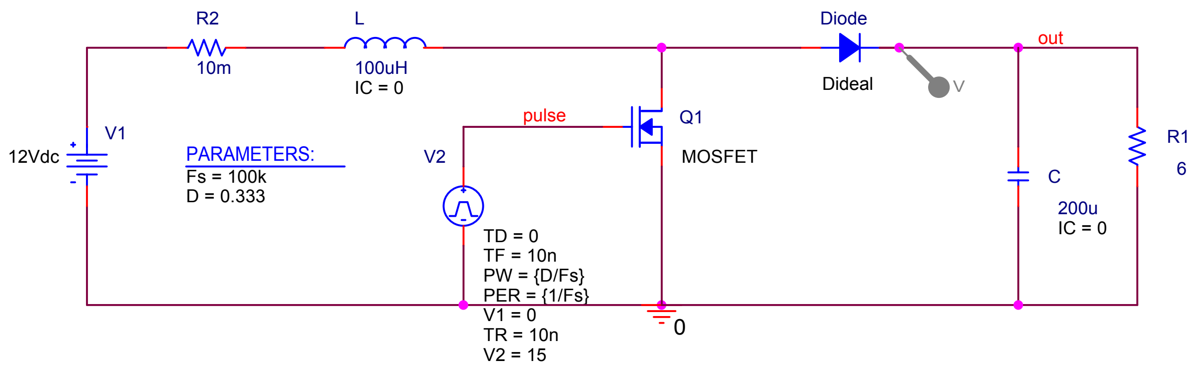
5. Boost Converter

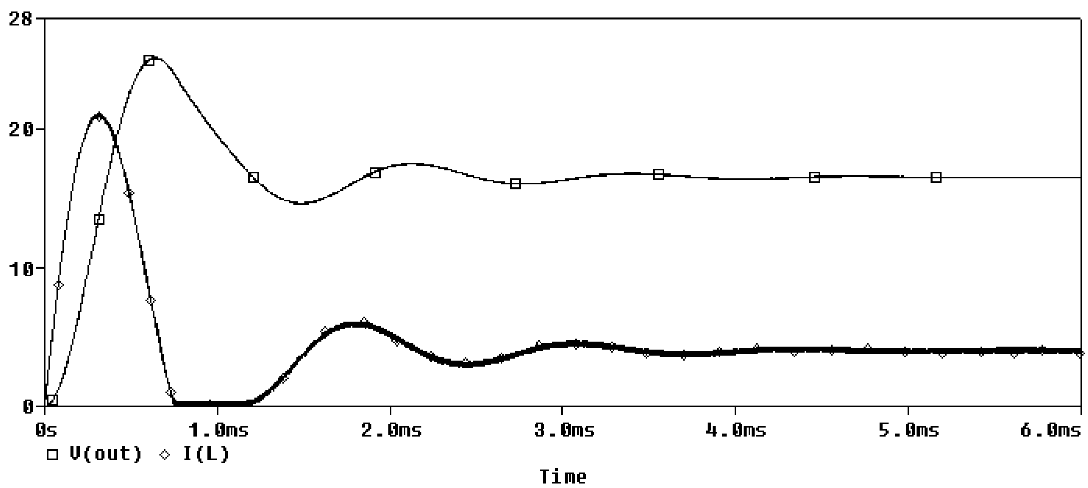
Circuit and its paramaters:



Basic Formula:

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

Pspice simulation:



Calculation:

Circuit Parameters:

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

Initial guess $\quad D := 0.5$

Given

$$\frac{V_o}{V_g} = \frac{1}{1-D} \qquad D := \text{Find}(D) \qquad D = 0.333$$

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

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

$$\Delta i_L := \frac{1}{L} \cdot V_g \cdot D \cdot T \qquad \Delta i_L = 0.4$$

$$I_o := \frac{V_o}{R} \qquad I_o = 3$$

$$I_L := \frac{I_o}{1 - D} \qquad I_L = 4.5$$

$$i_{Lmin} := I_L - \frac{\Delta i_L}{2} \qquad i_{Lmin} = 4.3$$

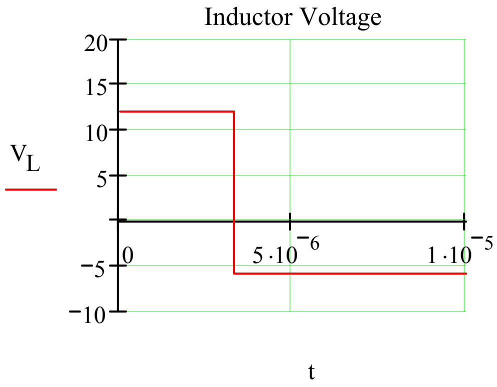
$$i_{Lmax} := I_L + \frac{\Delta i_L}{2} \qquad i_{Lmax} = 4.7$$

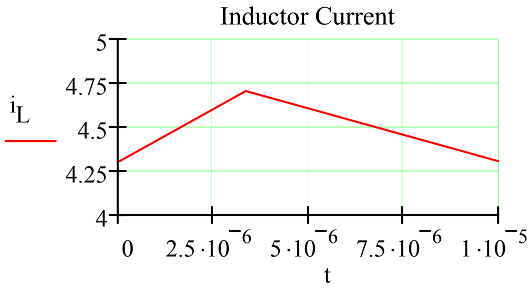
The waveforms are a piecewise linear. Collect numbers for plotting.

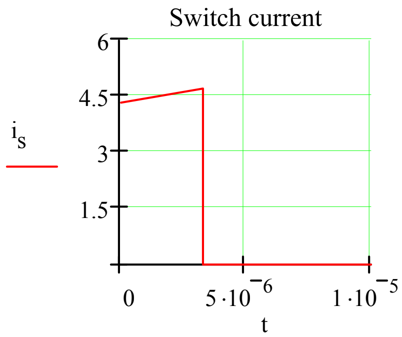
$$t := \begin{pmatrix} 0 \\ D \cdot T \\ D \cdot T \\ T \end{pmatrix} \qquad V_L := \begin{pmatrix} V_g \\ V_g \\ V_g - V_o \\ V_g - V_o \end{pmatrix} \qquad i_L := \begin{pmatrix} i_{Lmin} \\ i_{Lmax} \\ i_{Lmax} \\ i_{Lmin} \end{pmatrix} \qquad i_s := \begin{pmatrix} i_{Lmin} \\ i_{Lmax} \\ 0 \\ 0 \end{pmatrix} \qquad i_D := \begin{pmatrix} 0 \\ 0 \\ i_{Lmax} \\ i_{Lmin} \end{pmatrix}$$

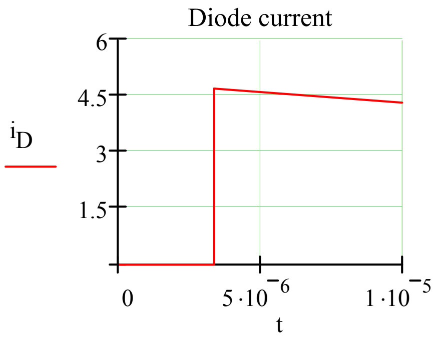
$$i_c := \begin{pmatrix} -I_o \\ -I_o \\ i_{Lmax} - I_o \\ i_{Lmin} - I_o \end{pmatrix}$$

