DIODE APPROXIMATIONS

SEMICONDUCTOR DIODE

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Electronics Engineer

TOPIC OUTLINE

Diode Approximations

- Ideal Diode
- 2^{nd} Approximation
- 3^{rd} Approximation

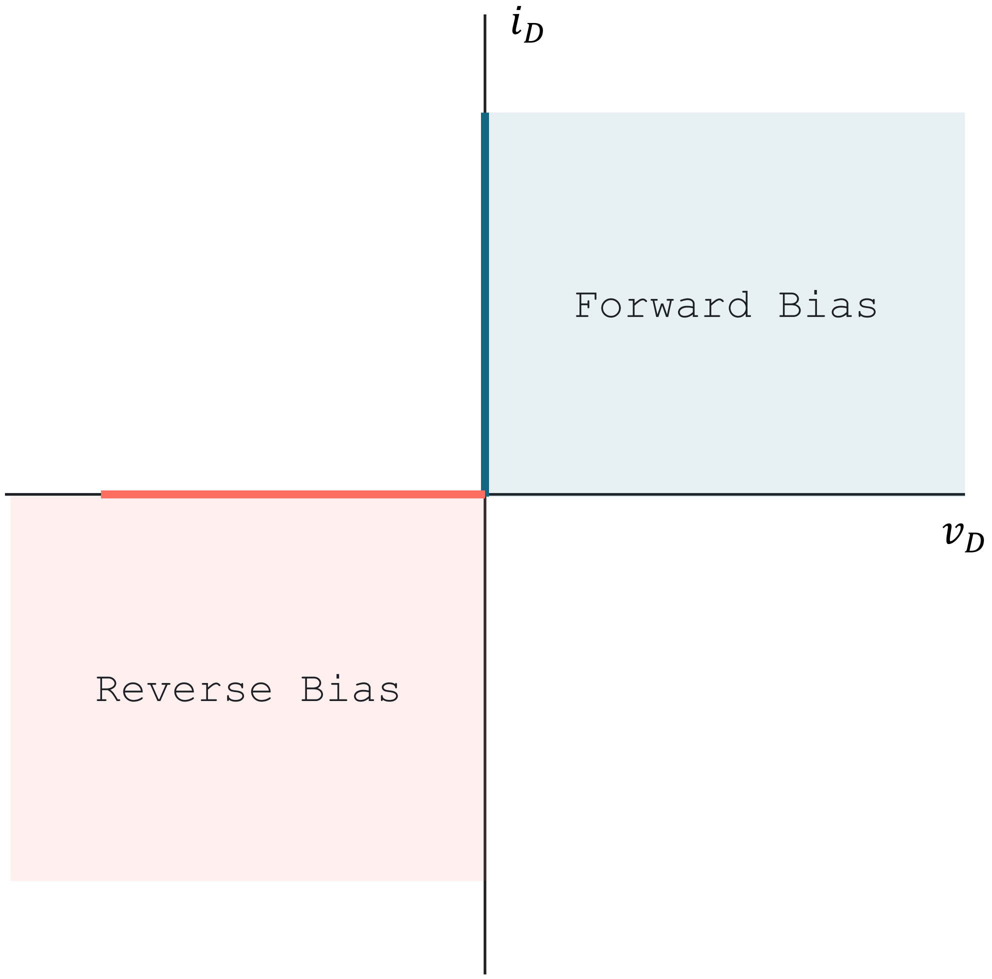
Shockley's Equation

Reading Datasheet

DIODE APPROXIMATIONS

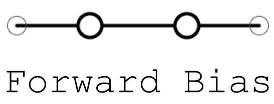
IDEAL DIODE

Characteristic Curve



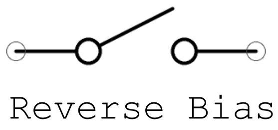
The diode is modeled as an ideal **switch**.

Circuit Equivalent



Acts like a closed switch.

(zero (0) resistance)

