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

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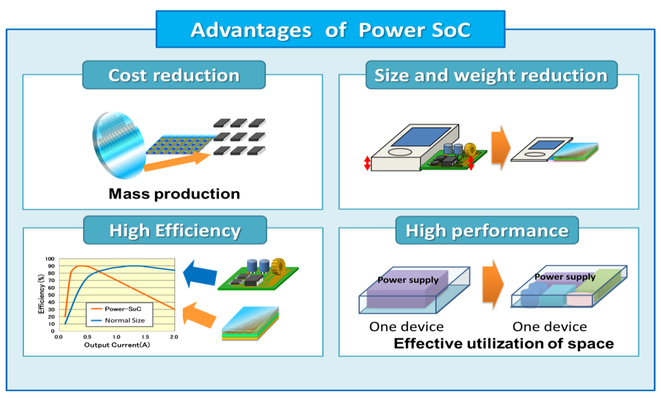
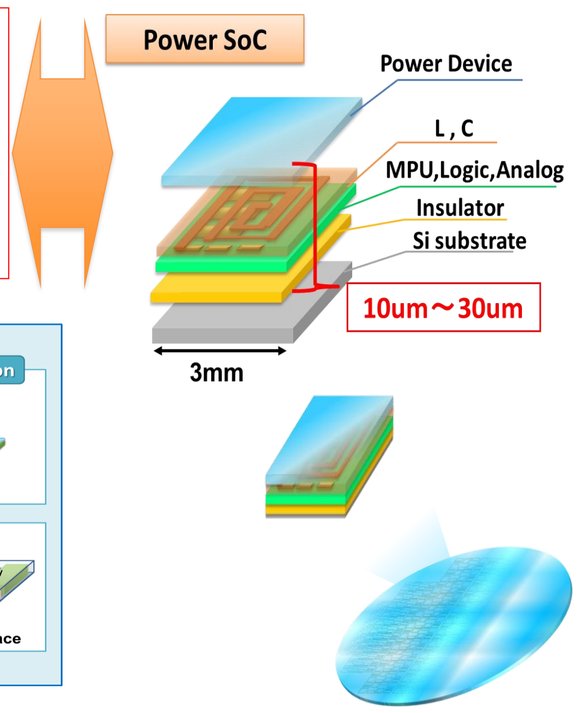
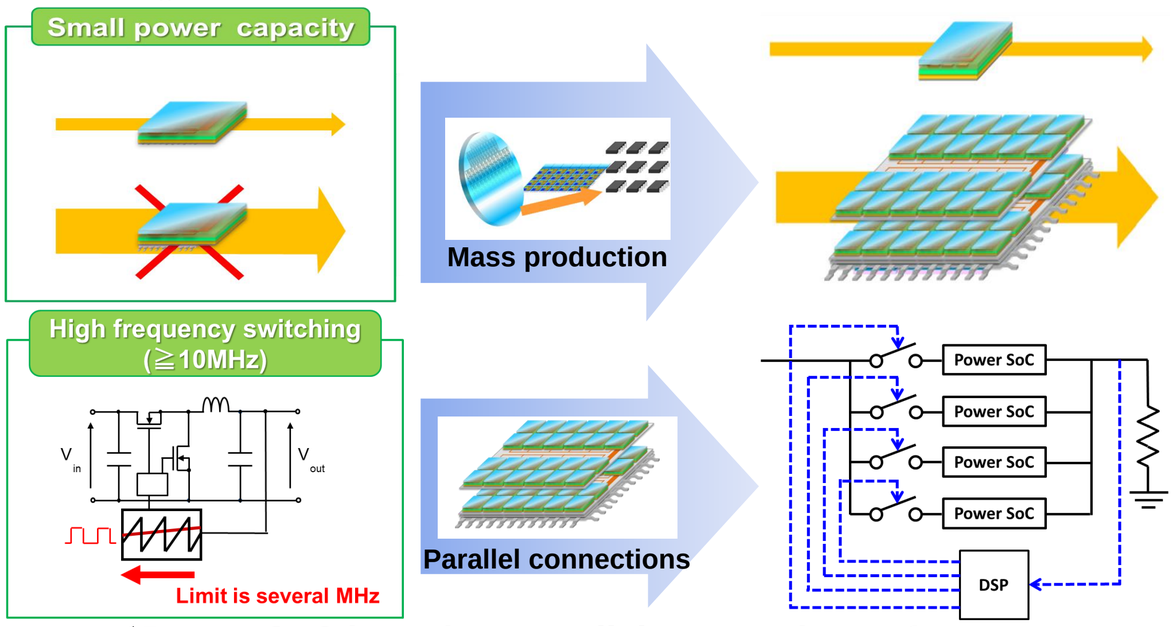
Introductions

