GATE-2023, EC-35

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Question:
In the circuit shown below, switch S was closed for a long time. If the switch is opened at t=0, the maximum magnitude of the voltage V_R in volts is. (round off to nearest integer).

solution : here at $t < 0$, switch is closed

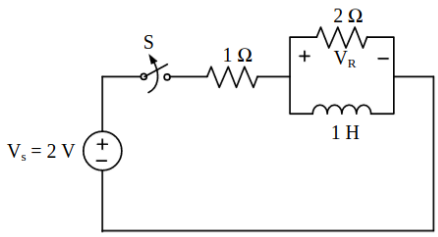

Fig. 0.

parameter	description	value
$i(0^-)$	current at $t < 0$	–
$i(0^+)$	current at $t > 0$	–
V_R	voltage across 2Ω	-
L	inductance	1
$i(t)$	current in small loop after $t = 0$	$\frac{V_R}{2}$

TABLE 0
INPUT PARAMETERS

after $t = 0$, switch is opened
for an inductor

$$i(0^+) = i(0^-) \tag{1}$$

apply KVL before $t < 0$
inductor acts as wire
-

$$-2V + i(0^-) = 0 \tag{2}$$
$$\implies i(0^-) = i(0^+) = 2A \tag{3}$$

after $t = 0$;
KVL in loop of inductor and 2Ω resistor

let i be current in the loop in anti clockwise direction

$$L\frac{di}{dt} = -2i \tag{4}$$
$$\implies \frac{di}{i} = \frac{-2dt}{L} \tag{5}$$
$$\int_{i(0^+)}^{i(t)} \frac{1}{i}\,di = \int_0^t \frac{-2}{L}\,dt \tag{6}$$
$$ln\left(\frac{i(t)}{2}\right) = -2t \tag{7}$$
$$\implies i(t) = 2 \cdot e^{-2t} \tag{8}$$
$$V_R = 2i(t)\,V \tag{9}$$
$$= 4 \cdot e^{-2t} V \tag{10}$$

$$As, t \to \infty \tag{11}$$
$$e^{-2t} \to 1 \tag{12}$$
$$|V_R(max)| = 4V \tag{13}$$