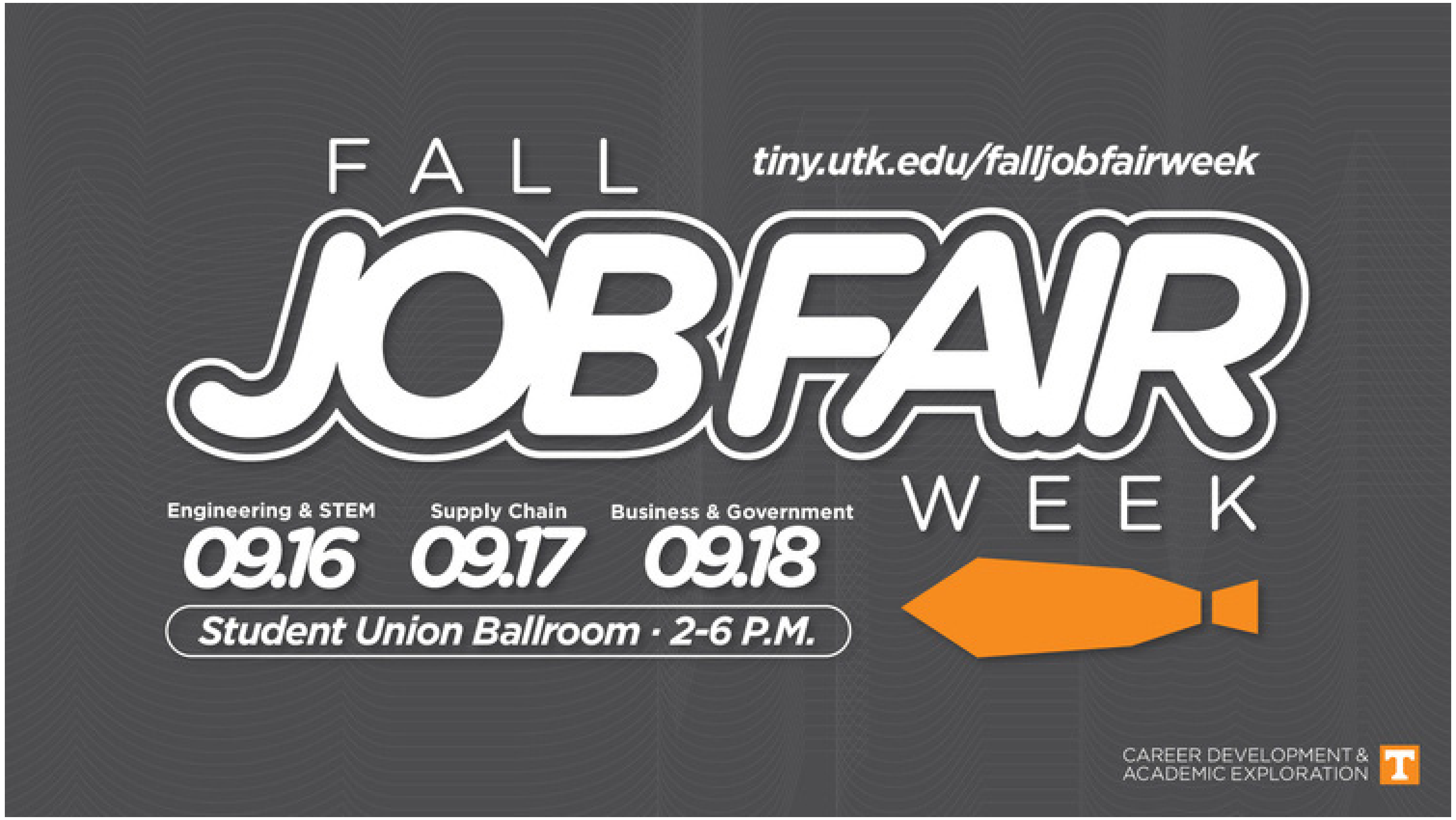
Announcements

- Engineering Job Fair – Sept 16th, 2-6:00pm
  - tiny.utk.edu/EngFair

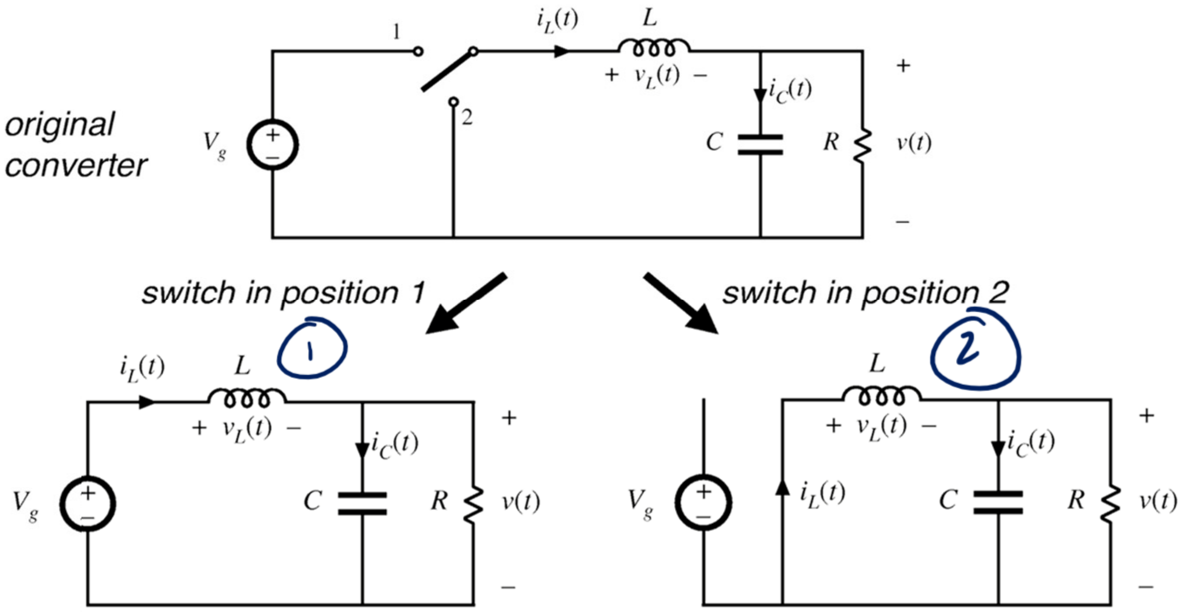


TEXAS INSTRUMENTS

- Analog Design Engineer
- Digital Design Engineer
- Systems Engineer
- Test Engineer
- Applications Engineer
- Layout Designer

Juniors up to grad students

Volt-Second Balance: Direct Application



