A review on Modern Converters in line with Power Factor Improvement

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ABSTRACT
Most renewable systems depend on converters parameters. With the help of low harmonics and better power factor the system stability has been improved.In this research, several converter topologies have been investigated for active power factor enhancement. In this paper, various topologies, including DC-DC input converters, quasi Z-source converters, DC-DC Buck Boost converters with inverters, three level modular DC-DC converters, SEPIC converters, CUK converters, and bridgeless Buck Boost converters, are differentiated, and the best solution for improving power factor in various fields of applications are reached after conducting a literature review.

Keywords: Z-source converters, DC-DC, SEPIC converters, CUK converters,

1. INTRODUCTION

DC voltage must be used in power distribution systems and industrial applications to supply current technology like DC motors, batteries, and other devices. This type of conversion is frequently accomplished with ac/dc converters. However, because converters are made up of non-linear electrical components like switches and diodes, harmonic components manifest in line current and voltage. These harmonic components exert significant strain on the transformer and transmission line, and they can even cause the distribution system to overheat.

For appropriate operation and functioning, it is necessary to repair the devices that are widely used in industrial, professional, and home appliances. They have non-linear input characteristics because they are connected to a grid with non-linear loads, which cause non-sinusoidal line current to be produced. Additionally, current with frequency content that is sum of the signal frequency generates line harmonics. They reduce the system's power factor, which has a negative impact on the efficiency of the devices. Therefore, it is necessary to lower the line current harmonics in order to raise the system's power factor.

The Power Factor Correction (PFC) control is recommended to minimize harmonic components and boost transmission efficiency by reaching unity power factor. Because the incoming voltage and current are maintained to be in-phase, the system may be thought of as a pure resistance and all power generated by the supply is entirely transferred to the load.Both the efficiency and the harmonic are greatly increased. PFC has become a popular research topic and has been examined in literature because of the benefits it provides the power system.

2. LITERATURE WITH BENEFITS

The following figure shows different types of DC-DC Converter families.Various topologies, including DC-DC input converters, Quasi Z-Source converters, DC-DC Buck Boost rectifiers with inverters, three level modular DC-DC converters, SEPIC DC-DC converters, CUK converters, and Bridgeless Buck Boost converters, will be analyzed in this review paper.

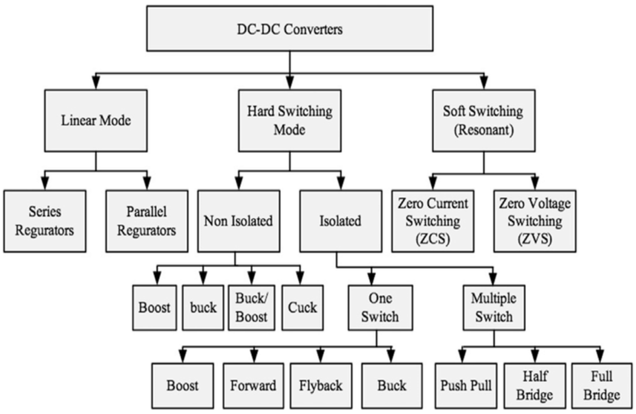


Fig.1 DC-DC Converter types

2.1. Survey on Pulsating power mismatch problem

One of the most important factors to determine the stability of the system are controller algorithms for converters specialized working in order to meet the requirement, grid connected converters predetermined shapes with utility.

Due to these factors, instantaneous grid power contains Pulsating components like spikes and surges along with DC [1].

