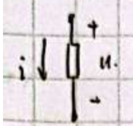
[电路复习]

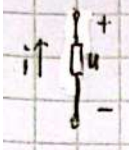
· 直接刷了一遍电路复习课，还有一些错题及历年卷.

[直流电路部分]

△ $p=ui$.

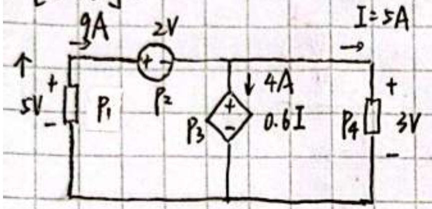


$P>0$. 正功率，实际吸收.



$P<0$. 吸收负功率，实际发出

[例3]:



电流正→负为正

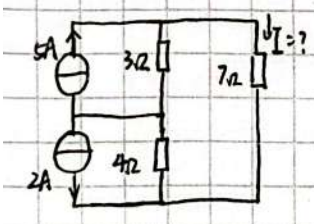
解: $P_1=-45W$，消耗45W.

$P_2=18W$，吸收18W

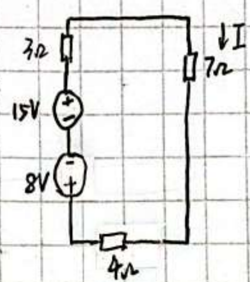
$P_3=12W$，吸收12W

$P_4=15W$，吸收15W

△ 电压源-电流源转换



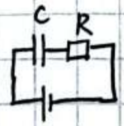
解:



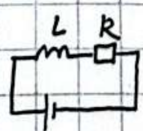
$I=\frac{7}{14}A=\underline{0.5A}$

△ 电容电感:

电容: $C=\frac{dq}{du} \Rightarrow du=\frac{1}{C}\cdot i dt \Rightarrow u=\frac{1}{C}\cdot\int_{t_0}^{t} i(\tau)d(\tau)+u(t_0)$

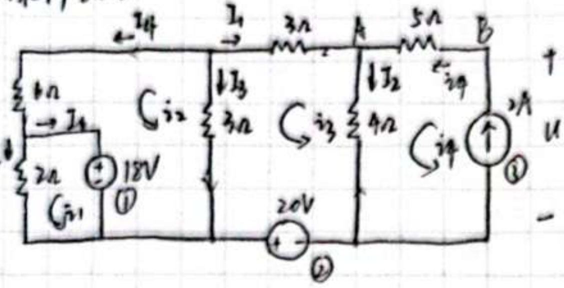


电感: $u=L\cdot\frac{di}{dt}$ $di=\frac{1}{L}\cdot u dt$ $i=\frac{1}{L}\cdot\int_{t_0}^{t} u(\tau)d(\tau)+i(t_0)$



△KCL, KVL:

课件Ex.6.



求I_1, I_3, 各电源功率, 判断吸收/发出

结后学了后我已经只会网络了.

$$\begin{cases} 2i_1 = 18 & ① \\ 0 - 9i_2 + 3i_3 = 18 & ② \\ -10i_3 + 3i_2 + 4i_4 = 20 & ③ \\ i_4 = 2A & ④ \end{cases}$$

③ ⇒ $10i_3 - 3i_2 = \cancel{28}\ -12$

② ⇒ $3i_3 - 9i_2 = 18$

$i_3 = \cancel{\frac{22}{9}}\ -2\,A \qquad i_2 = \cancel{-\frac{32}{27}}\ -\frac{8}{3}\,A$

$\therefore I_1 = I_3 = \cancel{\frac{22}{9}}\ -2\,A$

$I_2 = \cancel{i_4 - i_3 = -\frac{4}{9}A}$

$i_4 - i_3 = 4A$

$I_3 = I_5 - i_2 = 9 + \frac{8}{3} = \frac{35}{3}$

$P_1 = -18 \cdot \cancel{9}\ \frac{35}{3} = \cancel{-162}\ 210\,W$. 发出

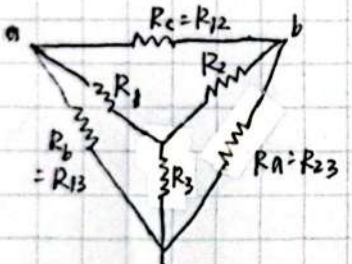
$P_2 = 20 \cdot \cancel{\frac{22}{9}}\ 2 = \cancel{\frac{440}{9}}\ 40\,W$. 吸收

