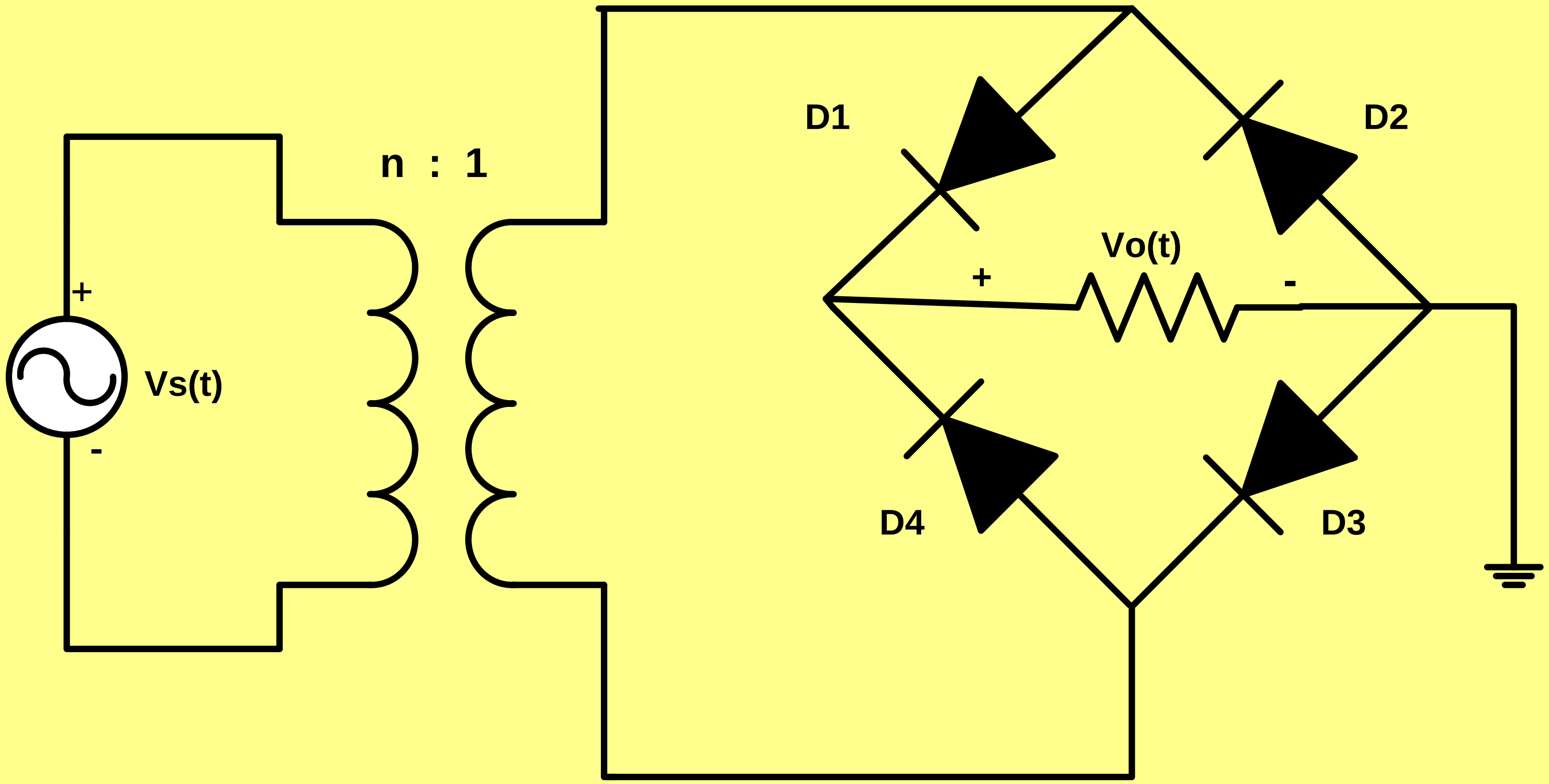
Dc Power Supply

Bridge Full Wave Rectifier

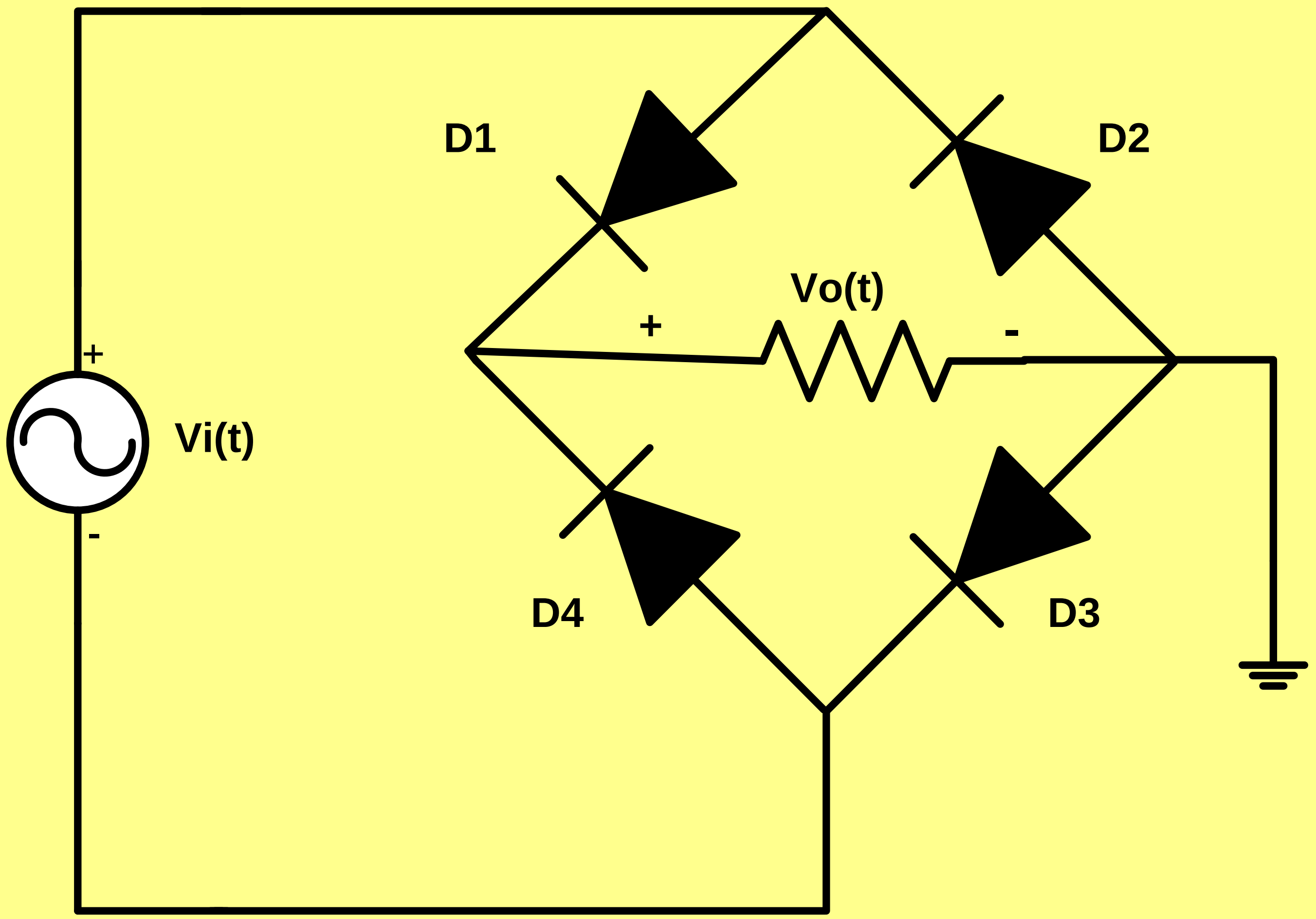
Filter

b) Bridge full-wave rectifier



b) Bridge full-wave rectifier

- Simplified circuit



b) Bridge full-wave rectifier

