Step up converter

$E = 100$ V

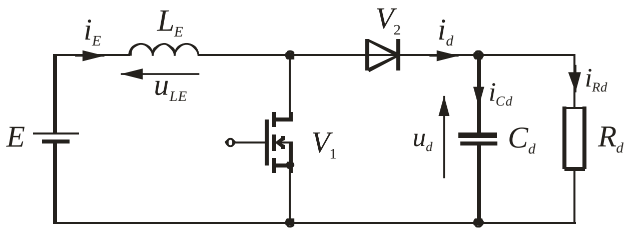
$f_s = 10$ kHz

$\alpha = 0{,}5$

$L_E = 10$ mH

$C_d = 100$ µF

$R_d = 100\ \Omega$



Analysis

$$U_{LE}(0) = 0 \Rightarrow \alpha T_s E = (1-\alpha) T_s [U_d(0) - E]$$

$$U_d(0) = \frac{E}{1-\alpha} \qquad \boxed{U_d(0) = 200\ \text{V}}$$

$$I_d(0) = I_{Cd}(0) + I_{Rd}(0), \qquad I_{Cd}(0) = 0 \qquad \Rightarrow I_d(0) = I_{Rd}(0)$$

$$I_d(0) = \frac{U_d(0)}{R_d} \qquad \boxed{I_d(0) = 2\ \text{A}}$$

Converter losses are equal to zero, $\eta \to 1$. So $P_E(0) = P_d(0)$

$$P_E(0) = E I_E(0) \qquad P_d(0) = U_d(0) I_d(0) \qquad \boxed{P_E(0) = P_d(0) = 400\ \text{W}}$$

$$I_E(0) = \frac{P_E(0)}{E} \qquad \boxed{I_E(0) = 4\ \text{A}}$$

$$T_s = \frac{1}{f_s} \qquad \boxed{T_s = 100\ \mu\text{s}}$$

$$\boxed{\alpha T_s = 50\ \mu\text{s}}$$

$$\tau = C_d R_d \qquad \boxed{\tau = 10\ \text{ms}}$$

$$\tau >> T_s \Rightarrow u_d \approx \text{const.} = U_d(0), \; i_{Rd} \approx \text{const.} = I_d(0)$$

Note 1: Although the output voltage u_d is considered as constant one need to calulate its ripple.
Note 2: Waveforms will be shown in simulation results.

$\underline{0 \le t \le \alpha T_s}$

$$u_{LE} = E, \; u_{LE} = L_E \frac{\mathrm{d}i_E}{\mathrm{d}t} \Rightarrow \text{Current } i_E \text{ is a straight line.}$$

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$i_E = \frac{E}{L_E} t + i_E(0)$ ... Sometimes, there is no need to calculate current function, but to find dc component $I_E(0)$ and current ripple Δi_E.

$$\Delta i_E = \frac{E}{L_E} \alpha T_s \qquad \boxed{\Delta i_E = 0{,}5\ \mathrm{A}}\ \boxed{I_E(0) = 4\ \mathrm{A}}$$

$i_{Cd} = C_d \frac{\mathrm{d}u_{Cd}}{\mathrm{d}t}$, $i_{Cd} \approx \mathrm{const.} = -I_d(0)$ $\Rightarrow$ Analogously to inductor's current, it is sufficient to find dc component $U_d(0)$ and voltage ripple Δu_d.

$$\Delta u_d = \frac{-I_d(0)}{C_d} \alpha T_s \qquad \boxed{I_d(0) = 2\ \mathrm{A}}\ \boxed{\Delta u_d = -1\ \mathrm{V}}$$

$\underline{\alpha T_s \le t \le T_s}$

$u_{LE} = E - U_d(0)$. Current i_E is a straight line.

$$\Delta i_E = \frac{E - U_d(0)}{L_E} (1-\alpha) T_s \qquad \boxed{\Delta i_E = -0{,}5\ \mathrm{A}}$$

$$i_{Cd} = i_d - i_{Rd},\ \ i_d = i_E,\ \ i_{Rd} = I_d(0)$$

$$i_{Cd} = i_E - I_d(0)$$

$$\omega_0 = \frac{1}{\sqrt{L_E C_d}},\ \ T_0 = \frac{2\pi}{\omega_0} \qquad \boxed{\omega_0 = 1000\ \frac{\mathrm{rad}}{\mathrm{s}}}\ \boxed{T_0 = 6{,}28\ \mathrm{ms}}$$

$T_0 >> T_s$ $\Rightarrow$ The condition to approximate waveforms with straight lines is satisfied. In ripple calculus it is considered that capacitor current is constant, so capacitor voltage changes like straight line.

