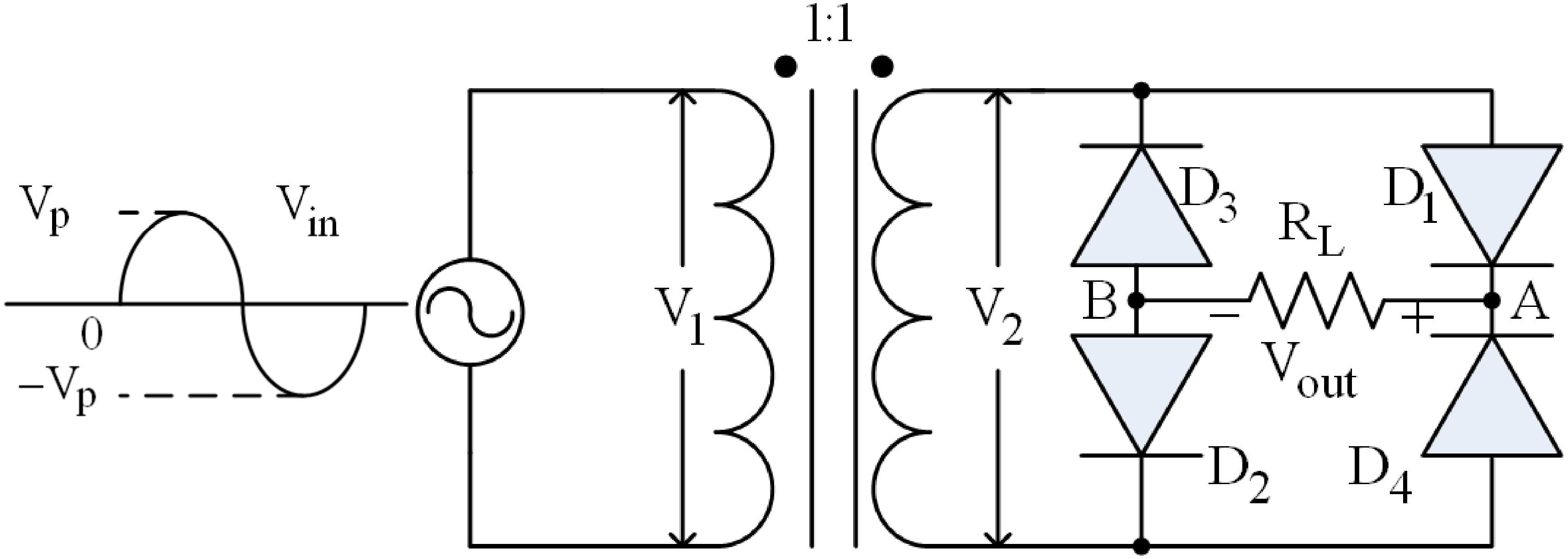
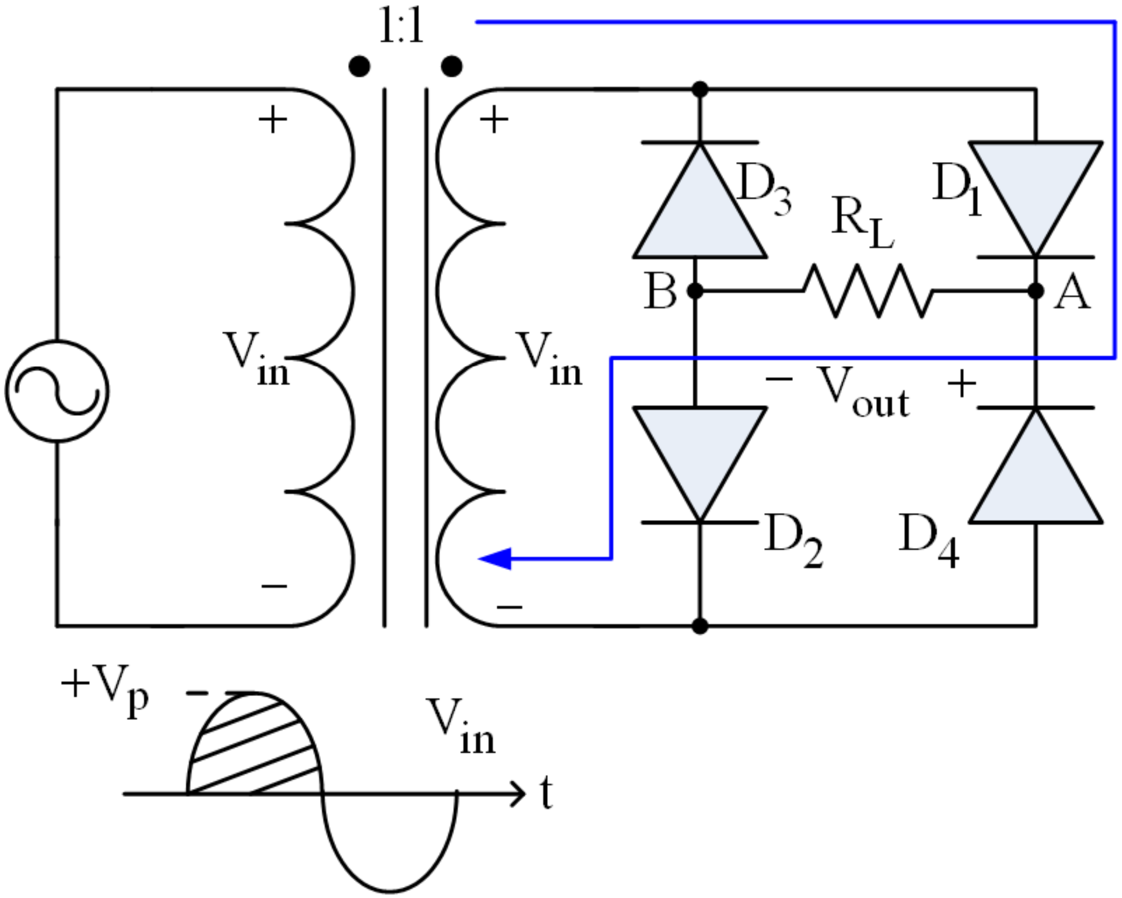
CLASS 11

Bridge full-wave rectifier, rectifier-filter circuit, clipping/limiting and clamping diode circuits

Bridge full-wave rectifier



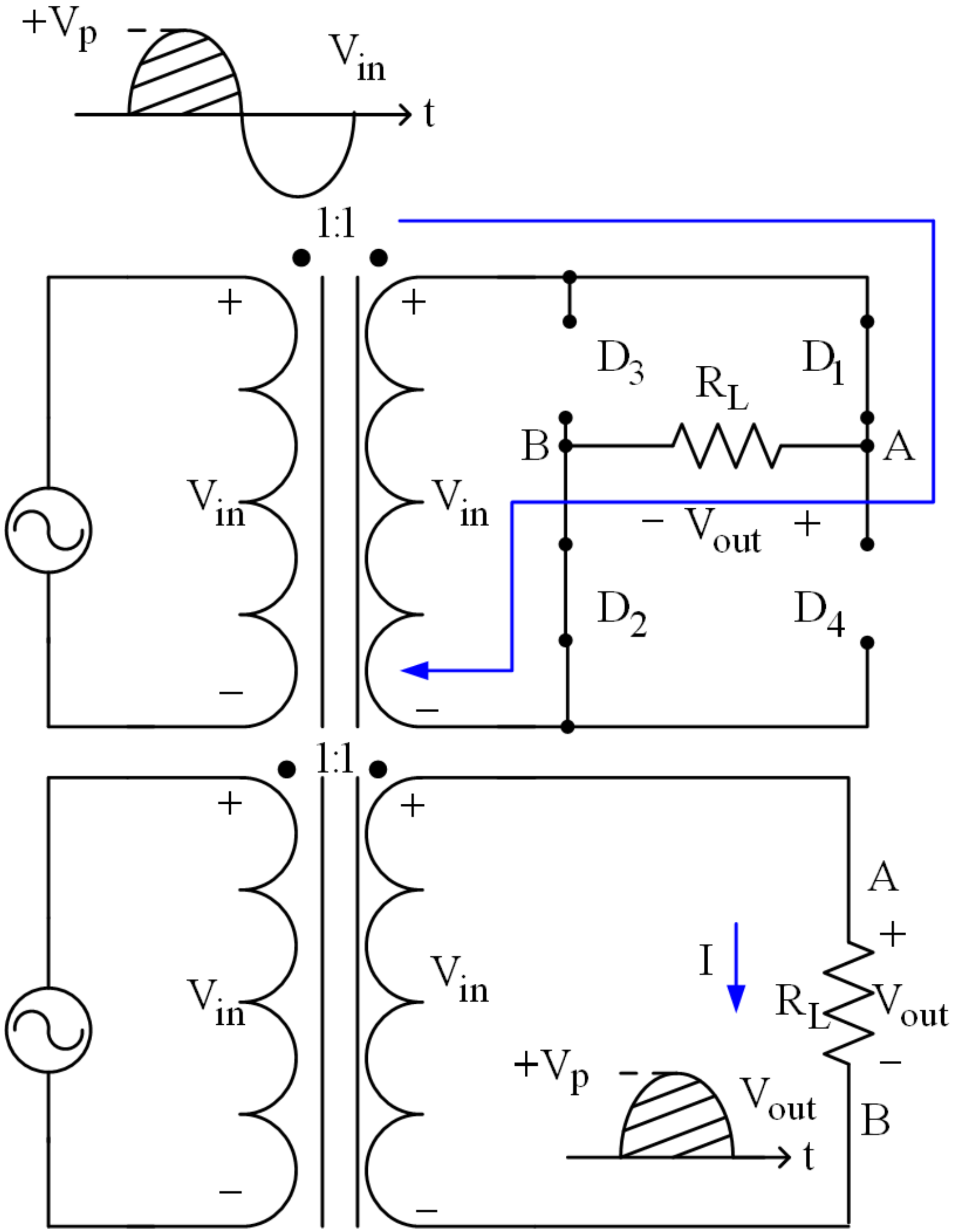
During +ve half cycle, D_1 and D_2 are fb. V_{out} is +ve at A and -ve at B.



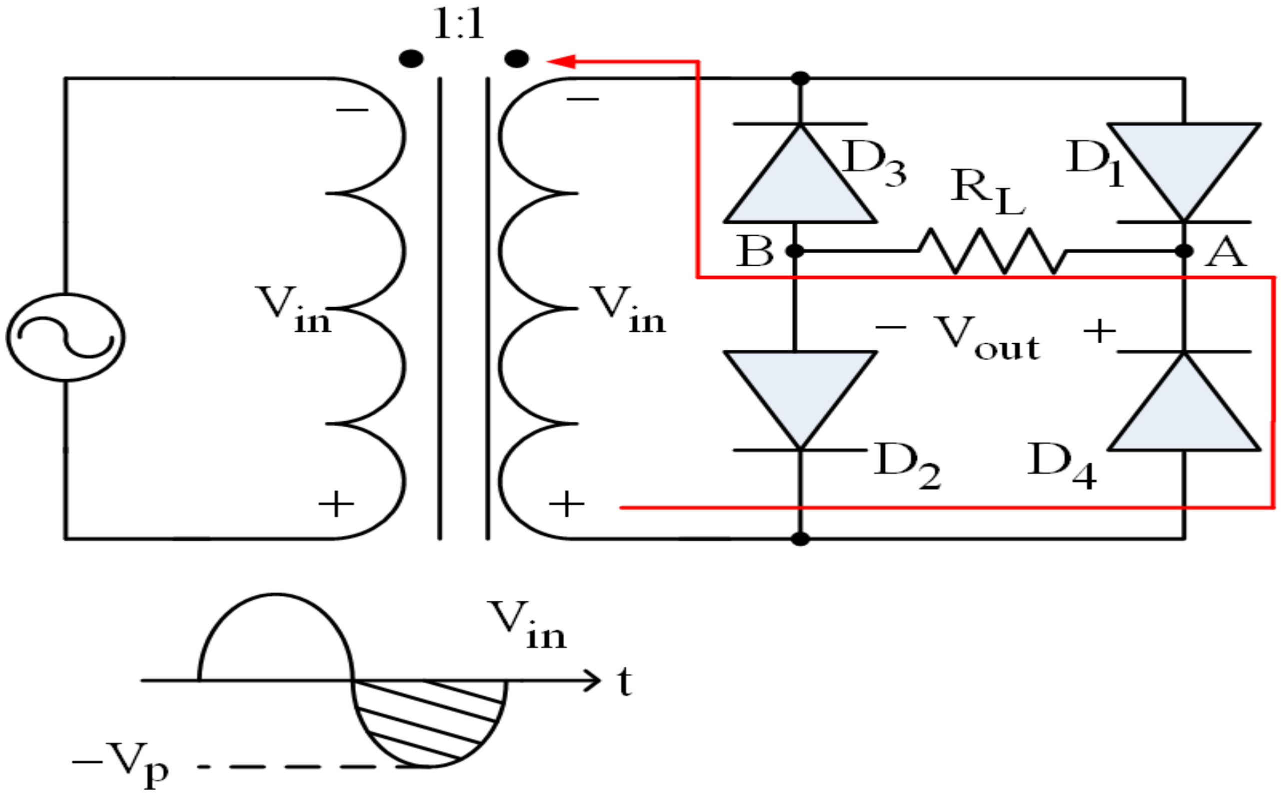
$$V_{out} = V_{in}$$

If $V_{in} = V_p$,

$$V_{out} = V_p$$



During -ve half cycle, D_3 and D_4 are fb. V_{out} is still +ve at A and -ve at B.



