ADVANCED ELECTRICAL CIRCUIT
BETI 1333
FIRST ORDER STEP RESPONSE RL CIRCUIT

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LESSON OUTCOMES

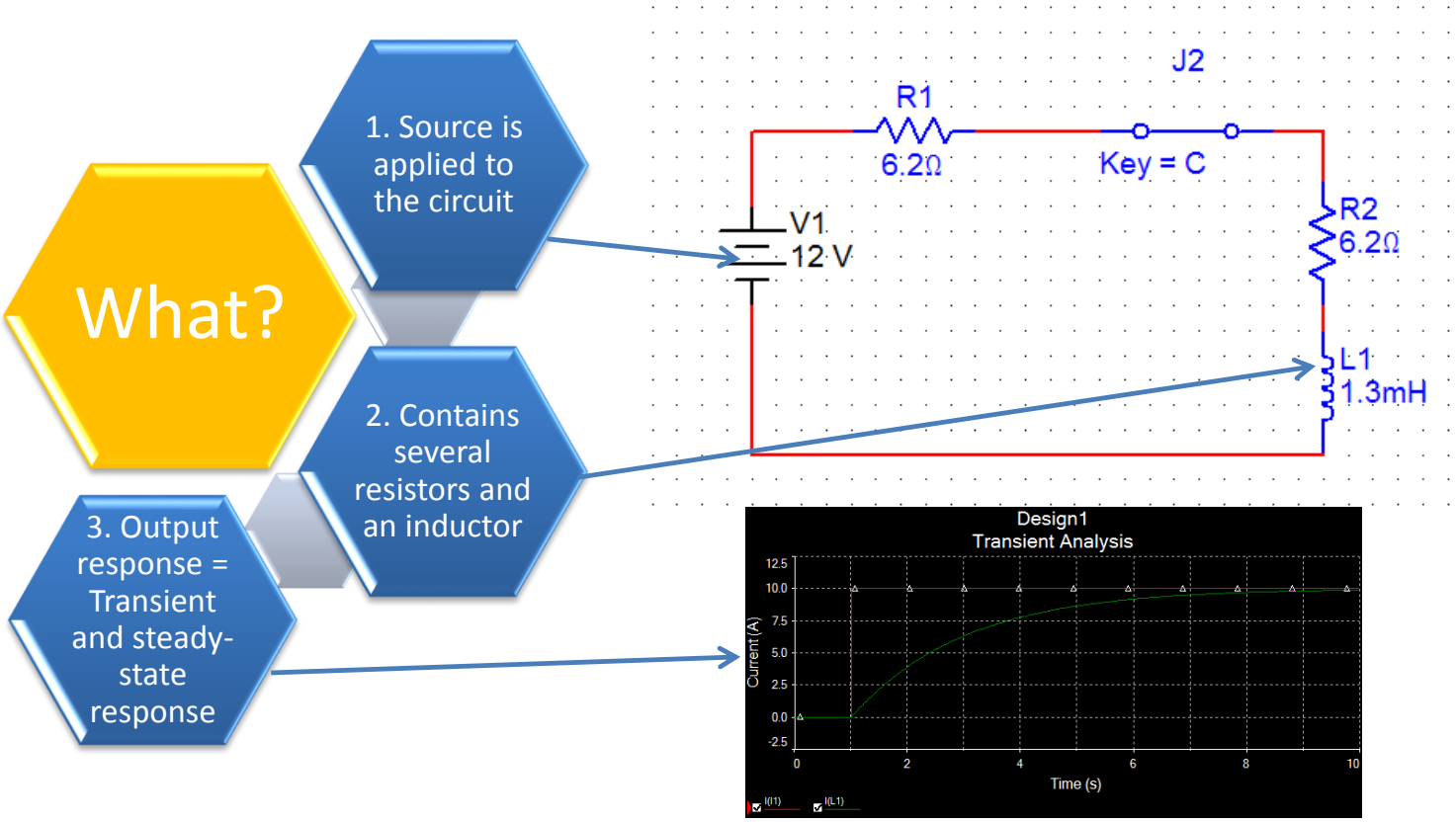
At the end of this chapter, students are able:

- to describe first order step response RL circuit
- to illustrate output response of first order step response RL circuit

