Chapter 2:
Diode Applications

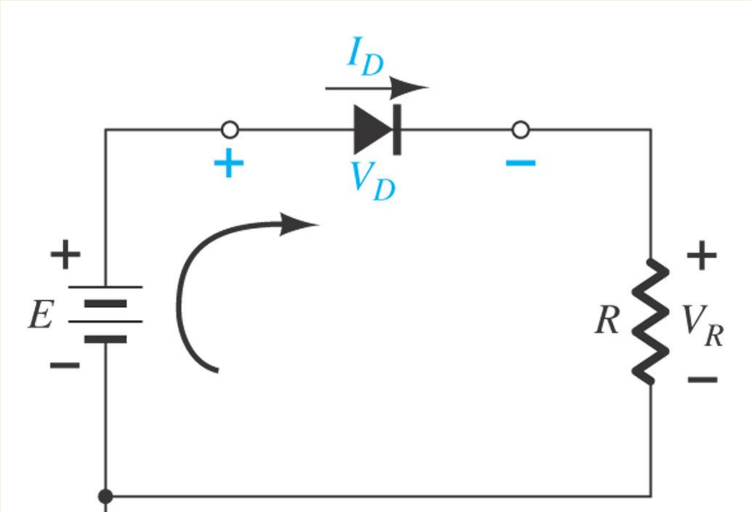
2.2 Load-Line Analysis

The load line plots all possible current (I_D) conditions for all voltages applied to the diode (V_D) in a given circuit. E / R is the maximum I_D and E is the maximum V_D.

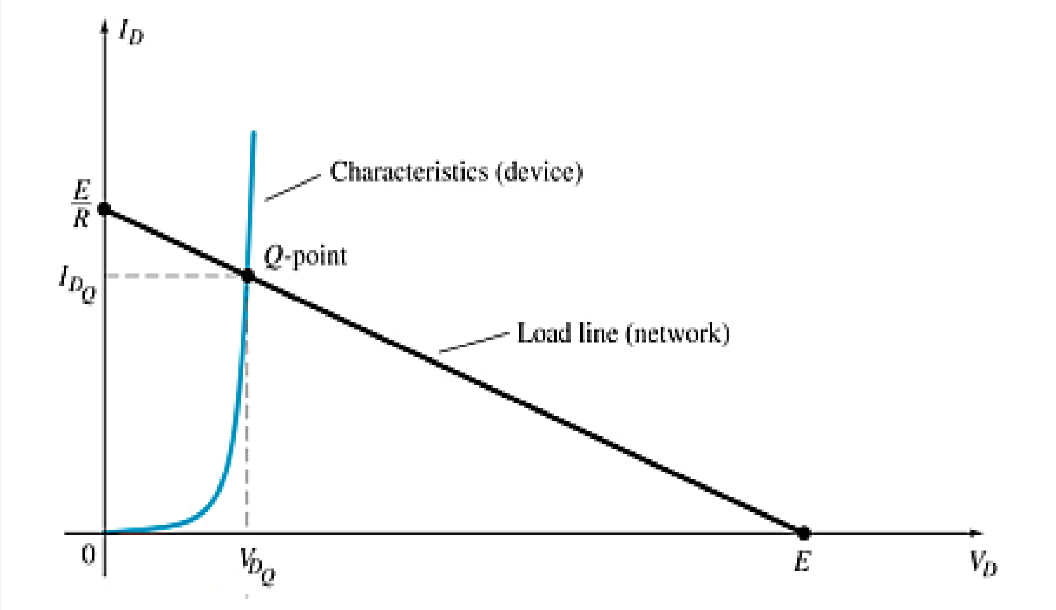
$$E = V_D + I_D R$$

Where the load line and the characteristic curve intersect is the Q-point, which specifies a particular I_D and V_D for a given circuit.

Load-line analysis $\begin{cases} \text{Characteristic curve of the solid-state device} \\ \text{Load line of the circuit} \end{cases}$



(a)



2.3 Equivalent Model Analysis

Forward Bias: E>0.7

Constants as known

- Silicon Diode: $V_D = 0.7V$
- Germanium Diode: $V_D = 0.3V$

Analysis

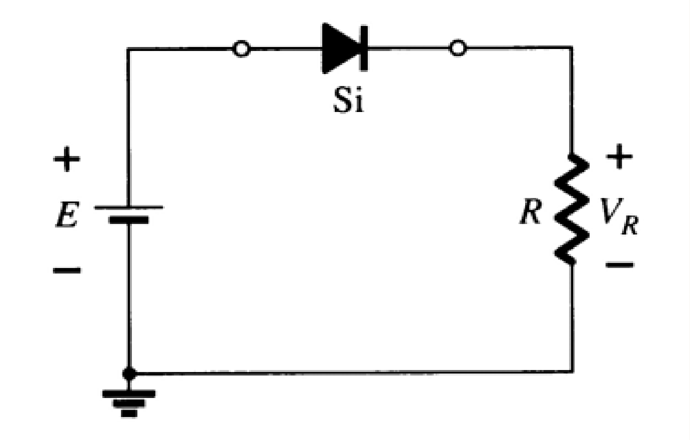
- $V_D = 0.7V$
- $V_R = E - V_D$
- $I_D = I_R = I_T = V_R / R$

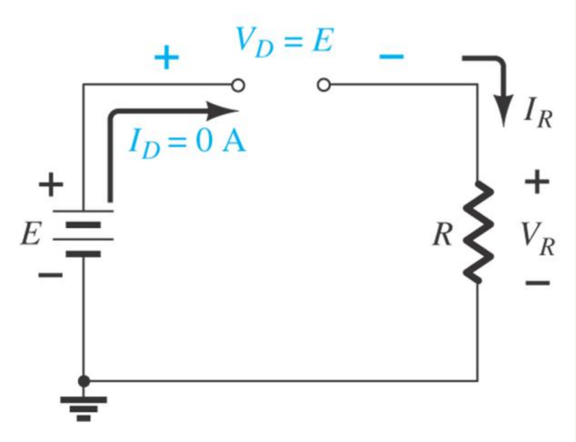
Reverse Bias: E<0.7

Diodes ideally behave as open circuits

Analysis

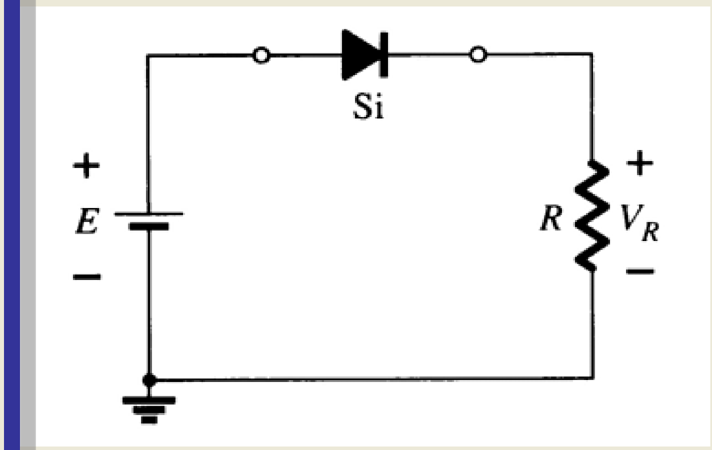
- $V_D = E$
- $V_R = 0\ V$
- $I_D = 0\ A$

