

Capacitor, Inductor Notes

ECE 2210 / 00

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

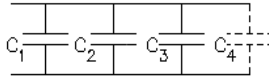
Capacitors

$$C = \frac{Q}{V} \quad \text{farad} = \frac{\text{coul}}{\text{volt}} = \frac{\text{amp}\cdot\text{sec}}{\text{volt}} \quad v_C = \frac{1}{C} \int_{-\infty}^t i_C dt \quad i_C dt = \frac{1}{C} \int_0^t i_C dt + v_C(0) \quad i_C = C \frac{d}{dt} v_C$$

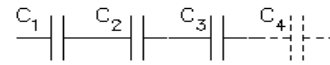
Energy stored in electric field: $W_C = \frac{1}{2} \cdot C \cdot V_C^2$

Capacitor voltage **cannot** change instantaneously

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



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



Steady-state sinusoids:

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

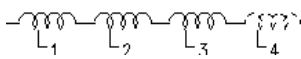
Inductors

henry = $\frac{\text{volt}\cdot\text{sec}}{\text{amp}}$ $i_L = \frac{1}{L} \int_{-\infty}^t v_L dt \quad v_L dt = \frac{1}{L} \int_0^t v_L dt + i_L(0) \quad v_L = L \frac{d}{dt} i_L$

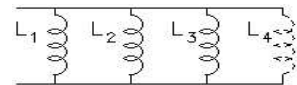
Energy stored in magnetic field: $W_L = \frac{1}{2} \cdot L \cdot I_L^2$

Inductor current **cannot** change instantaneously

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



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



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: $v_X(t) = v_X(\infty) + (v_X(0) - v_X(\infty)) \cdot e^{-\frac{t}{\tau}}$ $i_X(t) = i_X(\infty) + (i_X(0) - i_X(\infty)) \cdot e^{-\frac{t}{\tau}}$

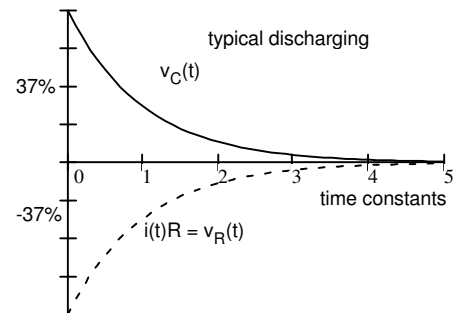
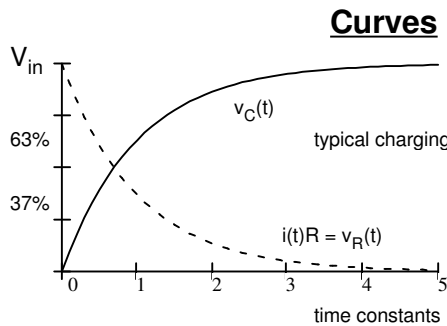
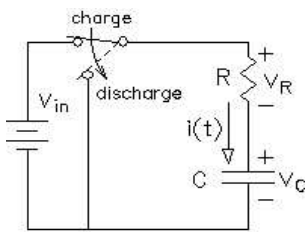
Find initial Conditions (v_C and/or i_L)

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 $i_X(\infty)$

RC Time constant = $\tau = RC$



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

