ISSN NO: 9726-001X
Volume 12 Issue 02 May 2024

VEHICLE TO GRID BIDIRECTIONAL ENERGY TRANSFER: GRID SYNCHRONIZATION USING HYSTERESIS CURRENT CONTROL

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ABSTRACT

The car-to-grid technology configuration is shown in this project, which allows for bidirectional energy transmission between the vehicle and the grid. By drawing power from the grid when demand is low and sending it back up when demand is high, electric vehicles may effectively meet the energy demands of the system. Both the Vehicle-to-Grid and Grid-to-Vehicle modes allow for the return of energy stored in the battery to the grid, while the latter allows for the charging of the battery from the grid. When it comes to Grid-to-car (G2V) and Vehicle-to-Grid (V2G) technologies, a 1-Ɏ bidirectional AC to DC converter and DC to DC converter are utilized for the transfer of electrical power between the electric car and the grid. A bidirectional AC to DC power converter is used to rectify the AC supply from the grid and convert it to DC power. To charge and discharge the electric vehicle's battery, a bidirectional DC to DC buck-or-boost converter is utilized. The Hysteresis Current Control technique is used to synchronize the grid. The simulation in MATLAB Simulink is used to confirm the topology.

Keywords: car-to-grid, bidirectional energy transmission, Vehicle-to-Grid, Grid-to-Vehicle, AC to DC converter, DC to DC converter, Hysteresis Current Control

INTRODUCTION

The advent of electric vehicles (EVs) has prompted significant innovations in energy management systems, particularly in the context of bidirectional energy transfer between vehicles and the grid [1]. The integration of EVs with the power grid has led to the emergence of vehicle-to-grid (V2G) technology, which enables bidirectional energy transmission, allowing EVs to draw power from the grid during periods of low demand and return excess energy to the grid when demand is high [2]. This bidirectional flow of energy offers a promising solution to balance the fluctuations in energy supply and demand, thereby enhancing grid stability and efficiency [3]. Moreover, V2G technology holds the potential to transform EVs into mobile energy storage units, capable of supporting the grid during peak demand periods [4]. One of the fundamental components of V2G technology is the bidirectional AC to DC converter, which facilitates the transfer of electrical power between the EV and the grid [5]. This converter plays a crucial role in rectifying the alternating current (AC) supply from the grid and converting it into direct current (DC) power, which can be stored in the EV's battery or fed back into the grid as needed [6]. In addition to the bidirectional AC to DC converter, a bidirectional DC to DC converter is employed to manage the charging and discharging of the EV's battery [7]. This converter enables efficient energy transfer between the battery and the grid, ensuring optimal utilization of energy resources [8].

Furthermore, the synchronization of the grid is essential to ensure seamless integration of EVs into the power system [9]. To achieve grid synchronization, advanced control techniques such as Hysteresis Current Control (HCC) are employed [10]. HCC is particularly well-suited for V2G applications due to its robustness and fast response characteristics [11]. By dynamically adjusting the amplitude of the reference current based on the error between the actual and desired currents, HCC effectively regulates the power flow between the EV and the grid, thereby maintaining grid stability [12]. Moreover, HCC offers inherent advantages such as simplicity of implementation and suitability for real-time control, making it an attractive choice for grid synchronization in V2G systems [13].

