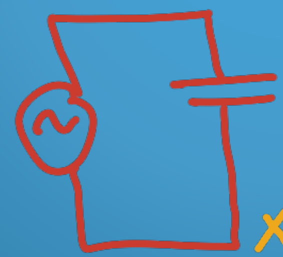
Chapter 1 (part 2)
Altenating current circuit

$Z = R + 0j$

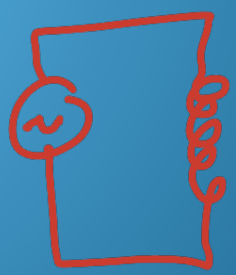
$R \angle 0$



X_C

$Z = 0 + \frac{1}{wC} j$

$\frac{1}{wc} \angle -90$



X_L

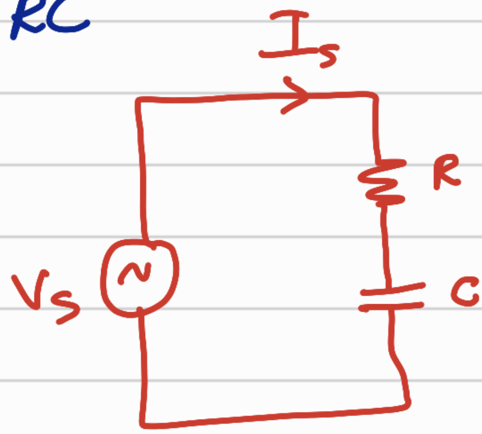
$Z_L = 0 + wL j$

$wL \angle 90$

Dr. Asmae Mimouni

RC

التوصيلات على التوالي



$$\boxed{Z = R - jX_C}$$

$$Z = \angle -\Phi$$

$$\phi = \tan^{-1}\left(\frac{X_C}{R}\right)$$

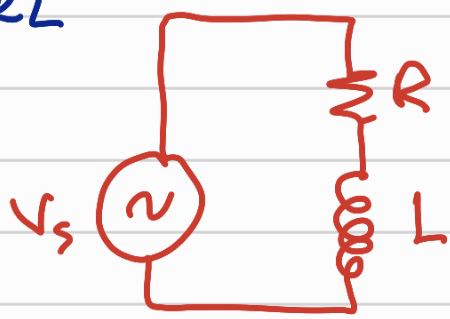
$$|Z| = \sqrt{R^2 + X_C^2}$$

I_s التيار ثابت

$$V_s = \sqrt{V_C^2 + V_R^2}$$

$$I_s = \frac{V_s}{|Z|} = \frac{V_s}{\sqrt{R^2 + X_C^2}}$$

RL



$$\boxed{Z = R + jX_L}$$

$$\phi = \tan^{-1}\left(\frac{X_L}{R}\right)$$

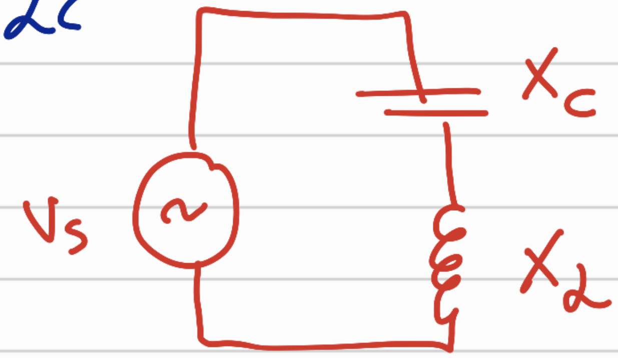
$X_L = \omega L$

$$I_s = \frac{V_s}{|Z|} = \frac{V_s}{\sqrt{R^2 + X_L^2}}$$

$$V_s = \sqrt{V_R^2 + V_L^2}$$

$$Z = \angle +\Phi$$

LC



$$Z = 0 + X_L j - X_C j$$

$$Z = (X_L - X_C) j$$

$$Z = \sqrt{X_L^2 - X_C^2}$$

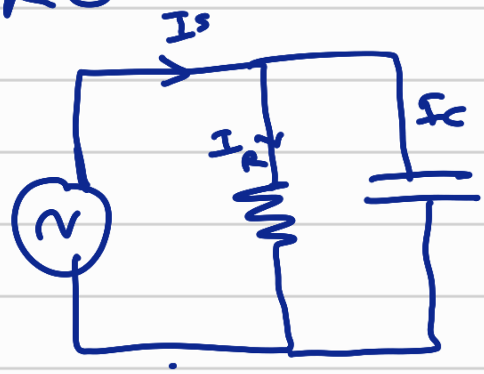
$$\omega = \frac{1}{\sqrt{LC}}$$

$X_L = X_C$ حالة خاصة

$V_L = V_C$

التوصيلات على التوازي

RC



$$I_R = \frac{V_s}{R} \qquad I_C = \frac{V_C}{X_C}$$

$$I_s = \sqrt{I_R^2 + I_C^2}$$

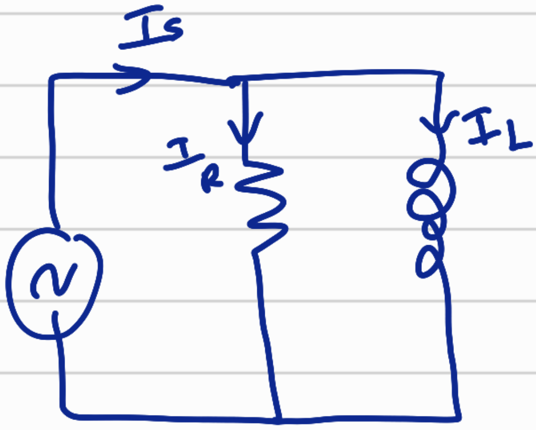
$$V_s = V_R = V_C$$

$$\phi = \tan^{-1}\left(\frac{I_C}{I_R}\right)$$

$$\underbrace{\frac{1}{Z}}_{Y} = \sqrt{\underbrace{\frac{1}{R^2}}_{G^2} + \underbrace{\frac{1}{X^2}}_{B_C^2}}$$

