AC to DC Converters

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# 1 AC to DC Converters, Rectifiers

A AC/DC Converter, or rectifier, is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. Physically, rectifiers take a number of forms, including vacuum tube diodes, mercury-arc valves, copper and selenium oxide rectifiers, semiconductor diodes, silicon-controlled rectifiers and other silicon-based semiconductor switches. Historically, even synchronous electromechanical switches and motors have been used. #
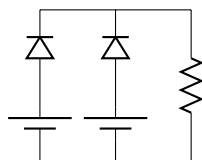
Rectifiers
- Switching
  - Uncontrolled
  - Controlled
- Phases
  - Monophasic
  - Triphasic
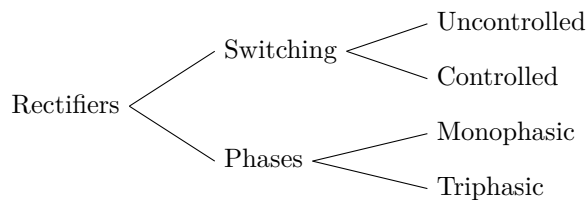
- Uncontrolled rectifiers use diodes as switching devices. They don't need a control circuit.
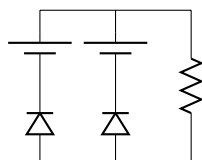
Diodes

$$i_D$$
$$+ \quad v_{AK} \quad -$$
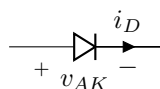
Common Cathode Diodes If two or more diodes are connected with a common cathode, the closed diode is the one with the most positive anode voltage. The rest of the diodes are open.
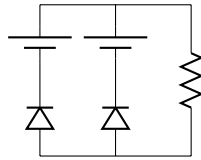
Common Anode Diodes If two or more diodes are connected with a common anode, the closed diode is the one with the most negative anode voltage. The rest of the diodes are open.

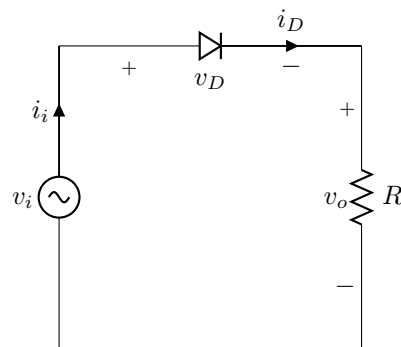| Configuration	Circuit diagram	Conducting Diode
Common Cathode		The diode with the most positive anode voltage

| Common Anode | | The diode with the most negative cathode voltage |

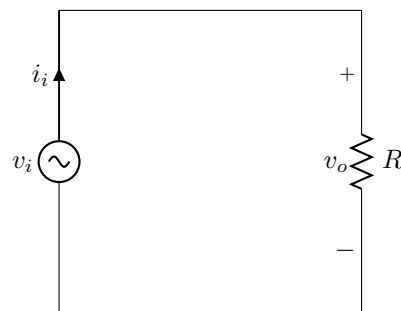General rule: The most polarized diode is the one conducting. The one with the biggest v_{AK}

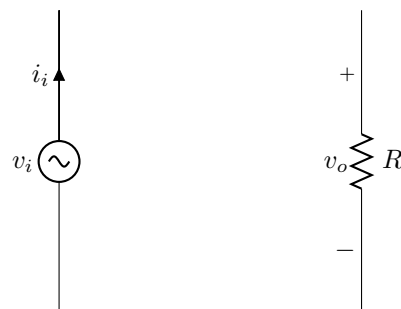# 2 Monophasic Rectifiers

2.1 Half Wave Rectifier

- $v_i > 0$: D ON, $i > 0$
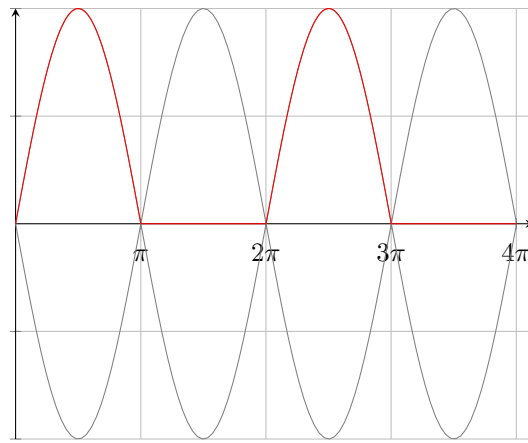- $v_i < 0$: D OFF, $i = 0$

