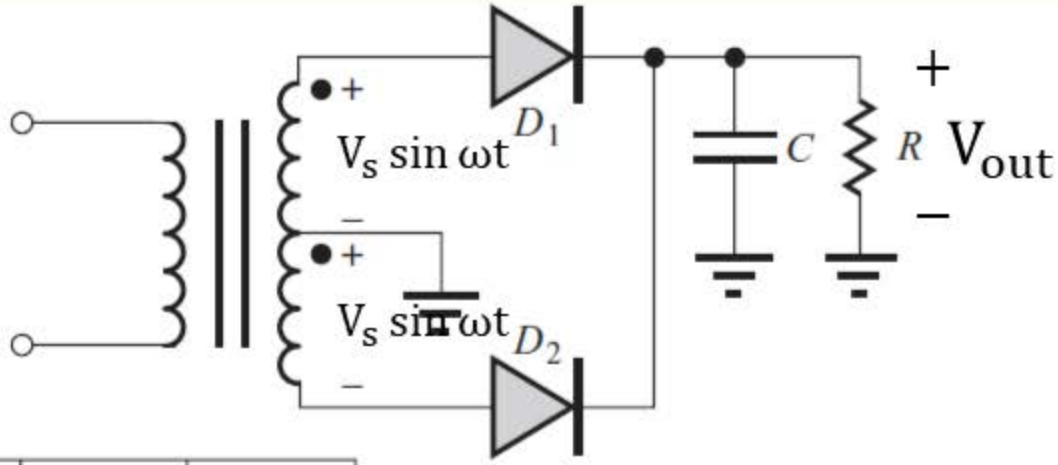
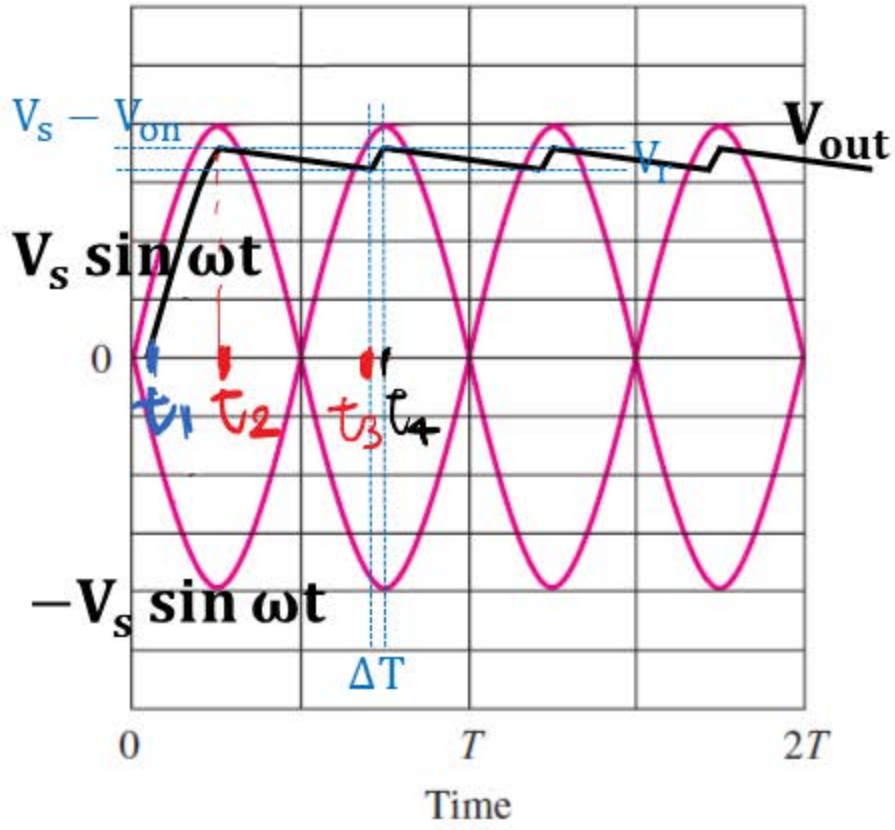
Full-Wave Rectifier (I)





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

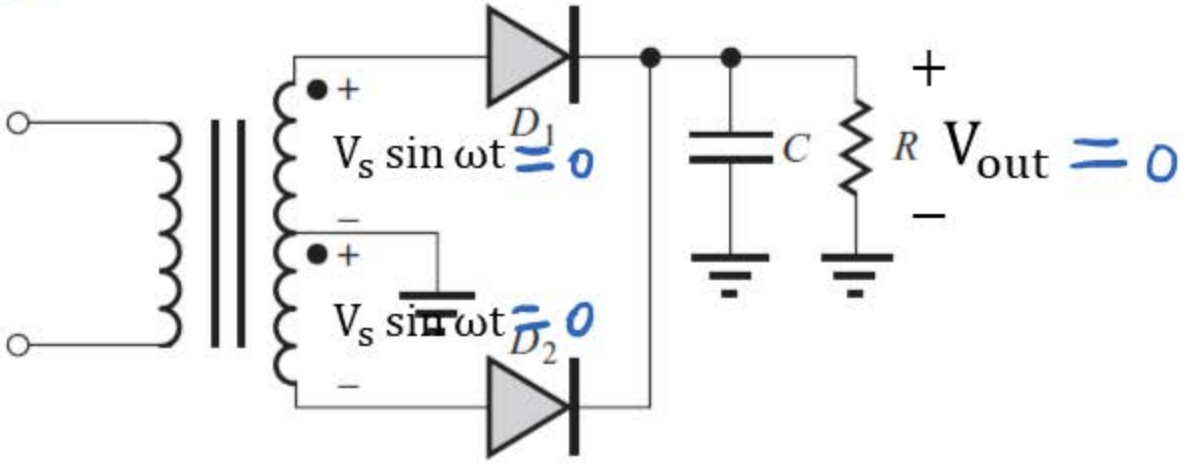
$$I_{dc} = \frac{V_{dc}}{R}$$

$$V_r = (V_s - V_{on})\left(1 - e^{-\frac{T/2 - \Delta T}{RC}}\right)$$

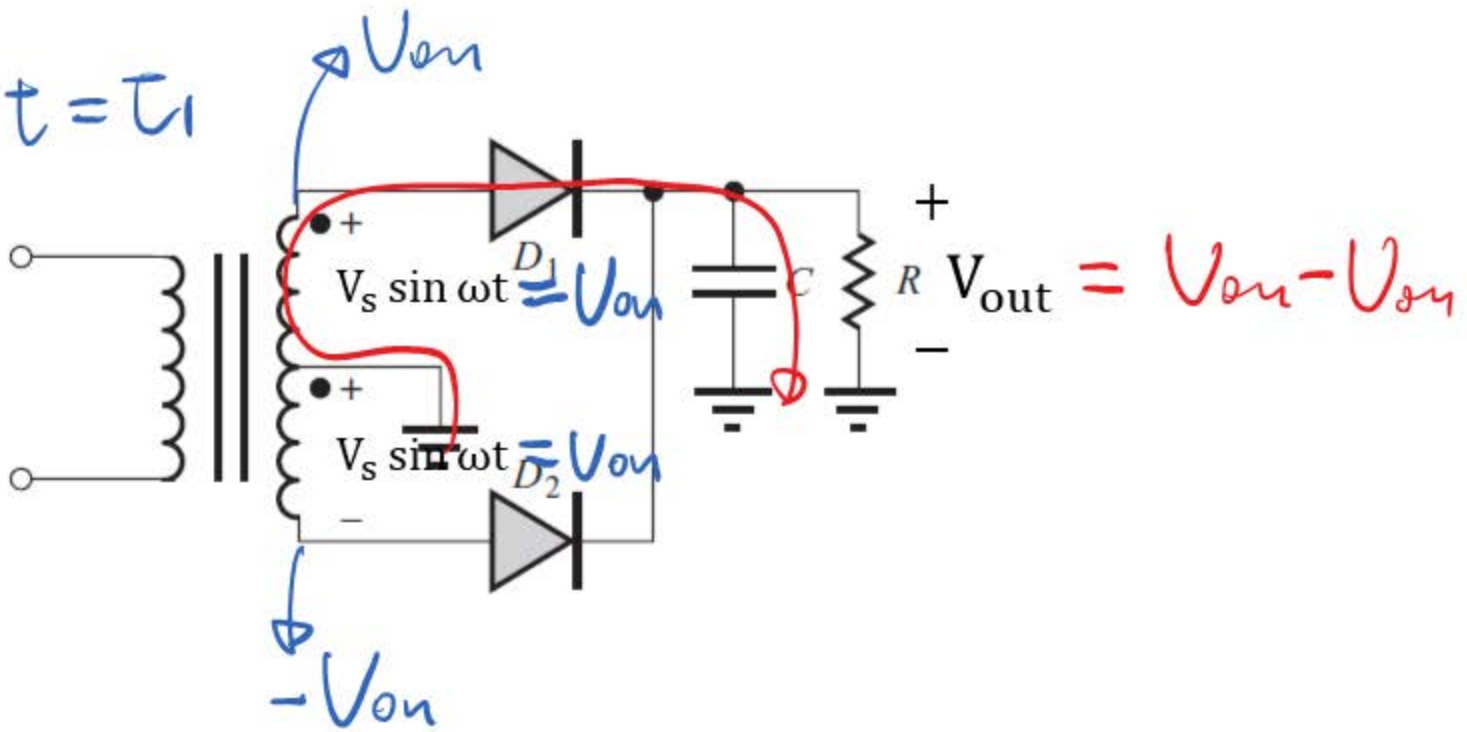
$$\cong (V_s - V_{on})\left(\frac{T/2 - \Delta T}{RC}\right) \quad if \left(\frac{T}{2} - \Delta T\right) \ll RC$$