$$\langle v_L \rangle \big|_{T_s} = 0 = \frac{1}{T_s}\left[V_{L_1} t_1 + V_{L_2} t_2 \right]$$

$$0 = \frac{1}{T_s}\left[(V_g - V) D T_s + (-V) D' T_s \right]$$

$$0 = (V_g - V) D + (-V) D'$$

$$0 = D V_g - V \quad \rightarrow \quad \boxed{V = D V_g} \quad \boxed{M = \frac{V}{V_g} = D}$$

Current Ripple Magnitude

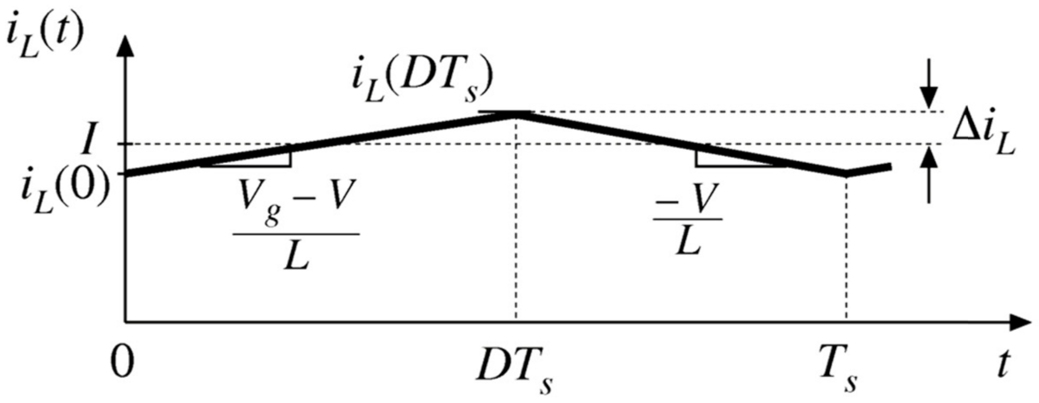
Δi_L = peak-to-average current ripple in steady-state

