Single-Inductor Dual-Output DC-DC Converter Design With ZVS-PWM Control

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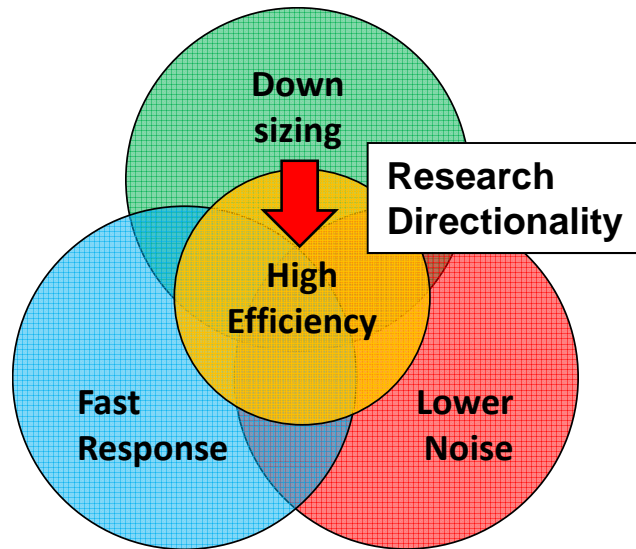
Outline

- Research Objective

- Research Background

- Key Technologies

    - SIMO and ZVS

- Proposed Buck Converter with ZVS-PWM

- Proposed Boost Converter with ZVS-PWM

- Summary and Future Research

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Research Objective

- Performance improvement
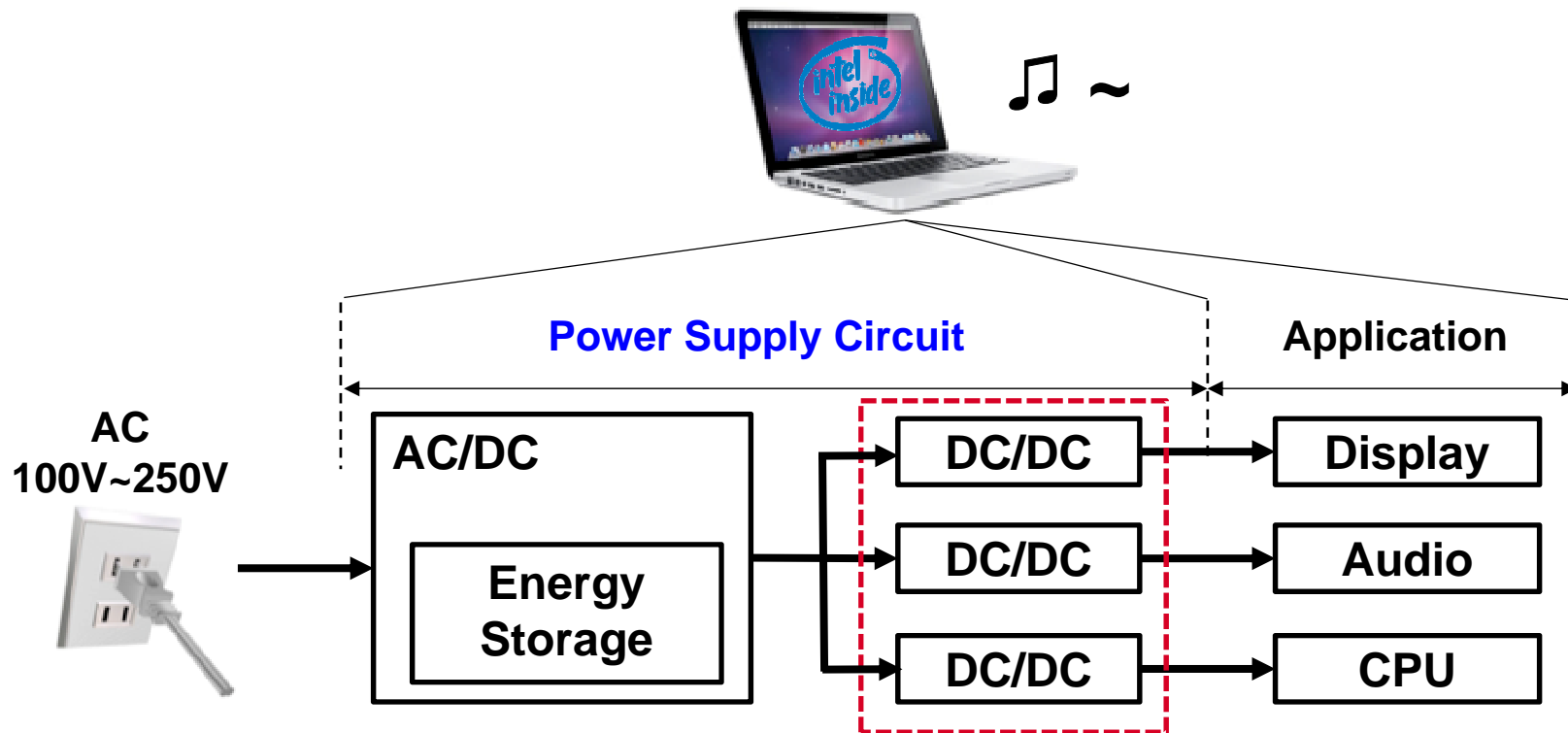 of DC/DC converter power supply

Target	Key technology
Downsizing	**Single-Inductor-Multi-Output**
High Efficiency Lower Noise	**ZVS-PWM Control**

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Research Background(1)

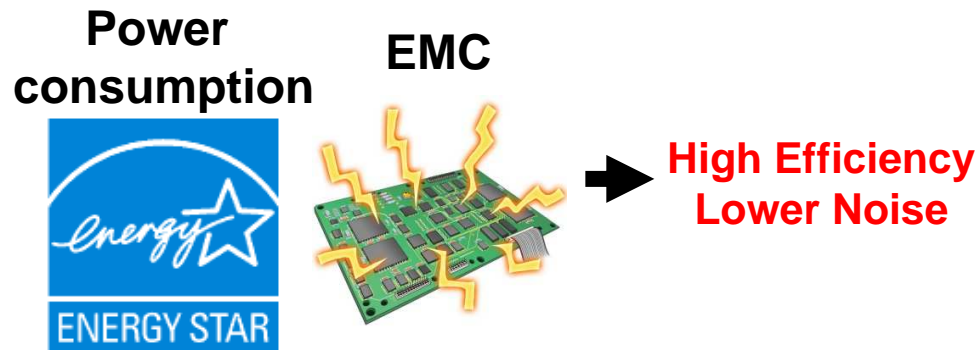- Power supply circuit is required

  for all electronic devices

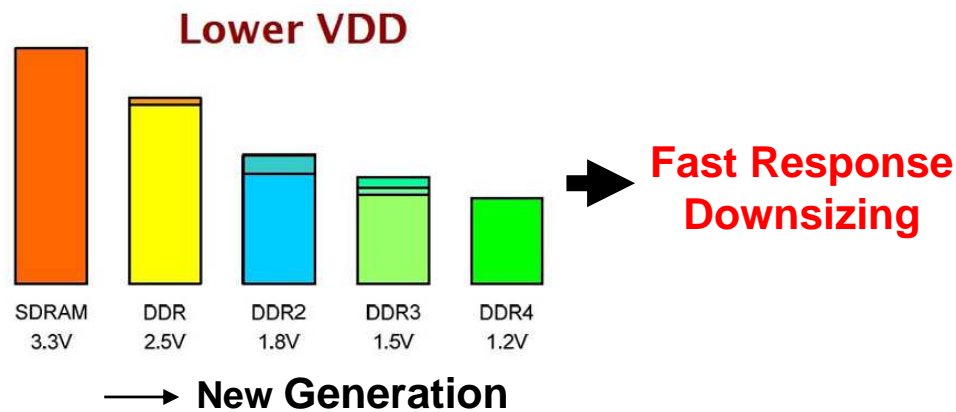**Several DC / DC converters are required for each application**

Research Background(2)

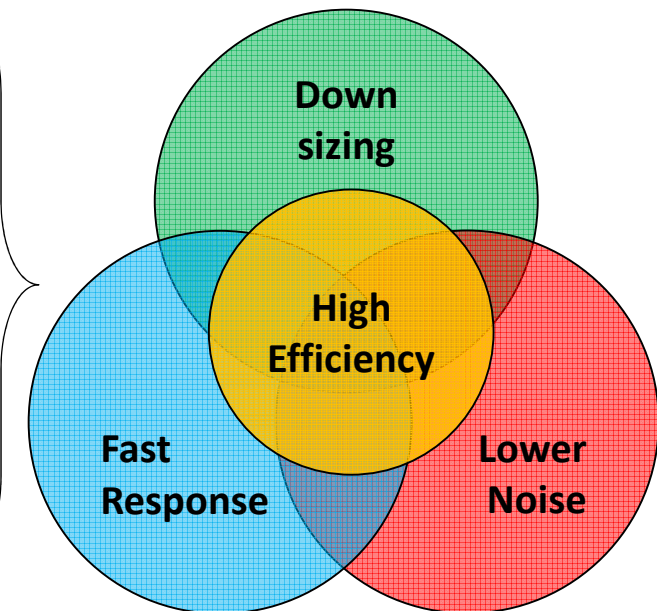- Background of power supply performance requirements

  1. Enhancement of environmental regulations

  Power consumption **EMC**

  High Efficiency Lower Noise

  Required Performance

  2. Semiconductor process evolution

  Lower VDD

  | SDRAM 3.3V | DDR 2.5V | DDR2 1.8V | DDR3 1.5V | DDR4 1.2V |

  → **New Generation**

  Fast Response Downsizing

  Down sizing

  High Efficiency

  Fast Response

  Lower Noise

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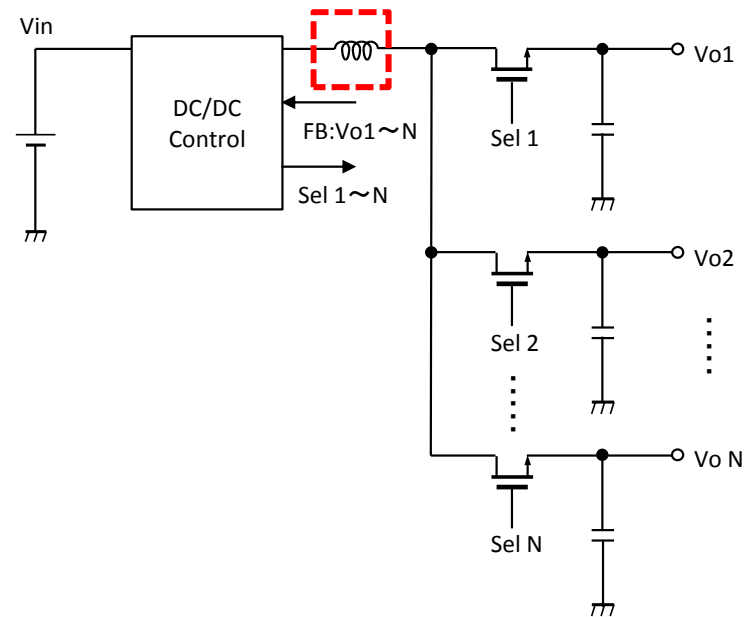# SIMO:Single-Inductor Multi-Output for Downsizing

Conventional

Proposed

SISO:Single-Inductor Single-Output

SIMO:Single Inductor Multi-Output
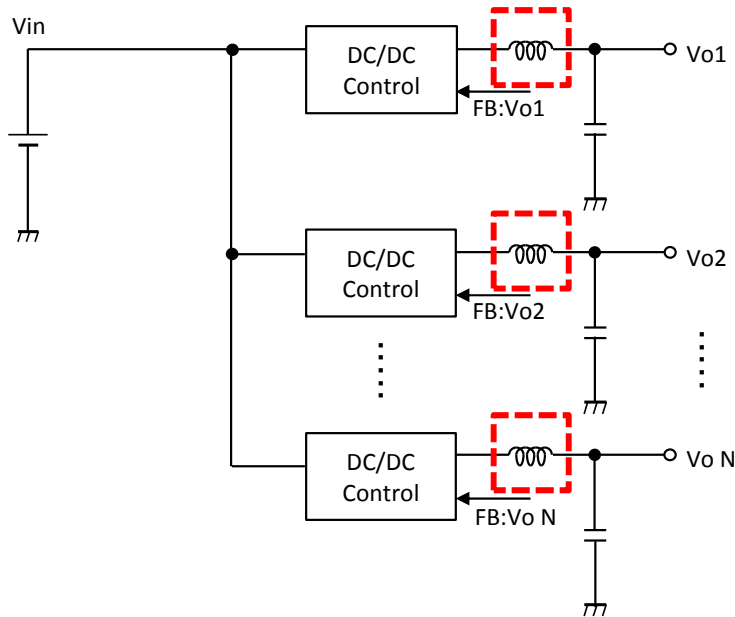
One inductor for one voltage

