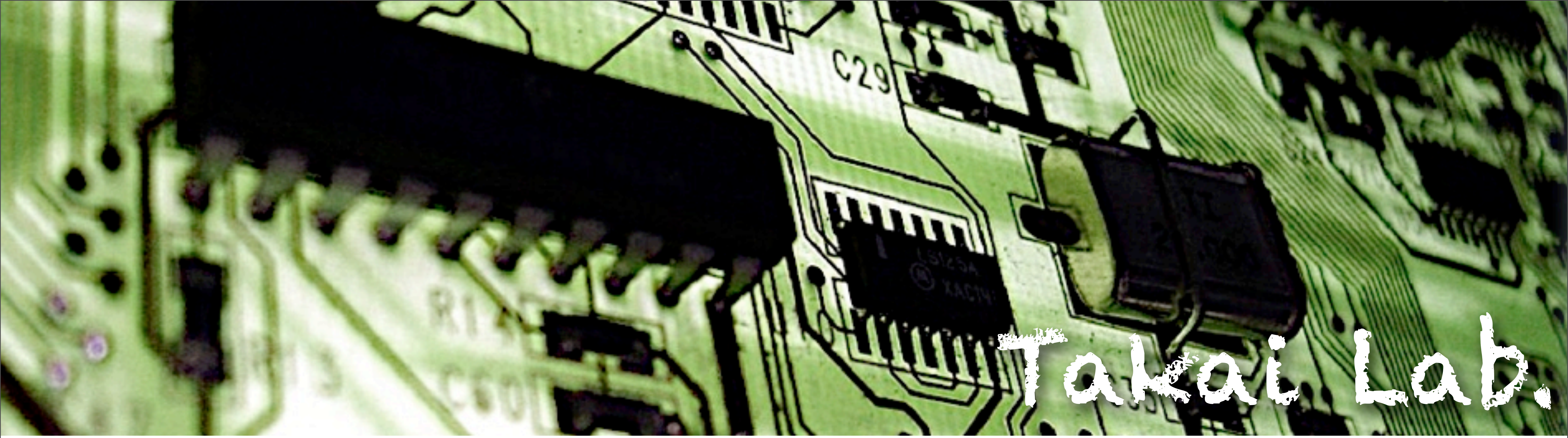

SIDO converter with variable control time duty

Naoya Shiraishi
Yasunori Kobori, Nobukazu Takai, Nobukazu Tsukiji,
Kotaro Kaneya, Shunsuke Tanaka, Haruo Kobayashi

Gunma University.

群馬大学
GUNMA UNIVERSITY

4S-AVIC2014, Ho Chi Minh, Vietnam, Oct 23

OUTLINE

- Background and Objective
- Conventional Buck-Buck SIDO converter
  and drawback of conventional control method
- Proposed control method
- Sawtooth wave generator circuit
- Simulation results
- Conclusions and Future works

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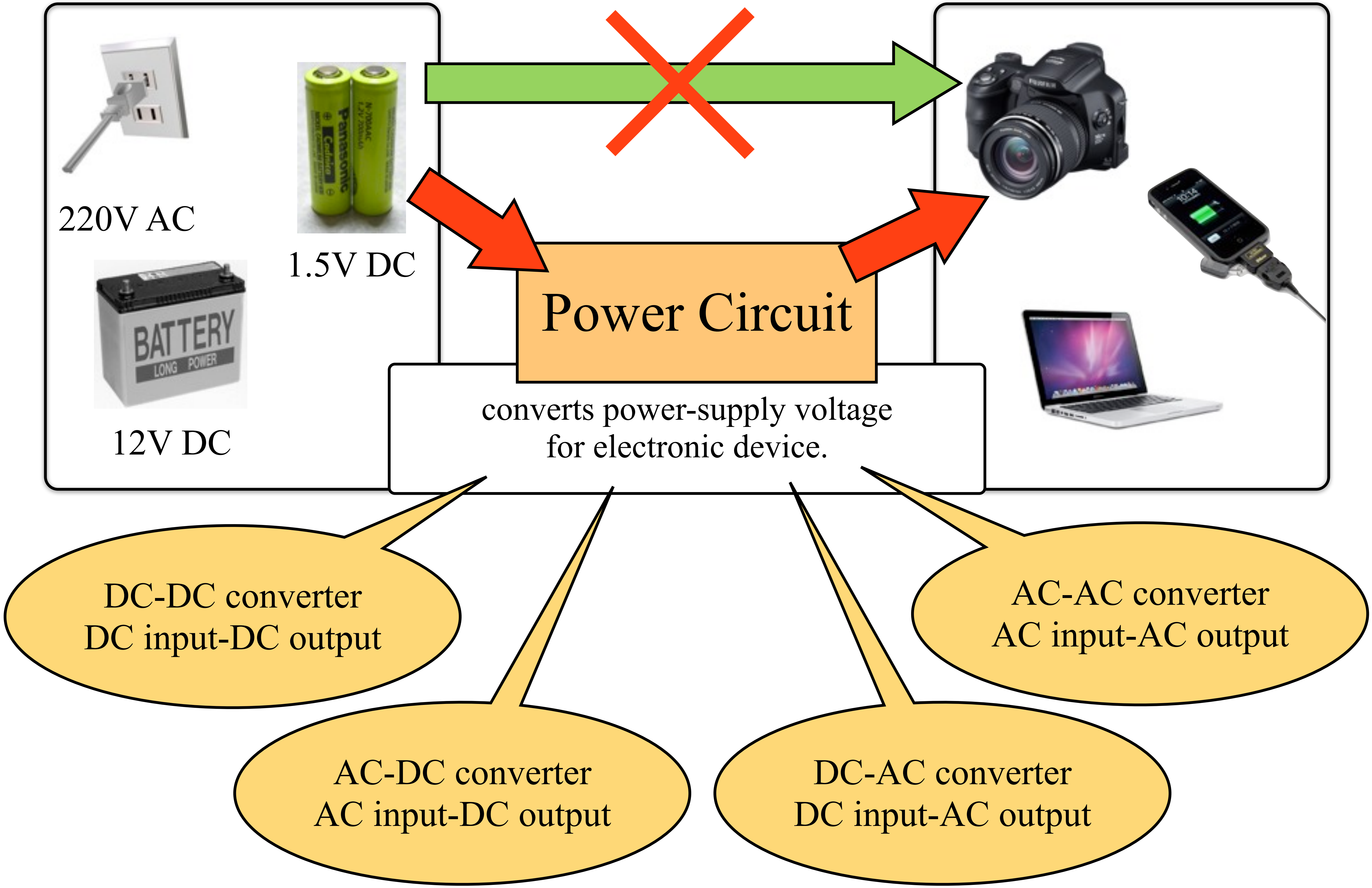
Background and Objective



Background and Objective

220V AC

1.5V DC

12V DC

Power Circuit

Converts power-supply voltage
for electronic device.

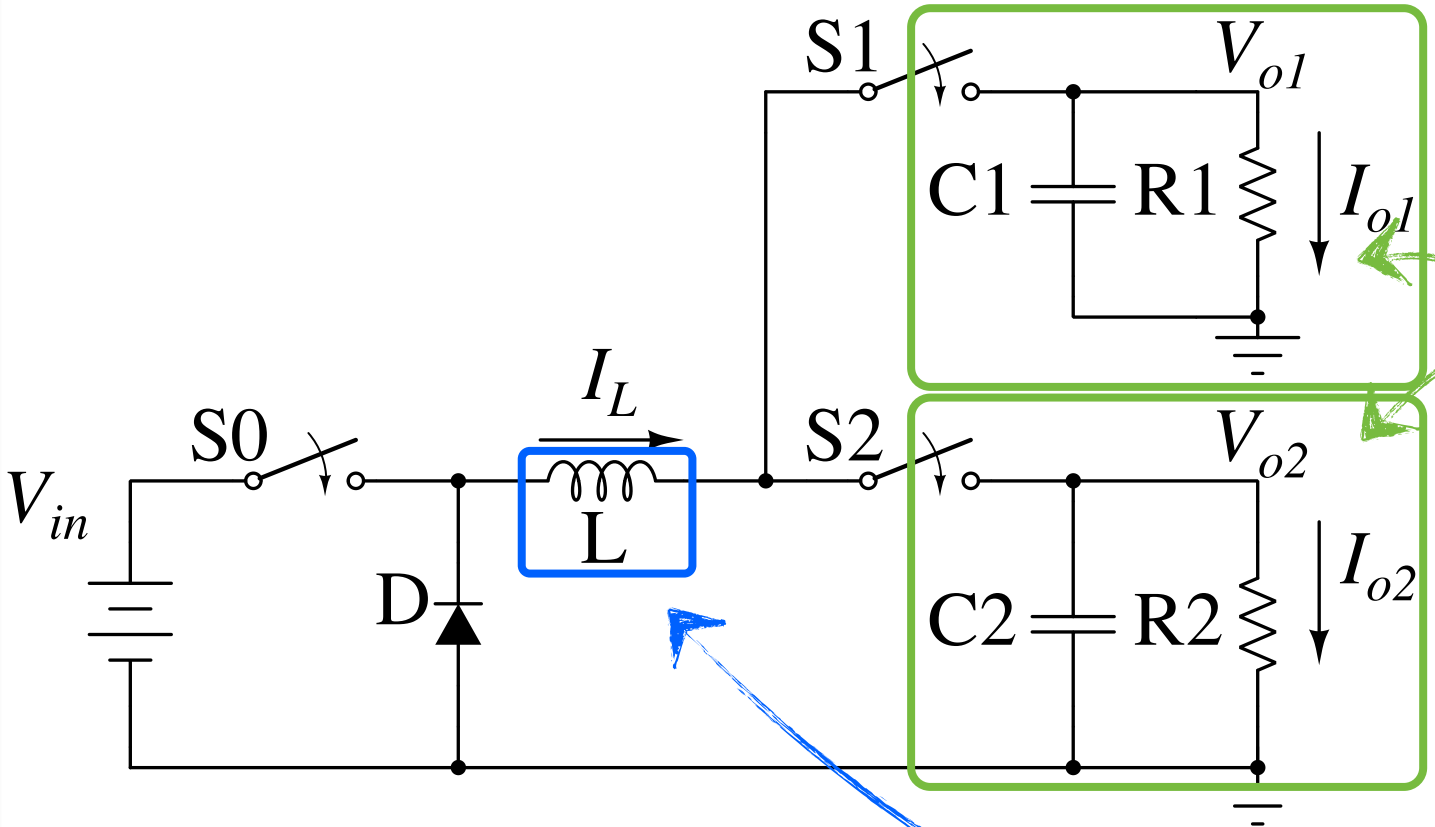
DC-DC converter
DC input-DC output

Numerous converters used in a single device.

↓

Increases the area of electronic devices.

Background and Objective



Buck-Buck SIDO converter

DC-DC converter
DC input-DC output

SIDO means・・・

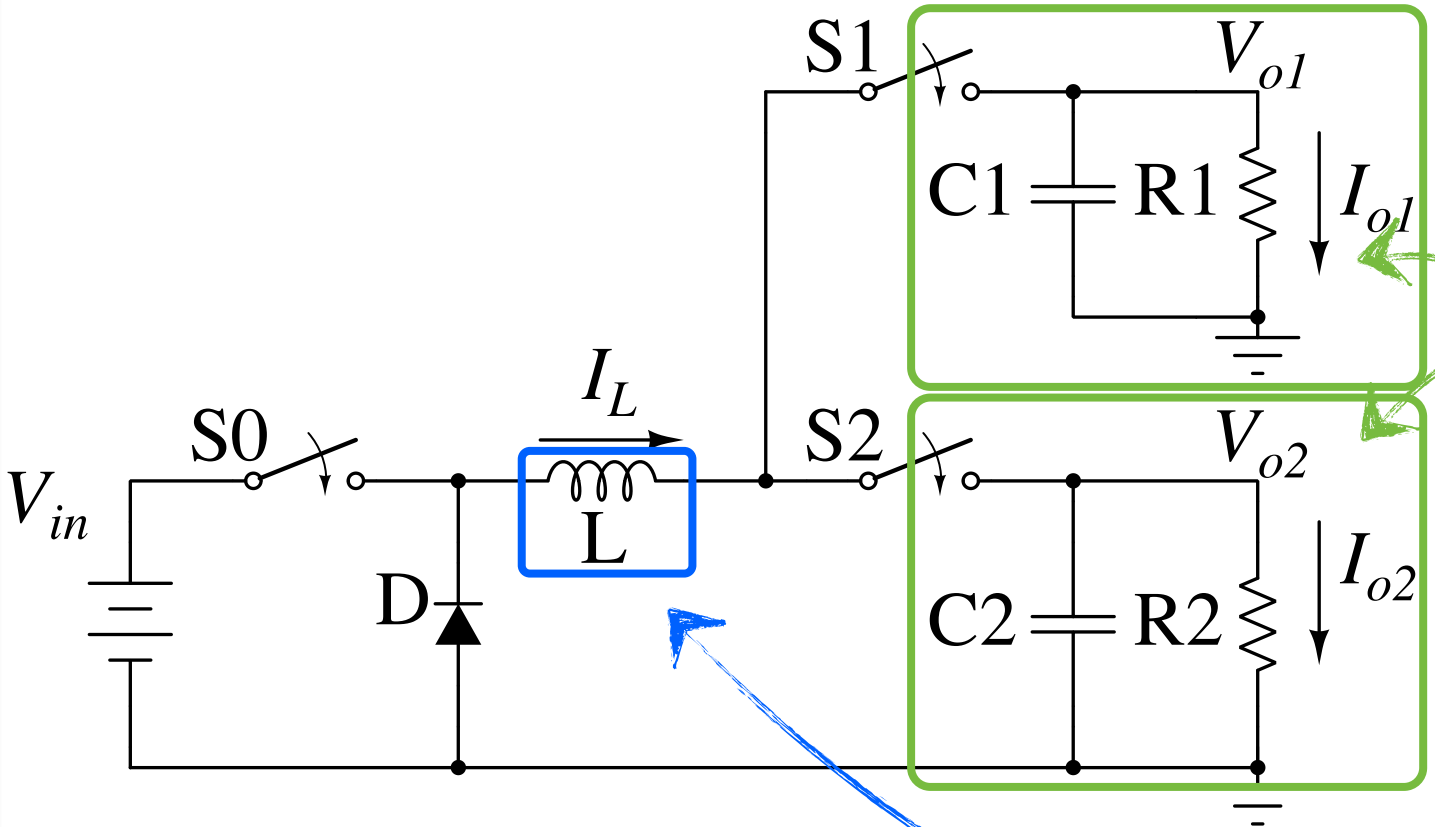
Single Inductor Dual Output

Dual Outputs

Single Inductor

Miniaturization

Background and Objective



Buck-Buck SIDO converter

DC-DC converter
DC input-DC output

SIDO means・・・

Single Inductor Dual Output

Dual Outputs

Single Inductor

Miniaturization

High Performance

New control method

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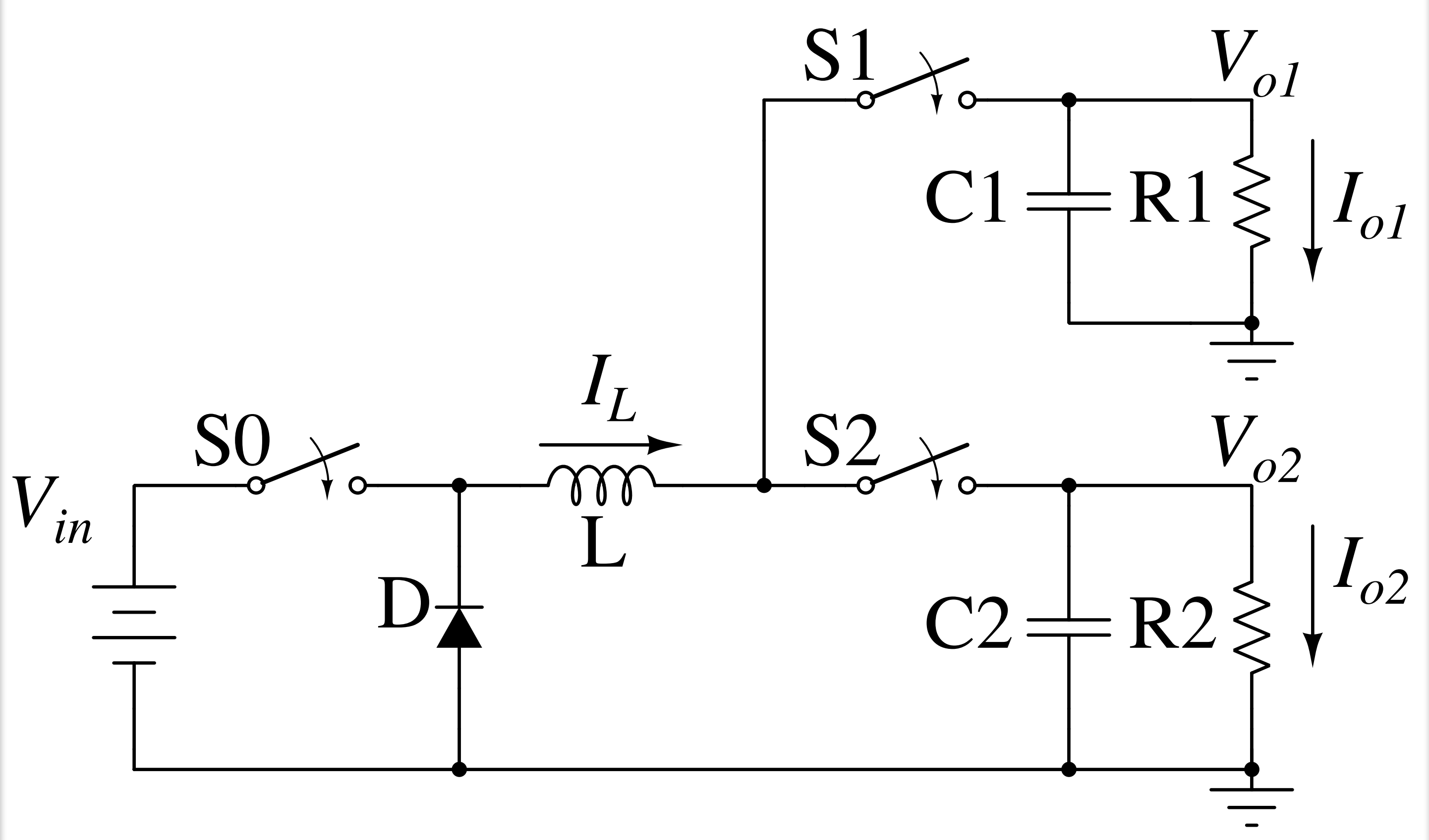
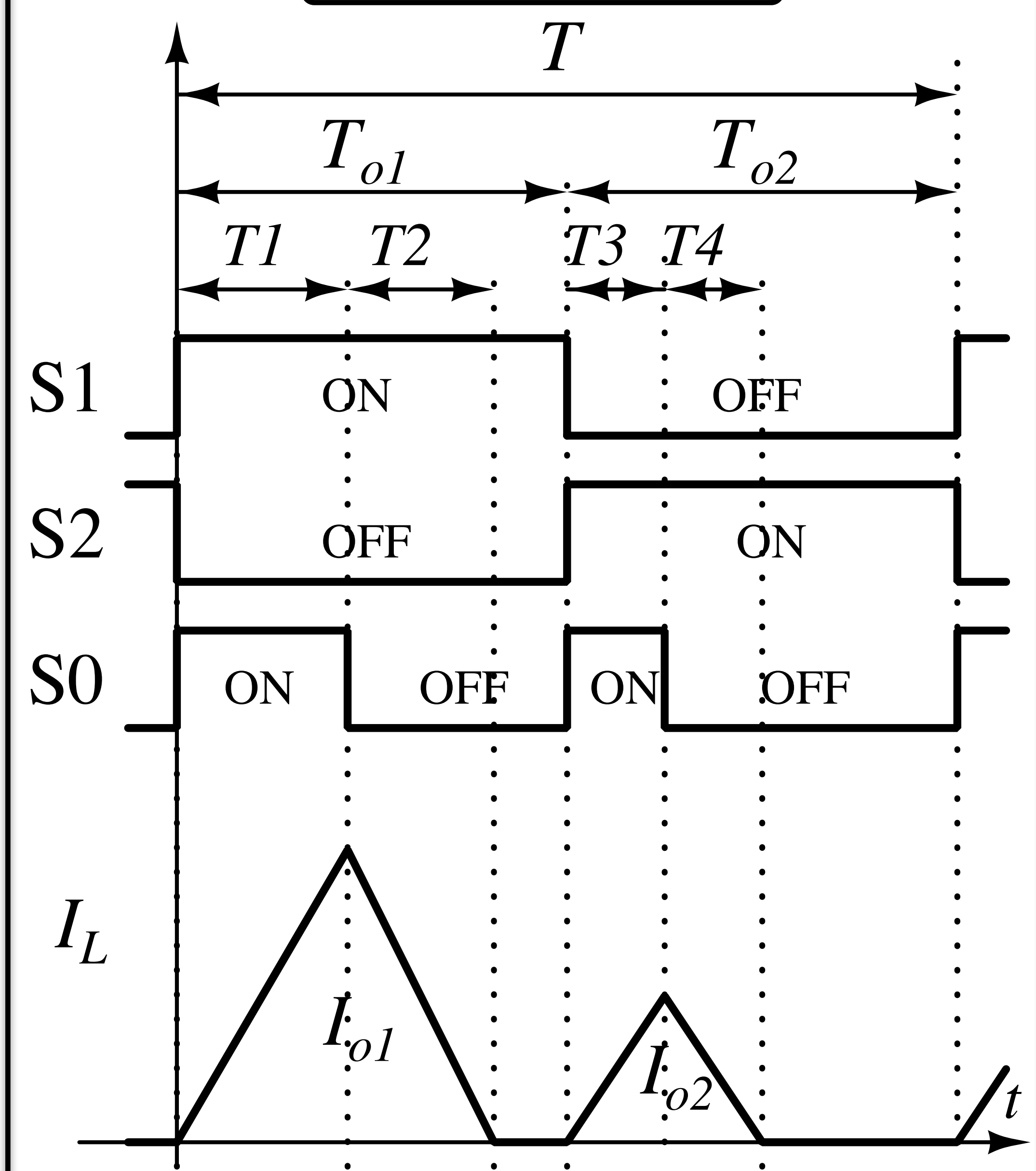
Conventional Buck-Buck SIDO converter

