Journal of Image Processing and Intelligent Remote Sensing
ISSN 2815-0953
Vol: 03, No. 02, Feb-Mar 2023
http://journal.hmjournals.com/index.php/JIPIRS
DOI: https://doi.org/10.55529/jipirs.32.11.21

DC-DC Converters Topology

Nikita Prashant Besekar*

**Department of Electrical Engineering, Rastrasant tukdoji maharaj Nagpur University, India*

*Corresponding Email: *nikitabesekar21@gmail.com*

Received: 18 October 2022 **Accepted:** 06 January 2023 **Published:** 08 February 2023

Abstract: In this paper the various perspectives on different dc-dc converters are reviewed . The various advantages and disadvantages of both Converter topologies that are classical and recent converters and overview of dc micro grid are discussed. From the data we found that every Converter has some advantages and disadvantages also but the Buck, Boost, Cuk and zeta Converter have less ripple. And Buck and Boost has the best efficiency as per cost. The dc micro grid has lots of advantages over AC microgrids; they can perform reliable operation, higher efficiency, low power loss and no skin effect. Theoretical and practical implications were discussed. Advanced dc converters are also reviewed.

Keywords: Micro Grid, Converters, Zeta Convert, Buck Converter, Advancement in DC Converters.

1. INTRODUCTION

In 1892 the first dc microgrid was built by Thomas Edison. dc power was phased out after the advent of AC power as it was found that such power was much suitable and it was found that such power is very easy for generation, And it was found that such power is very easy for transmission ,distribution and generation [1]. dc power is most reliable and has some advantages to use in long transmission of power . For generating ac power the different kind of fuels are used which creates disturbance in surrounding areas but in case of generating dc power there is no such problem. A microgrid is a low voltage (LV) power network with distributed energy sources such as photovoltaic (PV) arrays, micro-wind turbines, fuel cell and energy storage devices (e.g. batteries, super capacitor and flywheel), which offer better control capability over network operation. Microgrids are more reliable and they can operate in grid connected mode and island mode [2]. microgrids .dc microgrids has efficiency and easy Microgrid can be a Ac , dc or combination of both depending upon application. Ac microgrids are perfect when the source as well as load will be Ac .I want to give power to dc load as well then in case of Ac microgrids the number of conversion stages are most and it will introduce losses in the system which reduces the overall efficiency of the system. dc microgrids are

Journal of Image Processing and Intelligent Remote Sensing
ISSN 2815-0953
Vol: 03, No. 02, Feb-Mar 2023
http://journal.hmjournals.com/index.php/JIPIRS
DOI: https://doi.org/10.55529/jipirs.32.11.21

introduced to minimise the conversion stages, if the conversion stages are less losses(up to 34%) will be minimised and it saves the power. There are number of advantages over ac microgrid which are seen that dc microgrids are better than Ac integration of dc DERs, no need of additional compensating device to manage the reactive power because of absence of reactive power in dc , no skin effect, no power loss due to charging current, etc.
The generalized structure of the dc microgrid is as shown in figure 1.

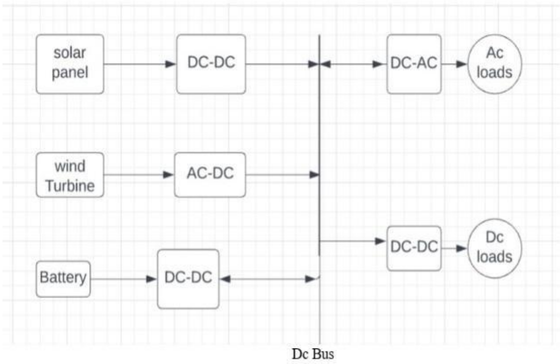


Fig.1 Generalized structure of Dc micro grid

In this review paper the overall idea about different kinds of dc -dc converters topology are introduced. Small introduction and why we choose dc microgrids and advantages of dc microgrids over ac microgrids are written specifically. The advantages and some different problems in the converters are also mentioned in this . The design parameters of Buck-Boost and Boost converters are also given, it will be very helpful in designing part of converters.

