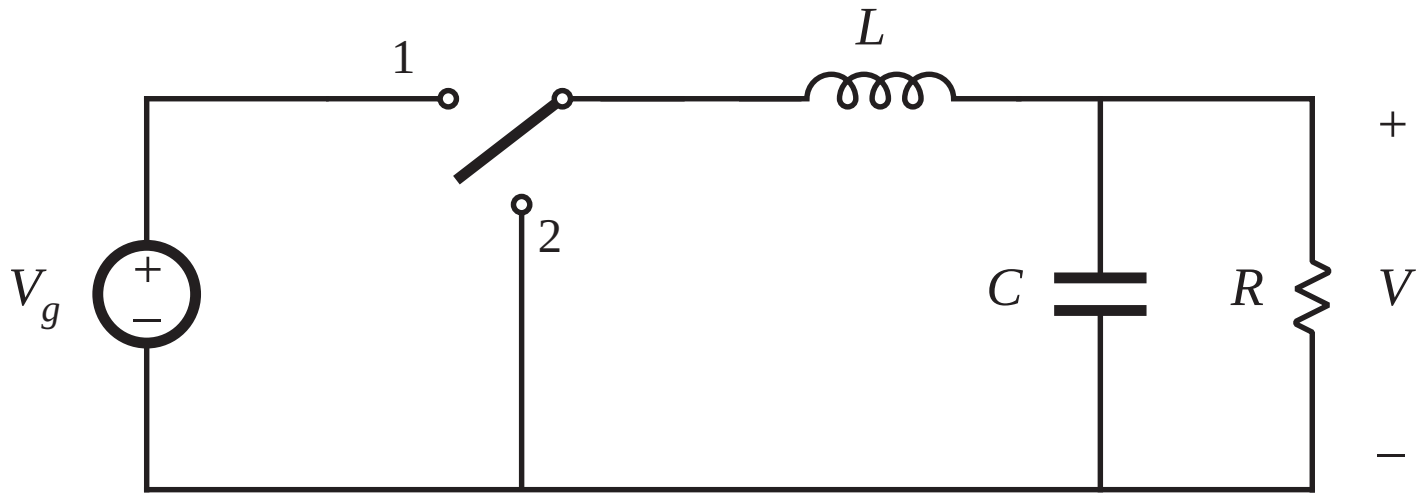
6.1. Circuit Manipulations



Begin with buck converter: derived in Chapter 1 from first principles

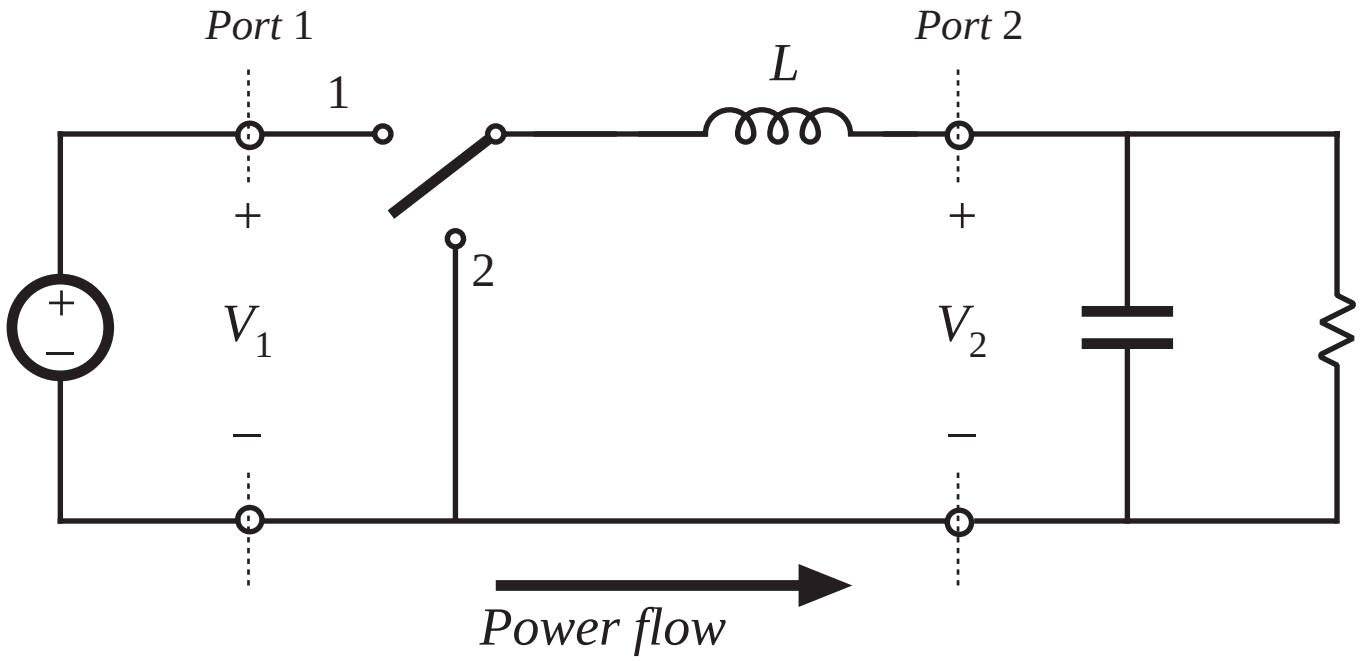
- Switch changes dc component, low-pass filter removes switching harmonics
- Conversion ratio is $M = D$