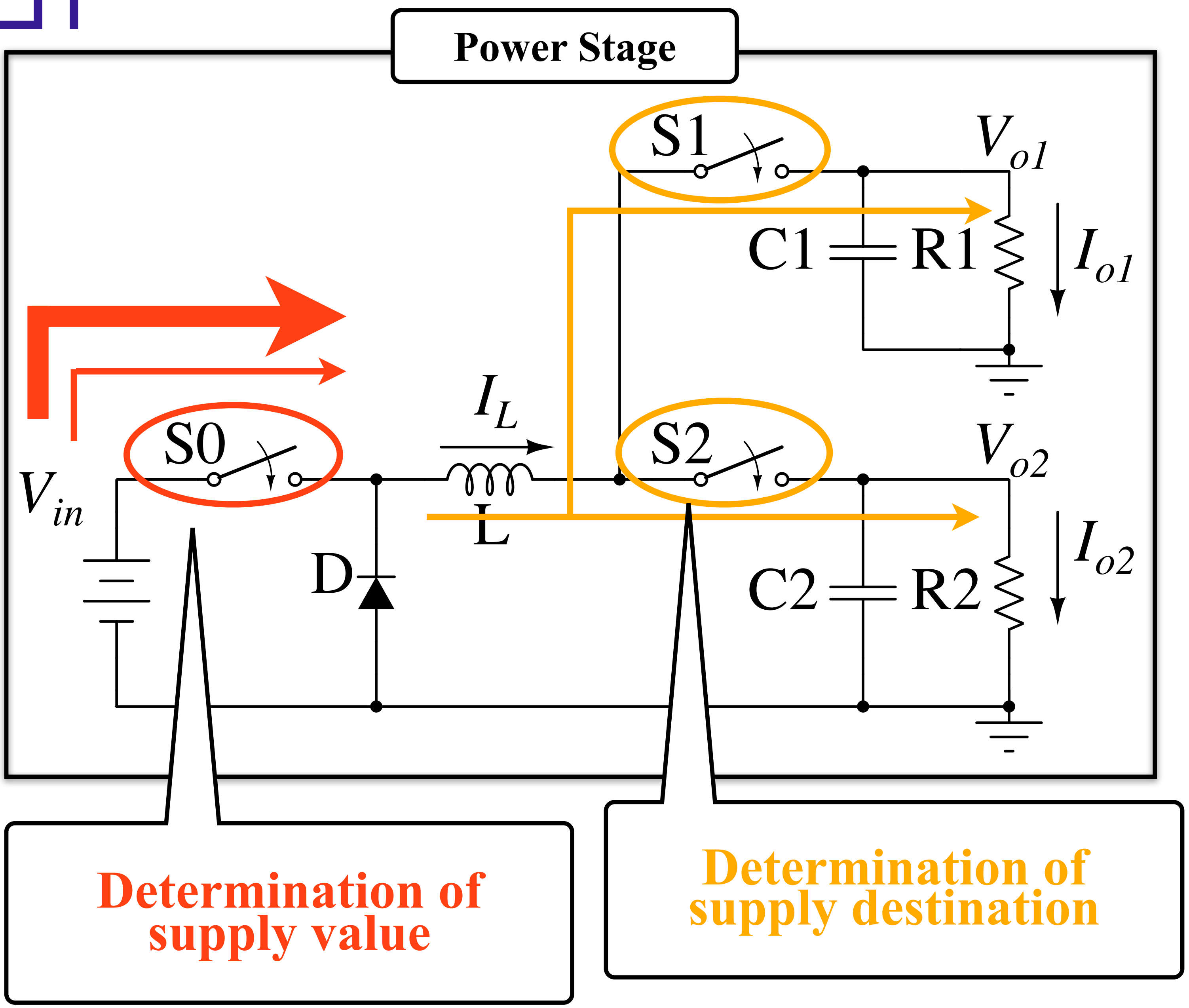
Power Stage

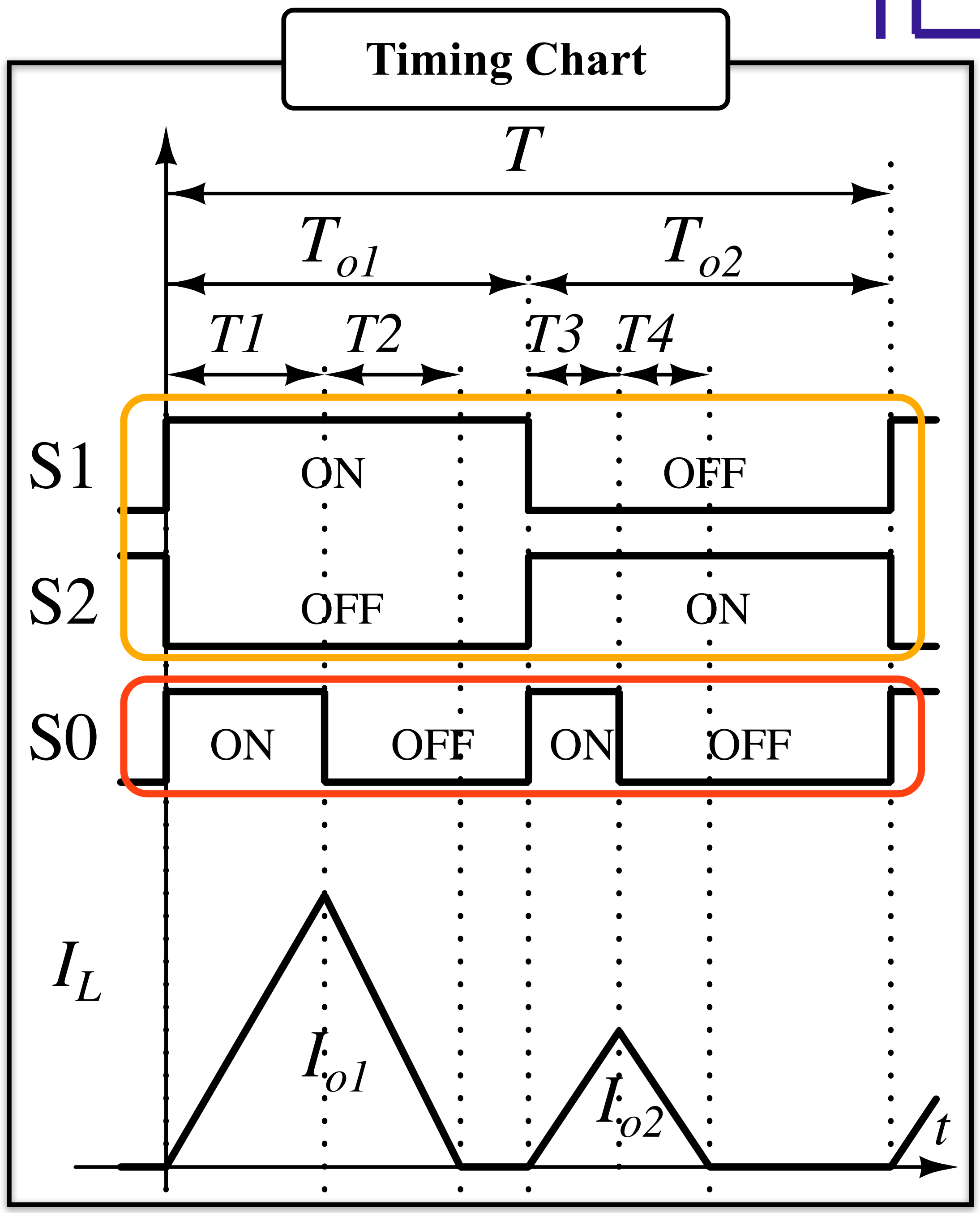


Timing Chart



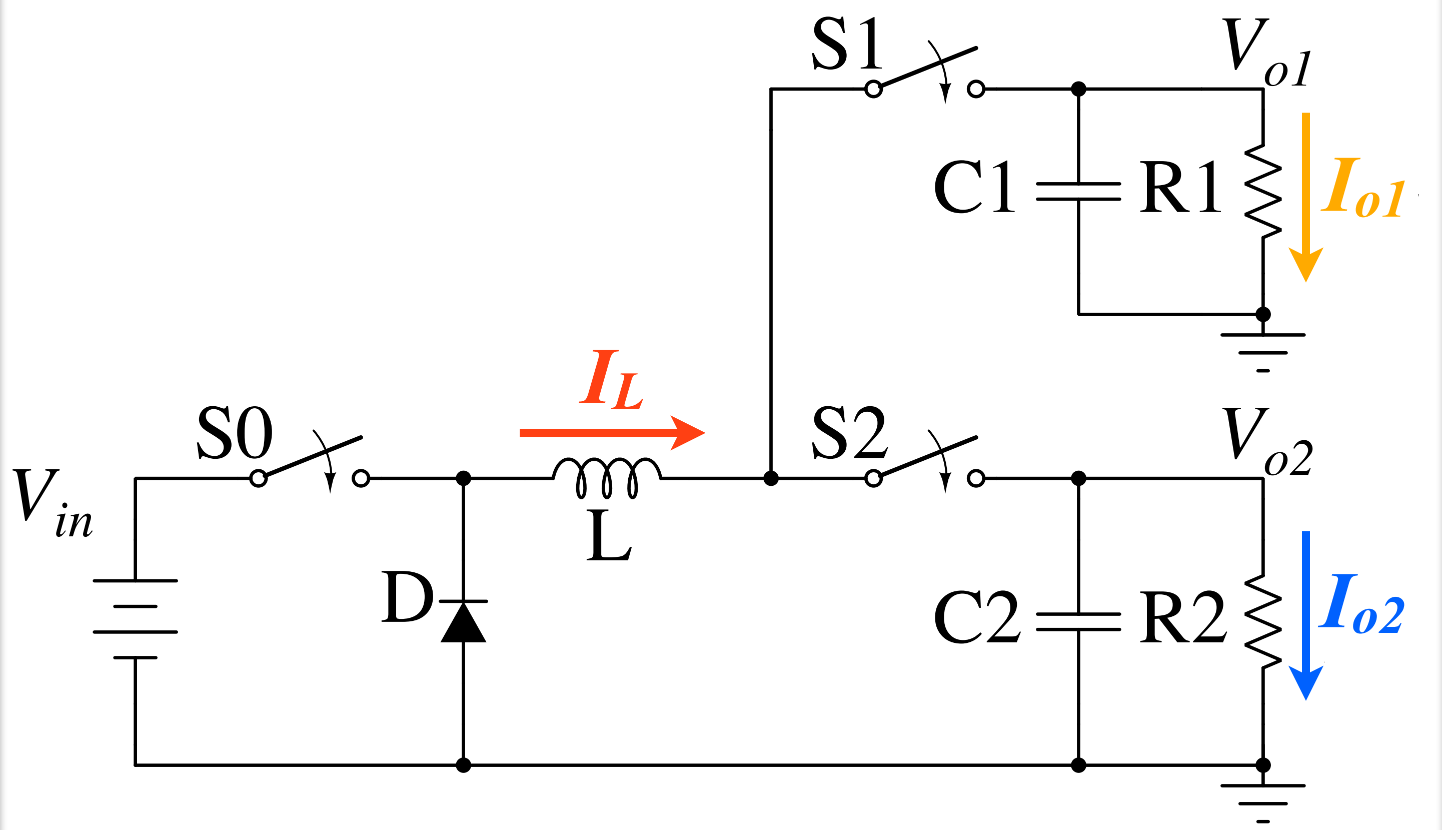
Conventional Buck-Buck SIDO converter



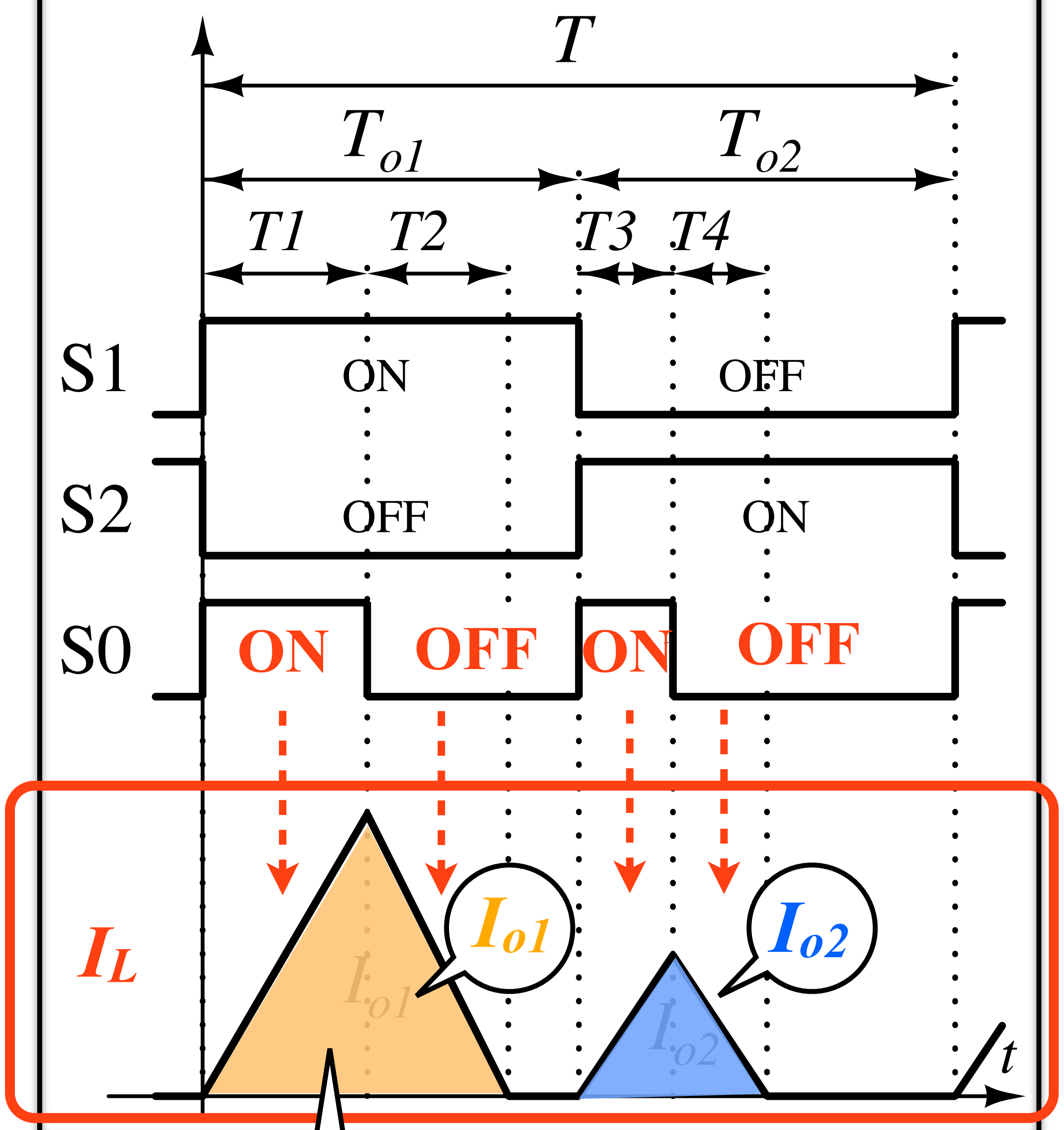


Conventional Buck-Buck SIDO converter

Power Stage

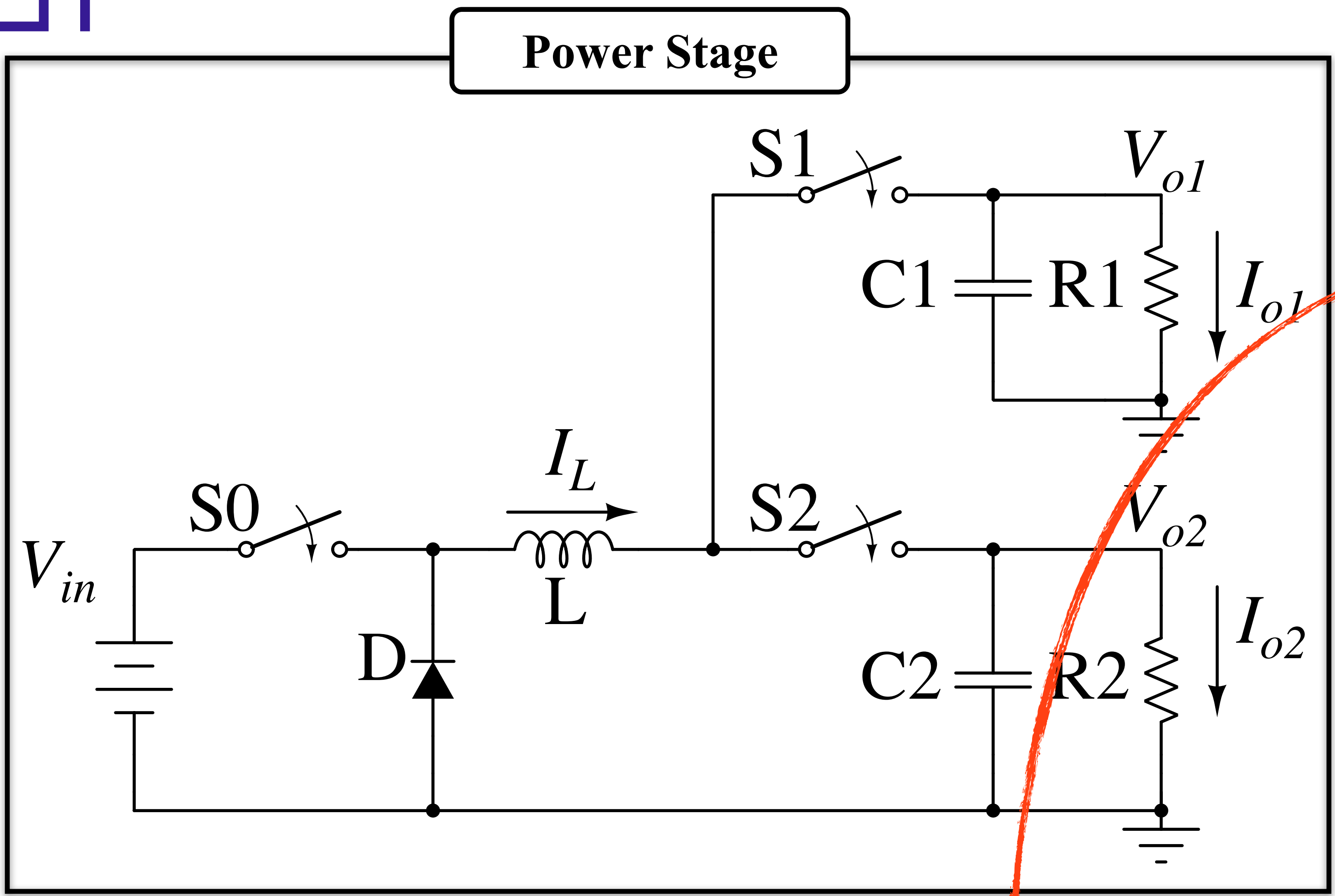


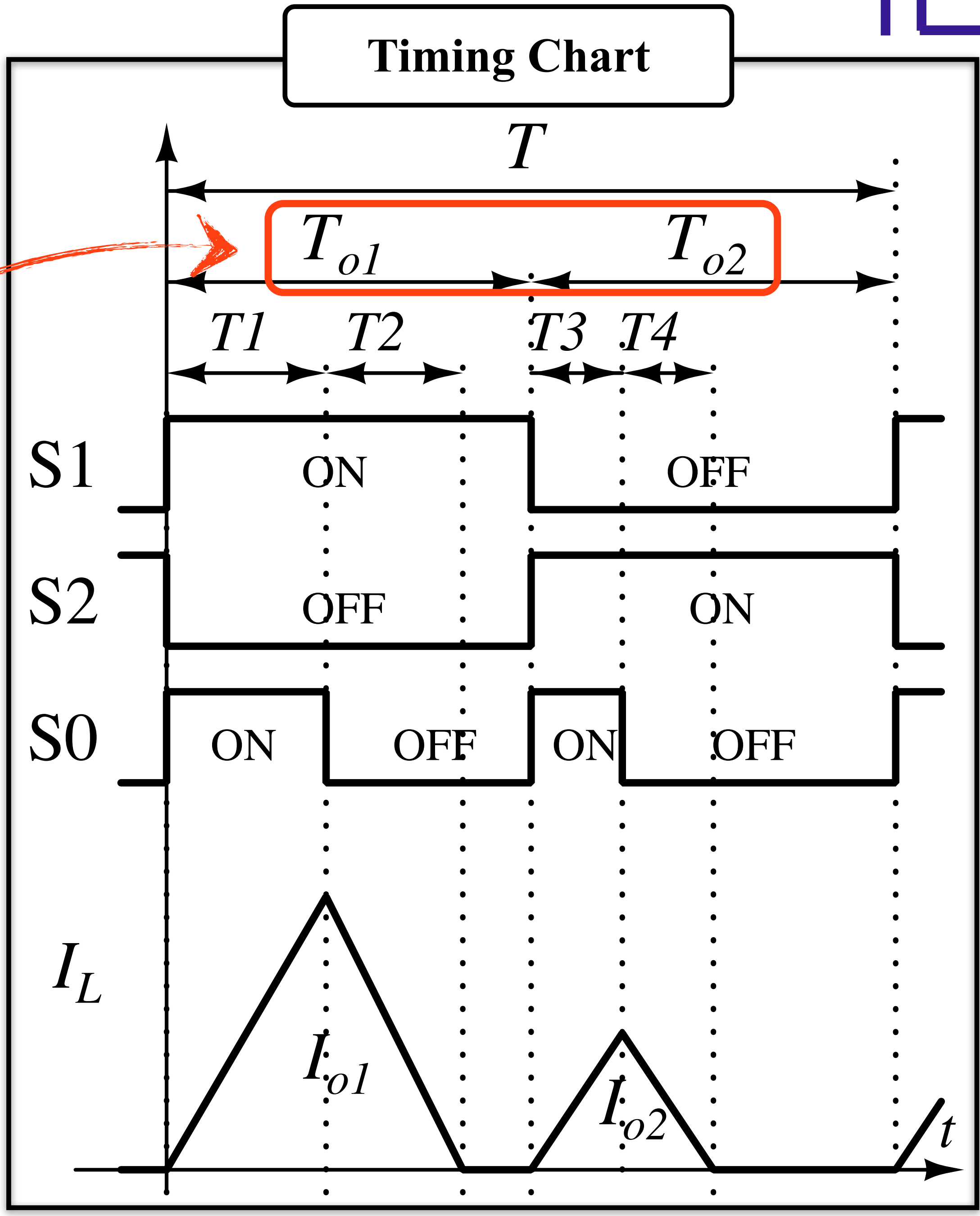
Timing Chart



Load current is determined by this area

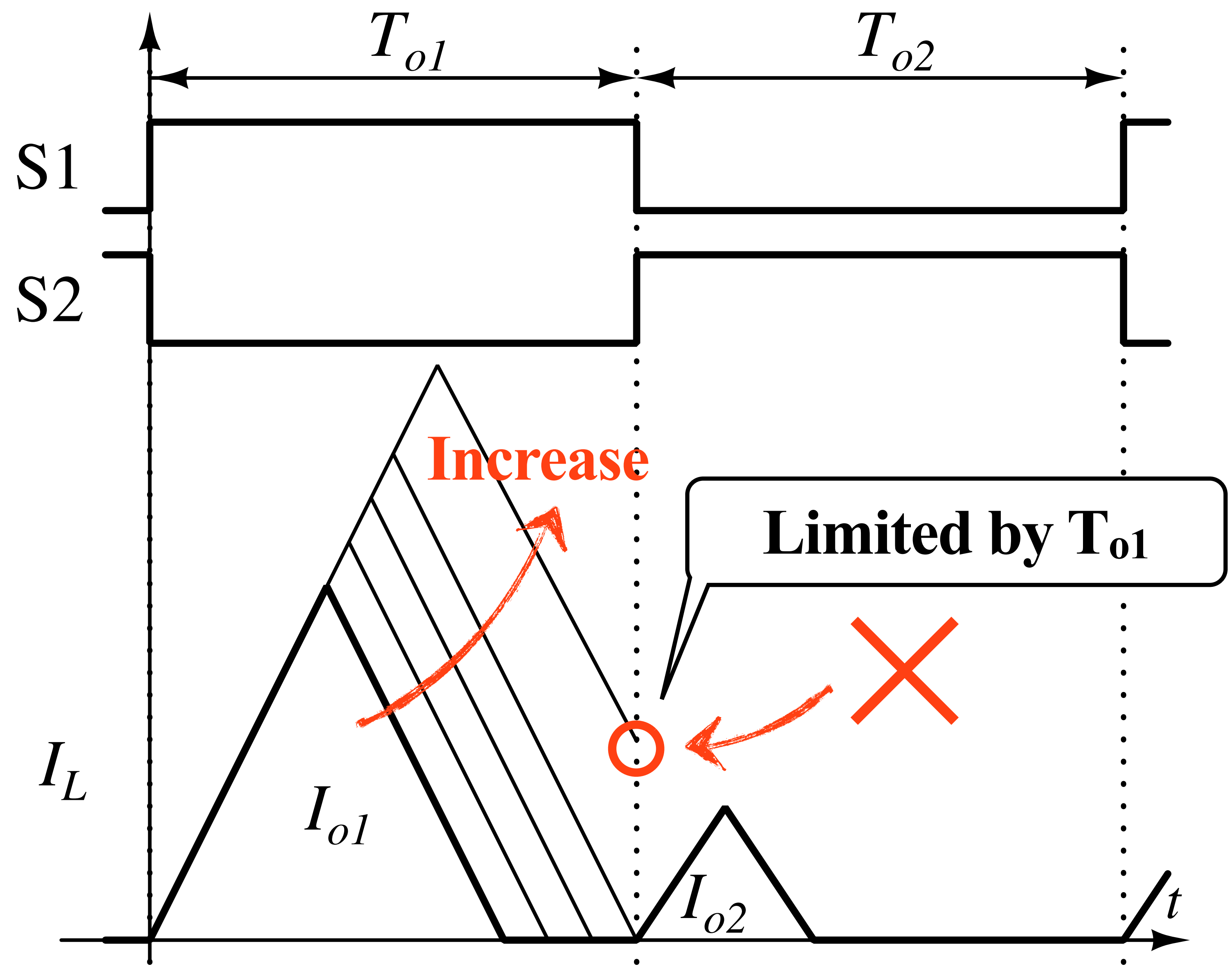
Conventional Buck-Buck SIDO converter





Control time ratio To1:To2 is **fixed**.

Drawback of conventional control method



