

Evaluation and Tabulation of Myriad Types of Multiport Converters on Renewable Energy

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Abstract:

This paper presents a review on what a multiport converter is and its pros & cons. It discusses about the types of multiport converters present and those that have been developed in recent times. The efficient use of such converter in different types of renewable energy like solar and wind are laid out. For better understanding, a brief description based on the types of renewable energies is also added. Circuit and block diagram are added to give a vivid picture. Finally, the paper also gives a comparative study on the converters present in the current day based on efficiency, duty cycle and various other parameters.

Keyword: *multiport isolated converter with and without transformer-multiport non-isolated converter-maximum power point tracking-comparative study about converters*

I. INTRODUCTION

Non-renewable energy sources such as fossil fuel, natural gas and many more are available only in limited quantity. They are towards the verge of depletion and will soon get exhausted in the future. It won't be easy to get them back as they take time to develop and form. The major reason for depletion of the resources is because of over – exploitation of them. This causes a variety of harmful impacts on our environment either due to the way they are extracted and processed, or in terms of how they are used and thereafter disposed of. The problems associated include air pollution (emission of greenhouse gasses), water pollution, land pollution, acid rain (forms when sulphur and other chemicals are introduced into the atmosphere from industrial processes) global warming (drastic variation in temperature and climatic patterns threatening the biodiversity of the world) and so on. For example, In the US, CO₂ emissions from the electric power sector calculated in 2015 indicate that 71 percent were attributable to coal^[18]. Therefore, it is important to go for renewable energy resources which are available in abundance and never get exhausted. The nation is running towards this. They

believe the renewable energy resources would mark the beginning of a new era for a healthier nation. There are many types of renewable energy sources but the popular ones are solar and wind. They are highly efficient however are seasonal. Converters are required to implement energy transfer efficiently. DC-DC converters are preferred. One can have a step-up or a step-down or a combination of converters. Fly-back converter use transformer to store energy while forward converter uses transformer to send energy^[7]. Converters reduce the number of switches and are much simpler in construction. Choosing the multiport converter (may be SIMO, MISO or MIMO) over single port converter has many advantages. Thorough analysis on the comparison between converters present is important to know so that you can decide which will suit your requirement.

II. ANALYSIS ON DIFFERENT TYPES OF MULTIPORT CONVERTER

Multiport converters are preferred over the single input converters because of the following features embedded in them:

- ✓ Increased efficiency
- ✓ More reliability
- ✓ Reduced switching loss due to less number of switches
- ✓ Flow of power can be unidirectional or bidirectional
- ✓ Highly controllable
- ✓ Reduced cost
- ✓ More flexible
- ✓ High step-up and step-down ratio
- ✓ Compact structure
- ✓ Grid integration of multiple sources^[14]

III. MULTIPORT ISOLATED CONVERTER

It is a converter that uses a transformer with a separate winding for each port, being electrically isolated. Output can be in positive, negative or in floating ground. It consist of low voltage side (LVS) and a high voltage side (HVS) circuit connected by a high frequency transformer. The AC voltage supply

according to the requirement is either stepped down or stepped up by a transformer. It is then passed through a rectifier to convert it into DC. A capacitor used to filter out the ripples and harmonics. It is then passed through controller^[14].

Advantages of using a transformer:

- ✓ To create a galvanic or a magnetic isolation
- ✓ Fault current is restricted
- ✓ Tapping system is being employed

Disadvantages of using a transformer:

- ✓ Weight is increased
- ✓ Area is increased

There are two groups of isolated multiport converter. One group of converters uses a transformer with separate winding for each port while another class has multiple ports connected to the same winding. In second category we can either have a full bridge or half bridge dc-dc converter. In the half bridge dc-dc converter half of the input is provided to the bridges^[1].

IV. MULTIPOINT NON ISOLATED CONVERTER

It is a converter without a transformer, which has a dc path between its input and output. It is preferred because transformers are bulky and their cost is high^[14].