SUBTOPICS

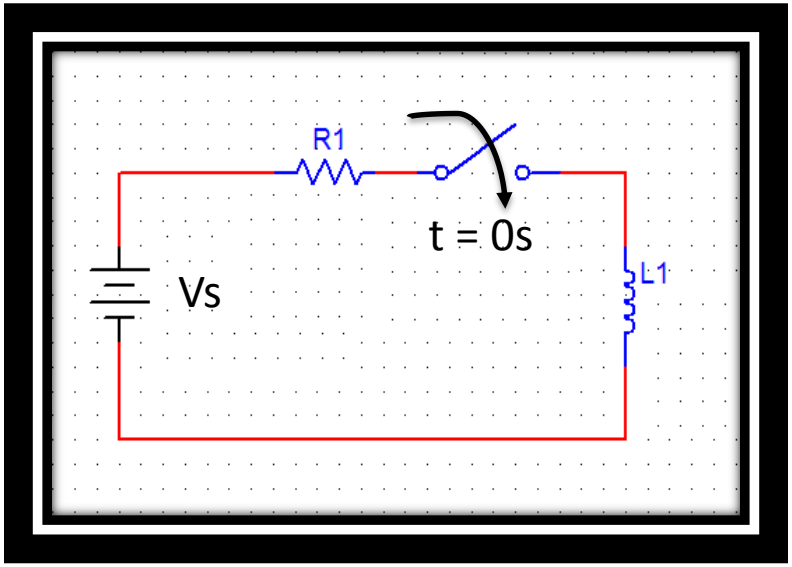
- Step Response RL Circuit
- Application of RC and RL Circuit

