

Diodes.

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Lecture 05

Notes

Midterm exam

Where: In the lab

When: During the first hour of the lab

Material:

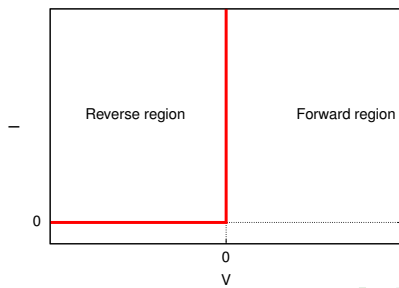
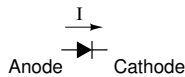
- everything from first 4 weeks of class
- Resistors, capacitors, inductors, and transformers.
- Kirchhoff's laws
- Complex impedances.
- Thévenin's theorem
 - Source impedance and voltage
- Voltage divider in various forms
- Filters

Lab will follow the midterm.

You can skip design exercise preparation prior to the lab. However, at the time of log book submission it must be fully done. Treat it as a home work.

Notes

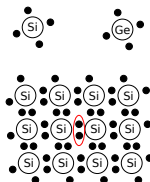
Ideal diode



Notes

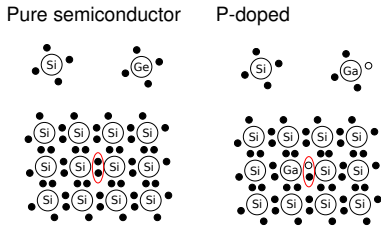
Semiconductors and doping

Pure semiconductor

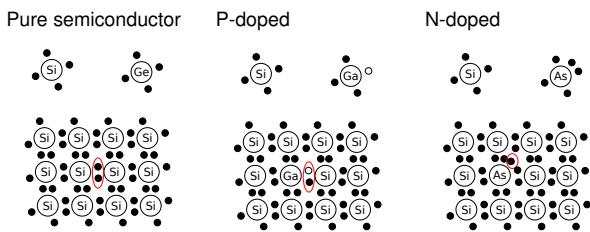


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Semiconductors and doping

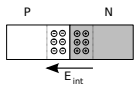


Semiconductors and doping



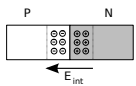
PN-junction

No bias

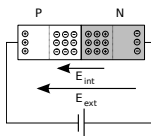


PN-junction

No bias



Reverse bias



Notes

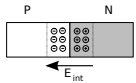
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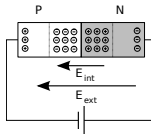
Notes

PN-junction

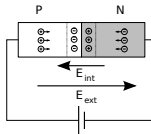
No bias



Reverse bias

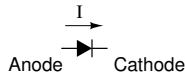


Forward bias



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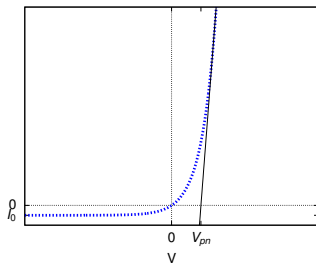
Real diode



$$I(V) = I_0 \left(e^{V/(nV_T)} - 1 \right)$$

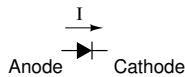
Typical parameters

- saturation current $I_0 = 1 \text{ nA}$
- thermal voltage $V_T = \frac{kT}{q} = 25.85 \text{ mV at } 300 \text{ K}$
- emission coefficient $n = 1..2$



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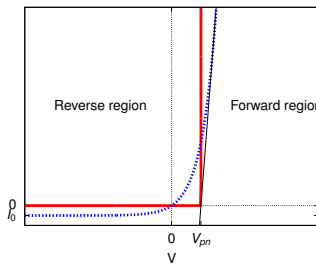
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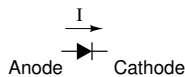
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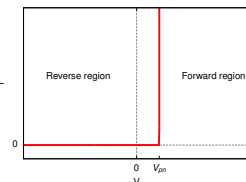
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Simplified diode

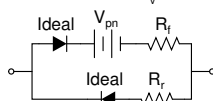


V_{pn} diode P-N junction opening voltage

- $V_{pn} = 0.6 \text{ V for Si}$
- $V_{pn} = 0.3 \text{ V for Ge}$



A bit more realistic diode ($R_r \gg R_f$)



Notes

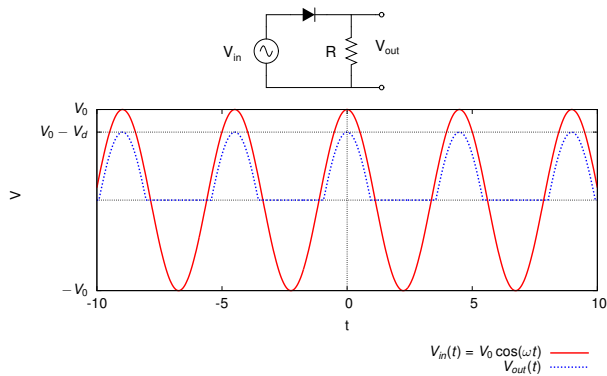
Diodes applications

- Circuit Protection
- Rectification
 - current gate
 - half wave rectifier
 - full wave rectifier
 - Power Supplies
- Frequency manipulation
 - Frequency multiplier
 - Mixers
- and more ...
 - Voltage clamps
 - light emitting diodes (LED)
 - photo-diode

