

MOTOR TRIFASICO conectado en estrella (Unidades en el SI)

$$\begin{aligned}
 Un1L &:= 380 & Un1F &:= \frac{Un1L}{\sqrt{3}} & Un1F &= 219.393 & r_t &:= 2 \\
 p &:= 2 & ns &:= \frac{60}{p} \cdot f & ns &= 1.5 \times 10^3 & P_{fe} &:= 218 \\
 f &:= 50 & R1 &:= 0.5 & P_{mec} &:= 180
 \end{aligned}$$

a) Parámetros de circuito equivalente

VACIO-ROTOR LIBRE

$$\begin{aligned}
 Un1L &:= 380 & Un1F &:= \frac{Un1L}{\sqrt{3}} & Un1F &= 219.393 \\
 Io1L &:= 3.8 & Io1F &:= Io1L & Io1F &= 3.8 \\
 P_{fe} &= 218 & P_{feF} &:= \frac{P_{fe}}{3} & P_{feF} &= 72.667 \\
 Ango &:= \arccos\left(\frac{P_{feF}}{Un1F \cdot Io1F}\right) & Ango \cdot \frac{180}{\pi} &= 85 & R_{fe} &:= \frac{Un1F}{Io1F \cdot \cos(Ango)} & R_{fe} &= 662.385 \\
 I_{fe} &:= Io1F \cdot \cos(Ango) & I_{fe} &= 0.331 & X_m &:= \frac{Un1F}{Io1F \cdot \sin(Ango)} & X_m &= 57.956 \\
 I_{mag} &:= Io1F \cdot \sin(Ango) & I_{mag} &= 3.786
 \end{aligned}$$

CC-ROTOR BLOQUEADO

$$\begin{aligned}
 U_{cc1L} &:= 107 & U_{cc1F} &:= \frac{U_{cc1L}}{\sqrt{3}} & U_{cc1F} &= 61.776 \\
 I_{cc1L} &:= 15 & I_{cc1F} &:= I_{cc1L} & I_{cc1F} &= 15 \\
 P_{cc} &:= 670 & P_{ccF} &:= \frac{P_{cc}}{3} & P_{ccF} &= 223.333 \\
 Ang_{cc} &:= \arccos\left(\frac{P_{ccF}}{U_{cc1F} \cdot I_{cc1F}}\right) & U_{ccr} &:= U_{cc1F} \cdot \cos(Ang_{cc}) & U_{ccx} &:= U_{cc1F} \cdot \sin(Ang_{cc}) \\
 Ang_{cc} \cdot \frac{180}{\pi} &= 76.054 & U_{ccr} &= 14.889 & U_{ccx} &= 59.955 \\
 R_{cc} &:= \frac{U_{ccr}}{I_{cc1F}} & R_{cc} &= 0.993 \\
 X_{cc} &:= \frac{U_{ccx}}{I_{cc1F}} & X_{cc} &= 3.997 \\
 R2_{reducida} &:= R_{cc} - R1 & R2_{reducida} &= 0.493 \\
 X1 &:= \frac{X_{cc}}{2} & X2_{reducida} &:= X1 & Z1 &:= R1 + X1 \cdot i & Z1 &= 0.5 + 1.999i \\
 Z2_{reducida} &:= R2_{reducida} + X2_{reducida} \cdot i & Z2_{reducida} &= 0.493 + 1.999i \\
 Z2 &:= \frac{Z2_{reducida}}{r_t^2} & Z2 &= 0.123 + 0.5i
 \end{aligned}$$

b) Par

$$s_s := 0, 0.01.. 1 \quad T(s) := \frac{3 \cdot Un1F^2 \cdot R2_{reducida}}{s \cdot \left[ 2 \cdot \frac{\pi}{60} \cdot ns \cdot \left[ \left( R1 + \frac{R2_{reducida}}{s} \right)^2 + (X1 + X2_{reducida})^2 \right] \right]}$$

b) Corriente

$$I_o := I_{fe} - I_{mag} \cdot i \quad I_o = 0.331 - 3.786i \quad |I_o| = 3.8$$

$$I2F(s) := \frac{Un1F}{Z1 + Z2_{reducida} + R_{c\_reducida}(s)} \quad R_{c\_reducida}(s) := R2_{reducida} \cdot \left( \frac{1}{s} - 1 \right) \quad I1F(s) := I_o + I2F(s)$$

