Automatic Current Balancing Circuit for Multi-Phase Constant On-Time Hysteresis Control Converter

Shogo Katayama, Jing Li, Yifei Sun, Tran Minh Tri, Yasunori Kobori, Anna Kuwana,
Haruo Kobayashi (Gunma University) t15304906@gunma-u.ac.jp

1B-07

1. Objective

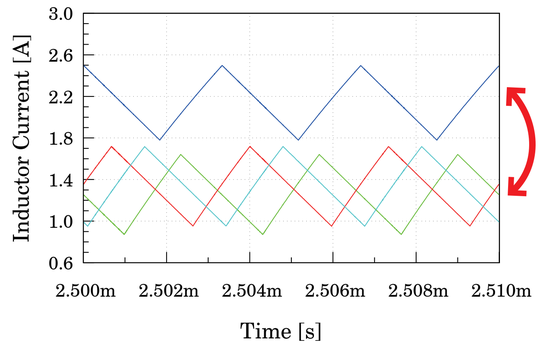
COT hysteresis control converter

1. For large load current
   Multi-Phase configuration
2. Automatic current imbalance correction
   Feedback the current difference

COT: Constant On-Time

2. Background

Current imbalance from L, C element variation



Current imbalance

Causes overcurrent

Increase voltage ripple

Goal

Automatic current balancing

3. Proposed Circuit

Dual Phase COT Converter

Proposal 1

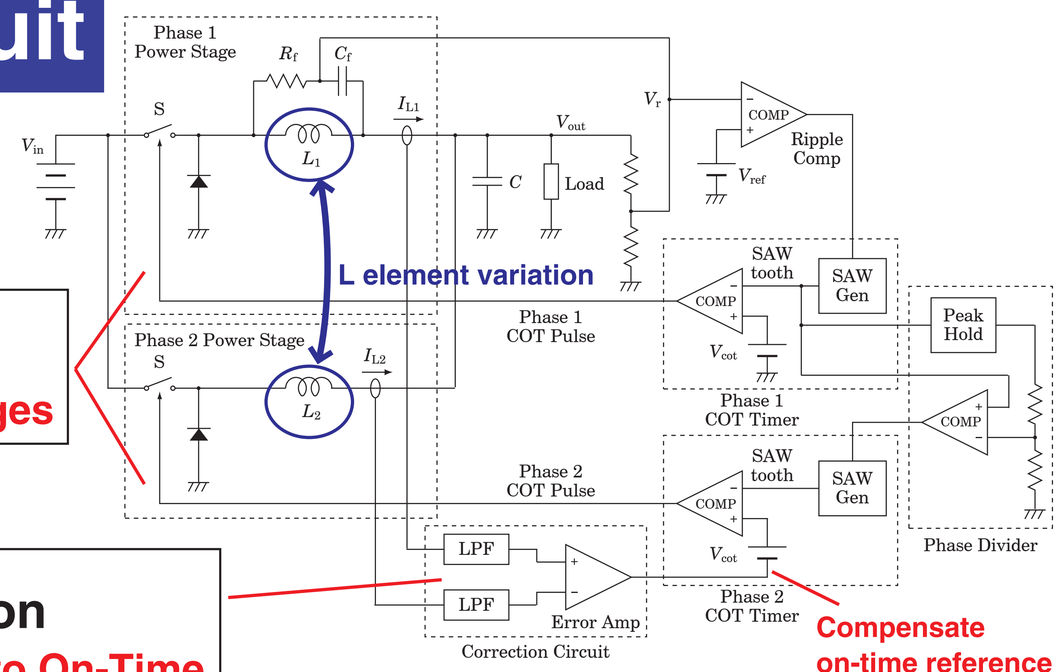
For large load current

Parallel connection of power stages

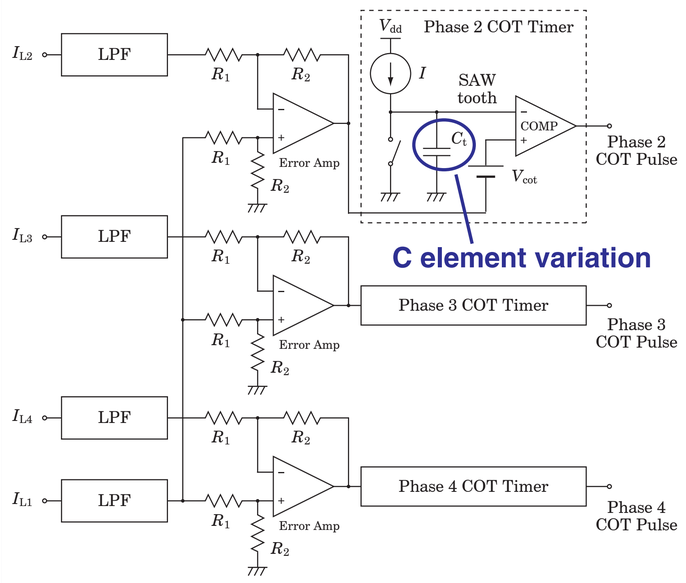
Proposal 2

Current imbalance correction

Feedback the current difference to On-Time



In Quad-Phase



Feedback the current difference to each sub-converter

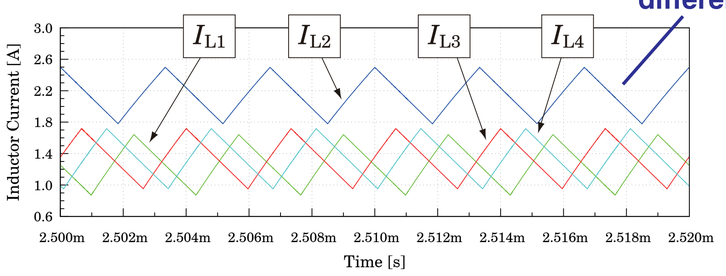
4. Simulation

Conditions

Element variation: C_{t2} increase by 10%

Before imbalance correction

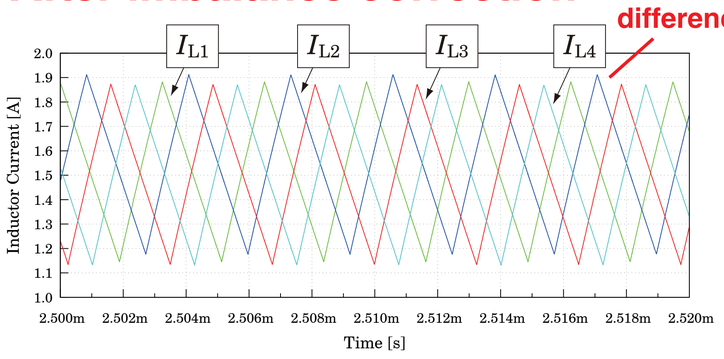
Inductor current difference 41%



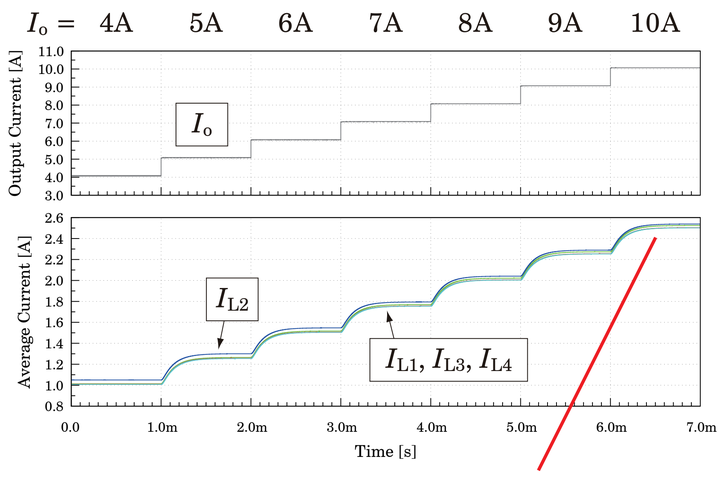
Reduce current imbalance

After imbalance correction

Inductor current difference 1%



Increase load current 4A to 10A



I_o=10A: Inductor current difference 2%

Proposal correction circuit in large load current: Stable

