Cascaded Multicell Trans-Z-Source Inverter

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Abstract: *Inverters with high-output voltage gain usually face the problem of high-input current flowing through their components. The problem might further be exaggerated if the inverters use high-frequency magnetic devices like transformers or coupled inductors. Leakage inductances of these devices must strictly be small to prevent overvoltage's caused by switching of their winding currents. To avoid these related problems, cascaded trans-Z-source inverters are proposed. They use multiple magnetic cells in an alternately cascading pattern rather than a single magnetic cell with large turn's ratio. The Z-source dc–ac inverter was proposed before various Z-source dc–dc converters surfaced.*

Keywords: inverter, Trans-Z-source, single magnetic cell, magnetic cell

1. Introduction

Traditional voltage-source inverter (VSI) and current source inverter (CSI) are either a buck or a boost converter and not a buck-boost converter. That is, their obtainable output voltage range is limited to either more or less than the input voltage. Z –source inverter has the following advantages It uses an exclusive impedance network coupled between the source and the converter circuit which consists of inductors and capacitors (L1, L2 and C1 , C2) connected in X shape. The X-arms connects the inverter to a DC voltage source.
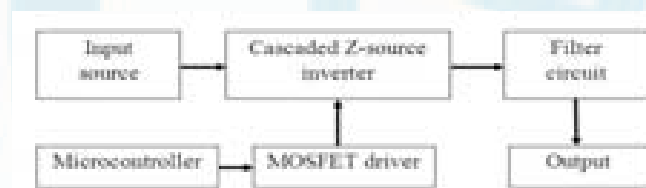

Figure 1: Proposed System

Working here the dc to dc converter is used to boost up the input dc voltages. The dc to dc converter contains an additional inductance. Here we are using multi cell cascaded Z-source inverter circuit so the dc link voltage droops will be low. Microcontroller circuits are used to generate the PWM signals to drive the dc to dc boost converter and the inverter circuit.
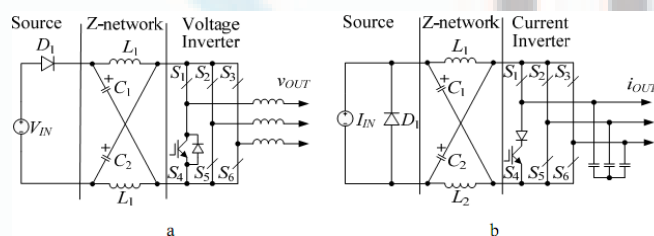

Figure 2: Z-Source Inverter

A uniqueness of PWM control in ZSI is the ability of the shoot-through state to boost to a desired output voltage (greater than available dc-link voltage) and under single stage process. Maximum Boost PWM, Maximum Constant PWM, Modified Space Vector PWM and Sine Carrier PWM.

1.1 Simple Boost Control

When the triangular carrier waveform is greater than the upper envelope, V1, or lowers than the bottom envelope, V2, the circuit turns into shoot-through state. Otherwise it operates just as traditional carrier-based PWM. However, greater voltage stress on the devices is due to small modulation indices. As the modulation index is raises, the switching frequency of the inverter also raises and hence the switching losses.
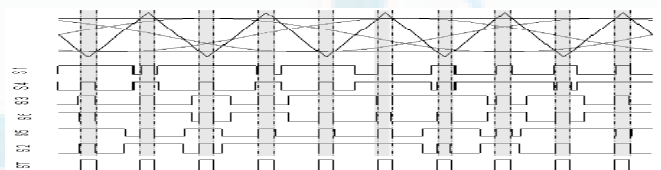

Figure 3: Triangular Carrier Waveform

1.2 Maximum Boost Control

Maximum boost control utilizes all traditional zero states into shoot-through state, however, doing so also causes a shoot-through duty ratio varying in a line cycle, which causes inductor current ripple. This method of control produces the output voltage and current with better harmonic profile, Z-source inverter circuit with the help of this high voltage gains are obtained while keeping the current and voltage components low Stress on the semiconductor devices will be less.
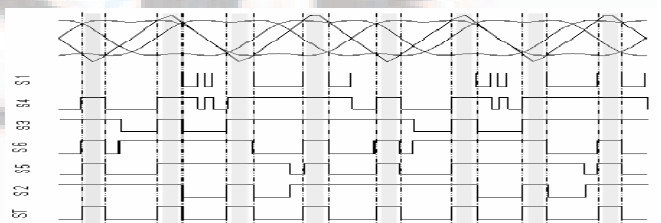

