Power Management in a Micro-grid Using Electric Vehicle

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Abstract— The batteries in electric vehicles (EVs) may play an important role in storing potential energy. They can return excess energy back to the grid. In this way, electric vehicle batteries help in power management. To bring this vision into the picture, the necessary framework and control strategy must be designed. This study presents a framework for setting up a vehicle to grid and grid to vehicle system employing fast charging of electric vehicles. A DC test system with a fast- charging platform for interfacing electric vehicles is designed. V2G-G2V power transfer is verified through simulation. The results of the tests reveal that EV batteries, operating in G2V-V2G modes, can actively regulate power in the micro-grid.
Keywords—Electrical Vehicle, Micro-grid, power management

1.INTRODUCTION

When plugged in for charging, EV cells can probably be used as efficient storage gadgets in micro-grids. Electric vehicles can help manage the potential of micro-grids by storing surplus power (G2V) and returning to the grid when needed (Vehicle to Grid). Vehicle to Grid in general faces a few challenges,requiring a large number of EVs, and are difficult to implement quickly [1]. A V2G system in a micro-grid can be created simply. For electric vehicles, the association of automotive planners has triplex charging levels. The automobile's built-in charger is connected to a socket that plugs into a typical household (120 V) outlet for first-level charging. That remains the sluggish charging method, which is suitable only for those who navigate less than sixty km per day and have the rest of thetime to charge. The level two method employs a specific electrical cabinet supply accessory to provide power at domestic voltage and up to 30 A at the apartment or a clientele station. Because of the speedy power deportation necessary while electrical automobiles are used for energy accumulation, direct current rapid charging is preferable to gadgets in a micro-grid. The direct current bus may also be connected to include sustainable genesis into the setup.V2G is the technology consisting of energy in two directions, either from the vehicle to the grid when the energy in the battery is high, or to the vehicle when the energy stored in the battery is low.

The automobile to grid ideas have been used in the generic power grid for utilities such as crown shaving, valley filling, coordination, and spinning reserves in the majority of prior studies [2]. The use of V2G in a micro-grid to maintain power output from irregular sustainable power sources is currently in the early stages of development.

In addition, major efforts described in [3] use first- and second-level ac charging for V2G technology. The power specification of the in-built charger is what limits these ac charging results. One more issue is that the distribution infrastructure was not built to handle two-way energy drift. In this situation, investigation is needed to lay out high-tech applicable charging station terminal engineering that will enable vehicles to grid technical knowledge in micro-grids. In a micro-grid facility, this task presents a direct current rapid charging terminal framework along with vehicle-to-grid functionality. A photovoltaic cell (PV) design is integrated into the micro-grid using the same DC bus that is used to interface EVs. Through off-board chargers, the recommended planning enables large-power two-way charging for EVs. Simulations in MATLAB/Simulink are operated to assess the validity of the proposed layout in both V2G and G2V forms of procedure.

II. CONFIGURATION OF A DC RAPID CHARGING PLATFORM FOR V2G

Figure 1 [4] shows the configuration of a DC rapid charging station for enforcing the V2G-G2V frame in a micro-grid. Through outboard dishes, electrical cart cells are joined to the DC perpendicular lines of power force(motorcars), as shown in fig. 1[4].

