Tarea # 6

7-709-1004
25 de octubre, 2021

Problemas Solución

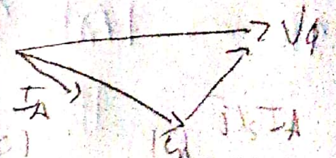
5.1) Motor sincrónico ⇒ 480V, 60 Hz, 400 hp, $pf = 0.8(+)$, 8 polos
conectado "Δ" ; $X_s = 0.6\Omega$; $|E_A|$ directamente proporcional → I_F
$|E_A| = 480V$; $I_F = 4A$

a) n_m

$$n_m = \frac{120f}{P} = \frac{120(60)}{8} \Rightarrow n_m = \underline{900\ rpm}$$

b) si motor suministra ⇒ 400 Hp, 0.8(+) ; $|E_A| = ?$; $I_A = ?$

$$P_{in} = 400\,Hp\left(\frac{746\,W}{1\,Hp}\right) = 298.4\ kW$$



$$S = \sqrt{3}\,V_{LL} I_L \qquad P = S\,pf \qquad S = \frac{P}{pf}$$

$$I_L = \frac{P}{\sqrt{3}\,V_{LL}\,pf}$$

"Δ" ⇒ $V_{LL} = V_{LN}$

$I_L = \sqrt{3}\, I_\phi$ → I_A

$$I_L = \frac{298.4\times10^3}{\sqrt{3}(480)(0.8)} = 449A$$

$$I_A = \frac{449}{\sqrt{3}} = \underline{259A}$$

$pf = 0.8(+)$
$\theta = \cos^{-1}(0.8)$
$\theta = 36.87°$

$$\boxed{I_A = 259\angle{-36.87°}}$$

$$E_A\angle\delta = 480\angle0 - (0.6j)(259\angle{-36.87°})$$

$$\boxed{E_A = 406\angle{-17.8°}}$$

c) $P = T_{ind}\,\omega_m$

$$T_{in} = \frac{298.4\,kW}{900\left(\frac{2\pi}{60}\right)} = \underline{3166\,N.m}$$

$$T_{ind(max)} = \frac{3V_\phi E_A}{\omega_m X_s}\sin\delta \quad \delta = 90°$$

$$= \frac{3(480)(406)\sin(90°)}{900\left(\frac{2\pi}{60}\right)(0.6)}$$

$$\boxed{T_{ind(max)} = 10340\,N.m}$$

d) $|E_A| \uparrow 30\%$

$|E_{A_2}| = 1.30|E_{A_1}| = 1.30|406|$

$\boxed{|E_{A_2}| = 487.2V}$

$E_{A_1}\sin\delta_1 = E_{A_2}\sin\delta_2$

$$\delta_2 = \sin^{-1}\left(\frac{E_{A_1}\sin\delta_1}{E_{A_2}}\right) = \sin^{-1}\left(\frac{406\sin(-17.8)}{487.2}\right)$$

$\delta_2 = -14.8°$

$$I_{A_2} = \frac{480 - 487.2\angle{-14.8°}}{j0.6}$$

$$\boxed{I_{A_2} = 208\angle{-4.1°}A}$$

e)

5.2) Motor del prob. 1 → opera condición nominal

a)
$$I_L = \frac{P}{\sqrt{3}\, V_{LL}\, PF} = \frac{298.4\,kW}{\sqrt{3}(480)(0.8)} = 449A$$

$$I_A = I_L/\sqrt{3} = 259A \qquad pf = 0.8(+)$$

$$\boxed{I_A = 259\angle 36.87^\circ\ A}$$

$$E_A = 480\angle 0^\circ - (0.6j)(259\angle 36.87^\circ)$$

$$\boxed{E_A = 587\angle -12.2^\circ\ V}$$

$I_F = 4A \Rightarrow |E_A| = 480V$

$I_F = ? \rightarrow |E_A| = 587$

$$I_{F_2} = \frac{(587V)(4A)}{480V} = \underline{4.89A}$$

b) si carga se quita ⇒ $|E_A|$ se mantiene, pero $\delta \Rightarrow 0^\circ$

$$I = \frac{480\angle 0^\circ - 587\angle 0^\circ}{}$$

$$\boxed{I_A = 178.3\angle 90^\circ\ A}$$

5.4) Motor Sinc ⇒ 2300V ; 1000Hp ; $pf = 0.8(+)$, 60Hz, 2polos, conectado "Y"

V_{LL} $X_S = 5\Omega$; $R_A = 0.3\Omega$; Perdidas ⇒ Fricción → 30kW, Nucleo → 20kW

CKT campo ⇒ $200V_{(cd)}$ y $I_{F(max)} = 10A$

*Suponer q' alimenta → Bus infinito

a) $I_F \Rightarrow pf = 1.0^\circ$, suministra plena carga ⇒ $P_{in} = P_{out} + P_{Fric} + P_c + P_{elec}$

