Diode Applications

Dr. Lasith Yasakethu

DC Power Supply

- Active electronic devices require a source of constant DC that can be supplied by a battery or a DC power supply
- The DC power supply converts the standard AC voltage (230 V,50 Hz) available at wall outlets into a constant DC voltage

How?

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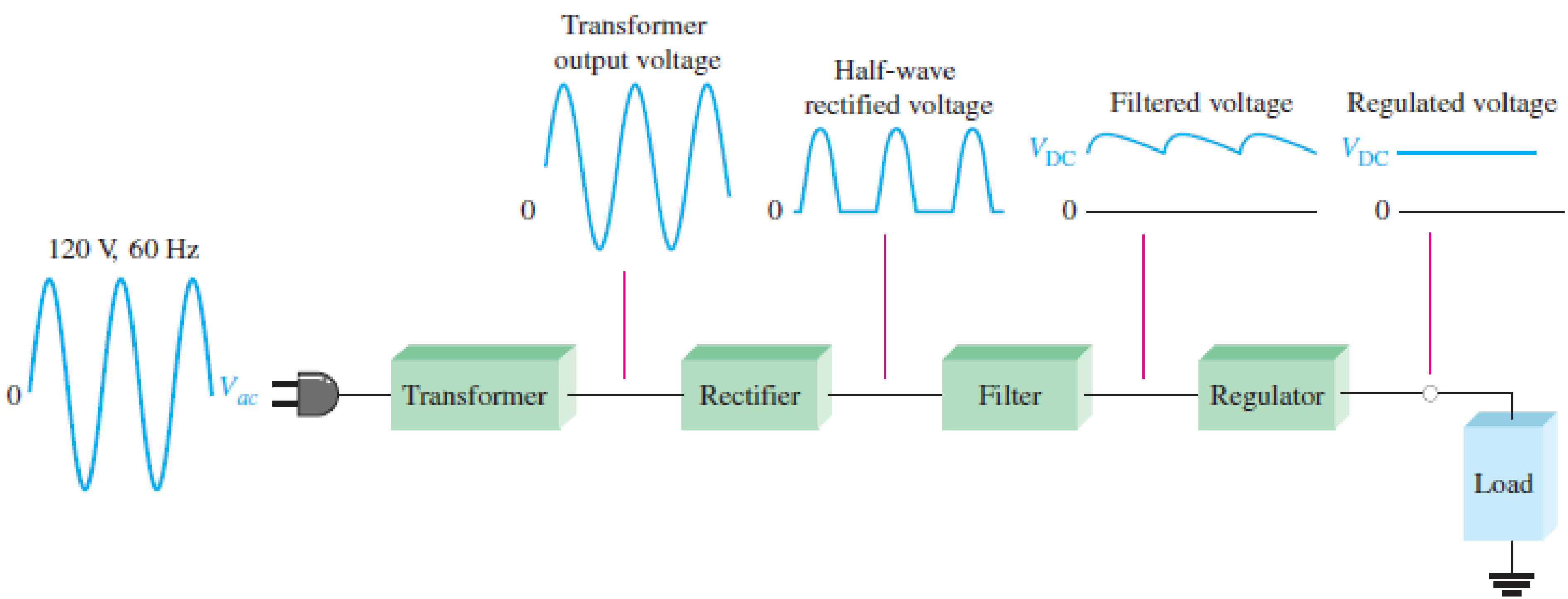
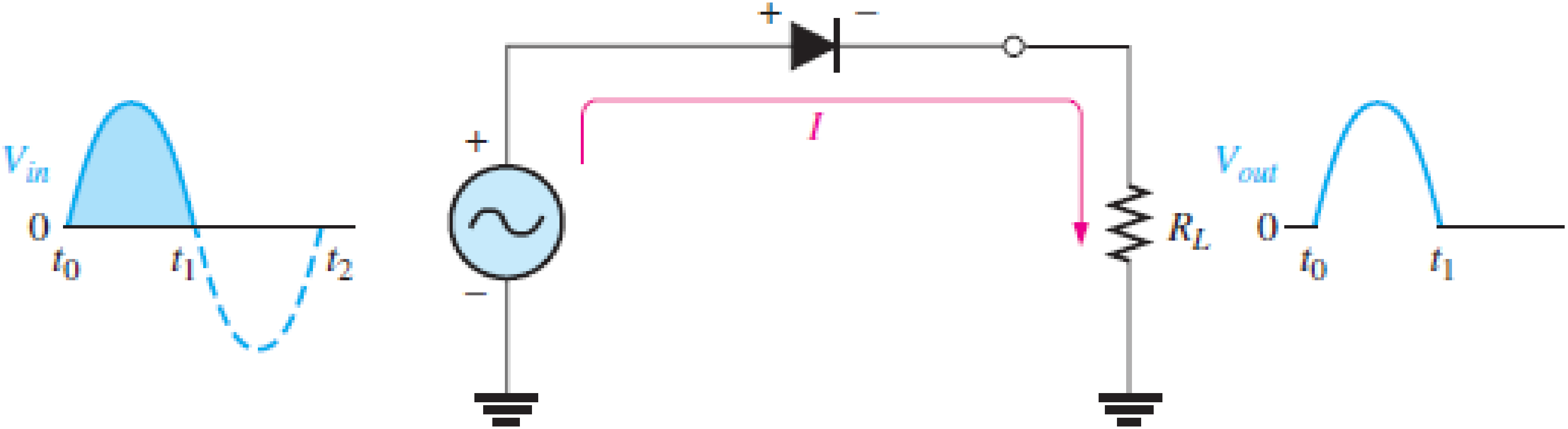
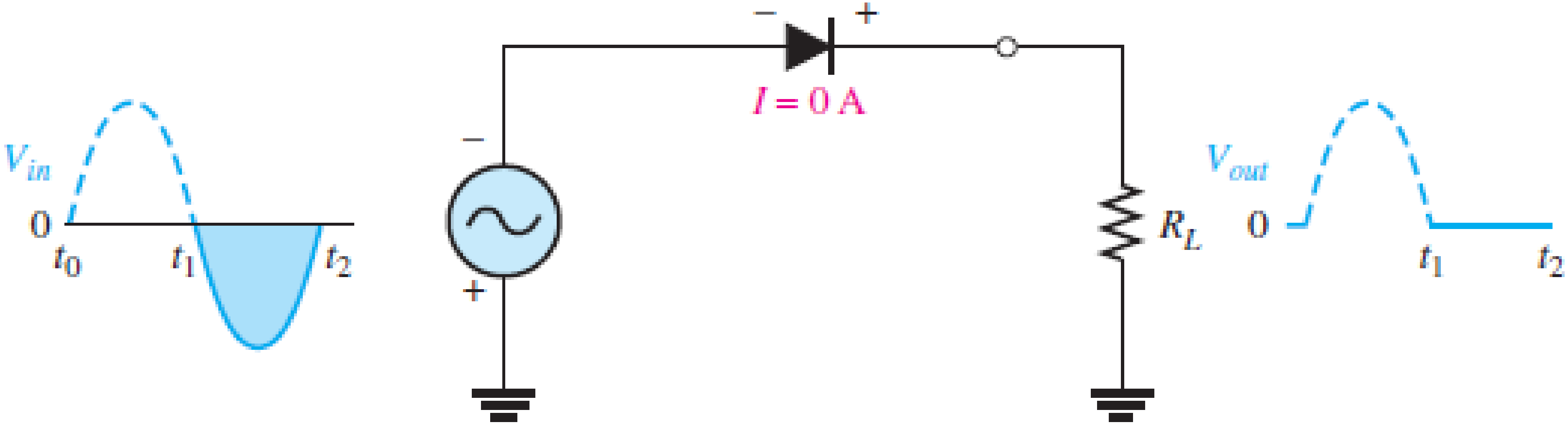


Half-Wave Rectifier



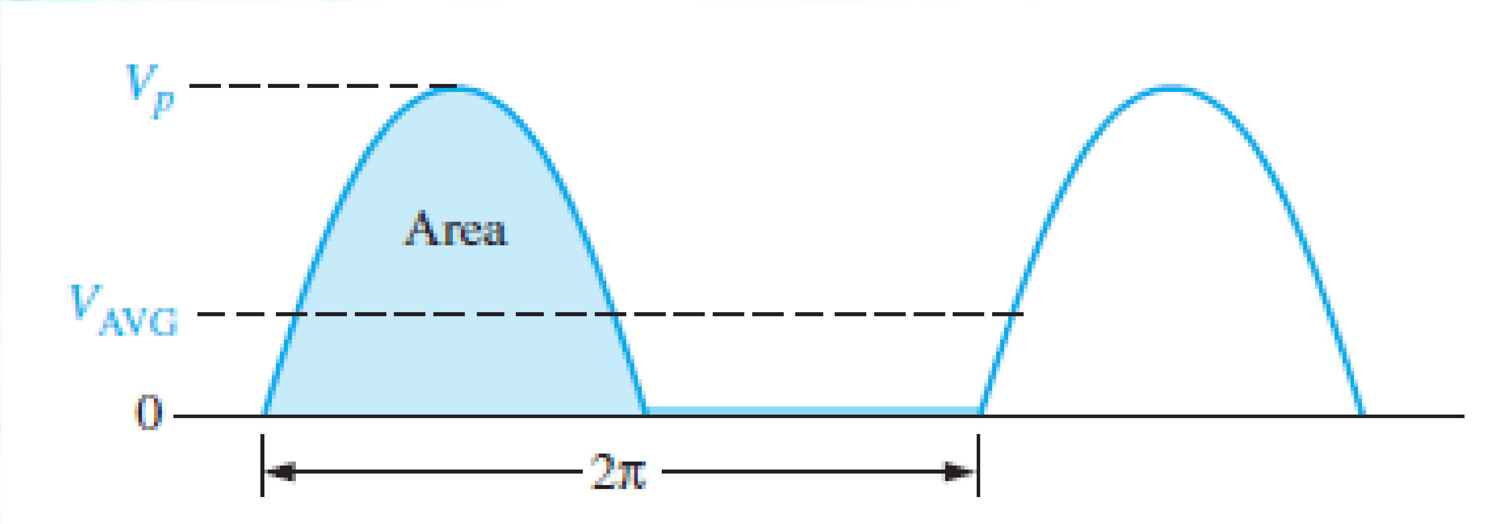


Half-Wave Rectifier

- **Average Value of the Half-Wave Output Voltage**
  - Is the value you would measure on a DC voltmeter
  - Mathematically, it is determined by finding the area under the curve over a full cycle, and then dividing by 2π

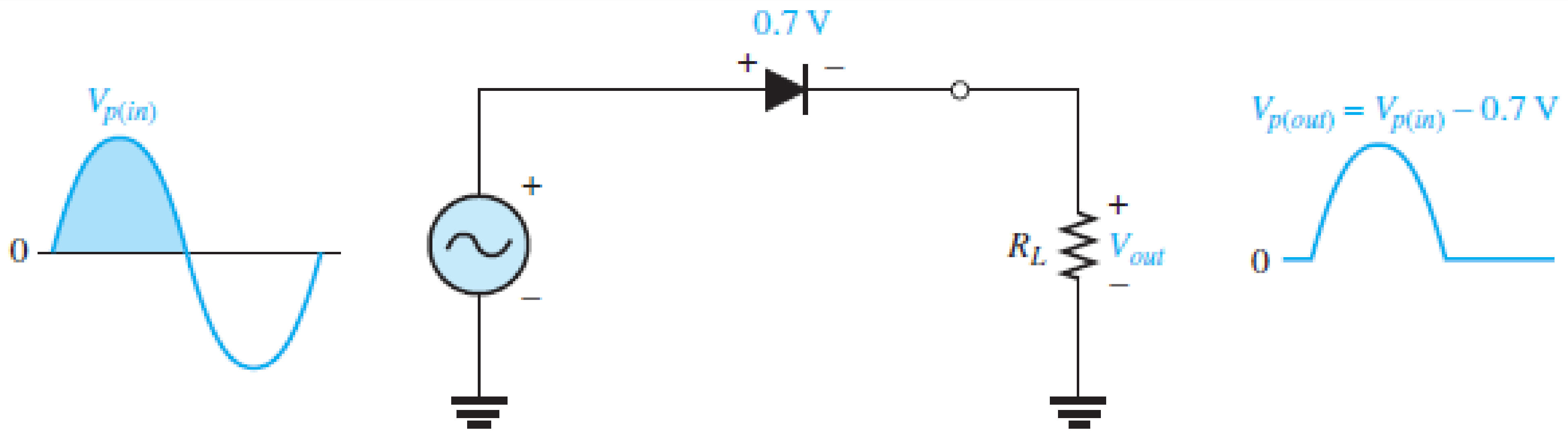
$$V_{avg} = \frac{V_p}{\pi} = 0.318V_p$$

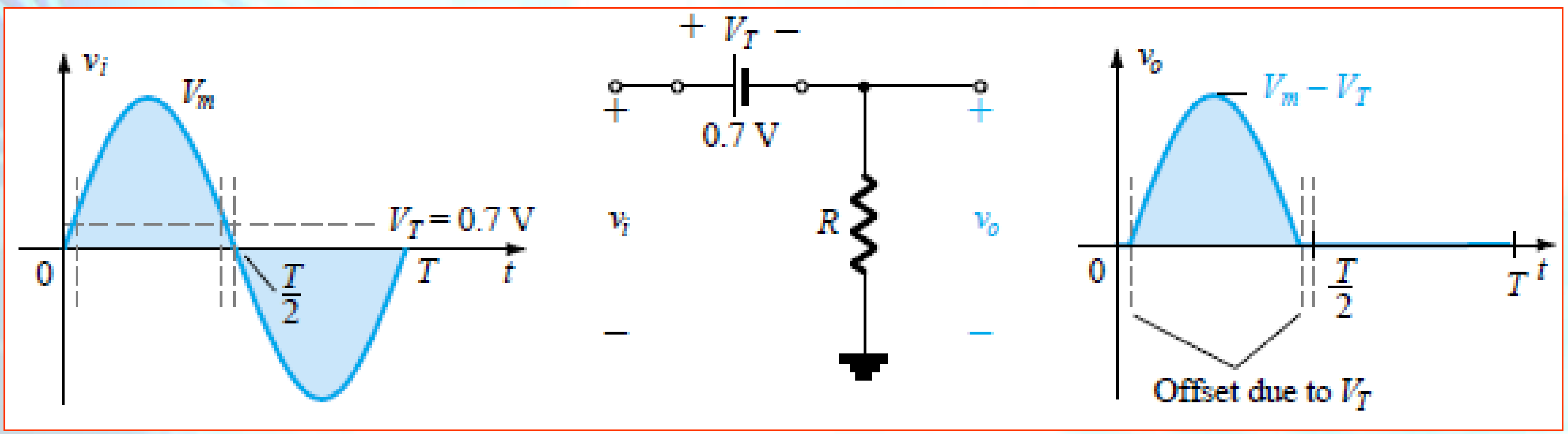
Notice that V_{AVG} is 31.8% of V_p.



