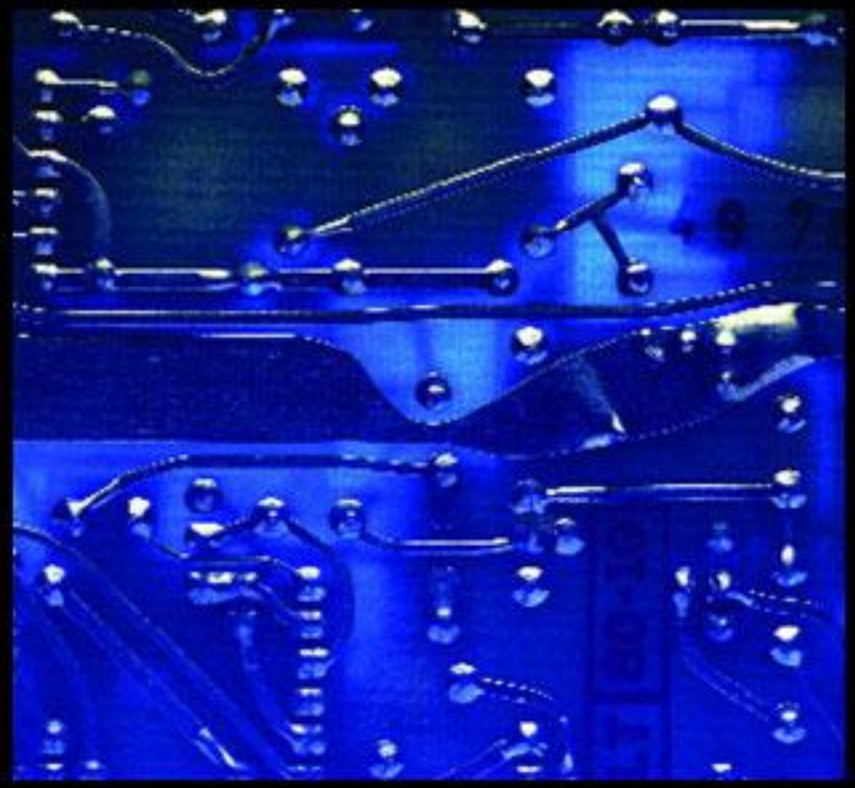
Electronic Devices and Circuit Theory

Tenth Edition



BOYLESTAD

PEARSON

Chapter 2:
Diode Applications

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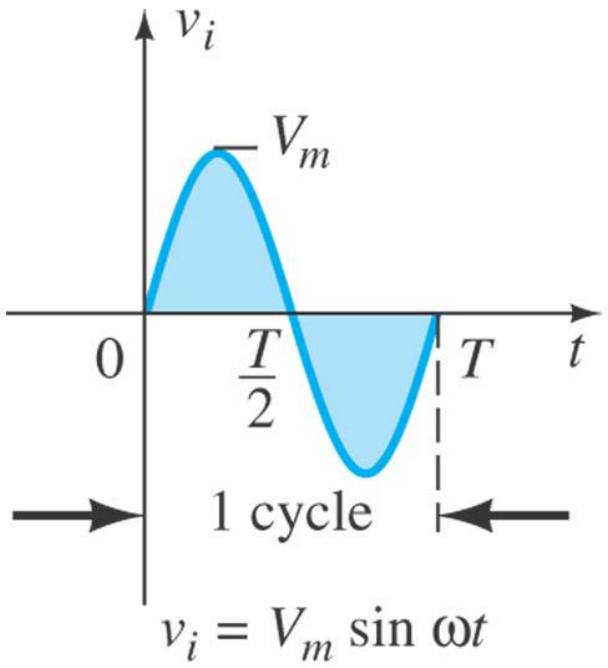
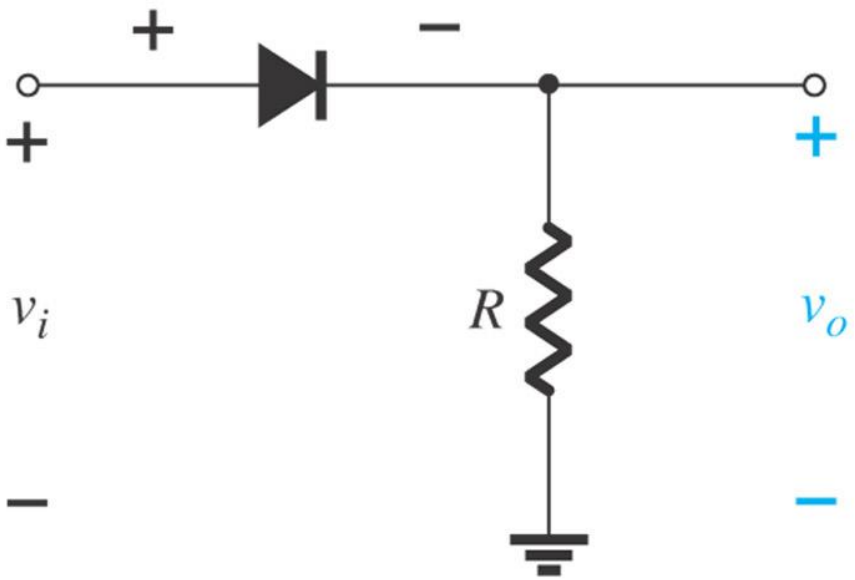
Diode Applications

Diodes are used in many applications:

(a) Rectifiers
(b) Clippers or Limiters
(c) Clampers
(d) Voltage Multipliers

Sinusoidal Inputs: Half-Wave Rectification

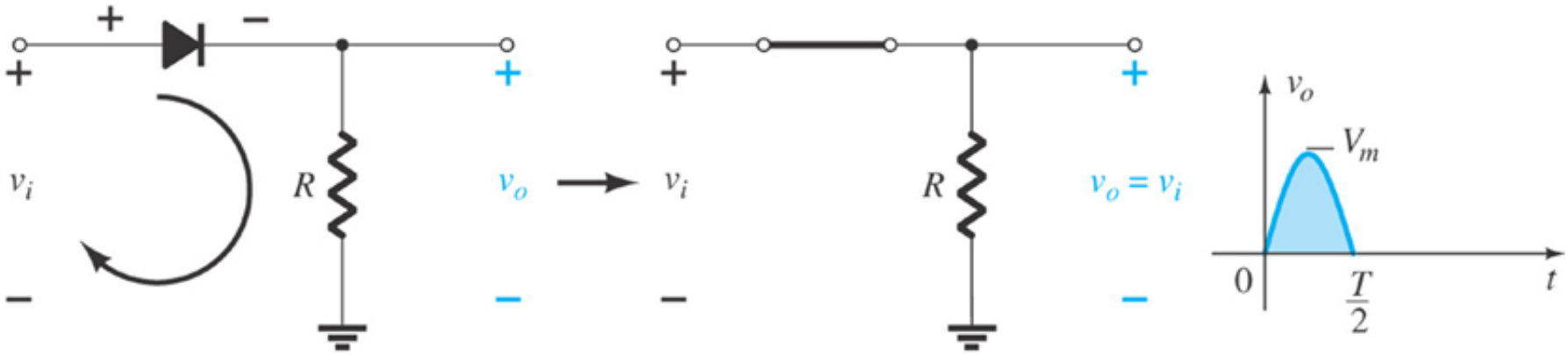




Half-wave Rectifier

Sinusoidal Inputs: Half-Wave Rectification

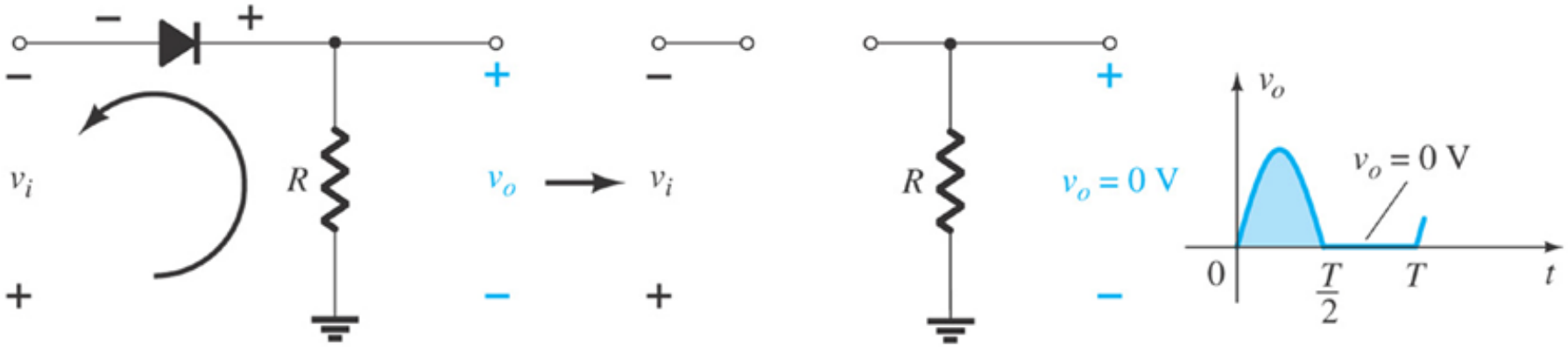
- For t= 0 → T/2, the diode is on.
- Diode is substituted with short-circuit equivalence for ideal diode (reduce complexity).



Conduction region (0 → T/2).

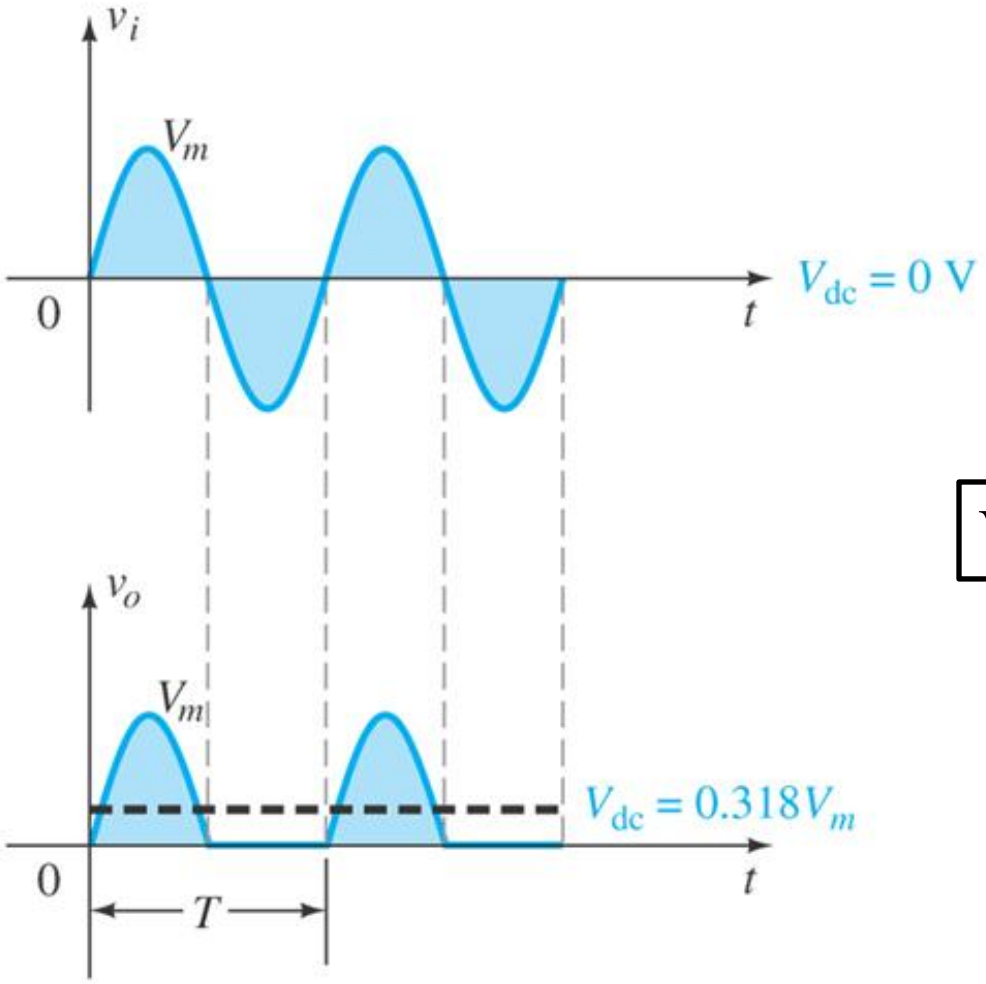
Sinusoidal Inputs: Half-Wave Rectification

- For the period $T/2 \rightarrow T$, the diode is off.
- Diode is substituted with an open circuit.



Nonconduction region ($T/2 \rightarrow T$).