Theory of Converter Topology in DC Micro grid

In dc microgrids many of the converters are used to maintain continuity of power flow , some of the places the power can be step up or step down for this purpose the converters used like Buck-Boost, Boost converters and others also. In converters the power electronic devices like IGBT or MOSFETs are used for switching purposes by giving signal to the gate terminal of the device. Buck-Boost converters can perform both the action of step up and step down depending on the duty cycle the conversion is decided. The design parameters of Buck-Boost and Boost converter are also mentioned in further discussion. The dc-dc converters are divided into the Isolated and Non-Isolated Converters. Isolated converters are the converters which isolates the input and output part and prevents direct flow between input and output, it uses transform for isolating purposes. In case of non isolating converters, there is a dc path between input and output. The non isolated dc-dc converter is more efficient (>95%) and compact than isolated dc-dc converter [3], [4]. Further sections explain different dc-dc converter topology for dc microgrid.

1. Buck Converters:

Buck Converters are simple in construction and they are highly efficient, showing 90% of efficiency. It is also called step down converter. In these converters the output is smaller than input. During fault conditions of load di/dt is limited by the inductor. In this type of converter

Journal of Image Processing and Intelligent Remote Sensing
ISSN 2815-0953
Vol: 03, No. 02, Feb-Mar 2023
http://journal.hmjournals.com/index.php/JIPIRS
DOI: https://doi.org/10.55529/jipirs.32.11.21

High voltage rating switch is required and current is discontinued. It requires a filter to get pure dc and overcome the discontinuity of current [5], [6].

2. Boost Converters:

It is also called step up converter because the output of these converters is greater than input side During fault conditions of switch di/dt of fault current is limited by inductor. peak current flow through the power transistor. Input current continues in these converters. Larger filter capacitor and larger inductor is required [7]. Boost Converter operation will be unstable in practical condition at duty ration D=1.Duty Ratio,D-1 means switch will be closed permanently due to this capacitor will be discharged completely so that average output voltage is zero. At the input side, the inductor will store energy continuously and will be driven towards saturation. Generally Boost Converter is operated for duty ration : D= 0 to 0.5[4], [7]. The inductor has the property to oppose the change in current quantity either higher or lower and stores the energy in the form of a magnetic field. The load gets continuous power due to this stored energy. The traditional boost converter has several drawbacks. Because of the absence of a control mechanism over input current at high duty cycle it may cause serious damage to the components which are used in dc-dc converters. Step up and step down voltage can be obtained with less number of components (cuk , Sepic and Zeta uses more components compared to boost converters) and compared to other converters boost converters have low cost.

3. Buck-Boost converters:

The Buck-Boost converter is the dc dc converter which can step up and step down the input voltages . In this type of converter we can obtain higher or lower voltage but the input and output side voltages are not pure dc it is a main drawback in these converters. There is no isolation provided between input and output and has lower efficiency because of this it cannot achieve high gain output. But the efficiency of Buck-Boost converters can be improved by only operating it either in buck mode or boost mode. It has minimal components in the circuit and various voltage ranges can be achieved.

4. Cuk converter:

In the year of 1977 the Cuk converter was invented by Dr Slobodan Cuk of Caltech. In buck converters it is seen that the buck converters only step downs the input voltage and in case of boost converters they can only step ups the input voltage and in Buck-Boost converters they can step up and step down the input voltage as well but the input and output voltages cannot be pure dc, for this reasons the Cuk converter is introduced. It is an inverted converter and with presence of inductor and capacitor in input and output side we got pure dc. These components work like filters. But the limitation is that it used more components compared to boost converters. This converter circuit needs the high ripple current carrying capacity of coupling capacitor is the one of the drawback but the it is highly efficient and has low switching losses. [9]

5. Sepic converters:

Single ended primary inductor converter is a dc dc converter similar to the buck -boost converters it can step up or step down the input voltage. In Sepic converters extra inductor and

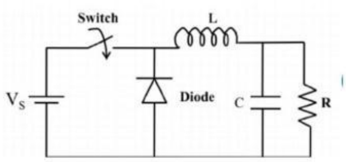
Journal of Image Processing and Intelligent Remote Sensing
ISSN 2815-0953
Vol: 03, No. 02, Feb-Mar 2023
http://journal.hmjournals.com/index.php/JIPIRS
DOI: https://doi.org/10.55529/jipirs.32.11.21

capacitor are used to increase the overall efficiency of the system. As same as the buck and boost converters it also has minimal components and it has efficiency about 88% and provides low noise operation.[12].
The given table gives the comparison between different dc-dc converters as shown below