$$Y = \sqrt{G^2 + B_C^2}$$

RL



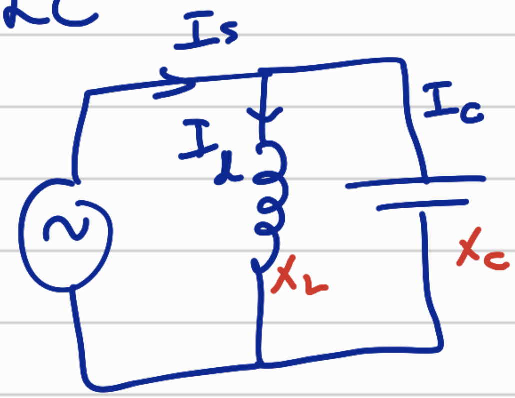
$$I_s = \sqrt{I_R^2 + I_l^2}$$

$$I_R = \frac{V_s}{R} \qquad I_l = \frac{V_s}{X_L}$$

$$\phi = \tan^{-1}\left(\frac{I_L}{I_R}\right)$$

$$\frac{1}{Z} = \sqrt{\frac{1}{R^2} + \frac{1}{X_L^2}}$$

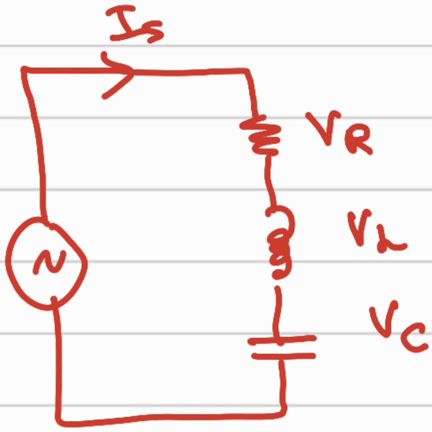
LC



$$\underbrace{\frac{1}{Z}}_{Y} = \underbrace{\frac{1}{X_L}}_{B_L} + \underbrace{\frac{1}{X_C}}_{B_C}$$

$$Y = B_L + B_C$$

$$\omega = \frac{1}{\sqrt{LC}}$$



$$Z = R + (X_L - X_C)j$$
$$= R + Xj$$

$$V_R = IR$$

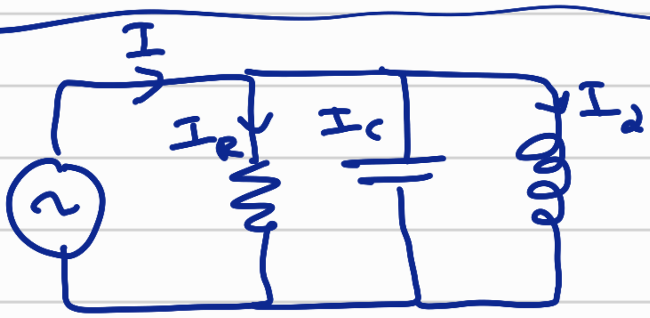
$$V_L = IX_L$$

$$V_C = IX_C$$

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

$$V_S = \sqrt{V_R^2 + (V_L - V_C)^2}$$

$$\Phi = \tan^{-1}\left(\frac{X_L - X_C}{R}\right)$$



$$I = \sqrt{I^2 + (I_L - I_C)^2}$$

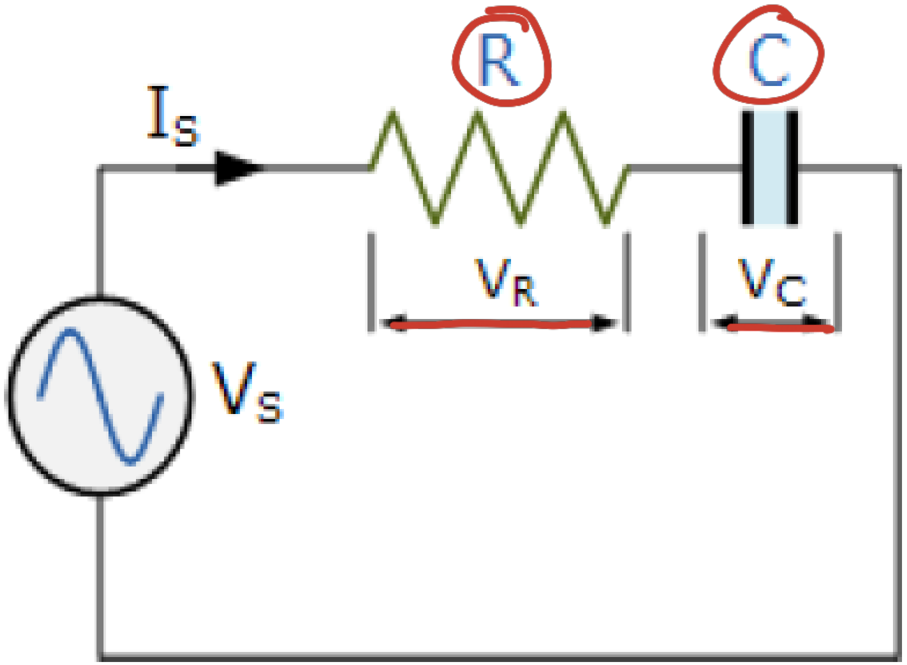
$$\underbrace{\frac{1}{Z}}_{Y} = \sqrt{\underbrace{\frac{1}{R^2}}_{G} + \left(\underbrace{\frac{1}{X_L}}_{B_L} + \underbrace{\frac{1}{X_C}}_{B_C}\right)^2}$$

$$Y = \sqrt{G^2 + (B_L - B_C)^2}$$

Series AC Circuits

Passive components in AC circuits can be connected together in series combinations to form RC, RL and LC circuits as shown below.

