Power Electronics Education
Electronic Book

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Tutorial 5: Non-isolated DC-DC Converters

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Q1: A Buck converter operates in Continuous Conduction Mode. Find L and C values.
V_{in}=100V; f_{sw}=10kHz; V_{out}=10V; Δv=1%; 1 watt <P_{laod}< 10 watt

$$D = \frac{V_{out}}{V_{in}} = \frac{10}{100} = 0.1, \quad D' = 1 - 0.1 = 0.9$$

$$L = \frac{DD'V_{in}}{2 f_{sw} \Delta i}$$

$$= \frac{0.1 \times 0.9 \times 100}{2 \times 10 \times 10^3 \times \Delta i}$$

$$D' < \frac{2L}{R T_{sw}}$$

$$C_v = \frac{DD'V_{in}}{16 \times L \times f_{sw}^2 \times \Delta V_c} = \frac{0.1 \times 0.9 \times 100}{16 \times L \times 10^8 \times 0.1}$$

$P_{load=1} = \frac{V_{out}^2}{R} = \frac{100}{R} \Rightarrow R = 100\ \Omega$

$P_{load=10} = \frac{100}{R} \Rightarrow R = 10\ \Omega$

$D' < \frac{2L}{RT_{SW}} \rightarrow 0.9 < \frac{2L}{100} \times 10^4$

$R \rightarrow 100\ \Omega$

$\frac{0.9}{200} < L$

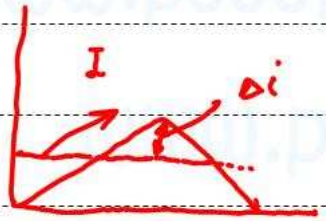
Δi_L

$C =$

$4.5\ mH < L \rightarrow R = 100\ \Omega$

$0.45\ mH < L \rightarrow R = 10\ \Omega$

$\Delta i = \frac{10}{100} = 0.1\ A$



$I_{load} = \frac{10}{10} = 1\ A$

$R = 10\ \Omega$

$C = 12.5\ \mu F$

Q2: In a boost converter, V_{in}=12V, L=0.1mH, f_{sw}=5kHz, R=100 Ohms. What are an output voltage for D=0.1 and D=0.9?
What is maximum resistance value to ensure that the boost converter always operates in CCM?

$$D(1-D)^2 < \frac{2L}{R} \times f_{sw}$$

$$0.1(1-0.1)^2 < \frac{2 \times 0.1 \times 10^{-3} \times 5 \times 10^{3}}{100} = 0.01$$

$$0.1 \times 0.9^2 < 0.01$$

$$0.081 < 0.01$$ ✗

DCM ?

$$\frac{V_{out}}{V_{in}} = \frac{1}{(1-D)}$$

$$0.9 \times 0.1^2 < 0.01 \Rightarrow 0.009 < 0.01$$ ✓ CCM

$$V_{out} = \frac{12}{0.1} = 120^{V} \longrightarrow D = 0.9$$

$$V_{out} = V_{in}\left[\frac{1+\sqrt{1+\frac{2RD^2T_{sw}}{L}}}{2}\right] = 12\times\left[\frac{1+\sqrt{1+\frac{2\times100\times0.1}{0.1\times10^{-3}\times5\times10^{3}}}}{2}\right]$$

$$= 12\times\left[\frac{1+\sqrt{1+4}}{2}\right] \simeq 12\times1.6 = 19.41^{V}$$

$$\frac{4}{27} < \frac{2L f_{sw}}{R} = \frac{2 \times 0.1 \times 10^{-3} \times 5 \times 10^{3}}{R}$$

$$R < 6.75\ \Omega \quad \text{CCM}$$