V-code: ???

Diodes

Lecture 18
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Slide credits: *Prof. Anant Agarwal at MIT*

V-code: ???

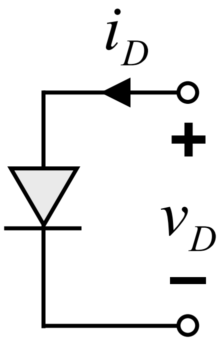
Outline

Textbook: 16.1, 16.2, 16.3, 16.4.1, 16.5.3

- **Diode Characteristics**
- Analysis of Diode Circuits
- Additional Example: Limiter

First, let's look at the diode

V-code: ???



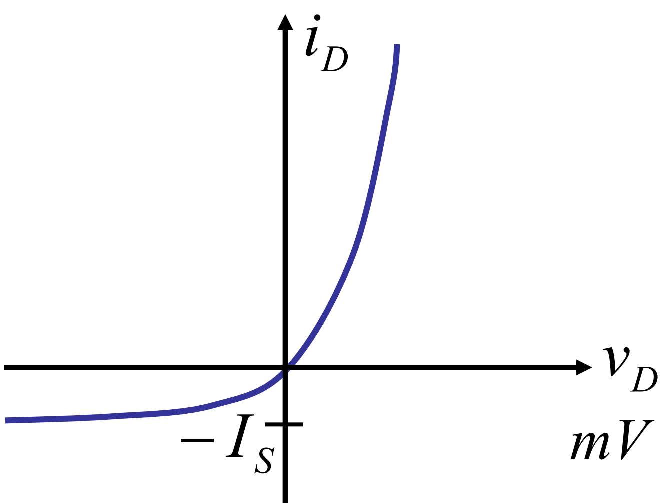
$$i_D = I_S\left(e^{\frac{v_D}{V_T}} - 1\right)$$

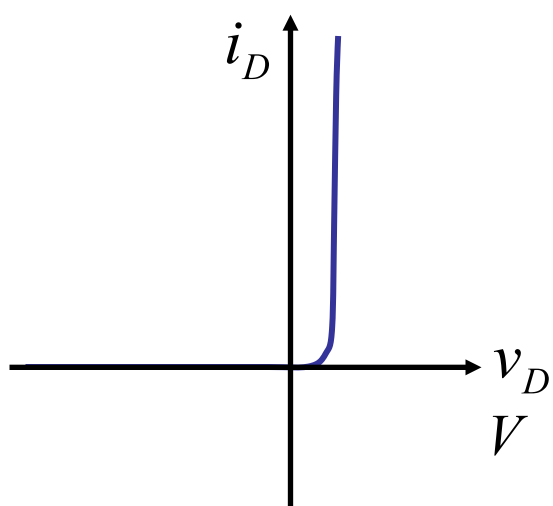
$$I_S = 10^{-12}\,A$$

$$V_T = 0.025V$$

$$V_T = \frac{kT}{q}$$

Boltzmann's constant
temperature in Kelvins
charge of an electron





Can use this exponential model with analysis methods learned earlier:

- **Analytical**
- **Graphical**
- **Incremental**

V-code: ???

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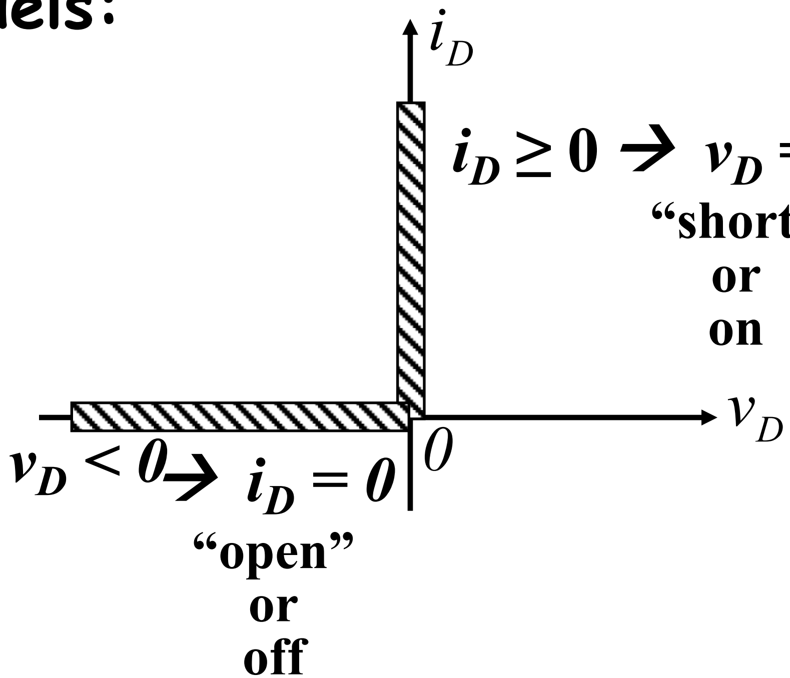
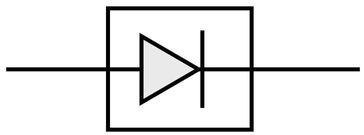
Another analysis method: piecewise-linear analysis

