Al-Mustaqbal University College

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Third year: Lecture 2:

Diode Equivalence Circuits:

LOAD-LINE ANALYSIS: The applied load will normally have an important impact on the point or region of operation of a device. If the analysis is performed in a graphical manner, a line can be drawn on the characteristics of the device that represents the applied load. The intersection of the load line with the characteristics will determine the point of operation of the system. Such an analysis is, for obvious reasons, called load-line analysis

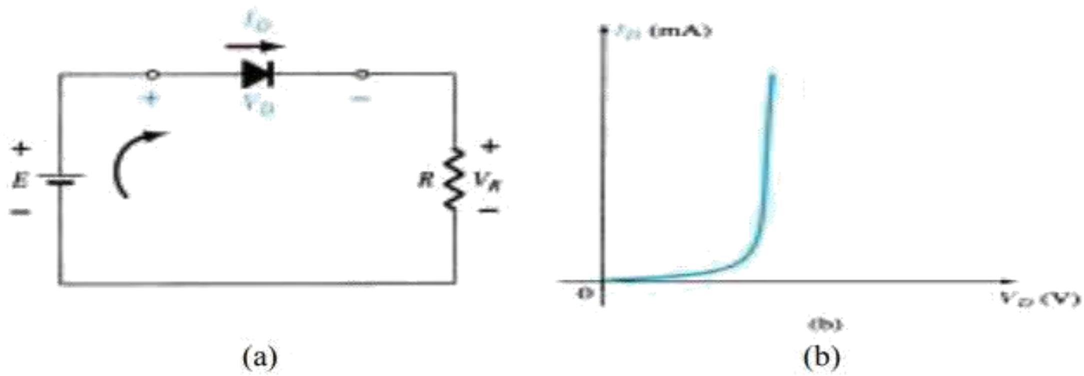


Fig (1) diode series configuration (a): circuit (b): characteristic

Applying Kirchhoff‟s voltage law to the series circuit of Fig.1a will result in

$$E - V_D - V_R = 0$$

Or

$$E = V_D + I_D R$$

If we set VD =0 V in Eq. (2.1) and solve for ID, we have the magnitude of ID on The vertical axis. Therefore, with VD =0 V, Eq. (2.1) becomes:

$$\begin{aligned} E &= V_D + I_D R \\ &= 0\text{ V} + I_D R \end{aligned}$$

$$I_D = \frac{E}{R}\bigg|_{V_D = 0\text{ V}}$$

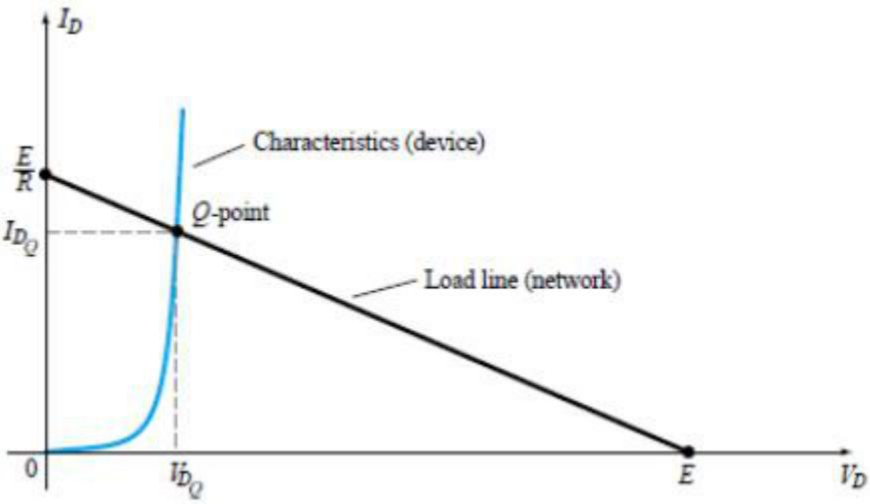


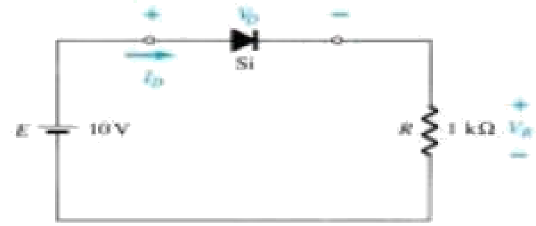
Fig.2

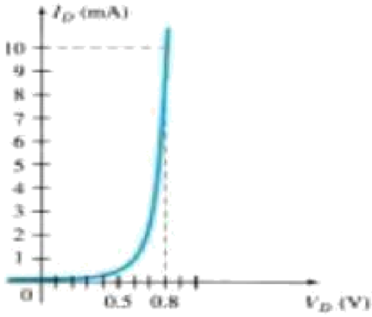
As shown in Fig. 2.2. If we set ID =0 A in Eq. (2.1) and solve for VD, we have the Magnitude of VD on the horizontal axis. Therefore, with ID =0 A,