Half-Wave Rectifier

- **With practical diodes**

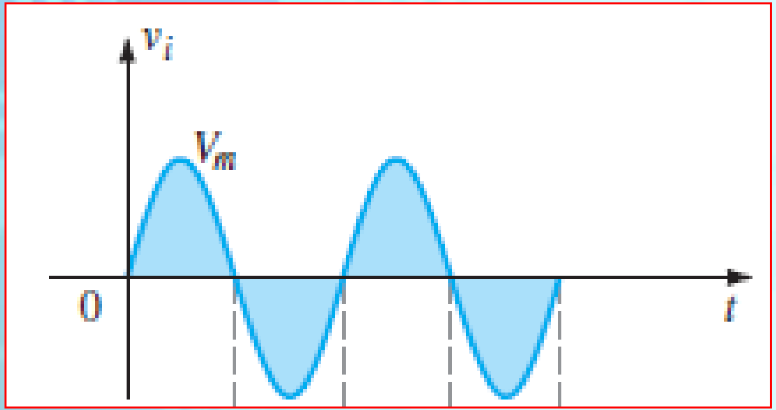


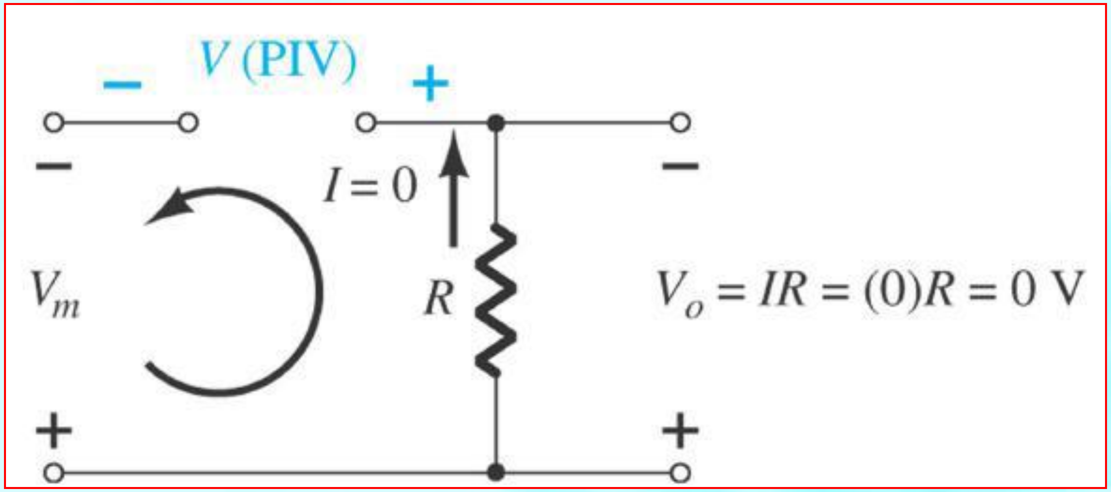


Half-Wave Rectifier

- **Peak Inverse Voltage (PIV)**
  - The diode is only forward biased for one-half of the AC cycle, it is also reverse biased for one-half cycle
  - PIV rating of the diode is of primary importance in the design of rectification systems
  - PIV rating of the diode must not be exceeded when the diode is reverse biased

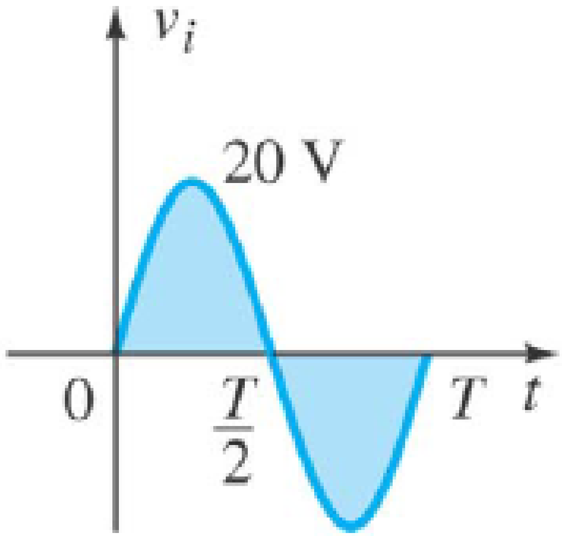
$$\mathbf{PIV} > V_m$$

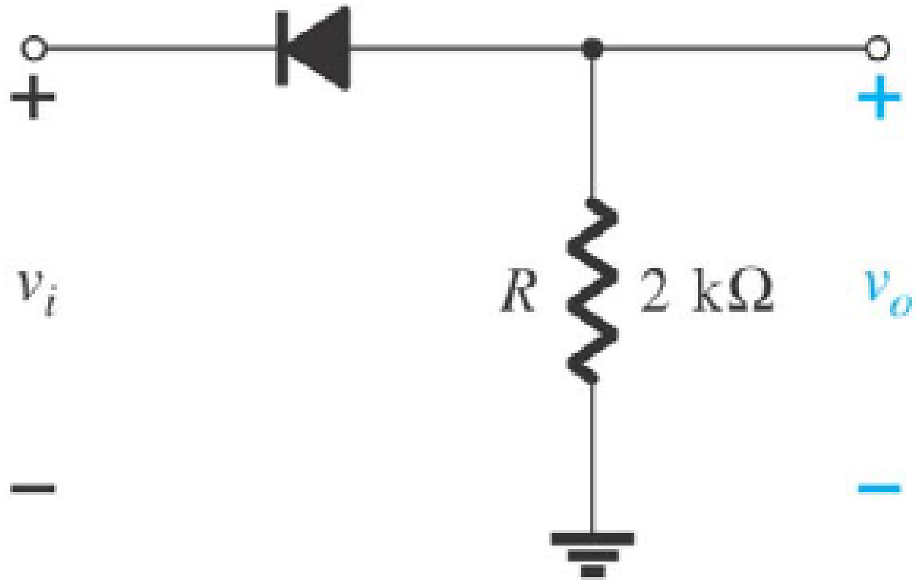




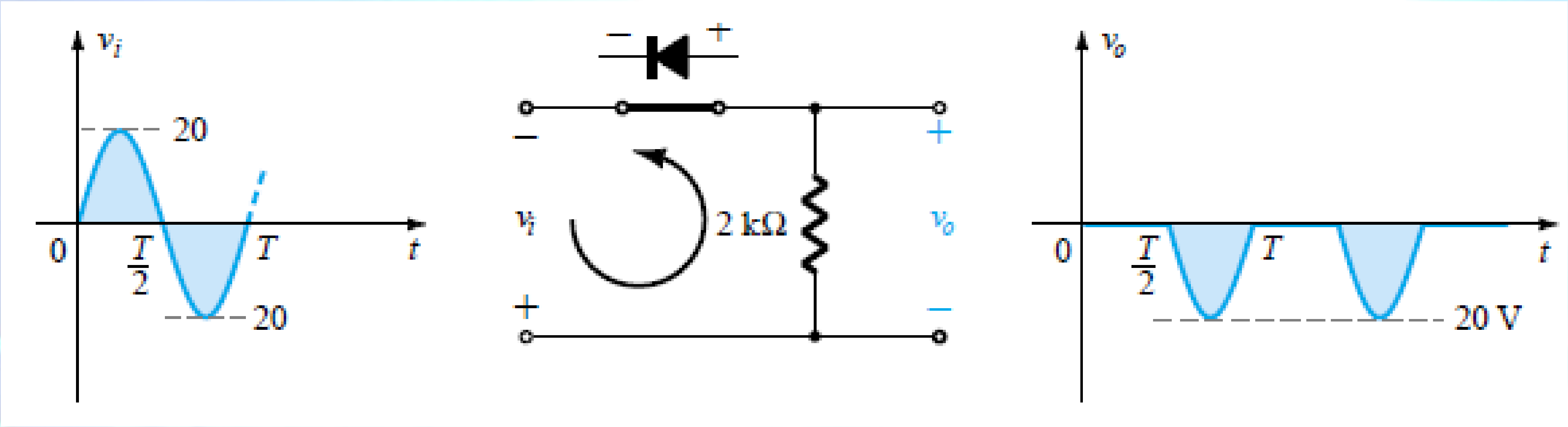
Problem

- Sketch V_o and calculate the average output voltage assuming an ideal diode





Solution



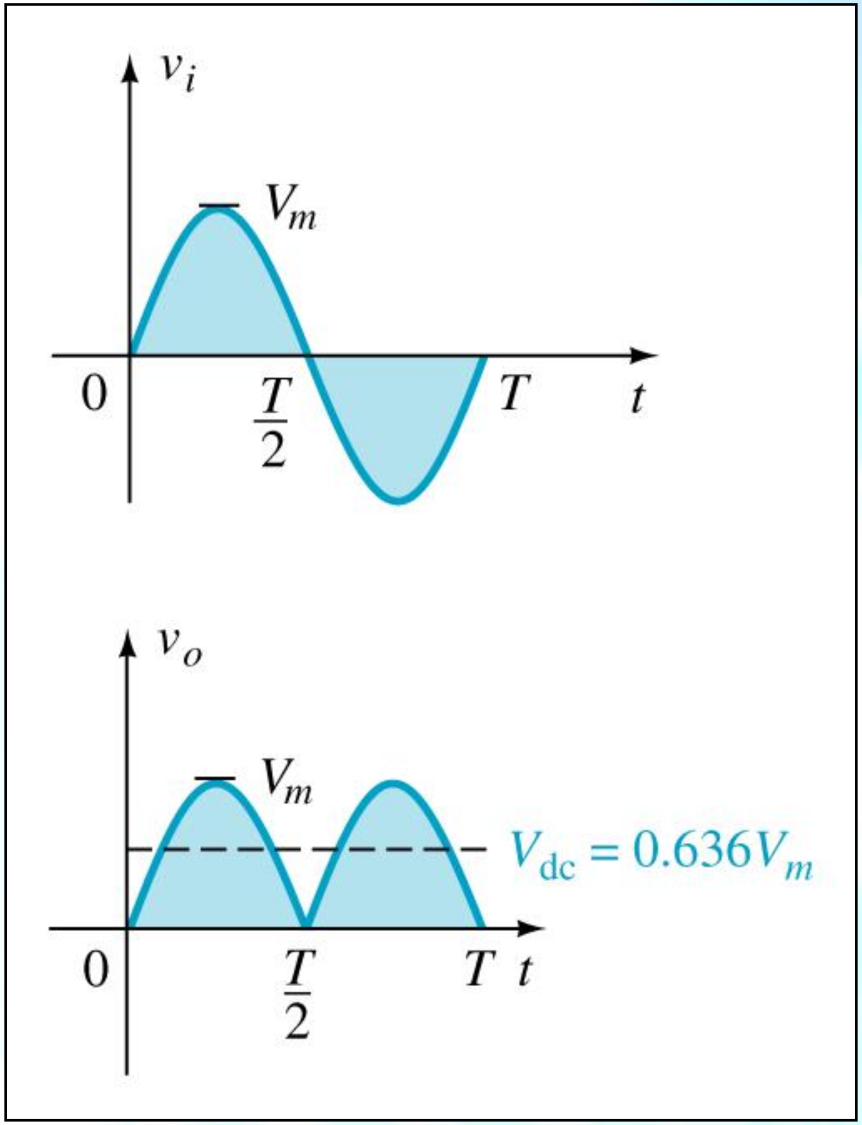
$$V_{avg} = \frac{Vp}{\pi} = \frac{(-20)}{\pi} = -6.37\,V$$

Full Wave Rectifier

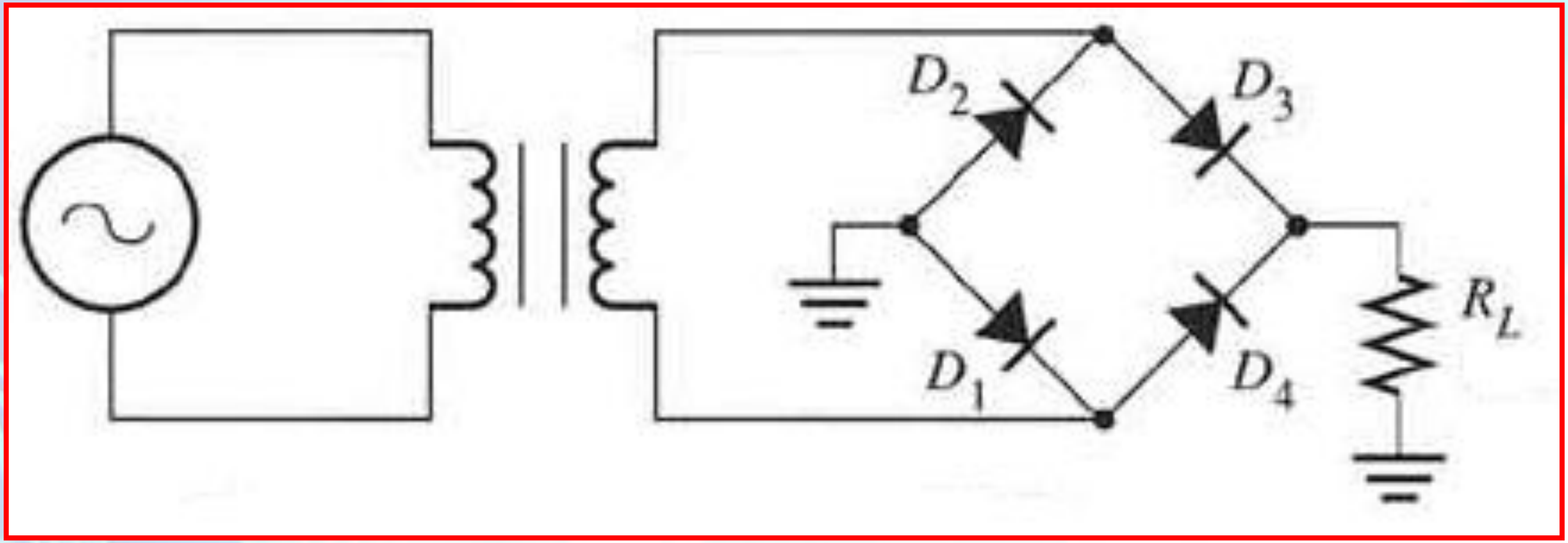
- The rectification process can be improved by using a full-wave rectifier circuit
- Full-wave rectification produces a greater DC output:

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

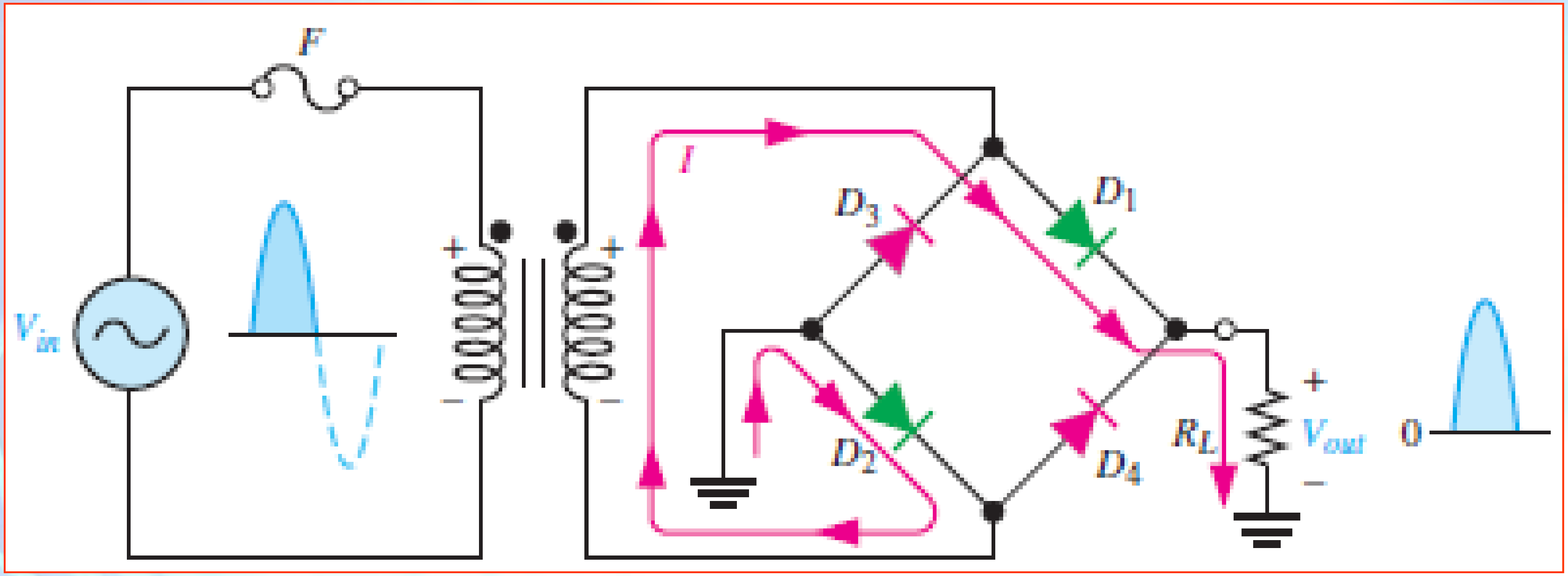
Full-wave: $V_{dc} = 0.636V_m$

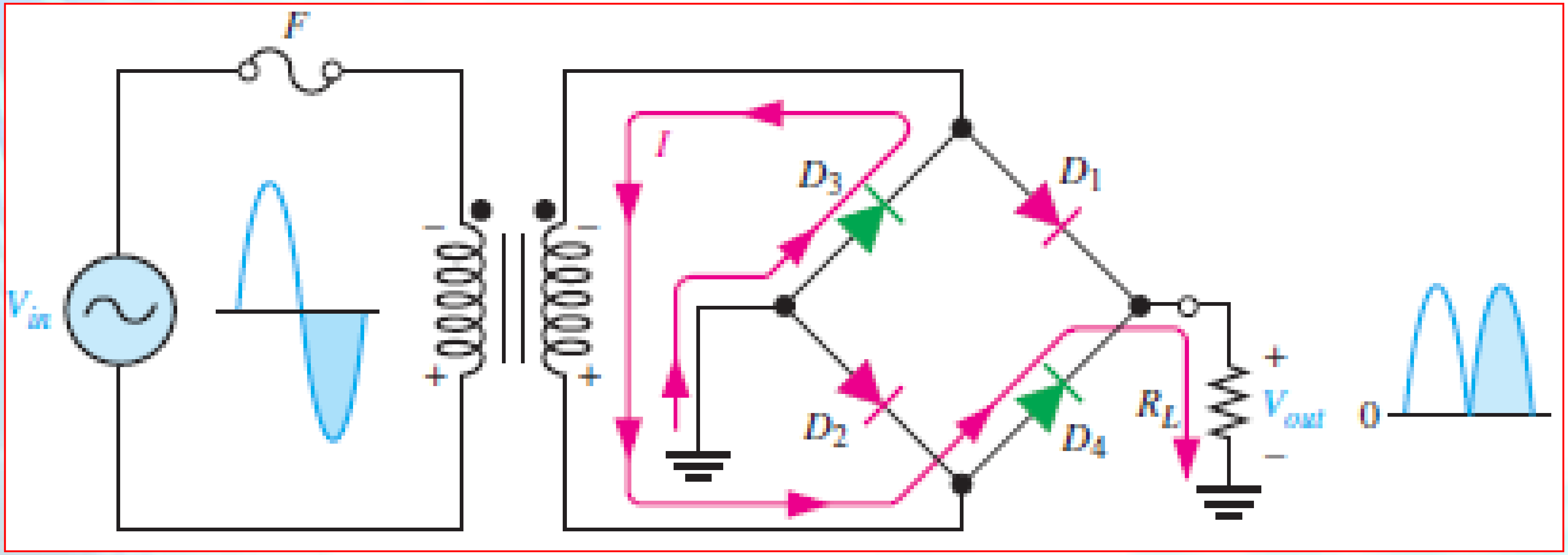


Bridge Full Wave Rectifier

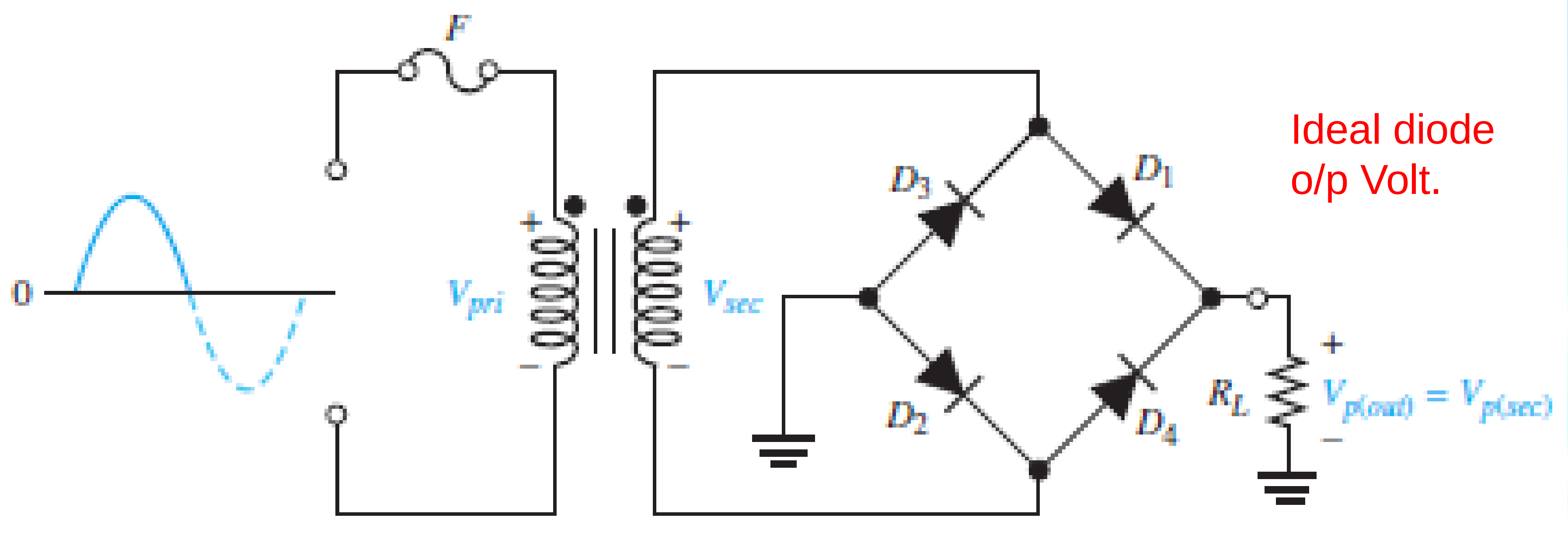


Bridge Full Wave Rectifier

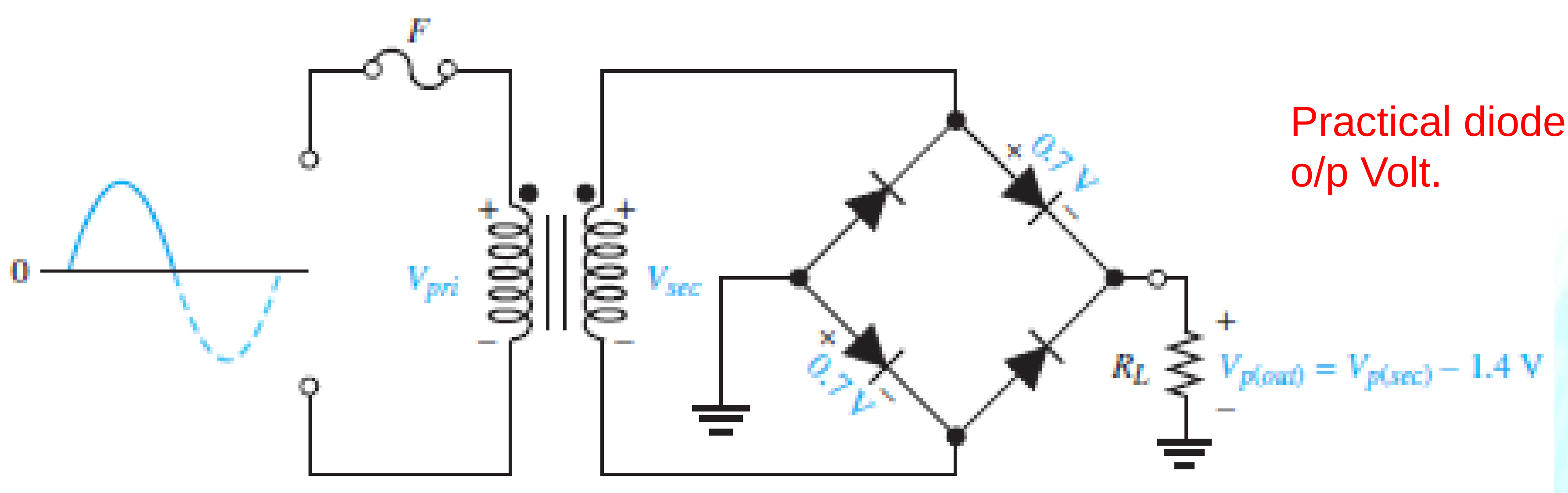




Bridge Full Wave Rectifier

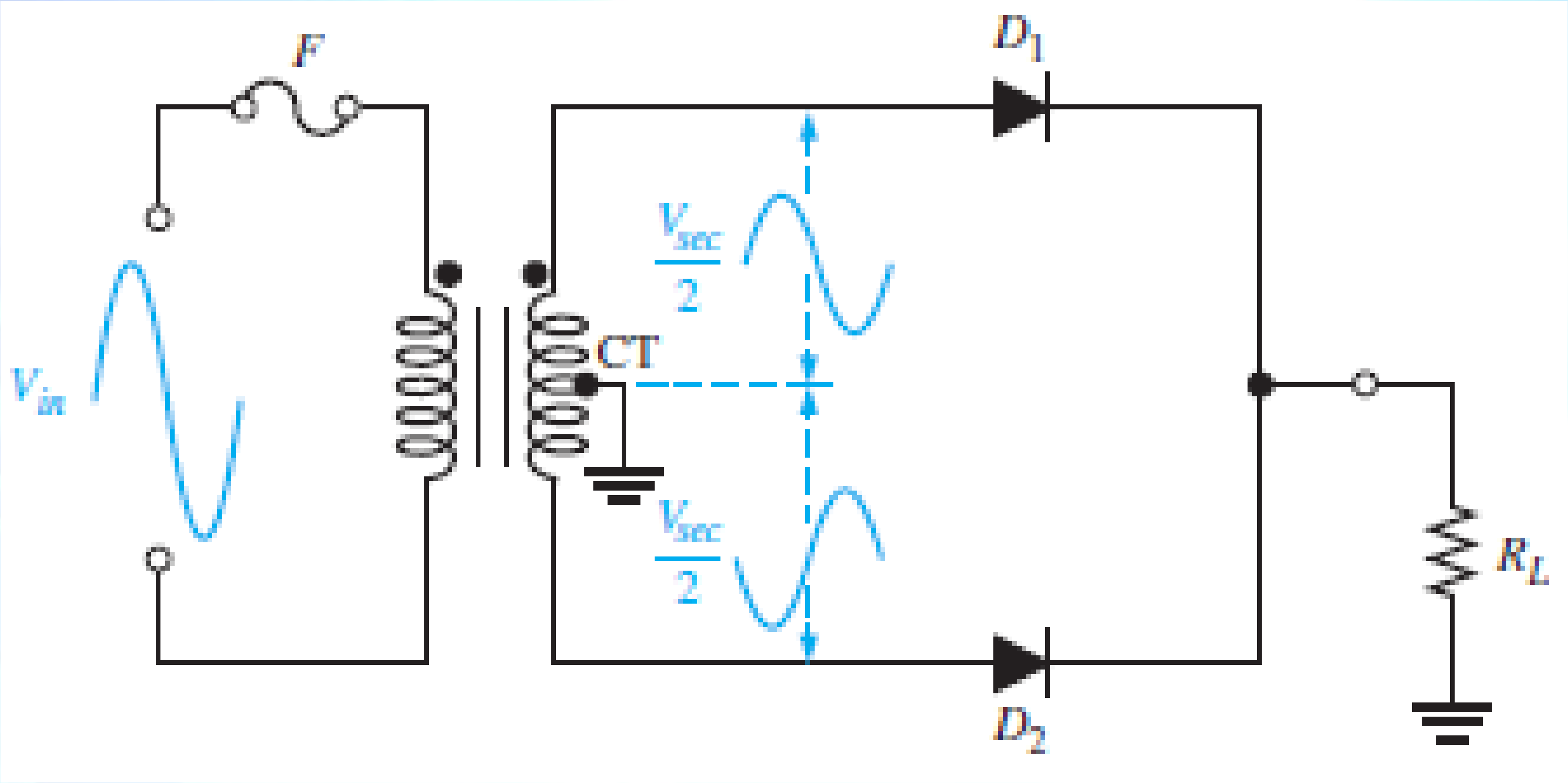


Ideal diode
o/p Volt.



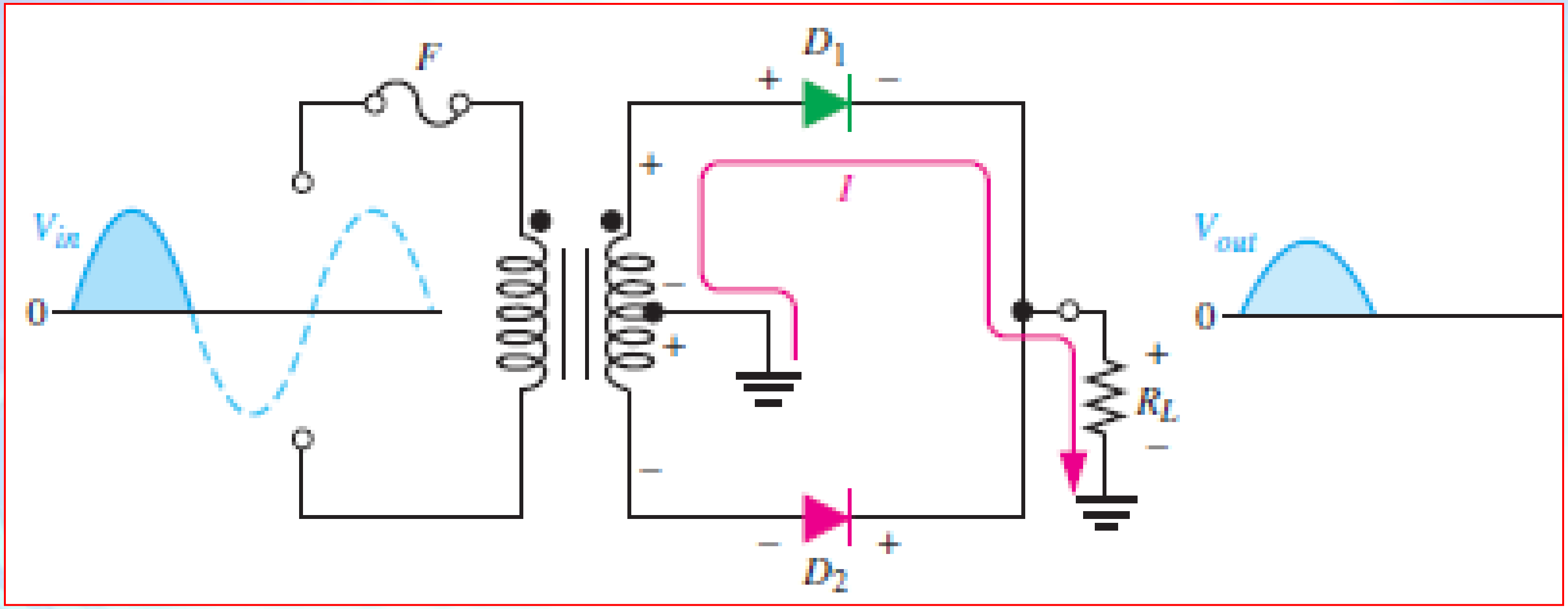
Practical diode
o/p Volt.

