Australian Journal of Basic and Applied Sciences, 9(5) March 2015, Pages: 424-434

ISSN:1991-8178

Australian Journal of Basic and Applied Sciences

Journal home page: www.ajbasweb.com

A Soft Switched Dynamic Cross-Linked Mechanism in Three-Phase Z-Source Inverter for Solving Shoot-Through Problems

[1]J. Shanmugapriyan, [2]Dr. A. Chilambuchelvan and [3]Dr. S. Vijayan

[1]*Assistant Professor, Chettinad College of Engineering and Technology, Anna University-Chennai, Department of Electrical and Electronics Engineering,Karur-639114, Tamil Nadu, India.*
[2]*Professor, RMD Engineering College, Anna University-Chennai, Department of Electronics and Instrumentation Engineering, Kavaraipettai -601206, Tamil Nadu, India.*
[3]*Principal, Surya Engineering College, Anna University-Chennai, Erode-638107, Tamil Nadu, India.*

ARTICLE INFO

Article history:
Received 12 October 2014
Received in revised form 26 December 2014
Accepted 1 January 2015
Available online 27 February 2015

Keywords:
Power Factor Adjustment, Z-source Inverter, Cross-Linked, Three-phase Circuit, Soft Switched, Output Voltage/Current Rate,

ABSTRACT

Background: Z-source inverter makes use of a distinctive impedance circuit that couples the circuit with power source. Three phase circuit with Z-source inverter do not control the result of voltage-fed and current-fed while using capacitor and inductors. The distribution of the shoot-through problems with different switching waveforms is the key factor to be controlled in Z-source inverter. **Objective:** The shoot-through problem in Z-source inverter is one of the major drawbacks observed in the three phase circuit, which decreases the reliability rate. Also, the shoot-through problem causes low voltage stepping up with high current values which leads to degradation of the system with heavy losses on three phase circuit. As a result, serious attention is needed to develop a soft switching system based on the modulation techniques on three phase circuits to remove the shoot-through problems. To address the shoot-through problems, Dynamic Cross-Linked Three-phase Z-Source Inverter Injected with Soft-switched (DCT-ZSIIS) mechanism is proposed in this paper. DCT-ZSIIS mechanism develops a three phase interface concept to achieve a mixture of low current with high voltage waveform for easy flow in power electronics applications. The initial work carries out the Power Factor Adjustment (PFA) to improve the speed of electron move in three-phase circuit for achieving higher voltage factor through cross links. **Results:** As a result, PFA also increase the flow of electrons with dynamic structure on three-phase circuit by decreasing the current waveform. Analytical equations are developed with current and output voltage, and injected to the soft-switching waveform. Soft-switching waveform improves the voltage factor and reduces the current flow on power electronics, thereby reducing the loss functions on three-phase circuit using DCT-ZSIIS mechanism**.** **Conclusion:** DCT-ZSIIS circuit topology comprises of power factor adjustment to improve the reliability rate. Experiment conducted on factors namely, Output Voltage/Current Rate on three phase circuit, soft-switching waveform rate based cross links, Power factor performance gain.

To Cite This Article: J.Shanmugapriyan, Dr. A.Chilambuchelvan and Dr. S.Vijayan., A Soft Switched Dynamic Cross-Linked Mechanism in Three-Phase Z-Source Inverter for Solving Shoot-Through Problems. ***Aust. J. Basic & Appl. Sci.,*** 9(5): 424-434, 2015

INTRODUCTION

Certain modern electrical instruments consisting of generators, air and power conditioners, have significantly increased the pivotal role of DC-AC inverters, with which the conditioning of energy is made in an appropriate manner. Existing inverter still have certain problems that has to be addressed with the foremost issue being the adverse conversion conditions of voltage or current.

Besides, the conventional Voltage Source Inverter (VSI) and Current Source Inverter (CSI) have been applied in a smaller range because of their narrow range of output voltage, occurrence of shoot-through problems and so on. Among these topologies, ZSI has received higher amount of attention and many researchers have contribution in this area. New Shoot Through Control (NSTC) (Indrek Roasto, 2013) methods was introduced with the aid of new pulse modulation technique called Pulse Width Modulation (PWM) to solve unequal switching frequencies. Cascaded Multi cell Trans-Z-Source Inverters (CMTZSI) (Ding Li, 2013) used multiple magnetic cells in order to obtain high voltage gain.

Corresponding Author: J. Shanmugapriyan, Assistant Professor, Department of Electrical and Electronics Engineering, Chettinad College of Engineering and Technology, Anna University - Chennai, Karur-639114, Tamil Nadu, India.
E-mail: jspriyan@gmail.com.

The advantages of applying Z-source inverter is that it not only boost the dc input voltage but also avoid the problems related to conventional voltage source inverter in terms of cost. Simple Boost and Maximum Boost (SBMB) (Husodo, B.Y., 2010) control methods maximized the power delivery capacity of the inverter. However, the reliability and power factor remained unaddressed. To solve the issues related to reliability and power Z-Source Inverter for Motor Drives (ZSI-MD) (Fang Zheng Peng, 2005) was introduced by controlling the shoot through duty cycle. But, the efficiency of the inverter remained unsolved. To improve the efficiency of the inverter in (Jae-Hyung Kim, 2010) Zero Voltage Switching (ZVS) was designed.

