Basic Electrical Engineering ONESHOTS

Unit 3

AC Fundamentals

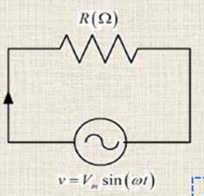
$$\boxed{I_{rms} = \sqrt{\frac{i_m^2}{2}} = \frac{I_m}{\sqrt{2}} = 0.707 I_m}$$

$$\boxed{I_{av} = \frac{2I_m}{\pi} = 0.637\, I_m}$$

$$K_{ff} = \frac{I_{rms}}{I_{avg}} = \frac{\frac{I_m}{\sqrt{2}}}{\frac{2I_m}{\pi}} = \frac{\pi}{2\sqrt{2}} = 1.11$$

$$K_{pf} = \frac{I_m}{0.707 I_m} = \sqrt{2} = 1.414$$

Purely Resistive:
Let us consider pure resistance across a 1- φ AC supply



$v = V_m \sin\omega t$

$i = \frac{v}{R}$

$i = \frac{V_m \sin\omega t}{R} = \frac{V_m}{R}\sin\omega t$

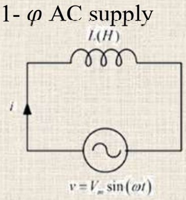
$i_m = \frac{V_m}{R}$

$i = i_m \sin\omega t$

$v = V_m \sin\omega t$

Here ωL *is* inductive reactance. it is represent by $X_L = \omega L = 2\pi f L$

Purely Inductive:
Let us consider pure inductance across a 1- φ AC supply



According to faraday law of electromagnetic induction, induce emf in the inductor is :

$e = -L\frac{di}{dt}$

$i = -\frac{1}{L}\int e\,dt$

According to lenz's law

v = -e, so

$i = \frac{1}{L}\int v dt \ldots\ldots(4)$

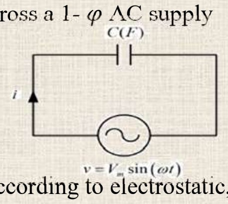
$i = \frac{1}{L}\int V_m \sin\omega t dt$

$i = \frac{V_m}{L}\left(\frac{-\cos\omega t}{\omega}\right) = \frac{V_m}{\omega L}\sin(\omega t - 90)$

$i = \frac{V_m}{X_L}\sin(\omega t - 90) = I_m \sin(\omega t - 90)$

$v = V_m \sin\omega t$

Purely Capacitive:
Let us consider pure capacitance across a 1- φ AC supply



According to electrostatic, the charge in capacitor is:

$q = c \times v$

We know that current is

$i = \frac{dq}{dt}$

$i = c\frac{dv}{dt}$

$i = C\frac{dV_m \sin\omega t}{dt} = C\,V_m \frac{d}{dt}\sin\omega t$

$i = \omega C\,V_m \cos\omega t = \frac{V_m}{\frac{1}{\omega C}}\cos\omega t$

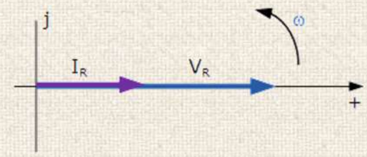
$i = \frac{V_m}{X_C}\sin(\omega t + 90)$

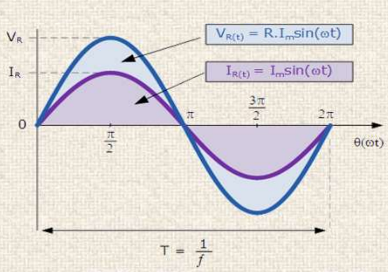
$i = I_m \sin(\omega t + 90)$

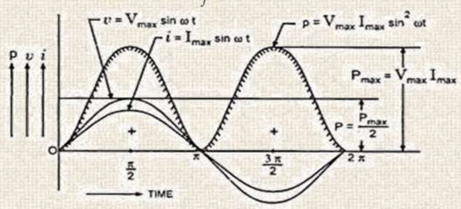
$v = V_m \sin\omega t$

Here $\frac{1}{\omega C}$ *is* capacitive reactance. it is represent by $X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$

Purely resistive







Instantaneous Power

$$p = v \times i$$

$$p = v_{max}\sin\omega t \times i_{max}\sin\omega t$$

$$= v_{max} i_{max}\sin^2\omega t$$

$$= v_{max} i_{max}\left(\frac{1-\cos 2\omega t}{2}\right)$$

$$p = \frac{v_{max}}{\sqrt{2}}\frac{i_{max}}{\sqrt{2}} - \frac{v_{max}}{\sqrt{2}}\frac{i_{max}}{\sqrt{2}}\cos 2\omega t$$

