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Study And New Approach Electric Vehicle Charger Design With The Help Of Buck And Boost Converter

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Abstract: An Electric vehicle can be future trends Because of their rapid growth, electric vehicles (EVs) are expected to play a significant role in the global transportation sector's energy transition. The integration of high-level EVs into the electrical grid will present several difficulties for standards, safety, planning, operation, and stability of the power system. To meet the expected charging solutions for EV batteries and to enhance ancillary services, the widespread adoption of EVs necessitates research and development of charging systems and EV supply equipment (EVSE). In order to improve desired charging efficiency and grid support, find a remedy for any negative effects, and hasten EV adoption with sophisticated control strategies, it is critical to analyze the current state of EV charging technology. An extensive review of EV charging technologies is presented in this publication. worldwide standards, EV charging station layout, and EV charging system power converter combinations. To achieve optimal operation and improve grid support, the charging systems need a specific converter architecture, a control strategy, compatibility with standards, and grid codes for charging and discharging. An overview of several charging methods is assessed, including AC and DCbased charging station layouts, onboard and off-board chargers, and AC-DC and DC-DC converter configurations. A presentation of contemporary charging systems that incorporate renewable energy sources is also included to show the power architecture of contemporary charging stations. The research's future path is finally summed up by EV charging trends and problems, as well as grid integration issues.

Key Words: AC-DC , DC-DC, V2G – G2V .

I. INTRODUCTION

When it comes to cutting greenhouse gas emissions, battery-electric vehicles (EVs) are seen as a desirable substitute for conventional cars, which are mostly powered by internal combustion engines (ICEs). Thanks to recent advancements in battery technology, power electronics interfaces (i.e., inverters, DC to DC conversions, on/off-board charger methods), electric motors, and power management control, the marketing of batterypowered automobiles has increased dramatically in recent years. But there are a few significant problems with EVs that still need to be resolved. These problems include high battery costs, short battery lives, poor charging speeds, inefficient charging systems, low energy density, weight, and reliability. Moreover, the most significant issues facing EVs are related to optimizing EV drivetrains and associated management systems for maximum energy efficiency and lowest total cost of ownership (cost of ownership) in [1].

