$I_{cc} = I_{cc}A + I_{cc}B = 2405,5 + 1924,5 = 4330\ A$

Le Transformateur

Exc1 :

1/ $E_2 = 118 \angle 0^\circ$ V

$K = \dfrac{N_2}{N_1} = \dfrac{E_{2n}}{E_{1n}} = \dfrac{120}{480} = \dfrac{1}{4}$

$E_1 = \dfrac{E_2}{K} = 4\,(118 \angle 0^\circ) = 472 \angle 0^\circ$ V

2/ $\overline{Z}_c = \dfrac{\overline{E}_2}{\overline{I}_2}$

$\overline{S}_2 = \overline{E}_2 \cdot \overline{I}_2^*$

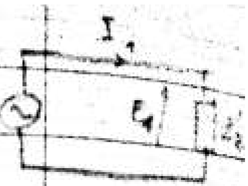
$\overline{S}_2 = 15000 \angle \cos^{-1}(0{,}8) = 15000 \angle 36{,}87^\circ$

$I_2^* = \dfrac{\overline{S}_2}{\overline{E}_2} \longrightarrow \overline{I}_2 = \left(\dfrac{\overline{S}_2}{\overline{E}_2}\right)^*$

$\overline{I}_2 = \left(\dfrac{15000 \angle 36{,}870}{118 \angle 0^\circ}\right) = 127{,}12 \angle -36{,}87^\circ$

$\overline{Z}_2 = \dfrac{\overline{E}_2}{\overline{I}_2} = \dfrac{118 \angle 0^\circ}{127{,}12 \angle -36{,}87} = 0{,}9283 \angle 36{,}87^\circ$

3 $Z_2' = \dfrac{\overline{E}_1}{\overline{I}_1} = \dfrac{\overline{E}_2 / K}{K \, \overline{I}_2} = \dfrac{E_2}{I_2} \, \dfrac{1}{K^2} = \dfrac{Z_2}{K^2}$



$\overline{Z}_2' = (4)^2 (0,9283 \angle 36,87°) = 14,85 \angle 38,87° \ \Omega$

$\overline{I}_2 = 127,12 \angle -36,87°$

$I_2 = 127,12 \left[\cos(-36,87) + j \sin(-36,87)\right]$

$\overline{I}_2 = 127,12 \quad \left[\cos(36,87) - j \sin(36,87)\right]$

$\overline{I}_2 = 101,69 - j\,76,27 \text{ A}$

$\overline{I}_2^* = 101,69 + j\,76,27 \text{ A}$

$\overline{I}_2^* = 127,12 \angle 36,87°$

$(\overline{S} = E \times I)$ c'est faut

$\overline{S} = \overline{E} \times \overline{I}^*$ c'est vrai

4/

transformateur idéal sans pertes:

$\overline{S}_1 = \overline{S}_2 = 15\,000 \left[\cos 36,87 + j \sin 36,87\right]$

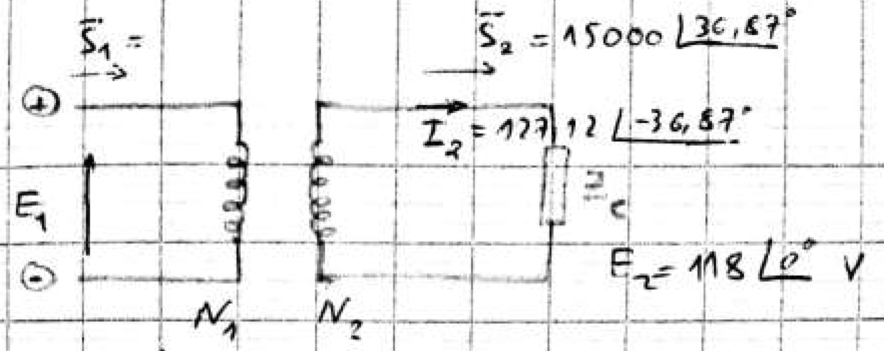
$\overline{S}_1 = 15\,000 \ (0,8 + j\,0,6)$