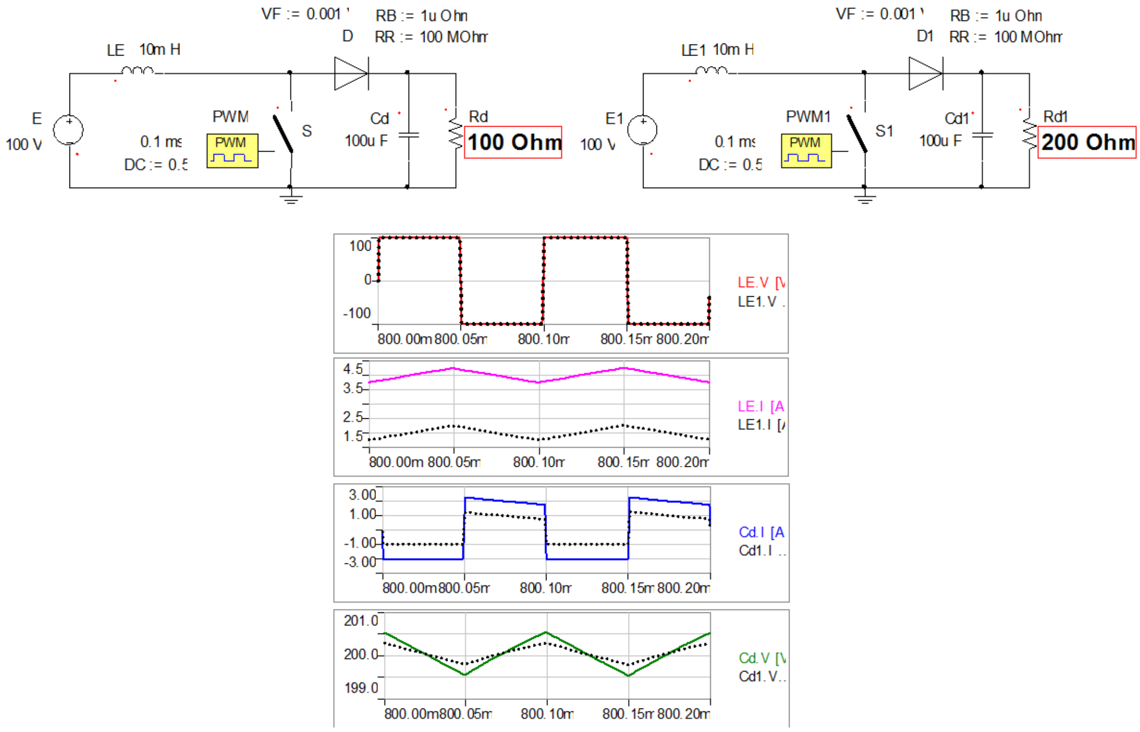
$$i_{Cd} = I_E(0) - I_d(0)$$

$$\Delta u_d = \frac{I_E(0) - I_d(0)}{C_d} (1-\alpha) T_s \qquad \boxed{\Delta u_d = 1\ \mathrm{V}}$$

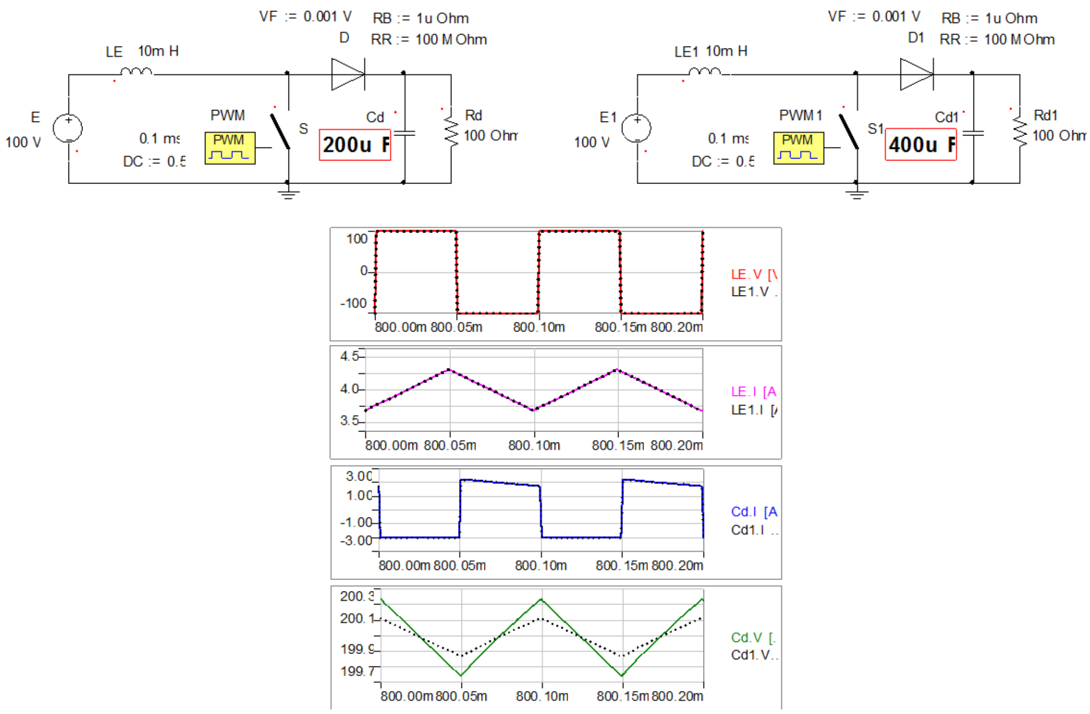
Waveforms obtained by changing of parameters R_d, C_d, α and f_s will be presented.