It isn't possible to work in large load current ratio.

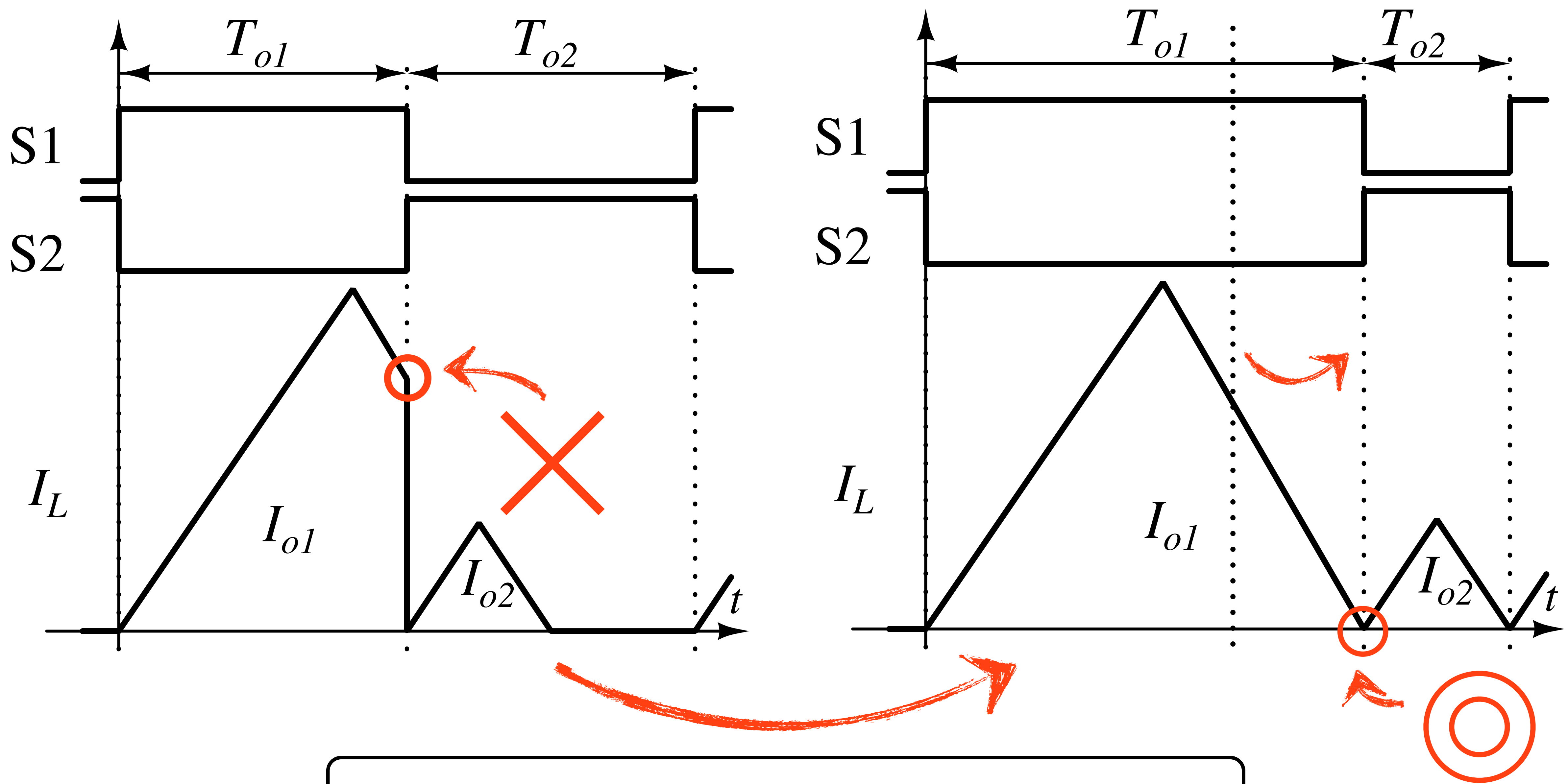
Proposed method

Conventional

Control time ratio is **fixed**

Proposal

Control time ratio is **variable**



Operation range will become larger

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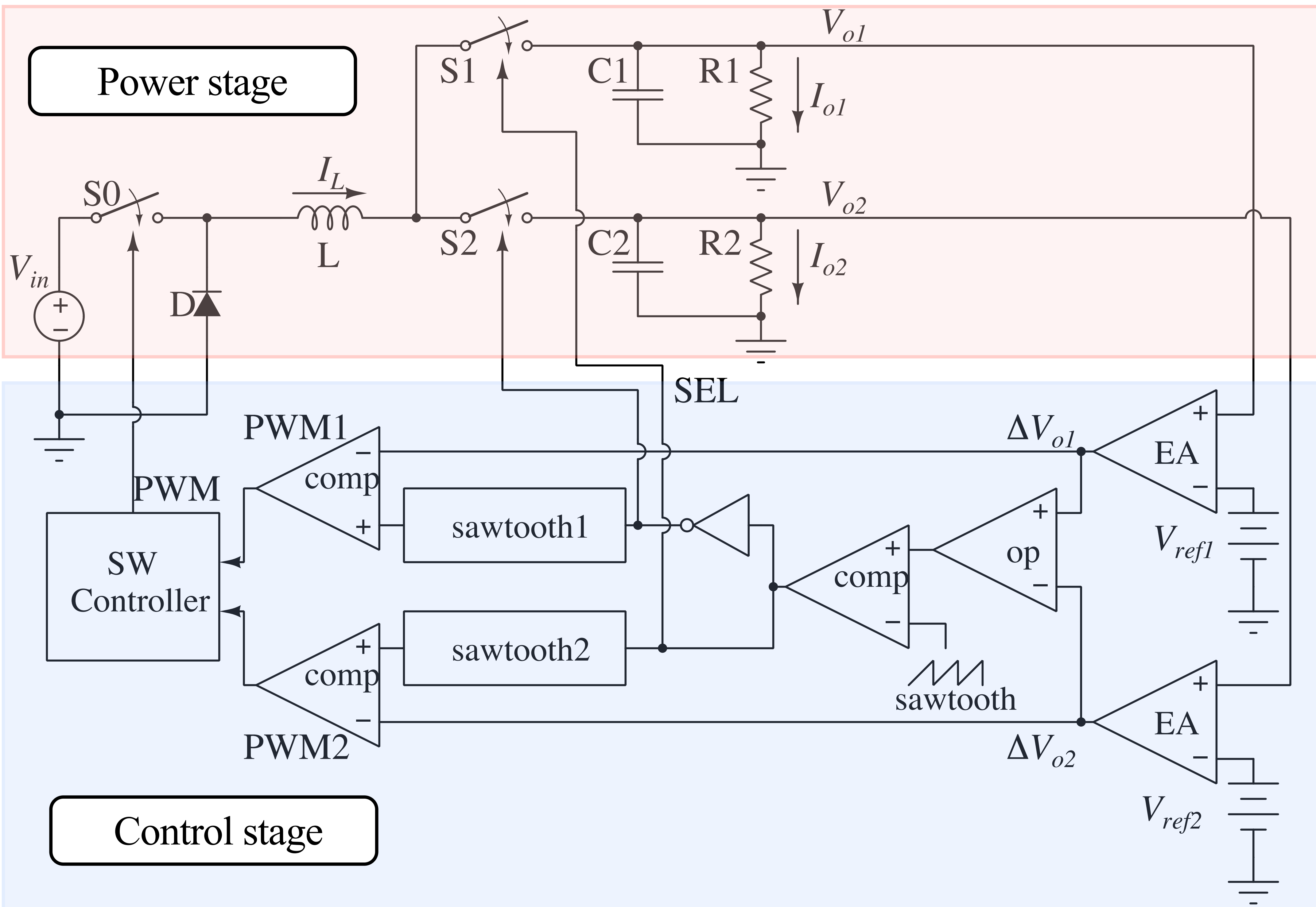
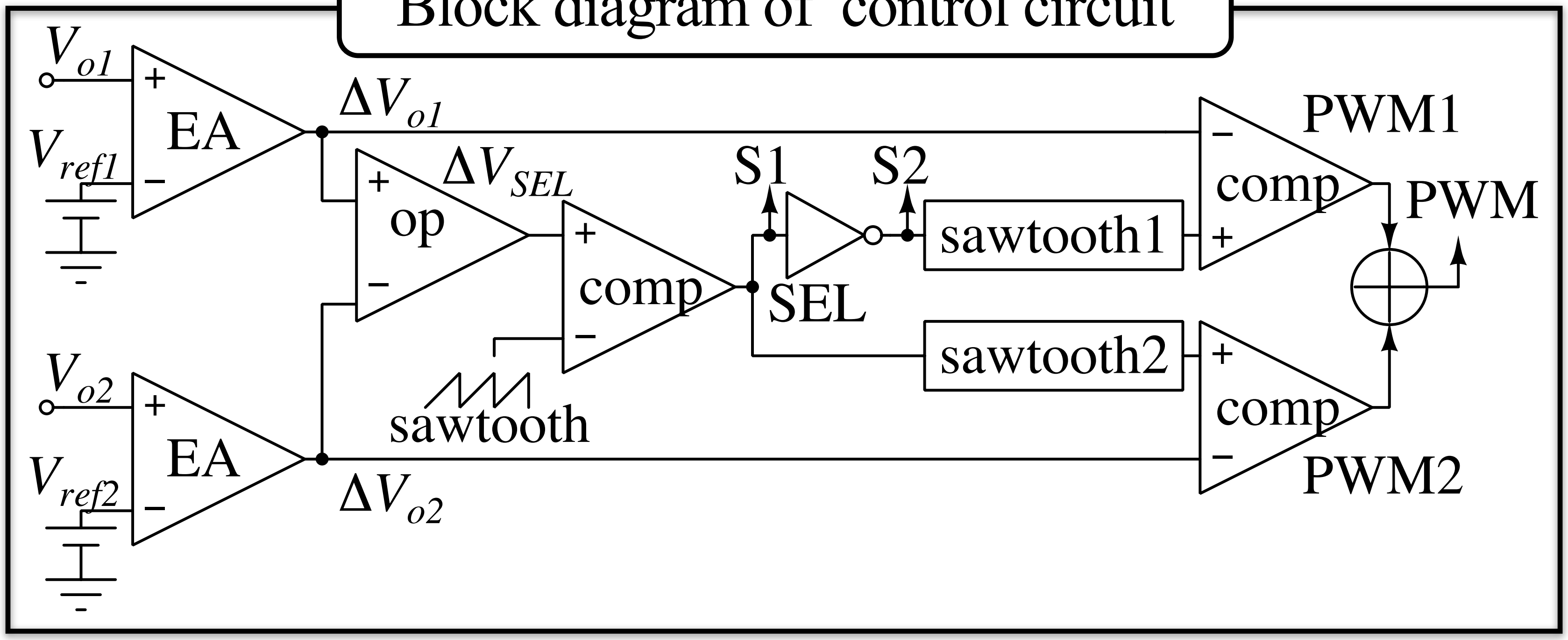
Proposed control method

Entire block diagram of the proposed circuit



Proposed control method

Block diagram of control circuit



【Flow of the proposed control method】

I.Acquisition of error voltage ΔV_{o1},ΔV_{o2}.

