Chapitre III : Machines à courant alternatif synchrones

Exercice 1 :

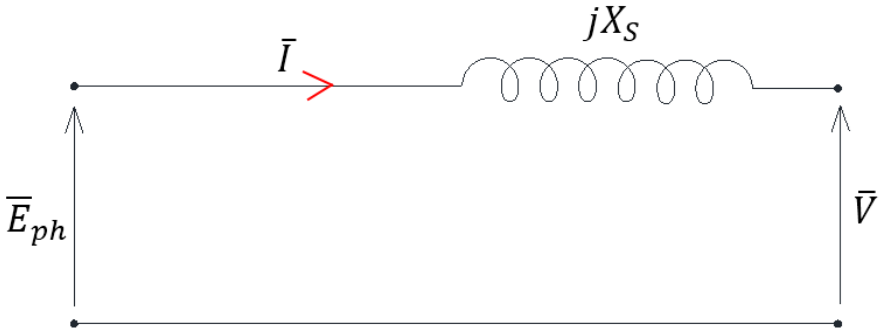
1/ La vitesse de rotation :

$$N_S = \frac{N}{p} = \frac{60f}{p} = \frac{60 \times 50}{14} = 214\ tr/mn$$

2/ La f.e.m :

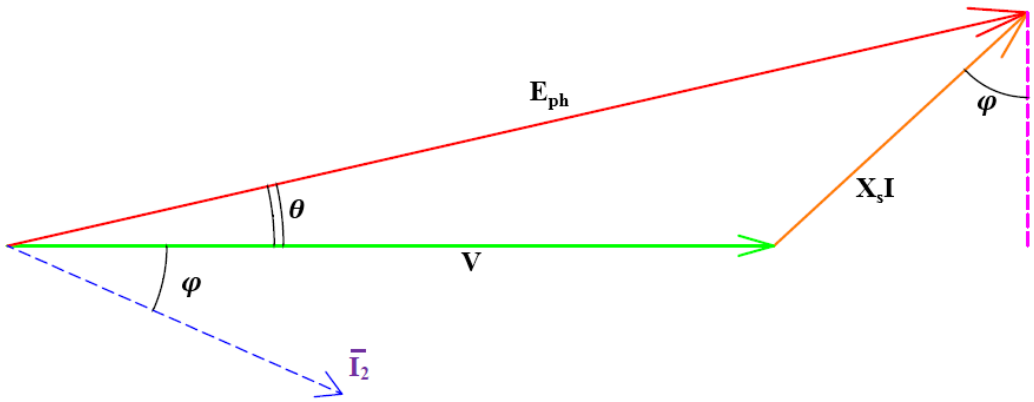
$$E_{ph} = knf\phi$$
$$\Rightarrow E_{ph} = 2{,}22 \times 2950 \times 50 \times 23 \times 10^{-3} = 7531{,}35\ V$$

3/ Le schéma équivalent :



$$\bar{V} = \overline{E}_{ph} - jX_s\bar{I} \quad \Leftrightarrow \quad \overline{E}_{ph} = \bar{V} + jX_s\bar{I}$$

4/ Le diagramme de Behn-Eschenburg :



5/ Calcul de la f.e.m :

$$E_{ph} = \sqrt{(V + R_sI\cos\varphi + X_sI\sin\varphi)^2 + (-R_sI\sin\varphi + X_sI\cos\varphi)^2}$$
$$E_{ph} = \sqrt{\left(\frac{10500}{\sqrt{3}} + 0{,}4 \times 5200 \times \sin\varphi\right)^2 + (0{,}4 \times 5200 \times \cos\varphi)^2} = 4796{,}9\ V$$

6/ Calcul de la puissance utile lorsque $P_{fer} + P_{méc} + P_{JR} = 1450$ KW :

$$P_u = \sqrt{3}UI\cos\varphi = 75{,}65 \times 10^6\ W$$

Le rendement :

$$\eta = \frac{P_u}{P_a} = \frac{P_u}{P_u + P_{pertes}} = 0{,}9811$$

Exercice 2 :

1/ La vitesse de synchronisme :