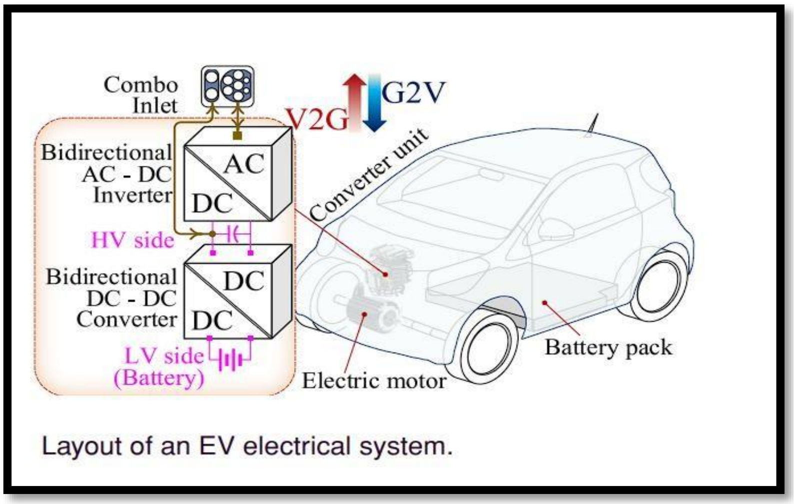

Fig: -Layout and image of Plug-in Electric vehicle

The difficulty finding a charging station is one of the main factors contributing to the public's adoption of EVs in 2010. Thus, the annoyance and safety issues related to charging infrastructure and their availability are major barriers to EVs' mass market development. These days, several studies are finding that light-duty EV safety and fast-charging systems are fascinating subjects. Furthermore, because more EVs and PHEVs are becoming available and can function as mobile storage units, vehicle-to-grid (V2G) has attracted a lot of attention. The discharge performance enables standalone loads like outdoor illumination and emergency rescue, while also enhancing the flexibility of transferring battery energy back into the grid. Utilizing the charger to maximize the energy from the EV batteries to support independent demands or the power grid is becoming more and more popular. Thus, for the mobile offboard charger, bidirectional functioning, high power density, and high efficiency are crucial. The designs in the aforementioned research are inappropriate for three-phase high-power applications (>5 kW). Regarding isolation, EMI, and/or ripple in the charging current, there is no regard to EV charging regulations. Similarly, it was found that the majority of designs disregarded the need for EV separation after reviewing a number of EV-PV topologies [2].A high-frequency ac connection built on a multiwinding transformer was employed in integrate renewable energy sources, battery storage, and electric vehicles. The topology is appropriate for high powers and has the advantage of isolation among all ports, however it is not helpful for EV-PV applications for two reasons. There is no requirement for grid and photovoltaic isolation in European regulations. Second, since PV and EV are both dc devices by nature, using an ac link will require extra conversion processes. In order to charge the EV from PV, a 10-kW non-isolated bidirectional converter. The grid, PV, and EV are all integrated via a 575 V dc bus, and the closed- loop control is intended to lessen PV intermittency. For charging electric vehicles from PV, a symmetrically separated 5 kW Z-source conversion was employed. The Z-source converter was shown to be overall superior when compared to transformer-less and high-frequency transformer-isolated topologies in terms of performance. In a similar vein, a modified Zsource inverter with isolation is the basis for a proposed 3.3 kW solar EV charger prototype in [3]. Given the growing popularity of electric vehicles (EVs) and their suitability for integration into smart grid systems, a high-efficiency, high-power charger with minimal total harmonic distortion (THD) is needed. Reactive power regulation and vehicle to grid (V2G) skills are also necessary to enable proper EV-grid interaction, particularly for EV incorporation in smart grids. Creating a proper charging structure and control strategy that satisfies all the stated requirements as well as additional ones for the proper management of the battery system is the first step in this topic. Concentrating on the battery system itself is the second phase. A battery pack's life cycle can be extended with the right charge/discharge technique, but a charger won't work as well if it doesn't take into account the unique characteristics of EV batteries. An EV needs a comparatively high voltage and power output, but a battery cell's rating is insufficient. Several battery cells are linked in series and parallel, respectively, to get the required voltage and current ratings. There is never a charge imbalance between parallel battery cells or modules because of the intrinsic charge balancing function of a parallel connection [4].

1.1 POWER ELECTRONICS CHARGER TOPOLOGY:

It is anticipated that PEVs and their chargers would play a bigger role in the grid. In order for PEVs to become more competitive when compared to Internal Combustion Engine (ICE) vehicles, chargers and the intelligent management systems that go along with them are essential. This is because these chargers are what make it possible to establish an optimal interface between the PEV and the grid. Noncontrolled rectifiers, inverters, filters, and DC/DC converters are used in common topologies. Studies on the control of voltage, active power, and reactive power in these kinds of power converters— discussed in Section I—have also been conducted. In terms of topology architectures, our concept exhibits certain parallels with those and the controller's methodology in[5]

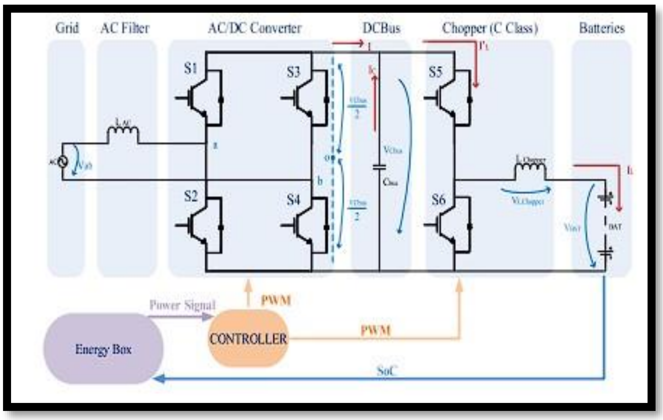

Fig: - Layout Of Converter Which Consist of Buck &Boost.