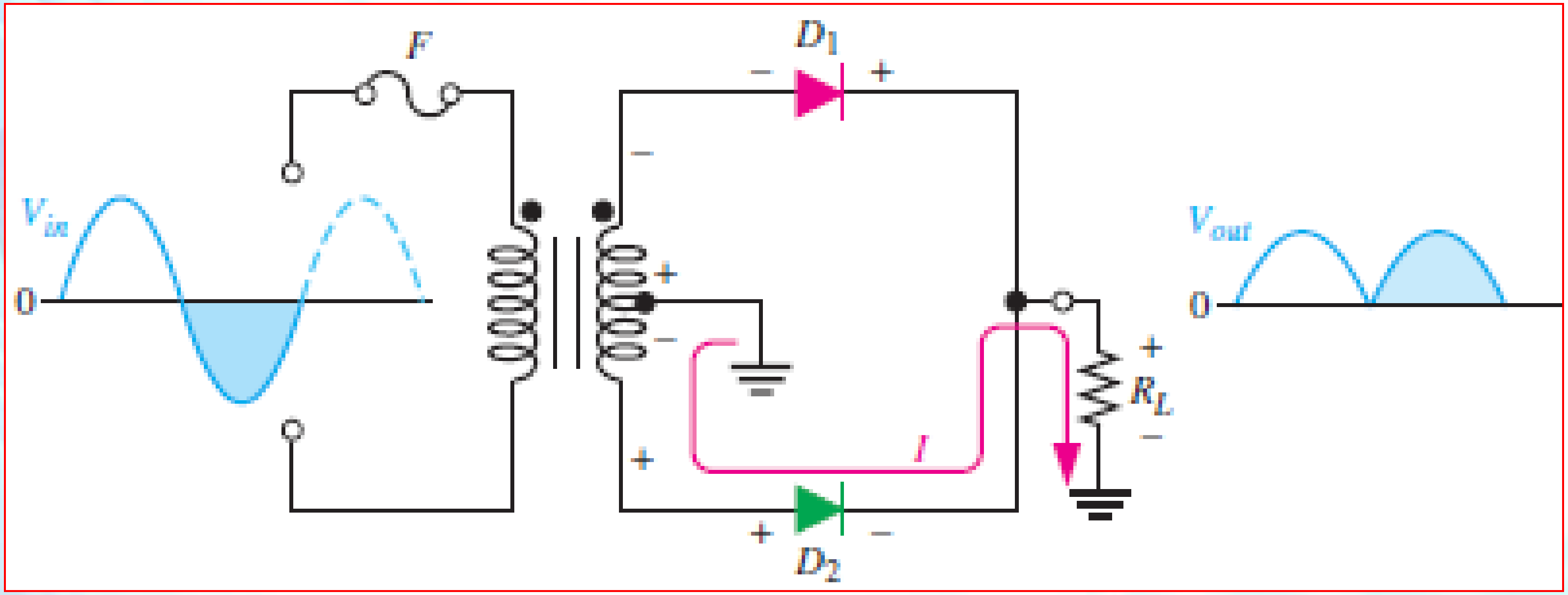
Center-tapped Full Wave Rectifier



- Half of the total secondary voltage appears between the center tap and each end of the secondary winding

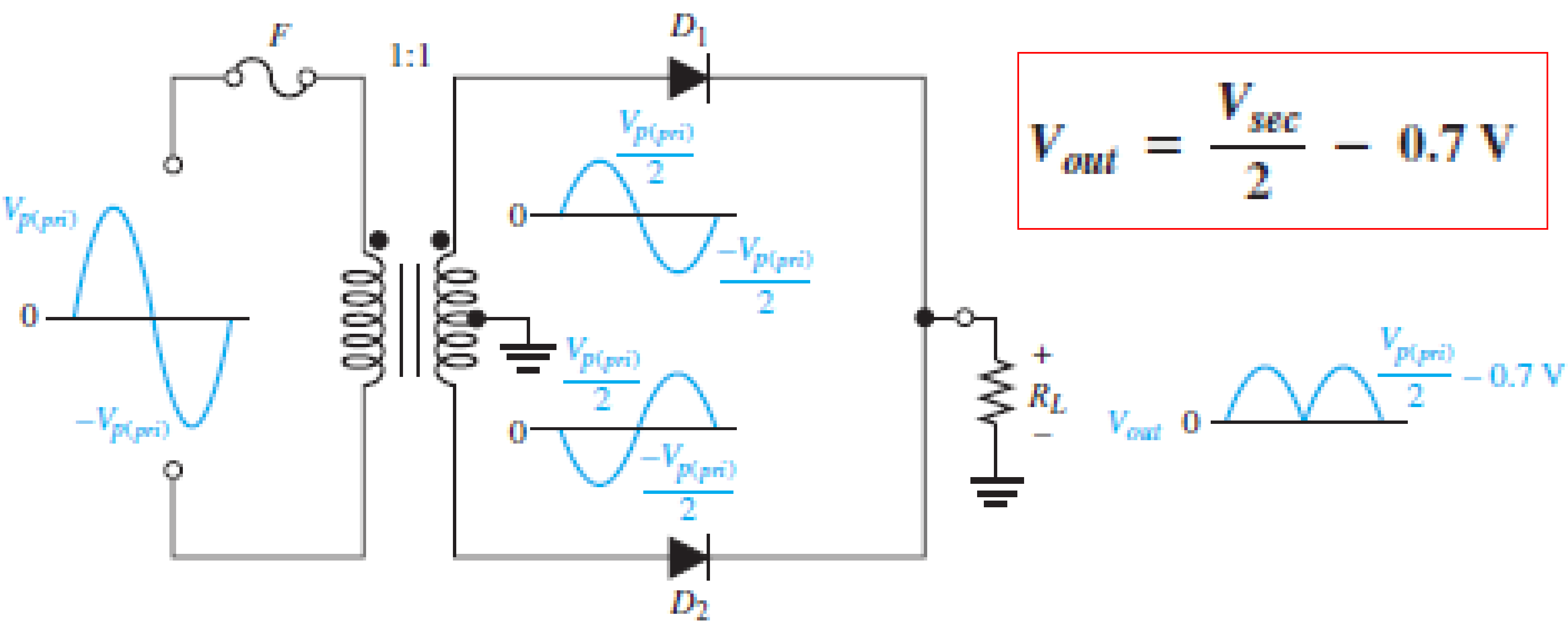
Center-tapped Full Wave Rectifier





Center-tapped Full Wave Rectifier

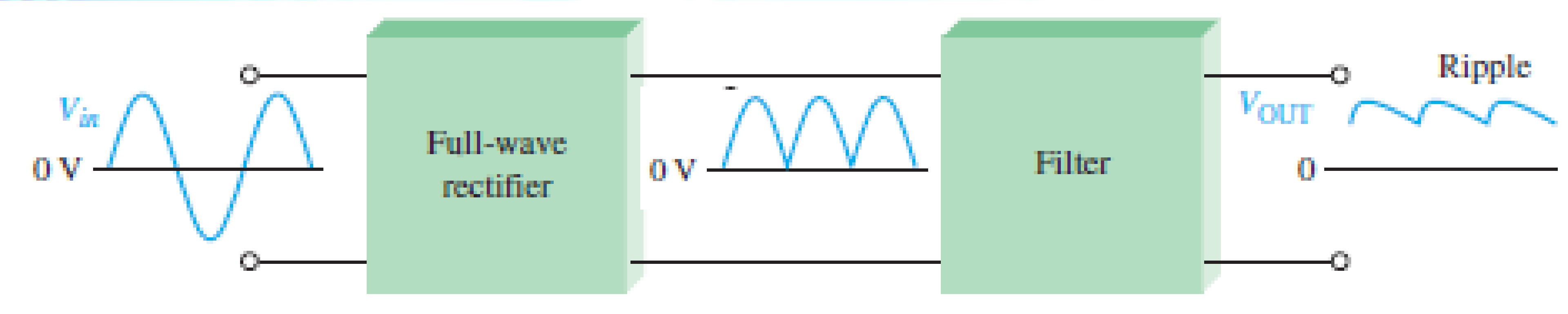
- Output voltage (practical diodes)
  - The output voltage is one-half of the total secondary voltage less the diode drop



$$\boxed{V_{out} = \frac{V_{sec}}{2} - 0.7\ \mathrm{V}}$$

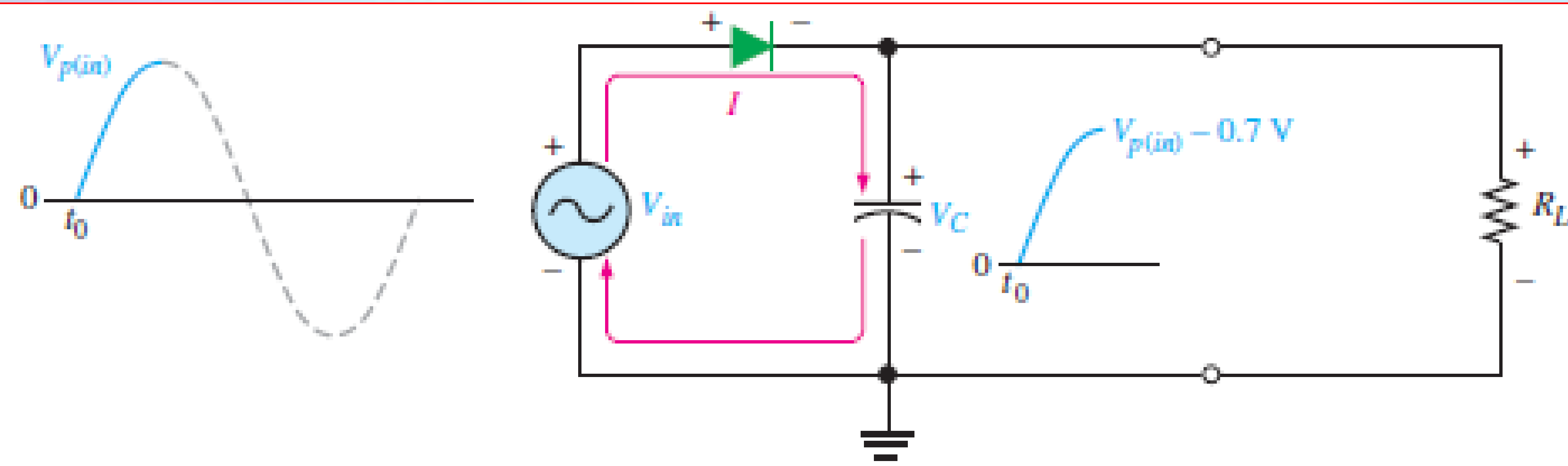
Capacitor Filter

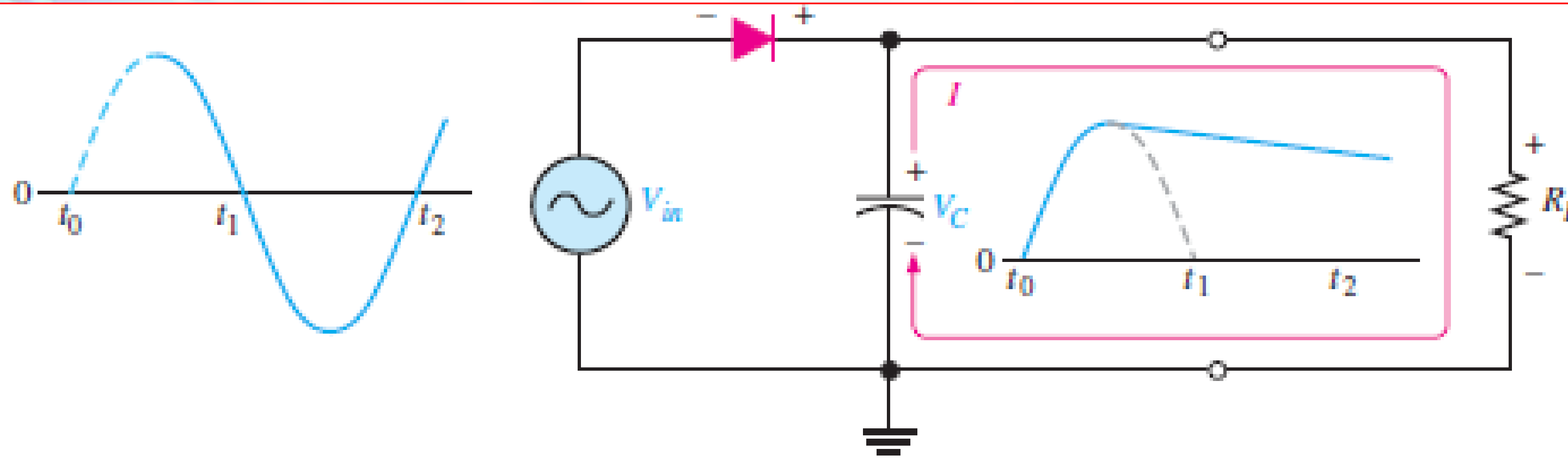
- Capacitor filters ideally eliminates the fluctuations in the output voltage of a half-wave or full-wave rectifier and produces a constant-level DC voltage
- Filtering is necessary because electronic circuits require a constant source of DC voltage and current to provide power and biasing for proper operation



Capacitor Filter

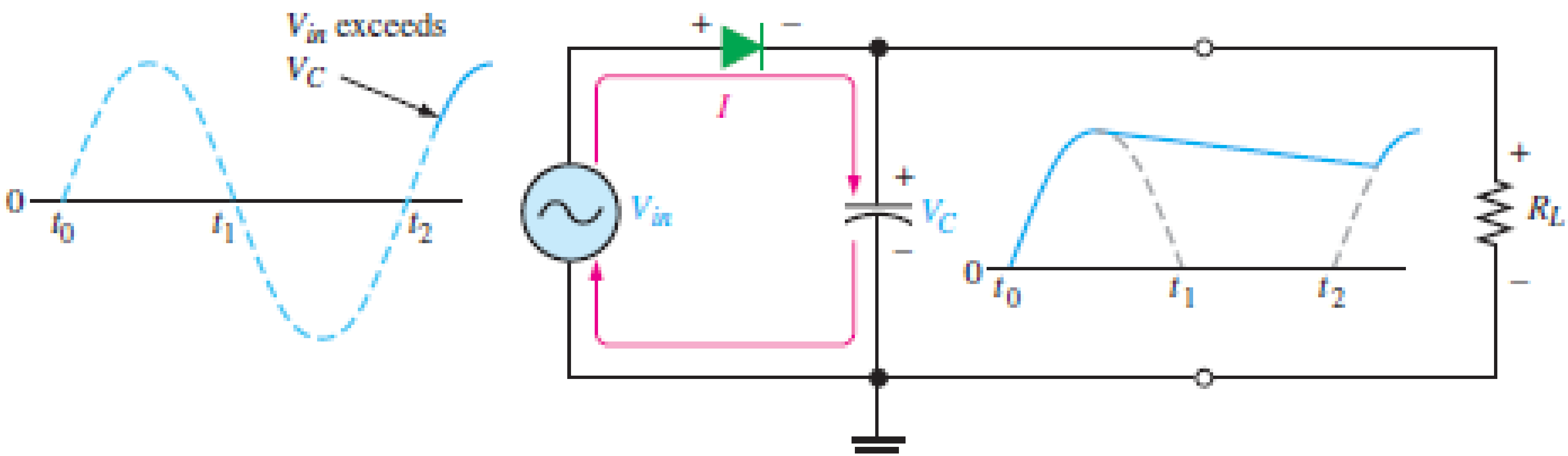
- Half-wave rectifier with capacitor input





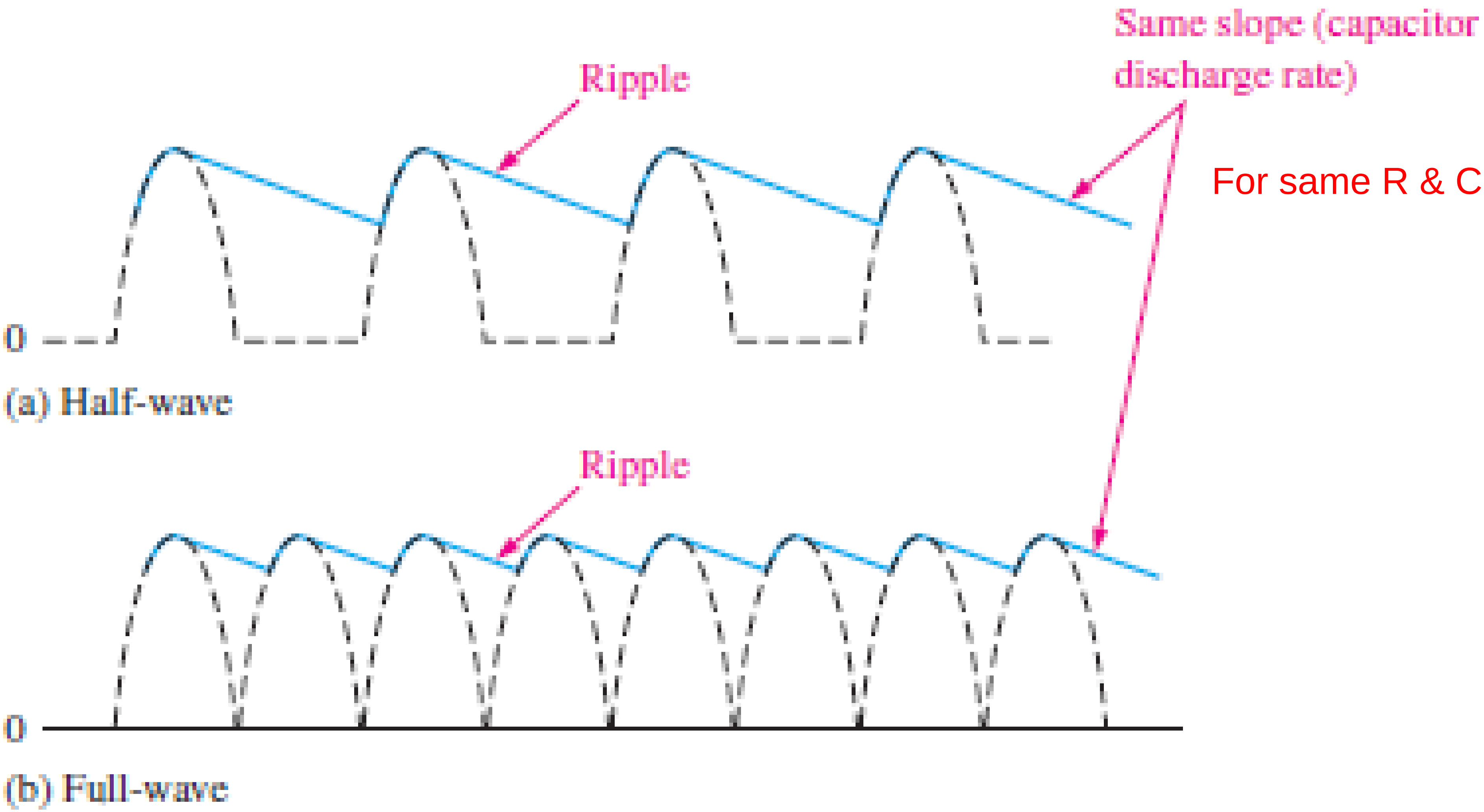
Capacitor Filter

- Discharge rate of the capacitor is determined by the time constant: RC
  - The larger the time constant, the less the capacitor will discharge
- When the input voltage exceeds the capacitor voltage by approximately 0.7V again the diode will conduct and capacitor will charge



