Electronic Devices

Lecture 5
P-N Junction

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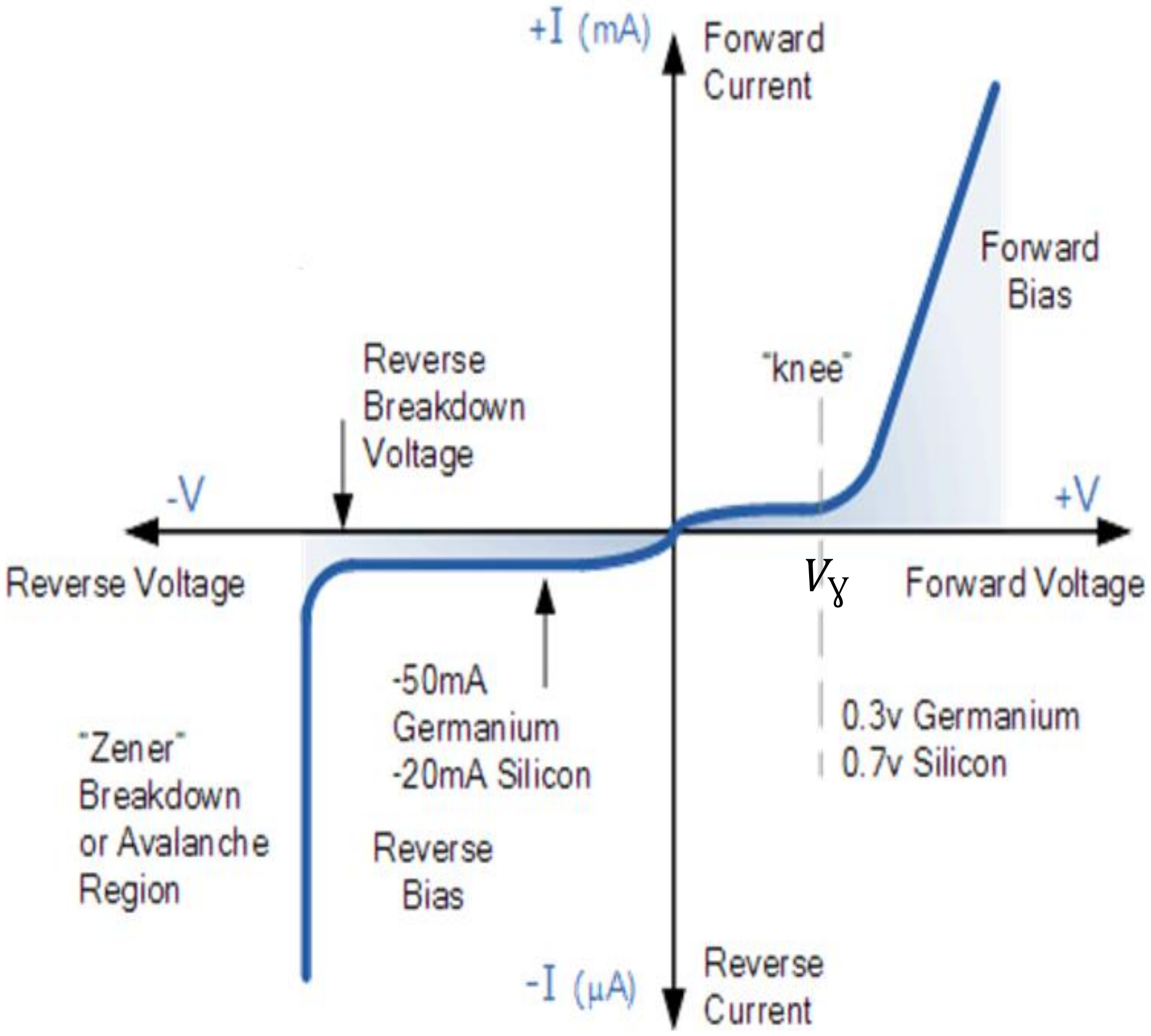
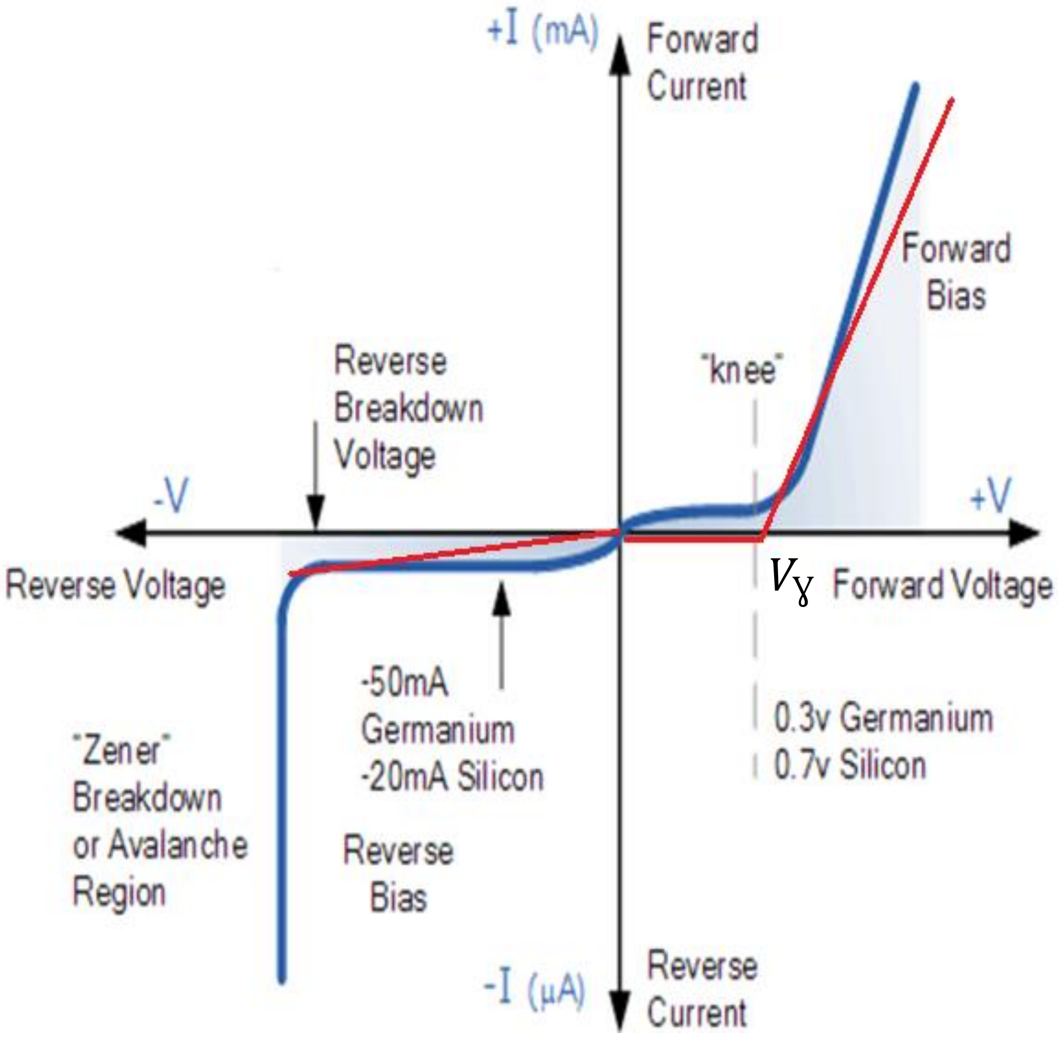
Diode Models