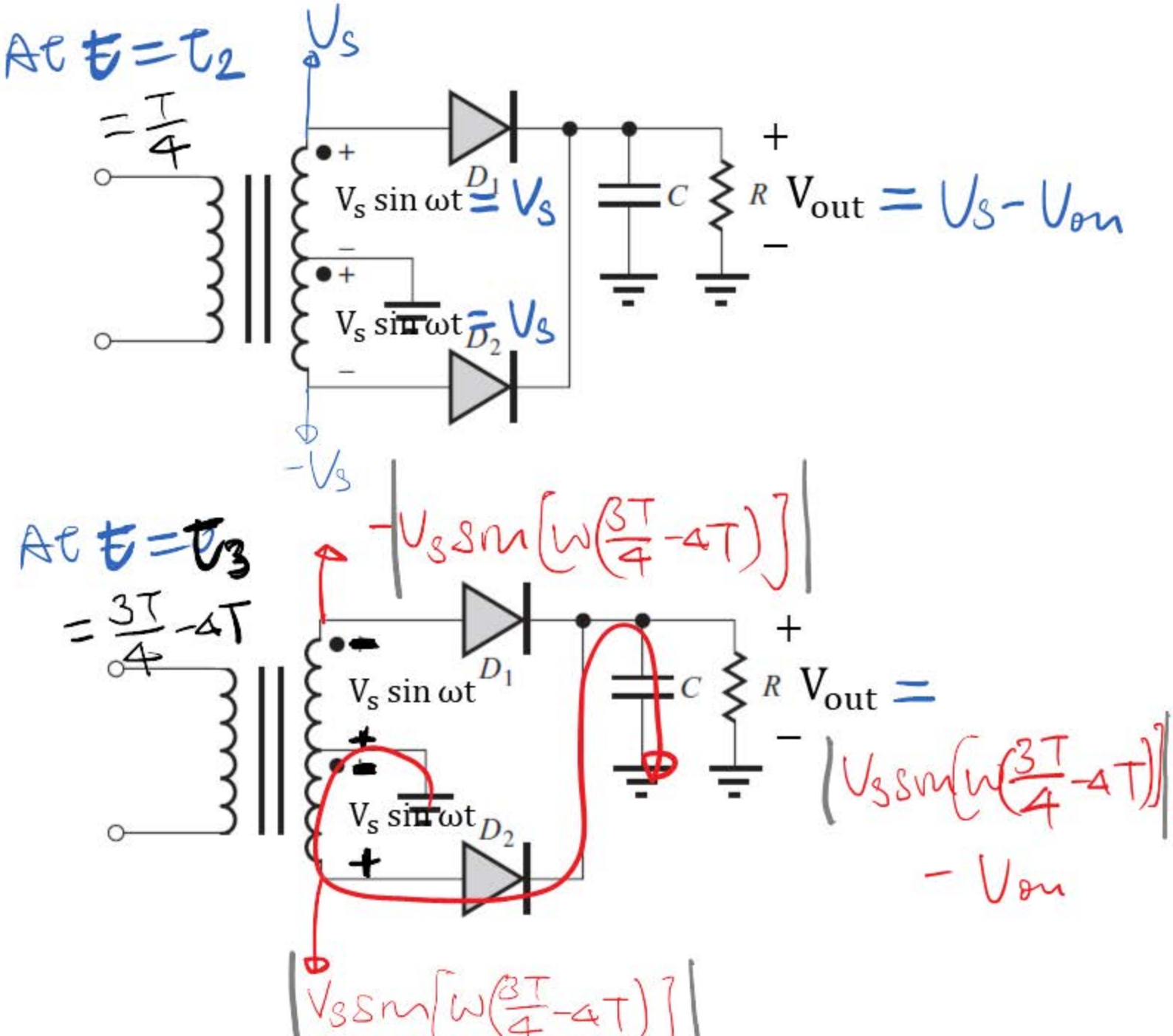
$$\cong \boxed{(V_s - V_{on})\left(\frac{T}{2RC}\right)} \quad if \Delta T \ll \frac{T}{2}$$

At $t = 0$

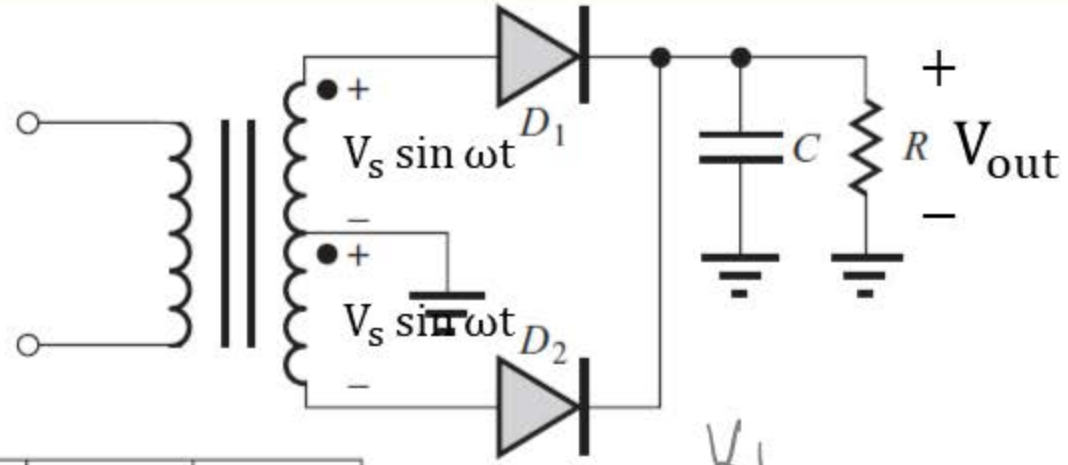

+
$V_s \sin \omega t$
D_1
$= 0$
–
+
$V_s \sin \omega t$
D_2
$= 0$
–
C
R
+
V_{out}
$= 0$
–

