

the source keeps flipping, and every element answers it differently

AC source

$$v = v_0 \sin \omega t$$

voltage reverses every half cycle

→ measured by

Instantaneous value

$$i = i_0 \sin(\omega t - \phi)$$

current, generally out of step with voltage by phase ϕ

→ measured by

RMS value

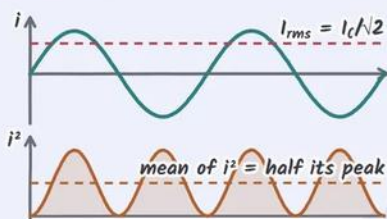
$$i_{\text{rms}} = \frac{i_0}{\sqrt{2}}$$

the steady DC that delivers the same average power

$\phi = 0$ only for a pure resistor: everywhere else, L and C shift current out of step with voltage

Mean and RMS, said precisely *

- average of $\sin \omega t$ over a full cycle is **zero**, positive and negative halves cancel exactly
- RMS squares first (always positive), averages that, then square-roots: $v_{\text{rms}} = \frac{v_0}{\sqrt{2}}$, $i_{\text{rms}} = \frac{i_0}{\sqrt{2}}$
- power and heating always use RMS values: the whole reason RMS exists



i^2 averages to half its peak: the steady current with the same heat is $I_0/\sqrt{2}$

which reactance is bigger, X_L or X_C , at this frequency?

$$X_L > X_C$$

circuit is inductive

current lags voltage, net reactance is positive

$$X_L = X_C$$

resonance

reactances cancel, circuit behaves as pure R , current peaks

$$X_L < X_C$$

circuit is capacitive

current leads voltage, net reactance is negative

only R ever dissipates power; L and C just trade energy back and forth with the source each cycle

AC through R , L , C alone

Resistor

- current **in phase** with voltage, $\phi = 0$
- opposition is R , the same value at any frequency

Inductor

- current **lags** voltage by 90°
- reactance $X_L = \omega L$, grows with frequency

Capacitor

- current **leads** voltage by 90°
- reactance $X_C = \frac{1}{\omega C}$, shrinks with frequency

remember it as CIVIL: in a Capacitor, I leads V ; in an inductor L , V leads I