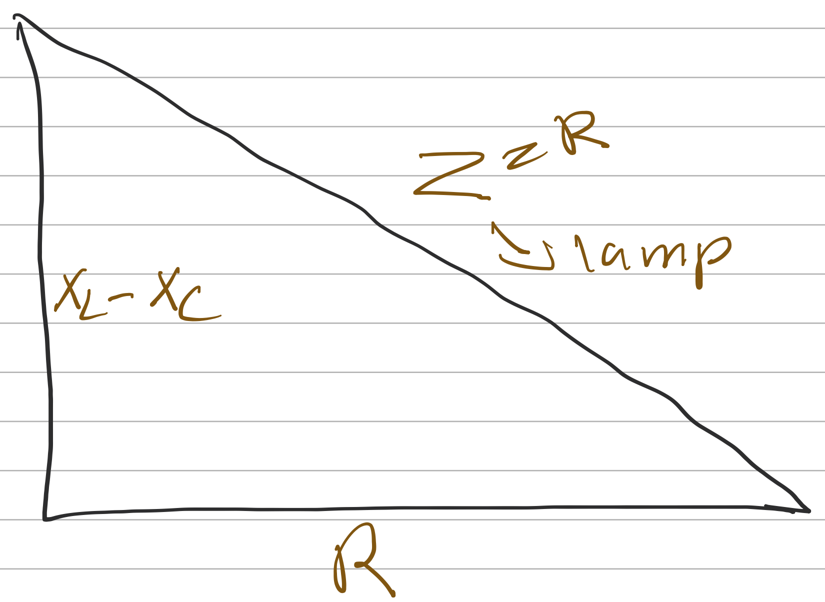
Series AC circuit:

if AC circuit consist of R only,
The value of impedence same as R

$$Z = R$$

$$I = \frac{V}{Z}$$ => instead of R



if AC consist of R and either
[L] or [C],

The Z not same as R $Z \neq R$

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

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

دائماً الرقم الكبير
ناقص الرقم الصغير
نعوضه

Examples :o

Resistive (R), Capacitive (C) and Inductive (L) Circuits

Resistors and Inductors (RL) in Series

Example: inductor

A series circuit consisting of 6Ω lamp and 0.021 H coil are connected in series to a source of 110 volts at 60 Hz. What is the value of the impedance and the current through the lamp and the coil?

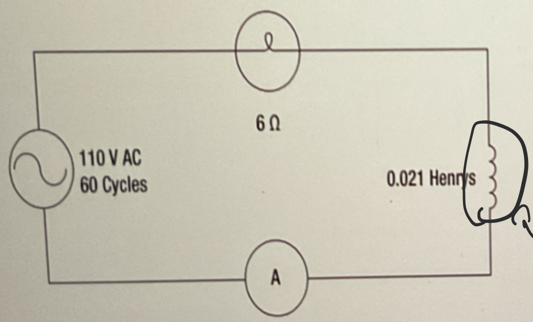


Figure 14-3. A circuit containing resistance and inductance.

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

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

$X_L = 2\pi F C$

يعني

نحن عندنا L بـ
بنطلع X_L بـ وبنعوضها

[1] $R = 6\,\Omega$ lamp

$L = 0.02\,H$ coil

$V_s = 110\,V$

$f = 60\,HZ$

$Z = ??$

$I = ??$

[1] $X_L = 2\pi F L$

هذا ثابت ما يتغير

$= 6.28 \times 60 \times 0.021$

$= 7.9 \simeq 8\,\Omega$

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

unit (Ω) ohm

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

$= 10\ \Omega$

[3] $I = \dfrac{V}{Z}$

unit Ampere (A)

$= \dfrac{110}{10}$

$I = 11\ A$

Resistive (R), Capacitive (C) and Inductive (L) Circuits

Resistors and Capacitors (RC) in Series

Example: capacitor

A series circuit in which a capacitor of 200 µf is connected in series with a 10 ohm lamp. What is the value of the impedance, the current flow, and the voltage drop across the lamp?

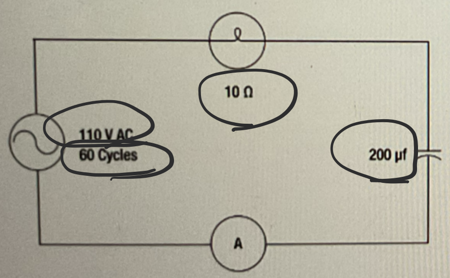


Figure 14-4. A circuit containing resistance and capacitance.

لها unit [illegible] $\times 10^{-6}$ [illegible] micro

$C = 200\ \mu F$ or $200 \times 10^{-6}\ F$

$R = 10\ \Omega$ lamp

$f = 60\ Hz$

$V = 110\ V$

$Z = ??$

$I = ??$

$V_{drop} = ??$

[1] $X_C = \dfrac{1}{2\pi F C}$

$= \dfrac{1}{6.28 \times 60 \times 200 \times 10^{-6}}$

$= 13.3\ \Omega$

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

$= \sqrt{10^2 + 13.3^2}$

$= 16.6 \approx 17\ \Omega$

3) $I = \frac{V}{Z}$

$= \frac{110}{17}$

$= 6.5 \approx 7A$

4) $V_{drop} = I \times R_{lamp}$

(I ↓ total)

$= 6.5 \times 10$

$= 65V$

Parallel AC circuit:

impedance

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

$$Z = \frac{1}{\sqrt{\left(\frac{1}{R}\right)^2 + \left(\frac{1}{X_L} - \frac{1}{X_C}\right)^2}}$$

Current:

$I_R = \frac{V}{R}$

Voltage:

$V_R = IR$

$$I_C = \frac{V}{X_C}$$

$$V_C = I X_C$$

$$I_L = \frac{V}{X_L}$$

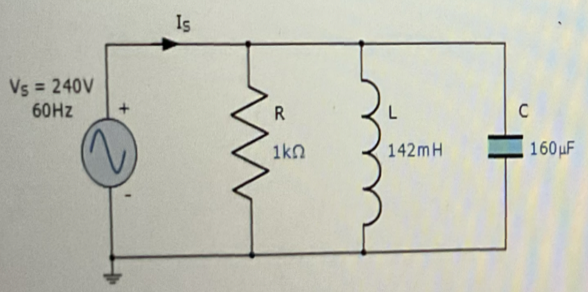
$$V_L = I X_L$$

Resistive (R), Capacitive (C) and Inductive (L) Circuits

RCL Parallel Circuit

Example:

A 1kΩ resistor, a 142mH coil and a 160uF capacitor are all connected in parallel across a 240V, 60Hz supply. Calculate the impedance of the parallel RLC circuit and the current drawn from the supply.



$R = 1k\Omega$ or $1 \times 10^3\ \Omega$

$L = 142\ mH$ or $142 \times 10^{-3}\ H$

$C = 160\ \mu F$ or 160×10^{-6}

$V = 240V$

$f = 60\ Hz$

$Z = ??$

$I = ??$

1. $X_L = 2\pi FL$
$= 6.28 \times 60 \times 142 \times 10^{-3}$
$= 53.5\ \Omega$

$X_C = \frac{1}{2\pi FC}$
$= \frac{1}{6.28 \times 60 \times 160 \times 10^{-6}}$
$= 16.6\ \Omega$

2. or parallel

$Z = \frac{1}{\sqrt{\left(\frac{1}{R}\right)^2 + \left(\frac{1}{X_L} - \frac{1}{X_C}\right)^2}}$

المنيه يعتمد فو الرقم الكبير و انقص منه الصغير
[larger − smaller.]

$= \frac{1}{\sqrt{\left(\frac{1}{1 \times 10^3}\right)^2 + \left(\frac{1}{53.5} - \frac{1}{16.6}\right)^2}}$

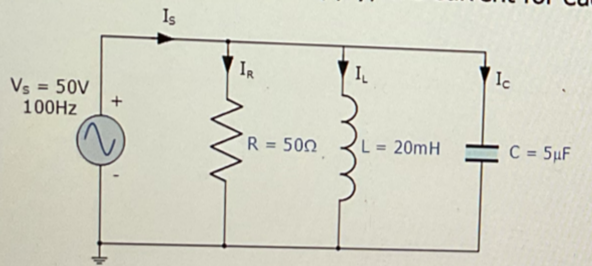
$= 24\ \Omega$

3. $I = \frac{V}{Z}$
$= \frac{240}{24}$
$= 10\ A$

Resistive (R), Capacitive (C) and Inductive (L) Circuits

RCL Parallel Circuit

Example:
A 50Ω resistor, a 20mH coil and a 5uF capacitor are all connected in parallel across a 50V, 100Hz supply. Calculate the total current drawn from the supply, the current for each branch, the total impedance of the circuit.



$R = 50\,\Omega$

$L = 20\text{ mH}$ or $20 \times 10^{-3}\text{ H}$

$C = 5\,\mu F$ or $5 \times 10^{-6}\text{ F}$

$V = 50\text{ V}$

$f = 100\text{ HZ}$

$I_T = ??$

find current of each branch

$I_R = ??$

$I_L = ??$

$I_C = ??$

$Z_T = ??$

1)

$X_L = 2\pi f L$

$= 6.28 \times 100 \times 20 \times 10^{-3}$

$= 12.56\,\Omega$

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

$= \dfrac{1}{6.28 \times 100 \times 5 \times 10^{-6}}$

$= 318.5\,\Omega$

2)

$$Z = \frac{1}{\sqrt{\left(\frac{1}{50}\right)^2 + \left(\frac{1}{318.5} - \frac{1}{12.56}\right)^2}}$$

$= 12.7\,\Omega$

3)

$I_T = \dfrac{V}{Z_T}$

$= \dfrac{50}{12.7}$

$= 3.9 \approx 4A$

4) $I_R = \dfrac{V}{R}$ | $I_L = \dfrac{V}{X_L}$

$= \frac{50}{80}$

$I_R = 1 A$

$= \frac{50}{12.56}$

$= 3.9 A$

$I_C = \frac{V}{X_C}$

$= \frac{50}{318.5}$

$= 0.1 A$

parallel Resonance :-

in parallel resonence the inductor reactance and capacitor reactance are equall $X_L = X_C$

