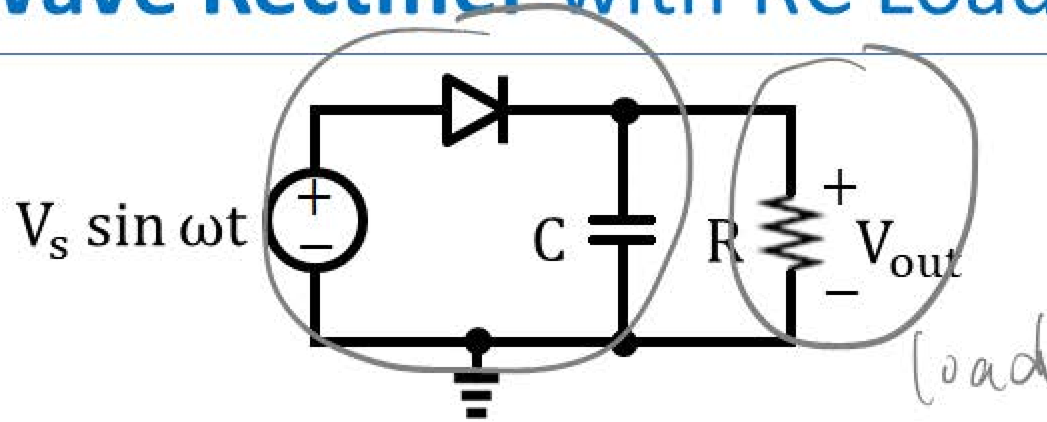
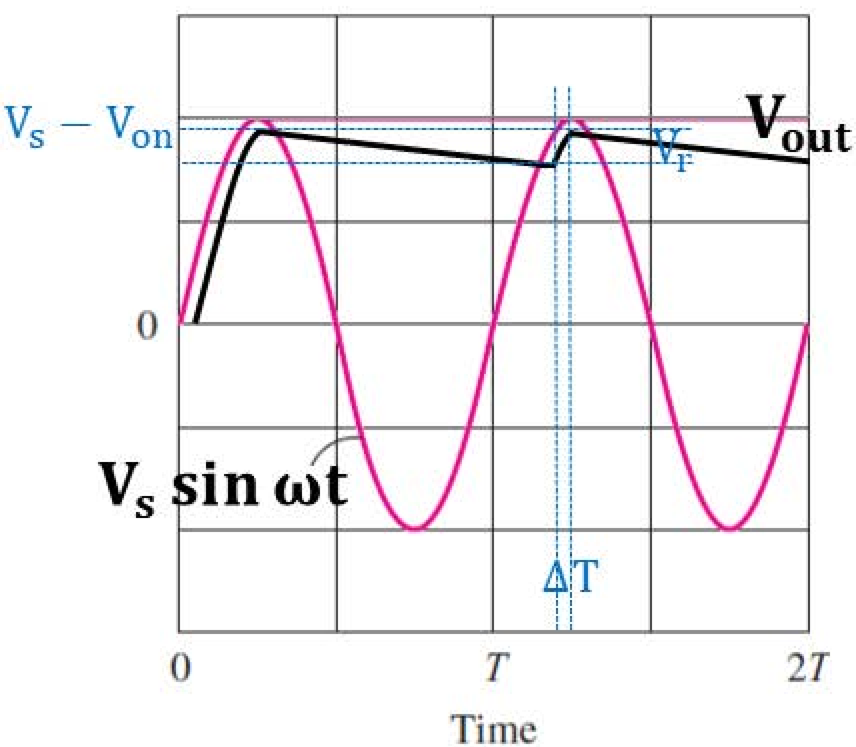
Half-Wave Rectifier with RC Load (I)





