Inverting Buck-Boost Converters

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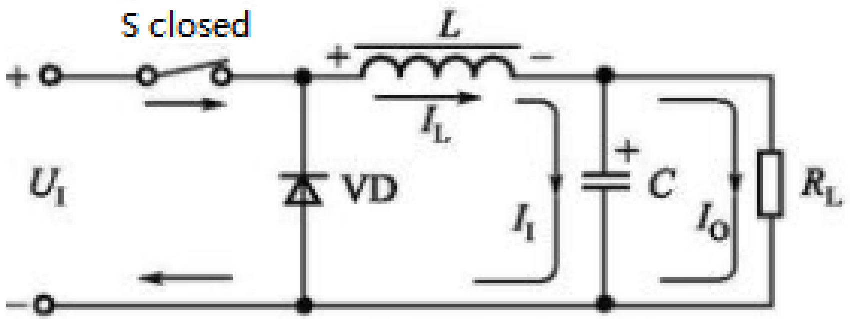
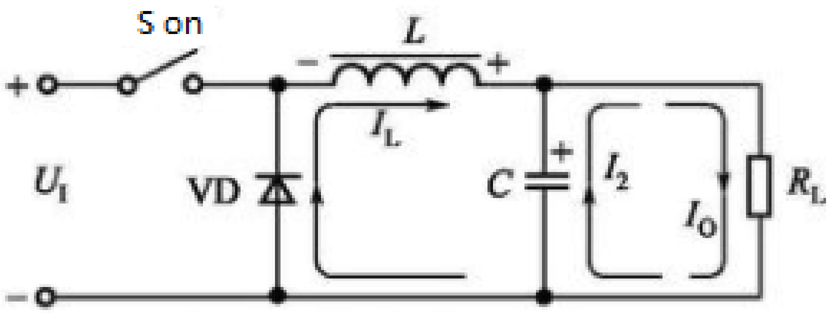


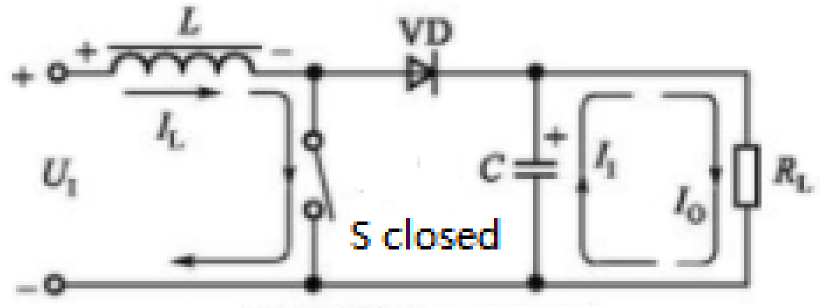
1-1: Current path when VT is on



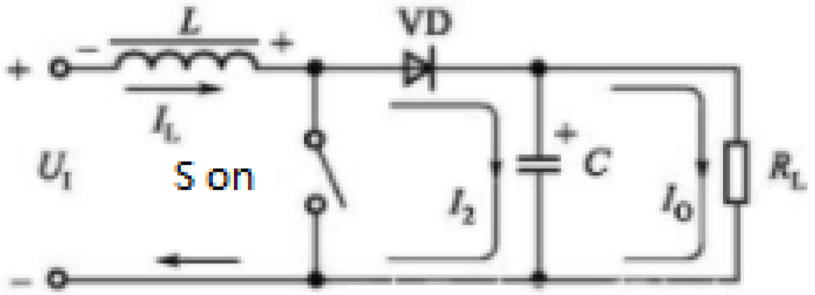
1-2: Current path when VT is off

Buck Converters

- Steps down voltage by stepping up current
- High efficiency (>90%)
- $V_{out} = D \times Vin$
  - D is the duty cycle of the switch