1.1. Plug-in Electric Vehicle Charger Topology: -

These advantages mostly relate to the data exchanged and bidirectional power flow between the EV battery charger and the power grid. It is important to remember that an EV battery charger that is bidirectional can either take energy from or give it to the power grid. As a result, in addition to the process of charging the battery (also known as grid-to-vehicle, or G2V mode), some of the electricity that had been stored in the battery pack can also be returned to the power grid (also known as vehicleto-grid, or V2G mode). The advantages available to the EV driver and the demands on the power grid must be considered in the V2G operation mode. A few crucial factors are taken into account in this procedure, such as the cost of energy to buy or sell and the battery's state of charge (SoC) in [6] .The primary benefits of the V2G operation mode are associated with electric utility, supplementary services, and load shedding. Furthermore, the interaction of EVs with smart grids will necessitate work in the area of smart house development. The term "conversion elements" refers to the devices utilized in the Ac-Dc conversion process, such as diodes, IGBTs, GTOs, MOSFETs, etc., which use their power and capacity ratings. The number of power electrical gadgets being utilized is growing daily, and we are currently doing fantastic work in this area. Power must be transferred from G2V and V2G to electric vehicles via power electronic switches in [5]. Automakers are working hard to increase the range of electric vehicle batteries and to provide an increasing number of infrastructures for charging them. This implies that there is a chance that the EV may need to be linked to several entities. This is known as the vehicle-to-X (V2X) concept, where X can be any number of things that are able to connect to an EV. At the moment, X is regarded as the grid (V2G), house loads provided by another EV (V2V) or vehicle-to-home (V2H). The advantages of the V2X have been studied in the literature, allowing EV batteries to release energy for local loads, other EVs, or the grid. While the growth of the V2G is the primary focus of present studies on the V2X idea. For EV owners, the V2V charging method holds great promise in offering the efficiency and flexibility of EV charging. EV owners are able to autonomously exchange their stored energy with one another. In order to implement the V2X concept, research must be done to create converter and electrical power plugs that are compatible with all EV operating modes. Fig(a)shows the modern EVs include a built-in onboard charger as well as a charging port that supports both ac and dc power sources. The charging connector standards, such as SAE J1772, SAE Combo, IEC 62196, or CHAdeMO, are the foundation upon which the charging socket is designed. The V2V implementation is not covered by these standards [7]. Conventional connectors, such IEC 62196-2&3 (CCS-type 2), only permit EV charging from CSs; because of inconsistencies in power conversion systems, communication signals, and charging connectors, EVs cannot be charged from other EVs. Redesigning the communication system for the CSs' charger connectors will help to solve these drawbacks. The two power stages—acto-dc and dc-to-dc—that are integral to the power conversions, however, cannot be altered. This indicates that a significant power loss is anticipated since the electricity will pass through four power stages (ac/dc/dc/ac) even if current charging connectors are modified to operate with V2V. The work displays the various power transfer connections for the V2V [7]. Depending on the amount of time needed for charging, the particular topology could be chosen based on their power rating. The following sections will focus on each topology's power level. Currently, bidirectional OBCs with power outputs ranging from 3.7kW to 22kW are primarily utilized for level-2 AC charging. The low cost and low power rating of Level-1 OBC make it unsuitable for a bidirectional power flow. With power levels ranging from 22 kW to 43.5 kW, Level-3 AC charging reduces charging time. However, because of battery capacity and degradation, reverse power flow is often restricted to 6.6 kW to 12 kW. The fig (b) shows the single stage structure [8].At the moment, unidirectional OBCs—also known as gridto-vehicle (G2V) OBCs—are more prevalent and have the only purpose of charging batteries. Studies do, however, highlight the drawbacks of widespread EV use in addition to the benefits of bidirectional OBCs that operate as a power reserve in vehicle-to-home (V2H) mode or as a distributed generation unit while aggregating the vehicle-to-grid (V2G) function. As a result, the idea of bidirectional chargers has been put out along with the potential for battery energy transfer to an ac system. Due to their soft switching properties, high power density operation, and highfrequency galvanic isolation, the dual-active-bridge (DAB) and CLLC topologies stand out as viable options for the dc–dc stage in operations with bidirectional power flow. In OBCs, the CLLC topology has been studied the most since soft switching is maintained over a wider voltage range [9].

1.2 DC/DC Converter Circuit Analysis: -

According to, typical two-stage designs use an isolated dc-dc converter after a diode bridge rectifier with PFC as a front-end ac-dc converter. In this setup, a back-end isolated dc-dc stage and a front-end ac-dc stage work together to reduce grid-side power quality problems. Themed ac-dc topologies, which have a full-bridge voltage-fed converter on the acside and a full-bridge converter on the dc-side, have been researched. In addition, an expanded modulation method has been presented to achieve open-loop power factor adjustment and softswitching [10]. The bidirectional power converter, which serves as an interface circuit stage between the grid side and the battery pack, is a crucial component of a vehicle-to-grid system. These converters ought to have the capacity to enable gridto-vehicle (G2V) and vehicle-to-vehicle (V2G) operating modes with high performance and quality, as well as excellent effectiveness, low cost, and safe operation. Due to the EV's battery's relatively low voltage, a wide-range high-voltage-gain bidirectional dc–dc converter is required to match the battery's low-voltage (LV) level and the grid side's highvoltage (HV) level [11].

The wide voltage range, common ground dc–dc converters shown in have limited voltage gain, and the high duty cycles of the power switch limit their efficiency and dynamic responses. Numerous brand-new bidirectional dc–dc converters with large voltage gains have recently been introduced in [11] . As also shown in Fig. 2, a traditional single-phase full-bridge dc-ac converter employing unipolar PWM modulation is utilized to connect the bidirectional dc-dc converter to the ac grid. On the grid side of the dc–ac is an inductive filter Lg. Figures 3 and 4 depict the step-down and step-up modes of the dc-dc converter in both the discontinuous conduction mode (DCM) and the continuous conduction mode (CCM). A comprehensive analysis of each mode is provided below. It is clear that the intermediate dc connection is crucial to maintaining the independent operation of both charging converters in the majority of cascaded topologies for ac-dc power conversion. Double frequency ripples occur at the DC bus during single-phase power conversions; these ripples are suppressed by a sizable electrolytic capacitor. Nevertheless, the electrolytic capacitor has a finite lifespan [9], and adding a large capacitor result in higher overall circuit losses from higher equivalent series resistances (ESR). Several charging setups with variable dc link-based designs and capacitorless architecture have been identified by substituting film capacitors for the intermediate capacitor [12]. Because of its straightforward circuit design and capacity for continuous power flow revision, the converter is typically regarded as an isolated dc–dc converter. Its narrow zero-voltage switching (ZVS)range and high circulation current with wide voltage variations are some of its disadvantages, though. For bidirectional operation, frequencycontrolled resonance dc–dc converters were developed. Because of its soft-switching properties, outstanding effectiveness and low electromagnetic emission are to be expected. However, because the switching patterns vary depending on the direction of the electricity, they are unable to continually alter the flow of power. Replace large electrolytic capacitors at dc-link, bidirectional EV chargers with sinusoidal film capacitors of less value.