One inductor for multiple voltages
Share one inductor
Reduce the number of inductors

ZVS:Zero-Voltage-Switching
for High Efficiency & Lower Noise
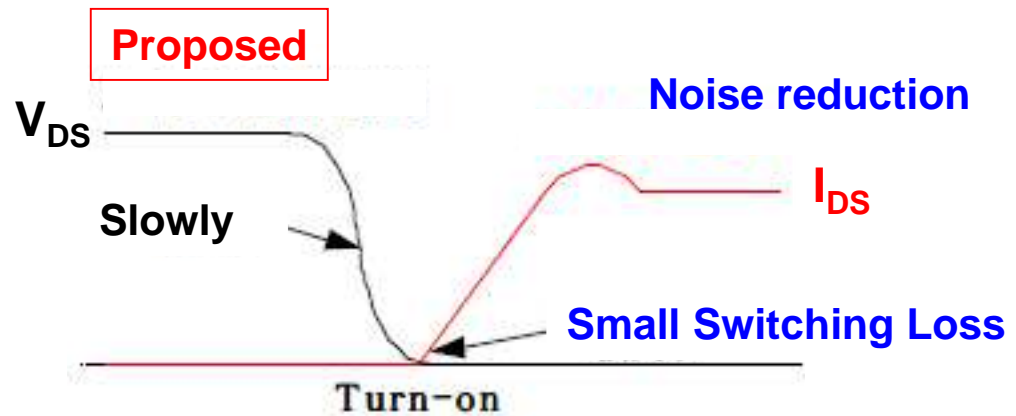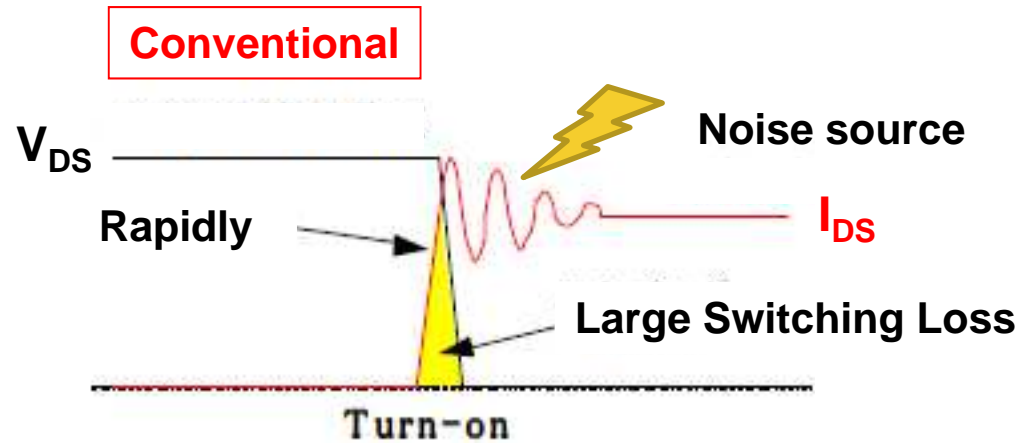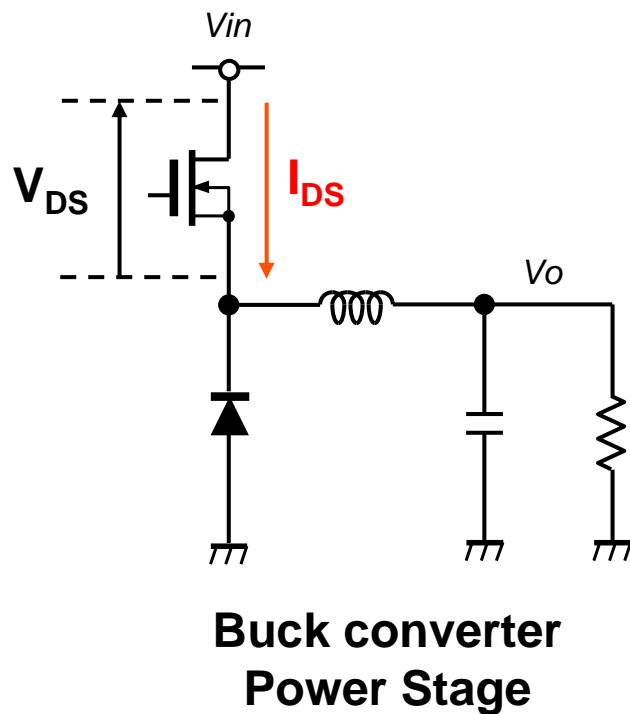
V_{in}

V_{DS} I_{DS}

V_o

**Buck converter
Power Stage**

Conventional

V_{DS} — **Noise source**

Rapidly — I_{DS}

Large Switching Loss

Turn-on

Proposed

V_{DS} — **Noise reduction**

Slowly — I_{DS}

Small Switching Loss

Turn-on

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- **Proposed Buck Converter with ZVS-PWM**