Series RC Circuit



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

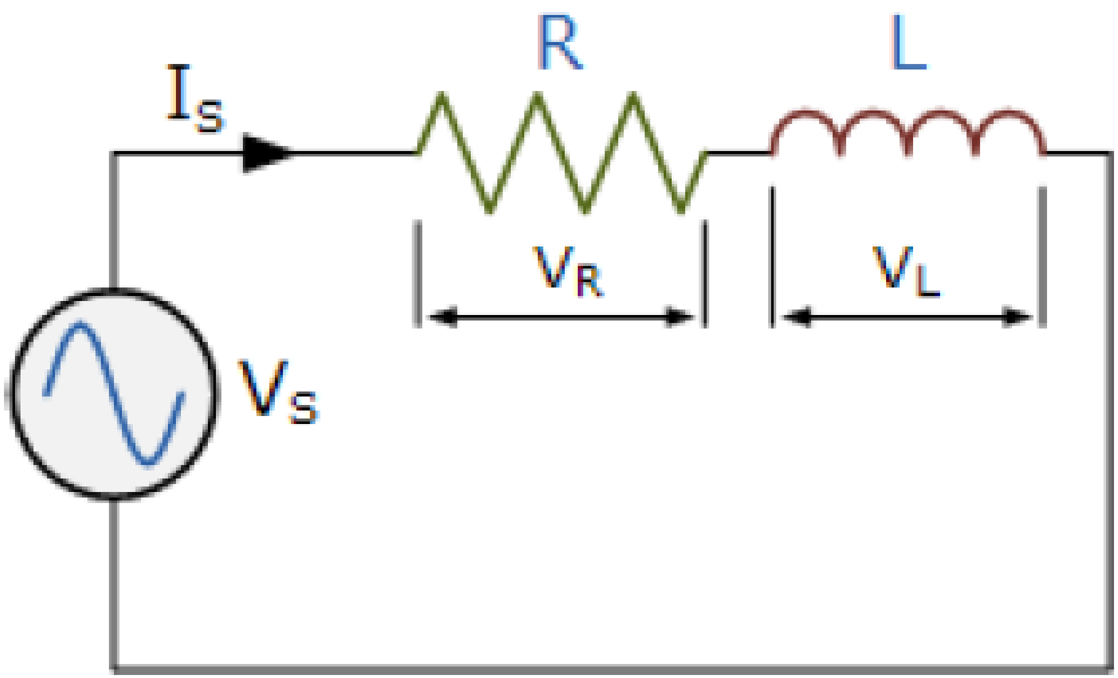
$$Z = \angle{-\phi} = \boxed{R - jX_C}$$

$$\phi_{(-90 \to 0)} = \tan^{-1}\left(-\frac{X_C}{R}\right)$$

$$\boxed{I_S = \frac{V_S}{Z} = \frac{V_S}{\sqrt{R^2 + X_C^2}}}$$

$$V_S = \sqrt{V_R^2 + V_C^2}$$

Series RL Circuit



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

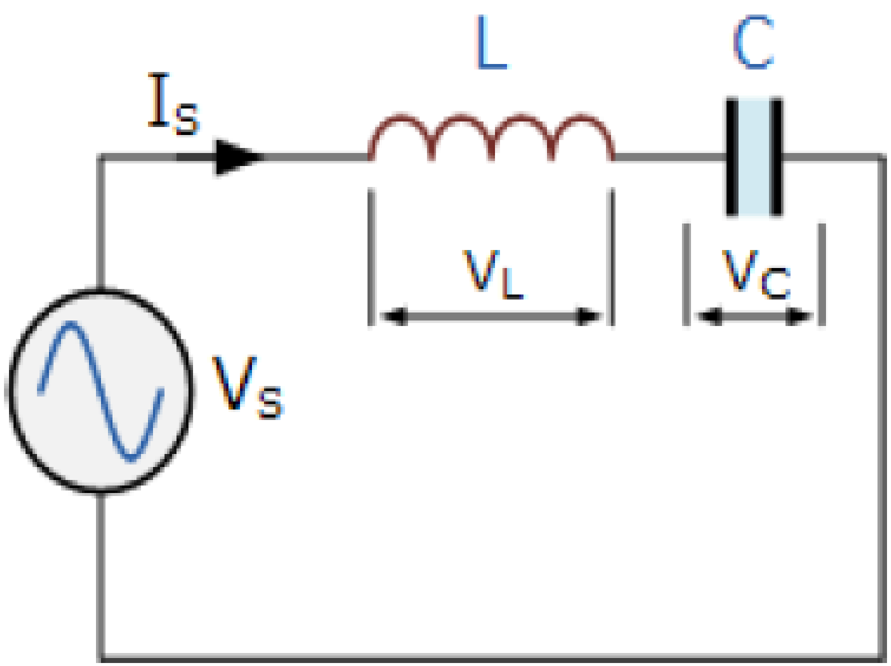
$$Z = \angle{+\phi} = \boxed{R + jX_L}$$