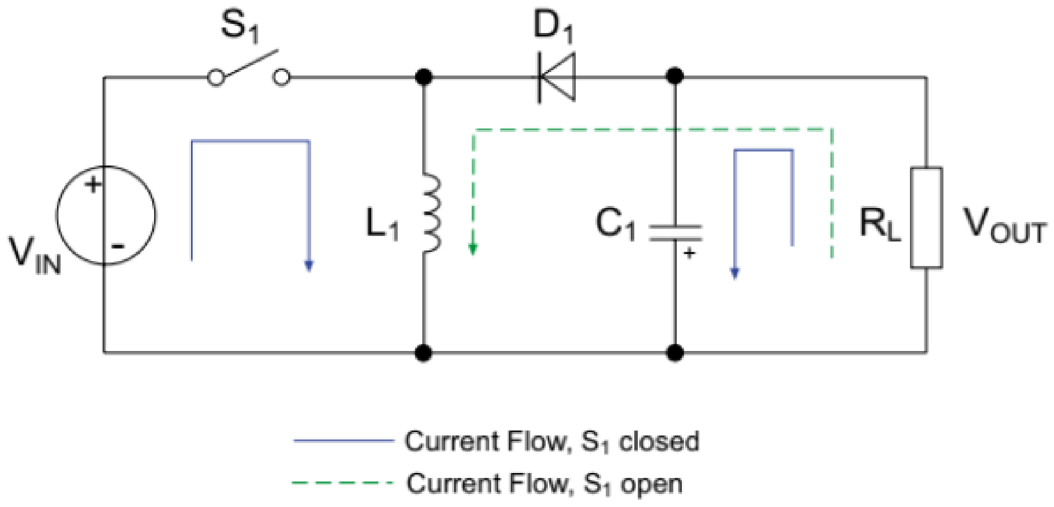
3-1:Current path when VT is on



3-2: Current path when VT is off

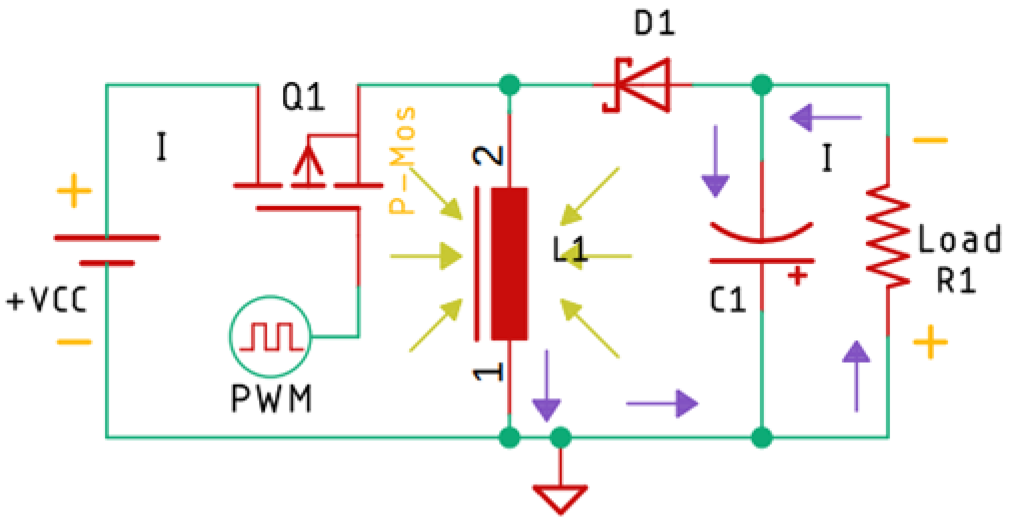
Boost Converters

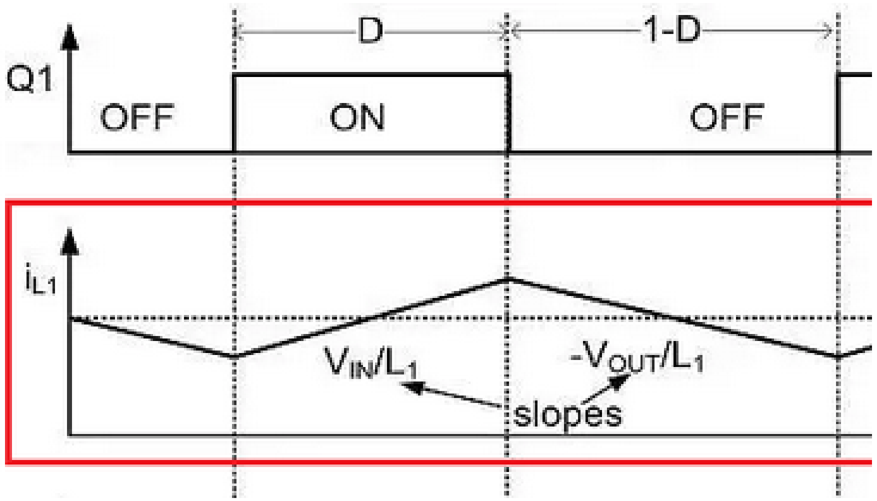
- Steps up voltage by stepping down current
- High efficiency (>90%)
- $V_{out} = \frac{V_{in}}{(1-D)}$
    - D is the duty cycle of the switch



Inverting-Buck Boost Circuit (simplified)

- Can either step up or step down voltage
- Lower efficiency (80%)
- Output voltage is inverted.
- $V_{out} = ?$





Output Voltage Derivation

- $V_{in} = L\frac{di_L}{dt}$
- Current increases when the switch is connected
- $\Delta i_{L,on} = \int_0^{DT} \frac{V_i}{L} dt = \frac{V_i DT}{L}$
- Current decreases when switch is open
- $\Delta i_{L,off} = \int_{DT}^{T} \frac{-V_o}{L} dt = \frac{-V_o(1-D)T}{L}$
- $\Rightarrow \Delta i_{L,on} + \Delta i_{L,off} = 0$
- $\Rightarrow \frac{V_i DT}{L} - \frac{V_o(1-D)T}{L} = 0$
- $\Rightarrow \boxed{V_o = \frac{D}{1-D} V_i}$

