1 Phys 2426 Fall 2016-10-20 Lec 17

AC Components

Resistors

$$V_R = I R$$
$$V_0 \sin(\omega t) = I_0 \sin(\omega t) R$$

$$V_{rms} = I_{rms} R$$

$$P_R = V I$$
$$P = I^2 R$$
$$P = I_0^2 \sin^2(\omega t) R$$
$$P_{avg} = I_{rms}^2 R$$

Inductors

$$V_L = L \frac{dI}{dt}$$
$$I = I_0 \sin(\omega t)$$

$$V_L = L I_0 \omega \cos(\omega t)$$
$$= V_0 \cos(\omega t)$$

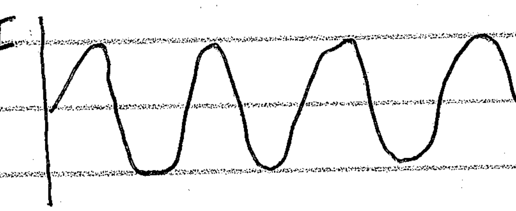
$$P = V I$$
$$= V_0 I_0 \sin(\,)\cos(\,)$$
$$= V_0 I_0 \tfrac{1}{2} \sin(2\theta)$$
$$P_{avg} = 0$$

$$V_{rms} = I_{rms} X_L$$

- Block high-f

X_L = Inductive Reactance
$$X_L = \omega L = 2\pi f L$$

I



- High Freq
- High X_L
- Without high V_{rms}, little current

$$\text{Energy} = \tfrac{1}{2} L I^2$$

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Capacitor - Break in circuit w/ lots of surface area.

$V_c = Q/C$

$Q = CV$

$I = C \frac{dV_c}{dt}$

Inductor Review

$V_L = L \frac{dI}{dt}$

- Current makes V_c increase
- Const V → Zero I
- Doesn't use power on average.

- Voltage makes I ↗
- Const I → Zero V

$I = I_0 \sin(\omega t)$

$Q = \int I \, dt = \frac{-I_0}{\omega} \cos(\omega t)$

$V = \frac{Q}{C} = \underbrace{\left(\frac{I_0}{\omega C}\right)}_{V_0} \left(-\cos(\omega t)\right)$

$(\text{Energy})_C = \frac{1}{2} C V^2$

$V_{rms} = I_{rms} X_C$

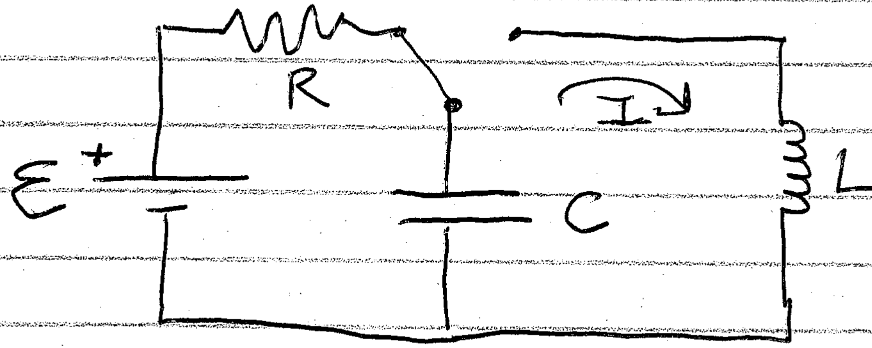
* Blocks Low-f

X_C = Capacitive Reactance

$= \frac{1}{\omega C} = \frac{1}{2\pi f C}$

③

LC Circuit



Preparation: Charge the cap thru the resistor

Eventually: $V_c = \mathcal{E}$

At $t=0$: Flip the switch to the inductor

The voltage makes the current increase

Energy = const

$$\frac{1}{2} C \mathcal{E}_0^2 = \frac{1}{2} L I_0^2$$

$$V_c = V_L \qquad I = -\frac{dQ}{dt}$$

$$Q/C = L \frac{dI}{dt}$$

$$\frac{dQ}{dt} / C = L \frac{d^2 I}{dt^2} \qquad \omega^2 = \frac{1}{LC}$$

$$+I = -LC \frac{d^2 I}{dt^2} \qquad \omega = \frac{1}{\sqrt{LC}}$$

$$\frac{-1}{LC} I = \frac{d^2 I}{dt^2} \qquad \boxed{f = \frac{1}{2\pi\sqrt{LC}}}$$

