MALVINO & BATES

Electronic PRINCIPLES

SEVENTH EDITION

Chapter 4

Diode Circuits

Topics Covered in Chapter 4

- **Half-wave rectifier**
- **Transformer**
- **Full-wave rectifier**
- **Bridge rectifier**
- **Choke-input filter**
- **Capacitor-input filter**

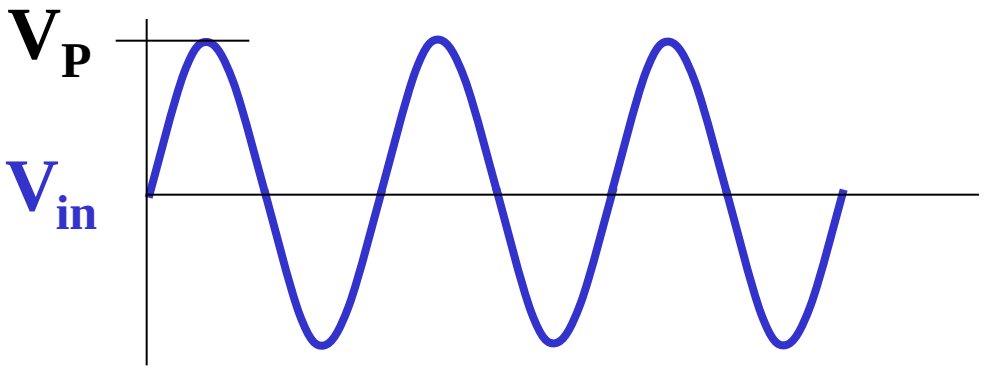
Topics Covered in Chapter 4 (Continued)

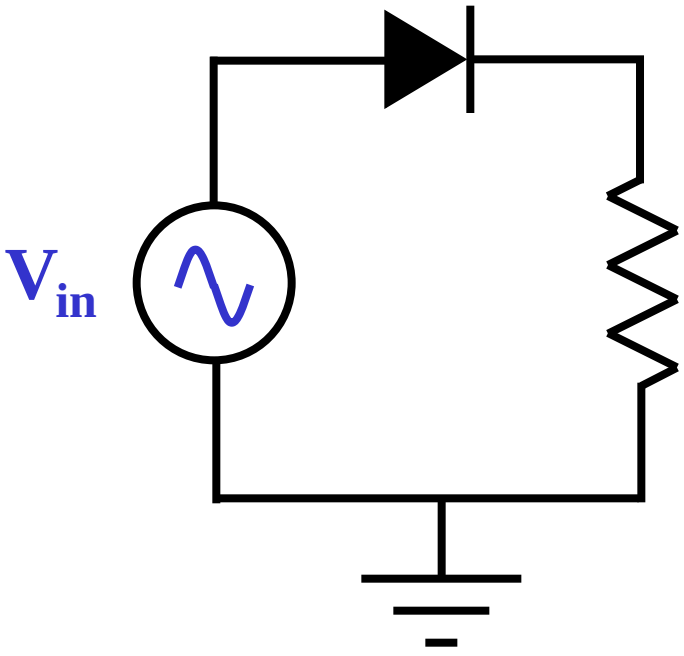
- Peak inverse voltage and surge current
- Other power supply topics
- Troubleshooting
- Clippers and limiters
- Clampers
- Voltage multipliers

Half-wave rectifier

- Has a diode in series with the load resistor
- Load voltage is a half-wave output

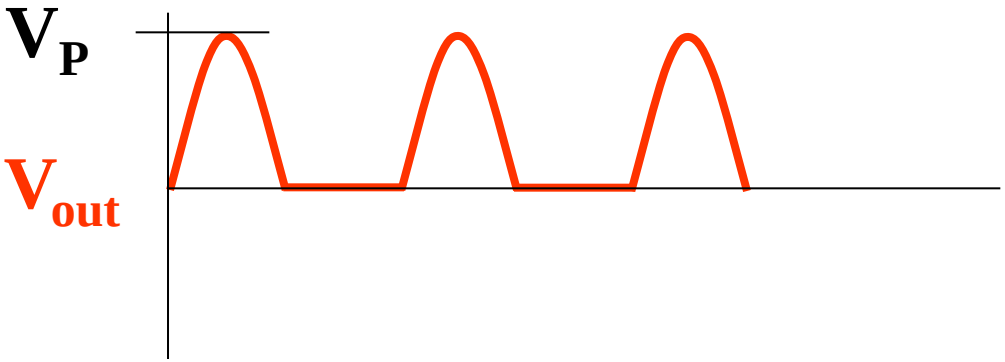
The half-wave rectifier





V_{out}

Ideal: $V_{P(in)} = V_{P(out)}$



Half-wave rectifier signals

- **The dc value of the output is the average value.**
- $V_{dc} = V_P/\pi$
- $f_{out} = f_{in}$
- **Second approximation:**

$$V_{P(out)} = V_{P(in)} - 0.7\ V$$

Input transformer

- Step down
- Voltage steps down
- Current steps up
- Secondary voltage equals the primary voltage divided by the turns ratio

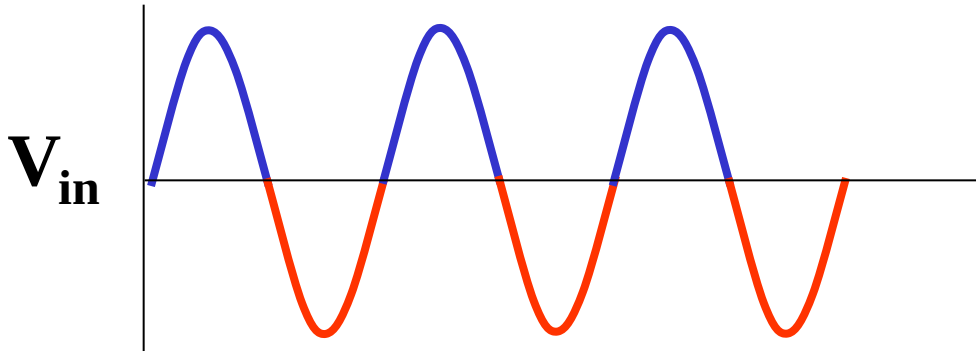
Transformer review

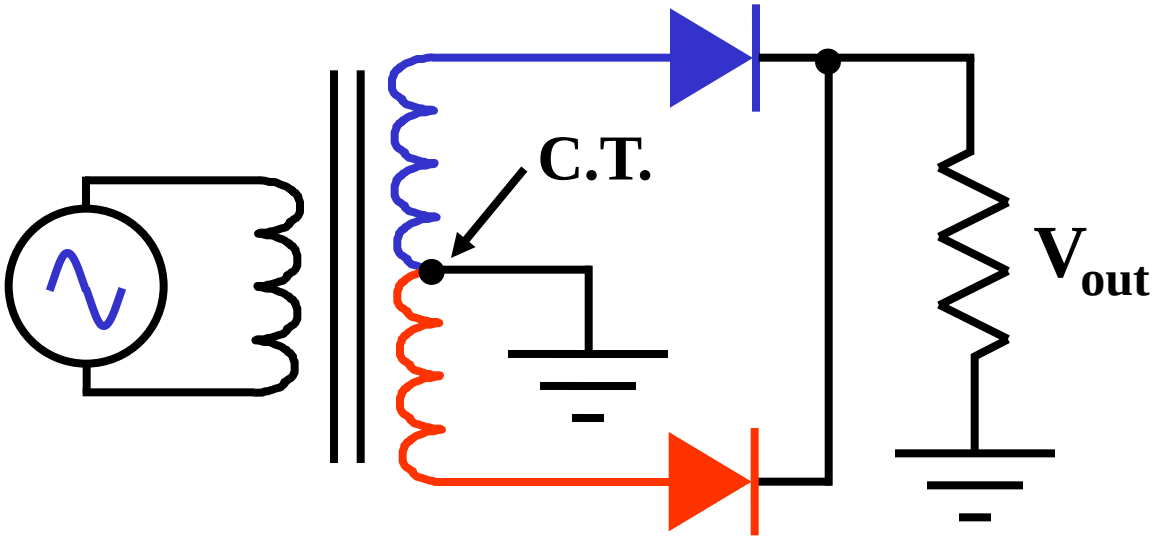
- When the turns ratio (N_1/N_2) is greater than 1, the primary voltage is stepped down.
- When the turns ratio is less than 1, the primary voltage is stepped up.
- Dotted ends have the same instantaneous phase.
- Full-wave rectifiers require a winding with a center tap.

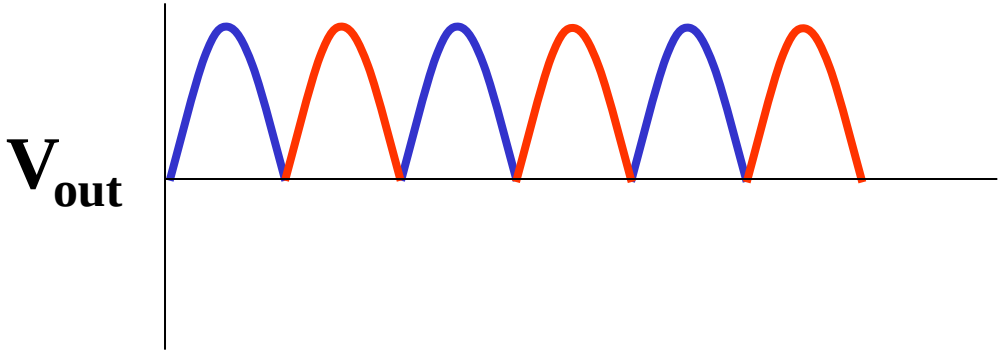
Full-wave rectifier

- Has a center-tapped transformer with two diodes and a load resistor
- Load voltage is a full-wave signal whose peak is half of the secondary voltage

The full-wave rectifier







Full-wave rectifier signals

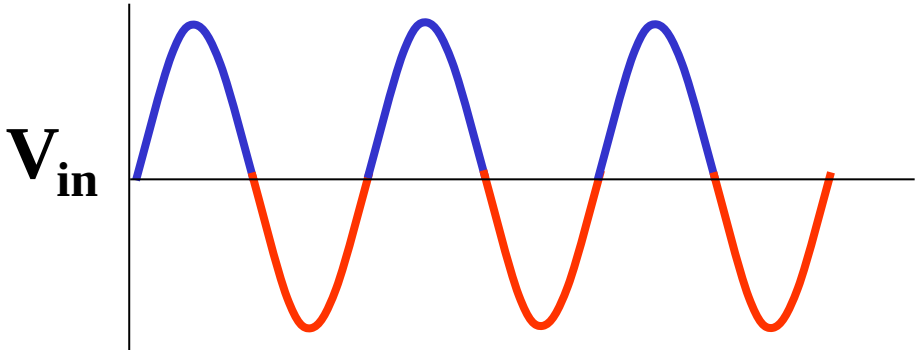
- The dc value of the output is the average value.
- $V_{dc} = 2V_P/\pi$
- $f_{out} = 2f_{in}$
- The input to each diode is half the secondary voltage.
- Second approximation:

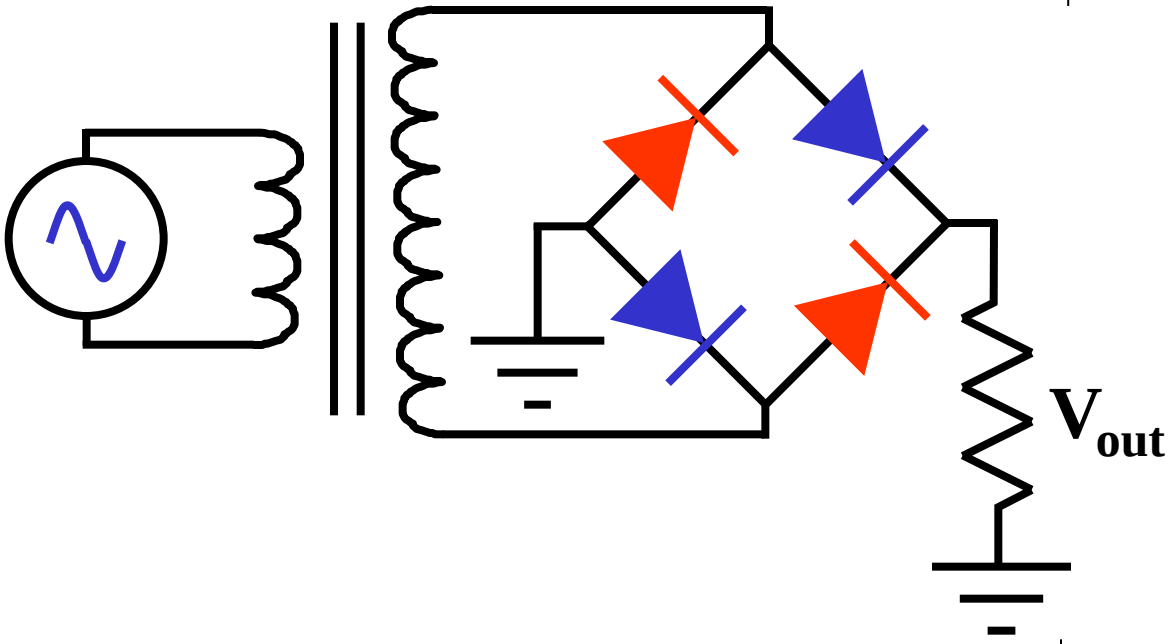
$$V_{P(out)} = V_{P(in)} - 0.7\ V$$

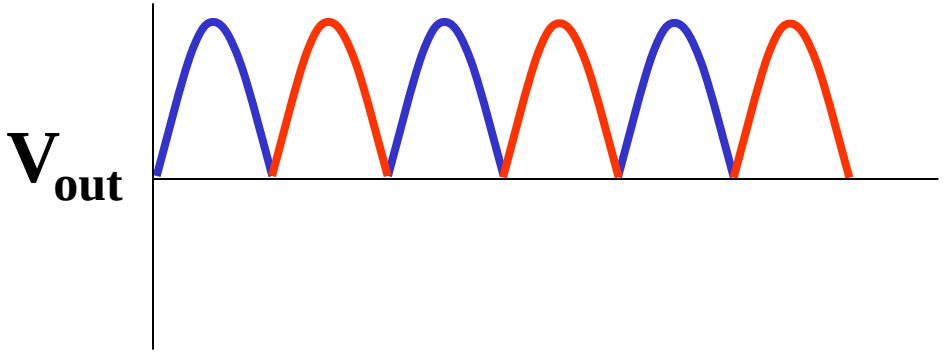
Bridge rectifier

- Has four diodes
- Load voltage is a full-wave signal with peak value equal to the secondary voltage

The bridge rectifier







Bridge rectifier signals

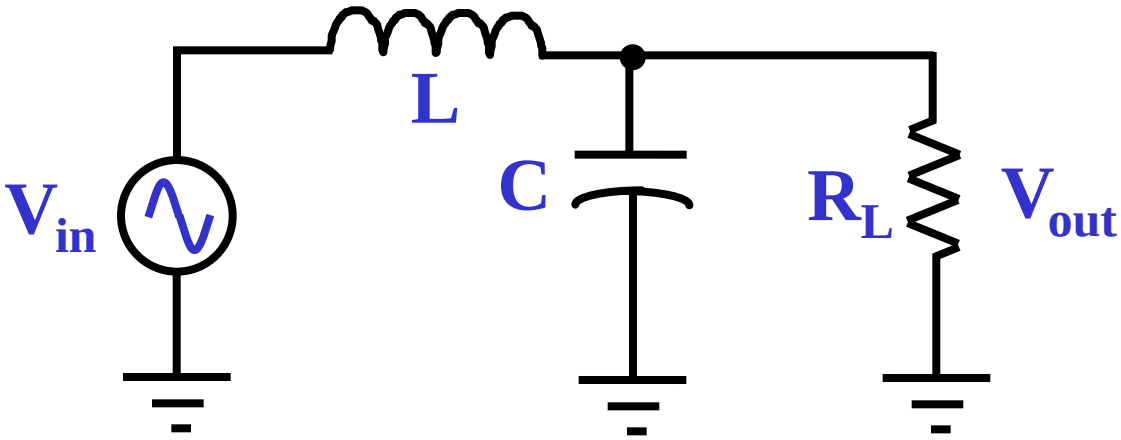
- The dc value of the output is the average value.
- $V_{dc} = 2V_P/\pi$
- $f_{out} = 2f_{in}$
- Second approximation:

$$V_{P(out)} = V_{P(in)} - 1.4\ V$$

Choke-input filter

- **LC voltage divider**
- $X_L >> X_C$
- **The average value of a rectified signal passes to the load resistor**

The choke-input filter



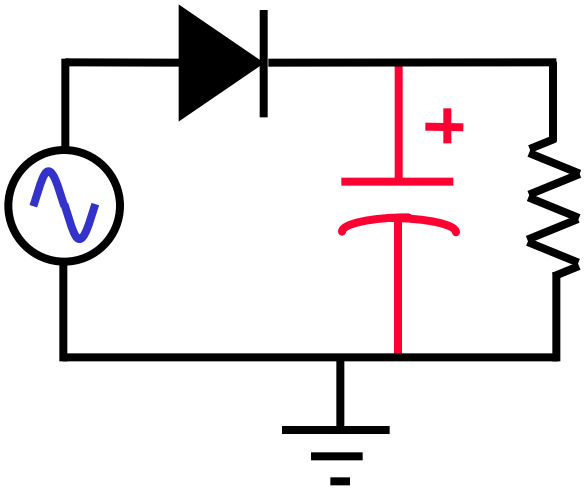
When $X_L >> X_C$:

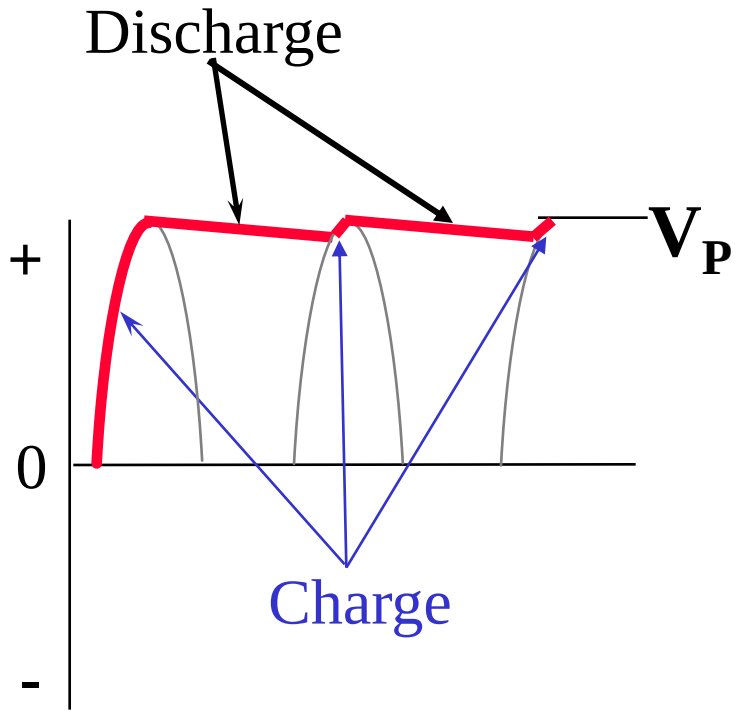
$$V_{out} \cong \frac{X_C}{X_L} V_{in}$$

Capacitor-input filter

- Most widely used
- The peak value of the rectified signal passes to the load resistor
- With a large capacitor, ripple is small

The capacitor-input filter





$$V_R = \frac{I}{fC}$$

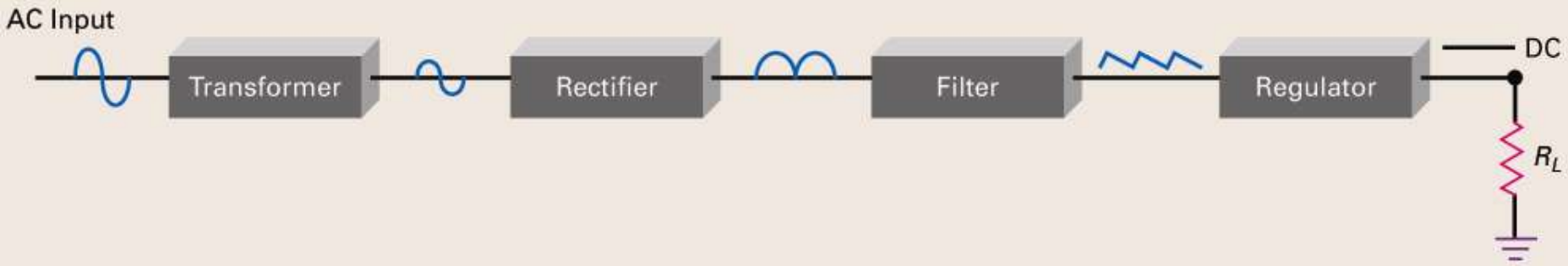
Where V_R is the peak-to-peak ripple voltage

Effects on voltage and current

- Ac line regulation can have an effect
- Bulk resistance of rectifiers causes a voltage drop
- Resistance of transformer windings causes a voltage drop
- Ac ripple increases and average dc decreases when load current increases

Power supply block diagram

Summary Table 4–3 | **Power Supply Block Diagram**



Purpose	Provides proper secondary ac voltage and ac ground isolation	Changes ac input to pulsating dc	Smooths out dc pulses	Provides a constant output voltage under varying loads and ac input voltage
Types	Step-up, step-down, isolation (1:1)	Half-wave, full-wave, full-wave bridge	Choke-input, capacitor input	Discrete components, integrated circuit (IC)

Peak inverse voltage

- **Maximum voltage across the nonconducting diode of a rectifier circuit**
- **Voltage must be less than diode breakdown voltage**

Diode ratings

- **Half-wave rectifier with capacitor-input filter:** $PIV = 2V_P$ $I_{diode} = I_{dc}$
- **Full-wave rectifier with capacitor-input filter:** $PIV = V_P$ $I_{diode} = 0.5I_{dc}$
- **Bridge rectifier with capacitor-input filter:** $PIV = V_P$ $I_{diode} = 0.5I_{dc}$

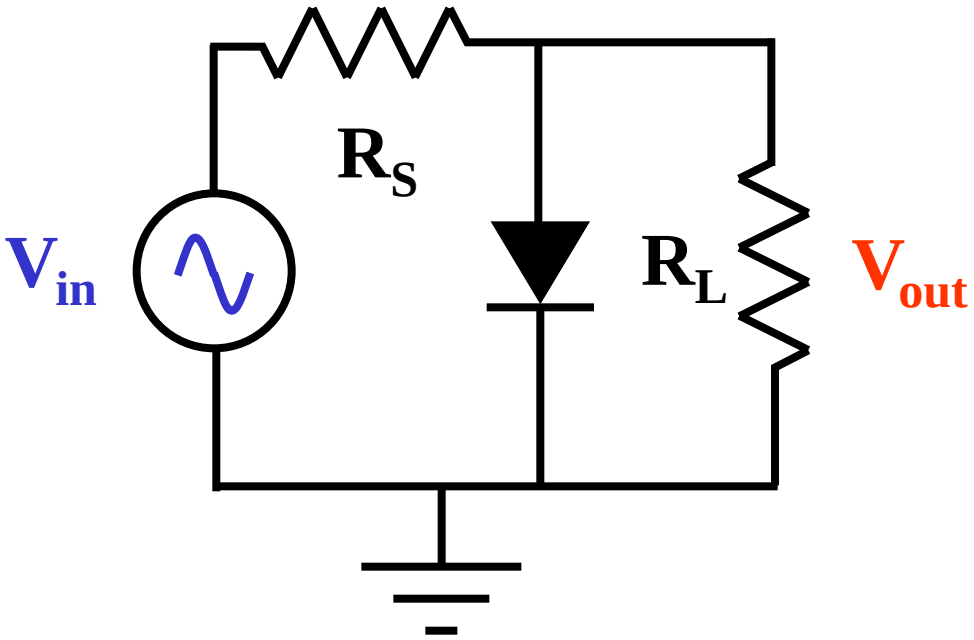
Typical bridge supply problems

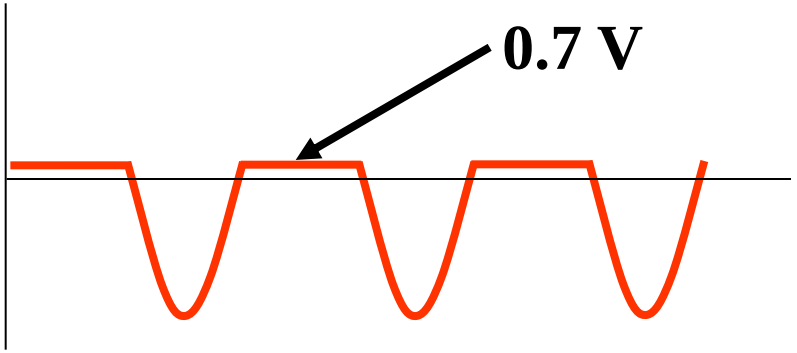
- **No output - - blown fuse, two or more diodes open, load shorted**
- **Low output/extra ripple - - bad filter, open diode, shorted winding, overload**
- **Full-wave signal at output - - open filter capacitor**
- **Half-wave ripple frequency - - open diode**

Power supply topics

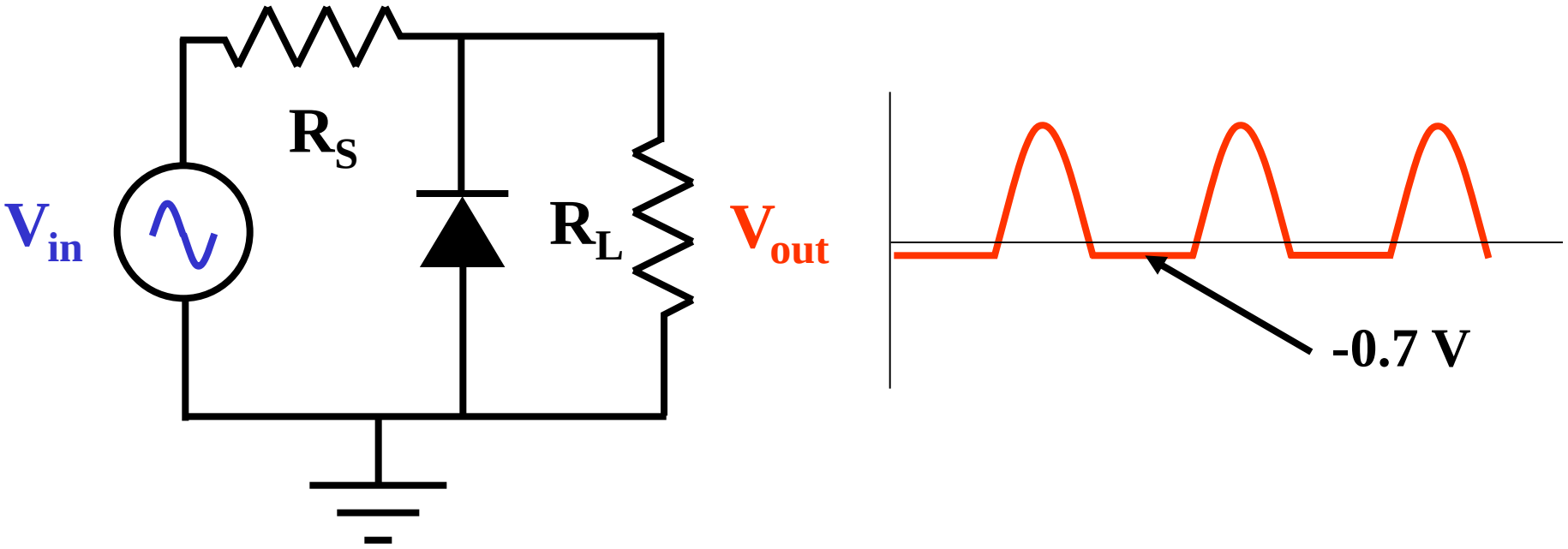
- **Real transformers usually specify secondary voltage at a rated load current**
- **Slow-blow fuses are often used to protect against surge current**
- **Average diode current in a half-wave rectifier equals the dc load current**
- **In a full-wave or bridge, the average current in any diode is half the dc load current**

Positive clipper





Negative clipper



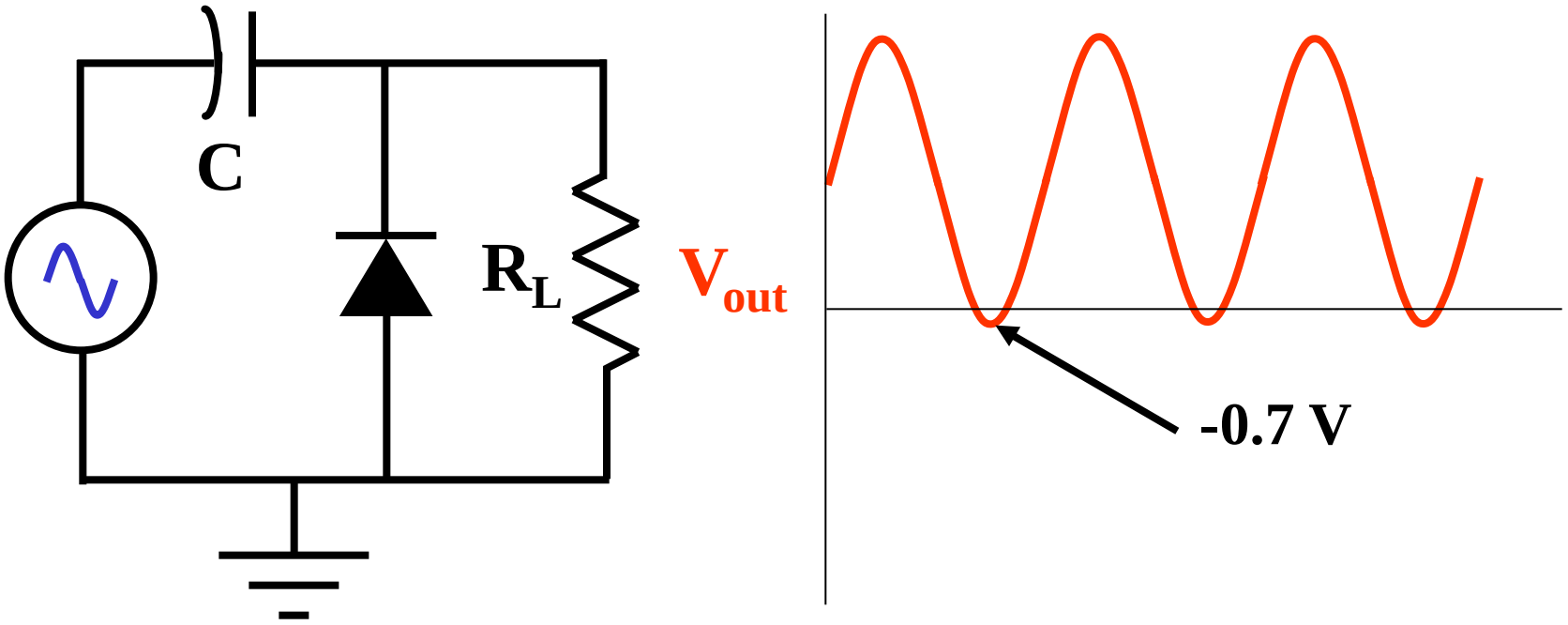
Clippers and limiters

- A clipper shapes the signal by clipping off positive or negative parts of the signal
- The limiter or diode clamp protects sensitive circuits from too much input

Clamper

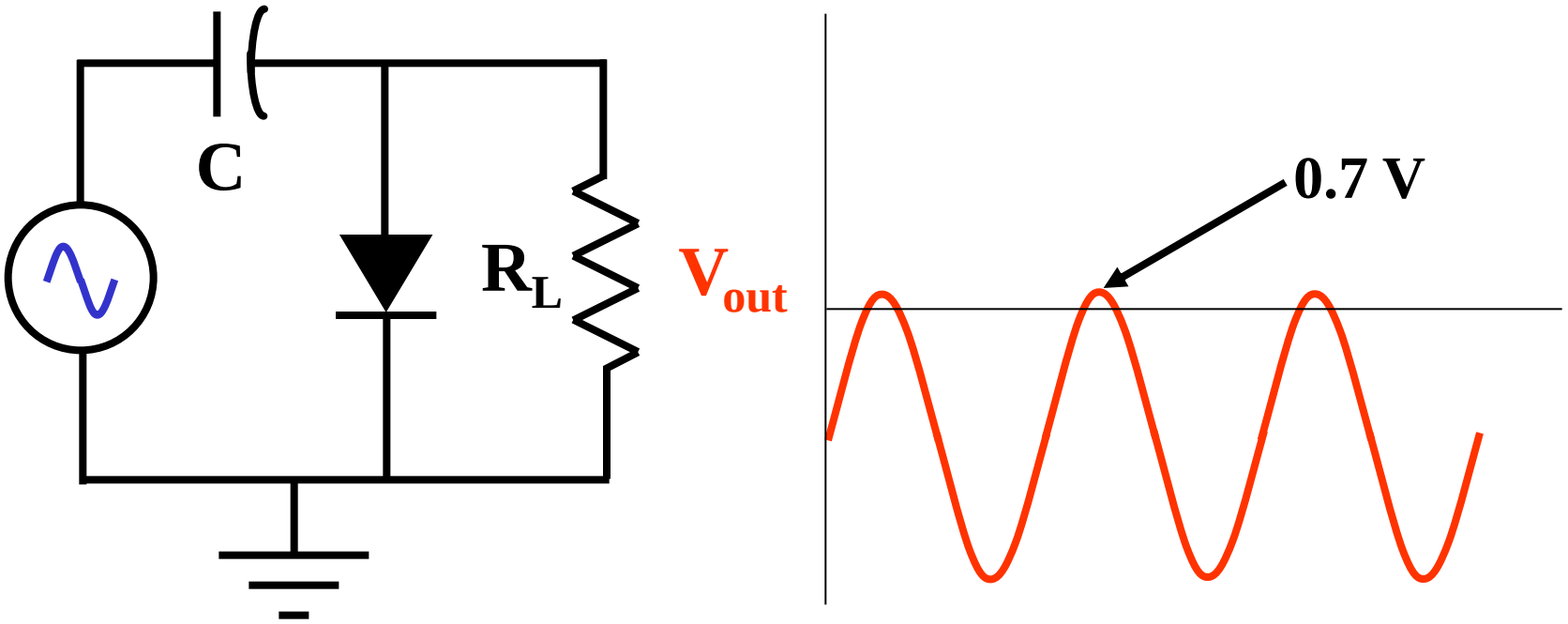
- Shifts a signal positively or negatively by adding a dc voltage to the signal
- Peak-to-peak detector produces a load voltage equal to the peak-to-peak value

Positive clamper



Stiff clamper: $R_L C > 100T$

Negative clamper

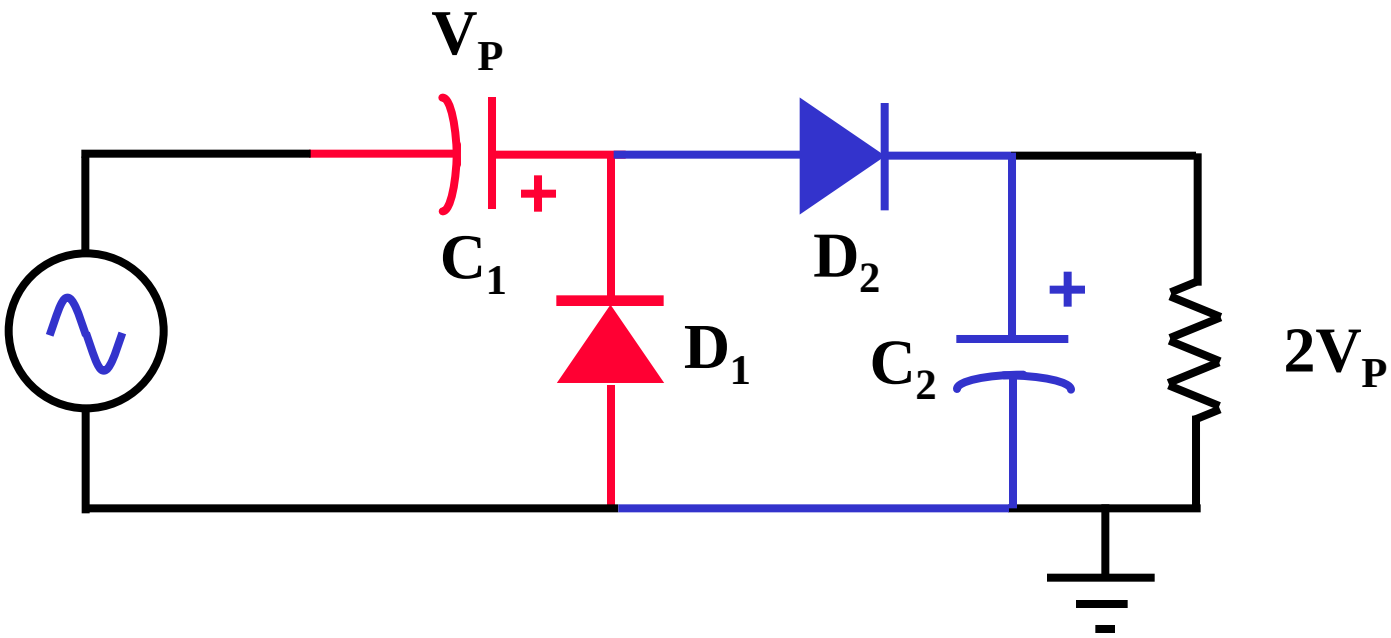


Stiff clamper: $R_L C > 100T$

Voltage multipliers

- A voltage doubler is similar to the peak-to-peak detector but uses rectifier diodes instead of small-signal diodes
- Voltage triplers and quadruplers multiply the input peak by factors of 3 and 4

Half-wave voltage doubler



Full-wave voltage doubler