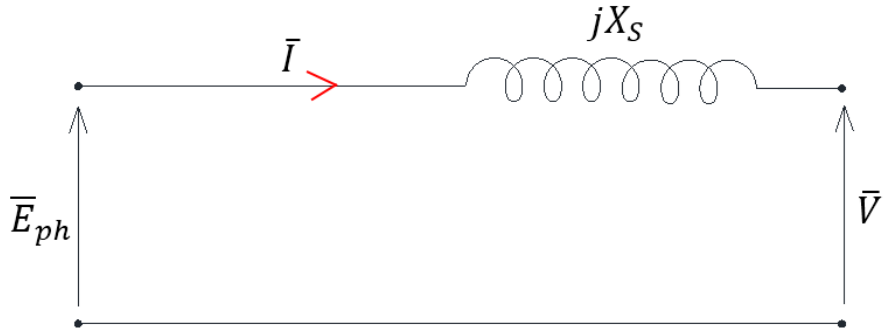
$$N_S = \frac{N}{p} = \frac{60f}{3} = \frac{60 \times 50}{3} = 1000\ tr/mn$$

2/ Le courant nominal In :

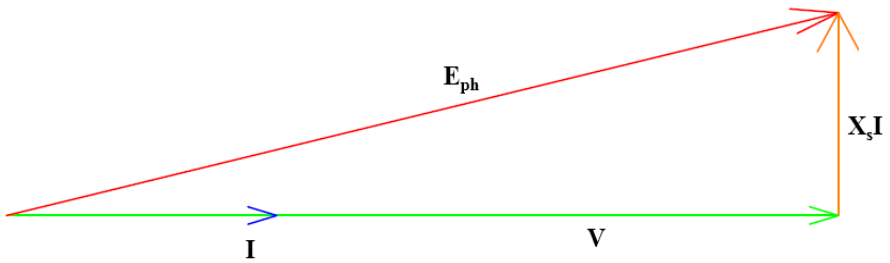
$$I_n = \frac{S_n}{\sqrt{3}U} = 76\ A$$

3/

a/ Calcul de X_s :



$$\bar{V} = \overline{E}_{ph} - jX_s\bar{I} \quad \Leftrightarrow \quad \overline{E}_{ph} = \bar{V} + jX_s\bar{I}$$



$$I_{ex} = 37\ A \ \ d'après\ le\ tableau \ \ E_{ph} = 260\ V$$

$$E_{ph}^2 = V^2 + (X_sI)^2 \quad \Rightarrow \quad X_s = \frac{\sqrt{E_{ph}^2 - V^2}}{I}$$

$$\Rightarrow X_s = 1{,}82\ \Omega$$

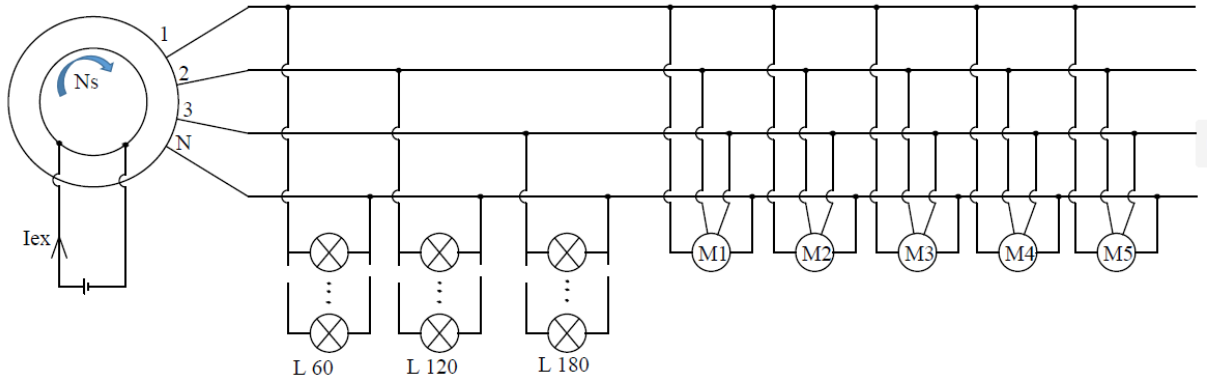
b/ Calcul du courant d'excitation :

