

Control Algorithm for Preventing Input Current Distortion in Totem-Pole PFC Converters

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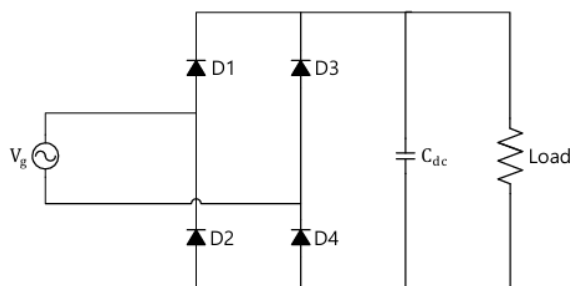
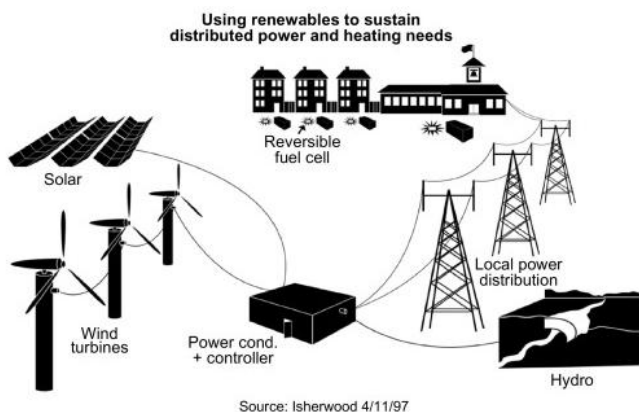


Based on GreenTech Philosophy

Introduction

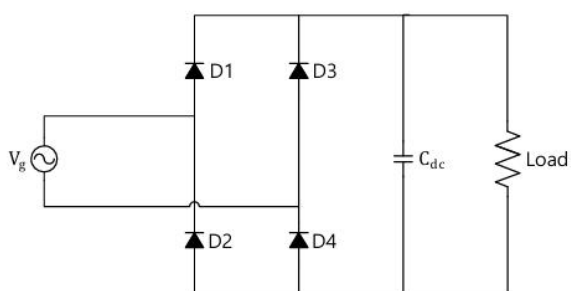
Introduction

- ❖ Expansion of distributed generation systems due to the rise of renewable energy.
- ❖ Surge in demand for high-efficiency grid-connected AC/DC converters.
- ❖ Grid-connected converters must maintain a high power factor in accordance with international standards and regulations.

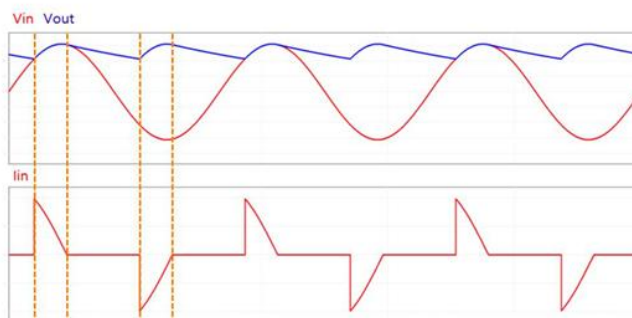


Introduction

- ❖ Diode Full-Bridge Rectifier
 - AC/DC conversion can be performed very simply.
 - Current only flows when the input voltage exceeds the output voltage, resulting in a discontinuous and distorted input current.



(a) circuit



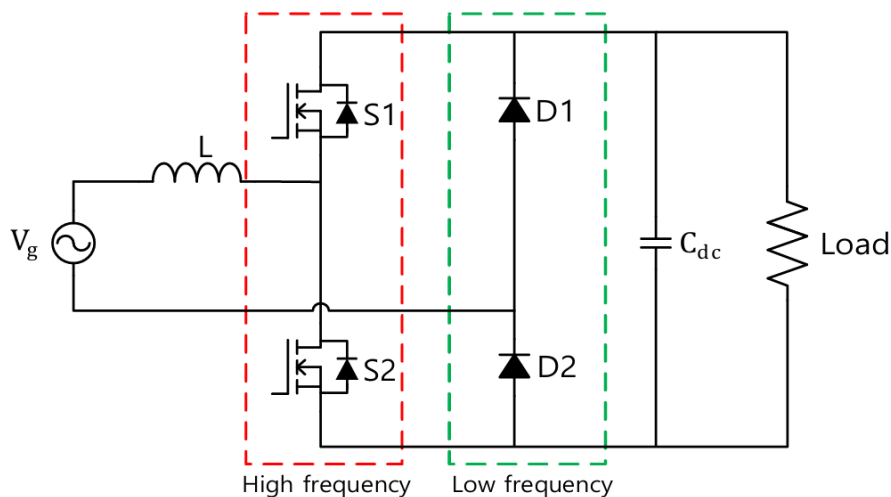
(b) input voltage/current and output voltage

