The DC House for Low Power Households – DC-DC Converter Analysis

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Presentation Overview

1. Introduction
2. Power Budget of a Small House
3. DC House Standard Voltage
4. The Dc-Dc Converter Evaluations
5. Load Testing
6. Conclusion

INTRODUCTION

1. Utilities are under increasing pressure to expand the grid
2. Potential customers in remote areas present a challenge
3. Use renewable energy sources
4. Stand-alone microgrids
5. Provide DC power exclusively
6. Unique solutions for developing nations

Small house maximum instantaneous power budget (all appliances operating simultaneously)

Load	Power per unit (W)
Large Appliances	1 400
Small Appliances	600
Lighting (LED)	30
Personal Electronics	100
Total Power	2 130

Peak instantaneous power demand ~ 2 500 W

DC House Standard Voltages

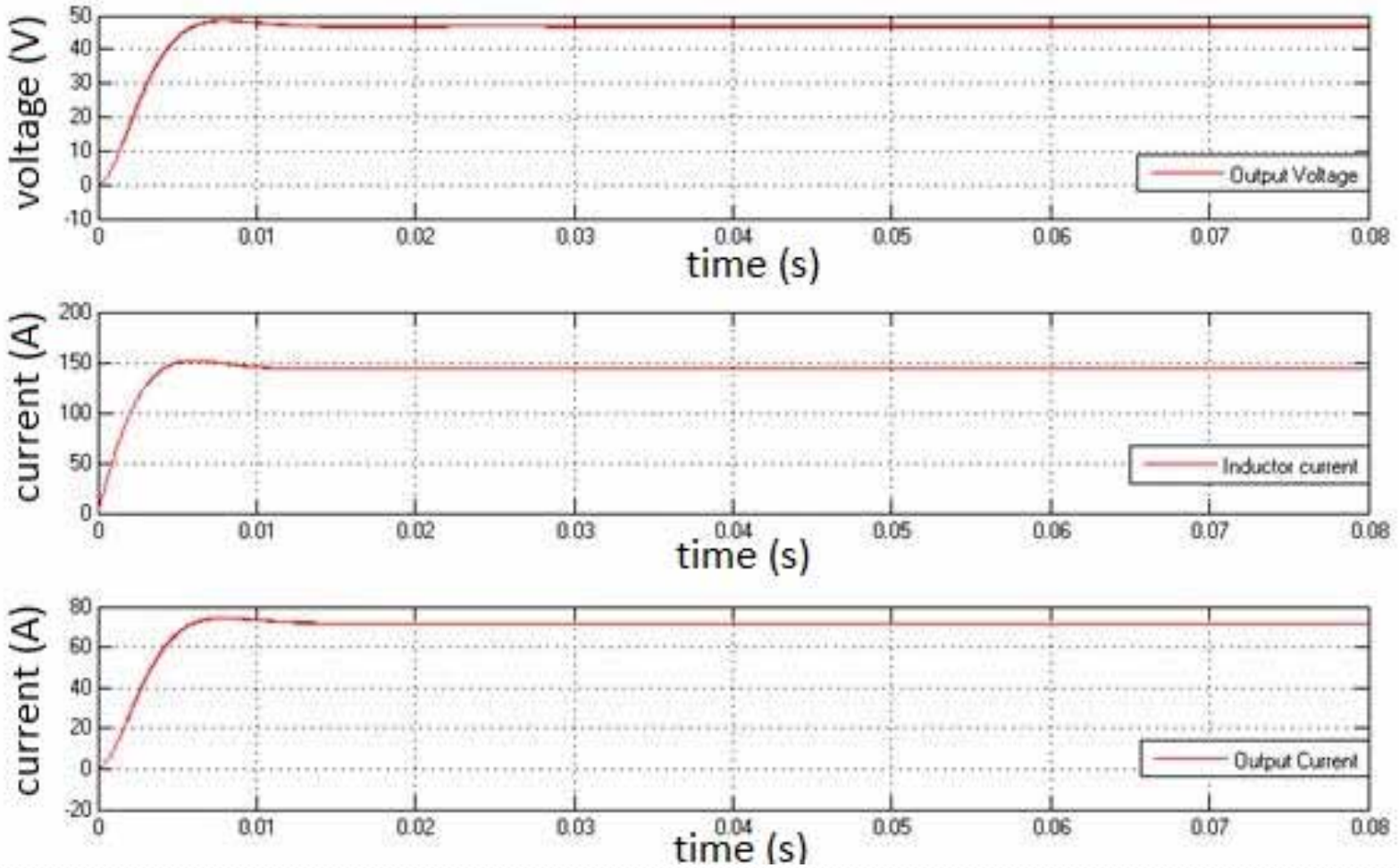
- Many standards for various applications
- 120 V DC upper boundary of extra low-voltages - International Electrotechnical Commission (IEC)
- EMerge Alliance standard – 24 V DC for commercial buildings interiors
- From an economic perspective …

