Advanced V2G and G2V Solutions for Microgrids with DC Fast Charging Architecture

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Abstract - *The batteries of Electric Vehicles act as an energy storage device in microgrids. When there is an excessive amount of energy, they store it (G2V, Grid to Vehicle), and during the peak when there is an energy demand, they give it back to the grid (V2G, Vehicle to Grid). For this to work, a well-developed infrastructure and management mechanism must be set up. This paper introduces a Framework for creating a V2G and G2V system using level-3 fast charging for EVs in a microgrid. A test system for the micro-grid is built with a Charging station to connect the vehicles. The power flow in V2G and G2V is estimated by the simulations. The results show that EV batteries can actively control power in the microgrid using these modes. The charging station is designed to keep the grid current clean with minimal distortion, and the controller ensures stable DC bus voltage performance.*

***Key Words*: Grid connected inverter, Micro-grid, Vehicle-to-grid, Off-board charger, DC fast charging, Electric vehicle**

1.INTRODUCTION

Electric vehicles play an important role in maintaining a clean, sustainable environment, as they are not dependent on fossil fuels. As their population rose, so did their vehicle numbers. Hence, energy demand should be balanced with supply. Widespread adaptation of electric vehicles. To these rising demands, DC-fast charging was presented as a solution. AC power may be stored in high-level batteries and utilized for propelling the vehicle.

Simulation packages allow engineers to study power flow, stability of the system, control measures, and the effect of high-level penetration of EVs within the grid. Modelling charge and discharge (G2V/V2G) allows for the capability of designers to study system performance under various operating conditions, as well as identify weak points in the system and identify viable solutions.

2.Block Diagram

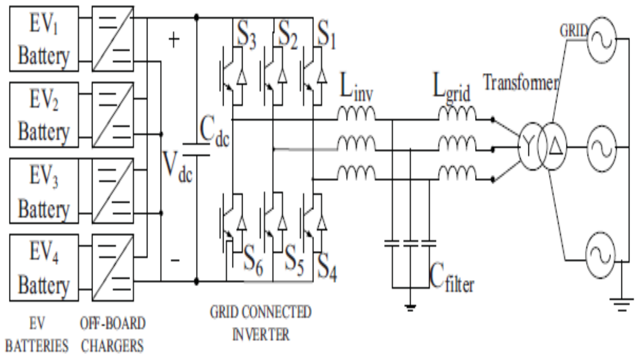

Fig.2 Block Diagram of DCFC Charging Station

I. Configuration of V2G direct current fast charging station:

A. Battery Charger topology

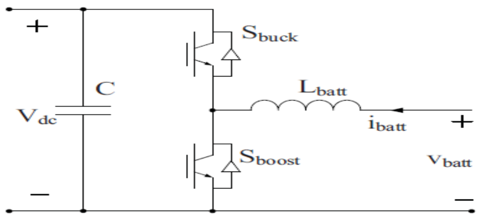

Fig.2.1 Battery Charger Configuration

The chargers are integrated in an EVSE and are off-board for DC rapid charging. The off-board charger system has as a core component a DC-DC bidirectional converter, which can support V2G. Physical interface between the distribution grid (DC) and EV battery system. Fig.2.1 shows the converter arrangement. Converter arrangement contains two IGBT/MOSFET switches, with the complementary(control) signals applied to both switches

B. LCL filter and inverter connected to grid

By enabling reverse current flowing as well as the extension of the DC bus voltage of DC to a three-phase AC voltage

(Fig.1), the grid-connected inverter (GCI) makes utilization of the anti-parallel diode's switches from each leg possible. The LCL filter is connected across the terminal of the inverter with the objective of reducing the harmonics and producing pure sinusoidal current and voltage.

II. CONTROL SYSTEM

A. Off-board charging control

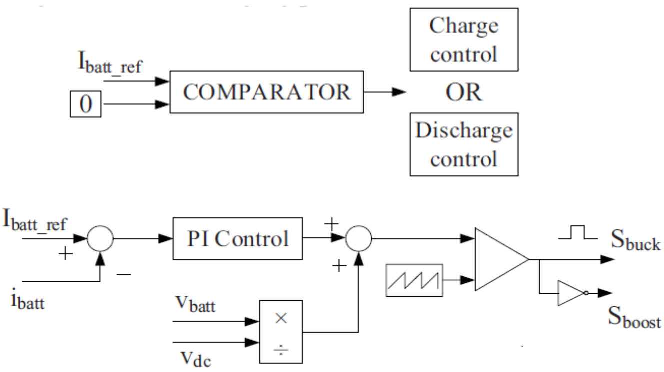

Fig.2. 2 Constant Current Control (Battery charger)

Fig. 1.2, PI control scheme is employed for control charging & discharging in the (constant current control) method for the battery charger circuit. Initially, the controller verifies the current polarity signal to identify which mode of operation (charging or discharging) will be adhered to by comparing the reference battery current with zero. After the mode selection, pulses of Sbuck/Sboost will be generated by contrasting the reference current with the measured current. An error will be corrected through the PI controller. During charging and draining operations, control over Sbuck will be disabled.

