

Automatic Adjustment of Current Imbalance due to Component Variations in Multi-Phase Ripple Controlled DC-DC Converter

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Introduction

Objective

Development of ripple control power supply with :

- ① Multi-phase converters for clockless control
- ② Fast response & Low output voltage ripple

Problem

Current imbalance due to element variations

Proposed method

Automatic current correction for multi-phase converter

Application

Target application in microcontroller

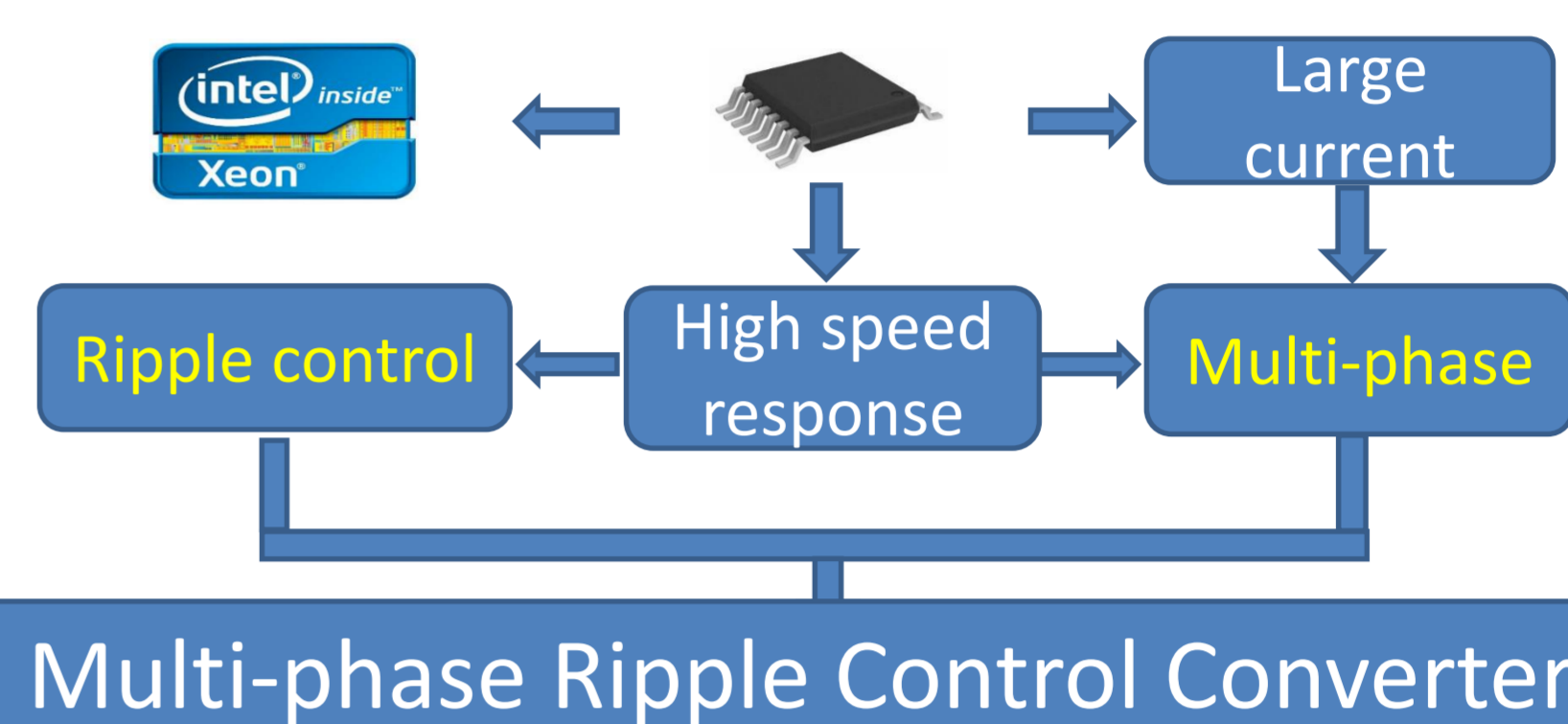
Power Supply



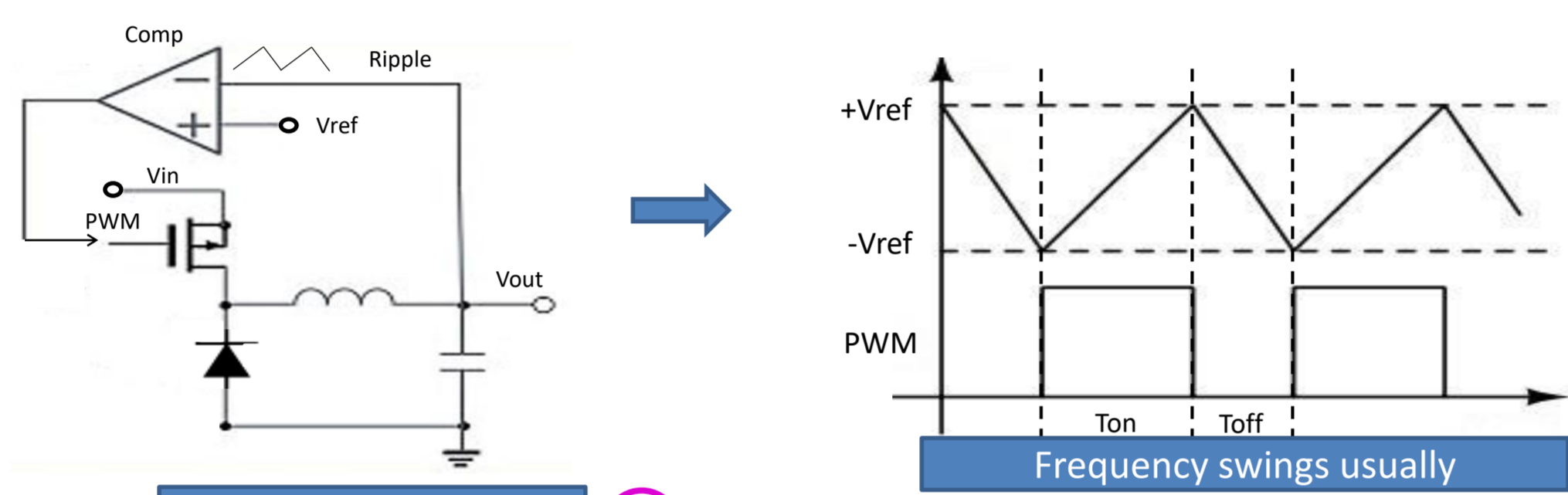
Power supply → demanded everywhere provide appropriate voltage for electronic device

Why multi-phase and ripple control

DC input	DC output	Max. output current	Max. output current step	Max. output current slew rate
12V	1.5V	120A	100A/us	930A/us



Basic Ripple Control Converter



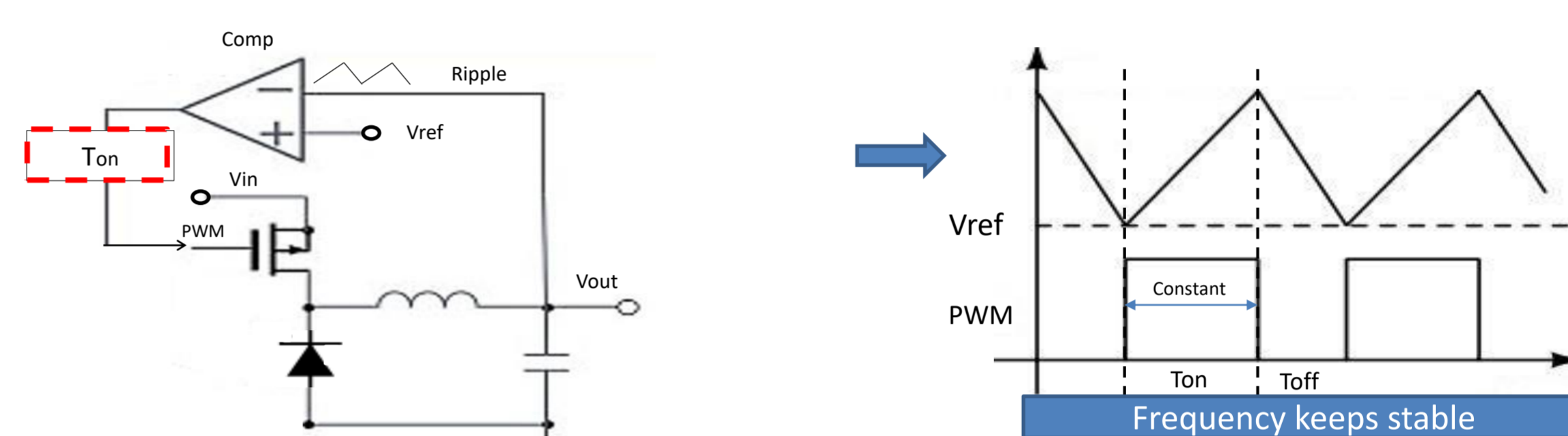
Merit:

- ① High-speed response
- ② Easy to obtain high frequency
- ③ No Op-Amp

Demerit:

