Circuit Analysis Techniques

Lecture 11
RL and RC Circuit

Lecture delivered by:

Topics

- RL Circuit
- Transient Curves of RL Circuit
- RC Circuit
- Transient Curves of RC Circuit

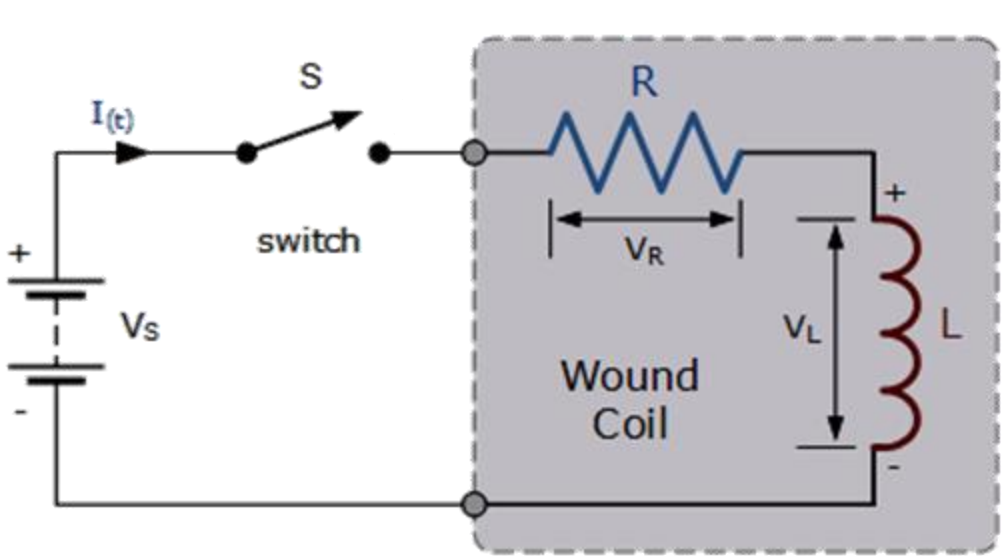
Objectives

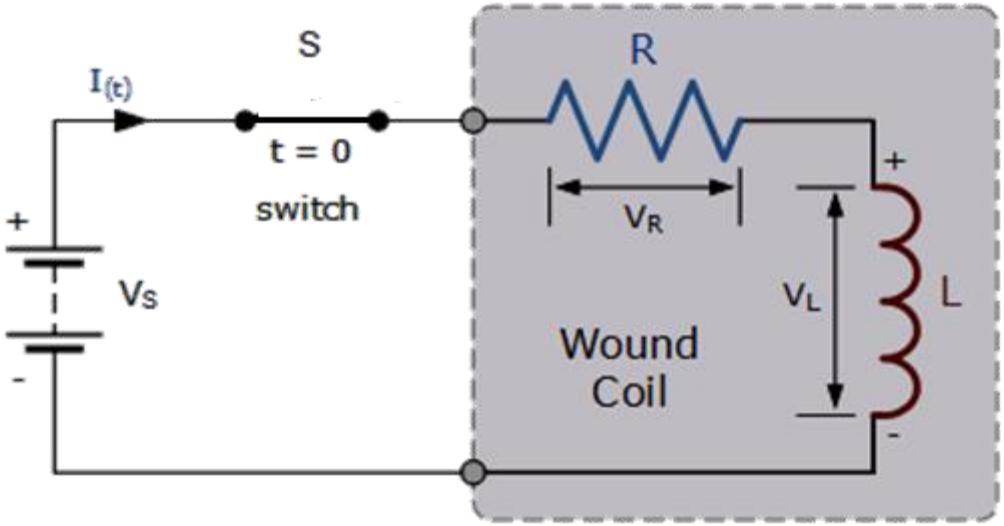
At the end of this lecture, student will be able to:

- Explain and analyze transient characteristics of RL and RC circuits

RL Circuit

- **RL Circuit** consists basically of an inductor of inductance L connected in series with a resistor of resistance R.
- Consider the LR series circuit below





RL Circuit

- Kirchoff's voltage law (KVL) gives us,

$$V_{(t)} = V_R + V_L = 0$$

- The voltage drop across the resistor, R is given by

$$V_R = I \times R$$

- The voltage drop across the inductor, L is given by

$$V_L = L\frac{di}{dt}$$

- Then the final expression for the individual voltage drops around the LR series circuit can be written as

$$V_{(t)} = I \times R + L\frac{di}{dt}$$

RL Circuit

$$\frac{di}{dt} + i * \frac{R}{L} = V_s$$

$$\left(D + \frac{R}{L}\right) I(t) = V_s$$

Solution to this differential equation is of the form

$$I(t) = Ae^{-\frac{Rt}{L}} + B$$

RL Circuit

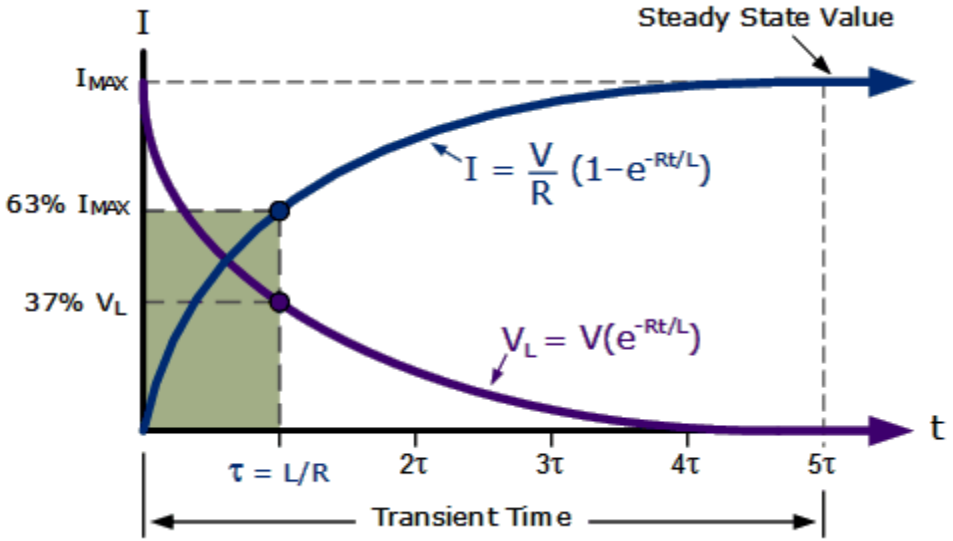
Where A and B are constants to be determined
At t=0 I=0 and as t->∞ I=Vs/R

$$\therefore I(t) = \frac{V_s}{R}(1 - e^{-\frac{t}{\tau}})$$

- Where τ is known as the time constant
- It denotes how fast the current reaches steady state

