in an electric vehicle's (EV) engine, which means less expensive repairs. The engines are smaller, less complicated, and noiseless since they don't need a cooling circuit, gearshift, clutch, or noise-reduction components.
3. Reliability: This sort of vehicle has fewer failures since it has fewer and simpler components. Electric vehicles also don't be damaged by things like vibrations, gasoline corrosion, explosions, or engine wear and tear.
4. Cost: Rather than traditional gas powered motor vehicles, which bring about a lot higher upkeep and fuel costs, electric vehicles have considerably less expensive support and power costs. Contrasted with traditional vehicles, electric vehicles have a much lower energy cost per kilometer.
5. Comfort: There are no tremors or engine noise while you ride in an electric vehicle, making it a more pleasant option.

2. ELECTRICAL VEHICLES

On a worldwide scale, the vehicle business has developed into a force to be reckoned with as far as both financial result and Research and development spending. To an ever increasing extent, cars are equipped with innovation includes that intend to improve the security of the two people on foot and travelers. Even better, we can go in relative solace and speed since there are more vehicles out and about.

Tragically, this has brought about a huge ascent in degrees of air toxins in metropolitan regions, including particulate matter (PM), sulfur dioxide (SO2), nitrogen oxides (NOx), and carbon monoxide (CO). Besides, more than 70% of CO2 emanations from transportation are owing to street transport, and the area in general is liable for around 28% of all discharges, as per an EU examination.

To mitigate the buildup of CO2 and other greenhouse gases in the air, officials in the majority of industrialized nations are pushing for the adoption of EVs. In particular, they advocate for efficient and environmentally friendly transportation via a variety of programs, mostly in the form of tax breaks, buying subsidies, or other unique policies, such free public parking or highway usage. Electric vehicles have many benefits over conventional cars:

1. No emissions: these vehicles discharge no nitrogen dioxide (NO2) or tailpipe poisons, CO2. The creation techniques are likewise generally better for the climate, regardless of whether making batteries adversely affects carbon impression.
2. The diminished intricacy of electric vehicle (EV) motors brings about much lower upkeep costs. The motors are more modest, less confounded, and quiet since they needn't bother with a cooling circuit, gearshift, grip, or commotion decrease parts.
3. This sort of vehicle has fewer failures because to its reliability, which is enhanced by having fewer and simpler components. Electric vehicles also don't be damaged by things like vibrations, gasoline corrosion, explosions, or engine wear and tear.
4. Maintenance and energy expenditures for electric cars are much cheaper than those for conventional gas-powered automobiles. As

seen in Figure, the energy cost per kilometer for electric cars is much lower compared to conventional automobiles.

5. Traveling in an electric vehicle is more pleasant than in a conventional vehicle since there are no vibrations or engine noises.
6. Compared to conventional cars, electric vehicles have higher efficiency. The total efficiency of the power plant is another factor that will determine the well-to-wheel (WTW) ratio. A diesel vehicle's overall WTW efficiency may be anywhere from 25% to 37%, whereas a gasoline vehicle's might be anywhere from 11% to 27%. In comparison, EVs powered by renewable energy sources may achieve an overall efficiency of up to 70%, whereas EVs powered by natural gas power plants have a WTW efficiency ranging from 13% to 31%.
7. Accessibility: Other combustion cars are not permitted to enter some metropolitan areas, such as low emissions zones, but this vehicle type may. In major cities, EVs are not subject to the same traffic restrictions, even during the most polluted times of day. To make matters worse, a new research out of the OECD indicates that EVs will not help the air quality problem, at least not when it comes to PM emissions.

3. MODELING CASE STUDY

COMPONENTS OF BI-DIRECTIONAL BATTERY CHARGER DC bus is present in between the converters on each side which make up the battery charger that is being displayed. One will connect to the electrical grid, while the other will connect to the traction batteries. in chronological order. A FB AC-DC BC is used to communicate with the power grid. ACDC Bidirectional converter can act active rectifier with sinusoidal current and UPF in the Grid-to-vehicle system This AC-DC converter performs the function of an inverter in case of V2G and V2L. The converter functions as a CCS in the V2G mode to feed the necessary power into the grid. In the vehicle-to-load case FB AC-DC converter acts as source of voltage, supplying the household loads. To link the batteries a DC/DC converter is used. In the grid-to-vehicle mode of bidirectional DC/DC converter behave as a buck converter for maintaining the current and voltage stages of the charging cycle throughout in the batteries. The DC/DC functions as a boost converter during V2G and V2H to raise the battery voltage to a suitable DC bus voltage in BBC. In Fig.1 displays the bidirectional battery charger's full electric schematic [1]. The whole architecture is similar hardware is comparable with a controlled Full bridge even though it uses two bidirectional converters.Fig.1 shows the basic layout of BBC topology [2].