P-L diode models:



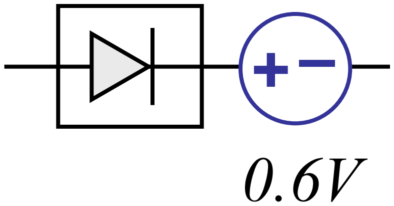
Ideal diode model

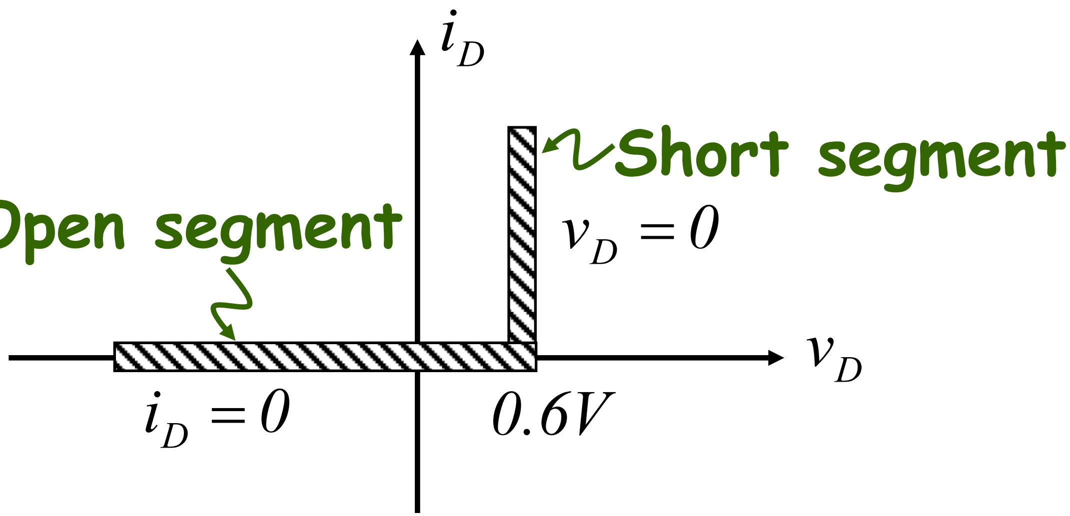


Another analysis method: piecewise-linear analysis

V-code: ???

"Practical" diode model
ideal with offset





Another analysis method: piecewise-linear analysis

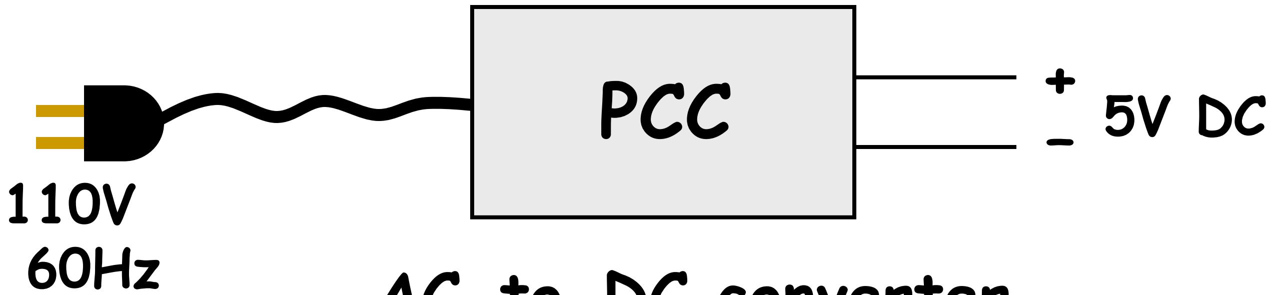
V-code: ???

Piecewise-linear analysis method

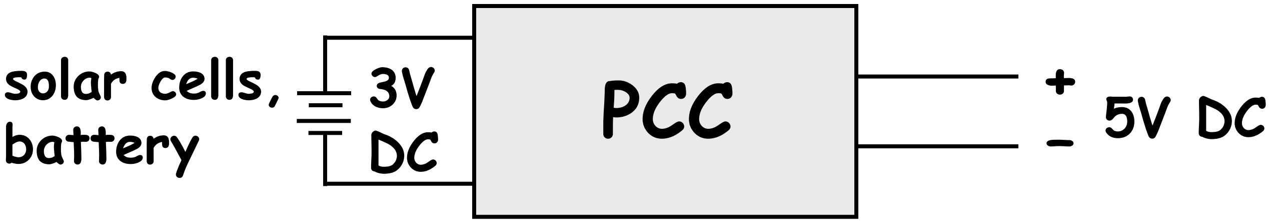
- Replace nonlinear characteristic with linear segments.
- Perform linear analysis within each segment.

V-code: ???

Power Conversion Circuits (PCC)



AC-to-DC converter



DC-to-DC UP converter

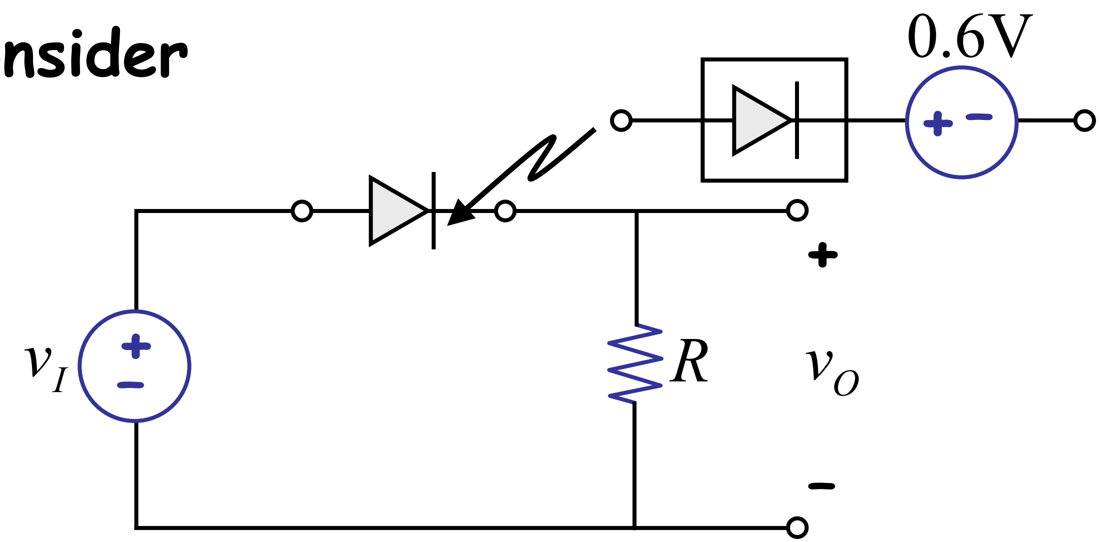
Power efficiency of converter important,
so use lots of devices:
MOSFET switches, clock circuits,
inductors, capacitors, op amps, diodes

Example

V-code: ???

