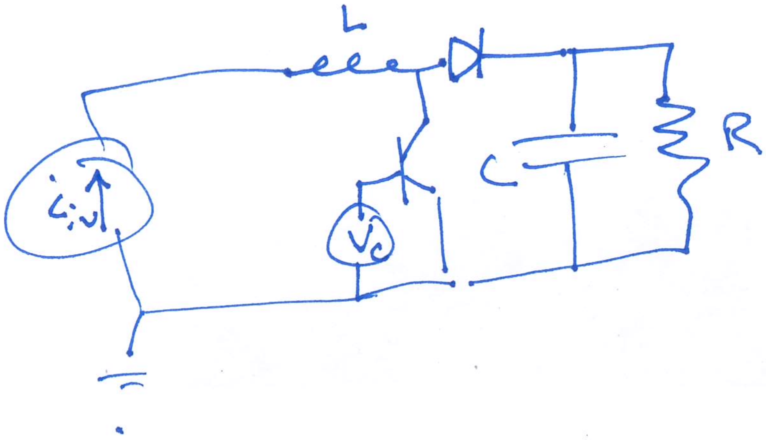
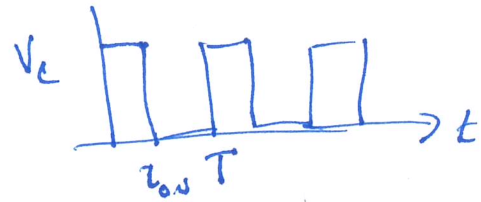
Step-up (Boost Converter)

this makes more sense w/ a current source than a Voltage source





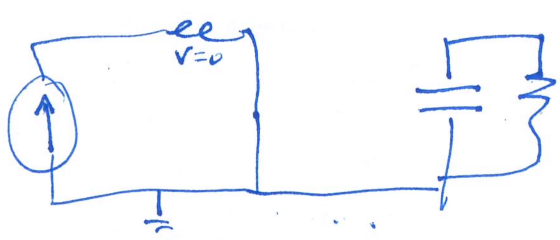
w/ a current source the current flowing through the inductor is steady.

$i_L = i_{in}$ it is where the current goes after leaving the inductor that shifts ~~below~~ to the transistor.

since

$$\frac{di_L}{dt} = \frac{1}{L} V_L \quad \text{we have } V_L = 0.$$

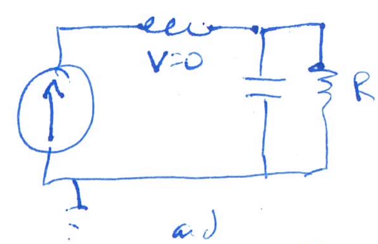
so w/ V_c high the ~~circuit~~ transistor conducts and our circuit becomes



and

$V_{in} = 0$ for $0 < t < t_{on}$

w/ V_c low



and

$$V_{out} = \cancel{V_L}^{\,0} + V_{in}$$
$$= V_{in}$$

for $t_{on} < t < T$

w/ C large (capacitance) $\langle V_{out} \rangle$ is steady ;

$$\langle V_{in} \rangle = \frac{1}{T}\int_0^T V_{in}\,dt = \frac{1}{T}\int_0^{t_{on}} V_{in}\,dt + \frac{1}{T}\int_{t_{on}}^{T} V_{in}\,dt = 0 + \frac{1}{T} V_{out}(T - t_{on})$$

$$\langle v_{in} \rangle = V_{out}\left(1 - \frac{t_{on}}{T}\right) = V_{out}(1-D)$$

and

$$V_{out} = \frac{\langle V_{in} \rangle}{1-D}$$

Considering the current recall that $\langle i_{cap} \rangle = 0$ in steady state

so $\langle i_{Load} \rangle = \langle i_{diode} \rangle$

so

$$\langle i_{Load} \rangle = \frac{1}{T}\int_0^T i_{diode}\, dt$$

$$= \frac{1}{T}\int_0^{t_{on}} \underbrace{i_{diode}}_{0\text{, diode is reverse biased}}\, dt + \frac{1}{T}\int_{t_{on}}^{T} \underbrace{i_{diode}}_{i_{in}}\, dt$$

$$= \frac{1}{T}\, i_{in}(T - t_{on}) = i_{in}(1-D)$$

and

$$P_{out} = \langle V_{out} \rangle \langle i_{out} \rangle = \frac{\langle V_{in} \rangle}{1-D}\, i_{in}(1-D)$$

$$= \langle V_{in} \rangle\, i_{in}$$

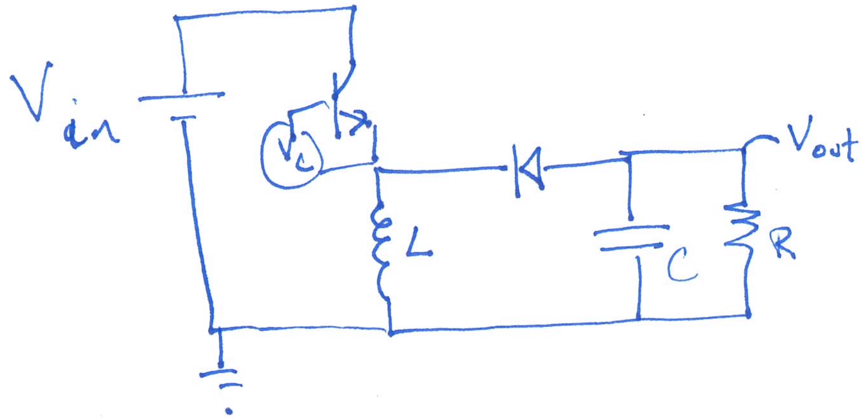
Notice that the transistor is again shutting off the power from the current source, by shorting it.

a Voltage source yields the same relationship BTWN $\langle V_{in} \rangle, \langle V_{out} \rangle$, $\langle i_{in} \rangle$ and $\langle i_{out} \rangle$ w/ much larger variation in $i_L(t)$

for a current source, all values of D yield a continuous current through i_L

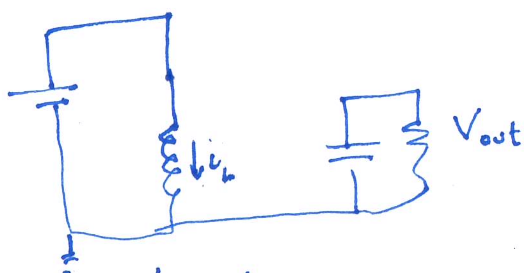
for a Voltage source ~~Non-continuous~~ i_L is only cont. for some values of D.

Buck - Boost Converter



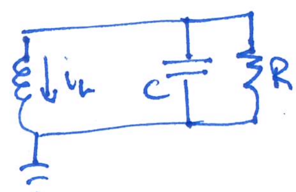
1st thing to note, current only leaves R/C combo going through a forward biased diode. This means that $V_{out} < 0$ while $V_{in} > 0$. The buck-boost circuit flips the sign of the output wrt input.

when V_c is high the circuit simplifies to



$\Rightarrow V_L = V_{in}$

when V_c is low the circuit simplifies to



$V_L = V_{out}$

$$\langle V_L \rangle = \frac{1}{T}\int_0^T V_L \, dt = \frac{1}{T}\int_0^{t_{on}} V_L \, dt + \frac{1}{T}\int_{t_{on}}^T V_L \, dt = 0$$

$$= \frac{1}{T} t_{on} V_{in} + \frac{1}{T}(T - t_o) V_{out} = 0$$

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

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

You can think of the inductor as being like a flywheel.
inductor can get overloaded if R is too low