IPS03 Analog and Power
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Bridge-less Power Factor Correction Converter with Adaptive Switching Pulse Enabling Control

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Outline

- Background and Purpose
- Basic PFC Circuit
- Conventional PFC (Half-bridgeless) Circuit
- Proposed PFC (Full-bridgeless) Circuit
- Conclusion

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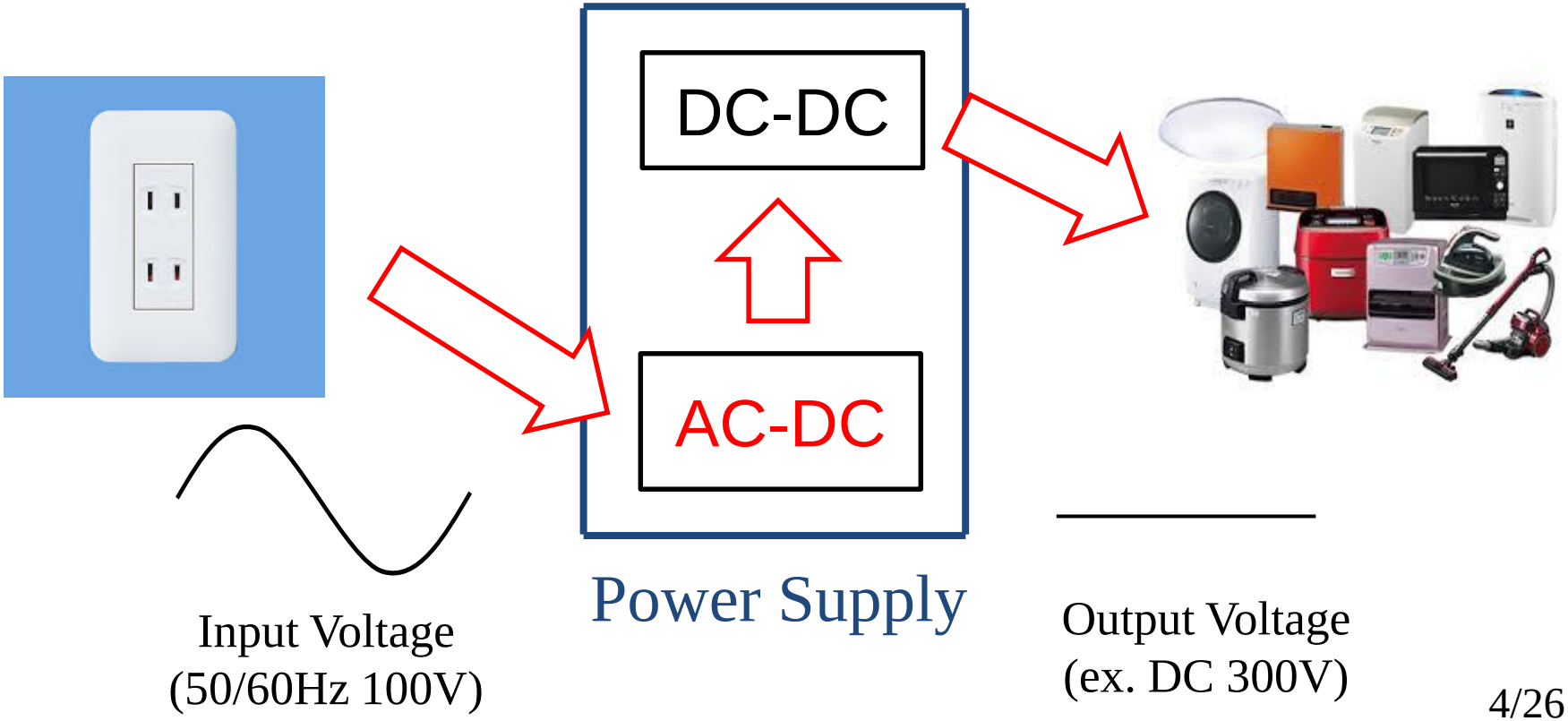
What is Power Supply Circuit ?

