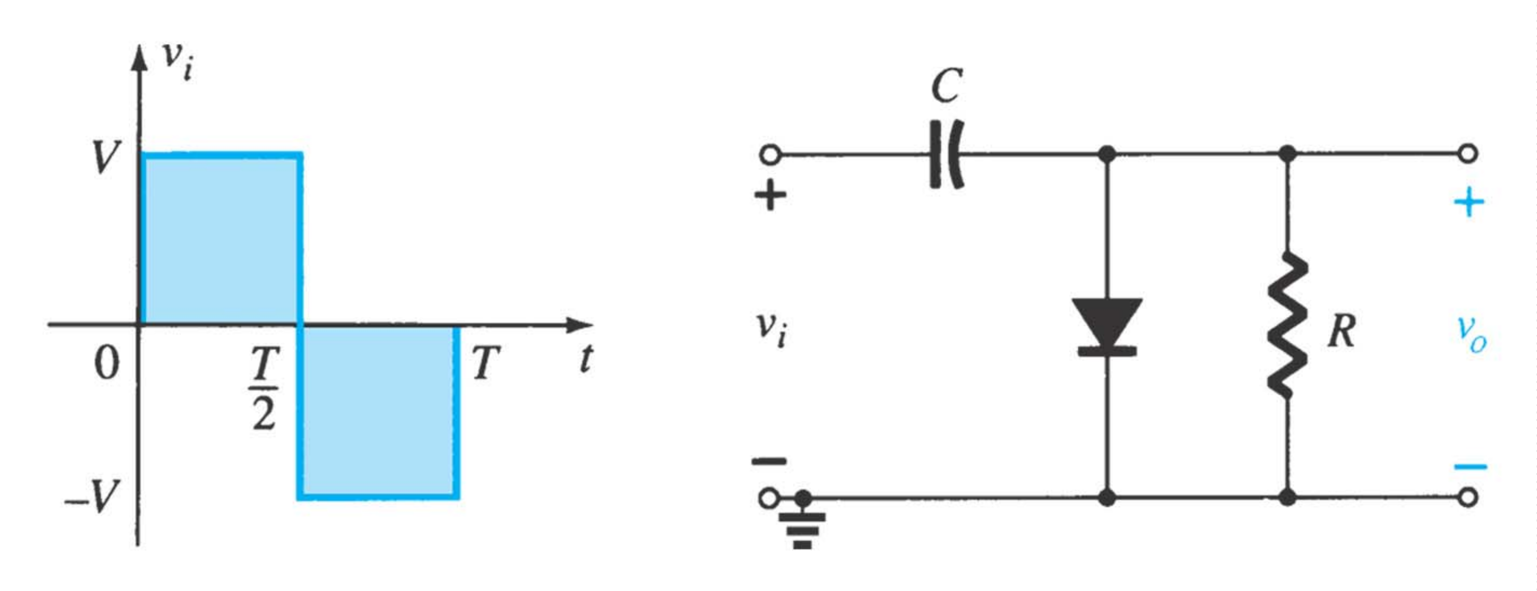
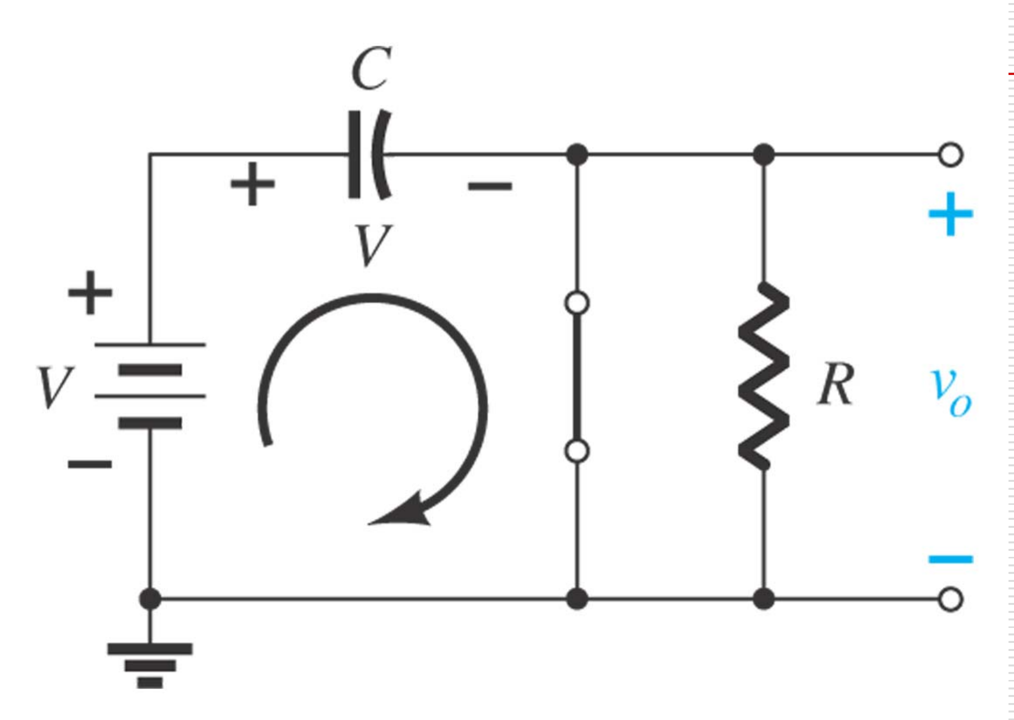
CLAMPERS



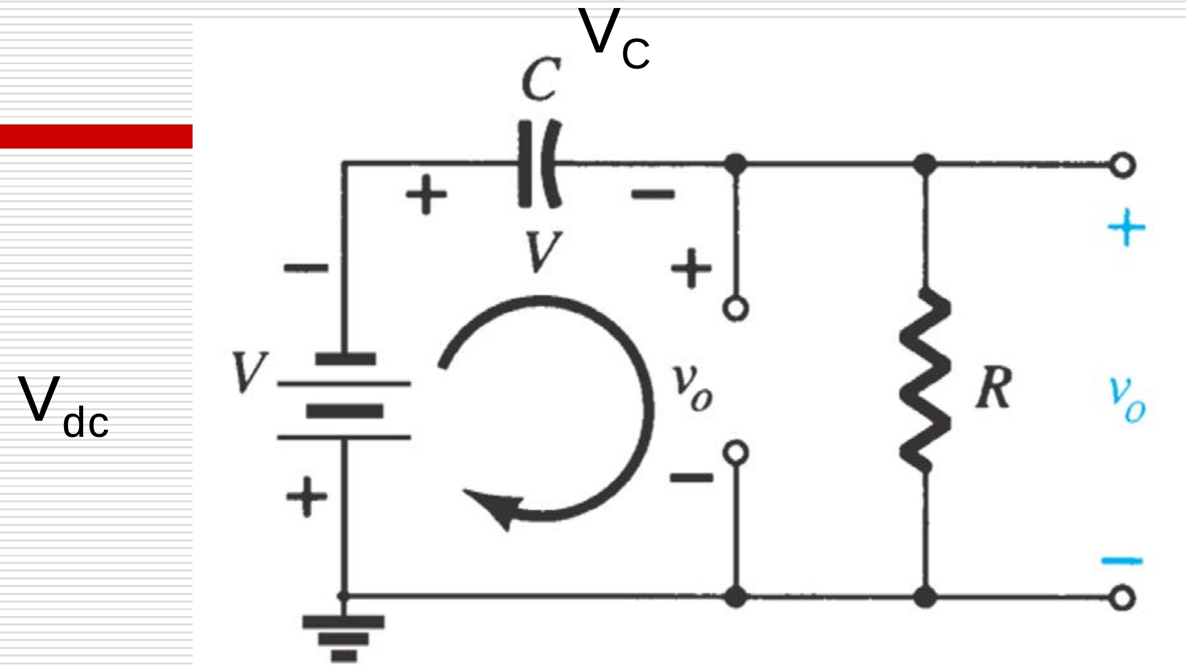
A clamper is a network constructed of a diode, a resistor and a capacitor that shifts a waveform to a different dc level without changing the appearance of the applied signal.

Analysis (ideal diode)



Operation at forward biased, the diode is short circuited (i.e "on" state). The voltage will be v_o=0 since the current is shorted thru diode and the capacitor is charged up to a voltage V.

Analysis



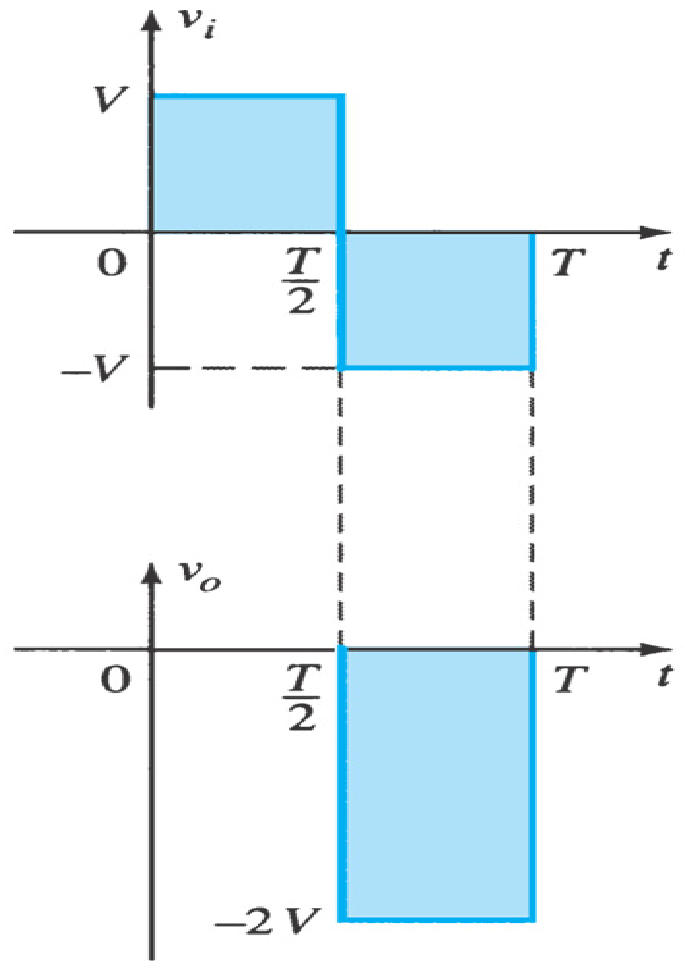
During reverse biased, the diode is open circuited (i.e “off” state). The voltage will be v_o=0 since the current is shorted thru diode. The voltage across R will be

$V_{dc} + V_c = -V + (-V) = -2V$

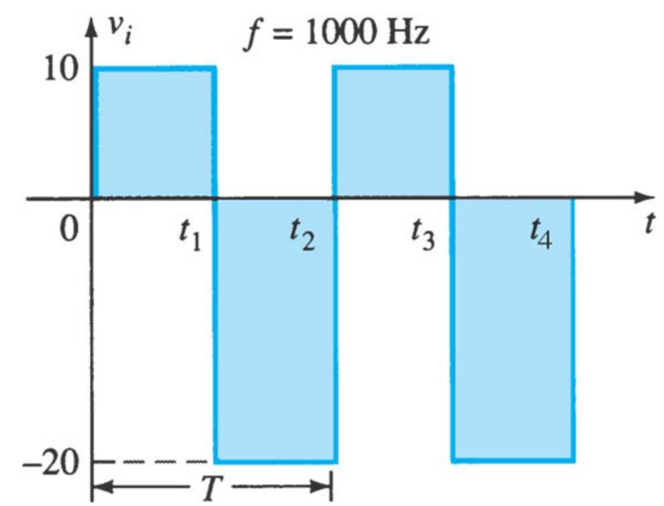
Result

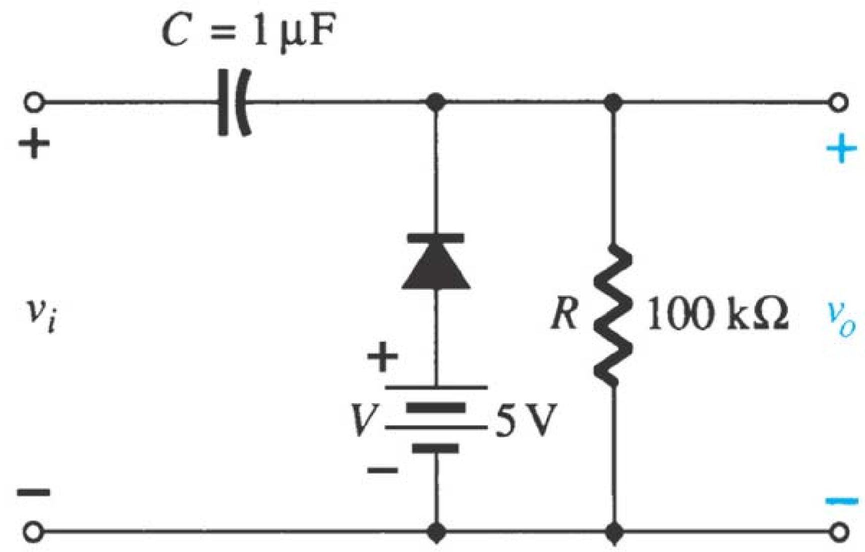
Input

Output



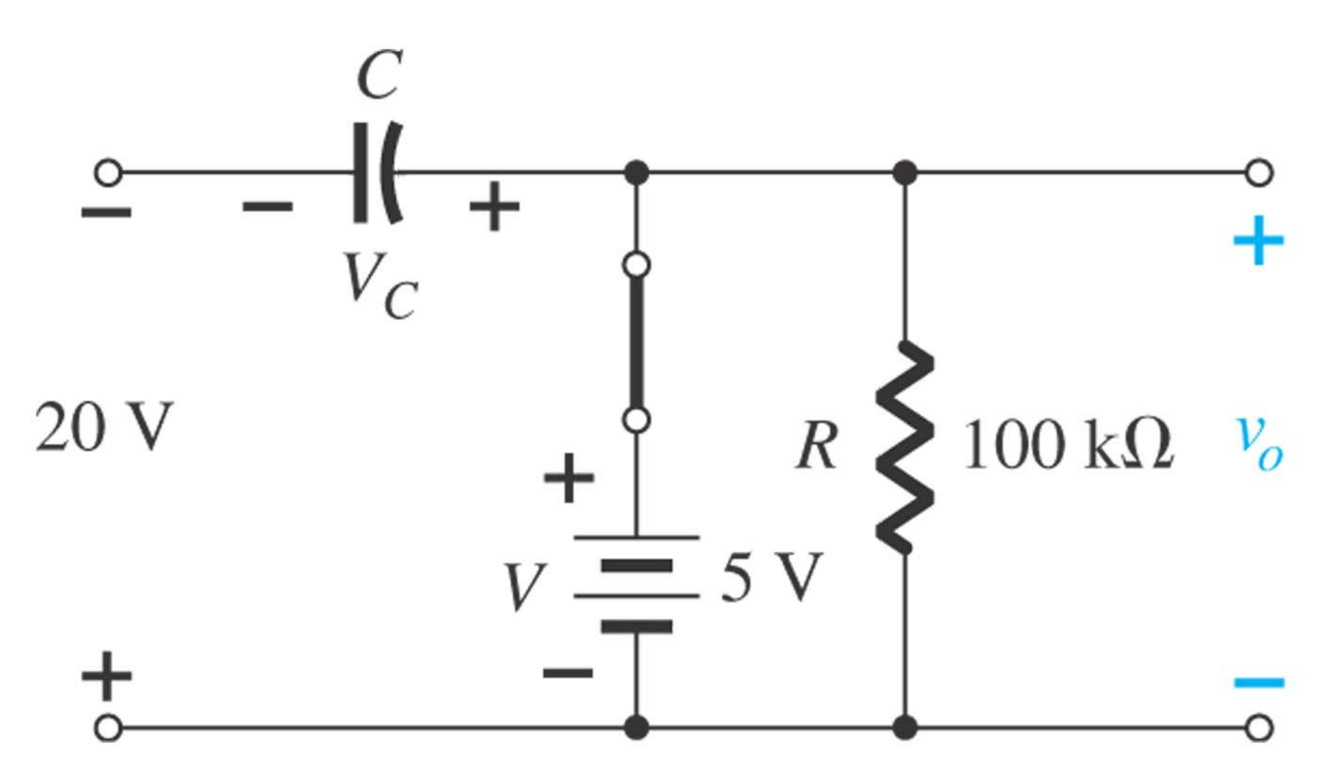
Determine v_o for the following network with the input shown (for ideal diode).





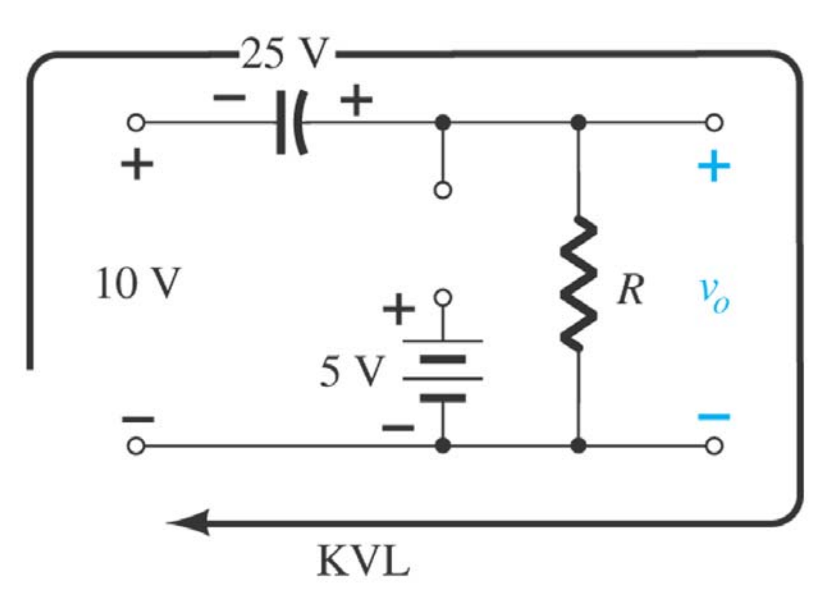
Solution: Frequency is 1000Hz, then the period will be 1/f = 1ms ,so the interval for each level state is t_1= 0.5ms. At first interval the diode is open circuited, so no current at output, therefore $v_o = 0$

Analysis (forward biased)



At 2nd interval, the diode is short circuited, the voltage across R will be the same as across the batery (parallel) V_o = 5V
The voltage that charge up the capacitor, Applying KVL

-20V +Vc -5V =0 , then V_C=25V



The third interval will make the diode open circuited again and current start to flow in the resistor (discharged the capacitor).

