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Fast Charging Station for Electrical Vehicles Based on DC Microgrid by using Fuzzy Logic Controller

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Abstract*: The rapid adoption of electric vehicles (EVs) has heightened the need for fast charging stations that can meet high-power demands efficiently. Conventional charging methods struggle with long durations and grid instability, especially when charging multiple vehicles simultaneously. This paper presents a fast charging station powered by a DC microgrid integrated with renewable energy sources, particularly solar photovoltaics (PVs), to mitigate the impact on the power grid. A fuzzy logic controller (FLC) is employed to regulate charging process, optimizing energy flow based on battery state-of-charge (SOC) levels. By utilizing a multistep constant current charging algorithm, the proposed system ensures faster charging while maintaining battery health. Simulation results demonstrate significant reductions in grid voltage dips and transformer overheating. A software validates the proposed methodology, highlighting the system's potential for sustainable EV charging infrastructure*

Keywords: solar, boost converter, Electric vehicle, charging station, Inverter, Fuzzy logic controller

I. INTRODUCTION

Electric vehicles (EVs) have become a game-changing solution in the quest to decrease dependence on fossil fuels and address climate change [1]. With increasing global environmental awareness, the adoption of EVs is growing rapidly, driven by their potential to enhance urban air quality, reduce greenhouse gas emissions, and boost energy efficiency [2]. Despite these benefits, the widespread integration of EVs poses a major challenge to existing power grids, particularly in managing the substantial energy demand required for fast charging. Traditional charging systems, such as Level 1 and Level 2 chargers, are too slow to meet the expectations of modern consumers seeking rapid refuelling. Therefore, the development of fast-charging infrastructure is essential to support the smooth transition to EVs, ensuring convenience and efficiency for users [3].

Fast charging stations, especially those operating at high power levels (80–240 kW), can create substantial stress on the power grid [4]. These stations often cause voltage instability, transformer overheating, and increased harmonic distortions, particularly during peak demand periods. Voltage dips and swells during the fast-charging process can affect grid reliability, necessitating advanced solutions that mitigate these impacts [5]. Furthermore, the need to balance fast charging with grid stability has prompted the exploration of innovative charging solutions that can enhance power quality and minimize disruptions to the distribution network. A promising solution to address these challenges is the integration of renewable energy sources (RES) [6], particularly solar PV systems, into the charging infrastructure. DC microgrids offer an effective platform to incorporate renewable energy, enabling efficient energy management between the grid, EVs, and renewable sources. By using a DC microgrid, the dependency on the main power grid is reduced, which minimizes voltage fluctuations and transformer overloads [7]. Additionally, this setup allows for bidirectional energy flow, facilitating vehicle-to-grid (V2G) and grid-to-vehicle (G2V) operations to support grid stability during peak demand periods [8].

The proposed fast-charging system leverages a multistep constant current charging algorithm to optimize the charging process based on the battery's SOC [9]. Traditional charging methods, such as constant current and constant voltage charging, often fail to adapt to the dynamic requirements of fast charging [10]. The use of fuzzy logic control ensures precise regulation of charging current, which enhances battery life and prevents overheating, especially during critical SOC stages. By intelligently varying the charging current, the system ensures rapid charging without compromising battery health, particularly during the initial and final stages of the charging cycle [11-13]. Simulation results reveal that the proposed DC microgrid-based fast charging station significantly mitigates the adverse effects on the power grid. Voltage stability is maintained even during high-power charging operations, and the risk of transformer overheating is minimized [14]. Additionally, the system's ability to utilize solar PV energy reduces dependency on grid power, making it a sustainable and cost-effective solution. Simulink software’s validation confirms the effectiveness of the proposed system, demonstrating its potential for real-world deployment [15].

This paper aims to present a comprehensive solution for EV fast charging using renewable energy-integrated DC microgrids and fuzzy logic controllers. It outlines the design, implementation, and validation of a novel charging algorithm that ensures rapid, efficient, and grid-friendly EV charging. The proposed approach addresses the key challenges of grid stability, power quality, and renewable energy integration, contributing to the development of a sustainable and scalable EV charging infrastructure. The growing demand for fast EV charging necessitates innovative solutions that balance rapid charging with grid stability. The integration of DC microgrids with renewable energy sources offers a promising pathway to achieve this balance, ensuring sustainable and efficient EV charging. The subsequent sections of this paper detail the design methodology, control strategies, simulation results validation of proposed method.

The organization of the following paper contains: Section II provides a comprehensive system description. Section III introduces a proposed method, focusing on the implementation of Fuzzy logic controller for enhanced voltage regulation. Section IV presents the simulation results along with the corresponding discussions. Finally, Section V concludes the paper with key findings and suggests avenues for future research.