Figure 4: Triangular Carrier Waveform

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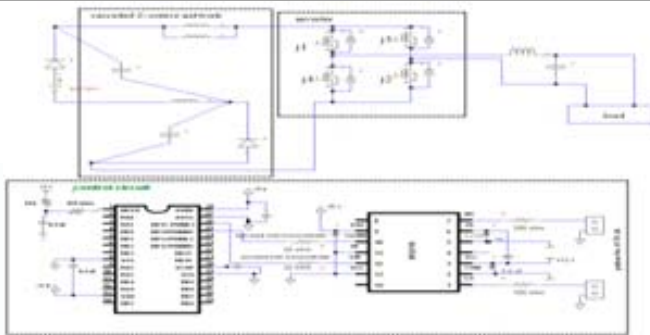Volume 2 Issue 3, March 2014

Figure 5: Circuit diagram

An alternative way of realizing the trans-Z-source inverter with high gain, Instead of a transformer with high turns ratio as in multiple smaller transformers with lower turns ratios are used. Their W1 windings are connected in parallel to share the extreme high instantaneous current stress, Turns ratios of these smaller transformers should be chosen based on available core and wire sizes that can more readily produce better coupling. Besides transformers, the circuit shows multiple diodes and capacitors connected in for cases where component parameters drifted greatly. With capacitors, it should also be noted that the smallest capacitance endures the highest voltage which might unintentionally create a single point of failure. Balancing resistors for capacitors (and diodes), together with their losses, are therefore almost always added to the circuit for long term usage. To avoid direct series connection, an alternate cascading technique is discussed after describing the generic trans-Z-source cell. The figure has two dc sources labeled as;

V_dc and $V\_\_dc$

When they are set as

$V\_dc = Vdc$ and $V\_\_dc = 0$, the network in

Inversely,

For $V\_dc = 0$ and $V\_\_dc = Vdc$

The network in produced. Therefore, a generic representation of the two networks, Moreover, it is intentionally drawn with an X-shaped structure that resembles the original Z-source network proposed. With this X-shaped cell, the alternate cascading technique can be performed based on the following few steps:

Begin with cell 1 with its windings labeled as W11 and W2;
Duplicate a copy of cell 1, and name it as cell 2.Windings of cell 2 are labeled asW12 andW3 with their turns ratio marked as γ3 ;
Flip cell 2 vertically and place it below cell 1;
Merge cell 1 and cell 2 with W2 of cell 1 replacing W12 of cell 2;
Shift W12 of cell 2 to be in parallel with W11 of cell 1;
Duplicate cell k with windings W1k and W(k + 1), and turns ratio γk+1;

2. MATLAB Simulation

MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation.

2.1 Simpower Systems Libraries

The libraries contain models of typical power equipment such as transformers, lines, machines, and power electronics. The capabilities of Sim Power Systems for modeling a typical electrical system are illustrated in demonstration files. And for users who want to refresh their knowledge of power system theory, there are also self-learning case studies. The Sim Power Systems main library, power lib, organizes its blocks into libraries according to their behavior. The power library window displays the block library icons and names.. This is possible because all the electrical parts of the simulation interact with the extensive Simulink modeling library. Since Simulink uses MATLAB as its computational engine, designers can also use MATLAB toolboxes and Simulink.
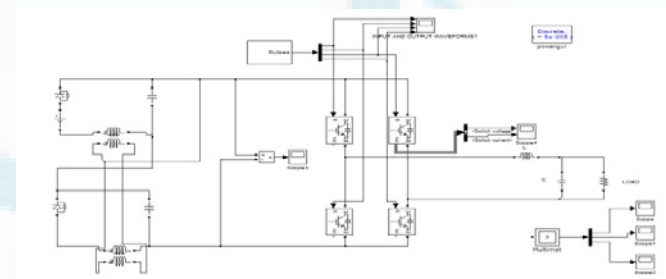

