A Study on Feed-forward Control for SIDO Buck Converter

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Out-line

- Research Objective
- PWM Feedback control,

  Load response and cross-regulation
- Feed-forward control
- Simulation results
- Conclusion and future work

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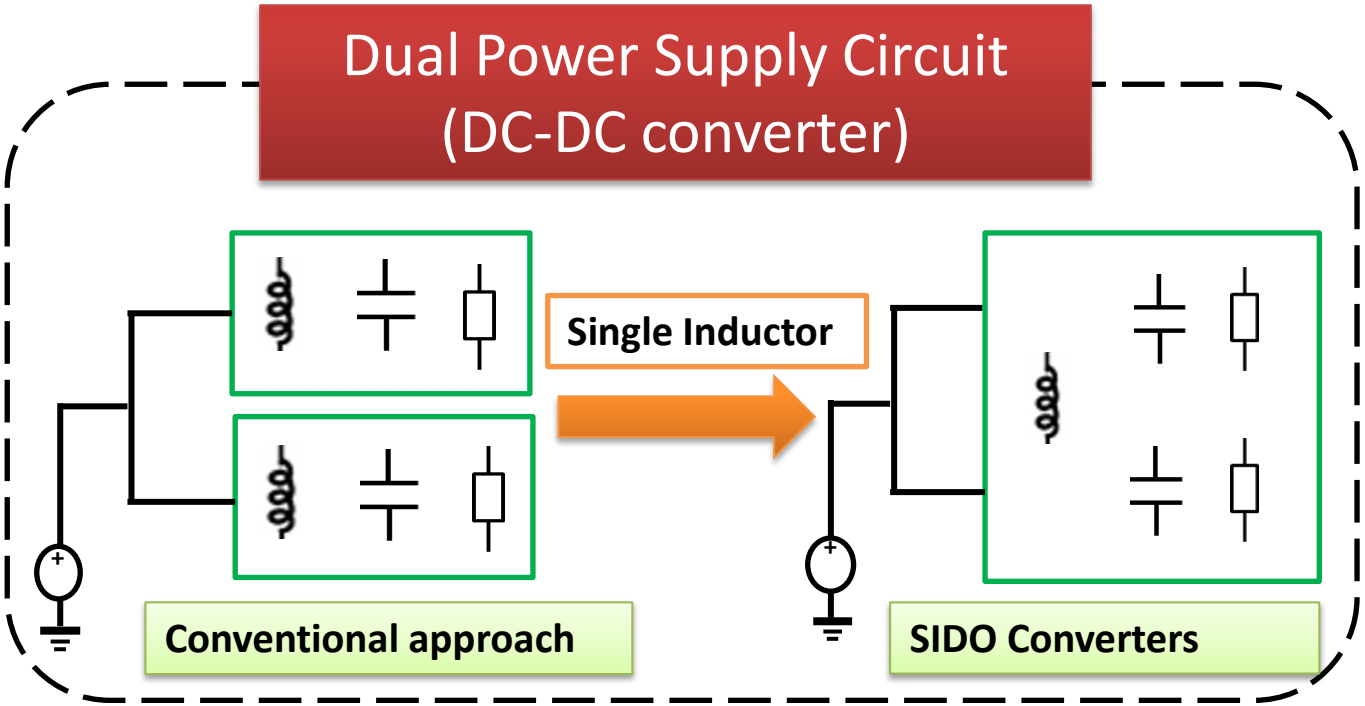
Background