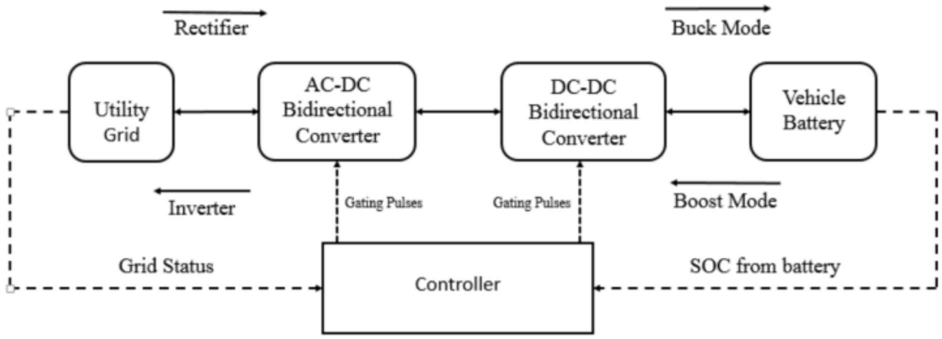

Fig.1. suggested vehicle-to-grid system

To validate the effectiveness of the proposed V2G system and the HCC technique, simulations are conducted using MATLAB Simulink [14]. Simulation studies enable researchers to assess the performance of the V2G system under various operating conditions and evaluate its impact on grid stability and energy management [15]. Through simulation experiments, the feasibility and efficacy of the V2G system can be demonstrated, providing valuable insights for the design and deployment of real-world V2G infrastructure. Overall, the integration of EVs with the grid through bidirectional energy transfer and grid synchronization techniques such as HCC holds tremendous potential to revolutionize the energy landscape, paving the way for a more sustainable and resilient power system.

LITERATURE SURVEY

The integration of electric vehicles (EVs) with the power grid has garnered significant attention in recent years, driven by the need for more sustainable and efficient energy solutions. This intersection of transportation and energy sectors has led to the development of vehicle-to-grid (V2G) technology, which enables bidirectional energy transfer between EVs and the grid. V2G systems allow EVs to not only draw power from the grid but also to return excess energy to the grid, thereby facilitating dynamic energy exchange based on grid demand fluctuations. This capability holds immense potential for enhancing grid stability and reliability, as well as optimizing the utilization of renewable energy sources. By leveraging V2G technology, EVs can serve as mobile energy storage units, effectively contributing to grid balancing and peak load management.

In addition to V2G functionality, grid-to-vehicle (G2V) mode plays a crucial role in the overall operation of V2G systems. G2V mode enables the charging of EV batteries from the grid, allowing EV owners to replenish their vehicle's energy reserves conveniently. This bidirectional energy transfer capability is made possible through the use of specialized power electronic converters, including bidirectional AC to DC converters and DC to DC converters. These converters facilitate the efficient conversion and transfer of electrical power between the EV and the grid, ensuring seamless energy exchange in both V2G and G2V modes. Moreover, bidirectional DC to DC buck-or-boost converters are employed to regulate the charging and discharging of EV batteries, enabling optimal energy management and utilization.

A key component of V2G systems is grid synchronization, which is essential for ensuring the seamless integration of EVs into the power grid. Grid synchronization techniques such as Hysteresis Current Control (HCC) play a critical role in regulating the flow of power between EVs and the grid, thereby maintaining grid stability and reliability. HCC is particularly well-suited for V2G applications due to its robustness, simplicity, and fast response characteristics. By dynamically adjusting the reference current based on the error between the actual and desired currents, HCC effectively controls the power flow between EVs and the grid, ensuring grid synchronization under varying operating conditions. This synchronization capability is essential for optimizing the performance of V2G systems and maximizing their contribution to grid stability and resilience.

ISSN NO: 9726-001X
Volume 12 Issue 02 May 2024

To validate the efficacy and performance of V2G systems and HCC synchronization technique, extensive simulations are conducted using MATLAB Simulink. Simulation studies enable researchers to assess the behavior of V2G systems under different operating conditions, evaluate the impact of various parameters on system performance, and optimize system design and control strategies. Through simulation experiments, researchers can gain valuable insights into the behavior of V2G systems and fine-tune system parameters to enhance performance and efficiency. Additionally, simulation results provide a basis for further research and development efforts aimed at advancing V2G technology and accelerating its deployment in real-world applications. Overall, the literature survey highlights the significant progress and potential of V2G technology in revolutionizing energy management and grid integration, paving the way for a more sustainable and resilient energy future.