$$\phi_{(0\to 90)} = \tan^{-1}\left(\frac{X_L}{R}\right)$$

$$\boxed{I_S = \frac{V_S}{Z} = \frac{V_S}{\sqrt{R^2 + X_L^2}}}$$

$$V_S = \sqrt{V_R^2 + V_L^2}$$

Series LC Circuit



$$Z = \sqrt{X_L^2 - X_C^2}$$

$$\therefore Z = X_L - X_C \text{ or } X_C - X_L$$

$$Z = \angle\phi + j = 0 + (jX_L - jX_C)$$

$$f_R = \frac{1}{2\pi\sqrt{LC}} \qquad \omega = \frac{1}{\sqrt{LC}}$$

at f_R $X_L = X_C$ and $V_L = V_C$

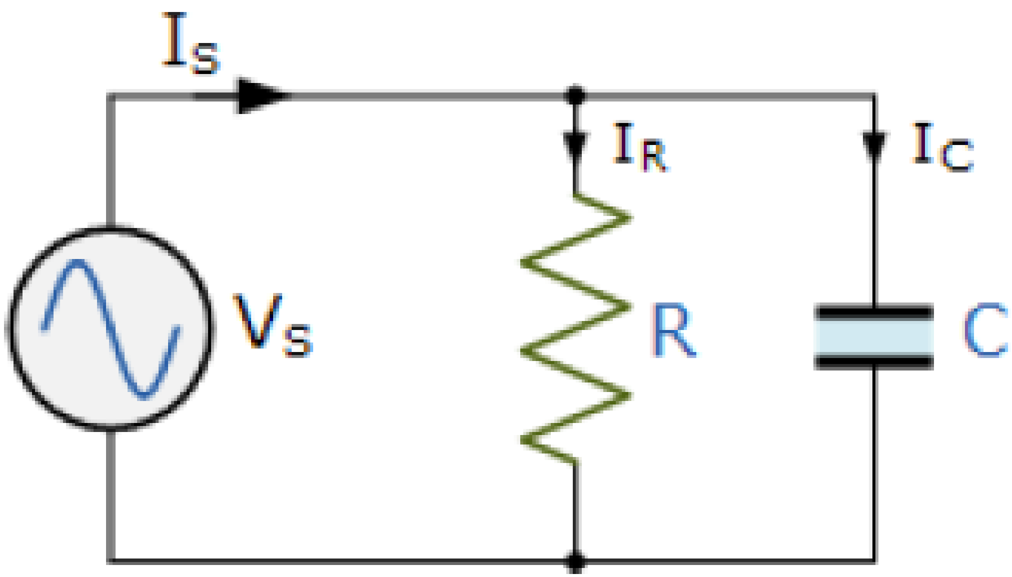
$$I_S = I_L = I_C$$

Parallel AC Circuits

Passive components in AC circuits can also be connected together in parallel combinations to form RC, RL and LC circuits as shown below.

Parallel RC Circuit

توازي



$$I_R = \frac{V_S}{R}, \quad I_C = \frac{V_S}{X_C}$$

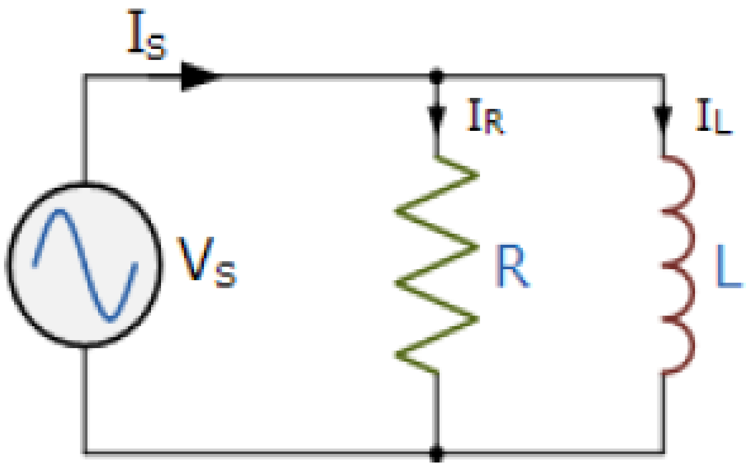
$$I_S = \sqrt{I_R^2 + I_C^2}$$

$$\phi = \tan^{-1}\left(\frac{I_C}{I_R}\right)$$

$$Y = \frac{1}{Z} = \sqrt{G^2 + B_C^2}$$

$$V_S = V_R = V_C$$

Parallel RL Circuit



$$I_R = \frac{V_S}{R}, \quad I_L = \frac{V_S}{X_L}$$

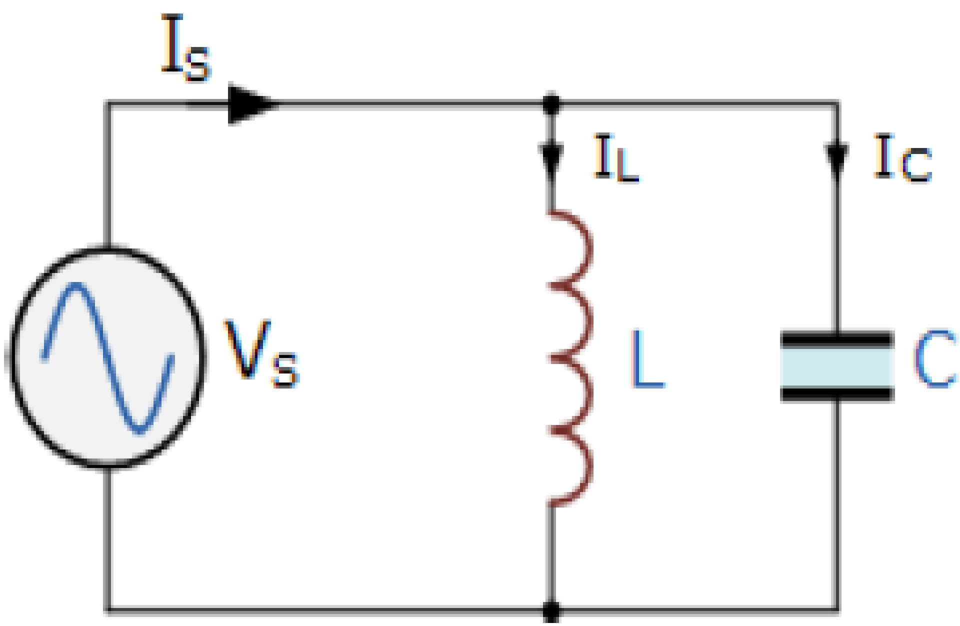
$$I_S = \sqrt{I_R^2 + I_L^2}$$

$$\phi = \tan^{-1}\left(\frac{I_L}{I_R}\right)$$

$$Y = \frac{1}{Z} = \sqrt{G^2 + jB_L^2}$$

$$V_S = V_R = V_L$$

Parallel LC Circuit



$$B_L = \frac{1}{X_L}, \quad B_C = \frac{1}{X_C}$$

$$Y = \frac{1}{Z} = B_L + B_C$$

$$f_R = \frac{1}{2\pi\sqrt{LC}} \qquad \omega = \frac{1}{\sqrt{LC}}$$

at f_R $X_L = X_C$ and $I_L = I_C$

$$V_S = V_L = V_C$$

Passive RLC Circuits

All three passive components in AC circuits can also be connected together in both series RLC and parallel RLC combinations.