$$V_{dc} = \boxed{\mathbf{V_s - V_{on}}}$$

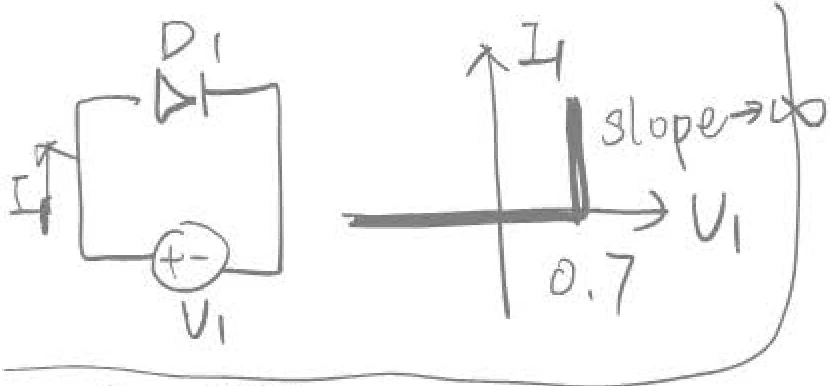
$$I_{dc} = \frac{V_{dc}}{R}$$

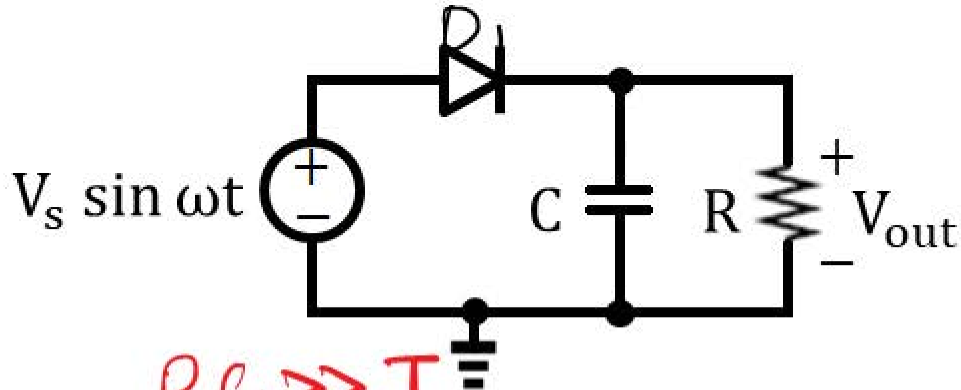
ripple voltage

$$V_r = (V_s - V_{on})\left(1 - e^{-\frac{T-\Delta T}{RC}}\right)$$

$$\cong (V_s - V_{on})\left(\frac{T - \Delta T}{RC}\right) \quad if (T - \Delta T) \ll RC$$

$$\cong \boxed{\mathbf{(V_s - V_{on})\left(\frac{T}{RC}\right)}} \quad if \Delta T \ll T$$

