(1) Phys 2426 2014-10-22

Power in AC Circuits

For DC: $P = IV$

$$\frac{\text{Energy}}{\text{Time}} = \frac{\text{Charge}}{\text{Time}} \frac{\text{Energy}}{\text{Charge}}$$

For AC: $P(t) = I(t)\,V(t)$

But $P_0 = I_0 V_0$ is not generally true.

For a resistor: $V(t) = I(t)R$

So: $P_0 = I_0 V_0$ "Peak Power"

If $V(t) = V_0 \sin(2\pi f t)$

$I(t) = I_0 \sin(2\pi f t)$

$$P(t) = I_0 V_0 \sin^2(2\pi f t)$$

V	I	P
⊕	⊕	⊕
0	0	0
⊖	⊖	⊕

Average R power $P_{ave} = P_0/2$

$$P_{R,ave} = V_{RMS} I_{RMS}$$

Inductor energy $= \frac{1}{2}LI^2$

As $|I|$ builds up, the inductor absorbs energy.
As $|I|$ decreases, " " releases energy.

On average, an inductor neither uses nor supplies power.

$$P_{L,ave} = 0$$

Capacitor energy $= \frac{1}{2}CV^2$

$$P_{C,ave} = 0$$

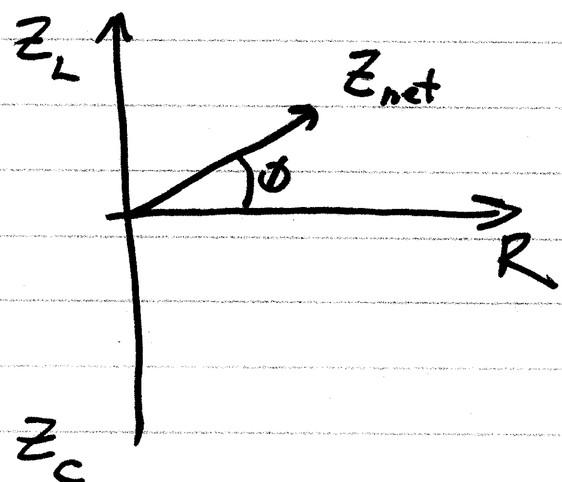
Whole AC Circuit

Power Factor ↓

$$P_{ave} = V_{Rms} I_{rms} \underline{\cos(\phi)}$$

ϕ is the phase angle of the circuit.

It's the angle of the impedance vector.



Only resistors use power in AC.

- Find the current in the resistors.
- Use

$$P_{R,ave} = I_{rms} V_{rms} = I_{rms}^2 R$$

- Add the power usage of the R's.

Other Components

Transformer - shuttles energy efficiently.

Motor - acts like R.

Coil rotating in B

$$\Phi_{max} = NBA$$

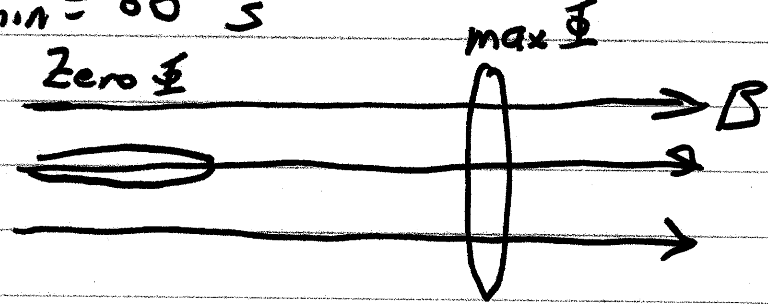
$$\mathcal{E} = \frac{d\Phi}{dt} \qquad \mathcal{E}_{max} = NBA \frac{d\theta}{dt}$$

↑ ω in rad/s

1 rev = 2π rad

1 min = 60 s

$$1 \text{ rpm} = \frac{2\pi}{60} \text{ rad/s}$$



(4)

$$\Phi = LI$$

$$\Phi = NBA \quad (A = \pi r^2)$$

$$B = \mu_0 NI/l$$

$$\mathcal{E} = \frac{d\Phi}{dt} = \frac{d}{dt}(LI) = L\frac{dI}{dt}$$

Series AC Circuit

R

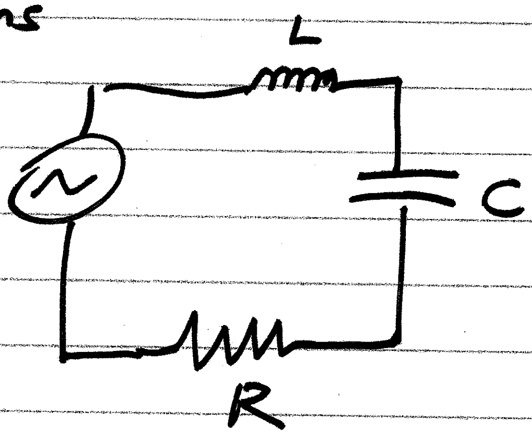
L $\quad Z_L = 2\pi f L$

C $\quad Z_C = 1/(2\pi f C)$

$\Big\} X = Z_L - Z_C$ reactance

$$Z = \sqrt{R^2 + X^2}$$

V_{Rms}



$$V_{Tot} = I_{tot} Z$$

$$P_{tot} = I^2 R$$

(5)

General $V = V_0 \sin(2\pi f t + \phi_0)$

$V = 30 \sin(50\, t)$

$V_0 = 30\text{ V}$ $\qquad 2\pi f = 50$

$f = 50/(2\pi)$ Hz

$= 7.96$ Hz

$V_{rms} = V_0/\sqrt{2}$

$= 21.2$ V

$Z_L = 2\pi f L$

← inductance in H.

$V_{Rms} = I_{Rms} Z$