Due to the increasing amount of problems related to energy in the recent years, several renewable energy resources are widely used ranging from wind turbine, photovoltaic (PV) cell and so on. A single phase semi Z source inverter (Tejasri Gunnam S.K., 2006) was introduced to address the issues related to doubly grounded problems using nonlinear sinusoid pulse width modulation method. But, shoot through duty cycle was not addressed extensively. To improve the reliability of the inverter and boost the output voltage, a harmonic study was conducted in (Atul Kushwaha, 2012) using continuous modulation of three-phase-leg Z-source-inverter. Though the output voltage was observed to be good, voltage gain was not addressed. Modified simple boost and multiple boosts' was analyzed in (Budi Yanto Husodo, 2013) using high modulation index to obtain high voltage gain.

The advantages of using ZSI is that it utilizes the shoot-through forms to maximize the direct current (DC) voltage by gating both upper and lower switches of similar phase leg. An enhanced modulation scheme was proposed in (Sengodan, Thangaprakash and Ammasai Krishnan, 2012) on the basis of ripple profile to reduce the current and ripple voltage. Though the scheme provided additional voltage boost, but was only designed theoretically. Simulations were conducted in (Rongjun Huang and Sudip K. Mazumder, 2009) using boost control pulse width modulation technique for several modulation indices. However, switching losses were introduced with increased modulation indices. In (Surya Suresh Kota, 2013), a soft-switching mechanism was introduced under various load conditions minimizes the switching losses drastically. But the mechanism was not suitable for high voltage conversion. Multi-Level Inverter (MLI) (Swapnil, S., 2013) was integrated with Z source inverter to minimize the number of switches with the aid of powering mode and free-wheeling mode.

In this work, a Dynamic Cross-Linked three-phase Z-Source Inverter Injected with Soft-switched (DCT-ZSIIS) mechanism is presented. The contributions included in DCT-ZSIIS mechanism are given as below:

(i) To address the shoot-through problems a Dynamic Cross-Linked Three-phase Z-Source Inverter Injected with Soft-switched (DCT-ZSIIS) mechanism is developed.
(ii) To achieve a mixture of low current and voltage waveform for easy flow by developing a three phase interface concept
(iii) To improve the speed of electron move in three-phase circuit for obtaining higher voltage through cross links using Power Factor Adjustment (PFA)
(iv) To increase the flow of electrons by designing a dynamic structure by decreasing the current waveform
(v) To improve the voltage factor and reduce the current flow on power electronics by applying soft-switching waveform on three-phase circuit

The design of the paper is structured as follows. Section 1 provides an introductory part of Z Source Inverter as designed by various researchers through different angles. Section 2 reviews the related work. Section 3 designs a Cross-Linked three-phase Z-Source Inverter Injected with Soft-switched (DCT-ZSIIS) mechanism with the help of a neat architecture diagram and algorithmic flow. Section 4 provides experimental setup. Section 5 includes the discussions in detail. Finally, Section 6 provides a concluding remark.

2. Related Works:

Several power generators with renewable energy dissipate dc output voltage. As a result, the interfacing of inverter with the grid has to be taken place. Several inverter topologies have been designed and a review of literatures is also included. A doubly grounded non isolated z source inverter (Gaurav Sharma, Ankita Kosti, 2014) was introduced to obtain desired output voltage using sinusoidal pulse width modulation method. To reduce the voltage stress and increase the reliability for Hybrid Electric Vehicles (HEV) a modified Z source inverter was designed in (LIU Ping, LIU He-ping, 2011). However, the method was not feasible. To improve the feasibility, in (Kuppuswamy, C.L., T.A. Raghavendiran, 2012), Permanent Magnet Synchronous Motor (PMSM) was designed with the aid of Bidirectional Z Source Inverter (BZ-SI).

The Z-source Neutral Point Clamped is a type of single stage multilevel inverter possessing the capability of voltage boost. Though capable of voltage boost, but are heavily susceptible to renewable sources. A Multilevel inverter was introduced in (Miaosen Shen, 2006) to minimize the circuit complexity using two separate impedance networks. Z Source neutral point clamped was designed in for nonlinear loads. Two constant boost controls in (Kuppuswamy, C.L., T.A. Raghavendiran, 2012) reduced the stress in voltage using carried based Pulse Width Modulation. A design of single impedance was made in by reducing the clamping diodes to improve the voltage output.

Based on the aforementioned techniques and methods, a model of dynamic cross-linked three-phase z-source inverter is designed in the forthcoming sections.

3. Modeling of Dynamic Cross-Linked Three-Phase Z-Source Inverter:

The three phase Z-source inverter is a low cost, efficient and reliable inverter used to solve the shoot-through problems in power electronics. Shoot-through problems such as short circuiting on three phase circuit are overcome using the proposed work. The Z-source inverter based on three phase circuit uses the Power Factor Adjustment to boost the direct current (DC) bus voltage by gating on the upper and lower switches. The upper and lower switches of the similar phase leg of three phase circuit are adjusted to reduce the current fed in power electronic system. Three phase circuit with Z-source inverter boost the voltage using DCT-ZSIIS mechanism by speeding up the electrons and produce the desired output voltage gain.

