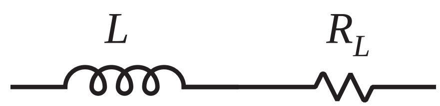
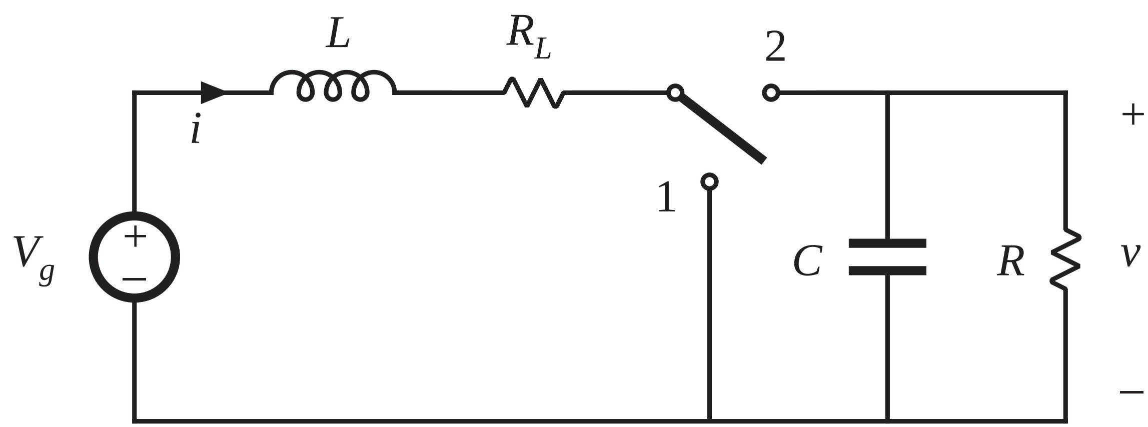
3.2. Inclusion of inductor copper loss

Dc transformer model can be extended, to include converter nonidealities.

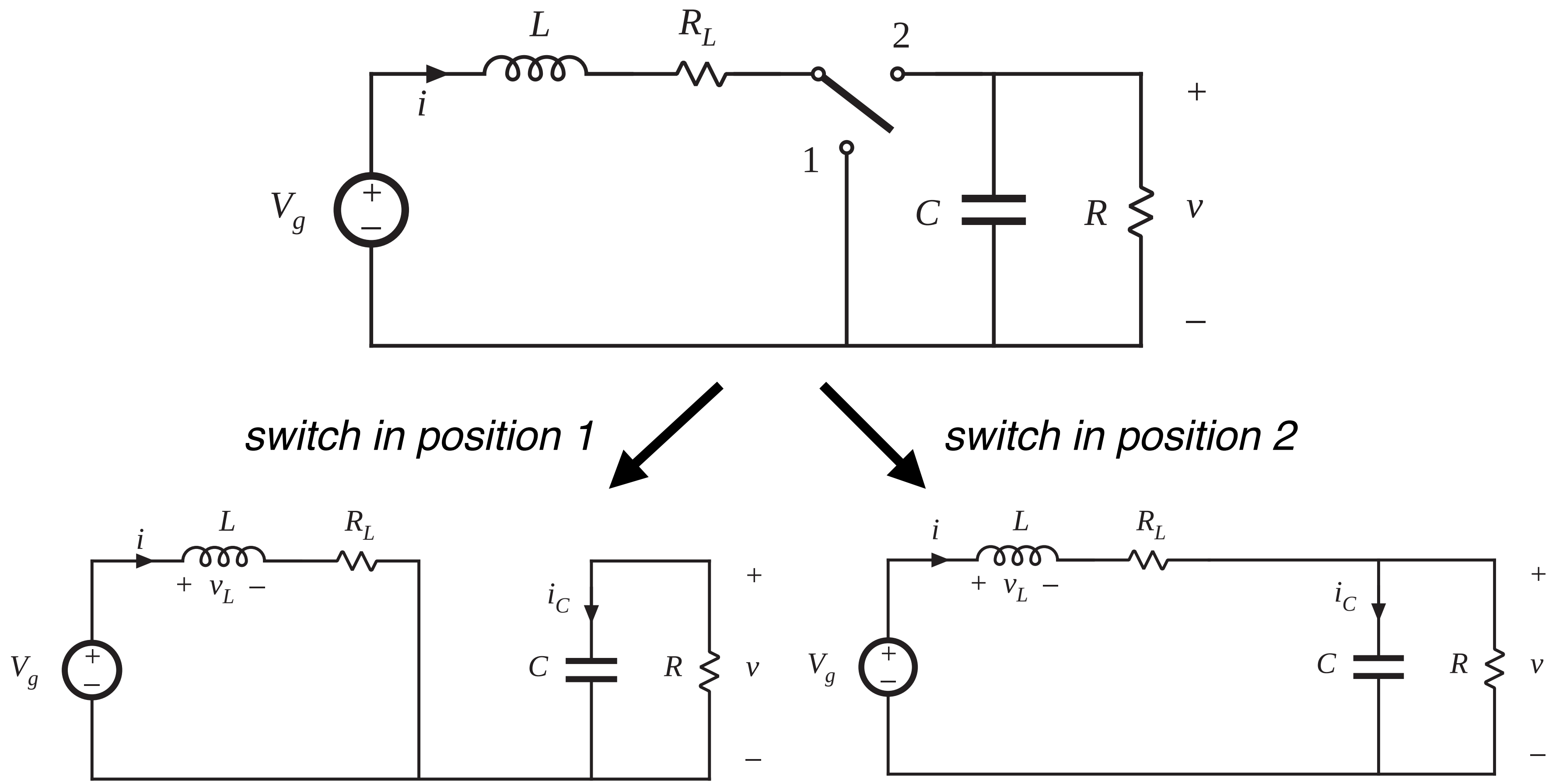
Example: inductor copper loss (resistance of winding):