$$2\Delta i_L = \frac{V_g - V}{L} DT_s$$

$V = DV_g$ from volt-sec balance

$$\Delta i_L = \frac{V_g - DV_g}{2L} DT_s$$

$$\Delta i_L = \frac{V_g}{2L} D' D T_s$$

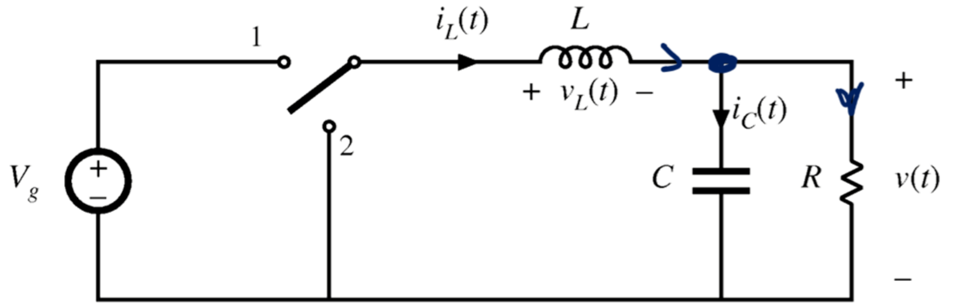


(change in i_L) = (slope)(length of subinterval)

Reduce Δi_L by

1. Increase L
2. Decrease T_s ⟷ Increase f_s

Buck Cap Charge Balance → Dual of volt-second Balance



In ①

$$i_c(t) = i_L(t) - \frac{v(t)}{R}$$

↓ SRA

$$i_c(t) = I_L - \frac{V}{R}$$

In ②

$$i_c(t) = i_L(t) - \frac{v(t)}{R}$$

↓ SRA

||

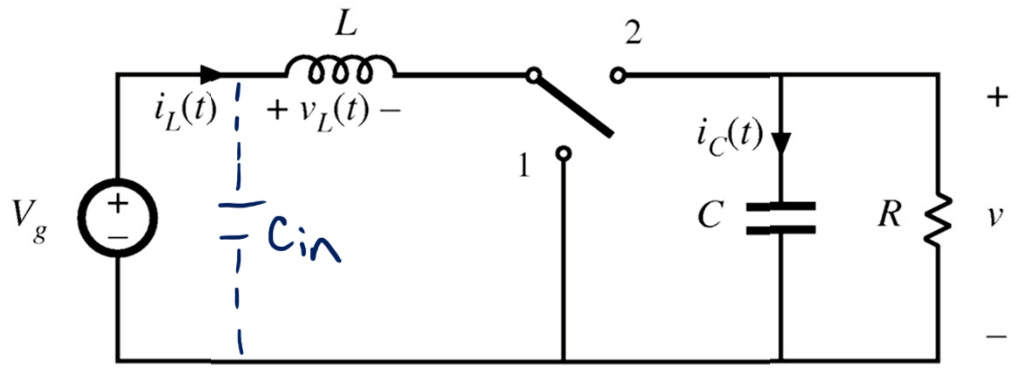
Cap-charge Balance

$$\langle i_c \rangle \Big|_{T_s} = 0 = \frac{1}{T_s}\left[DT_s\left(I_L - \frac{V}{R}\right) + D'T_s\left(I_L - \frac{V}{R}\right)\right]$$

