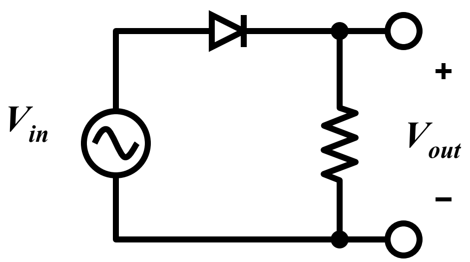
Half-Wave Rectifier



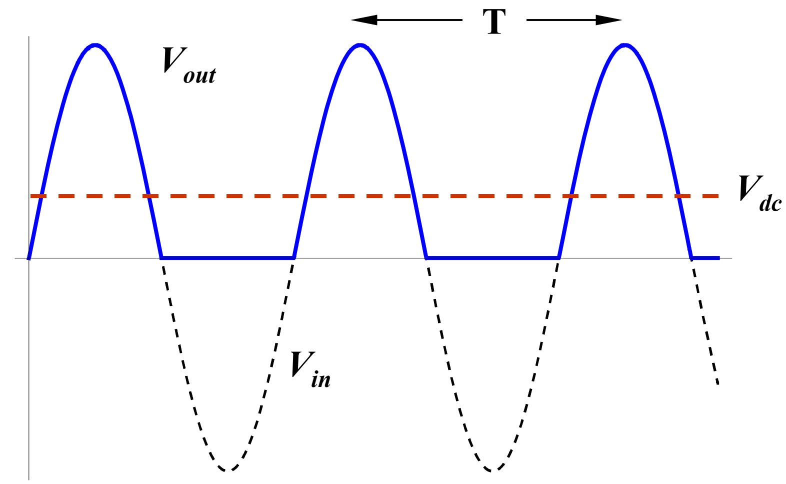
Diode conducts only for positive input voltages. An AC input with zero average yields a non-sinusoidal output with a non-zero DC component. The conversion of AC to DC is called rectification.

The "conduction angle" θ_c is that part of the cycle during which the diode is conducting.