B. Control system of inverter

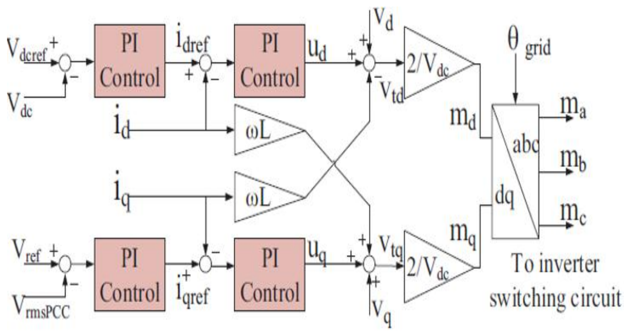

Fig.2.3 Control System of Inverter

• On the d-axis, the outer loop controls DC bus voltage, and the inner loop controls active (AC) current.

• On the q-axis, the outer loop controls AC voltage magnitude through regulating reactive current, once again to be controlled by the q-axis (inner current loop)

3. Circuit diagram

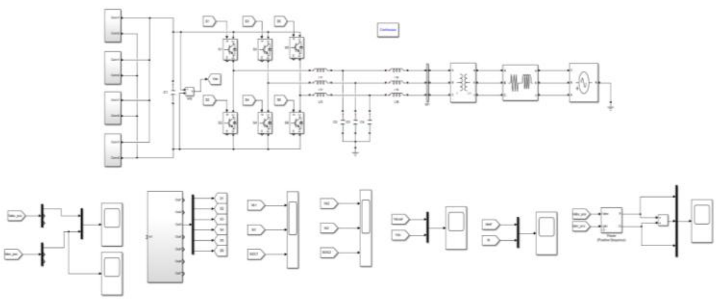

Fig.3 Circuit Diagram of EV DCFC Station

The circuit diagram that follows illustrates the configuration of different components in MATLAB Simulink using the Simulink library. The overall circuit diagram for a charging station utilizing DC charging for vehicle-to-grid operation is shown.

4.Results

The specifications of the charging station, along with the specific numbers, can be found in the Appendix. The wind turbine operates at optimum speed, generating 100 kW (or the maximum available power) in ideal conditions. PV system test conditions (1000W/m2 sunlight and 25 °C), producing the highest power output of 50 kW. A 150-kW resistive electrical load connected to a 480 V ac supply. The reactive current target set for GCI is zero; thus, the power factor is one. In the simulation, both EV batteries are half charged and have a SOC of 50%. Once everything stabilizes, both the EV1 and EV2 batteries will start to transfer power back and forth between the vehicles and the grid. Table I shows the current targets provided to battery chargers in EV1 and EV2, and the results observed in the following figures. Fig. 4.1 and Fig. 3.2 provide information about the batteries while EV1 is sending V2G, and EV2 is receiving G2V.

Table 4.1 Current, EV Batteries

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

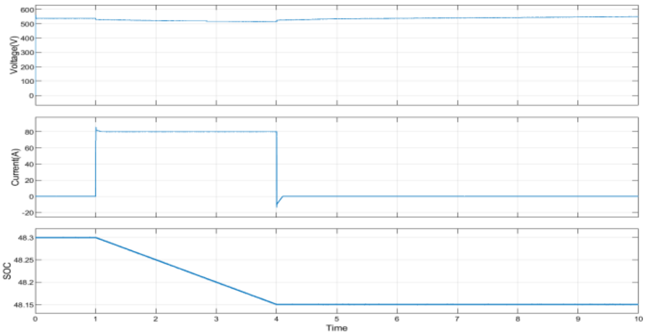

Fig. 4.1 Voltage, current & SOC of EV1 Battery (V2G)

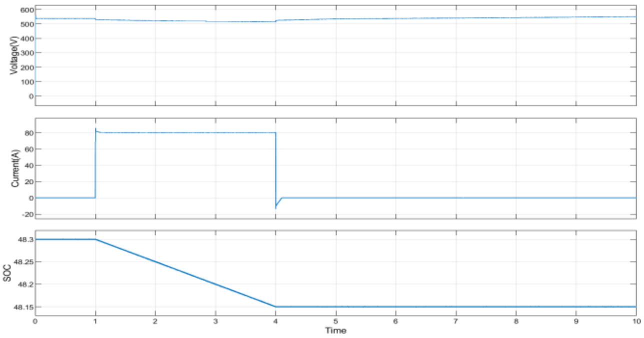

Fig. 4.2 Voltage, Current & SOC of EV2 Battery (G2V)

Grid power adapts to the electricity provided by EVs. Fig. 4.3, active power generation by different system components is presented. A negative sign of grid power (1 to 4) means the grid is receiving power from the car. The change of the grid power sign at 4 s suggests that the grid is now providing the electricity to charge the car battery; thus, demonstrating the operation of the V2G-G2V system. The zero net power of PCC reflects an ideal power balance.

