4th International Conference on Power Engineering, Energy and Electrical Drives
POWERENG
13-17 May 2013 İstanbul-TURKEY

Single Inductor Dual Output Switching Converter using Exclusive Control Method

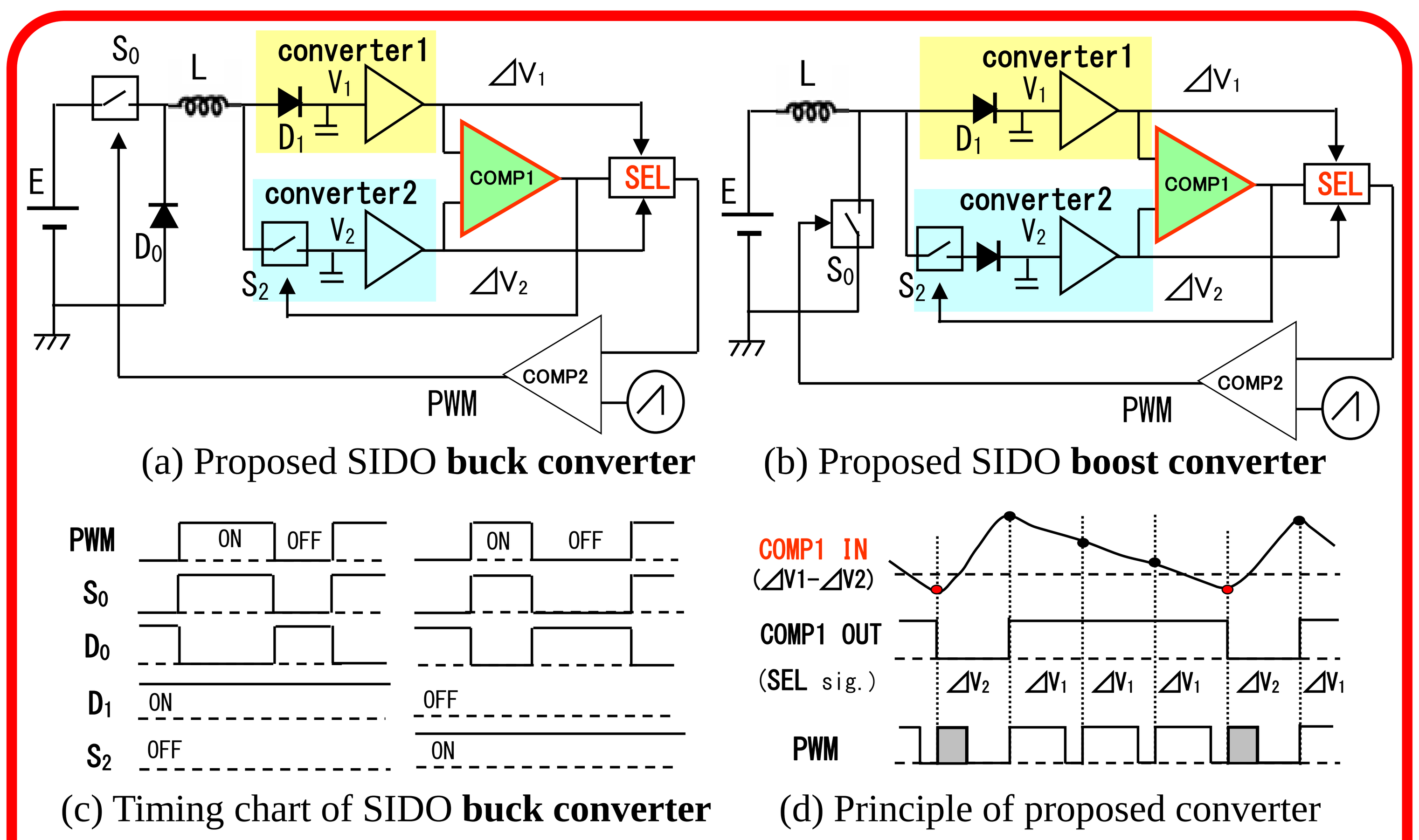
Yasunori Kobori, Member IEEE, Feng Zhao, Quan Li, Murong Li, Shu Wu, Zachary Nosker,
Shaiful N. Mohyar, Nobukazu Takai, Member IEEE, Haruo Kobayashi, Member IEEE,
*Takahiko Odaguchi, Member IEEE, **Isao Nakanishi, ***Kimio Ueda and ****Jun-ichi Matsuda
Division of Electronics and Informatics, Faculty of Science and Technology, Gunma University, Kiryu, Gunma Japan
*AKM Technology Corp. Sendai, Miyagi Japan, **Asahi Kasei Power Devices Corp. Asaka, Saitama Japan,
***Asahi Kasei Microdevices Corp. Chiyoda, Tokyo Japan, ****Asahi Kasei Power Devices Corp. Nobeoka, Miyazaki Japan