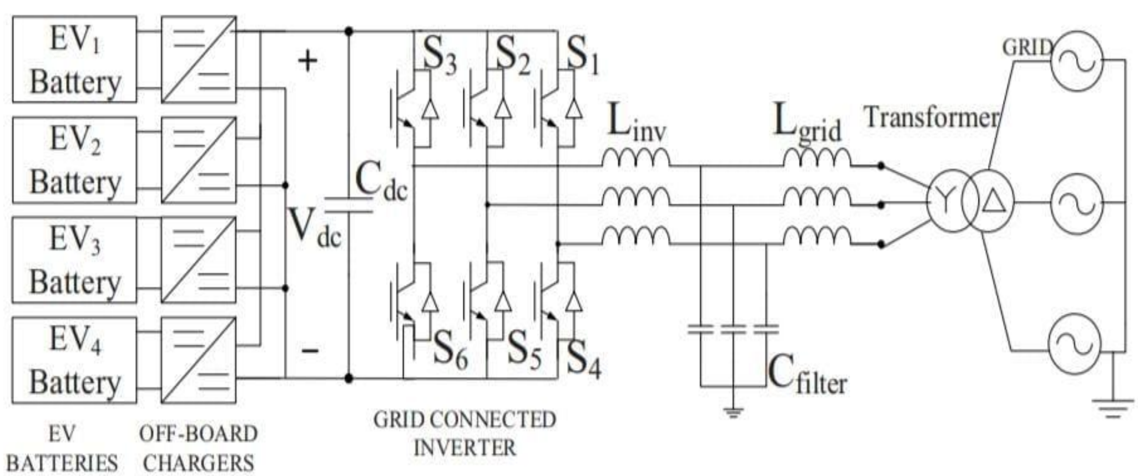

Fig 1 EV Charging platform for dc charging

An LCL sludge and a voltage controller connect the dc machine to the effective grid through a grid-
connected inverter. The charging station's most critical factors are listed below. The electricity in the batteries of electrical vehicles is transferred to the grid to compensate for the supply–demand balance in the electricity grid.[7]

A. Battery Charger Configuration: -Instant charging instantaneous containers are installed and installed on EVSE. An important feature of the V2G built-in container is the DC-DC dual-engine. It serves as a binding unit between the electric car's battery system and the distribution grid. Figure 2 shows the engine setup. It is made up of two IGBT/MOSFET switches that are coordinated by completely compatible signal times.

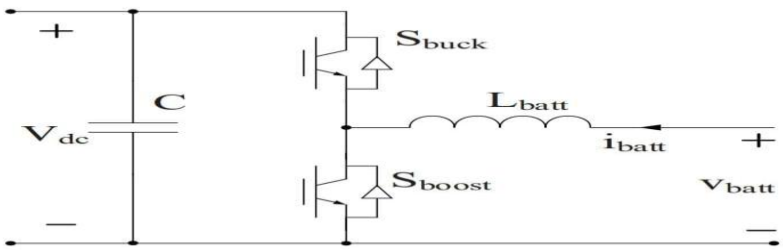

Fig 2. Battery charger configuration

B.Buck (charging) way of operation-The motor functions as a buck motor when the upper switch (Sbuck) is actuated, decreasing the input voltage (Vac) to the battery charging voltage (Vbatt). Current overflows to the battery via the switch and inductor when the switch is turned on. This is where the power flows from the grid to the vehicle during charging (G2V). When the key is put off, the current returns to the lower switch's inductor and diode, completing the unrestricted path. However, the battery voltage is calculated as

V batt = D * Vac if D is the advanced switch's duty cycle.

Parameter	Value	Parameter	Value
Rated capacity	250KVA	EV rated power	40kW
Vbatt	500V	Battery Capacity	48Ah
Cdc	850mF	Cfilter	133 mF
Linv	0.25mH	Lgrid	0.25mH

Table I Charging station parameters

C.Boost (discharging) mode of operation -The motor operates as a boost motor when the lower switch (Sboost) is turned on, increasing the battery voltage (Vbatt) to the DC machine voltage (Vdc). Just as the key is in the on position, current overflows via the inductor and is completed by the anti-parallel diode of the top switch and the capacitor. In this situation, the final power drift is from the vehicle to the grid (V2G), and the battery is in the discharge state. In this situation, the battery is in the discharge state and the net power inflow is from the vehicle to the grid (V2G). The capacitor is adequate for maintaining a constant DC voltage, and the boost state turnout voltage is acceptable.

Vdc = Vbatt/ 1-D' where D' = Duty cycle of the lower switch

D. LCL Filter and Grid-Connected Inverter -The grid connected inverter (GCI) transforms dc machine voltage to 3-phase ac voltage and permits current to propagate in both directions through the anti-parallel diodes of the switches in respective branches (Fig. 1). For harmonious diminishment and to get a true sinusoidal voltage and current, LCL sludge is attached to the inverter's output. The LCL sludge parameters were determined using a design approach modified by a pattern [4]

III. CONTROL SYSTEM

Off Board charger control: -Off-board charge/discharge monitoring of the cell's column circuit is controlled using constant current control mode [5] using a PI controller as shown in Fig. 3. To adjust the direction of the current signal and select between charge and discharge operating modes, the controller compares the quoted battery current with 0. The reference current is compared with the intentional current and the error is passed through the PI controller to develop the Sbuck/Sboost off set. While charging, Sboost will turn off, and during discharge, Sbuck will turn off.

