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” $\theta_c$ is that part of the cycle during which the diode is conducting.

The average DC component is given by

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

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

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

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

Average DC Value

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

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

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

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

Ideal diode model

Constant voltage drop model

Other than the polarity reversal, all math on conduction angle and DC magnitude is identical.
Peak Detector

\[ V_{in} \quad + \quad \rightarrow \quad \neg \quad V_{out} \quad - \]

\[
\begin{array}{c}
\text{Voltage} \\
\hline
-5.0 & 0 & 2.5 & 5.0 \\
\hline
0 & 1.0m & 2.0m & 3.0m & 4.0m \\
\end{array}
\]
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.

\[ \tau = RC \]
\[ T = 1 \text{ mS} \]

For \( \tau \ll T \), circuit acts like an ideal rectifier
For \( \tau \gg T \), circuit acts like an ideal peak detector

\[ \tau = R C \]
\[ T = 1 \text{ mS} \]
Peak-Detector as an AM Demodulator

Amplitude-modulated signal

Output of detector

Time (S)

Voltage

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