ISSN 2395-1621

Power Electronics Converter Topologies In EV Charging Applications

Afzal.B.Madar, Mahesh.M.Bhise, Dhage Rahul Keshav, Prof .T.S.Pinjari, Prof. Sumpreet Singh

1,2B.E Student Department Of Electrical Engineering Trinity College Of Engineering & Research, Pune 411008.

3,4Assistant Professor, Dept. Of Electrical Engineering, Trinity College Of Engineering And Research, Pune, Maharashtra, India - 411048

ABSTRACT

Power converter important role within the future in EV technologies. This paper Proposes is Power Electronics Converter Topologies for EV charging With the increasing interest in efficiency, cost, and environmental protection of electrical vehicles (EVS) technology has been obvious nowadays, supported the pollution regulations within the USA and Europe also like plenty of nations within the planet, the fossil-fueled vehicles are targeted due to the main source of emissions that make pollution leading to the worldwide warming The technologies involved in EVs are include electrical and electronics engineering, automotive engineering. Challenges associated with designing controlling and operating the facility electronic converters and EV charging are getting to be discussed and also the kinds of a convert, which is DC to DC converters, AC to AC converter, DC to AC converter, AC to DC converters, ONBOARD charging, OFF BOARD charging. So converter topology are wont to increase the speed of EV charging.

ARTICLE INFO

Article History

Received: 15th September 2020

Received in revised form : 15th September 2020

Accepted:19th September 2020

Published online : 20th September 2020

Key Words: Chargers, electric buses, charging methods, charging standards.

I. INTRODUCTION

India is member of a multi-governmental forum electric vehicle initiatives (evi) which launched EV 30@30 campaign in 2017 Setting goal of achieving over 30% sale till 2030, by which government is putting force to exchange the ice vehicles to electric-powered vehicles consistent with which this paper will give help in understanding the electric vehicle charging system.

Studies to reinforce the performance of the battery through charging and discharging operations, different converter topologies have been used and are being continuously performed to possess a reliable, controlled charging devices, A classification which comprises of power circuit architectures, circuit typologies (converters), and control methods are studied for PHEV battery chargers. However, this paper would only be discussing intimately on the disparate converter topologies used for charging applications for a PHEV. An in-depth discussion on the challenges associated with designing controlling and operating the facility electronic converters and EV charging is getting to be discussed and also the kinds of the converter, which is DC to DC converters, AC to AC converter, DC to AC converter, AC to DC converters, ONBOARD charging, OFF BOARD charging. and elaborating on the foremost efficient and reliable topology to be adopted for the EV charging system. Moreover, the event in charging operation might be well achieved when an appropriate topology is selectively used. the selection of an efficient converter topology is completed supported the factors like high efficiency, true soft switching for the operation range, and cost- effectiveness., IEEE, the society of engineer (SAE), infrastructure institute council (IWC) are making efforts in creating standards & codes concerning utility & customer interference All which deals here may be a proper notification to the operator and therefore the driver of the soc (state of charge) which goes on, the battery shouldn't be completely discharge nor it should be overcharge thanks to which there's a chance of reducing the lifetime of a battery as you recognize battery is that the heart of electrical.

1.1 Types of ev charging

Some barriers in an electrical vehicle are high cost, battery life cycle, compliance of charge & charge infrastructure, harmonic interference within the distribution system within the power system . Charging the battery of electrical vehicle needs some parameters which should fulfill the requirements for successfully charging the battery without making the impact on the lifetime of A battery.[9][10]

As we already skill much the battery is vital within the electric vehicle so taking into consideration the availability from which the EV battery goes to charge the has got to fulfill and match the need of battery some are like, constant

supply of rated voltage, rate of charge, charging time, constant frequency, amount of flow of current at which it'll charge.[5][8] thanks to all this parameter, an electrical owner should charge its vehicle only with an appropriate charger or at the corporate outlet charging station which matches the necessity & safety purpose of the electrical al vehicle hence the electric car owner is given a single-phase level one charger which it is often installed in its home premises. In the conductive method, the electric vehicle battery is charged to while connecting the battery with a wire which is then connected to the electricity power supplier or charging station the inductive method of the charging is completed by the means of electromagnetic transmission and there's no any media in between it the charger and electric vehicle battery mainly conductive charging is widely used everywhere world conductive charging because it's less expensive and more efficient. The classification of electric vehicle chargers is split into three categories as follows.

Level1:- Slow Charging Usually Installed In Home Premises.
Level2:- Is Primary Level Charger Which Operates On 240v Outlet Also Called As Semi – Fast Charging Method Can Be Implemented Can Be Installed At Private And Public Sector
Level3:-Dc Fast Level Charger Can Be Used At Commercial & Public Sector Like Charge Filling Station And Requires 3 Phase Normally [8][16][10]

1.2 DC –DC CONVERTER

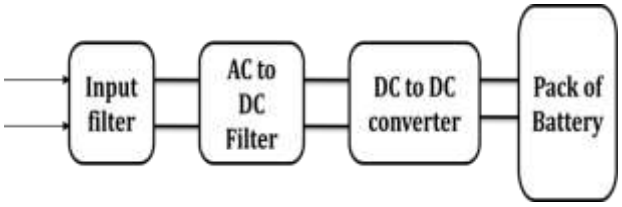

Fig-1: Dc –Dc Converter

In electric vehicle main part is DC-DC converter to charge the battery.dc-dc the converter is sort of power converter and that is converts source of dc from one level to a different level, it can design to transfer power in just one direction input to output, however, most dc-dc converters are often made bidirectional, bidirectional converter are often move power in both directions which use-full for application of regenerative braking by adjusting work cycle input and output power flow is often controlled, normally this happens to regulate the output voltage and constant power input current and output current figure shows the input which is within the sort of ac which is on board could also be or using solar energy which generated dc, ac to dc filter as referred to as power factor correction, which converts ac voltage into dc voltage [22]so, its overall efficiency and power density depend more on the operation of the dc-dc converter. the high-frequency switching converter is widely utilized in the dc-dc converter. the switching frequency is usually at the tens of kHz level the appliance of this technology in conventional switching power supply topology can reduce switching loss and noise interference of power switching devices within the high-frequency state of the converter, which may further improve efficiency and power density and reduce the quantity and weight of converter.[1][4][2]

1.3 Ac-Dc Converter

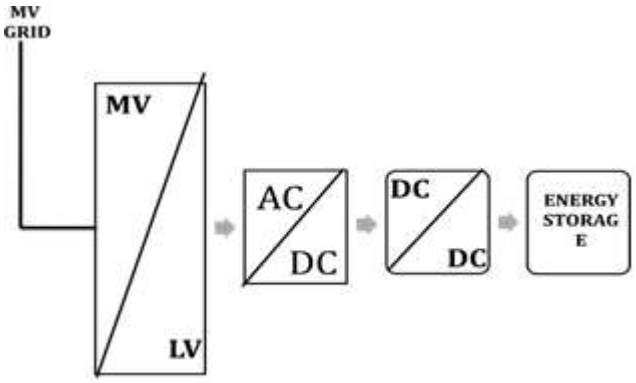

Fig-2: Ac-Dc Converter

Ac to dc converter is shown in figure A and figure B. figure A shows the medium frequency and figure be shows the line frequency of the transformer, figure A has long non – isolated ac-dc converter the current preventing is the realized by using an isolated medium switching frequency which is the dc-dc converter. this structure has small transformer figure B is the line frequency transformer it can be isolated the diode rectifier is used in line frequency transformer three-phase transformer and multiple transformers, which reduce harmonic produced in diode rectifier. [10][4][8][23]

1.4 DC-AC CONVERTER

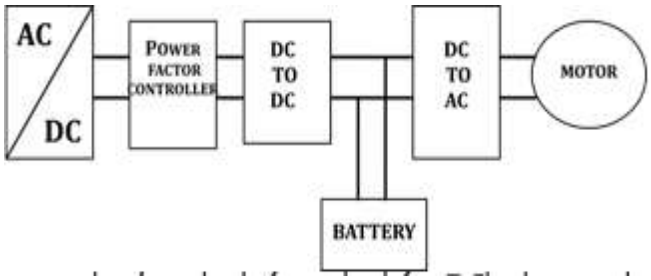

Fig-3: Dc-Ac Converter

Dc to ac converter is used to convert dc supply into ac to a valuable frequency, the supply voltage is unidirectional which directly feeds to the converter, the inverter is usually designed three-phase or single output to motor A dc to ac converter is an electronic device or circuitry that changes direct current (DC) to alternating current (AC).[10][11][1] A power dc to ac converter can be entirely electronic or maybe a combination of mechanical effects and electronic circuitry. The input and output voltage, 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. In the figure above it can be seen that the motor requires AC input. The main source of electrical power is the battery which is a DC source. The DC output of the battery is bucked or boosted according to the requirement and then converted into AC using a DC-AC inverters.

