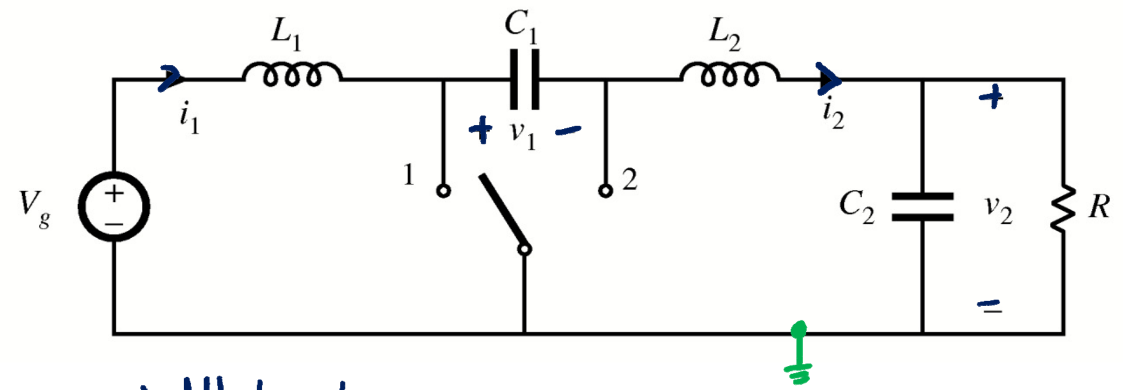
Ćuk Converter



Robert Middlebrook
PhD in 1955 on FET modeling
- "Design-oriented Analysis"

Slobodan Ćuk (PhD 1976) → Prof @ Caltech
- Average Modeling of SMPS

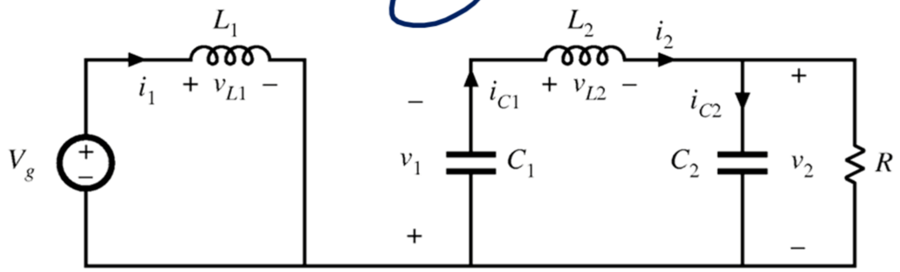
Robert Erickson (PhD 1982)
- large-signal models of SMPS

Dragan Maksimović (PhD 1989)
- Synthesis of Power Converters

→ Authors of our textbook
↳ Both Professors @ University of Colorado

Cuk Equivalent Circuits

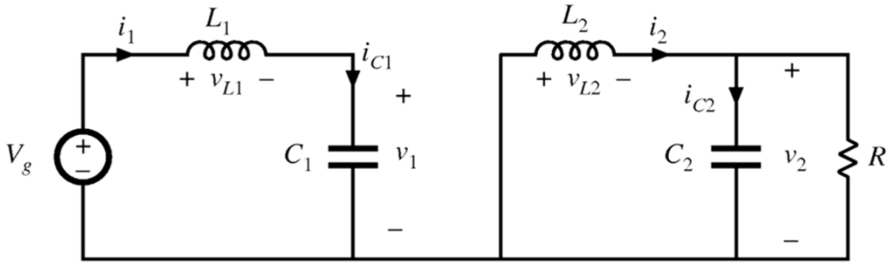
(1)



Apply SRA

$$v_{L1} = V_g$$
$$v_{L2} = -V_1 - V_2$$
$$i_{C1} = I_2$$
$$i_{C2} = I_2 - \frac{V_2}{R}$$

(2)

