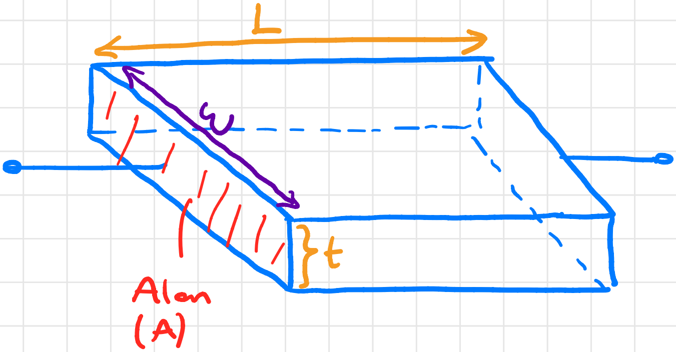
ELEKTRONIK ELEMANLAR

* Diyotlar
* LED (Light Emitting Diodes)
* Transistörler
* Mikroçipler (Tümdevreler - Integrated Circuits)
* Thermistors
* Fototransistörler
* Fotoresistörler
* Lazerler
* Fotovoltaik hücreler (Photovoltaic cells)

Yarıiletkenlik Nedir?

→ İletkenler (Conductors)
→ Yalıtkanlar (Insulators)
→ Yarıiletkenler (Semiconductors)

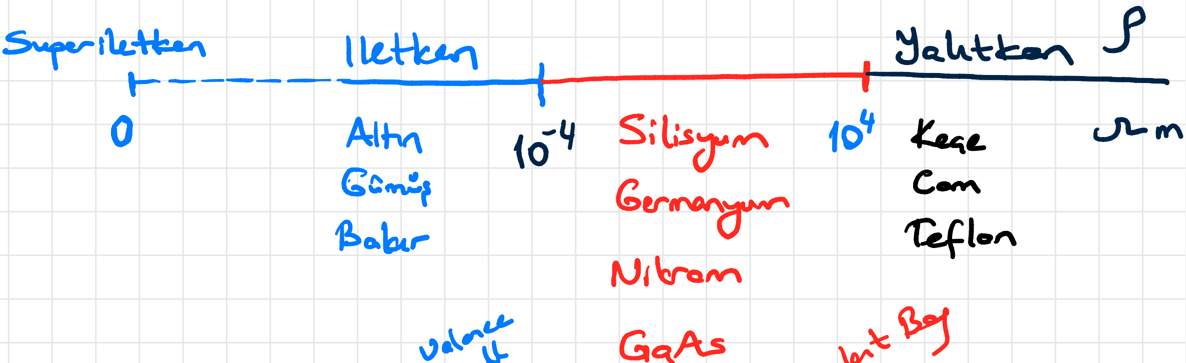


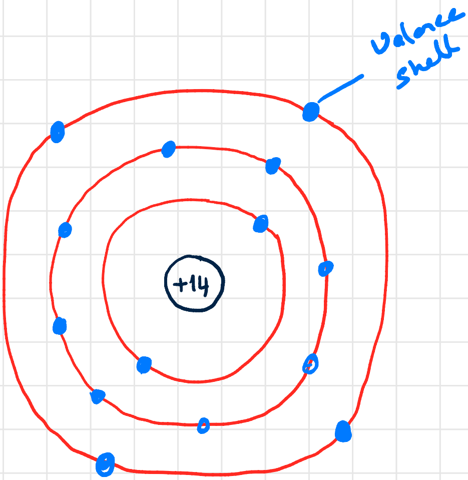
$$R = \rho \cdot \frac{L}{A}$$

R → Direnç
ρ → Resistivity (Ωm)
L → Boy
A → Alan

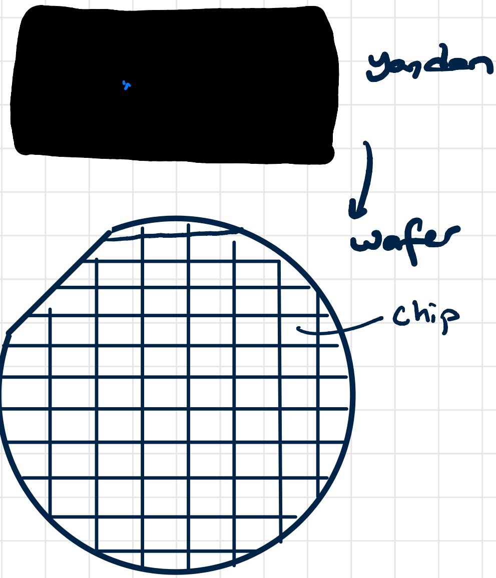
$$\sigma = \frac{1}{\rho}$$

σ → conductivity (iletkenlik)
ρ → resistivity

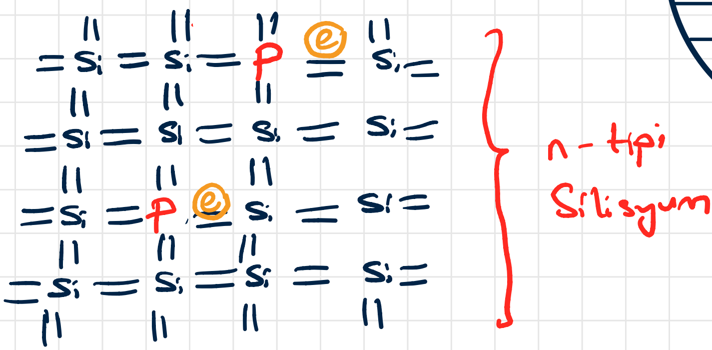




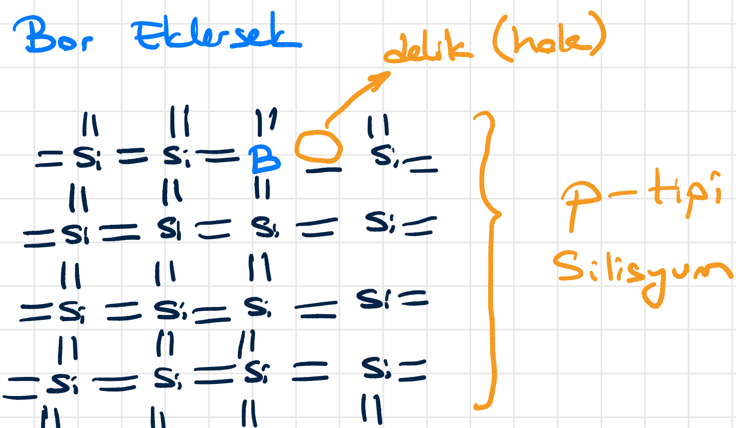
III	IV	V
B	C	N
Al	Si	P
Ga	G	As
In	Sn	Sb

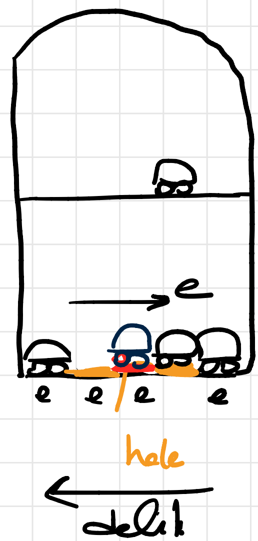


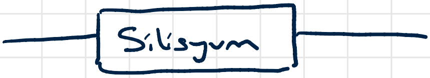
Fosfor Ekle

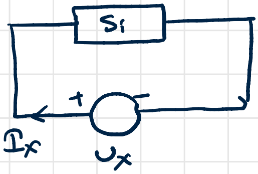


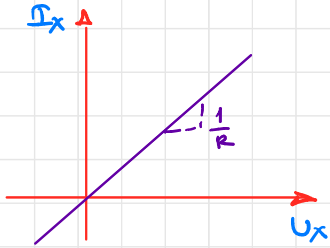
Bor Eklersek

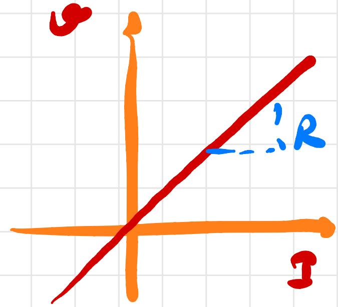


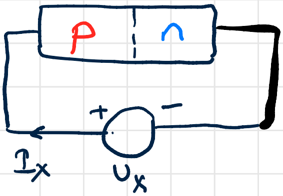


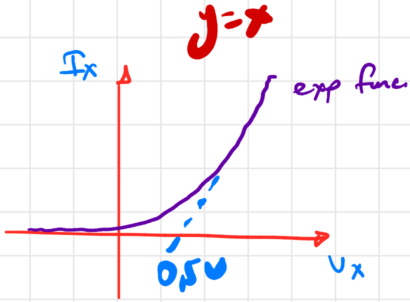


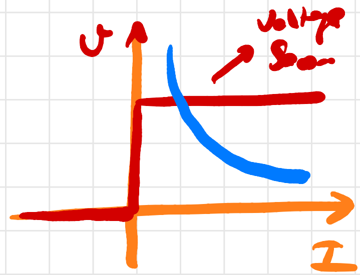






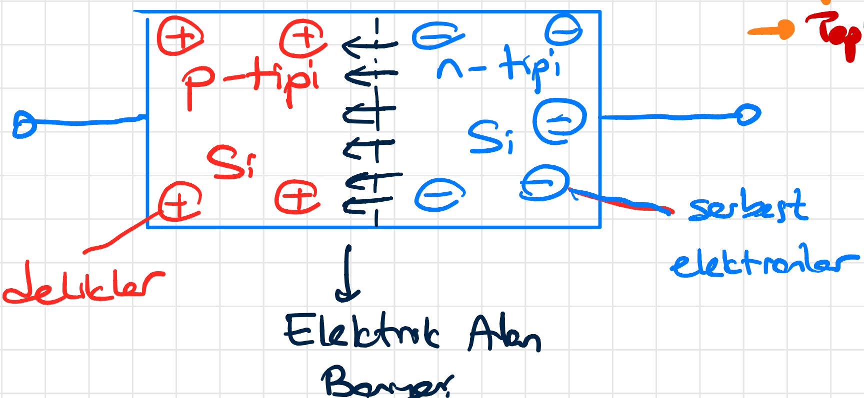


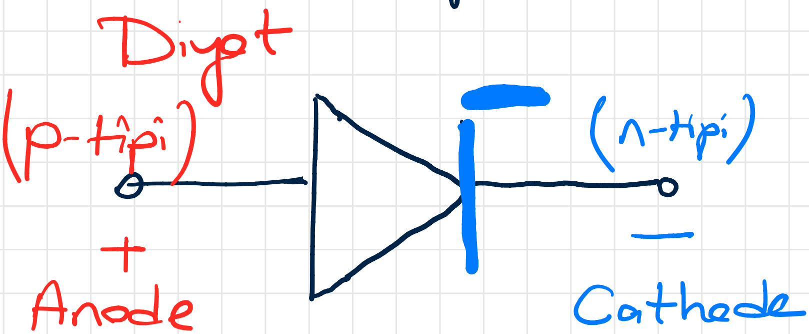


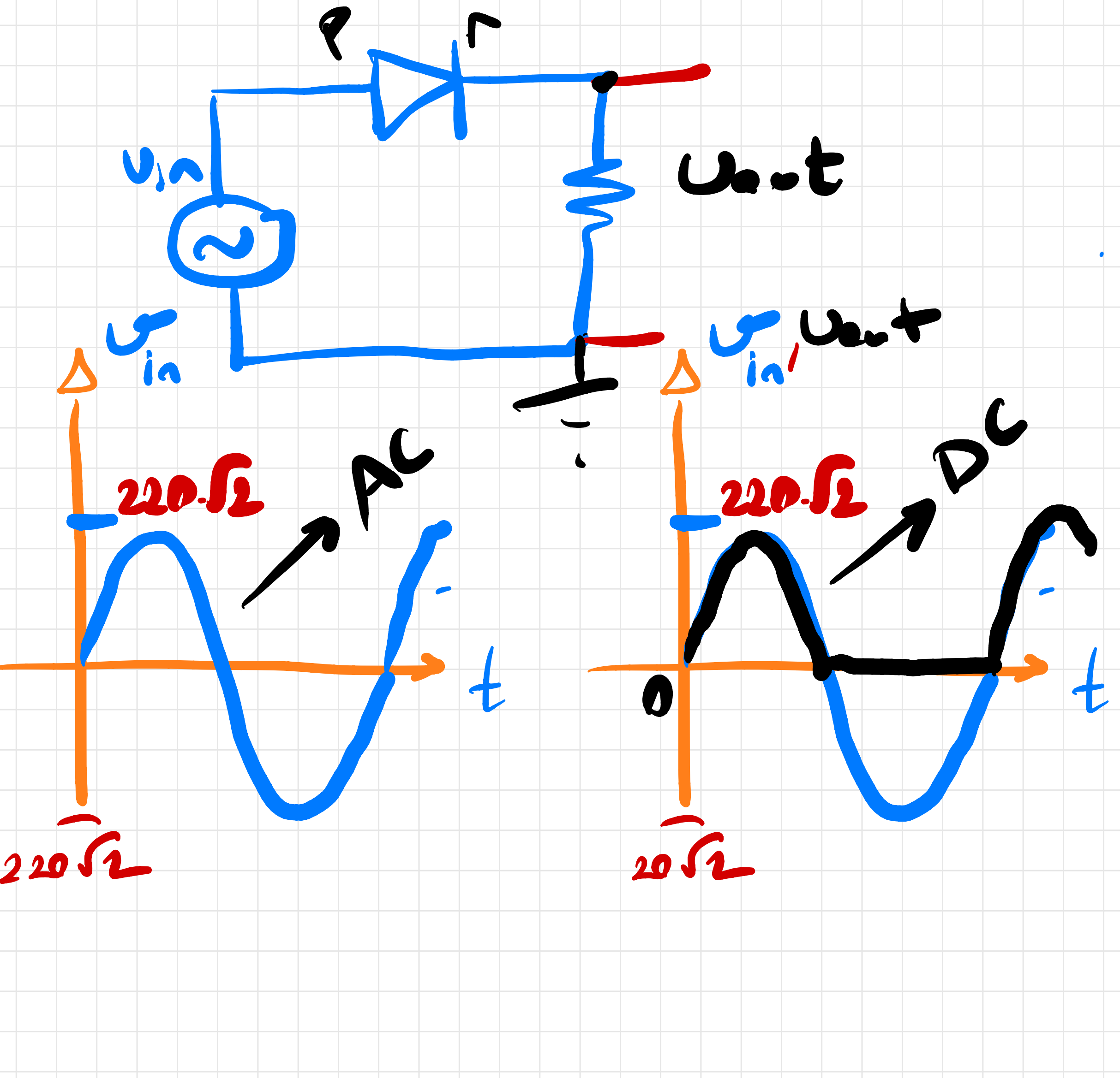


→ Çarpma (Multiply)

→ Toplama (Superposition)







p
n
v in
Uout
v in
v in'
Uout
220√2
AC
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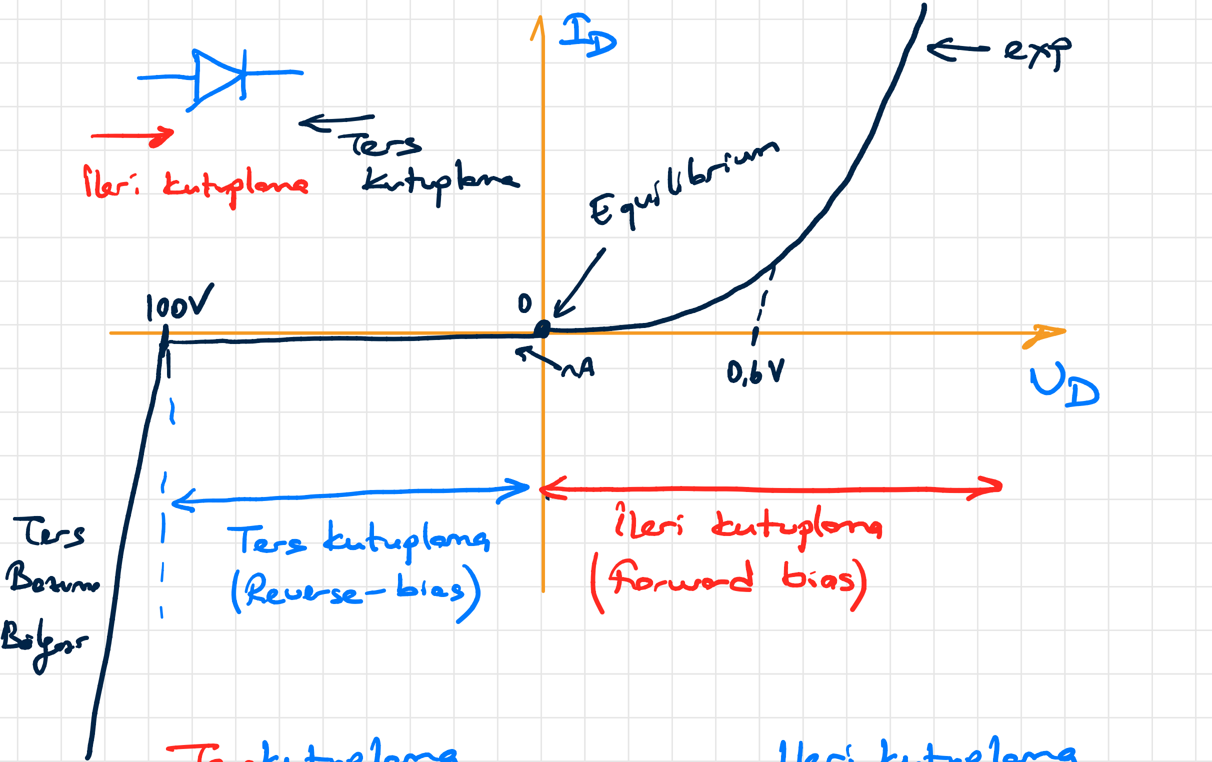
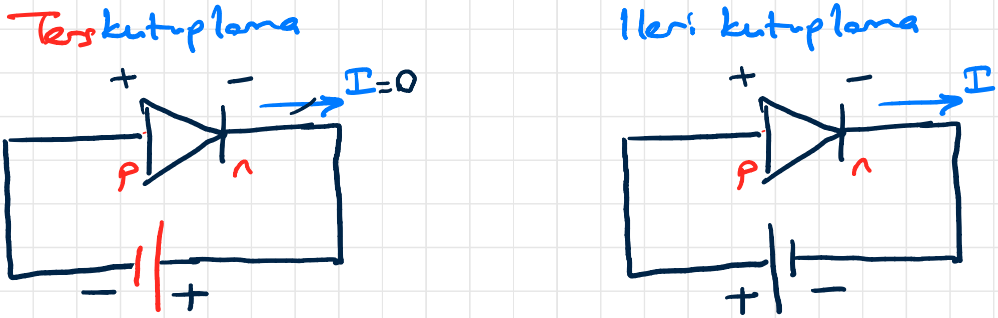
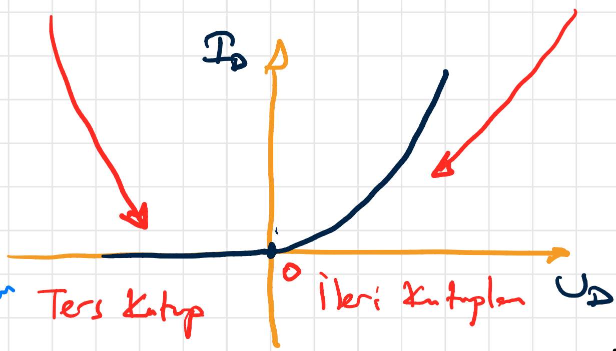
220√2
DC
0
t
220√2
20√2







Ters akım doyma

Diyot Akımı ← $$I_D = I_s \left(\exp \frac{U_D}{V_T} - 1 \right)$$

V_T : Termal Gerilim

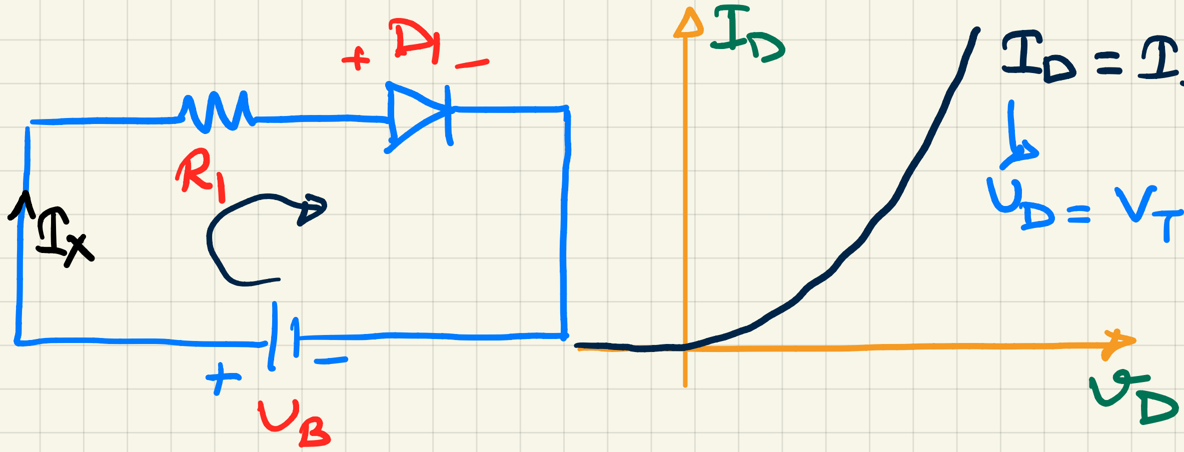
$V_T \approx 26\ mV$

DİYOT MODELLERİ

* Direnç, C, L lineer iken Diyot nonlineer elemandır.

KCL veya KVL → lineer problemleri çözer.

1) Exponential model (Üstel model) (%15-20)



$$I_D = I_S \exp \frac{V_D}{V_T}$$

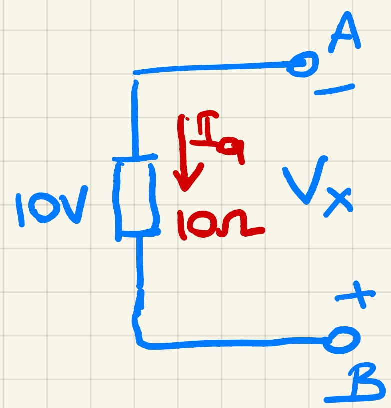
$$V_D = V_T \ln \frac{I_D}{I_S}$$

$$-V_B + I_x R_1 + V_{D1} = 0$$

$$-V_B + I_x R_1 + V_T \ln \frac{I_x}{I_S} = 0$$

⇒ Iteration (Tekrarlama)

$$V_{BE} = V_B - V_E$$



$V_B = 2V$

$V_A =$

$$V_{BA} = 10V = V_B - V_A$$

$V_B = 2$

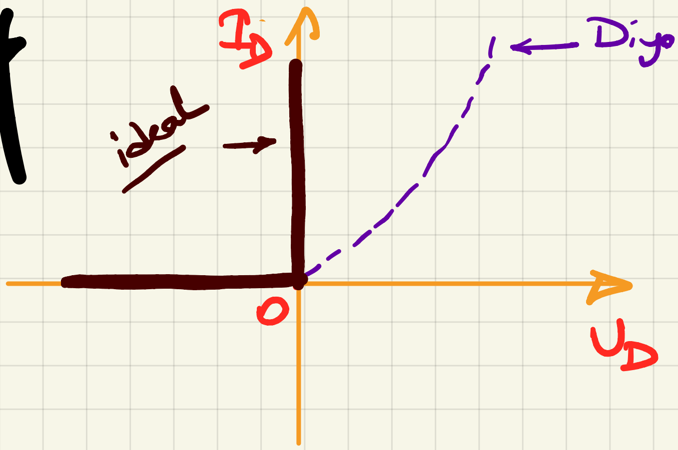
$$10V = 2V - V_A$$

$$V_A = -8V$$

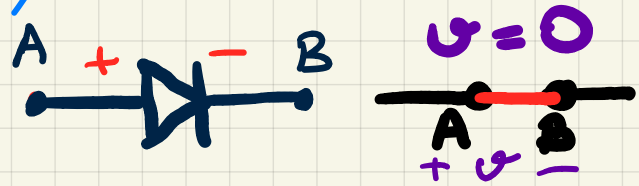
$$V_A - V_B = \frac{-8-2}{10}$$

$$I_a = -1A$$

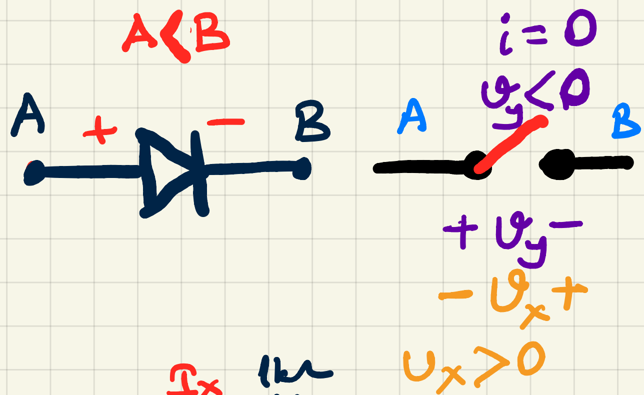
2) IDEAL-DİYOT MODELİ (%5)



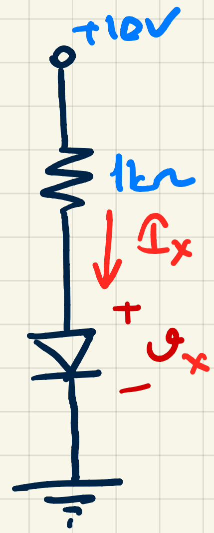
A>B



A<B



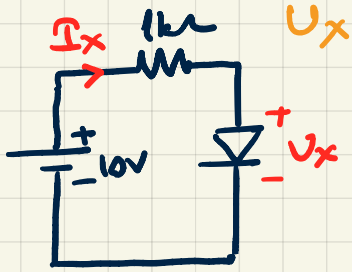
Örnek;

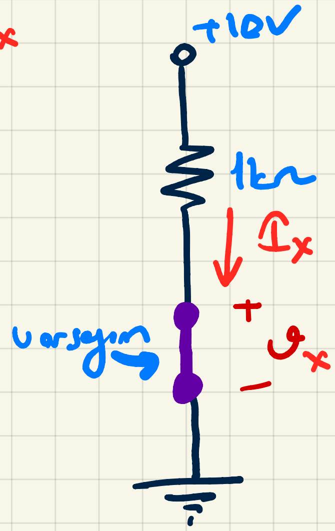


$I_x = ?$

$v_x = ?$

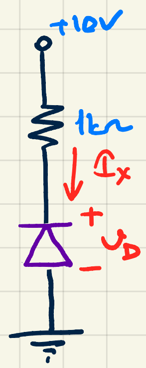
Diyot ideal.





$$I_x = \frac{10-0}{1k\Omega} = 10mA$$

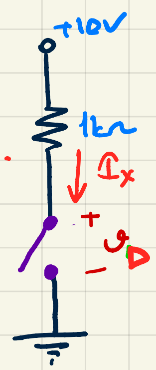
$$v_x = 0$$



$I_x = ?$

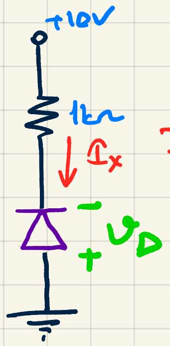
$v_x = ?$

Diyot ideal.



$I_x = 0$

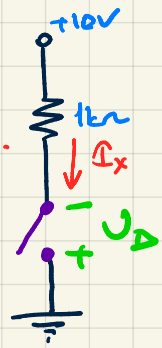
$v_D = 10V$



$I_x = ?$

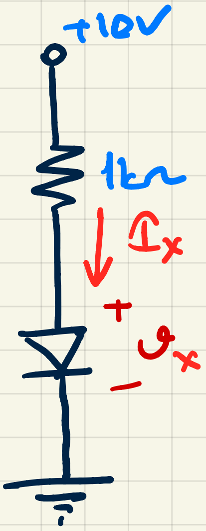
$v_x = ?$

Diyot ideal.



$I_x = 0$

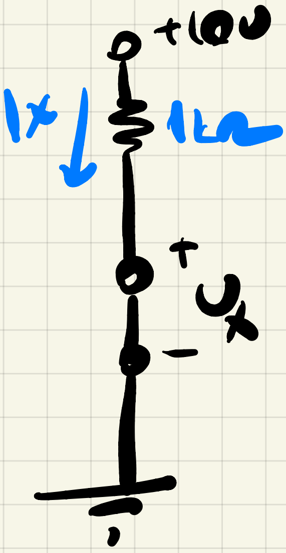
$v_D = -10V$



$I_x = ?$ ✓

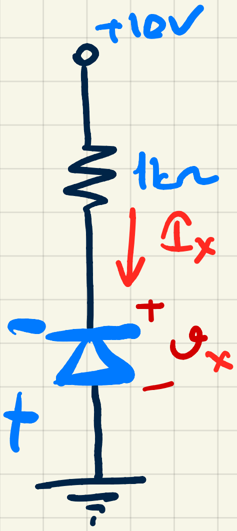
$U_x = ?$

Diyot ideal.



$$I_x = \frac{10-0}{1k\Omega} = 10mA$$

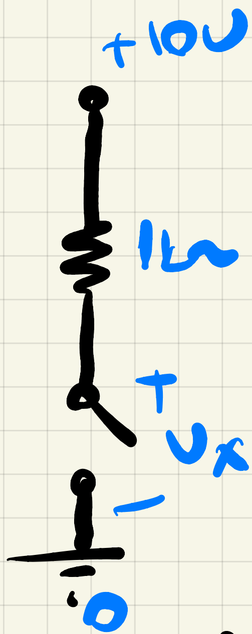
$U_x = 0V$ ✓



$I_x = ?$

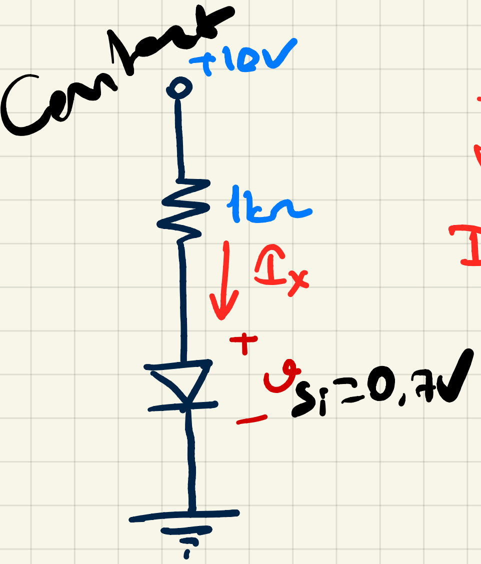
$U_x = ?$

Diyot ideal.