II. SYSTEM DESCREPTION

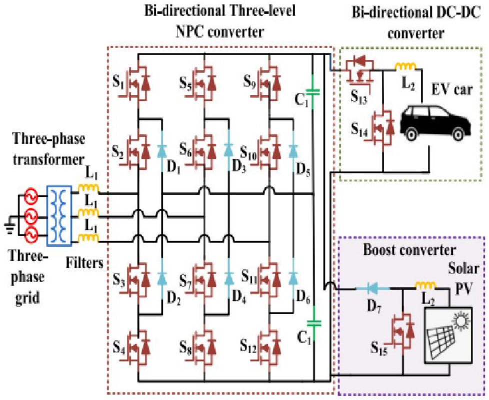


Fig.1 Proposed block diagram of electric vehicle charging station

A) DC Microgrid Configuration for EV Charging Stations

The proposed system integrates a DC microgrid to enhance the efficiency and reliability of fast charging stations for electric vehicles (EVs), providing a superior alternative to traditional AC-based setups. Central to this architecture are three critical converters: an AC-DC bidirectional neutral point clamped (NPC) converter, a bidirectional DC-DC converter (BIDC), and a DC-DC boost converter as shown in the figure-1. The NPC converter plays a dual role by rectifying three-phase AC power from the grid into DC for EV charging and enabling DC-to-AC conversion for vehicle-to-grid (V2G) operations, thus supporting bidirectional power flow [6-18]. This design ensures seamless energy transfer between the grid, EVs, and renewable energy sources, making it ideal for modern EV infrastructure. The BIDC is essential for regulating the charging and discharging processes of the EV battery. In buck mode, it reduces the DC voltage to charge the battery efficiently, while in boost mode, it raises the voltage for discharging and feeding power back to the grid when needed. This converter's dynamic operation allows precise control over charging currents, ensuring optimal battery health and efficient energy utilization. Additionally, it safeguards against overcharging or undercharging, which can adversely affect battery longevity [19]. This flexibility is critical in fast-charging environments where high currents are frequently required, especially during peak demand.

The integration of RES, such as solar photovoltaics, is managed through the DC-DC boost converter [20]. This converter maximizes the energy harvested from the PV panels using Maximum Power Point Tracking (MPPT) techniques, ensuring that the solar PV operates at its optimal output. By feeding this renewable energy directly into the DC bus, the system reduces its reliance on the main grid, lowering the likelihood of voltage fluctuations and transformer overheating during high-demand periods [21]. Furthermore, the boost converter enables the system to store excess energy during low-demand times, which can be later utilized during peak charging sessions [22]. The DC microgrid-based design minimizes grid dependency while enhancing system stability and sustainability. By incorporating renewable energy sources and advanced power electronics, this architecture addresses common challenges associated with fast EV charging, such as voltage dips, harmonic distortions, and transformer stress 23-24]. This ensures that the system not only meets the high-power demands of fast charging but also does so in an environmentally friendly and grid-supportive manner. The combination of renewable integration, bidirectional power flow, and dynamic charging control makes this DC microgrid a forward-looking solution for the expanding EV market [25].

B) SOC Estimation and Multistep Charging Algorithm

The proposed fast-charging system employs a SOC-based multistep constant current charging algorithm to optimize battery charging and ensure grid stability. SOC estimation plays a vital role in determining the battery's remaining capacity and controlling the charging current accordingly. The algorithm divides the charging process into three distinct phases based on SOC levels: slow charging from 0% to 20% and 80% to 100%, and fast charging between 20% and 80%. This strategy not only minimizes battery degradation but also reduces the likelihood of overheating and lithium plating, which are critical concerns during fast charging.

To estimate SOC accurately, the system uses the Coulomb Counting Method (CCM), which tracks charge flowing in and out of battery over time. The SOC at any given moment is calculated using the equation:

$$SOC(t) = SOC(t0) + \frac{1}{Crated}\int_{t0}^{t}(Ibatt - Iloss)dt \quad 1$$

Where SOC (t0) is the initial SOC, Crated is the rated battery capacity, Ibatt is the battery current, and Iloss accounts for current losses due to internal reactions. This method provides high accuracy by continuously updating the SOC value as the battery charges and discharges, ensuring precise control of charging currents throughout the process.

The algorithm dynamically adjusts the charging current based on SOC levels to maximize efficiency and minimize charging time. During the initial phase (0% to 20% SOC), a lower charging current is used to prevent thermal stress and ensure battery safety. As the SOC reaches 20%, the current increases significantly—up to three times the initial value—to enable rapid charging, which continues until the SOC reaches 80%. Beyond 80%, the charging current is again reduced to protect the battery's long-term health and avoid exceeding its voltage limits. This staged approach ensures that the battery is charged quickly while maintaining its integrity.

The use of a multistep constant current algorithm enhances both the speed and safety of the charging process. By tailoring the charging current to the SOC level, the system balances fast charging with battery protection. Additionally, the fuzzy logic controller integrated into the system ensures that the charging current remains within safe limits by continuously monitoring SOC and other battery parameters. This advanced control mechanism allows the system to adapt to changing conditions, making it both efficient and reliable for high-power EV charging applications.

C) System Modes and Control Strategy

The proposed DC microgrid-based fast charging station operates in three distinct modes, each tailored to optimize power flow and maintain grid stability during the charging process. These modes—Grid-to-Vehicle (G2V), Grid and Solar PV Hybrid Charging (G+PV)2V, and Power Export to Grid (PV2G/V2G)—ensure efficient energy management by leveraging both grid power and renewable sources. A sophisticated control strategy, incorporating a fuzzy logic controller and a proportional-integral (PI) controller, ensures smooth transitions between modes and precise regulation of the charging current.