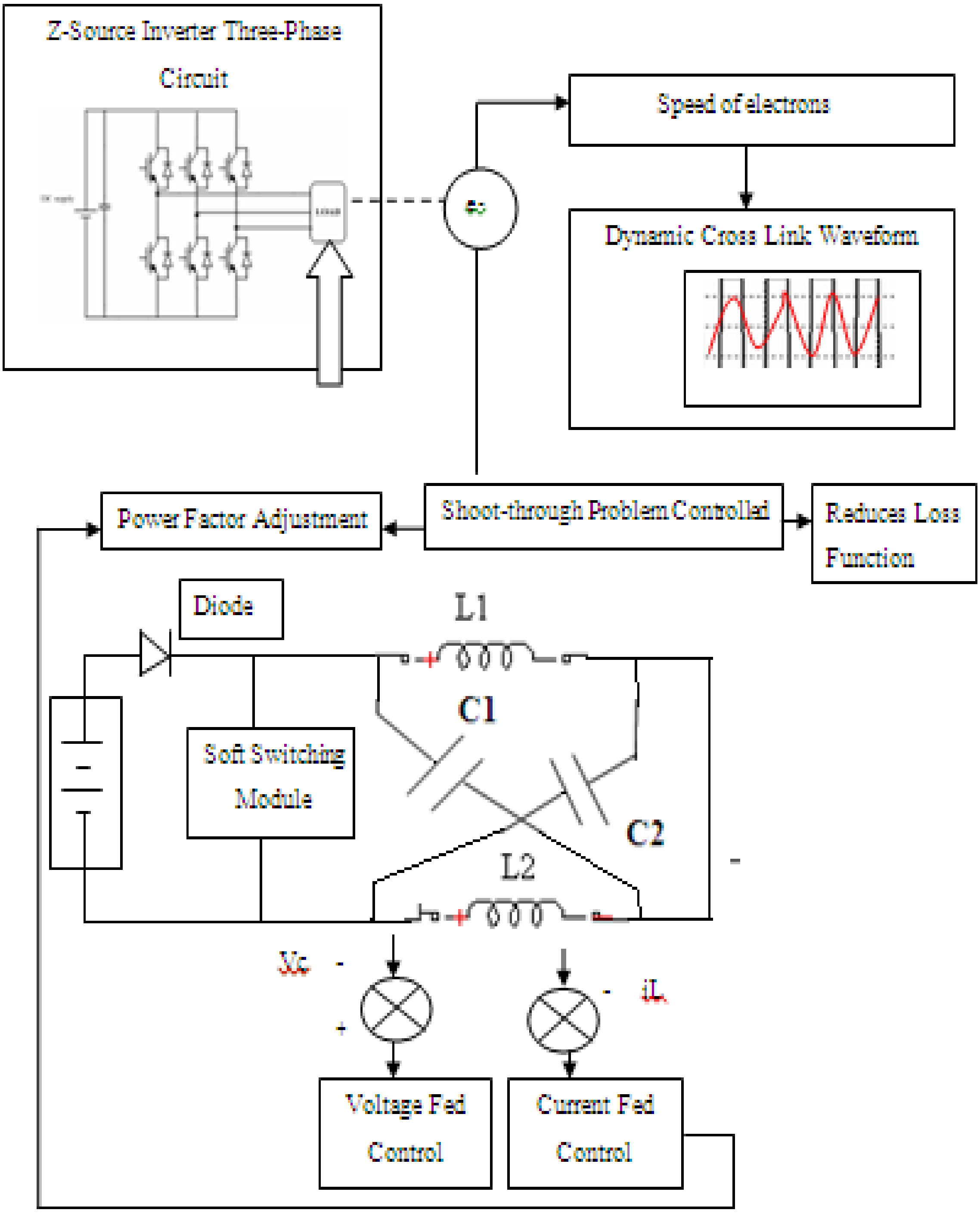

Fig. 1: Structure Diagram of DCT-ZSIIS Mechanism.

The shoot-through problems is solved using DCT-ZSIIS mechanism by injecting the Soft Switching Module. The Soft Switching Module improves the reliability rate with low cost factor. Three phase circuit with Z-source inverter make sure that the soft operation supplies the desired voltage to the load even during voltage sags. On the other hand, the Inverter Bridge in power electronics system with impedance network reduces the heavy loss function on short circuiting.

The basic design considerations of Z source three-phase inverter using DCT-ZSIIS mechanism is structured in such a way that the Z-source inverter works with non-zero vector state and shoot-through non-zero vector state. Indeed, all the non-zero vector state reduces the short circuit and also minimizes the voltage fed. The soft switching buffers the source current through the inductor and earthing of dc link and input source is performed simultaneously. As a result, the common noise factor is reduced. The Structure Diagram of Dynamic Cross-Linked Three-phase Z-Source Inverter Injected with Soft-switched (DCT-ZSIIS) mechanism is illustrated in Figure 1.

As illustrated in Figure 1,the structure diagram of DCT-ZSIIS Mechanism is implemented on the three-phase circuit. The three-phase circuit on power electronic using DCT-ZSIIS mechanism converts the DC supply into alternating current (AC) supply. The load is processed with the flow of electron (e-) speed as illustrated in the circuit. The dynamic cross-link waveform shoot-through the problems by reducing the current and voltage fed. Power Factor Adjustment works to alter the power flow on different load. As shown in the figure1, the power factor is adjusted in the Z-source inverter with the capacitor ‘C1’ and ‘C2’ and inductor ‘L’. The inductor works well to reduce the current flow on varying load factor and simultaneously the voltage is gained through Vc.

The three phase sinusoidal modulating signals with 120 degree phase shift are injected with the soft switching procedure to control the shoot-through problems. The dynamic cross link waveform produce reliable result by inserting the soft switched waveform with the help of XOR gate. The Z-source inverter has seven soft switched states in three phase circuit to avoid short circuit on a one phase-leg (P1), two phase-legs (P2) and three phase-legs (P3). These soft switched states using DCT-ZSIIS mechanism boost the capacitor voltages and partially increase the zero states to non-zero states within a fixed soft switching cycle. Finally, the soft switched cycle removes the shoot-through problems and produces an effective result on loss function ratio.