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If $V_{in} = V_p$,

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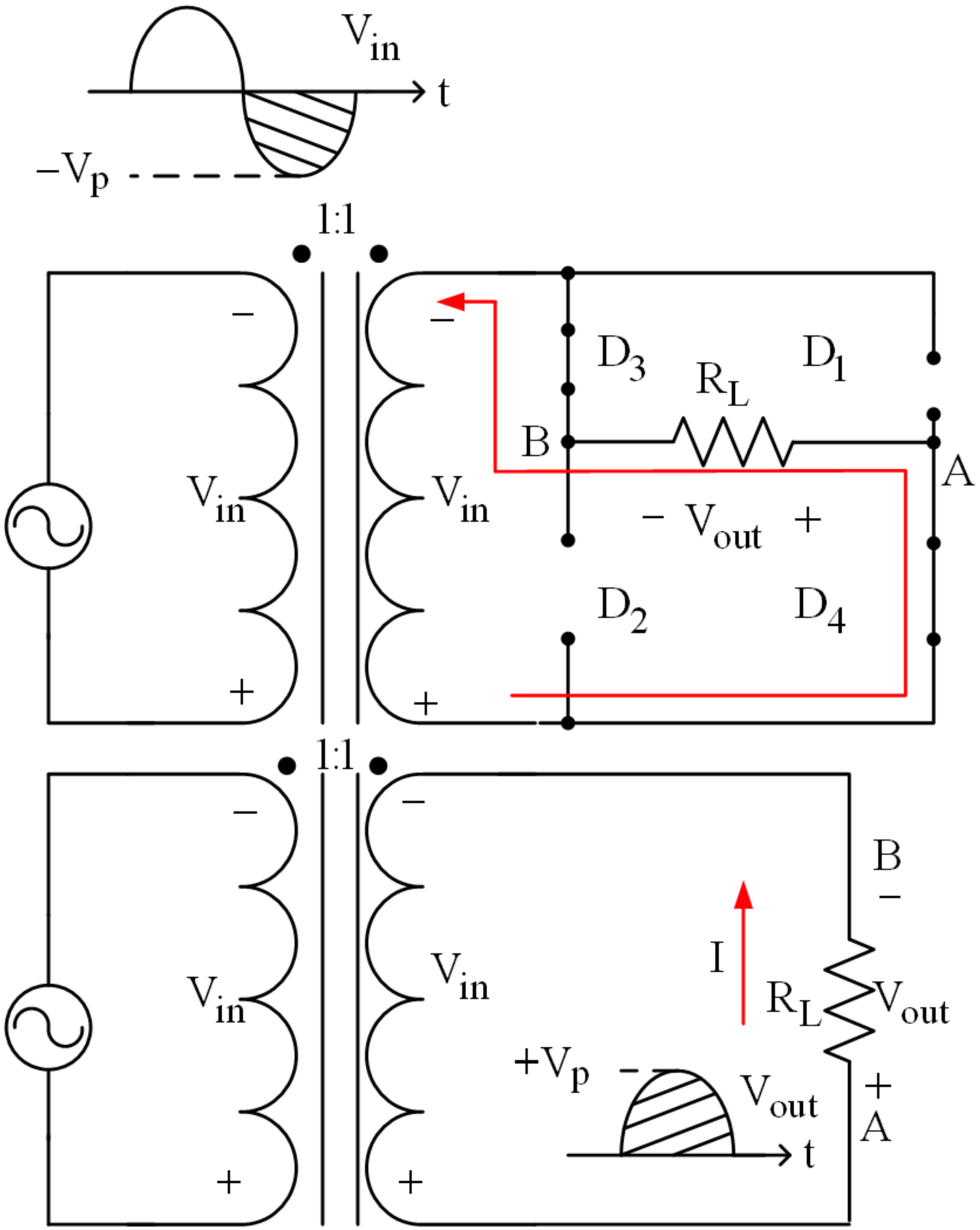
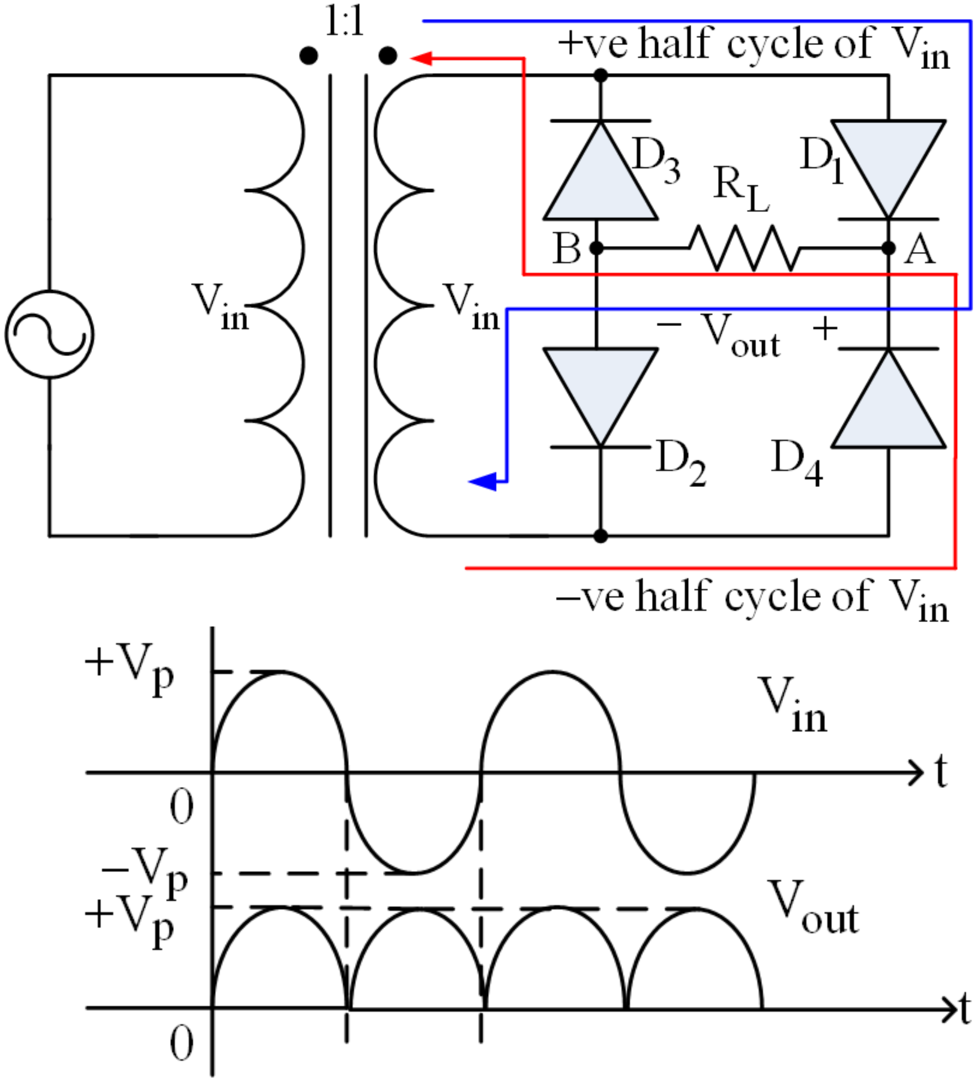


Overall performance

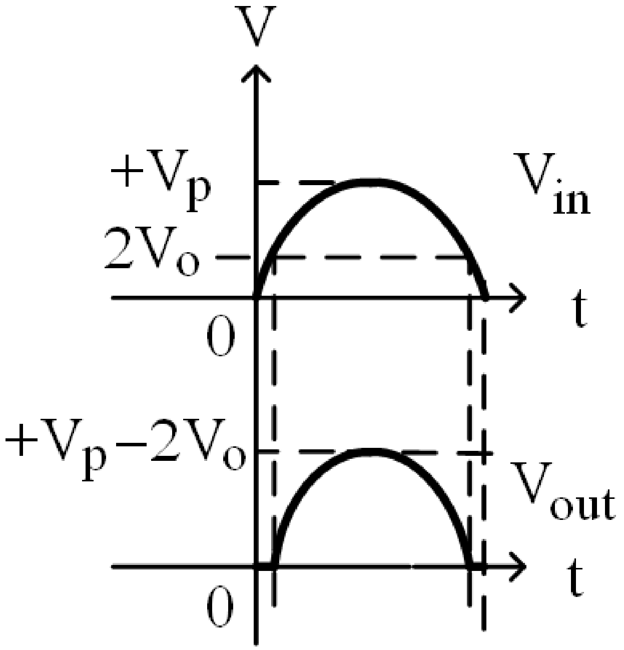


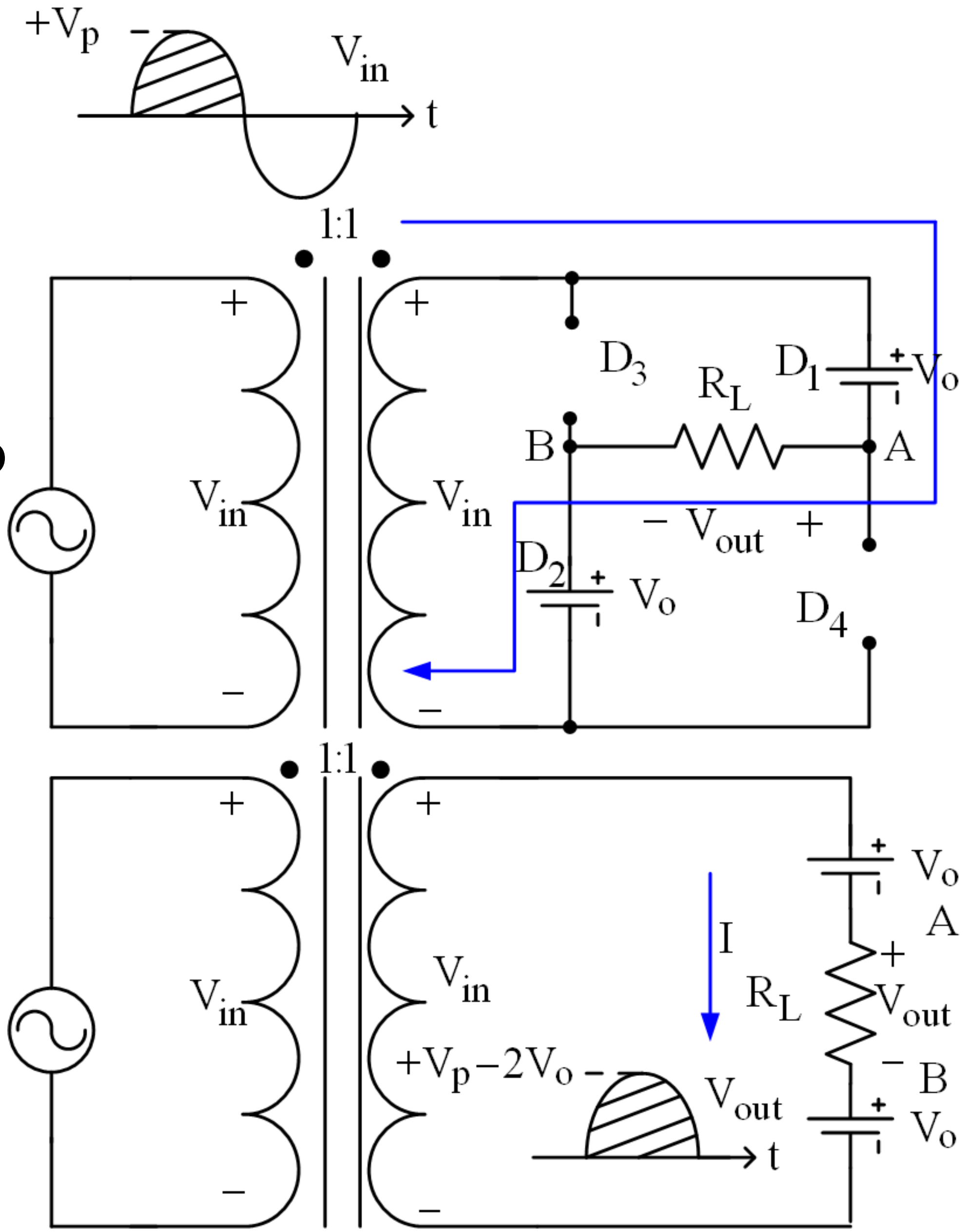
If potential barrier of the diode is considered:

$V_{in} = 2V_o + V_{out}$

$V_{out} = V_{in} - 2V_o$

D_1 and D_2 will only be fb if $V_{in} > 2V_o$





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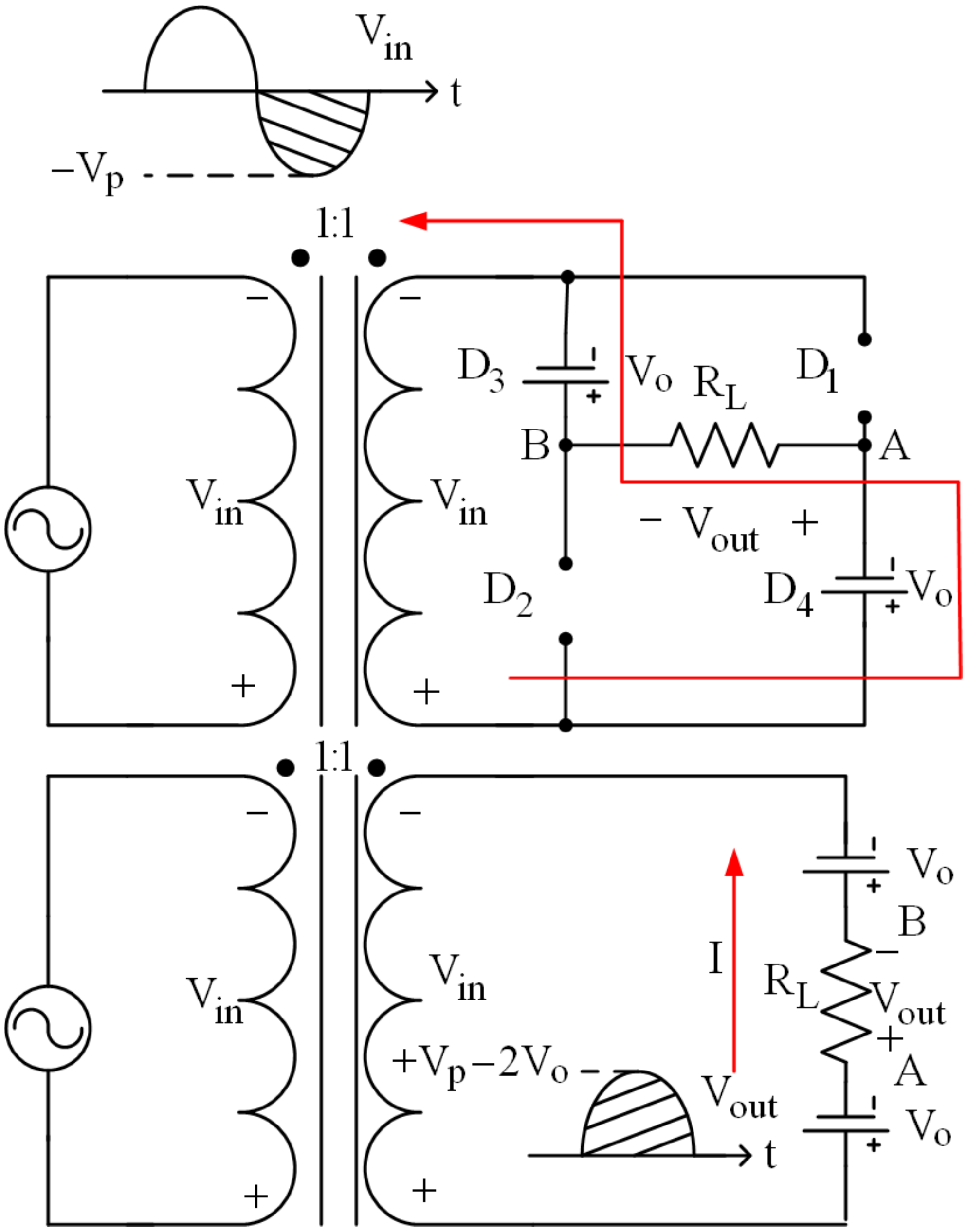
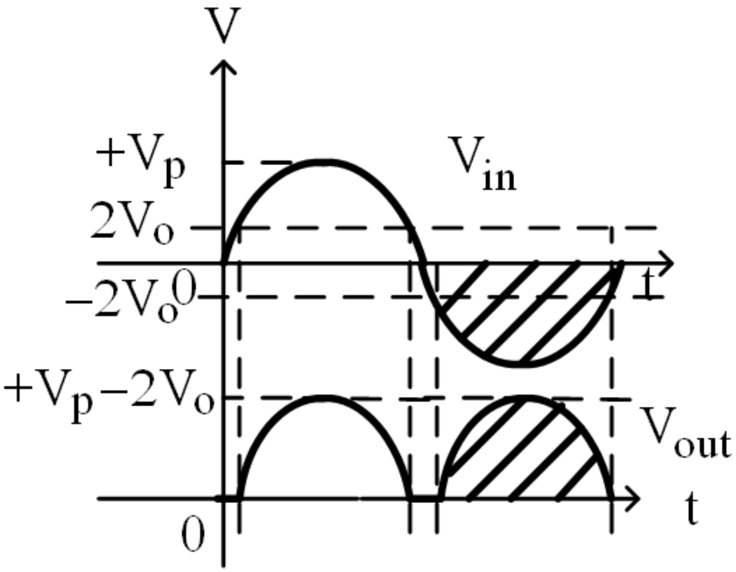
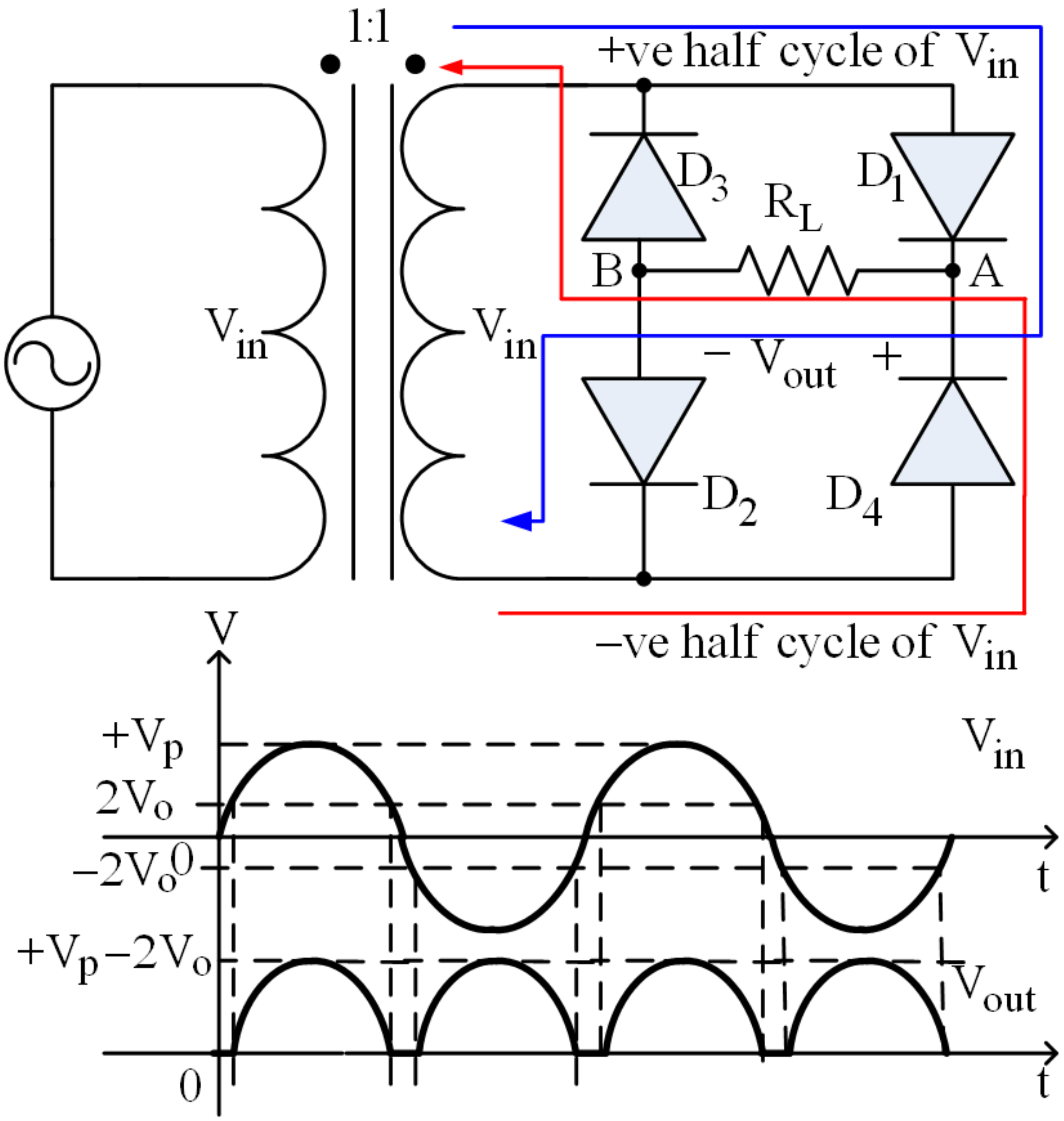




Overall performance:



PIV of the diodes in the bridge full-wave rectifier

To determine PIV_{D1} and PIV_{D2}, analyze the circuit when V_{in} is at its negative half cycle.

When determining PIV of the diodes,

$V_{in} = V_p$.

$V_p - V_{out} = 0$

$PIV_{D2} - V_{out} + PIV_{D1} - V_p = 0$

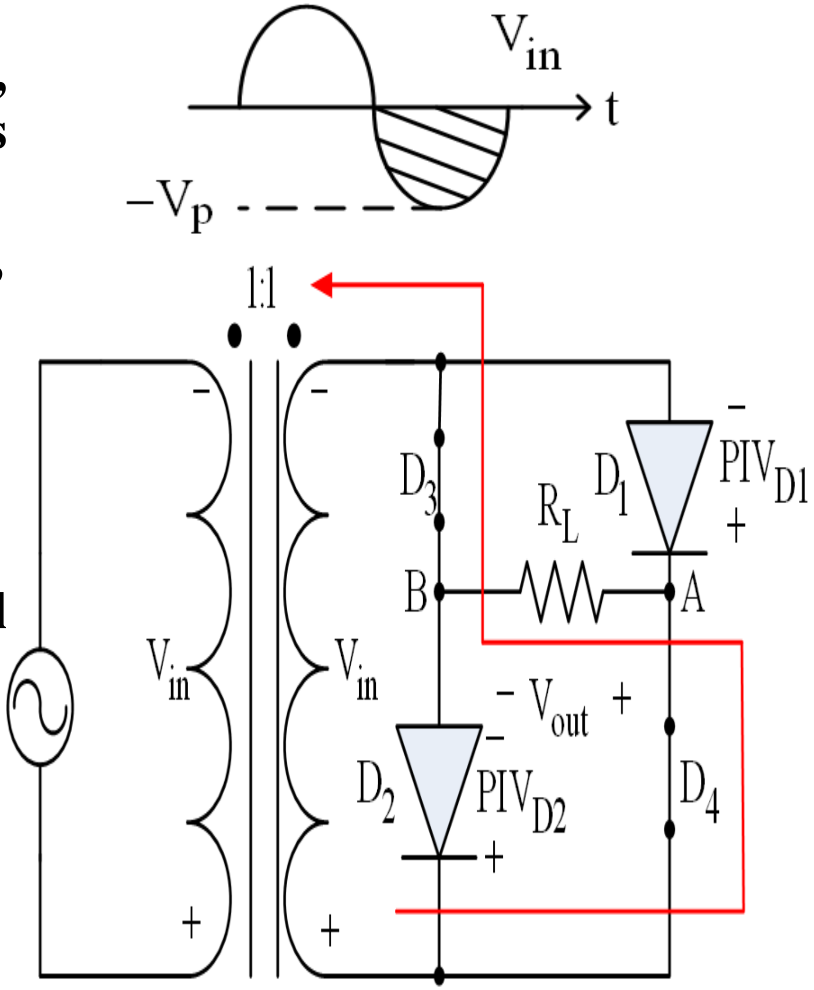
$PIV_{D2} + PIV_{D1} - V_p = V_{out}$

Assuming the diodes are identical and therefore $PIV_{D2} = PIV_{D1}$

$V_p - (PIV_{D2} + PIV_{D1} - V_p) = 0$

$2V_p - 2PIV = 0$

$PIV = V_p$



If the potential barrier of each diode is taken into consideration:

$$V_p - 2V_o - V_{out} = 0$$

$$PIV_{D2} - V_{out} + PIV_{D1} - V_p = 0$$

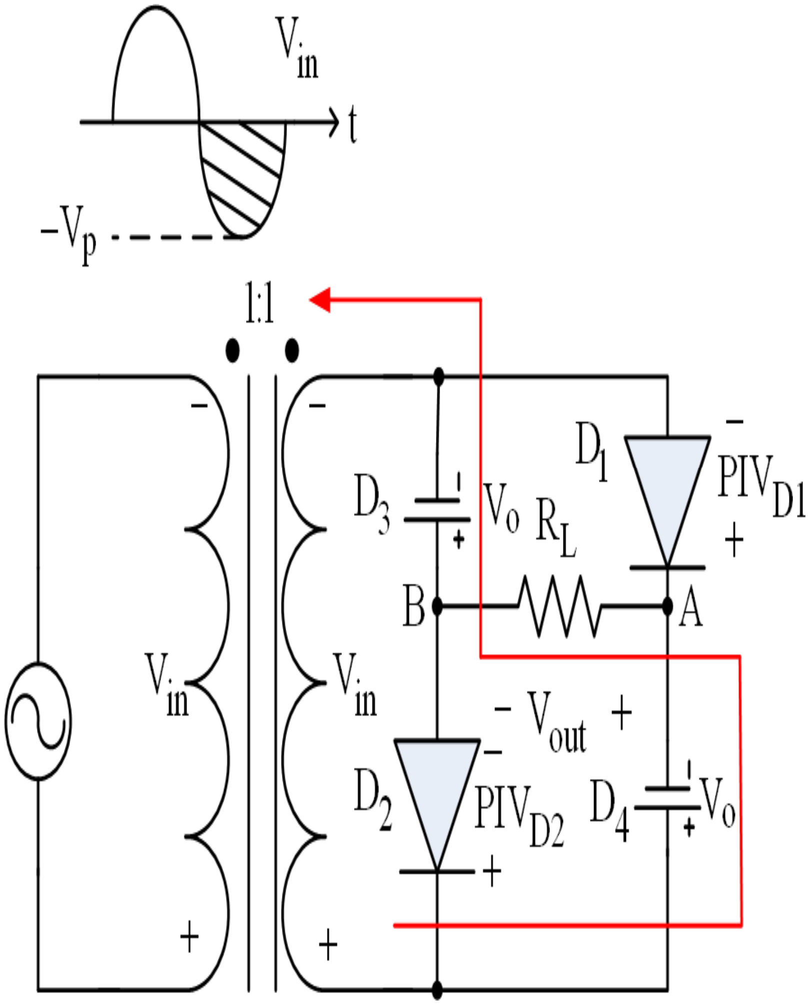
$$PIV_{D2} + PIV_{D1} - V_p = V_{out}$$

$$V_p - 2V_o - (PIV_{D2} + PIV_{D1} - V_p) = 0$$

Assuming the diodes are identical and therefore $PIV_{D2}=PIV_{D1}=PIV$

$$2V_p - 2V_o - 2PIV = 0$$

$$PIV = V_p - V_o$$



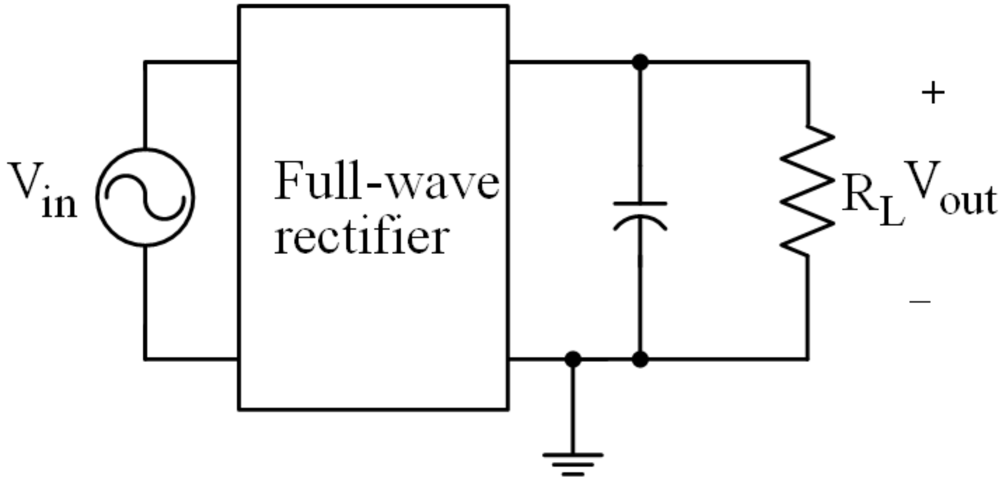
Rectifier-filter circuit

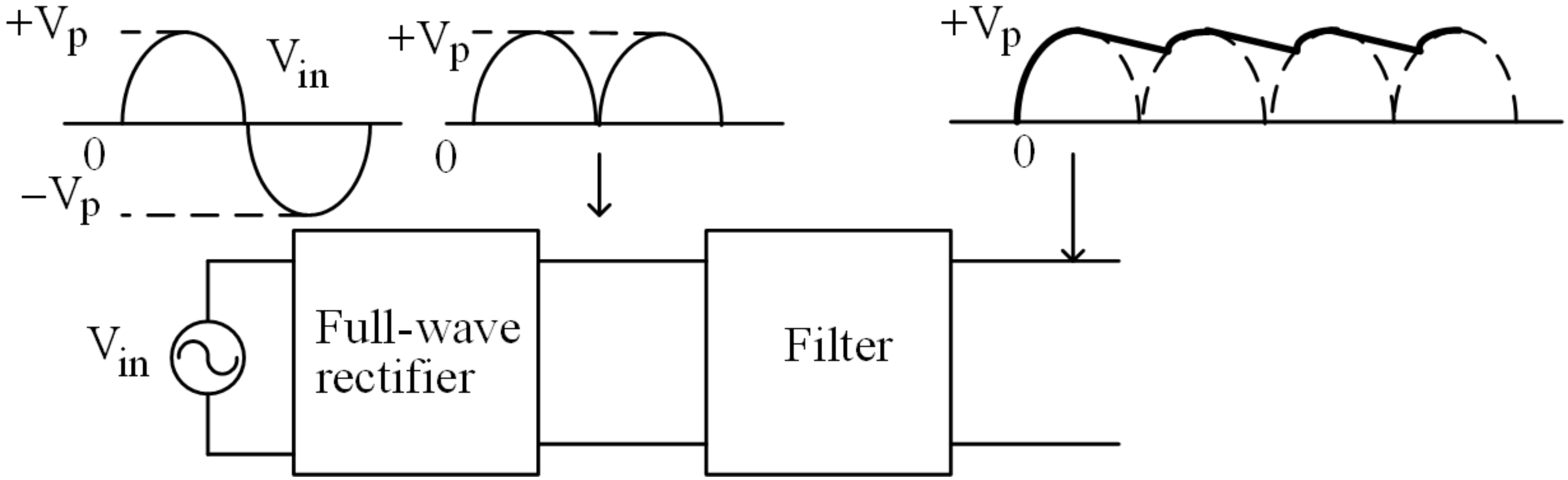
- This circuit reduces the rise and fall of the rectifier’s output voltage. Hence, the dc voltage level is quite constant.

- The constant dc voltage and current sources are needed by electronic circuits for power and biasing purposes in order to operate.

- The rectifier-filter circuit is implemented using a capacitor or an inductor or the combination of both.

Rectifier-filter circuit



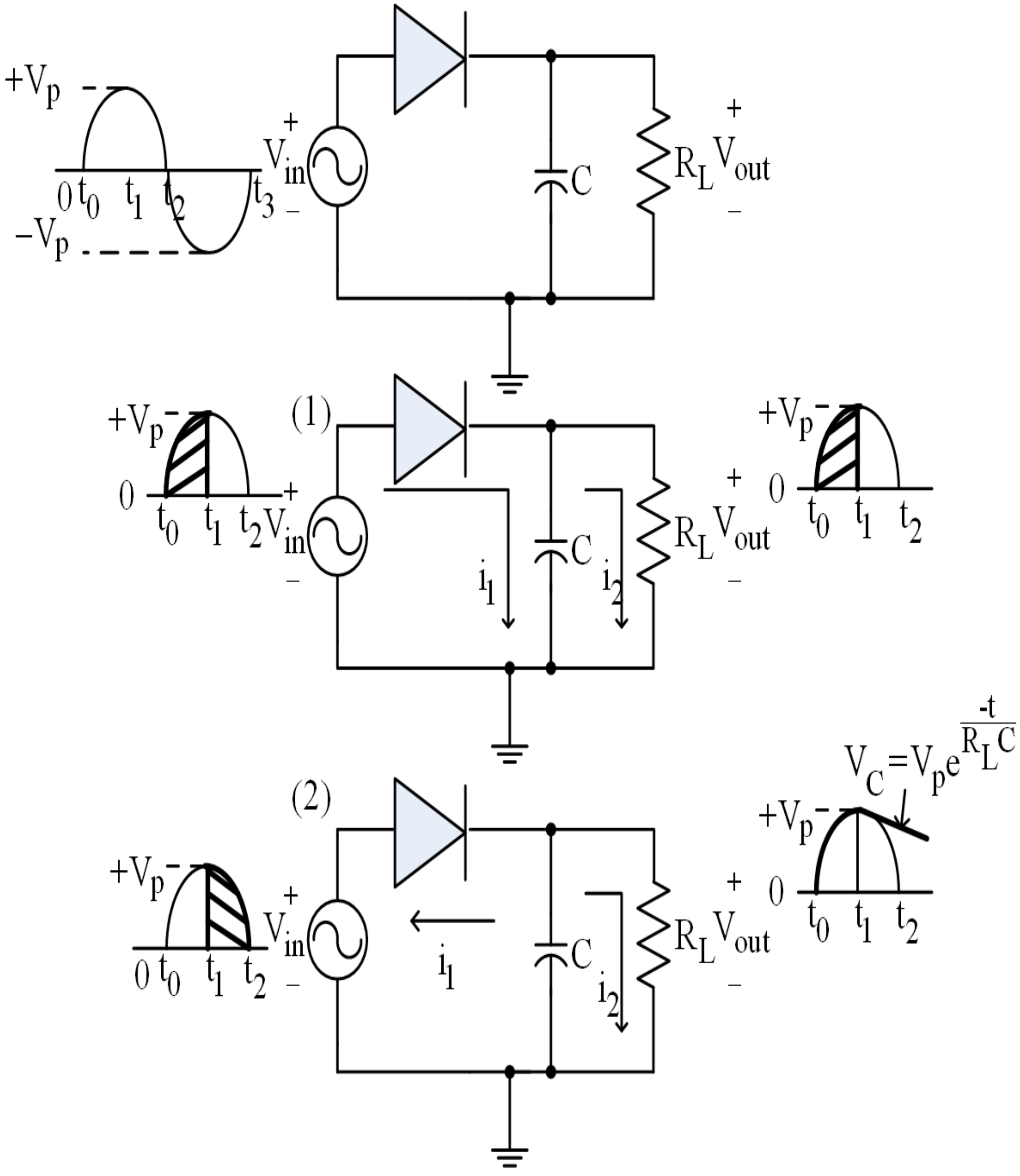


For a rectifier-filter circuit with the rectifier from the half-wave type:

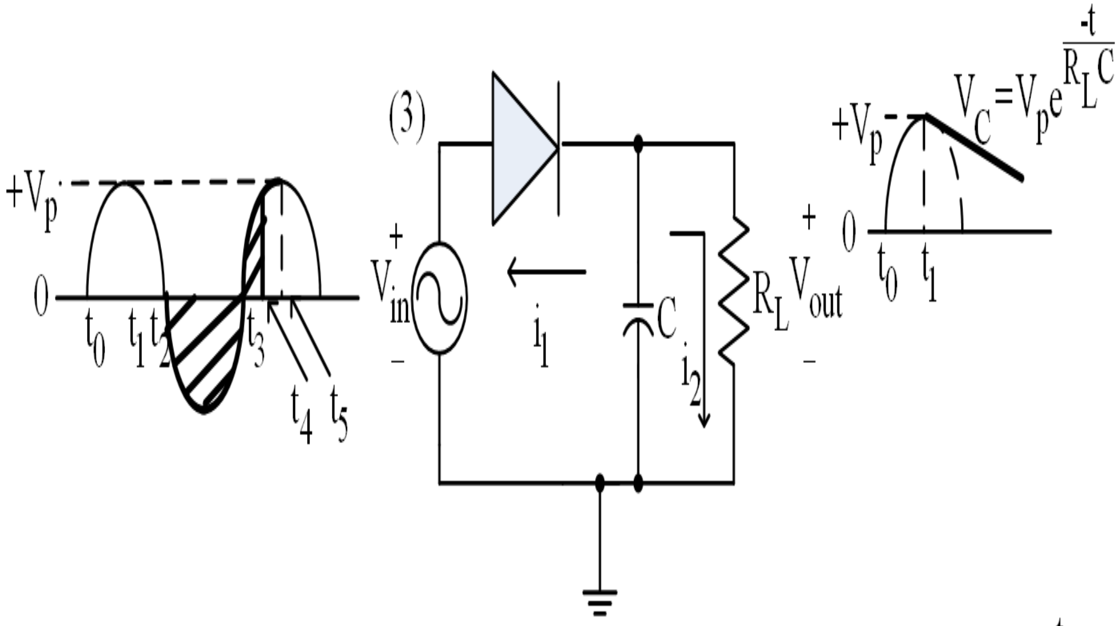
(1)Diode fb. C charged to V_p. $V_C = V_{out}$ as C and R_L are in parallel.

(2)Diode rb. Diode is an o/c. C discharge through R_L.

