GATE-EC-51

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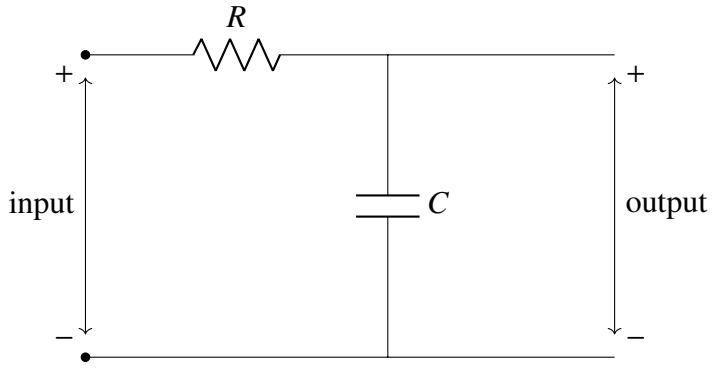
Consider an FM broadcast that employs the pre-emphasis filter with frequency response

$$H_{pe}(\omega) = 1 + \frac{j\omega}{\omega_0},$$

where $\omega_0 = 10^4$ rad/sec.
For the network shown in the figure to act as a corresponding de-emphasis filter, the appropriate pair(s) of (R,C) values is/are _____



A. $R = 1k\Omega$, $C = 0.1\mu F$
B. $R = 2k\Omega$, $C = 1\mu F$
C. $R = 1k\Omega$, $C = 2\mu F$
D. $R = 2k\Omega$, $C = 0.5\mu F$

Solution:

Variable	Description	Value
H_pre	Frequency response of pre-emphasis filter	$1 + \mathrm{j}\frac{\omega}{\omega_0}$
ω_0	Fundamental Frequency	10^4 rad/sec

TABLE 0
INPUT PARAMETERS

Taking KVL around the loop,

$$-V_i(t) + i(t)R + V_0(t) = 0 \tag{1}$$

$$\mathcal{L}(f'(t)) \overset{\mathcal{L}}{\leftrightarrow} sF(s) - f(0) \tag{2}$$

$$i(t) = C\frac{dV_0(t)}{dt} \tag{3}$$

Using (2) and (3),

$$\mathcal{L}\left(-V_i(t) + RC\frac{dV_0(t)}{dt} + V_0(t)\right) = \mathcal{L}(0) \tag{4}$$

$$V_0(s)(1 + j\omega RC) = V_i(s) \tag{5}$$

$$H(j\omega) = \frac{V_o(j\omega)}{V_i(j\omega)} = \frac{1}{1 + j\omega RC} \tag{6}$$

The given RC circuit to act as de-emphasis filter

$$|H(j\omega)| = \frac{1}{\left|H_{pre}(\omega)\right|} \tag{7}$$

$$\frac{1}{\sqrt{1 + (\omega RC)^2}} = \frac{1}{\sqrt{1 + \left(\frac{\omega}{\omega_0}\right)^2}} \tag{8}$$

$$\omega_0 = \frac{1}{RC} \tag{9}$$

$$\omega_0 = 10^4 rad/sec \tag{10}$$

Thus $\omega_0 = 10^4$ rad/sec only possible if we choose $R = 1k\Omega$ and $C = 0.1\mu F$ from options. Hence, the correct option is (B).

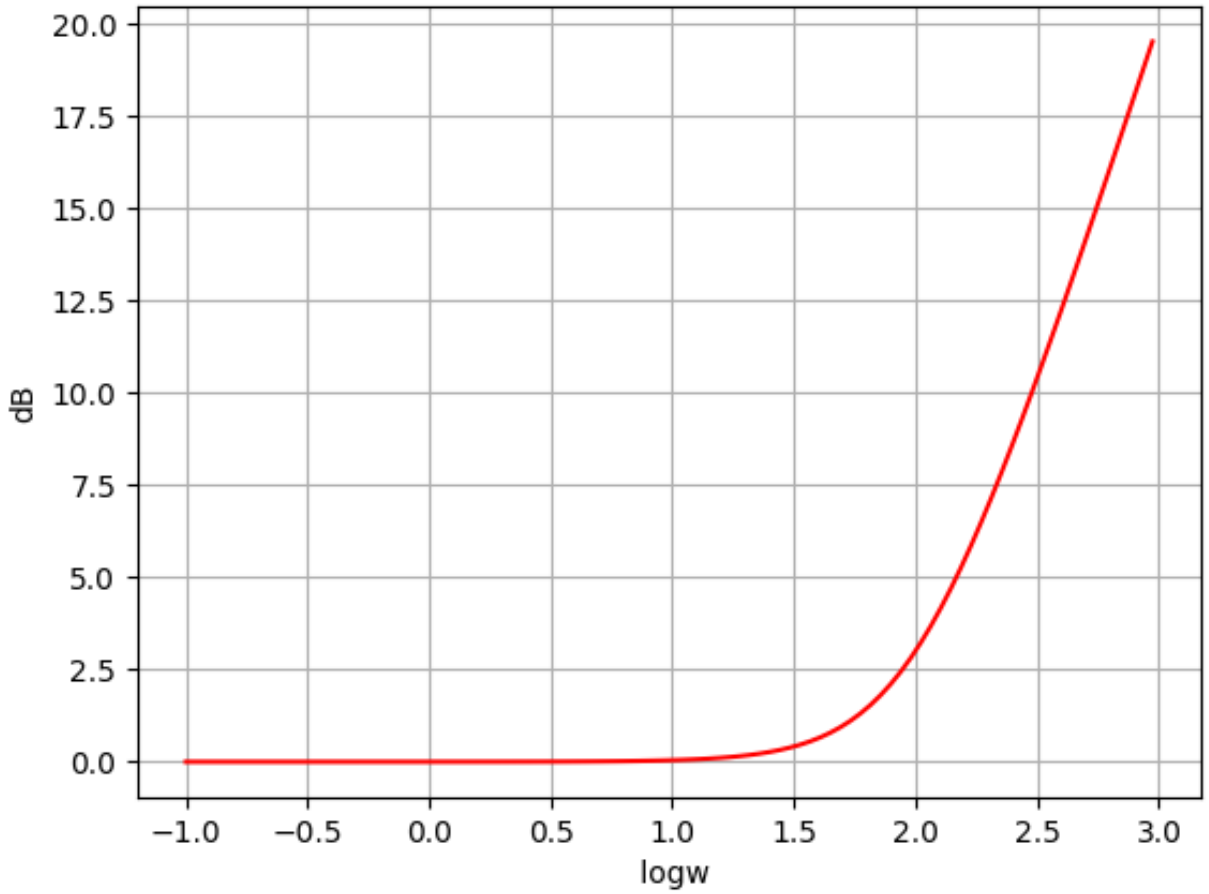


Fig. 0. Frequency response of a pre-emphasis filter.