Insert this inductor model into boost converter circuit:



Analysis of nonideal boost converter

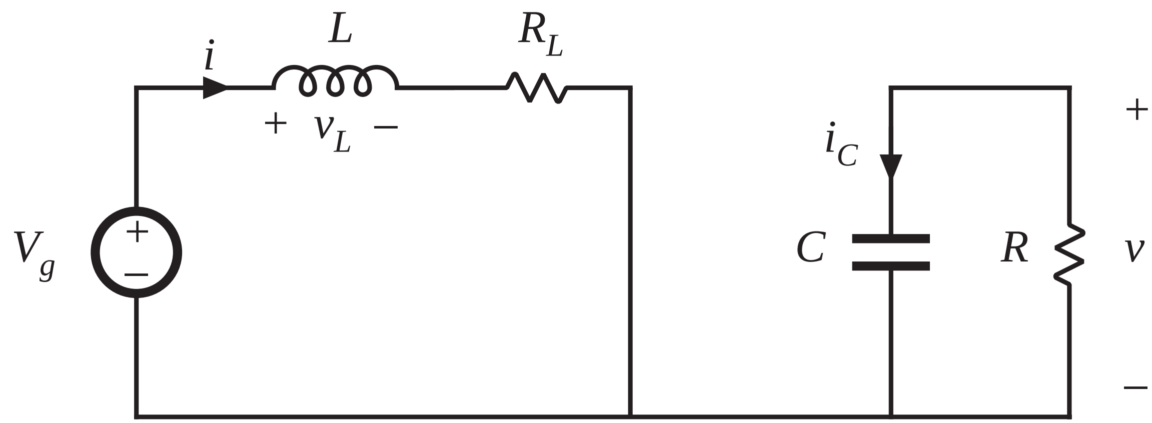


Circuit equations, switch in position 1

Inductor current and capacitor voltage:

$$v_L(t) = V_g - i(t)\, R_L$$

$$i_C(t) = -v(t) / R$$

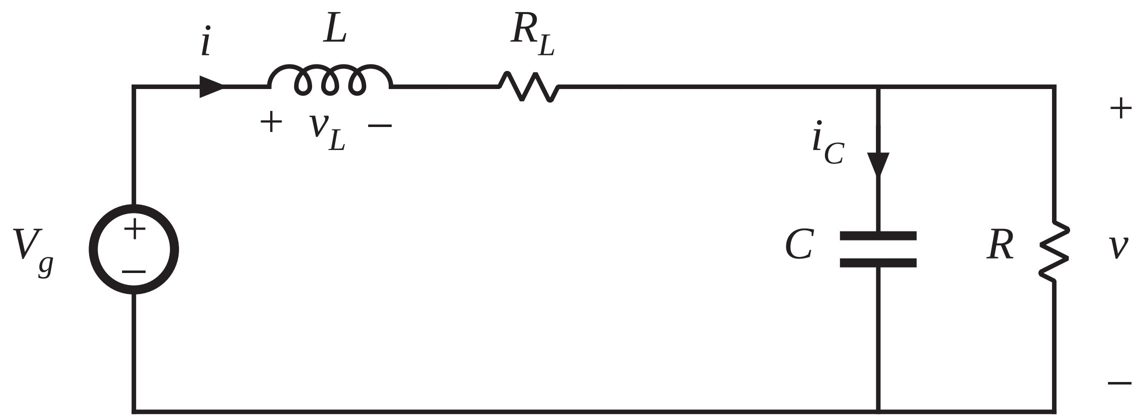


Small ripple approximation:

$$v_L(t) = V_g - I\, R_L$$

$$i_C(t) = -V / R$$

Circuit equations, switch in position 2



$$v_L(t) = V_g - i(t)\ R_L - v(t) \approx V_g - I\ R_L - V$$
$$i_C(t) = i(t) - v(t)\ /\ R \approx I - V\ /\ R$$

Inductor voltage and capacitor current waveforms

Average inductor voltage:

$$\left\langle v_L(t) \right\rangle = \frac{1}{T_s}\int_0^{T_s} v_L(t)dt$$

$$= D(V_g - I\,R_L) + D'(V_g - I\,R_L - V)$$

Inductor volt-second balance:

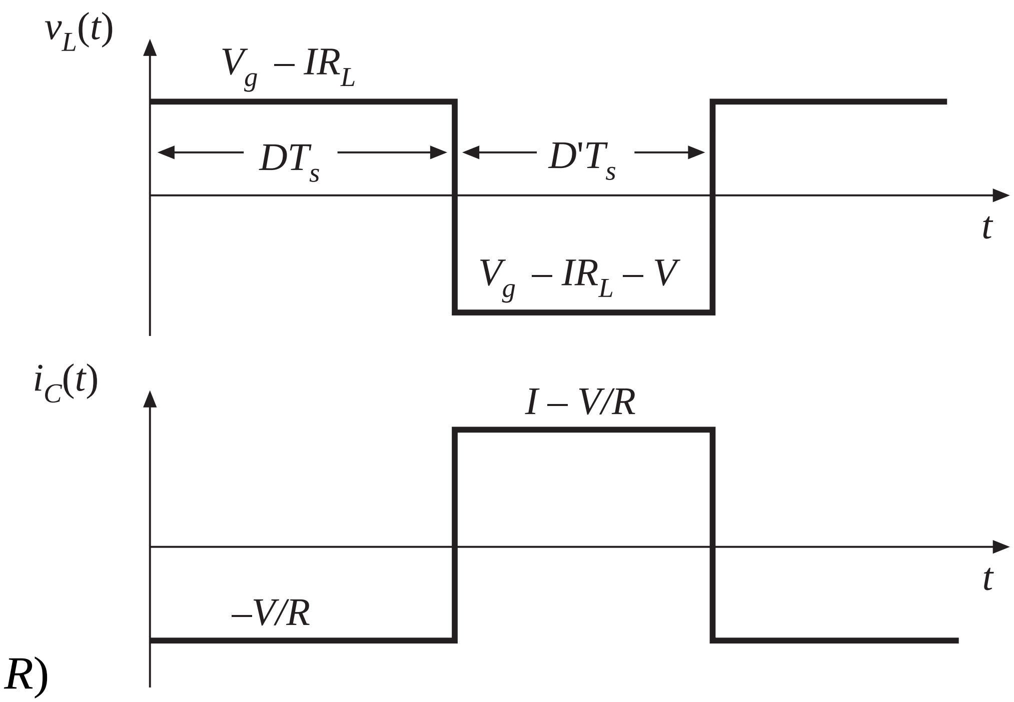
$$0 = V_g - I\,R_L - D'V$$

Average capacitor current:

$$\left\langle i_C(t) \right\rangle = D\,(-V/R) + D'\,(I - V/R)$$

Capacitor charge balance:

$$0 = D'I - V/R$$



Solution for output voltage

We now have two equations and two unknowns:

$$0 = V_g - I\,R_L - D'V$$

$$0 = D'I - V\,/\,R$$

Eliminate I and solve for V:

$$\frac{V}{V_g} = \frac{1}{D'}\,\frac{1}{(1 + R_L\,/\,D'^2R)}$$