ISSN (Online): 2455-7838
SJIF Impact Factor : 6.093

EPRA International Journal of

Research & Development

(IJRD)

Monthly Peer Reviewed & Indexed International Online Journal

Volume: 4, Issue:1, January 2019

Published By
EPRA Publishing

SJIF Impact Factor: 6.093 Volume: 4 | Issue: 1 | January | 2019 ISSN: 2455-7838(Online)
EPRA International Journal of Research and Development (IJRD)
Peer Reviewed Journal

QUASI Z SOURCE INVERTER WITH ENERGY STORAGE FOR PHOTOVOLTAIC POWER GENERATION SYSTEM

Celeste A Lagali[1]
[1]8th SEM Student in Department of Electrical and Electronics Engineering, K.L.E.I.T, Hubballi, Karnataka, India.

Asst. Prof. Chaitanya K Jambotkar[2]
[2] Assistant Professor in Department of Electrical and Electronics Engineering, K.L.E.I.T, Hubballi, Karnataka, India.

ABSTRACT

In recent years, Photovoltaic (PV) power generation systems have always been considered as an alternative energy source that can lighten the rapid consumption of fossil fuels. The current developments in the photovoltaic materials and power converters has emerged this as promising technology. A PV inverter is widely used to convert the photovoltaic energy into electrical energy as most of the demands are in AC voltage, either for local loads or supplied into the grid. Power converter topologies employed in the PV power generation systems are mainly characterized by single or multi stage inverters. The Z-source inverter (ZSI) has a single stage structure to achieve the voltage buck/boost character in a single power conversion stage. The energy storage device integrated to Quasi Z-source inverter (QZSI) topology eliminates need for an extra charging circuit. This upgraded topology acquires the operating characteristics from the traditional ZSI, along with the capability of operating under very low PV power conditions. Its main operating points are classified into two modes, the low PV power mode, where the battery is discharged and the high power mode, where the battery is charge up. An extended input power operating range is achieved since the lack of Photovoltaic power can be compensated by the battery. Hence we can conclude that QZSI realize boost/buck function in a single-stage with improved reliability, lower component rating, constant DC current from source and good power quality showing an efficient method for the energy-stored PV power generation

INDEX TERMS: *Quasi Z source, Inverter, PV application.*

I. INTRODUCTION

The various activities (such as industrialization) which involve energy consumption that consequently leads to depletion of energy sources and degradation of environment are stretching the resources of our planet to breaking point. When it comes to the future of energy, the world needs a reality check.

The economic growth and prosperity of any country or region in the world is related to the level of its consumption of energy. With the various developments, particularly with the Industrial Revolution, there has been a quantum leap towards the tremendous consumption energy which is supplied through fossil fuels such as gas, petroleum and coal.

During 1920s, coal accounted for the maximum part of total energy supply of the world. Later in early 1990s, its share dropped to only 26%, while 40% of the world's energy needs was taken by oil. Now the depletion rate of fossil fuels has reached to 100,000 times faster than its formation rate.

When the resource under consideration is non-renewable energy source, the problem of depletion is an obvious addition to its consumption. At present, non-renewable fossil fuels (natural gas, coal and petroleum) contribute to 90% of world commercial energy production. The remaining 10% generated from non-conventional form of energy (nuclear, hydropower, geothermal, wind, solar, etc.). Even if the present reserves of fossil fuels may be sufficient enough to meet the global energy demand for years in future, any consumption of such resources represents an absolute loss in its finite supply.

Projections on the energy demand in the early years of 21st century are alarming. The estimates are about100 million tons per year for petroleum, 400 million tons per year for coal and 100,000 MW per year for power. This energy scenario poses a great challenge for our technology, and also to our environment, which is suffering a tremendous pressure. The same is expressed in Table 1.

The present total installed capacity of electrical power generation in India is 1, 44,912 MW (as on June 2008), produced from various resources as given in Table 2

Table 1 Sector Wise Energy Consumption In India

Sector	Percentage power consumption
Industry	49%
Transport	22%
Residential	10%
Agriculture	5%
Others	14%

Table 2 Significance of renewable energy

Resources	Production	Percentage Share
Coal	76648	52.8
Gas	14716	10
Diesel	1119	0.8
	Total = 92563	**Total = 63.6**
Nuclear	4120	2.8
Hydro	36033	24.8
RES	12194	8.4
Total	**144910**	**100**

In modern world the demand for energy has increased dramatically in the past century and it will grow even further in the near future than ever before. Renewable energy is that energy which comes from the natural energy flows on earth. Unlike conventional forms of energy, renewable energy will not get exhausted. Renewable energy is also termed as green energy, clean energy, sustainable energy and alternative energy.