Types	Attributes
Boost [7][9]	Minimal components are used , better efficiency, simple , low cost
Buck [5] [6]	Simple in construction, has efficiency up to 90%, current is discontinuous, high Voltage rating switch is required.
Buck-Boost [9]	Minimal components are used, simple , can obtain higher or lower voltage, lower efficiency , input and output voltages are not pure dc , no isolation is provided between input and output
Cuk [9][12]	Minimise the drawback in Buck-Boost converters, more components are used compare to buck and boost converters, higher efficiency
Sepic [12]	Extra inductor and capacitor are used, higher efficiency, provide low noise operation
Zeta [12]	dc isolation is provided between input and output, it can be step up or step down the input voltages, output current is continued.

Designing parameters of different Converters:

Buck Converter:



Selection of Inductor:

$$L = \frac{D.(1-D).V_S}{\Delta I_L}.T$$

$$V_O = D.V_S$$

$$D = \frac{V_O}{V_S}$$

Journal of Image Processing and Intelligent Remote Sensing
ISSN 2815-0953
Vol: 03, No. 02, Feb-Mar 2023
http://journal.hmjournals.com/index.php/JIPIRS
DOI: https://doi.org/10.55529/jipirs.32.11.21

Where,
D – Duty cycle
Vo – Output voltage
Vs – source voltage
T – Time period
ΔIL – Ripple inductor current (Typically 20% - 40% of Load current)

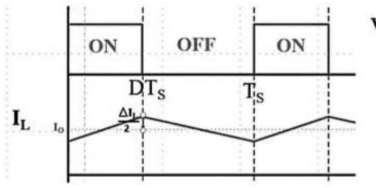
Selection of capacitor:

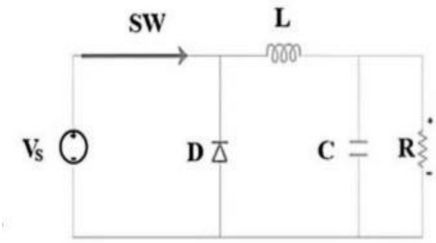
$$C = \frac{D.(1-D).V_S}{8.L.\Delta V_C}.T^2$$

Where , T = 1/ fsw. (fsw – switching frequency)
ΔVc – Ripple output voltage . (ΔVc 1%-5% of Vo)

Selection of Switch:

$$I_{SW} = I_{max} + \frac{\Delta I_L}{2}$$





Selection of Diode:

Current through Diode;

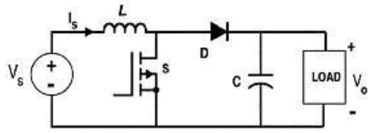
$$I_F = I_O \times (1-D)$$

Power dissipation:

$$P = I_F \times V_F$$

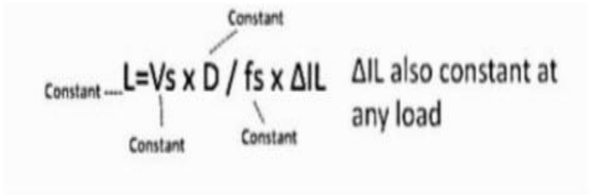
Journal of Image Processing and Intelligent Remote Sensing
ISSN 2815-0953
Vol: 03, No. 02, Feb-Mar 2023
http://journal.hmjournals.com/index.php/JIPIRS
DOI: https://doi.org/10.55529/jipirs.32.11.21

Boost Converter:



Selection of Inductor:
L= Vs . D / fsw . ΔIL
D= 1- Vs / Vo
Where,
Vs – source voltage
Vo- Output voltage
Fsw – switching frequency
ΔIL- Ripple inductor current(According to the Thumb rules, ΔIL. can be 20% to 40%. The value of ΔIL should be maintain , it should not be very high or very low if it is then it may be faced problems like instability in operation and susceptive to electromagnetic interference .
Inductor current : IL=P/Vo

