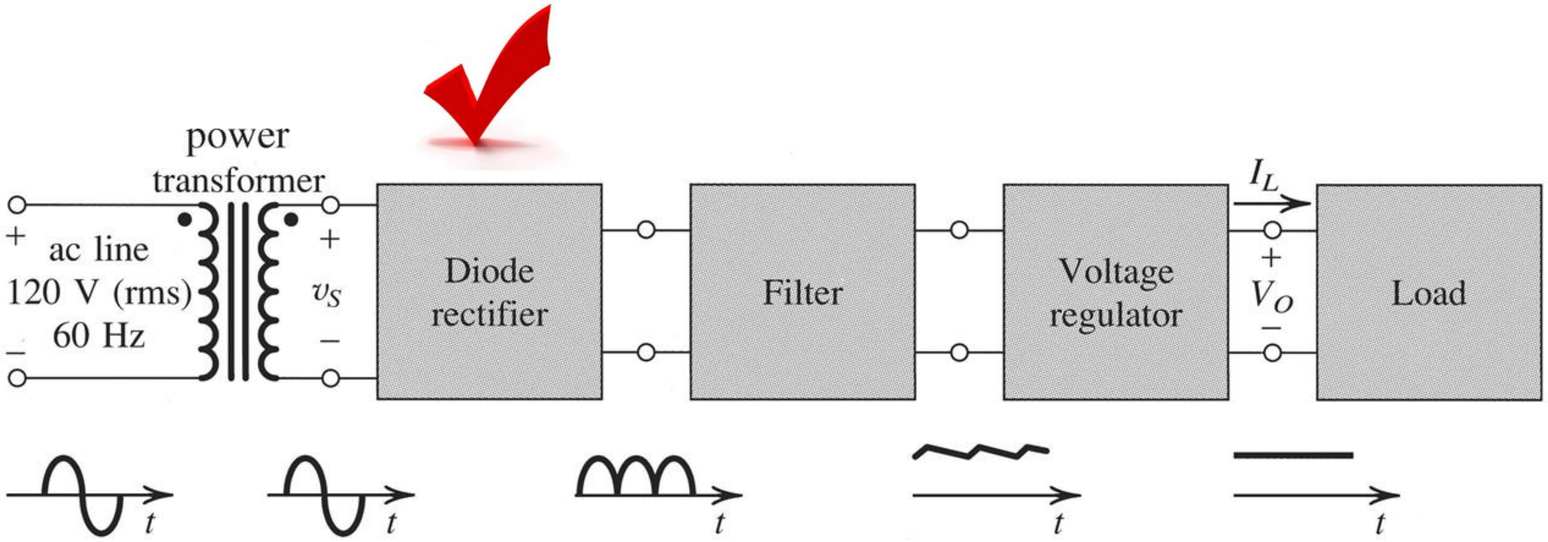


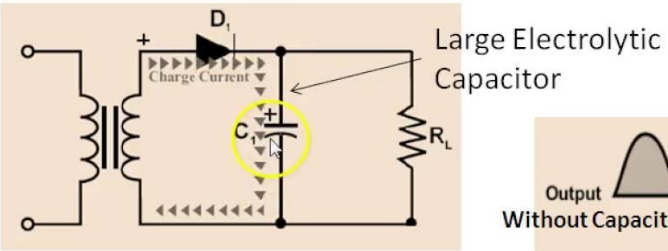
power
transformer
+
ac line
120 V (rms)
60 Hz
−
+
v_S
−
Diode
rectifier
Filter
Voltage
regulator
I_L
+
V_O
−
Load
t
t
t
t
t

Filters

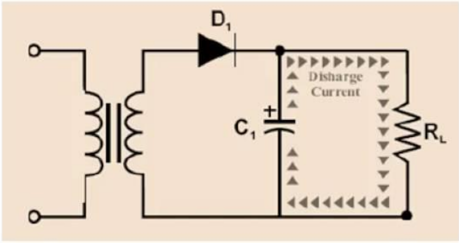
- A capacitor is added in parallel with the load resistor of a half-wave rectifier to form a simple filter circuit. At first there is no charge across the capacitor

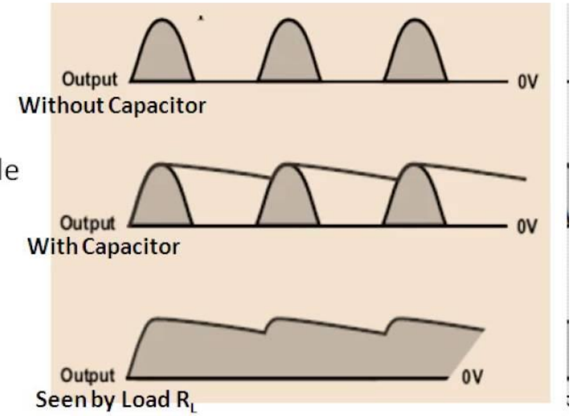
- During the 1st quarter positive cycle, **diode is forward biased**, and C charges up.

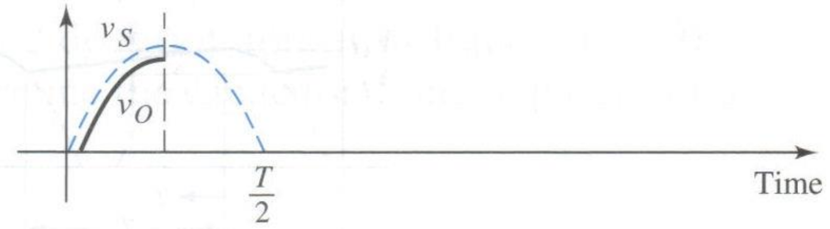
- $\mathbf{v_C = v_O = v_S - v_D}$

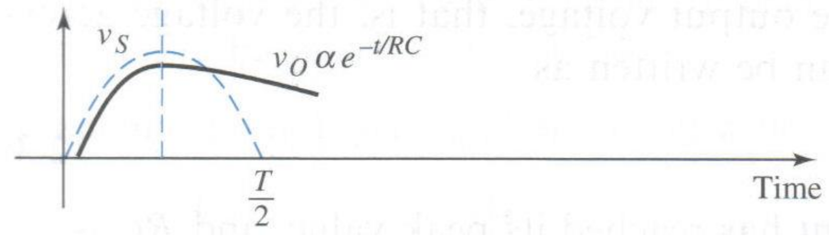


Half Wave Rectifier : Positive Half Cycle







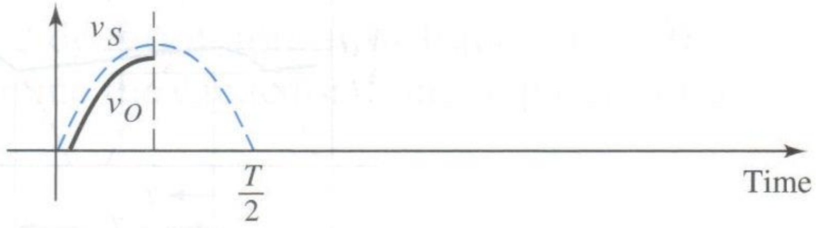


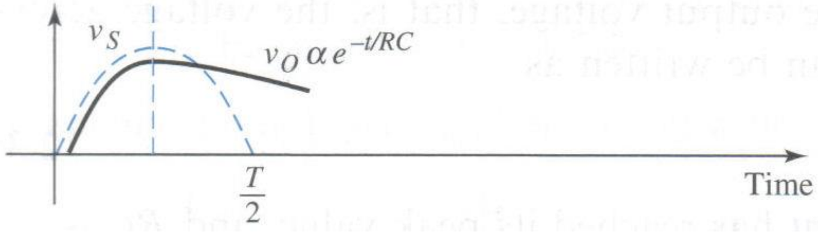
$V_D = V\gamma = 0.7$ V

$V_S = 5 \sin \theta$

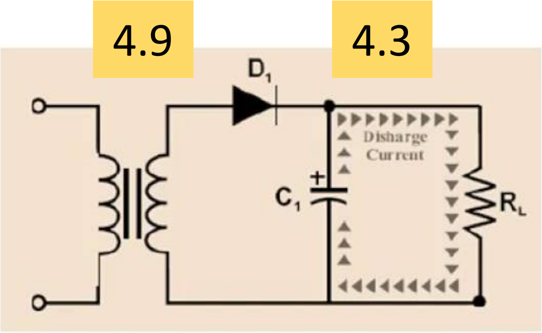
$V_O = 5 \sin \theta - 0.7$

At $V_{Speak} = 5V$
