

NCERT Physics 12.7 Q6

EE23BTECH11212 - SWATHI DEEPIKA*

Question: Obtain the resonant frequency of a series LCR circuit with $L = 2.0 \text{ H}$, $C = 32 \mu\text{F}$, and $R = 10 \Omega$. What is the Q-value of the circuit.

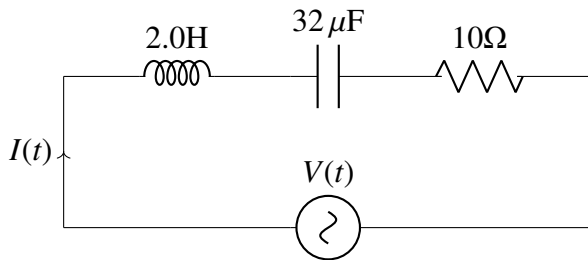


Fig. 1. LCR Circuit

Solution: In Figure Fig. 1 the following information is provided:

Symbol	Value	Description
L	2.0 H	Inductance
C	32 μF	Capacitance
R	10 Ω	Resistance
Q	$\frac{1}{R} \sqrt{\frac{L}{C}}$	Quality Factor

TABLE I
PARAMETERS

SERIES LCR CIRCUIT ANALYSIS

The resonant frequency (f_r) of a series LCR circuit can be calculated using the formula:

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

where L is the inductance, C is the capacitance, and π is a mathematical constant.

Given $L = 2.0 \text{ H}$ and $C = 32 \mu\text{F}$ ($32 \times 10^{-6} \text{ F}$), the resonant frequency is calculated as follows:

$$f_r = \frac{1}{2\pi \sqrt{(2.0 \text{ H})(32 \times 10^{-6} \text{ F})}} \approx \frac{1}{2\pi \times 0.008} \approx 20 \text{ Hz}$$

Next, the quality factor (Q) of the circuit can be calculated using the formula:

$$Q = \frac{1}{R} \sqrt{\frac{L}{C}}$$

Given $R = 10$, $L = 2.0 \text{ H}$, and $C = 32 \mu\text{F}$, the Q-value is found as:

$$Q = \frac{1}{10} \sqrt{\frac{2.0 \text{ H}}{32 \times 10^{-6} \text{ F}}} \approx \frac{1}{10} \times \frac{1}{0.004} \approx 25$$

Now, the voltage transfer function ($\frac{V(s)}{I(s)} = H(s)$) is given by Ohm's Law in the Laplace domain:

$$\frac{V(s)}{I(s)} = R + sL + \frac{1}{sC} = 10 + 2s + \frac{1}{32 \times 10^{-6}s}$$

This is the voltage transfer function for the series LCR circuit in the Laplace domain.

The equivalent s domain of the circuit is :

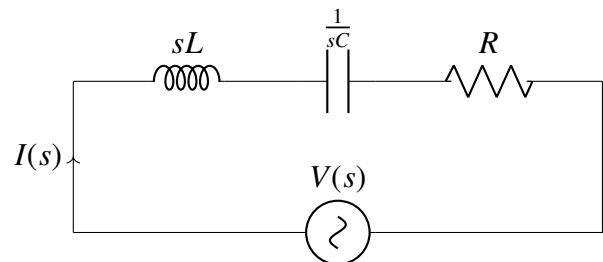


Fig. 2. LCR Circuit in s-domain