2-5 型号为 SFS-40000/220 的三相三绕组变压器，容量比为 100/100/100，额定变比为 220/38.5/11，查得 $\Delta P_0=46.8$ kW，$I_0=0.9\%$，$\Delta P_{S(1-2)}=217$ kW，$\Delta P_{S(1-3)}=200.7$ kW，$\Delta P_{S(2-3)}=158.6$ kW，$U_{S(1-2)}=17\%$，$U_{S(1-3)}=10.5\%$，$U_{S(2-3)}=6\%$。试求归算到高压侧的变压器参数有名值。

$\Delta P_{S1}=(\Delta P_{S(1-2)}+\Delta P_{S(1-3)}-\Delta P_{S(2-3)})/2=129.55$ kW

$\Delta P_{S2}=(\Delta P_{S(1-2)}+\Delta P_{S(2-3)}-\Delta P_{S(1-3)})/2=87.45$ kW

$\Delta P_{S3}=(\Delta P_{S(1-3)}+\Delta P_{S(2-3)}-\Delta P_{S(1-2)})/2=71.15$ kW

$R_{T1}=\frac{\Delta P_{S1}}{S_{NT}^2}U_N^2=3.919\,\Omega$　$R_{T2}=\frac{\Delta P_{S2}}{S_{NT}^2}U_N^2=2.645\,\Omega$　$R_{T3}=\frac{\Delta P_{S3}}{S_{NT}^2}U_N^2=2.152\,\Omega$

$U_{S1}\%=(U_{S(1-2)}\%+U_{S(1-3)}\%-U_{S(2-3)}\%)/2=10.75$

$U_{S2}\%=(U_{S(1-2)}\%+U_{S(2-3)}\%-U_{S(1-3)}\%)/2=6.75$

$U_{S3}\%=(U_{S(1-3)}\%+U_{S(2-3)}\%-U_{S(1-2)}\%)/2=-0.05$

$X_{T1}=\frac{U_{S1}\%}{100}\frac{U_N^2}{S_{TN}}=130.875\,\Omega$，$X_{T2}=\frac{U_{S2}\%}{100}\frac{U_N^2}{S_{TN}}=75.625\,\Omega$　$X_{T3}=\frac{U_{S3}\%}{100}\frac{U_N^2}{S_{NT}}=-3.025\,\Omega$

$G_T=\frac{\Delta P_0}{U_N^2}=9.669\times10^{-7}$ S，$B_T=\frac{I_0\%}{100}\frac{S_{TN}}{U_N^2}=7.438\times10^{-6}$ S

2-7 三台单相三绕组变压器组成三相变压器组，每台单相变压器的数据如下：额定容量为 30000 kV·A；容量比为 100/100/50；绕组额定电压为 127/69.86/38.5 kV；$\Delta P_0=19.67$ kW；$I_0=0.332\%$；$\Delta P'_{S(1-2)}=111$ kW；$\Delta P'_{S(2-3)}=92.33$ kW；$\Delta P'_{S(1-3)}=88.33$ kW；$U_{S(1-2)}=9.09\%$；$U_{S(2-3)}=10.75\%$；$U_{S(1-3)}=16.45\%$。试求三相接成 YN，yn，d 时变压器组的等值电路及归算到低压侧的参数有名值。

题设额定电压为 $127/69.86/\frac{38.5}{\sqrt3}$ kV $=127/69.86/22.228$ kV

$\Delta P_{S(1-2)}=\left(\frac{S_N}{S_{N1}}\right)^2\Delta P'_{S(1-2)}=111$ kW　$\Delta P_{S(1-3)}=\left(\frac{S_N}{S_{N3}}\right)^2\Delta P'_{S(1-3)}=353.32$ kW

$\Delta P_{S(2-3)}=\left(\frac{S_N}{S_{N3}}\right)^2\Delta P'_{S(2-3)}=369.32$ kW

$\Delta P_{S1}=(\Delta P_{S(1-2)}+\Delta P_{S(1-3)}-\Delta P_{S(2-3)})/2=47.5$ kW

$\Delta P_{S2}=(\Delta P_{S(1-2)}+\Delta P_{S(2-3)}-\Delta P_{S(1-3)})/2=63.5$ kW

$\Delta P_{S3}=(\Delta P_{S(1-3)}+\Delta P_{S(2-3)}-\Delta P_{S(1-2)})/2=305.82$ kW

