# A Non-Isolated Partial Power Processing DC-DC Converter For Renewable Energy


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## Introduction

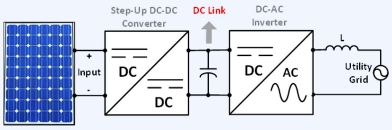


Figure 1 Grid Integrated Renewable Energy Resource.

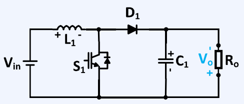


Figure 2 Traditional Boost Converter.

- Global demand for renewable energy and grid integration is driving the need for efficient, high-gain DC-DC converters in electric vehicles and solar power systems.
- Traditional boost converters face limitations such as high voltage/current stress, input current ripple, and restricted gain under high duty ratios.
- This work proposes a step-up differential partial power processing converter with ripple reduction, aimed at improving efficiency and reliability in renewable energy systems.

## Proposed Converter

- The proposed converter is a step-up differential partial power processing DC-DC converter designed to reduce ripple and device stress.
- It builds on a floating output boost converter by adding a polarity reversal (inverting) stage to generate a negative output voltage.
- Two inverting boost converters are then connected differentially to achieve high voltage gain, ripple reduction (input/output), and improved performance.

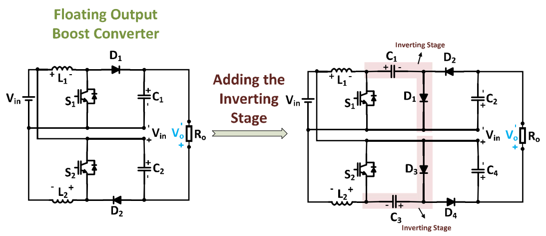


Figure 3 Synthesis of the proposed converter.

## Advantages

The proposed converter has the following advantages:

1- High voltage gain to step up the voltage produced by the renewable energy resources/ Electric Vehicle's battery.

2- The complementary operation of the switches reduces the input current ripple which increases the life-time of the PV panel / Electric Vehicle's battery.

3- The differential connection and the inverting stage create a transformerless power flow path from the input to the output. Thus, reducing the power processed by the lossy elements of the converter. As a result of that, the efficiency increases.

4- The elimination of the high voltage spikes on the switches caused by the transformer's leakage inductance in dc-dc converters that use transformers to step-up the voltage and achieve partial power processing.

## Modeling and Analysis

SCAN ME

- The CCM operation of the converter is governed by the switching behavior of S1 and S2, depending on the duty cycle range.
- For 0 < D < 0.5, the switching sequence is (10-00-01-00); for 0.5 < D < 1, it changes to (11-10-11-01).
- Figure 4 provide a detailed view of the converter's switching states across different operating modes.

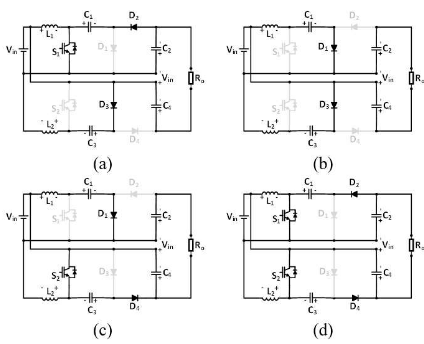


Figure 4 Synthesis of the proposed converter

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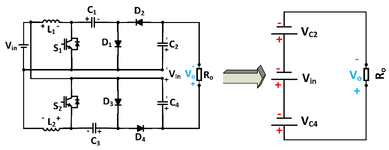

Figure 5 Equivalent circuit model of the proposed converter.

**State 10:** The voltage on L1 and L2 in state 1 is derived:

$$V_{L1} = V_{in}$$
$$V_{L2} = V_{in} - V_{C3}$$

**State 01:** The voltage on L1 and L2 in state 1 is derived:

$$V_{L1} = V_{in} - V_{C1}$$
$$V_{L2} = V_{in}$$

The voltage gain is calculated to be:

$$M_{Ideal} = \frac{V_o}{V_{in}} = \frac{3-D}{1-D}$$

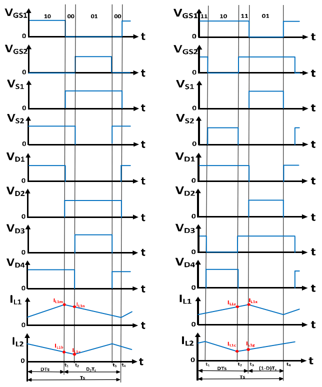

Figure 6 Key waveforms of the proposed converter

## Results and Discussion

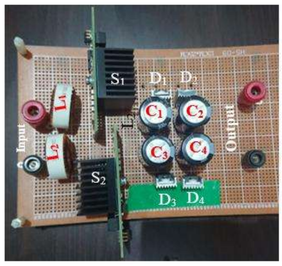

Figure 7 The proposed converter's prototype.

| Table 1 The prototype parameters | |
|---|---|
| **Input Voltage (V)** | 40 |
| **Output Voltage (V)** | 200 |
| **Duty** | 0.5 |
| **Switching Frequency (kHz)** | 31 |
| **$C_1$, $C_2$, $C_3$, and $C_4$ (μF)** | 100 |
| **$L_1$ (μH)** | 270 |
| **$L_2$ (μH)** | 270 |
| **Ro (Ω)** | 200 |
| **$D_1$, $D_2$, $D_3$, and $D_4$** | STTH2002C |
| **$S_1$ and $S_2$** | GS66508T |

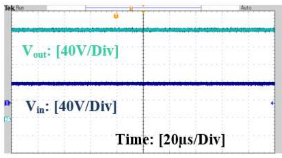


Figure 8 Input and output voltage.

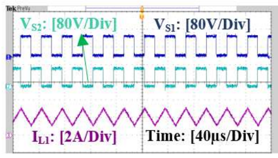


Figure 9 The current through L1.

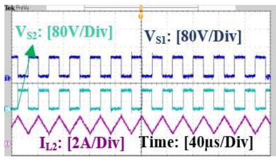


Figure 10 The current through L2.

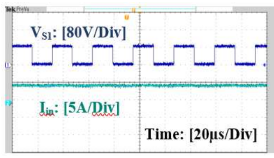


Figure 11 The Input current.

## Conclusion

- A differential partial power processing DC-DC converter was developed and shown to achieve high voltage gain with reduced input current ripple and low voltage stress on devices.
- The converter allows direct power transfer from input to output, minimizing losses and improving overall efficiency.
- Experimental results confirmed the theoretical analysis, demonstrating the converter's superior performance and potential for cost-effective implementation using output diodes.

## References


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