3.1 Three Phase Z-source Inverter:

The impedance source power network in an electronics system develops a circuit to buck boost converter. The voltage gain minimizes the current source factor in three phase Z-source inverter by considering a ‘dc’ source as a diode rectifier. Z-source inverter employs a unique impedance circuit to couple converter main circuit to power source, load for providing unique features in DCT-ZSIIS mechanism using a capacitor ‘C’ and inductor ‘L’ used respectively. Switches used in the Z-source inverter with three phases are a combination of switching devices and diodes used for the dynamic cross links.

For distributed power generation, our proposed three phase Z-source inverter directly produces an ac voltage which is greater than the input voltage. The diode in series is used for preventing reverse current flow. The three phase Z-source inverter is illustrated in Figure 2.A Z-source impedance network is a symmetrical network and encloses L1and L2 which is in sequence inductances. C1 and C2 are cross linked capacitance which is connected to the dc source and the converter.

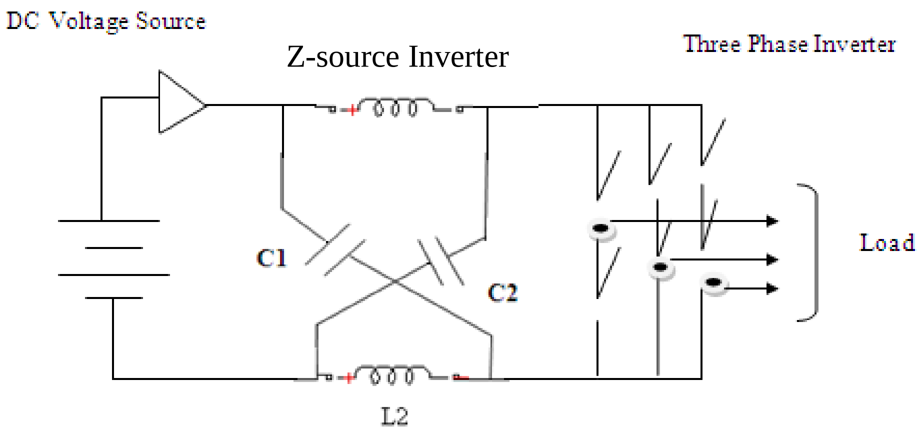

Fig. 2: Three Phase Circuit Topology with Z-source Inverter.

The full inverter bridge in DCT-ZSIIS mechanism consists of three legs and two switches where each leg is switched in such a way that when one of the leg is in off state, the other two is in on condition. The algorithmic step of the three phase cross link Z-source inverter circuit is described as,

// Cross Link Z-Source Inverter
Begin
Input : Three phase circuit with three legs 'P1','P2','P3', two switches and seven soft switched states
1: Apply Power Factor Adjustment with average power factor value on three leg Z-source inverter
2: For each load factor
3: Current Fed on Three phase Z-source inverter through dynamic inductance

$$V_L = \frac{Start\ Time.V_c + T_1(V_0 - V_c)}{Total\ Time}$$

4: Voltage Fed on three phase Z-source inverter through cross linked capacitance
5:Apply Soft switching waveform
6: Improve voltage factor, go through step 4
7: Improve current flow, repeat step 3 for different load factor
8: end for
Output: Reduces the loss functions in Z-source three phase circuit

As described in the above steps, a three phase circuit in DCT-ZSIIS comprises of power factor adjustment and Soft switching waveform to improve voltage factor and reduce the current flow on power electronics. One Phase-leg (P1), two Phase-legs (P2) and three Phase-legs (P3)are monitored to reduce the loss functions in a circuit with Z-source inverter. DCT-ZSIIS mechanism handles entire shoot-through problem smoothly and produces higher reliability rate.

3.1.1 Dynamic Cross-Link:

The output current will flow continuously through load using DCT-ZSIIS mechanism and the output voltage is obtained according to the status of soft switching with dynamic cross links. The z-source inverter considers the capacitor and inductor with fast moving of electrons to construct a symmetrical network. A Symmetrical Network with dynamic cross-linked Z-source inverter is considered as,

$$V_{L1} = V_{L2} = V_L \quad (1)$$

According to (1), if the inductor of 'L1' and 'L2' are symmetrical, then the output value of the inductor V_L over the soft switching is described as,

$$V_L = \frac{Start\ Time.V_c + T_1(V_0 - V_c)}{Total\ Time} \quad (2)$$

In (2), the factor, Total Time evaluates the summing of Start Time, $T_1,\ldots,T_n$ whereas the dc source voltage is denoted by V_0 with a capacitor value V_c for three phase Z-source inverter. From the above (2), the output value of the inductor V_L at time T_1 is measured. In a similar manner, the output value of the inductor V_L till time for T_n can be measured. The soft switching based current measure in DCT-ZSIIS mechanism improves the reliability on three phase circuit.

In a similar manner, the capacitor voltage is expressed as,

$$V_{C1} = V_{C2} = V_C \quad (3)$$

The non-zero state based voltage gain equivalently produces the voltage to the load terminal and the values for V_C is computed as,

$$V_c = \frac{1 - \frac{Start\ Time}{Total\ Time}}{1 - 2\frac{Start\ Time}{Total\ Time}} V_0 \quad (4)$$

The above computed analytical equations are used for injecting the value in the soft-switching waveform to reduce the loss function in three phase Z-source inverter circuit.

