ECE 2100 Lecture Notes 2/5/03 Now in EMCB 101

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2/4/03

Stuff Exam 1 Friday, 2/7/03, Monday 2/10 ?
Chapters 1 & 2, Lectures through 1/31
HWs 1 - 8 Understand problems.
Try some old exams (Web HW page, download view and print ASAP, some people have trouble with my pdf files).

HW #9, due M, 2/10
Ch. 3, Ex3.1 - Ex3.5, Repeat Ex3.1 - Ex3.5 using the 0.7V drop model of the diode.
Ex3.4c book ans. wrong, should be: -5V

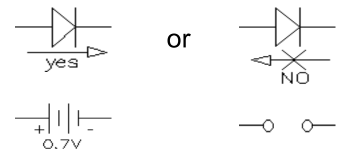
HW #10 handout, due F, 2/14

Diodes

Start with Diode curve in Monday's lecture notes.

Diode circuit analysis

conducting or not conducting



Make an educated guess about each diode's state.

Replace each diode with the appropriate model:

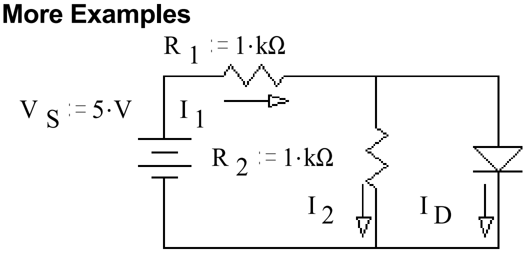
Analyze circuit.

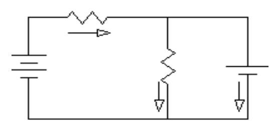
Make sure that each diode is actually in the state you assumed: current + - $V_d < 0.7V$

Note: 0.7V is for silicon junction diodes & will be different for other types. (2V for LED)

If any of your guesses don't work out right, then you'll have to start over with new guesses.
In a circuit with multiple diodes (say "n" diodes), there will be 2^n possible states, all of which may have to be tried until you find the right one. Try to guess right the first time.

More Examples





Assume diode conducts $V_D := 0.7 \cdot V$ $= V_{R2}$
Analyze

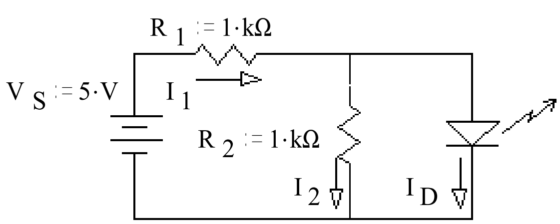
$V_{R2} := V_D$ $I_2 := \frac{V_{R2}}{R_2}$ $I_2 = 0.7 \cdot mA$

$V_{R1} := V_S - V_D$ $V_{R1} = 4.3 \cdot V$ $I_1 := \frac{V_{R1}}{R_1}$ $I_1 = 4.3 \cdot mA$

Check If you assumed conducting, then check current.

$I_D := I_1 - I_2$ $I_D = 3.6 \cdot mA$ > 0, so assumption was correct

With an LED



Assume diode conducts $V_D := 2 \cdot V$ $= V_{R2}$
Analyze

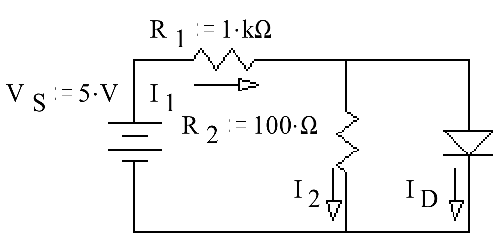
$V_{R2} := V_D$ $I_2 := \frac{V_{R2}}{R_2}$ $I_2 = 2 \cdot mA$

$V_{R1} := V_S - V_D$ $V_{R1} = 3 \cdot V$ $I_1 := \frac{V_{R1}}{R_1}$ $I_1 = 3 \cdot mA$

Check If you assumed conducting, then check current.

$I_D := I_1 - I_2$ $I_D = 1 \cdot mA$ > 0, so assumption was correct, but the current is probably too small to create noticeable light

Smaller R_1



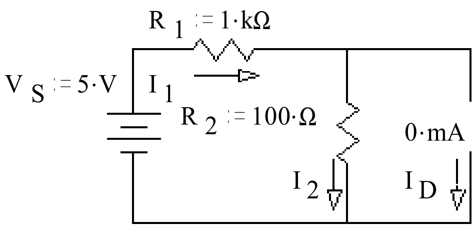
Assume diode conducts $V_D := 0.7 \cdot V$ $= V_{R2}$
Analyze

$V_{R2} := V_D$ $I_2 := \frac{V_{R2}}{R_2}$ $I_2 = 7 \cdot mA$

$V_{R1} := V_S - V_D$ $V_{R1} = 4.3 \cdot V$ $I_1 := \frac{V_{R1}}{R_1}$ $I_1 = 4.3 \cdot mA$

Check If you assumed conducting, then check current.

