Power Supply Circuits

- Power distributed in the form of AC
- Many electrical devices are DC & operate at lower voltages.
- Wall outlets are 110 V ; this is an RMS voltage

RMS Voltage

We want to be able to easily calculate power lossed due to resistive loads.

$$P_{loss}(t) = i^2(t)\,R$$

$$P_{loss_{Ave}} = \frac{1}{T}\int_0^T i^2(t)\,R\,dt$$

$$i^2R = \frac{v^2}{R}$$

$$\therefore$$

$$P_{loss_{ave}} = \frac{1}{T}\int_0^T \frac{v^2(t)}{R}\,dt$$

$$= \frac{1}{R}\left[\frac{1}{T}\int_0^T v^2(t)\,dt\right]$$

Define

$$v_{RMS} = \sqrt{\frac{1}{T}\int_0^T v^2(t)\,dt}$$

Now

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$$P_{loss_{ave}} = \frac{v_{RMS}^2}{R}$$

For AC,

$$v(t) = v_0 \cos(\omega t + \phi)$$

$$\therefore v_{RMS} = \sqrt{\frac{1}{T}\int_0^T v_0^2 \cos^2(\omega t + \phi)\, dt}$$

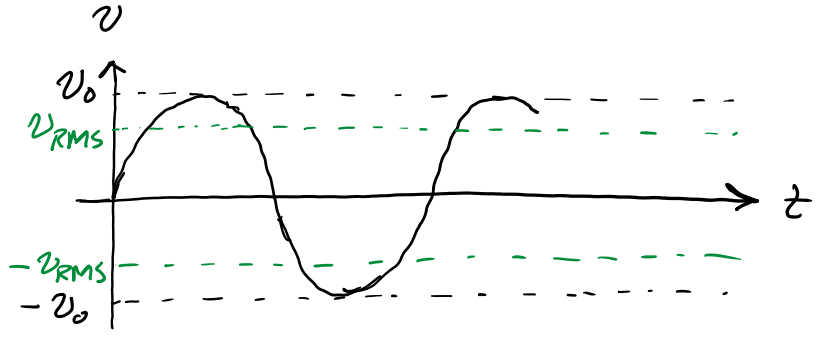
$$= v_0 \sqrt{\frac{1}{T}\int_0^T \cos^2(\omega t + \phi)\, dt}$$

$$= v_0 \sqrt{\frac{1}{2}}$$

$$\boxed{v_{RMS} = v_0 \frac{1}{\sqrt{2}}}$$

v_0 = peak voltage

$v_0 = \sqrt{2}\, v_{RMS}$



How to convert AC power (110 V_{ac}) to DC power (~5V)?

Design of a power supply circuit can be broken down into 3 problems:

1. Voltage reduction

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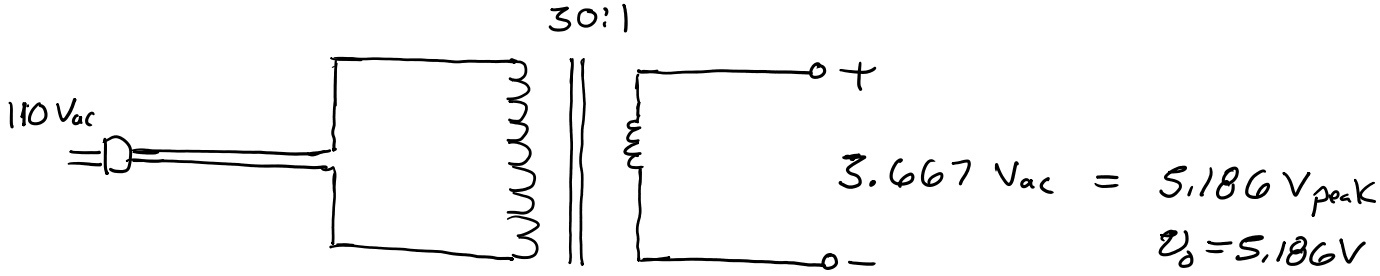
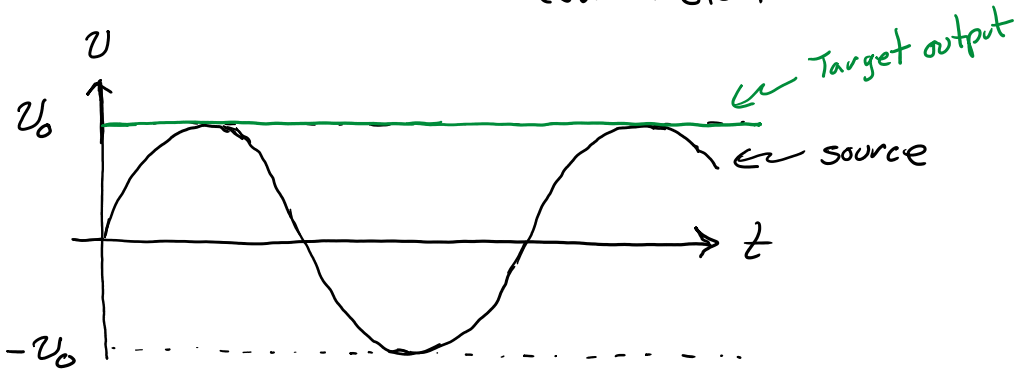
2. AC to DC conversion
3. Voltage regulation

Problem 1: Voltage reduction

Use stepdown transformer



Problem 2: AC to DC conversion

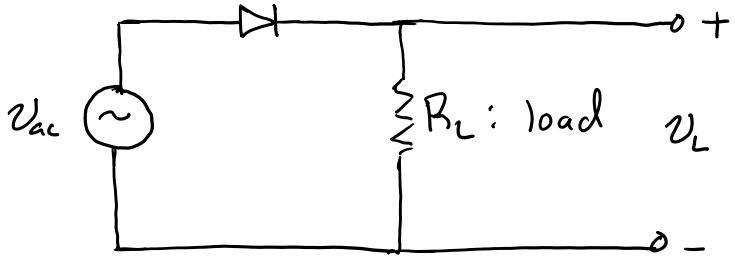


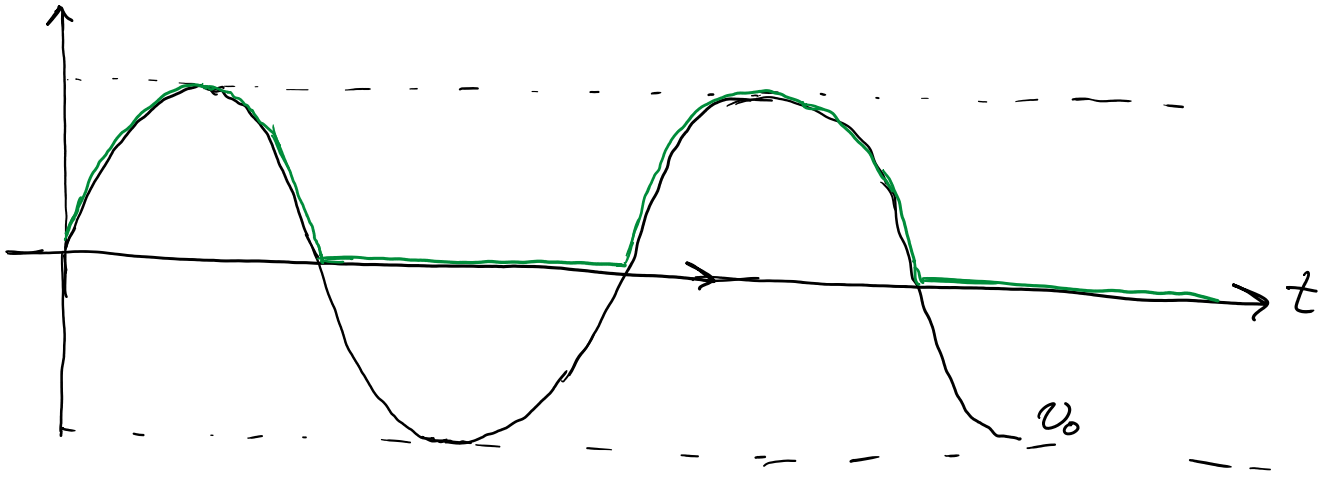
A number of strategies have been devised

