Corrigé de l'examen partiel H2002

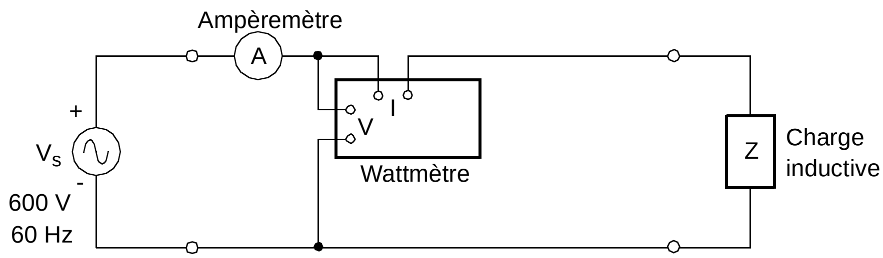
<u>Problème no. 1</u> (10 points)

Premier montage:

V = 600 V

I = 36 A

P = 18060 W



La puissance apparente dans la charge **Z**: $S = 600 \times 36 = 21600\,\text{VA}$

Le facteur de puissance de la charge **Z**: $\cos\phi = \dfrac{P}{S} = \dfrac{18060}{21600} = 0.836$

Le module de l'impédance **Z** est: $Z = \dfrac{V}{I} = \dfrac{600}{36} = 16.67\,\Omega$

L'angle de l'impédance **Z** est: $\phi = \mathrm{acos}(0.836) = 33.28°$

L'impédance **Z** est donc: $Z = (16.67\angle 33.28°)\Omega = (13.94 + j9.15)\Omega$

Montage 2:

V = 600 V

I = 48 A

S = 600 x 48 = 28800 VA

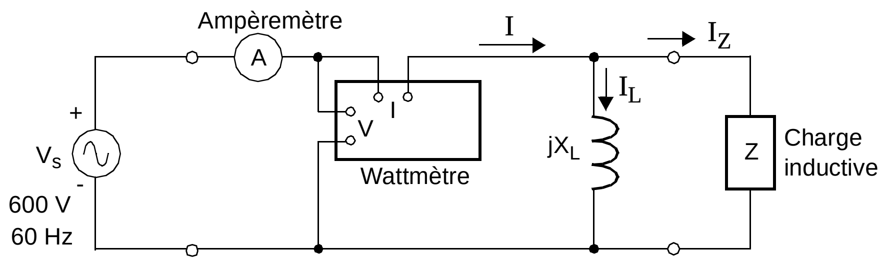
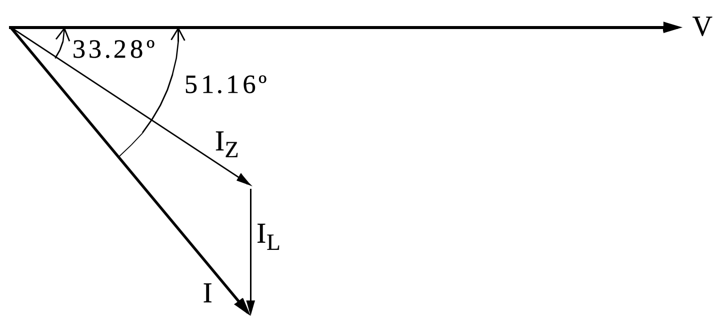


Diagramme vectoriel:



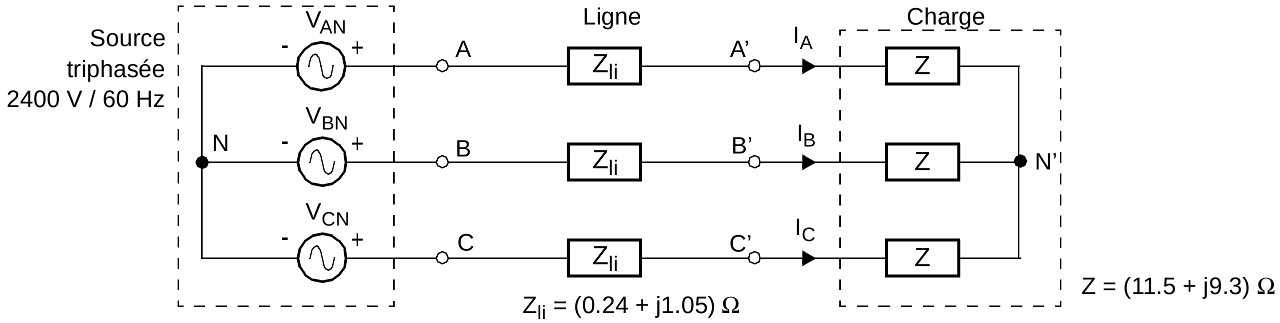
Le wattmètre indique toujours 18060 W car la puissance active n'a pas changé.

Le nouveau facteur de puissance: $\cos\phi' = \dfrac{P}{S'} = \dfrac{18060}{28800} = 0.627 \rightarrow \phi' = 51.16°$

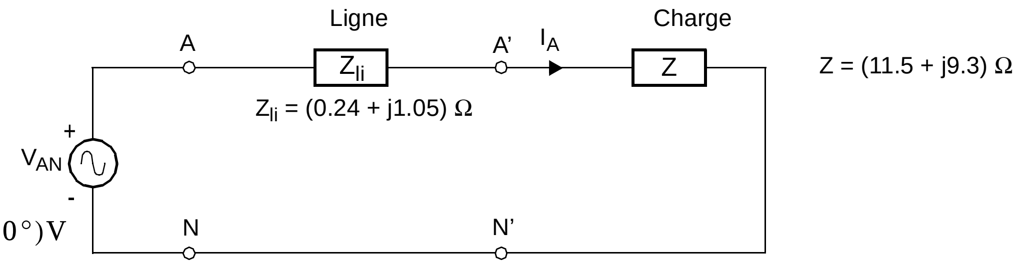
Le courant dans l'inductance est: $I_L = 48\sin(51.16°) - 36\sin(33.28°) = 17.63\,\text{A}$

La réactance X_L de l'inductance est: $X_L = \dfrac{V}{I_L} = \dfrac{600}{17.63} = 34\Omega$

Problème no. 2 (10 points)



On trace le circuit monophasé équivalent du système:



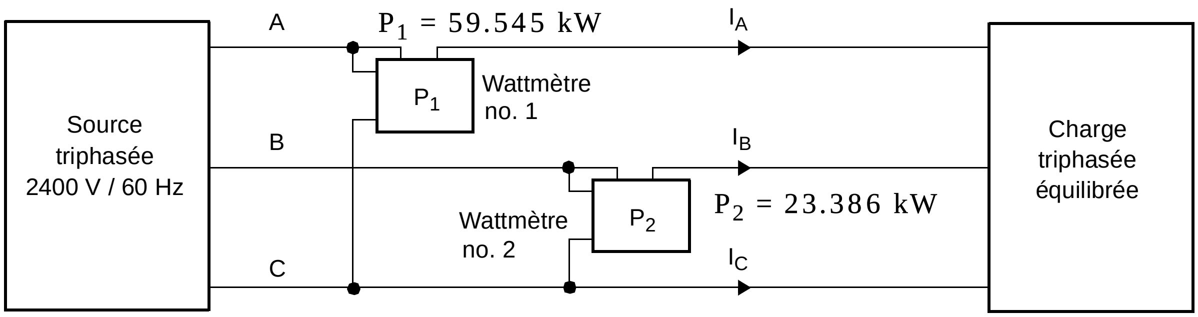
$V_{AN} = (1385.7\angle 0°)\text{V}$

Courant de ligne A: $$I_A = \frac{V_{AN}}{Z_{li} + Z} = \frac{1385.7\angle 0°}{0.24 + j1.05 + 11.5 + j9.3} = 88.53\angle{-41.4°}$$