Reduce number of inductors → Reduce cost, Reduce volume

SIDO: Single Inductor Dual Output

Research Objective

Design feed-forward controller

- Improve cross-regulation of SIDO buck converter
- With simple circuit

SIDO: Single Inductor Dual Output

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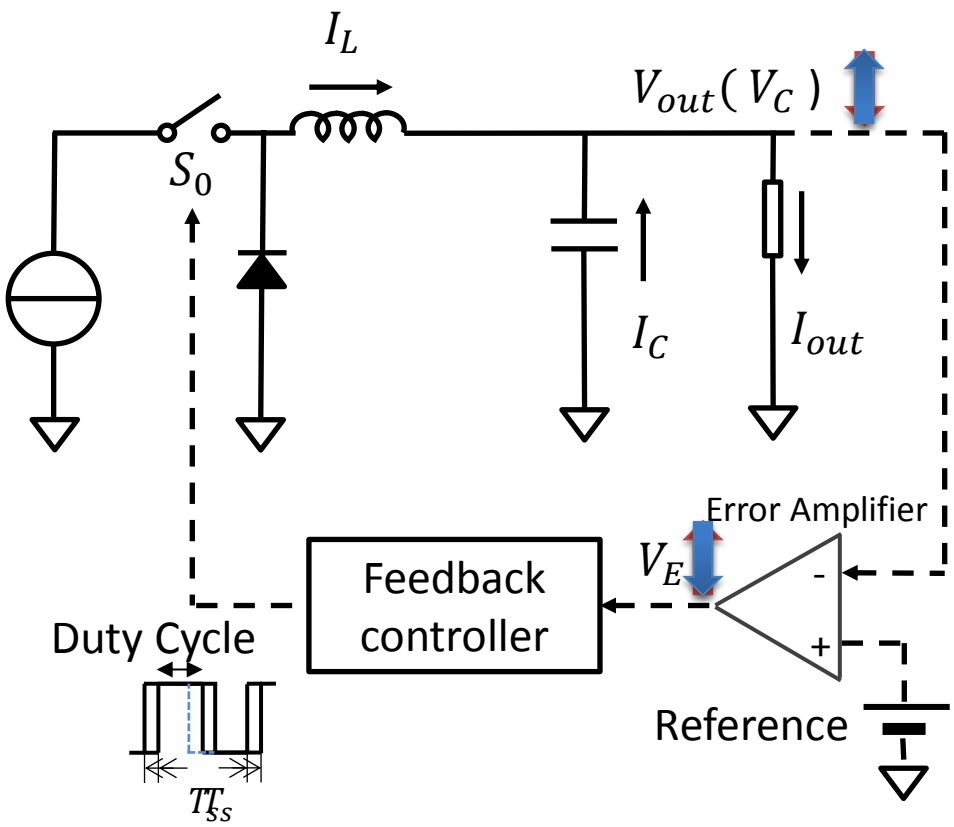
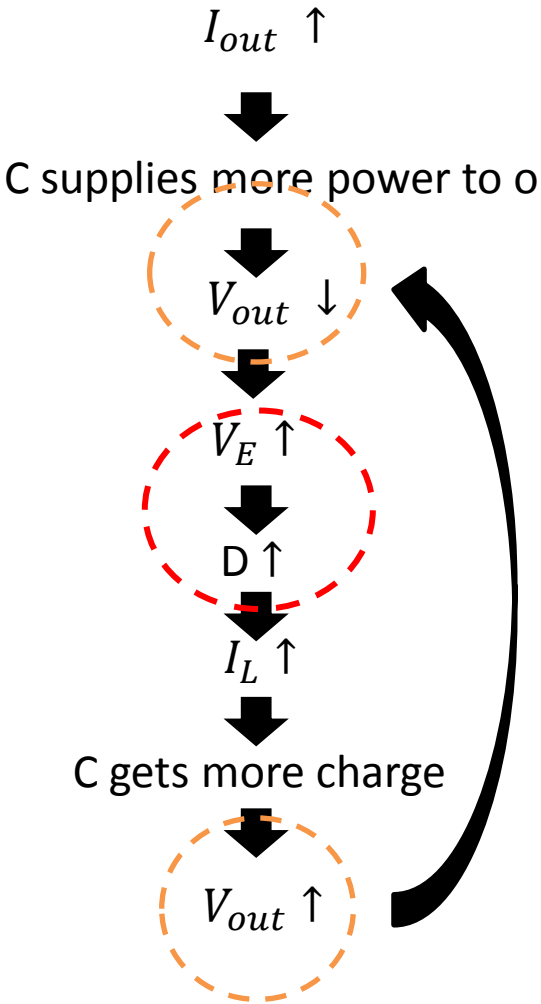
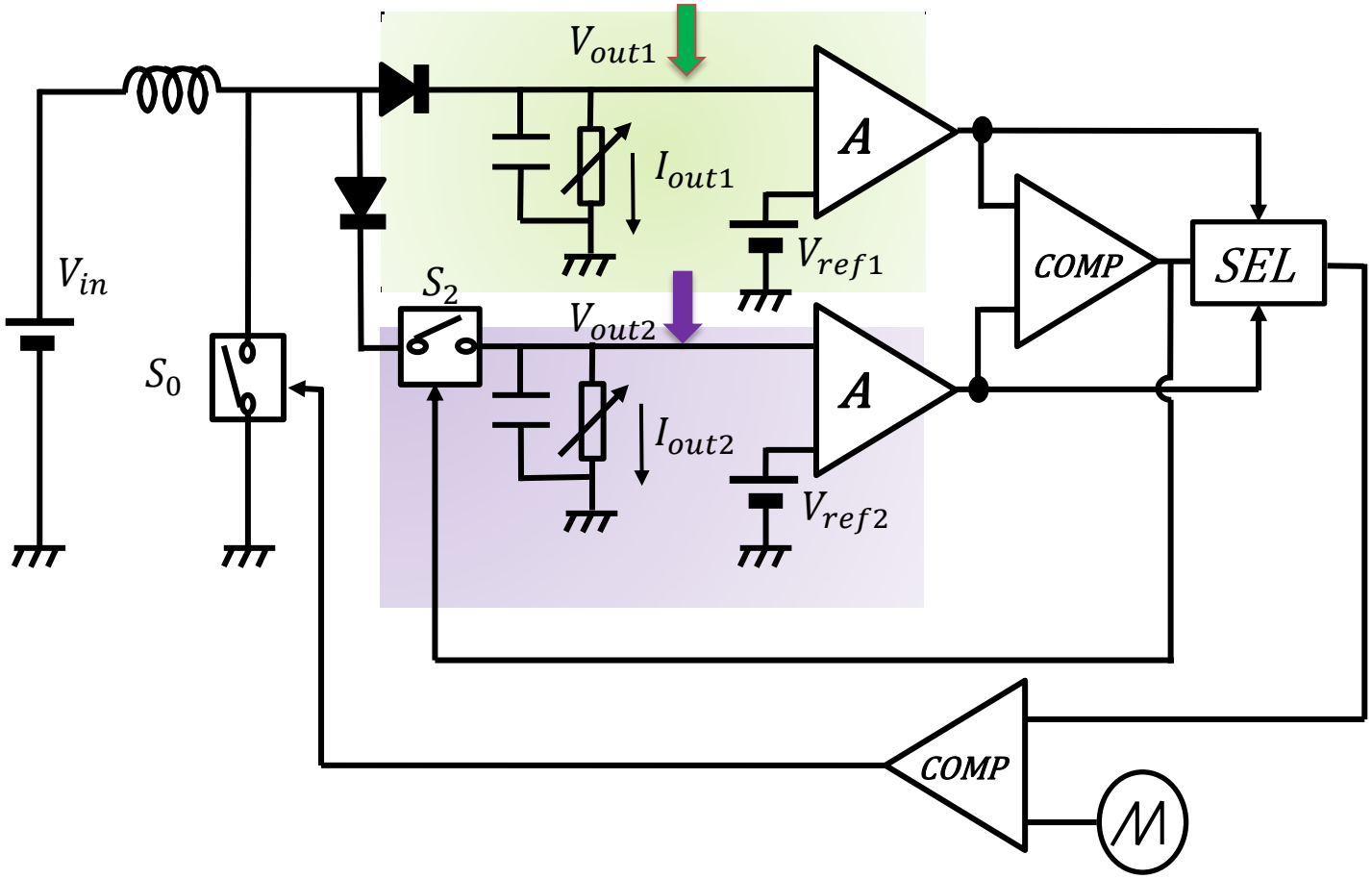
Load response & PWM Feed-back control





