

SIBO DC-DC Converter with Current Mode Control Circuit

Takashi Okada, Nobukazu Takai, Hiroyuki Iwase, Yasunori Kobori, Haruo Kobayashi, Takahiro Odaguchi†, Isao Nakanishi†, Kenji Nemoto†, Jun-ichi Matsuda†
 Graduate School of Engineering, Gunma University, JAPAN, †AKM, JAPAN
 email: t11801607@gunma-u.ac.jp

Introduction

Introduction

power supply circuit
This circuit stably supplies the necessary voltage to an objective circuit

Introduction

Industry Demands

- Design in consideration for environment
- Small size and price reduction
- Tip area of the inductor reduction

We focus the circuit that can output multi voltage by using one inductance

Multi output power supply circuit

SIMO DC-DC Converter

Introduction

Voltage Mode Control → Slow Response

Current Mode Control → Fast Response

To design high-speed response DC-DC converter

SIBO DC-DC Converter

Transfer Function

Positive: $\frac{V_{op}}{V_{in}} = \frac{T_1 + T_2}{T_2} = \frac{T_{S1on} + T_{S2on}}{T_{S2on}}$

Negative: $\frac{V_{om}}{V_{in}} = -\frac{T_4 + T_5}{T_5} = -\frac{T_{S1on} + T_{S3on}}{T_{S3on}}$

Control Mode

Power Supply

Switching method
Load regulation, Other regulation, Output voltage regulation

Necessary

Control Mode

Voltage mode control

Only the output voltage feedback

Current mode control

Voltage and current feedback

Current Mode Control

Used as a control signal to the peak inductor current

Simulation Condition

Simulation Condition

$V_{in} : 3V$ $R_{on} : 10m\Omega$ Set Output
 $L : 2\mu H$ $R_s : 100\Omega$ Positive : 8V
 $C_c : 2\mu F$ $f_{sw} : 500KHz$ Negative : -5V
 $R_{op}, R_{om} : 50\Omega$ $C_{op}, C_{om} : 10\mu F$

Simulation Results

Confirmed the output control action

Comparison with Voltage Mode Control

Control Mode	Convergence Time	Peak Voltage(P)	Peak Voltage(N)
Voltage Mode	0.98ms	14.1V	-10.2V
Current Mode	0.47ms	8.49V	-4.98V

Simulation Results

Comparison of The Load Regulation

Voltage mode control

Current mode control

Results

- Shorten of the transient response by the Load Change
- High-speed response properties of SIBO by the current mode control

Summary

Conclusion

- Response of voltage mode control
- Fast response can be improved by current mode control
- Realize high-speed response properties of SIBO by the current mode control

References

- [1] Nobukazu Takai, Kenji Takahashi, Hajime Yokoo, Shunsuke Miwa, Kengo Tsushida, Hiroyuki Iwase, Haruo Kobayashi, Takahiro Odaguchi, Shigeki Takayama, Isao Fukai, Jun-ichi Matsuda, "Single Inductor Bipolar Outputs DC-DC Converter Using Charge Pump," IEEJ International Analog VLSI Workshop, Pavia, Italy (Sept. 2010).
- [2] Yi Zhang and Dongsheng Ma, "Integrated SIMO DC-DC Converter with On-Line Charge Meter for Adaptive PCCM Operation", IEEE International Symposium on Circuits and Systems (May. 2011).
- [3] K. Takahashi, H. Yokoo, S. Miwa, H. Iwase, N. Takai, H. Kobayashi, T. Odaguchi, S. Takayama, T. Oomori, I. Nakanishi, K. Nemoto, J. Matsuda "Single Inductor DC-DC Converter with Independent Bipolar Outputs using Charge Pump of Circuit Voltage Control", 24th Workshop on Circuits and Systems, Awaji Island (Aug. 2011).

Related Works

- Considering parasitic capacitance, parasitic interconnect simulation
- Improvement of cross-regulation

SIBO with Control Circuits