$$i_{cmax} := i_{Lmax} - I_o \qquad i_{cmax} = 1.7$$



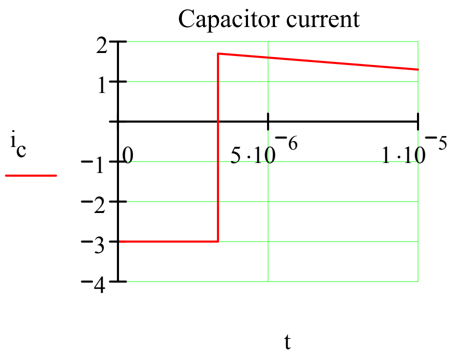






$I_s := D \cdot I_L$ $\quad I_s = 1.5$

$I_D := (1 - D) \cdot I_L$ $\quad I_D = 3$



$$\Delta v_o := \frac{1}{C} \cdot I_o \cdot D \cdot T \qquad \Delta v_o = 0.05$$

$I_g := I_L$ $\quad I_g = 4.5$ $\quad V_g = 12$ $\quad I_o = 3$ $\quad V_o = 18$

$P_g := V_g \cdot I_g$ $\quad P_g = 54$ $\quad P_o := V_o \cdot I_o$ $\quad P_o = 54$

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

DCM/CCM Boundary

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

$i_{Lmin} := 0$ $i_{Lmax} := \Delta i_L$

$i_{L1} := \begin{pmatrix} i_{Lmin} \\ i_{Lmax} \\ i_{Lmax} \\ i_{Lmin} \end{pmatrix}$ $I_L := \frac{\Delta i_L}{2}$ $I_L = 0.2$ $I_o := (1 - D) \cdot I_L$ $I_o = 0.133$

$R := \frac{V_o}{I_o}$ $R = 135$

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

$R := 6$ $I_o := \frac{V_o}{R}$ $I_o = 3$ $I_L := \frac{I_o}{1 - D}$ $I_L = 4.5$

$i_{Lmin} := 0$ $i_{Lmax} := 2 \cdot I_L$ $i_{Lmax} = 9$ $\Delta i_L := i_{Lmax}$ $i_{Lmax} = 9$

$i_{L2} := \begin{pmatrix} i_{Lmin} \\ i_{Lmax} \\ i_{Lmax} \\ i_{Lmin} \end{pmatrix}$ $\Delta i_L = 9$

$\Delta i_L = \frac{1}{L} \cdot V_g \cdot D \cdot T$ $L_{min} := \frac{1}{\Delta i_L} \cdot V_g \cdot D \cdot T$ $L_{min} = 4.444 \times 10^{-6}$

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

$R := 6$ $I_o := \frac{V_o}{R}$ $I_o = 3$ $I_L := \frac{I_o}{1 - D}$ $I_L = 4.5$

$i_{Lmin} := 0$ $i_{Lmax} := 2 \cdot I_L$ $i_{Lmax} = 9$ $\Delta i_L := i_{Lmax}$ $i_{Lmax} = 9$

$\Delta i_L = 9$

$\Delta i_L = \frac{1}{L} \cdot V_g \cdot D \cdot \frac{1}{f}$ $f_{min} := \frac{1}{\Delta i_L} \cdot V_g \cdot D \cdot \frac{1}{L}$ $f_{min} = 4.444 \times 10^{3}$

Collect numbers for plotting

$$t1 := \begin{pmatrix} 0 \\ \frac{D}{f_{min}} \\ \frac{D}{f_{min}} \\ \frac{1}{f_{min}} \end{pmatrix} \qquad i_{L3} := \begin{pmatrix} i_{Lmin} \\ i_{Lmax} \\ i_{Lmax} \\ i_{Lmin} \end{pmatrix} \qquad I_{L3} := \begin{pmatrix} 4.5 \\ 4.5 \\ 4.5 \\ 4.5 \end{pmatrix} \qquad I_{L2} := I_{L3} \qquad I_{L1} := \begin{pmatrix} 0.2 \\ 0.2 \\ 0.2 \\ 0.2 \end{pmatrix}$$

$$T_{max} := \frac{1}{f_{min}} \qquad T_{max} = 2.25\times 10^{-4}$$

Waveforms for iL and IL: