Grid Connected Efficient and Effective Eco-Friendly Vehicles

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Abstract— An Electric vehicle reflecting their potential to reduce air pollutants and greenhouse gas emissions they are expected to significantly increase in number in coming years. Charging such vehicles will impose additional demands on the electricity network but given the pattern of vehicle usage, the possibility exists to discharge the stored energy back to the grid when required, for example when lower than expected wind generation is available. Such vehicle-to-grid operation could see vehicle owners supplying the grid if they are rewarded for providing such services. This paper describes a model of an electric vehicle storage system integrated with a standardized power system. A decision-making strategy is established for the deployment of the battery energy stored, taking account of the state of charge, time of day, electricity prices and vehicle charging requirements. Applying empirical data, the benefits to the network in terms of load balancing and the energy and cost savings available to the vehicle owner are analysed. The results show that for the case under study, the EVs have only a minor impact on the network in terms of distribution system losses and voltage regulation but more importantly the vehicle owner's costs are roughly halved.

Key words: Eco-Friendly, Air Pollutants, Smart Grid

I. INTRODUCTION

The challenge of the smart grid is formidable, and fully explaining all the nuances is beyond the scope of this article. Nevertheless, what makes a grid smart, or at least different from the grid of today, is the fact that it must deliver both energy and information. The delivery of both energy and information must also be end-to-end and bidirectional. Energy will be generated both at traditional generation facilities as well as in local or distributed generation facilities. Information covering every aspect of electricity from generation to consumption will also be conveyed. The motivation for this monumental change is equally broad and is driven by a desire to ensure the future power needs of a region by improving power reliability and quality, generation, and transmission efficiency, expand the use of renewable energy, and implement new load shifting and energy efficiency programs at the point of use that reduce consumption on a per customer basis, while boosting consumer awareness and choice, to name but a few. Additionally, a smart grid is key to more effectively managing and meeting our carbon footprint goals and building a workable electric vehicle infrastructure.

Given that our own homes are a key factor in any smart grid equation, the balance of this article is devoted to some of the important things targeted at homes in terms of applications and standards development. Consider the following:

- Over 50 percent of electricity is consumed in the home.
- The home will be the location of the largest number of distribution generation devices.
- The home will be the home base for electric vehicles.

Impacting consumer behavior in homes will be essential to reduce the growth in electric demand, and because of the sheer number of residences and consumers, workable demand response and load control requires a high level of information, communication, automation, and participation. One industry alliance that has taken the lead in delivering open energy management solutions for the home is the Zig- Bee Alliance. Zig-Bee was launched in 2002 to develop open standards for wireless sensor networks. The idea is simple: make it easy and cost effective to put sensors and controllers in everything, and give them a way to network and exchange information for a variety of purposes. By doing this, we achieve an Internet of things. By connecting a variety of applications, from heating and air conditioning, lighting systems, and home security systems to things like remote controls, consumers gain greater control of their home and see a variety of convenience, safety, and comfort benefits, as well as an opportunity to save money.

When it comes to defining and building the smart grid, the hope is that through efforts like this, it is possible to achieve not only consensus solutions on specific requirements, but a harmonized and coordinated systems approach as well. As shown in Fig1. When the charge is fed back to grid, its being used for many useful applications.

