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Simulation Of Vehicle To Grid Connection Using Renewable Energy

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Abstract: The major drawbacks of the most battery chargers for plug-in hybrid electric vehicle (PHEV) are high volume and weight, low power, long charging time, deleterious harmonic effects on the electric utility distribution systems and low flexibility and reliability. This paper proposes a new battery charger structure for PHEV application using back to back (B2B) converter in a utility connected micro-grid. In the proposed structure, an AC micro-grid, based on the typical household circuitry configuration, is connected to the grid via a B2B converter; and the DC link is used for battery charging. In fact, the B2B converter can provide an isolated, low cost, simple and reliable connection with power-flow management between the grid, micro-grid and battery. This proposed structure, depending on the power requirement of the vehicle, can run in four different modes: battery charging mode from the grid (G2V) or micro-grid (M2V), vehicle to grid mode (V2G) and vehicle to micro-grid mode (V2H). The feasibility of the proposed scheme has been validated in the simulation study for various operating conditions.

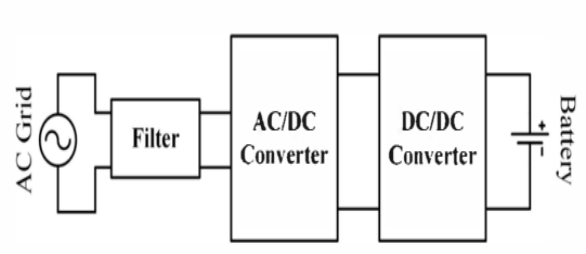
Keywords— AC micro-grid, Back to back converter, Battery charger, PHEV application.

1. INTRODUCTION

Plug-in hybrid electric Vehicles (PHEV) have due attracted a lot of attention to their attractive properties such as their reduced fuel usage and green house emissions. PHEV s have the advantage of a long driving range since fuel provides a secondary resource. In fact, PHEV is a hybrid electric vehicle that uses rechargeable batteries that can be recharged by plugging it in to an external source of electric power.

In PHEV s, a power electronic converter, called battery charger, is utilized to regulate the supplied power by the electric utility or distributed generation (DG) for recharging the battery pack.

Battery charger systems are classified into the off-board and on-board types with unidirectional or bidirectional power flow.



Recently bi-directional battery chargers are used to operate the PHEV as DG to supply power to the grid or micro-grids. As a result, connection to the grid or micro-grid allows opportunities such as ancillary services, flexibility, reliability, tracking the output of renewable energy sources, and load balance. Indeed, the battery charger can charge and discharge the battery pack for various operating conditions and we can use this property for improving the reliability and flexibility.

However, the major drawbacks associated to the typical on board battery chargers for PHEV s are high volume and weight, low power, long charging time, deleterious harmonic effects on electric utility distribution systems and low flexibility and reliability. They can be integrated in different configurations to overcome these problems.

In this paper, a new battery charger structure for PHEV application using back to back (B2B) converter in a utility connected micro-grid is proposed to implement the integration of PHEV with a micro-grid and main grid.

In the proposed strategy, an AC micro-grid, based on the typical house hold circuitry configuration, is connected to the grid via a B2B converter, and the DC link is used for battery charging. With this configuration, grid-connected AC-DC converter of battery charger will be removed. It facilitates desired real & reactive power flow between the utility and the micro-grid.

The back to back converters also provide the frequency isolation between the utility & the micro-grid. The system configuration & four operational modes principles are described in this paper.

