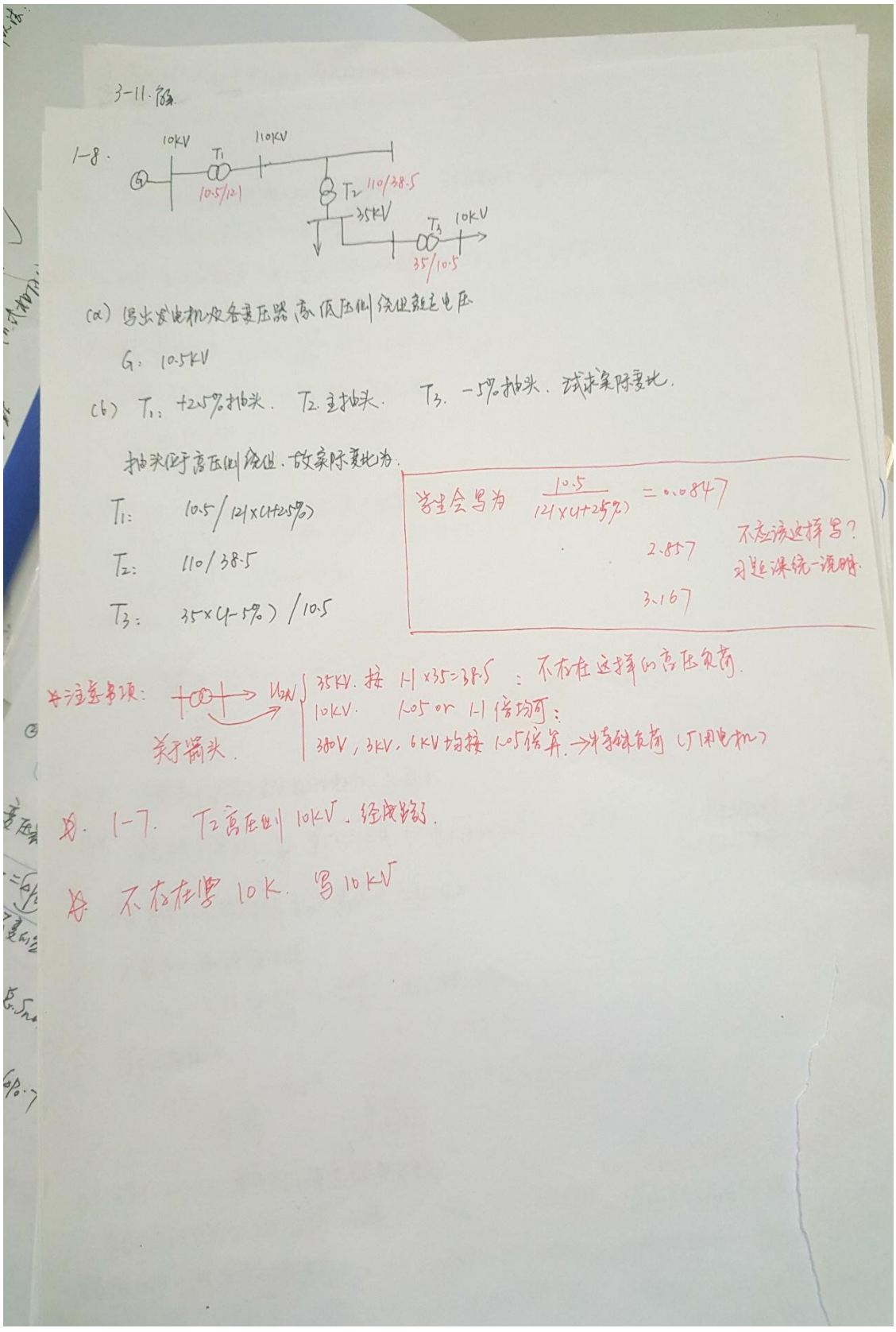
电力系统分析作业题答案

第一章



第二章

2-3.

解：LGJ-120，查附录表3知，$r_0=0.27\Omega/km$，计算半径 $r=\frac{15.2}{2}=7.6mm$。

等值半径 $D_m=\sqrt[3]{3.5^2\times7}=4.41m$

双回线单位长度正序电阻和零序电阻为 $x_1=\frac{1}{2}\times(0.1445\times\lg\frac{D_m}{r}+0.0157)=0.2075\Omega/km$。

单位长度电阻（40°C） $r_1=\frac{1}{2}r_0[1+\alpha(t-20)]=\frac{1}{2}\times0.27[1+0.0036\times20]=0.145\Omega/km$。

每相单位长度电纳为 $b_1=2\times\frac{7.58}{\lg\frac{D_m}{r}}\times10^{-6}=5.49\times10^{-6}S/km$

[1] 100km 2×LGJ-120 双回线路的单位长度参数为

$z_1=r_1+jx_1=0.145+j0.2075=0.253\angle55°\Omega/km$。

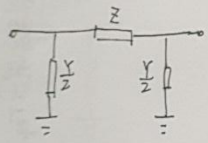
$y_1=j5.49\times10^{-6}S/km$。

对于线路长度不超过300km线路，其π型电路可将参数 z' 和 y' 取为 z,y。

$Z=z_1\cdot l=(0.145+j0.2075)\times100=14.5+j20.75\Omega$

$Y=y_1\cdot l=j5.49\times10^{-4}S$

π型电路如下：



2-7. 分裂导线求每公里电抗和电纳，x_1 及 b_1

解：分裂导线计算半径 $r_{eq}=\sqrt[4]{r\cdot a^2\cdot2a}=\sqrt[4]{13.6\times400^3\cdot\sqrt{2}}=187.3mm$。（注意分裂导线计算公式中的开方次数和r后的乘数项）

三相导线的几何均距 $D_m=\sqrt[3]{12^3\times2}=15.12m$

∴分裂导线单位长度电抗：

$x_1=0.1445\lg\frac{D_m}{r_{eq}}+\frac{0.0157}{n}=0.2795\Omega/km$。

单位长度电纳：

$b_1=\frac{7.58}{\lg\frac{D_m}{r_{eq}}}\times10^{-6}=\frac{7.58}{\lg\frac{15.12}{0.1873}}\times10^{-6}=3.975\times10^{-6}S/km$。

(2) 设 $l=200km$，求该导线的等值模型参数。

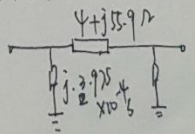
查表知，该导线型号为LGJQ-400型，20°C $r_1=0.08\Omega/km$，其余参数需自己计算。

根据(1)知，线路单位长度参数为 $z_1=0.08+j0.2795\Omega/km=0.28\angle85.91°\Omega/km$

$y_1=jb_1=j3.975\times10^{-6}S/km=3.975\times10^{-6}\angle90°S/km$

$l<300km$，$Z'=Z=z_1\cdot l=(0.02+j0.2795)\times200=4+j55.9\Omega$

$Y'=Y=y_1\cdot l=j3.975\times10^{-6}S/km\times200km=j7.95\times10^{-4}S$



3-11. 答

2-7. (3). $l=500km$. 求传输参数.