Feed-back control is based on the error

Self-regulation & Cross-regulation



I_{out1} ↑

V_{out2} ↓

Cross-regulation

Self-regulation

SIDO buck converter with exclusive control

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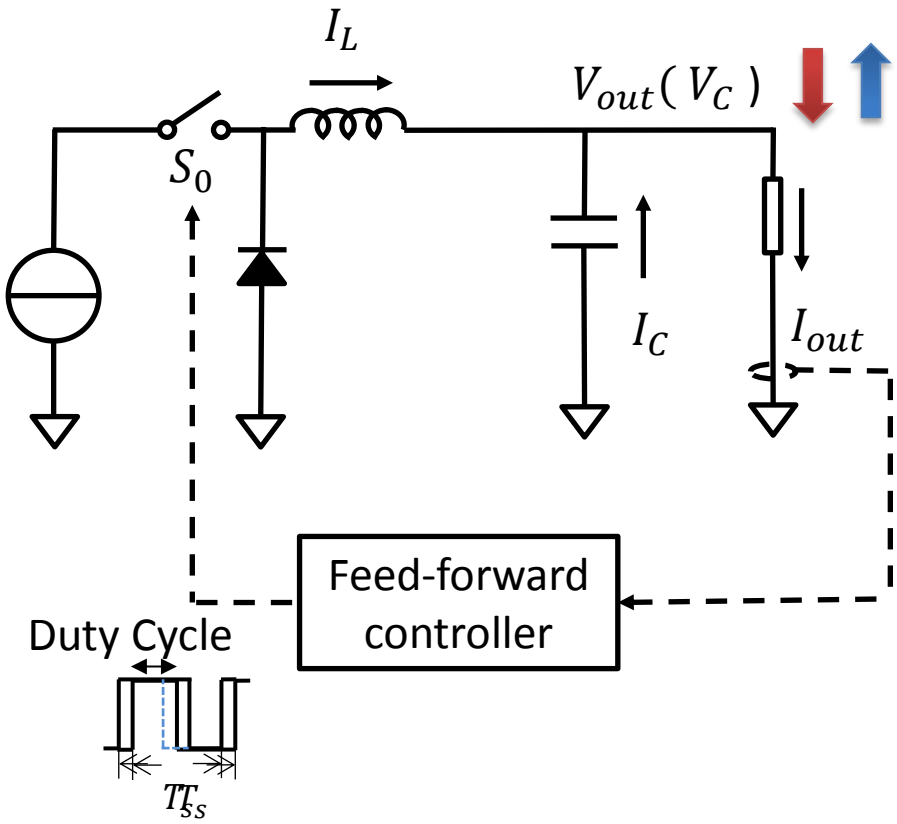
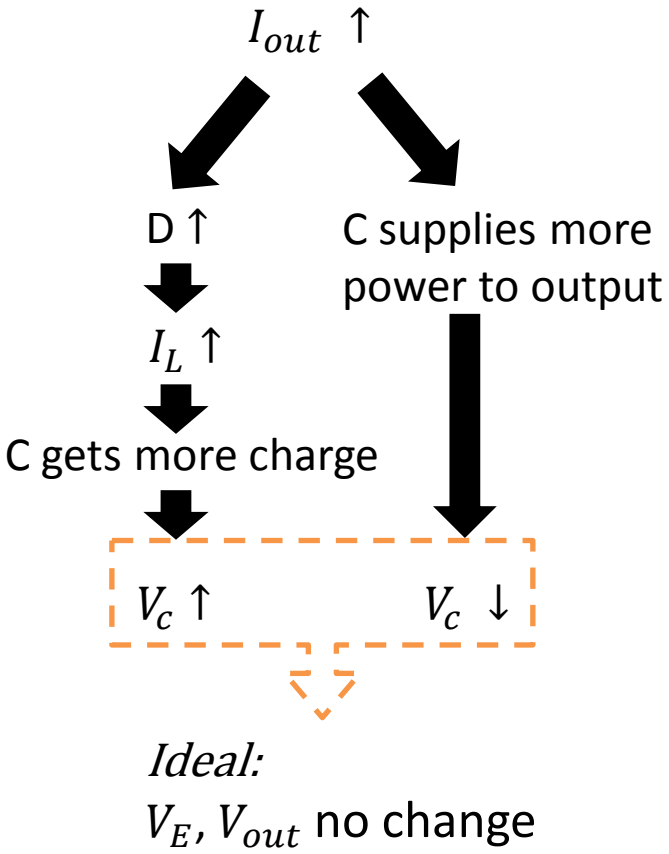
Feed-forward control





Feed-forward control is based on predication

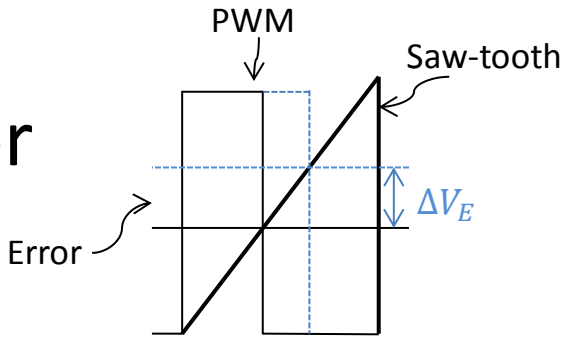
Accurate feed-forward

For buck converter with PWM,

feed-forward controller have two choices.

