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# Analysis of Extended Z-source Inverter for Photovoltaic System

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**Abstract:** The Z-source inverter has picked up prominence as a solitary stage buck-support inverter topology among numerous specialists. Notwithstanding, its boosting capacity could be constrained, and in this manner, it may not be reasonable for a few applications requiring high lift request of falling other dc-dc help converters. The Z-source inverter is a recent converter topology that exhibits both voltage-buck and voltage-boost capability. This could lose the effectiveness and request all the more detecting for controlling the additional new stages. This paper is proposing another group of broadened help semi Z - source inverter (ZSI) to fill the exploration hole left in the improvement of ZSI. These new topologies can be worked with same regulation strategies that were produced for unique ZSI. Likewise, they have a similar number of dynamic switches as unique ZSI saving the single-organize nature of ZSI. Proposed topologies are dissected in the enduring state and their exhibitions are approved utilizing recreated comes about acquired in MATLAB/Simulink. Besides, they are tentatively approved with comes about acquired from a model created in the research facility. The trend of fast increase of the PV energy use is related to the increasing efficiency of solar cells as well as the improvements of manufacturing technology of solar panels.

## 1. Introduction

Recently interest in renewable power generation technologies are rapidly increasing due to global pollution problems. Also fuel cell system can always produce electric power regardless of climate conditions as long as hydrogen and oxygen are supplied. Inverter plays an important role in day to day life. There is a large demand for electricity which increases the need for inverter. Initially, there were two types of inverters, they are current source inverter (CSI) and voltage source inverter (VSI). In this existing inverter, voltage gain is very less, more components are required, boosting of voltage is less. The main disadvantage of existing system is that it requires two stage conversion [DC –DC] and [AC-DC]. This can be overcome by using Extended Z-Source Inverter which is the proposed system. If this inverter is used, more boosting of voltage is possible and efficiency will be more. The proposed system involves the single stage conversion mechanism. Both voltage and current can be made stable



using Extended Z-source inverter. Z-source inverter which is used presently involves two stage conversions. The first stage is dc converter portion for boost operation and the second stage is inverter portion to convert the dc supply to ac. There are many disadvantages in the present system. Voltage gain is very less; Ripple currents are more Input current is not continuous high voltage stress. These disadvantages can be rectified by using Extended Z source inverter. The fuel cell produces low DC output voltage. The low DC output voltage is boosted and it is used as an input to inverter to produce higher AC voltage for power distribution system. To achieve this, the conventional fuel cell system has used a DC/DC boost converter and a DC/AC inverter. The main objective of the project is to design an Extended Z-source inverter using SPWM technique. The Extended Z-source inverter provides the following advantages over the conventional inverters. They are Increased voltage gain Reduced switching cost Increased stability Single stage conversion

F.Z. Peng presented an impedance-source power converter (abbreviated as “EZ-source converter”) and its control method for implementing dc-to-ac, ac-to-dc, ac-to-ac, and dc-to-dc power conversion. “EZ-source converter” overcomes the conceptual and theoretical barriers and limitations of the traditional voltage-source converter and current-source converter and provides a novel power conversion concept. In [1] proposed three different inverters: Traditional PWM inverter, DC/DC boosted PWM inverter, and “Z-source inverter” for fuel cell vehicles were investigated. For the purposes of comparison, and example of the total switching device power, requirement of passive components, efficiency, and the constant power speed ratio of the different inverters powered by the same fuel cell and loaded by the same motor were conducted. Loh F and Blaabjerg F [2] presented a detailed circuit analysis and PWM implementation of a fuel cell based “Z-source converter” using L and C components. Also, a Sinusoidal Pulse Width Modulation is described in detail for stepping up the DC-link voltage and generating a sinusoidal AC output voltage. Jennifer Vining investigated the explores the impact of applying a variety of Sinusoidal Modulated Voltage waveforms – a type of pulse width modulation - to the stator of a squirrel-cage induction machine with a focus on the frequency spectra of the resulting voltage, current, and torque waveforms. Four different Sinusoidal Pulse Width Modulation (SPWM) algorithms are investigated [3]. Kojabadi H M, Kivi H F and Blaabjerg F [4] presented an Impedance Source Inverter for A.C. Electrical Drives. By controlling the shoot-through duty cycle, the “EZ-source inverter” system using a MOSFETS provide ride-through capability during voltage sags, reduces line harmonics, improves power factor and high reliability, and extends output voltage range. Battiston A, Miliani E H [5] expressed the analysis of dynamic response of the fuel cells, PWM implementation, and design of a closed-loop controller for a “EZ-source converter”. A discrete-time state space equation is given to implement digital control and a sinusoidal pulse width modulation (SPWM) technique is modified to realize the shoot-through zero vector that boost the DC-link voltage. Siwakoti Y H[6] proposed the two constant boost-control methods of the “Z-source inverter”, which can obtain maximum voltage gain at any given modulation index without producing any low-frequency and minimize the voltage stress at the same time [7]-[8].