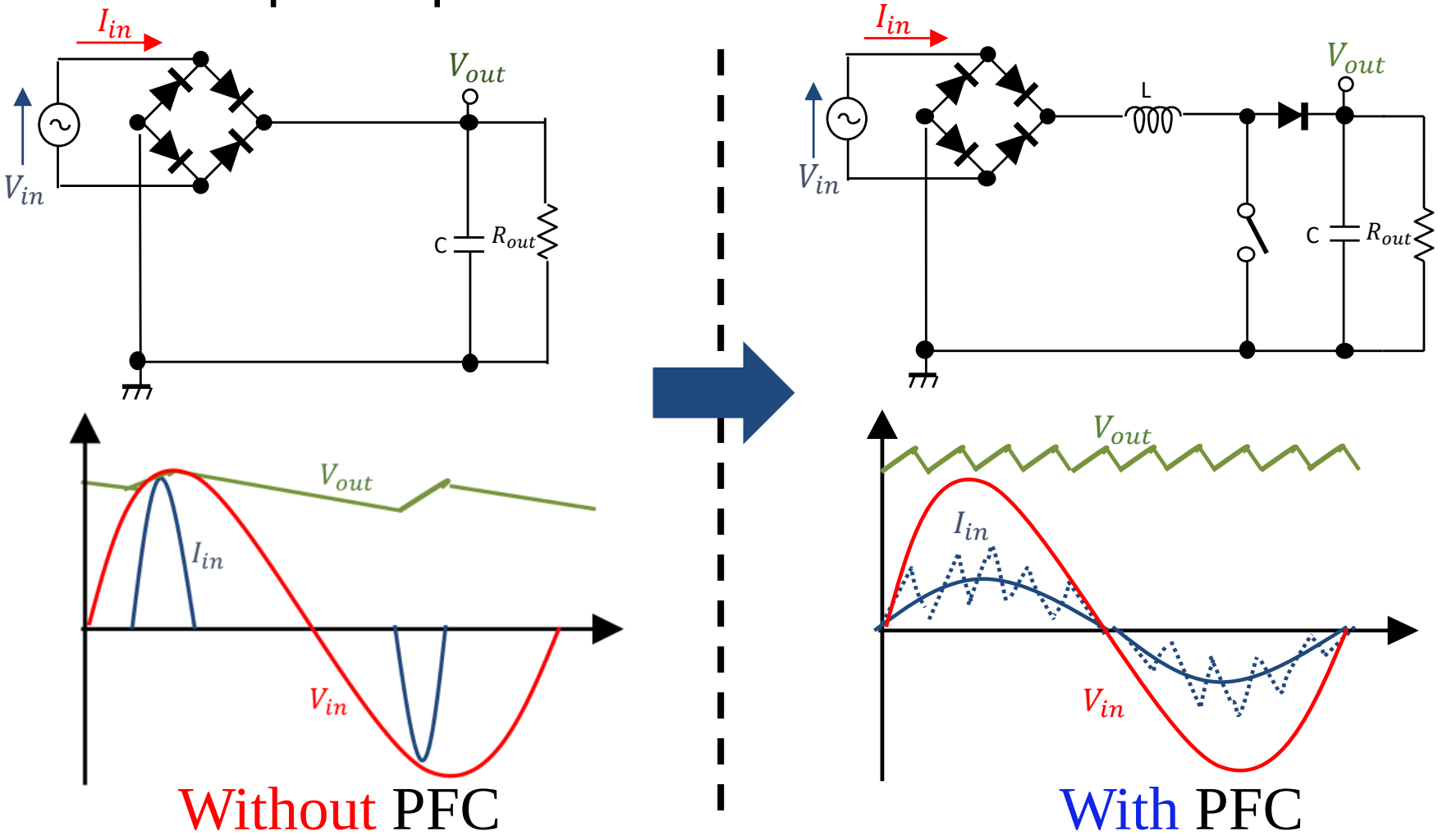
- Commercial power supply circuits

  → Convert AC into DC voltages



PFC Circuit

PFC shapes input current waveform

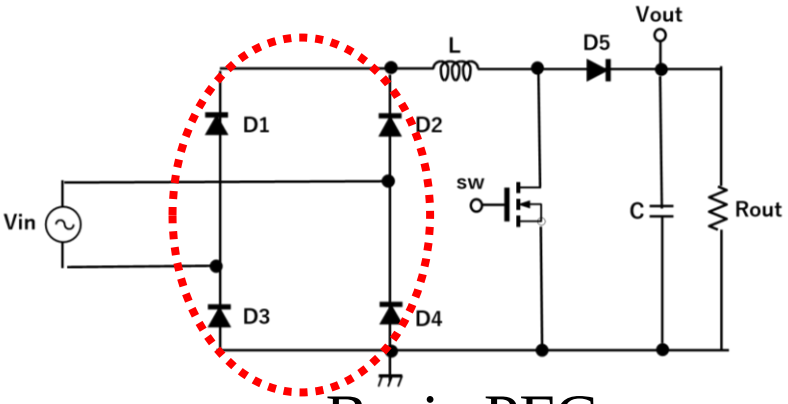


Without PFC

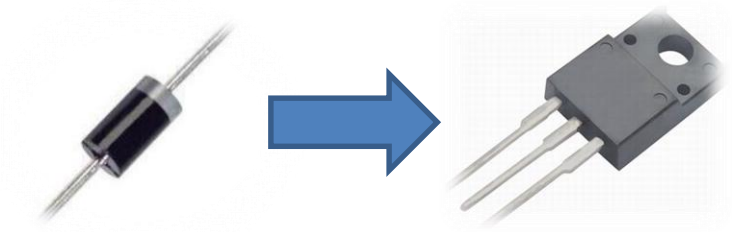
With PFC

PFC: Power Factor Correction

Research Purpose



Basic PFC

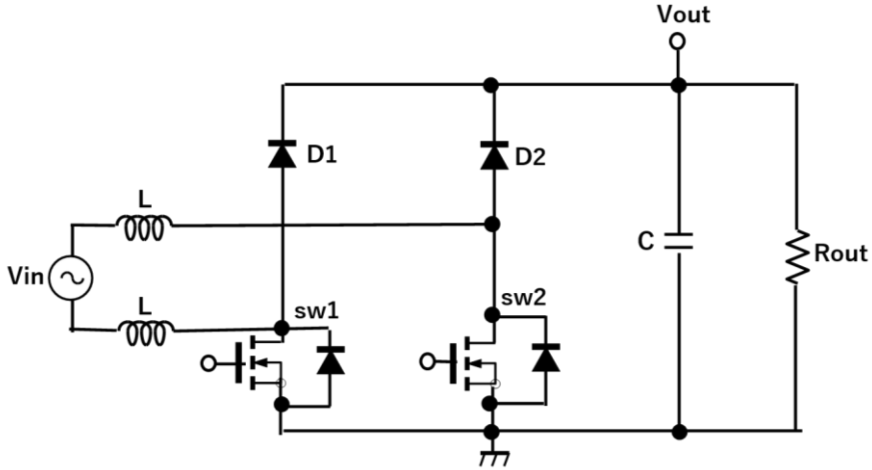


$V_{ON} = 0.8V$

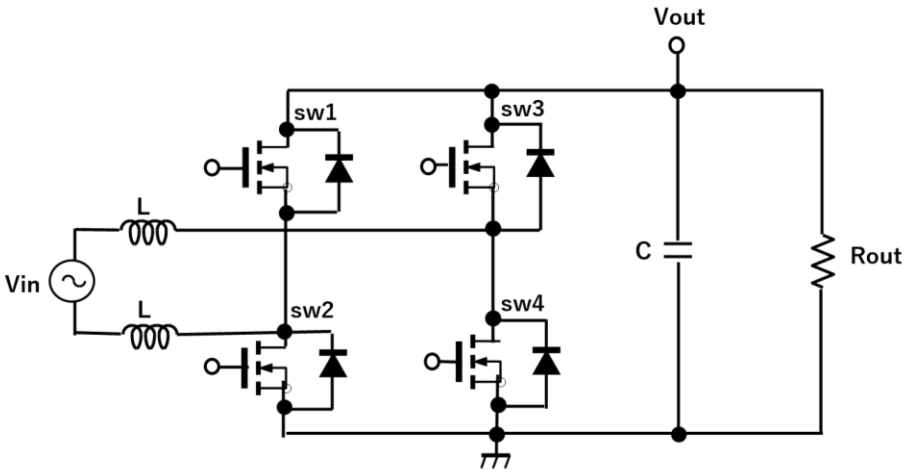
$V_{ON} = 0.2V$

Loss

- Efficiency improvement in PFC converter



Conventional PFC(Half-bridgeless)



Proposed PFC(Full-bridgeless)

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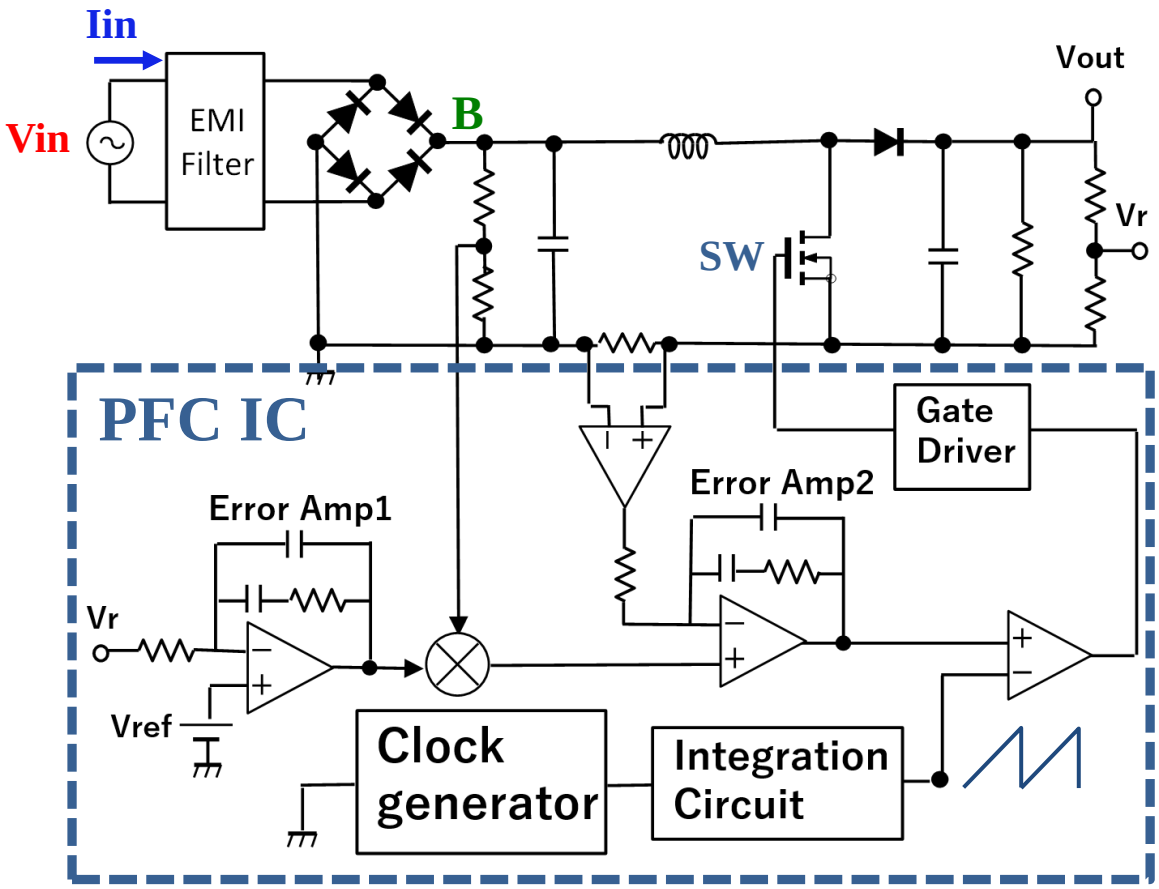
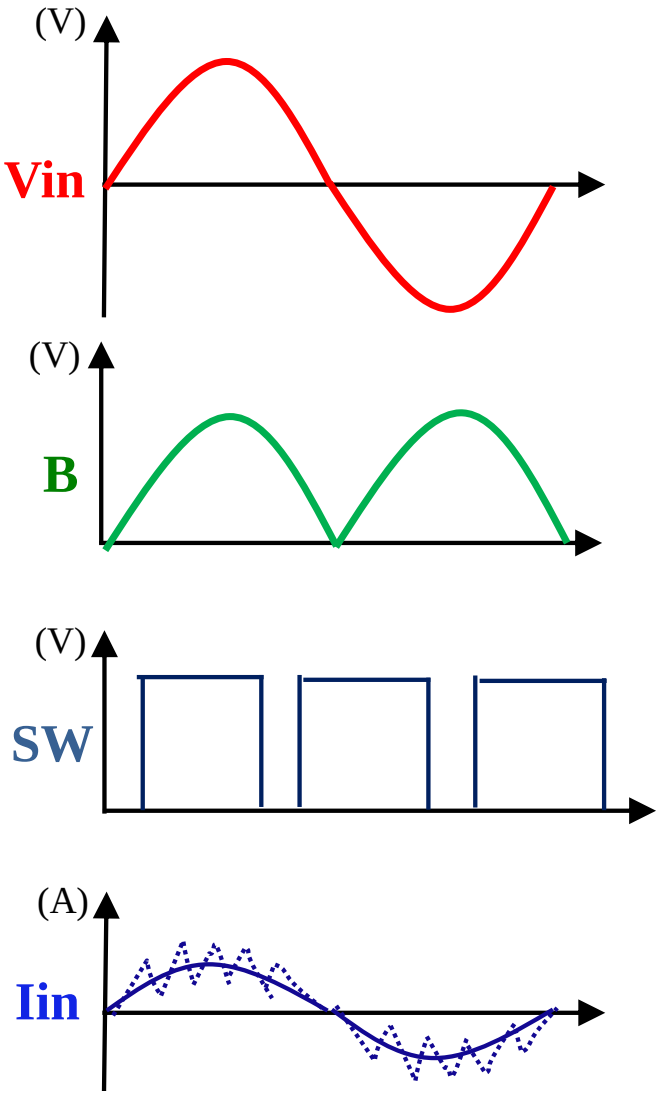
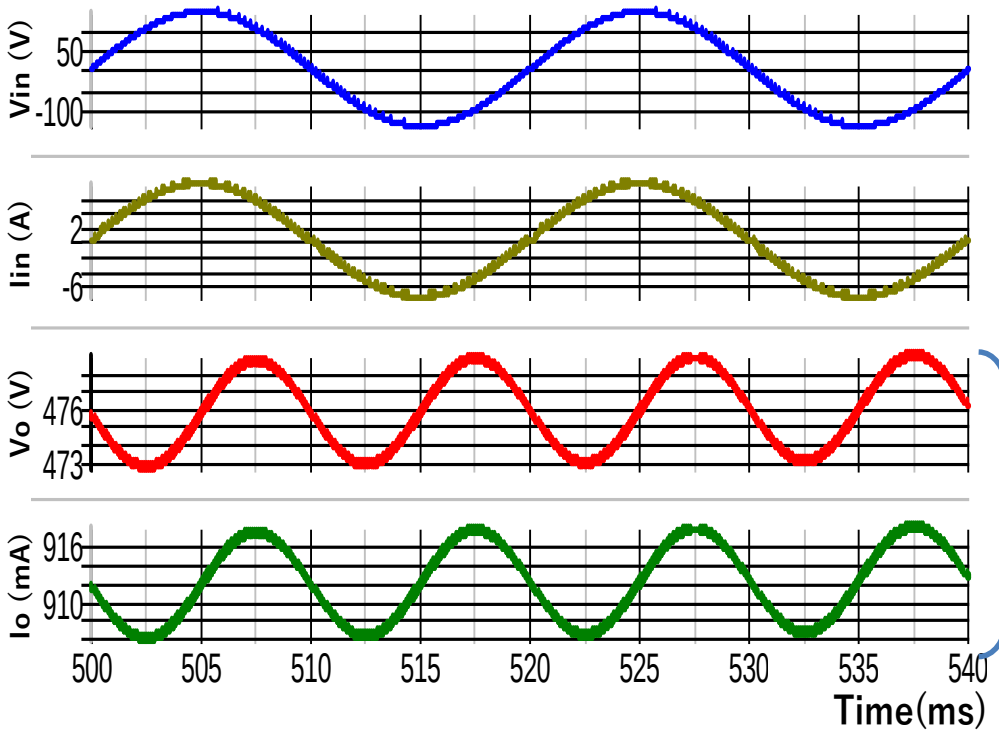
Basic PFC Circuit