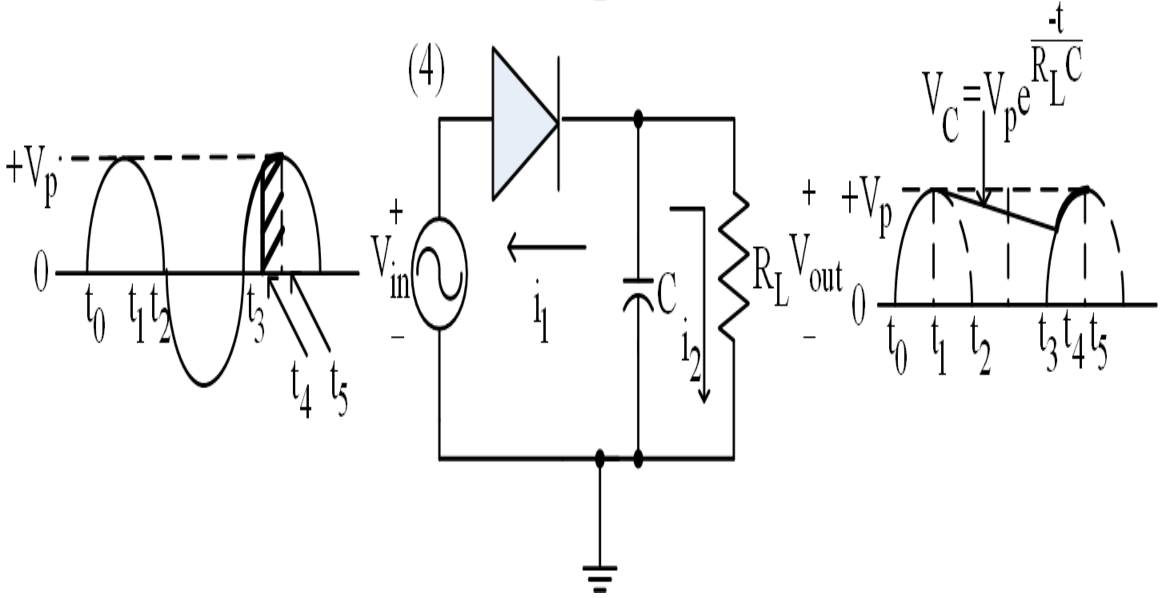
$V_{out}=V_C=V_p\, e^{-t/(R_L C)}$



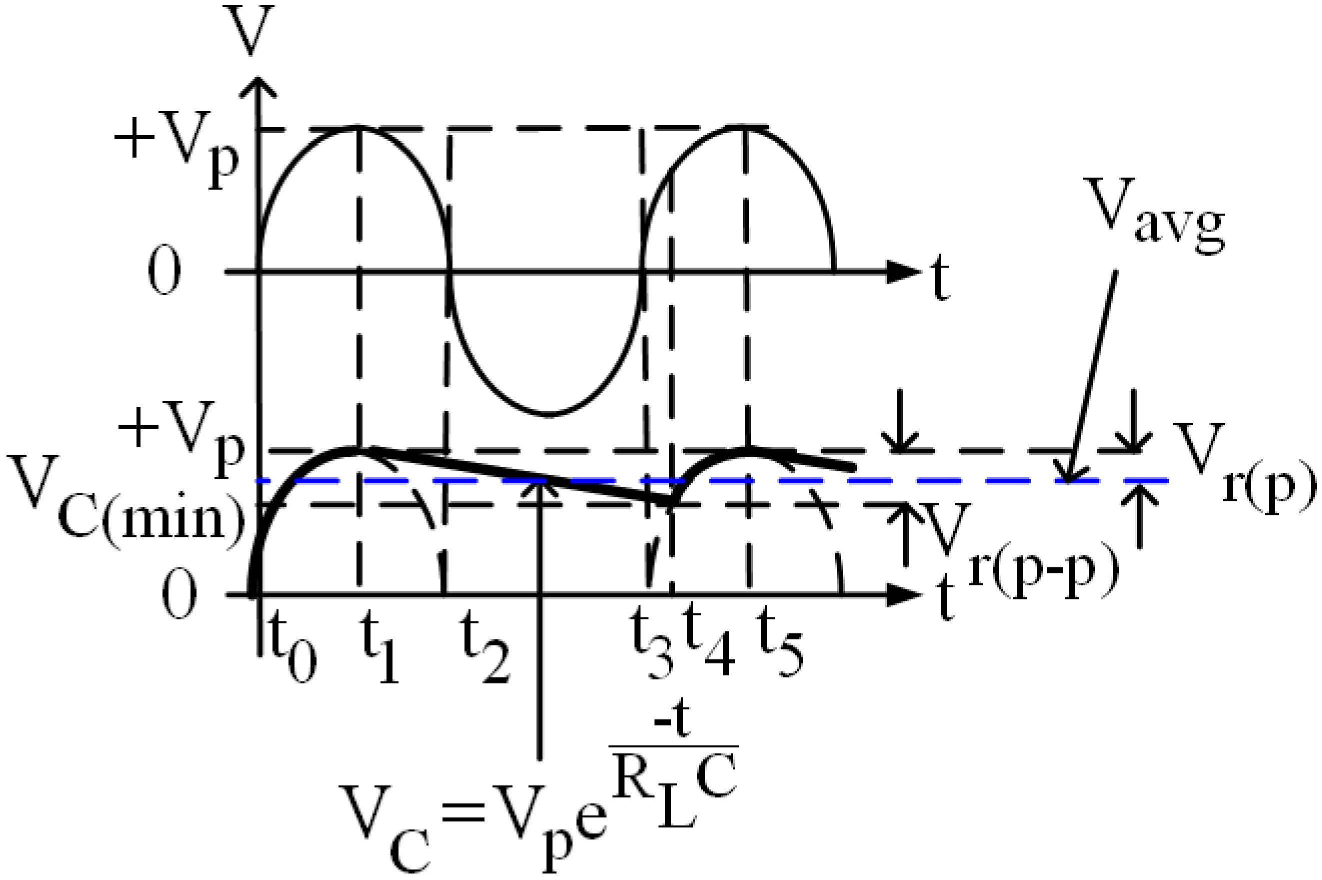
(3) $V_{out}=V_C=V_p\ e^{-t/(R_L C)}$
$t_3 \rightarrow t_4$, V_{in} is +ve but $V_{in} < V_C$. Diode is still rb. C still discharging through R_L .



(4) $t_4 \rightarrow t_5$, V_{in} is +ve and $V_{in} > V_C$. Diode is fb. Diode is s/c. V_{in} is charging C back to V_p.



Output of the rectifier-filter circuit with the rectifier from the half-wave type. $V_{r(p-p)} = V_p - V_{C(min)}$. Smaller ripple voltage indicates that the rectifier-filter circuit is more efficient.

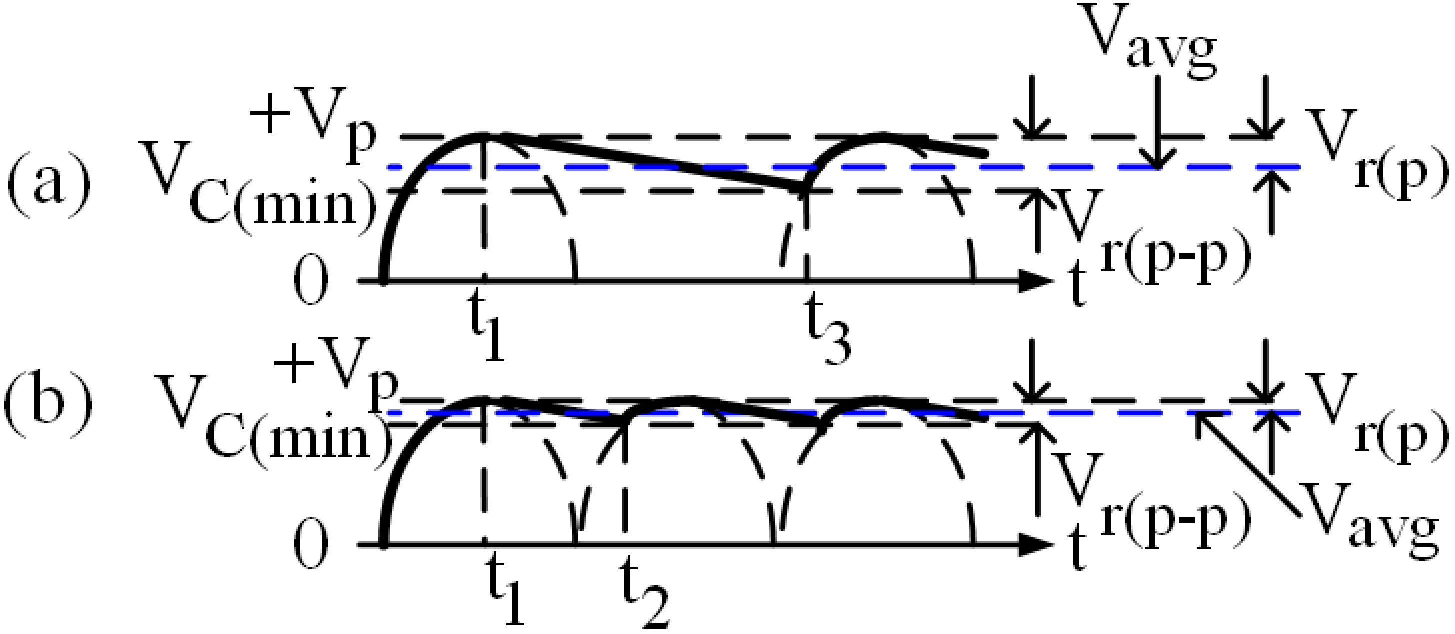


$$V_C = V_p e^{\frac{-t}{R_L C}}$$

(a) is the output of a rectifier-filter circuit with the rectifier of the half-wave type. C discharges from t_1 to t_3.

(b) is the output of a rectifier-filter circuit with the rectifier of the full-wave type. C discharges from t_1 to t_2.

Discharging time is less for the full-wave rectifier-filter circuit. $V_{r(p\text{-}p)\_Full\text{-}wave} < V_{r(p\text{-}p)\_Half\text{-}wave}$



V_C is min when $t \approx T$

$$V_{C\,(min)} = V_p e^{-\frac{T}{R_L C}}$$

Ripple voltage, $V_{r\,(p\text{-}p)} = V_p - V_{C\,(min)}$

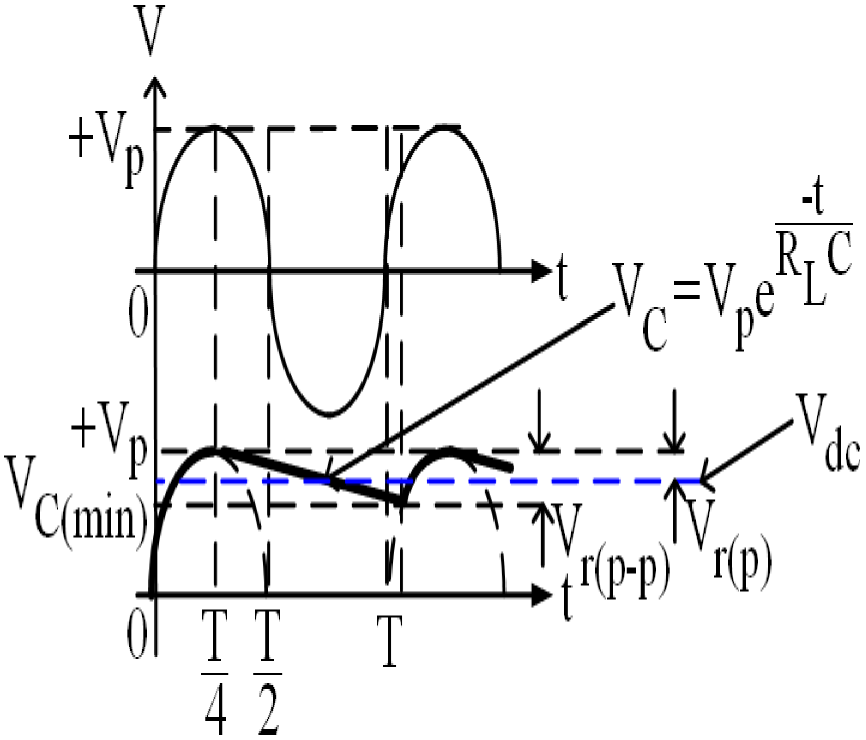
$$V_{r\,(p\text{-}p)} = V_p - V_p e^{-\frac{T}{R_L C}}$$

$$= V_p\left(1 - e^{-\frac{T}{R_L C}}\right)$$

$$= V_p\left(1 - e^{-\frac{1}{R_L C f}}\right)$$

$$V_{r\,(p)} = \frac{V_p}{2}\left(1 - e^{-\frac{1}{R_L C f}}\right)$$

$$V_{dc} = V_{avg} = V_p - V_{r\,(p)}$$



$$V_{dc} = V_p - \frac{V_p}{2}\left(1 - e^{-\frac{1}{R_L C f}}\right)$$

$$V_{dc} = V_p\left[1 - \frac{1}{2}\left(1 - e^{-\frac{1}{R_L C f}}\right)\right] = \frac{V_p}{2}\left[1 + e^{-\frac{1}{R_L C f}}\right]$$

