Trans-Z-source Inverter

Eastern Washington University

Nhat Nguyen

EENG 401: Electromagnetism

Research Project

Images' courtesy of *VinFast Auto* *and* *Tesla Motors.*

Agenda

Traditional inverter

Z-source inverter (ZSI)

trans-ZSI inverter

EM theory

Scope

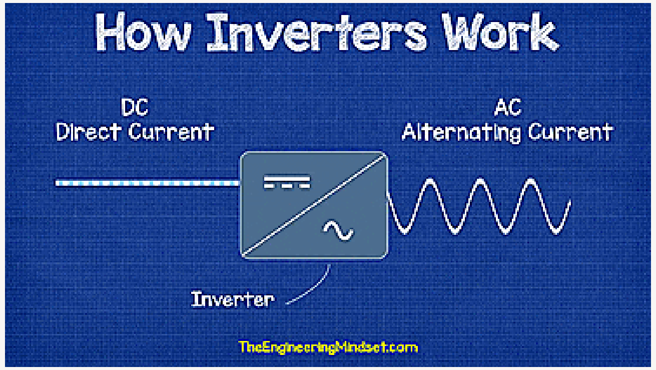
Budget

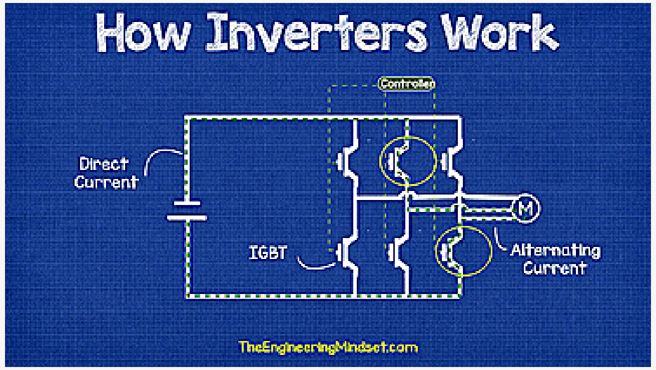
Research

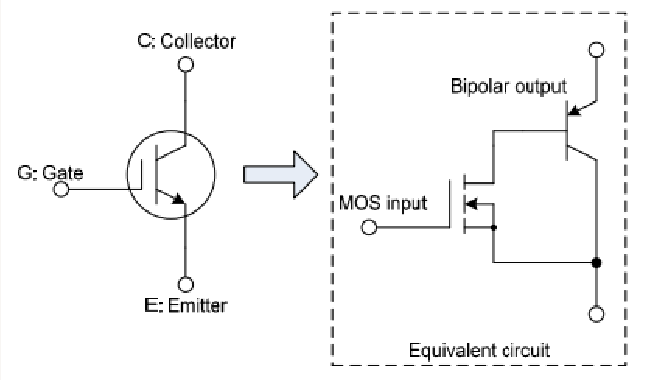
Timeline

What is an inverter?

- Converts DC to AC
- High frequency switching achieved with Insulated Gate Bipolar Transistors (IGBTs)







Images' courtesy of [The Engineering Mindset](), [EEWeb](), [Amazon](), [Win-source](), and [Tesla Motors.]()

Traditional inverter?

- Simple conversion stage
- Prone to Electromagnetic Interference (EMI) noise → reduce reliability
- Either be a buck or boost, can not be either
- No two-way power flow