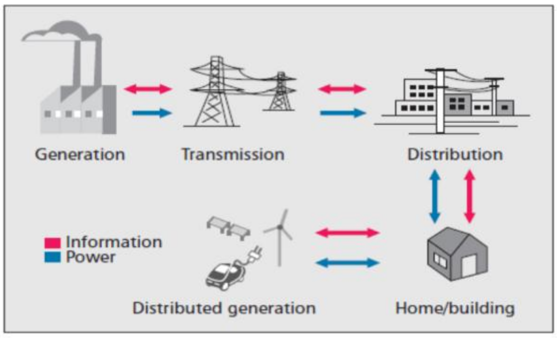

Fig.1: Smart Grid Challenges

As with anything, time will tell. But with a lot of work and a bit of luck, we can achieve extensible core architecture capable of growing and evolving as effectively as the Internet does today. Electric vehicle technology, albeit more expensive than conventional vehicles, is poised for entry into new markets. This will present a number of opportunities and advantages, given that the right policies and complementary standards (including fuel quality standards) are in place and policy makers, industry groups, consumers, and vehicle maintenance providers are sufficiently informed and have realistic expectations of technology. It is also important to consider that are not the only clean vehicle option available today. Cleaner diesel vehicles, compressed natural gas vehicles, and vehicles that run on liquid biofuel blends are also viable alternatives for reducing air pollution and greenhouse gas emissions. In addition, electric vehicles are not necessarily fuel specific;

this technology is versatile and can be applied to natural gas, diesel and flexi fuel vehicles.

II. MODELING OF GRID CONNECTED EFFICIENT AND EFFECTIVE ECO-FRIENDLY VEHICLE

A. *Block Diagram:*

The principle parts and functions of grid connected efficient and effective eco-friendly vehicles are explained in this session. A bock diagram is a specialized, high-level type of flowchart. Its highly structured form presents a quick overview of major process steps and key process participants, as well as the relationships and interfaces involved. A block diagram is a useful tool both in designing new processes and in improving existing processes. In both cases the block diagram provides a quick, high-level view of the work and may rapidly lead to process points of interest. The block diagram is shown in Fig.2.

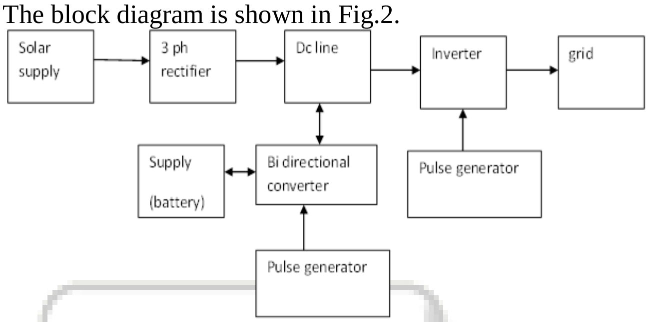

Fig. 2: Block Diagram of Grid Connected Eco Friendly

B. *Components of Block Diagram:*

Rectifier: A rectifying circuit is one which links an AC supply to dc load, that is, it converts an alternating voltage supply to a direct voltage. Here the rectifier used is a full bridge rectifier.Bi-Directional Converter: A bi-directional converter is a device which converts alternating-current power to direct-current power and vice-versa. The converter is based on a cascaded buck-boost structure with active snubber circuits in order to achieve zero voltage and zero current transition, showing high efficiency. Pulse Generator: A pulse generator is either an electronic circuit or a piece of electronic test equipment used to generate rectangular pulses. Simple bench pulse generators usually allow control of the pulse repetition rate (frequency), pulse width, delay with respect to an internal or external trigger and the high- and low-voltage levels of the pulses. More-sophisticated pulse generators may allow control over the rise time and fall time of the pulses. Pulse generators are available for generating output pulses having widths (duration) ranging from minutes down to under 1 picosecond. Pulse generators are generally voltage sources, with true current pulse generators being available only from a few suppliers. Pulse generators may use digital techniques, analog techniques, or a combination of both techniques to form the output pulse.

1) *Inverter:*

A power inverter, or inverter, is an electronic device or circuitry that changes direct current (DC) to alternating current (AC).The input voltage, output voltage and frequency, and overall power handling depend on the design of the specific device or circuitry. The inverter does not produce any power; the power is provided by the DC source. A power inverter can be entirely electronic or may be a combination of mechanical effects (such as a rotary apparatus) and electronic circuitry. Static inverters do not use moving parts in the conversion process.