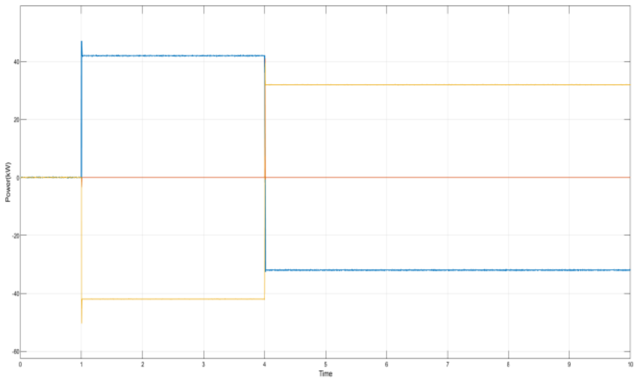

Fig. 4.3 Active Power Profile of Various Components in the System

Fig. 4.4, inner current loop of control is then performed by measuring the modified d-axis reference current.

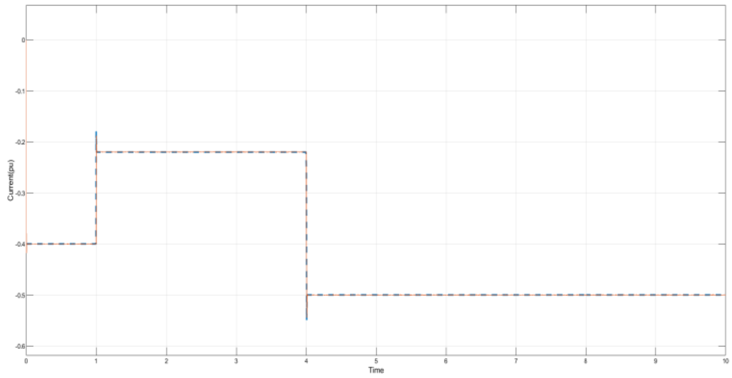

Fig. 4.4 Tracking of Reference Current (by Inverter Controller)

Fig. 4.5 shows current & voltage at PCC. reverse power is shown by both voltage & current being in phase for G2V operation & 180 degrees out phase for the V2G operation.

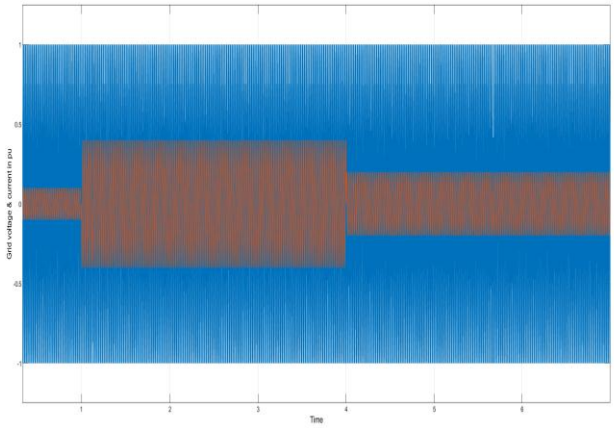

Fig. 4.5 Grid Voltage & Injected Grid Current (V2G&G2V)

5.Conclusion

The paper discusses the development and planning system for EVs to both provide power to, and draw power from, a local area power system (LAPS). The LAPS operates using a unique fast-charging method. A fast-charging station employing external charging ports and an inverter connected to the main electrical grid enables connection of EVs within the overall network. In use, the developed system controls the connection, allowing power to flow bidirectionally between electric vehicles and the electrical network. Results from the evaluations demonstrate that flow is smooth in both directions, and power exported from the electric vehicle system to the grid meets necessary standards. The controller that was developed operates effectively in the face of changing conditions - maintaining voltage stability and following the desired output of power changes. This paper considers power management within the local accounting grid, but the proposed system could be deployed to support other types of operation as well, such as reactive power and frequency management. As it relates to future improvements, it is suggested to create a master controller to dispatch commands to the controllers connected to the electric vehicle chargers.

6.Refrences

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