第六章 储能元件

- 电容元件
- 电感元件

§6-1 电容元件

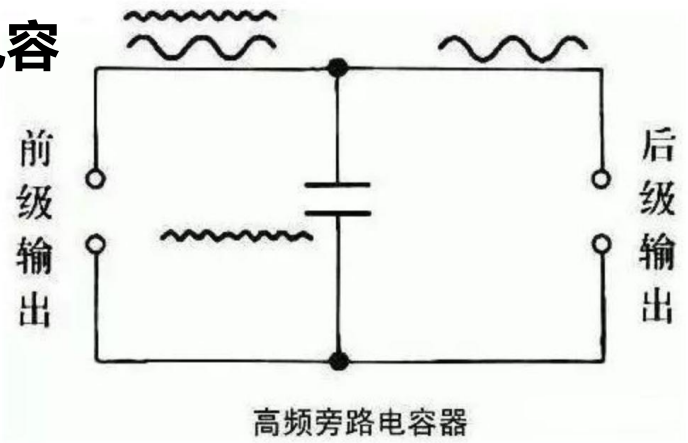
电容元件

钽电解电容

独石电容

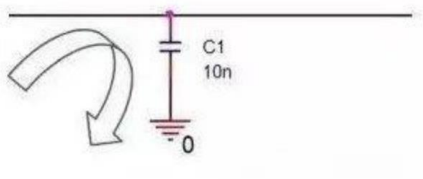
贴片电容

旁路电容



高频旁路电容器

滤波



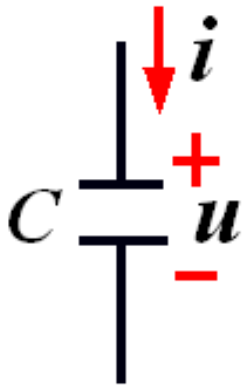
$$Z=\frac{1}{2\pi fC}$$

§6-1　电容元件

q–u 特性关系：　$q = Cu$

$$C = \frac{q}{u}$$　—电容：法拉

图形符号



伏安特性：　$$i = \frac{dq}{dt} = C\frac{du}{dt}$$

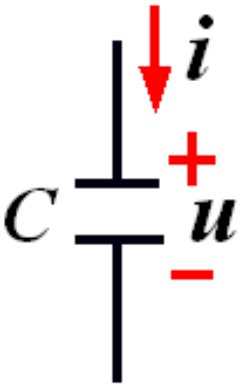
$$u = \frac{1}{C}\int_{-\infty}^{t} idt = \frac{1}{C}\left[\int_{-\infty}^{0} idt + \int_{0}^{t} idt\right] = u(0) + \frac{1}{C}\int_{0}^{t} idt$$

§6-1 电容元件

电容元件的功率：

关联方向下： $P_C = ui = Cu\dfrac{du}{dt}$

图形符号



$\dfrac{\mathrm{d}u}{\mathrm{d}t} > 0$ $p_C > 0$ 吸收电能

$\dfrac{\mathrm{d}u}{\mathrm{d}t} < 0$ $p_C < 0$ 释放电能

结论

1. $\dfrac{\mathrm{d}u}{\mathrm{d}t} = 0$ $i = 0$ 对于直流，电容为开路元件。
2. 电容是储能（记忆）元件，不消耗电能。

