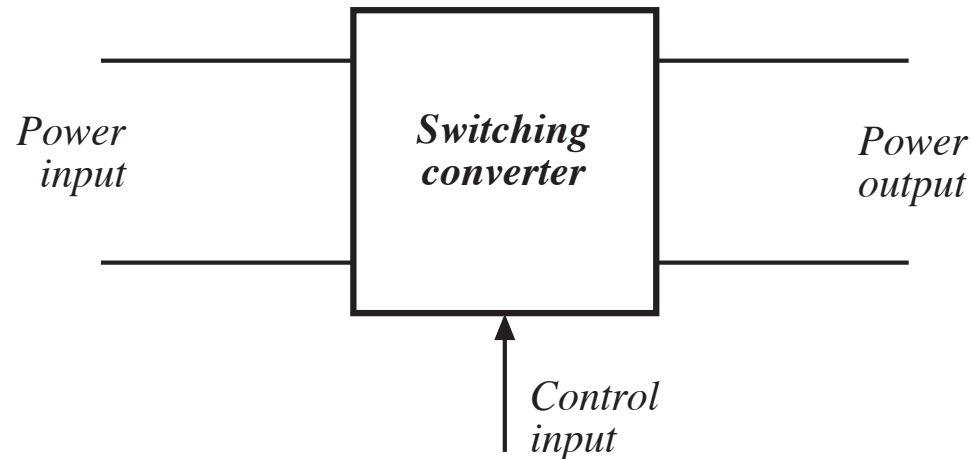


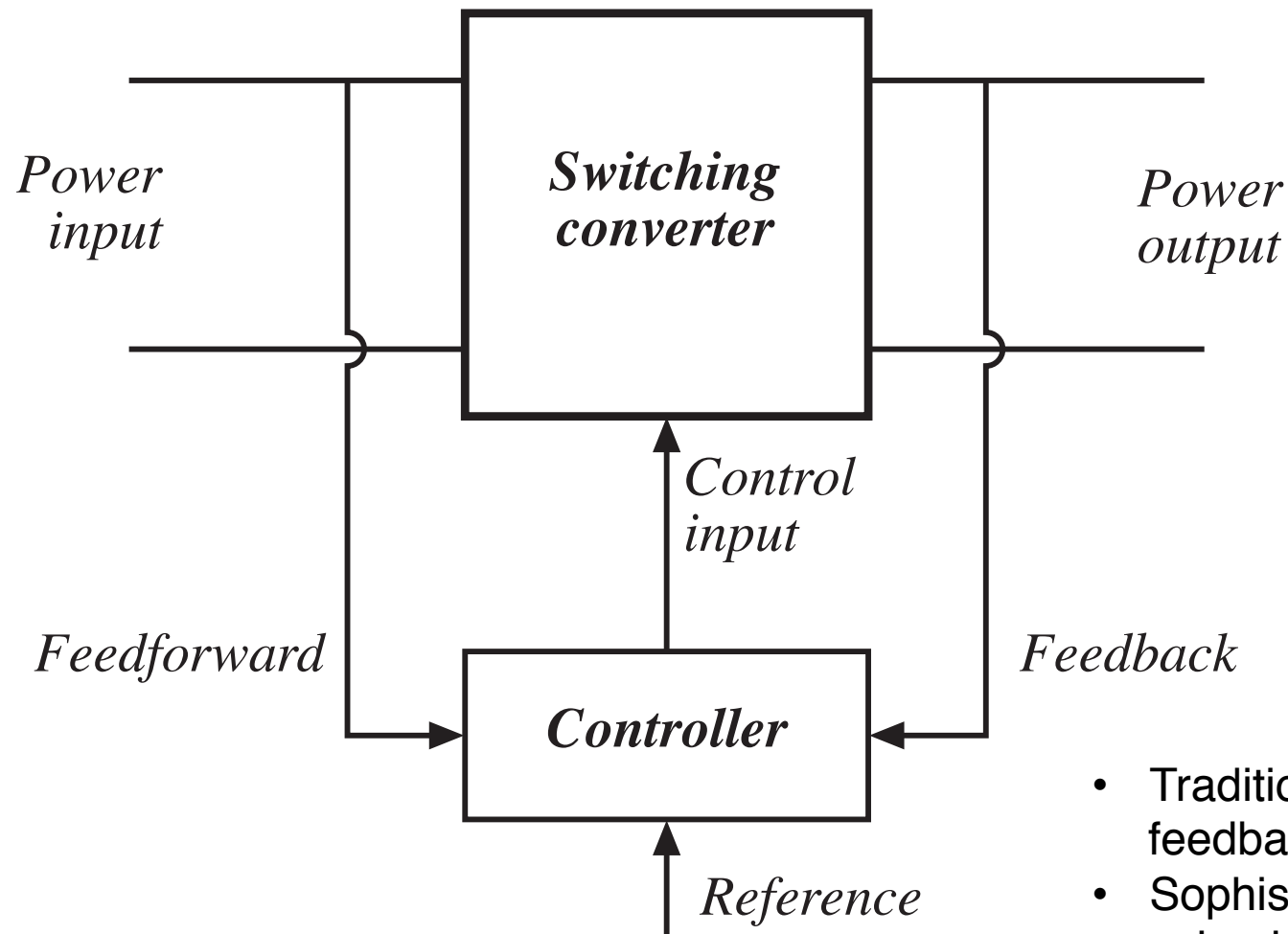
1.1 Introduction to Power Processing



- Dc-dc conversion:* Change and control voltage magnitude
- Ac-dc rectification:* Possibly control dc voltage, ac current
- Dc-ac inversion:* Produce sinusoid of controllable magnitude and frequency
- Ac-ac cycloconversion:* Change and control voltage magnitude and frequency

The switching converter is the “brain” of the power system, allowing conversion of voltage and current levels with high efficiency, plus control