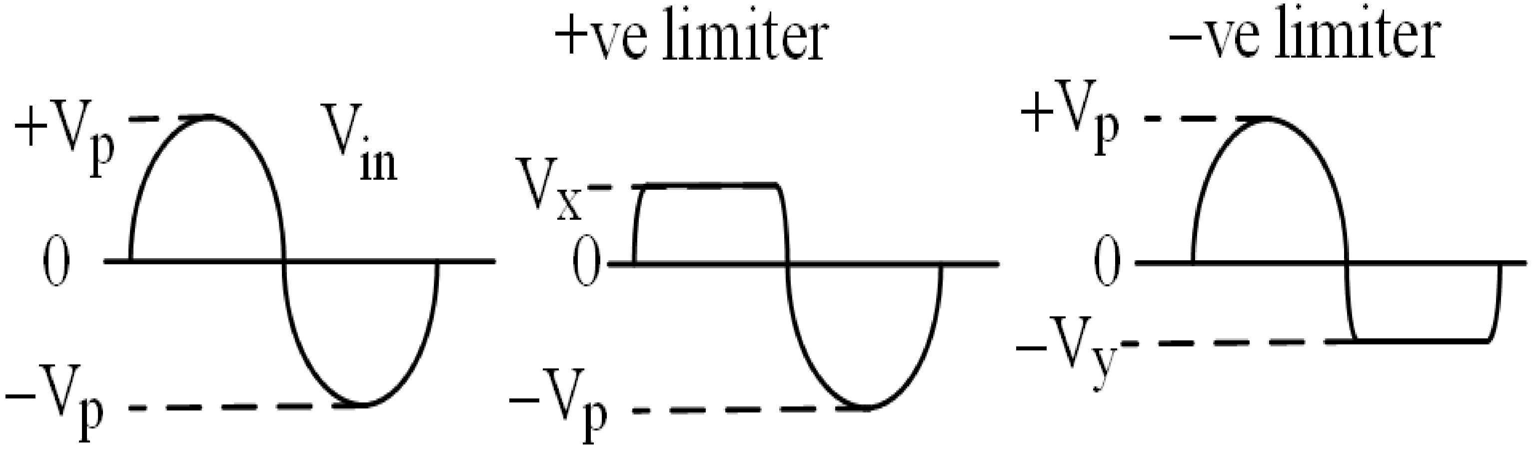
Ripple factor, $r = \frac{V_{r\,(p\text{-}p)}}{V_{dc}}$

Ripple factor, r, is a benchmark of the effectiveness of a filter. The smaller the r is, the better is the filter. r can be reduced by increasing the capacitance, C, or load resistance, R_L.

Clipping/Limiting Diode Circuit

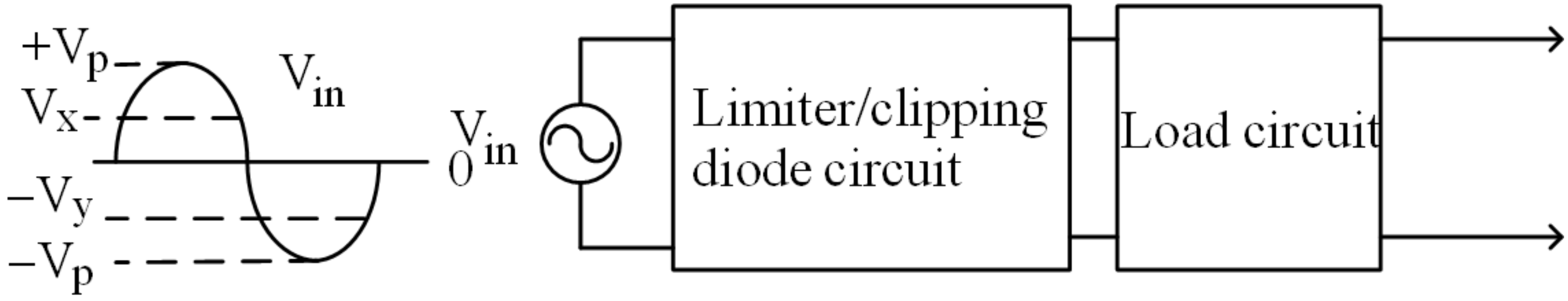
Function:

To limit the output voltage from exceeding a certain desired value. This circuit can limit the output voltage from exceeding a certain +ve or –ve voltage.

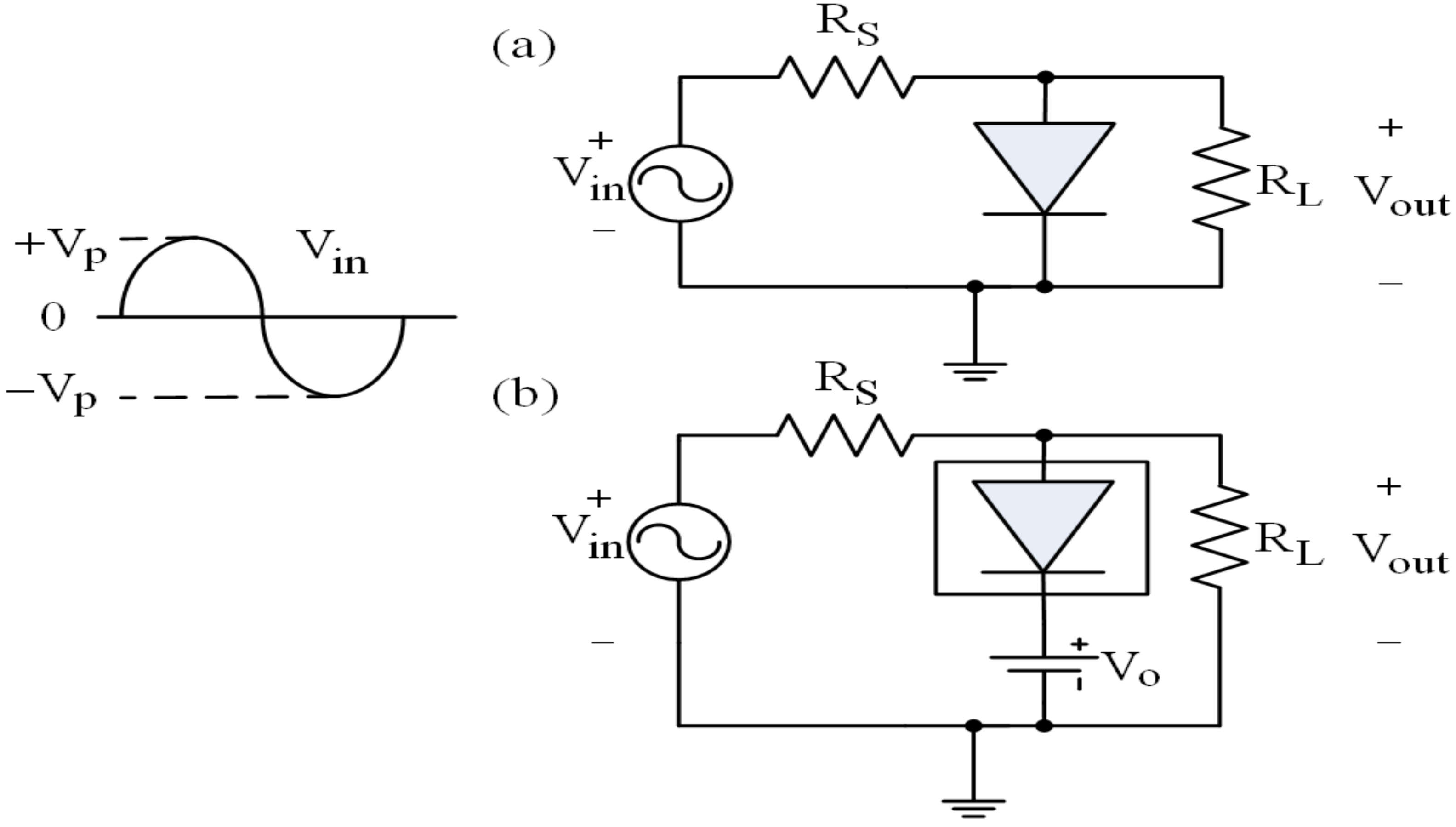


Application:

A circuit (which in the diagram below is termed as the 'Load circuit') may not be able to process a voltage which is higher (or lower) than a certain value. If the source is unable to provide a signal that follows this requirement, a limiting/clipping diode circuit may need to be used.



- **(a) is the limiting/clipping diode circuit with the potential barrier and forward resistor effects excluded.**
- **(b) is the limiting/clipping diode circuit with the potential barrier effect included.**



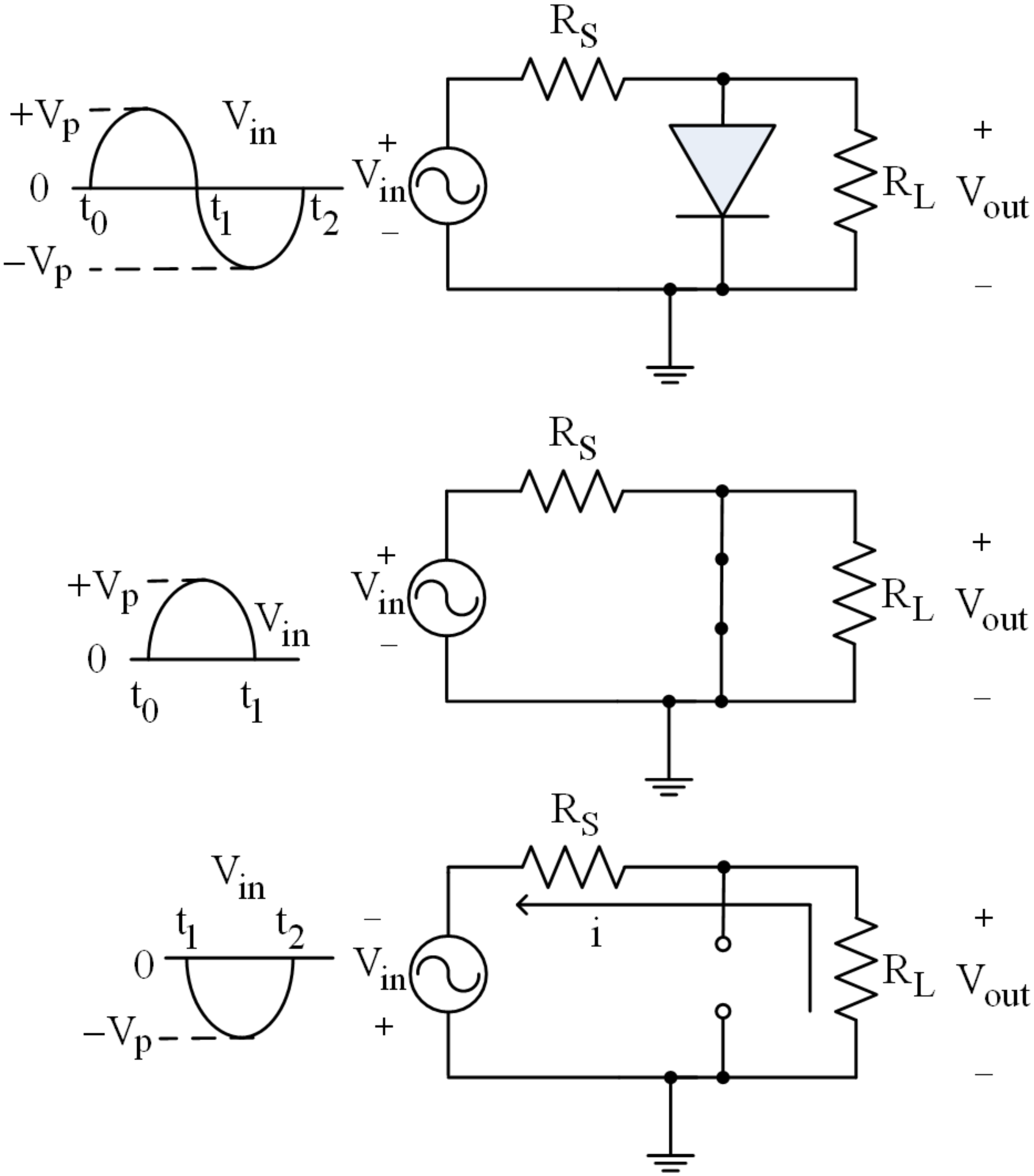
Ideal diode.

During the +ve half cycle, diode is fb. Hence,

$V_{out} = 0$.

