

GATE 2022 EC

EE:1205 Signals and System
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Question 42: A circuit with an ideal OPAMP is shown. The Bode plot for the magnitude (in dB) of the gain transfer function $(A(j\omega)) = \frac{V_{out}(j\omega)}{V_{in}(j\omega)}$ of the circuit is also provided (here, ω is the angular frequency in rad/s). The values of R and C are

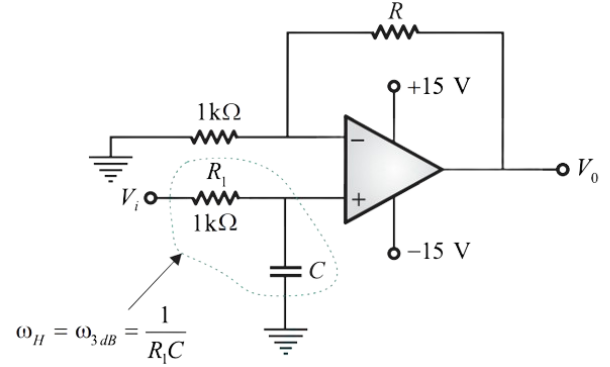
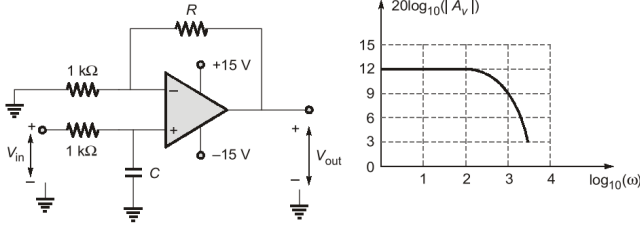


Fig. 1: Active Low Pass Filter

From (1) and (2),

$$\frac{sV_{IN}(s)}{sR_1C + 1} - sRi_2(s) = sV_0(s) \quad (3)$$

$$-\frac{i_1(s)}{C} = sR_1i_2(s) \quad (4)$$

From (1), (2) and (4),

$$-\frac{V_{IN}(s)}{R_1^2Cs + R_1} = \frac{V_{IN}(s)}{RsR_1C + R} - \frac{V_0(s)}{R} \quad (5)$$

Solution

Parameter	Description	Value
R	Resistance	?
C	Capacitance	?
R_1	Resistance	1000
ω_{dB}	Cut-off frequency	1000
A_V	Gain Transfer	$\frac{V_{out}}{V_{in}}$

TABLE 1: Given Parameters

$$sR_1i_1(s) + \frac{i_1(s)}{C} = V_{IN}(s)s \quad (1)$$

$$\frac{i_1(s)}{C} - sRi_2(s) = sV_0(s) \quad (2)$$

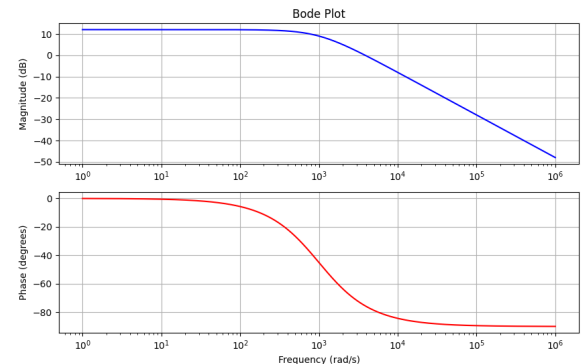


Fig. 2: bode plot

The 3-dB frequency from bode magnitude plot,

$$\Rightarrow \omega_{3dB} = 1000 \text{ rad/sec} \quad (6)$$

$$\omega_{3dB} = \frac{1}{R_1 C} \quad (7)$$

$$\Rightarrow C = 1 \mu F \quad (8)$$

$$\Rightarrow A(s) = \frac{V_{OUT}(s)}{V_{IN}(s)} \quad (9)$$

$$= \frac{1 + 10^{-3}R}{1 + sC10^3} \quad (10)$$

$$|A(s)| = \frac{1 + 10^{-3}R}{\sqrt{1 + \omega^2 10^{-6}}} \quad (11)$$

$$(12)$$

A_V at low frequency,

$$|A_V| = 1 + 10^{-3}R \quad (13)$$

$$1 + 10^{-3}R = 10^{\frac{3}{5}} \quad (14)$$

$$R = 3k\Omega \quad (15)$$

Hence, The correct option is (A).