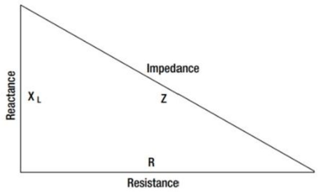
Series AC Circuits

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:

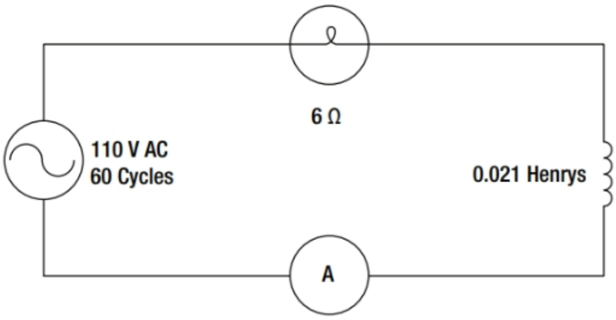


Figure 14-3. A circuit containing resistance and inductance.

$X_L = 2 \pi \times f \times L$
$X_L = 6.28 \times 60 \times 0.021$
$X_L = 8$ ohms inductive reactance

$Z = \sqrt{R^2 + X_L^2}$
$Z = \sqrt{6^2 + 8^2}$
$Z = \sqrt{36 + 64}$
$Z = \sqrt{100}$
$Z = 10$ ohms impedance

Then the current flow,

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

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

$I = 11$ amperes current

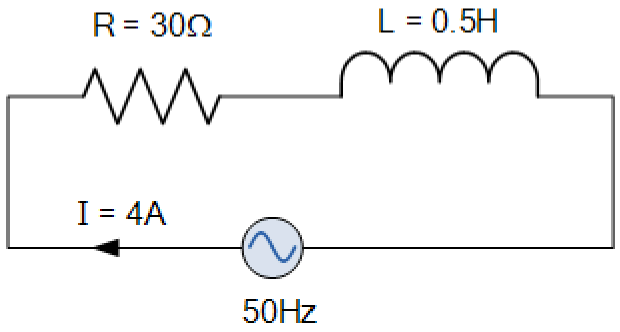
The voltage drop across the resistance (ER) is:

$E^R = I \times R$
$E^R = 11 \times 6 = 66$ volts

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

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

Ex:



$$X_L = 2\pi f L = 2\pi \times 50 \times 0.5 = 157\Omega$$

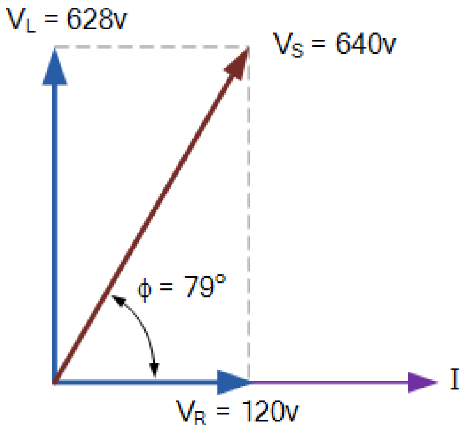
$$Z = \sqrt{R^2 + X_L^2}$$
$$Z = \sqrt{30^2 + 157^2}$$
$$Z = 159.8\Omega$$

$$V_S = I.Z = 4 \times 159.8 = 640v$$

$$V_R = I.R = 4 \times 30 = 120v$$

$$V_L = I.X_L = 4 \times 157 = 628v$$

$$\tan^{-1}\phi = \frac{X_L}{R} = \frac{157}{30} = 79.2^o$$ Phase angel



Ex: Rc

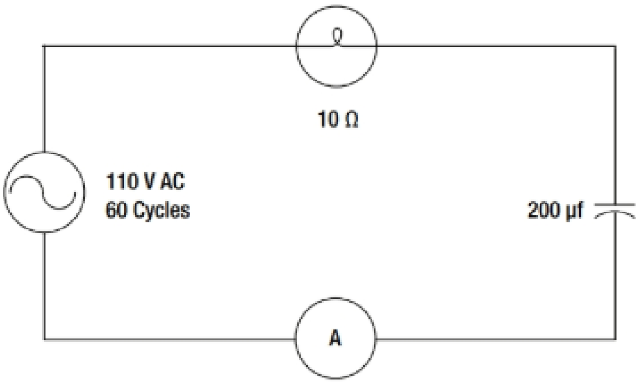


Figure 14-4. A circuit containing resistance and capacitance.

