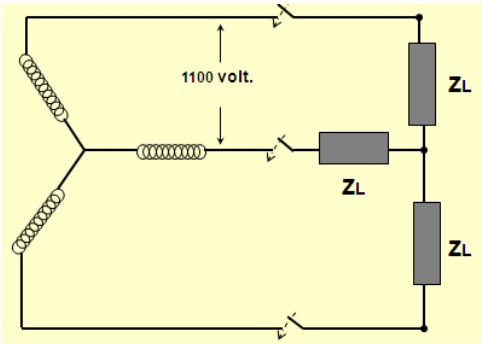
SOLUCIÓN DE PROBLEMA MAQUINAS SINCRONAS

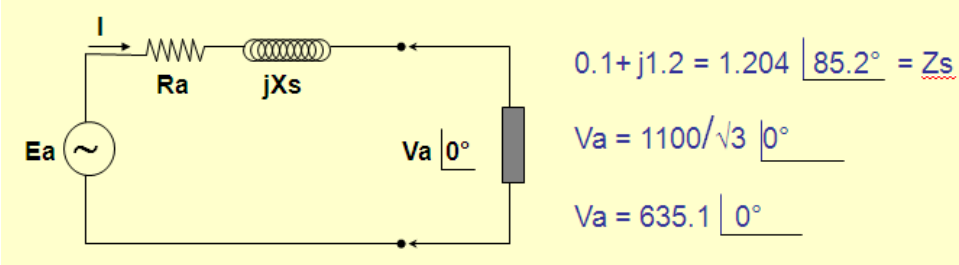
1. Se tiene un alternador de 600 KVA, polos lisos, 1100 volt., 60 Hz, 3Φ conectado en estrella con

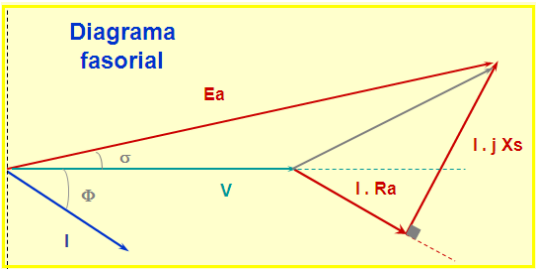
- Ra = 0.1Ω y Xs = 1.2 Ω

Se pide calcular: Reg.(%), σ, diagrama fasorial, cuando la máquina alimenta una carga a potencia nominal y además:

- Cosϕ_L=1
- CosϕL=0.8 Ind.
- CosϕL=0.9 capac.







a) Cosϕ =1
Sn = 600kVA → Sn = 600 0°
Sn = 600 = 3×V×Ia = 3×635.1 0° ×Ia*
Ia* = 314.9 0°
Regulac.(%) = (Ea – Va)/Va
Ea = Va 0° + Ia 0°× (Ra+jXs)
Ea = 635.1 0° + (314.9 0° ×1.204 85.2°)
Ea = 635.1 0° + 379.14 85.2°
Ea = 766.42 29.5°
Regul.(%) = (766.42 – 635.1)/635.1
Regul.(%) = 20.68%

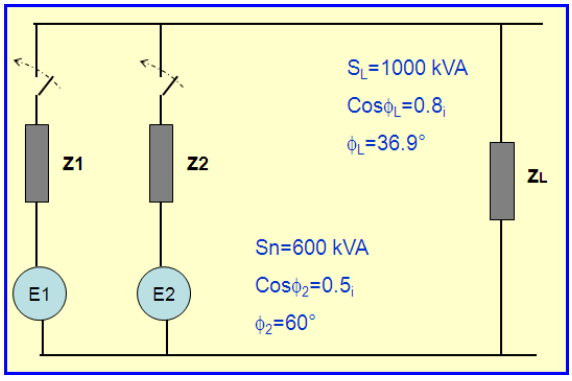
b) Cosϕ =0.8 ind. → ϕ = 36.9° ind.
Sn = 600 36.9° kVA
Sn = 3×635.1 0°×Ia*
Ia* = 314.9 36.9° → Ia = 314.9 -36.9° Amp.
Regulac.(%) = (Ea – Va)/Va
Ea = 635.1 0°+ (314.9 -36.9°×1.204 85.2°)