$I_x = 0\,A$

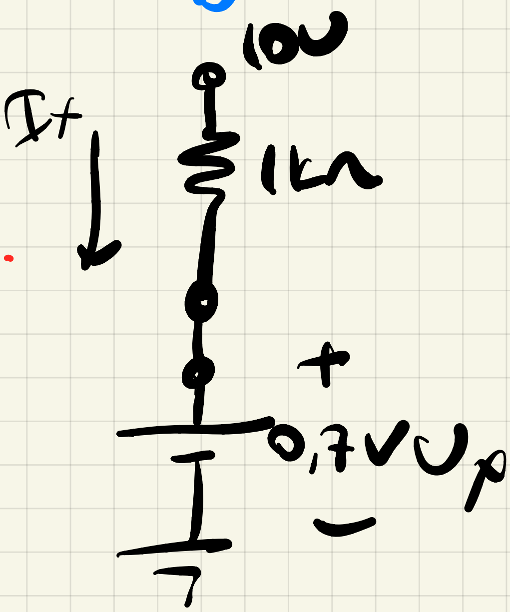
$U_x = 10V$



$I_x = ?$

$U_x = ?$

Diyot ideal.



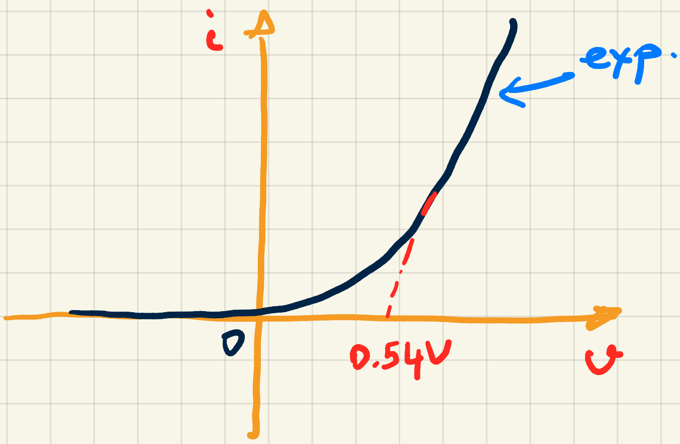
$$I_x = \frac{10-0,7}{1k\Omega}$$

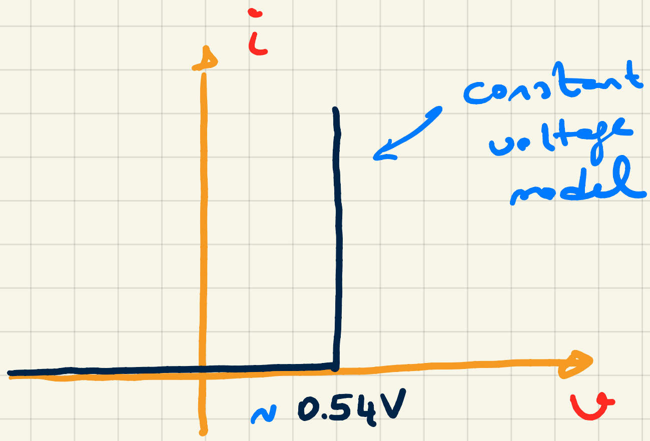
$I_x = 9,3mA$

$U_x = 0,7V$

3) SABİT GERİLİM MODELİ (CONSTANT VOLTAGE MODEL)

→ Basit ve yaklaşık %80 oranında (modeller arasında) kullanılır.



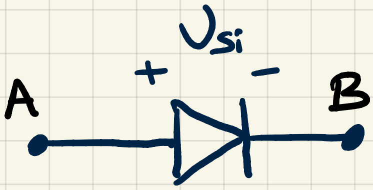


$V_{Si} \cong 0,6V$ veya $0,7V$ alınacak (0.5 de alınabilir)

$V_{Ge} \cong 0.3V$

$V_{GaAs} \approx 1.2V$

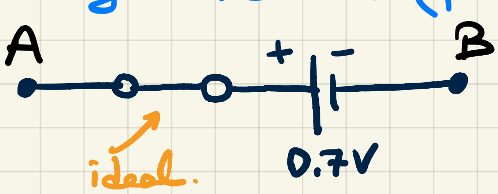
önemli

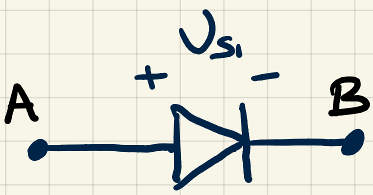


$V_{Si} = 0.7V$

⟹

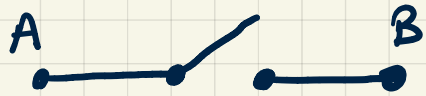
Diyot iletimde (forward bias)



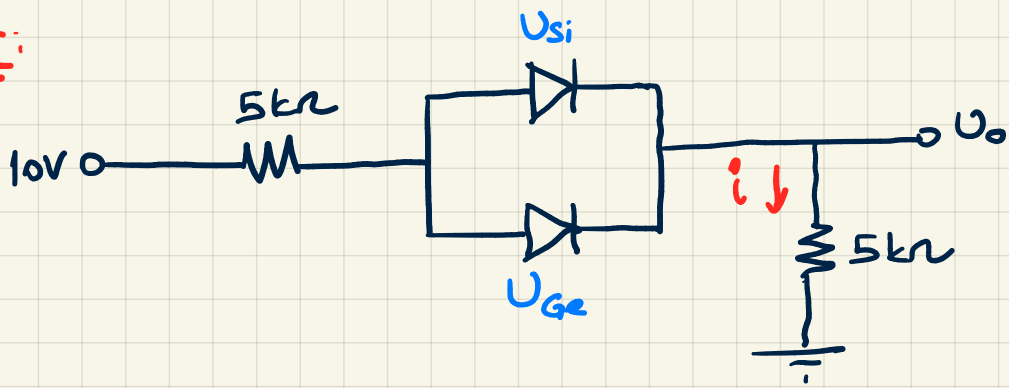


$V_{Si} = 0.7V$

Diyot kesimde (Reverse B.)



Ör:



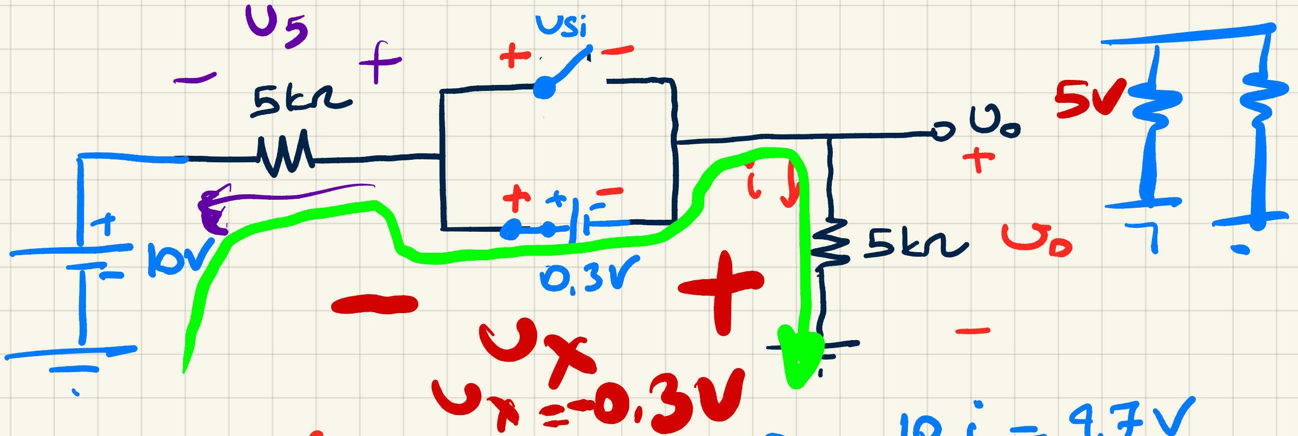
$V_{Si} = 0.7V$

$V_{Ge} = 0.3V$ olsun

$i = ?$

$V_o = ?$

Çözüm



a) $-10 + 5i + 0{,}3V + 5i = 0$

$10i = 9.7V$

$i = \dfrac{9.7V}{10k} = \dfrac{9.7V}{10000\Omega} = 0{,}97 mA$

b) U_o için $-10 + 5.i + 0{,}3 + U_o = 0$

$-10 + 5.0{,}97 + 0{,}3 + U_o = 0$

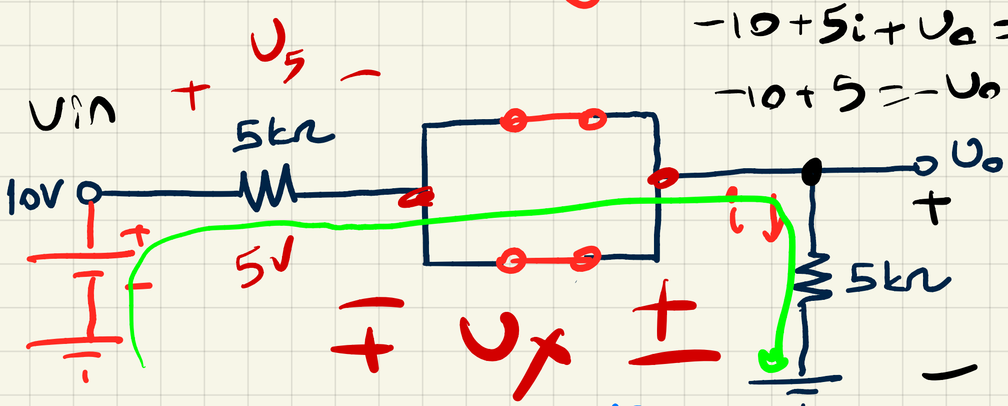
$U_o = 4{,}85V$

Diyotlar ideal olsaydı :

$U_o = ?$

$-10 + 5i + U_o = 0$

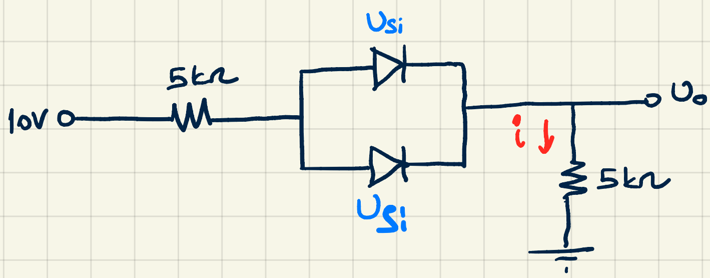
$-10 + 5 = -U_o$ ($U_o = 5V$)

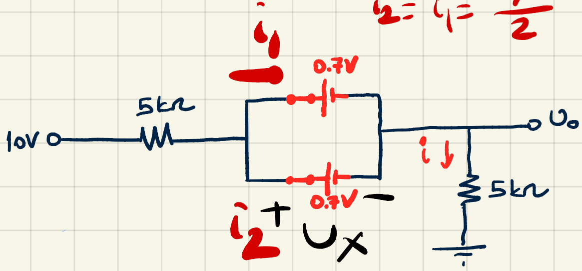


$-10 + 5i + 5i = 0 \quad i = \dfrac{10}{10k} = 1 mA$

U_o için $-10 + 5i + U_o = 0 \quad U_o = 5V$

İki Diyot da Si olsun:

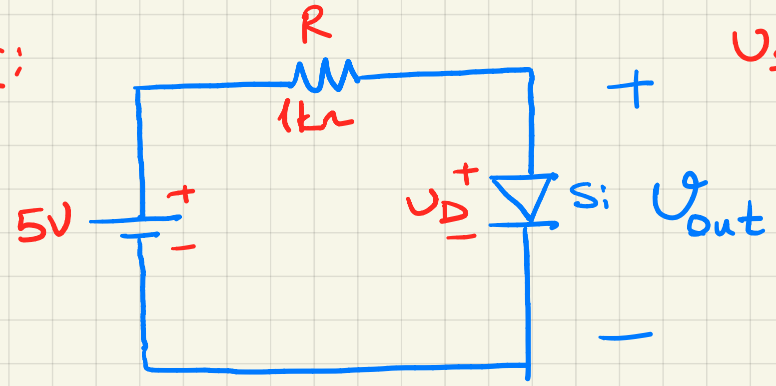




$-10 + 5i + 0.7 + 5i = 0$

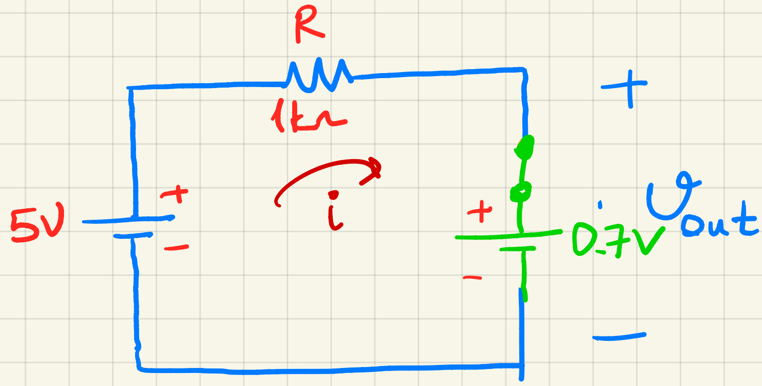
$i = 0.93 mA$

Ör:



$V_{Si} = 0.7V$

$V_{out} = ?$



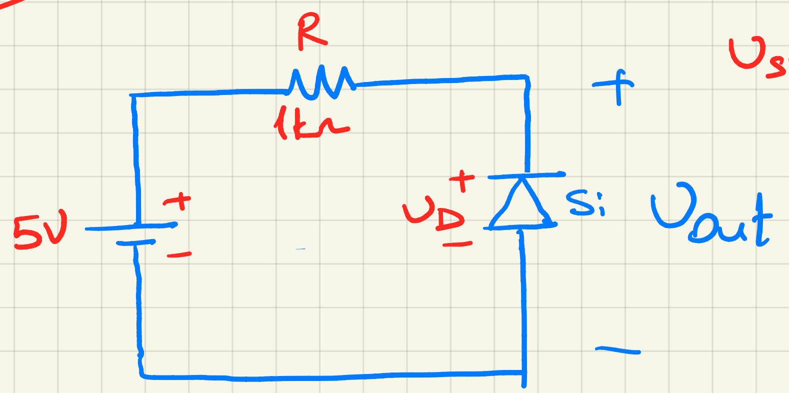
$$-5 + \underset{k\Omega}{1} \cdot i + 0.7 = 0 \Rightarrow \frac{4.3V}{1k\Omega}$$

$i = 4.3\ mA$

$V_{out} = 0.7V$

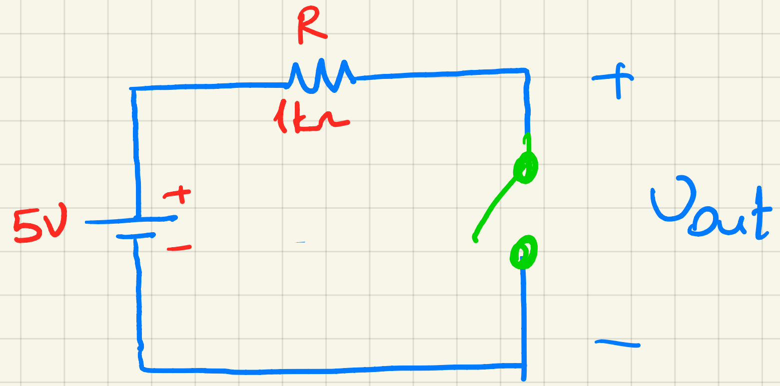
$P_{out} = 0.7V \times 4.3\ mA$

Örnek 2



$V_{Si} = 0.7V$

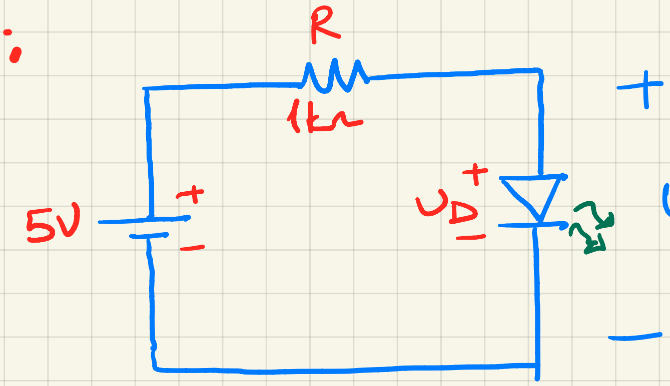
$V_{out} = ?$



$i = 0$

$V_{out} = 5V$

Ör:



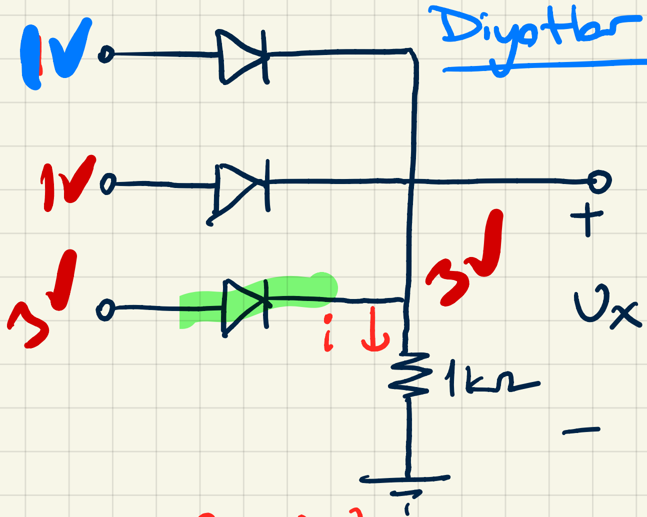
$U_{Gr} = 2.2V$ $i = ?$

$U_{out} = ?$

$-5 + 1 \cdot i + 2.2V = 0$ $i = 2.8\,mA$ $U_{out} = 2.2V$

Ör:

Diyotlar ideal

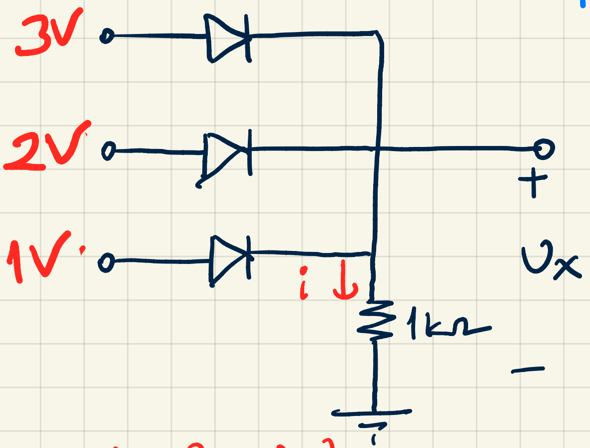


$U_x = ?$ $i = ?$

A) 0 B) 1 C) 2 D) 3 E) −3

F) −2 G) −1

$i = \frac{3}{1} = 3\,mA$



$U_x = ?$ $i = ?$

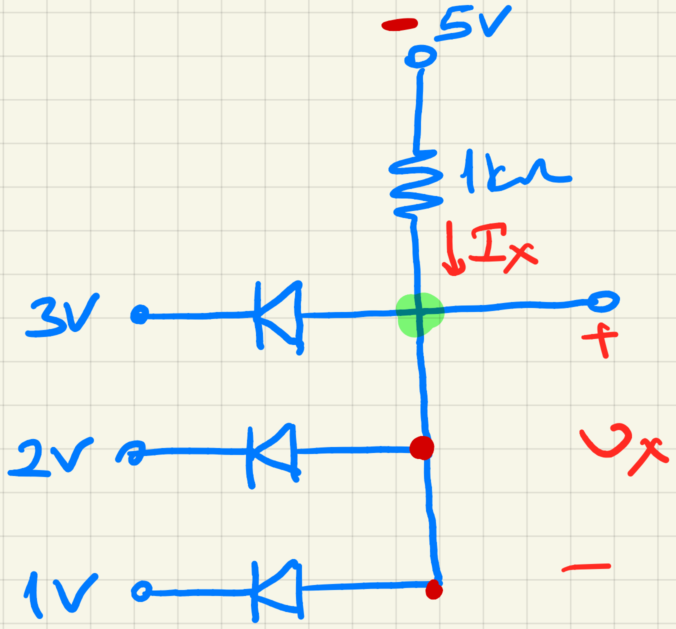
A) 0 B) 1 C) 2 D) 3 E) 6

Örn!

Diyotlar ideal

$V_x = ?$

$I_x = ?$

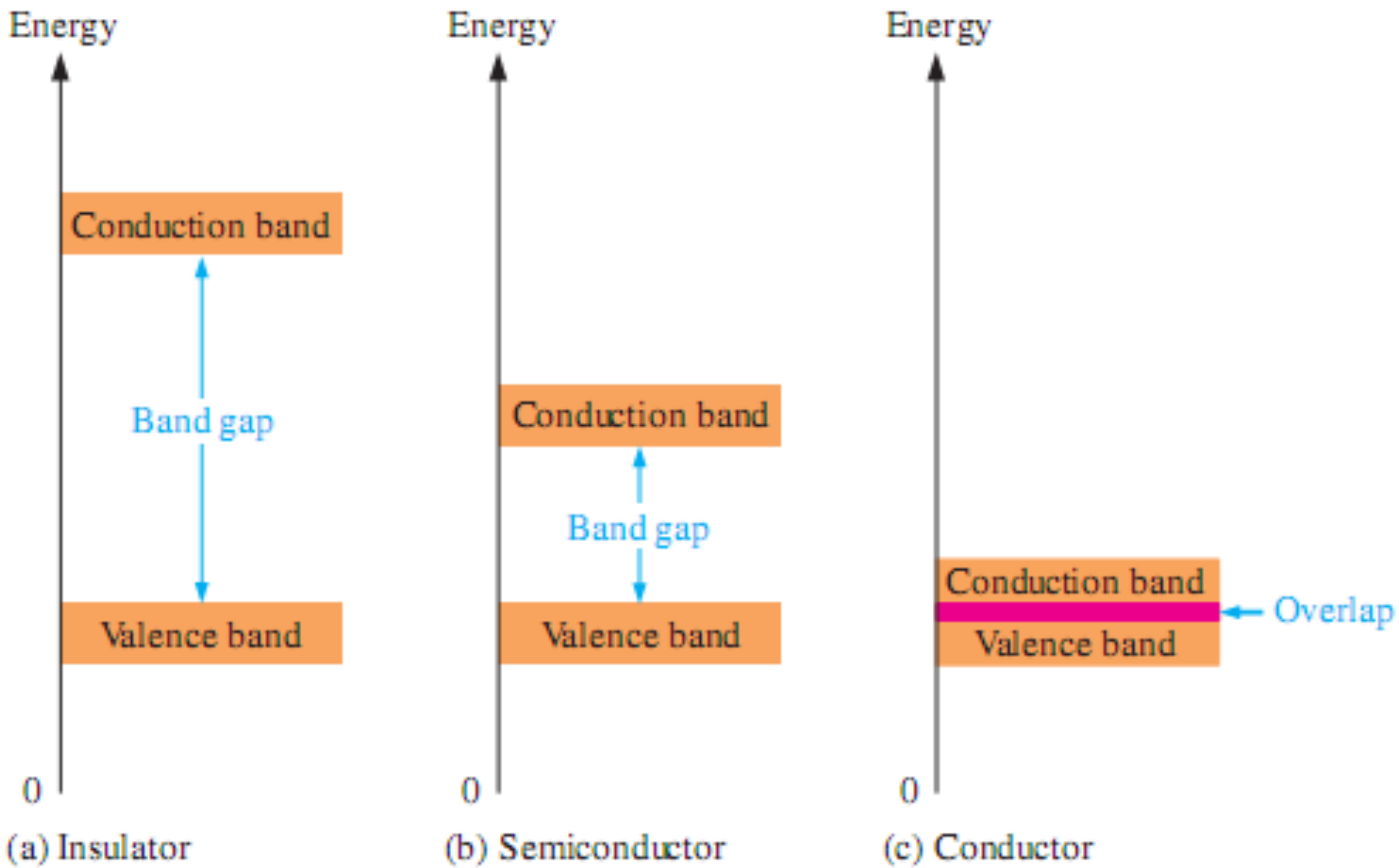


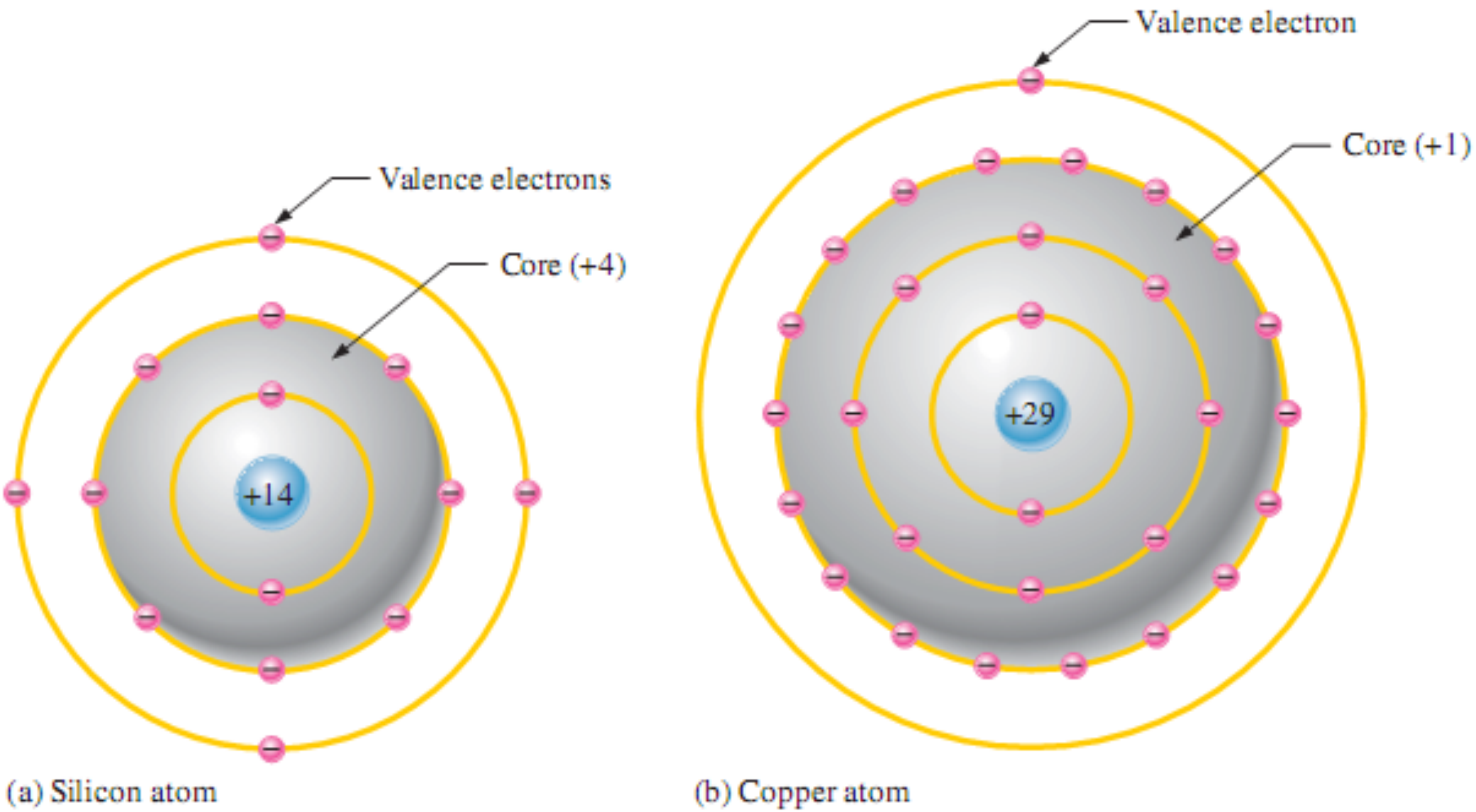
A) 0 B) 1V C) 6V D) 3V E) 5V

$V_x = 1V$ $I_x = \frac{5-1}{1k} = 4\,mA$

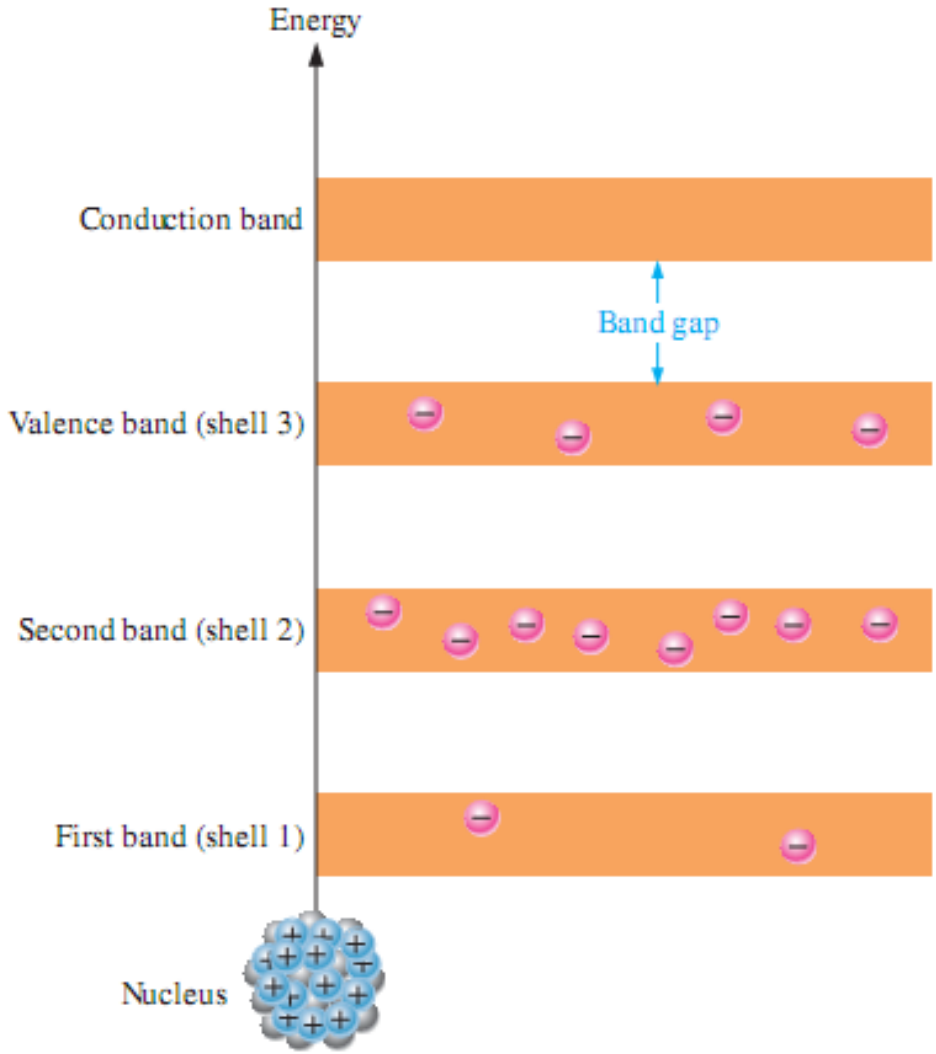
Band Gap

The difference in energy between the valence band and the conduction band is called an energy gap or band gap.