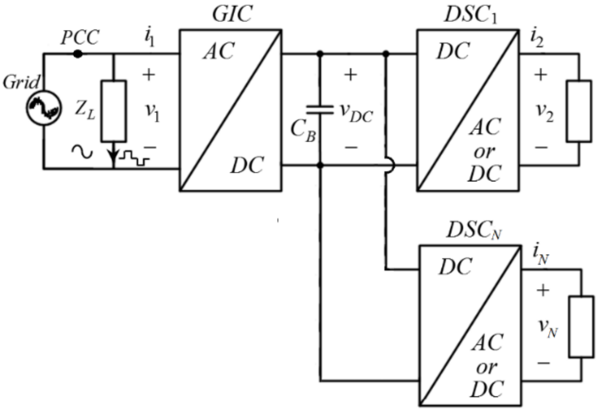


Fig 2. Generalized grid-connected power conversion system

This module improves the harmonic spectrum, uses less resistive and capacitive loads as filtering elements, and boosts the power capacity of low wattage devices. Multiple input DC-DC converters are a concept that has been created to counteract the drawbacks of hybrid energy systems.

Pulsating power mismatches the regular phenomena which occurs in the power quality domain. With the help of [3] we can eliminate this common problem and eradicate the whole substance from the converter side.

Grid-connected conversions transfer electricity with the utilities in predetermined shapes in order to adhere to the strict mains restrictions of today. [1], [2] and [3]. This forces both DC and pulsing components to be present in the instantaneous grid power. To maintain energy balance in steady state, the power flow DC elements must sum to zero, and the pulsating power must have a dynamic nature. The pulsing output balance element is the summation of all pulsating elements that is not zero—is modified as a result. For this reason, a bulk capacitor is placed across the DC link of the power conversion device [4].

DC link voltage ripple is caused by pulsating power components is directly correlated with the power conversion system rating and inversely correlated with the bulk capacitance value. DC link ripple must stay within predetermined bounds, which are typically established by the voltage rating of the bulk capacitor as well as the efficiency of the power conversion system.

Electrolytic capacitorsare often used in systems with wattages more than a few tens of watts. Unfortunately, electrolytic capacitors'are well-known for reliability issues [5, 6] as well as their substantial weight and volume [7, 8] frequently cause system bottlenecks.

2.2 Survey on Quasi Z source converter

The continued development of commercial Photovoltaic circuit topologies toward multilevel structure has been Better harmonic spectra, lighter filtering components, and higher power capabilities can all be obtained with such a setup [9]–[11].

The qZS-CMI has recently attracted more attention in Photo-voltaic applications [12]–[18].

The viability and assessment of the qZSCMI were provided by Xue et al. [12].

In order to achieve distributed MPPT, grid electricity input, autonomous dc-link voltage stability, and, Liu et al. [14]–[17] investigated control techniques for qZS-CMI-based systems. To balance out the PV power, Modular battery system storage was combined [18].

Given the inherent dc and scattered characteristics of PV, the MMC was developed for direct current collection of high-power Photovoltaic system with the goal of simplifying power conversion stages, decreasing the power loss on transmission lines, and enhancing efficiency[19]–[21].

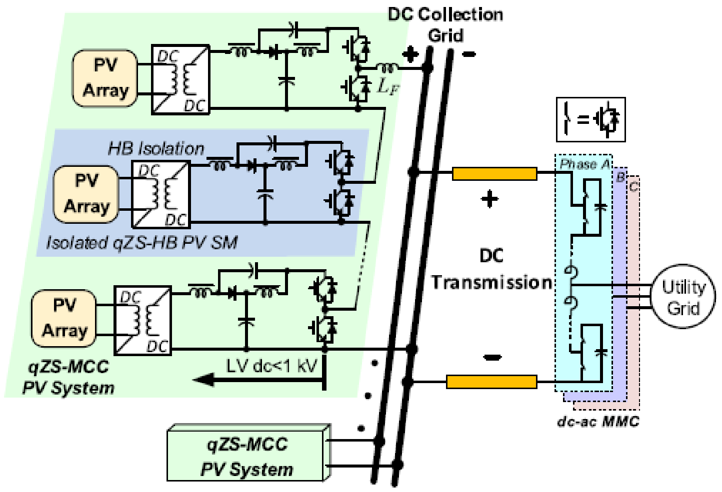


Fig.3 Utility grid interface for MMC

2.3 Survey on DC-DC input converters

The hybrid energy system, which can accept numerous unconventional energy sources to meet varied electrical needs in both countryside and urban areas, is a very promising technological advancement [24]. Without a suitable power electronic interface, the Hybrid Energy System (HES) idea is insufficient [24]–[26]. In the past, the integration of numerous input sources has been encouraged.

