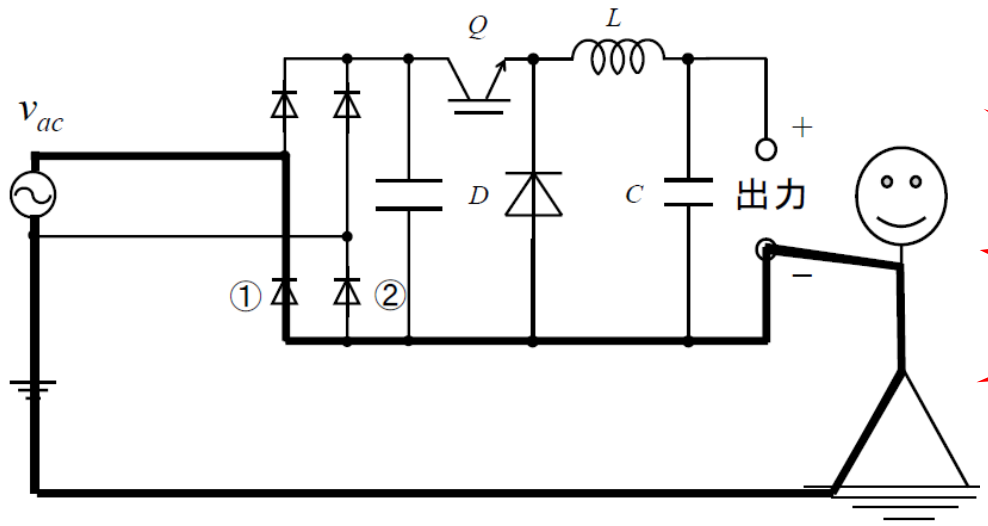
絶縁型コンバータ

電気電子工学専攻
鵜野 将年

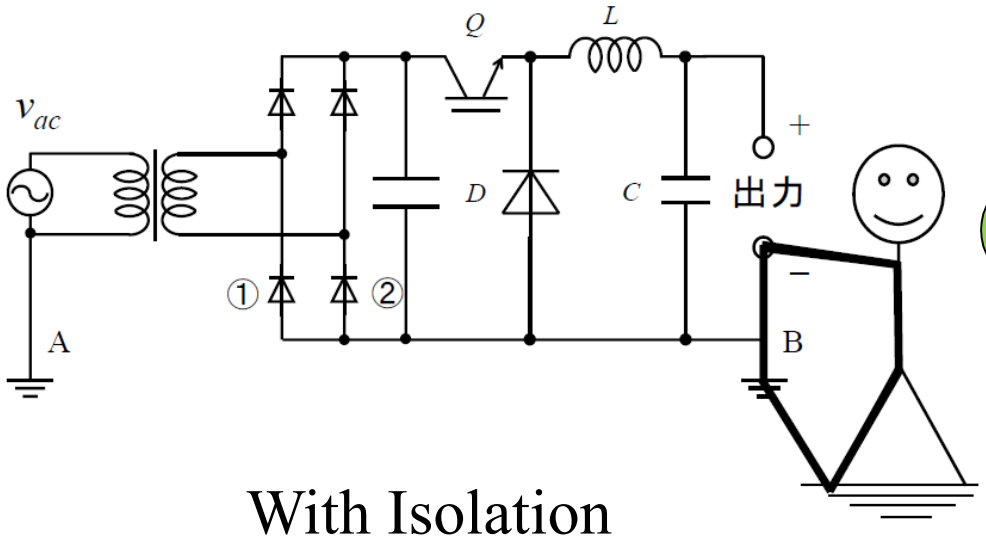
Outline

1. Why Isolation?
2. Isolated Converter Applications
3. Isolated Converters
4. Primary- and Secondary-Side Topologies
5. Soft Switching in Isolated Converters
6. Fundamental Operation (Waveforms and Current Flows)

Why Isolation?



Without Isolation

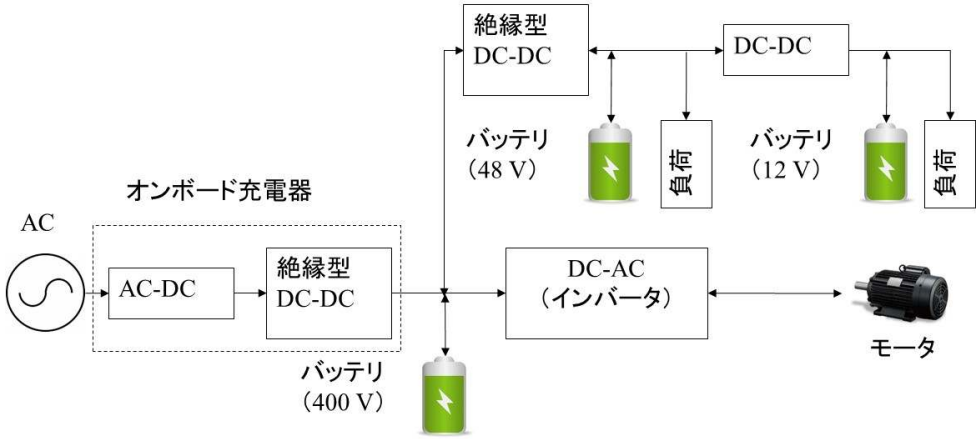


With Isolation

Primary and secondary circuits can be separately grounded

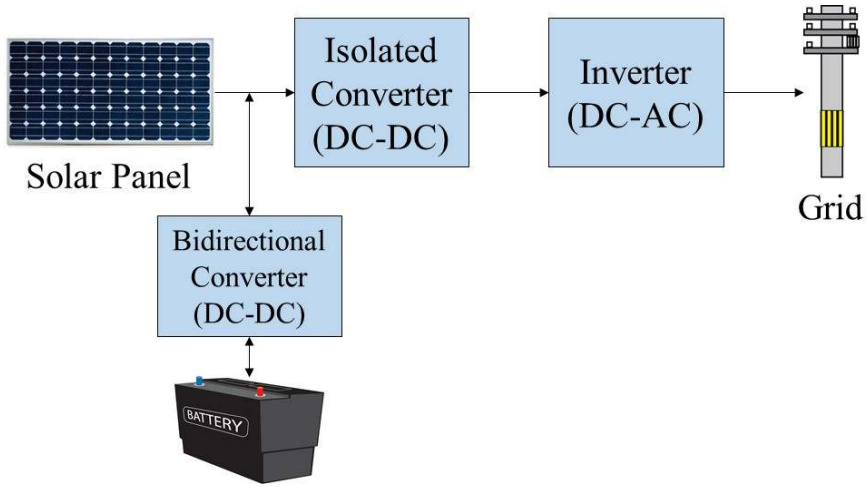
Isolated Converter Applications

- Home appliance
- Electric vehicle
- Renewable energy
- etc.