We'll explore basic methods:

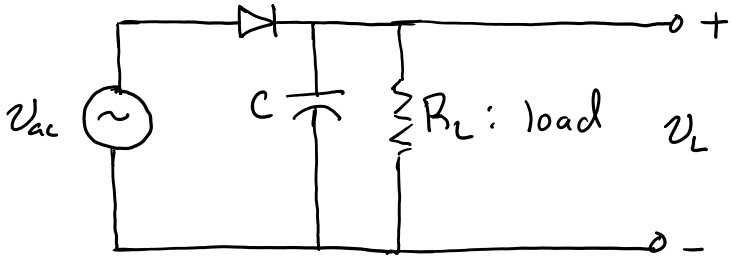
1. Half-wave rectification
2. " " with filtering
3. Full-wave rectification
4. " " with filtering

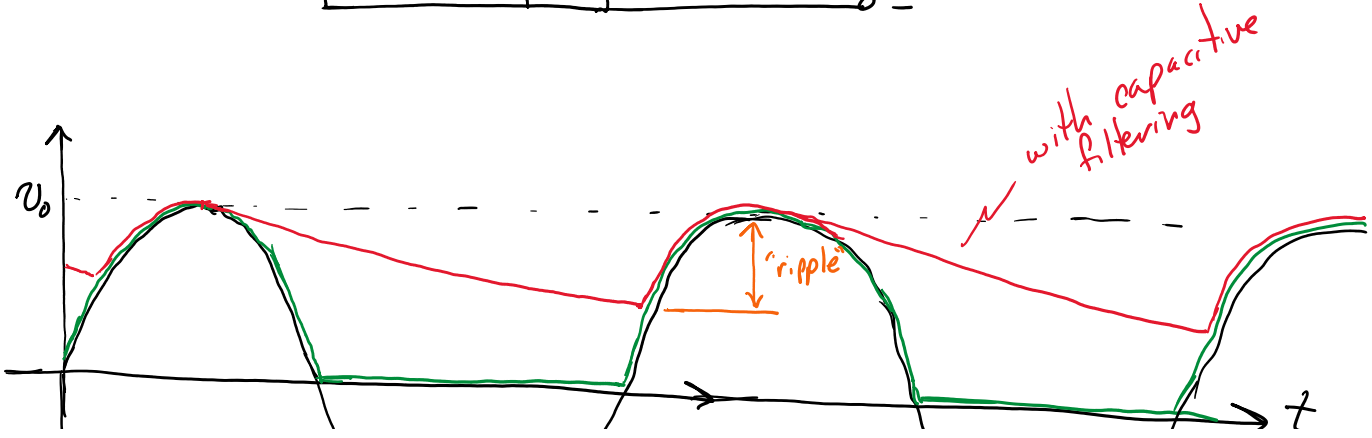
Half-Wave Rectifier:

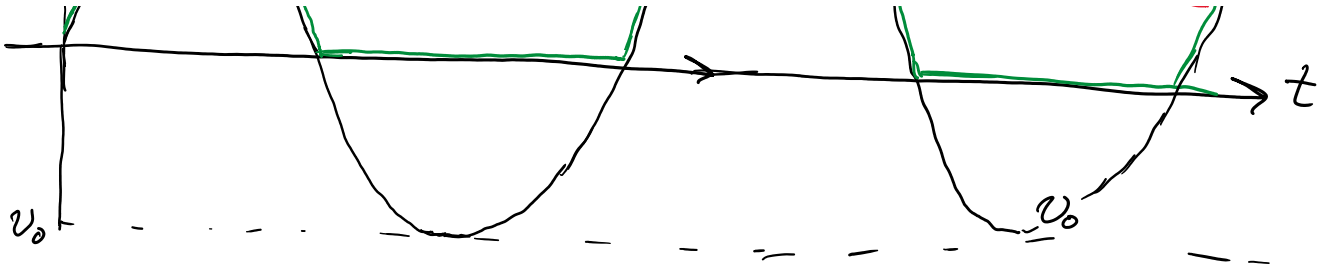




We can improve this with capacitive filtering.