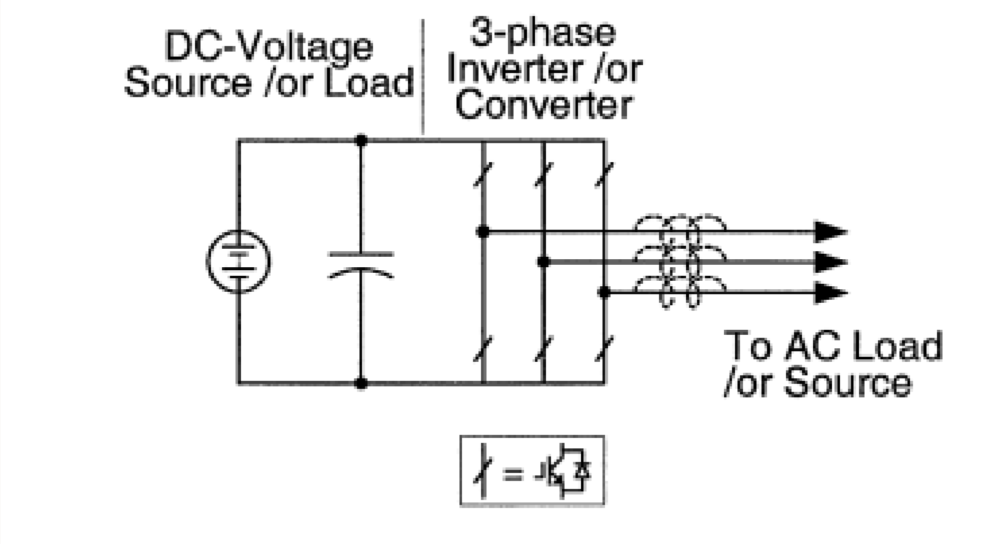


Fig. 1. Traditional V-source converter.

Figure 1 IKW40N60H3 device package

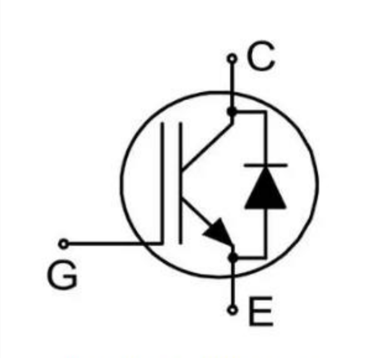
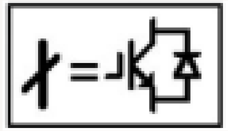
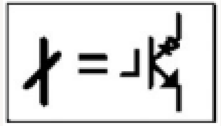


Figure 2 IKW40N60H3 schematic symbol





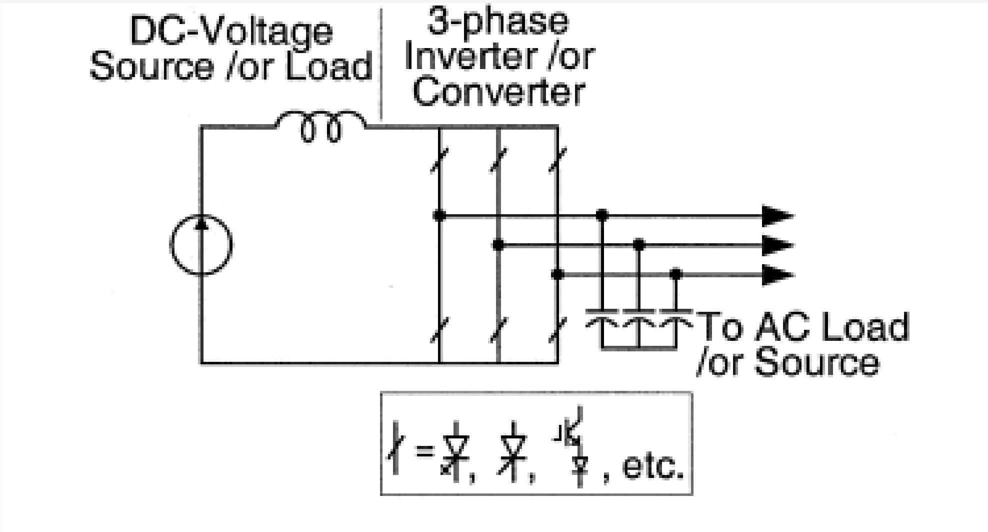


Fig. 2. Traditional I-source converter.

Images' courtesy of [Fang Zheng Peng, Z-source Inverter, IEEEXplore.]

Z-source inverter?