Advantages:

- ✓ Response is fast
- ✓ No bulky circuit
- ✓ Less components are been used

Disadvantages:

- ✓ Voltage level is constant
- ✓ Isolation is absent

V. MAXIMUM POWER POINT TRACKING ALGORITHM (MPPT)

It is done in transformer less multiport converters. It has two parameters current and voltage. Analysis is done to find the best combinations of current and voltage to provide the maximum output power. It is used to adjust the impedance which can be done by varying the duty cycle of DC-DC converter. The Perturb and Observe technique (P&O) is used to extract continuous power^[9]. By employing MPPT algorithm one can find the knee point. Most of the converters use MPPT algorithm. It is used in PV module where the output is compared with the battery voltage then fixes the best power that the PV module can produce to charge the battery and converts it to the best voltage to get maximum

current in to the battery^[1]. PV is nonlinear in nature meaning that the variation in temperature and irradiance changes the voltage and current produced. Hence, this algorithm is used as it is a good controller technique. It is a highly efficient. Microcontrollers are required to employ this technique.

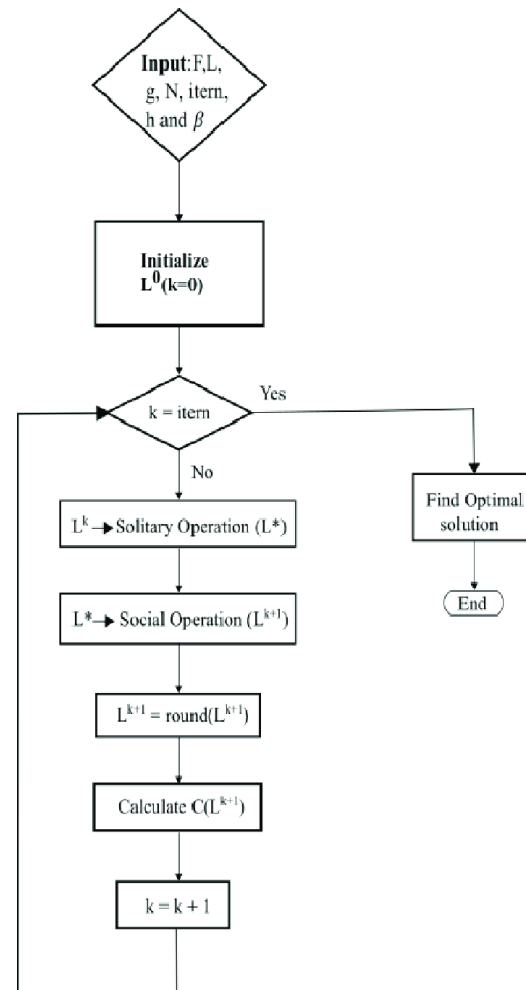


Fig.1^[9]

VI. SOLAR PV PANEL

In earlier days, PV was used along with a boost converter. Nowadays, to minimize the number of switches, PV sources along with parallel connected 3 port converter are used. PV cells or solar cells connected in series, supply solar power to the system. The sunlight is converted into electricity. This source is being encouraged to be adopted by all because of the depletion and rise in cost of other energy sources. PV panel is connected to a variable load^[9]. The PV array input varies as the sunlight input varies and thus causing a decline in efficiency. So, smart controllers are preferred while going for Solar PV panel using MPPT algorithm.

Advantages:

- ✓ No pollution
- ✓ No emission of greenhouse gasses.

Disadvantages:

- ✓ seasonal source



VII. WIND

Wind is basically defined as air in motion. The prime aim of the wind mill is to generate electricity. The turbines in the wind farm collect the wind when it hits the blade. It is collected as kinetic energy and later is converted into electrical energy. Windmills work because they slow down the speed of the wind .Their working is similar to that of an aircraft. The shaft is connected to the turbine which in turn is connected to the generator. It is then interfaced with a multiport converter and finally given to the utility centre.



VIII. TWO INPUT BOOST DC-DC CONVERTER

Multi- input converters have a profound use in renewable energy applications because hybridisation of sources is best in this. Three-input converters were first designed but were not that efficient because of low-voltage conversion ratio^[1]. They were not widely used because they had high step-up capability and continuous input current. So, the two input DC_DC converter has been proposed. This converter coalesce the pros of high step-up and multi-input DC_DC converter. It has been proved experimentally. Other major advantages include high voltage conversion ratio and bidirectional power flow ability^[2].