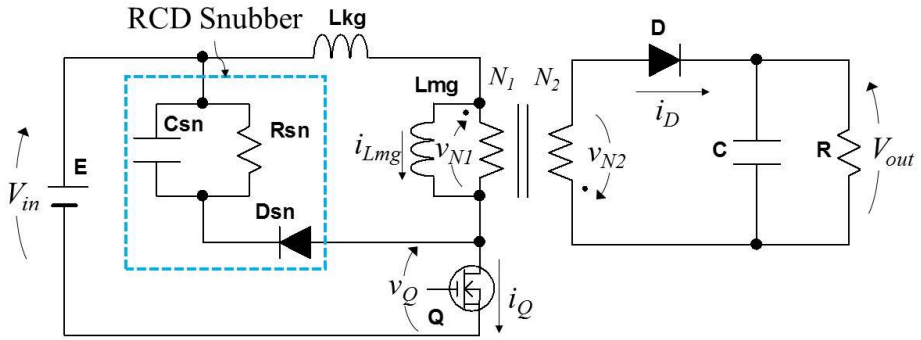
Electric Vehicle Power System Example

Isolated Converters

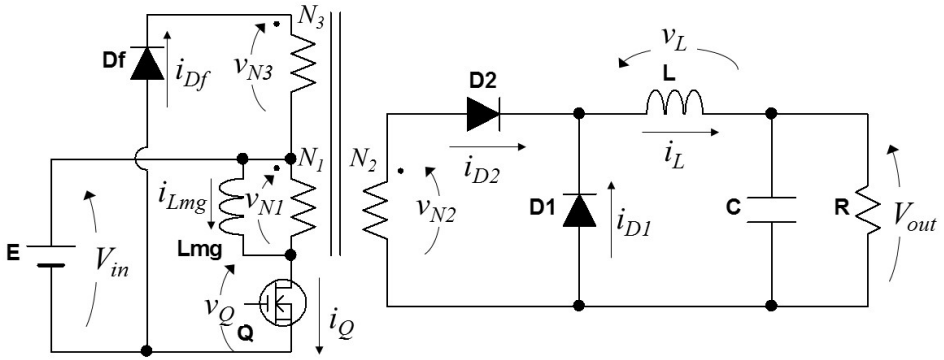


Grid-Connected PV System Example

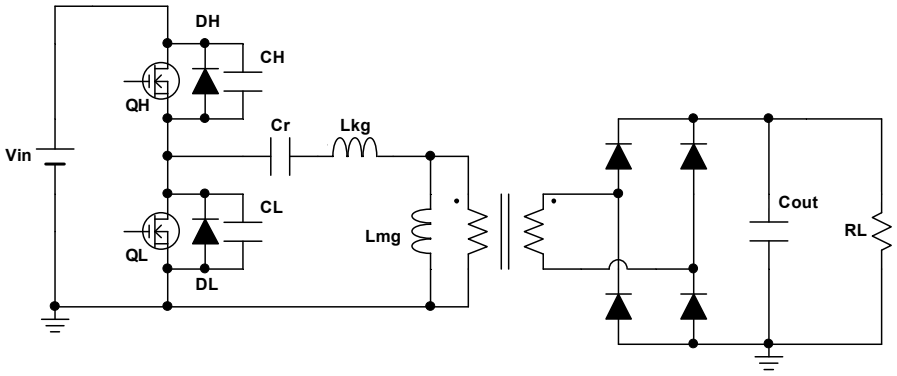
Isolated Converters



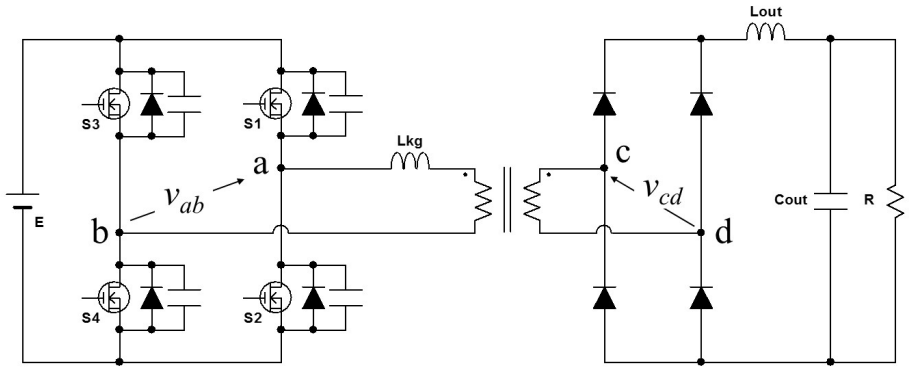
Flyback Converter



Forward Converter

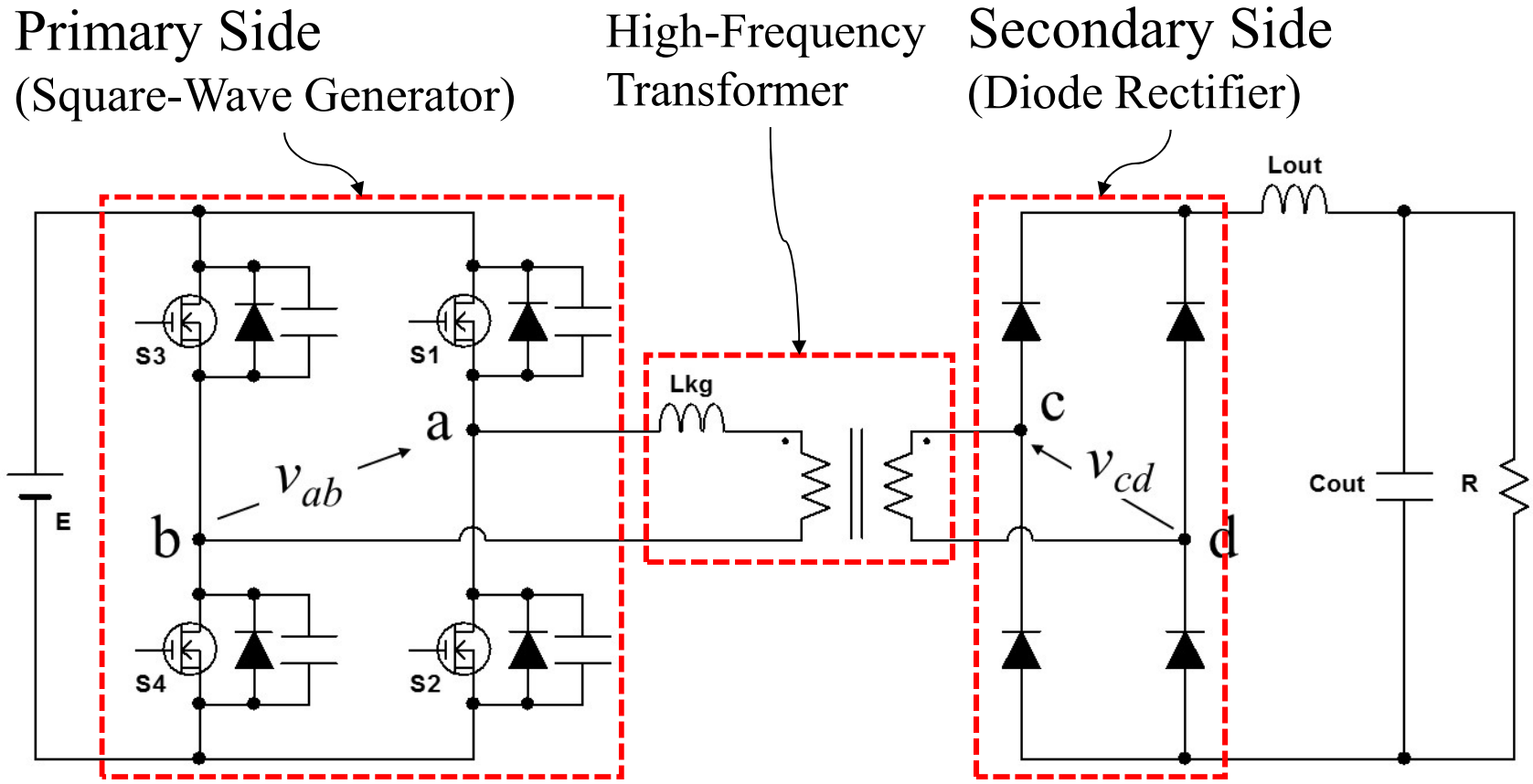


Resonant Converter
(LLC Converter)



Full-Bridge Converter

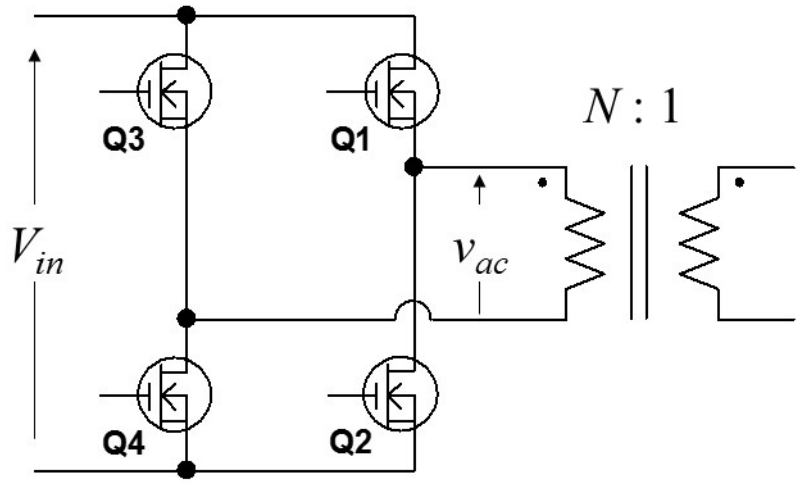
Isolated Converter Topology



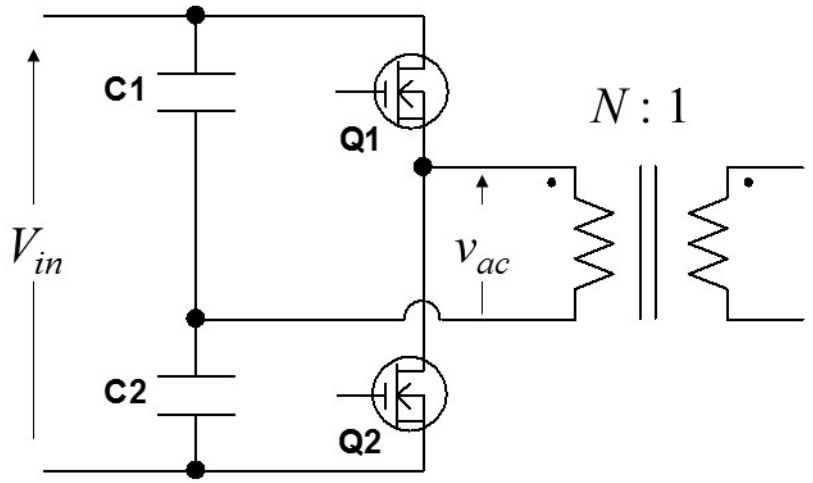
Full-Bridge Converter (with Full Bridge Diode Rectifier)

Combination of primary- and secondary-side circuits with high-frequency transformer in between

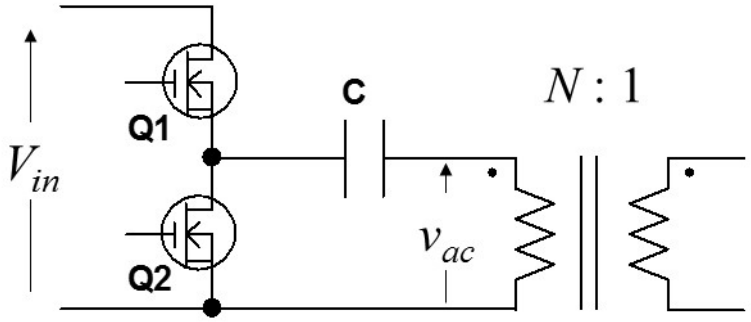
Primary-Side Topologies for Isolated Converters



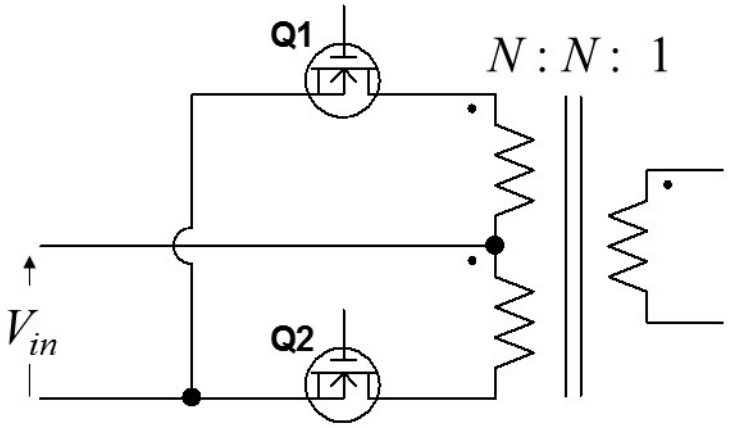
Full-Bridge



Half-Bridge



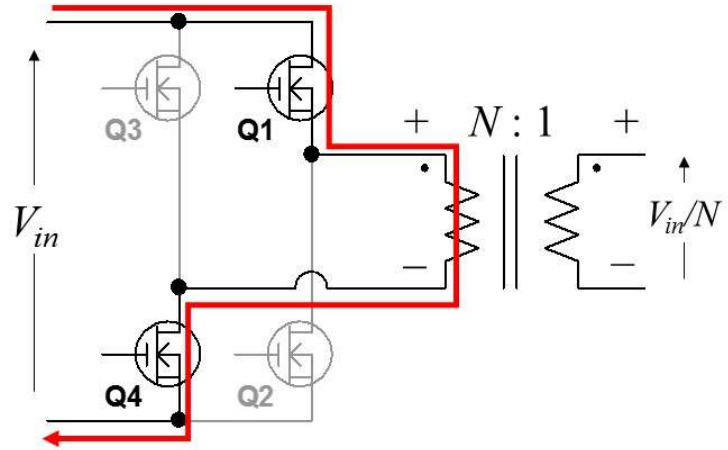
Asymmetric Half-Bridge (AHB)