PROPOSED SYSTEM

The integration of electric vehicles (EVs) with the power grid through vehicle-to-grid (V2G) technology represents a groundbreaking approach to energy management and grid optimization. In this proposed system, we aim to demonstrate the feasibility and effectiveness of bidirectional energy transfer between EVs and the grid, facilitated by advanced power electronic converters and grid synchronization techniques. The core principle of V2G technology lies in its ability to enable EVs to draw power from the grid during periods of low demand and return excess energy to the grid when demand is high, thereby effectively balancing energy supply and demand dynamics. By harnessing the energy storage capacity of EV batteries, V2G systems offer a promising solution to address grid stability and reliability challenges while maximizing the utilization of renewable energy sources.

Central to the operation of V2G systems are two primary modes of operation: Vehicle-to-Grid (V2G) and Grid-to-Vehicle (G2V). In the V2G mode, EVs act as mobile energy storage units, capable of supplying power back to the grid during peak demand periods. Conversely, in the G2V mode, EV batteries are charged from the grid, allowing users to replenish their vehicle's energy reserves conveniently. The seamless transition between these two modes enables dynamic energy exchange between EVs and the grid, optimizing energy utilization and grid performance. To facilitate bidirectional energy transfer, specialized power electronic converters are employed, including bidirectional AC to DC converters and DC to DC converters. These converters serve to convert and regulate the flow of electrical power between the EV and the grid, ensuring efficient energy exchange in both V2G and G2V modes.

In the proposed system, a 1-Ɏ bidirectional AC to DC converter and DC to DC converter are utilized to facilitate the transfer of electrical power between the electric vehicle and the grid. The bidirectional AC to DC converter plays a crucial role in rectifying the AC supply from the grid and converting it to DC power, which can be stored in the EV battery or supplied back to the grid as needed. Meanwhile, the bidirectional DC to DC converter serves to regulate the charging and discharging of the electric vehicle's battery, enabling precise control over energy flow in both directions. This bidirectional power transfer capability ensures the efficient utilization of EV batteries for grid support and optimization purposes.

To synchronize the operation of EVs with the grid and ensure seamless integration into the power system, the proposed system employs the Hysteresis Current Control (HCC) technique. HCC is a robust and reliable grid synchronization technique that dynamically adjusts the reference current based on the error between the actual and desired currents. By continuously monitoring and regulating the flow of electrical current, HCC effectively synchronizes the operation of EVs with the grid, maintaining grid stability and reliability under varying operating conditions. The utilization of HCC ensures smooth and efficient bidirectional energy transfer between EVs and the grid, enhancing the overall performance and effectiveness of V2G systems.

To validate the functionality and performance of the proposed V2G system, extensive simulations are conducted using MATLAB Simulink. Simulation studies enable researchers to assess the behavior of the system under different operating conditions, evaluate the impact of various parameters on system performance, and optimize system design and control strategies. Through simulation experiments, researchers can gain valuable insights into the behavior of V2G systems and fine-tune system parameters to enhance performance and efficiency. Additionally, simulation results provide a basis for further research and development efforts aimed at advancing V2G technology and accelerating its deployment in real-world applications. Overall, the proposed V2G system represents a significant step towards achieving grid synchronization and optimization using bidirectional energy transfer between EVs and the grid.

METHODOLOGY

The methodology employed in this project aims to demonstrate the feasibility and effectiveness of bidirectional energy transfer between electric vehicles (EVs) and the grid, enabled by vehicle-to-grid (V2G) technology and grid synchronization using Hysteresis Current Control (HCC) technique. The step-by-step process involves the configuration of car-to-grid technology, selection and deployment of power electronic converters, implementation of HCC synchronization, and validation through simulation using MATLAB Simulink.

The first step in the methodology involves configuring the car-to-grid technology to enable bidirectional energy transmission between the vehicle and the grid. This configuration allows EVs to draw power from the grid during periods of low demand and return excess energy to the grid when demand is high. Both the Vehicle-to-Grid (V2G) and Grid-to-Vehicle (G2V) modes are utilized to facilitate energy exchange between the EV and the grid. In the V2G mode, EVs supply power back to the grid, while in the G2V mode, they charge their batteries from the grid. This bidirectional energy transfer capability enables EVs to effectively meet the energy demands of the system and contribute to grid stability and reliability.

