International Journal of Electronic and Electrical Engineering.
ISSN 0974-2174 Volume 16, Number 1 (2023), pp. 25-33

https://dx.doi.org/10.37624/IJEEE/16.1.2023.25-33

Implementation of V2G and G2V Technology in Micro Grid using MATLAB Simulink

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Abstract

Electric Vehicle (EV) Batteries can be used as potential energy storage devices in Micro-Grid. They can help in Micro-grid energy management by storing energy when there is Surplus (Grid to Vehicle, G2V) and supplying energy back to the grid (Vehicle to Grid, V2G) when there is demand for it. Architecture for implementation aV2G-G2V system in a micro grid using level- 3 fast charging, off-board chargers, and advanced power electronics components such as grid interfacing inverter, LCL filter, and step-up transformer is described in this project. The simulation results will provide insight into the effectiveness of this approach, with active power regulation in the micro-grid by EV batteries through G2V-V2G modes of operation. The charging station design ensures minimal harmonic distortion of grid injected current and the controller gives good dynamic performance in terms of dc bus voltage stability. This research could have significant implications for sustain able and efficient energy systems that incorporate renewable energy source and electric vehicles.

Keywords: EV Batteries, OFF board charges, LCL filters, Step Up transformer, grid interfacing inverter, Distribution system micro grid.

INTRODUCTION

The world is moving towards renewable energy sources and electric vehicles, and micro grids are becoming increasingly popular as a means of integrating these technologies [1]. The Implementation of Grid-to-Vehicle (G2V) and Vehicle-to-Grid (V2G) technology in micro grids using Level 3 DC fast charging stations, off-board chargers, grid interfacing inverter, LCL filter, step-up transformer, and distribution system or micro grid is a promising approach to achieving a sustainable and efficient energy system [1,3,5]. This project aims to investigate the impact of G2V and V2G technology on the performance and stability of micro grids with advanced charging technologies and power electronics components [2]. By simulating the micro grid using MATLAB Simulation, the study will provide insight into the effectiveness of G2V and V2G technology in micro grids with Level3 DC fast charging stations and off-board chargers [4]. The aim of this document is to study the implementation of Grid to Vehicle (G2V) and Vehicle to Grid (V2G) technology in micro grids using DC fast charging stations, and to study the regulation of active power and minimization of frequency deviation. To achieve efficient micro grid energy management by storing energy during surplus and supplying energy back to the grid during peak demand. The use of DC fast charging stations will reduce charging time, and G2V and batteries as a source of energy [3].

