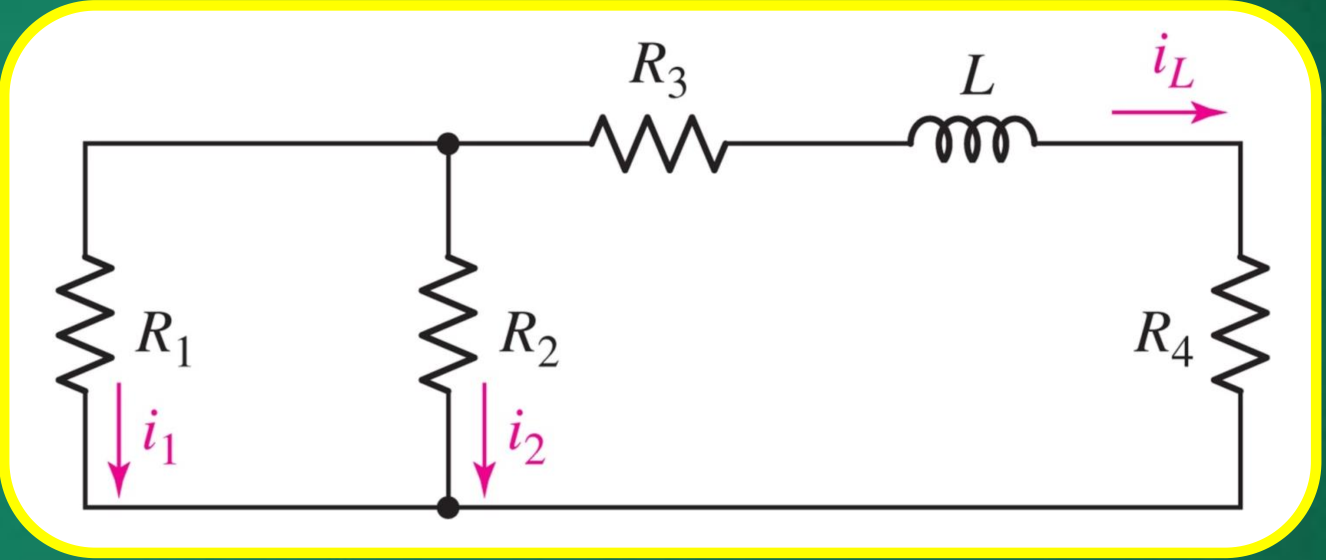
Electrical Science - I
(IEC-102)

Lecture-07

General RL Circuits



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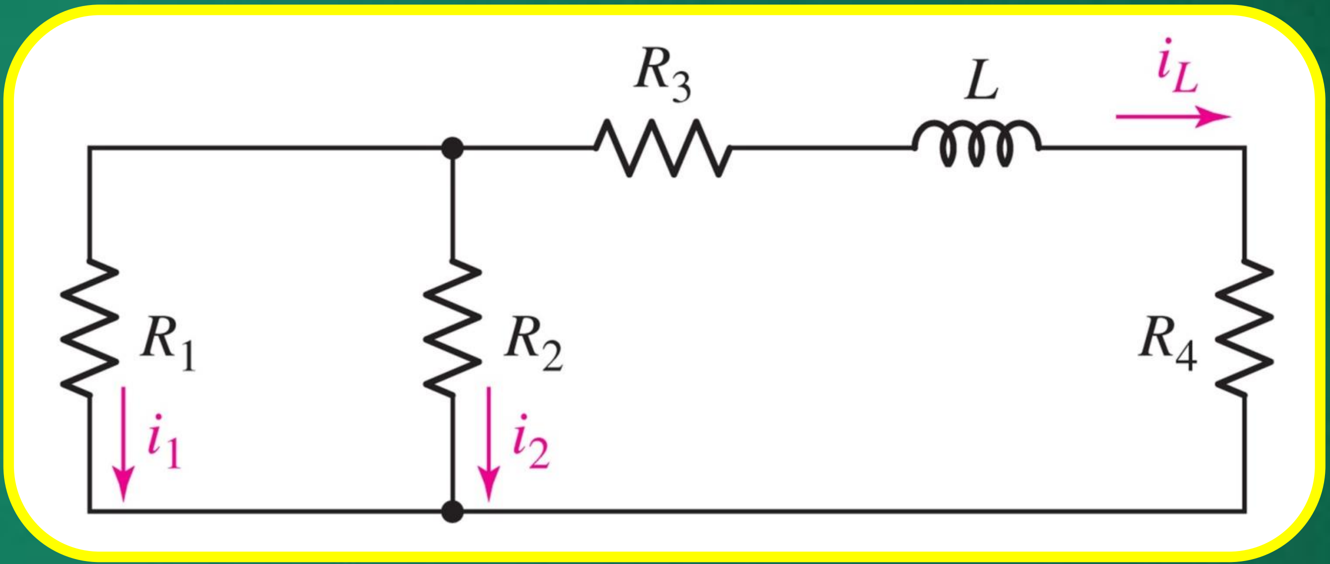

The time constant of a single-inductor circuit will be $\tau = L/R_{eq}$ where R_{eq} is the resistance seen by the inductor.

