International Journal of Applied Electromagnetics and Communication Systems
Volume 1, Issue 01, 2025

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

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Research Article

Date of Submission: 10-05-2025 **Date of Acceptance: 19-05-2025** **Date of Publication: 09-07-2025**

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.

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 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. ANALYSISONDIFFERENTTYP ESOF MULTIPORT CONVERTER

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

1. Increased efficiency
2. More reliability
3. Reduced switching loss due to less number of switches
4. Flow of power can be unidirectional or bidirectional
5. Highly controllable
6. Reduced cost
7. More flexible
8. High step-up and step-down ratio
9. Compact structure
10. Grid integration of multiple sources[14]

III. MULTIPORTISOLATED 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 highfrequencytransformer.TheACvoltagesupply 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].

Advantagesofusing a transformer:

- ✓ Tocreateagalvanicoramagneticisolation
- ✓ Faultcurrent isrestricted
- ✓ Tappingsystemisbeingemployed

Disadvantagesofusing a transformer:

- ✓ Weightisincreased
- ✓ Areaisincreased

IV. MULTIPORTNON ISOLATED CONVERTER

Itisaconverterwithoutatransformer, whichhasadc path between its input and output. It is preferred because transformers are bulky and their cost is high[14].

Advantages:

- ✓ Responseisfast
- ✓ Nobulkycircuit
- ✓ Lesscomponentsarebeen used

Disadvantages:

- ✓ Voltage levelisconstant
- ✓ Isolationisabsent

V. MAXIMUMPOWERPOINTTRACKING ALGORITHM (MPPT)

Transformer-less multiport converters are used for this. It contains two parameters: voltage and current. The optimal voltage and current combinations to deliver the most output power are determined through analysis. It is employed to modify the impedance, which can be accomplished by altering the DC-DC converter's duty cycle. Continuous power is extracted using the Perturb and Observe technique (P&O) [9]. The knee point can be found by using the MPPT method. The MPPT algorithm is used by the majority of converters. In a photovoltaic module, it compares the output to the voltage of the battery, determines the optimal power the module can provide to charge the battery, and converts it to the optimal voltage to obtain the highestthe battery's current [1]. PV is nonlinear, which means that the voltage and current generated vary with temperature and irradiance. Because it is an effective controller technique, this algorithm is used. It is quite effective. This method must be used with microcontrollers**.**

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VI. SOLARPVPANEL

PV was previously utilized in conjunction with a boost converter. These days, PV sources and a three-port converter connected in parallel are employed to reduce the number of switches. The system is powered by solar energy from PV cells, also known as solar cells, connected in series. Electricity is produced from sunshine. Due to the depletion of other energy sources and their increasing expense, this source is being promoted for universal adoption. A variable load is connected to a PV panel [9]. Efficiency decreases because the PV array's input fluctuates in tandem with variations in the amount of sunlight. Therefore, when choosing a solar PV panel that uses the MPPT algorithm, smart controllers are recommended.

Advantages:

- ✓ Nopollution
- ✓ Noemissionofgreenhousegasses.

Disadvantages:

- ✓ seasonalsource

VII. WIND

Air in motion is the basic definition of wind. Producing power is the wind mill's main goal. When wind strikes a blade, it is collected by the wind farm's turbines. After being gathered as kinetic energy, it is subsequently transformed into electrical energy. The reason windmills

function is that they reduce wind speed. They function similarly to an airplane. The turbine, which is connected to the generator, is connected to the shaft. After that, it is connected to a multiport converter and delivered to the utility center.



VIII. TWOINPUTBOOSTDC-DC CONVERTER

Multi- input converters have a profound use in renewable energy applications because hybridisation ofsources is best inthis. Three-input converterswere first designed but were not that efficient because of low-voltageconversionratio[1].Theywere not widely used because they had high step-up capability and continuous input current. So, the two input DC_DC converter has beenproposed. 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].

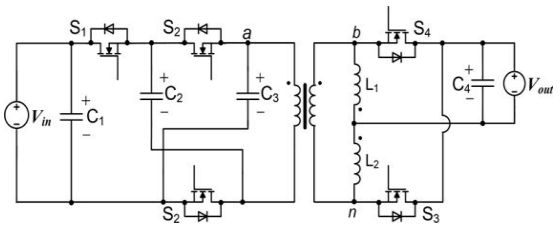


Fig.2[3]

IX. TRANSFORMERLESSTHREE-PORT POWER CONVERTER

An inverter typically has two ports. Two grid-connected power converters were utilized in the past. Its inability to be connected in parallel and its expensive installation costs were two of its main drawbacks. Additionally, obtaining a high step-up ratio would require at least one transformer. Recent designs of grid-connected converters have made it possible to use renewable energy sources more effectively. It employs two DC-DC converters instead of a transformer [3]. Each of its three ports—high voltage DC, low voltage AC, and AC—is connected to a fuel cell, solar cell, or utility. In order to transform solar and fuel cell power into high-quality AC power that may subsequently be supplied to utilities, we choose this kind of converter. This converter has a simpler circuitry and has been shown to lower costs. The converter's ability to efficiently deliver the maximum power point with fewer ripples is one of its main advantages. Power factor is getting close to unity [2].