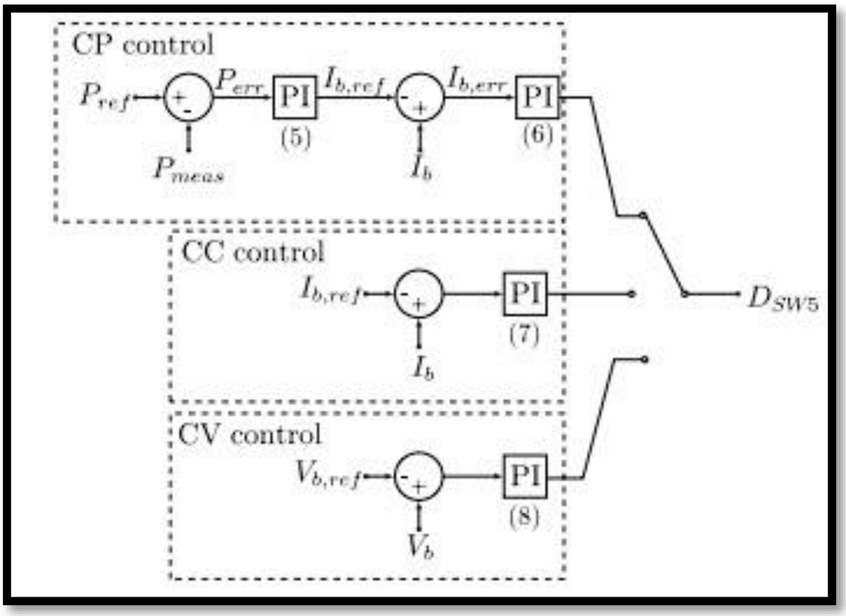

Fig 3: - Control Strategy of the Ac-Dc control

Large dc-link electrolytic capacitors are typically found in the aforementioned two-stage topologies when they are utilized for constant-current/constant-voltage (CC/CV) charging in order to absorb twice the line frequency ripple (2LFR), which is an inevitable consequence of single-phase ac-dc power conversion [13].

Together with its PWM and control techniques, an integrated architecture developed from a Twoswitch converter is provided. This topology offers full decoupling between bidirectional ac-dc and dc-dc stages, where the switches are soft switched to enable higher switching frequency of operation. A traditional integrated ac-dc single stage bidirectional converter running in CCM is incapable of achieving such decoupling [14].

II. CONTROL STRATIGY

The control strategy consists of the converter operating functions.

2.1 AC/DC CONVERTER CONTROLLER: - The idea behind synchronous frame control is to transform time varying quantities, such as current and voltage, into time-invariant quantities, so that linear control can be implemented without introducing steadystate error. In three-phase systems, the most common transformation is the direct-quadraturezero (dqo) transform, which cannot be applied directly in single-phase systems since it requires at least two signals.

A common approach in singlephase systems is to apply first an αβ transform by keeping the original signal as the α component, and Fig.. AC/DC dq controller with reactive power support. introducing a delay of 90◦ over the original signal to obtain the β component; after that, the αβ signals are transformed to dq components. In this kind of controllers, a phase-locked loop (PLL) is needed to determine the fundamental frequency, as well as to produce an angle θ to synchronize the dq frame to the grid voltage. The block diagram for a dqcontroller is given in Fig. . In this controller, the error term for the dc link voltage Vdc is fed through a proportional-integral (PI) regulator and then used as the reference term for Id. The Iq reference is derived from the desired reactive power. Thus, for Vq = 0, due to the PLL action, one has that: S = Ps + jQs = 0.5VdId − 0.5jVdIq where all variables in this and other equations and figures in the paper are defined in the Nomenclature section. The only controllable variable on the right-hand side is Iq, since Vd is determined by the system voltage vs, and Id is determined by the battery current and losses in the system. Therefore, by setting Iq,ref , reactive power can be controlled, decoupled from active power control. To obtain this value, Qref is subtracted from Qmeas, then divided by −0.5Vd, and fed to a PI regulator to produce Iq,ref . This solution allows reactive power to be readily calculated with its control being decoupled from active power control [15].