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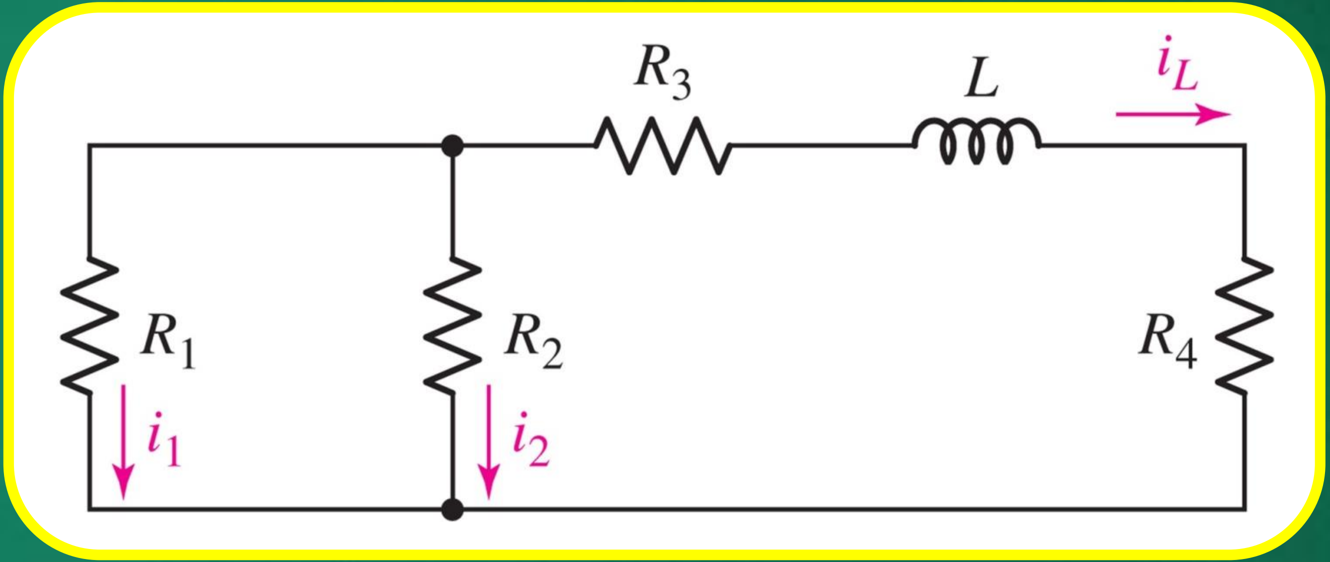

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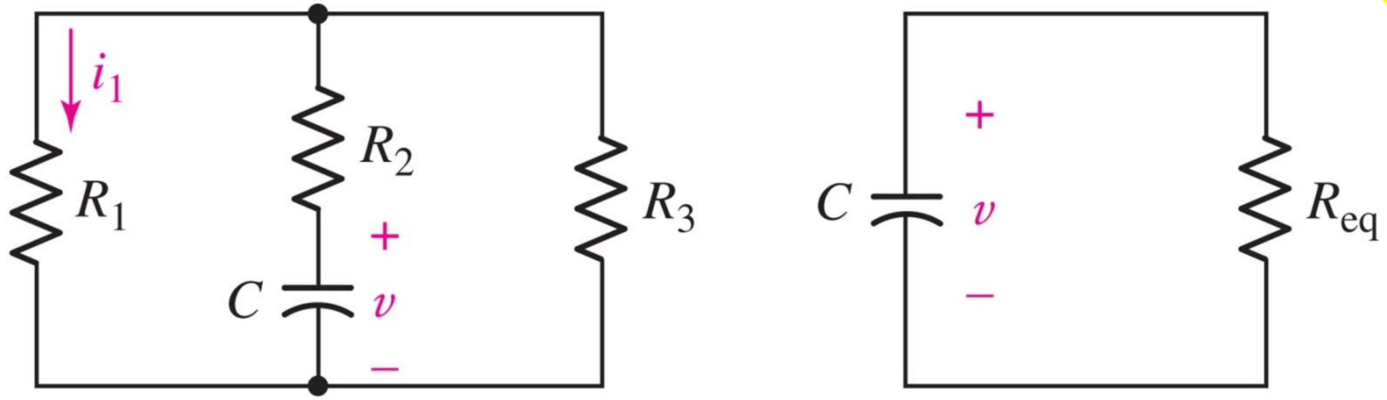
$$R_{eq} = R_3 + R_4 + R_1R_2/(R_1 + R_2)$$

General RC Circuits



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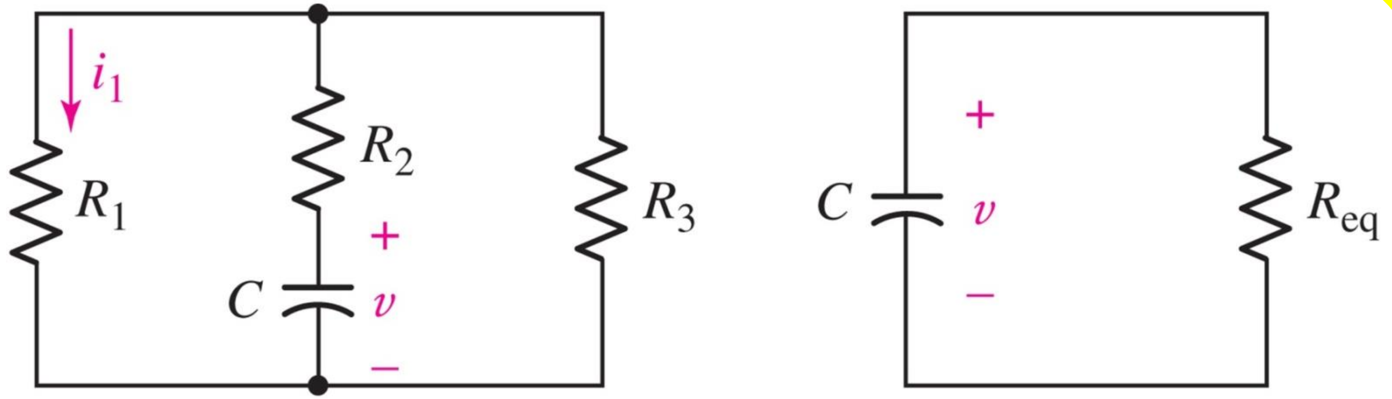

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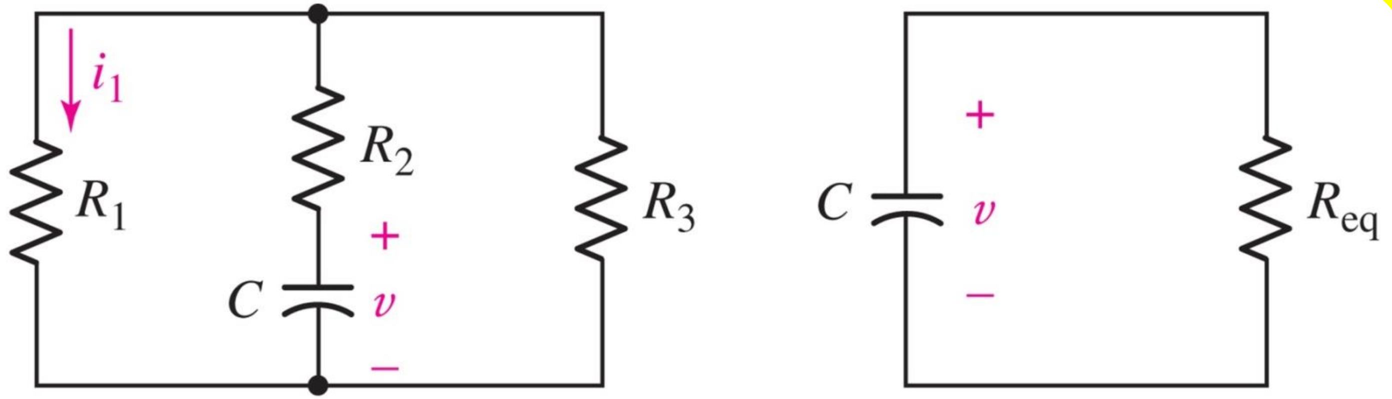

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$$R_{eq} = R_2 + R_1R_3/(R_1 + R_3)$$

1^{st} Order Response Observations

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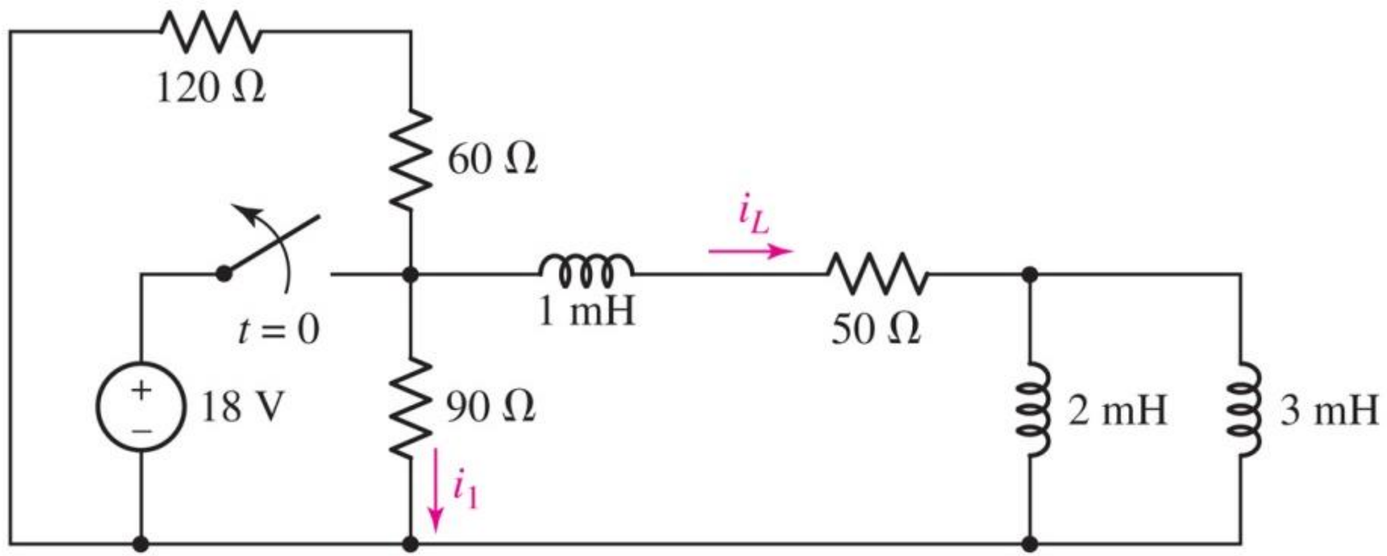
- Resistor voltage (or current) prior to the switch $v(0^-)$ can be different from the voltage after the switch $v(0^+)$.

- All voltages and currents in an RC or RL circuit follow the same natural response $e^{-t/\tau}$.

Example: L and R Current

Find τ , $i_1(t)$ **and** $i_L(t)$ **for** $t \geq 0$**. Given that the circuit is in steady state at** t = 0-**.**



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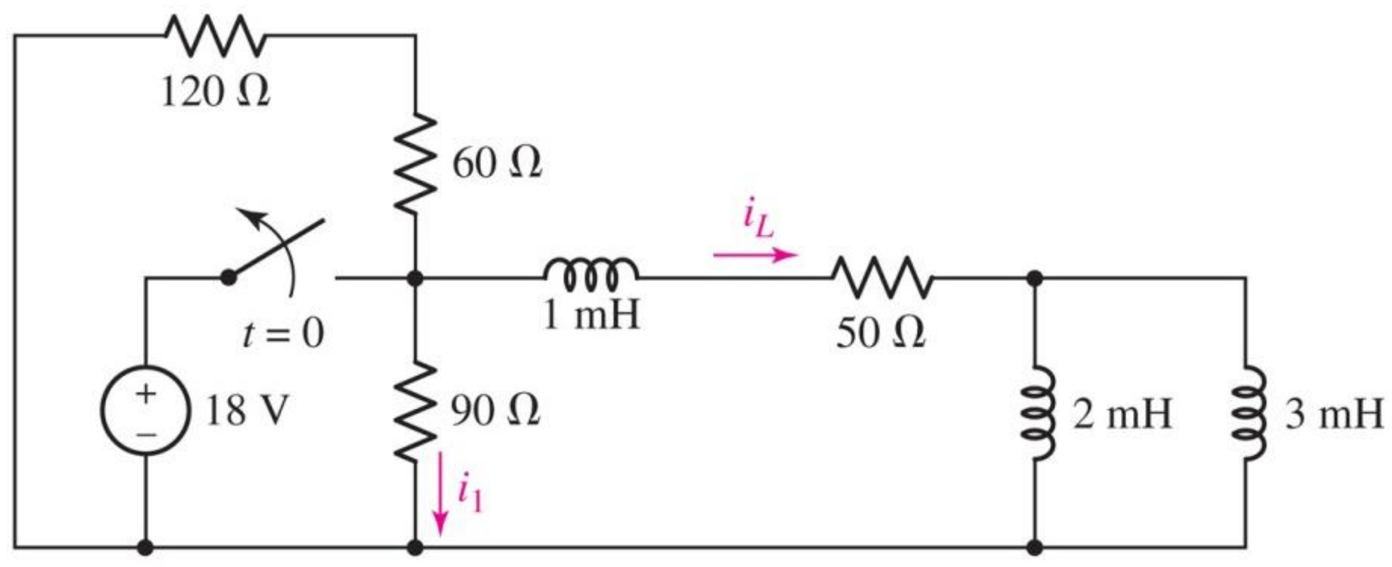

Answer: $\tau = 20\ \mu s$; $i_1 = -0.24e^{-t/\tau}$; $i_L = 0.36e^{-t/\tau}$ for $t \geq 0$

The Unit Step Function

The unit-step function $u(t)$ is a convenient notation to represent change.

