2021 IEEE 14th International Conference on ASIC
Kunming, China
26-29, Oct. 2021,

Adaptive Convergence Method of Notch Frequency in Noise Spread Spectrum for Pulse Coding Switching DC-DC Converter

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Outline

1. **Research Background**
2. **Pulse coding of automatic PWC method**
3. **Adaptive convergence method**
   - **Digitalization of adaptive convergence method**
   - **Adaptive convergence method simulation results**
4. **Conclusion**

Research Background

EMI in switching converter

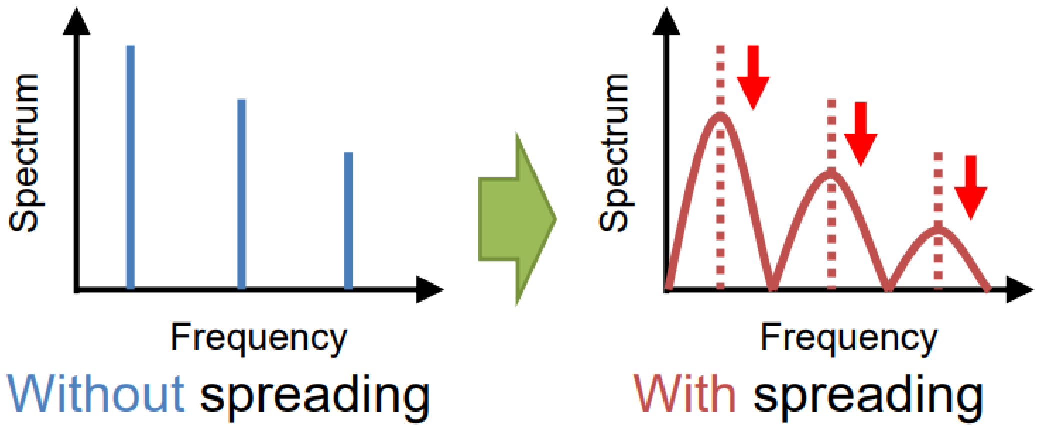
Pulse Width Modulation (PWM) control method
is employed in switching converters

EMI

EMI: Electro Magnetic Interference

Research Background

EMI Reduction by Noise Spectrum Spread



- Switching frequency modulation

Noise spectrum peak ⇨ Reduced

- Band-select noise spectrum spread

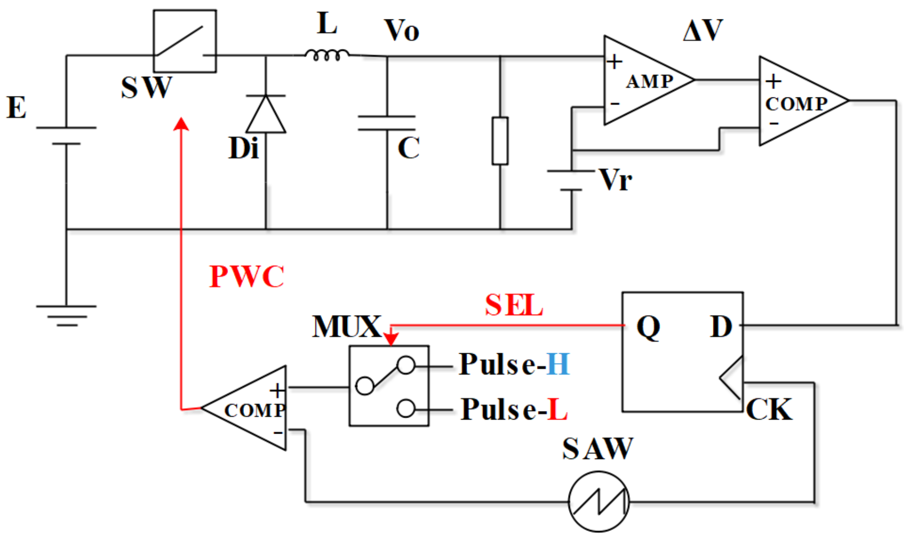
Noise is NOT spread in the signal bands of radios such as AM, FM signal bands