LITERATURE REVIEW

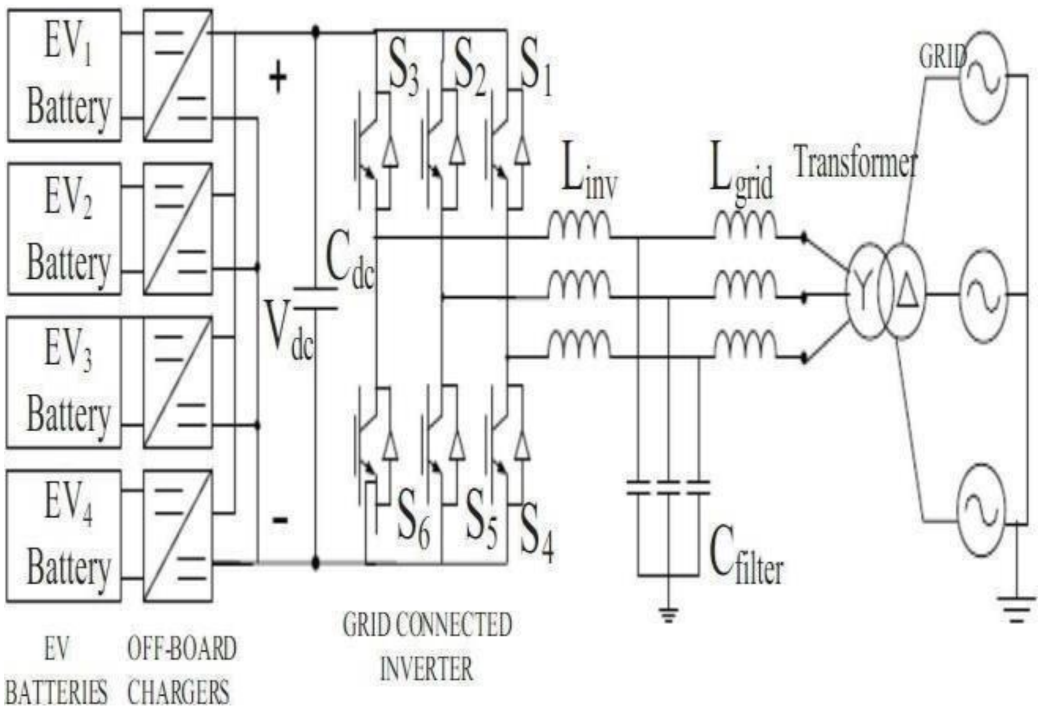

Figure 1: Block diagram

The increasing demand for electric vehicles has led to a global sale of 6.6 million in 2021, which has created a need for micro-grids to integrate large scale renewable and

EVs into the power system. The use of DC energy transfer in micro grids for vehicle-to-grid and grid-to-vehicle technology poses power quality challenges, but simulations using PI and fuzzy controllers show that the latter is more effective in minimizing total harmonic and improving waveform quality leading to high system efficiency for consumers [4].

This paper describes Vehicle to Grid (V2G) and Grid to Vehicle (G2V) technology using MATLAB Simulation. The Electric Vehicle (EV) batteries can be used as a potential energy storage device in micro-grid, which can help in micro grid energy management [5]. When energy is surplus, the energy is transferred from grid to vehicle and when there is demand for energy, it is transferred from vehicle to grid. For V2G the voltage is stepped- up using Off-Board Charger (Which consists of Buck and Boost converters) and then voltage is then given to grid connected inverter, which converts into 3 phase voltage. LCL filter is used to reduce Total Harmonic Distortion (THD) by reducing ripples and Transformer steps up the voltage and supplies it to the grid. For G2V, voltage is stepped down using transformer, LCL filter reduces the distortion and supplies it to inverter which is bidirectional for converting 3-phase AC to DC and supplies voltage to off-board charger where buck converter is used to step down voltage and Then Stepped down voltage is supplied to the batteries of Electric Vehicle. It utilizes Level-3 charging, also known as DC Fast charging which nearly takes 20-30 minutes to charge at 200/450 V and power up to 90 KW [6,7].

METHODOLOGY

The Micro grid is a small network of electricity which is distributed to the consumers on need. Electric vehicles utilize the energy from the grid for the operation. This project describes the concept of not only Grid to Vehicle but also Vehicle to Grid, when vehicle is in steady condition and not in use, by implementing level 3 or fast charge architecture. The operation of Grid to Vehicle and Vehicle to Grid is observed and parameters such as voltage, current, state of charge (SOC), active power profile and determined.

Flowchart describes the operation of the project. In order to design the Vehicle to Grid and Grid to Vehicle Technology, it is necessary to know the requirements of the capacity of the electric vehicle battery and the Micro grid parameters. To start with the flowchart determines the number of Electric vehicle batteries to be connected to the grid. Then it is necessary to determine the capacity of the EV batteries and their charging requirements. Then establish a connection between micro grid and the Electric Vehicles using the inverter and filter interface. The inverter used here is a bidirectional inverter which converts DC to AC and the filter is used to reduce the harmonic and ripple content, thereby providing a pure sinusoidal waveform of voltage and current. By determining the optimal

charging and discharging rates, it is decided to charge the battery or discharge the battery. The shortage of energy implies charge the batteries and excess energy implies discharge of batteries.

In the simulation diagram, purple color block represents electric vehicle battery and Off board charger configuration. Blue color block represents grid integrating inverter, which is bi-directional and off-white color block represents LCL filter, white color block represents 3 phase transformer, and orange color block represents grid. The Inverter control system block, and its output is connected to 6 switches (S1, S2, S3, S4, S5, S6). Scopes are used to determine active power, Voltage, current, SOC during V2G and G2V. The mentioned stop time is 6s.

