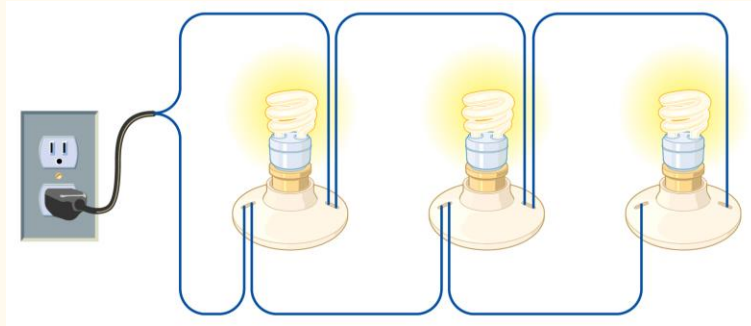


AC Circuits

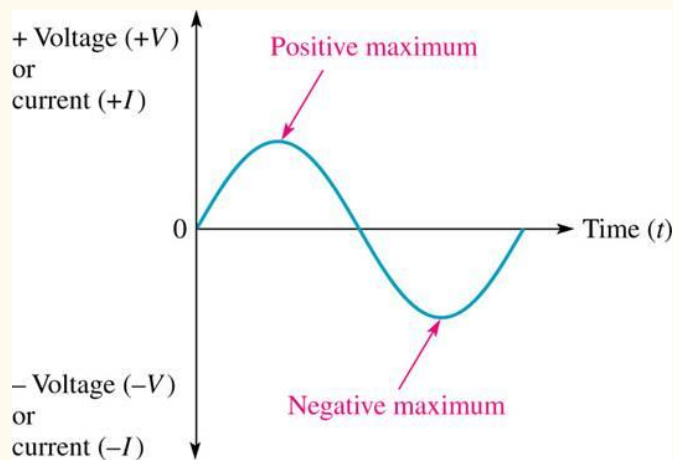


Dr Rabya Kadhim

1

Sine waves

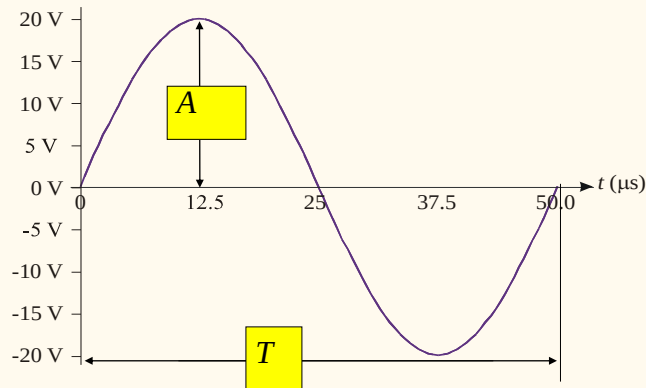
The sinusoidal waveform (sine wave) is the fundamental alternating current (ac) and alternating voltage waveform.



2

Sine waves

Sine waves are characterized by the amplitude and period. The **amplitude** is the maximum value of a voltage or current; the **period** is the time interval for one complete cycle.



3

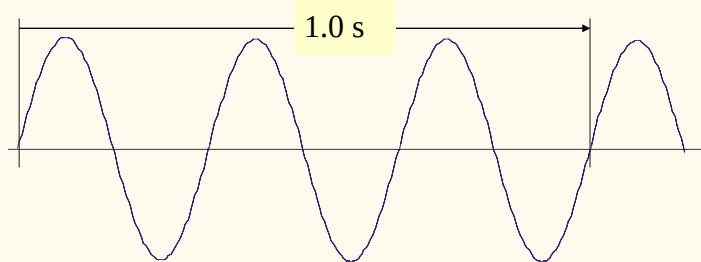
Frequency

Frequency (f) is the number of cycles that a sine wave completes in one second.

Frequency is measured in **hertz (Hz)**.

Example

If 3 cycles of a wave occur in one second, the frequency is **3.0 Hz**



4

Period and frequency

The period and frequency are reciprocals of each other.