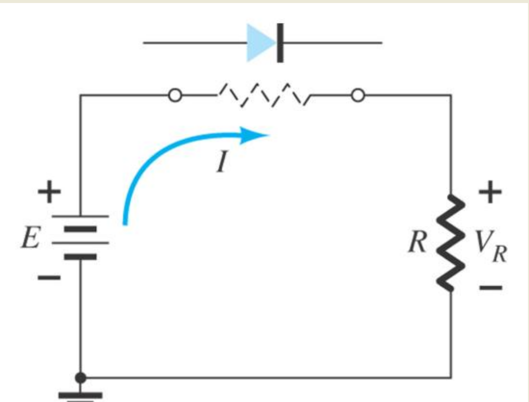




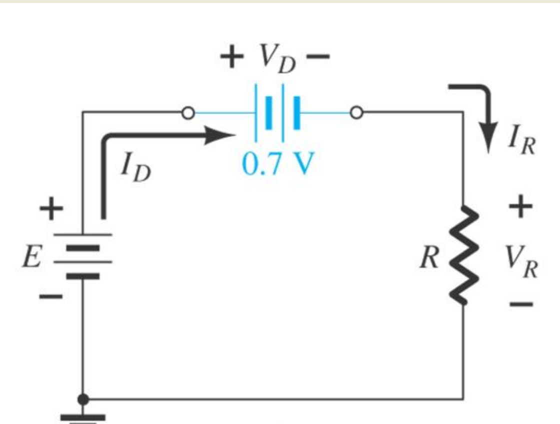
Equivalent Model Analysis

Step 1. Make assumptions (‘short/forward’ or ‘open/reverse’)
Step 2. Analysis/Check assumptions
Step 3. Make final decision

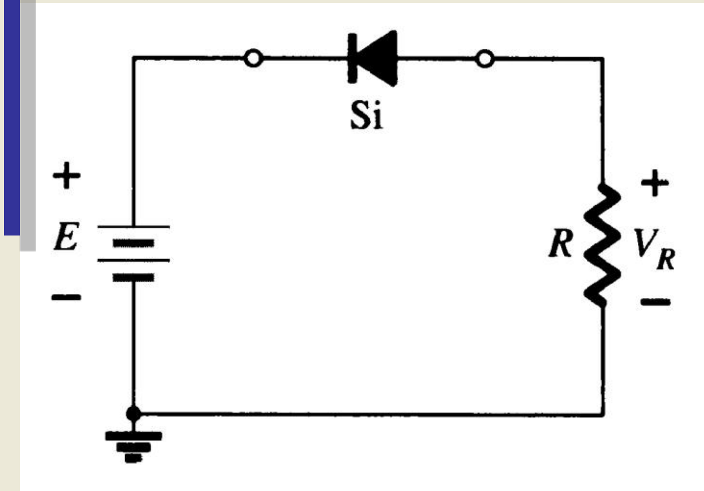


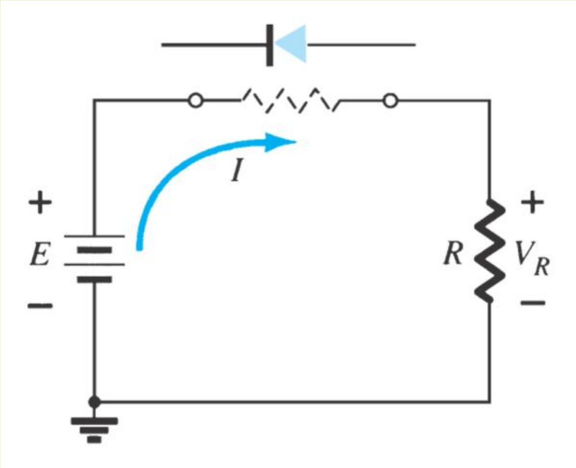


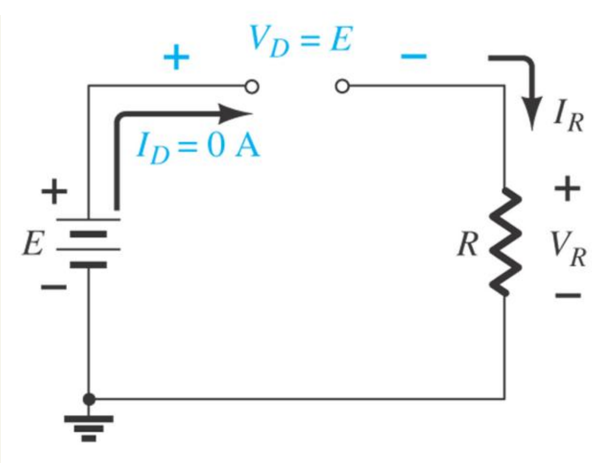
(a)



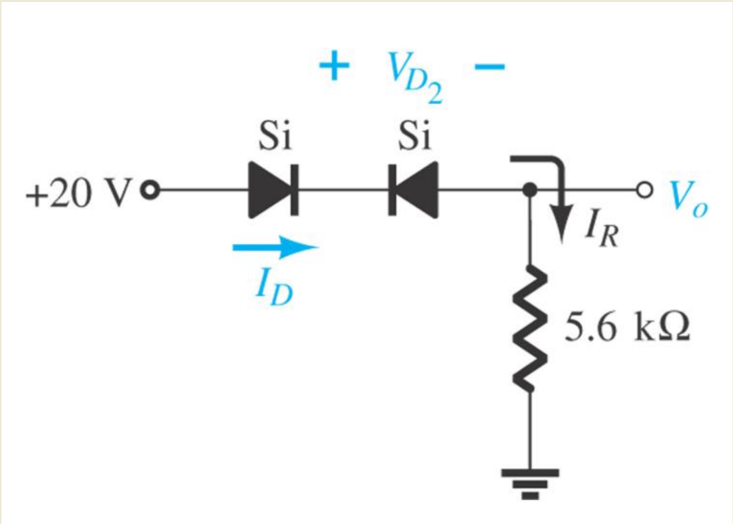
(b)