(We will build up towards an AC-to-DC converter)

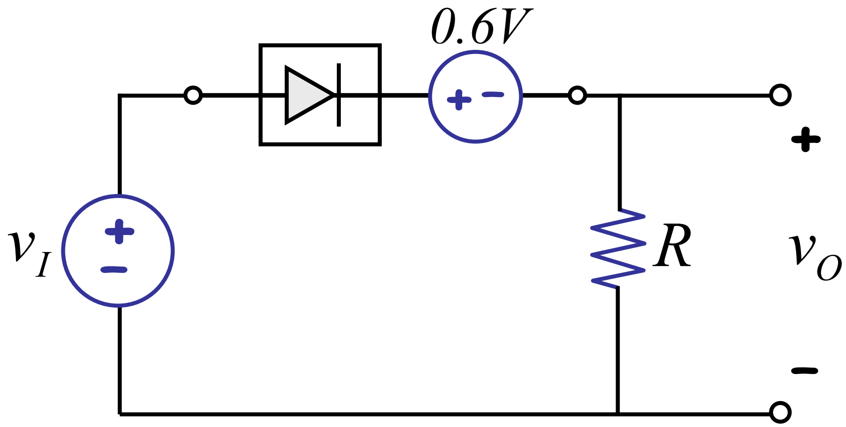
Consider



v_I is a sine wave

Example

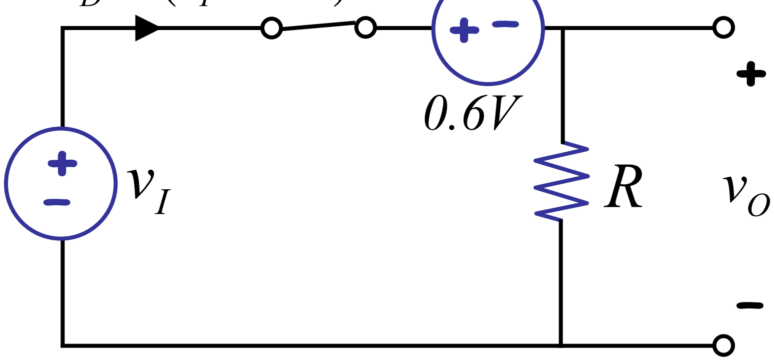
V-code: ???



Equivalent circuit

"Short segment":

$i_D = (v_I - 0.6)/R$

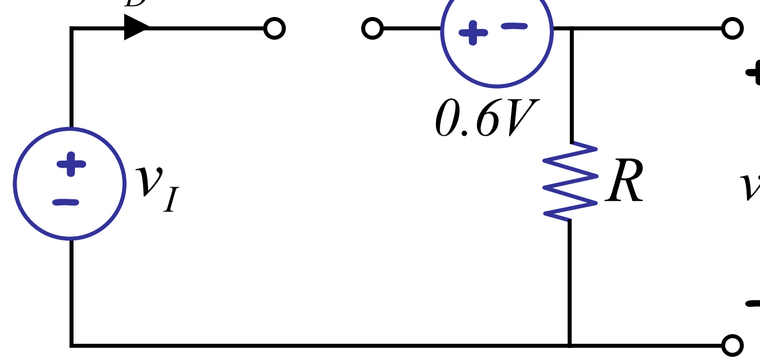


$v_O = v_I - 0.6$

$v_I \geq 0.6$

"Open segment":