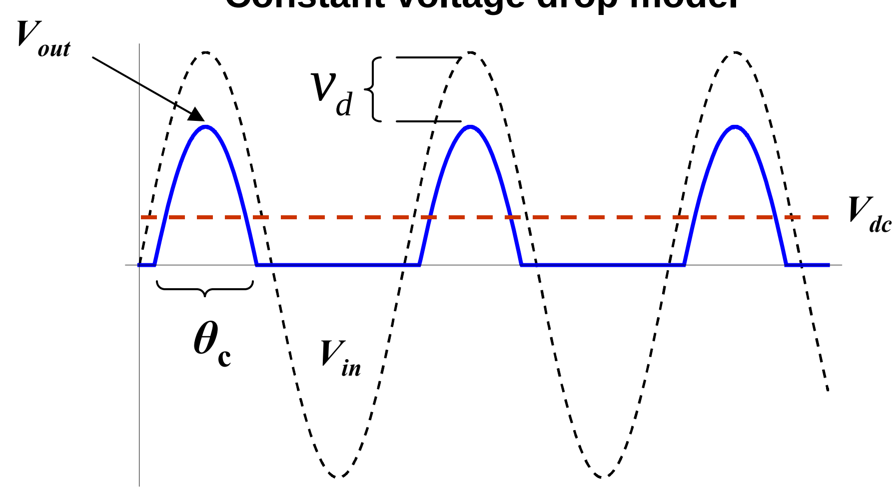
The average DC component is given by

$$V_{dc} = \frac{1}{T}\int_0^T V(t)\,dt$$

Ideal diode model



Constant voltage drop model



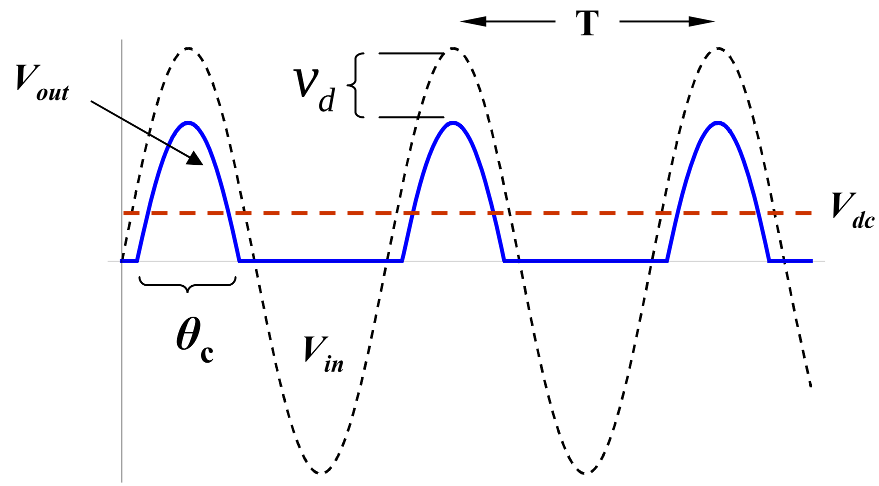
Back to TOC

Half-Wave Rectifier

Assume constant voltage drop model

$$V_{in}(t) = V_m \sin \omega t$$

$$V_{out}(t) = \begin{cases} V_{in}(t) - v_d & V_{in} > v_d \\ 0 & \text{otherwise} \end{cases}$$



Conduction Angle

$$\omega t_{on} = \sin^{-1}\left(\frac{v_d}{V_m}\right) \qquad \omega t_{off} = \pi - \sin^{-1}\left(\frac{v_d}{V_m}\right)$$

$$\boxed{\theta_c = \omega(t_{off} - t_{on}) = \pi - 2\sin^{-1}\left(\frac{v_d}{V_m}\right)}$$

$$\theta_c \approx \pi - \frac{2v_d}{V_m} \quad \text{for} \quad v_d \ll V_m$$

Ideal rectifier:

$$v_d = 0$$

$$\theta_c \approx \pi$$

$$V_{dc} = \frac{V_m}{\pi} = 0.318 V_m$$

Average DC Value

$$V_{dc} = \frac{1}{T}\int_0^T V_{out}(t)\,dt = \frac{1}{T}\int_{t_{on}}^{t_{off}} \left(V_m \sin \omega t - v_d\right) dt$$

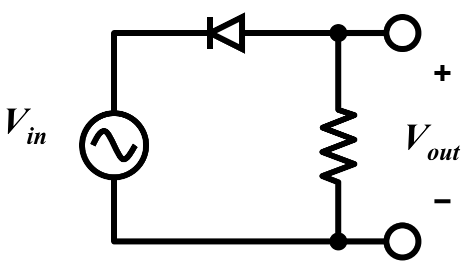
$$\boxed{= \frac{V_m}{\pi}\left[\sqrt{1 - \frac{v_d^2}{V_m^2}} - \frac{\theta_c}{2}\frac{v_d}{V_m}\right]}$$

$$V_{dc} \approx \frac{V_m}{\pi}\left[1 - \frac{\pi}{2}\frac{v_d}{V_m} + \frac{v_d^2}{2V_m^2}\right] \quad \text{for} \quad v_d \ll V_m$$

