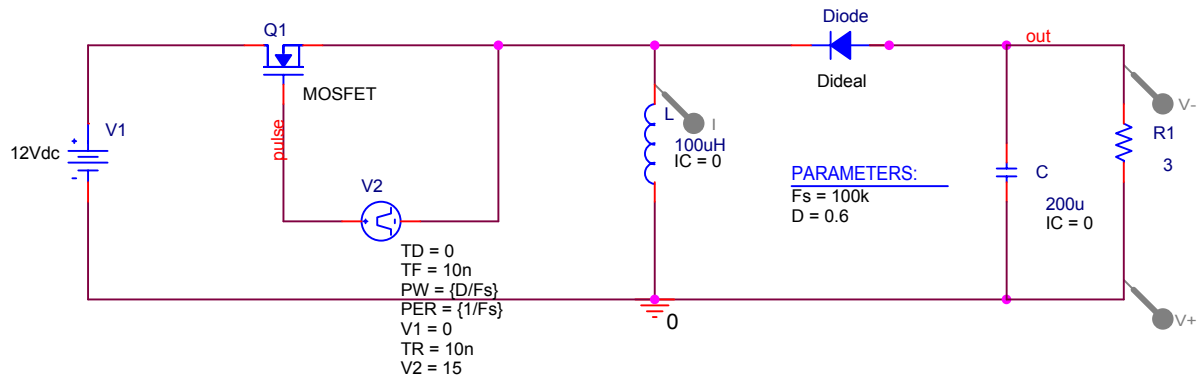


6. Buck-boost Converter

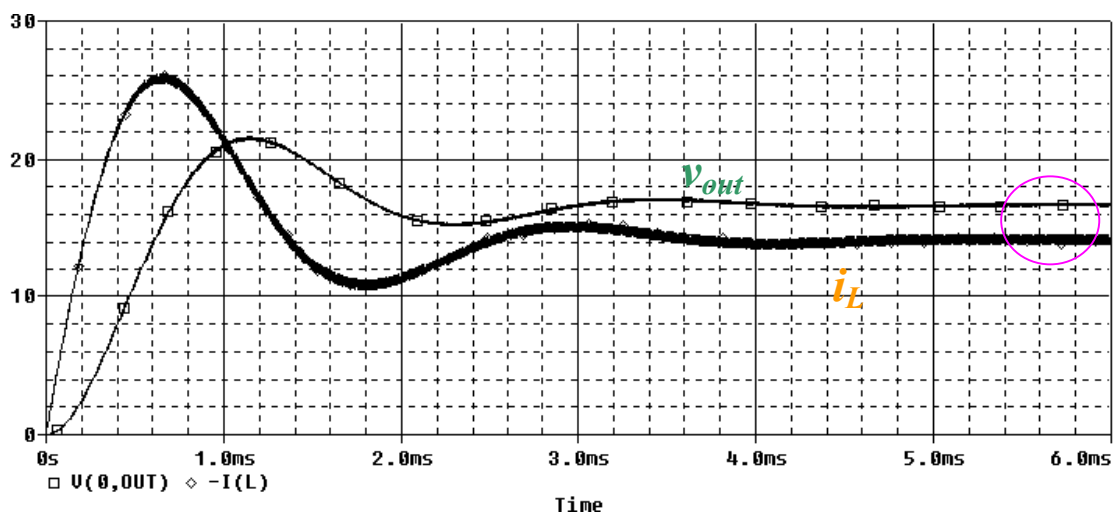
Circuit and its parameters:



Basic Formula:

$$\frac{V_o}{V_g} = \frac{D}{1-D} \quad I_o = I_D = \frac{V_o}{R} \quad I_D = (1-D)I_L \quad I_g = I_s = DI_L$$

Pspice Simulation:



Calculation:

Circuit Parameters:

$$V_g := 12 \quad V_o := 18 \quad L := 100 \cdot 10^{-6} \quad C := 200 \cdot 10^{-6} \quad f := 100 \cdot 10^3 \quad R := 3$$

$$\text{Initial guess} \quad D := 0.5$$

Given

$$\frac{V_o}{V_g} = \frac{D}{1-D} \quad D := \text{Find}(D)$$

$$D = 0.6$$

$$V_L(t) := \begin{cases} (V_g) & \text{if } 0 < t < D \cdot T \\ (-V_o) & \text{otherwise} \end{cases}$$

$$T := \frac{1}{f}$$

$$\Delta i_L := \frac{1}{L} \cdot V_g \cdot D \cdot T$$

$$\Delta i_L = 0.72$$

$$I_o := \frac{V_o}{R}$$

$$I_o = 6$$

$$I_L := \frac{I_o}{1 - D}$$

$$I_L = 15$$

$$i_{Lmin} := I_L - \frac{\Delta i_L}{2}$$

$$i_{Lmin} = 14.64$$

$$i_{Lmax} := I_L + \frac{\Delta i_L}{2}$$

$$i_{Lmax} = 15.36$$

The waveforms are a piecewise linear. Collect numbers for plotting.