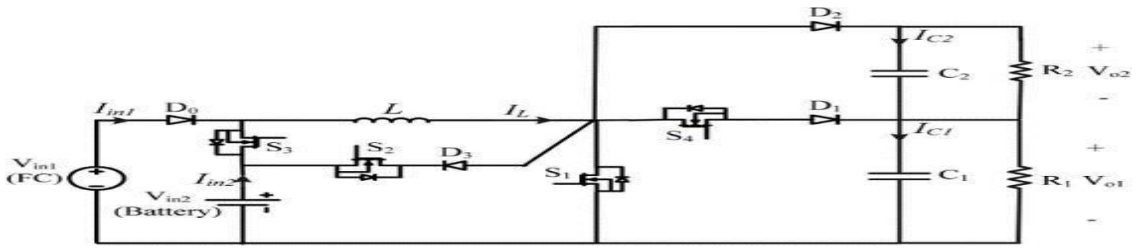


Fig.3[10]

X. ACTIVEMULTIPORTD-CLINKFORTHE GRID CONNECTED PMG- BASED WECSs

WECSs are produced using permanent magnet and inductor generators. The PMG-

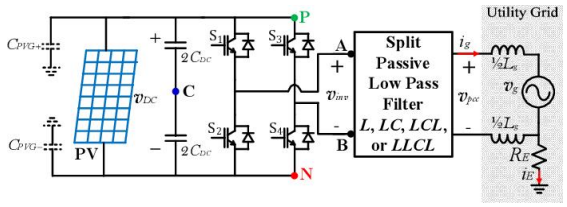
WECSs feature a high power to weight ratio, strong thermal properties, and a high power factor. The machine's stator winding experiences harmonics produced by the generator side ac-dc PEC. This results in flux components with varying frequencies, which causes torque pulsation. The performance and stability of the PMG may be impacted by the torque pulsing so generated [17]. These detrimental effects of torque pulsing restrict the PMG's capacity totake energy out of the wind turbine. We must regulate the generator side ac-dc PEC in order to prevent this [17]. Prior to

They used the dc-dc PEC to the output of a three-phase FWR using the MPPT algorithm. SMR is the name given to this combo. We choose a three phase voltage source six pulse PWM ac-dc PEC on the generator side because, despite its benefits, such as its straightforward design, it has numerous drawbacks. Multilevel ac-dc PECS was created as a result of this constraint. This was later altered and built with the help of H-bridges. It is set up to receive power from a single three-phase source. Therefore, an active multiport D-C link has been created for the grid-connected PMG-BASED WECSs. MPC topology is used [17]. This type of device generates a number of DC voltages in a discontinuous manner that are highly manageable. There is also a high level of stability and dependability.

Fig.4[17]

XI. MULTIPORT DC-DC BIDIRECTIONALCONVERTERFORPV BATTERYSYSTEM

The isolated multiport converter with half bridge isolated converter architecture was used to get over the drawbacks of both isolated and non-isolated converters. 2n+2 controlled switches are used [18]. A separate multiport converter with an isolated complete bridge was later used. Because it requires additional switches, an isolated multiport bidirectional DC-DC converter was created for the PV battery system. It is designed to manage power in parallel. Its ability to control power between two sources is one of its main advantages [1].



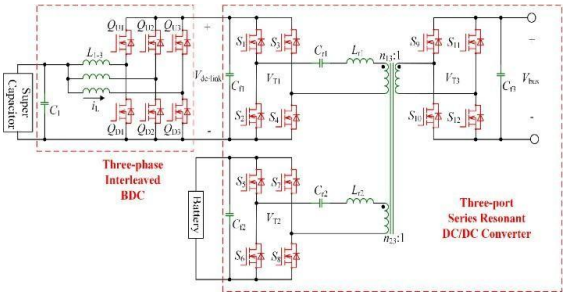


Fig.4[11]

XII. TABULATIONOFMYRIADTYPESOFMULTIPORTCONVERTERSBASEDONCERTAIN PARAMETERS FOR RENEWABLE ENERGY

Converters / Parameters	Two Input Boost DC-DCConverter	TransformerLess Three Port Grid ConnectedPower Converter	ActiveMultiport DC –Link For GridConverter PmgBasedWecs	Multiport DC-DC BidirectionalconverterforPVBattery System
EFFICIENCY	Efficiencyishigh. Itvaries from 92% (at its worst)to 96% (at its best)[3]	Theripplesproduced is low.so the efficiency is better	Efficiencyis high.	Maximum efficiency reaches 91.7%.Theefficiencyisalwayshigher than90%[11].