6.1.1. Inversion of source and load

Interchange power input and output ports of a converter

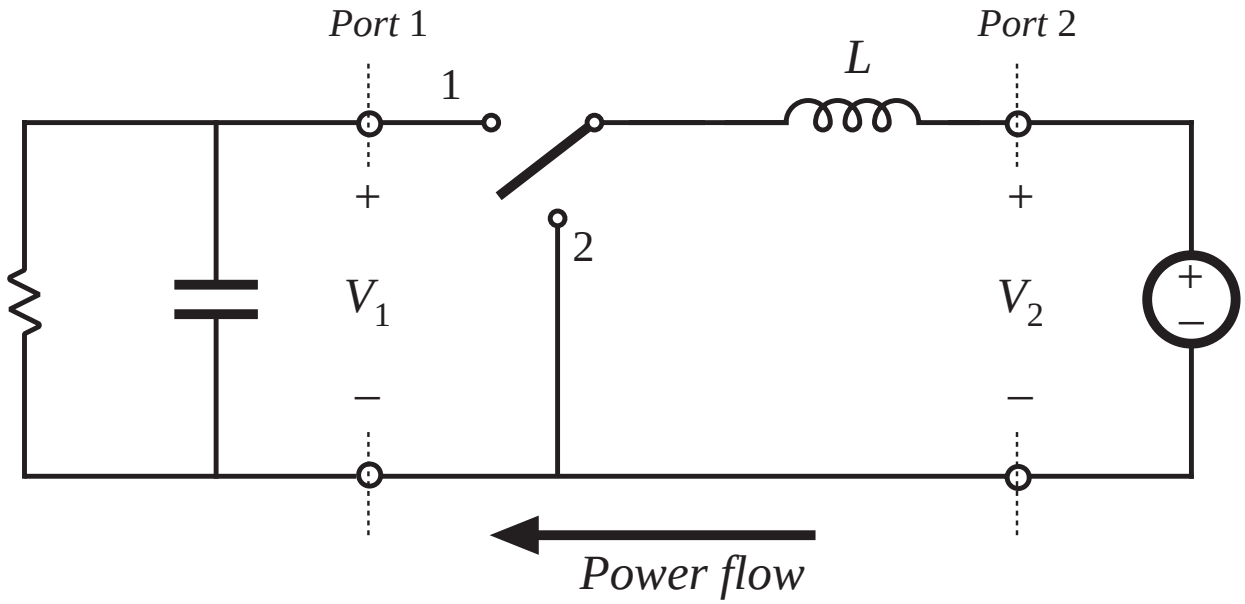
Buck converter example

$$V_2 = DV_1$$



Inversion of source and load

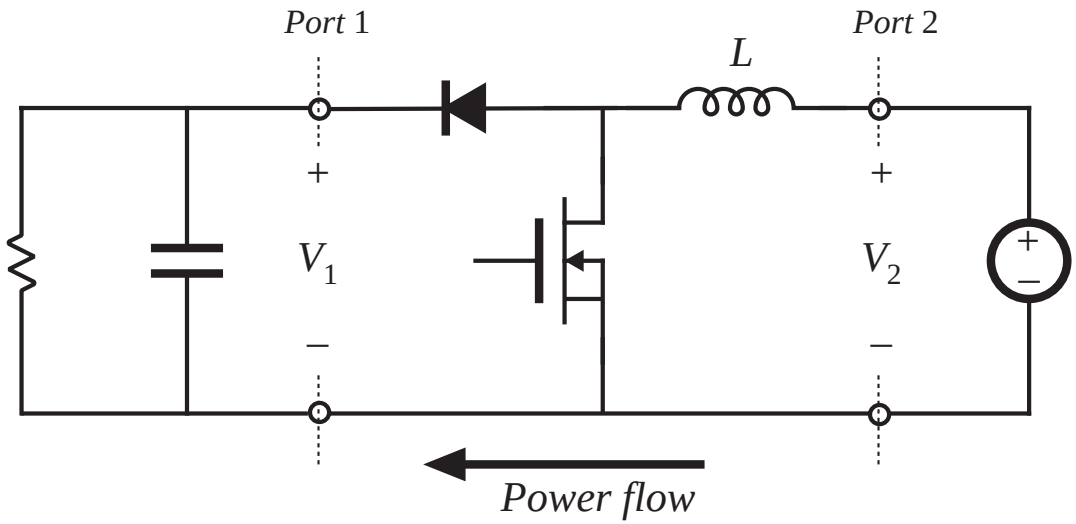
Interchange power source and load:



$$V_2 = DV_1 \qquad V_1 = \frac{1}{D} V_2$$

Realization of switches as in Chapter 4

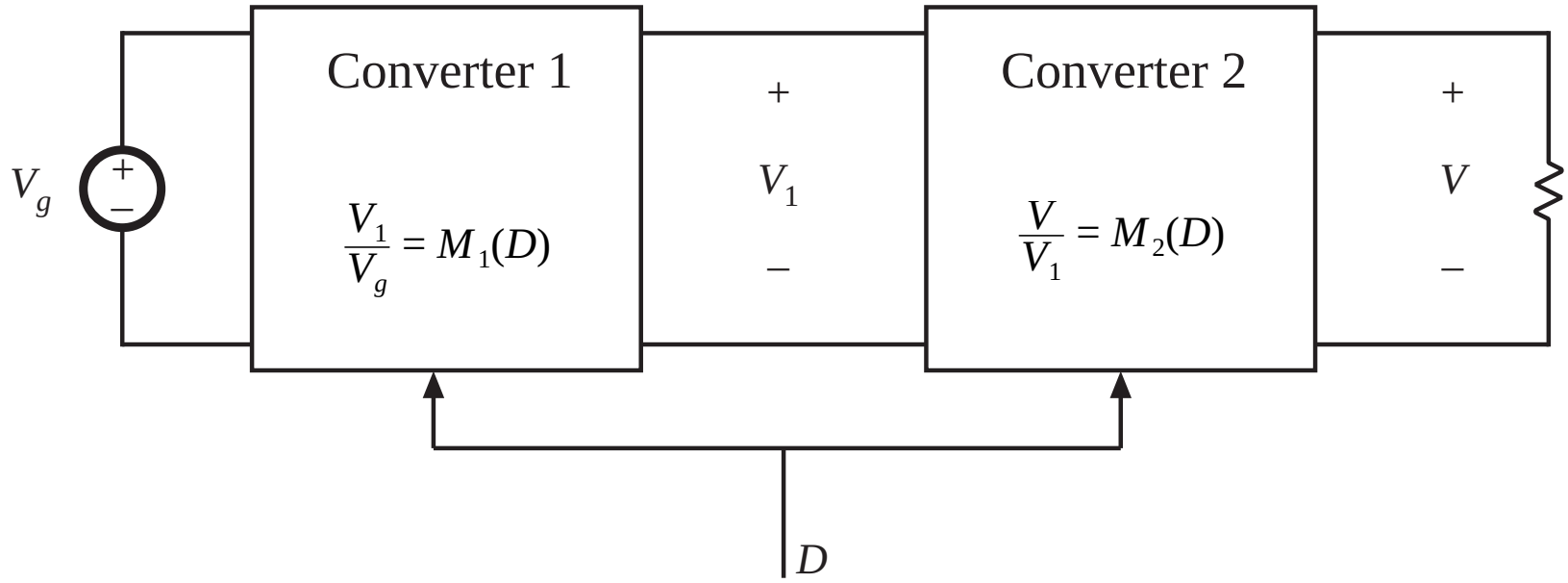
- Reversal of power flow requires new realization of switches
- Transistor conducts when switch is in position 2
- Interchange of D and D'



