

Sample Problems

DC/DC Converters

1) Buck Converter Problem.

Design a buck converter for the following specs.

$$V_d = 40 - 100 \text{ V}$$

$$V_o = 28 \text{ V} \quad \Delta V_o \leq 1\% \text{ of } V_o \text{ at the worst case}$$

$$P_o = 420 \text{ W} \quad f_s = 50 \text{ kHz}$$

$$\Delta I_L \leq 30\% \text{ of } I_L \text{ at the worst case.}$$

a) Determine D , L , and C

b) Determine the switch ratings

c) sketch $v_o(t)$ at the worst case

d) sketch the topology

Solutions

$$a) 40 \leq V_d \leq 100$$

$$0.7 \geq D \geq 0.28$$

$$L \geq \frac{28(1-0.28)}{(0.3 \times 15)(50000)}$$

$$L \geq 89.6 \mu\text{H}$$

$$C \geq \frac{(0.3 \times 15)}{8(0.01 \times 28)(50000)}$$

$$C \geq 40.1786 \mu\text{F}$$

$$\Delta I_L = \frac{(V_d - V_o)D}{L f_s} = \frac{V_o(1-D)}{L f_s}$$

The worst case is when D is minimum
when $D_{\min} = 0.28$, $V_d = 100 \text{ V}$, and

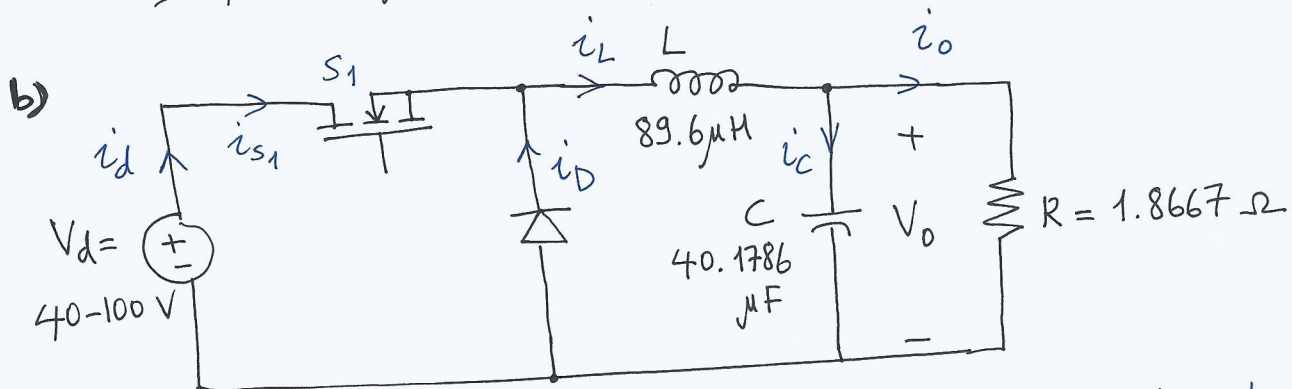
$$I_L = \frac{420}{28} = 15 \text{ A} \text{ since } I_L = I_o$$

$$\Delta V_o = \frac{\Delta I_L}{8 C f_s}$$

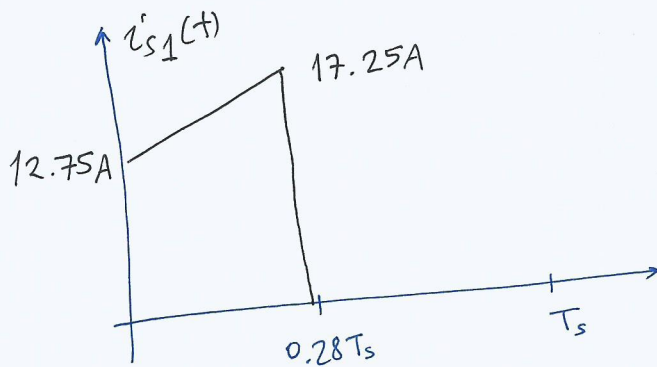
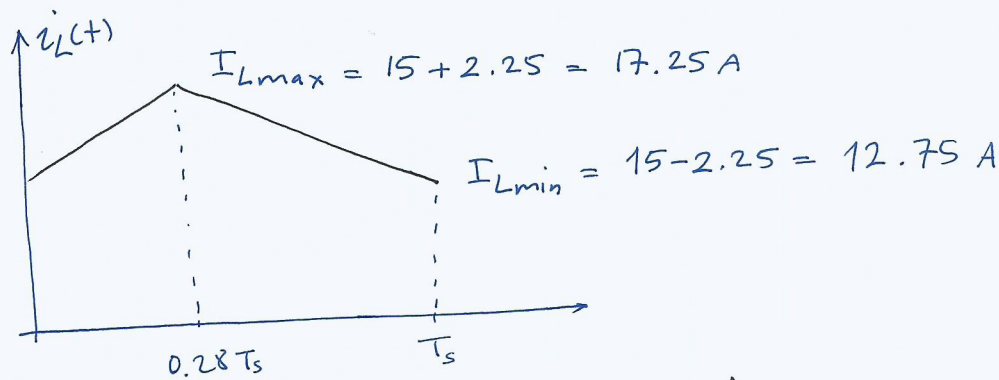
The worst case for ΔV_o is when