Examples of Buck and Boost

$$V_{in} = 5\,, D = 0.25$$

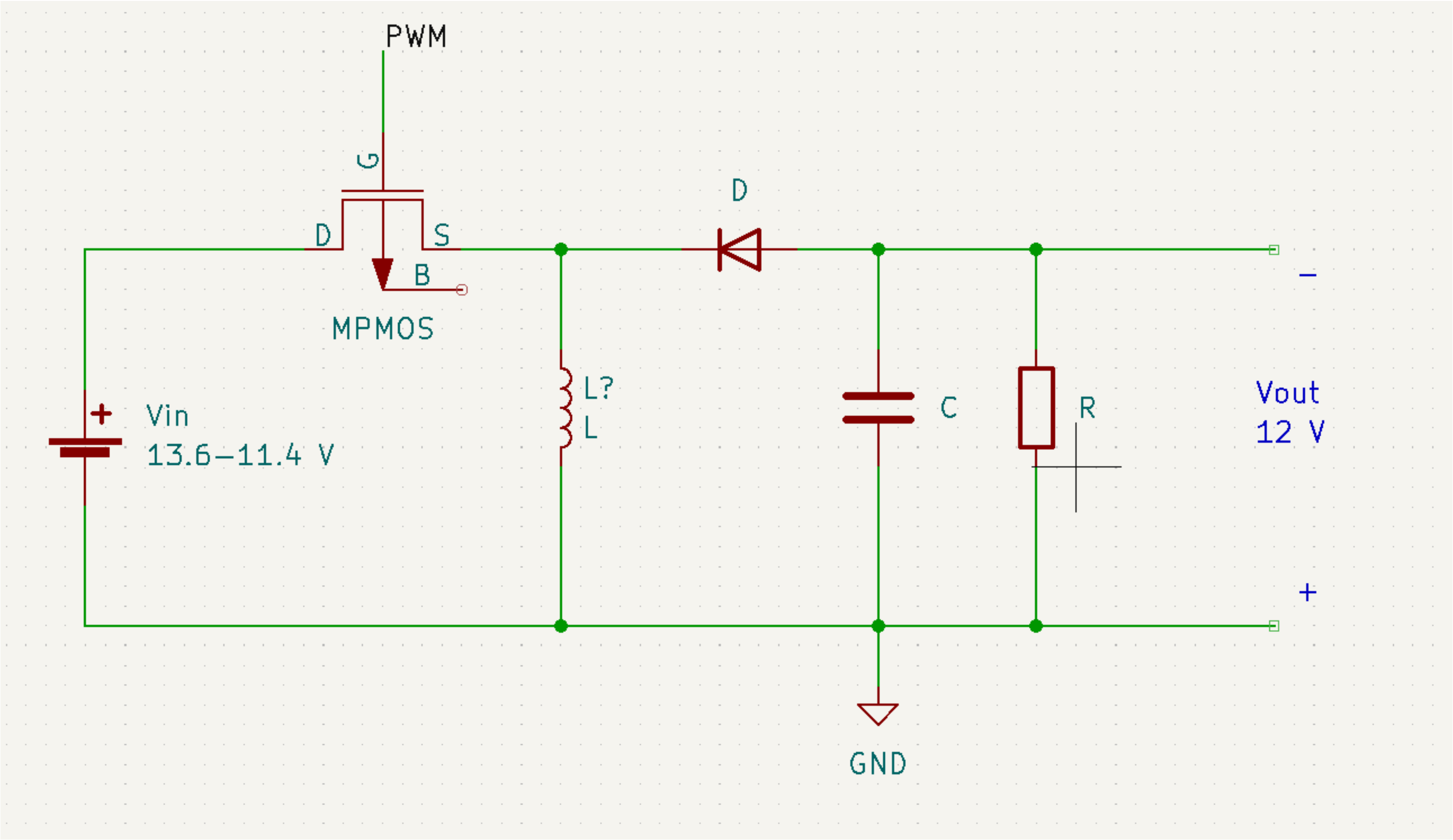
$$V_o = \frac{D}{1-D} V_i$$

$$\Rightarrow V_o = \frac{0.25}{1-0.25}(5) = 1.67\ V$$

$$V_{in} = 5\,, D = 0.75$$

$$V_o = \frac{D}{1-D} V_i$$

$$\Rightarrow V_o = \frac{0.75}{1-0.75}(5) = 15\ V$$



Application

Buck-Boost over Buck/Boost

<u>Pros</u>

- Uses same components
- Useful when the input voltage can be above or below desired voltage

<u>Cons</u>

- Less efficient
- Discontinuous current output

References

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Questions?