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

2π → 6.28

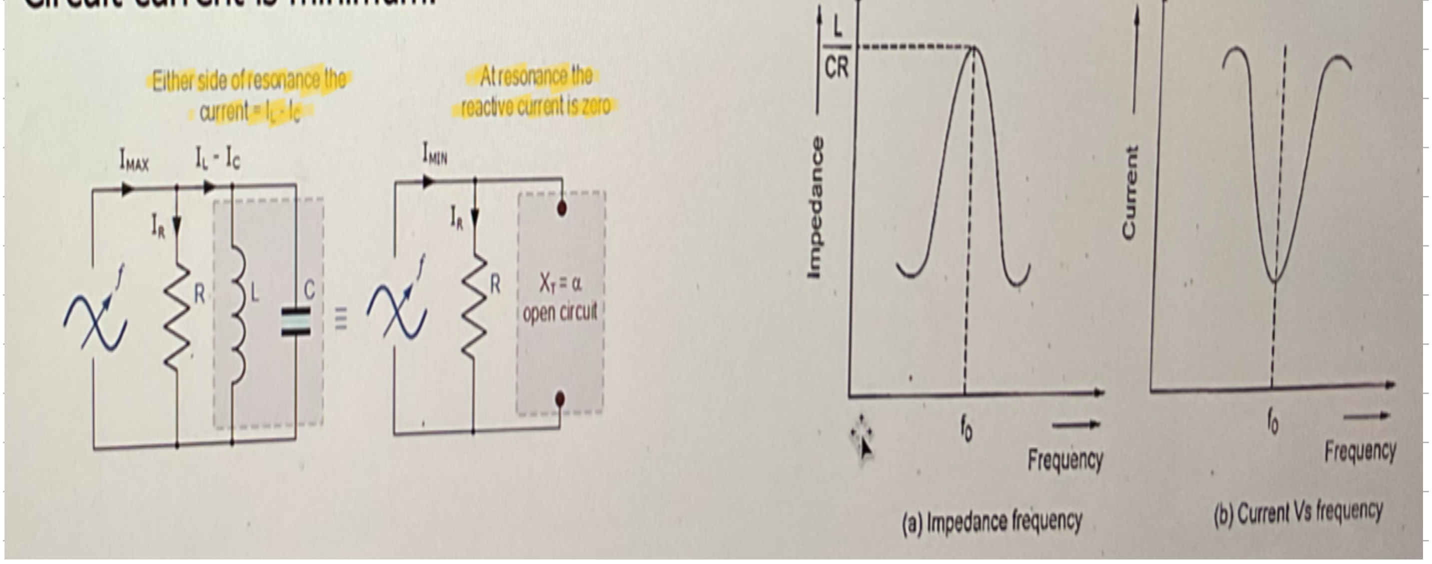
L → inductor

C → capacitor

→ circuit impedanc Z is maxmum

→ circuit current I is minimum

Circuit current is minimum.

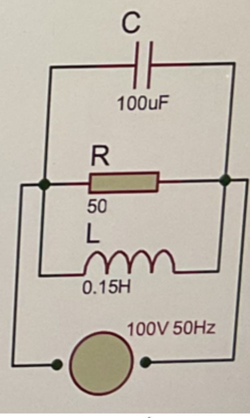


Parallel Resonance

Example:

A 50Ω resistor is placed in parallel with a 0.15H inductor and a 100μF capacitor with voltage supply of 100V, 50 Hz. Calculate:

a) Resonant frequency
b) The current in each branch
c) The supply current
d) The phase angle between supply current and supply voltage



[1]

$R = 50\Omega$

$L = 0.15H$

$C = 100\mu F$ or 100×10^{-6}

$V = 100V$

$f = 50\ HZ$

$$f_{resonant} = \frac{1}{2\pi\sqrt{LC}}$$

$$= \frac{1}{6.28 \times \sqrt{(0.15)(100 \times 10^{-6})}}$$

$$= 41.1\ HZ$$

[2]

$f_{resonant}$ = ?? ✓✓

I in each branch??

$X_L = 2\pi f L$

$= 6.28 \times 50 \times 0.15$

$47.1\ \Omega$

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

$$\frac{1}{6.28 \times 50 \times 100 \times 10^{-6}}$$

$= 31.8\ \Omega$

[3]

$$I_R = \frac{V}{R}$$

$$I_C = \frac{V}{X_C}$$

$= \frac{100}{50}$

$= 2A$

$= \frac{100}{31.8}$

$= 3.1A$

$I_L = \frac{V}{X_L}$

$= \frac{100}{47.1}$

$= 2.1A$

4 $Z = \frac{1}{\sqrt{\left(\frac{1}{50}\right)^2 + \left(\frac{1}{47.1} - \frac{1}{31.8}\right)^2}}$

$= 44.5\ \Omega$

5 $I_T = \frac{V}{Z_T}$

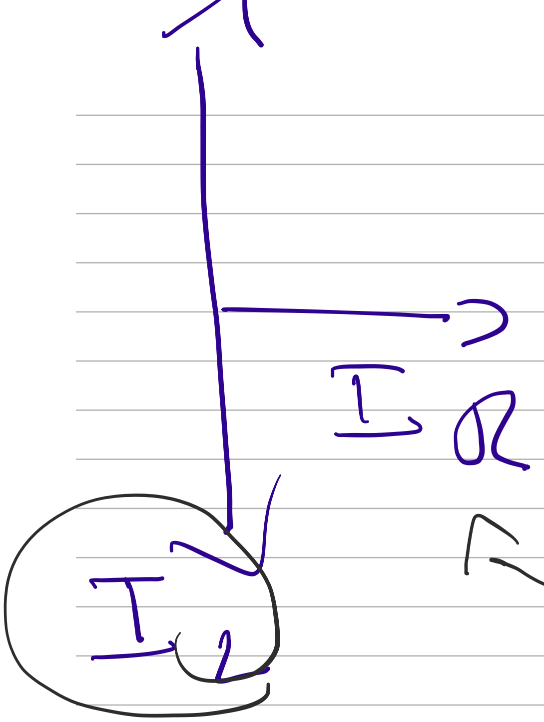
$= \frac{100}{44.5}$

$= 2.2A$

6 phase angle = ??

