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Neutral Point Clamped Converter (NPC) based Electric Vehicle Charging Station with an Energy Storage System

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ABSTRACT: This paper proposes a new balancing approach for the bipolar charging station of an electric vehicle at a megawatt level, which is provided by means of a fixed neutral point-to-point converter linked to a grid. The work uses the existence of a phase of energy storage with access to both DC buses for additional balance. It offers a common balancing structure that can provide a balance regardless of the ESS used. This is done to reduce the hardware requirements of the system and maximize the use of ESS, the main function of which is to perform tasks related to power management. To achieve this goal, a three-level dc-dc interface is used, which allows to compensate DC currents with one ESS. In addition, to prevent the appearance of harmonics of even order in the input current during asymmetrical operation, an alternative switching sequence for the central converter is proposed. The results show that without a significant change in the ESS charging process, it is possible to cover the entire load scenario without the need for balancing. This allows you to use finished products for both the rectifier and fast chargers. This article presents simulation results and experimental results to justify the proposed balancing strategy.

KEYWORDS: Bipolar dc bus, electric vehicles, energy storage stage, fast charger, power balance management, dc-dc converter MATLAB.

I. INTRODUCTION

ELECTRIC VEHICLES WITH PLUGGING, considered in this category for both electric hybrid vehicles and vehicles with electric batteries, have become the most likely successor for vehicles with conventional internal combustion engines. During these last years, the sales of these vehicles have increased constantly and it is expected that they will remain in this trend for the next years [1], [2]. Despite the growing fleet of electric vehicles (EV), these vehicles still have to solve some deficiencies before becoming a real alternative to transport. The long battery recharging process, the limited mileage capacity (typically below 200 km) and the lack of fast charging public infrastructure are the main barriers to widespread use [3]-[5]. However, to allow a large-scale penetration of this technology, changes are also required from the point of view of the grid, since the demand for electricity will grow accordingly [6]. Nowadays, there is no real threat to the public network, since the automotive industry comes mainly from the gasoline supply chain, but will gradually move to a higher consumption of electricity for transport purposes, and if it is not adequately addressed, the current electric system will not be able to meet this demand [2],[7].

To address the impacts of large-scale adoption of these vehicles in public service systems, several studies have been carried out [8]-[12], based mainly on the conventional slow charge process of batteries. This is mainly due to the fact that conventional charging is expected to remain the preferred charging method, and also the fast charge process of EV batteries is not a widespread practice among owners, due to the lack of facilities and Misconceptions about the impact of this process on the battery pack. However, rapid loading methods remain essential for a large-scale adoption of EV, as they will provide more flexibility to drivers, occasional longer trips that address range anxiety. In addition, to reduce the consumption of public network energy during peak consumption times, the presence of ESS in these stations is

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gaining attention. An alternative to allow fast charging is in the form of fast charging stations, which refers to the concept of having high-powered fast chargers installed off-board, similar to service stations located in public places. The structure of these charging stations can be with an AC bus, where each load unit is powered by its independent AC stage, or each unit connected to a common DC bus enabled by a single AC stage with higher levels of power. Power. Currently, fast charging is only enabled by independent units, each with its independent rectifier stage using the ac bus concept. However, considering the nature of the cd of the loads, the common DC bus configuration appears as the viable solution, and also has advantages in terms of cost, efficiency and size, since fewer energy conversion stages are needed. In addition, this structure facilitates the integration of distributed generators or energy storage systems (ESS). The central converter stage plays a fundamental role in this charging architecture, and it is convenient to provide various functions such as low distortion operation, high power capacity, fully adjustable power factor, reduce the size of the input filters, while It presents a reduced number in both assets and passive components. Among the alternatives, the conventional two-level voltage source converter may arise, however, it has a limited capacity to meet the power ratings, power quality and efficiency requirements due to the voltage / current limits of the power supply semiconductors. Other works propose the use of a 12-pulse diode bridge rectifier, improving its harmonic performance through the use of an active filter stage. However, the lack of control of the power factor and its unidirectional power flow capacity. Section IV presents experimental results showing results of images tested. Finally, Section V presents conclusion.

II. LITERATURE SURVEY

D. Aggeler, F. Canales, H. Zelaya-De La Parra, A. Coccia, N. Butcher and O. Apeldoorn, "Ultra-fast CC Load Infrastructure for EVMobility and Future Smart Grids", in IEEE PES Innov. Smart Grid Technol. EUR. (ISGT), Gothenburg, Sweden, October 2010, pp. [3]

Today, Power Electronics (PE) is increasingly entering technology that traditionally belongs to different engineering disciplines. E-mobility is one of these. In fact, Power Electronics is emerging as an emerging technology to improve sustainable mobility, addressing all aspects of engineering, from the distribution of energy for loading purposes to the transformation of energy on board vehicles related to traction. This document, in particular, focuses on newly developed PE infrastructure technologies that allow for rapid battery charging processes. Depending on the battery and the type of vehicle, you can easily achieve a sufficient recharge for a journey of more than 100 km in less than 10 min. As battery technologies progress continuously, recharging will be available with the speed and simplicity of today's fuel stop.

Two PE converter architectures will be presented and discussed for the recharging of infrastructure applications based on low frequency (LF) and high frequency (HF) insulation requirements. The technical evaluation of the two different technologies will be addressed and presented, including a pro and con analysis. The impact on the network is studied by means of simulation with the assumption of a fast CD loading station placed in a rural area of Sweden.

J. Gomez and 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 [9].

In this document, we test the entire process of charging a single external charger at a charging station in Beijing. Among the test data, we chose the typical power quality parameters and compared them with the national standard. Then we draw conclusions as follows: 1) the battery of the electric vehicle is the capacitive load. You can export reactive power when it is loaded. 2) In the charging process of the external charger, the indicators of voltage deviation, frequency deviation, power factor and voltage distortion speed are qualified. 3) The external charger produces strange harmonics in the charging process, and with the increase of the harmonic order, the harmonic content is reduced. There is a certain amount of high order harmonics in the external charger, distributing mainly around 6650 kHz. 4) Harmonics generated from the real device, the harmonic is mainly reflected in the current, the voltage, only a small distortion.

Exemplar based Inpainting technique is used for inpainting of text regions, which takes structure synthesis and texturesynthesis together. The inpainting is done in such a manner, that it fills the damagedregion or holes in an image, with surrounding colour and texture. The algorithm isbased on patch based filling procedure. First find target region using mask image and then find boundary of target region. For all the boundary points it defined patch andfind the priority of these patches. It starts filling the target region from the highestpriority patch by finding the best match patch. Thisprocedure is repeated until entire target region is inpainted. The algorithm automatically generates mask image without user interaction that contains only text regions to be inpainted.

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J. Sexauer, K. McBee, and K. Bloch, “Applications of probability model to analyze the effects of electric vehicle chargers on distribution transformers,” *IEEE Trans. Power Syst.*, vol. 28, no. 2, pp. 847–854, May 2013 [11].

The aim of this paper is to avoid overloading a private customer distribution transformer (DT) in a Portuguese insular area through the means of solar PV micro generation. Firstly, the consequence of the penetration of electric vehicles (EV) on dielectric oil deterioration of a DT in an industrial unit is estimated. The workplace has local PV generation, allowing the EVs to charge while their owners are working at three different working shifts during a day. Secondly, the model is tested and the resulting scenarios are analyzed. This paper shows that the solar PV micro generation decreases the overloading of the DT due to a lower daily load profile. It also contributes to the reduction of the loss-of-life (LoL) of the DT.

P. Fan, B. Sainbayar, and S. Ren, “Operation analysis of fast charging stations with energy demand control of electric vehicles,” *Smart Grid, IEEE Transactions on*, vol. PP, no. 99, pp. 1–1, 2015 [12].

The growing, though still nascent, plug-in electric vehicle (PEV) market currently operates primarily via level 1 and level 2 charging in the United States. Fast chargers are still a rarity, but offer a confidence boost to oppose “range anxiety” in consumers making the transition from conventional vehicles to PEVs. Because relatively no real-world usage of fast chargers at scale exists yet, the National Renewable Energy Laboratory developed a simulation to help assess fast charging needs based on real-world travel data. This study documents the data, methods, and results of the simulation run for multiple scenarios, varying fleet sizes, and the number of charger ports. The grid impact of this usage is further quantified to assess the opportunity for integration of renewables; specifically, a high frequency of fast charging is found to be in demand during the late afternoons and evenings coinciding with grid peak periods. Proper integration of a solar array and stationary battery pack thus helps ease the load and reduces the need for new generator construction to meet the demand of a future PEV market.

III. PROPOSED METHODOLOGY AND DISCUSSION

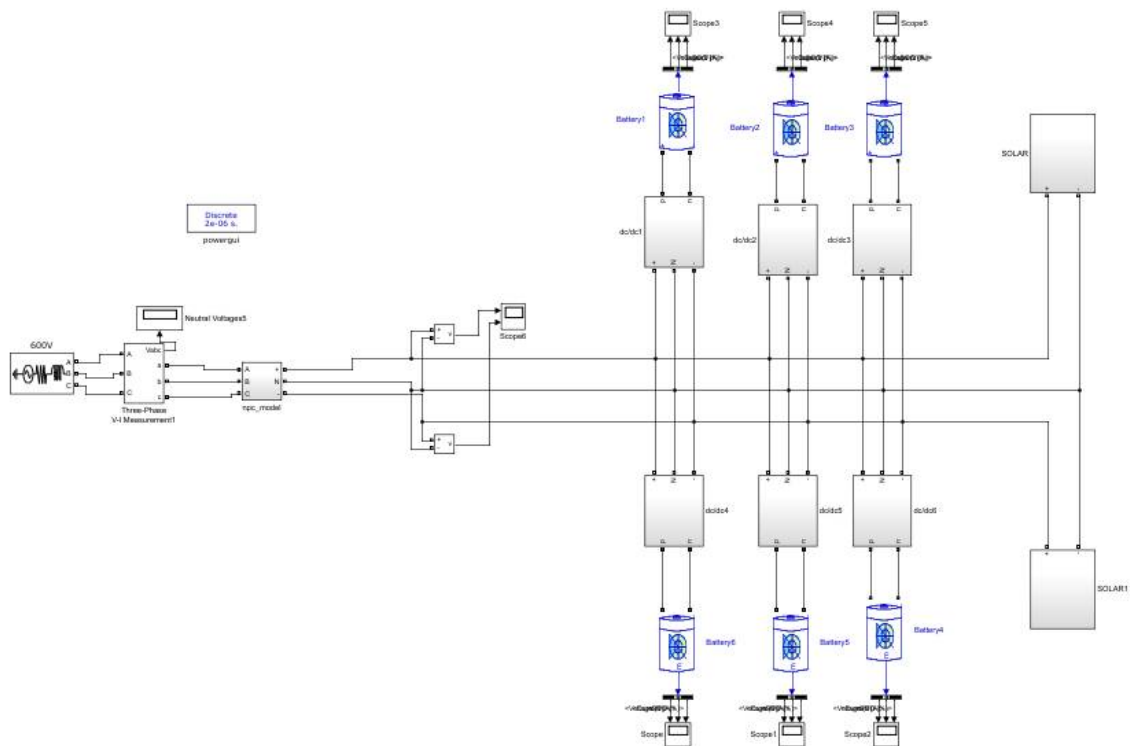


Fig.1 Proposed architecture of NPC based electric vehicle charging system with energy storage system.

The above figure represents the architecture of NPC based electric vehicle charging system with energy storage system. Circuit is designed and analysed using a MATLAB v2017 software. Here energy storage system is used as battery for

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storing the energy. Here the AC input is generated using the signal generator unit then it is passed through the NPC converter where the AC signals are converted into DC. Then the voltage is passed through the dc bus line and dc/dc port will receive the voltage and charges the energy storage system at the output of dc/dc port.

- Switching devices - converter is modelled on the IGBT / diode pairs motion WM firing pulses produced by the generator. This model provides the most accurate simulation results.
- Switching function - a role model converter is modelled, mutatis mutandis. The two sources and two diodes are replaced at the wedding as a stimulus on the side AC voltage and current sources in the two side 600. And the converter is controlled by firing pulses produced by the generator WM (0/1 signals) firing pulses chat or in a predetermined time (WM averaging between 0 and 1 signals). The modes of operation normally produce harmonics generated by the WM converter and a well-controlled operation and then pretend to establish blanking it. This model is well-suited to the type of real-time simulation.
- Average model (Uref controlled) - converter and, mutatis mutandis role model used directly controlled by the reference voltage signals (Uref). Wm a sire he is not required. This class provides the fastest simulation process model. This is not a precedent for the notion of neither the equilibrium of the point of the voltage.

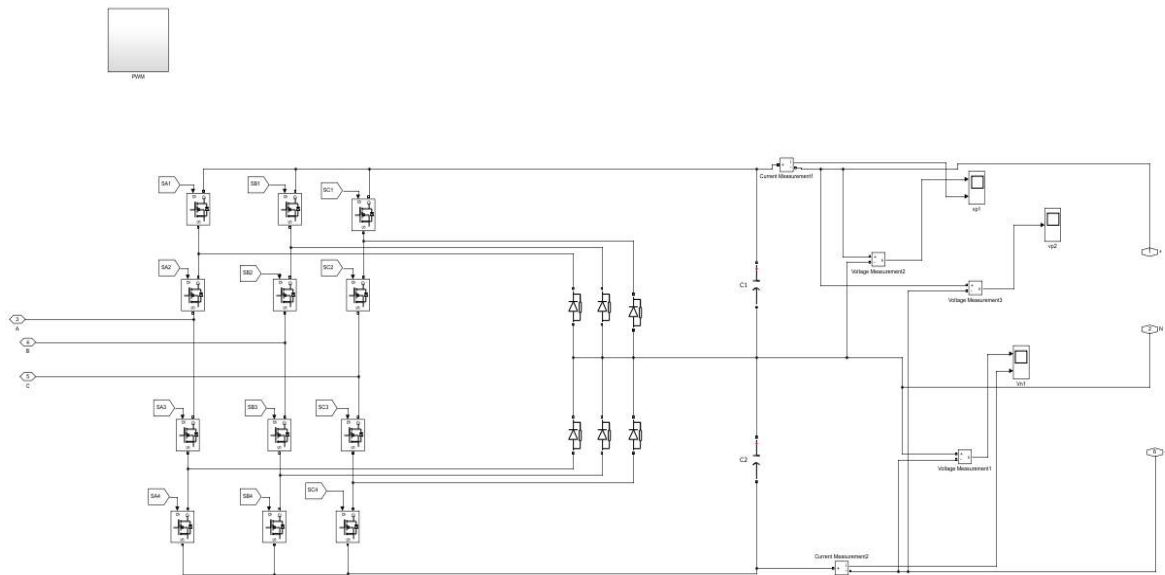


Fig 2. NPC converter

The figure 2 represents the neutral point converter three-stage voltage source converter. The NPC topology has been adopted for high performance applications because it can achieve better harmonic reduction than conventional two-stage voltage source converters and the associated control strategies help minimize semiconductor losses. This model is designed to deliver power from a dynamic DC source to a 50 Hz, 600 base voltage network.

