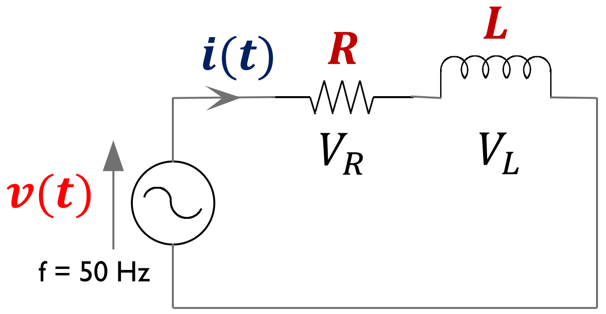
Basic Electrical Technology

[ELE 1051]

CHAPTER 3 - SINGLE PHASE AC CIRCUITS

(3.3)

RL circuit analysis



Let $\bar{I}$ *be along the reference*

$$\overline{V_R} = \bar{I}R$$

$$\overline{V_L} = j\bar{I}X_L$$

$$\bar{V} = \overline{V_R} + \overline{V_L} = |V|\angle\emptyset$$

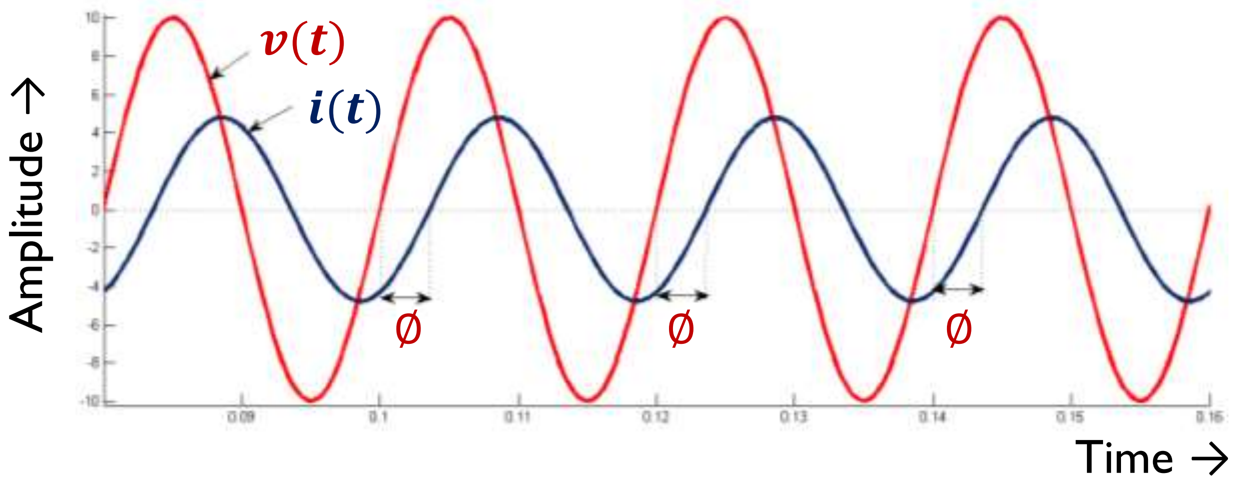
Mathematical Representation

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

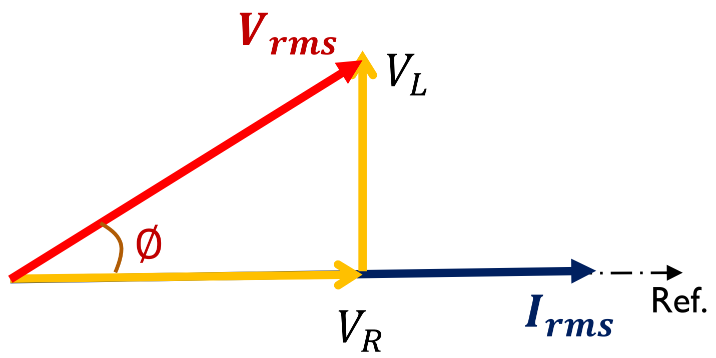
$$v(t) = V_m \sin(\omega t + \emptyset)$$