Applying the KVL $\quad +10V + 25V - v_o = 0$

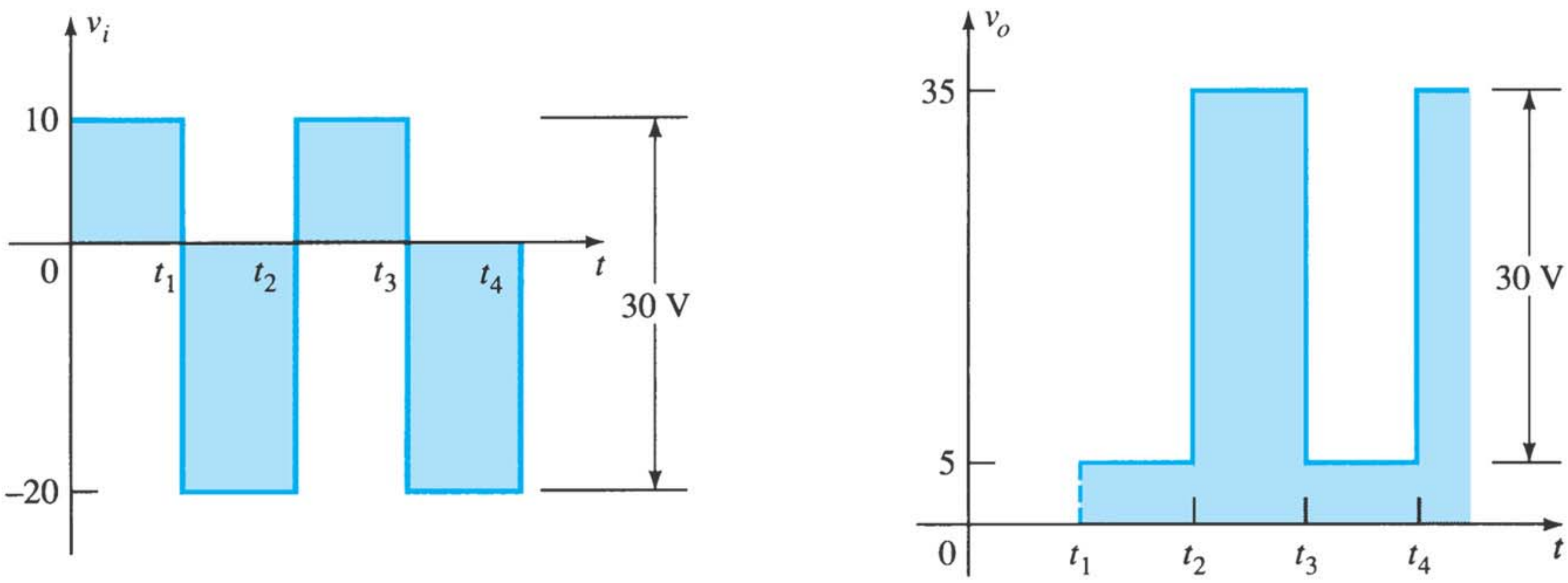
Give us $\quad v_o = 35V$

Noted : the discharge time is can be determined as t= RC

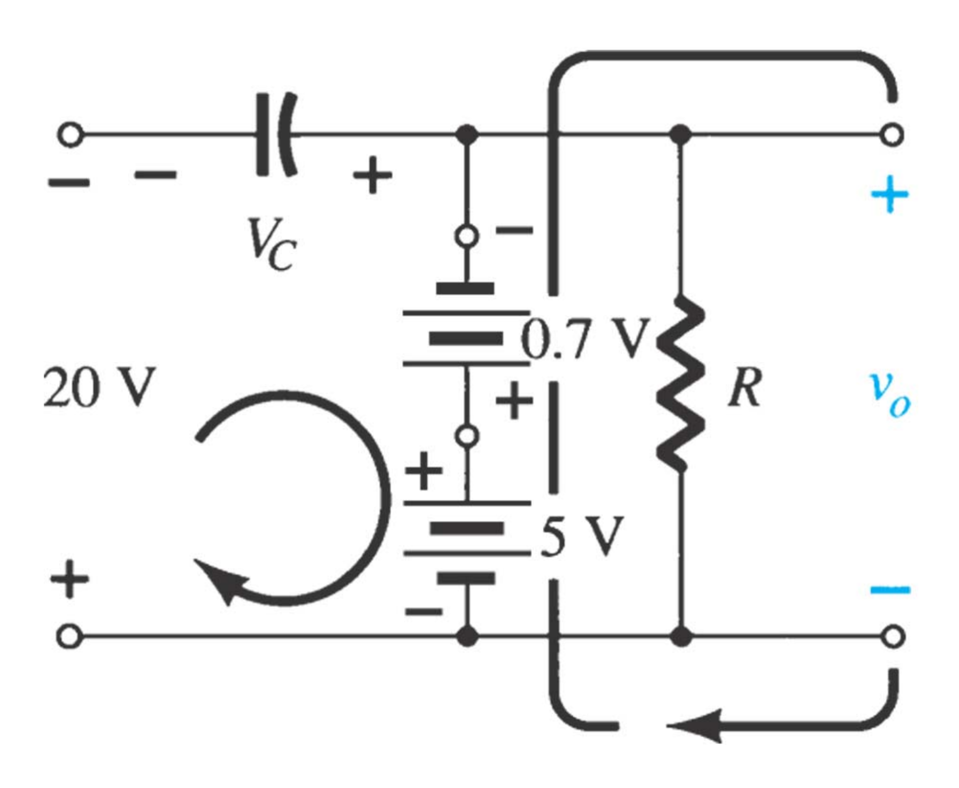
RC=100kΩ x 0.1mF= 0.01s= 10ms

Total discharge 5t= 5x10ms=50ms which is >>interval time which allow the capacitor to hold significantly the input voltage.

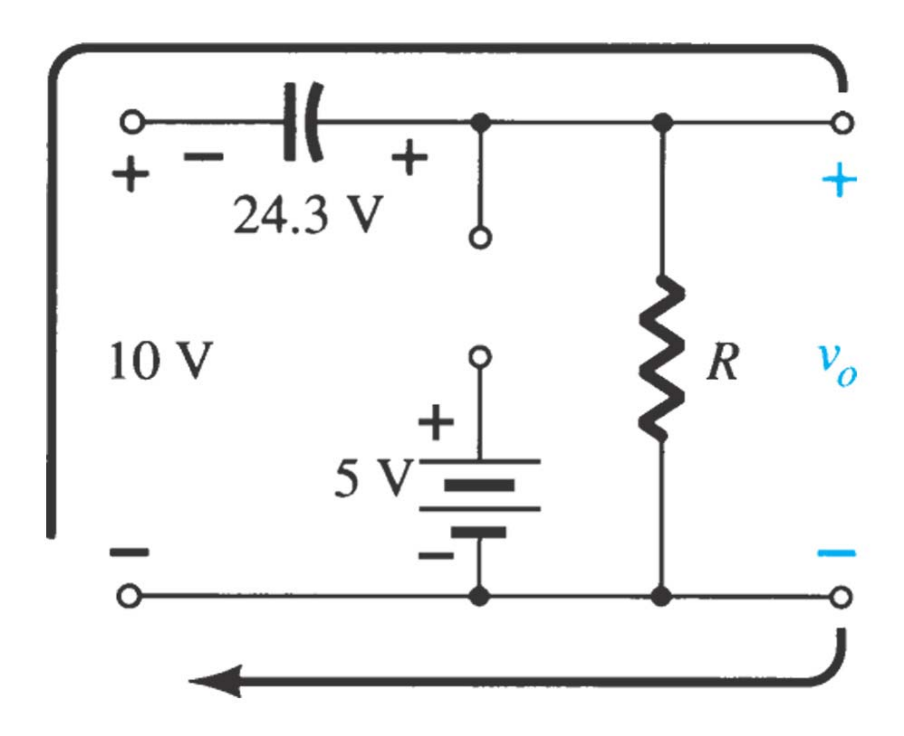
The result



Practical case with diode of V_k=0.7V

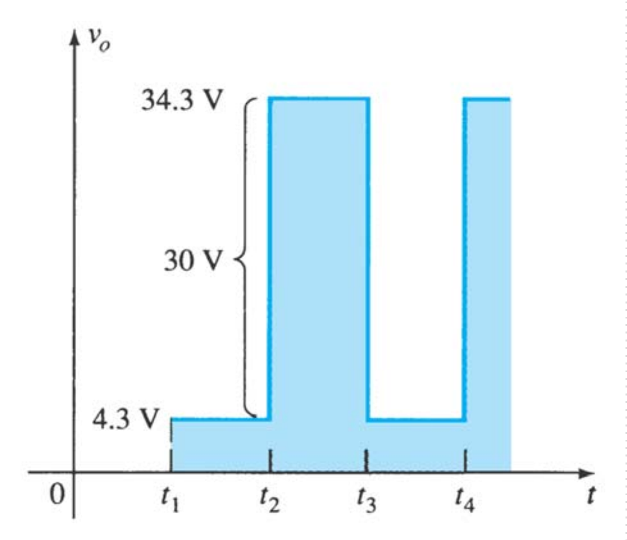


At second interval v_o = 5V-0.7V= 4.3V
and the charging up voltage -20V-5V +0.7V+V_c=0
Therefore V_c= 24.3V



Circuit

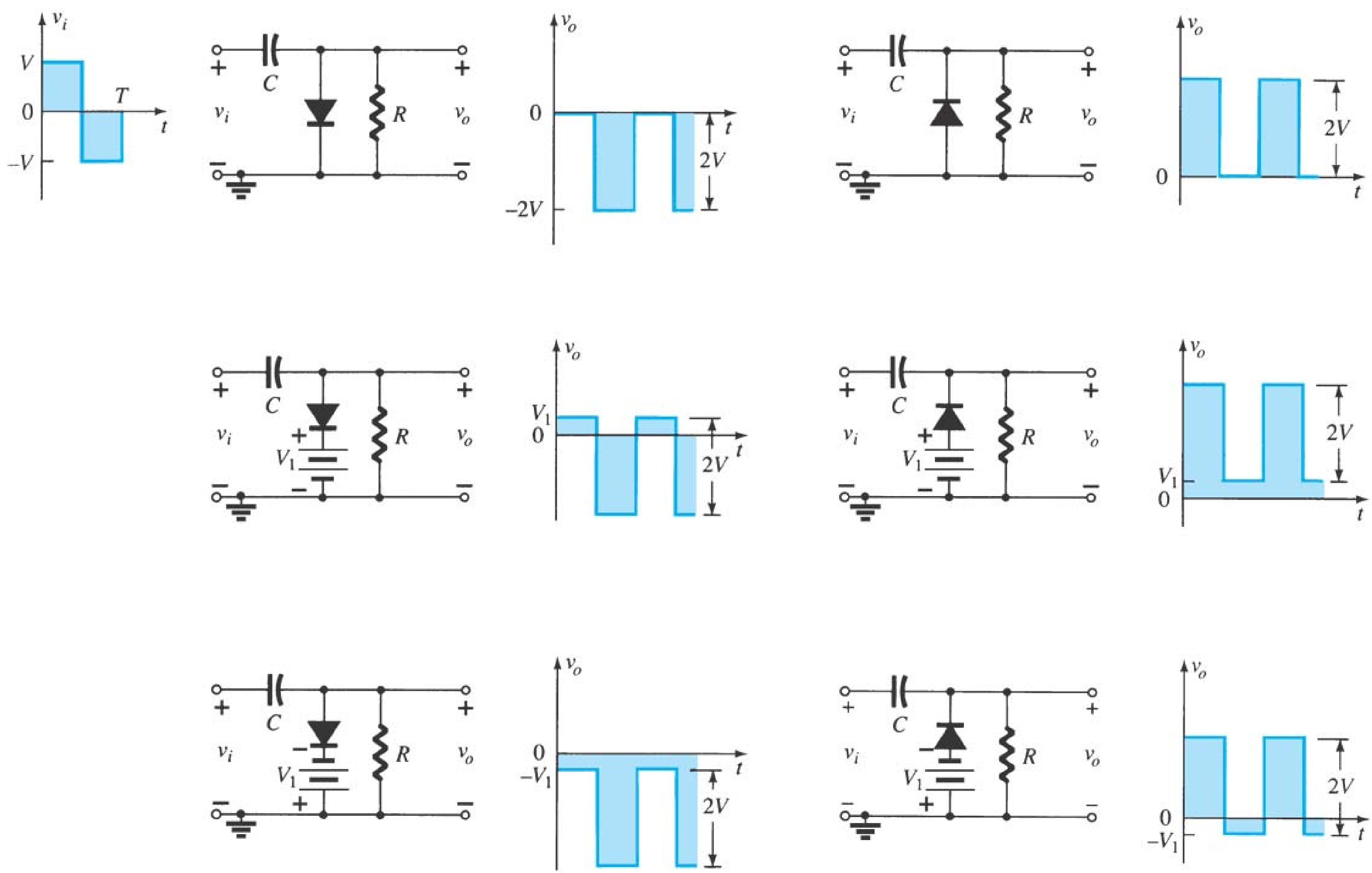
result



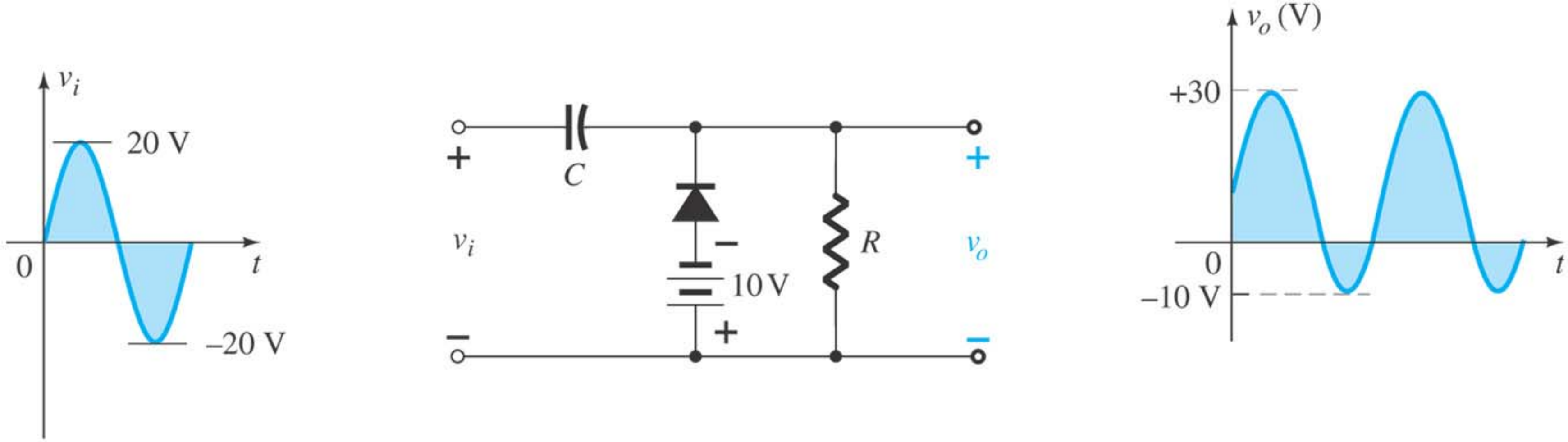
The third interval we have
$10V+24.3V-v_o=0$
Thus $v_o = 34.3V$

Other example of clampers

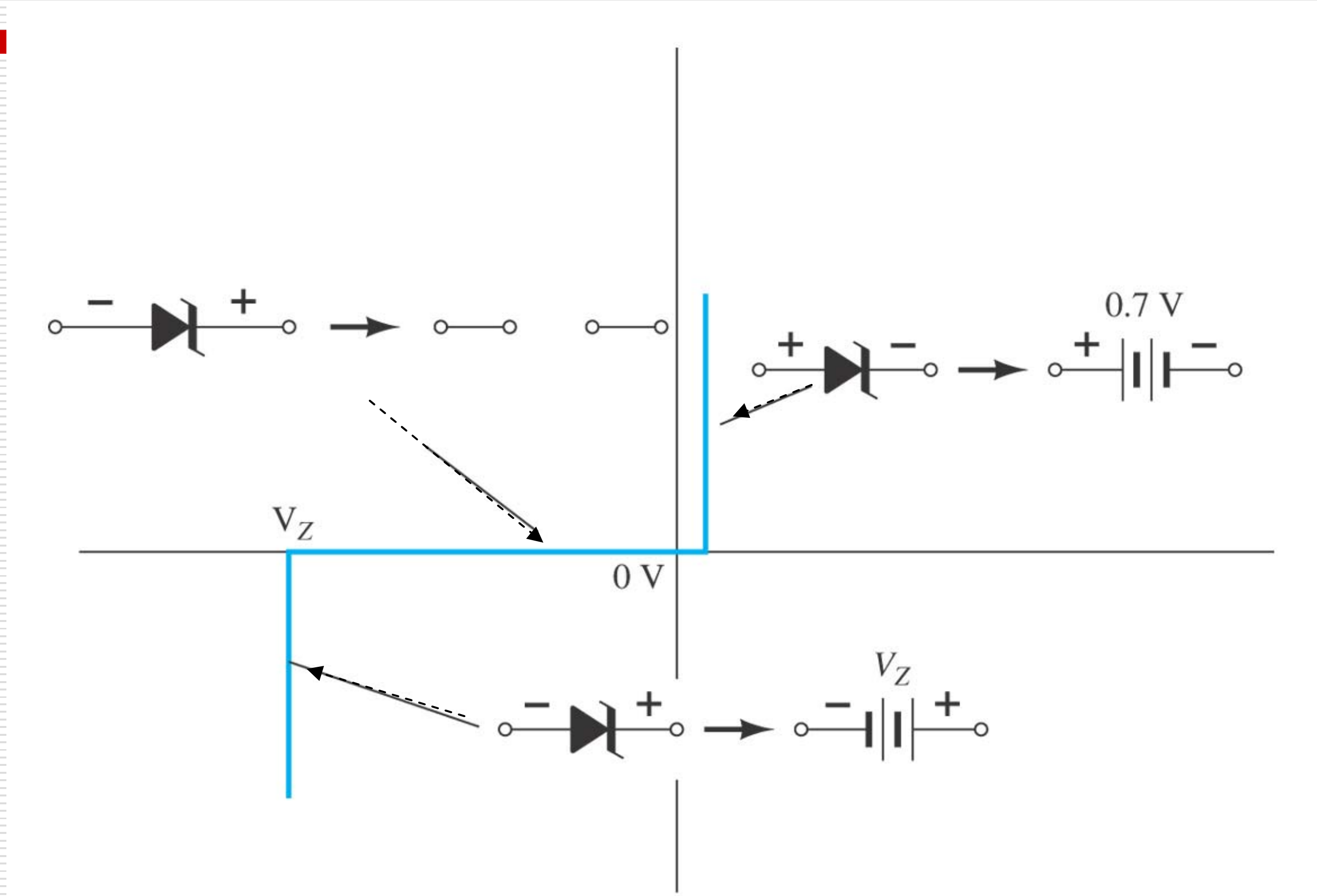
Clamping Networks



The clamper also work well for sinusoidal wave.



