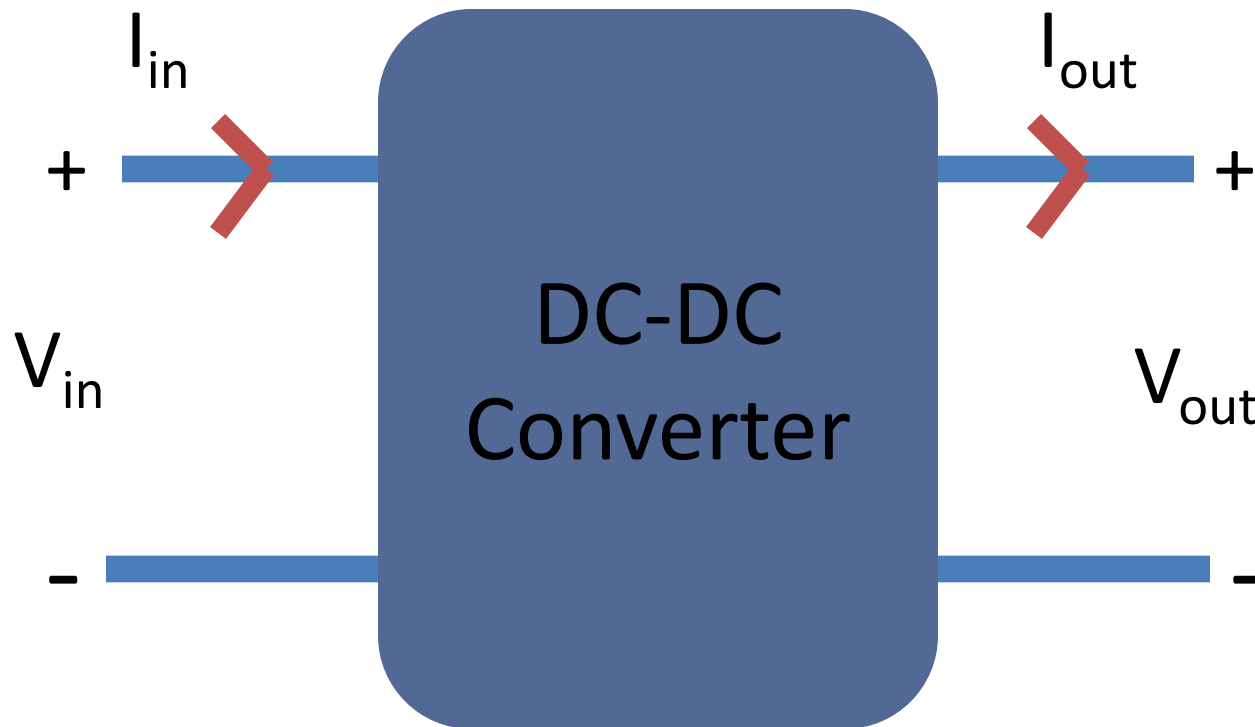


# DC-DC Switching Converter