$$p = v_{rms}\, i_{rms} - v_{rms}\, i_{rms}\cos 2\omega t$$

Average Power

For a complete cycle i.e. 0 to 2π Part two is zero

$$\boxed{P_{av} = v_{rms}\ i_{rms}}$$

$$\boxed{\text{Power factor} = \cos\emptyset = 1}$$

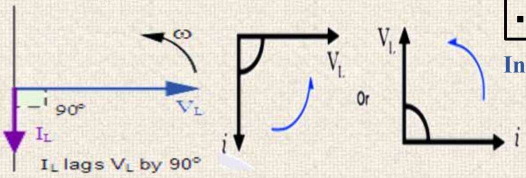
$$\boxed{S = V \times I}$$

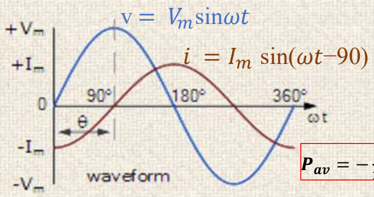
$$\boxed{P = V \times I \times \cos\emptyset = V \times I}$$

$$\boxed{Q = V \times I \times \sin\emptyset = 0}$$

Purely Inductive

- Voltage and current not in-phase quantity
- Current lags 90^o by voltage
- Voltage leads 90^o by current



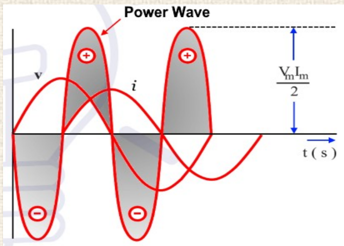


Instantaneous Power $p = v \times i$

$$p = v_{max}\sin\omega t \times i_{max}\sin(\omega t - 90)$$
$$= -v_{max}\sin\omega t\, i_{max}\cos\omega t$$
$$= -\frac{v_{max} i_{max}}{2} 2\sin\omega t\cos\omega t$$
$$p = -\frac{v_{max}}{\sqrt{2}}\frac{i_{max}}{\sqrt{2}}\sin 2\omega t$$
$$\boxed{p = -v_{rms}\ i_{rms}\ \sin 2\omega t}$$

Power for a complete cycle i.e. 0 to 2π

$$\boxed{P_{av} = -\frac{1}{2\pi}\int_0^{2\pi} v_{rms}\ i_{rms}\ \sin 2\omega t\ d\omega t \quad = -\frac{1}{2\pi} v_{rms}\ i_{rms}\int_0^{2\pi}\sin 2\omega t\ d\omega t = 0}$$



$\boxed{P_{av} = 0}$

Hence, the average power consumed in a purely inductive circuit is zero.

Phase angle $\emptyset = 90$ lagging

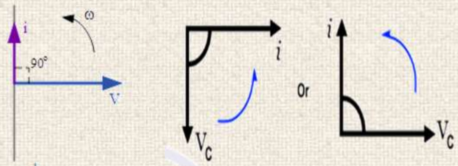
$\boxed{\text{Power factor} = \cos\emptyset = 0}$ $\boxed{S = V \times I}$

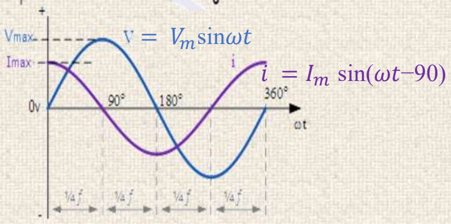
$\boxed{P = V \times I \times \cos\emptyset = 0}$

$\boxed{Q = V \times I \times \sin\emptyset = V \times I}$

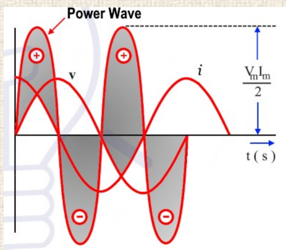
Purely Capacitive

- Voltage and current not in-phase quantity
- Current lead 90^o by voltage
- Voltage lag 90^o by current





- Circuit
- $v = V_m \sin\omega t$
- $i = \frac{v}{R}$
- $i = I_m \sin\omega t$
- Phasor Diagram
- Waveform Diagram
- Phase Angle
- Instantaneous Power
- Average Power
- Power Factor
- Power Waveform
- Apparent Power
- Active Power
- Reactive Power



Phase angle $\emptyset = 90$ leading

$\boxed{\text{Power factor} = \cos\emptyset = 0}$

$p = v_{rms}\ i_{rms}\ \sin 2\omega t$

$\boxed{P_{av} = 0}$

$\boxed{S = V \times I}$ $\boxed{P_{av} = v_{rms}\ i_{rms}}$

$\boxed{P = V \times I \times \cos\emptyset = 0}$

$\boxed{Q = V \times I \times \sin\emptyset = V \times I}$

Power factor:

It is the ratio of Power actually consumed in the circuit to the total power supplied.
It is the ratio of true power to apparent power.
It cannot be greater than 1.
Since the actual power is consumed In the resistance and the total power is supplied to the impedance it is also defined as the ratio of resistance to impedance.

$$\text{Power factor} = \frac{\text{True Power}}{\text{Apparent Power}} = \frac{VI\cos\phi}{VI} = \cos\phi$$

Apparent power

It is the total power supplied by the source to the circuit.
The product of root mean square (RMS) value of voltage and current is known as Apparent Power.
This power is measured in kVA or MVA.

$$S = V \times I$$

Active power

- ✓ The power which is actually consumed or utilized in an AC Circuit is called True power, Active Power, Real power or Actual power
- ✓ The product of apparent power and power factor is called active power
- ✓ It is measured in kilo watt (kW) or MW.