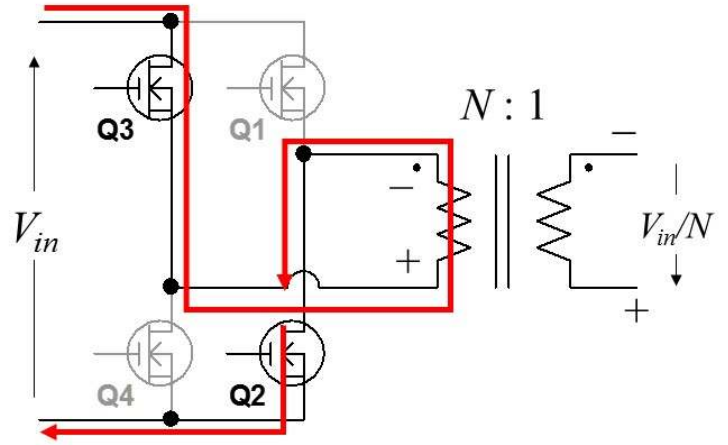


Push-Pull

Primary Side Operations (Full- and Half-Bridges)

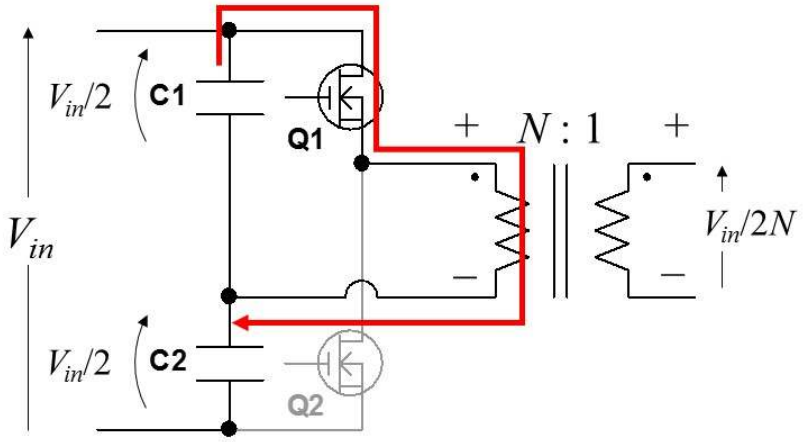
Full-Bridge

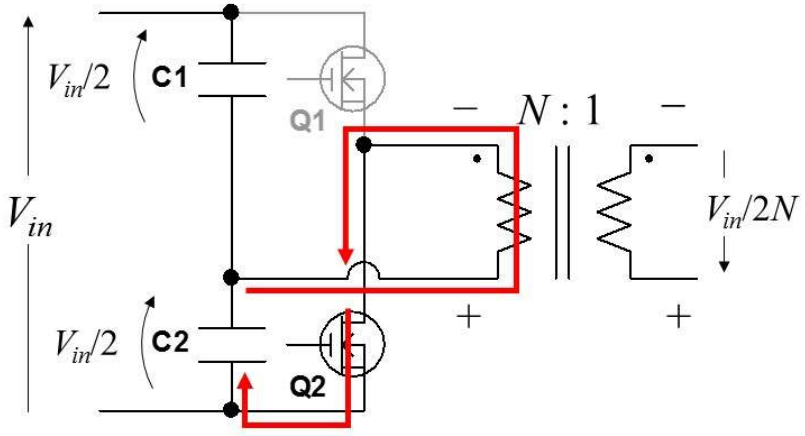




Output is $\pm V_{in}/N$

Half-Bridge

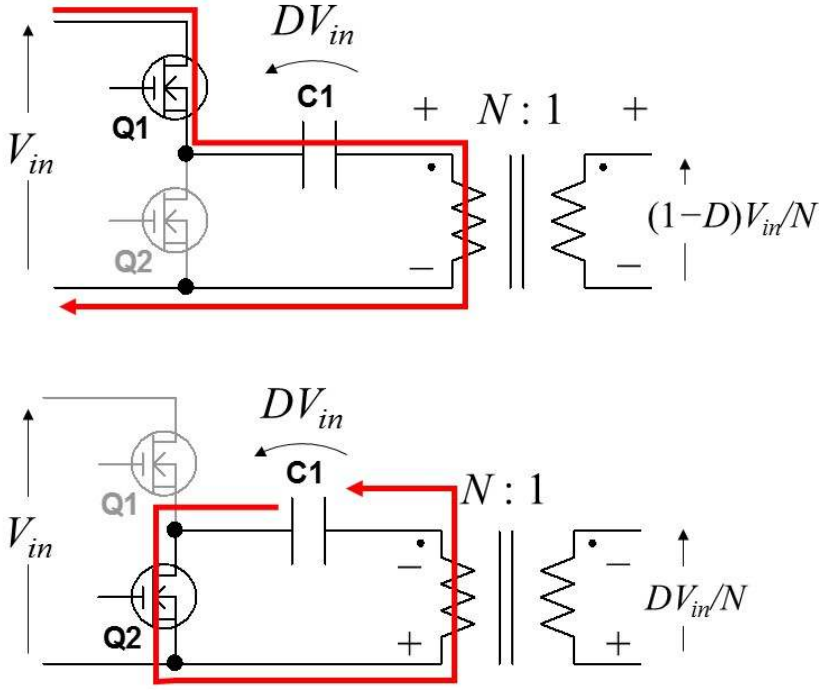




Output is $\pm V_{in}/2N$

Primary Side Operations (AHB and Push-Pull)

Asymmetric Half-Bridge

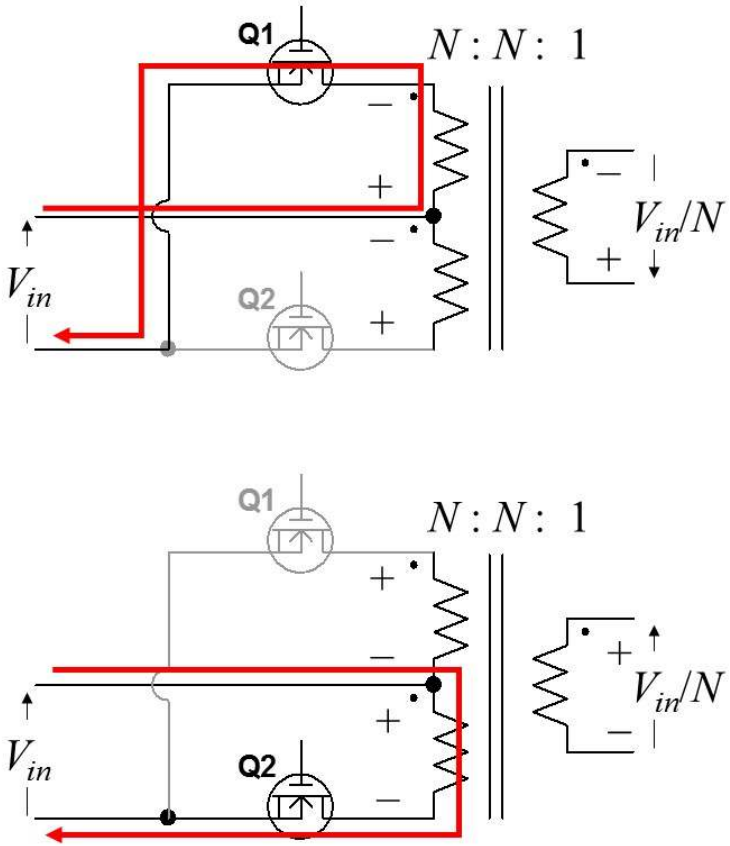


D: Duty cycle of Q_1

Voltage of C_1 is DV_{in} because the average winding voltage must be 0 under steady-state conditions

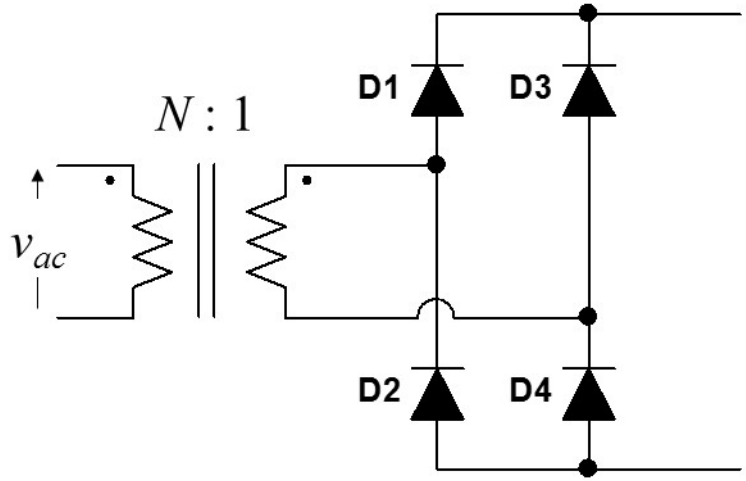
Output is $+(1-D)V_{in}/N$ and $-DV_{in}/N$