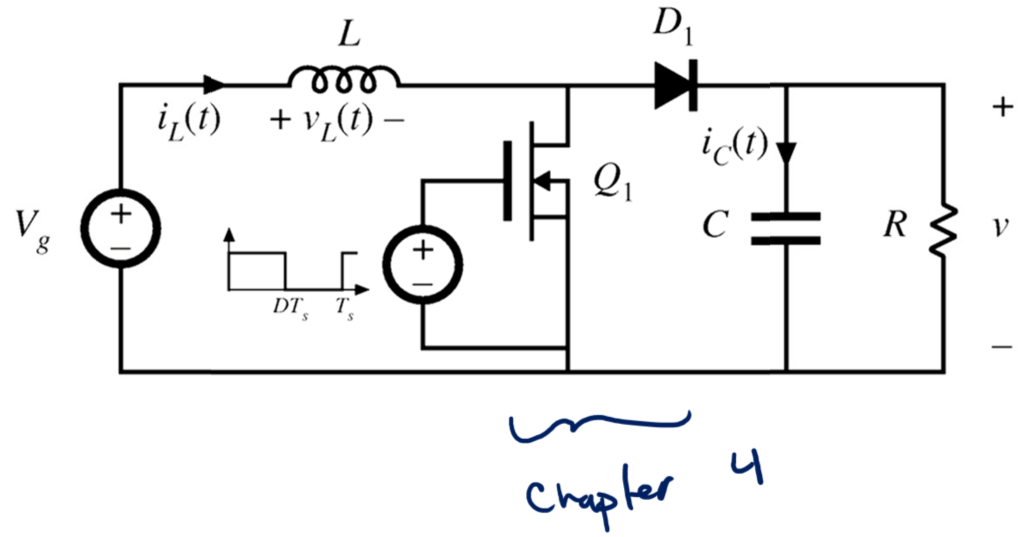
$$0 = I_L - \frac{V}{R} \quad \rightarrow \quad \boxed{I_L = \frac{V}{R}}$$