$$\begin{aligned} E &= V_D + I_D R \\ &= V_D + (0\text{ A})R \end{aligned}$$

$$V_D = E|_{I_D = 0\text{ A}}$$

EX1: For the series diode configuration of Fig. 2.3a employing the diode characteristics of Fig.3 determine: (a) VDQ and IDQ. (b) VR.





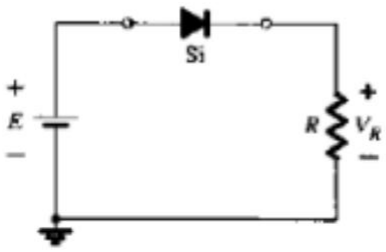
$$I_D = \frac{E}{R}\bigg|_{V_D=0\,V} = \frac{10\ V}{2\ k\Omega} = 10\ mA$$

$$V_R = I_R R = I_{D_Q} R = (9.25\ mA)(1\ k\Omega) = 9.25\ V$$

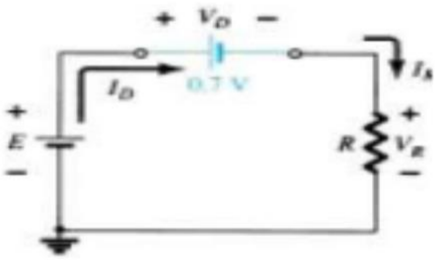
$$V_R = E - V_D = 10\ V - 0.78\ V = 9.22\ V$$

SERIES DIODE CONFIGURATIONS WITH DC INPUTS

In general, a diode is in the on state if the current established by the applied sources is such that its direction matches that of the arrow in the diode symbol, and VD≥ 0.7V for silicon and VD ≥ 0.3V for germanium



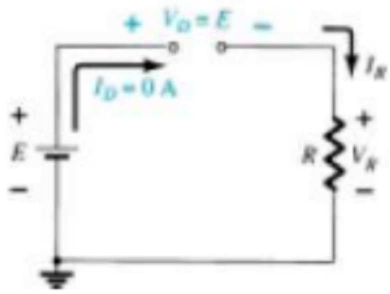
(a)Series diode configuration



$$V_R = E - V_D$$

$$I_D = I_R = \frac{V_R}{R}$$

(b) Reversing diode of diode



The diode is in the "off" state, resulting in the equivalent circuit due to the open circuit, the diode current is 0 A and the voltage across the resistor R is the following:

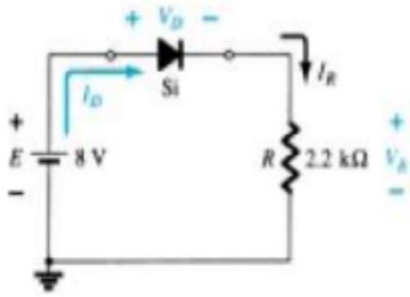
Example2: for series diode configurations of fig below determine VD.VR and ID.

sol:

$$V_D = 0.7\ \text{V}$$

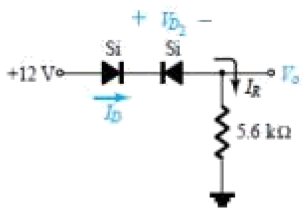
$$V_R = E - V_D = 8\ \text{V} - 0.7\ \text{V} = 7.3\ \text{V}$$

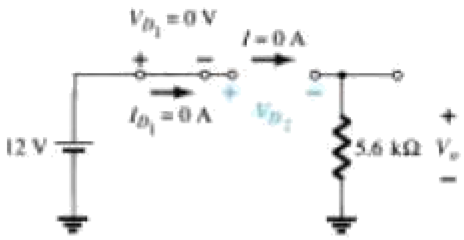
$$I_D = I_R = \frac{V_R}{R} = \frac{7.3\ \text{V}}{2.2\ \text{k}\Omega} \cong 3.32\ \text{mA}$$