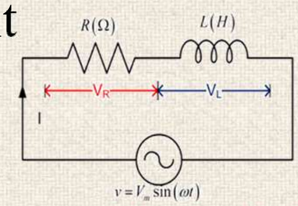
$$P = V \times I \times \cos\emptyset$$

Reactive power

The power which flows back and froth that mean it moves in both the direction in the circuit or react upon itself, is called Reactive Power
The product of apparent power and "sin" angle is called reactive power
The reactive power is measured in kilo volt ampere reactive (KVAR) or MVAR.

$$Q = V \times I \times \sin\emptyset$$

1-φ AC on Series R-L Circuit



From the series RL circuit diagram
- ✓ Apply KVL then

$$V = V_R + V_L \ldots..(1)$$

Since $V_R = I_R \times R = I \times R$

$V_L = I_L \times X_L = I \times jX_L$

Put the value of V_R & V_L in eq^n (1), then

$$V = I\,(R + jX_L)$$

$$\frac{V}{I} = (R + jX_L) \ldots\ldots(2)$$

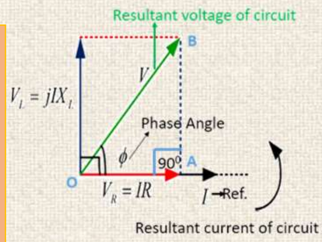
From eq^n (2) define the impedance and phase angle of series RL circuit

$Z = R + jX_L$ (in rectangular form)

$Z = |Z|\angle\phi$ (in polar form) where

$$|Z| = \sqrt{R^2 + {X_L}^2} \quad and\ \emptyset = \tan^{-1}\frac{X_L}{R}$$

Impedance is the opposition to alternating current presented by the combined effect of resistance and reactance in a circuit.



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

$$\tan\emptyset = \frac{\text{perpendicular}}{\text{base}} = \frac{V_L}{V_R} = \frac{I X_L}{IR} = \frac{X_L}{R}$$

$$\boxed{\emptyset = \tan^{-1}\frac{X_L}{R}}$$

Instantaneous Power $p = v \times i$

$$p = v_{max}\sin\omega t \times i_{max}\sin(\omega t - \phi)$$

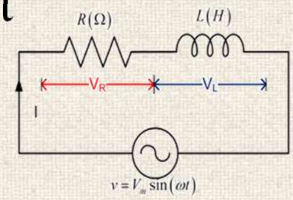
$$= v_m i_m[\sin\omega t\,\sin(\omega t - \phi)] =$$

$$= \frac{v_m i_m}{2}[\cos\phi - \cos(2\omega t - \phi)]$$

$$p = \frac{v_m i_m}{2}\cos\phi - \frac{v_m i_m}{2}\cos(2\omega t - \phi)$$

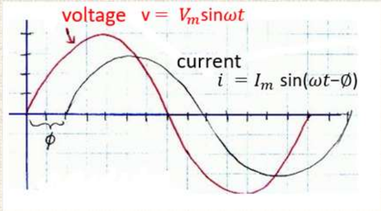
Vector sum of resistance and inductive reactance is called **Impedance** of series RL circuit

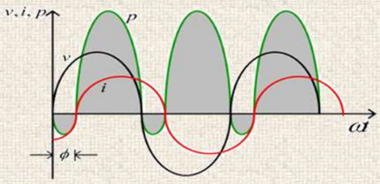
1-φ AC on Series R-L Circuit

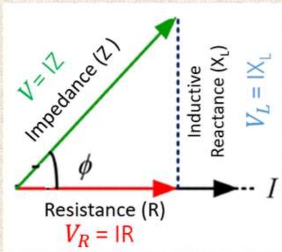


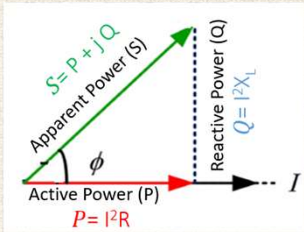
$$PF = \cos\emptyset = \frac{Base}{Hypotenuse} = \frac{V_R}{V} = \frac{IR}{I\,Z} = \frac{R}{Z}$$

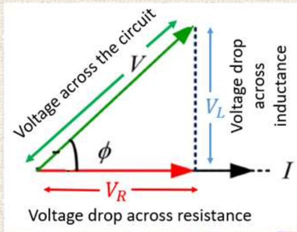
$$\sin\emptyset = \frac{\text{Perpendicular}}{Hypotenuse} = \frac{V_L}{V} = \frac{I\,XL}{I\,Z} = \frac{X_L}{Z}$$