Sinusoidal Inputs: Half-Wave Rectification

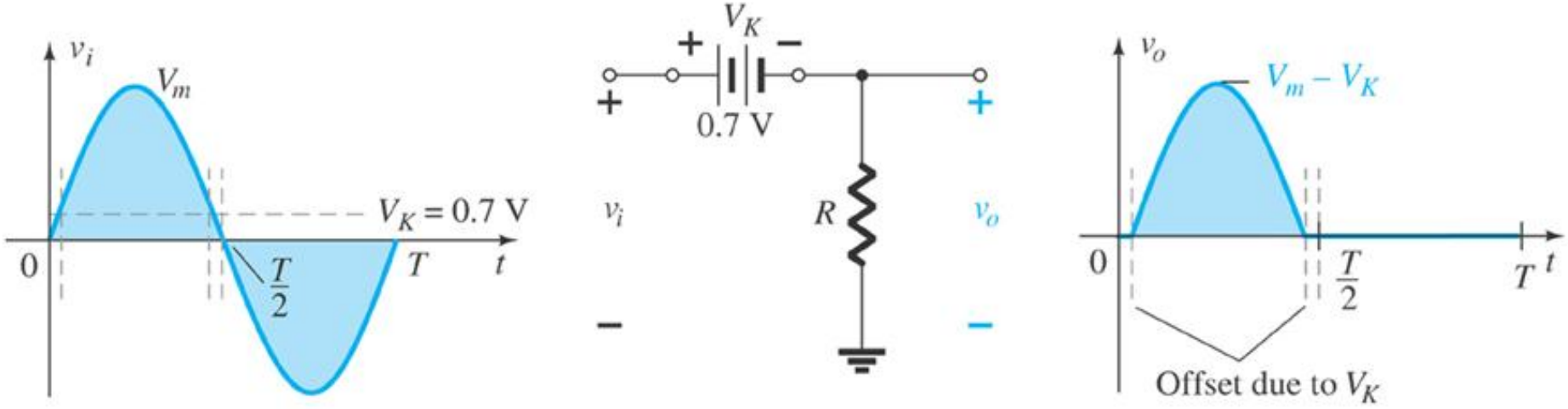


$$V_{DC}=0.318\ V_m$$

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

Sinusoidal Inputs: Half-Wave Rectification

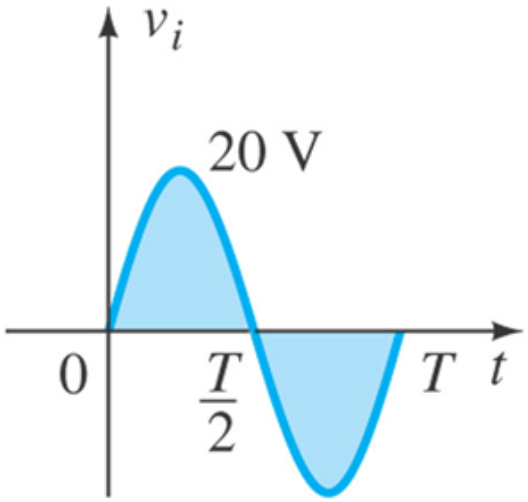
- The effect of using a silicon diode with V_K=0.7 is shown.
- The diode is "**on**" when the applied signal is at least 0.7 V.
- $v_o = v_i - V_K$
- For $V_m >> V_k$: $V_{DC} \approx 0.318 (V_m - V_K)$

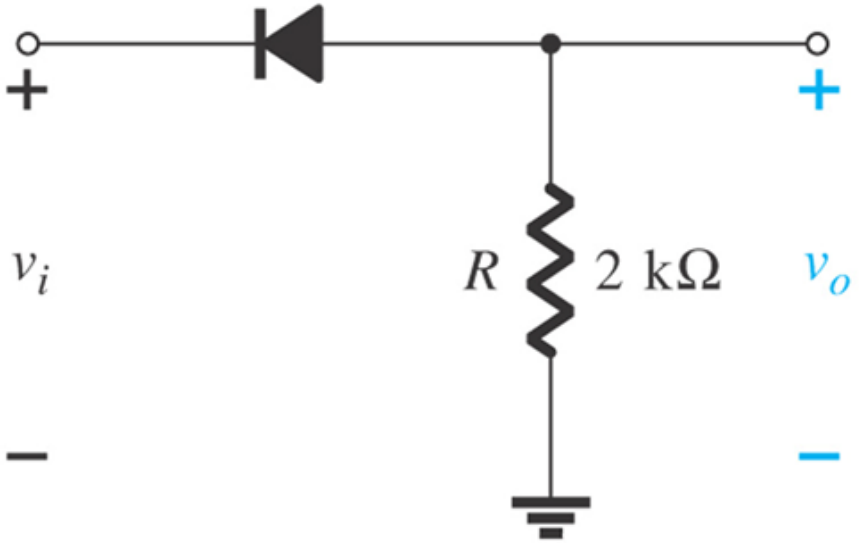


Example 2.16

a) Sketch dc output $\mathbf{v_o}$ and determine the dc level of the output.

b) Repeat (a) if the ideal diode is replaced by silicon diode.