Tension $V_{A'N'}$: $$V_{A'N'} = Z \times I_A = (11.5 + j9.3) \times (88.53\angle{-41.4°}) = 1309.4\angle{-2.44°}\ \text{V}$$

Tension $V_{A'B'}$: $$V_{A'B'} = \sqrt{3}e^{j\frac{\pi}{6}}V_{A'N'} = 2267.9\angle 27.56°$$

Problème no. 3 (10 points)



La puissance active totale dans la charge: $P = P_1 + P_2 = 59.545 + 23.386 = 82.931\,\text{kW}$

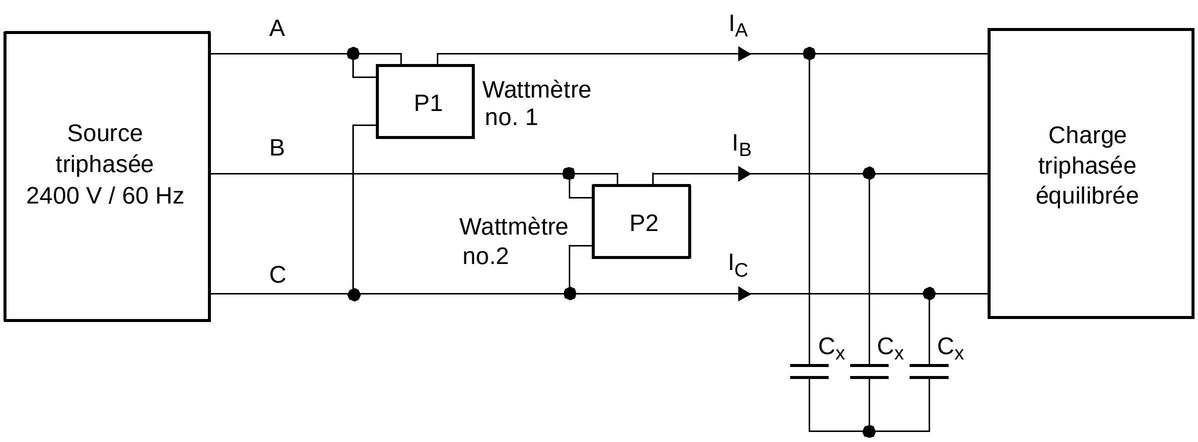
L'angle ϕ de la charge est: $\phi = \operatorname{atan}\left(\sqrt{3}\left(\frac{P_1 - P_2}{P_1 + P_2}\right)\right) = 37.1°$

Le facteur de puissance de la charge: $fp = \cos\phi = \cos(37.1°) = 0.798$

La puissance apparente totale: $S = \frac{P}{\cos\phi} = \frac{82.931\times10^3}{0.798} = 103.98\,\text{kVA}$

La puissance réactive totale: $Q = \sqrt{S^2 - P^2} = \sqrt{103980^2 - 82931^2} = 62.724\,\text{kVAR}$

La valeur efficace des courants de ligne est: $I_L = \frac{S}{\sqrt{3}V_L} = \frac{103.98\times10^3}{\sqrt{3}\times2400} = 25\,\text{A}$



Nouvelle valeur de S: $S' = \frac{P}{\cos\phi'} = \frac{82.931\times10^3}{0.9} = 92.146\,\text{kVA}$

Nouvelle valeur de Q: $Q' = \sqrt{(S')^2 - P^2} = (92146)^2 - (82931)^2 = 40.165\,\text{kVAR}$

La puissance réactive totale des condensateurs:

$$Q_{CT} = Q - Q' = 62.724 - 40.165 = 22.559\,\text{kVAR}$$

La puissance réactive d'un condensateur: $Q_C = Q_{CT}/3 = 22.559/3 = 7.52\,\text{kVAR}$

La valeur d'un condensateur: $C_x = \frac{Q_C}{V_{AN}^2\omega} = \frac{7520}{\left(\frac{2400}{\sqrt{3}}\right)^2\times120\pi} = 10.4\mu\text{F}$