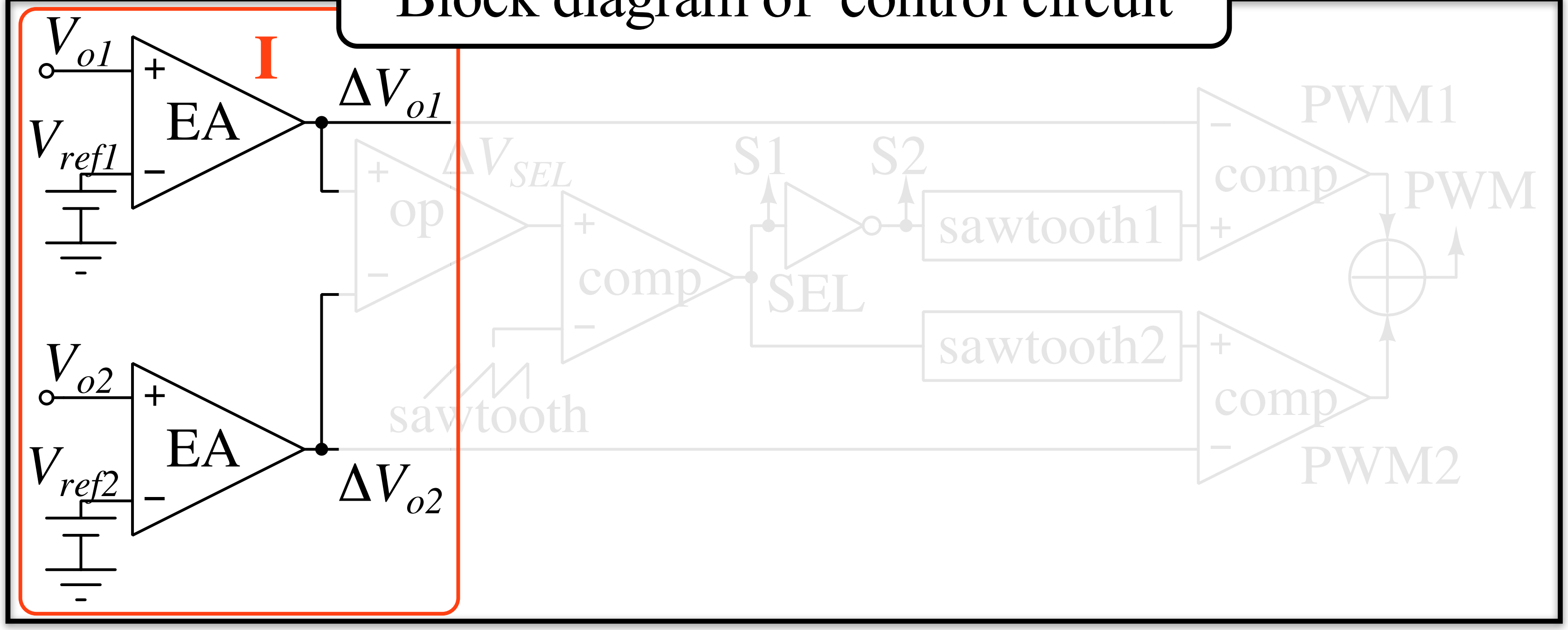
II.Generation of SEL signal responding to two output voltage error ratio.

III.Generation of sawtooth wave with matching the High/Low time width of SEL signal.

IV.Generation of PWM signal by comparing sawtooth with ΔV_{o1},ΔV_{o2}.

Proposed control method

Block diagram of control circuit



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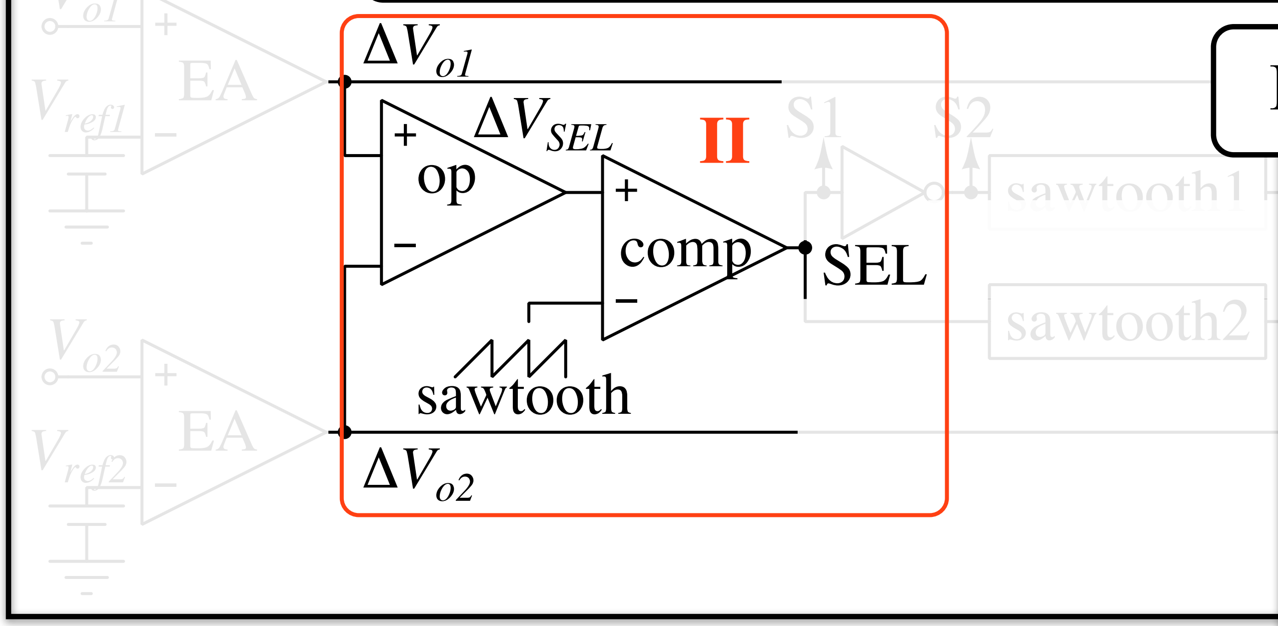
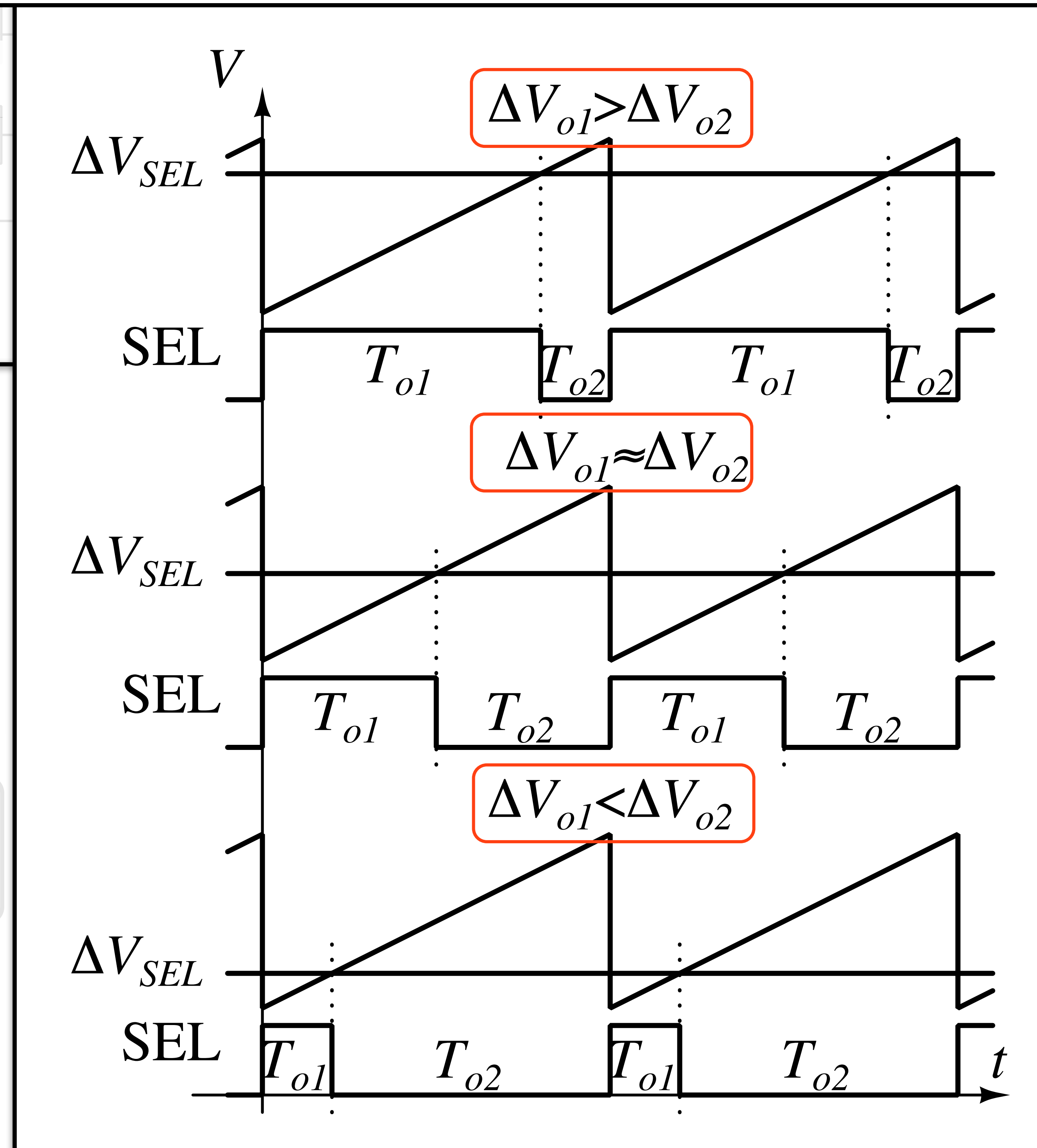
Block diagram of control circuit



Relation between the value of and control time ratio



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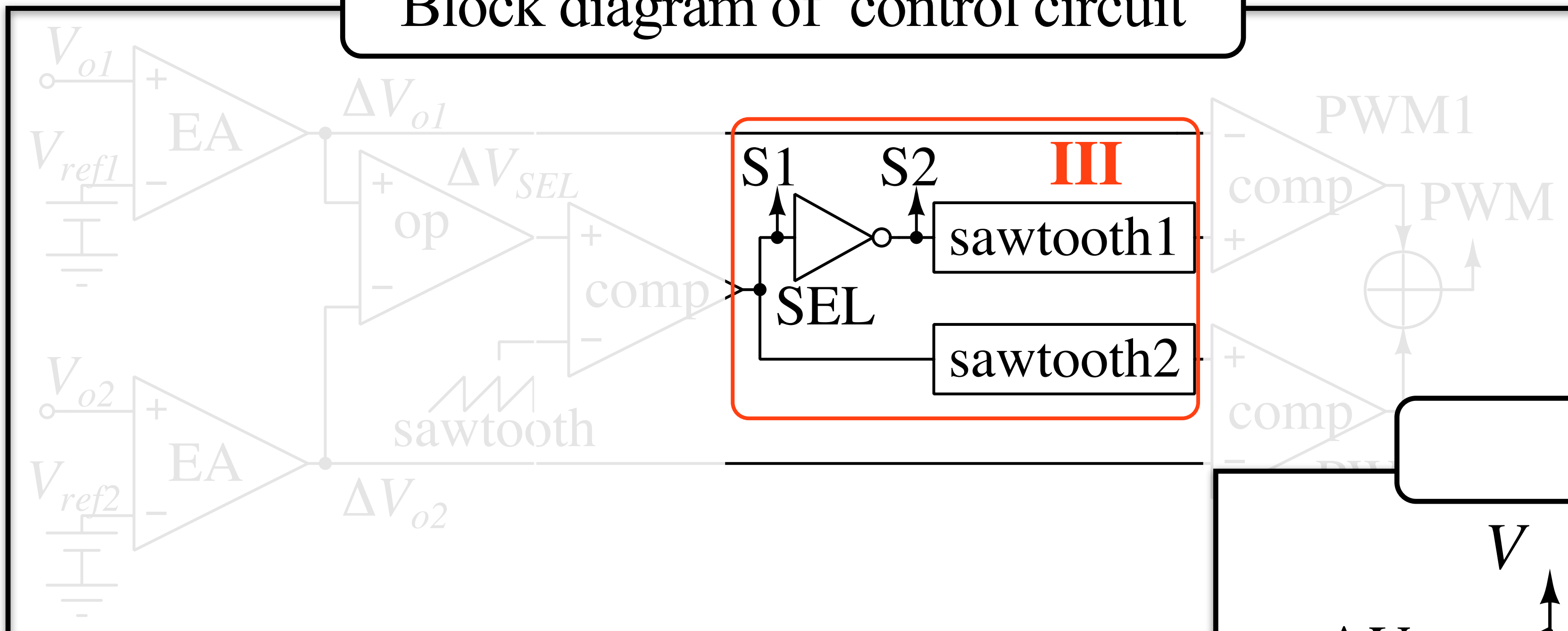
Proposed control method

Block diagram of control circuit



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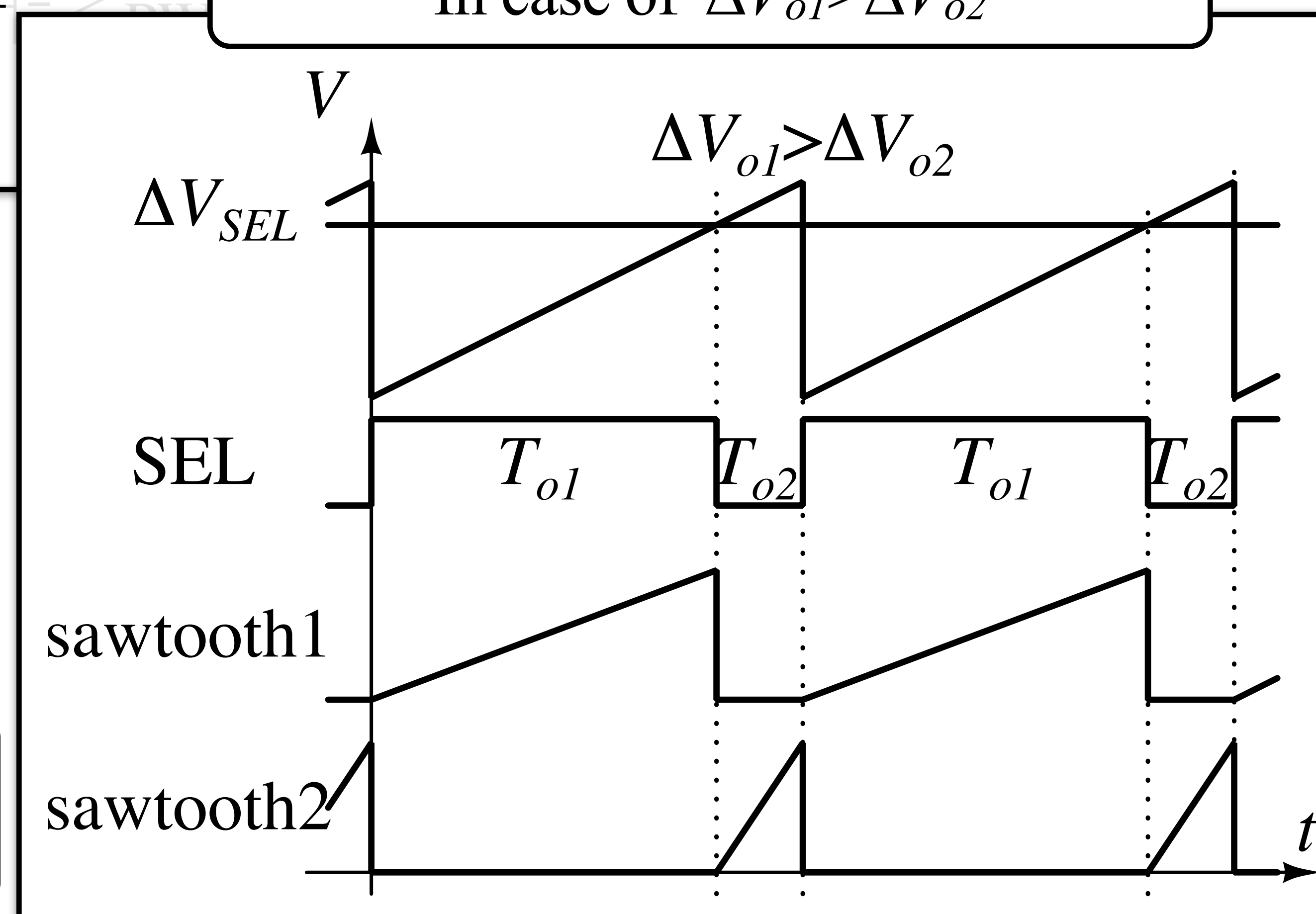
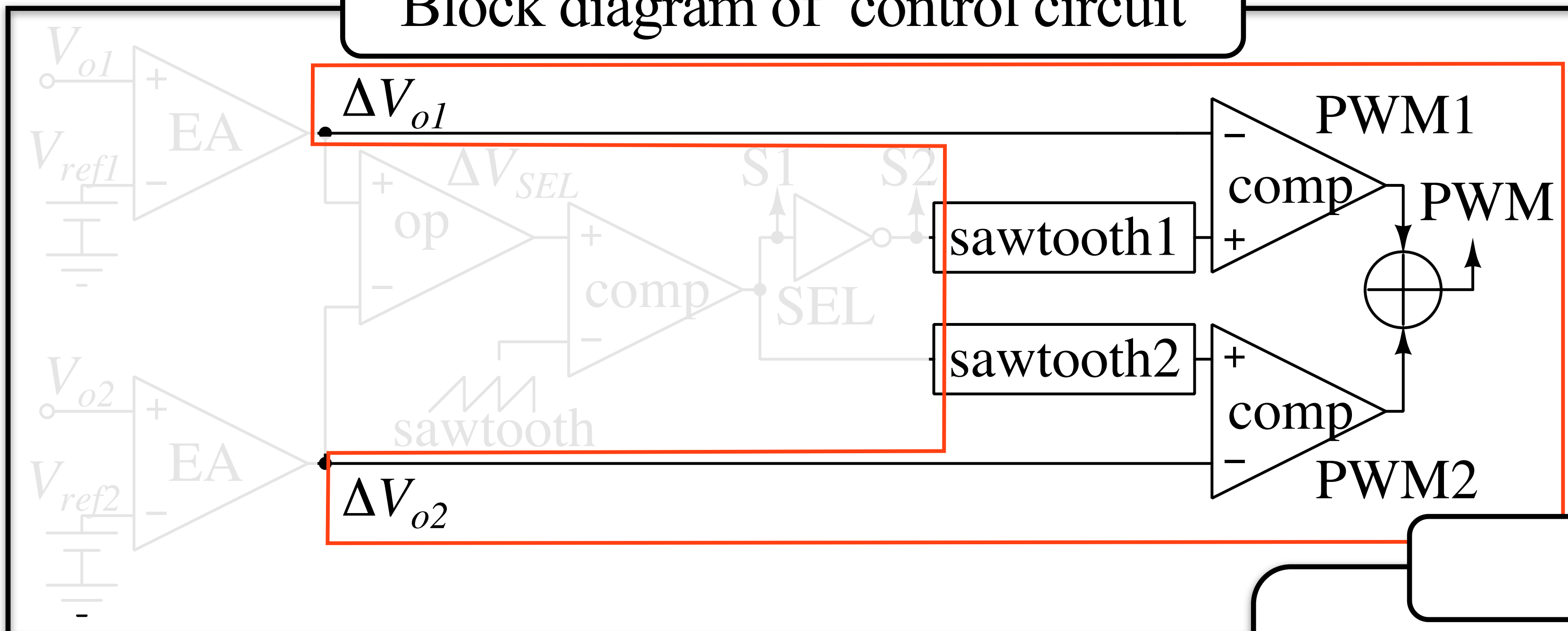
In case of ΔV_{o1}>ΔV_{o2}