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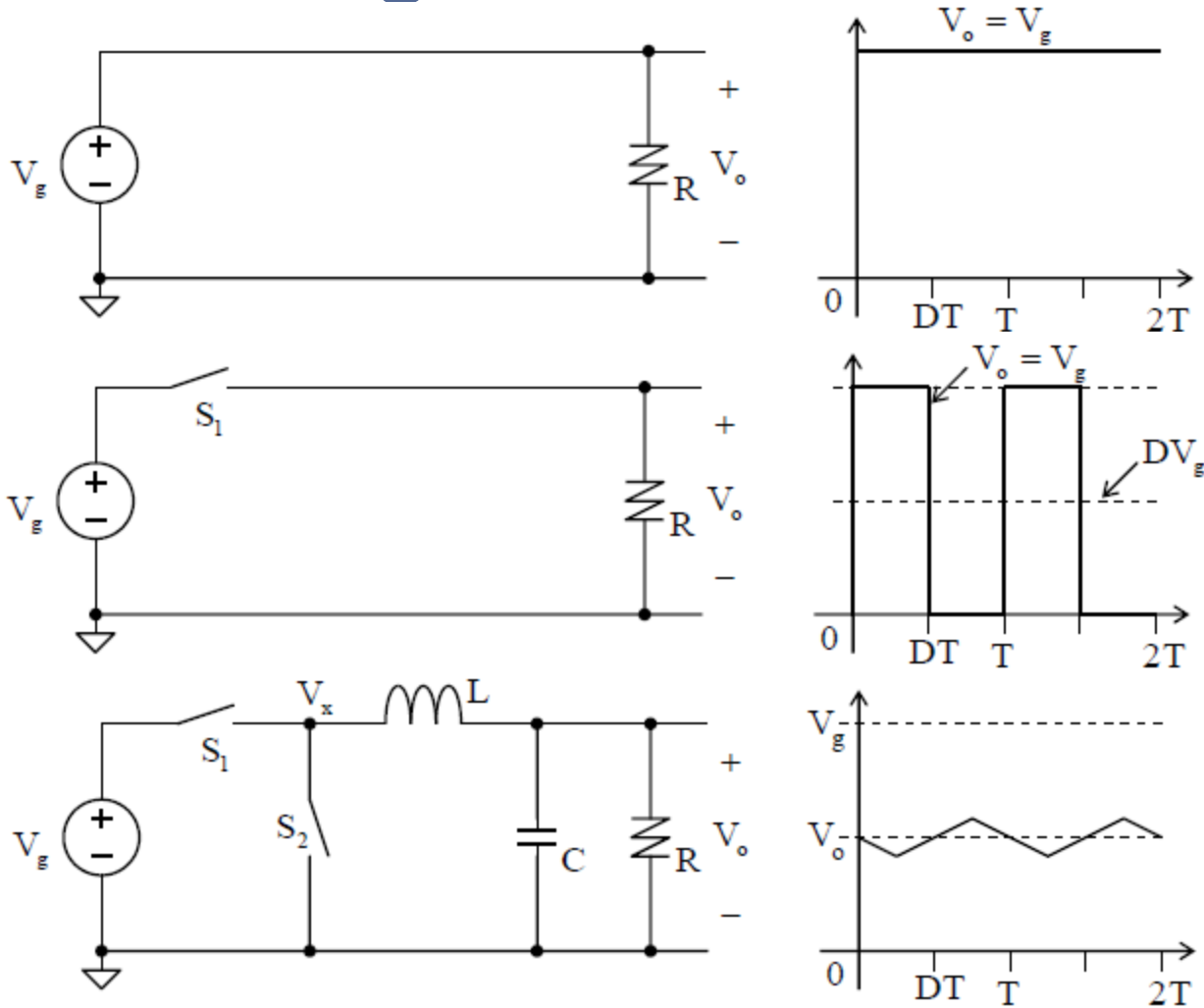
# DC-DC Converter



