GATE 2022 EC

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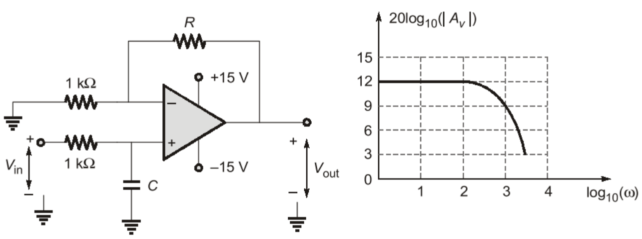
Question 42: A circuit with an ideal OPAMP is shown. The Bode plot for the magnitude (in dB) of the gain transfer function $(A(j\omega)) = \frac{V_{out}(j\omega)}{V_{in}(j\omega)}$ of the circuit is also provided (here, ω is the angular frequency in rad/s). The values of R and C are



(A) $R = 3k\Omega$, $C = 1\mu F$

(B) $R = 1k\Omega$, $C = 3\mu F$

(C) $R = 4k\Omega$, $C = 1\mu F$

(D) $R = 3k\Omega$, $C = 2\mu F$

Solution

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

TABLE 1: Given Parameters

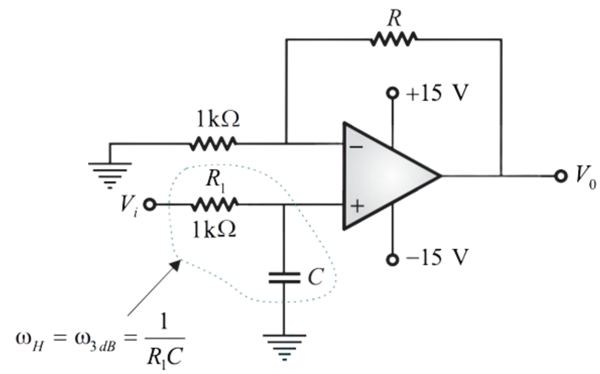


Fig. 1: Active Low Pass Filter

The given Op-Amp is first order active low pass filter, so low frequency ($\omega = 0$) gain of given low-pass filter is,

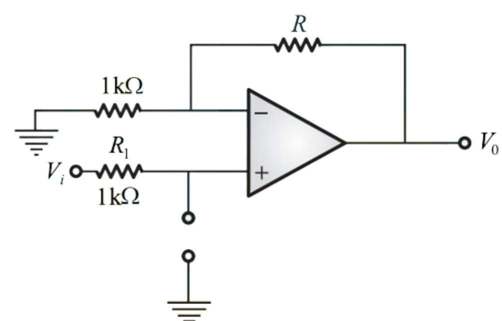


Fig. 2: Non-Inverting

The above OP-Amp circuit becomes as non-inverting closed loop Op-Amp, so gain (A_V) is,

$$A_V = \lfloor 1 + \frac{R}{1} \rfloor \tag{1}$$
$$= 1 + R \tag{2}$$

The $3-dB$ cut-off frequency of given low pass filter circuit is,

$$\omega_{3dB} = \frac{R_1}{C} rad/s \tag{3}$$

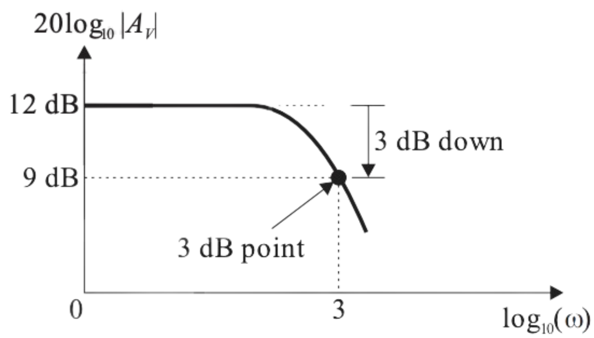


Fig. 3: bode magnitude plot

Low frequency ($\omega = 0$) gain from bode magnitude plot is,

$$\implies 12dB = 20\ \log_{10}(A_V) \tag{4}$$

$$A_V = \text{Antilog}\lfloor\frac{12}{20}\rfloor \tag{5}$$

$$\implies 1 + R = 4 \tag{6}$$

$$R = 3k\Omega \tag{7}$$

The 3-dB frequency from bode magnitude plot,

$$\implies \log_{10}\omega_{3dB} = 3 \tag{8}$$

$$\omega_{3dB} = 1000\ rad/sec \tag{9}$$

$$\omega_{3dB} = \frac{1}{R_1 C} \tag{10}$$

$$= 1000 \tag{11}$$

$$\implies C = \frac{1}{1000R_1} \tag{12}$$

$$= 1\mu F \tag{13}$$

Hence, the correct option is (A).