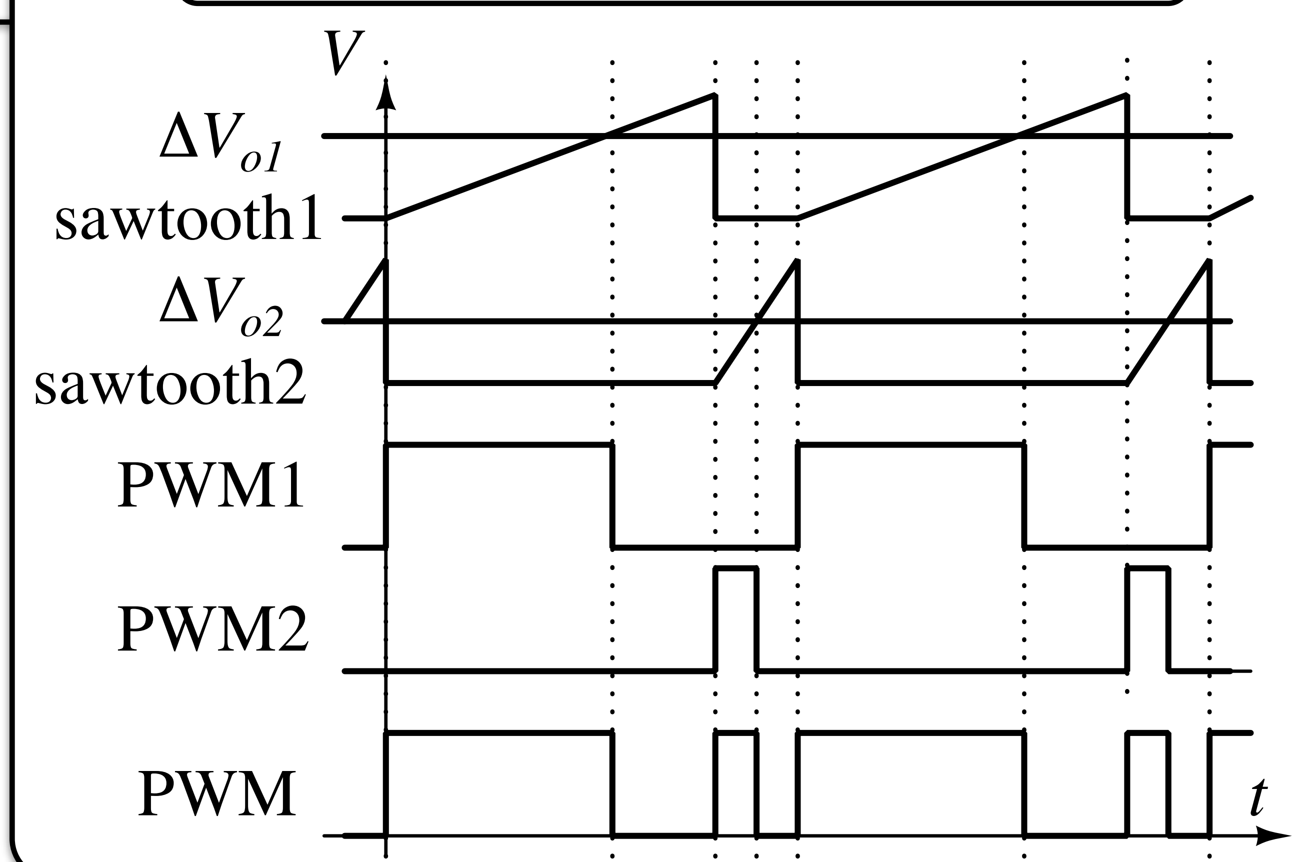
Proposed control method

Block diagram of control circuit



IV

In case of $\Delta V_{o1} > \Delta V_{o2}$



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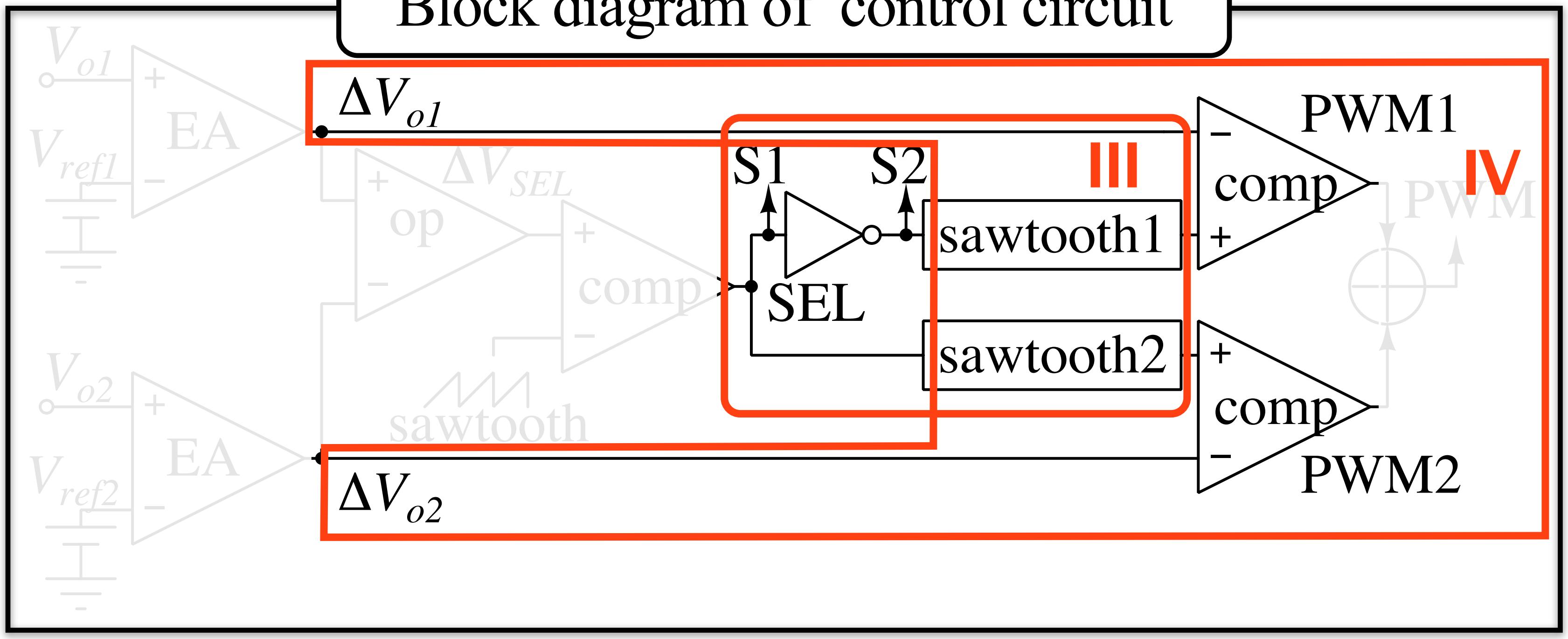
Sawtooth wave generator circuit

Block diagram of control circuit



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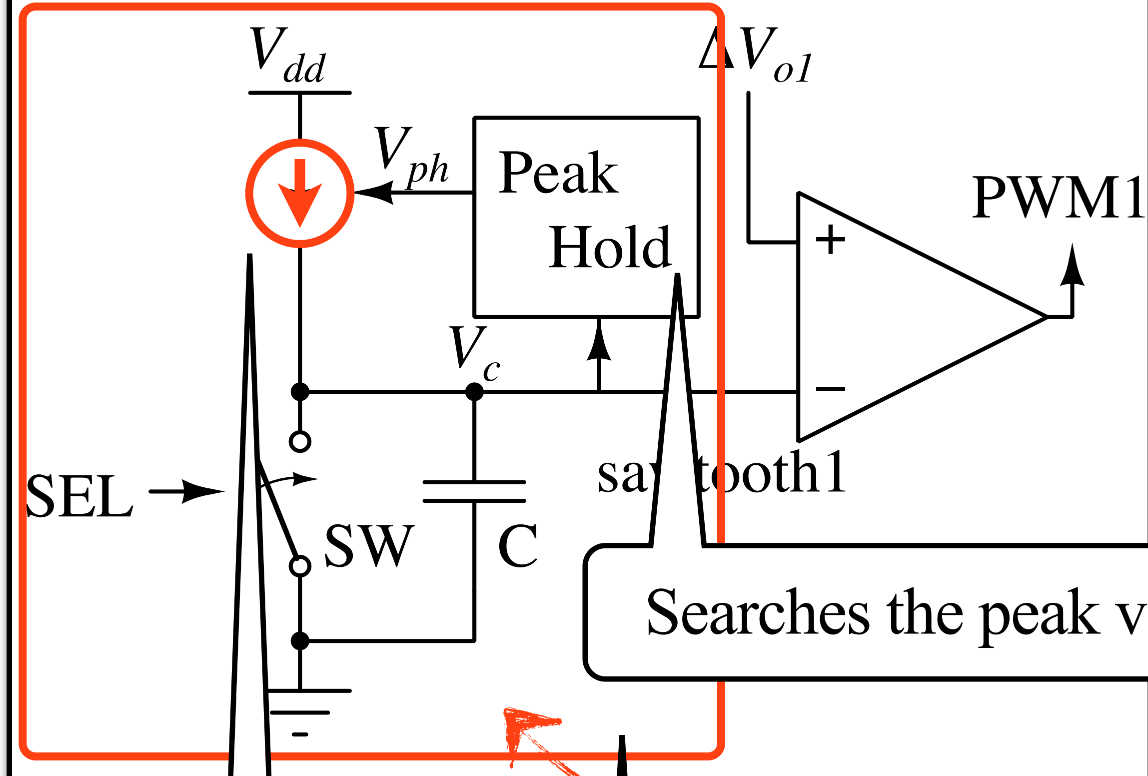
More detail

Sawtooth wave generator circuit

Sawtooth wave generator used in proposal method

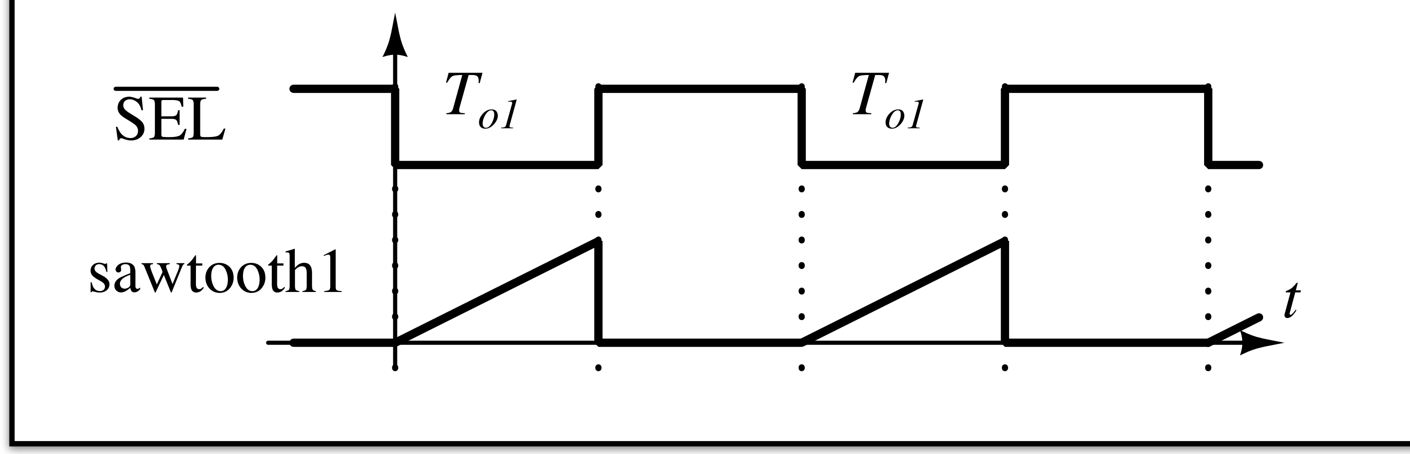


Searches the peak value of sawtooth.

