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 $\omega_0 T=2\pi$ $\therefore \omega_0=\frac{\pi}{7}$ rad/s

$k=1,3,5$ 时 $a_0=0$ $2\le t\le 12$ 时，$f(t)=\begin{cases}1: 2\le t<5\\ 0: 5\le t<9\\ -1: 9\le t<12\\ 0: 12\le t\le 16\end{cases}$

$\therefore$ 为奇函数 $\therefore a_k=0$

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

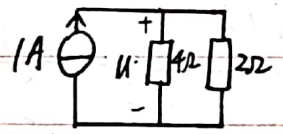
$$=\frac{4}{k\omega_0 T}(-\cos k\omega_0 t)\Big|_2^5$$

$$=\frac{2}{k\pi}\left(\cos\frac{2\pi k}{7}-\cos\frac{5\pi k}{7}\right)\quad(k=1,3,5\cdots)$$

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

[15-8] 11)

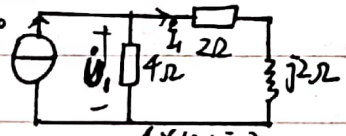
① 直流分量单独作用：



$$I_0=\frac{4}{4+2}\times 1A=\frac{2}{3}A$$

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

② 基波电源单独作用

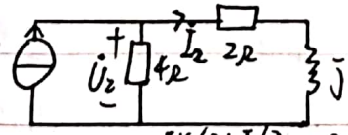


$$Z_{eq1}=\frac{4\times(2+j2)}{6+j2}=(1.6+j0.8)\Omega$$

$$\dot{U}_1=3\angle 0^\circ\times(1.6+j0.8)=5.37\angle 26.57^\circ V$$

$$\dot{I}_1=3\angle 0^\circ\times\frac{4}{6+j2}=1.8-j0.6=1.90\angle -18.43^\circ A$$

③ 三次谐波电源单独作用：



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

$$\dot{U}_2=2\angle 30^\circ\times\left(\frac{8}{3}+j\frac{4}{3}\right)=\frac{-4+8\sqrt{3}}{3}+j\frac{8+4\sqrt{3}}{3}$$

$$=5.96\angle 56.57^\circ=\frac{8\sqrt{3}}{3}\angle 56.57^\circ V$$

$$\dot{I}_2=2\angle 30^\circ\times\frac{4}{6+j6}=\frac{1+\sqrt{3}}{3}+j\frac{1-\sqrt{3}}{3}$$

$$=0.94\angle -15^\circ A$$

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

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

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

$=1.64A$

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

$=5.83V$

13) $P_0=\left(\frac{2}{3}\right)^2\times 2=0.89W$

$P_1=\left(\frac{1.9}{\sqrt{2}}\right)^2\times 2=3.61W$

$P_2=\left(\frac{0.94}{\sqrt{2}}\right)^2\times 2=0.88W$

$\therefore P=P_0+P_1+P_2=5.39W$

14) $P_0'=\frac{4}{3}\times 1=1.33W$

$\dot{U}_1'=3\angle 0^\circ\times(1.6+j0.8)\Omega$

$P_1'=\frac{1}{2}U_1 I_1''\cos(\varphi_{u1}-\varphi_{i1})=7.20W$

$\dot{U}_2'=2\angle 30^\circ\times\left(\frac{8}{3}+j\frac{4}{3}\right)$

$P_2'=\frac{1}{2}U_2 I_2'\cos(56.57^\circ-30^\circ)$

$=5.33W$

$\therefore P'=P_0'+P_1'+P_2'=13.86W$

[15-12] 11) 知 $T=2\pi\times 10^{-3}s$

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

$\omega_0 L=100\Omega$，$\frac{1}{\omega_0 C}=2500\Omega$

12) u_S 为正方波，查表知

$$f(t)=5\pi+20\sum_{k=1}^{\infty}\frac{1}{2k-1}\sin 1000(2k-1)t$$

取前5项，则

$$u_S=[5\pi+20\sin 1000t+\frac{20}{3}\sin 3000t+4\sin 5000t+\frac{20}{7}\sin 7000t]V$$

