ECE 310- Lecture 13

Thursday, February 8, 2018 1:12 PM

Half wave Rectifier:

PIV ≃ $2V_p$

$$V_R \simeq \frac{V_p - V_{D,on}}{R_L C_1 f_{in}} = \frac{I_L}{C_1 f_{in}}$$

← peak load current

Full-wave Rectifier:

PIV ≃ V_p

$$V_R \simeq \frac{1}{2} \frac{(V_p - 2V_{D,on})}{R_L C_1 f_{in}} = \frac{I_L}{C_1 f_{in}}$$

Diode Peak Current:

$$I_p \simeq \frac{V_p}{R_L}\left(R_L C_1 \omega_{in} \sqrt{\frac{2V_{in}}{V_p}} + 1\right)$$

← Page 92-93

$R_L C_1 \uparrow \Rightarrow I_p \uparrow$

Book Ex 3.28 ⇒ $I_p = 577$ A ← Too large!

Read Book Examples: 3.27 & 3.28

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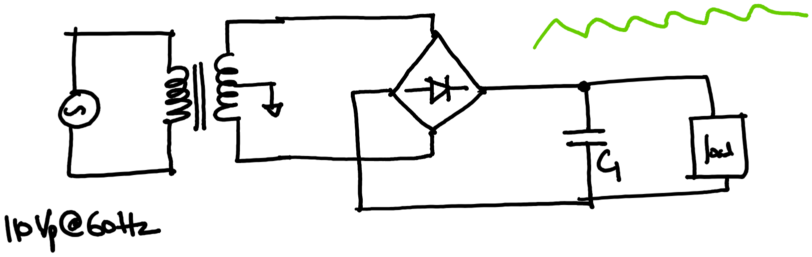
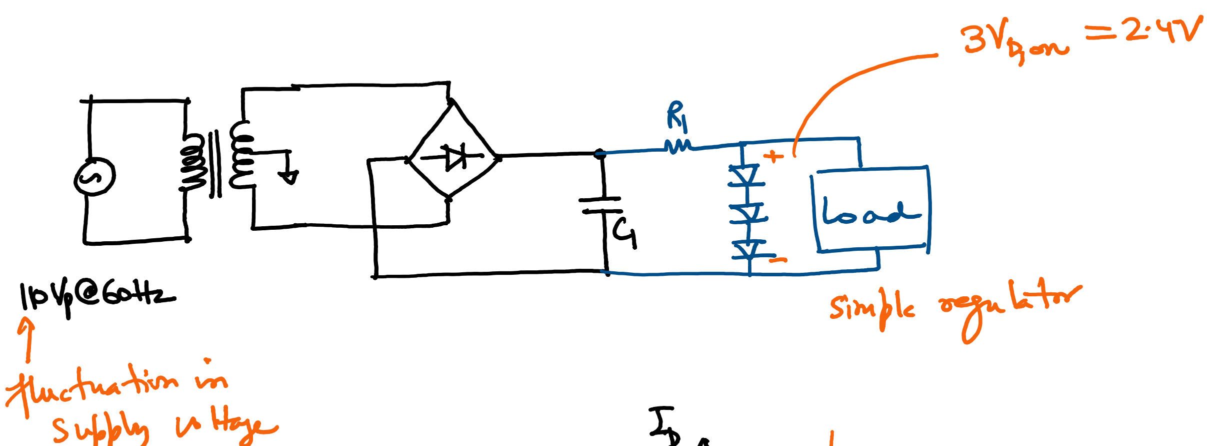
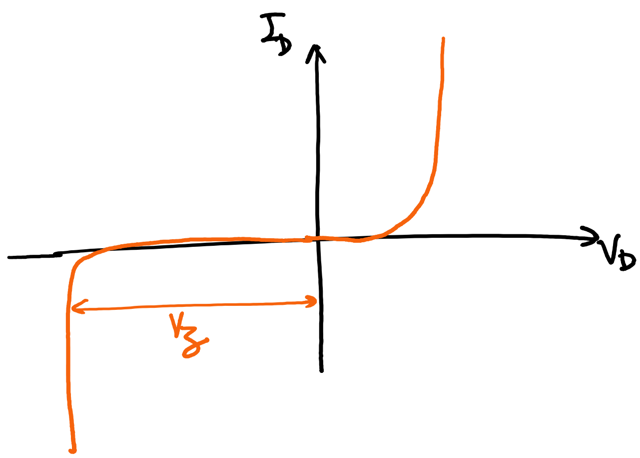
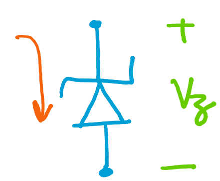
Section 3.5.2