$V_{Opeak} = V_{Cpeak} = 4.3$ V





- As V_S falls back towards zero, and into the negative cycle, the capacitor discharges through the resistor R. The diode is reversed biased (turned off) – WHY?



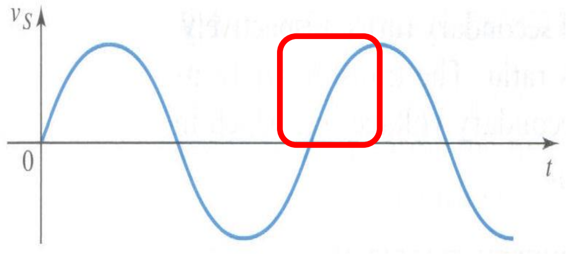
So, $V_D = 4.9 - 4.3 = 0.6$ V which is less than Vγ -- hence the diode is off

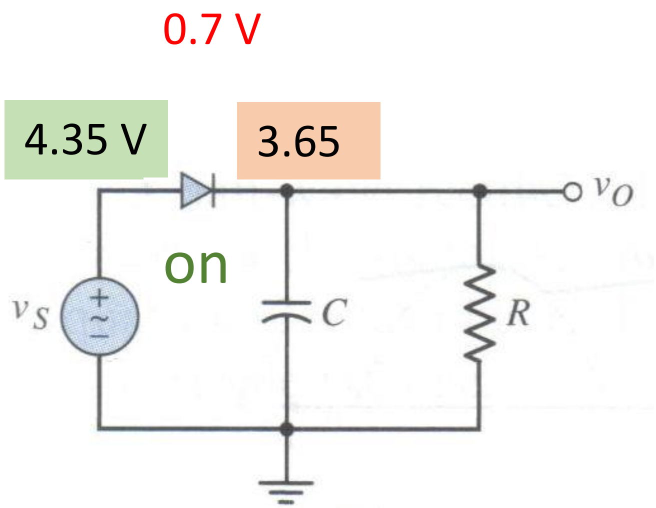
And then the sine wave goes to negative cycle where the diode is reversed biased as well

- If the *RC* time constant is large, the voltage across the capacitor discharges exponentially.