- Unique impedance network (circuit) involves a different way to put capacitor and inductors
- Power conversion and solve the issues that traditional inverter had

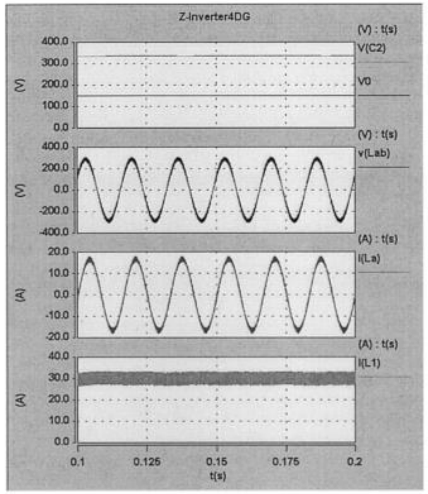


Fig. 14. Simulation waveforms when the fuel-cell voltage $V_0 = 150$ V, inverter modulation index $M = 0.642$, and shoot-through duty cycle $T_0/T = 0.358$.

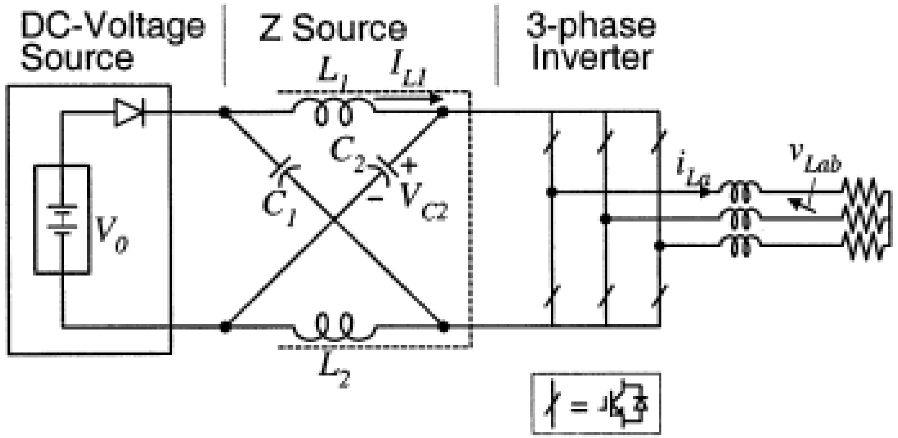


Fig. 13. Simulation and prototype system configuration.

Journals & Magazines > IEEE Transactions on Industry... > Volume: 39 Issue: 2

Z-source inverter

Publisher: IEEE | Cite This | PDF

Fang Zheng Peng   All Authors

Published in: IEEE Transactions on Industry Applications (Volume: 39 , Issue: 2, March-April 2003)

Page(s): 504 - 510

INSPEC Accession Number: 7557765

Date of Publication: 26 March 2003

DOI: 10.1109/TIA.2003.808920

▸ **ISSN Information:**

Publisher: IEEE

Authors

Fang Zheng Peng
College of Electrical Engineering, University of Zhejiang, Hangzhou, China
Department of Electrical and Computer Engineering, Michigan State University, East Lansing, MI, USA

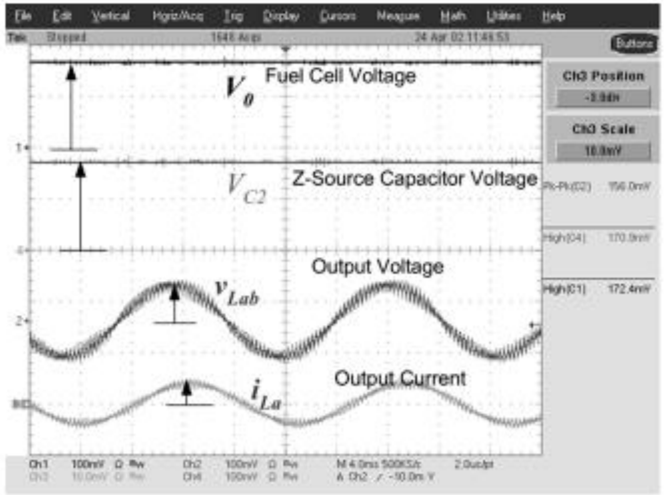


Fig. 16. Experimental waveforms when the fuel-cell voltage is high. Inverter modulation index $M = 1.0$, and without using the shoot-through state or shoot-through period ratio $T_0/T = 0$.

