BUCK AND BOOST EXAMPLES

1.

A Buck converter operates at frequency of 2000 Hz from 200 V d.c supply. It supplies to a 5 Ω resistor For output voltage of 100V, Find out ;

a) The duty cycle (D, λ, conductance ratio)

b) Ton

c) The average value of output current

d) I_T

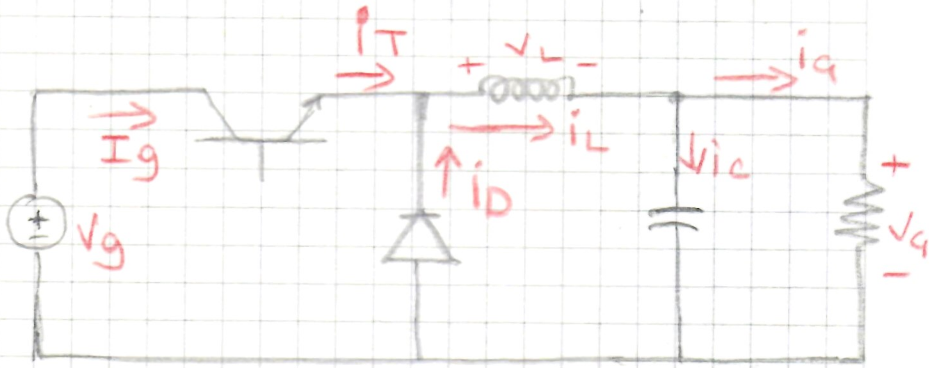
e) I_D

f) For continuous current control Lcritic

a) $V_a = D \cdot V_g$

$$D = \frac{V_a}{V_g} = \frac{100}{200}$$

$$D = \frac{1}{2}$$



b) $T = \frac{1}{f} = \frac{1}{2000} = 0.5 \text{ ms}$

$T_{on} = D \cdot T = \frac{1}{2} \cdot 0,5 \text{ ms} = 0.25 \text{ ms}.$

c) $I_a = \frac{100}{5} = 20 \text{ A}$

d) $D = \frac{T_{on}}{T} = \frac{I_T}{I_L}$ and $-i_T - i_D + i_L \Rightarrow$

$i_L = i_T + i_D$

$i_L = i_a = 20 \text{ A}$

$$\frac{1}{2} = \frac{I_T}{I_L} \Rightarrow I_T = 10 \text{ A}.$$

e) $I_D = 20 - 10 = 10 \text{ A}$

f) $L_{critic} = \frac{\left(1-\frac{1}{2}\right) 5 \cdot 0.5 \cdot 10^{-3}}{2} = \frac{(1-D) \cdot R \cdot T}{2} = 625 \, \mu H$

2.

A Buck converter has $V_g = 15$, $V_a = 5V$, $I_a = 5A$
$f = 100\ kHz$, Find out;

a) L value for Boundary Current Mode
b) I_L
c) I_D
d) Peak value of Transistor voltage.

a) $$L_{critic} = \frac{(1-D)\,R\cdot T}{2}$$

$$R = \frac{V_a}{I_a} = 1\,\Omega \qquad D = \frac{V_a}{V_g} = \frac{5}{15} = 0.33$$

$$T = \frac{1}{100\cdot 10^3} = 10\,\mu s \qquad T_{on} = 3.3\,\mu s.$$

$$L_{critic} = \frac{(1-0.33)\cdot 1\cdot 10\cdot 10^{-6}}{2} = 3.3\,\mu H$$

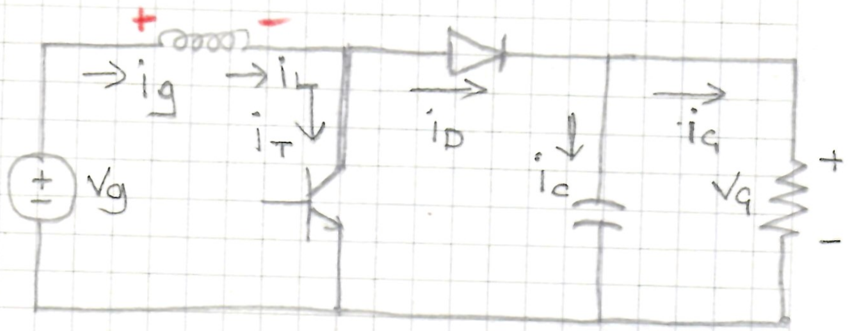
b) $$I_L = \frac{V_a}{R} = \frac{5}{1} = 5A. = I_a$$

c) $$D = \frac{I_T}{I_L} = 0.33 = \frac{I_T}{5} \Rightarrow I_T = 1.65\,V.$$

d) $$V_T = V_g = 15\ V.$$

3. For a boost converter $V_g = 100V$, $V_a = 200V$, $f = 100\,kHz$ and $P_a = 1kW$ what is the L value for BCM operation? If the output power is reduced to 100 W while the same output maintains as 200V, what about the operation mode of the boost converter?

$$\frac{V_a}{V_g} = \frac{1}{1-D} \quad \text{for boost converter}$$



$$\frac{200}{100} = \frac{1}{1-D}$$

$D = 0.5$

$$P_a = 1 \cdot 10^3 = \frac{V_a^2}{R} = \frac{200^2}{R}$$

$R = 40\,\Omega$.

$$T = \frac{1}{100 \cdot 10^3} = 10\,\mu s \qquad I_a = \frac{200}{40} = 5A.$$

$$L_{critic} = \frac{(1-D)^2 \cdot D \cdot R \cdot T}{2} = \frac{(1-0.5) \cdot 0,5 \cdot 40 \cdot 10 \cdot 10^{-6}}{2}$$

$L_{critic} = 50\,\mu H$ $\qquad I_L = I_g = \frac{I_a}{1-D} = 10A$

For new power value

$$P_a = 100 = \frac{V_a^2}{R} = \frac{200^2}{R} \Rightarrow R = 400\,\Omega.$$

$$I_a = \frac{200}{400} = 0.5\,A. \qquad I_L = I_g = \frac{1}{1-D} \cdot I_a = \frac{0.5}{1-0.5} = 1A$$

Since the inductance current is lower than the one with BCM, the converter operates at discontinuous operation mode

4.

In a boost converter, the inductance current has $\Delta i_L = 2A$. It is operated in dc steady state under the following conditions: $V_g = 5V$, $V_a = 12V$, $P_a = 11W$ and $f = 200\,kHz$. (Load is pure resistive)

a) Calculate L value

b) Find out I_g and I_a values

$$\frac{V_a}{V_g} = \frac{12}{5} = \frac{1}{1-D} \Rightarrow D = 0.583$$

$$P_a = \frac{V_a^2}{R} \Rightarrow R = \frac{144}{11} = 13.1\,\Omega$$

$$L \cdot \frac{di}{dt} = V_L = V_g \quad \text{for on state}$$

$$\frac{\Delta i_L}{T_{on}} = \frac{V_g}{L} \Rightarrow \Delta i_L = \frac{V_g \cdot D \cdot T}{L} \Rightarrow$$

$$T = \frac{1}{f} = \frac{1}{200 \cdot 10^3} = 5\mu s \qquad L = \frac{5 \cdot 0.583 \cdot 5 \cdot 10^{-6}}{2}$$

$$L = 7.29\,\mu H$$

$$I_a = \frac{V_a}{R} = \frac{12}{13.1} = 0.91\,A$$

$$I_g = \frac{1}{1-D} \cdot I_a = 0.91 \cdot \frac{1}{1-0.583} = 2.19\,A$$