ZENER DIODES



Showing the equivalent circuit at each state in V-I characteristic

Determine
(i) the voltages at references Vo1 and Vo2
(ii) the current thru LED and the power delivered by the supply
(iii) How does the power absorbed by the LED compare to that 6V Zener diode

$V_{o1} = V_{Z2} + V_K = 3.3V + 0.7V = 4.0V$

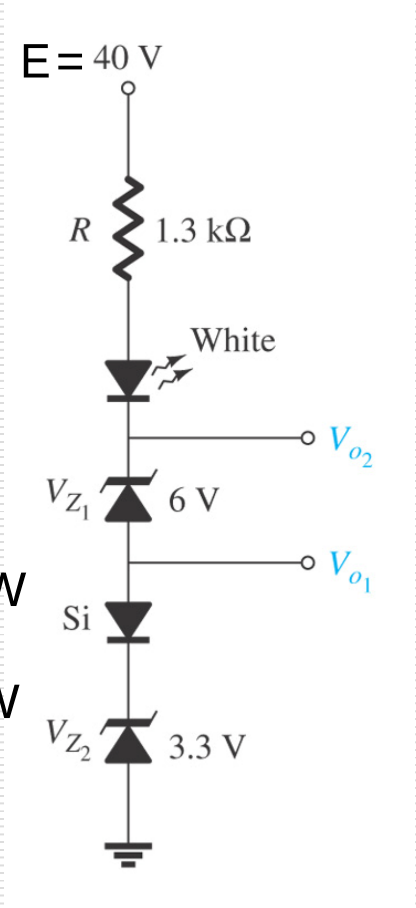
$V_{o2} = V_{o1} + V_K = 4V + 6V = 10V$

$$I_R = I_{LED} = \frac{V_R}{R} = \frac{40v - V_{02} - V_{LED}}{1.3k\Omega} = \frac{40v - 10V - 4V}{1.3k\Omega} = 20mA$$

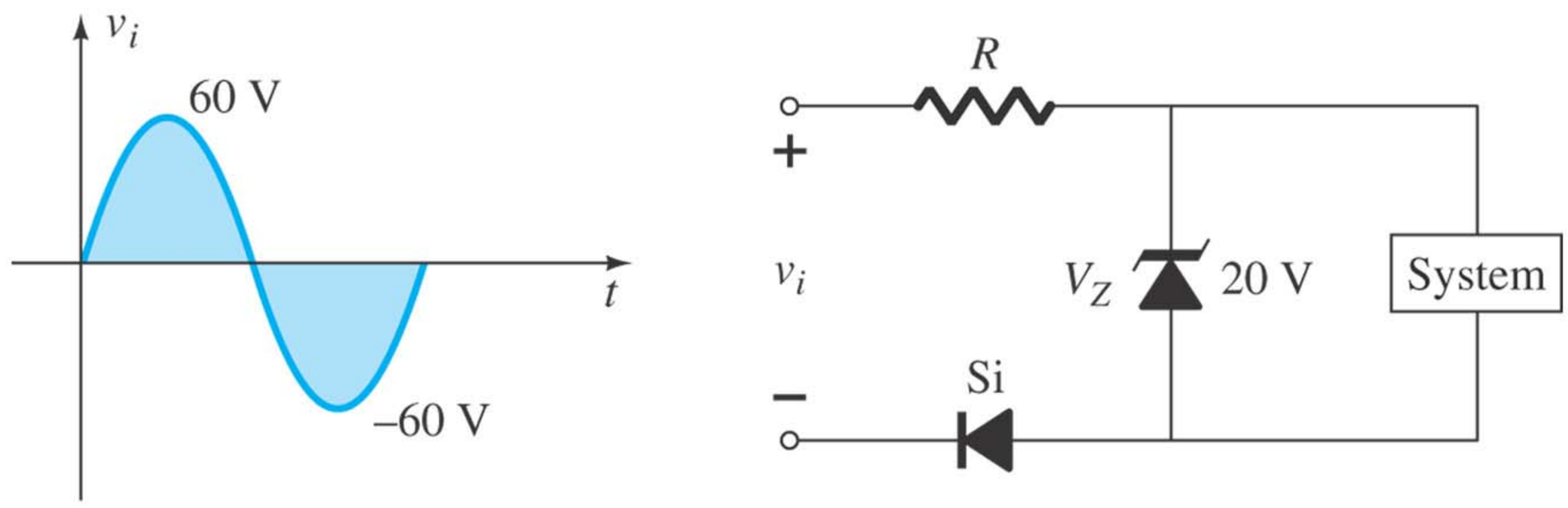
Power delivered $P_s = EI_s = EI_R = (40V)(20mA) = 800mW$

Absorbed by LED $P_{LED} = V_{LED} I_{LED} = (4V)(20mA) = 80mW$

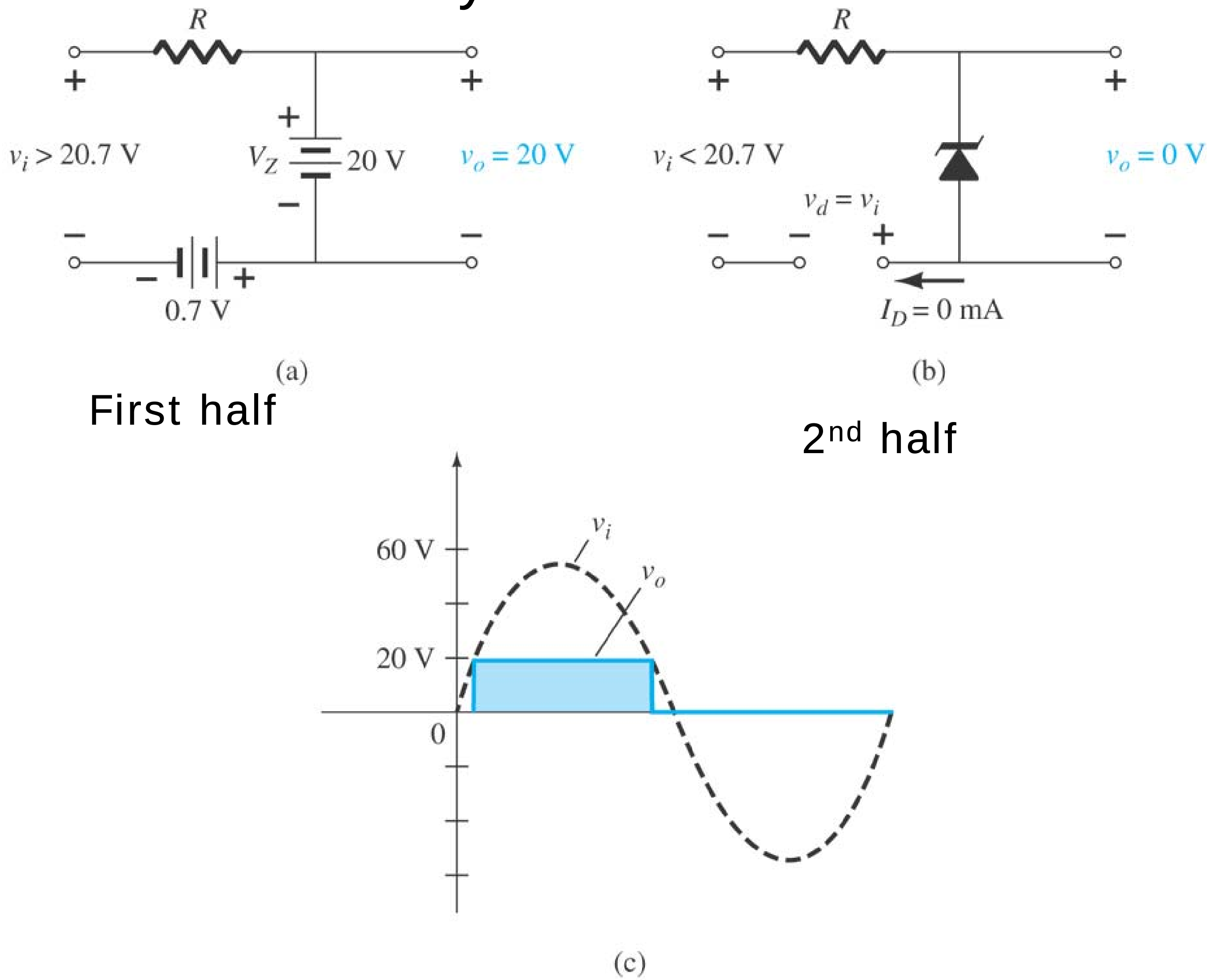
Absorbed by Zener $P_Z = V_Z I_Z = (6V)(20mA) = 120mW$



A LIMITER



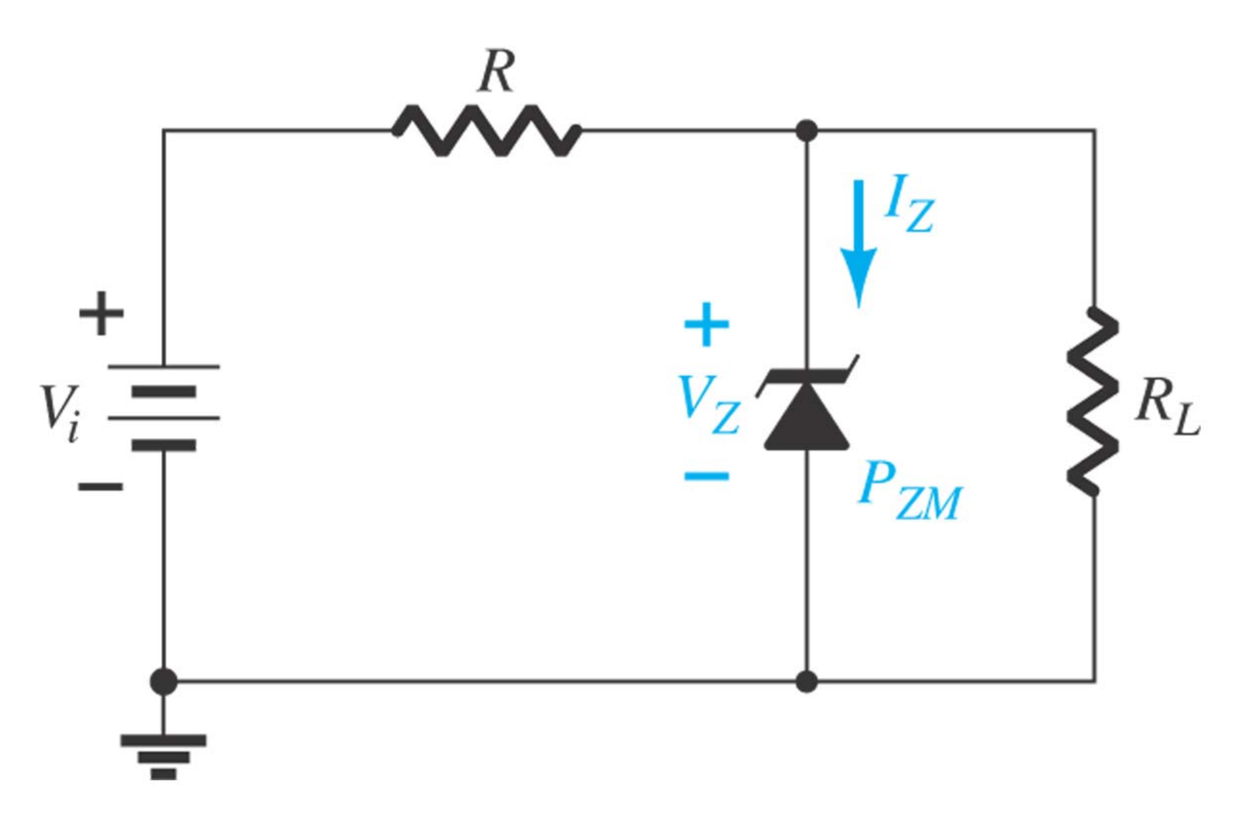
Analysis



First half

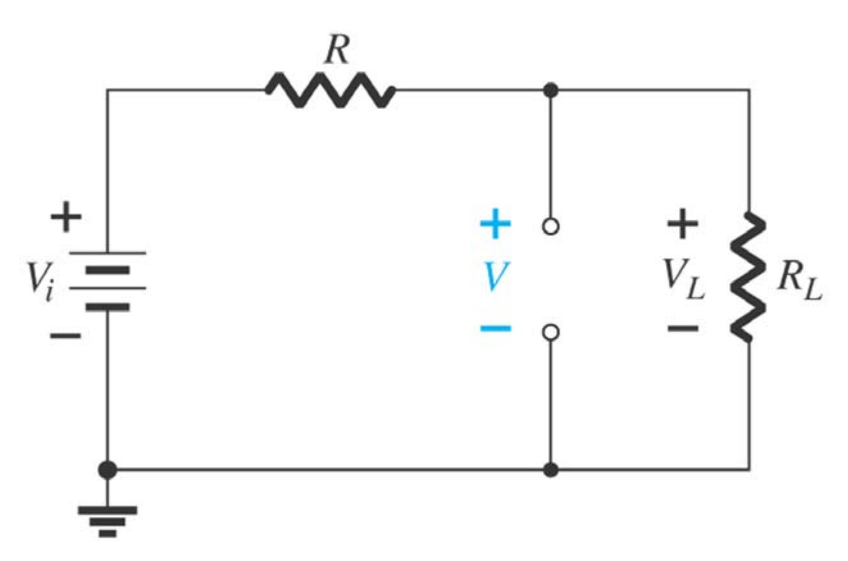
2nd half

Fixed V_i and R as a dc regulator



A simplest Zener diode regulator network

To determine the state of Zener diode by removing the diode from the network



Thus applying voltage divider rule

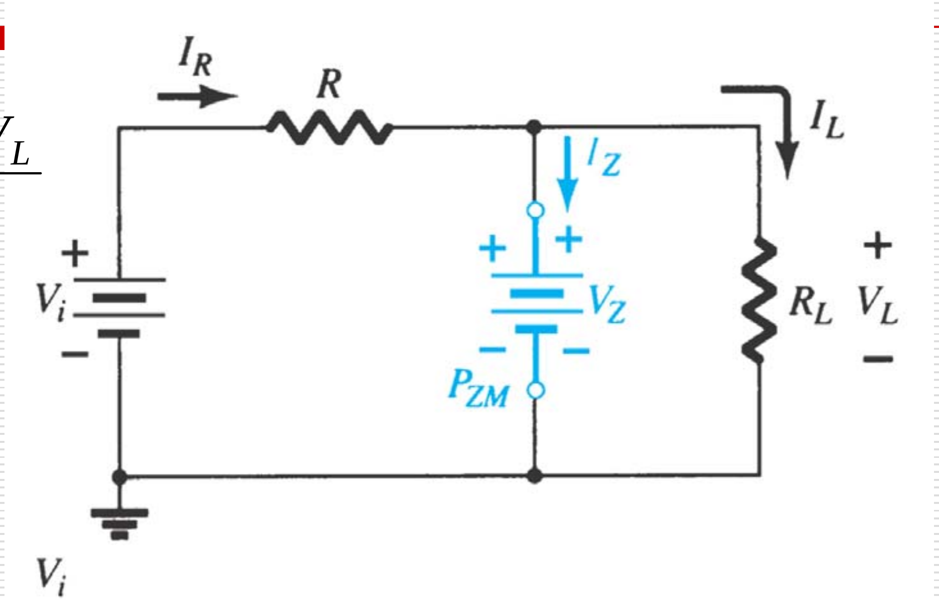
$$V = V_L = \frac{R_L V_i}{R + R_L}$$

If $V \geq V_Z$, the Zener diode is on.

If $V < V_Z$, the Zener diode is off.

Zener equivalent for the “on” situation

$$I_R = \frac{V_R}{R} = \frac{V_i - V_L}{R}$$



$$I_L = \frac{V_L}{R_L}$$

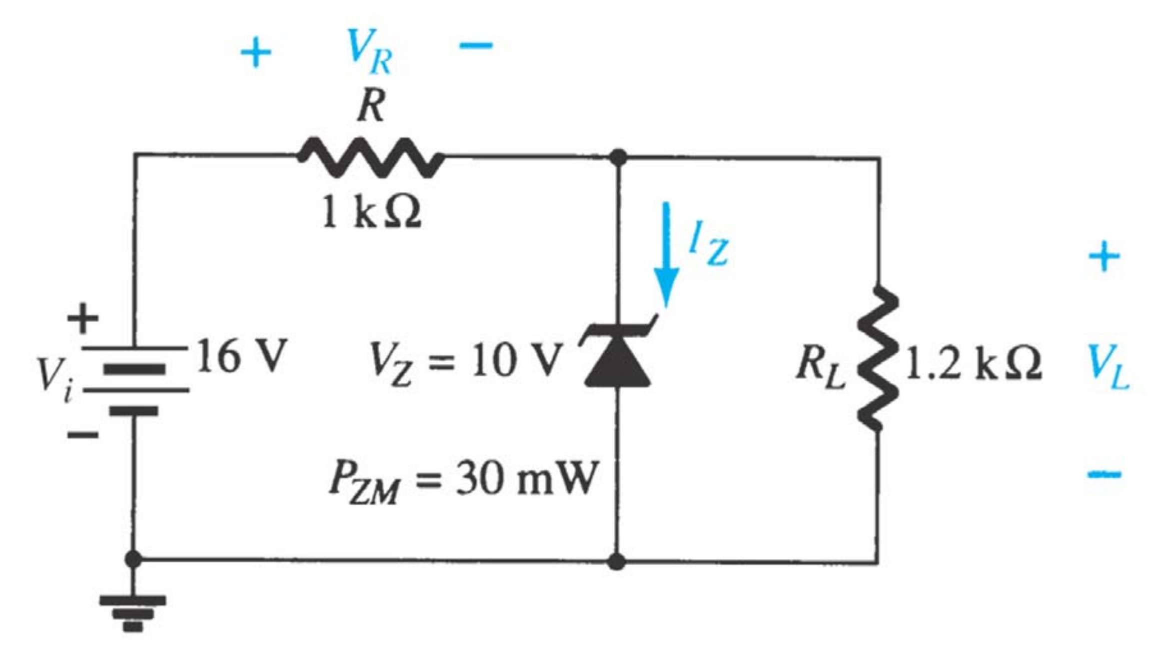
Since Zener is directly parallel to R_L , then $V_L = V_Z$