I_C

$\tan\theta = \frac{opp}{adj}$

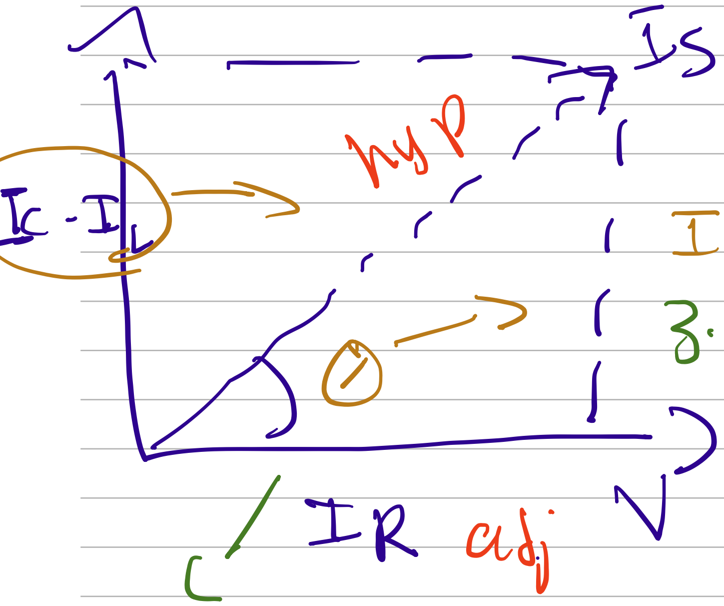


$$\theta = \tan^{-1}\left(\frac{1}{2}\right)$$

$$= 26.56^\circ$$

دايما إذا كان parallel

تكون جي الرسمة



$I_C - I_L$

$3.1 - 2.1$

$= 1$

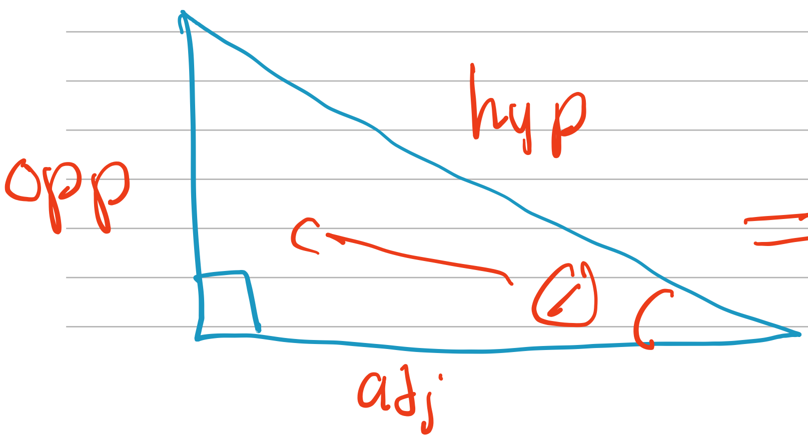
$$\frac{opp}{adj}$$

انجوف اتجاه

opp وحدد angle

$$\tan^{-1}\left(\frac{1}{2}\right)$$

$$\theta = 26.56^\circ$$



$\Rightarrow$ هذا بسهل

نستخرج اي واحد

sin, cos, tan

يعطينا نفس الجواب جربوا

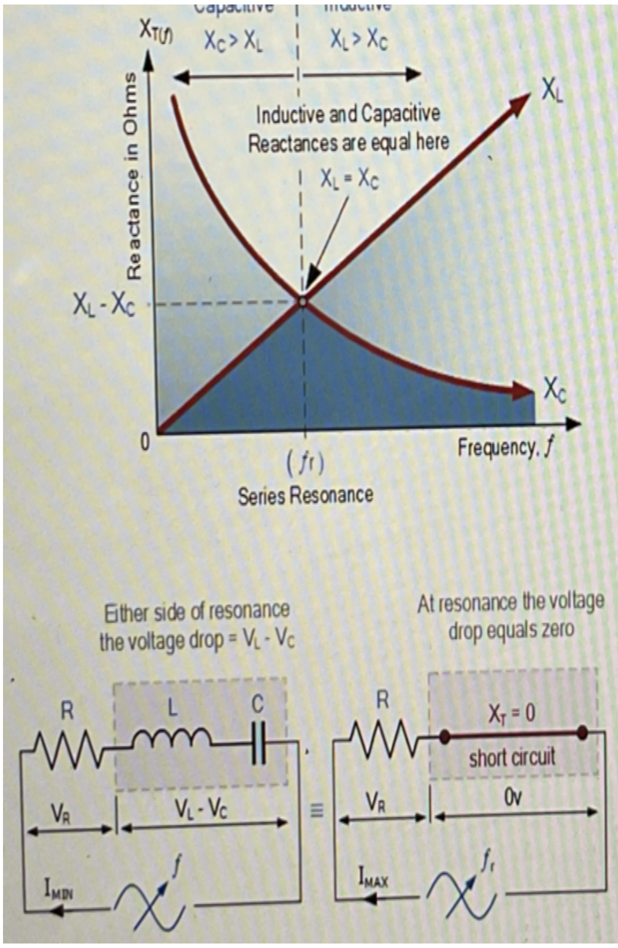
Series Resonant:

At series resonant the inducter and capacitor is equal $X_C = X_L$

→ circuit impedance Z is minimum

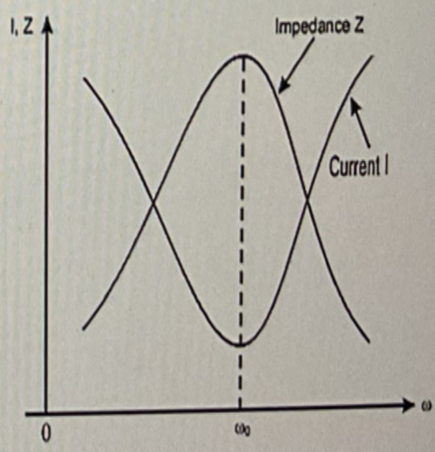
→ circuit current I is maximum.

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



At series resonance:

- Circuit impedance is minimum
- Circuit current is maximum

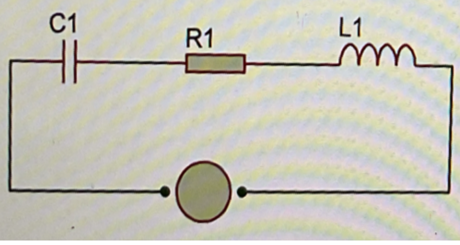


Series Resonance

Example:

In the following circuit at resonance, calculate: (1) The resonant frequency, (2) the current flowing in the circuit at resonance, (3) the voltage drop across each component at resonance.