The diode as a circuit elements:

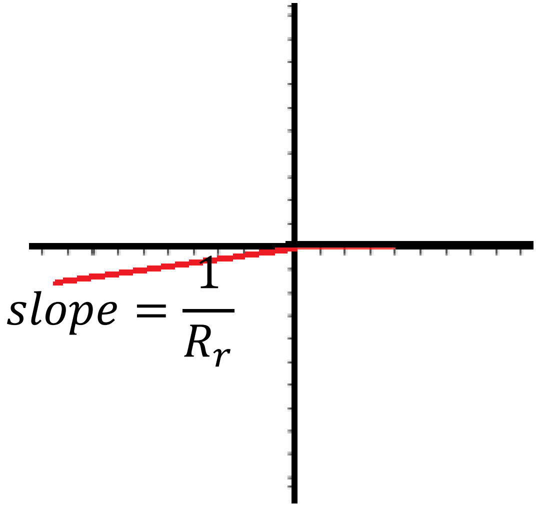
- Ideal Diode Model
- Large Signal model
- Small Signal model

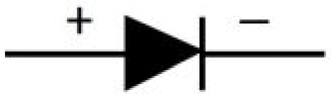
Large Signal Diode Model " Piecewise Linear Model"

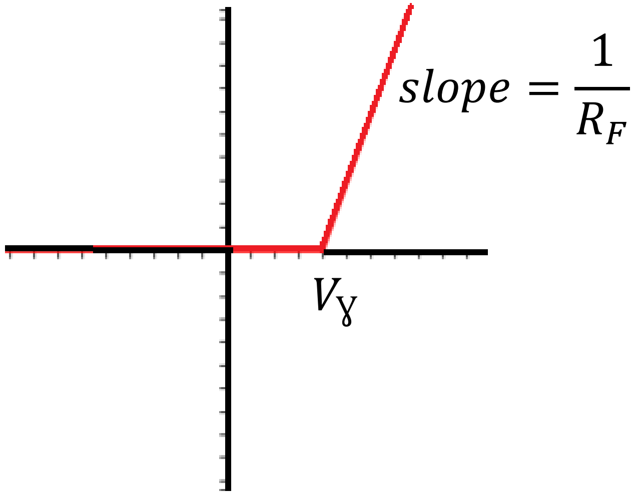


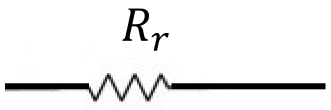


Large Signal Diode Model " Piecewise Linear Model"









Reverse biased

$R_r \gg 100\text{K}\Omega \longrightarrow \infty$

Open Circuit

OFF

Forward biased

V_γ = 0.7v Si or = 0.3v Ge

R_F= 5 ⟶ 50Ω

ON

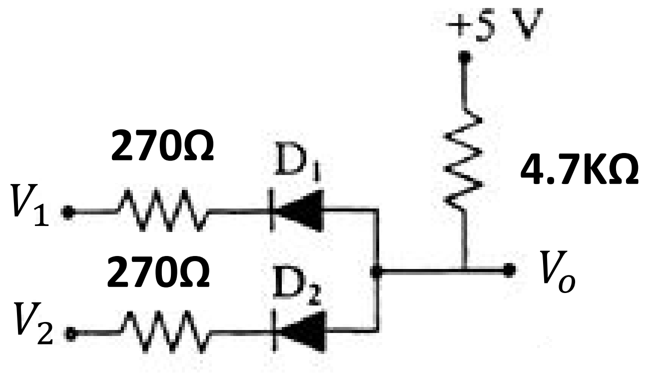
Example

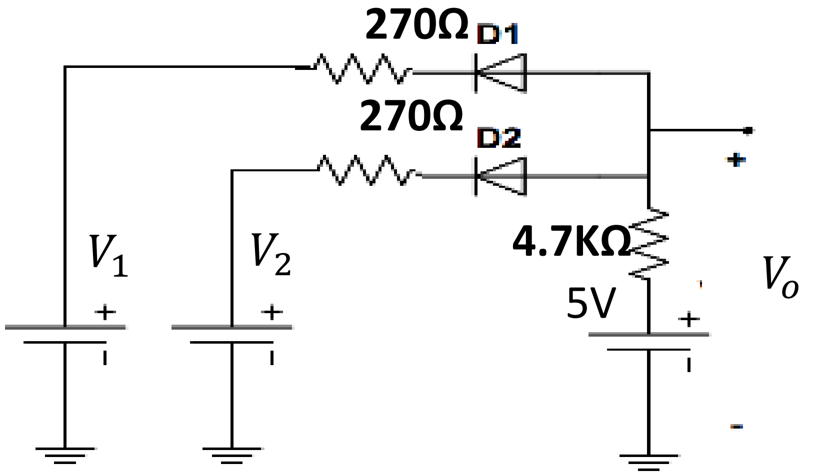
- Determine the output voltage Vo in the circuit with silicon diodes have R_F =30Ω, V_γ=0.6v ,Rr=∞ for the following values of inputs voltages.