- Add an additional voltage to error

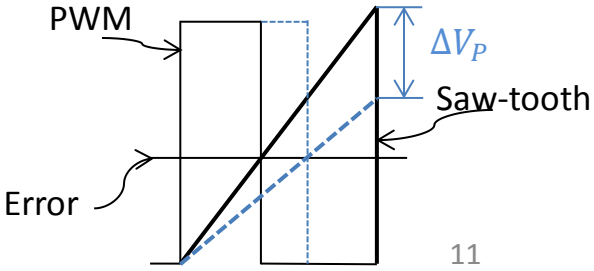
  ---$\Delta V_E = V_P L \Delta I_o / (V_{in} T_s)$



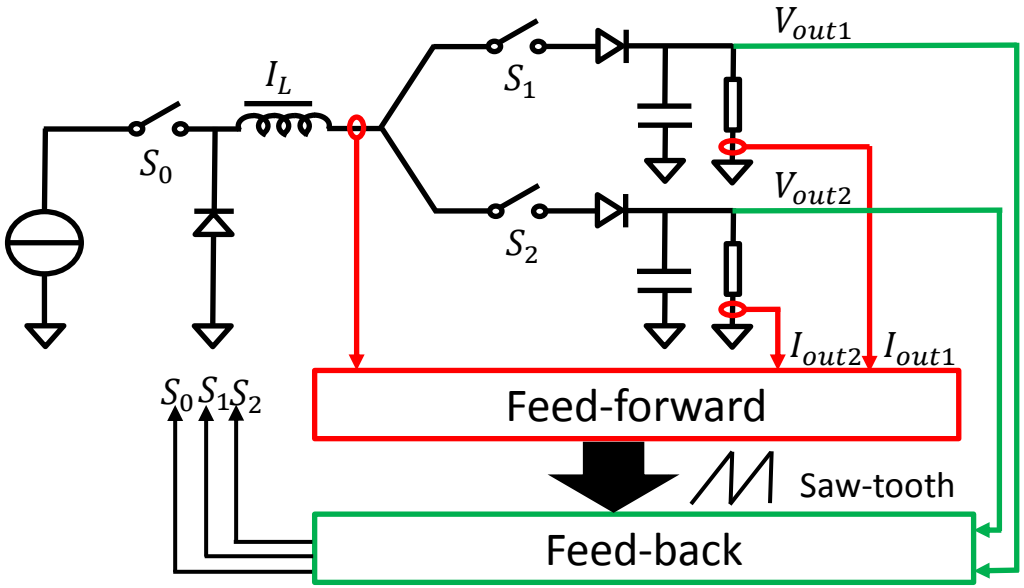
- Regulate the peak voltage of saw-tooth

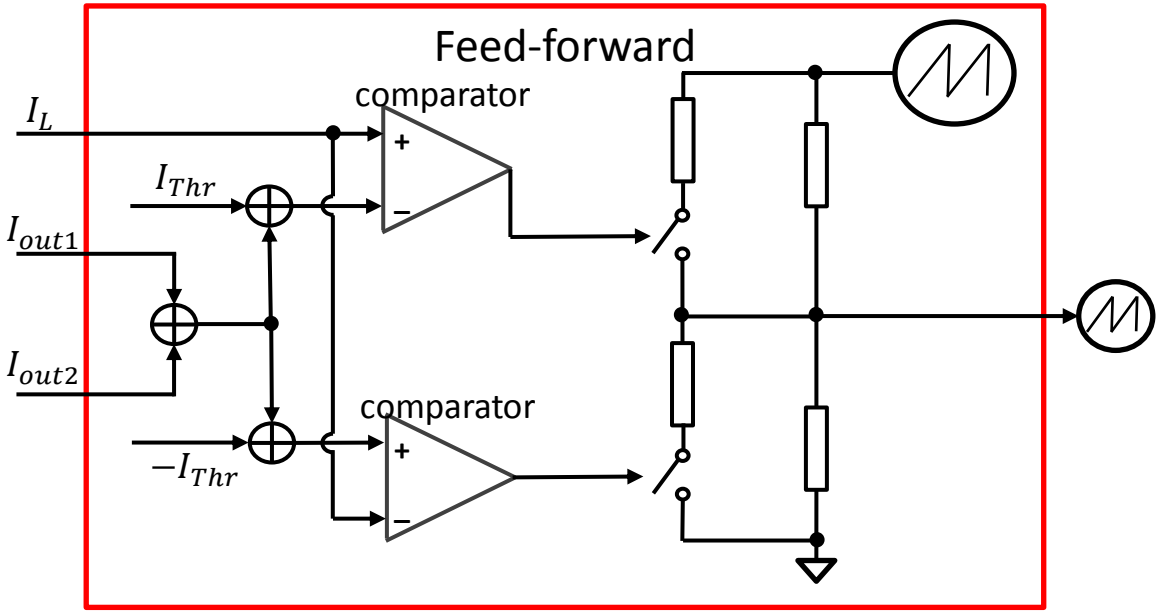
  ---$\Delta V_P = V_E V_{in} L \Delta I_o / [V_{out}(L \Delta I_o + V_{out} T_s)]$