⇨ Noise spectrum notch frequency generation

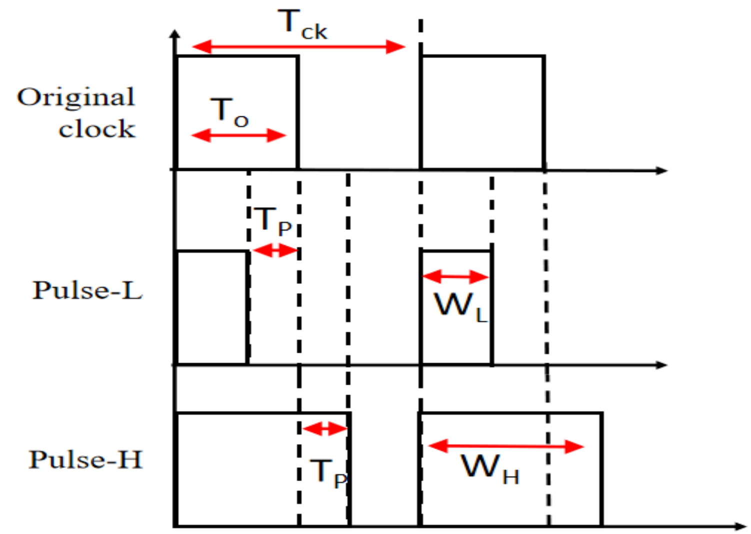
Our original

Outline

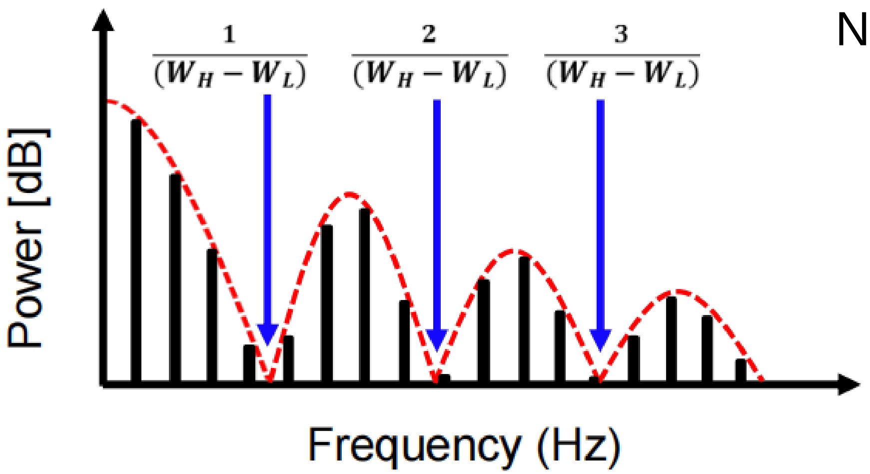
Pulse coding switching converter



PWC method switching converter



Coded pulses of the PWC control



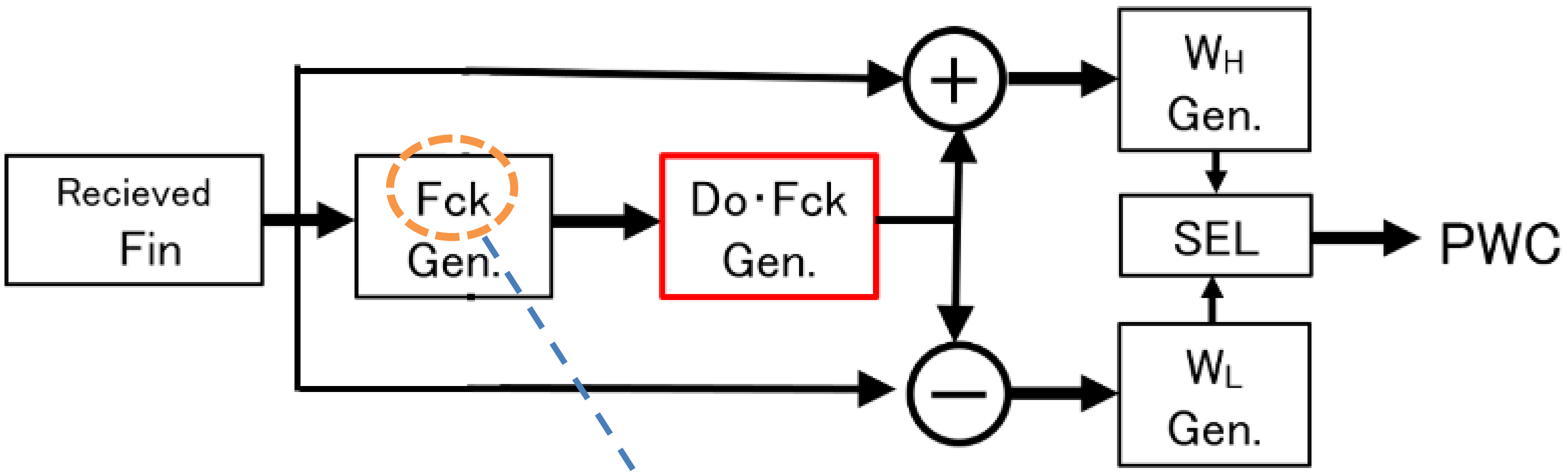
Spectrum of the switching converter with PWC