Market demand of power supply
- Reduction in Size and Weight
- High efficiency
- High speed response
- Reduction in Cost





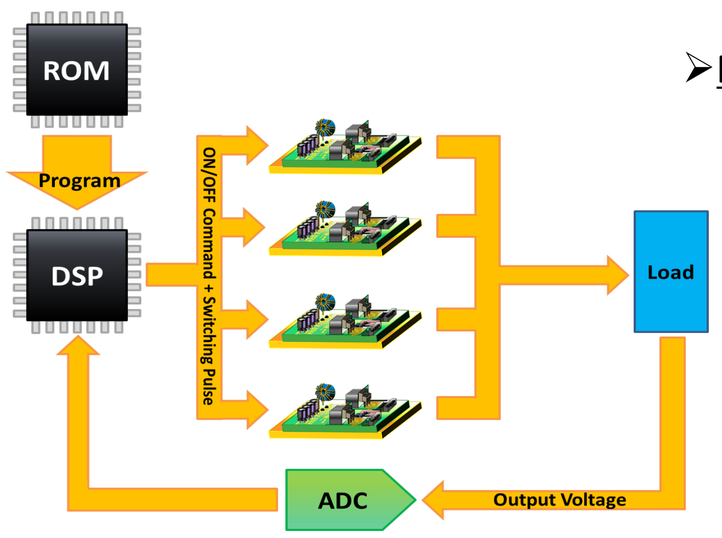
➢Challenges and Approaches



✓ Power-SoC based on parallel connections of many dc-dc converters

Block Diagram and Control Method

➢Block Diagram



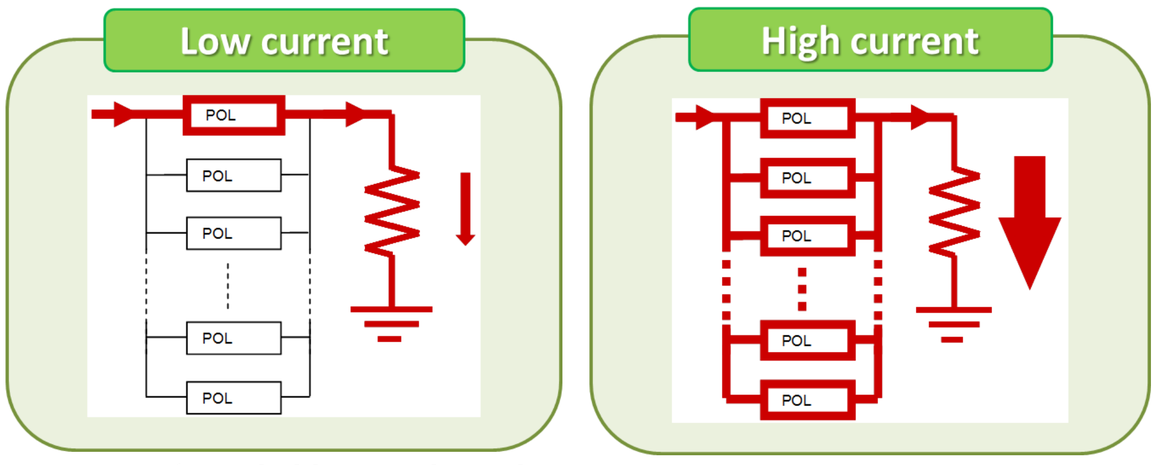
➢Formula

$$V_{out} = D \cdot V_{in} - \frac{r}{N} I$$

D: Duty ratio
r : Internal resistance
N: Number of DC-DC converter
I : Output Current