计及分布参数影响

$z_1 = 0.28\angle 85.9^\circ \quad \Omega/km.$

$y_1 = jb_1 = 3.975\times10^{-6}\angle 90^\circ \quad S/km$

$Z_c = \sqrt{z_1/y_1} = 265.4\angle -2.05^\circ$

$\gamma l = \sqrt{z_1 y_1}\, l = 0.527\angle 87.95^\circ = 0.01887 + j0.5272 = \alpha l + j\beta l$

$\sinh\gamma l = \sinh(0.01887 + j0.5272) = \sinh 0.01887\cos 0.5272 + j\cosh 0.01887 \sin 0.5272 = 0.0163 + j0.5032$

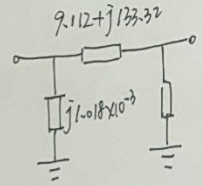
$= 0.5035\angle 88.14^\circ$

$\cosh\gamma l = \cosh(0.01887 + j0.5272)$

$= \cosh 0.01887\cos 0.5272 + j\sinh 0.01887\sin 0.5272 = 0.8644 + j0.0095 = 0.8645\angle 0.63^\circ$

$Z' = Z_c \sinh\gamma l = 265.4\angle -2.05^\circ \times 0.5035\angle 88.14^\circ = 133.64\angle 86.09^\circ = 9.112 + j133.32 \ (\Omega)$

$$Y'/2 = \frac{1}{Z_c}\cdot\frac{\cosh\gamma l - 1}{\sinh\gamma l} = \frac{0.8644 + j0.0095 - 1}{265.4\angle -2.05^\circ \times 0.5035\angle 88.14^\circ} = \frac{0.1364\angle 175.99^\circ}{133.63\angle 86.09^\circ} = j0.018\times10^{-3} \ (S)$$



(4) LGJ-185 线路参数

2-11. △ 由手册知 $S_N=25MW$. 均折算到高压侧. 1侧 2侧和3侧(分别)为 110, 38.5, 11 KV

$$G_m=\frac{P_0}{1000U_N^2}=\frac{52.6}{1000\times110^2}=4.347\times10^{-6}\,S$$

$$B_m=-\frac{I_0\%\,S_N}{100\,U_N^2}=\frac{2.6\times25}{100\times110^2}=-4.298\times10^{-6}\,(S)$$

△ 分别两两做短路试验 P_{kmax} 都为加在100%容量绕组上的短路损耗.

$$\therefore R_{T1}=R_{T2}=\frac{1}{2}\times\frac{P_{kmax}\cdot U_N^2}{1000S_N^2}=\frac{185\times110^2}{2000\times25^2}=1.79\,\Omega.$$

相应的 $R_{T3}=3.58\,\Omega$

△ 由短路电压的数 $U_{k(1-2)}\%$; $U_{k(1-3)}\%$ 和 $U_{k(2-3)}\%$ 为知.

$$U_{k1}\%=\frac{1}{2}\left[U_{k(1-2)}+U_{k(1-3)}-U_{k(2-3)}\right]=10.75$$

$U_k\%$ { 自耦变压: 求折算 / 普通三绕组: 已折算

$$U_{k2}\%=-0.25$$

$$U_{k3}\%=6.75$$

$$\therefore X_{T1}=\frac{U_{k1}\%\cdot U_N^2}{100\,S_N}=\frac{10.75\times110^2}{100\times25}=52.03\,\Omega.\quad X_{T2}=-1.21\,\Omega.\quad X_{T3}=32.67\,\Omega$$

等值电路同图 2-20 所示.

2-12.

解: 1号为 3×350MV·A 的三相双绕组变压器. $S_N=10.5MV\cdot A$. 额定电压 242/6.3 KV

则. $P_K=P_{K1}+P_{K2}+P_{K3}=85.9\,KW$ 为该3台变压器的短路损耗. $U_K\%=\frac{\Sigma}{3}=6.5$

$P_0=30.05\,KW$ 为该3台变压器的空载损耗. $I_0\%=1.75$

$$R_T=\frac{P_K U_N^2}{1000S_N^2}=\frac{85.9\times6.3^2}{1000\times(3\times350)^2}=3.09\times10^{-3}\,\Omega.$$

$$G_T=\frac{30.05}{1000\times6.3^2}=7.57\times10^{-4}\,S$$

$$X_T=\frac{U_K\%\,U_N^2}{100\,S_N}=\frac{6.5\times6.3^2}{100\times10.5}=0.246\,\Omega$$

$$B_m=-\frac{I_0\%\,S_N}{100\,U_N^2}=-\frac{1.75\times10.5}{100\times6.3^2}=-4.63\times10^{-3}\,S$$

Y/△ 接线. 3台该变压器额定电压为 242KV/6.3KV

R_T (低压侧) =

$$R_T(\text{高压侧})=\frac{85.9\times242^2}{1000\times10.5^2}=45.63\,\Omega$$

$X_T=262.731\,\Omega$

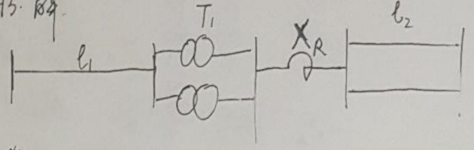
$G_T=5.1\times10^{-7}\,S$

$B_T=3.14\times10^{-6}\,S$

2-11, 2-12

(1) LGJ-185 线路参数

2-13. 解



忽略元件并联支路. 用近似计算的方法, 求各元件标幺值

$U_B = U_{av}$

l_1: LGJ-120. $r_1 = 0.27$, $x_1 = 0.365$ (设 $D_m = 2m$)

$\therefore Z_{l1}^* = (r_1 + x_1) \cdot L_1 \cdot \frac{S_B}{U_{av}^2} = (0.27 + j0.365) \times 70 \times \frac{100}{115^2} = 0.143 + j0.193$

$X_{T1}^* = \frac{10.5}{100} \times \frac{100}{2 \times 20} = 0.2625$ 此为已并联参数 此处用10.5/100直接表示为标幺值, 只须折算容量. 是否表示电压基准一样? 都是即近似计算下变压器代入额定值代入1.05 U_N 是! 近似计算表示, 即变比 $K^* = 1$

$X_R^* = \frac{X_R\%}{100} \times \frac{U_N}{I_N} \times \frac{S_B}{U_{av}^2} = 0.04 \times \frac{10}{\sqrt{3} \times 0.3} \times \frac{100}{6.3^2} = ~~0.582\Omega~~$ 1.94Ω

$Z_{l2}^* = \frac{1}{2} \times (\frac{18.8}{70} + j0.08) \times 2.5 \times \frac{100}{~~10.5^2~~ \; 6.3^2} = ~~0.305 + j0.091~~$

$0.847 + j0.252$

$(1.69 + j0.5039)/2$

2-10. 由题知. $S_N = 15MVA$. 代入公式即可.

