# Implementations of PV Boost Control Employing Impedance Source Inverter

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## ABSTRACT

*The purpose of this work is to investigate an impedance source inverter (ZSI) and the analysis of its steady state in a range of different operating conditions. ZSI is being used to alleviate a myriad of issues that VSI and CSI have The shoot-through control approach that is utilized to generate pulses that are sent to semiconductor switches is directly related to the output voltage of the ZSI. Among the several techniques that can be used, the one that involves the least amount of complexity is the one that is used here. Voltage boosting and ZSI operation of the converter are only required when the input from the solar panel is low, because the dc input from the panel is not always stable; otherwise Typical PWM inverter activities will be carried out by this device. The triggering pulses are generated by bringing the input sinusoidal and triangular waves on the same graph Modeling a basic boost controller using MATLAB/SIMULINK is performed., and the outcomes of both conditions are investigated.*

*Keywords: PWM Inverter; Transformer; Shoot-through; PV Module; Control Approaches.*

## 1.0 Introduction

Just 6.7GW of India's TIC was devoted to solar energy in 2016, but today that number is closer to 56.95GW, or nearly nine times more [1], [2]. PV systems' modular design makes it simple to boost installed power. In [8], [9], many layouts of an AC module have indeed been explored. The output of PV module which is mostly of lower range must be increased in able to link to the grid due to its inconsistent and fluctuating nature. Transformers are therefore used to achieve this boosting intent, however transformer-less layouts are greatly favored since they offer excellent efficiency, relatively inexpensive, and easy fabrication [10]-[13]. Transformer-less systems can also be subdivided into dual step and single step configurations. The low output of a PV module can be enhanced with the use of DC-DC choppers in a two-step configuration, which is then followed by the module's output being converted into AC for a three-phase load. By replacing the stage involving the chopper or DC-DC boosting with a simple network consisting of passive components and having only two ports, this layout is further optimized (L & C). Boosting and inversion can be accomplished via a Z-source inverter in a sole step. The constraints of traditional multi step layouts have been alleviated by ZSI. [15]. As demonstrated in Fig. 3 [14, 15], ZSI is being used to alleviate a myriad of issues that

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VSI and CSI have, such as the need for double up and dead time to put off the concern of device malfunction and inductor getting disconnected as well as alongside the restrictive output voltage range. It may be able to incorporate buck-boost capabilities without even employing a transformer.
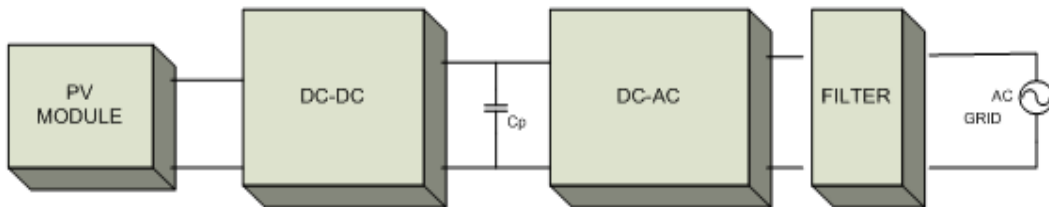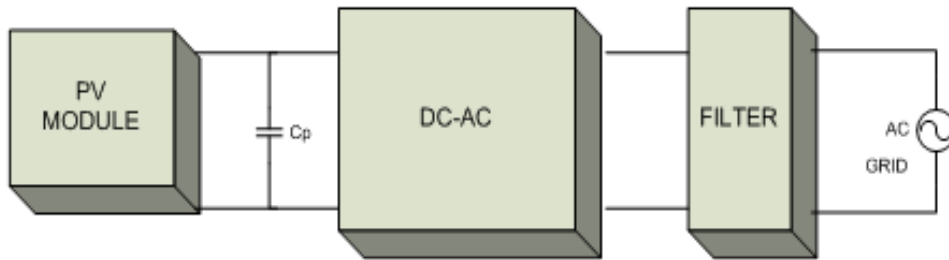
**Figure 1: Dual Step Arrangement**