The following are merits and demerits of renewable energy sources,

Merits:

- Renewable energy sources are available in nature free of cost
- They produce no or very little pollution
- They are inexhaustible
- They have low gestation period

Demerits

- In general , the energy is available in dilute form from these sources
- Though available freely in nature, the cost of harnessing energy from non-conventional source is generally high
- Availability is uncertain; the energy flow depends on various natural phenomena beyond human control
- Difficulty in transporting such forms of energy

Located in tropical region, India is endowed with abundant renewable energy resources i.e. solar, wind and biomass including agriculture residue which are perennial in nature. Harnessing these resources is best suited to meet the energy requirement in rural areas in a decentralised manner.

India has the potential of generating more than 100000 MW from non-conventional resources. Up to June 30 2008, the electrical power generation by conventional resources has reached 12,194 MW, which is about 8.4% of total installed electrical power generation capacity. The government plans to increase this share to 10% by 2012. The current status of various resources is given in table.

Table 3 Renewable energy-estimated potential and cumulative achievements (Dec, 2017 data)

SI. No.	Source/System	Estimated Potential	Cumulative achèvement
Rural & Decentralised Energy systems			
1	Family type biogas plant	120 lakhs	39.40 lakhs
2	Solar photovoltaic program Solar street lighting system Home lighting system Solar lantern Solar power plants	50 MW/sq.Km - - - -	110 MWp (p-peak) 69,849 nos. 363399 nos. 585001 nos. 2.28 MWp
3	Solar thermal program Solar water heating system Solar cooker	140 million sq.m collector area	2.15 million sq.m collector area 6.17 lakhs
4	Wind pumps	-	1284 nos.
5	Aero generator/hybrid system	-	675.27 KW
6	Solar photovoltaic pump	-	7068 nos.
7	Remote village electrification	-	3368/830 villages/hamlets

II. SOLAR - THE CENTRE STAGE OF RENEWABLE ENERGY

The radiant heat and light energy from the Sun is called as solar energy. This is the most readily and abundantly available source of energy. Since ancient times this energy has been harnessed by humans using a range of innovations and ever-evolving technologies.

The earth receives more energy in just one hour from the sun than what is consumed in the whole world for one year. This energy comes from within the sun itself through process called nuclear fusion reaction. In this reaction four atoms of hydrogen combine to form one helium atom with loss of matter. This matter is emitted as radiant energy.

India is a tropical country with sunshine in plenty and long days. About 301 clear sunny days are available in a year. Theoretically, India receives solar power of about 5000 trillion yr. (600TW approx.) on its land area. On an average, daily solar energy incident over India ranges from 4 to 7 kWh/m^2. Depending on the location sunshine hours varies from 2,300–3,200 hours in a year. This is far more than current total energy consumption. For instance, assuming conversion efficiency of 10% for PV modules, it will still be thousand times greater than the likely electricity demand in India by the year 2015.

This energy from the sun is used as solar thermal and solar power applications. Solar thermal energy, through various technologies, is utilized for various purposes which includes Heating, Drying, Cooking, seasoning of timber, water treatment (Distillation and disinfection), Cooling (Refrigeration and Cold storage), High temperature process heat or industrial purposes

Solar power is the conversion of sunlight into electricity. Photovoltaic or PV is used to convert Sunlight directly into electricity, or uses concentrating solar power or CSP to indirectly generate electricity. Solar Photovoltaic or SPV cells convert solar radiation into DC electricity directly. SPV finds a number of applications in areas such as Domestic or household lighting, Street lighting, electrification in rural or village areas, water pumping, desalination of salty water, powering of remote telecommunication repeater stations and railway signals.

Advantages of SPV Systems

The major advantages of using SPV systems are as follows.