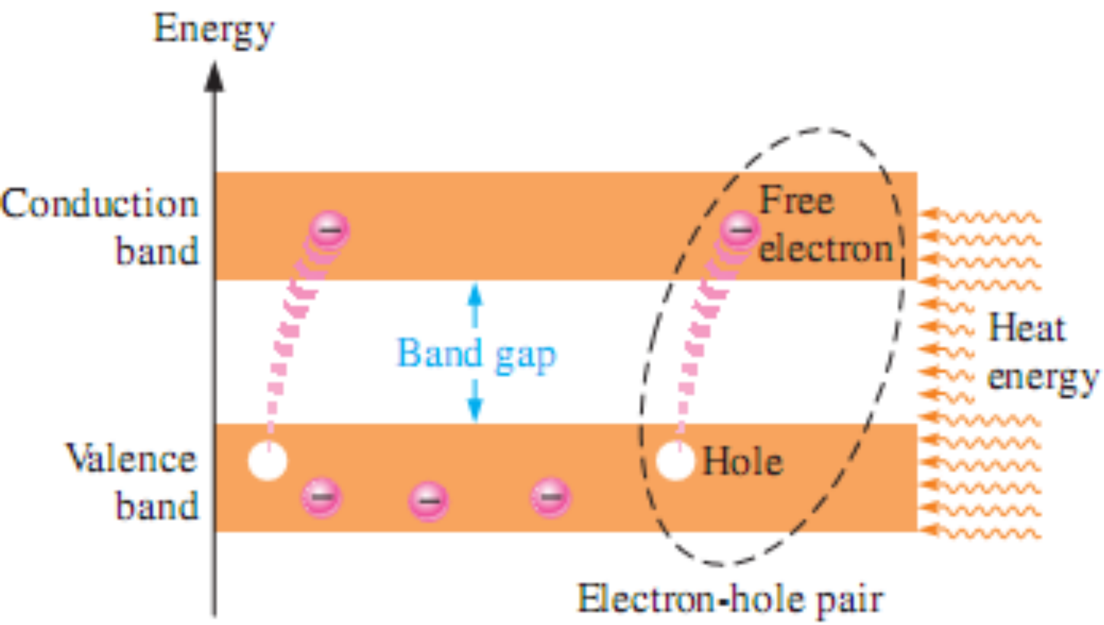




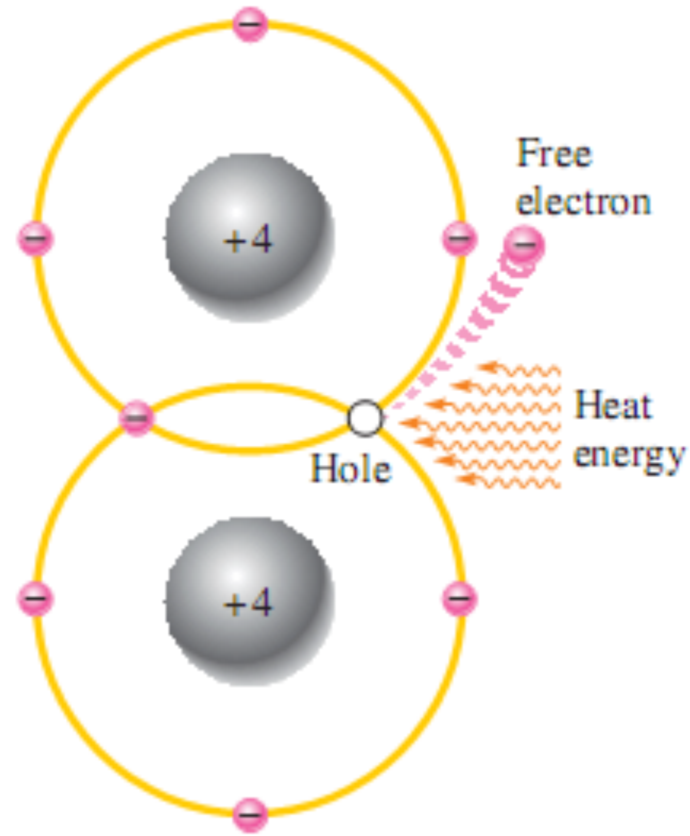
Bohr diagrams of the silicon and copper atoms.



Energy band diagram for an unexcited atom in a pure (intrinsic) silicon crystal. There are no electrons in the conduction band.

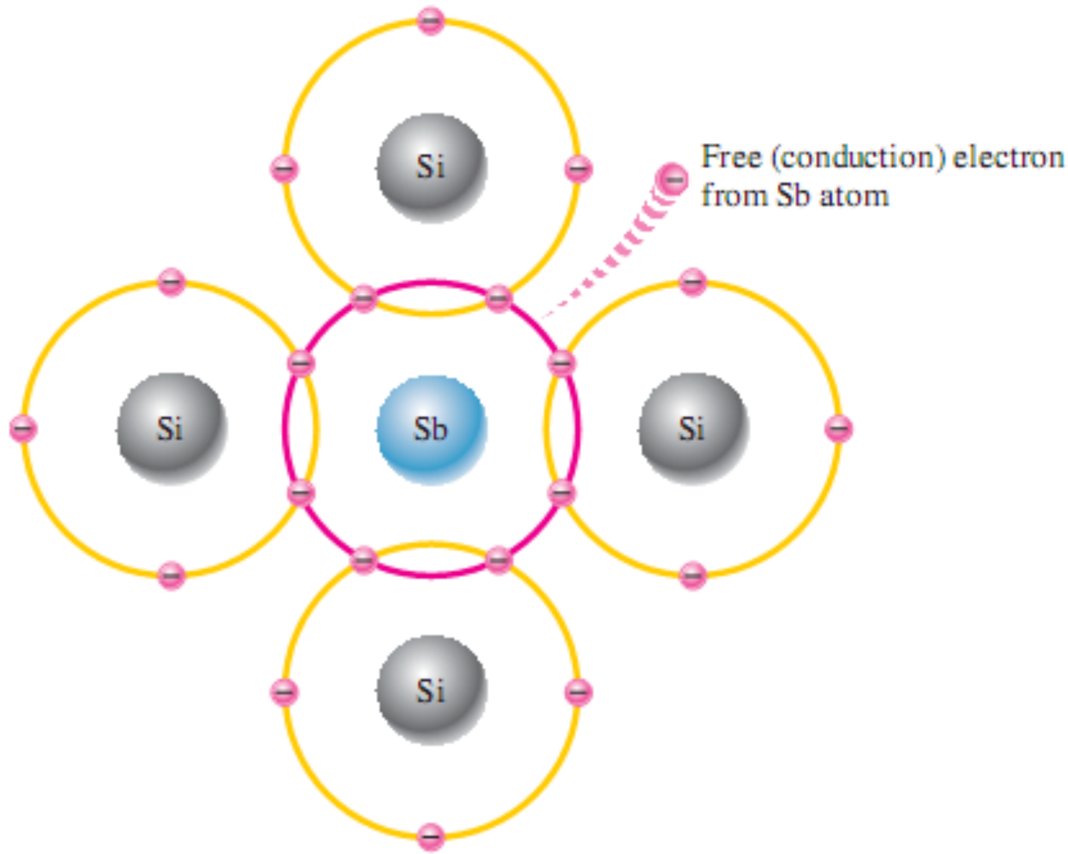


(a) Energy diagram



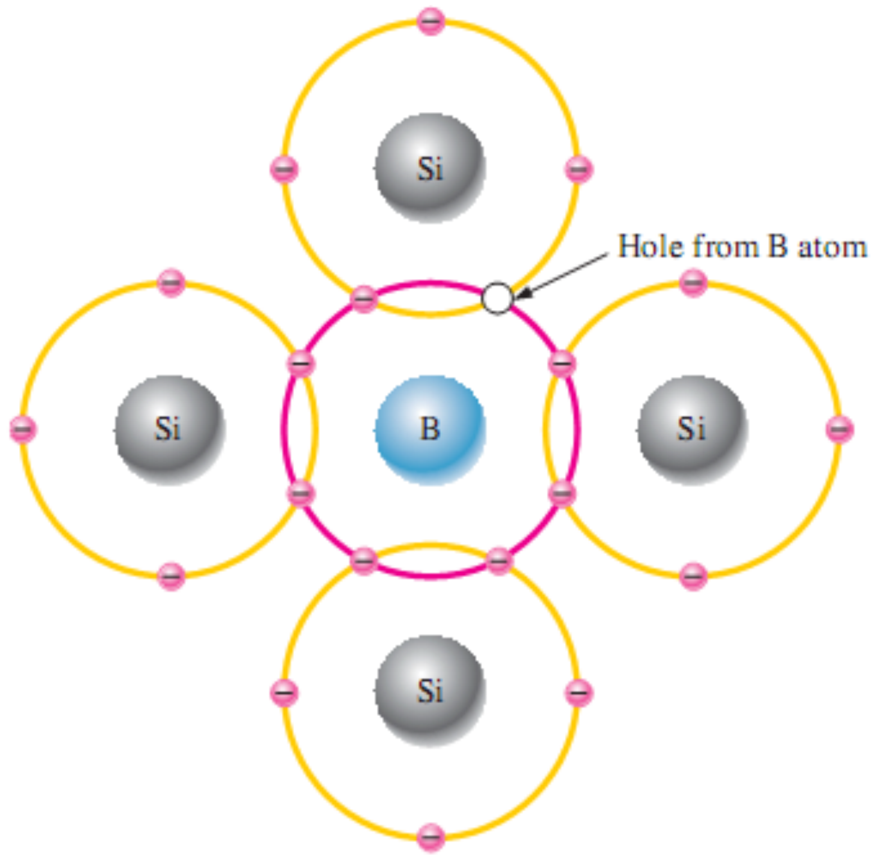
(b) Bonding diagram

N-type Semiconductor



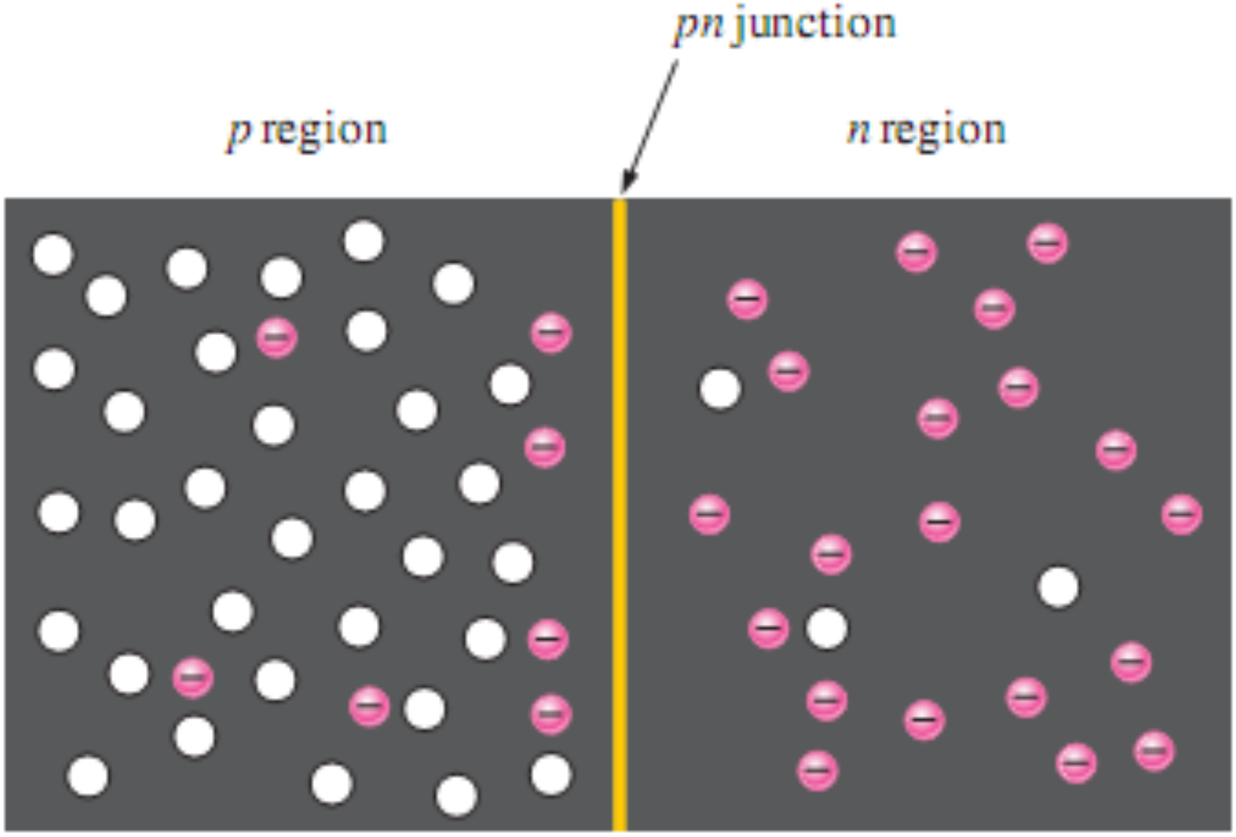
To increase the number of conduction-band electrons in intrinsic silicon, pentavalent impurity atoms are added. These are atoms with **five valence electrons** such as arsenic (As), phosphorus (P), bismuth (Bi), and antimony (Sb).

P-type Semiconductor



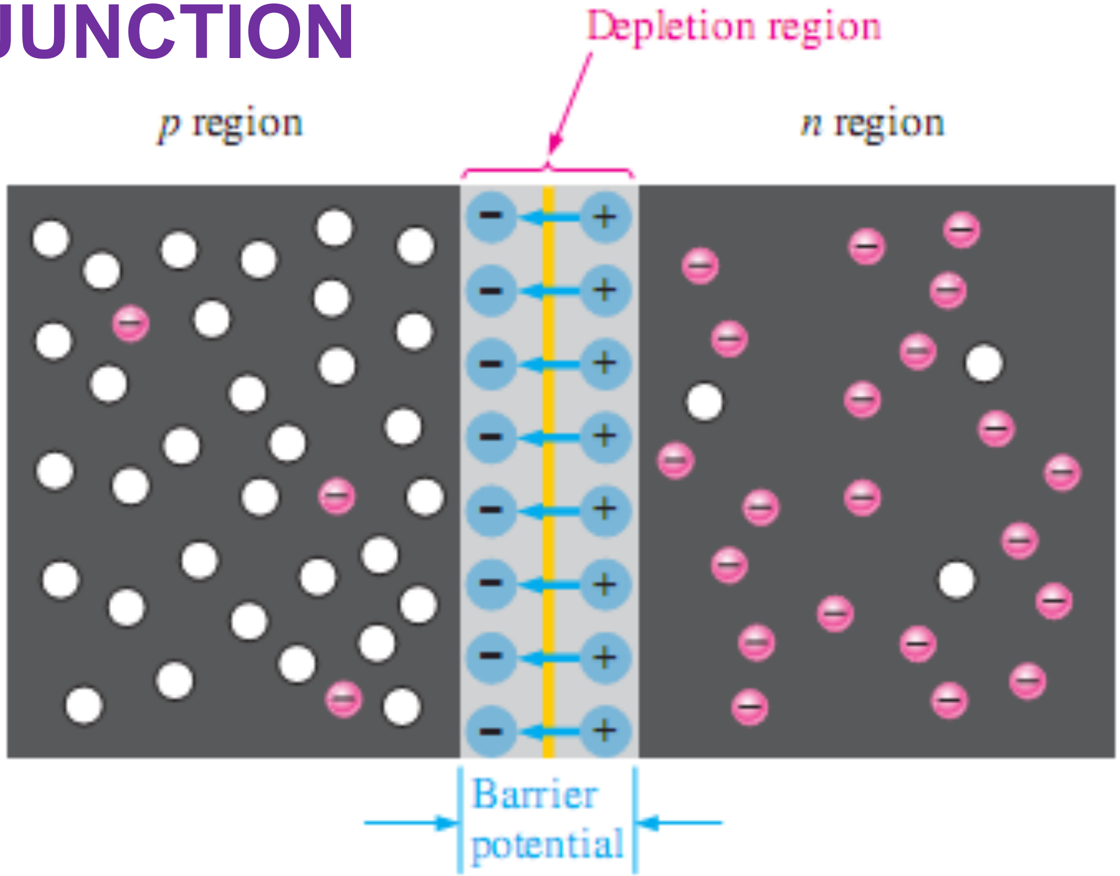
To increase the number of holes in intrinsic silicon, trivalent impurity atoms are added. These are atoms with **three valence electrons** such as boron (B), indium (In), and gallium (Ga).

THE PN JUNCTION



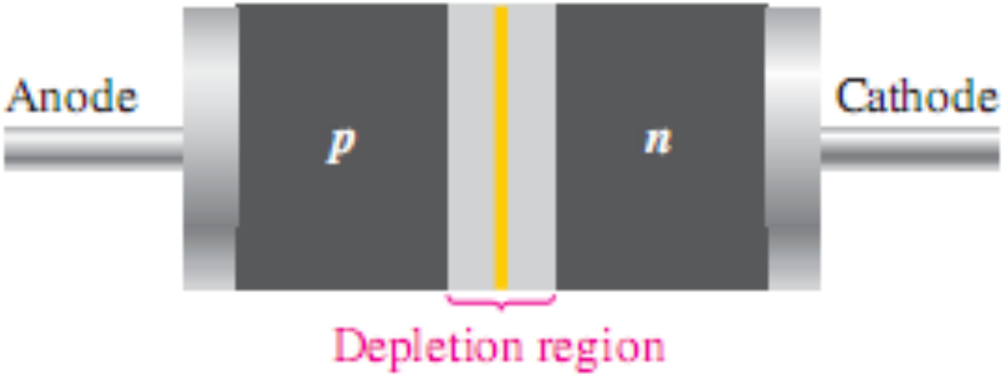
The basic silicon structure at the instant of junction formation showing only the majority and minority carriers. Free electrons in the n region near the pn junction begin to diffuse across the junction and fall into holes near the junction in the p region.

THE PN JUNCTION



For every electron that diffuses across the junction and combines with a hole, a positive charge is left in the n region and a negative charge is created in the p region, forming a barrier potential. This action continues until the voltage of the barrier repels further diffusion. The blue arrows between the positive and negative charges in the depletion region represent the electric field.

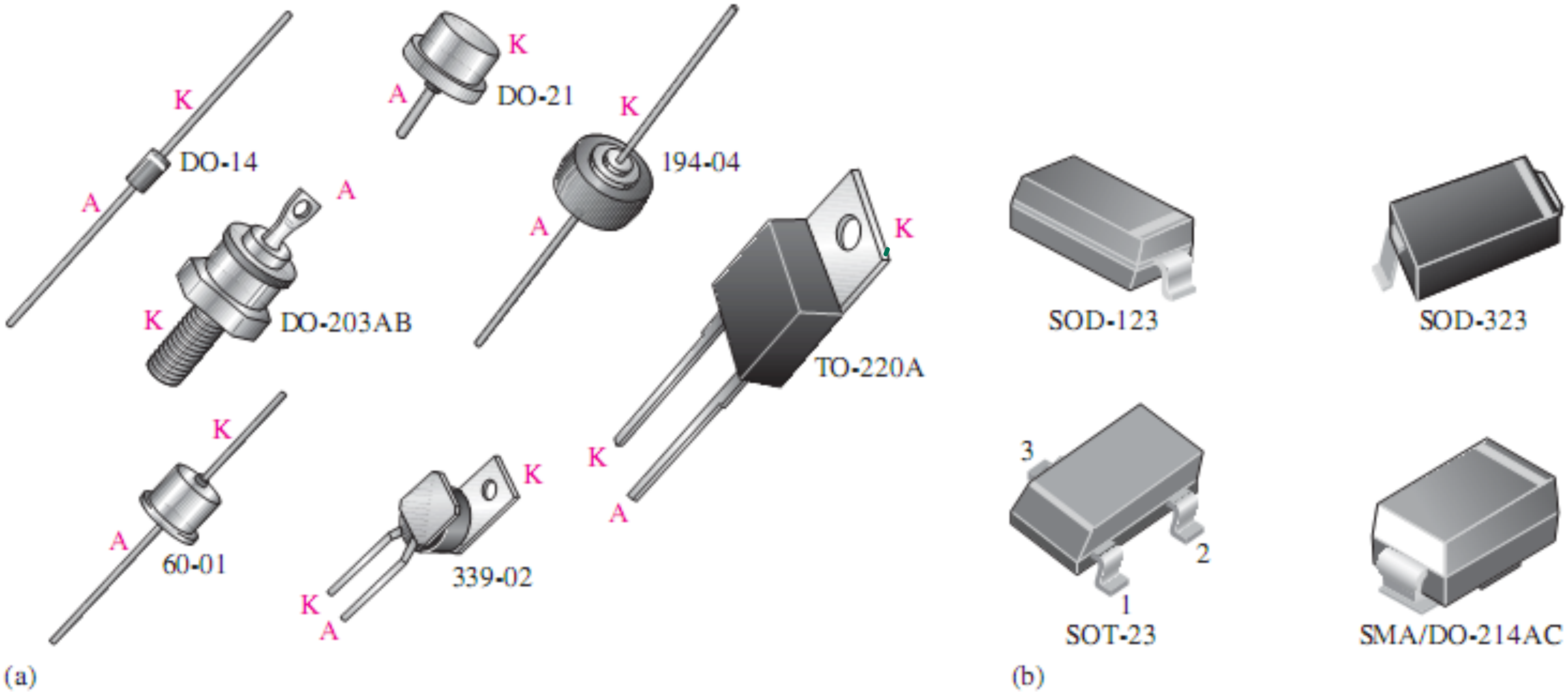
The Diode



(a) Basic structure

(b) Symbol

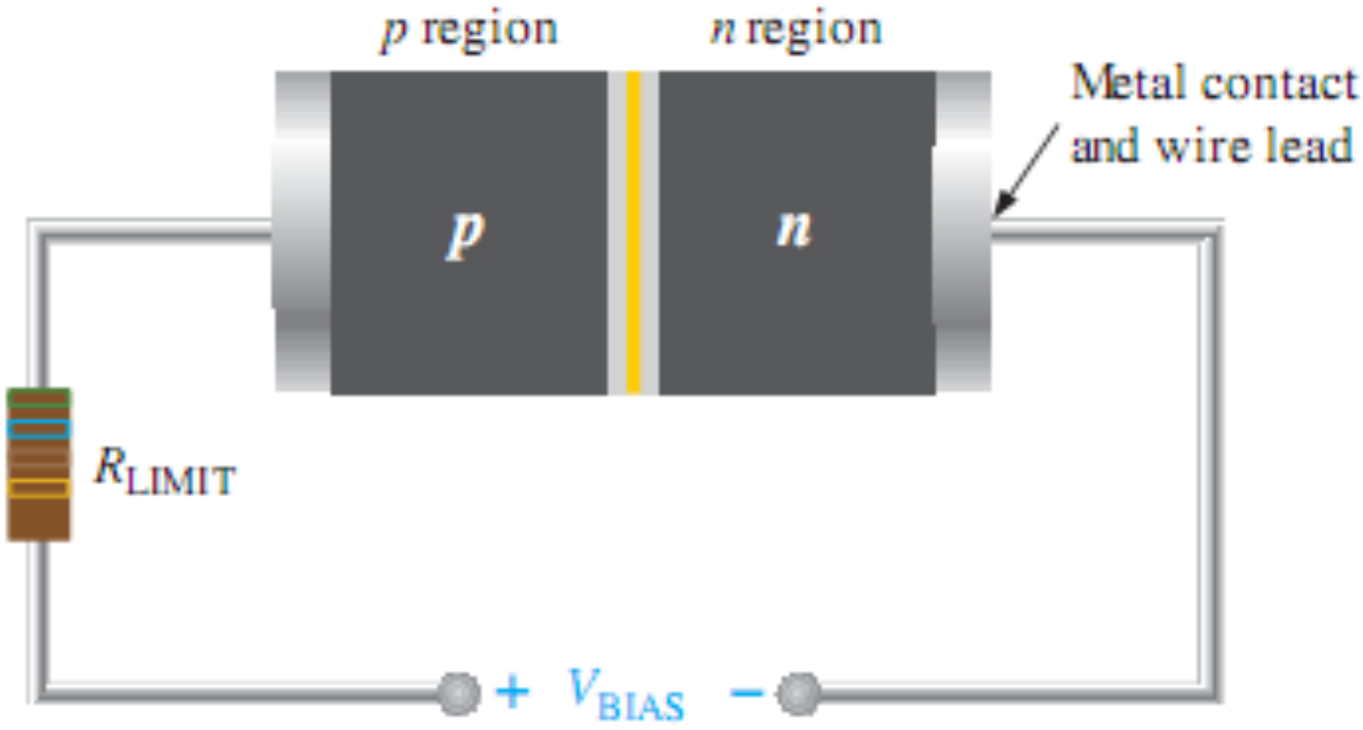
Typical Diode Packages



Typical diode packages with terminal identification. The letter K is used for cathode to avoid confusion with certain electrical quantities that are represented by C.

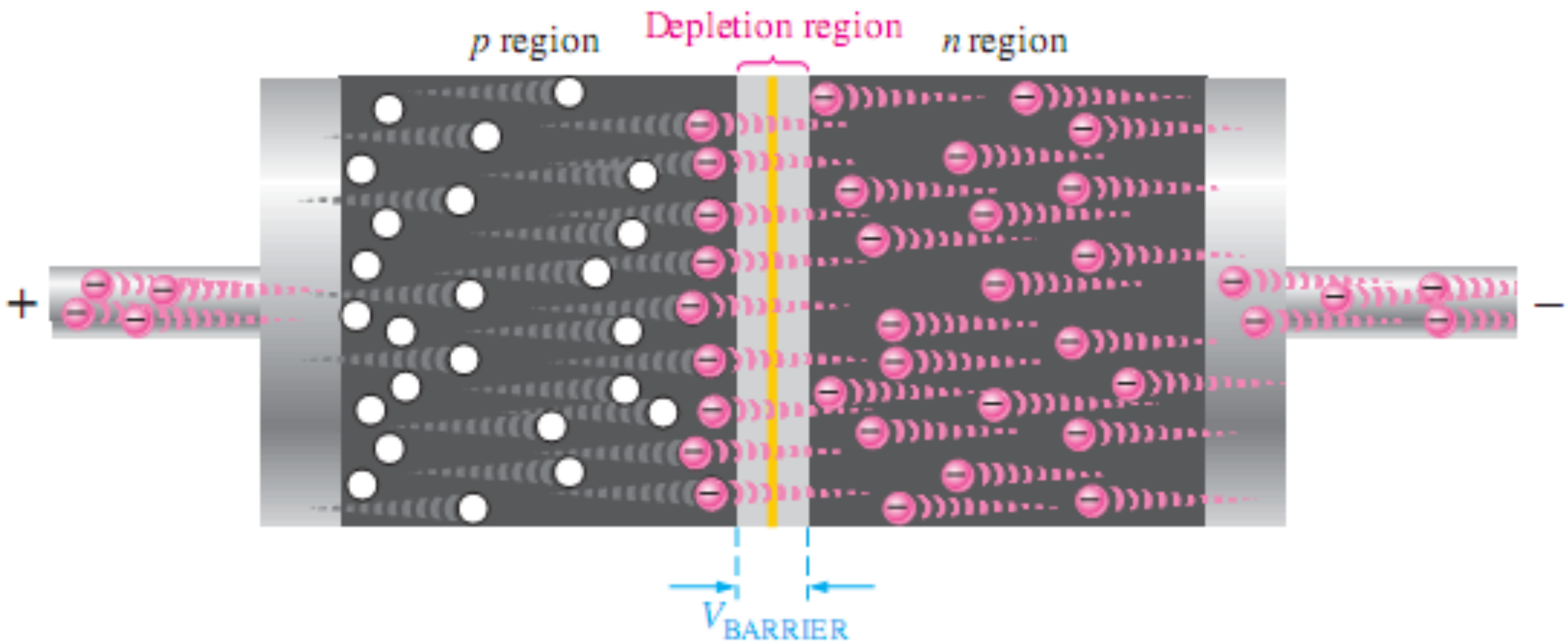
Forward Bias

Forward bias is the condition that allows current through the pn junction.



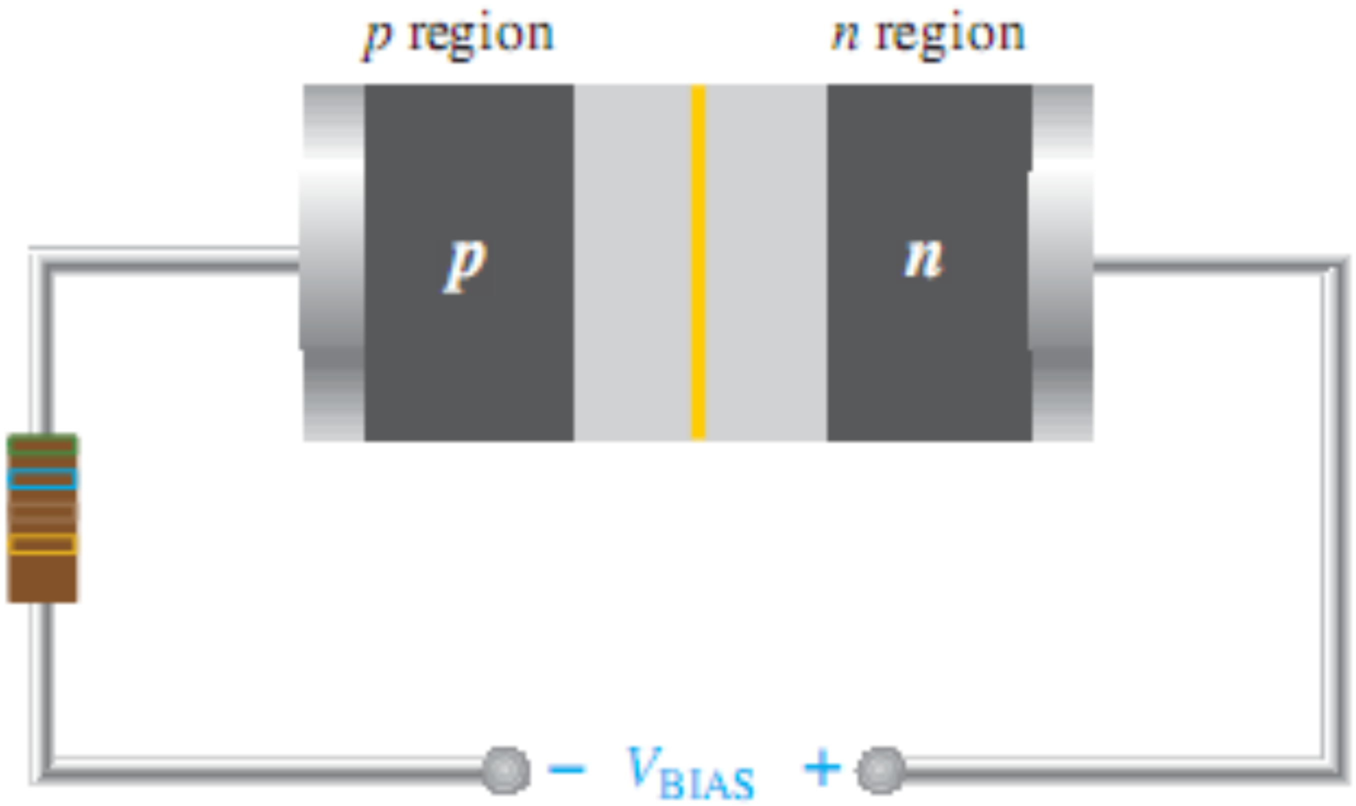
Firstly, the negative side of V_{BIAS} is connected to the n region of the diode and the positive side is connected to the p region. This is one requirement for forward bias. Secondly, V_{BIAS}, must be greater than the barrier potential.

Forward Bias



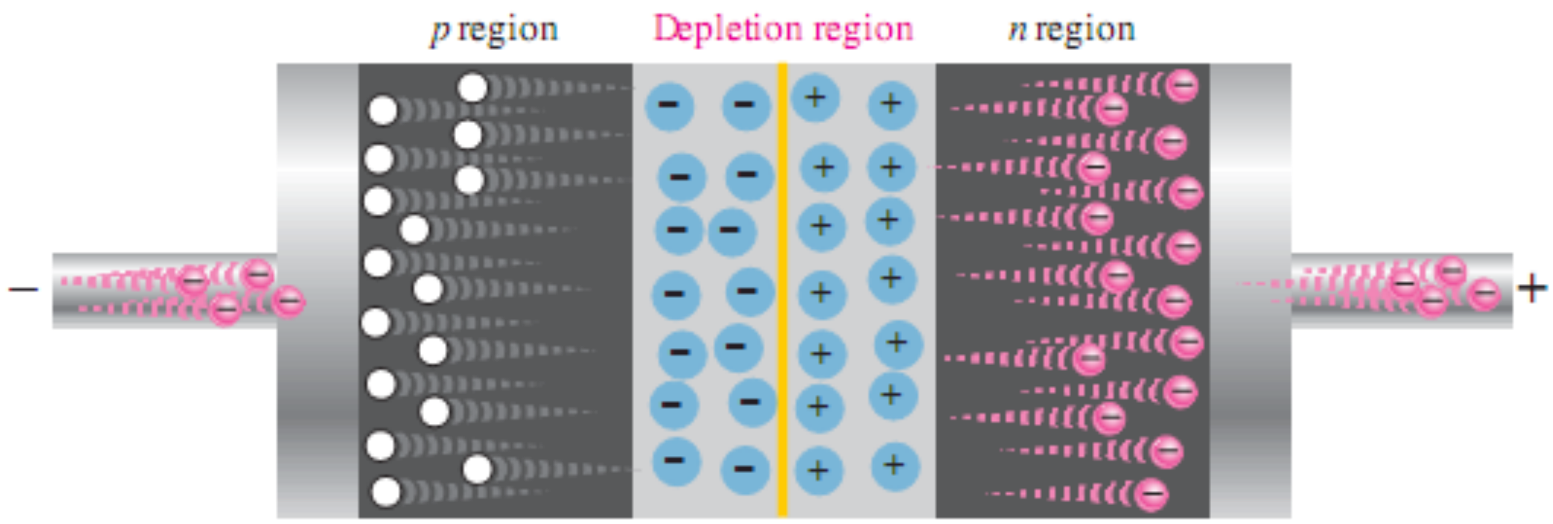
A forward-biased diode showing the flow of majority carriers and the voltage due to the barrier potential across the depletion region.

Reverse Bias



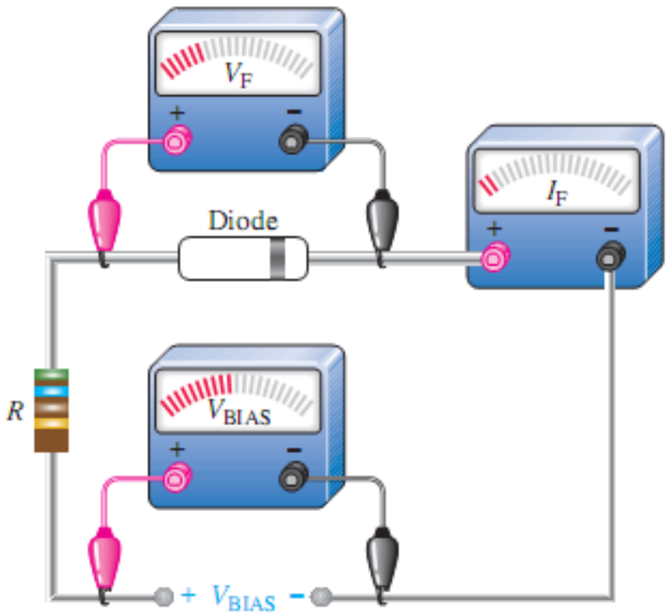
A diode connected for reverse bias. A limiting resistor is shown although it is not important in reverse bias because there is essentially no current.

Reverse Bias

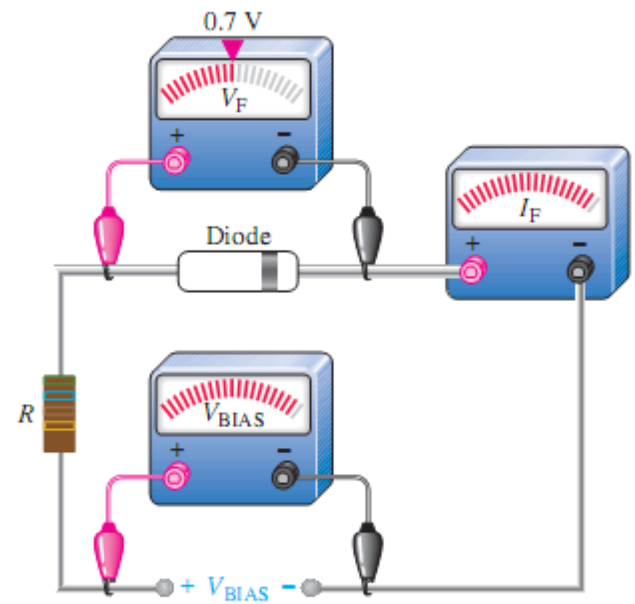


The diode during the short transition time immediately after reverse-bias voltage is applied.

V-I Characteristic for Forward Bias

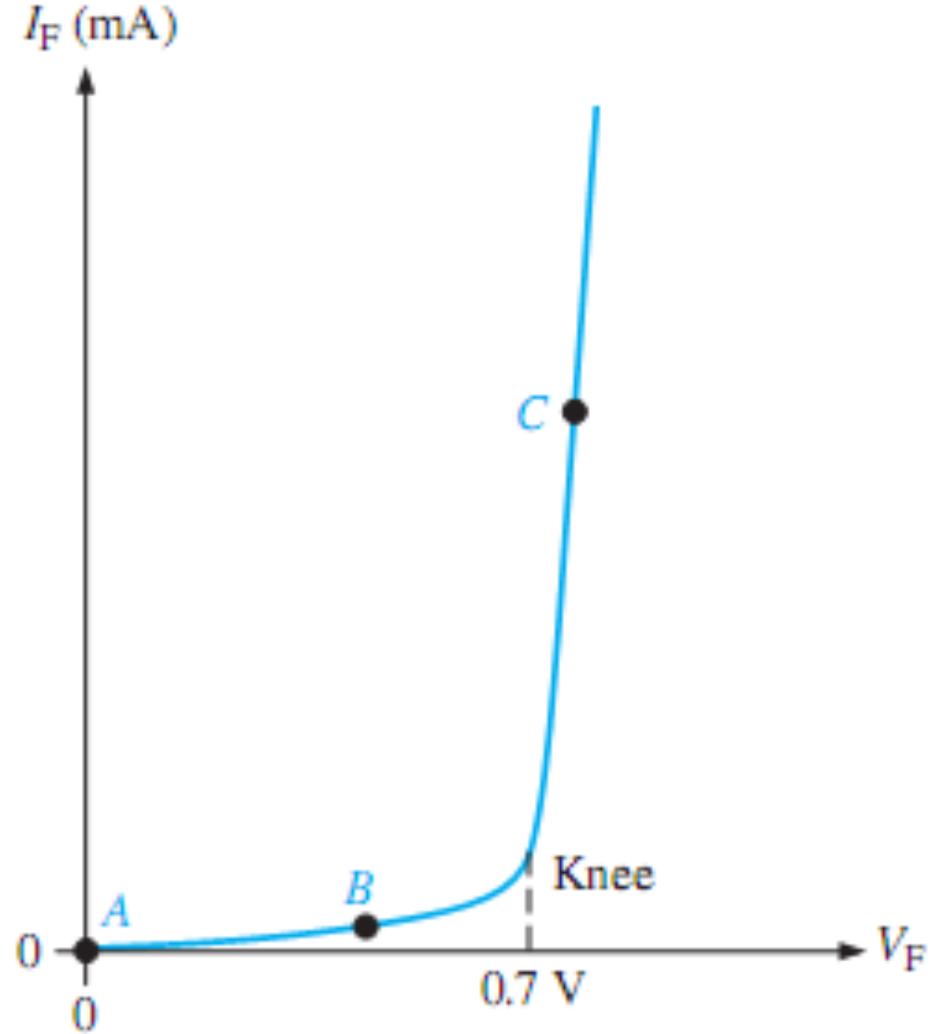


(a) Small forward-bias voltage ($V_F < 0.7$ V), very small forward current.



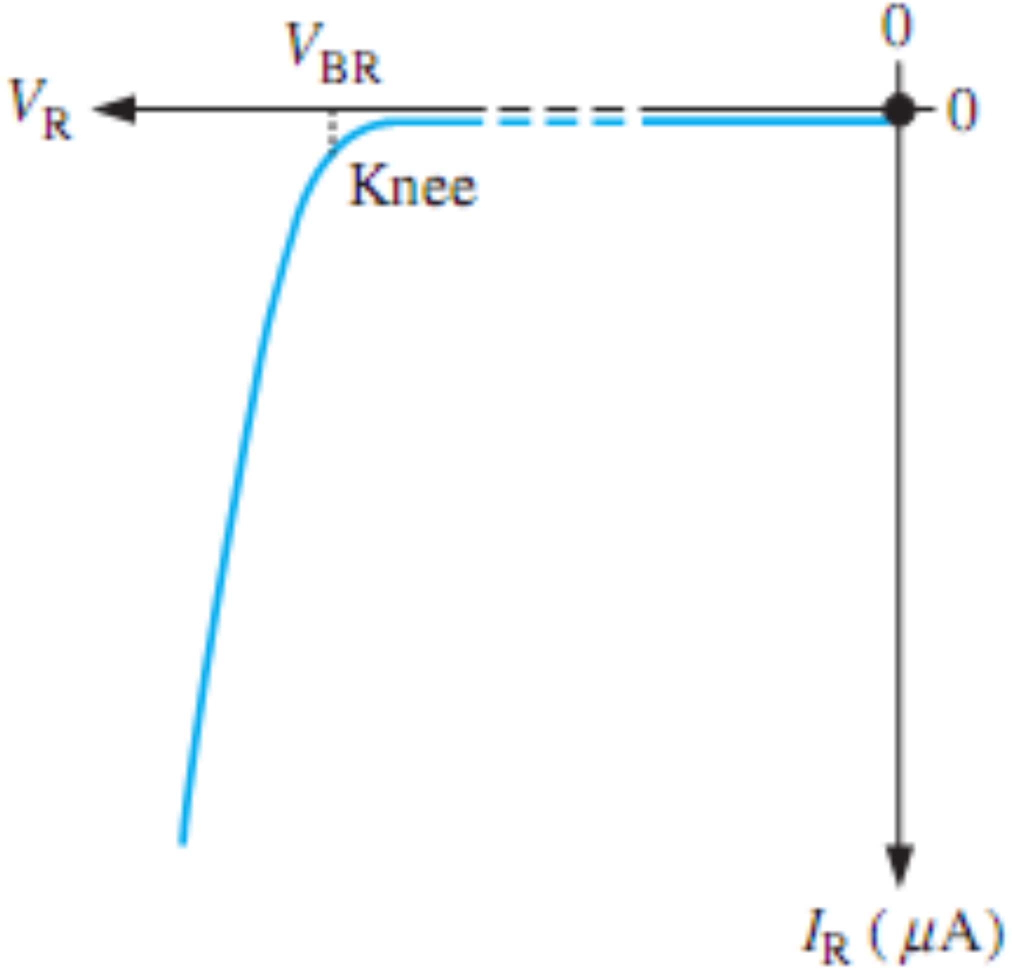
(b) Forward voltage reaches and remains nearly constant at approximately 0.7 V. Forward current continues to increase as the bias voltage is increased.

V-I Characteristic for Forward Bias

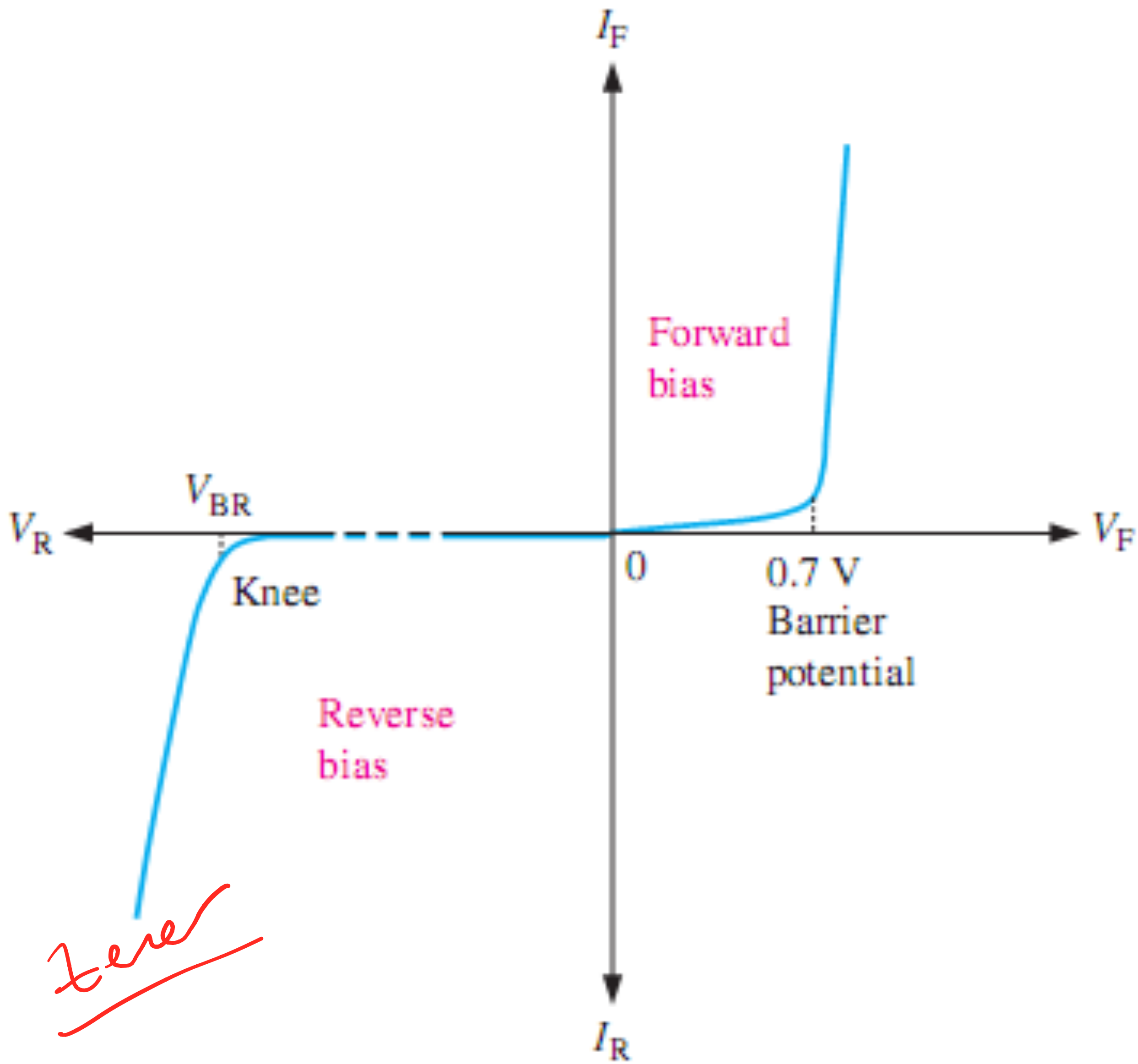


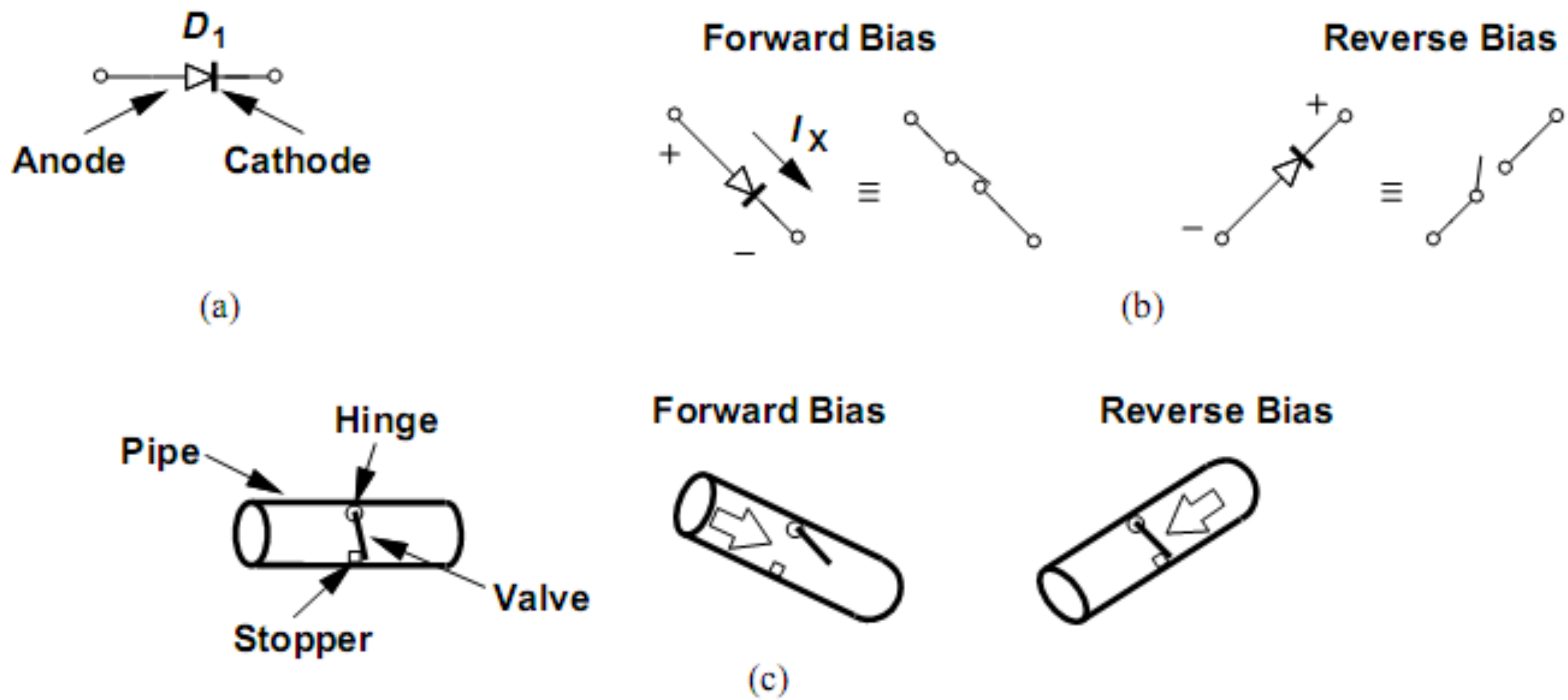
(a) *V-I* characteristic curve for forward bias.

V-I Characteristic for Reverse Bias



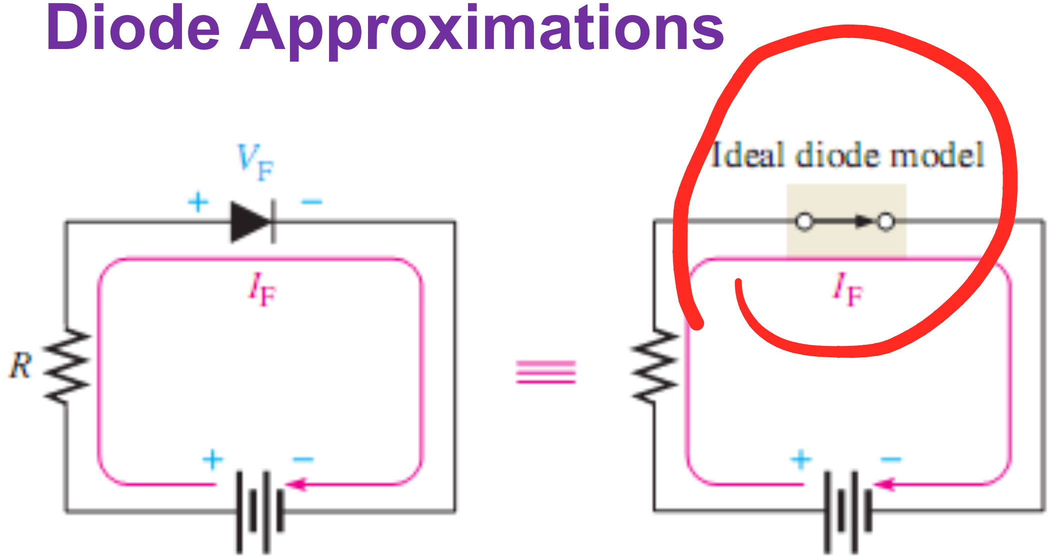
The Complete V-I Characteristic Curve



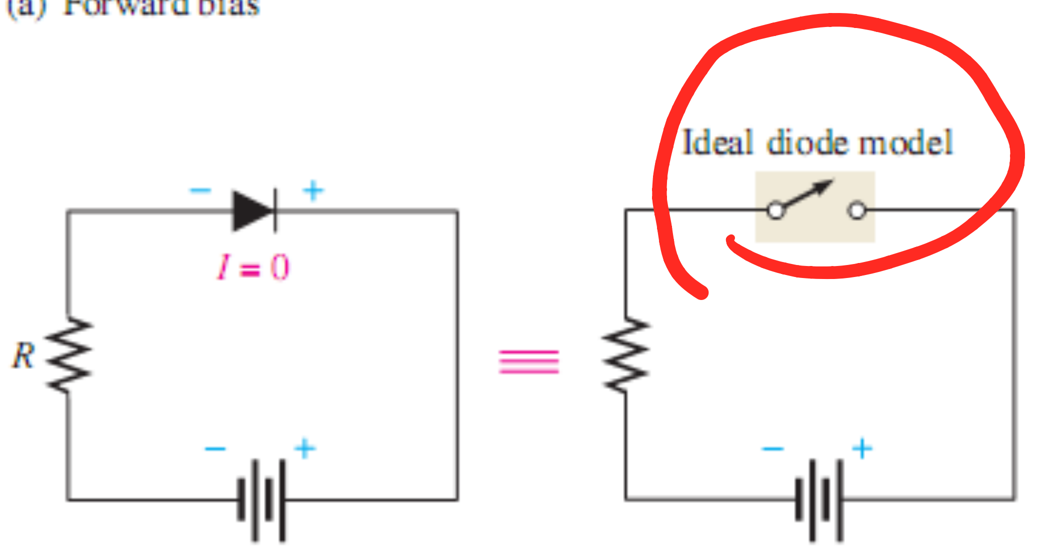


(a) Diode symbol, (b) equivalent circuit, (c) water pipe analogy.

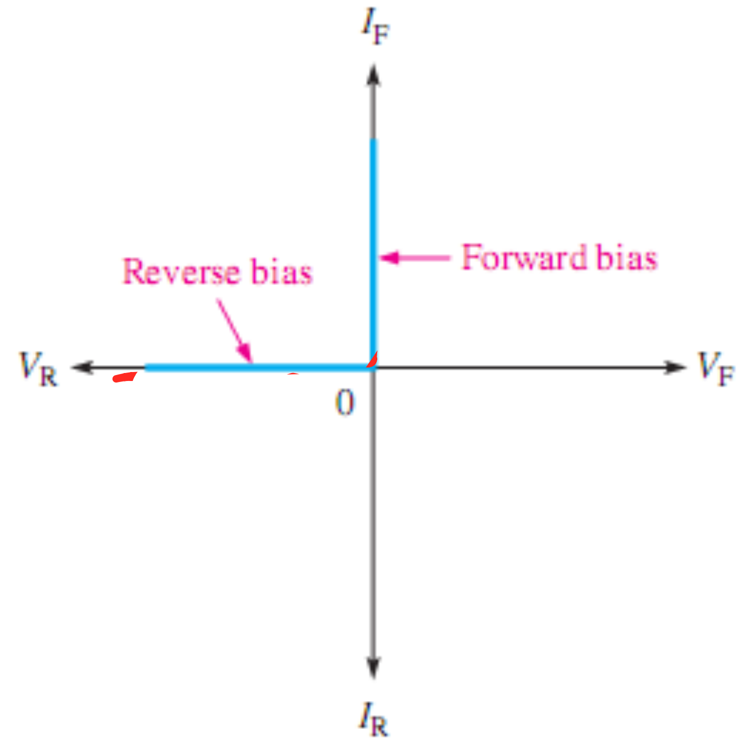
Diode Approximations



(a) Forward bias

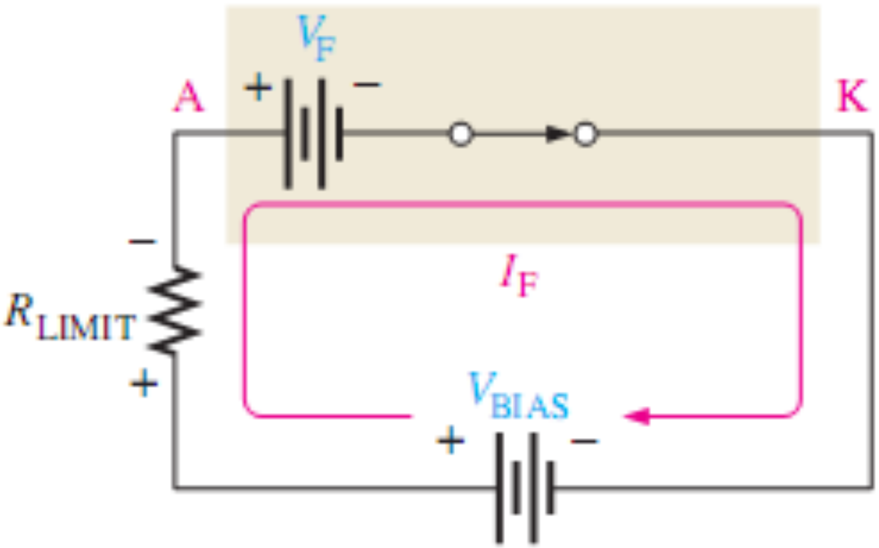


(b) Reverse bias

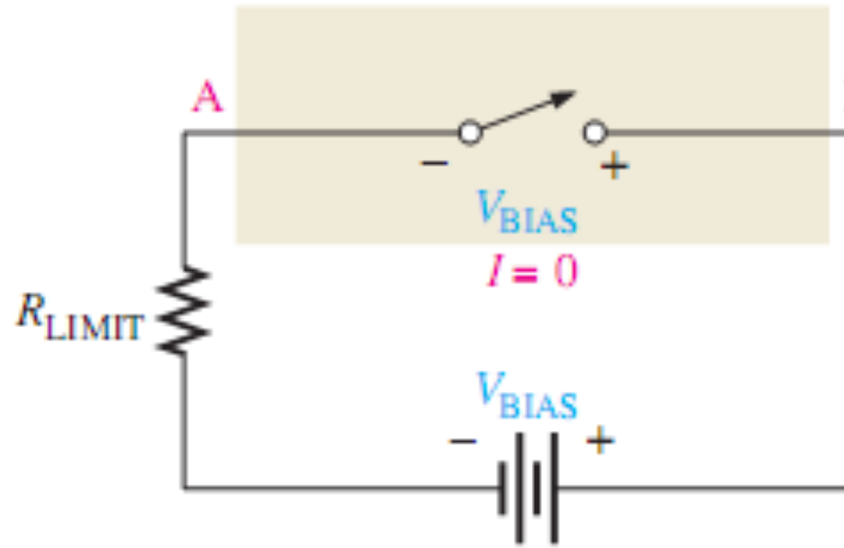


(c) Ideal V-I characteristic curve (blue)

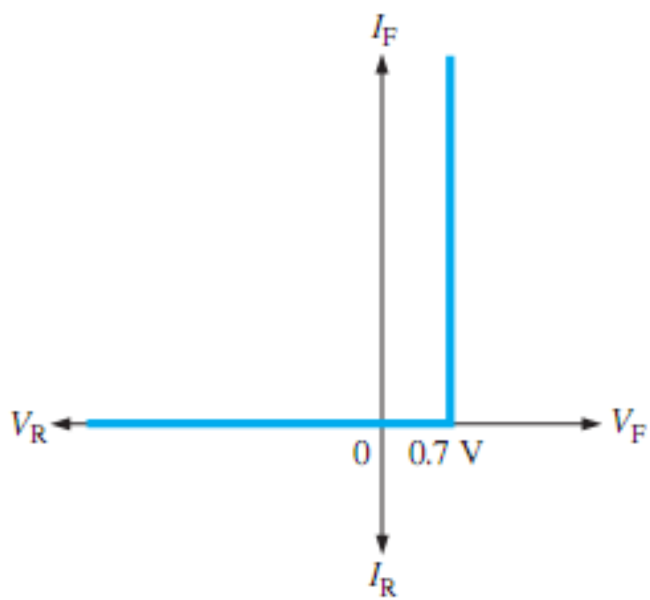
The Practical Diode Model (Sabit Gerilim)



(a) Forward bias



bias



(c) Characteristic curve (silicon)

DIODE SPECIFICATION SHEETS

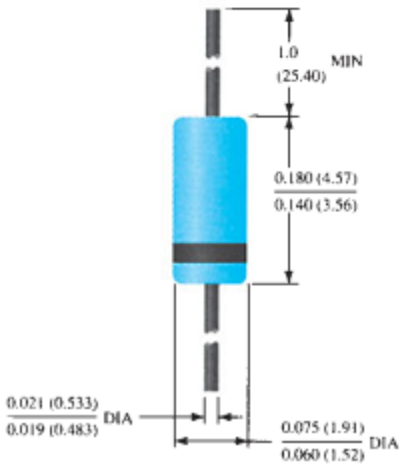
Data on specific semiconductor devices are normally provided by the manufacturer in one of two forms. Most frequently, they give a very brief description limited to perhaps one page. At other times, they give a thorough examination of the characteristics using graphs, artwork, tables, and so on. In either case, there are specific pieces of data that must be included for proper use of the device. They include:

1. **The forward voltage V_F (at a specified current and temperature)**
2. **The maximum forward current I_F (at a specified temperature)**
3. **The reverse saturation current I_R (at a specified voltage and temperature)**
4. **The reverse-voltage rating [PIV or PRV or V(BR), where BR comes from the term "breakdown" (at a specified temperature)]**
5. **The maximum power dissipation level at a particular temperature**
6. **Capacitance levels**
7. **Reverse recovery time t_{rr}**
8. **Operating temperature range**

DIFFUSED SILICON PLANAR

A • **BV . . . 125 V (MIN) @ 100 µA (BAY73)**

DO-35 OUTLINE



NOTES:
Copper clad steel leads, tin plated
Gold plated leads available
Hermetically sealed glass package
Package weight is 0.14 gram

ABSOLUTE MAXIMUM RATINGS (Note 1)

Temperatures

B

Storage Temperature Range	–65°C to +200°C
Maximum Junction Operating Temperature	+175°C
Lead Temperature	+260°C

Power Dissipation (Note 2)

C

Maximum Total Power Dissipation at 25°C Ambient	500 mW
Linear Power Derating Factor (from 25°C)	3.33 mW/°C

Maximum Voltage and Currents

D

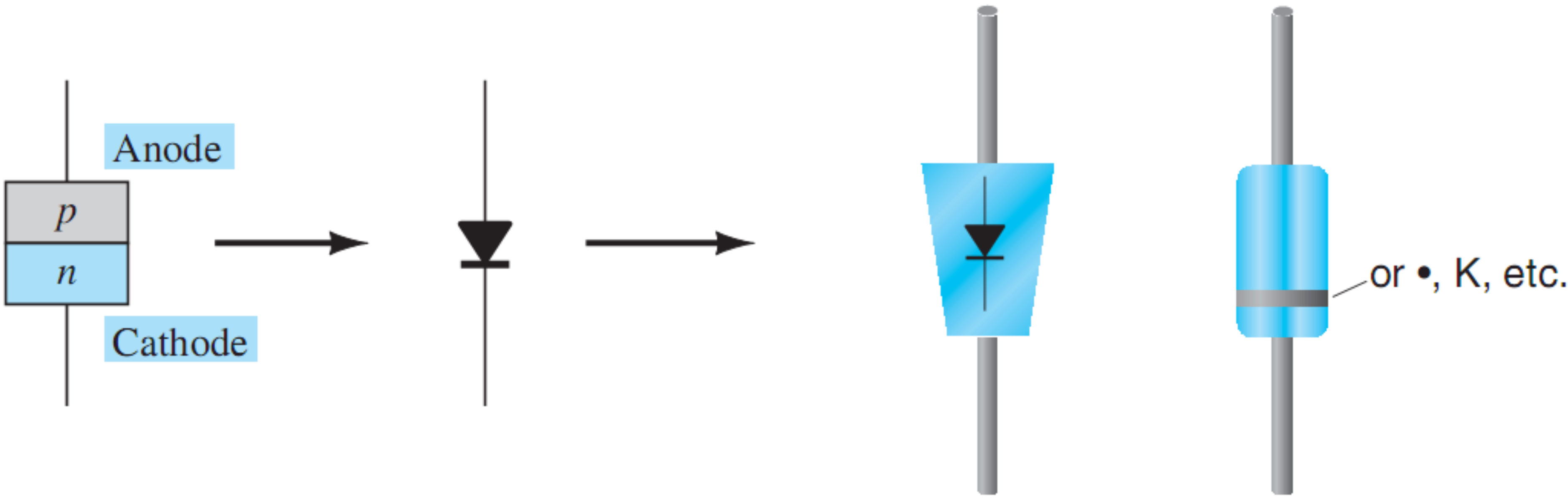
WIV	Working Inverse Voltage	BAY73	100 V
I_O	Average Rectified Current		200 mA
I_F	Continuous Forward Current		500 mA
i_f	Peak Repetitive Forward Current		600 mA
$i_{f\,(surge)}$	Peak Forward Surge Current		
	Pulse Width = 1 s		1.0 A
	Pulse Width = 1 µs		4.0 A

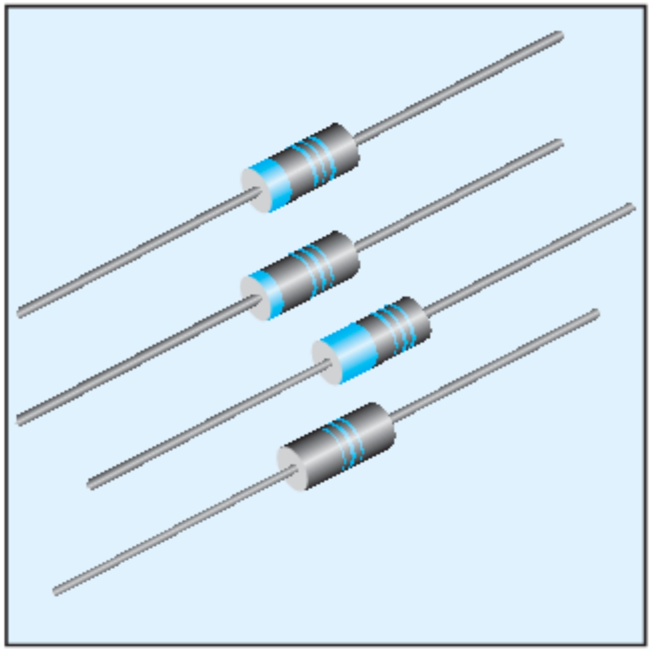
ELECTRICAL CHARACTERISTICS (25°C Ambient Temperature unless otherwise noted)

E

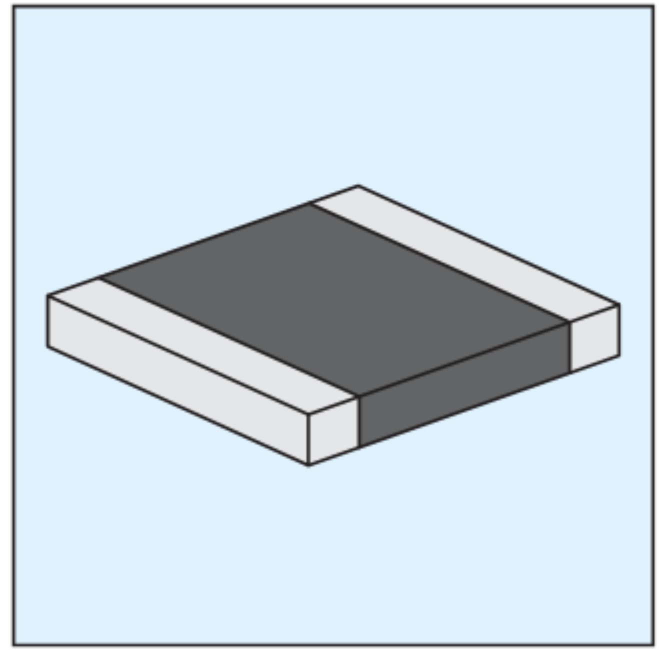
SYMBOL	CHARACTERISTIC	BAY73		UNITS	TEST CONDITIONS
		MIN	MAX		
V_F	Forward Voltage	0.85	1.00	V	I_F = 200 mA
		0.81	0.94	V	I_F = 100 mA
		0.78	0.88	V	I_F = 50 mA
		0.69	0.80	V	I_F = 10 mA
		0.67	0.75	V	I_F = 5.0 mA

SEMICONDUCTOR DIODE NOTATION

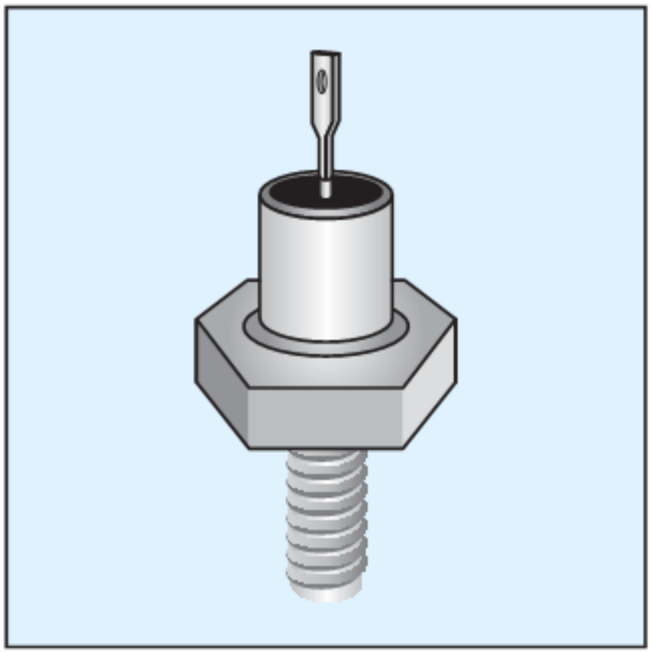




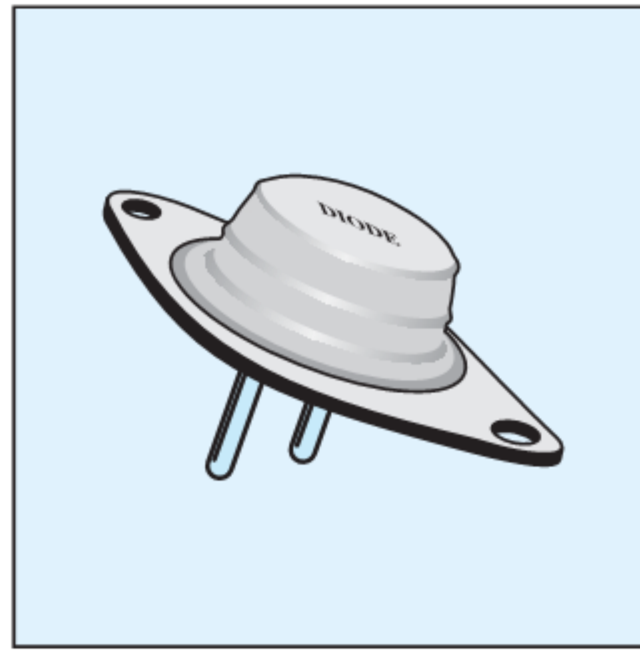
General purpose diode



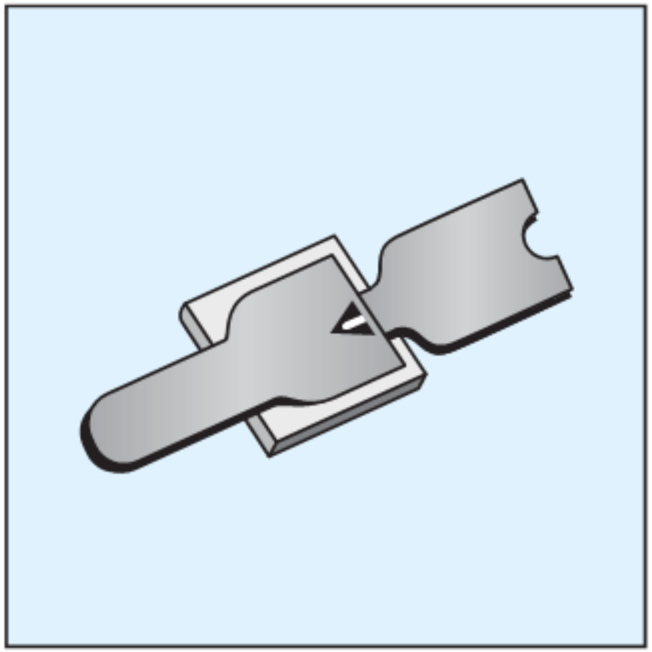
Surface mount high-power PIN diode



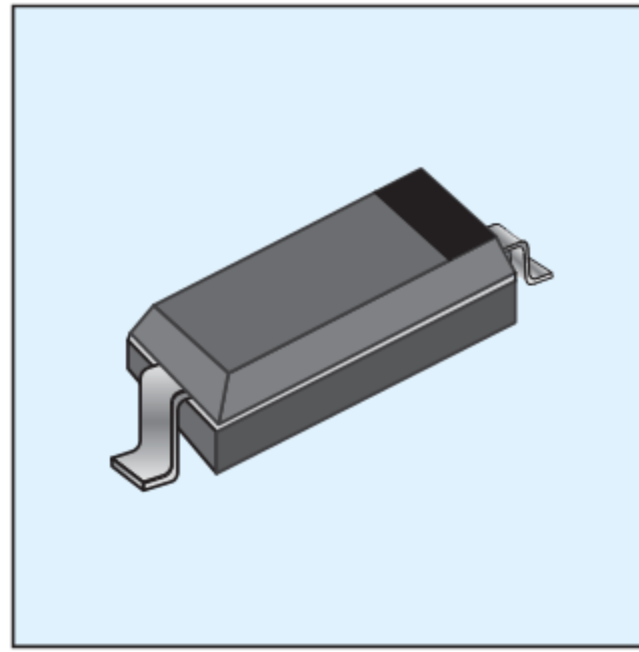
Power (stud) diode



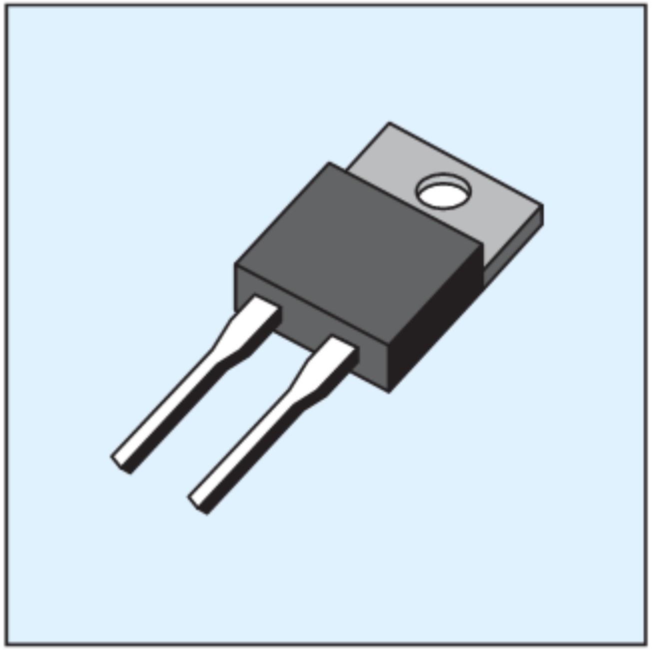
Power (planar) diode



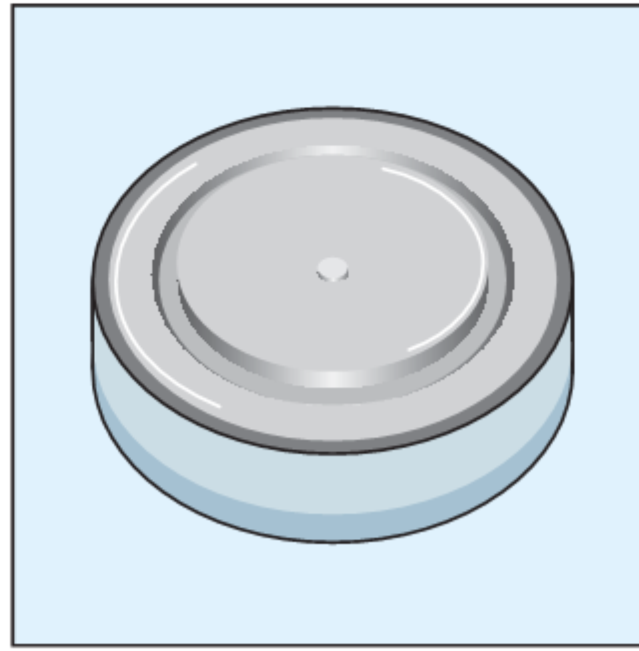
Beam lead pin diode



Flat chip surface mount diode



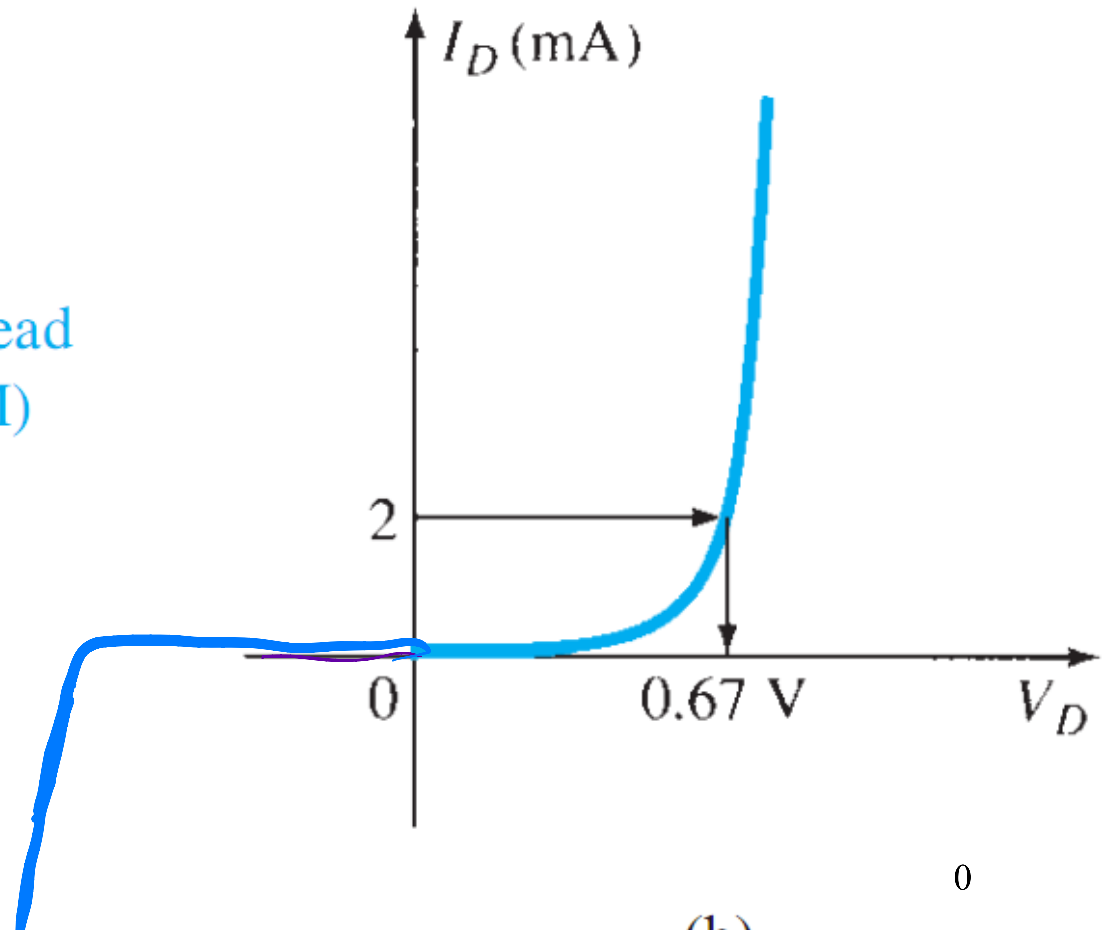
Power diode



Power (disc, puck) diode

Diode Checking Function

(a)



(b)

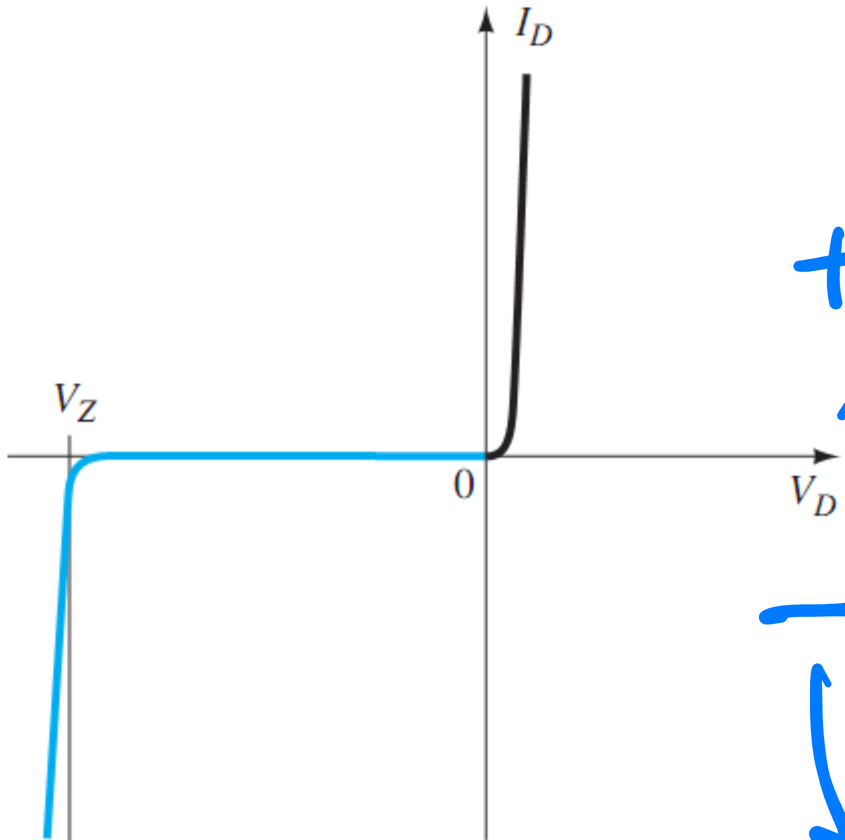
0

ZENER DIODES

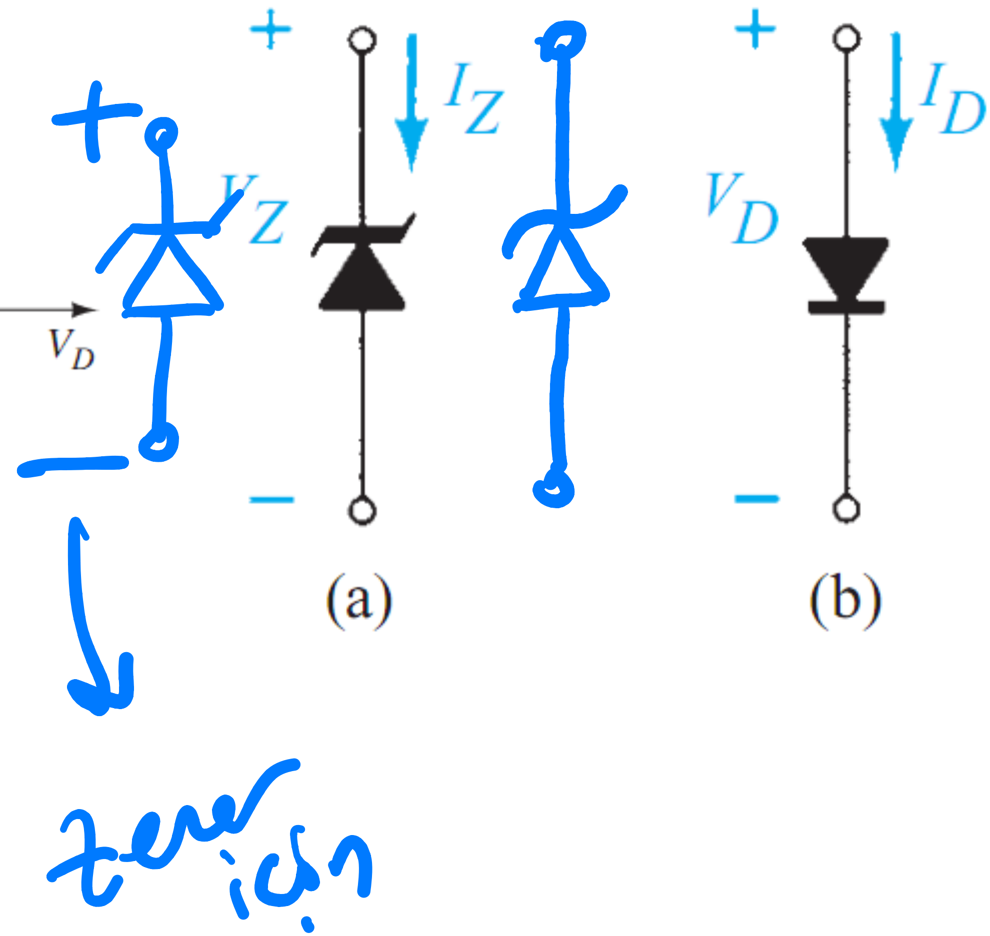
The characteristic drops in an almost vertical manner at a reverse-bias potential denoted V_Z. The fact that the curve drops down and away from the horizontal axis rather than up and away for the positive- V_D region reveals that the current in the Zener region has a direction opposite to that of a forward-biased diode.

The location of the Zener region can be controlled by varying the doping levels. An increase in doping that produces an increase in the number of added impurities, will decrease the Zener potential. Zener diodes are available having Zener potentials of 1.8 V to 200 V with power ratings from 1⁄4 W to 50 W. Because of its excellent temperature and current capabilities, silicon is the preferred material in the manufacture of Zener diodes.

ZENER DIODES

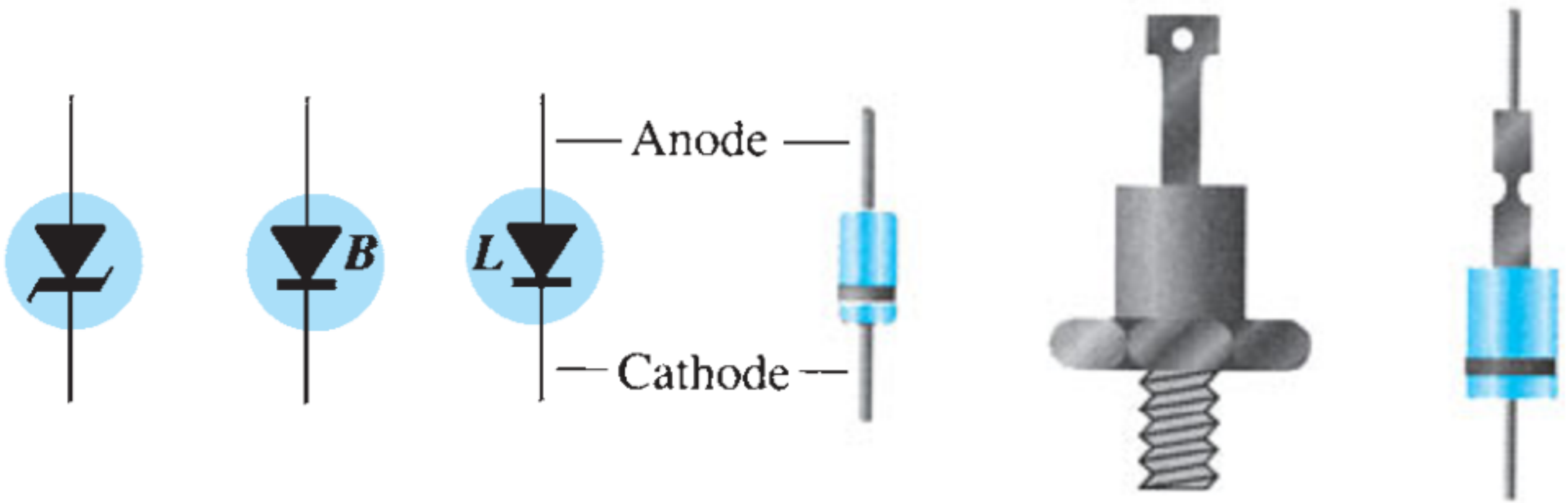


Reviewing the Zener region.



ZENER DIODES

The terminal identification and the casing for a variety of Zener diodes appear in Figure. Their appearance is similar in many ways to that of the standard diode.



Zener terminal identification and symbols.

LIGHT-EMITTING DIODES (LED)

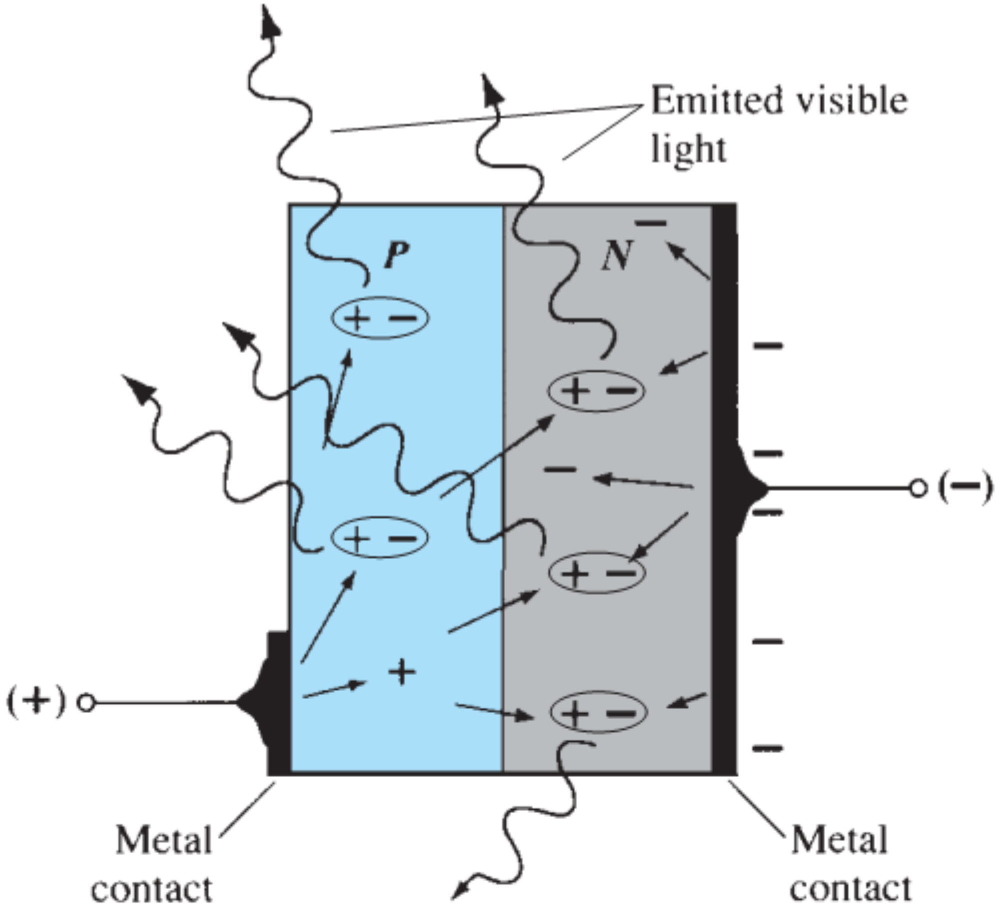
The increasing use of digital displays in calculators, watches, and all forms of instrumentation has contributed to an extensive interest in structures that emit light when properly biased.

The increasing use of digital displays in calculators, watches, and all forms of instrumentation has contributed to an extensive interest in structures that emit light when properly biased.
In Si and Ge diodes the greater percentage of the energy converted during recombination at the junction is dissipated in the form of heat within the structure, and the emitted light is insignificant. For this reason, silicon and germanium are not used in the construction of LED devices.

