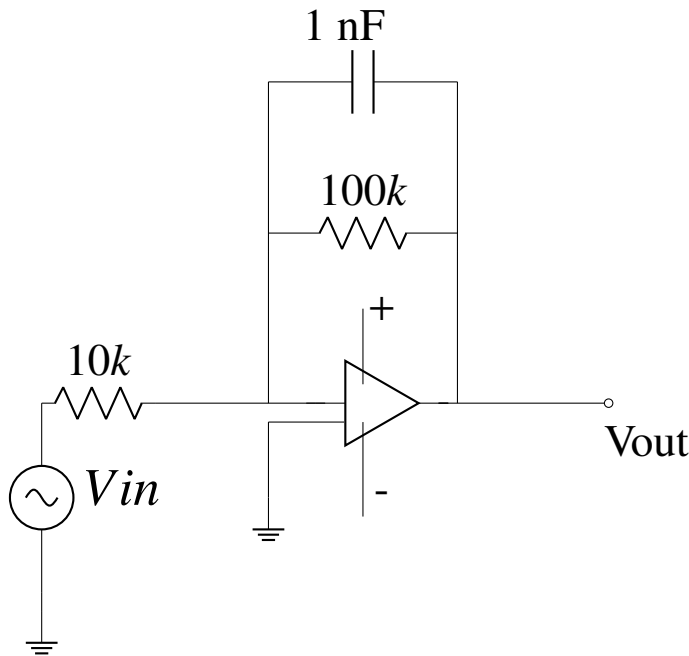


# GATE 2022 IN-56

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**Question:** The circuit shown is driven by a sinusoidal input voltage,  $V_{in}$ , resulting in the output voltage  $V_{out}$ . The frequency (in kilohertz) at which the voltage gain is 0 dB is (rounded off to two decimal places). (GATE IN 2022)



$$Z_1 = R_1 \quad (1)$$

$$Z_2 = \frac{R_2}{1 + j\omega R_2 C} \quad (2)$$

$$\frac{1}{Z_2} = \frac{1}{R_2} + j\omega C \quad (3)$$

$$\frac{V_{out}}{V_{in}} = -\frac{Z_2}{Z_1} \quad (4)$$

$$\frac{|V_{out}|}{|V_{in}|} = \frac{|Z_2|}{|Z_1|} \quad (5)$$

$$20 \log \left( \frac{V_{out}}{V_{in}} \right) = 0 \quad (6)$$

$$\frac{V_{out}}{V_{in}} = 1 \quad (7)$$

$$\frac{|V_{out}|}{|V_{in}|} = \frac{|R_2|}{|(1 + j\omega R_2 C)R_1|} = 1 \quad (8)$$

$$\frac{R_2}{R_1} = \sqrt{1 + (R_2 \omega C)^2} \quad (9)$$

$$10 = \sqrt{1 + (10^5 \cdot \omega 10^{-9})^2} \quad (10)$$

$$99 = \omega^2 \times 10^{-8} \quad (11)$$

$$\omega = \sqrt{99} \times 10^4 \quad (12)$$

$$2\pi f = 99.49 \times 10^3 \quad (13)$$

$$f = 15.84 \text{ kHz} \quad (14)$$

**Solution:**

This circuit is an inverting OP-AMP. The transfer function of an inverting OP-AMP is given by

Parameter	Value	Description
$20 \log \left( \frac{V_{out}}{V_{in}} \right)$	0	Voltage gain
Sinusoidal input voltage	$V_{in}$	Input voltage applied to the circuit
Output voltage	$V_{out}$	Voltage across the output of the circuit
$R_1$	10 k $\Omega$	Resistor connected to the inverting input of the OP-AMP
$R_2$	100 k $\Omega$	Feedback resistor connected from the output to the inverting input of the OP-AMP
$C$	1 nF	Capacitor connected in parallel with $R_2$
$Z_1$	?	Impedance of resistor $R_1$
$Z_2$	?	Impedance of capacitor $C$ in series with resistor $R_2$

TABLE 0  
PARAMETERS

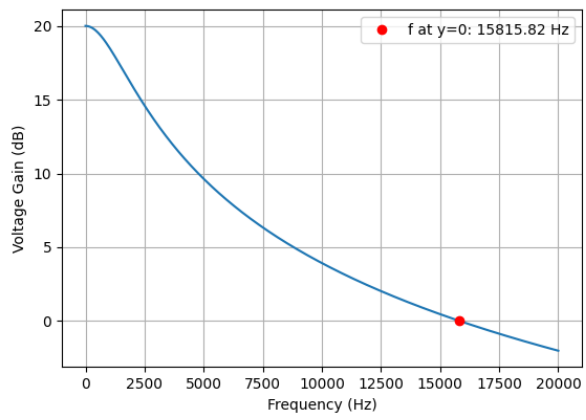


Fig. 0. Frequency vs Voltage gain