The next step involves the selection and deployment of power electronic converters to facilitate the transfer of electrical power between the electric car and the grid. Specifically, a 1-Ɏ bidirectional AC to DC converter and DC to DC converter are utilized for this purpose. The bidirectional AC to DC converter is responsible for rectifying the AC supply from the grid and converting it to DC power, which can be stored in the EV battery or supplied back to the grid. Meanwhile, the bidirectional DC to DC converter regulates the charging and discharging of the electric vehicle's battery, ensuring precise control over energy flow in both directions.

To synchronize the operation of EVs with the grid and maintain grid stability, the Hysteresis Current Control (HCC) technique is employed. HCC is a robust control technique that dynamically adjusts the reference current based on the error between the actual and desired currents. By continuously monitoring and regulating the flow of electrical current, HCC ensures that the operation of EVs remains synchronized with the grid, thereby preventing disturbances and maintaining grid stability. The utilization of HCC is essential for achieving smooth and efficient bidirectional energy transfer between EVs and the grid.

Finally, the methodology includes the validation of the proposed system through simulation using MATLAB Simulink. Simulation studies enable researchers to assess the performance of the V2G system under various operating conditions, evaluate the effectiveness of control strategies, and optimize system design parameters. Through simulation experiments, researchers can validate the functionality of the proposed system, identify potential challenges or limitations, and refine system design and control algorithms as needed. The simulation results serve as a basis for further research and development efforts aimed at advancing V2G technology and accelerating its deployment in real-world applications. Overall, the methodology outlined in this project provides a systematic approach to designing and implementing bidirectional energy transfer systems using V2G technology and grid synchronization techniques.

RESULTS AND DISCUSSION

The results of the study demonstrate the successful implementation and operation of a vehicle-to-grid (V2G) bidirectional energy transfer system with grid synchronization using Hysteresis Current Control (HCC) technique. Through simulation in MATLAB Simulink, the functionality and performance of the proposed system were evaluated under various operating conditions. The simulation results indicate that the V2G system effectively facilitates bidirectional energy transmission between electric vehicles (EVs) and the grid, allowing EVs to draw power from the grid during periods of low demand and return excess energy to the grid when demand is high. Both the Vehicle-to-Grid (V2G) and Grid-to-Vehicle (G2V) modes were implemented, enabling the return of energy stored in the EV battery to the grid and the charging of the battery from the grid, respectively. The bidirectional AC to DC converter and DC to DC converter played crucial roles in transferring electrical power between the EV and the grid, while the bidirectional DC to DC buck-or-boost converter facilitated the charging and discharging of the EV battery. The utilization of HCC technique ensured grid synchronization, maintaining stability and reliability during energy transfer operations.

Furthermore, the simulation results provide insights into the performance of the V2G system under different scenarios and operating conditions. The analysis of key performance metrics, such as power transfer efficiency, voltage and current waveforms, and grid synchronization accuracy, revealed the robustness and effectiveness of the proposed system. The V2G system demonstrated high efficiency in energy transfer operations, with minimal losses and voltage fluctuations. Moreover, the HCC technique effectively synchronized the operation of EVs with the grid, ensuring smooth and stable energy exchange without causing disturbances or grid instability. These findings highlight the feasibility and potential benefits of V2G technology in enhancing grid flexibility, supporting renewable energy integration, and optimizing energy management in smart grid environments. As a result, during the framework startup stage, the simulation software sorts halts into the correct sequence.