**Figure 2: Single Step Arrangement**

An impedance network is incorporated into the ZSI circuit layout to link with the circuit constituting inverter and the power supply in order to offer distinct features that are unavailable from standard CSI and VSI [16]. The impedance connection is made by an X-shaped connection between two capacitors ($C_N$ & $C_T$) and a split inductor ($L_N$ & $L_T$). After this impedance network, a 3-phase inverter is used to change the increased Direct Current voltage to Alternating Current. A certain input DC voltage is fed to the inverter, and by manipulating the on/off switch time period of the switches of inverter, a regulated output AC voltage could be derived from this. The output of PV module which is mostly of lower range must be increased in able to link to the grid due to its inconsistent and fluctuating nature. To utilize the potential energy in solar AC block is needed that can function as an inverter which is directly connected to the grid, employed after the PV conversion structure. For such approach, a triangular carrier signal of high frequency and a three-phase sinusoidal wave as modulating signal with a 120-degree phase shift are selected, and the time between the meeting sites of these signals determines the pulsing or turning on period of modulated pulses and commutation. Unusually, ZSI permits continuous conduction of an inverter phase leg, that is made to happen only and only possible by tweaking the duty-cycle ($T_0/T$), leading to enhanced AC output voltage. [14].

Typically, there are 8 switching states in commonly used VSI and CSI, with 6 of them being actively functional states and the other 2 are null positions where shorting of end terminals occur ). The 0- shoot through (ST) state, when sustained conductivity via up and down switches in different inverter legs is carried on, is one of the ZSI's supplementary switching states. ZSI has nine switching states altogether. Buck and boost features are permitted in ZSI inside this zone [16]. ZSI consists of two components :- ST & NST. The DC voltage source and inductors keep the power flowing to the

load without interruption. throughout NST (Non-Shoot Through) phase as a continuous pathway is offered by a forward biased diode. Additionally, capacitors were being charged concurrently.

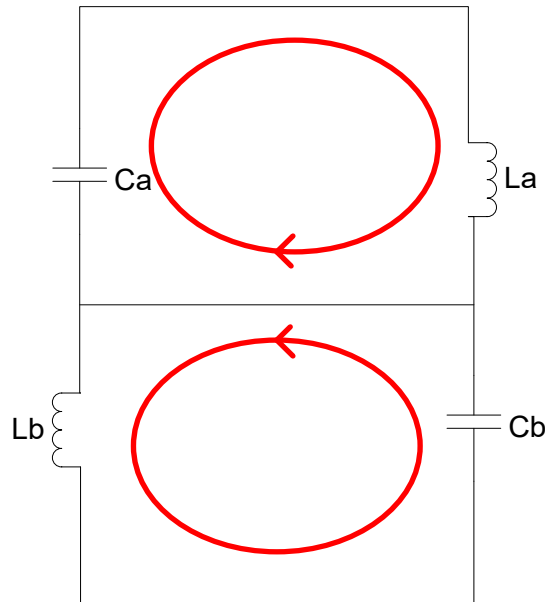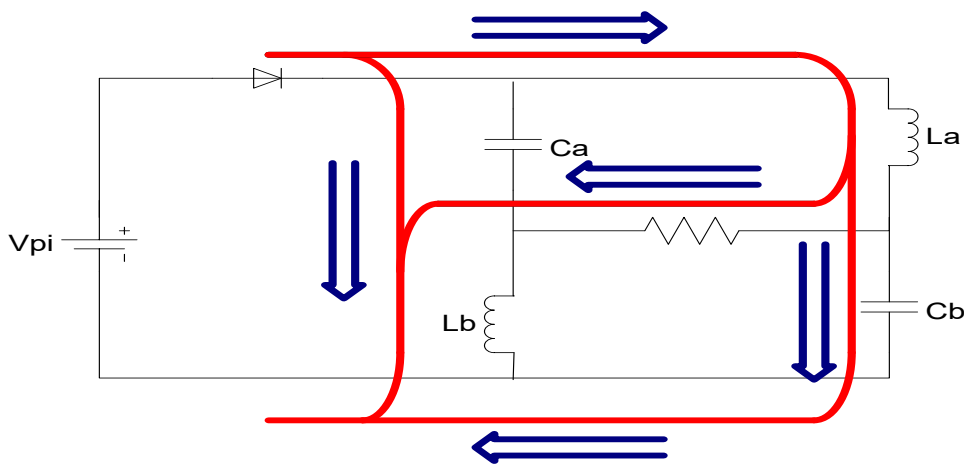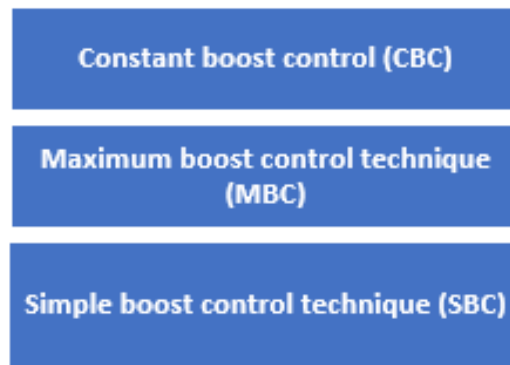**Figure 3: Flow of Current during Shoot through Mode**