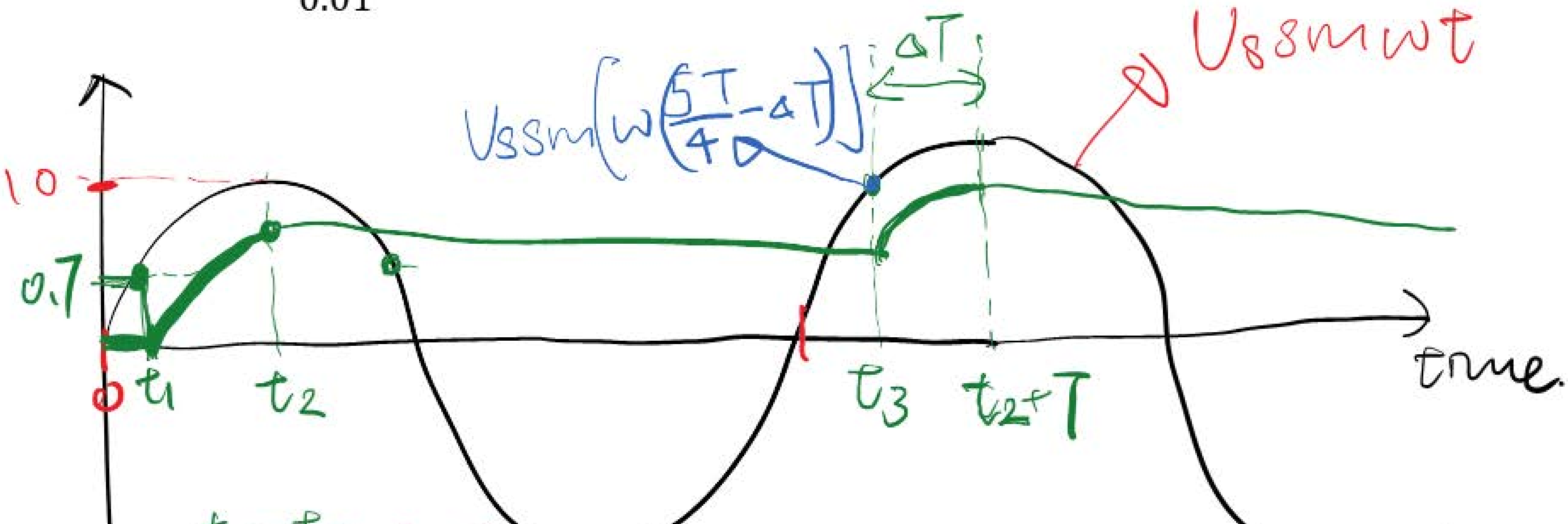




$V_s = 10\ \mathrm{V}$

$$\omega = 2\pi f = 2\pi \frac{1}{0.01} = 200\pi\ (\mathrm{rad/sec})$$

$RC \gg T$

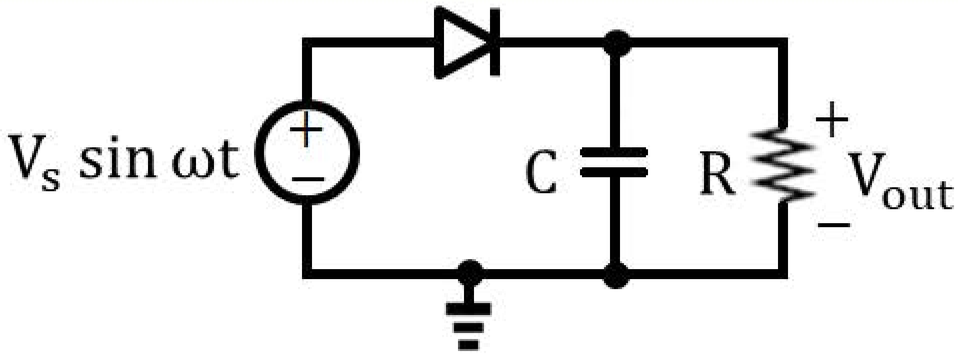


$t_1 \sim t_2$: D_1 on

$t_3 \sim t_2 + T$: D_1 on

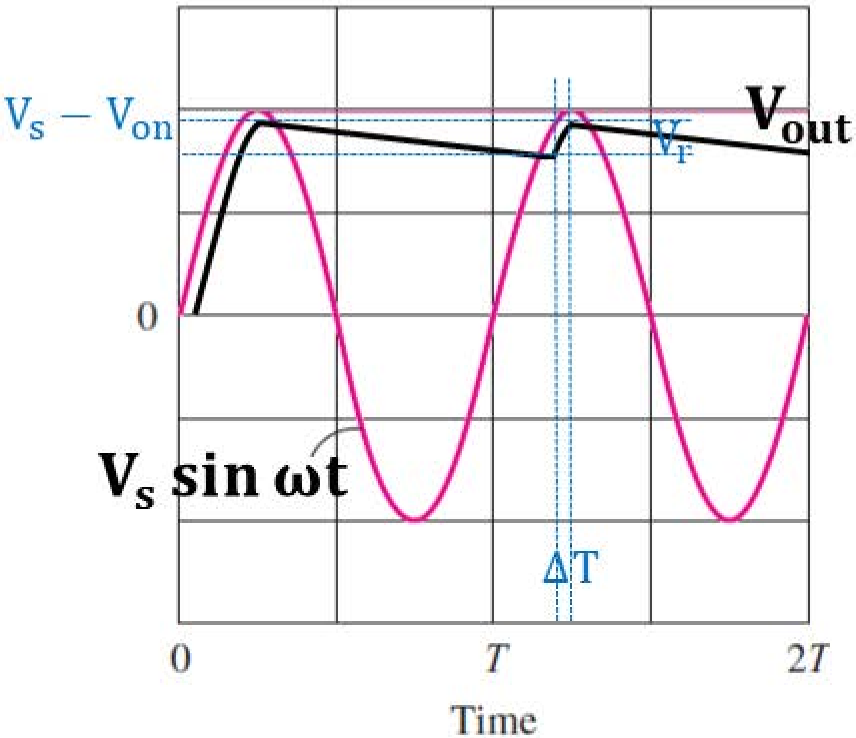
$t_2 \sim t_3$: D_1 off

Half-Wave Rectifier with RC Load (II)