Notes

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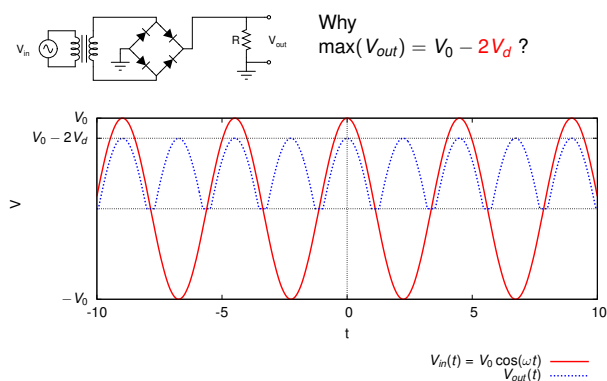
Half-wave rectifier, current gate



Notes

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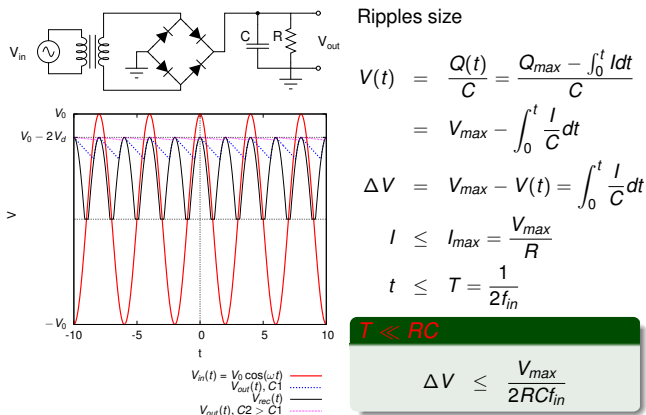
Full-wave rectifier: $V_{in} \gg V_d \rightarrow V_{out} \approx |V_{in}|$



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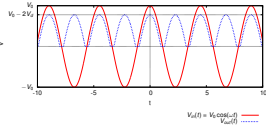
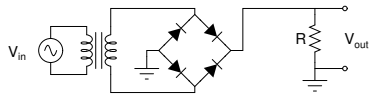
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Full-wave rectifier filtered - power supply



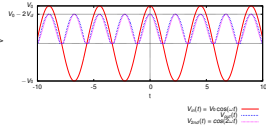
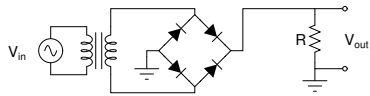
Notes

Full-wave rectifier as Frequency doubler



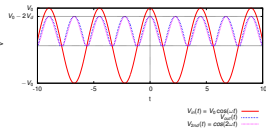
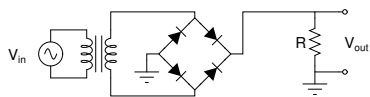
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Full-wave rectifier as Frequency doubler



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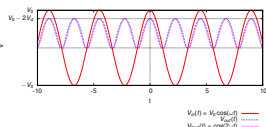
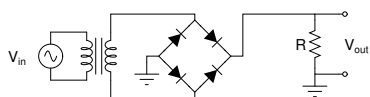
Full-wave rectifier as Frequency doubler



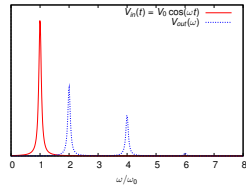
FFT

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Full-wave rectifier as Frequency doubler

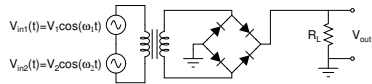


FFT



Notes

Full-wave rectifier as Frequency adder



$$V_{in1}(t) = V_1 \cos(\omega_1 t)$$

$$V_{in2}(t) = V_2 \cos(\omega_2 t)$$

$$V_{out}(t) = |V_{in}(t)| = \sqrt{V_{in}^2(t)} = \sqrt{(V_1 \cos(\omega_1 t) + V_2 \cos(\omega_2 t))^2}$$

$$= \sqrt{V_1^2 \cos^2(\omega_1 t) + 2 V_1 V_2 \cos(\omega_1 t) \cos(\omega_2 t) + V_2^2 \cos^2(\omega_2 t)}$$

Assuming $V_1 \gg V_2$

$$V_{out}(t) \approx \sqrt{V_1^2 \cos^2(\omega_1 t) + 2 V_1 V_2 \cos(\omega_1 t) \cos(\omega_2 t) + V_2^2 \cos^2(\omega_2 t)}$$

$$\approx V_1 \left(\cos(\omega_1 t) + \frac{V_2}{V_1} \cos(\omega_1 t) \cos(\omega_2 t) \right)$$

$$\approx V_1 \left(\cos(\omega_1 t) + \frac{V_2 \cos((\omega_1 + \omega_2)t) + \cos((\omega_1 - \omega_2)t)}{2} \right)$$

Navigation icons: back, forward, search, etc.

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