$$V_1 = \frac{1}{D'} V_2$$

Inversion of buck converter yields boost converter

6.1.2. Cascade connection of converters

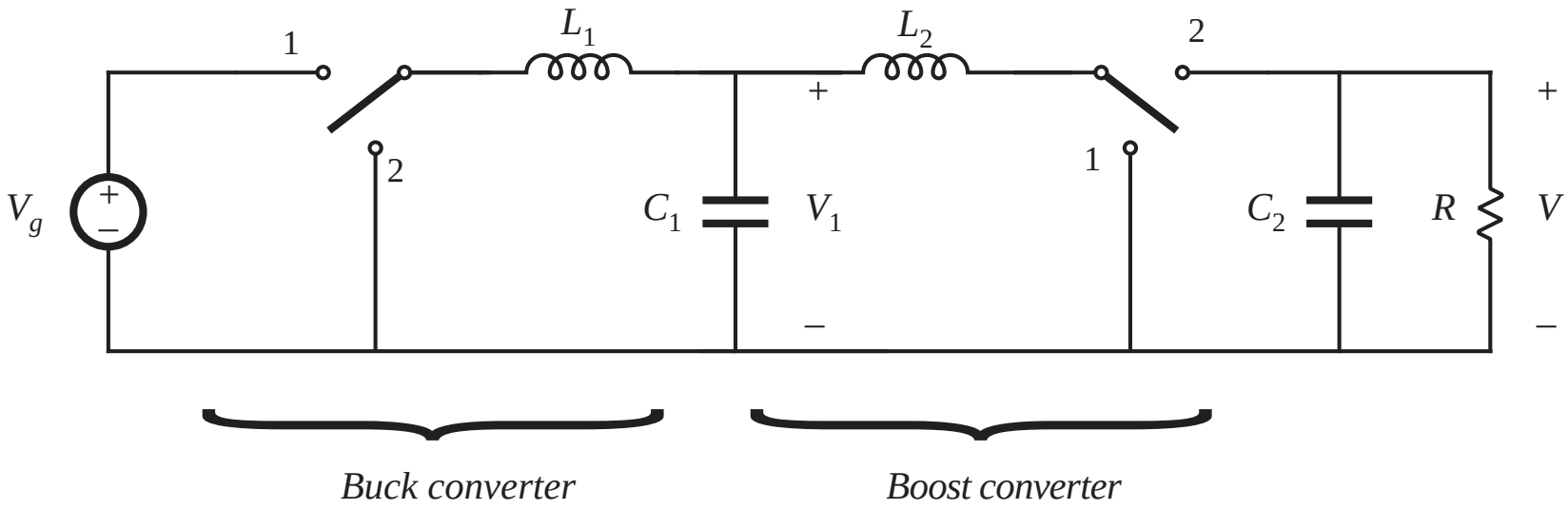


$$V_1 = M_1(D)V_g$$

$$V = M_2(D)V_1$$

$$\rightarrow \quad \frac{V}{V_g} = M(D) = M_1(D)M_2(D)$$