$u_B = 0 + 4I_2 + 5i_4$

$= \cancel{\frac{16}{9}}\ 16 + 10 = \cancel{\frac{74}{9}}\ 26\,V$

$\therefore P_3 = -\cancel{\frac{74}{9}}\ 26 \cdot 2 = \cancel{-\frac{148}{9}}\ -52\,W$

△Y-△等效变换, $R_\Delta = 3R_Y$



叠加定理.

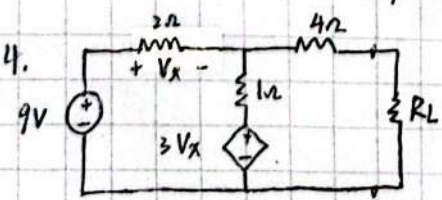
戴维南定理

诺顿定理.

Req: 去独立源, 加压求流

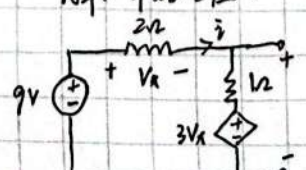
oc → 保留独立源, 开路电压/短路电流

Ex.4.



求R_L取__, 最大功率.

解: 开路电压:

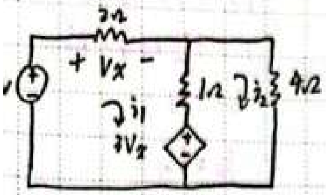


$$\begin{cases} V_x = 2i \\ V_x + i + 3V_x = 9 \end{cases}$$

$\therefore 2i + i + 6i = 9 \quad i = 1A$

$\therefore U = 7V$

短路电流:

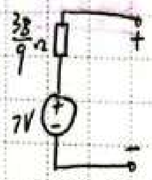


$$\begin{cases} 3i_1 - i_2 + 3V_x = 9 \\ 3V_x - 5i_2 + i_1 = 0 \\ V_x = 2i_1 \end{cases}$$

$\therefore i_1 = \frac{45}{38}A$, $i_2 = \frac{63}{38}A$

$V_x = \frac{45}{19}V$

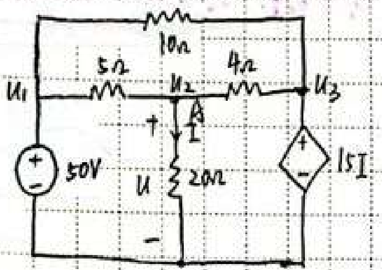
$\Rightarrow R_{eq} = \frac{u}{i_2} = \frac{7}{\frac{63}{38}} = \frac{38}{9}\Omega$



$R_L = R_{eq} = \frac{38}{9}\Omega$ 时, 最大 $P = \frac{7^2}{4\times\frac{38}{9}} = \frac{441}{152}W \approx 2.901\,W$

[这部分习题无非是计算. 等模电复习完再做习题]

(节点电压法) 求u.



对点A列节点电压:

$(\frac{1}{5}+\frac{1}{4}+\frac{1}{20})u_2 - \frac{1}{5}u_1 - \frac{1}{4}u_3 = 0$

$u_3 = 15I = 15\cdot\frac{u_2}{20} = \frac{3}{4}u_2$ $\quad u_1 = 50V$

$\therefore \frac{1}{2}u_2 - 10 - \frac{3}{16}u_2 = 0 \quad \frac{5}{16}u_2 = 10 \quad u_2 = 32V$

[一阶电路响应]