Efficiency of Basic PFC



AC Vin=100[V]@50Hz

Parameters	Simulation Value
Iin	5.26[A]
Input power	526[W]
Output power	434[W]

Expand

$Vo = 476V \pm 3V$

$Io = 912mA \pm 6mA$

$$efficiency = \frac{Output\ power}{Input\ power} \times 100 = \frac{434}{526} \times 100$$

$$= 82.5\%$$

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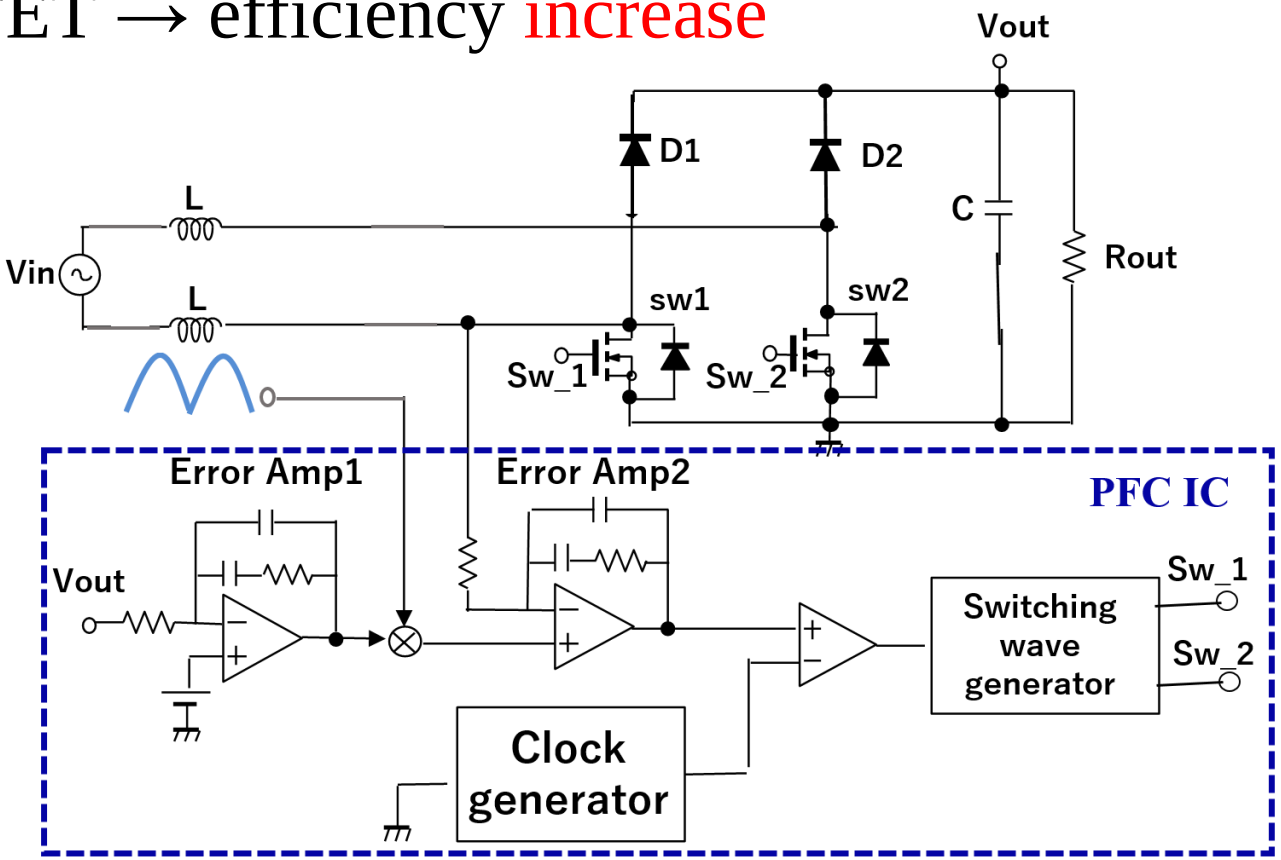
Half-Bridgeless Circuit

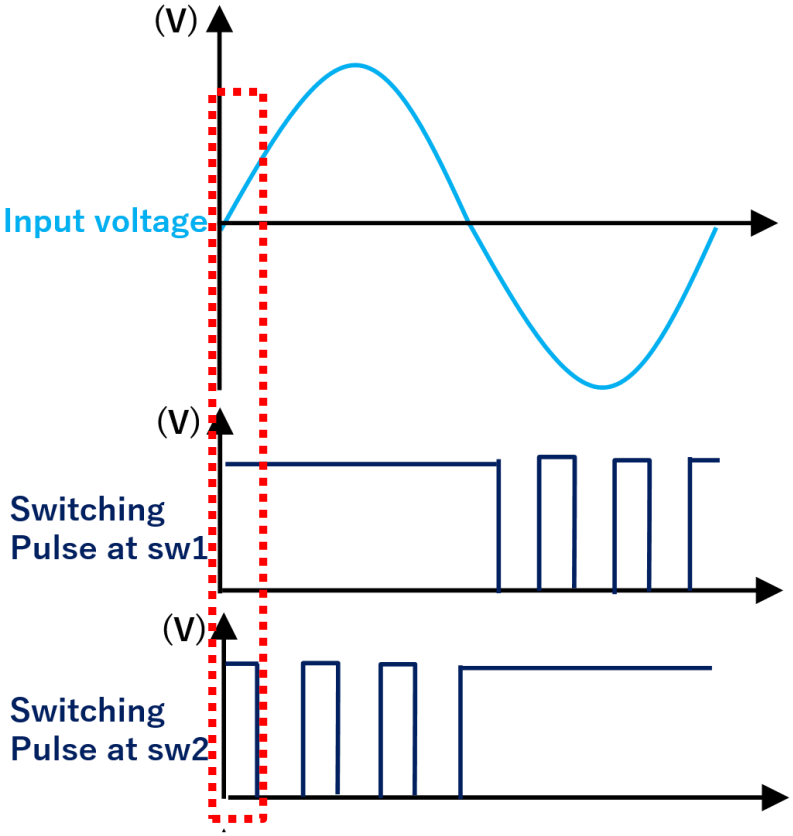
MOSFET → efficiency increase

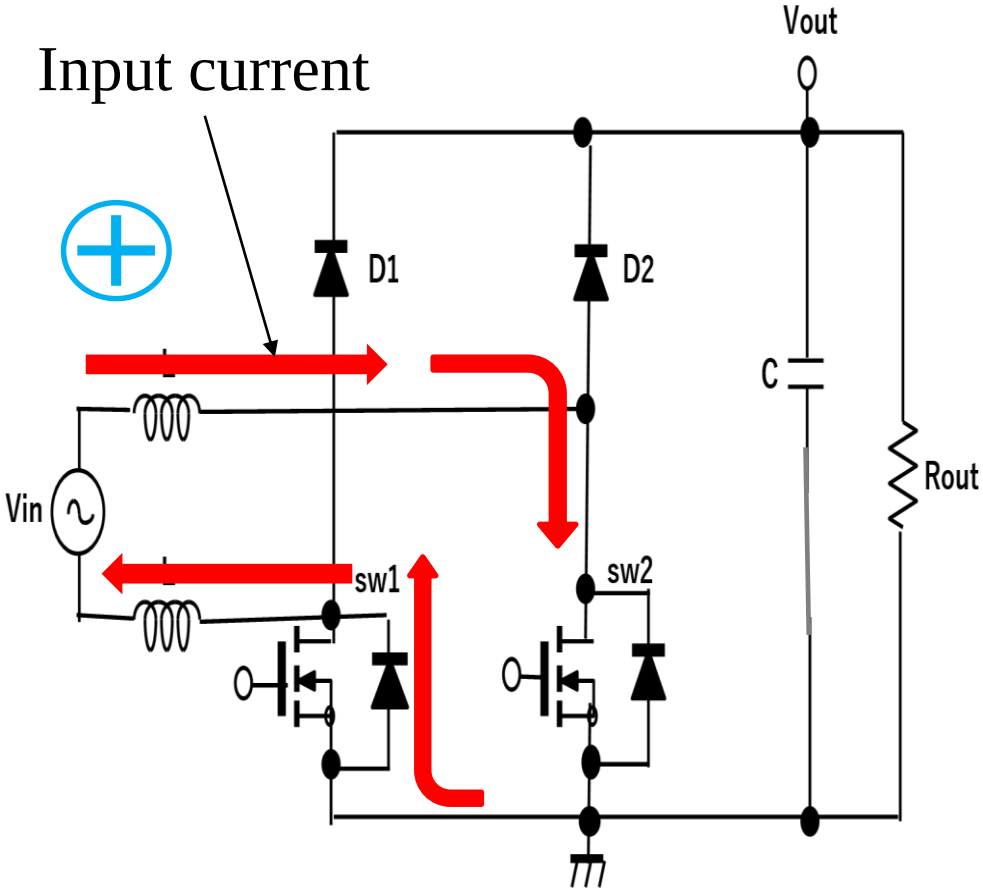


Conditions

- Vin = 100[Vrms]@50Hz
- Clock frequency = 200[kHz]
- L = 1[mH]
- C = 500[uF]
- $R_{DS(on)}$ = 1[mΩ]