Control is invariably required



- Traditional analog feedback
- Sophisticated control using inexpensive digital microcontrollers

High Efficiency is Essential

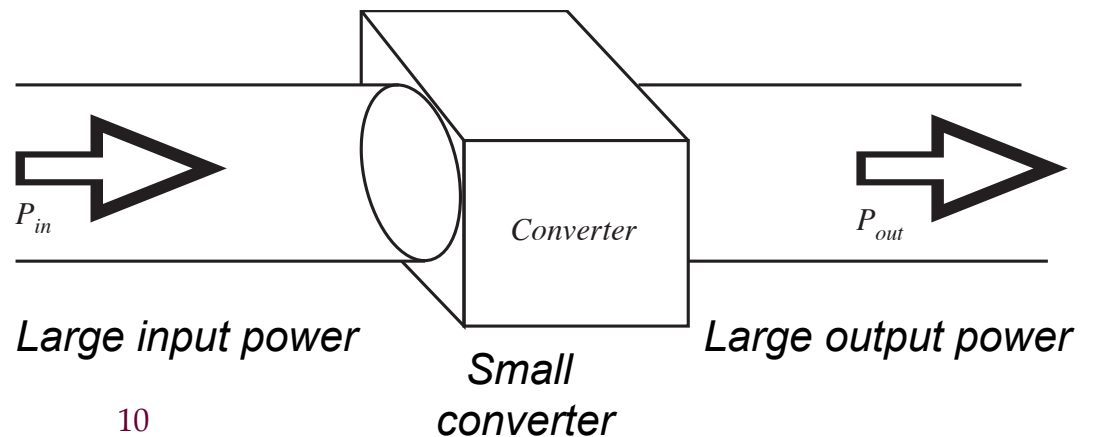
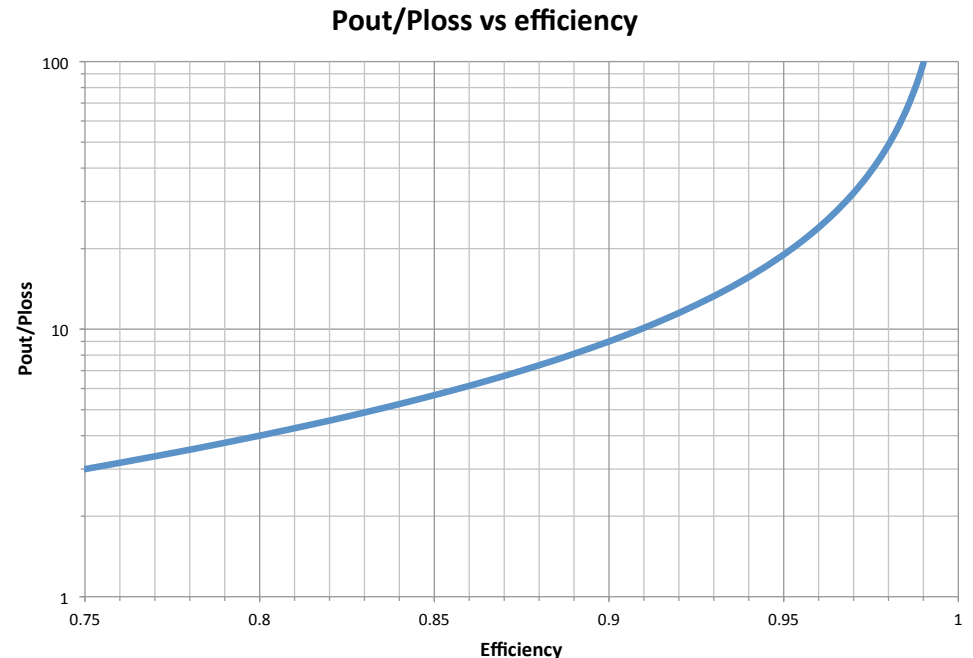
$$\eta = \frac{P_{out}}{P_{in}}$$

$$P_{loss} = P_{in} - P_{out} = P_{out} \left(\frac{1}{\eta} - 1 \right)$$

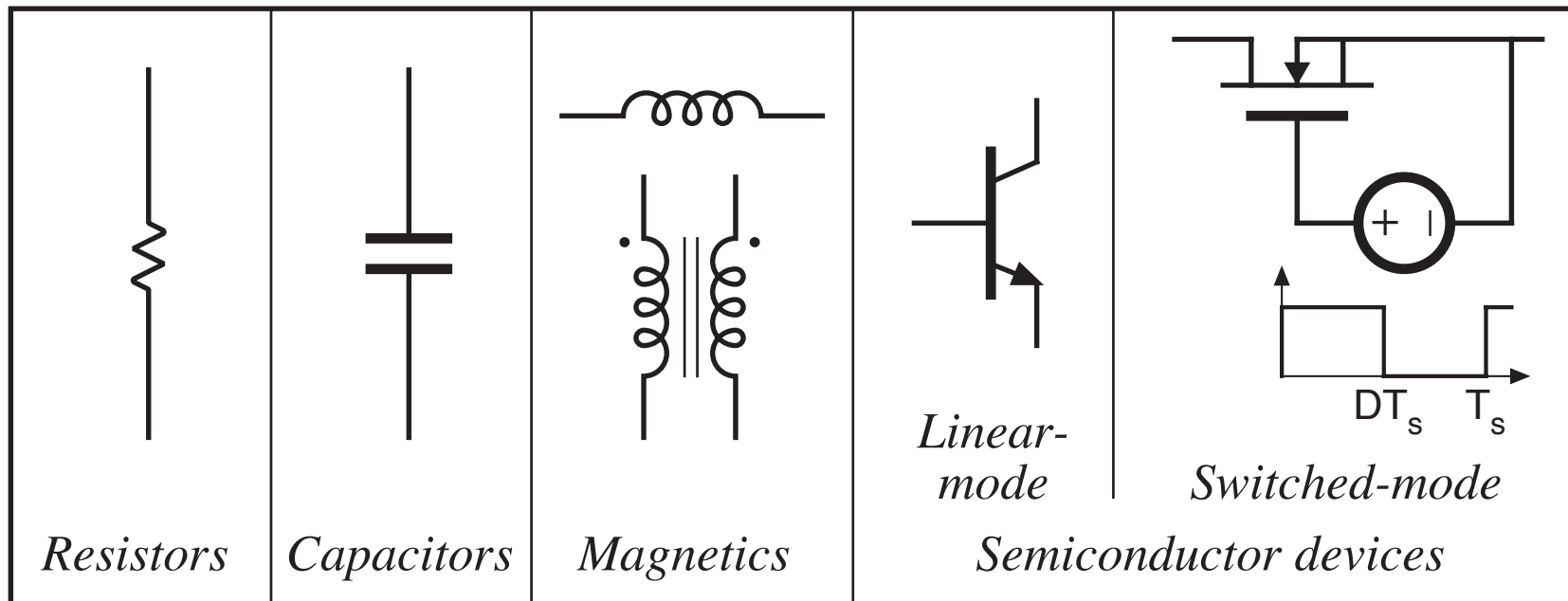
- High efficiency leads to low power loss within converter
- Small size and reliable operation is then feasible
- A good measure of converter performance is the ratio of output power to loss:

$$\frac{P_{out}}{P_{loss}} = \frac{\eta}{1 - \eta}$$

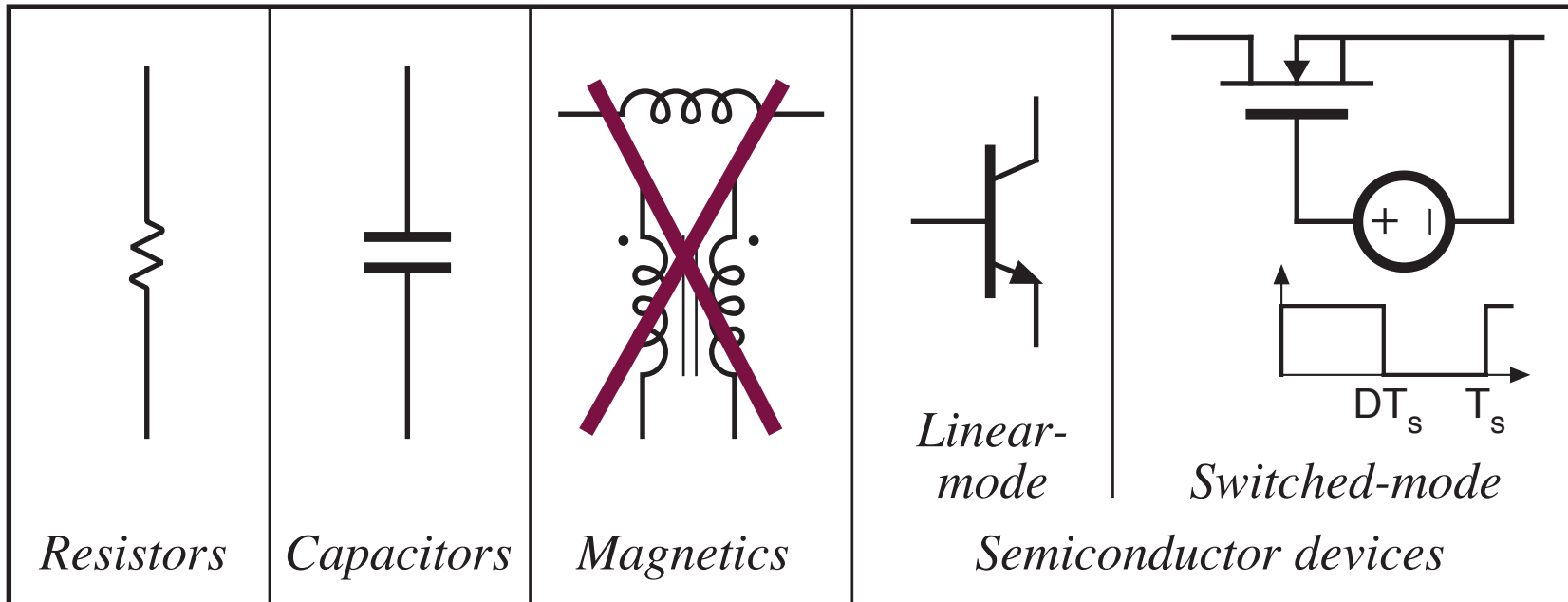
Converters generally are loss-limited, and technologies that can produce large output power while incurring small loss result in small size and low cost



Devices available to the circuit designer

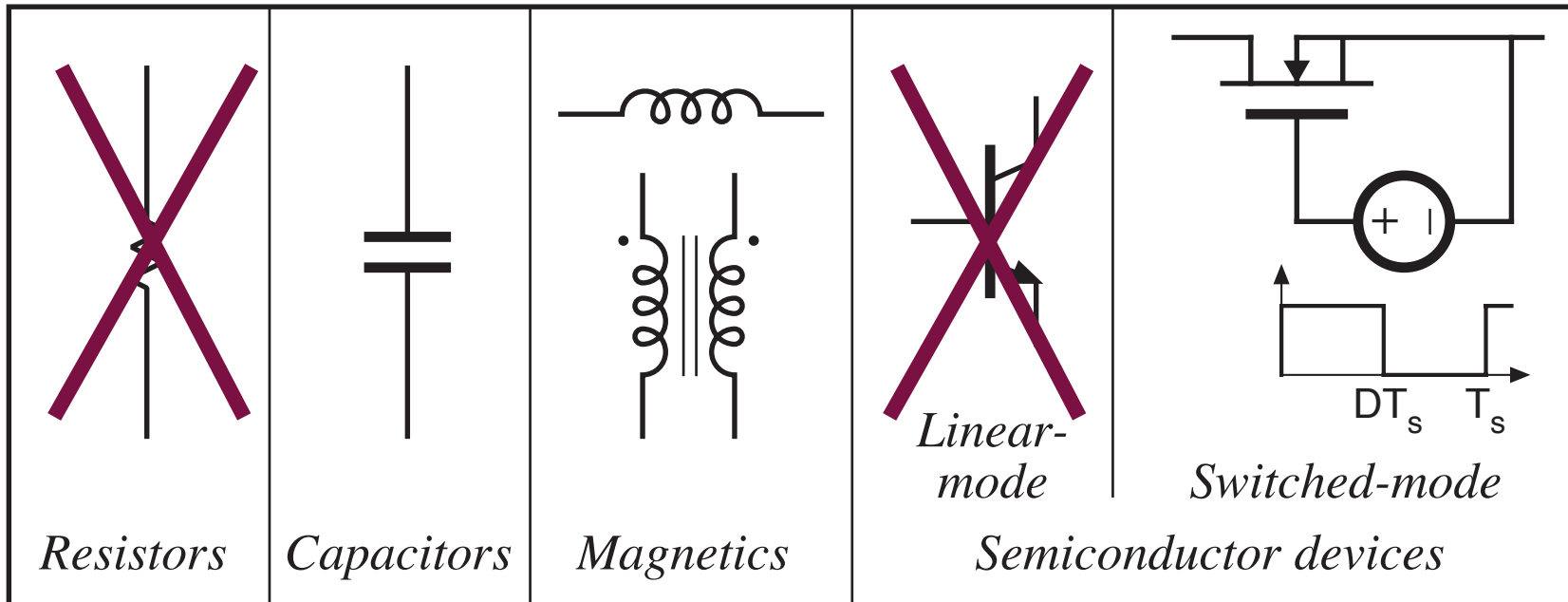


Devices available to the circuit designer



Signal processing: avoid magnetics

Devices available to the circuit designer



Power processing: avoid lossy elements

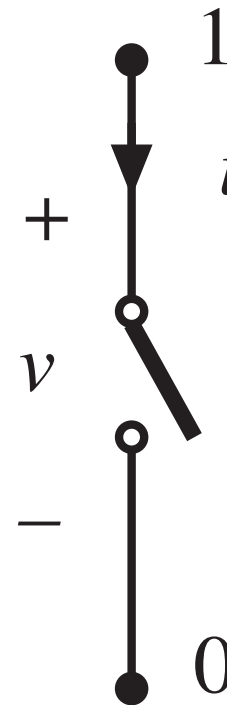
Power loss in an ideal switch

Switch closed: $v(t) = 0$

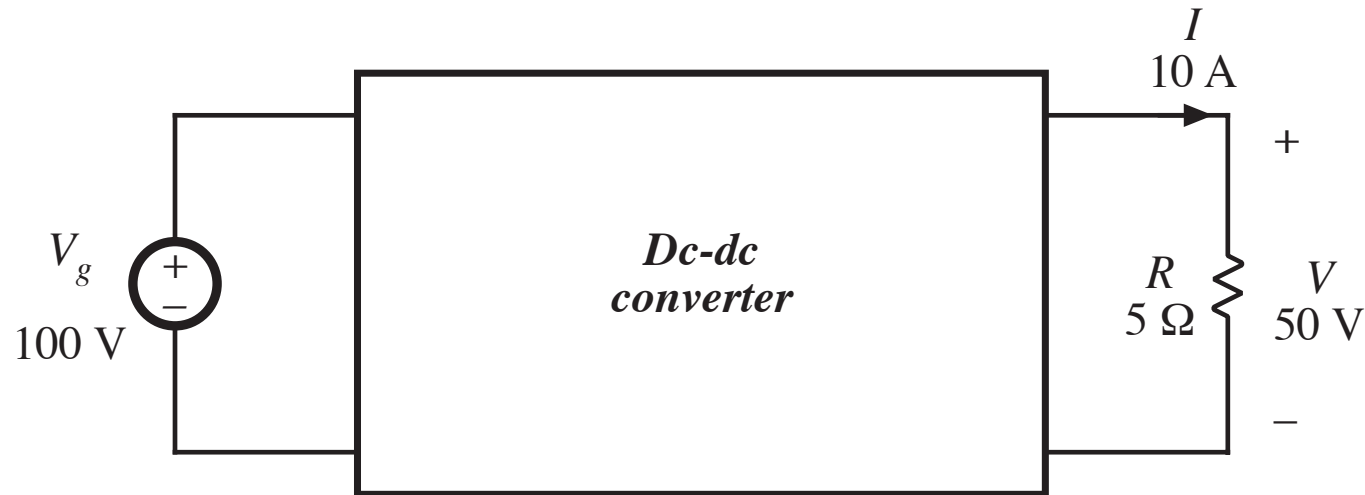
Switch open: $i(t) = 0$

In either event: $p(t) = v(t) i(t) = 0$

Ideal switch consumes zero power



A simple dc-dc converter example



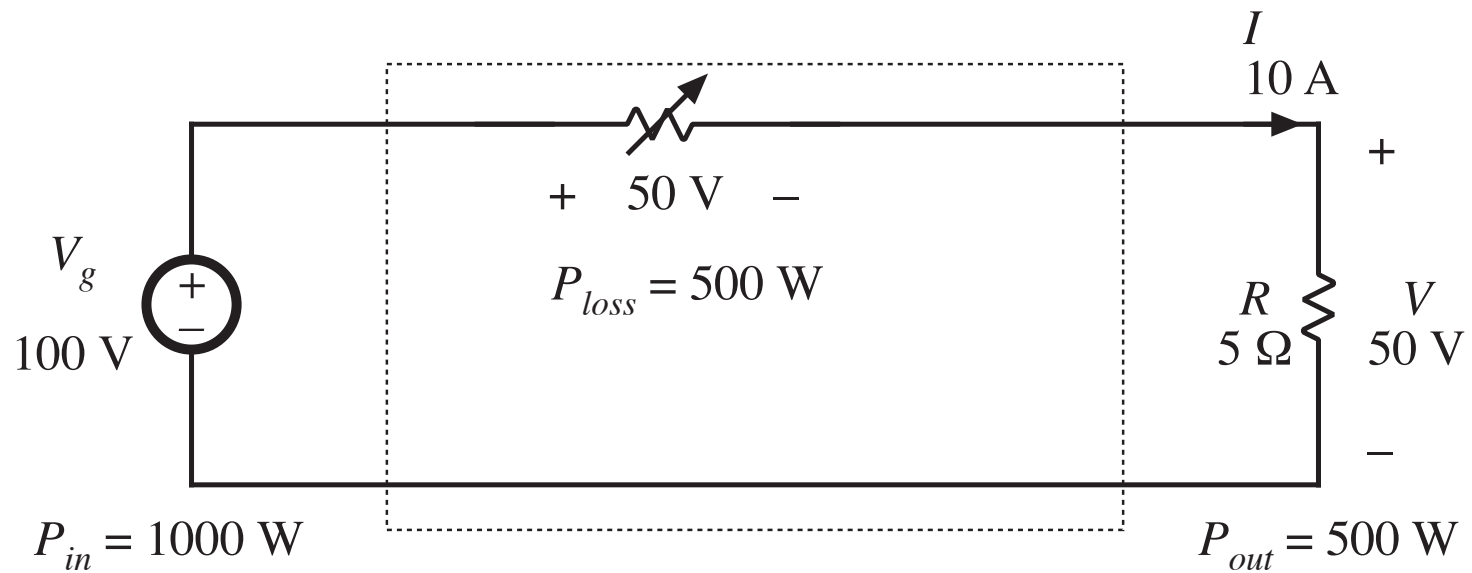
Input source: 100V

Output load: 50V, 10A, 500W

How can this converter be realized?

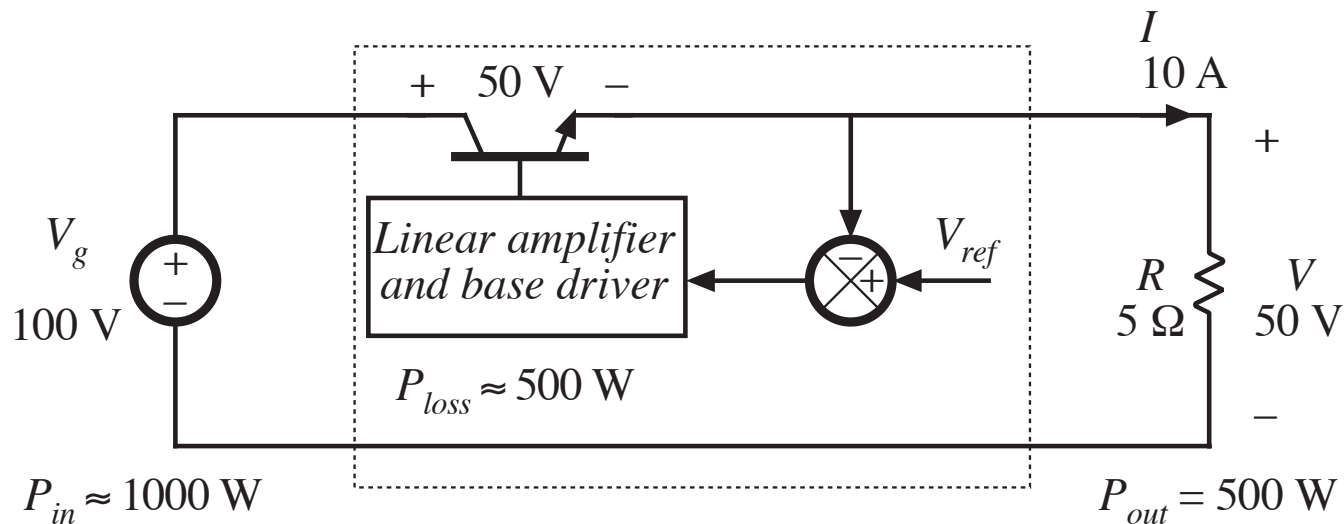
Dissipative realization

Resistive voltage divider

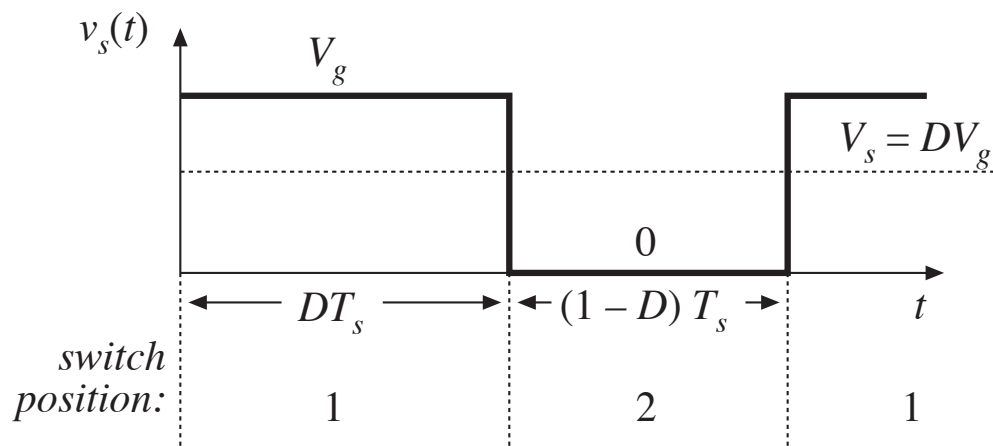
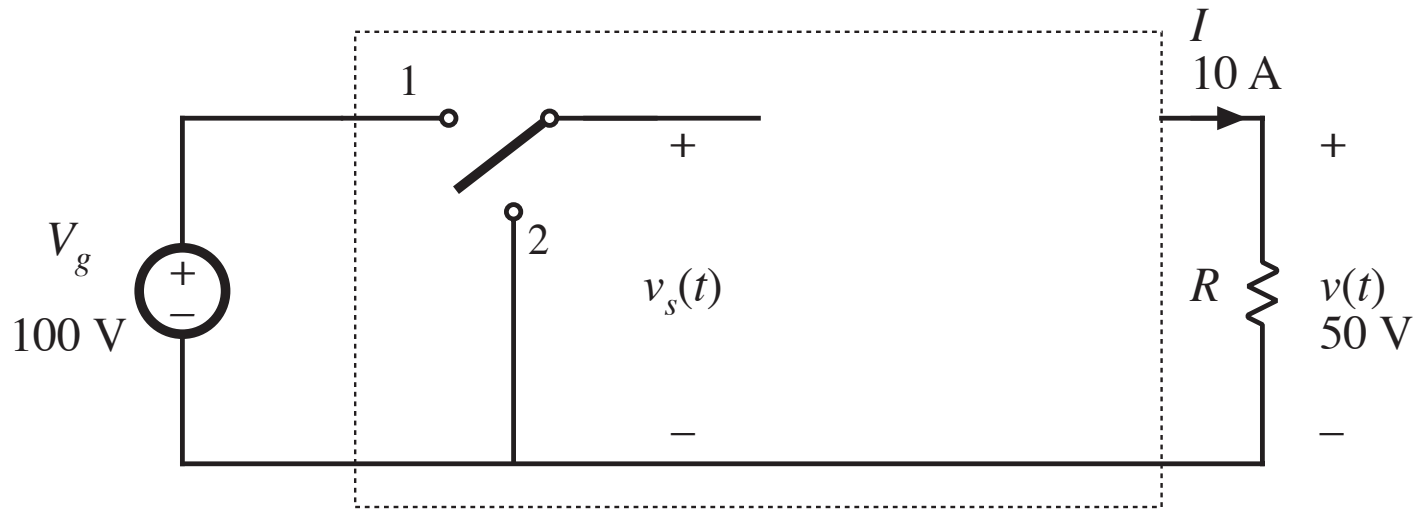


Dissipative realization

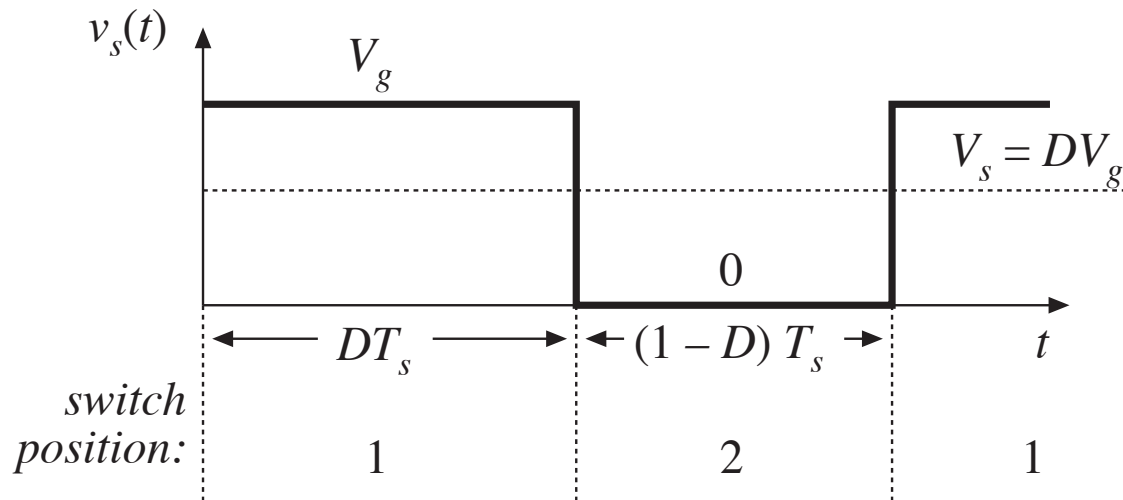
Series pass regulator: transistor operates in active region



Use of a SPDT switch



The switch changes the dc voltage level



D = switch duty cycle
 $0 \leq D \leq 1$

T_s = switching period

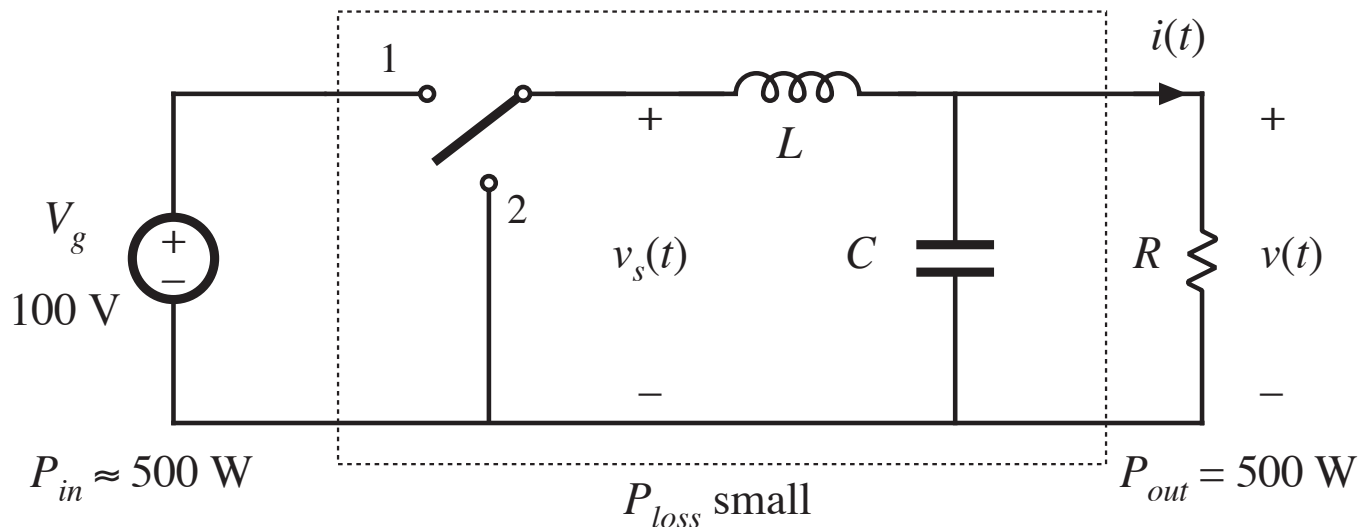
f_s = switching frequency
 $= 1 / T_s$

DC component of $v_s(t)$ = average value:

$$V_s = \frac{1}{T_s} \int_0^{T_s} v_s(t) dt = DV_g$$

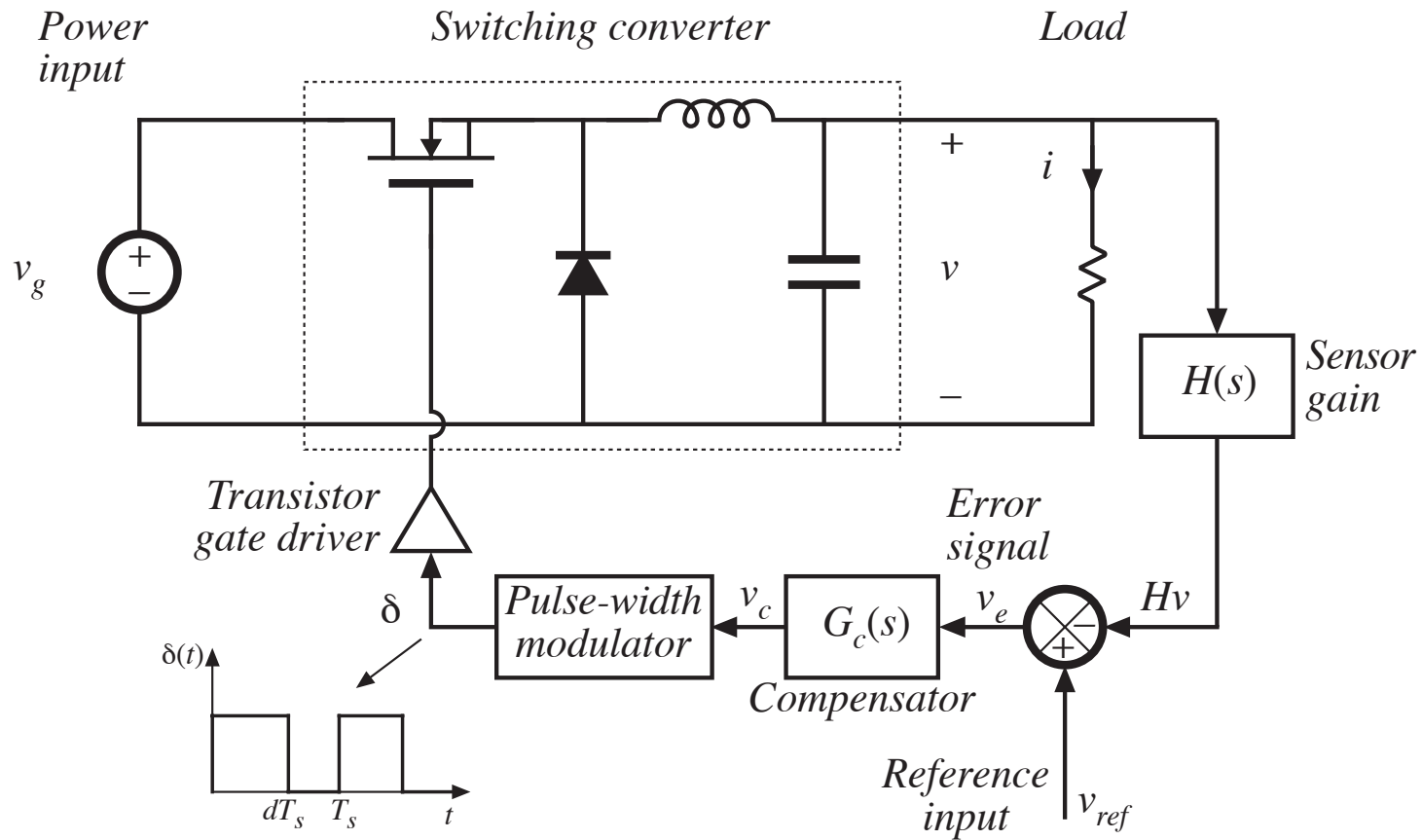
Addition of low pass filter

Addition of (ideally lossless) L - C low-pass filter, for removal of switching harmonics:

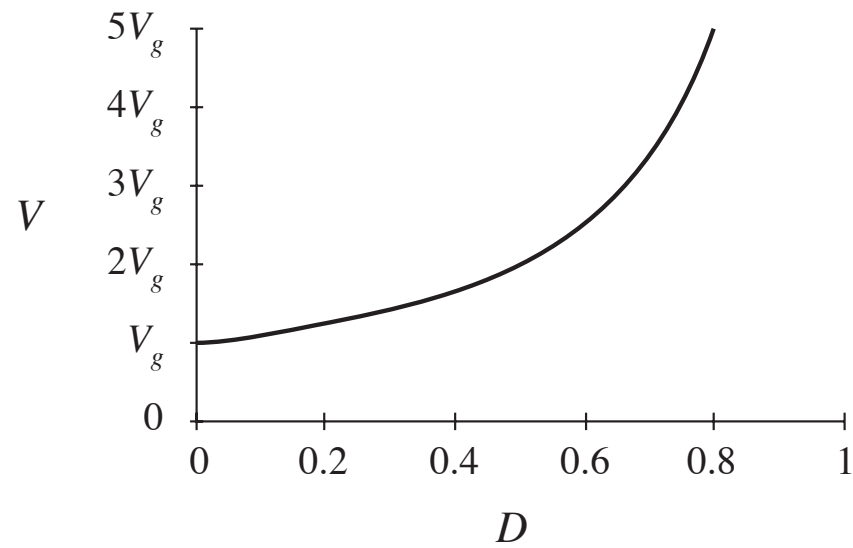
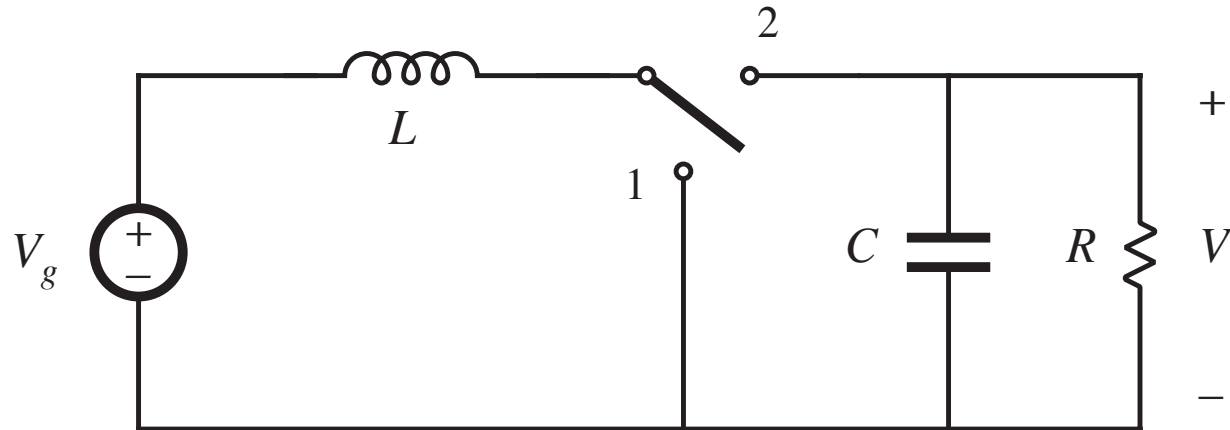


- Choose filter cutoff frequency f_0 much smaller than switching frequency f_s
- This circuit is known as the “buck converter”

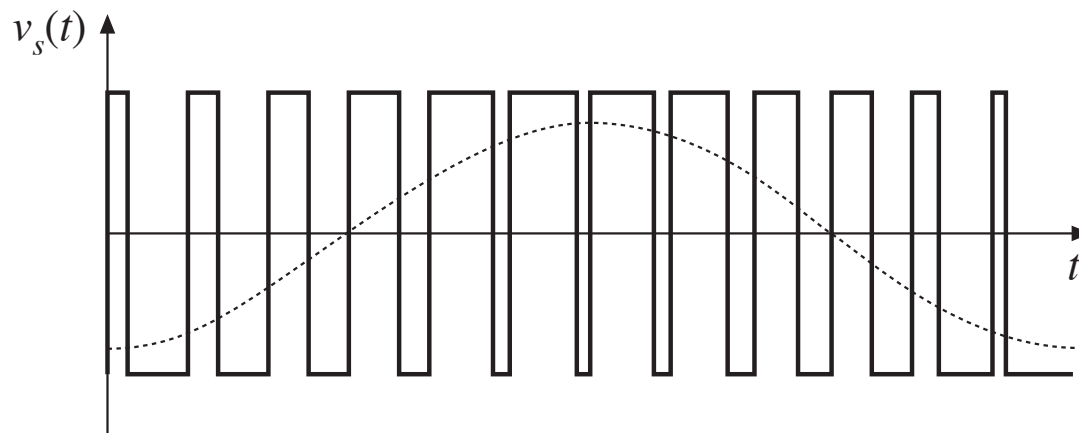
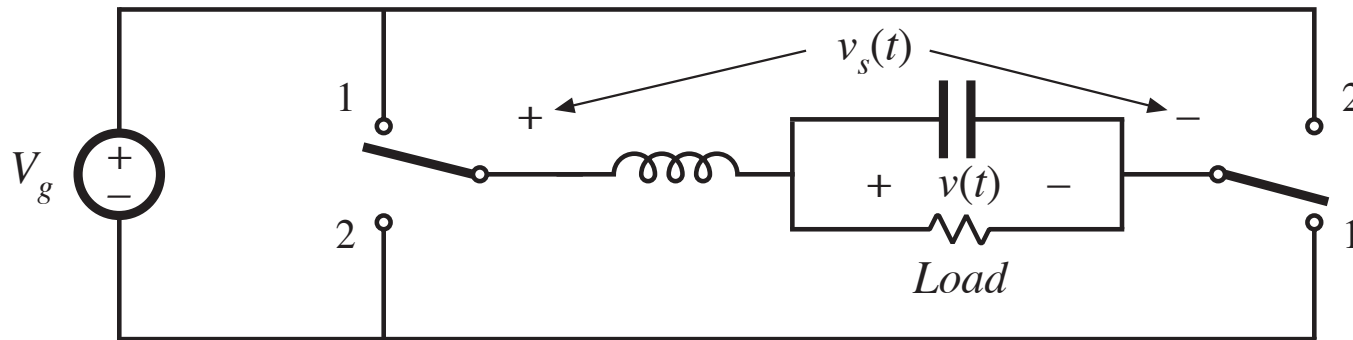
Addition of control system for regulation of output voltage



The boost converter



A single-phase inverter



“H-bridge”

Modulate switch
duty cycles to
obtain sinusoidal
low-frequency
component