WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Converters Used for Charging Electric Vehicles

S. Chaitanya[1], Dr. A. Srilatha[2]

[1]Assistant Professor, Vidya Jyothi Instuite of Technology, Hyderabad
[2]Assistant Professor, Vidya Jyothi Instuite of Technology, Hyderabad
DOI: https://doi.org/10.55248/gengpi.4.823.49863

ABSTRACT—

EVs are a more advantageous option to gasoline-powered cars, and they are also more environmentally friendly for human travel. The charging of EVs is its key feature. Depending on the specifications, each charging station has a varied level of power and a power converter is employed in every charger. A converter produces superior results for each EV battery charger. This paper analyzes and discusses a few effective power converters. The approximate efficiency and disadvantages are also covered and then each converter's the suitability for EVs is provided.

Keywords: Cuk Converter, DC-DC Converter, Electric Vehicle, Luo converter, SEPIC, Vienna Rectifier

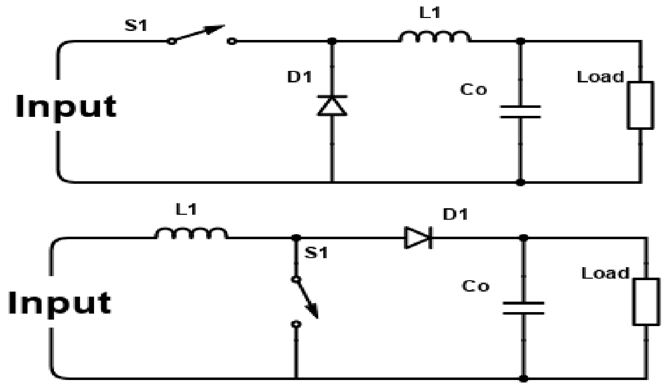
I. INTRODUCTION

One of the essential elements of applications that require the storage and use of power is an electronic converter. Switch Mode Power Supplies, Renewable Energy Conversion, Electric Vehicle Charging, Machine Motion Control, LED Optimization, etc. are a few of the applications. In power electronics, we use power switches with storage (passive) components to control the flow of electric power and achieve the necessary levels of voltage and current. The efficiency of the entire system has increased with the development of modern convertor topologies. A power converter serves as the principal conduit between the power source and the battery during EV charging. In EV charging stations, the converter's design, price, and dependability are crucial factors. In this paper, we'll discuss a few modern converters in this context. SEPIC, Luo, Zeta, and Cuk converters and vienna Rectifier.

II. POWER CONVERTERS

In this paper, we discuss four level converters with two inductors and two capacitors in converters, which can be designed for single- or three-phase operation or for direct DC charging depending on the power level required. The basic goals of each converter are to decrease line

current, THD and improve net power available to the battery for charging. The primary level of converters to be discussed are Buck, Boost and Buck-Boost converters. With the proper management, these converters serve as switched mode regulators. Fig. 1 depicts the circuits of the Buck, Boost, and Buck-Boost converters. The average output voltage of a Buck converter is lower than the input voltage. The average output voltage in a boost converter is higher than the input voltage. Depending on the switch's duty ratio, the average output voltage of a Buck-Boost converter can be lower or higher than the input voltage.



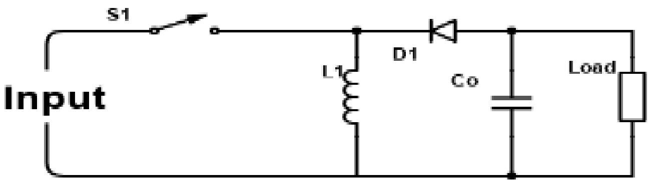


Fig 1**:** Buck, Boost and Buck-Boost Converters

Buck converters have an efficiency of more than 90% and only produce electricity in one direction with one polarity. The output of a boost converter is significantly dependent on the duty ratio, necessitating larger filter capacitance and inductance than in a buck converter. Due to its ability to combine the benefits of both Buck and Boost converters, Buck-Boost offers great efficiency. The output voltage polarity can be reversed using the fundamental Buck-Boost topology [1]. We need to use high level converters like these, which we will cover in this paper, to increase output quality and to be suitable for applications like EV charging.

A) SEPICCONVERTER

Low output current ripple, a feature of the SEPIC converter, is beneficial for extending battery life. Fig. 2 displays the SEPIC conventional circuit [2].