I. Introduction

- Single-inductor dual/multi-output (SIDO/SIMO) converters → 1. Reduce the number of inductors. 2. Mobile equipment applications
- SIDO converter design challenge: →
  1. Control two output voltages stable. 2. Suppress the output ripples. 3. Stabilize the dynamic load regulations as self and cross regulations.
- Our proposed control scheme: → Based on exclusive control method (instead of periodic alternative control).
  Decide the next controlled converter by comparing the output voltage of each error amplifier.
  At every cycle of PWM signal, the converter and its PWM signal are selected according to the select signal from the comparator.
  For dynamic load regulation, error voltage of concerned converter can be largely changed.
  Continuously controlled until error voltages of both converters are equal.
  Behavior of the selected converter is like a independent converter.
  Independent of the output voltage/current to control SIDO buck converters or boost converters.

II. Proposed SIDO Converter

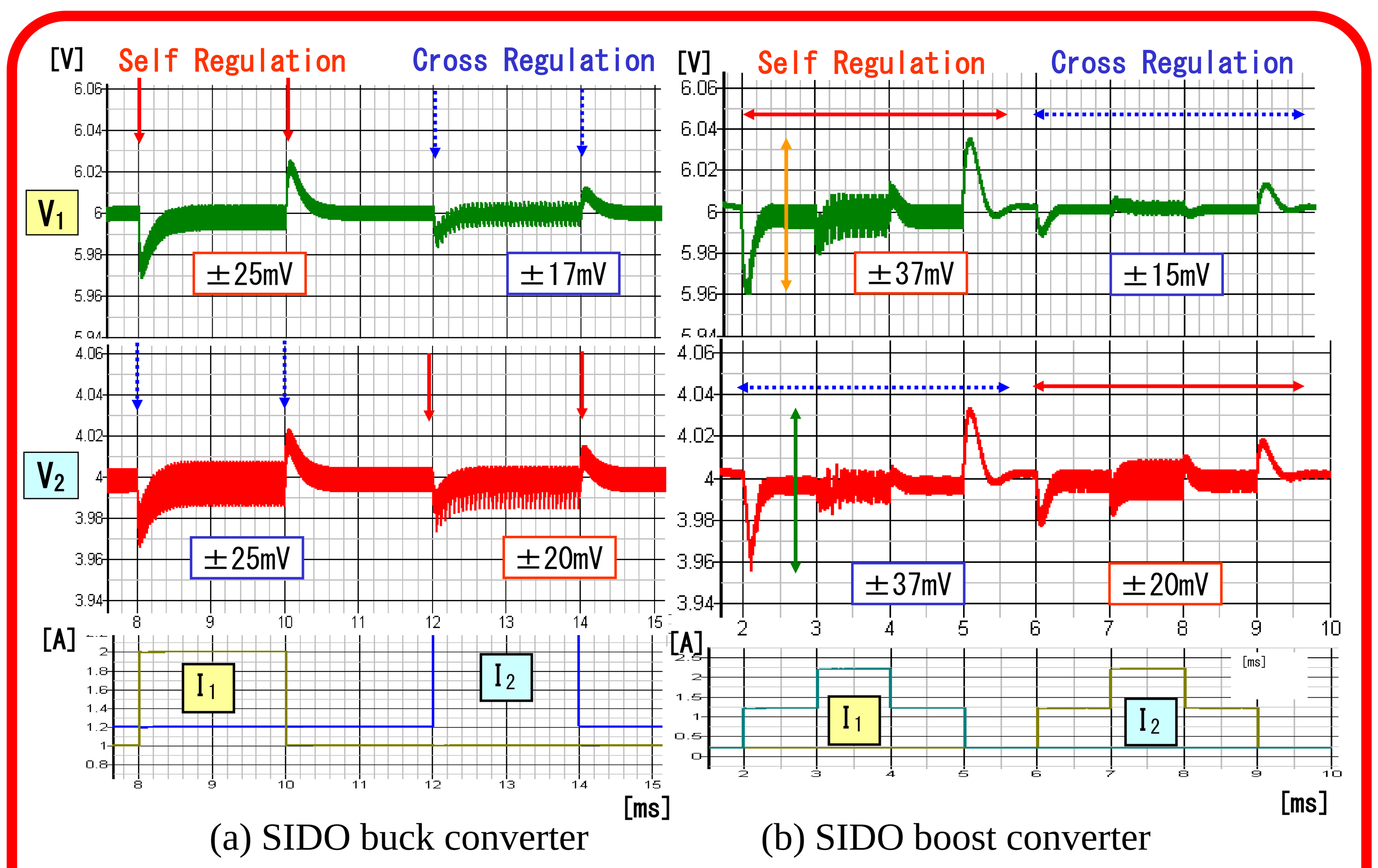
- Two converters are exclusively controlled by the SEL signal.
- SEL signal
  - generated by comparing two error voltages (⊿V1-⊿V2)
  - selects the correct PWM signal for the controlled converter.
  To select the converter 2, the switch S2 is ON.



(a) Proposed SIDO **buck converter** (b) Proposed SIDO **boost converter**
(c) Timing chart of SIDO **buck converter** (d) Principle of proposed converter
Figure 1. Block diagram and timing chart of the proposed SIDO converter

III. Simulation Results

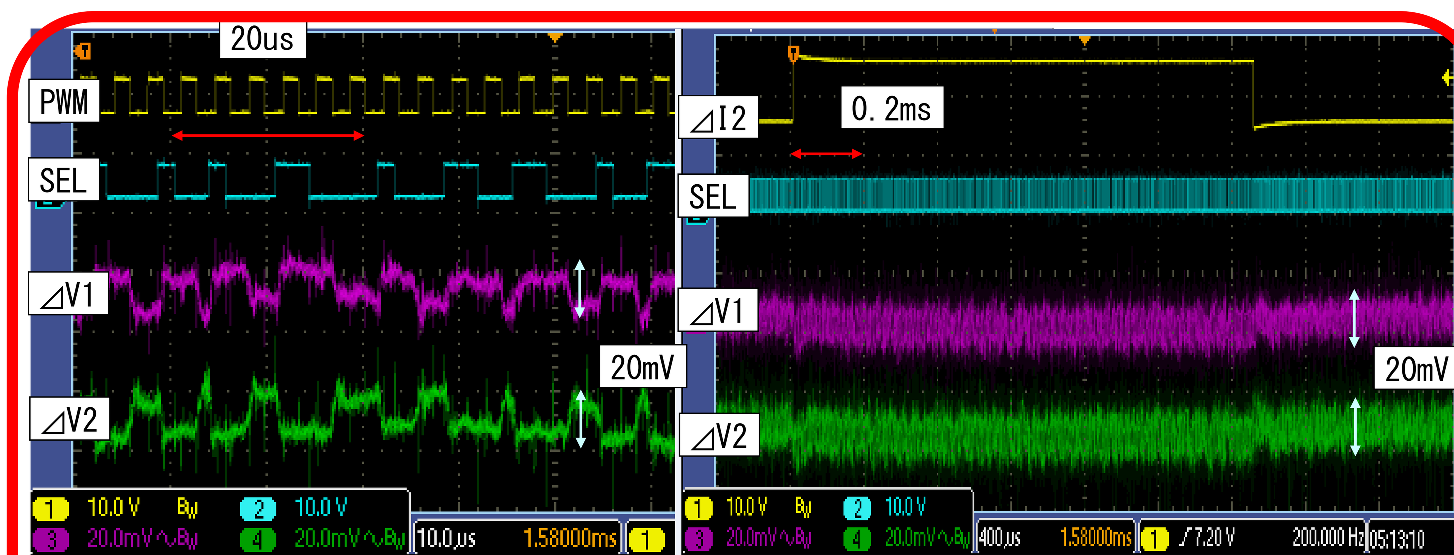
- Fig.2 (a) Output ripples of proposed SIDO buck converter.
  Change of output current is I1=2.1/1.0A or I2=2.2/1.2A
- Fig.2 (b) Proposed SIDO boost converter.
  Output current is changed by three steps of 0.2/1.2/2.2A.
  Overshoots of self- and cross-regulations are less than ±40 mV.