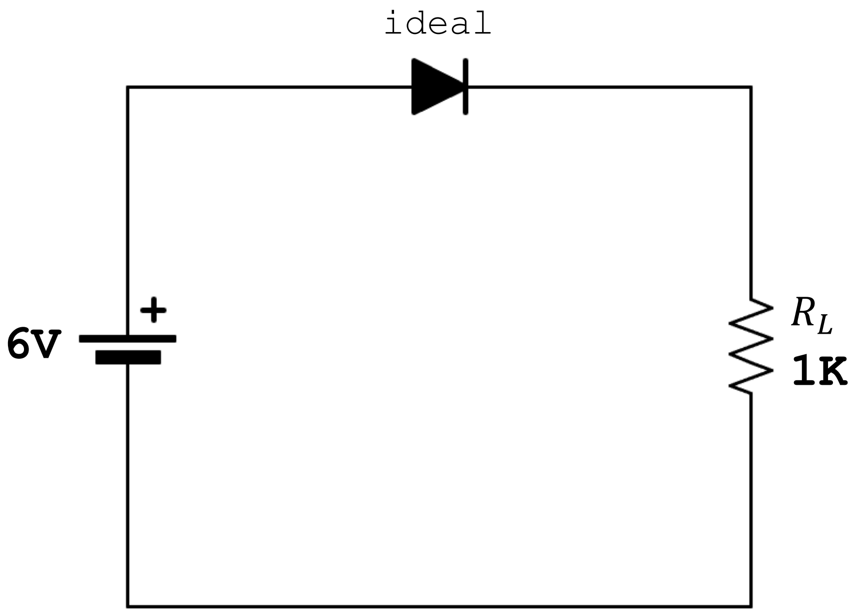


Acts like an open switch.

(infinite (∞) resistance)

EXERCISE

Using the ideal diode model, determine the load voltage, load current, and the power dissipated by the diode in the given circuit.

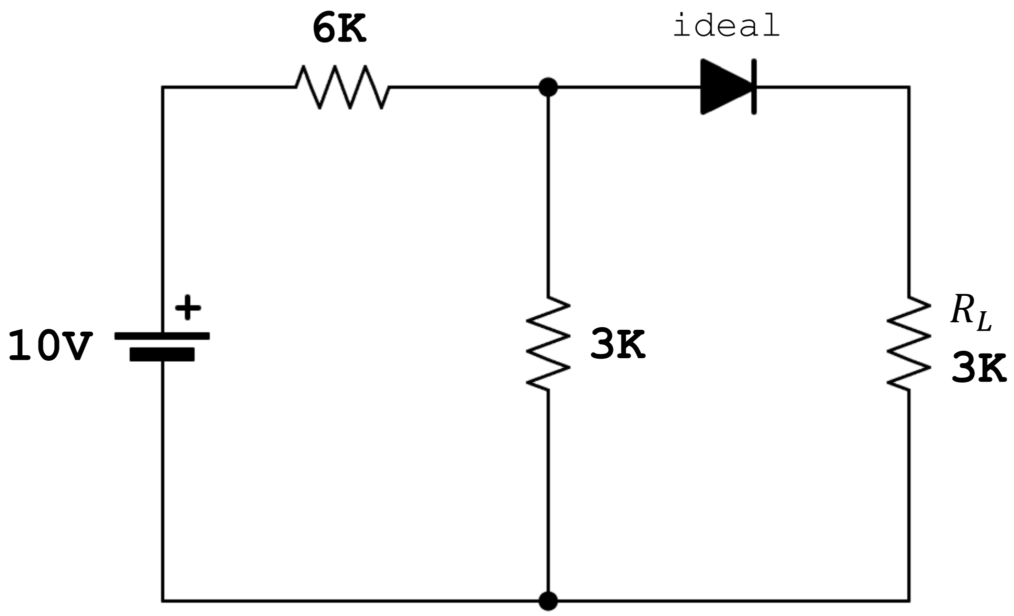


Solution

EXERCISE

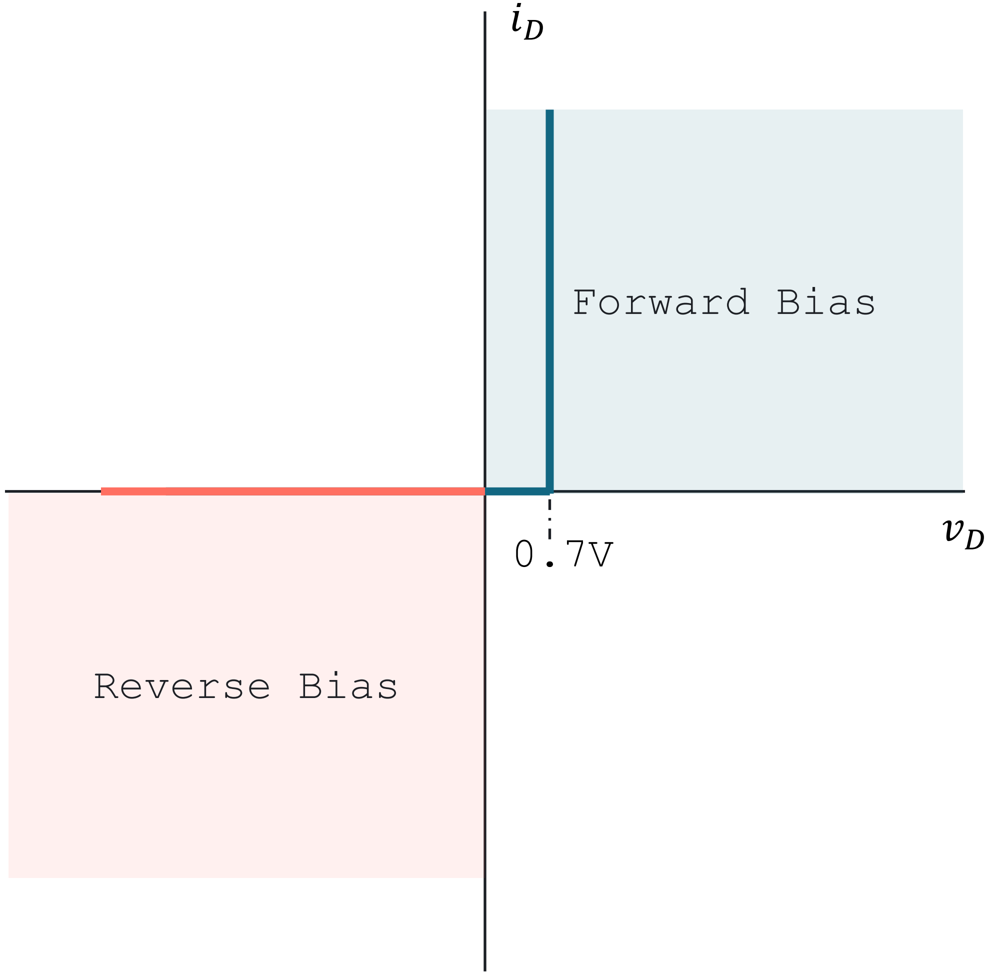
Using the ideal diode model, determine the load voltage, load current, and the power dissipated by the diode in the given circuit.