<u>Problème no. 4</u> (10 points)

Charge déséquilibrée en Y: $Z_A = 10\ \Omega$ $Z_B = 5\ \Omega$ $Z_C = 20\ \Omega$

On convertit la charge Y en Δ:

$$Z_{AB} = \frac{Z_A Z_B + Z_B Z_C + Z_C Z_A}{Z_C} = \frac{50 + 100 + 200}{20} = 17.5\,\Omega$$

$$Z_{BC} = \frac{Z_A Z_B + Z_B Z_C + Z_C Z_A}{Z_A} = \frac{50 + 100 + 200}{10} = 35\,\Omega$$

$$Z_{CA} = \frac{Z_A Z_B + Z_B Z_C + Z_C Z_A}{Z_B} = \frac{50 + 100 + 200}{5} = 70\,\Omega$$

Les courants de triangle:

$$I_{AB} = \frac{V_{AB}}{Z_{AB}} = \frac{2400\angle 30^\circ}{17.5} = 137.14\angle 30^\circ \text{ A}$$

$$I_{BC} = \frac{V_{BC}}{Z_{BC}} = \frac{2400\angle -90^\circ}{35} = 68.57\angle -90^\circ \text{ A}$$

$$I_{CA} = \frac{V_{CA}}{Z_{CA}} = \frac{2400\angle 150^\circ}{70} = 34.29\angle 150^\circ \text{ A}$$

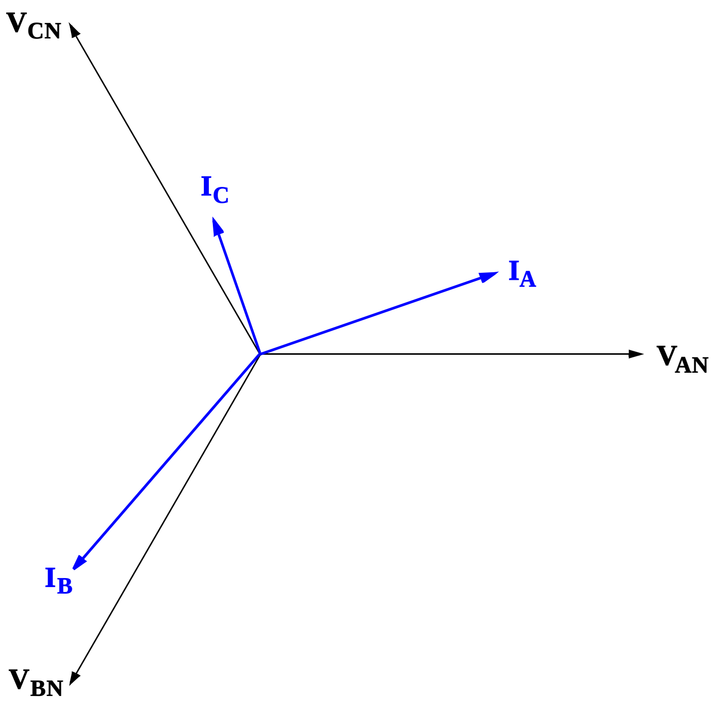
Les courants de ligne:

$$I_A = I_{AB} - I_{CA} = (137.14\angle 30^\circ) - (34.29\angle 150^\circ) = 157.12\angle 19.1^\circ \text{ A}$$