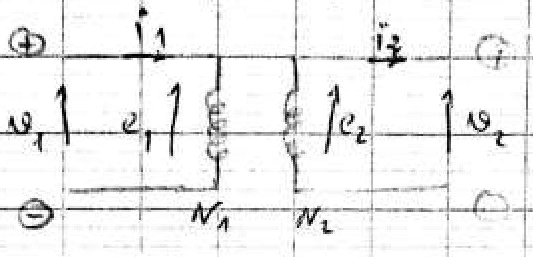
$\overline{S}_1 = 12\,000 + j\,9000 = P_1 + j\,Q_1$

$P_1 = 12\,000 \text{ W} \ ; \ Q_1 = 9000 \text{ VA}$

$F.P. = \cos\theta = \dfrac{R}{Z} = \dfrac{P}{S}$

5/





$$V_2 = \frac{N_2}{N_1} V_1 = \frac{500}{2000} \left(1200 \angle 0° \right) = 300 \angle 0° \ \text{V}$$

$$I_2 = \frac{N_1}{N_2} I_1 = \frac{2000}{500} \left(5 \angle -30° \right) = 20 \angle -30° \ \text{A}$$

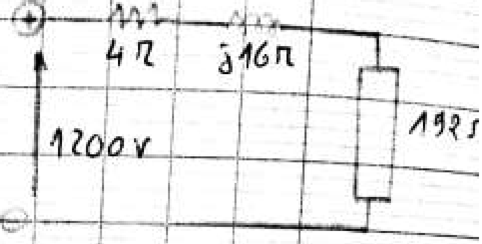
$$Z_2 = \frac{V_2}{I_2} = \frac{300 \angle 0°}{20 \angle -30°} = 15 \angle 30° \ \Omega$$

$$Z_2' = Z_2 \left(\frac{N_1}{N_2} \right)^2 = 15 \angle 30° \left(\frac{2000}{500} \right)^2 = 240 \angle 30° \ \Omega$$

ou bien :

$$Z_2' = \frac{V_1}{I_1} = \frac{1200 \angle 0°}{5 \angle -30°} = 240 \angle 30° \ \Omega$$

III – $k = \dfrac{N_2}{N_1} = \dfrac{500}{2000} = \dfrac{1}{4}$



$R_1 = 2 + 0{,}125\,(4)^2 = 4{,}0\ \Omega$

$X_1 = 8 + 0{,}5\,(4)^2 = 16\ \Omega$

$Z_L' = 12 \times (4)^2 = 192\ \Omega$

$$I_1 = \frac{1200\angle 0^\circ}{192 + 4 + j16} = 6{,}10\angle{-4{,}67^\circ}\ \text{A}$$

$$\frac{V_2}{k} = 6{,}10\angle{-4{,}67} \times 192 = 1171{,}6\angle{-4{,}67^\circ}$$

$$V_2 = \frac{1171{,}6\angle{-4{,}67^\circ}}{4} = 292{,}9\angle{-4{,}67^\circ}\ \text{V}$$

regulation de tension:

$$\Delta V\% = \frac{1200/4 - 292{,}9}{292{,}9}$$

$\Delta V\% = 2{,}42\ \% = 0{,}0242.$

$$I_{nominal} = \frac{S_n}{V_{1n}} = \frac{20 \times 10^3}{480} = 41,667A$$

$$R_{eq1} = \frac{P_1}{I_{1n}^2} = \frac{300}{(41,667)^2} = 0,1728\ \Omega$$

$$|Z_{eq1}| = \frac{V_1}{I_{1n}} = \frac{35}{41,667} = 0,84\ \Omega$$

$$X_{eq1} = \sqrt{Z_{eq1}^2 - R_{eq1}^2} = 0,8220\ \Omega$$

$$Z_{eq1} = R_{eq1} + j\,X_{eq1} = 0,1728 + j0,8220 = 0,84 \angle 78,13^\circ$$

V –

$$V_1 = E_1 = \frac{E_2}{K} = \frac{N_1}{N_2} V_{2n} = \frac{480}{120}(120) = 480V$$