1-φ AC on Series R-L Circuit

Average Power

$$P_{av} = \frac{1}{2\pi}\int_0^{2\pi}\left(\frac{v_m i_m}{2}\cos\phi - \frac{v_m i_m}{2}\cos(2\omega t - \phi)\right)d\omega t$$

Since the integration of cosine over a complete cycle is zero. Second term will be zero.

$$\therefore P_{av} = \frac{1}{2\pi}\int_0^{2\pi}\frac{v_m i_m}{2}\cos\phi\, d\omega t = \frac{v_m i_m}{2}\cos\phi$$

$$\boxed{P_{av} = V_{rms} I_{rms} \cos\phi}$$

$$PF = \cos\emptyset = \frac{Base}{Hypotenuse} = \frac{V_R}{V} = \frac{IR}{I\,Z} = \frac{R}{Z} = \frac{R}{\sqrt{R^2+X_L^2}}$$

$$\sin\emptyset = \frac{\text{Perpendicula}}{Hypotenuse} = \frac{V_L}{V} = \frac{I\,X_L}{I\,Z} = \frac{X_L}{Z} = \frac{X_L}{\sqrt{R^2+X_L^2}}$$

$S = V\,I = I^2\,Z = \frac{V^2}{Z} = P + jQ$ Apparent Power

$P = V \times I \times \cos\emptyset = I^2 R = \frac{V^2}{R}$ Active Power

$Q = V \times I \times \sin\emptyset = I^2 X_L = \frac{V^2}{X_L}$ Reactive Power

- Circuit
- $v = V_m \sin\omega t$
- $i = \frac{v}{Z}$
- $i = I_m \sin\omega t$
- Phasor Diagram
- Waveform Diagram
- Phase Angle
- Instantaneous Power
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- Power Waveform
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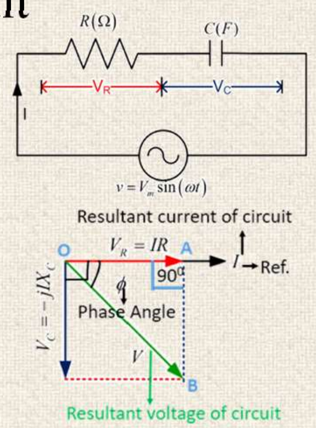
- Active Power
- Reactive Power

1-φ AC on Series R-C Circuit



From the series RC circuit diagram

✓ Apply KVL then

$$\mathbf{V} = \mathbf{V_R} + \mathbf{V_C} \ldots\ldots (1)$$

Since $V_R = I_R \times R = I \times R$

$V_C = I_L \times -jX_C = -I \times jX_C$

Put the value of V_R & V_C in eq^n (1), then

$V = I\,(R - jX_C)$

$\frac{V}{I} = (R - jX_C) \ldots\ldots(2)$

From eq^n (2) define the impedance and phase angle of series RL circuit

$Z = R - jX_C$ (in rectangular form)

$Z = |Z|\angle\phi$ (in polar form) where

$|Z| = \sqrt{R^2 + X_C{}^2}$ *and* $\emptyset = \tan^{-1}\frac{-X_C}{R}$

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

$$\tan\emptyset = \frac{\text{perpendicular}}{\text{base}} = \frac{V_L}{V_R} = \frac{-I\,X_C}{IR} = -\frac{X_C}{R}$$

$$\boxed{\emptyset = \tan^{-1}\frac{-X_C}{R}}$$

Instantaneous Power $p = v \times i$

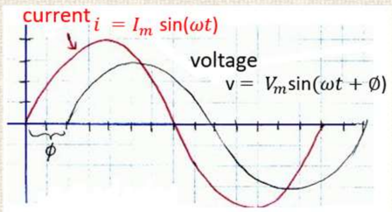
$$p = v_{max}\sin\omega t \times i_{max}\sin(\omega t + \phi)$$
$$= v_m i_m[\sin\omega t\,\sin(\omega t + \phi)]$$
$$= \frac{v_m i_m}{2}[\cos\phi - \cos(2\omega t + \phi)]$$
$$p = \frac{v_m i_m}{2}\cos\phi - \frac{v_m i_m}{2}\cos(2\omega t + \phi)$$

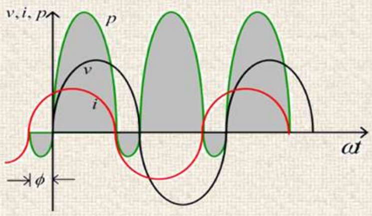
Vector sum of resistance and inductive reactance is called **Impedance** of series RL circuit

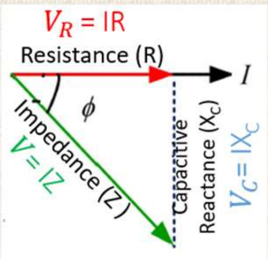
1-φ AC on Series R-C Circuit

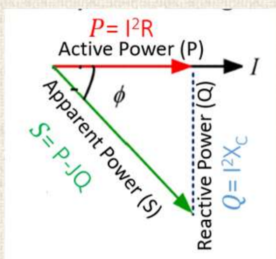
$$\textbf{Power Factor} = \cos\emptyset = \frac{Base}{Hypotenuse} = \frac{V_R}{V} = \frac{IR}{I\,Z} = \frac{R}{Z}$$