☹ **Complicated**



Block diagram of proposed method





Stiff

-- constant threshold

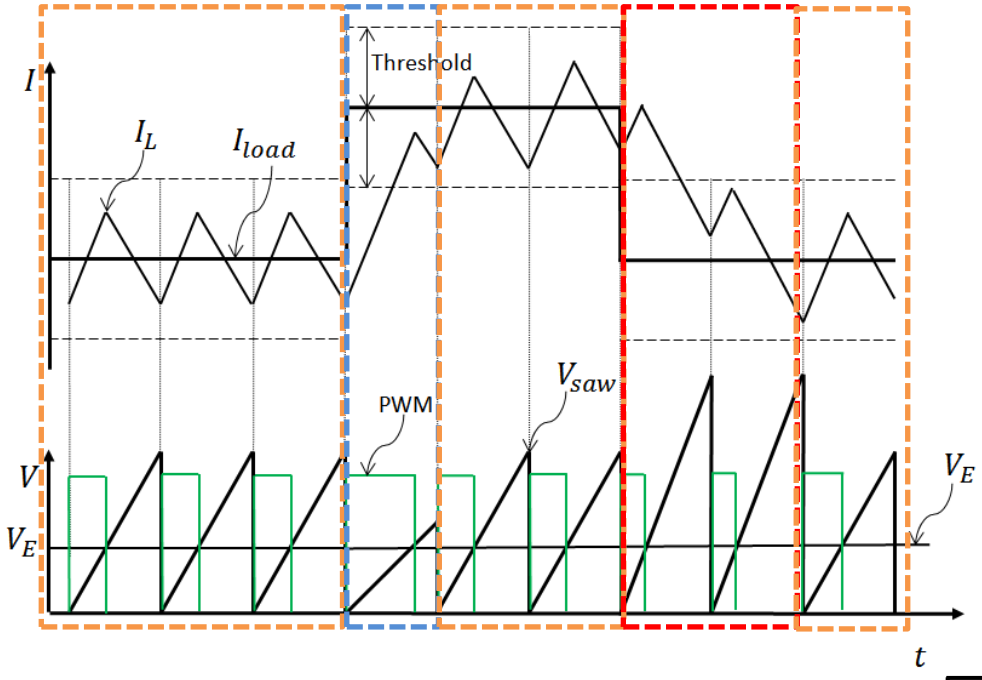
Fuzzy

-- constant ΔV_P

Simple

-- Only a few additional components

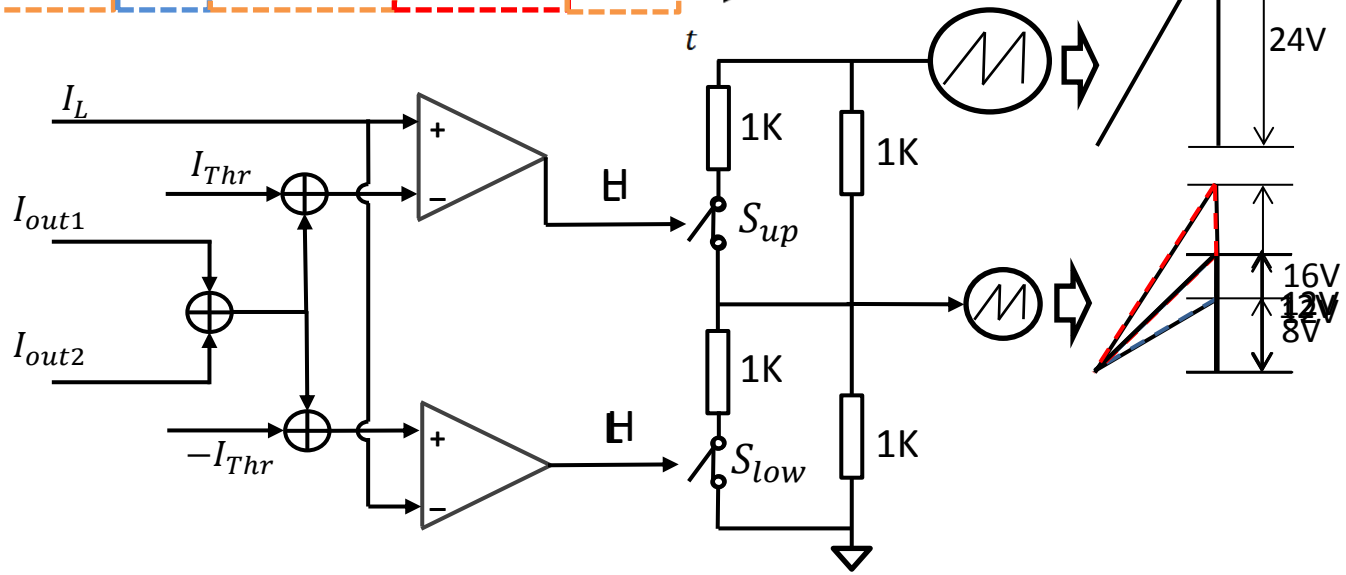
Regulation process