## 2. Z-SOURCE INVERTER

The figure 1 shows a two-port network that consists of a split-inductor  $L_1$  and  $L_2$  and electrolytic capacitors  $C_1$  and  $C_2$  connected in X shape is employed to provide an impedance source ( Z-source ). The inductance  $L_1$  and  $L_2$  can be provided through a split inductor or two separate inductors.

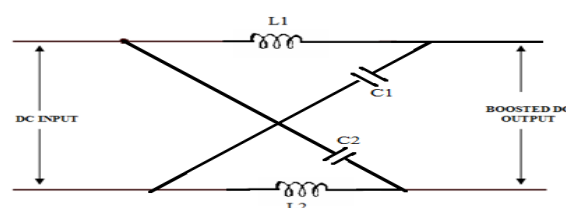


Figure 1. Z-Source Network

In Non-Shoot through mode it acts as a traditional Voltage Source Inverter (VSI). Shoot through mode plays an important role. In shoot through mode, two MOSFET switches are turned on in the same leg. AC is converted into DC by using a rectifier. This DC is given to voltage sensing unit which senses the input variations and gives to microcontroller. Microcontroller varies the duty cycle of the MOSFET according to the input variations and gives to Z-source inverter. There are two types of rps used, one for microcontroller and the other for gate driver. Since the microcontroller is a digital device, it is mandatory to supply +5V DC supply. Gate driver is mainly used to isolate between Z-source inverter and microcontroller and also to drive the MOSFET effectively. The input to gate driver is +12V and -12V since 12V supply is required for effective on and off of the MOSFET switch. Signal conditioning can include amplifications, filtering, converting, range matching, isolation and any other processes required to make sensed output suitable for processing after rectifying. Logic used in microcontroller is Fuzzy logic and technique used is SPWM. Extended Z-source is the advancement of modified Z-source inverter. Single stage conversion is an important advantage. Current and Voltage can be made stable using Extended Z-source inverter. So voltage boosting can be achieved to a greater extent using a Extended Z-source inverter. Thus dc is converted into ac and given to respective load [15]-[21].

### 3. Extended Z Source Inverter

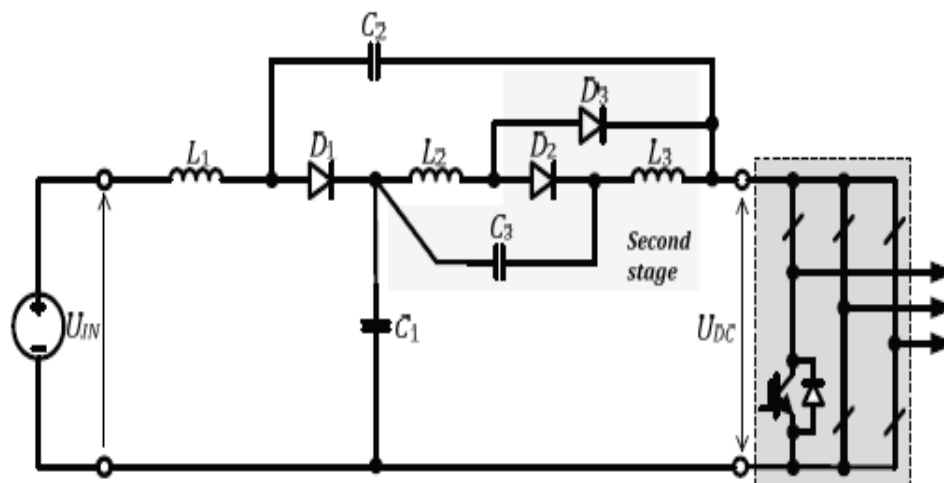


Figure 2. Equivalent circuit

Extended Z-source is the advancement of modified Z-source inverter shown in figure 2. Single stage conversion is an important advantage. Current and Voltage can be made stable using Extended Z-source inverter. So voltage boosting can be achieved to a greater extent using a Extended Z-source inverter. Thus dc is converted into ac and given to respective load.