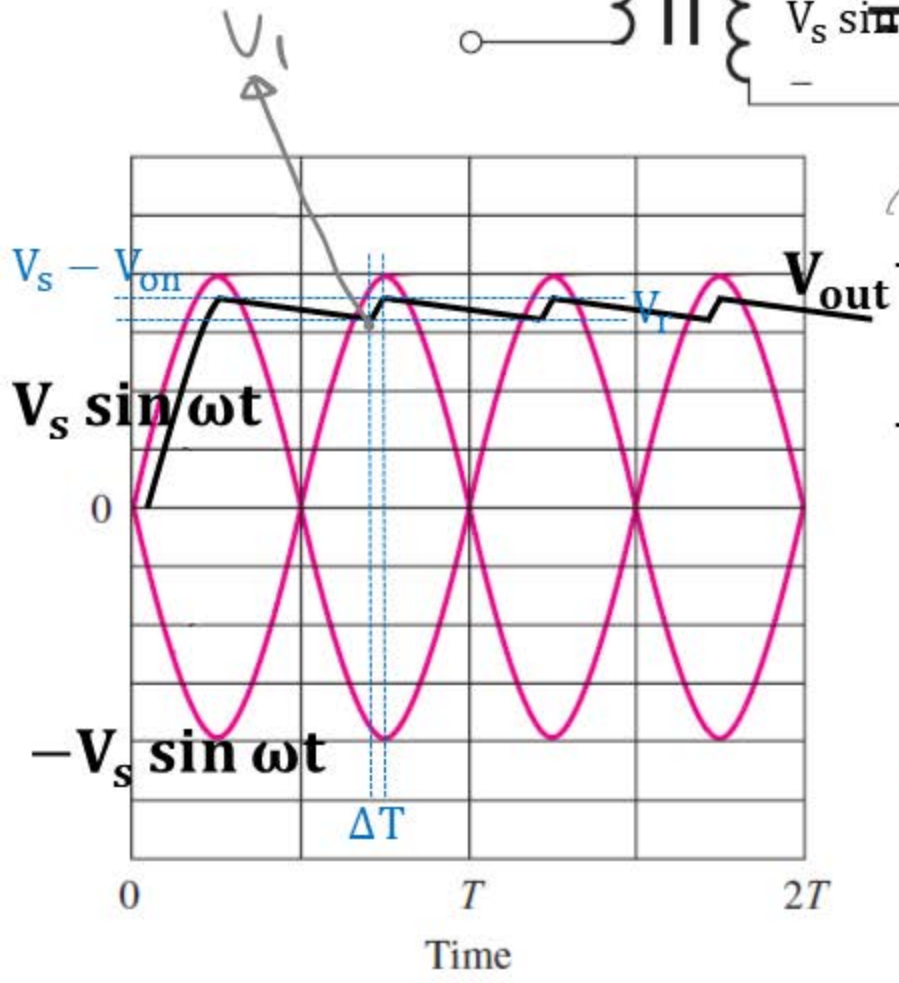
At $t = T_1$


V_{on}
+
$V_s \sin \omega t$
D_1
$= V_{on}$
–
+
$V_s \sin \omega t$
D_2
$= V_{on}$
–
$-V_{on}$
C
R
+
V_{out}
$= V_{on} - V_{on}$
–


At t = t2
= T/4
Vs
+
Vs sin ωt
−
+
Vs sin ωt
−
D1
D2
C
R
+
Vout
−
= Vs − Von
−Vs
At t = t3
= 3T/4 − 4T
−Vs sin[ω(3T/4 − 4T)]
D1
D2
C
R
+
Vout
−
= Vs sin[ω(3T/4 − 4T)]
− Von
Vs sin[ω(3T/4 − 4T)]

Full-Wave Rectifier (II)





$$-V_s \sin\left[\omega\left(\frac{3T}{4} - \Delta T\right)\right] - V_{on} = (V_s - V_{on}) - V_r$$

$$-V_s \sin\left(\frac{3\pi}{2} - \theta_c\right) - V_{on} = (V_s - V_{on}) - V_r$$

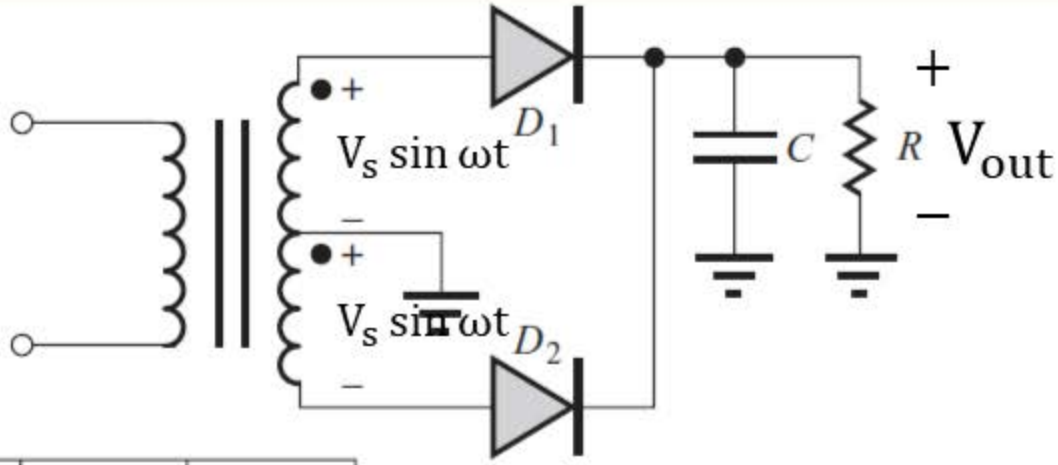
$$V_s \cos\theta_c = V_s - V_r$$

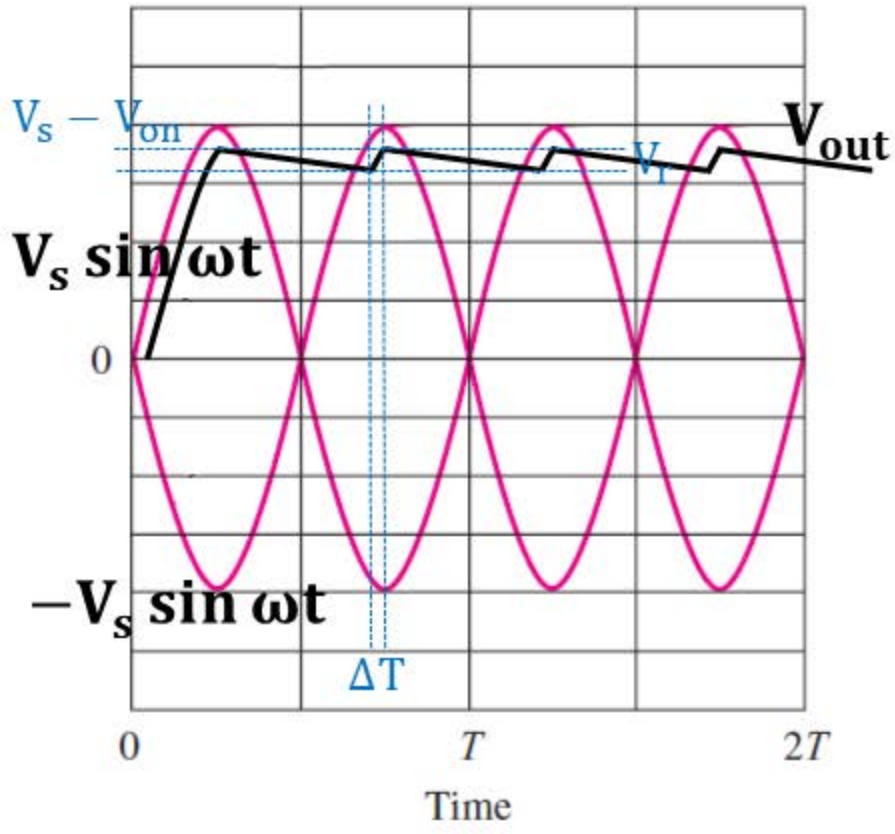
$$\cos\theta_c = \frac{V_s - V_r}{V_s} \cong 1 - \frac{{\theta_c}^2}{2} \quad \textit{if } \theta_c \textit{ very small}$$

$$\boldsymbol{\theta_c = \sqrt{\frac{2V_r}{V_s}}}$$

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

Full-Wave Rectifier (III)





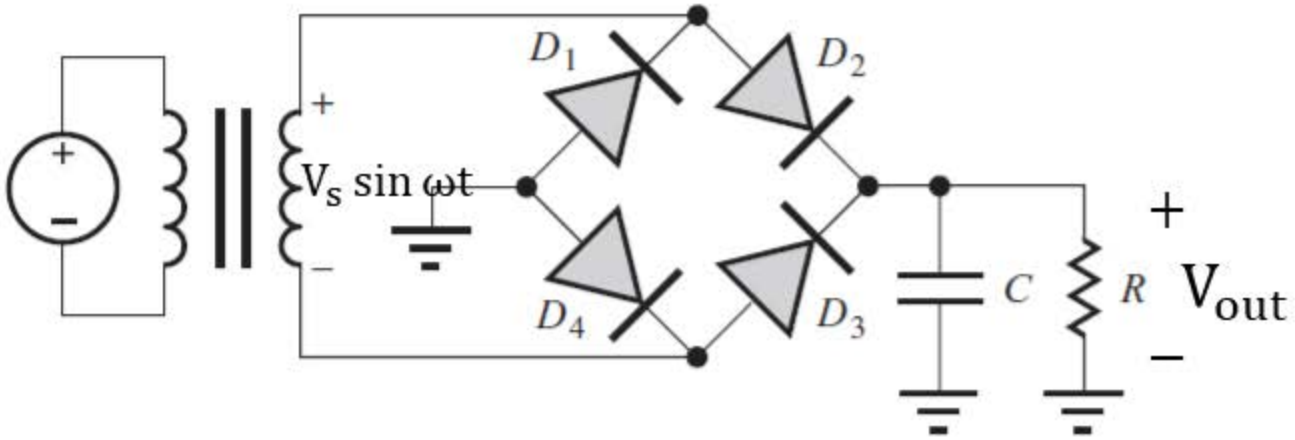
$$Q \cong \frac{I_{peak}\Delta T}{2} = I_{dc}\left(\frac{T}{2} - \Delta T\right) \cong I_{dc}\frac{T}{2}$$