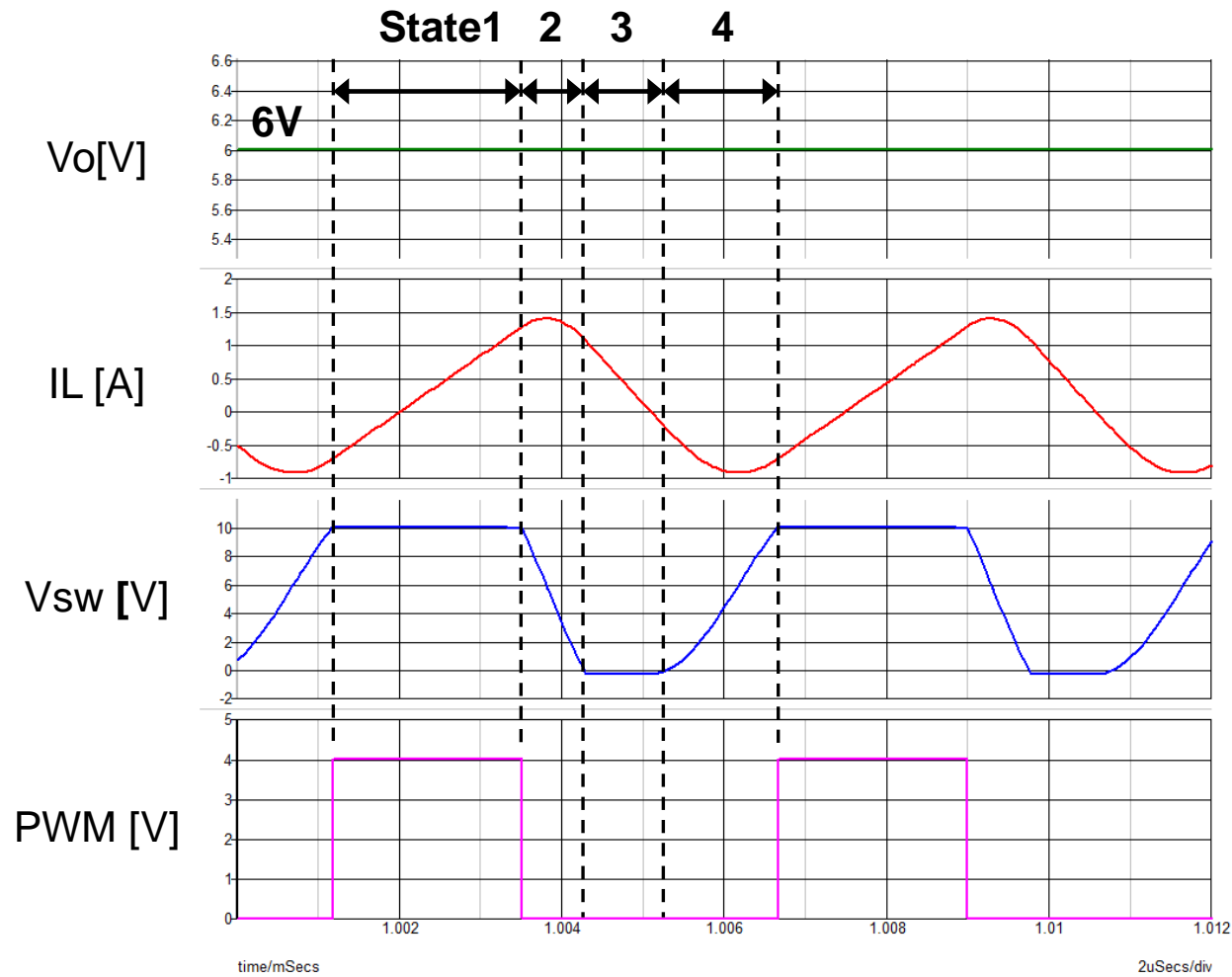- Proposed Boost Converter with ZVS-PWM

- Summary and Future Research

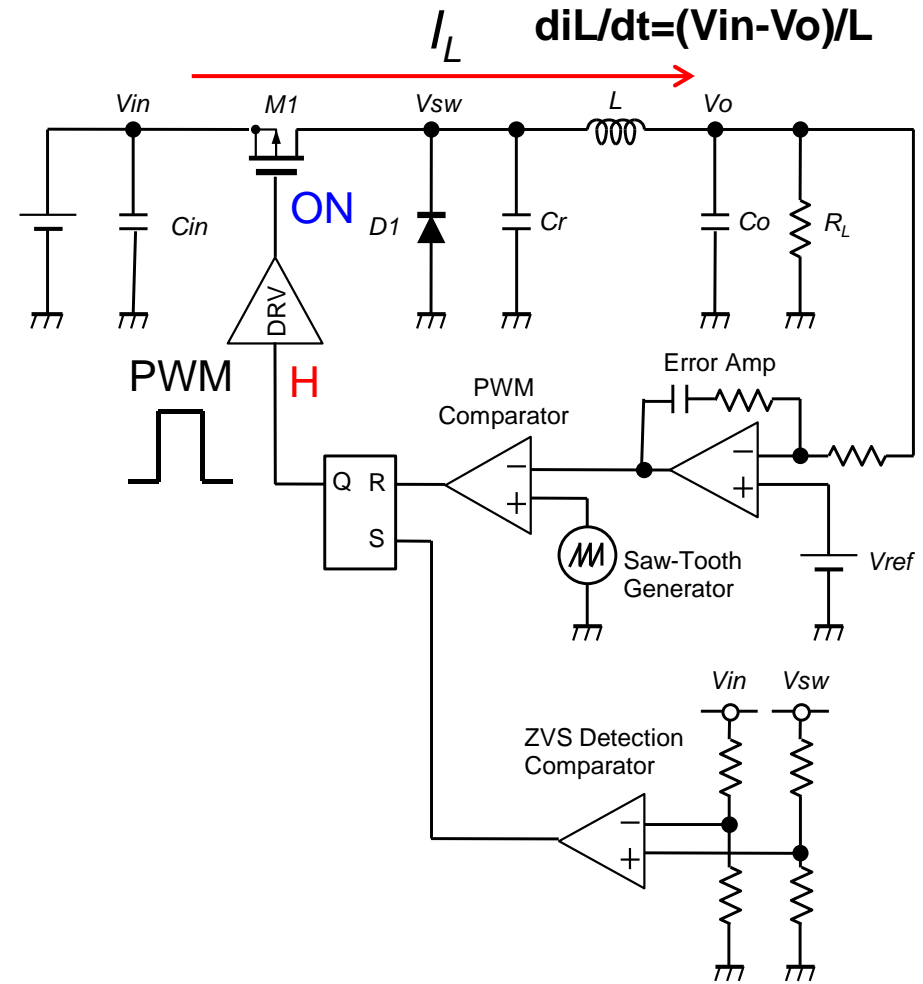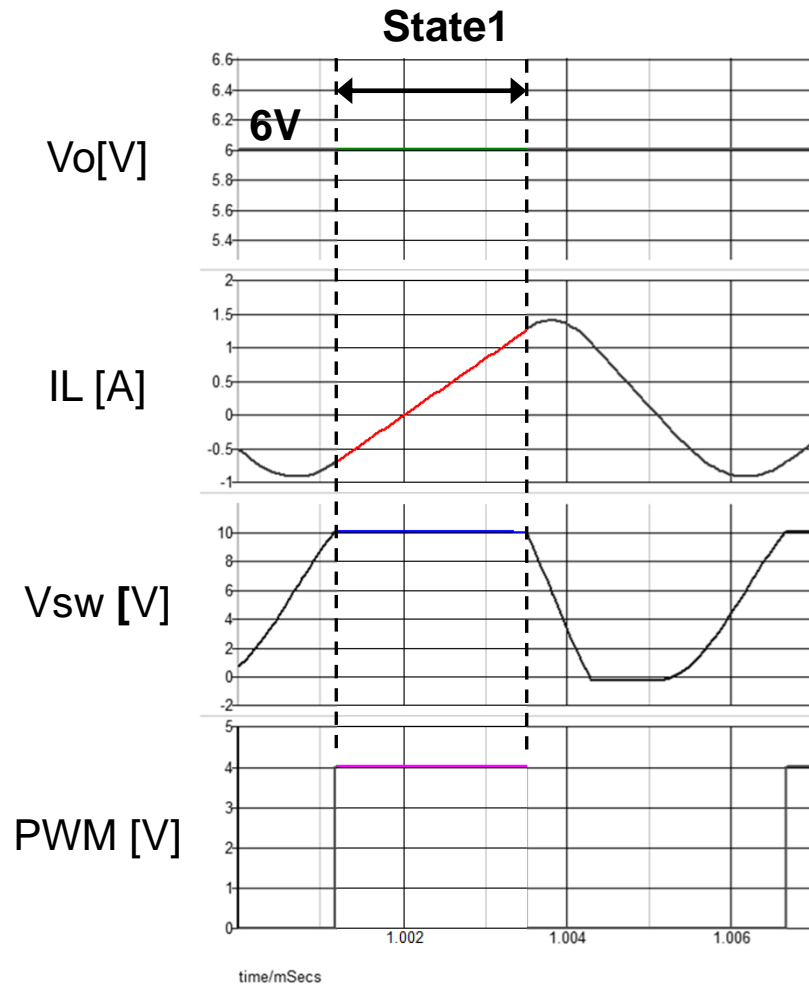# SISO Buck Converter Circuit with ZVS-PWM Control

Changes from Conventional circuit

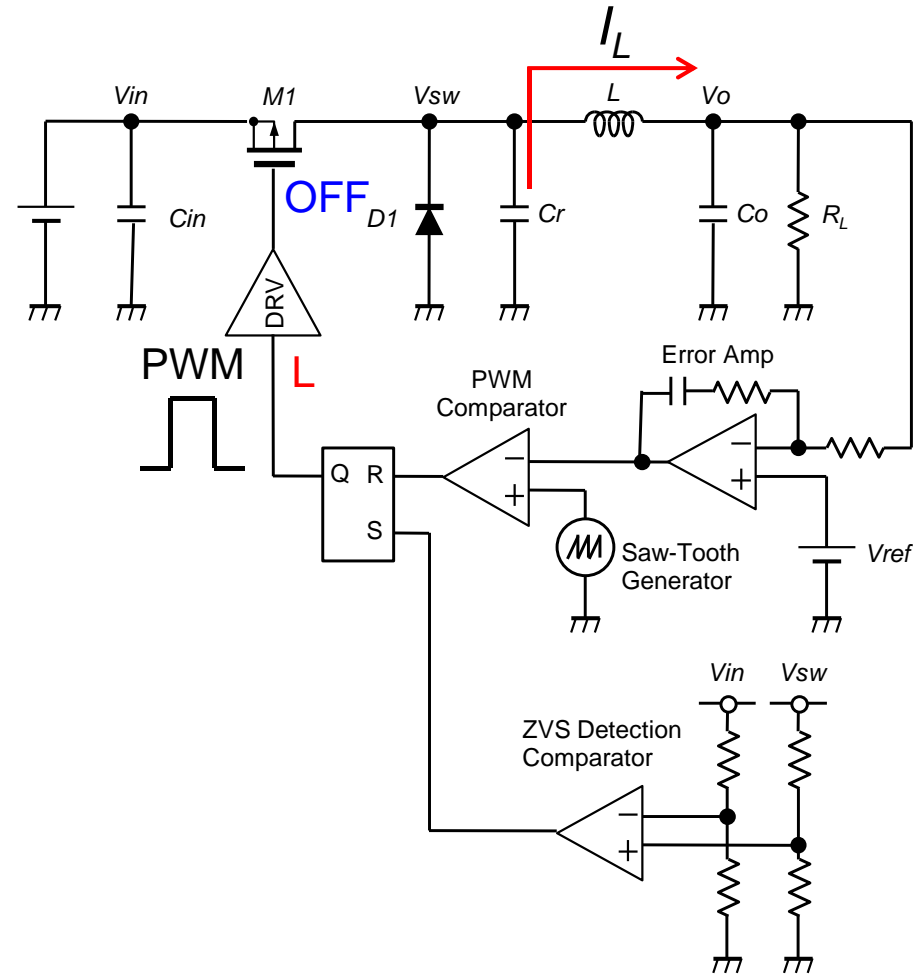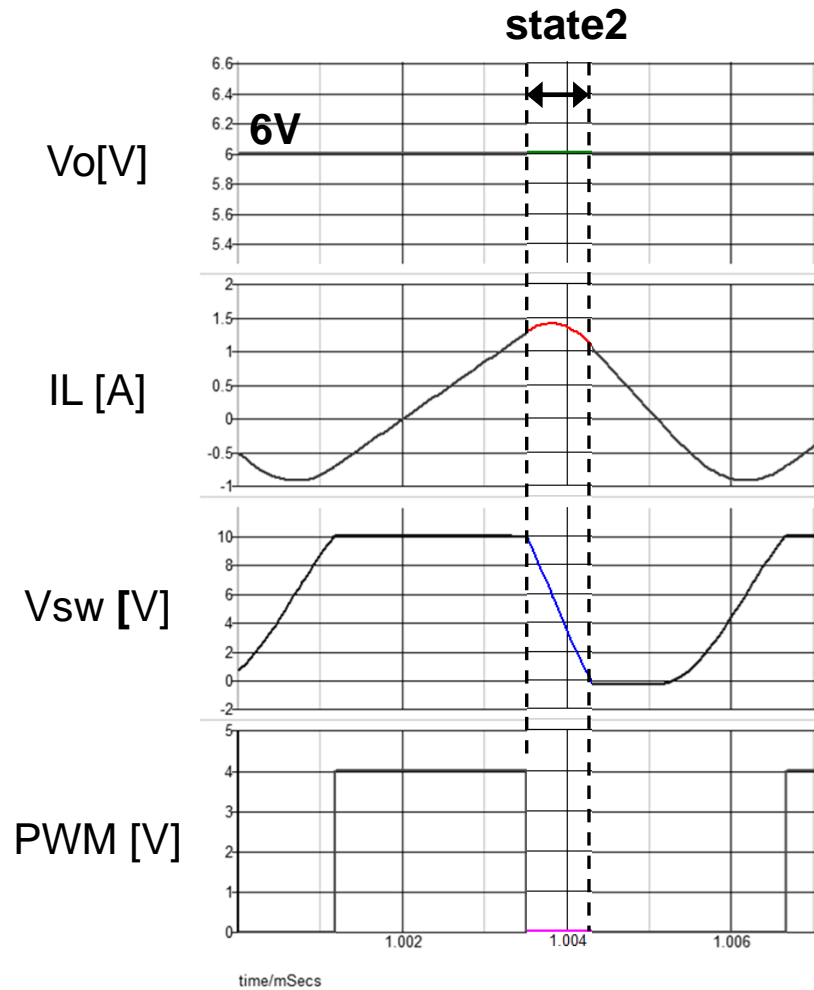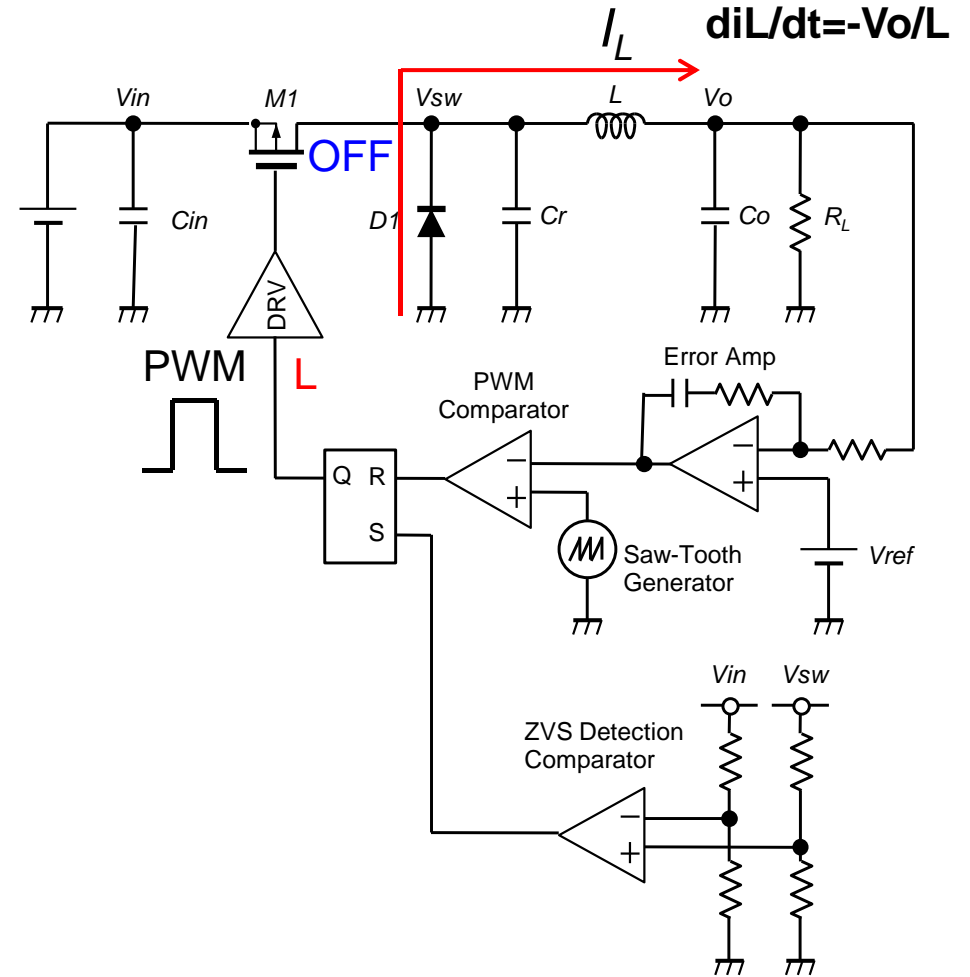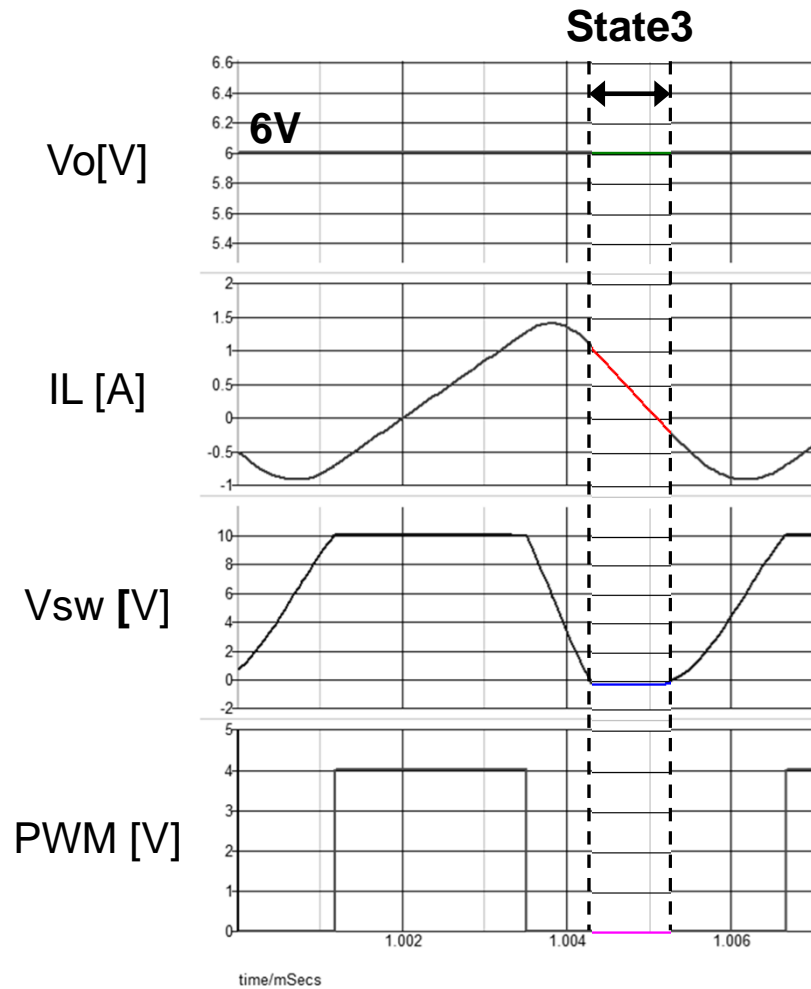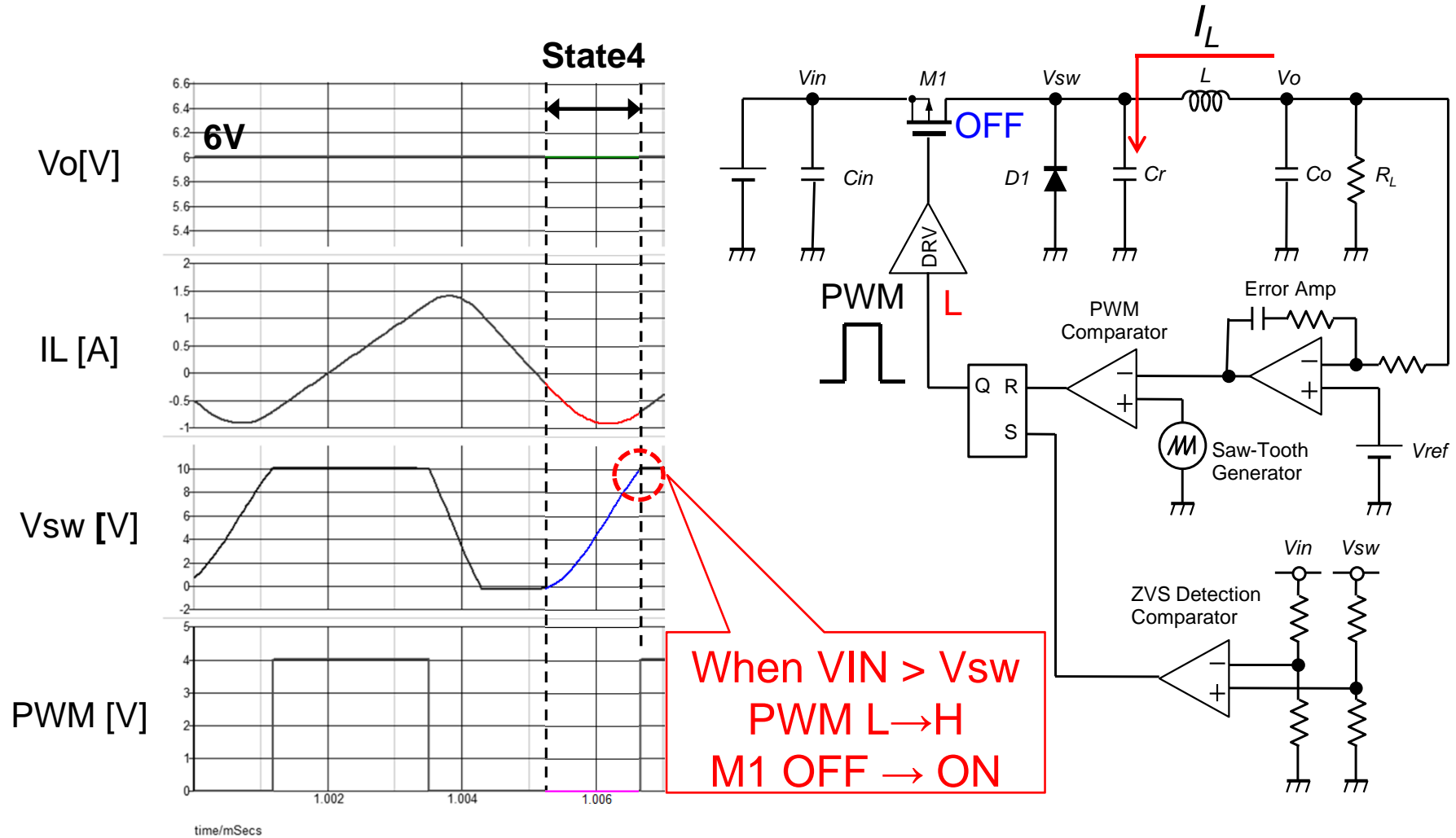| Parameter	Value
Vin	10V
Vo	6V
L	4.7uH
Cr	100nF
Co	470uF
Io	200mA