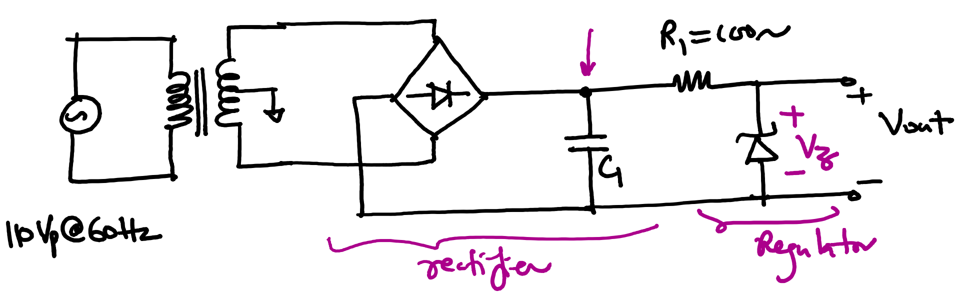
Ripples can be problem in meeting the design specifications







Can use zener diode as a regulator



Read on your own: 3.5.2 → Voltage Regulators

Limiting Circuits

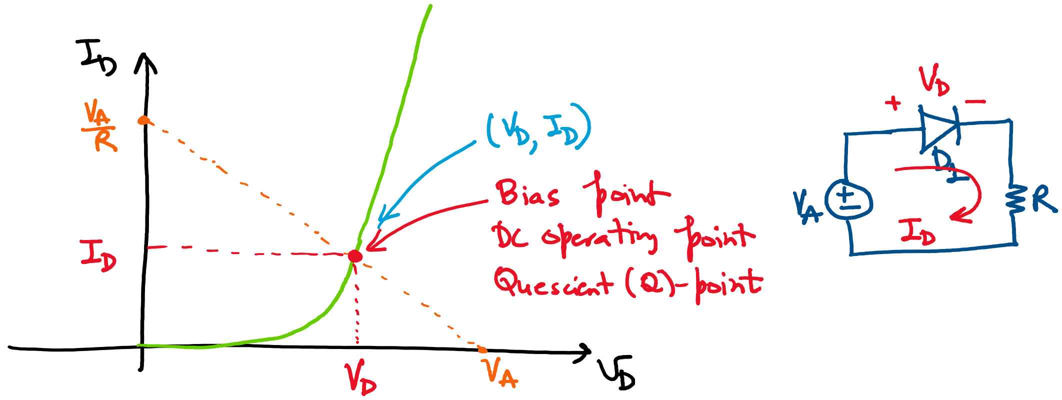
Read on your own:

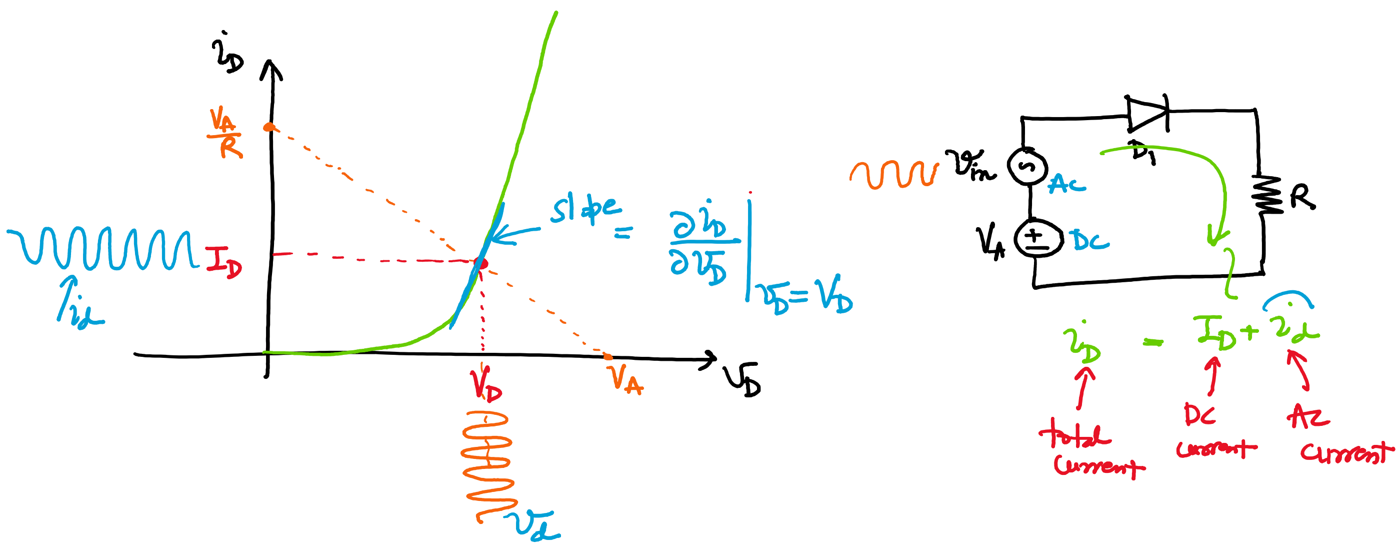
3.5.2 → Voltage Regulators

3.5.3 → Limiting Circuits

3.5.4 → Voltage Doublers.

Small signal operation of a Diode:





input voltage $\Rightarrow$ $V_A + v_{in}$

Diode voltage $\Rightarrow$ $v_D = V_D + v_d$

Diode current $\Rightarrow$ $i_D = I_D + i_d$

How does i_d relates to v_d

$$\Delta i_D = \left.\frac{\partial i_D}{\partial v_D}\right|_{v_D = V_D} \cdot \Delta v_D$$

$$\Rightarrow i_d = \left(\left.\frac{\partial i_D}{\partial v_D}\right|_{v_D = V_D} \right) \cdot v_d$$

Small signal → i_d

v_d ← Small signal voltage (ac)

$$i_d = \left(\frac{\partial i_D}{\partial v_D} \Big|_{v_D = V_D} \right) \cdot v_d$$

Small signal current (i_d); small signal voltage (ac) (v_d)

$$\frac{\partial i_D}{\partial v_D} = \frac{\partial}{\partial v_D}\left(I_s e^{\frac{v_D}{nV_T}} - 1 \right) = \frac{1}{nV_T} \cdot I_s e^{\frac{v_D}{nV_T}}$$

$I_s e^{\frac{v_D}{nV_T}} \simeq i_D$

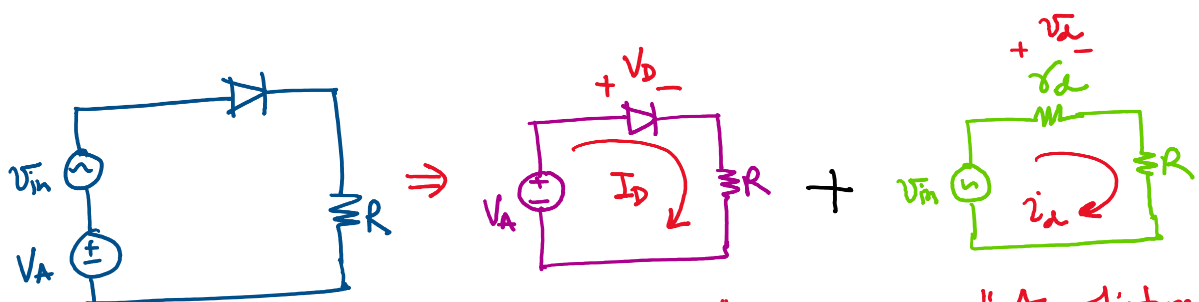
$$= \frac{i_D}{nV_T}$$

$$\frac{\partial i_D}{\partial v_D}\Big|_{v_D = V_D} = \frac{I_D}{nV_T} = \frac{I_D}{V_T} \text{ for } n=1$$