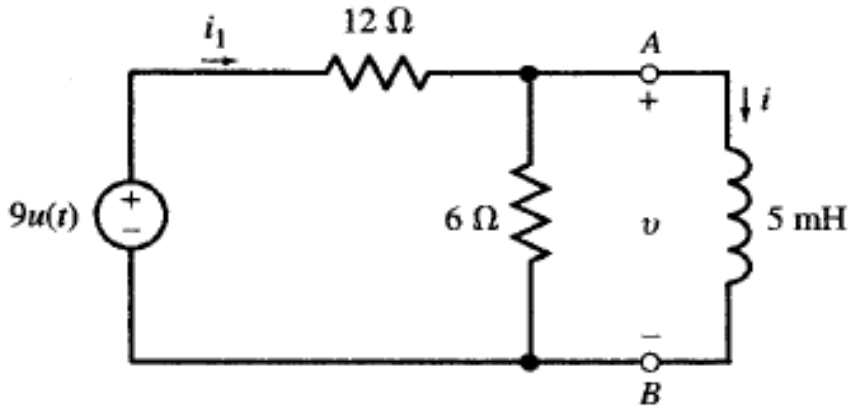
Transient Curves of RL Circuit

- Transient Curves for a RL Series Circuit



RL Circuit

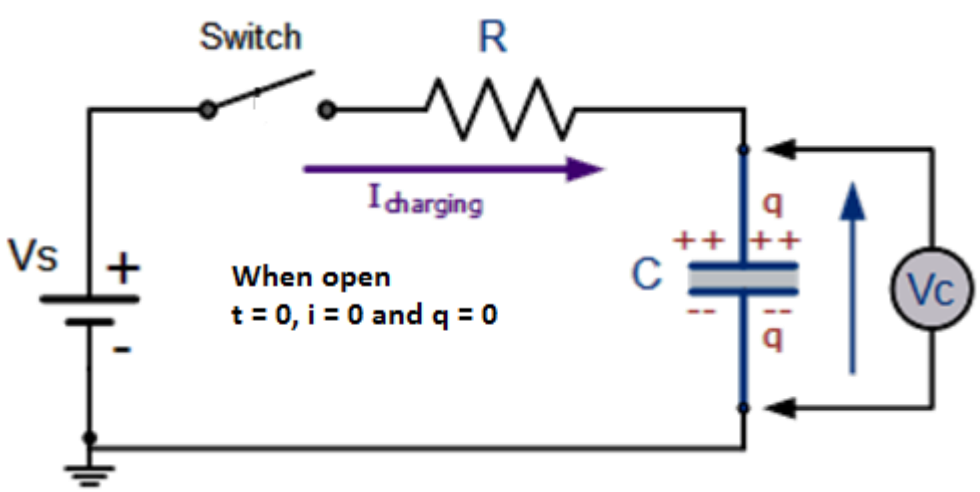
- Problem: Find i, v, and i_1 in Fig. a

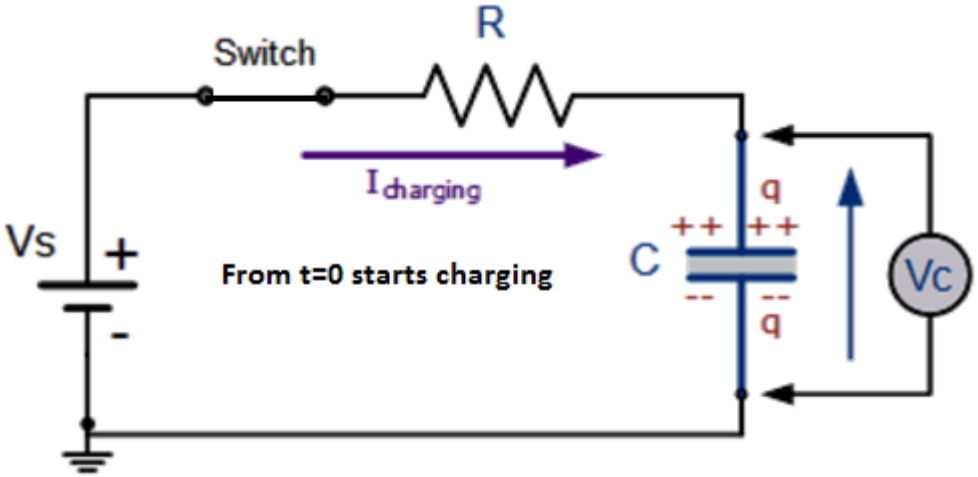


(a)

RC Circuit

- A **RC Circuit** consists basically of an inductor of Capacitor C connected in series with a resistor of resistance R.
- Consider the RC series circuit below