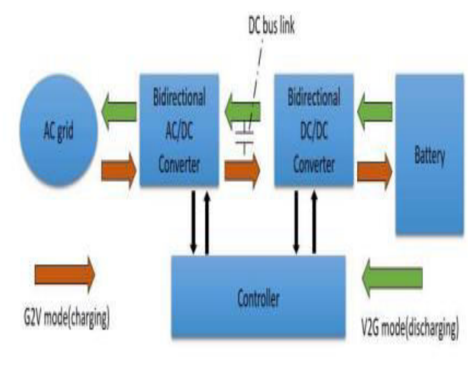
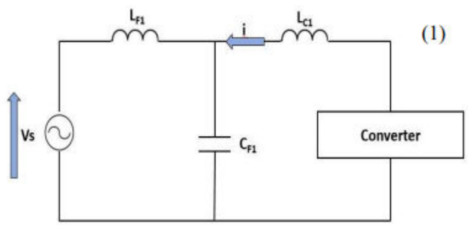


Fig.1 Structure of Bi-directional battery charger topology.

LCL FILTER

The LCL filter, which is seen in Fig. 2, is used to reduce ripple at the grid side in order to obtain low THD at the grid side. The grid side filter's single-phase circuit is depicted in Fig. 2 [2]. While preserving the stability of the entire system, the values of the filter's elements must be selected. Because of this, the transfer function of the filter is established [2]:



AC-DC BI-DIRECTIONAL CONVERTER

Depending on the operating mode, a power electronics circuit known as an AC-DC bi-directional converter can convert alternating current (AC) power to direct current (DC) power or vice versa. The converter can serve as a rectifier in one mode, converting AC power to DC power. In this mode, a diode bridge rectifier and a filter capacitor are commonly used to convert the AC voltage to a high DC voltage. Different electrical devices can then be powered by the resulting DC voltage. Broad output voltage buck-boost converters for unidirectional applications can lower the THD of AC current [4]. The converter can also operate as an inverter in the other mode, converting DC power to AC power.

In this manner, a switching circuit is often used to convert the DC voltage to a high-frequency AC voltage, which is subsequently transformed by a transformer to the appropriate voltage level. [8]. Hence the converter is used where he capacity to both charge and discharge a battery is required.

DC/DC CONVERTER TOPOLOGIES

DC-DC Converter is used to transforms a DC signal with a given voltage into another DC signal with a different voltage. In order to increase battery life, it is frequently utilized in constant voltage and constant current application in case of charging & discharging of car battery [3]. Moreover, it uses transformers to create isolation between both the sides, and it also controls output voltage by applying a control signal to it. The non-isolated topologies change the DC voltage from one level to another level without using a transformer to provide galvanic isolation between the circuits [9]. As a result, these topologies lack benefits such isolation between the source and the load and high step-up voltage gain ratio. Yet, because no transformer is used and the system will be small without one, their weights are lowered. Reactive power is generated in supply lines when transformers and converters are utilized, hence greater compensation is needed. Transformers cannot handle high current because when they are employed at high frequencies, Both the transformer & its coil size are decreased [9]. Moreover, the employment of a transformer with a converter might result in conductor core loss and skin effect.

1. Buck-Boost-derived bi-directional DC-DC converter

The single directional buck/boost converter's basic structure is modified by adding one additional switch to create the buck-boost DC-DC converter topology [9].It transfers power in each side as usual with the exception that the polarity of voltage at load side & the input side are of different sign.

2. Dual Active bi-directional DC-DC Converter

This topology is composed of full-bridge and half-bridge circuits that are already in use and are powered by voltage or current. The converter's use of number of switches will proportionally affect how much power is transferred. Low loss semiconductor switches can be used to alleviate the problem of switching losses caused by using additional switches in the topology [9]. Due to the involvement of two bridges, one is on the primary side and the other is on the secondary side. To function each bridge, complementary switching signals are provided to each bridge. Since this topology includes a greater number of switching elements, soft switching phenomenon can be simply utilised to reduce total switching losses. The control logic is made simpler by digital control because the circuit is complex. Controllable energy transfer is possible from the input side to the output side. The efficiency of these converters can be improved by utilizing effective control approaches. The converter's first stage can convert DC signals into AC signals using either current- or voltage-fed-based control [9]. By employing a transformer in the second stage of the converter to step-up the voltage level and a resonant tank circuit with a transformer to obtain ZVS/ZCS, this system with the transformer is made to operate with a high degree of efficiency. . In the converter's third stage, a full-bridge AC - DC converter transforms the AC signal provided from the transformer into a DC signal using control signal [9]