But this strategy has some significant drawbacks, such as high system complexity, rising costs, decreased efficiency, and loss of system simplicity.

To eliminate these drawbacks, the MIC idea iscreated. Ithas the potential benefits of a relatively simple and compact form, fewer parts, and improved efficiency [27]-[29].

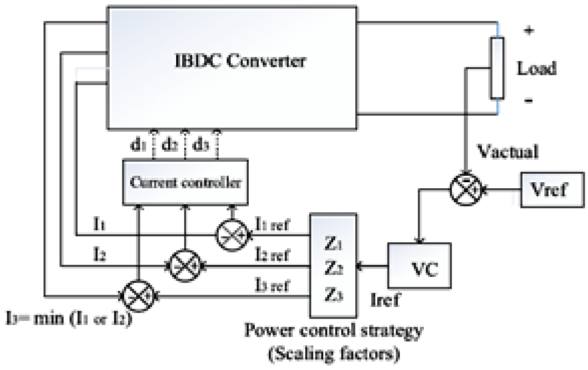


Fig.4 IBDC converter control technique based on ACM control

This research suggests two brand-new hybrid energy source integration topologies for bridge type dual input DC-DC converters (BDC converter and IBDC converter).

The BDC converter's description and operational modes have been presented first, followed by a thorough examination of the upgraded IBDC converter that is created from the BDC converter for three different operational modes, including buck, boost, and buck-boost
To evaluate the simulation results, a comprehensive experimental investigation of the IBDC converter is conducted.

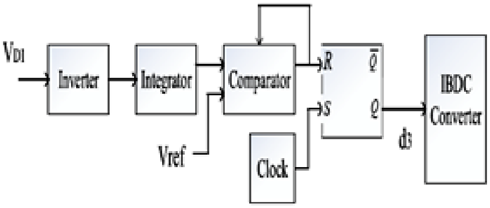


Fig.5 IBDC converter control technique using OCC

The control mechanisms (ACM and OCC) have been established,tested and the outcomes are compared in order to maintain the voltage output at the required value.
From the findings, the OCC approach offers better dynamic performance than the ACM method. These convertersare small size and the low component count increases its significance in applications for the aerospace, micro grid, and smart grid.

2.4 Survey on Buck-Boost Converter

The angular velocity control for configurations using the Buck-Boost converter has been discovered to be solved unidirectional [30] through [32] and bidirectional [33]. Therefore, a control for the bidirectional trajectory tracking of the Buck-Boost based Motor drive system is provided here.
The control strategy is passive, and Lyapunov and the Sylvester criterion are used to analyse the stability of the system [31]. Furthermore, using Matlab-Simulink and a DS1104 board, the control is experimentally tested in a developed model of the system.

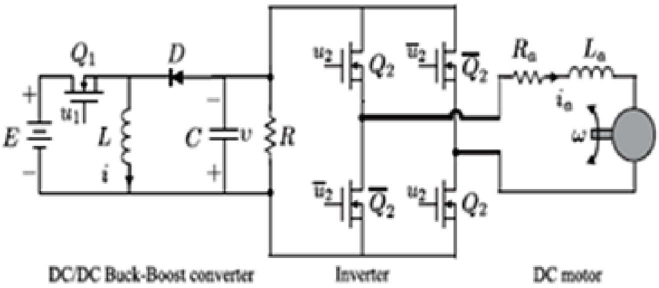


Fig.6 Buck-Boost converter-inverter

A passive tracking control for a Buck-Boost converter inverter drive was developed, requiring just electrical measurements for experimental implementation. With the help of this control system, bidirectional angular velocities can be driven.