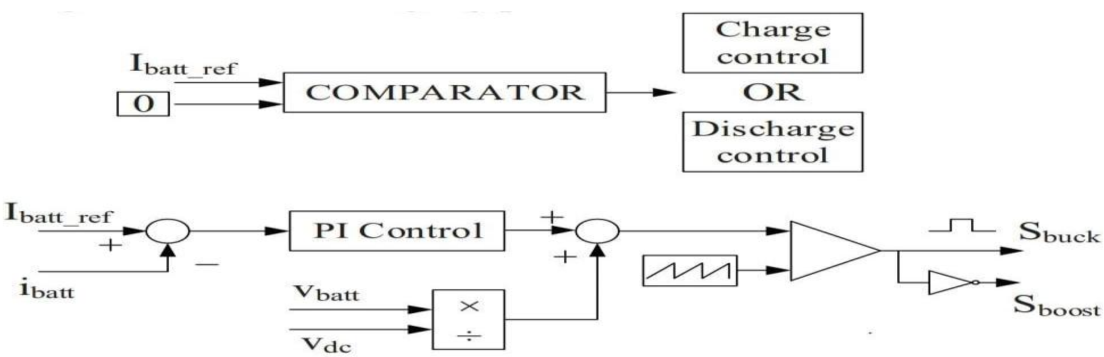

Fig 3. Fixed current control circuit for battery charger

Inverter Control: - For the inverter controller, a coincident reference cascading control system is presented. Figure 4 [4] shows a nested circle of controls, which are the specified vector controllers. A pair of external voltage control circuits and two internal current control circuits form the control structure. The active alternating current is protected by the d-axis internal circuit, while the machine's voltage is controlled by the external circuit. The current in the q axis regulates the reactive current, and the current in the q axis regulates the amplitude of the AC voltage. To increase excitation during transients, the terms decoupling dq - oL and linear charge voltage signal have been introduced.

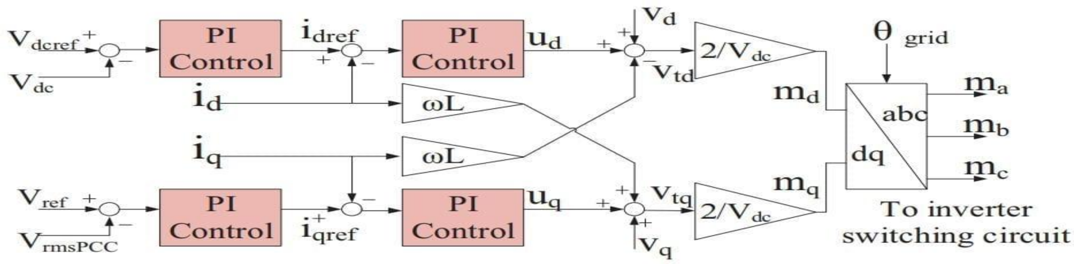

Fig 4. Inverter control system

IV. EXPERIMENTAL SETUP

Figure 5 depicts the micro-grid trial setup with the DC rapid-fire charging platform. The system's generation sources include a 100-kW wind turbine (WT) and a 50 kW photovoltaic solar generator. The electric vehicle battery storehouse system is made up of four EVbattery cells that are joined to the charging station's1.5 kV dc bus through in-erected dishes. A boost converter with a maximum power point tracker (MPPT) is also used to link the solar PV to this DC machine. The identical 25 kV distribution circuit and 120 kV transmission network form the kilometric network. At the common coupling point, the induction generator is powered twice by a wind turbine connected to the micro grid (PCC).