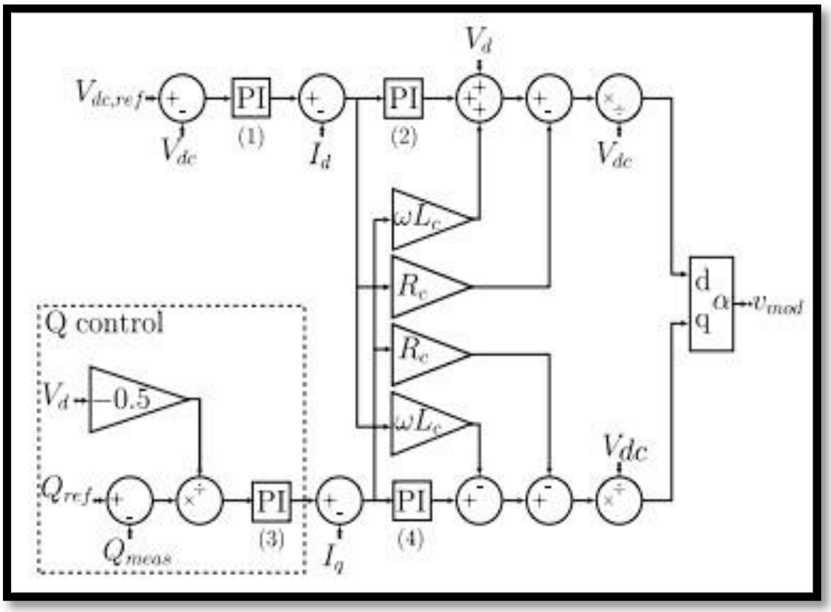

Fig 4:- Control Strategy of the Dc-Dc control

2.2. DC/DC Converter Controller :- The active power flow from/to the grid is dictated by the battery current, battery voltage, and losses in the charger. The function of the ac/dc controller is to regulate the dc link voltage, and if properly tuned, it will be able to automatically respond to changes in the dc link voltage by either pulling power from the grid, if the dc link voltage drops, or pushing power to the grid, if the dc link voltage rises. Thus, by controlling the charging and discharging of the battery with the dc/dc converter component of the charger, active power control can be achieved. The proposed control uses the active power request at the grid interface (Pref) sent by the utility to dictate the charging current, as shown in Fig. 3, where Pmeas is the calculated real component from (1), representing the active power at the point of common coupling; the error is processed by a PI regulator to determine Ib, ref . This is a nested-loop control structure where the outer loop has a slower response than the inner loop. This controller is also able to perform constant current (CC)-constant voltage (CV) charging, as it is normally done with lithium-ion batteries, which is the most common battery chemistry for EVs. Thus, the controller can be switched between three alternatives, i.e., constant power (CP), CC, and CV, depending on the desired mode of operation. The output for all control modes is the duty ratio of the buck switch SW5 [15] .The(DC_{BUS}) capacitor is essentially used for assisting the stabilization of (DC_{BUS}) voltage with low ripple. The Cbus sizing was made taking into account the need for a stable DCbus voltage during the LChopper current regulation. In fact, these capacitors need to support the DCbus energy demand for a higher time than the highest LChopper current regulation.

III. RESULT

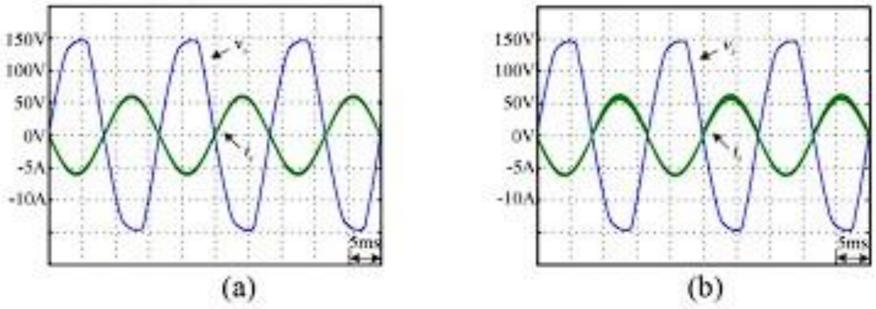

Fig 5 :- V2G & G2V Waveform

The result shows the operation of the V2G and G2V which consist of the bidirectional in nature and which is easy to control the by the buck and boost structure and which help to get the system are bidirectional