3. RESULTS AND DISCUSSION:

3.1 Need forPower Factor Correction

In traditional AC rectification, the mains are used to pull a highly distorted current. This will produce a broad spectrum of harmonic signals that could communicate with other devices. Power factor correction offers a variety of advantages.

1. Decreased demand fees
2. Enhanced load carrying capacity in already-installed circuits
3. A higher voltage
4. Reduced losses in the power system

A technique for raising power factor and lowering input current THD is power factor correction.

3.2 Comparison of Various Converters

There have been numerous proposals for power factor adjusted AC-DC converters to comply with the harmonic requirements. Two basic methods can be used to increase power factor while lowering THD. That is power factor correction, both passive and active.

The following are characteristics of a good power factor correction circuit:

1. Separation with a well-regulated output voltage between the ac Input main supply and the output DC mains.
2. A sinusoidal line current that complies with international standards and has a low THD.
3. High efficiency through the elimination or reduction of switching and conduction losses.
4. Use of components with small sizes and suitable current and voltage ratings.

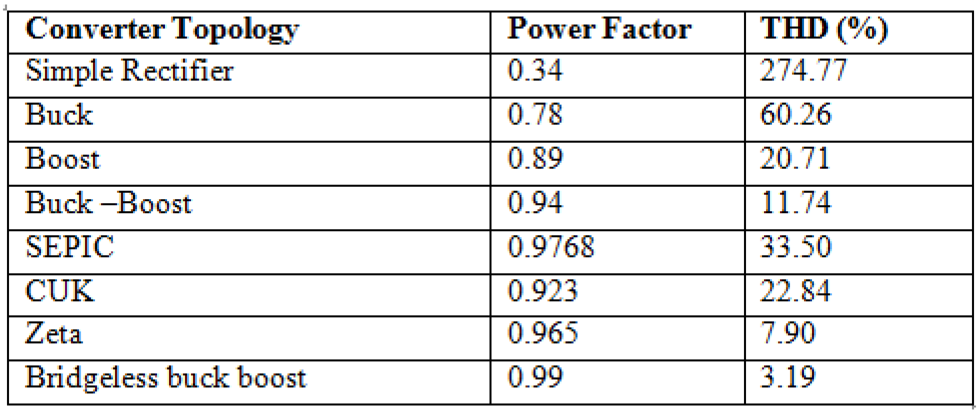
The converters are designed to meet the aforementioned features. Today, numerous topologies have been created for use in power factor adjustment. A boost converter is the standard power factor modification converter. The terminal voltage is always greater than the supply voltage due to the boosting property. Therefore, it is suitable for high power applications.

Therefore, low voltage and low power applications need buck type converters. Since the buck converter's input current is not continuous, it is rarely employed in power factor correction applications. Additionally, it has a high total harmonic distortion and a low power factor.

Low voltage stress, better thermal control, and minimal conduction losses are all features of CUK converters.

3.3 Comparison for various Converters

Table.1 Different converter topology with obtained power factor and THD values



Converter Topology	Power Factor	THD (%)
Simple Rectifier	0.34	274.77
Buck	0.78	60.26
Boost	0.89	20.71
Buck –Boost	0.94	11.74
SEPIC	0.9768	33.50
CUK	0.923	22.84
Zeta	0.965	7.90
Bridgeless buck boost	0.99	3.19

Following the studies [19–27], the above table compares the power factor and THD for several PFC converters. We can determine the optimal performing power factor correction converter by graphing the observed values.