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

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

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

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

X_C = 13 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 ohms capacitive reactance

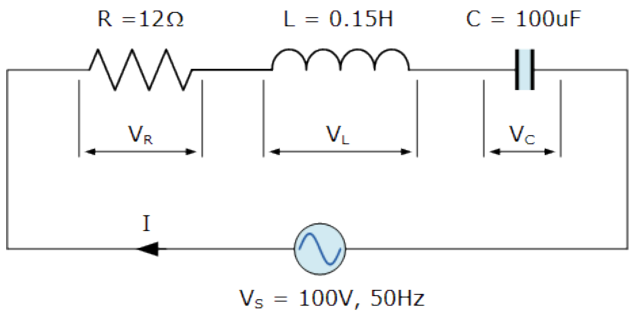
To find the current:

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

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

I = 6.7 amperes

Ex: RLC



$$X_L = 2\pi f L = 2\pi \times 50 \times 0.15 = 47.13\Omega$$

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

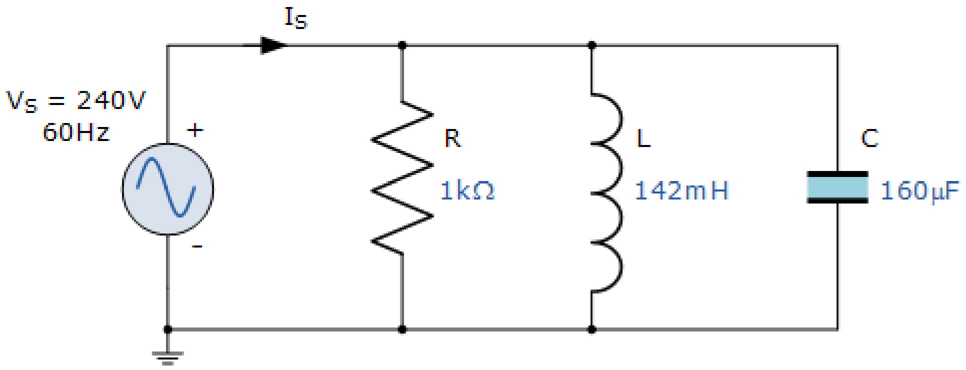
$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

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

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

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

Parallel AC Circuits



$$X_L = \omega L = 2\pi f L = 2\pi.60.142\times10^{-3} = 53.54\Omega$$

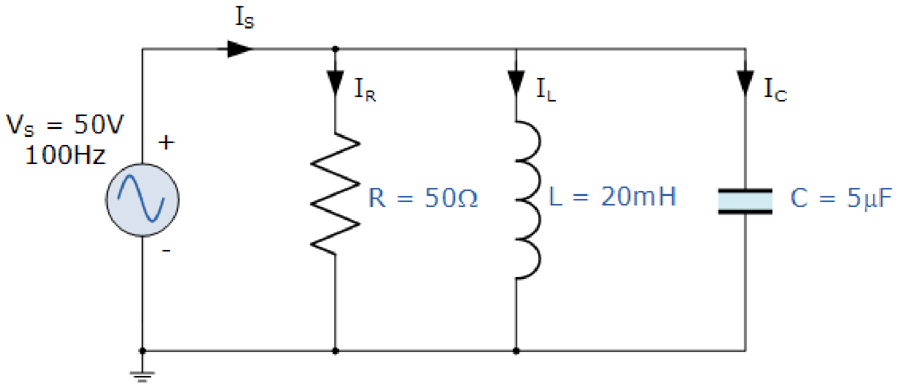
$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C} = \frac{1}{2\pi.60.160\times10^{-6}} = 16.58\Omega$$

$$IL = \frac{V}{XL} \qquad IC = \frac{v}{XC}$$

$$IL = \frac{240}{53.54} = 4.48A \qquad IC = \frac{240}{16.58} = 14.4A \qquad IR = \frac{240}{1000} = 0.24A$$

