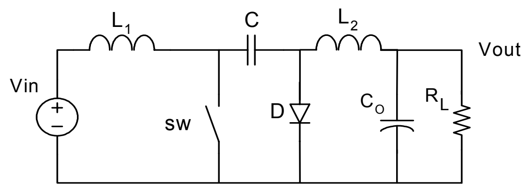
<u>Exercise 5 solution</u>

Problem 1

C'uk converter:



When converter is in steady state operation the average voltage on both inductors must be zero. The voltages across each inductor are:

$$V_{L1} = \begin{vmatrix} V_{in}, \text{"ON"} \\ V_{in} - V_c, \text{"OFF"} \end{vmatrix} \qquad V_{L2} = \begin{vmatrix} -V_c - V_{out}, \text{"ON"} \\ -V_{out}, \text{"OFF"} \end{vmatrix}$$

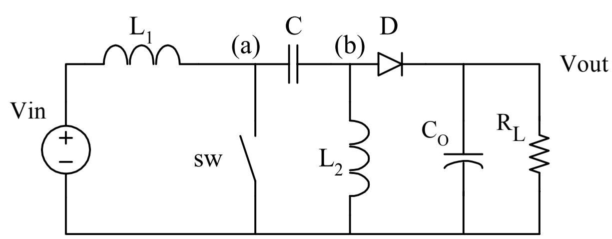
$$V_c = \frac{V_{in}}{1-D} \qquad V_{out} = -D \cdot V_c$$

From each of these equations it can be concluded:

$$\frac{Vo}{Vin} = -\frac{D}{1-D}$$

Problem 2

SEPIC converter:



1.1

When converter is in steady state operation the average voltage on both inductors must be zerc
Therefore the average voltages in the nodes (a) and (b) (with respect to the ground) are:

$$\langle V(a) \rangle = Vin \qquad (1)$$

$$\langle V(b) \rangle = 0 \qquad (2)$$

The first conclusion from the previous equations that capacitor C average voltage is:

$$\langle V(a,b)\rangle = Vin$$

If C is big enough, so that $\frac{1}{2\pi\cdot\sqrt{L_1\cdot C}}, \frac{1}{2\pi\cdot\sqrt{L_2\cdot C}} << f_{sw}$, the average voltage can be considered as constant (there is no resonant).

The voltage in the nodes (a) and (b) can be expressed the following way:

$$V(a) = \begin{cases} 0, \text{"ON"} \\ Vo + Vin, \text{"OFF"} \end{cases} \qquad V(b) = \begin{cases} -Vin, \text{"ON"} \\ Vo, \text{"OFF"} \end{cases}$$

Using these equations and average values in (1) and (2):

$$V(a) = 0\cdot D + (Vo + Vin)\cdot(1 - D) = Vin$$

$$V(b) = -Vin\cdot D + Vo\cdot(1 - D) = 0$$

From each of these equations it can be concluded:

$$\frac{Vo}{Vin} = \frac{D}{1 - D}$$

1.2

Since the average (output) capacitor current must be zero, the average inductor L2 current is equal to the outpur current

$$I_{L2} = I_{out} = \frac{V_{out}}{R} = \frac{V_{in}}{R}\cdot\frac{D}{1 - D}$$

The currents ratio can be expressed using the voltages ratio by:

$$I_{L1} = I_{out}\cdot\frac{D}{1 - D} = \frac{V_{in}}{R}\cdot\left(\frac{D}{1 - D}\right)^2$$

$$\Delta I_{L1} = 2\cdot I_{L1} = \frac{V_{in}\cdot D\cdot T}{L1} \qquad L1_{min} = \frac{R\cdot D\cdot(1 - D)^2}{2\cdot D^2\cdot f_s}$$

In a similar way, the minimal value of L2 is obtained:

$$\Delta I_{L2} = 2\cdot I_{out} = \frac{V_{out}\cdot(1 - D)\cdot T}{L2} \qquad L2_{min} = \frac{R\cdot(1 - D)}{2\cdot f_s}$$