EMI Noise Reduction for PFC Converter with Improved Efficiency and High Frequency Clock

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1.Objective

AC-DC converter improvement

1.EMI noise reduction

⇛ Frequency modulation

2.Efficiency improvement ⇛ SiC-SBD

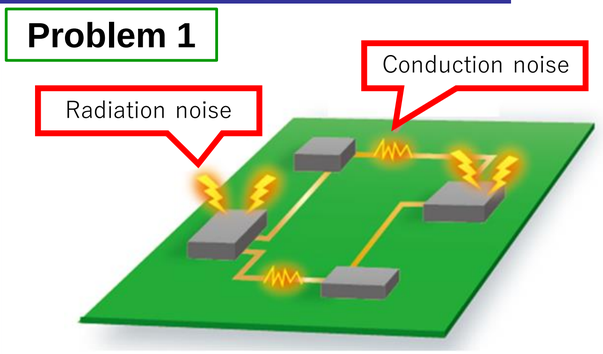
3.Input LPF size reduction

⇛ SiC-SBD (high clock frequency)

SBD: Schottky Barrier Diode
SiC: Silicon Carbide

2.Background

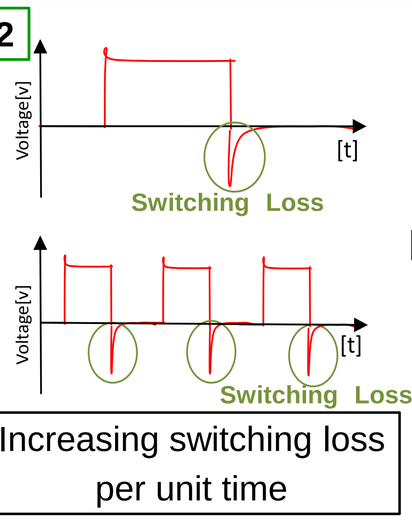
Problem 1



Current flow →EMI noise generation

EMI: Electro-Magnetic Interference

Problem 2

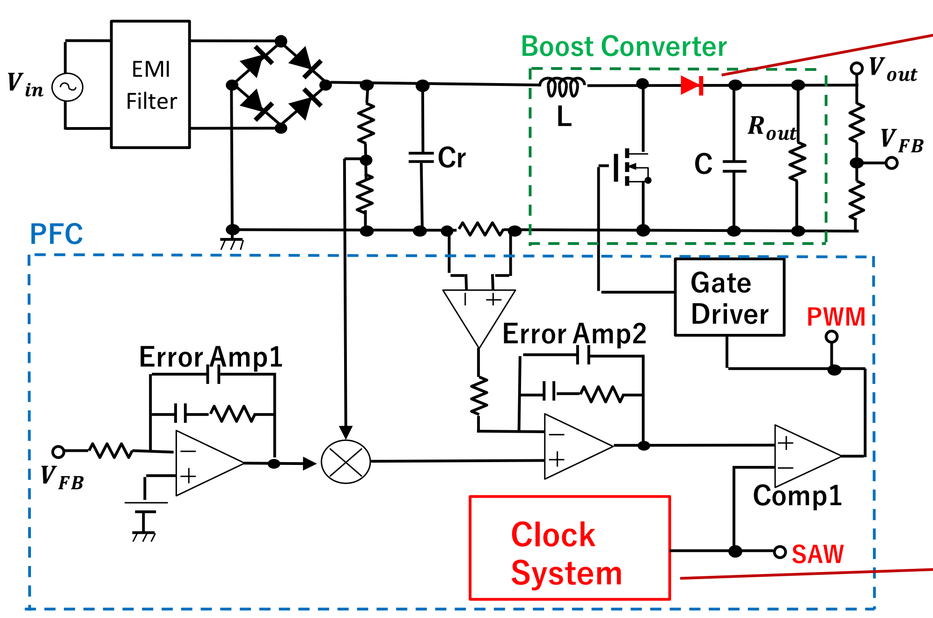


Increasing switching loss per unit time

Goal

- EMI noises reduction for regulation
- Decreasing switching loss

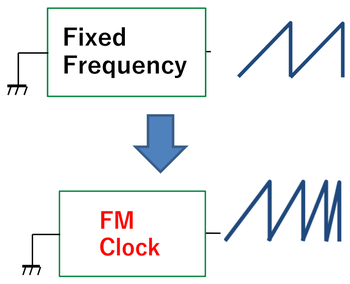
3.Proposed Circuit



Proposal 1

Power diode
PN-diode
⇩
SiC-SBD

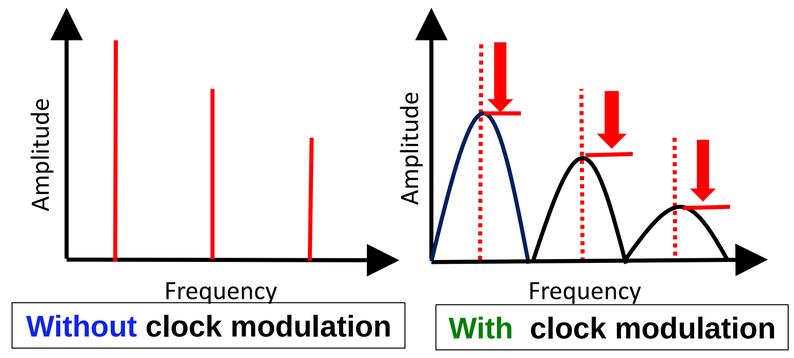
Proposal 2



Noise Spectrum Spread

Clock frequency modulation
→ Noise spectrum ⇨ Spread
→ Harmonics peak reduction

In this paper, frequency modulation usage

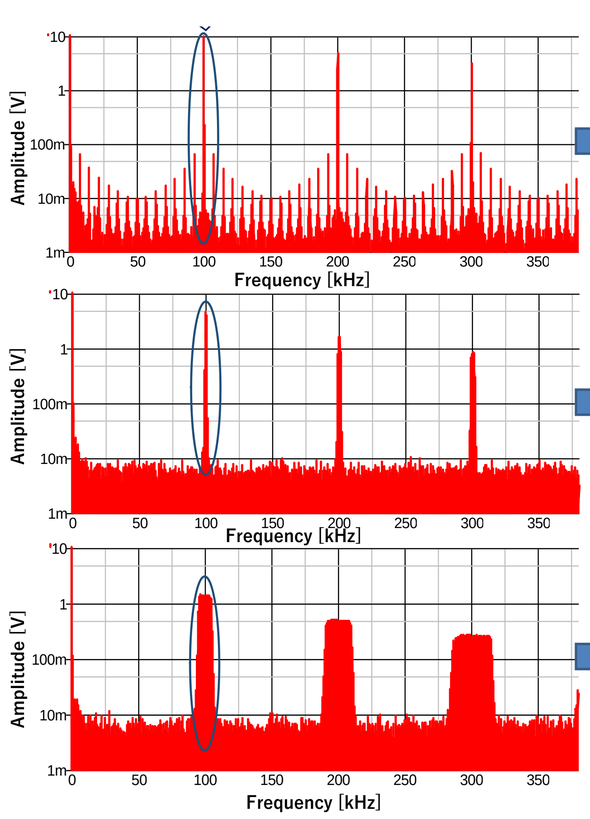


4.Noise Spreading Results

Parameter	Simulation Value
Vin	AC 100V/50Hz
L	2.2 mH
Cout	330 μF
Vout	400V
Fck	100 kHz

- Voltage controlled oscillator usage → Linear frequency modulation