Basic ZVS-PWM operation in SISO buck converter

Basic ZVS-PWM operation in SISO buck converter

Basic ZVS-PWM operation in SISO buck converter

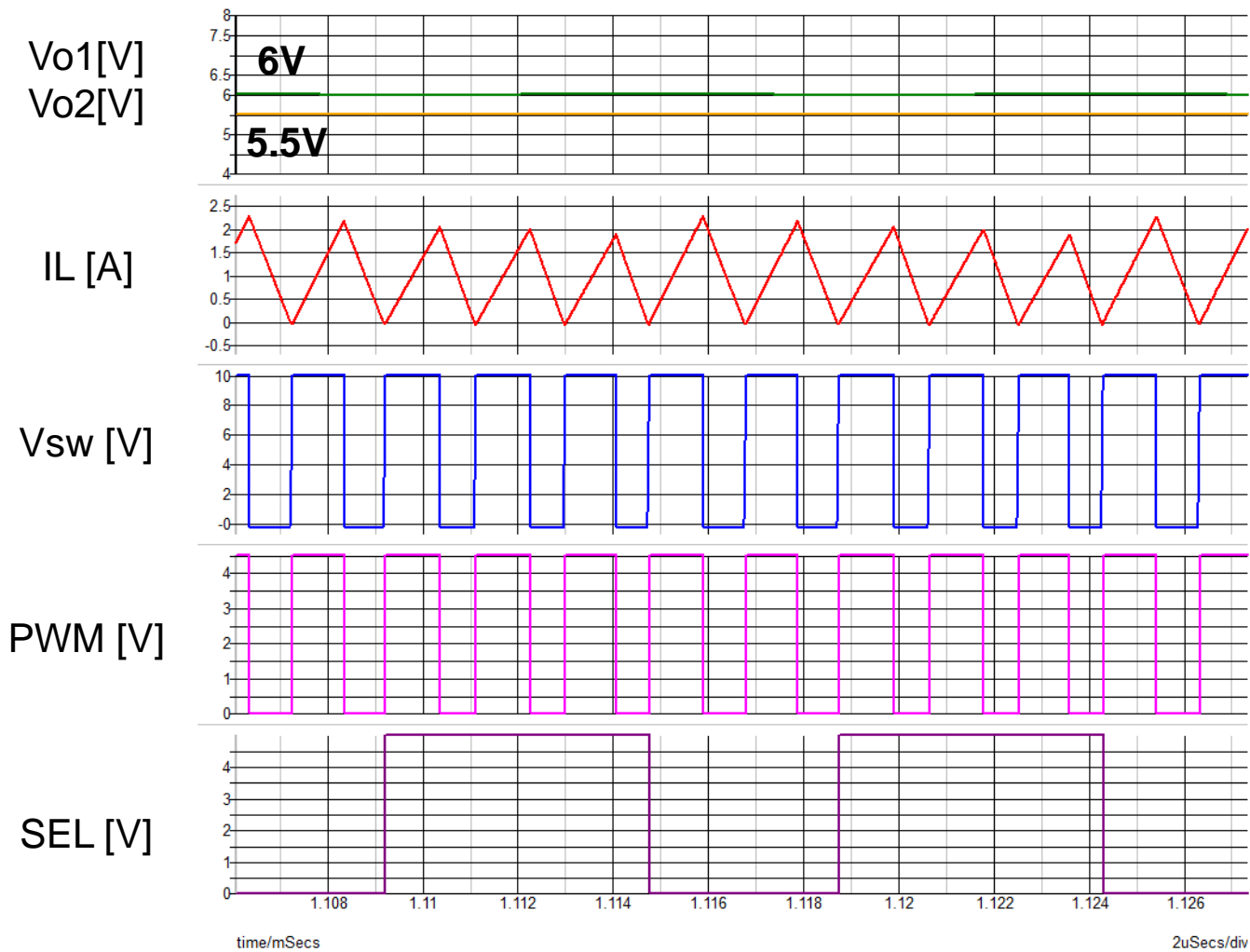# Basic ZVS-PWM operation in SISO buck converter

Basic ZVS-PWM operation in SISO buck converter

When VIN > Vsw
PWM L→H
M1 OFF → ON

SIDO Buck Converter Circuit with ZVS-PWM Control
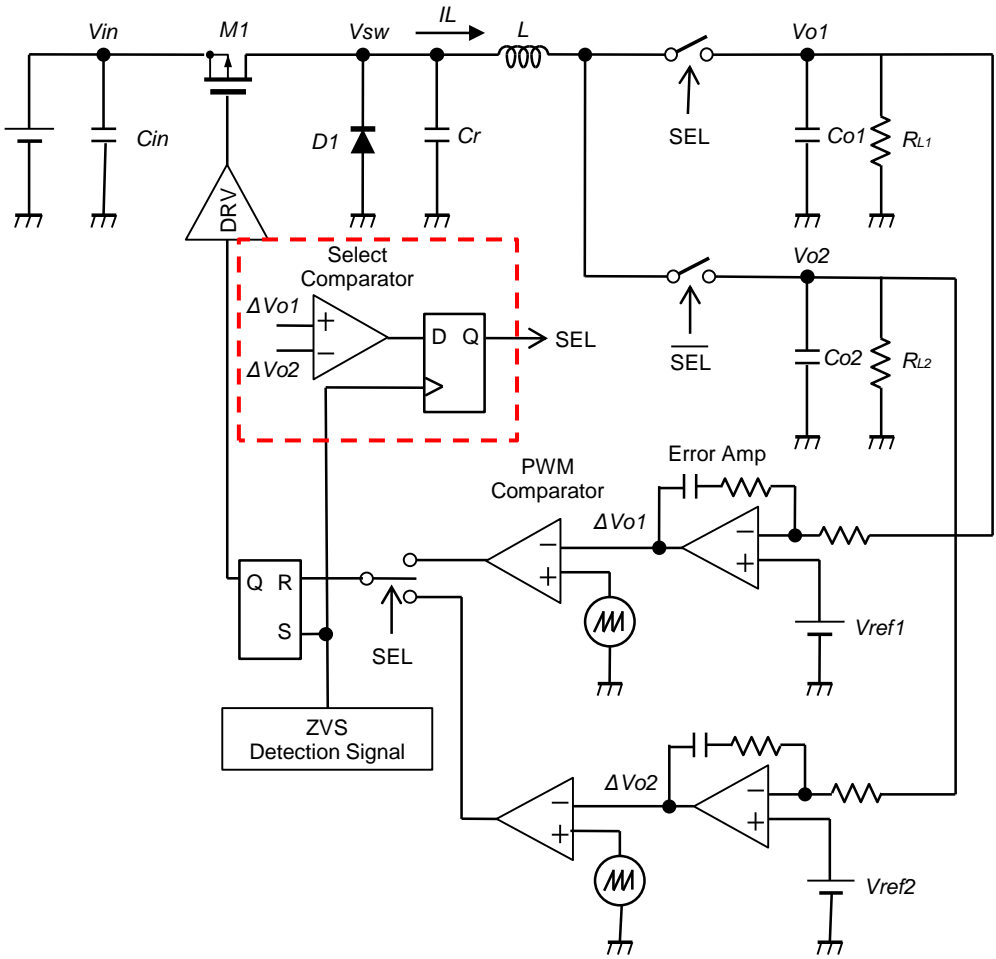
Exclusive Control For selecting either output

Parameter	Value
Vin	10V
Vo1	6V
Vo2	5.5V
L	2.2uH
Cr	100pF
Co1 & Co2	470uF

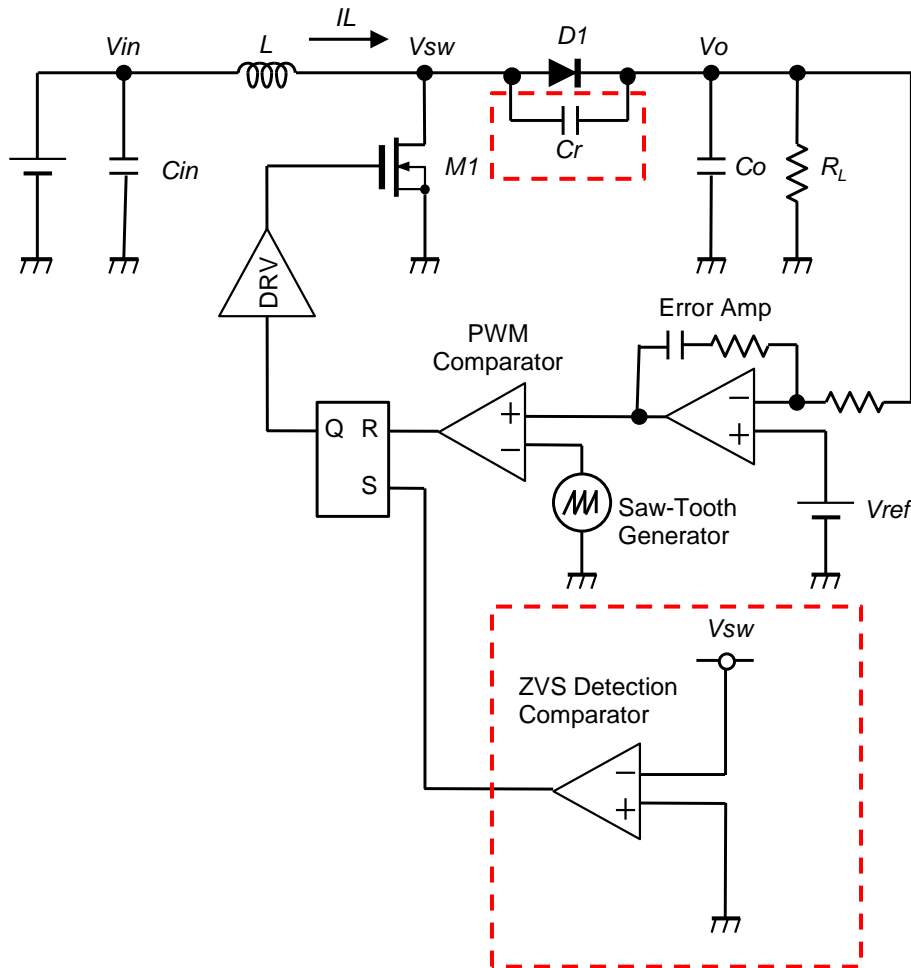# Steady-State operation with ZVS-PWM in SIDO buck converter

Transient operation with ZVS-PWM in SIDO buck converter
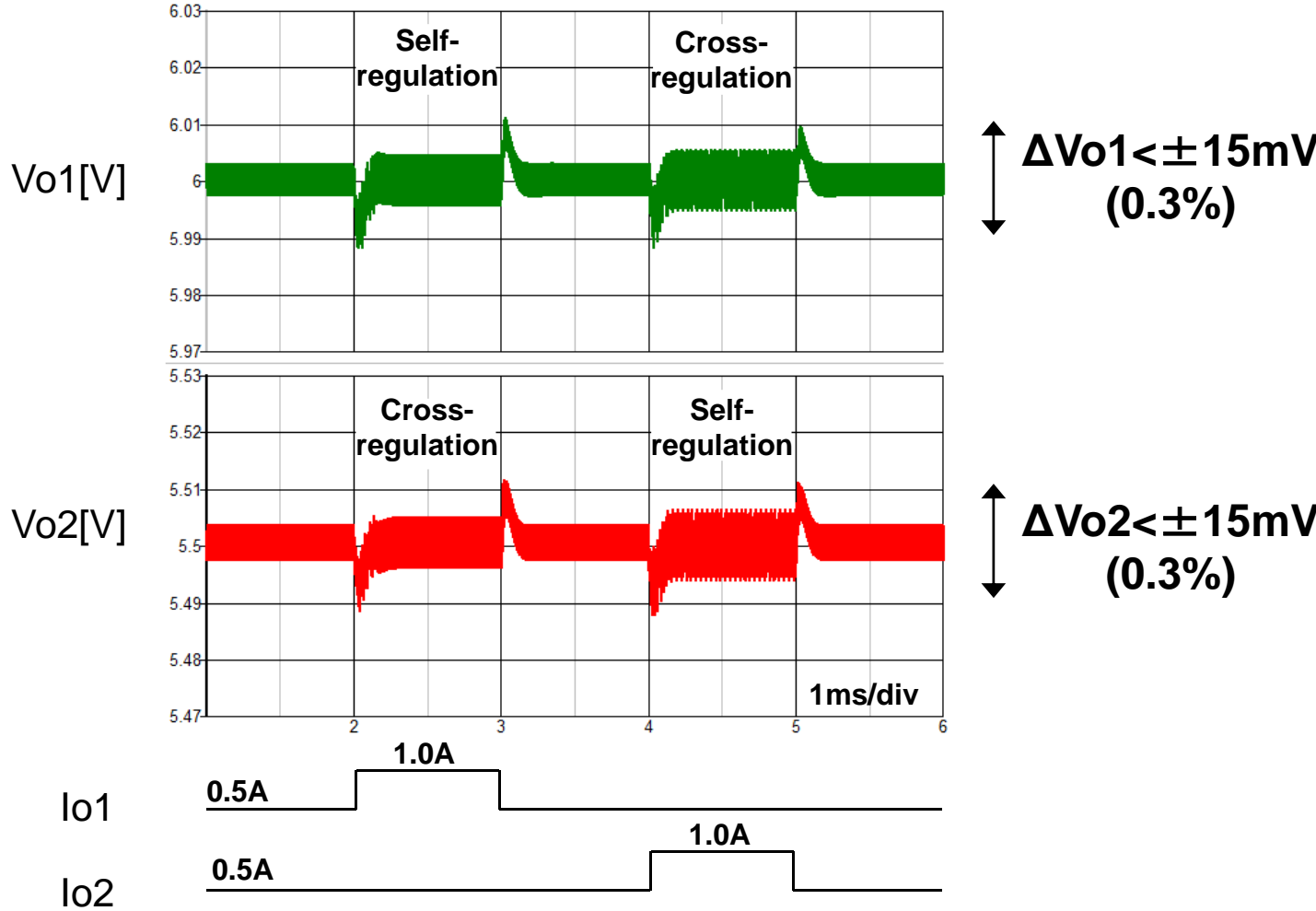
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- **Proposed Boost Converter with ZVS-PWM**
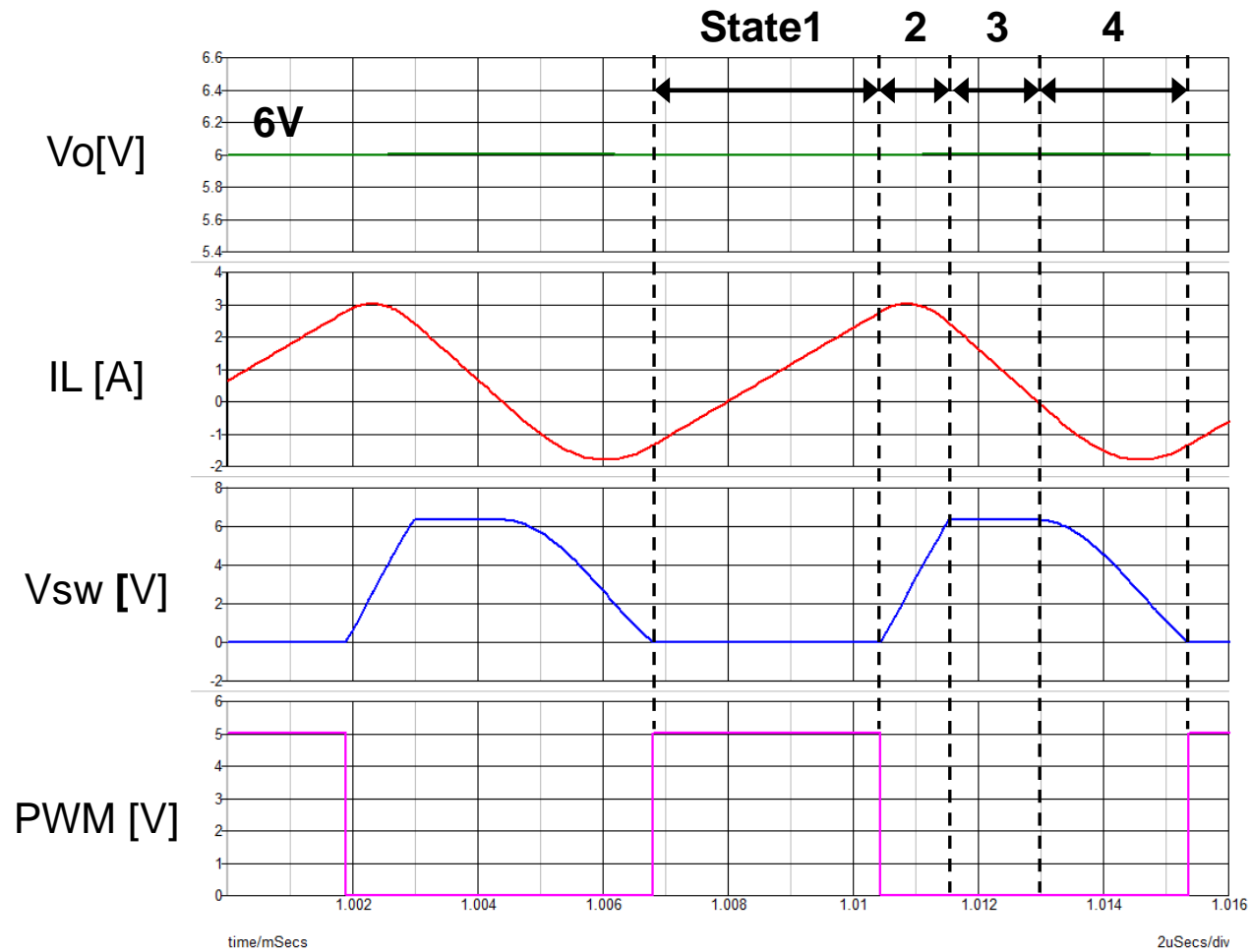
- Summary and Future Research