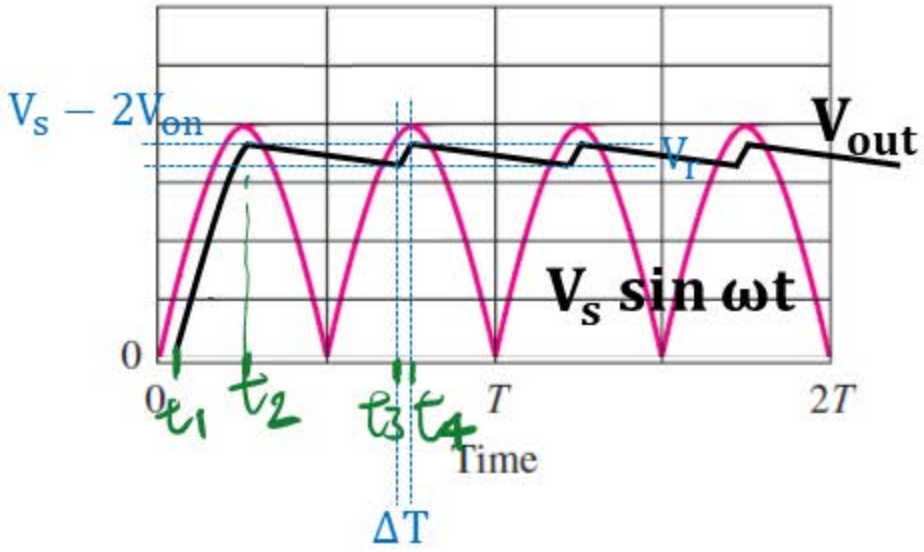
$$I_{peak} = \frac{I_{dc}T}{\Delta T}$$

$$I_{surge} = \omega C V_s$$

$$PIV = 2V_s - V_{on}$$

Full-Wave Bridge Rectifier (I)





$$V_{dc} = \mathbf{V_s - 2V_{on}}$$

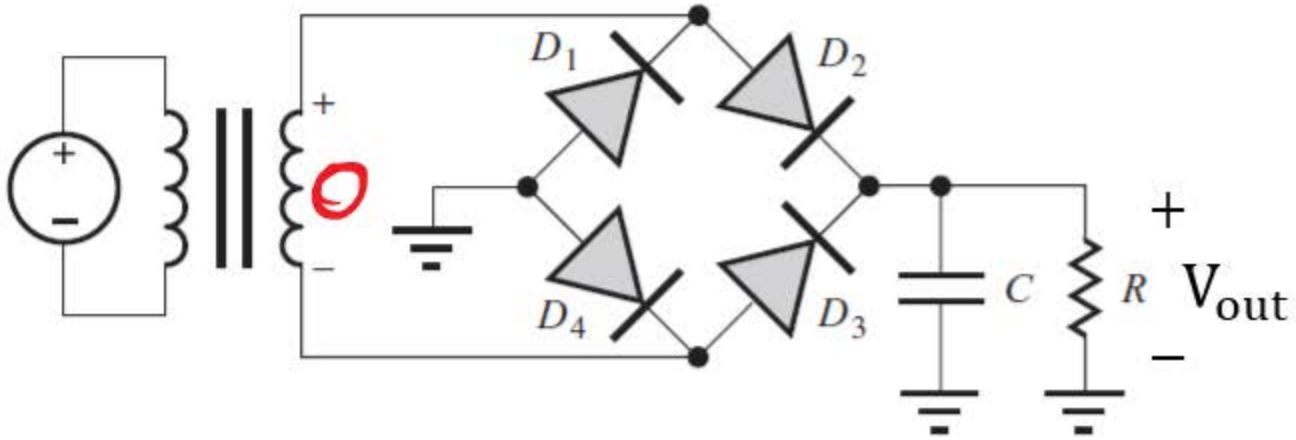
$$I_{dc} = \frac{V_{dc}}{R}$$

$$V_r = (V_s - 2V_{on})\left(1 - e^{-\frac{T/2 - \Delta T}{RC}}\right)$$

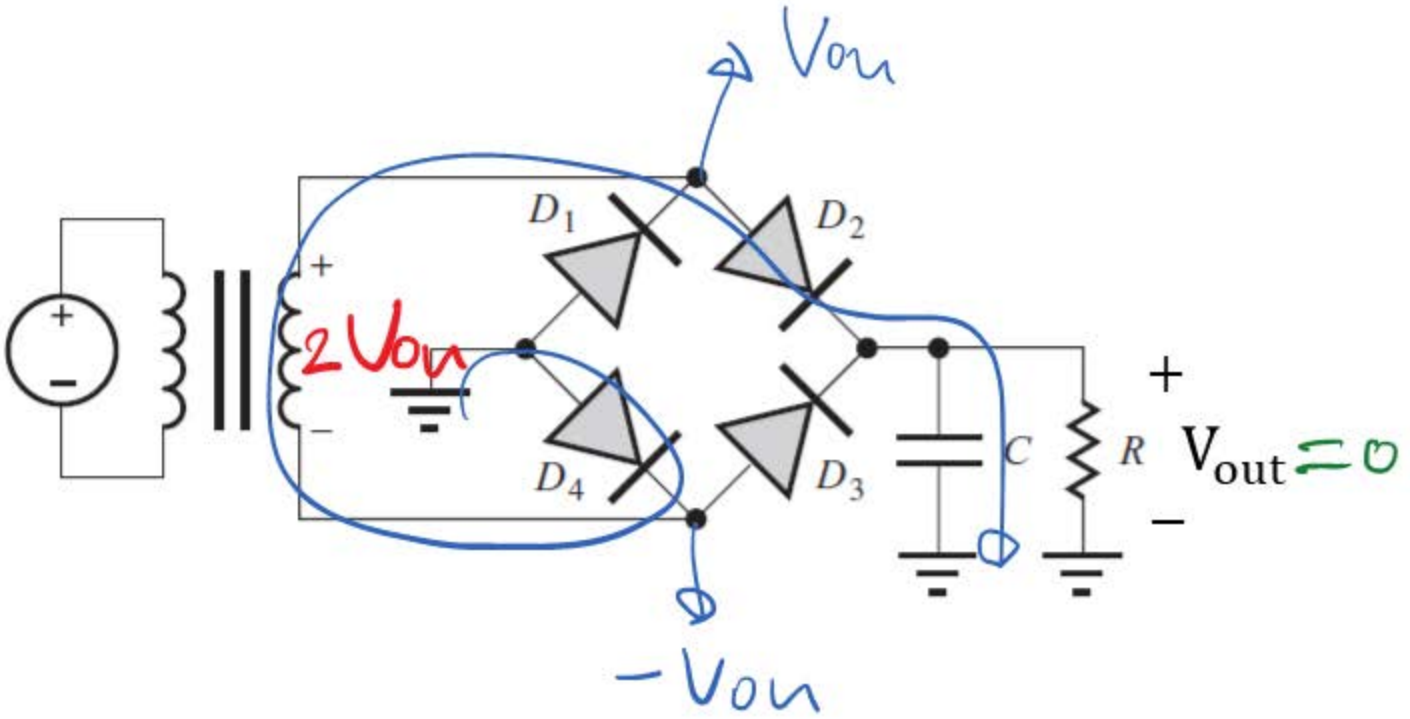
$$\cong (V_s - 2V_{on})\left(\frac{T/2 - \Delta T}{RC}\right) \; if \left(\frac{T}{2} - \Delta T\right) \ll RC$$

$$\cong \mathbf{(V_s - 2V_{on})\left(\frac{T}{2RC}\right)} \; if \; \Delta T \ll \frac{T}{2}$$

