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International Journal for Modern Trends in Science and Technology
Volume 10, Issue 03, pages 390-400.
ISSN: 2455-3778 online
Available online at: http://www.ijmtst.com/vol10issue03.html
DOI: https://doi.org/10.46501/IJMTST1003065

Integration of Wind, Solar, and Electric Vehicle Connections to the Electrical Grid Using ANN Control-Based Topology

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To Cite this Article
Dr. S .Ravindra, A.Vanisha Meghali, B.Teja Naga Sri, D.Manikanta and K.Chirudeep, Integration of Wind, Solar, and Electric Vehicle Connections to the Electrical Grid Using ANN Control-Based Topology, International Journal for Modern Trends in Science and Technology, 2024, 10(03), pages. 390-400.https://doi.org/10.46501/IJMTST1003065

Article Info
Received: 24 February 2024; Accepted: 21 March 2024; Published: 26 March 2024.

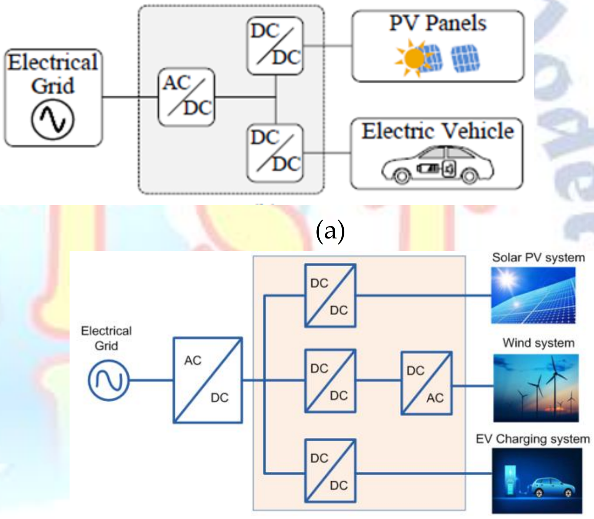
ABSTRACT

This paper presents an analysis and experimental validation of an integrated topology designed to interface electric vehicles (EVs) and renewables from solar photovoltaic (PV) panels and wind turbines with the electrical power grid. The integrated system comprises power converters sharing a common DC-link, enabling operation in four distinct modes towards future smart grids: Grid-to-Vehicle (G2V), Vehicle-to-Grid (V2G), Renewable-to-Grid (R2G), and Renewable-to-Vehicle (R2V). Additionally, the paper introduces an artificial neural network (ANN) control approach to efficiently extract power from renewable energy sources and enhance the charge and discharge processes of electric vehicles. This innovative approach maximizes the utilization of renewable energy sources and improves the overall efficiency of electric vehicle charging and discharging. The MATLAB simulations validate the operation modes and assess the performance of the ANN-controlled system under various operating conditions. The integration of wind and solar energy offers several advantages, including diversification of renewable sources, enhanced energy capture, increased energy harvesting potential, and resilience and redundancy.

KEYWORDS: Electric Vehicle, Integrated Topology, Power Converters, Renewable, Smart Grid.

1. INTRODUCTION

The usage of electric cars (EVs), hybrid EVs, fuel cell vehicles, and electric bicycles are all examples of how electric mobility has made a substantial contribution to the improvement of sustainability and efficiency in the transportation industry [1-2]. However, the huge entry of electric vehicles into the electrical grid needs to be regulated in order to avoid issues with power quality, maximize their interaction with other electrical appliances, and make the most of their use in emerging paradigms such as microgrids, smart grids, and smart homes [3]. Several studies describe optimized electric vehicle charging procedures that take into account the views of customers, the amount of electricity that is required, and the income that the aggregator generates [4-6]. Through grid-to-vehicle (G2V) and vehicle-to-grid (V2G) operating modes, electric vehicles (EVs) may be integrated into the electrical grid in order to facilitate the exchange of energy in a bidirectional manner [7]. There are a number of studies that postulate the existence of a single-phase on-board bidirectional charger that is capable of functioning in both G2V and V2G modes [8]. There are a number of studies that suggest the use of electric vehicles in vehicle-to-grid (V2G) operations for the purpose of demand response management in smart grids [9-12]. The introduction of new modes of operation presents both possibilities and problems for the development of smart grids in the future. Taking into consideration the many limits imposed by the electrical grid, new options for the integration of electric vehicles with renewable energy sources are also emerging as micro generation continues to advance. Several studies have presented several strategies for the operation of electric vehicles (EVs) that take into consideration energy storage systems and renewable energy sources [13]. To integrate electric vehicles (EVs) and renewable energy sources into electrical networks, control algorithms are used. The primary emphasis is on large-scale utilization, with many EVs and renewable energy sources being spread across the electrical power system. Two power converters are often required in traditional topologies in order to connect an electric vehicle (EV) to the electrical grid. Additionally, two power converters are required in order to connect a renewable source to the electrical grid [14]. This article presents the findings of an investigation into the performance of an integrated topology designed for residential usage. An AC-DC converter and two DC-DC converters are going to be used in order to accomplish the objective of connecting electric vehicles and renewable energy sources to the power grid. A new research demonstrates the most effective method for incorporating electric vehicle charging stations, photovoltaic panels, and wind turbines equipped with storage batteries into a direct current (DC) microgrid that is linked to a three-phase power grid in order to achieve various objectives [15]. It is also claimed that there is a system that can connect electric vehicles (by means of an external DC-DC charger), photovoltaic panels (by means of a conventional inverter), and wind turbines (by means of a wind turbine converter) to the electrical power grid. A one-of-a-kind system based on a multimode single-leg power converter has been shown that can control the flow of power between direct current (DC) systems, like energy storage systems and renewable energy systems, without connecting to the power grid [16-18]. This technology provides a number of benefits, including the capability to operate the electric vehicle in a bidirectional mode, the ability to charge batteries from the electrical grid, wind turbines, or photovoltaic panels, and the ability to provide energy to the electrical grid as shown in fig 1. Comparing the suggested topology to the traditional approach, the proposed topology has a maximum estimated efficiency that is 8.8% higher and a total cost that is 33.5% cheaper. Grid-to-vehicle (G2V), Vehicle-to-grid (V2G), Renewable-to-grid (R2G), Renewable-to-vehicle (R2V), Wind-to-grid (W2G), and Wind-to-vehicle (W2V) are some of the modes that can be utilized in order to establish a connection between the electric vehicles (EV), photovoltaic (PV) panels, wind turbines, and the electrical grid as shown in fig 2.