INTRODUCTION



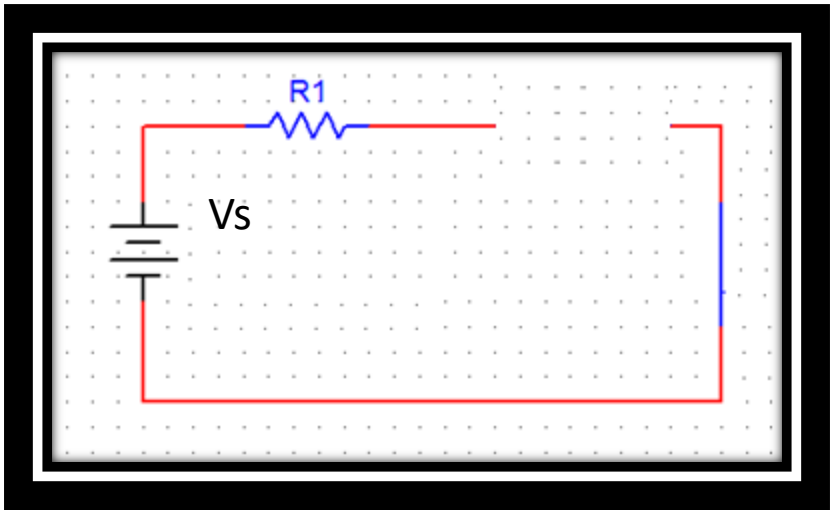
STEP RESPONSE RL CIRCUIT

A switch is closed when t = 0



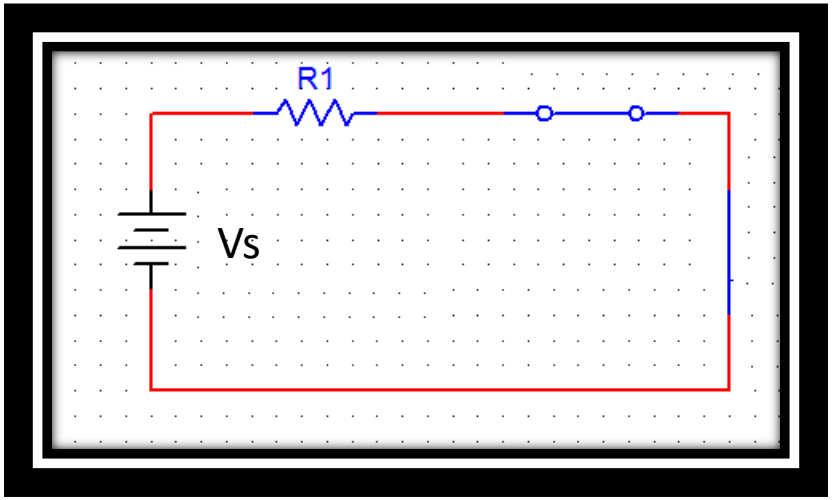
STEP RESPONSE RL CIRCUIT

Step 1: When t = 0^-



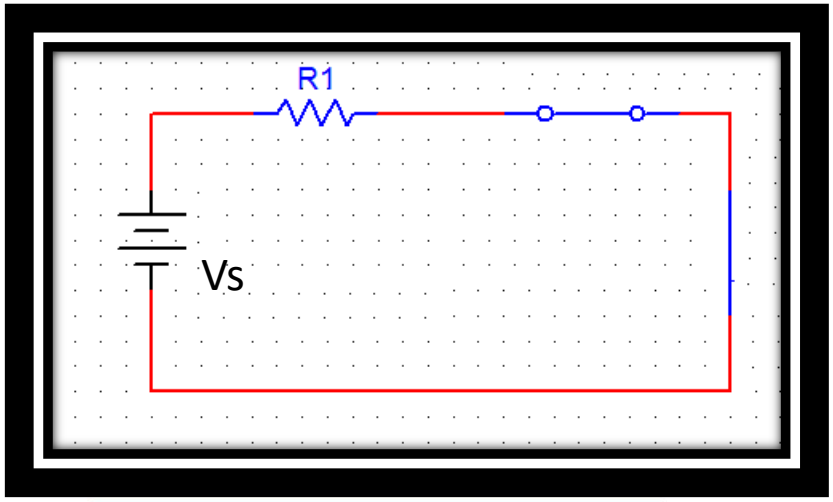
i_L = 0 A

Step 2: When t = 0^+



i_L = 0 A
Initial current

Step 3: When t = ∞

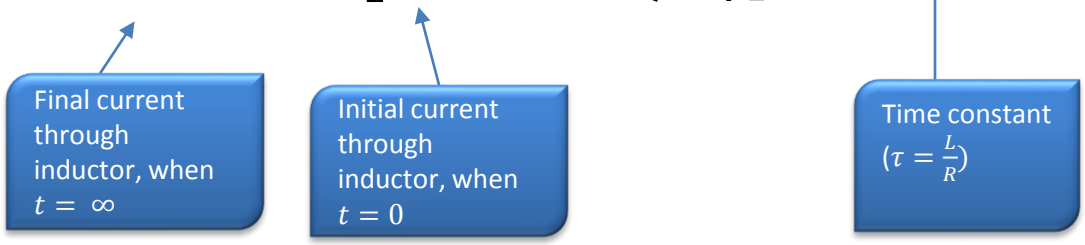


i_L = Vs/R1
Final current

STEP RESPONSE RL CIRCUIT

Current response of an RL circuit:

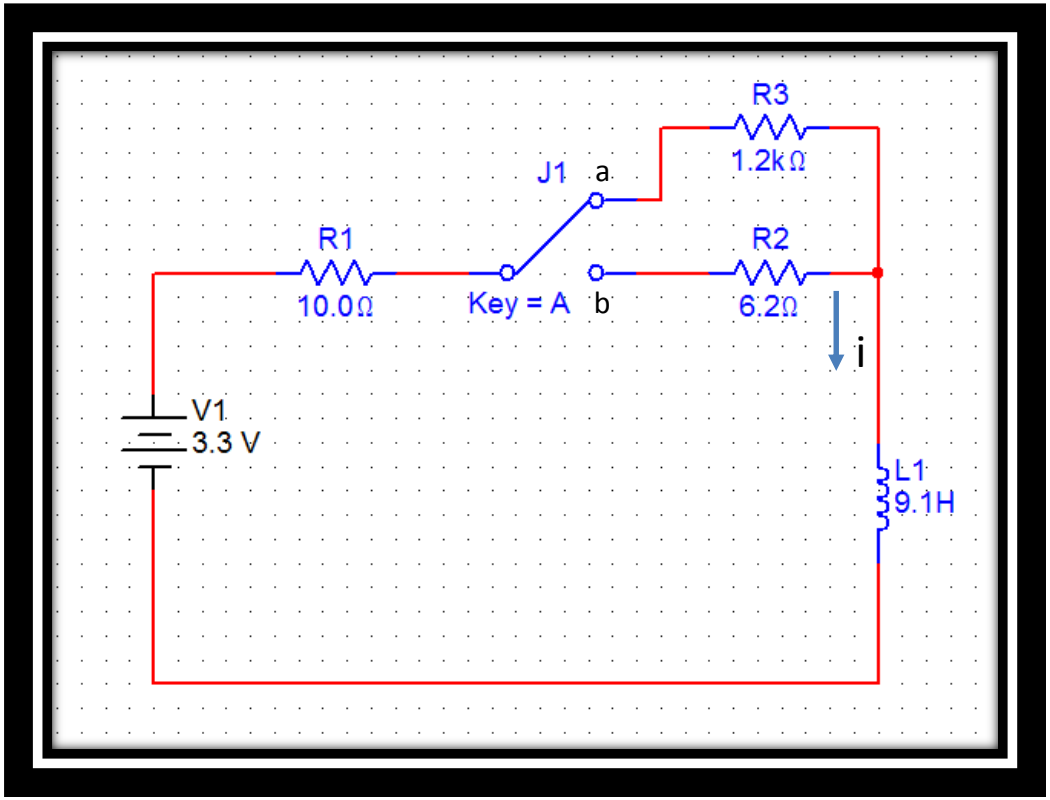
$$i(t) = i(\infty) + [i(0) - i(\infty)]\, e^{-t/\tau}$$