$\theta_c = \omega \Delta T$

conduction angle and interval



$$V_s \sin\left[\overset{2\pi f}{\omega}\left(\frac{5T}{4} - \Delta T\right)\right] - V_{on} = (V_s - V_{on}) - V_r$$

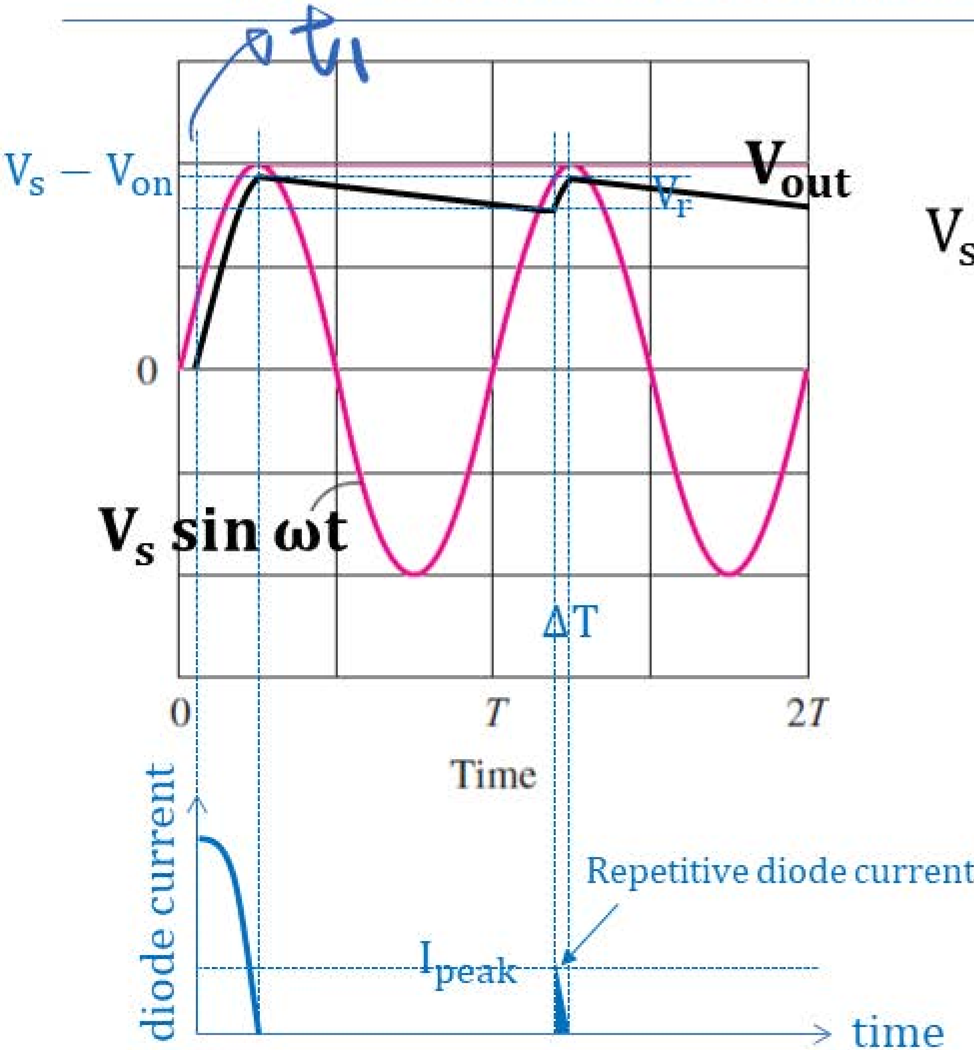
$$V_s \sin\left(\frac{5\pi}{2} - \theta_c\right) - V_{on} = (V_s - V_{on}) - V_r$$

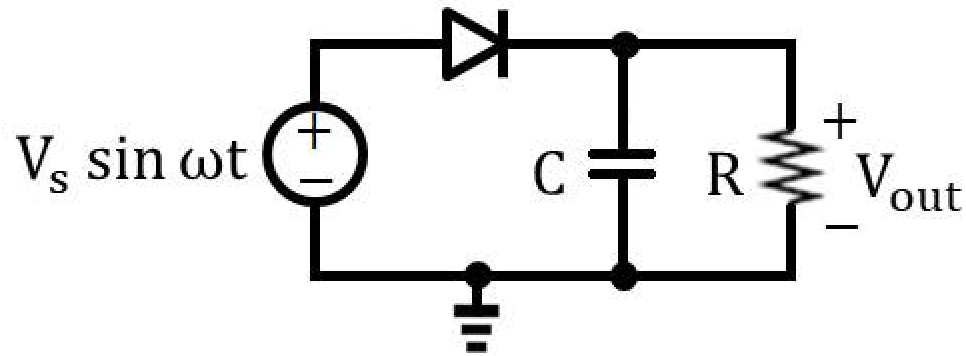
$$V_s \cos \theta_c = V_s - V_r$$

$$\cos \theta_c = \frac{V_s - V_r}{V_s} \cong 1 - \frac{\theta_c^{\,2}}{2} \quad \textit{if } \theta_c \textit{ very small}$$

$$\boxed{\boldsymbol{\theta_c = \sqrt{\frac{2V_r}{V_s}}}} \qquad \boxed{\boldsymbol{\Delta T = \frac{\theta_c}{\omega} = \frac{1}{\omega}\sqrt{\frac{2V_r}{V_s}}}}$$

Half-Wave Rectifier with RC Load (III)





The charge filled on C during ΔT is discharged during $T - \Delta T$.

$$Q \cong \frac{I_{peak}\Delta T}{2} = I_{dc}(T - \Delta T) \cong I_{dc}T$$

$$\boxed{\mathbf{I_{peak} = \frac{2I_{dc}T}{\Delta T}}}$$

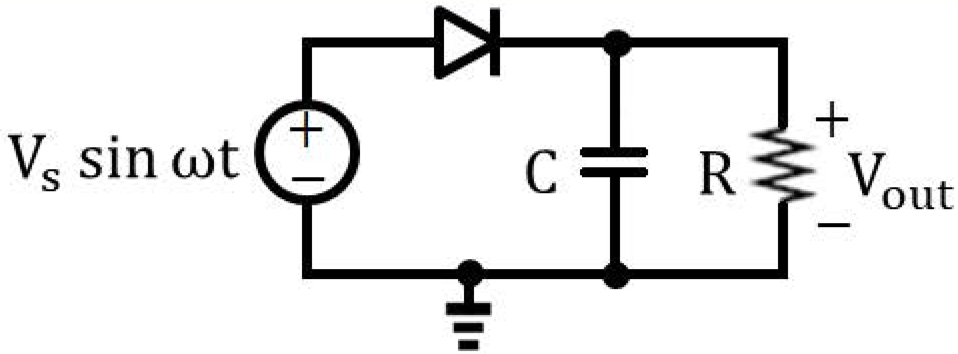
During charging period (ΔT), almost all diode current goes to C.