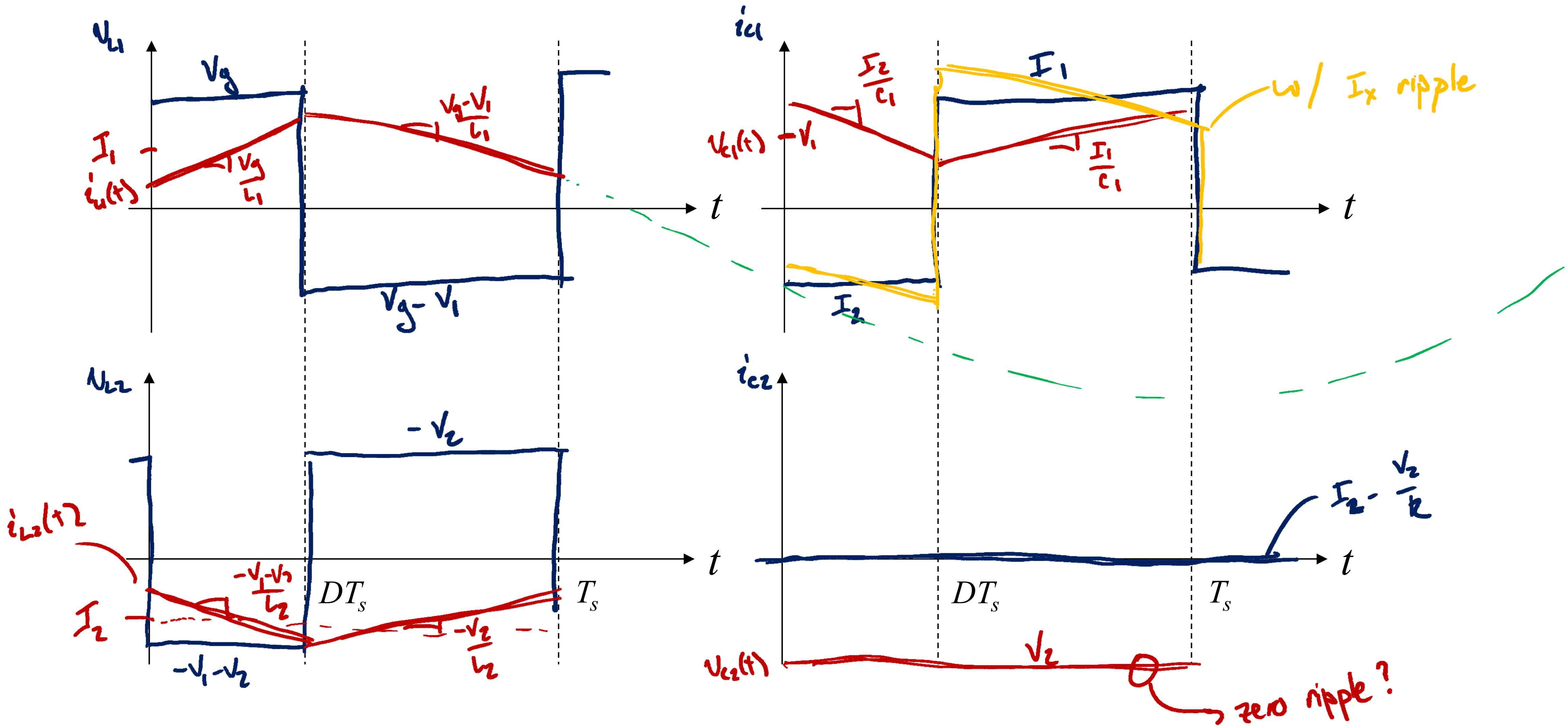


$$v_{L1} = V_g - V_1$$
$$v_{L2} = -V_2$$
$$i_{C1} = I_1$$
$$i_{C2} = I_2 - \frac{V_2}{R}$$

We want to write

$$v_{Lx} = f(V_{src} \;\&\; V_{Cx}, \text{ or } I_x R_y)$$
$$i_{Cx} = f\left(I_{src} \;\&\; I_{Lx}, \text{ or } \frac{V_x}{R_y}\right)$$

Cuk Converter Waveforms



Waveform Averaging

Volt-second Balance:

$\langle v_{L1} \rangle |_{T_s} = 0 = V_g - D' V_1 \longrightarrow V_1 = \frac{V_g}{D'}$

$\langle v_{L2} \rangle |_{T_s} = 0 = D(-V_1) - V_2 \longrightarrow V_2 = -D V_1$

$$V_2 = -\frac{D}{D'} V_g$$

$$M(D) = -\frac{D}{D'} = \frac{V_2}{V_g}$$

Cap-Charge Balance

$\langle i_{C1} \rangle |_{T_s} = 0 = D I_2 + D' I_1 \longrightarrow I_1 = -\frac{D}{D'} I_2$

$\langle i_{C2} \rangle |_{T_s} = 0 = I_2 - \frac{V_2}{R} \longrightarrow I_2 = \frac{V_2}{R}$

$$\eta = \frac{P_{out}}{P_{in}} = \frac{V_2^2/R}{V_g \cdot I_1} = \frac{V_2 I_2}{V_g \left(\frac{-D}{D'} I_2\right)} = \frac{-\left(\frac{D}{D'}\right) V_g I_2}{V_g \left(\frac{-D}{D'}\right) I_2} = 1 \checkmark$$

– 100% efficiency in a lossless converter in steady-state

Cuk Conversion Ratio