第15章作业

[15-6] 图示波形为奇函数，且具有半波对称性

知 T=14s，令 $\omega_0 T=2\pi$ ∴ $\omega_0=\frac{\pi}{7}$ rad/s

k=1,3,5…时 $a_0=0$　2≤t≤12时，$f(t)=\begin{cases}1, & 2\le t\le5\\ 0, & 5\le t\le9\\ -1, & 9\le t\le12\\ 0, & 12\le t\le16\end{cases}$

∵为奇函数 ∴ $a_k=0$

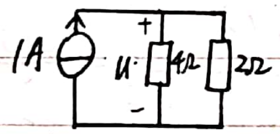
$b_k=\frac{4}{T}\int_2^5 1\cdot\sin k\omega_0 t\,dt$

$=\frac{4}{k\omega_0 T}(-\cos k\omega_0 t)\big|_2^5$

$=\frac{2}{k\pi}(\cos\frac{2\pi k}{7}-\cos\frac{5\pi k}{7})$ (k=1,3,5…)

∴ $f(t)=\frac{2}{\pi}\sum_{k=1,3,5\cdots}^{\infty}\frac{1}{k}(\cos\frac{2k\pi}{7}-\cos\frac{5k\pi}{7})\sin\frac{\pi k t}{7}$

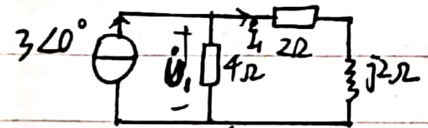
[15-8] (1) ① 直流分量单独作用



$I_0=\frac{4}{4+2}\times1A=\frac{2}{3}A$

$U_0=1A\times\frac{4\times2}{4+2}\Omega=\frac{4}{3}V$

② 基波电源单独作用

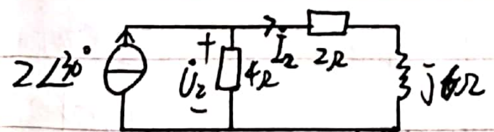


$Z_{eq1}=\frac{4\times(2+j2)}{6+j2}=(1.6+j0.8)\Omega$

$\dot U_1=3\angle0°\times(1.6+j0.8)=5.37\angle26.57°V$

$\dot I_1=3\angle0°\times\frac{4}{6+j2}=1.8-j0.6=1.90\angle-18.43°A$

② 三次谐波电源单独作用



$Z_{eq2}=\frac{4\times(2+j6)}{6+j6}=(\frac{8}{3}+j\frac{4}{3})\Omega$

$\dot U_2=2\angle30°\times(\frac{8}{3}+j\frac{4}{3})=\frac{-4+8\sqrt3}{3}+j\frac{8+4\sqrt3}{3}$

$=5.96\angle56.57°=\frac{8\sqrt5}{3}\angle56.57°V$

$\dot I_2=2\angle30°\times\frac{4}{6+j6}=\frac{1+\sqrt3}{3}+j\frac{1-\sqrt3}{3}$

$=0.94\angle-15°A$

∴ $i=[0.67+1.90\cos(t-18.43°)+0.94\sin(3t-15°)]A$

$u=[1.33+5.37\cos(t+26.57°)+5.96\sin(3t+56.57°)]A$

(2) $I=\sqrt{I_0^2+\sum_{k=1}^{\infty}I_k^2}=\sqrt{(\frac{2}{3})^2+(\frac{1.90}{\sqrt2})^2+(\frac{0.94}{\sqrt2})^2}$

$=1.64A$

$U=\sqrt{U_0^2+\sum_{k=1}^{\infty}U_k^2}=\sqrt{(\frac{4}{3})^2+(\frac{5.37}{\sqrt2})^2+(\frac{5.96}{\sqrt2})^2}$