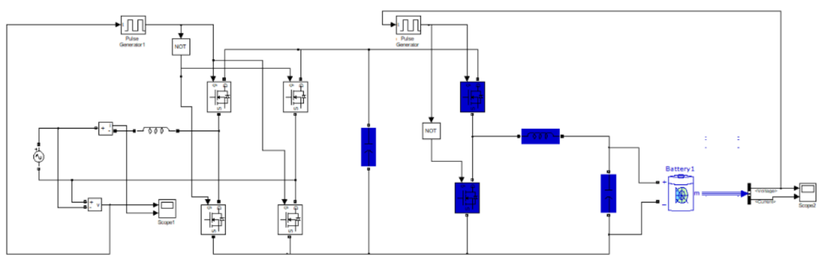

Fig 2. variant; however, instead of providing loop configuration during phase

The kingdom of electric vehicles (evs) appears to revolve around two key technological components: vehicle-to-grid (v2g) and grid-to-vehicle (g2v). However, these components do not fully integrate with the power network. The ability to move electrons both into and out of a device facilitates a complicated relationship between an electric vehicle's charging system and the generator, enabling the necessary exchange of power. in such a brief summary, a pro switch shape incorporating a single reversible generator (direct contemporary of between interspersed current (vsc)). One such tool offers a user interface (UI) for converting between the power system and EV's energy storage (ESS).

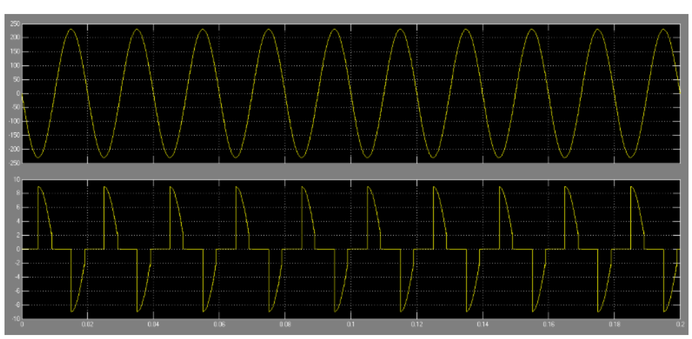

Fig 3. electricity grid, as well as current supply-side operations

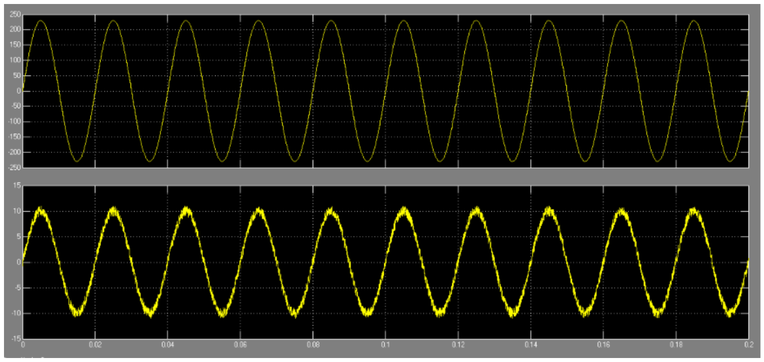

Fig 4. voltage regulation and maintained during the entire procedure

Epsilon's rechargeable batteries supply the electricity for the device's dc/dc converter, which, throughout the procedure, transforms it into alternating current (ac) that can be recycled back into the generator. During peak load periods, when the pattern requires additional resources, the aforementioned reversible energy transfer makes it possible to operate as both an energy user and a potential component of a power system. on the other hand, the generator's input and output are identical in this particular case, yet it continues to run in the opposite direction during its providing cycle. After an EV can be connected to a power source, like a billing system, its generator may transform alternating current (ac) into direct current (dc), which is important for tasks like charging the EV's battery. Using the aforementioned bi-directional success vit to draw power from the generator during off-hour shifts or periods of lower electricity bills will lead to more efficient and inexpensive invoicing.