a) $V_1 = V_2$ =5v

b) V_1 =5v, V_2 =0

c) $V_1 = V_2$ =0





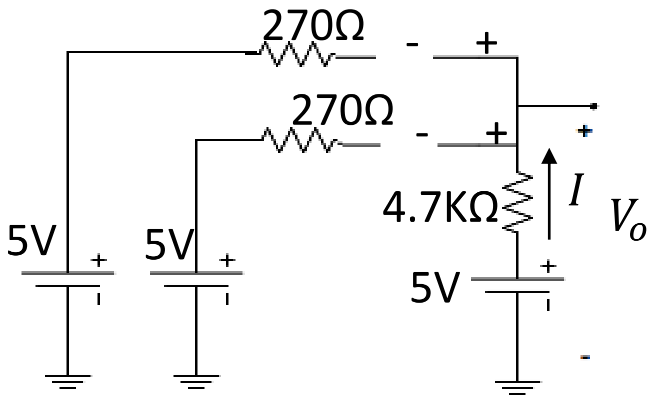
Solution:

a) $V_1 = V_2$ =5v

Assume D1 & D2 are off replacing diode with Rr= ∞,

means open circuit, the Vo=5V

VD1&VD2 =0 our assumption is true.



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b) V_1 =5v, V_2 =0

Assume D1 is off & D2 is on

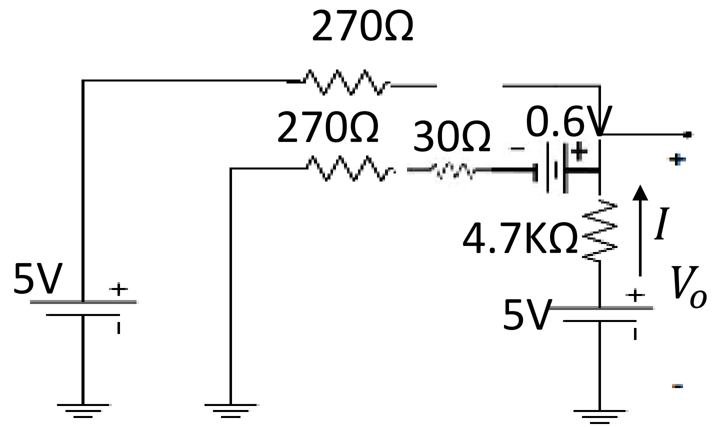
$V_o = 5 - 4700\,I$

Applied KVL

$-5 + 4700I + 0.6 + 30I + 270I = 0$

$$I = \frac{5-0.6}{4700+30+270} = 0.88\text{ mA} \text{ ------ } I > 0 \text{ our assumption is true.}$$

$V_o = 5 - 4700\,I = 0.864V$



$c)\ V_1 = V_2 = 0$

Assume D1 & D2 are on

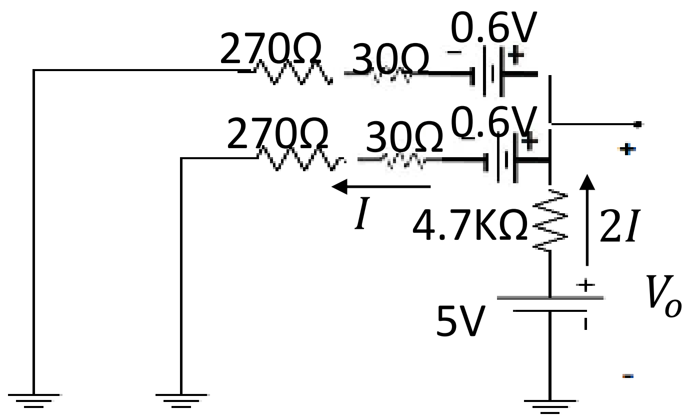
Vo = 5- 4700 (2I)

Applied KVL

-5 +4700(2I) +0.6+ 30I +270I =0

$$I = \frac{5-0.6}{4700(2)+30+270} = 0.454 \text{ mA}$$ ------ $I > 0$ our assumption is true