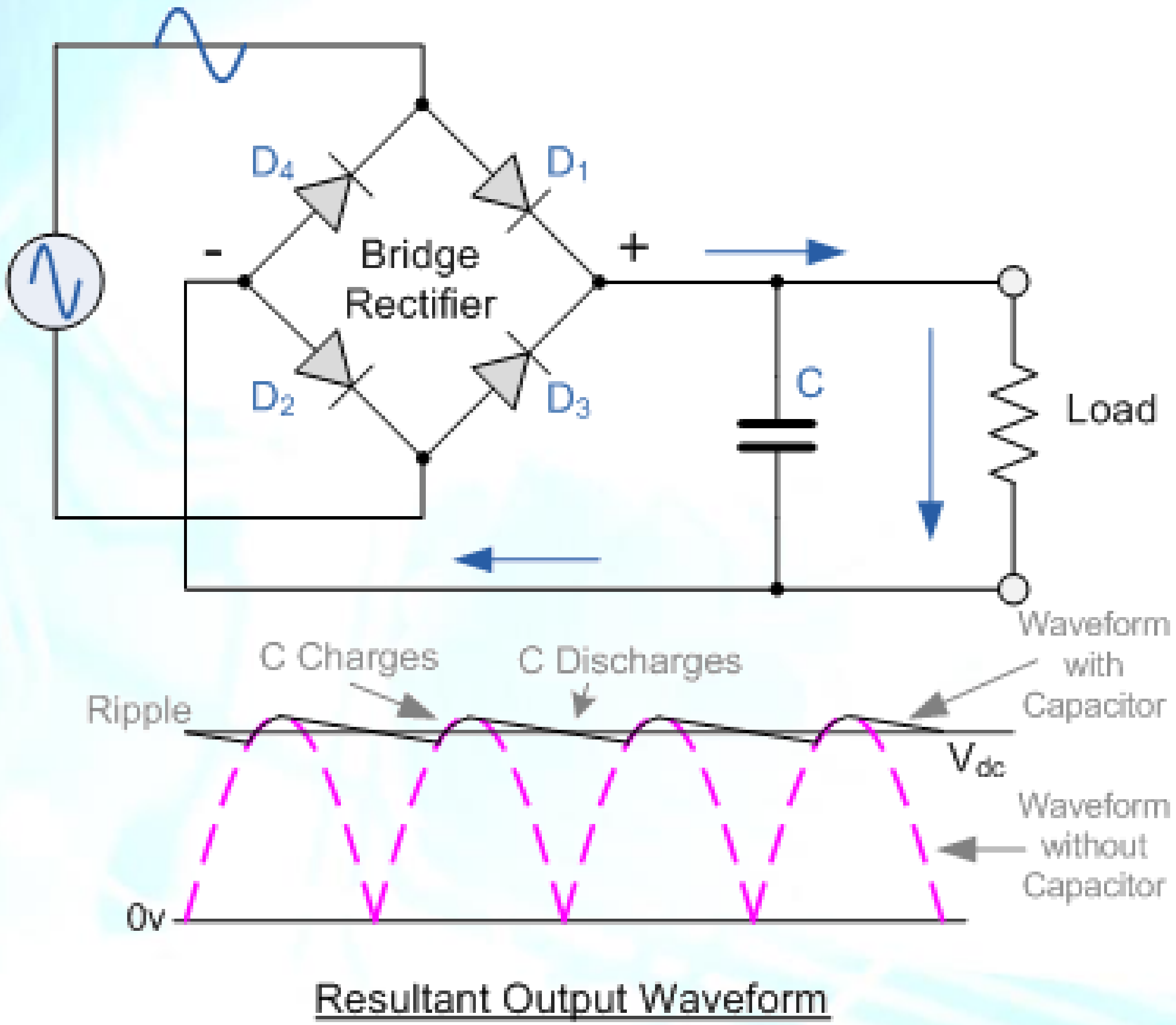
Capacitor Filter

- Ripple voltage



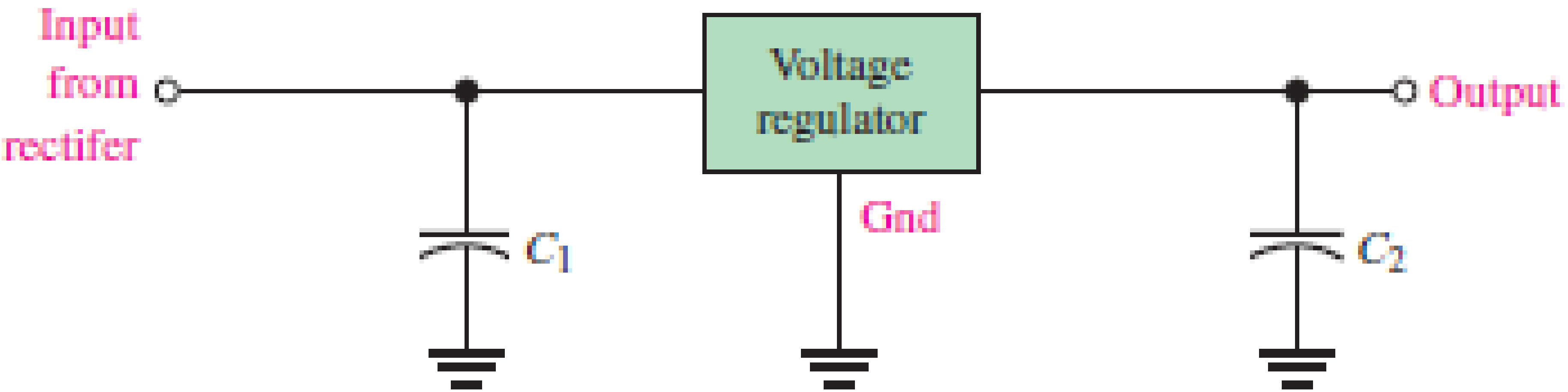
Capacitor Filter

- Ripple voltage : Full wave rectifier



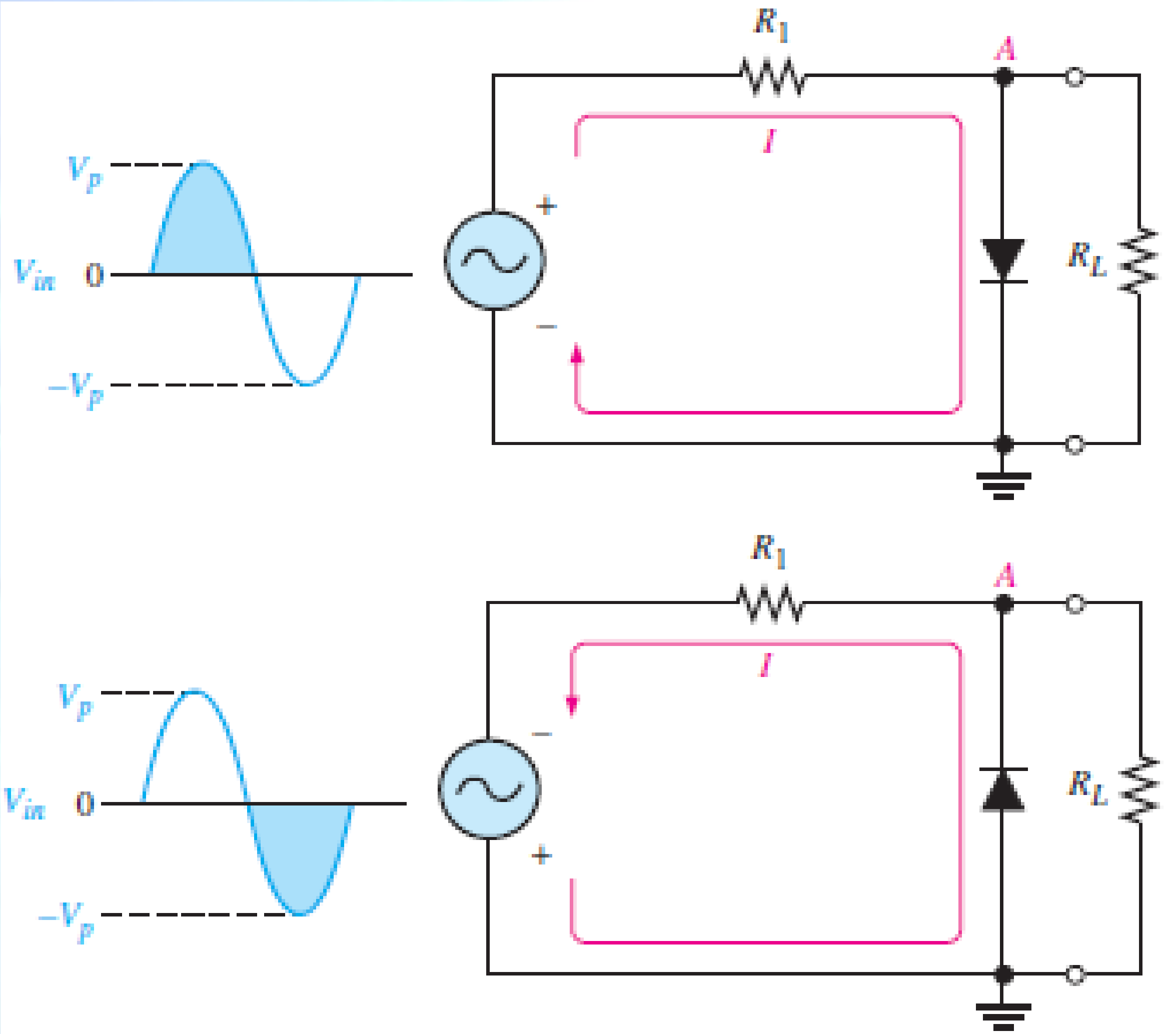
Voltage Regulator

- Voltage regulator is connected to the output of a filtered rectifier and maintains a constant output voltage (or current)



Limiters

- Limiters (clippers) are sometimes used to clip off portions of signal voltages above or below certain levels



Sketch V_{out}

Limiters

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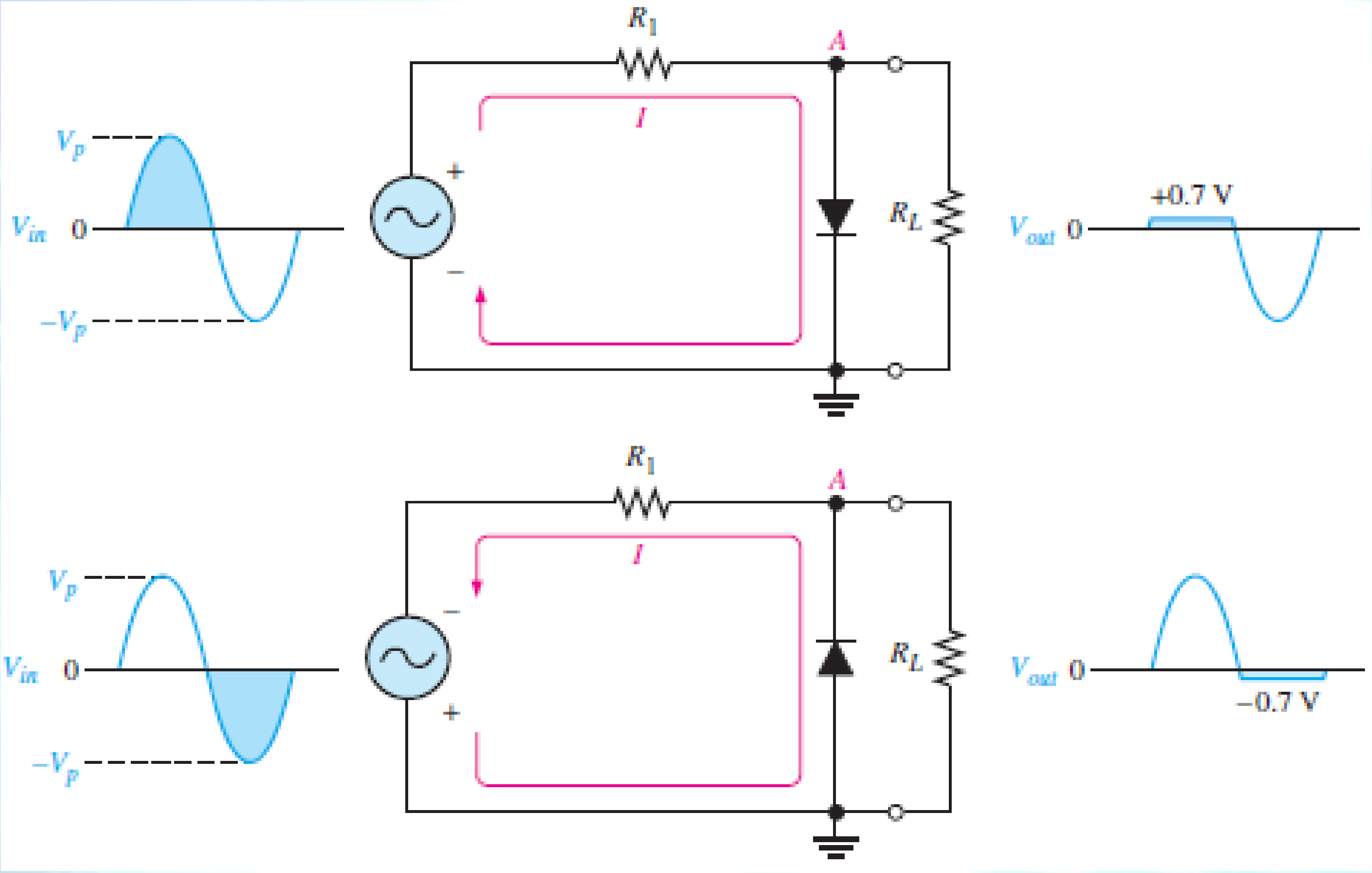
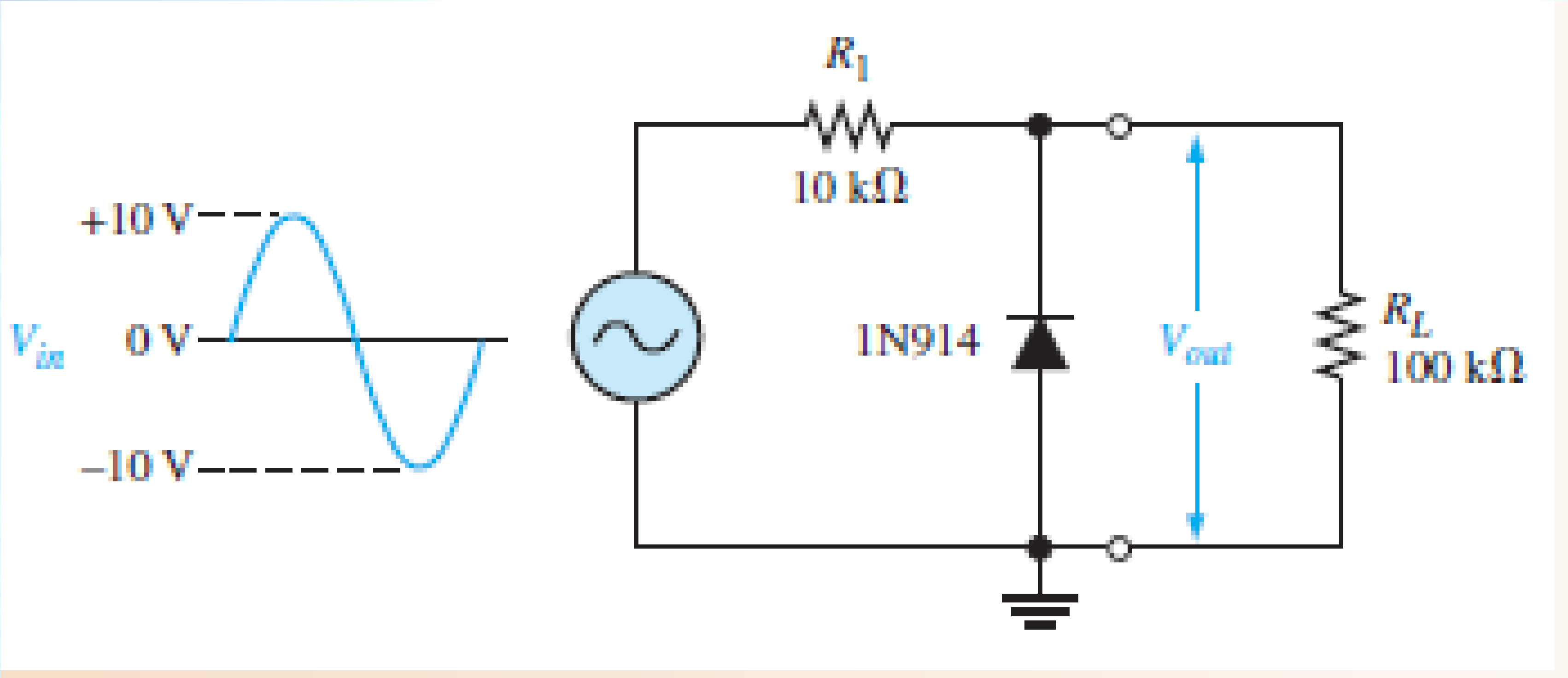