The Boost Converter

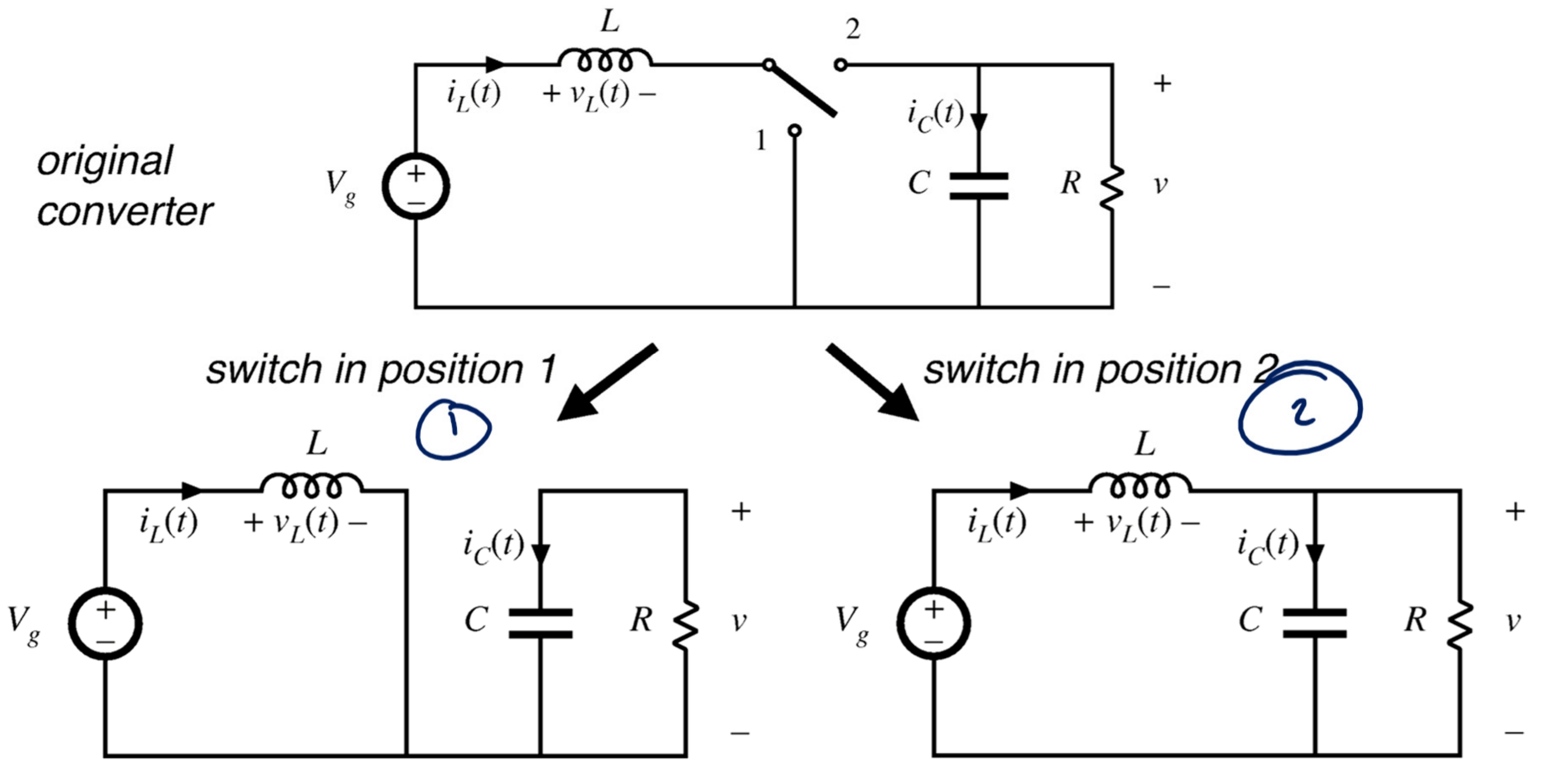
Boost converter with ideal switch



Realization using power MOSFET and diode



Boost Subintervals



Boost: Subinterval 1

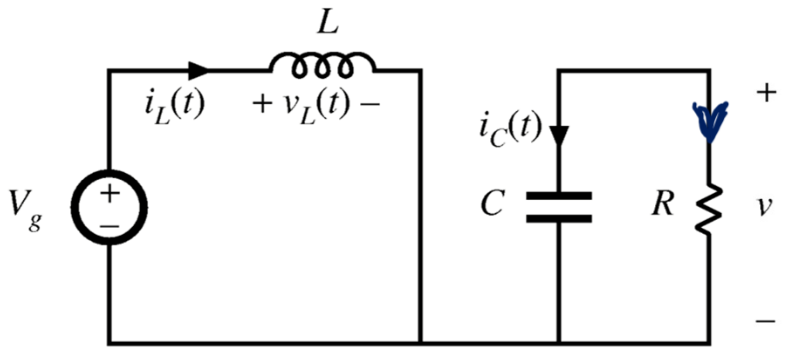
$v_L(t) = V_g$

$i_C(t) = -\frac{v(t)}{R}$

↓ Apply SRA

$i_C(t) = -\frac{V}{R}$

①



Boost: Subinterval 2

$$v_L(t) = V_g - v(t)$$

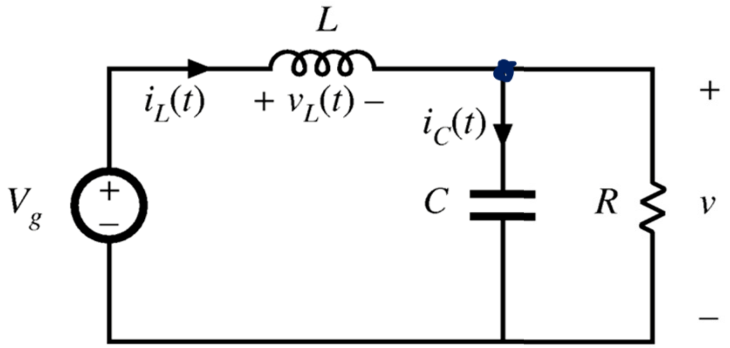
$\downarrow$ Apply SRA

$$v_L(t) = V_g - V$$