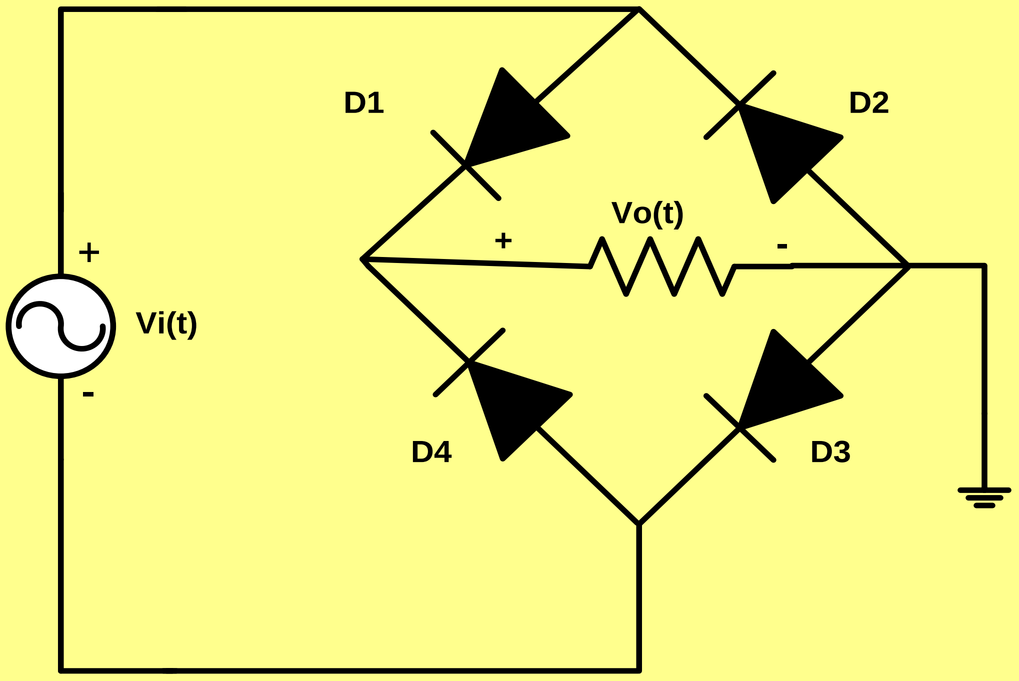
- 1) when $V_s(t) > 0$

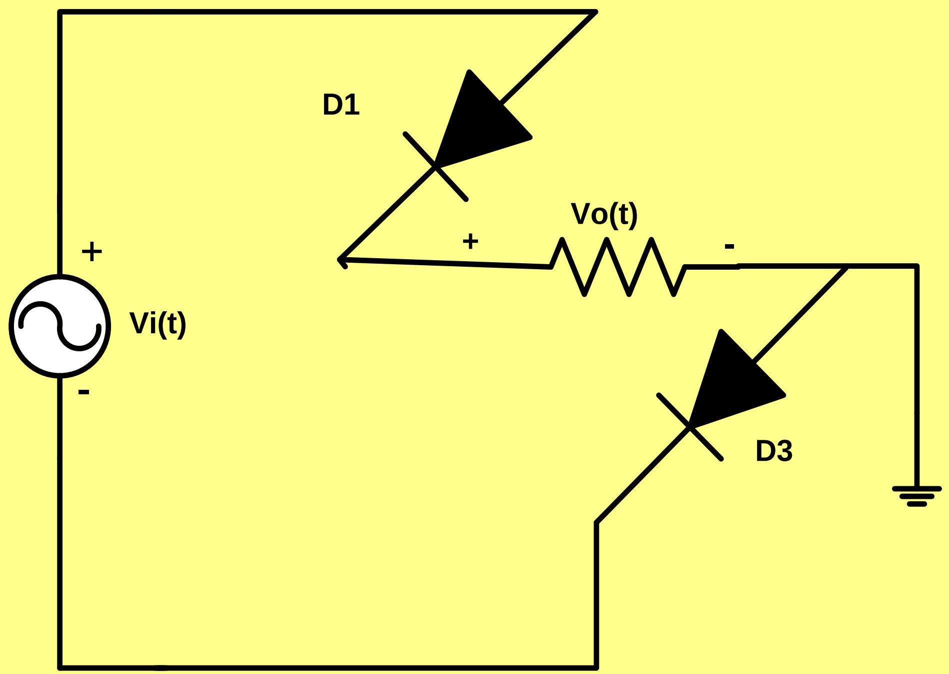
  $\therefore V_i(t) > 0$

  $\therefore$ D_1 and D_3 are on

  $\therefore$ D_2 and D_4 are off

- $V_o(t) = V_i(t)$





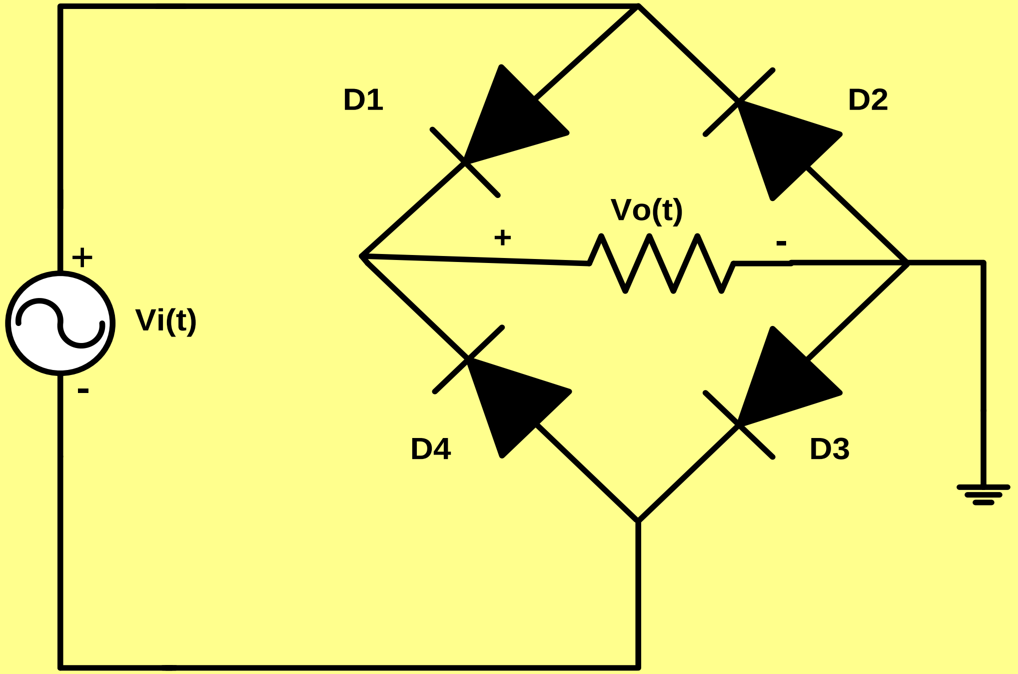