Series RLC Circuit

- these components are connected in series, the current in each element remains the same:

$$I_R = I_C = I_L = I(t)\ ;where: I(t) = I_m \sin \omega t$$

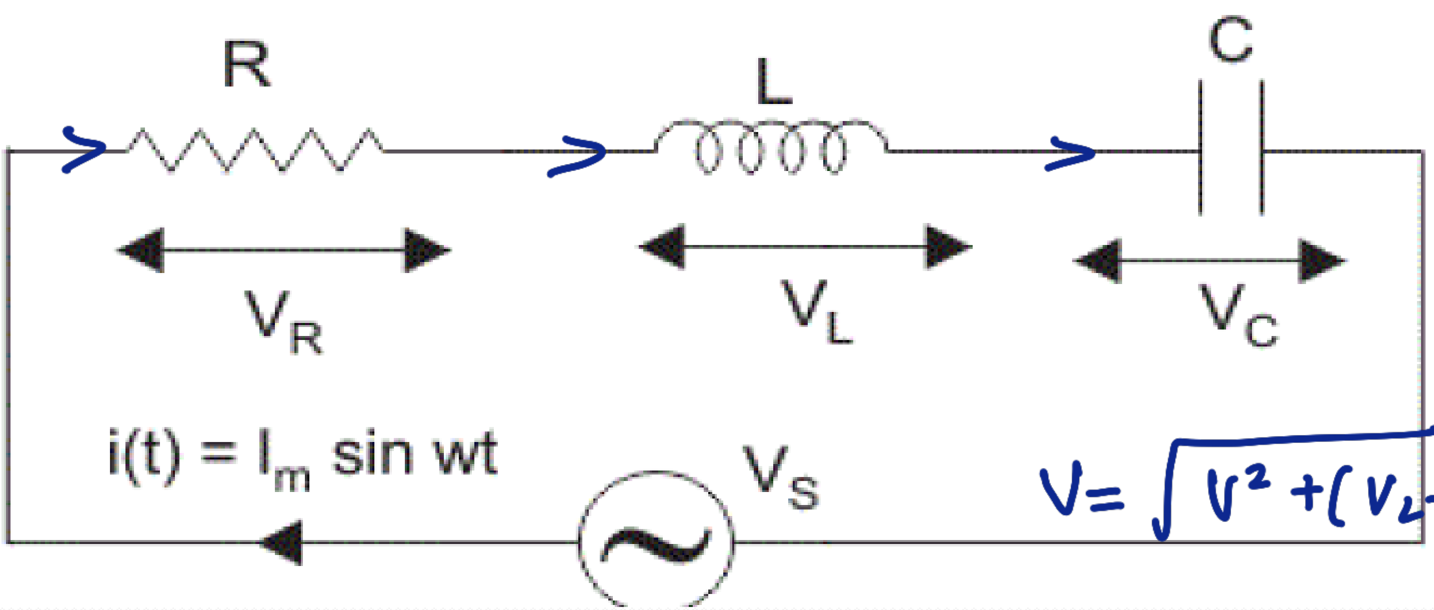
- V_R be the voltage across resistor, R.
- V_L be the voltage across inductor, L.
- V_C be the voltage across capacitor, C.
- X_L be the inductive reactance and X_C be the capacitive reactance.

ممانعة الملف

ممانعة المكثف

The total voltage in RLC circuit is not equal to algebraic sum of voltages across the resistor, the inductor and the capacitor; but it is a vector sum because, in case of resistor the voltage is in-phase with the current, for inductor the voltage leads the current by 90° and for capacitor, the voltage lags behind the current by 90°.So, voltages in each component are not in phase with each other; so they cannot be added arithmetically.

التيارات وتساوي قيمة التيار الكلي



$$V = \sqrt{V^2 + (V_L - V_C)^2}$$

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

$$Z = \angle\phi = R + jX \quad X_L - X_C$$

$$V_S = \sqrt{V_R^2 + (V_L - V_C)^2}$$

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

$$\phi = \tan^{-1}\left(\frac{X_L - X_C}{R}\right)$$

$$\underline{I_S = I_R = I_L = I_C}$$

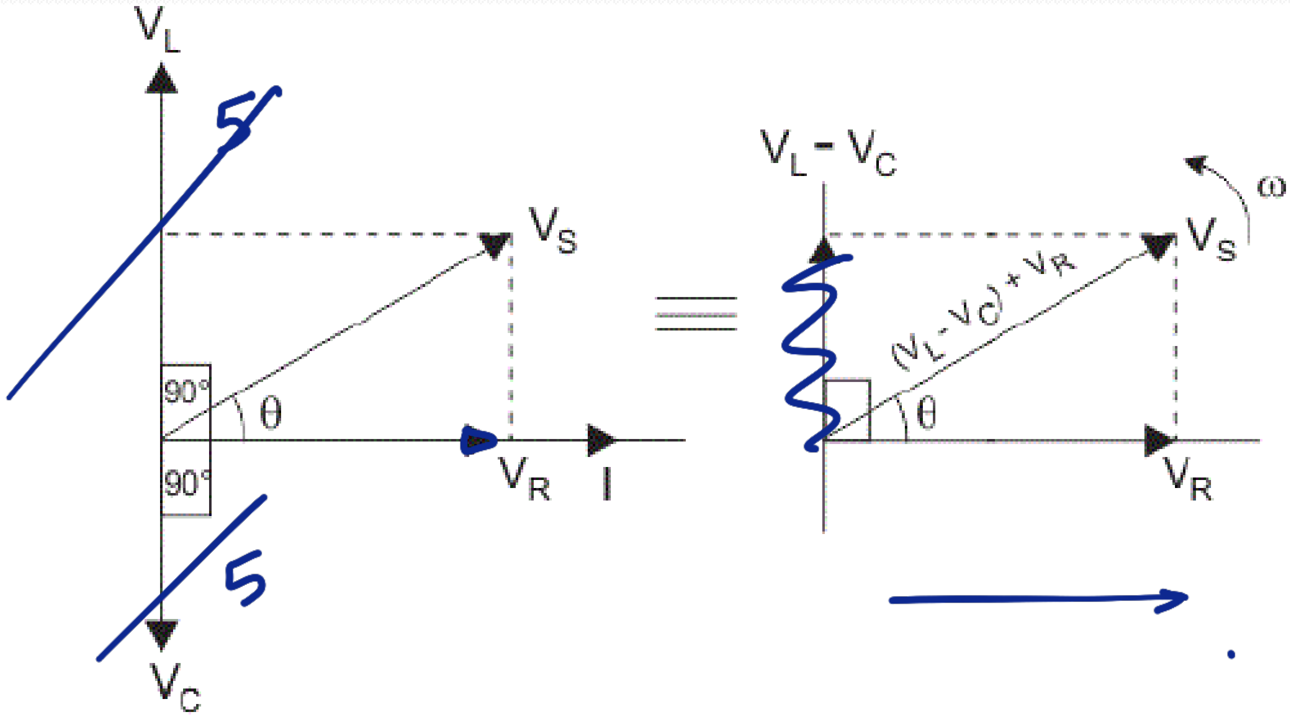
$$V_S^2 = V_R^2 + (V_L - V_C)^2 (if V_L > V_C)$$