- ❖ Abundant solar radiation is available in most parts of India. Hence, SPV systems can be used anywhere in the country.
- ❖ SPV systems are modular in nature. Hence, they can be expanded as desired and used for small and large applications.
- ❖ There are no running costs associated with SPV systems, as solar radiation is free.

- ❖ Electricity is generated by solar cells without noise.
- ❖ PV systems have no moving parts. Hence, they suffer no wear and tear.

III. SOLAR ENERGY IN INDIA

India lies in the sunny regions of the world. Most parts of India receive 4–7 kWh (kilowatt-hour) of solar radiation per square meter per day with 250–300 sunny days in a year. The highest annual radiation energy is received in western Rajasthan while the north-eastern region of the country receives the lowest annual radiation. Solar energy, experienced by us as heat and light, can be used through two routes: the thermal route uses the heat for water heating, cooking, drying, water purification, power generation, and other applications; the photovoltaic route converts the light in solar energy into electricity, which can then be used for a number of purposes such as lighting, pumping, communications, and power supply in un-electrified areas. Energy from the sun has many features, which make it an attractive and sustainable option: global distribution, pollution free nature, and the virtually inexhaustible supply.

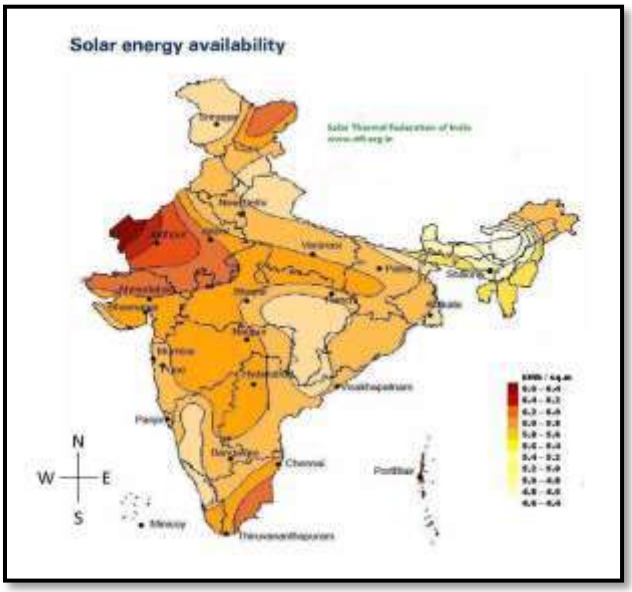

Fig. 1 Solar Radiation in India.

IV. Z SOURCE INVERTER

The Z-source inverter is one of quite new ideas designated to renewable energy system, mainly fuel cell and photovoltaic. In the Z-source inverter, a special Z-network is introduced and shoot-through states may be used in similar manner as in Current Source Inverter. ZSI employs a unique impedance network (or circuit) to couple the converter main circuit to the power source, load, or another converter, for providing unique features that cannot be observed in the traditional voltage and current source inverters where a capacitor and inductor are used respectively. The Z-source converter overcomes the conceptual and theoretical barriers and limitations of the traditional voltage source and current source inverters and provides a novel power conversion concept.

To overcome the above problems of the traditional V-source and I-source converters, this paper presents an impedance source power converter (abbreviated as Z-source converter) and its control method for implementing dc-to-ac, ac-to-dc, ac-to-ac, and dc to-dc power conversion.