C. *Working*

Initially supply is taken from the solar supply. Then the rectifier circuit converts the AC to DC supply and the output is filtered and given to the bi-directional converter and then it is supplied to the inverter and then to the grid. The excess charge is either supplied to the grid or the adequate charge is taken from the grid .

III. BATTERY CHARACTERISTICS

Given a constant discharge current, any battery's state of charge (SoC), , may be described with reference to its capacity by

$$S(t)=1- i_d\, t /\ 3600C^a \qquad (3.1)$$

Where

I_d discharge current in Ampere;
C^a available capacity in Ampere-hour (Ah);
t time in seconds.

According to the Peukert equation, the available capacity of the battery, C^{ta} , is modelled as

$$C^{ta} = i_d\, C^P / (i_d)^k \qquad (3.2)$$

Where

C^P Peukert capacity of the battery in Ah;
K Peukert exponent typically between 1.1–1.3.

Both C_p and k are fixed parameters with respect to a given. The Peukert capacity, C^p, is computed as

$$C^P = T\, (C^N / T)^k \qquad (3.3)$$

Where

C^N nominal capacity in Ah;
T nominal capacity in Ah;
C^N/T the nominal discharge current in Ampere.

The value of the Peukert exponent in (3.2) for a specific battery can be derived by experimental test and the lower the Peukert exponent, the better the performance of the battery (K=1 is used to model the ideal battery). For a battery rated at 100 Ah for 5 h discharge time and a Peukert exponent the available capacity decreases from the 158.5 Ah to 87.1 Ah when the discharge current increases from 0.1 C/5 (2 A) to 2 C/5 (40 A), as shown in Fig. 3.

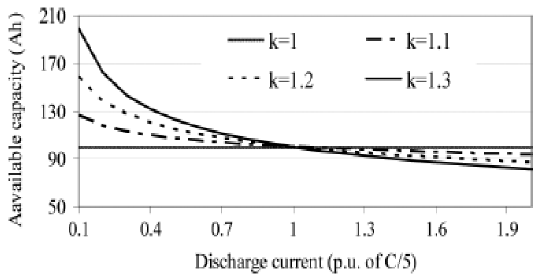

Fig. 3: Effective Battery Capacities At Different Discharge Currents, 100 Ah At 5h

The battery no-load voltage is also a nonlinear dynamic variable. Fig. 3, shows the variation of voltage for different types of battery (all nominal values of 240 V, 100 Ah), at a discharge current of 1.5 C/5 (30 A) with respect to time.

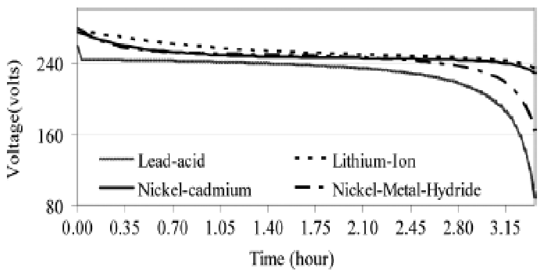

Fig. 4: Battery Voltage Versus Time Of Use, For A Range Of 240 V /100 Ah, Batteries At A Discharge Current Of 1.5 C/5 (30 A).

To derive the charge/discharge energy during a specified time interval, the dynamic battery voltage must be first discretized by extracting the data from the discharge/charge curve of the battery. Since detailed information on the discharge/charge curves at different current levels for actual EV batteries is limited, this paper uses the simplified generic rechargeable battery model described by Tremblay, Dessaint, and Dekkiche .

IV. SIMULATION AND ANALYSIS OF EFFICIENT AND EFFECTIVE GRID CONNECTED ECO-FRIENDLY VEHICLES

Simulation and analysis of high gain soft switching bi-directional dc-dc converter for eco-friendly vehicles is demonstrated using MATLAB Simulink software. Each and every component is designed using MATLAB/SIMULINK and Sim Power System software package to verify the effectiveness of the system.