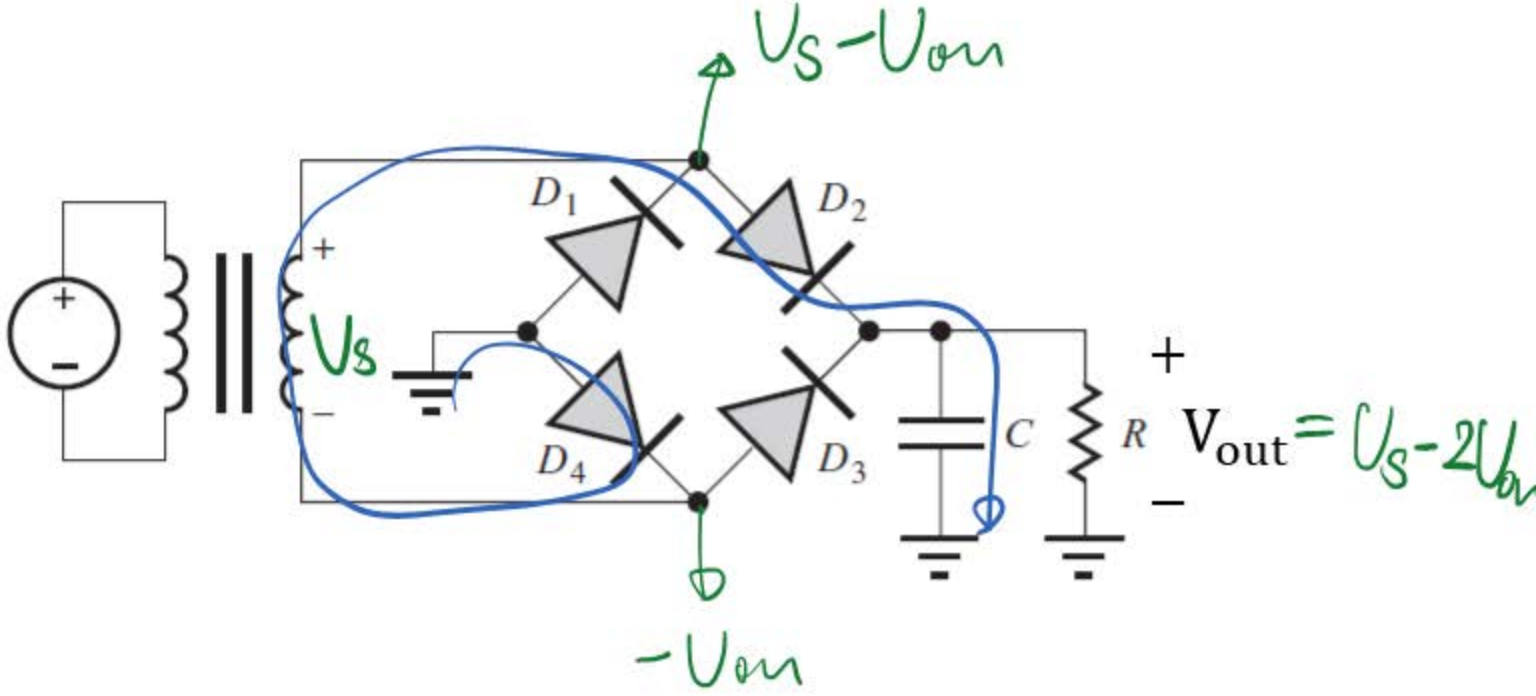
$t = 0$



$t = t_1$



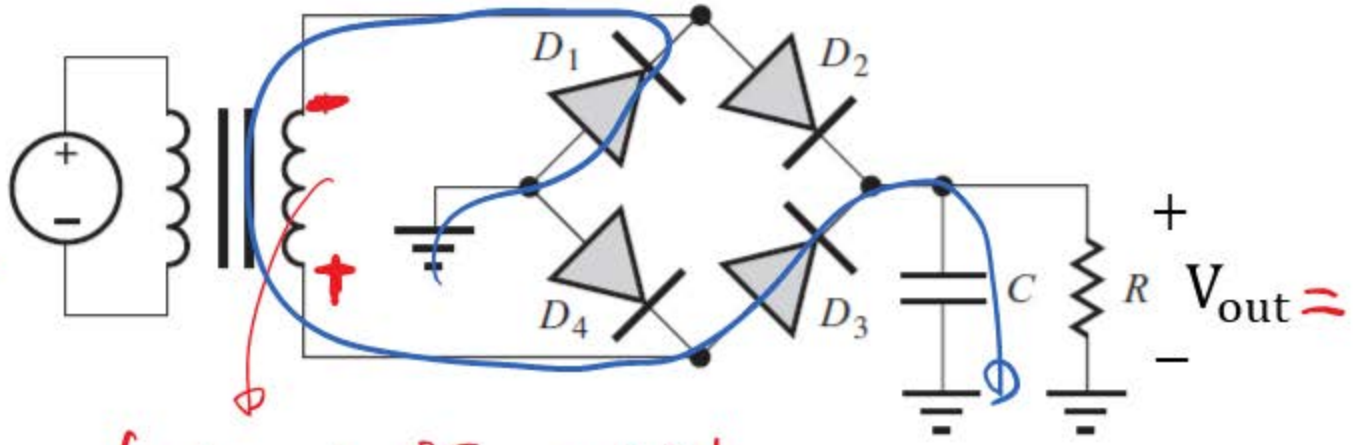
$t = t_2$



$V_{out} = V_S - 2V_{on}$

$t = t_3$

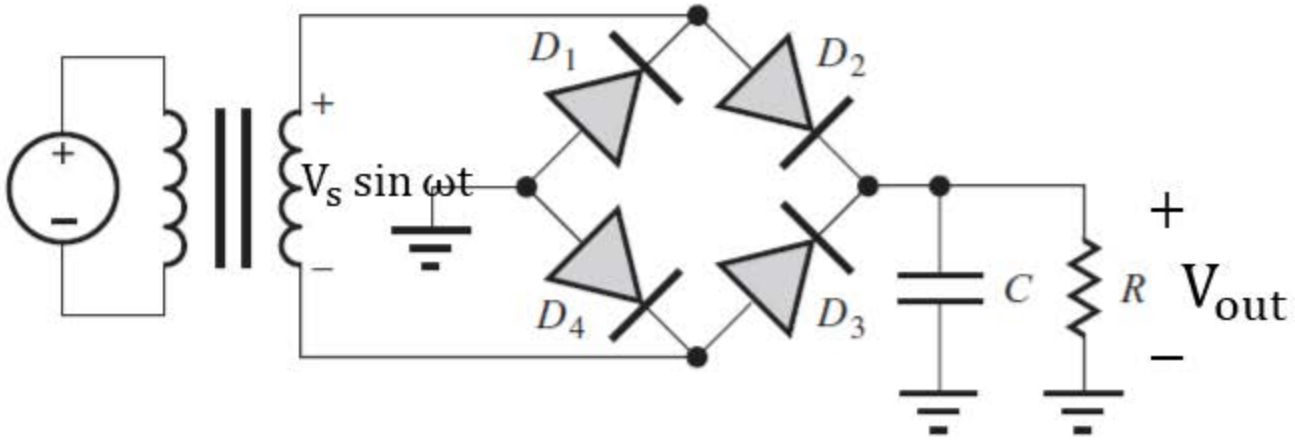
$= \frac{3T}{4} - 4T$

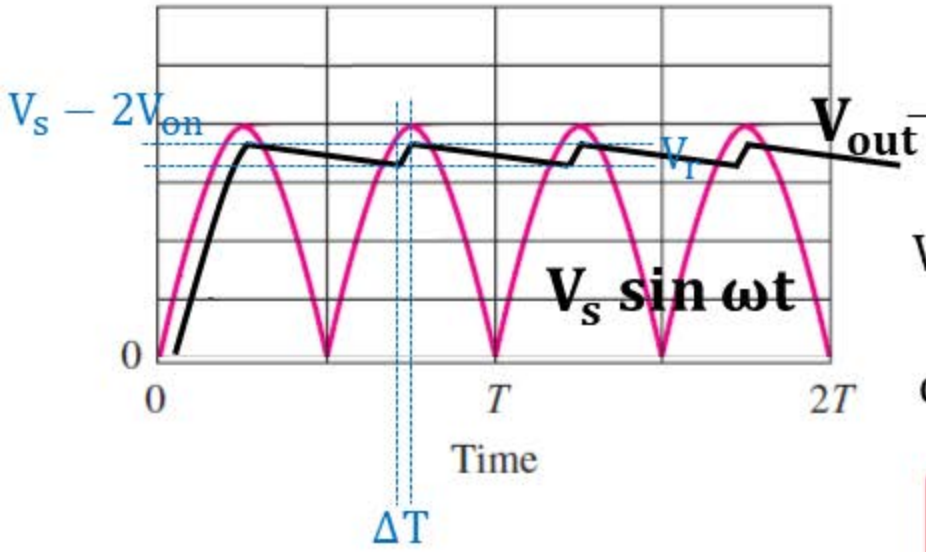


$V_{out} =$

$\left[V_{sm} \sin\left(\omega\left(\frac{3T}{4} - 4T\right)\right)\right]$

Full-Wave Bridge Rectifier (II)





$$-V_s \sin\left[\omega\left(\frac{3T}{4} - \Delta T\right)\right] - 2V_{on} = (V_s - 2V_{on}) - V_r$$

