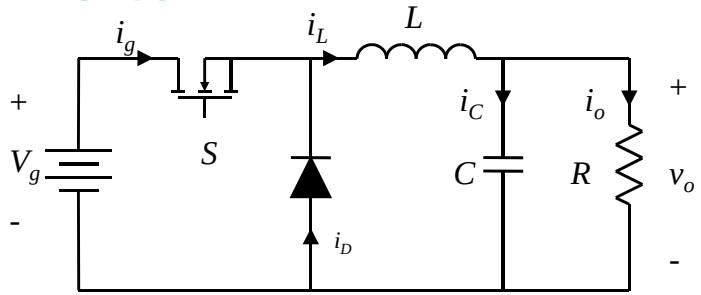
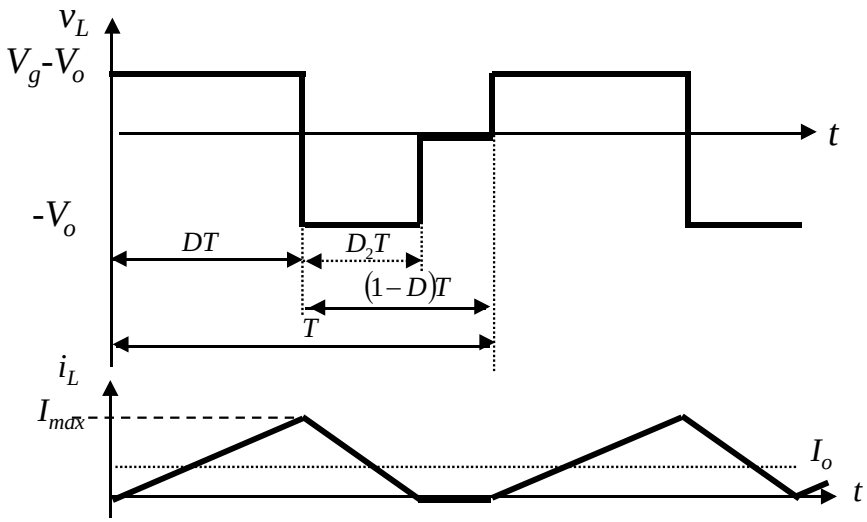
Isolated Power Supply Techniques