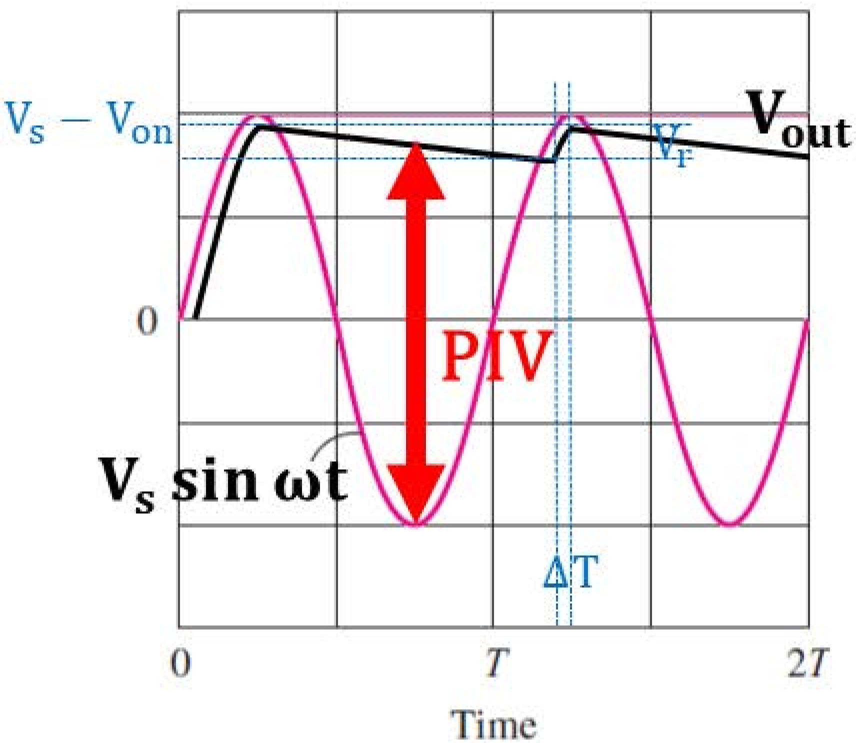
$$\left|\frac{1}{SC}\right| = \frac{1}{2\pi\frac{1}{T}C} = \frac{T}{2\pi C} \ll R \quad \text{if } RC \gg T$$

$$\boxed{\mathbf{I_{surge} = C\frac{d(V_s \sin \omega t - V_{on})}{dt} = \omega C V_s} \cos\omega t \quad \text{if } t = 0}$$

$$i_1 = C\frac{dv_1}{dt}$$

Half-Wave Rectifier with RC Load (IV)





Peak-inverse-voltage (PIV) $\cong 2V_s - V_{on}$

If too large, the diode breaks down.

Example

Find the value of the dc output voltage, dc output current, ripple voltage, conduction interval, conduction angle and diode peak current for a half-wave rectifier driven from a transformer having a secondary voltage of 12.6 V_{rms} (60 Hz) with $R = 15\ \Omega$ and $C = 25{,}000\ \mu F$. Assume $V_{on} = 1$ V.

$$V_{dc} = \underbrace{\boxed{12.6\sqrt{2}}}_{V_s} - 1 = 16.8\ (V)$$

$$I_{dc} = \frac{16.8}{15} = 1.12\ (A)$$

$$V_r \cong V_{dc}\frac{T}{RC} = 16.8\,\frac{\frac{1}{60}}{15 \times 25000 \times 10^{-6}} = 0.747\ (V)$$

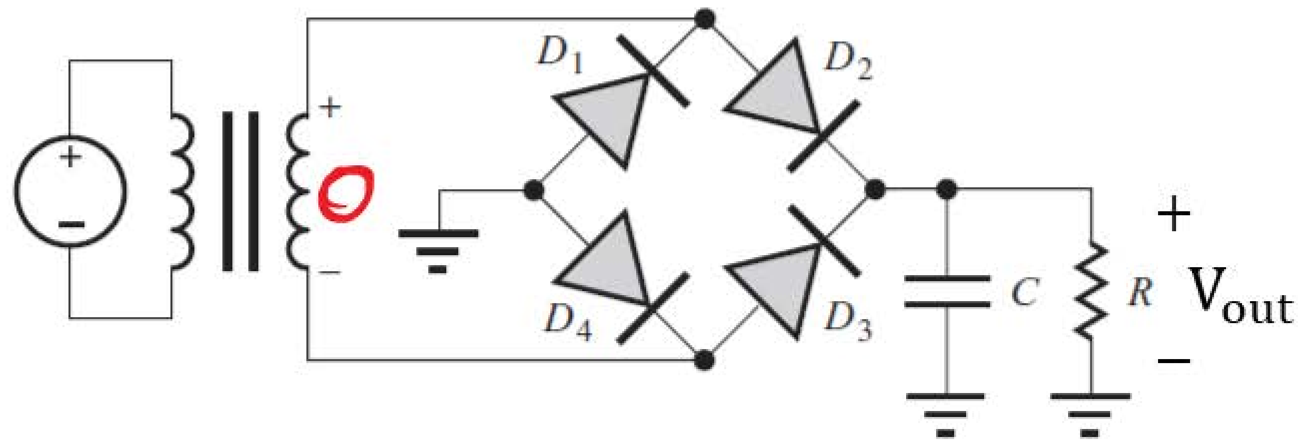
$$\theta_c \cong \sqrt{\frac{2V_r}{V_s}} = \sqrt{\frac{2 \times 0.747}{12.6 \times \sqrt{2}}} = 0.29\ (rad)\ \text{or}\ 16.6^{\circ}$$

