ELEC-E8412 **Power Electronics**
Exercise No 05 16.11.2023

Problem 1:

A buck converter has an input of 12 V and an output of 3 V.
The load resistor is 6 Ω, the f_{sw} is 400 kHz, L = 5 μH, and C =10 μF.

Determine

a) duty ratio

$D = \frac{V_o}{V_{in}} = \frac{3}{12} = 0.25$

b) average and peak inductor currents

$$I_{avg} = \frac{(I_{\max} + I_{min})}{2} = \frac{V_o}{R} = \frac{3}{6} = 0.5\ A$$

$$I_{max} = V_o\left(\frac{1}{R} + \frac{1-D}{2*L*f}\right) = 3\left(\frac{1}{6} + \frac{1-0.25}{2*5*10^{-6}*4*10^5}\right) = 1.0625A$$

c) average source current

for an Ideal converter, $P_{in} = P_{out}$

$P_{in} = \frac{V_o^2}{R}$ $V_{in} * I_{in} = \frac{V_o^2}{R}$

$I_{in} = \frac{V_o^2}{R * V_{in}} = \frac{3^2}{6*12} = 0.125A$

d) peak and average diode current

$I_{D(avg)} = I_{L(avg)} * (1-D) = \frac{V_o}{R} * (1-D) = \frac{3}{6} * (1-0.25) = 0.375\ A$

$$I_{D(peak)} = I_{L(peak)} = I_{max} = 1.0625A$$

Problem 2:

A buck converter has an input of 50 V and an output of 25 V.
The f_{sw} is 100 kHz, and the output power to a load resistor is 125 W.
Determine

a) **duty ratio**

$R = \frac{V_o^2}{P_{out}} = \frac{25^2}{125} = 5\Omega$

a) duty ratio

$D = \frac{V_o}{V_{in}} = \frac{25}{50} = 0.5$

b) **value of inductance to limit the peak inductor current to 6.25 A.**

$$I_{max} = V_o\left(\frac{1}{R} + \frac{1-D}{2*L*f}\right) = 25\left(\frac{1}{5} + \frac{1-0.5}{2*L*10^5}\right)$$

$$I_{max} = 6.25\ A \longrightarrow L = 50\ \mu H$$

c) **minimum inductor current**

$$I_{min} = V_o\left(\frac{1}{R} - \frac{1-D}{2*L*f}\right) = 25\left(\frac{1}{5} + \frac{1-0.5}{2*50*10^{-6}*10^5}\right) = 3.75A$$

Problem 3:

A boost converter circuit has the following parameters:

V_{in} = 5 V, V_{out} = 20 V, and P_{out} = 40 W, f_{sw} = 85 kHz.

Minimum value of the inductor current must be at least 80% of the average inductor current. Determine the duty ratio and the minimum inductor value.

$$I_{min} > 0.8\ I_{avg}$$

$$I_{min} = \left(\frac{V_{in}}{(1-D)^2 * R}\right) - \left(\frac{V_{in}}{2*L}\ DT\right)$$

$$I_{max} = \left(\frac{V_{in}}{(1-D)^2 * R}\right) + \left(\frac{V_{in}}{2*L}\ DT\right)$$

$$I_{avg} = \left(\frac{V_{in}}{(1-D)^2 * R}\right)$$

$$\left(\frac{V_{in}}{(1-D)^2 * R}\right) - \left(\frac{V_{in}}{2*L}\ DT\right) > 0.8 * \left(\frac{V_{in}}{(1-D)^2 * R}\right)$$

$$\left(\frac{V_{in}}{(1-D)^2 * R}\right) - 0.8 * \left(\frac{V_{in}}{(1-D)^2 * R}\right) > \left(\frac{V_{in}}{2*L}\ DT\right)$$

$$0.2 * \left(\frac{V_{in}}{(1-D)^2 * R}\right) > \left(\frac{V_{in}}{2*L}\ DT\right)$$

After rearranging, we get

$$L > \frac{D*(1-D)^2*R}{0.4*f}$$

For D and R,

$$\frac{1}{1-D} = \frac{V_o}{V_{in}} = \frac{20}{5}, \qquad D = 0.75$$

$$R = \frac{V_o^2}{P_{out}} = \frac{20^2}{40} = 10\Omega$$

$L > 13.79\ \mu H$

Problem 4:

A boost converter circuit has the following parameters:

V_{in} =20 V, D =0.6, R =12.5 Ω, L=10 μH, C =40 μF, f_{sw} =200 kHz.

Determine

a) V_{out}

$$V_o = \frac{V_{in}}{1-D} = \frac{20}{1-0.6} = 50V$$

b) Average, maximum, and minimum inductor currents.

$$I_{avg} = \frac{(I_{\max} + I_{min})}{2} = \left(\frac{V_{in}}{(1-\ D)^2 * R}\right) = \left(\frac{20}{(1-0.6)^2 * 12.5}\right) = 10A$$

$$I_{min} = \left(\frac{V_{in}}{(1-\ D)^2 * R}\right) - \left(\frac{V_{in}}{2*L}\ DT\right) = \left(\frac{20}{(1-0.6)^2 * 12.5}\right) - \frac{20*\ 0.6}{2*10*10^{-6}*2*10^5} = \ 7A$$

$$I_{max} = \left(\frac{V_{in}}{(1-\ D)^2 * R}\right) + \left(\frac{V_{in}}{2*L}\ DT\right) = \left(\frac{20}{(1-0.6)^2 * 12.5}\right) + \frac{20*\ 0.6}{2*10*10^{-6}*2*10^5} = 13A$$

c) Average current in the diode

$$I_{D(avg)} = \ I_{L(avg)} * (1-D) = 10 * (1-0.6) = 4A$$

Or

$$I_{D(avg)} = \frac{V_o}{R} = \frac{50}{12.5} = 4A$$