课后习题

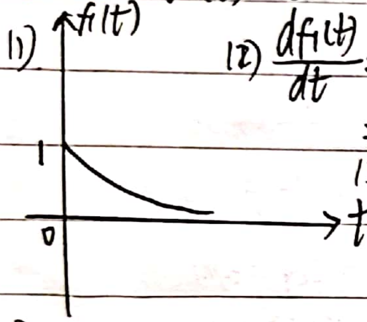
[7-1] $f_1(t) = -4\varepsilon(t)$

$f_2(t) = 5[\varepsilon(t-1)-\varepsilon(t-3)]-3[\varepsilon(t-3)-\varepsilon(t-5)]$
$= 5\varepsilon(t-1)-8\varepsilon(t-3)+3\varepsilon(t-5)$

$f_3(t) = (2-t)[\varepsilon(t-1)-\varepsilon(t-3)]+(t-4)[\varepsilon(t-3)-\varepsilon(t-5)]+\varepsilon(t-5)$
$= (2-t)\varepsilon(t-1)+(2t-6)\varepsilon(t-3)+(5-t)\varepsilon(t-5)$

[7-2] (1) $f_1(t)=e^{-t}\varepsilon(t)$

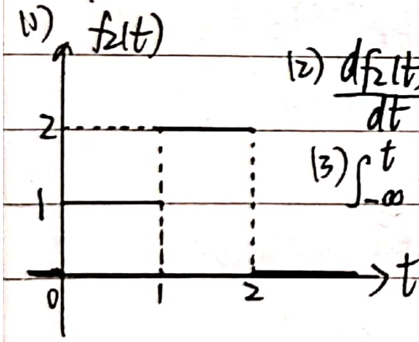
(1)



(2) $\frac{df_1(t)}{dt} = -e^{-t}\varepsilon(t)+e^{-t}\delta(t)$
$= \delta(t)-e^{-t}\varepsilon(t)$

(3) $\int_{-\infty}^{t} f_1(t)dt = \left(\int_0^t e^{-t}dt\right)\varepsilon(t)$
$= (1-e^{-t})\varepsilon(t)$

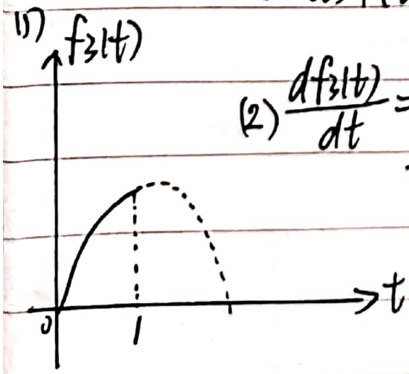
(1)



(2) $\frac{df_2(t)}{dt} = \delta(t)+\delta(t-1)-2\delta(t-2)$

(3) $\int_{-\infty}^{t} f_2(t)dt = \left(\int_0^t 1dt\right)\varepsilon(t) + \left(\int_1^t 1dt\right)\varepsilon(t-1) + \left(\int_2^t -2dt\right)\varepsilon(t-2)$
$= t\varepsilon(t)+(t-1)\varepsilon(t-1)-2(t-2)\varepsilon(t-2)$

(1)



(2) $\frac{df_3(t)}{dt} = \cos t\,\varepsilon(t)+\sin t\,\delta(t) - \cos t\,\varepsilon(t-1)-\sin t\,\delta(t-1)$
$= \cos t[\varepsilon(t)-\varepsilon(t-1)] - \sin 1\,\delta(t-1)$

(3) $\int_{-\infty}^{t} f_3(t)dt = \left(\int_0^t \sin t\,dt\right)\varepsilon(t) - \left(\int_1^t \sin t\,dt\right)\varepsilon(t-1)$
$= (1-\cos t)\varepsilon(t)-(\cos 1-\cos t)\varepsilon(t-1)$

[7-3] (1) (a) $f_1 = 2[\varepsilon(t)-\varepsilon(t-1)]-2[\varepsilon(t-1)-\varepsilon(t-2)] = 2\varepsilon(t)-4\varepsilon(t-1)+2\varepsilon(t-2)$