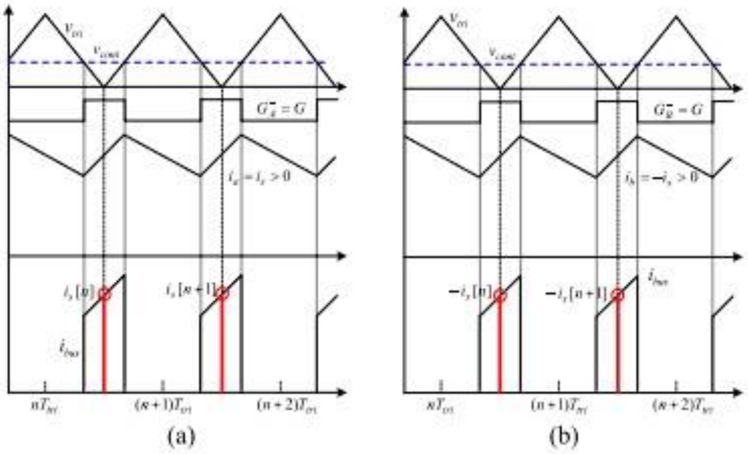

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Fig 6 :- Dc-Dc Converter Waveform

IV. CONCULSION

This paper proposes a simple and functional bidirectional PEV (or stationary battery) charger topology, which allows enhancing the capabilities of a joint operation of storage and an autonomous EMS in a residential setting, with potential benefits for end-users and utilities/system operator. The PEV role as load or power supplier is also emphasized. This charger is adjustable for charging or discharging operations using a power level provided by the EMS, instead of minimizing the charging time by using only the maximum power level. Since the charger is power flexible and bidirectional, its power electronics topology allows performing charge/discharge operations at different power levels, which benefits the integrated power allocation and scheduling among all residential loads.

REFERENCES

[1]. Y. Yang *et al.*, "Design , Modeling and Control of a Bidirectional Wireless Power Transfer for Light-Duty Vehicles : G2V and V2G Systems Keywords Resonant wireless power transfer system," *EPE 2017 - assigned jointly to Eur. Power Electron. Drives Assoc. Inst. Electr. Electron. Eng.*, pp. 1–12, 2017.

[2]. H. Li, Z. Zhang, S. Wang, J. Tang, X. Ren, and Q. Chen, "A 300-kHz 6.6-kW SiC Bidirectional LLC Onboard Charger," *IEEE Trans. Ind. Electron.*, vol. 67, no. 2, pp. 1435–1445, 2020, doi: 10.1109/TIE.2019.2910048.

[3]. G. R. Chandra Mouli, J. Schijffelen, M. Van Den Heuvel, M. Kardolus, and P. Bauer, "A 10 kW Solar-Powered Bidirectional EV Charger Compatible with Chademo and COMBO," *IEEE Trans. Power Electron.*, vol. 34, no. 2, pp. 1082–1098, 2019, doi: 10.1109/TPEL.2018.2829211.

[4]. N. Tashakor, E. Farjah, and T. Ghanbari, “A Bidirectional Battery Charger With Modular Integrated Charge Equalization Circuit,” *IEEE Trans. Power Electron.*, vol. 32, no. 3, pp. 2133– 2145,2017,doi: 10.1109/TPEL.2016.2569541.

[5]. H. N. De Melo, J. P. F. Trovão, P. G. Pereirinha, H. M. Jorge, and C. H. Antunes, “A controllable bidirectional battery charger for electric vehicles with vehicle-To-grid capability,” *IEEE Trans. Veh. Technol.*, vol. 67, no. 1, pp. 114–123, 2018, doi: 10.1109/TVT.2017.2774189.