Limiters

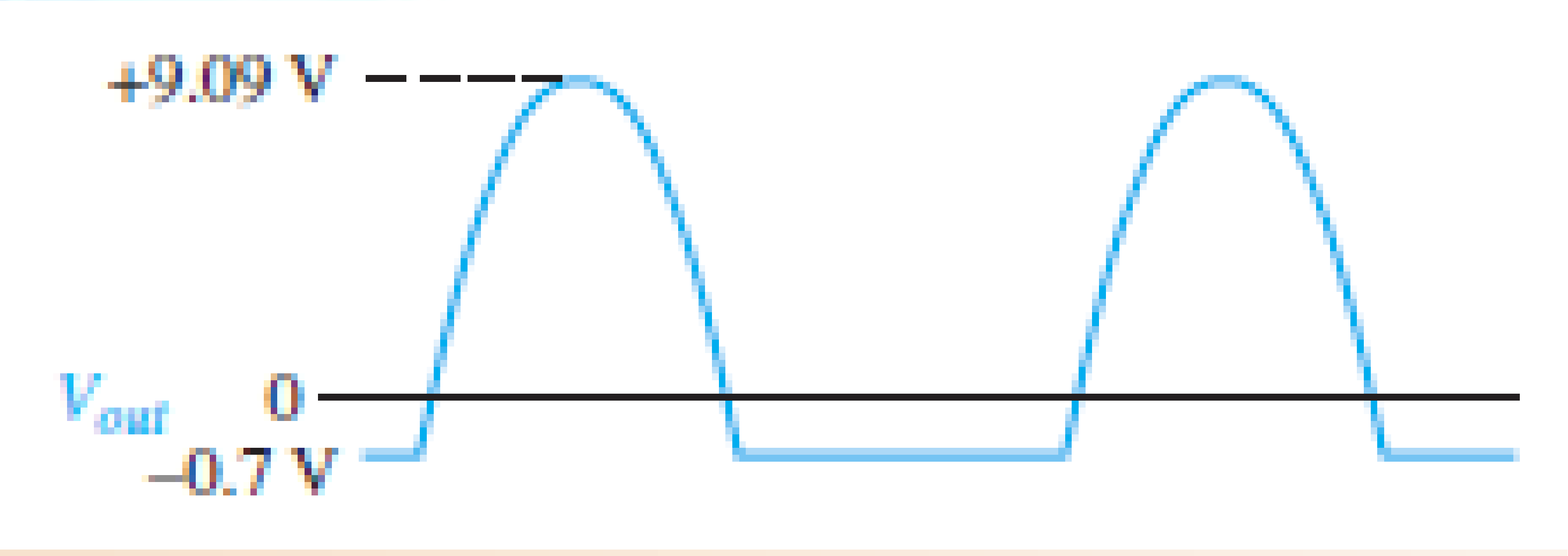
- Calculate the peak voltage across the load resistor and Sketch V_{out}



Limiters

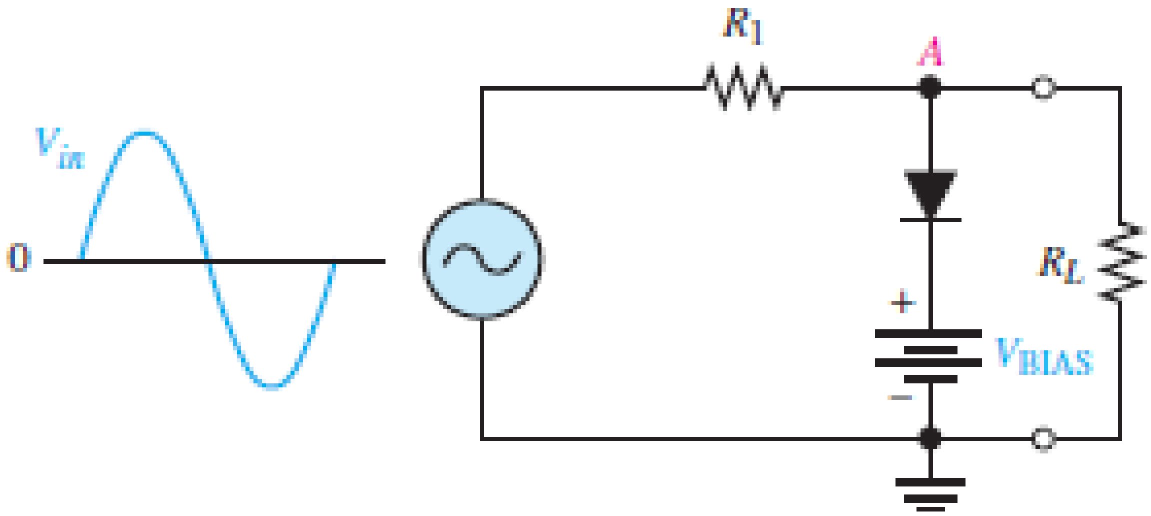
- Solution

$$V_{p(out)} = \left(\frac{R_L}{R_1 + R_L}\right)V_{p(in)} = \left(\frac{100\text{ k}\Omega}{110\text{ k}\Omega}\right)10\text{ V} = 9.09\text{ V}$$

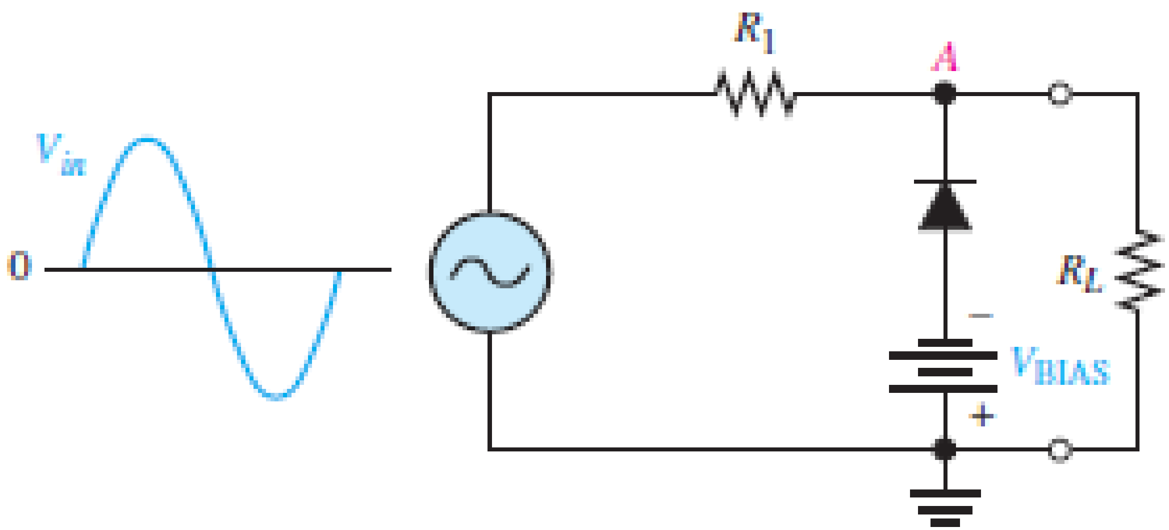


Biased Limiters

- The level to which an AC voltage is limited can be adjusted by adding a bias voltage



Sketch V_{out}



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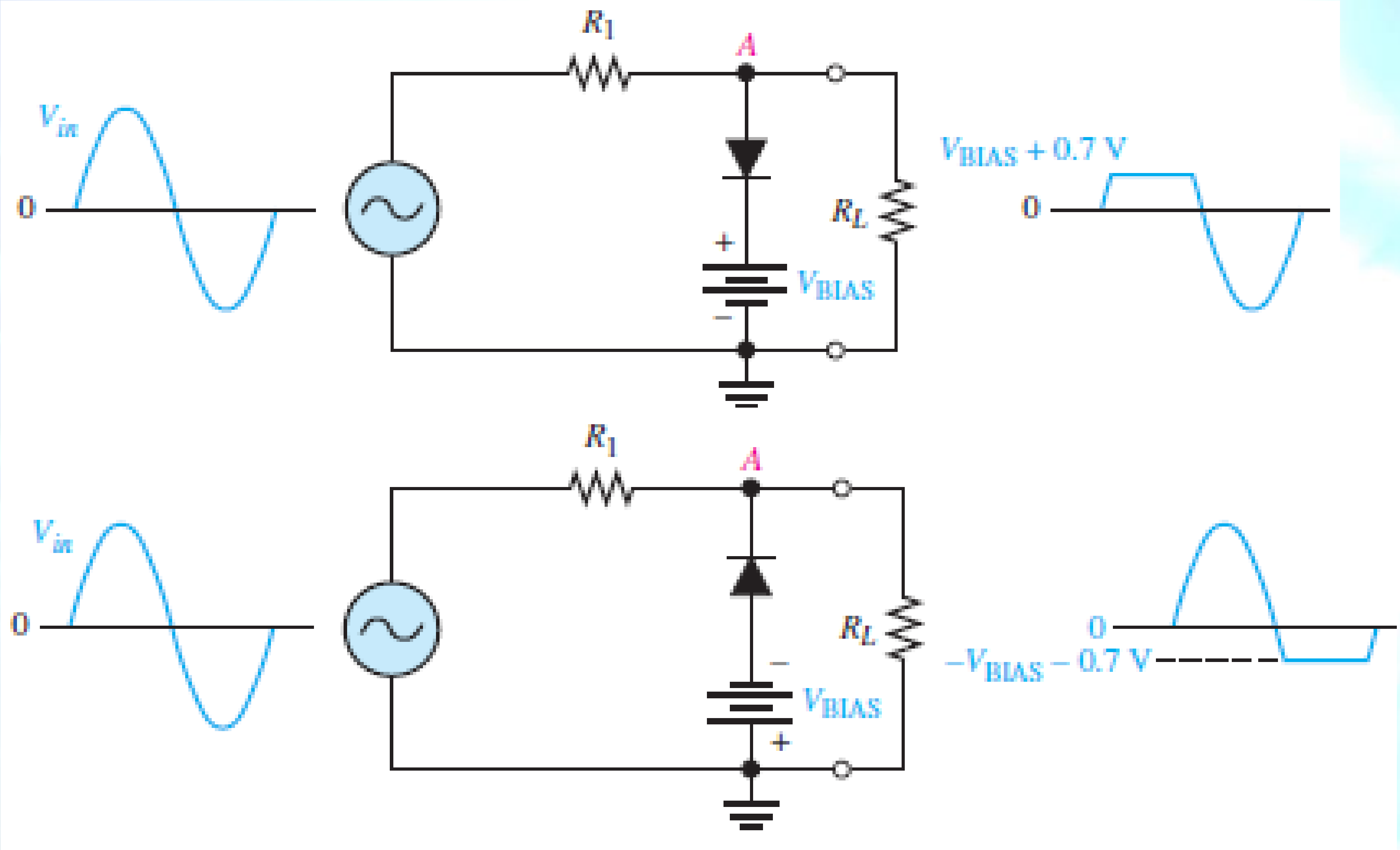
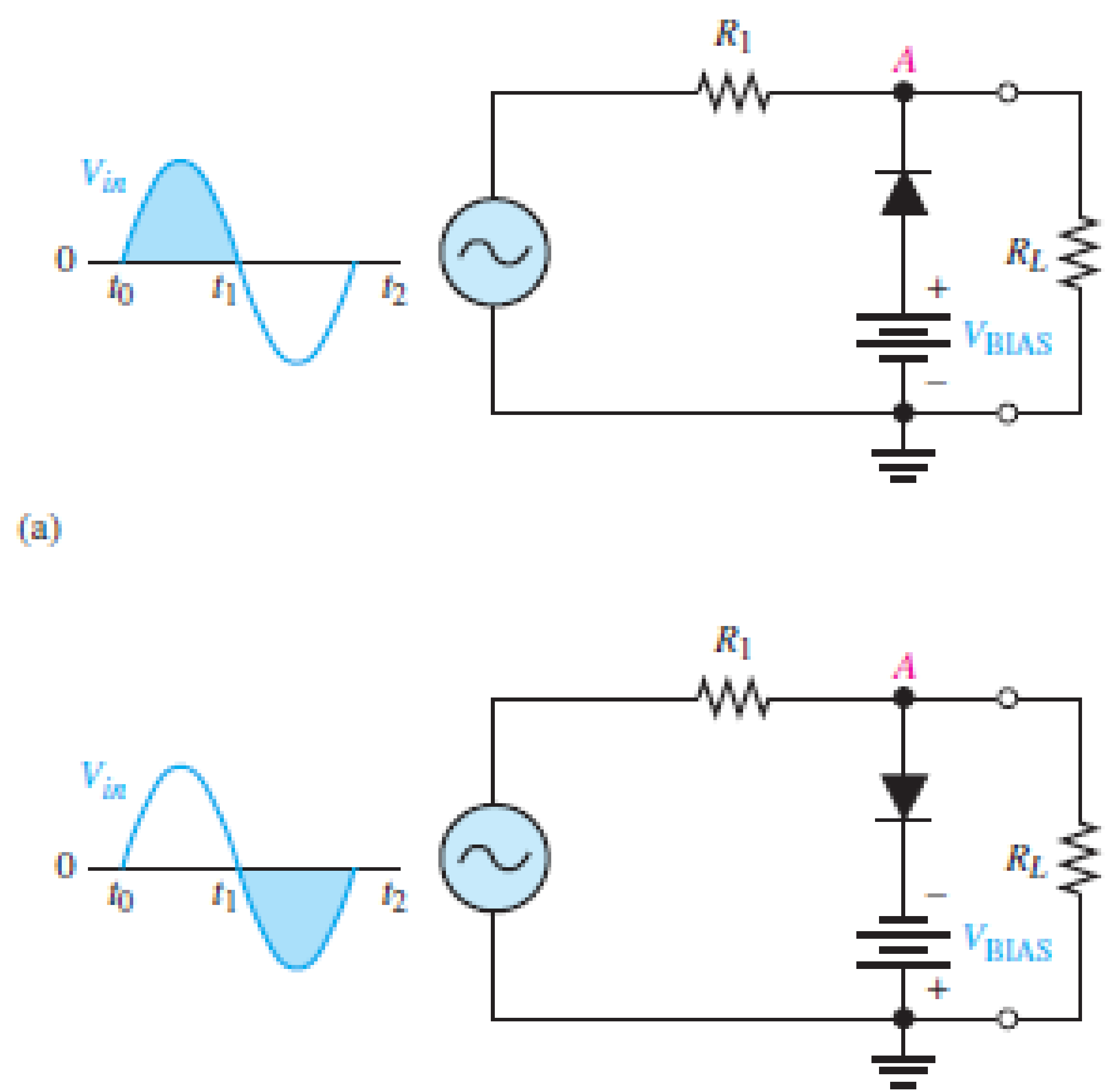
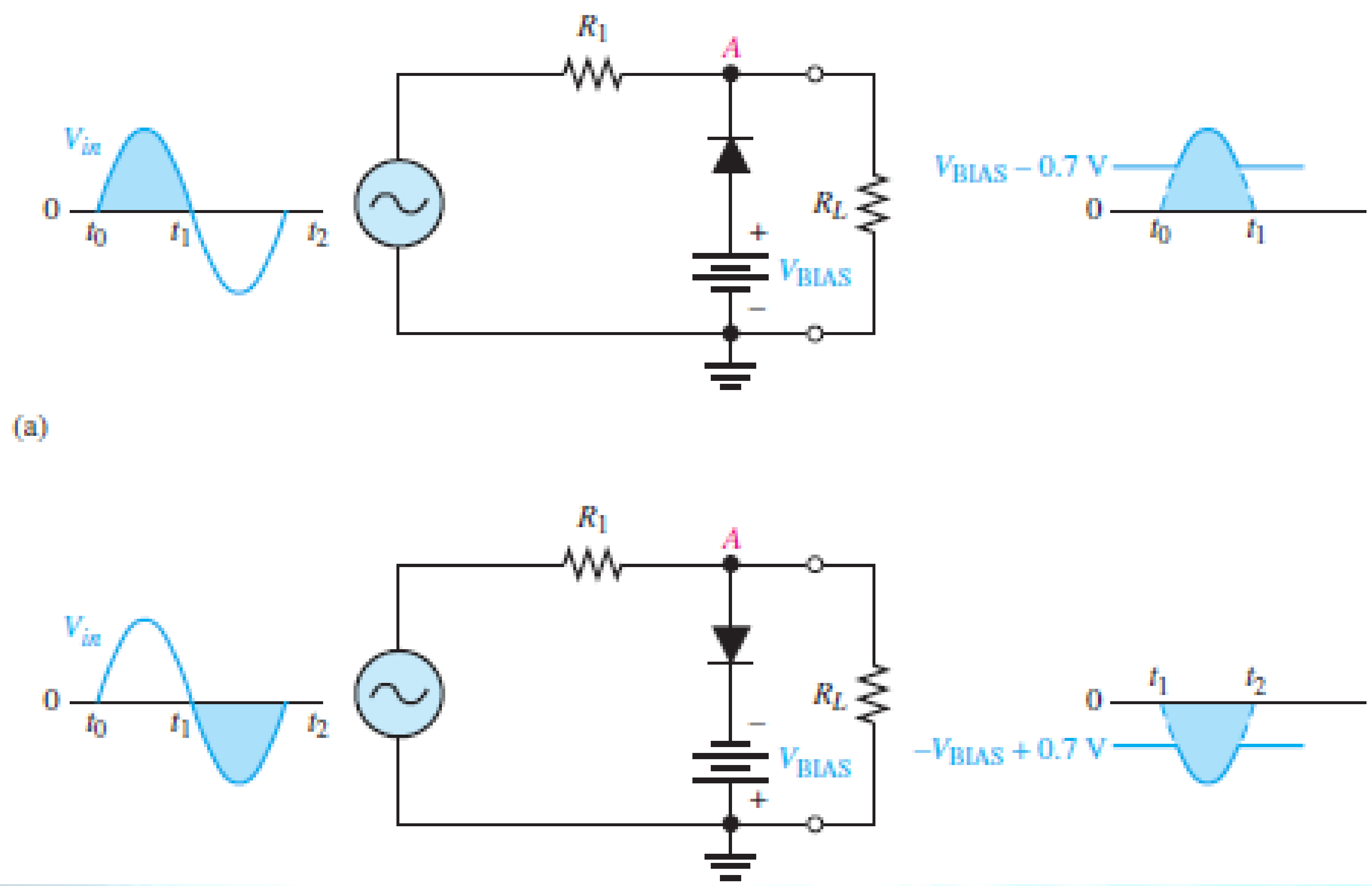