SISO Boost Converter Circuit with ZVS-PWM Control

Changes from Conventional circuit
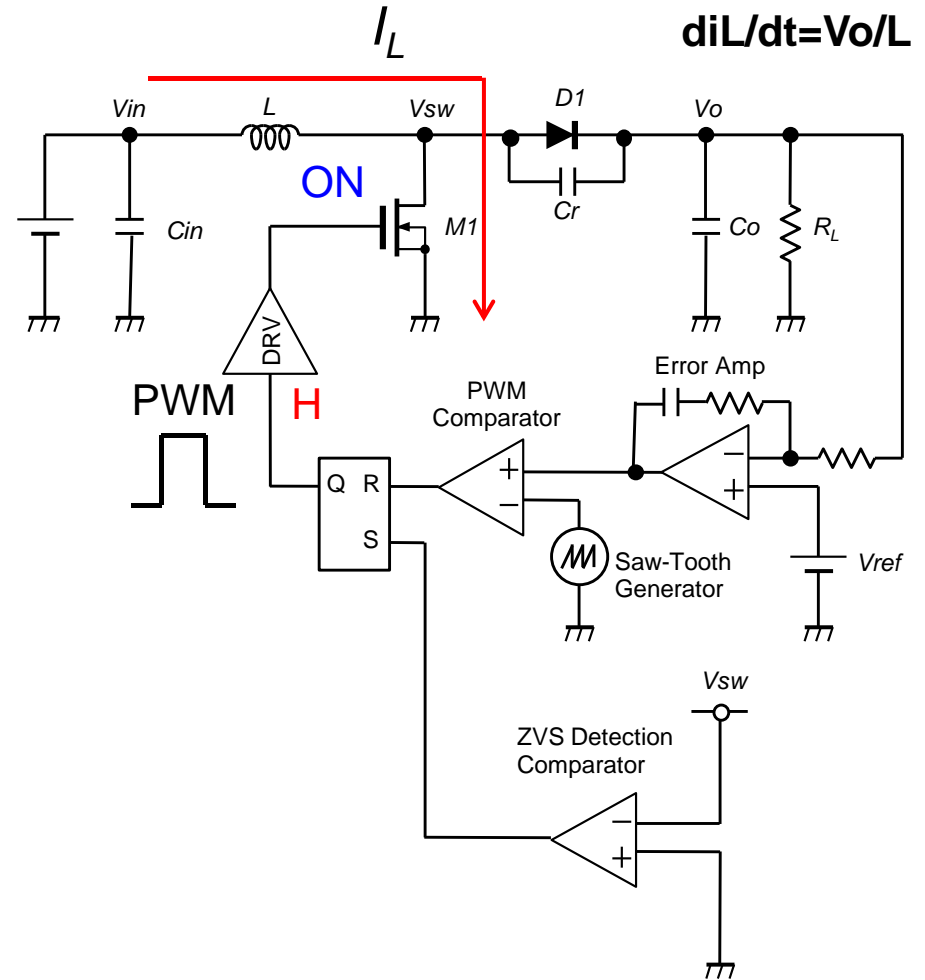
Parameter	Value
Vin	2.5V
Vo	6V
L	2.2uH
Cr	500nF
Co	470uF
Io	200mA

Basic ZVS-PWM operation in SISO boost converter

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Basic ZVS-PWM operation in SISO boost converter
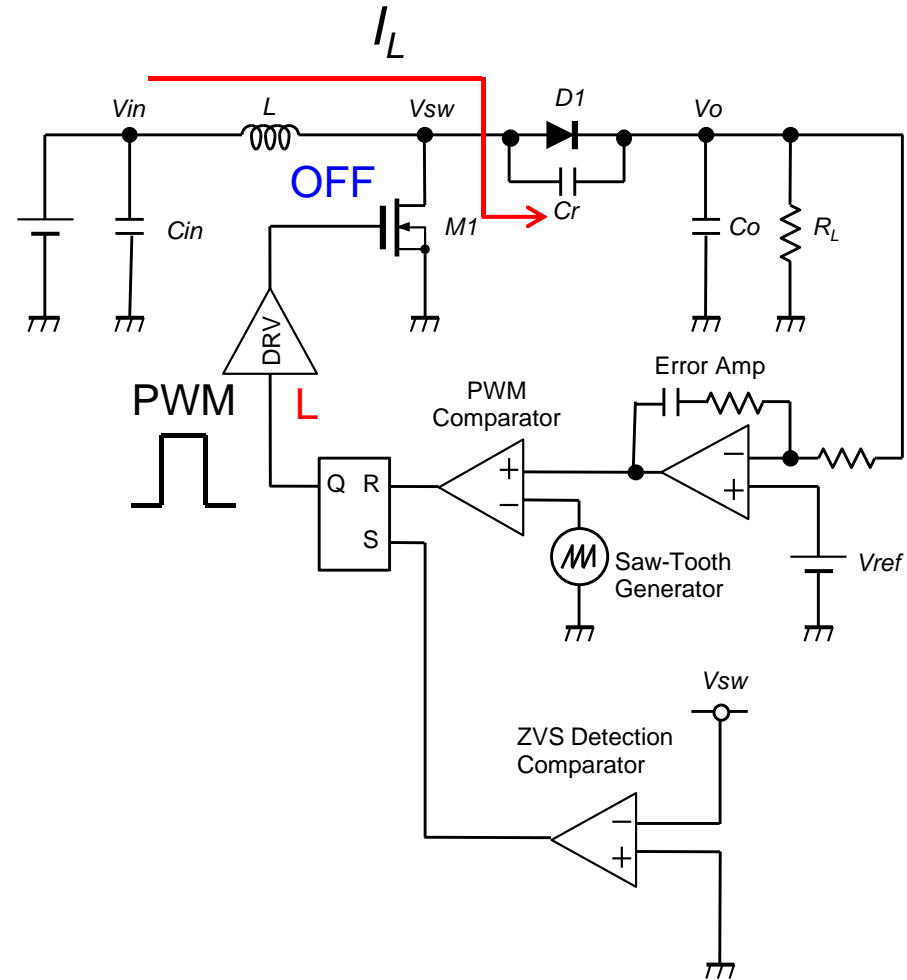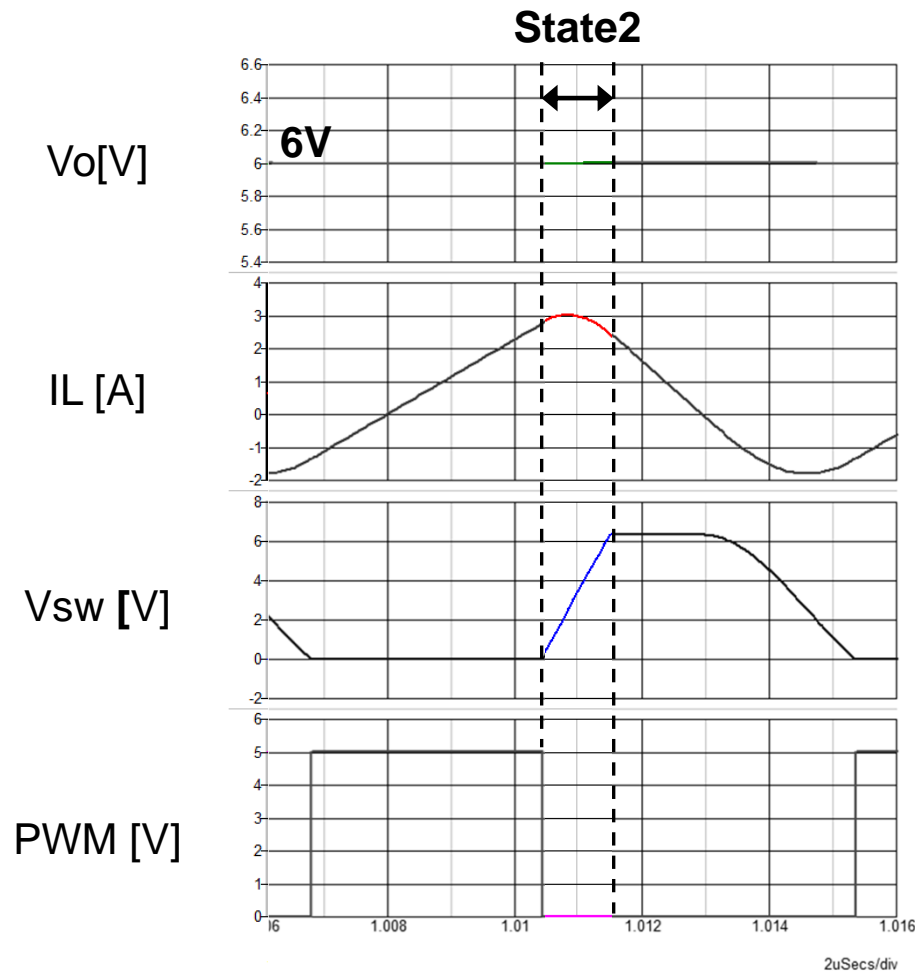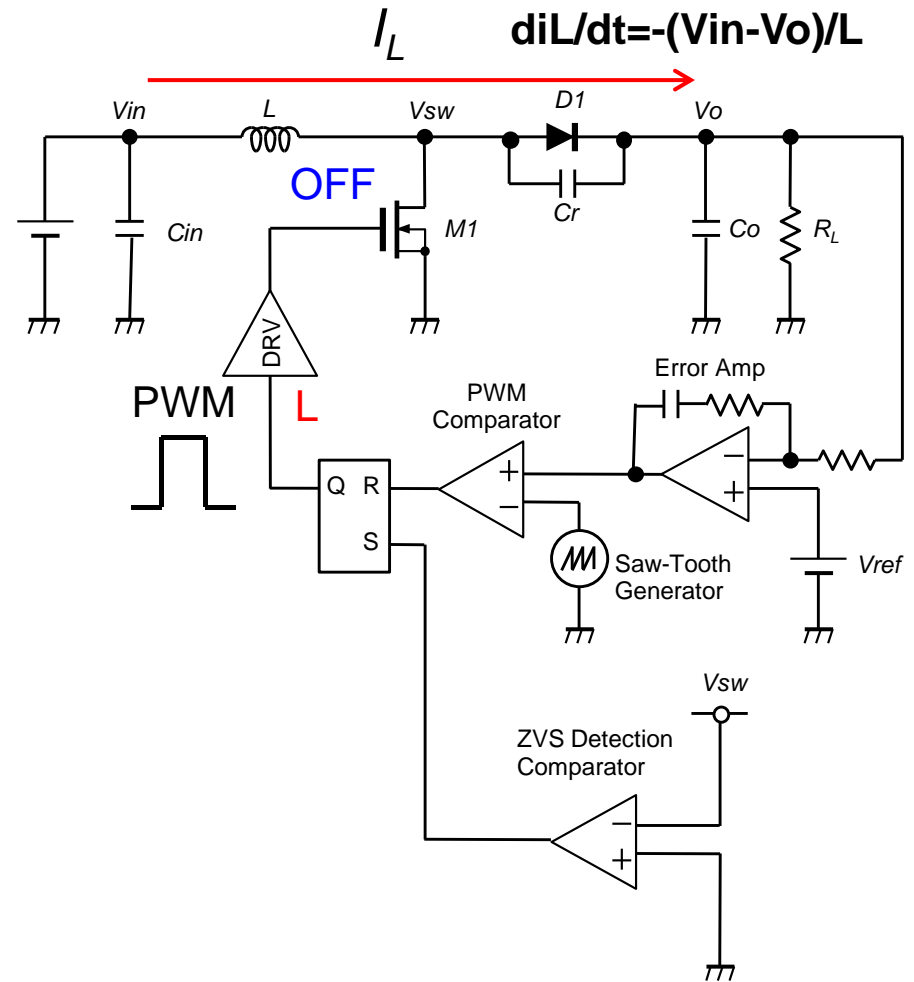

State4

Vo[V]
6V

IL [A]

Vsw [V]

PWM [V]