Example3: determine ID.VD, V_o for circuit below

sol:





$$V_o = I_R R = I_D R = (0\text{ A})R = 0\text{ V}$$

and

$$V_{D_2} = V_{\text{open circuit}} = E = \mathbf{12\ V}$$

Applying Kirchhoff's voltage law in a clockwise direction gives us

$$E - V_{D_1} - V_{D_2} - V_o = 0$$

and

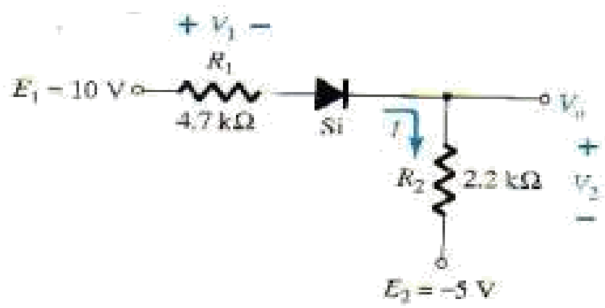
$$V_{D_2} = E - V_{D_1} - V_o = 12\text{ V} - 0 - 0 = \mathbf{12\ V}$$

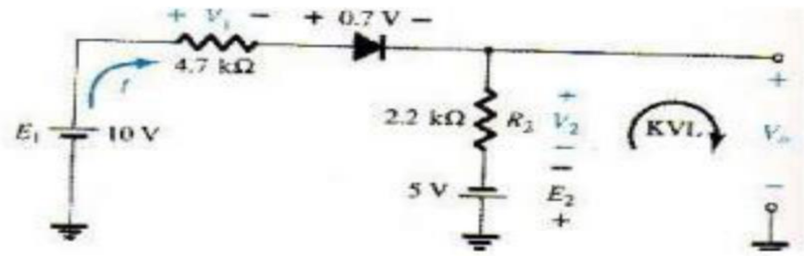
with

$$V_o = \mathbf{0\ V}$$

Example4: Determine I, V1, V2 and VO for the circuit of fig

sol:





$$I = \frac{E_1 + E_2 - V_D}{R_1 + R_2} = \frac{10\text{ V} + 5\text{ V} - 0.7\text{ V}}{4.7\text{ k}\Omega + 2.2\text{ k}\Omega} = \frac{14.3\text{ V}}{6.9\text{ k}\Omega}$$

$$\cong \mathbf{2.072\text{ mA}}$$

and the voltages are

$$V_1 = IR_1 = (2.072\text{ mA})(4.7\text{ k}\Omega) = \mathbf{9.74\text{ V}}$$

$$V_2 = IR_2 = (2.072\text{ mA})(2.2\text{ k}\Omega) = \mathbf{4.56\text{ V}}$$

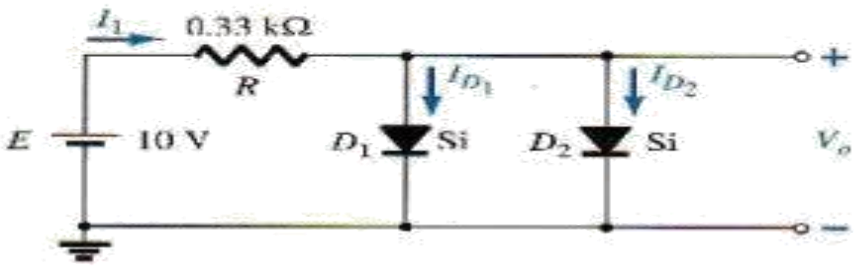
Applying Kirchhoff's voltage law to the output section in the clockwise direction will result in

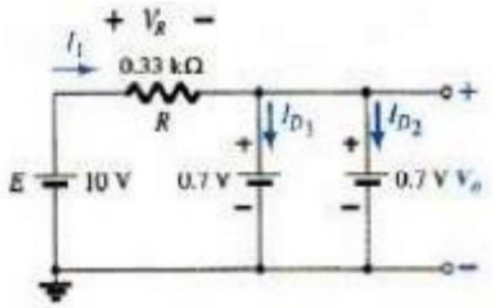
$$-E_2 + V_2 - V_o = 0$$

and $$V_o = V_2 - E_2 = 4.56\text{ V} - 5\text{ V} = \mathbf{-0.44\text{ V}}$$

Parallel and series-parallel configurations:

Example 5: Determine I 1, ID1, ID2 and VO for the circuit of fig:





Solution:

$$V_o = \mathbf{0.7\ V}$$

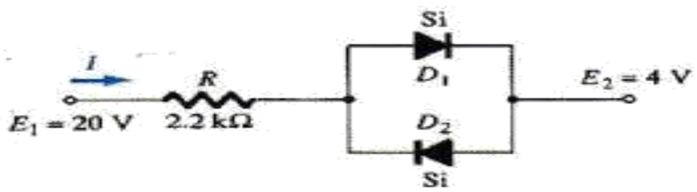
The current

$$I_1 = \frac{V_R}{R} = \frac{E - V_D}{R} = \frac{10\ \text{V} - 0.7\ \text{V}}{0.33\ \text{k}\Omega} = \mathbf{28.18\ mA}$$

Assuming diodes of similar characteristics, we have

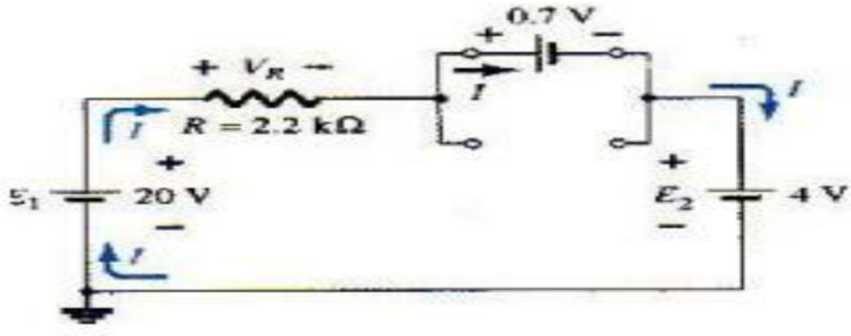
$$I_{D_1} = I_{D_2} = \frac{I_1}{2} = \frac{28.18\ \text{mA}}{2} = \mathbf{14.09\ mA}$$

Example 6: Determine the current I for the network of fig below



Solution:

$$I = \frac{E_1 - E_2 - V_D}{R} = \frac{20\ \text{V} - 4\ \text{V} - 0.7\ \text{V}}{2.2\ \text{k}\Omega} \cong \mathbf{6.95\ mA}$$



Diode switching circuit

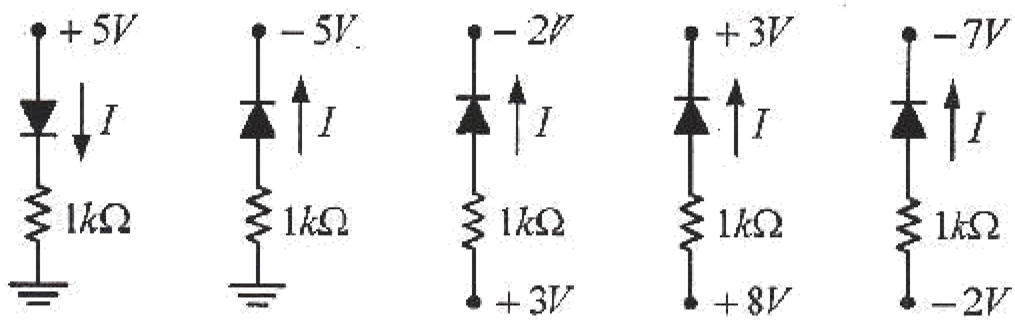
Diode switching circuits typically contain two or more diodes, each of which is connected to an

independent voltage source. Understanding the operation of a diode switching circuit depends

on determining which diodes, if any, are forward biased and which, if any, are reverse biased.