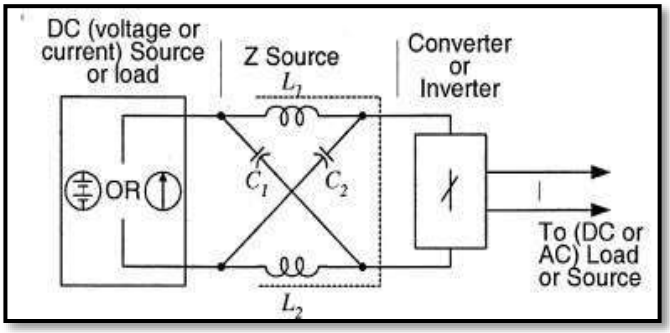

Fig. 2 Basic Topology

Fig. 2 shows the general Z-source converter structure proposed. It employs a unique impedance network (or circuit) to couple the converter main circuit to the power source, load, or another converter, for providing unique features that cannot be observed in the traditional V- and I-source converters where a capacitor and inductor are used, respectively. The Z-source converter overcomes the above-mentioned conceptual and theoretical barriers and limitations of the traditional V-source converter and I-source converter and provides a novel power conversion concept. In Fig. 3, a two-port network that consists of a split-inductor L1 and L2 and capacitors and connected in X shape is employed to provide an impedance source (Z-source) coupling the converter (or inverter) to the dc source, load, or another converter. The dc source/or load can be either a voltage or a current source/or load. Therefore, the dc source can be a battery, diode rectifier, thyristor converter, fuel cell, an inductor, a capacitor, or a combination of those. Switches used in the converter can be a combination of switching devices and diodes this paper focuses on an application example of the Z-source converter: a Z-source inverter for dc-ac power conversion needed for fuel-cell applications.

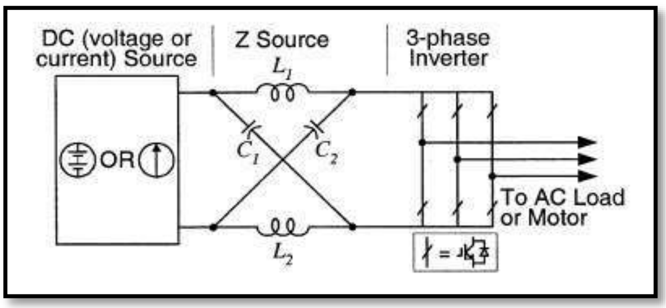

Fig. 3 ZSI for fuel cell application

Fig. 3 shows a Z-source inverter for such fuel-cell applications, which can directly produce an ac voltage greater and less than the fuel-cell voltage. A diode in series with the fuel cell is usually needed for preventing reverse current flow.

The unique feature of the Z-source inverter is that the output ac voltage can be any value between zero and infinity regardless of the fuel-cell voltage. That is, the Z-source inverter is a buck–boost inverter that has a wide range of obtainable voltage. The traditional V- and I-source inverters cannot provide such feature.

V. OPERATION, AND CONTROL OF Z SOURCE INVERTER

To describe the operating principle and control of the Z-source inverter in Fig. 2, let us briefly examine the Z-source inverter structure. In Fig. 2, the three-phase Z source inverter bridge has nine permissible switching states (vectors) unlike the traditional three-phase voltage source inverter that has eight. The traditional three phase voltage source inverter has six active vectors when the dc voltage is impressed across the load and two zero vectors when the load terminals are shorted through either the lower or upper three devices, respectively.

However, the three-phase Z-source inverter bridge has one extra zero state (or vector) when the load terminals are shorted through both the upper and lower devices of any one phase leg (i.e., both devices are gated on), any two phase legs, or all three phase legs. This shoot-through zero state (or vector) is forbidden in the traditional voltage source inverter, because it would cause a shoot-through. We call this third zero state (vector) as the shoot- through zero state (or vector), which can be generated by seven different ways: shoot-through via any one phase leg, combinations of any two phase legs, and all three phase legs.

The Z-source network makes the shoot-through zero state possible. This shoot through zero state provides the unique buck-boost feature to the inverter.

Fig. 3 shows the equivalent circuit of the Z-source inverter shown in Fig. 3 when viewed from the dc link. The inverter bridge is equivalent to a short circuit when the inverter bridge is in the shoot-through zero state, as shown in Fig. 4, whereas the inverter bridge becomes an equivalent current source as shown in Fig. 5 when in one of the six active states. Note that the inverter bridge can be also represented by a current source with zero value (i.e., an open circuit) when it is in one of the two traditional zero states. Therefore, Fig. 5 shows the equivalent circuit of the Z-source inverter viewed from the dc link when the inverter bridge is in one of the eight non shoot-through switching states.

