Fundamental Notions About Electrical Transients

Note Title 2/3/2014

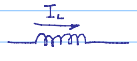
* Electrical transients occure when a switch opens or closes or a during faults. A New path for the current to flow is created or an existing path is disconnected.
* Although transients period is very short (in comparison to steady-state conditions), the voltage and current stresses are high that may damage some components in the power system.

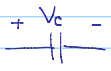
* Transient (Surge):

* Basic Circuit Relationship:

	Circuit	Model	Energy
Resistor (Ω)	i(t) → + v(t) -	$v(t) = R\, i(t)$	$E = RI^2 t$
Inductor (H)	i(t) → + v(t) -	$v(t) = L \frac{di(t)}{dt}$	$E = \frac{1}{2} LI^2$
Capacitor (F)	i(t) → + v(t) -	$i(t) = C \frac{dV(t)}{dt}$	$E = \frac{1}{2} CV^2$

* Three Fundamental Characteristics of Circuits with Lumped Parameters:

1) I_L doesn't change insantaneously. 

2) V_C " " " 

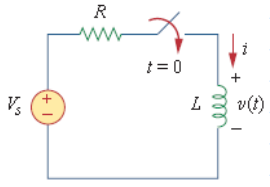
3) At steady-state and transient conditions, the energy conservation is valid.

$$E_{total} = E_{stored} + E_{dissipated}$$

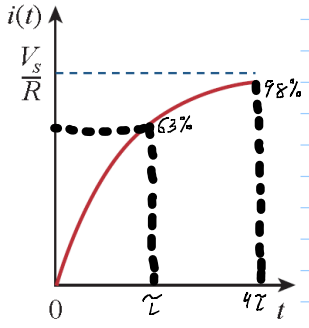
or

$$E_{stored\text{-}before\_event} = E_{stored\text{-}after\_event} + E_{dissipated}$$

Ex. Switching an RL Circuit:



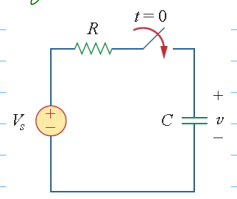
$$i(t) = \frac{V_s}{R}(1 - e^{-t/\tau}) \quad , \quad \tau = \frac{L}{R} \text{ (time constant)}$$



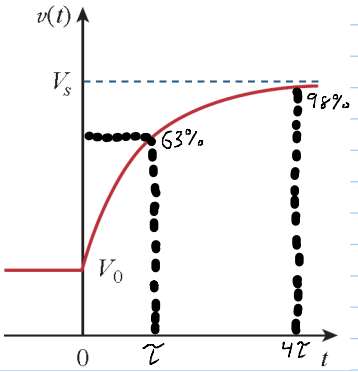
Ex. Switching an RC Circuit:

time Constant

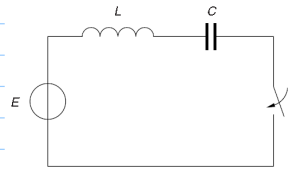
$$v(t) = V_s + (V_0 - V_s)e^{-t/\tau}, \quad \tau = RC$$



V_0 is the capacitor initial charge.



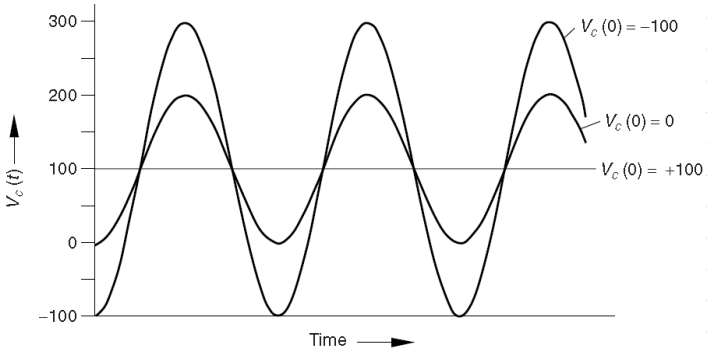
Ex. Switching an LC Circuit:



$$i(t) = E\sqrt{\frac{C}{L}}\sin(\omega_0 t)$$

oscillation frequency → $\omega_0 = \sqrt{LC}$

characteristic Impedance → $Z_0 = (L/C)^{1/2}$



$$V_c(t) = E - [E - V_c(0)]\cos(\omega_0 t)$$