2. LELITERATURE SURVEY

A. *Development of a Dual-Fuel Power Generation System for an Extended Range Plug-in Hybrid Electric Vehicle*

In recent decades, there has been a growing global concern with regard to vehicle-generated greenhouse gas emissions and the resulting air pollution. In response, automotive original equipment manufacturers focus their efforts on developing “greener” propulsion solutions in order to meet the societal demand and ecological need for clean transportation. Hydrogen is an ideal vehicle fuel for use not only in fuel cells (FCs) but also in a spark-ignition internal combustion engines (ICEs). The combustion of hydrogen (H2) fuel offers vastly superior tail-pipe emissions when compared with gasoline and can offer improved performance. H2 is ideally suited for use in an extended range plug-in hybrid electric vehicle architecture where engine efficiency can be optimized for a single engine speed. H2 ICEs are significantly more cost effective then an equivalent-sized H2 FC making them a better near-term solution. Before hydrogen can replace gasoline and diesel as the main source of automotive fuel, a number of hurdles must first be overcome. One such hurdle includes developing a suitable hydrogen infrastructure, which could take decades. As such, dual-fuel capabilities will help to create a transition between gasoline- and hydrogen-powered vehicles in the near term, while a full-service hydrogen infrastructure is developed.

B. *A Supervisory Control Strategy for Plug-in Hybrid Electric Vehicles Based on Energy Demand Prediction and Route Preview*

This paper presents a supervisory control strategy for plug-in hybrid electric vehicles (PHEVs) based on energy demand prediction and route preview. The aim is to minimize the fuel consumption in real-time operation. This strategy is realized through three successive steps. First, a neural network (NN) model is established to predict the energy demand of the vehicle. It reduces the complete traffic data to several statistical parameters, which contributes to ease the prediction process. Second, a mathematical model is proposed to translate the predicted energy demand into a state of charge (SOC) reference of the battery, which significantly simplifies the SOC-programming method. Finally, the adaptive equivalent consumption minimization strategy (A-ECMS) is used to track the SOC reference and to determine the power train state. The proposed strategy can optimally distribute the energy between the engine and the motor on a global range and achieve an optimal torque split on a local range. Simulations are carried out on a power-split plug-in hybrid electric bus, and the proposed strategy shows substantial improvements in fuel economy and other indexes compared to the rule-based strategy and the equivalent consumption minimization strategy (ECMS).

3. REVIEW OF BATTERY CHARGER TOPOLOGIES, CHARGING POWER LEVELS, AND INFRASTRUCTURE FOR PLUG-IN ELECTRIC AND HYBRID VEHICLES

This paper reviews the current status and implementation of battery chargers, charging power levels, and infrastructure for plug-in electric vehicles and hybrids. Charger systems are categorized into off-board and on-board types with unidirectional or bidirectional power flow. Unidirectional charging limits hardware requirements and simplifies interconnection issues. Bidirectional charging supports battery energy injection back to the grid. Typical on-board chargers restrict power because of weight, space, and cost constraints. They can be integrated with the electric drive to avoid these problems. The availability of charging infrastructure reduces on-board energy storage requirements and costs. On-board charger systems can be conductive or inductive. An off-board charger can be designed for high charging rates and is less constrained by size and weight. Level 1 (convenience), Level 2 (primary), and Level 3 (fast) power levels are discussed. Future aspects such as roadbed charging are presented. Various power level chargers and infrastructure configurations are presented, compared, and evaluated based on amount of power, charging time and location, cost, equipment, and other factors.

Hybrid Micro-grid with DC Connection at Back to Back Converters

The necessity of an AC or DC micro-grid is governed by available micro sources and connected loads. A hybrid structure can ensure a sustainable configuration blending both the forms. In this paper, a hybrid micro-grid structure for a grid connected micro-grid with DC connection at back to back (B2B) converters is proposed. While a B2B connection between two AC systems could bestow a reliable, isolated and efficient coupling, an extra DC bus connection can facilitate use of the DC micro sources. The DC bus can supply the local DC loads and can also trade part of the power with the AC grids. The voltage support at the DC link (of the B2B converters) can be used for the DC bus formation.

4. PLUG IN HYBRID ELECTRIC VEHICELS

Plug in electric vehicles:

A plug-in electric vehicle (PEV) is any motor vehicle that can be recharged from an external source of electricity, such as wall sockets, and the electricity stored in the rechargeable battery packs drives or contributes to drive the wheels. PEV is a subset of electric vehicles that includes all-electric or battery electric vehicles (BEVs), plug-in hybrid vehicles (PHEVs), and electric vehicle conversions of hybrid electric vehicles and conventional internal combustion engine vehicles. In China, plug-in electric vehicles are called new energy vehicles (NEVs).