3.2 Power Factor Adjustment:

Power Factor Adjustment in DCT-ZSIIS mechanism is the ratio of working power to the total power capacity range. DCT-ZSIIS mechanism with high adjustments produces improved reliability ratio on Z-Source Inverter (ZSI). The results of power factor adjustment in a distributed three phase circuit is formularized as given below,

$$Average\ Power\ Factor\ on\ ZSI\ (PFZSI) = \frac{KWH}{\sqrt{(KWH)^2 + (KVAH)^2}} \quad (5)$$

The consumed level of power factor is measured using the average power factor as provided in (5). 'KWH' denotes Kilo Watt per Hour whereas 'KVAH' denotes the Kilo Volt Ampere Hours. The volt denotes the electrons speed measurement unit. The over power adjusted using DCT-ZSIIS mechanism is denoted as,

$$Adjusted\ Power = KW\ power * ((.95 - PFZSI) + 1) \quad (6)$$

The power is adjusted if the factor is less than 0.95 and DCT-ZSIIS mechanism performs the adjustment power factor through (6).

3.3 Soft Switching Module:

The switching of the three phase circuit using soft switching module prevents the occurrence of the voltage and current fed simultaneously. To improve their efficiency of high-power inverters, DCT-ZSIIS mechanism uses soft switching waveforms. The soft switching waveform improves the voltage factor and reduces the current flow on power electronics using DCT-ZSIIS mechanism thereby reduce loss functions on three-phase circuit. The illustrative of Soft Switching Waveform is provided below,

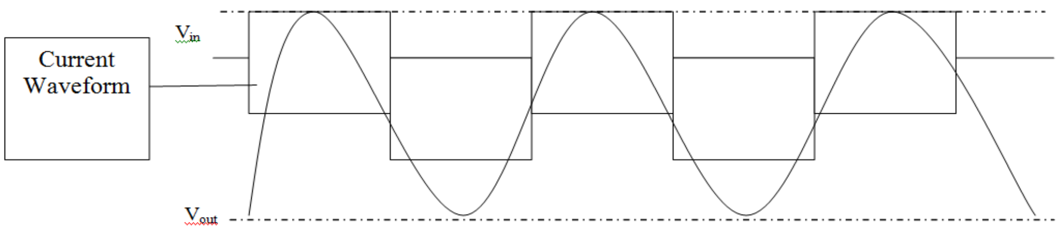

Fig. 3: Design of Soft Switching Waveform.

The three-phase Z-source inverter with soft switching is coupled with inductors ‘L’to reduce the current fed through soft sinusoidal waveforms. The voltage input ‘V_{in}’ is taken and produces higher output voltage with resultant ‘V_{out}’ as shown in Figure 3. This in turn results in improving the inverter efficiency on the three phase circuit.

4 Experimental Evaluation:

Dynamic Cross-Linked Three-phase Z-Source Inverter Injected with Soft-switched (DCT-ZSIIS) mechanism is proposed in this paper. The resultant parametric factors are experimented through the three phase circuit. The three phase circuit is designed in gaining the voltage factor and also generates Modified Pulse Width Modulation (MPWM) using timers and compares the values. As a rule, predictable microcontrollers have only one or two measure up values per timer, which is not sufficient in the current case. The problem was solved by generating the shoot-through states dynamic space vector values.

One of the high performance languages used for technique computing is MATLAB that not only integrates computation, visualization, but also designing the programming in an easy. Moreover, MATLAB is considered to be the excellent tool for conducting research works. Our work uses MATLAB simulink models for several Z-Source Inverter topologies. The Z-Source Inverter topologies are simulated with different Modified Pulse Width Modulation (MPWM) using timers and compare the values. The results are studied based on the performance of the proposed Dynamic Cross-Linked Three-phase Z-Source Inverter Injected with Soft-switched (DCT-ZSIIS) mechanism and comparison made with two different mechanisms New Shoot-Through Control (NSTC) (Indrek Roasto, 2013) Methods and Cascaded Multicell Trans-Z-Source Inverters (CMTZSI) (Ding Li, 2013).

The dynamic space uses the switched capacitor integrator to reduce the current rate. Simulation results are confirmed by the measured results. The voltage gain factor with dynamic voltage restorer methods gave similar results. The current value is also reduced by solving the shoot-through state problem. Proposed result is compared against the existing New Shoot-Through Control(NSTC) (Indrek Roasto, 2013) Methods and Cascaded Multicell Trans-Z-Source Inverters (CMTZSI) (Ding Li, 2013). The experiment is conducted on factors such as Output Voltage/Current Rate on three phase circuit, power factor performance gain, and reliability rate on current reduction.

Results:

To validate the efficiency and theoretical advantages of the proposed Z-Source Inverter Injected with Soft-switched mechanism, simulation results under MATLAB Simulink are presented. The parameters of the DCT-ZSIIS mechanism are chosen as provided in Table I.

The range of time that is measured in terms of milliseconds (ms) are chosen initially as 5and then increased in step to 10, 15, 20, 25, 30, 35and 40 as described above. Table 1 tabulates the comparison of output voltage/current on three phase circuit using the proposed DCT-ZSIIS and comparison made with two other methods namely, NSTC (Indrek Roasto, 2013) and CMTZSI (Ding Li, 2013). Comparatively better performance is achieved using DCT-ZSIIS and the optimal output voltage/current was found to be 38 V and 95 A respectively. In this learning strategy, though not linear, both the voltage and current rate gets increased. The DCT-ZSIIS mechanism requires large training sets and long duration of training time, but for experimental purpose we have considered till 45 ms. Also when the time interval is higher, the voltage/current rate gets increased.

