Basic Electrical Technology

RL Transient

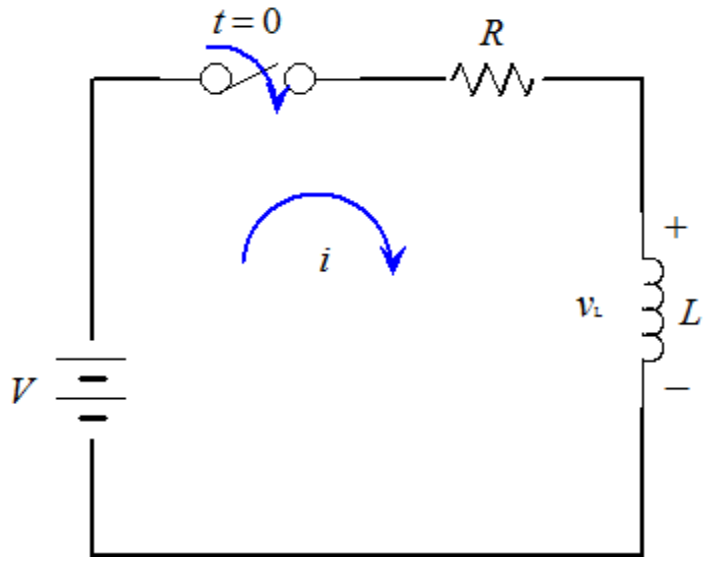
Growth of Current in an Inductive Circuit

Applying KVL,

$$V - R\,i - L\frac{di}{dt} = 0$$

Initial Conditions,

$$At\ t = 0\ sec, i = 0\ A$$



Final current & voltage equation,

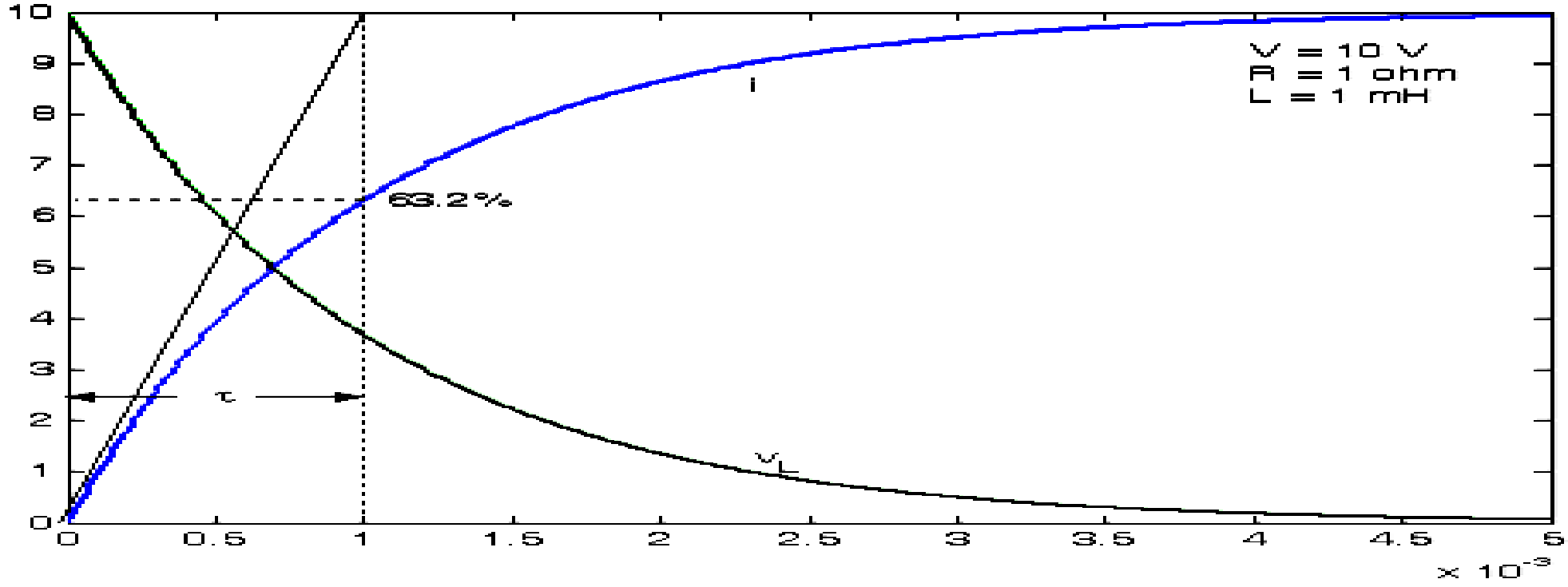
$$i = \frac{V}{R}\left(1 - e^{-\frac{Rt}{L}}\right)$$

$$v_L = V\,e^{-\left(\frac{R}{L}\right)t}$$

Growth of current in an inductive circuit

Time Constant (τ): Time taken by the current through the inductor to reach its final steady state value, had the initial rate of rise been maintained constant