Plug-in cars have several benefits compared to conventional internal combustion engine vehicles. They have lower operating and maintenance costs, and produce little or no local air pollution. They reduce dependence on petroleum and may reduce greenhouse gas emissions from the on board source of power, depending on the fuel and technology used for electricity generation to charge the batteries. Plug-in hybrids capture most of these benefits when they are operating in all-electric mode. Despite their potential benefits, market penetration of plug-in electric vehicles has been slower than expected as adoption faces several hurdles and limitations.

Plug in hybrid electric vehicles:

A plug-in hybrid electric vehicle (PHEV or PHV), also known as a plug-in hybrid, is a hybrid electric vehicle with rechargeable batteries that can be restored to full charge by connecting a plug to an external electric power source. A plug-in hybrid shares the characteristics of both a conventional hybrid electric vehicle and an all-electric vehicle: it uses a gasoline engine and an electric motor for propulsion, but a PHEV has a larger battery pack that can be recharged, allowing operation in all-electric mode until the battery is depleted.

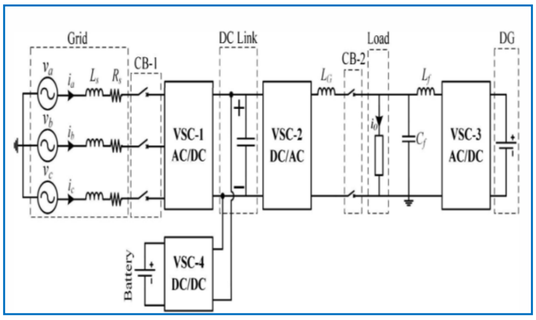


Fig. 2. Power stage of the proposed structure.

SYSTEM PARAMETERS

Parameter	Description	Value
C	capacitance of DC link	6 mf
C_f	LC filter capacitance	25 µF
L_f	LC filter inductance	3.7 mH
r_L	LC filter resistance	0.2 Ω
L_s	grid filter inductance	3.7 mH
V_{Load}	micro-grid load voltage (rms)	220 V
V_s	grid voltage (rms)	110 V
V_{dc}	B2B DC link voltage	400 V
V_{DG}	micro-grid DC link voltage	500 V
f_s	sampling/switching frequency	20 kHz
f	fundamental frequency	50 Hz
P	DG nominal power	1200 W

5. CONVERTERS

Power converters:

A power converter is an electrical or electro -mechanical device for converting electrical energy. It may be converting AC to or from DC, or the voltage or frequency, or some combination of these.

Among the many devices that are used for this purpose are;

Rectifier

Inverter

DC - DC converter

AC - AC converter

6. SYSTEM CONFIGURATION AND OPERATION

The power circuit of the proposed structure is shown in Fig. 2. The parameters of the circuit are listed in Table I.

Based on Fig.2, a mathematical model, describing the dynamics of the system can be derived as

$$v_{abc} = R_s i_{abc} + L_s \frac{di_{abc}}{dt} + v_{CB-1}$$
$$i_{L_f} + \frac{dv_o}{dt} \quad (2)$$

Where Vabc, VCB-l and Va are the output voltage of the grid, the input voltage of the B2B converter and the load voltage, respectively, and iabc. hf, he, and io are the grid, the filters, and load currents, respectively.

Different bidirectional AC-DC converter topologies could be used as the micro-grid and the battery charger. The specific topology chosen depends on the micro-grid and PREY requirements such as the flexibility, cost, reliability, volume and weight [11-15]. In this paper, the converters are chosen as follows:

VSC-l: bidirectional three-phase full-bridge AC-DC converter

VSC-2: bidirectional single-phase full-bridge AC-DC converter

VSC-3: unidirectional single-phase full-bridge AC-DC converter

.

VSC-4: bidirectional isolated dual active full-bridge

DC-DC converter With this proposed structure, different operation modes can be created that is divided into two main categories: battery charging and discharging modes. Different categories of the battery charging and discharging modes are shown in Figs. 14 and 15, respectively

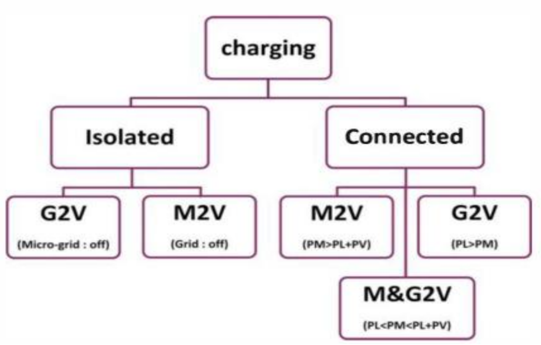


Fig. 14. Operation modes of battery charging

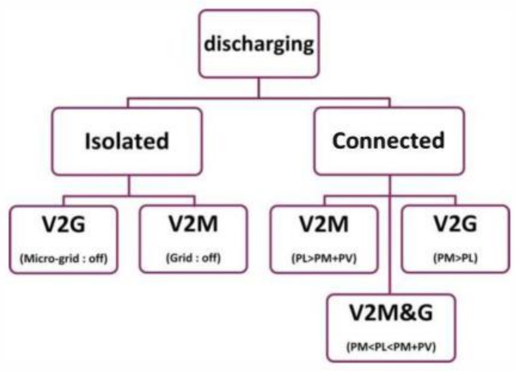


fig. 15. Operation modes of battery discharging

As can be seen in Fig. 14, charging mode is divided into two main categories: isolated mode that the battery only connects to the main grid (G2V) or micro-grid (M2V) and connected mode that depending on the DG power, the battery is charged from the main grid (G2V), micro-grid (M2V) or both of them (M&G2V). On the other hand, discharging mode is classified as similar as charging mode and only operation modes in connecting state is depends on the load power, not DG power. In this paper, for the full study, only the isolated cases are investigated that in this case the other modes are also included.

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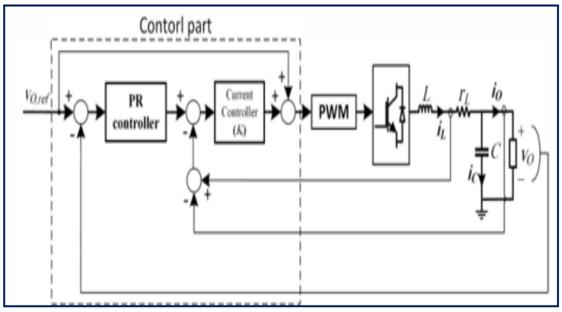
PROPOSED CONTROL METHODS FOR CONVERTERS

As mentioned before, there are three DC-AC converters in the proposed structure, which, depending on their application, are controlled. In the following, how to control the converters are examined

A. Controlled voltage source inverter



In this case, the inverter should be able to support the local network or critical load with the appropriate voltage and frequency from the DC input. VSC-2 and VSC-3 can should be operated in this type. Various control methods for these inverters are available in the literature. We followed offered guidelines in the [16 and 17]. An outer loop with the PR controller regulates the output voltage, while the capacitor current is selected as the feedback signal in the inner control loop and provides active damping, stability over a wide range and fast dynamic for disturbances. The controller parameters are designed in the frequency domain based on the required bandwidth and stability margin [16].

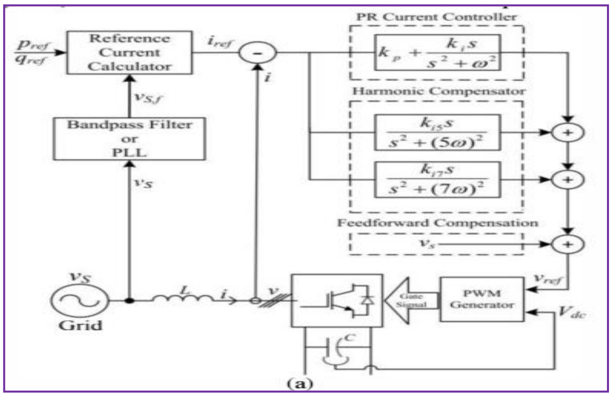


Fig 16.Suggested control scheme for controlled voltage source inverter

B. Controlled current source inverter

In this case, the voltage is imposed by main grid or another inverter. Therefore, the output voltage of this type of inverter is specified and it must control its current. VSC-l, VSC-2 and VSC-3 can be operated in this type. In this case, also, there are different control methods.

C Active voltage source rectifier

In the last converter, active voltage source rectifier is investigated, where VSC-l and VSC-2 can be operated in this type. Fig. 17 (b) shows the suggested control scheme for the active voltage source rectifier [18]. As shown in Fig. 17 (b), the controller uses the outer voltage loop to generate the magnitude reference for the inner current loop and the magnitude is multiplied with the phase reference supplied directly by the grid voltage. In fact, it is important to follow two aims in this controller:

1. set up DC link in a specified amount
2. Drag the current from the main grid in the same phase with the voltage of the source.

These aims are achieved in the simulations as have been investigated in the next section.

IX. SIMULATION RESULTS

To confirm the feasibility and performance of the proposed scheme, the structure of Fig. 13 has been extensively investigated using MATLAB/SIMULINK simulations. The simulation parameters are listed in Table II. As mentioned before, in this paper, only isolated cases are investigated that connected states are also included. Fig. 27 shows the voltage and current waveforms for the battery charging operation in the grid-connected mode.

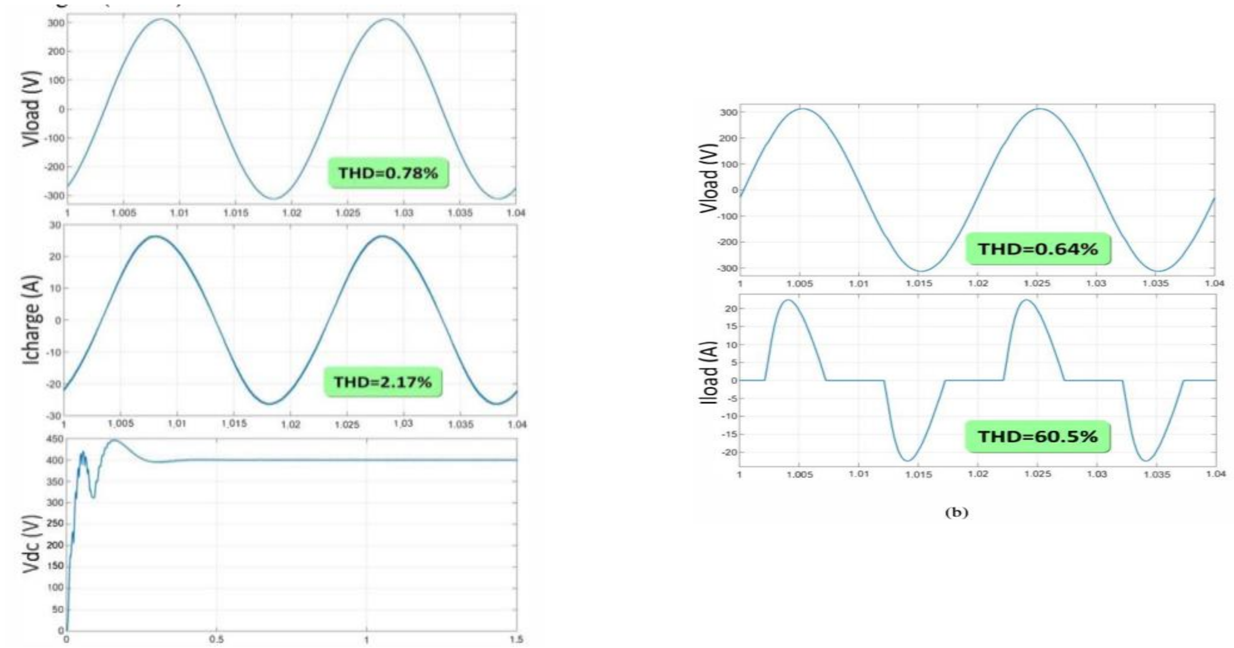


Fig. 27. Waveforms for the battery charging in grid-connected mode.

As can be seen in Fig. 27, the power factor is good (nearly one) and the DC-link voltage is reached to the desired value. Furthermore, the currents of source are sinusoidal with the total harmonic distortion (THD) of 3.48%.

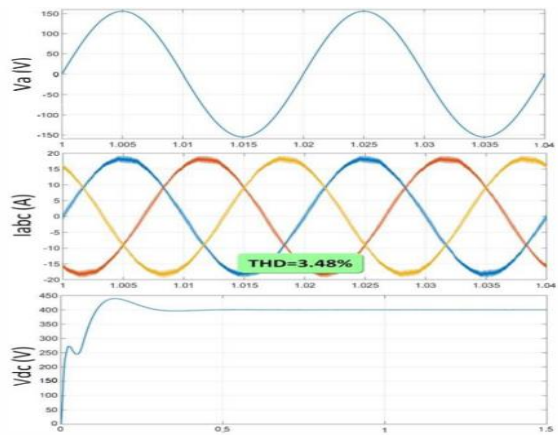


Fig. 28. Waveforms for the battery charging in islanded mode

Fig. 28 presents the performance of the system for the battery charging operation in the island mode. In this case, the DG is the only source and therefore, is responsible for load power and battery charging power supply. It can be seen that the load voltage and current are also sinusoidal even without the main grid, which are very good results. In fact, the load voltage remains almost unchanged during the charging mode change from grid-connected mode to island mode. Again, the

DC link voltage is also set at desirable amount. This excellent performance is achieved due to the proper control of the inverter of micro-grid.

In another case, the battery discharging operation in the grid-connected mode is investigated and results are shown in Fig. 29. In this case, it is assumed that the battery pack delivers 2 K W to the main grid. Therefore, the actual injected power tracks the reference one accurately in simulations and transient-state dies out rapidly. Furthermore, injected currents to the main grid are sinusoidal with the THD of 3.95%.

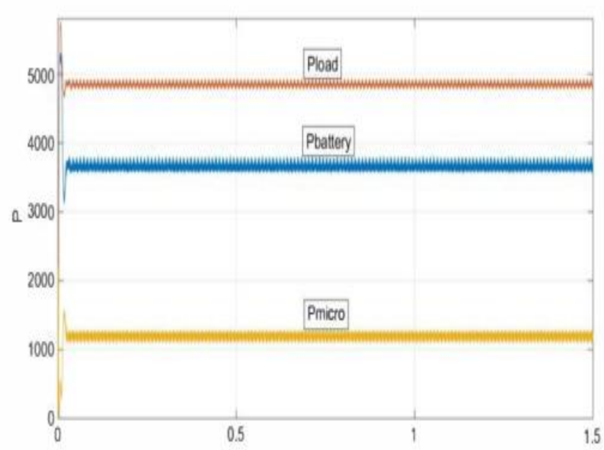


Fig. 29. Waveforms for the battery discharging in grid-connected mode.

Finally, as the worst case operation, the battery discharging in island mode is investigated. In this case, it is assumed that the DG is working at the rated power (1200 W), in other words, DG works in PQ mode and battery charger (VSC-2) acts as a controlled voltage source. Therefore, the load type is important and this study is investigated in two cases. In the frst case, the nominal linear load is investigated and the load waveforms are depicted in Fig. 30 (a). The load voltage is a perfect sinusoidal waveform with a negligible THD value (THD = 0.39%). Furthermore, the powers are shown in Fig. 31 that shows the power of the load is provided by the both battery and DG.