$R_T = \frac{P_K \cdot U_N^2}{1000 \times S_N^2} = 7.152\Omega$ $\quad X_T = \frac{U_K\% U_N^2}{100 S_N} = 84.7\Omega$

$G_T = \frac{P_0}{1000 U_N^2} = 4.132 \times 10^{-6} S$ $\quad B_T = \frac{-I_0\% S_N}{100 U_N^2} = -4.339 \times 10^{-5} S.$

变比: U_{av} / U_{av}

基: U_{av}

$K_* = 1$

2-13

(1) LGJ-185 线路参数

r=0.17Ω/km x=0.41Ω/km 0.038+j0.123

2-16. 各参.

有名值若干.

(1) 线路参数. (折算至220kV侧)

l_1: $X_{L1}=0.432\times150=64.8\Omega$

l_2: $X_{L2}=\frac{1}{2}\times0.379\times800\times\left(\frac{220}{38.5}\right)^2=495\Omega$ (990.04/2)

l_3: $X_{L3}=\frac{1}{2}\times0.416\times60\times\left(\frac{220}{121}\right)^2=411.26\Omega$ (82.51/2)

(2) 发电机. $X_{G1}=0.15\times\frac{10.5^2}{100\times0.85}\times\left(\frac{242}{10.5}\right)^2=0.15\times\frac{242^2}{117.65}=74.67\Omega$.

$117.65=S_{GN}$

(3) 变压器. $X_{T1}=\frac{U_K\%\cdot U_N^2}{100\cdot S_N}=\frac{12\times242^2}{100\times100}=70.28\Omega$ $\left(=\frac{1}{2}\frac{12\times242^2}{100\times50}\right)$

T_2: $U_{K1}\%=15$ $U_{K2}\%=0$ $U_{K3}\%=9$.

$\therefore X_{T21}=\frac{1}{2}\times\frac{15\times220^2}{100\times50}=72.6\Omega$ $X_{T22}=0$ $X_{T23}=43.56\Omega$

T_3: $X_{T3}=\frac{10.5\times110^2}{100\times2\times31.5}\times\left(\frac{220}{121}\right)^2=66.67\Omega$

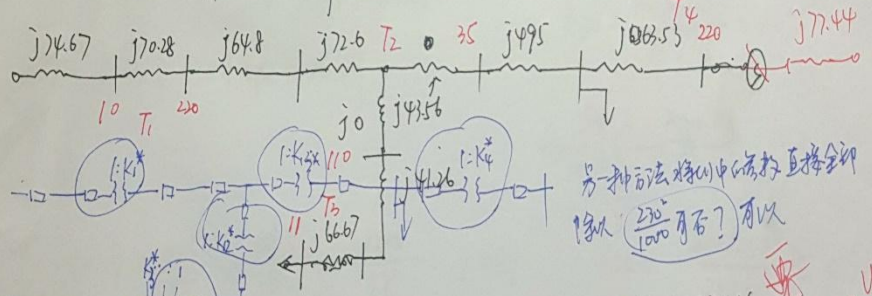
T_4: $X_{T4}=\frac{10.5\times385^2}{100\times80}\times\left(\frac{220}{38.5}\right)^2=\frac{10.5\times220^2}{2\times80\times100}=\cancel{6}63.53\Omega$

有名值计算时用的是变压器

$U_K\%$ 变压器铭牌值

$X_S=0.8\times\frac{9U_N^2}{S_N}=0.8\times\frac{220^2}{500}=77.44\Omega$

各元件参数值归算至220kV侧后电力系统有名值等值电路为:



另一种方法,特别中的参数直接全部除以 $\frac{230^2}{1000}$ 可否? 可以

标幺值若干. $S_B=1000MV\cdot A$. $U_B=U_{AV}$. 即分别取 10.5kV, 230kV. 115kV. 37kV.

(1) 线路参数.

$X_{L1}^*=0.43\times150\times\frac{1000}{230^2}=1.225$

$X_{L2}^*=\frac{1}{2}\times0.379\times80\times\frac{1000}{37^2}=1.034$

$X_{L3}^*=\frac{1}{2}\times0.416\times60\times\frac{1000}{115^2}=0.944$

(2) 发电机.

$X_G^*=\frac{X_G\%}{100}\times\frac{U_G^2}{S_{GN}}\times\frac{S_B}{U_B^2}=0.15\times\frac{1000}{117.65}=1.275$

(3) 变压器. 标幺参数及铭牌标准化

$X_{T1}^*=0.12\times\frac{1000}{250}=1.2$

$X_{T21}^*=0.15\times\frac{1000}{100}=1.5$

$X_{T22}^*=0$

$X_{T23}^*=0.9$

$X_{T3}^*=\frac{10.5}{100}\times\frac{1000}{2\times31.5}=1.667$

$X_{T4}^*=0.105\times\frac{1000}{80}=1.313$

$K_{1x}=\frac{242/230}{10.5/10.5}=1.052$

$K_{12x}=\frac{121/115}{220/230}=1.1$

$K_{13x}=\frac{38.5/37}{220/230}=1.088$

$K_{3x}=\frac{11\div10.5}{110\div115}=1.095$

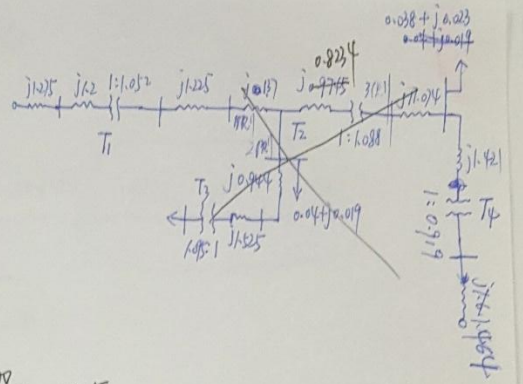
$K_{4x}=\frac{38.5/37}{220/230}=1.088$

$X_S^*=0.8\times\frac{1000}{500}=1.6$

(1) LGJ-185 线路参数

r=0.17Ω/km

2-16 (2) 取 $U_B = U_{av}$. 求标幺值等值电路



① 线路参数

$X_{L1}^* = 0.43 \times 150 \times \frac{1000}{230^2} = 1.225$

$X_{L2}^* = \frac{1}{2} \times 0.379 \times 80 \times \frac{1000}{37^2} = 11.074$