Push-Pull

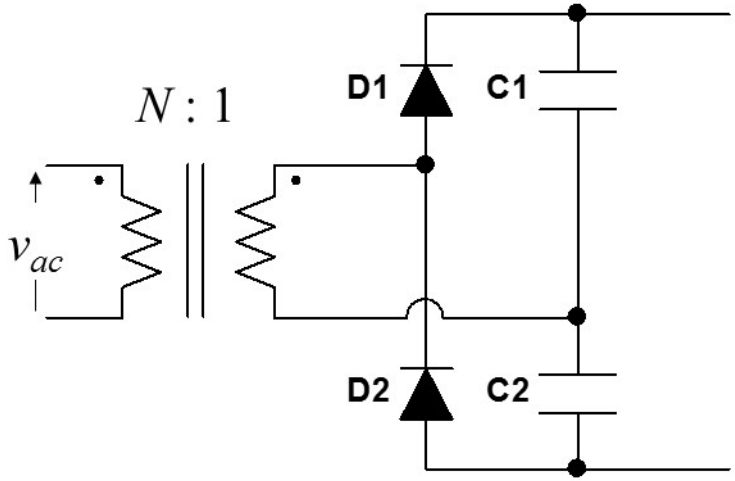


Output is $\pm V_{in}/N$

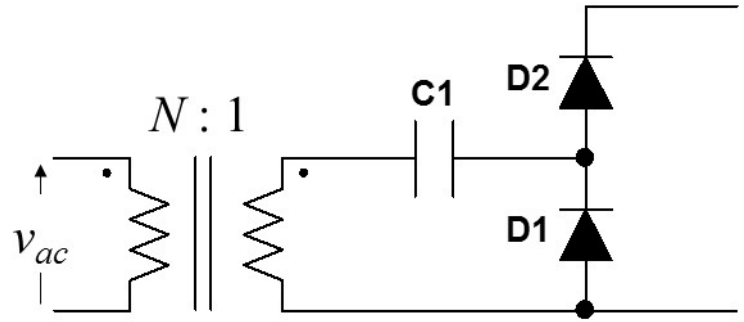
Secondary-Side Topologies for Isolated Converters



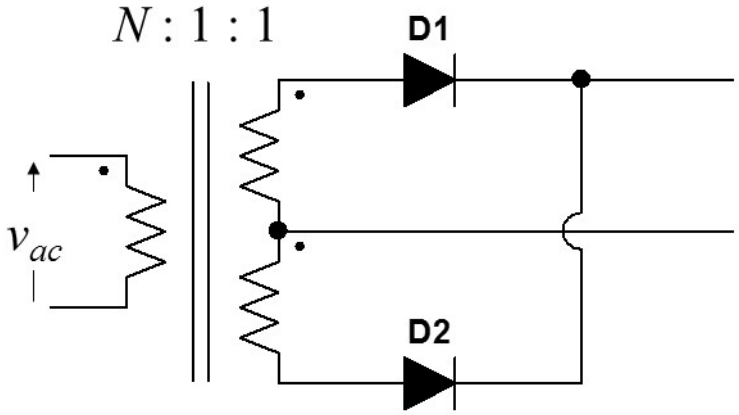
Full-Bridge Rectifier



Doubler



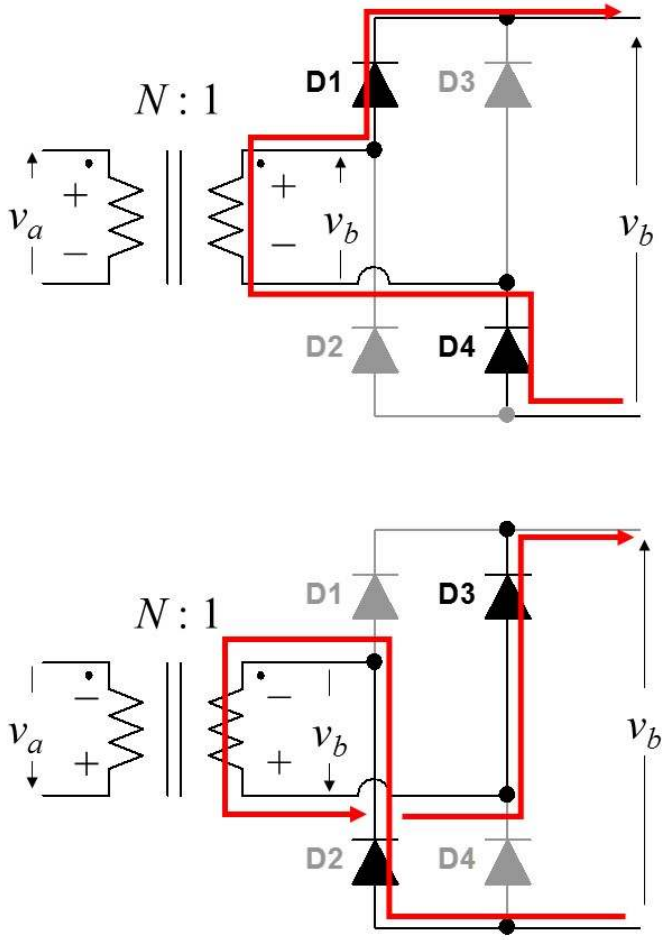
Doubler



Center-Tap Rectifier

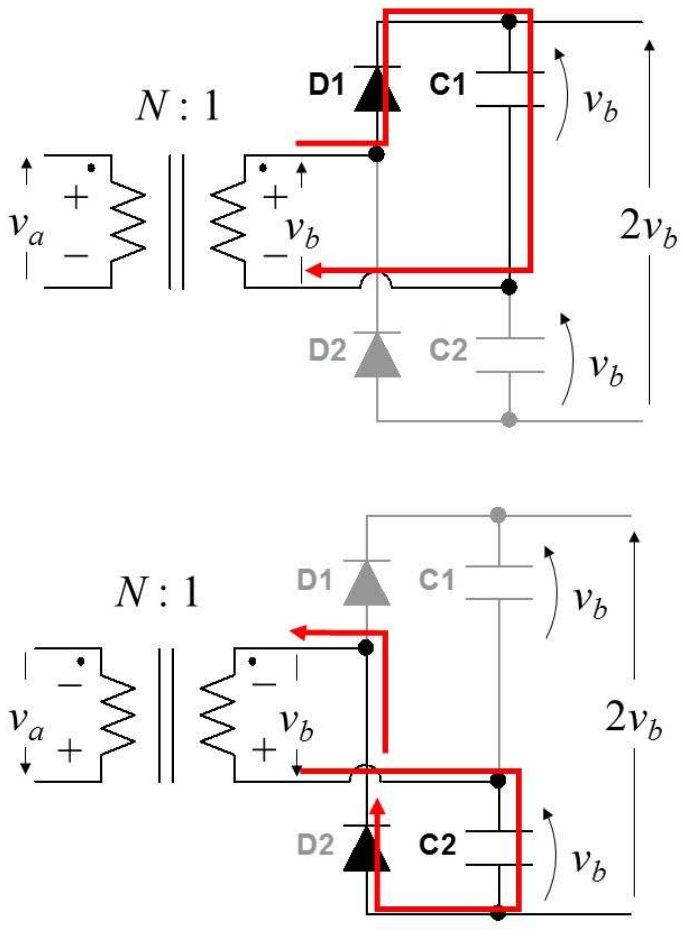
Secondary Side Operations (Full Bridge and Doubler)

Full-Bridge



Output is v_b

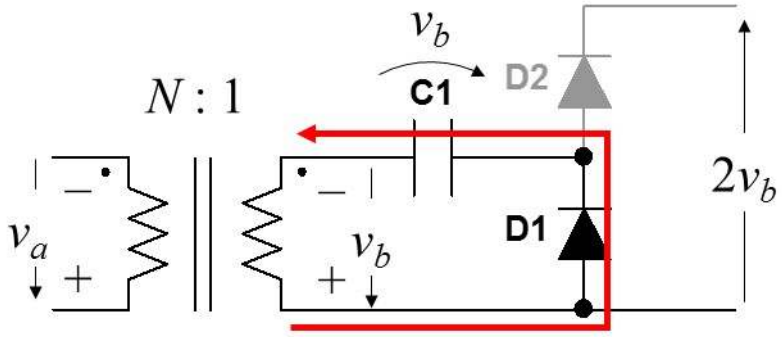
Doubler

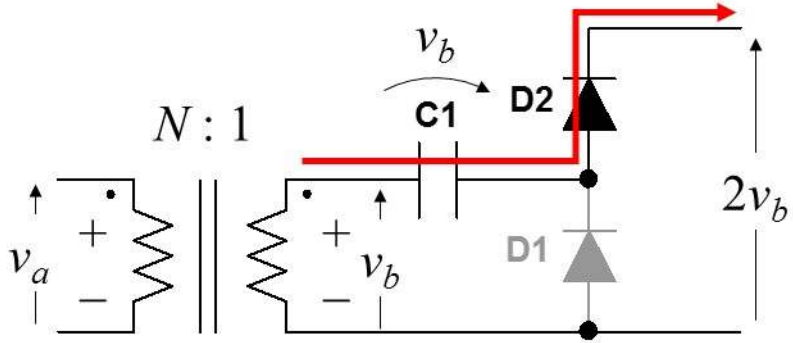


Output is $2v_b$

Secondary Side Operations (Doubler and Center-Tap)