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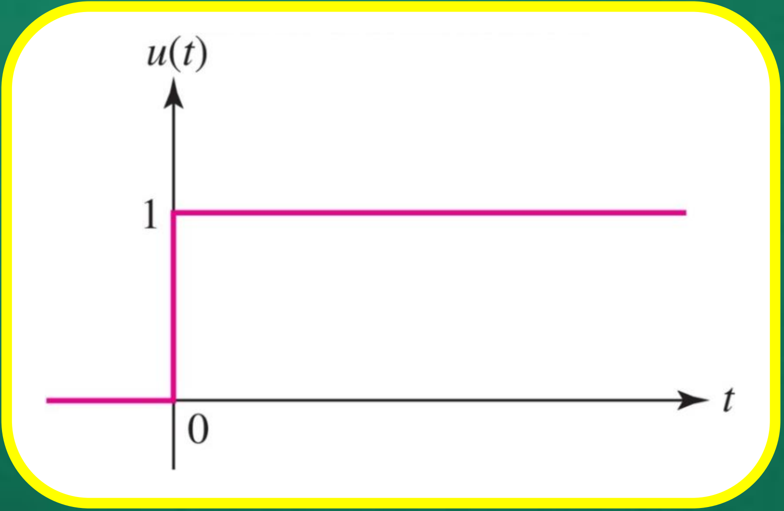

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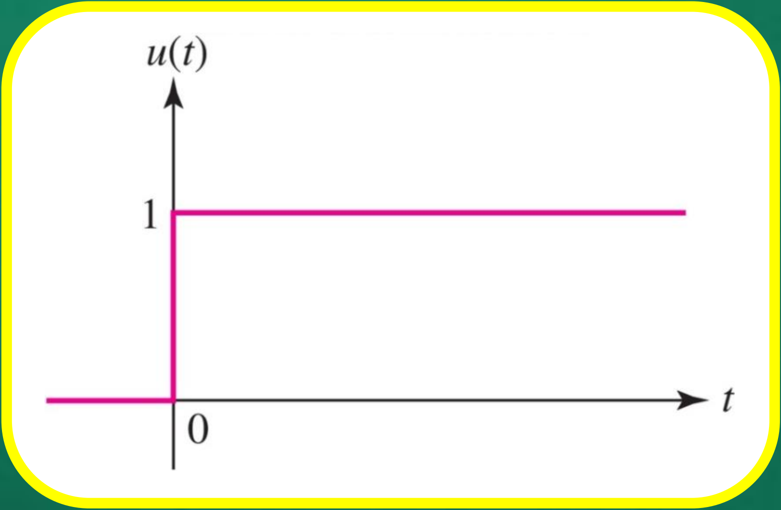
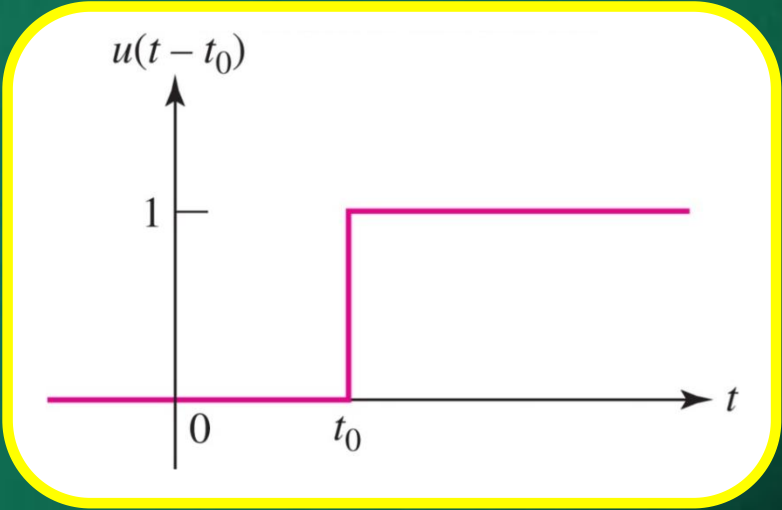
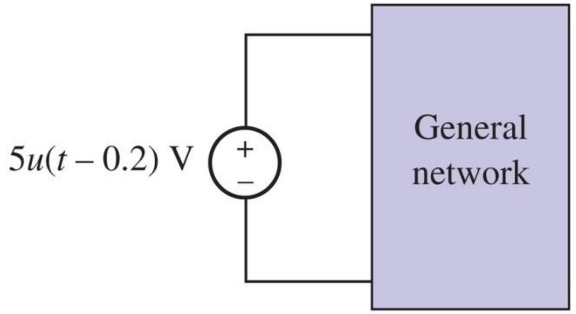




Switches and Steps



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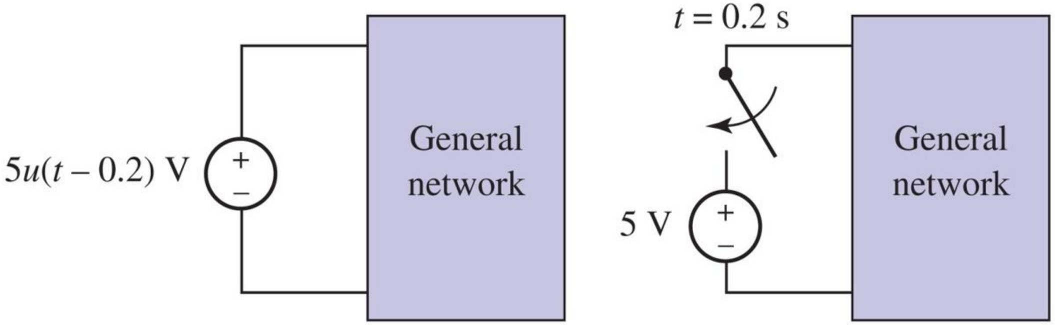