(a)

(b)

Fig. 1. Interface between an EV and PV panels with the electrical grid: (a) Classical topology; (b) Proposed topology.

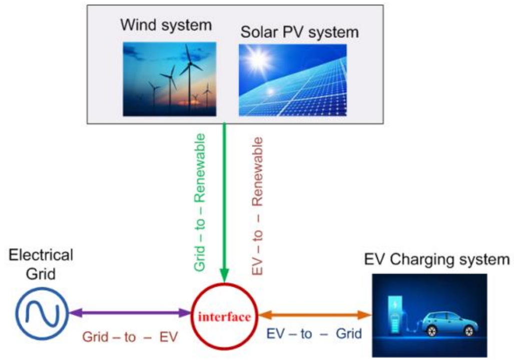


Fig. 2. Proposed hybrid system used to interface electric vehicles (EVs) and renewables from photovoltaics (PV) and wind system

These modes were developed in preparation for the implementation of future smart grids. It is possible to reorganize these modes in order to create combination operation modes. Reducing carbon footprint, improving self-energy consumption, and increasing energy efficiency are the goals of the proposed system, which is centered on residential levels and includes a single electric vehicle (EV) as well as a collection of photovoltaic panels and wind turbines. An electric vehicle battery charger and renewable energy sources are both connected to the power grid via the use of a single AC-DC converter. The electric vehicle's battery may be charged directly from the photovoltaic panels, wind turbines, or even while the power grid is down thanks to this feature. In addition, the suggested topology has a single DC-link that connects the AC-DC converter and the two DC-DC converters. Additionally, the design incorporates sinusoidal grid current and unitary power factor for all three converters [19-20]. By ensuring the seamless integration of renewable energy sources and the effective charging of the electric vehicle's battery, the system eventually contributes to the promotion of sustainability and reduces dependency on the conventional power grid infrastructure. The system provides a complete solution for environmentally aware homes that are interested in adopting clean energy technology. The system is a cutting-edge energy solution that uses a unified power factor and optimizes energy flow, reducing carbon emissions and providing a stable electricity supply even when the conventional grid is unavailable. This innovative design benefits residential property owners by reducing their carbon footprint and offering a reliable and environmentally friendly energy solution. Artificial Neural Networks (ANNs) are integrated into the system to enhance efficiency and adaptability. ANNs control the extraction of maximum power from renewable energy sources using the MPPT algorithm, allowing for optimized energy production and utilization. This integration reduces property owners' reliance on traditional energy sources and offers a more sustainable and cost-effective energy solution. ANNs can also predict energy demand and adjust production accordingly, leading to greater energy savings. This innovative approach benefits the environment and offers long-term financial savings for users. The ANN controller controls electric vehicle charging processes, optimizing energy consumption and reducing costs. The system ensures efficient energy management and promotes renewable energy usage.

2. SYSTEM CONFIGURATION

2.1 Introduction :

The proposed system configuration integrates various components to create an efficient and sustainable energy ecosystem. At their core are electric vehicles (EVs), equipped with bidirectional chargers capable of both Grid-to-Vehicle (G2V) and Vehicle-to-Grid (V2G) operations. Complementing the EVs are renewable energy sources, including photovoltaic (PV) panels and wind turbines. These sources feed energy into the system, contributing to both local energy generation and grid support. Power conversion units, comprising an AC-DC converter and three DC-DC converters, facilitate the seamless integration of EVs and renewable sources with the grid as shown in fig 3. Additionally, Artificial Neural Networks (ANNs) are implemented to optimize various aspects of the system, including charging algorithms, predictive maintenance, load forecasting, grid stability, and user interface optimization. This comprehensive approach not only enhances energy efficiency but also reduces dependency on conventional grid infrastructure, promoting sustainability at a residential level

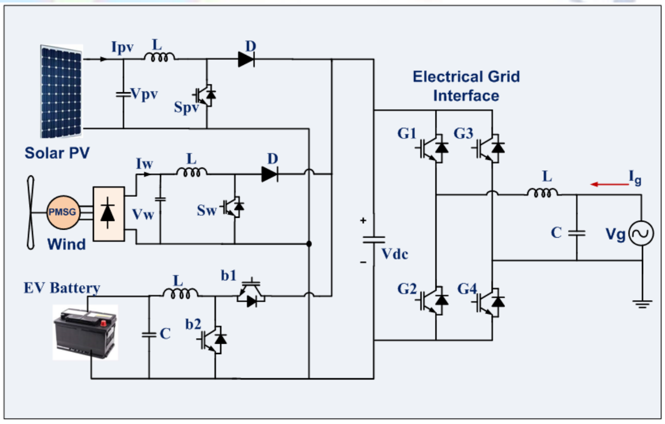


Fig. 3. Circuit of the proposed three-port integrated topology (TPIT) used to interface EVs and renewables with the electrical grid