$$= \frac{P_2}{V_1^2} = \frac{200}{(480)^2} = 0,000868\ s$$

$$|Y_m| = \frac{\frac{N_2}{N_1} \cdot I_2}{V_1} = \frac{(120/480)(12)}{480} = 0,00625\ s$$

$$B_m = \sqrt{Y_m^2 - G_c^2} = 0,00619\ s$$

$$Y_m = G_c - j\,B_m = 0,000868 - j0,00619$$

$$= 0,00625 \angle -82,0^\circ\ s$$

VI

(courant nominal) $I_{1n} = \dfrac{\text{Puissance nominale } S_{1n}}{\text{tension nominale } V_{1n}} = \dfrac{S_1}{V_1} = \dfrac{15000}{69}$

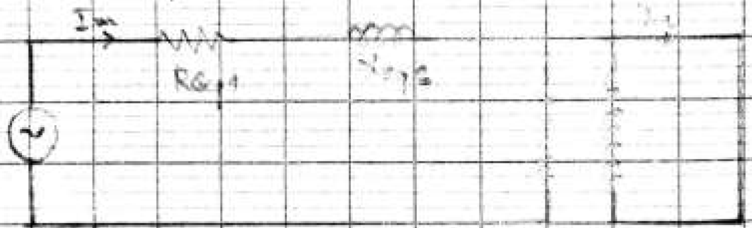
$$I_n = 217,4 \text{ A}$$

$$R\ I_1^2 = P_{1s} = 105800 = (217,4)^2 * Req_1$$

$$Req_1 = 2,24\ \Omega$$

$$|Zeq| = \frac{U_{1s}}{I_{1n}} = \frac{5500}{217,4} = 25,30\ \Omega$$

$$Xeq_1 = \sqrt{Zeq_1^2 - Req_1^2} = \sqrt{(25,30)^2 - (2,24)^2} = 25,20\ \Omega$$



secondaire en court circuit

$$I_2 = \frac{V_2}{Z_2} = \frac{V_2}{0} = \infty$$

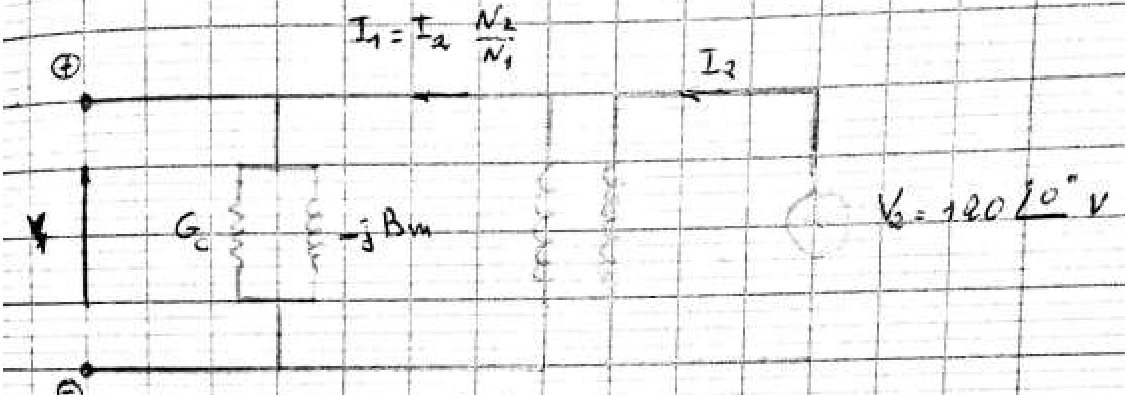
VII $k = \dfrac{N_2}{N_1} = \dfrac{1}{6}$

$$\frac{V_a^2 G_c}{k^2} = (11,5 \times 10^3)^2 \times 36 \times G_c = 66,7 \times 10^3 \text{ W}$$

$G_c = 14 \times 10^{-6}$ siemens

$$y = \frac{I_1}{V_1} \times a^2 = \frac{30,4}{11,500} \times \frac{1}{36} = 73,4 \times 10^{-6}\, S$$

$$B_m = \sqrt{y^2 - G_c^2} = 10^{-6}\sqrt{(73,4)^2 - (14)^2} = 72,05 \times 10^{-6}\, S$$



circuit ouvert

rendement:

$$\rho = \frac{P_{sortie}}{P_{entrée}} = \frac{P_{sortie}}{P_{sortie} + Pertes} = \frac{12000}{12000 + (105,8 + 66,7)}$$

$$\rho = 0,986 \qquad \rho\% = 98,6\ \%$$

<u>VIII</u>.