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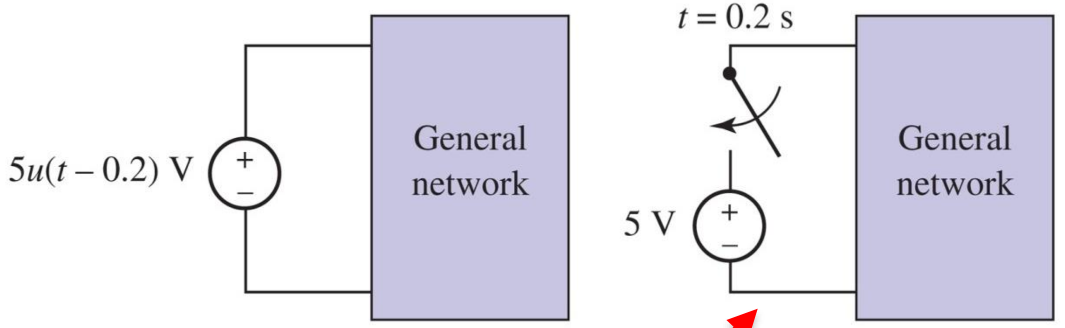
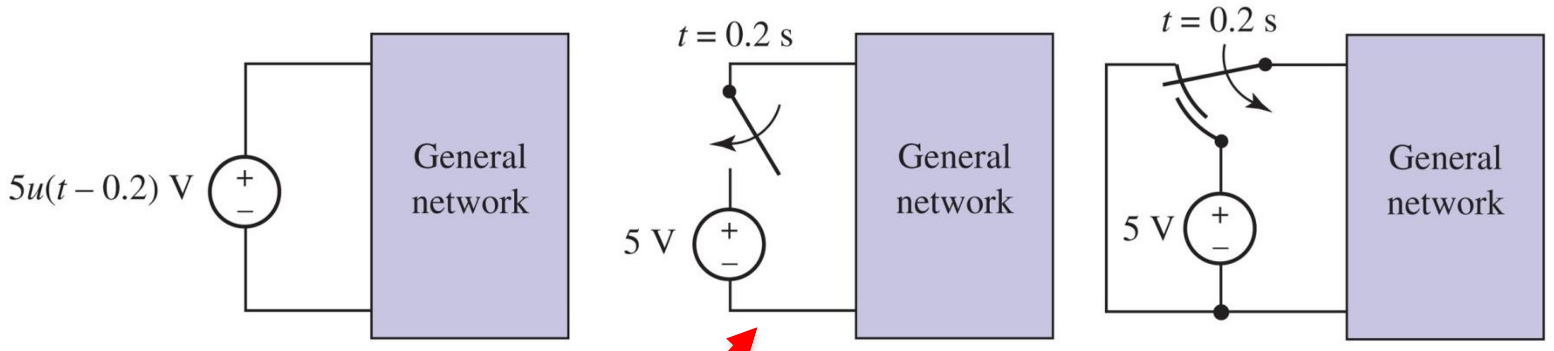


A single-throw switch shown is open circuit for $t < 0$, not short circuit.

Switches and Steps



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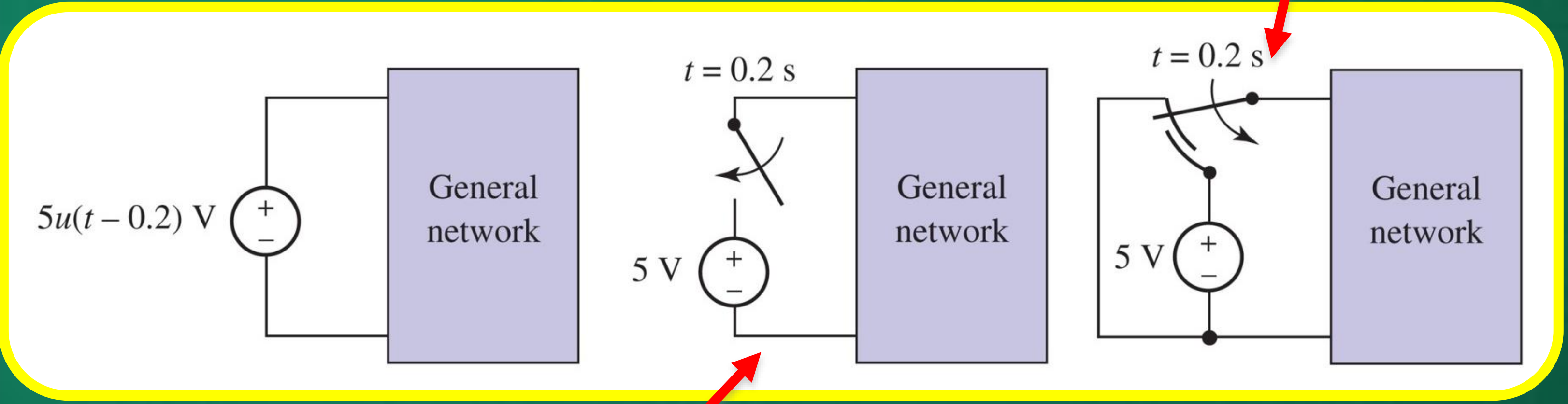
Switches and Steps

The unit step models a double-throw switch.



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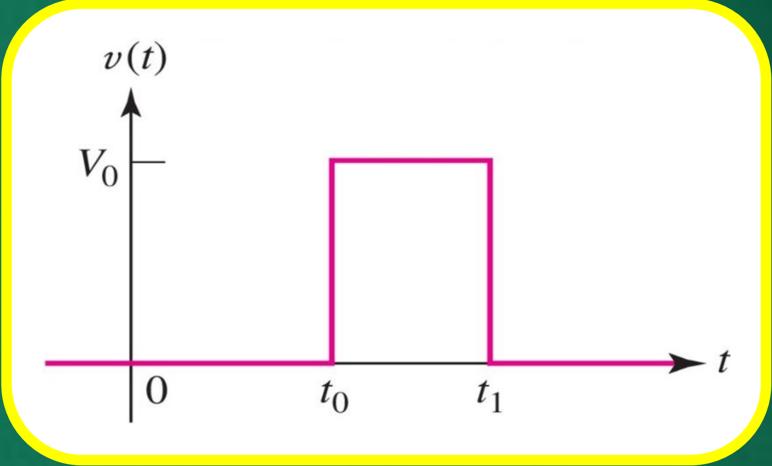
Modeling Pulses using $u(t)$