Totem-Pole PFC Converter

Totem-Pole PFC Converter

❖ Totem-Pole PFC Converter

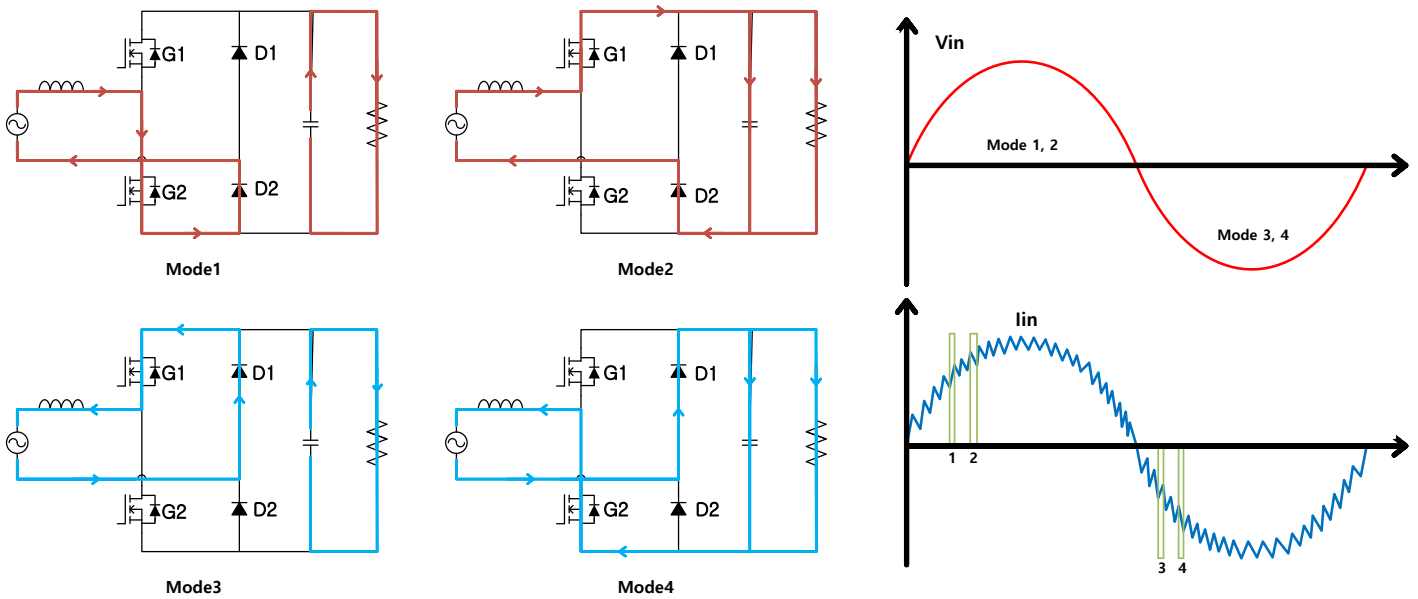
- Currently, the most widely adopted PFC converter, favored for its superior EMI characteristics and high efficiency.
- S1 and S2 operate at switching frequencies many tens of times greater than the grid frequency, while the diodes switch at the grid frequency.