Biased Limiters

- Figure the out put wave form of the following limiters



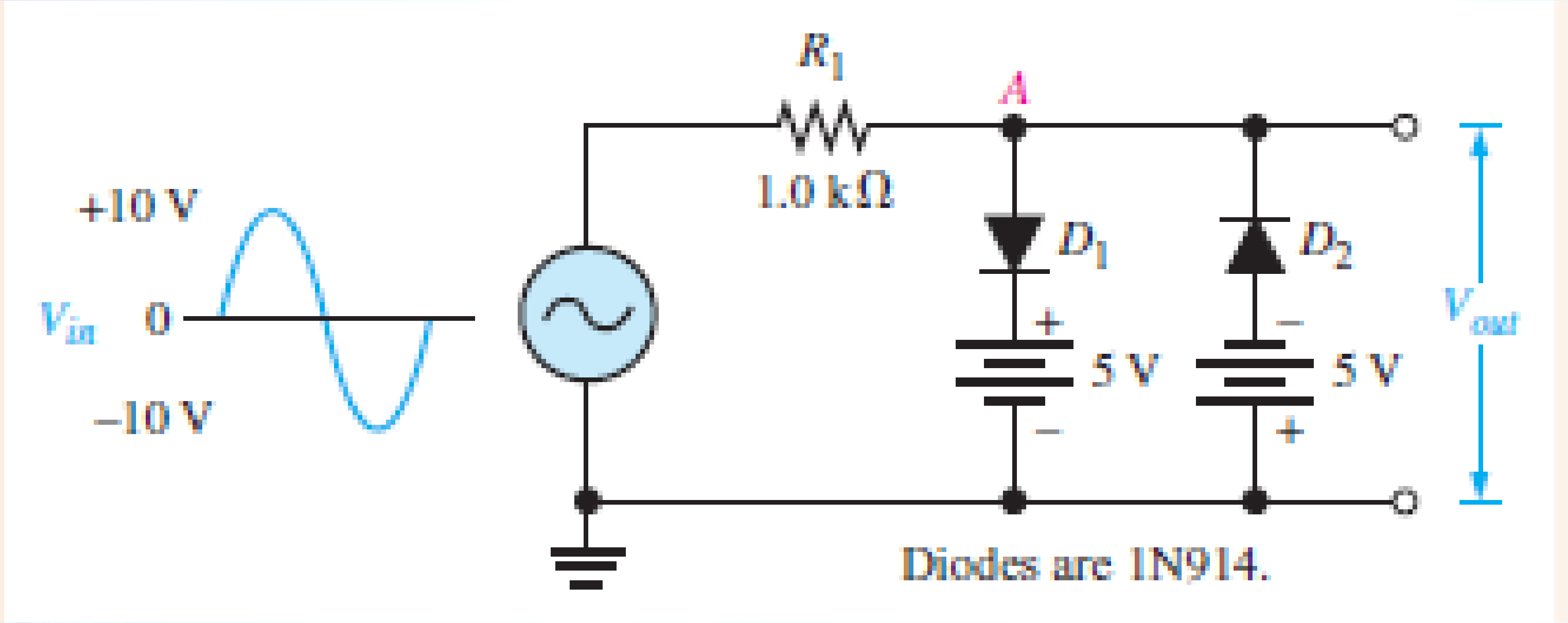
Solution



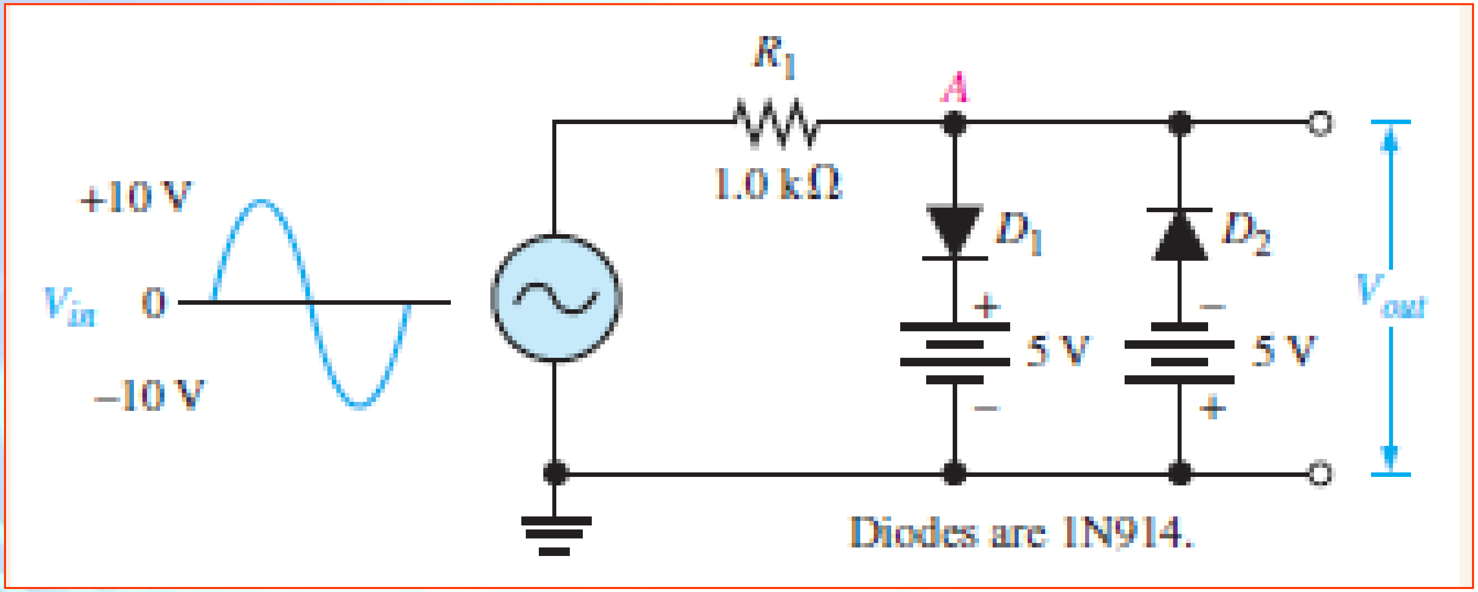
R1
A
Vin
0
t0
t1
t2
RL
+
VBIAS
−
VBIAS − 0.7 V
0
t0
t1
(a)
R1
A
Vin
0
t0
t1
t2
RL
−
VBIAS
+
t1
t2
0
−VBIAS + 0.7 V

Problem

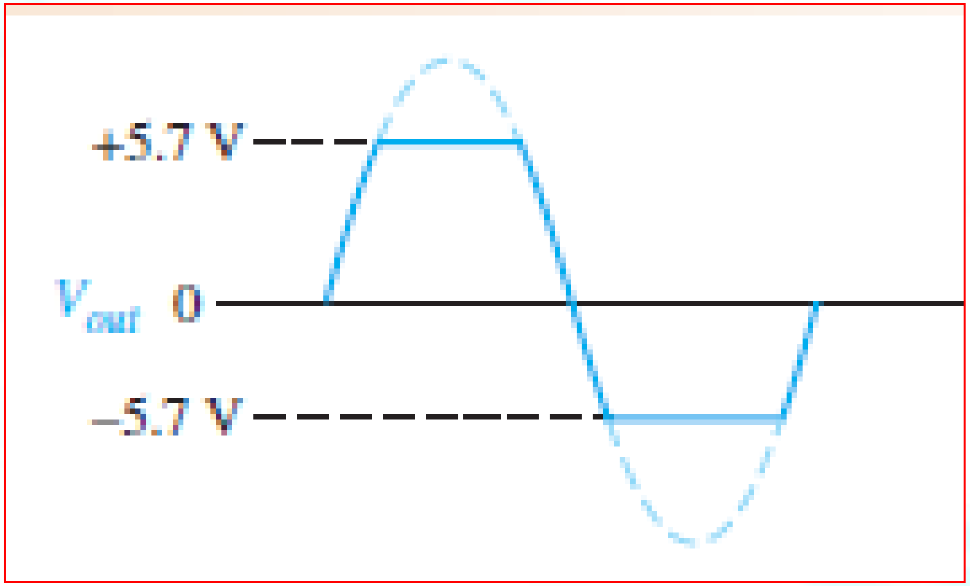
- Determine the output voltage waveform



Solution



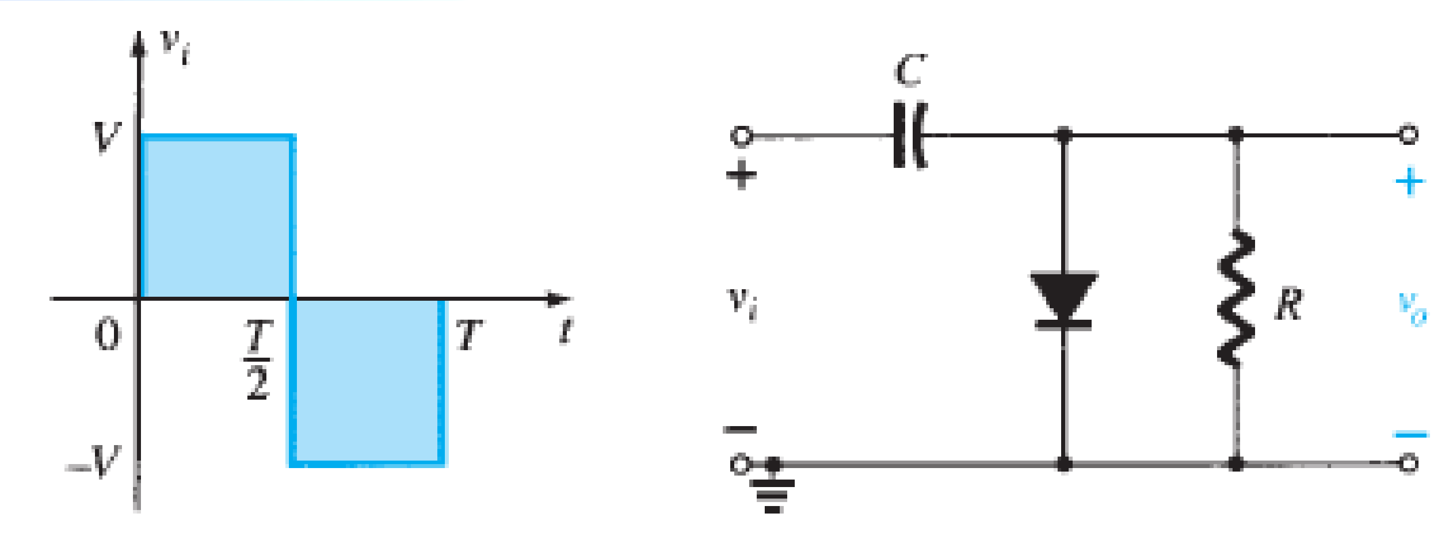
R_1
A
1.0 kΩ
+10 V
V_{in} 0
−10 V
D_1
D_2
+
5 V
−
−
5 V
+
V_{out}
Diodes are 1N914.



