

NCERT Physics 12.7 Q19

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Question: Suppose the circuit in Exercise 7.18 (in Figure Fig. 1) has a resistance of $15\ \Omega$. Obtain the average power transferred to each element of the circuit, and the total power absorbed.

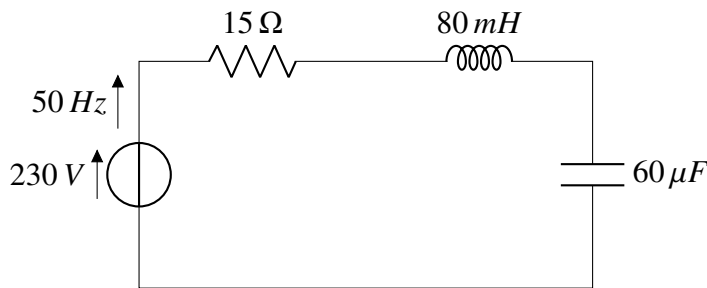


Fig. 1. LCR Circuit

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

Symbol	Value	Description
L	80 mH	Inductance
C	$60\ \mu\text{F}$	Capacitance
R	$15\ \Omega$	Resistance
V	$230\ \text{V}$	Voltage
f	$50\ \text{Hz}$	Frequency
ω	$2\pi f = 100\pi$	Angular Frequency

TABLE I
GIVEN PARAMETERS

Applying Kirchoff's Voltage Law in the Fig. 2

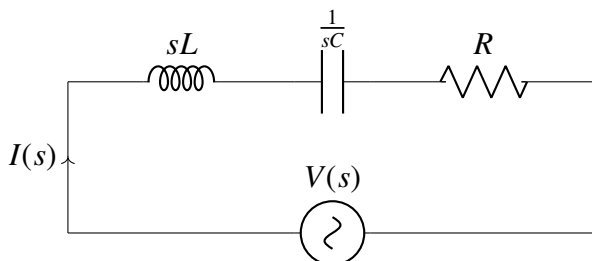


Fig. 2. s domain circuit

$$V(s) = RI(s) + sLI(s) + \frac{1}{sC}I(s) \quad (1)$$

$$= I(s) \left(R + sL + \frac{1}{sC} \right) \quad (2)$$

$$I(s) = \frac{V(s)}{\left(R + sL + \frac{1}{sC} \right)} \quad (3)$$

$$H(s) = \frac{V(s)}{I(s)} \quad (4)$$

$$H(s) = R + sL + \frac{1}{sC} \quad (5)$$

Substituting s with $j\omega$

$$H(j\omega) = R + j\omega L + \frac{1}{j\omega C} \quad (6)$$

$$\Rightarrow |H(j\omega)| = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C} \right)^2} \quad (7)$$

a) Average power transferred to the capacitor, P_C :

$$P_C = 0 \quad (8)$$

b) Average power transferred to the inductor, P_L

$$P_L = 0 \quad (9)$$

c) Average Power transferred to the resistor, P_R :

$$P_R = (I(j\omega))^2 R \quad (10)$$

$H(j\omega)$ is obtained by substituting the numerical values from the Table I in equation (7):

$$H(j\omega) = 31.728\ \Omega \quad (11)$$

Current flowing through the circuit $I(j\omega)$ is :

$$I(j\omega) = \frac{V}{H(j\omega)} = \frac{230}{31.728} \quad (12)$$

$$= 7.25\ \text{A} \quad (13)$$

$$P_R = (I(j\omega))^2 \cdot R = (7.25)^2 \times 15 \quad (14)$$

$$= 788.44 \text{ W} \quad (15)$$

d) Total power absorbed by circuit:

$$= P_R + P_C + P_L \quad (16)$$

$$= 788.44 + 0 + 0 \quad (17)$$

$$= 788.44 \text{ W} \quad (18)$$

Total power absorbed by circuit is 788.44W

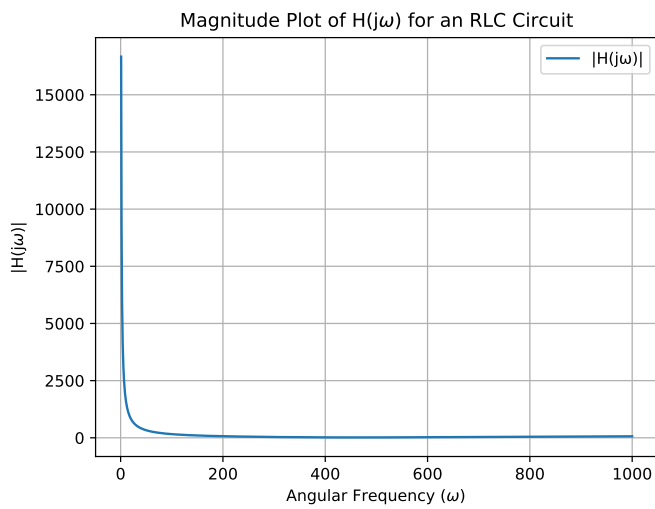


Fig. 3. Impedance vs ω