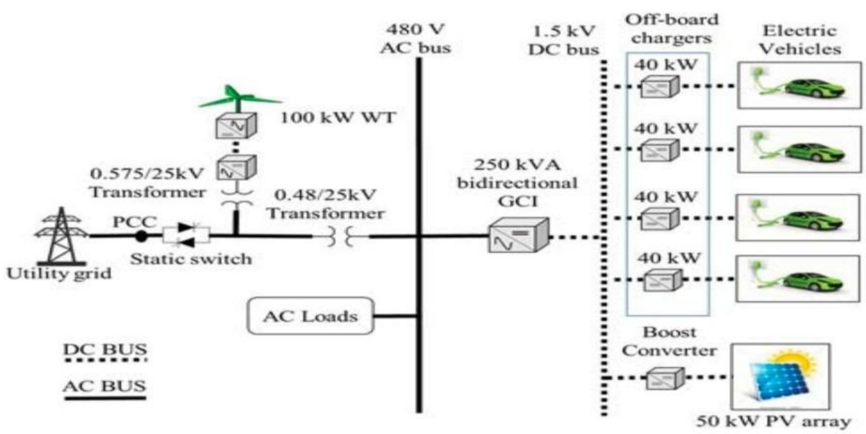

Fig 5- Micro -gridsystem configuration

Induction generators powered by wind turbines are connected to the microgrid at the point of common connection (PCC). Blenders are used to upgrade the voltage and link the AC system to a particular grid.While several studies have shown that EVs can accurately follow system regulation dispatch signals [6]

V. SIMULATION RESULTS.

The process for designing charging stations was deduced from (4), and the collected specification values are listed in the postscript. The wind turbine is set to an incline speed, producing a maximum bargain power of one hundred kilowatts. The solar PV system is tested under normal trial circumstances (1000W/ m^2 irradiance and 25 °C temperature) and produces a peak power output of 50 kW. The 480 V ac machine is fed by a 150 KW resistor. For consistency purpose, the indicator line reacts when GCI is set to none.The first state of charge (SOC) of the electric vehicle battery is set to 50. V2G and G2V power switching is accomplished by operating the batteries of EV1 and EV2 (Figure 1) when steady-state conditions are suitable. Table I represents the current setpoints for the EV1 and EV2 batteries' battery charging circuits, with the results presented in the following images

Time range (s)	0 to 1	1 to 4	4 to 6
Current set-point to EV_1 battery (A)	0	+80	0
Current set-point to EV_2 batter y(A)	0	0	-40

Table II - EV Batteries current set points

Figure 6 and 7 show the battery specifications while the EV1 is in V2G state and when the EV is in V2Gstate, respectively.