Ea = 635.1 $\angle$ 0°+ 379 $\angle$ 48.3°
Ea = 931.38 $\angle$ 17.7°
Regul.(%) = (931.38 – 635.1)/635.1
Regul.(%) = 46.65%

c) Cosϕ =0.9 cap. → ϕ = 25.8° ind.
Sn = 600 $\angle$ -25.8° kVA
Sn = 3×635 $\angle$ 0°×Ia*
Ia* = 314.9 $\angle$ -25.8° → Ia = 314.9 $\angle$ 25.8° Amp.
Regulac.(%) = (Ea – Va)/Va
Ea = 635 $\angle$ 0° + (314.9 $\angle$ 25.8°×1 $\angle$ 85.2°)
Ea = 635 $\angle$ 0° + 379 $\angle$ 111°
Ea = 611.9 $\angle$ 35.3°
Regul.(%) = (611.9 – 635.1)/635.1
Regul.(%) = 36.5%

2. Se tiene dos alternadores en paralelo de 600 kVA, 1100 volt., 60 Hz, 3Φ, conectado en estrella. La Xs = 1.2Ω/fase de cada alternador. Ra≈0
Hallar la regulación de tensión de los dos alternadores si se tiene encuenta que están trabajando en paralelo alimentando una carga de 1000 kVA y Cosϕ_i = 0.8
Uno de los alternadores se encuentra trabajando a potencia nominal (Sn) y Cosϕ_i = 0.5

Además determine la potencia activa y reactiva de cada generador, Cos ϕ_2, σ_1 y σ_2, diagrama fasorial del G_1, G_2, y la corriente de carga

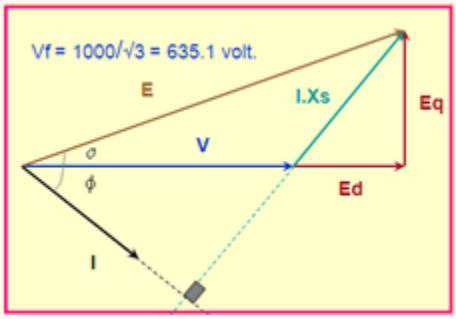


S2 = 600 $\angle$ 60° = 300 + j520 kVA
(P2, Q2)

S_L = 1000 $\angle$ 36.9° = 799.7 + j600 kVA
(P_L, Q_L)

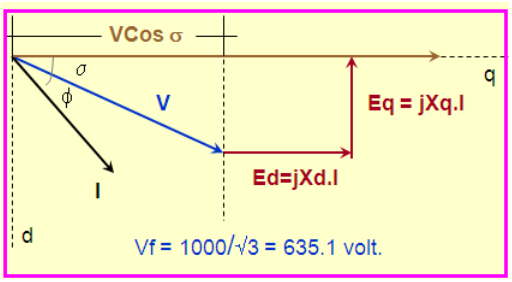
$P_L = P_1 + P_2$
P_1= 799.7 – 300 = 499.7 kW
QL= Q1 + Q2
Q1 = 600 – 520 = 80 kVAR
S1= 499.7 + 180 kVA
S1= 506.1 $\angle$ 9.1° kVA
S2= 1000 $\angle$ 36.9° - 506.1 $\angle$ 9.1° = 600.64 $\angle$ 60.04° kVA

Polos lisos
S = V × Ia*
Por fase Vf = 1000/√3 = 635.1 volt.
V = 635.1 volt.
Ia^*_1 = **(**1/3**)(**506.1 $\angle$ 9.1° / 635.1 $\angle$ 0°**)** = 265.6 $\angle$ -9.1°
Ia^*_2 = **(**1/3**)(**600 $\angle$ 60° / 635.1 $\angle$ 0°**)** = 314.9 $\angle$ -60°
En el generador 1
$E_1 = \{(V+Ed_1)^2+(Eq_1)^2\}^{1/2}$
$Ed_1 = I_1 \times Xs \times Sen\phi_1$ = 256.6×1.2×Sen(9.1°) = 50.41 volt.