↑ dimension of conductance $\equiv g_d \triangleq r_d^{-1}$

$$\boxed{i_d = g_d v_d = \frac{v_d}{r_d}} \rightarrow r_d = \frac{V_T}{I_D}$$

Diode behaves like a linear resistor for small signal inputs



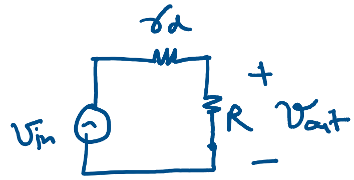
"DC picture"
DC circuit
↳ remove all independent AC sources
↳ solve for DC operating points

"AC picture"
Small signal equivalent circuit
↳ remove all DC sources
↳ replace devices by their small signal models
↳ Solve for "ac" or small-signal voltages & currents

Combine results to get

Combine results to get final answers.

"Small signal Analysis" method

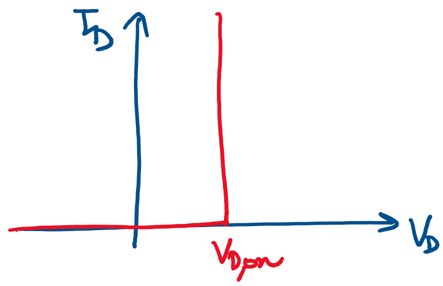


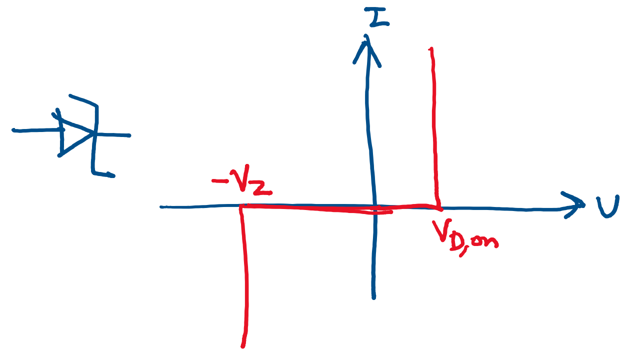
$$v_{out} = v_{in} \cdot \frac{r_d}{r_d + R}$$

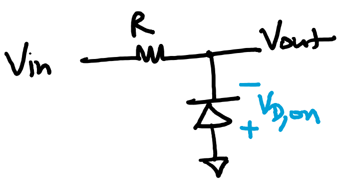
$$V_{out} = I_D R$$

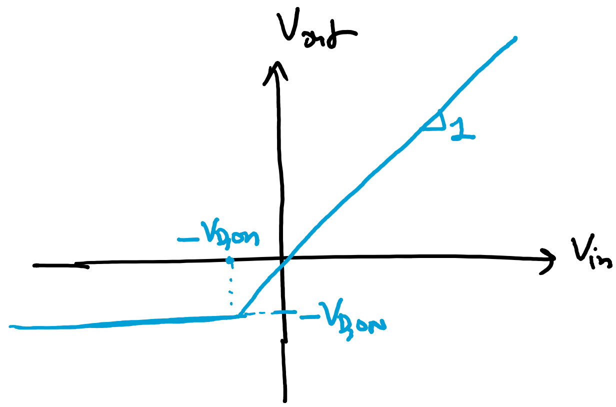
$$\text{Total output voltage} = \underbrace{I_D R}_{DC} + \underbrace{v_{in} \cdot \frac{r_d}{r_d + R}}_{AC}$$

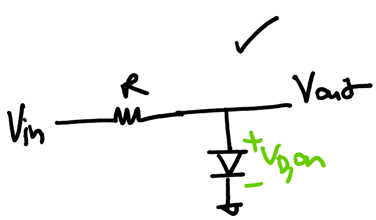
Clipping + Clamping :