Notch frequencies

$$F_n = \frac{M}{W_H - W_L}$$

M=1, 2, 3,…

Pulse coding of automatic PWC method



Pulse coding of automatic PWC method (previously proposed)

$$T_{ck}=F_{ck}/1$$
$$T_{ck}=(N+0.5)\times T_{in}$$

$$W_H = D_O \times T_{ck} + T_{in} / 2$$
$$W_L = D_O \times T_{ck} - T_{in} / 2$$

Problem of Pulse coding of automatic PWC method

Tracking **duty cycle** of **control signal** automatically is important.

The previously proposed Duty tracking method

Difficult to detect the control duty.

Error is large.

Slow transient response of change of Io.

Proposed method

Adaptive convergence method

Changes of Do (Vi) , Io can be detected at high speed.

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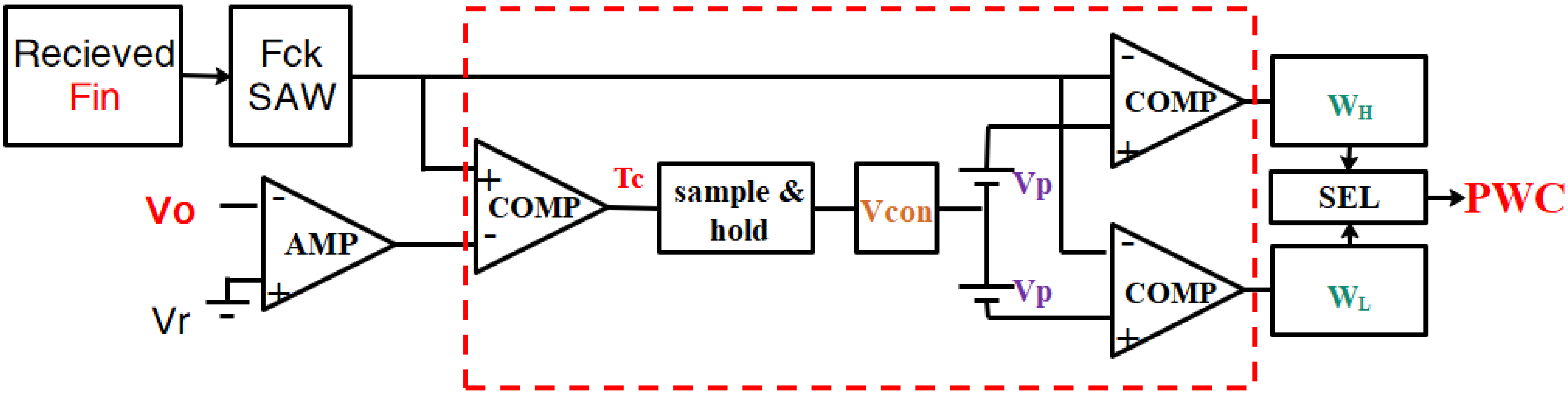
Adaptive convergence method

Digitalization of adaptive convergence method



Adaptive convergence method circuit

This control is achieved by **moving Tc**.