# Figures of Merit

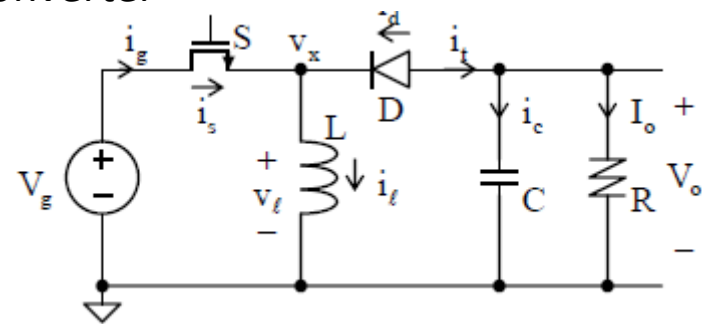
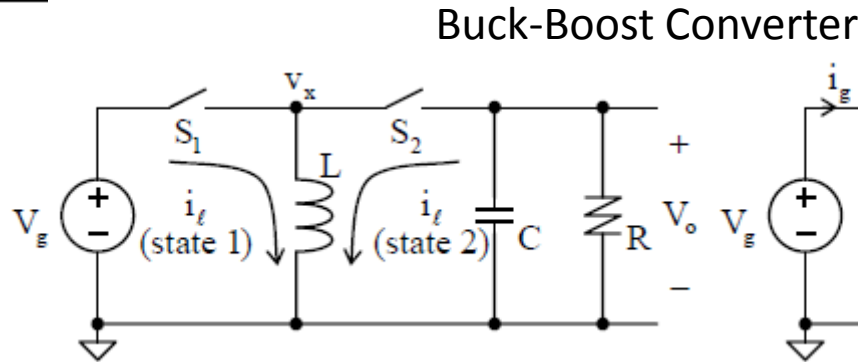
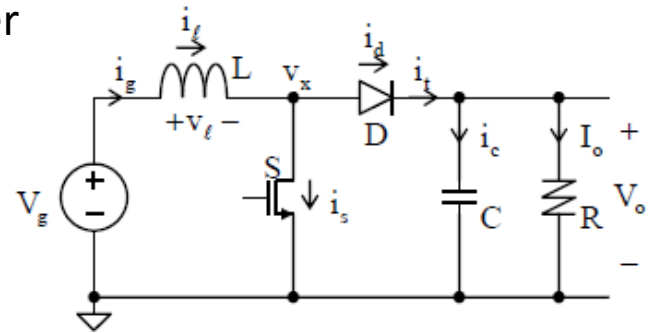
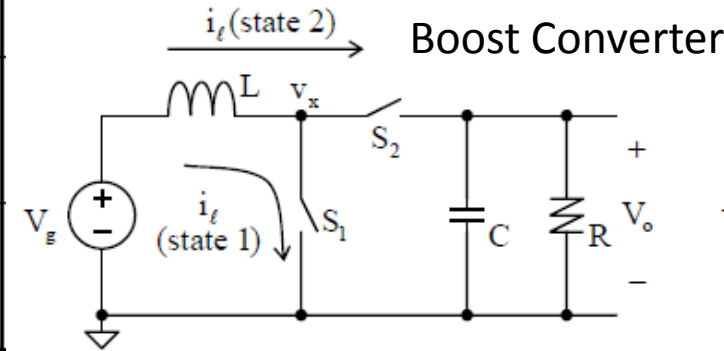
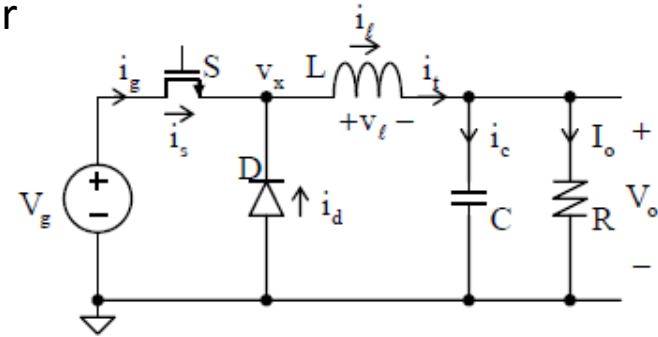
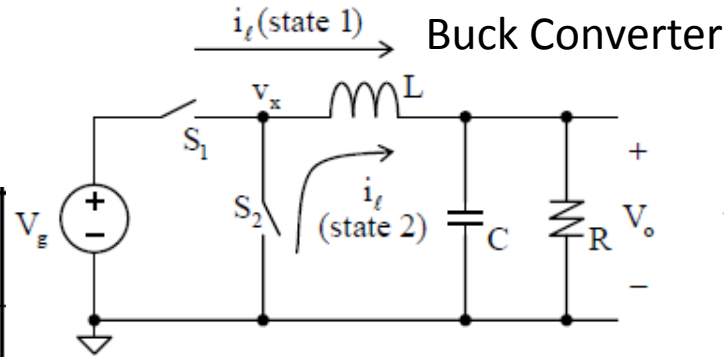
- Efficiency  $\eta = \frac{V_{out} I_{out}}{V_{in} I_{in}}$
- Input range: voltage
- Output range: voltage, current
- Output ripple
- Load regulation  $\frac{V(I_{min}) - V(I_{max})}{V_{nom}} \times 100\%$
- Line regulation  $\frac{\Delta V_{out}}{\Delta V_{in}}$
- Settling time