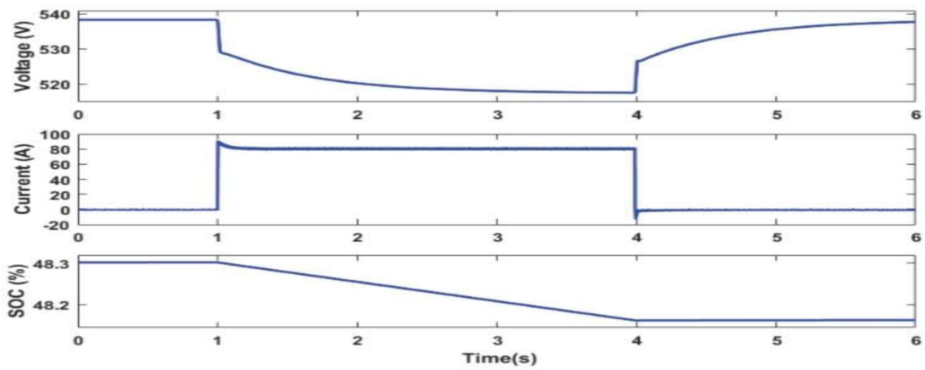

Fig 6 - Voltage, current and SOC of EV1 battery in V2G state

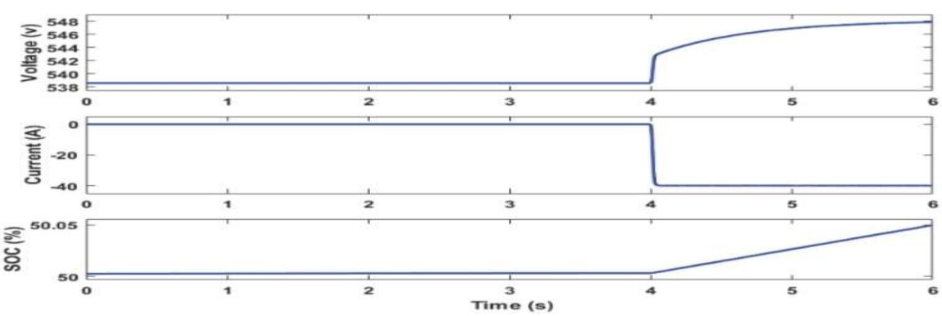

Fig 7. Voltage,Current and SOC of EV2 battery during V2G state

Figure 8 depicts the system's active power profile for several factors. The grid's power is adjusted to meet the EVs' power. From 1-4 s, the grid electricity has a negative opposition, indicating that the vehicle is supplying power to the grid. The shift in the sign of grid power at 4 s indicates that the grid is furnishing power to charge the vehicle battery. The V2G-G2V is demonstrated in this illustration. Likewise, the final power at the power control centre is zero, indicating that the system's power balance is ideal.

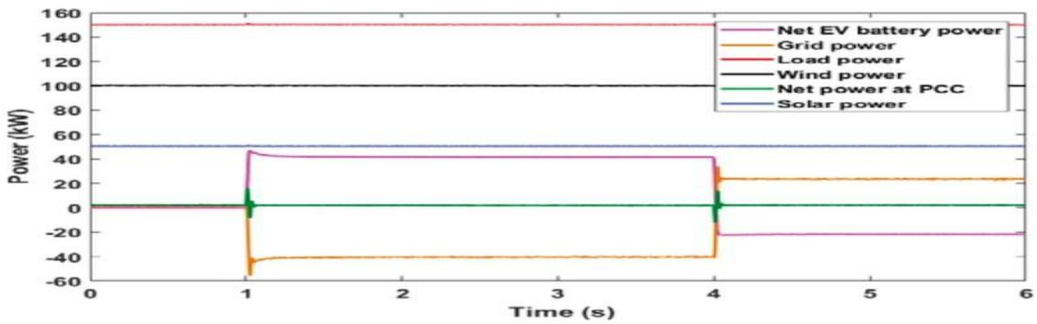

Fig 8. True power sketch of distinct units in the setup

The outer potential control loop of the inverter controller coordinates the dc bus potential near to 1500
V, as shown in Figure 9.