$\emptyset$ *– Phase Angle*

Graphical Representation



Phasor Representation



Impedance

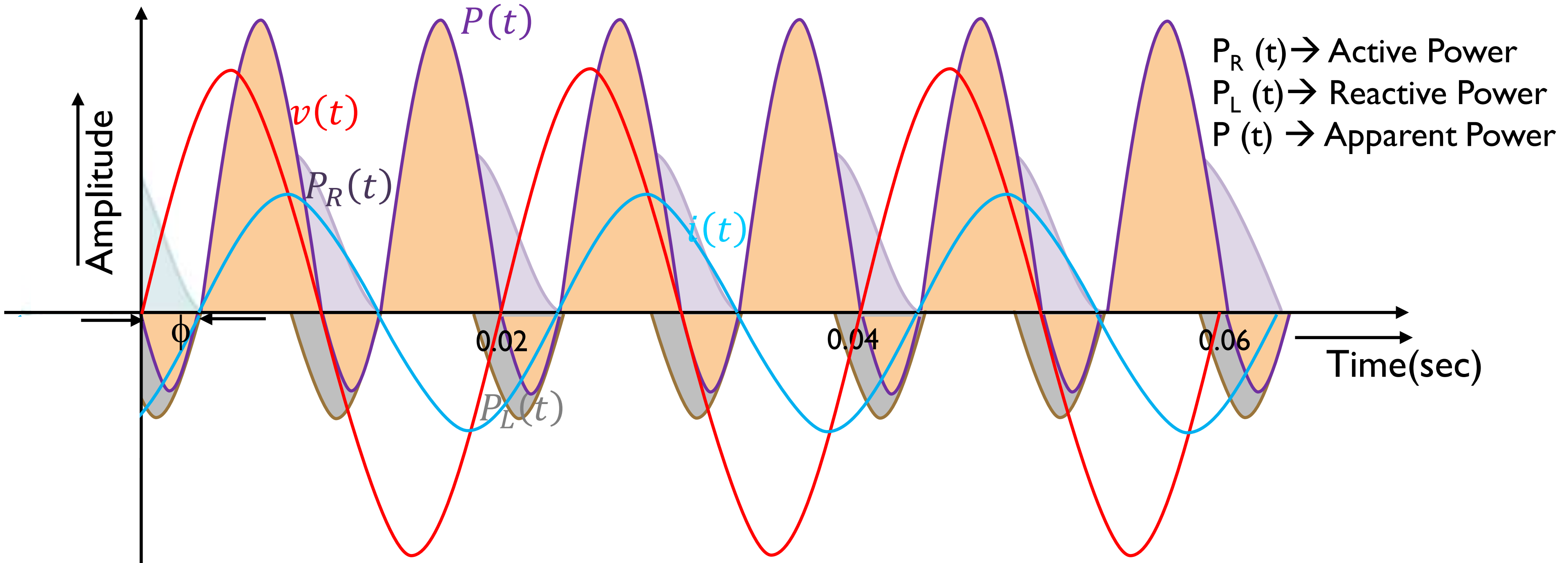
$$\frac{\bar{V}}{\bar{I}} = \frac{\bar{I}(R + jX_L)}{\bar{I}} = R + jX_L = |Z|\angle\emptyset$$

Z *– Impedance of the circuit*

$$\therefore\ \boldsymbol{R = |Z|\cos\emptyset} \qquad \boldsymbol{X_L = |Z|\sin\emptyset}$$

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

Power associated - RL circuit



Instantaneous power,

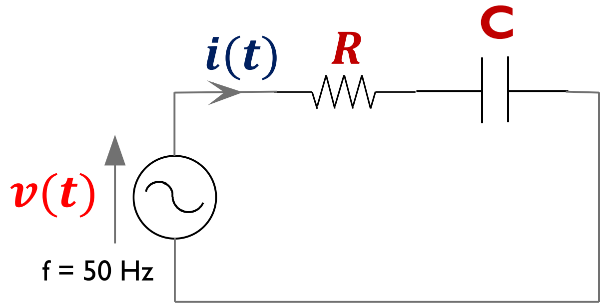
$$p(t) = v(t).\,i(t)$$
$$= V_m I_m \sin\omega t\,.\sin(\omega t + \emptyset)$$
$$= V_{rms} I_{rms}[\cos\emptyset - \cos(2\omega t + \emptyset)]$$

$$\boldsymbol{Average\ Power, P = \frac{1}{T}\int_0^T p(t)dt = \frac{V_m I_m}{2}\cos\emptyset}$$

$$\boxed{\mathbf{P_{avg} = V_{rms} I_{rms} \cos\emptyset}}$$

$\cos\emptyset$ *is called the* ***Power Factor***

RC circuit analysis



Let $\bar{I}$ *be along the reference*

$$\overline{V_R} = \bar{I}R$$

$$\overline{V_C} = -j\bar{I}X_C$$

$$\bar{V} = \overline{V_R} + \overline{V_C} = |V|\angle -\emptyset$$

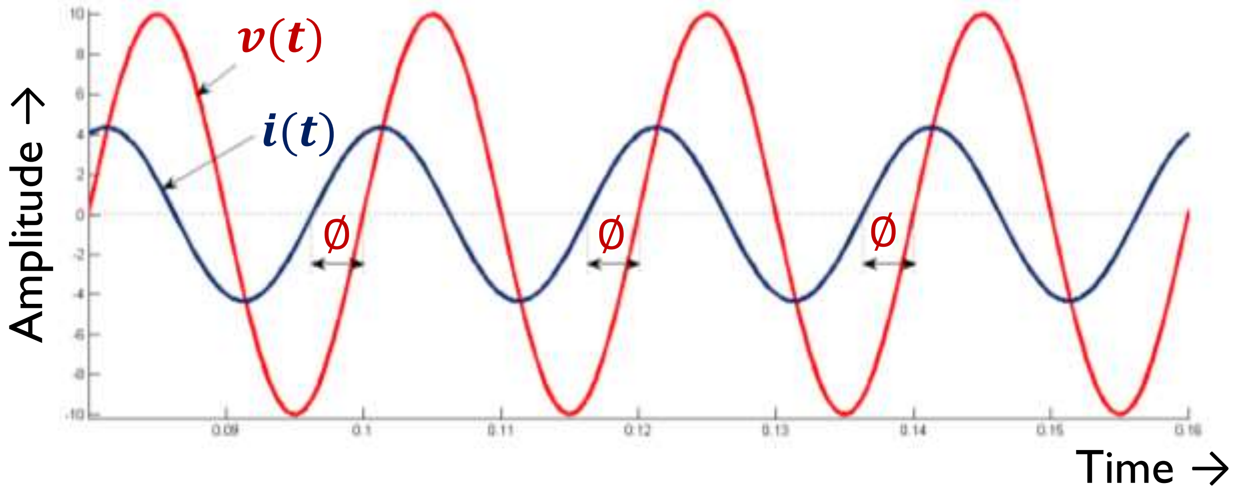
<u>*Mathematical Representation*</u>

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

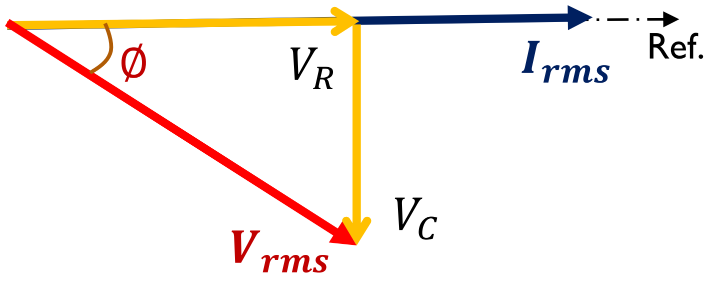
$$v(t) = V_m \sin(\omega t - \emptyset)$$

$\emptyset$ *– Phase Angle*

<u>*Graphical Representation*</u>



<u>*Phasor Representation*</u>



<u>*Impedance*</u>

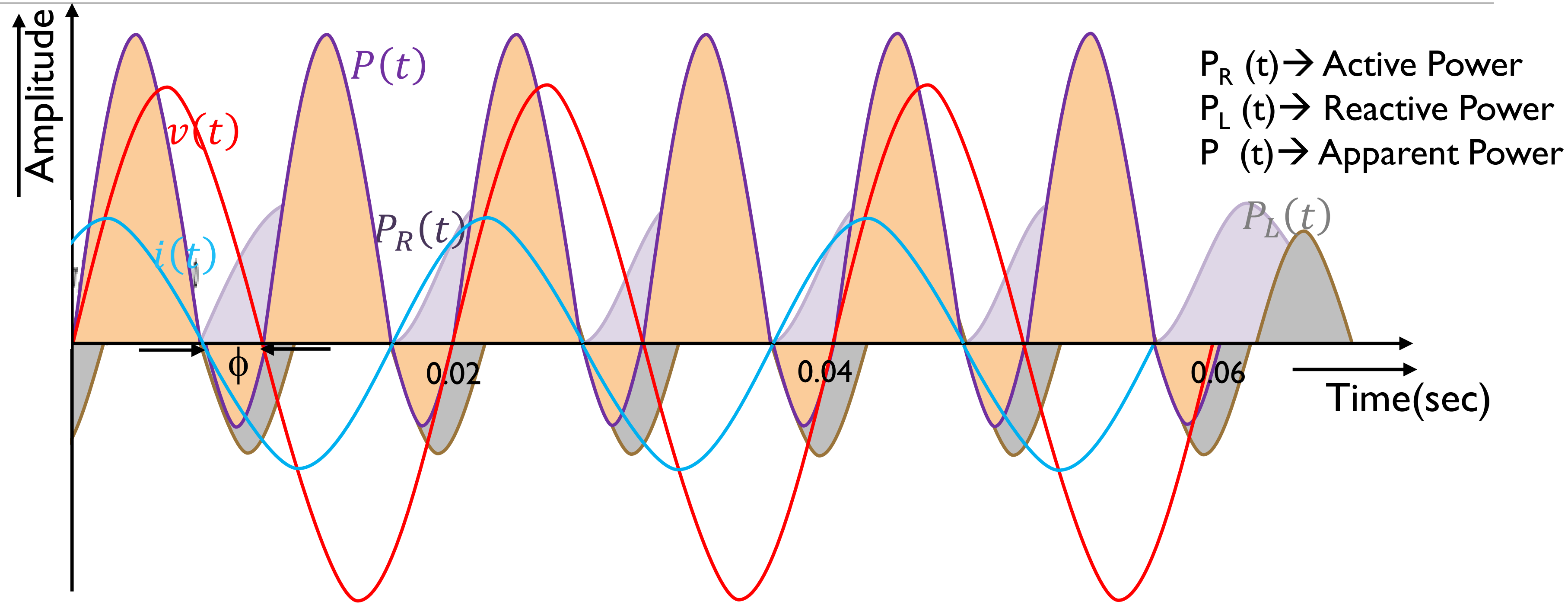
$$\frac{\bar{V}}{\bar{I}} = \frac{\bar{I}(R - jX_C)}{\bar{I}} = R - jX_C = |Z|\angle -\emptyset$$

Z *– Impedance of the circuit*

$$\therefore \boldsymbol{R = |Z|\cos\emptyset} \qquad \boldsymbol{X_C = |Z|\sin\emptyset}$$

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

Power associated - RC circuit



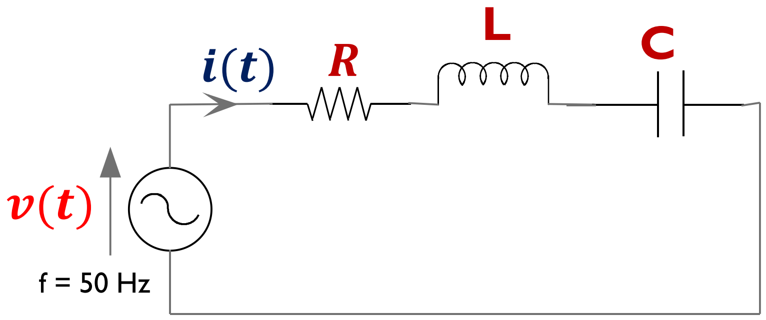
Instantaneous power,

$$p(t) = v(t).\,i(t)$$
$$= V_m I_m \sin \omega t \,.\, \sin(\omega t - \emptyset)$$
$$= V_{rms} I_{rms} [\cos \emptyset - \cos(2\omega t - \emptyset)]$$

$$\boldsymbol{Average\ Power, P = \frac{1}{T}\int_0^T p(t)dt = \frac{V_m I_m}{2}\ cos\ \emptyset}$$

$$\boxed{\mathbf{P_{avg} = V_{rms} I_{rms} \cos \emptyset}}$$

RLC circuit



$Let\ i(t)\ be\ the\ reference$

$$\boldsymbol{Impedance, Z = R + j(X_L \sim X_c)}$$

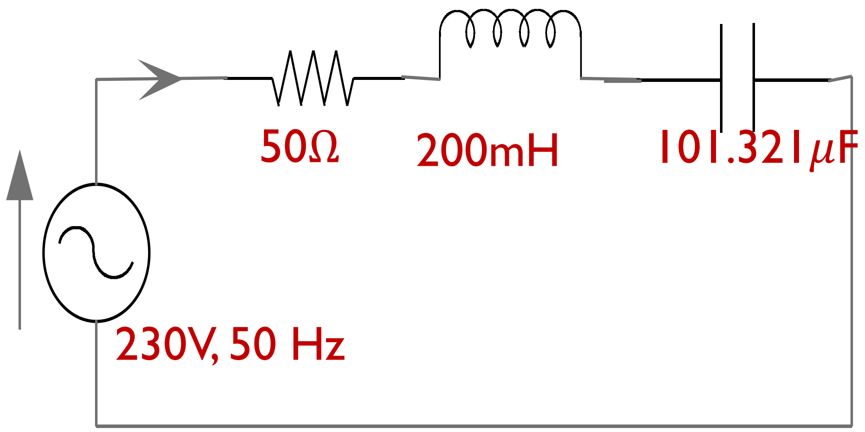
$if\ X_L = X_C$	$\Longrightarrow$	$Resistive\ circuit$ $(Resonance\ condition)$
$if\ X_L > X_C$	$\Longrightarrow$	$RL\ series\ circuit$
$if\ X_L < X_C$	$\Longrightarrow$	$RC\ series\ circuit$

Illustration 1

A resistance of 50Ω is connected in series with an inductance of 200mH and capacitance of 101.321μF across a 230V, 50 Hz, single phase AC supply. Obtain,

a) *Impedance of the circuit*
b) *Current drawn*
c) *Power factor*
d) *Power consumed*
e) *Phasor diagram*

a) $Z = 50 + j31.4156\Omega = 59.050\angle 32.14^{\circ}\ \Omega$
b) $I = 3.898\angle -32.14^{\circ}\ A$
c) $PF = 0.846\ lag$
d) P = $759.15W$