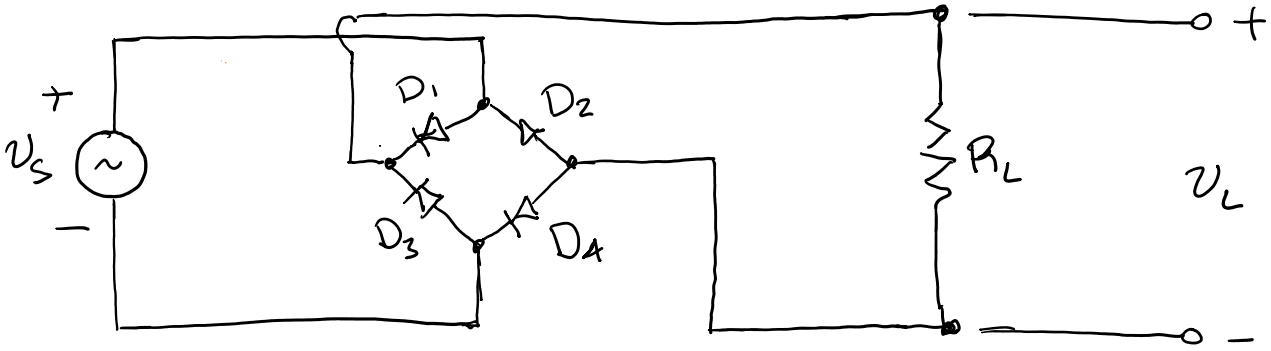


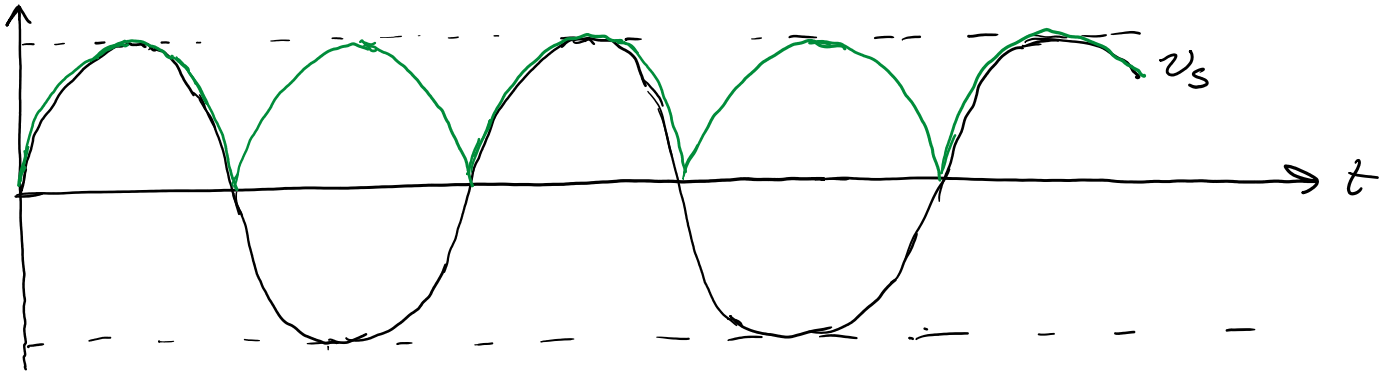


Increasing C reduces ripple because the capacitor can store more energy.

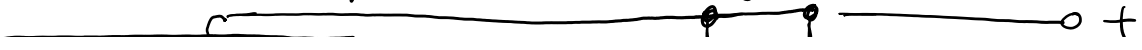
Increasing R_L reduces ripple because the load draws less current.