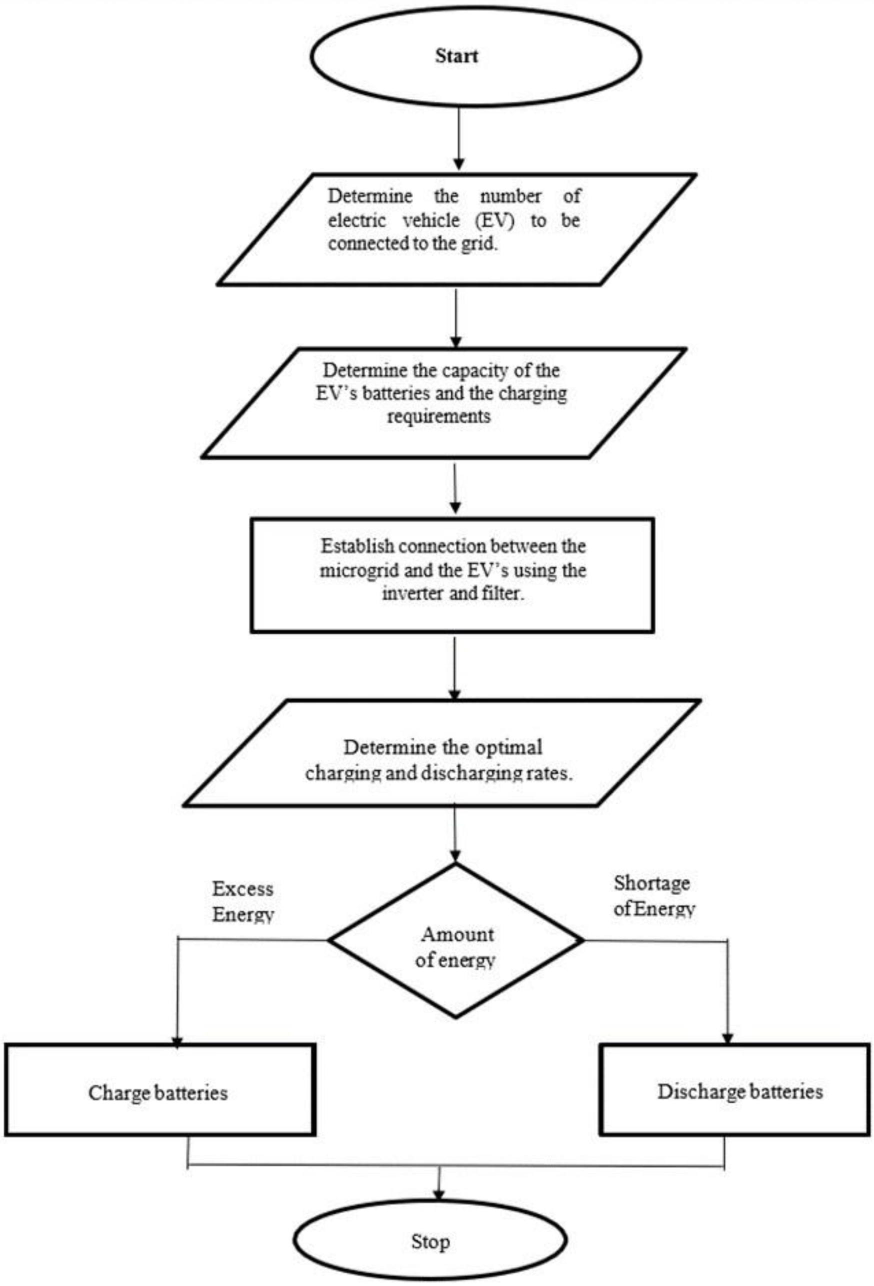

Figure 2: Flow Chart.