$$V_S^2 = V_R^2 + (V_C - V_L)^2 (if V_L < V_C)$$

$$Where\ V_R = IR, V_L = IX_L, V_C = IX_C$$

Phasor Diagram

- The figure below shows the phasor diagram of series RLC circuit.
- For drawing the phasor diagram for RLC series circuit, the current is taken as reference because, in series circuit the current in each element remains the same and the corresponding voltage vectors for each component are drawn in reference to common current vector.

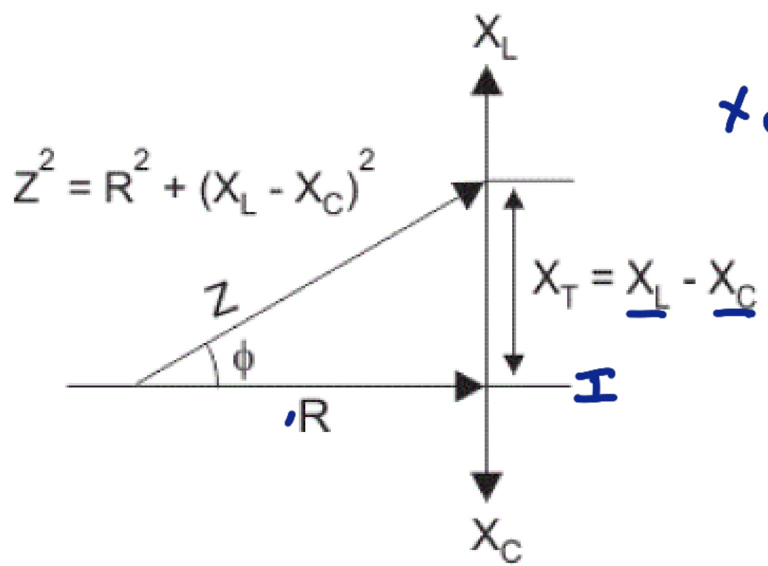


The Impedance for a Series RLC Circuit

The impedance Z of a series RLC circuit is defined as opposition to the flow of current due circuit resistance R, inductive reactance, XL and capacitive reactance, XC.

زاوية متأخرة

- If $X_L > X_C$, then the RLC circuit has lagging phase angle.
- if $X_C > X_L$ then, the RLC circuit have leading phase angle. زاوية طور متقدمة
- if both inductive and capacitive are same i.e $X_C = X_L$ then circuit will behave as purely resistive circuit.

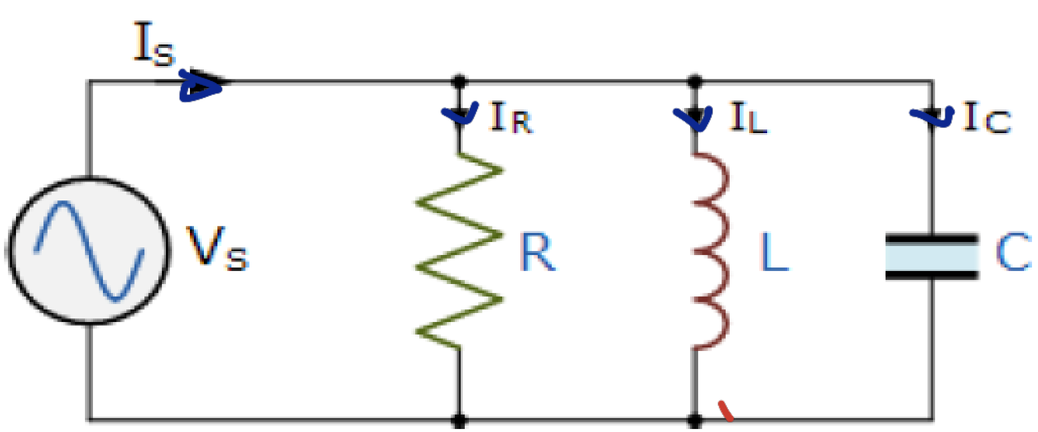


$x_c = x_L$

في حالة تساوي
تتصرف الدارة
وكأنها تحتوي
فقط على مقاومة

Parallel RLC Circuit

- In parallel RLC Circuit the resistor, inductor and capacitor are connected in parallel across a voltage supply so the voltage across each element is the same .
- The parallel RLC circuit is exactly opposite to the series RLC circuit.
- The applied voltage remains the same across all components and the supply current gets divided.
- The total current drawn from the supply is not equal to mathematical sum of the current flowing in the individual component, but it is equal to its vector sum of all the currents, as the current flowing in resistor, inductor and capacitor are not in the same phase with each other; so they cannot be added