Operation of Half-Bridgeless Circuit (1/2)



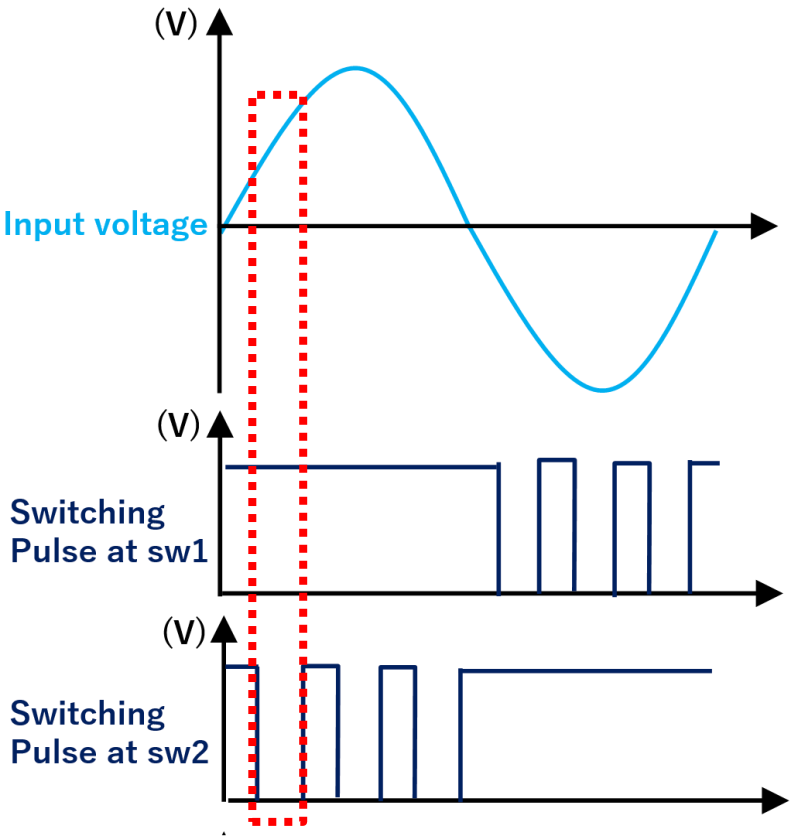


Vin > 0

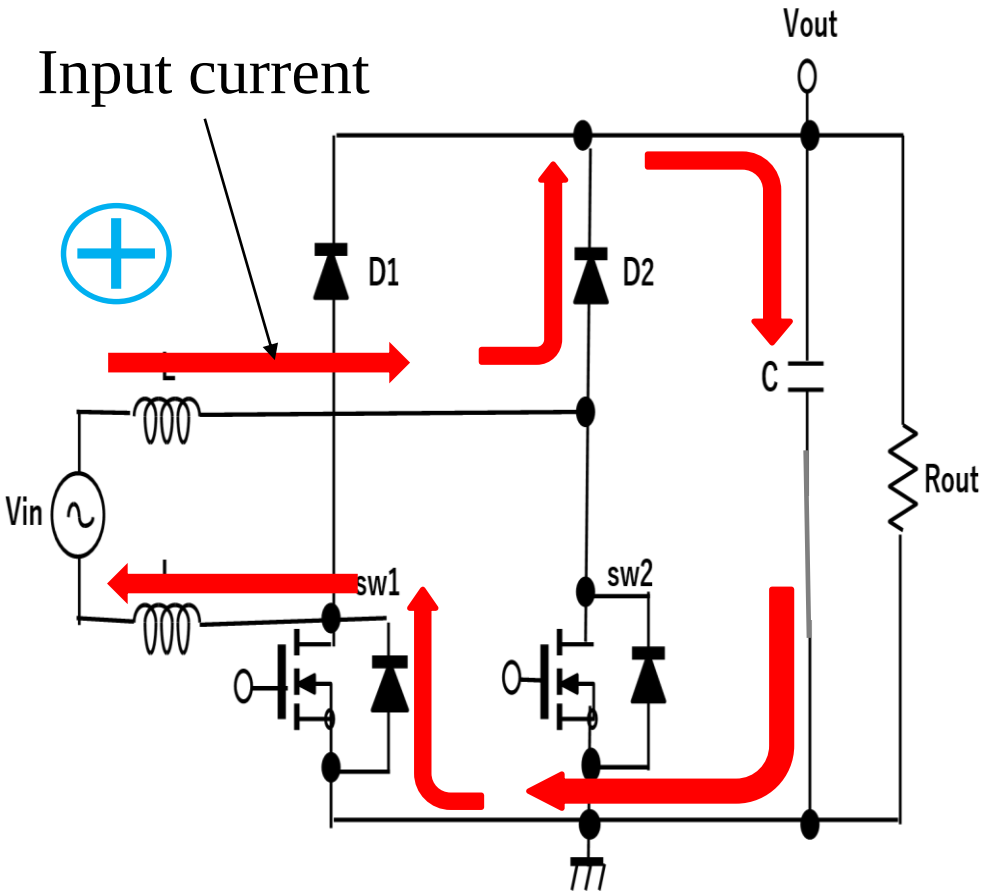
sw1 → ON

sw2 → ON

Operation of Half-Bridgeless Circuit (2/2)



Boost Converter



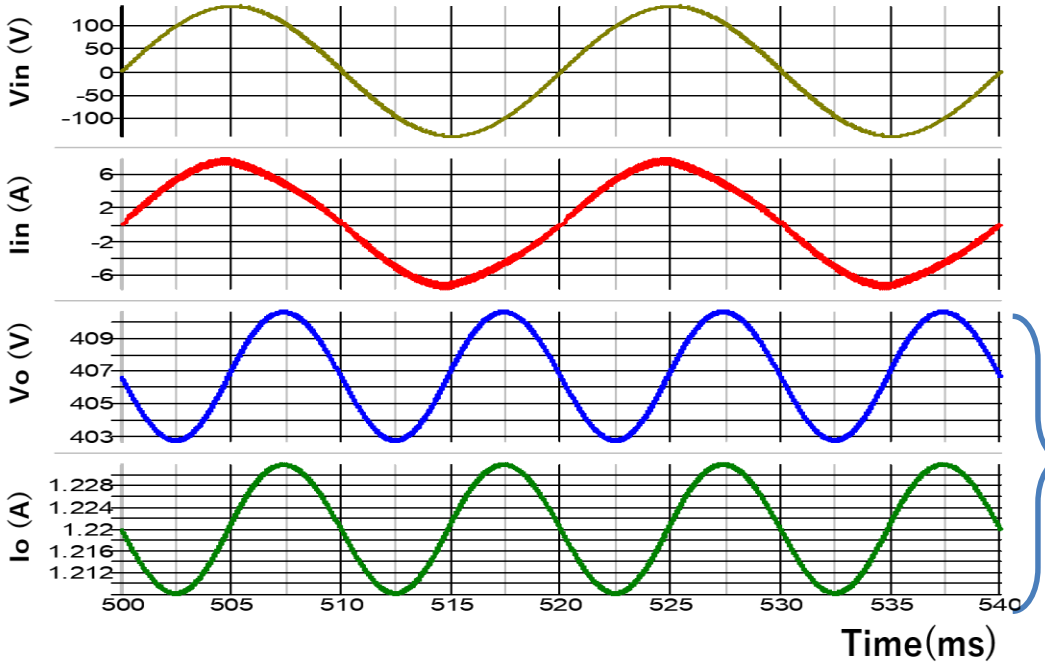
Vin > 0

sw1 → ON

sw2 → OFF

Efficiency of Half-Bridgeless PFC

AC Vin=100[V]@50Hz



Parameters	Simulation Value
Iin	5.26[A]
Input power	526[W]
Output power	496[W]

Expand

$$Vo = 406.5V \pm 4V$$
$$Io = 1.22A \pm 0.012A$$

$$efficiency = \frac{Output\ power}{Input\ power} \times 100 = \frac{496}{526} \times 100$$