✓ Only rewriting of digital code , It can be multiple input and output

➢Control Method



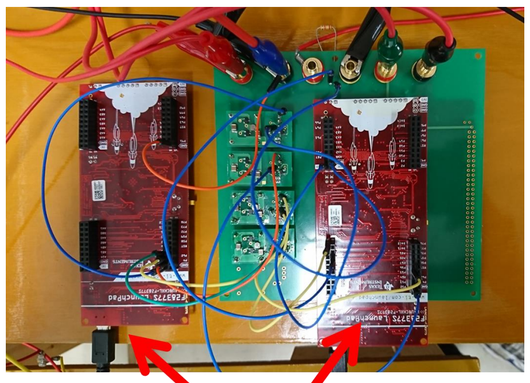
✓ Switching number N in response to output current.

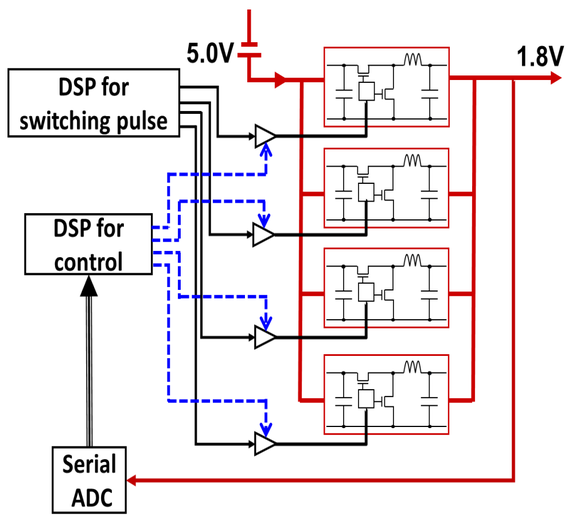
References

[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

Circuit Configurations and Control algorithm

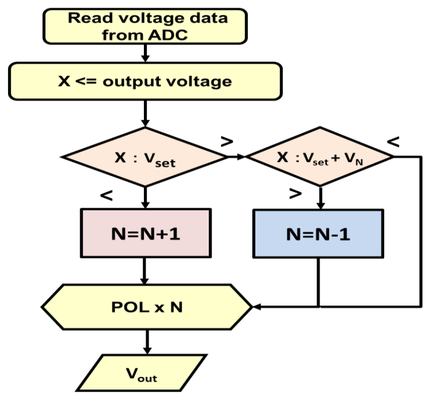
➢Circuit Configuration



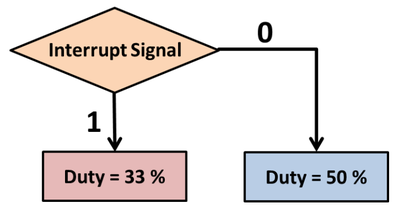


➢Control Algorithm

◆ Feedback Mode



◆ DVFS Mode



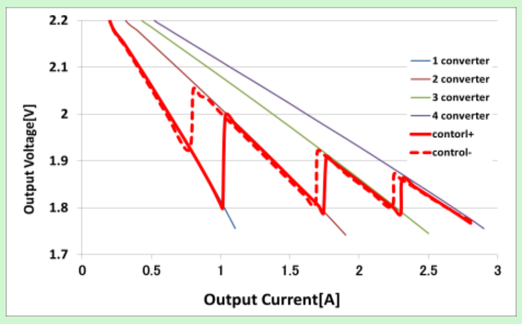
V_{set} : Target Voltage
V_N :Hysteresis
(preventing oscillation)