Zener current , applying Kirchoff’s current law $I_R = I_Z + I_L$

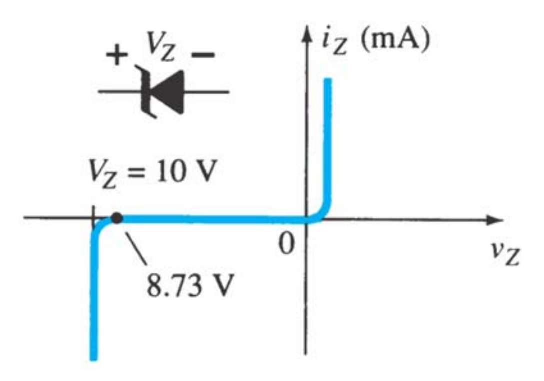
Thus $I_Z = I_R - I_L$

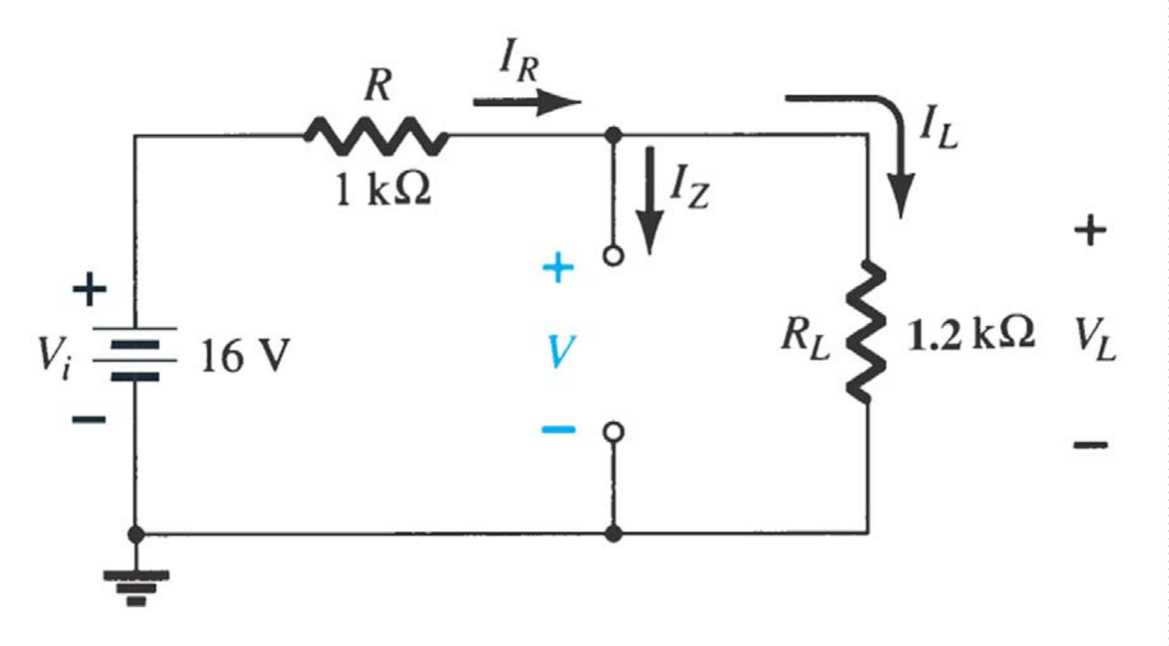
And Power $P_Z = V_Z\ I_Z$

Ex: Determine V_L , V_R, I_Z and P_Z



Solution





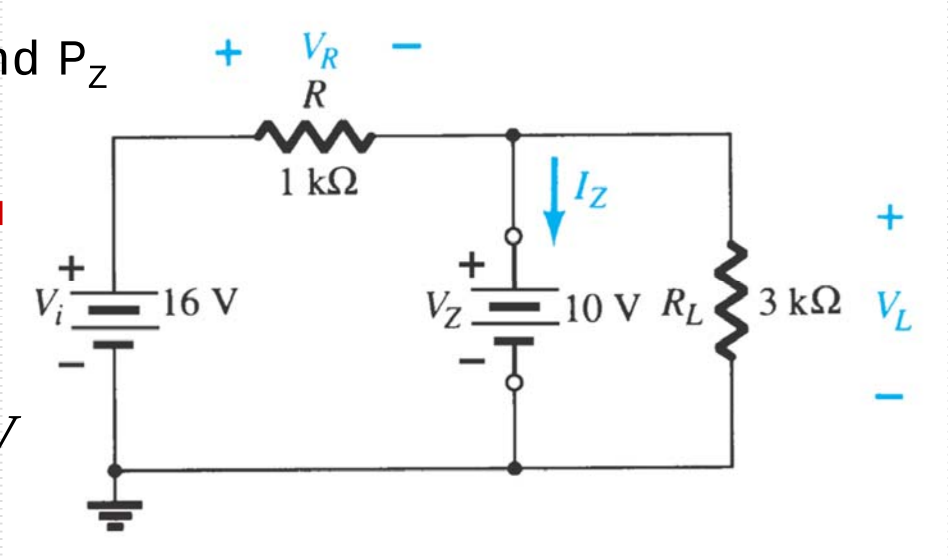
Applying voltage divider rule $V = \dfrac{R_L V_i}{R + R_L} = \dfrac{1.2k\Omega(16V)}{1k\Omega + 1.2k\Omega} = 8.73V$

Since V=8.73V is less than 10V , the diode is in the "off" state

Thus $V_L = V = 8.73V$ And $V_R = V_i - V_L = 16V - 8.73V = 7.27V$

Since the Zener is off , then $I_Z = 0$ and $P_Z = V_Z I_Z = 0W$

Ex: Determine V_L , V_R, I_Z and P_Z



Applying voltage divider rule

$$V = \frac{R_L V_i}{R + R_L} = \frac{3k\Omega(16V)}{1k\Omega + 3k\Omega} = 12V$$

Since V=12V is greater than V_Z=10V, the Zener is in "on" state

Therefore V_L=V_Z=10V and V_R= V_i- V_L =16V -10V=6V

$$I_L = \frac{V_L}{R_L} = \frac{10V}{3k\Omega} = 3.33mA \qquad I_R = \frac{V_R}{R} = \frac{6V}{1k\Omega} = 6mA$$

and $$I_Z = I_R - I_L = 6mA - 3.33mA = 2.67mA$$

To determine the resistor range

To determine the minimum load that can turn on the diode So that $V_L = V_Z$ ‘ that is

$$V_L = V_Z = \frac{R_L V_i}{R_L + R}$$

Solving for R_L ‘ we have

$$R_{L\min} = \frac{R V_Z}{V_i - V_Z} \quad \text{and} \quad I_{L\min} = \frac{V_L}{R_L} = \frac{V_Z}{R_{L\min}}$$

Thus any resistance value greater than R_{Lmin} will ensure that the Zener diode is in the “on” state

To determine the resistor range

Once the diode is in the "on" state, the voltage across R remains fixed at

$$V_R = V_i - V_Z$$

And IR remains fixed at $$I_R = \frac{V_R}{R}$$

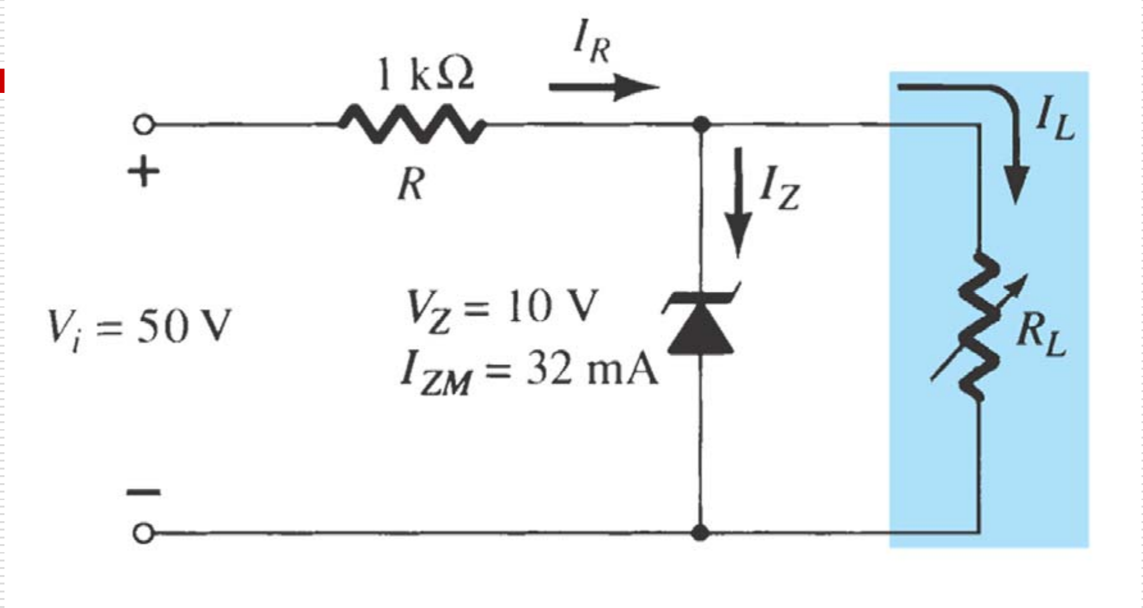
The Zener current $$I_Z = I_R - I_L$$

But the I_Z is limited by the manufacturer I_{ZM} , then

$I_{Lmin} = I_R - I_{ZM}$

And the maximum load resistance as $$R_{L\min} = \frac{V_Z}{I_{L\min}}$$

Determine the range of RL and IL that will result in VRL being maintained at 10V



Calculating for minimum load $R_{L\min}$

$$R_{L\min} = \frac{RV_Z}{V_i - V_Z} = \frac{(1k\Omega)(10V)}{50V - 10V} = \frac{10k\Omega}{40} = 250\Omega$$

The voltage across the resistor R is $V_R = V_i - V_Z = 50V - 10V = 40V$

This will give us

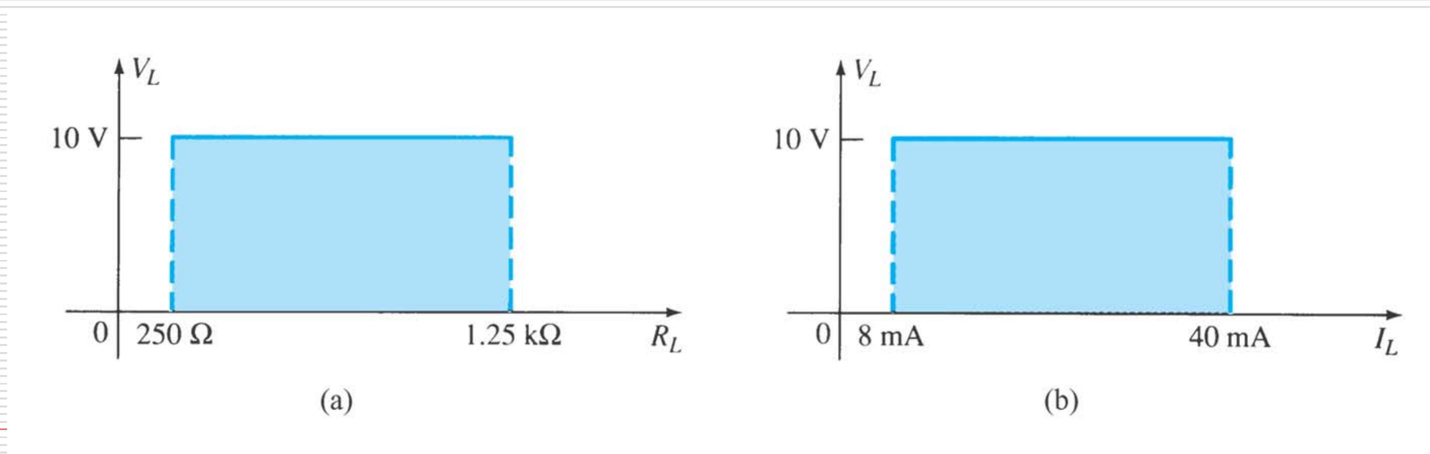
$$I_R = \frac{V_R}{R} = \frac{40V}{1k\Omega} = 40mA$$

Continue

The minimum level of I_L is $I_{Lmin} = I_R - I_{ZM} = 40mA - 32mA = 8mA$

Maximum load R_{Lmax}, $$R_{L\max} = \frac{V_Z}{I_{L\min}} = \frac{10V}{8mA} = 1.25k\Omega$$

Power $P_{max} = V_Z I_{ZM} = (10V)(32mA) = 320mW$



Fixed R_L and Variable V_i

The voltage V_i must be sufficiently large to turn the Zener diode on. The minimum turn on voltage $V_i = V_{imin}$ is

$$V_L = V_Z = \frac{R_L V_i}{R_L + R} \quad \text{therefore} \quad V_{i\min} = \frac{(R_L + R)V_Z}{R_L}$$

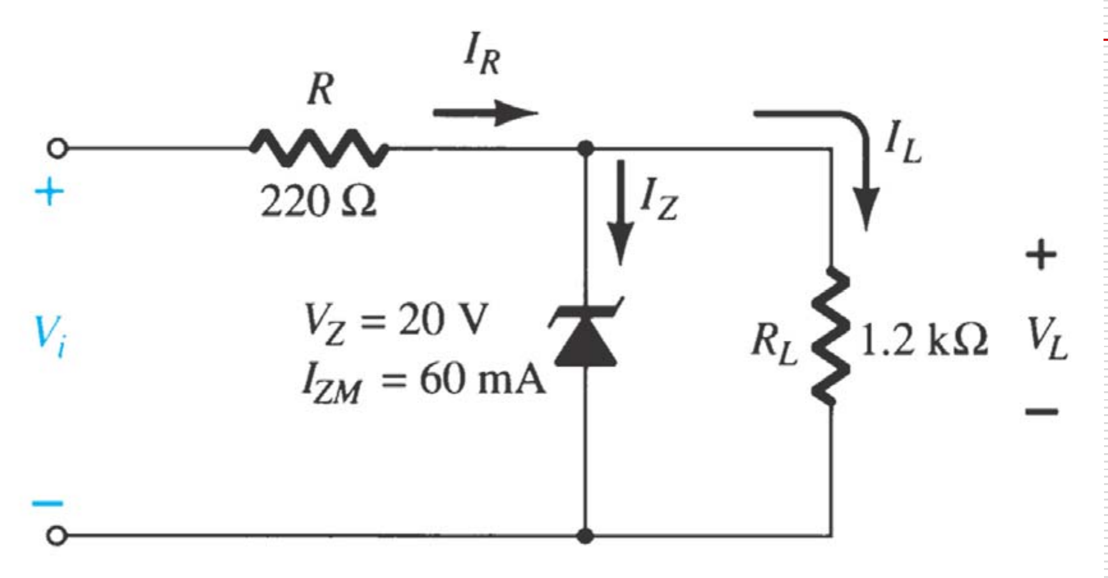
Since the maximum Zener current I_{ZM}, Thus $I_{ZM} = I_R - I_L$

Then $I_{RMAX} = I_{ZM} + I_L$

The maximum voltage

$$V_{i\max} = V_{R\max} + V_Z \quad \text{or} \quad V_{i\max} = I_{R\max} R + V_Z$$

Determine the range of values of Vi that will maintain the Zener diode of in the “on” state.



Using the formula given before

$$V_{i\min} = \frac{(R_L + R)V_Z}{R_L} = \frac{(1200\Omega + 220\Omega)(20V)}{1200\Omega} = 23.67V$$

