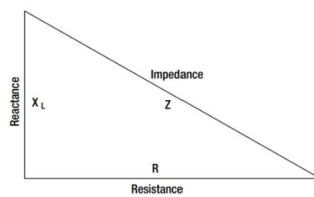


Series AC Circuits

Impedance: may be illustrated by a right triangle.



$$Z^2 = R^2 + X_L^2$$

The square root of both sides of the equation gives:

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

Resistance and reactance cannot be added directly, but they can be considered as two forces acting at right angles to each other

EX:

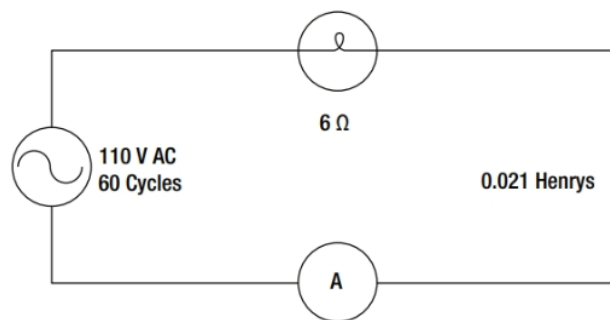


Figure 14-3. A circuit containing resistance and inductance.

$$X_L = 2 \pi \times f \times L$$

$$X_L = 6.28 \times 60 \times 0.021$$

$$X_L = 8 \text{ ohms inductive reactance}$$

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

$$Z = \sqrt{6^2 + 8^2}$$

$$Z = \sqrt{36 + 64}$$

$$Z = \sqrt{100}$$

$$Z = 10 \text{ ohms impedance}$$

The voltage drop across the resistance (E_R) is:

$$E^R = I \times R$$

$$E^R = 11 \times 6 = 66 \text{ volts}$$

The voltage drop across the inductance (E_{X_L}) is:

$$E_{X_L} = I \times X_L$$

$$E_{X_L} = 11 \times 8 = 88 \text{ volts}$$

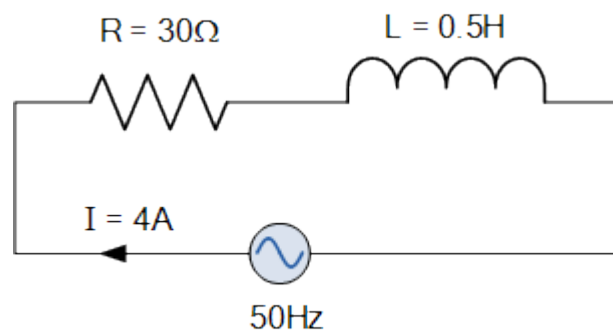
Then the current flow,

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

$$I = \frac{110}{10}$$

$$I = 11 \text{ amperes current}$$

Ex:



$$X_L = 2\pi fL = 2\pi \times 50 \times 0.5 = 157\Omega$$

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

$$Z = \sqrt{30^2 + 157^2}$$

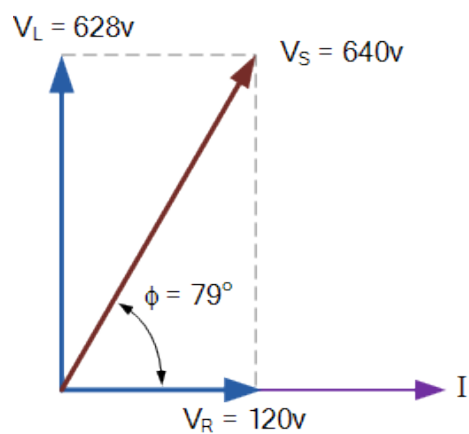
$$Z = 159.8\Omega$$

$$V_S = IZ = 4 \times 159.8 = 640\text{V}$$

$$V_R = I.R = 4 \times 30 = 120\text{V}$$

$$V_L = I.X_L = 4 \times 157 = 628\text{V}$$

$$\tan^{-1}\phi = \frac{X_L}{R} = \frac{157}{30} = 79.2^\circ \quad \text{Phase angle}$$



Ex: Rc

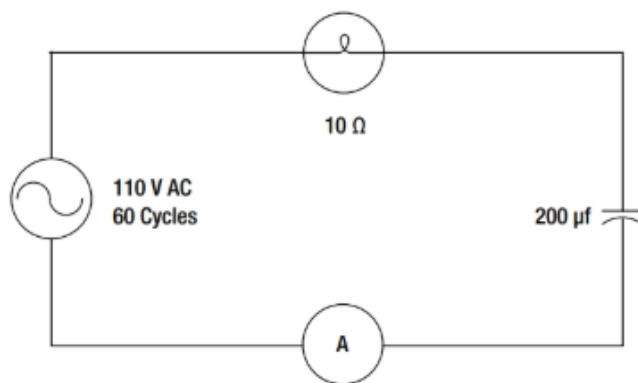


Figure 14-4. A circuit containing resistance and capacitance.