+5.7 V
V_{out} 0
−5.7 V

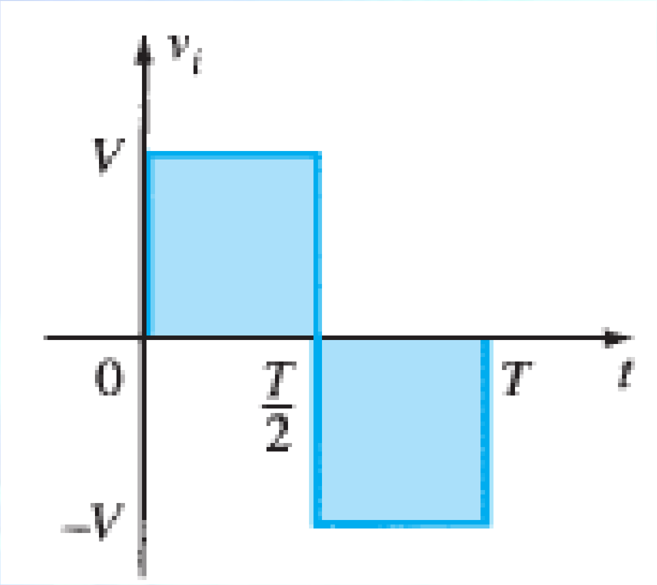
Clampers

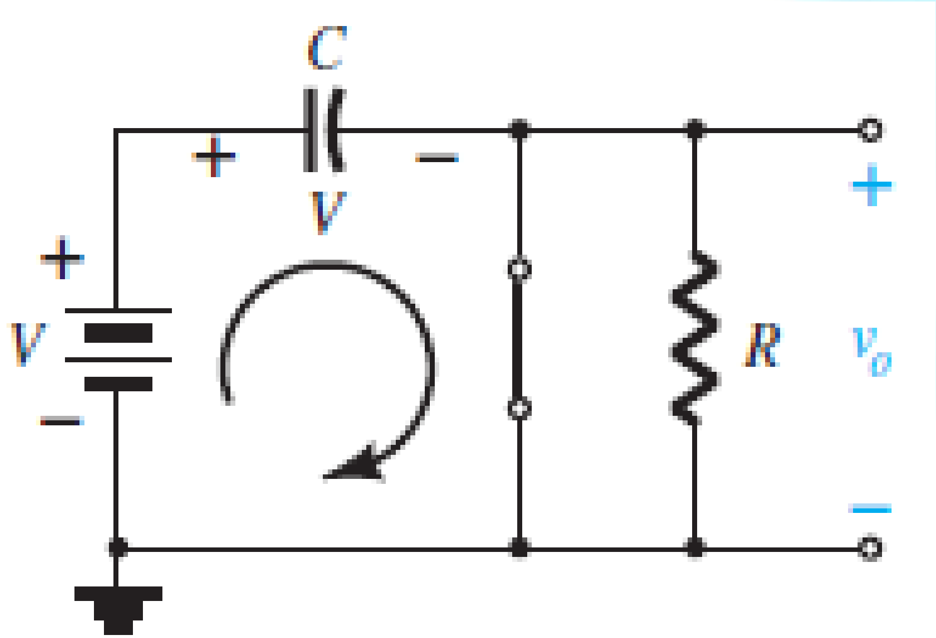
- A clamper adds a DC level to an AC voltage



- From t=0 to t=T/2 (assume ideal diodes)
  - Diode is ON
  - Capacitor charge up-to V volts

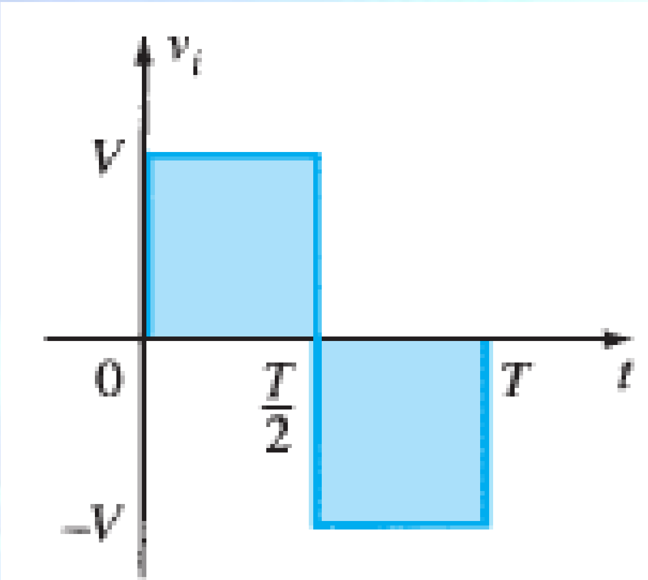
Clampers

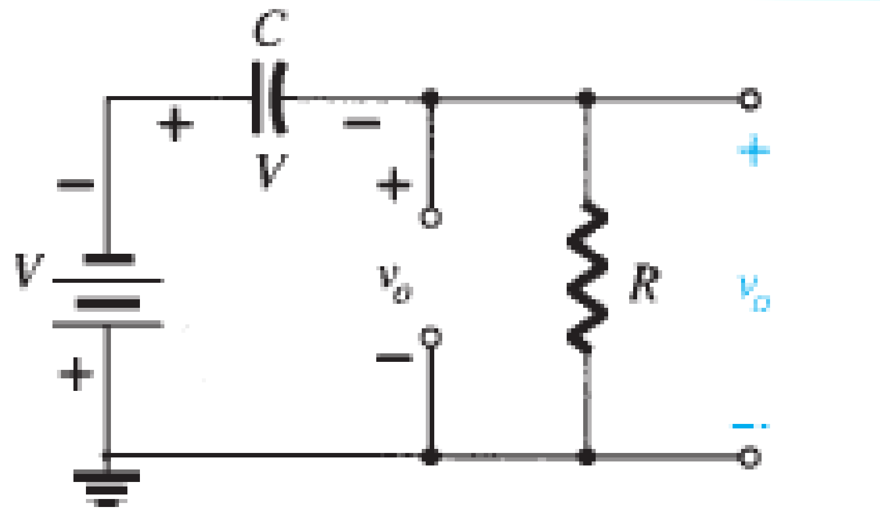




- From t=0 to t=T/2   (assume ideal diodes)
  - Diode is ON
  - Capacitor charge up-to V volts
  - Voltage across R is zero

Clampers

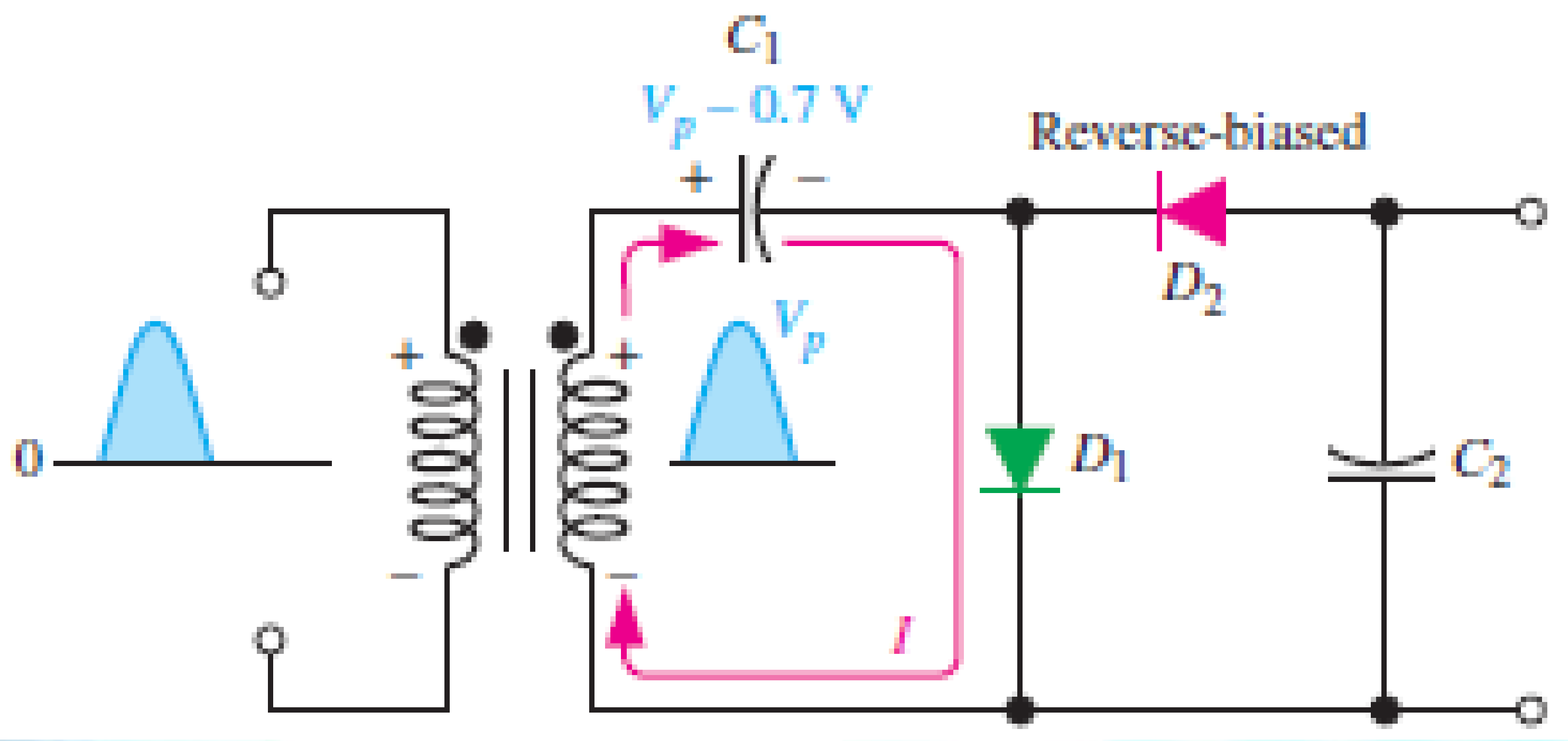




- From t=T/2 to t=T (assume ideal diodes)
  - Diode is OFF
  - Current flows through R
  - If capacitance is large (hence time constant), capacitor will discharge slowly
  - Voltage across R is -2V

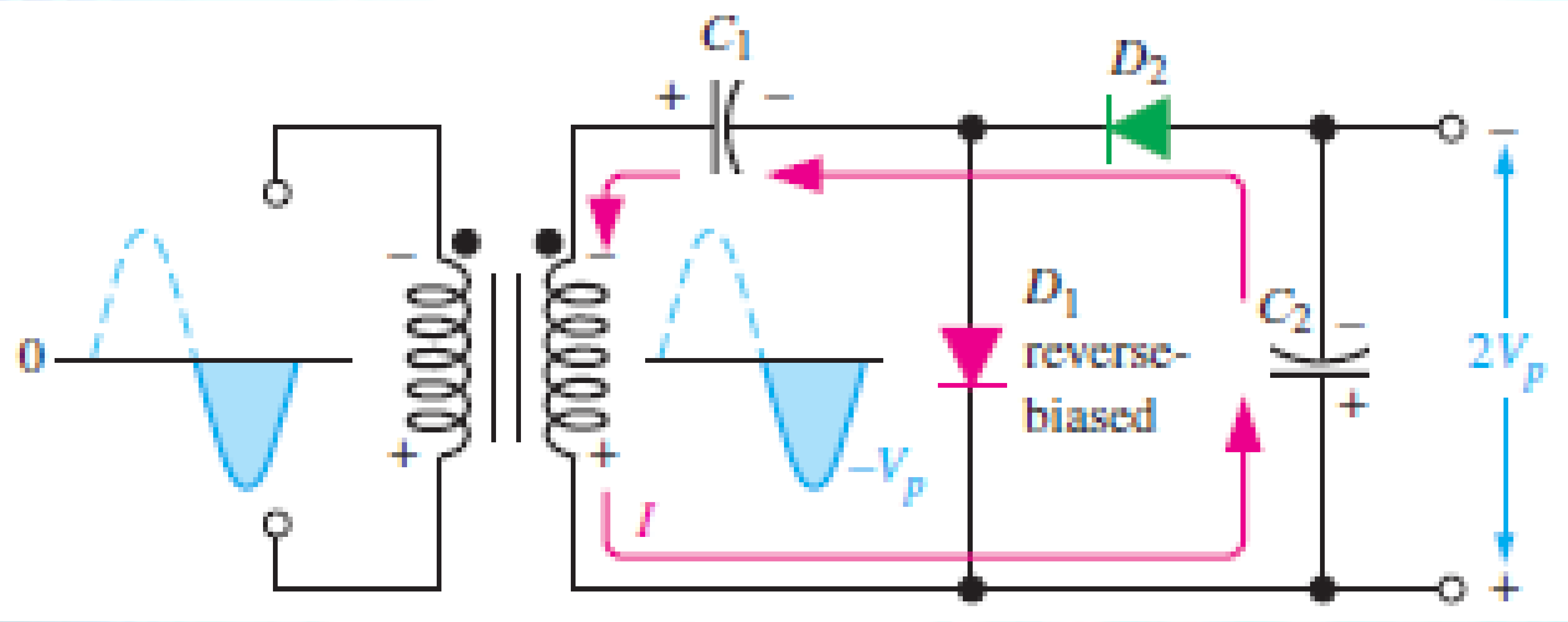
Voltage Multipliers

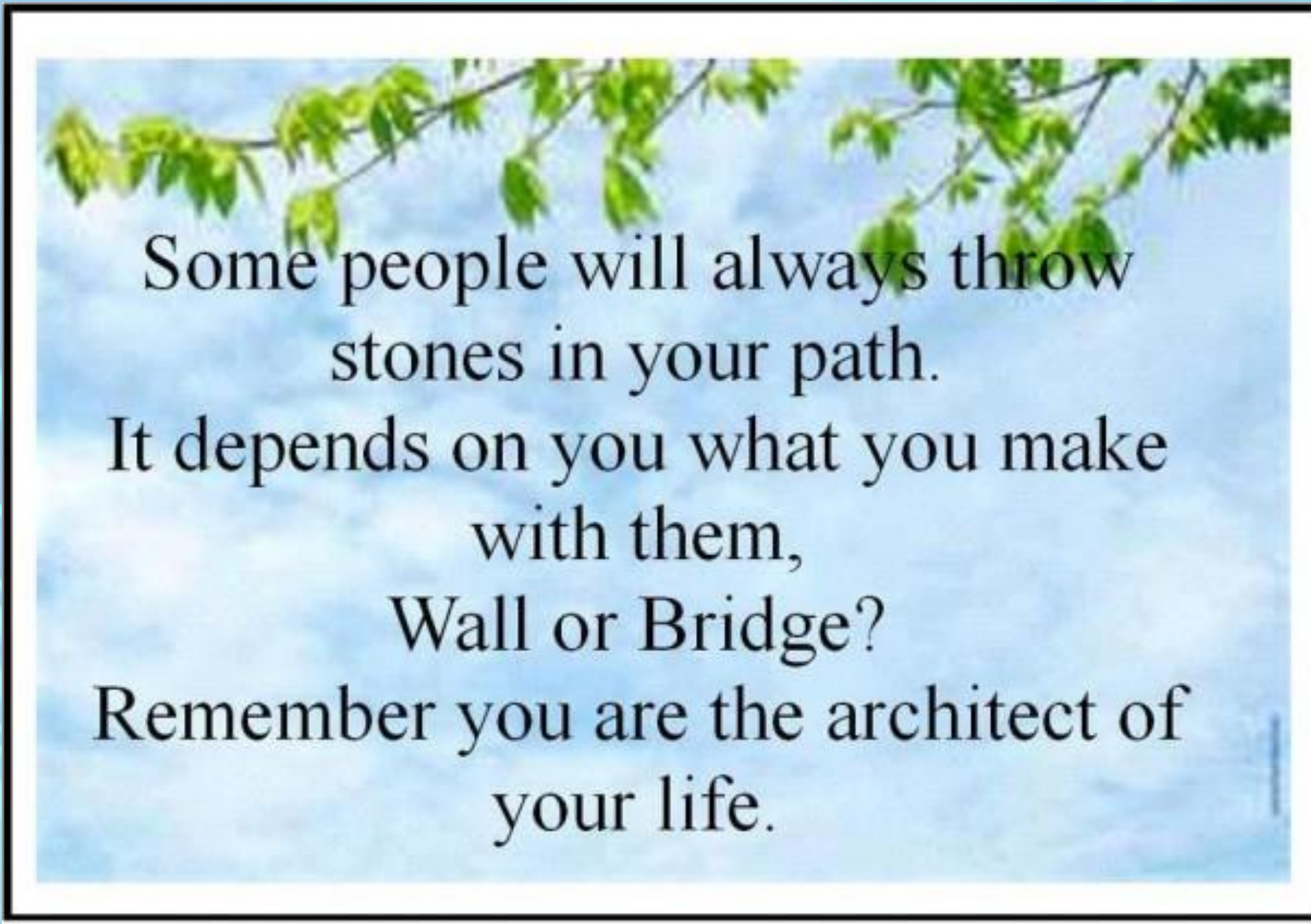
- Half-wave Voltage Multiplier
  - Multiplies the peak voltage by a factor of two
- During the +ve half cycle
  - D1 ON, D2 OFF, C1 is charged



Voltage Multipliers

- During the -ve half cycle
  - D1 OFF, D2 ON
  - the peak voltage on C1 adds to the secondary voltage to charge C2 to approximately 2Vp (2Vp if diodes are ideal)
  - Thus output voltage is 2Vp




Some people will always throw
stones in your path.
It depends on you what you make
with them,
Wall or Bridge?
Remember you are the architect of
your life.