$$(I_{Load} - I_{Thr}) < I_L \lessapprox (I_{Load} + I_{Thr})$$

Load decrease → reduce V_{cp}

Load increase → rise V_{cp}



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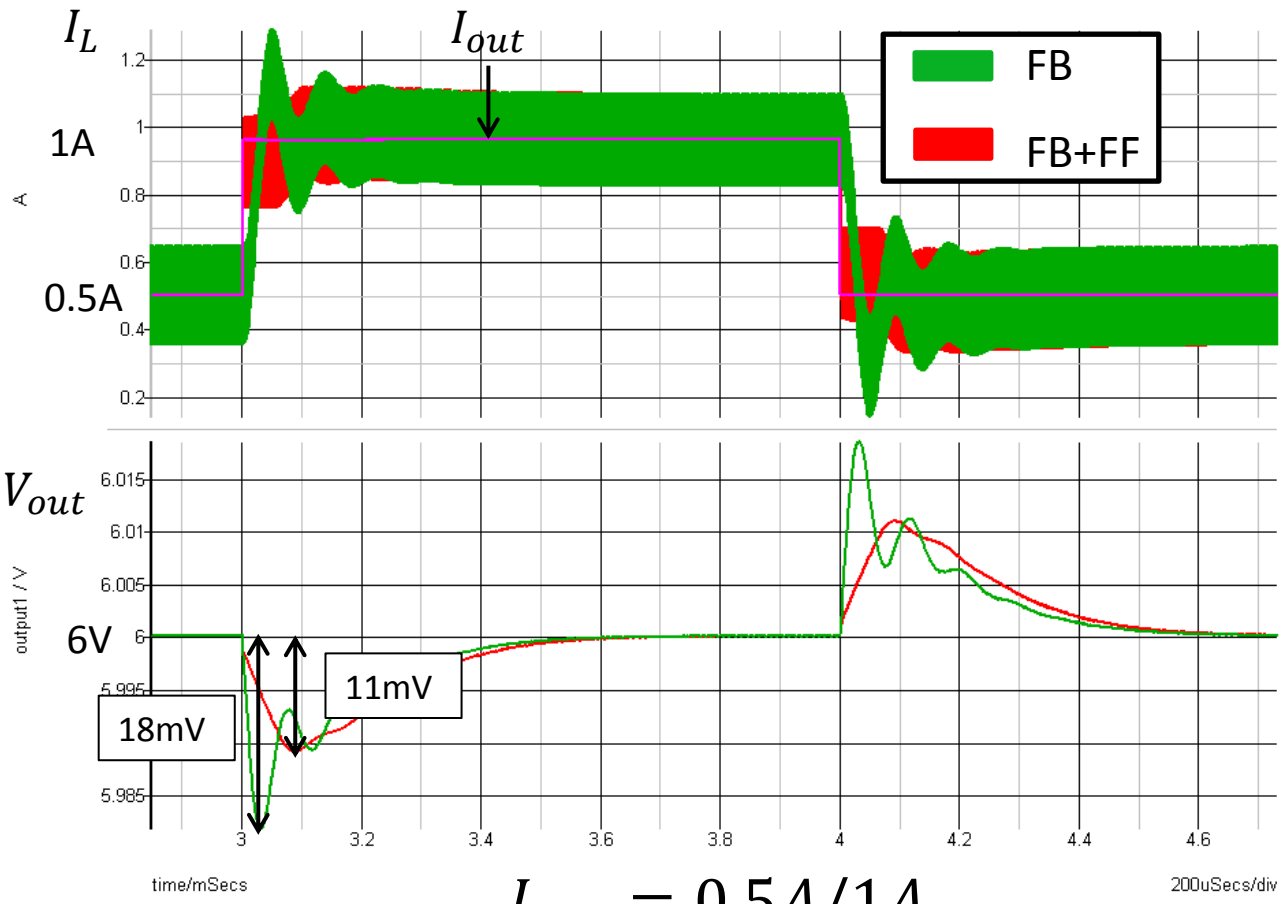
SISO buck converter (1)