### 4. Results and Discussion

The simulated circuit of EZ source inverter shown in figure 3. Normally one alteration of the input voltage will reverse the polarities. Opposite ends of the transformer will therefore always be 180 deg out of phase with each other. For a positive cycle, two diodes are connected to the positive voltage at the top winding and only one diode conducts. At the same time one of the other two diodes conducts for the negative voltage that is applied from the bottom winding due to the forward bias for that diode. In this circuit due to positive half cycle D1 & D2 will conduct to give 10.8v pulsating DC. The DC output has a ripple frequency of 100Hz. Since each alteration produces a resulting output pulse. The output obtained is not a pure DC and therefore filtration has to be done. Filter circuit is usually capacitor acting as a surge arrester always follows the rectifier unit. This capacitor is also called as a decoupling capacitor or a bypassing capacitor, is used not only to 'short' the ripple with frequency of

120Hz to ground but also to leave the frequency of the DC to appear at the output. A load resistor R1 is connected so that a reference to the ground is maintained. C1R1 is for bypassing ripples. C2R2 is used as a low pass filter, i.e. it passes only low frequency signals and bypasses high frequency signals. The load resistor should be 1% to 2.5% of the load. Voltage sensing is also called as potential divider is a linear circuit that produces an output voltage that is the fraction of its input voltage. It refers to the partitioning of a voltage among the components of the divider. It can include amplification, filtering, and any other processes required to make sensed output suitable for processing after rectifying. The PWM pulse and output voltage of EZ source inverter are shown in figure 4 and figure 5.