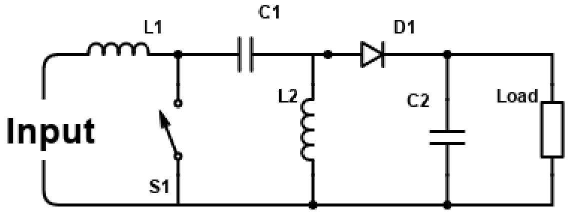


Fig. 2 SEPIC Converter

By adjusting the duty cycle of the MOSFET switch S1, we can decide whether the converter's output is Buck or Boost. To charge an electric vehicle, we use boost mode when the amount of generated power is low (like from a PV source), and buck mode when the level of generated power is high (like from a high-voltage grid). Many customized topologies for PFC and high voltage gain can be found in the literature. A more effective and efficient SEPIC converter was simulated in [3] to lower THD, and a converter with more components than the standard one is presented in [4] to lower the converter's overall losses.

B) CUK CONVERTER

Comparing Cuk Converter to other DC-DC converters, there are several benefits. This can be utilized in low-voltage vehicles such as E-rickshaws, hybrid bikes, and low-CC motorbikes. Fig. 3 displays a Conventional Cuk Converter [5].

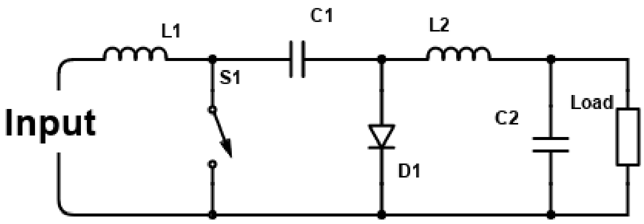


Fig 3: Cuk Converter

We can utilize a Cuk regulator for solar energy charging stations to provide a smooth energy flow between the PV and DC links. To enhance the power supply accessible to EVs while they are charging, various converters based on Cuk [5], [6] were present.

C) ZETA CONVERTER

The SEPIC converter family includes the Zeta converter. In contrast to SEPIC, where the switch is on the low voltage side, the Zeta converter's switch is located on the input. Figure 4 depicts the circuit diagram of a zeta converter [7].

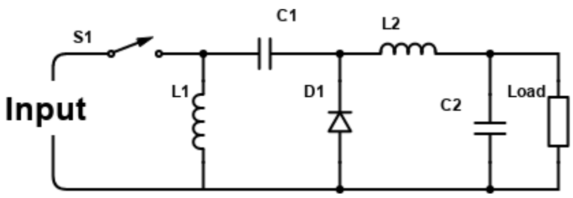


Fig4: Zeta Converter

D) LUO CONVERTER

Luo converters, which retain the name of its author, are derived from basic Zeta/SEPIC circuits. Combining a switched capacitor, voltage lift, and impedance network makes up a luo converter. Fig. 4 serves as the foundation for the Luo converter's basic circuit [8].

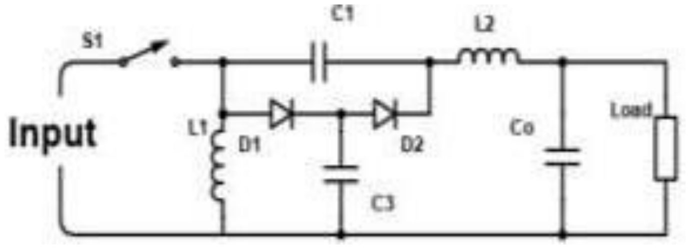


Fig 5: Luo Converter

By substituting Diode D1 with a capacitor and diodes, voltage lift can be achieved. The voltage lift can be self-lifting, re-lifting, triple-lifting, or even quadruple-lifting as in [8]. Due to their capacity to elevate voltage, Luo converters are appropriate for battery electric cars because they offer a high-power density with a straightforward layout. Additionally, it is a preferable option for off-grid locations when charging EVs using solar energy [9]. High power EV chargers that offer high precision, high power density, and cheap cost in a single switching cycle can use a Modified Bridgeless Luo Converter as in [10].

E) VIENNA RECTIFIER

The Vienna rectifier has a proven use in the production of atypical renewable energy. With easy control, this rectifier offers active power factor correction.Vienna rectifier performs better in a charging station with hybrid smart grid for medium- to high-power applications with non-isolated input. This three-phase rectifier provides a high power density that can be used for a big electric car [11]. It is suitable for EV applications because of its high Power to weight ratio, reduced THD and small filter size need [12]. In order to increase efficiency, many control systems are available and are consequently used for EV applications. High power (DC rapid) charging stations can make use of this [13]. When examining the converter, the only factor to take into account is the rectifier's unidirectional nature

III. CONVERTERS IN EV's

Power converters used for charging have a little impact on the supply (whether it be AC or DC), reduced switching losses, are simpler and smaller in design, and have less output distortion [14]. The converters take the power from the supply, store it in an energy storage device, and then feed the motor with the stored power. Through these converters, power is occasionally recovered to the battery bank during regenerative breaking. In this work, a few of these converters are discussed.