$v_i > 0$ (**D ON**) equivalent circuit

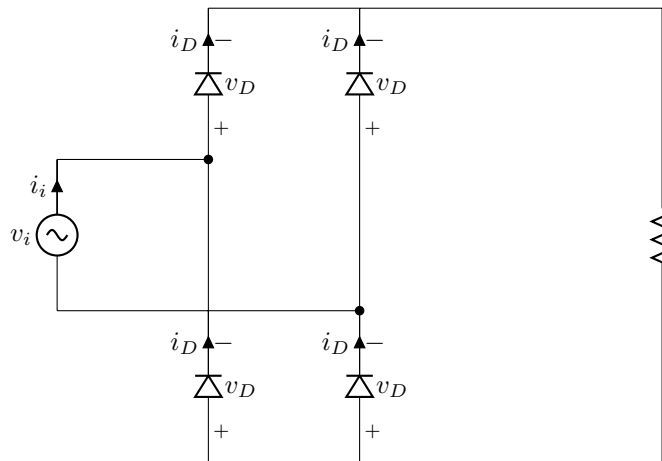$v_i < 0$ (**D OFF**) equivalent circuit
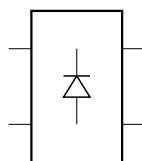

Output voltage, v_o

The voltage in the resistive load, v_R, and the current demanded to the source depends on the load type, and can be different for a same kind of rectifier depending on the load that is connected to it.
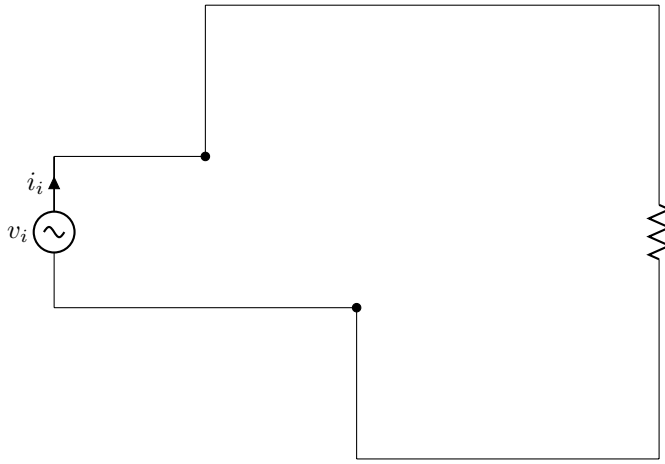
2.2 Full Wave Rectifier

Full Wave Rectifier Symbol
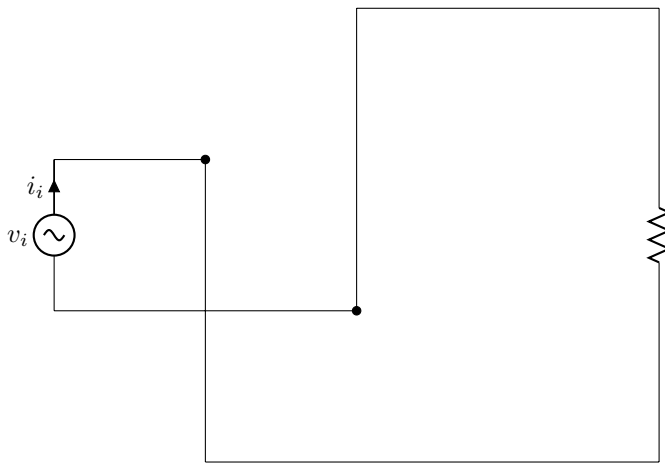

Diode table

	D1	D2	D3	D4
$v_i > 0$	ON	OFF	OFF	ON
$v_i < 0$	OFF	ON	ON	OFF

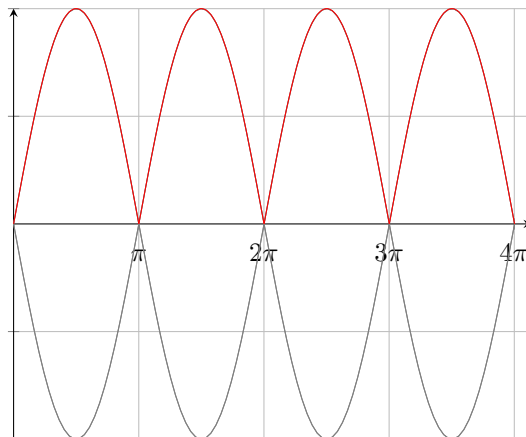$v_i > 0$ **equivalent circuit:** D1, D4 are ON

**$v_i < 0$ equivalent circuit:** D2, D3 are ON

Output voltage, v_o

The voltage in the resistive load, v_R, and the current demanded to the source depends on the load type, and can be different for a same kind of rectifier depending on the load that is connected to it.