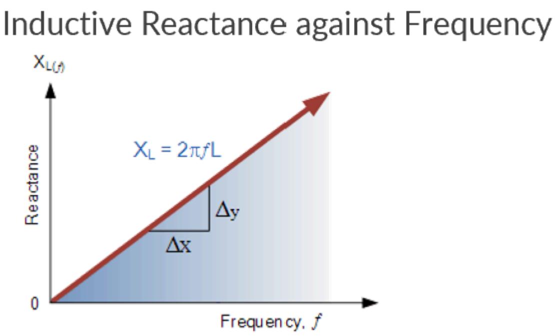
$$I = \sqrt{IR^2 + (IL - IC)^2} \qquad I = \sqrt{(0.24)^2 + (4.48 - 14.4)^2} = 9.9A$$

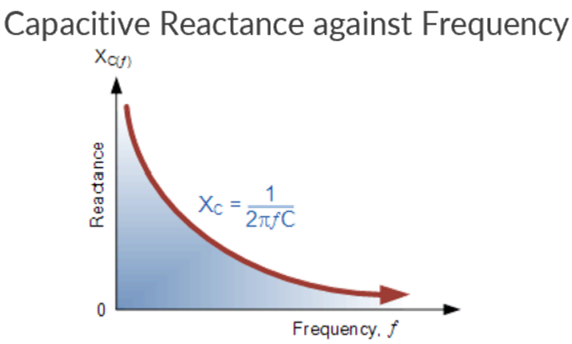
$$z = \frac{V}{I} = \frac{240}{9.9} = 24.24\Omega$$

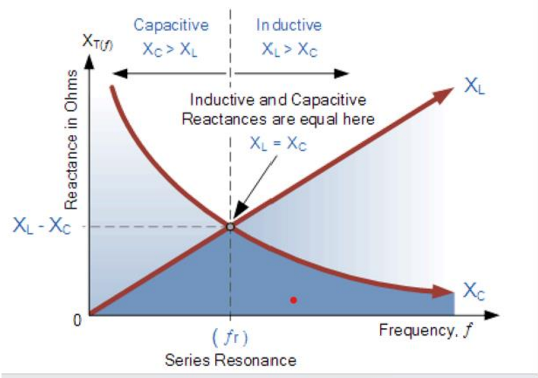


Series Resonance Circuit

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







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

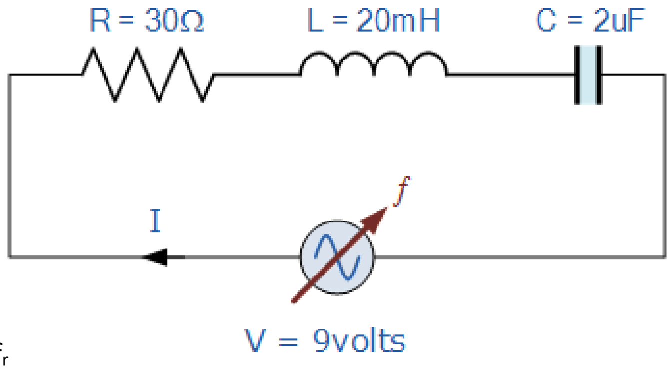
$$X_L = X_C \quad \Rightarrow \quad 2\pi f L = \frac{1}{2\pi f C}$$

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

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

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

Ex:



Resonant Frequency, f_r

$$f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{0.02\times2\times10^{-6}}} = 796Hz$$

Circuit Current at Resonance, I_m

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

Inductive Reactance at Resonance, X_L

$$X_L = 2\pi fL = 2\pi\times796\times0.02 = 100\Omega$$

Voltages across the inductor and the capacitor, V_L, V_C

$$V_L = V_C$$
$$V_L = I\times X_L = 300mA\times100\Omega$$
$$V_L = 30volts$$

I did not calculate the XC 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.