- ① Operation frequency is changed by the load current transient
- ② Large noise

Ripple Control with Constant on-time Method



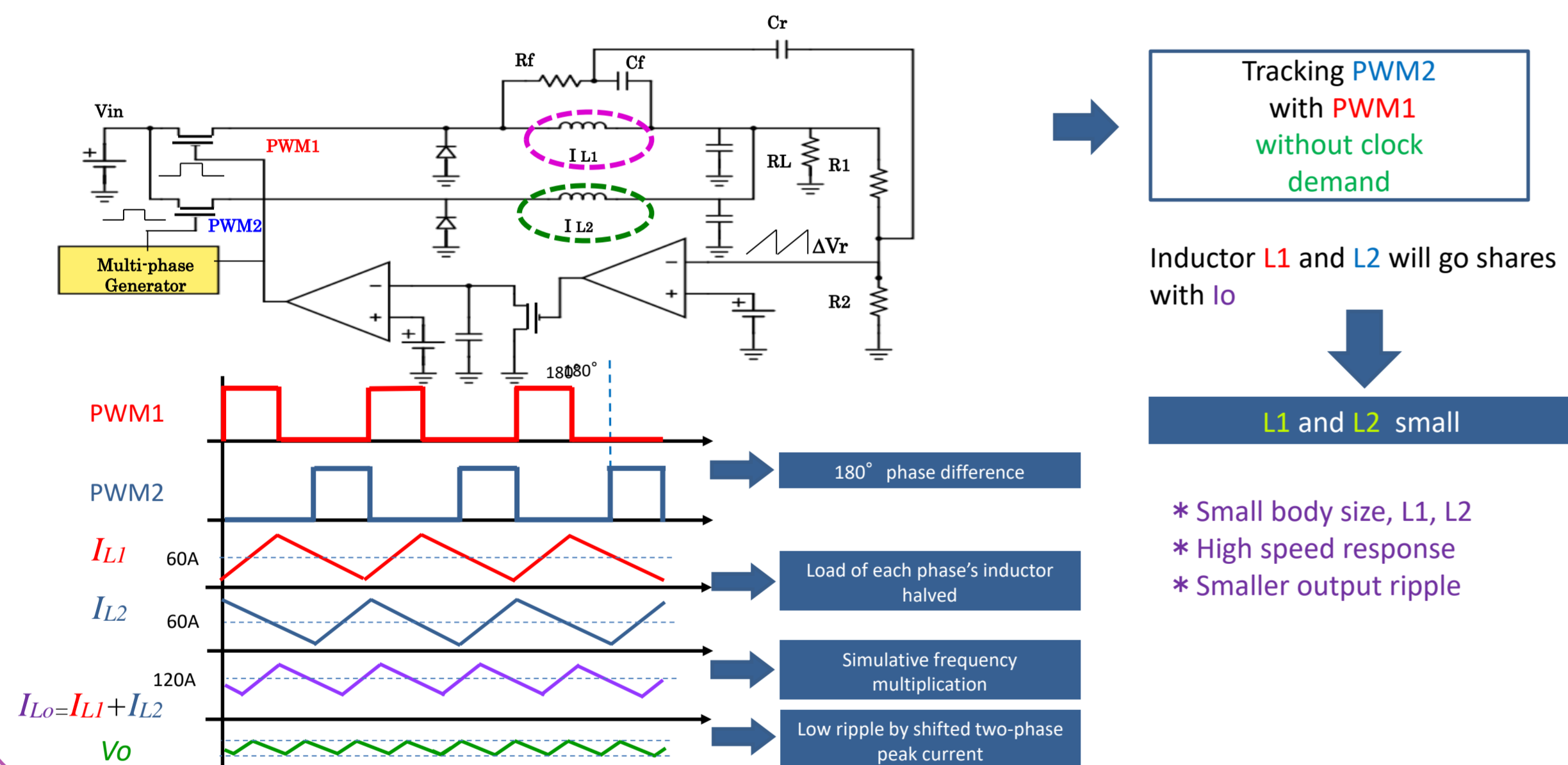
$$V_{out} = V_{in} \frac{T_{on}}{T_s} \Rightarrow f_s = \frac{V_{out}}{V_{in} T_{on}}$$