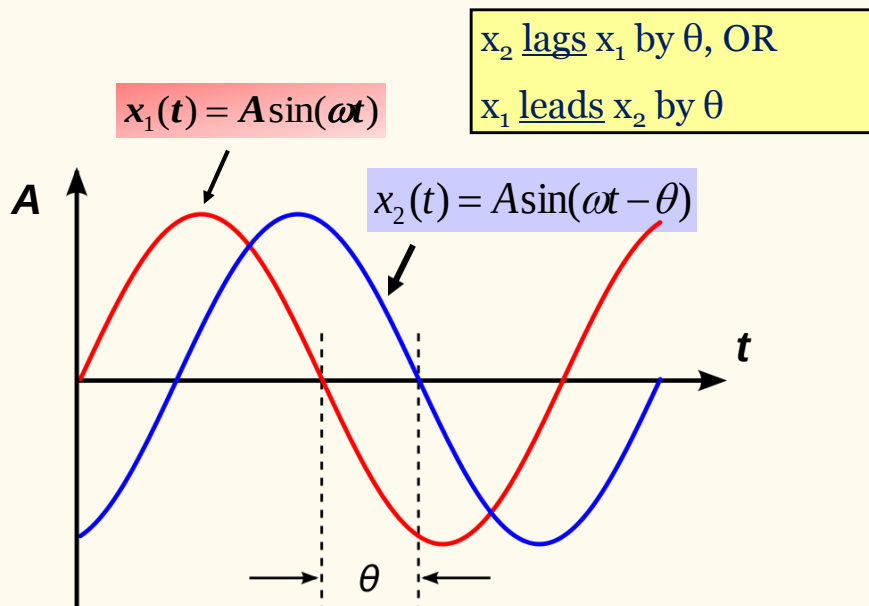
$$f = \frac{1}{T} \quad \text{and} \quad T = \frac{1}{f}$$

Thus, if you know one, you can easily find the other.

(The $\boxed{1/x}$ key on your calculator is handy for converting between f and T .)

5

Sinusoids: Phase



6

Capacitive reactance

Capacitive reactance is the opposition to ac by a capacitor. The equation for capacitive reactance is

$$X_C = \frac{1}{2\pi fC}$$

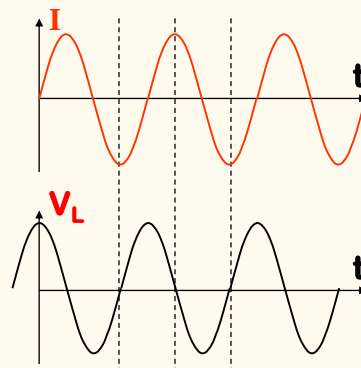
The reactance of a 0.047 mF capacitor when a frequency of 15 kHz is applied is 226 Ω

7

Inductors in AC circuit

- Inductive Reactance: $X_L = 2\pi fL$
- Voltage across inductor “LEADS” current.

$$X_L = 2\pi fL = \omega L$$



8

COMPARISON OF X_L & X_C

- X_L is directly proportional to frequency and inductance.

$$X_L = 2\pi fL = \omega L$$

- X_C is inversely proportional to frequency and capacitance.

$$X_C = \frac{1}{2\pi fC} = \frac{1}{\omega C}$$

9

RLC Series Circuit

When

a pure resistance of **R ohms**,

a pure inductance of **L Henry** and

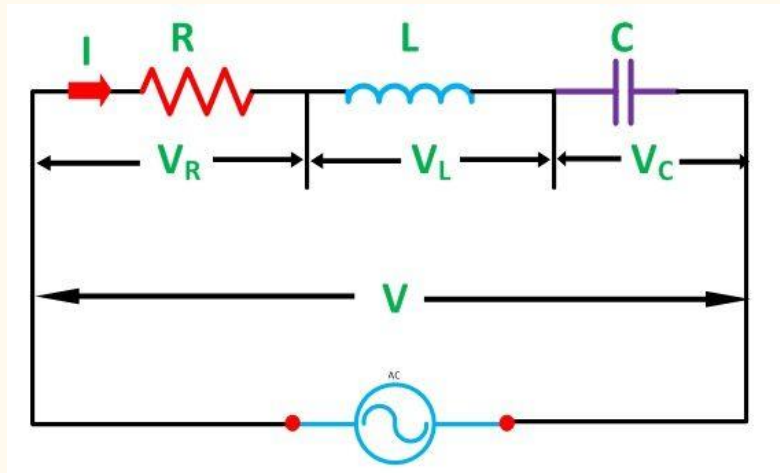
a pure capacitance of **C farads**

are connected together in series combination with each other then **RLC Series Circuit** is formed.

As all the three elements are connected in series so, the **current flowing** through each element of the circuit will be the same as the **total current I** flowing in the circuit.