Totem-Pole PFC Converter

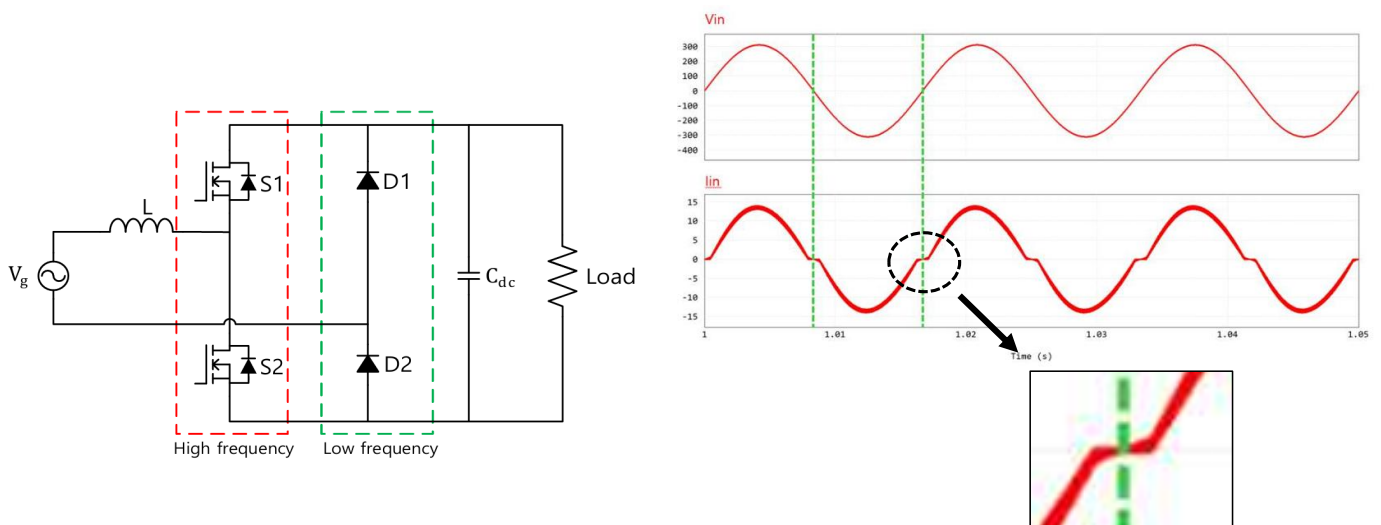
❖ Operation

- Mode 1 and Mode 2 interleave when the voltage phase is positive.
- Mode 3 and Mode 4 interleave when the voltage phase is negative.



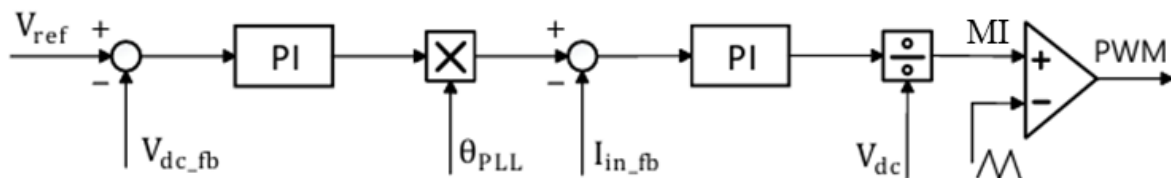
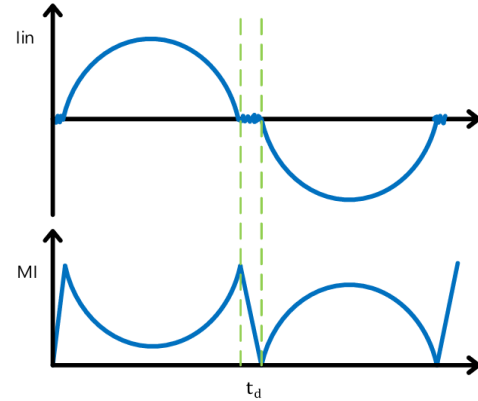
Totem-Pole PFC Converter

❖ Input Current Distortion



Totem-Pole PFC Converter

- ❖ Totem-pole PFC converters are typically controlled using a dual-loop PI voltage/current controller.
 - Unable to quickly control the rapid MI fluctuations during zero-crossing.
 - The totem-pole converter's diode conducts during the delay time(T_d), causing instantaneous distortion.