EXAMPLE 1

The switch is at position a for a long time before it moves to position b.

Find i(t) for t > 0.



EXAMPLE 1

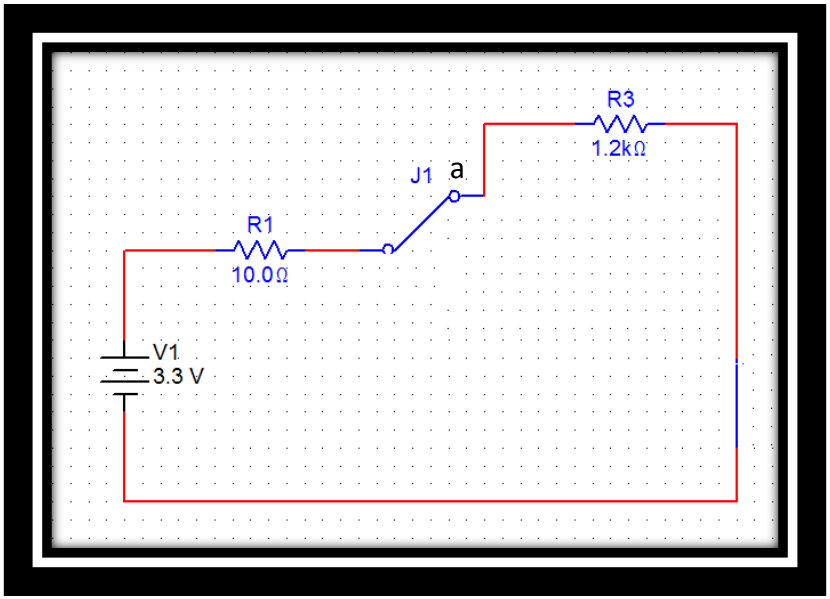
STEP 1 :

When t < 0s:

i(0) = V1/R

= 3.3V/1210 Ω

=2.73mA (initial value)



EXAMPLE 1

STEP 2 :

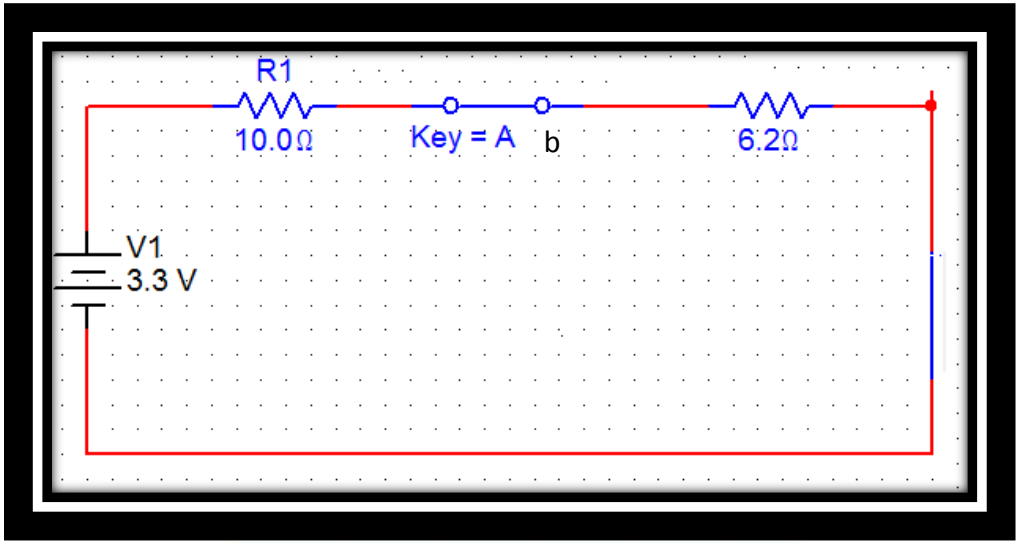
When t = 0s: i(0) = 2.73mA

When t > 0s:

$i(\infty) = V1/R$

$= 3.3V/16.2\ \Omega$

$= 203.7mA$



EXAMPLE 1

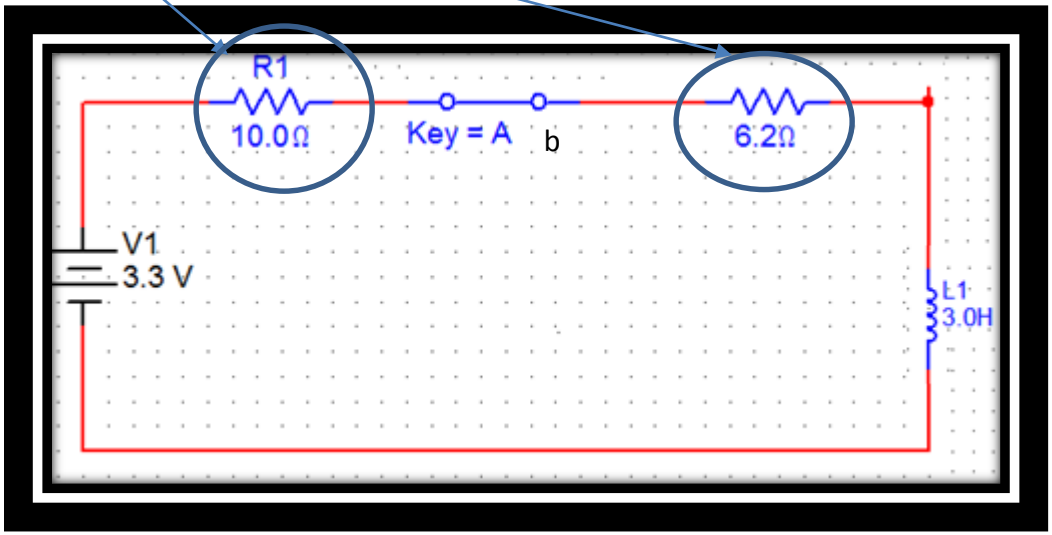
STEP 3 :

$$\tau = \frac{L}{R}$$

= 9.1H / 16.2Ω

= 0.562s

R = 10 + 6.2 = 16.2 Ohm



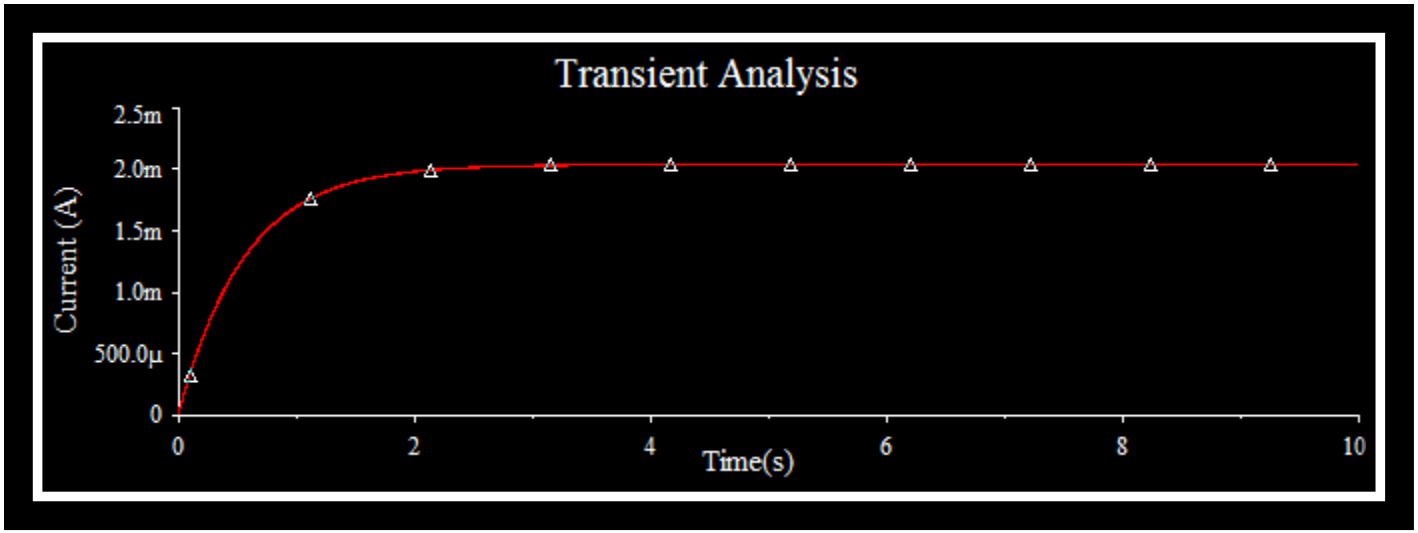
EXAMPLE 1

STEP 4 :

