

Analysis of Single-Phase ZSI with various Loads

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Abstract:

This paper presents a high performance, low cost Z-Source inverter (ZSI) for variable load or house hold applications. It is an improvement over traditional voltage and current source inverters (VSI and CSI) with a unique X-shaped network. The X-shaped network can provide a single stage power conversion concept whereas the traditional inverter requires two stages of power conversion for renewable applications. ZSI system is designed and simulated using Matlab-Simulink PWM signals generated by using microcontroller with 10KHz switching speed. The performance analysis, simulation and comparison have been carried out it result the ZSI system is more suitable as compared to traditional inverters. The efficiency, stability, the total harmonic distortion against the non-linear load is also better as variations in modulation index.

Keywords: ZSI, PWM , Matlab-Simulink, Modulation index

I. INTRODUCTION

Z-Source inverters are new breed of inverters in which voltage boost operation can be simultaneous performed along with inversion operation, which greatly reduced the losses occurring due to two stages while using conventional inverter method. These losses include the losses occurring due to transformer or due to DC-DC boost converter. ZSI although reduce the overall cost by reducing the stages[1] in the part of paper a review of the resultant analysis of hardware and software with their modulation index. The technique used in a ZSI is attractive for three main reasons; first the traditional PWM inverter has only one control freedom, used to control the output AC voltage [5]. Second, the ZSI provides the ability to produce the same features of a DC-DC boosted inverter, yet its single stage is less complex and more cost effective. Third, the ZSI has the benefit of enhanced reliability due to the fact that momentary shoot-through can no longer destroy the inverter [4]. The develop system includes SMPS, microcontroller and its board, capacitor, inductor, MOSFET as a switch, step-up transformer and R-load up-to 200watts.

In recent years there is a lot of research been done to improve the topology design of ZSI but only a few designs have removed the disadvantages such as cost, size and performance of ZSI.

In this paper some latest topologies designs are discussed which are modified to give optimum performance by either reducing the size, total harmonic distortion or other factors like number of passive elements. These parameters are very important in determining the overall performance of the inverter. ZSI is different from conventional voltage source inverter in a way that the former uses passive elements apart from DC source and power electronics switches[1-2].

II. Z-SOURCE INVERTER

The ZSI has overcome the limitations of conventional VSI and CSI. Included so as to obtain both inversion and boost operation. The operation of ZSI is different from conventional VSI in a way that it uses shoot-through states apart from four active states.

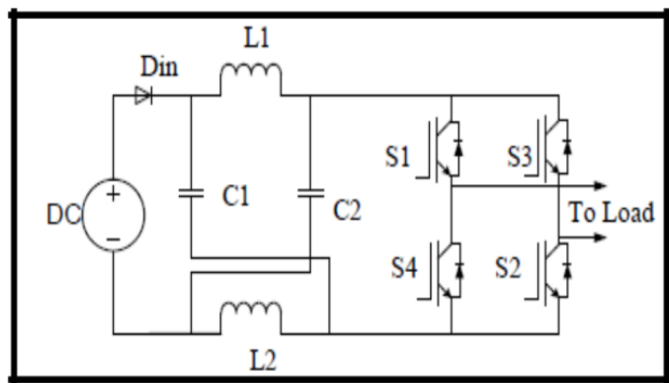


Fig:1 Structure of ZSI

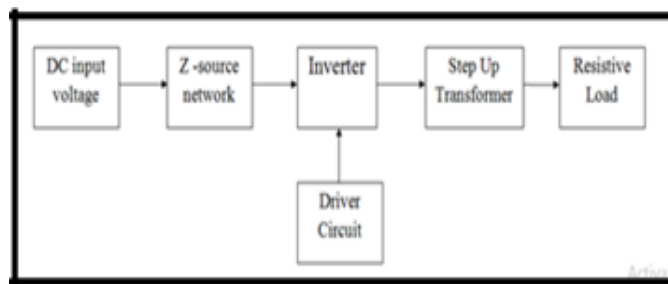


Fig:2 Block diagram of single phase ZSI

The ZSI concept can be applied for all dc-dc, dc-ac, ac-dc, ac-ac power conversions.

The ZSI employs a unique impedance network to couple the converter main circuit to the power source, thus proving unique features that cannot be observed in the traditional VSI and CSI where a capacitor and inductor are used.

III. PROPOSED SYSTEM

It has three stages, the input stage having rectifier unit with AC supply, the middle stage consists of impedance network, and the output stage consisting of any resistive or inductive loads.

It has three stages:

- DC voltage source of the rectifier supply-fed to the impedance network.
- Impedance network-fed to the inverter
- Inverter-fed to the load

This is a two-port network fig:1 that consists of split inductors L1 and L2 ($L1=L2$) and capacitors C1 and C2 ($C1=C2$) connected in X-Shape. L1 and L2 are series arms inductors, C1 and C2 are diagonal arms capacitors.

This network is coupled with the main circuit and the source. This network is also called as Z-source network.

IV. SIMULATION OF SINGLE PHASE ZSI

In this paper, MATLAB/SIMULINK is used to design the ZSI with R-load. The circuit diagram of ZSI based test feeding load is depicted and triggered by PWM control technique.

Table: 1 Simulation results for an input of 24 volts using ZSI for various R-loads at modulation index $m=0.6$.

S.No	P in	V out	% η	Inverter Output
1	2.13k	190.2	-	35
2	60	170.2	25	35
3	64.8	140.8	92.59	35
4	69.6	115.2	143.7	35
5	97.2	110	205.8	35

Table: 2 Simulation results for an input of 24 volts using ZSI for various R-loads at modulation index $m=0.7$.