[C1 = 60 μF; R1 = 10 Ω; L1 = 125 mH; Supply voltage = 120 V]



$f_{resonant}$ = ? ? ✓✓

I at resonant = ? ? ✓✓

V_{drop} = ? ? across each compont

[1]

$$f_{resonant} = \frac{1}{2\pi\sqrt{LC}}$$

$$= \frac{1}{6.28 \times \sqrt{(125\times10^{-3})\times(60\times10^{-6})}}$$

$C_1 = 60\ \mu F$ or $60 \times 10^{-6}\ F$

$R_1 = 10\ \Omega$

$L_1 = 125\ mH$ or $125 \times 10^{-3}\ H$

$V = 120V$

$= 58.14\ Hz$

2 $X_L = 2\pi F L$

$= 6.28 \times 58.14 \times 125 \times 10^{-3}$

$= 45.63\ \Omega$

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

$= \frac{1}{6.28 \times 58.14 \times 60 \times 10^{-6}}$

$= 45.64\ \Omega$

in series resonant the cir 𝑓𝑜𝑛𝑑 [illegible] X_L and X_C are equal $X_L = X_C$

3 $Z = \sqrt{R^2 + (X_L - X_C)^2}$

$R = Z$

$= \sqrt{10^2 + (45.63 - 45.63)^2}$

$= 10\ \Omega$

4 $I_T = \frac{V}{Z}$

$= \frac{120}{10}$

$= 12\ A$

5 $V_R = I R$

$= 12 \times 10$

$= 120V$

$V_C = I X_C$

$= 12 \times 45.64$

$= 547.68V$

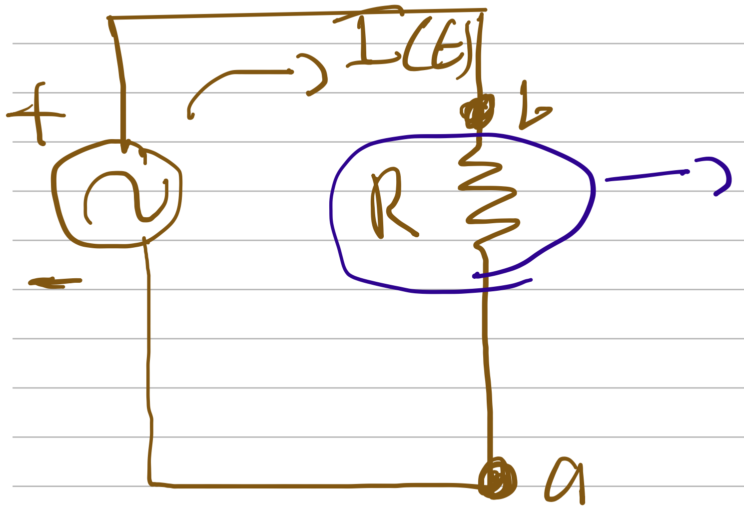
$V_L = I X_L$

$= 12 \times 45.63$

$= 547.56V$

pure Resistore :-

$$R = \frac{V_{pk}}{I_{pk}} \qquad R = \frac{V_{rms}}{I_{rms}}$$



resistor

unit ohm (Ω)

inductors in AC circuits

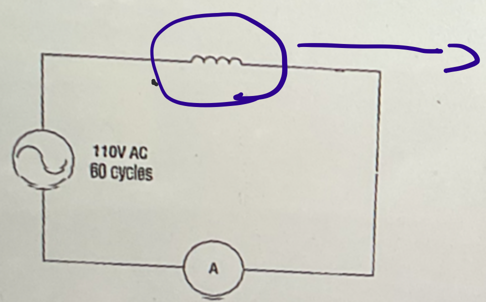
unit ohm (Ω)

$$X_L = 2\pi F L$$

6.28 constant

Inductors in AC circuits

- AC series circuit is shown in which the inductance is 0.146 Henry, and the voltage is 110 volts at a frequency of 60 cycles per second. Determine inductive reactance?



inductor

$L = 0.146\ H$

$V = 110\ V$

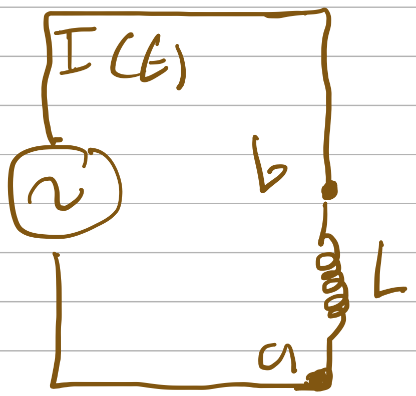
$f = 60\ cps$

$X_L = ??$

$X_L = 2\pi F L$

$= 6.28 \times 60 \times 0.146$

$\approx 55\ \Omega$



to find V_L:

$V_L = I_L X_L$

to find X_L

$X_L = \frac{V_L}{I_L}$

to find

$I_L = \frac{V_L}{X_L}$

* voltage contains pure inductors will lead current by $90°$

L => unit Henry (H)

Capacitor in AC circuits:

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

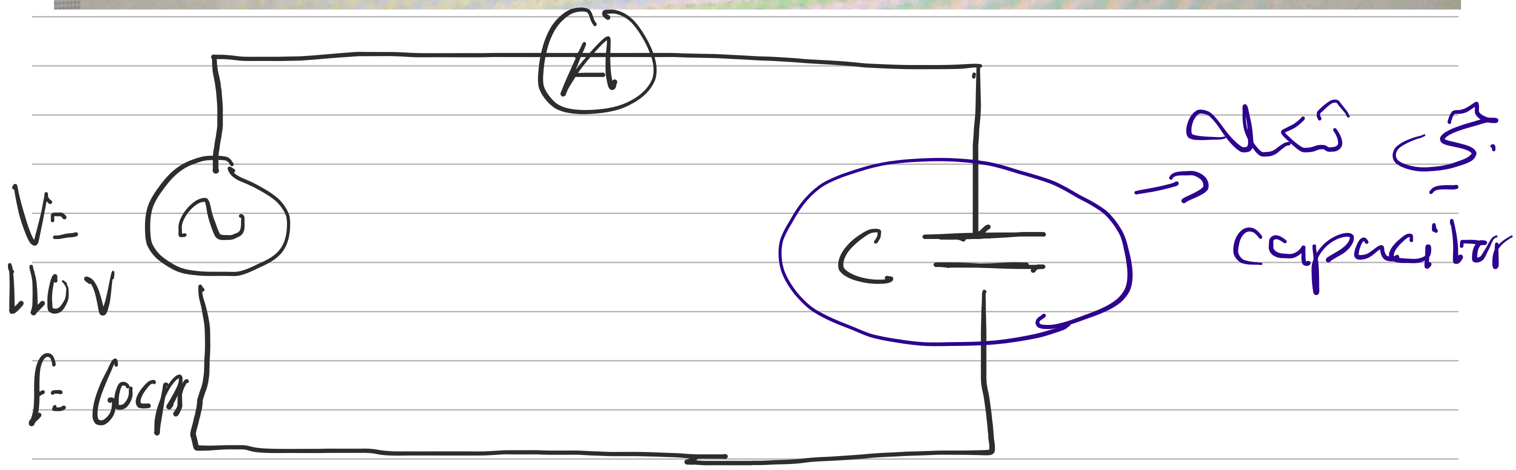
X_C → unit ohm (Ω)

C → unit Farad (F)

Capacitive Reactance

Problem:

A series circuit is assumed in which the impressed voltage is 110 volts at 60 cps, and the capacitance of a condenser is 80 μF. Find the capacitive reactance and the current flow.



$V = 110\,V$

$f = 60\ cps$

$C = 80\,\mu F$

or

$80 \times 10^{-6}\,F$

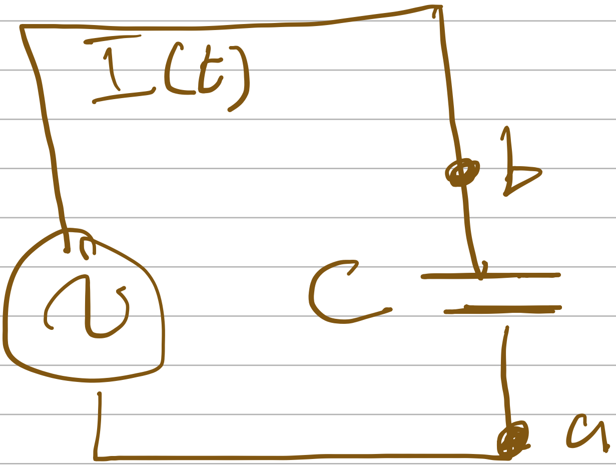
$X_C = ??$

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

$$= \frac{1}{6.28 \times 60 \times 80 \times 10^{-6}}$$

$$= 33.17\ \Omega$$

→ voltage containing pure capacitor will lag current by 90°.



to find V:

$$V_C = I X_C$$

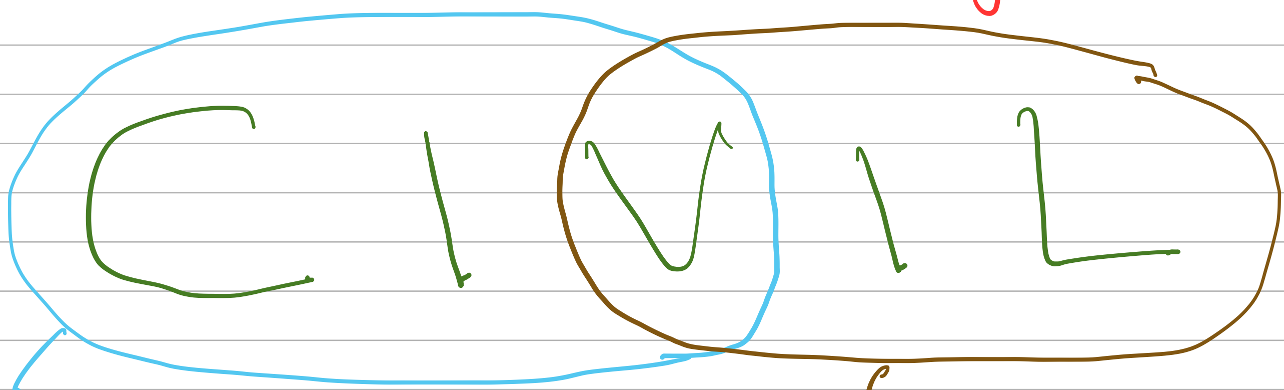
to find X_C:

$$X_C = \frac{V_C}{I}$$

to fin I_C:

$$I_C = \frac{V_C}{X_C}$$

phaser Diagrams:



in capacitor

in inductor, current lag

Current lead voltage.

Voltage

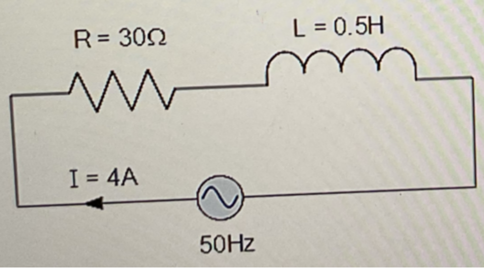
Resistors and Inductors (RL) in Series

RL circuit

Example:

A coil has a resistance of 30Ω and an inductance of 0.5H. If the current flowing through the coil is 4amps.