$$= 94.3\% \quad (> 82.5\%\ \text{Basic})$$

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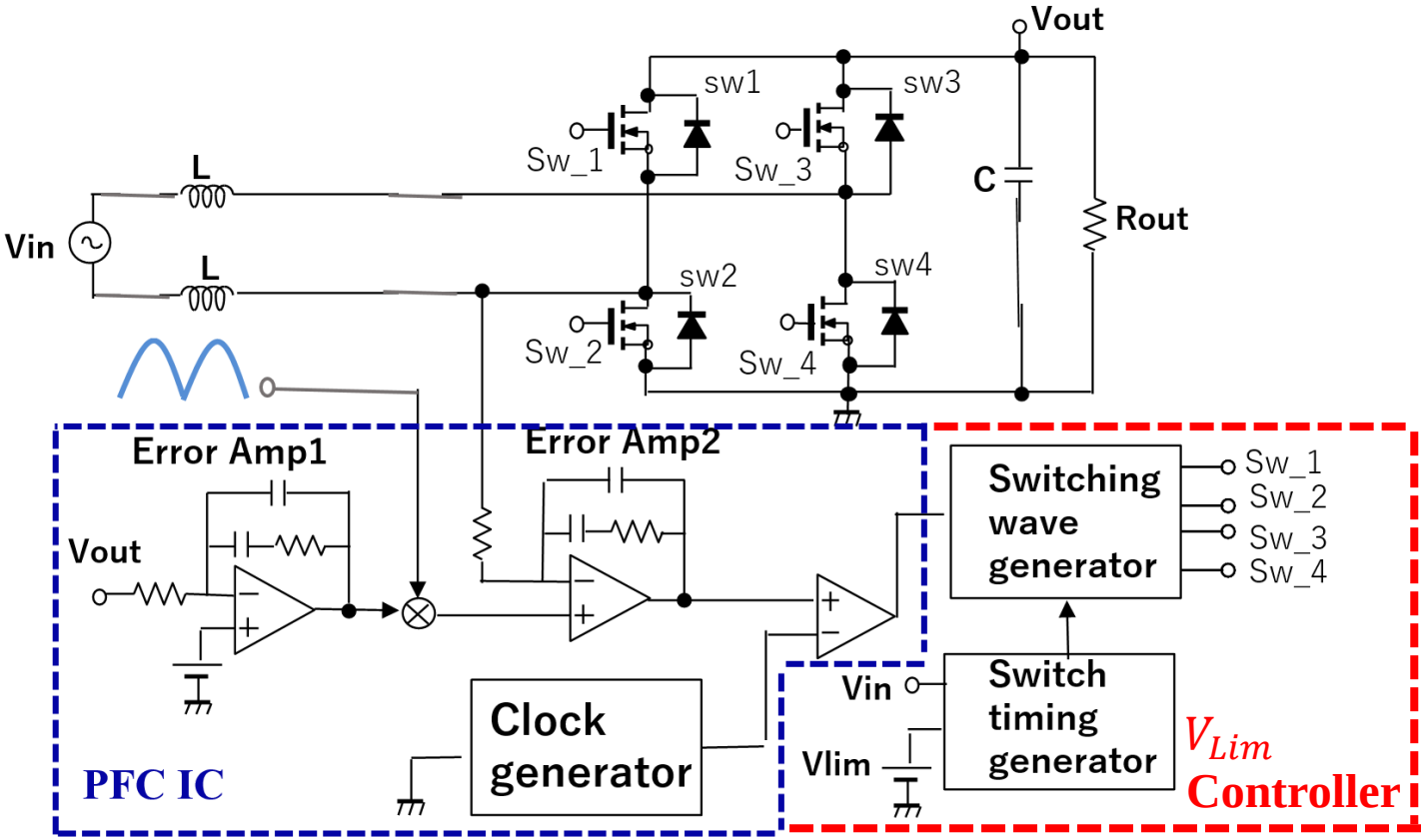
Proposed Full-Bridgeless Circuit

V_{Lim} Controller → Prevention of reverse current of sw1 or sw3



Conditions

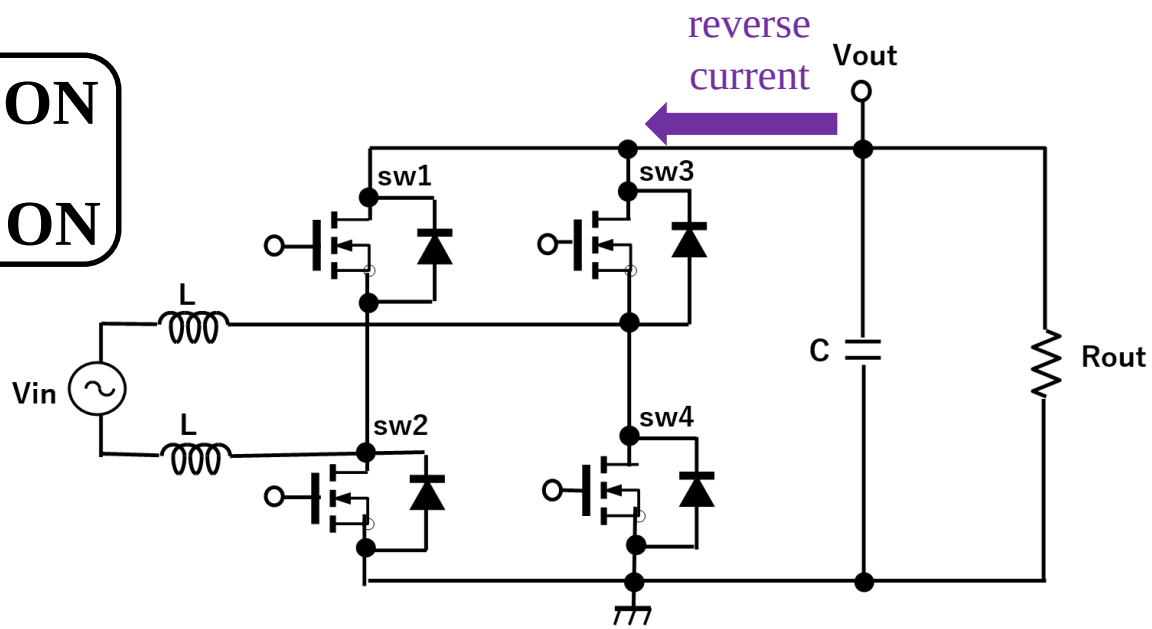
- Vin = 100[Vrms]@50Hz
- Clock frequency = 200[kHz]
- L = 1[mH]
- C = 500[uF]
- $R_{DS(on)}$ = 1[mΩ]