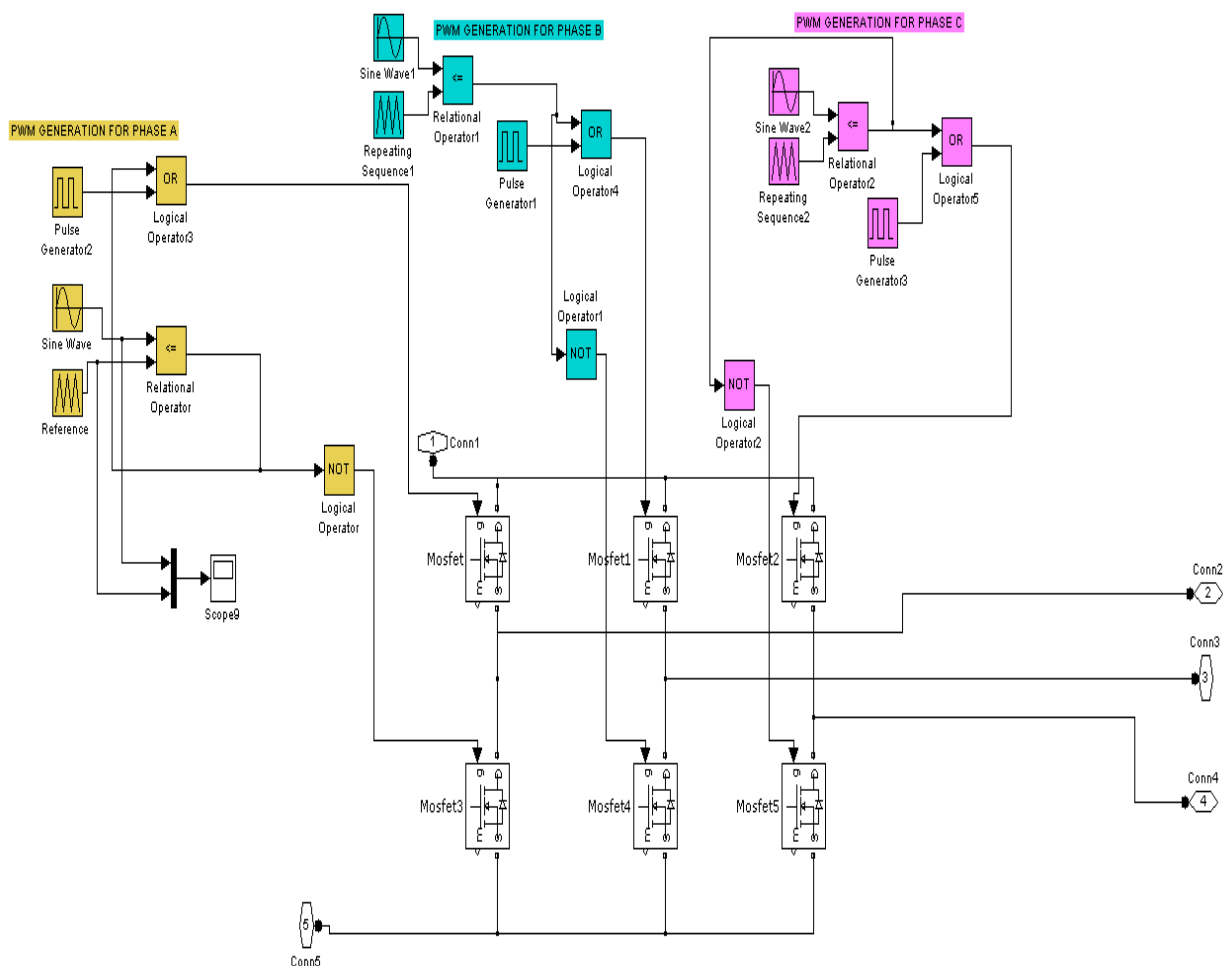


Figure 3. Simulated Circuit

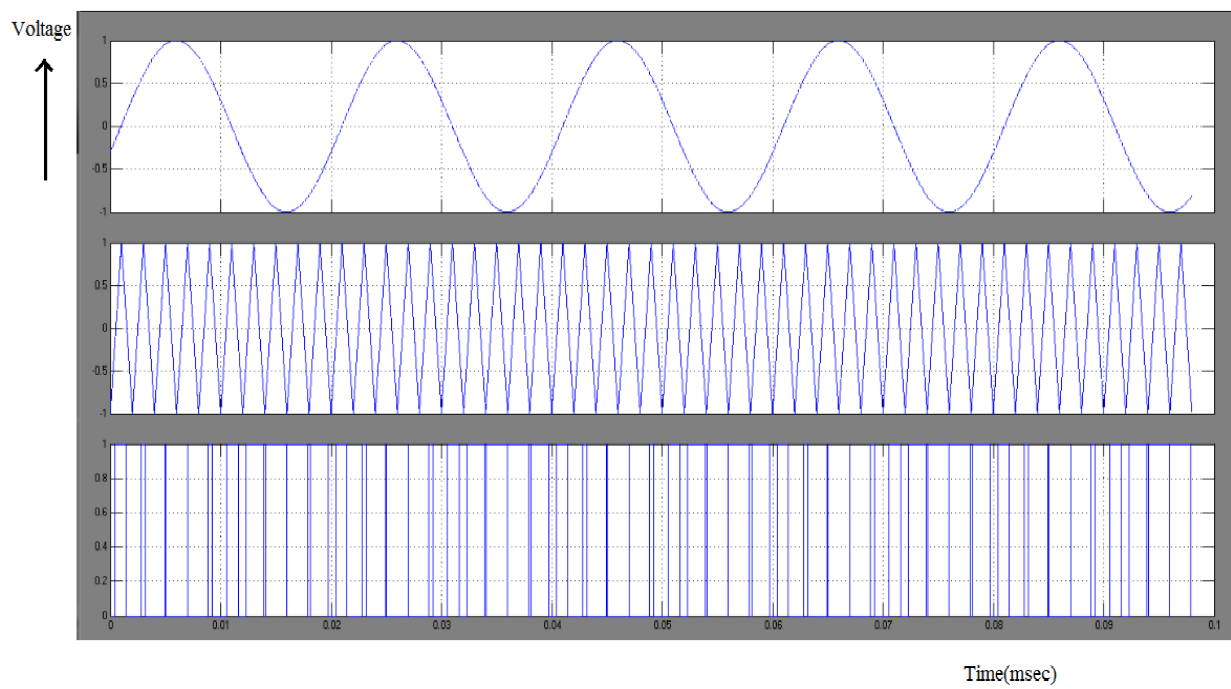


Figure 4. PWM pulse

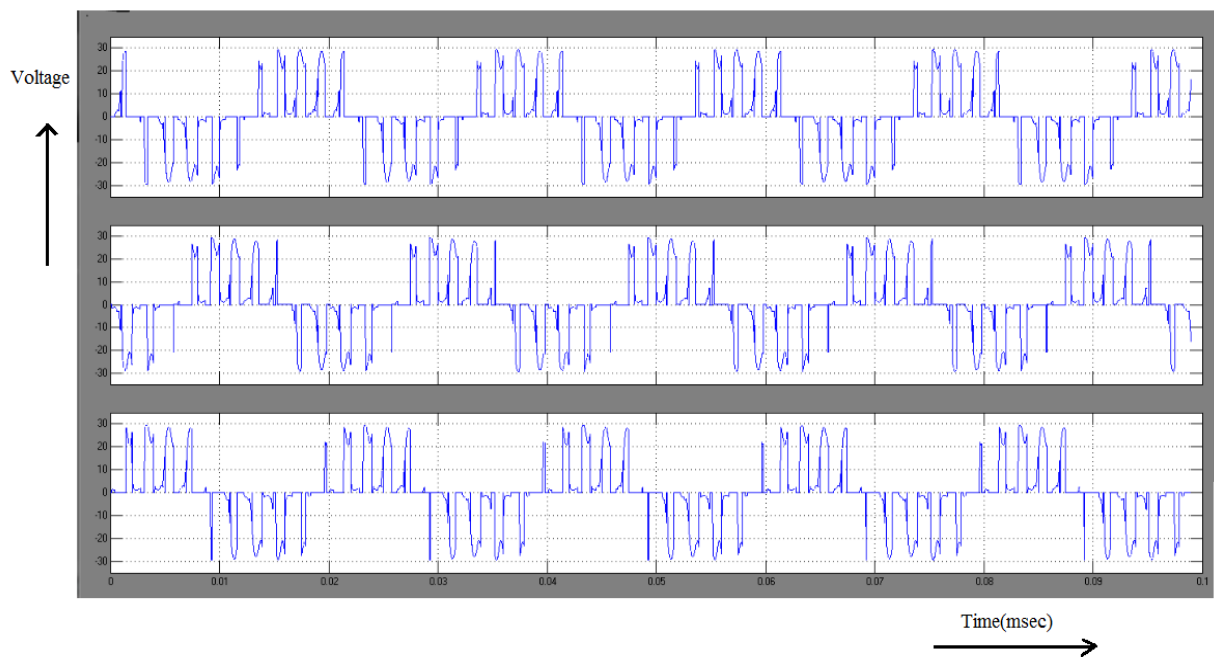


Figure 5. Output of EZ-Source inverter

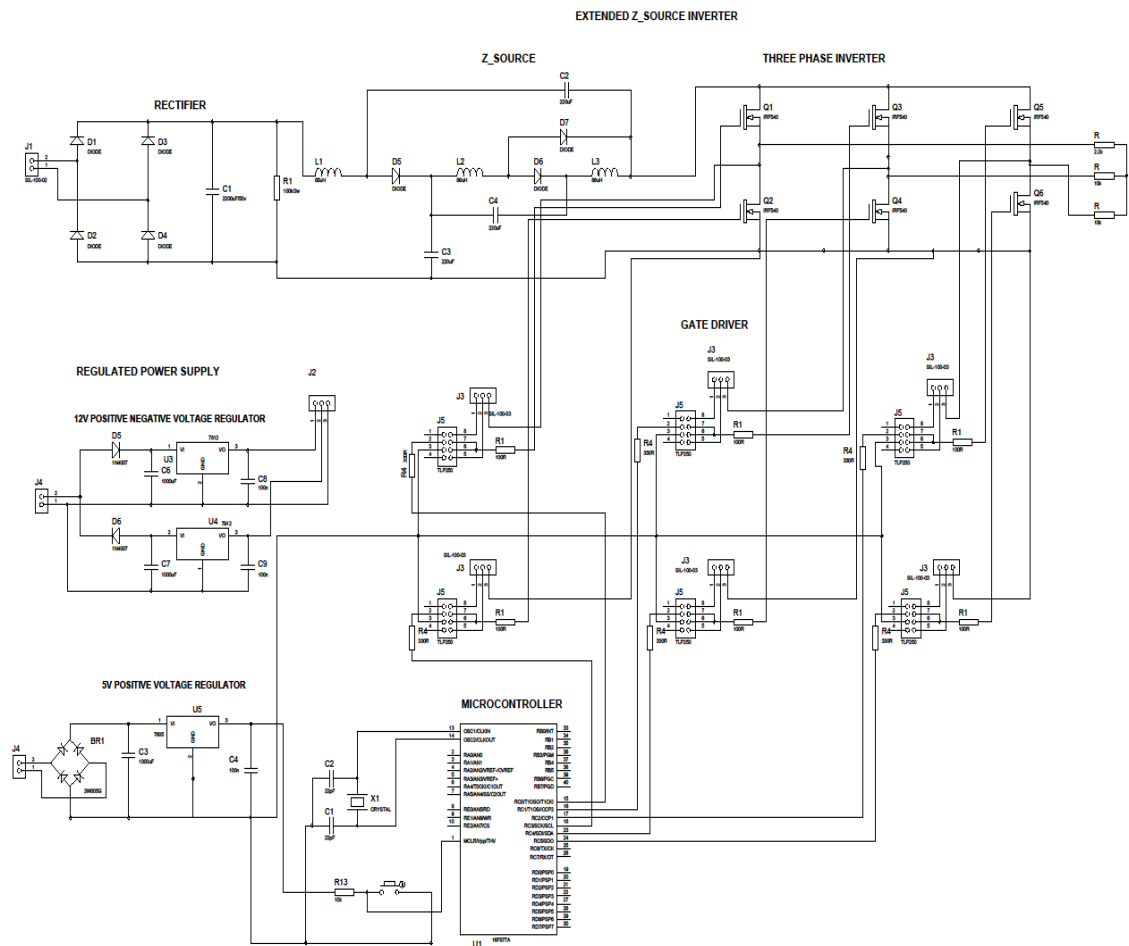


Figure 6. Experimental Circuit

The figure 6 shows the experimental circuit of EZ source inverter. Since the MOSFET'S used to switch the capacitor voltage into the supply line there will be switching transients produced by them. These switching transients in turn will affect the pulses developed by the dsPIC30F2010 and by time the micro controller itself. So in order to protect the microcontroller and the control circuit from power circuit we are providing isolation circuit. Once the logical gate signals G1-G4 are available for four MOSFET switches, these have to be isolated before giving to the gate terminals of the switches. An opto-coupler (IC 6N136) is used to provide isolation of logic gate pulse from power circuit. Since there are four switches in