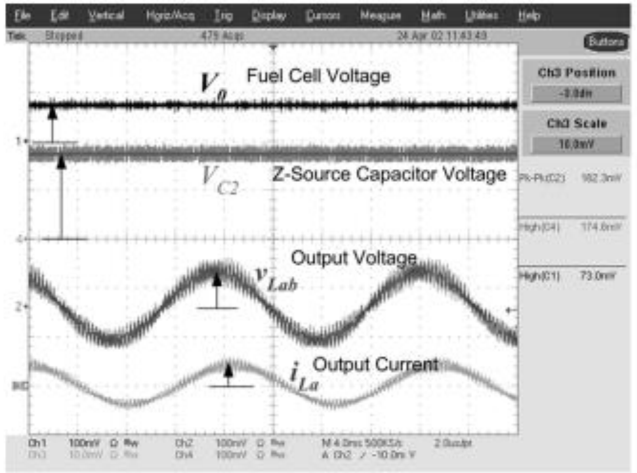


Fig. 15. Experimental waveforms when the fuel-cell voltage is low, inverter modulation index $M = 0.642$, and shoot-through period ratio $T_0/T = 0.358$ (V_0 and V_{C2} : 200 V/div, V_{Lab} : 2*s 200 V/div, i_{La}: 50 A/div, and time: 4 ms/div).

Images' courtesy of Fang Zheng Peng, Z-source Inverter, IEEEXplore.

Trans-ZSI?

- Higher boost gain (voltage-fed)
- More motoring operation range (current-fed)
- Broaden use cases, e.g. microinverter for photovoltaic systems, etc.

Trans-Z-Source Inverters

Publisher: IEEE Cite This PDF

Wei Qian ; Fang Zheng Peng ; Honnyong Cha All Authors

Published in: IEEE Transactions on Power Electronics (Volume: 26 , Issue: 12, December 2011)

Page(s): 3453 - 3463 **INSPEC Accession Number:** 12391164

Date of Publication: 03 March 2011 **DOI:** 10.1109/TPEL.2011.2122309

ISSN Information: **Publisher:** IEEE



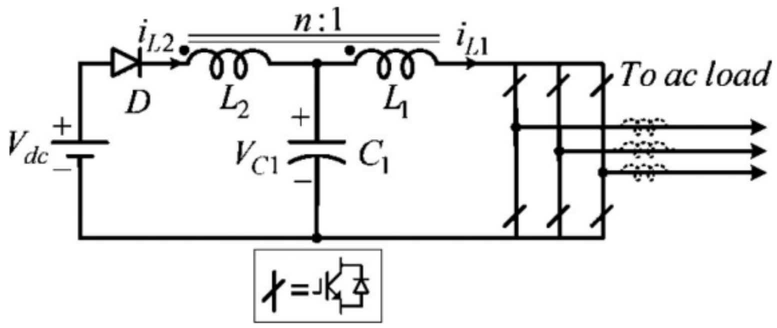


Fig. 6. Voltage-fed trans-Z-source inverter.

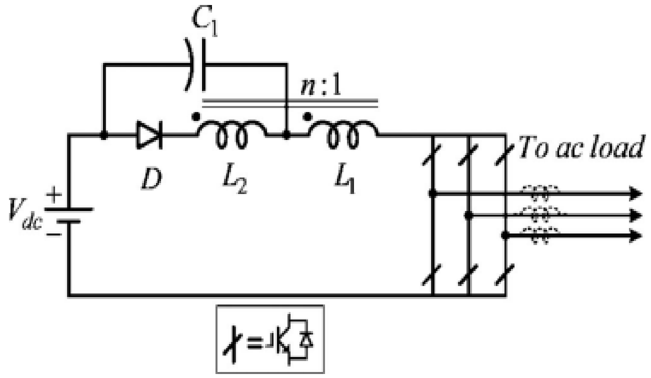


Fig. 2. Voltage-fed trans-quasi-Z-source inverter.