$$f_s = \frac{1}{T_s}$$

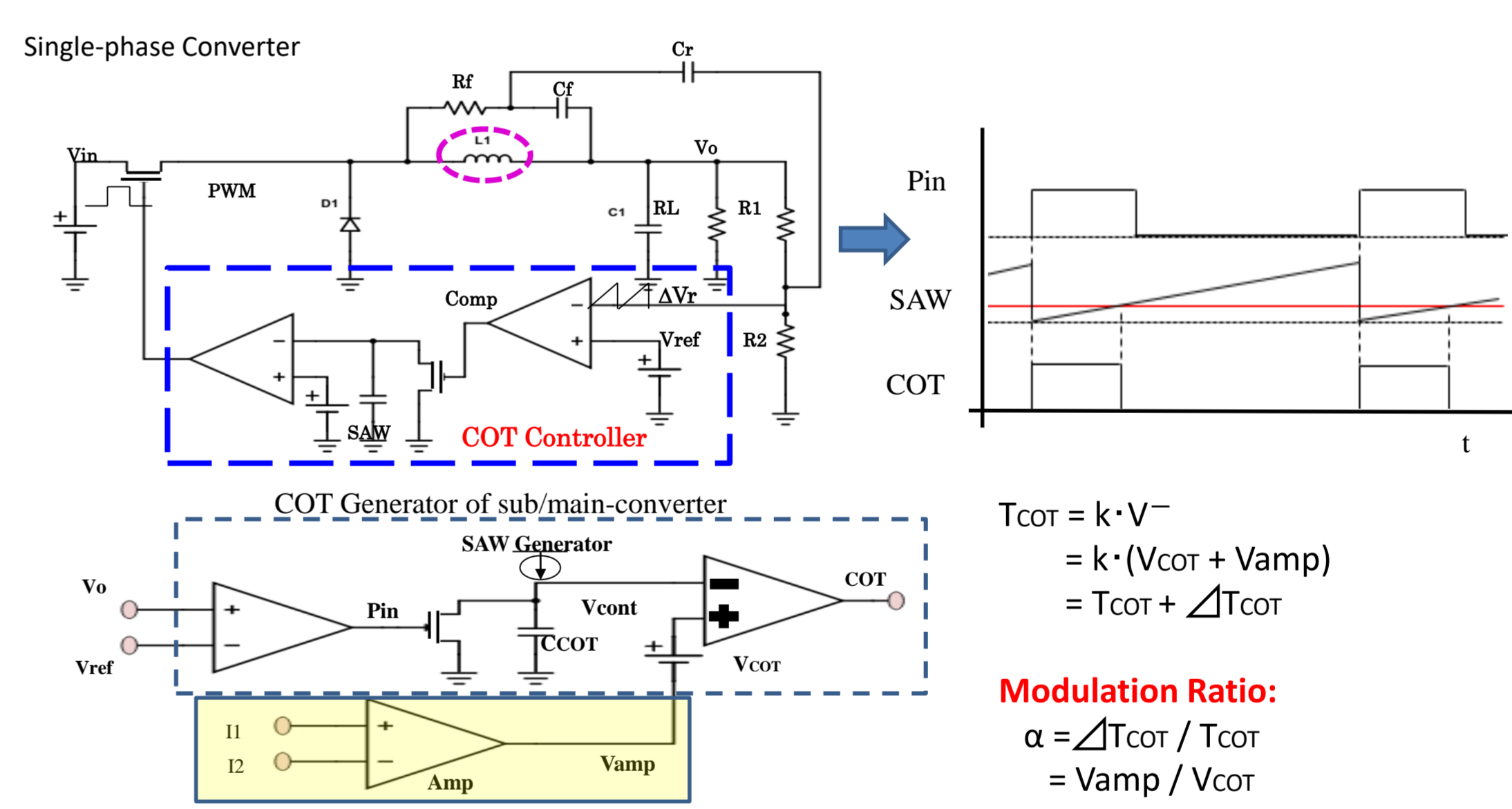
$f_{op} \approx \text{constant}$ } Low frequency
Stable operating frequency