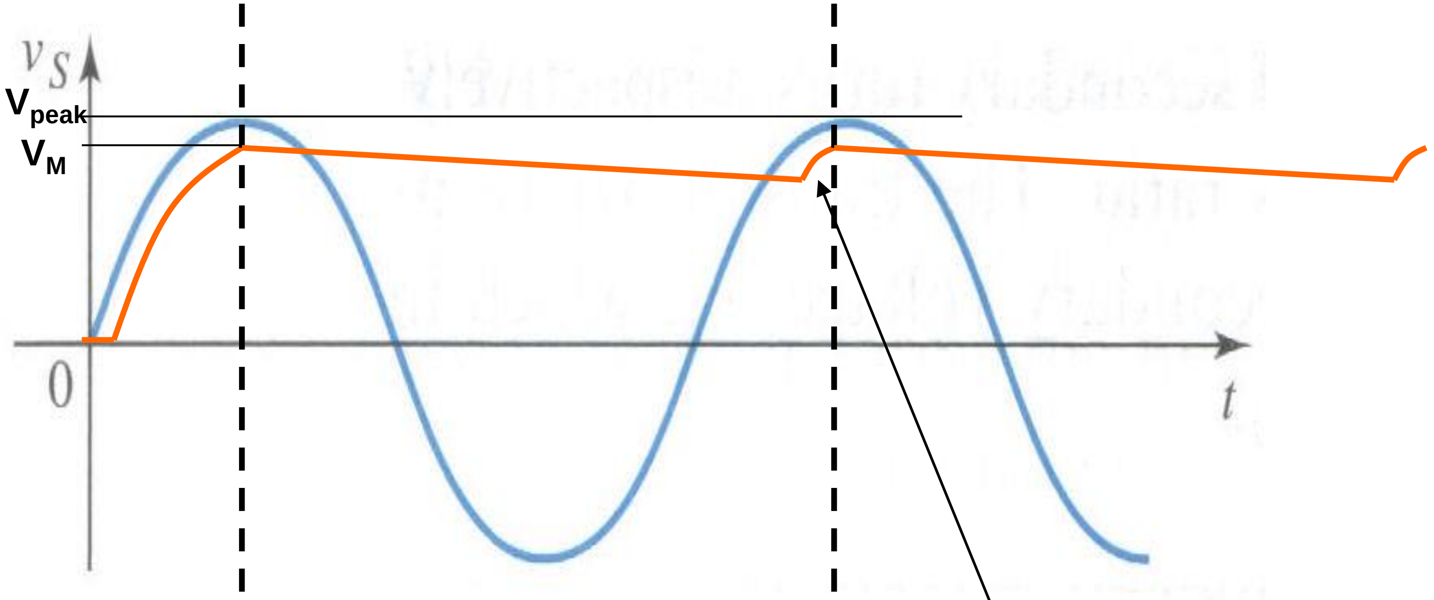
Filters

- During the <u>next positive cycle</u> of the input voltage, **there is a point at which the input voltage is greater than the capacitor voltage, diode turns back on.**





- The diode remains on until the input reaches its peak value and the **capacitor voltage is completely recharged.**