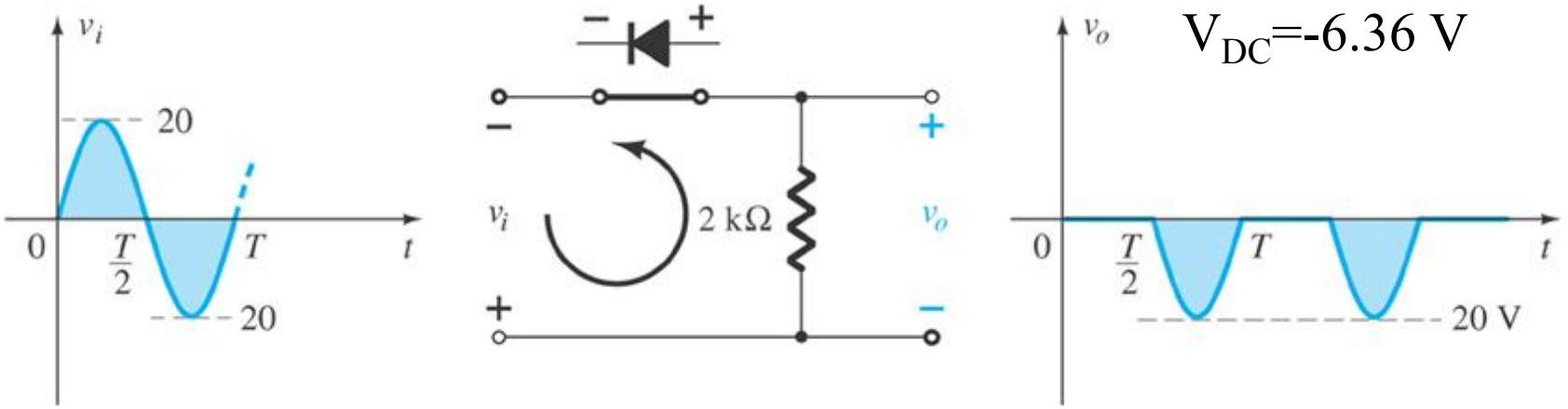




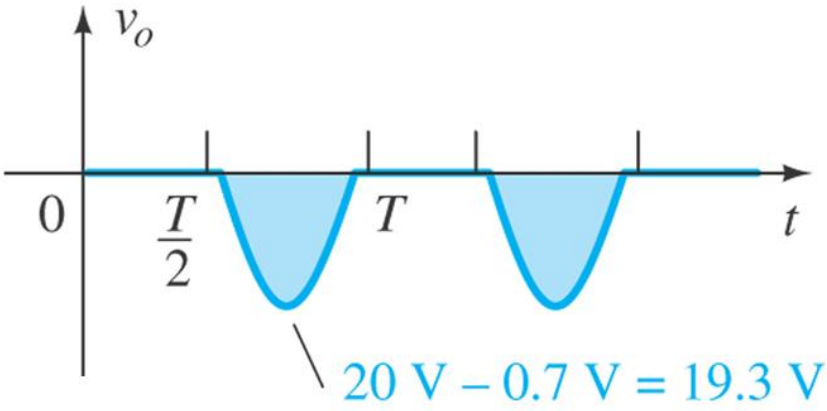
Example 2.16 - Solution

(a)

V_{DC}=-0.318 V_m
V_{DC}=-0.318 (20)
V_{DC}=-6.36 V



(b)



V_{DC}=-0.318 (V_m- 0.7)
V_{DC}=-0.318 (19.3)
V_{DC}=-6.14 V

PIV (PRV)

Because the diode is only forward biased for one-half of the AC cycle, it is also reverse biased for one-half cycle.

It is important that the reverse breakdown voltage rating of the diode be high enough to withstand the peak, reverse-biasing AC voltage and avoid entering the Zener region.

PIV (or PRV) > V_m

- **PIV = Peak inverse voltage**
- **PRV = Peak reverse voltage**
- **V_m = Peak AC voltage**

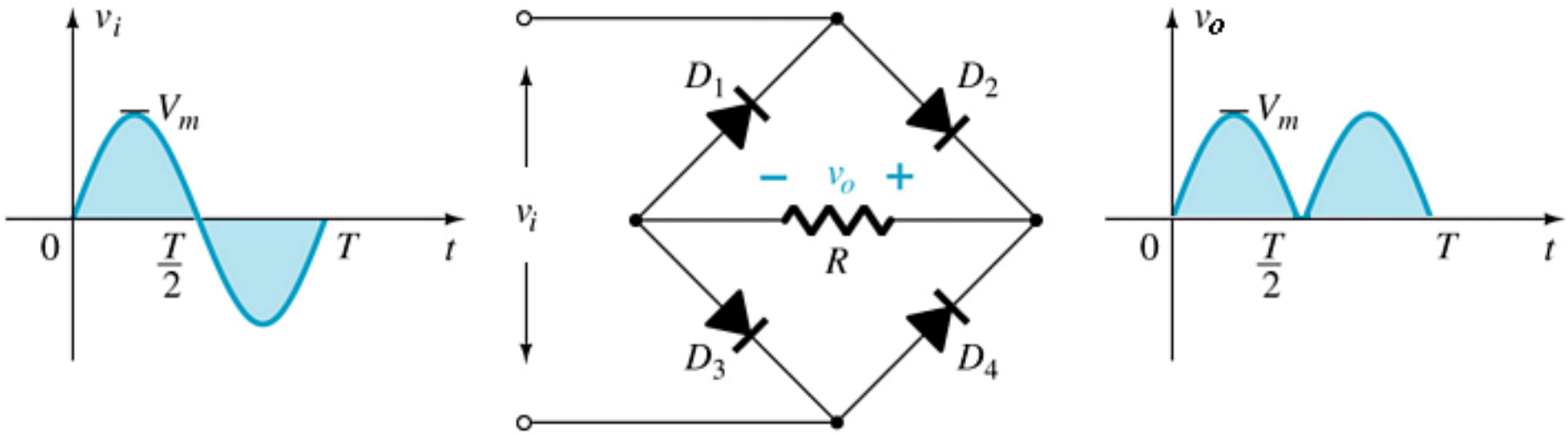
Full-Wave Rectification

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

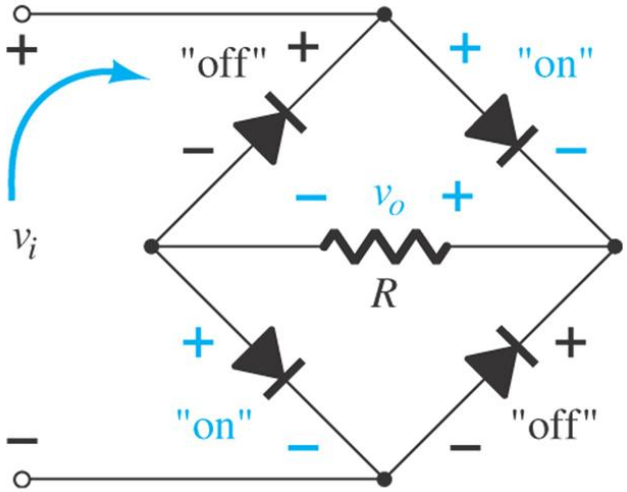
- Full-wave rectification produces a greater DC output:

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

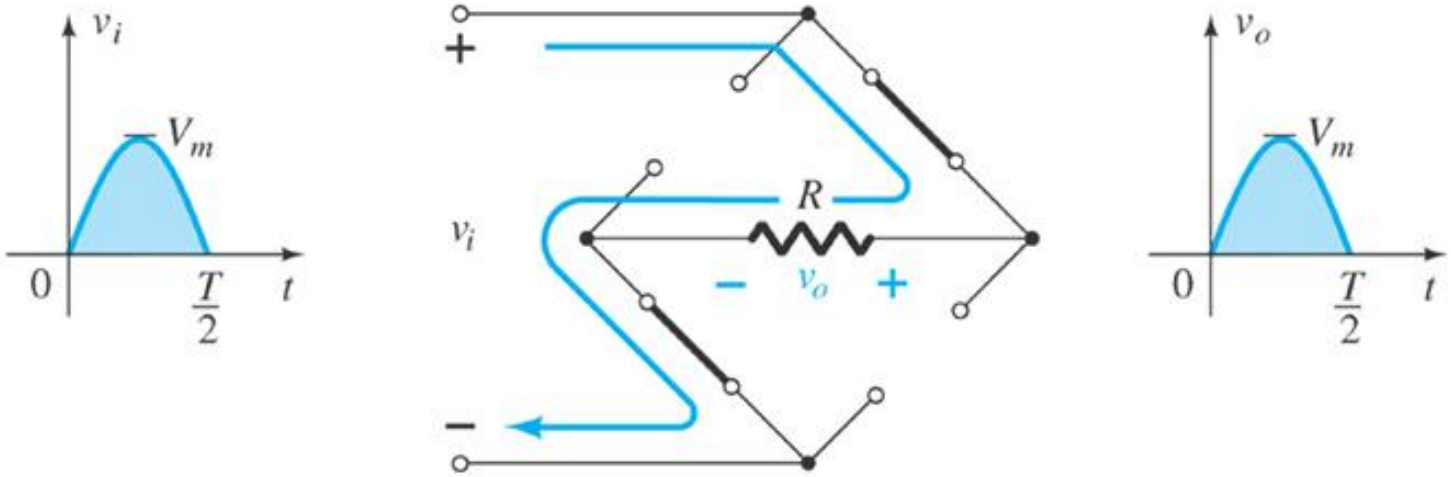
Full-Wave Rectification – Bridge Network



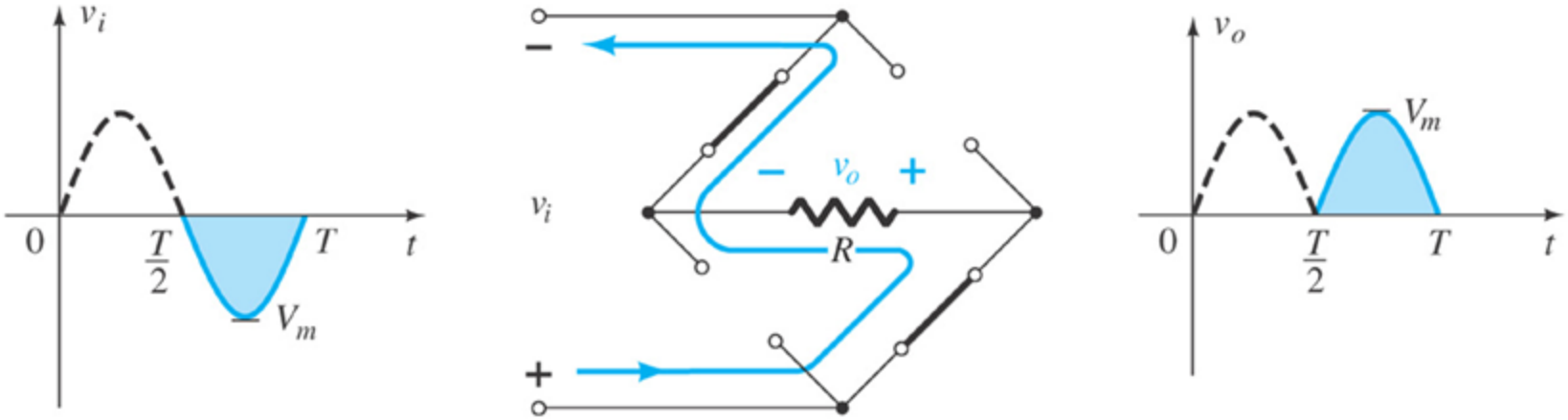
Network for the period 0 → T/2 of the input voltage v_i