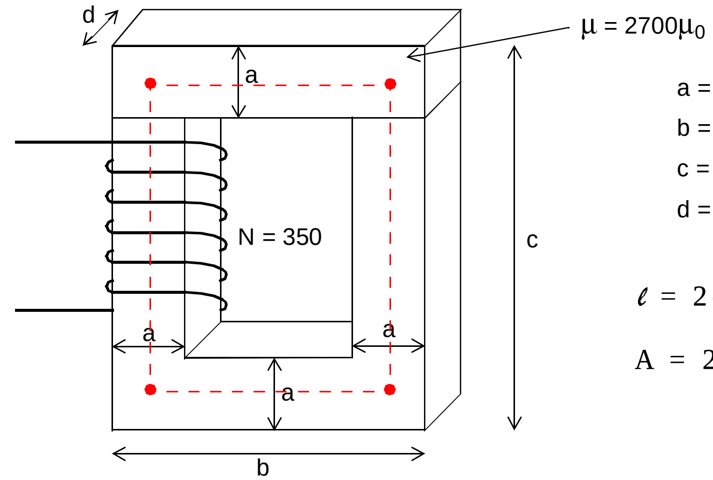
$$I_B = I_{BC} - I_{AB} = (68.57\angle -90^\circ) - (137.14\angle 30^\circ) = 181.42\angle -130.9^\circ \text{ A}$$

$$I_C = I_{CA} - I_{BC} = (34.29\angle 150^\circ) - (68.57\angle -90^\circ) = 90.71\angle 109.1^\circ \text{ A}$$

Diagramme vectoriel:



Problème no. 5 (10 points)



a = 2.5 cm

b = 12 cm

c = 15 cm

d = 4 cm

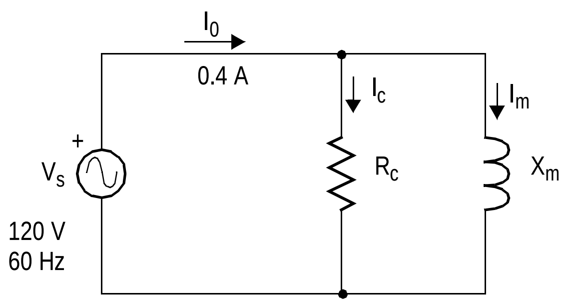
$$\ell = 2(9.5 + 12.5) = 44\,\text{cm}$$

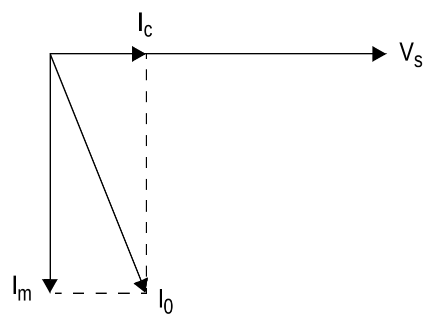
$$A = 2.5 \times 4 = 10\,\text{cm}^2$$

La réluctance du circuit magnétique: $\mathcal{R} = \dfrac{\ell}{\mu A} = \dfrac{0.44}{2700 \times 4\pi\times10^{-7} \times 10\times10^{-4}} = 129680\ \text{At/Wb}$

L'inductance de la bobine: $L = \dfrac{N^2}{\mathcal{R}} = \dfrac{(350)^2}{129680} = 0.9446\ \text{H}$

Circuit équivalent de la bobine:





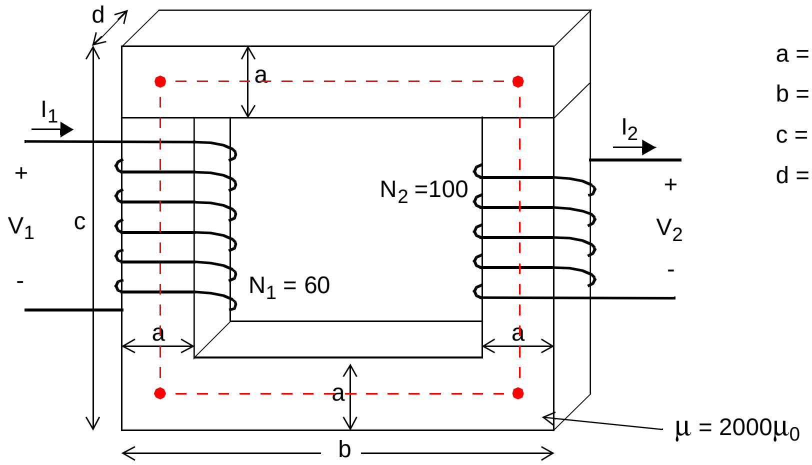
Le courant de magnétisation: $I_m = \dfrac{V_s}{X_m} = \dfrac{V_s}{\omega L} = \dfrac{120}{120\pi \times 0.9446} = 0.337\ \text{A}$