Solution



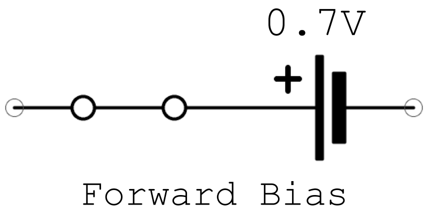
2ND APPROXIMATION

Characteristic Curve

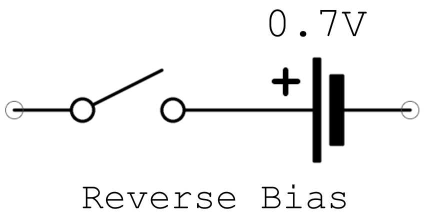


The diode is modeled as an ideal **switch** in series with a **barrier potential**.

Circuit Equivalent



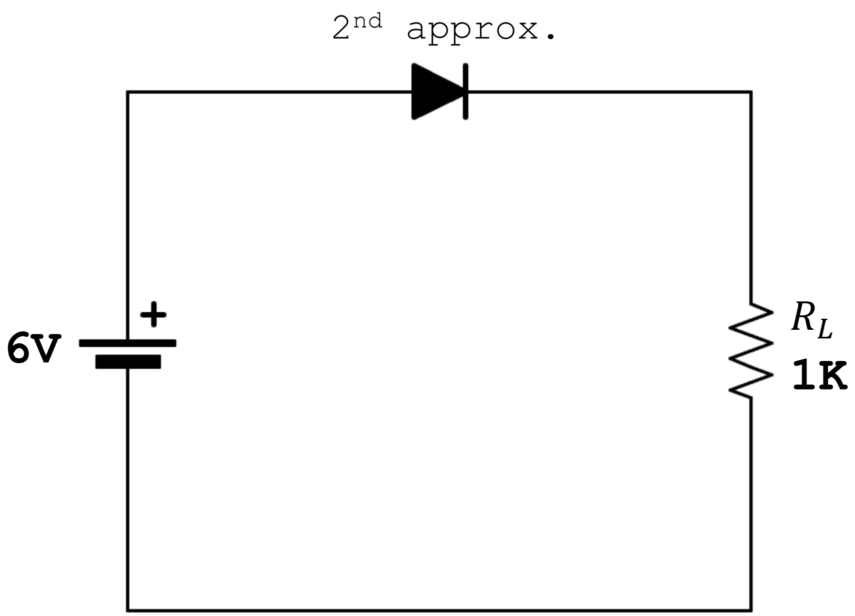
If $v_D \geq 0.7$ V, the switch is closed, and the diode conducts.



If $v_D < 0.7$ V, the switch is open, and the diode does not conduct.

EXERCISE

Apply the second approximation of the diode model to determine the load voltage, load current, and the power dissipated by the diode in the given circuit.