(b) $f_2 = \varepsilon(t-1)-\varepsilon(t-2)+2\varepsilon(t-2)$
$= \varepsilon(t-1)+\varepsilon(t-2)$

(c) $f_3 = 2t[\varepsilon(t)-\varepsilon(t-1)]+2\varepsilon(t-1)$
$= 2t\varepsilon(t)-(2t-2)\varepsilon(t-1)$

(d) $f_4 = t[\varepsilon(t)-\varepsilon(t-1)]-\frac{1}{2}(t-3)[\varepsilon(t-1)-\varepsilon(t-3)]$
$= t\varepsilon(t)-\frac{3}{2}(t-1)\varepsilon(t-1)+\frac{1}{2}(t-3)\varepsilon(t-3)$

[7-4] $f_1(t)=2$, $f_2(t)=2e^{-4}$

$f_3(t)=2e^{-4}\sin 2$

[7-5] $i = C\frac{du}{dt}$

$\therefore i = 8e^{-2t}(1-2t)\,\mu A$

$W=\frac{1}{2}Cu^2 = 1.6\times10^{-5}t^2e^{-4t}\,J$

[7-6] $u = u(0_-)+\frac{1}{C}\int_{0_-}^{t} i\,dt$ $u(0_-)=0$

$= \frac{1}{4}\times10^3\int_0^{10} 0.4e^{-0.1t}\varepsilon(t)dt$

$= (1-e^{-1})\times10^3\,V$

$W=\frac{1}{2}Cu^2 = 2\times(1-e^{-1})^2\times10^{-3}\,J$

[7-7] (1) $W=\frac{1}{2}Cu_1^2-\frac{1}{2}Cu_2^2 = 84\,J$

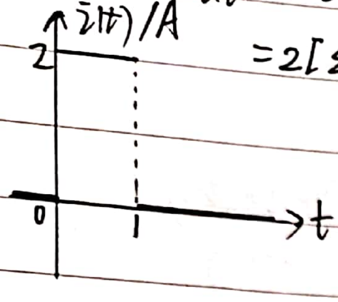
(2) $P=\frac{W}{t}=8.4\,W$

$i=\frac{Q}{t}=\frac{Cu_1-Cu_2}{t}=0.12\,A$

[7-8] 知: $u(t)=2t\varepsilon(t)-(2t-2)\varepsilon(t-1)$ (V)

$i(t)=C\frac{du(t)}{dt}=2\varepsilon(t)+2t\delta(t)-2\varepsilon(t-1)+2(t-1)\delta(t-1)$

$=2[\varepsilon(t)-\varepsilon(t-1)]$ (A)



[7-10] $u=u(0_-)+\frac{1}{C}\int_{0_-}^{t} i\,dt$

$=\int_0^t t[\varepsilon(t)-\varepsilon(t-1)]dt$

$=(\int_0^t t\,dt)\varepsilon(t)-(\int_1^t t\,dt)\varepsilon(t-1)$

$=\frac{1}{2}t^2\varepsilon(t)-\frac{t^2-1}{2}\varepsilon(t-1)$

∴ t=1s时, $u_1=0.5V$. $W_1=\frac{1}{2}Cu_1^2=0.125J$

t=2s时, $u_2=0.5V$ $W_2=\frac{1}{2}Cu_2^2=0.125J$

t=3s时, $u_3=0.5V$ $W_3=\frac{1}{2}Cu_3^2=0.125J$

[7-11] $i=0.1[\varepsilon(t)-\varepsilon(t-1)]+0.1[\varepsilon(t-2)-\varepsilon(t-3)]+\dots+0.1[\varepsilon(t-2n)-\varepsilon(t-2n-1)]$ (A)

$u=u(0)+\frac{1}{C}\int_0^t i\,dt$

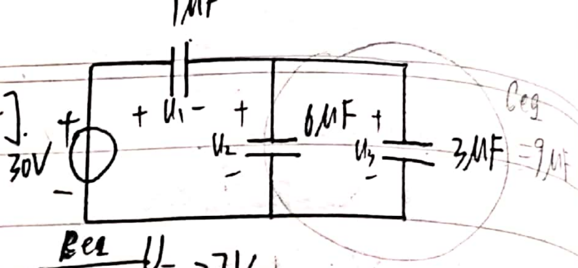
2s一个周期,一个周期增加0.1V,2个脉冲

∴升至10V时经过50个周期,共100个脉冲

[7-12] $C_{eq}=1\mu F$

[7-13] 要用到阻抗变换

[7-14]