Solution: $I = I_0 \sin(\omega t) + \cancel{B \cos(\omega t)}$

$$\frac{d^2 I}{dt^2} = -I_0 \omega^2 \sin(\omega t)$$

$$= -I_0 \frac{1}{LC} \sin(\omega t)$$

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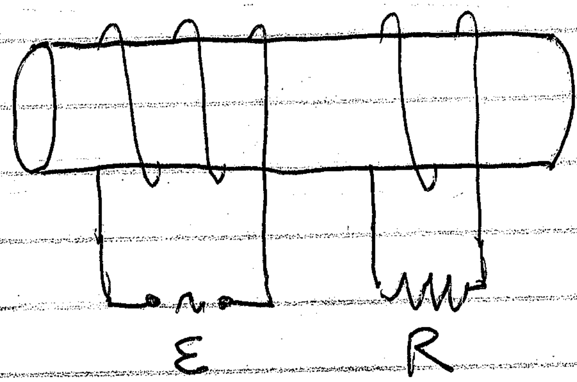
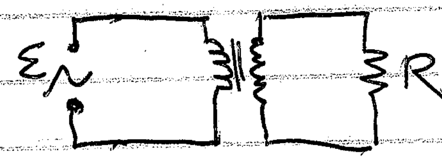
Transformers





In a transformer:

- $\mathcal{E}$ is applied to the primary
  - AC current flows
  - Oscillating B
- Secondary coil "feels" B.
  - Φ_B oscillates
  - Emf generated
- Load (R) attached to secondary
  - $\mathcal{E}_2$ pushes I_2 in load

$\Phi_p = N_p \Phi_1$ $\qquad$ $\Phi_1 = BA =$ flux in 1 loop

$\Phi_s = N_s \Phi_1$

$$\boxed{\mathcal{E}_p I_p = \mathcal{E}_s I_s}$$

$\mathcal{E}_p = N_p \mathcal{E}_1$

$\mathcal{E}_s = N_s \mathcal{E}_1$

$$\text{Voltage Ratio} = \boxed{\frac{\mathcal{E}_s}{\mathcal{E}_p} = \frac{N_s}{N_p}} = \text{Turns Ratio}$$

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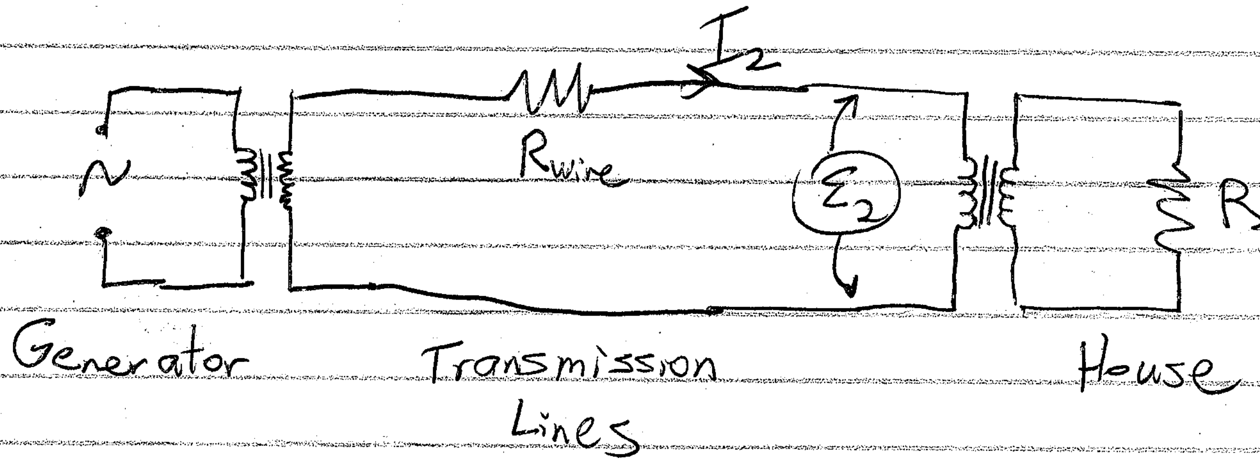

Power Lost $= I^2 R_{wire}$

Power Transmitted $= \mathcal{E}_2 I_2$