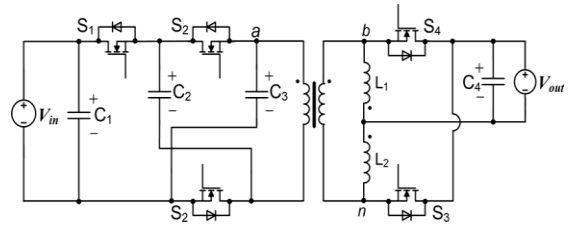


Fig.2^[3]

IX. TRANSFORMER LESS THREE-PORT POWER CONVERTER

Generally, an inverter has 2 ports. In olden days, two grid connected power converters were used .It had major disadvantages such as high installation cost and the fact that it could not be connected in parallel. Also, at least one transformer would be required to obtain high step-up ratio. The grid connected converter so designed in recent times can utilize the renewable energy sources more efficiently. It has no transformer but instead uses two DC-DC converter^[3]. It has 3 ports namely the high voltage DC port, low voltage AC port and AC port each connected to solar cell, fuel cell and the utility. We go for this type of converter to convert solar power and the fuel cell power to high quality AC power which can later be fed into utility. This converter has proved to reduce the cost and has a simpler circuitry. One of the major advantage is that converter designed gives less ripples it can effectively give the maximum power point .power factor approaches unity^[2].

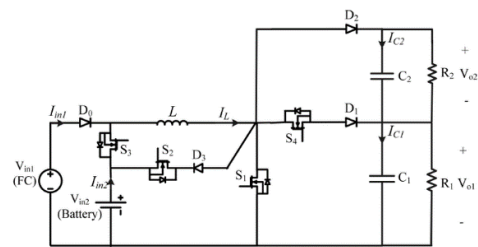


Fig.3^[10]

X. ACTIVE MULTI-PORT D-C LINK FOR THE GRID CONNECTED PMG- BASED WECSs

WECSs is manufactured based on inductor generator and permanent magnet generator .The PMG- WECSs have a high power factor, good thermal characteristics and high power to weight ratio. The generator side ac-dc PEC creates harmonics which flows through the stator winding of the machine. This leads to flux components that have different frequency, which in turn leads to torque pulsation. The torque pulsation so produced can affect the PMG performance and stability^[17]. These adverse impact of torque pulsation limits the ability of the PMG to extract power from wind turbine. To stop this we need to control generator side ac-dc PEC^[17]. Earlier

they used MPPT algorithm which employed the usage of dc-dc PEC on the output of a three phase FWR. This combination is known as SMR. Though it has advantages like simple design it has many limitations so we go for a three phase voltage source six pulse PWM ac-dc PEC on the generator side. The limitation in this has led to the invention of multilevel ac-dc PECS. Later this was modified and constructed using the H-bridges. It has been configured to be fed from one three phase supply. So, Active multiport D-C link for the grid connected PMG- BASED WECSs has been developed. It employs MPC topology^[17]. It produces multiple DC voltages in discontinuous nature which can be handle very efficiently in this type. The stability and reliability is also high.

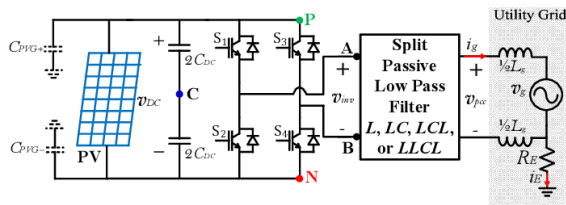


Fig.4^[17]

XI. MULTIPOINT DC-DC BIDIRECTIONAL CONVERTER FOR PV BATTERY SYSTEM

In order to overcome the disadvantages the isolated and non-isolated converter had, the isolated multiport converter with half bridge isolated converter topology was employed. It uses $2n+2$ controllable switches^[18]. Later, an isolated multiport converter which consists of isolated full bridge was employed. It uses more number of switches and hence isolated multiport bidirectional DC-DC converter for PV battery system was designed. It is built for parallel power management. One major advantage is that it can manage power between two sources^[1].

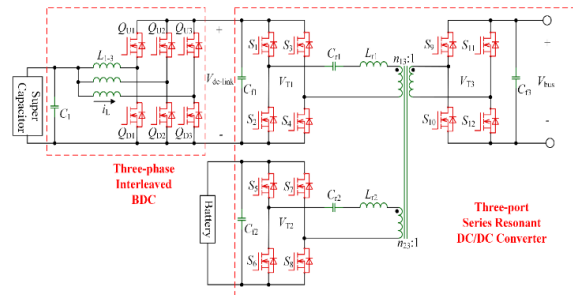


Fig.4^[11]