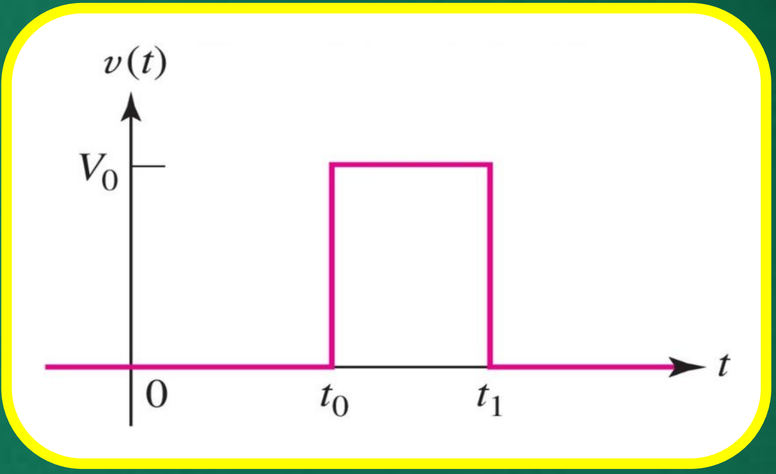
Rectangular pulse



Modeling Pulses using $u(t)$

Rectangular pulse

$$v(t) = V_0[u(t-t_0) - u(t-t_1)]$$



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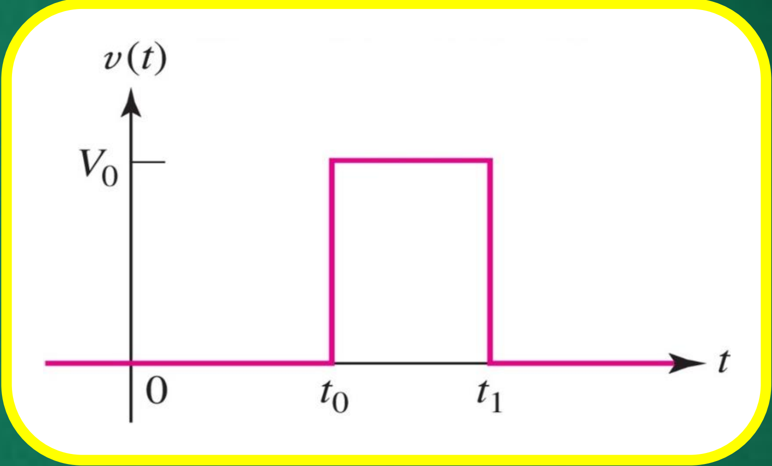
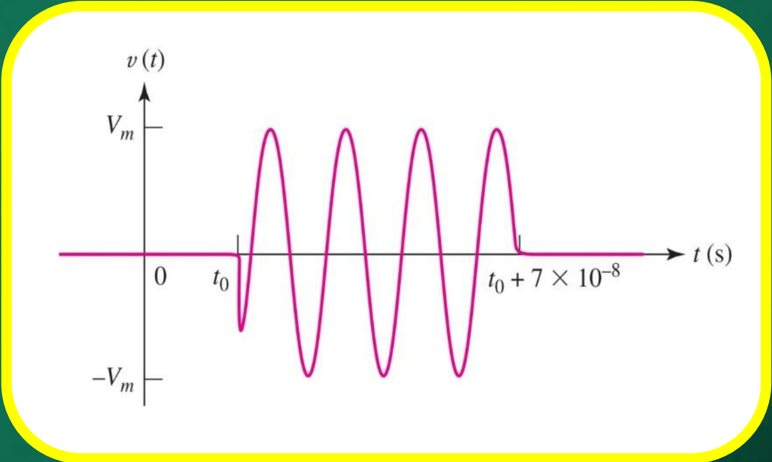


Pulsed sine wave



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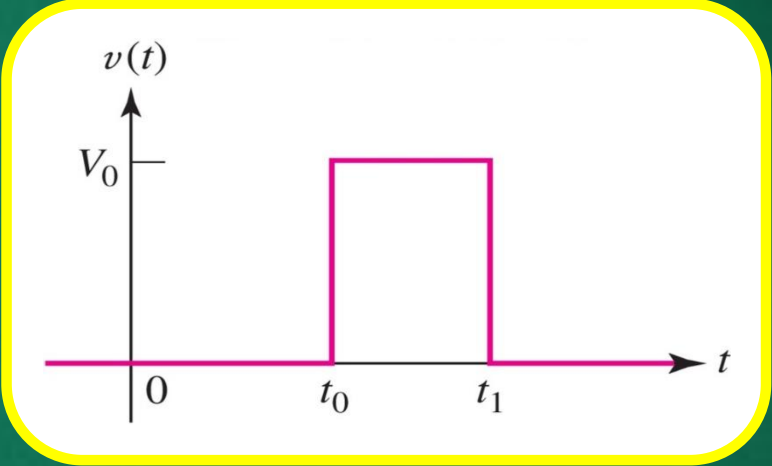