3. SOLAR OPERATION

A DC-DC boost converter that is powered by solar energy and uses the Perturb and Observe (P&O) Maximum Power Point Tracking (MPPT) algorithm is capable of maximising the amount of solar energy that is produced, allowing it to either charge batteries or power additional loads. Components such as an inductor, diode, capacitor, and switch, which is often a MOSFET or IGBT, are required for the converter to function properly. The P&O MPPT algorithm makes constant adjustments to the operating point of the solar panel in order to follow its maximum power point (MPP), which is the point at which the panel's power production is at its peak as shown in fig.4. This repeated procedure guarantees that the solar panel will extract the maximum amount of electricity possible. It is possible to achieve efficient energy conversion and utilisation in solar-based systems by integrating the P&O MPPT algorithm with the DC-DC boost converter. The system is able to continually function near its maximum power output, which improves both its overall efficiency and performance. This is accomplished by dynamically modifying the operational parameters of the converter depending on the circumstances that are occurring in real time.

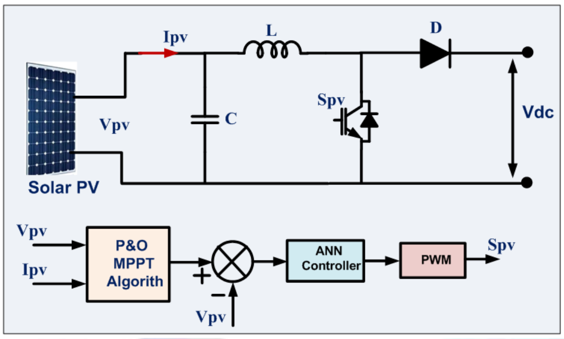


Fig.4 solar MPPT DC-DC unidirectional converter

4. WIND OPERATION

In a wind power generation system using a Permanent Magnet Synchronous Generator (PMSG), wind energy is harnessed to rotate the turbine blades, causing an alternating current (AC) to be converted to direct current (DC). This conversion is done using a rectifier circuit, which transforms the AC output into pulsating DC voltage. This is achieved using diodes arranged in a bridge configuration, allowing current to flow in only one direction. However, the rectified DC voltage still contains ripples due to its pulsating nature. To reduce ripples and produce a more stable DC output, capacitors are used to store and discharge electrical energy. The DC voltage may need to be boosted to a higher level, especially for charging batteries or supplying power to loads requiring a higher voltage. This is achieved through a DC to DC boost converter, which stores energy in an inductor and releases it to the load during another phase. The Perturb and Observe (P&O) Maximum Power Point Tracking (MPPT) algorithm ensures that the wind turbine operates at its maximum power point, optimizing energy extraction from the wind. The MPPT algorithm adjusts the turbine's operating parameters based on real-time measurements of wind speed, turbine output, and other relevant factors, maximizing power output and enhancing overall efficiency and performance. Additionally, the MPPT algorithm continuously monitors and adjusts the turbine's operating point to account for changing environmental conditions, ensuring optimal performance under varying wind speeds. By dynamically adjusting the turbine's parameters, the MPPT algorithm helps to maximize energy production and overall system efficiency. This adaptive control system allows the turbine to operate at its peak efficiency, regardless of fluctuations in wind conditions. As a result, the MPPT algorithm significantly improves the overall performance and output of the wind turbine system.

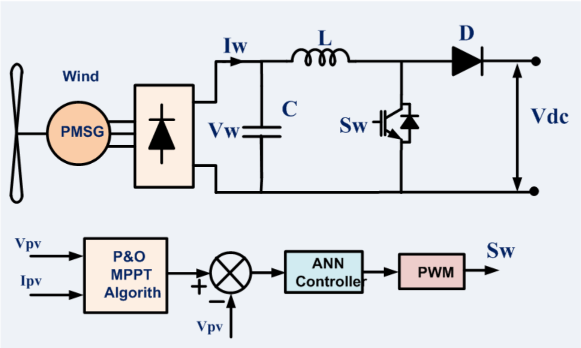


Fig.5 wind power generation with MPPT DC-DC unidirectional converter

5. AC - DC BIDIRECTIONAL CONVERTER

As shown in fig.6 AC-DC bidirectional converter is a complex device that plays an essential part in contemporary power systems. It provides flexibility and efficiency in the management of power flow between AC and DC grids, making it an essential component. The converter also functions as a rectifier while it is operating in its AC to DC mode. It is able to convert AC power from the mains or other AC sources into DC power in an effective manner. It is necessary to make use of intricate control algorithms and semiconductors such as diodes, thyristors, or IGBTs in order to alter the voltage. The waveform of the AC current is transformed into a smooth DC output by these devices. Not only are bidirectional converters capable of rectification, but they also have the potential to function in the reverse mode, which allows them to convert direct current (DC) electricity into alternating current (AC). This conversion from direct current to alternating current, also known as inversion, is necessary for applications such as grid-tied renewable energy systems. In these systems, direct current (DC) electricity from sources such as solar panels or batteries must be converted into alternating current (AC) power in order to be fed into the grid or to power AC loads. By intelligently regulating the switching of semiconductor devices, bidirectional converters enable effective conversion with low losses, hence maximising the overall efficiency of the system. In addition, bidirectional converters provide the benefit of bidirectional power flow, which enables energy to be transported between alternating current (AC) and direct current (DC) grids to meet the requirements of the situation. When it comes to applications such as energy storage systems, this bidirectional capacity is very useful since it allows energy to be stored in batteries during times of low demand and then discharged back into the grid or transformed into alternating current power during times of high demand. These converters contribute to the stabilisation of the grid, the integration of renewable energy sources, and the general resilience of the system by enabling the flow of electricity in both directions. In general, AC-DC bidirectional converters are an essential component of contemporary power systems. They make it possible to integrate AC and DC sources in a smooth manner while simultaneously maximising efficiency, flexibility, and dependability. Because of their adaptability, they are vital in a broad variety of applications, such as grid-tied power systems, electric cars, renewable energy systems, and industrial power supplies. This makes them an important contributor to the development of energy infrastructure that is both sustainable and durable.