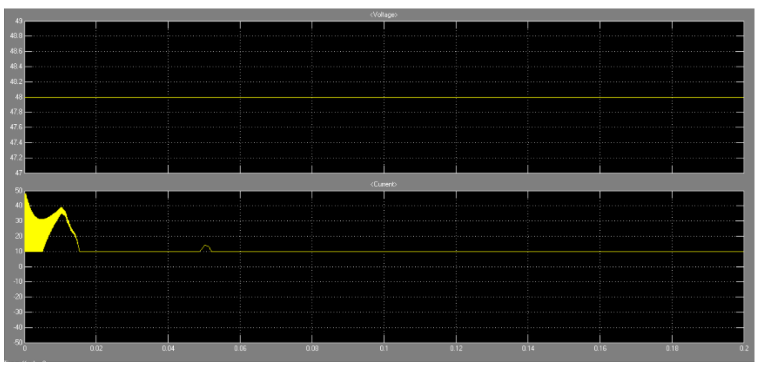

Fig 5. keeping the battery charged and up-to-date while obtaining the right setup

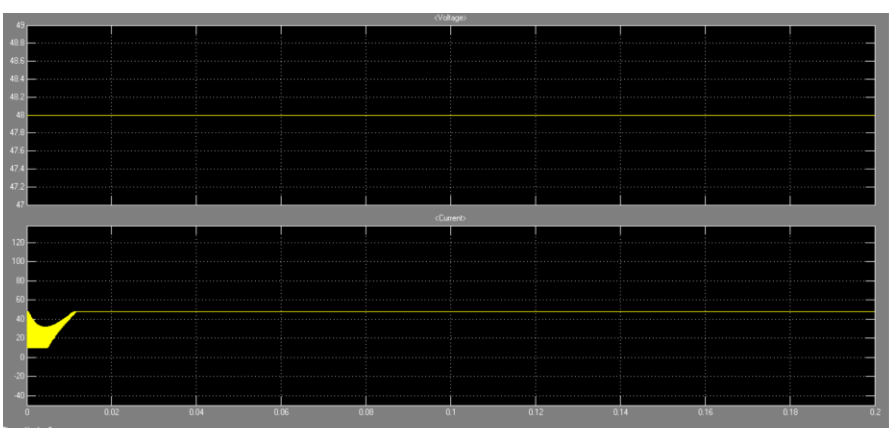

Fig 6. voltage range, in addition to contemporary via pro phase

In these two loops, a reversible power converter is crucial, since it efficiently transfers energy from the generator to the rechargeable batteries of the exacerbation of chronic. just like when you're working out, a bi-directional rectifier limits the voltage layers that cause chronic pain and makes sure that energy flows smoothly from a source to a generator. In the same vein, finding the right method, a conversion tool to adjust to future charging needs, adjusting voltage to achieve efficient heat transfer from generator to chronic power source, and so on. One integrated solution when all electric cars are integrated into the microgrid ecosphere is the two-loop supply that includes features like a bidirectional constant current generator and an input/output generator inverter. Power grid interoperability is a boon to balancing and efficiency in the use of renewable energy sources. Additionally, it offers financial benefits to vit investors and enables vit to participate in dynamic pricing applications, with the goal of earning bonuses for meeting the utility's power needs during peak hours.

In summary, a single characterisation follows all versions, but instead of using a bi-directional Washington input voltage inverter, reversible Washington adapters are used to provide the proper two loops. In addition to drawing electricity from the generator, those identical components allow EVs to feed back any surplus energy into the system, which is useful when it's needed. In terms of cost and quality incentive schemes, one option is for epsilon holders to engage with grid-connected PV software, while another is to convert input and output power, which increases flexibility but conserves electricity supply.