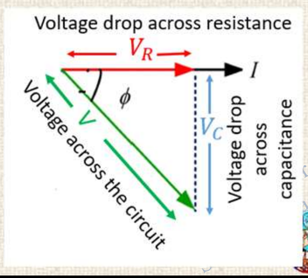
$$\sin\emptyset = \frac{\text{perpendicular}}{Hypotenuse} = \frac{V_C}{V} = \frac{I\,X_C}{I\,Z} = \frac{X_C}{Z}$$











1-φ AC on Series R-C Circuit

Average Power

$$P_{av} = \frac{1}{2\pi}\int_0^{2\pi}\left(\frac{v_m i_m}{2}\cos\phi - \frac{v_m i_m}{2}\cos(2\omega t + \phi)\right)d\omega t$$

Since the integration of cosine over a complete cycle is zero. Second term will be zero.

$$\therefore P_{av} = \frac{1}{2\pi}\int_0^{2\pi}\frac{v_m i_m}{2}\cos\phi\, d\omega t = \frac{v_m i_m}{2}\cos\phi$$

$$\boxed{P_{av} = V_{rms} I_{rms}\cos\phi}$$

$$\text{PF} = \cos\emptyset = \frac{Base}{Hypotenuse} = \frac{V_R}{V} = \frac{IR}{IZ} = \frac{R}{Z} = \frac{R}{\sqrt{R^2+X_C^2}}$$

$$\sin\emptyset = \frac{\text{Perpendicul}}{Hypotenuse} = \frac{V_L}{V} = \frac{I\,XL}{I\,Z} = \frac{X_c}{Z} = \frac{X_C}{\sqrt{R^2+X_C^2}}$$

Apparent Power

$$S = VI = I^2 Z = \frac{V^2}{Z} = P + jQ$$

Active Power

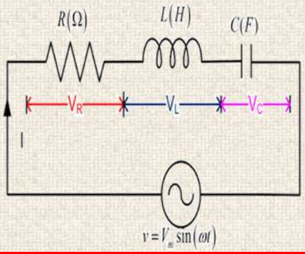
$$P = V \times I \times cos\emptyset = I^2 R = \frac{V^2}{R}$$

Reactive Power

$$Q = V \times I \times sin\emptyset = I^2 X_L = \frac{V^2}{X_C}$$

- Circuit
- Impedance
- Phase angel
- $i = I_m \sin\omega t$
- Phasor Diagram
- Waveform Diagram
- Phase Angle
- Instantaneous Power
- Average Power
- Power Factor
- Power Waveform
- Apparent Power
- Active Power
- Reactive Power

1-φ AC on Series R-L-C Circuit



For the better understanding of series R-L-C circuit Here consider three different case

a) **Case I $X_L > X_C$**
b) **Case II $X_L < X_C$**
c) **Case III $X_L = X_C$**

Case I $X_L > X_C$

Series RLC phasor diagram under case I i.e. $X_L > X_C$

From the series RLC circuit diagram

✓ Apply KVL then

$$V = V_R + V_L + V_C \ldots..(1)$$

Since $V_R = I \times R$; $V_L = I \times jX_L$; $V_C = I \times (-jX_C)$

Put the value of V_R & V_L in eq^n (1), then

$$V = I\,(R + j(X_L - X_C))$$

$$\frac{V}{I} = R + j(X_L - X_C) \ldots\ldots(2)$$

From eq^n (2) define the impedance and phase angle of series RL circuit

$Z = R + j(X_L - X_C)$(in rectangular form)

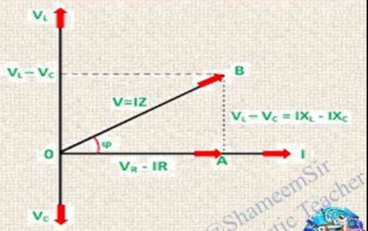
$Z = |Z|\angle\phi$ (in polar form) where

$$|Z| = \sqrt{R^2 + (X_L - X_C)^2} \quad and\ \emptyset = \tan^{-1}\frac{(X_L - X_C)}{R}$$

✓ when $X_L > X_C$ the circuit is predominantly RL circuit

✓ $X_L \longrightarrow X_L - X_C$

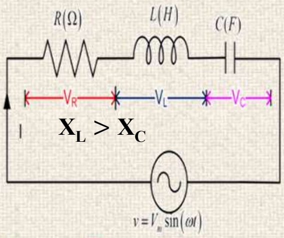
✓ $V_L \longrightarrow V_L - V_C$

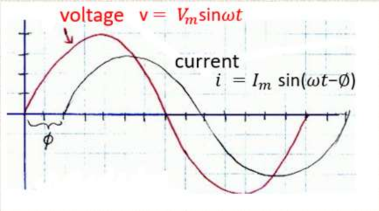


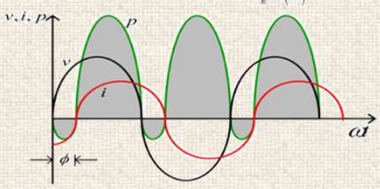
1-$\boldsymbol{\varphi}$ AC on Series R-L-C Circuit

