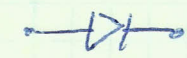
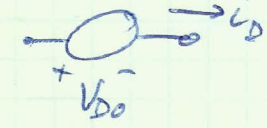
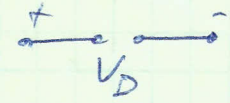
Model for Zener Diodes



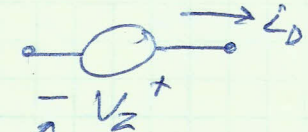
ON : $V_D = V_{D0}$, $i_D \geq 0$



OFF : $-V_Z < V_D < V_{D0}$, $i_D = 0$



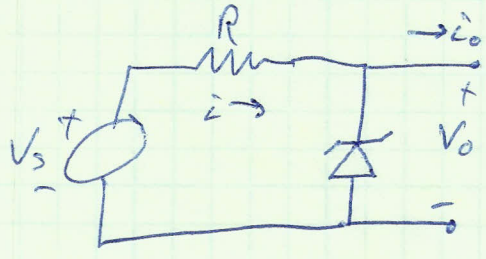
Zener Region : $V_D = -V_Z$, $i_D \leq 0$

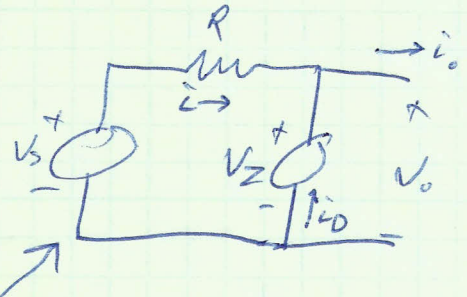


note change in sign

A Simple Power Supply

- Assume that a power supply has some variation or ripple
- Zener diodes can be used to take out the ripple





Case 1: Zener region

$V_o = V_Z$ = constant

output voltage is independent of i_o – ideal voltage source

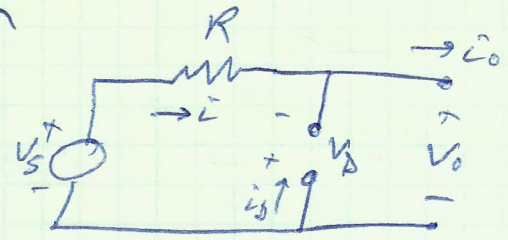
KCL: $i_D = i_o - i$

KVL: $V_S = R \cdot i + V_Z$ $\rightarrow$ $i_D = i_o - \frac{V_S - V_Z}{R} \leq 0$

$\hookrightarrow i_o \leq \frac{V_S - V_Z}{R}$

- As long as this condition is satisfied, diode will be in Zener region

Case 2: Reverse bias region



$i_D = 0$

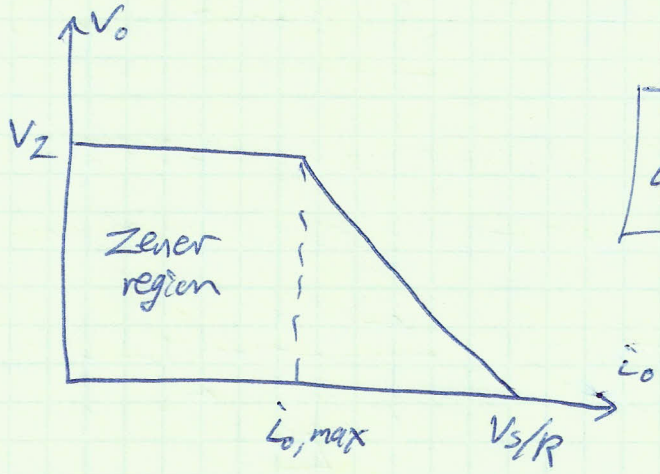
$i = i_o$

$V_S - R i_o = V_o$

- Output voltage drops as more current is drawn from circuit

Case 3: forward bias region

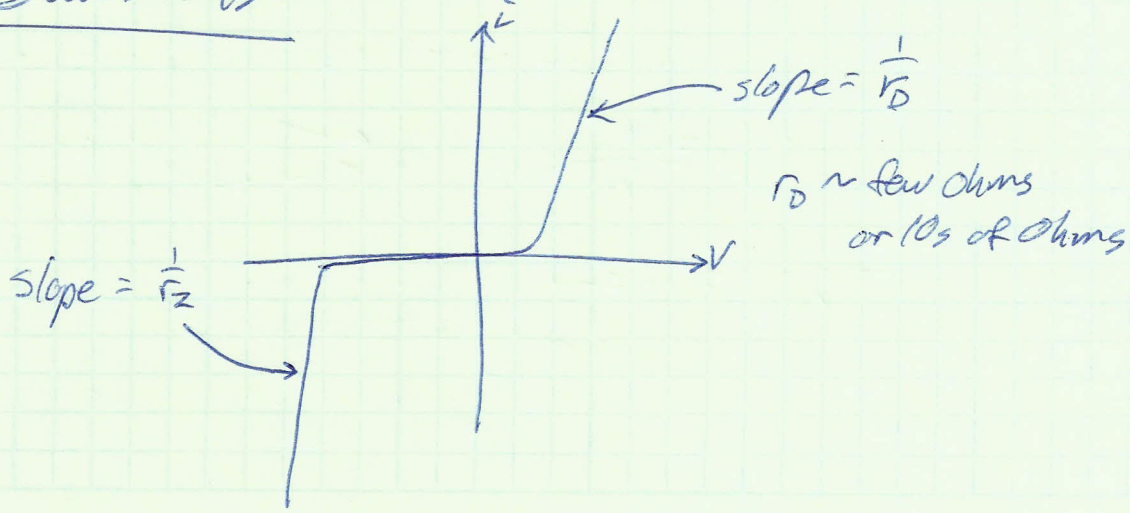
not possible – V_S is positive.