Reduced model of the rectifier If v_o is already known, a simplified model of the rectifier can be represented to study the loaded rectifier. The left hand side of the circuit is substituted by

- a v_o voltage source, that represents the bridge output voltage
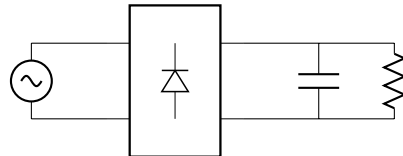- a diode that represents that current cannot enter in the rectifier
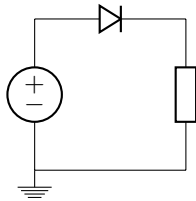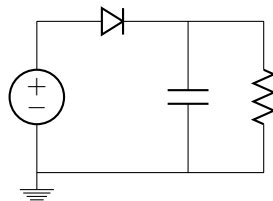
2.2.1   R Load
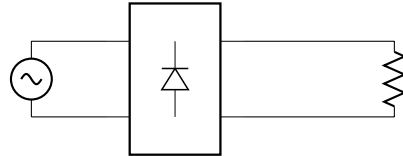
2.2.2   RC Load

A condenser can be added in parallel with the R load to smooth the voltage across it. In this case, the circuit is
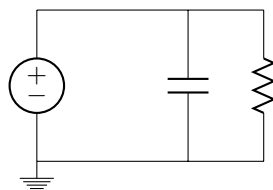

Load voltage, v_R

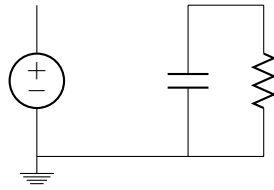Not exactly like this, it's more complex.

- When the diode conducts, $v_o = v_R$ and the capacitor is charged with the current from the source.

The charge is sinusoidal:
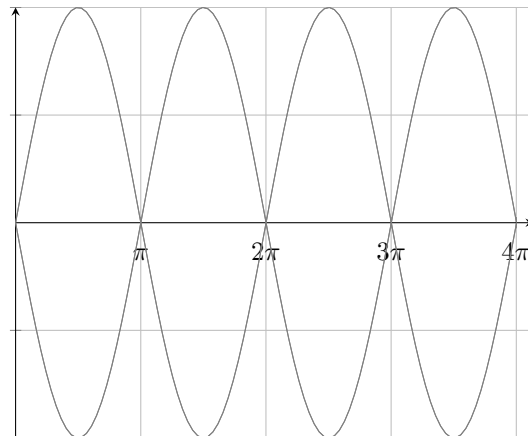
$$i_C(t) = \frac{dv(t)}{dt} = sinusoidal$$

- When the diode is not conducting, the capacitor provides the current to the load. It would continue to discharge until $v_o = v_i$.
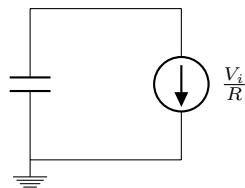
The discharge is exponential:

$$formulita$$

The voltage in the load is:

Triangular approximation

- The charge is considered instantaneous: $t_{\text{charge}} = 0 \rightarrow t_{\text{discharge}} = \frac{T}{2}$
- The discharge is linear, with constant current: $I_R = V_m/R$
- The diode opens in the maximum of v_o: $I_R = V_i/R$ (in the slides it says "if ripple is small enough").

The ripple of the wave using the triangular approximation is

$$\Delta v_o = \frac{V \Delta T}{C}$$

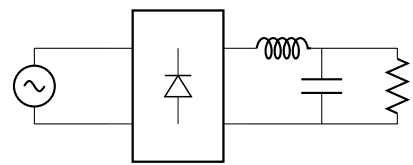$$\Delta v_o = \frac{V_i T}{2RC}$$

Advantages of a smoothing condenser

- Small size
- Cheap
- Robust

Disadvantages of a smoothing condenser

- High peaks of current through the diodes.
- Harmonics in the source current.
- Need of a big capacitor if the required ripple is small.

2.2.3 RLC Load

Advantages of LC filtering

- No current peaks in the diodes.
- Less condenser ripple.
- Less capacity and current capacitor required.

Disadvantages of LC filtering

- Size and weight of the inductor

2.2.4 RL load

2.2.5 Loads table

What	R load	RC load	RLC load
Circuit Diagram			
v_g vs i_g		RC	RLC

Flyback Diode

3 Triphasic Rectifiers

4   Reference

- https://en.wikipedia.org/wiki/Rectifier