En court-circuit : V = 0 et I = I_{cc}

$$\overline{E}_{ph} = jX_s\bar{I} \quad \Rightarrow \quad E_{ph} = X_s I_{cc} = 139\ V$$

D'après le tableau : $I_{ex} = 17$ A

4/ a/ La figure :



b/ calcul de la puissance active consommée par l'installation :

$$Lampe : \begin{cases} P_L = 100\ W \\ Q_L = 0 \end{cases}$$

$$Moteur : \begin{cases} P_M = \sqrt{3}UI_m cos\varphi_m = 5881\ W \\ Q_M = \sqrt{3}UI_m sin\varphi_m = 4411\ VAR \end{cases}$$

Pour l'ensemble de l'installation :

$$P = 180 \times P_L + 5 \times P_M = 47{,}4\ kW$$
$$Q = 180 \times Q_L + 5 \times Q_M = 22{,}1\ kVAR$$

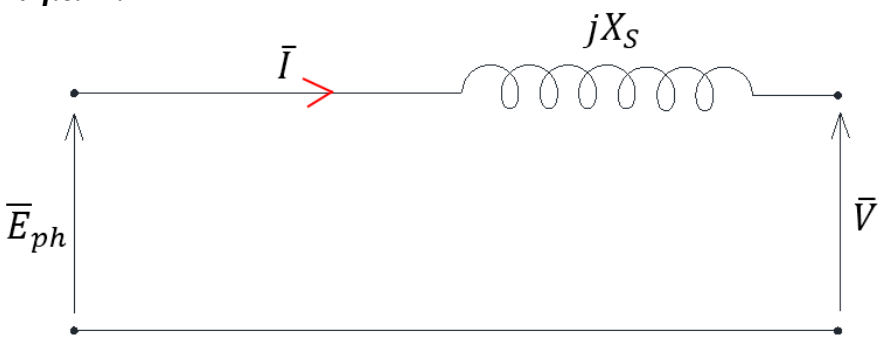
c/ Le courant de ligne I :

$$S = \sqrt{P^2 + Q^2} = \sqrt{3}UI \quad \Rightarrow I = \frac{\sqrt{P^2 + Q^2}}{\sqrt{3}U} = 79{,}5\ A$$

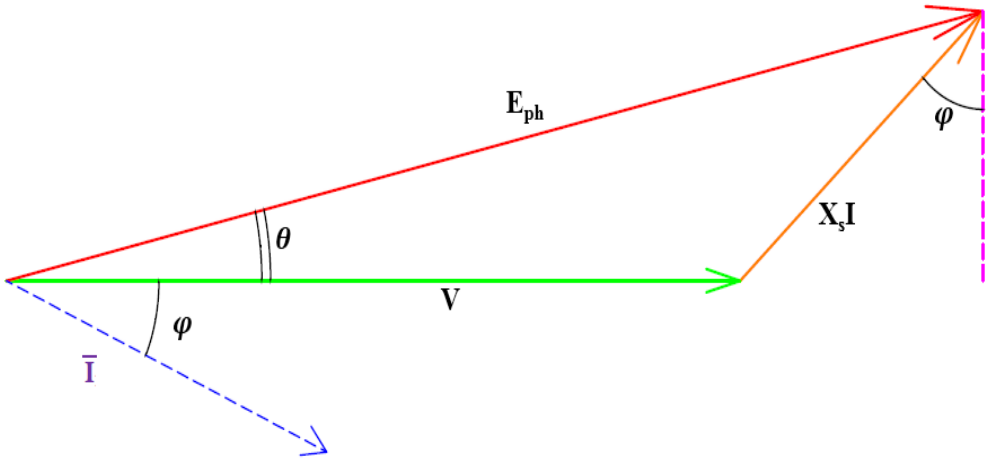
Le déphasage :

$$tg\varphi = \frac{Q}{P} \quad \Rightarrow \quad \varphi = arctg\left(\frac{Q}{P}\right) = 25$$

d/ Calcul de la f.e.m :



$$\bar{V} = \overline{E}_{ph} - jX_s\bar{I} \iff \overline{E}_{ph} = \bar{V} + jX_s\bar{I}$$



$$E_{ph}cos\theta = V + X_sIsin\varphi$$
$$E_{ph}sin\theta = X_sIcos\varphi$$
$$\Rightarrow E_{ph} = \sqrt{(V + X_sIsin\varphi)^2 + (X_sIcos\varphi)^2}$$
$$\Rightarrow E_{ph} = 310\ V$$