$$I_L = \frac{V_L}{R_L} = \frac{V_Z}{R_L} = \frac{20V}{1.2k\Omega} = 16.67mA$$

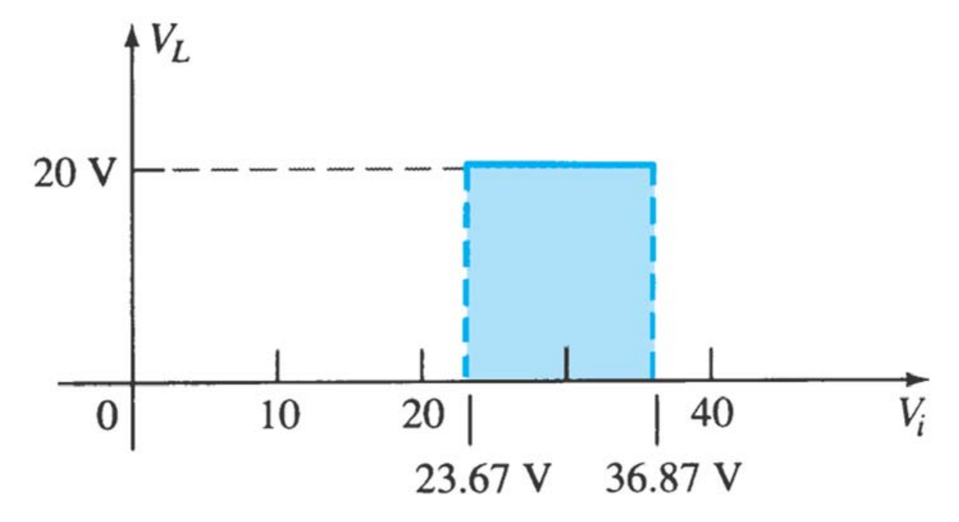
$$V_{i\max} = I_{R\max}R + V_Z$$

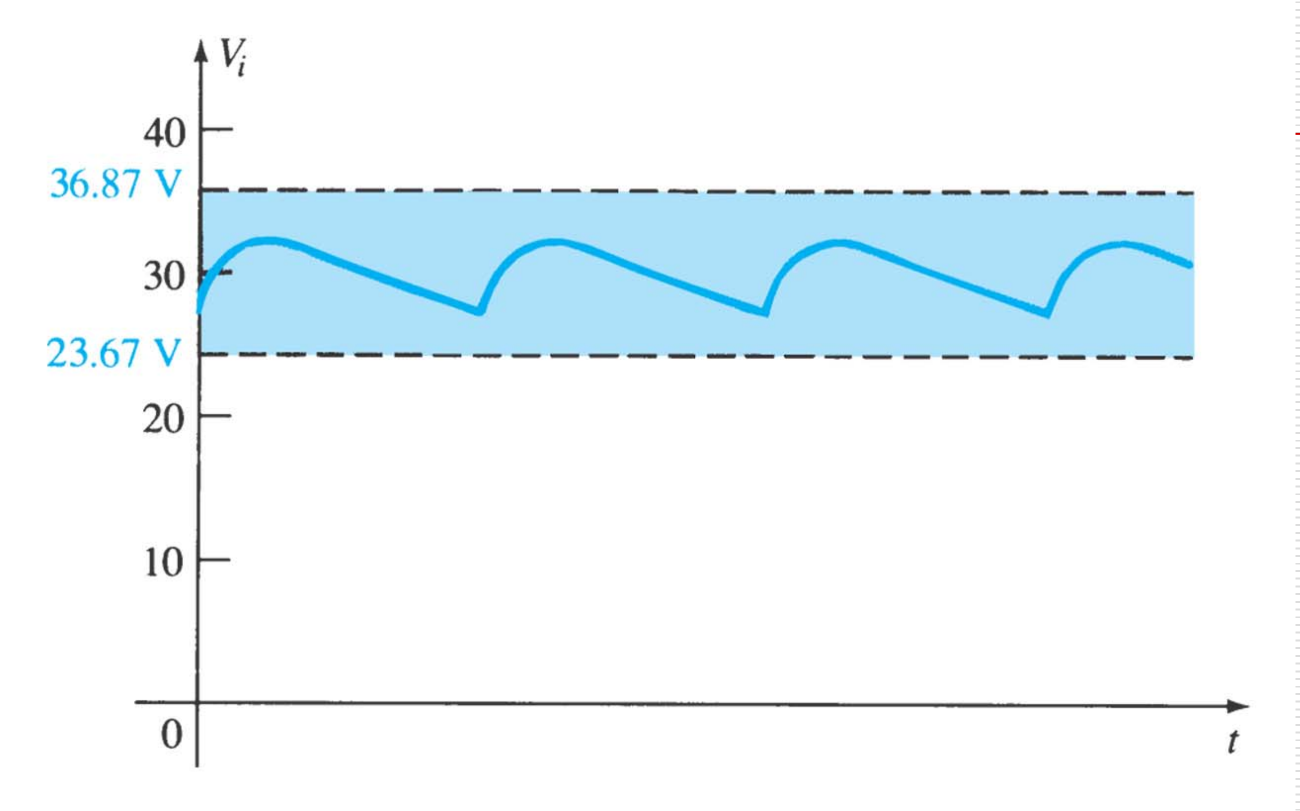
Continue

$$I_{R\max} = I_{ZM} + I_L = 60mA + 16.67mA = 76.67mA$$

$$V_{i\max} = I_{R\max}R + V_Z = (76.67mA)(0.22k\Omega) + 20V = 36.87V$$

The V_i range is plotted below

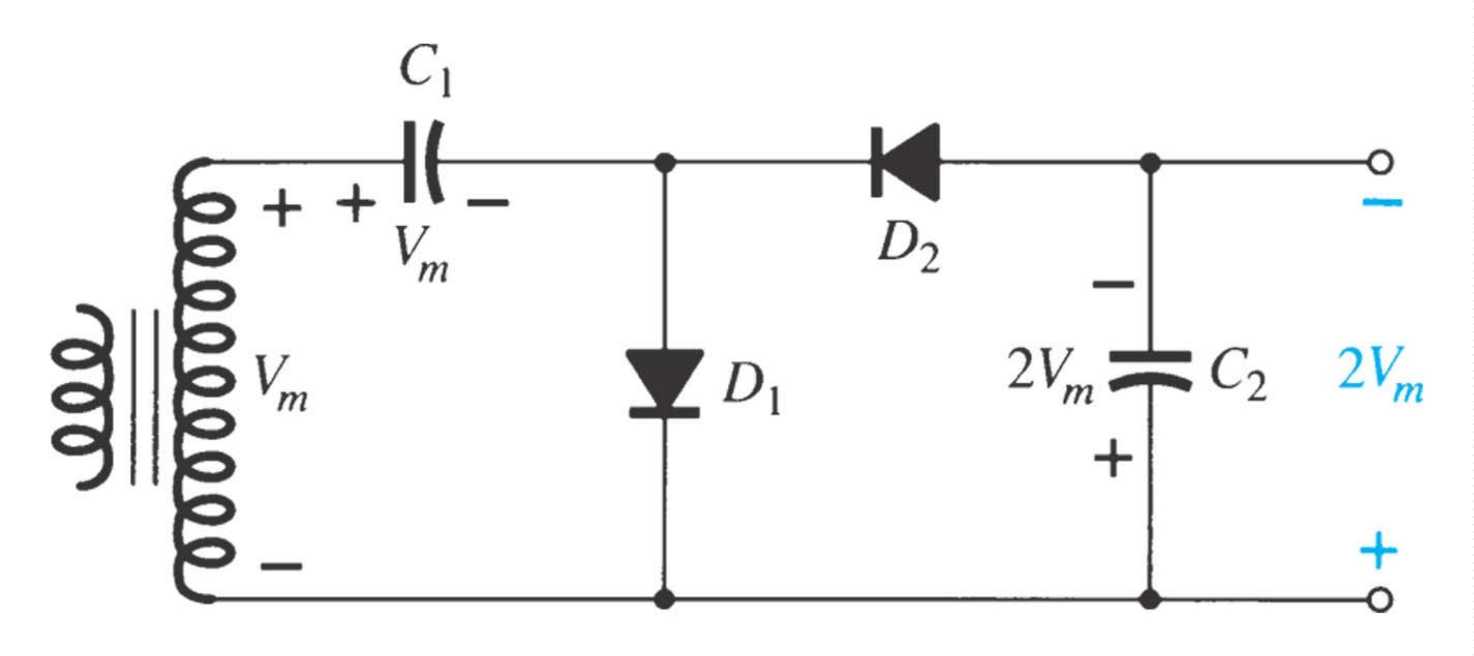


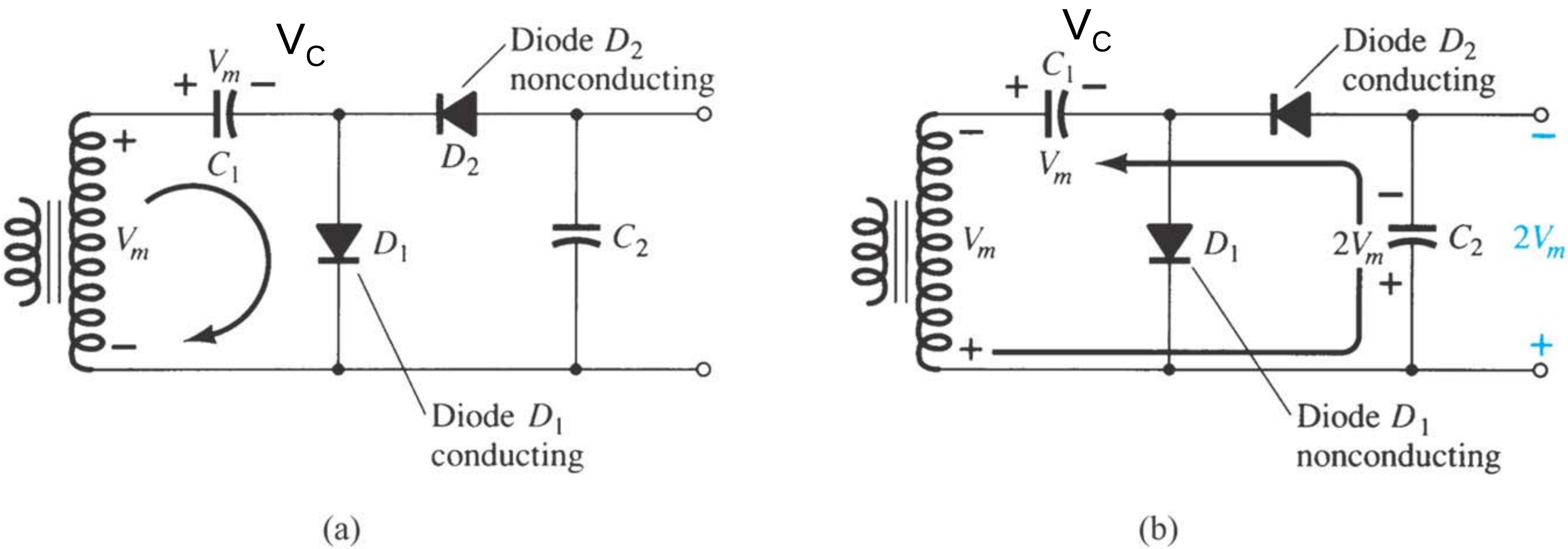


If the input is a ripple from full-wave rectified and filtering as shown, as long as within the specified voltage, the output will still remain constant at 20V.

Voltage Multiplier

HALF-WAVE VOLTAGE DOUBLER

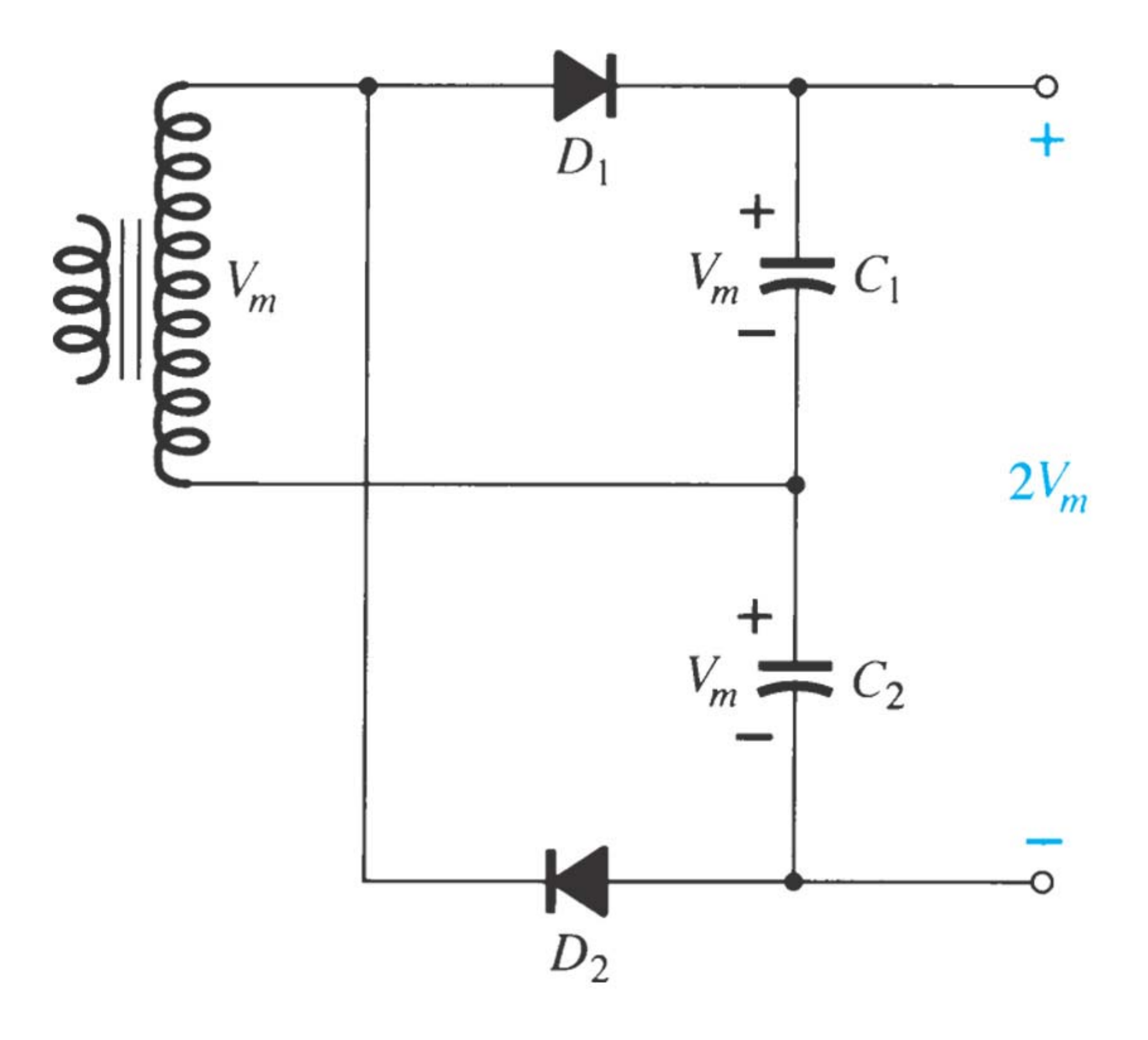


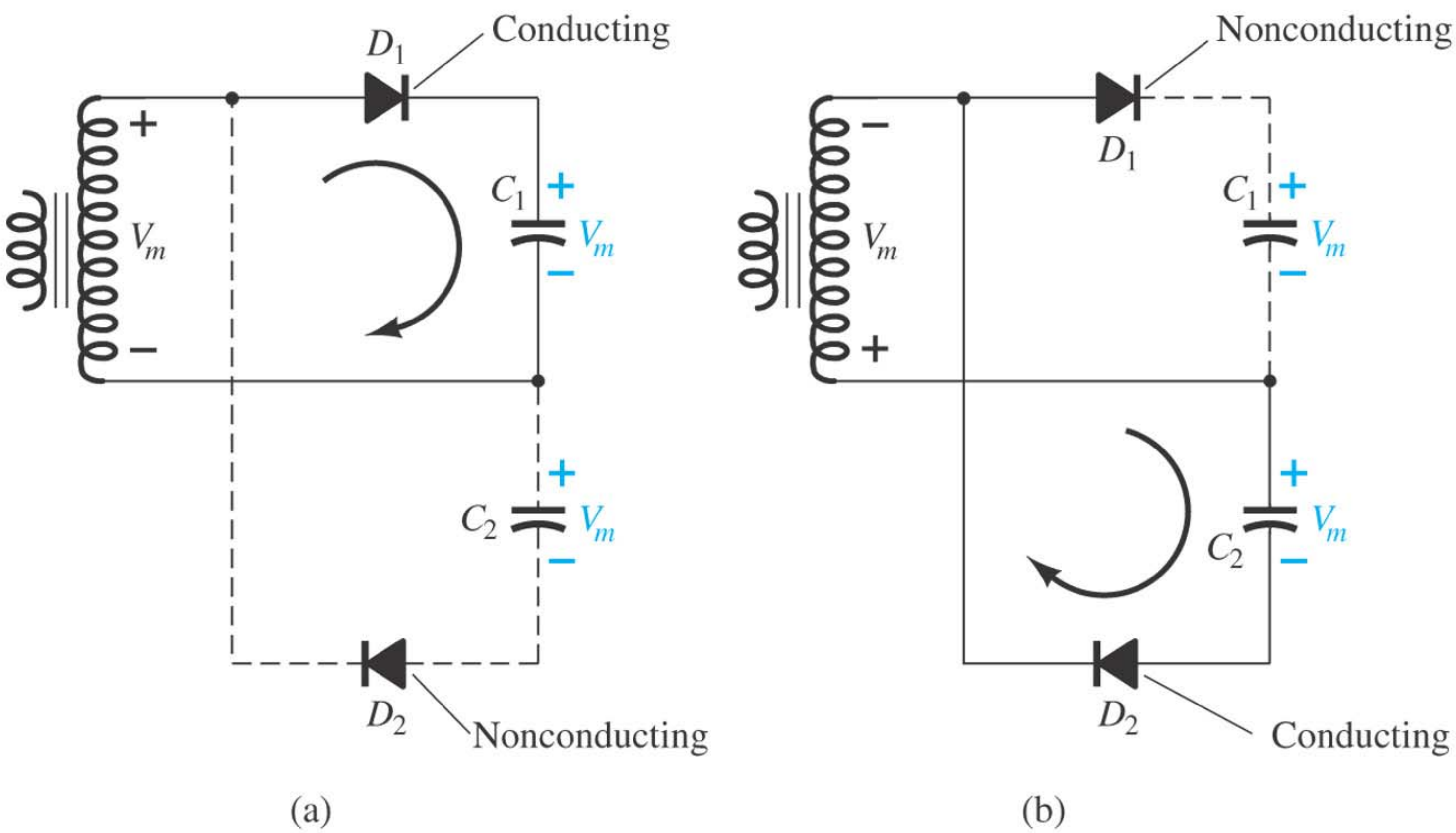


(a)During the positive voltage half-cycle across the transformer, the diode D1 conducts and D2 is cut off. The capacitor C1 charge up to peak rectified voltage V_m .

(b) Second half cycle, D2 conducts and D1 is cut-off. Now the capacitor C2 is charged up with $V_m + V_C = V_m + V_m = 2V_m$

FULL-WAVE VOLTAGE DOUBLER

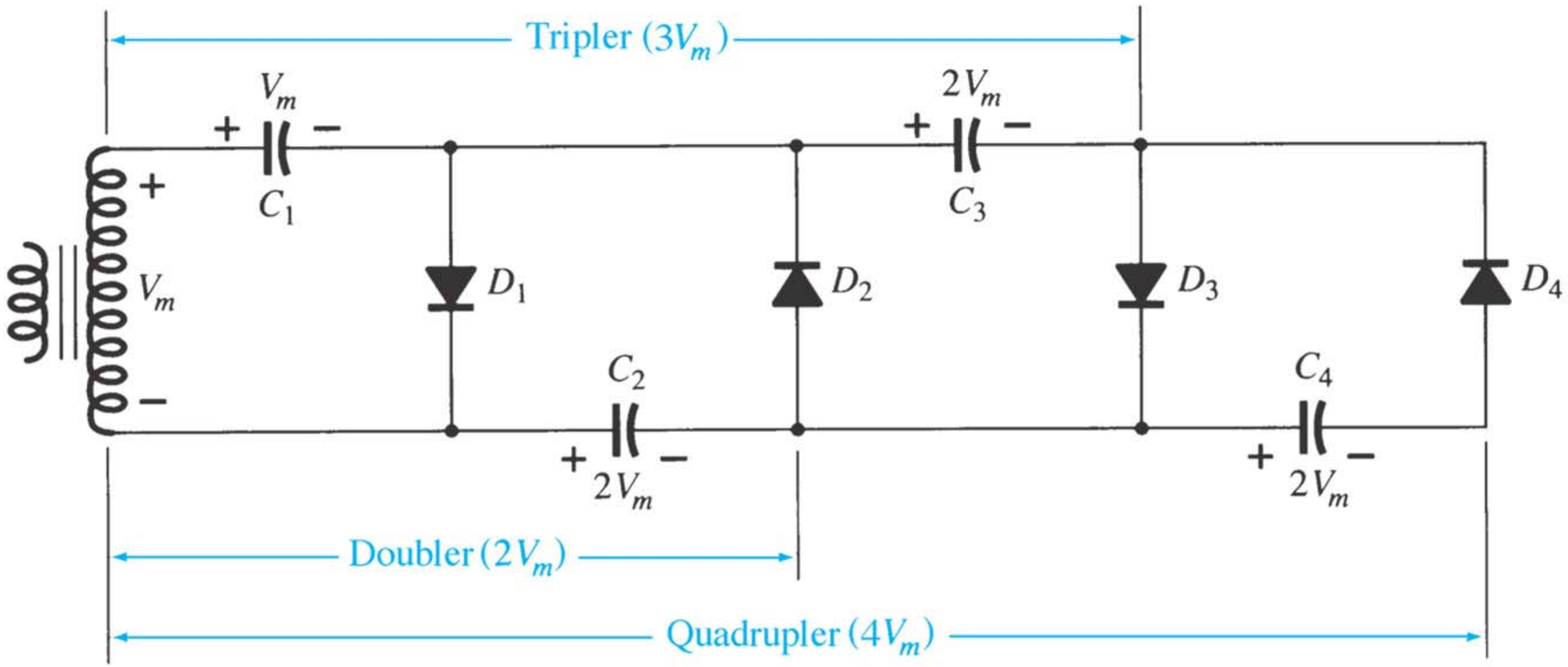




(a) Positive cycle, D_1 is conducting, thus charging C1 to V_m . D2 is not conducting so charging on capacitor C_2.

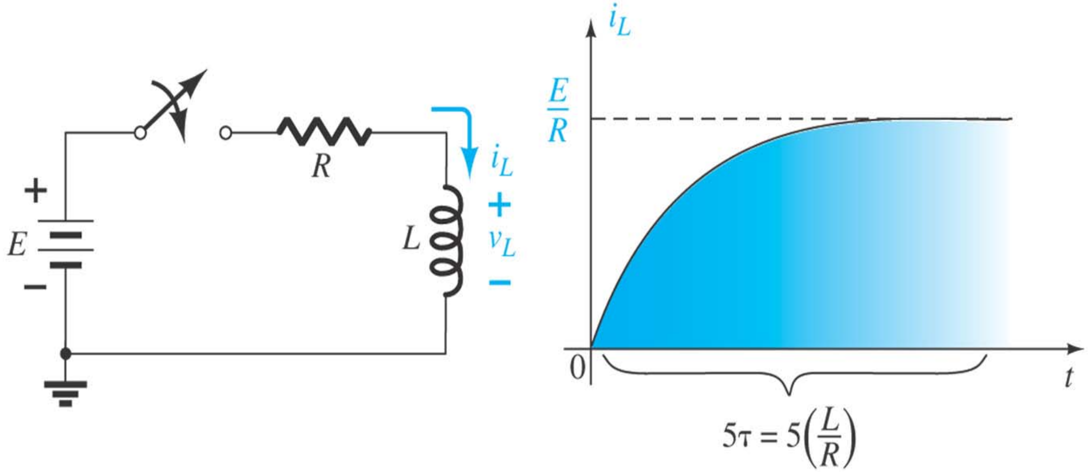
(b) Negative cycle, D_2 is conducting, thus charging C_2 to V_m. D_1 is not conducting so C_1 still maintain the charging voltage

HALF-WAVE DOUBLER, TRIPLER AND QUADRUPLER

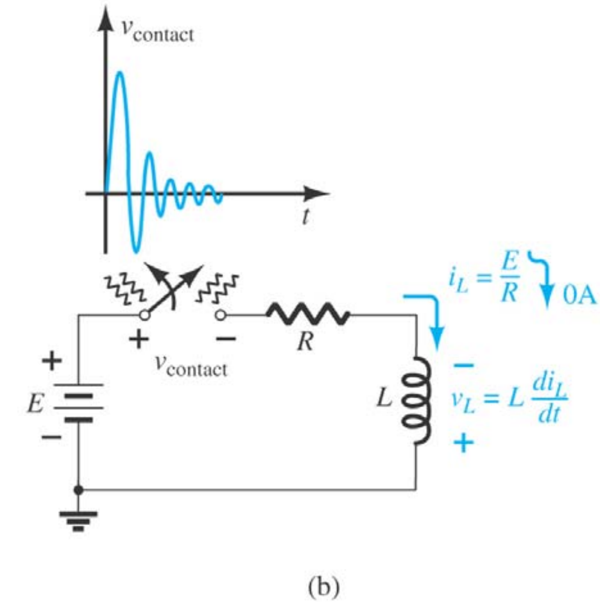


By arranging alternately capacitor and diode, we are able to obtain voltage doubler, tripler and quadrupler. C1 plus transformer charging C2. C2 charging C3 and C3 charging C4.