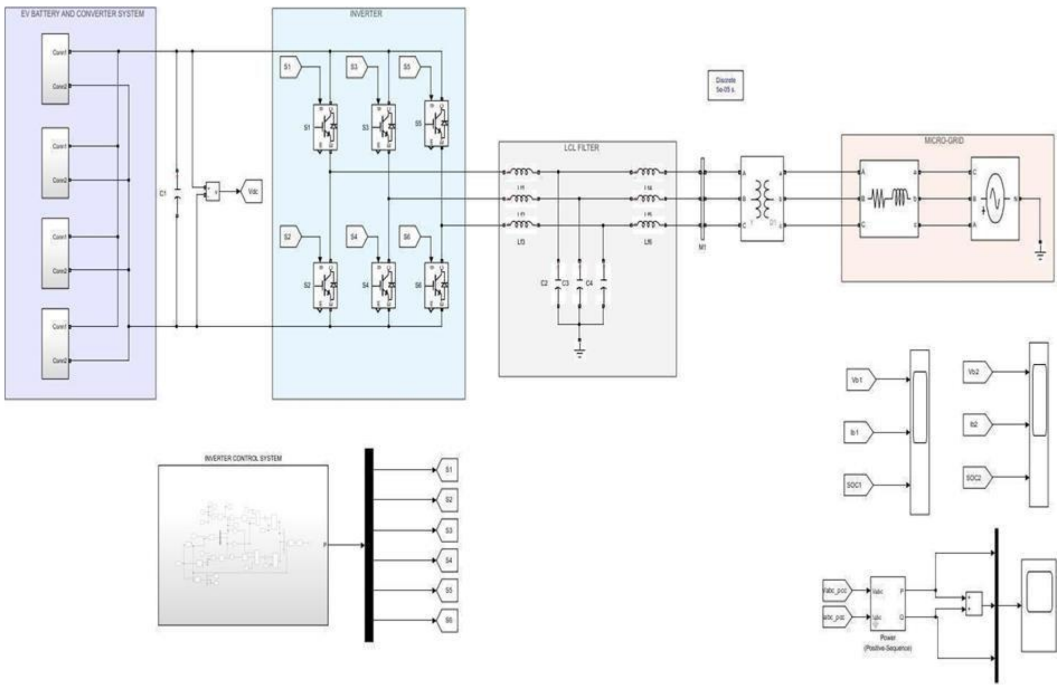

Figure 3: Simulation diagram.

In Battery and charger configuration, two IGBT/Diode as buck and boost converters. The values are taken as capacitance C1: 330e^-9. Inductance L: 1e^-3. IGBT values are Internal Resistance Ron: 1e^-3 ohms, Snubber Resistance Rs: 1e^5 ohms, Snubber Capacitance Cs: inf (F). Battery values are Nominal Voltage: 48V and Rated Capacity: 500AH and Battery type is Lithium – ion battery. For PI controller, values are proportional(p): 0.025 and Integral(I): 0.0896. The control system consists of outer voltage control loops and two inner current control loops. The outer loop in the d-axis is responsible for regulating the DC bus voltage, while the inner loop controls the active AC current. On the other hand, the outer loop in the q-axis ensures the desired AC voltage magnitude by adjusting the reactive current, which is controlled by the inner q-axis current loop. To enhance performance during transients, the system incorporates dq decoupling terms (such as wL) and utilizes feed-forward voltage signals. This controlling mechanism is used to generate triggering pulses of the inverter in the micro grid network.

RESULTS & DISCUSSION

Vehicle to Grid (V2G) Operation: During the V2G operation, the graph depicting voltage, current, and state of charge (SOC) shows a gradual decrease in voltage, an increase in current, and a decrease in the SOC. This indicates that energy is being transferred from the electric vehicle to the grid. The operation occurs between 1-4 seconds, while the system returns to a normal steady-state condition before and after this operation.