# Converting Intuition

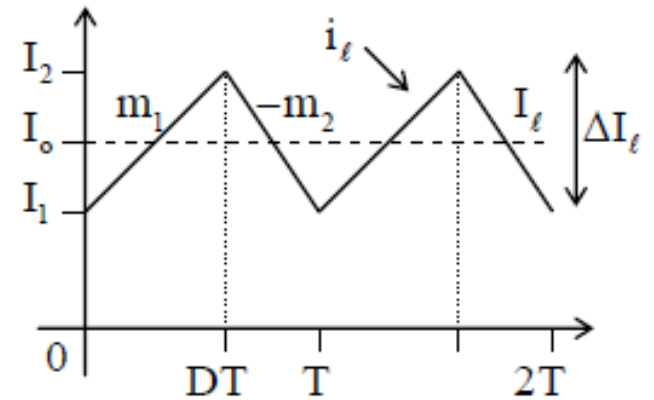
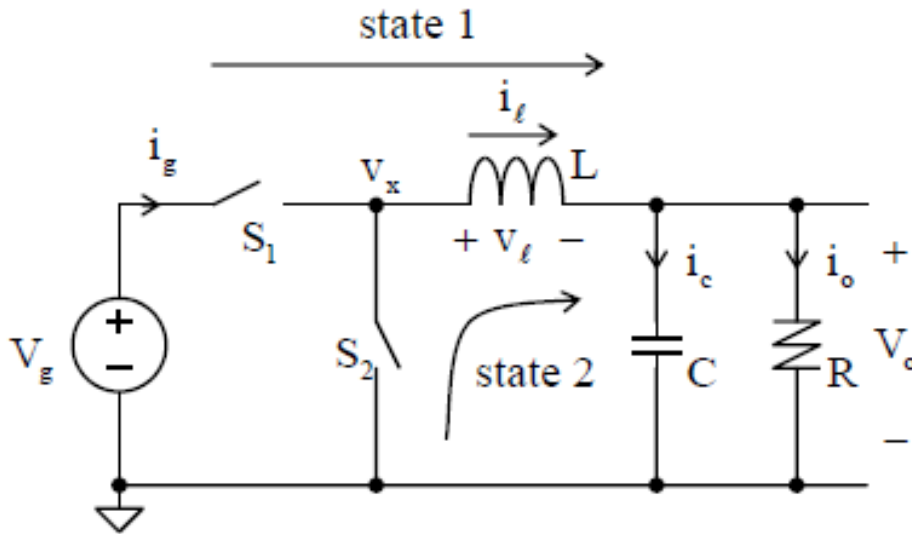


# Converter Topologies

	M	$\frac{\Delta V_o}{V_o}$
Buck	D	$\frac{1-D}{8LCf_s^2}$
Boost	$\frac{1}{1-D}$	$\frac{D}{CRf_s} (I_1 > I_o)$
Buck-boost	$\frac{-D}{1-D}$	$\frac{D}{CRf_s} (I_1 >  I_o )$



# Working Principle



$$m_1 = \left. \frac{di_l}{dt} \right|_{\text{State 1}} = \frac{v_l(\text{State 1})}{L}$$

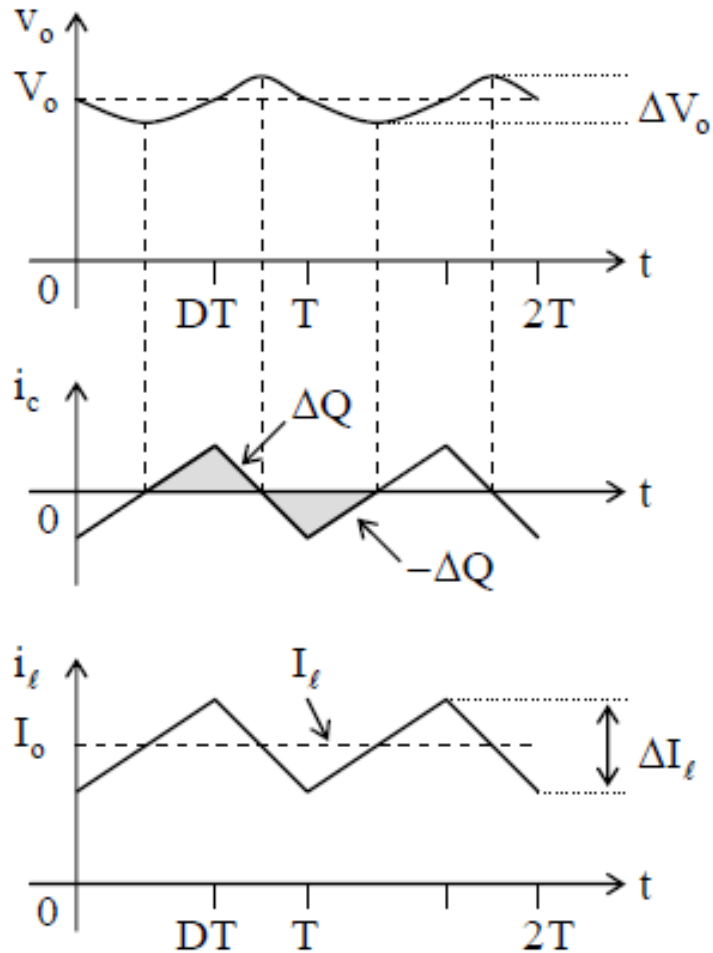
$$m_2 = - \left. \frac{di_l}{dt} \right|_{\text{State 2}} = - \frac{v_l(\text{State 2})}{L}$$