Voltage	Current	Cable size	Cable price
24 V	145.83 A	50 mm^2	R57.50 p/m
48 V	72.92 A	25 mm^2	R38.78 p/m

The Dc-Dc Converter

- Considered boost and buck-boost converters
  - Buck-boost converter
    - Output DC voltage polarity reversed
    - Power switch needs floating drive
  - Boost converter is a simpler implementation
- Design parameters:
    - input voltage 24 V, output voltage 48 V
    - switching frequency 100 kHz
    - load resistance 0.685 Ω
    - output ripple current must be <1%
    - output ripple voltage 0.1 V

Boost converter output waveforms



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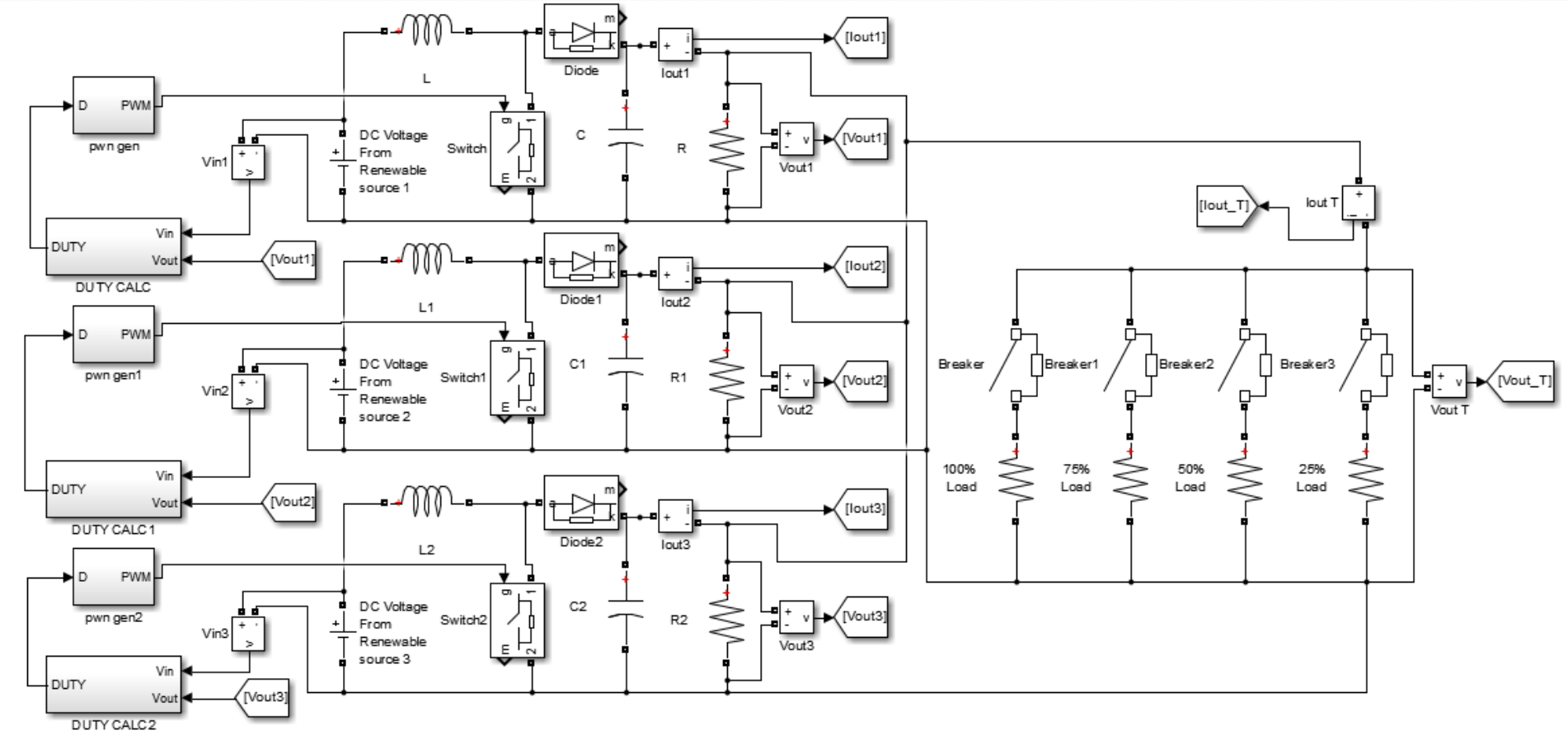
LOAD TESTING CIRCUIT