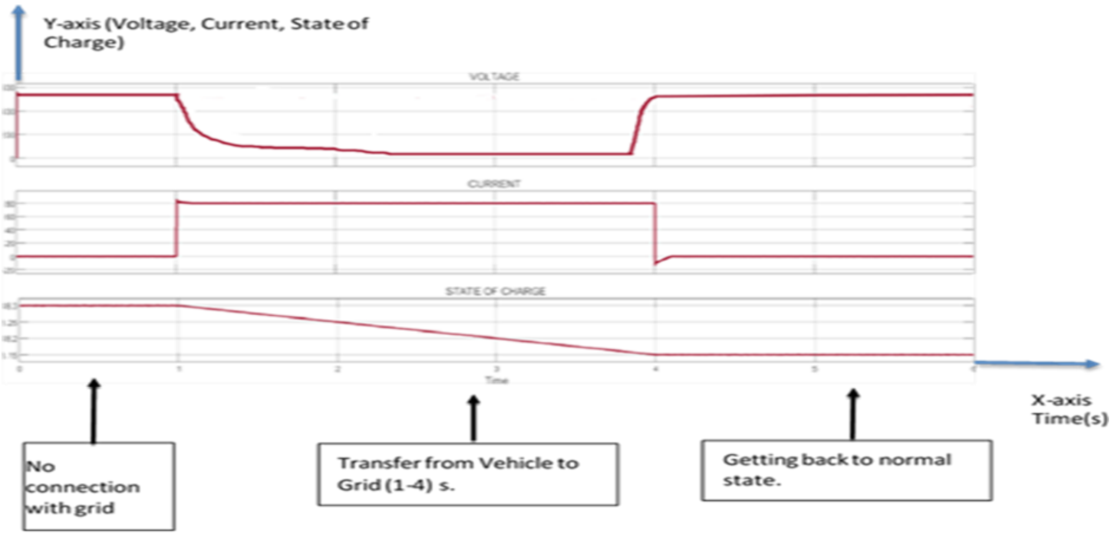

Figure 4: V2G Operation

Grid to Vehicle (G2V) Operation: The G2V operation is represented by the graph showing voltage, current, and SOC. It demonstrates a gradual increase in voltage, a decrease in current, and an increase in the SOC. This indicates that energy is being transferred from the grid to the electric vehicle. The G2V operation takes place between 4-6 seconds, while the system remains in a steady- state condition before and after this operation.

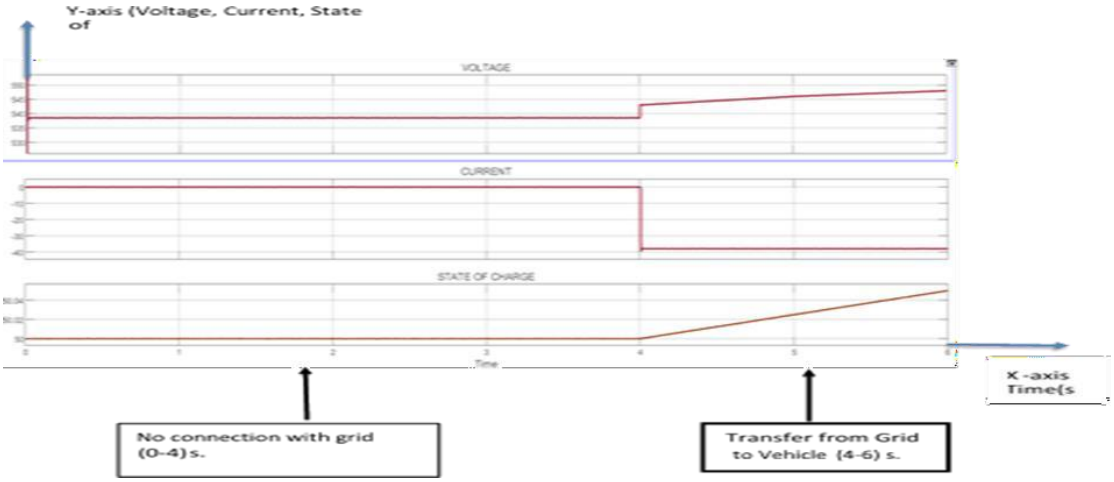

Figure 5: G2V Operation

The Active power profile graph illustrates the power flow during the operation. The blue line represents the net power, the yellow line represents the power supplied by the battery, and the red line represents the power received from the grid. In the steady-state condition (0-1 second), the net power, battery power, and grid power remain constant at zero. During the V2G operation (1-4 seconds), the net power remains constant, but the battery power becomes positive (indicating power being supplied by the battery) while the grid power becomes negative (indicating power being received from the grid). Similarly, during the G2V operation (4-6 seconds), the net power remains constant, but the battery power becomes negative (power being drawn from the battery) while the grid power becomes positive.