$$t := \begin{pmatrix} 0 \\ D \cdot T \\ D \cdot T \\ T \end{pmatrix}$$

$$V_L := \begin{pmatrix} V_g \\ V_g \\ -V_o \\ -V_o \end{pmatrix}$$

$$i_L := \begin{pmatrix} i_{Lmin} \\ i_{Lmax} \\ i_{Lmax} \\ i_{Lmin} \end{pmatrix}$$

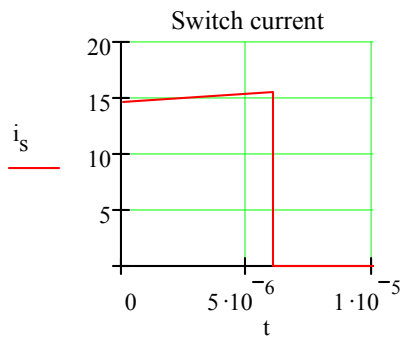
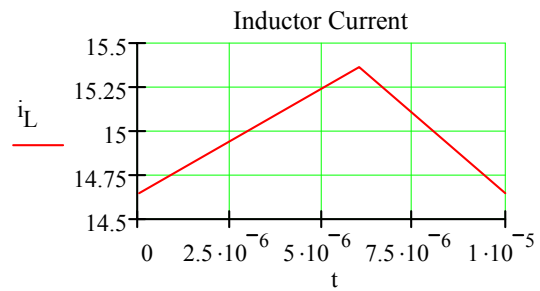
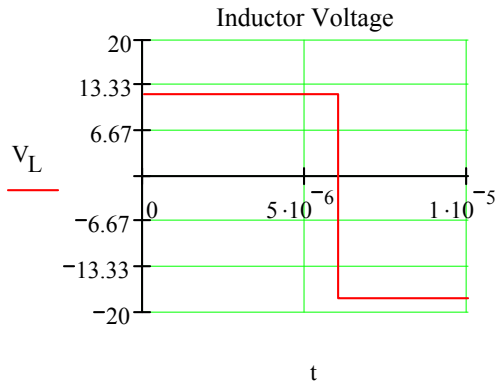
$$i_s := \begin{pmatrix} i_{Lmin} \\ i_{Lmax} \\ 0 \\ 0 \end{pmatrix}$$

$$i_D := \begin{pmatrix} 0 \\ 0 \\ i_{Lmax} \\ i_{Lmin} \end{pmatrix}$$

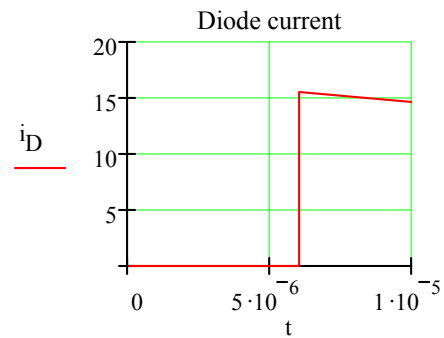
$$i_c := \begin{pmatrix} -I_o \\ -I_o \\ i_{Lmax} - I_o \\ i_{Lmin} - I_o \end{pmatrix}$$

$$i_{cmax} := i_{Lmax} - I_o$$

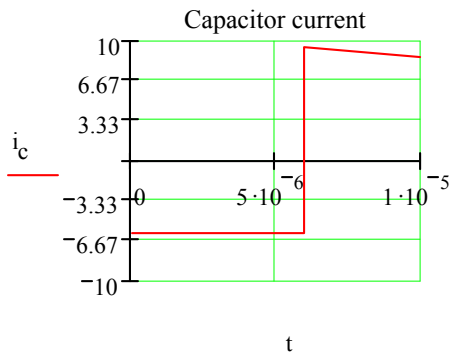
$$i_{cmax} = 9.36$$



$$I_s := D \cdot I_L \quad I_s = 9$$



$$I_D := (1 - D) \cdot I_L \quad I_D = 6$$



$$\Delta v_o := \frac{1}{C} \cdot I_o \cdot D \cdot T \quad \Delta v_o = 0.18$$

$$I_g := I_s \quad I_g = 9 \quad V_g = 12$$

$$I_o = 6 \quad V_o = 18$$

$$P_g := V_g \cdot I_g \quad P_g = 108$$

$$P_o := V_o \cdot I_o \quad P_o = 108$$

Due to ideal components (switch, diode, L and C) that we assume, the circuit is lossless, the efficiency is 100% and as such $P_g = P_o$.