$$i(t) = i(\infty) + [i(0) - i(\infty)]\, e^{-t/\tau}$$

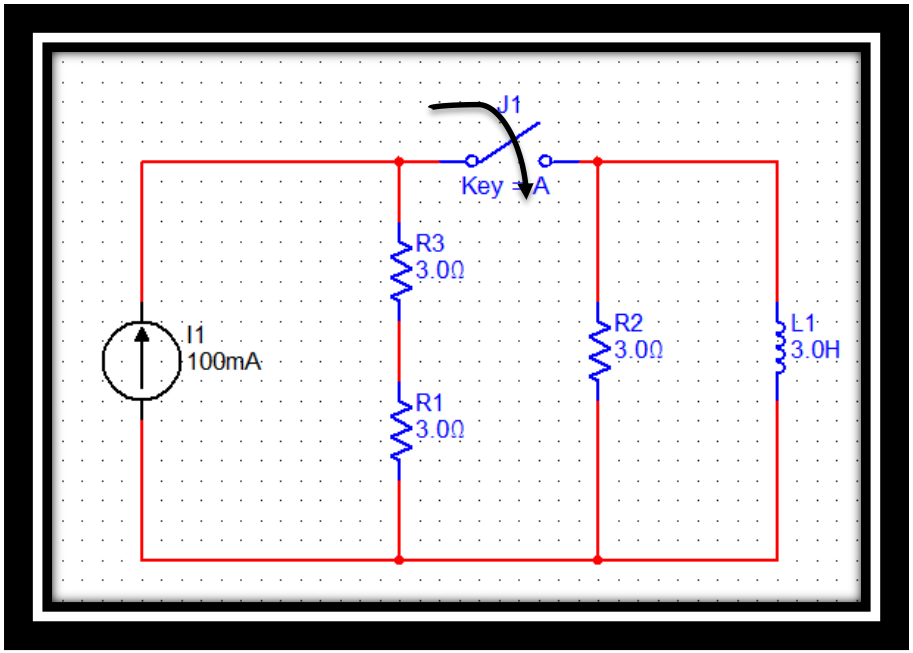
$$i(t) = 203.7m + [2.37m - 203.7m]\, e^{-1.78t}$$

$$i(t) = 203.7 - 201.3e^{-1.78t} \text{ mA}$$



EXAMPLE 2

The switch is closed at t = 0 s. Find $i(t)$ for t > 0 s.



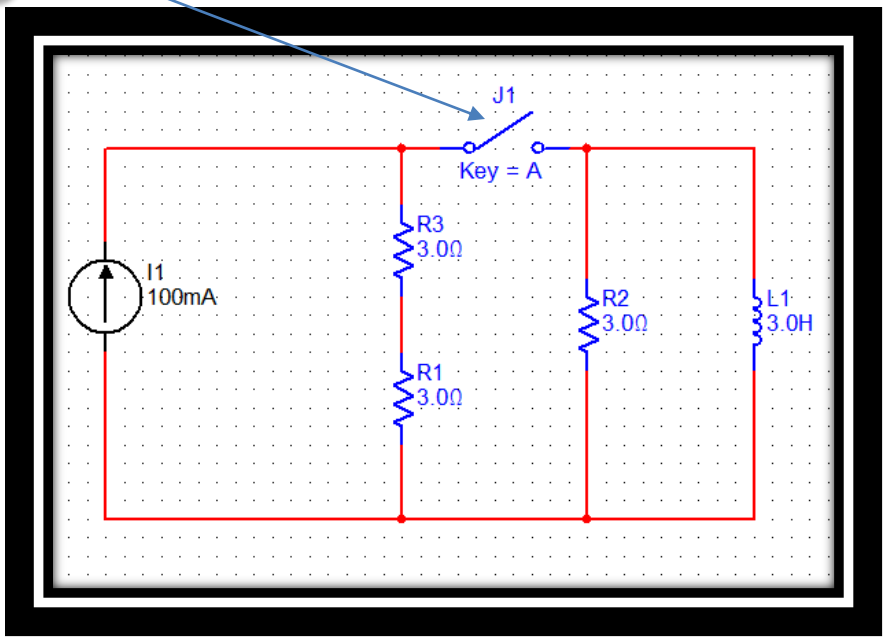
EXAMPLE 2

STEP 1 :

