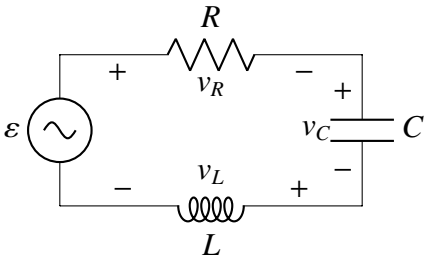
EE23BTECH11217 - Prajwal M*

Exercise 9.1

The given figure shows a series LCR circuit connected to a variable frequency 230 V source. L = 5.0 H, C = 80 μF, R = 40 Ω.



1) Determine the source frequency which drives the circuit in resonance.
2) Obtain the impedance of the circuit and the amplitude of current at the resonating frequency.
3) Determine the rms potential drops across the three elements of the circuit. Show that the potential drop across the LC combination is zero at the resonating frequency.

Solution:

Paramater	Description	Value
ε	Voltage power supply	230 V
L	Inductance	5.0 H
C	Capacitance	80 μF
R	Resistance	40 Ω
s_{res}	resonance frequency	?
Z_{res}	Resonance impedance	?
I_{res}	Amplitude of current at resonance	?
V_R	Potential drop across Resistor	?
V_L	Potential drop across Resistor	?
V_C	Potential drop across Resistor	?
V_{LC}	Potential drop across LC combination	?

TABLE 3
Parameter description

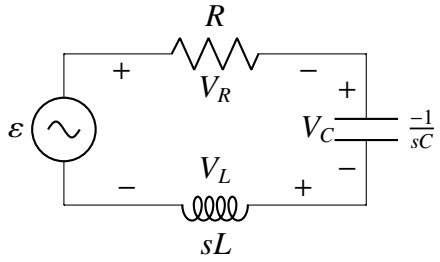


Fig. 3. s-domain circuit diagram

1)

$$V_L + V_C = 0 \tag{1}$$

$$s_{\text{res}}L - \frac{1}{s_{\text{res}}C} = 0 \tag{2}$$

$$s_{\text{res}} = \frac{1}{\sqrt{LC}} \tag{3}$$

$$s_{\text{res}} = \frac{1}{\sqrt{(5.0\,\text{H})(80\times10^{-6}\,\text{F})}} \tag{4}$$

$$s_{\text{res}} = 50\,\text{rad/s} \tag{5}$$

2)

$$Z_{\text{res}} = R = 40\,\Omega \tag{6}$$

$$I_{\text{res}} = \frac{\sqrt{2}\varepsilon}{Z_{\text{res}}} \tag{7}$$

$$= \frac{\sqrt{2}(230)}{40} \tag{8}$$

$$= 8.1\,\text{A} \tag{9}$$

3)

$$
\begin{aligned}
I_{\text{rms}} &= \frac{I_{\text{res}}}{\sqrt{2}} && (10)\\
&= \frac{8.1}{\sqrt{2}} && (11)\\
&\approx 5.75\,\text{A} && (12)\\
V_R &= I_{\text{rms}} R && (13)\\
&= 5.75\,\text{A} \times 40\,\Omega && (14)\\
&\approx 230\,\text{V} && (15)\\
V_L &= I_{\text{rms}}\, s_{\text{res}} L && (16)\\
&= 5.75\,\text{A} \times 50\,\text{rad/s} \times 5.0\,\text{H} && (17)\\
&\approx 1437.5\,\text{V} && (18)\\
V_C &= I_{\text{rms}} \frac{-1}{s_{\text{res}} C} && (19)\\
&= 5.75\,\text{A} \times \frac{-1}{50\,\text{rad/s} \times 80 \times 10^{-6}\,\text{F}} && (20)\\
&\approx -1437.5\,\text{V} && (21)\\
V_{LC} &= I_{\text{rms}}\, s_{\text{res}} L - I_{\text{rms}} \frac{1}{s_{\text{res}} C} && (22)\\
&= V_L + V_C && (23)\\
&= 1437.5\,\text{V} - 1437.5\,\text{V} = 0\,\text{V} && (24)
\end{aligned}
$$