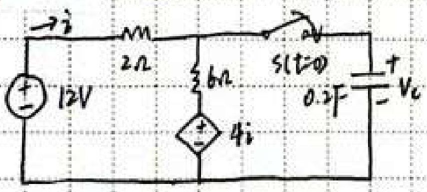
三要素法: $f(t) = f(\infty) + [f(0_+) - f(\infty)]e^{-\frac{t}{\tau}}$

$$\begin{cases} f(\infty): \text{稳态解, } t\to\infty \text{时稳态电路求解} \\ f(0_+): \text{初始值, } t\to 0^+ \text{等效电路求解} \\ \tau: \text{时间常数} \quad \tau = RC \text{ 或 } \tau = \frac{L}{R} \end{cases}$$

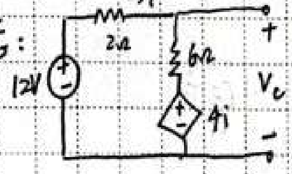
$v(t) = v(\infty) + [v(0) - v(\infty)]e^{-\frac{t}{\tau}}$

$i(t) = i(\infty) + [i(0) - i(\infty)]e^{-\frac{t}{\tau}}$

[错题: Ex8]



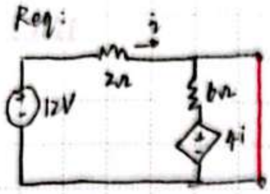
稳态:



$i = 1A$

$V_c = 10V$

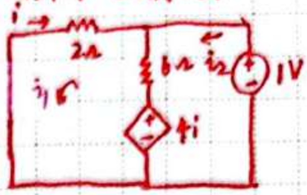
初态: $V_c = 0$ 　而 $\tau = R_{eq}C$. $C = 0.2F$



开路电压 $u=10V$. $i=6A$

$Req = \frac{5}{3}\Omega$ 有问题；不是直接短路. $\frac{12}{2}$.

用外加电源法：



$$\begin{cases} 4i - 8i_1 + 6i_2 = 0 \\ 1 - 6i_2 + 6i_1 = 4i \\ i = -i_1 \end{cases}$$

$\therefore i_2 = 2i_1$

$6i_1 - 2i_2 + 1 = 0$

$\Rightarrow 2i_1 + 1 = 0 \quad i_1 = -\frac{1}{2}A$

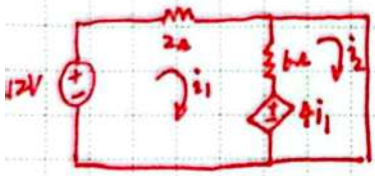
$i_2 = -1A \quad \underline{Req = 1\Omega}$

$\therefore \tau = Req \cdot C = \frac{5}{3} \times \frac{1}{5} s = \frac{1}{3} s$

$\therefore V_c = V(\infty) + [V(0) - V(\infty)] e^{-\frac{t}{\tau}} = 10 - 10e^{-5t}$ (SI)

而 $i = \frac{12 - V_c}{2} = 6 - 5 + 5e^{-5t} = 1 + 5e^{-5t}$ (SI)

再用短路电流法：

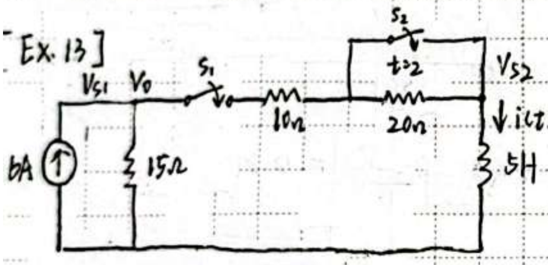


$$\begin{cases} 4i_1 + 8i_1 - 6i_2 = 12 \\ 6i_2 - 6i_1 = 4i_1 \end{cases} \Rightarrow \begin{cases} 2i_1 - i_2 = 2 \Rightarrow i_2 = 2i_1 - 2 \\ 5i_1 = 3i_2 \end{cases}$$

$\therefore 3i_2 = 6i_1 - 6 = 5i_1 \quad i_1 = 6A. \quad \underline{i_2 = 10A \quad Req = 1\Omega}$

居然就一道错的，再看两题，找两道看起来复杂的

[Ex.13]



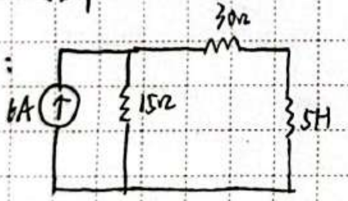
$t=0^-$ 时刻，S_1, S_2 均开

$t=0^+$ 时刻，S_1 闭合

$t=2s$，S_2 闭合.