Full-Wave Rectification – Bridge Network

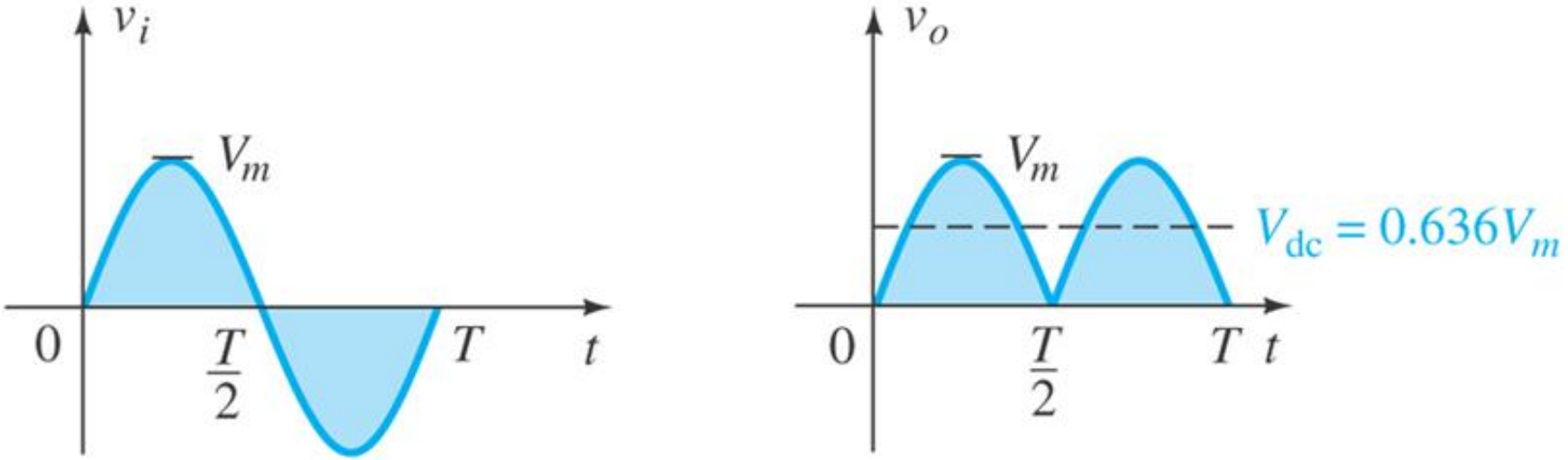


Conduction path for the positive region of v_i



Conduction path for the negative region of v_i

Full-Wave Rectification – Bridge Network



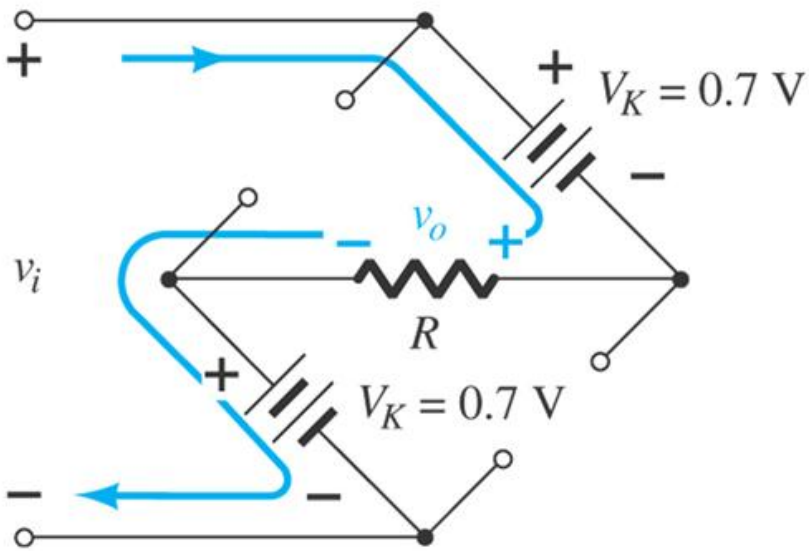
The DC level is now twice that of half wave rectifier=2(0.318V_m)