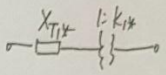
$X_{L3}^* = \frac{1}{2} \times 0.416 \times 60 \times \frac{1000}{115^2} = 0.944$

② 发电机参数

$X_G^* = \frac{X_G\%}{100} \times \frac{U_{GN}^2}{S_{GN}} \times \frac{S_B}{U_B^2} = 0.15 \times \frac{1000}{117.65} = 1.275$

③ 变压器参数. ~~均标~~

$X_{T1}^* = 0.12 \times \frac{242^2}{100} \times \frac{1000}{230^2 \times 10.5^2} = 1.3285 \approx 1.2$ $K_1^* = \frac{242/230}{10.5/10.5} = 1.052$



变压器 T_1 标准侧在低压侧.

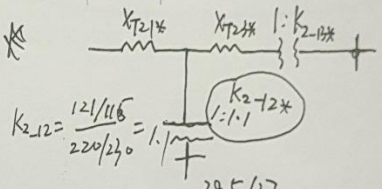
UK的含义：在变压器短路试验中使其达到额定电流. 故实际值应按 U_N 算.

$X_{T21}^* = 0.15 \times \frac{220^2}{100} \times \frac{1000}{230^2} = 10.137$

将T2标准侧放在高压侧[即220侧].

$X_{T22}^* = 0$

$X_{T23*} = 0.09 \times \frac{38.5^2}{100} \times \frac{1000}{37^2 \times 230^2} = 0.8234$ ~~0.9445~~



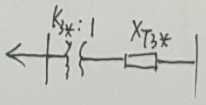
$K_{2-12} = \frac{121/11}{220/230} = 1.1$

$K_{2-13}^* = \frac{38.5/37}{220/230} = 1.088$

$X_{T3}^* = \frac{10.5}{100} \times \frac{110^2}{2 \times 31.5} \times \frac{1000}{115^2} = 1.525$

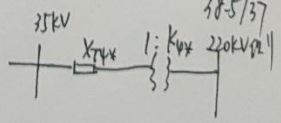
变压器T3标准侧为在110kV侧.

$K_{3*} = \frac{11/10.5}{110/115} = 1.095$



$X_{T4}^* = \frac{10.5}{100} \times \frac{38.5^2}{80} \times \frac{1000}{37^2} = 1.421$ $K_{4*} = \frac{220/230}{38.5/37} = 0.919$

变压器T4标准侧在35kV侧



④ 系统参数.

~~$X_{S*} = 0.8 \times \frac{1000}{500} = 1.6$ 还是~~

$X_{S*} = 0.8 \times \frac{220^2}{500} \times \frac{1000}{230^2} = 1.464$

0.8是基于什么~~电压等级~~的标幺值.

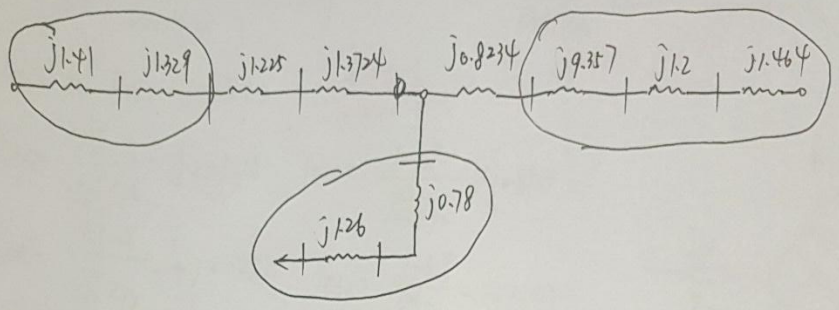
额定电压 U_N 的

(1) LGJ-185 线路参数

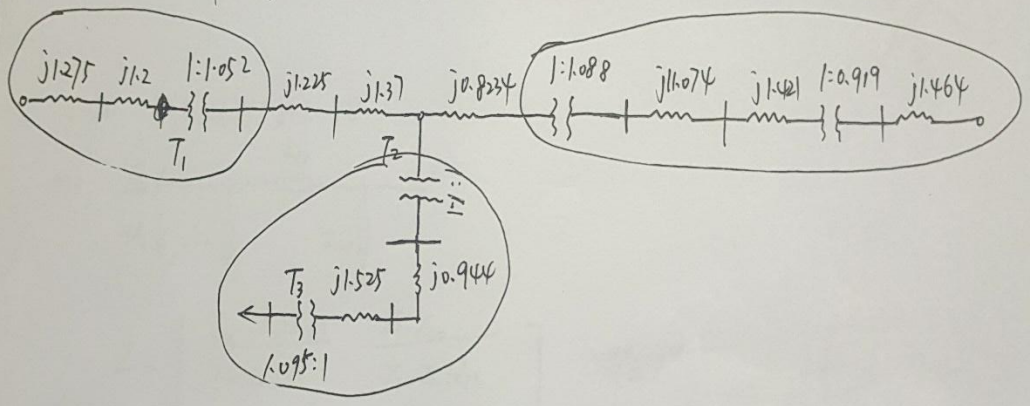
$r_1 = 0.17\Omega/km$

方法二：将(1)中所有参数除以 $Z_B = \frac{230^2}{1000} = 52.9\Omega$

得等效电路如下



将方法(1)中的等效电路画在下面.