[6]. V. Monteiro, J. P. Carmo, J. G. Pinto, and J. L. Afonso, “A flexible infrastructure for dynamic power control of electric vehicle battery chargers,” *IEEE Trans. Veh. Technol.*, vol. 65, no. 6, pp. 4535–4547, 2016, doi: 10.1109/TVT.2015.2478151.

[7]. V. T. Tran, M. R. Islam, K. M. Muttaqi, O. Farrok, M. R. Kiran, and D. Sutanto, “A Novel Universal Magnetic Power Plug to Facilitate V2V/V2G/G2V/V2H Connectivity for Future Grid Infrastructure,” *IEEE Trans. Ind. Appl.*, vol. 58, no. 1, pp. 951–961, 2022, doi: 10.1109/TIA.2021.3130106.

[8]. J. Yuan, L. Dorn-Gomba, A. D. Callegaro, J. Reimers, and A. Emadi, “A review of bidirectional on-board chargers for electric vehicles,” *IEEE Access*, vol. 9, pp. 51501–51518, 2021, doi: 10.1109/ACCESS.2021.3069448.

[9]. S. G. Barbosa, L. H. S. C. Barreto, and D. D. S.Oliveira, “A Single-Stage Bidirectional AC-DC Converter Feasible for Onboard Battery Chargers,” *IEEE J. Emerg. Sel. Top. Power Electron.*, vol. 10, no. 3, pp. 3024–3032, 2022, doi: 10.1109/JESTPE.2021.3108958.

[10]. N. Patel, L. A. C. Lopes, and A. K. Rathore, “Analysis and Design of Soft-Switching SingleStage Single-Phase PFC Converter for Bidirectional Plug-in EV Charger,” in *2022 IEEE Energy Conversion Congress and Exposition, ECCE 2022*, Institute of Electrical and Electronics Engineers Inc., 2022. doi: 10.1109/ECCE50734.2022.9947730.

[11]. H. Heydari-Doostabad and T. O’Donnell, “A Wide-Range High-Voltage-Gain Bidirectional DC-DC Converter for V2G and G2V Hybrid EV Charger,” *IEEE Trans. Ind. Electron.*, vol. 69, no. 5, pp. 4718–4729, 2022, doi: 10.1109/TIE.2021.3084181.

[12]. D. Mishra, B. Singh, and B. K. Panigrahi, “Adaptive Current Control for a Bidirectional Interleaved EV Charger with Disturbance Rejection,” *IEEE Trans. Ind. Appl.*, vol. 57, no. 4, pp. 4080–4090, 2021, doi: 10.1109/TIA.2021.3074612.

[13]. M. Kwon and S. Choi, “An Electrolytic Capacitorless Bidirectional EV Charger for V2G and V2H Applications,” *IEEE Trans. Power Electron.*, vol. 32, no. 9, pp. 6792–6799, 2017, doi: 10.1109/TPEL.2016.2630711.

[14]. S. K. Dube, R. Nair, and P. Das, “Analysis and Design of an Integrated Bidirectional ThreePhase AC-DC Resonant Converter,” *IEEE Trans. Ind. Electron.*, vol. 70, no. 5, pp. 4369– 4379, 2022, doi: 10.1109/TIE.2022.3183274.

[15]. M. Restrepo, J. Morris, M. Kazerani, and C. A. Cañizares, “Modeling and testing of a ystem EV integration,” *IEEE Trans. Smart Grid*, vol. 9, no. 1, pp. 152–162, 2018, doi: 10.1109/TSG.2016.2547178.

[16] H. C. Chen and B. W. Huang, “Integrated G2V/V2G Switched Reluctance Motor Drive with Sensing only Switch-Bus Current,” *IEEE Trans. Power Electron.*, vol. 36, no. 8, pp. 9372–9381, 2021, doi: 10.1109/TPEL.2021.3054875.