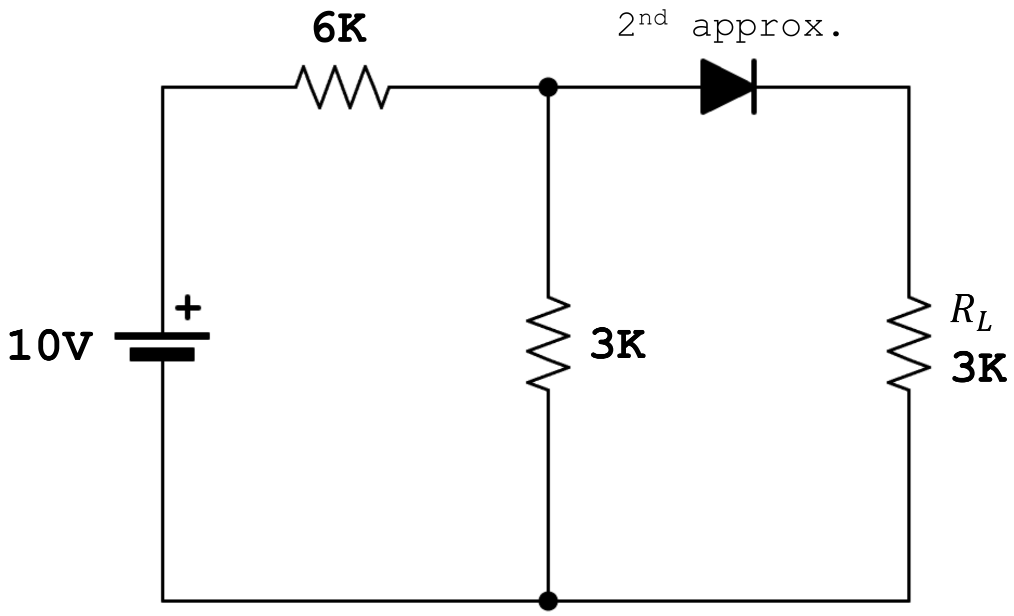


Solution

EXERCISE

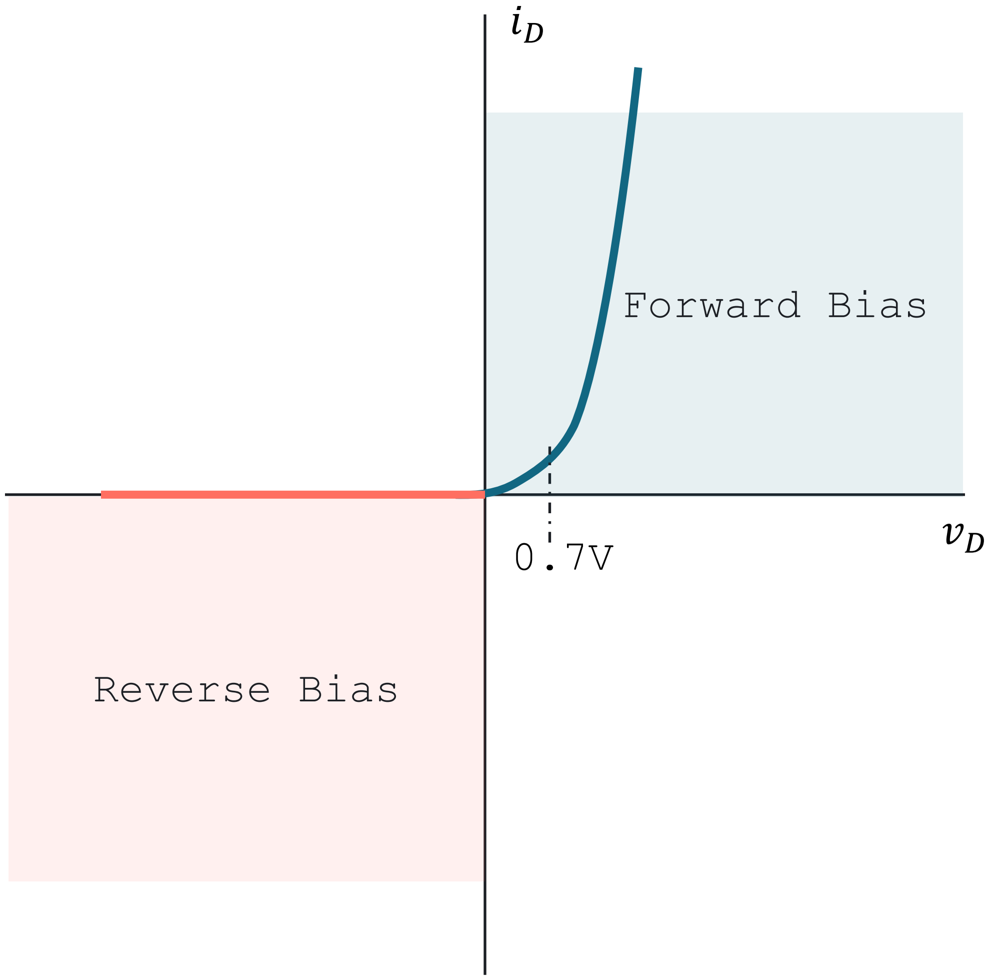
Apply the second approximation of the diode model to determine the load voltage, load current, and the power dissipated by the diode in the given circuit.