CONTROL BLOCK DIAGRAM & TOPOLOGY CIRCUIT

Three Phase Bi-directional Battery Charger: In this the basic model of a three-phase EV battery charger shown in fig.5. To control the battery current during charging and discharging operations, a bi-directional buck/boost converter is used in the input. This device is also referred to as an active rectifier and converts the ac grid voltage to direct current voltage while also maintaining a constant voltage across the dc bus. And the specifications of the complete system are as grid voltage is 415V phase-to-phase at 50 Hz, filter inductance is 5mH & capacitance is 30µF.In the inverter bridge we used IGBT and value of bus capacitance is 5600µF, mosfet is used in buck converter & buck filter inductance is 20mH, output capacitance is 0.625µF. Battery nominal voltage is 360V, switching frequency of both the converter is 10kHz.Total rated power is 10kW.

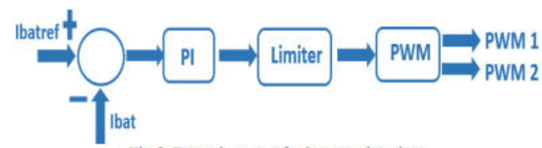


Fig.3 Control system for battery charging

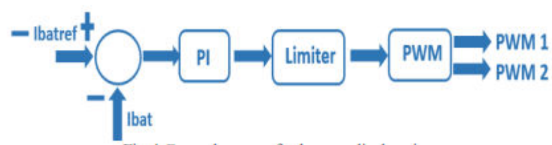
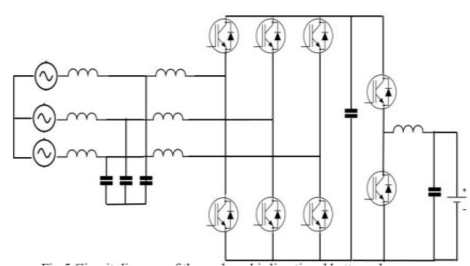


Fig.4 Control system for battery discharging



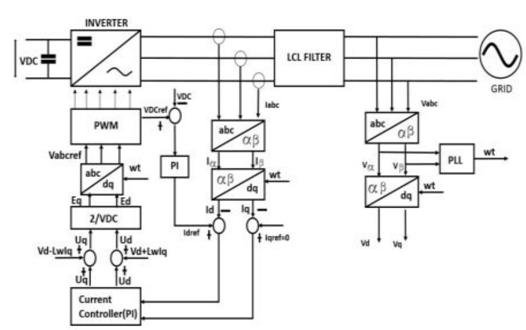
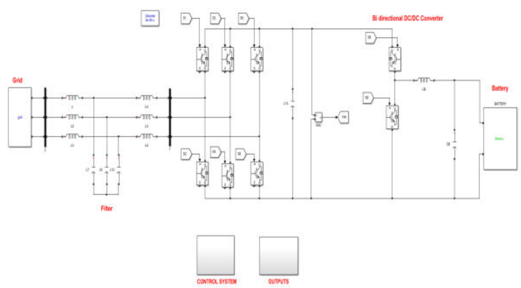


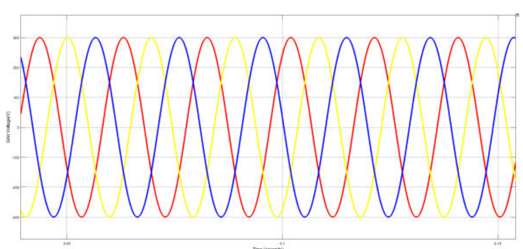
Fig.6 Block diagram of Active rectifier controller