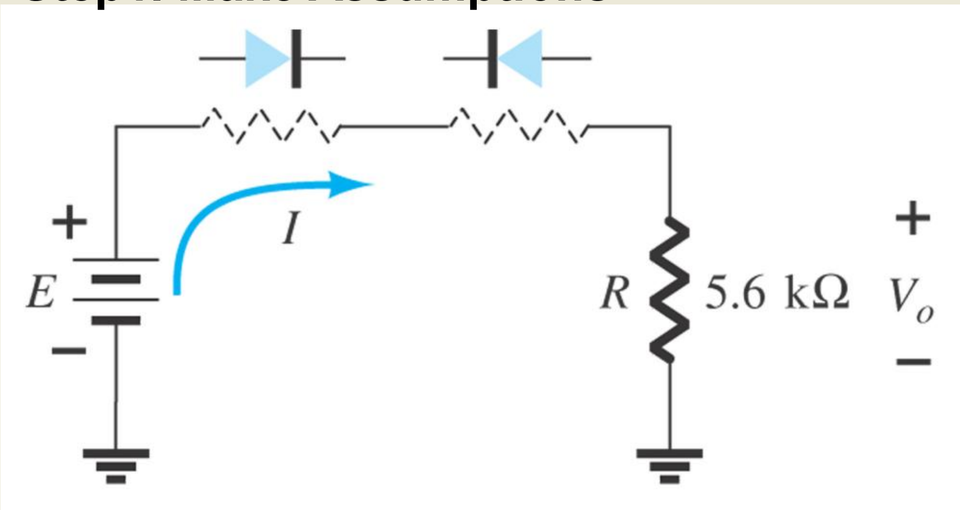




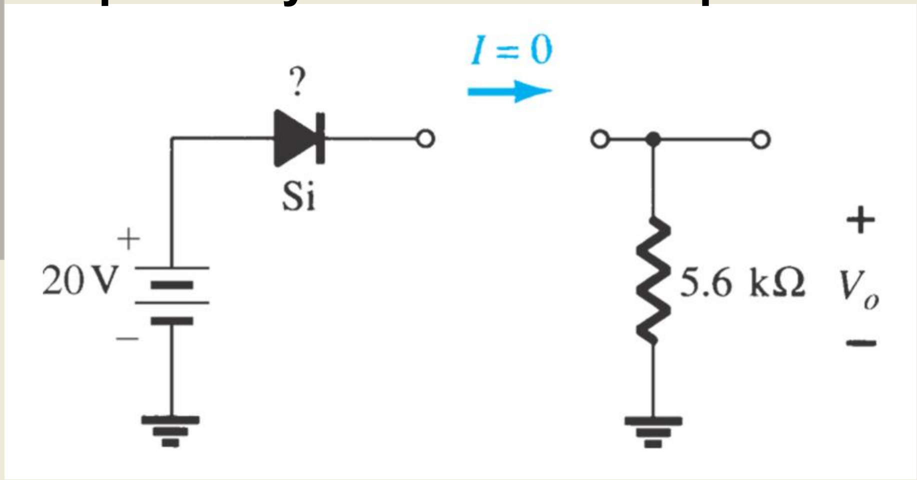
Example 2.4 Determine I_D, V_{D2}, and V_o