2uSecs/div

When Vsw < Gnd
PWM L→H
M1 OFF → ON
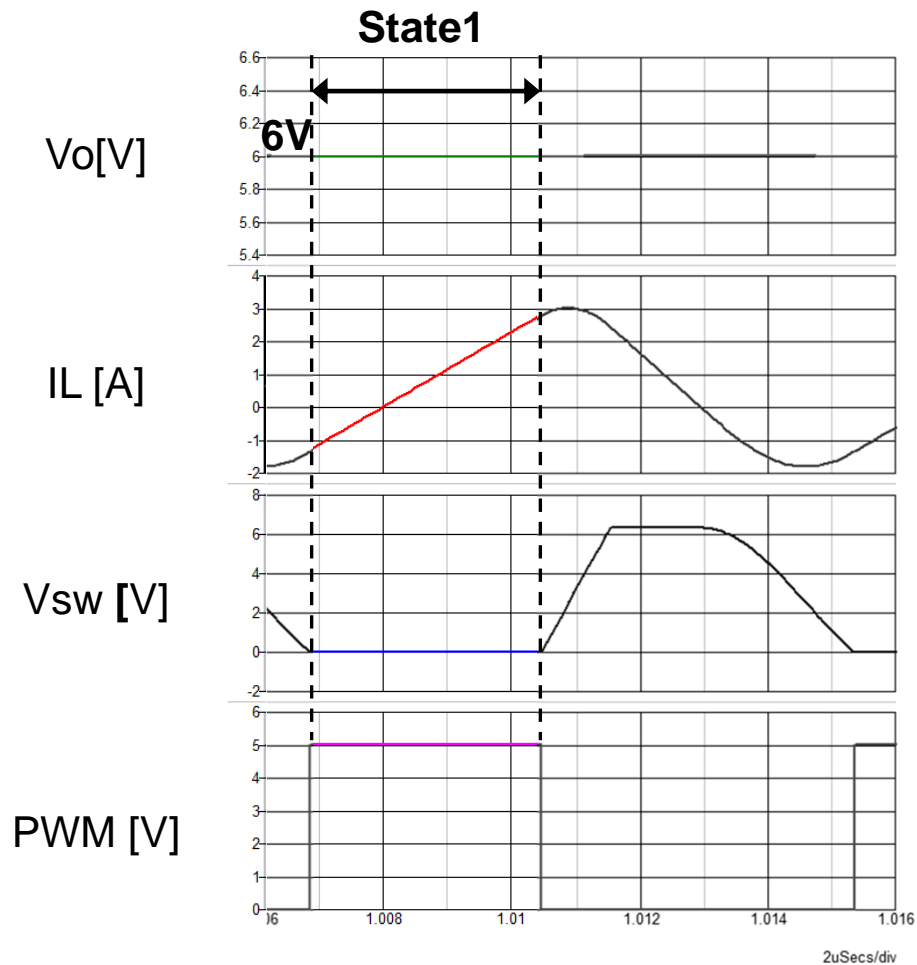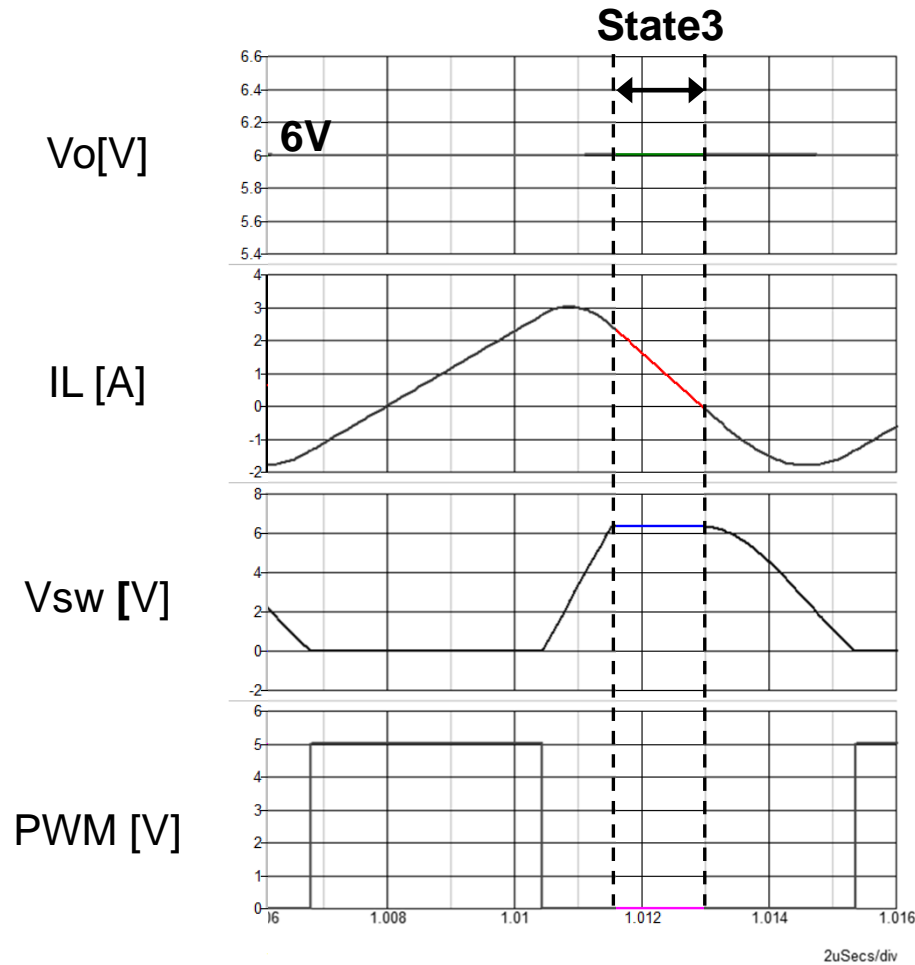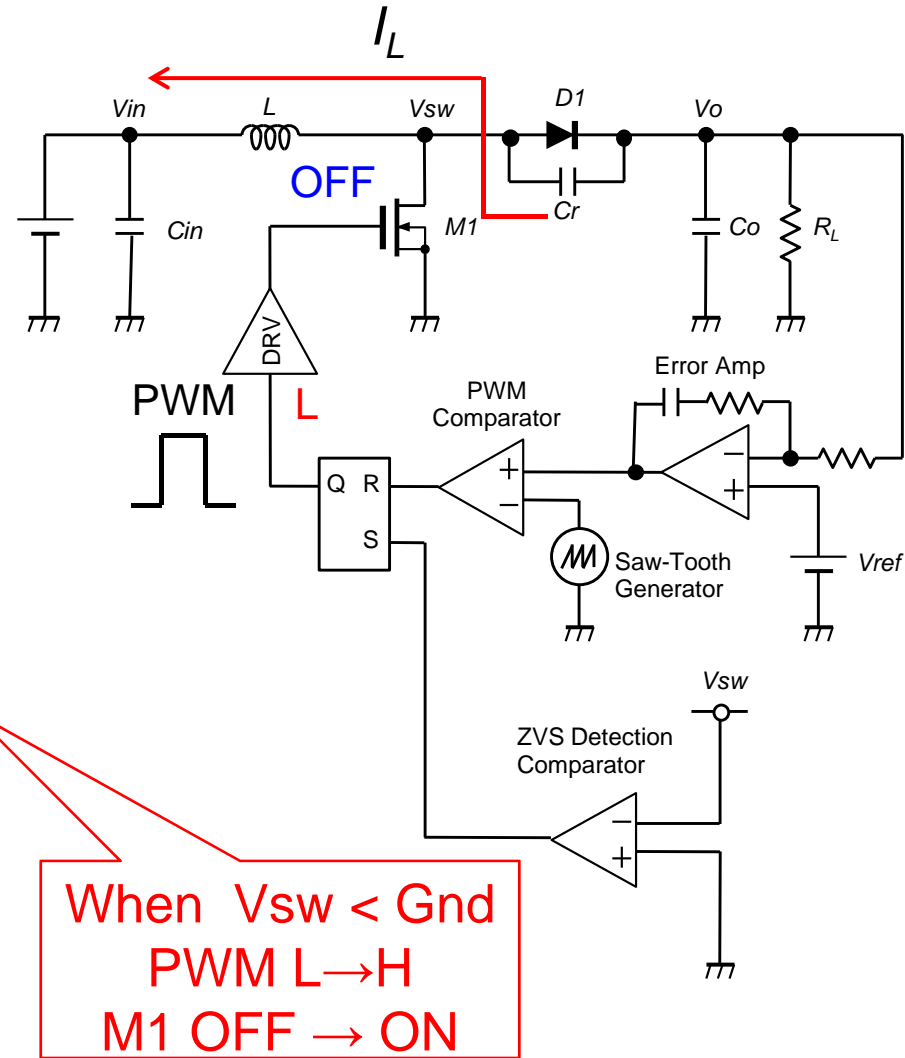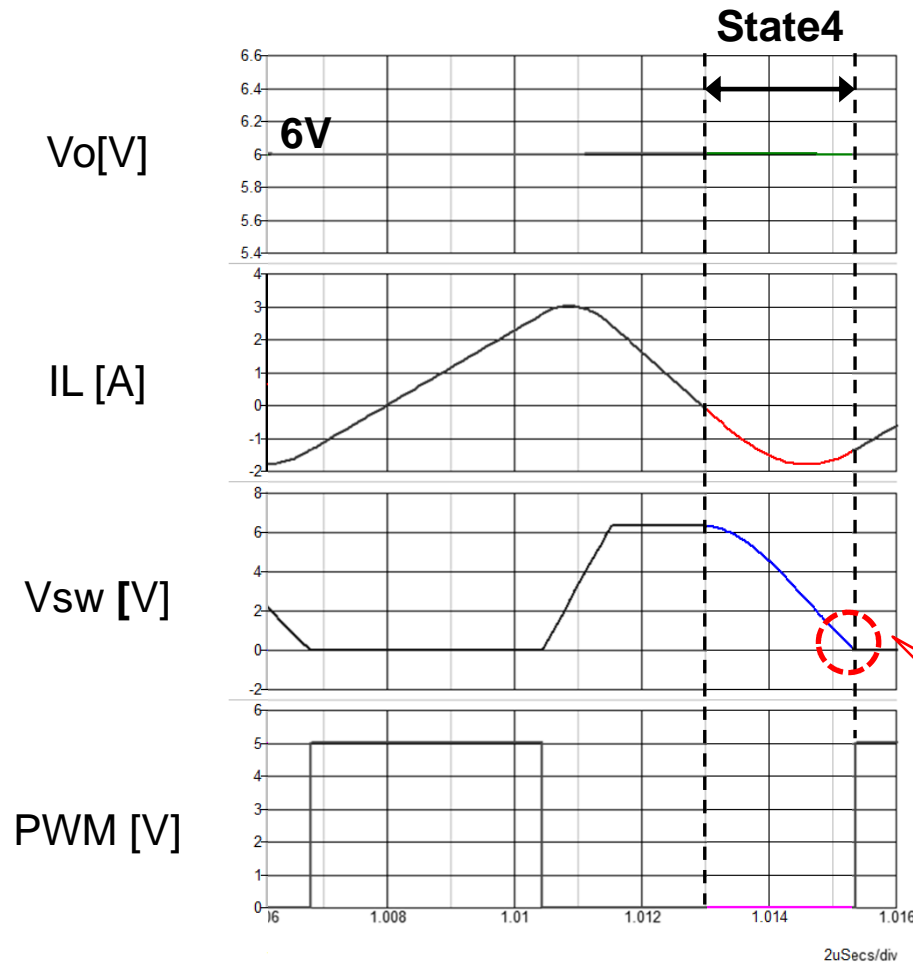
SIDO Boost Converter Circuit with ZVS-PWM Control
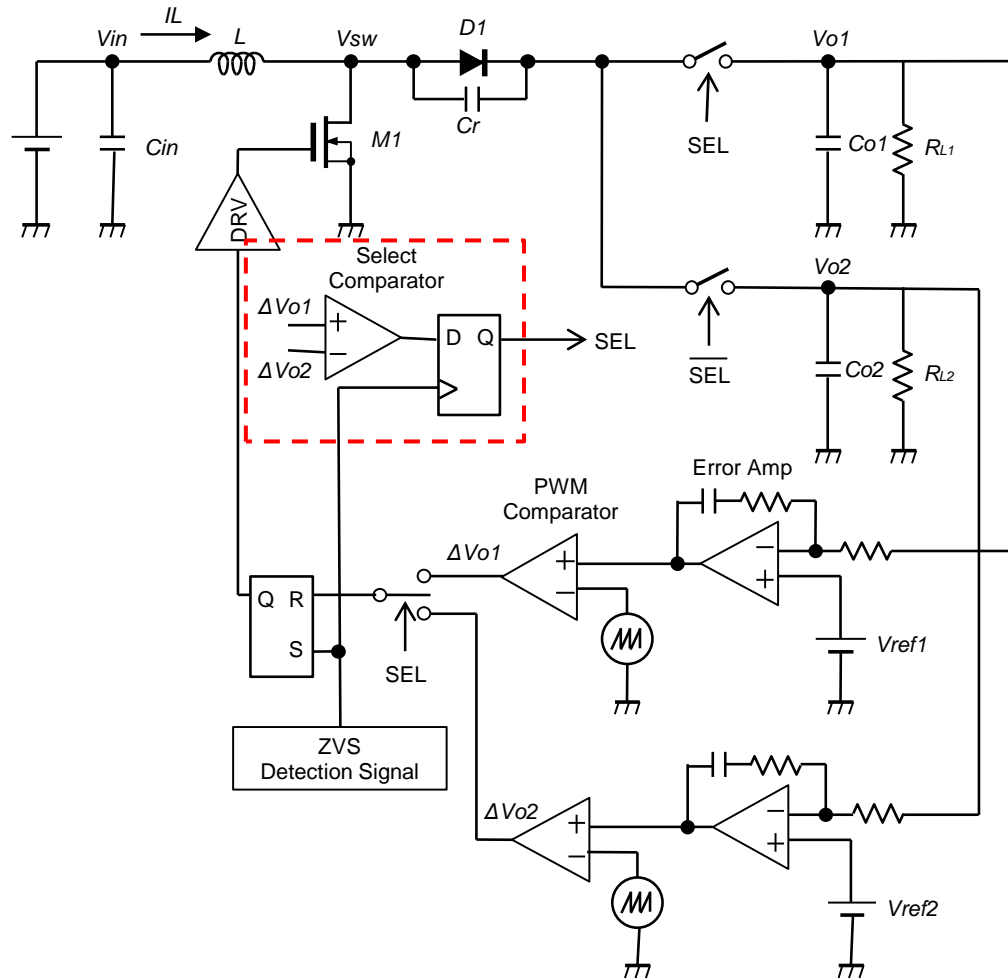
Exclusive Control
For selecting either output

