A REVIEW ON METHOD FOR ELECTRIC VEHICLE BATTERY CHARGER

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Abstract

In the field of economic and environment, electric vehicles are a new and advance technology in the transportation sector and power sector which have many benefits. The below study gives a detailed review and evaluation of many types of electric vehicles and also its related equipment in a specific charger and charging station. This technological infrastructure includes apparatus of common hardware of every station, namely: PV array, dc-dc converter provided with MPPT control, energy storage unit, bidirectional dc charger and inverter. We examine, evaluate and estimate many valuable researches that contain the design and control of PV-EV charging system. Furthermore this brief summary gives the information about the studies that includes charging standards, the power converters topologies that focuses on the approval of vehicle-to grid technology and the control for both PV-grid and PV standalone DC charging systems.

Keywords: PV array, dc-dc converter, Electric vehicles, Fuzzy Controller, DC charging systems

I. INTRODUCTION

An increase in the oil price and issues of environment its has been seen that there is an increase in the interest of technologies of clean vehicle such as EV and Fuel EV. Electric vehicles(EV) are becoming more attractive solution than conventional vehicles (CV). EVs are power driven by electric batteries, which needs to get recharged by electricity grid. It is clear that the EVs constitute a proper connection between the electricity and the transport sectors. Moreover, the EVs can provide a proper solution to decrease the effect of environmental transportation and dependence of energy because they have low energy utilization and zero emissions [1].

Usually there are only two types of battery chargers which are used: off board and on-board battery chargers with one and two way direction power flow. From the utility grid most of the battery chargers takes power,thisis the reason that they often termed as unidirectional battery chargers (UBCs). Unidirectional charging decreases the issues of interconnection and battery degradation. On the otherside , some battery chargers work in two direction and these are called bidirectional battery chargers (BBCs). These chargers support stabilization of power with proper power conversion. On-board chargers can be used at the workplaceas it charge from the utility outlet or household plug or shopping malls at day time. Off-board charging is like a gas station used for conventional vehicles and thus its purpose is to charge fast. Compared to off-board charging, equipment is less for on-board charging.

A. Electric vehicle battery charger

In current years the "range anxiety" problems are linked with electric vehicles (EVs) which have been reduced by the hybrids introduction (HEVs) and plug in hybrids(PHEVs) and the growth of higher energy density batteries wich are able to store more energy in the same place. As the electric vehicles are getting more popular "range anxiety" are getting replaced by "charging anxiety". This sheet covers the issues which are related with providing suitable charging infrastructures which is very important to maintain the growing population of EVs.

B. *Types of Electric Vehicle Battery Charger*

There are mainly three types of electric vehicles (EVs) which are divided on the basis of electricity which are used by the sources of energy. These are as following: BEVs or battery vehicles, PHEVs or plug-in hybrid electric vehicles and HEVs or hybrid electric vehicles. Only BEVs have the capability of charging on the 3rd level i.e. DC fast charge.