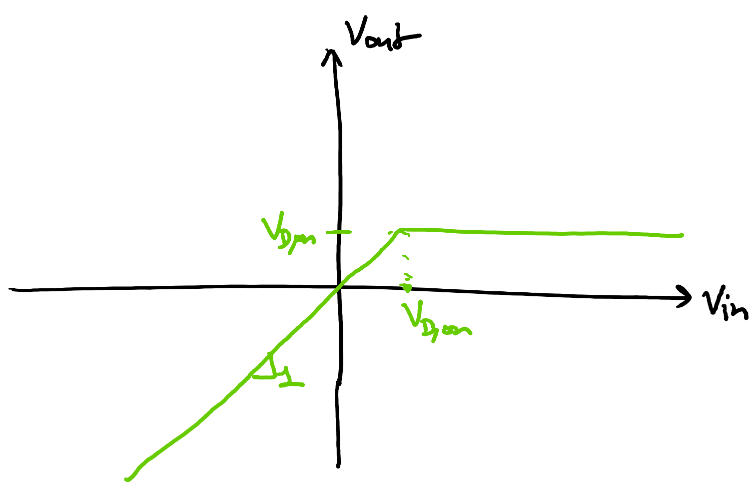


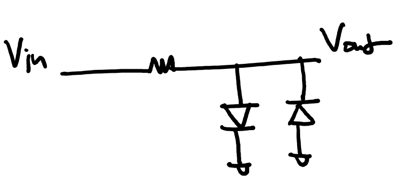


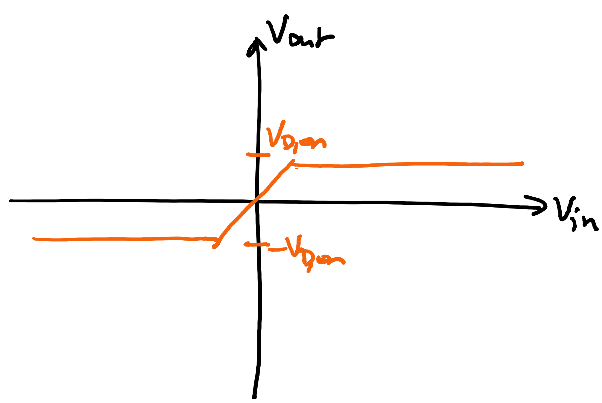


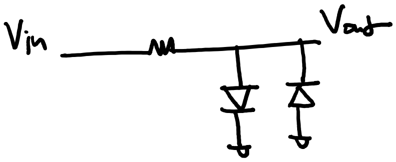


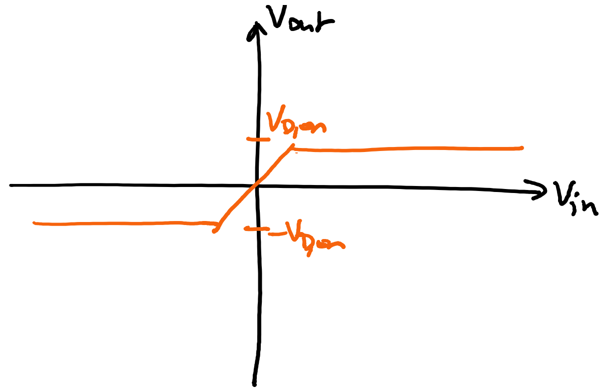


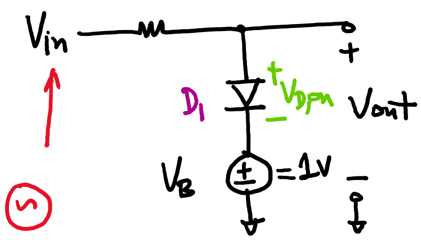


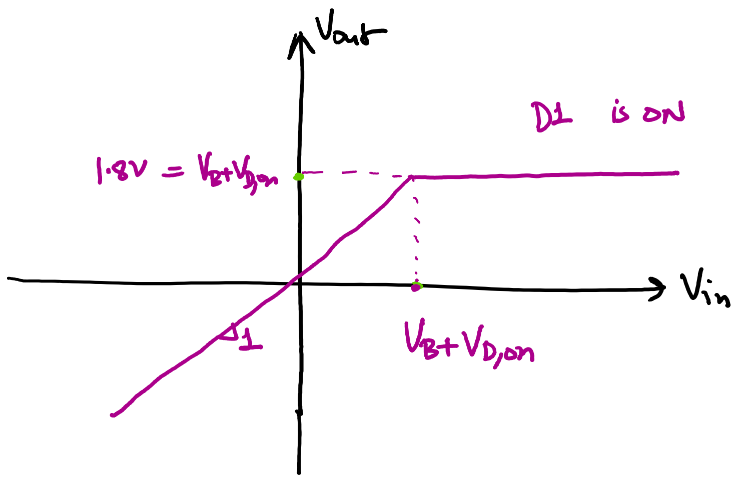


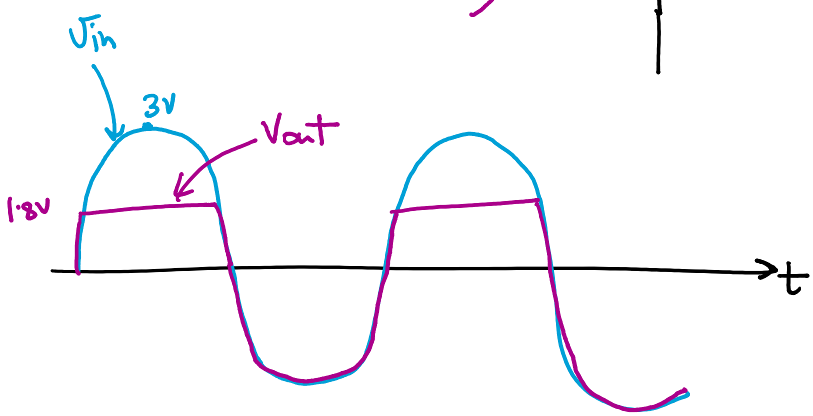


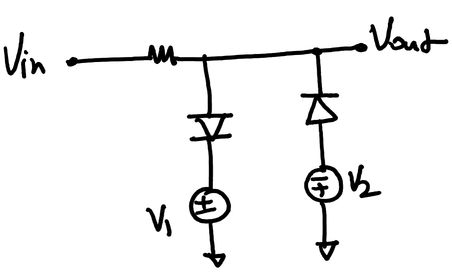

Vin
Vout