LIGHT-EMITTING DIODES

On the other hand:
Diodes constructed of GaAs emit light in the infrared (invisible) zone during the recombination process at the p–n junction.
Even though the light is not visible, infrared LEDs have numerous applications where visible light is not a desirable effect. These include security systems, industrial processing, optical coupling, safety controls such as on garage door openers, and in home entertainment centers, where the infrared light of the remote control is the controlling element.

LIGHT-EMITTING DIODES



(a)

(b)

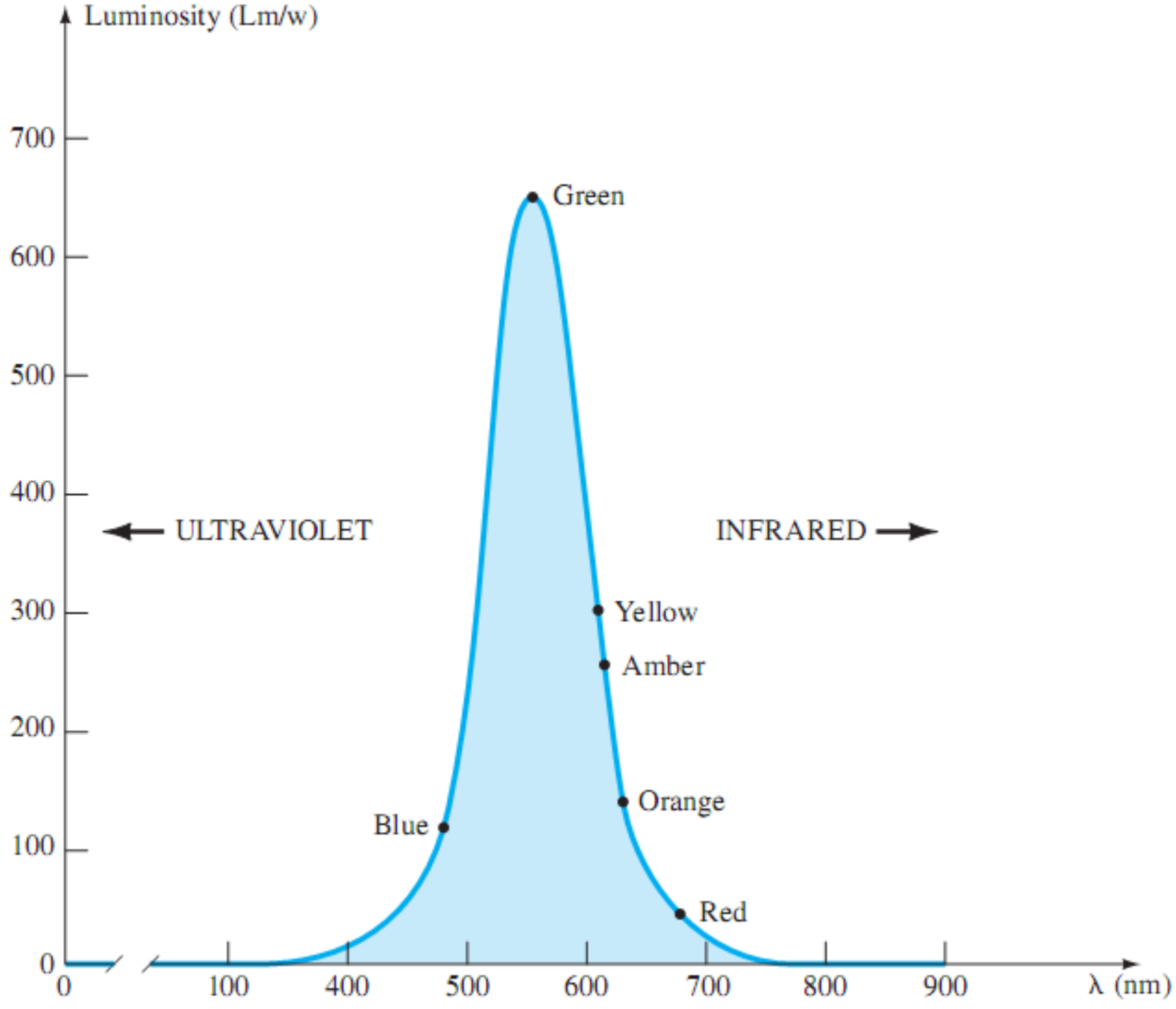
(a) Process of electroluminescence in the LED; (b) graphic symbol.

LIGHT-EMITTING DIODES

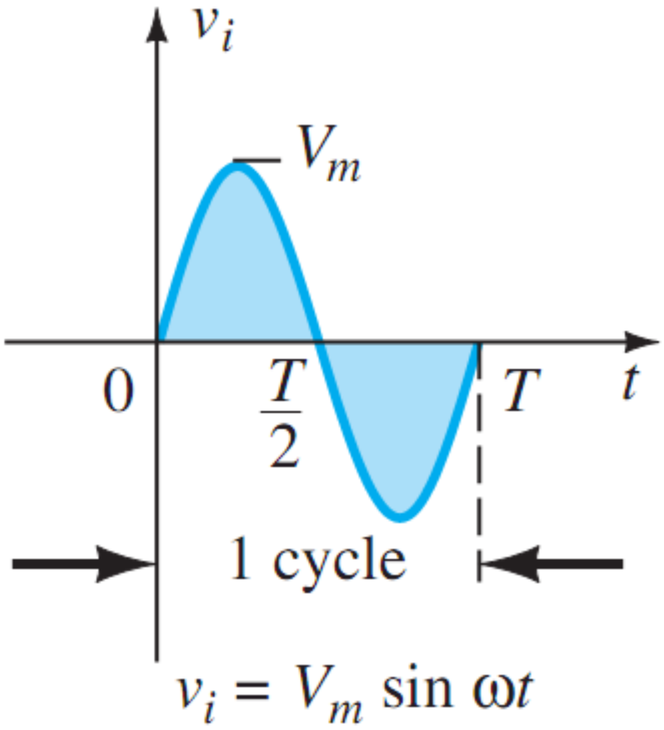
Light-Emitting Diodes

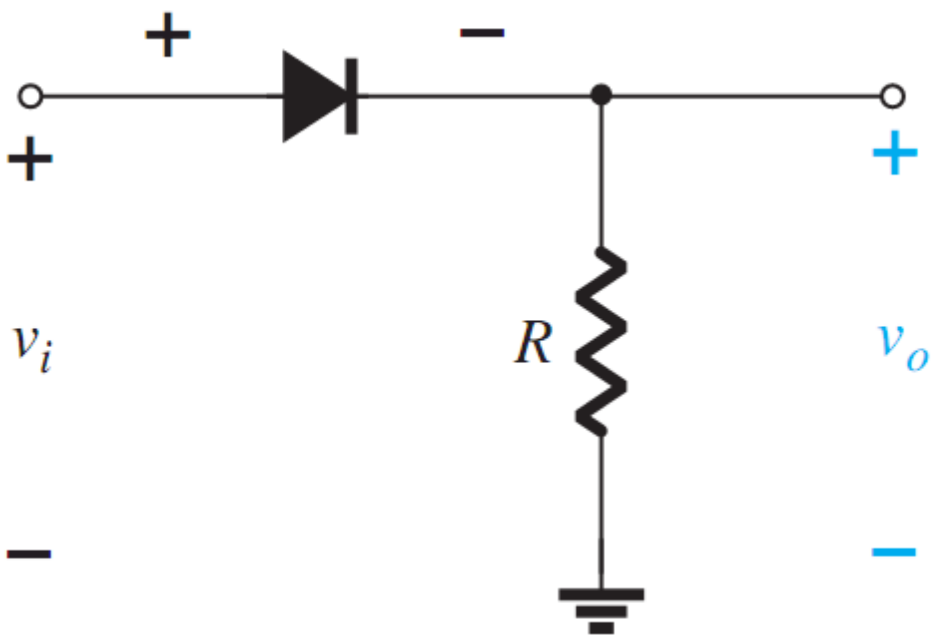
Color	Construction	Typical Forward Voltage (V)
Amber	AlInGaP	2.1
Blue	GaN	5.0
Green	GaP	2.2
Orange	GaAsP	2.0
Red	GaAsP	1.8
White	GaN	4.1
Yellow	AlInGaP	2.1

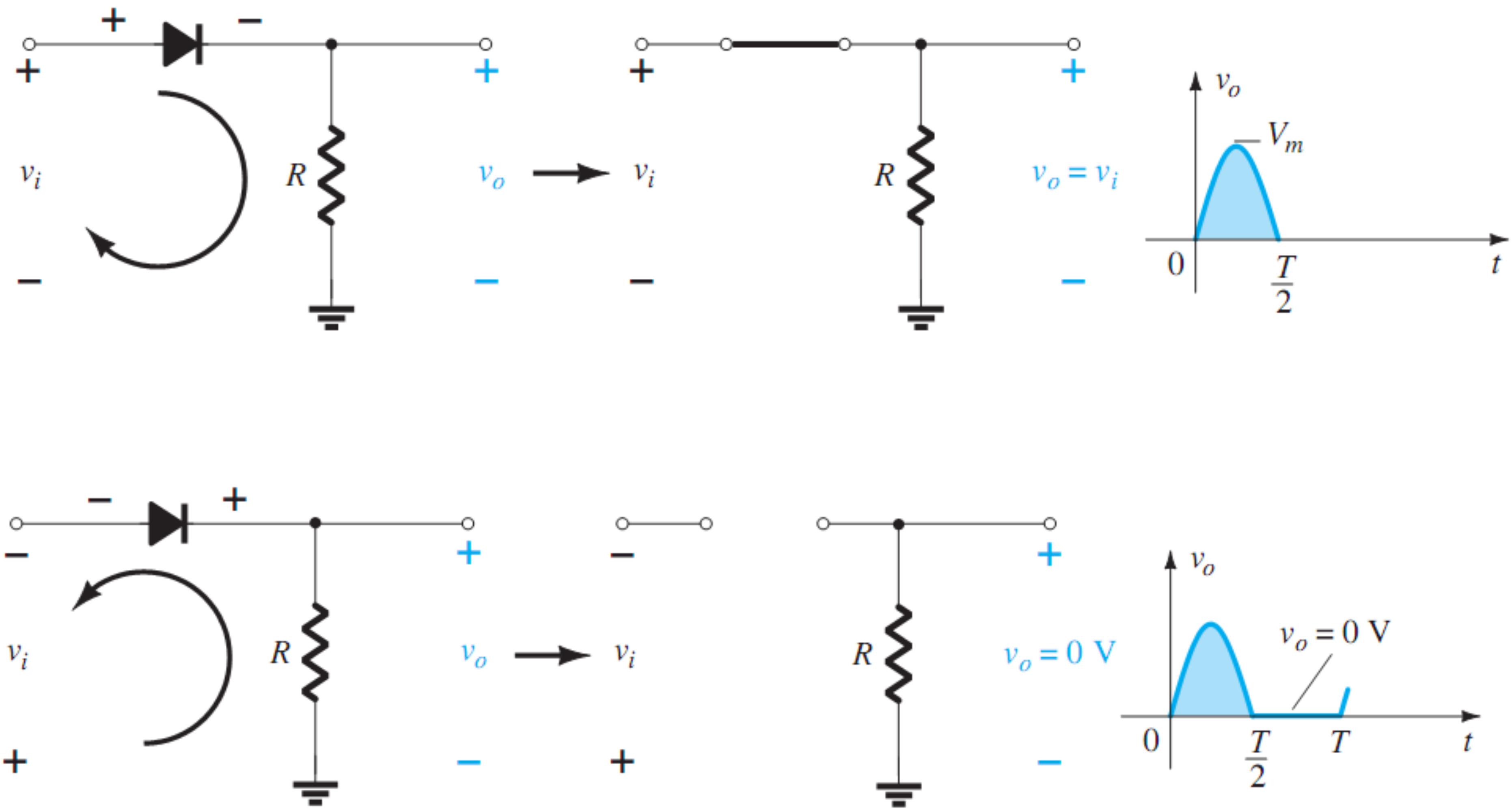
The response of the average human eye as provided in Fig. extends from about 350 nm to 800 nm with a peak near 550 nm.



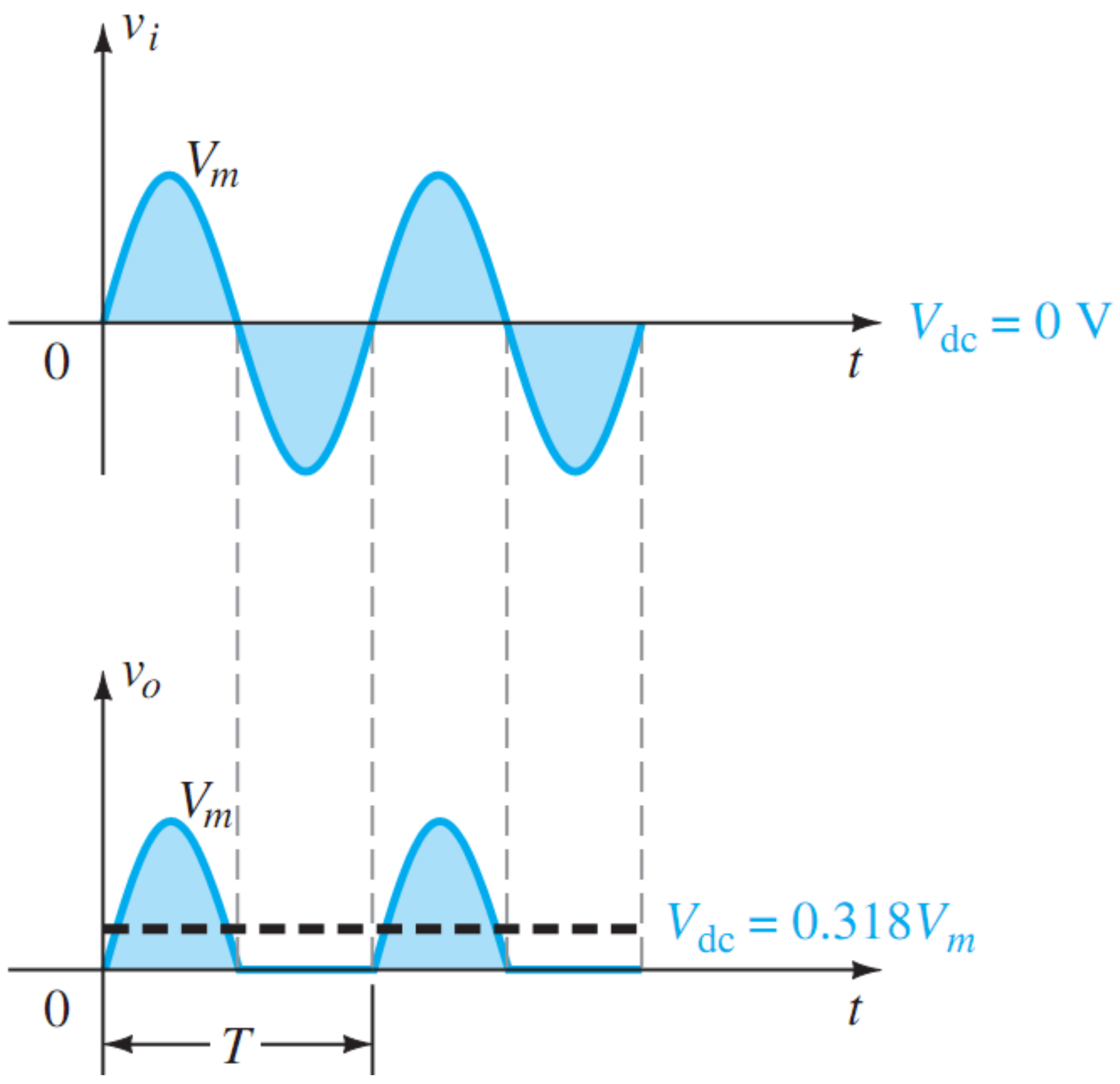
SINUSOIDAL INPUTS; HALF-WAVE RECTIFICATION







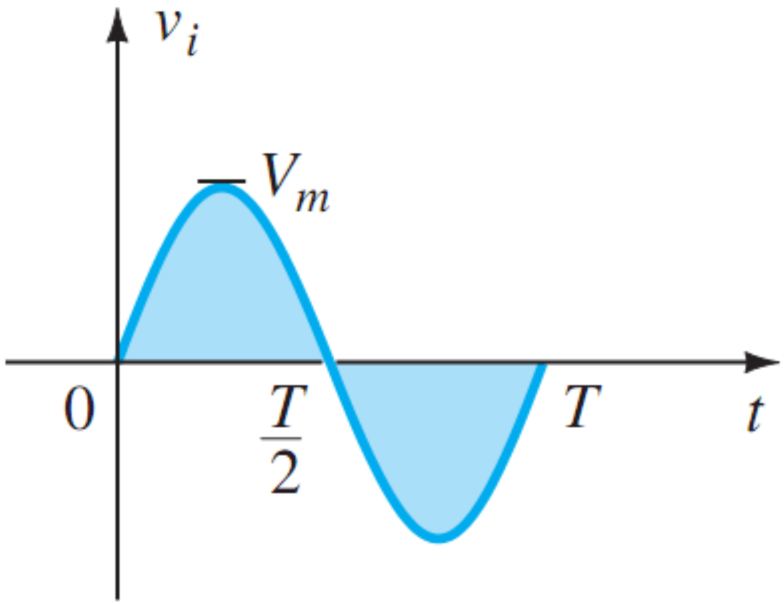
+
−
v_i
R
v_o
$v_o = v_i$
v_o
V_m
0
T/2
t
$v_o = 0$ V
T

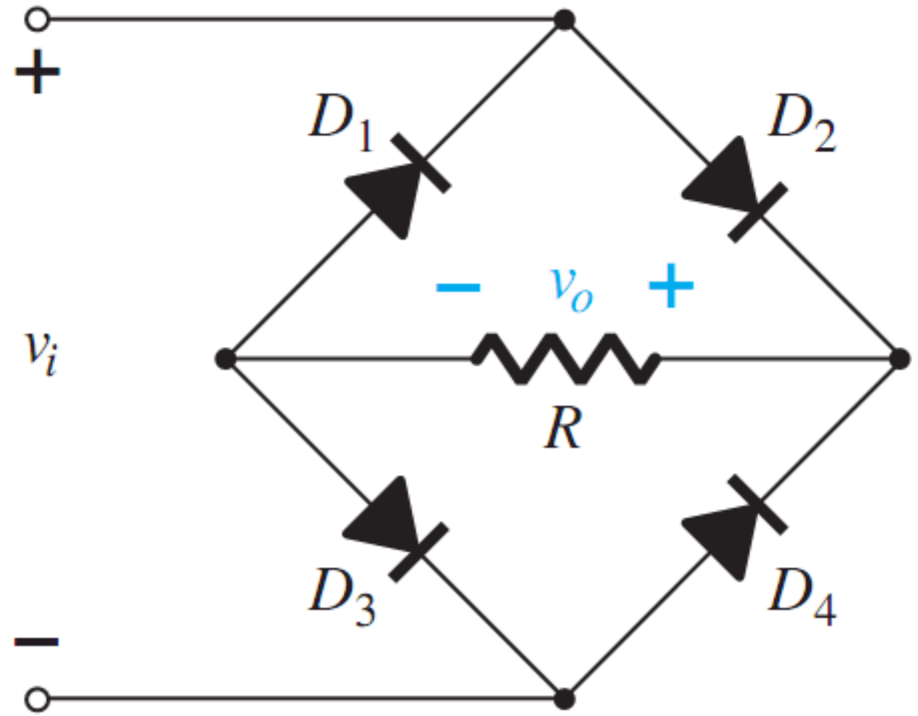


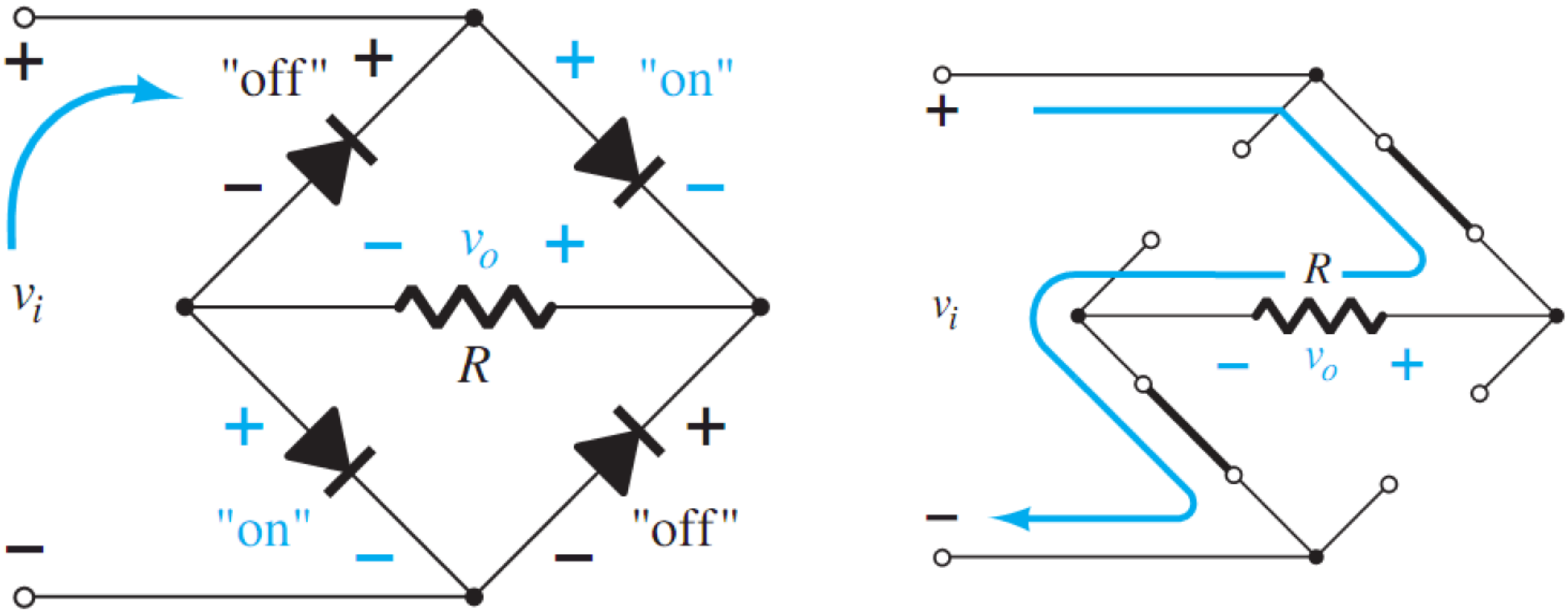
v_i
V_m
0
t
$V_{dc} = 0$ V
v_o
V_m
$V_{dc} = 0.318V_m$
0
t
T

FULL-WAVE RECTIFICATION

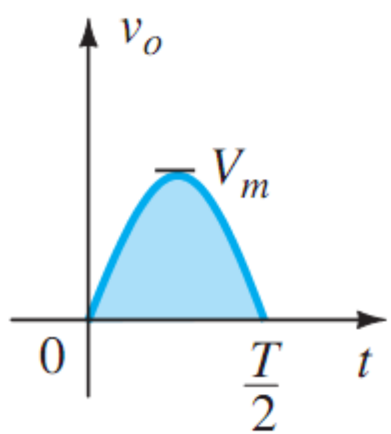
Bridge Network

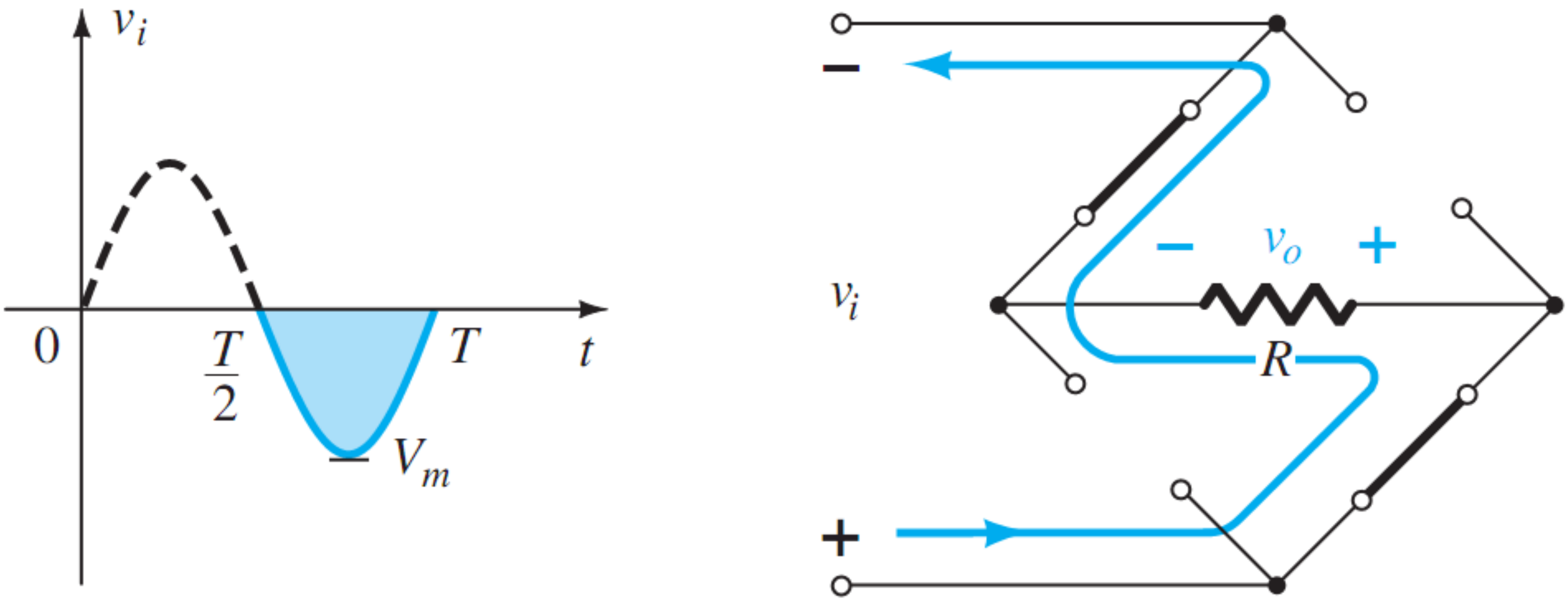




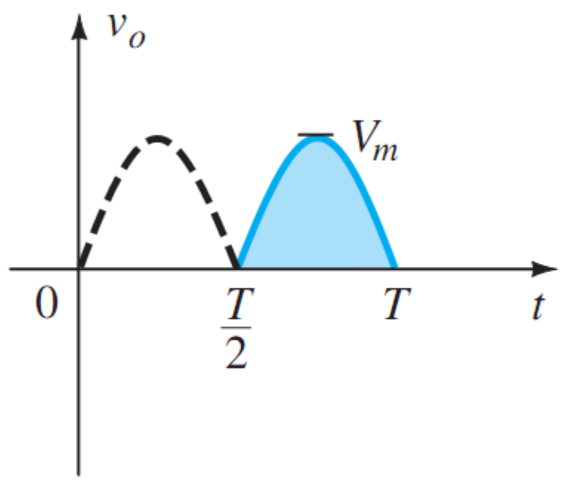


$0 \rightarrow T/2$ *of the input voltage* v_i.

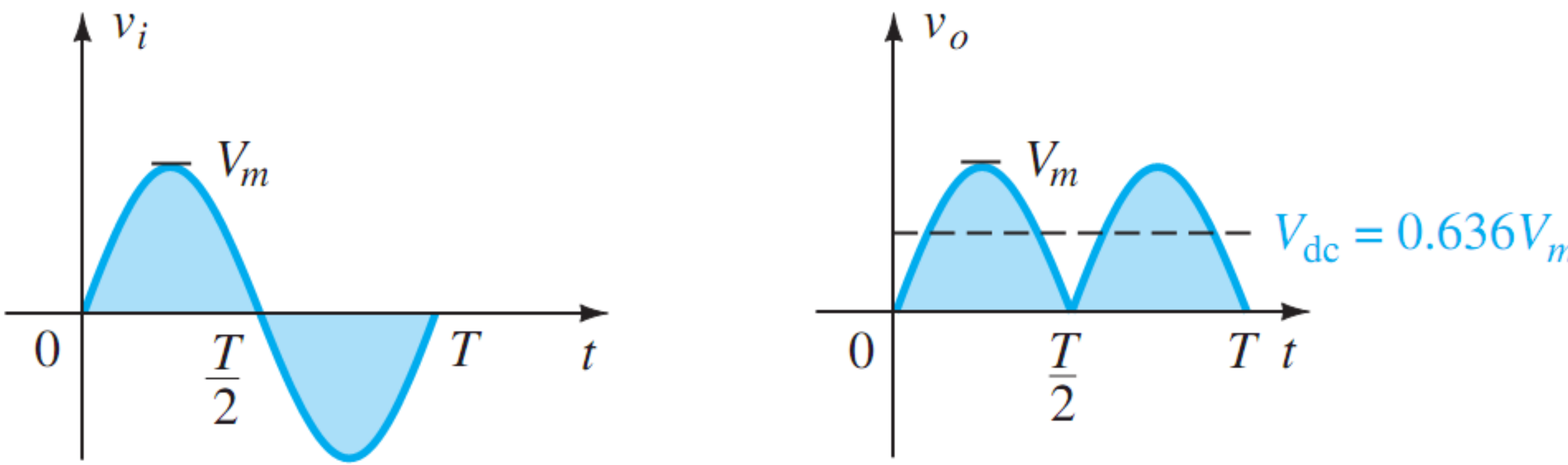




Conduction path for the negative region of v_i.