$=5.83V$

(3) $P_0=(\frac{2}{3})^2\times2=0.89W$

$P_1=(\frac{1.9}{\sqrt2})^2\times2=3.61W$

$P_2=(\frac{0.94}{\sqrt2})^2\times2=0.88W$

∴ $P=P_0+P_1+P_2=5.39W$

(4) $P_0'=\frac{4}{3}\times1=1.33W$

$\dot U_1'=3\angle0°\times(1.6+j0.8)\Omega$

$P_1'=\frac{1}{2}U_1I_1\cos(\varphi_{u1}-\varphi_{i1})=7.20W$

$\dot U_2'=2\angle30°\times(\frac{8}{3}+j\frac{4}{3})$

$P_2'=\frac{1}{2}U_2I_2\cos(56.57°-30°)$

$=5.33W$

∴ $P'=P_0'+P_1'+P_2'=13.86W$

[15-12] (1) 知 $T=2\pi\times10^{-3}s$

知 $\omega_0T=2\pi$ 则 $\omega_0=1000$ rad/s

$\omega_0L=100\Omega$，$\frac{1}{\omega_0C}=2500\Omega$

(2) u_s为正方波，查表知

$f(t)=5\pi+20\sum_{k=1}^{\infty}\frac{1}{2k-1}\sin1000(2k-1)t$

取前5项，则

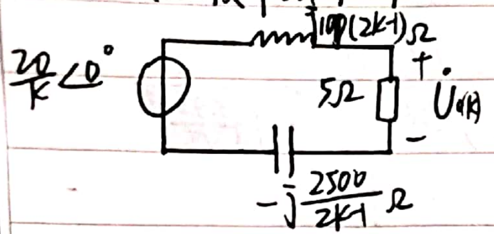
$u_s=[5\pi+20\sin1000t+\frac{20}{3}\sin3000t+4\sin5000t+\frac{20}{7}\sin7000t]V$

(3) ① 直流分量单独作用下

$U_0=0$

→

② K次谐波单独作用下：



$$\dot{U}_{0(K)}=\frac{20}{K}\angle 0^\circ \times \frac{5}{j100(2K-1)+5-j\frac{2500}{2K-1}}$$

$\therefore K=1$时，$\dot{U}_{01}=20\angle 0^\circ \times \frac{5}{j100+5-j2500}$

$=0.042\angle 89.9^\circ V$

$K=2$时，$\dot{U}_{02}=\frac{20}{3}\angle 0^\circ \times \frac{5}{j300+5-j\frac{2500}{3}}$

$=0.062\angle 89.5^\circ V$

$K=3$时，$\dot{U}_{03}=\frac{20}{5}\angle 0^\circ \times \frac{5}{j500+5-j\frac{2500}{5}}$

$=4\angle 0^\circ V$ （串联谐振）

$K=4$时，$\dot{U}_{04}=\frac{20}{7}\angle 0^\circ \times \frac{5}{j700+5-j\frac{2500}{7}}$

$=0.042\angle -89.2^\circ V$

取前5项

$\therefore u_0\approx[0.042\sin(1000t+89.9^\circ)+0.062\sin(3000t+89.5^\circ)+4\sin 5000t+0.042\sin(7000t-89.2^\circ)]V$

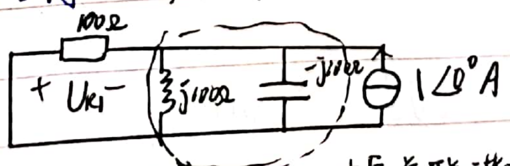
(4) $U_0=\sqrt{(\frac{0.042}{\sqrt2})^2+(\frac{0.062}{\sqrt2})^2+(\frac{4}{\sqrt2})^2+(\frac{0.042}{\sqrt2})^2}$

$\approx 2.829V$

(5) 取前5项合适

（带通滤波器，选择5次谐波分量）

[15-21] i_S单独作用时，

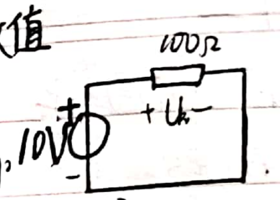


$j100\Omega$电感与$-j100\Omega$电容并联谐振

$\therefore U_{R1}=-1\times 100V=-100V$

取有效值

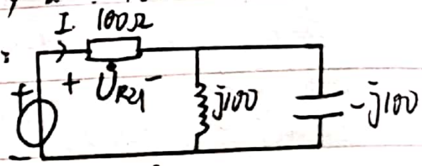
U_S单独作用时：



① 直流分量单独作用

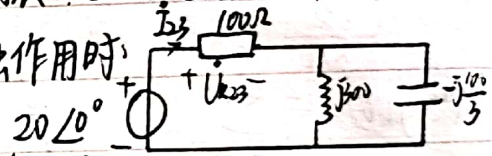
$U_{R0}=10V$，$P_{21}=\frac{10^2}{100}=1W$