$P_{in} = 1000(746\,W/_{hp}) + 30kW + 20kW = 796kW$

$$I_A = I_L = \frac{796k}{\sqrt{3}(2300)(1.0)} = \underline{200A} \qquad P_{el} = (0.3)(200)^2 = 36kW$$

$P = 832kW$ (36kW) $= 832kW$

$$I_A = \frac{832kW}{\sqrt{3}(2300)(1)} = 209A \rightarrow \boxed{I_A = 209\angle 0^\circ A}$$

$$E_A = \frac{2300\angle 0^\circ}{\sqrt{3}} - (0.3 + j5)(209\angle 0^\circ) = \underline{1370\angle -22.44^\circ\ V}$$

$$E_{A(LL)} = \sqrt{3}(1370\angle -22.44^\circ) \Rightarrow |E_{A(LL)}| = 2371V$$

$$\boxed{I_F \Rightarrow 4.54\ A}$$

b) $$\eta(\%) = \frac{P_{out}}{P_{in}} \times 100 = \frac{1000(746)}{832\,kW} \times 100$$

$$\boxed{\eta(\%) = 89.7\%}$$

c) $I_{F_2} = 1.05 I_F$; I_A, pf, Q ; I_{ygual} R_A

$I_F = 1.05(4.54) = 4.77A \Rightarrow 2450\,V = |E_{A_2}|$

$E_{A_1}\sin\delta_1 = E_{A_2}\sin\delta_2$

$\delta_2 = \sin^{-1}\left[\dfrac{1370\sin(-27.44)}{\left(\frac{2450}{\sqrt{3}}\right)}\right] = -23.9°$

$I_A = \dfrac{\left(\frac{2300}{\sqrt{3}}\right)\angle 0 - \left(\frac{2450}{\sqrt{3}}\right)\angle -23.9°}{(j\,2.5\Omega)} = \underline{227\angle 2.6°}$

$pf = \cos(2.6) = 0.999(+)$

$Q = \sqrt{3}\,V_T\,I_A\sin\theta = \sqrt{3}(2300)(227)\sin(2.6°)$

$\boxed{Q = 41k\ VAR}$

d) $\tau_{ind} \to pf = 1.0$ $\delta = 90°$

$\tau_{ind\,(max)} = \dfrac{3 V_\phi E_A \sin\delta}{\omega_m X_s} = \dfrac{3\left(\frac{2300}{\sqrt{3}}\right)(1370)}{(3600)\left(\frac{2\pi}{60}\right)(2.5)} = 5790\ N{\cdot}m$

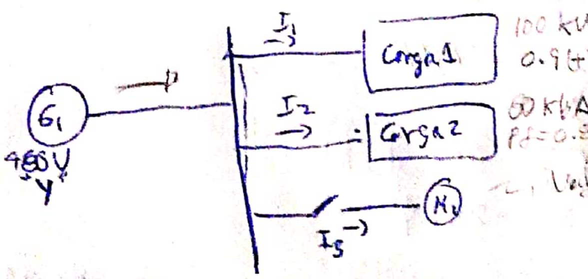
$*\tau_{ind\,(max)} \Rightarrow$ si $pf = 0.8(+)$

$I_A = I_L = \dfrac{1000k}{\sqrt{3}\left(\frac{2300}{\sqrt{3}}\right)(0.8)} = \underline{250A}$ $\boxed{I_A = 250\angle 36.87°\ A}$

$E_A = \left(\frac{2300}{\sqrt{3}}\right)\angle 0° - (2.5j)(250\angle 36.87) = 1775\angle -16.4°$

$\tau_{ind\,(max)} = \dfrac{3\left(\frac{2300}{\sqrt{3}}\right)(1775)\sin(90°)}{3600\left(\frac{2\pi}{60}\right)(2.5)} \Rightarrow \boxed{\tau_{ind\,(max)} = 7505\ N.m}$

5.12)



a) Carga 1 $\theta = \cos^{-1}(0.9)$

$P_1 = 100kW$

$Q_1 = (100kW)\tan(\theta)$

$Q_1 = 48\ KVAR$

Carga 2

$S_2 = 80kVA$

$P_2 = S_2\cos\theta = 80(0.8) = 64kW$

$Q_2 = 64\tan(\cos^{-1}(0.8)) = 48\ kVAR$

P_{total}, Q_{total}, S_{total} → potencia planta

$P_{total} = P_1 + P_2 = 164kW$

$Q_{total} = Q_1 + Q_2 = 96\ kVAR$

$S_{Tot} = \sqrt{P_{total}^2 + Q_{total}^2} = 190kVA$

$I_L = \dfrac{S_{total}}{\sqrt{3}\,V_L} = \dfrac{190kVA}{\sqrt{3}(480)}$

$\boxed{I_L = 228.5A}$

b) Motor

$P_{motor} = 100hp\left(746 \, W/hp\right) = 74.6 \, kW$

$S_{Base} = \frac{74.6kW}{0.8} = 93.2kVA$

$V_{Base} = 480 \, V$

$V_{LN(m)} = \frac{480}{\sqrt{3}} = 266V$

$I_A = I_L = \frac{93.2kVA}{\sqrt{3}(480)} = 117A$

$Z_{Base} = \frac{3(V_{LN,base})^2}{S_{Base}} = \frac{3(266)^2}{93.2\times10^3}$

$Z_{Base} = 2.778\Omega$

$R_A = (0.01)(2.778) = 0.023\Omega$

$X_S = (1.1)(2.778) = 2.051\Omega$

$P_{motor} (100hp)(746 \, W/hp) = 74.6kW$ $\quad pf \; 0.8 \Rightarrow \theta = 36.87°$