Mode 1: Grid-to-Vehicle (G2V) Charging

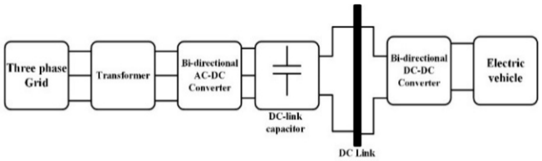


Fig. 2. Power flow direction from G2V

In G2V mode, the EV battery is charged exclusively from the power grid. The AC-DC neutral point clamped (NPC) converter rectifies the three-phase AC grid power into DC voltage, which is then regulated by the BIDC operating in buck mode. This converter adjusts the charging current according to the battery's SOC. The duty cycle (Dfc) of the DC-DC converter is controlled using following equation:

$$Dfc = (Imax - Ibatt)\left(kp + \frac{ki}{s}\right) \quad 2$$

Where Imax is the maximum charging current, Ibatt is the actual battery current, Kp is the proportional gain, and Ki is the integral gain. This mode effectively manages slow charging (0%–20% and 80%–100% SOC) and fast charging (20%–80% SOC), although it can cause voltage dips during high-power demand, which is mitigated in other modes.

Mode 2: Grid and Solar PV Hybrid Charging (G+PV) 2V

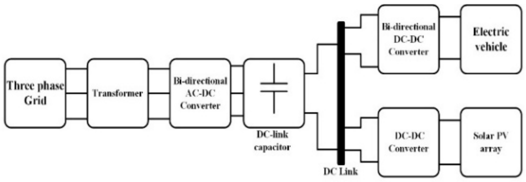


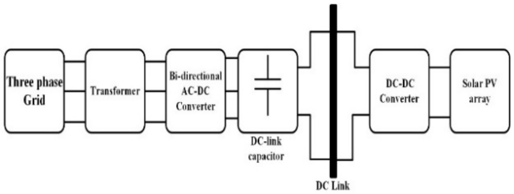
Fig. 3. Power flow direction in (G+PV) 2V

In this mode, power from the grid is combined with solar photovoltaic (PV) energy to alleviate the strain on the grid during fast charging operations. A DC-DC boost converter linked to the PV system ensures optimal energy extraction by utilizing maximum power point tracking (MPPT). During the initial and final stages of charging (SOC levels between 0 to 20 percentage and 80–100 percent), the system primarily depends on PV energy. However, during the fast-charging phase (SOC levels between 20–80%), both the grid and PV sources supply power. The total current delivered to the battery can be expressed as:

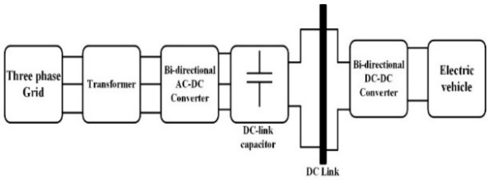
$$Ibatt = Igrid + Ipv \quad 3$$

This hybrid approach reduces grid dependency, alleviates voltage instability, and enhances the overall efficiency of the charging station by utilizing renewable energy during peak periods.

Mode 3: Power Export to Grid (PV2G/V2G)



(a)



(b)

Fig.4 (a) Solar PV to grid, (b) V2G

In the PV2G/V2G mode, excess energy from the solar PV system or the EV battery is fed back into the grid as shown in the above fig, providing support during periods of high demand. The AC-DC NPC converter operates in inversion mode, converting DC power into AC for grid supply. The power flow equations in this mode are as follows:

$$Ppv = -Pgrid\ (for\ PV\ to\ grid) \tag{4}$$

$$Pbatt = -Pgrid\ \ (for\ battery\ to\ grid) \tag{5}$$

These operations help maintain grid stability by supplying additional power during peak demand and absorbing excess energy during low demand.

Table-1 parameter values

Parameter	**Value**
Input Power	320 W
Input Power	20 kHz
Input Voltage (NPC	80 V
DC-Link Voltage	80 V
Input Voltage (DC-DC Converter)	80 V
Output Voltage (DC-DC Converter)	51.2 V
Charging Current (DC-DC Converter)	0.595 V/Ah
Battery Rating	0.595 V/Ah
Input Voltage (Solar PV)	51.2 V
Output Voltage (Solar PV)	51.2 V
Battery Voltage (V)	51.2 V
Battery Capacity (Ah)	86 Ah
Battery Current	86 A
Battery Current	258 A
Initial State of Charge (SOC)	16%

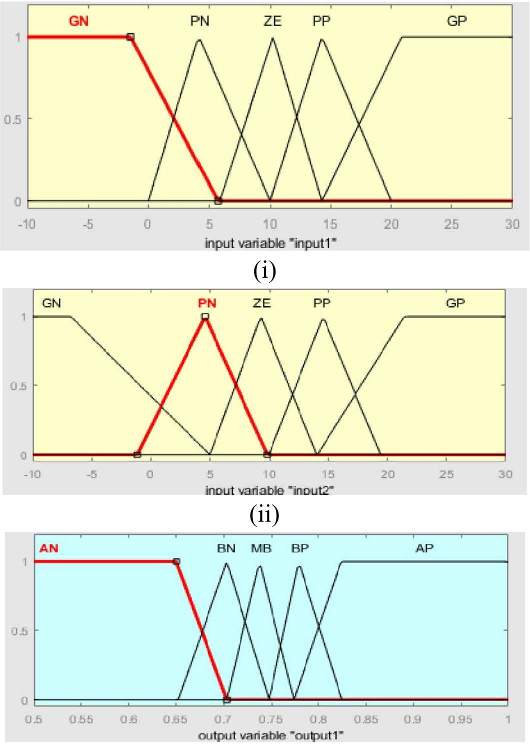
III. PROPOSED METHOD

Proposed Method: Integration of Fuzzy Logic Controller

The proposed system integrates a FLC to enhance the performance and efficiency of the DC microgrid-based fast charging station for electric vehicles (EVs). The FLC is designed to manage the dynamic charging process by adjusting the duty cycle of BIDC based on real-time inputs such as battery SOC, battery current, and grid voltage. Unlike conventional control methods, the FLC offers a more adaptive approach by handling the nonlinear characteristics of the charging system, ensuring smooth transitions between charging phases while maintaining battery safety and grid stability.