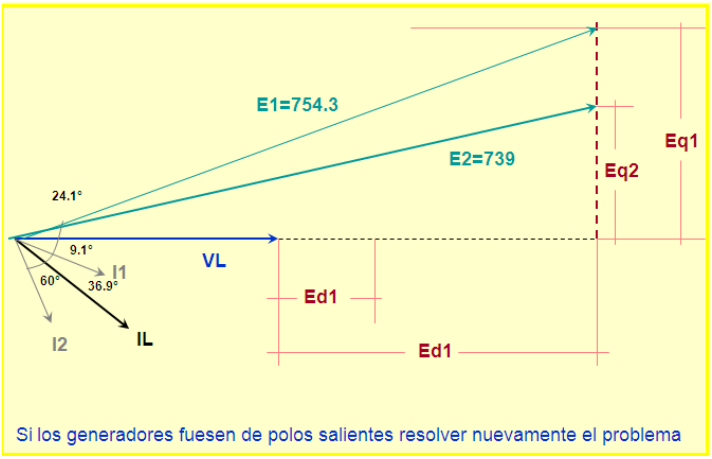


$Eq_1 = I_1 \times Xs \times Cos\phi_1 = 256.6 \times 1.2 \times Cos(9.1°) = 314.7$ volt.
$E_1 = \{(635.1+50.41)^2+(314.7)^2\}^{1/2}$
$E_1 = 754.3$ volt

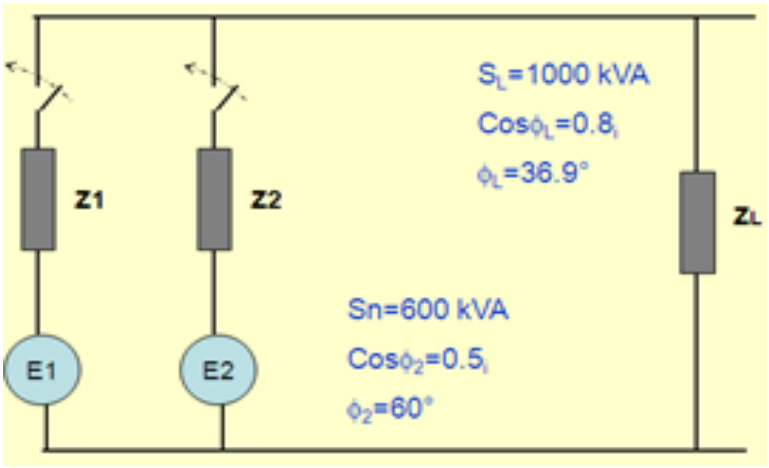
Regul.(%) = { (754.3 -635.1)/635.1 } ×100 = 18.76 %
$Sen\sigma_1 = Eq_1/E_1 = 317.4 / 754.3$
$\sigma_1 = 24.66°$



En el generador 2
$E_2 = \{(V+Ed_2)^2+(Eq_2)^2\}^{1/2}$
$Ed_2 = I_2 \times Xs \times Sen\phi_2 = 314.9 \times 1.2 \times Sen(60°) = 327.3$ volt.
$Eq_2 = I_2 \times Xs \times Cos\phi_2 = 314.9 \times 1.2 \times Cos(60°) = 188.94$ volt.
$E_2 = \{(635.1+327.3)^2+(188.94)^2\}^{1/2}$
$E_2 = 980.8$ volt.
Regul.(%) = { (980.8 -635.1)/635.1 } ×100 = 54.4 %
$Sen\sigma_2 = Eq_2/E_2 = 188.94 / 980.8$
$\sigma_2 = 11.1°$



5.- Se tiene dos alternadores en paralelo de 600 KVA, 1100 V, 60 Hz, 3Ø, conectado en estrella. X_s= 1.2 Ω/f de cada alternador. R_a = 0. Hallar la regulación de tensión de los dos alternadores si se tiene en cuenta que están trabajando en paralelo alimentando una carga de 1000 KVA y $\cos\emptyset_i = 0.8$. Uno de los alternadores se encuentra trabajando a potencia nominal (Sn) y $\cos\emptyset_i = 0.5$. Además determine la potencia activa y reactiva de cada generador $\cos\emptyset_2, \sigma_1$ y σ_2, diagrama Fasorial del G_1, G_2 y la corriente de carga.