The switch is opened at t < 0s

When t < 0s:

i(0) = 0A (initial value)



EXAMPLE 2

STEP 2 :

When t = 0s: i(0) = 0A

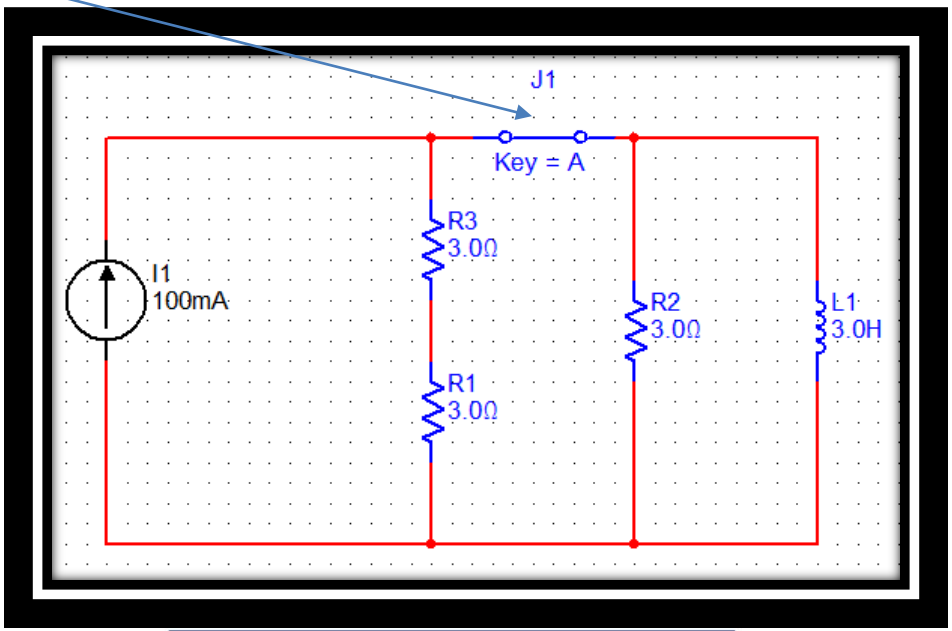
When t > 0s:

Req = $(1/6\Omega + 1/3\Omega)^{-1}$

= 2Ω

i(∞) = 100mA

The switch is closed at t = 0s



EXAMPLE 2

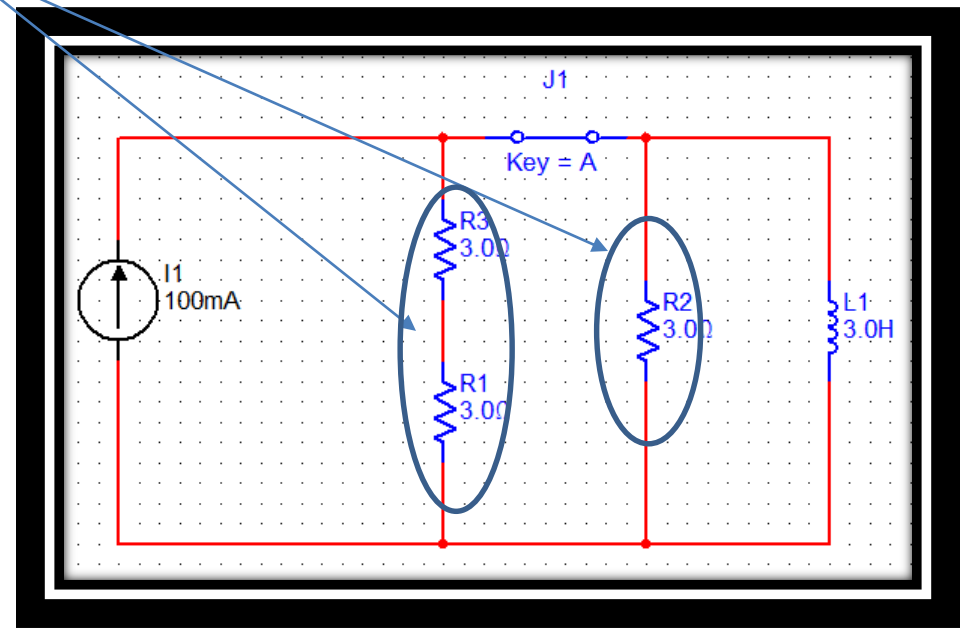
STEP 3 :