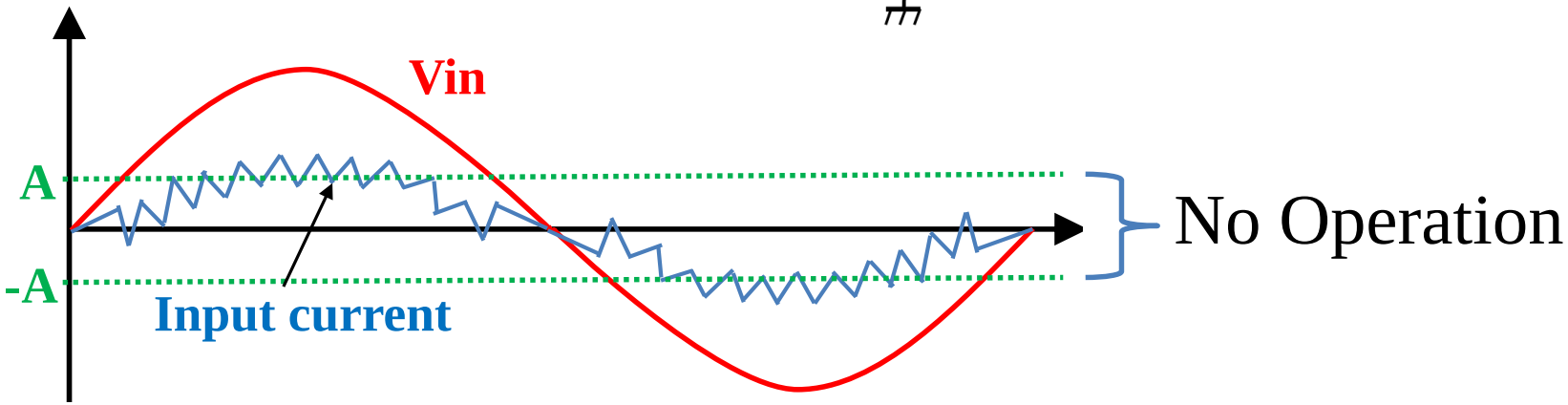
Reverse Current

- Without V_{Lim} controller circuit

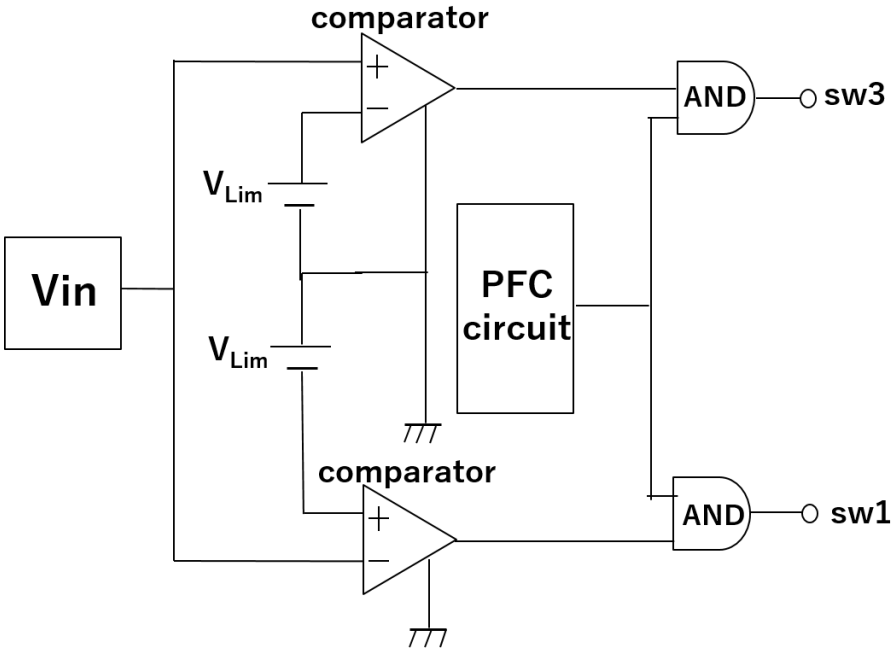
Vin < A & sw3 ON

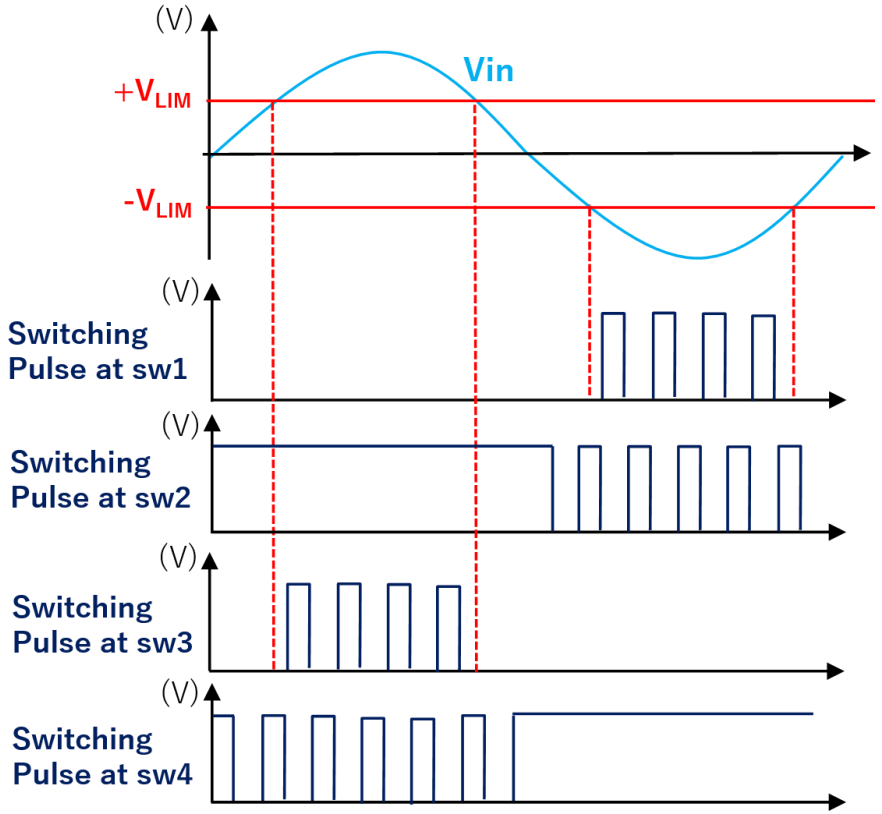
Vin > -A & sw1 ON





V_{Lim} controller circuit





Vin < V_{Lim} ⇒ sw3 OFF

Vin > $-V_{Lim}$ ⇒ sw1 OFF

Operation of Full-Bridgeless Circuit (1/4)

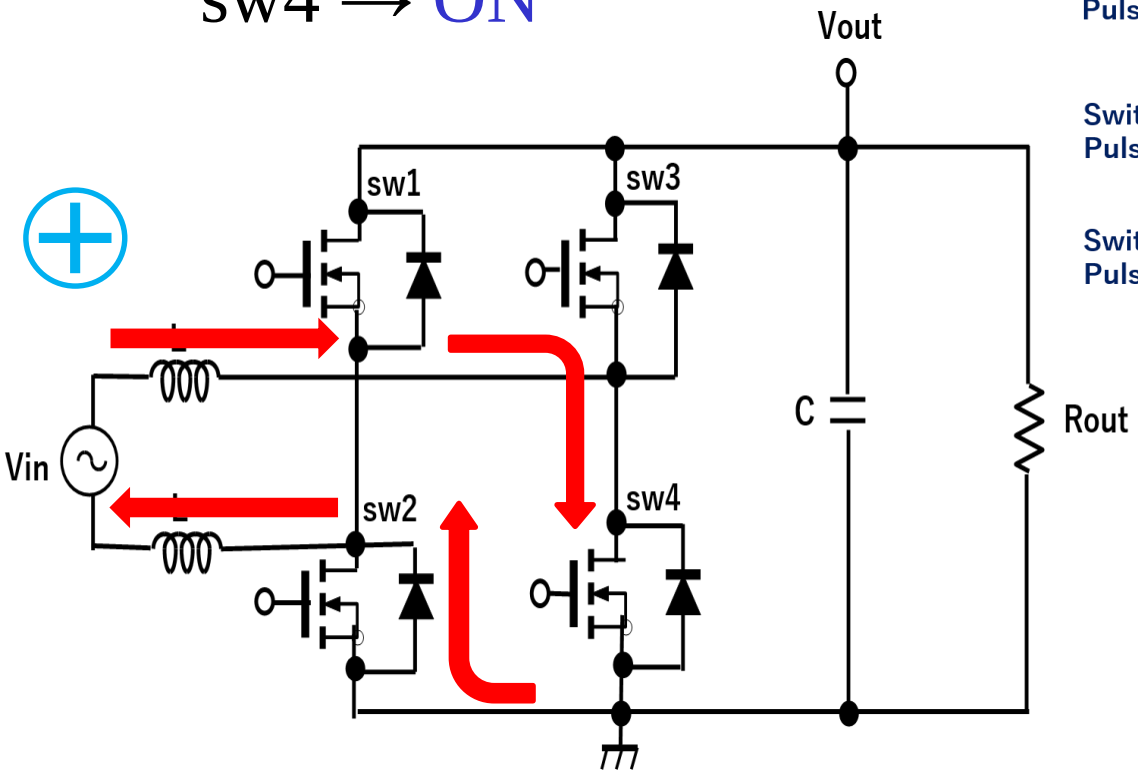
Vin < V_{Lim}

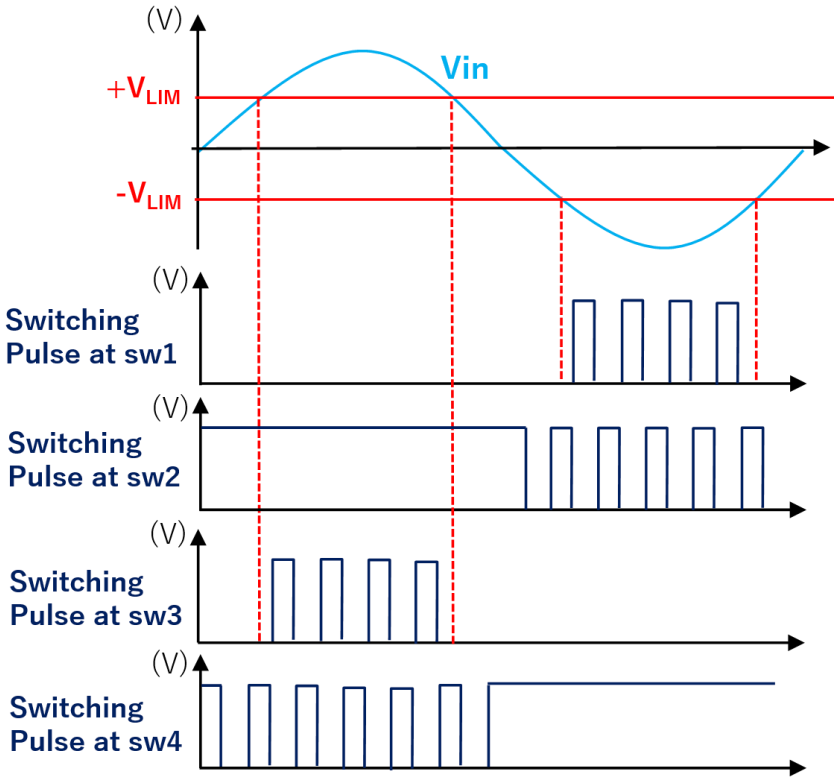
sw1 → OFF

sw2 → ON

sw3 → OFF

sw4 → ON





Operation of Full-Bridgeless Circuit (2/4)

