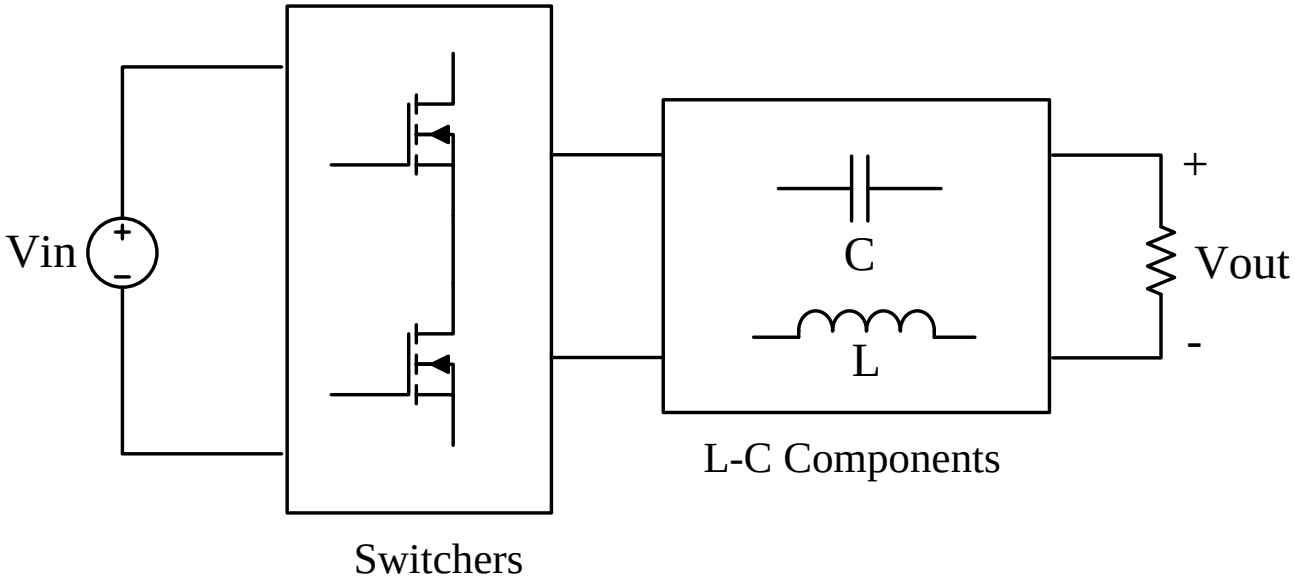
DC-DC Fundamentals

1.3 Switching Regulator

What is a Switching Regulator?

- The switching regulator is a DC-DC converter that delivers power by using switcher components.
- It offers high power conversion efficiency and design flexibility



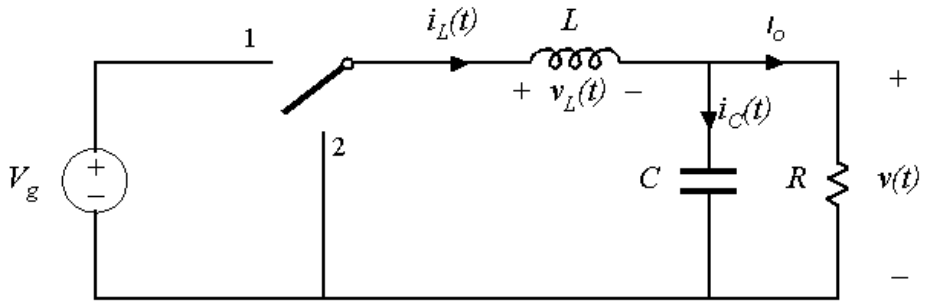
Pros and Cons

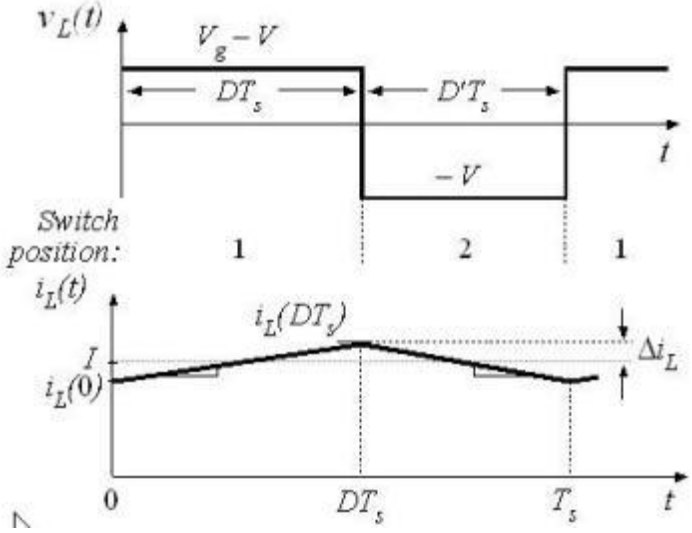
Advantages	Disadvantages
• High efficiency • Good thermal performance • High power density • Allow wide input voltage range • V_{out} can be smaller or larger than V_{in} • Isolation possible with transformer • Multiple outputs possible with transformer	• Switching produces higher output ripple & noise • Slow transient response • High complexity as more external components and design variables

How Does a Switching Regulator Work?