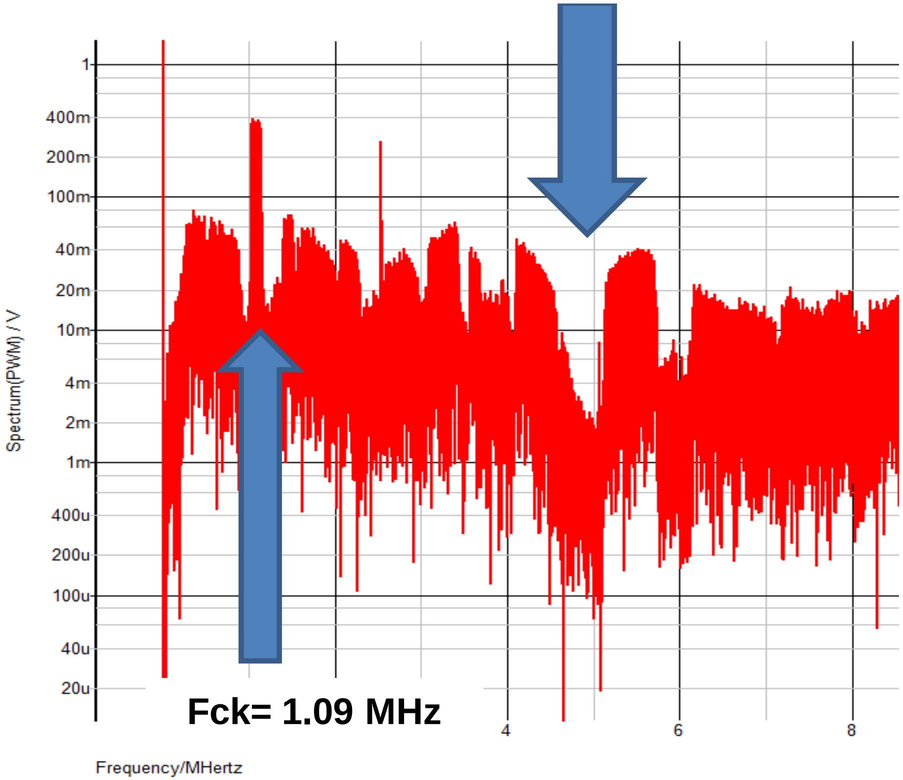
The voltage difference is $(V_H - V_L) = 2 \times V_p$.

Voltage **Vcon** is generated by sample&hold circuit.