This work

Proposed Multi-Phase Ripple Control Converter



Proposed Current Balance Modulation



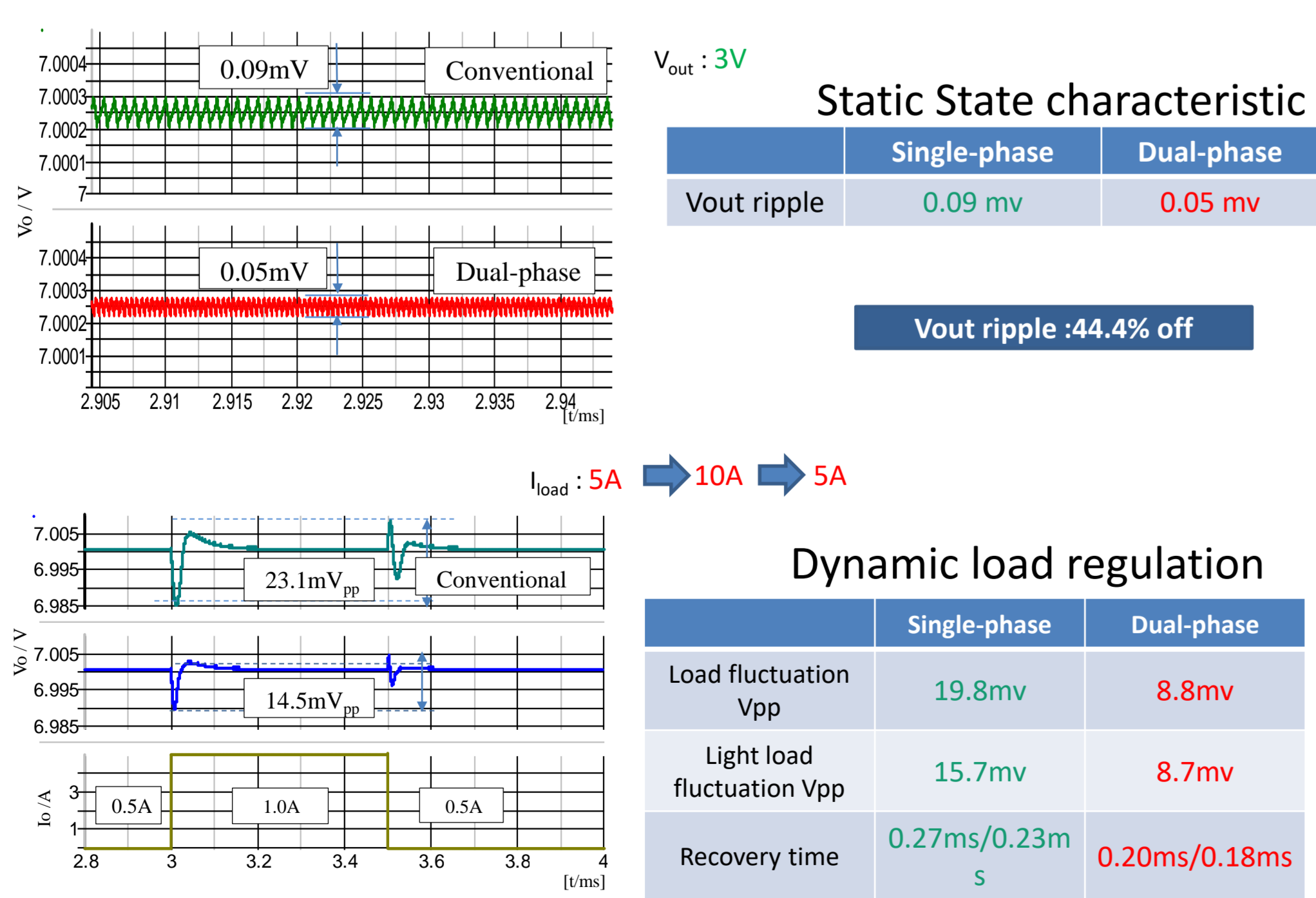
$$T_{COT} = k \cdot V^{-}$$

