**AC Voltage Characterization**

\[ v(t) \]

\[ \text{Period } T = \frac{1}{f} \]

- **Peak voltage** \( V_p \): \[ V_p = \max_t \left| v(t) \right| \]
- **Peak-to-peak voltage** \( V_{pp} \): \[ V_{pp} = \max_t v(t) - \min_t v(t) \]
- **Average voltage** \( V_{avg} \): \[ V_{avg} = \frac{1}{T} \int_0^T v(t) \, dt \]
- **Root-mean-square voltage** \( V_{rms} \): \[ V_{rms} = \sqrt{\frac{1}{T} \int_0^T \left| v(t) \right|^2 \, dt} \]

For \( v(t) = A \sin 2\pi ft \) \[ V_{rms} = \frac{A}{\sqrt{2}} = 0.707 A \]

Transformer voltages are usually given in \( V_{rms} \).
**Half-wave Rectifier**

\[ v_s(t) = A \sin 2\pi f t \]

\[ V_p = V_{pp} = A \]

\[ V_{avg} = \frac{A}{\pi} = 0.318 A \]

\[ V_{rms} = \frac{A}{\sqrt{2}} = 0.5 A \]

**Note:** \( V_{pp} \) is also called **ripple voltage** \( V_{ripple} \)
Reducing Ripple in $v(t)$

$V_s(t) = A \sin 2\pi ft$

 Capacitor stores energy during negative cycle of $V_s(t)$

Capacitor charges during $\frac{1}{4f}$ sec
Capacitor discharges during $\frac{3}{4f}$ sec

$V_{pp} = V_{ripple} = (1 - e^{-3/4fR_LC})A = \frac{3A}{4fR_LC}$

If $V_{pp} \ll V_p = A$

$\min_t v(t) = V_p - V_{pp} = e^{-3/4fR_LC} \cdot A = (1 - \frac{3}{4fR_LC})A$

For a linear regulator this must be larger than the desired output voltage plus the minimum voltage drop across the regulator.
Full Wave Rectifiers

\[ v_s(t) = A \sin(2\pi f t) \]

\[ v(t) = |A \sin(2\pi f t)| \]

\[ V_p = V_{pp} = V_{ripple} = A \]

\[ V_{avg} = \frac{2A}{\pi} = 0.637 A \]

\[ V_{rms} = \frac{A}{\sqrt{2}} = 0.707 A \]
Reducing ripple in \( v(t) \)

Capacitor discharge during \( \approx \frac{3}{8f} \) sec

Capacitor charges during \( \approx \frac{1}{8f} \) sec

\[ V_{pp} = V_{ripple} = (1 - e^{-\frac{3}{8fRCL}})A \approx \frac{3A}{8fRCL} \]

If \( V_{pp} \ll V_p = A \)

\[ \min v(t) = V_p - V_{pp} = e^{-\frac{3}{8fRCL}}A = (1 - \frac{3}{8fRCL})A \]