1.5 Ac To Ac Converter

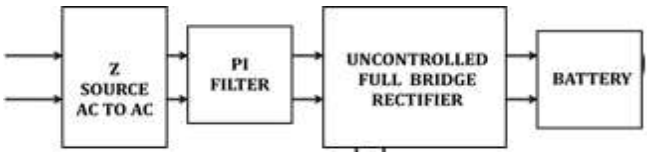

Fig-4: Ac To Ac Converter

Z-source converters have focused mainly on DC/AC inverters and AC/AC converters. In applications Where only voltage regulation is required, the family of single- phase Z-source AC/AC converters presented in has several merits, as an example, it adds boost or buck situation and features a bigger range of output voltages, reducing inrush, and harmonic suppression. [6][16][10][1] However, few people are applying Z-source AC/AC converters to EV battery chargers, where an honest range of output voltages is usually needed when charging battery series on several scales. It's a singular topology of EV charger, which uses a Z-source AC/AC converter It consists of three parts: a Z-source converter, a PI filter, and an uncontrolled full bridge rectifier. The novel charger has other advantages: a simple structure, low costs, and an easy control strategy. of the diagram is presented, and thus it is good performance for EV battery charging AC/AC [5][6][2][1]

1.6 Onboard Charger

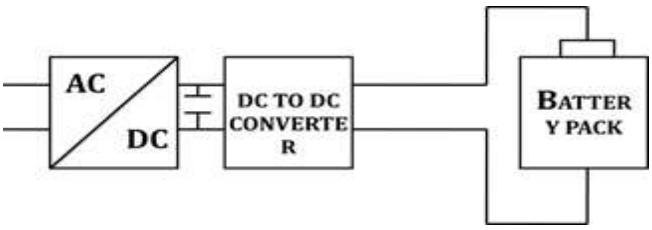

Fig-5: Onboard Charger

The figure shows the topology of onboard electric vehicle charger onboard charger is a single-stage structure or two-stage structure single-stage structure is straightforward and low in cost, but it's just one stage conversion .one stage conversion it limits the range of output voltage and effective to the power factor .ac to dc converter is used boost circuit for power factor correction & dc-dc converter used as isolation converter on basis of safety converter it provides DC with small load the onboard charger is often employed by the customer to charge his EV from his house power outlet as soon as he/she gets it home. But these chargers are very basic and don't accompany any advanced features and hence would normally take around 8 hours to charge a typical EV Onboard rectification is employed manage the battery management system during this figure no- shows ac to dc converter is an input the vehicles should be equipped with dedicated on-board chargers that are capable of attraction of 1.92 kW (level-1) and 19.2 kW (level-2) from the mains. Typically, these chargers take quite 8 h to feature 200 miles of golf range on the EV, which is undesirable for highway driving and long trips. Therefore, there's a big got to enhance the facility capability of on-board battery chargers, which may quickly replenish the charge in an EV battery.[1][7][9] However, it's difficult to develop high power on-board chargers thanks to the dimensions, cost, weight, and safety constraints of the EVs. [5][11][9] The converter operates as inverting buck/boost, boost, and buck in plug-in charging, propulsion, and regenerative braking modes, respectively. Moreover, this converter shows improvement over converter in terms of several components and efficiency in each mode. Therefore, it's a low-cost solution for manufacturers. But the main drawback of this converter is, don't have buck/boost operation in propulsion and regenerative braking modes; therefore, flexible control of DC-link voltage and capturing of regenerative braking energy. [7].

1.7 Off board Charger

The off-board chargers are located outside the EV that can deliver the DC power to the EV battery through a power conditioning unit(PCU).