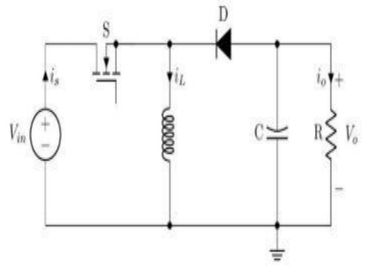
Load at rated power:
$P = V^2/R$
$R=V^2/P$
Output current : Io=P/Vo
Selection of Capacitor:
C = Io . D / fsw . ΔVc
ΔVc : Ripple voltage (1% -5%)if we reduce ripple In output voltage further, the size and cost of the
Capacitors will increase.
Load at rated power: $P = V^2/R$
$R=V^2/P$.
ΔIL=20% to 40% of IL
ΔVc= 1% to 5% of Vo
For inductor value:



For capacitor value:
C = Io x D / fs x ΔVo
-Io is dependent on load
-If load is increased then output current will decrease and vice-versa. So current will decrease if R is increased. Resulting ΔVc means ripple in voltage, also decreases.

Journal of Image Processing and Intelligent Remote Sensing
ISSN 2815-0953
Vol: 03, No. 02, Feb-Mar 2023
http://journal.hmjournals.com/index.php/JIPIRS
DOI: https://doi.org/10.55529/jipirs.32.11.21

Buck-Boost Converter:



Output voltage:

On state :

VL(on) =Vi

Duty cycle, D = Ton /Ton +Toff
D=Ton/T

- Ton =DT

Off state:

VL(off)= -Vo

- Toff=(1-D)T

- VL(on) x Ton+VL(off) x T(off)=0
  VDT +(-Vo)(1-D)T=0
  Vo=(D/1-D)V

- **Work as a buck converter**

D<0.5

Ex-
D=0.4
Vo=0.4/0.6 V
Vo=2/3 V

Is as Work as a boost converter if duty cycle is less than 0.5

- **Working as a boost converter**

D > 0.5

Ex-
D = 0.6
Vo = 0.6/0.4 V
Vo=3/2V

It is work as a boost converter if duty cycle is greater than 0.5

Journal of Image Processing and Intelligent Remote Sensing
ISSN 2815-0953
Vol: 03, No. 02, Feb-Mar 2023
http://journal.hmjournals.com/index.php/JIPIRS
DOI: https://doi.org/10.55529/jipirs.32.11.21

Isolated and non-isolated Converter Topologies:
The components used in the non-isolated converter circuit and the losses due to those components, its output gain is very low. That's the reason they can not provide high output gain and efficiency gets affected. To solve this problem the new converter is introduced by using three winding coupled inductors as proposed in [9]. In [14] the high voltage gain can be attained by using voltage lift techniques and also by using switched inductor techniques the high voltage gain can be obtained [15]. But in these techniques the conduction losses due to high transient current were found and a solution for this by adding two capacitors and diodes can overcome this problem and also achieve higher efficiency with high voltage gain [10,12,13]. Isolated dc-dc Converter normally used in power supply many of the power supplies used dc-dc isolated converter because the regulation becomes actually a two port process one is high frequency transformer which will step down at the load end and apart from the dc-dc converter before that which will adjust the output voltage by means of Duty ratio. Isolated dc-dc converters have many types but we will discuss some of them . Flyback converter is only meant for less than 100 watt capacity because it heavily depends upon the magnetizing inductance of the transformer that we are going to use. It is very popular and easy to design, high output voltages provide higher efficiency [16]. Forward converters are a slight modification of the flyback converter, but the only thing is we are not dependent only on magnetising inductance of the transformer. That is the high amount of leakage still we will be able to manage. Capacity is about 100-150 watt. Push pull converters are used transformers with Centre taps. This can work for high ratings. People are using this expensively for solar PV applications as well. So this is not just limited to personal computer power supply this can go for 10 KW rating at least. This converter provides zero voltage switching and continuous current and has advantages like providing zero turn on loss at the condition of hard switching as well [17].