The fuzzy logic controller operates by defining input membership functions for SOC levels and battery current, which are categorized into linguistic variables such as "low," "medium," and "high." Based on these inputs, the FLC applies a set of predefined rules to determine the appropriate duty cycle for the converter. For example, when the SOC is low, the FLC reduces the charging current to prevent overheating, whereas it increases the current during the intermediate SOC range (20%–80%) for faster charging. The output is defuzzified into a crisp value that adjusts the duty cycle of boost converter, ensuring precise control over the charging process.

By continuously monitoring key parameters, the FLC dynamically regulates the charging current, minimizing voltage ripples and preventing grid disturbances. This integration ensures that the system can efficiently transition between slow and fast charging modes while optimizing energy flow from both the grid and renewable sources. The use of fuzzy logic not only enhances charging speed but also extends battery life by preventing excessive stress on the battery cells. This makes the proposed method an effective solution for managing high-power demands in fast EV charging stations while ensuring grid compatibility and sustainability.



(i)

(ii)

(iii)

Fig.5 Fuzzy logic variables

The rules of a fuzzy logic system of combination of inputs and outputs represents a rule in the fuzzy inference system, where the inputs correspond to specific linguistic terms (such as "GN," "PN," "PP," etc.) and the output results in values like "AN," "BN," "MB," "AP," etc.

In this system:

*Input 1 and Input 2 are defined by different membership functions (e.g., "GN," "PN," "PP," "GP," "ZE").

*Output is determined by the rules applied to these inputs (e.g., "AN," "BN," "AP").

Fig.6 Fuzzy logic rules

This structure is used to create fuzzy rules based on the relationships between the inputs and outputs for controlling the system. The membership functions for these terms likely correspond to specific ranges or conditions, with the fuzzy system's output being adjusted accordingly.

IV. SIMULATION RESULTS AND DISCUSSION

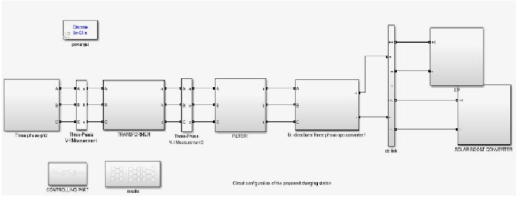


Fig. 7 Simulation configuration of the proposed charging station

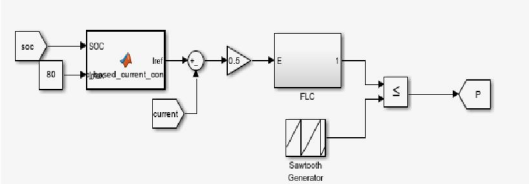
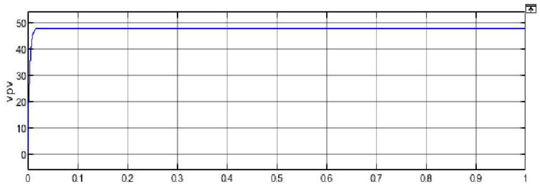
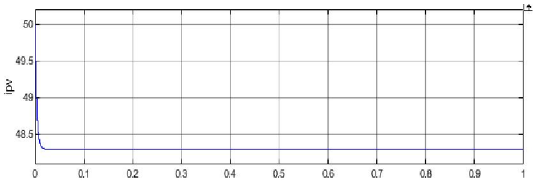


Fig.8 controlling part



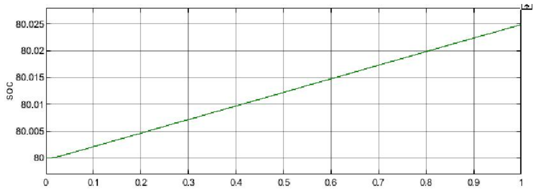
(a)

The EV charging station is powered by both grid electricity and solar energy. The accompanying figure illustrates the voltage output from the solar power system.



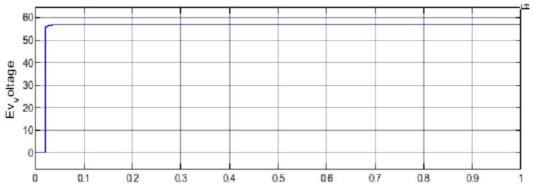
(b)

The EV charging station integrates power from both the grid and the solar energy system. The figure above depicts the current generated by the solar power source.



(c)

Both solar and grid power are connected to the EV charging station. The battery's SOC in the EV charging station increases rapidly as the vehicle is charged, to be combined energy input from the solar panels and the grid, optimizing charging efficiency.



(d)

The EV voltage at the charging station is shown in the figure above.