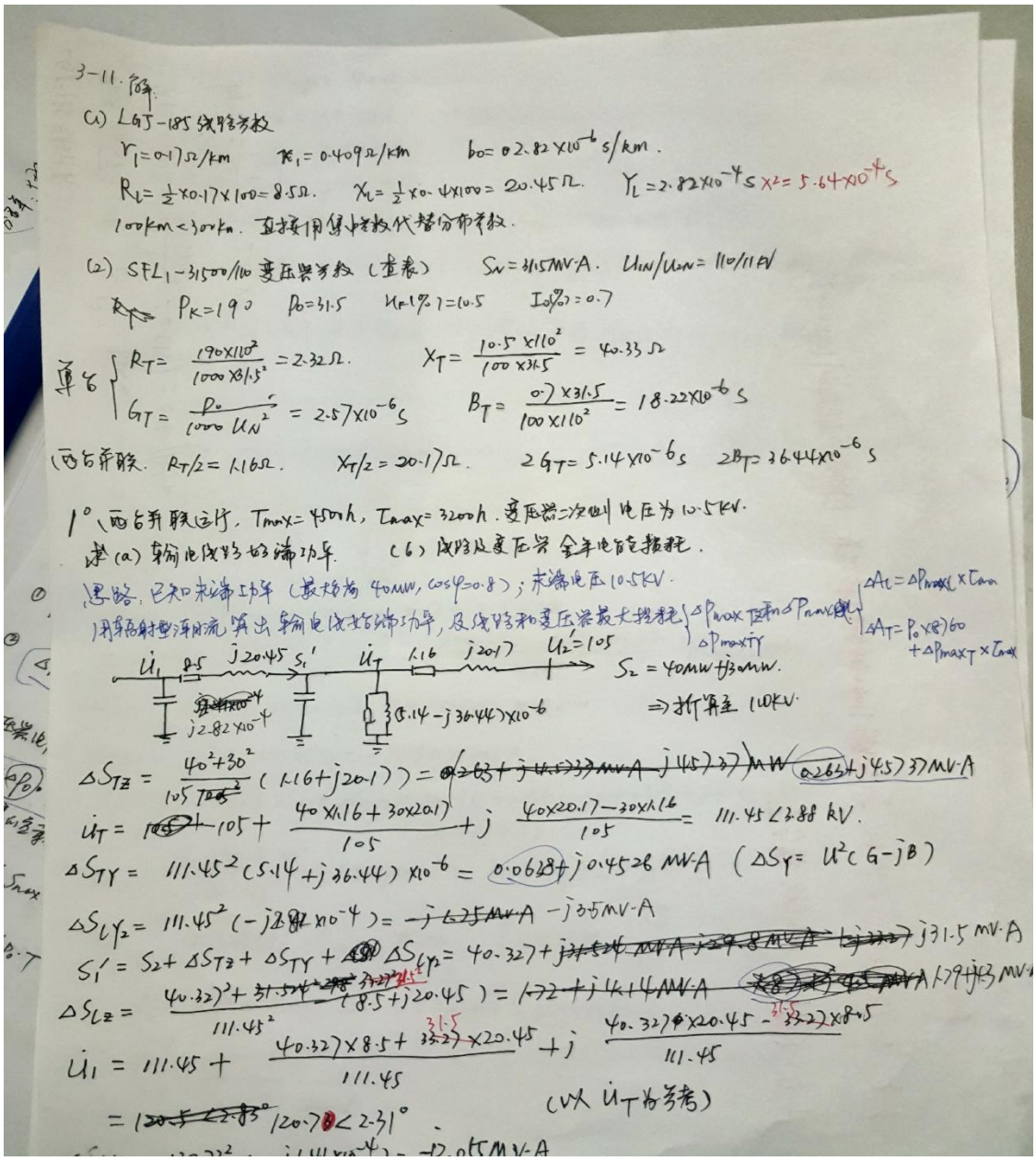
$(1.275+1.2) \times 1.052^2 = 1.41 + 1.329$

$\left[1.464 \times \frac{1}{0.919^2} + 1.421 + 11.074\right] \times \frac{1}{1.088^2} = 9.357 + 1.2 + 1.464$

$(1.525+0.944)\frac{1}{1.1^2} = 0.78 + 1.26$

三部分数据表明：全部折到220kV侧完全等效

第三章



3-11. 解.

(1) LGJ-185 线路参数

$r_1=0.17\Omega/km$　$x_1=0.409\Omega/km$　$b_0=2.82\times10^{-6}S/km$.

$R_L=\frac{1}{2}\times0.17\times100=8.5\Omega$.　$X_L=\frac{1}{2}\times0.4\times100=20.45\Omega$.　$Y_L=2.82\times10^{-4}S$　$X_2=5.64\times10^{-4}S$

100km<300km. 直接用集中参数代替分布参数.

(2) $SFL_1-31500/110$ 变压器参数 (查表)　$S_N=31.5MV\cdot A$.　$U_{1N}/U_{2N}=110/11kV$

$P_K=190$　$P_0=31.5$　$U_K(\%)=10.5$　$I_0(\%)=0.7$

算得 $R_T=\frac{190\times110^2}{1000\times31.5^2}=2.32\Omega$.　$X_T=\frac{10.5\times110^2}{100\times31.5}=40.33\Omega$

$G_T=\frac{P_0}{1000U_N^2}=2.57\times10^{-6}S$　$B_T=\frac{0.7\times31.5}{100\times110^2}=18.22\times10^{-6}S$

两台并联. $R_T/2=1.16\Omega$.　$X_T/2=20.1\Omega$.　$2G_T=5.14\times10^{-6}S$　$2B_T=36.44\times10^{-6}S$

1°、两台并联运行. $T_{max}=4500h$, $T_{max}=3200h$. 变压器二次侧电压为 10.5kV.

求 (a) 输电线路的始端功率.　(b) 线路及变压器全年电能损耗.

思路: 已知末端功率 (最终为 40MW, $\cos\varphi=0.8$); 末端电压 10.5kV.

利用额定电压求出末端功率, 及线路和变压器最大损耗 (ΔP_{max} 近似 ΔP_{max} 代入).

$\Delta A_L=\Delta P_{max}\times T_{max}$

$\Delta A_T=P_0\times8760+\Delta P_{max}\times T_{max}$

$\Delta P_{max}=\Delta P_{max}$

U_1 — 5 — $j20.45$ — S_1' — U_T — 1.16 — $j20.1$ — $U_2'=10.5$ — $S_2=40MW+j30MW$.

$j2.82\times10^{-4}$　$(5.14-j36.44)\times10^{-6}$

⇒折算至 110kV.

$\Delta S_{T2}=\frac{40^2+30^2}{105^2}(1.16+j20.1)=(0.263+j4.533)MW-(0.263+j4.5)MV\cdot A$

$U_T=105+\frac{40\times1.16+30\times20.1}{105}+j\frac{40\times20.1-30\times1.16}{105}=111.45\angle2.88kV$.