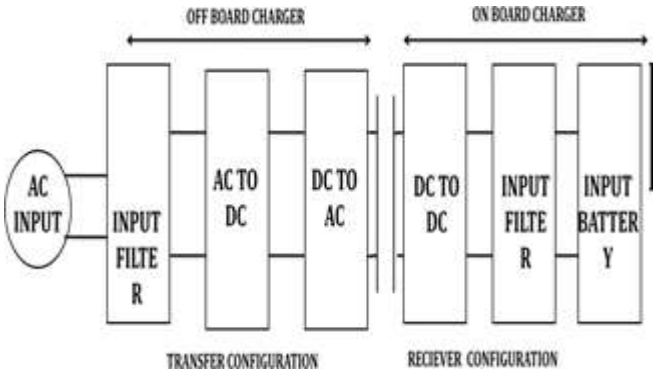

Fig-6: Off Board Charger

dc fast charger provides enough A charge in 60 min to provide an additional 200 km of driving range, while 350 kW requires only 10 min to deliver a 200 km range. These chargers can be installed either as single-stall units or multiple stall units. Each stall is typically rated at 50 kW, which is composed of three-phase AC/DC rectification stages with power factor correction (PFC) and is powered by a dedicated low frequency (LF) transformer.18714 However, the LF transformer adds to the system cost and complicates the installation when directly connected to the MV line. To overcome the aforementioned problems, utilization of solid-state transformer (SST) technology to extreme fast charging (XFC) architectures helps to achieve an improved power density and efficiency, thus eliminating the LF step-down transformer. Moreover, it provides better power quality and additional functionality such as bi-directional power flow.

Power level	Charger location	Typically use	Expected power	Charging time
Level 1 :- 120vac 230vac	On board 1-phase	Charging at home or office	1.4 KW (12 A) 1.9 KW (20 A)	4-11 HOURS 11-36 HOURS
Level 2 :- 240vac 400vac	On board 1-phase or 3 phase	Charging at private or public outlets	4 KW (17A) 8 KW (32A) 19.2 (80A)	1-4 HRS 2-6HRS 2-3HRS
Level 3 :- fast (208-600vac)	On board 1-phase or 3phase	Commerci al analogous to a filling station	50 KW- 100 KW	0.4-1 HRS 0.2-0.5 HRS

Table -1: Charging Power Levels [16][5]

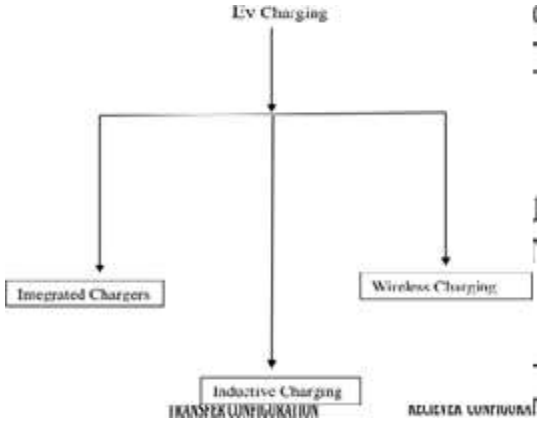

Fig-7: Types of ev charging

1.8.1 Integrated Chargers

In the grated charger is mainly used because having high efficiency, low cost, The very much advantage of integrated charging is that the is charger used for charging the battery of electric vehicle we can also minimize weight, volume, and cost integrating the charging function into the electric vehicle.[8][9] The function can be integrated if charging and traction are not simultaneous. In an integrated charger, motor windings are used for filter inductors or an isolated transformer and the motor drive inverter serves as a bidirectional AC/DC converter. The most important advantage is that low-cost high power (Levels 2 and 3) bidirectional fast charge can be supported with a unity power-factor.[10][9]

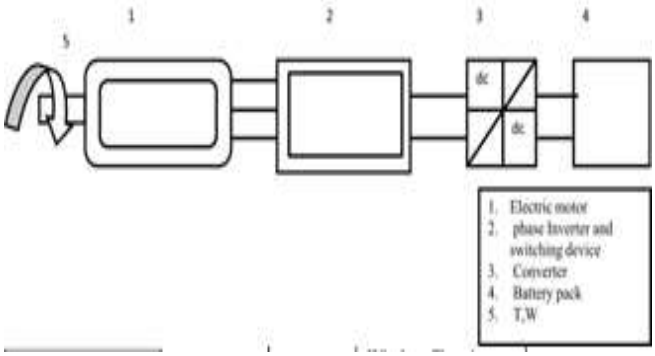

Fig-8: Integrated Chargers

1.8.2 Inductive Charging

Inductive charger transfer power magnetically conductive chargers use metal-to-metal contact as in most appliances and electronic devices. Inductive charging of EVs is based on magnetic contactless power transfer. An inductive charger transfers power magnetically. [8][9][18].This type of charger can be seen in levels 1 and 2 devices. the advantage of inductive charging is its simplicity for the user of the electric vehicle. Instead of only charging the battery once at home or charging station, the vehicle battery can be charged simultaneously while parked at home or work, when shopping, and even at traffic lights.10