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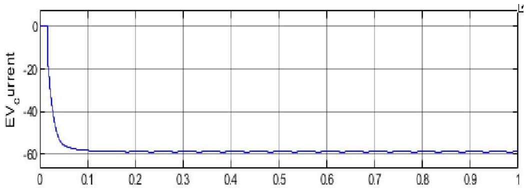
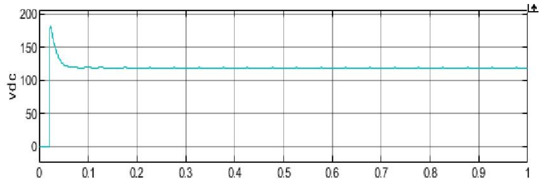


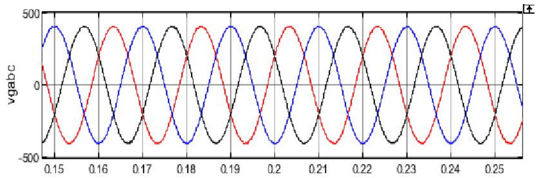
(e)

The EV current at the charging station is shown in the figure above



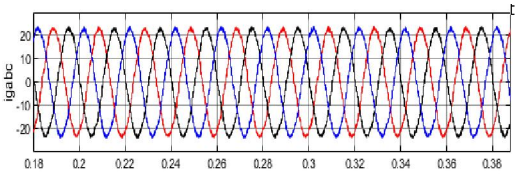
(f)

The above figure shows the Vdc link of the voltage



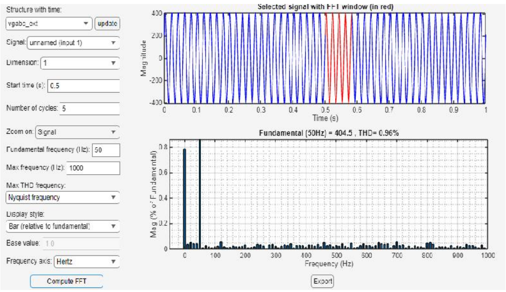
(g)

The voltage on the grid side of the proposed system is illustrated in the figure above.



(h)

The figure above displays the current on the grid side of the proposed system.



Structure with time: vgabc_ext

Signal: unnamed (input 1)

Dimension: 1

Start time (s): 0.5

Number of cycles: 5

Zoom on: Signal

Fundamental frequency (Hz): 50

Max frequency (Hz): 1000

Max THD frequency: Nyquist frequency

Display style: Bar (relative to fundamental)

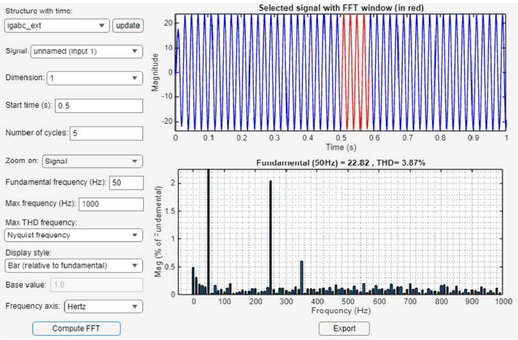
Base value: 1.0

Frequency axis: Hertz

Fundamental (50Hz) = 404.5 , THD= 0.96%

(i)

The above figure shown the grid voltage values of the thd.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Signal: unnamed (input 1)
Dimension: 1
Start time (s): 0.5
Number of cycles: 5
Zoom on: Signal
Fundamental frequency (Hz): 50
Max frequency (Hz): 1000
Max THD frequency: Nyquist frequency
Display style: Bar (relative to fundamental)
Base value: 1.0
Frequency axis: Hertz

Selected signal with FFT window (in red)

Fundamental (50Hz) = 22.82 , THD= 3.87%

(j)

The figure above illustrates the Total Harmonic Distortion (THD) values of the grid-side current.

Fig.9 a) vpv, b) ipv, c) soc, d) EV_voltage, e) EV_current, f) Vdc, g) vgabc, h) igabc, i) THD of grid voltage, j) THD od grid current

G2V mode:

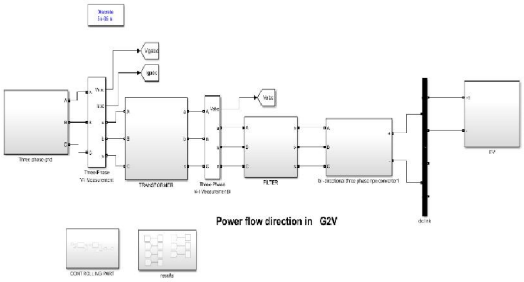
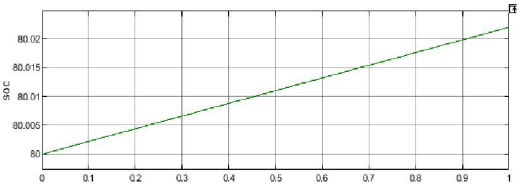


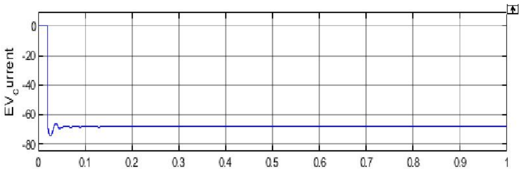
Fig.10 simulation model of the G2V

In this mode, the charging process occurs without the integration of solar PV, with the grid providing all the power for vehicle charging. The bidirectional NPC converter at the front end functions as a rectifier, while the DC-DC converter operates in buck mode to efficiently charge the EV battery. The grid supplies the necessary charging power, whether for fast or slow charging. The FLC manages and minimizes the battery's SOC, DC-link voltage, and voltage ripples, thereby enhancing system stability and charging efficiency. This sophisticated controller optimizes performance by adapting to varying conditions throughout the charging process.