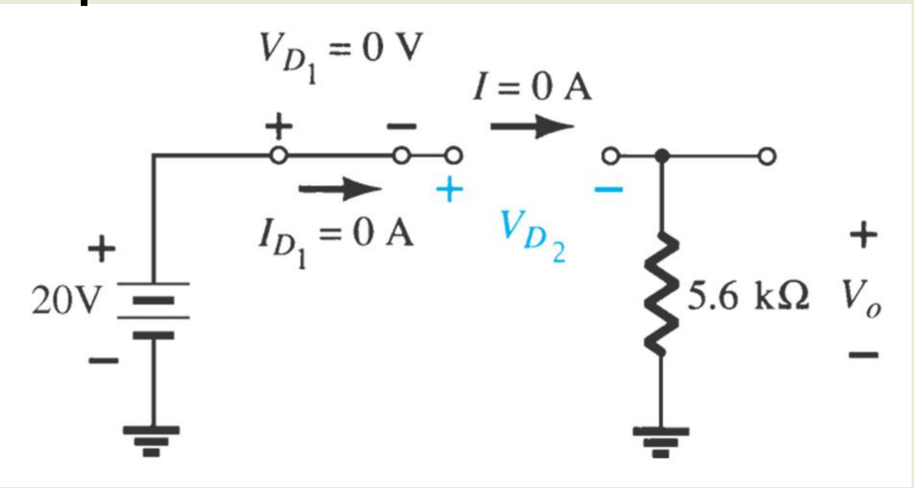
Step1. Make Assumptions



Step2. Analysis/Check assumptions

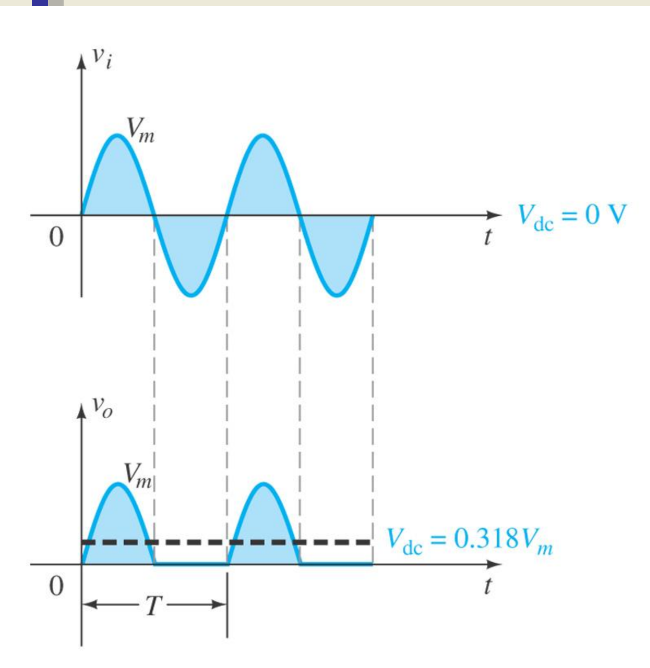


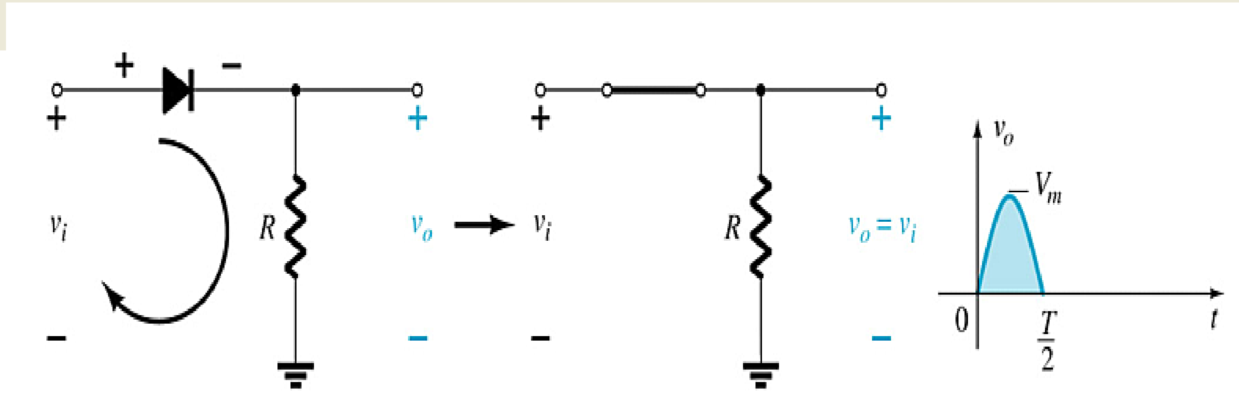
Step3. Make final decision

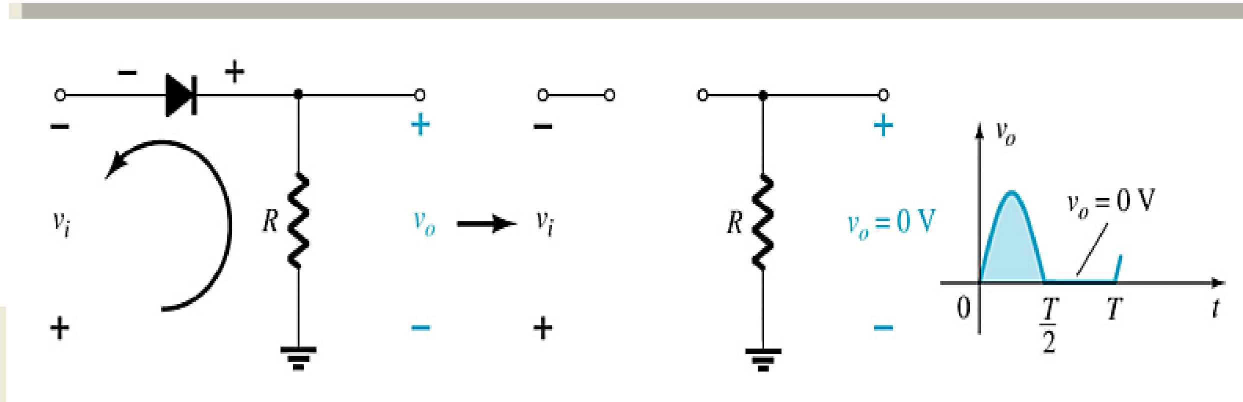


2.5 Half-Wave Rectification

The diode only conducts when it is in forward bias, therefore only half of the AC cycle passes through the diode.



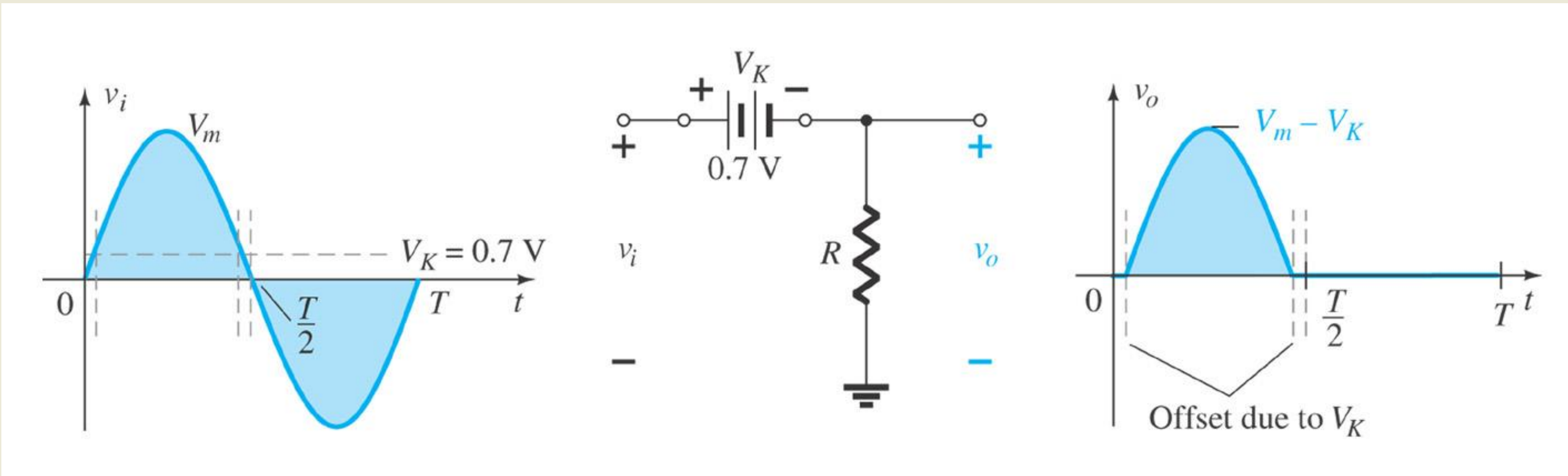




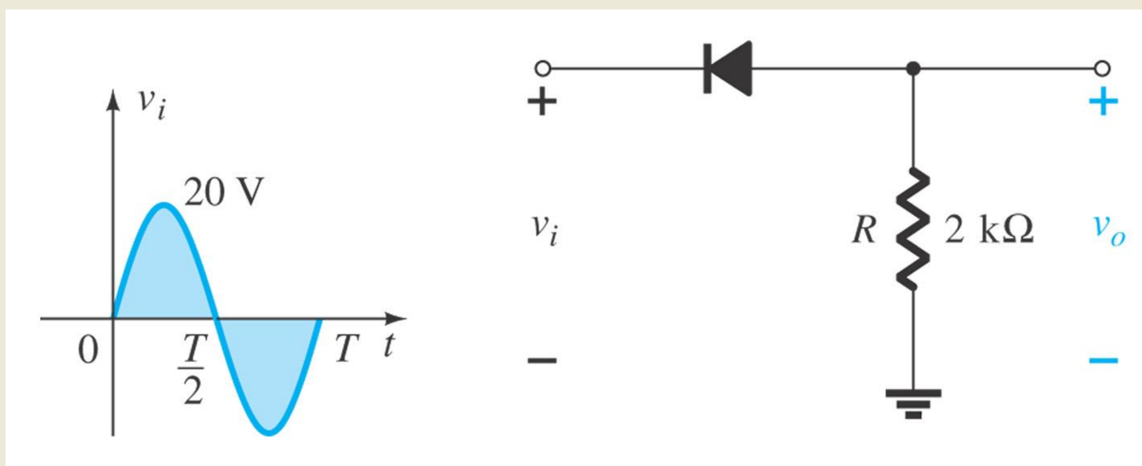
The DC output voltage is $0.318V_m$, where V_m = the peak AC voltage.