Protective configuration



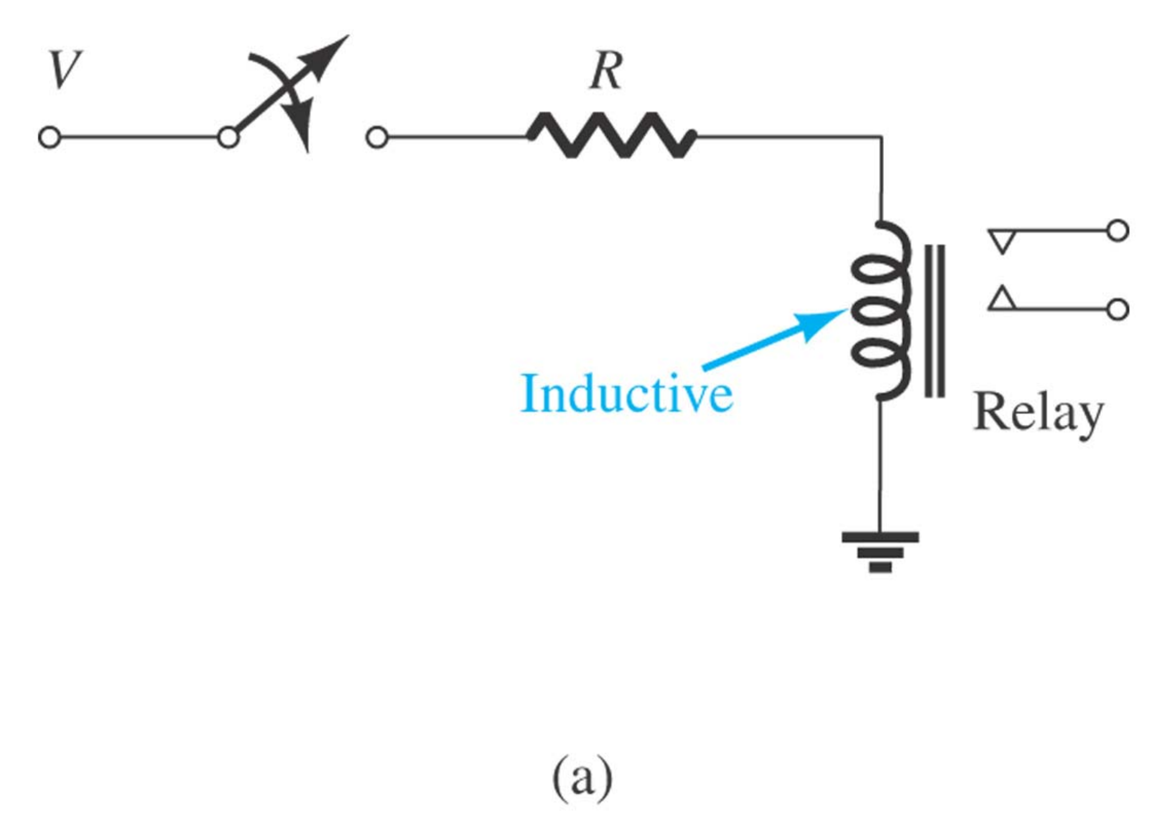
Transient phase of a simple RL cct



Arcing during opening the switch

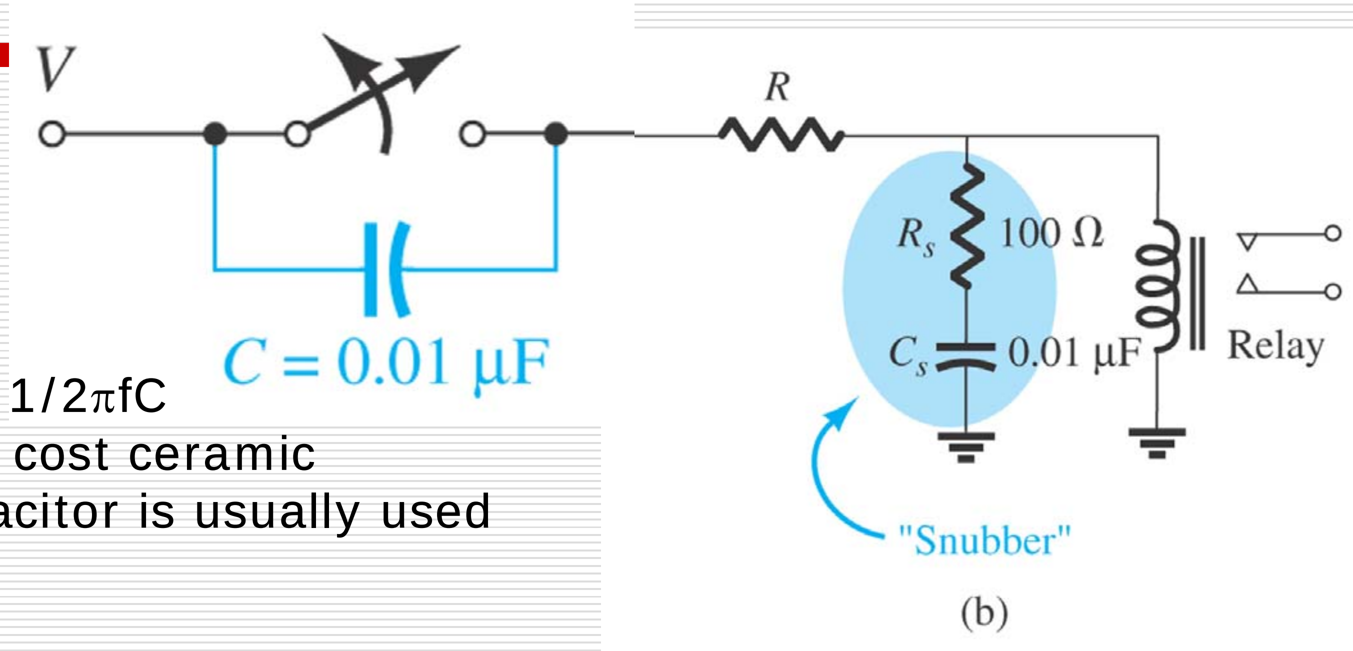
Trying to change the current through an inductive element too quickly may result in an inductive kick that could damage surrounding elements or the system itself

The RL circuit may be used to control the relay



During closing the switch the coil will gain a steady current.
When closing, the arcing may cause the problem to the relay.

This is the cheapest circuit to protect the switching system.



(b)

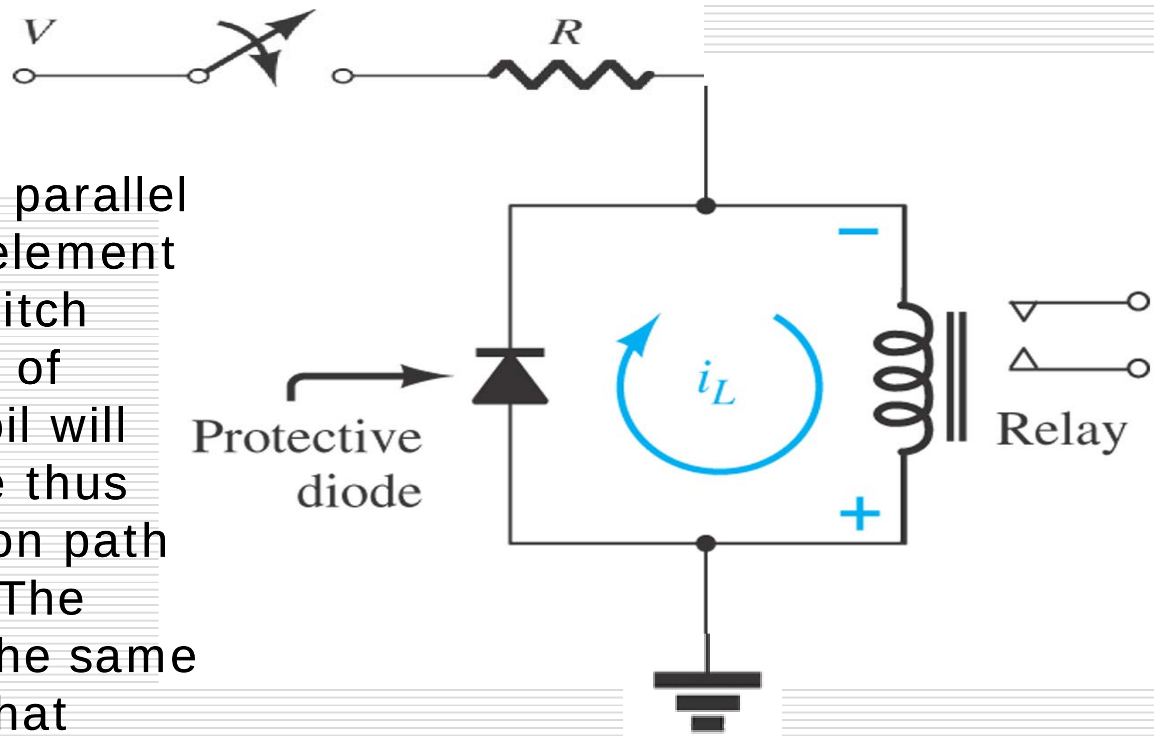
$X_c = 1/2\pi fC$
Low cost ceramic capacitor is usually used

A capacitor is parallel to the switch. It is acting as a bypass (or shorting) the high frequency component.

A snubber is also to short circuit the high frequency component

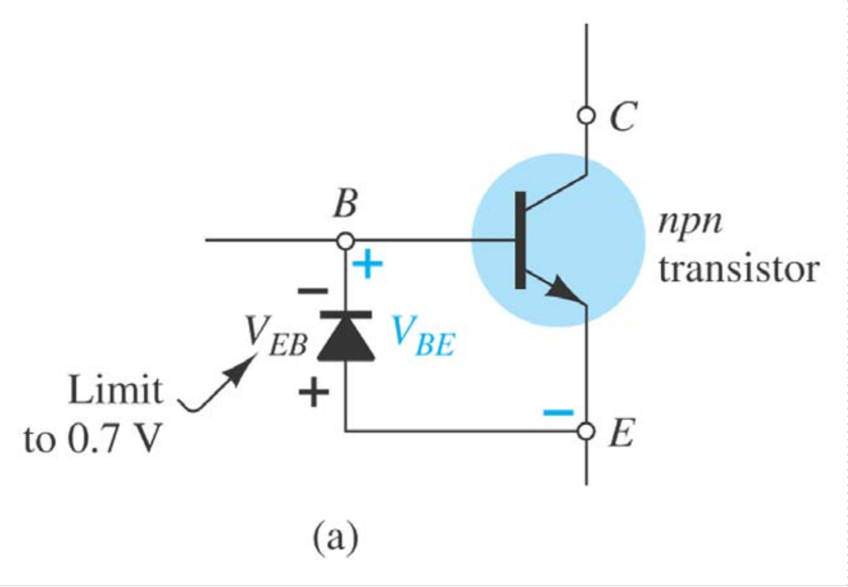
The resistor in series is to protect the surge current.

Diode protection for RL circuit



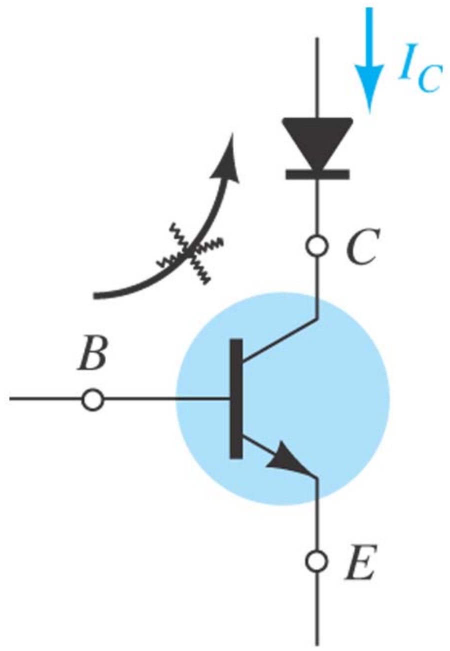
A diode is placed parallel to the inductive element (relay). When switch open the polarity of voltage across coil will turn on the diode thus provide conduction path for the inductor. The diode must has the same current level to that current passing the coil

Diode protector to limit the emitter –base voltage



V_{BE} is limited to 0.7V (knee voltage of the silicon diode)

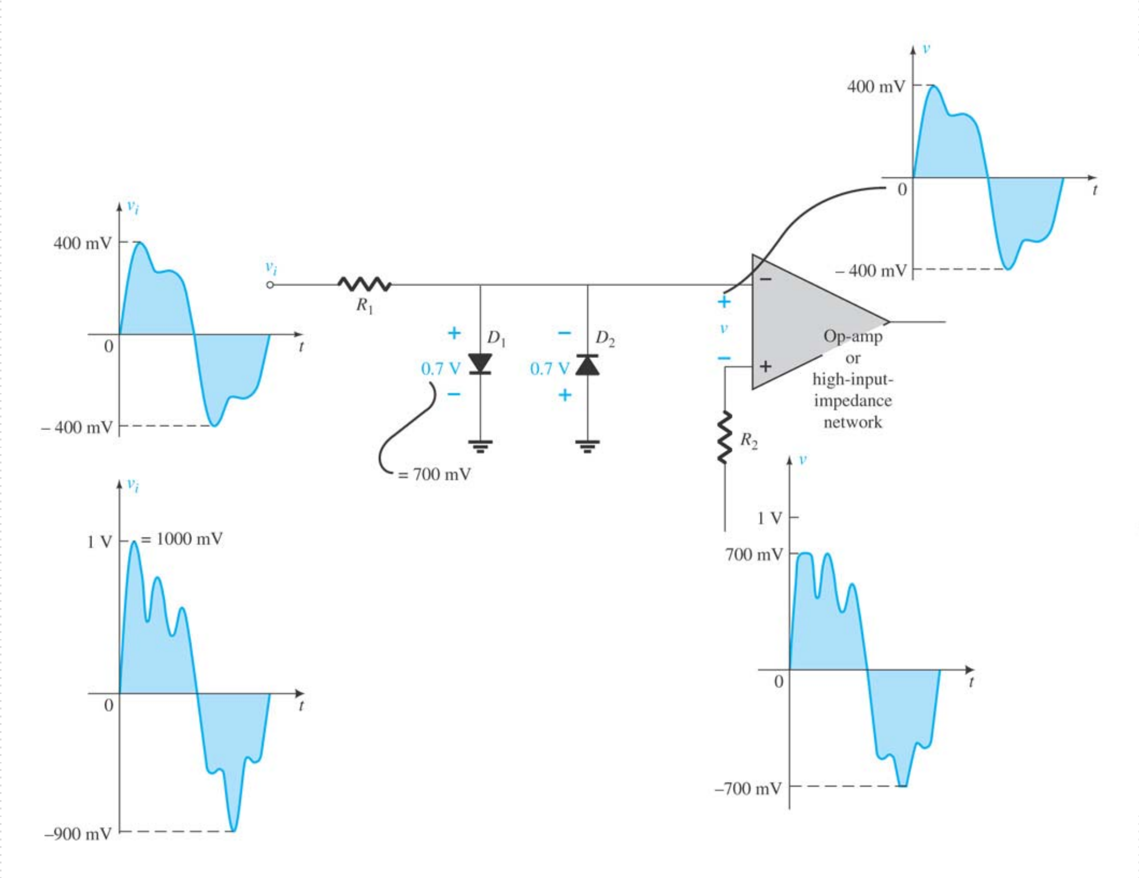
Diode protection to prevent a reversal in collection current

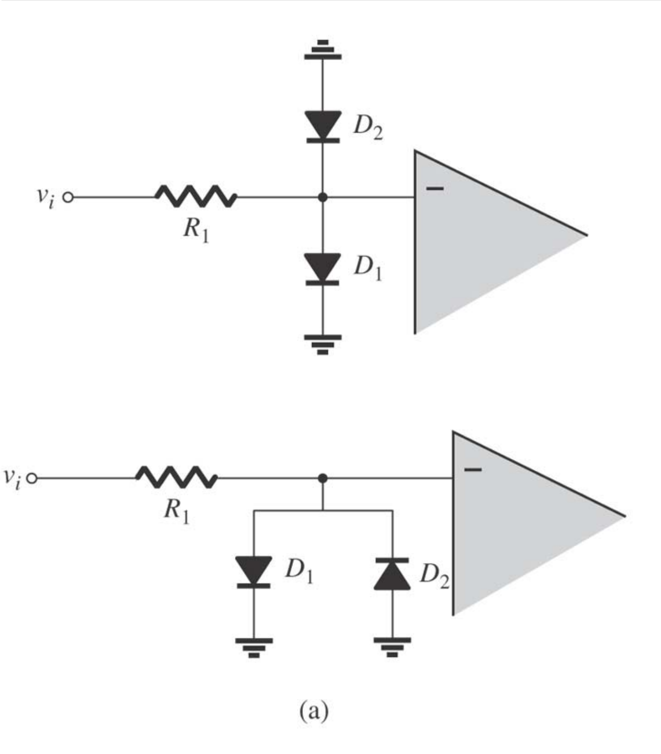


(b)