ΔI_L is maximum.

$$\Delta I_L = (0.3 \times 15) = 4.5 \text{ A}$$



The switch ratings should be determined based on the maximum stresses that the switches are faced to.

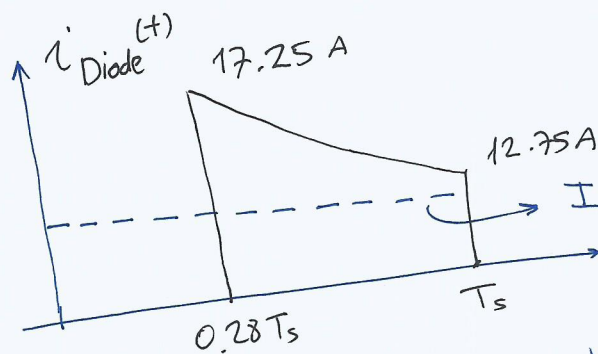


$$\hat{I}_{s1} = 17.25 A$$

$$I_{s1-rating} = 2 \times (17.25) = 34.5 A$$

$$\hat{V}_{s1} = V_{dmax} = 100 V$$

$$V_{s1-rating} = 200 V$$



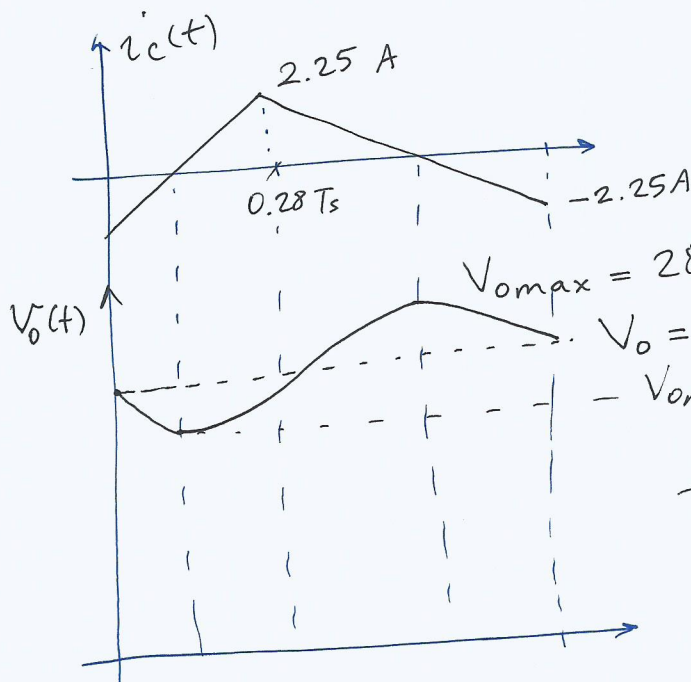
$$\hat{V}_{Diode} = V_{dmax} = 100 V$$

$$\hat{I}_D = 10.8 A$$

$$I_{Diode-rating} = 16.2 A$$

$$V_{Diode-rating} = 2 \times 100 = 200 V$$

The worst case for Diode is when D is minimum.



The worst case for $V_o(t)$ is when ΔI_L is maximum which is when V_d is maximum

2) Design a boost converter for the following specifications.