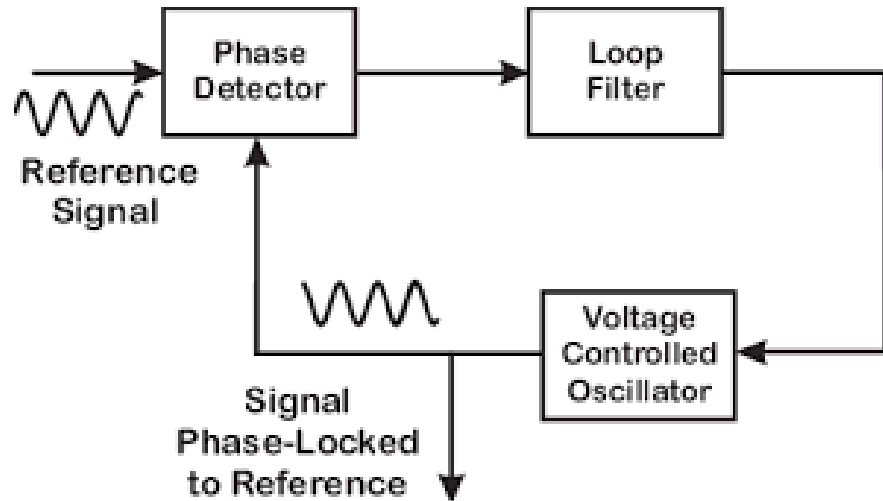


Based on GreenTech Philosophy

PLL and Proposed Control Algorithm

❖ PLL(Phase-Locked Loop)

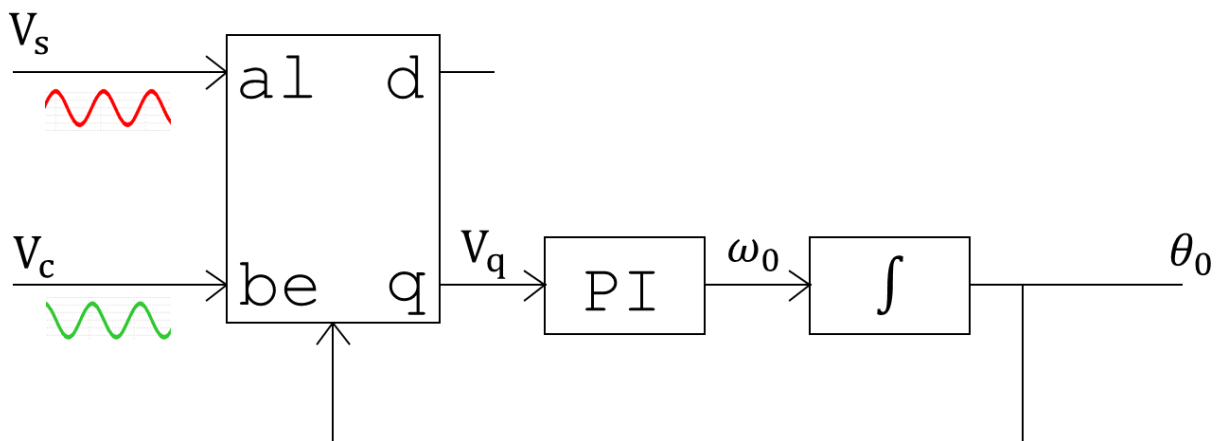
- A feedback loop designed to enable the output signal to track the phase and frequency of the input signal.
- Essential for systems where phase tracking is critical, such as inverters and power factor correction converters.



SRF PLL

❖ SRF(Synchronous Reference Frame)-PLL

- After converting two signals with a 90° phase difference to DC using a d-q transform, a PLL is implemented based on the q-axis output.
- PI control reduces q-axis error.

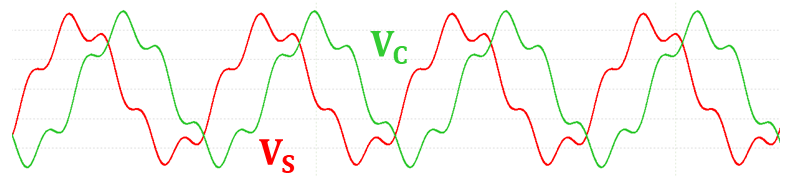
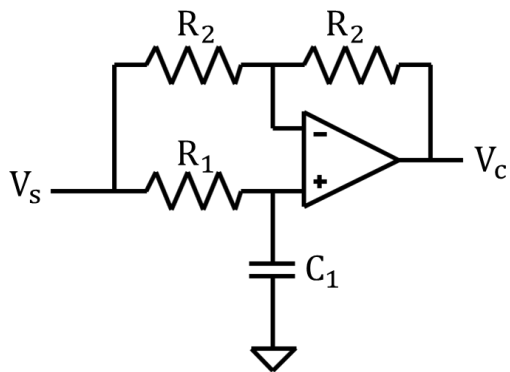


APF(All Pass Filter)

- ❖ A filter that passes all frequency band signals with a gain of 1.
 - Creates a phase difference between input and output signals depending on the combination of resistors and capacitors.