The key to this determination is remembering that is a diode is forward biased only if its

anode is positive with respect to it's cathode

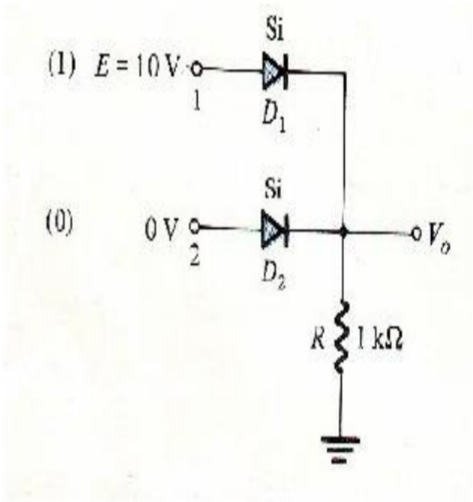


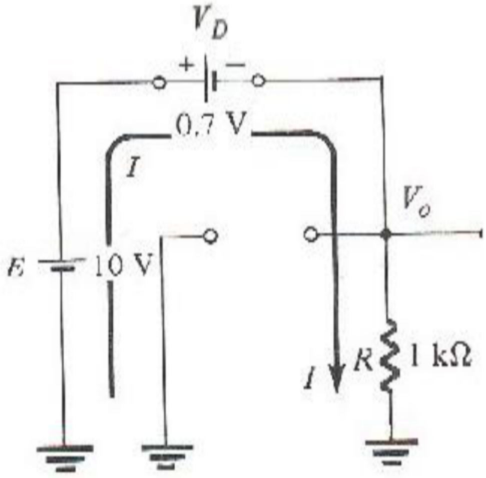
One of the very import applications of diode switching circuits is diode logic circuits ***AND/OR* *Gates***.

OR gate*:* is such that the output voltage level will be a 1 if either or both input is a 1. The

10V level is assigned a 1 for Boolean algebra while the 0V input is assigned a ***0***

Example 7: Determine Vo for the network in fig





D1 is in the on state due to the applied voltage (10V) while D2 is in the off state

. Vo = E - VD = 10v - 0.7 = 9.3v

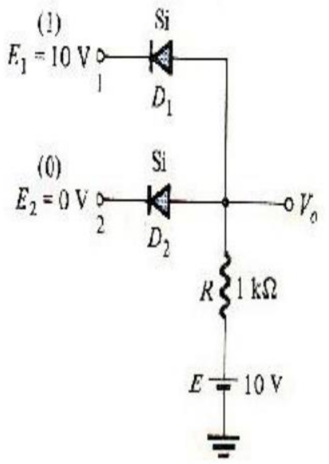
= **(E - VD) / R = (10-0.7) / 1KΩ = 9.3mA**

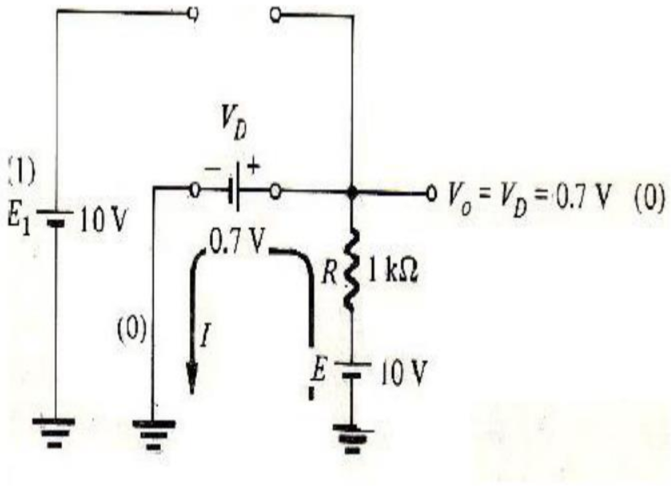
The output voltage level is not 10V as defined for an input of 1, but the 9.3V is sufficiently at a
1 level with only one input.

Input voltages		State of diodes		Output voltage
V_A	V_B	D_1	D_2	V_o
0	0	off	off	0
0	1	off	on	1
1	0	on	off	1
1	1	on	on	1

AND gate*: is such that the output voltage level is will be* ***1 if both inputs are a 1****.*

Example 8: Determine the output level for the positive logic AND gate of fig below





With 10v at the cathode D1 , is assumed that D1 is in the off state.
D2 is assumed to be in the on state due to the low voltage at the cathode side and the
availability of the 10v source through 1KΩ resistor.The voltage at Vo is 0.7v due to forward biased diode D2

$I = (E-V_o) / R = (10-0.7) / 1K\Omega = 9.3mA$

Input voltages		State of diodes		Output voltage
V_A	V_B	D_1	D_2	V_o
0	0	on	on	0
0	1	on	off	0
1	0	off	on	0
1	1	off	off	1