$I_D := I_1 - I_2$ $I_D = -2.7 \cdot mA$ < 0, so assumption **wrong**



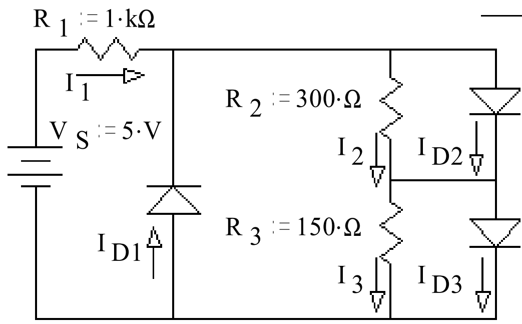
Assume diode does not conduct $I_D := 0 \cdot mA$

Analyze $I_1 := \dfrac{V_S}{R_1 + R_2}$ $\quad I_2 := I_1$

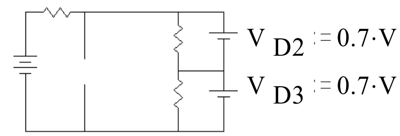
Check If you assumed nonconducting, then check voltage.

$V_{R2} := I_2 \cdot R_2$ $\quad V_{R2} = 0.455 \cdot V$ < 0.7V, so assumption was correct

Actually, this final check isn't necessary, since first assumption didn't work, so this one had to.



You can safety say that diode D_1 doesn't conduct without rechecking later because no supply is even trying to make current flow through that diode the right way.



Assume both D_2 and D_3 conduct.

Analyze $V_{R1} := V_S - V_{D2} - V_{D2}$

$V_{R1} = 3.6 \cdot V$ $\quad I_1 := \dfrac{V_{R1}}{R_1}$ $\quad I_1 = 3.6 \cdot mA$

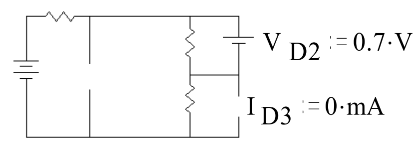
$I_2 := \dfrac{V_{D2}}{R_2}$ $\quad I_2 = 2.333 \cdot mA$ $\quad I_3 := \dfrac{V_{D3}}{R_3}$ $\quad I_3 = 4.667 \cdot mA$

Check If you assumed conducting, then check current.

$I_{D2} := I_1 - I_2$ $\quad I_{D2} = 1.267 \cdot mA$ > 0, so assumption OK

$I_{D3} := I_1 - I_3$ $\quad I_{D3} = -1.067 \cdot mA$ < 0, so assumption **wrong**

Assume both D_2 conducts and D_3 doesn't.



Analyze $I_2 := \dfrac{V_{D2}}{R_2}$ $\quad I_2 = 2.333 \cdot mA$ $\quad I_1 := \dfrac{V_S - V_{D2}}{R_1 + R_3}$ $\quad I_1 = 3.739 \cdot mA$

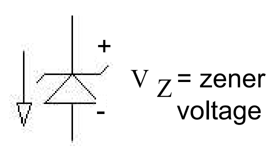
Check If you assumed conducting, then check current. $I_{D2} := I_1 - I_2$ $\quad I_{D2} = 1.406 \cdot mA$ > 0, so assumption OK

Check If you assumed nonconducting, then check voltage. $V_{R3} := I_1 \cdot R_3$ $\quad V_{R3} = 0.561 \cdot V$ < 0.7V, so OK

Once you find one case that works, you don't have to try any others.

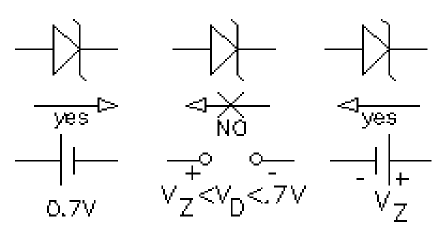
Zener Diodes

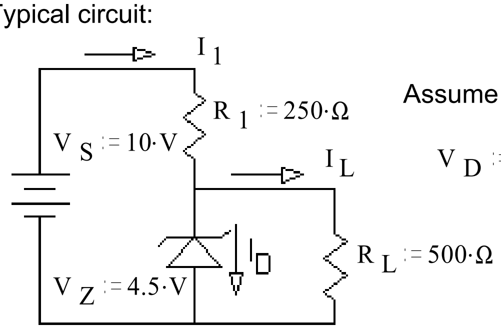
Zener diodes are special diodes designed to operate in the reverse breakdown region. Since the reverse breakdown voltage across the diode is very constant for a large range of current, it can be used as a voltage reference or regulator. Diodes are not harmed by operating in this region as long as their power rating isn't exceeded. In the forward direction zeners work the same as regular diodes.



Typical circuit:

Now there are three possible regions of operation:





Shunt regulator

Assume conducting in breakdown region

$V_D := V_Z$ $\quad I_L := \dfrac{V_Z}{R_L}$ $\quad I_L = 9 \cdot mA$

$I_1 := \dfrac{V_S - V_Z}{R_1}$ $\quad I_1 = 22 \cdot mA$

Check If you assumed conducting, then check current.

$I_D := I_1 - I_L$ $\quad I_D = 13 \cdot mA$ > 0, so assumption OK