$$200 \mu f = \frac{200}{1\,000\,000} = 0.000\,200 \text{ farads}$$

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

$$X_C = \frac{1}{6.28 \times 60 \times 0.002\,00 \text{ farads}}$$

$$X_C = \frac{1}{0.075\,36}$$

$$X_C = 13 \text{ ohms capacitive reactance}$$

To find the impedance:

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

$$Z = \sqrt{10^2 + 13^2}$$

$$Z = \sqrt{100 + 169}$$

$$Z = \sqrt{269}$$

$$Z = 16.4 \text{ ohms capacitive reactance}$$

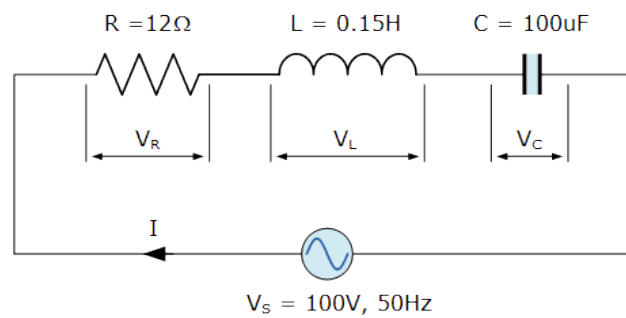
To find the current:

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

$$I = \frac{110}{16.4}$$

$$I = 6.7 \text{ amperes}$$

Ex: RLC



$$X_L = 2\pi fL = 2\pi \times 50 \times 0.15 = 47.13\Omega$$

$$X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi \times 50 \times 100 \times 10^{-6}} = 31.83\Omega$$

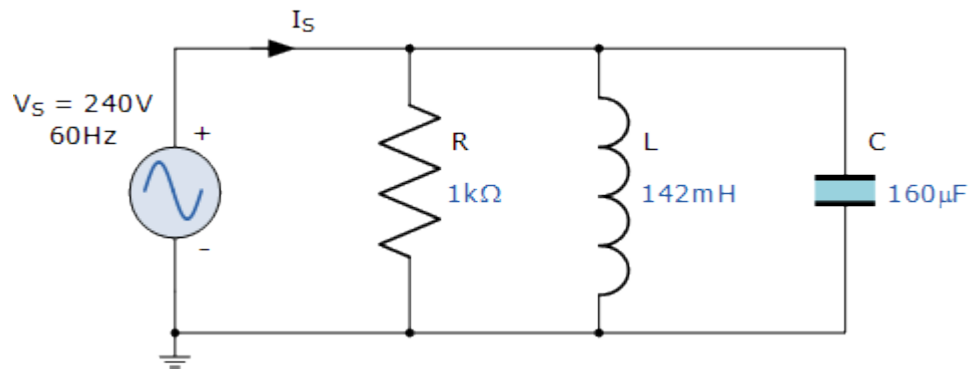
$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$$Z = \sqrt{12^2 + (47.13 - 31.83)^2}$$

$$Z = \sqrt{144 + 234} = 19.4\Omega$$

$$I = \frac{V_s}{Z} = \frac{100}{19.4} = 5.14\text{Amps}$$

Parallel AC Circuits



$$X_L = \omega L = 2\pi fL = 2\pi \cdot 60 \cdot 142 \times 10^{-3} = 53.54\Omega$$

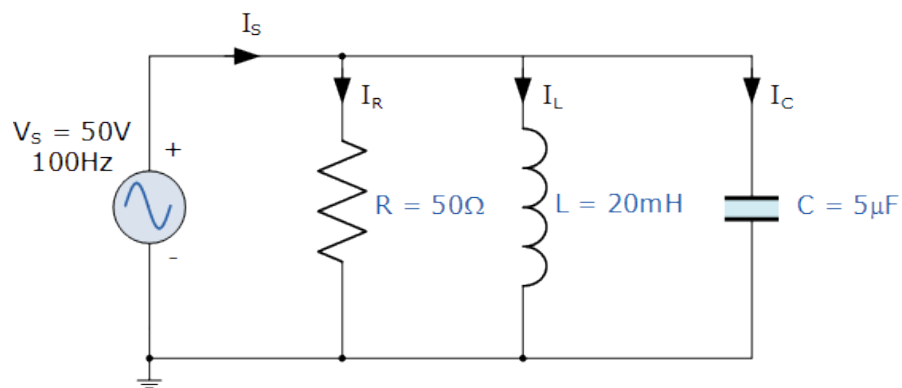
$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi fC} = \frac{1}{2\pi \cdot 60 \cdot 160 \times 10^{-6}} = 16.58\Omega$$

$$I_L = \frac{V}{X_L} \quad I_C = \frac{V}{X_C}$$

$$I_L = \frac{240}{53.54} = 4.48A \quad I_C = \frac{240}{16.58} = 14.4A \quad I_R = \frac{240}{1000} = 0.24A$$

$$I = \sqrt{I_R^2 + (I_L - I_C)^2} \quad I = \sqrt{(0.24)^2 + (4.48 - 14.4)^2} = 9.9A$$