$Q = 74.6kW \tan(36.87°) = -56 \, kVA$ → absorbe

$I_A = \frac{74.6kW}{\sqrt{3}(480)(0.8)} = 112A \Rightarrow \boxed{I_A = 112\angle 36.87° A}$

$E_A = \left(\frac{480}{\sqrt{3}}\right)\angle 0° - (0.023 + 2.3j)(117\angle 36.87°)$

$\boxed{E_A = 498\angle -27° \; V} \Rightarrow I_F = 1.9A$

c) $\delta = -27°$

d)

$P_{total} = P_1 + P_2 + P_{motor} = 238.6 \, kW$

$Q_{total} = Q_1 + Q_2 + Q_{motor} = (46 + 48 - 56) = 40.41 \, kVAR$

$S_{Total} = \sqrt{238.5^2 + 40.4^2} \Rightarrow \boxed{S_{total} = 242kVA}$

$I_L = \frac{242kVA}{\sqrt{3}(480)} = 291A$

e) $I_F \Rightarrow 2A \Rightarrow E_A = 498 \rightarrow 517$ (occ graph)

$\delta_2 = \sin^{-1}\left(\frac{498\sin(-27)}{517}\right) = -25.9°$

$I_{A_2} = \frac{\left(\frac{480}{\sqrt{3}}\right)\angle 0° - 517\angle -25.9}{j2.5\Omega} = 117\angle 39.8° A$ $\quad \theta = 39.8° \Rightarrow \theta = -39.8°$ dominante

$P_{motor} = 3V_\phi I_A \cos\theta = 3\left(\frac{480}{\sqrt{3}}\right)(117)\cos(-39.8°) = 74.6kW$

$Q_{mot} = 3V_\phi I_A \sin\theta = 3\left(\frac{480}{\sqrt{3}}\right)(117)\sin(-39.8°) = -62.2kVAR$

f) $\delta =$

h) $P_{total} = P_1 + P_2 + P_{mot} = 238.6kW$

$Q_{Total} = Q_1 + Q_2 + Q_{mot} = 34.6kVAR$

$S_{Total} = \sqrt{P_{TM}^2 + Q_{TM}^2} = 240kVA$

$I_L = \frac{240}{\sqrt{3}(480)} = 288.7A$

g) $pf = 0.768$ (i)

$\theta = 39.8$

$pf = \cos(39.8)$

$= 0.768$ (i)

5.14) Motor Sincrónico: 2300 V; 400 hp; 60 Hz, 8 polo; conectado "Y"
Plena carga → $\eta(\%) = 90\%$; $R_A = 0.8\,\Omega$; $X_S = 11\,\Omega$

a)
$$n_m = \frac{120(60)}{8} = 900\,rpm$$

$$P_{out} = 400\,hp\,(746\,W/hp) = 298\,kW$$

$$\tau_{out} = \frac{298\,kW}{900\left(\frac{2\pi}{60}\right)} = \underline{3162\ N\cdot m}$$

c) $n_m = 900\,rpm$

b) $$\eta(\%) = \frac{P_{out}}{P_{in}}$$

$$P_{in} = \frac{298\,kW}{0.9} = \underline{331\,kW}$$

d)
$$I_A = I_L = \frac{S_{in}}{\sqrt{3}\,V_{LL}} = \frac{331\,kW}{\sqrt{3}(2300)(0.85)}$$

$P = S\ pf$
$S = P/pf$

$$\boxed{I_A = 97.8\,A \angle 31.8^\circ\,A}$$

$$E_A = \left(\frac{2300}{\sqrt{3}}\right)\angle 0^\circ - (0.8 + 11j)(97.8\angle 31.8)$$

$$\boxed{E_A = 2063\angle -27.6^\circ\ V}$$

$|E_A| = 2063$

e) $P_{conv} = P_{in} - P_{elect}$

$$P_{ele} = R_A (I_A)^2 = 0.8(97.8)^2 = 23\,kW$$

$$P_{conv} = 331 - 23 = \underline{308\,kW}$$

g) $P_{in} = P_{out} + P_{mec} + P_{c} + P_{core}$

$$P_{mec} + P_{stray} + P_{core} = \underbrace{P_{in} - P_{ele}}_{P_{con}} - P_{out} = 308 - 298 = \underline{10\,kW}$$