解：先求 $t=0$ 时刻：

稳态：

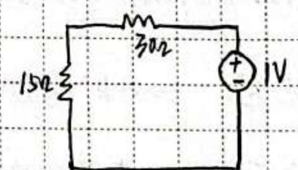


$i(\infty) = 2A$

初态 $i(0) = 0$,

$T = \frac{L}{Req}$.

Req 用外加电源法. Ⓘ开路



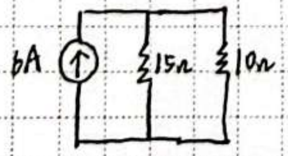
$\therefore Req = 45\Omega$

$\therefore \tau = \frac{5}{45} = \frac{1}{9}$

$\therefore i(t) = i(\infty) + [i(0) - i(\infty)] e^{-\frac{t}{\tau}}$

$= 2 - 2e^{-9t}$ (A), $0<t<2$.

再求 $t=2$ 时刻：稳态：



$i = \frac{15^{3}}{15+10_{5}} \times 6 = 3.6A$

$Req = 25\Omega \quad \therefore \tau = \frac{1}{5}$

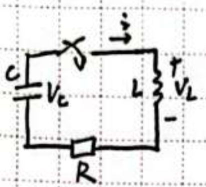
$i(2) = 2 - 2e^{-18}$

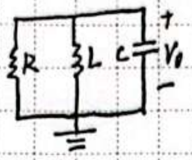
$\therefore i(t) = 3.6 + (2 - 2e^{-18} - 3.6) e^{-5(t-2)}$

$\approx 3.6 - 1.6e^{-5(t-2)} \quad (t \geq 2)$

【二阶电路响应】

串联RLC　　并联RLC





$\alpha = \frac{R}{2L}$　　$\alpha = \frac{1}{2RC}$

关键：i_L　　关键 V_C

通用解法：

(1) 选择合适变量 i_L / V_C

(2) 求该变量初始值/导数初始值

(3) 列响应方程 — 稳态 — 特解；瞬态 — 通解 } 相当于非齐次…

(4) 相加 → 全响应通解

(5) 代初值，求 k_1, k_2

(6) 求所需值.

串联：

$R > 2\sqrt{\frac{L}{C}}$	$V_C = k_1 e^{s_1 t} + k_2 e^{s_2 t}$
$R = 2\sqrt{\frac{L}{C}}$	$V_C = k_1 e^{-\alpha t} + k_2 t e^{-\alpha t}$
$R < 2\sqrt{\frac{L}{C}}$	$V_C = k e^{-\alpha t} \sin(wt+\beta)$

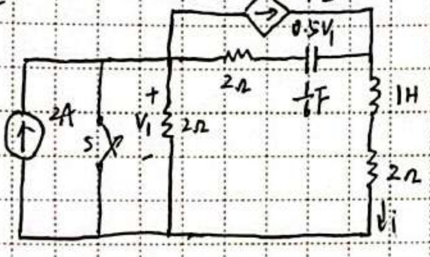
→ 串并联不同，还是记 $\alpha > w_0$ 比较合适

$s_{1,2} = -\alpha \pm \sqrt{\alpha^2 - w_0^2}$　　$\alpha = \frac{R}{2L}$　　$w_0 = \sqrt{\frac{1}{LC}}$

$w = \sqrt{\alpha^2 - w_0^2}$

故并联 $\alpha = \frac{1}{2RC}$，$w_0 = \sqrt{\frac{1}{LC}}$

[复习课的例题 — Ex.]

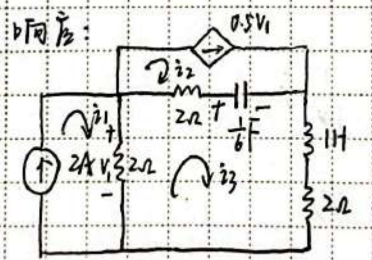


$t=0$ 时刻打开.