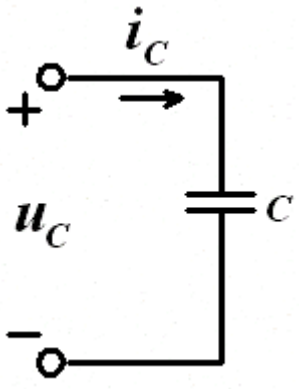
§6-1 电容元件

电容元件

$$u_C = \sqrt{2}U_C \sin(\omega t + \varphi_u)$$

$$i_C = C\frac{\mathrm{d}u_C}{\mathrm{d}t}$$

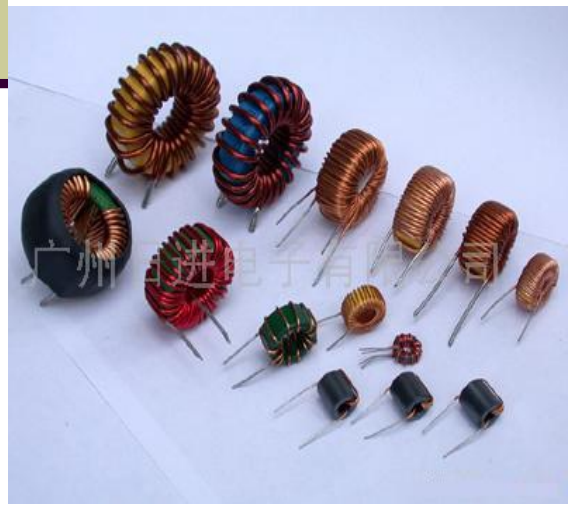
$$i_C = \sqrt{2}\omega C U_C \sin(\omega t + \varphi_u + \frac{\pi}{2}) = \sqrt{2}I_C \sin(\omega t + \varphi_i)$$



相位差 $\varphi = \varphi_u - \varphi_i = -\frac{\pi}{2}$ 电压滞后电流90°

§6-2 电感元件

电感元件



环形电感

电感线圈

贴片电感

§6-2 电感元件

电感元件伏安特性

韦安特性关系： $\psi = Li$

$L = \dfrac{\psi}{i}$ —自感系数：亨利

伏安特性： $u_L = L\dfrac{\mathrm{d}i}{\mathrm{d}t}$

$$i = \frac{1}{L}\int_{-\infty}^{t} u\,dt = \frac{1}{L}\left[\int_{-\infty}^{0} u\,dt + \int_{0}^{t} u\,dt\right] = i(0) + \frac{1}{L}\int_{0}^{t} u\,dt$$

电感是动态元件，也是记忆元件。

§6-2 电感元件

电感元件的功率：

关联方向：

$$P_L = u\,i = Li\frac{di}{dt}$$

$\frac{\mathrm{d}i}{\mathrm{d}t} > 0$ $p_L > 0$ 吸收电能

$\frac{\mathrm{d}i}{\mathrm{d}t} < 0$ $p_L < 0$ 释放电能

结论

1. $\frac{\mathrm{d}i}{\mathrm{d}t} = 0$ $u = 0$ 对于直流，电感为短路元件。
2. 电感是储能（记忆）元件，不消耗电能。

§6-2 电感元件

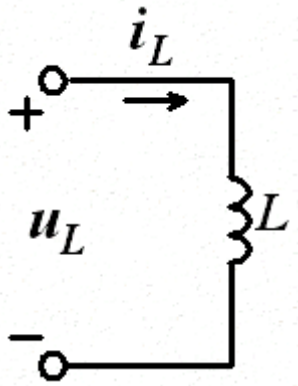
电感元件

$$i_L = \sqrt{2} I_L \sin(\omega t + \varphi_i)$$

$$u_L = L \frac{\mathrm{d}i_L}{\mathrm{d}t}$$

$$u_L = \sqrt{2}\omega L I_L \sin(\omega t + \varphi_i + \frac{\pi}{2})$$

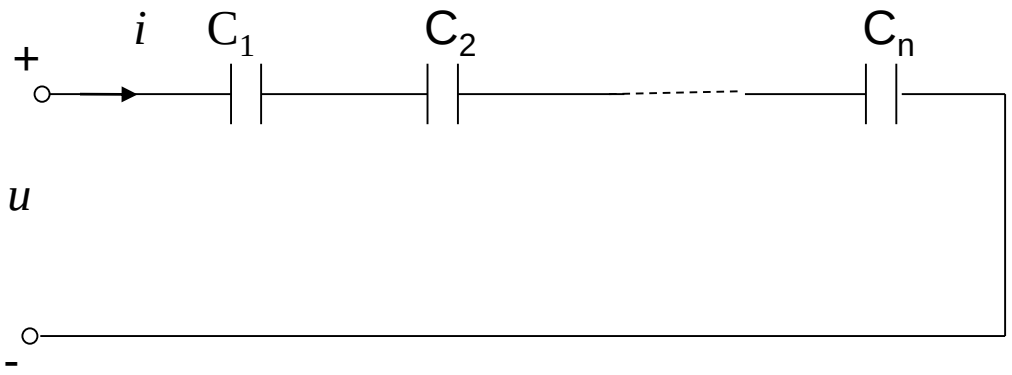
$$= \sqrt{2} U_L \sin(\omega t + \varphi_u)$$