DCM/CCM Boundary

Case I: L, f, and other parameters are kept constant, R is varied $i_{Lmin} := 0$ $i_{Lmax} := \Delta i_L$

$$i_{L1} := \begin{pmatrix} i_{Lmin} \\ i_{Lmax} \\ i_{Lmax} \\ i_{Lmin} \end{pmatrix} \quad I_L := \frac{\Delta i_L}{2} \quad I_L = 0.36 \quad I_o := (1 - D) \cdot I_L \quad I_o = 0.144$$

$$R := \frac{V_o}{I_o} \quad R = 125$$

Case II: R, f, and other circuit parameters are kept constant, L is varied

$$R := 3 \quad I_o := \frac{V_o}{R} \quad I_o = 6 \quad I_L := \frac{I_o}{1 - D} \quad I_L = 15$$

$$i_{Lmin} := 0 \quad i_{Lmax} := 2 \cdot I_L \quad i_{Lmax} = 30 \quad \Delta i_L := i_{Lmax} \quad i_{Lmax} = 30$$

$$i_{L2} := \begin{pmatrix} i_{Lmin} \\ i_{Lmax} \\ i_{Lmax} \\ i_{Lmin} \end{pmatrix} \quad \Delta i_L = 30$$

$$\Delta i_L = \frac{1}{L} \cdot V_g \cdot D \cdot T \quad L_{min} := \frac{1}{\Delta i_L} \cdot V_g \cdot D \cdot T \quad L_{min} = 2.4 \times 10^{-6}$$

Case III: R, L, and other circuit parameters are kept constant, f is varied

$$R := 3 \quad I_o := \frac{V_o}{R} \quad I_o = 6 \quad I_L := \frac{I_o}{1 - D} \quad I_L = 15$$

$$i_{Lmin} := 0 \quad i_{Lmax} := 2 \cdot I_L \quad i_{Lmax} = 30 \quad \Delta i_L := i_{Lmax} \quad i_{Lmax} = 30$$

$$\Delta i_L = 30$$

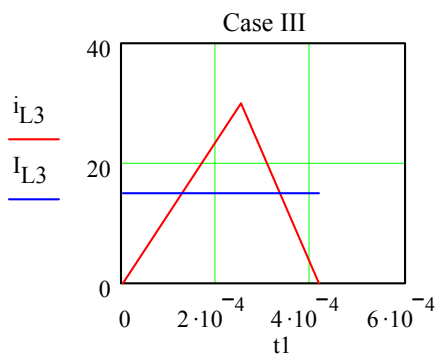
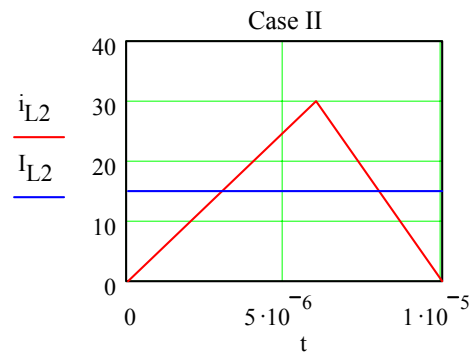
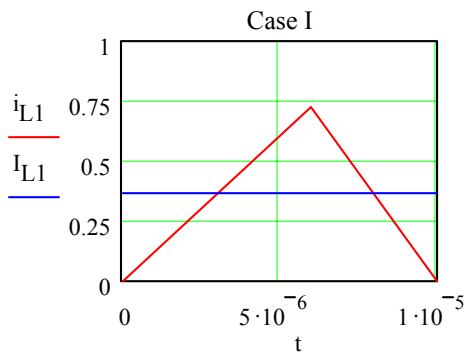
$$\Delta i_L = \frac{1}{L} \cdot V_g \cdot D \cdot \frac{1}{f} \quad f_{min} := \frac{1}{\Delta i_L} \cdot V_g \cdot D \cdot \frac{1}{L} \quad f_{min} = 2.4 \times 10^3$$

Collect numbers for plotting

$$t1 := \begin{pmatrix} 0 \\ \frac{D}{f_{\min}} \\ \frac{D}{f_{\min}} \\ \frac{1}{f_{\min}} \end{pmatrix} \quad i_{L3} := \begin{pmatrix} i_{L\min} \\ i_{L\max} \\ i_{L\max} \\ i_{L\min} \end{pmatrix} \quad I_{L3} := \begin{pmatrix} 15 \\ 15 \\ 15 \\ 15 \end{pmatrix} \quad I_{L2} := I_{L3} \quad I_{L1} := \begin{pmatrix} 0.36 \\ 0.36 \\ 0.36 \\ 0.36 \end{pmatrix}$$

$$T_{\max} := \frac{1}{f_{\min}} \quad T_{\max} = 4.167 \times 10^{-4}$$

Waveforms for i_L and I_L :



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