$$G = \frac{1}{R},\quad B_L = \frac{1}{X_L},\quad B_C = \frac{1}{X_C}$$

$$Y = \frac{1}{Z} = \sqrt{G^2 + (B_L - B_C)^2}$$

$$I_S = \sqrt{I_R^2 + (I_L - I_C)^2}$$

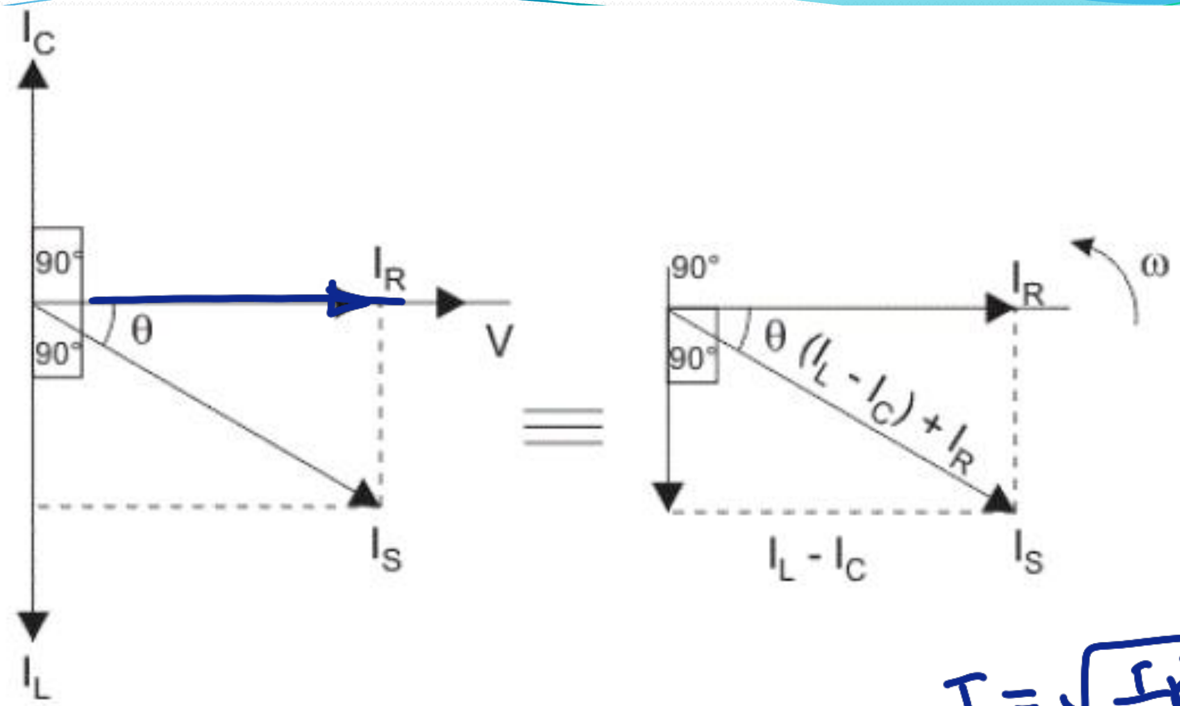
$$f_R = \frac{1}{2\pi\sqrt{LC}}$$

$$\omega = \frac{1}{\sqrt{LC}}$$

$$V_S = V_R = V_L = V_C$$

Phasor diagram of parallel RLC circuit

- I_R is the current flowing in the resistor, R in amps. I_C is the current flowing in the capacitor, C in amps. I_L is the current flowing in the inductor, L in amps. $\boxed{I_S}$ is the supply current in amps.
- for drawing phasor diagram, take voltage as reference vector and all the other currents I_R, I_L *and* I_C are drawn relative to this voltage vector. The current through each element can be found using Kirchhoff's Current Law, which states that the sum of currents entering a junction or node is equal to the sum of current leaving that node.



$I_c = \sqrt{I_R^2 + (I_L - I_C)^2}$

$$I_S^2 = I_R^2 + (I_L - I_C)^2$$

$$Now,\ I_R = \frac{V}{R}, I_C = \frac{V}{X_C}\ and\ I_L = \frac{V}{X_L}$$

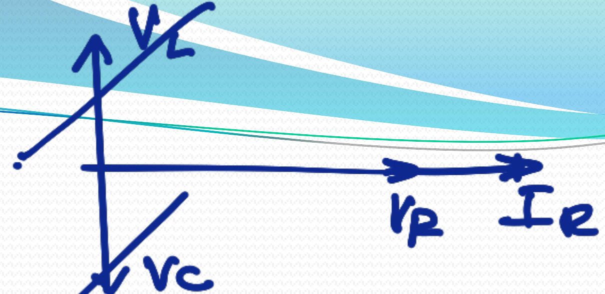
$$I_S = \sqrt{\frac{V^2}{R^2} + \left(\frac{V}{X_L} - \frac{V}{X_C}\right)^2}$$

$$So,\ admitance,\ \frac{1}{Z} = \frac{I_S}{V} = Y = \sqrt{\frac{1}{R^2} + \left(\frac{1}{X_L} - \frac{1}{X_C}\right)^2}$$

Resonance in RLC Circuit

- The passive components in AC circuits behave very differently than when connected in a DC circuit due to the influence of frequency, (f).
- In a purely resistive circuit, the current is in-phase with the voltage. In a purely capacitive circuit the current in the capacitor leads the voltage by 90° and in a purely inductive circuit the current lags the voltage by 90°.
- The opposition to current flow through a passive component in an AC circuit is called: **resistance**, R for a resistor, **capacitive reactance**, XC for a capacitor and **inductive reactance**, XL for an inductor. The combination of resistance and reactance is called **Impedance**. Z
- In a series circuit, the phasor sum of the voltages across the circuits components is equal to the supply voltage, VS. $V_s =$
- In a parallel circuit, the phasor sum of the currents flowing in each branch and therefore through each of the circuits components is equal to the supply current, IS. I

$X_C = X_L$



- For both parallel and series connected RLC circuits, when the supply current is "in-phase" with the supply voltage the circuit **resonance** occurs as $\boxed{X_C = X_L}$.

دارة الرنين

RLC — دارة مستقبلة

- A Series Resonance Circuit is known as an Acceptor Circuit.
- A Parallel Resonance Circuit is known as a Rejecter Circuit. دارة رافضة
- In **RLC circuit**, all these elements are linear and passive in nature; i.e. they consume energy rather than producing it and these elements have a linear relationship between voltage and current. There are number of ways of connecting these elements across voltage supply,

تستهلك طاقة

- The RLC circuit exhibits the property of resonance in same way as LC circuit exhibits, but in this circuit the oscillation dies out quickly as compared to LC circuit due to the presence of resistor in the circuit.