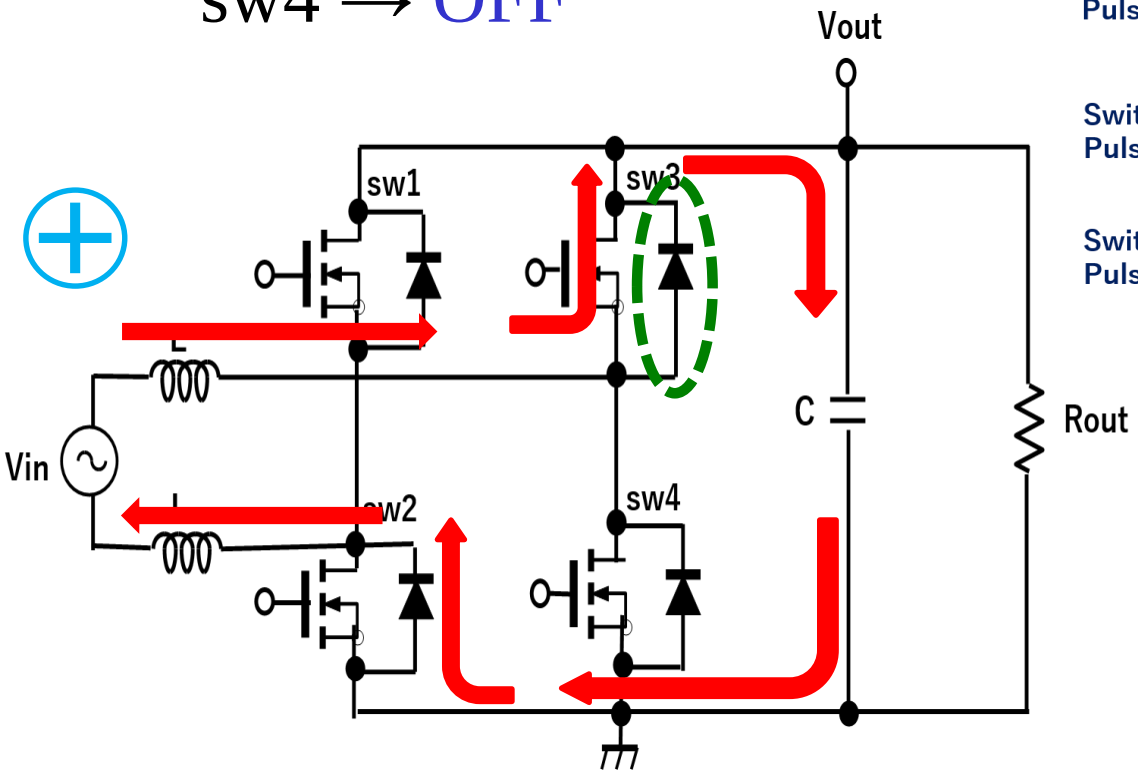
Vin < V_{Lim}

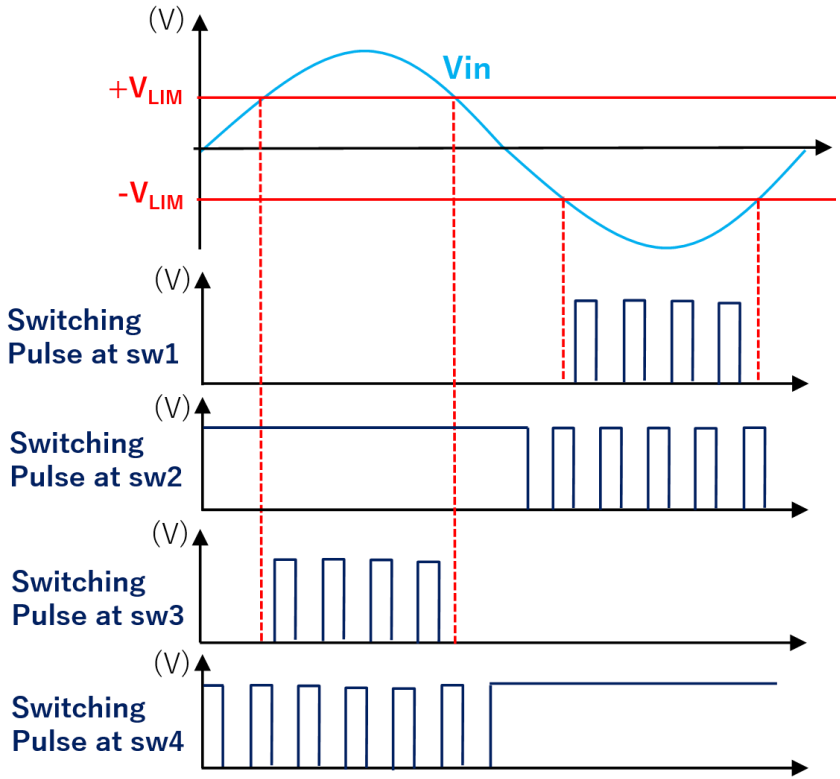
sw1 → OFF

sw2 → ON

sw3 → OFF

sw4 → OFF





Operation of Full-Bridgeless Circuit (3/4)