- Measuring PWM of Fourier transform in SIMPLIS simulator
- Clock frequency change → No increase of output ripple

⇨ Only EMI noise reduction



100kHz point

9.5 V
(Fixed frequency)

Bad!

- 9.7dB

3.1 V
(Modulated frequency
Δf= 1kHz)

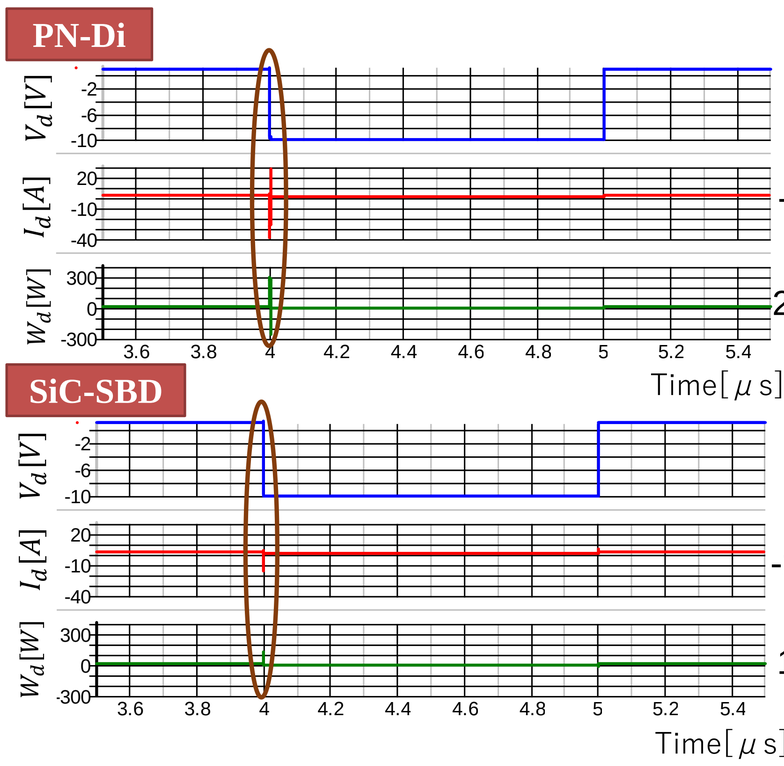
Good!

- 7.5dB

1.3 V
(Modulated frequency
Δf= 10kHz)

Very good!

5.Loss Comparison Results



-24 A
-40 A
280 W
-16 A
106 W
-62 %

Conventional Si Power Diode

Recovery current generation at turn off

▼

Fck increase→Switching loss increase

⇕

SiC Power Diode

- Recovery current reduction
- High breakdown voltage
- High cost at device level

▼

Total cost down at circuit level !

6.Conclusion

● **PFC with frequency modulation**

Fixed frequency → Frequency modulation

⇨ **EMI noise reduction by more than 17 dB**

● **Diode recovery current reduction**

PN-Di → SiC-SBD employment

⇨ **Efficiency improvement**

Reference

[1] N. Miki, N. Tukiji, K. Asaishi, Y. Kobori, N. Takai, H. Kobayashi. “EMI Reduction Technique With Noise Spread Spectrum Using Swept Frequency Modulation for Hysteretic DC-DC Converters”, IEEE International Symposium on Intelligent Signal Processing and Communication Systems, Xiamen, China (Nov. 2017)

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