相位差 $\varphi = \varphi_u - \varphi_i = \frac{\pi}{2}$　　电压超前电流90°

§6-3 电容、电感元件的串并联

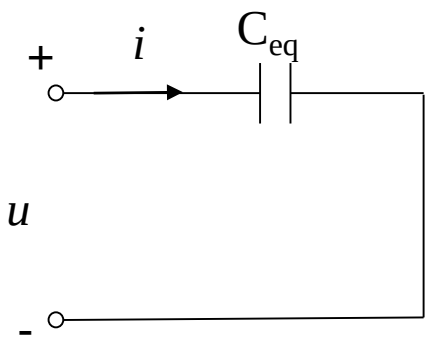
- 电容的串联



$$u = u_1 + u_2 + \cdots + u_n = u_1(t_0) + \frac{1}{C_1}\int_{t_0}^{t} i\,\mathrm{d}\xi + \cdots + u_n(t_0) + \frac{1}{C_n}\int_{t_0}^{t} i\,\mathrm{d}\xi$$

$$= u_1(t_0) + u_2(t_0) + \cdots + u_n(t_0) + \left(\frac{1}{C_1} + \frac{1}{C_2} + \cdots + \frac{1}{C_n}\right)\int_{t_0}^{t} i\,\mathrm{d}\xi$$

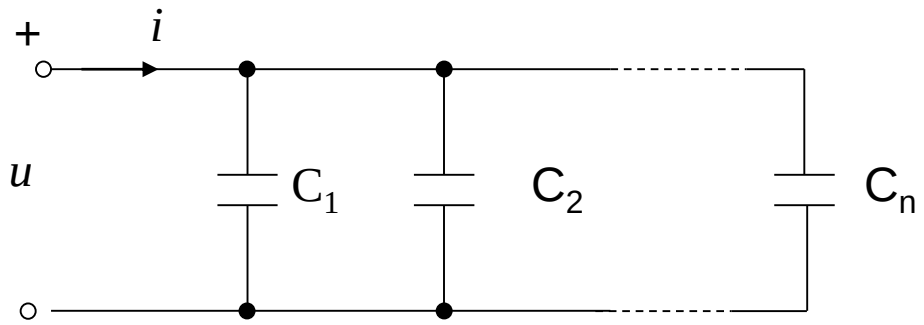
$$= u(t_0) + \frac{1}{C_{eq}}\int_{t_0}^{t} i\,\mathrm{d}\xi$$



$$\frac{1}{C_{eq}} = \sum_{k=1}^{n} \frac{1}{C_k}$$

§6-3 电容、电感元件的串并联

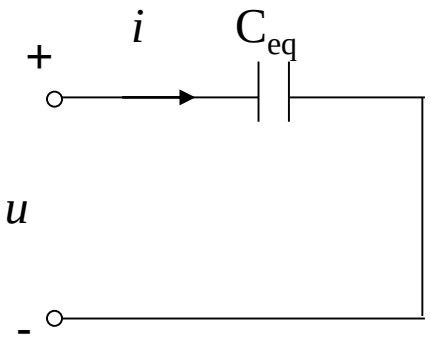
- 电容的并联



$$i = i_1 + i_2 + \cdots + i_n = C_1 \frac{\mathrm{d}u}{\mathrm{d}t} + C_2 \frac{\mathrm{d}u}{\mathrm{d}t} + \cdots + C_n \frac{\mathrm{d}u}{\mathrm{d}t}$$