- 2) when $V_s(t) < 0$

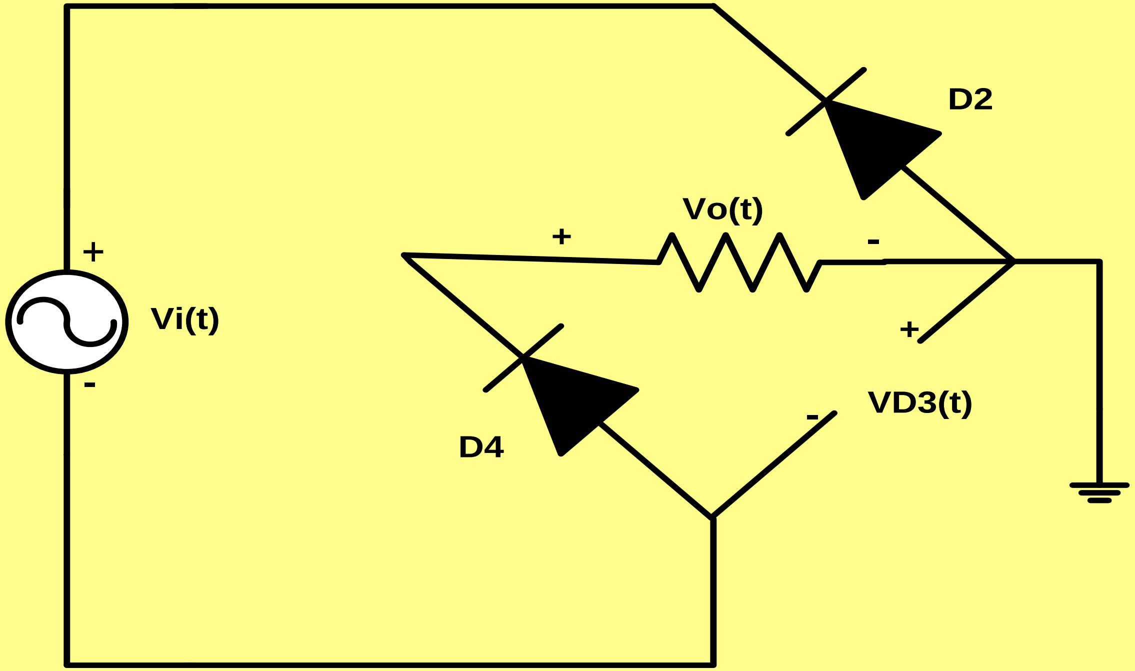
$\therefore V_i(t) < 0$

$\therefore$ D_1 and D_3 are off

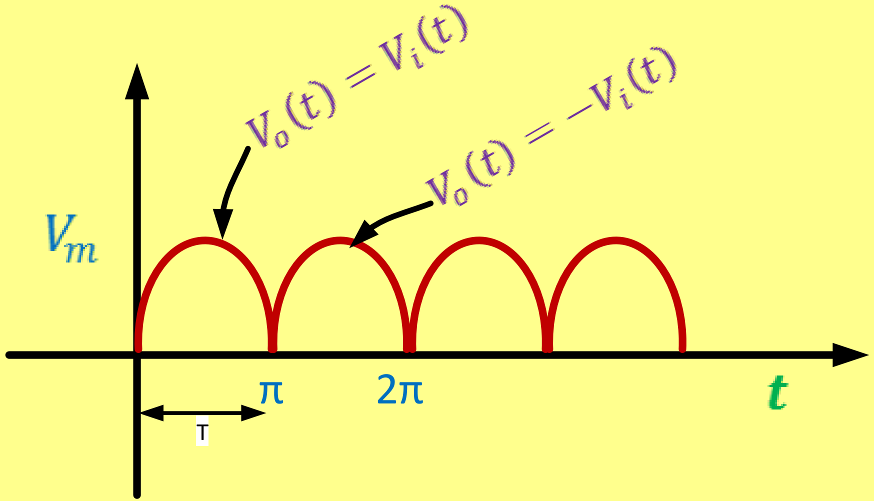
$\therefore$ D_2 and D_4 are on

$$\therefore\ V_o(t) = -V_i(t)$$



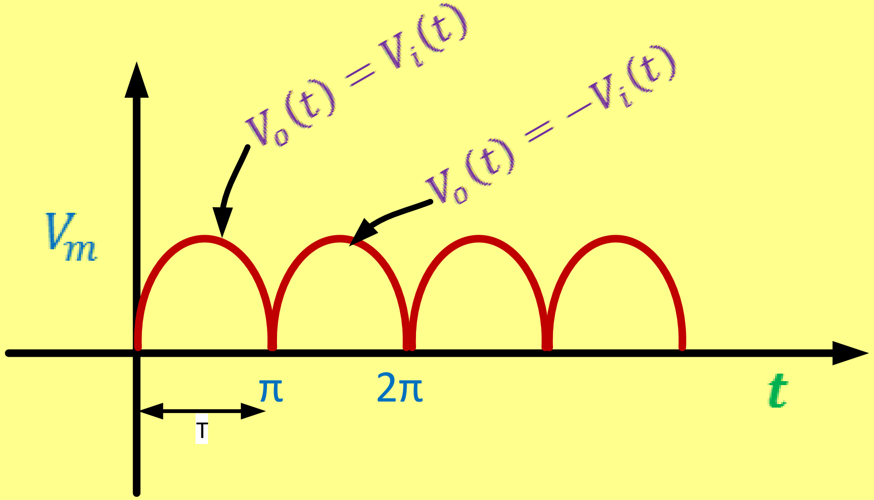