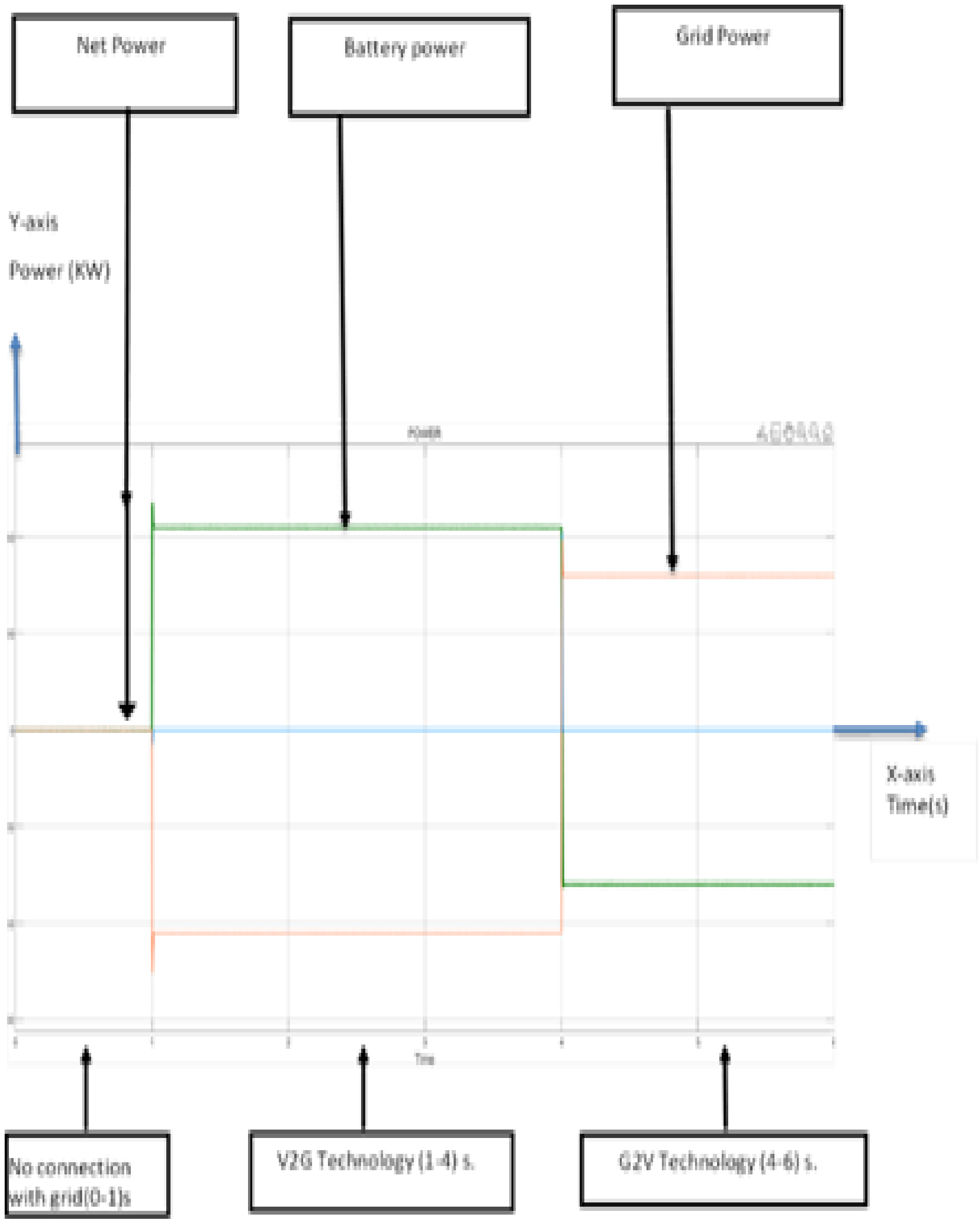

Figure 6: Active Power Profile

These findings and results demonstrate the effectiveness and functionality of the V2G and G2V technology in the micro grid system. The simulations provide valuable insights into the dynamic energy exchange between the electric vehicles and the grid, showcasing the capability to utilize EV batteries as energy storage devices. The analysis of voltage, current, SOC, and power profiles helps in understanding the energy flow patterns and the system's ability to balance energy supply and demand. Further analysis and optimization of the system based on these findings can lead to more efficient and sustainable energy management in micro grid environments.

CONCLUSION

In conclusion, the world's transition towards renewable energy sources and electric vehicles has created a demand for innovative solutions to integrate these technologies into the energy system. Micro grids are emerging as a promising solution, and the implementation of Grid to Vehicle (G2V) and Vehicle to Grid (V2G) technology using Level 3 DC fast charging stations, off-board chargers, and power electronics components can significantly improve the efficiency and sustainability of micro grids. The simulation study conducted using MATLAB Simulink provides valuable insights into the effectiveness of G2V and V2G technology in regulating active power and minimizing frequency deviation. The successful implementation of G2V and V2G technology can lead to a more reliable, resilient, and sustainable energy system that can meet the growing energy demand while reducing greenhouse gas emissions. and sustainability of micro grids. The simulation study conducted using MATLAB Simulink provides valuable insights into the effectiveness of G2V and V2G technology in regulating active power and minimizing frequency deviation. The successful implementation of G2V and V2G technology can lead to a more reliable, resilient, and sustainable energy system that can meet the growing energy demand while reducing greenhouse gas emissions.

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