$S_{base} = 20KVA$, $V_{1base} = 480\,V$; $V_{2\,base} = 120\,V$

$$Z_{base} = \frac{V_{2base}^2}{S_{base}} = \frac{120^2}{20,000} = 0,72\,\Omega$$

$$Z_{eqe\,p.u} = \frac{Z_{eq2}}{Z_{base2}} = \frac{0,0525\angle 78,13°}{0,72} = 0,0729\angle 78,13°\ p.u$$

Z_{eq1} rapporté au primaire 1 :

$$Z_{eq1} = \frac{Z_{eq2}}{k^2} = \left(\frac{N_1}{N_2}\right)^2 Z_{eq2} = \left(\frac{480}{120}\right)^2 \left(0{,}0525 \angle 78{,}13^\circ\right)$$

$$Z_{eq1} = 0{,}84 \angle 78{,}13^\circ \ \Omega$$

$$Z_{base\,1} = \frac{V_1\,base}{S_{base}} = \frac{480^2}{20000} = 11{,}52\ \Omega$$

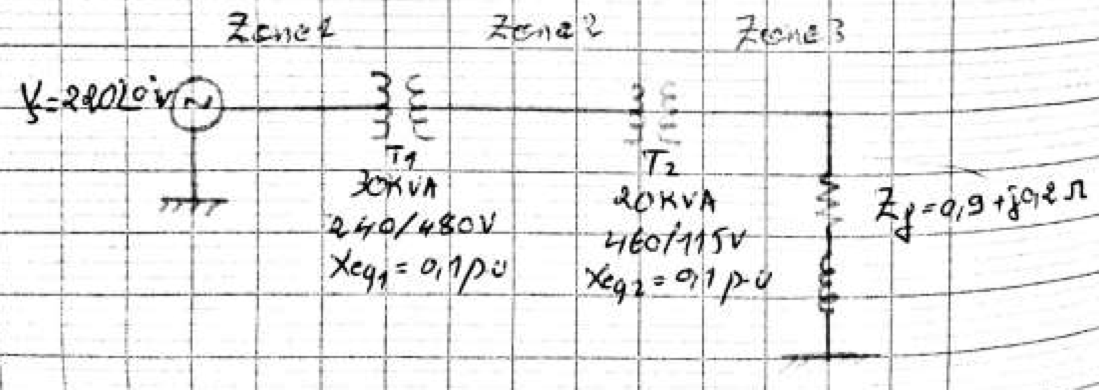
$$Z_{eq\,pu} = \frac{Z_{eq1}}{Z_{base1}} = \frac{0{,}84}{11{,}52} \angle 78{,}13^\circ$$

$$Z_{eq.p.u} = 0{,}0729 \angle 78{,}19^\circ \ p.u = Z_{eq\,p.u}$$

Remarque :

$$\frac{V_1\,base}{V_2\,base} = \frac{V_{1n}}{V_{2n}} = \frac{480}{120}$$

IX



Zone 1:

$$V_{base} = 240\,V \quad ; \quad Z_{base} = \frac{(240)^2}{30000} = 1{,}92\ \Omega$$

$$S_{base} = 30\ KVA.$$

Zone 2:

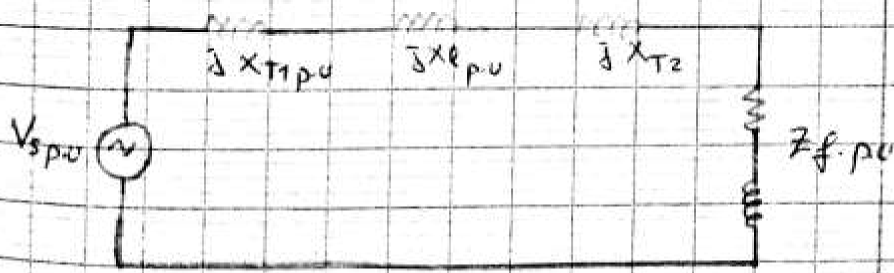
$$V_{base} = 480\ V = \frac{480}{240} \times 240 \quad ; \quad Z_{base} = \frac{480^2}{30000} = 7{,}68\ \Omega = \frac{V_{base}^2}{S_{base}}$$

Zone 3:

$$V_{base} = 120\,V = \frac{115}{480} \times 480 \quad ;$$

$$Z_{base} = \frac{120^2}{30000} = 0{,}48\ \Omega = \frac{V_{base}^2}{S_{base}}$$

$$I_{base} = \frac{30000}{120} = 250\,A = \frac{S_{base}}{V_{base}}$$



$j\, X_{T1.pu} = 0{,}1\ pu$

$j\, X_{T2.pu} = 0{,}10 \dfrac{460^2}{480} \dfrac{30000}{20000} = 0{,}1378\ p.u$

ou bien :

$V_{base} = 120\,V$

$X_{T2.pu} = 0{,}10 \dfrac{115^2}{120} \dfrac{30000}{20000} = 0{,}1378\ p.u$

$X_{\ell\,pu} = \dfrac{X\ell}{Z_{base}} = \dfrac{2}{7{,}68} = 0{,}2604\ p.u$

$Z_{f\,pu} = \dfrac{Z_f}{Z_{base}} = \dfrac{0{,}9 + j0{,}2}{0{,}68} = 1{,}875 + j0{,}4167\ pu$

$I_{f\,pu} = I_{s\,pu} = \dfrac{U_{s\,pu}}{j(X_{T1.pu} + X_{2\,pu} + X_{\ell\,pu}) + Z_{f\,pu}}$

$I_{f\,p.u} = 0{,}6395 \angle -26{,}05\ p.u$

intensité du courant en Amp :

$I_f = I_{f\,pu} \times I_{base} = 109{,}9 \angle -26{,}01^\circ\ A$

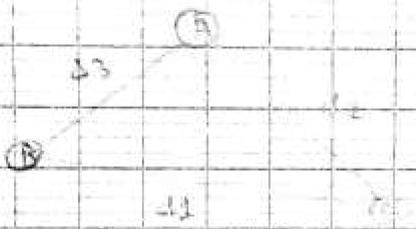
Inductance d'une ligne triphasée :

$\phi_{AA} = \mu_0 \dfrac{I_A}{2\pi} \left[\dfrac{1}{4} + \int_r^{\infty} \dfrac{dx}{x} \right]$ = flux dans conducteur du courant I_A

$$\phi_{AB} = \mu_0 \frac{I_B}{2\pi} \int_{d_3}^{\infty} \frac{dx}{x} = \text{flux du conducteur A dû au courant } I_B.$$

$$\phi_{AC} = \mu_0 \frac{I_C}{2\pi} \int_{d_2}^{\infty} \frac{dx}{x} = \text{flux dû à } I_C$$

flux total du conducteur A : $\phi_A = \phi_{AA} + \phi_{AB} + \phi_{AC} = \mu_0 \frac{I_A}{2\pi}$



$$\phi_A = \frac{\mu_0}{2\pi} \left\{ \left(\frac{1}{4} - \ln r\right) I_A - I_B \ln d_3 - I_C \ln d_2 + \ln \infty (I_A + I_B + I_C) \right\}$$

$$\phi_A = \frac{\mu_0}{2\pi} \left\{ \left[\frac{1}{4} - \ln r\right] I_A - I_B \ln d_3 - I_C \ln d_2 \right\}$$

1er cas : espacement symétrique

$$d_1 = d_2 = d_3 = d$$

2ème cas : espacement disymétrique

$$d_1 \neq d_2 \neq d_3$$