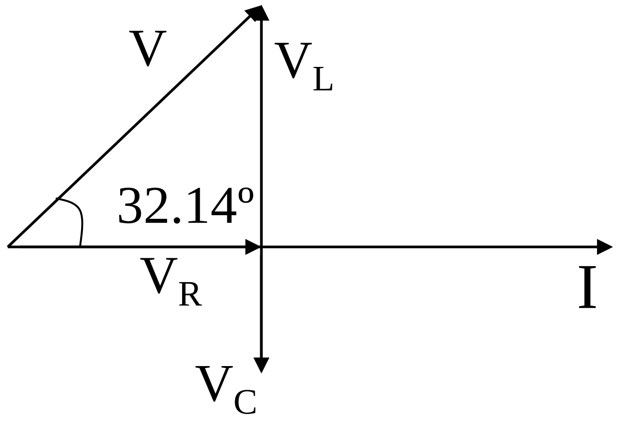
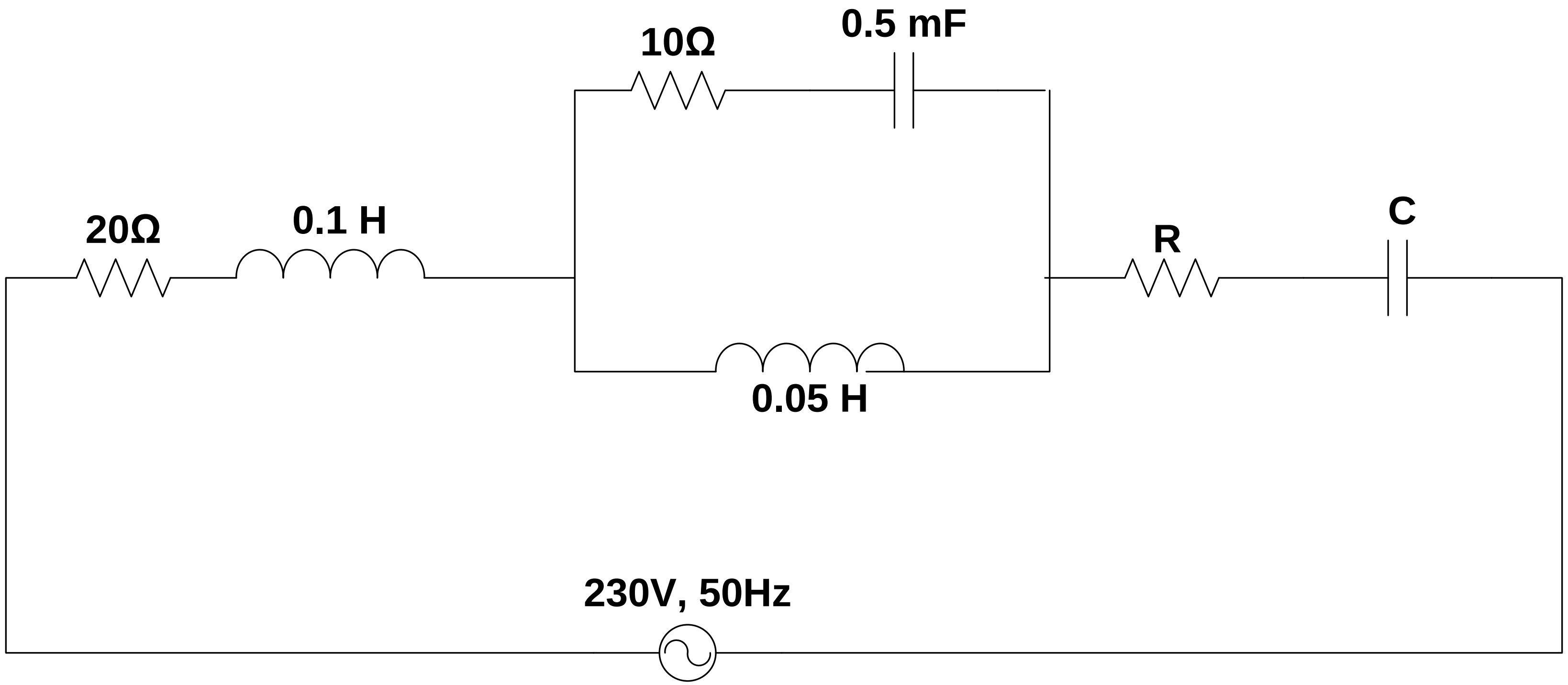


Illustration 2

The circuit shown below has a source of 230V, 50 Hz. If the current through 0.05H inductor is 3.5 ∠-80 A, find the value of 'R' and 'C'.



R = 23.58 Ω
C = 0.104 mF

Thank You!