$i_D = 0$

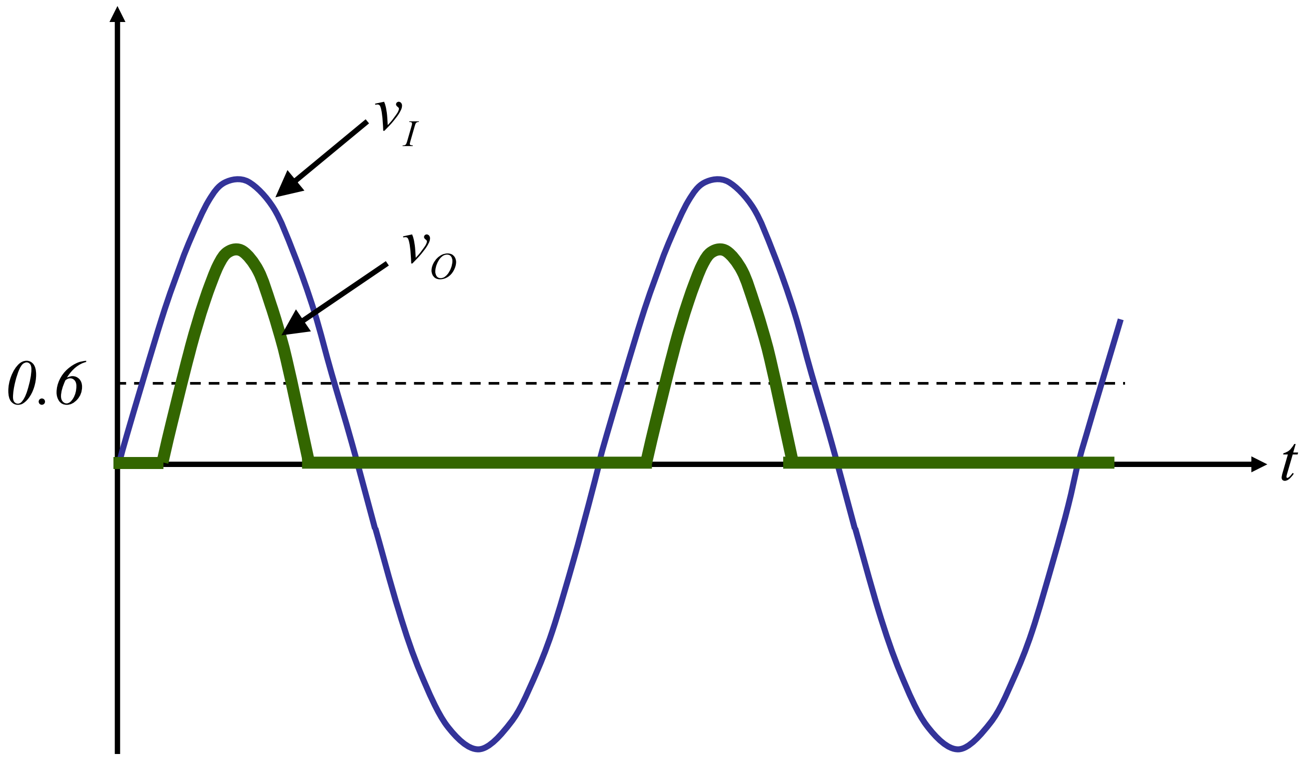


$v_O = 0$

$v_I < 0.6$

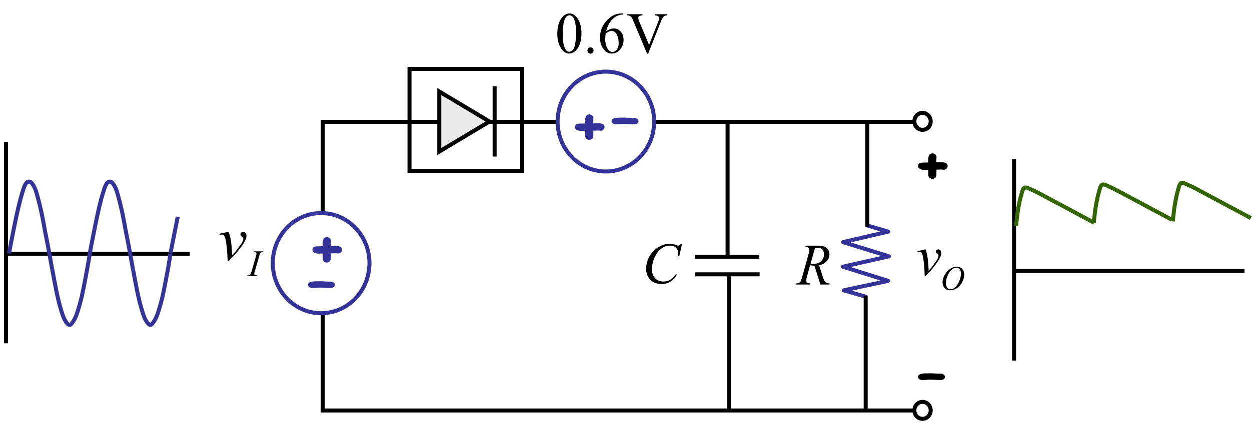
Example

V-code: ???