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

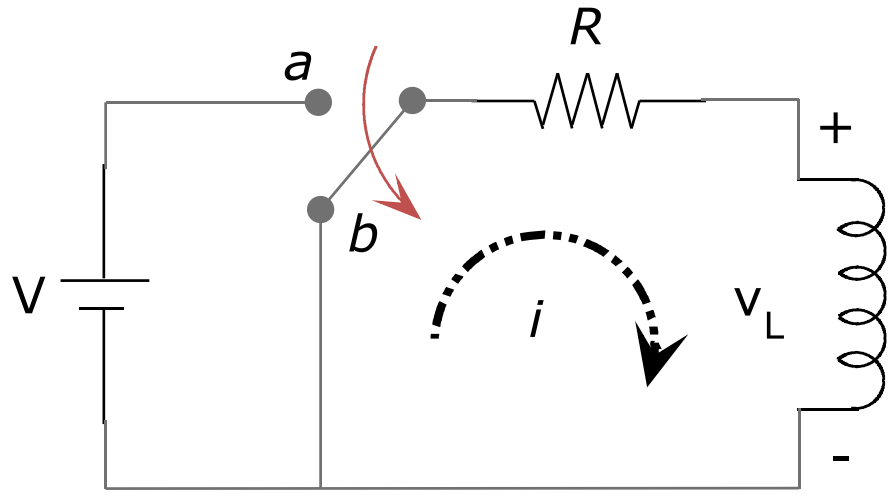


Decay of current in an Inductive Circuit

- Initial current is through inductor is

$$I_0 = V/R$$

- At $t = 0$, switch is moved from position ***a*** to ***b***



Applying KVL,

$$L\frac{di}{dt} + R\,i = 0$$

Using initial conditions and then solving

$$i = I_0 e^{\left(\frac{-Rt}{L}\right)}$$