A current from B to C will be blocked by the diode

Diodes can be used to limit the input of OPAM to 0.7V

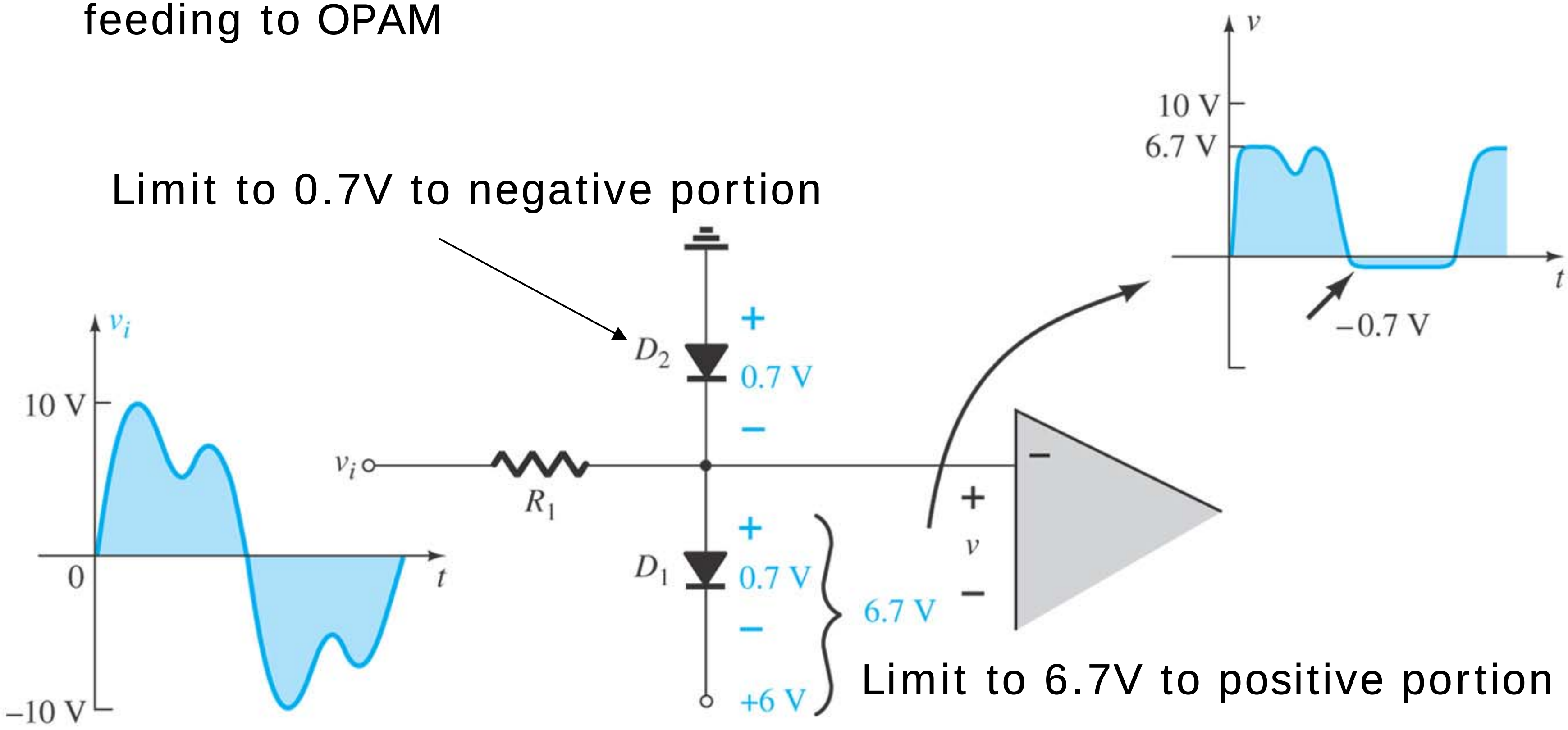




Same appearance

Introduce voltage to increase limitation of the positive portion and limit to 0.7V to the negative portion before feeding to OPAM

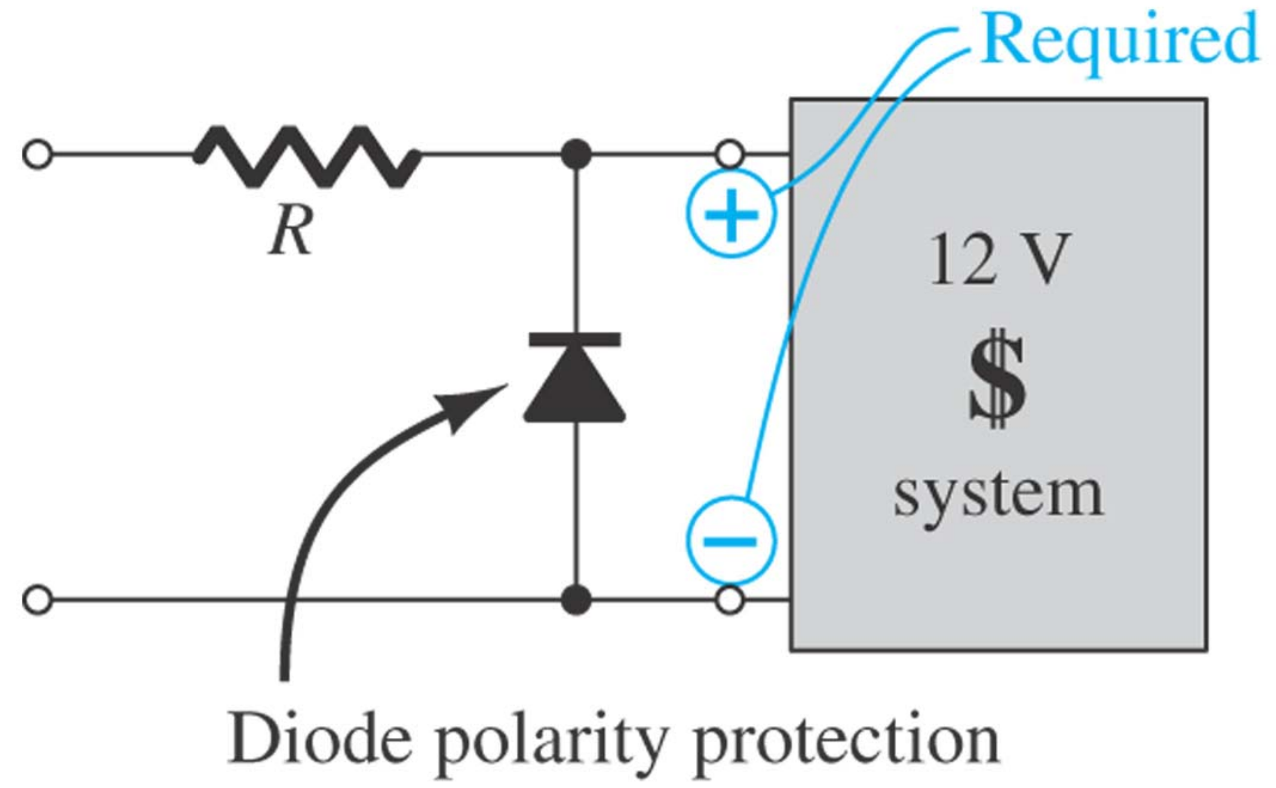
Limit to 0.7V to negative portion



Limit to 6.7V to positive portion

(b)

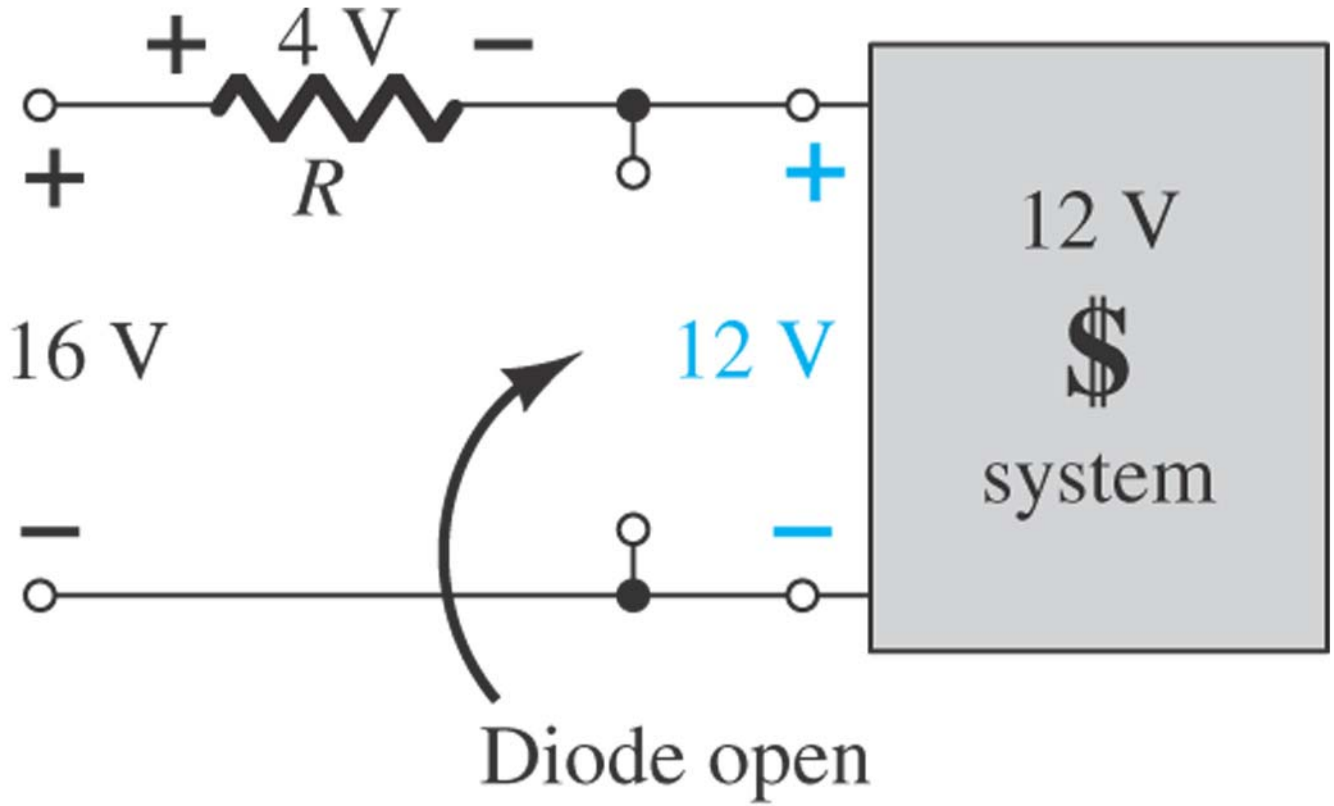
POLARITY INSURANCE



(a)

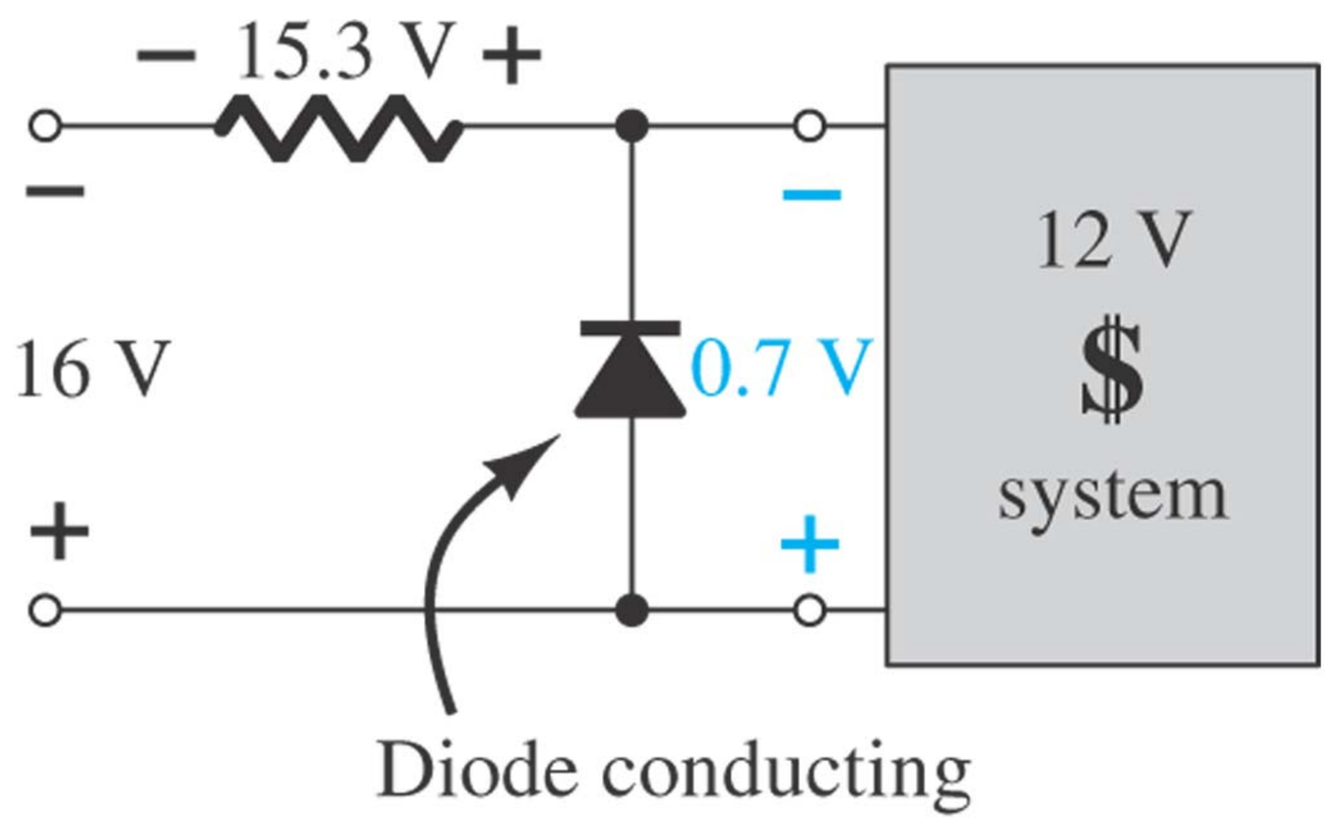
This circuit is to prevent from mistaken connecting the battery with wrong polarity

If the polarity is okay then the diode circuit is in open state



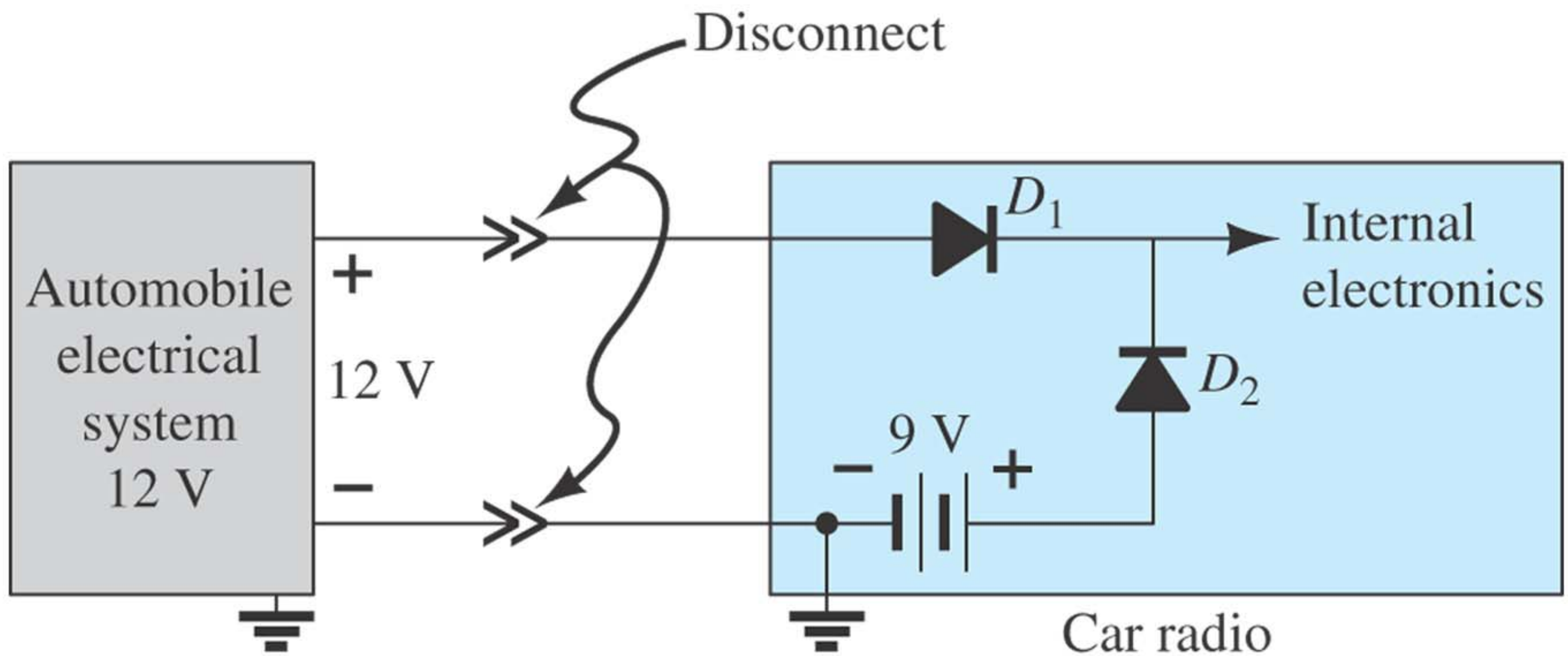
(b)

If the polarity is not okay then the current is bypass thru diode.
This will stop the battery to damage the $ system



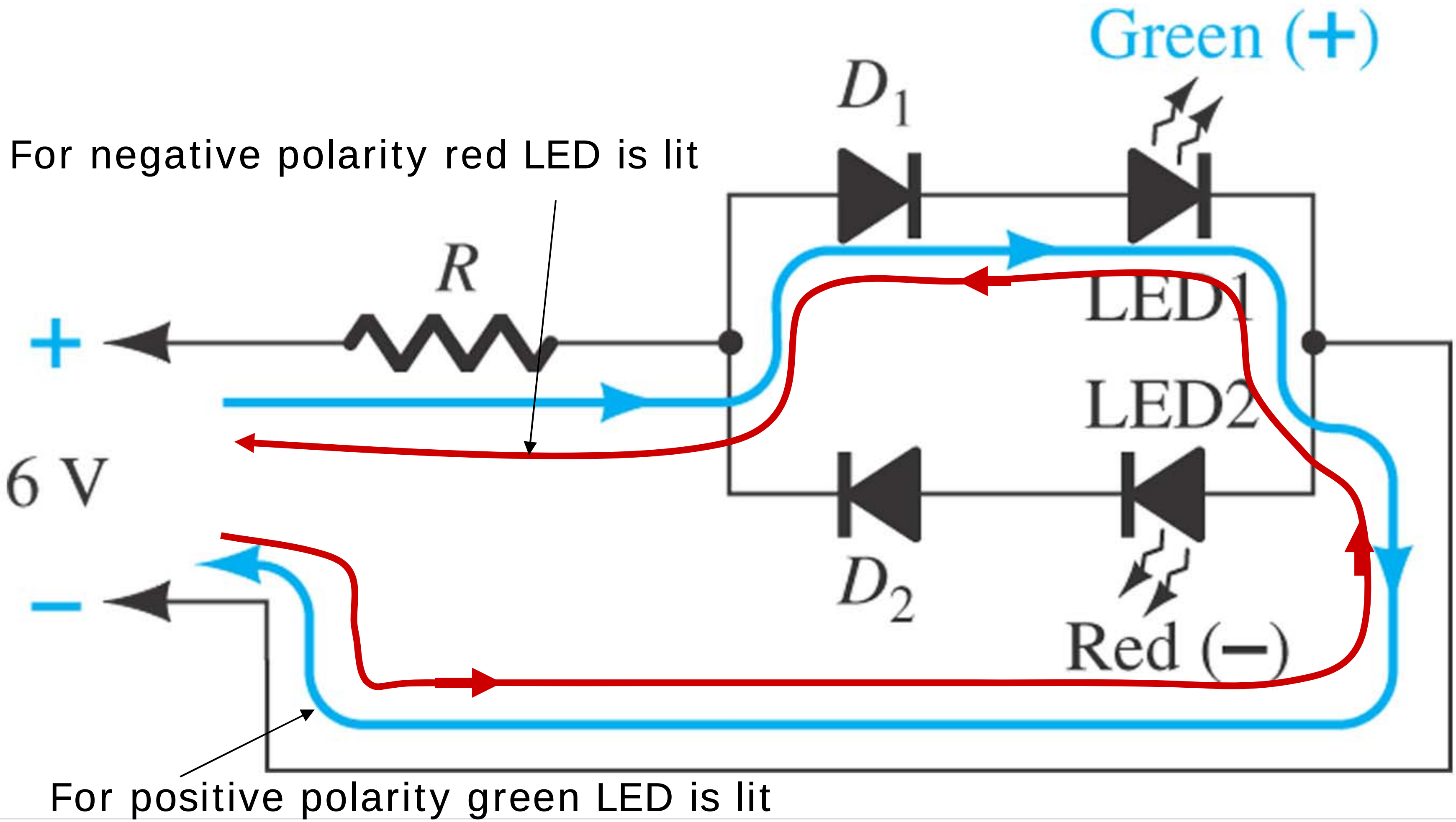
(c)