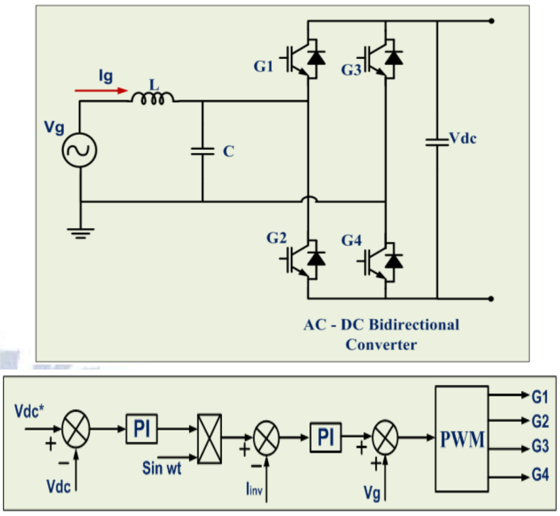


Fig.6 configuration of a AC-DC Bidirectional Converter control

Rectification operation

Rectification Efficiency: The rectification efficiency of a diode-based rectifier can be calculated as the ratio of DC output power to AC input power, considering diode forward voltage drop and other losses:

$$\frac{P_{DC}\,output}{P_{AC}\,input} \times 100\%$$

Peak Voltage (V_{Peak}): The peak voltage of the rectified output waveform can be calculated as:

$$V_{Peak} = V_{rms} \times \sqrt{2}$$

Where V_{rms} is the root mean square (RMS) voltage of the AC input waveform.

Peak-to-Peak Voltage (V_{PP}): The peak-to-peak voltage of the rectified output waveform is twice the peak voltage:

$$V_{PP} = 2 \times V_{Peak}$$

Average DC Voltage (V_{avg}): The average DC voltage of the rectified output waveform can be approximated as:

$$V_{avg} = \frac{V_{Peak}}{\pi}$$

Ripple Voltage (V_{ripple}): The ripple voltage, representing the variation in DC output voltage, can be calculated as:

$$V_{ripple} = V_{Peak} - V_{avg}$$

Ripple Factor: The ripple factor, which quantifies the ripple voltage as a percentage of the average DC voltage, can be calculated as:

$$Ripple\ factor = \frac{V_{ripple}}{V_{avg}} \times 100\%$$

Peak Current (I_{Peak}): The peak current flowing through the load resistance can be calculated as:

$$I_{Peak} = \frac{V_{Peak}}{R}$$

Where R is the load resistance.

Inversion operation

Inversion Efficiency (η): The inversion efficiency is a measure of how effectively an inverter converts DC input power into AC output power. It can be calculated as the ratio of AC output power to DC input power, considering losses:

Inversion Efficiency (η)=$\frac{P_{AC\,output}}{P_{DC}\,\text{input}}$×100%

Where P_{AC} output is the power delivered to the load by the inverter in the form of AC voltage and current, and P_{DC} input is the power supplied to the inverter from the DC source.

AC Power Output (P_{AC}): The AC power output of the inverter can be calculated as the product of the RMS voltage and RMS current of the output AC waveform:

$P_{AC} = V_{rms} \times I_{rms}$

DC Power Input (P_{AC}): The DC power input to the inverter is the product of the DC input voltage and current:

$P_{DC} = V_{DC} \times I_{DC}$

Power Losses (P_{loss}): Power losses in the inverter, including switching losses, conduction losses, and other losses, can be calculated as the difference between the DC input power and the AC output power:

$P_{loss} = P_{DC} - P_{AC}$

Efficiency Losses:

Efficiency losses in the inverter, representing the difference between the ideal and actual inversion efficiency, can be calculated as:

Efficiency Losses=100%−η

6. DC-DC BIDIRECTIONAL CONVERTER

In V2G operations, the bidirectional DC-DC converter enhances grid reliability and efficiency by leveraging the energy stored in EV batteries to support grid stability during peak demand periods or grid emergencies as shown in fig.7. Through intelligent control algorithms, the converter can actively manage power flow bidirectional, ensuring that EV batteries remain charged within specified limits while providing valuable grid services. These services may include frequency regulation, voltage support, and peak shaving, all of which contribute to optimizing grid performance and reducing reliance on traditional fossil fuel-based power generation. Moreover, bidirectional converters enable innovative grid services such as vehicle-to-home (V2H) and vehicle-to-building (V2B) capabilities, allowing EVs to power homes or buildings during power outages or periods of high electricity prices. By tapping into the energy stored in EV batteries, these systems provide a reliable backup power source and promote energy resilience at the community level. In G2V operations, bidirectional converters play a critical role in facilitating efficient EV charging from the grid. By converting grid AC power to DC power suitable for charging EV batteries, these converters ensure fast and reliable charging while minimizing losses. Additionally, bidirectional converters enable bi-directional communication between the EV and the grid, allowing for smart charging strategies such as load balancing, demand response, and time-of-use charging. These capabilities not only optimize charging efficiency but also help to mitigate grid congestion and reduce infrastructure costs associated with EV charging. Overall, bidirectional DC-DC converters are key enablers of the transition to a smarter, more resilient, and sustainable energy ecosystem. By seamlessly integrating EVs with the grid and unlocking the full potential of vehicle-to-grid capabilities, these converters pave the way for a future where transportation and energy systems are closely interconnected, driving greater efficiency, reliability, and environmental sustainability.