S.No	P in	V out	% η	Inverter Output
1	2.01k	100	-	35
2	67.2	166.9	22.32	35
3	69.6	123	86.20	35
4	72	111.7	138.88	35
5	84	109	238.09	35

Table: 3 Simulation results for an input of 24 volts using ZSI for various R-loads at modulation index $m=0.8$.

S.No	P in	V out	% η	Inverter Output
1	2.15k	97.2	–	35
2	78.72	154.6	19.05	35
3	82.8	115.5	72.46	35
4	84	112.5	119.09	35
5	86.4	100.2	231.32	35

Table: 4 Simulation results for an input of 24 volts using ZSI for various R-loads at modulation index $m=0.9$.

S.No	P in	V out	% η	Inverter Output
1	2.32k	100.2	--	35
2	88.8	170.02	16.89	35
3	91.2	115	71.42	35
4	74.4	108.9	134.4	35
5	77.74	99.9	260.4	35

Table: 5 Simulation results for an input of 24 volts using ZSI for various R-loads at modulation index $m=1.0$.

S.No	P in	V out	% η	Inverter Output
1	2.43k	102.25	--	35
2	67.2	167.40	22.32	35
3	65.28	115.5	92.59	35
4	85.92	111.4	119.04	35
5	88.08	100.5	227.06	35

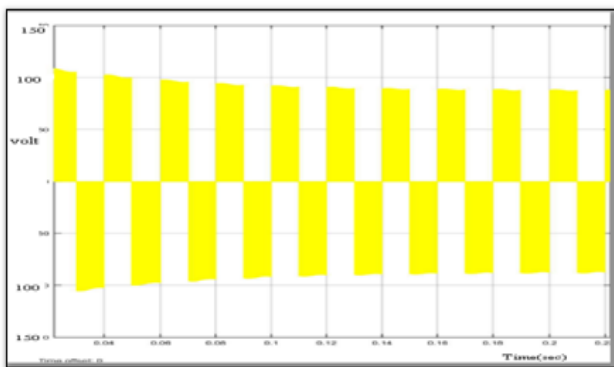


Fig: 5 Output voltages across the 100 watts load.

V. SIMULATION OF TRADITIONAL SINGLE PHASE PWM INVERTER

Table: 6 Simulation results for an input of 24 volts using PWM Inverter for various R-loads at modulation index $m=0.6$.

S.No	P in	V out	% η	Inverter Output
1	1.8k	65	–	35
2	93.6	121	7.1	35
3	93.84	102.9	31.79	35
4	96	99.05	59.10	35
5	100.8	64.07	86.71	35

Table: 7 Simulation results for an input of 24 volts using PWM Inverter for various R-loads at modulation index $m=0.7$.

S.No	P in	V out	% η	Inverter Output
1	1.9k	65.5	–	35
2	93.84	172	14.29	35
3	93.84	114.7	36.66	35
4	93.84	96.8	59.33	35
5	94.08	64.07	86.71	35

Table: 8 Simulation results for an input of 24 volts using PWM Inverter for various R-loads at modulation index $m=0.8$.

S.No	P in	V out	% η	Inverter Output
1	2.34k	69.5	–	35
2	93.84	138.94	9.40	35
3	93.84	111.5	33.26	35
4	93.84	92.7	54.33	35
5	94.08	60.52	76.29	35

Table: 9 Simulation results for an input of 24 volts using PWM Inverter for various R-loads at modulation index $m=0.9$.

S.No	P in	V out	% η	Inverter Output
1	2.52k	71.02	–	35
2	93.84	138.2	9.26	35
3	93.84	108.58	32.39	35
4	93.84	92.7	54.33	35
5	93.84	60.45	76.29	35

Table: 10 Simulation results for an input of 24V using PWM Inverter for various R-loads at modulation index $m=1.0$.

S.No	P in	V out	% η	Inverter Output
1	2.15k	68.5	–	35
2	93.84	126.6	8.25	35

Table: 11 comparative analysis of single phase ZSI with traditional PWM inverter for Modulation index $m=0.6$

Sr.No.	Type of Parameter	Traditional inverter		Z -source inverter	
		No Load	Full Load	No Load	Full Load
1	Input voltage	24	24	24	24
2	Input Current	76	3.94	89	4.05
3	Output voltage	65	67.16	190.2	110
4	Output current	65	1.34	90	2.18
5	Input Power	1.8k	94.56	2.13k	97.24
6	Output Power	4.22k	89.99	17.11k	239.8
7	Efficiency(% η)	-	95.16	-	246.60

VII. CONCLUSION

In above discussion, the sinusoidal PWM method is used to control switching operation of the MOSFET it eliminate the problem of shoot through states of ZSI. These shoot through switching state in the ZSI shows that input voltage is boosted and it eliminate the effect of total harmonic distortion in the output signals. The prototype of the ZSI source inverter is simulated with the help of Matlab-Simulink. The simulated results of the inverter are compared with

3	93.84	114.58	35.40	35
4	93.84	92.75	53.34	35
5	93.08	61.84	86.71	35

VI. RESULT AND DISCUSSION

In the comparative analysis we compare the parameters of single phase ZSI the traditional single phase PWM inverter. The parameters used in comparison are as shown I below table. The comparative analysis shows that the output voltage, efficiency of ZSI is much better than that of single phase traditional PWM inverter. The ZSI is buck-boost type of inverter so in this case it will boost the output voltage for respected resistive load.

the traditional PWM inverter. It results efficiency, THD, switching operation and stability of the ZSI is better than the traditional inverter.

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