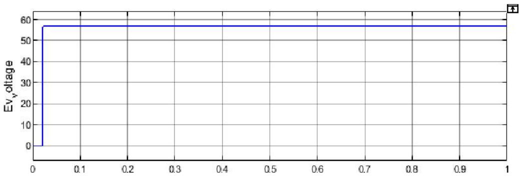
(a)

In G2V charging mode, the state of charge (SOC) slope increases as the electric vehicle (EV) battery charges, especially during the fast-charging period the control of this charging process, a fuzzy logic controller (FLC) can be introduced, which dynamically adjusts the charging current based on SOC levels, grid conditions, and battery health parameters.



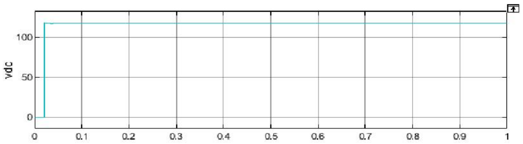
(b)

In this figure, the grid power continuously supplies the EV charging station, ensuring a stable flow of energy to the battery. By implementing a Fuzzy Logic Controller (FLC), the system dynamically regulates the EV battery current

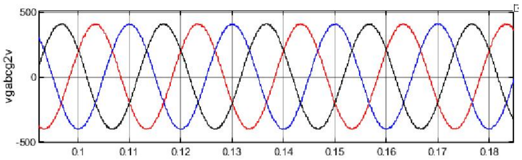


(c)

In this figure, the grid power continuously supplies the EV charging station, as reflected in the EV battery voltage profile. By utilizing a Fuzzy Logic Controller (FLC), the system intelligently manages the charging process by adjusting the battery voltage based on real-time factors like state of charge (SOC), grid load, and battery condition. The FLC ensures that the charging voltage remains within safe limits, preventing overvoltage conditions

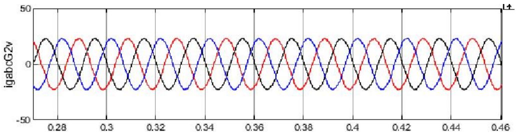


(d)



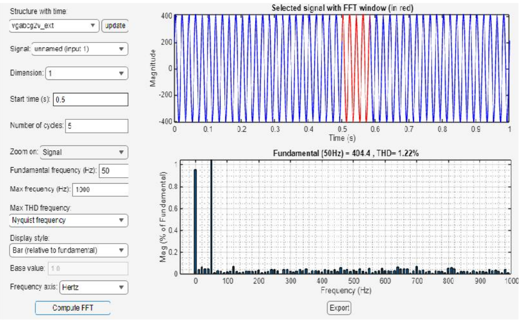
(e)

In this figure, we can see that the grid voltage from the grid to vehicles conditions



(f)

In this figure we seen about the grid current from the grid to vehicle conditions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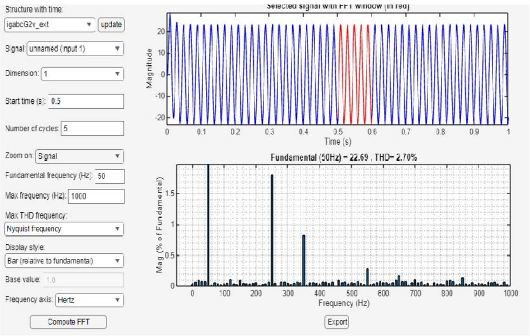
Dimension: 1
Start time (s): 0.5
Number of cycles: 5
Zoom on: Signal
Fundamental frequency (Hz): 50
Max frequency (Hz): 1000
Max THD frequency: Nyquist frequency
Display style: Bar (relative to fundamental)
Base value: 1.0
Frequency axis: Hertz

Fundamental (50Hz) = 404.4 , THD= 1.22%

(g)

Grid to vehicle conditions in grid side voltage thd values


Structure with time: igabcG2v_ext
Signal: unnamed (input 1)
Dimension: 1
Start time (s): 0.5
Number of cycles: 5
Zoom on: Signal
Fundamental frequency (Hz): 50
Max frequency (Hz): 1000
Max THD frequency: Nyquist frequency
Display style: Bar (relative to fundamental)
Base value: 1.0
Frequency axis: Hertz
Fundamental (50Hz) = 22.69 , THD= 2.70%

(h)

Grid to vehicle conditions in grid side current thd values

Fig.11 a) SOC, b) EV_current, c) EV_voltage, d) Vdc, e) vgabc, f) igabc, g) THD of grid voltage, h)THD of grid current

Grid and Solar PV Source Integration

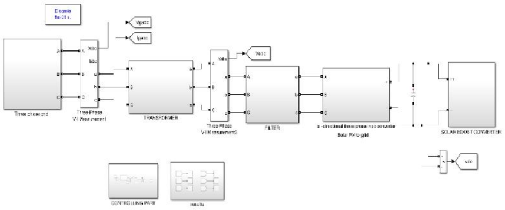
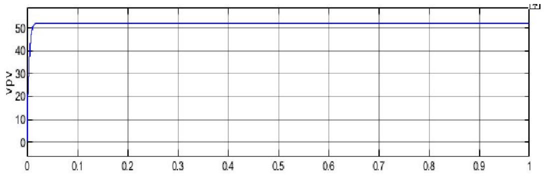


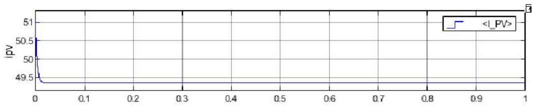
Fig.12 simulation model of PV2G

The figure above depicts the simulation system for connecting solar PV to the grid. In this configuration, the solar PV array produces renewable energy, which is integrated into the DC microgrid via boost converter. The system employs MPPT to optimize the energy extracted from the PV array. The generated power is then delivered to the grid through a bidirectional NPC converter, ensuring efficient power conversion and maintaining grid stability.