C) Arranque:  $s=1$

$$T(1) = 26.698 \quad I1F(1) = 13.17 - 55.486i \quad \text{Angarr} := \text{atan}\left(\frac{\text{Im}(I1F(1))}{\text{Re}(I1F(1))}\right)$$

$$\text{fdp\_arr} := \cos(\text{Angarr}) \quad \text{fdp\_arr} = 0.231$$

$$|I1F(1)| = 57.028 \quad \text{Angarr} \cdot \frac{180}{\pi} = -76.647 \quad I2F(1) = 12.839 - 51.701i$$

d) Velocidad de par máximo, corriente y par máximo

$$s_{\text{max}} := \frac{R2_{\text{reducida}}}{\sqrt{R1^2 + (X1 + X2_{\text{reducida}})^2}} \quad s_{\text{max}} = 0.122$$

$$I1F(s_{\text{max}}) = 27.563 - 27.823i$$

$$n_{\text{smax}} := (1 - s_{\text{max}}) \cdot n_s \quad n_{\text{smax}} = 1.317 \times 10^3 \quad T(s_{\text{max}}) = 101.506 \quad |I1F(s_{\text{max}})| = 39.165$$

e) Intensidad de línea y f.d.p. para deslizamiento 5%

$$s1 := 0.05 \quad R_{c\_reducida}(s1) = 9.359 \quad I1F(s1) = 18.775 - 10.907i$$

$$\text{Ang} := \text{atan}\left(\frac{|\text{Im}(I1F(s1))|}{\text{Re}(I1F(s1))}\right) \quad \text{fdp} := \cos(\text{Ang}) \quad \text{fdp} = 0.865$$

$$I1L(s) := I1F(s) \quad I1L(s1) = 18.775 - 10.907i \quad |I1L(0.05)| = 21.713$$

$$|I2F(0.05)| = 19.771$$

F) Potencia y par en el eje para deslizamiento 5%

$$Pm\dot{i}(s) := 3 \cdot (|I1F(s)|)^2 \cdot R_{c\_reducida}(s) \quad Pu(s) := Pm\dot{i}(s) - P_{mec} \quad Pu(s1) = 1.306 \times 10^4$$

$$n := n_s \cdot (1 - s1) \quad n = 1.425 \times 10^3$$

$$Pm\dot{i}(s1) = 1.324 \times 10^4 \quad Tu := \frac{Pu(s1)}{2 \cdot \frac{\pi}{60} \cdot n} \quad Tu = 87.503$$

$$Rend(s) := \frac{Pu(s)}{Pu(s) + P_{mec} + P_{fe} + 3 \cdot (I1F(s)^2) \cdot R_{cc}}$$

$$Rend(s1) = 0.916 + 0.079i$$

F) Deslizamiento nominal

$$s_n := 0.0410i \quad s_n := 0.0273i$$

$$Pm\dot{i}(s) := 3 \cdot (|I1F(s)|)^2 \cdot R_{c\_reducida}(s)$$

$$Pm\dot{i}(s_n) := 3 \cdot (|I1F(s_n)|)^2 \cdot R_{c\_reducida}(s_n) \quad Pu(s_n) := Pm\dot{i}(s_n) - P_{mec} \quad Pm\dot{i}(s_n) = 9.18 \times 10^3$$

$$n_n := n_s \cdot (1 - s_n) \quad n_n = 1.459 \times 10^3 \quad \text{fdp} = 0.865 \quad Pu(s_n) = 9 \times 10^3$$

$$I1F(s_n) = 11.655 - 6.231i$$

$$\text{Ang} := \text{atan}\left(\frac{|\text{Im}(I1F(s_n))|}{\text{Re}(I1F(s_n))}\right) \quad \text{fdp} := \cos(\text{Ang}) \quad Tu := \frac{Pu(s_n)}{2 \cdot \frac{\pi}{60} \cdot n} \quad Tu = 60.31$$

$$|I2F(s_n)| = 11.585$$

$$Rend_n(s_n) := \frac{Pu(s_n)}{Pu(s_n) + P_{mec} + P_{fe} + 3 \cdot (I1F(s_n)^2) \cdot R_{cc}}$$

$$R_{c\_reducida}(s_n) = 17.518$$

$$Rend_n(s_n) = 0.927 + 0.041i \quad 3 \cdot (I1F(s_n)^2) \cdot R_{cc} = 288.924 - 432.508i$$

g) Resistencia adicional para par de arranque el máximo.

$$Ra\_reducida := \left( \sqrt{R1^2 + Xcc^2} \right) - R2reducida \quad Ra\_reducida = 3.536$$

$$Ra := \frac{Ra\_reducida}{rt^2}$$

$$Ra = 0.884 \quad R2a\_reducida := R2reducida + Ra\_reducida$$

$$Ta(s) := \frac{3 \cdot Un1F^2 \cdot \frac{R2a\_reducida}{s}}{2 \cdot \frac{\pi}{60} \cdot ns \cdot \left[ \left( R1 + \frac{R2a\_reducida}{s} \right)^2 + (X1 + X2reducida)^2 \right]}$$

$$Ta(1) = 101.506$$

$$Rca\_reducida(s) := (R2a\_reducida + Ra\_reducida) \cdot \left( \frac{1}{s} - 1 \right)$$

$$I2aF(s) := \frac{Un1F}{Z1 + Z2reducida + Ra\_reducida + Rca\_reducida(s)}$$

$$I1aF(s) := Io + I2aF(s)$$

$$I1aF(1) = 27.563 - 27.823i \quad |I1aF(1)| = 39.165$$