Back to TOC

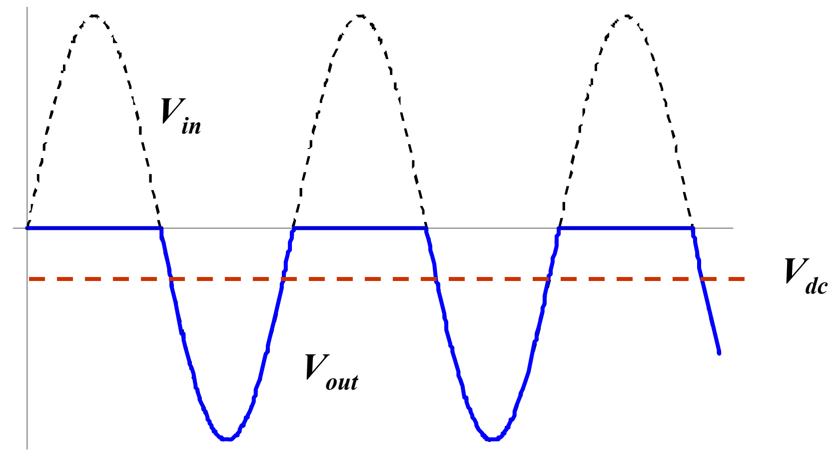
Half-Wave Rectifier

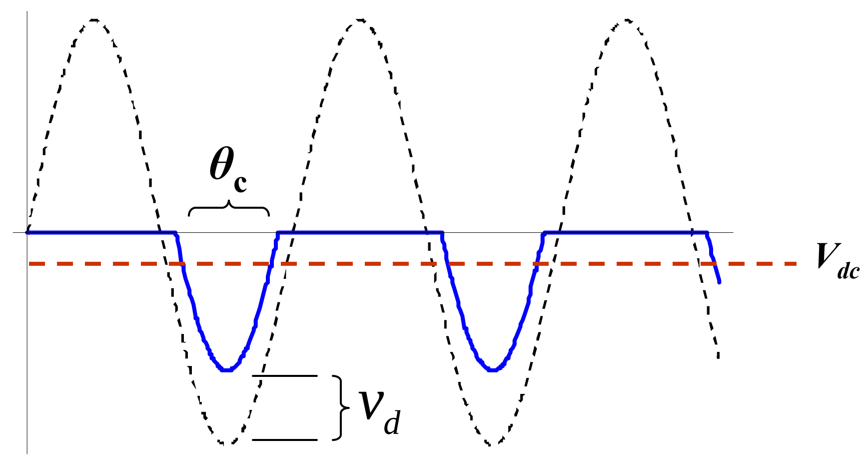
Suppose we reverse the diode: now only the negative portion of the input signal passes through



Other than the poarity reversal, all math on conduction angle and DC magnitude is identical