Quarter cycle; capacitor charges up

Capacitor discharges through R since diode becomes off

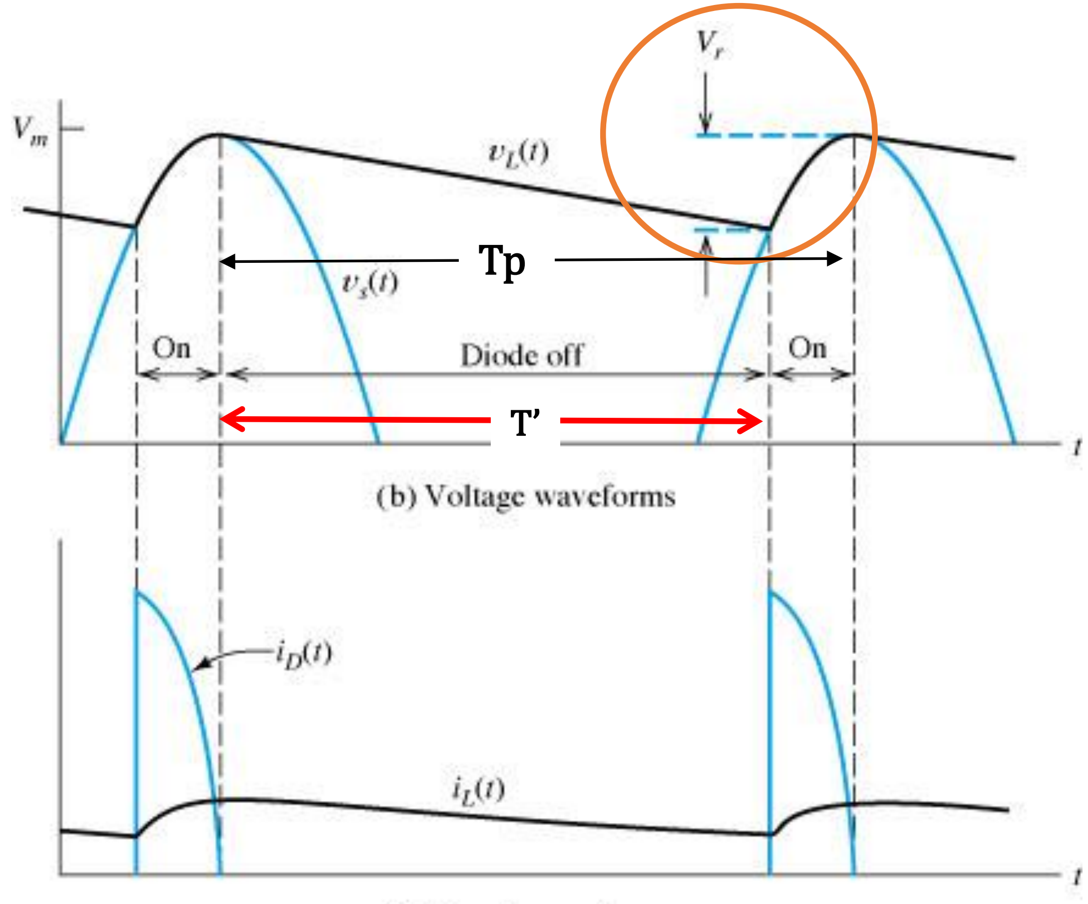
$$V_C = V_M e^{-t/RC}$$

Input voltage is greater than the capacitor voltage; recharge before discharging again

NOTE: V_m is the <u>peak value</u> of the output or capacitor voltage

Since the capacitor filters out a large portion of the sinusoidal signal, it is called a **filter capacitor**.

Ripple Voltage, and Diode Current



- V_r = ripple voltage
- $V_r = V_M - V_M e^{-T'/RC}$

where T' = time of the capacitor to discharge **to its lowest value**

$$V_r = V_M\,(1 - e^{-T'/RC})$$

Expand the exponential in series,

$V_r = (V_M T') / RC$

If the ripple is very small, we can approximate $T' = T_p$ which is the period of the input signal