5. Conclusion

COT hysteresis control converter for large load current

- Automatic current imbalance correction
  - Correcting the on-time of the COT pluse by the error amplifier feedback control
  - Error amplifier feedback the inductor current difference to on-time reference
- Simulate proposal corection circuit
  - Increase 10% COT timer capacitor C_{t2}
  - Without correction circuit:
    Inductor current difference 41%
  - Within correction circuit:
    Inductor current difference 1%

Current balance improves significantly

References

[1] H. Kobayashi, T. Nabeshima (Editors), Handbook of Power Management Circuits, Pan Stanford Publisher (2016)

[2] Y. Xiong, K. Asaishi, N. Miki, N. Tsukiji, Y. Kobori, H. Kobayashi, “Constant On-Time Controlled Four-Phase Buck Converter via Two Ways of Saw-tooth-wave Circuit and PLL Circuit” , IEEE International Symposium on Intelligent Signal Processing and Communication Systems, Xiamen, China (2017).

[3] J. Li, Y. Xiong, Y. Sun, T. M. Tri, Y. Kobori, H. Kobayashi, “ Fourphase Ripple Controlled Switching Converter with EMI Noise Reduction Circuit” , International Conference on Mechanical, Electrical and Medical Intelligent System, Kiryu (2018).

[4] K. Asaishi, N. Tsukiji, Y. Kobori, Y. Sunaga, N. Takai, H. Kobayashi, “ Hysteresis Control Power Supply with Switching Frequency Insensitive to Input/Output Voltage Ratio ” , IEEE 13th International Conference on Solid-State and Integrated Circuit Technology, Hangzhou, China (2016).