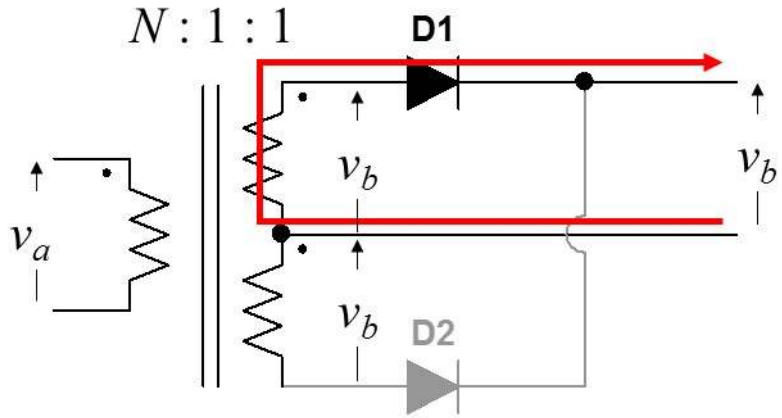
Doubler

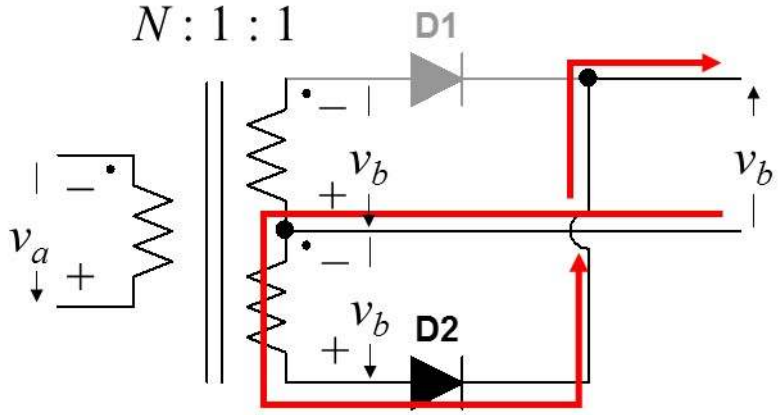




Output is $2v_b$

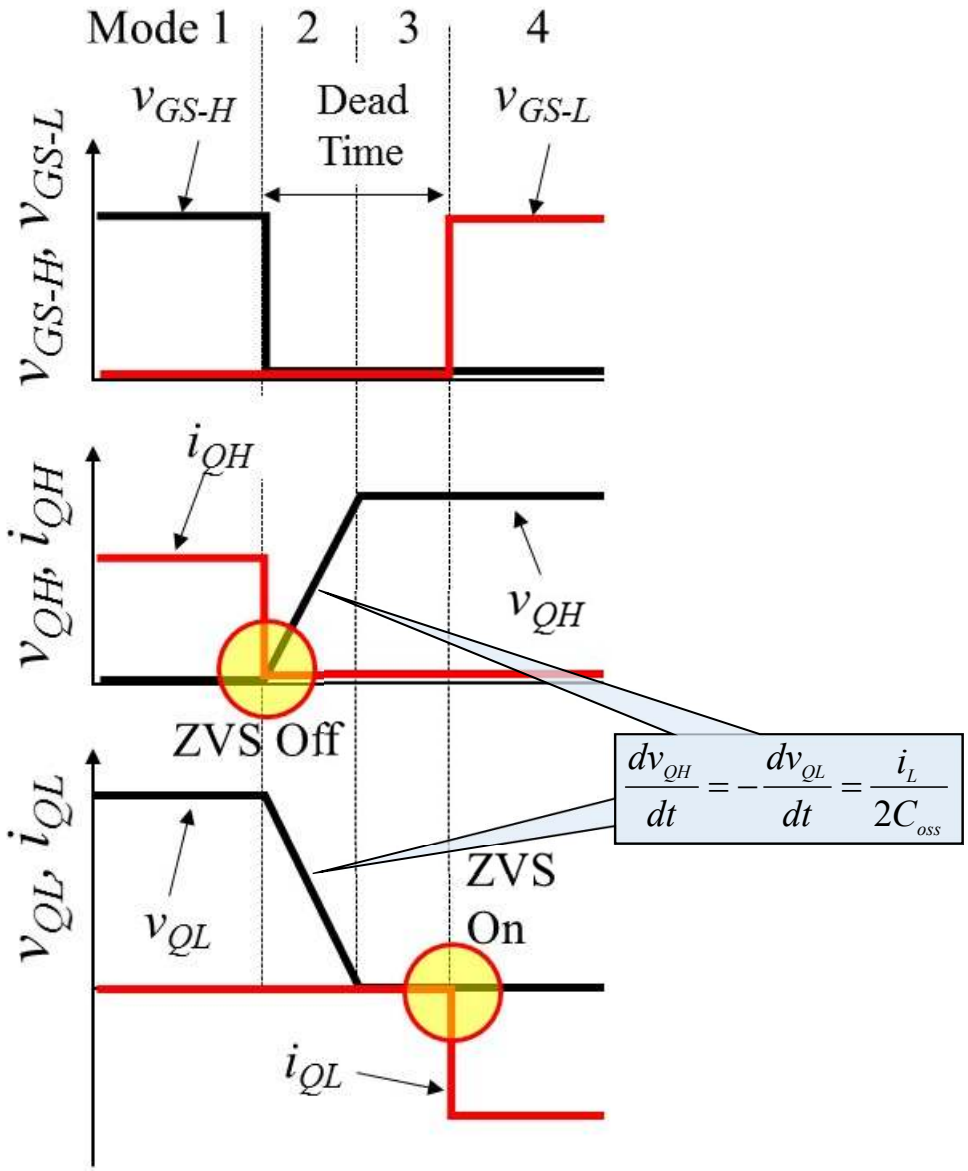
Center-Tap

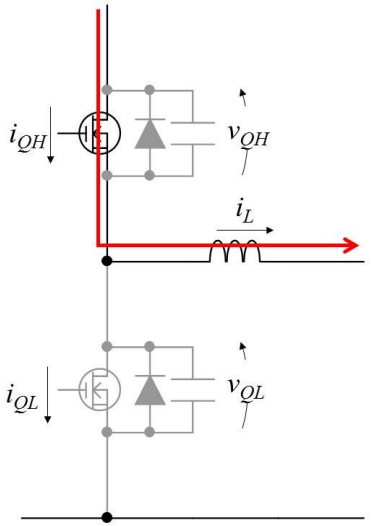




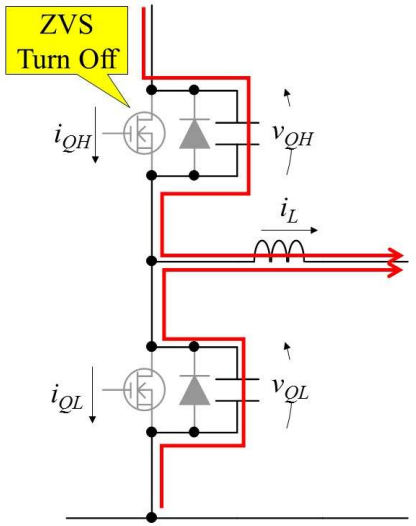
Output is v_b

Switching Transitions of Isolated Converter

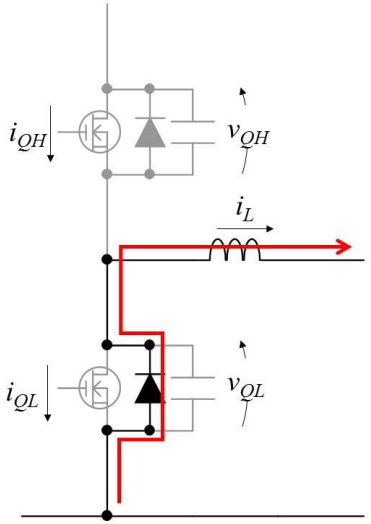




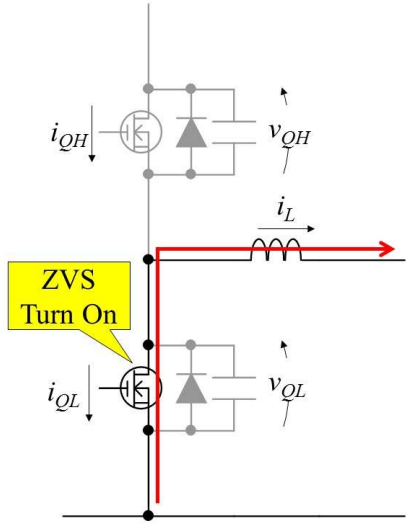
Mode 1



Mode 2

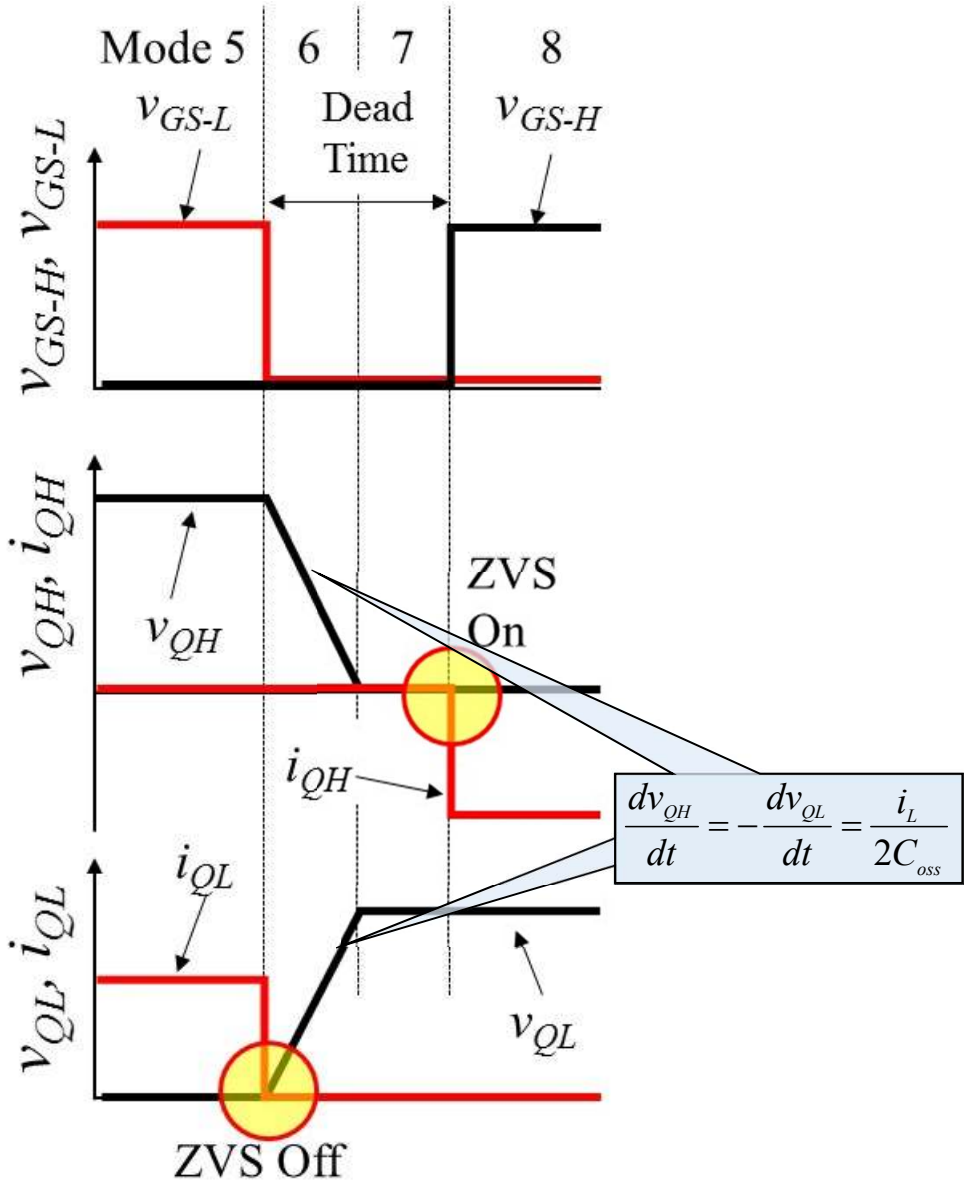