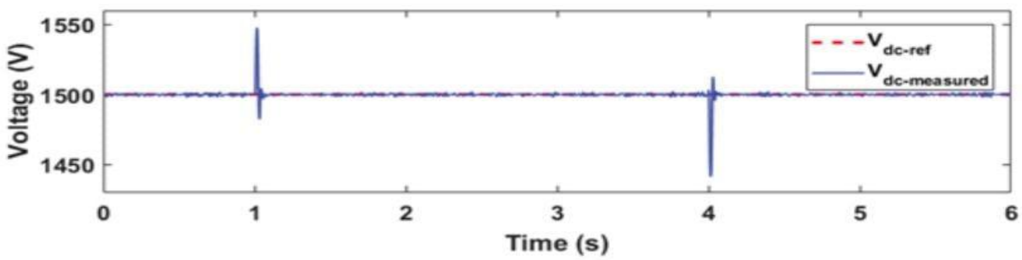

Fig 9.Variation in the dc bus voltage

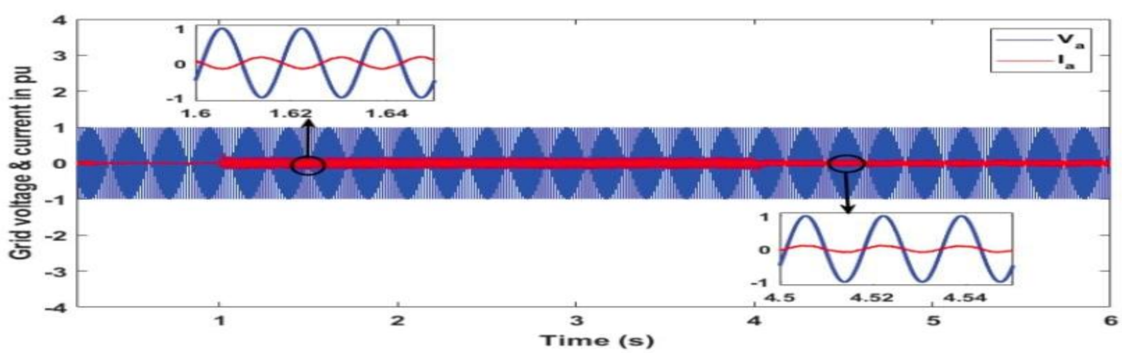

Fig 10. Grid voltage and grid injected current during V2G –G2V modes

Fig.10 illustrates the grid potential and current at Power Control Center. During G2V state, the current as well as voltage are synchronized, whereas during V2G modes, voltage and current are 180° out of phase, indicating reverse power flow[8].

VI. CONCLUSIONS

This study introduced the base and blueprint of the V2G set up on a small grid using the built-in DC fire charging technology. A DC charging platform with in-built dishes and a grid-connected inverter connects EVs to the microgrid. Power transfers between EVs and the grid are possible due to the control system created for this definition of power. The simulation issues display an invariant electrical power exchange between the EVs and the grid, and the aspect of grid-fitted current from the EVs complies with the compatible criteria. The EVs meet the compatible criteria for DC grid withstand voltage and monitoring grid fitted current. In terms of DC grid withstand voltage and monitoring the altered true power mentioned, the advanced regulator performs well. The proposed V2G scheme can be employed for several uses, such as reactive power operation and frequency regulation, and it takes into account the true power collaboration features of the microgrid.

References

[1] C. Shumei, L. Xiaofei, T. Dewen, Z. Qianfan, and S. Liwei, “The construction and simulation of V2G system in micro-grid,” in Proceedings of the International Conference on Electrical Machines and Systems, ICEMS 2011, 2011, pp. 1-4
[2] S. Han, S. Han, and K. Sezaki, “Development of an optimal vehicle-to grid aggregator for frequency regulation,” IEEE Trans. Smart Grid, vol. 1, no. 1, pp. 65–72, 2010.
[3] M. C. Kisacikoglu, M. Kesler, and L. M. Tolbert, “Single-phase on-board bidirectional PEV charger for V2G reactive power operation,” IEEE Trans. Smart Grid, vol. 6, no. 2, pp. 767–775, 2015
[4] A. Arancibia and K. Strunz, “Modeling of an electric vehicle charging station for fast DC charging,” in Proceedings of the IEEE International Electric Vehicle Conference (IEVC), 2012, pp. 1-6.
[5]. K. M. Tan, V. K. Ramachandaramurthy, and J. Y. Yong, “Bidirectional battery charger for electric vehicle,” in 2014 IEEE Innovative Smart Grid Technologies - Asia, ISGT ASIA 2014, 2014, pp. 406–411.
[6] E. Sortomme, M. A. El-Sharkawi, “Optimal Combined Bidding of Vehicle-to-Grid Ancillary Services,” IEEE Trans. SmartGrid, vol.3, no. 1, pp. 70-79, Mar. 2012.
[7]Berthold F, Ravey A, BlunierB, Bouquain D, WilliamsonS, “Design and Development of a Smart Control Strategy for Plug-In Hybrid Vehicles Including Vehicle-to-Home Functionality” IEEE Trans2015, 168–177.
[8]Kumar, S. (2022). A quest for sustainium (sustainability Premium): review of sustainable bonds. Academy of Accounting and Financial Studies Journal, Vol. 26, no.2, pp. 1-18
[9]Allugunti V.R (2022). A machine learning model for skin disease classification using convolution neural network. International Journal of Computing, Programming and Database Management 3(1), 141-147
[10]Pinto J.G.,MonteiroV, GonçalvesH, ExpostoB,PedrosaD, CoutoC,Afonso J.L, “Bidirectional battery charger with Grid-to-Vehicle, Vehicle-to-Grid and Vehicle-to-Home technologies” In Proceedings of the IECON 2013-39th Annual Conference of the IEEE Industrial Electronics Society, Vienna, Austria, 10–13 November 2013; pp. 5934–5936.