- What will be the value of the supply voltage if its frequency is 50Hz?
- What will be the phase angle between the current and supply voltage?



$X_L = 2\pi f L$

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

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

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

$R = 30\ \Omega$

$L = 0.5H$

$I = 4A$

$V_s = ??$

$f = 50HZ$

$\phi = ??$

between I and supply V

[1] $X_L = 2\pi F L$

$= 6.28 \times 50 \times 0.5$

$= 157\ \Omega$

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

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

$= 159.84\ \Omega$

[3] $I = \frac{V}{Z} \Rightarrow V = IZ$

$= 4 \times 159.84$

$= 639.36\ V$

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

$\tan^{-1}\left(\frac{157}{30}\right)$

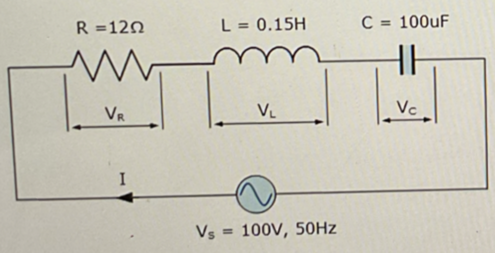
$= 79.18°$

RLC circuit :

RLC Series Circuit

Example:

A series RLC circuit containing a resistance of 12Ω, an inductance of 0.15H and a capacitor of 100uF are connected in series across a 100V, 50Hz supply. Calculate the total circuit impedance and the circuit's current.



$R = 12\,\Omega$

$L = 0.15\,H$

$C = 100\,\mu F$

$V = 100\,V$

$f = 50\,Hz$

$Z_T = ??$

$I_t = ??$

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

$= \frac{1}{6.28 \times 50 \times 100 \times 10^{-6}}$

$= 31.85\,\Omega$

$X_L = 2\pi f L$

$= 6.28 \times 50 \times 0.15$

$= 47.1\,\Omega$

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

$= \sqrt{12^2 + (47.1 - 31.85)^2}$

$= 19.4\,\Omega$

3. $I = \frac{V}{Z}$

$= \frac{100}{19.4}$

$= 5.15\,A$

Power in AC circuit

Active power (P)

(Real power or True power)

$$P = I^2 R \qquad P = \frac{V^2}{R}$$

obtained by "wattmeter"

اذا كان في circuit R تتحقق في true power

Reactive power (Q)

$$Q = I^2 X \qquad Q = \frac{V^2}{X}$$

"reactance"

X_L and X_C

it measured in VAR

(Volt-ampere-reactive)

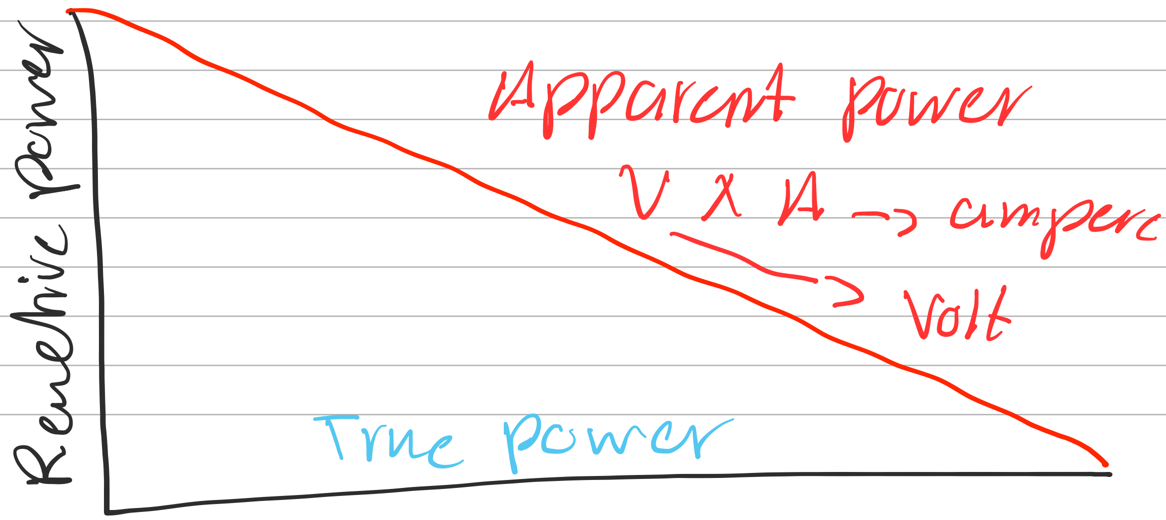
اذا فيها في circuit X يعني في reactive power

X_L → X_C

Apparent power (S)