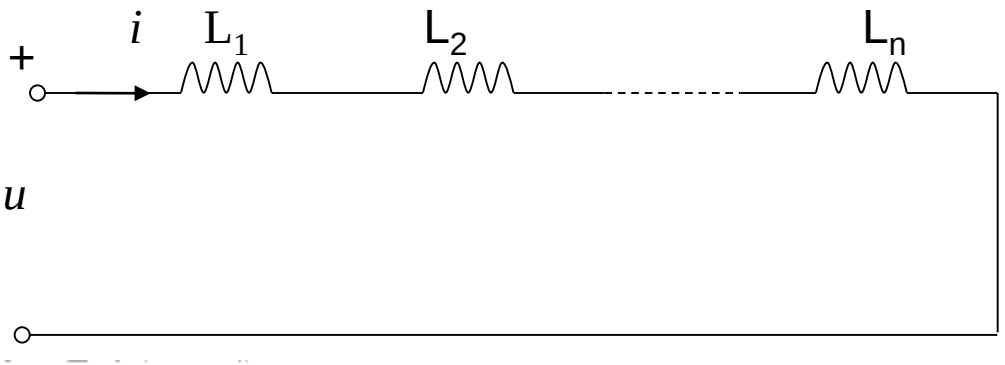
$$= C_{eq} \frac{\mathrm{d}u}{\mathrm{d}t}$$

$$C_{eq} = \sum_{k=1}^{n} C_k$$



§6-3 电容、电感元件的串并联

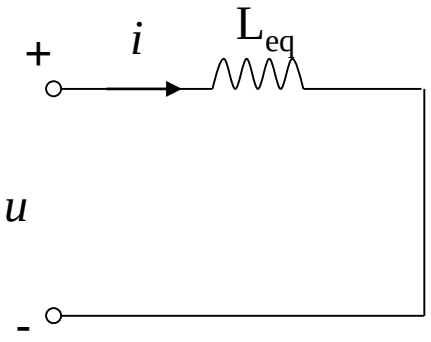
- 电感的串联



$$u = u_1 + u_2 + \cdots + u_n = L_1\frac{\mathrm{d}i}{\mathrm{d}t} + L_2\frac{\mathrm{d}i}{\mathrm{d}t} + \cdots + L_n\frac{\mathrm{d}i}{\mathrm{d}t}$$

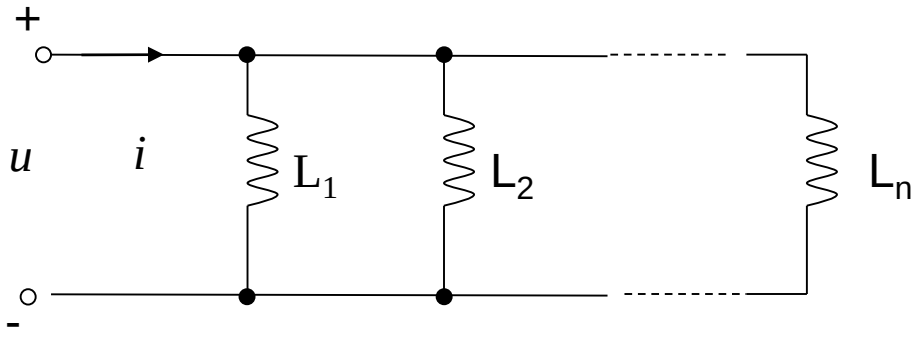
$$= (L_1 + L_2 + \cdots + L_n)\frac{\mathrm{d}i}{\mathrm{d}t} = L_{eq}\frac{\mathrm{d}i}{\mathrm{d}t}$$

$$L_{eq} = \sum_{k=1}^{n} L_k$$

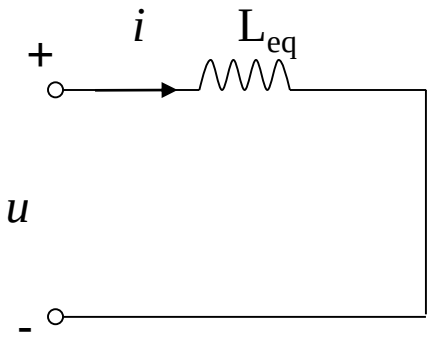


§6-3 电容、电感元件的串并联

- 电感的并联



$$\frac{1}{L_{eq}}=\sum_{k=1}^{n}\frac{1}{L_k}$$



作业

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