$\Delta S_{TY}=111.45^2(5.14+j36.44)\times10^{-6}=0.0638+j0.4526MV\cdot A$　$(\Delta S_Y=U^2(G-jB))$

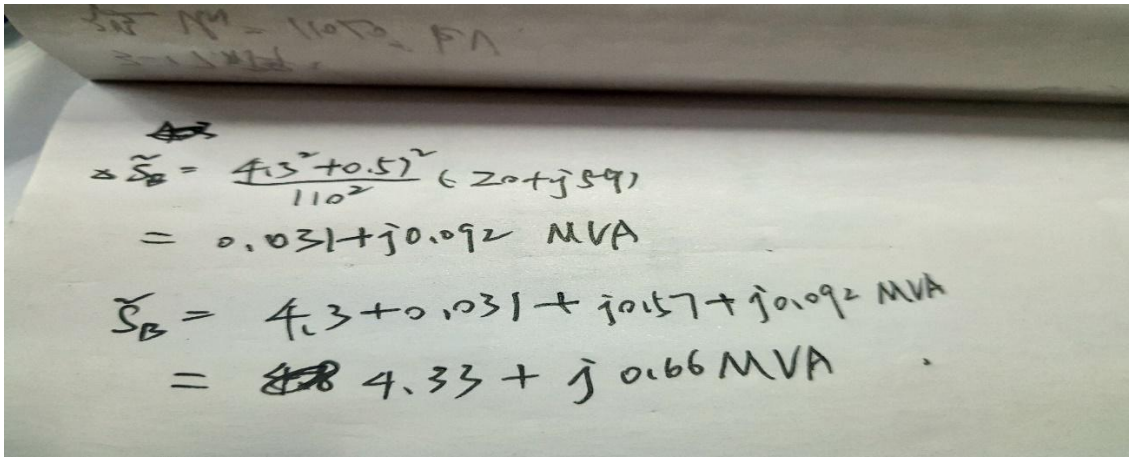
$\Delta S_{L/2}=111.45^2(-j2.82\times10^{-4})=-j3.5MV\cdot A$

$S_1'=S_2+\Delta S_{T2}+\Delta S_{TY}+\Delta S_{L/2}=40.327+j34.53MV\cdot A$

$\Delta S_{L2}=\frac{40.327^2+34.53^2}{111.45^2}(8.5+j20.45)=1.72+j4.14MV\cdot A$

$U_1=111.45+\frac{40.327\times8.5+34.53\times20.45}{111.45}+j\frac{40.327\times20.45-34.53\times8.5}{111.45}$

$=120.78\angle2.31°$.　(以 U_T 为参考)



$\Delta\tilde{S}_B=\frac{4.3^2+0.5^2}{110^2}(20+j59)$

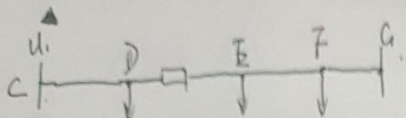
$=0.031+j0.092MVA$

$\tilde{S}_B=4.3+0.031+j0.57+j0.092MVA$

$=4.33+j0.66MVA$.

3-17 解：

设 $U_N = 110\angle 0°$ kV.



$$\Delta\tilde{S}_{DB} = \frac{(30+j14)^2}{110^2}(12+j30)$$

$$= 1.09 + j2.72 \text{ MVA}$$

$$\tilde{S}_C = 31.09 + j16.72 \text{ MVA}$$

$$\Delta U_{CD} = \frac{P_{CD}R_{CD} + Q_{CD}X_{CD}}{U_C}$$

$$= \frac{31.09\times 12 + 16.72\times 30}{110}$$

$$= 7.95 \text{ kV}$$

$$\delta U_{CD} = \frac{P_{CD}X_{CD} - Q_{CD}R_{CD}}{U_C}$$

$$= \frac{31.09\times 30 - 16.72\times 12}{110}$$

$$= 6.66 \text{ kV}$$

$$\dot{U}_D = 109.58 + j9.5 - 7.95 - j6.66$$

$$= 101.63 + j2.84$$

$$= 101.67\angle 1.6° \text{ kV}$$

$$\Delta\tilde{S}_{EF} = \frac{20^2+9^2}{110^2}(14+j40)$$

$$= 0.56 + j1.59 \text{ MVA}$$

$$\tilde{S}_F = 20+j9+0.56+j1.59+15+j8$$

$$= 35.56 + j18.59 \text{ MVA}$$

$$\Delta\tilde{S}_{FG} = \frac{35.56^2+18.59^2}{110^2}(10+j24)$$

$$= 1.33 + j3.19 \text{ MVA}$$

$$\tilde{S}_G = 36.89 + j21.78 \text{ MVA}$$

(2) $\tilde{S}_C = \dfrac{\tilde{S}_D^*(Z_{DE}+Z_{EF}+Z_{FG}) + \tilde{S}_E^*(Z_{EF}+Z_{FG}) + \tilde{S}_F^* Z_{FG}}{Z_{DE}+Z_{EF}+Z_{FG}+Z_{CD}} + \dfrac{(\dot{U}_C - \dot{U}_D)U_N}{Z_E}$

$$= \frac{(30-j14)(44+j123)+(20-j9)(24+j64)+(15-j8)(10+j32)}{56+j153} + \frac{(110\angle 0° - 120\angle 10°)/110}{56+j153}$$

$$= 34.83 - j16.27 - 9.13 + j2.84$$

$$= 25.70 - j13.43 \text{ MVA}$$

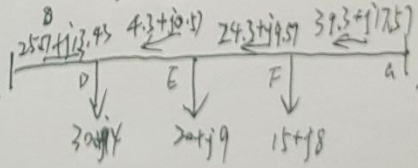
$$\tilde{S}_C = 25.7 + j13.43 \text{ MVA}$$

$$\tilde{S}_G = \frac{(15-j8)(46+j128)+(20-j9)(32+j88)+(8+j24)(12+j30)}{56+j153} + \frac{(120\angle 10° - 110\angle 0°)/110}{56+j153}$$