$$v_L = -V\,e^{-\left(\frac{Rt}{L}\right)}$$

Decay of current in an Inductive Circuit

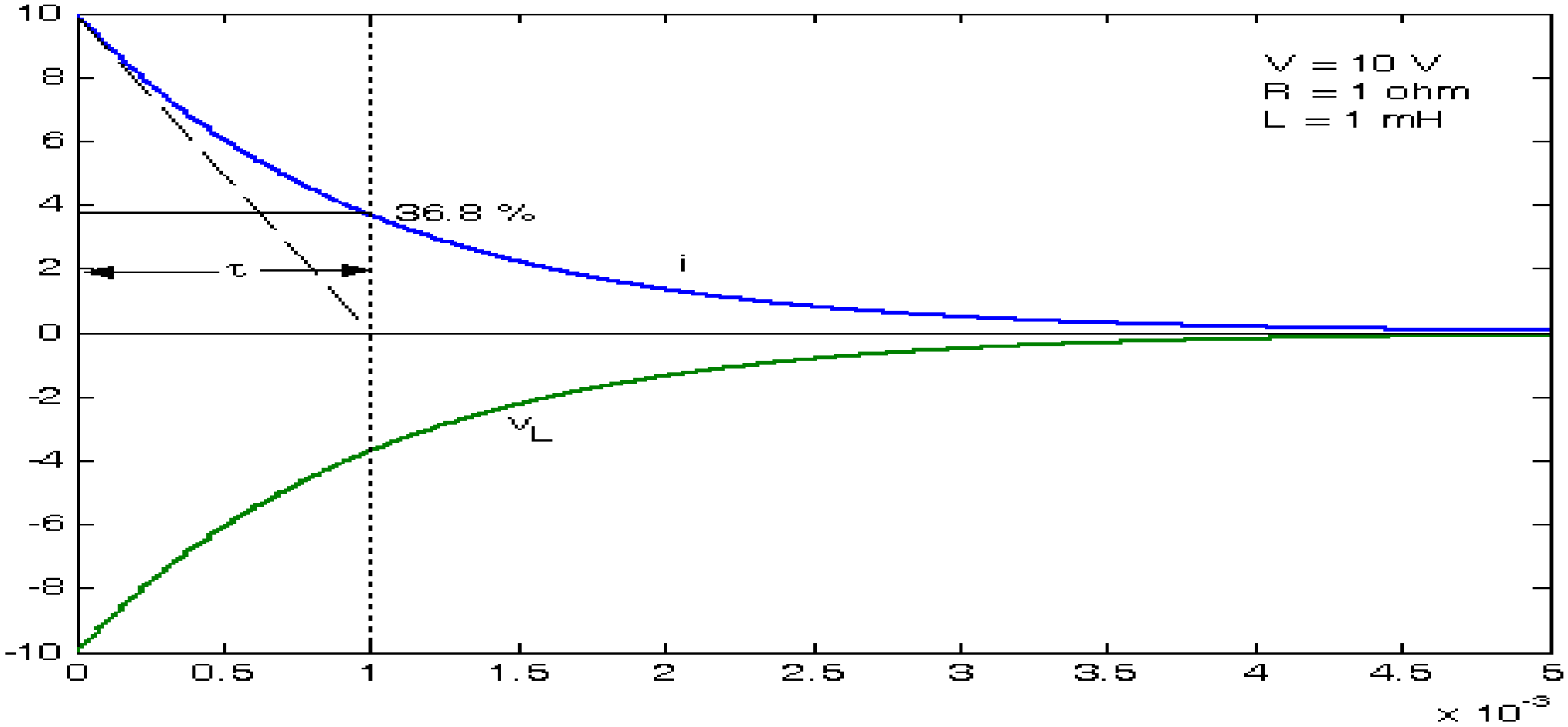
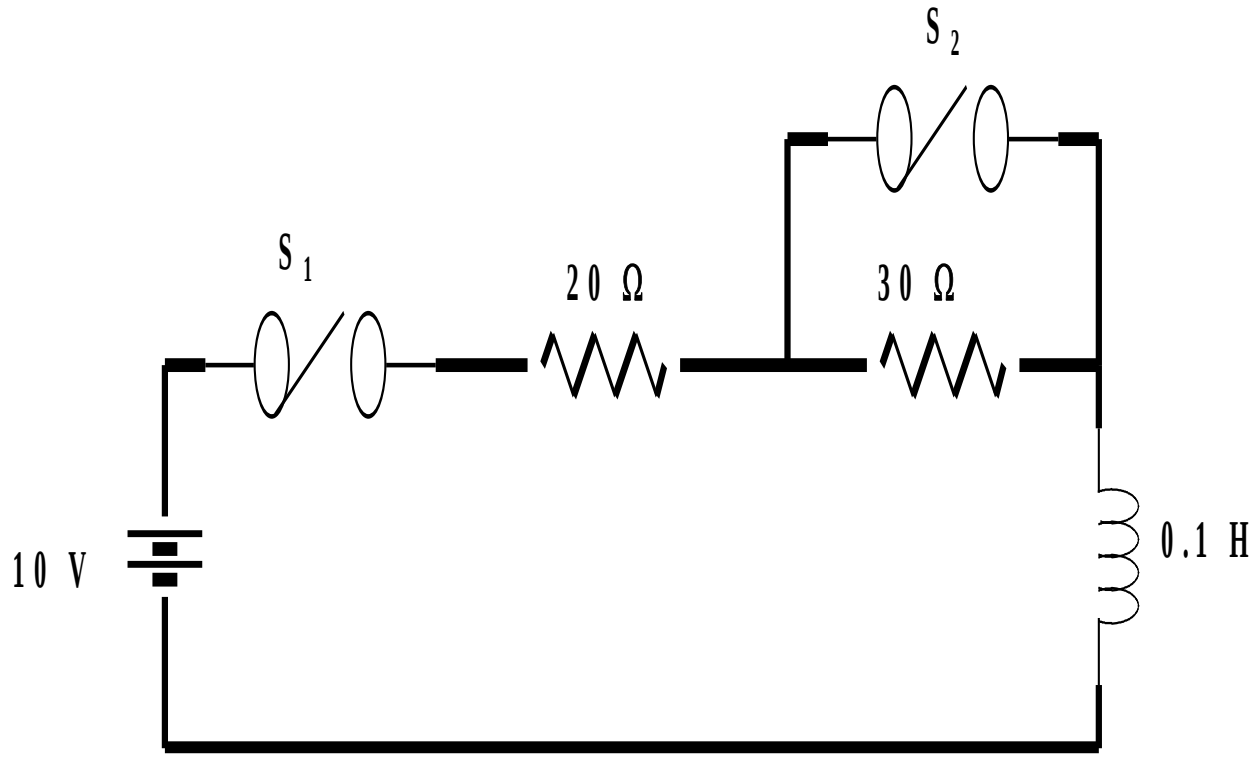


Illustration 1

In the circuit shown below, both the switches, S_1 & S_2, are open initially. At t = 0 sec, S_1 is closed (& S_2 remains open). At t = 4 ms S_2 is closed. Sketch the inductor current $\boldsymbol{i(t)}$ for 0 ≤ t ≤ 25 ms.