Parameter	Value
Vin	2.5V
Vo1	6V
Vo2	8V
L	4.7uH
Cr	100pF
Co1 & Co2	470uF

Steady-State operation with ZVS-PWM in SIDO boost converter
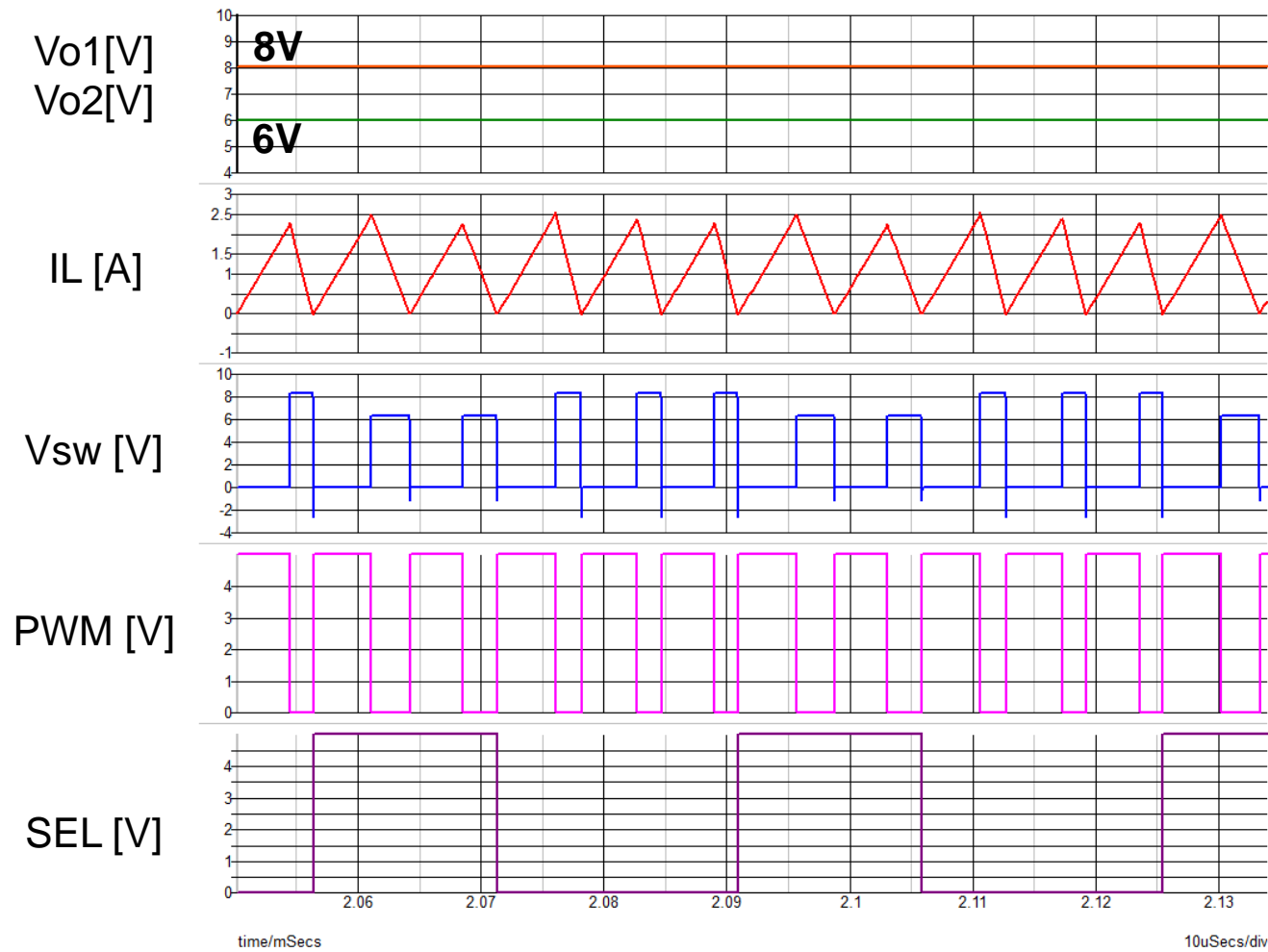
Transient operation with ZVS-PWM in SIDO boost converter
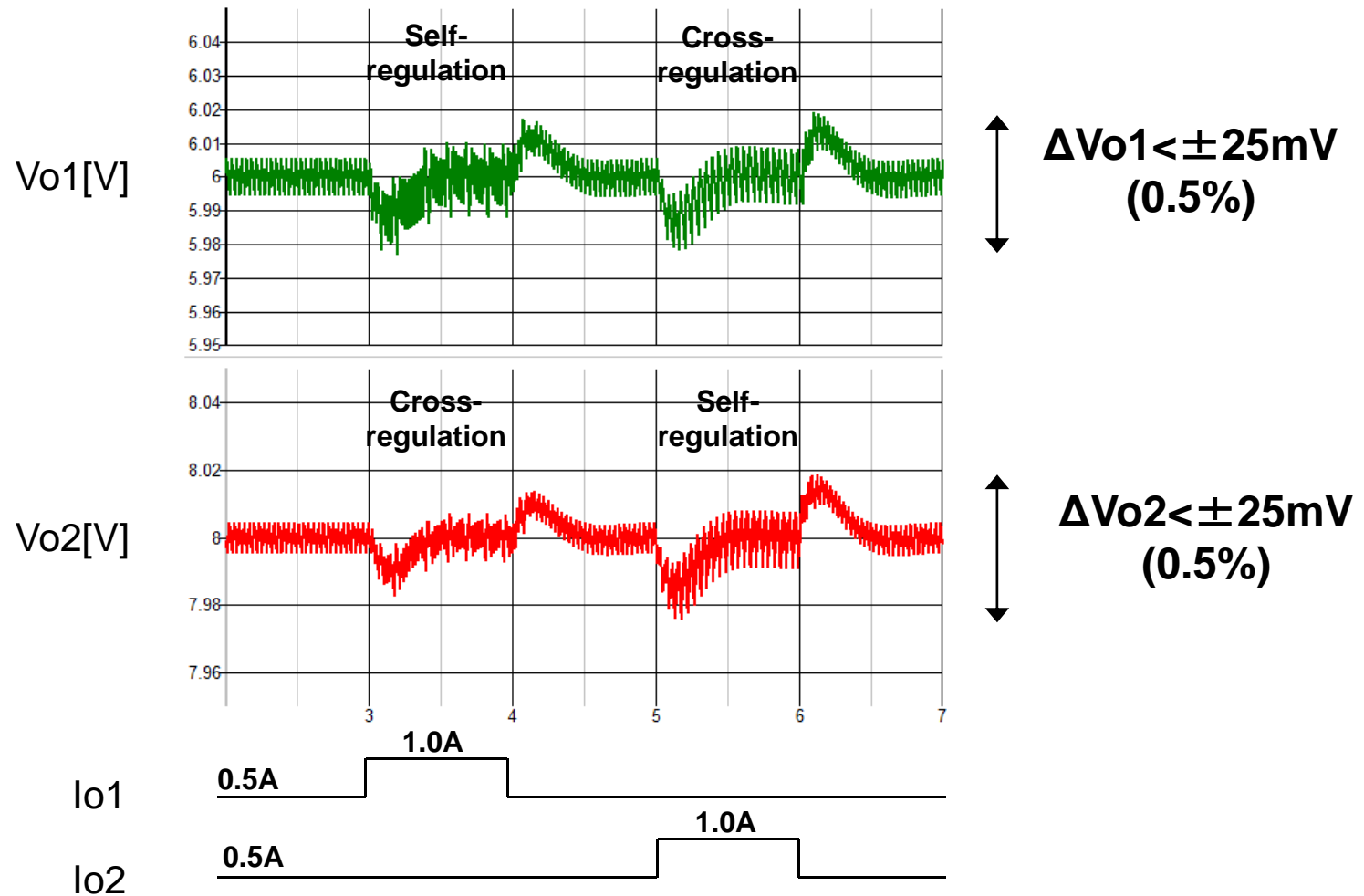
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Summary

- We have described

  ZVS configuration and operation

  for SISO buck and boost converters.

- We have extended this ZVS method

  to SIDO converters, and

  shown only their simulation results

  in the steady and transient states.

Future Research

- We consider that

  ZVS improves efficiency of these converters,

  which we will investigate

  in theory, simulations and experiments.

  ➡️ SIDO converters with ZVS control

are expected to realize cost down & high efficiency power supply circuits.

Question and Answer

Q1: Perhaps, In your system, the symmetry needed for the dual output. If the change , the phase of the regulator 1 and regulator 2 , perhaps , ZVS activity is different.

A1:Why?

Q1:The current of inductor is very important achieve to the ZVS. OK, it's fine. it's my inspiration.

Q1:Hiroo Sekiya, Chiba university

Question and Answer

Q2: How to control the output voltage of the regulator 1 and 2 in this system?

A2: In this system, we use the time division control for Vo1 and Vo2.

Exclusive control will select the output that requires more power.

So, by comparing the ΔVo1 and ΔVo2, the supply circuit is determined.

Q2: Hiroo Sekiya, Chiba university

Question and Answer

Q3: How about the size of the inductor in real circuit ? Because the L include the each inductor current of high amplitude. So, in that case, the size of the L maybe larger.

A3:The Inductor size may be larger.

But, the inductor can be reduced if you use our configuration.

Q3:Hiroo Sekiya, Chiba university

Question and Answer

Q4:I agree with your opinion that the number of inductor is just one. How about the Inductor size?

If the current trough the inductor is low amplitude, in that case, the core size become a small.

but, for the high amplitude case, the core size become a Large. So, Which is better?

A4:It is Case by Case. However, we think that the total area of power supply will be reduced in our configuration.   **Q4:Hiroo Sekiya, Chiba university**