**Fig.4: Flow of Current during Non Shoot-through Mode**



## 2.0 Methods for the Control of Shoot-through

The control approach that is used to insert shoot-through has a direct bearing on the impedance network capacitor voltage, the controlled range of AC output voltage, the voltage stress across the switching devices, or the boost in the voltage of the dc link, as well as the harmonic profile [10]. In ZSI, the insertion of ST states is the fundamental requirement that has resulted in the development of a variety of control approaches. In the research done up until this point, 3 distinct solutions have been suggested as shown in figure 5.

**Figure 5: PWM Control Approaches**



Constant boost control (CBC)

Maximum boost control technique (MBC)

Simple boost control technique (SBC)

Using simulation findings, an in-depth examination of these control approaches is given in [11], [12]. The classification of these various control mechanisms can be broken down into two distinct categories. Those that properly level shift the modulation signals of the VSI and insert ST states at each and every state change fall into the first group. The second type of situation falls into the category of situations in which the null states (111 and 000) are directly substituted by the ST states [13]. When comparing the two categories mentioned above, it has been demonstrated that the second category is superior to that of the first category [14]. The second group includes techniques that are simple to execute, such as control over the boost.

## 3.0 Simple Boost Control (SBC) Scheme

Two straight lines with values equal to the peak of the modulating sinusoidal signal are used to generate the ST standards in this manner. The values of these lines are equivalent to the signal's crest. OR gates serve as the connecting mechanism for merging these lines into the standard switching patterns. When the upper straight line is below the top triangular carrier waves or the lower straight line is higher than the bottom triangular carrier waves, the circuit enters ST mode; in all other circumstances, it operates as a conventional PWM circuitry [14]. ST mode is triggered when either Straight lines below or above the bottom triangle carrier waves are used to represent these two possible states of matter. Hiking is a phenomenon that occurs in an SBC system when in all switching devices there is an increase in voltage stress.

With an increase in M (z), D z will decrease, resulting in a maximum limit of (1-M z). As a result, when M z=1, the ST duty ratio will be zero, indicating that no voltage gain or boost has occurred. The selection of 'M z' in ZSI has a few restrictions. Low output voltage at the load side is evident when M z is high, while high voltage stress on the switches occurs when M d is low. The high voltage gain that can be attained with a high M z if the interdependence between D z and M z becomes insignificant [14].