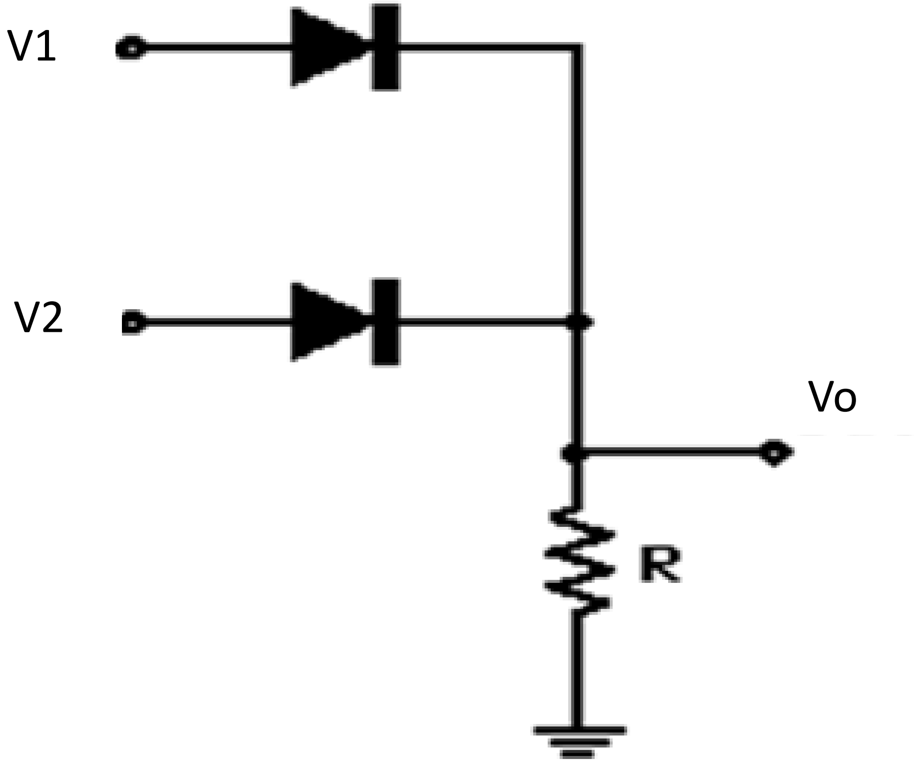
Vo = 5- 4700 (2I) = 0.736 V



V1	V2	Vo
0	0	0.736
0	5	0.864
5	0	0.864
5	5	5

V1	V2	Vo
0	0	0
0	1	0
1	0	0
1	1	1

AND GATE

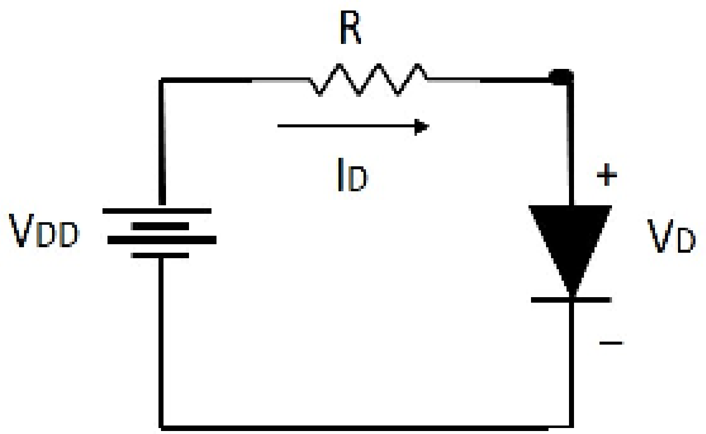


OR GATE

V1	V2	Vo
0	0	0
0	1	1
1	0	1
1	1	1

Load Line Concept (Graphical Analysis)

As shown in the circuit by applying KVL



$$-V_{DD} + I_D R + V_D = 0$$

$$I_D R + V_D = V_{DD}$$

$$I_D R = V_{DD} - V_D$$

$$I_D = -\frac{1}{R} V_D + \frac{V_{DD}}{R}$$

At $V_D = 0 \rightarrow I_D = \frac{V_{DD}}{R}$

At $I_D = 0 \rightarrow V_D = V_{DD}$