13) ① 直流分量单独作用下：

$U_0=0$ →

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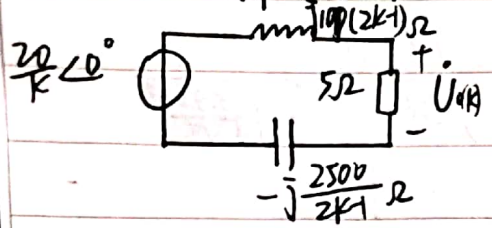
② K次谐波单独作用下，



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

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

$=0.042\angle 89.9°\ V$

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

$=0.062\angle 89.5°\ V$

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

$=4\angle 0°\ V$（串联谐振）

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

$=0.042\angle -89.2°\ V$

取前5项

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

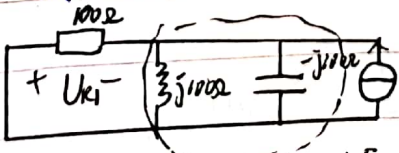
(1) $U_0=\sqrt{(\frac{0.042}{\sqrt2})^2+(\frac{0.062}{\sqrt2})^2+(\frac{4}{\sqrt2})^2+(\frac{0.042}{\sqrt2})^2}$

$\approx 2.829\ V$

(2) 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，

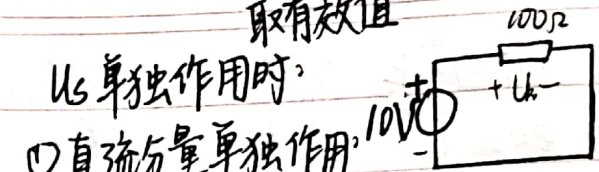


$j100\Omega$电感与$-j100\Omega$电容并联谐振

∴ $U_{R1}=-1\times 100\ V=-100\ V$

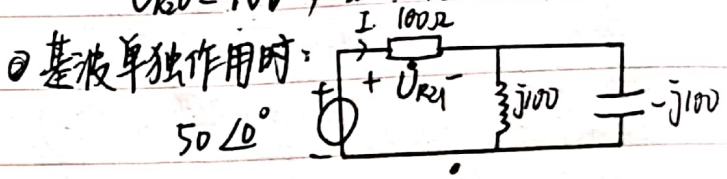
取有效值

u_S单独作用时，



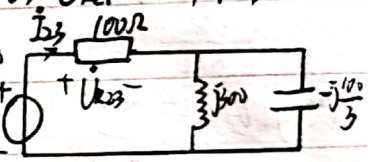
① 直流分量单独作用，$U_{R0}=10V$，$P_{21}=\frac{10^2}{100}=1W$

② 基波单独作用时，



L与C并联谐振，$I=0$，$\dot{U}_{R1}=0$，$P_{21}=0$

③ 三次谐波单独作用时，



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

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

$=18.72\angle -20.5°\ V$

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

$$\dot{I}_{23}=\frac{20\angle 0°}{100-j37.5}=(0.175+j0.066)A=0.18\angle 20.66°\ A$$

$P_{23}=20\times 0.18\cos(0°-20.66°)$

$=3.499\ W$

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

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∵ K=1, 7, 13, ... 正序，K=3, 9, 15, ... 零序，

K=5, 11, 17, ... 负序

∴ $u_{nN}=-u_3=-120\sin 3\omega_0 t\ V$

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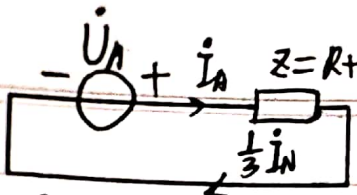


(2) A相电路

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

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

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

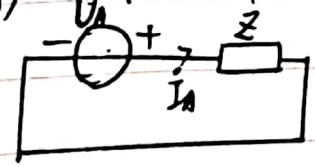
同理，$u_{BC}=[180\sqrt{3}\sin(\omega_0 t+30^\circ-120^\circ)+80\sqrt{3}\sin(5\omega_0 t-30^\circ+120^\circ)]V$

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

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

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

(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

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

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

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