XII. TABULATION OF MYRIAD TYPES OF MULTIPOINT CONVERTERS BASED ON CERTAIN PARAMETERS FOR RENEWABLE ENERGY

Convertors Parameters	Two Input Boost DC-DC Converter	Transformer Less Three Port Grid Connected Power Converter	Active Multiport DC –Link For Grid Converter Pmg Based Weccs	Multiport DC-DC Bidirectionalconverter for PV Battery System
EFFICIENCY	Efficiency is high. It varies from 92% (at its worst)to 96% (at its best) ^[3]	The ripples produced is low.so the efficiency is better	Efficiency is high.	Maximum efficiency reaches 91.7%.The efficiency is always higher than 90% ^[11] .
OUTPUT VOLTAGE GAIN	High output voltage gain because it can boost low DC voltage to a higher level ^[3] . It is $1/(1-d^2)$	High output voltage is obtained without the use of transformer and instead of this inductors are used ^[10] .	Active dc link is used to maintain the output voltage constant.	High output voltage gain.
TOPOLOGY	It has a simplified control strategy.	Employs MPPT algorithm and hence output voltage of solar cell array is boosted. Uses the concept of various modes of Electro Magnetic Interference (EMI) ^[10] .	Employs MPC topology which handles changes in wind speed. The proposed design is insensitive to changes in wind speed ^[17] .	Employs MPPT (P&O) algorithm ^[11] .
RIPPLES& HARMONICS	Capacitor is chosen to have ripples less than 2% ^[3] .	Ripple current is very small and the ripple voltage to solar cell is nearly zero. Fuel	The generator side ac-dc PEC had harmonic distortions and	Decreased by interleaved control system

Convertors Parameters	Two Input Boost DC-DC Converter	Transformer Less Three Port Grid Connected Power Converter	Active Multiport DC –Link For Grid Converter Pmg Based Wecs	Multiport DC-DC Bidirectionalconverter for PV Battery System
		cell voltage is ripple free ^[10] . The converter protects fuel cell from damage of ripple current. Inductor is used to filter out the harmonics.	pulsation ^[17] .It limited the PMG ability but now have controlled it.	
COST& CONSTRUCTION	Simple and low cost.	Low cost since Power and control circuit is simplified instead of the previous design which required two individual DC-DC converter to control output power and thus increasing the cost ^[10] .	It requires H bridges and the use of atleast one transformer ^[17] . They require a 2 grid power converter leading to complex circuit and hence cost high.	Low cost due to simultaneous power management and the construction is also simple ^[11]
LOSS & STRESS ANALYSIS	Diodes can withstand voltage stress of about 200V. Power loss on switches =48% of total power loss. Diode power loss = 42% of power loss Power loss is said to be much less as only 2 inductors and 2 capacitors are used ^[3,14] .	Minimize power fluctuation and hence PV output power loss.	Losses and voltage stress are lower than the grid –connected converter ^[17]	Conduction losses are reduced and the voltage stress are also low ^[11]
POWER OUTPUT	It processes high amount of output power.	Maximum output power of solar cell array =593W. Output power of fuel cell array = 500W. Rate of maximum power=75W ^[10] .	Rated power =7.5KW.	This can process high amount of output power
SAFETY, STABILITY RELIABILITY	It has a common ground in input and output voltage stresses and hence is highly safe ^[3] .	Here,the renewable energy is used very effectively and safely.	It has high stability and reliability. It shows good performance .	It has limited stability and reliability.
MISCALLNEOUS	It has a bidirectional port. Since coupled capacitors and inductors are employed, there are no voltage strikes on main switches. It would increase the life time of a battery ^[3]	In this three power converter is controlled to generate a set of differential-mode current and a set of common – mode ^[12,10] current.	Accurate response to possible changes in its input voltage in order to maintain the output voltage ^[17] .It is able to maintain output voltage during and post-grid connection and disconnection.	It does simultaneous power management for multiple renewable energy sources.

XIII. CONCLUSION

Here we have discussed about four converters that is used to generate electricity using the renewable energy sources. These converters are compared based on this parameters such as efficiency, output voltage gain, topology used, ripple & harmonics, cost & construction, loss & stress analysis, power output, safety, reliability and stability. Out of this four converters, efficiency is high for two input boost dc-dc converter. Except active multiport dc-link converter all the other three converters are at low cost and simple in construction. Losses are equal in all the four converters. The stability and reliability is high for active multiport dc-link converter when compared to other converters. Multiport DC bidirectional converter can process high amount of output power. High output voltage gain is obtained from all the converters.

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