Solution

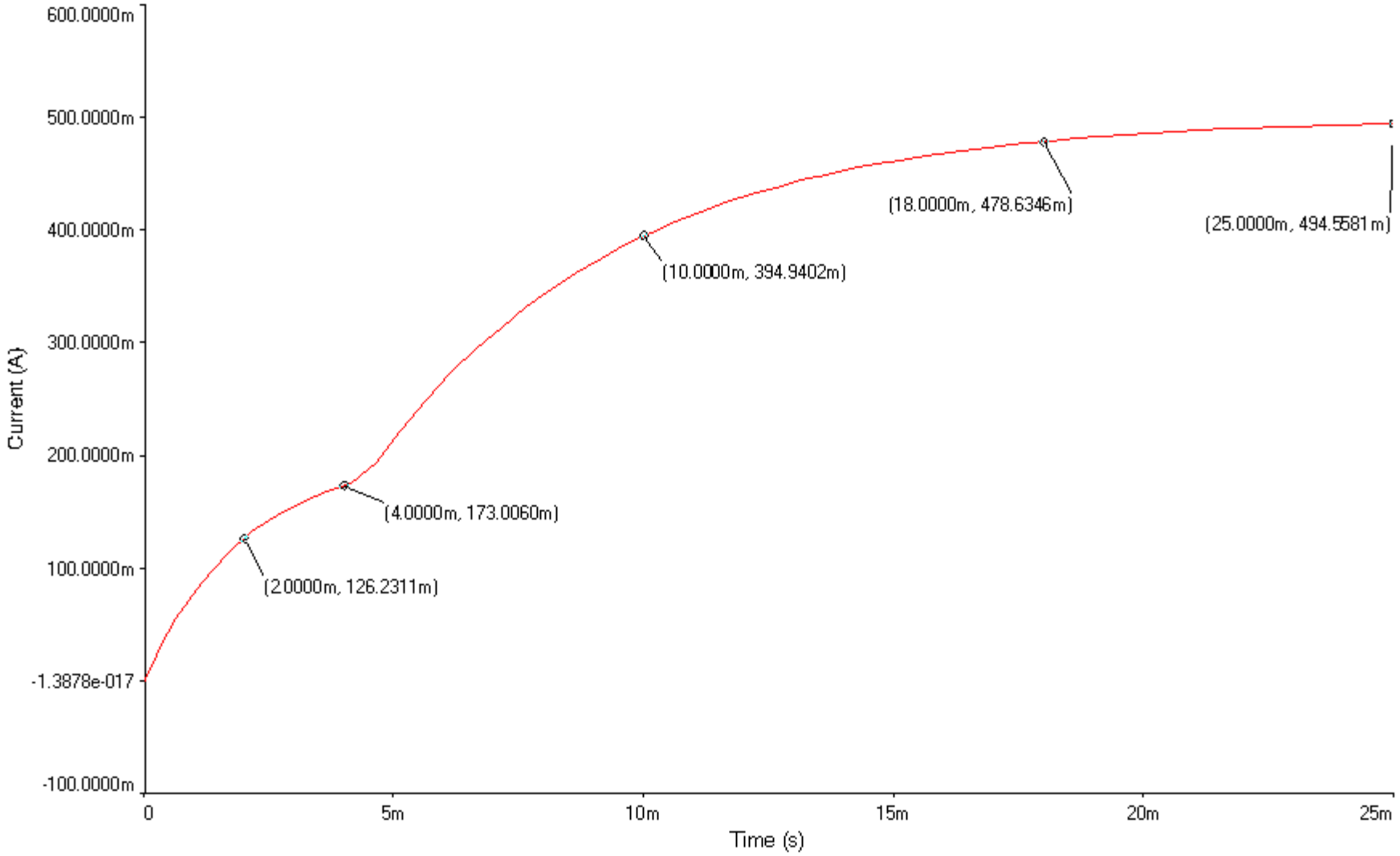

600.0000m
500.0000m
400.0000m
300.0000m
200.0000m
100.0000m
-1.3878e-017
-100.0000m
Current (A)
0
5m
10m
15m
20m
25m
Time (s)
(2.0000m, 126.2311m)
(4.0000m, 173.0060m)
(10.0000m, 394.9402m)
(18.0000m, 478.6346m)
(25.0000m, 494.5581m)

Illustration 2

A coil of resistance 5Ω and inductance of 0.02H is connected to a battery of voltage 12V for a long time. At t = 0, the coil is short circuited. Find the time taken for the current to reach the value 1.2A.

Ans: 2.77 m-sec

Illustration 3

An R-L series circuit is designed for a steady current of 250mA. A current of 120 mA flows in the circuit at an instant 0.1 sec after connecting the supply voltage. Calculate i) time constant of the circuit ii) the time from closing the circuit at which the circuit current has reached 200 mA.

Ans:

i. ζ = 0.1529 s

ii. t = 0.2461 s