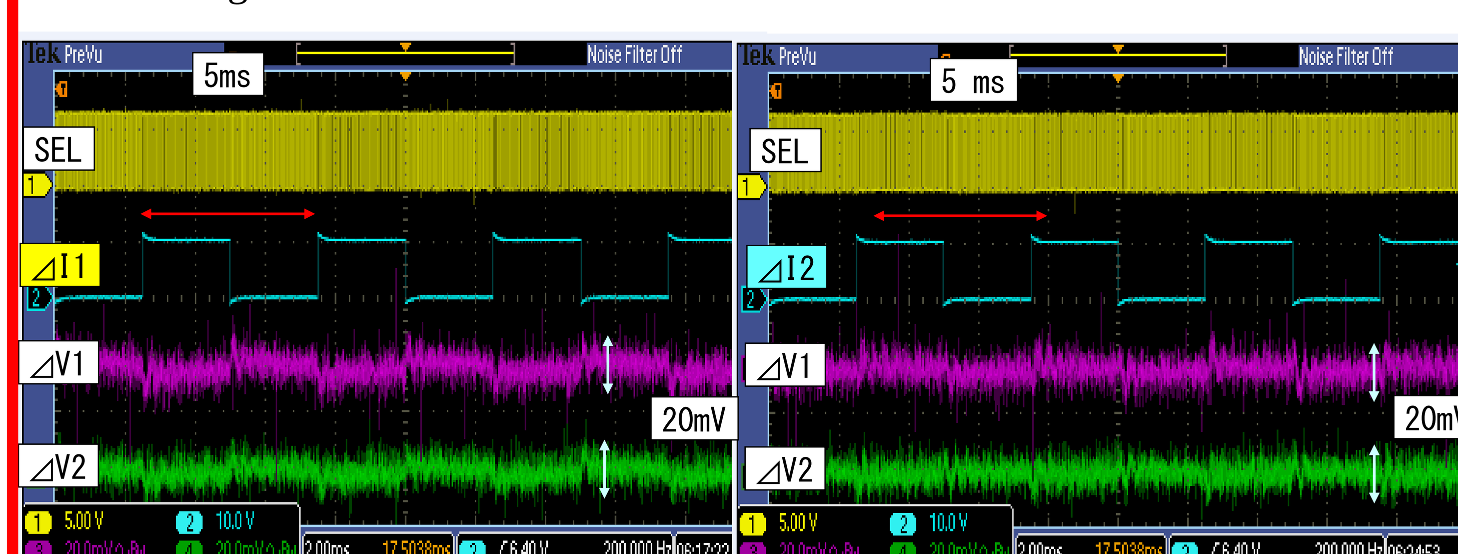
(a) SIDO buck converter (b) SIDO boost converter
Figure 2. Simulation results of the proposed SIDO converters

IV. Experimental Results

- Experimental circuit is built on universal board.
  Clock frequency=300kHz. Output current: I1=0.50A,I2=0.36A.
- Fig.3 (a): Output voltage ripples, whose polarities are complementary each other because of exclusive control.
- Fig.3 (b) : Self-regulation ⊿V2 and cross-regulation ⊿V1 for current change ⊿I2=0.60/0.36A. Both are about 20 mV.
- Fig. 4: Self-regulation and cross-regulation for current change of ⊿I1=0.18/0.03A, ⊿I2=0.22/0.11A in SIDO boost converter.
- Voltage ripples at steady state are about 10mV.
  Overshoots of self/cross regulation are about 20mV.



(a) PWM signal and output ripples (b) Dynamic load regulations
Figure 3. Characteristics of the SIDO buck converter



(a) Dynamic load regulations for ⊿I1 (b) Dynamic load regulations for ⊿I2
Figure 4. Characteristics of the SIDO boost converter (self/cross-regulation)

IV. Conclusion

- Two types of single-inductor dual-output (SIDO) converter
- New exclusive control method: independent of output voltage/ current.
- Operation principle of the proposed method is verified by simulation.
  Self/cross regulations in simulation are about ±25 mV in buck converter and about ±37mV in the boost converter (⊿I=1.0A step).
- Experimental results of the buck converter: 15mV of output ripple, 20mV of self/cross regulations at I1=0.60/0.36A and I2=0.22A.
- Experimental results of the boost converter:10mV of output ripple, 15mV of self/cross regulations at I1=0.18/0.03A and I2=0.22/0.11A.