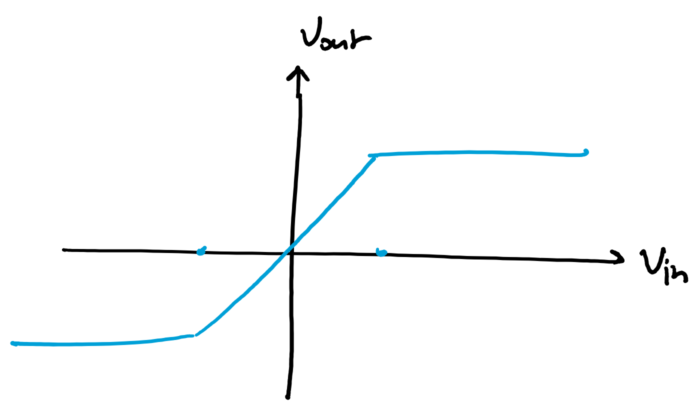

Vout
VD,on
Vin
-VD,on

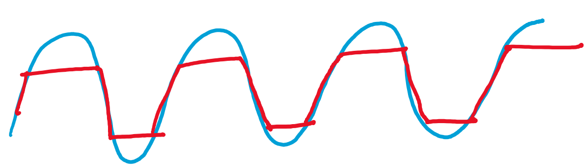

Vin
D1
+
VD,on
-
Vout
VB
=1V
+
-


Vout
D1 is ON
1.8V = VB+VD,on
Vin
D1
VB+VD,on

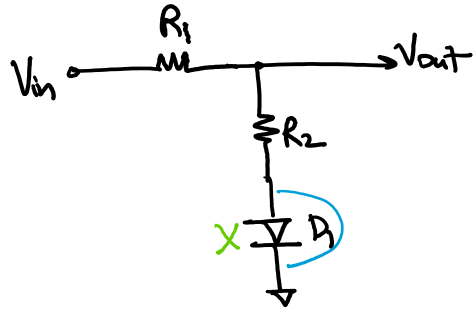

Vin
3V
Vout
1.8V
t


Vin
Vout
V1
V2

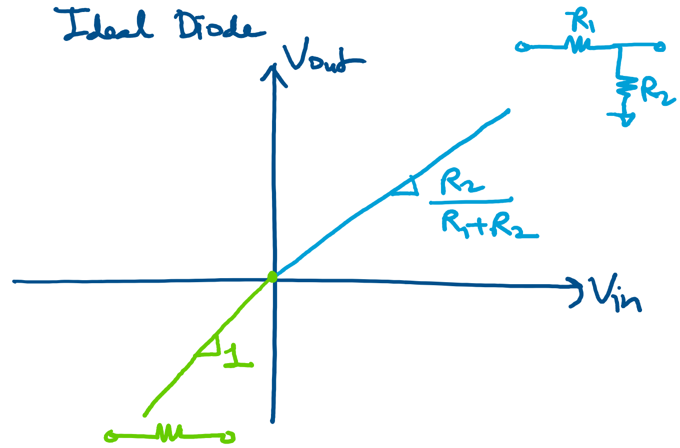

Vout
Vin



Ex 3.12.

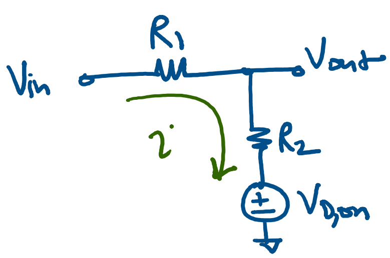


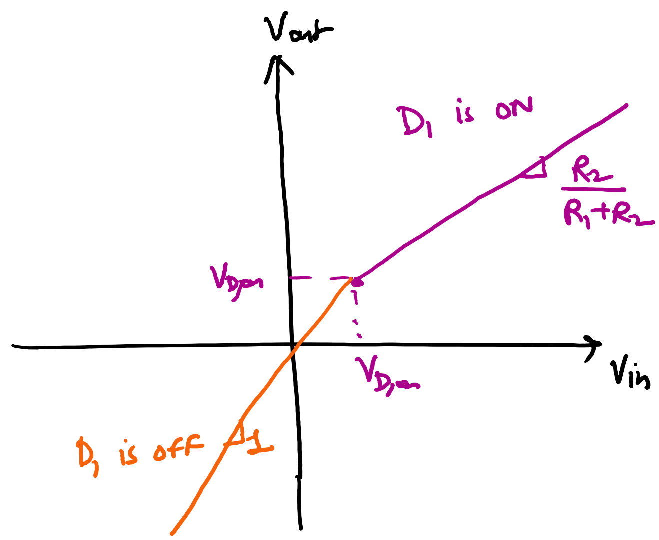
Ideal Diode



a) for $V_{in} < V_{D,on}$, D_1 is off $\Rightarrow$ $V_{out} = V_{in}$

b) for $V_{in} > V_{D,on}$, D_1 is ON $\Rightarrow$





$$i = \frac{V_{in} - V_{out}}{R_1} = \frac{V_{out} - V_{D,on}}{R_2}$$

$$\Rightarrow \quad V_{out} = \frac{\frac{R_2}{R_1} V_{in} + V_{D,on}}{1 + \frac{R_2}{R_1}}$$

* Do Ex 3.15 & 3.16 on your own

Concludes Chapter 3.

* Start with <u>chapter 6</u> on wednesday.