② 基波单独作用时：



L与C并联谐振 $I=0$，$\dot{U}_{R21}=0$，$P_{22}=0$

③ 三次谐波单独作用时：



$$Z_{eq}=\frac{j300\times(-j\frac{100}{3})}{j300-j\frac{100}{3}}=-j37.5\Omega$$

$$\dot{U}_{R23}=20\angle 0^\circ \times \frac{100}{100-j37.5}=(17.53-j6.58)V$$

$=18.72\angle -20.57^\circ V$

由叠加定理，$U_R=\sqrt{100^2+10^2+(18.72)^2}=102.22V$

$$\dot{I}_{23}=\frac{20\angle 0^\circ}{100-j37.5}=(0.175+j0.066)A=0.187\angle 20.66^\circ A$$

$P_{23}=20\times 0.187\cos(0^\circ-20.66^\circ)$

$=3.499W$

$P=P_{21}+P_{23}=1+3.499=4.5W$

即U_R有效值$102.22V$，

U_S提供的平均功率$4.5W$

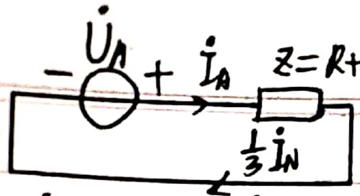
[15-22] (1) 由对称三相非正弦稳态电路零序电压电流的分布特征知，Y_N-Y_n联结下，线电流中含零序分量，除线电压外，其他电量均含零序分量。中线电流、中性点之间的电压全是零序分量，没有正序和负序分量

又$\because K=1,7,13,\dots$正序，$K=3,9,15,\dots$零序，

$K=5,11,17,\dots$负序

$\therefore U_{nN}=-U_3=-120\sin 3\omega_0 t\ V$

(2)



$Z=R+j3\omega_0 L=(4+j3)\Omega$

A相电路

$$\dot{I}_A=\frac{1}{3}\dot{I}_N=\frac{\dot{U}_A}{Z}=\frac{120\angle 0^\circ}{4+j3}=24\angle -36.86^\circ A$$

$\therefore \dot{I}_N=72\angle -36.86^\circ A$

即 $i_N=72\sin(3\omega_0 t-36.86^\circ)A$

(3) 线电压中总没有零序分量，无论三线制还是四线制连接，∴上述两种情况下，均为：

$u_{A1}=180\sin\omega_0 t\ V$ 作用时，正序对称，

$u_{AB1}=180\sqrt{3}\sin(\omega_0 t+30^\circ)V$

$u_{A5}=80\sin 5\omega_0 t\ V$ 作用时，负序对称

$u_{AB5}=80\sqrt{3}\sin(5\omega_0 t-30^\circ)V$

叠加得：$u_{AB}=[180\sqrt{3}\sin(\omega_0 t+30^\circ)+80\sqrt{3}\sin(5\omega_0 t-30^\circ)]V$

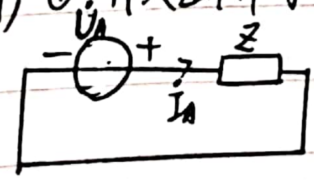
同理，$u_{BC}=[180\sqrt{3}\sin(\omega_0 t+30^\circ-120^\circ)+80\sqrt{3}\sin(5\omega_0 t-30^\circ+120^\circ)]V$

$=[180\sqrt{3}\sin(\omega_0 t-90^\circ)+80\sqrt{3}\sin(5\omega_0 t+90^\circ)]V$

$u_{AC}=[180\sqrt{3}\sin(\omega_0 t+30^\circ+120^\circ)+80\sqrt{3}\sin(5\omega_0 t-30^\circ-120^\circ)]V$

$=[180\sqrt{3}\sin(\omega_0 t+150^\circ)+80\sqrt{3}\sin(5\omega_0 t-150^\circ)]V$

(4) ① 开关断开时：线电流中不含零序分量！(Y-Y联结)



$$\dot{I}_{A1}=\frac{180\angle 0^\circ}{4+j1}=43.66\angle -14.04^\circ A$$

$$\dot{I}_{A5}=\frac{80\angle 0^\circ}{4+j5}=12.49\angle -51.34^\circ A$$

$\therefore i_A=[43.66\sin(\omega_0 t-14.04^\circ)+12.49\sin(5\omega_0 t-51.34^\circ)]A$

② 开关闭合时：Y_N-Y_n 联结，线电流中含有零序分量

$$\dot{I}_{A3}=\frac{120\angle 0^\circ}{4+j3}=24\angle -36.86^\circ A$$

$\therefore i_A=[43.66\sin(\omega_0 t-14.04^\circ)+24\sin(3\omega_0 t-36.86^\circ)+12.49\sin(5\omega_0 t-51.34^\circ)]A$