解：L.C串联，变量 i_L

初始 $i=0$，$V_C=0$.

响应：



$i_1 = 2A$

$i_2 = 0.5V_1$

$0 - 6i_3 - V_C - V_L + 2i_2 + 2i_1 = 0$

$i_3 = i_L$

$V_1 = 2(i_1 - i_3)$　　$i_2 = i_1 - i_3 = 2 - i_3$

$i_C = i_3 - i_2 = 2i_3 - 2$

$q = CU$

$\therefore u = \frac{1}{C} q$

$\therefore 6i_L + V_C + V_L = 4 + V_1$

$\therefore 6i_L + \frac{1}{C}\int \overset{(2i_3-2)}{i_L} dt + L\frac{di_L}{dt} = 4 + 4 - 2i_L$

$\Rightarrow 8i_L + \frac{1}{C}\int \overset{(2i_L-2)}{i_L} dt + L\frac{di_L}{dt} = 8$

瞬态：$\therefore 8\frac{di_L}{dt} + \frac{2}{C} i_L + L\frac{di_L^2}{dt^2} = \cancel{0}\ 12.$

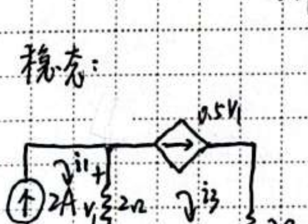
$\therefore$ 求通解：

特征方程为 $s^2 + 8s + \cancel{6}\,12 = 0$

$s_1 = -2$，$s_2 = -\cancel{4}\,6$

$\therefore i_L = 1 + k_1 e^{-2t} + k_2 e^{-\cancel{4}6t}$

稳态：



此时 $i_1 = 2A$，$i_3 = 0.5V_1$

$V_1 = 2(i_1 - i_3)$

则 $i_3 = i_1 - i_3$　$i_3 = 1A$

$i_L = 1A$

$t=0 \Rightarrow \begin{cases} k_1 + k_2 + 1 = 0 \\ -2k_1 - \cancel{4}\,6k_2 = 0 \end{cases}$　$k_1 = -\cancel{2}\,3k_2$

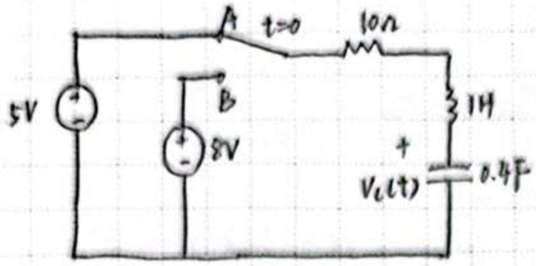
$\therefore k_1 = \cancel{-2}\,-\frac{3}{2}$，$k_2 = \cancel{1}\,\frac{1}{2}$

~~$i_L = 1 - \frac{3}{2}e^{-2t} + \frac{1}{2}e^{-4t}$~~

$i_L = 1 - \frac{3}{2}e^{-2t} + \frac{1}{2}e^{-4t}$

[错题]

6x2-1: $A \xrightarrow{t=0} B$ $t>0$ 求 $i(t)$、$V_c(t)$



解: 串联 $i_L(t)$

初态: $i_L(t)=0$ $V_c(t)=5V$.

开关→B:

瞬态: $\alpha = \frac{R}{2L} = \frac{10}{2} = 5$ $\quad w = \sqrt{\frac{1}{LC}} = \sqrt{\frac{1}{0.4}} = \sqrt{2.5}$ $\quad \therefore s = -\alpha \pm \sqrt{\alpha^2 - w^2} = -5 \pm 4.74$

$s_1 = -0.26$ $\quad s_2 = -9.74$

∴通解: $\underline{i_L(t) = k_1 e^{-0.26t} + k_2 e^{-9.74t}}$

特解: 稳态 $i_L(t)=0$ $\quad V_c(t) = \frac{1}{C}\cdot\int i_L dt$

$$\therefore \begin{cases} k_1 + k_2 = 0 \\ \left[k_1 \cdot \frac{1}{-0.26} + k_2 \cdot \frac{1}{-9.74}\right] \cdot \frac{1}{0.4} = 5 \end{cases} \qquad \begin{cases} k_1 = \frac{8}{15} = 0.53 \times \\ k_2 = -\frac{8}{15} = -0.53 \times \end{cases}$$

$\Rightarrow 3.85k_1 + 0.10k_2 = 2$

还是要以 $V_c(t)$ 为变量, 不然求不了微分. 这题教训仅此, 后略.