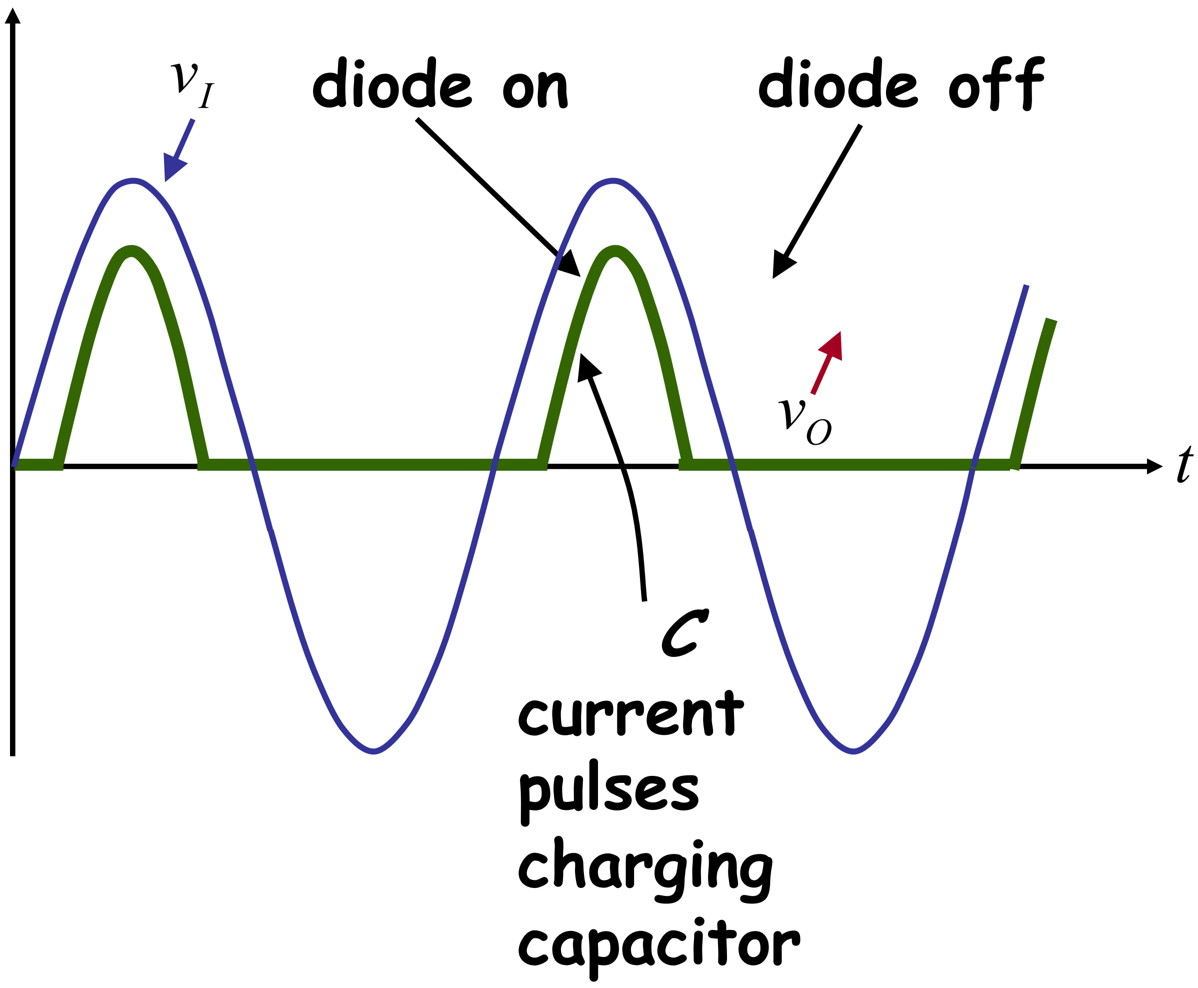
Now consider — a half-wave rectifier

V-code: ???



A half-wave rectifier

V-code: ???



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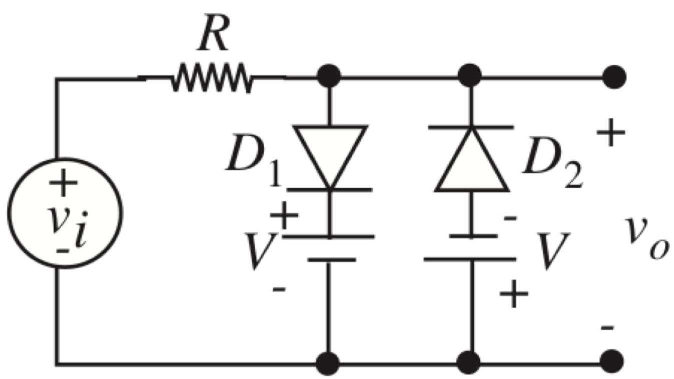
Limter (Clipper) Circuit

V-code: ???