$$= 30.17 - j14.73 + 9.13 - j2.84$$

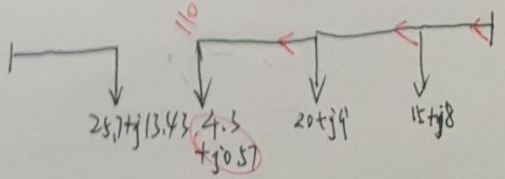
$$= 39.30 - j17.57$$

$$\tilde{S}_G = 39.3 + j17.57$$

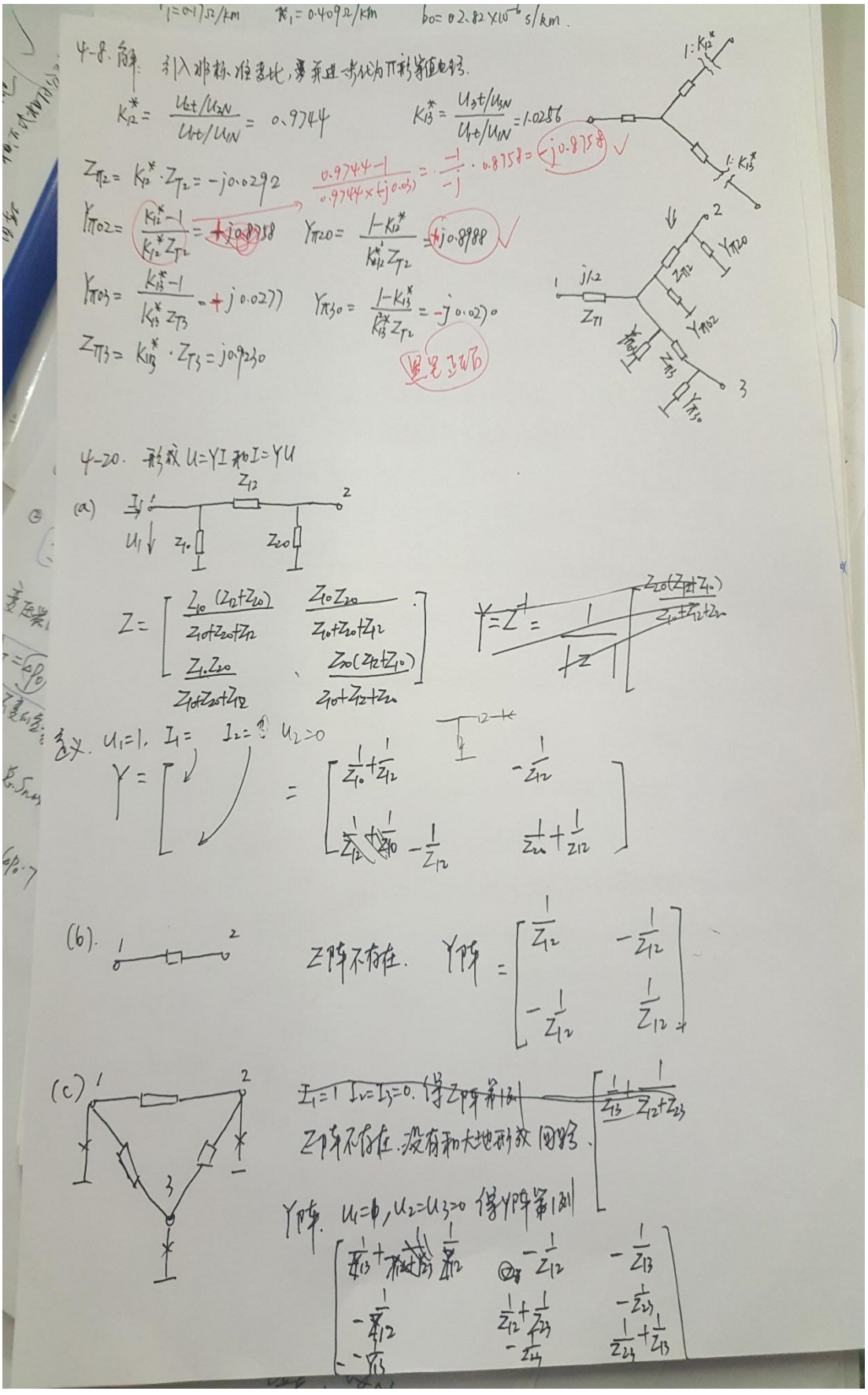


$\therefore \tilde{S}_B = 4.3 + j0.57$ MVA.

∴ D点为功率分点



第四章



$S_1 = S_1' + \Delta S_{LZ} + \Delta S_{LY_1} = (40.32 + j33.2) + 1.8 + j4.5 - j2.05 = 42.3 + j35.7\ MV\cdot A$

$\Delta P_{maxL} (= \Delta P_{LZ} + \Delta P_{LY}) = 1.8\ MW$，~~$\Delta P_{maxT} = \Delta P_{TZ} + \Delta P_{TY} = 0.263 + 0.0638 =$~~

变压器不变损耗 $P_0 = 0.0638\ MW$

最大可变损耗 $P_{kmax} 0.263\ MW$

∴ 线路的全年电能损耗 $\Delta A_L = \Delta P_{maxL} \cdot T_{max} = 5784\ MW\cdot h$

变压器 $\Delta A_T = 0.0638 \times 8760 + 0.263 \times \left(\frac{50}{\sqrt{3}\times 115}\right)^2 \times 3200 = 1727.85\ MW\cdot A$ ~~1400A~~ $1400.48\ MW\cdot h$

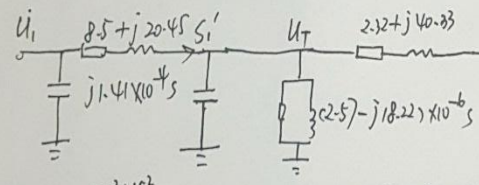
2°

退役一台变压器下，重算潮流，用 $0.5 P_{max}$ 算得 ΔP_{LZ} 和 ΔP_{TZ2}，~~ΔP_{LY}~~ 和以总损耗为

$\Delta A_L = \Delta P_{maxL} \times 2000 + \Delta P_{LZ} \times 4000 + \frac{1}{4}\Delta P_{LZ} \times 2760$

~~$\Delta P_{TZ} \times 4000$~~

$\Delta A_T =$ ~~$\Delta P_{T0} \times 8760 + \Delta P_{TZmax} \times 2000 +$~~ $\Delta P_{TY} \times 2000 + \frac{1}{2}\Delta P_{T0} \times 6760$ ~~$\frac{1}{2}\Delta P_{TY} \times 6760$~~ $+ \Delta P_{TZmax} \times 2000 + \Delta P_{TZ} \times 4000 + \frac{1}{4}\Delta P_{TZ} \times 2760$



$\Delta S_{TZ} = \frac{20^2 + 15^2}{105^2}(2.32 + j40.33) = 0.13 + j2.3\ MV\cdot A$

$U_T = 105 + \frac{20 \times 2.32 + 15 \times 40.33}{105} + j\frac{20 \times 40.33 - 20.15 \times 1.162.32}{105} = 111.45\angle 3.88 kV$

$\Delta S_{TY} = U_T^2(G_T - jB_T) = 0.0319 + j0.2263$ ~~MVA~~ MW.