New Trend in Dc Dc Converters and Literature Survey:
In a new trend of a dc-dc converters the researchers try to minimize the size of the components which they are used in converter circuit to make it compact and highly efficient as well. The new trend is mainly application based and researchers are trying to make very highly efficient converters and controlling mechanisms for particular applications such as power factor correction, electric vehicle application, renewable energy extraction, battery charging application , HVdc Application ,etc. In addition the voltage lift techniques are also used to improve circuit characteristics of dc-dc converters , increase the output voltages and efficiency also improved. In Modern techniques by embedding the voltage lift techniques we can make seven new dc dc step up converters with reliable operation, low cost and in a simple way we can get high voltage output. This converter calls seven self lift converters which has many advantages and it is different from other dc step up converters with smooth ripple they can give high voltage output. Modified positive output Luo converters are the slight modification of positive output Luo converters which give greater output voltages with the combination of inductor and capacitor to provide lifted output voltage. One of the applications of this converter for pv systems [18] . Voltage lift techniques are also very important in case of designing of dc dc converters , e.g Luo converters . Double output Luo converters are mostly used in industrial applications and computer periphery circuits. It can convert positive input voltage to positive

and negative output voltage by two conversation paths . Luo converters and Double output Luo converters which have single output (positive and negative) are the link of new dc step up converters with the use of only one switch . They are different from other dc dc step up converters having advantages like high output voltage with simple design and highly effective converters. LLC converters are the type of resonant converter based on the use of a resonant tank . Practically it is not so used because of their complex controlling mechanism and design but these have many advantages including providing high efficiency and electrical isolation, wide output range, and low EMI pollution. Now a days for application of pv system lots of advancement are done in many of the dc dc converters as includes Asynchronous boost and a series -resonant converter, the main advantage of this type of convert that offer high efficiency due to there is no switching losses which is attend by zero voltage switching. The asynchronous boost and a series -resonant converter can be simplified by inserting a passive impedance network in place of boost converter and the converter is named as Quazi-Z source resonant converter. Recently many of the approaches are studied for the efficiency command interpreter when used for high voltage range. One of the converters suitable for this approach is the LLCC series-parallel resonant converter, which has appropriate components with greater efficiency over a wide range of voltage. The Dual-mode resonant converter offers 97% of efficiency when converting ZVS for primary side switches and ZCS for rectifier diodes but this should be done at the same time in both the resonance modes . Another dc dc converters are also preferred for achieve greater efficiency, Series resonant converter, Half-bridge LLC resonant converter, Parallel resonant current-fed push-pull converter , Multi resonant two inductor boost converter with non-dissipative regenerative snubber .

2. CONCLUSION

For many of the applications where the dc dc converters are used , their topology and their suitability for the particular applications is most important for this reason topology of different dc dc converters are introduced in this paper. From many of the research papers we have found differences, advantages, and problems concerning their design are also mentioned in this paper. Advanced search into the dc dc converters , modification in converters which are used for pv systems are also mentioned in this paper. Topology of different dc dc converters and deep discussion about isolated and non isolated dc dc converters are also reviewed. A short discussion of why we have to go toward dc power is also mentioned. Many of the researchers studied for reducing the complex design, reduction in size of components which are used in converters and looking for highly efficient converters. The following points and the solution is also written in this paper. Voltage lift techniques are also discussed to increase the efficiency of converters.

3. REFERENCES

1. D. Kumar, F. Zare and A. Ghosh, “dc Microgrid Technology: System Architectures, AC Grid Interfaces, Grounding Schemes, Power Quality, Communication Networks, Applications, and Standardizations Aspects,” in IEEE Access, vol. 5, no. , pp. 12230-12256, 2017.

Journal of Image Processing and Intelligent Remote Sensing
ISSN 2815-0953
Vol: 03, No. 02, Feb-Mar 2023
http://journal.hmjournals.com/index.php/JIPIRS
DOI: https://doi.org/10.55529/jipirs.32.11.21