During the –ve half cycle, diode is rb. Hence,

$$V_{out} = \frac{R_L}{R_L + R_S}\left(-V_{in}\right)$$



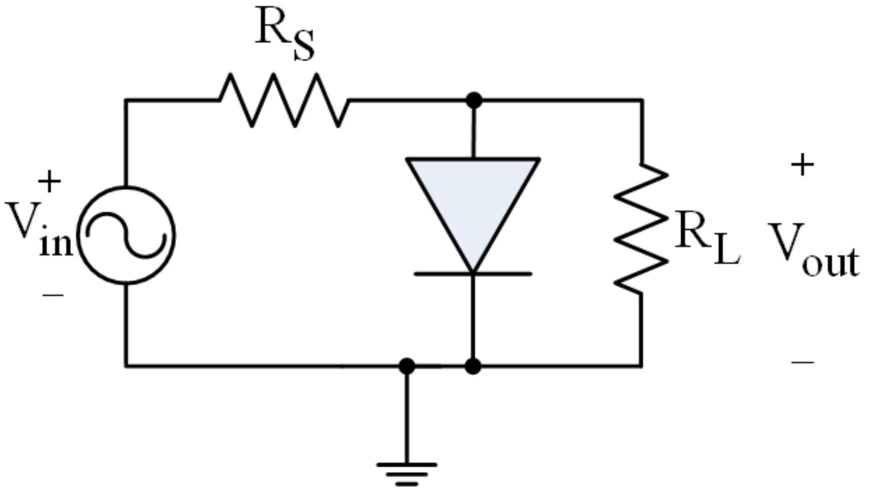
Overall performance:

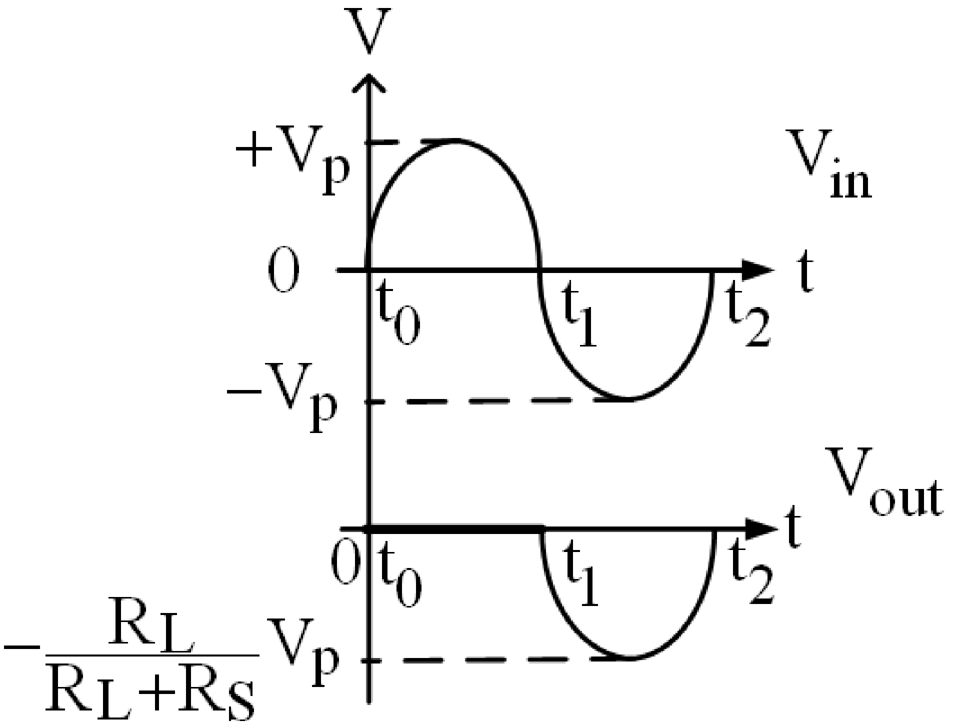
+ve half cycle,

$V_{out} = 0$.

–ve half cycle,

$$V_{out} = \frac{R_L}{R_L + R_S}\left(-V_{in}\right)$$

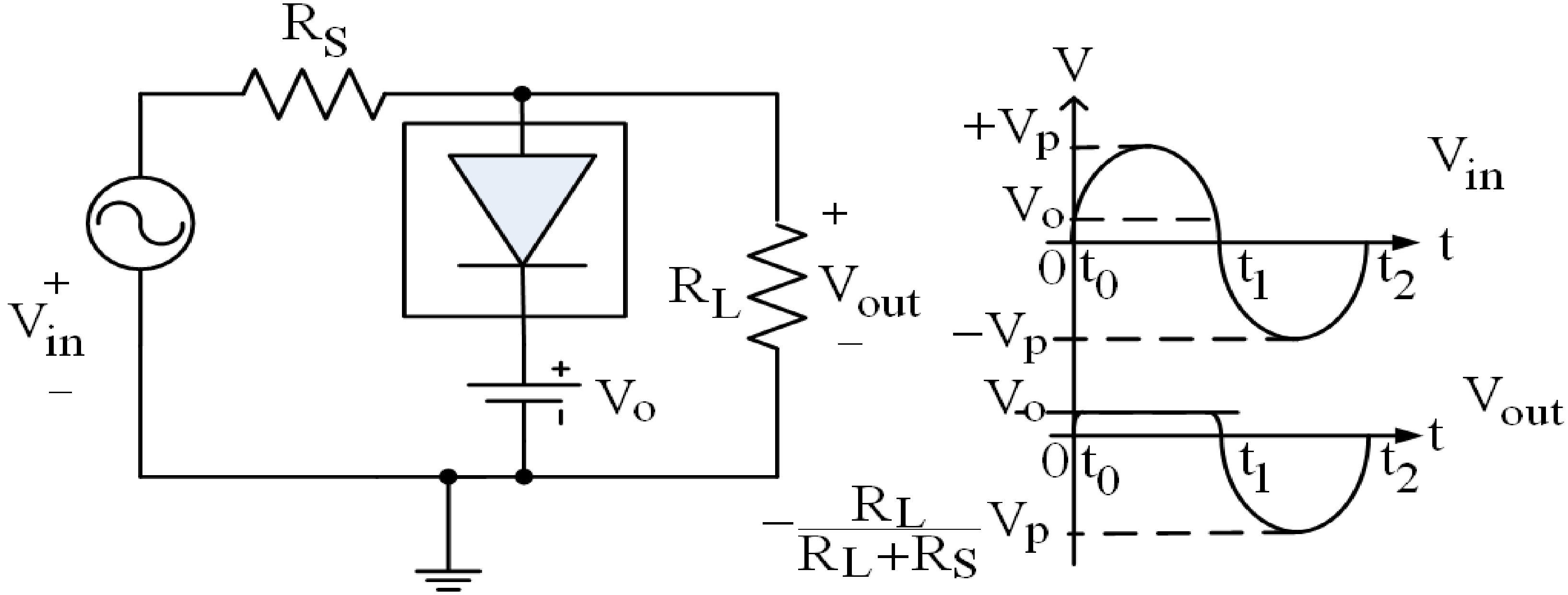




If potential barrier is considered: Diode fb (s/c) if $V_{in} > V_o$. Hence, $V_{out} = V_o$. If $V_{in} < V_o$ or V_{in} is at its –ve half cycle, diode is rb (o/c). Hence,

$V_{out} = \frac{R_L}{R_L + R_S}\left(V_{in}\right)$ **for $V_{in} < V_o$ and V_{in} is +ve.**

$V_{out} = \frac{R_L}{R_L + R_S}\left(-V_{in}\right)$ **for V_{in} during its –ve cycle.**

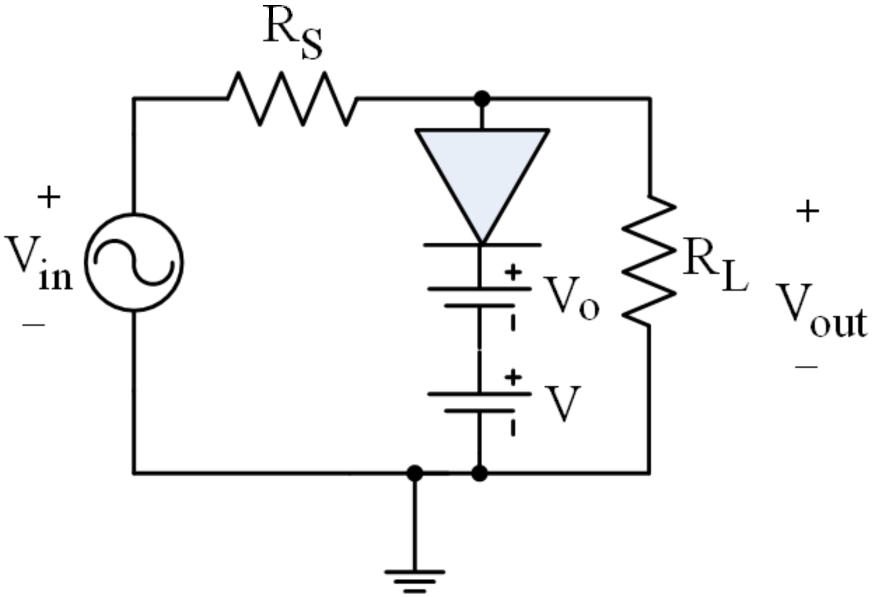


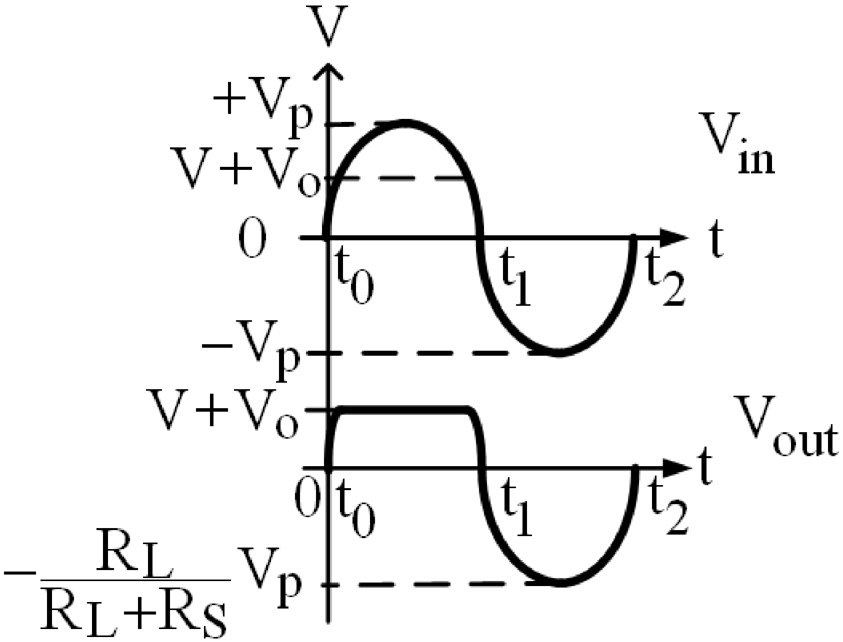
Variable +ve clipper

Diode fb (s/c) when $V_{in} > V + V_o$. Hence, $V_{out} = V + V_o$. Diode rb (o/c) when $V_{in} < V + V_o$.

$$V_{out} = \frac{R_L}{R_L + R_S}\left(V_{in}\right)$$ **for $V_{in} < V + V_o$ and V_{in} is +ve.**

$$V_{out} = \frac{R_L}{R_L + R_S}\left(-V_{in}\right)$$ **for V_{in} during its –ve cycle.**



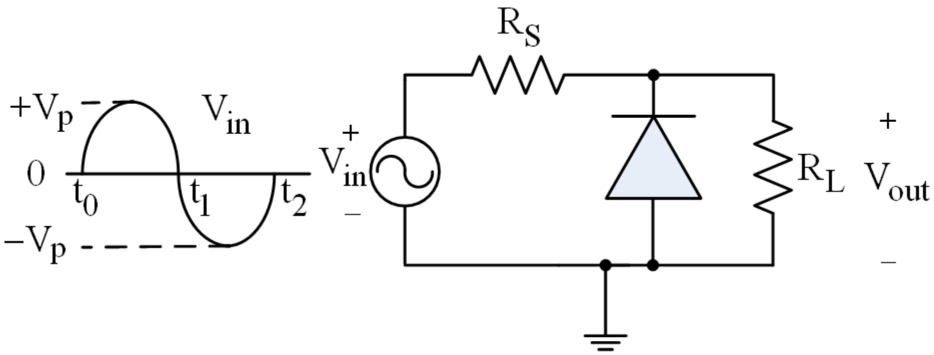


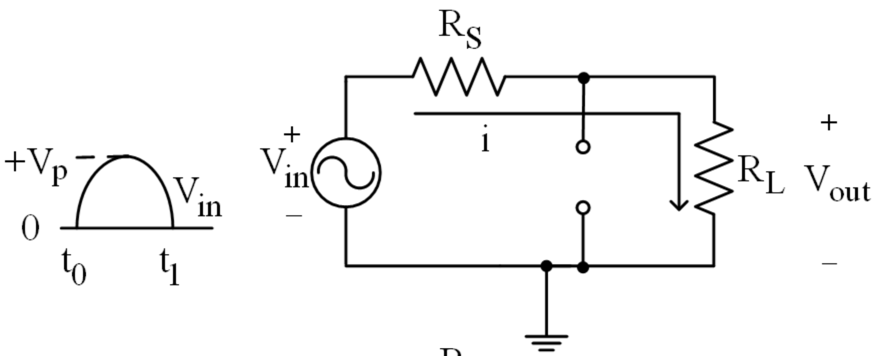
-ve clipper

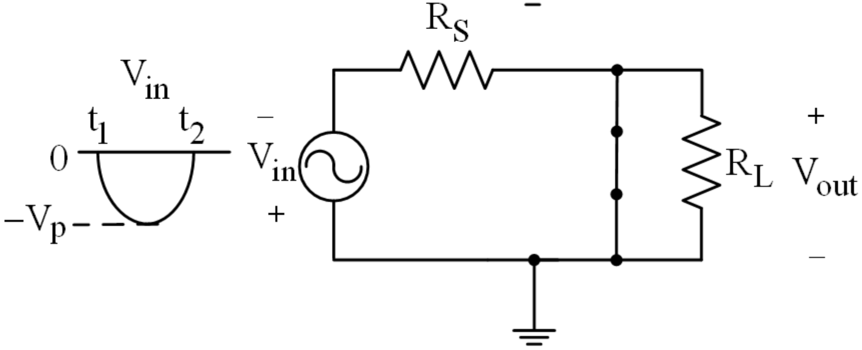
During the +ve half cycle, diode is rb and o/c. Hence,

