Transformer

\[ V_1 = N_1 E \]
\[ V_2 = N_2 E \]
\[ E_1 = E_2 \]

Iron core gives perfect coupling

Overhead viewer for outlets

Same \( B \) through both \( \Rightarrow V_2 = \frac{N_2}{N_1} V_1 \)

- \( \frac{N_2}{N_1} > 1 \) "step-up transformer" \( V_2 > V_1 \)
- \( \frac{N_2}{N_1} < 1 \) "step-down transformer" \( V_2 < V_1 \)
- \( \frac{N_2}{N_1} = 1 \) "isolation transformer" \( V_2 = V_1 \)

LC circuit aka "tank circuit"

\[ V = \frac{Q}{C} \]

(1) charge cap with switch open

(2) close switch

Kirehoff:

\[ \frac{Q}{C} - L \frac{dI}{dt} = 0 \]

\[ I = -\frac{dQ}{dt} \]

\[ \frac{Q}{C} + L \frac{d^2Q}{dt^2} = 0 \]

Spring equation: simple harmonic oscillator

\[ \omega^2 = \frac{1}{LC} \]

Energy transfers from \( E \) to \( B \) and back.

- Frequency
- Oscillatory
AC circuits = main application of inductors since they only matter then $I \neq 0$

**AC Voltage Source**

Typ: $V(t) = V_{\text{max}} \sin \omega t = V_{\text{max}}$  

**Symbol**

$120 \text{ V, 60 Hz}$

Well say voltage source is $\sin \omega t$ and then trace phase delays with respect to that.

**Resistors**

$I = \frac{V}{R}$ so we phase shift: $V_{\text{max}} \sin \omega t$

$V(t) = V_{\text{max}} \sin \omega t$

$I(t) = \frac{V_{\text{max}}}{R} \sin \omega t$

Current has same phase $\omega t$ as voltage.

**Phasor Diagram** - polar coordinate style way of viewing voltage and current at a specific time

Advantages:

- Graphical trig soln

As phasor rotates at $\omega$:

$V(t) = V_{\text{max}} \sin (\omega t)$

$I(t) = I_{\text{max}} \sin \omega t$
RMS values = Root Mean Square

Suppose quantity \( A(t) = A_{\text{max}} \sin \omega t \)

\[ A_{\text{avg}} = 0 \] because \( \sin \omega t \) has zero average.

\[ A^2(t) = A_{\text{max}}^2 \sin^2 \omega t \]

\[ \text{avg. } A^2(t) = \langle A^2(t) \rangle = A_{\text{max}}^2 \langle \sin^2 \omega t \rangle = A_{\text{max}}^2 \frac{1}{2} \]

\[ \text{RMS: } A_{\text{rms}} = \sqrt{\langle A^2 \rangle} = \sqrt{\frac{1}{2} A_{\text{max}}^2} = 0.707 A_{\text{max}} \]

Usually quote RMS values of AC quantities like voltage, current, power, etc.

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**Standard N.A. Wall Outlets:**

Not upside down!

- Ground - connected to building/earth (NEMA 5-15)
- Longer: \( V_{\text{rms}} = 120V \)
- Normal: \( V = 0 \) w.r.t.
- Ground but not connected to ground
- 15 A RMS maximum
- Standard circuit breaker limit

- Ground (NEMA 5-20)
- Up to 20 A RMS
- With T-shaped plug
- Older clothes dryers

- Neutral
- Older clothes dryers

- Standard Circuit Breaker Limit
- 240 V rms

- "Two-Phase"
- \( V_x \) to \( V_x \)