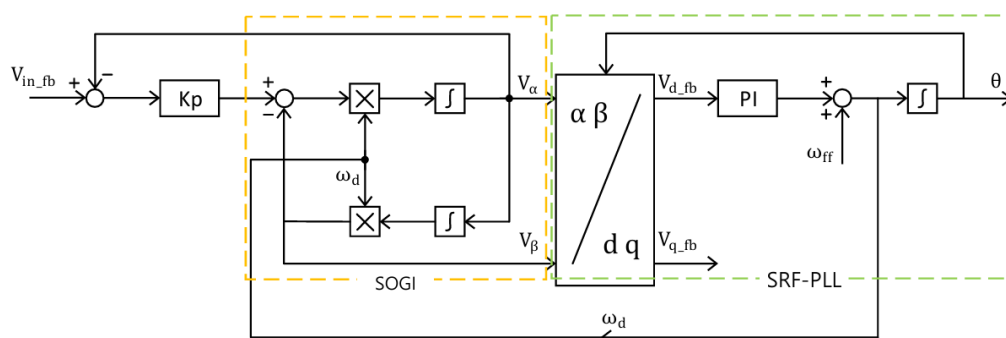
$$\phi = -2 \arctan(2\pi f \cdot R_1 C_1)$$

- ❖ Noise and harmonics are not filtered out and are reflected in the output.



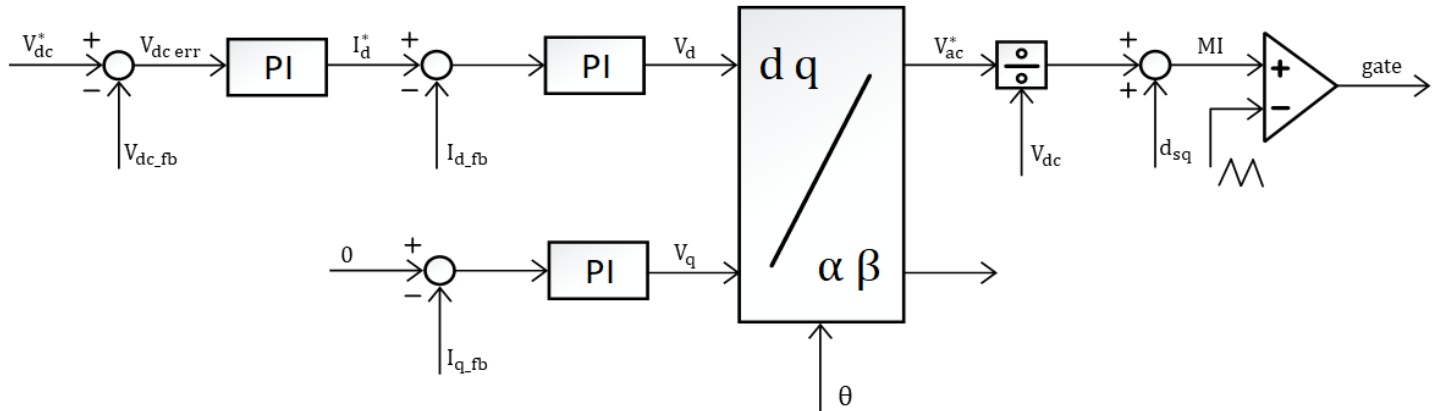
SOGI-PLL

- ❖ SOGI(second order generalized integrator) - PLL(phase locked loop)
 - Maintains stable tracking of power system phase information despite frequency fluctuations and disturbances.
 - Generates 90-degree delayed waveforms, enables dq transform & phase tracking