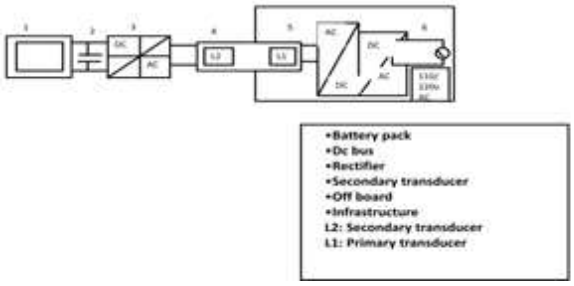

Fig-9: Inductive Charging

Advantages include eco-friendly, simplicity, and galvanic isolation. Charging while driving is also possible to build charging strips into highways .Due to which inductive charging can decrease the need for fast-charging infrastructure.[5910] Disadvantages include are low efficiency and power density, manufacturing problems, size, and cost. But energy saving is an important motivator for Ev, the extra power loss is an important consideration. Principles of inductive power transfer (input) are the same as transformers, although more versions have poor magnetic coupling and high leakage flux. The secondary side can be stationary and moving [10]

1.8.3 Wireless Charging

Wireless charging consists of the use of power and energy transfer at a much wider distance. Completely different from inductive charging which uses a transformer with the closely placed primary and secondary winding. in inductive charging the direct electric contact, which requires a plug, cable, and physical connection of the inductive coupler. Wear and tear of the plug and cable with time could cause danger as well as increase the cost of maintenance. [9]Wireless charging could eliminate the cable and plug. In this condition, a driver parks the electric vehicle at the specially designed parking lot and the battery will automatically be charged without the pulling of any cable or plug which is also safe for EV battery charging. There have been some different experiments carried out for wireless energy transfer. The most effective technology is using electromagnetic resonance. In this system, there are two antennas with one placed in the parking structure as the transmitter while others placed inside the car as the receiver. The two antennas are designed to resonate at the controlled frequency [[10].

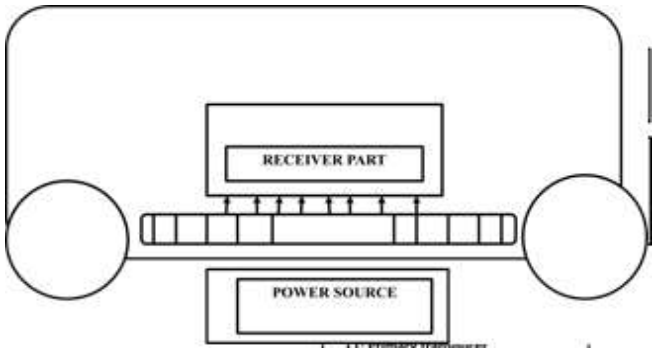

Fig-10: Wireless Charging

II. TYPES OF TOPOLOGIES

A general two-stage EV battery charger has two main stages. The first stage carries out the AC DC conversion with power factor correction (PFC). The second stage is DC-DC converter which is convert the output DC voltage level of AC-DC PFC converter to the battery DC voltage level. Main parts of EV charger; AC-DC PFC converter and DC-DC converter will be given in subsections.

2.1. AC/DC Power Factor Correction

A variety of AC/DC PFC circuit has been evolved for implementation of PFC. The conventional PFC topology is boost PFC. This topology includes a diode bridge that rectify the ac input voltage to DC. There is a boost PFC circuit after this circuit. The circuit diagram of this topology is given in Fig. 11. In this topology, very high ripple occurs at the output capacitor current, there is a difference between dc output current and the diode current. At the high power levels, the diode bridge heats up and power losses increase, and the efficiency drops greatly. Therefore, this converter is suitable for powers below 1 kW.