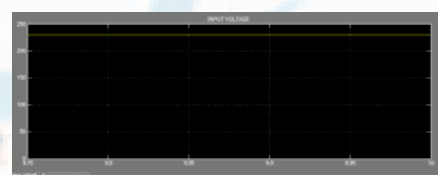**Figure 6:** Simulation Circuit Diagram
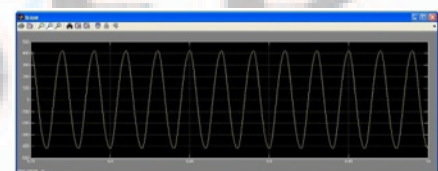
3. Simulation Result

Figure 7: Input voltage

Figure 8: Output voltage

Figure 9: Output current

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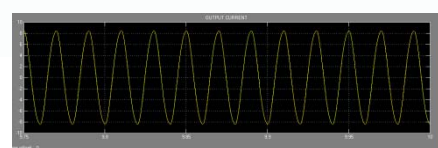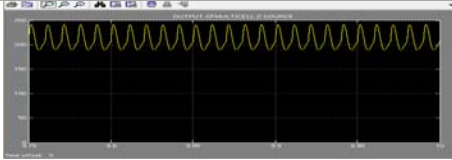**Figure 10:** Output of multicell Z source

Capacitors are widely used in electronic circuits for blocking direct current while allowing alternating current to pass. In analog filter networks, they smooth the output of power supplies. In resonant circuits they tune radios to particular frequencies. In electric power transmission systems they stabilize voltage and power flow.

Figure 11: Capacitor

A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. The current through a resistor is in direct proportion to the voltage across the resistor's terminals. This relationship is represented by Ohm's law:

$$I = $$

Where I is the current through the conductor in units of amperes, V is the potential difference measured across the conductor in units of volts, and R is the resistance of the conductor in units of ohms.

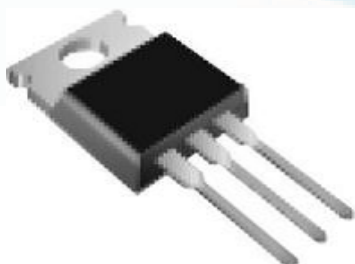**Figure 12:** A typical axial-lead resistor

Figure 13: MOSFET-IRF840

Third generation Power MOSFETs from Vishay provide the designer with the best combination of fast switching, ruggedized device design, low on-resistance and cost-effectiveness. The TO-220AB package is universally preferred for all commercial-industrial applications at power dissipation levels to approximately 50 W. The low thermal resistance and low package cost of the TO-220AB contribute to its wide acceptance throughout the industry.

An inductor, also called a coil or reactor, is a passive two-terminal electrical component which resists changes in electric current passing through it. It consists of a conductor such as a wire, usually wound into a coil. When a current flows through it, energy is stored temporarily in a magnetic field in the coil. When the current flowing through an inductor changes, the time-varying magnetic field induces a voltage in the conductor, according to Faraday's law of electromagnetic induction, which opposes the change in current that created it. An inductor is characterized by its inductance, the ratio of the voltage to the rate of change of current, which has units of henries (H). Many inductors have a magnetic made of iron or ferrite inside the coil, which serves to increase the magnetic field and thus the inductance.

Figure 14: A selection of low-value inductors

4. Conclusion

A generic trans-Z-source cell is presented, which can be duplicated and alternately cascaded to form various CMC trans-Z-source inverters with different source placements. Although the inverters use multiple components to tolerate higher voltage gains, they do not rely on direct series connections of the components. Common voltage sharing problems that vary randomly with parameters are therefore not experienced by the proposed CMC trans-Z-source inverters. Moreover, by using smaller coupled transformers with lower turn's ratios, the proposed inverters divide their instantaneous current stresses among windings better. Performances and practicalities of the inverters have already been verified in simulation and experiment.

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