In a perspective to evaluate the output voltage on three phase circuit using the proposed method DCT-ZSIIS mechanism, we simulated the time with the aid of Three-phase Z-Source Inverter Injected with Soft-switched mechanism with time $T_1 = 5\ ms\ to\ T_7 = 40\ ms$ as illustrated in Figure 4 (a).The output of the proposed output voltage converges to 60 at time $'T_4'$ = 20 to NSTC and CMTZSI whose output voltage converges to 45 and 35respectively. This is observed due to the application of Power Factor Adjustment which is a measure of working power to total power capacity that is carried out to improve the electron move that in a way efficiently adjusts the power factor by increasing the output voltage on three phase circuit by 7 – 33 % when compared to NSTC. In addition, using the factor adjusted power (6), less than .95 increases the output voltage by 25 – 46 % when compared to CMTZSI respectively.

Table 1: Comparison of Output Voltage/Current on three phase circuit.

Parameter				Value		
Three phase sinusoidal modulating signals				120 degree phase shift		
Input voltage				45.5 V		
Load inductance				8 mH		
Capacitance				145 µF		
Switching Frequency				10 kHz		
Time (ms)	Output Voltage on three phase circuit (V)			Output Current on three phase circuit (A)		
	DCT-ZSIIS	NSTC	CMTZSI	DCT-ZSIIS	NSTC	CMTZSI
5	55	39	30	95	110	120
10	78	55	48	102	120	135
15	77	58	50	72	85	110
20	60	45	34	75	88	105
25	68	45	38	125	135	145
30	80	74	60	127	142	159
35	93	77	60	95	110	135
40	65	55	35	102	140	155

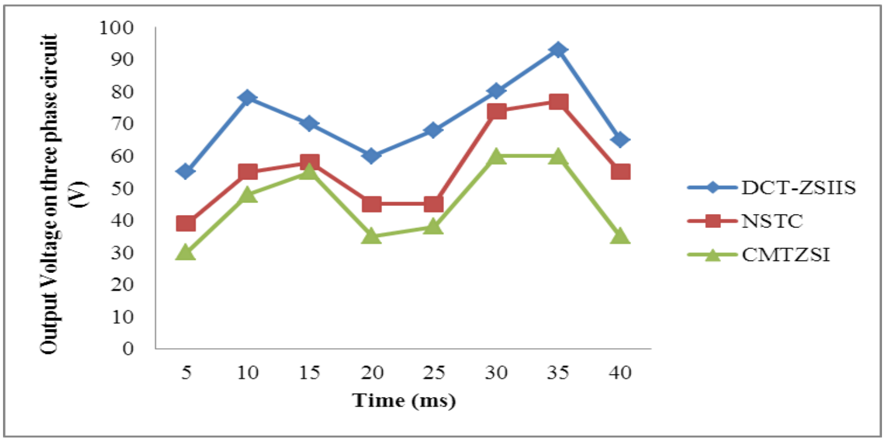

Fig. 4(a): Experimental Results for Output Voltage on three phase circuit using DCT-ZSIIS, NSTC and CMTZSI.

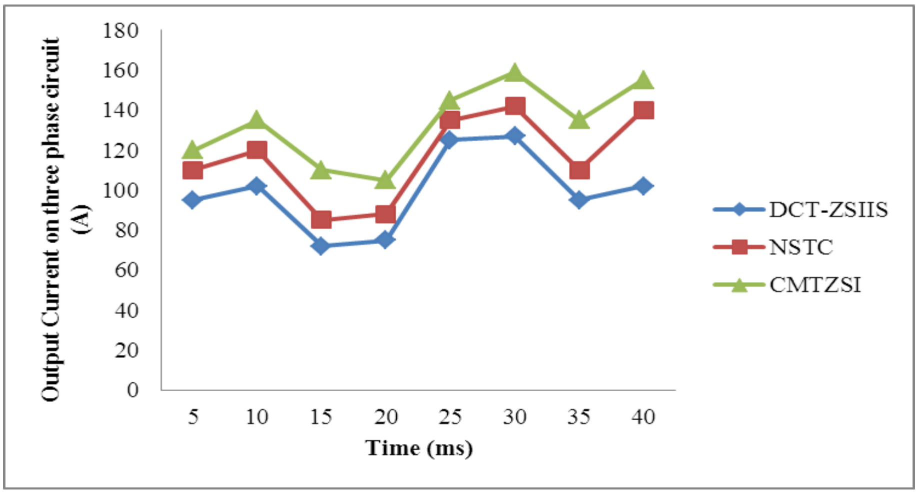

Fig. 4(b): Experimental Results for Output Current on three phase circuit using DCT-ZSIIS, NSTC and CMTZSI.

Figure 4(b) provides the experimental analysis for output current on three phase circuit and comparison made with two other existing methods namely, NSTC and CMTZSI respectively. From the figure, an illustrative analysis shows that the output current is comparatively observed to be lesser than the NSTC (Indrek Roasto, 2013) and CMTZSI (Ding Li, 2013). This is because by applying Power Factor Adjustment, the flow of electrons is increased with dynamic structure by minimizing the current waveform by 8 – 35 % compared to NSTC. In addition, with the application of Soft switching waveform, prevents the occurrence of current and voltage simultaneously and as a result the current flow is reduced by 16 – 52 % compared to CMTZSI.

Table 2: Comparison of Power Factor Performance Gain on three phase circuit.

Time (ms)	Power Factor Performance Gain (W)		
	DCT-ZSIIS	NSTC	CMTZSI
5	95	75	65
10	110	90	82
15	170	140	125
20	180	155	140
25	250	235	225
30	300	275	245
35	310	290	350
40	340	305	318

In order to evaluate the performances of the proposed power factor performance gain on three phase circuit, we consider various time interval that are taken in to account during the training process. The scenarios observed during training process are subjected under various conditions such as on a phase-leg (P1), two phase-legs (P2) and three phase-legs (P3).The tests results of the proposed mechanism, DCT-ZSIIS with that of the two state-of-the-art methods NSTC (Indrek Roasto, 2013) and CMTZSI (Ding Li, 2013) are presented in Table 2.