D'après le tableau $I_{ex} = 48$ A

e/ Calcul du couple d'entrainement :

$$\eta_{Alt} = \frac{P_u}{P_a} = \frac{P}{\Gamma\Omega_s} = \frac{60P}{2\pi\Gamma N_s}$$
$$\Rightarrow \Gamma = \frac{60P}{2\pi\eta_{Alt}N_s} = 476\ N.m$$

Exercice 3 :

1/ La vitesse de synchronisme :

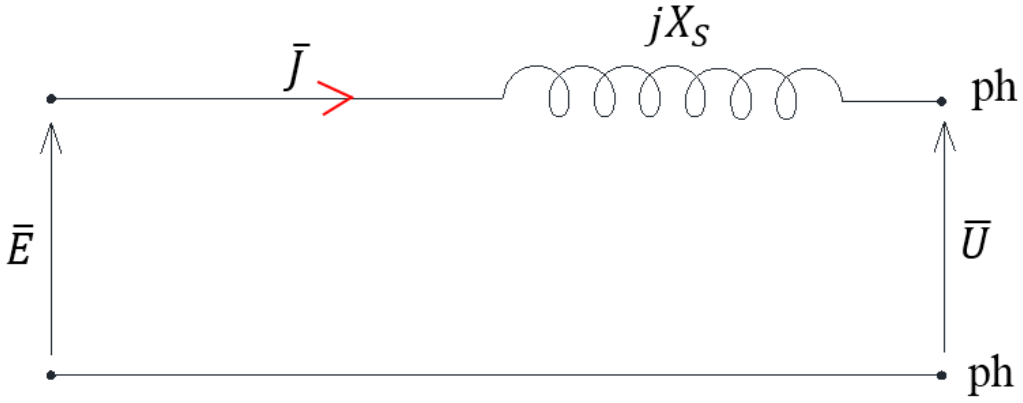
$$N_S = \frac{N}{p} = \frac{60f}{8} = \frac{60 \times 50}{8} = 375\ tr/mn$$

2/ 1er point : un point à vide E = 400 V

3/ 2ème point : un point en charge U = 380 V et I = 37,5 A

4/ 3ème point : un point en court-circuit : I_{cc} = 138 A

5/ calcul de Xs de deux façons différentes :



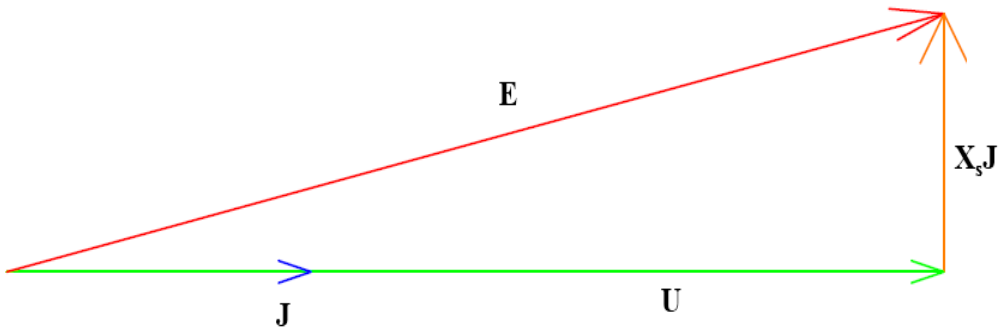
$$\bar{U} = \bar{E} - jX_s\bar{J} \quad \Leftrightarrow \quad \bar{E} = \bar{U} + jX_s\bar{J}$$