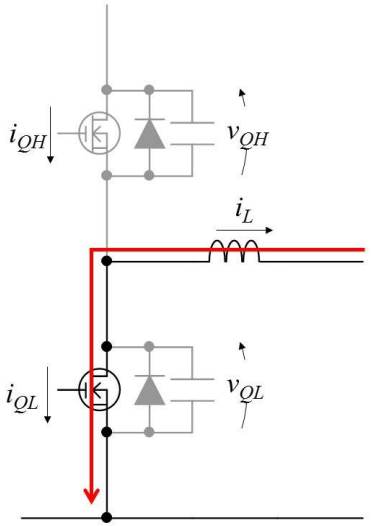
Mode 3



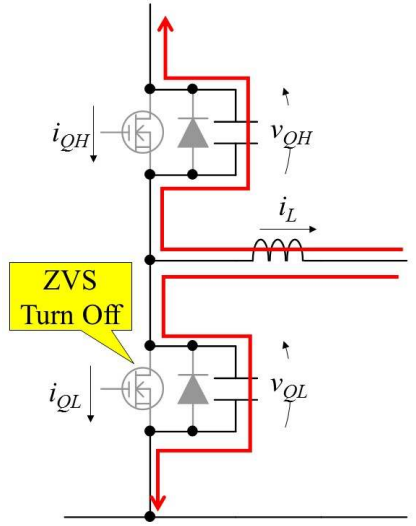
Mode 4

Switching Transitions of Isolated Converter

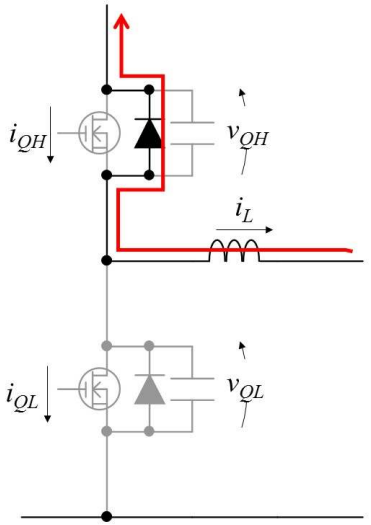




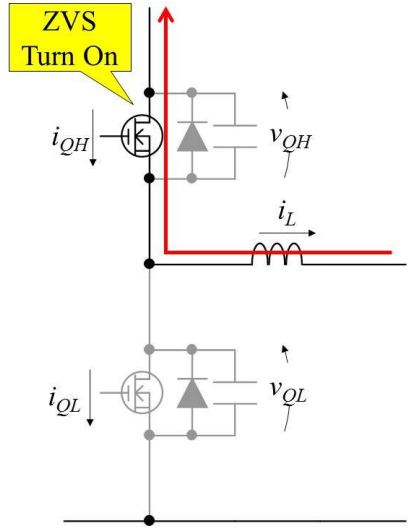
Mode 5



Mode 6

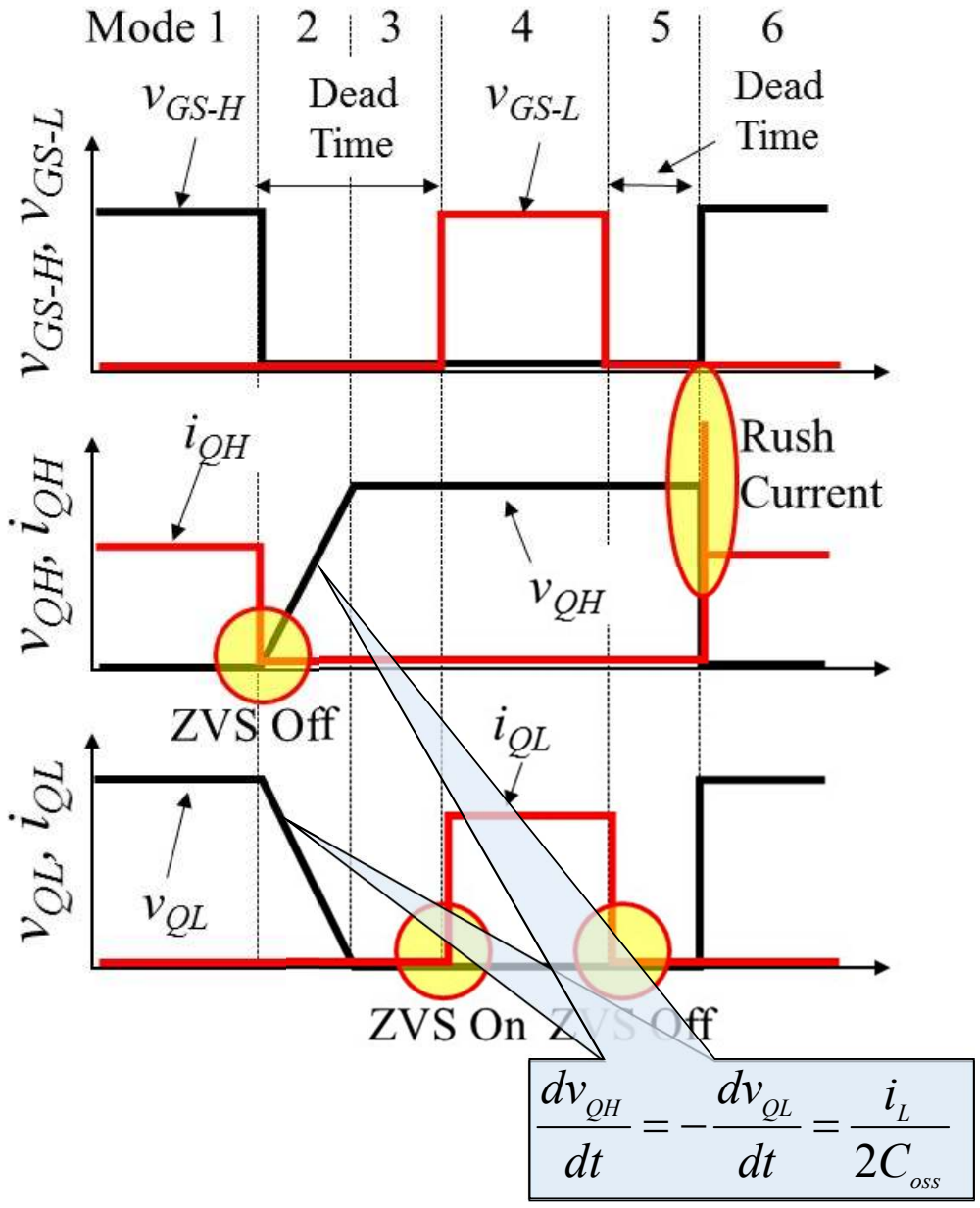


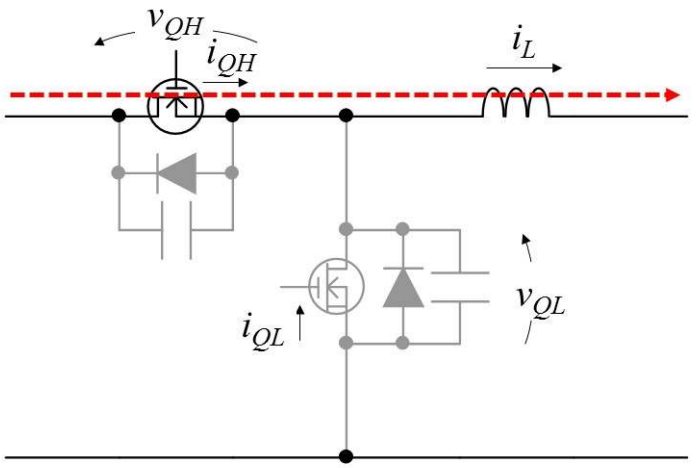
Mode 7



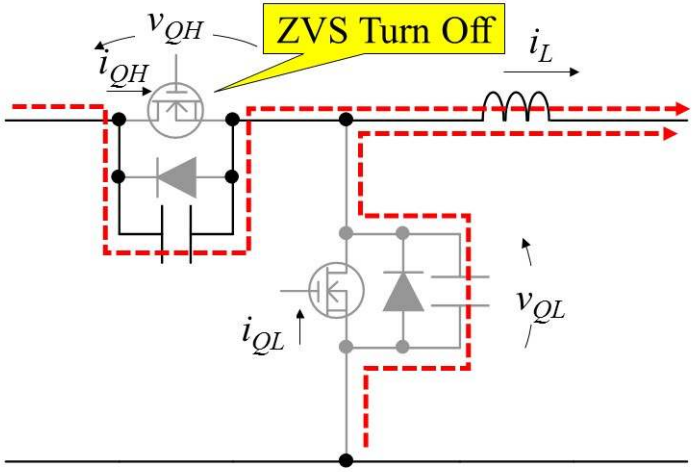
Mode 8

Switching Transitions of PWM Buck Converter



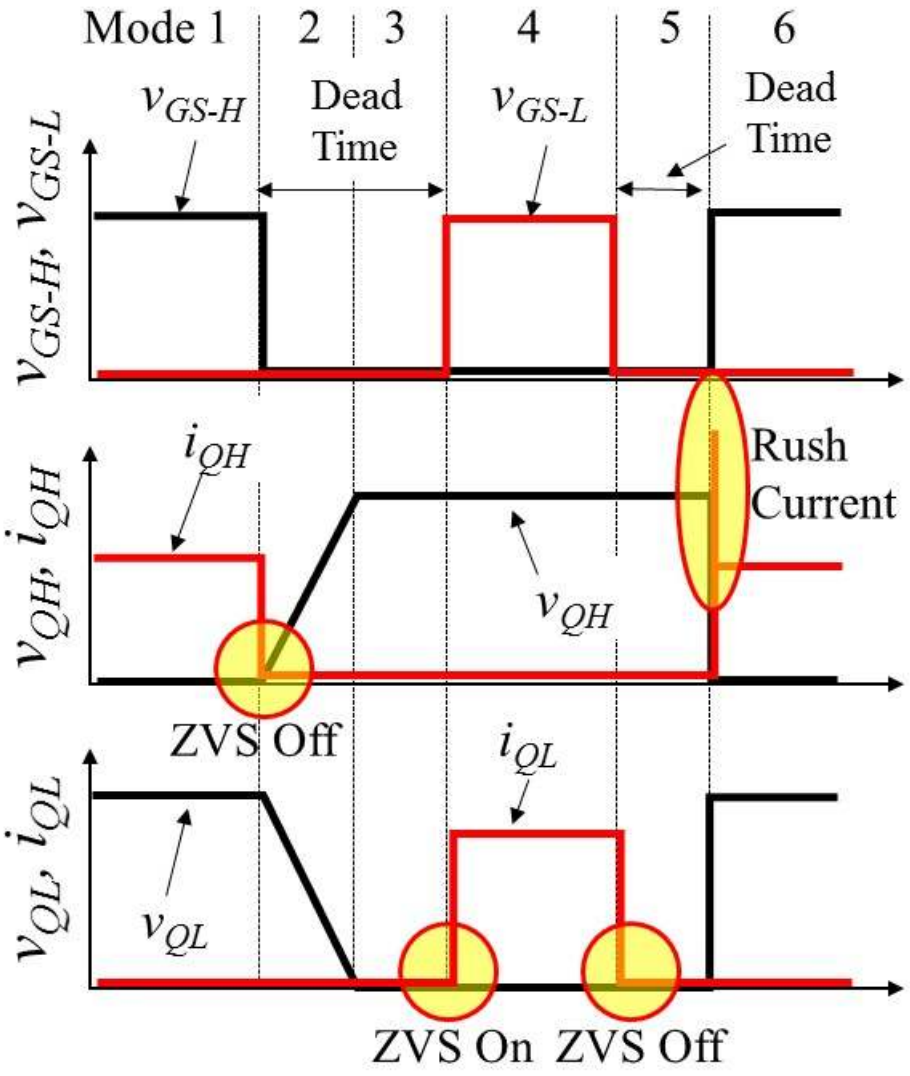