Example: buck cascaded by boost



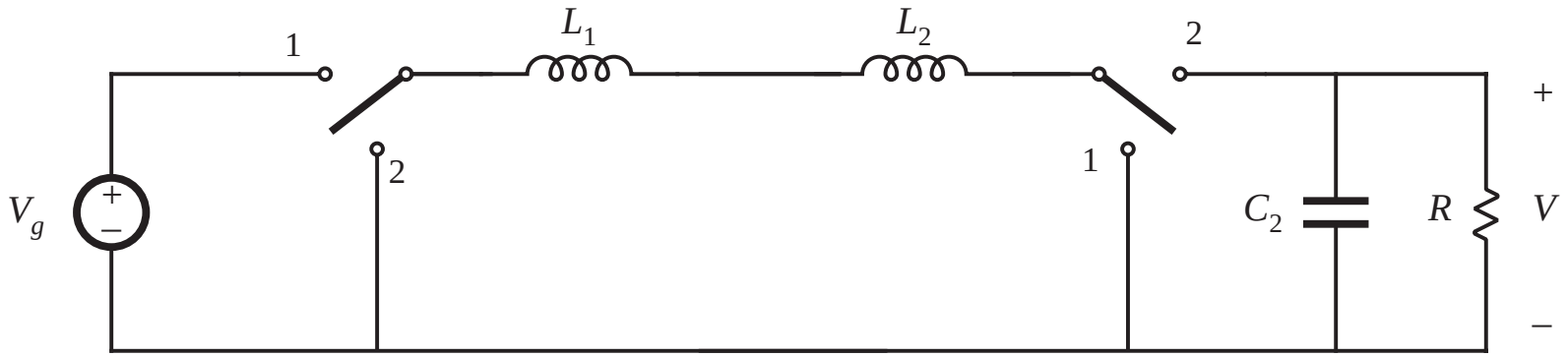
$$\frac{V_1}{V_g} = D$$

$$\frac{V}{V_1} = \frac{1}{1-D}$$

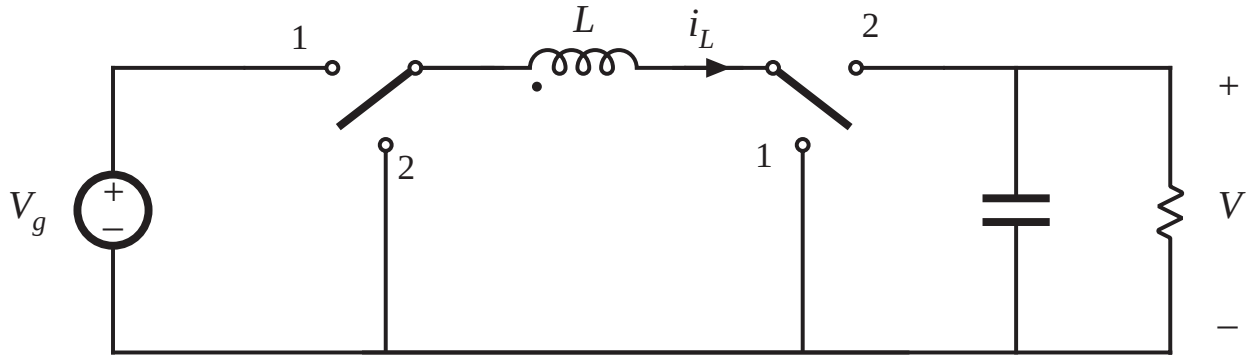
$$\longrightarrow \quad \frac{V}{V_g} = \frac{D}{1-D}$$