$$= k \cdot (V_{COT} + V_{amp})$$

$$= T_{COT} + \Delta T_{COT}$$

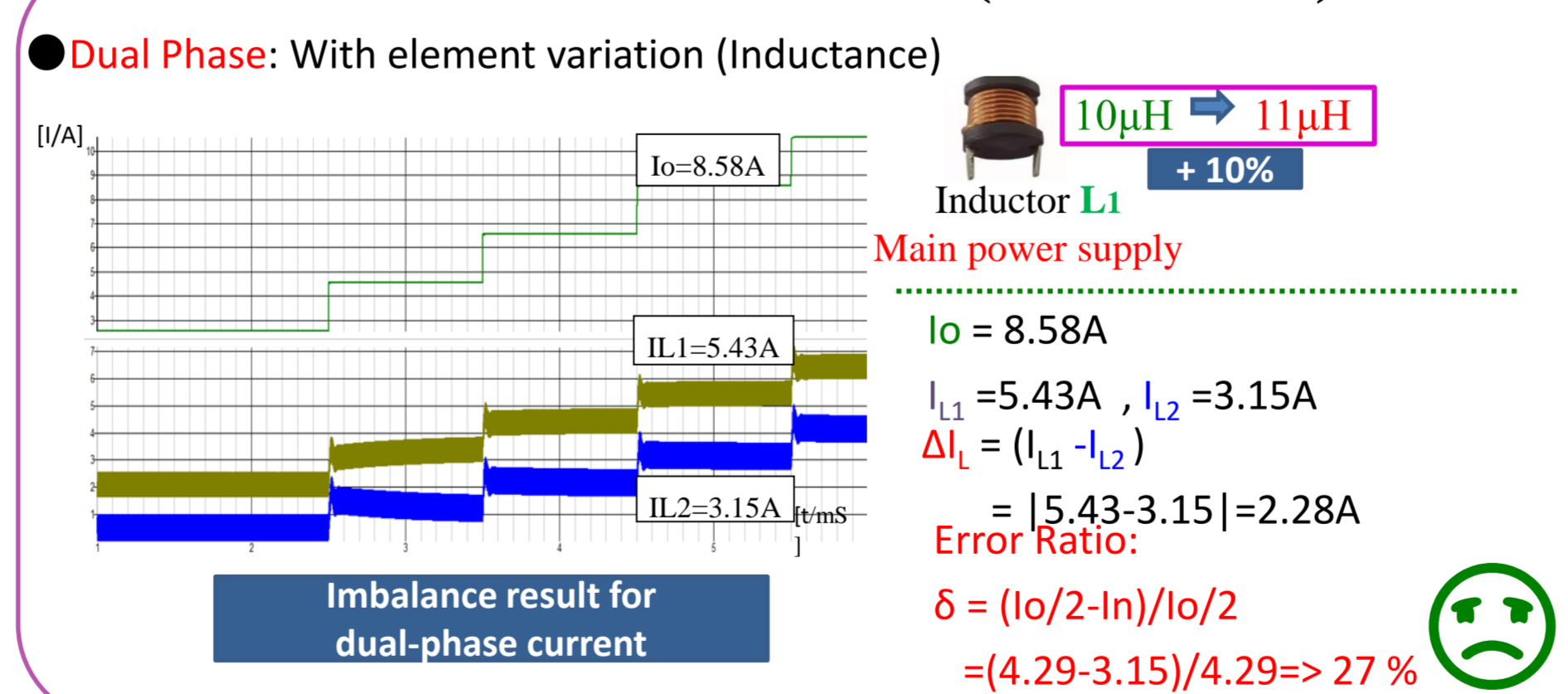
Modulation Ratio:
 $\alpha = \Delta T_{COT} / T_{COT}$
 $= V_{amp} / V_{COT}$