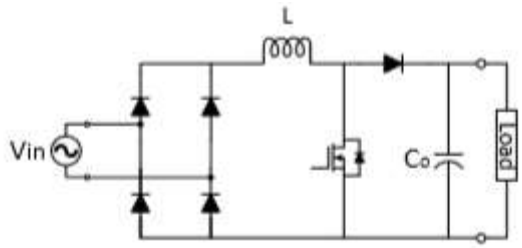

Fig 11. Circuit topology of conventional boost PFC

2.2 Bridgeless boost PFC topology

The second topology is bridgeless boost PFC topology which is avoids the use of the rectifier input bridge, however maintains the classical boost PFC topology, is illustrated in Fig. 12. This topology solves the problem of efficiency drop due to heat losses but increases EMI due to the inductor used at the inlet.

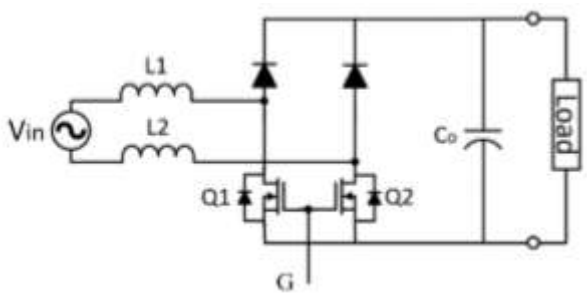

Fig. 12. Circuit topology of bridgeless boost PFC

2.3 Interleaved boost PFC topology

The third topology is interleaved boost PFC topology which is consists of two boost PFC in parallel, is illustrated in Fig. 13. This topology decreases the EMI but heat management problem is still remaining.

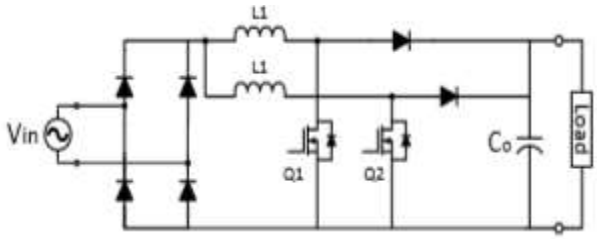

Fig. 13. Circuit topology of interleaved boost PFC

2.4 Bridgeless interleaved boost PFC topology

The other topology is bridgeless interleaved boost PFC topology, which is solve the heat management problem and EMI problem, is illustrated in Fig. 14. It is an attractive solution for power levels above 3.5kW.

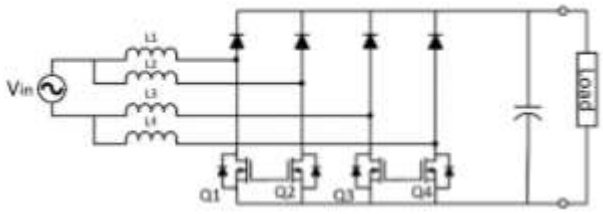

Fig. 14. Circuit topology of bridgeless interleaved boost PFC

III. CONCLUSIONS

The demand of electric power supply in electric vehicle application is growing rapidly as theme chemical components are being replaced by the electrical and electronic components .issues associated with power electronic converters as the heart of electrical driving force system are presented during this paper, the various EV charging methods and kinds and subtypes are presented. an electrical vehicle is often charged with mainly two types (conductive or inductive charging method). Using the conductive method the electricity provider is connected by a cable and plugged directly into EV accumulator. The inductive method works through electromagnetic transmission with none contact between the Ev and therefore the charging system The DC/DC converter may be a main a part of the entire system of an electrical or hybrid vehicle. the consequences of varied components on one another in terms of the electrical performance packaging and thermal management should be taken under consideration to optimize the vehicle system for top efficiency, high reliability, safety, and low cost.

REFERENCES

1. Research Article Onboard Charging DC/DC Converter of Electric Vehicle Based on Synchronous Rectification and Characteristic Analysis Received 14 February 2019; Revised 5 May 2019; Accepted 15 May 2019; Published 2 June 2019(page 1)

2. DC-DC Converter Topologies for Electric Vehicles,Plug-in Hybrid Electric Vehicles and Fast Charging Stations: State of the Art and Future Trends(Energie 2019,12, 1569; doi:10.3390/en12081569 p.p-18-43)

3.Extreme Fast Charging Technology—Prospects to Enhance Sustainable Electric Transportation(Energies 2019,12,3721; doi:10.3390/en12193721)(page 8)