Le courant I_c: $I_c = \sqrt{I_0^2 - I_m^2} = \sqrt{(0.4)^2 - (0.337)^2} = 0.2155\ \text{A}$

Les pertes fer dans le noyau magnétique sont:

$$\text{Pertes} \cdot \text{Fer} = V_s \times I_c = 120 \times 0.2155 = 25.86\ \text{W}$$

Problème no. 6 (10 points)



a = 2 cm

b = 8 cm

c = 10 cm

d = 3 cm

$$\ell = 2(6+8) = 28\,\text{cm}$$

$$A = 2 \times 3 = 6\,\text{cm}^2$$

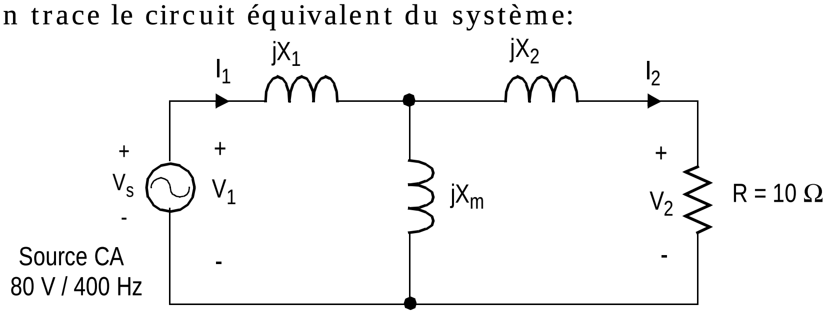
La réluctance du circuit magnétique: $\mathcal{R} = \dfrac{\ell}{\mu A} = \dfrac{0.28}{2000 \times 4\pi\times10^{-7} \times 6\times10^{-4}} = 185680\ \text{At/Wb}$

L'inductance de la bobine no. 1: $L_1 = \dfrac{N_1^2}{\mathcal{R}} = \dfrac{(60)^2}{185680} = 0.0194\ \text{H}$

L'inductance de la bobine no. 2: $L_2 = \dfrac{N_2^2}{\mathcal{R}} = \dfrac{(100)^2}{185680} = 0.0539\ \text{H}$

L'inductance mutuelle: $M = \dfrac{N_1 N_2}{\mathcal{R}} = \dfrac{60 \times 100}{185680} = 0.0323\ \text{H}$

On trace le circuit équivalent du système:



$jX_1 = j\omega(L_1\text{-}M) = \text{-}j32.48\ \Omega$

$jX_m = j\omega M = j81.21\ \Omega$

$jX_2 = j\omega(L_2\text{-}M) = j54.14\ \Omega$

Le courant dans la bobine 1 est:

$$I_1 = \frac{V_1}{(jX_1) + (jXm \parallel (jX2 + R))} = \frac{80\angle 0°}{(-j32.48) + (j81.21 \parallel (j54.14 + 10))} = 22.28\angle{-4.2°}\ \text{A}$$

La valeur efficace du courant I_1 est donc 22.28 A.

Le courant I_2 est calculé par la loi du diviseur de courant:

$$I_2 = \frac{jX_m}{jX_m + (jX_2 + R)} \times I_1 = \frac{j81.21}{j81.21 + (j54.14 + 10)} \times 22.28\angle{-4.2°} = 13.33\angle 0°\ \text{A}$$

La valeur efficace du courant I_2 est donc 13.33 A.

La tension V_2 est égale à: $V_2 = RI_2 = 10 \times 13.33\angle 0° = 133.33\angle 0°\ \text{V}$

La valeur efficace de la tension V_2 est donc 133.33 V.