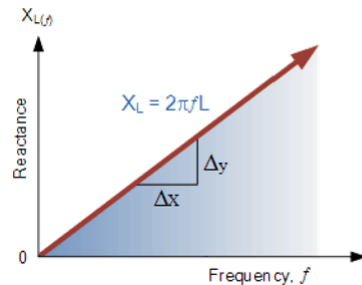
$$z = \frac{V}{I} = \frac{240}{9.9} = 24.24\Omega$$



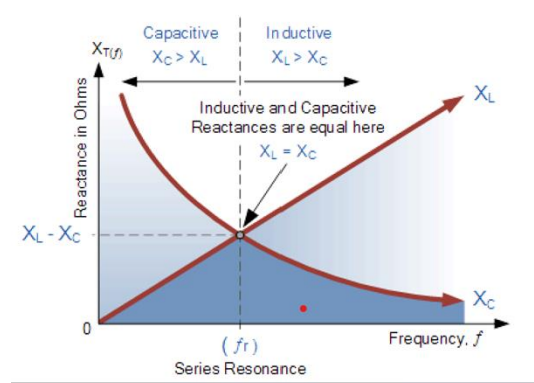
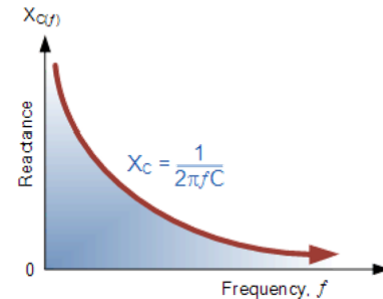
Series Resonance Circuit

Resonance occurs in a series circuit when the supply frequency causes the voltages across L and C to be equal and opposite in phase.

Inductive Reactance against Frequency



Capacitive Reactance against Frequency



Resonance occurs in a series circuit when the supply frequency causes the voltages across L and C to be equal and opposite in phase. ■

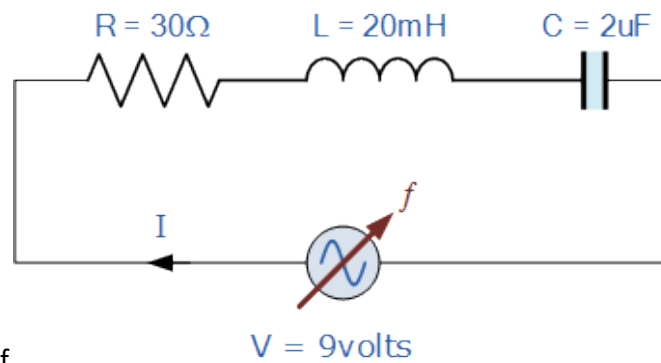
$$X_L = X_C \Rightarrow 2\pi fL = \frac{1}{2\pi fC}$$

$$f^2 = \frac{1}{2\pi L \times 2\pi C} = \frac{1}{4\pi^2 LC}$$

$$f = \sqrt{\frac{1}{4\pi^2 LC}}$$

$$\therefore f_r = \frac{1}{2\pi\sqrt{LC}} \text{ (Hz)} \quad \text{or} \quad \omega_r = \frac{1}{\sqrt{LC}} \text{ (rads)}$$

Ex:



Resonant Frequency, f_r

$$f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{0.02 \times 2 \times 10^{-6}}} = 796\text{Hz}$$

Circuit Current at Resonance, I_m

$$I = \frac{V}{R} = \frac{9}{30} = 0.3\text{A or } 300\text{mA}$$

Inductive Reactance at Resonance, X_L

$$X_L = 2\pi fL = 2\pi \times 796 \times 0.02 = 100\Omega$$

Voltages across the inductor and the capacitor, V_L , V_C

$$V_L = V_C$$

$$V_L = I \times X_L = 300\text{mA} \times 100\Omega$$

$$V_L = 30\text{volts}$$

I did not calculate the X_C because its resonance frequency.

Power in AC Circuits

true power: is the product of the volts and the amperes in the circuit.

True Power Defined

1, The power dissipated in the resistance of a circuit, or the power actually used in the circuit.

2, In an AC circuit, a voltmeter indicates the effective voltage and an ammeter indicates the effective current.

Apparent Power Defined

1, It is the product of effective voltage times the effective current, expressed in volt-amperes.

2, It must be multiplied by the power factor to obtain true power available.