The waveforms are simulated in Simplorer 6.0.

Effect of load resistance R_d on waveforms



Effect of capacitance C_d on waveforms



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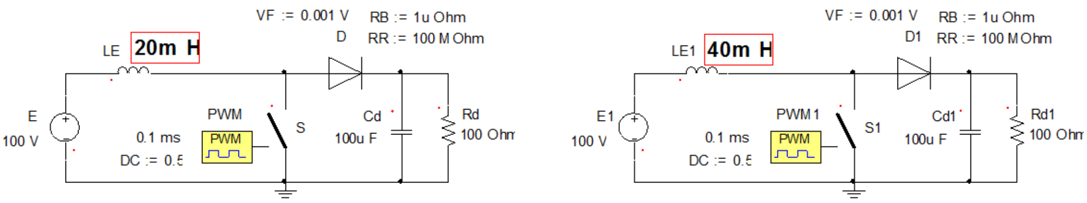
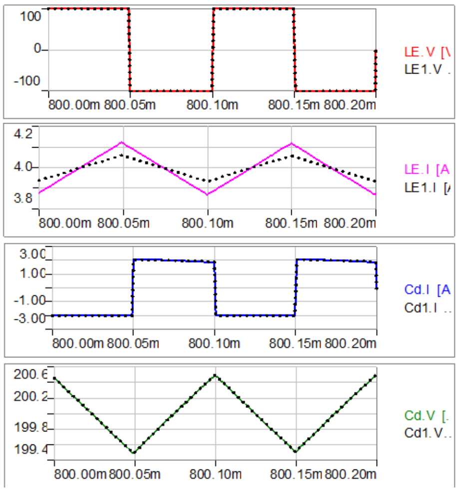
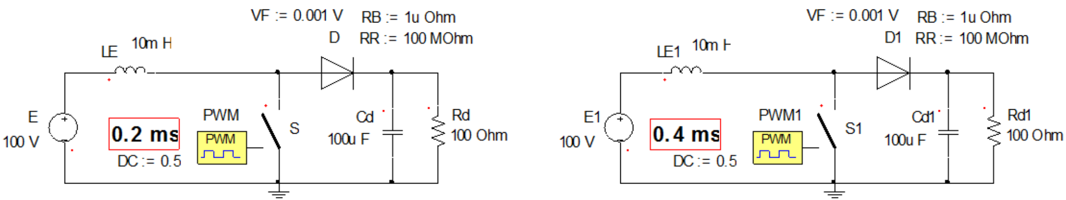
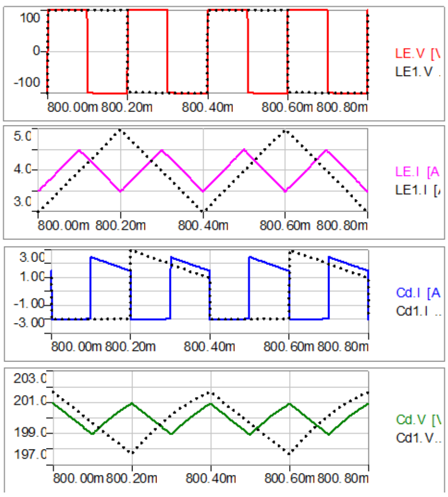
Effect of inductance L_E on waveforms





Effect of switching frequency f_s on waveforms





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