In the second case, the performance of the proposed scheme was evaluated under a highly nonlinear load; and the results are shown in Fig. 30 (b). The nonlinear load, shown in Fig. 32, consists of a diode rectifier bridge feeding an RC circuit through a small resistor. The values of R" R2 and C are 30, 300 and 400uF, respectively. This nonlinear load is designed according to the requirements of IEC 62040-3 standard (Annex E) [21]. One can see in Fig. 30 (b) that while the load current is highly distorted, with a THD of about 60%, the voltage waveform remains sinusoidal (THD = 0.64%). In fact, this excellent performance is achieved due to the proper control of VSC-2.

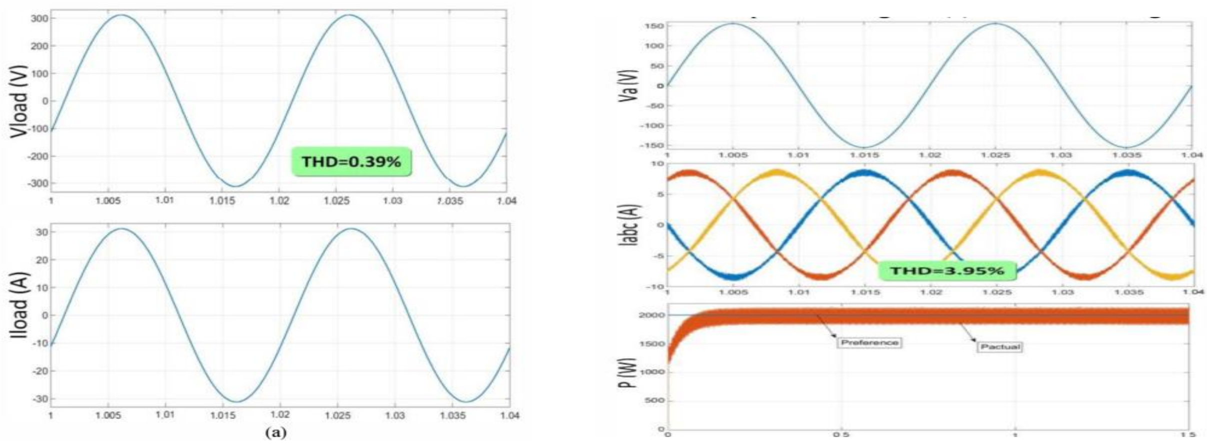


Fig. 30. Waveforms for the battery discharging in islanded mode: (a) under the nominal linear load, and (b) under a highly nonlinear load.

CONCLUSION

The feasibility and performance of a battery charger for Plug - in Hybrid Electric Vehicle (PHEV) application using back to back (B2B) converter in a utility connected micro-grid has been investigated in this paper. A structure has been proposed involving three parts: an AC micro-grid, in which the load is fed from the Distributed Generation source, a battery charger, in which the bi-directional DC-DC converter is used, and main grid. The system infrastructure and operational principles are illustrated. The best controllers have been utilized to achieve better performances in Vehicle to Micro-grid (V2M), Vehicle to Grid (V2G), Grid to Vehicle (G2V), and Micro- grid to Vehicle (M2V) modes. In principle, the proposed scheme is very flexible and reliable, particularly for sensitive loads. The excellent performance of the proposed structure has been confirmed through extensive simulations on MATLAB/SIMULINK for various operating conditions.

FUTURE SCOPE

An AC micro-grid, based on the typical household circuitry configuration, is connected to the grid via a Back to Back (B2B) converter and the DC link is used for battery charging. A Distributed Generation with solar energy has been in this paper. All the renewable energy sources can be used as a source for this paper & can be implemented using artificial intelligence and machine learning and by using internet of things (IOT) this can be done as it improves its accessibility with high accuracy and efficiency.

Combination of Internet of Things & machine learning increases the chances of reliability & its performance.

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