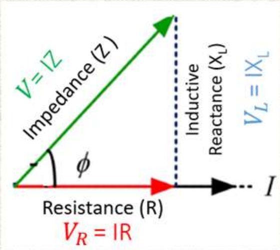
$$\text{PF} = \cos\emptyset = \frac{Base}{Hypotenuse} = \frac{V_R}{V} = \frac{IR}{I\,Z} = \frac{R}{Z}$$

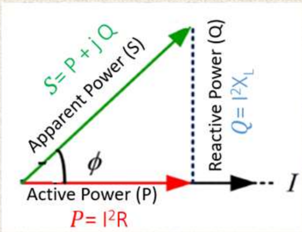
$$\sin\emptyset = \frac{\text{Perpendicula}}{Hypotenuse} = \frac{V_L}{V} = \frac{I\,(X_L - X_C)}{I\,Z} = \frac{X_L - X_C}{Z}$$

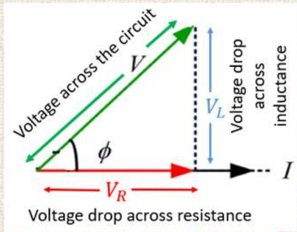












1-$\boldsymbol{\varphi}$ AC on Series R-L-C Circuit

$$\text{PF} = \cos\emptyset = \frac{Base}{Hypotenuse} = \frac{V_R}{V} = \frac{IR}{I\,Z} = \frac{R}{Z} = \frac{R}{\sqrt{R^2 + (X_L - X_C)^2}}$$

$$\sin\emptyset = \frac{\text{Perpendicula}}{Hypotenuse} = \frac{V_L}{V} = \frac{I\,X_L}{I\,Z} = \frac{X_L}{Z} = \frac{X_L}{\sqrt{R^2 + (X_L - X_C)^2}}$$

$$\text{S} = \text{V I} = \text{I}^2\,\text{Z} = \frac{\text{V}^2}{\text{Z}} = P + jQ$$ Apparent Power

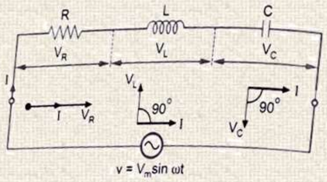
$$\text{P} = \text{V} \times I \times cos\emptyset = \text{I}^2\,\text{R} = \frac{\text{V}^2}{\text{R}}$$ Active Power

$$\text{Q} = \text{V} \times I \times sin\emptyset = \text{I}^2\,\text{X}_\text{L} = \frac{\text{V}^2}{X_L - X_C}$$ Reactive Power

1-φ AC on Series R-L-C Circuit

Case II $X_C > X_L$

Series RLC phasor diagram under case I i.e. $X_C > X_L$



From the series RLC circuit diagram

- ✓ Apply KVL then

$$V = V_R + V_L + V_C \;..... (1)$$

Since $V_R = I \times R$; $V_L = I \times jX_L$; $V_C = I \times (-jX_C)$

Put the value of V_R & V_L in eq^n (1), then

$$V = I\,(R + j(X_L - X_C)) \quad (since\ X_C > X_L)$$

$$\frac{V}{I} = R - j(X_C - X_L) \;......(2)$$

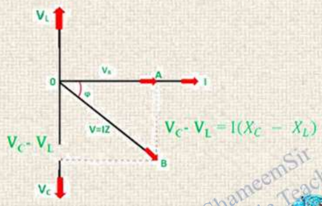
From eq^n (2) define the impedance and phase angle of series RL circuit

$Z = R - j(X_C - X_L)$ (in rectangular form)

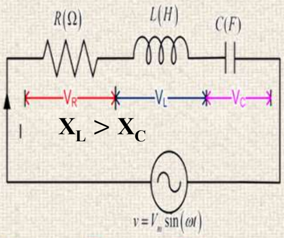
$Z = |Z|\angle\phi$ (in polar form) where

$$|Z| = \sqrt{R^2 + (X_C - X_L)^2} \quad and\ \emptyset = \tan^{-1}\frac{-(X_C - X_L)}{R}$$

- ✓ when $X_C > X_L$ the circuit is predominantly RC circuit
- ✓ $X_C \longrightarrow X_C - X_L$
- ✓ $V_C \longrightarrow V_C - V_L$