Discontinuous Conduction Mode
Steady-state Analysis

Buck Converter





$$I_{\max} = \frac{V_g - V_o}{L} DT = \frac{V_o}{L} D_2 T$$

$$V_o = V_g \frac{D}{D + D_2}$$

$$D_2 = D \frac{V_g - V_o}{V_o}$$

$$I_o = \frac{I_{\max}(D + D_2)}{2}$$

$$I_o = \frac{1}{2} DT \frac{V_g - V_o}{L}(D + D_2)$$

$$V_o = I_o \cdot R$$

$$\frac{V_o}{R} = \frac{DT}{2} \frac{V_g - V_o}{L}(D + D_2)$$

$$V_o = \frac{RDT}{2L}(V_g - V_o)\left(D + D\frac{V_g - V_o}{V_o}\right)$$

$$V_o^2 = \frac{RDT}{2L}(V_g - V_o)\left[DV_o + D(V_g - V_o)\right]$$

$$V_o^2 + V_o V_g D^2 \frac{RT}{2L} - V_g^2 D^2 \frac{RT}{2L} = 0$$

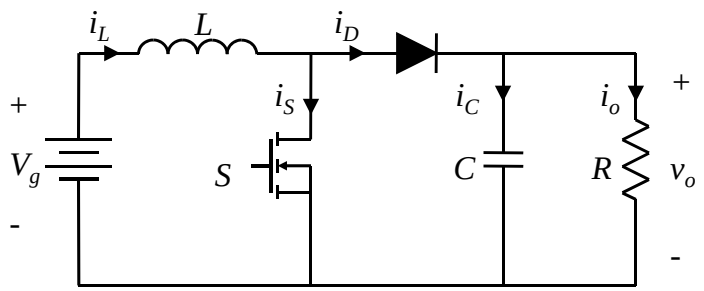
$$K = \frac{2L}{RT}$$

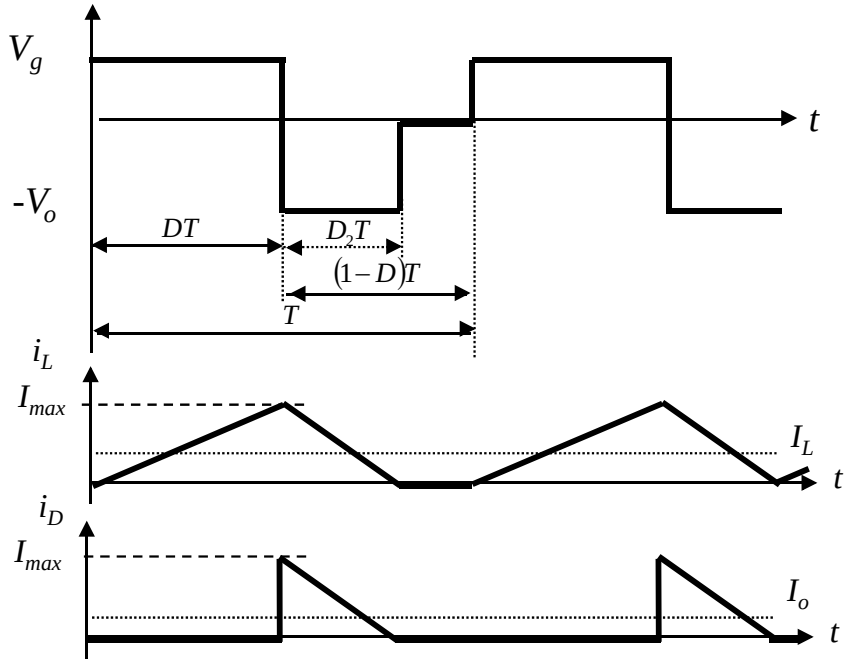
$$V_o = \frac{-\frac{V_g D^2}{K} + \sqrt{\frac{V_g^2 D^4}{K^2} + 4\frac{V_g^2 D^2}{K}}}{2}$$

$$V_o = V_g \frac{D^2}{2K}\left[-1 + \sqrt{1 + \frac{4K}{D^2}}\right]$$

$$\frac{V_o}{V_g} = \frac{2}{1 + \sqrt{1 + \frac{4K}{D^2}}}$$

Boost Converter





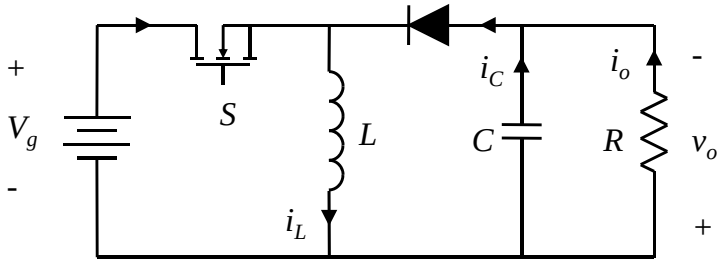
$$I_{\max} = \frac{V_g}{L} DT = \frac{V_o - V_g}{L} D_2 T$$

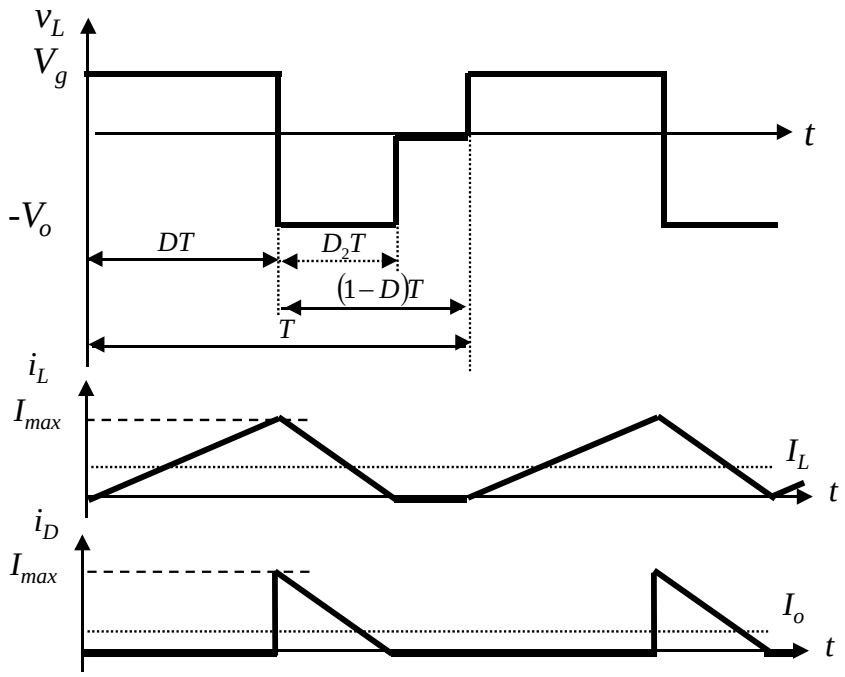
$$V_g D + (V_g - V_o) D_2 = 0 \qquad V_o = V_g \frac{D + D_2}{D_2}$$