A. Matlab Simulation of Forward Direction:

The interleaving technique can be applied to reduce the size of passive components and current stresses. A 5-kW prototype of the two-phase interleaved version of the proposed converter shown in Fig. 5.1 was built according to the following specification: Po = 5 kW, fs = 30 kHz, VH = 400 V, VL = 72–100 V, Lf = 130 μH, La = 13 μH, Ca = 30 μF, $C1$=$C2$ =470 μF.

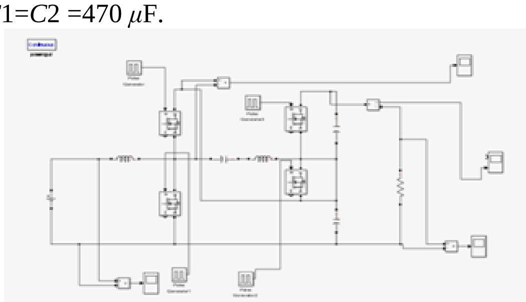

Fig. 5: Simulation Circuit for Forward Direction

A. Waveforms of Forward Direction:

Below shows the input and output voltage waveform of forward direction.

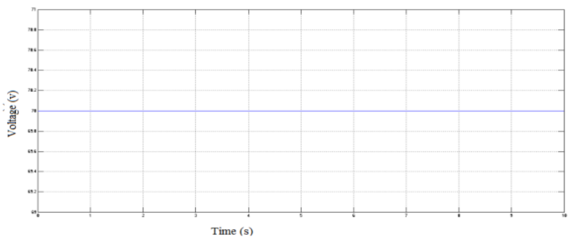

Fig. 6: Waveform of Input Voltage

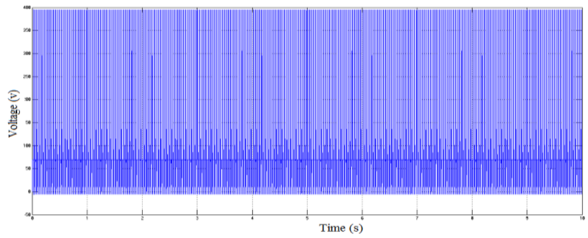