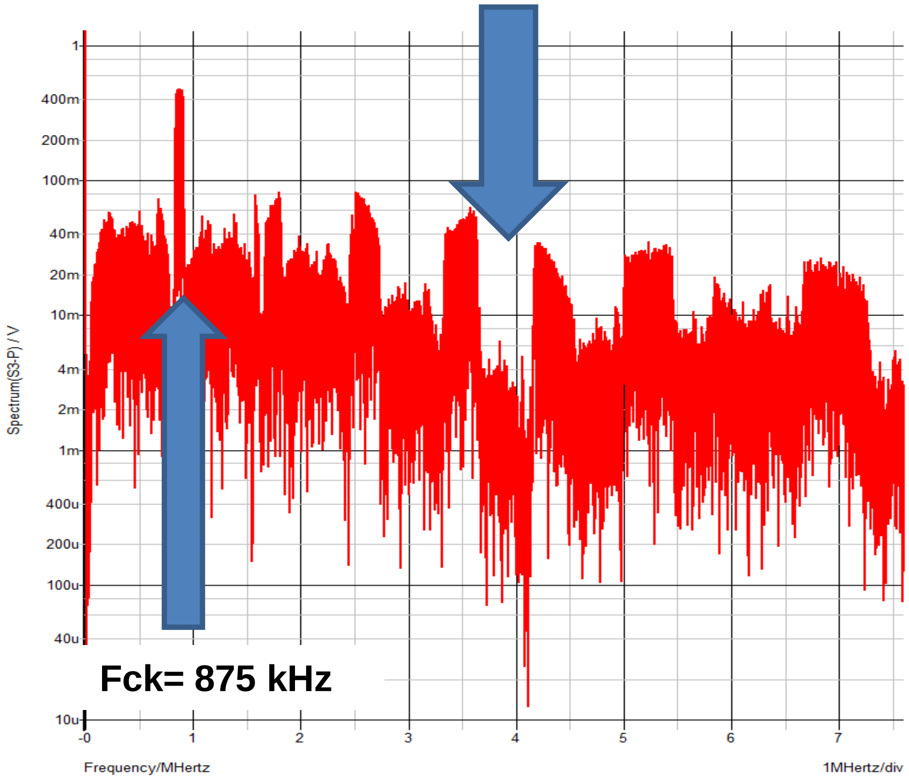
Adaptive convergence method

Adaptive convergence method simulation results

(When Fi=5.0MHz) **Fn=5.0MHz**



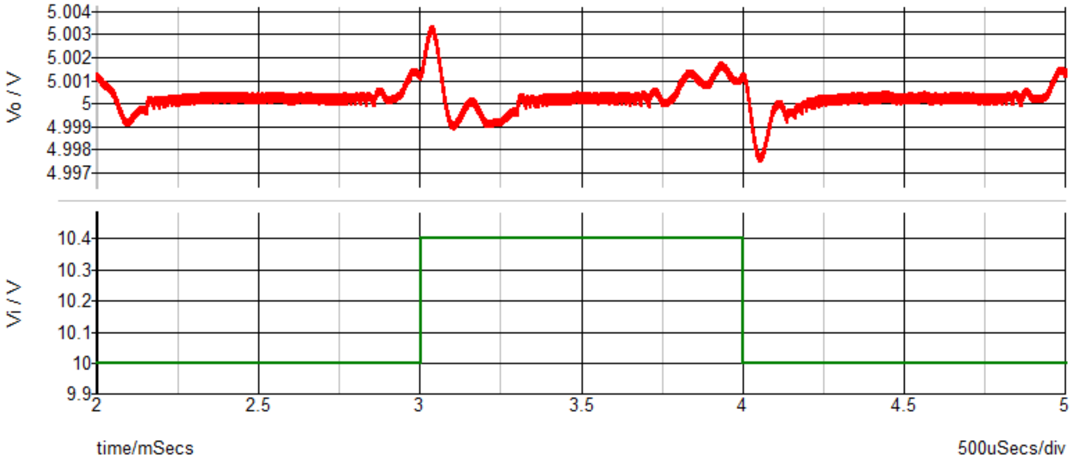
(When Fi=4.0MHz) **Fn=4.0MHz**



$$Fn = (N + 0.5) \times Fck, \quad N = 4$$

3. Adaptive convergence method

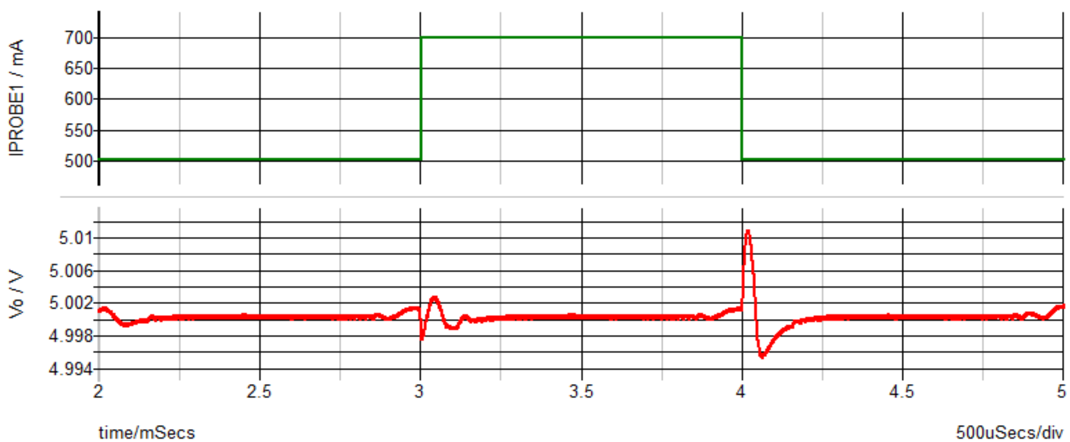
Adaptive convergence method simulation results



Vo： Overshoot = 0.6mV

Vi=10V->10.4V

Line regulation: Transient response for input change



Io=500mA->700mA

Vo: Overshoot=8.0mV

Load regulation: Transient response for load change

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Conclusion

This work:

- **Proposal** of **adaptive convergence method**
  ➡ Accurate generation of high frequency notches
- **Verification by simulations**
- **Applications** to
  ➡ radio receivers without interference from switching converter EMI noise

Future work:

- **Hardware experiments**
- Generation of notch frequencies above **80MHz**.