VSI, therefore four units of opto-couplers are used. However, only three isolated regulated DC voltage supplies are required. Two isolated DC power supplies for upper two switches of the inverter and one isolated power supply for lower two switch. Microcontroller is the device which controls the output of the system by controlling the duty cycle of devices. Coding used in microcontroller is fuzzy logic. Fuzzy logic is the advancement of PI controller. This logic is mainly employed to reduce the errors and to control the errors. Fuzzy logic is also called as error optimization technique. The final experimental result of EZ source inverter is shown in figure 7.





Figure 7. Experimental Output of EZ inverter

## 5. Conclusion

A comprehensive comparison of the three inverter systems has been performed. The comparison results show that the EZ-source inverter can increase inverter conversion efficiency by 1% over the two existing systems and inverter system efficiency by 1% to 15% over the conventional PWM inverter. The EZ-source also reduces the total average SDP by 15%, which leads to cost reduction. Moreover, the constant power speed ratio is greatly (1.55 times) extended over the system driven by the conventional PWM inverter. Thus, the EZ-source inverter system can minimize stresses and size of the motor and increase output power greatly. Along with these promising results, the EZ-source inverter offers a simplified single stage power conversion topology and higher reliability because the shoot through can no longer destroys the inverter. The existing two inverter systems suffer the shoot through reliability problem. Extended Z-source inverter improves the efficiency of the system, it is proved that if the proposed system is used, voltage gain will be more. And single stage conversion reduces the number of switches devices. Researches are in process to reduce the ripples to further extend. The Extended Z-source inverter is very promising for fuel cell vehicles.

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