Note: It is important that the reverse breakdown voltage rating of the diode be high enough to withstand the peak reverse-biasing AC voltage: Vm <PIV (or PRV)

- **Using an ideal diode equivalent**
- **Using a simplified diode equivalent**



Example 2.8

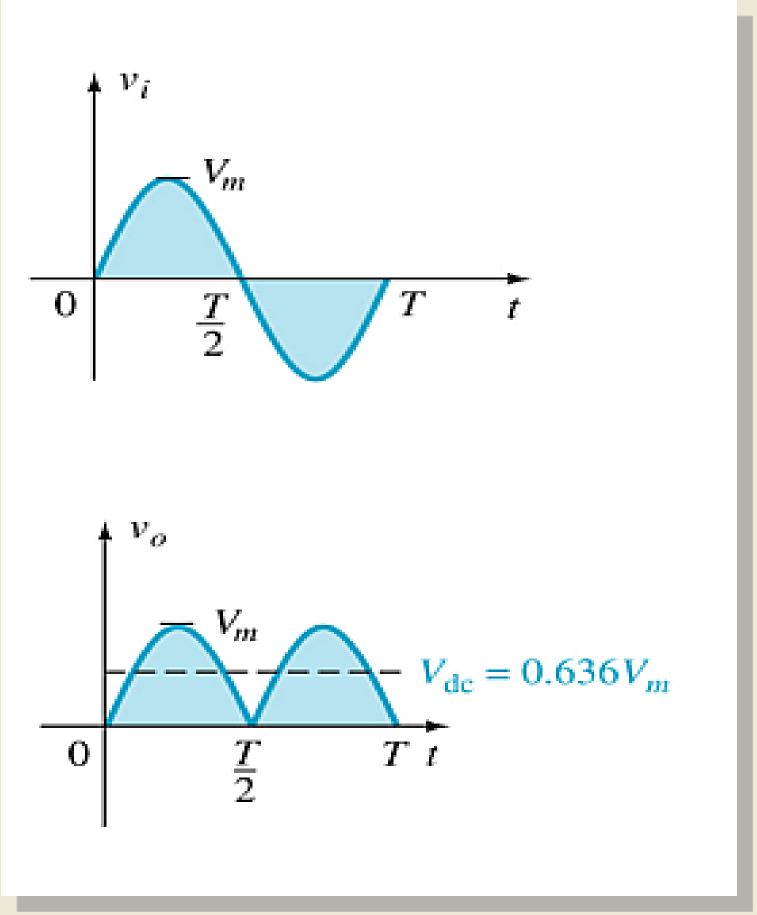


2.6 Full-Wave Rectification

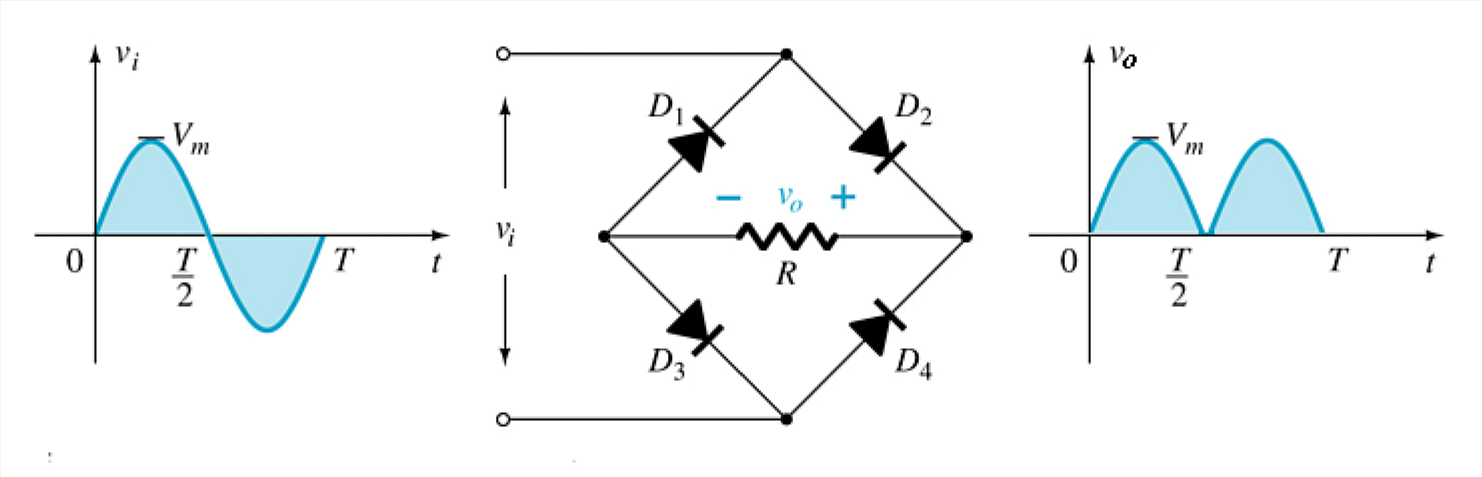
The rectification process can be improved by using more diodes in a full-wave rectifier circuit.