Solution



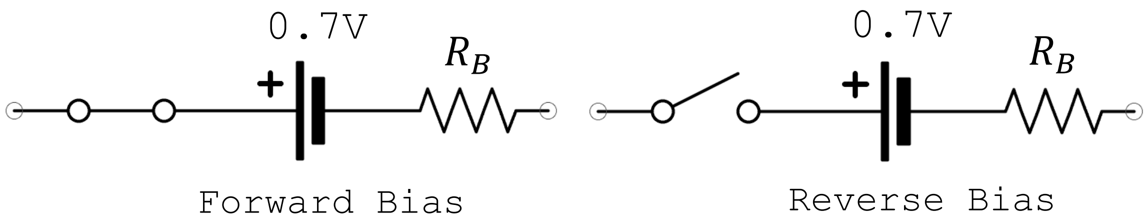
3RD APPROXIMATION

Characteristic Curve



The diode is modeled as an ideal **switch** in series with a **barrier potential** and a **bulk resistance**.

Circuit Equivalent



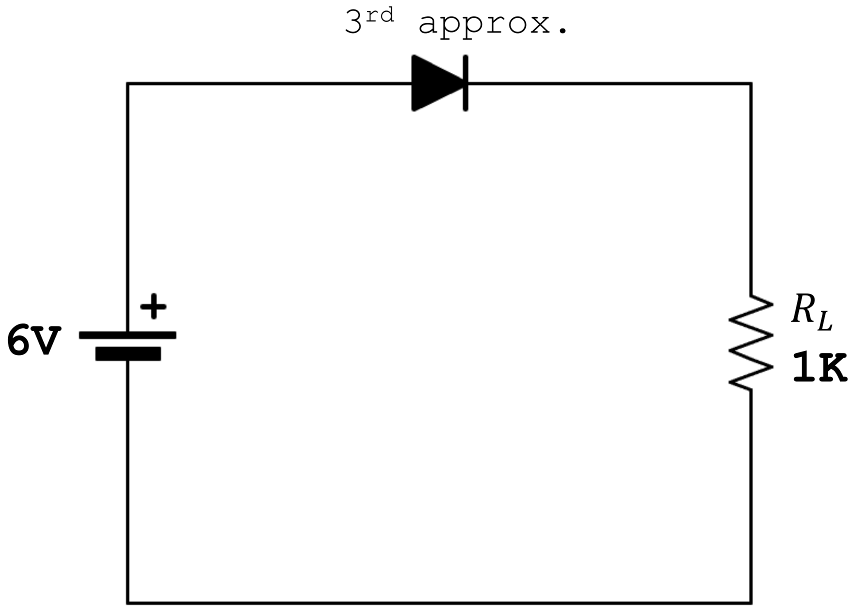
$v_D = 0.7\text{V} + i_D R_B$

Typical value of $R_B < 1\Omega$,

and often ignored if $R_B < 0.01 R_{TH}$

EXERCISE

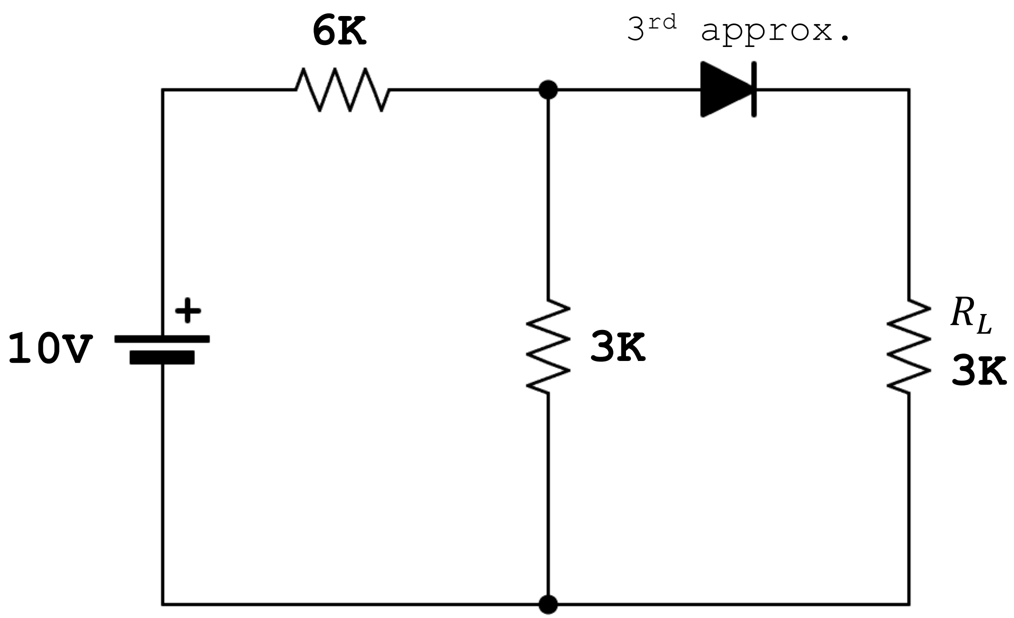
The 1N4001 of the given network has a bulk resistance of 0.23 Ω. What is the load voltage, load current, and the power dissipated by the diode?