Full-wave Rectifier:





Can improve with capacitive filtering



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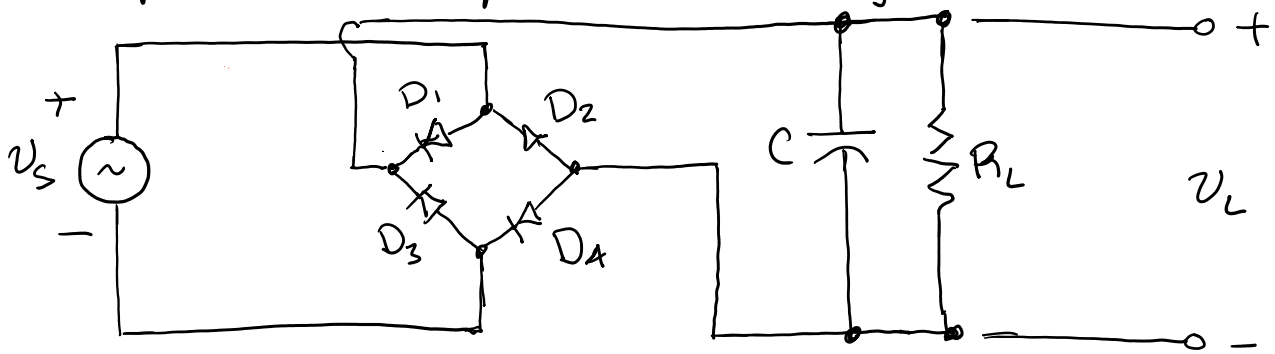
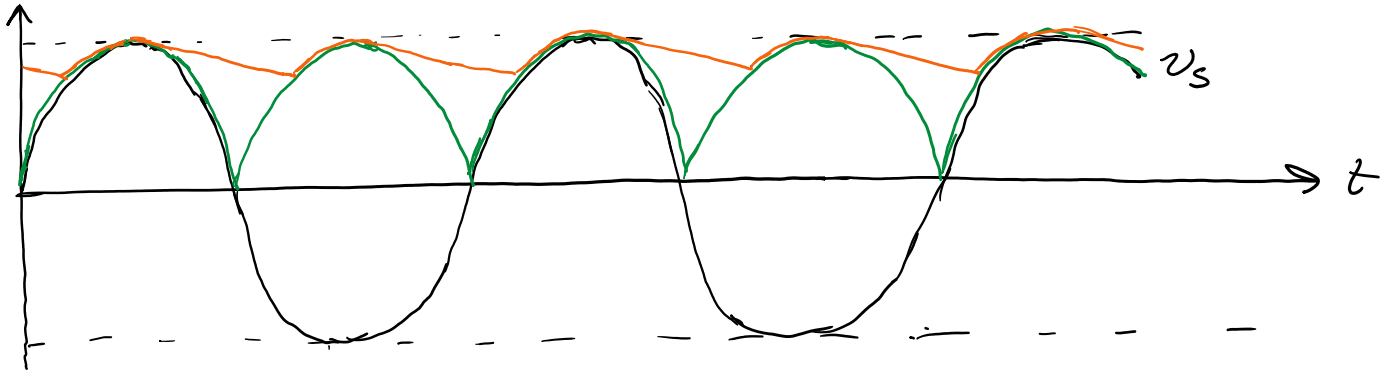
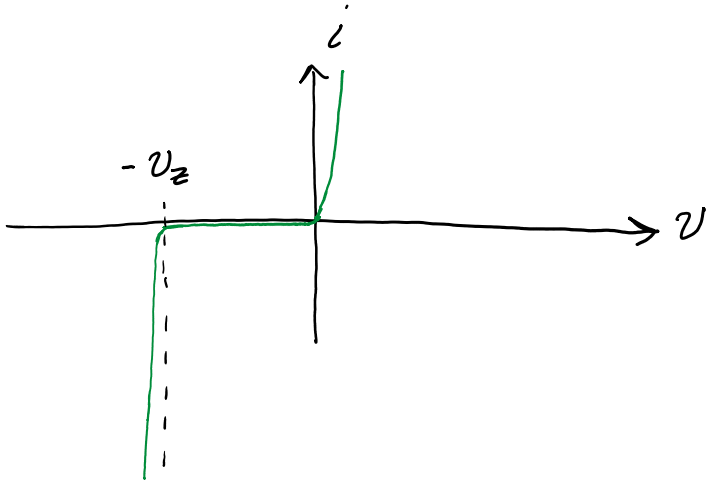