$\bar{S}_2 = 600\angle 60^\circ = 300 + j520 = (P_2 + jQ_2)\ KVA$
$\bar{S}_L = 1000\angle 36.9^\circ = 799.7 + j600 = (P_L + jQ_L)\ KVA$

$* P_L = P_1 + P_2 \rightarrow P_1 = P_L - P_2 = 799.7 - 300 \rightarrow P_1 = 499.7\ KW$

$* Q_L = Q_1 + Q_2 \rightarrow Q_1 = Q_L - Q_2 = 600 - 520 \rightarrow P_1 = 80\ KVAR$

$* S_1 = P_1 + jQ_1 = 499.7 + j80 \rightarrow S_1 = 506.1\angle 9.1$

$* S_2 = 1000\angle 36.9^\circ - 506.1\angle 9.1^\circ = 600.64\angle 60.04^\circ\ KVA$

Polos lisos: $\overline{S} = \overline{V} x \overline{I}^*$

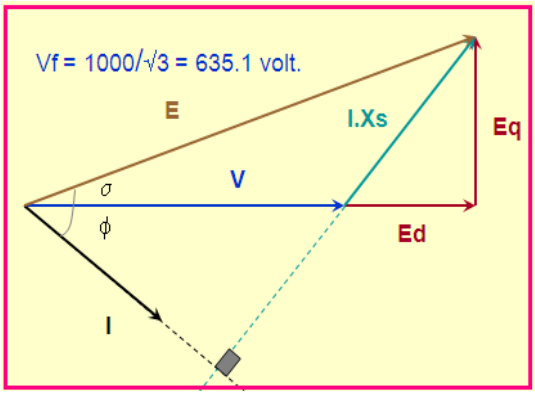
Por fase:

$* V_f = \dfrac{1000}{\sqrt{3}} = 577.4\ V$

$* \bar{I}_{a1}{}^* = \left(\dfrac{1}{3}\right)\dfrac{506.1\angle 9.1^\circ}{577.4\angle 0^\circ} \rightarrow \bar{I}_{a1}{}^* = 292\angle -9.1^\circ\ A$

$* \bar{I}_{a2}{}^* = \left(\dfrac{1}{3}\right)\dfrac{600\angle 60^\circ}{577.4\angle 0^\circ} \rightarrow \bar{I}_{a2}{}^* = 346\angle -60^\circ\ A$

En el generador 1:



$* E_1 = \sqrt{(V + Ed_1)^2 + (Eq_1)^2}$

$* Ed_1 = I_1 X_s \sin \emptyset_1 = 292x1.2xsin9.1^\circ$

$\rightarrow Ed_1 = 55.4\ V$

$* Eq_1 = I_1 X_s \cos \emptyset_1\ 292x1.2x \cos 9.1^\circ$

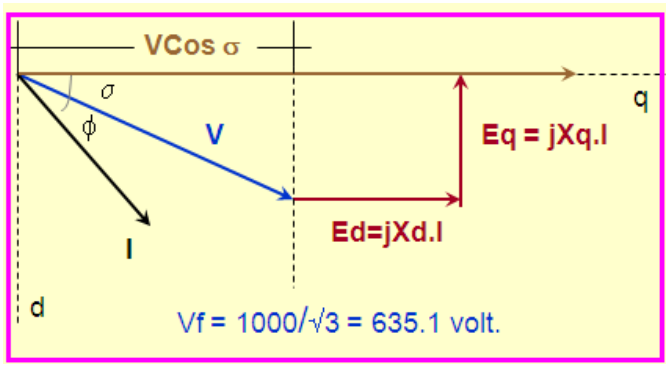
$\rightarrow Eq_1 = 346\ V$

$* E_1 = \sqrt{(577.4 + 55.4)^2 + (346)^2} \rightarrow E_1 = 721\ V$

$* Reg_{(\%)} = \dfrac{(721 - 577.4)}{577.4} x100\% \rightarrow Reg_{(\%)} = 24.87\ \%$

$* sin\sigma_1 = \frac{Eq_1}{E_1} = \frac{346}{721} = 0.48 \rightarrow \sigma_1 = 28.7^\circ$

En el generador 2:



$* E_2 = \sqrt{(V + Ed_2)^2 + (Eq_2)^2}$

$* Ed_2 = I_2 X_s \sin \emptyset_2 = 346x1.2xsin60^\circ$

$\rightarrow Ed_2 = 360\ V$

$* Eq_2 = I_2 X_s \cos \emptyset_2 = 346x1.2x \cos 60$

$\rightarrow Eq_2 = 208\ V$

$* E_2 = \sqrt{(577.4 + 360)^2 + (208)^2}$

$\rightarrow E_2 = 960\ V$

$* Reg_{(\%)} = \frac{(960 - 577.4)}{577.4} x100\% \rightarrow Reg_{(\%)} = 66.3\ \%$