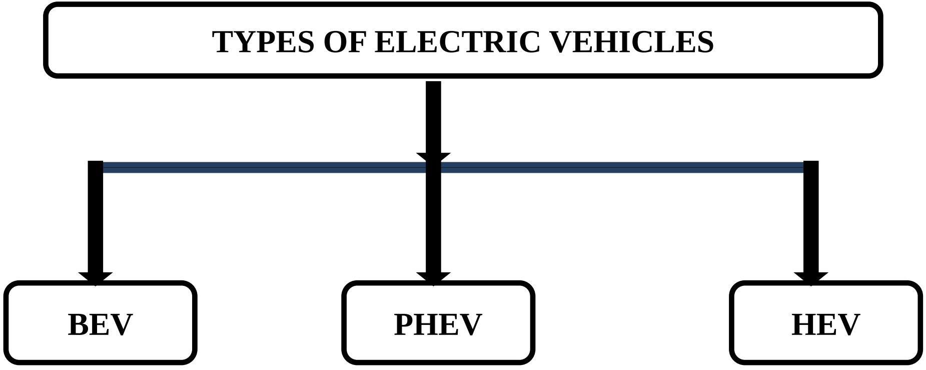

Fig. 1. Types of electric vehicles

II. LITERATURE REVIEW

R. Kushwaha et al., [1]This work is all about the design and execution of a new charger an electric vehicle which is operated by the battery. In the planned pattern, the conventional diode converter at the end of existing source EV battery charger is removed with the customized Landsman power factor correction(PFC) converter. The PFC converter falls down to an isolated converter, which produces the EV battery control to charge it, firstly in regular mode of current and then in regular voltage mode.The prior PFC converter is used to control single sensed entity to get the robust regulation of dc-link voltage and to make sure the unity power factor operation. The planned topology provides an improved power quality, low device stress; and low input and output current wave with low input current harmonics when balanced to the standard one. Besides to show the conventionality of the planned charger to an IEC 61000-3-2 standard, a sample is made and tested to charge a 48 VEV battery of 100 Ah capacities, under transients in input voltage. The performance of charger is found to be suitable in all the situations.

M. Gjelaj et al., [2] In general, the us e of electric vehicles (EVs) needs an investigating effects of vehicles which gets charge on power systems. This study brings focus on the new DC fast-charging station's design for EVs which are joint by the local battery energy storages (BESs). Due to the BESs, the DCFCS are able to disconnect the highest load demand which is caused y multiple EVs and low down the installation costs and the connection fees. The charging system is prepared with a two way direction alternating current/direct current(DC) converter, two lithium-ion batteries and a DC/DC converter. The introduction of BES with DCFCS is examined with regard to operational costs of the CSs and also the ability of a BES to alleviate the negative impacts on the power grid during the clogging hours. The planned solution is used to reduce the installation costs as well as charging time and also it provides addition of fast chargers in an existing low voltage grids. A cost-benefit analysis is performed to estimate the financial feasibility of BES within the DCFCSs by taking into consideration the installation costs, grid connection costs and battery life cycle costs.

A. Tayloret al., [3]"The two perfect candidates of wide-band gap devices, SIC MOSFETs and GAN HEMTs are considered as a substitute of Si devices in the medium of high voltage (>1200) and low voltage (<650 V) domains, in order to thanks to their outstanding switching presentation and thermal ability. SIC MOSFETs and GAN HEMTs, are the two technologies which are in a direct competition in the domains which are <650 V, for instance 2 level battery chargers for electric vehicles (EVs). This research gets applicable on 650 V SIC and GAN to two 240 VAC/7.2 kW EV battery chargers, in that order, aiming to make available a head-to-head relationship of these two devices in terms of generaleffectiveness, power density, thermal performance, and cost. Basically the charger is an indirect matrix converter which have a dual active bridge stage which handles the power factor correction and deliver the power at the same time. The two chargers uses the same control strategy, which varies from phase shift and frequency of switching to cover the wide input range (80- 260 VAC) and wide output range(200V- 450VDC). The results show the same level of efficiency, the GAN charger is smaller, much more effective and also at very low cost, whereas the SIC charger has a better thermal performance."

M. Truntič et al., [4]"According to him, the structure of a converter which is meant to charge batteries are comprise of EV. The geometry is achieved by changing the uniform 3- phase inverter, which are now present in the framework of capacity train EV. While the semiconductor parts of the motor inverter's and electric motor's winding structures the charger circuit of battery, a decrease in the power train's system's size and weight is available. The proposed totally planned battery charger chips away at the other deliver two modes, buck and lift, while giving power factor (PF) cure limit constantly. Likewise this inspection proposes an information controlling current system which guarantees the smooth working mode changes, which takes place during the battery charger action. Inside the microcontroller, the control is totally executed and also guarantees the movement with a high PF and low hard and fast compatible bending of the data current. The information of the converter which uses the control plot was probably checked."