A) ZVS Interleaved AC-DC BOOST PFC Converter

A DC-DC Buck Converter is utilized as the front-end converter after this one. Series inductance, shunt capacitance and switches that are possibly MOSFETs make up the converter. The voltage switching occurs at the instant of zero voltage and a very brief dead period is introduced between MOSFET switching to accomplish this. Before this dead time, the MOSFET's parasitic capacitance is charged and discharged. The value of the series inductor, which serves as the boost inductor [14].

Numerous benefits of this architecture include soft switching, nearly nil switching losses, near unity power factor, and effective battery charging. This converter can provide the required voltage because EVs need to be charged at voltages between 48 and 400 volts. This converter's limitation on duty ratio control necessitates the use of an auxiliary circuit for zero voltage switching to get a wide range of output voltage and a universal input voltage (86 - 265 RMS), which is a drawback .

B) DC-DC converter with limited power

The name "Partial Power Converter" refers to the fact that only a portion of the power is transformed using the converter and the remainder is bypassed directly to the load. Because intermediate conversion only lasts a brief period of time, losses from magnetic, switching and conduction processes are reduced. The converter is therefore appealing for use in DC rapid charging stations. This converter can be used for grid-connected rapid charging and it has a 3% higher efficiency than a full converter [15].In [16], a partial power converter is analyzed using two scaled-down prototypes. It is determined that this kind of converters do not need galvanic separation and the partial power method also results in a smaller converter size.

C). Quadratic Double Boost Converter

To use this power directly to charge an EV, a double Boost converter is recommended [17]. Renewable sources like solar have low voltage output and require a boost. By overlapping the supply with capacitance discharge to charge an EV battery, the double boost effect can be achieved utilizing the superposition concept. The double boost increases solar efficiency overall to 80%, but the control is difficult since more diodes are needed to superimpose the voltage [18].

D)Bi-Directional DC-DC Converter

Energy can be stored in batteries and retrieved for supply to motors using a three level bi-directional converter. This works well for a variety of driving situations. A converter is suggested in , where the battery is charged in buck mode and discharged in boost mode. L and C two passive elements, serve as filters during conversion.Pulse Rate This kind of converter uses modulated techniques. This method regulates the process of switching on and off by comparing the reference current with the battery input current. Phase locked loops in charging controls extract the necessary current for sinusoidal signal production .

E) Multi Level Converters

In an interleaved converter, the conversion is accomplished with the aid of passive components, while in a multi-level converter, the voltage is divided into n levels with the aid of suitable switching components. When compared to traditional interleaved converters, multilevel converters use fewer switches and have lower component stress .The battery of an EV has been used repeatedly, putting it under a lot of voltage stress. Multilevel inverters are appropriate when a varied charge profile is required, and chargers using these converters also experience less voltage stress . Multi-level converters' conversion efficiency is also higher than that of interleaved converters due to the absence of as many passive storage components.

IV. CONVERTERS COMPARISON

The examined converters are contrasted and displayed in tabular style. The mode of operation, an estimated THD, and efficiency are displayed in Table 1. Table 2 lists the limitations of each converter along with comments about its usability. Low current ripple, high power output, dependable efficiency, and Current THD less than 5% as per IEC Standard 61000-3-2 are some of the benefits of the power converters examined.You can combine a Cuk and a SEPIC. With the help of available renewable energy, this design efficiently and constantly produces power. An electric vehicle (EV) can be charged using the electricity generated by this fused converter [22]. Compared to other converters, Luo Converters with extreme lift technology provide high power from a given input. The Vienna rectifier, which provides high power density per charging cycle, has been studied by a number of researchers to be implemented in on-board chargers as in [15], and research is currently being conducted to use the Vienna rectifier off-board.When compared to other converters, the multi-level converters used in the study are particularly effective for use in electric vehicles. Depending on the application, converters can be advantageous. For example, a solar power double boost converter provides an overall system efficiency of 80%.

V. CONCLUSIONS

The comparison of several converters that can be utilized in EV charging stations is done in this research. The SEPIC and Cuk converters can be used for low power EVs, Zeta can be used for solar-powered EV charging, Luo converter can be used for high power EVs, and Vienna can be used for both on-board and off-board off-grid EV charging stations, according to the literature. Future work could include developing new topologies or including more filter components to further raise the caliber of power converters. The development of power converters has reduced the cost and increased the dependability of EV charging, which has led to a rise in EV charging stations.

REFERENCES

1) Rashid, Muhammad H. "Power Electronics Circuits, Devices and Applications", 4th Ed. Pearson education, 2014

2) G. Mohanty, "SEPIC Based Multi Input Dc-Dc Converter," 2019 IEEE 5th International Conference for Convergence in Technology (I2CT), 2019, pp. 1-4, doi: 10.1109/I2CT45611.2019.9033886.