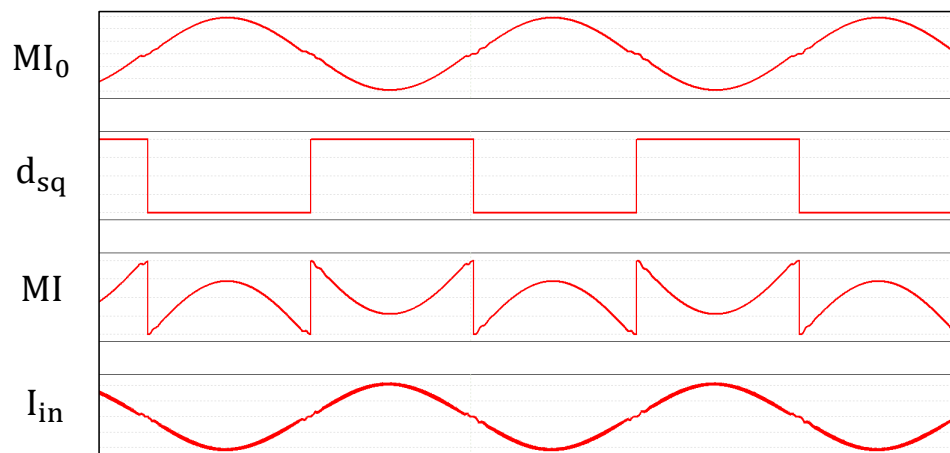
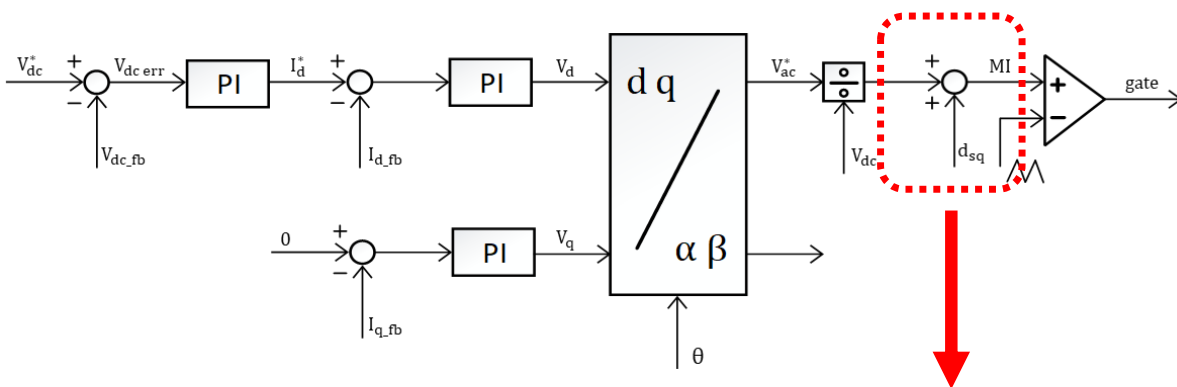


Proposed Control Algorithm

- ❖ Controls by converting AC signals to DC.
- ❖ Achieves precise control through additional compensation.
- ❖ Synchronizes input signal phase information for effective power factor correction.