- The inductor stored and released energy to output load get energy from the input source which is controlled by the switches.
- An example of Buck converter:
  - When switched to position 1, the inductor is storing energy; when switched to position 2, the inductor is releasing energy
  - The average voltage over the inductor is zero: $D(V_{in}-V_o)-D'V_o=0 \Rightarrow V_{out} = D*V_{in}$

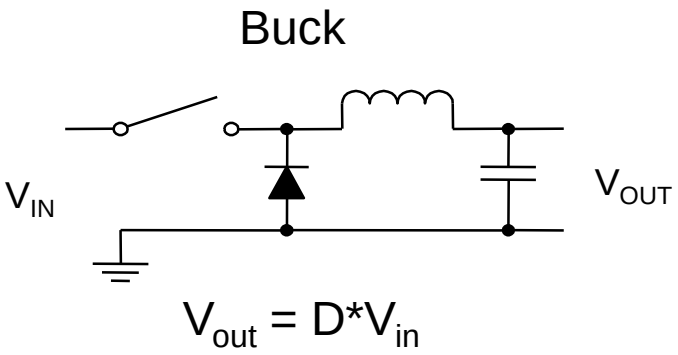
D = Duty Cycle (% of time switch in the position for charging L)
D' = 1-D

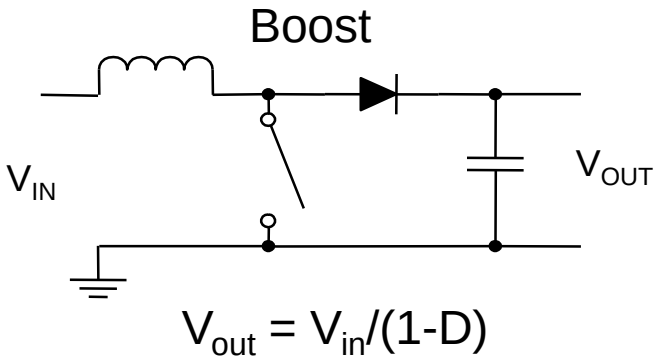


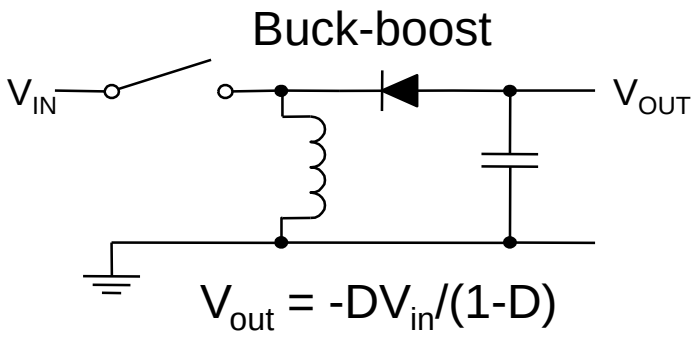


Basic Topologies

- Three basic types of switching converter topologies: Buck, Boost and Buck-boost