Buck cascaded by boost: simplification of internal filter

Remove capacitor C_1

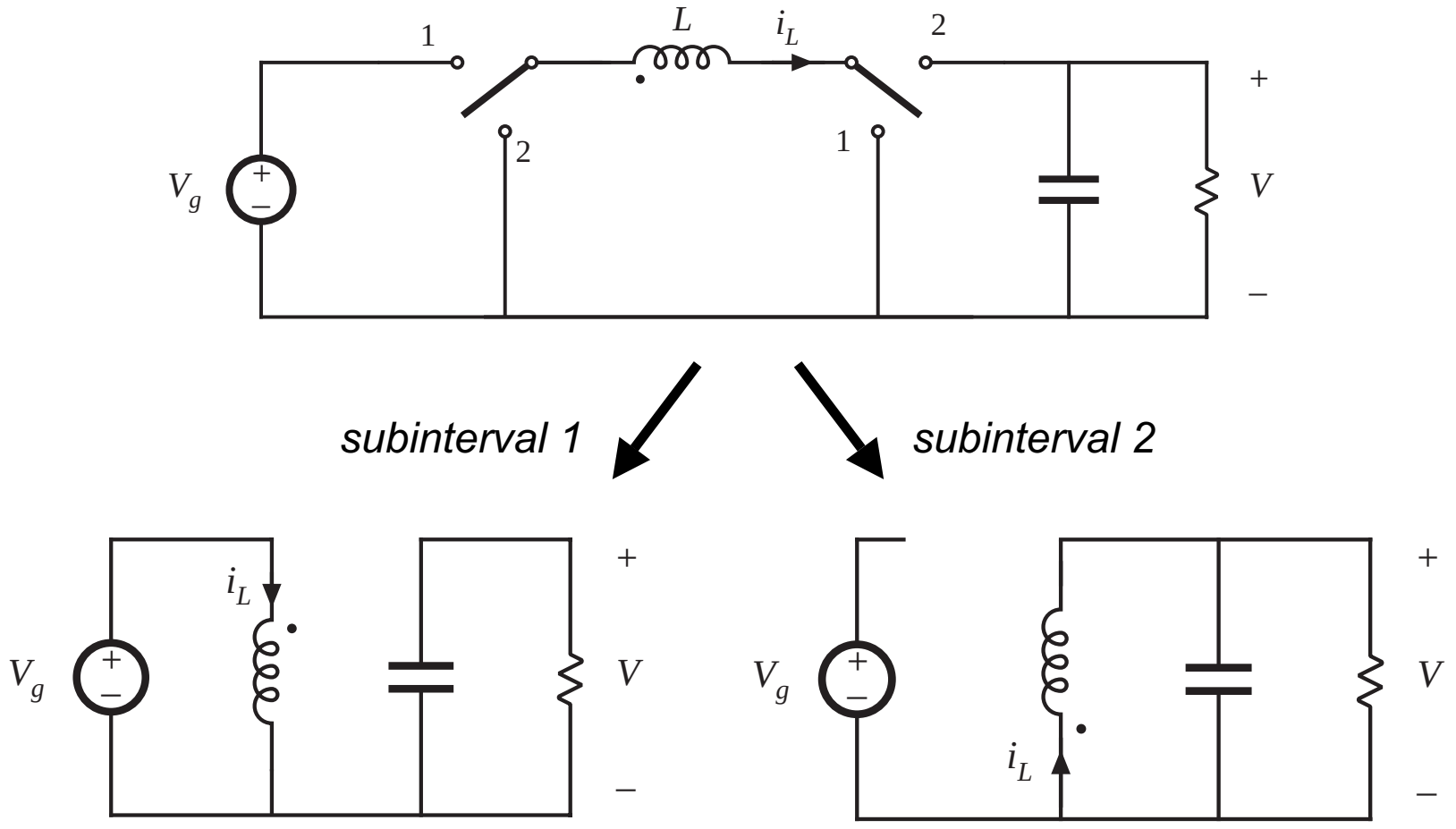


Combine inductors L_1 and L_2

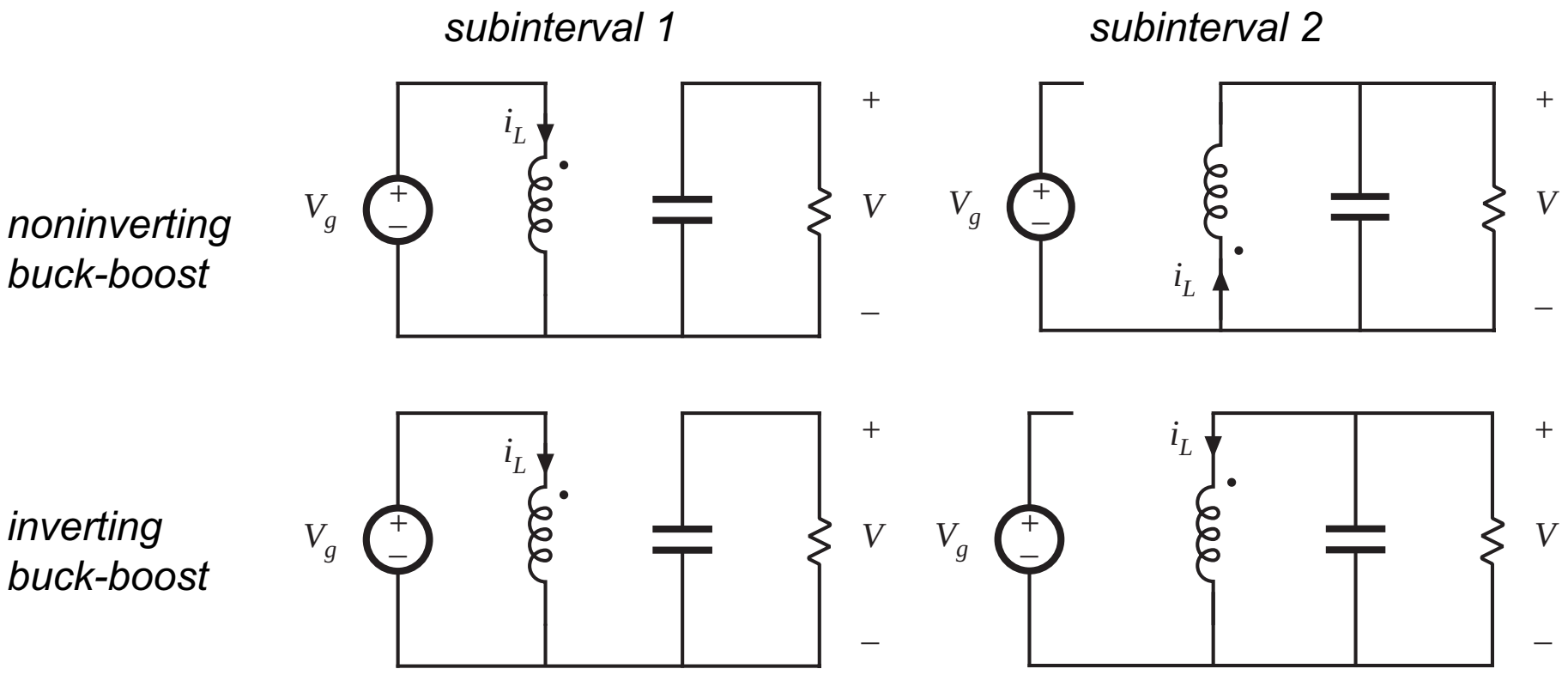


Noninverting buck-boost converter

Noninverting buck-boost converter

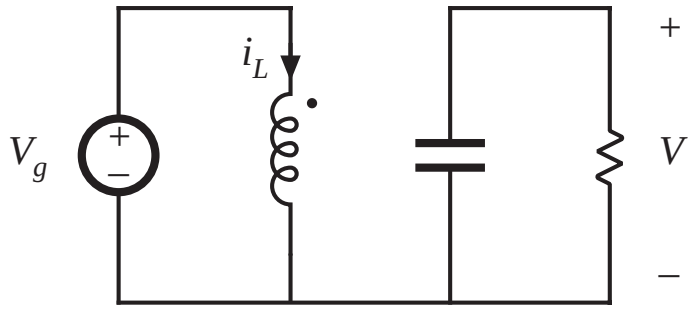


Reversal of output voltage polarity

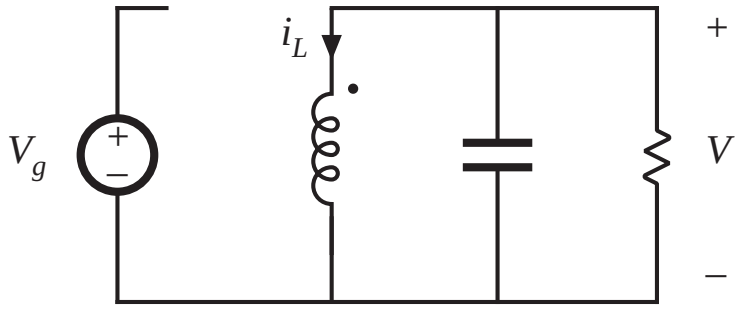


Reduction of number of switches: inverting buck-boost

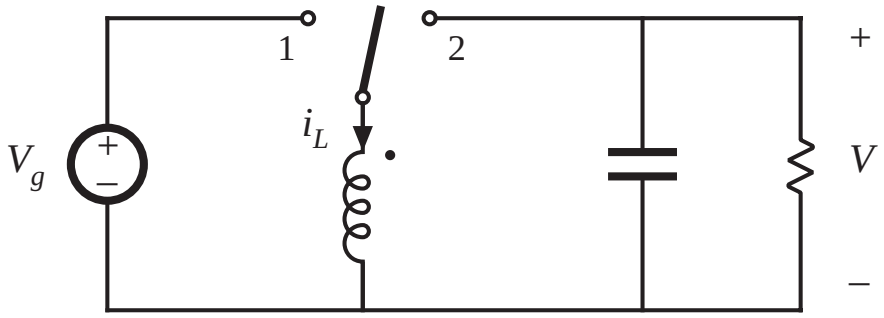
Subinterval 1



Subinterval 2



One side of inductor always connected to ground
— hence, only one SPDT switch needed:



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

Discussion: cascade connections

- Properties of buck-boost converter follow from its derivation as buck cascaded by boost

  Equivalent circuit model: buck 1:D transformer cascaded by boost D':1 transformer

  Pulsating input current of buck converter

  Pulsating output current of boost converter

- Other cascade connections are possible

  Cuk converter: boost cascaded by buck