$R_{T1}=\frac{\Delta P_{S1}}{S_N^2}U_N^2=2.608\times10^{-2}\,\Omega$　$R_{T2}=\frac{\Delta P_{S2}}{S_N^2}U_N^2=3.486\times10^{-2}\,\Omega$　$R_{T3}=\frac{\Delta P_{S3}}{S_N^2}U_N^2=1.679\times10^{-1}\,\Omega$

$U_{S1}\% = (U_{S(1-2)}\% + U_{S(1-3)}\% - U_{S(2-3)}\%)/2 = 7.395$

$U_{S2}\% = (U_{S(1-2)}\% + U_{S(2-3)}\% - U_{S(1-3)}\%)/2 = 1.695$

$U_{S3}\% = (U_{S(1-3)}\% + U_{S(2-3)}\% - U_{S(1-2)}\%)/2 = 9.055$

$X_{T1} = \frac{U_{S1}\%}{100} \cdot \frac{U_N^2}{S_N} = 1.218\Omega$ $X_{T2} = \frac{U_{S2}\%}{100} \cdot \frac{U_N^2}{S_N} = 0.279\Omega$. $X_{T3} = \frac{U_{S3}\%}{100} \cdot \frac{U_N^2}{S_N} = 1.491\Omega$

$G_T = \frac{\Delta P_0}{U_N^2} = 39.811\times10^{-6}S$ $B_T = \frac{I_0\%}{100} \cdot \frac{S_N}{U_N^2} = 2.015\times10^{-4}S$

2-8 一台三相双绕组变压器，已知：$S_N=31500$ kV·A，$k_{TN}=220/11$，$\Delta P_0=59$ kW，$I_0=3.5\%$，$\Delta P_S=208$ kW，$U_S=14\%$。

(1) 计算归算到高压侧的参数有名值；

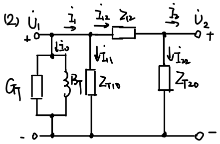
(2) 作出 Π 型等值电路并计算其参数；

(3) 当高压侧运行电压为 210 kV，变压器通过额定电流，功率因数为 0.8 时，忽略励磁电流，计算 Π 型等值电路各支路的电流及低压侧的实际电压，并说明不含磁耦合关系的 Π 型等值电路是怎样起到变压器作用的。

(1) $R_T = \frac{\Delta P_S}{S_N^2} U_N^2 = 10.146\Omega$ $X_T = \frac{U_S\%}{100} \cdot \frac{U_N^2}{S_N} = 215.111\Omega$

$G_T = \frac{\Delta P_0}{U_N^2} = 1.219\ S$ $B_T = \frac{I_0\%}{100} \cdot \frac{S_N}{U_N^2} = 22.779\times10^{-6}S$

(2)



$k_T = \frac{U_{N1}}{U_{N2}} = \frac{220}{11} = 20$. $Z_T = R_T + jX_T = (10.146 + j215.111)\Omega$

$Z_{12} = \frac{Z_T}{k_T} = (0.507 + j10.756)\Omega$

$Z_{T10} = \frac{Z_T}{1-k_T} = (-0.534 - j11.322)\Omega$ $Z_{T20} = \frac{Z_T}{k_T(k_T-1)} = (0.027 + j0.566)\Omega$

(3) $\dot U_1 = \frac{210}{\sqrt3}\angle 0°\ kV = 121.244\angle 0°\ kV$ $I_1 = I_N = \frac{S_N}{\sqrt3 U_N} = 82.666A$

由于 $\lambda = \cos\varphi = 0.8$. $\varphi = \arccos\lambda = 36.87°$. $\sin\varphi = 0.6$.

则 $\dot I_1 = I_1\angle-\varphi = 82.666\angle-36.87°A$

$\dot I_{11} = \frac{\dot U_1}{Z_{T10}} = 10.697\times10^3\angle 92.7°A$ $\dot I_{12} = \dot I_1 - \dot I_{11} = 10749.85\angle-88.96°A$

$\dot U_2 = \dot U_1 - \dot I_{12} Z_{12} = 5535.257\angle-7.148°V$. 低压侧电压 $U_{2L} = \sqrt3 U_2 = 9.5874kV$

$\dot I_{22} = \frac{\dot U_2}{Z_{T20}} = 9767.53\angle-94.448°A$ $\dot I_2 = \dot I_{12} - \dot I_{22} = 1660.005\angle-36.896°A$.

由于 $Z_\Sigma = Z_{T10} + Z_{12} + Z_{T20} = 0$. 构成谐振三角形，将产生很大的顺时针感性环流

感性环流流过 Z_{12} 产生的电压降从而完成变压器两侧的电压变换。