Fig. 7: Waveform Of Output Voltage

B. Matlab Simulation of Reverse Conduction:

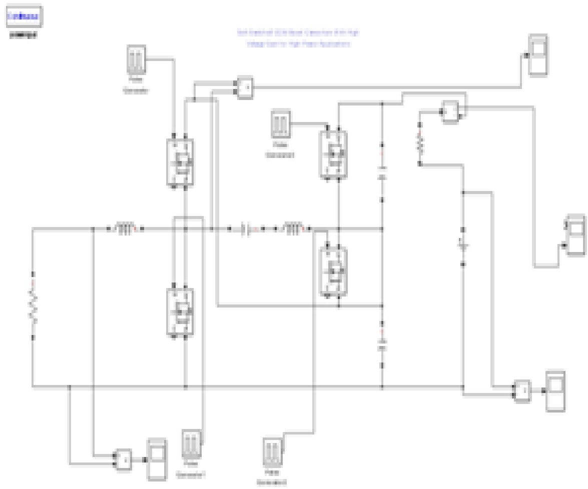

Fig. 8: Simulation Circuit for Reverse Direction

C. Waveforms of Reverse Conduction:

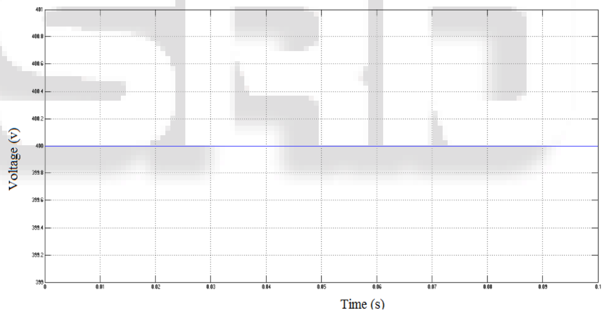

Fig. 9: Input Waveform of Input Voltage

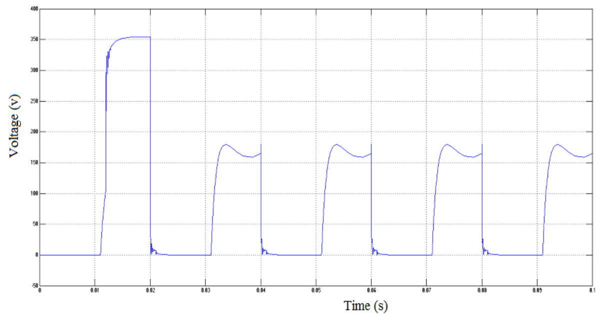

Fig. 10: Output Waveform of Output Voltage

D. Modified Grid Connected Matlab Simulation Circuit:

The Simulink model used for the implementation of modified high gain soft-switching bidirectional dc–dc converter for eco-friendly vehicles.

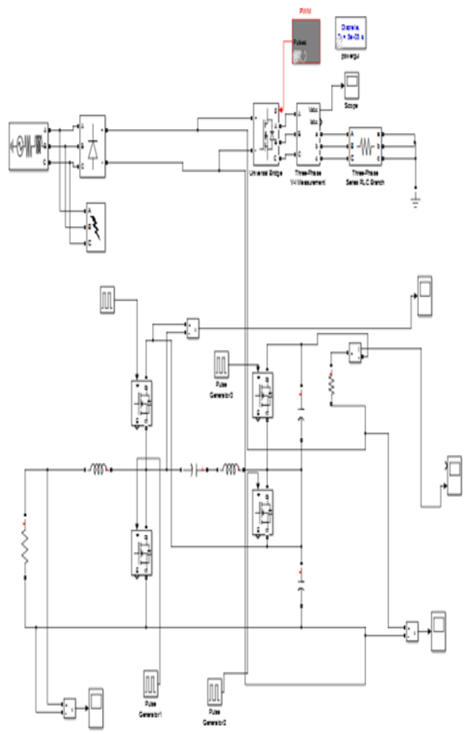

Fig. 11: Modified Grid Connected Simulation Circuit for Forward Direction.