$\therefore$ For the complete cycle of $V_i(t)$



- ∴ For Bridge full-wave rectifier
- $V_{o,av} = \frac{1}{T} \int_0^T V_o(t)dt$

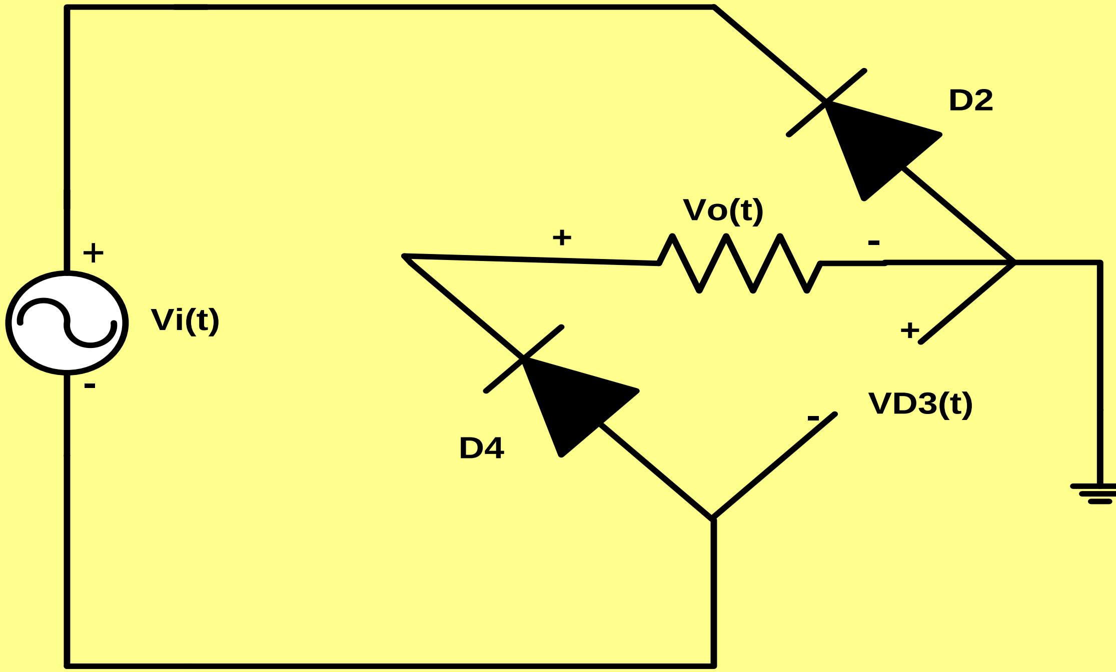
  $V_{o,av} = \frac{2V_m}{\pi}$
- $T = \frac{1}{2} T_o$
- $f = 2f_o$