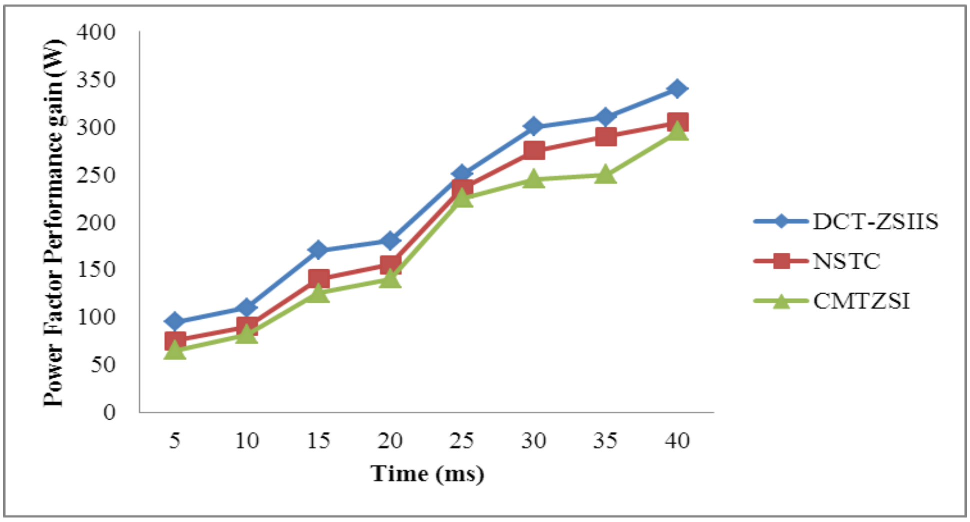

Fig. 5: Experimental Results for Power Factor Performance Gain on three phase circuit using DCT-ZSIIS, NSTC and CMTZSI.

In order to show the higher convergence rate of the proposed mechanism, DCT-ZSIIS, under the influence of different time, with three phase sinusoidal modulating signals with 120 degree phase shift injected with soft switching procedure, the results of power factor performance gain at switching frequency 10 kHz is simulated and illustrated in Figure 5. We noticed that the proposed Cross Link Z-Source Inverter algorithm makes it significantly possible to increase the power factor by gating on the upper and lower switches at a faster convergence time.

The power factor at time t = 20 ms observed a performance gain of 250 V with an observed switching frequency $'f_1'$ = 10 kHz using the proposed method, DCT-ZSIIS whereas the performance gain of 235 V and 225 V was observed at time t = 20 ms for frequency $'f_1'$ = 10 kHz. Thus it is clear that the proposed DCT-ZSIIS mechanism can accurately improves the power factor performance gain than the other two state-of-the-art methods. This is because with the application of three phase circuit with Z-source inverter that subsequently boost the voltage by speeding up the electrons increasing the power factor by 6 – 21 % compared to NSTC (Indrek Roasto, 2013) and 10 – 31 % compared to CMTZSI (Ding Li, 2013) respectively.

Table 3 presents the effect of the reliability rate on current reduction on the proposed method DCT-

ZSIIS and comparison made with two other methods, NSTC (Indrek Roasto, 2013) and CMTZSI (Ding Li, 2013). Indeed the reliability rate is measured with respect to input voltage 45.5 V with load inductance of 8 mH considered for experimental evaluation

Table 3: Comparison of Reliability rate on current reduction.

Methods	Reliability rate on current reduction (%)
DCT-ZSIIS	82.35
NSTC	73.49
CMTZSI	65.43

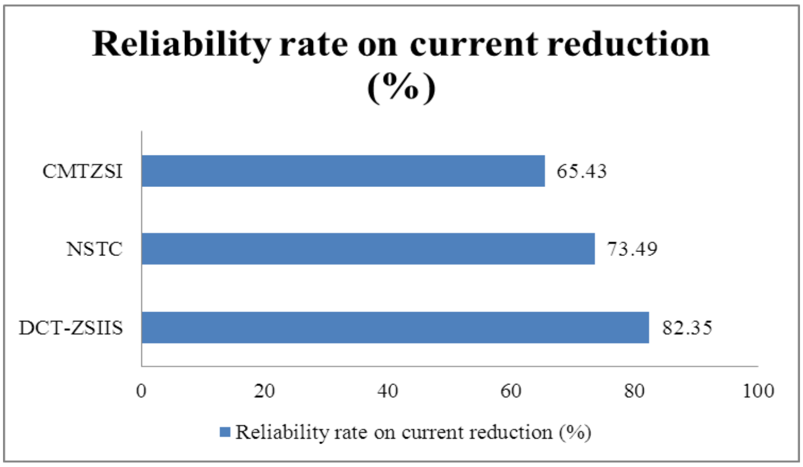

Fig. 6: Experimental Results for Reliability rate on current reduction using DCT-ZSIIS, NSTC and CMTZSI.

The reliability rate on current reduction using different methods is presented in Figure 6. These results proved that by the coordination of the Power Factor Adjustment with average power factor value on three leg Z-source inverter, improves reliability rate compared to the state-of-the-art methods namely, NSTC (Indrek Roasto, 2013) and CMTZSI (Ding Li, 2013) respectively. This is because with the help of soft switching mechanism with higher adjustments improve the reliability rate by 10.75 % and 10.96 % compared to NSTC and CMTZSI respectively.