A bidirectional DC-DC converter is a critical component in electric vehicles (EVs) that enable the efficient transfer of energy between the EV battery and external power sources (e.g., charging stations) during battery charging (buck mode) and power delivery to the vehicle's systems (boost mode).

Mode 1: Battery Charging (Buck Mode)

- **Switch S1 and Diode D2 Operation:** In this mode, switch S1 is closed, and diode D2 is forward-biased. The closed switch allows current to flow from the external power source (e.g., a charging station) to the EV battery, while diode D2 ensures one-way current flow.
- **Buck Mode Operation:** The converter operates in buck mode, which means it steps down the voltage from the external power source to match the lower voltage of the EV battery. It is necessary to ensure that the battery receives the correct voltage for efficient charging.
- **Charging the Battery:** Energy flows from the external power source to the EV battery, efficiently charging the battery. The buck mode operation

involves controlling the duty cycle of the switch to achieve the desired voltage conversion ratio. The key formulas for buck mode include:

- Voltage Conversion Ratio (Duty Cycle, D): D = $\frac{V_{out}}{V_{in}}$
- Inductor Current (I_L): $V_{out} = \frac{V_{in}\times(1-D)}{D\times(1-D)\times I_L}$
- Output Power (Pout): Pout = $V_{out} \times I_L$
- Efficiency (η): η = $\frac{P_{out}}{P_{in}}$ × 100%

Mode 2: Battery Discharging for Power Delivery (Boost Mode)

- **Switch S2 and Diode D1 Operation:** In this mode, switch S2 is closed, and diode D1 is forward-biased. The closed switch allows current to flow from the EV battery to the load (e.g., electric motors), while diode D1 ensures one-way current flow.
- **Boost Mode Operation:** The converter operates in boost mode, meaning it increases the voltage from the EV battery to match the load's required voltage. This is essential to supply sufficient power to the vehicle's systems, even if the load voltage is higher than the battery voltage.
- **Power Delivery:** Energy flows from the EV battery to the load, allowing the vehicle to move and operate as required. The boost mode operation involves controlling the duty cycle of the switch to achieve the desired voltage conversion ratio. The key formulas for boost mode include:
- Voltage Conversion Ratio (Duty Cycle, D): D = $\frac{1}{1-\left(\frac{V_{out}}{V_{in}}\right)}$
- Inductor Current (I_L): Vout = $\frac{V_{in}}{(1-D)\times I_L}$
- Output Power (Pout): $P_{out} = V_{out} \times I_L$
- Efficiency (η): η = $\frac{P_{out}}{P_{in}}$ × 100%

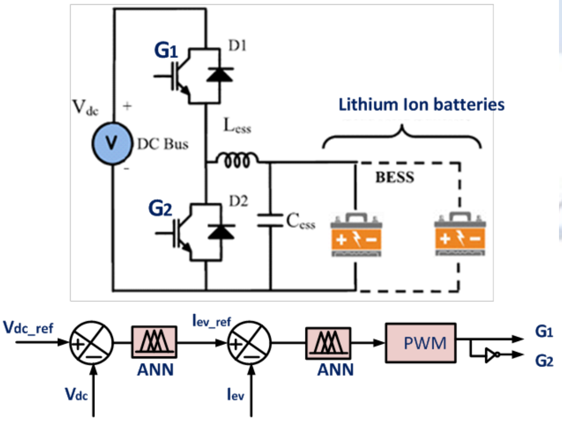


FIGURE 7. Bidirectional DC-DC converter configuration for Electric Vehicle Battery charging.

7. DC-DC UNIDIRECTIONAL CONVERTER

A DC-DC unidirectional boost converter is a kind of power converter that raises the input voltage to a greater level than the output voltage as shown in fig.8. It accomplishes its function by moving energy in a single direction, often from a source with a lower voltage to a load with a higher voltage, from the input source to the output load. An inductor, a switch (often a MOSFET), a diode, and an output capacitor are the principal components that make up the fundamental configuration of a boost converter. When the switch is allowed to remain closed, current is allowed to flow through the inductor, which causes the magnetic field to store energy. The inductor is able to withstand changes in current flow when the switch is opened, which results in the induction of a voltage across itself on the opposite side of the switch. An increase in the voltage across the output capacitor is brought about as a result of this voltage being added to the input voltage. As a result of the diode being forward-biased, current is able to pass from the inductor to the output capacitor and load. The duty cycle of the switch may be controlled in order to ensure that the output voltage of the boost converter is precisely controlled. Power supplies, LED drivers, and renewable energy systems are all examples of applications that often make use of the unidirectional boost converter. This kind of converter is typically used in situations when the input voltage has to be boosted in order to meet the load requirements.

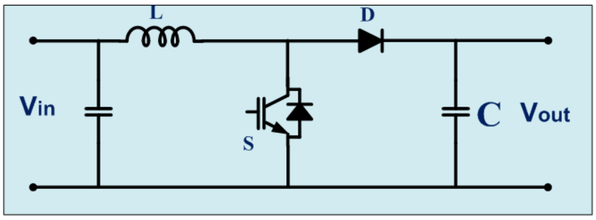


Fig.8 DC-DC unidirectional boost converter

- **Output Voltage (V_{out}):** The output voltage of a boost converter can be calculated using the following formula:

  $V_{out} = \frac{V_{in}}{1-D}$

Where *Vin* is the input voltage and *D* is the duty cycle of the converter.