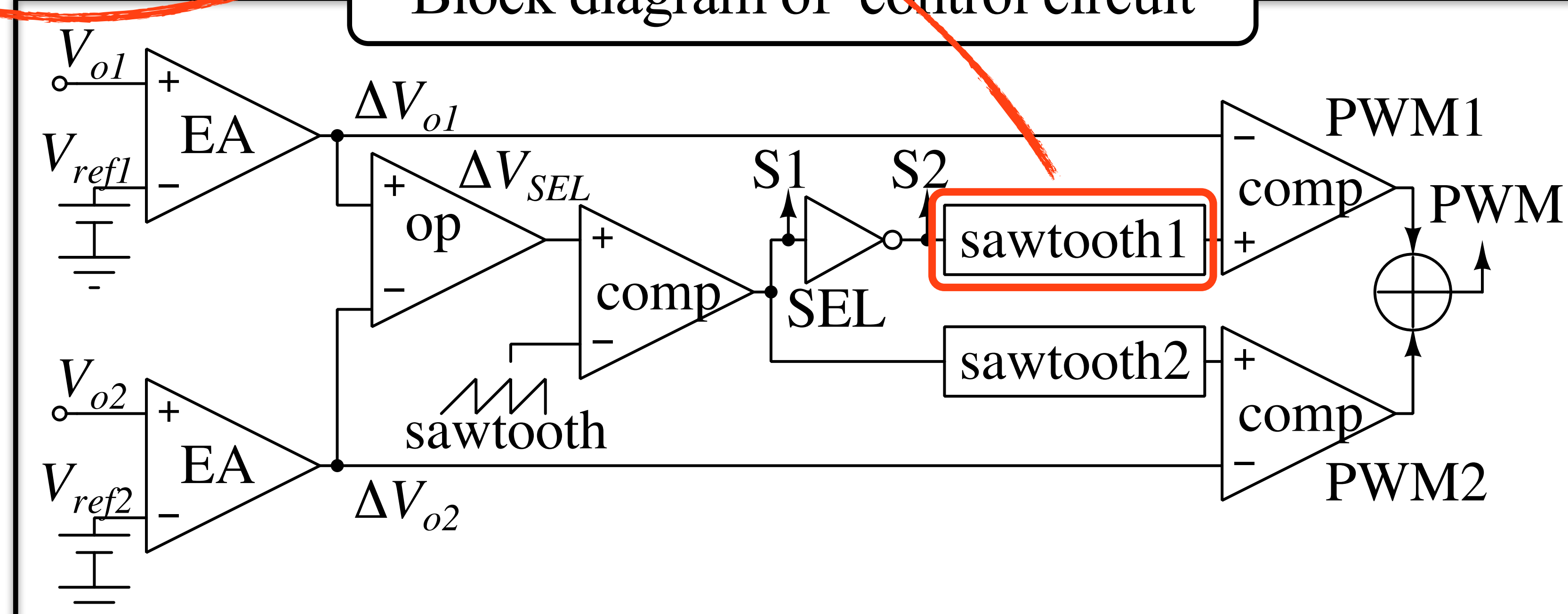
voltage controlled current source

Internal of sawtooth1

Timing chart

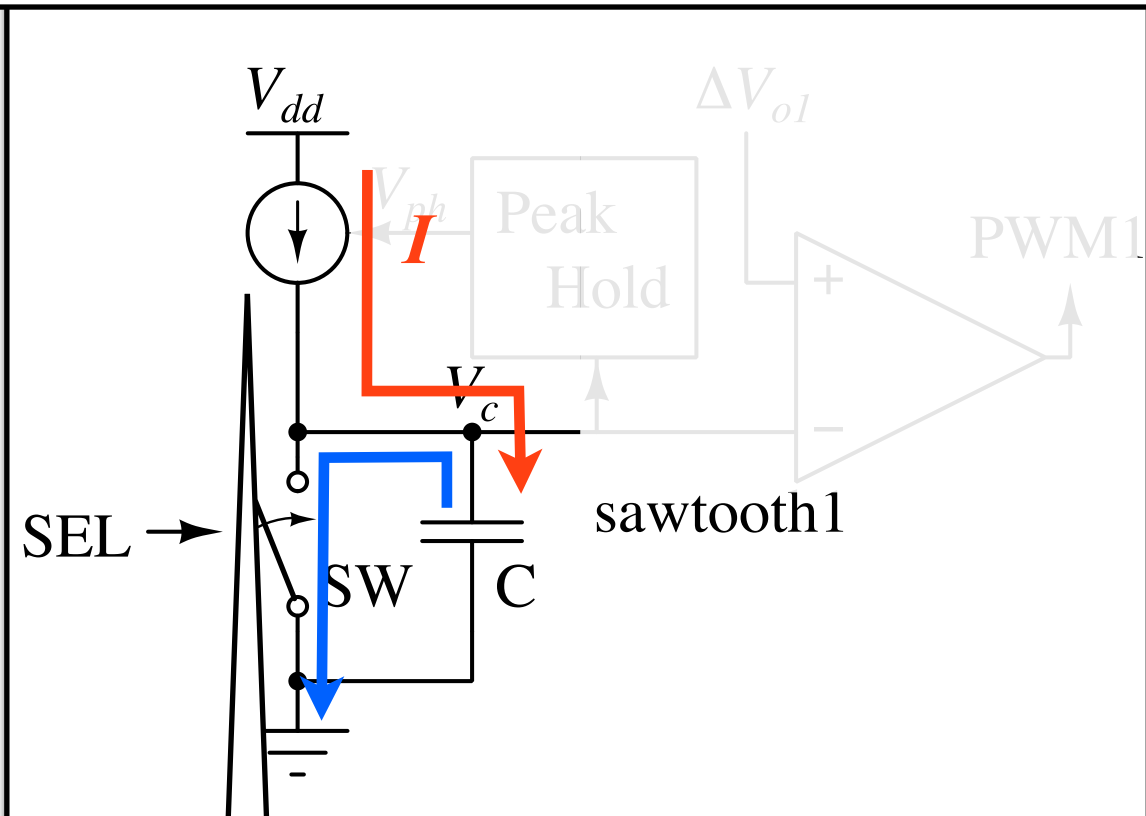


Block diagram of control circuit



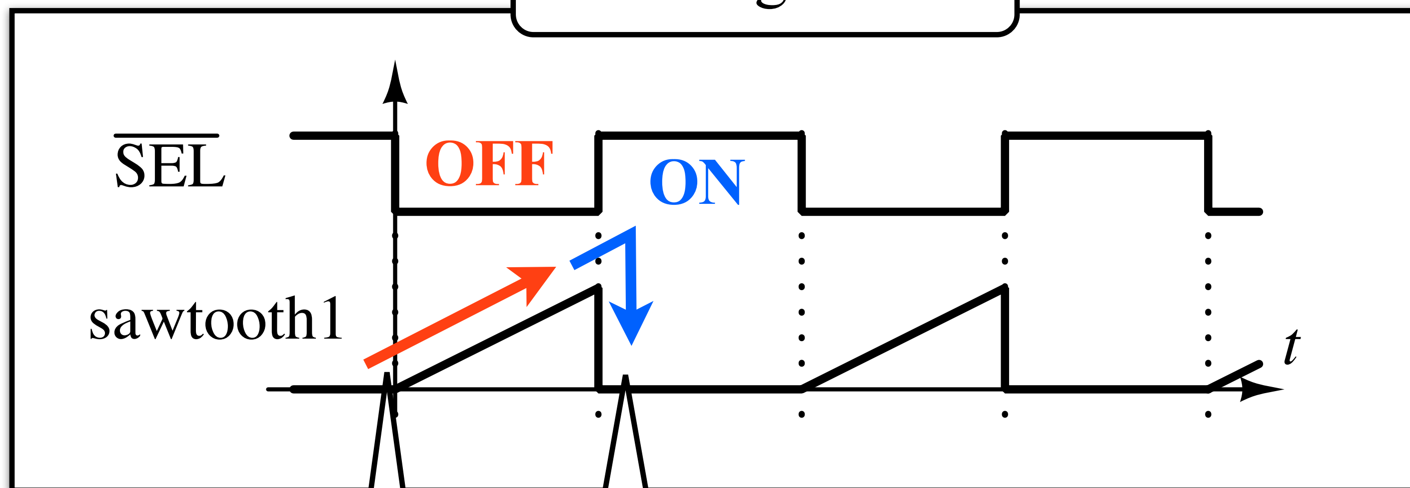
Sawtooth wave generator circuit

Sawtooth wave generator used in proposal method



voltage controlled current source

Timing chart



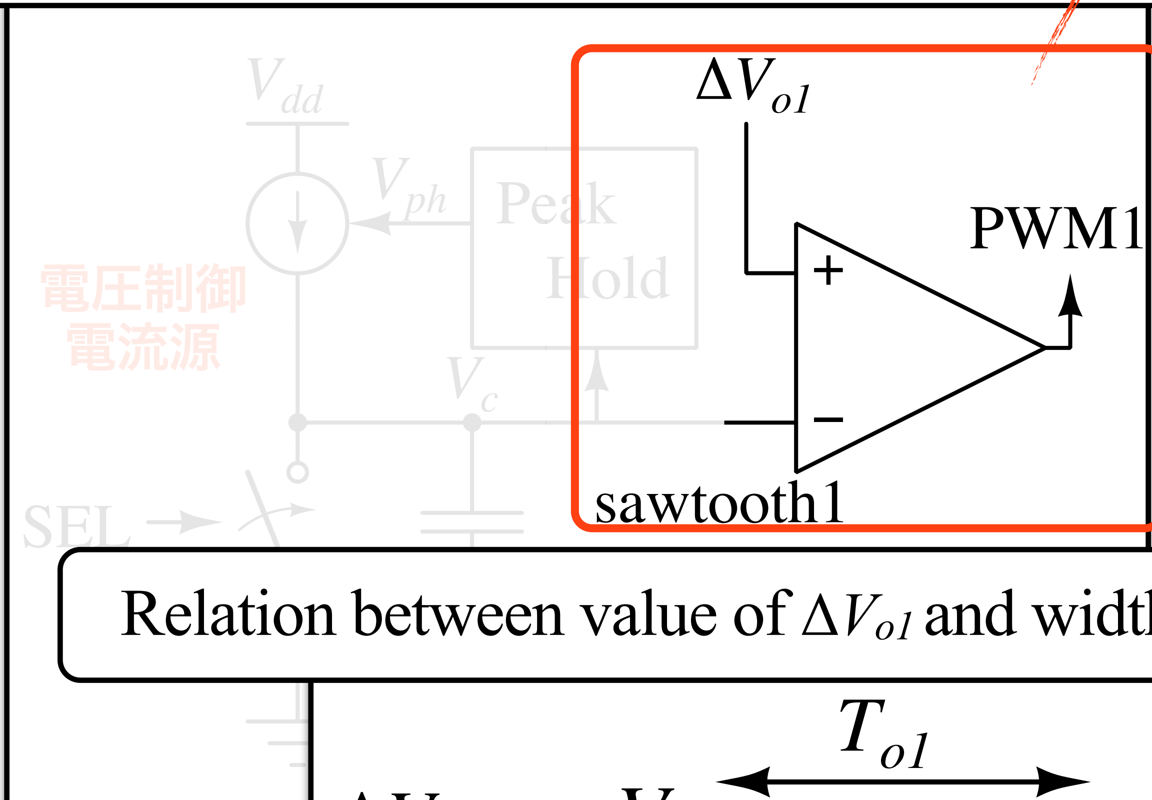
Increase

Reset

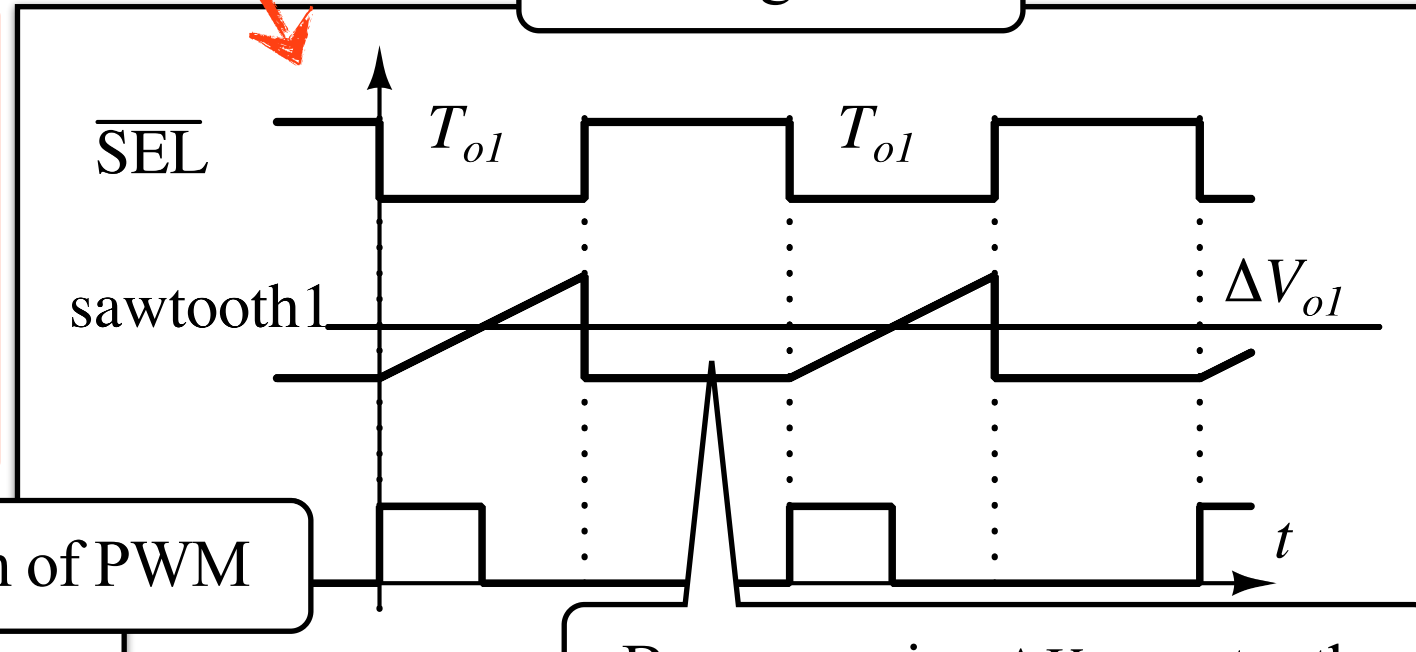
Sawtooth wave is generated.

Sawtooth wave generator circuit

Sawtooth wave generator used in proposed method

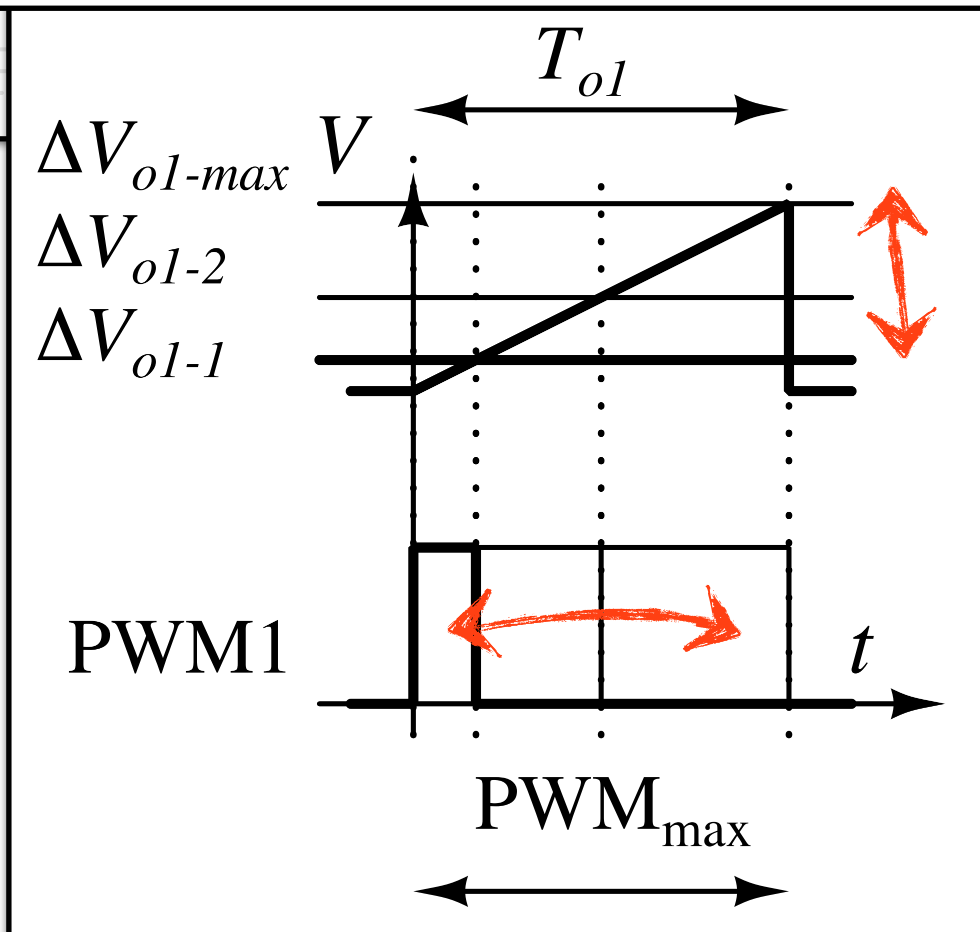


Timing chart



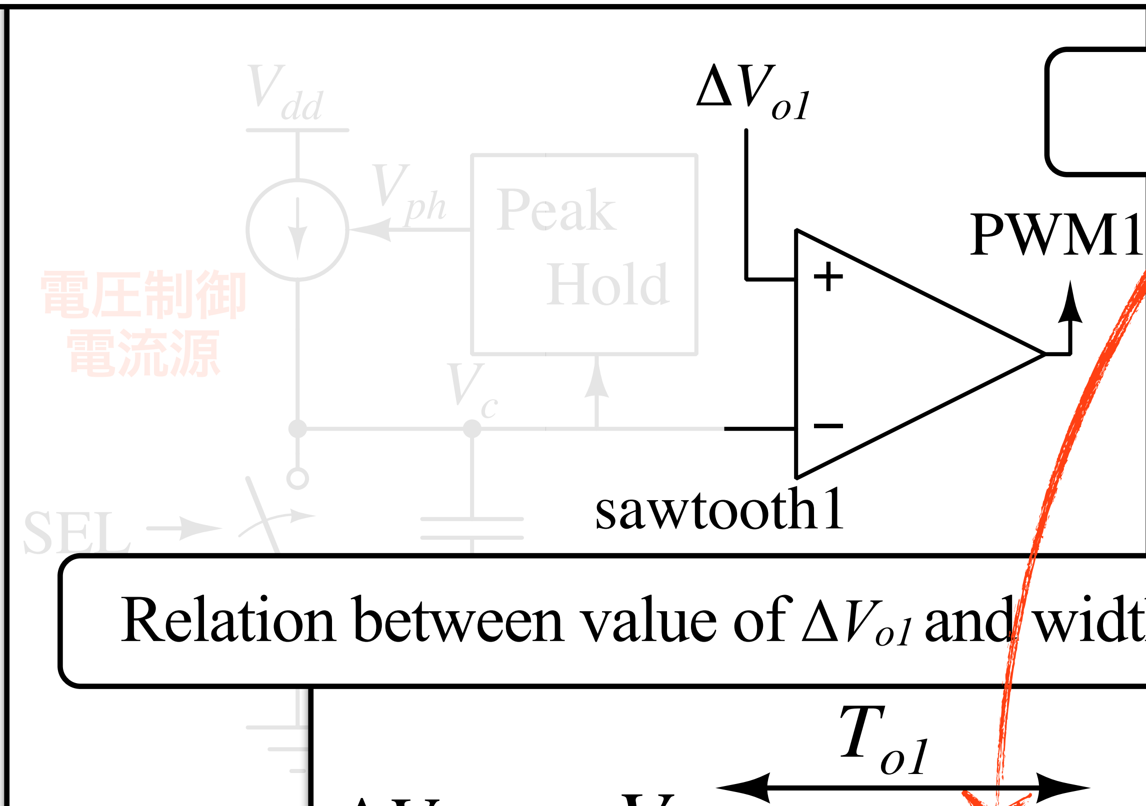
By comparing ΔV_{o1} sawtooth, PWM1 is generated.