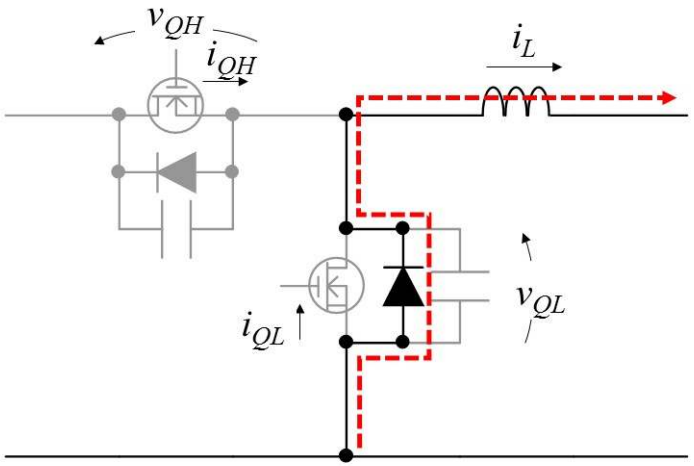
Mode 1



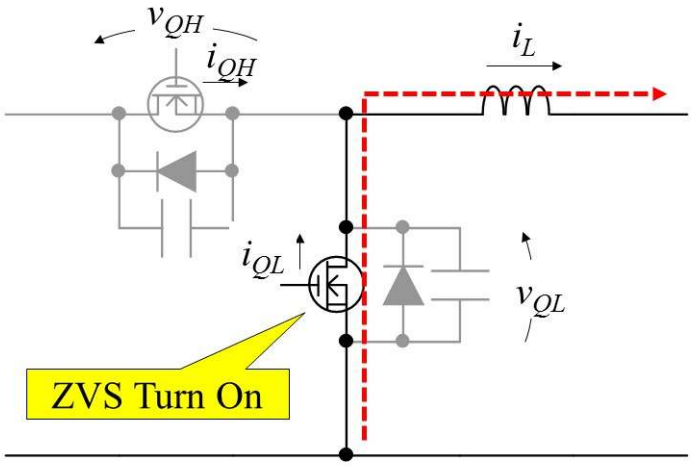
Mode 2

Switching Transitions of PWM Buck Converter



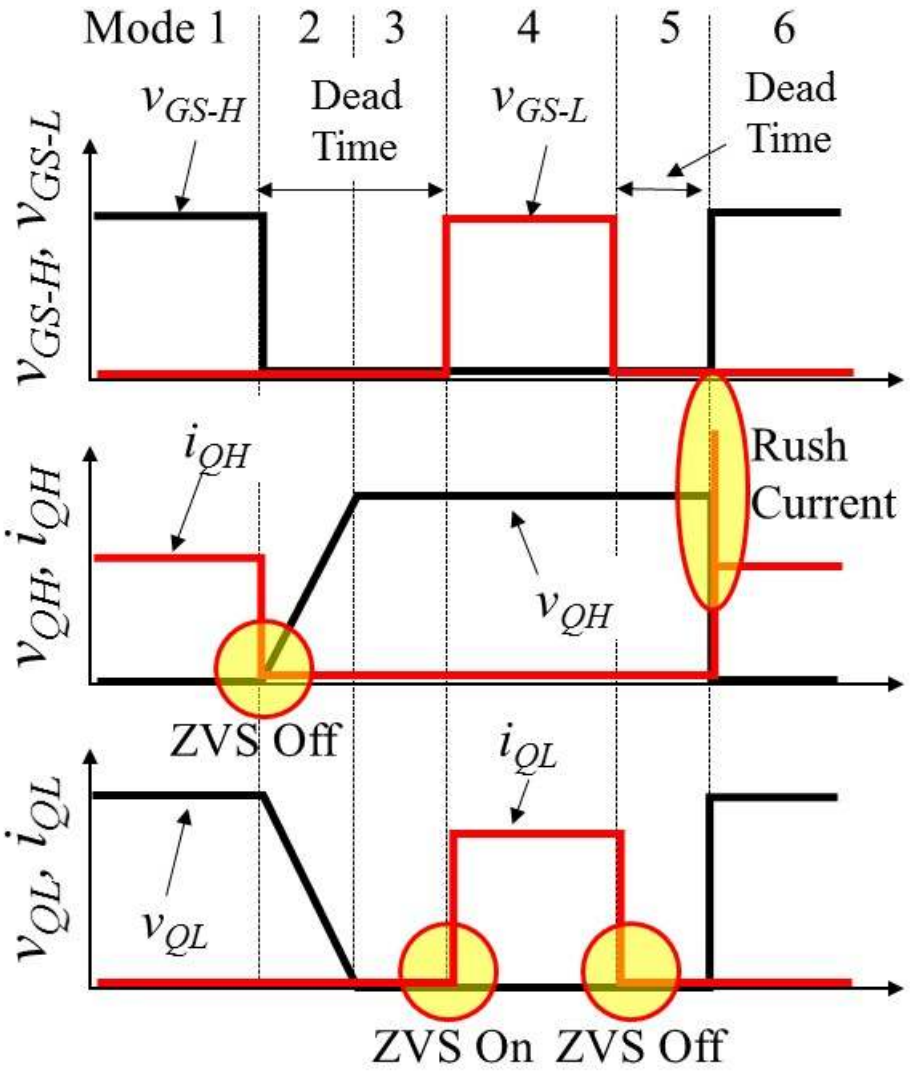


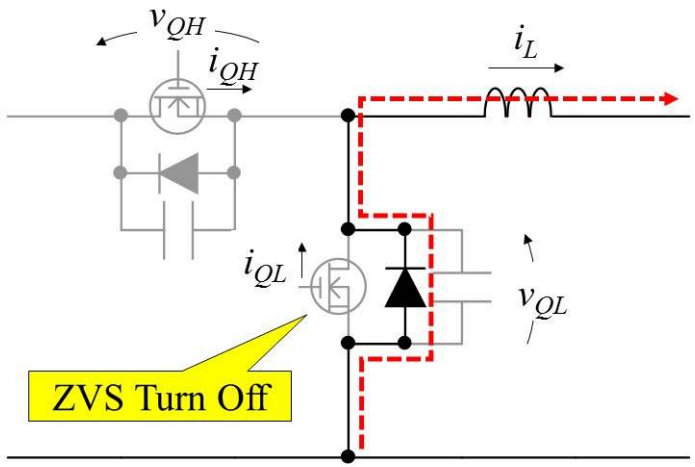
Mode 3



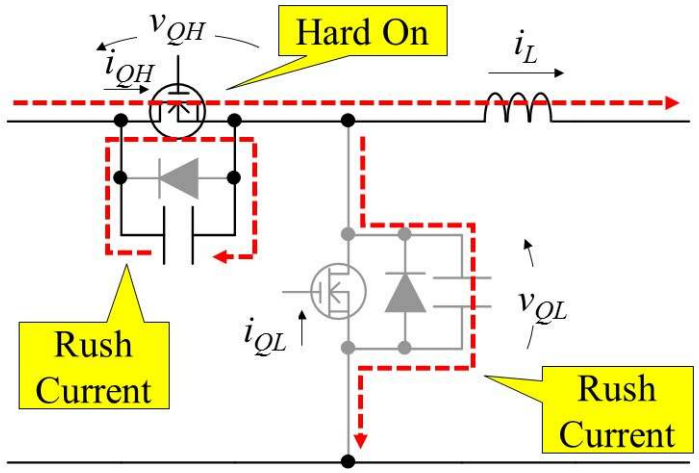
Mode 4

Switching Transitions of PWM Buck Converter



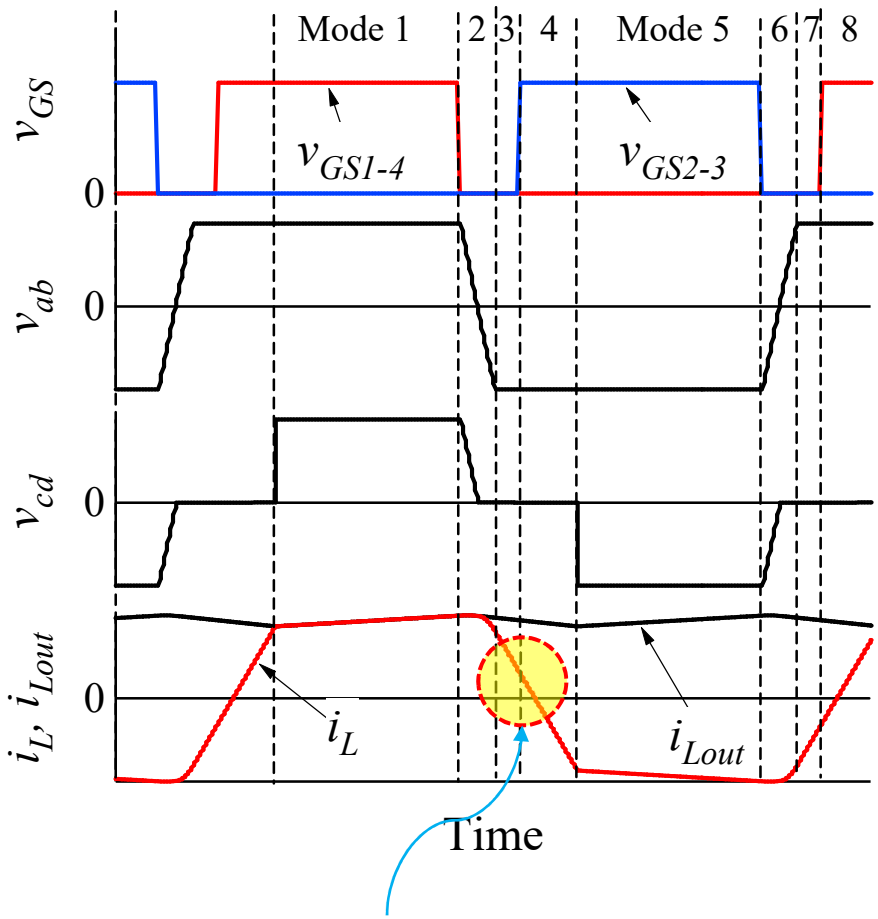


Mode 5

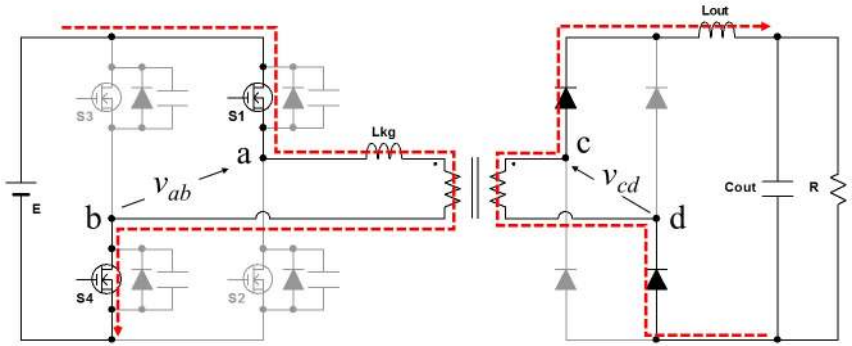


Mode 6