- Hence for half wave rectifier

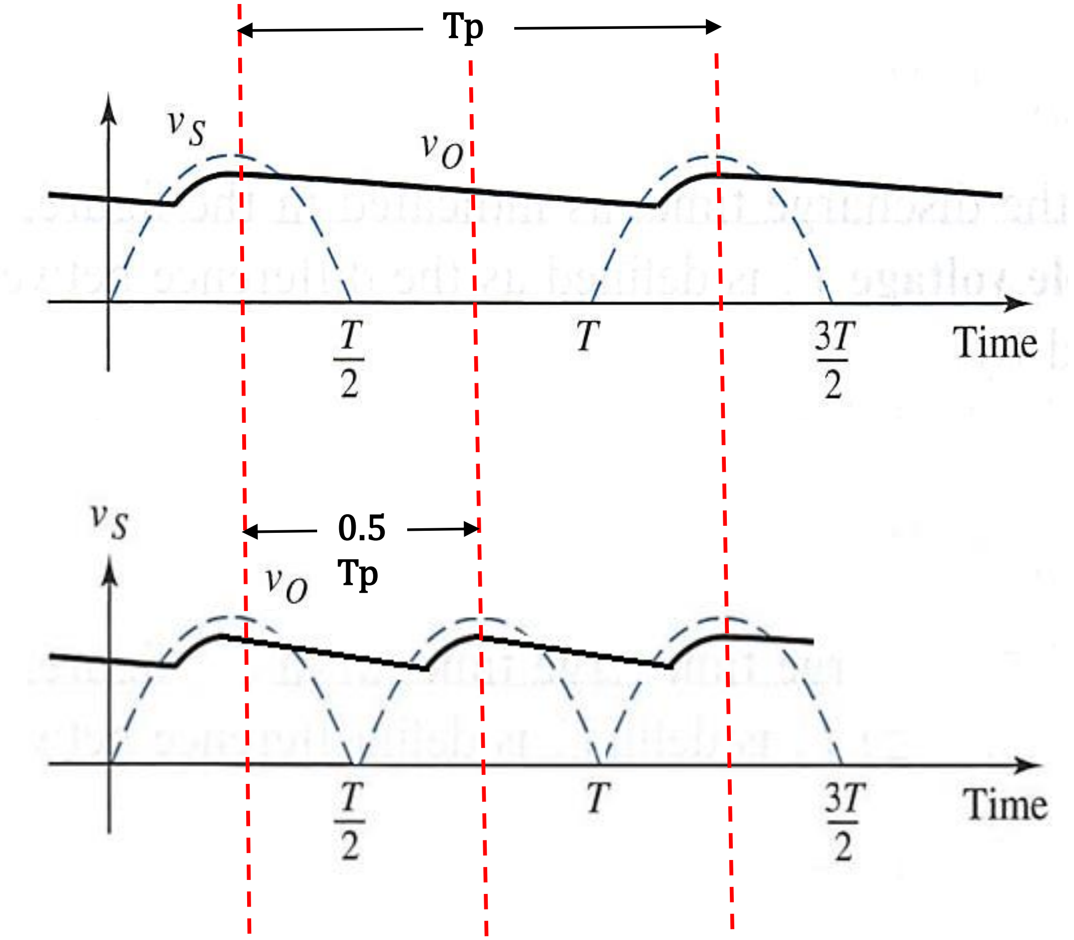
$V_r = (V_M T_p) / RC$

$$V_r = \frac{V_M}{fRC}$$

- For full wave rectifier

$V_r = (V_M\, 0.5T_p) / RC$

$$V_r = \frac{V_M}{2fRC}$$



Example 1

Consider a full wave center-tapped rectifier. The capacitor is connected in parallel to a resistor, R = 2.5 kΩ. The input voltage has a peak value of 120 V with a frequency of 60 Hz. The output voltage cannot be lower than 100 V. Assume the diode turn-on voltage, V_γ = 0.7 V. Calculate the value of the capacitor.

$$V_r = \frac{V_M}{2fRC}$$

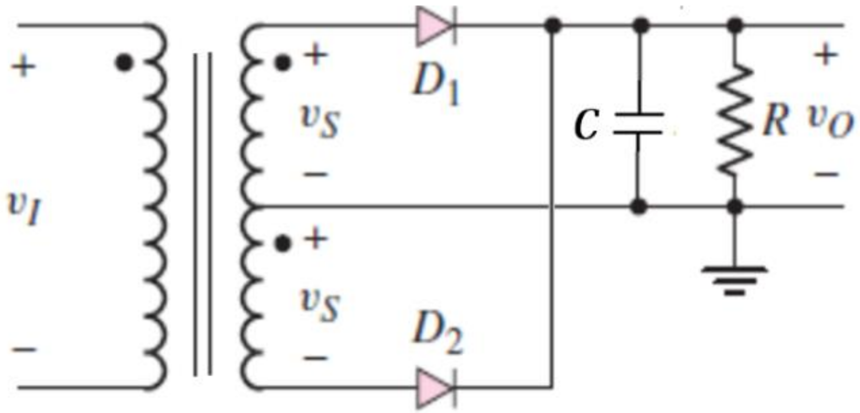
Example 2

Consider a full wave bridge rectifier. The capacitor C = 20.3 μF is connected in parallel to a resistor, R = 10 kΩ. The input voltage, v_s = 50 sin (2π(60)t). Assume the diode turn-on voltage, V_γ = 0.7 V. Calculate the value of the ripple voltage.

$$V_r = \frac{V_M}{2fRC}$$

Example 3

The full-wave rectifier circuit is shown in the figure below. The output peak current of the circuit is 200 mA when the peak output voltage is 12 V. Assume that input supply, v_I is 120 V(rms), 60 Hz and diode cut-in voltage V_γ = 0.7 V. Find the required value of C for limiting the output ripple voltage, V_r = 0.25 V.



$$V_r = \frac{V_M}{2fRC}$$

Answer: C = 6.67 mF