- To calculate the PIV of the D3
- $V_i(t) < 0$

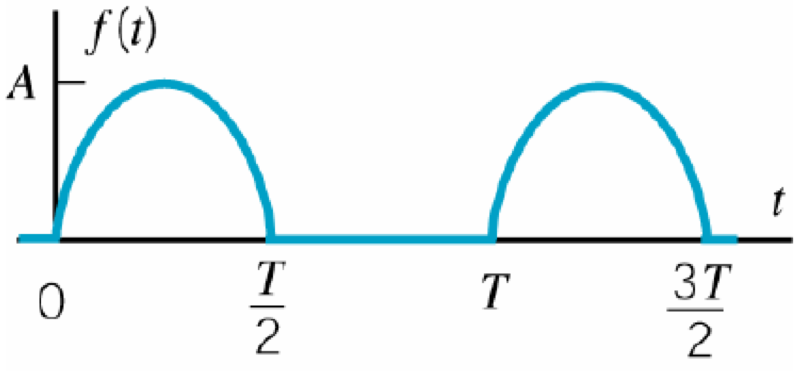
  $V_{D3}(t) = V_i\ (t)$

  $\therefore\ V_{D3}(t)_{,max} = -V_m$ ∴ PIV $= -V_m$



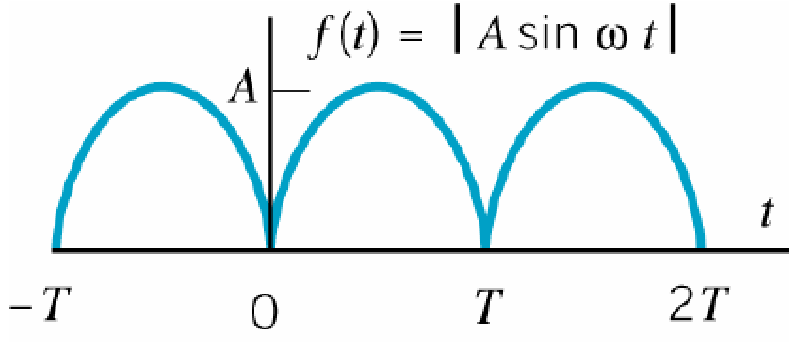
Filter

The Fourier Series of Selected Waveforms



Half wave rectified sine wave: $\omega_0 = \frac{2\pi}{T}$

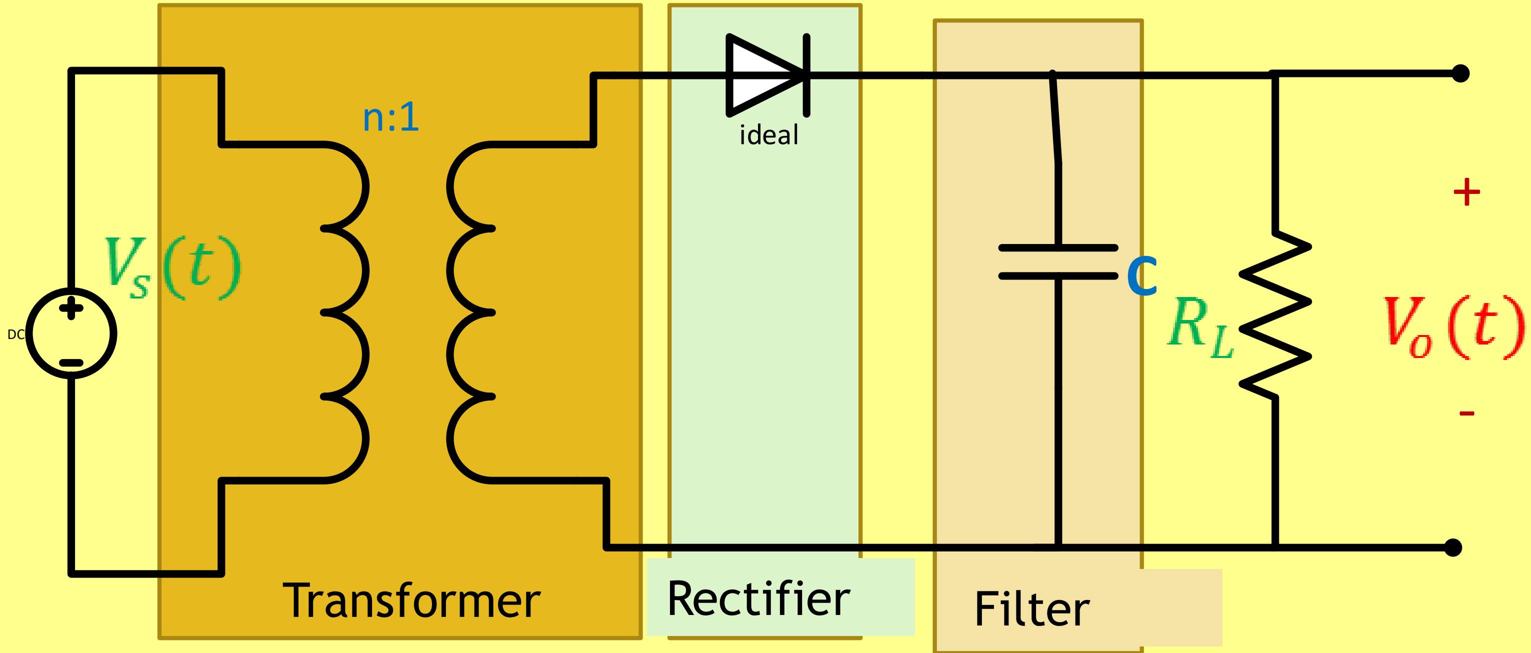
$$f(t) = \frac{A}{\pi} + \frac{A}{2}\sin\omega_0 t - \frac{2A}{\pi}\sum_{n=1}^{\infty}\frac{\cos(2n\omega_0 t)}{4n^2 - 1}$$



Full wave rectified sine wave: $\omega_0 = \frac{2\pi}{T}$

$$f(t) = \frac{2A}{\pi} - \frac{4A}{\pi}\sum_{n=1}^{\infty}\frac{\cos(n\omega_0 t)}{4n^2 - 1}$$

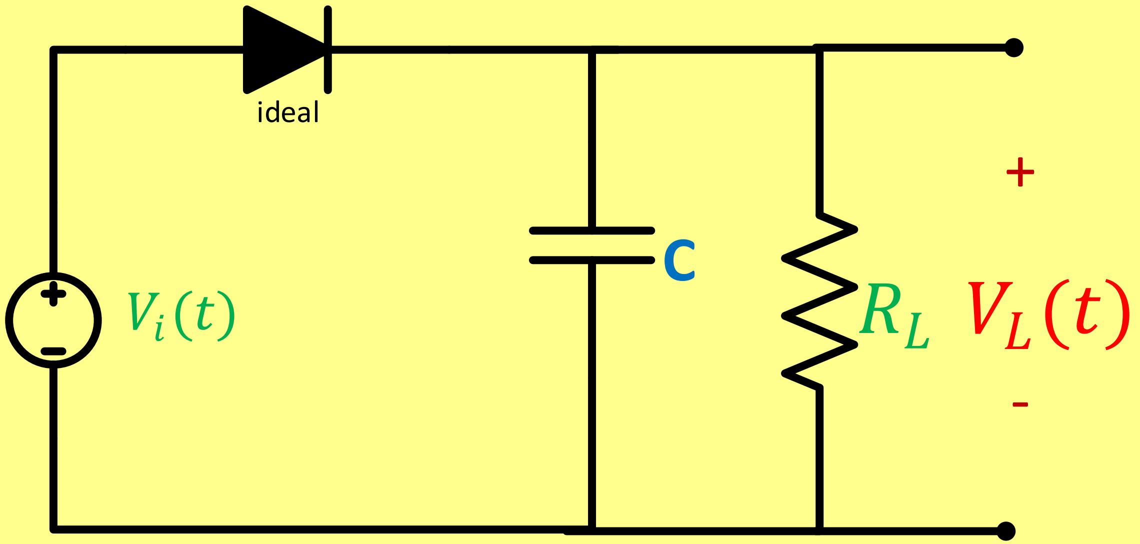
- Filter: used to smooth out the pulsating dc produced by the rectifier by removing its ac ripple contents and passing its dc component (average value)