4. DC/DC and DC/AC Converters Control for Hybrid Electric Vehicles Energy Management- Ultracapacitors and Fuel Cell(EEE TRANSACTIONS ON INDUSTRIAL INFORMATICS, VOL. 9, NO. 2, MAY 2013)(page 3)
5. A Review of Converter Topologies for Battery Charging Applications in Plug-in Hybrid Electric Vehicles(978-1-5386-4536-9/18/$31.00 © 2018 IEEE)(page 1)
6. EV battery charger that Uses Z-source AC/AC converter 978-1-4577-2088-8/11/$26.00 ©2012 IEE(page 1)
7. A Comprehensive Review of Integrated Charger for on-Board Battery Charging Applications of Electric Vehicles 978-1-5386-7339-3/18/$31 © 2018 IEE(3-6)
8. Extreme Fast Charging Technology—Prospects to Enhance Sustainable Electric Transportation(Energies 2019, 12, 3721; doi:10.3390/en12193721)(2-3)
9. Review of Battery Charger Topologies, Charging Power Levels, and Infrastructure for Plug-In Electric and Hybrid Vehicles Murat Yilmaz, Member, IEEE, and Philip T. Krein, Fellow, IEEE IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 28, NO. 5, MAY 2012 2151 p.p(2-19)
10. Power Electronic Converter Topologies used in Electric Vehicles(profiles for this publication at: https://www.researchgate.net/publication/3213 60237)(64-66)
11. DC/DC and DC/AC Converters Control for Hybrid Electric Vehicles Energy Management- Ultracapacitors and Fuel Cell(1551-3203/$31.00 © 2012 IEEE)
12. "Sample-data modeling of a zero voltage transition DC-DC converter for on-board battery charger in EV," T. R. Granados-Luna, I. Araujo- Vargas, and F. J. Perez-Pinal, Mathematical Problems in Engineering, vol. 2014, Article ID 712360, 15 pages, 2014.
13. "Analysis of electromagnetic behavior in switched reluctance motor for the application of integrated air conditioner on-board charger system," J. Liang, L. Jian, G. Xu, and Z. Shao, Progress in Electromagnetics Research, vol. 124, pp. 347–364, 2012.
14."Boost full bridge bidirectional DC/DC converter for supervised aeronautical applications," A. Cavallo, B. Guida, and L. Rubino, International Journal of Aerospace Engineering, vol. 2014, Article ID 808374, 2014.
15. Considerations of physical design and implementation for 5 MHz-100 W LLC resonant DC-DC converters," A. Hariya, K. Matsuura, H. Yanagi, S. Tomioka, Y. Ishizuka, and T. Ninomiya, Active and Passive Electronic Components, vol. 2016, Article ID 4027406, 11 pages, 2016
16. "An EL capacitorless EV on-board charger using harmonic modulation technique," J.-Y. Lee, IEEE Transactions on Industrial Electronics, vol. 61, no. 4, pp. 1784–1787, 2014
17. international journal of advances on automotive and technologypromech research article – ijaat – 2018 – 8, corp. press, istanbul, turkeyvol.2, no. 1, pp. 61-70, january, 2018http://dx.doi.org/10.15659/ijaat.18.01.892 manuscript received november 4, 2017; accepted december 21, 2017
18. "Modeling and optimization of an integrated transformer for electric vehicle on-board charger applications," S. Zou, J. Lu, A. Mallik, and A. Khaligh, IEEE Transactions on Transportation Electrification, vol. 4, pp. 355–363, 2018.
19. "A closer look at the on-board charger: the development of the second-generation module for the chevrolet volt," D. Cesiel and C. Zhu, IEEE Electrification Magazine, vol. 5, pp. 36–42, 2017
20. "High-efciency highdensity critical mode rectifer/inverter for WBG-device-based on-board charger," Z. Liu, B. Li, F. C. Lee, and Q. Li, IEEE Transactions on Industrial Electronics, vol. 64, pp. 9114–9123, 2017.
21. "Research and modeling of the bidirectional half- bridge current-doubler DC/DC converter," L. Huang, X. Dong, C. Xie, S. Quan, and Y. Gao,International Journal of Rotating Machinery, vol. 2017, Article ID 4854169 , 2017.
22. DC/DC Converters for Electric Vehicles By Monzer Al Sakka, Joeri Van Mierlo and Hamid Gualous Submitted: October 18th 2010Reviewed: March 21st 2011Published: September 12th 2011 DOI: 10.5772/17048
23. Investigating the Power Architectwes and Circuit Topologies for Megawatt Superfast ElecYic Vehicle Charging Stations with Enhanced Grid Support Functionality