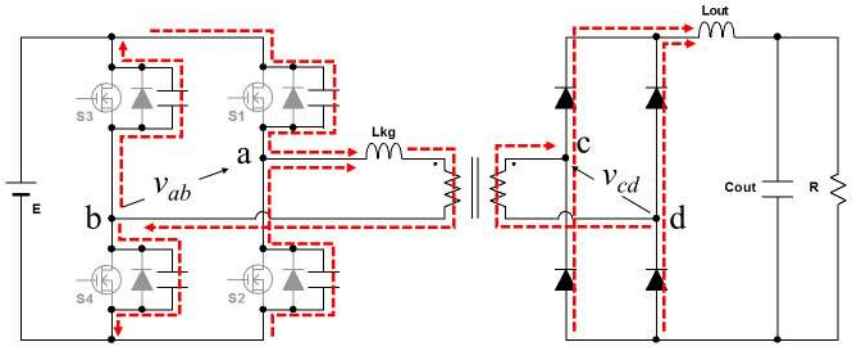
Key Waveforms and Current Flow Directions



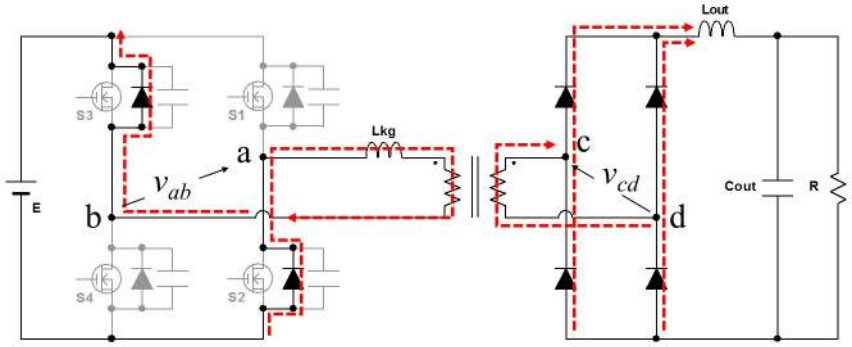
Q_2 and Q_3 need to be turned on before i_L reaches zero



Mode 1

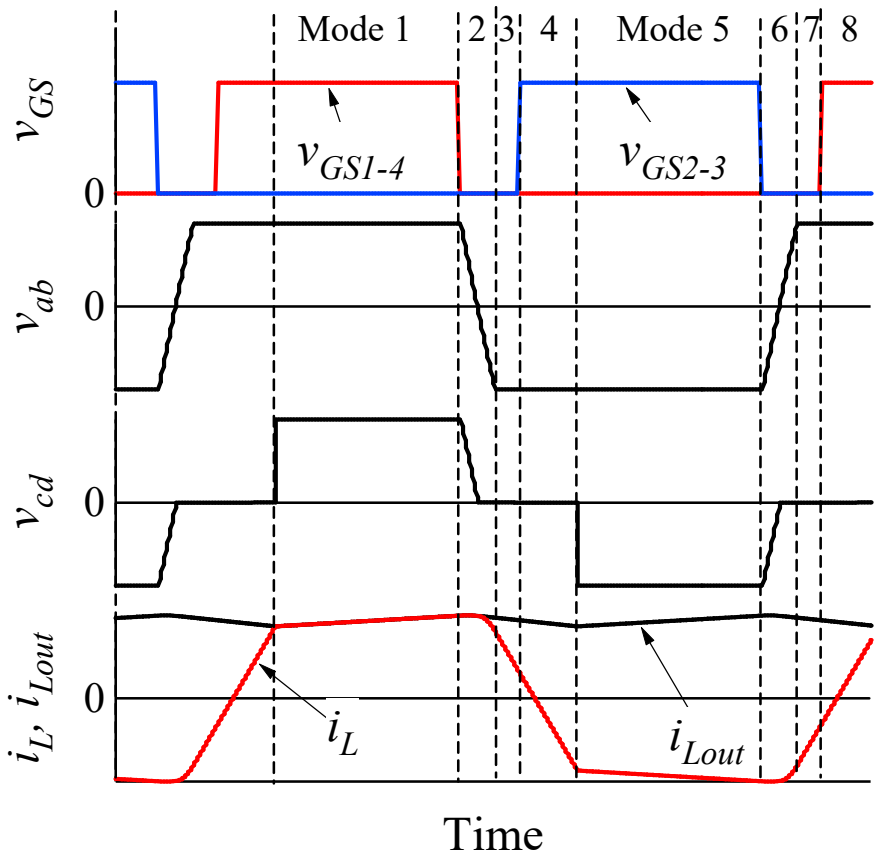


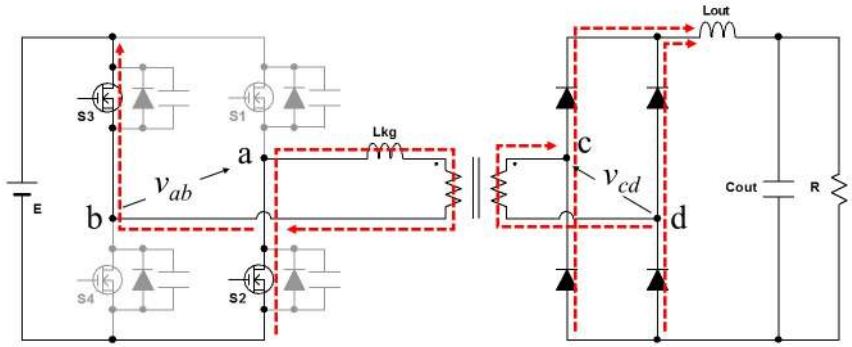
Mode 2



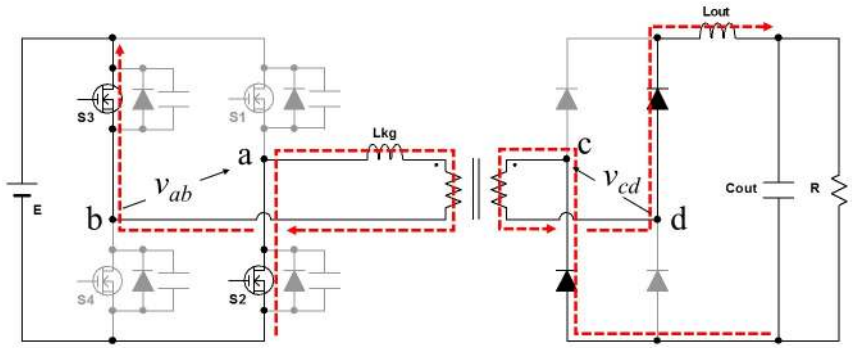
Mode 3

Key Waveforms and Current Flow Directions





Mode 4



Mode 5

Modes 5–8 are symmetrical to Modes 1–4

Example: Failure in Soft Switching