[相量分析电路] $\quad i \to \dot{I}$ $\quad v \to \dot{V}$

① 正弦量的微分、积分运算:

$\frac{di}{dt} \leftrightarrow jw\dot{I}$ $\qquad \int v dt \leftrightarrow \frac{1}{jw}\cdot\dot{V}$

类似 $4i + 8\int i dt - 3\cdot\frac{di}{dt} = 50\cos(2t+75^\circ)$

可以化成 $4\dot{I} + 8\cdot\frac{1}{jw}\dot{I} - 3jw\dot{I} = 50\angle 75^\circ$, $w=2$

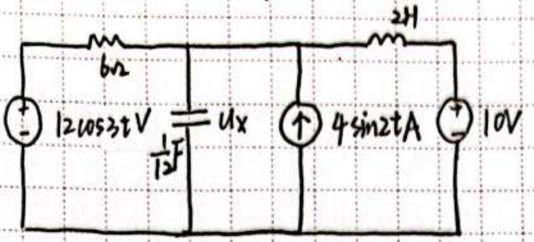
$\therefore 4\dot{I} - 4j\dot{I} - 6j\dot{I} = 50\angle 75$ $\quad \dot{I} = \frac{50\angle 75^\circ}{4-10j} = 4.642\angle 143.2^\circ$

$\therefore i = 4.642\cos(2t + 143.2^\circ)$ A

② $\dot{V}_R = R\dot{I}_R$ $\quad \dot{V}_L = jwL\dot{I}_L$ $\quad \dot{V}_C = \frac{1}{jwC}\dot{I}_C$ $\quad$ 阻抗: $Z = \frac{\dot{V}}{\dot{I}}$

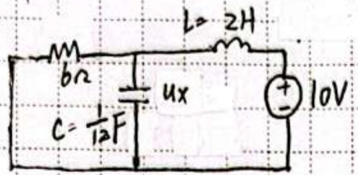
后面就是基础电路知识.

例题：用叠加定理求 $u_x(t)$



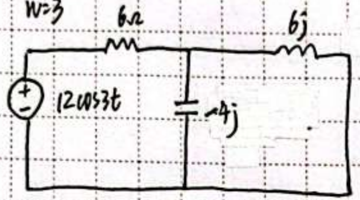
解：三个时域：

①



稳定后，$u_x=10V$

② $w=3$



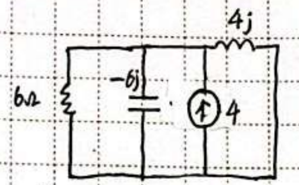
$$\dot{U}_x = 12\times\frac{(-4j)//(6j)}{6+(-4j)//6j}$$

$$= 12\times\frac{-12j}{6-12j} = 9.6-4.8j$$

$$= 10.73\angle -26.56^\circ$$

$(-4j)//6j = -12j$

③ $w=2$ $\frac{1}{jwC}=-6j$ $jwL=4j$



$$\dot{U}_x = 4\times 6//(-6j)//(4j)$$

$$= 4\times(3-3j)//4j = 21.46\angle 26.57^\circ$$

$\therefore u_x=10+10.73\cos(3t-26.56^\circ)+21.46\cos(3t+26.57^\circ)$

§一阶电路响应

Ex.11. $f(t)=f(\infty)+[f(0)-f(\infty)]e^{-\frac{t}{\tau}}$

稳态：B位置： $V_0(t)=6V$

初态：A位置： $V_0(t)=8V$

$\tau=R_{eq}C$