10

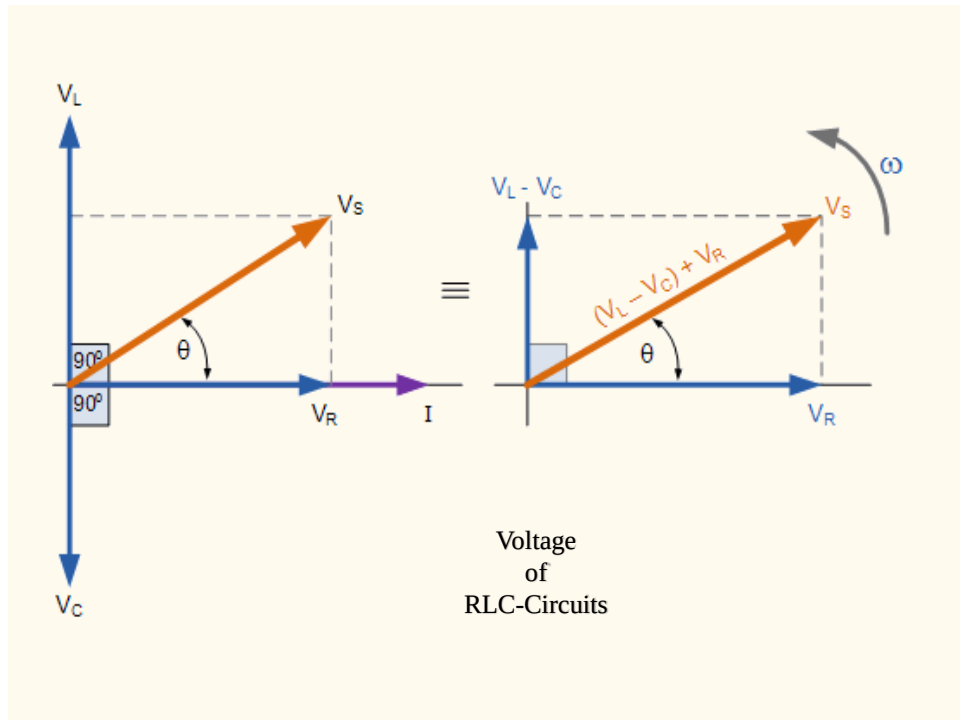
RLC Series Circuit



11

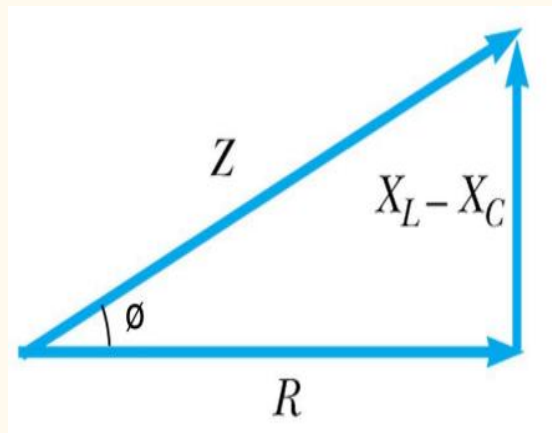
Impedance (Z) of RLC-Circuits

12



13

Impedance (Z)
of
RLC-Circuits



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

14

Impedance for RLC Series :

$$Z_{\text{RL-series}} = \sqrt{R^2 + X_L^2}$$

$$Z_{\text{RC-series}} = \sqrt{R^2 + X_C^2}$$

$$Z_{\text{LC-series}} = \sqrt{(X_L - X_C)^2}$$

$$Z_{\text{RLC-series}} = \sqrt{R^2 + (X_L - X_C)^2}$$

$$X_L = 2\pi fL$$

$$X_C = \frac{1}{2\pi fC}$$

15

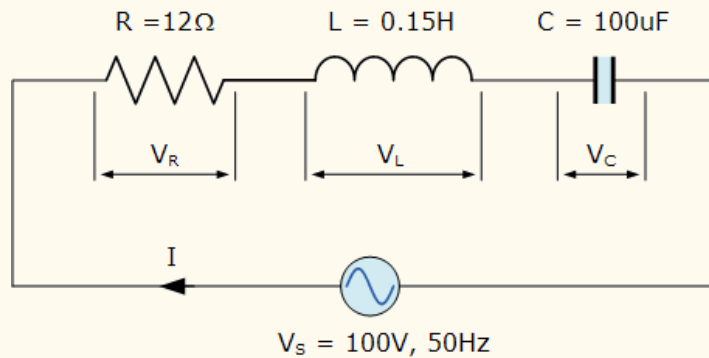
Analysis of series *RLC* circuits

Ohm's law is applied to series ***RLC*** circuits using ***Z***, ***V***, and ***I***.