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

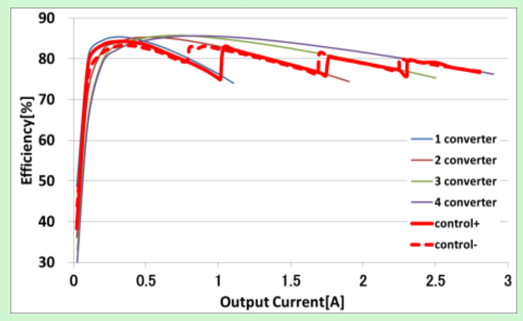
Results

➢Experimental Results

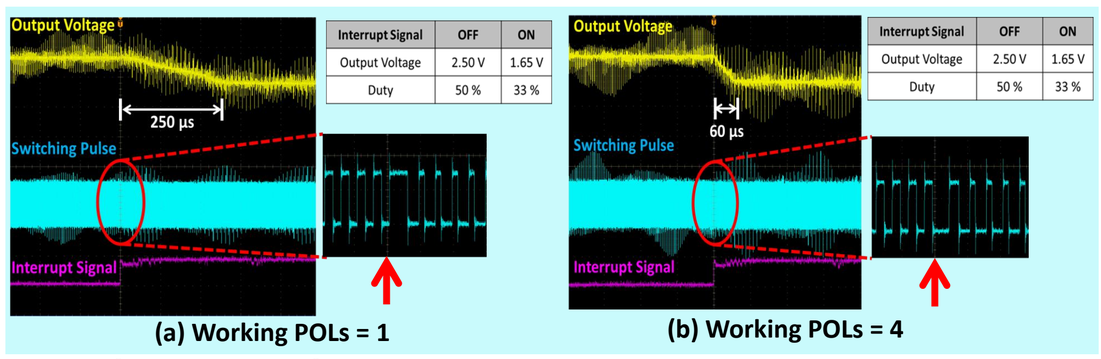
◆ Load characteristic



◆ Efficiency characteristic

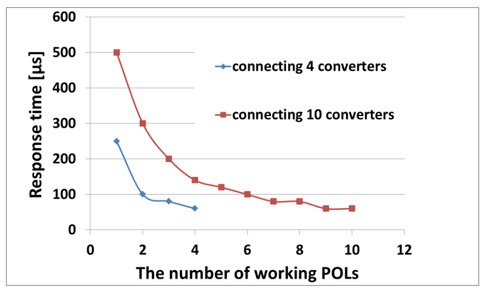


✓ Obtained a constant output voltage ✓ Keeping high efficiency over wide range

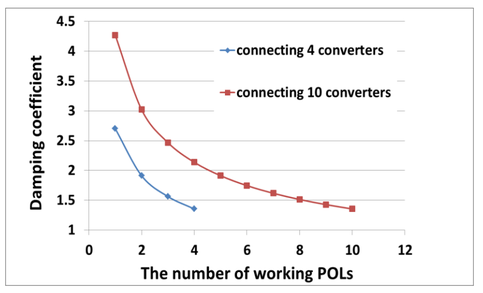


(a) Working POLs = 1 (b) Working POLs = 4

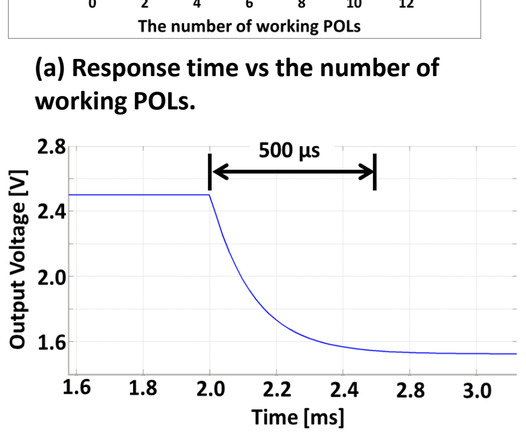
➢Simulation Results



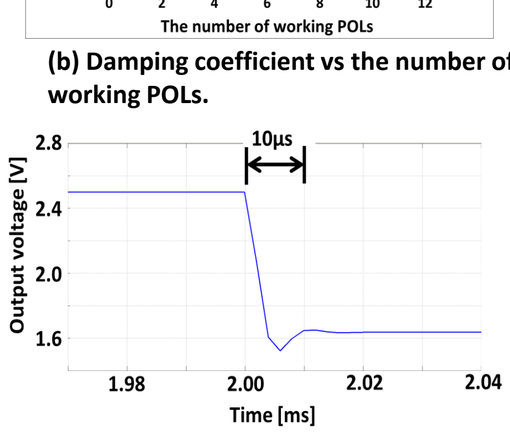
(a) Response time vs the number of working POLs.



(b) Damping coefficient vs the number of working POLs.



(a) Fsw = 1 MHz



(b) Fsw = 10MHz

✓ Transient response is dependent on the damping coefficient and the switching frequency

Conclusions

✓Transient response is faster as the number of working POLs increases, the damping coefficient is closer to 1 and the switching frequency increases.