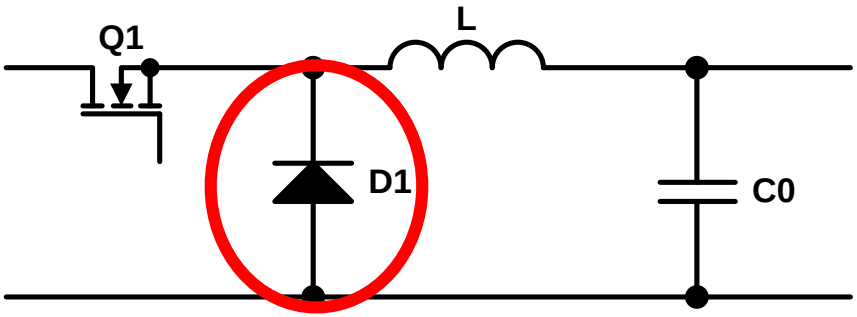






Synchronous vs. Non-Synchronous

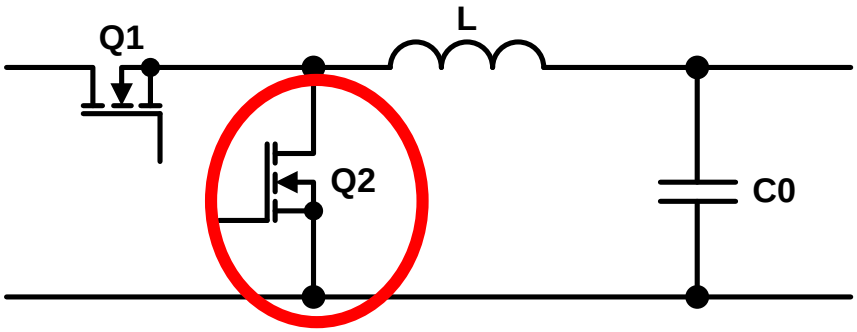
Non-Synchronous Buck



Non-synchronous

1. Diode voltage drop is fairly constant with output current
2. Less efficient
3. Less expensive
4. Used with higher output voltages

Synchronous Buck

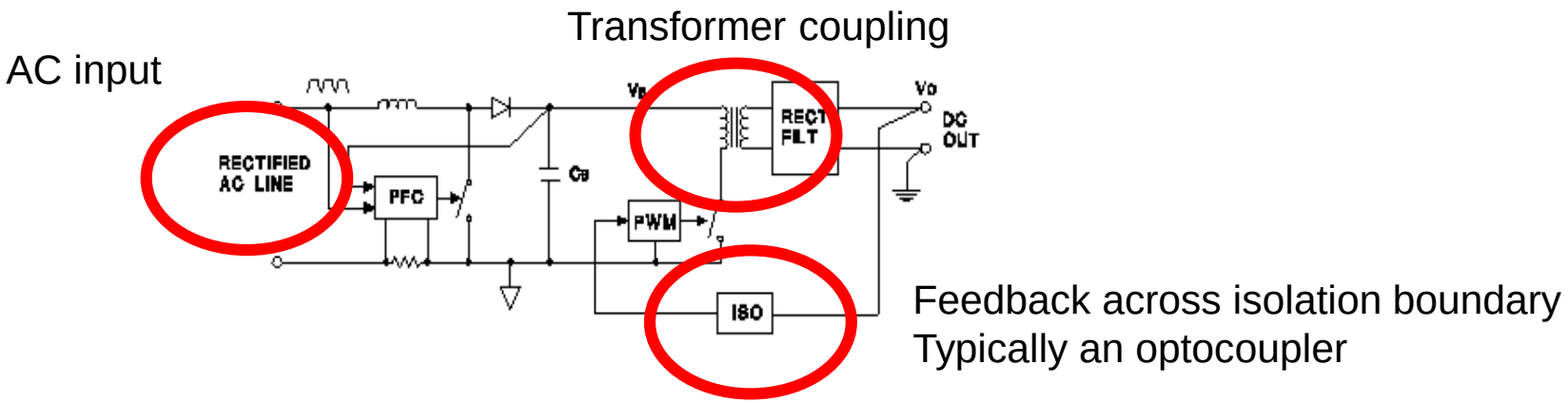


Synchronous

1. MOSFET has lower voltage drop
2. More efficient
3. Requires additional control circuitry
4. Costs more

Isolated vs. Non-isolated

- Isolated has no DC current flow between input and output.
- Transformer couples energy from primary to secondary through magnetic fields
- Isolated typically used in medical and offline applications requiring primary to secondary isolation
- Not typical for standard point of load solutions



Primary Side Switched Mode Power Supply with Power Factor Correction (PFC)

Controller vs. Regulator

- Controller
  - Discrete MOSFETs
  - Provides the “brains” to control the power stage
  - More complicated to design
  - Full control over FET selection, switching frequency, overcurrent, compensation, softstart
  - Can tailor the power supply to meet your specific needs
- Fully integrated regulator
  - Integrated switches
  - “plug and play” design
  - Limited range of output filter components
  - Limited control over functionality
- Partially integrated regulator
  - May offer full or partial feature set , internal or external compensation
  - Internal Power FET, external sync-FET or catch diode
  - Limited control over frequency, overcurrent, softstart, etc.
  - Allows wider range of output filter components

Summary

- Introduction to switching regulator
- The operation of switching regulator
- Types of switching regulator
  - Basic topologies
  - Synchronous vs. Non-synchronous
  - Isolated vs. Non-isolated

Thank you!