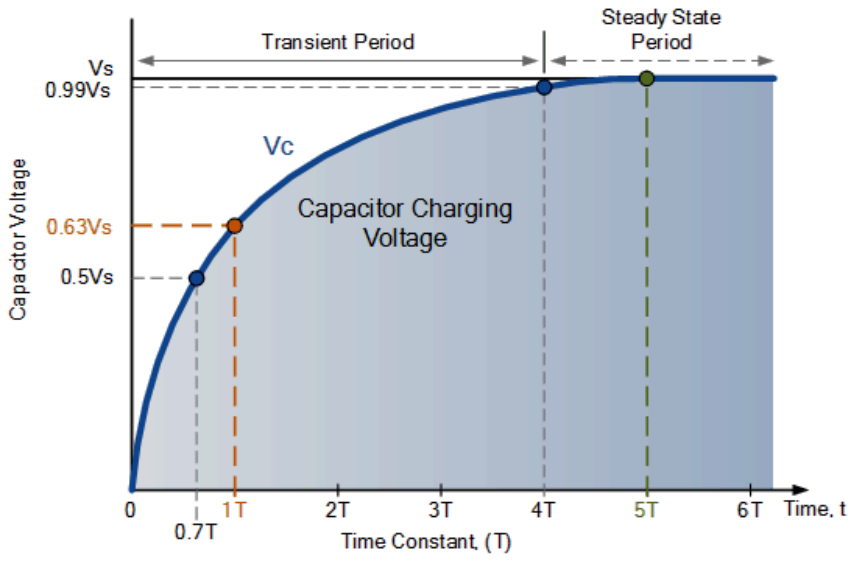


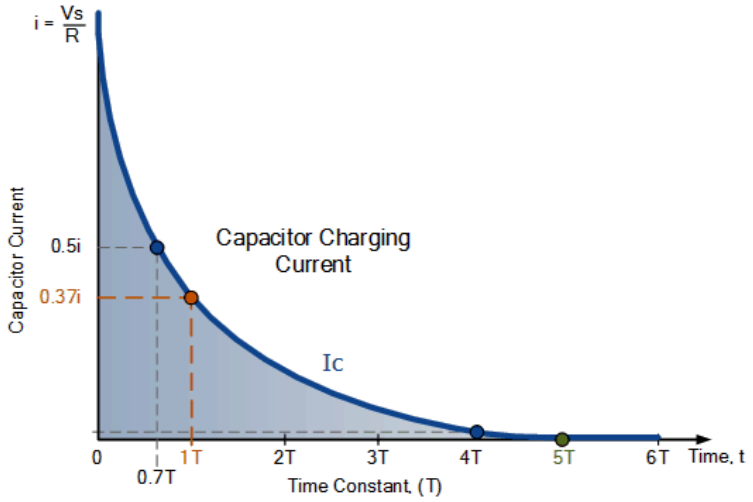
Transient Curves of RC Circuit

- Then by using Kirchoff's voltage law (KVL), the voltage drops around the circuit are given by

$$V_S - R.i(t) - V_C(t) = 0$$

- The current now flowing around the circuit is called the **Charging Current** and is found by using Ohms law i = Vs/R





RC Circuit

- Since voltage V is related to charge on a capacitor given by the equation, Vc = Q/C
- the voltage across the value of the voltage across the capacitor (Vc) at any instant in time during the charging period is given by

$$Vc = Vs\,(1 - e^{-t/RC})$$

Where:

- Vc is the voltage across the capacitor
- Vs is the supply voltage
- t is the elapsed time since the application of the supply voltage
- RC is the *time constant* of the RC charging circuit

RC Circuit

- τ is time constant given by

$$\tau \equiv R.C$$

- Where,

  R is in Ω‘s

  C in Farads

Summary

- RL Circuit consists basically of an inductor of inductance L connected in series with a resistor of resistance R.
- Transient characteristics of RL Series Circuit is discussed
- RC Circuit consists basically of an inductor of capacitance C connected in series with a resistor of resistance R.
- Transient characteristics of RC Series Circuit is discussed