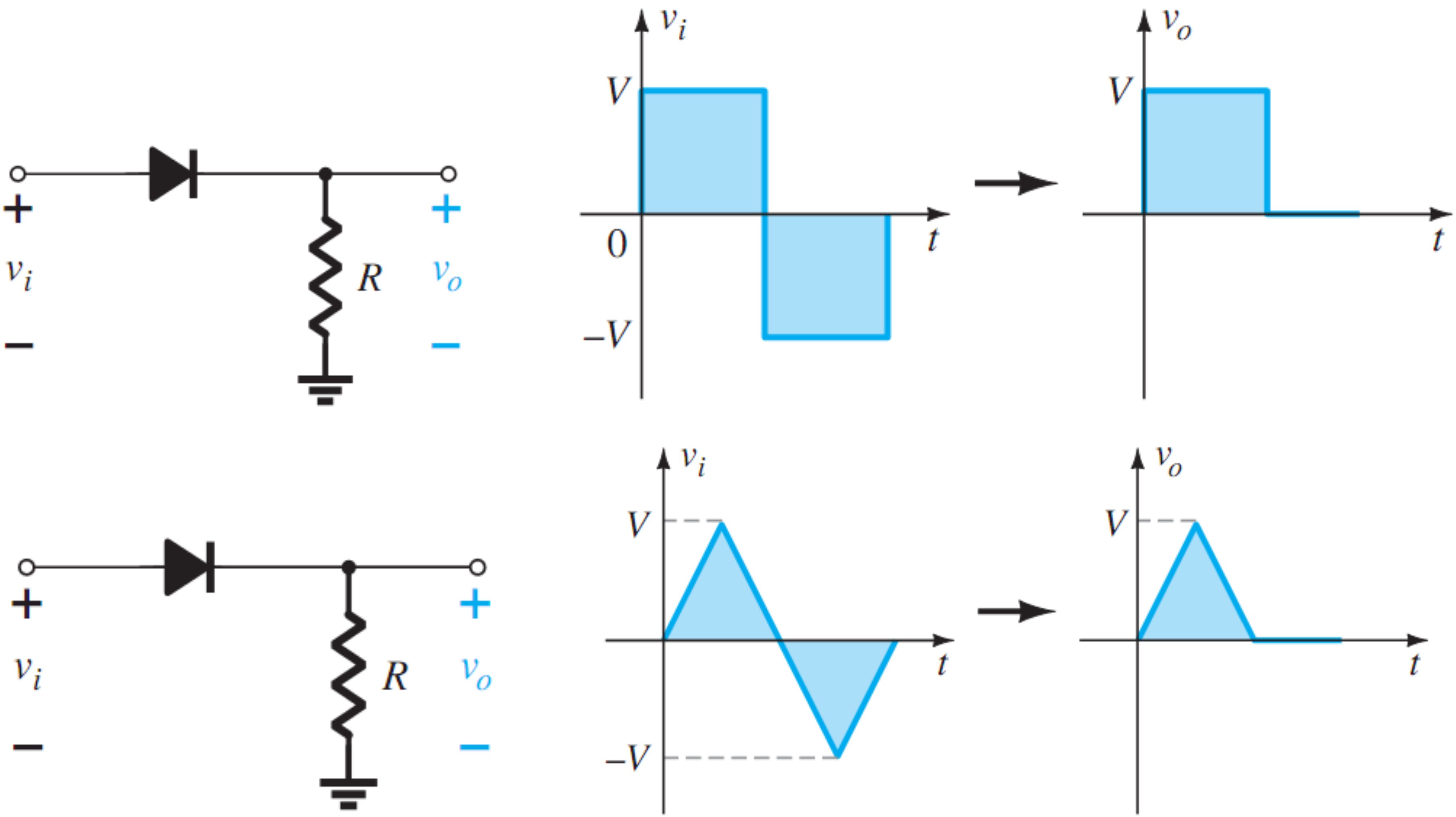


Input and output waveforms for a full-wave rectifier.

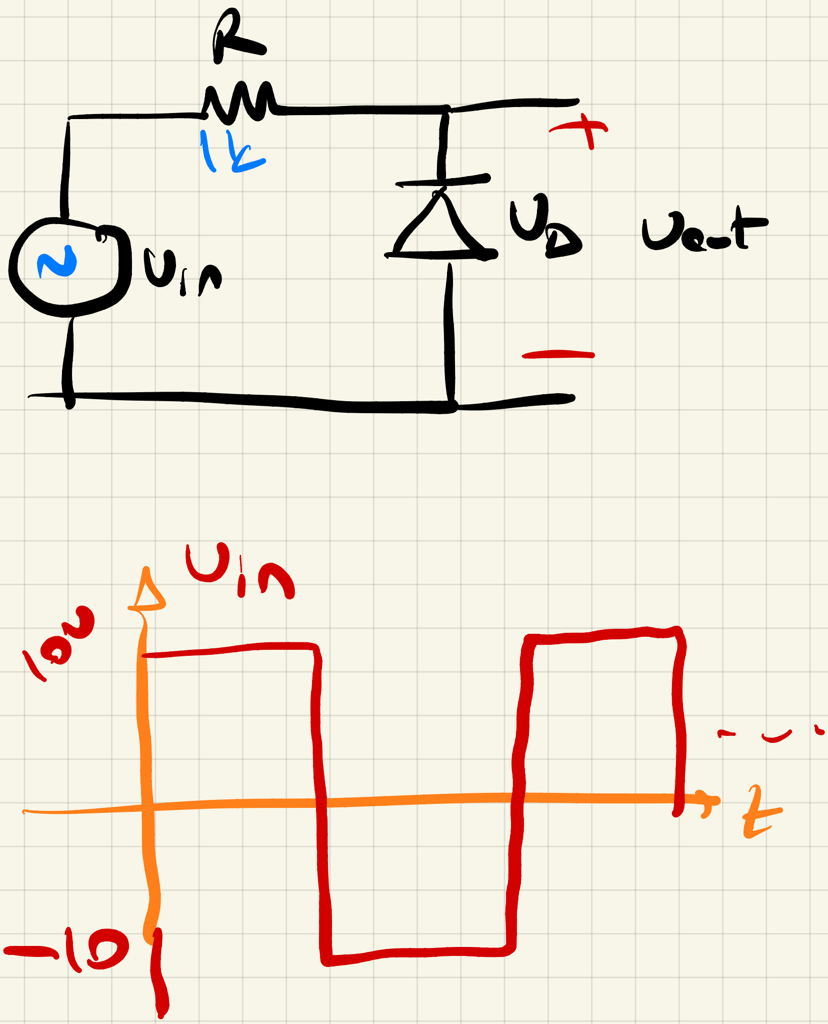


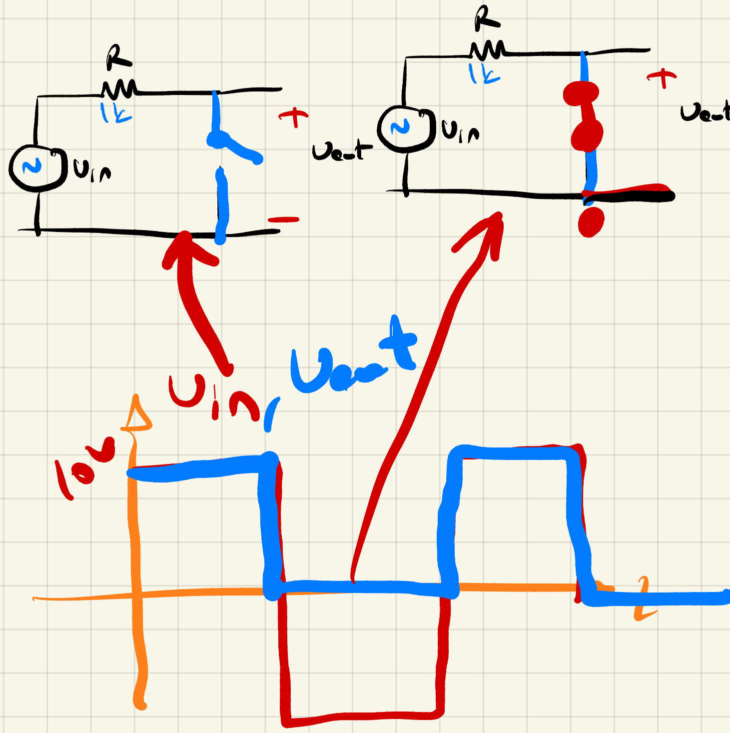
CLIPPERS

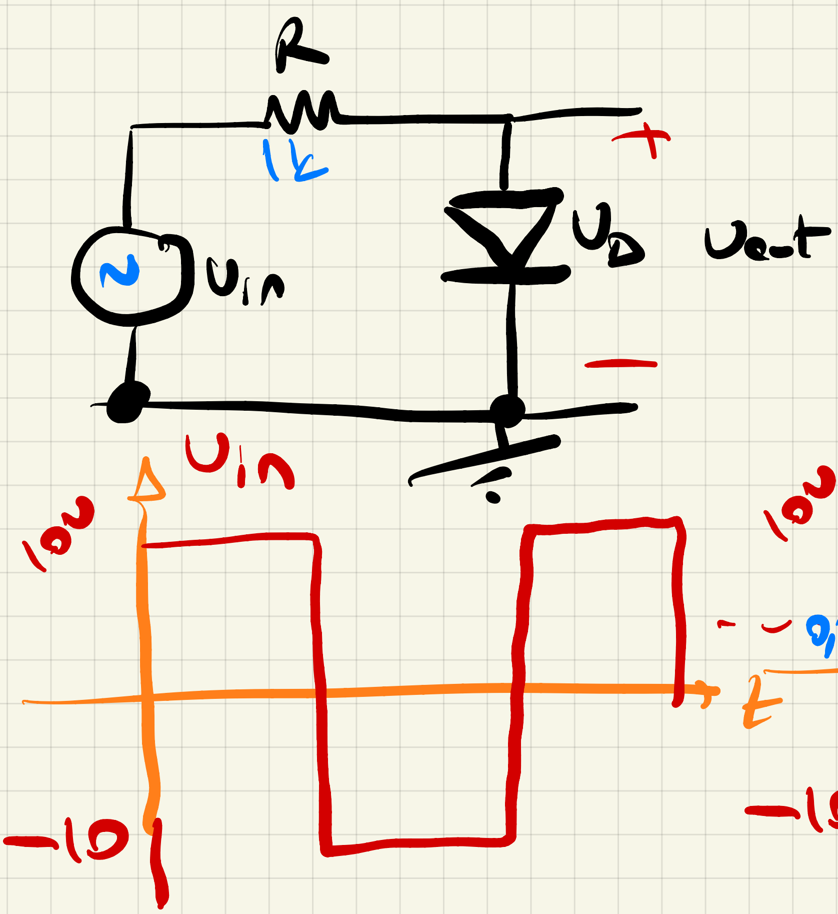
Clippers are networks that employ diodes to “clip” away a portion of an input signal without distorting the remaining part of the applied waveform.

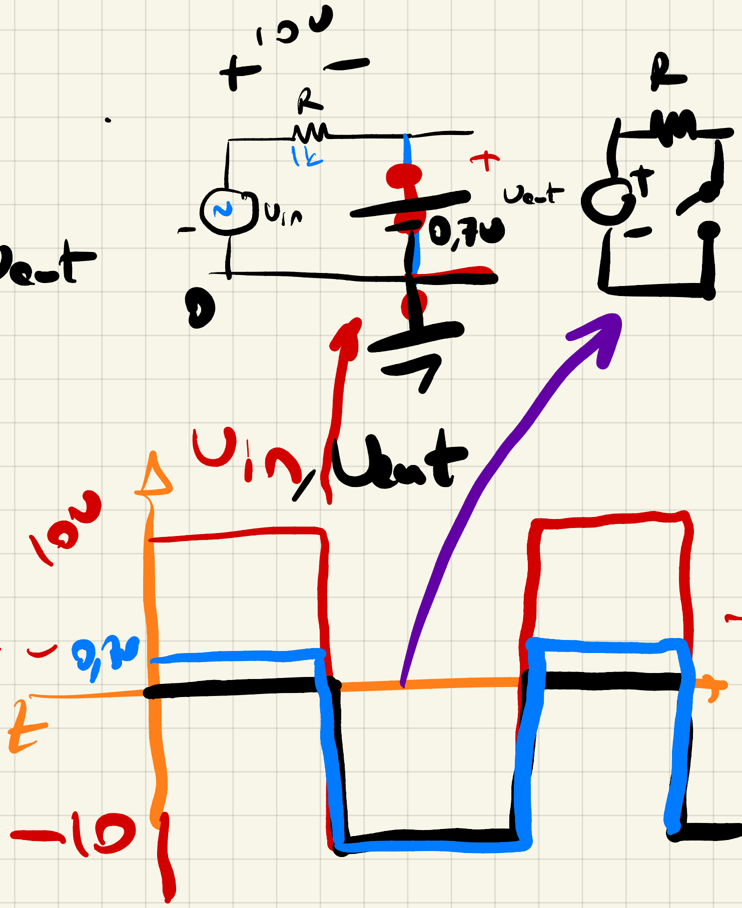


$U_D \rightarrow$ ideal





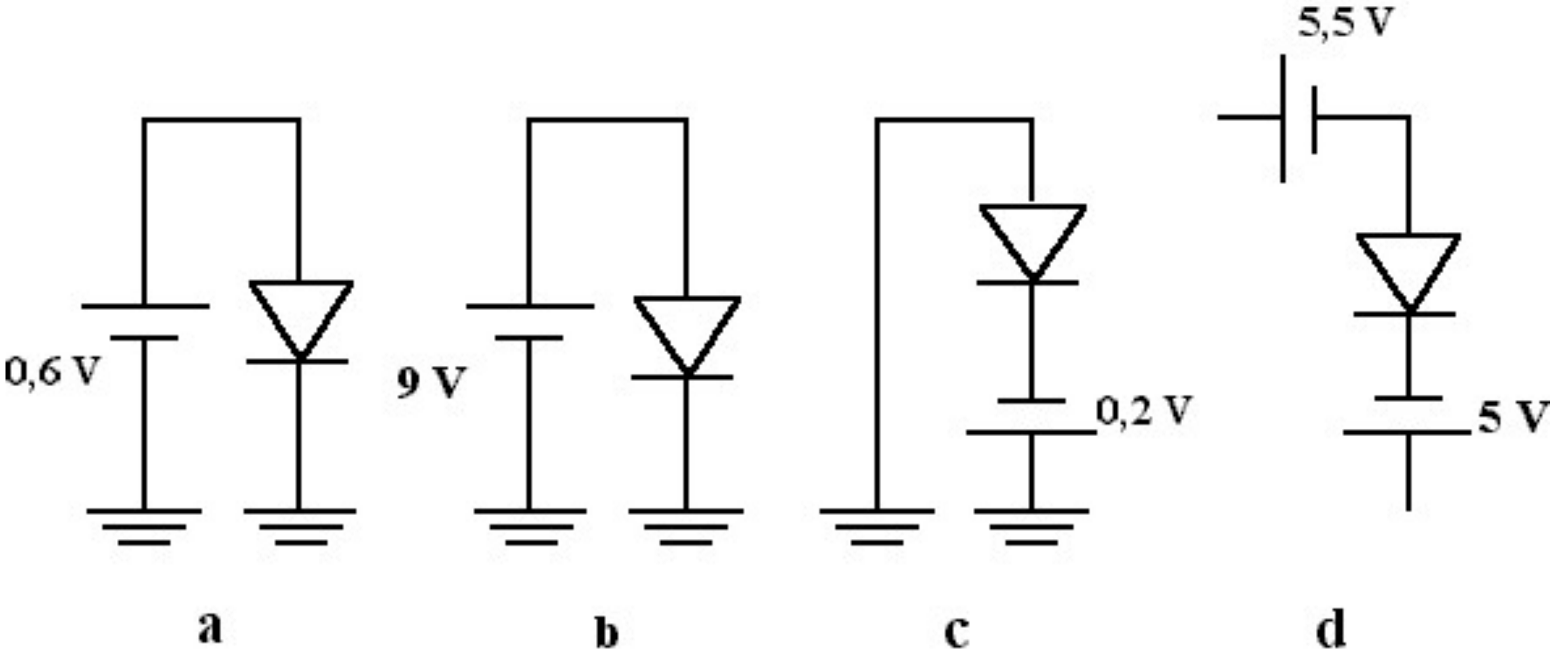


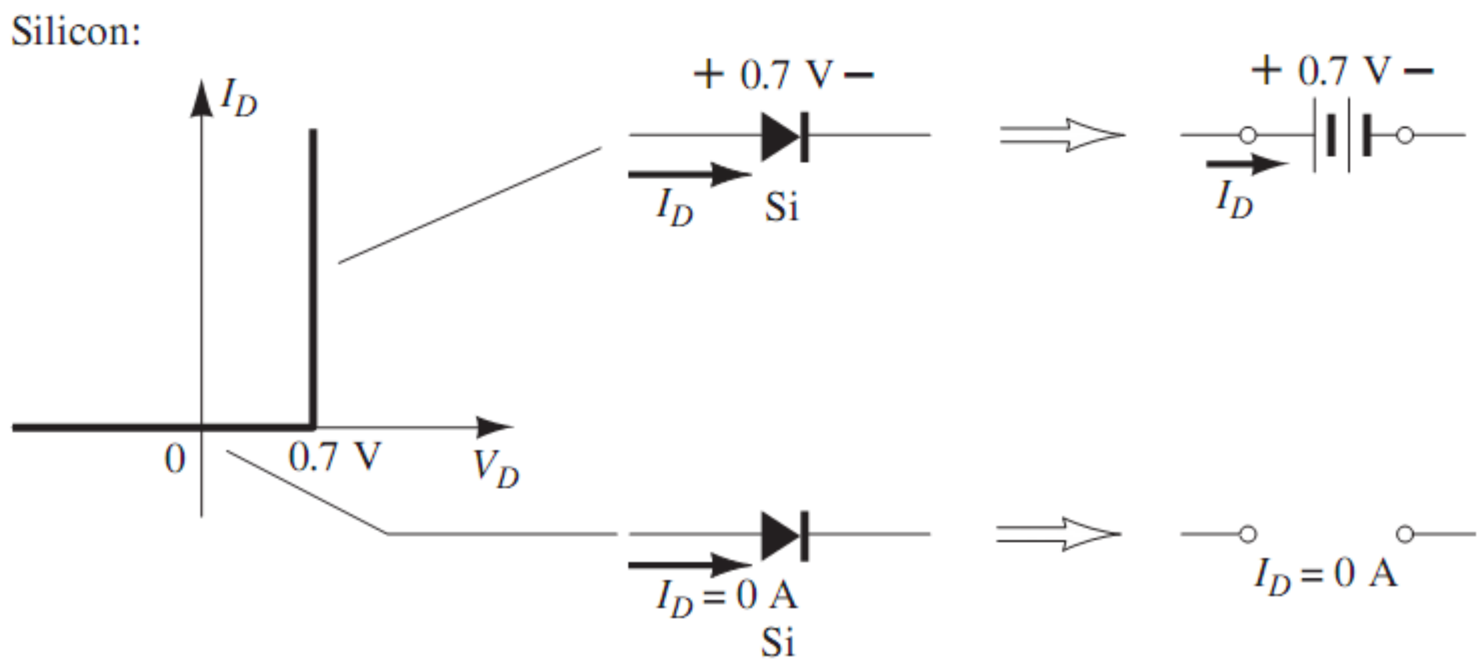


Diode Applications

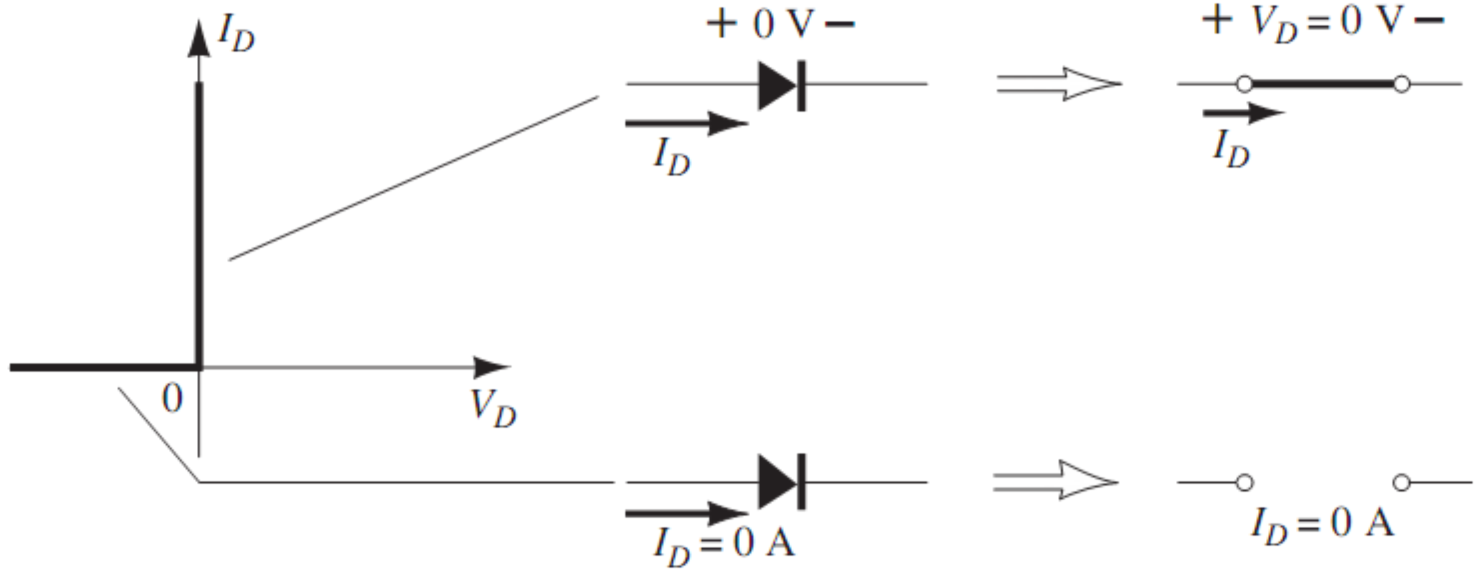
In general, a diode is in the "on" state if the current established by the applied sources is such that its direction matches that of the arrow in the diode symbol, and $V_D \geq 0.7V$ for silicon, $V_D \geq 0.3V$ for germanium, and $V_D \geq 1.2\,V$ for gallium arsenide.

Are these diodes forward or reverse region?

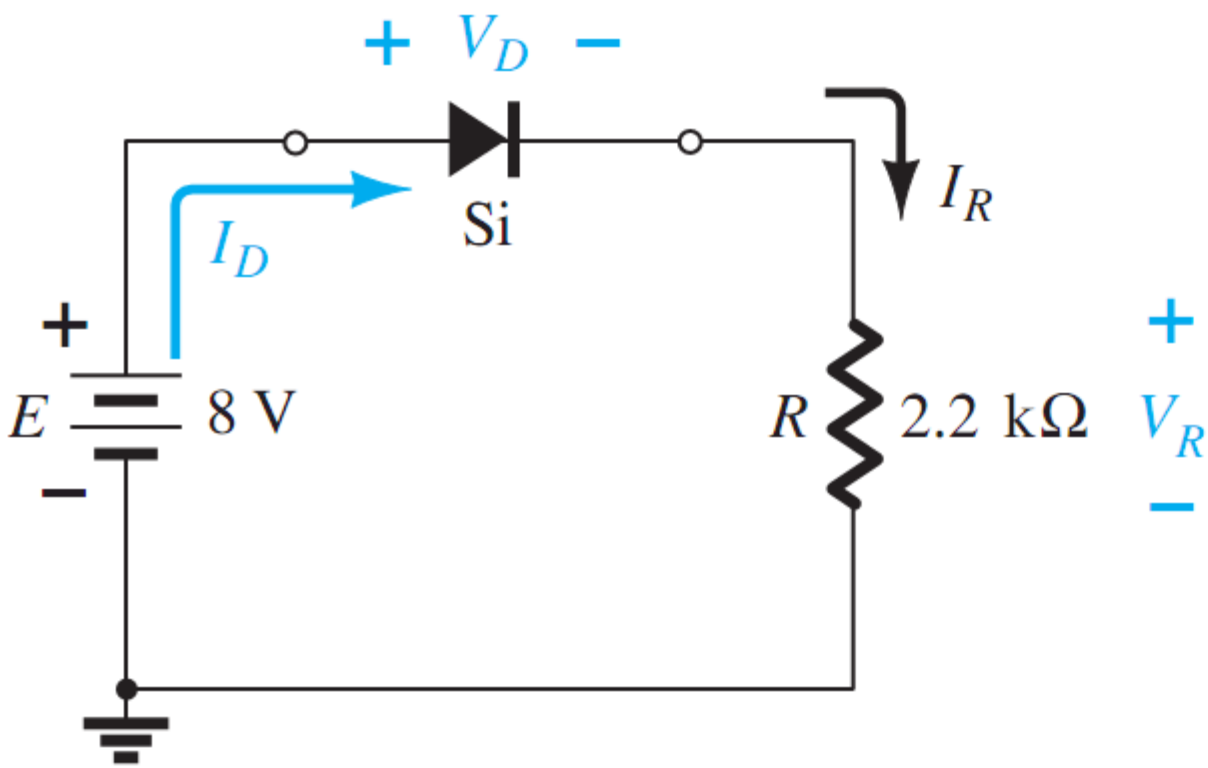



Silicon:
I_D
0
0.7 V
V_D
+ 0.7 V −
I_D
Si
+ 0.7 V −
I_D
$I_D = 0$ A
Si
$I_D = 0$ A

Ideal:

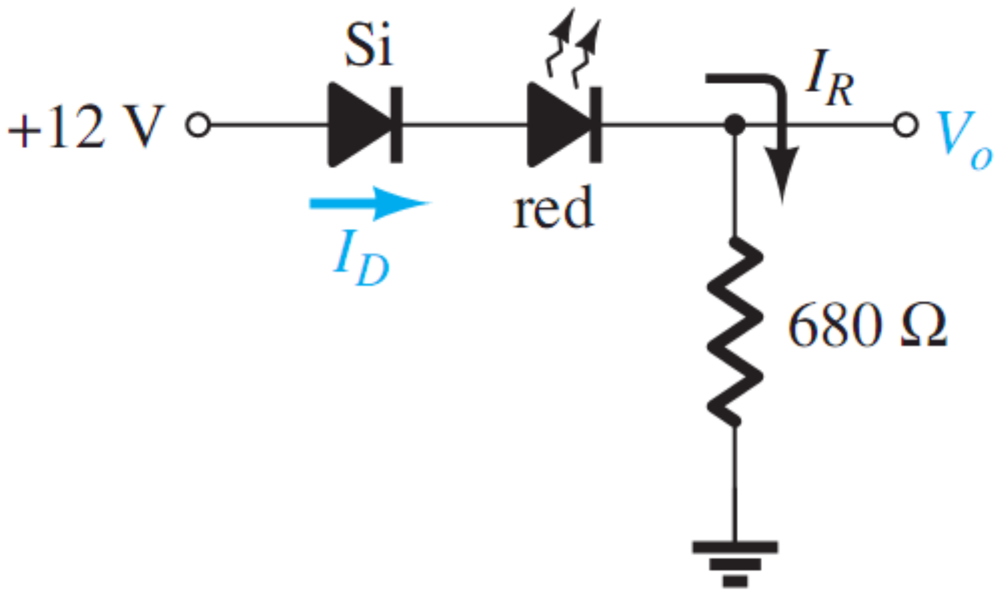


For the series diode configuration of Fig, determine V_D, V_R, I_D

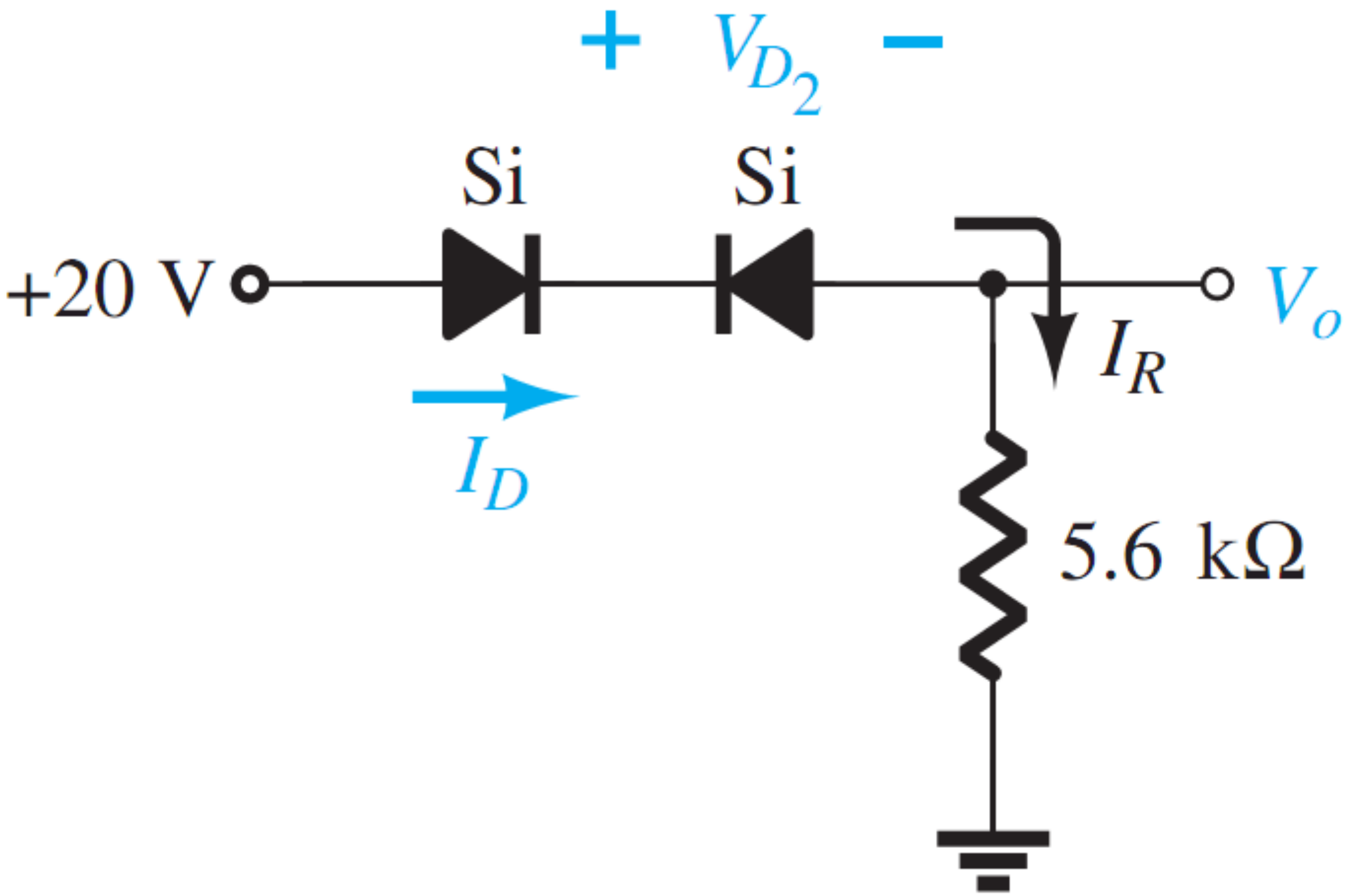


Repeat with diode reversed!!