Advantages of using NPC converter :

- Neutral point the fixed topology will have a lower ripple of the output current and half of the output voltage.
- This will reduce the effort for filtration and insulation in the filter inductor.
- The DC voltage is divided into positive and negative voltage, which supports the serial connection of DC capacitors without the need for compensation of leakage current.

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The output side for storing energy storage nickel metal hydride battery is used, the advantages of using this types batteries are:

- Capacity 30 to 40% higher than standard Ni-Cd.
- The nickel metal hydride battery has the potential for even higher energy densities.
- Less subject to memory than Ni-Cd.
- Periodic exercise cycles are required less often.
- Simple storage and transport - transport conditions are not subject to regulatory control.
- Environmentally friendly - contains only mild toxins; and
- Cost effective for recycling.

IV. EXPERIMENTAL RESULTS

Specifications:

Table 1: Parameters values of Supply

Phase to phase voltage	1200V
Base voltage	600V
X/R ratio	7

From the above table the parameter values if the supply is set during the performance of the simulation circuit that is for figure 1.

Table 2: Parameters values of Nickel metal hydride battery

Nominal voltage	120V
Rated capacity	1000Ah
Initial SOC	50
Battery response time	30s

From the above table 2 the parameters values are entered for the battery at the output side of the simulation circuit in figure 1.



Fig 3. NPC output

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The above figure 3 represents the output of the NPC whose x-axis is voltage and y-axis is time

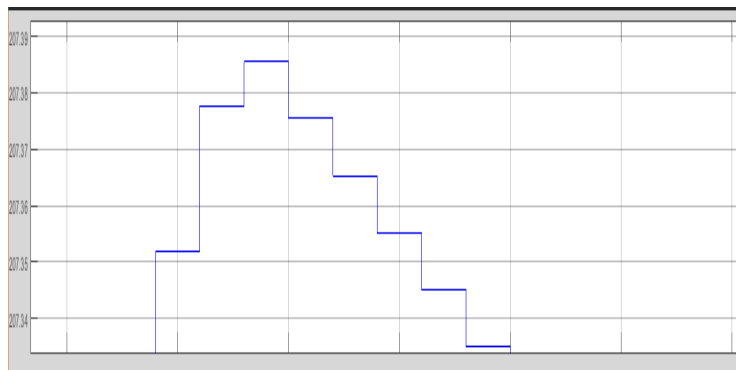


Fig 4. Dc/dc output

The above figure 4 represents the output of the dc/dc port x-axis represents the voltage and y-axis represents the time

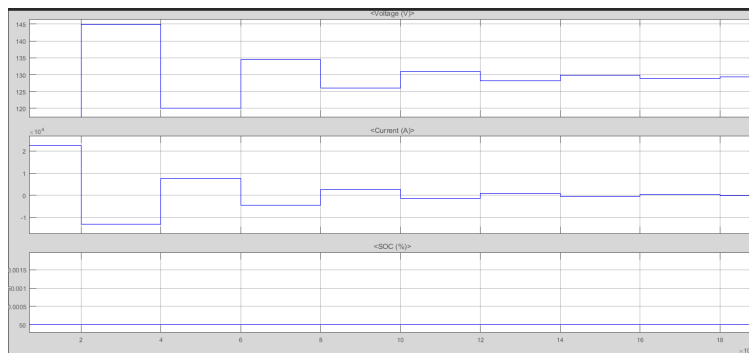


Fig 5. Battery output

The above figure 5 represents the output of the battery here in first window represents output voltage, Second window gives the output current and third window represents the state of charge of the battery.

V. CONCLUSION

Architecture for energy storage system using neutral point converter splitting of the dc bus bars and storing energy using battery for the use of electric vehicles is designed using required software and circuit is made to run and results are validated. Using of splitting bus dc bus bars is the advantage so that we can utilize both positive and negative voltages to charge up the system. Interfacing dc/dc bus with energy storage system helps in elimination of balancing leg which leads to the reduction of the cost of charging architecture. Using of two solar cells which are connected to the bus provides backup for the ESS if any problem in the generating side.

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