Solution

EXERCISE

The 1N4001 of the given network has a bulk resistance of 0.23 Ω. What is the load voltage, load current, and the power dissipated by the diode?

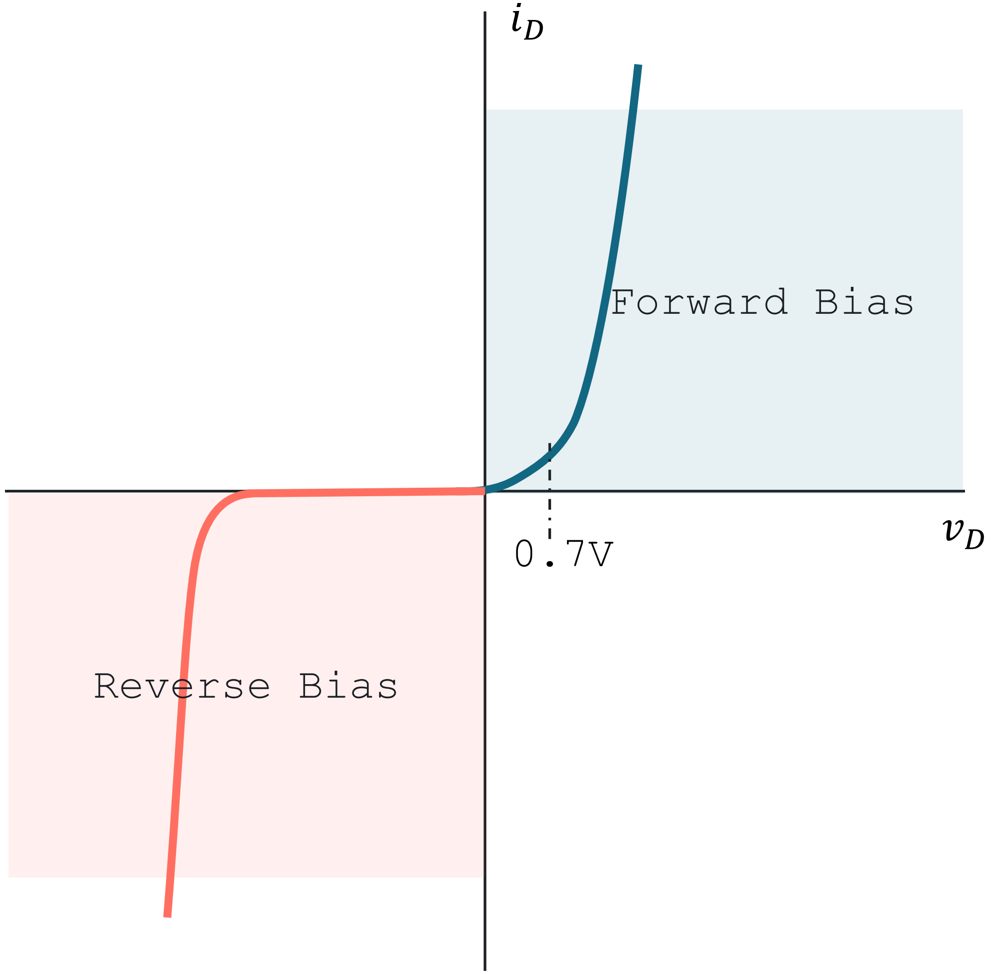


Solution

SHOCKLEY'S EQUATION

SHOCKLEY'S EQUATION

Characteristic Curve



Shockley's Equation

$$i_D = i_S\left(e^{\frac{v_D}{n v_T}} - 1\right)$$

where:

i_D = diode current

i_S = reverse saturation current

v_D = voltage across the diode

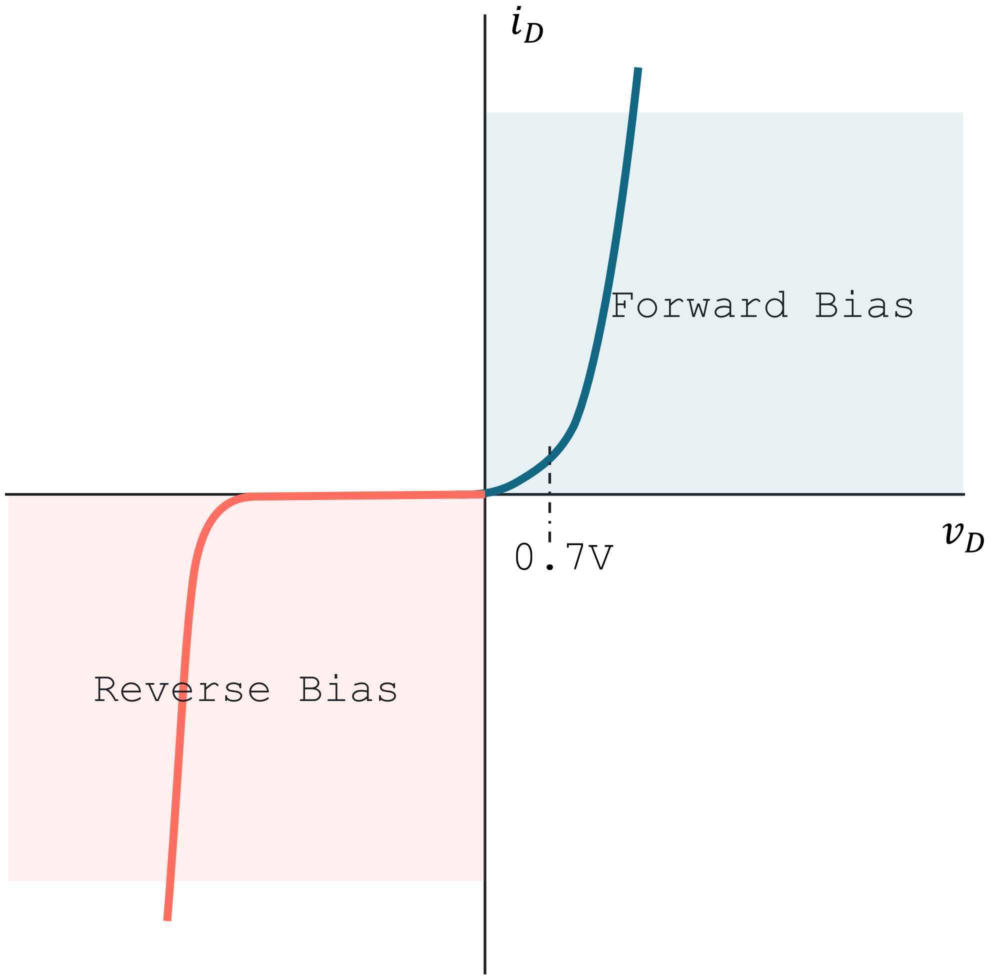
n = ideality factor ($1 \leq n \leq 2$)

- $n = 1$ for ideal diode

v_T = thermal voltage ($\approx 25.85mV$ at room temperature)

THERMAL VOLTAGE

Characteristic Curve



Thermal Voltage

$$v_T = \frac{kT}{q}$$

where:

k = Boltzmann's constant (1.38×10^{-23} J/K)

T = absolute temperature (°C + 273)

q = electron charge (1.602×10^{-19} C)