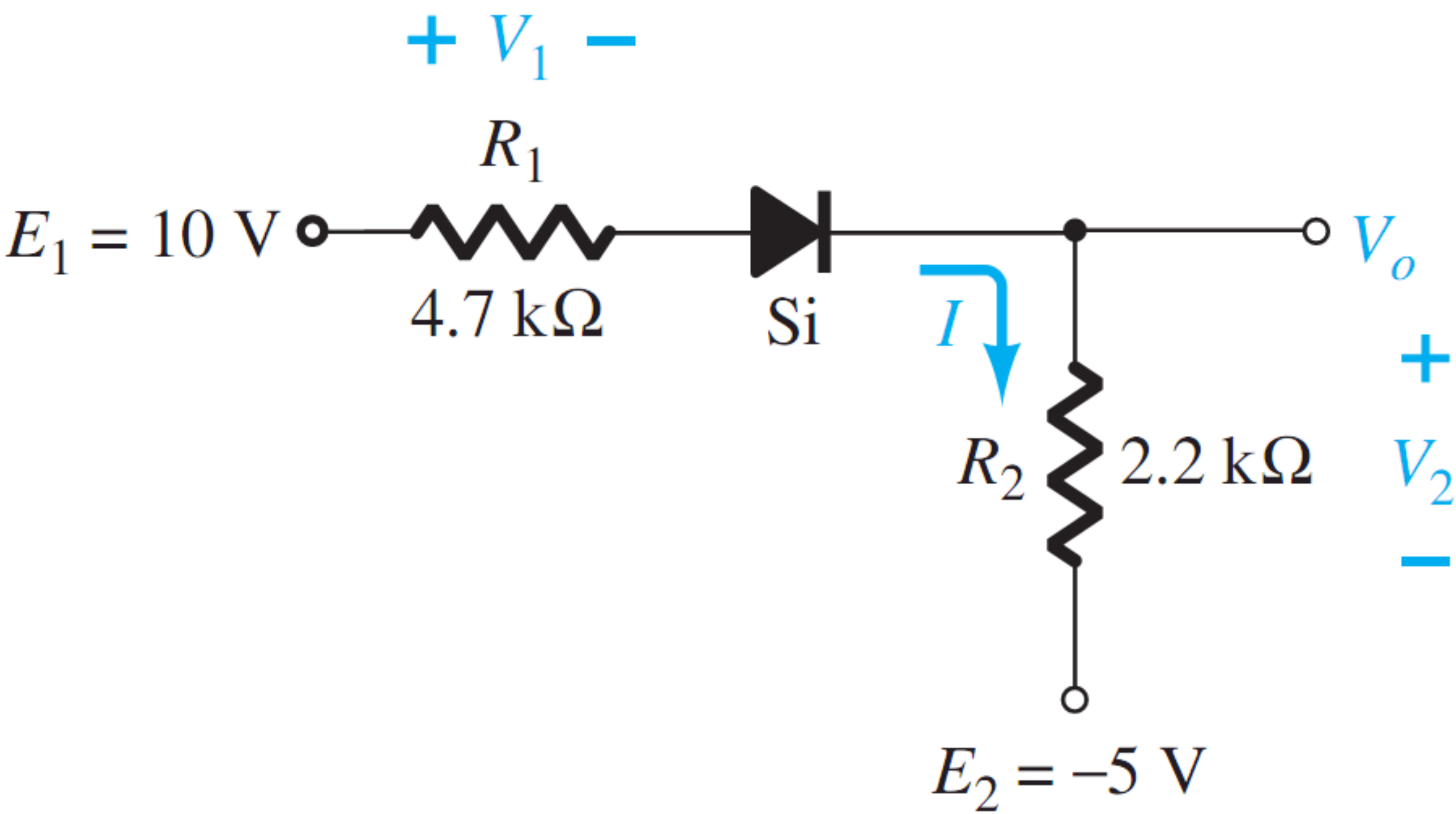
Determine V_o and I_D for the series circuit of Figure



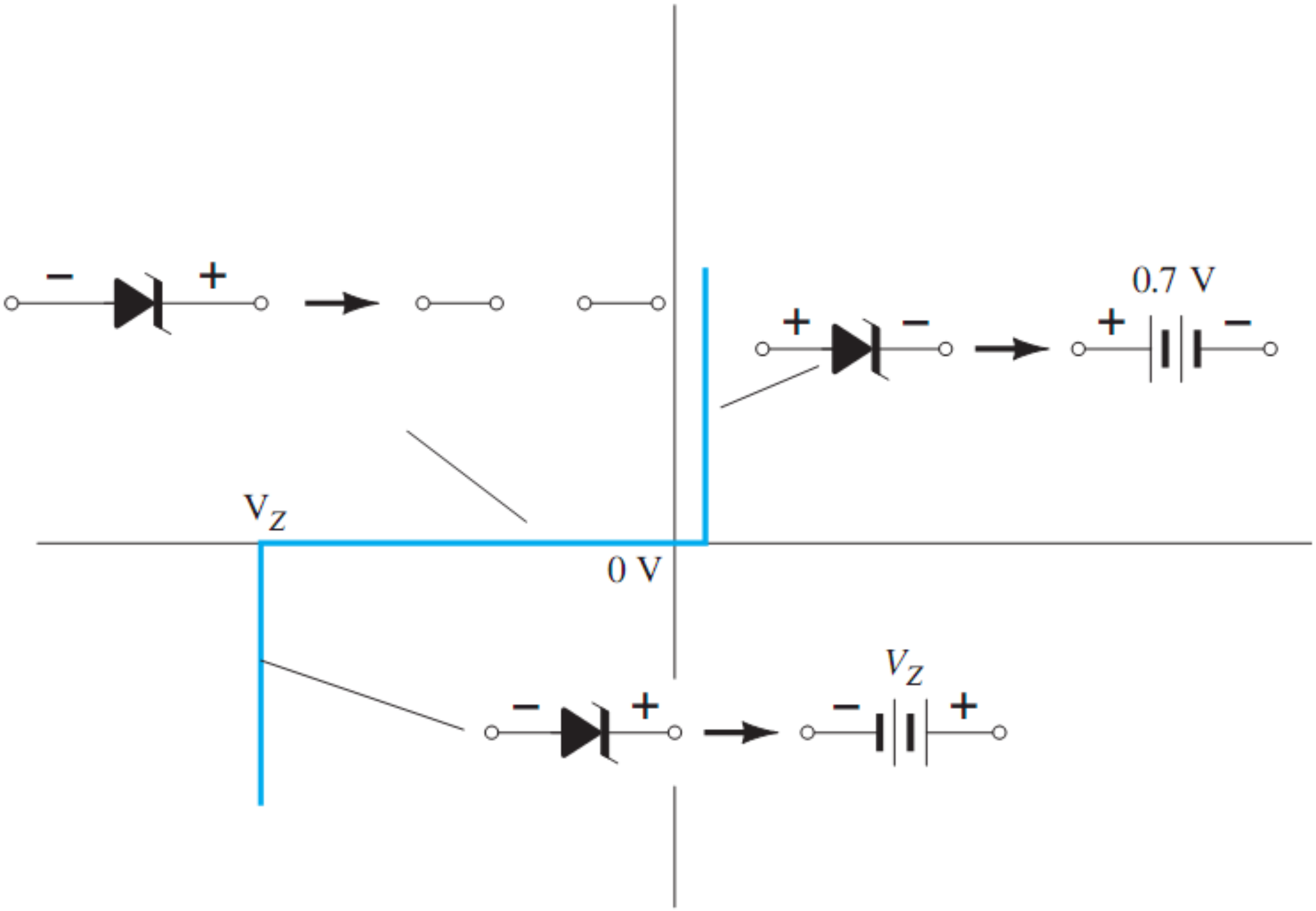
Determine I_D , V_D , and V_o for the circuit of Fig.



Determine I , V_1 , V_2 and V_o for the circuit of Fig.

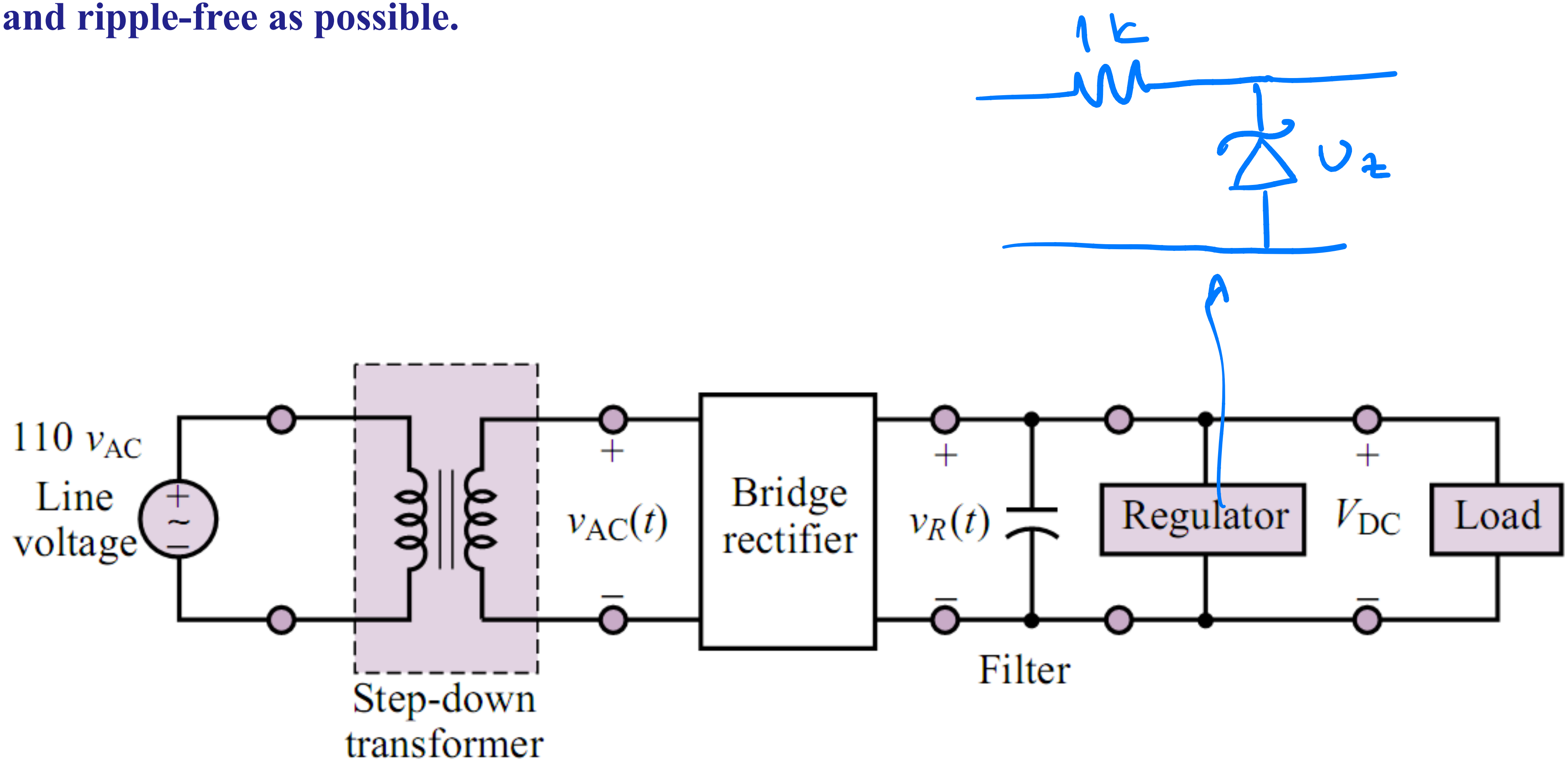


ZENER DIODES



DC Power Supplies

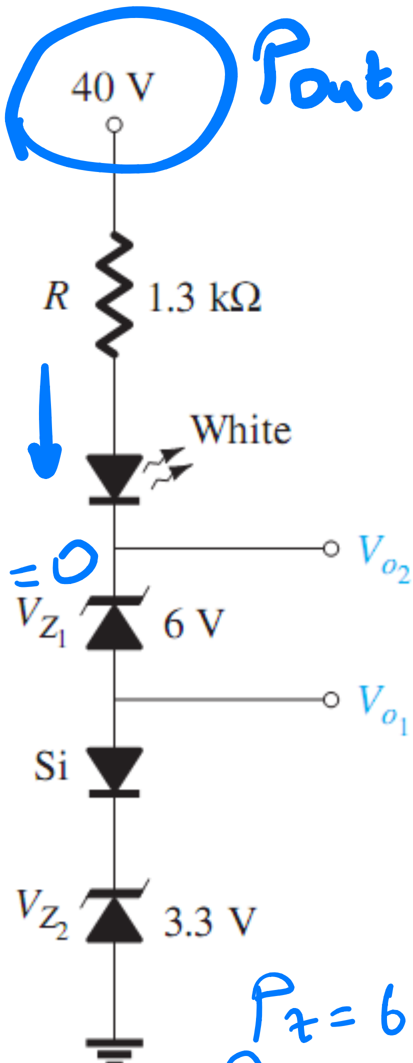
The principal application of rectifier circuits is in the conversion of AC to DC power. A circuit that accomplishes this conversion is usually called a DC power supply. In power supply applications, transformers are employed to obtain an AC voltage that is reasonably close to the desired DC supply voltage. DC power supplies are very useful in practice: Many familiar electrical and electronic appliances (e.g., radios, personal computers, TVs) require DC power to operate. For most applications, it is desirable that the DC supply be as steady and ripple-free as possible.



Determine the reference voltages provided by the network of Fig., which uses a white LED to indicate that the power is on. What is the level of current through the LED and the power delivered by the supply? How does the power absorbed by the LED compare to that of the 6-V Zener diode?

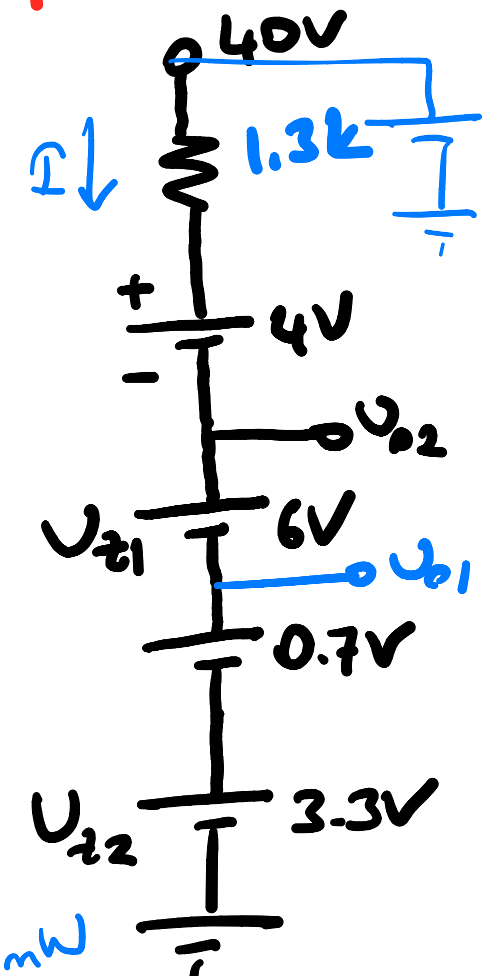
White LED = 4V

$V_{D(Si)} = 0.7$ V



$P_{out} = ?$

Hepsi iletimde!



$-40 + 1.3i + 4 + 6 + 0.7 + 3.3 = 0$

$1.3i = 40 - 14$

$i = \frac{26}{1.3} = 20mA$

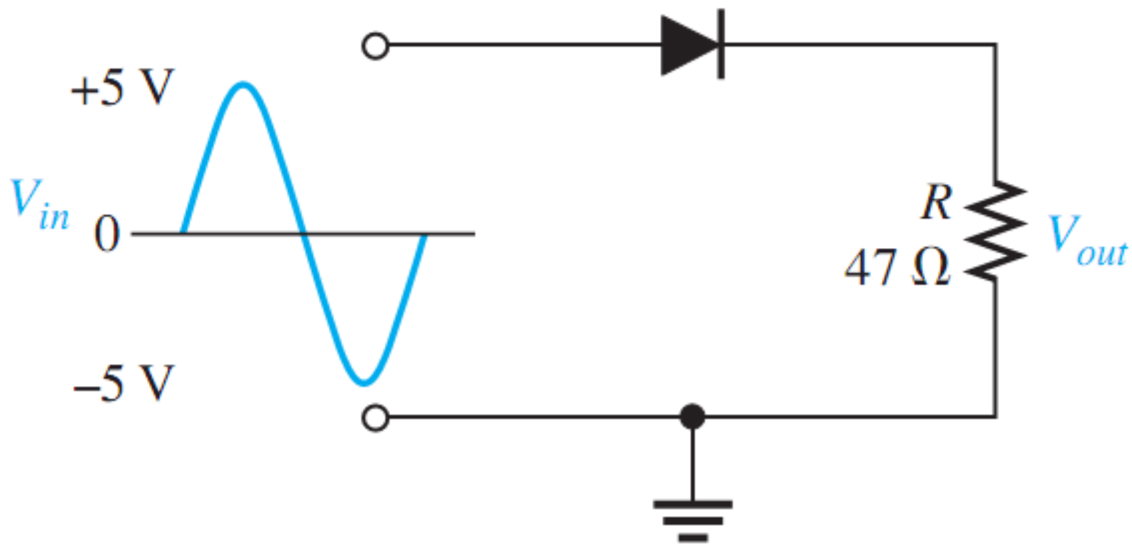
$P_{LED} = 4 \times 20mA = 80\,mW$

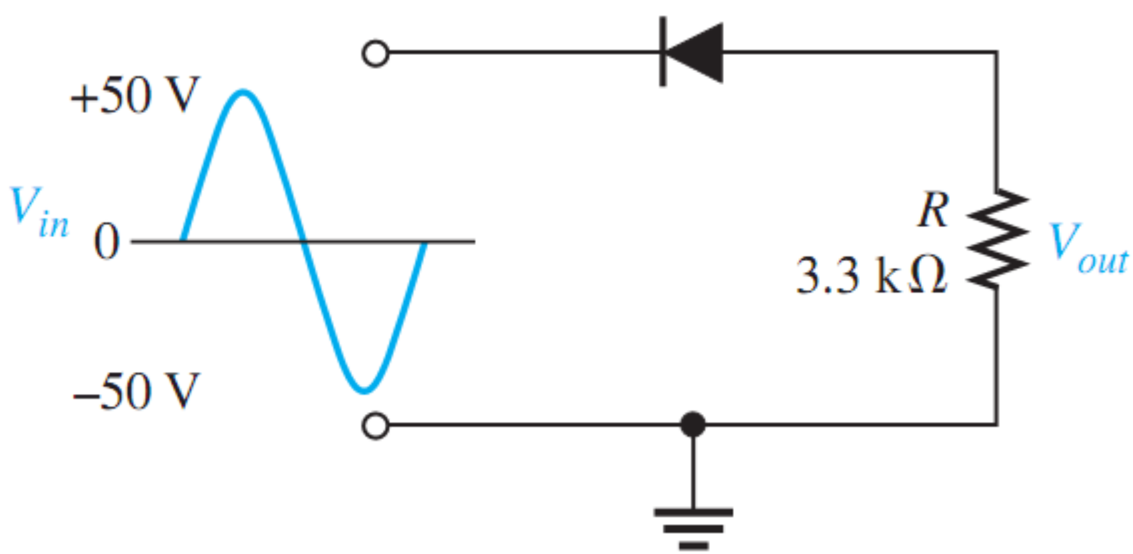
$P_z = 6 \times 20 = 120\,mW$

$P_{out} = 40 \times 20mA = 800\,mW$

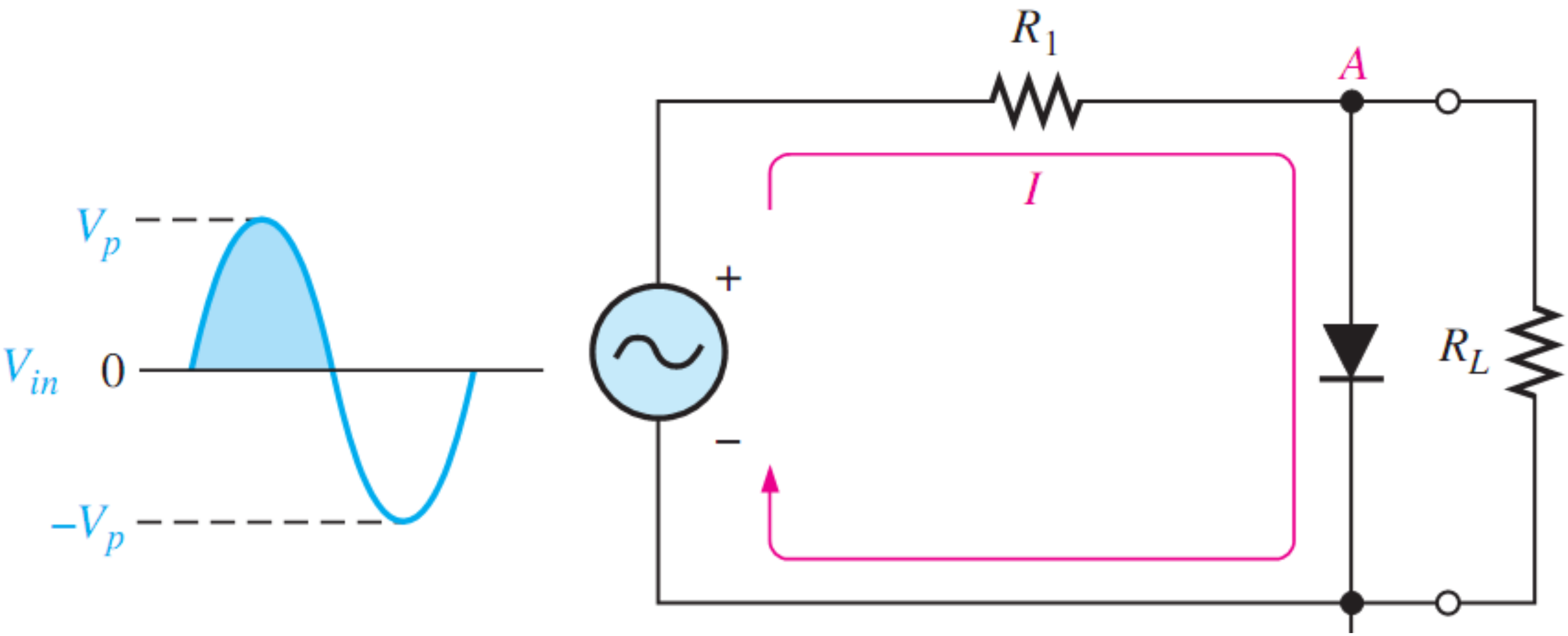
0

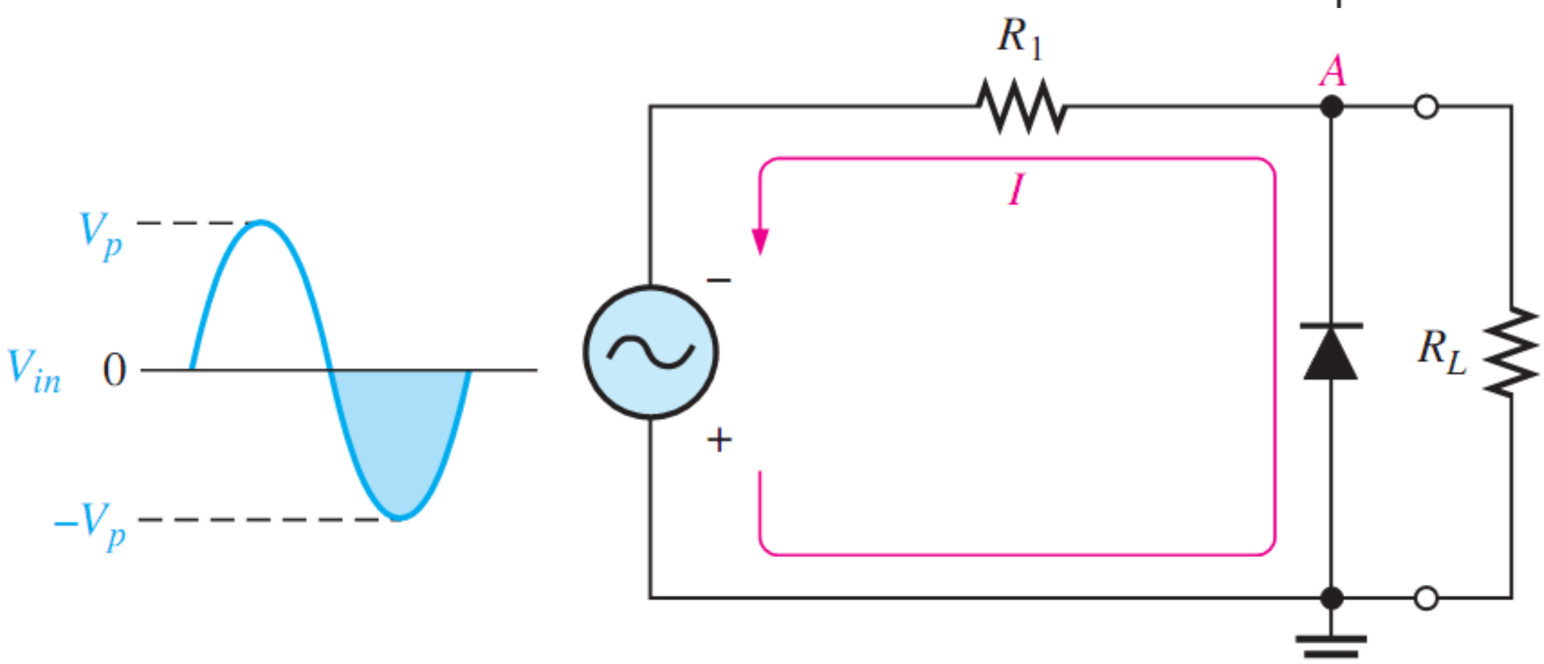
Draw the output voltage waveform for each circuit in Figure



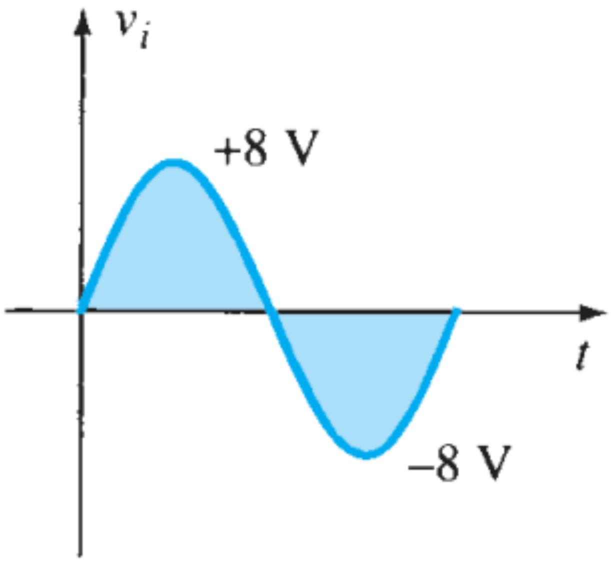


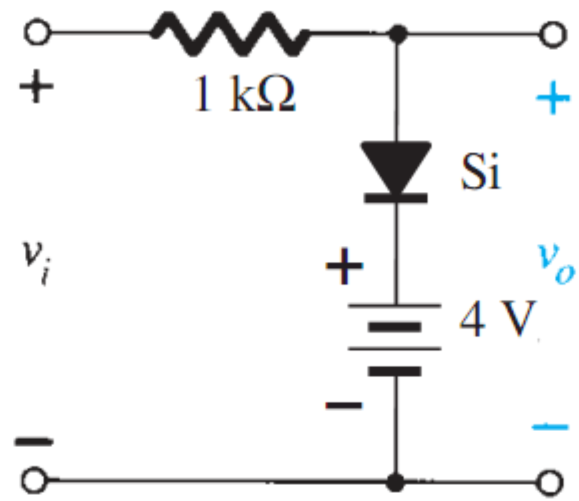
Draw the output voltage waveform for each circuit in Figure



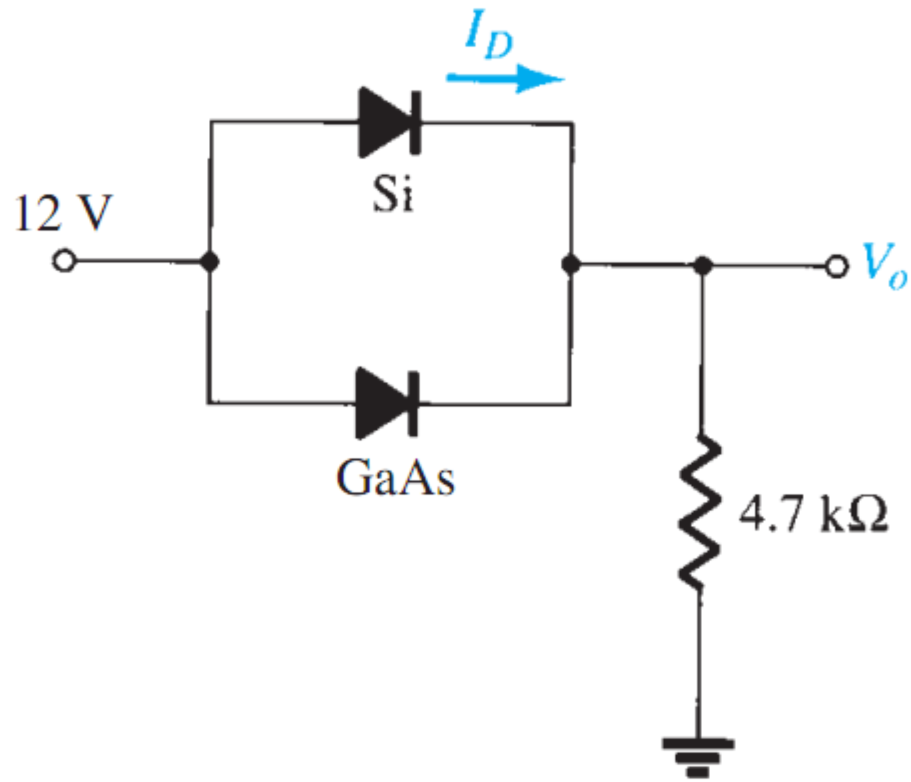


Determine v_o for each network of Fig. for the input shown.

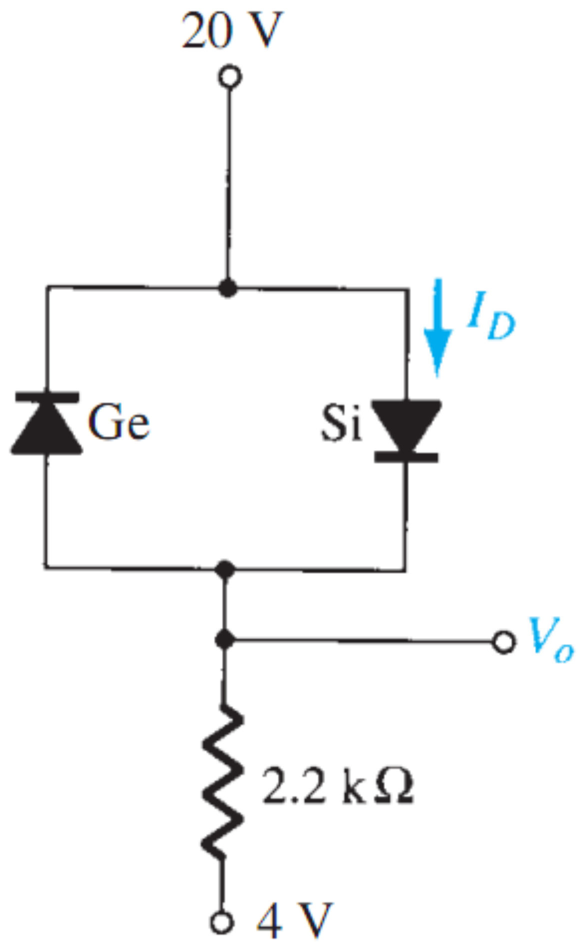




Determine V_o and I_D for the networks of Fig.



Determine V_o and I_D for the networks of Fig.



Determine V_{o_1}, V_{o_2}, and I for the network of Fig.