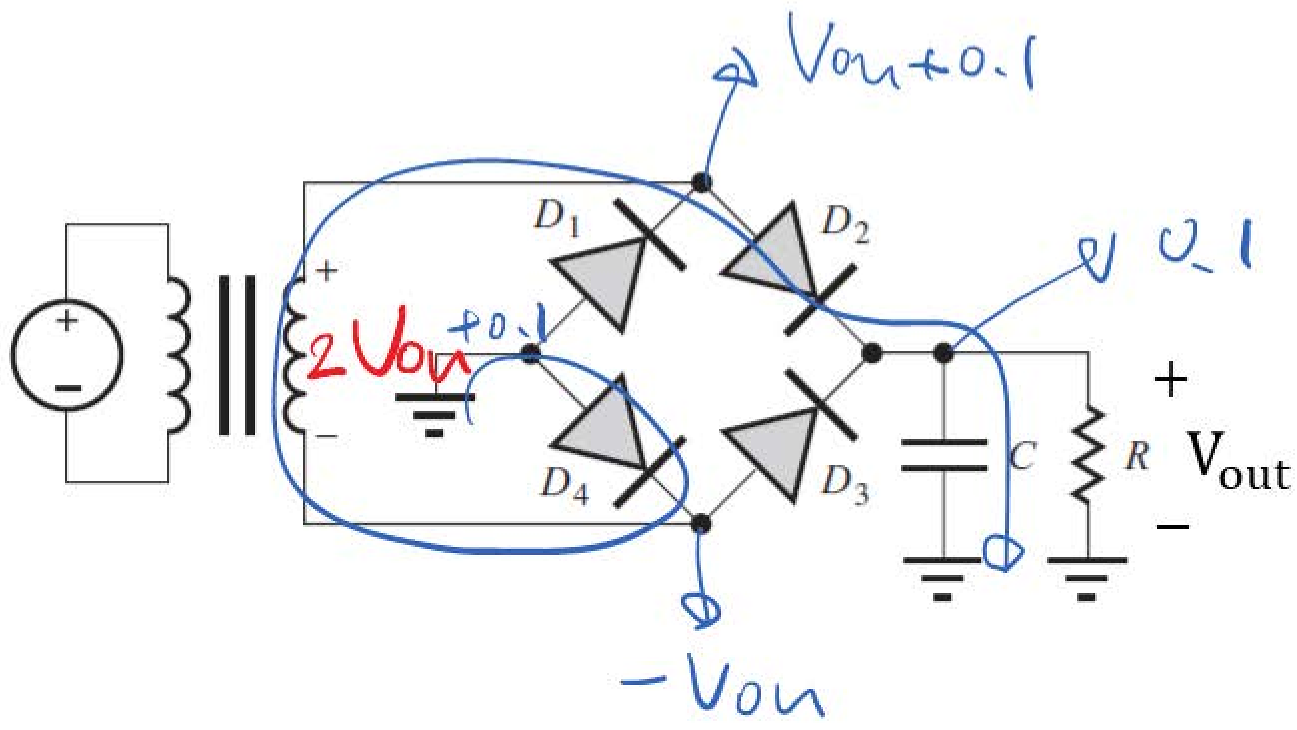
$$\Delta T \cong \frac{\theta_c}{\omega} = \frac{0.29}{2\pi \times 60} = 7.69 \times 10^{-4}\ (sec)$$

$$I_{peak} = \frac{2 \times 1.12 \times \frac{1}{60}}{7.69 \times 10^{-4}} = 48.6\ (A)$$

- Make sure all assumptions are valid. → Make sure $RC >> T$
- Since R is small (15 Ω), C needs to be large (25,000 μF) to maintain a low V_r.
- The diode must be able to handle these repetitively high peak currents.

Full-Wave Bridge Rectifier (I)





Full-Wave Bridge Rectifier (I)