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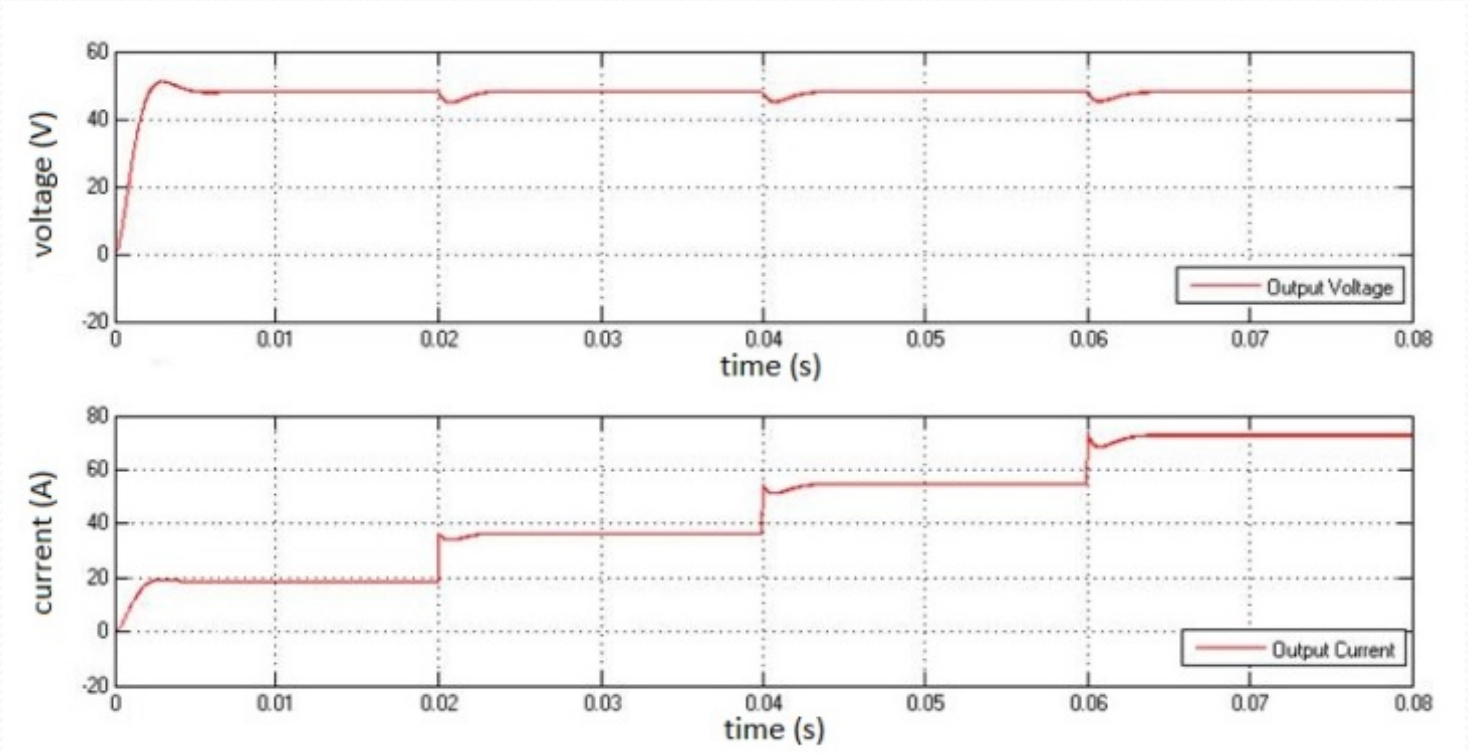
LOAD TEST SCENARIOS