Ideal diode model

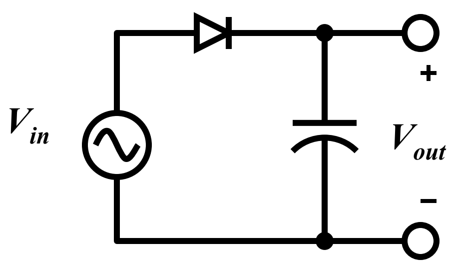


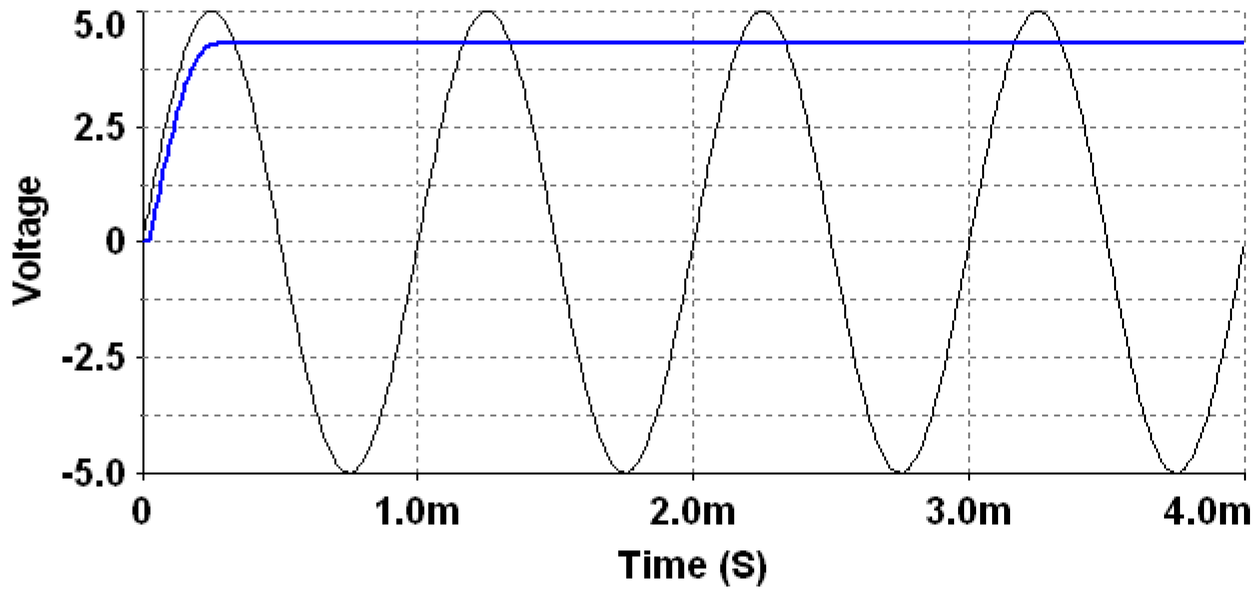


Constant voltage drop model

Back to TOC

Peak Detector

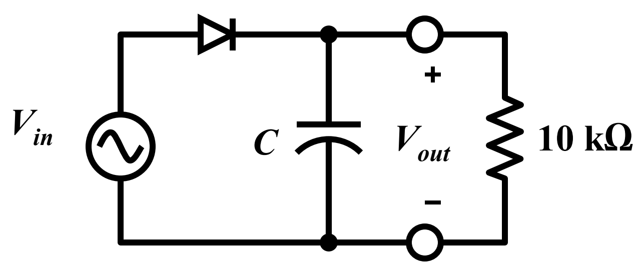




Back to TOC

Peak-Detector with Load

Any load or leakage path will discharge the capacitor. In this case, the output will depend on how the RC time constant compares with the period of the input signal.

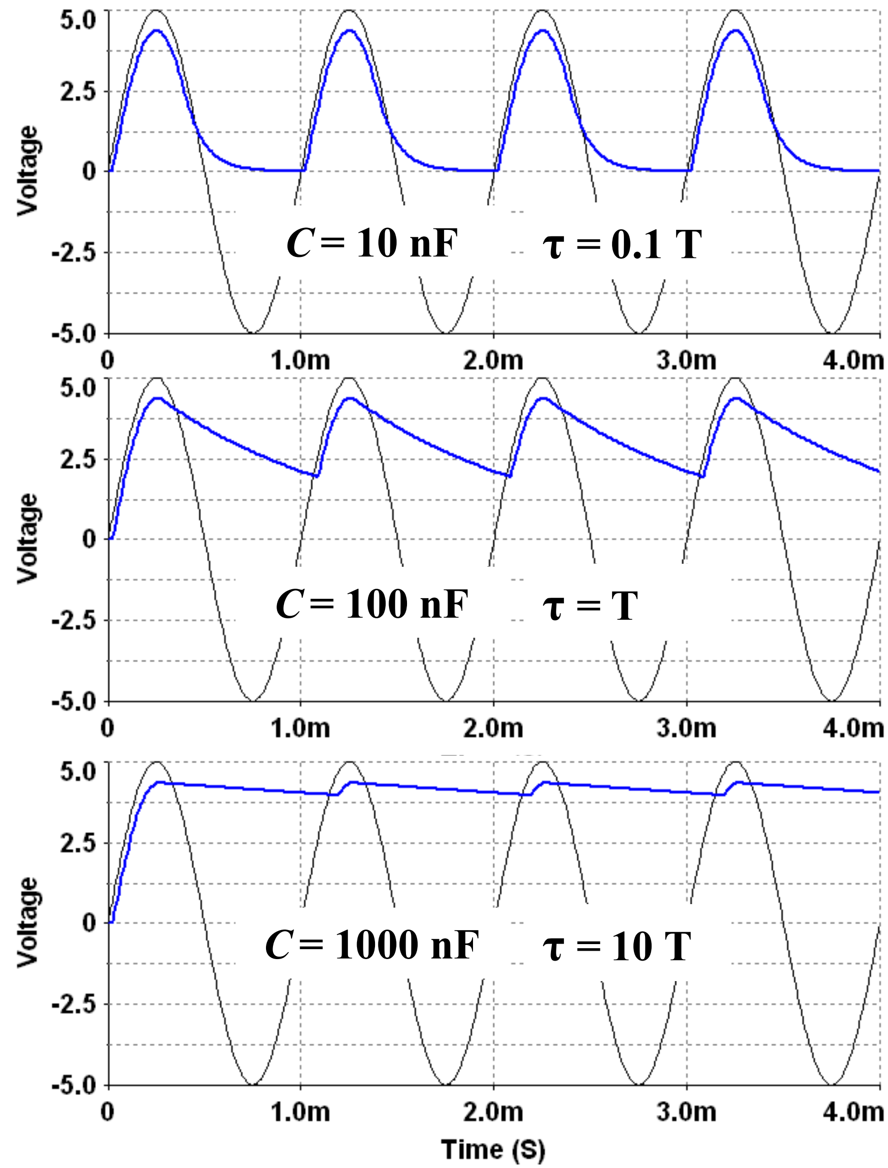


The plots at right consider the various cases for the simple circuit above with a 1kHz, 5V sinusoidal input

