Quantities

Impedance - analogue of resistance in DC circuits. Associated with a phases angle -> becuase peaks of current and voltage do not occur at the same time

Average Power - accounts for phase difference in AC circuits

angular frequency (ω) - relates to angular frequency of sin wave representing emf

Formulas

Ohm's law for AC circuits:

$$I = \frac{V}{Z}$$

I and V correspond to rms / effective values

Average power:

$$P_{\text{avg}} = VI\cos\phi = V_{\text{rms}}I_{\text{rms}}$$

Where ϕ is the phase angle

Peak voltage and current

$$V = \frac{V_m}{\sqrt{2}}$$
$$I = \frac{I_m}{\sqrt{2}}$$

Impedance of various components

Resistor

- same as DC resistance (use rms values for V and I)

Capacitor

- called capacitave reactance
- complex contribution to impedance ($\frac{-j}{\omega c}$)

$$X_c = \frac{1}{\omega C}$$

- pure C circuit will cause voltage to LAG current by 90 deg

Inductor

- called inductive reactance
- complex contribution to impedance: $j\omega L$

$$X_L = \omega L$$

- pure L circuit will cause voltage to LEAD current by 90 deg

RC circuit

- voltage LAGS current, but by less than 90 deg

$$\text{contribution to complex impedance} = R - \frac{j}{\omega C}$$
$$Z = \sqrt{R^2 + (\frac{1}{\omega C})^2}$$
$$\text{phase angle} = \phi = \tan^{-1}\frac{-1/\omega C}{R}$$

(note: formula for phase angle aligns with opp / adj = (impedance from capacitor) / (impedance from resistor))

RL circuit

- voltage LEADS current, but by less than 90 deg

$$\text{contribution to complex impedance} = R + j\omega L$$
$$Z = \sqrt{R^2 + \omega^2 L^2}$$
$$\text{phase angle} = \phi = \tan^{-1}\frac{\omega L}{R}$$

RLC Series Circuit

example of a resonant circuit. Minimum impedance of $Z = R$ at resonant frequency

Resonant condition:

$$Z = R$$
$$\omega = \frac{1}{\sqrt{LC}}$$
$$X_C = L_C$$
$$\text{Phase} = \phi = 0$$

Normal conditions:

$$X_C = \frac{1}{\omega C}$$
$$X_L = \omega L$$
$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$
$$\text{phase} = \phi = \tan^{-1}\frac{X_L - X_C}{R}$$

RLC Parallel (and combination)

Dealing with parallel circuits can be more complex and tedious becuase each branch can have a different phase angle that combines differently.

In general, impedance combines like resistance:

$$Z_{\text{parallel}} = (\frac{1}{Z_1} + \frac{1}{Z_2} + \ldots)^2$$
$$Z_{\text{series}} = Z_1 + Z_2 + \ldots$$

remember that we're doing these calculations with complex numbers, so the denominators must be rationalized.

See this for a more detailed overview of the forms we can use for dealing with complex impedance