2. IEEE Power and Energy Magazine, vol.15, no.4, pp.25, July/Aug 2017.
3. Prabhakar, Mahalingam. “Transformerless high-gain dc–dc converter For microgrids.” IET Power Electronics, vol.9, no.6, pp.1170-1179, May 2016.
4. Rehman, Zubair, Ibrahim Al-Bahadly, and Subhas Mukhopadhyay. “Multi Input dc–dc converters in renewable energy applications–An Overview.” Renewable and Sustainable Energy Reviews, vol. 41, pp. 521-539, 2015.
5. Walker, Geoffrey R., and Paul C. Sernia. “Cascaded dc-dc converter Connection of photovoltaic modules.” IEEE Trans. Power. Electron, Vol.19, no.4, pp.1130-1139, July 2004.
6. M. Dursun and A. Gorgun, “Analysis and performance comparison of dc-dc power converters used in photovoltaic systems,” 2017 4 the International Conference on Electrical and Electronic Engineering , Ankara, 2017, pp. 113-119.
7. Xiao, Weidong, Nathan Ozog, and William G. Dunford. “Topology Study of photovoltaic interface for maximum power point Tracking.” IEEE Trans.Ind.Electron., vol.54, no.3, pp.1696-1704, June 2007
8. Soedibyo, B. Amri and M. Ashari, “The comparative study of Buck-Boost, Cuk, Sepic and Zeta converters for maximum power point Tracking photovoltaic using P&O method,” 2nd International Conference on Information Technology, Computer, and Electrical Engineering, Semarang, 2015, pp. 327-332.
9. Wai, Rong-Jong, et al. “High-efficiency dc-dc converter with high Voltage gain and reduced switch stress.” IEEE Trans.Ind.Electron, Vol. 54, no.1 , pp. 354-364, Feb 2007
10. T. F. Wu, Y. S. Lai, J. C. Hung, Y. M. Chen, “Boost converter with Coupled inductors and buck–boost type of active clamp”, IEEE Trans. Ind. Electron., vol. 55, no. 1, pp. 154-162, Jan. 2008.
11. Prudente, Marcos, et al. “Voltage multiplier cells applied to non-isolated dc–dc converters.” .” IEEE Trans. Power.Electron, vol.23,no.2,pp. 871-887,March 2008.
12. Hsieh, Yi-Ping, et al. “A novel high step-up dc–dc converter for a Microgrid system.” IEEE Trans.Power.Electrons, vol. 26, no. 4, pp. 1127-1136, April 2011.
13. Axelrod, Boris, Yefim Berkovich, and Adrian Ioinovici. “Switched-Capacitor/switched-inductor structures for getting transformerless Hybrid dc–dc PWM converters.” IEEE Trans. Circuits and Systems I, Vol. 55, no .2, pp. 687-696, March 2008.
14. A new dc–dc converter based on voltage-lift technique. September 2015 International Transactions on Electrical Energy Systems 26(6)DOI:10.1002/etep.2133. Authors:Farzad Mohammadzadeh Shahir, University of Tabriz, Ebrahim Babaei, University of Tabriz, M. Sabahi, University of Tabriz, Sara Laali
15. “Step-Up dc-dc Converter with High Voltage Gain " Using Switched-Inductor Technique 1 Mayur N. Parmar, 2 Prof.Vishal G. Jotangiya 1 P.G. Scholar , Assistant Professor Department of electrical engineering, MEFGI, Rajko
16. “Design and implementation of flyback converters” ,Publisher: IEEE, Authors - Nasir Coruh, Department of Electrical Engineering, Kocaeli University, Kocaeli, TurkeyS, Urgun, Civil Aviation College, Kocaeli University, Kocaeli, Turkey, Tarik Erfidan, Department of Electrical Engineering, Kocaeli University, Kocaeli, Turkey
17. “Push pull boost converter with low loss switching”, Publisher: IEEE, Authors – S.L. PIndi Instrument Design Development Centre, Indian Institute of Technology Delhi, New

ISSN 2815-0953
Vol: 03, No. 02, Feb-Mar 2023
http://journal.hmjournals.com/index.php/JIPIRS
DOI: https://doi.org/10.55529/jipirs.32.11.21

Delhi, A.K. Agarwala Instrument Design Development Centre, Indian Institute of Technology Delhi, New Delhi, India

18. Analysis of a modified positive output Luo converter and its application to solar PV system, Publisher: IEEE, Authors - Chaitanya Pansare, EED, SGSITS, Indore, India, Shailendra Kumar Sharma, EED, SGSITS, Indore, Chinmay Jain, Shakti Pumps India Ltd, Pithampur, Rakesh Saxen, E SGSITS, Indore, India