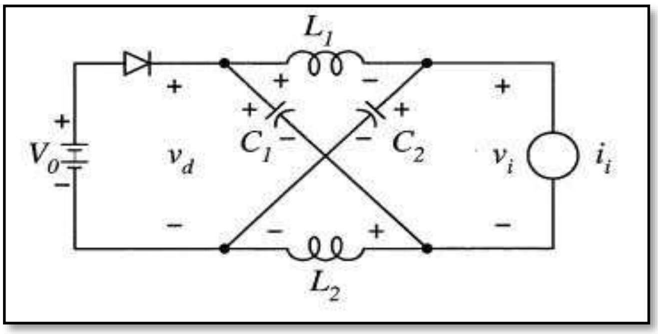

Fig. 4 Equivalent circuit of the Z-source inverter viewed from the dc link

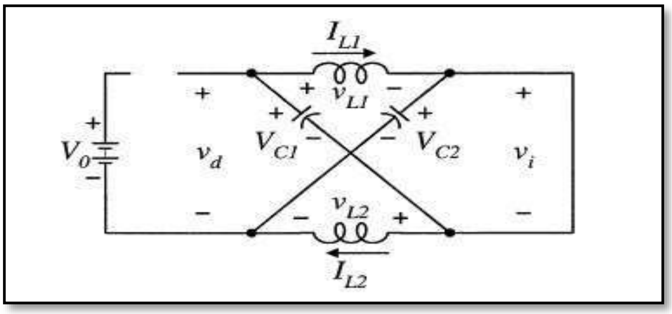

Fig. 5 Equivalent circuit of the Z-source inverter viewed from the dc link When the inverter bridge is in the shoot-through zero state

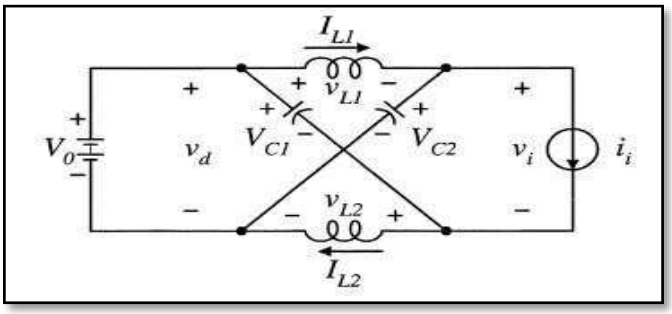

Fig. 6 Equivalent circuit of the Z-source inverter viewed from the dc link when the inverter bridge is in one of the eight non shoot-through switching states

All the traditional pulse width-modulation (PWM) schemes can be used to control the Z source inverter and their theoretical input–output relationships still hold. In every switching cycle, the two non-shoot-through zero states are used along with two adjacent active states to synthesize the desired voltage. When the dc voltage is high enough to generate the desired ac voltage, the traditional PWM of Fig. 2.6 is used. While the dc voltage is not enough to directly generate a desired output voltage, a modified PWM with shoot-through zero states will be used to boost voltage.

CONCLUSION

This Quasi Z-Source inverter for advanced power conditioning of various renewable energy sources using distributed generator is discussed. The dynamic character has been analyzed experimentally. The system is able to withstand the fluctuation in voltage and does not require any additional converter. This system can provide a better operation with lower cost, higher reliability and higher efficiency. Along with this, the system is highly immune to EMI Noise.

REFERENCES

1. *Fang. Z. Peng, Xiaoming Yuan, Xupeng Fang, and Zhaoming Qian, "Z-source inverter for Adjustable speed drives," IEEE Power Electronics Letters, 1(2), June 2003, pp. 33–35.*
2. *Fang. Z. Peng, Miaosen Shen, and Zhaoming Qian, "Maximum boost control of the Zsource inverter," published in IEEE transactions on Power Electronics, 20(4), 2005.*
3. *Amitava Das, Debasish Lahiri and Barnali Kar, "Space Vector PWM Based AC Output Voltage Control of Z – Source Inverter," International Conference On "Control, Automation, Communication And Energy Conservation -2009.*
4. *Poh Chiang Loh, D. Mahinda Vilathgamuwa, Yue Sen Lai, Geok Tin Chua and Yunwei Li,"Pulse-Width Modulation of Z-Source Inverters" Proc. of IEEE IAS 2004.*
5. *Miaosen Shen, Alan Joseph, Jin Wang, Fang Z. Peng, and Donald J. Adams, "Comparison of traditional inverter and Z-Source inverter for fuel cell vehicles," IEEE WPET 2004, p 125–132.*
6. *X. Ding, Z. Qian, S. Yang, B. Cui, and F. Z. Peng, "A Direct Peak DC-link Boost Voltage Control Strategy in Z-Source Inverter" in Proc. IEEE Applied Power Electron. Conf., Feb. 2007, pp. 648-65.*