Design of Hysteresis Controlled Single-Inductor Multi-Output DC-DC Converter

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Nowadays, various applications require DC-DC converters with multiple output voltages. DC-DC converters are desirable for small size and low cost. To overcome this problem, single-inductor multiple-output (SIMO) converters have recently been introduced [1],[2]. However they suffer from performance degradation with conventional control methods because the energy charged in one inductor is distributed to each output voltage one by one.

In this paper, we study a hysteresis control method applied to singule-inductor dual-output (SIDO) converters, which can obtain faster response and lower voltage ripple. As shown in Fig.1, compared with current controlled PWM converter, the proposed hysteresis controlled converter does not require saw-tooth wave generator or current sensor.

First, we have evaluated the performance of single-inductor single-output (SISO) power supply circuit using the proposed hysteresis control with simulation and experiment. Next, we have applied the hysteresis control to SIDO power supply and verified its performance with imulation and experiment.

Furthermore, we propose a new SIDO circuit for the output voltage ripple reduction as shown in Fig. 2. In the proposed circuit, output voltages are set as Vo1 > Vo2. Timing chart for the proposed SIDO buck converter circuit operation is shown in Fig.3. In the timing chart, in mode 1 (when both S1 and S2 are off) the inductor current is charged but it is not supplied to Vo1, Vo2. In mode 2 (S1 is on, S2 is off) the inductor current is supplied to Vo1. Similarly in mode 3 (S1 is off, S2 is on) the inductor current is supplied to Vo2. In mode 4 (both S1, S2 are on), the inductor current is supplied to the lower voltage terminal, i.e., Vo2. Fig.4 shows the simulation results, and we see that the static output voltage ripple is less than 15mVpp and the transient voltage ripple is within 13mVpp.

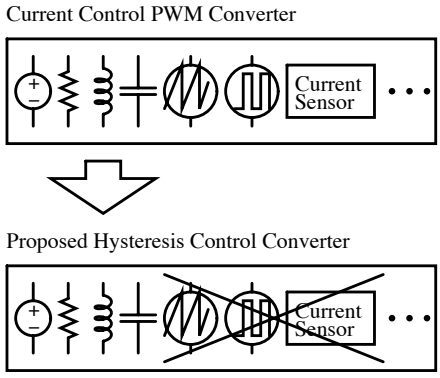


Fig. 1 Difference between the proposed circuit and current controlled PWM.

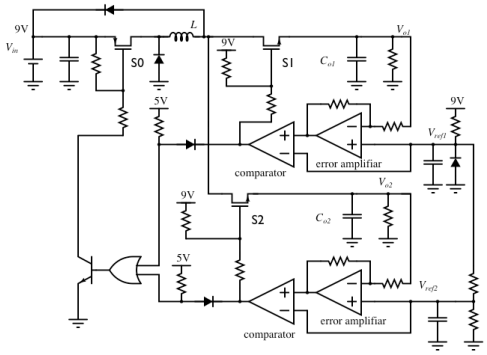
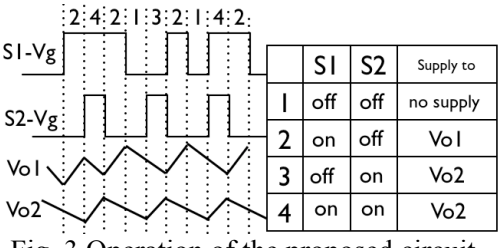


Fig. 2 Proposed circuit of SIDO buck converter.



	S1	S2	Supply to
1	off	off	no supply
2	on	off	Vo1
3	off	on	Vo2
4	on	on	Vo2

Fig. 3 Operation of the proposed circuit.

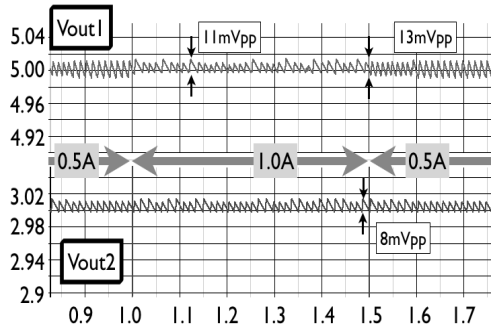


Fig. 4 Simulation results of the proposed circuit.

[1] N. Takai, H. Iwase, T. Okada, T. Sakai, Y. Kobori, H. Kobayashi, T. Omori, T. Odaguchi, I. Nakanishi, K. Nemoto, and J. Matsuda. Low power consumption control circuit for sibo dc-dc converter. International Conference on Analog VLSI Circuits, Valencia, Spain, October 2012.

[2] Y. Kobori, S. Tanaka, T. Nagashima, T. Sakai, K. Kaneya, S. Todoroki, Z. Nosker, N. Takai, and H. Kobayashi. High- speed response single inductor multi output dc-dc converter with hysteretic control. 1st Annual International Conference on Power, Energy and Electrical Engineering, Singapore, August 2013.