- **Input Current (I_{in}):** The input current of the boost converter can be calculated as:

$$I_{in} = \frac{I_{out}}{1-D}$$

Where I_{out} is the output current of the converter.

- **Output Current (I_{out})**: The output current of the boost converter can be approximated as: $I_{out} = \frac{P_{out}}{V_{out}}$

Where P_{out} is the output power.

- **Efficiency (η)**: The efficiency of the boost converter can be calculated as the ratio of output power to input power:

$$\eta = \frac{P_{out}}{P_{in}} \times 100\%$$

Where Pin is the input power.

- **Inductor Current Ripple (ΔI_L)**: The peak-to-peak ripple current flowing through the inductor can be approximated as:

$$\Delta I_L = \frac{V_{in} \times D \times T_{on}}{L}$$

where Ton is the on-time of the switching device and L is the inductance.

- **Output Voltage Ripple (ΔV_{out})**: The peak-to-peak ripple voltage at the output can be approximated as:

$$\Delta V_{out} = \frac{V_{in} \times D \times T_{on}}{C}$$

Where C is the output capacitance.

8. Neural Network Model:

For a single-input, single-output (SISO) control system, let:

- $x(t)$ be the input at time t,
- $u(t)$ be the control output at time t,
- $y(t)$ be the actual output of the system at time t.

The neural network consists of an input layer, a hidden layer, and an output layer. Let:

- *wij* be the weight connecting the *i*-th node in the input layer to the *j*-th node in the hidden layer,
- *vj* be the bias of the *j*-th node in the hidden layer,
- *zj*(t) be the output of the *j*-th node in the hidden layer.

Similarly, let:

- *bk* be the bias of the *k*-th node in the output layer,
- *wjk* be the weight connecting the *j*-th node in the hidden layer to the *k*-th node in the output layer,
- *yk*(t) be the output of the *k*-th node in the output layer.

Forward Pass Equations:

The forward pass of the neural network can be expressed as follows:

Hidden Layer Output (*zj*(t)):

$$z_j(t) = \sigma\left(\Sigma_i w_{ij} \cdot x(t) + v_j\right)$$

Where σ is the activation function (e.g., sigmoid, tanh, ReLU).

Output Layer Output (*yk*(t)):

$$y_k(t) = \Sigma_j w_{jk} \cdot z_j(t) + b_k$$

Training and Backpropagation:

During training, the weights and biases are adjusted to minimize a chosen loss function L. One common loss function for regression problems is the mean squared error:

$$L = \frac{1}{2N} \sum_{t=1}^{N} \left(y(t) - u(t)\right)^2$$

The backpropagation algorithm is used to compute the gradients of the loss function with respect to the weights and biases. The weights and biases are then updated using gradient descent or other optimization algorithms. The weight update rule for the hidden layer weights *wij* is given by:

$$\Delta w_{ij} = -\eta \frac{\partial L}{\partial w_{ij}}$$

Where η is the learning rate.

The chain rule is applied to compute the partial derivatives in the backpropagation algorithm.

This is a simplified representation, and actual implementations may involve additional considerations, such as regularization techniques, different activation functions, and optimization strategies. The specific choice of these components depends on the characteristics of the control problem and the desired properties of the control algorithm.

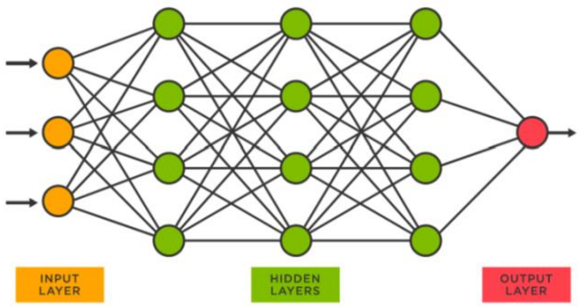
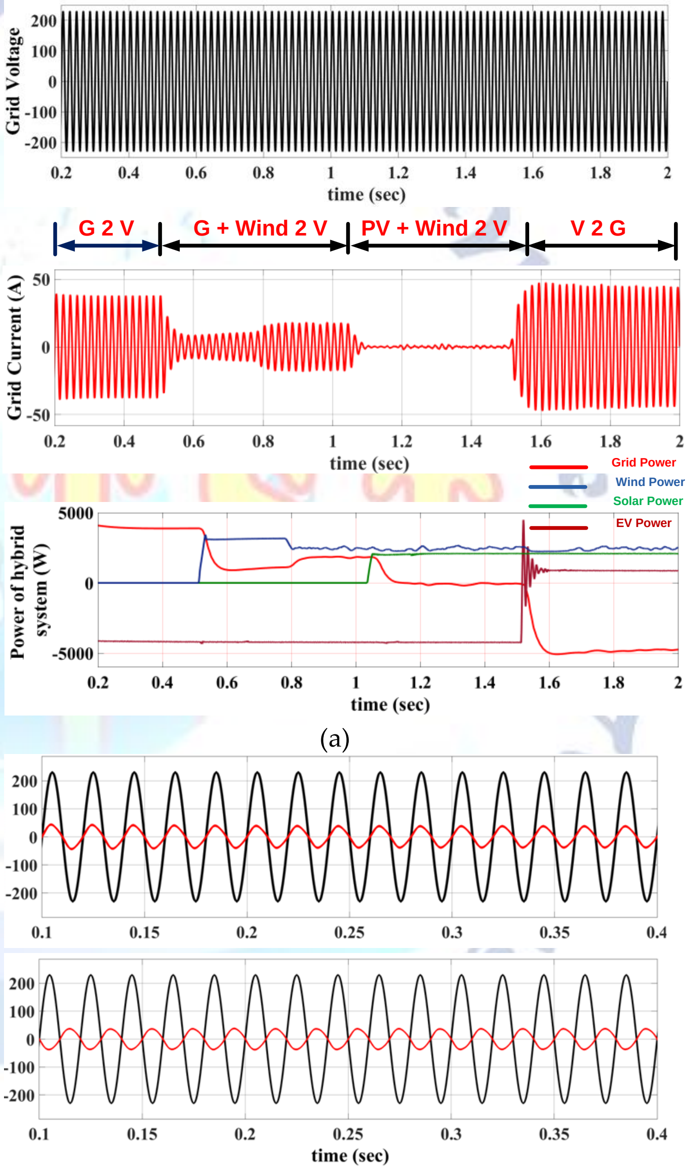