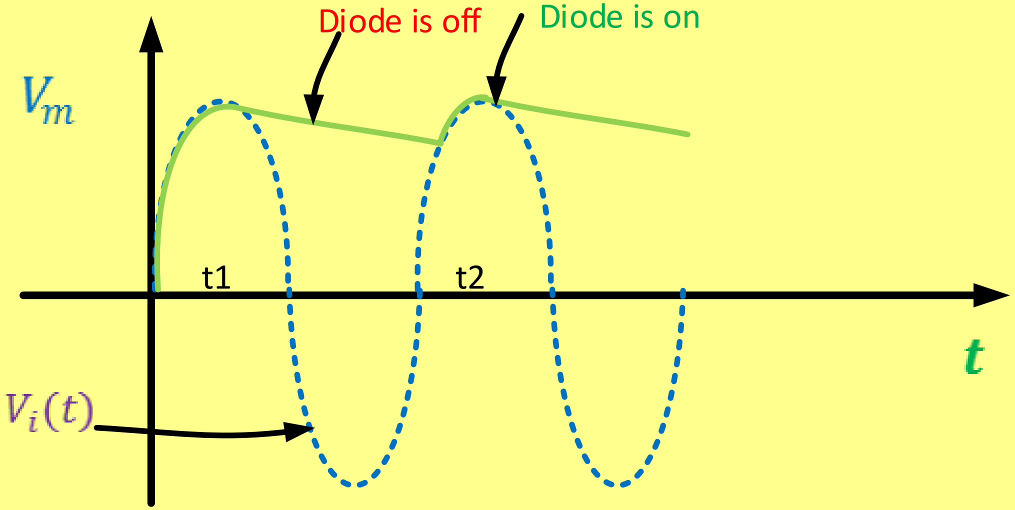


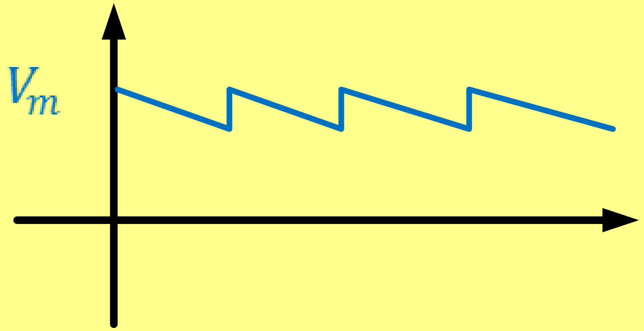
Simplified Circuit

- A) when $V_i(t) > V_c(t)$
  Diode is on and
- $V_L(t) = V_c(t) = V_i(t)$

- B) when $V_i(t) < V_c(t)$
  Diode is off and the capacitor starts discharging







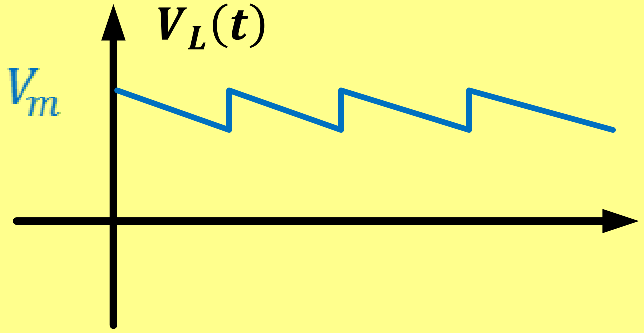
Approximated

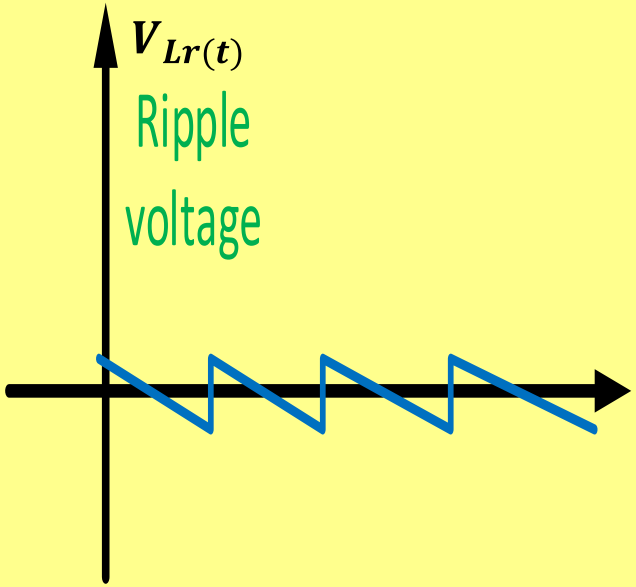
- Ripple factor is an indicator for the effectiveness of the filter

$$r = \frac{RMS(ripple\ voltage)}{Average\ value\ of\ the\ output\ signal} \times 100\%$$

- The output signal can be approximated as shown

$$V_L(t) = V_{L,dc} + V_{Lr(t)}$$





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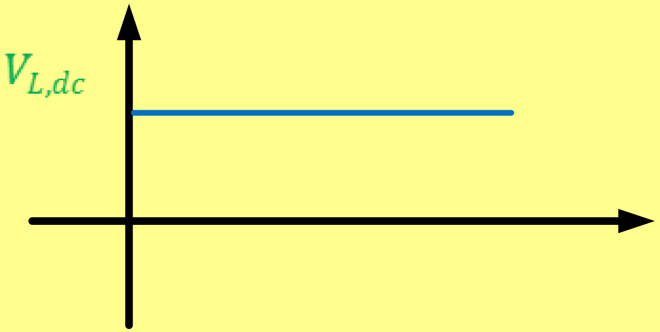
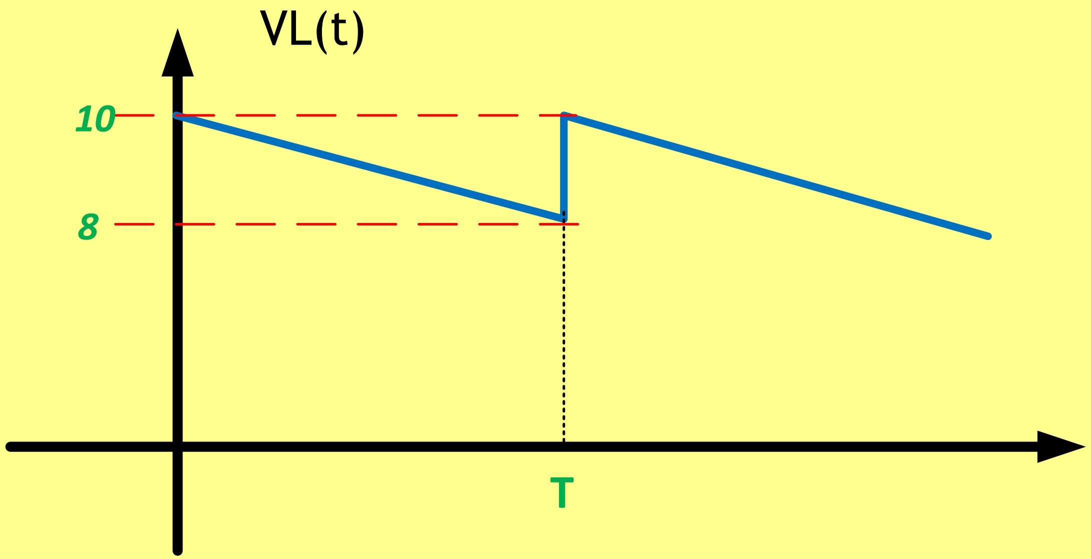