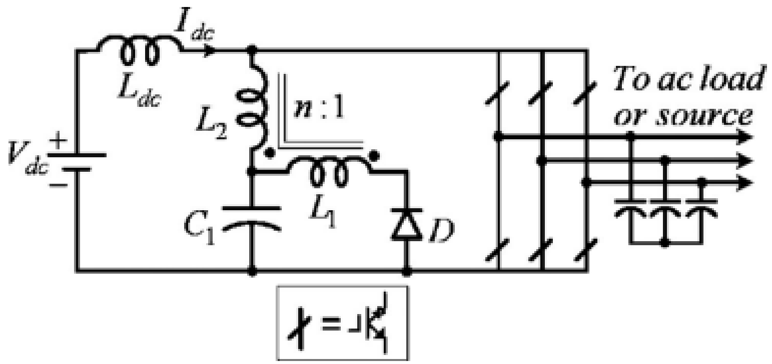


Fig. 8. Current-fed trans-quasi-Z-source inverter.

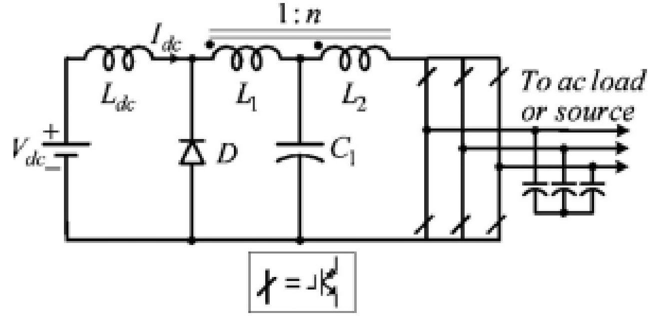


Fig. 11. Current-fed trans-Z-source inverter.

Images' courtesy of Wei Qian, Fang Zheng Peng, Honnyong Cha, Trans-Z-source Inverter, IEEEXplore.

EM theory

	$\nabla \times E = -\frac{\partial B}{\partial t}$	$\nabla \cdot B = 0$	$\nabla \times H = J + \frac{\partial D}{\partial t}$	$\nabla \cdot D = \rho_v$	$F = Q(E + u \times B)$	Where?
Faraday's Law (Inductance)	x					Ind. and cap. Config.
No monopoles magnets		x				Ind.
Ampere's Circuit Law			x			Ind. and Cap.
Gauss's Law				x		EMI noise reduction
Lorentz Force					x	AC load (motors, etc.)

Plan for the future

Planning

Conduct more testing and simulation to verify the current results better

Marketing

Connecting research groups to companies of interests

Design

Patent designs for different applications with a cost-aware approaches

Strategy

Manufacture at scale to consider cost

Launch

Implementation in commercial systems

Timeline

May 2023
Planning

Nov 2023
Marketing

Jan 2024
Design

Mar 2024
Strategy

May 2024
Launch

Areas of focus

EV charging

Tesla, VinFast, Ford, etc.

Solar panels

First Solar, Lind, GE, etc.

Microgrids

Avista, Seattle City Lights, PUDs, etc.

Large energy storage

Tesla Mega Pack, etc.

Thank you

Nhat Nguyen

nnguyen32@ewu.edu




Reference:

[1] F. Z. Peng, “Z-source inverter,” IEEE Trans. Ind. Appl., vol. 39, no. 2, pp. 504–510, Mar./Apr. 2003.

[2] W. Qian, H. Cha, F. Z. Peng, “Trans-Z-source inverter,” IEEE Trans. Pow. Elec., vol. 26, no. 12, Dec. 2011.