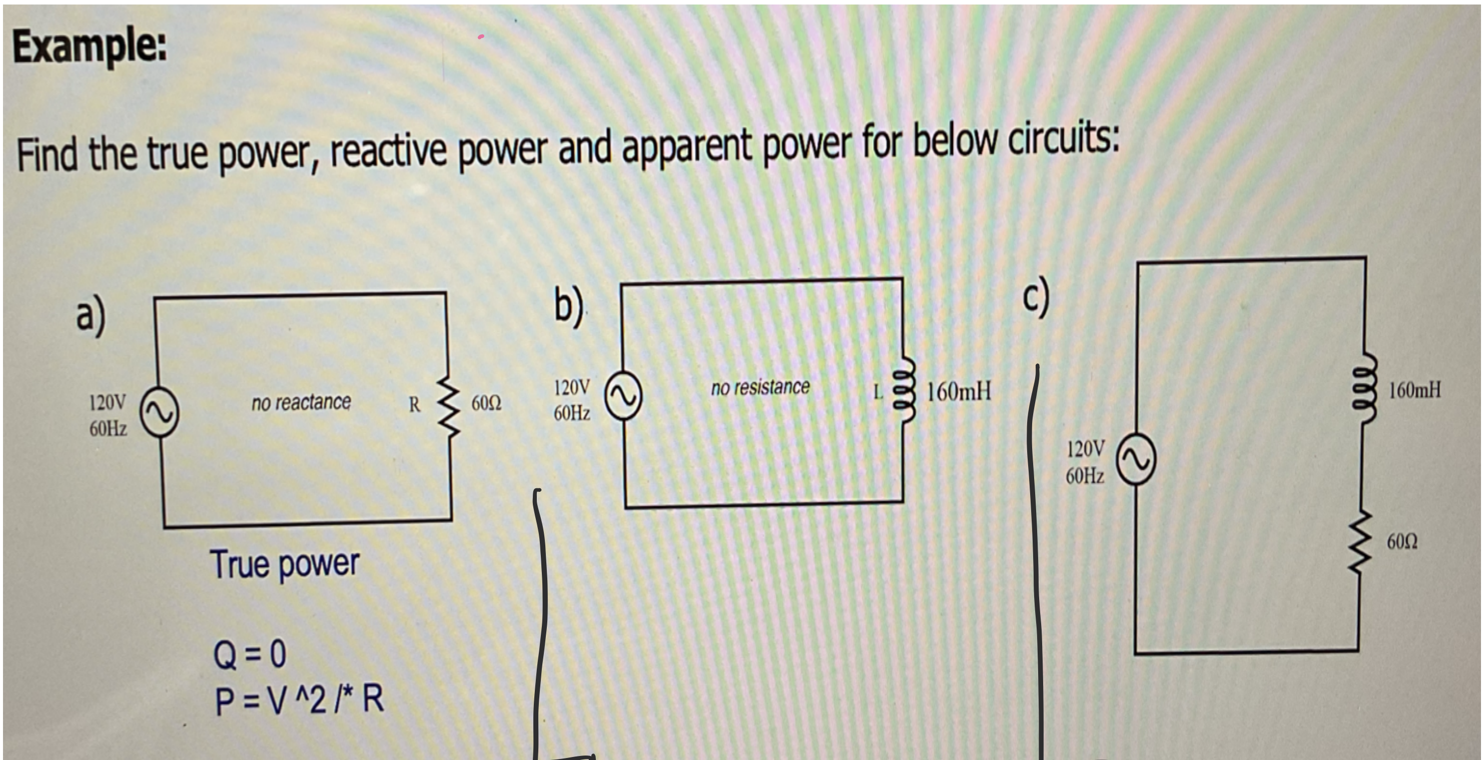
$$S = I^2 Z \qquad S = \frac{V^2}{Z} \qquad S = I V$$

measured in VA (Volt-ampere)



Draft

Examples :



a)

اهنيه عندنا R

حتجيب true power

[1] True power :

$V = 120V$

$f = 60Hz$

$R = 60\Omega$

[b]

اهنيه عندنا L

يعني راح نطلع Reactive power

[1] True power

ما في عندنا R

$P = 0$

[2] Reactive power

[1]

$X_L = 2\pi f L$

$= 6.28 \times 60 \times 160 \times 10^{-3}$

$= 60.28\ \Omega$

[2]

[c]

اهنيه عندنا الاثنين R and X

[1] True power

$V = 120$

$f = 60$

$R = 60$

$L = 160 \times 10^{-3}$

$P = I^2 R$

$I = \frac{V}{R} = \frac{120}{60}$

$I = 2A$

$P = I^2 R$

$= 2^2 \times 60$

$= 240\ W$

[2] Reactive power

$P = I^2 R$

$I = \frac{V}{R} = \frac{120}{60}$

$I = 2A$

$P = I^2 R$

$= 2^2 \times 60$

$= 240W$

2 Reactive power

There is no reactive power.

عشان ماشي X وأداة

يعني Reactive power شي

∴ P = S → Apparent

true power

$Q = \frac{V^2}{X} \to X_L$

$= \frac{120^2}{60.28}$

$= 238.88\ VAR$

3 Apparent power

ما يكون ساوي P

أو Q تستخدم لأنه

يعني P

$S = Q$

$Q = \frac{V^2}{X}$

$X_L = 2\pi F L$

$= 6.28 \times 60 \times 160 \times 10^{3}$

$= 60.28\ \Omega$

$Q = \frac{V^2}{X}$

$= \frac{120^2}{60.28}$

$= 238.88\ VAR$

3 Apparent power

$S = \sqrt{P^2 + Q^2}$

$= \sqrt{240^2 + 238.88^2}$

$= 338.6\ VA$

Power factor

$$PF = \frac{P \to \text{true power}}{S \to \text{Apparent power}} \times 100$$

Power Factor

Example:

A 220-volt AC motor takes 50 amperes from the line, but a wattmeter in the line shows that only 9 350 watts are taken by the motor. What are the apparent power and the power factor?

$V = 220V$

$I = 50 A$

$P = 9350 W$

True power (wattmeter)

$S = ??$

Apparent power

$PF = ??$

1

$S = IV$

$= 50 \times 220$

$= 11000 VA$

2

$PF = \frac{P}{S} \times 100$

$= \frac{9350}{11000} \times 100$

$= 85\%$

Useful Formulas:

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

Inductive Reactance: $X_L = 2\pi f L$

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

Impedance (parallel): $\frac{1}{Z} = \sqrt{\left(\frac{1}{R}\right)^2 + \left(\frac{1}{X_L} - \frac{1}{X_C}\right)^2}$

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

True Power: $P = I^2 R$

Reactive Power: $P_R = I^2 X$

Apparent Power: $P_A = I^2 Z$

Cut-off Frequency: $f_C = \frac{1}{2\pi RC}$

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