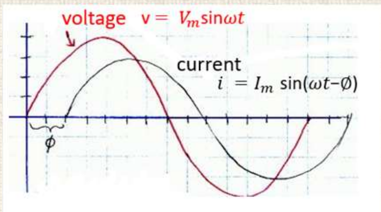


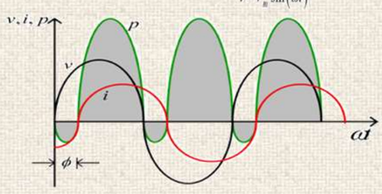
1-φ AC on Series R-L-C Circuit

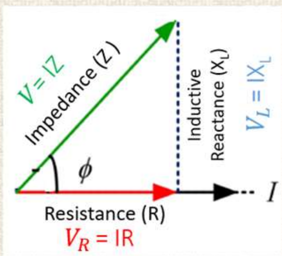


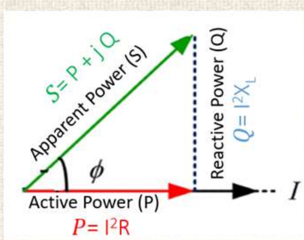
$$PF = \cos\emptyset = \frac{Base}{Hypotenuse} = \frac{V_R}{V} = \frac{IR}{I\,Z} = \frac{R}{Z}$$

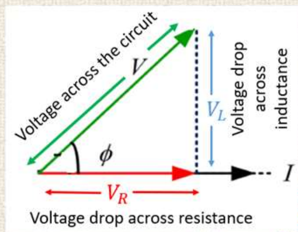
$$\sin\emptyset = \frac{\text{Perpendicular}}{Hypotenuse} = \frac{V_L}{V} = \frac{I\,(X_L - X_C)}{I\,Z} = \frac{X_C - X_L}{Z}$$











1-φ AC on Series R-L-C Circuit

$$PF = \cos\phi = \frac{Base}{Hypotenuse} = \frac{V_R}{V} = \frac{IR}{I\,Z} = \frac{R}{Z} = \frac{R}{\sqrt{R^2+X_L^2}}$$

$$\sin\phi = \frac{\text{Perpendicula}}{Hypotenuse} = \frac{V_L}{V} = \frac{I\,X_L}{I\,Z} = \frac{X_L}{Z} = \frac{X_L}{\sqrt{R^2+(X_C-X_L)^2}}$$

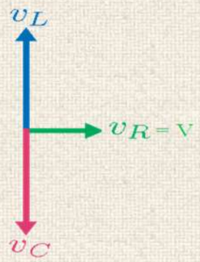
$$S = V\,I = I^2\,Z = \frac{V^2}{Z} = P + jQ$$ Apparent Power

$$P = V \times I \times \cos\phi = I^2\,R = \frac{V^2}{R}$$ Active Power

$$Q = V \times I \times \sin\phi = I^2\,X_L = \frac{V^2}{X_C - X_L}$$ Reactive Power

Case III $X_L = X_C$

Note –
- ✓ when X_L=X_C the circuit is predominantly R circuit
- ✓ This case also called resonance state of series RLC circuit



From the series RLC circuit diagram
✓ Apply KVL then

$$V = V_R + (V_L + V_C) \ldots..(1)$$

Since $V_R = I_R \times R = I \times R$

$V_L = I_L \times jX_L = I \times jX_L$

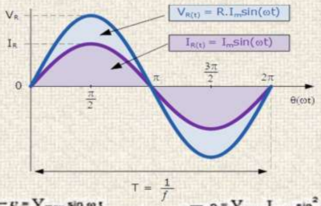
$V_C = I_C \times -jX_C = -I \times jX_C$

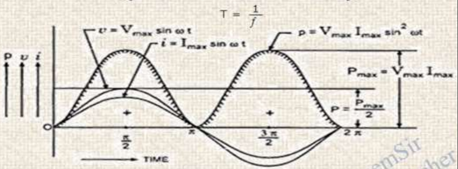
Net reactance voltage resultant is zero because $X_L = X_C$

$$V = V_R + j0 = IR$$

$$\frac{V}{I} = R \ldots\ldots\ldots\ldots\ldots\ldots..(2)$$

From eqn (2) $\boxed{Z = R}$ & $\boxed{\phi = \tan^{-1}\frac{(0)}{R} = 0}$

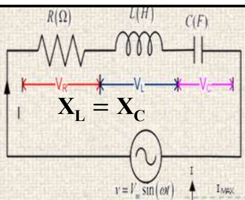




Summary of RLC Circuits :