$\Delta S_{LY_2} = U_T^2(-j1.41 \times 10^{-4}) = -j1.25$ ~~MW~~ $MV\cdot A$

$S_1' = S_2 + \Delta S_{TZ} + \Delta S_{TY} + \Delta S_{LY_2} = 20 + j15 + 0.13 + j2.3 + 0.0319 + j0.2263 - j1.25$

$= 20.16 + j15.78$

$\Delta S_{LZ} = \frac{20.16^2 + 15.78^2}{111.45^2}(8.5 + j20.45) = 0.45 + j1.079\ MW$

~~以此~~ ∴ 线路损耗 $\Delta P_{LZ} = 0.45\ MW$. 变压器损耗 $\begin{cases} \text{不变} & 0.0319\ MW = \frac{\Delta P_{TY}}{2} \\ \text{可变} & 0.13MW = \Delta P_{TZ2} \end{cases}$

结果也和这线损之 $\left(\frac{S}{S_N}\right)^2$

$\Delta A_L =$ ~~$0.45^2 \times 3200 = 1440$~~ $1.87 \times 2000 + 0.45 \times 4000 + \frac{1}{4} \times 0.45 \times 2760 = 5850.5\ MW\cdot h$

$\Delta A_T = 0.0638 \times 2000 + 0.0319 \times 6760 + 0.263 \times 2000 + 0.13 \times 4000 + \frac{1}{4} \times 0.13 \times 2760$

$= 1478.94\ MW\cdot h$

第五章

5-8(1) $K_{GN}=\frac{100}{4}=25$ $K_G=\frac{25\times100}{50}=50(MW/H_2)$

∵前三台满载 ∴第四台负载 20MW. $\Delta P=100-20=80MW$

$\Delta f=\frac{\Delta P}{K_G}=-\frac{80}{50}=-1.6H_2>0.2H_2$ ∴不能满载.

(2) $K_{G2}=\frac{4\times25\times100}{50}=200(MW/H_2)$

$\Delta P=320MW$ $\therefore \Delta f=-\frac{\Delta P}{K_{G2}}=\frac{-320}{200}=-1.6H_2$.

5-9解:(1)∵ $P_{G3}=80MW$ ∴三号机满负荷调频

$P_{G2}=80MW$ ∴二号机仅分担 20MW 负荷.

∵ $K_{G1}=\frac{100}{2}\times\frac{100}{50}=100(MW/H_2)$

$K_{G2}=\frac{100}{6}\times\frac{100}{50}=\frac{100}{3}MW/H_2)$

$\therefore \Delta f=-\frac{40}{100+\frac{100}{3}}-\frac{10}{100}=-0.1H_2$

(2) $\Delta f=-\frac{40}{100+\frac{100}{3}}-\frac{20}{100}=-0.5H_2$.

5-10 $P_{GMAX}=0.1P_{LN}$ $K_{GMAX}=\frac{1}{0.05}\times\frac{0.1P_N}{F_N}=0.1P_{LN}$

$K_S=\frac{0.05P_{LN}}{0.1}=0.5P_{LN}$ $P_{GMAX}=0.1P_{LN}(1-0.15)=0.085P_{LN}$

$K_S'=K_S-K_{GMAX}=(0.5-0.1)P_{LN}=0.4P_{LN}$

$\Delta f=-\frac{0.085P_N}{0.4P_{LN}}=-0.1848H_2$.

$\frac{}{100+100}$ $\frac{}{100}$

5-9. 解：(1) ∵ $P_{G3}=100$ 已满载 ∴ 3号机不参与调频

$K_{G1}=\frac{100}{2}\times\frac{100}{50}=100\ MW/Hz$

$K_{G2}=\frac{100}{6}\times\frac{100}{50}=\frac{100}{3}\ MW/Hz$

$\Delta f=-\frac{\Delta P}{\Sigma K_G}=-\frac{50}{100+\frac{100}{3}}=-0.375\ Hz$

$\Delta P_1=0.375\times100=37.5MW\geq40MW$

(✱ $\Delta P_2=0.375\times\frac{100}{3}=12.5MW<20MW$，∴满足要求)

若二号机组调差系数较小，承担负担大于20MW，则应只为2号机组分配 系统频率变化后 20MW负荷，再计算系统频率变化，考试时注意。)

(2). $\Delta f=\frac{-\Delta P}{\Sigma K_G}=-\frac{60}{100+\frac{100}{3}}=-0.45Hz$

$\Delta P_1=0.45\times100=45MW>40MW$. 不满足要求.

~~$\therefore \Delta f=\frac{\Delta P_1}{K_{G1}}=\frac{\Delta P_2}{K_{G2}}=\frac{40}{100}=\frac{20}{\cdot}$~~.

$\therefore \Delta f_1=-\frac{\Delta P_1}{K_{G1}}=-\frac{40}{100}=-0.4Hz$

$\Delta P_2'=0.4\times\frac{100}{3}=13.33MW$.

$\Delta P_2''=20-13.33=6.67MW$.

$\Delta f_2=\frac{-6.67}{\frac{100}{3}}=-0.2Hz$

$\Delta f=\Delta f_1+\Delta f_2=-0.6Hz$

5-11. 解：

(1) 主调频厂调频器不动作下，即二次调频不起作用，系统依靠发电机的调速系统进行一次调频。下面各物理量均用标幺值表示，省略"*"号，以 P_{LN} 为基准

由题意知：$K_L=2$，$\Delta P_G = P_D - 1 = 0.1$，$\Delta f = \frac{-0.3}{50}$ Hz

$$\Delta P_{L0} = \Delta P_{G自调} - \Delta P_L = 0.1 + 2\times\frac{0.3}{50} = 0.112$$

$$K_S = \Delta P_{L0}/\Delta f = 18.67 \quad \cdots\cdots \text{系统的功率频率特性系数}.$$

(2) 主调频厂动作，即增加出力 $\Delta P_{G主}$，使得 $\Delta f = \frac{-0.1}{50} = -0.002$

则 $\Delta P'_{L0} = -K_S \Delta f = 18.67 \times 0.002 = 0.03734$

$$\Delta P_{G主} = \Delta P_{L0} - \Delta P'_{L0} = 0.0747$$

∴二次调频增加的功率为 7.47% 额定负荷。

要点：① 理解 K_S，K_G，K_L 三者的关系。

② K_S 图为 f_0，二次调频总是将图 5-6 的直线上移或下移一段距离。

5-12：假设联络线断开后系统频率为 f

$$K_{SA} = -\frac{250MW}{0.1Hz} = 2500 MW/Hz. \qquad K_{SB} = -\frac{400}{0.1} = 4000 MW/Hz.$$

$$(f-49.85)2500 = 4000(50-f) = P_{联络}.$$

$$\Rightarrow f = \frac{200000+124625}{6500} = 49.9423 Hz.$$

$$P_{联络} = 2500\times(49.94-49.85) = 230.77 MW.$$