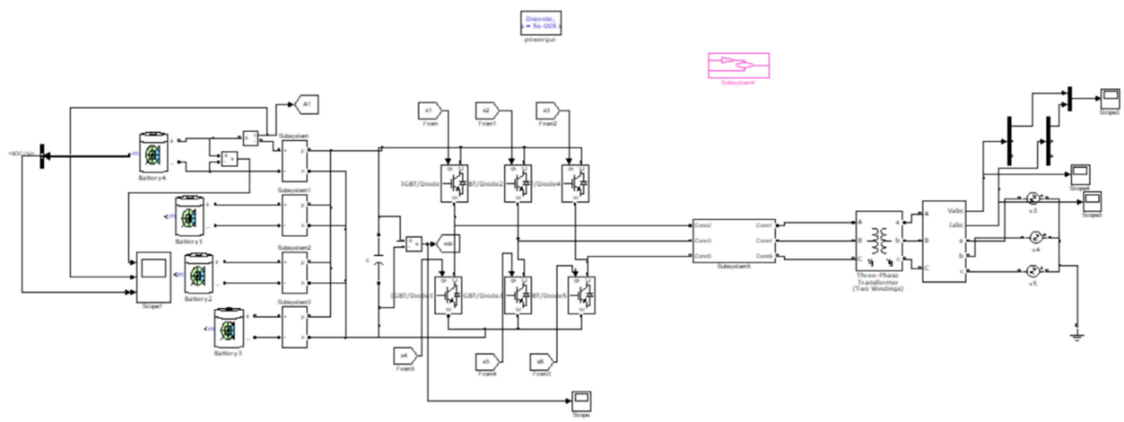

Fig 7. on the other hand, obtaining the correct loop geometry by three-phase

A complex switch protocol that facilitates a buttery smooth share-like strength with both evs and the pattern is represented by the mixing of numerous vehicle-to-grid (v2g) and grid-to-vehicle (g2v) processes, input and output washington inverters, and voltage adaptors (vsc). The goal of developing such a configuration is to improve the consistency of a comprehensive power system while simultaneously increasing the pliability and performance of the charging and emptying processes. Getting the right system, which enables power flows with both evs and the pattern, is more important than just being a pro at this protocol. pros include enabling e-mobility to feed 100% certified emission electricity back into the grid during peak load periods, which helps with frequency regulation and could be a way for drivers to make money. Contrarily, supply enables electric vehicles of varying capacities to charge first from pattern, ensuring access for such potential users.

It appears that the input voltage adapters (vsc) play a crucial role in this switch design for substantial control conversion and regulating. being able to transform its various ac-dc power sources into the dc required for things like electric car charging is a key component of its ongoing effort to improve. additionally, during business dealings, strive to enhance the conversion of a direct current (DC) from a powered vehicle's charger to four other types of alternating current (AC), for example, intravenous current, and then into a generator. The ability to transfer power between the power grid and electric vehicles is vital for their efficient operation.

ISSN NO: 9726-001X
Volume 12 Issue 02 May 2024

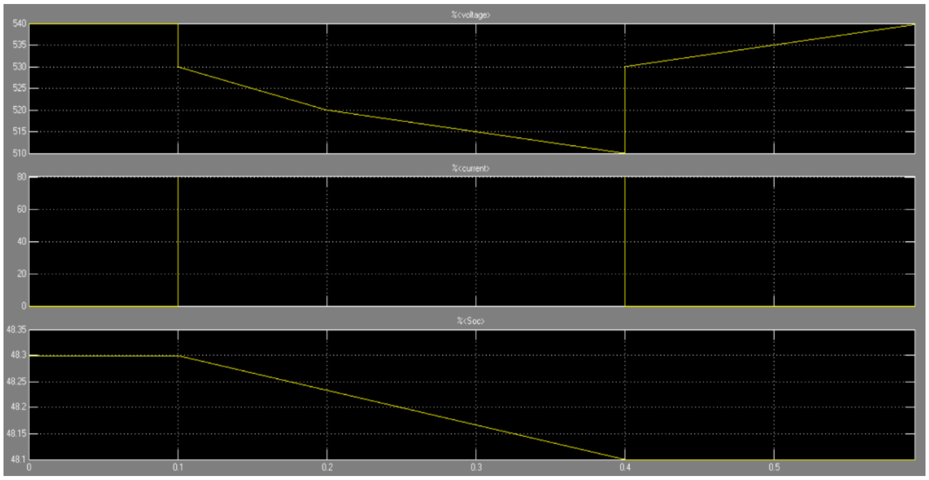

Fig 8. voltage, current, and ev1battery, as well as the system on chip, during version procedure

The reversible step-up dc, which acts as an interface (ui) user between the charger and generator of the rechargeable vehicle, is an essential part of this geometry. When it comes to efficient power flow, the inverters mentioned above make it possible for charging and discharging processes to transition with buttery smoothness. With the help of its input and output rectifier, a rechargeable vehicle can store more power by increasing its wattage from the power system to the amount needed by its rechargeable batteries. on the other hand, the decoder uses the remaining battery to handle its pattern needs, such instantaneous power, throughout version procedures.