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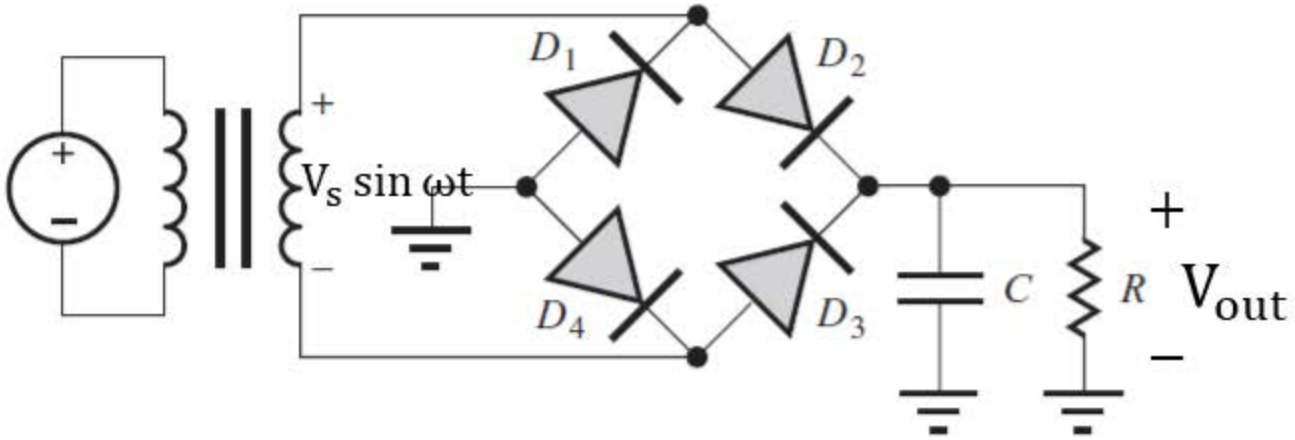
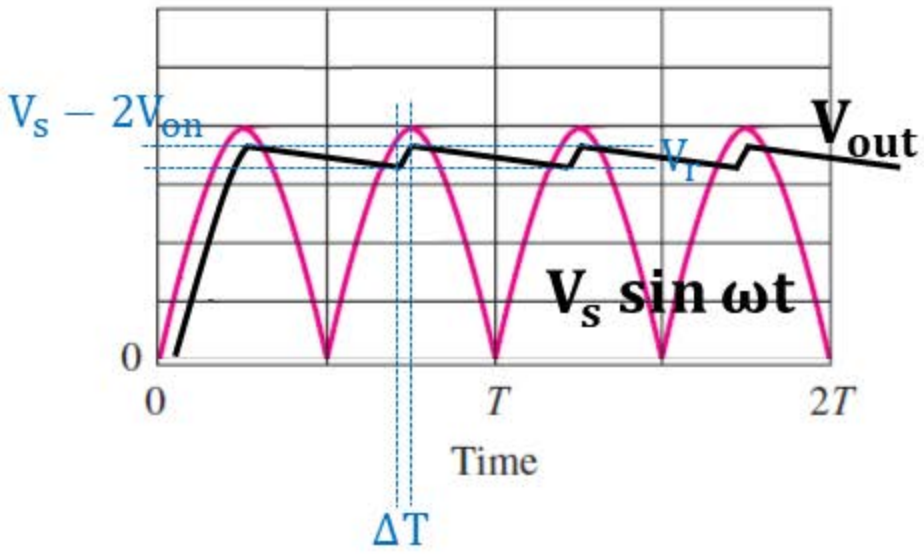
$$\boldsymbol{\theta_c = \sqrt{\frac{2V_r}{V_s}}}$$

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

Full-Wave Bridge Rectifier (III)





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

$$I_{peak} = \frac{I_{dc}T}{\Delta T}$$

$$I_{surge} = \omega C V_s$$

$$PIV = V_s - V_{on}$$

Example

Design a full-wave bridge rectifier to provide a dc output voltage 15 V with no more than 1 percent ripple at a load current of 2A. ($V_{on} = 1\ V, T = 1/60\ \ sec$)

$V_{dc} = 15\ (V)$

$V_r < 0.15\ (V)$

$I_{dc} = 2\ (A)$

Load resistance $= 15/2 = 7.5\ (\Omega)$

The required transformer voltage $V_s = 15 + 2 = \mathbf{17\ (V)}$ **or** $\mathbf{\frac{17}{\sqrt{2}}\ (V_{rms})}$

$$V_r \cong (V_s - 2V_{on})\left(\frac{T}{2RC}\right) = 15\left(\frac{1}{2 \times 60 \times 7.5 \times C}\right) = 0.15 \Rightarrow \mathbf{C = 0.111\ (F)}$$

$$\Delta T = \frac{1}{\omega}\sqrt{\frac{2V_r}{V_s}} = \frac{1}{2\pi \times 60}\sqrt{\frac{2 \times 0.15}{17}} = \mathbf{0.352 \times 10^{-3}\ (sec)}$$

$$I_{peak} = \frac{I_{dc}T}{\Delta T} = \frac{2 \times \frac{1}{60}}{0.352 \times 10^{-3}} = \mathbf{94.7\ (A)}$$

$$I_{surge} = \omega C V_s = 2\pi \times 60 \times 0.111 \times 17 = \mathbf{711\ (A)}$$

Make sure the diodes can handle these large currents

Example

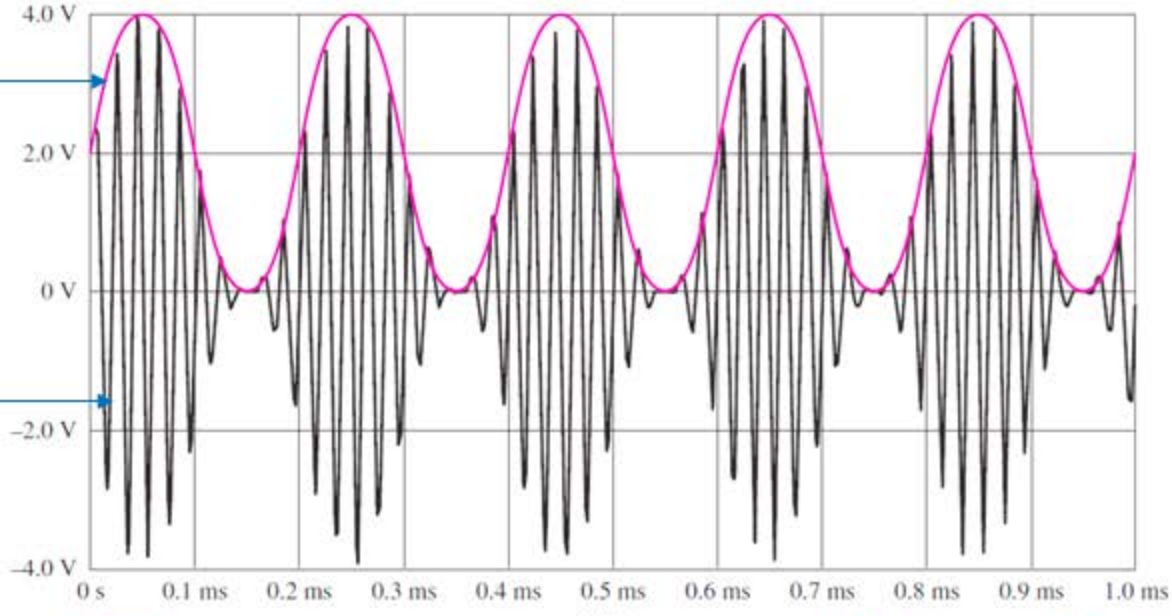
An amplitude modulated (AM) signal is shown below. The envelope of the AM signal contains the information being transmitted, and the envelope can be recovered using a single half-wave rectifier.