Proposed Control Algorithm



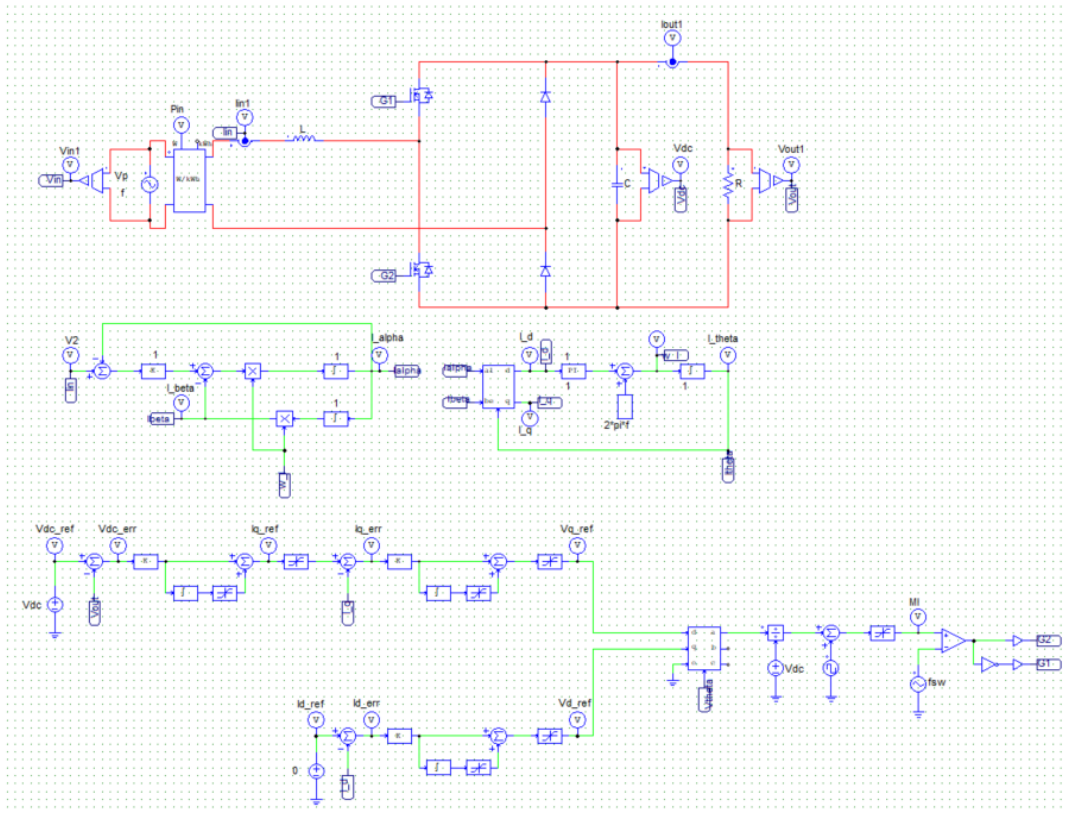
Simulation Analysis



Simulation Specifications

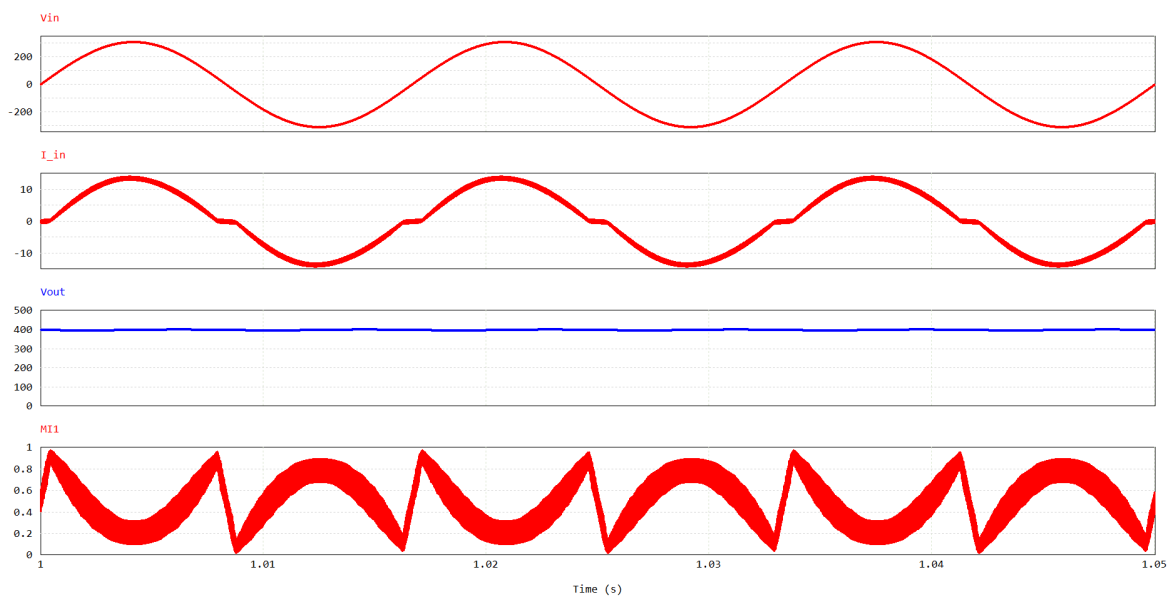
parameter		value	parameter		value
Power	P_{in}	2kW	Input Inductor	Lin	1500uH
Input V	V_g	220Vrms	I ripple	ΔI	10%
Grid f	f_g	60Hz	V ripple	ΔV	2%
Output V	V_{dc}	400Vdc	Output C	C_o	5%
Load	R_{Load}	80 Ω	Switching f	f_{sw}	50kHz