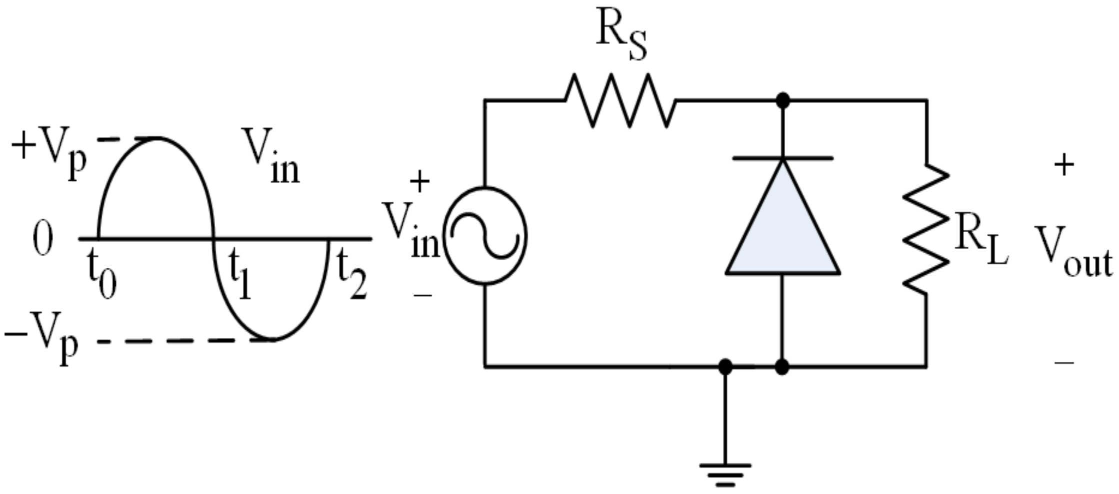
$$V_{out} = \frac{R_L}{R_L + R_S}\left(V_{in}\right)$$

During the -ve half cycle, diode is fb and s/c. Hence, $V_{out} = 0$.









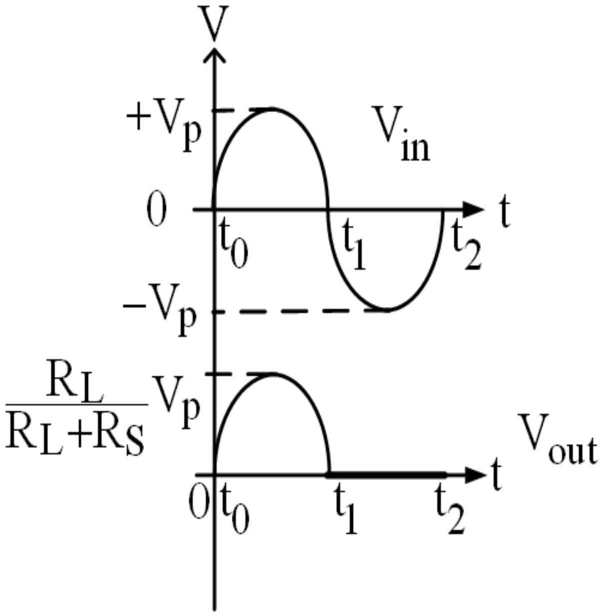
Overall performance:

+ve half cycle,

$$V_{out} = \frac{R_L}{R_L + R_S}\left(V_{in}\right)$$

–ve half cycle,

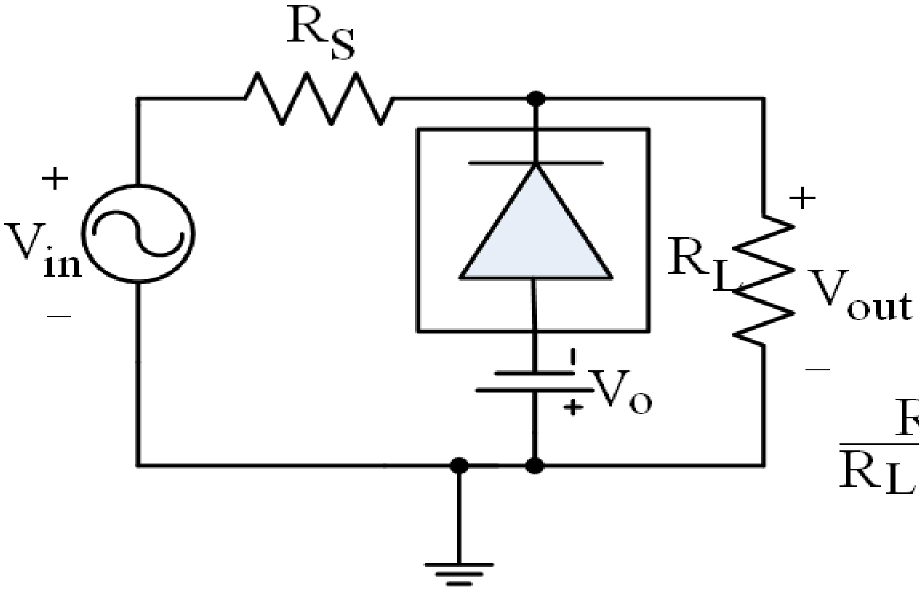
$V_{out} = 0$.

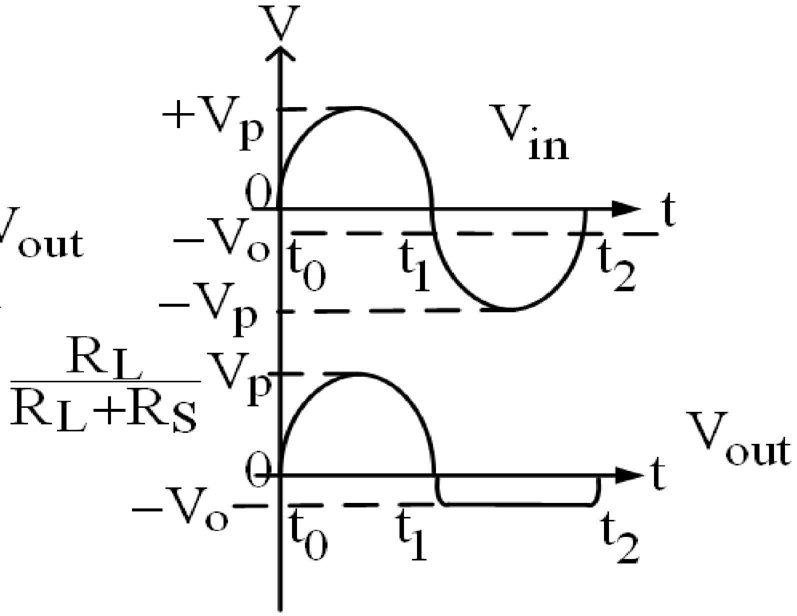


If potential barrier is considered: Diode fb (s/c) if V_{in} is –ve and V_{in} is more –ve than -V_o. Hence, V_{out} = -V_o . If V_{in} is –ve but V_{in} is more +ve than -V_o, diode is rb (o/c). Hence,

$$V_{out} = \frac{R_L}{R_L+R_S}\left(-V_{in}\right)$$

For V_{in} during its +ve cycle, $V_{out} = \frac{R_L}{R_L+R_S}\left(V_{in}\right)$



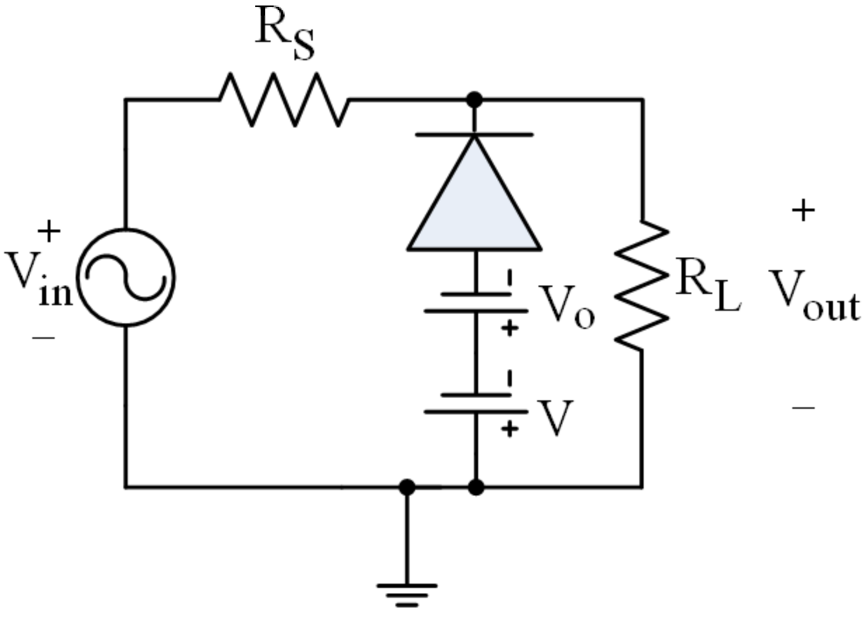


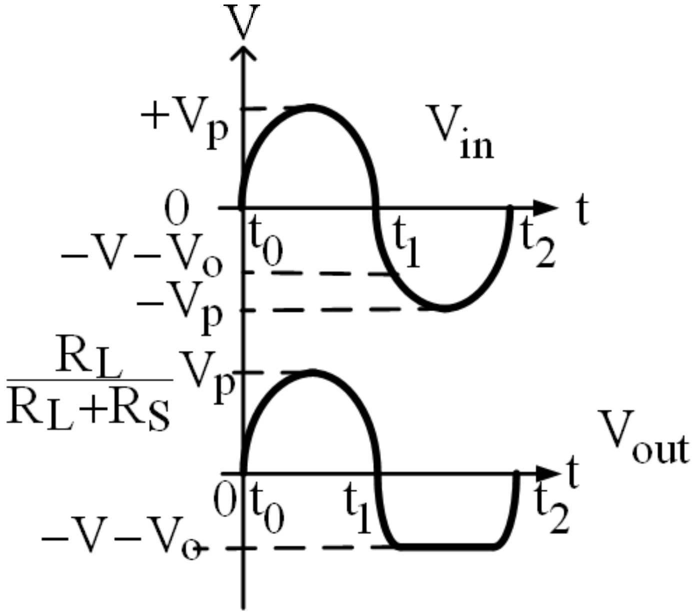
Variable –ve clipper

Diode fb (s/c) when $V_{in} < -V-V_o$. Hence, $V_{out} = -V-V_o$. Diode rb (o/c) when $V_{in} > -V-V_o$ (V_{in} is more +ve than $-V-V_o$)

$$V_{out} = \frac{R_L}{R_L+R_S}\left(-V_{in}\right)$$ **for $V_{in} > -V - V_o$ and V_{in} is -ve.**

$$V_{out} = \frac{R_L}{R_L+R_S}\left(V_{in}\right)$$ **for V_{in} during its +ve cycle.**





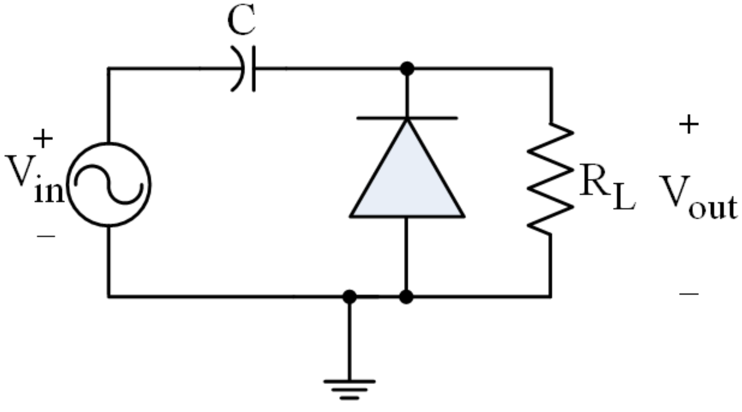
Clamping diode

Function:

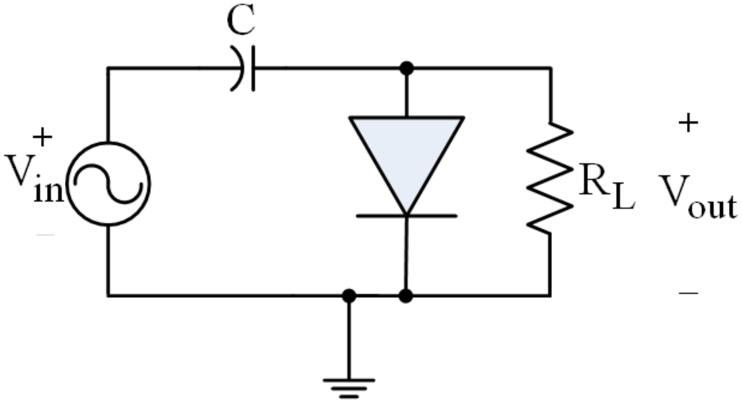
To include a dc level into an ac signal.

Also known as a dc restorer.

Main application is in the TV receiver as a dc restorer.



+ve clamper



–ve clamper