En CC : U = 0 et J = J_{cc}

$$E = X_s J_{cc} = X_s \frac{I_{cc}}{\sqrt{3}}$$

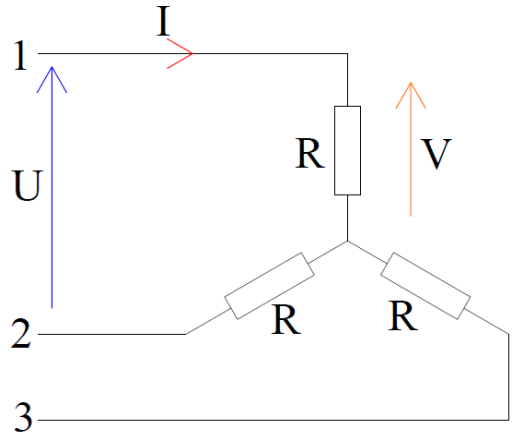
$$\Rightarrow X_s = \frac{\sqrt{3}E}{I_{cc}} = 5\ \Omega$$

2ème méthode :



$$E^2 = U^2 + X_s^2 J \quad \Rightarrow X_s = \frac{\sqrt{E^2 - U^2}}{J} = \sqrt{3}\frac{\sqrt{E^2 - U^2}}{I} = 5\ \Omega$$

6/ La résistance d'une phase du rhéostat :



$$V = RI \quad \Rightarrow \quad R = \frac{V}{I}$$

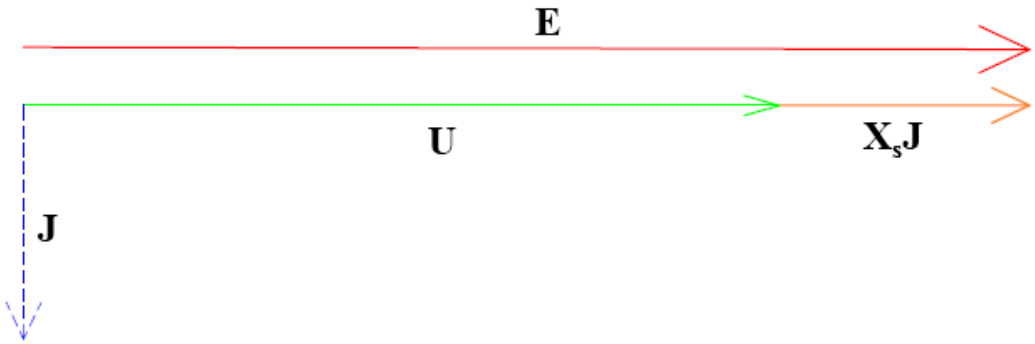
$$* \quad I = 0 \quad \Rightarrow \quad R = \infty$$

$$* \begin{cases} I = 37{,}6\ A \\ V = \dfrac{U}{\sqrt{3}} = 222{,}3\ V \end{cases} \Rightarrow R = 5{,}9\ \Omega$$

$$* \quad I = 138\ A\ , \quad R = 0$$

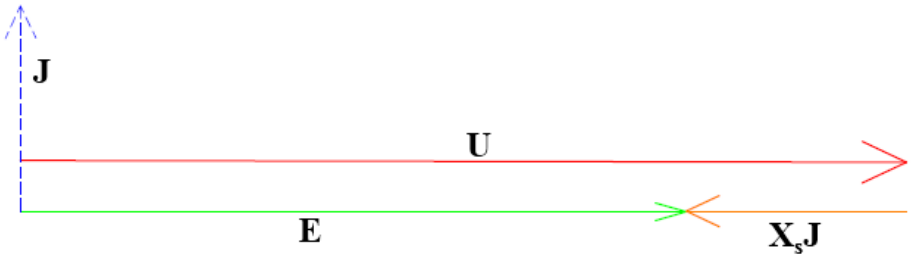
7/ la nouvelle valeur de tension :

Charge purement inductive phi = 90



$$U = E - X_s J = E - X_s \frac{I}{\sqrt{3}} = 291\ V$$

8/ la nouvelle valeur de la tension (charge purement capacitive phi = -90) :



$$U = E + X_s J = E + X_s \frac{I}{\sqrt{3}} = 508\ V$$