Inductor i-v Behaviors

- Its voltage v depends on the time-varying rate of current i.

$$v = L \cdot \frac{di}{dt}$$

- Steady state characteristics
  - The inductor is a short circuit to DC signal at steady state.

$$\frac{di}{dt} = 0, \quad v = 0$$

  - The inductor is an open circuit to high frequency signals at steady state.

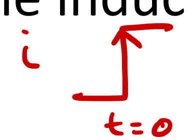
$$\frac{di}{dt} \to \infty, \quad v \to \infty$$

    Assume

$$i_L = I_0 \cdot \sin\omega t, \quad v = L \cdot \omega \cdot I_0 \cdot \cos\omega t$$

    As $\omega \to \infty$, $v \to \infty$ similar to an open circuit

- The current through an inductor does not change abruptly.
  - A discontinuous change of the inductor current requires an infinite voltage.



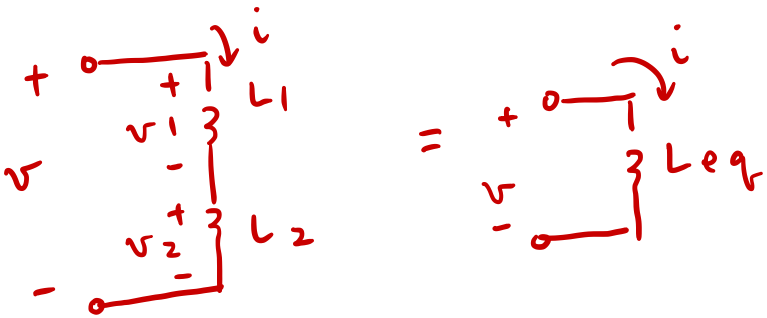
Summary

i_L

	R	C	L
v - i	$v_R = i_R \cdot R$	$v_C = v_C(t_0) + \frac{1}{C}\int_{t_0}^{t} i_C \cdot \mathrm{d}t$	$v_L = L\frac{\mathrm{d}i}{\mathrm{d}t}$
i - v	$i_R = \frac{v_R}{R}$	$i_C = C\frac{\mathrm{d}v}{\mathrm{d}t}$	$i_L = i_L(t_0) + \frac{1}{L}\int_{t_0}^{t} v_L \cdot \mathrm{d}t$
Power, Energy	$P_R = i_R^2 \cdot R = \frac{v_R^2}{R}$	$E_C = \frac{1}{2}C \cdot v_C^2$	$E_L = \frac{1}{2}L \cdot i_L^2$
Series	$R_{eq} = \sum R_k$	$\frac{1}{C_{eq}} = \sum \frac{1}{C_k}$	$L_{eq} = \sum L_k$
Parallel	$\frac{1}{R_{eq}} = \sum \frac{1}{R_k}$	$C_{eq} = \sum C_k$	$\frac{1}{L_{eq}} = \sum \frac{1}{L_k}$
DC steady state	(same)	open-circuit $\frac{dv}{dt}=0,\ i=0$	short-circuit $\frac{di}{dt}=0,\ v=0$
High freq. HF steady state	(same)	short-circuit $\frac{dv}{dt}\to\infty,\ i\to\infty$	open-circuit $\frac{di}{dt}\to\infty,\ v\to\infty$
Continuity	(no restriction)	v_C	i_L

Series and Parallel Inductors

$$v = L \cdot \frac{di}{dt}$$

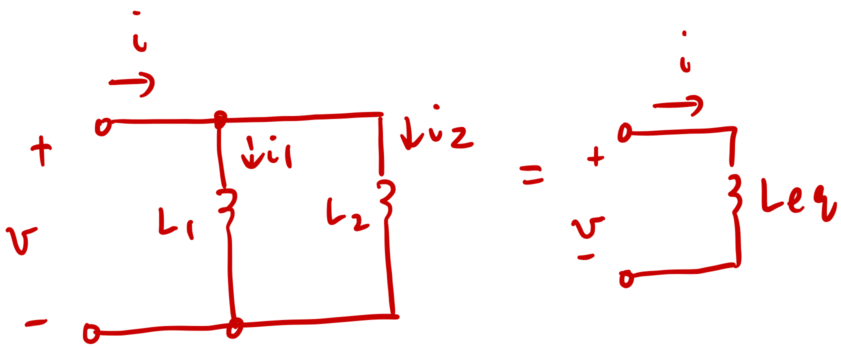


$$v = v_1 + v_2$$

$$= L_1 \frac{di}{dt} + L_2 \frac{di}{dt}$$

$$= (L_1 + L_2) \frac{di}{dt} = L_{eq} \cdot \frac{di}{dt}$$

$$\Rightarrow L_{eq} = L_1 + L_2$$



$$v = L_{eq} \cdot \frac{di}{dt} = L_{eq} \frac{d(i_1 + i_2)}{dt}$$

$$= L_{eq} \left(\frac{v}{L_1} + \frac{v}{L_2} \right)$$

$$\Rightarrow L_{eq} = \frac{1}{\frac{1}{L_1} + \frac{1}{L_2}}$$