$$V_d = 5V - 40V$$

$$V_o = 50V \quad P_o = 50W \quad \Delta V_o \leq 1V \text{ at the worst case}$$

$$\Delta I_L \leq 1A \text{ at the worst case} \quad f_s = 100 \text{ kHz}$$

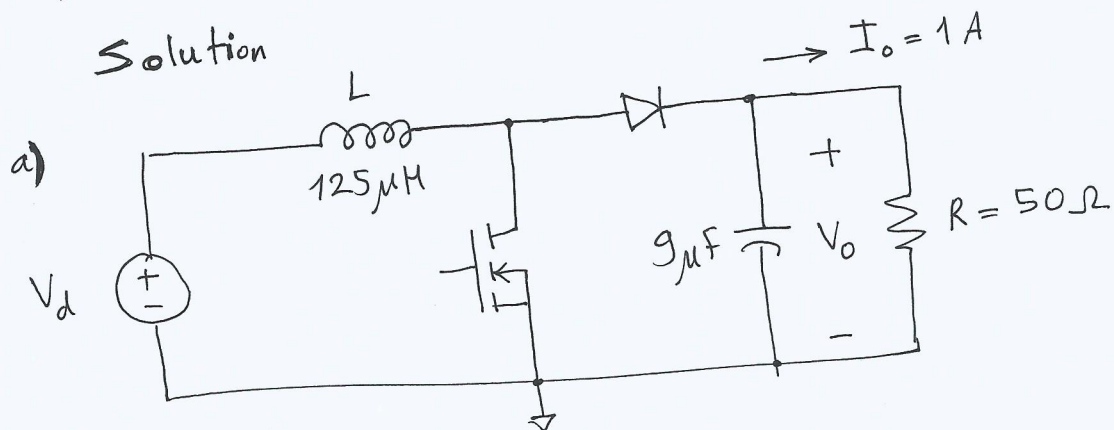
a) Sketch topology Guarantees CCM operation!

b) Determine L and C

c) Determine switch ratings

d) sketch $v_o(t)$ at the worst case

Solution



b)

$$5V \leq V_d \leq 40V$$

$$0.9 \geq D \geq 0.2$$

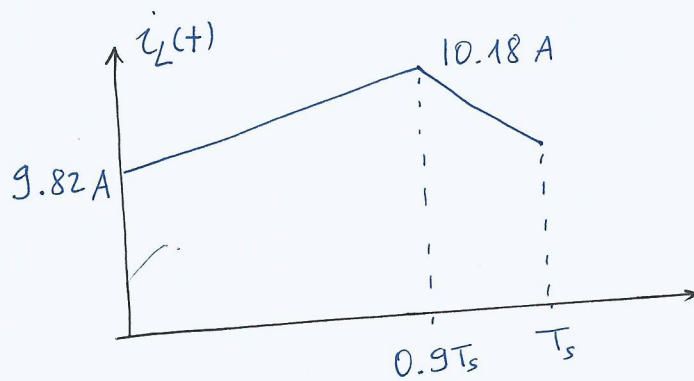
$$10A \geq I_d \geq 1.25A$$

The worst case for inductor calculation is when $D = 0.5$ and $V_d = 25V$.

$$L \geq \frac{(25)(0.5)}{(1)(100000)} = 125 \mu H$$

The worst case for capacitor sizing is when $D = 0.9$ and $V_d = 5V$.

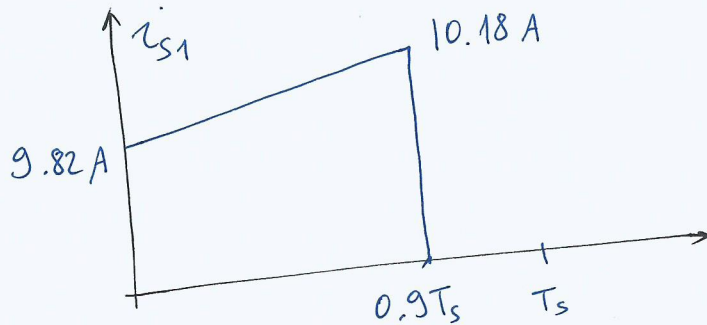
$$C \geq \frac{(1)(0.9)}{(1)(100k)} = 9 \mu F$$



The worst case is when I_d is maximum

$$I_d = 10 \text{ A}$$

$$\Delta I_L = \frac{5(0.9)}{(125 \mu\text{H})(100 \text{ k})} = 0.36 \text{ A}$$



$$\hat{I}_{S1} = 10.18 \text{ A} \quad I_{S1\text{-rating}} = 20.36 \text{ A}$$

$$\hat{V}_{S1} = V_o = 50 \text{ V} \quad V_{S1\text{-rating}} = 100 \text{ V}$$

$$\hat{I}_{\text{DIODE}} = 1 \text{ A} \quad I_{\text{DIODE-rating}} = 2 \text{ A}$$

$$\hat{V}_{\text{DIODE}} = V_o = 50 \text{ V} \quad V_{\text{DIODE-rating}} = 100 \text{ V}$$