S. Faddelet al., [5] "The saturation of EVs may probably increase in the future.

When the EVs are more on the road, on the power systems more loads are added which will affect the system voltage and loading. This work helps to study the effect of EVs on the distributed system which provides an automatic controller which fulfils the requirements of customer's and also decreases the negative effects of charging of EVs on the system. The controller takes into mind the voltage of the system and the customer's requirements and also the stage at which the battery is charged. By using the MATLAB Simulink which is a large-scale distribution the controller is tested. By using a small-scale four-bus experimental system the controller is validated. The controller is tested in the existence of DG units by showing the interference between local distributed generations(DGs) with electric vehicle charging. The outcomes reflect the better and greater performance of the controller in charging the EVs smoothly and by slowing down the negative effects of the grid."

G. Hilton et al., [6] High rate electric vehicle chargers (HREVCs) are essential for achieving the advantages to reduce CO2 and particulate release promised by EVs by authorizing the distance journey which are greater than the varieties of vehicles. A method for forecasting the estimated pattern of demand HREVCs are shown in this work. As it is important to plan the network chargers.

J. Lu et al., [7]This work presents a method for efficiency estimation of boost-derived continuous conduction mode power factor correction (CCM-PFC) converters for electric vehicle (EV) onboard chargers. The proposed methodology incorporates converter nonidealities, especially caused by magnetic components. The value of magnetizing inductance in an inductor or transformer core does not remain constant over variable current levels, which causes nonuniform power losses at different current levels. The method proposed in this work considers a time-variant inductance over various current levels and accordingly establishes a dynamic model of loss estimation. As a proof-of-concept verification, the approach is applied to three different PFC topologies for EV applications and the estimated conversion efficiencies exhibit good agreement with experimentally obtained efficiency values over a wide range of load power from 400 W to 4.6 kW. The deviation of the efficiency predicted from the experimental data is considerably.

J. Lu et al., [8] An indirect matrix converter is employed directly converting the grid ac to the battery voltage, with the dual-active-bridge taking care of the power factor correction and power delivery simultaneously. Such circuit is regarded as one candidate of the high-efficiency and high-power-density electric vehicle onboard chargers, if the double-frequency current ripple to the battery is tolerated. Instead of optimizing the overall charger, this work is focused on adopting variable switching frequency with multiple phase shifts to accommodate the wide input range (80-260 V_{ac}) and output range (200 V-450 V_{dc}). In addition to the phase shift between the transformer primary-side and secondary-side voltage, one extra phase shift is added to the primary-side H-bridge when the instantaneous input voltage is higher than the reflected output, otherwise, to the secondary side. The goal is to secure zero-voltage-switching for all switches at all voltage range. Such control strategy is further optimized incorporating with the switch parasitic capacitance and deadband settings. To further enhance the charger performance, GaN HEMTs are equipped to the on-board charger aiming at higher efficiency and higher power density than Si devices. Experimental results indicated that such charger with proposed control strategy embraces the peak efficiency of >97% at 7.2 kW and a power density of ~4 kW/L.

B. Lee et al., [9] According to this author, the work referred by any other candidate for two way direction dc/dc converter in electric vehicle on-board charger which is dependent on the PWM resonant converter (RC). The PWM-RC has a shifting ability but that's not sufficient for the two way direction applications because it always work under "buck type" operation in spite of power flowing directions. This problem can be solved by the method of structure change, which maximizes the gain converter into double.

N. Bodoet al., [10] A fully integrated on-board battery charger for future electric vehicles (EVs) has been recently introduced. It reutilizes all the propulsion components of an EV in charging/vehicle-to-grid (V2G) modes, it does not require any additional components or hardware reconfiguration, and charging/V2G modes are realized with zero electromagnetic torque production. Both fast (three-phase) and slow (single-phase) chargings are possible, with unity power factor operation at the grid side. The solution is based on the use of a triple three-phase machine and a nine-phase inverter/rectifier. This work reports on the results of efficiency evaluation for the said system. Testing is performed using both a nine-phase induction machine and a nine-phase permanent magnet machine for a range of operating conditions in charging/V2G modes, with both three-phase and single-phase grid connection. Additionally, the impact of converter interleaving on the losses and efficiency is also studied. Losses are separated for different subsystems, thus providing an insight into the importance of optimization of different EV power train components from the efficiency point of view. Promising efficiencies, in the order of 90%, are achieved although none of the system components have been optimized.