Single and multi-phase Comparison

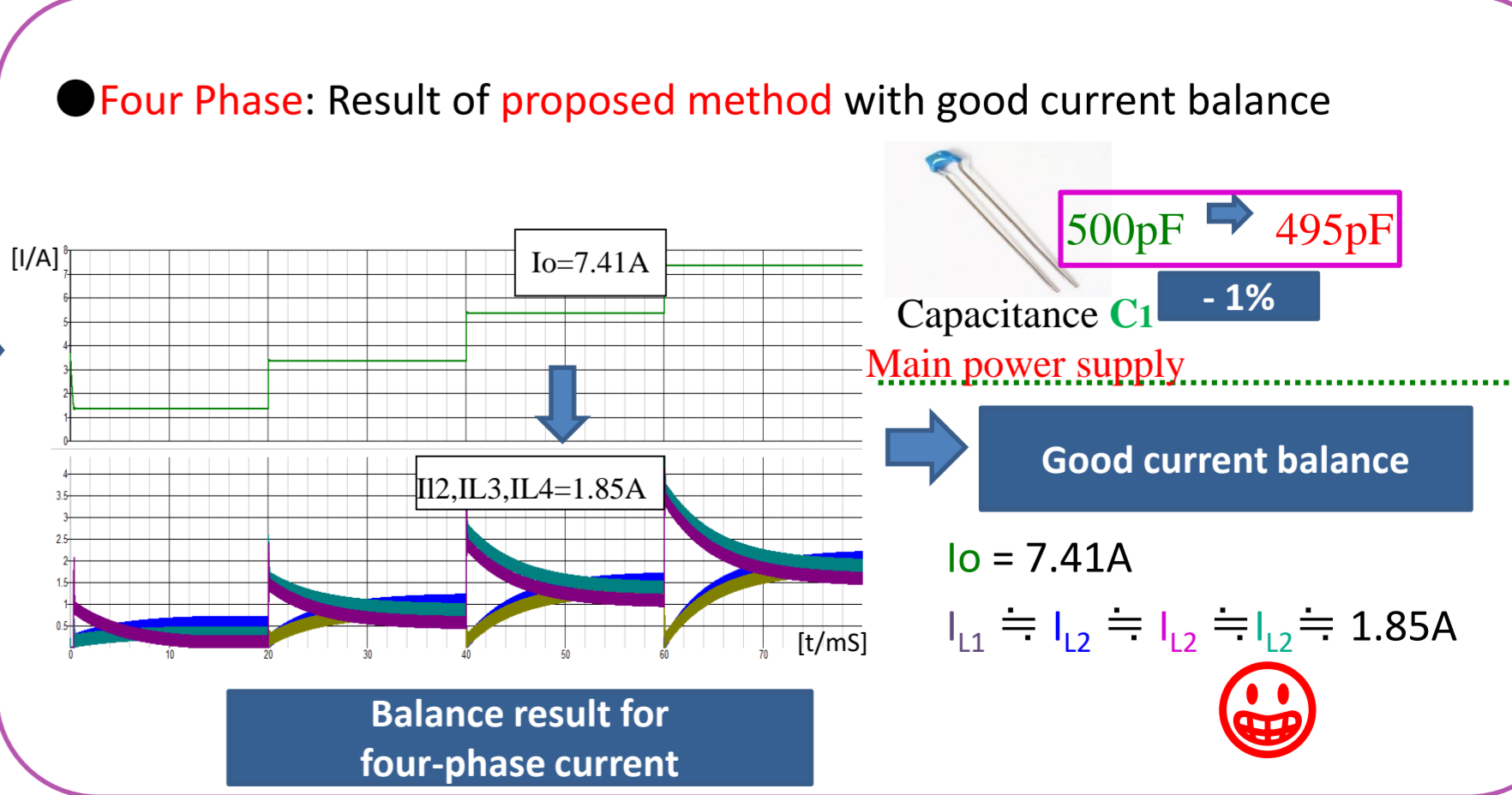
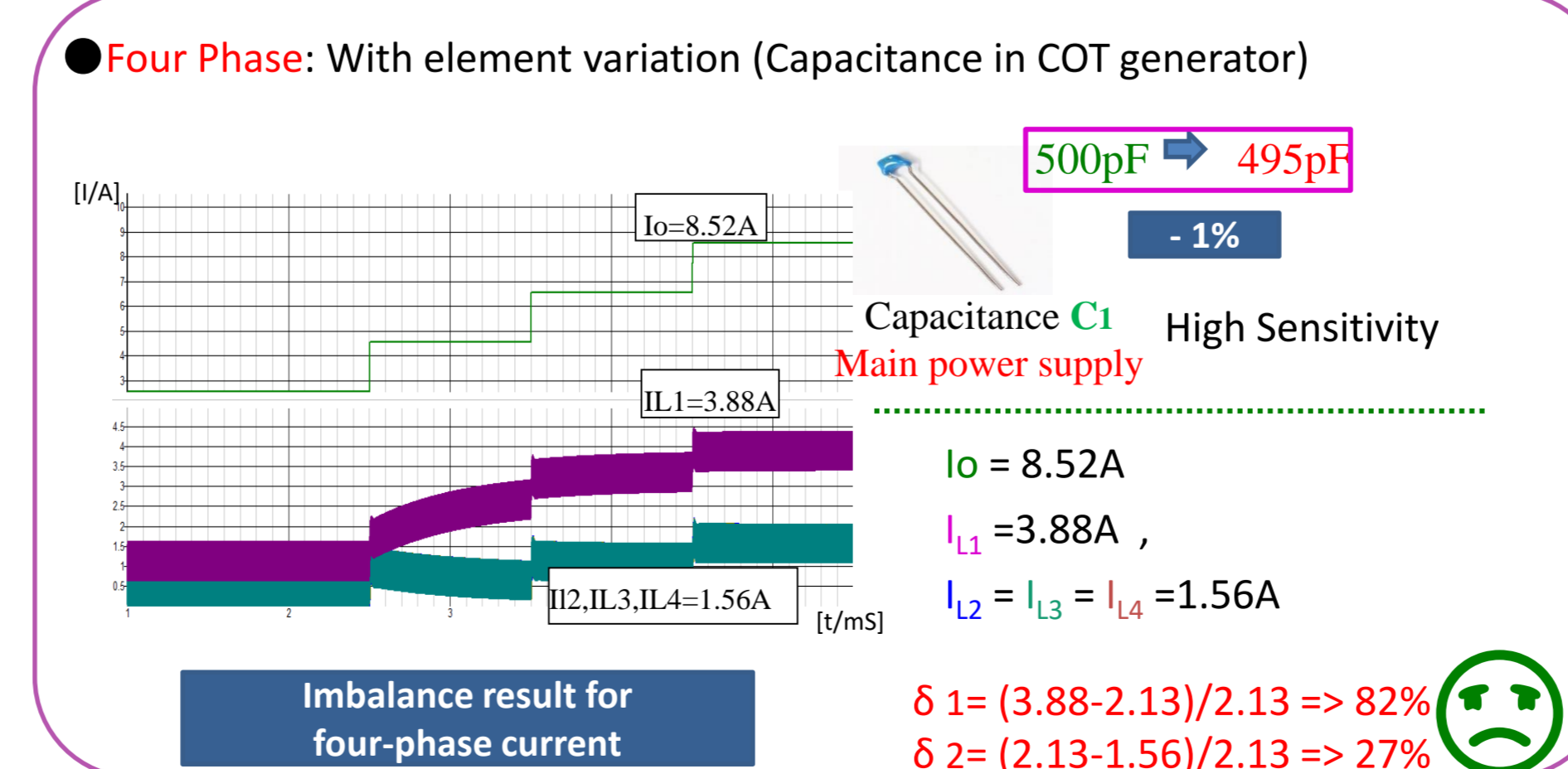
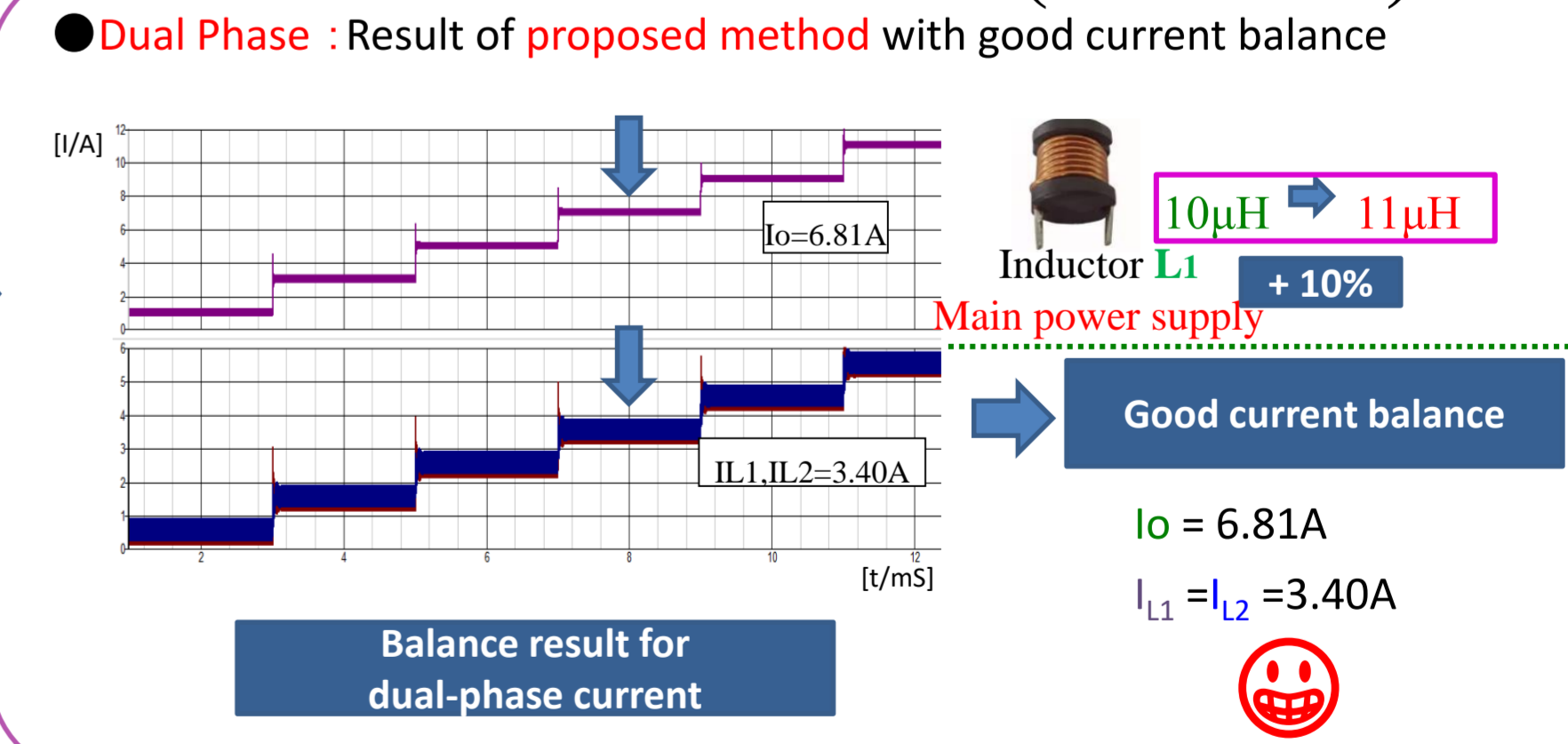


Results and Discussion

Imbalance Current (Problem)



Balance Current (Solution)



Conclusion

- A multi-phase ripple controlled converter is proposed
- The current imbalance due to inductance and capacitance variations is well improved
- Low output voltage ripple, Fast response