$$D_2 = D \frac{V_g}{V_o - V_g} \qquad I_o = \frac{1}{2} DT \frac{V_g}{L} D_2 \qquad V_o = I_o \cdot R \qquad \frac{V_o}{R} = \frac{DT}{2} \frac{V_g}{L} D_2 \qquad V_o = \frac{RDT}{2L} V_g D \frac{V_g}{V_o - V_g}$$

$$V_o^2 - V_o V_g = \frac{RT}{2L} D^2 V_g^2 \qquad K = \frac{2L}{RT} \qquad V_o = \frac{V_g + \sqrt{V_g^2 + 4 \frac{D^2 V_g^2}{K}}}{2} \qquad V_o = V_g \frac{1 + \sqrt{1 + \frac{4D^2}{K}}}{2}$$

Buck-Boost Converter





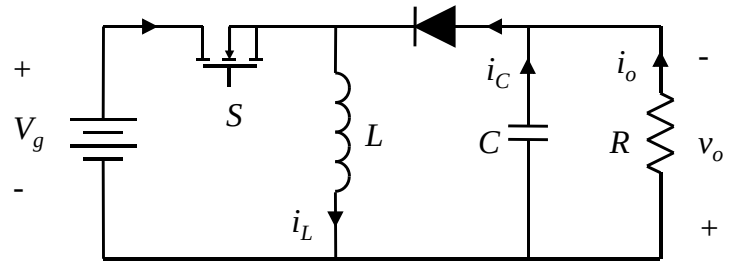
$$V_o = V_g \frac{D}{D_2} \qquad D_2 = D\frac{V_g}{V_o}$$

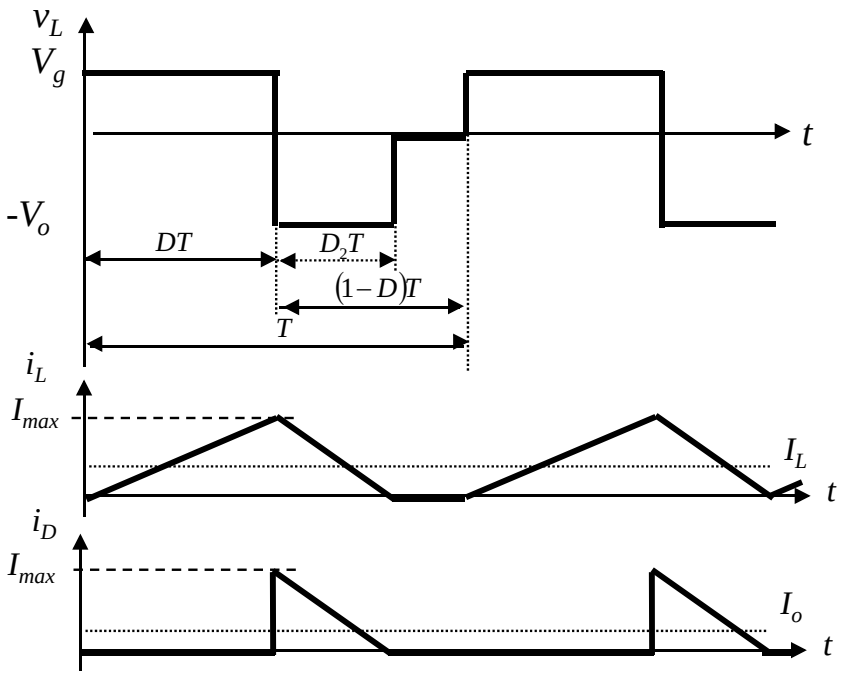
$$I_{\max} = \frac{V_g}{L}DT = \frac{V_o}{L}D_2T \qquad I_o = \frac{1}{2}DT\frac{V_g}{L}D_2$$