$$i_{o,max} = \frac{V_S - V_Z}{R}$$

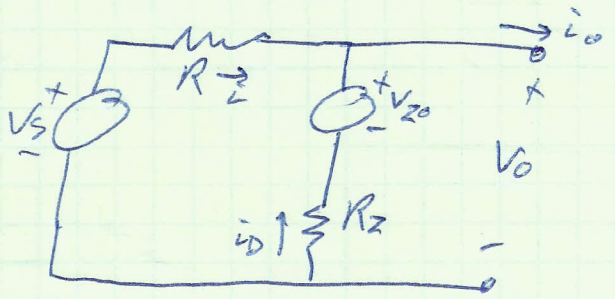
- In reality, there is a slight slope to the Zener region of the curve
  - real voltage sources are made with transistors and opamps, etc.

Other Diode Models



For Zener Diode, model as voltage source with resistor

Zener Region:



$i_D \neq i = i_o$

$V_S = R i + V_{Z0} - R_Z i_D$

Solve for i_D to see if in Zener region ($i_D < 0$)

$V_S = R(i_o - i_D) + V_{Z0} - R_Z i_D$

$i_D = -\dfrac{V_S - V_{Z0} - R i_o}{R + R_Z}$ $\quad i_D < 0$ when $i_o < \dfrac{V_S - V_{Z0}}{R}$ (same as before)

$V_o = V_{Z0} + R_Z i_D$

$V_o = V_{Z0} + R_Z \dfrac{V_S - V_{Z0} - R i_o}{R + R_Z}$

$V_o = \dfrac{R V_{Z0} + R_Z V_S}{R + R_Z} - \dfrac{R R_Z}{R + R_Z} i_o$

$\hat{V}_{Z0}$ modified V_{Z0}, slightly higher than V_{Z0}

assume $R_Z \ll R \rightarrow R_Z \| R \approx R_Z$

$V_o = \hat{V}_{Z0} - R_Z i_o$

- circuit looks like voltage source $\hat{V}_Z$ with output resistance R_Z

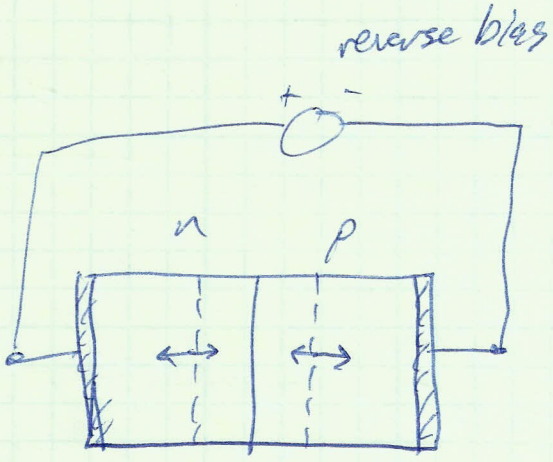
More additional diode types

We have already covered:

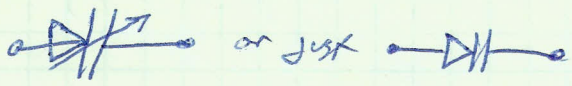
- Zener diodes
- Schottky diodes
- light emitting diodes

There are also:

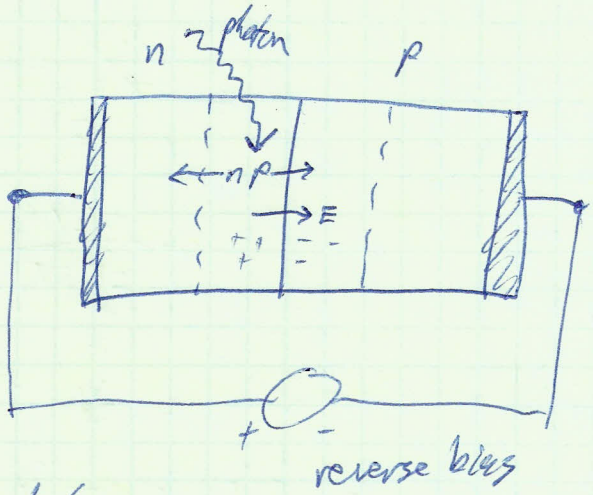
- Varactor Diodes



- depletion region moves in response to applied voltage
- appears as capacitor who's width depends on voltage



- Photodiodes



- photon generates electron - hole pair
- current is proportional to light hitting the detector
- these are often PIN diodes