1. Load increased in intervals of 25%



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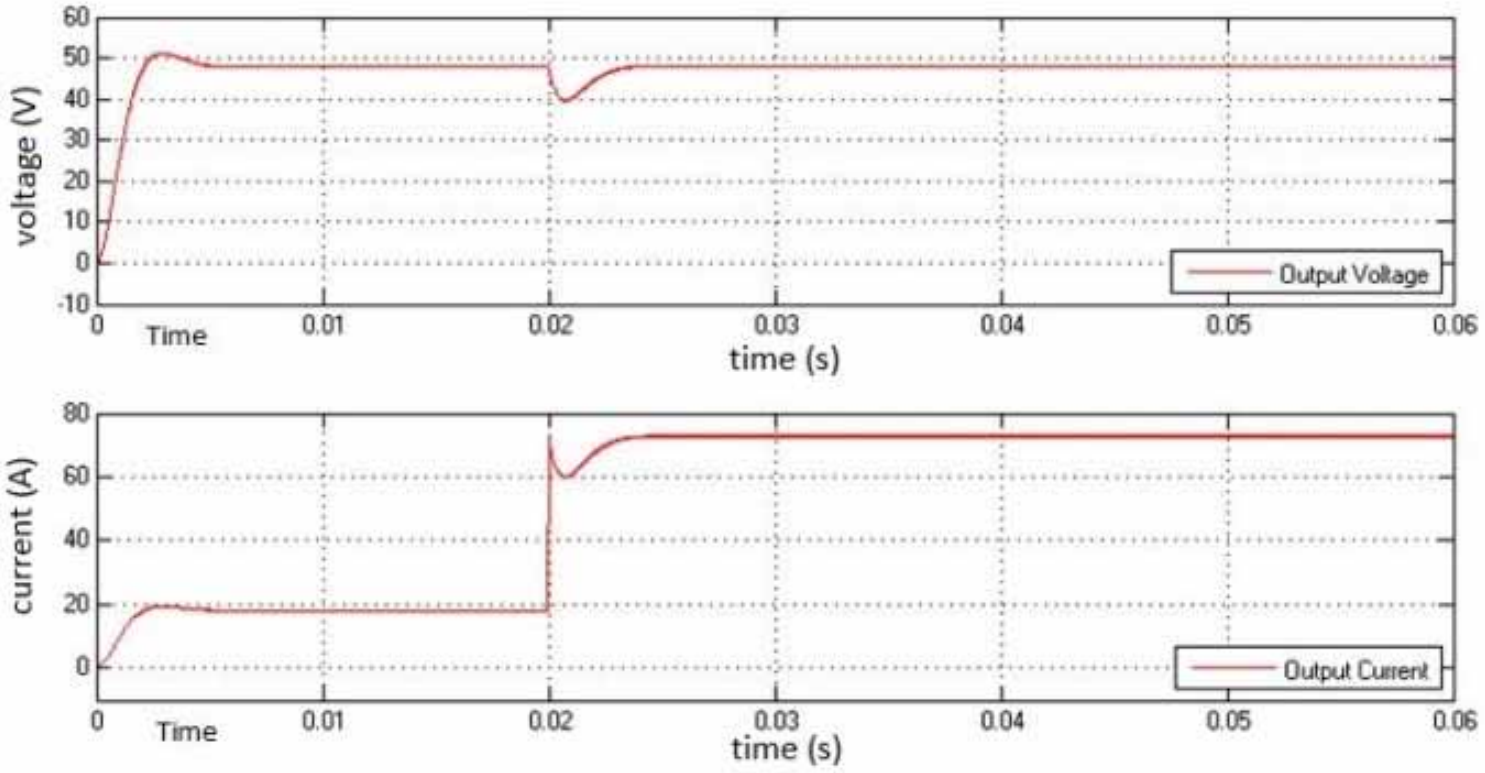
2. Load increased in one step from 25% to 100%