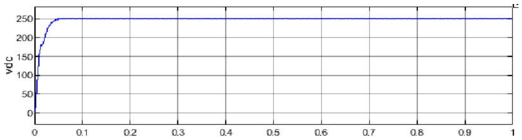
(a)

In the above figure shows the vpv voltage from the solar pv



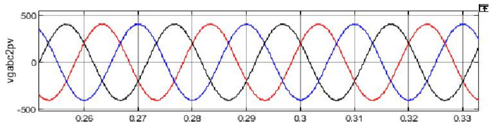
(b)

In the above figure shows the ipv current from the solar side in pv to grid side.



(c)

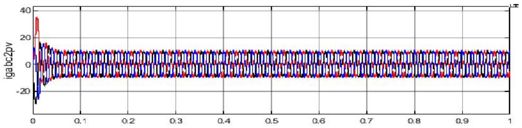
In dc link voltage maintain stable from the both solar and grid side



DOI: 10.48175/IJARSCT-24451

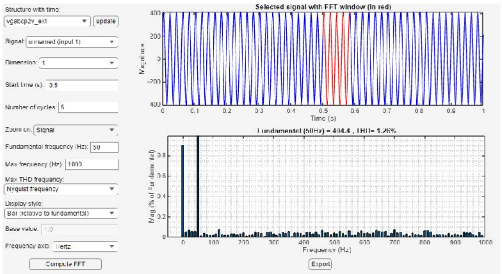
(d)

In the above figure the grid side voltage from the pv to grid side. Conditions



(e)

In the above figure the grid side current from the pv to grid side. Conditions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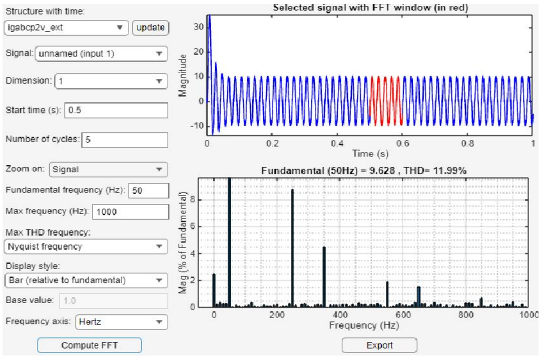
Signal: unnamed (input 1)
Dimension: 1
Start time (s): 0.5
Number of cycles: 5
Zoom on: Signal
Fundamental frequency (Hz): 50
Max frequency (Hz): 1000
Max THD frequency: Nyquist frequency
Display style: Bar (relative to fundamental)
Base value: 1.0
Frequency axis: Hertz

Fundamental (50Hz) = 404.4 , THD= 1.26%

(f)

Grid side voltage in thds values


Structure with time: igabcp2v_ext
Signal: unnamed (input 1)
Dimension: 1
Start time (s): 0.5
Number of cycles: 5
Zoom on: Signal
Fundamental frequency (Hz): 50
Max frequency (Hz): 1000
Max THD frequency: Nyquist frequency
Display style: Bar (relative to fundamental)
Base value: 1.0
Frequency axis: Hertz

Fundamental (50Hz) = 9.628 , THD= 11.99%

(g)

Grid side current in the thd's values

Fig.13 a) Vpv, b) ipv, c) vdc, d) vgabc, e) igabc, f) THD of grid side voltage, g)THD od grid side current

V2G mode:

During this operating mode, the NPC converter functions in inversion mode, facilitating the transfer of power from the vehicle back to the grid during periods of peak demand. The system uses a FLC to efficiently manage the discharge of the EV battery to the grid. The FLC continuously monitors the grid's power demand, battery SOC, and voltage levels, optimizing the discharge rate. This ensures that the battery's discharging power matches the grid's requirements, stabilizing grid voltage and preventing over-discharge of the battery

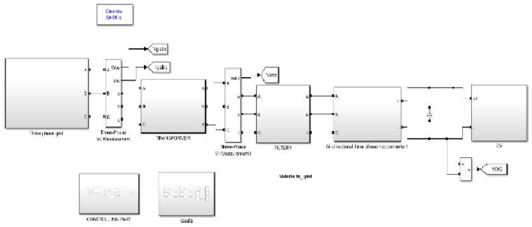
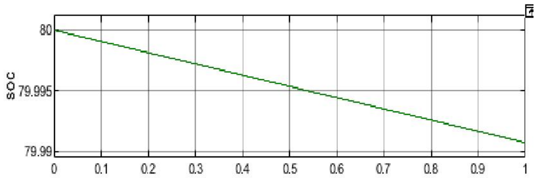


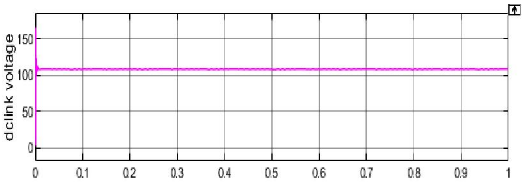
Fig.14 simulation model of V2G

DOI: 10.48175/IJARSCT-24451



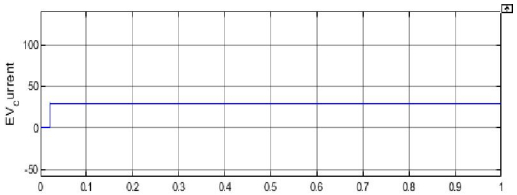
(a)

