AMDE

Four-Phase Ripple Controlled Switching Converter with EMI Noise Reduction Circuit

Jing Li, Yi Xiong, Yifei Sun, Tran Minh Tri
Yasunori Kobori and Haruo Kobayashi
Division of Electronics and Informatics, Gunma University
1-5-1 Tenjin-cho, Kiryu 376-8515, Japan
E-mail address t171a100.gunma-u.ac.jp

Multi-phase DC-DC buck converter technology has been studied since a long time ago. For the operation of high-performance processors such as PCs and servers, markets demand for fast response and low output voltage ripple of their power supplies [1].

Attempting to alleviate this problem, this paper describes a four-phase switching converter using a ripple control without a stable clock pulse. By dividing the peak hold voltage by four which is supplied from the saw-tooth signal of the main converter, four phase clocks are generated. In our converter, the output voltage ripple is reduced by 10% and the settling time is decreased to one-fifth. Good current balance is obtained for the large load current of 105 A. Moreover, the EMI noise of the PWM spectrum is reduced by 15 dB using the phase-modulating of main control signal.

Fig.1 shows the configuration of the four-phase converter with constant-on-time (COT) control [2]. The feedback voltage *Vr* and the reference voltage *Vref* are directly compared by the comparator, and the output pulse is used to set the SR flip-flop, and a Ton timer achieves the constant on-time [3]. The proposed pulse phase modulation circuit is shown as Fig. 2. The phase is randomly changed while maintaining the on-time fixed for each clock. Fig. 3 shows the spectrum of the conductive noise (input current) without the EMI reduction, whereas Fig. 4 shows that with the EMI reduction. In the single phase converter, the spectrum level at the clock frequency (Fpwm=390kHz) is reduced from 300 mV to 100 mV, which is 9.5 dB reduction. In the four phase converter, the spectrum level at the four-fold frequency of the clock frequency is reduced from 240 mV to 60 mV, which is 12 dB reduction.

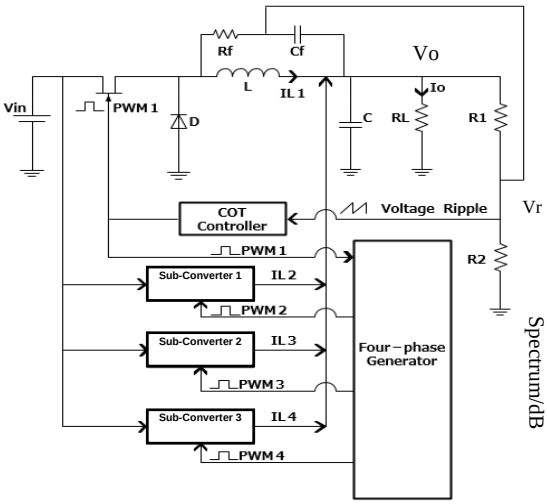


Fig1. Four-phase converter with COT control

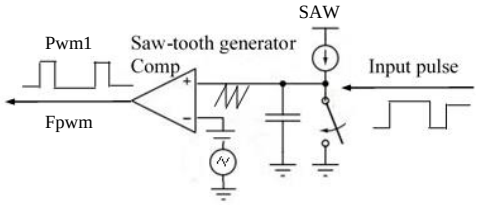


Fig. 2 Proposed COT phase modulation circuit.

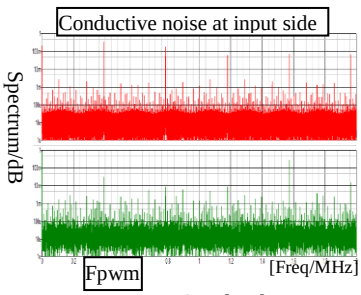
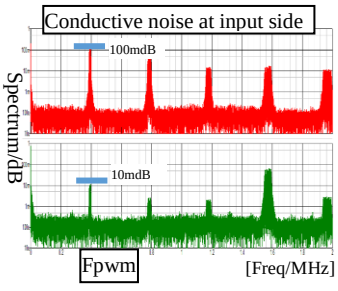


Fig. 3 Spectrum with EMI reduction



Top: Single phase, Bottom: Four-phase

Fig. 4 Spectrum with EMI reduction.

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

[2]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 (Oct. 2016)

[3]Y. Xiong, Y. Sun, N. Tsukiji, Y. Kobori, H. Kobayashi, "Two-phase Soft-switching DC-DC Converter with Voltage-mode Resonant Switch", IEEE International Symposium on Intelligent Signal Processing and Communication Systems, Xiamen, China (Nov. 2017).