Full-wave rectification produces a greater DC output:

- Half-wave: $V_{dc} = 0.318V_m$
- Full-wave: $V_{dc} = 0.636V_m$

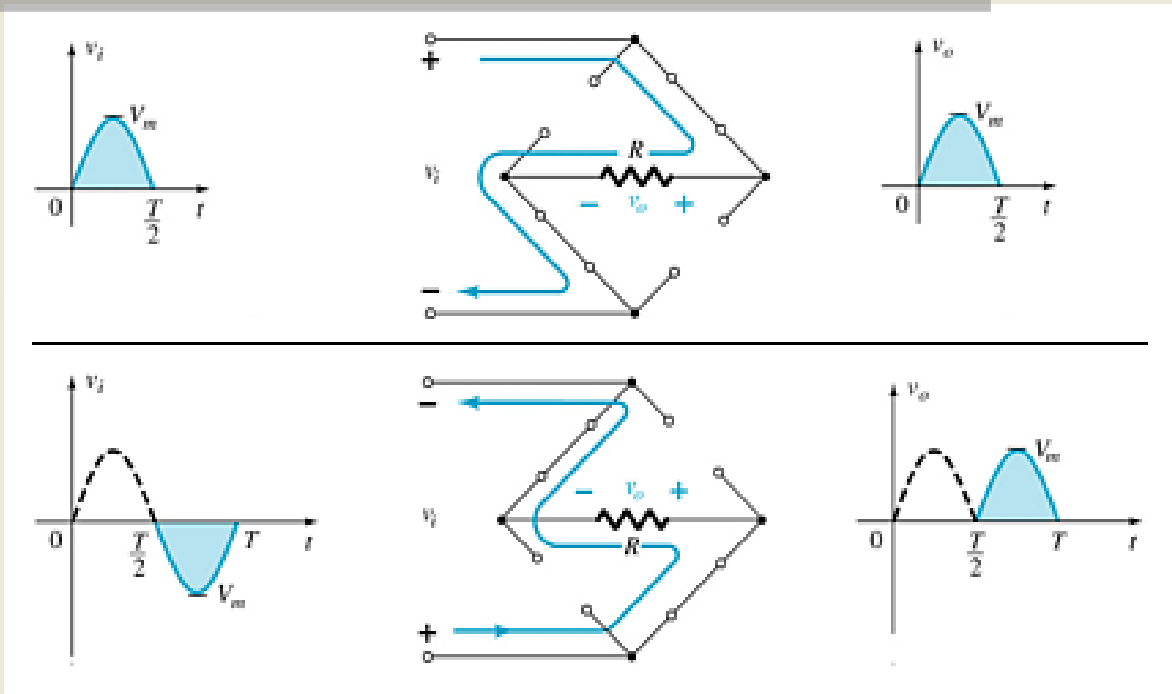


Full-Wave Rectification

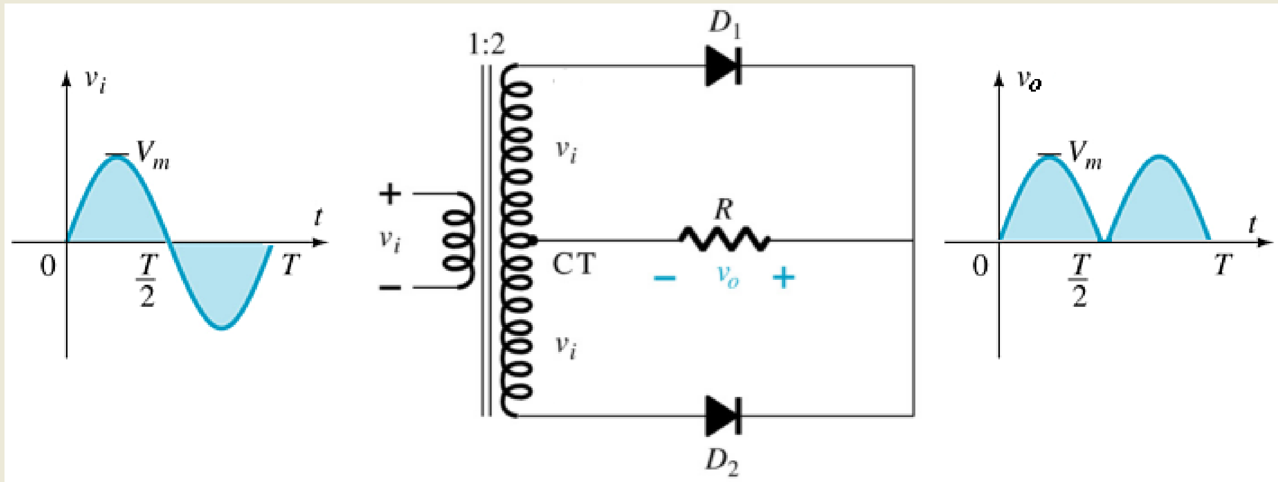


Bridge Rectifier

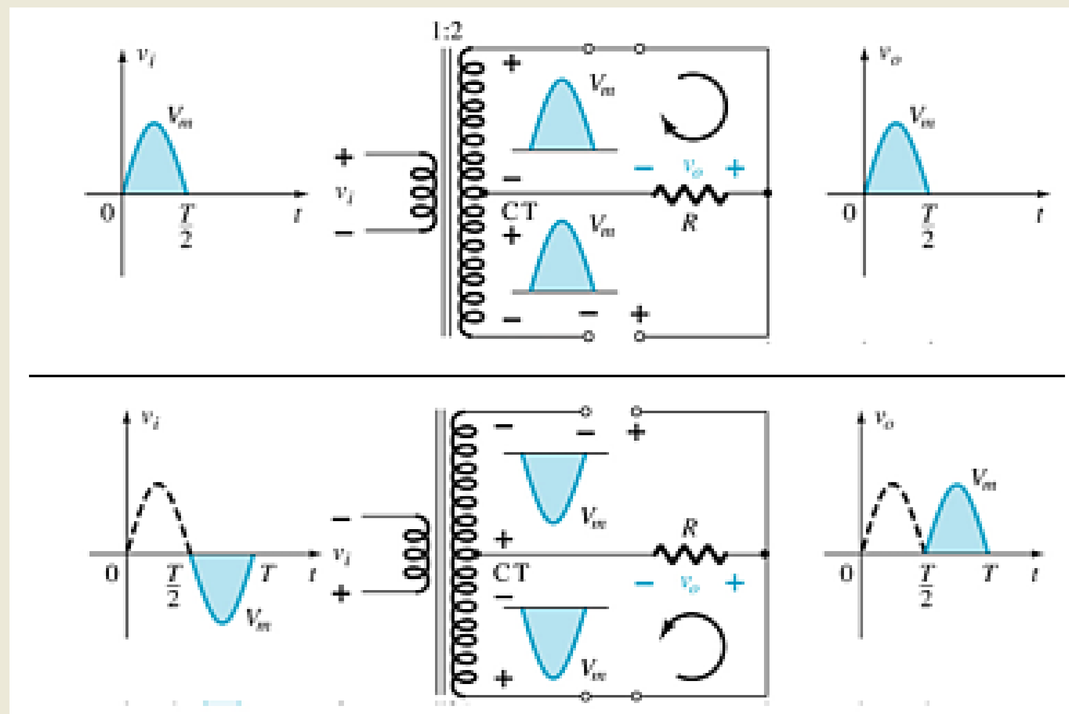
- Four diodes are required
- $V_{DC} = 0.636\ Vm$