3) Golam Sarowar et al, "Simulation of High Efficiency Switched Capacitor AC to DC SEPIC Converter for Improved Power Quality", International Journal of Computer Science and Network Security, Vol. 16 No. 10 pp. 9-15.

4) R. Kushwaha and B. Singh, "An Improved SEPIC PFC Converter for Electric Vehicle Battery Charger," 2019 IEEE Industry Applications Society Annual Meeting, 2019, pp. 1-8, doi: 10.1109/IAS.2019.8912344.

5) Wenzheng Xu, K. W. E. Cheng and K. W. Chan, "Application of Cuk converter together with battery technologies on the low voltage DC supply for electric vehicles," 2015 6th International Conference on Power Electronics Systems and Applications (PESA), 2015, pp. 1-5, doi: 10.1109/PESA.2015.7398944.

6) A. Kumar and B. Singh, "Solar Fed Cuk Converter Based SRM Drive Control of E-Rikshaw," 2020 3rd International Conference on Energy, Power and Environment: Towards Clean Energy Technologies, 2021, pp. 1-6, doi: 10.1109/ICEPE50861.2021.9404389.

7) Wenzheng Xu, K. W. E. Cheng and K. W. Chan, "Application of Cuk converter together with battery technologies on the low voltage DC supply for electric vehicles," 2015 6th International Conference on Power Electronics Systems and Applications (PESA), 2015, pp. 1-5, doi: 10.1109/PESA.2015.7398944.

8) A. M. Khatab, M. I. Marei and H. M. Elhelw, "An Electric Vehicle Battery Charger Based on Zeta Converter Fed from a PV Array," 2018 IEEE International Conference on Environment and Electrical Engineering and 2018 IEEE Industrial and Commercial Power Systems Europe (EEEIC / I&CPS Europe), 2018, pp. 1-5, doi: 10.1109/EEEIC.2018.8494541.

9) https://www.analog.com/en/technical-articles/the-low-output-voltage-ripple-zeta-dc-dc-converter-topology.html
10) J. S. Goud, K. R., K. R. and B. Singh, "Low Frequency Ripple Charging of Li-Ion Battery using Bidirectional Zeta DC-DC Converter to Improve Charge Transfer Efficiency," 2018 IEEE 7th International Conference on Power and Energy (PECon), 2018, pp. 62-66, doi: 10.1109/PECON.2018.8684089.
11) B. Saha and B. Singh, "Sensor less PMBLDC Motor Driven Solar-PV Battery Fed EV System with Regenerative Braking Employing Zeta Converter," 2021 International Conference on Sustainable Energy and Future Electric Transportation (SEFET), 2021, pp. 1-6, doi: 10.1109/SeFet48154.2021.9375728.
12) Fang Lin Luo, "Luo-Converters, a series of new DC-DC step-up (boost) conversion circuits," Proceedings of Second International Conference on Power Electronics and Drive Systems, 1997, pp. 882-888 vol.2, doi: 10.1109/PEDS.1997.627511.
13) A.Manikandan , N.Vadivel. "Design And Implementation Of Luo Converter For Electric Vehicle Applications". International Journal of Engineering Trends and Technology (IJETT). V4(10):4437-4441 Oct 2013. Pp. 4437-4441.
14) U. Muthuraman and R. Kabilan, "A High Power EV Charger based on Modified Bridgeless LUO Converter for Electric Vehicle," 2021 Third International Conference on Intelligent Communication Technologies and Virtual Mobile Networks (ICICV), 2021, pp. 512-515, doi: 10.1109/ICICV50876.2021.9388385.
15) H. Vahedi, P. Labbe and K. Al-Haddad, "Single-Phase Single-Switch Vienna Rectifier as Electric Vehicle PFC Battery Charger," 2015 IEEE Vehicle Power and Propulsion Conference (VPPC), 2015, pp. 1-6, doi: 10.1109/VPPC.2015.7353019.
16) G. Rajendran, C. A. Vaithilingam, N. Misron, K. Naidu and M. R. Ahmed, "Voltage Oriented Controller Based Vienna Rectifier for Electric Vehicle Charging Stations," in IEEE Access, vol. 9, pp. 50798-50809, 2021, doi: 10.1109/ACCESS.2021.3068653.
17) Thandapani, T. & Karpagam, R. & Paramasivam, S.. (2015). Comparative study of VIENNA rectifier topologies. International Journal of Power Electronics. 7. 147. 10.1504/IJPELEC.2015.075420.
18) M. Muntasir Nishat, M. A. Moin Oninda, F. Faisal and M. A. Hoque, "Modeling, Simulation and Performance Analysis of SEPIC Converter Using Hysteresis Current Control and PI Control Method," 2018 International Conference on Innovations in Science, Engineering and Technology (ICISET), 2018, pp. 7-12, doi: 10.1109/ICISET.2018.8745619.