$\tau = RC$ $\qquad$ $\mathrm{T} = 1\ \mathrm{mS}$

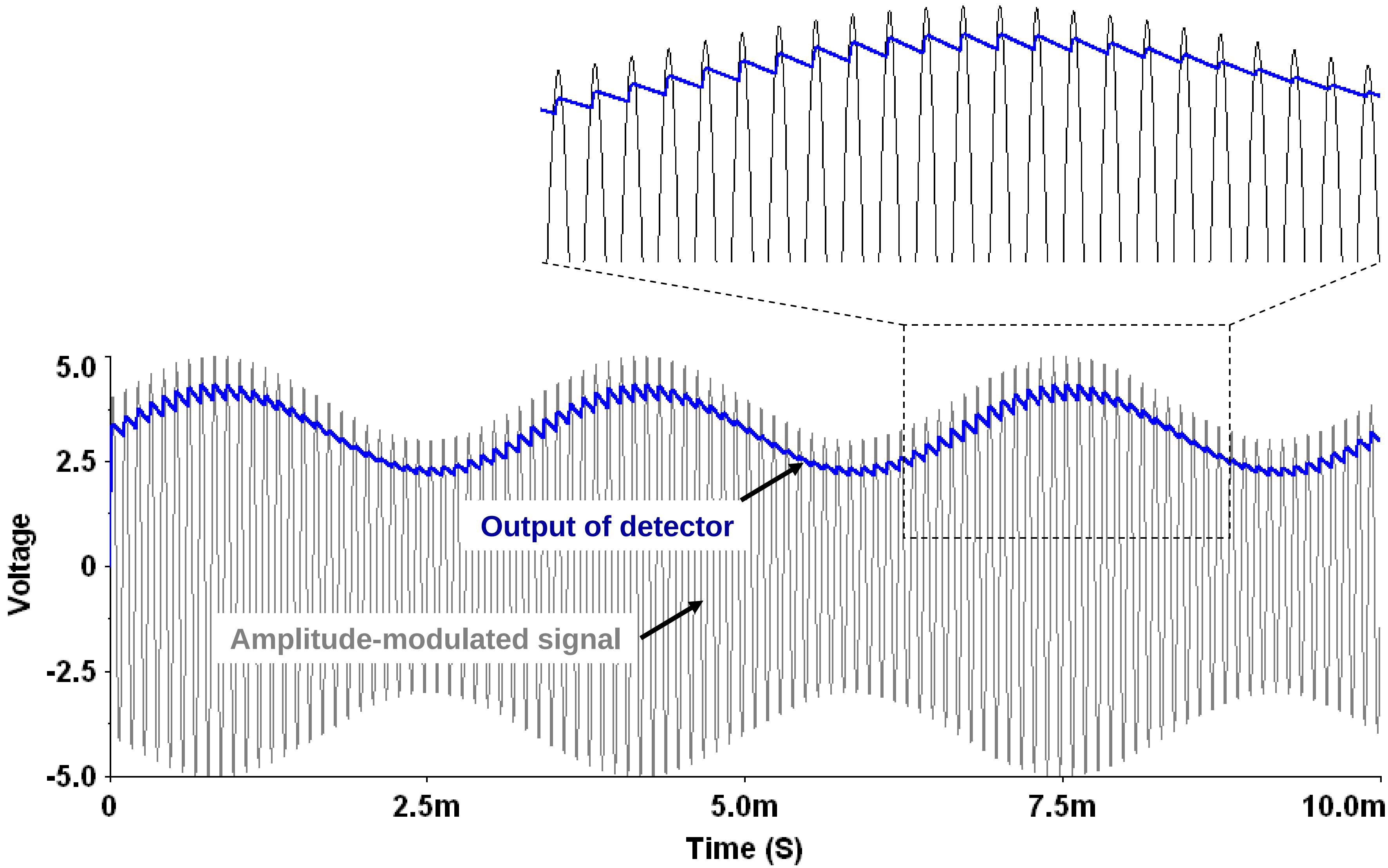
For $\tau \ll \mathrm{T}$**, circuit acts like an ideal rectifier**

For $\tau \gg \mathrm{T}$**, circuit acts like an ideal peak detector**



Back to TOC

Peak-Detector as an AM Demodulator



Back to TOC