Relation between value of ΔV_{o1} and width of PWM



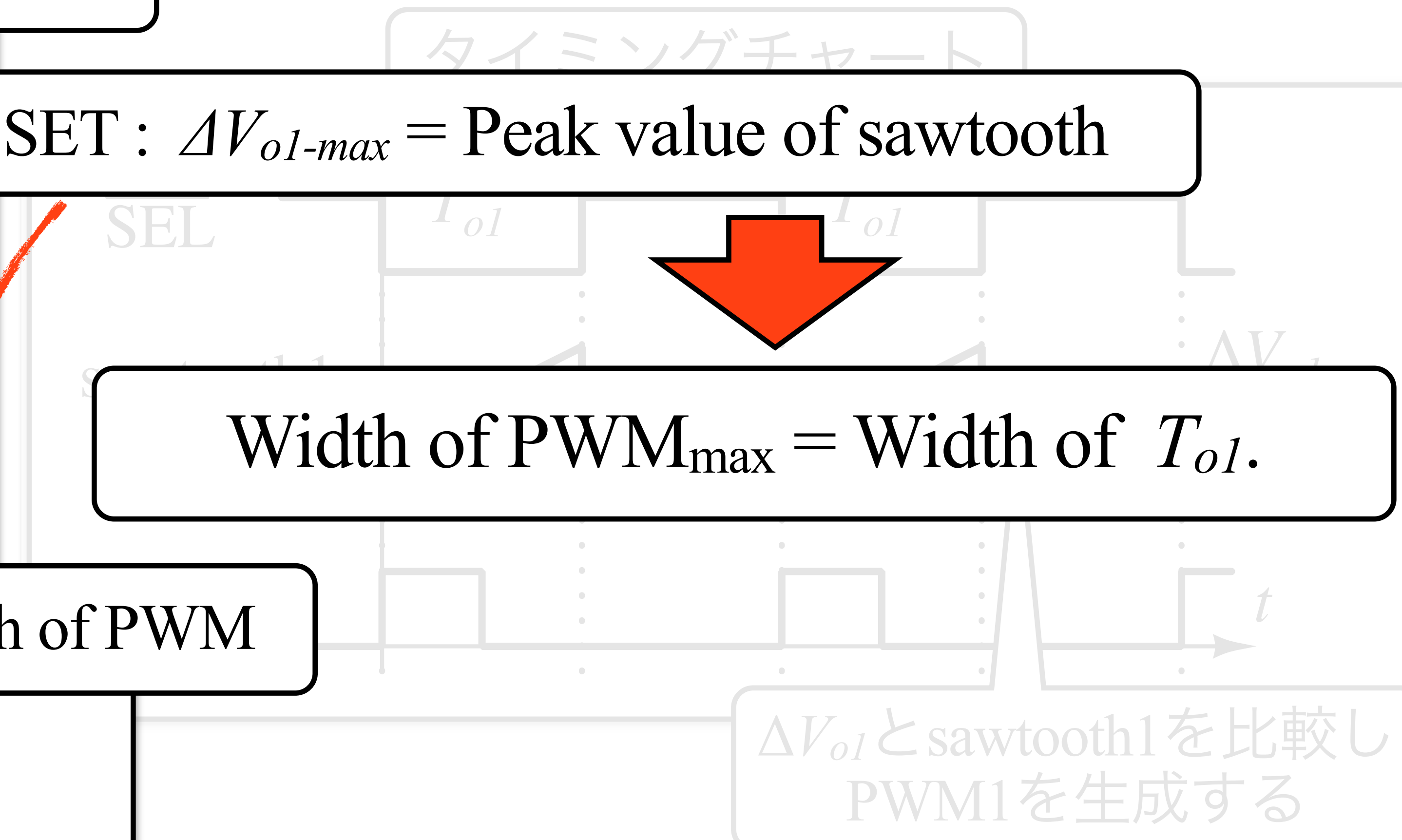
Sawtooth wave generator circuit

Sawtooth wave generator used in proposal method

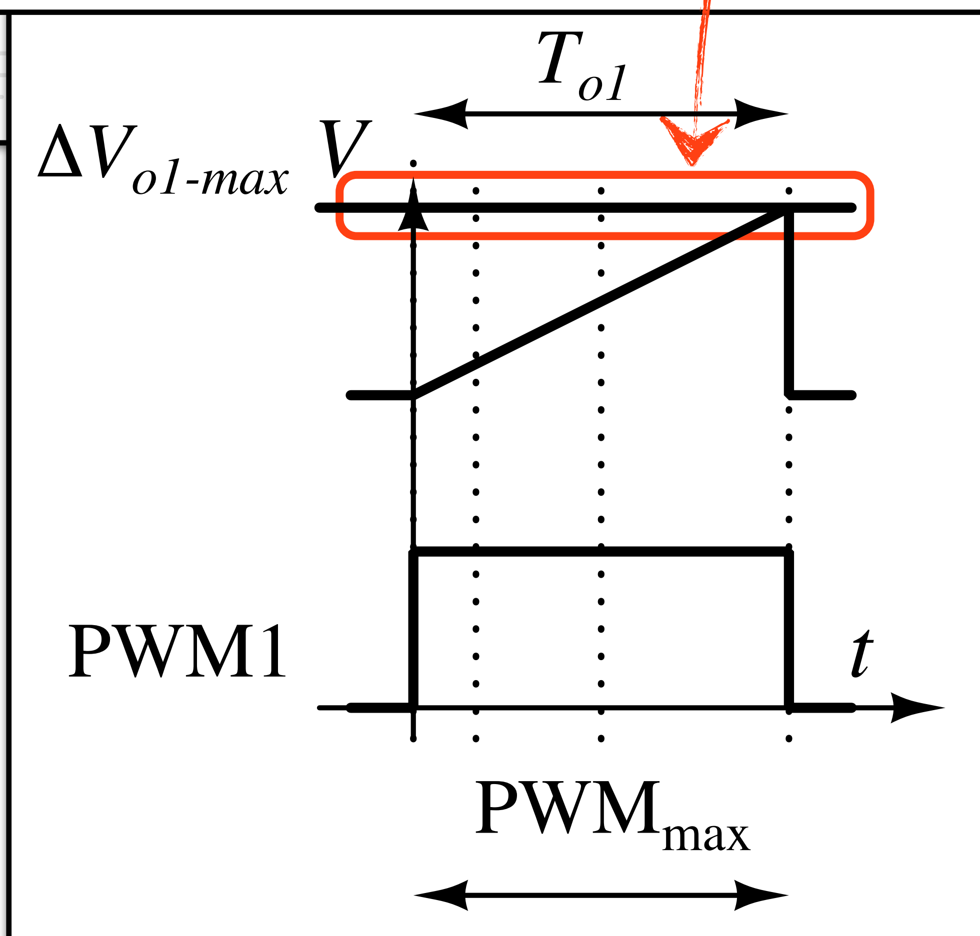


SET : $\Delta V_{o1\text{-}max}$ = Peak value of sawtooth

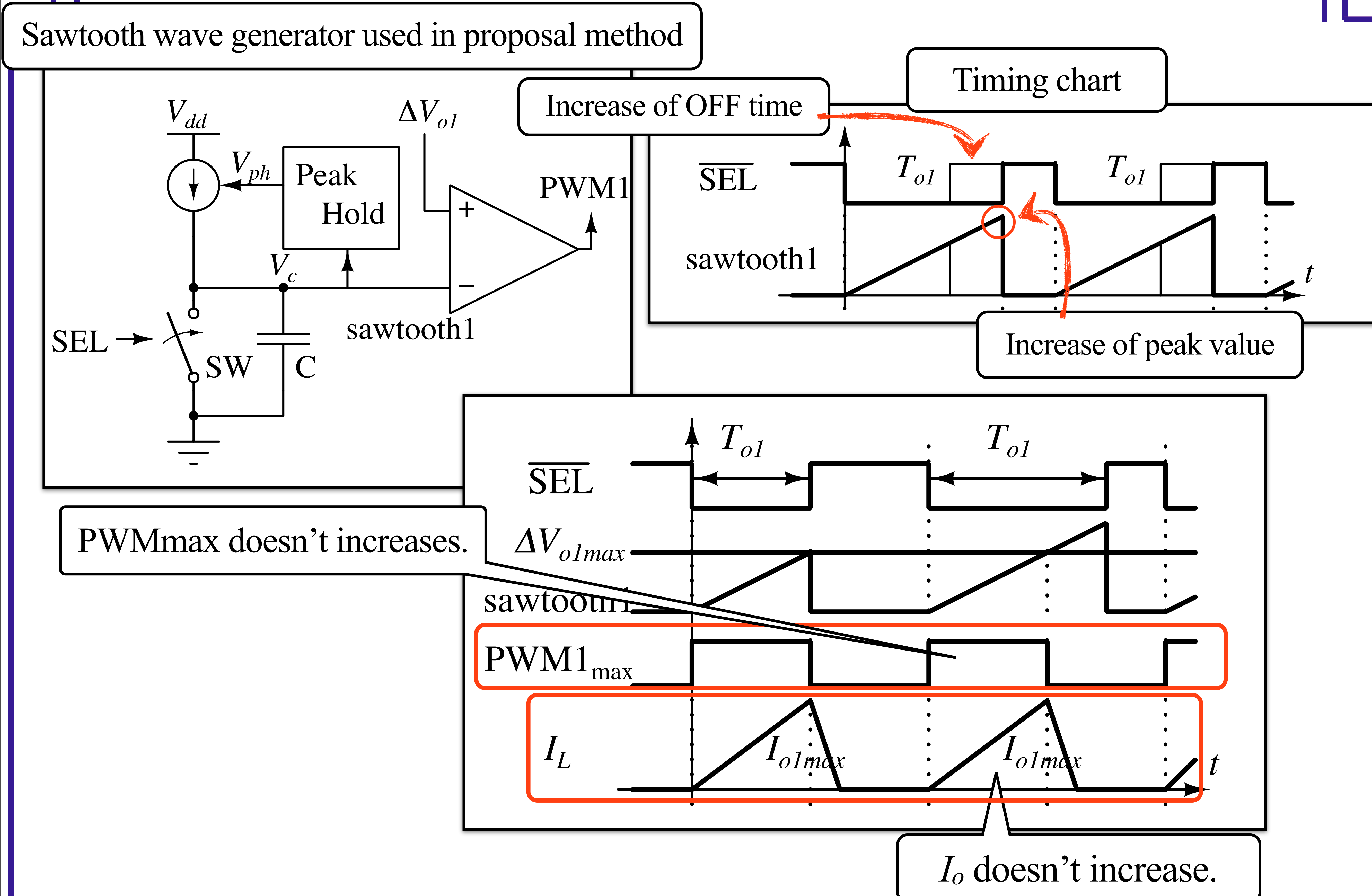
Width of PWM_{max} = Width of T_{o1}.



Relation between value of ΔV_{o1} and width of PWM



Sawtooth wave generator circuit

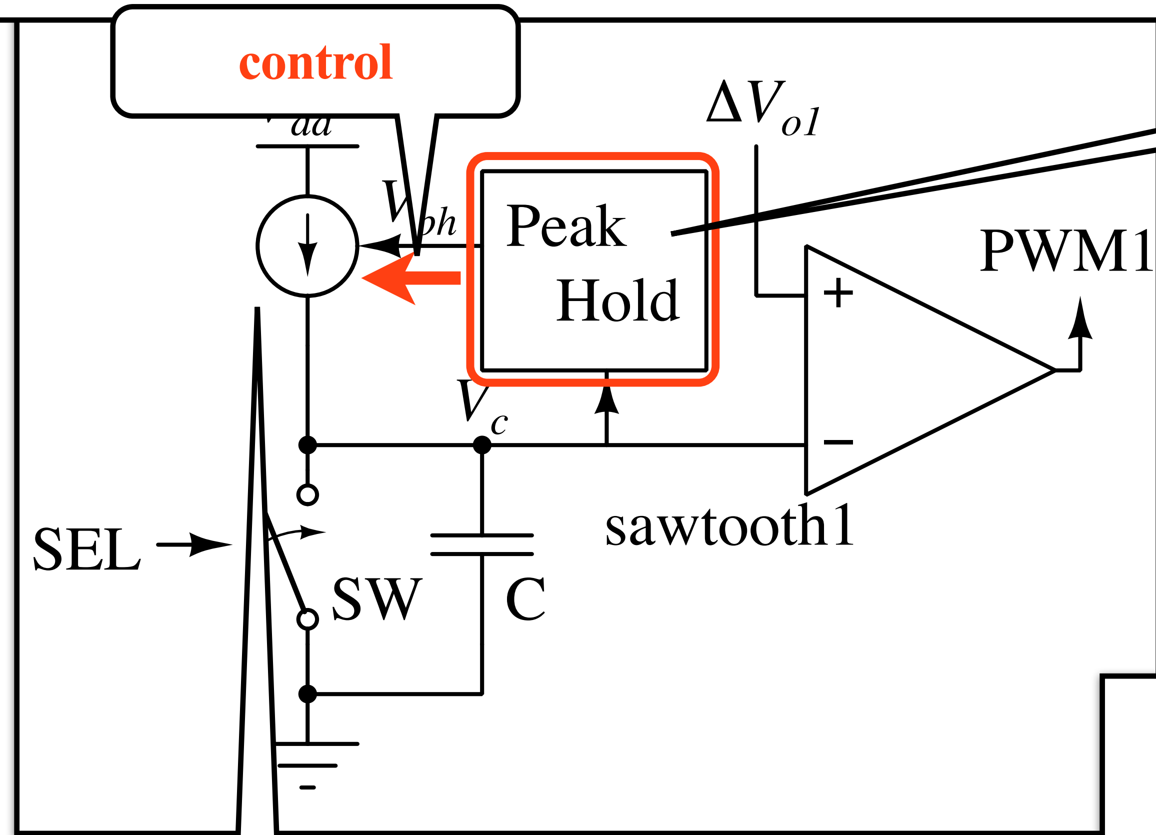


Sawtooth wave generator circuit

Sawtooth wave generator used in proposal method

control

voltage controlled current source



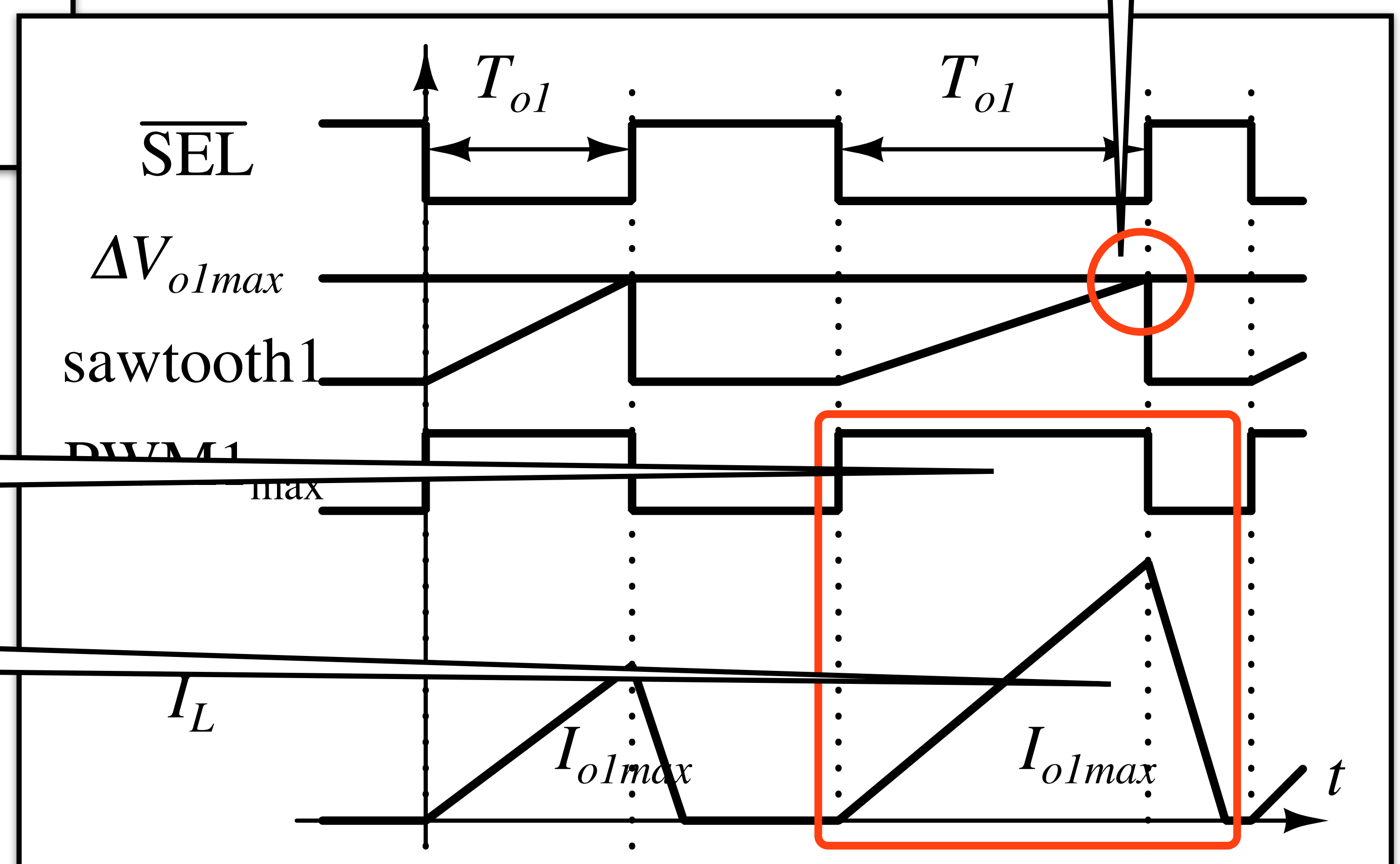
Searched peak value of sawtooth

Control of current source

For any To1, peak value of sawtooth is constant

$PWM1_{max}$ increases.

I_{o1max} increases.



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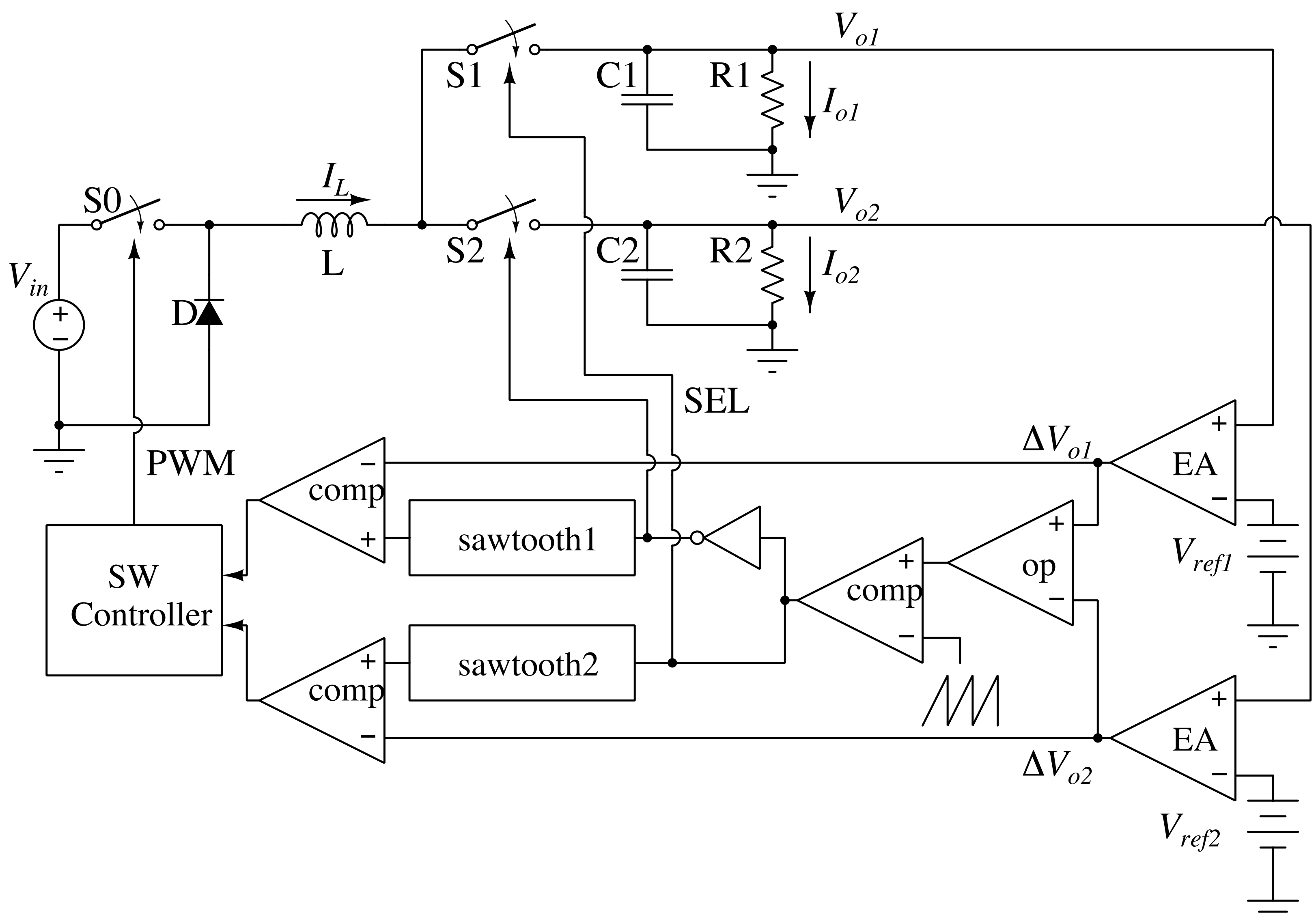
Simulation Results

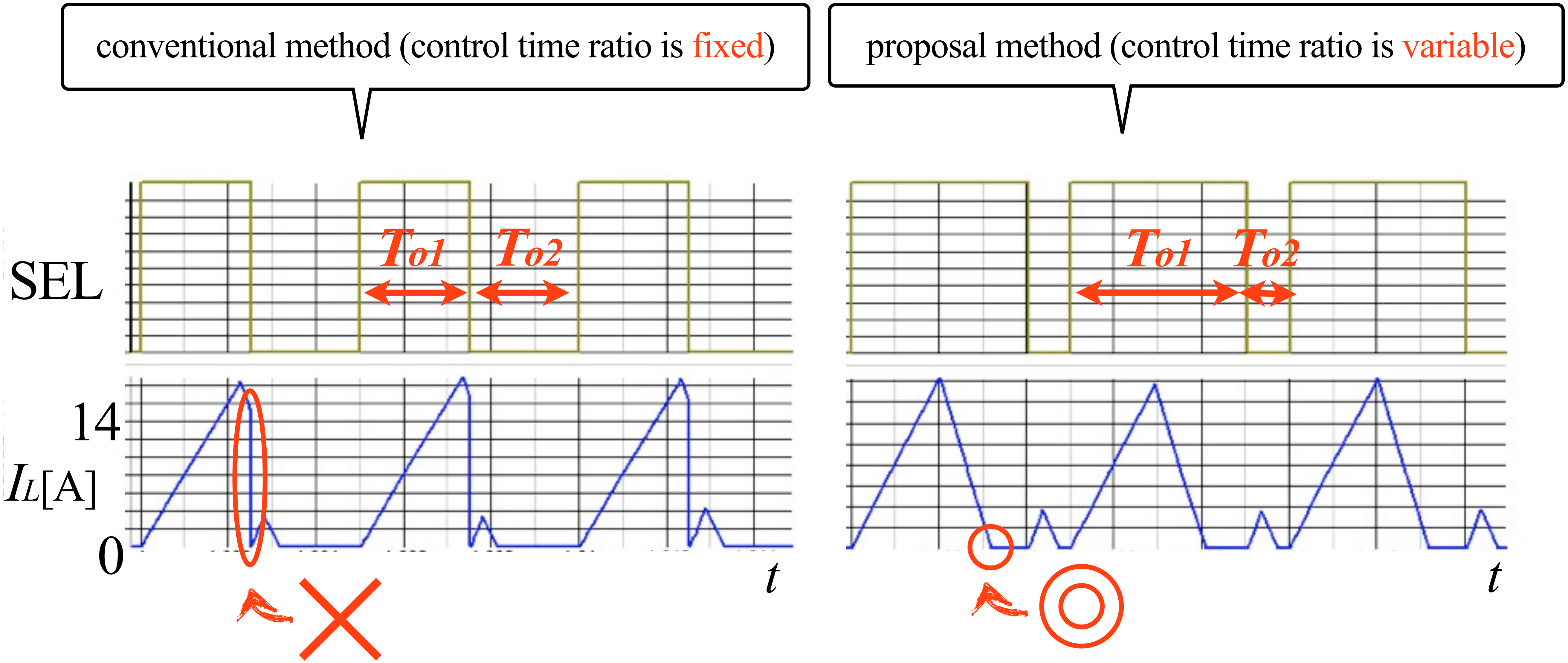
Schematic diagram of simulation circuit



Parameter

input voltage: V_{in}	10V
output voltage: V_{o1}	5.0V
output voltage: V_{o2}	4.0V
load current: I_{o1}	5.0A
load current: I_{o2}	0.5A
inductor:L	0.5µH
output capacitor:C	470µF
operating frequency: f	200kHz