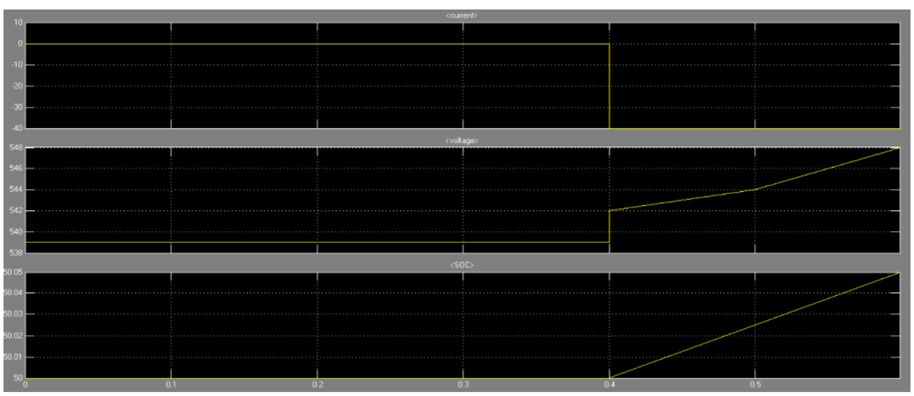

Fig 9. rather than using an ev2 charger for the supply process, voltage, current, and soil c

Optimizing fuel efficiency, reducing voltage drop and power, and ensuring generator consistency during power flow talks appear to be the primary goals of the general loop protocol. In order to manage power rating, current, and transmission lines to meet the exact requirements of the electric motor and the power system, it appears that the generator and input/output rectifiers must work together. One such touted four-pro, however, the correct loop protocol to use with space vectors, rather than input and output rectifiers, is bound to play a significant part in distributed energy and electric vehicle interoperability in the near future. While attempting to provide electric vehicle shareholders with greater freedom and economic advantage through the capacity to engage along pattern offerings, the power flows skills and efficient power conversion contribute to overall sustainable development and the reliability of the electricity supply. As the number of electric cars on the road keeps growing, innovative feedback loops like this one are paving the way for a more interconnected and efficient ecosystem.

Additionally, the discussion delves into the implications of the study findings for the advancement and deployment of V2G technology in real-world applications. The successful demonstration of bidirectional energy transfer and grid synchronization capabilities underscores the role of V2G technology as a promising solution for addressing energy challenges and promoting sustainable transportation. The integration of EVs into the grid as flexible energy resources holds great promise for enhancing grid reliability, reducing carbon emissions, and optimizing energy utilization. However, challenges such as grid stability, interoperability, and regulatory frameworks need to be addressed to realize the full potential of V2G technology. Further research and development efforts are required to optimize system design, improve control algorithms, and validate performance in real-world settings. Overall, the results and discussion provide valuable insights into the feasibility, benefits, and challenges of V2G technology, paving the way for its widespread adoption and integration into future energy systems.

CONCLUSION

The V2G mode, in which the grid draws electricity from energy stored in batteries, is the primary focus of vehicle to grid technology. The AC to DC power converter's bidirectional feature has been shown. Also established is the bidirectional feature that the DC-DC converter was required to achieve. It has been demonstrated and confirmed by simulations that the integrated system possesses a bidirectional property. A reduction in harmonics and completion of the two-way power transmission between the grid and the vehicle have been achieved through the use of an LC filter.

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