Example



- $V_{L,dc} = V_{L,av} = \frac{1}{T} \int_0^T V_L(t)dt$

  $V_{L,dc} = \frac{1}{T}$. area

  $= \frac{1}{T}(8T + \frac{2.T}{2})$

  $V_{L,dc} = 9\ V$

OR

- $V_{L,dc} = V_m - \frac{1}{2} V_{Lr,p-p}$

  where $V_m = 10\ V$

  $V_{Lr,p-p} = 2$ V p-p

  $\therefore V_{L,dc} = 10 - \frac{1}{2}(2) = 9V$

- Also for a triangle signal, the $RMS\ value = \frac{Peak\ Value}{\sqrt{3}}$

or $RMS\ value = \frac{Peak-to-peak\ Value}{2\sqrt{3}}$

$$= \frac{V_{Lr,p-p}}{2\sqrt{3}}$$

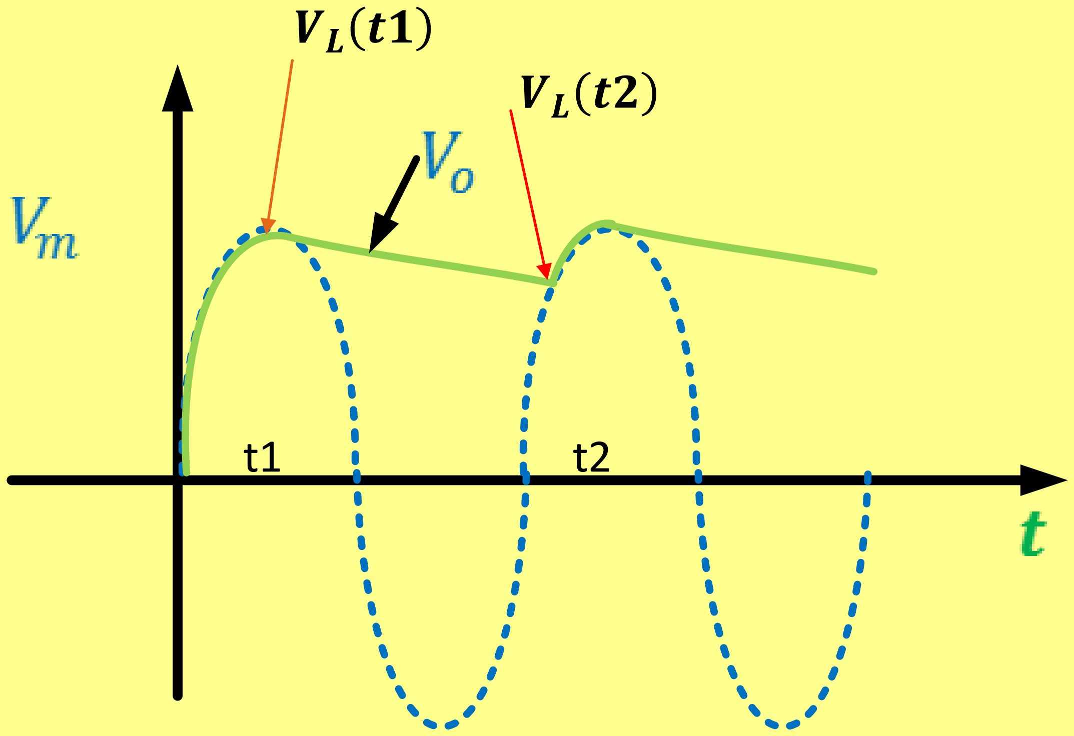
$$\therefore r = \frac{\frac{V_{Lr,p-p}}{2\sqrt{3}}}{V_m - \frac{1}{2}V_{Lr,p-p}} \times 100\%$$

$\therefore$ To determine the ripple factor we need to find $V_{Lr,p-p}$

Ripple Factor

- For $t_2 > t > t_1$
- $V_L(t) = V_m \; e^{-(t-t_1)/RC}$
- $V_{Lr,p-p} = V_L(t_1) - V_L(t_2)$
- $V_{Lr,p-p} = V_m \; - V_m \; e^{-(t_2-t_1)/RC}$
- $V_{Lr,p-p} = V_m \; (1 - e^{-(t_2-t_1)/RC})$

  Using $e^{-x} \cong 1 - x$
- $V_{Lr,p-p} = \frac{V_{m(t_2-t_1)}}{RC}$
- $V_{L,dc} = V_m - \frac{1}{2} V_{Lr,p-p}$

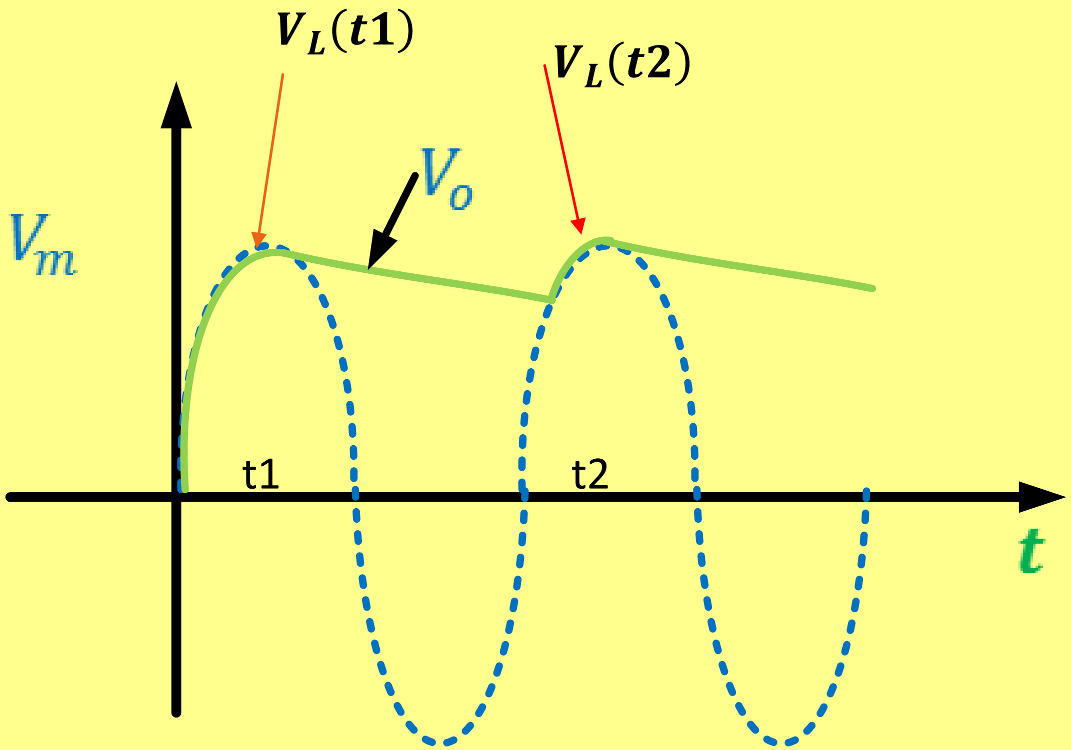


- For half-wave rectifier
- $t_2 - t_1 \approx T_o = \frac{1}{f_o}$

  $\therefore V_{Lr,p-p} = V_m \frac{1}{f_o RC}$
- $V_{L,dc} = V_m\left(1 - \frac{1}{2 f_o RC}\right)$
- $\left(V_{L,r}\right)_{rms} = \frac{V_{Lr,p-p}}{2\sqrt{3}}$