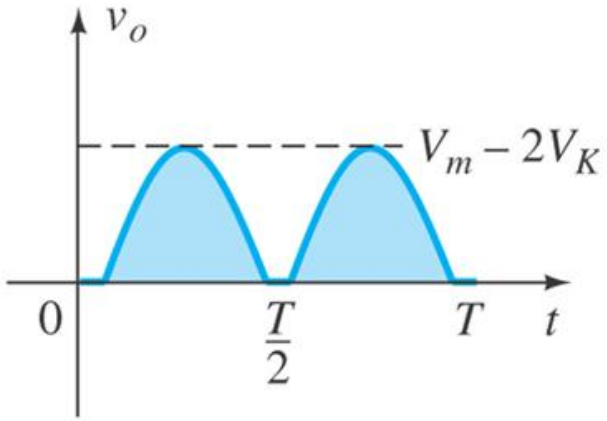
$$V_{DC}=0.636V_m$$

Full-Wave Rectification – Bridge Network

If silicon diode is used, $v_i - V_K - v_o - V_K = 0$

$$v_o = v_i - 2V_K$$

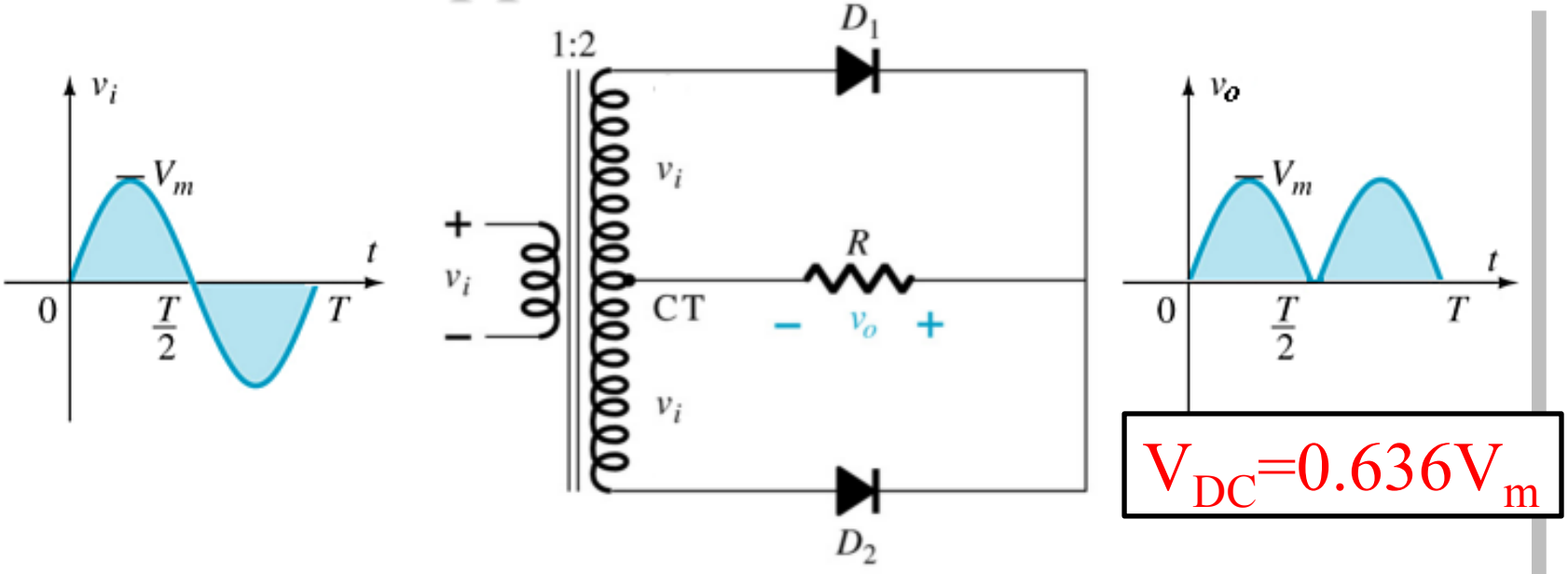


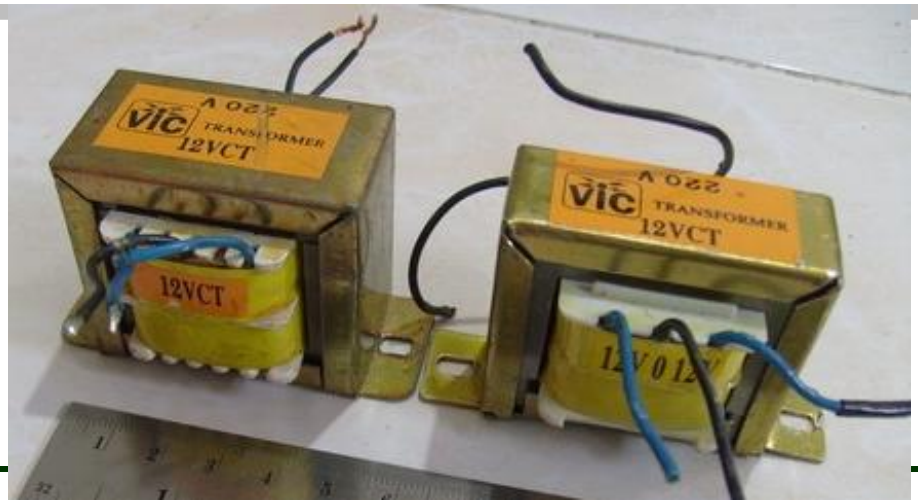


$$V_{o\,max} = V_m - 2V_K$$

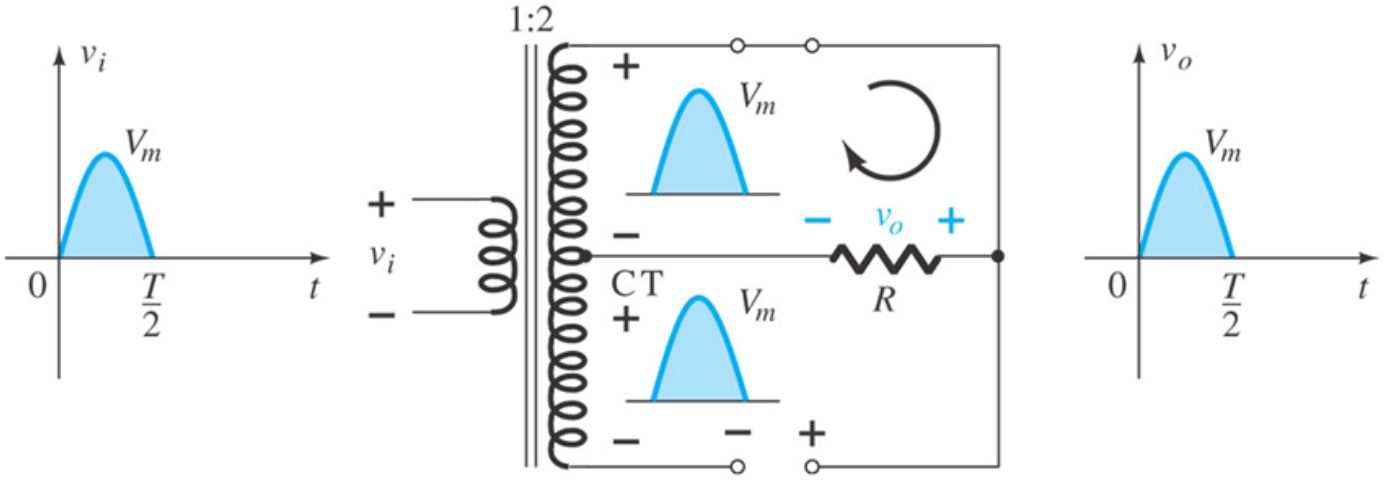
For $V_m >> 2V_k$: $V_{DC} \approx 0.636\,(V_m - 2V_K)$

Full-Wave Rectification
Center Tapped Transformer Rectifier

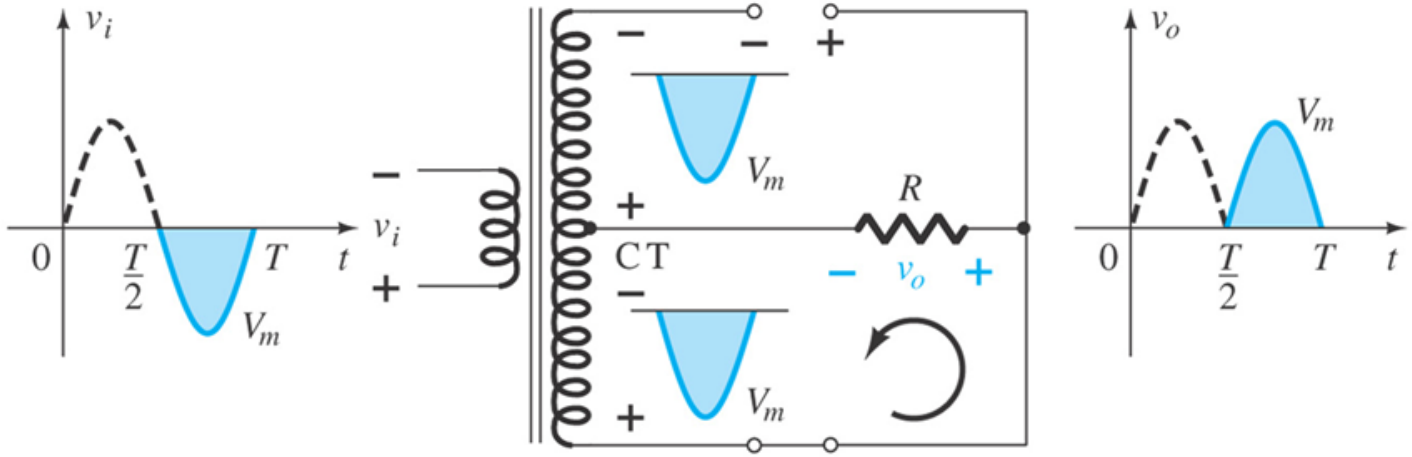




Center Tapped Transformer Rectifier



Network conditions for the positive region of v_i



Network conditions for the negative region of v_i

Summary of Rectifier Circuits

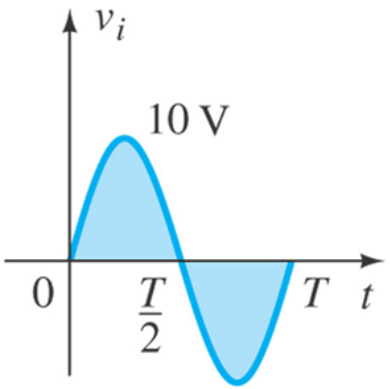
Rectifier	Ideal V_{DC}	Realistic V_{DC}
Half Wave Rectifier	$V_{DC} = 0.318\,V_m$	$V_{DC} = 0.318(V_m - 0.7)$
Bridge Rectifier	$V_{DC} = 0.636\,V_m$	$V_{DC} = 0.636(V_m - 2(0.7))$
Center-Tapped Transformer Rectifier	$V_{DC} = 0.636\,V_m$	$V_{DC} = 0.636(V_m - 0.7)$

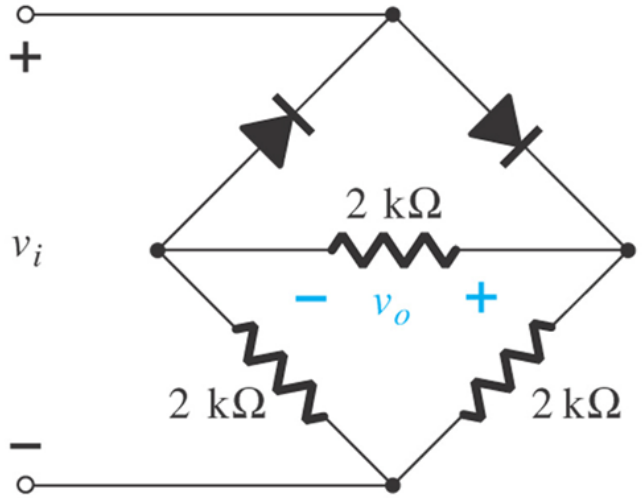
V_m = peak of the AC voltage.