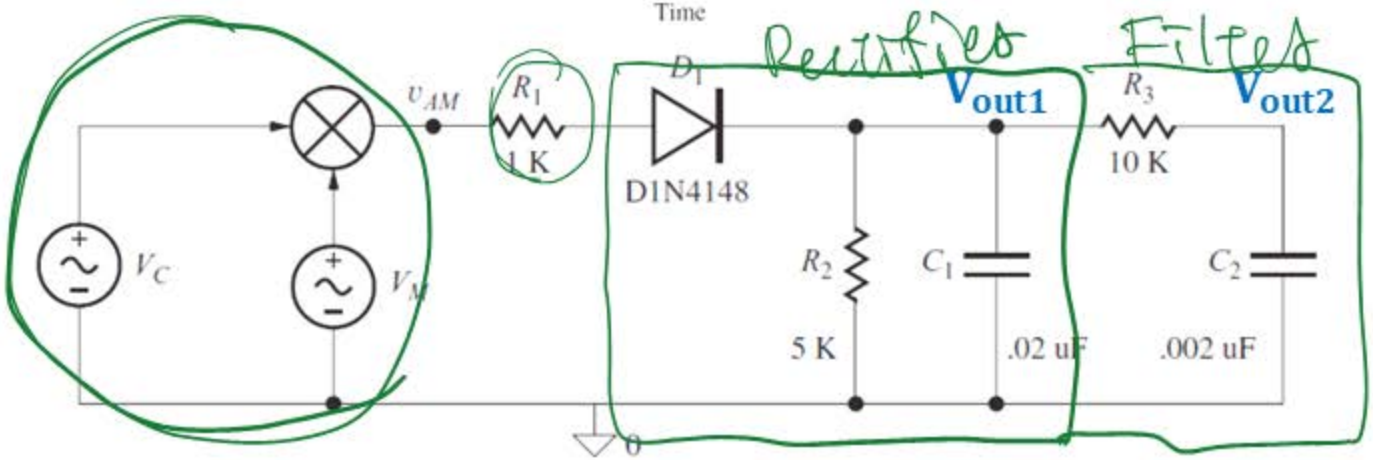
$2[1 + \sin(\omega_M t)]$

AM Signal

$2\sin(\omega_c t)[1 + \sin(\omega_M t)]$

carrier





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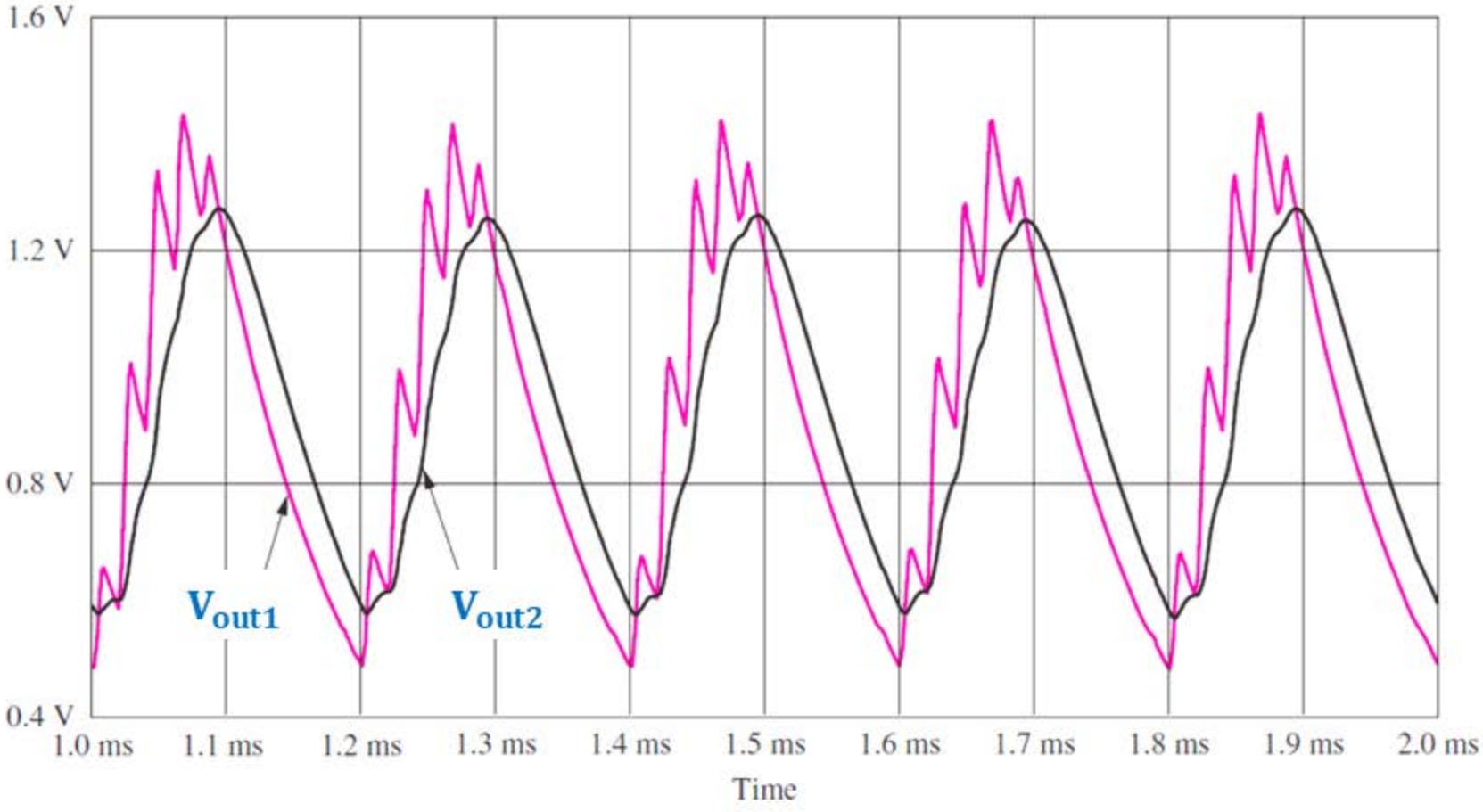

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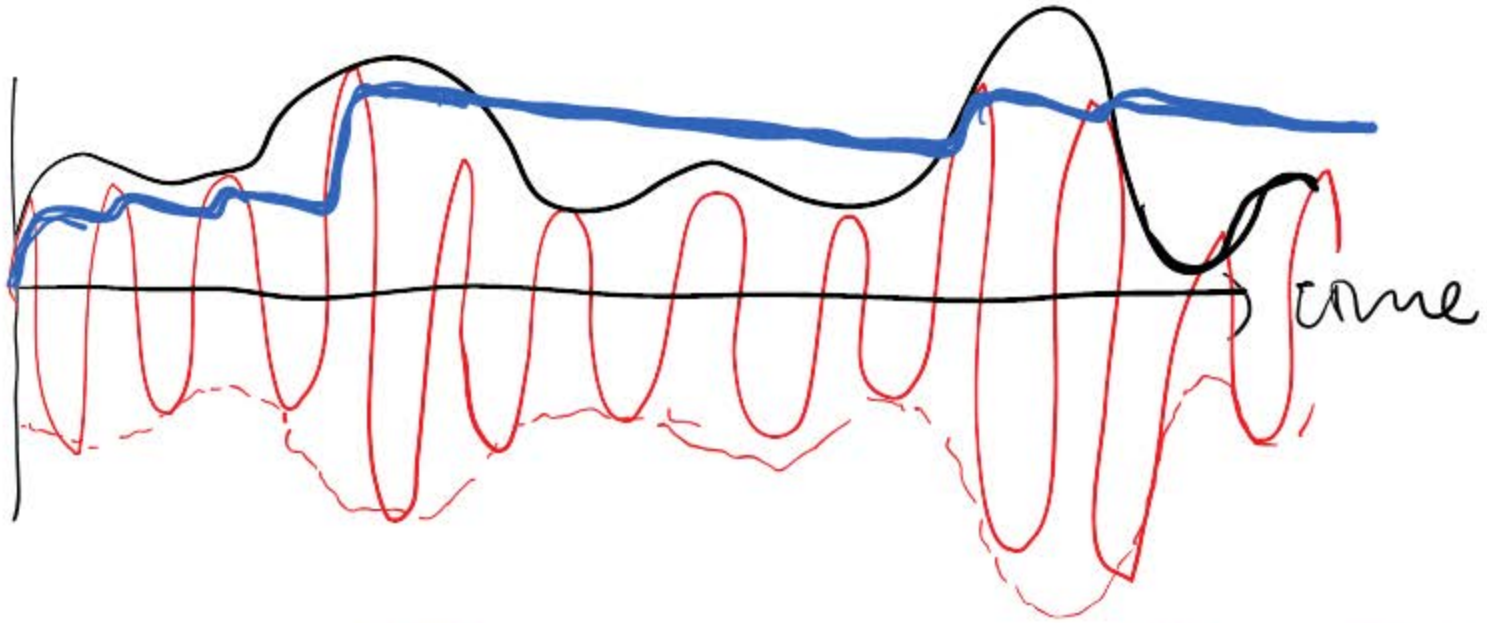