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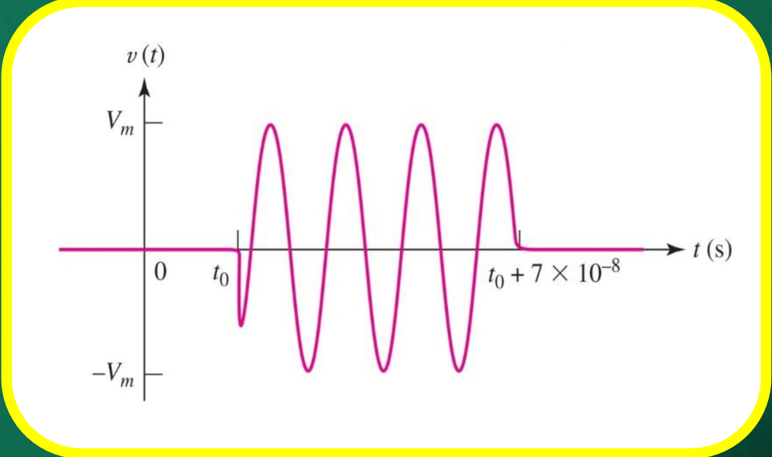
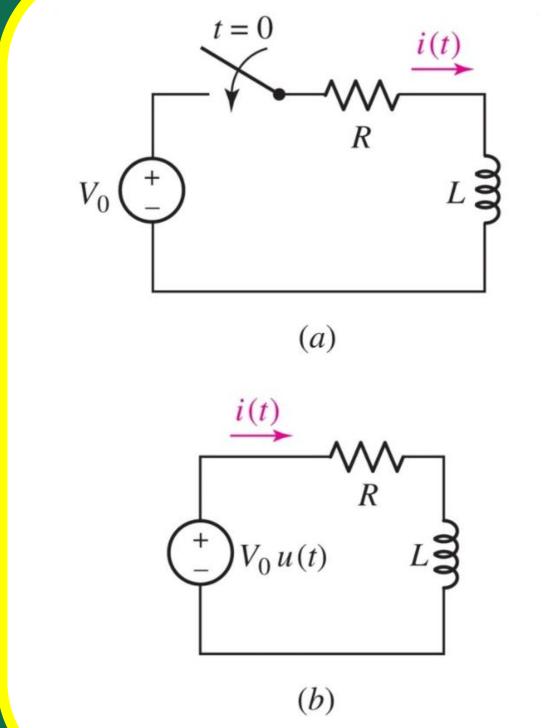


$v(t) = V_m \sin(w_0 t)[u(t-t_0) - u(t-t_1)]$ where $t_1 = t_0 + 7\text{x}10^{-8}$ s

Driven RL and RC Circuits

Driven RL Circuits

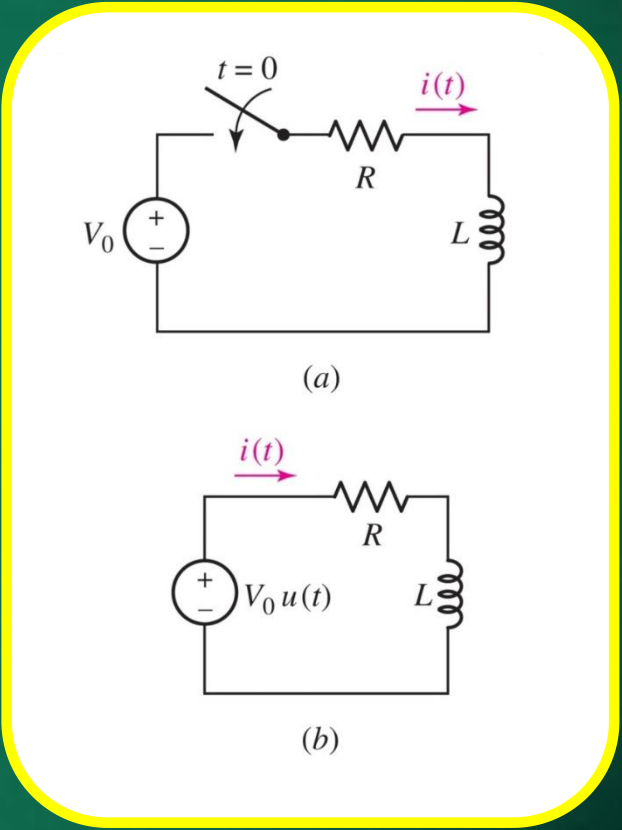
The two circuits shown both have $i(t) = 0$ for $t < 0$ and are also the same for $t > 0$.



Driven RL Circuits

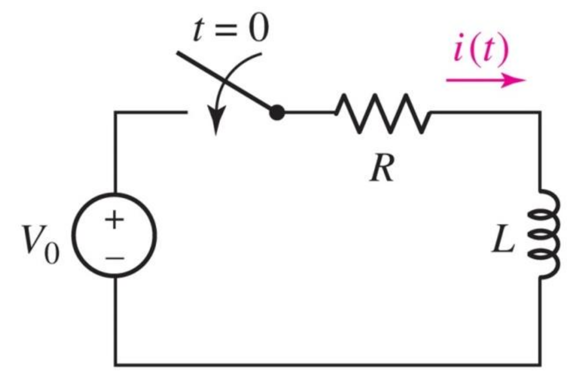
The two circuits shown both have $i(t) = 0$ for $t < 0$ and are also the same for $t > 0$.

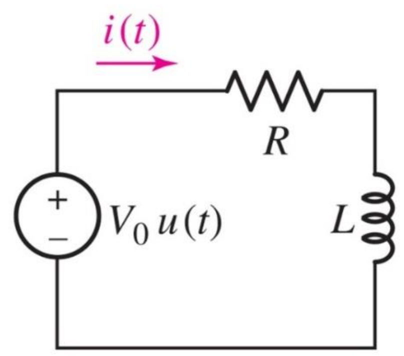
Find both the natural response and the forced response due to the source V_0



Driven RL Circuits

The total response is the combination of the natural response and the forced response.





$$i(t) = \frac{V_0}{R}\left(1 - e^{-Rt/L}\right)u(t)$$

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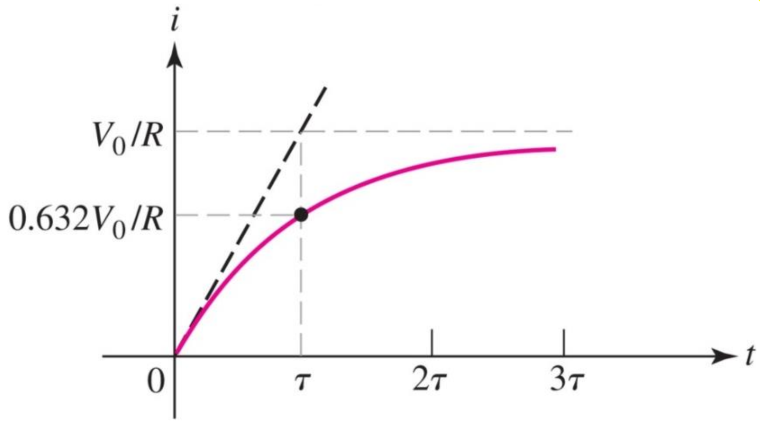