What are possible diode states?

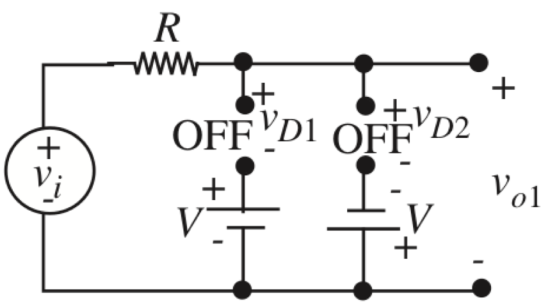
Recall: piecewise-linear analysis

1. Draw a subcircuit for each possible state (ON or OFF) of the diodes. For one diode there are two subcircuits. For n diodes there are 2^n such states, and hence 2^n subcircuits.
2. Analyze each resulting linear circuit to find an expression for the desired output variable. Because in each subcircuit the diode is either a short or an open circuit, the subcircuits are linear. Hence linear analysis methods can be used.
3. Establish the range of validity of each of the expressions in (2); then assemble the appropriate segments to form the complete output waveform.

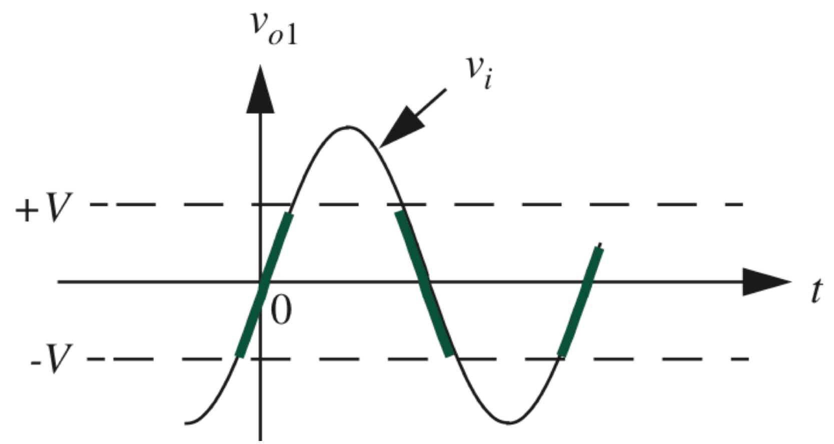
Limter (Clipper) Circuit

V-code: ???

Case 1: When both diodes are OFF



Subcircuit 1

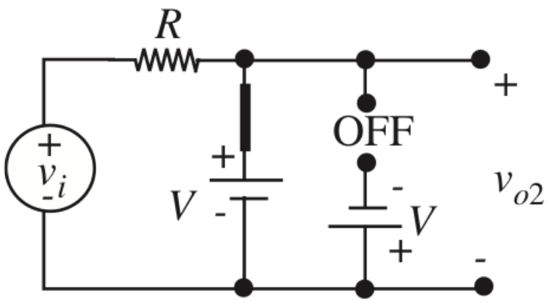


Output (V_{o1})

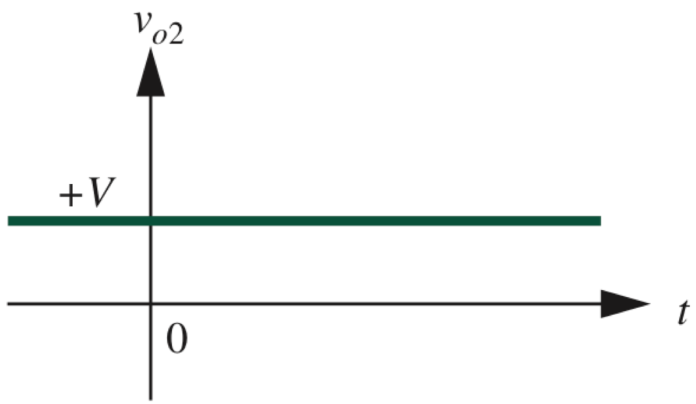
Limter (Clipper) Circuit

V-code: ???