## 4.0 Simulation Results

A MATLAB/SIMULINK-based virtual model has been constructed for the purpose of validating the theoretical study. In order to demonstrate the distinct behavior of VSI and ZSI, Fig. 7 utilizes two distinct values for the input and output variables. The panel's output voltage is 220 volts for the first half second and a half of the test. Boosting isn't necessary at this time, thus the converter circuit's typical VSI action, which has eight switching states, can deliver the desired output voltage.

**Figure 6: The Final Output of the SBC Scheme**
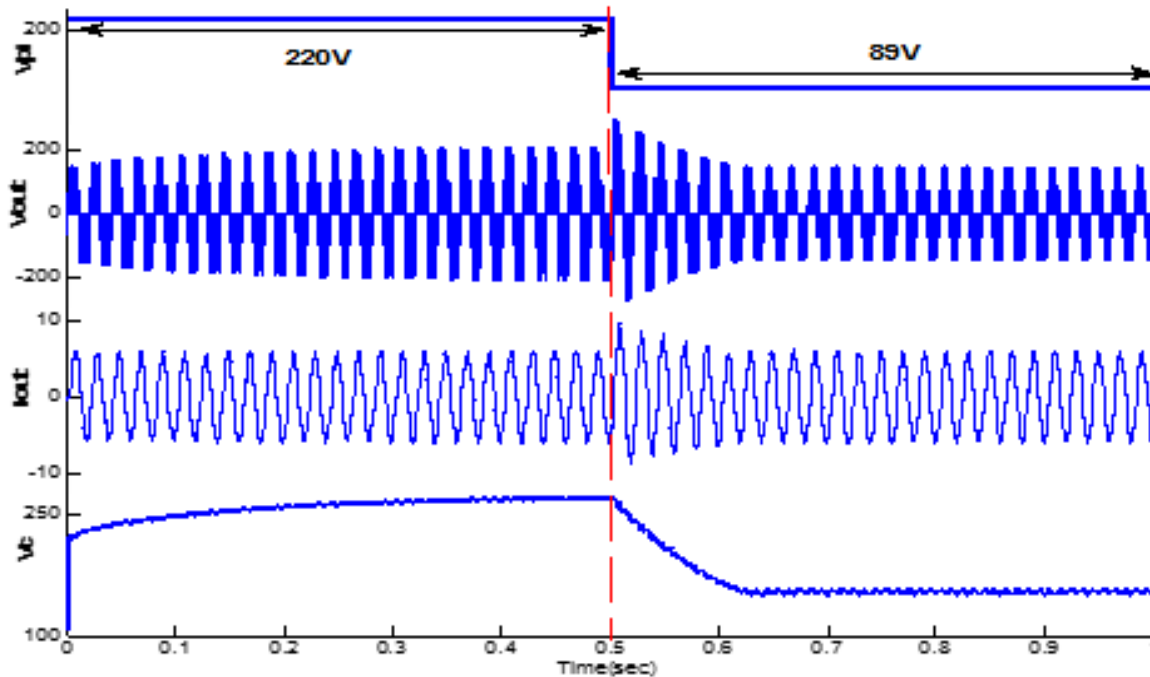


In contrast, the panel output will be 80V for the following 0.5 seconds, which is a value that is lower than the predicted input from the panel. Therefore, an increase in this voltage is required here, and it will be accomplished through the use of An inverter network with nine switching states. The modulation index and shoot-through time of the impedance source inverter can be controlled to maintain a constant output voltage and current for a wide range of input voltages, since the solar panel's output varies at different times. The constant output voltage and current may be achieved because the solar panel input fluctuates.

**5.0 Conclusion**

In this section of the research, a model of an impedance source inverter has been constructed through the use of a straightforward boost control method. The findings of the calculations made during the steady state study, which took into account the various operating conditions, are shown and validated. An impedance source inverter can be used instead of a two-step design to convert low voltage DC to high voltage AC since it is easier to install and uses fewer semiconductor devices. This is because the two-step topology requires more semiconductor devices. Consistent AC output is provided by the impedance source inverter despite receiving varying input because it can transition between the two modes of operation.

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