In the center tapped transformer rectifier circuit, the peak AC voltage is the transformer secondary voltage to the tap.

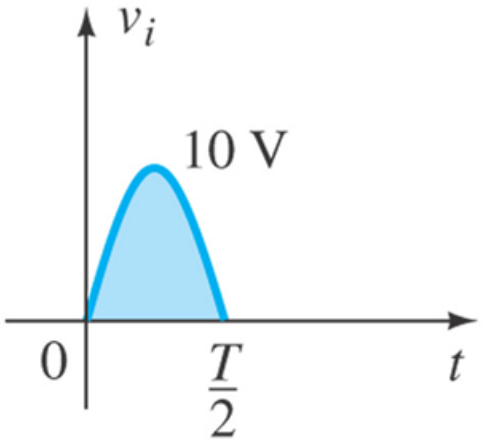
Example 2.17

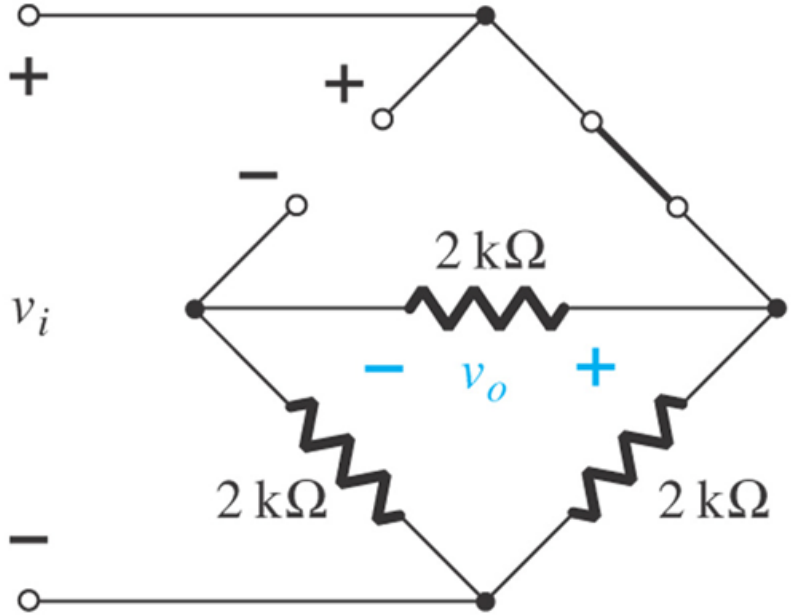
Determine the output waveform for the network and calculate the output dc level.





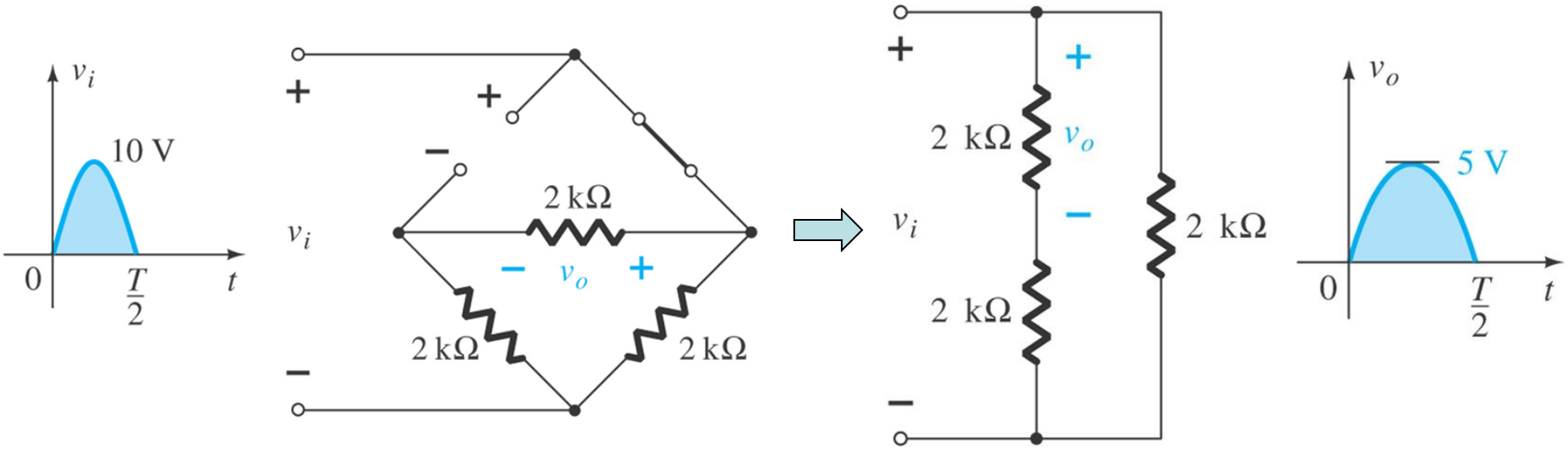
Solution

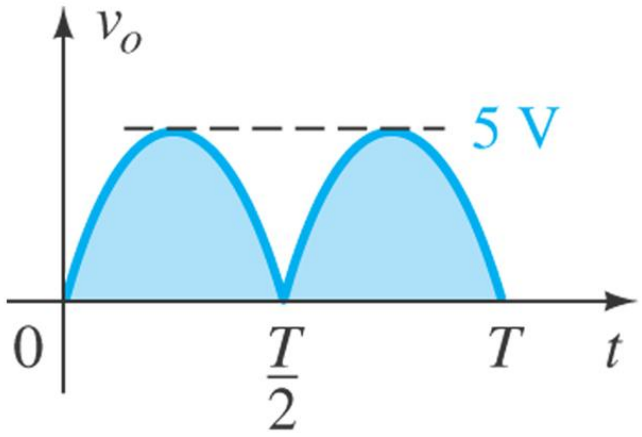




Network for the positive region of v_i

Example 2.17 - Solution





Resulting output

$v_o=(1/2)\ v_i$

$V_{omax}=(1/2)\ V_{imax}=(1/2)\ 10=5V$

$V_{DC}=0.636(5V)=3.18\ V.$

For the negative part the roles of the diodes are interchanged and v_o appears as shown in figure.

Full Wave Rectifier with Smoothing Capacitor (AC to DC Converter)