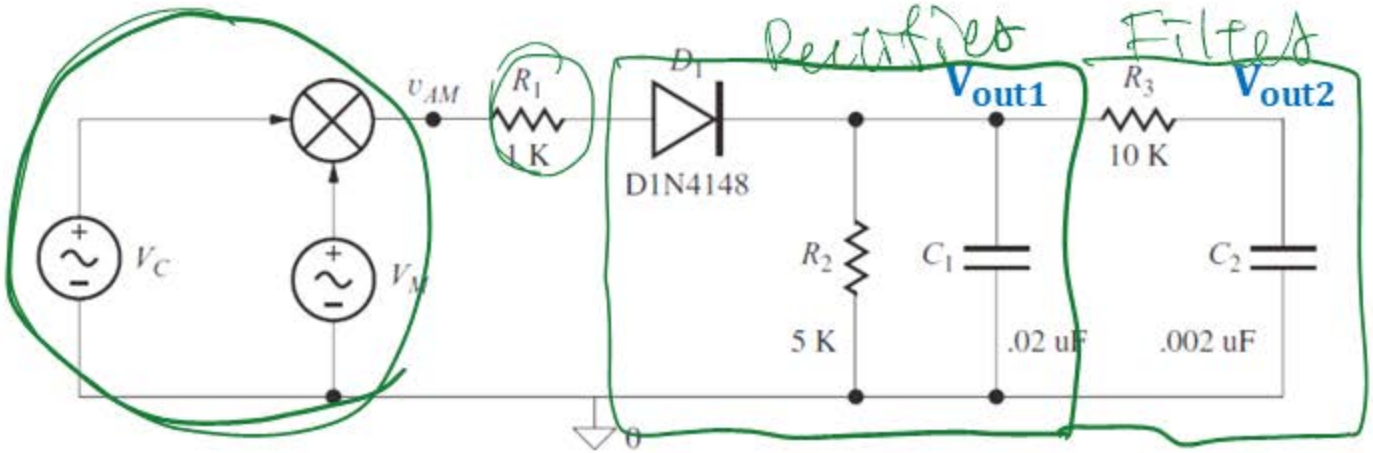

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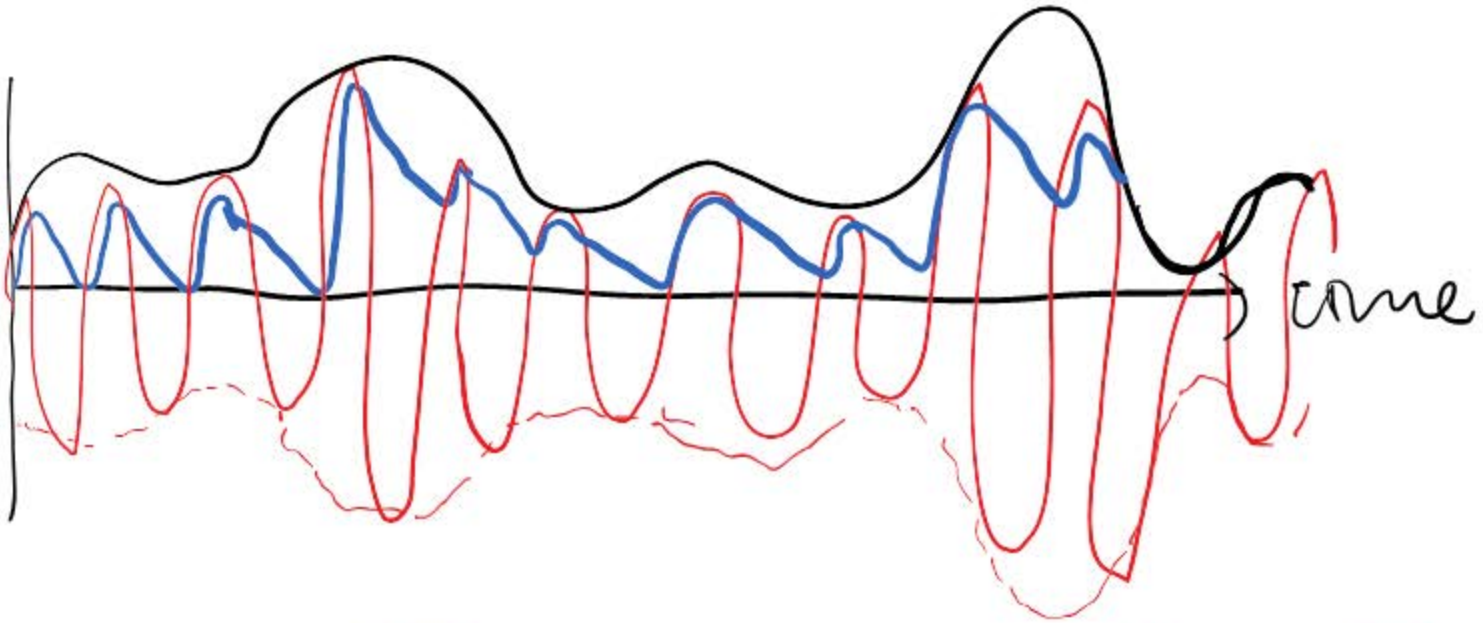

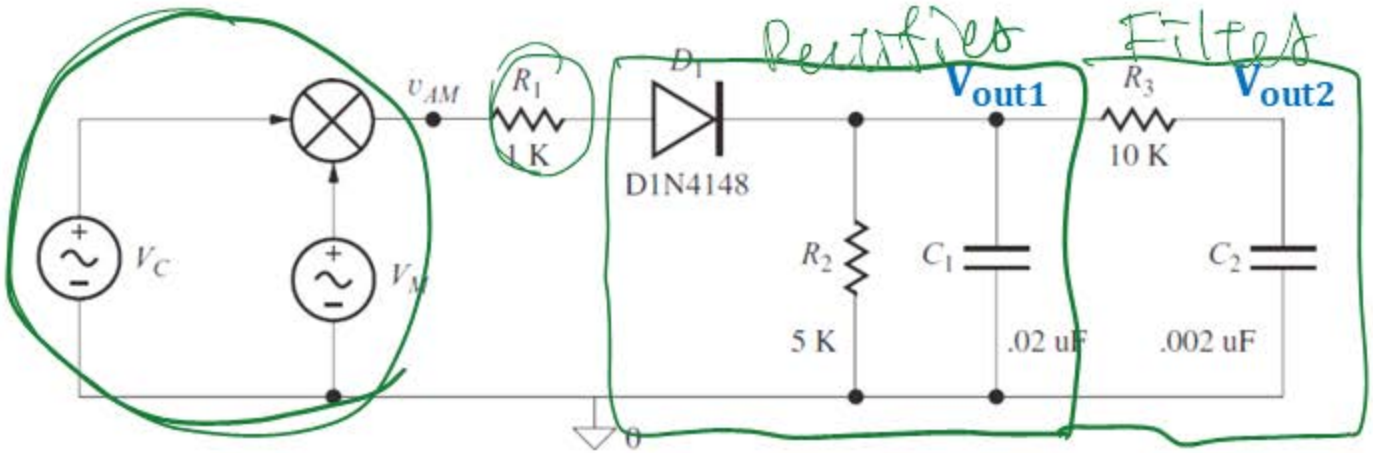

Example

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