Full-Wave Rectification



Center-Tapped Transformer Rectifier

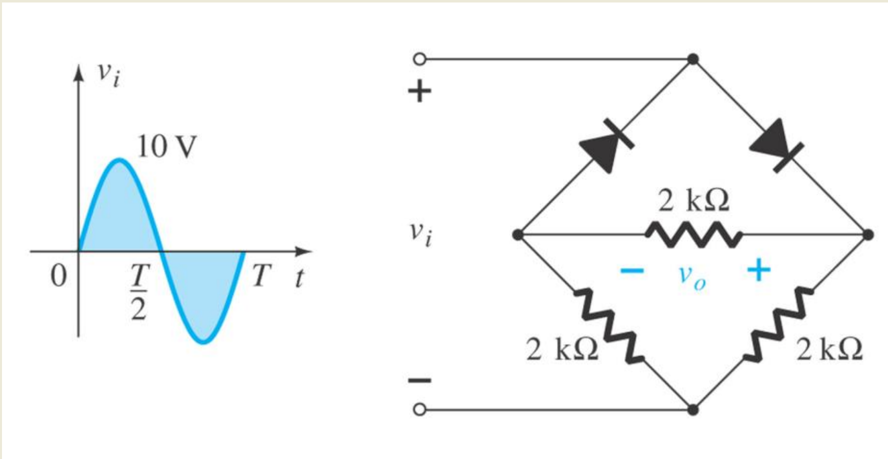


Requires

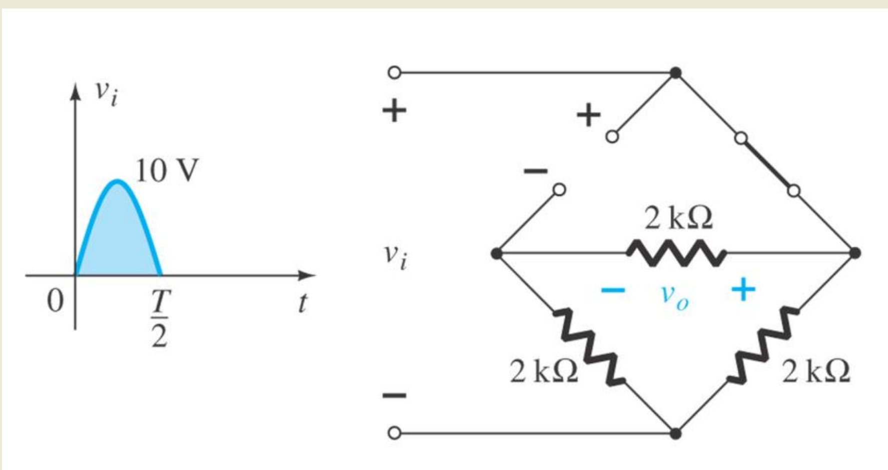
- Two diodes
- Center-tapped transformer

$$V_{DC} = 0.636(V_m)$$

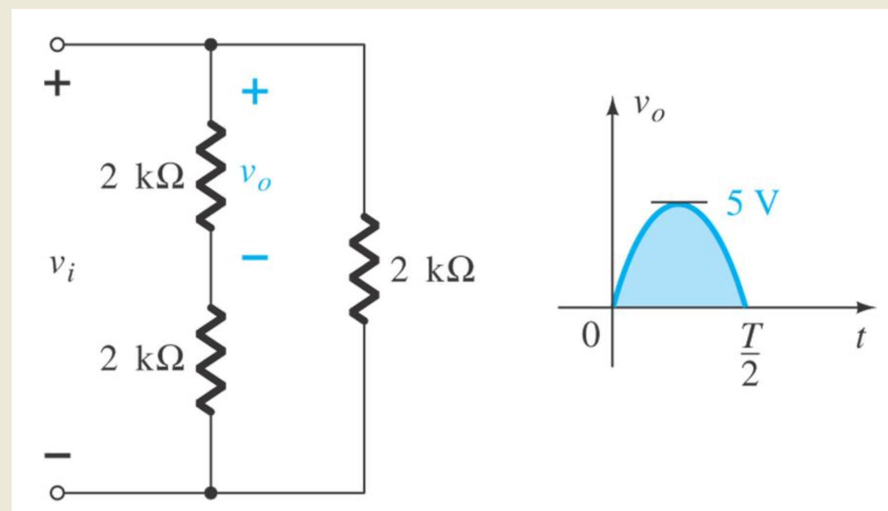
Example 2.9



v_i
10 V
0
$\frac{T}{2}$
T
t
+
v_i
−
2 kΩ
− v_o +
2 kΩ
2 kΩ



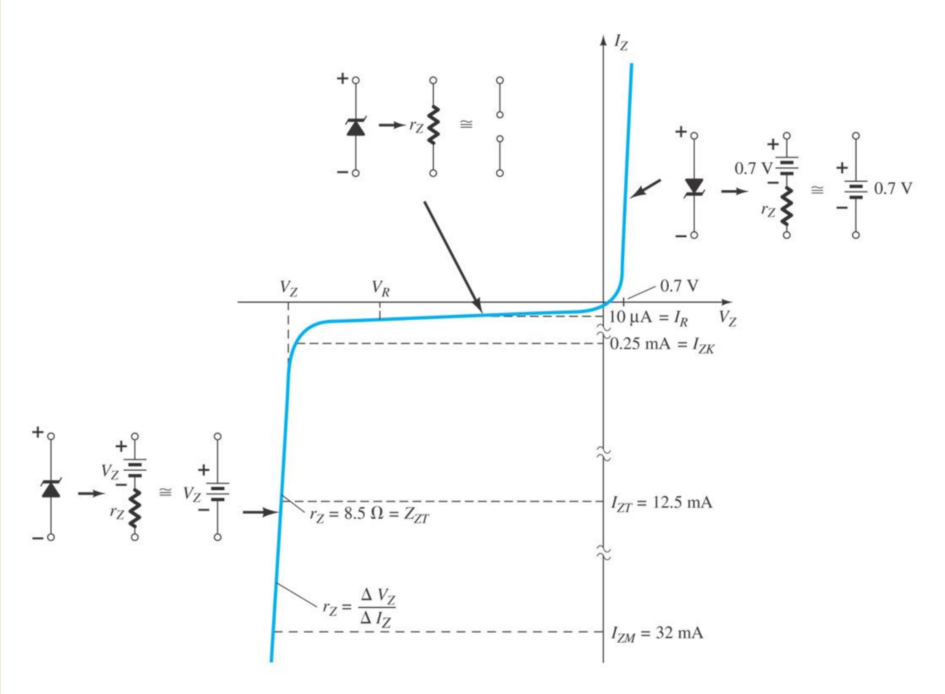
v_i
10 V
0
$\frac{T}{2}$
t
+
+
−
v_i
2 kΩ
− v_o +
2 kΩ
2 kΩ
−