$* sin\sigma_2 = \frac{Eq_2}{E_2} = \frac{208}{960} = 0.217 \rightarrow \sigma_2 = 12.5^\circ$

4.- Se tiene 2 alternadores iguales de 750 KVA, 1380 V, 60Hz y alimentan una carga de: $\bar{Z}_L = 1.9 - j10.75\ \Omega$ *conectada en Y. Si P es repartida por igual y Q es repartida de manera que uno de los alternadores tiene el 80% y el otro el 20%. Hallar:*

a) P, Q y S de cada alternador:

$\bar{Z}_L = 1.9 - j10.75\ \Omega \rightarrow \bar{Z}_L = 10.92\angle -80\ \Omega$

$V_f = \frac{1380}{\sqrt{3}} = 796\ V$

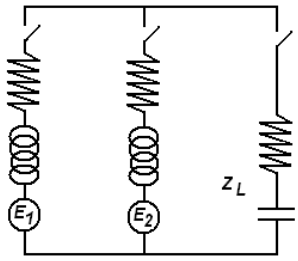
$\bar{S}_L = \frac{\bar{V}_f{}^2}{\bar{Z}_L} = \frac{796^2\angle 0}{10.92\angle -80}\ (fase) \rightarrow \bar{S}_L = 3x58023\ \angle 80$

$\bar{S}_L = 174.1\angle 80^\circ = 30.23 + j171.5\ KVA$

$P_L = 30.23 = P_1 + P_2 \rightarrow P_1 = P_2 = 15.12\ KW$

$Q_L = Q_1 + Q_2 = 171.5\ KVARs$

- $Q_1 = 0.8Q_L = 0.8x171.5 \rightarrow Q_1 = 137.2\ KVARs$
- $Q_2 = 0.2Q_L = 0.2x171.5 \rightarrow Q_2 = 34.3\ KVARs$



$\bar{S}_1 = 15.12 + j137.2 = 138\angle 83.7\ KVA$

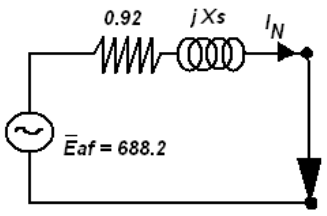
$\bar{S}_2 = 15.12 + j34.2 = 37.48\angle 66.2\ KVA$

b) Hallar la regulación de cada alternador:

Vacío: $I_f = 17.5\ A \rightarrow V_L = 1070\ V$

Corto circuito: $I_f = 19.5\ A \rightarrow I_L = I_N$

$\frac{17.5}{1070} = \frac{19.5}{x} \rightarrow x = 1192V = \bar{E}_{afL}$



✓ $688.2 = 314xZ_s \rightarrow Z_s = 2.192\ \Omega$

$$2.192^2 = 0.92^2 + {X_s}^2 \rightarrow X_s = 1.99\,\Omega$$

$$\bar{Z}_s = 0.92 + j1.99 = 2.192\angle 65.2\,\Omega$$

Regulación de $\bar{E}_{af1}$:

$$* \bar{I}_{a1} = \frac{138\angle 83.7}{\sqrt{3}x1380} \rightarrow \bar{I}_{a1} = 57.74\angle 83.7^{\circ}\,A$$

$$* \bar{E}_{af1} = \frac{1380}{\sqrt{3}}\angle 0^{\circ} + (2.192\angle 65.2^{\circ})(57.74\angle 83.7^{\circ}) \rightarrow \bar{E}_{af1} = 690.6\angle 5.4^{\circ}\,V$$

$$* Reg_{(\%)} = \frac{(690.6 - 796)}{796}x100\% \rightarrow Reg_{(\%)} = -13.24\%$$

$$* \bar{I}_{a2} = \frac{37.48\angle 66.2^{\circ}}{\sqrt{3}x1380} \rightarrow \bar{I}_{a2} = 15.68\angle 66.2^{\circ}\,A$$

$$* \bar{E}_{af2} = 796\angle 0^{\circ} + (2.192\angle 65.2^{\circ})(15.68\angle 66.2^{\circ}) \rightarrow \bar{E}_{af2} = 773.7\angle 1.9^{\circ}\,V$$

$$* Reg_{(\%)} = \frac{(773.7 - 796)}{796}x100\% \rightarrow Reg_{(\%)} = -2.8\%$$