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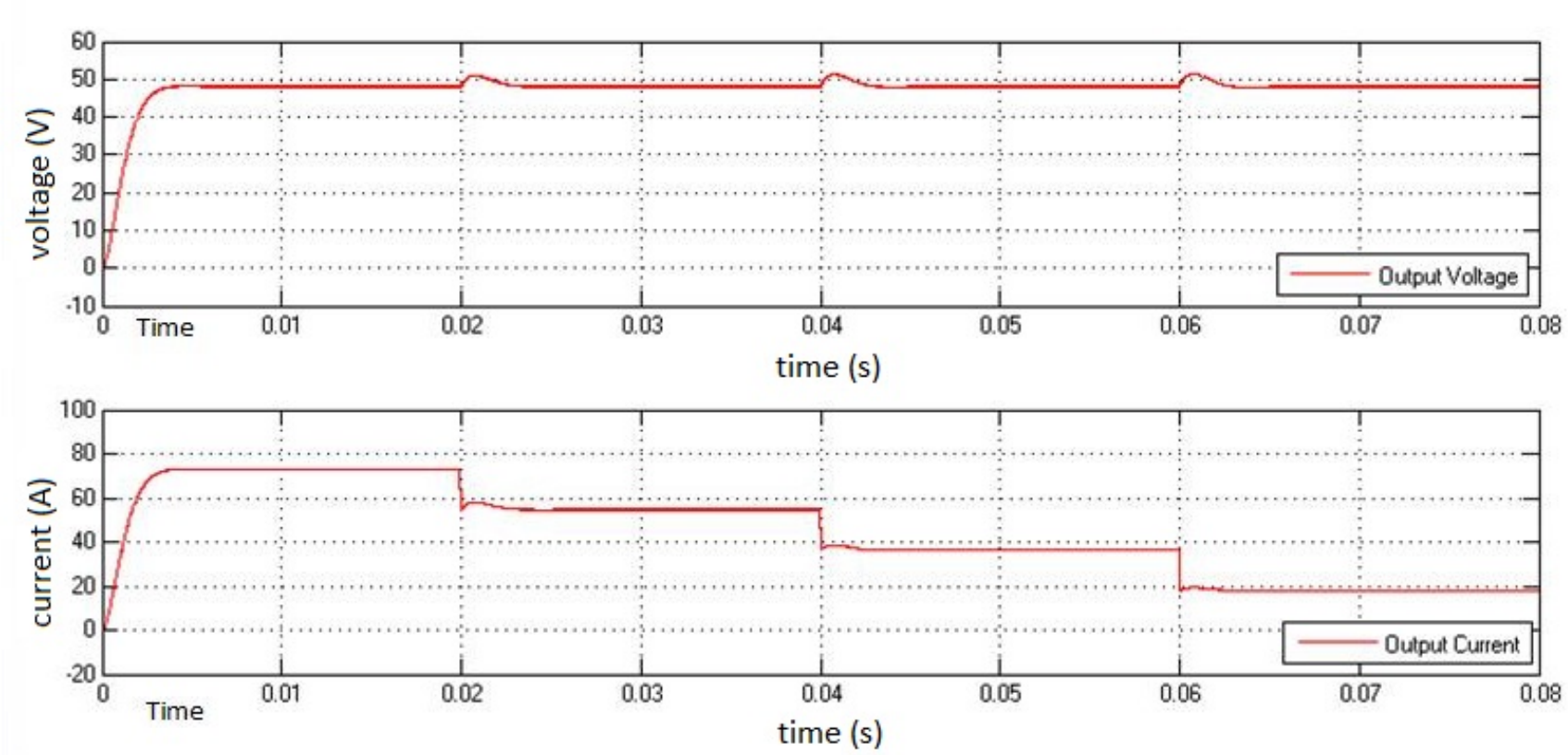
3. Load decreased in intervals of 25%