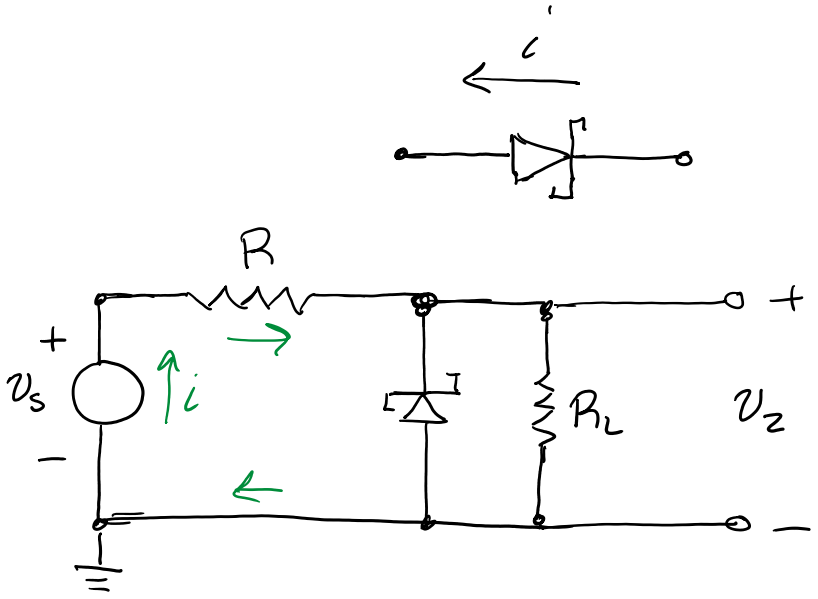
Shunt Voltage Regulator:

Recall current-voltage relation for a diode

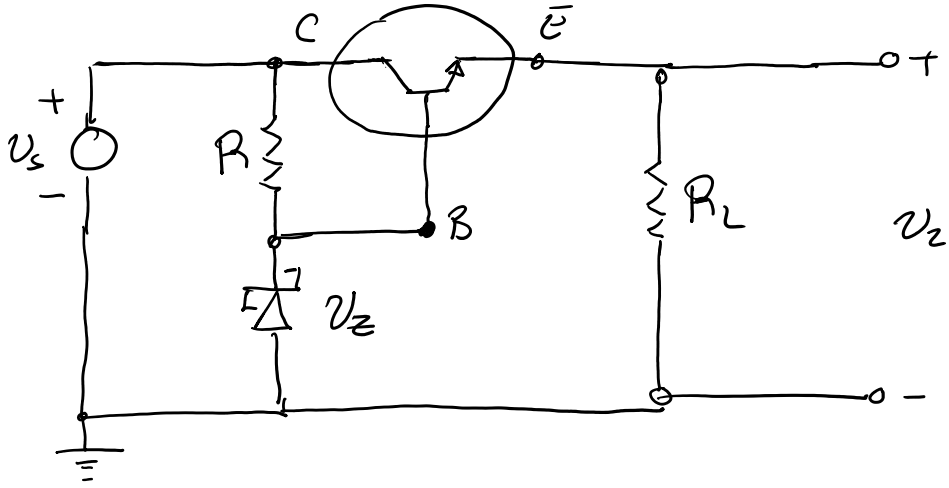


A "zener" diode is a diode designed to be operated in reverse. They're built to provide a

operated in reverse. They're built to provide a specific v_z value.



Emitter-follower voltage reg.



$v_z + v_{BE}$; $v_{BE} \cong$ activation voltage