دارة رنين RLC تشبه في سلوكها دارات رنين RC

تكون دارات RLC تتلاشى الاهتزازات بعد فترة

في دارة عما يتم تخزين
الطاقة باحدى الطرق التالية

- In a circuit containing inductor and capacitor, the energy is stored in two different ways.

في الملف تخزن على شكل مجال مغناطيسي

1- When a current flows in a inductor, energy is stored in magnetic field.

في المكثف تخزن على شكل طاقة كهربائية

2- When a capacitor is charged, energy is stored in static electric field.

رنين

During resonance, at certain frequency called resonant frequency, f_r.

$$X_L = X_C$$

$$We\ know\ that,\ X_L = 2\pi f L\ and\ X_C = \frac{1}{2\pi f C}$$

$$Therefore\ at\ resonant\ frequency,\ f_r :, 2\pi f_r L = \frac{1}{2\pi f_r C}$$

قاعدة
الرنين

$$or\ \boxed{f = \frac{1}{2\pi\sqrt{LC}}}$$

$$\omega = \frac{1}{\sqrt{LC}}$$

توالي توازي

Difference between Series RLC Circuit and Parallel RLC Circuit

NO.	RLC SERIES CIRCUIT	RLC PARALLEL CIRCUIT
1	Resistor, inductor and capacitor are connected in series	Resistor, inductor and capacitor are connected in parallel
2	والتيار نفسه Current is same in each element والجهد مقسم	Current is different in all elements and the total current is equal to vector sum of each branch of current i.e $I_s^2 = I_R^2 + (I_C - I_L)^2$ التيار يتقسم على مكونات الدائرة
3	Voltage across all the elements is different and the total voltage is equal to the vector sum of voltages across each component i.e $V_s^2 = V_R^2 + (V_L - V_C)^2$	والجهد ثابت Voltage across each element remains the same
4	For drawing phasor diagram, current is taken as reference vector	For drawing phasor diagram, voltage is taken as reference vector
5	Voltage across each element is given by : $V_R = IR$, $V_L = I X_L$, $V_C = I X_C$	Current in each element is given by: $I_R = V / R$, $I_C = V / X_C$, $I_L = V / X_L$
6	Its more convenient to use impedance for calculations ممانعة	Its more convenient to use admittance for calculations مقلوب المعاوقة
7	At resonance , when $X_L = X_C$, the circuit has minimum impedance	At resonance, when $X_L = X_C$, the circuit has maximum impedance

اقل مقدار ممانعة اعلى ممانعة

RMS Voltage Equation

القيمة الفعالة

$$V_{RMS} = V_m \frac{1}{\sqrt{2}} = V_m \times 0.7071$$

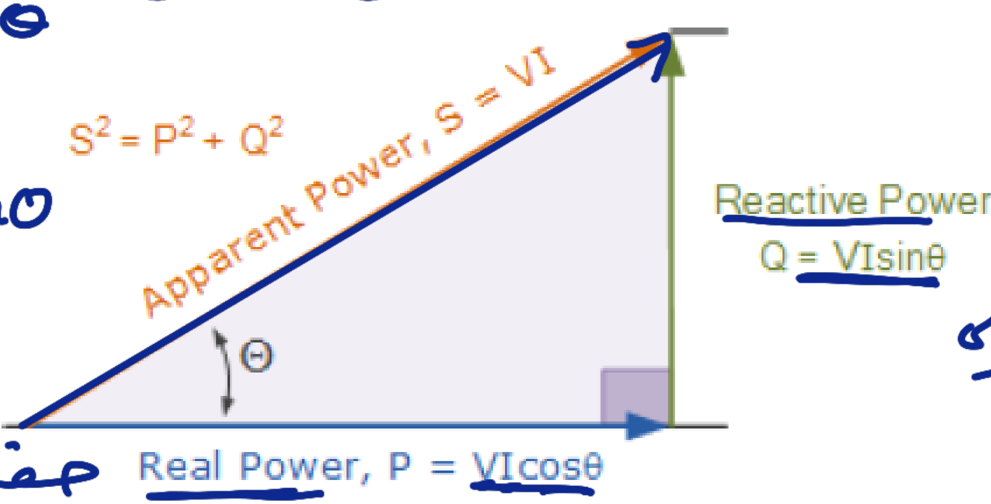
Average Voltage Equation

القيمة المتوسطة

$$V_{AVE} = \frac{2V_P}{\pi} = 0.637V_p$$

Power Triangle and Power Factor

$$P = IV \begin{cases} VI\cos\Theta \\ VI\sin\Theta \end{cases}$$



تخيلي

حقيقي

The three circuit elements which make up the electrical power consumed in an AC circuit can be represented by the three sides of a right angled triangle, known commonly as a power triangle.

القدره

Power in AC Circuits

$$P = V \times I = \frac{V^2}{R} = I^2 \times R \quad \text{(watts)}$$

Where: **V** is the dc voltage, **I** is the dc current and **R** is the value of the resistance.

القدره اللحظيه

Instantaneous AC Power Equation

$$\boxed{p = V \times I \cos\theta}$$

where **V** and **I** are the sinusoids rms values, and **θ** (Theta) is the phase angle between the voltage and the current. The units of power are in watts (W).

The AC Power dissipated in a circuit can also be found from the impedance, Z of the circuit using the voltage, V_{rms} or the current, I_{rms} flowing through the circuit

$$P = \frac{V^2}{Z} \cos\theta$$

$$= I^2 Z \cos\theta$$

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

$$\theta = \cos^{-1}\frac{R}{Z}, \quad \text{or} \quad \sin^{-1}\frac{X_L}{Z}, \quad \text{or} \quad \tan^{-1}\frac{X_L}{R}$$

$$\boxed{\therefore P = \frac{V^2}{Z}\cos(\theta) \quad \text{or} \quad P = I^2 Z \cos(\theta)}$$

قانون حساب القدرة
اللحظية في حال وجود
مكونات سلبية
في الدارة

$R \quad X_L \quad X_C$