4. SIMULATION MODEL AND RESULTS

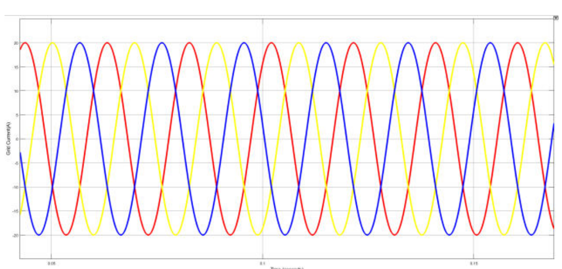
1. THREE PHASE GRID TO VEHICLE



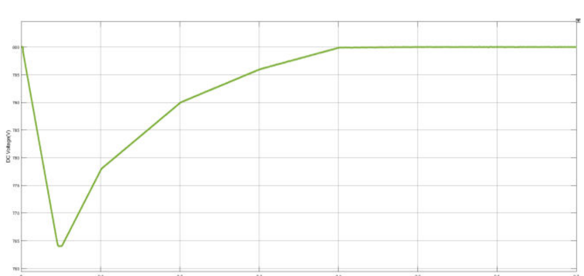
A. Grid-to-vehicle system:



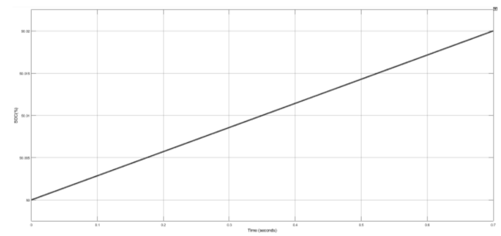
VG abc voltage of grid three phase in G2V mode.



IG abc (Current of three phase in G2V Mode)

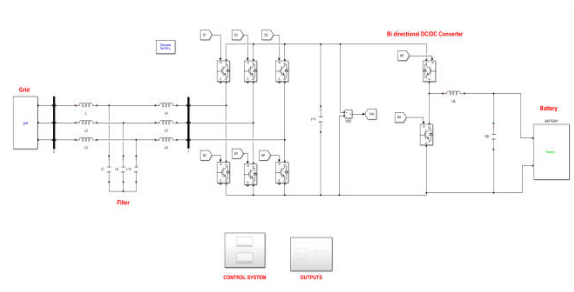


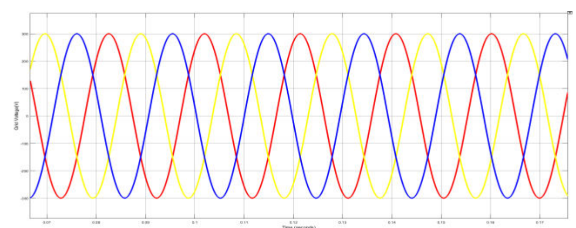
Vdc in G2V Mode



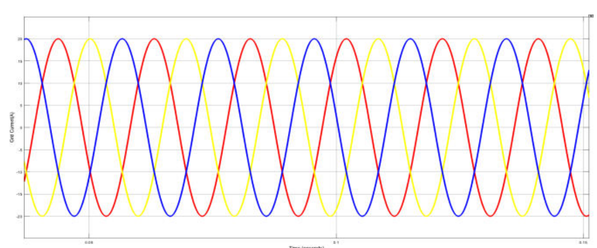
State of charge of the battery(SOC).

B. Vehicle-to-grid system:

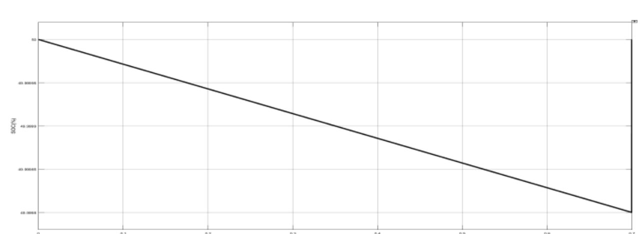




VG abc(voltage of three phase in V2G Mode)



IG abc (current of three phase in V2G Mode)



DC bus voltage in v2g mode

5. CONCLUSION

The ability for electricity to flow both into and out of electric vehicles (EVs) has only recently progressed to the point where more people can use it. The technology's promise will increase as it develops. Going bidirectional has a number of benefits, including the ability to increase revenue by reselling energy to the grid and achieve energy independence. This study describes the creation of an OBC for (EVs) that can function in (G2V) and (V2G) & V2L modes, which are key tools aimed at the future of smart grids. The presented battery charger's topologies are verified using the MATLAB program. Two types of topologies— two-stage and singlestage—are separated. Comparisons are made between both the types of ac-dc bi-directional converter in terms of component count, values of elements present in both the converter. The former converter having fewer devices, and smaller values for parts like the output inductor and High frequency inductor. LLC resonant DC/DC converter has a various benefit from being isolated, highly efficient, having a high power density, being small, having a wide output voltage range, having excellent dynamic performance, and being inexpensive.

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