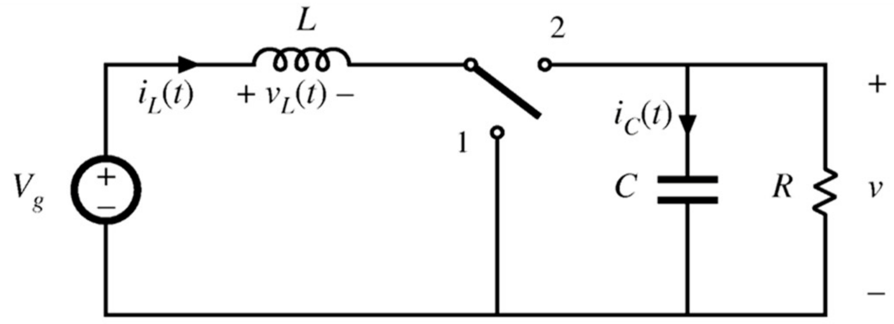
$$i_C(t) = i_L(t) - \frac{v(t)}{R}$$

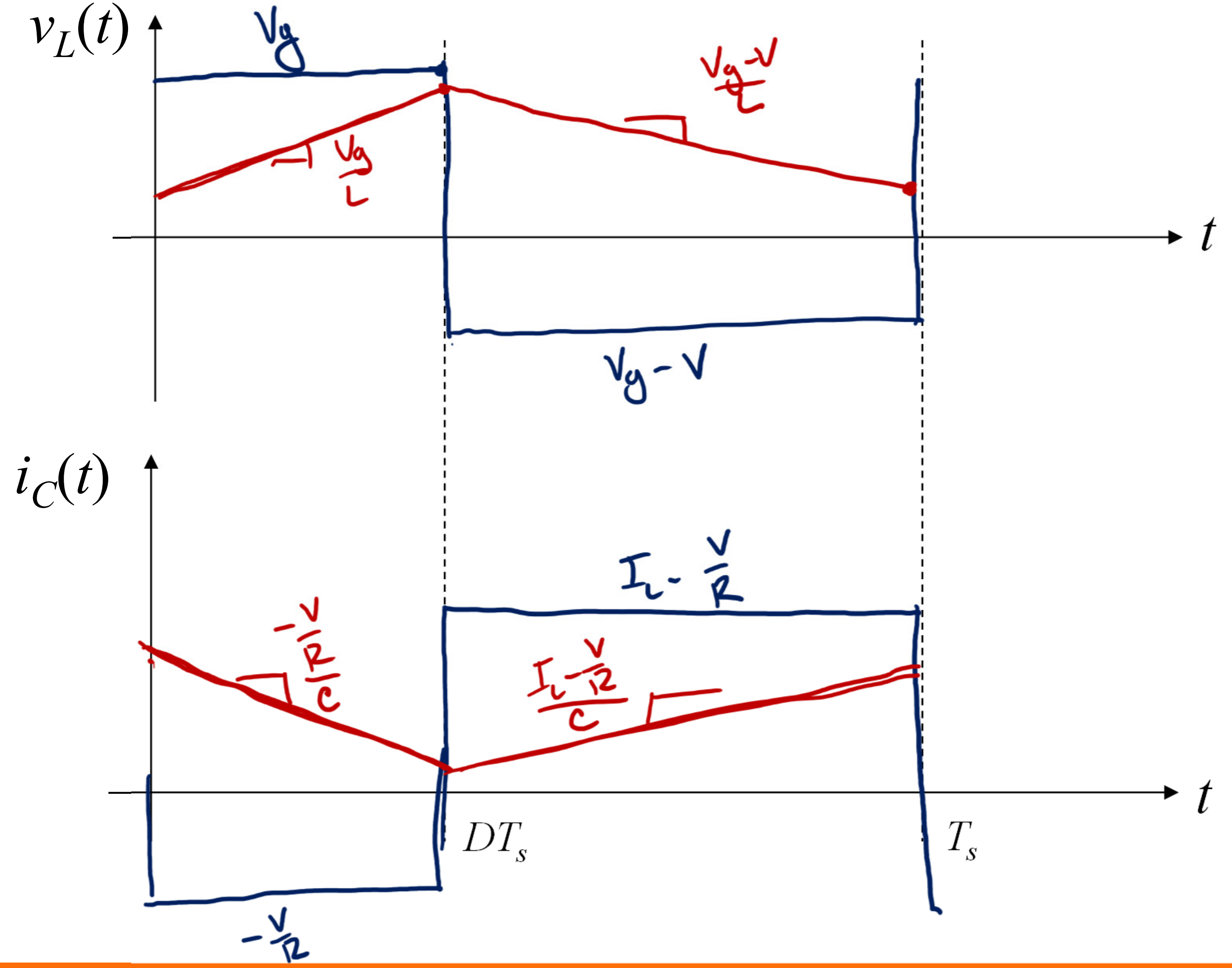
$\downarrow$ SRA

$$i_C(t) = I_L - \frac{V}{R}$$



Waveforms





Volt-sec balance

$$\langle v_L \rangle \big|_{T_s} = V_g - D'V = 0$$

$$V = \frac{1}{D'} V_g$$

$$M = \frac{V}{V_g} = \frac{1}{D'}$$

$$\langle i_C \rangle \big|_{T_s} = D' I_L - \frac{V}{R} = 0$$

$$I_L = \frac{1}{D'} \frac{V}{R}$$

Boost: Conversion Ratio