Capacitor, Inductor Notes

ECE 2210 / 00

A.Stolp
2/27/00,
9/13/05

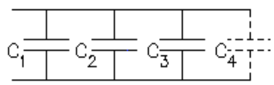
Capacitors

$C = \frac{Q}{V}$ farad $= \frac{\text{coul}}{\text{volt}} = \frac{\text{amp}\cdot\text{sec}}{\text{volt}}$ $v_C = \frac{1}{C}\cdot\int_{-\infty}^{t} i_C\,dt = \frac{1}{C}\cdot\int_{0}^{t} i_C\,dt + v_C(0)$ (initial voltage) $i_C = C\cdot\frac{d}{dt}v_C$

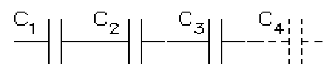
Energy stored in electric field: $W_C = \frac{1}{2}\cdot C\cdot V_C^{\,2}$

Capacitor voltage **cannot** change instantaneously

parallel: $C_{eq} = C_1 + C_2 + C_3 + \ldots$



series: $C_{eq} = \dfrac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots}$



Steady-state sinusoids:

Impedance: $Z_C = \frac{1}{j\cdot\omega\cdot C} = \frac{-j}{\omega\cdot C}$ Current leads voltage by 90 deg

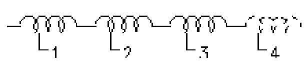
Inductors

henry $= \frac{\text{volt}\cdot\text{sec}}{\text{amp}}$ $i_L = \frac{1}{L}\cdot\int_{-\infty}^{t} v_L\,dt = \frac{1}{L}\cdot\int_{0}^{t} v_L\,dt + i_L(0)$ (initial current) $v_L = L\cdot\frac{d}{dt}i_L$

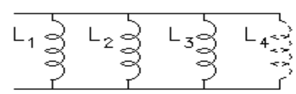
Energy stored in magnetic field: $W_L = \frac{1}{2}\cdot L\cdot I_L^{\,2}$

Inductor current **cannot** change instantaneously

series: $L_{eq} = L_1 + L_2 + L_3 + \ldots$



parallel: $L_{eq} = \dfrac{1}{\frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \ldots}$



Steady-state sinusoids:

Impedance: $Z_L = j\cdot\omega\cdot L$ Current lags voltage by 90 deg

RC and RL first-order transient circuits

For all first order transients: $v_X(t) = v_X(\infty) + \left(v_X(0) - v_X(\infty)\right)\cdot e^{-\frac{t}{\tau}}$ $i_X(t) = i_X(\infty) + \left(i_X(0) - i_X(\infty)\right)\cdot e^{-\frac{t}{\tau}}$

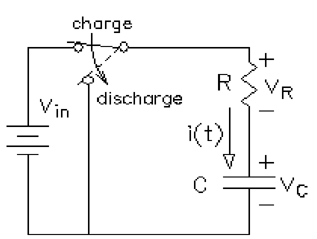
Find initial Conditions (v_C and/or i_L)

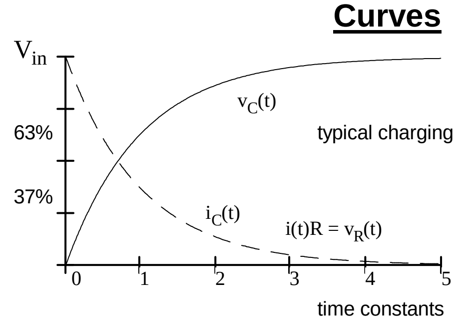
Find conditions just before time $t = 0$, $v_C(0-)$ and $i_L(0-)$. These will be the same just after time $t = 0$, $v_C(0^+)$ and $i_L(0^+)$ and will be your initial conditions. (If initial conditions are zero: Capacitors are shorts, Inductors are opens.)
Use normal circuit analysis to find your desired variable: $v_X(0)$ or $i_X(0)$

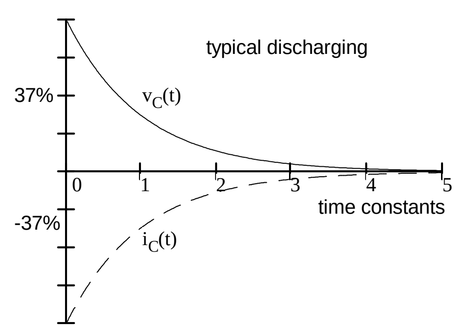
Find final conditions ("steady-state" or "forced" solution)
Inductors are shorts Capacitors are opens Solve by DC analysis $v_X(\infty)$ or $i_X(\infty)$

Curves

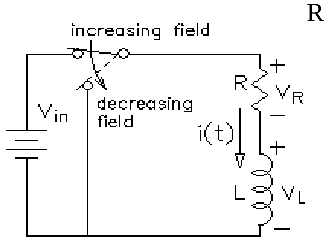
RC Time constant $= \tau = RC$

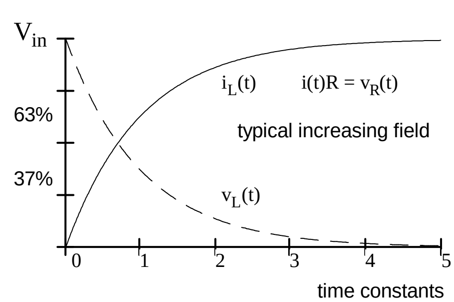


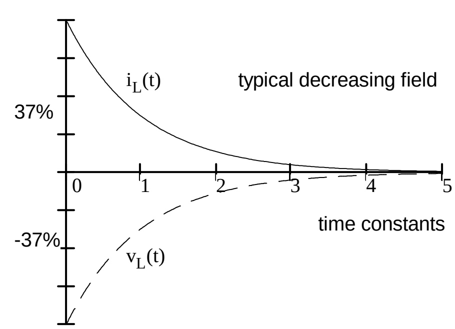




RL Time constant $= \tau = \frac{L}{R}$







$e^{-1} = 0.368$ $1 - e^{-1} = 0.632$