Conclusion:

An efficient Dynamic Cross-Linked Three-phase Z-Source Inverter Injected with Soft-switched (DCT-ZSIIS) mechanism is presented. To achieve higher voltage factor, Power Factor Adjustment (PFA) is carried out, Average Power Factor and Adjusted Power was presented that efficiently improved the reliability ratio on the measured load inductance and capacitance. Next, Soft switching waveform was introduced to improve voltage factor and reduce the current flow thereby minimizing the loss functions on three-phase circuit. A Cross link Z-Source Inverter using dynamic cross link constructed a symmetrical network to improve the reliability on three phase circuit. Finally, a power factor adjustment applied a short switching module to prevent the occurrence of voltage and current being fed at a simultaneous time. A comparative study of the proposed method with two other existing state-of-the-art method show that the dynamic cross linked mechanism using load and capacitor achieved power factor performance gain. This was obtained by improving the voltage factor and current flow with improved system response time using cross-link Z-Source Inverter algorithm. The simulation results have been shown under seven soft switched states in three phase circuit on a phase-leg (P1), two phase-legs (P2) and three phase-legs (P3). The obtained results indicate that the proposed Dynamic Cross-Linked Three-phase Z-Source Inverter Injected with Soft-switched significantly improves the output voltage and current rate on three phase circuit and obtaining power factor performance gain with high reliability.

REFERENCES

Atul Kushwaha, Mohd, Arif Khan, Atif Iqbaland Zakir Husain, 2012. Z- Source Inverter Simulation and Harmonic Study, Global Journal of Advanced Engineering Technologies, 1(1).

Budi Yanto Husodo, Shahrin Md. Ayob, Makbul Anwari, Taufik, 2013. Simulation of Modified Simple Boost Control for Z-Source Inverter, International Journal of Automation and Power Engineering (IJAPE), 2(4).

Ding Li, Poh Chiang Loh, Miao Zhu, Feng Gao and Frede Blaabjerg, 2013. Cascaded Multicell Trans-Z-Source Inverters, IEEE Transactions on Power Electronics, 28(2).

Fang Zheng Peng, Alan Joseph, JinWang, Miaosen Shen, Lihua Chen, Zhiguo Pan, Eduardo Ortiz-Rivera, and Yi Huang, 2005. Z-Source Inverter for Motor Drives, IEEE Transactions on Power Electronics, 20(4).

Gaurav Sharma, Ankita Kosti, 2014. Maximum Constant Boost Control of SL-Z-Source Inverter, International Journal of Emerging Technology and Advanced Engineering, 4(5).

Husodo, B.Y., M. Anwari and S.M. Ayob, Taufik, 2010. Analysis and Simulations of Z-Source Inverter Control Methods, IEEE, IPEC.

Indrek Roasto, Dmitri Vinnikov, Janis Zakis and Oleksandr Husev, 2013. New Shoot-Through ControlMethods for qZSI-Based DC/DC Converters, IEEE Transactions on Industrial Informatics, 9(2).

Jae-Hyung Kim, Yong-Chae Jung, Su-Won Lee, Tae-Won Leez and Chung-Yuen Won, 2010. Power Loss Analysis of Interleaved Soft Switching Boost Converter for Single-Phase PV-PCS, Journal of Power Electronics, 10(4).

Kuppuswamy, C.L., T.A. Raghavendiran, 2012. A Novel Single Impedance Network Based Neutral Point Clamped Seven Level Three Phase Inverter with Reduced Clamping Diodes for Regenerative Applications, Indian Journal of Computer Science and Engineering (IJCSE), 3(4).

Kuppuswamy, C.L., T.A. Raghavendiran, 2012. An Efficient Single Impedance Network Three Level Z-Source Neutral Point Clamped Inverter, International Journal of Computer Science Issues, 9(4).

LIU Ping, LIU He-ping, 2011. Application of Z-source Inverter for Permanent-magnet Synchronous Motor Drive System for Electric Vehicles, Advanced Control Engineering and Information Science, Elsevier.

Miaosen Shen, Jin Wang, Alan Joseph, Fang Zheng Peng, Leon M. Tolbert and Donald J. Adams, 2006. Constant Boost Control of the Z-Source Inverter to Minimize Current Ripple and Voltage Stress, IEEE Transactions on Industry Applications, 42(3).

Rongjun Huang and Sudip K. Mazumder, 2009. A Soft-Switching Scheme for an Isolated DC/DC Converter With Pulsating DC Output for a Three-Phase High-Frequency-Link PWM Converter, IEEE Transactions on Power Electronics, 24(10).

Sengodan, Thangaprakash and Ammasai Krishnan, 2012. A New Switching Scheme for Z-source Inverter to Minimize Ripples in the Z-source Elements, International Journal of Automation and Computing, 9(2): 200-210.

Surya Suresh Kota, Vishnu Prasad Muddineni, Adithya Kumar Dadiboina and Gopilatha Venna, 2013. Simulation and Analysis of Novel Cascaded Z Source Inverter, International Journal of Advances in Engineering & Technology.

Swapnil, S., A.V.V. Sudhakar, N. Lokesh, 2013. Single-Stage Non-Isolated Semi Z-Source Inverter for Renewable Systems, International Journal of Electrical, Electronics and Computer Systems, (IJEECS), 1(2).

Tejasri Gunnam S.K. Sadik Ahamad Khan Firozali Mohammed Anyam Naresh, 2013. Modeling of Single-Phase Semi-Z-source Inverter, International Journal of Research in Computer and Communication Technology, 2(9).