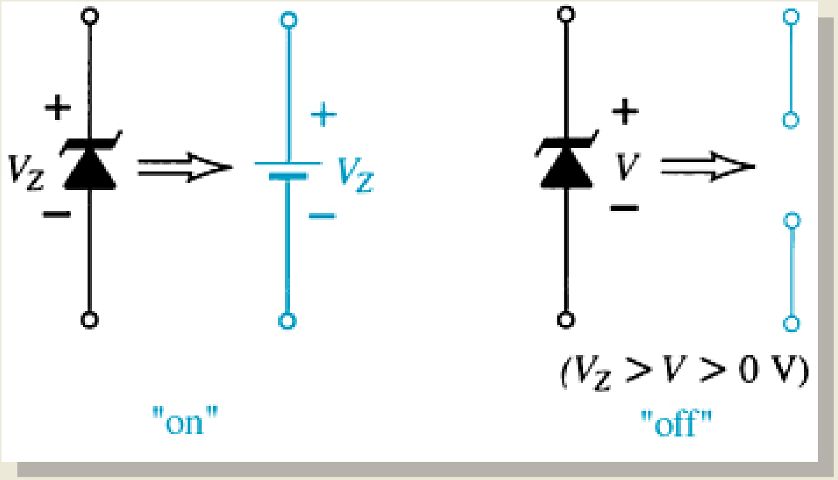
+
+
2 kΩ
v_o
−
v_i
2 kΩ
2 kΩ
−
v_o
5 V
0
$\frac{T}{2}$
t

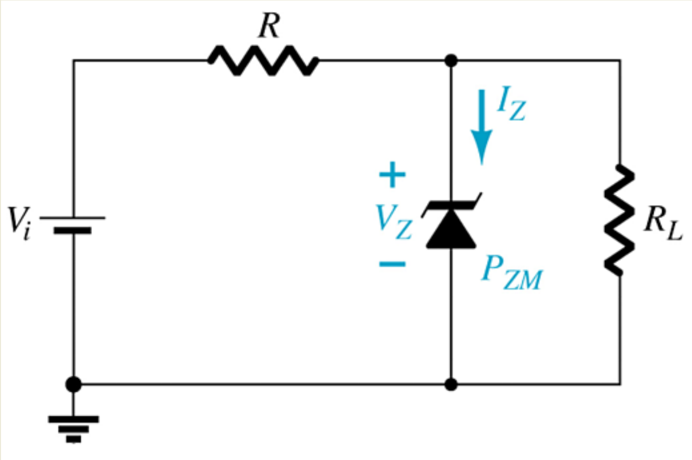
2.9 Zener Diodes

The Zener diode is operated in reverse bias at the Zener Voltage (V_z).



- When $V_i \geq V_z$
  - The Zener is on
  - Voltage across the Zener is V_z
  - Zener current: I_Z
  - The Zener Power: $P_Z = V_Z I_Z$
- When $V_i < V_z$
  - The Zener is off
  - The Zener acts as an open circuit





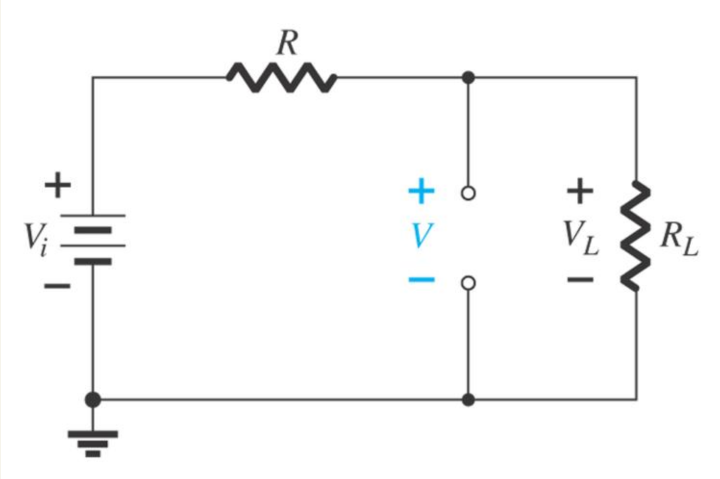
Example 2.17. Fixed V_i, Fixed R_L

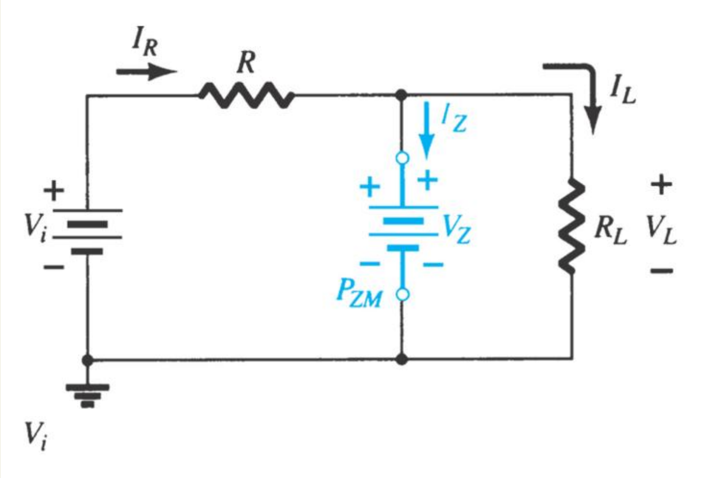
Example 2.18. Fixed V_i, Variable R_L

Example 2.19. Variable V_i, Fixed R_L

Step1. Determine the state of the Zener diode by removing it from the network and calculating the voltage across the resulting open circuit.

Step2. Substitute the appropriate equivalent and solve for the desired unknowns.





Summary of Chapter 2

- **Analysis methods of diode circuits**
  - **Equivalent Model**
  - **Load-Line Analysis**

- **Application of Diodes**
  - **Rectifier**
    - **Conversions of AC to DC for DC operated circuits**
    - **Battery Charging Circuits**
  - **Zener Diodes: Regulator**
    - **Over voltage Protection**
    - **Setting Reference Voltages**
  - **Clipper/limiter: self study**
  - **Clamper: self study**
  - **…**