Parameter Name	Value
V_{in}	12V
L	20µ
C	500µ
V_{out}	6V
f_{switch}	500kHz

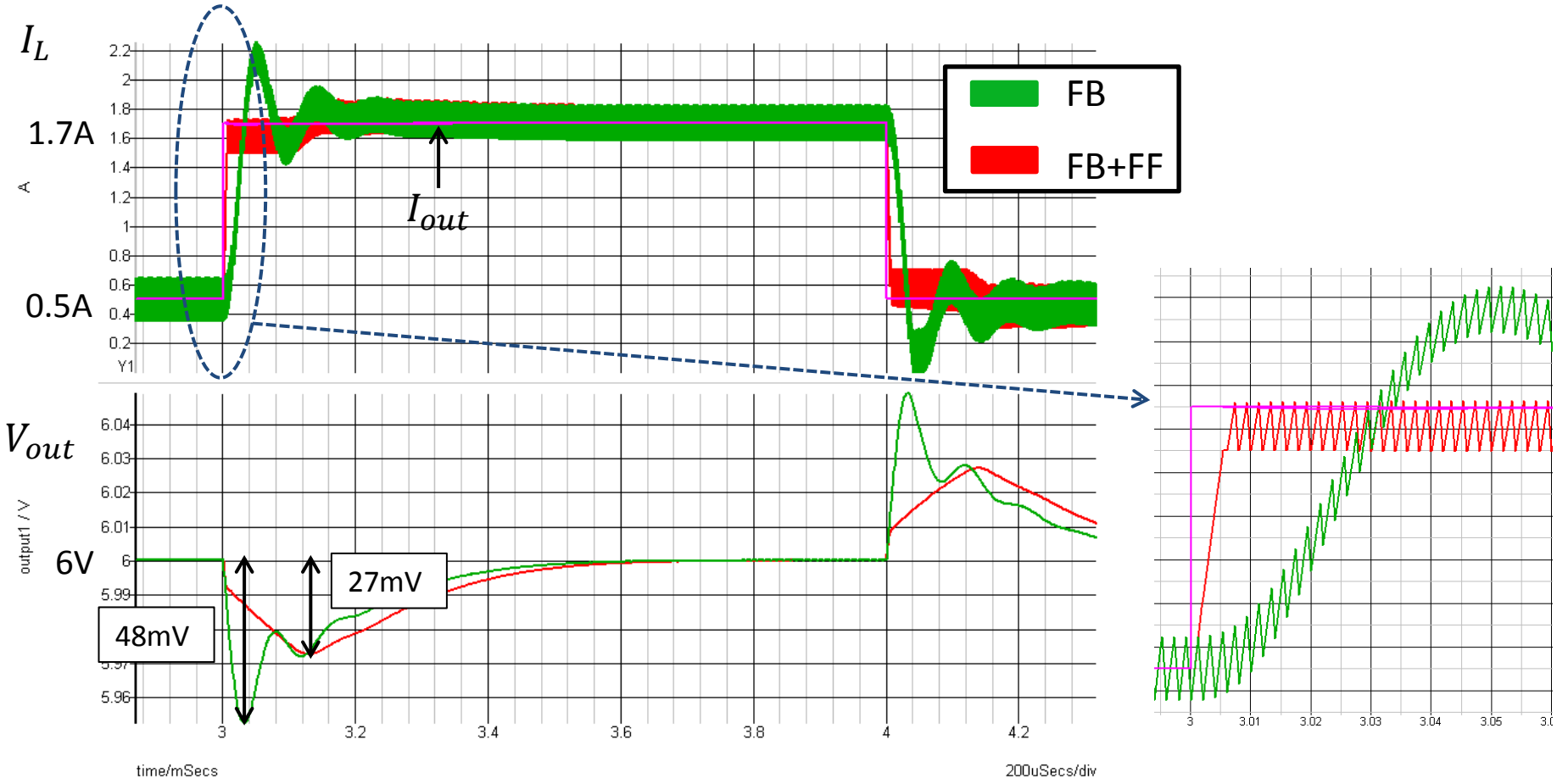
$$I_{out} = 0.5A/1A$$

SISO: Single Inductor Single Output

FB: Feed-back

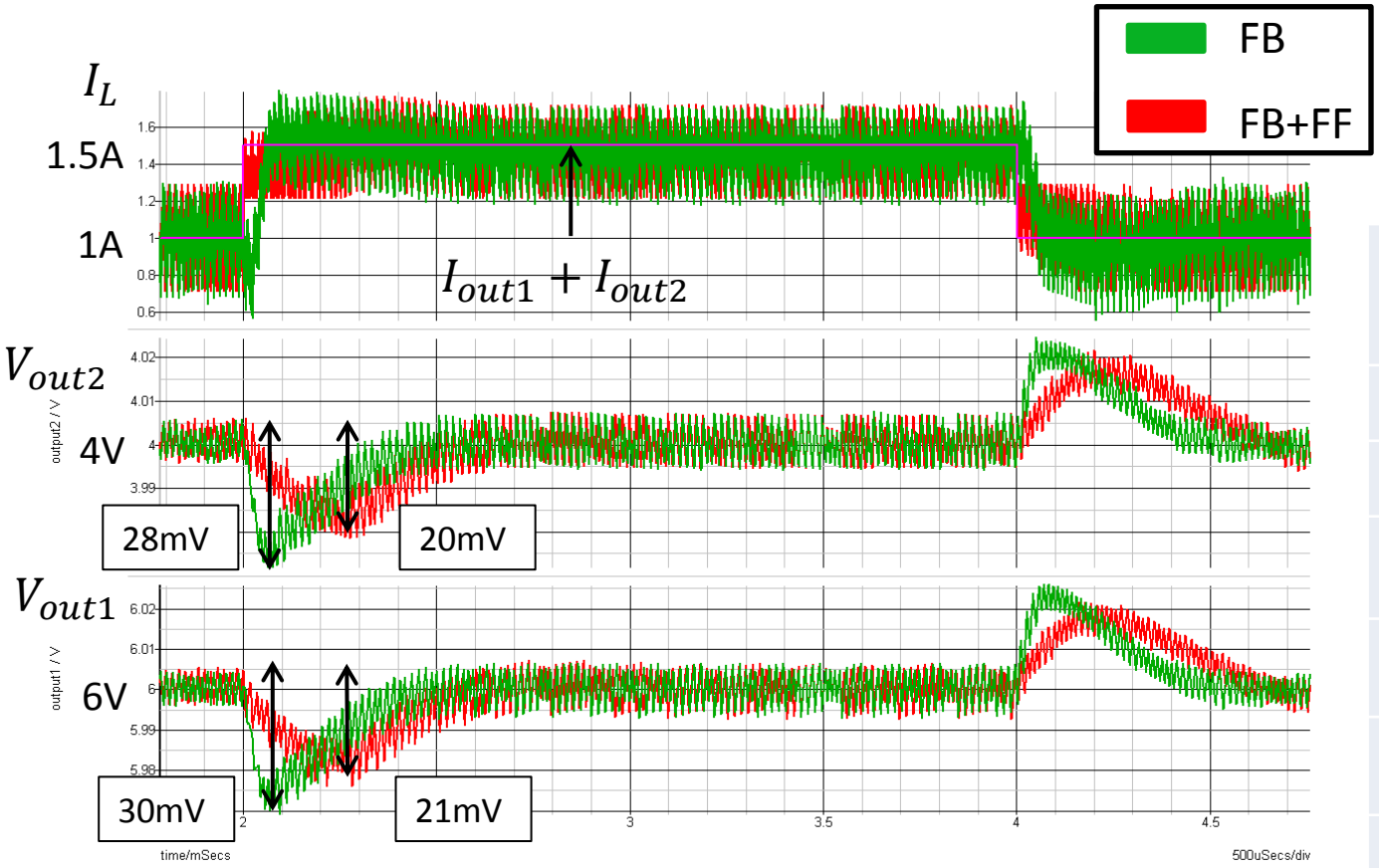
FF: Feed-forward

SISO buck converter (2)



