

Research Migration Project Synopsis

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Title of the circuit : Research Migration of an Inverting KY Buck-Boost Converter.

Theory/Description : The Inverting KY Buck-Boost converter is a high-performance **fourth-order DC-DC topology** designed to provide a stable negative output voltage with ultra-low ripple. The circuit integrates four MOSFET switches (S1–S4), an energy-storing inductor (L1), two intermediate transfer capacitors (C1, C3), and an output filter capacitor (C2).

The operation follows a specific two-phase switching cycle:

- **Phase 1 (Switches S1 and S3 ON):** During this interval, the input source charges the intermediate capacitors C1 and C3. Meanwhile, the energy stored in inductor L1 is released to the load, with the current flowing through diode D2.
- **Phase 2 (Switches S2 and S4 ON):** In this interval, the energy previously stored in the intermediate capacitors is discharged into the inductor L1 and the output stage.

The unique arrangement of these components allows the converter to achieve a linear voltage transformation ratio ($V_{out} = -V_{in} \cdot D$) and maintain a continuous output current. This makes it ideal for sensitive electronic applications where voltage stability is critical

Reason to reproduce with eSim : This migration validates a cutting-edge 2025 KY topology that eliminates recharging current peaks through a unique 4th-order LC network. Reproducing it in eSim provides a high-efficiency, low-ripple open-source reference for the FOSSEE power electronics library.

Expected Outcome/outputs : Upon successful simulation in eSim, the Inverting KY Buck-Boost converter is expected to exhibit a stable, negative DC output voltage with a linear transformation ratio relative to the input. The working behavior should demonstrate the converter's ability to operate in both step-down ($D < 0.5$) and step-up ($D > 0.5$) regions while maintaining continuous conduction mode (CCM).

Measurable Outputs and Validation:

- **Voltage Inversion:** Verification of the negative DC output voltage relative to the input.
- **Ripple Analysis:** Confirmation of the "ultra-low ripple" characteristic, showcasing minimal high-frequency switching noise.

- **Inductor Current (L1):** Observation of a continuous triangular waveform through L1, validating successful energy transfer between the buffer capacitors (C1, C3) and the output filter.
- **Benchmark Comparison:** Performance will be validated by comparing eSim transient analysis plots with the reference waveforms in Figures 8(b) (page 6) and 9(b) (page 7) of the research paper. Any performance gaps will be evaluated based on component parasitics within the Ngspice netlist.

Circuit Diagram:

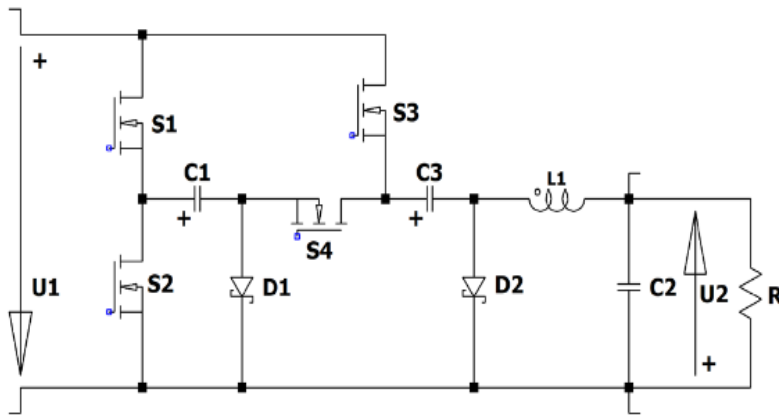
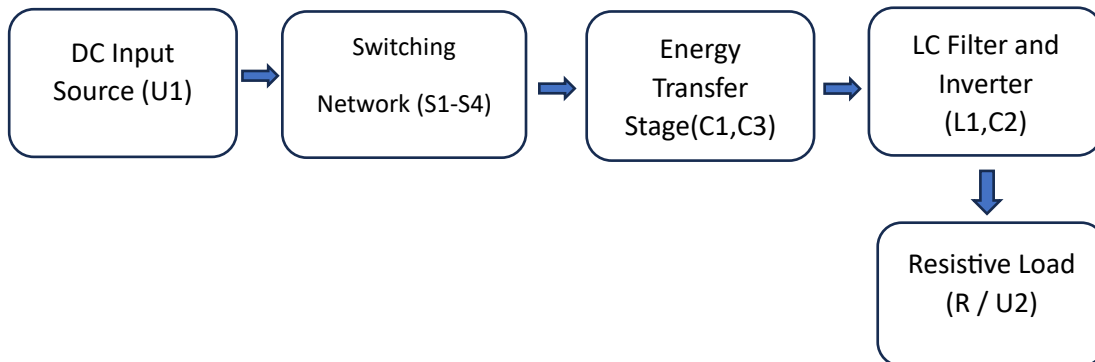