E. Input Waveforms for Grid Connected Forward Conduction:

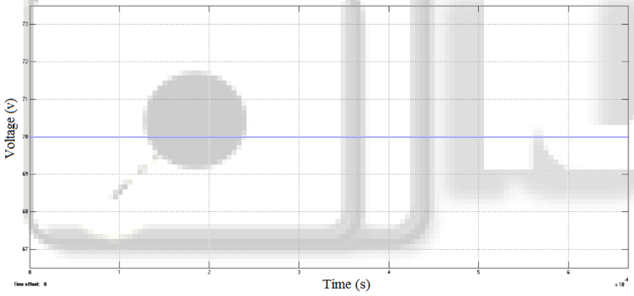

Fig. 12: Waveform of Input Voltage

F. Output Waveforms of Grid Connected Forward Conduction:

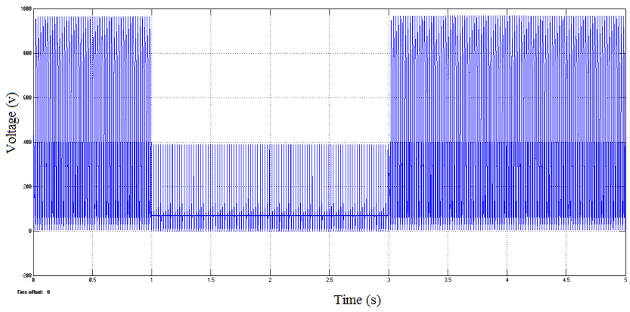

Fig. 13: Waveform of Output Voltage

G. Modified Grid Connected Matlab Simulation of Reverse Direction:

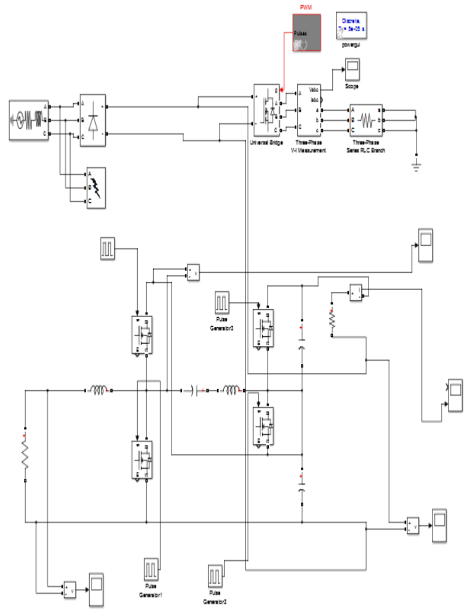

Fig. 14: Modified Simulation Circuit for Reverse Direction

H. Input Waveforms of Reverse Directions:

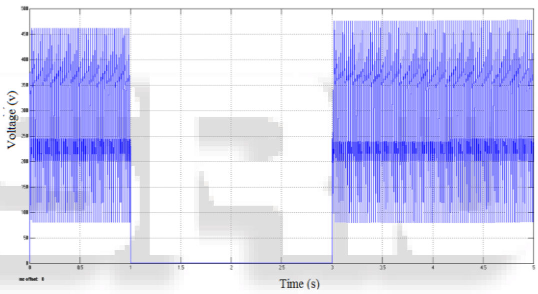

Fig. 15: Waveform of Input Voltage

I. Output waveforms of Reverse Direction:

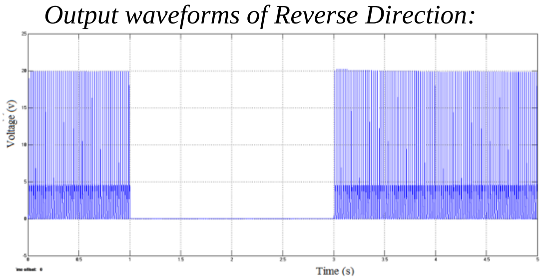

Fig. 16: Waveform of Output Voltage

J. Grid Voltage Waveform:

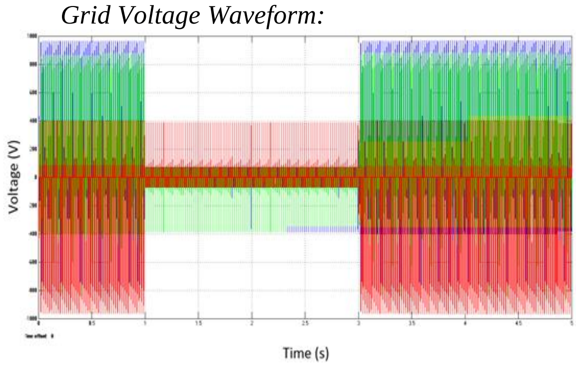

Fig. 17: Voltage Waveform of Grid

It is seen that there are no transients caused by change of switching patterns during the mode change. The measured efficiencies under different LVS voltage conditions in forward and reverse modes.

V. COMPARISON

The comparison of the proposed converter circuit and modified converter circuit is analysed and found out that, in the modified converter circuit the regenerative capability is being improved and net efficiency of the eco-friendly vehicle is improved to a higher level.

Electric vehicle batteries store energy when they are charged and release the energy when discharged. Apart from their intended main use for transportation, electric vehicles can serve as a rapid response load, or even as a generation source, for the power grid when they are parked, plugged into the grid and V2G enabled. However, the utilization of such storage energy from the electrical vehicle battery to power grid and vice versa is constrained by the battery state of charge and vehicle use requirements.

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