M. A. Awadallahet al., [11] This work presents a study of the impact of the electric vehicle (EV) charger load on the capacity of distribution feeders and transformers of an urban utility. A residential neighborhood of the city of Toronto, Canada, is selected to perform the study based on survey results that showed a high tendency for EV adoption. The two most loaded distribution transformers of such a neighborhood are studied along with their cable feeders via steady-state simulations in CYME software. A worst case scenario of full EV penetration is studied, where all chargers are connected to the system simultaneously at the peak summer or winter load. The effect of increasing the rate of EV adoption on the performance of distribution networks is examined with correlation to the ambient temperature. Finally, the impact of increasing the charger size on system performance is explored. The results send a few warning signals of potential equipment overload to utility companies under certain system loading and EV charging levels as EV use grows, impacting utility future planning and operation. This will assist utilities in taking appropriate measures with respect to operating the existing system and also planning for the future.

X. Wang, C et al., [12] It is expected that wide-bandgap devices like silicon-carbide MOSFETs and gallium-nitride HEMTs could replace Si devices in power electronics converters to reach higher system efficiency. This work adopts the conventional half-bridge LLC topology to realize a 10-kW all-SiC bidirectional charger used in electric vehicles. Though it is a well-known topology for the unidirectional charger, it has not been comprehensively explored for the bidirectional energy flow yet. A double-pulse-test (DPT) platform is utilized to provide accurate power losses. A state-space model is built to obtain accurate switching current waveforms, which is eventually combined with the DPT results to accurately predict the system efficiency. Based on this model, to further enhance the system efficiency, the dc-bus voltage is varied with LLC dc/dc converter running at the resonant frequency through the whole power range. Experimental results validated that the proposed approach could realize the bidirectional power flow. By varying the dc-bus voltage, the V2G and G2V modes reach ~96 % wall-to-battery efficiency.

M. S. Diabet al., [13] This work presents a new configuration for integrated on-board battery chargers of electric vehicles (EVs) incorporating symmetrical six-phase machines. The configuration proposes an exclusive utilization of a nine-switch converter (NSC) along with the machine windings during both propulsion and charging of EVs. The proposed configuration has the advantage of employing a reduced number of components in both the EV (on-board) and charging station (off-board), with the privilege of avoiding machine electromagnetic torque production during charging/vehicle-to-grid (V2G) mode of operation. During charging/V2G mode, the NSC is turned into a conventional three-phase pulse width modulation rectifier and is directly connected to the three-phase mains through the machine windings. Conventional three-phase transformers can be employed for galvanic isolation. Switching between propulsion and charging modes is carried out using a simple hardware reconfiguration. Control schemes for both propulsion and charging/V2G modes are elaborated, along with the principles of operation of the NSC. Experimental results are provided to validate the theoretical deductions for the different operating modes

S. Moon et al., [14] This work proposes a high-efficiency wireless power transfer system with an asymmetric four-coil resonator. It presents a theoretical analysis, an optimal design method, and experimental results. Multicoil systems which have more than three coils between the primary and secondary side provide the benefits of a good coupling coefficient, a long transfer distance, and a wide operating frequency range. The conventional four-coil system has a symmetric coil configuration. In the primary side, there are source and transmitter coils, and the secondary side contains receiver and load coils. On the other hand, in the proposed asymmetric four-coil system, the primary side consists of a source coil and two transmitter coils which are called intermediate coils, and in the secondary side, a load coil serves as a receiver coil. In the primary side, two intermediate coils boost the apparent coupling coefficient at around the operating frequency. Because of this double boosting effect, the system with an asymmetric four-coil resonator has a higher efficiency than that of the conventional symmetric four-coil system. A prototype of the proposed system with the asymmetric four-coil resonator is implemented and experimented on to verify the validity of the proposed system. The prototype operates at 90 kHz of switching frequency and has 200 mm of the power transmission distance between the primary side and the secondary side. An ac-dc overall system efficiency of 96.56% has been achieved at 3.3 kW of output power