$u_1=\frac{C_{eq}}{C_{eq}+C_1}U=27V$

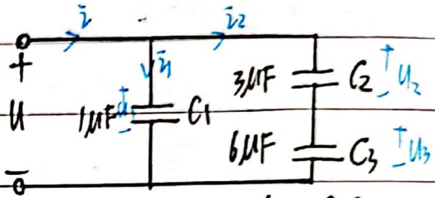
$W_1=\frac{1}{2}C_1u_1^2=364.5\mu J$

$u_2=u_3=\frac{C_1}{C_1+C_{eq}}U=3V$

$W_2=\frac{1}{2}C_2u_2^2=27\mu J$

$W_3=\frac{1}{2}C_3u_3^2=13.5\mu J$

[7-15]



(1) C_2与C_3串联等效电容 $C_{eq}'=\frac{C_2C_3}{C_2+C_3}=2\mu F$

端口等效电容 $C_{eq}=C_1+C_{eq}'=3\mu F$

(2) $u_1(t)=u_1(0_-)+u=10(1-e^{-0.5t})\varepsilon(t)V$

$u_2(t)=u_2(0_-)+\frac{C_3}{C_2+C_3}[u-u_2(0_-)-u_3(0_-)]$

$=6.67(1-e^{-0.5t})\varepsilon(t)V$

$u_3(t)=u_3(0_-)+\frac{C_2}{C_2+C_3}[u-u_2(0_-)-u_3(0_-)]$

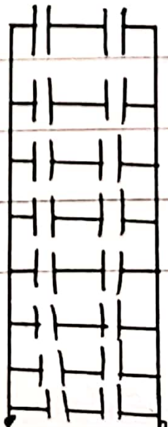
$=3.33(1-e^{-0.5t})\varepsilon(t)V$

(3) $i(t)=C_{eq}\frac{du_1(t)}{dt}=15e^{-0.5t}\varepsilon(t)\mu A$

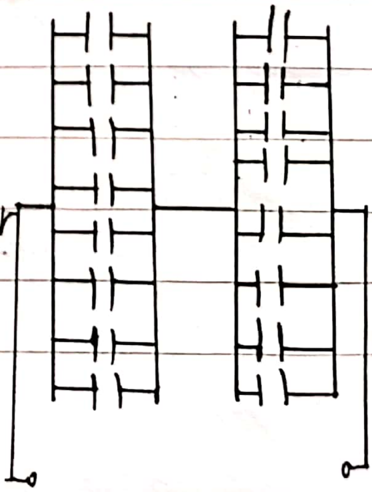
$i_1(t)=C_1\frac{du_1(t)}{dt}=5e^{-0.5t}\varepsilon(t)\mu A$

$i_2(t)=C_{eq}'\frac{du_1(t)}{dt}=10e^{-0.5t}\varepsilon(t)\mu A$

[7-16]



or



[7-17] (1) 开关闭合后：

因为电路中有电阻，不构成纯电容回路

∴为状态非跳变换路

∴ $u_1(0_+)=u_1(0_-)=3V$, $u_2(0_+)=u_2(0_-)=9V$

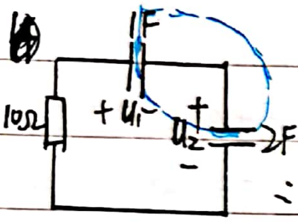
(2) $W_1=\frac{1}{2}C_1u_1^2+\frac{1}{2}C_2u_2^2=85.5J$

(3) $C_{eq}=\frac{C_1C_2}{C_1+C_2}=0.67F$

$u(0_+)=u_1(0_+)+u_2(0_+)=9V+3V=12V$

$W=\frac{1}{2}C_{eq}u^2(0_+)=48J$

(4)