Fig. 9 Design of a back propagation network to provide a standard reference signal.

8. RESULTS AND DISCUSSION

To facilitate the charging of electric vehicles, this hybrid system is designed to be interconnected with a microgrid and wind and solar power. A green answer to transportation and renewable energy, the system makes use of smart technologies to maximize energy storage and utilization. It can also sell whatever energy it doesn't use back to the grid, which is a great way to save costs and increase efficiency. A cleaner, more sustainable environment will be the result of using renewable energy sources to power electric car charging grids. This will minimize reliance on fossil fuels and greenhouse gas emissions. To maximize the advantages of renewable energy sources and guarantee optimal energy management, smart technology integration enables real-time monitoring and control. Figure 10 (a) shows that electric cars charged using grid-supplied solar and wind electricity did not produce any power during the G 2 V phase of operation, which runs from 0.2 sec to 0.5 sec. This emphasizes the need for a steady power supply from the grid to guarantee electric car charging is available at all times. To reduce the impact of these variations and make renewable energy sources for transportation even more reliable, energy storage technologies should be put into place. Electric car charging may be reduced, leading to a possible interruption in power availability since solar PV systems may provide G2V and PV2V modes of operation from 0.5 to 1.2 seconds of grid supply. A more reliable power supply for EVs may be achieved by integrating energy storage devices like batteries, which can store and utilize the surplus energy produced during peak hours. Optimizing the utilization of renewable energy sources and improving grid resilience for transportation demands may be achieved via the incorporation of storage systems. Electric vehicles never get any electricity from the grid since renewable energy sources like solar and wind can meet all of their power needs. Wind power production typically begins between 1.2 and 1.5 seconds after solar power generation. Here we have PV2V+W2V mode. This lessens the need for conventional fossil fuels and makes the energy supply for electric cars more sustainable and dependable. Furthermore, electric car charging systems that use solar and wind power may aid in the reduction of greenhouse gas emissions and the fight against climate change. When renewable energy is unavailable for 1.5 to 2 seconds, the vehicle switches to the back-to-grid (V 2 G) mode of operation. When renewable energy sources are unavailable, this mode enables the electric vehicle to provide extra energy back to the grid, facilitating a more effective utilization of resources. Incorporating V2G technology into electric car charging systems improves their sustainability and flexibility in general. This innovative technology allows electric vehicles to not only consume clean energy but also contribute to the overall stability of the grid during peak demand periods. By enabling bidirectional energy flow, V2G systems help balance supply and demand, making renewable energy integration more efficient and reliable.



(a)

(b)

Fig.10 different modes of hybrid system power flow conditions for bidirectional grid to vehicle with renewable energy sources

Charging electric cars is not possible using renewable energy sources, as seen in Figure 10 (b). Then power will come from the grid, and the electric car will be charged efficiently since the grid's voltage and current flow in phase. Overall energy usage is optimized, and dependence on non-renewable resources is reduced via the seamless integration of renewable energy sources with the grid. Additionally, with vehicle-to-grid operation, cars have the ability to feed the grid while also enabling the grid's voltage and current to travel in opposite directions, enabling energy to flow in both directions. Through the use of electric cars as portable energy storage units, this cutting-edge technology permits an energy system that is both more adaptable and environmentally friendly.

9. CONCLUSION

The integration of wind, solar, and electric vehicle (EV) connections into the electrical grid using Artificial Neural Network (ANN) control-based topology offers a promising solution for enhancing grid flexibility, resilience, and sustainability. ANN-based control systems can efficiently manage fluctuating renewable energy sources by dynamically adjusting power generation and distribution in response to changing environmental conditions and grid demand. This optimizes renewable energy utilization and minimizes grid instability. EV connections also allow bidirectional power flow, facilitating vehicle-to-grid and grid-to-vehicle functionalities. ANN control algorithms enable intelligent scheduling of EV charging and discharging, optimizing energy utilization and grid balancing while meeting EV user preferences. ANN-based control systems offer adaptability and scalability, allowing seamless integration of distributed energy resources and grid-connected devices. This flexibility enables the grid to accommodate a growing number of renewable energy sources, EVs, and smart grid technologies, paving the way for a more resilient and sustainable energy infrastructure. Overall, ANN-based control systems can address challenges in renewable energy integration and grid management, unlocking new opportunities for innovation and sustainability in the energy sector.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

REFERENCES

[1] Wencong Su, Habiballah Rahimi-Eichi, Wente Zeng, Mo-Yuen Chow, "A Survey on the Electrification of Transportation in a Smart Grid Environment," IEEE Trans. Ind. Informat., vol.8, no.1, pp.1-10, Feb. 2012.