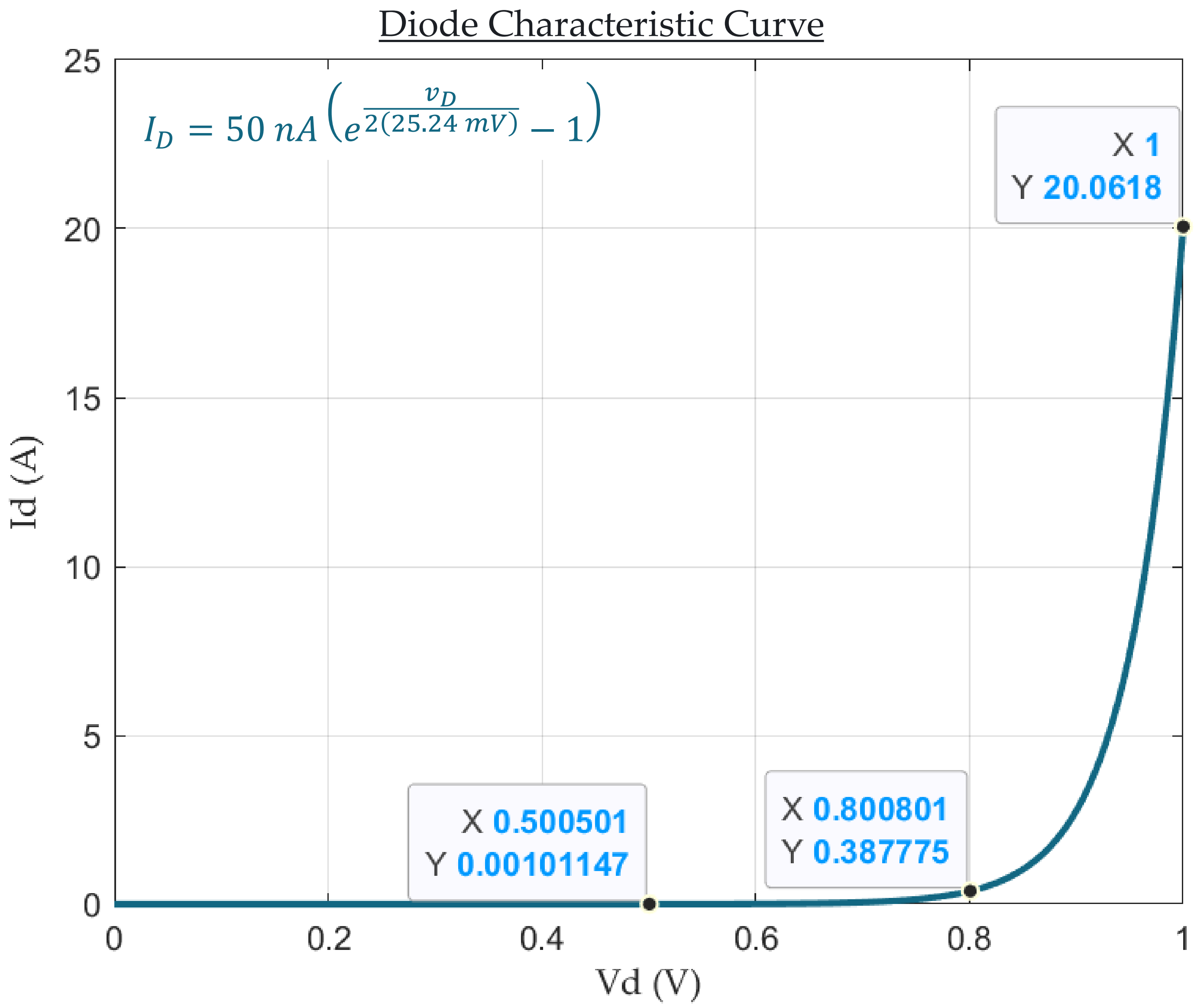
EXERCISE

Determine the diode current at 20℃ for silicon diode with a reverse saturation current of $50nA$ and an ideality factor of 2, under the following applied voltages:

- 0V
- 0.5V
- 0.7V
- 1V

Solution

EXERCISE



Diode Characteristic Curve
$I_D = 50\,nA\left(e^{\frac{v_D}{2(25.24\,mV)}} - 1\right)$
X 1
Y 20.0618
X 0.500501
Y 0.00101147
X 0.800801
Y 0.387775
Id (A)
Vd (V)
0
5
10
15
20
25
0.2
0.4
0.6
0.8
1

READING DATASHEET

REVERSE BREAKDOWN VOLTAGE

MAXIMUM RATINGS

Rating	Symbol	1N4001	1N4002	1N4003	1N4004	1N4005	1N4006	1N4007	Unit
†Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	800	1000	V
†Non–Repetitive Peak Reverse Voltage (halfwave, single phase, 60 Hz)	V_{RSM}	60	120	240	480	720	1000	1200	V
†RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	560	700	V
†Average Rectified Forward Current (single phase, resistive load, 60 Hz, $T_A = 75°C$)	I_O				1.0				A

Destructive level to avoid under all operating conditions.

Practice safety factor of 2.

MAXIMUM FORWARD CURRENT

MAXIMUM RATINGS

Rating	Symbol	1N4001	1N4002	1N4003	1N4004	1N4005	1N4006	1N4007	Unit
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†Average Rectified Forward Current (single phase, resistive load, 60 Hz, $T_A = 75°C$)	I_O	1.0							A

Level of forward current before the **diode burns out** because of excessive power dissipation.

FORWARD VOLTAGE DROP

ELECTRICAL CHARACTERISTICS†

Rating	Symbol	Typ	Max	Unit
Maximum Instantaneous Forward Voltage Drop, (i_F = 1.0 Amp, T_J = 25°C)	v_F	0.93	1.1	V
Maximum Full–Cycle Average Forward Voltage Drop, (I_O = 1.0 Amp, T_L = 75°C, 1 inch leads)	$V_{F(AV)}$	–	0.8	V
Maximum Reverse Current (rated DC voltage) (T_J = 25°C) (T_J = 100°C)	I_R	 0.05 1.0	 10 50	μA
Maximum Full–Cycle Average Reverse Current, (I_O = 1.0 Amp, T_L = 75°C, 1 inch leads)	$I_{R(AV)}$	–	30	μA

The typical voltage across the diode.

LABORATORY