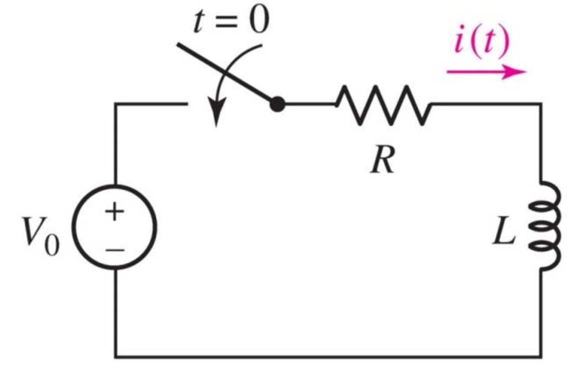

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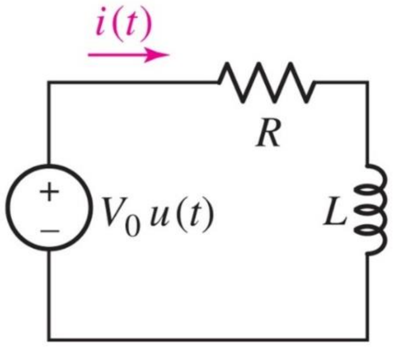
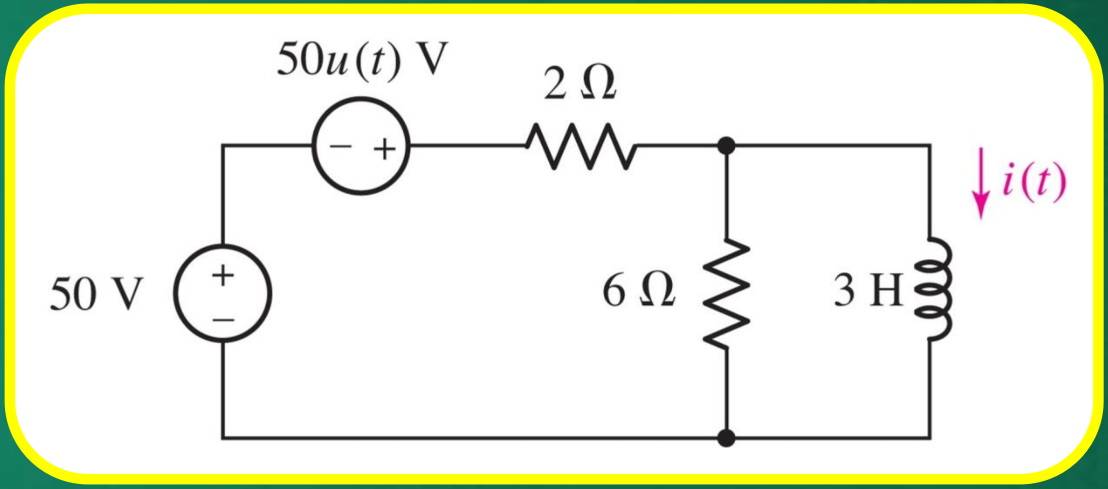


Example: RL Circuit with Step

Find $i(t)$ **for** $t \geq 0$.



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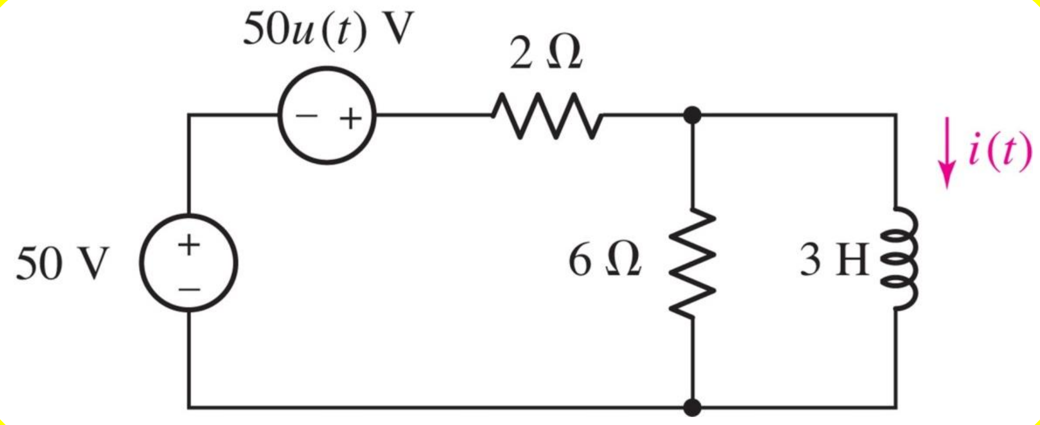

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$$i(t) = 25 + 25(1 - e^{-t/2})u(t) \text{ A}$$

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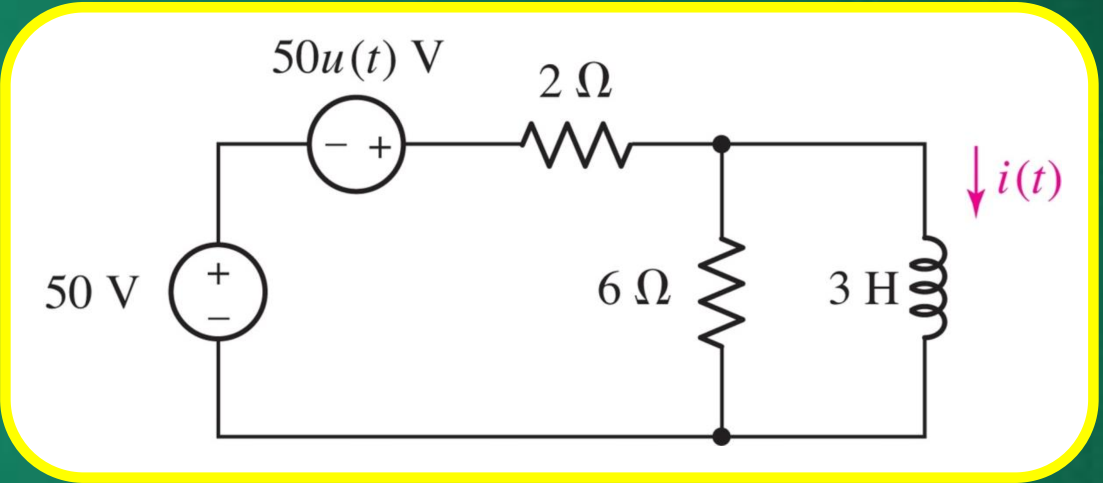

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