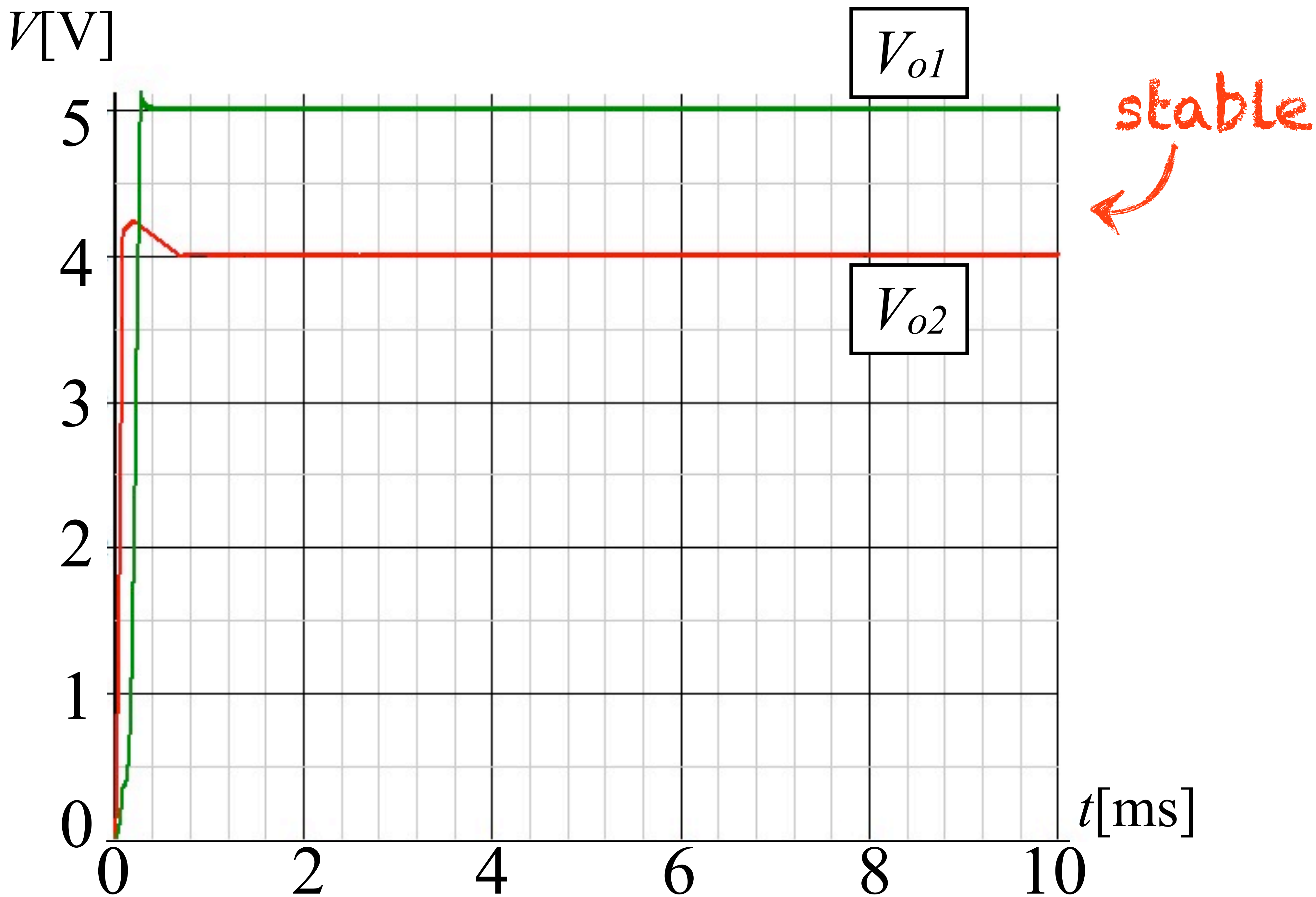
Simulation Results



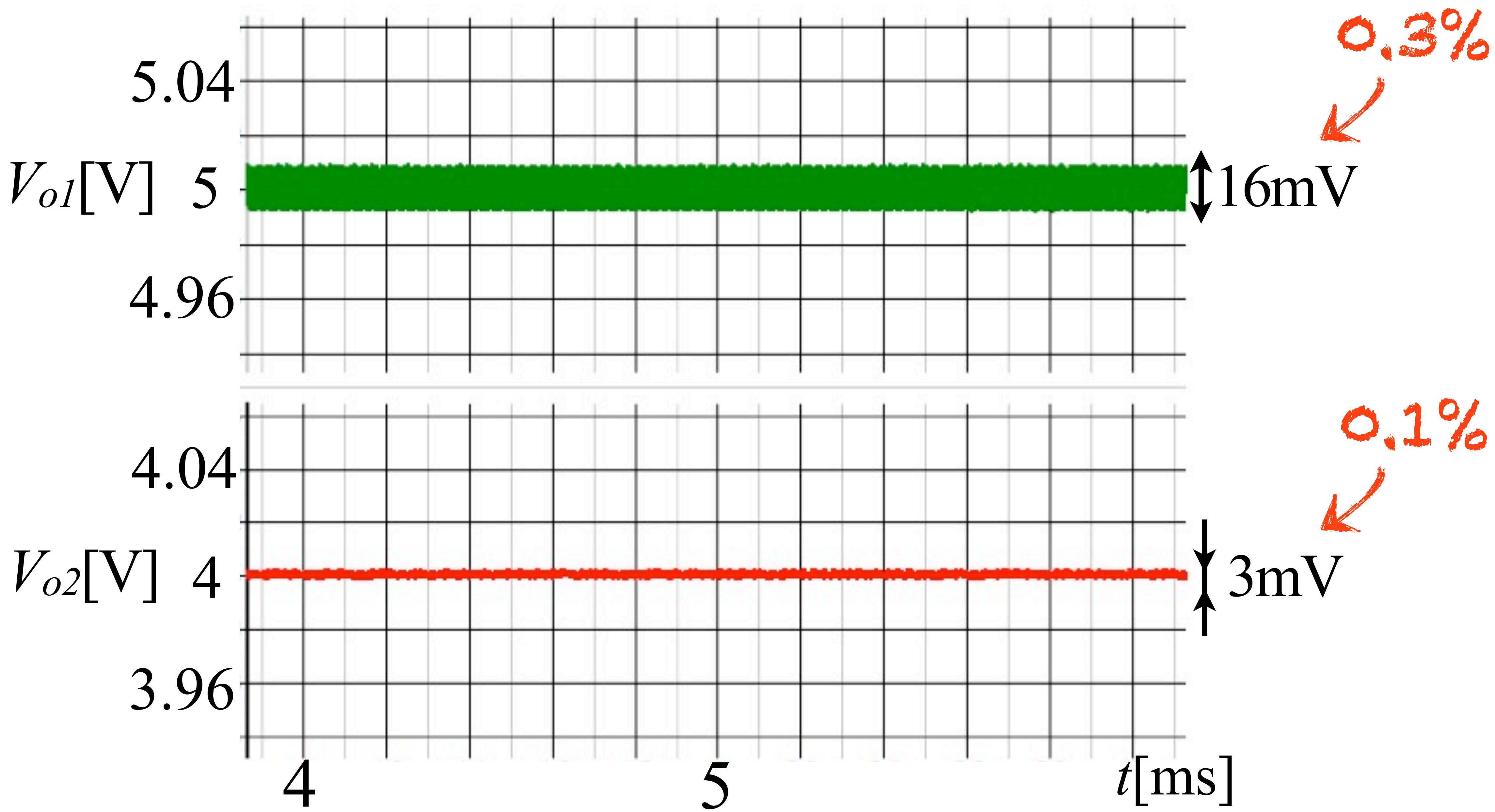
I_{o1}=5.0[A] , I_{o2}=0.5[A]

Waveforms of SEL and I_L

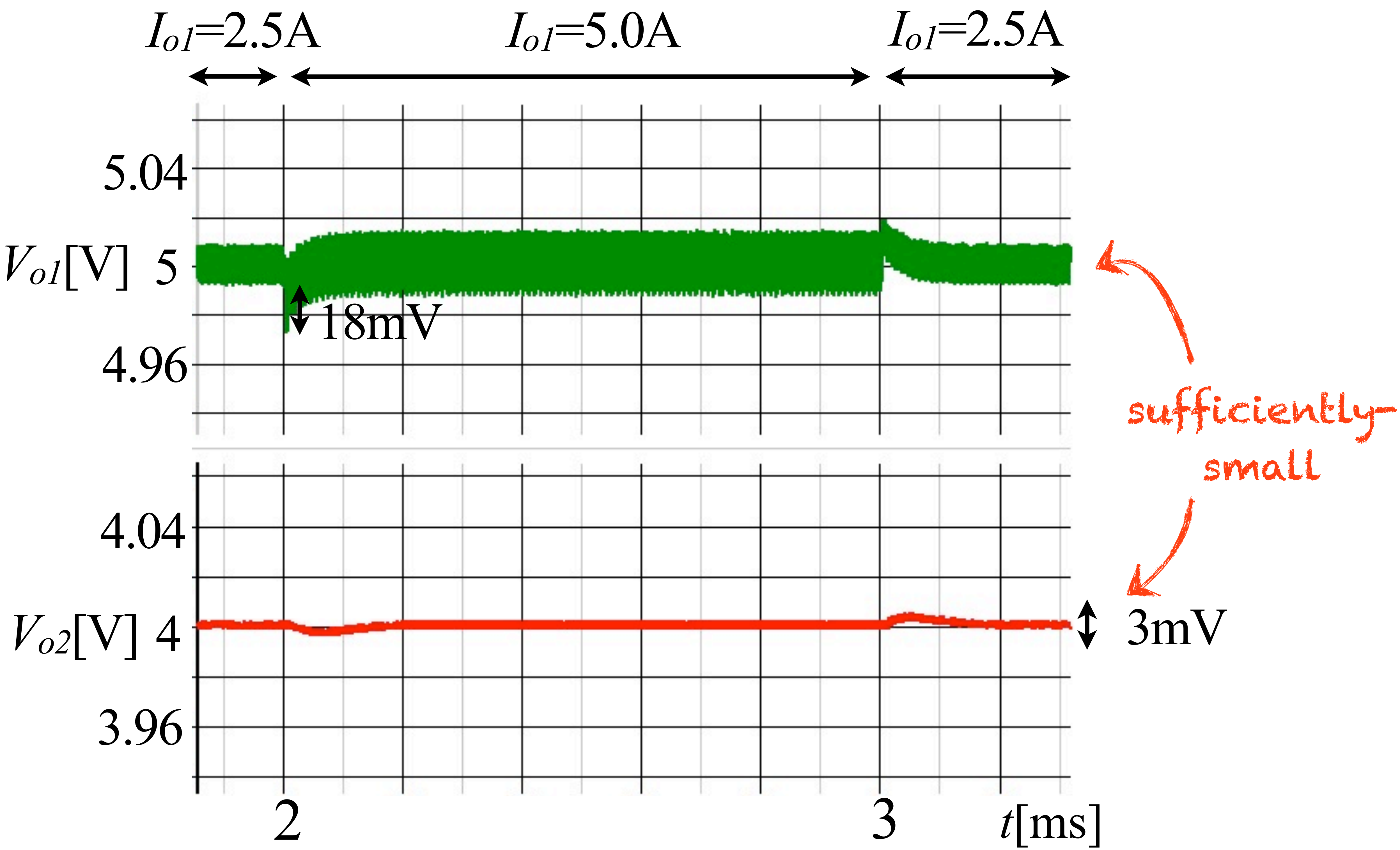
Waveform of output voltage



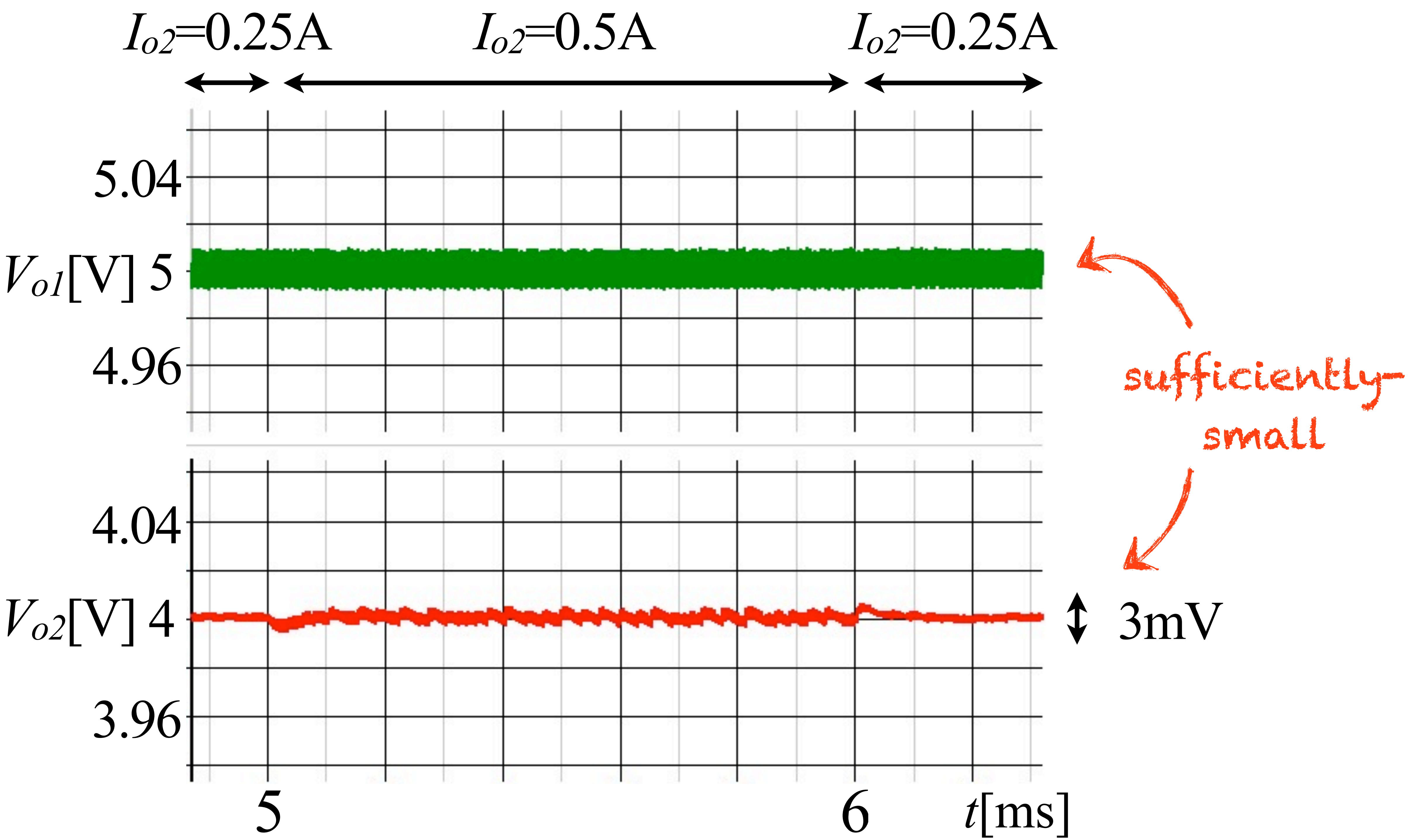
Steady state output voltage ripple characteristics



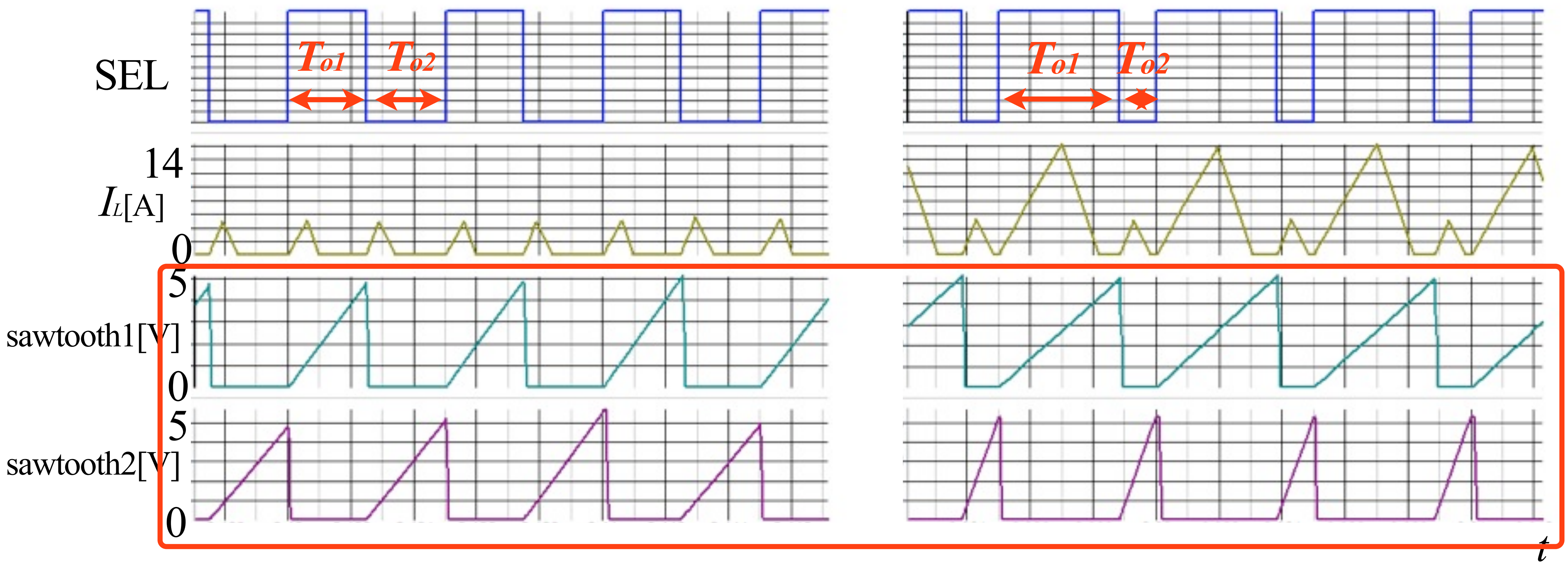
Load step response characteristics



Load step response characteristics



Peak value of sawtooth wave



I_{o1}=0.5[A] , I_{o2}=0.5[A]

I_{o1}=5.0[A] , I_{o2}=0.5[A]

peak value is constant

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Conclusions and Future works

Conclusions

◯we have proposed a new control method that works in case of a large load current ratio, and confirmed the basic characteristics.

By varying control time ratio of two converters, we have confirmed the operation of the proposed method in case of the load current ratio $I_{o1}:I_{o2}$ =5.0A:0.5A that is 10:1.

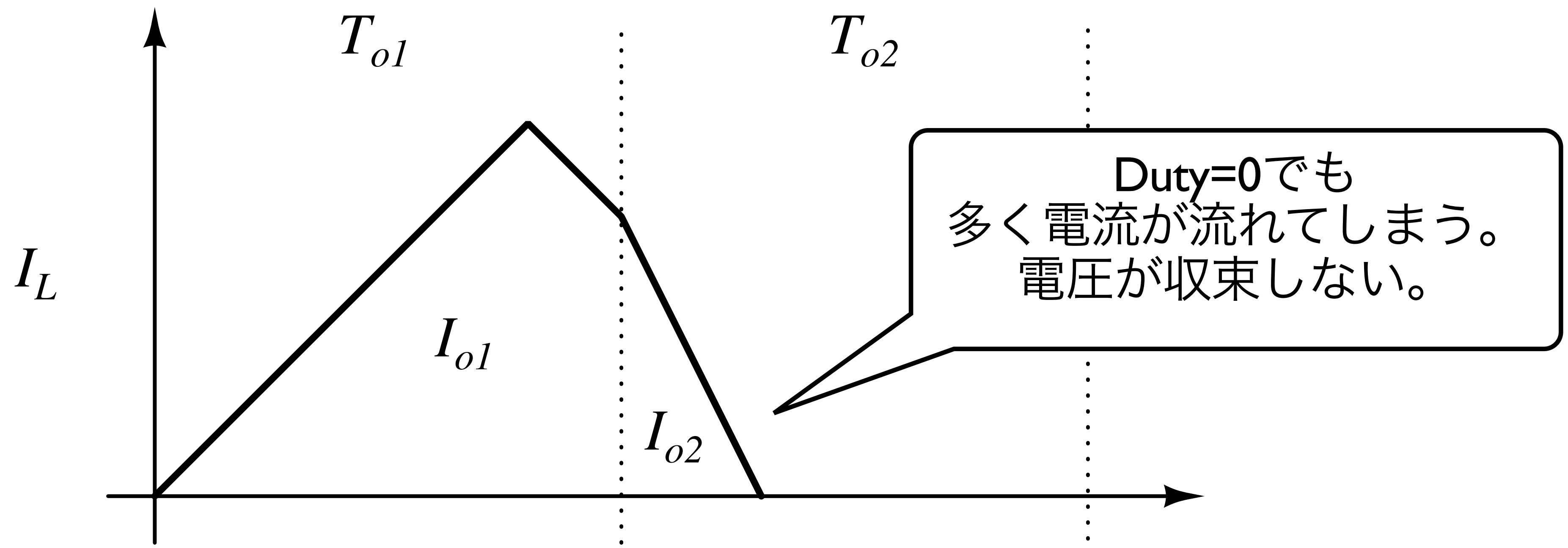
Future works

◯Operation in CCM (continuos current mode)

◯Operation with a much higher load current ratio

CCM動作での従来方式と提案方式の違い

従来方式



提案方式