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Transient Response of a Digitally Controlled Power Supply Based on Power-SoC

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Abstract

POLs (Point of Load) have become important technology because they can suppress the voltage drop and reduce the power consumption of MCUs (Micro controller Unit). Then, miniaturization of power supply is required for realizing POL and Power-SoC which can implement power semiconductor devices, passive components, and control circuits on silicon wafers has attracted attention and studied in recent years. The key applications of power SoC are DVFS(Dynamic Voltage and Frequency Scaling) and envelope tracking. These applications are required fast transient response for output voltage. In this paper, we discuss the transient response of a digitally controlled power supply, which we are previously proposed.

Brief Description and Figures

In this study, we use our previously proposed control strategy[1,2] which can regulate the output voltage by changing the number of working POLs[1,2]. For example, a small number of POLs are operated at light load, and a large number of POLs are operated at heavy load (Fig.1). Also, we proposed the control algorithm which require only 3 digital codes, the input voltage, the target output voltage and the switching frequency, without adjustment the complex parameters for DSP[3].

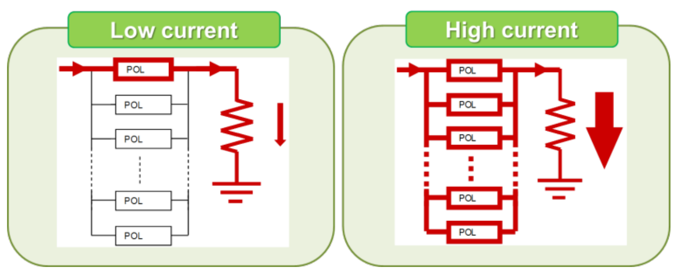
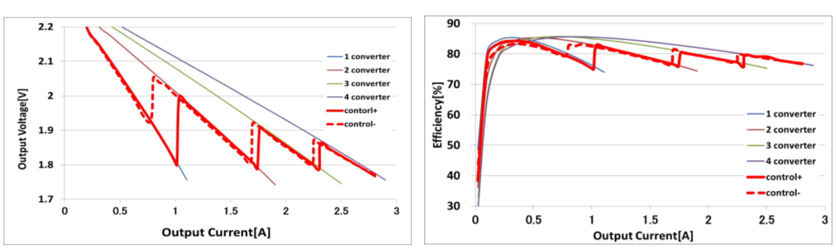


Fig.1 Parallel-connected POL system.

Figures 2 (a) and (b) show load and efficiency characteristic. Table 1 shows the circuit parameters and system specifications. These results indicate that the proposed algorithm can regulate the output voltage and realize high efficiency over the wide load range.



(a) Load characteristic. **(b) Efficiency characteristic.**

Fig.2 Experimental results.

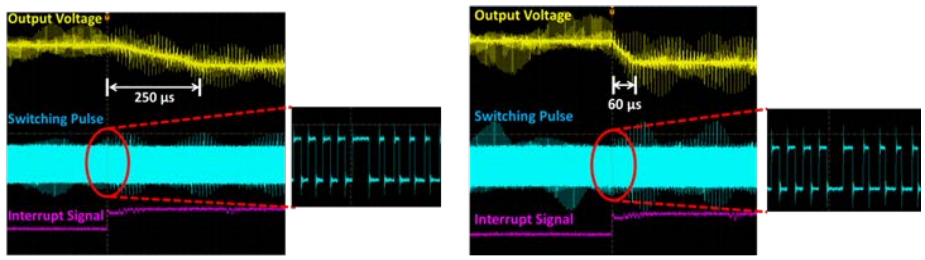
Table 1 Circuit Parameters and Conditions.

Symbol	Description	Value
Vin	Input Voltage	5 V
Vout	Output Voltage	1.8 V
L	Inductor	4.7 μH
rL	DCR	2.7 Ω
Co	Output Capacitor	4.7μF
rC	ESR	0.01 Ω
f	Switching Frequency	1 MHz

For DVSF and envelope tracking, faster response is required when the target output voltage changes. Equation (1) shows the damping coefficient δ at sudden duty change in the proposed POL. The transient response is faster as the damping coefficient is closer to 1.

Figures 3 (a) and (b) show the transient response of output voltage at sudden duty change for the proposed control algorithm. The number of connecting POLs is 4. The faster transient response is realized by increasing the number of working POLs and approaching 1 for the damping coefficient.

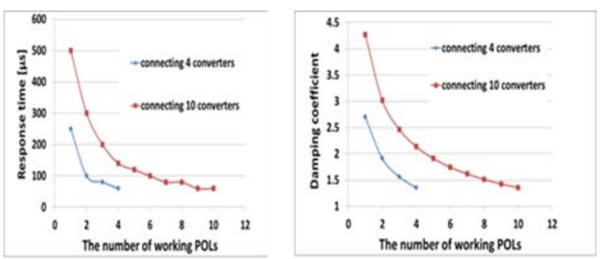
$$\delta = \frac{r_L + r_C}{2}\sqrt{\frac{C_0}{L}} \quad \cdots\cdots\cdots\cdots (1)$$



(a) Working 1 POLs. (b) Working 4 POLs.

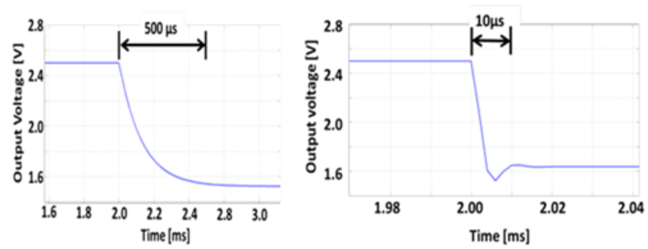
Fig.3 Response of output voltage at duty sudden changes.

Figures 4 (a) and (b) show dependence of the response time and the damping coefficient on the number of working POLs. Figures 5 (a) and (b) show simulation results of output voltage at sudden duty change. The number of connecting POLs is 10. These results indicate that the transient response is faster as the damping coefficient is closer to 1 and the switching frequency increases.



(a) Response time. **(b) Damping coefficient.**

Fig.4 Dependence of response time and damping coefficient on the number of working POLs.



(a) 1MHz. **(b) 10MHz.**

Fig.5 Response of output voltage at duty sudden changes by simulation.

Key Contributions

We investigated the transient response of DSP control algorithm. The simulation results show that the transient response is faster as the number of working POLs increase, the damping coefficient is closer to 1 and the switching frequency increases.

[Reference]

[1] T. Yamamoto et al. IEEE PEDS 2013, pp.109-112, 2013.

[2] M. Higashida, T. Yamamoto, S. Abe, S. Matsumoto, EPE'15 ECCE Europe, 0365,2015

[3] T. Oka, S. Abe, S. Matsumoto, EDD and SPC IEEJ, pp. 75-80, 2017