$$m_1 D = m_2 D'$$

$$(V_g - V_o) D = V_o D'$$

$$M = \frac{V_o}{V_g} = D$$

# Voltage Ripple

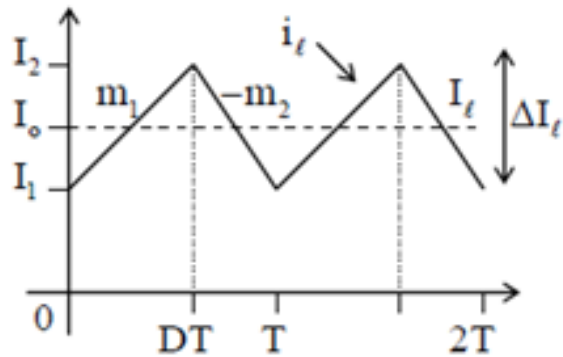


$$C\Delta V_o = \Delta Q = \frac{1}{2} \frac{\Delta I_l}{2} \frac{T}{2}$$

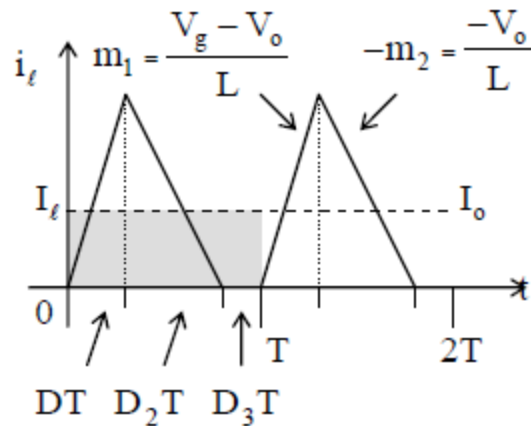
$$\frac{\Delta V_o}{V_o} = \frac{1}{8} \frac{D'}{LC} \frac{1}{f_s^2}$$

# DCM vs. CCM

- Continuous conduction mode

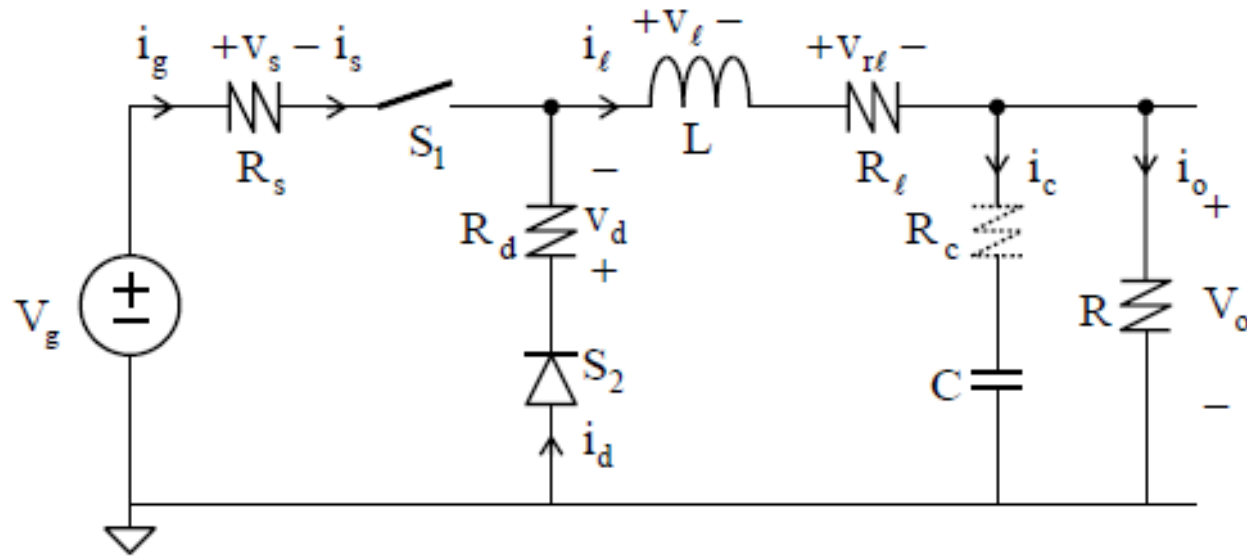


- Discontinuous conduction mode





# Efficiency Lost



$$\eta = \frac{V_o}{V_g} \times \frac{I_o}{I_g} = \frac{D}{1 + \frac{R_l + DR_s + D'R_d}{R}} \times \frac{1}{D}$$

# Duty Ratio Control