As shown in figure, the EV battery discharges to supply power to the grid, which is reflected in the SOC decrease. Under Fuzzy Logic Controller (FLC) conditions, the discharging process is intelligently managed by adjusting the discharge rate based on real-time SOC levels, grid demand, and battery parameters



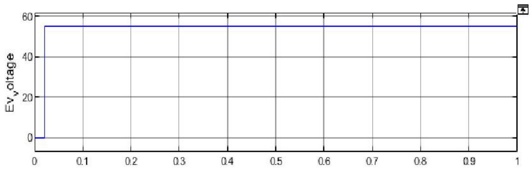
(b)

Dc link voltage



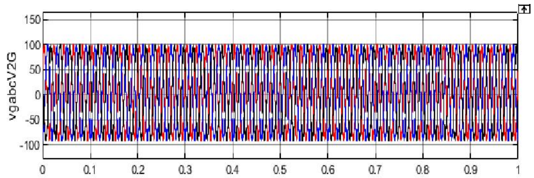
(c)

Ev battery conditions of the current value as shown in the figure.



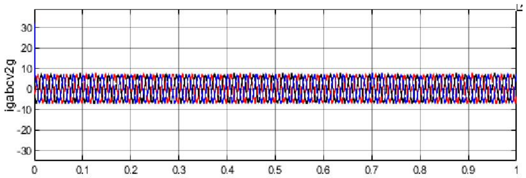
(d)

Ev voltages from to supply the voltage from through npc controller



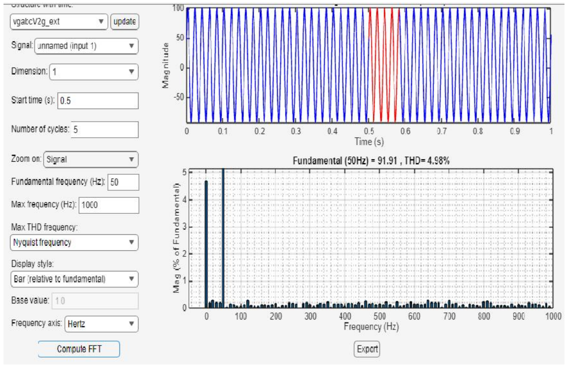
(e)

As shown in the figure, during V2G operation, the EV battery supplies power back to the grid, influencing the grid voltage. By using a Fuzzy Logic Controller (FLC), the system dynamically regulates the grid voltage



(f)

As shown in the figure, during V2G operation, the EV battery supplies power back to the grid, influencing the grid voltage. By using a Fuzzy Logic Controller (FLC), the system dynamically regulates the grid current



Structure with time: vgabcV2g_ext
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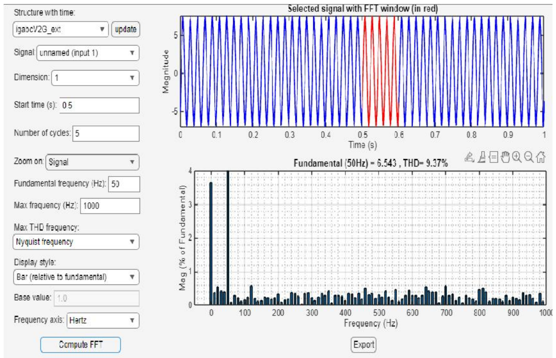
Dimension: 1
Start time (s): 0.5
Number of cycles: 5
Zoom on: Signal
Fundamental frequency (Hz): 50
Max frequency (Hz): 1000
Max THD frequency: Nyquist frequency
Display style: Bar (relative to fundamental)
Base value: 1.0
Frequency axis: Hertz

(g)

THD values of grid voltage in V2G operations



Structure with time: igabcV2G_ext
Signal: unnamed (input 1)
Dimension: 1
Start time (s): 0.5
Number of cycles: 5
Zoom on: Signal
Fundamental frequency (Hz): 50
Max frequency (Hz): 1000
Max THD frequency: Nyquist frequency
Display style: Bar (relative to fundamental)
Base value: 1.0
Frequency axis: Hertz

(h)

THD values of grid current in V2G operations

Fig.15 a) soc, b) vdc c) ev_current, d) ev_voltage, e)vgabc, f)igabc, g)thd of grid voltage, h) thd of grid current

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IV. CONCLUSION

This paper presents a novel approach to fast charging for EVs using a DC microgrid integrated with renewable energy sources, controlled by a FLC. The system aims to overcome the challenges of conventional charging methods, such as slow charging speeds and grid instability during high-power demands. By incorporating a multistep constant current charging algorithm, the system ensures fast and efficient charging while maintaining battery health. The use of a fuzzy logic controller provides adaptive, real-time adjustments based on the SOC, ensuring optimal charging currents throughout the process. Simulations implementation have demonstrated that the proposed system effectively reduces grid dependency and minimizes voltage fluctuations, transformer overheating, and other grid-related issues during fast charging. Moreover, integrating renewable energy sources like solar PV helps in reducing the carbon footprint, making the system more sustainable. The fuzzy logic-based approach not only enhances system efficiency but also guarantees smoother transitions between different charging phases. The proposed DC microgrid-based fast charging station, utilizing fuzzy logic control and renewable energy integration, offers a promising solution to meet the growing demand for fast EV charging infrastructure. This system can be scaled for widespread adoption, contributing to a sustainable, efficient, and grid-friendly EV charging network.

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