$$V_o = I_o \cdot R \qquad \frac{V_o}{R} = \frac{DT}{2}\frac{V_g}{L}D_2 \qquad V_o = \frac{RDT}{2L}V_g D\frac{V_g}{V_o} \qquad V_o^2 = \frac{RT}{2L}D^2V_g^2$$

$$K = \frac{2L}{RT} \qquad V_o = V_g\frac{D}{\sqrt{K}}$$

Buck-Boost Converter



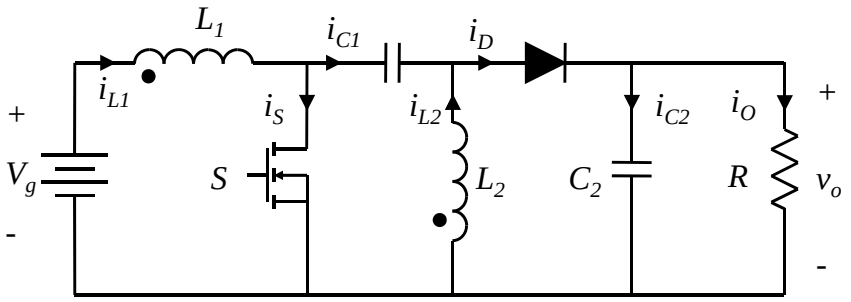


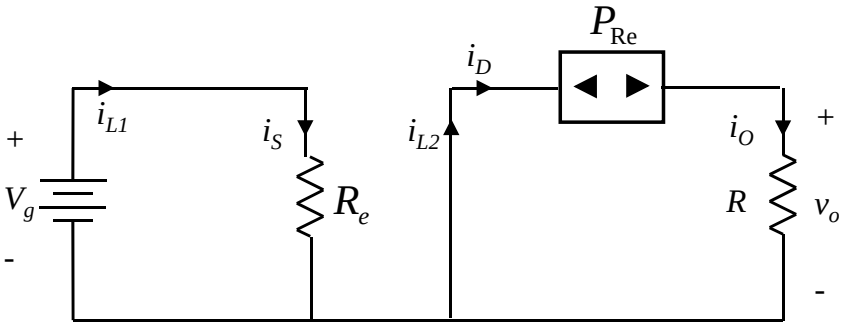
$$W_{L\max} = \frac{1}{2} L I_{\max}^2 \qquad I_{\max} = \frac{V_g}{L} DT$$

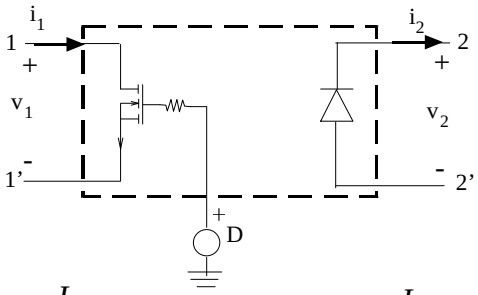
$$W_{L\max} = \frac{1}{2} L \frac{V_g^2}{L^2} D^2 T^2 \qquad \eta = 100\%$$

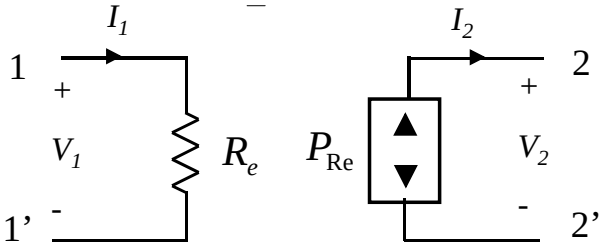
$$P = \frac{W_{L\max}}{T} = \frac{V_o^2}{R} \qquad \frac{1}{2} \frac{V_g^2}{L} D^2 T = \frac{V_o^2}{R} \qquad K = \frac{2L}{RT} \qquad V_o = V_g \frac{D}{\sqrt{K}}$$

Switch model DCM. Example SEPIC









$$R_e = \frac{2L_{eq}}{D^2T}$$

$$L_{eq} = \frac{L_1 L_2}{L_1 + L_2} \qquad K = \frac{2L_{eq}}{RT} \qquad \frac{V_g^2}{R_e} = \frac{V_o^2}{R} \qquad V_g^2 \frac{D^2T}{2L_{eq}} = \frac{V_o^2}{R}$$

$$\frac{V_o}{V_g} = \frac{D}{\sqrt{K}}$$