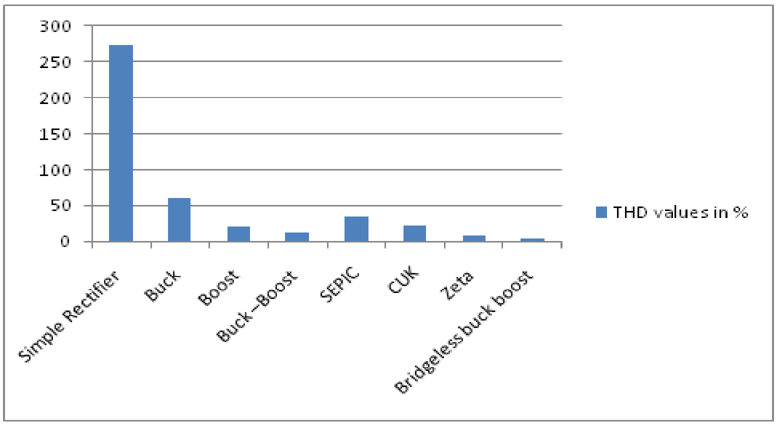


Fig.7 THD values with different converter topologies

The association between THD levels and various converter topologies is evident from the above bar chart. While the bridgeless buck boost converter has very little THD in this circuit, the simple rectifier has extremely high THD values.

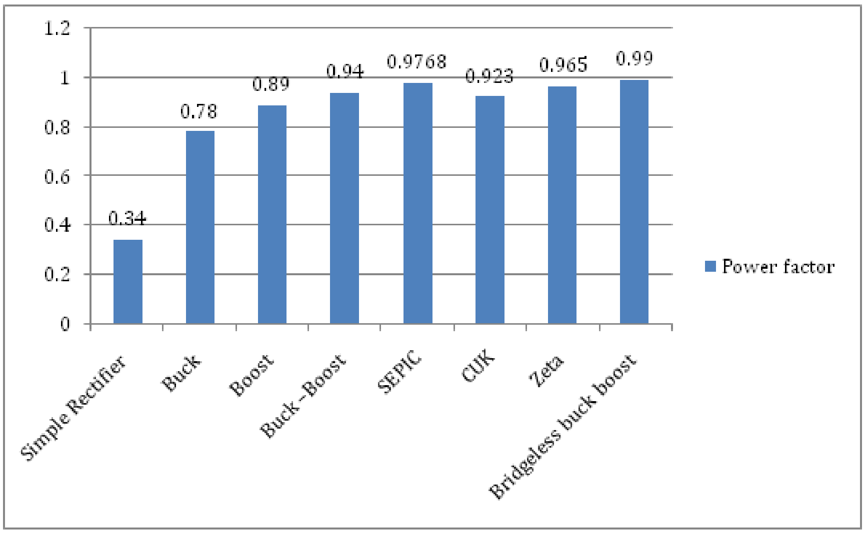


Fig.8 Power factor values with different converter topologies

It is evident from the above bar chart that the harmonic content of the Bridgeless Buck Boost, Zeta, and Cuk converters has decreased. The power factor of a simple rectifier is low, but that of other converter topologies ranges from 0.78 to 0.99, which is a good value. The Power Factor for the Bridgeless Buck Boost Converter is closer to unity.

Therefore, Bridgeless Buck Boost converter is the best one when compared to others based on the good power factor and lower THD values. This converter comes close to meet the requirements of a quality PFC converter.

CONCLUSION

In order to stabilize them, power systems, households, and industries can all use power factor correction techniques. Today, numerous topologies have been created for use in power factor adjustment. Boost converters are the typical PFC converters. The output voltage is always greater than supply voltage. Therefore, it is suitable for high power applications. Therefore, low voltage and low power applications need buck type converters. Since the buck converter's input current is not continuous, it is rarely employed in power factor correction applications. Additionally, it has a high total harmonic distortion and a low power factor. CUK topology can also be used in situations where minimal losses, a high power density, and little volume and weight are necessary.

A comparison of different converter topologies for active power factor modification has been done in this study. With the knowledge provided above, the power factor for the Bridgeless Buck Boost Converter is closer to unity. The features of good PFC converters can practically be satisfied by this converter. The goal of the research is to use a Bridgeless Buck Boost converter to increase the power factor in micro grids.

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