OUTPUTVOLTAGE GAIN	High output voltage gain because it can boost low DC voltage to a higherlevel[3]. It is 1/(1-d^2)	High output voltage is obtained without the use oftransformer and instead of this inductorsareused[10].	Active dc link is used to maintain theoutputvoltage constant.	Highoutputvoltage gain.
TOPOLOGY	Ithasasimplified control strategy.	Employs MPPT algorithmandhence output voltage of solar cell array is boosted. Uses the concept of various modes of Electro Magnetic Interference (EMI)[10].	Employs MPC topologywhich handleschanges in wind speed. Theproposed design is insensitive to changesinwind speed[17].	EmploysMPPT(P&O)algorithm[11].
RIPPLES& HARMONICS	Capacitor is chosen to have ripplesslessthan 2%[3].	Ripplecurrentisvery small and the ripple voltagetosolarcell isnearlyzero. Fuel	The generator sideac-dcPEC had harmonic distortionsand	Decreasedbyinterleavedcontrol system
Converters / Parameters	Two Input Boost DC-DCConverter	TransformerLess Three Port Grid ConnectedPower Converter	ActiveMultiport DC –Link For GridConverter PmgBasedWecs	Multiport DC-DC BidirectionalconverterforPVBattery System
		cell voltage is ripple free[10].Theconverter protects fuel cellfrom damage of ripple current. Inductorisusedto filter out the harmonics.	pulsation[17].Itlimited the PMG ability but now havecontrolled it.	
COST& CONSTRUCTION	Simpleandlow cost.	Low cost since Power and control circuitissimplified instead of the previous design whichrequiredtwo individual DC-DC convertertocontrol output power and thus increasing the	It requires H bridges and the use of atleast one transformer[17]. They require a 2 grid power converter leading tocomplexcircuit and hence cost high.	Low cost due to simultaneous power managementandtheconstructionis also simple[11]

		cost[10].		
LOSS&STRESS ANALYSIS	Diodes can withstandvoltage stress of about 200V. Power loss on switches=48% of total power loss. Diodepowerloss =42%ofpower loss Powerlossissaid tobemuchlessas only 2 inductors and2capacitors are used[3,14].	Minimizepower fluctuationandhence PV output powerloss.	Losses and voltagestressare lower than the grid – connected converter[17]	Conductionlossesarereducedand the voltage stress are also low[11]
POWEROUTPUT	Itprocesseshigh amountofoutput power.	Maximum output power of solar cell array=593W.Outputpoweroffuel cell array = 500W. Rate of maximum power=75W[10].	Ratedpower =7.5KW.	Thiscanprocesshighamountofoutput power
SAFETY, STABILITY RELIABILITY	Ithasacommon ground in input and output voltage stresses and hence is highlysafe[3].	Here,therenewable energyisusedvery effectivelyand safely.	It has high stabilityand reliability. It shows good performance.	Ithaslimitedstabilityandreliability.

MISCALLNEOUS	It has a bidirectionalport. Since coupled capacitors and inductors are employed,there are no voltage strikes on main switches.Itwould increase the life timeofabattery[3]	In this three power converter is controlledtogenerate a set of differential-mode current and a set of common_mode[12,10]current.	Accurateresponse topossible 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 anddisconnection.	It does simultaneous power managementformultiplerenewable energysources.

XIII. CONCLUSION

Here, we've spoken about four converters that employ renewable energy sources to produce electricity. Efficiency, output voltage gain, topology, ripple and harmonics, cost and construction, loss and stress analysis, power output, safety, dependability, and stability are some of the parameters that are used to compare these converters. Of these four converters, the two input boost dc-dc converter has the highest efficiency. All three converters, with the exception of the active multiport dc-link converter, are inexpensive and straightforward to build. All four converters have the same losses. When compared to other converters, the active multiport dc-link converter has a high level of stability and dependability. A multiport DC bidirectional converter has a large output power processing capacity. Each converter produces a high output voltage gain.

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