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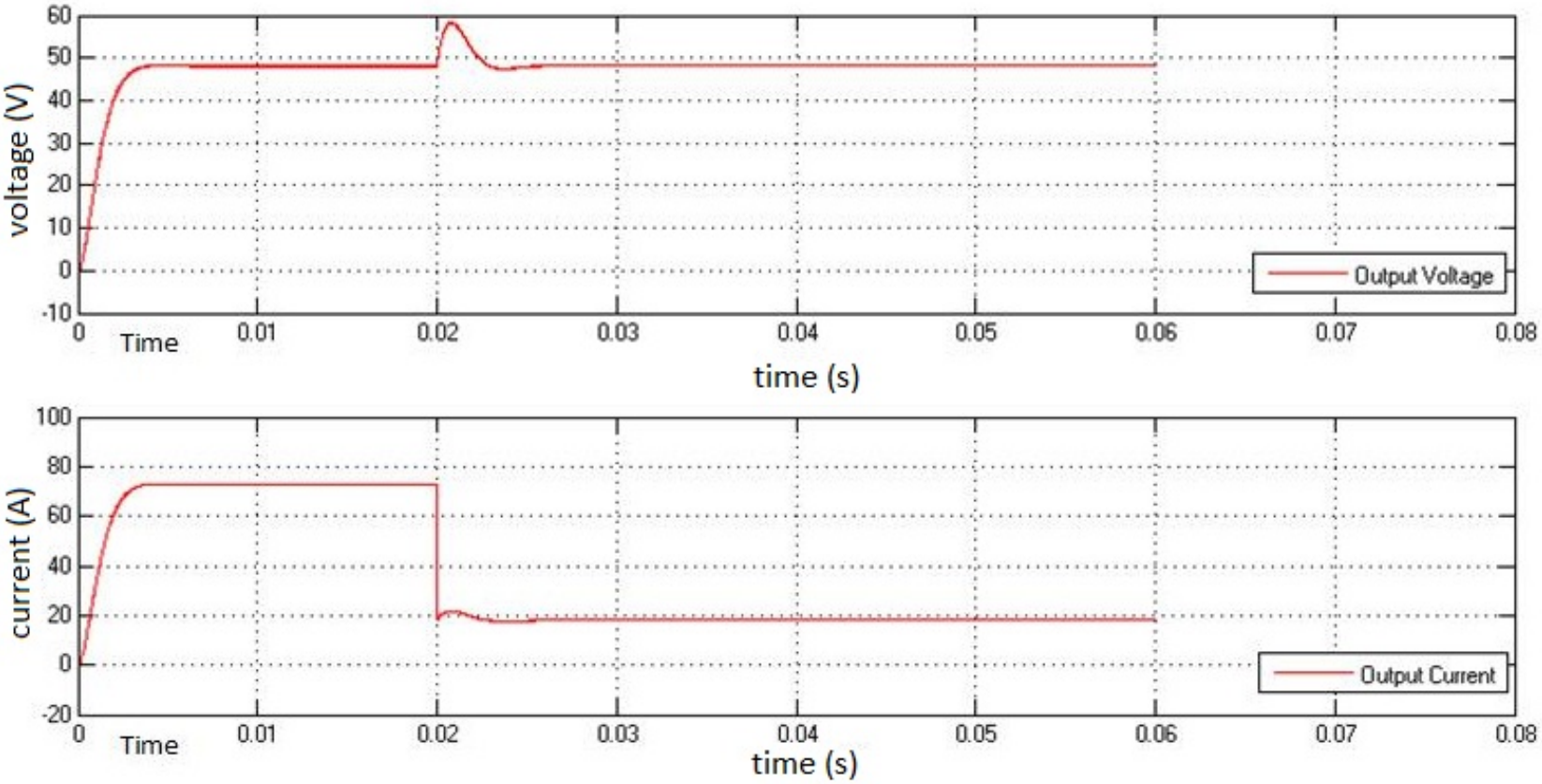
4. Load decreased in one step from 100% to 25%



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RESULTS

- No applicable National standard for power quality for low voltage DC power systems
- National power quality standard (NRS048-1/SABS0480-1) applicable to AC power systems
  - Describes voltage limits
  - For voltage supplies less than 500 V, the maximum deviation should not be more than 15%

RESULTS (CONT.)

- Open loop tests
- Voltage spikes produced:
  - Exists for approximately for 3 ms
  - 3 V p-p (scenarios 1 & 3)
  - 7 V p-p (scenarios 2 & 4)
- Transient range variation
  - Minimum 6.3%
  - Maximum 14.6% (<15%)

CONCLUSION

- Imperative the voltage supply in a residence remains stable and free from excessive spikes and prolonged transients as loads are connected and disconnected
- These voltage variations can cause damage to household appliances
- Various load tests performed show that through many switching scenarios that the load voltage level remains relatively stable
- Boost DC-DC converter a good candidate for implementation in a DC house

THANK YOU

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