Battery –powered backup

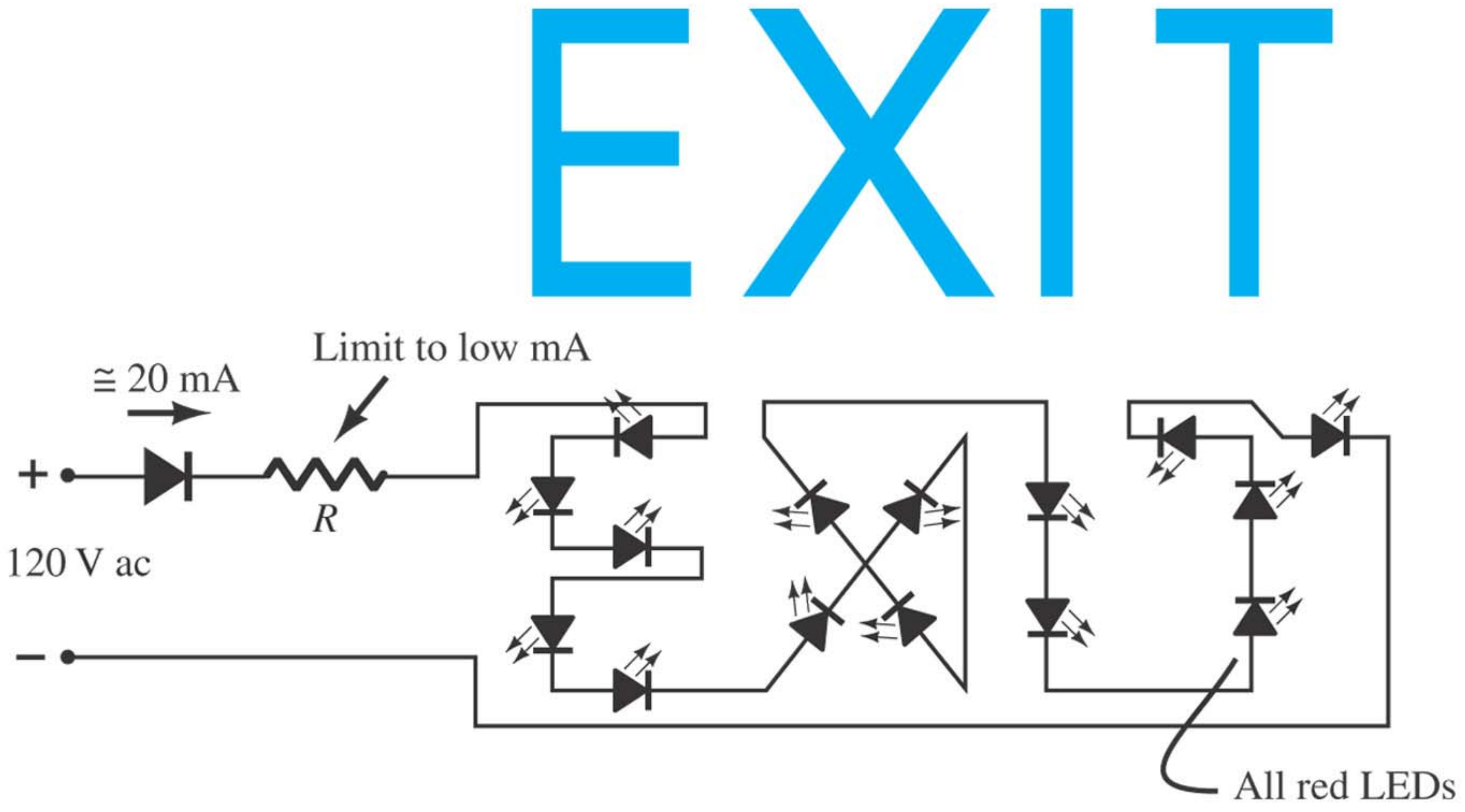


When electrical power is connected D1 id “on” state and D2 will be “off” state, thus only electrical power is functioned. When electrical power is disconnected D1 is “off” state and D2 is conducted , thus the power will come from the battery.

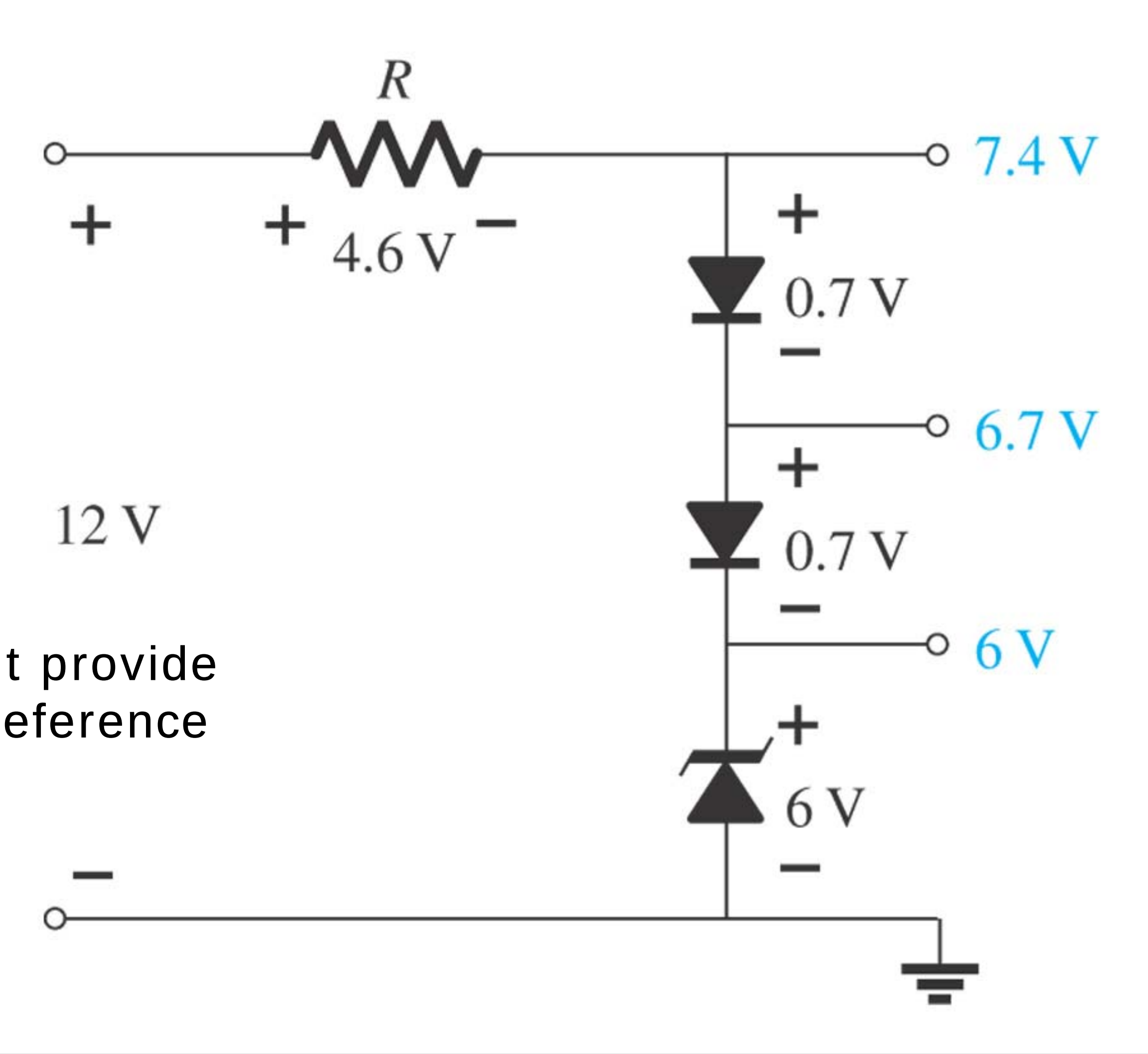
Polarity detector using diodes and LED



LED diodes are arranged for EXIT sign display.

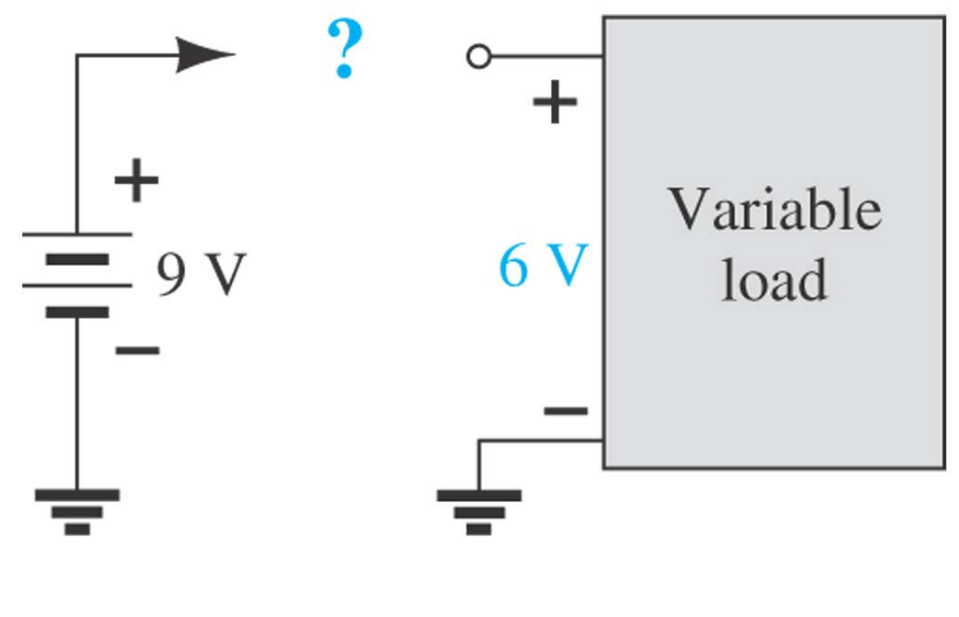


Voltage Reference Levels circuit



This circuit provide different reference levels

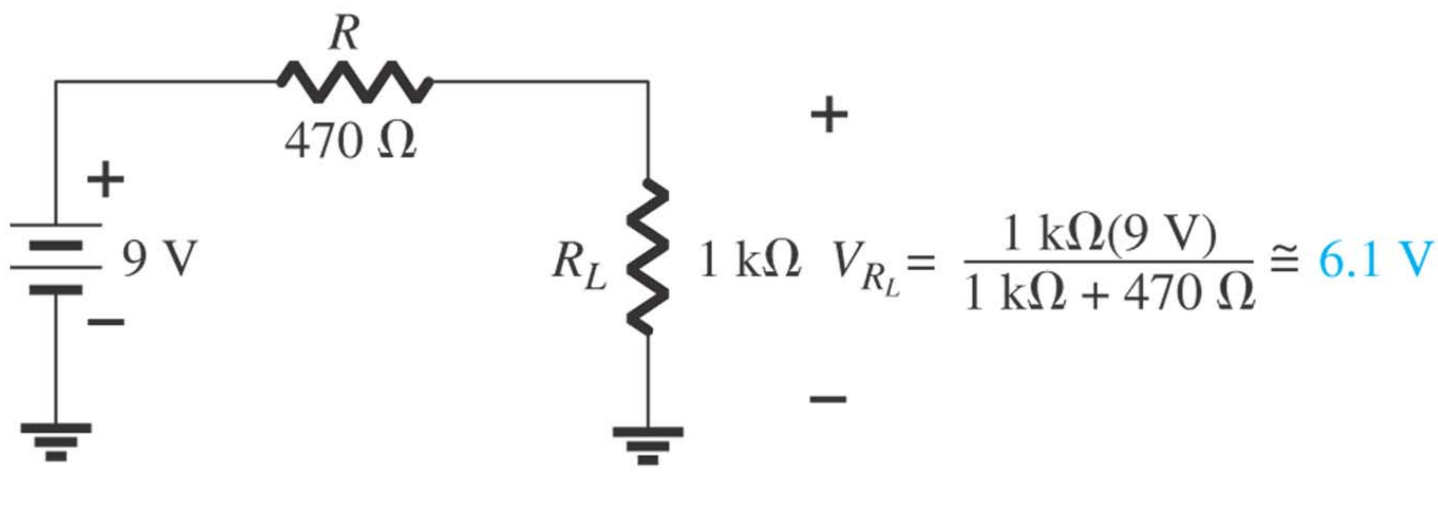
To establish a voltage level insensitive to the load current



(a)

A battery is connected to a network that has different voltage supply and variable load. The battery available is 9V but the network require 6V. How?

Using external resistor

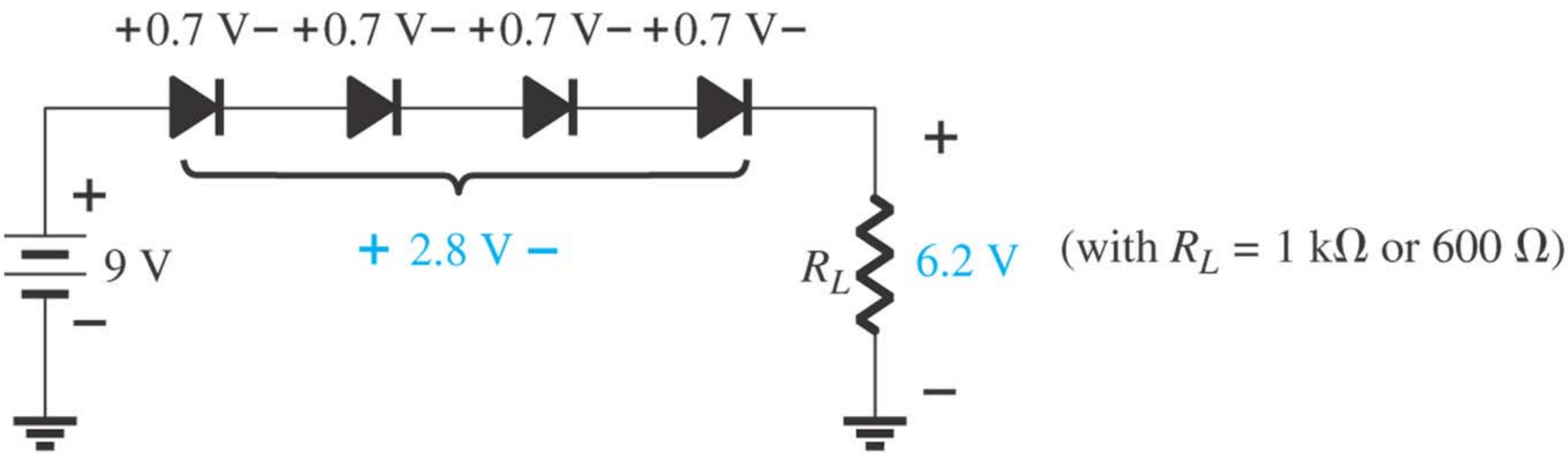


(b)

Let's say the load is 1kΩ , then using voltage divider ,we determine the value of external resistor we obtain approximately 470Ω
We calculate the V_{RL} , give us 6.1V

Now if we change the load to 600 W but the external still same , then V_{RL} become 4.9V ... thus the system will not operate correctly!!

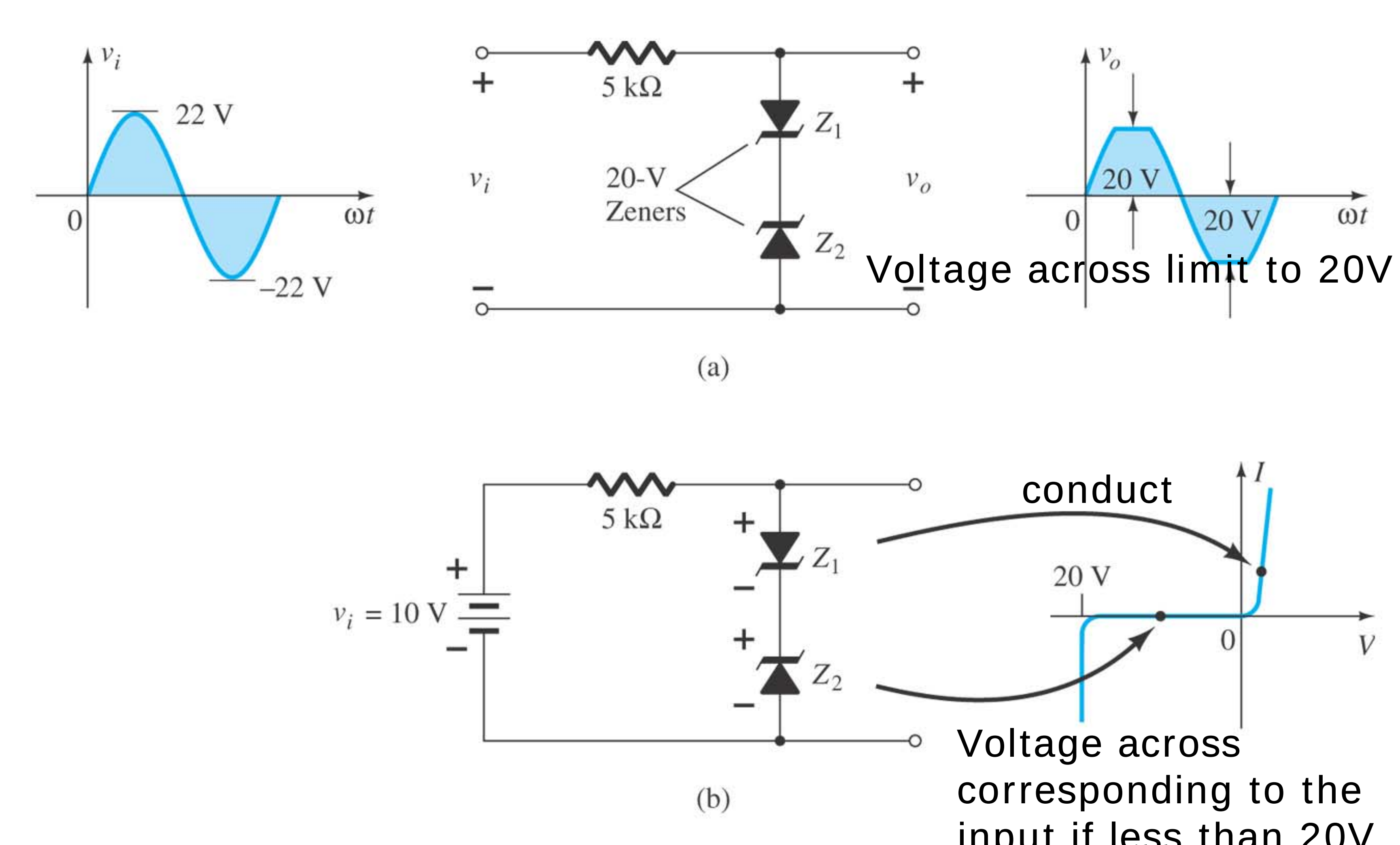
Using diode



(c)

Using diode the voltage can be converted using 4 silicon diode which give a drop of voltage around 2.8V , thus the required voltage of 6.2V is obtained. This network does not sensitive to the load.

AC regulator and square-wave generator



Voltage across limit to 20V

conduct

Voltage across corresponding to the input if less than 20V

Same configuration to produce square -wave