$$\tau = \frac{L}{Req}$$

= 3H/2Ω

= 1.5s

R = (1/6+1/3)$^{-1}$ = 2 Ohm



EXAMPLE 2

STEP 4 :

$$i(t) = i(\infty) + [i(0) - i(\infty)]\, e^{-t/\tau}$$

$$i(t) = 100m + [0 - 100]\, e^{-0.5t}$$

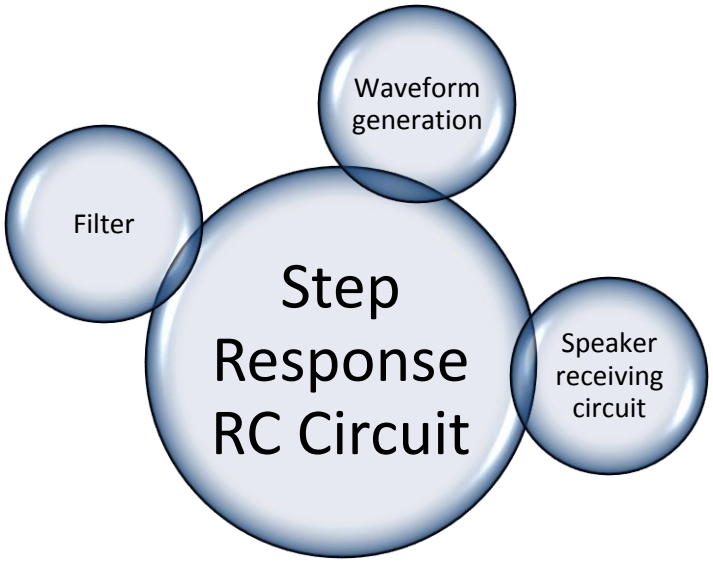
Final current through inductor, when $t = \infty$

Initial current through inductor, when $t = 0$

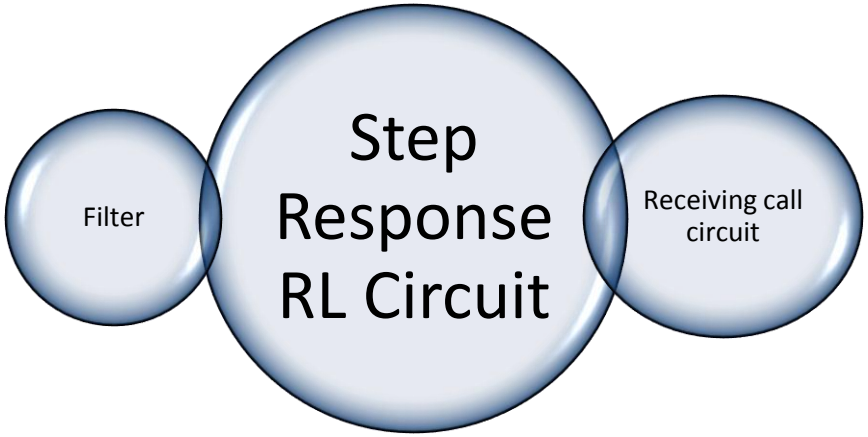
1/ Time constant ($\tau = \frac{L}{R}$)

$$i(t) = 100 - 100\, e^{-0.5t} \text{ mA}$$

APPLICATION



APPLICATION



SUMMARY

- Step response circuit requires a source supply.
- RC circuit has better time response during charging and discharging compared to RL circuit.
- Capacitor can handle higher frequency compared to inductor.

SELF REVIEW QUESTIONS

1. A step response circuit has an applied source.

   TRUE ☐ FALSE ☐

2. Name a storage element in a first order step response RL circuit.

   Answer: _____

3. Given R = 5Ω and L = 10H. What is the time constant for this RL circuit?

   a) 0.5s b) 1s

   c) 2s d) 10s

4. An inductor is connected with 12 Ohm resistor in series. What is the value of inductor that gives the time constant of the circuit is 10ms?

   a) 1200mH b) 0.12H

   c) 0.012H d) 12mH

5. A 5H inductor is connected with 12 Ohm resistor in series in a circuit. The circuit gives time constant of 0.417s. If the time constant need to be increased with the unchanged value of the inductor, the value of the resistor need to be

   a) increased b) unchanged

   c) decreased d) 100 Ohm

ANSWERS

1. TRUE
2. Inductor
3. c
4. b
5. c