  $\left(V_{L,r}\right)_{rms} = \frac{V_m}{2\sqrt{3}\ f_o RC}$
- $r = \frac{\left(V_{L,r}\right)_{rms}}{V_{L,dc}} \times 100\%$

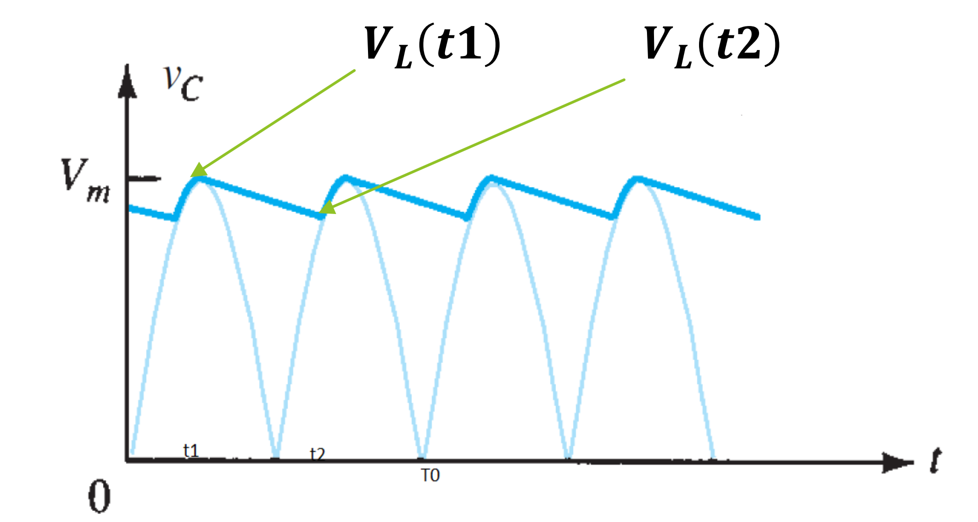
  $r = \frac{1}{\sqrt{3}\ (2 f_o RC - 1)} \times 100\%$



- For full-wave rectifier
- $t_2 - t_1 \approx \frac{1}{2} T_o = \frac{1}{2f_o}$

  $\therefore V_{Lr,p-p} = V_m \frac{1}{2f_oRC}$
- $V_{L,dc} = V_m(1 - \frac{1}{4f_oRC})$

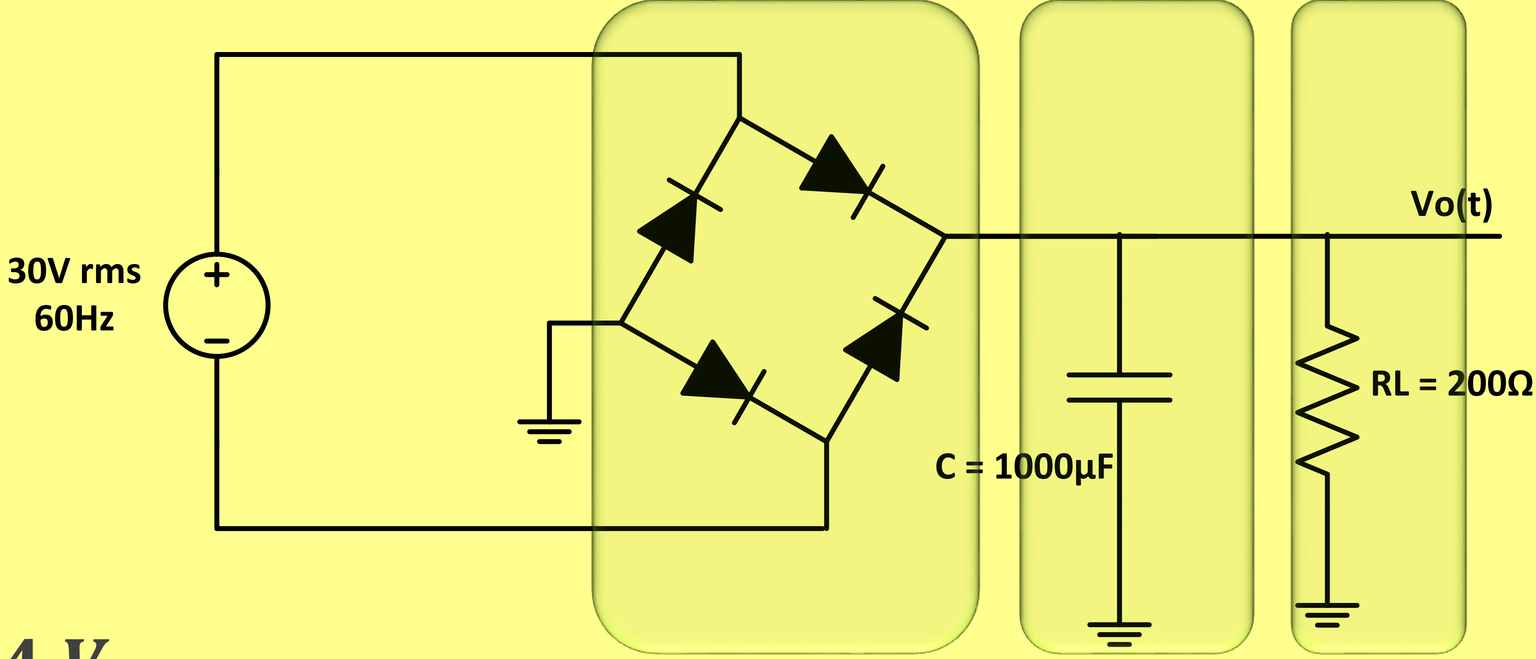
  $(V_{L,r})_{rms} = \frac{V_m}{4\sqrt{3}\ f_oRC}$



$$r = \frac{1}{\sqrt{3}\ (4f_oRC - 1)} \times 100\%$$

Example

- Find the ripple factor r



$$V_m = 30\sqrt{2} = 42.43\,V$$

- $V_{L,dc} = V_m - \frac{V_m}{4f_o R_L C} = 41.54\,V$
- $V_{Lr,p-p} = \frac{V_m}{2f_o R_L C} = 1.7677\,V$
- RMS (ripple voltage) $= \frac{V_{Lr,p-p}}{2\sqrt{3}} = 0.51 V\,rms$

$$\therefore r = \frac{0.51}{41.54} \times 100\%$$

$$r = 1.2277\,\%$$