I. Subotic et al., [15] The work considers integration of multiphase (more than three phases) machines and converters into a single-phase charging process of electric vehicles (EVs) and, thus, complements recently introduced fast charging solutions for the studied phase numbers. One entirely novel topology, employing a five-phase machine, is introduced and assessed jointly with three other topologies that use an asymmetrical nine-phase machine, an asymmetrical six-phase machine, and a symmetrical six-phase machine. In all topologies, both charging and vehicle-to-grid (V2G) mode are viable. Moreover, all are capable of unity power factor operation. A torque is not produced in machines during charging/V2G process so that mechanical locking is not required. Hardware reconfiguration between propulsion and charging/V2G mode is either not required or minimized by using a single switch. Theoretical analysis of operating principles is given, and a control scheme, applicable to all topologies and which includes current balancing and interleaving strategy, is developed. Finally, operation of all topologies is compared by means of experiments in both charging and V2G mode, with a discussion of influence of current balancing and interleaving strategy on the overall performance.

III. BATTERY CHARGING METHOD

The below structured diagram explains that how the key functions of level 1,2 and 3 chargers work. All the charging systems convert the AC power into DC power which is been taken from the grid at an appropriate voltage for charging the battery. In the EV application, Level 1 and 2 are totally contained in the vehicle except for the bicycles. However in the level 3 charging systems the functions are divided between the charging stations and vehicle on board charger.

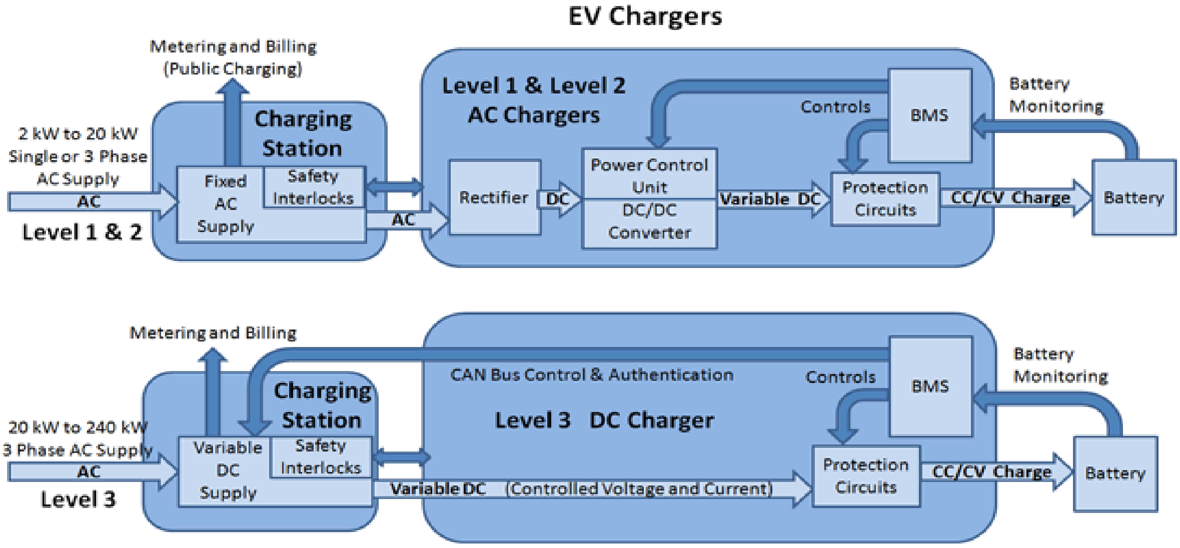

Fig. 2. Battery charging state

Presently there are total three standards of charger which are used for quick charging: CHADEMO, Combined Charging System (CCS) and Tesla Supercharger. The detailed information about this charging standards are shown below in the Table 1.