Sr. No.	Circuit	Impedance (Z) Polar	Impedance (Z) Rectangular	ϕ	p.f. $\cos\phi$	Remark
1.	Pure R	$R \angle 0^\circ \,\Omega$	$R + j0\,\Omega$	0°	1	Unity p.f.
2.	Pure L	$X_L \angle 90^\circ \,\Omega$	$0 + j\,X_L\,\Omega$	90°	0	Zero lagging
3.	Pure C	$X_C \angle -90^\circ \,\Omega$	$0 - j\,X_C\,\Omega$	-90°	0	Zero leading
4.	Series RL	$\lvert Z\rvert \angle +\phi^\circ \,\Omega$	$R + j\,X_L\,\Omega$	$0^\circ \angle \phi \angle 90^\circ$	$\cos\phi$	Lagging
5.	Series RC	$\lvert Z\rvert \angle -\phi^\circ \,\Omega$	$R - jX_C\,\Omega$	$-90^\circ \angle \phi \angle 0^\circ$	$\cos\phi$	Leading
6.	Series RLC	$\lvert Z\rvert \angle \pm\phi^\circ \,\Omega$	$R + j\,X\,\Omega$ $X = X_L - X_C$	ϕ	$\cos\phi$	$X_L > X_C$ Lagging; $X_L < X_C$ Leading; $X_L = X_C$ Unity

Resonance



- ✓ In a series RLC circuit when inductive reactance of the inductor becomes equal in value to the capacitive reactance of the capacitor is called resonance series RLC circuit
- ✓ In other words, $X_L = X_C$. The point at which this occurs is called the **Resonant Frequency** point, (f_r) of the circuit,

According to resonance circuit

$X_L = X_C$

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

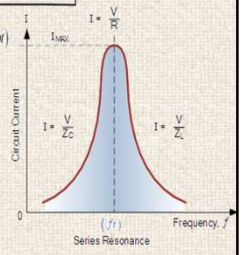
$\omega^2 = \frac{1}{LC}$

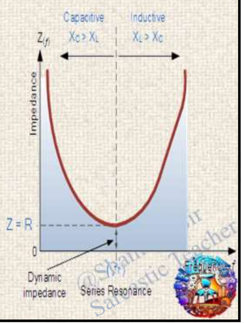
$\omega = \frac{1}{\sqrt{LC}}$

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

Resonant Frequency $f_r = \frac{1}{2\pi\sqrt{LC}}$

- Reactive part is zero i.e. imaginary part is zero
- Acceptor Circuit
- impedance value is very less/minimum i.e. Z=R
- current value is very high
- capacitive and inductive reactance equal and opposite
- phase angle is zero
- Power factor is unity





Admittance Useful in parallel circuits

- ✓ Conductance is the reciprocal of resistance: G =1/R
- ✓ Susceptance is the reciprocal of reactance: B =1/X
- ✓ Vector sum of conductance and Susceptance is called admittance
- ✓ Admittance is the reciprocal of impedance: Y =1/Z

Admittance in RL circuit

$\boxed{Y = G - jB_L}$ or $\boxed{Y = \sqrt{G^2 + B_L{}^2}}$

Admittance in RC circuit

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

Admittance in RLC circuit

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

$$\boxed{Y = \frac{I}{V}}$$

Admittance for series circuit

Ans. : Admittance is defined as the reciprocal of the impedance. It is denoted by Y and is measured in unit **siemens** or **mho**.

- Consider an impedance given as, $Z = R \pm jX$
- Positive sign for inductive and negative for capacitive circuit.

Admittance $Y = \frac{1}{Z} = \frac{1}{R \pm jX}$

- Rationalising the above expression,

$$Y = \frac{R \mp jX}{(R \pm jX)(R \mp jX)} = \frac{R \mp jX}{R^2 + X^2} = \left(\frac{R}{R^2 + X^2}\right) \mp j\left(\frac{X}{R^2 + X^2}\right)$$

$$= \frac{R}{Z^2} \mp j\frac{X}{Z^2}$$

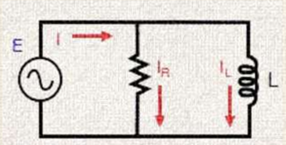
$\therefore$ $\boxed{Y = G \mp jB \text{ where } G = \text{Conductance} = \frac{R}{Z^2}, \quad B = \text{Susceptance} = \frac{X}{Z^2}}$

Analysis of 1-φ AC parallel R-L Circuit

From phasor diagram

$v = V_m \sin\omega t$

$i = I_m \sin(\omega t - \emptyset)$



From the parallel RL circuit diagram

✓ Apply KCL then $I = I_R + I_L$ ..... (1)

Since $I_R = V_R / R = V_R \times G$

$I_L = V_L / jX_L = -V_L \times jB_L$

Put the value of I_R & I_L in eq^n (1), then

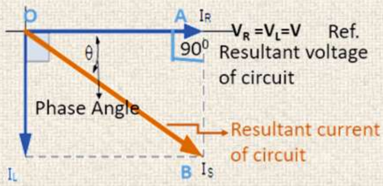
$I = (V_R / R + V_L / jX_L) = (V_R G - jV_L B_L)$

$\frac{I}{V} = (G - jB_L)$ ......(2) Since $V = V_R = V_L$

From eq^n (2) define the Admittance and phase angle of parallel RL circuit

$\boxed{Y = G - jB_L}$ And $\boxed{\emptyset = \tan^{-1}\left(-\frac{B_L}{G}\right)}$

$\boxed{Y = 1/Z}$



Thank You

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