Figure 1: Schematic of the Inverting KY Buck-Boost Converter (Source: Himmelstoss & Votzi, 2025)

Block Diagram (s) :



Expected Results (Input, Output waveforms and/or Multimeter readings) :

Signals: $V_{in} = 24V$ results in $V_{out} \sim -7.2V$ at $D = 0.3$ (Step-down) and $V_{out} \sim -16.8V$ at $D = 0.7$ (Step-up).

Waveform Shapes: Continuous, triangular inductor current (i_{L1}) and ultra-low ripple DC output voltage (V_{out}).

Validation: Steady-state and transient simulation plots in eSim will be benchmarked against Figures 8b and 9b of the reference paper.

1. Step-down Mode Validation (Duty Cycle $D < 0.5$)

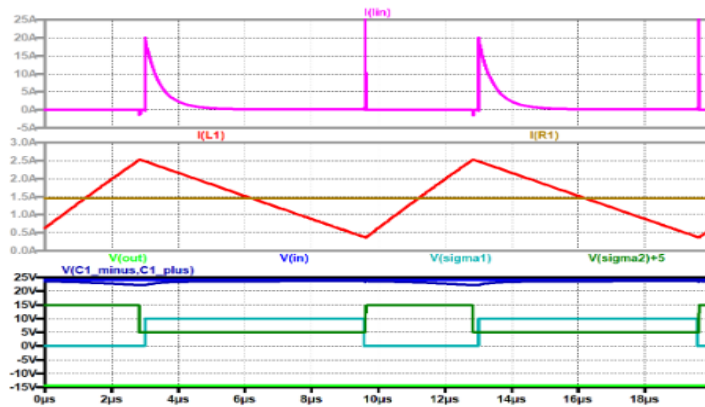


Figure 2 : Benchmark waveforms for Step-down operation ($D=0.3$).

2. Step-up Mode Validation (Duty Cycle $D > 0.5$)

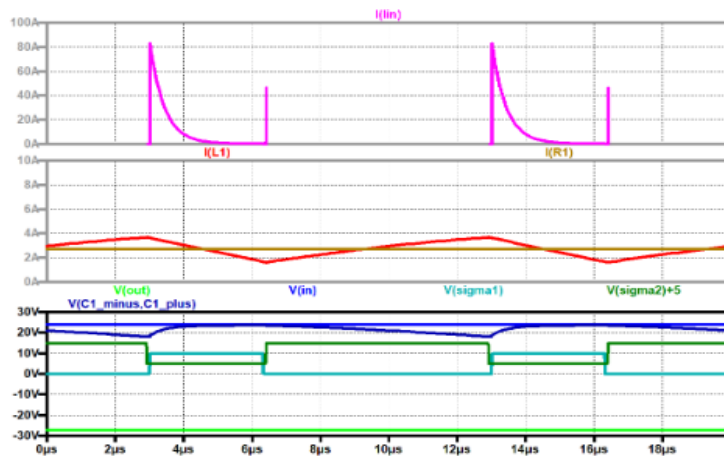


Figure 3: Benchmark waveforms for Step-up operation ($D=0.7$).

Research Paper/Journal/etc. :

Title: KY Converters and Their Improvements

Author: Felix A. Himmelstoss and Helmut L. Votzi

Page No. / Figures: **Page 5:** Figure 7 (Proposed Inverting KY Converter Schematic), **Page 6:** Figure 8b (Step-down simulation waveforms), **Page 7:** Figure 9b (Step-up simulation waveforms)

Link: <https://www.preprints.org/manuscript/202511.1269>

Source/Reference(s)

1. **Primary Research Paper:** Himmelstoss, F. A., & Votzi, H. L. (2025). *KY Converters and Their Improvements*. Preprints.org. <https://doi.org/10.20944/preprints202511.1269.v1> (Accessed: March 2026).
2. **Simulation Software:** FOSSEE, IIT Bombay. *eSim: Open Source EDA Tool User Manual*. <https://esim.fossee.in/>