Table1 SPECIFICATION OF CHARGING STANDARDS FOR DC FAST CHARGING.

Properties	**CHAdeMO**	**Combo 1 (CCS)**	**Combo 2 (CCS)**	**Tesla supercharger**
		DC charging		
Max. voltage (V)	500	600	850	480
Max. current (A)	125	150	200	
Connector	CHAdeMO	Combo 1 (IEC 62196-3/SAE J1772)	Combo 2 (IEC 62196-3)	Special
Max. power (kW)	50	90	170	120
AC charging				
Voltage (V)		250	400 (3 phase) 230 (1 phase)	
Current (A)		32	63 (3 phase) 70 (1 phase)	
Max. power (kW)		13	44	
Others				
Charging signal	CAN	PLC		
Charging protocol	CHAdeMO	HomePlug Green Phy		Special

A. *Fuzzy Controller*

The structure of the fuzzy controller is shown in Figure 3. The fuzzy sets for the input and output variables are very negative (VN), negative (N), zero (Z), positive (P), and very positive (VP).

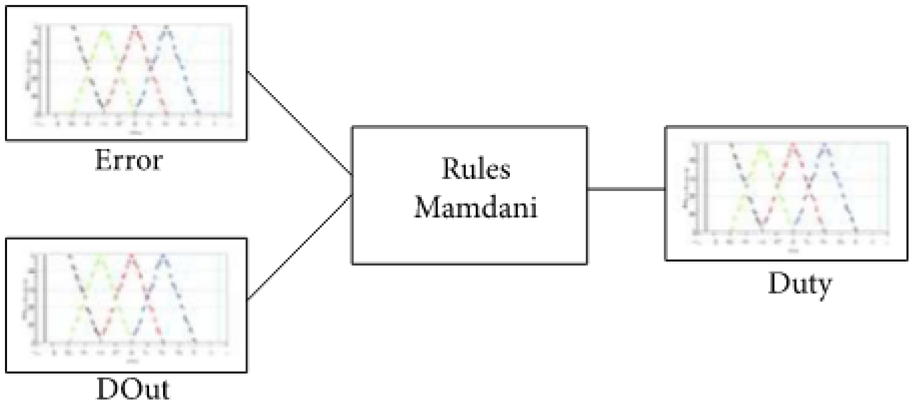

Fig. 3. Schematic representation of the structure of the fuzzy controller.

B. *Fuzzy logic controlled charging system with optimal frequency theory*

The frequencyof different charging results in different battery AC voltage and AC resistant of battery which is basically changed by different frequencies of charging. All the experiments has shown the best frequency of Li-ion battery charging which is the least of Ac impedance frequency FZ min. The occurrence of charging has a direct relation with the time of battery charging and the capability of charging , also on the least frequency of AC impedance the loss on the battery Z is minimized and then the energy charged is maximized, therefore the efficiency of battery charging is improved.

When by the optimal charging frequency fz min the battery is charged, the time of charging and its capability will get improved. In this research paper a SONY 18650 Li-ion battery is used to test and the time of charging and its capabilities are improved much better which is above 30.68% by using the fz min. By identifying the best charging frequency of a charged battery we will be able to charge the battery by best rate of switching which in this case is 2 KHz, thus it can enhance the charging system.

It should be noted that the process of charging the battery increase the temperature of battery and results in changing of resistance of battery; therefore the fzmin will change during the charging process and we will not be able to reach exact optimal frequency. Hence we get a temperature feedback of frequency producer in order to compare and produce the optimal new frequency to charge the battery with better efficiency and speed it up.

IV. CONCLUSION

Besides the shortage of fossil fuels and problems related to global warming have lead to an important change which is from internal combustion engine vehicles to Electric vehicles(EVs). This paper had gone throughout the battery charging infrastructure for the EVs and for the wired charging the charging and power infrastructure. A detailed study has also been done on the present standards which have been adopted for charging EV all over the world. For better knowledge on the EV art technology, a comparison is made on marketable and prototype EVs in the terms of electric range, battery size, charger power and charging time.

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