$t=\infty$时，$u_1(\infty)+u_2(\infty)=0$

作如图闭合面，电荷守恒

∴ $C_1u_1(0_-)-C_2u_2(0_-)$

$=C_1u_1(\infty)-C_2u_2(\infty)$

$u_1(\infty)=5V$

∴ $u_1(\infty)=-5V$, $u_2(\infty)=5V$ $u_2(\infty)=-5V$

(5) $W(\infty)=\frac{1}{2}C_1u_1^2(\infty)+\frac{1}{2}C_2u_2^2(\infty)=37.5J$

(4) $\Delta W=W_1-W(\infty)=48J$

[7-18] (1) (a)中 $u_1(0_+)=u_1(0_-)=5V$,

$u_2(0_+)=u_2(0_-)=2V$

(b)中，$u_1(0_+)+u_2(0_+)=10V$ (由KVL)

由电荷守恒：$C_1u_1(0_-)+C_2u_2(0_-)=C_1u_1(0_+)-C_2u_2(0_+)$

∴ $u_1(0_+)=7V$ $u_2(0_+)=3V$

(c)中，$u_1(0_+)+u_2(0_+)=0$

$C_1u_1(0_-)-C_2u_2(0_-)=C_1u_1(0_+)+C_2u_2(0_+)$

∴ $u_1(0_+)=\frac{1}{3}V$ $u_2(0_+)=-\frac{1}{3}V$

(2) 区别：(a)中不构成纯电容回路，为状态非跳变换路。(b)、(c)中分别构成含独立电压源的纯电容回路和仅含电容的纯电容回路，为状态跳变换路。(b)、(c)中满足的KVL关系不同，故结果不同

(3) 不指定 $u_1(0_-)$、$u_2(0_-)$ 的值就不知道满足的电荷守恒方程，就算不出来

[7-19] (a)中，$u_1(0_+)=u_1(0_-)=5V$,

$u_2(0_+)=u_2(0_-)=2V$

(b)中，KVL：$u_1(0_+)-u_2(0_+)=0$

$C_1u_1(0_+)+C_2u_2(0_+)=C_1u_1(0_-)+C_2u_2(0_-)$

∴ $u_1(0_+)=3V$ $u_2(0_+)=3V$

[7-20] (a)、(b)中开关闭合后都构成纯电容回路，都是状态跳变换路

(a)中，$u_1(0_-)=u_2(0_-)=5V$

$u_1(0_+)-u_2(0_+)=0$

$C_1u_1(0_-)+C_2u_2(0_-)=C_1u_1(0_+)+C_2u_2(0_+)$

∴ $u_1(0_+)=u_2(0_+)=5V$

(b)中，$u_1(0_-)=u_S=5V$

$u_1(0_+)-u_2(0_+)=0$

$C_1u_1(0_-)+C_2u_2(0_-)=C_1u_1(0_+)+C_2u_2(0_+)$

∴ $u_1(0_+)=u_2(0_+)=5V$

[7-21] $u_L=L\frac{di_L}{dt}$

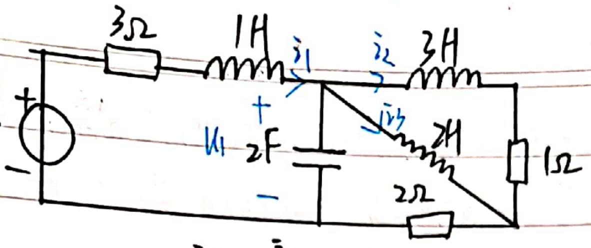
(1) $u_L=0$ (2) $u_L=2\delta(t)$ mV

(3) $u_L=2e^{-10t}[-10\varepsilon(t)+\delta(t)]$ mV $=2[\delta(t)-10e^{-10t}\varepsilon(t)]$ mV

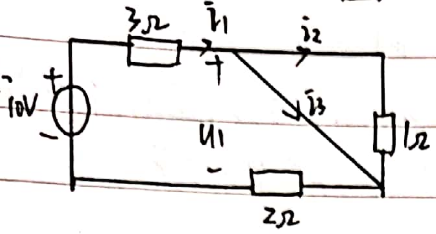
(4) $u_L=2[2\cos t\,\varepsilon(t)+2\sin t\,\delta(t)]$ mV

$=4\cos t\,\varepsilon(t)$ mV

[7-26]



稳定状态下:



$i_1=\frac{10V}{3\Omega+2\Omega}=2A$, $i_2=0$, $i_3=i_1-i_2=2A$

$u_1=\frac{2\Omega}{2\Omega+3\Omega}\times10V=4V$

电容储能: $W_1=\frac{1}{2}Cu_1^2=16J$

1H电感: $W_2=\frac{1}{2}L_1i_1^2=2J$

2H电感: $W_3=\frac{1}{2}L_2i_3^2=4J$

3H电感: $W_4=\frac{1}{2}L_3i_2^2=0$

[7-31] (1) $i_1(0_-)=i_s=4A$

$L_1i_1(0_-)+L_2i_2(0_-)=L_1i_1(0_+)+L_2i_2(0_+)$

$i_1(0_+)-i_2(0_+)=0$

∴ $i_1(0_+)=i_2(0_+)=2.2A$

(2) $i_1(0_-)=i_s=4A$, $i_2(0_-)=0$

∴构成状态跳变换路

$i_1(0_+)-i_2(0_+)=0$ ∴ $i_1(0_+)=1.6A$

$L_1i_1(0_-)+L_2i_2(0_-)=L_1i_1(0_+)+L_2i_2(0_+)$ $i_2(0_+)=1.6A$

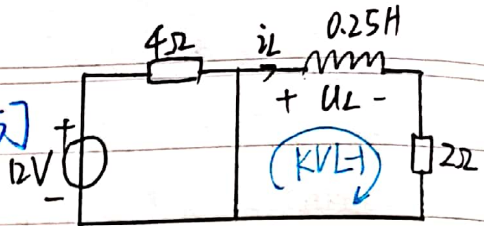
(3) $i_1(0_-)=4A$ 不构成纯电感广义结点

∴ $i_1(0_+)=i_1(0_-)=4A$

$i_2(0_+)=i_2(0_-)=1A$

(4) (a)、(b)中开关打开后都构成了纯电感广义结点,故为状态跳变换路;(c)中不构成纯电感广义结点,为状态非跳变换路

[7-35]



(1)只含一个电感 ∴为一阶电路

(2) KVL-1: $u_L+2i_L=0$ 又 $u_L=0.25\frac{di_L}{dt}$

∴ $\frac{di_L}{dt}+8i_L=0$

(3) 稳态时, $i_L(0_-)=\frac{12V}{4\Omega+2\Omega}=2A$

$i_L(0_+)=i_L(0_-)=2A$

$u_L(0_+)+2i_L(0_+)=0$ ∴ $u_L(0_+)=-4V$

(4) $i_L(\infty)=0$

(5) $\frac{di_L}{dt}+8i_L=0$ 特征方程 $s+8=0$ ∴ $s=-8$

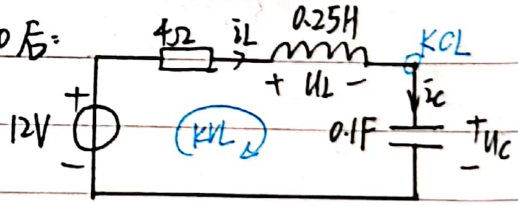
∴ $i_L=ke^{-8t}A$

又 $i_L(0_+)=2A$ ∴ $k=2$ 即 $i_L=2e^{-8t}A$

(6) $t\to\infty$时, $2e^{-8t}\to0$ 即 $i_L(\infty)=0$

[7-36] (1)电路含一个电容一个电感,为二阶电路

(2) $t>0$后:



KVL: $4i_L+u_L+u_C=12$ ①

KCL: $i_L-i_C=0$ ②

又 $u_L=0.25\frac{di_L}{dt}$, $i_C=0.1\frac{du_C}{dt}$

∴由①: $4i_L+0.25\frac{di_L}{dt}+u_C=12$

求导得 $4\frac{di_L}{dt}+0.25\frac{d^2i_L}{dt^2}+\frac{du_C}{dt}=0$

代入 $i_L=i_C=0.1\frac{du_C}{dt}$

∴ $\frac{d^2i_L}{dt^2}+16\frac{di_L}{dt}+40i_L=0$

同理, $\frac{d^2u_C}{dt^2}+16\frac{du_C}{dt}+40u_C=480$

(3) 开关打开前: $u_C(0_-)=\frac{2}{2+4}\times12V=4V$

$i_L(0_-)=\frac{12}{4+2}=2A$

$u_C(0_+)=u_C(0_-)=4V$

$i_L(0_+)=i_L(0_-)=2A$

$i_C(0_+)=i_L(0_+)=2A$

$u_L(0_+)=0$

(4) $\frac{du_C}{dt}\Big|_{0_+}=10i_C(0_+)=20V/s$

$\frac{di_L}{dt}\Big|_{0_+}=4u_L(0_+)=0$

(5) $u_C(\infty)=U_S=12V$, $i_L(\infty)=0$

(6) $\frac{d^2u_C}{dt^2}+16\frac{du_C}{dt}+40u_C=480$

特征方程: $s^2+16s+40=0$

$\therefore s_1=-8-2\sqrt{6}=-12.9$ $s_2=-8+2\sqrt{6}=-3.1$

特解: $\frac{480}{40}=12$

$\therefore u_C=k_1e^{-12.9t}+k_2e^{-3.1t}+12$

$\because \begin{cases}u_C(0_+)=4V\\ \frac{du_C}{dt}(0_+)=20V/s\end{cases}$ $\therefore \begin{cases}k_1+k_2+12=4\\ -12.9k_1-3.1k_2=20\end{cases}$

$\therefore k_1=0.49$ $k_2=-8.49$

$\therefore u_C=(0.49e^{-12.9t}-8.49e^{-3.1t}+12)V$

(7) $t\to\infty$时, $u_C\to12V=U(\infty)$

非作业课后题

[7-22] $i_L=i_L(0_-)+\frac{1}{L}\int_{0_-}^{t}u_L\,dt=[1+5(1-e^{-10t})]\varepsilon(t)A$

$t>0$时, $i_L=(6-5e^{-10t})A$

$t=1s$时, $i_L=(6-5e^{-1})A$ $W=\frac{1}{2}Li^2$

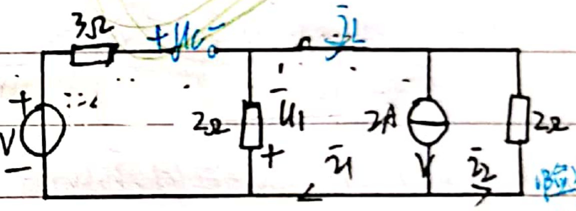
[7-23] 一个脉冲: $\Delta i=\int u_L\,dt=5\times10^{-2}A$

∴ 100个脉冲

[7-24] $\Delta W=\frac{1}{2}Li_2^2-\frac{1}{2}Li_1^2=0.192J$

$\frac{di}{dt}=-800A/s$ $u=L\frac{di}{dt}=-320V$ 注意正负号

[7-25]



知 $i_1=i_2=1A$. $u_1=2i_1=2V$

$u_C=10V+u_1=12V$. $i_L=1A$

$\therefore W_1=\frac{1}{2}Cu_C^2=72J$ $W_2=\frac{1}{2}Li_L^2=2J$

[7-27] 2H

[7-29] (1) $L_{eq}=3H$

(2) $i_1=(1-e^{-0.5t})\varepsilon(t)A$, $i_2=2(1-e^{-0.5t})\varepsilon(t)A$

$u_3=2\frac{di_1}{dt}=3e^{-0.5t}\varepsilon(t)V$

$u_2=1.5\frac{di_2}{dt}=1.5e^{-0.5t}\varepsilon(t)V$

[7-30] (1) 非跳变换路

$i_1(0_+)=i_1(0_-)=2A$, $i_2(0_+)=i_2(0_-)=1A$

(2) $W=\frac{1}{2}L_1i_1^2(0_+)+\frac{1}{2}L_2i_2^2(0_+)=7.5J$ $=\frac{1}{2}L_{eq}i^2(0_+)$

(3) $L_{eq}=1.5H$, $i(0_+)=3A$ $W_0=6.75J$

(4) $t=\infty$时, $i_1(\infty)+i_2(\infty)=0$

$L_1i_1(0_-)+L_2i_2(0_-)=L_1i_1(\infty)+L_2i_2(\infty)$

$\therefore i_1(\infty)=0.5A$, $i_2(\infty)=-0.5A$