Case 2: D1 is ON, D2 is OFF



Subcircuit 2

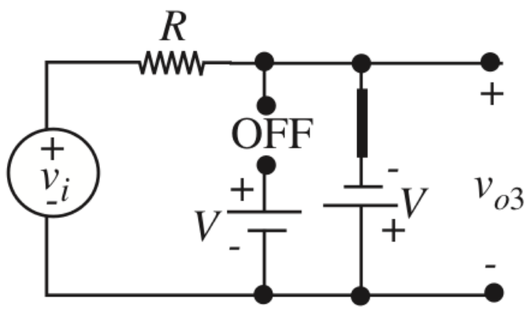


Output (V_{o2})

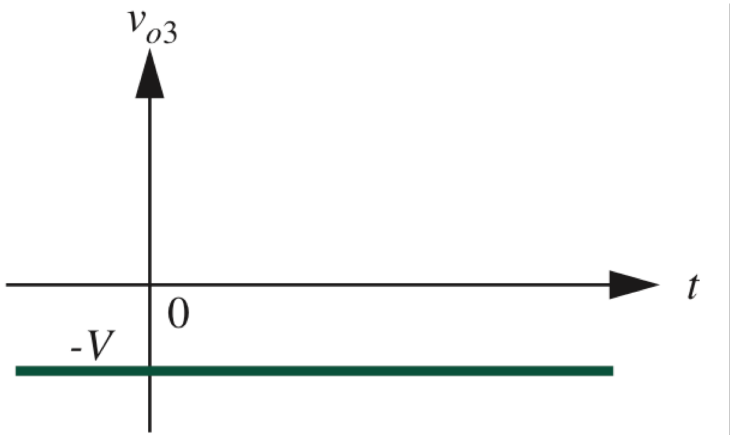
Limter (Clipper) Circuit

V-code: ???

Case 3: D1 is OFF, D2 is ON



Subcircuit 3

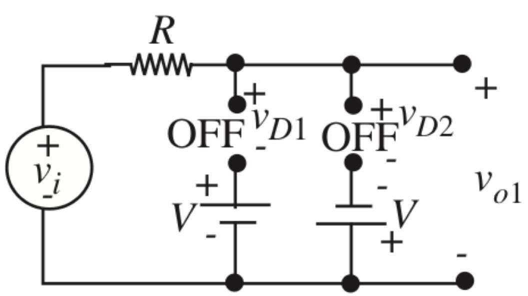


Output (V_{o3})

Limter (Clipper) Circuit

V-code: ???

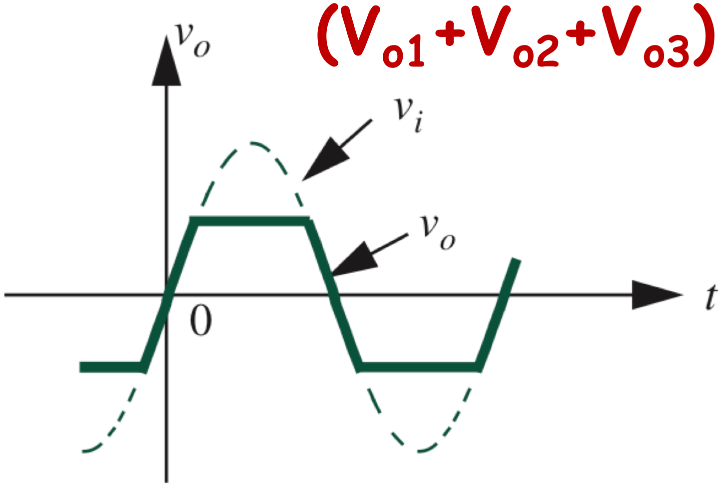
Case 4: Both D1 and D2 are OFF



Subcircuit 4

Can this case happen??

Complete waveform!
($V_{o1}+V_{o2}+V_{o3}$)



V-code: ???

Thank you!

- It was great to teach you this semester and I wish best of luck for your future endeavors!