[2] C. C. Chan, Alain Bouscayrol, Keyu Chen, "Electric, Hybrid, and Fuel- Cell Vehicles: Architectures and Modeling," IEEE Trans. Veh. Technol., vol.59, no.2, pp.589-598, Feb. 2010.

[3] C. C. Chan, "The State of the Art of Electric, Hybrid, and Fuel Cell Vehicles," Proc. IEEE, vol.95, no.4, pp.704-718, Apr. 2007.

[4] João C. Ferreira, Vítor Monteiro, José A. Afonso, João L. Afonso, "Mobile Cockpit System for Enhanced Electric Bicycle Use," IEEE Trans. Ind. Informat., vol.11, no.5, pp.1017-1027, Oct. 2015.

[5] João A. Peças Lopes, Filipe Soares, Pedro M. Rocha Almeida, "Integration of Electric Vehicles in the Electric Power Systems," Proc. IEEE, vol.99, no.1, pp.168-183, Jan. 2011.

[6] J. Carlos Gómez, Medhat M. Morcos, "Impact of EV Battery Chargers on the Power Quality of Distribution Systems," IEEE Trans. Power Del., vol.18, no.3, pp. 975-981, July 2003.

[7] Nikolaos G. Paterakis, Ozan Erdinç, Anastasios G. Bakirtzis, João P. S. Catalão, "Optimal Household Appliances Scheduling Under Day- Ahead Pricing and Load-Shaping Demand Response Strategies," IEEE Trans. Ind. Informat., vol.11, no.6, pp.1509-1519, Dec. 2015.

[8] Changsong Chen, Shanxu Duan, "Optimal Integration of Plug-In Hybrid Electric Vehicles in Microgrids," IEEE Trans. Ind. Informat., vol.10, no.3, pp.1917-1926, Aug. 2014.

[9] Vehbi C. Gungor, Dilan Sahin, Taskin Kocak, Salih Ergut, Concettina Buccella, Carlo Cecati, Gerhard P. Hancke, "Smart Grid and Smart Homes - Key Players and Pilot Projects," IEEE Ind. Electron. Mag., vol.6, pp.18-34, Dec. 2012.

[10] Joshua Traube, Fenglog Lu, Dragan Maksimovic, "Photovoltaic Power System with Integrated Electric Vehicle DC Charger and Enhanced Grid Support," EPE/PEMC International Power Electronics and Motion Control Conference, pp.1-5, Sept. 2012.

[11] Taesik Park, Taehyung Kim, "Novel Energy Conversion System Based on a Multimode Single-Leg Power Converter," IEEE Trans. Power Electron., vol.28, no.1, pp.213-220, Jan. 2013.

[12] Gustavo Gamboa, Christopher Hamilton, Ross Kerley, Sean Elmes, Andres Arias, John Shen, Issa Batarseh, "Control Strategy of a Multi-Port, Grid Connected, Direct-DC PV Charging Station for Plug-in Electric Vehicles," IEEE Energy Conversion Congress and Exposition, pp.1173-1177, Sept. 2010.

[13] Preetham Goli, Wajiha Shireen, "PV Integrated Smart Charging of PHEVs Based on DC Link Voltage Sensing," IEEE Trans. Smart Grid, vol.5, no.3, pp.1421-1428, May 2014.

[14] Christopher Hamilton, Gustavo Gamboa, John Elmes, Ross Kerley, Andres Arias, Michael Pepper, John Shen, Issa Batarseh, "System Architecture of a Modular Direct-DC PV Charging Station for Plug-in Electric Vehicles," IEEE IECON Annual Conference on Industrial Electronics Society, pp.2516-2520, Nov. 2010.

[15] Vítor Monteiro, J. G. Pinto, Bruno Exposto, Delfim Pedrosa, João L. Afonso, "Multifunctional Converter to Interface Renewable Energy Sources and Electric Vehicles with the Power Grid in Smart Grids Context," ICEE International Conference on Energy and Environment: Bringing Together Engineering and Economics, Guimarães Portugal, pp.654-661, June 2015.

[16] Andrés A. Valdez-Fernández, Pánfilo R. Martínez-Rodríguez, Gerardo Escobar, Cesar A. Limones-Pozos, José M. Sosa, "A Model-Based Controller for the Cascade H-Bridge Multilevel

Converter Used as a Shunt Active Filter," IEEE Trans. Ind. Electron., vol.60, no.11, pp.5019-5028, Nov. 2013.

[17] M. Depenbrock, "The FBD-Method, a Generally Applicable Tool for Analyzing Power Relations," IEEE Trans. Power Syst., vol.8, no.2, pp.381-387, May 1993.

[18] M. Karimi-Ghartemani, M. R. Iravani, "A Nonlinear Adaptive Filter for Online Signal Analysis in Power Systems: Applications," IEEE Trans. Power Del., vol.17, no.2, pp.617–622, Apr. 2002.

[19] Moacyr Aureliano Gomes de Brito, Luigi Galotto, Jr., Leonardo Poltronieri Sampaio, Guilherme de Azevedo e Melo, Carlos Alberto Canesin, "Evaluation of the Main MPPT Techniques for Photovoltaic Applications," IEEE Trans. Ind. Electron., vol.60, no.3, pp.1156-1167, Mar. 2013.

[20] Delfim Pedrosa, Vítor Monteiro, Henrique Gonçalves, Júlio S. Martins, João L. Afonso, "A Case Study on the Conversion of an Internal Combustion Engine Vehicle into an Electric Vehicle," IEEE VPPC Vehicle Power and Propulsion Conference, pp.1-5, Oct. 2014.