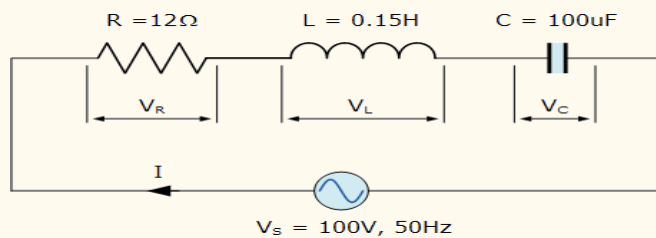
$$V = IZ \quad I = \frac{V}{Z} \quad Z = \frac{V}{I}$$

16

A series RLC circuit containing a resistance of 12Ω , an inductance of 0.15H and a capacitor of $100\mu\text{F}$ are connected in series across a 100V , 50Hz supply. Calculate the total circuit impedance and the circuits current.



17



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

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

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

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

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

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

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Series RLC Example

In a series RLC, circuit $R = 30\ \Omega$, $L = 15\ \text{mH}$, and $C = 51\ \mu\text{F}$. If the source voltage and frequency are 12 V and 60 Hz, respectively, what is the current in the circuit?

$$X_L = 2 * 3.14 * 60 * 0.015 = 5.655\Omega$$

$$X_C = \frac{1}{2 * 3.14 * 60 * 0.000051} = 5.655\Omega$$

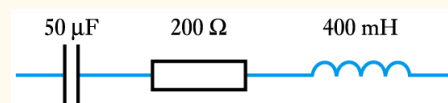
$$Z = \sqrt{30^2 + (52 - 5.655)^2} = 55.21\Omega$$

$$I = \frac{12}{55.21} = 217\text{mA}$$

19

Example

Determine the impedance of this circuit at a frequency of 50 Hz.



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

$$X_L = 2\pi fL = \omega L$$

$$X_C = \frac{1}{2\pi fC} = \frac{1}{\omega C}$$

20

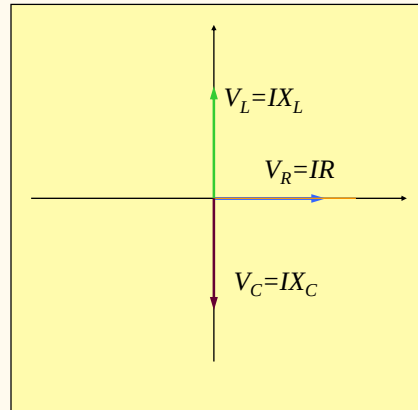
Perfect Match

- There is special behavior when

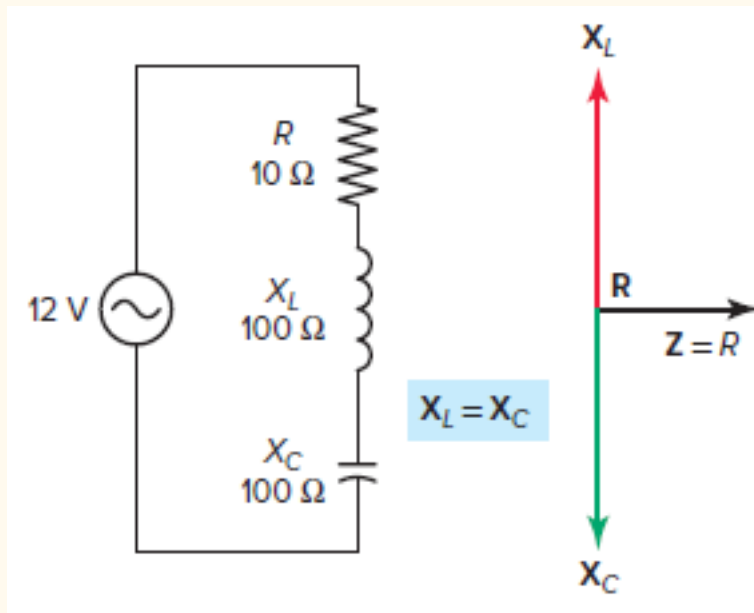
$$X_C = X_L$$

- Vectors cancel
- Impedance only from resistor

- This is called ***resonance***.



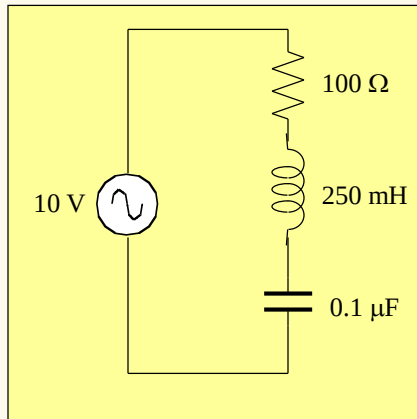
21



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Circuit Example

- Find the resonant frequency in the following circuit in Hz.



- The problem requires the formula for the frequency f .

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

- Only the inductance and capacitance matter.

$$= \frac{1}{2\pi (0.25 \text{ H } 10^{-7} \text{ F})^{1/2}} = 1 \text{ kHz}$$