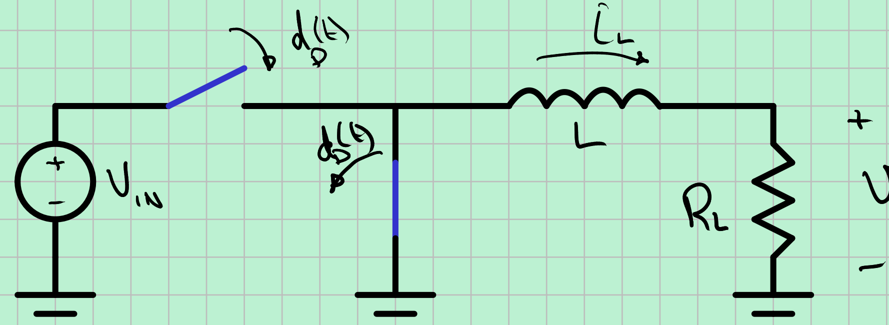
Buck Converter Without an Output Capacitor



$v_o = R_L i_L(t)$

For $d_D(t)$: $L\frac{di_L}{dt} = V_{IN} - v_o = V_{IN} - R_L i_L$

$$\frac{di_L}{dt} = \underbrace{-\frac{R_L}{L}}_{A} i_L + \underbrace{\frac{1}{L}}_{B} V_{IN}$$

For $1-d_D(t)$: $\frac{di_L}{dt} = -\frac{R_L}{L} + 0\, V_{IN}$

Average: $\frac{di_L}{dt} = -\frac{R}{L} i_L + \frac{1}{L} V_{IN} d_D(t)$

$$= -\frac{R}{L} i_L(t) + \frac{1}{L}\left(v_{IN}(t) + d_D(t)\right)$$

$v_{IN}(t) = V_{IN} + v_{in}(t)$ $\qquad$ $i_L(t) = I_L + i_\ell(t)$

$d_D(t) = D + d(t)$

$v_{IN}(t)\, d_D(t) \cong V_{IN}\, d(t) + D\, v_{in}(t) + DV_{IN}$

$$\frac{di_L}{dt} = 0 + \frac{di_\ell}{dt} = -\frac{R_L}{L} I_L - \frac{R_L}{L} i_\ell(t) + \frac{V_{IN}}{L} d(t) + \frac{D}{L} v_{in}(t) + DV_{IN}$$

Equate large signals. $-\frac{R_L}{\cancel{L}} I_L + \frac{DV_{IN}}{\cancel{L}} = 0$

$$v_o(t) = V_o + \tilde{v}_o(t) = R_L i_L(t)$$

$$V_o = R_L I_L = D V_{IN}$$ Operating Q Point

Equate small signals:

$$\frac{di_\ell}{dt} = -\frac{R_L}{L} i_\ell + \frac{V_{IN}}{L} d(t) + \frac{D}{L} v_{in}(t)$$

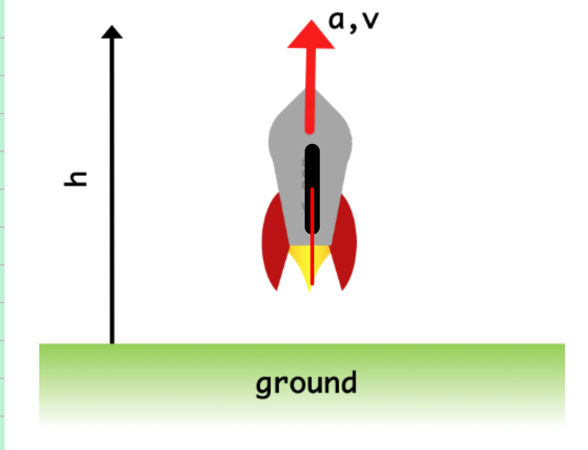
$$= -\frac{R_L}{L} i_\ell + \begin{bmatrix} \frac{V_{IN}}{L} & \frac{D}{L} \end{bmatrix} \begin{bmatrix} d(t) \\ v_{in}(t) \end{bmatrix}$$

$v_{in}(t)$ is a disturbance.

$d(t)$ is a control input. Use $d(t) = -K i_\ell(t)$

The pole is at $-\frac{R_L}{L} - \frac{V_{IN}}{L} K$.

See the tradeoff between speed and robustness.
Pick $K<0$ to speed up the response, but watch out. What if R_L changes?
According to the Q point it won't change.
If the inductor has some winding resistance, it will have a voltage divider effect.
To compensate D will be larger.
Without C in the output there should be no discontinuous conduction mode.



a,v
h
ground