$$I_{out} = 0.5A/1.7A$$

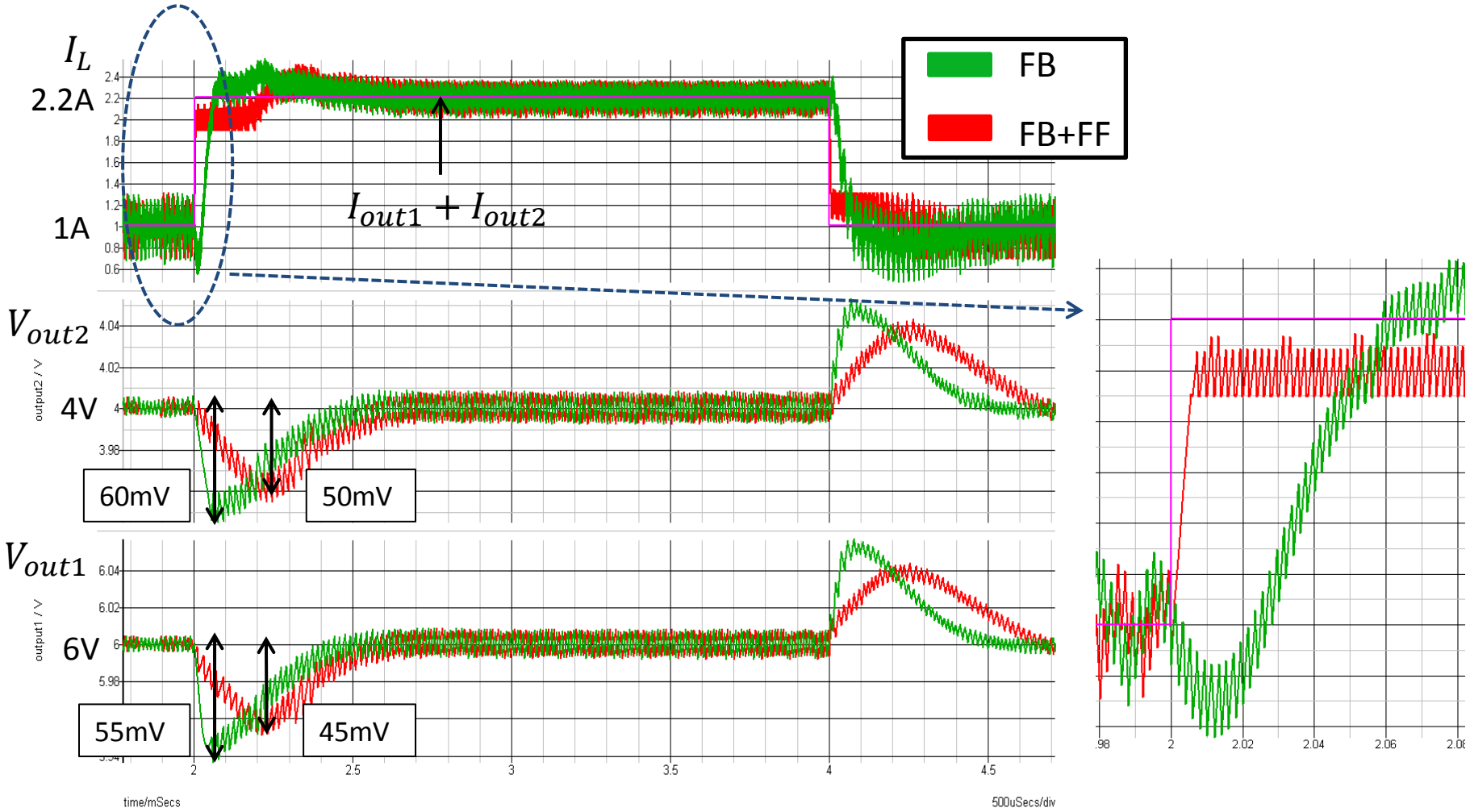
SIDO buck converter (1)



Parameter Name	Value
V_{in}	12V
L	20µ
C_1, C_2	500µ
V_{out1}	6V
V_{out2}	4V
f_{switch}	500kHz

$$I_{out1} = 0.5A/1A,\ I_{out2} = 0.5A$$

SIDO buck converter (2)



$$I_{out1} = 0.5A/1.7A,\ I_{out2} = 0.5A$$

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Conclusion

- SIDO converter is cost-effective
- Proposed a simple feed-forward controller.

- Verified it by simulation
- Cross-regulation is improved

Future work

- We will investigate dynamic threshold and adjustment of saw-tooth
- Design feed-forward controller for boost converter and buck-boost converter

THE END

THANKS FOR YOUR ATTENTION!

Q&A

Q1: In the proposed method (Page 12), voltage and current both are detected, so this method is voltage mode control or current mode control, or both of them are used?

A: the current is used only when the load is changed. If the load is always within the threshold, it just is a normally voltage mode PWM feedback control. So I think it is voltage control. And that no matter is voltage mode or current mode, they both are feed-back control.

Q2: in this presentation, only the current of resistor is consider as load, what about the current of capacitor?

A: the capacitor is used to keep output voltage, it is not a part of load. But in fact, if we want to get an accurate feed-forward control, especially in a SIDO converter, the current of capacitor must be consider. In this design, we don't consider it for simplifying the controller. In future research, it should be used.

Q3: which software is used for your simulation and program?

A: SImetrix