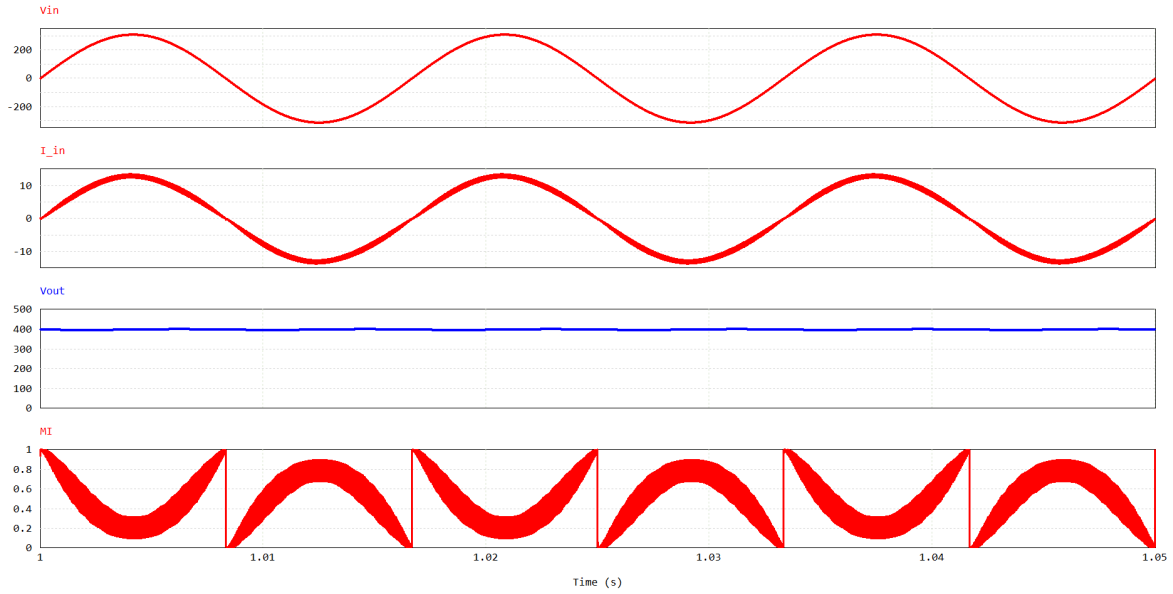
Simulation Result

❖ Before compensation



Simulation Result

❖ After compensation

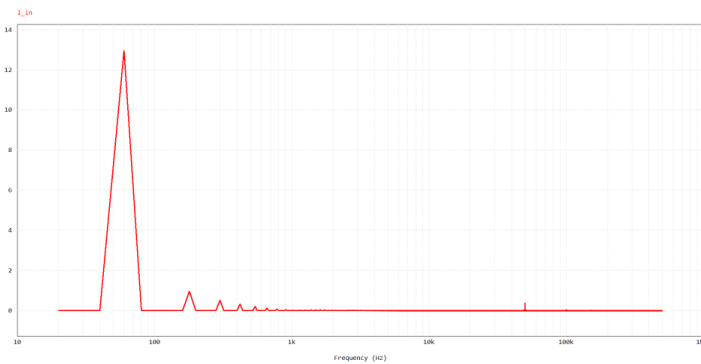


FFT Analysis

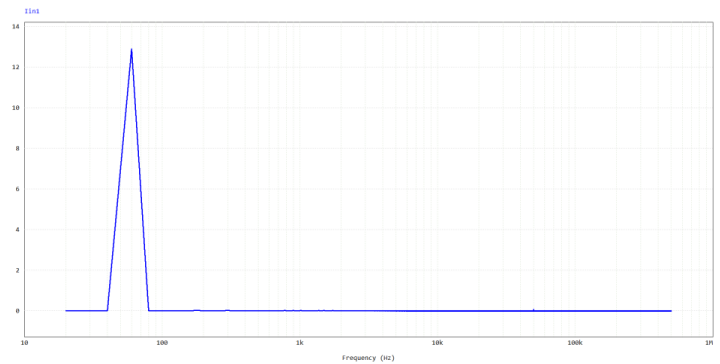
❖ $THD = \frac{\sqrt{\sum I^2/h}}{I_1}$

■ h = Harmonic Order

h	Before compensation	After compensation
3	4.244%	1.394%
5	1.729%	0.076%
7	0.938%	0.243%
9	0.545%	0.081%
11	0.319%	0.126%
THD	7.757%	1.92%



기존 PI제어



dq 좌표변환 기반 PI제어



Conclusions

Conclusions

- ❖ Summary
 - The control algorithm proposed in this study was validated through PSIM simulations, demonstrating its ability to mitigate current distortion and stably regulate the output of a totem-pole PFC converter.

- ❖ Future works
 - To experimentally validate the proposed algorithm, we are currently fabricating a 1kW SiC-based prototype system board. Experiments are scheduled to commence upon its completion.

Thank you for your attentions

ΓΙΑ ΟΙΣ ΛΟΓΙΣΤΕΣ ΛΟΓΙΣΤΕΣ ΣΥΣΤΗΜΑΤΩΝ

Questions & Answers

Power Electronics System
Power Conversion System / Electric Motor Control
Smart Energy Control System / Green Energy System