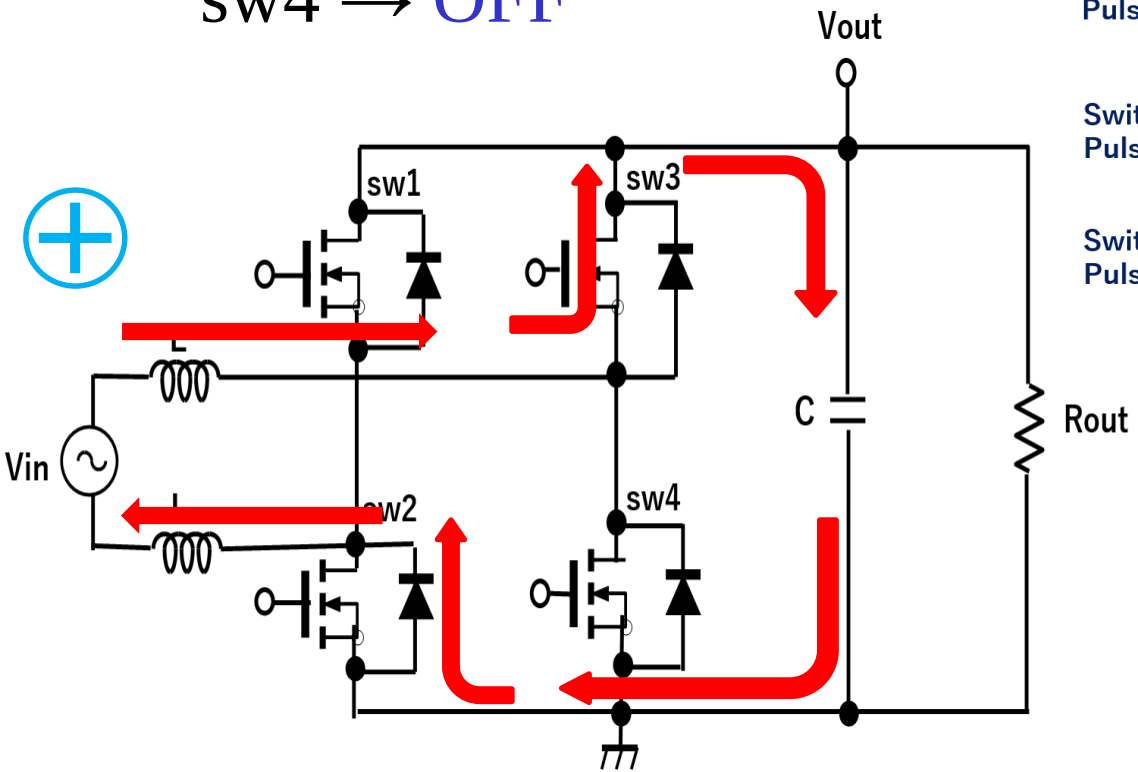
Vin > V_{Lim}

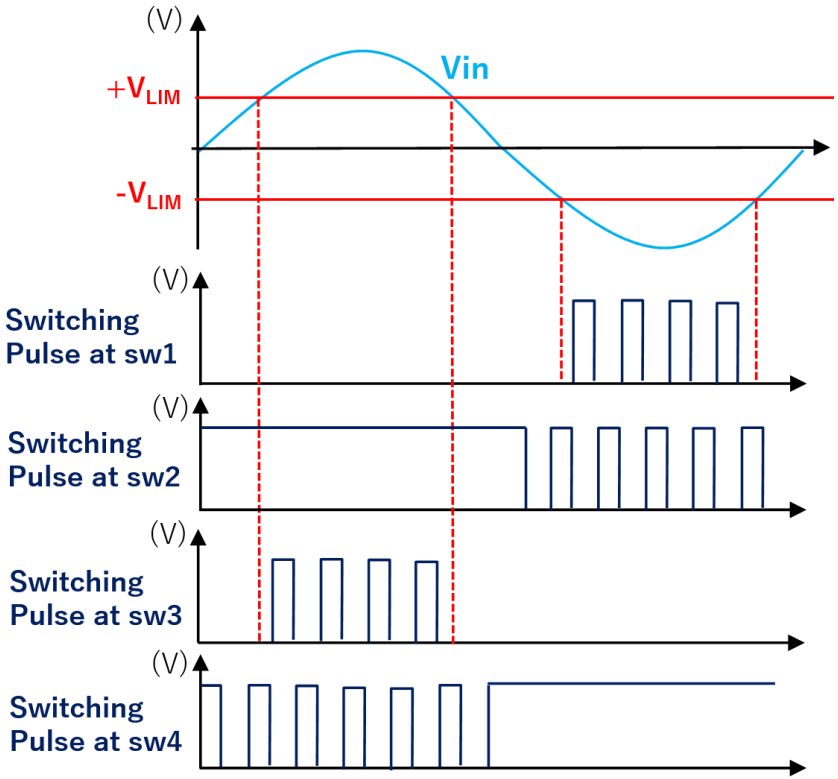
sw1 → OFF

sw2 → ON

sw3 → ON

sw4 → OFF

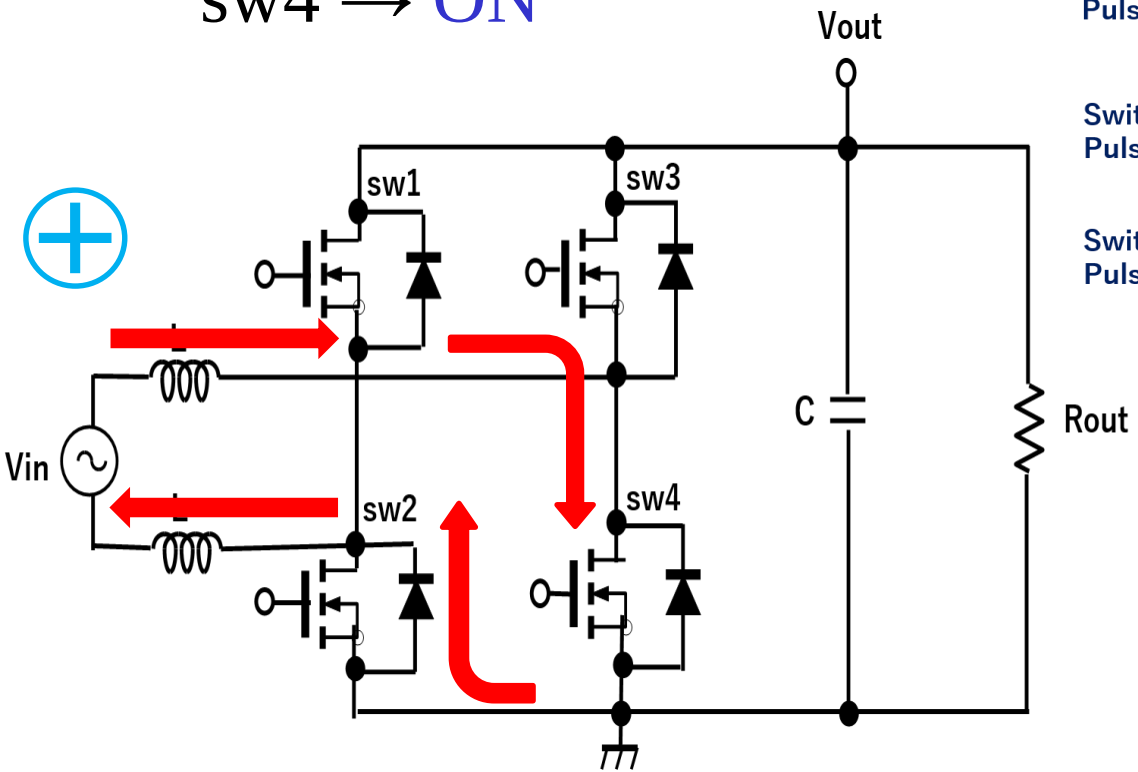


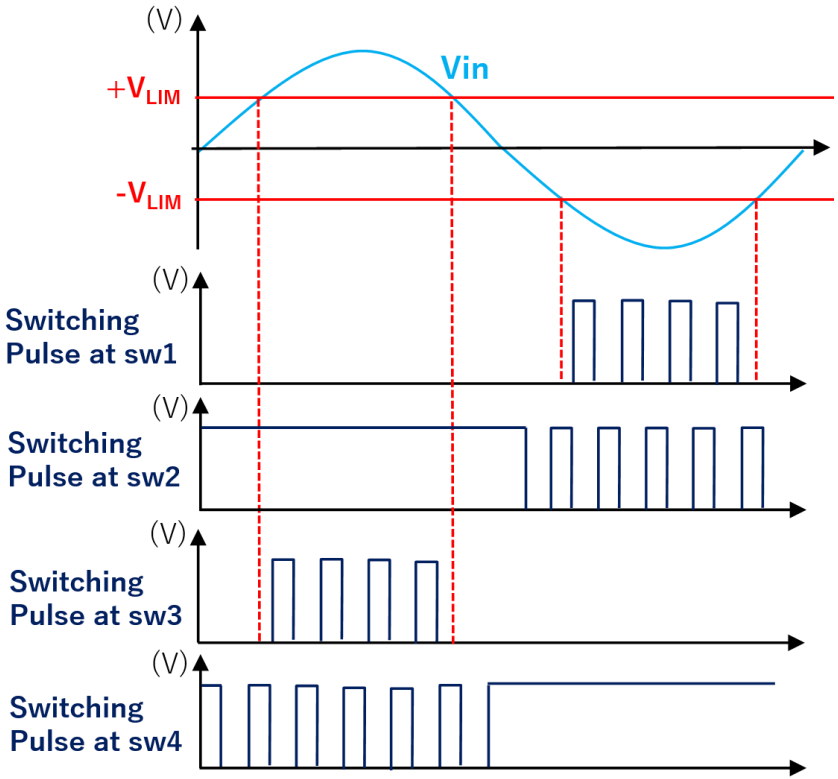


Operation of Full-Bridgeless Circuit (4/4)

Vin > V_{Lim}

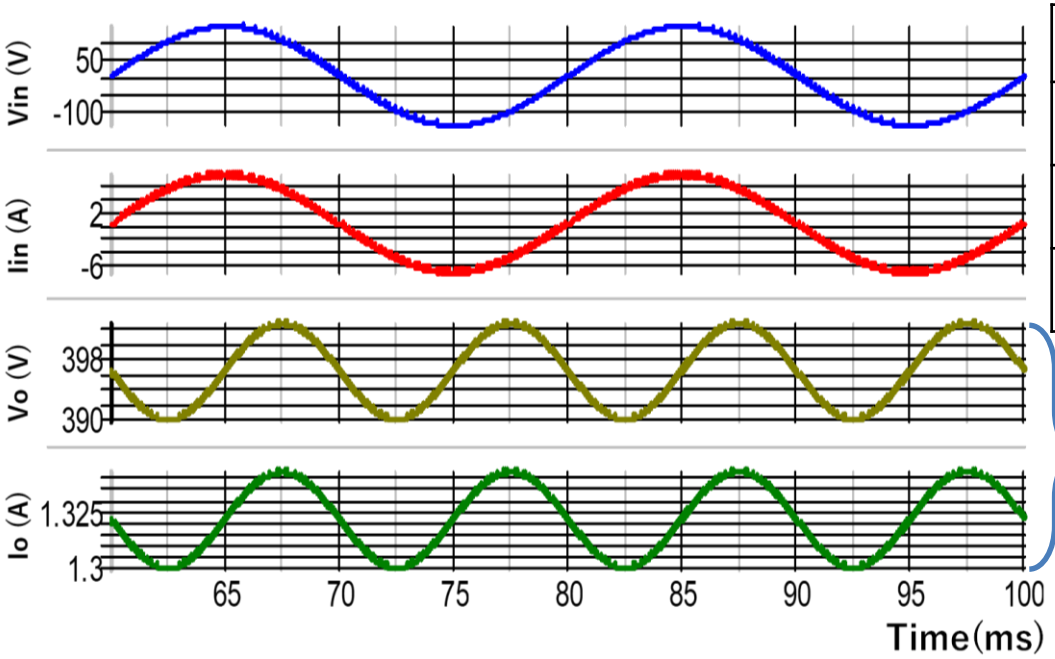
sw1 → OFF
sw2 → ON
sw3 → OFF
sw4 → ON





Efficiency of Full-Bridgeless PFC

AC Vin=100[V]@50Hz



Parameters	Simulation Value
Iin	5.25[A]
Input power	525[W]
Output power	523[W]

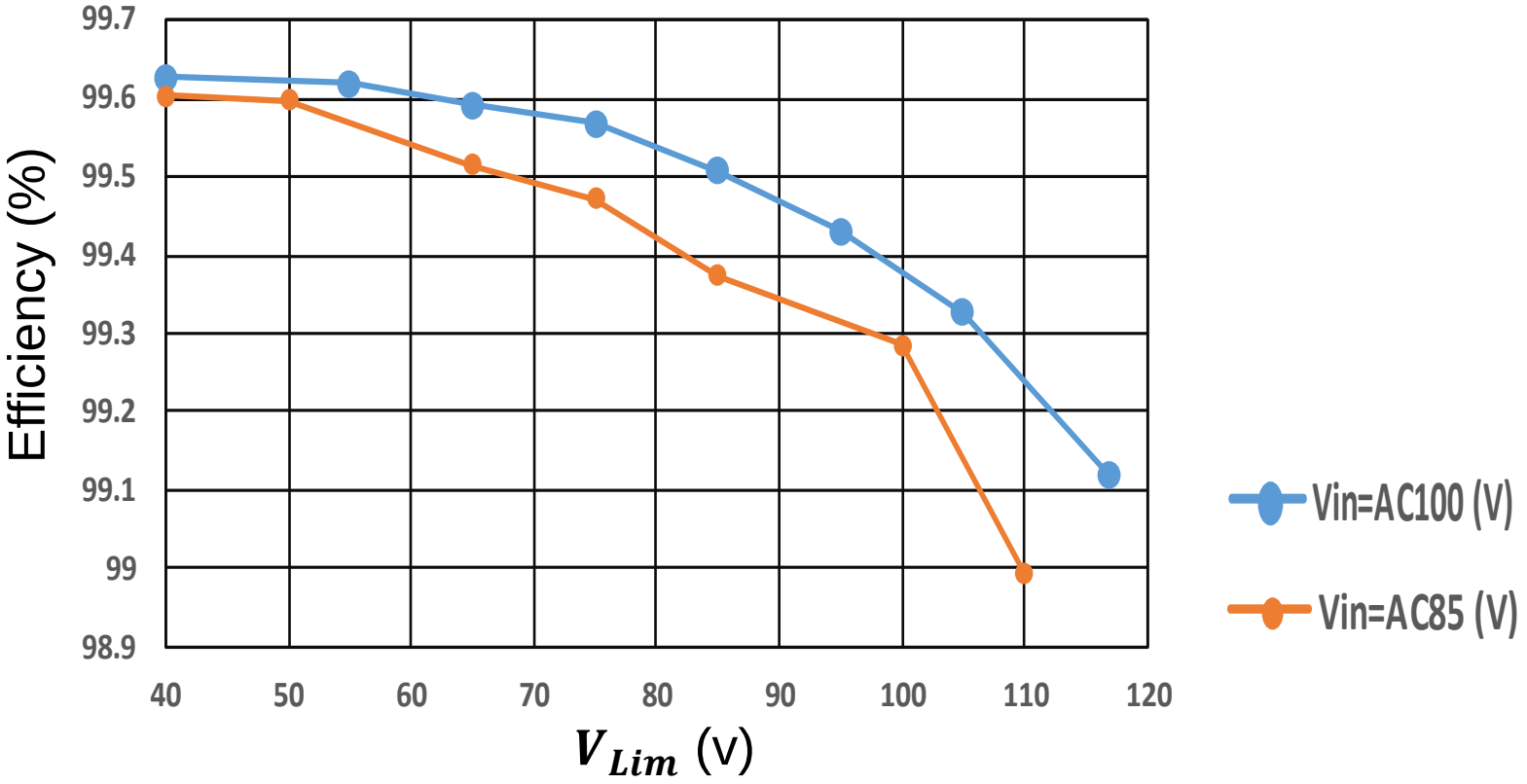
Expand

$$Vo = 396V \pm 6V$$
$$Io = 1.32A \pm 0.02A$$

$$efficiency = \frac{Output\ power}{Input\ power} \times 100 = \frac{523}{526} \times 100$$

$$= 99.6\%$$ (> 94.3% Conventional > 82.5% Basic)

Efficiency and Input Voltage



V_{Lim} High ⇒ Efficiency Low

Input Voltage High ⇒ Efficiency High

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Conclusion

- Replace diode with MOSFET

  Loss reduction → Efficiency improvement

  Basic PFC efficiency 82.5%

  Conventional PFC (Half-bridgeless) 94.3%

  Proposed PFC (Full-bridgeless) 99.6%

- Prevent reverse current in Full-bridgeless PFC by using V_{Lim} controller circuit

Thank you
for your attention!

Question and Advice (1/2)

1. Since the PFC circuit has an inductor, why does the input voltage and input current waveform have the same phase ?

   ⇨ By repeatedly turning on and off the switch (MOSFET), the input current waveform has the same in-phase as the input voltage waveform.

Question and Advice (2/2)

2. In the simulation, replace the ideal switch with an actual MOSFET and try to compare efficiency again.

   ➡ In the near future I will replace the ideal switch with the actual MOSFET and try to compare efficiency again.

3. In V_{Lim} controller circuit (P18), is the position of the second V_{Lim} correct?

   ➡ yes, the position is correct.