II. Calculate Needed Constants

$$P_{\text{max}} = \frac{3 \cdot V \cdot E}{X_s} \quad P_{\text{max}} = 89.802 \text{ MW}$$

$$\omega_{\text{sm}} = \frac{2 \pi \cdot 60}{N_p / 2} \text{ rad/sec} \quad \omega_{\text{sm}} = 13.464 \text{ Hz} \quad \text{mechanical synchronous angular velocity}$$

III. Pretransient Operating Conditions

$$t = 0 - \varepsilon$$

$$P_{e0} := P_m \quad P_{e0} = P_{\text{max}} \sin(\delta_0)$$

$$\delta_0 := \sin\left(\frac{P_{e0}}{P_{\text{max}}}\right) \quad \delta_0 = 0.793 \text{ rad} \quad \delta_0 = 45.453 \text{ deg}$$
IV. Transient, Calculating $\delta_x$

A. Reclose after 5 cycle

\[ \alpha := \frac{N_p}{2} \frac{P_m}{J \omega_{sm}} \quad \alpha = 53.624 \frac{1}{s^2} \quad \text{\( \alpha \) is angular acceleration} \]

\[ T_C := \frac{5}{60} \text{sec} \quad T_C = 0.083 \text{ s} \quad \text{T is reclosure time} \]

\[ \omega_R := \alpha \cdot T_C \quad \omega_R = 4.469 \frac{\text{rad}}{\text{sec}} \]

\[ \delta_C := \delta_0 + \frac{\alpha}{2} \cdot T_C^2 \quad \delta_C = 0.98 \text{ rad} \quad \delta_C = 56.122 \text{ deg} \]

$\delta_u := 1.8 \quad \text{initial guess}$

Given

\[ P_m \left( \delta_u - \delta_0 \right) = P_{\max} \left( \cos(\delta_C) - \cos(\delta_u) \right) \]

$\delta_x := \text{Find}(\delta_u)$

$\delta_x = 1.559 \text{ rad} \quad \delta_x = 89.335 \text{ deg}$

B. Reclose after 6.5 cycle

\[ T_C := \frac{6.5}{60} \text{sec} \quad T_C = 0.108 \text{ s} \]

\[ \omega_r := \alpha \cdot T_C \quad \omega_r = 5.809 \frac{\text{rad}}{\text{sec}} \]

\[ \delta_C := \delta_0 + \frac{\alpha}{2} \cdot T_C^2 \quad \delta_C = 1.108 \text{ rad} \quad \delta_C = 63.483 \text{ deg} \]

$\delta_u := 1.8 \quad \text{initial guess}$

Given

\[ P_m \left( \delta_u - \delta_0 \right) = P_{\max} \left( \cos(\delta_C) - \cos(\delta_u) \right) \]

$\delta_x := \text{Find}(\delta_u)$

$\delta_x = 1.987 \text{ rad} \quad \delta_x = 113.835 \text{ deg}$
V. Transient, Calculating $\delta_{cr}$  

$\delta_{max} := \pi - \delta_0$ only true for round rotor machine  

$\delta_{max} = 2.348 \text{ rad}$  

$\delta_{u} := 65 \text{ deg}$ initial guess  

Given  

$P_m(\delta_{max} - \delta_0) = P_{max} \cos(\delta_u) - \cos(\delta_{max})$  

$\delta_{cr} := \text{Find}(\delta_u)$  

$\delta_{cr} = 1.152 \text{ rad}$  

$\delta_{cr} = \delta_0 + \frac{1}{2} \cdot \alpha \cdot T_{CR}^2$  

$T_{CR} := \sqrt{(\delta_{cr} - \delta_0)^2 \alpha}$  

$T_{CR} = 0.116 \text{ s}$  

$\text{cycles} := 1$  

$T_{CR} \cdot 60 \text{ Hz} = 6.939 \text{ cycles}$  

V. Transient, $T_C = 0.85 \ T_{CR}$  

$T_C := 0.85 \cdot T_{CR}$  

$\omega_r := \alpha \cdot T_C$  

$\omega_r = 5.272 \frac{\text{rad}}{\text{sec}}$  

$\delta_C := \delta_0 + \frac{\alpha}{2} \cdot T_C^2$  

$\delta_C = 1.052 \text{ rad}$  

$\delta_{u} := 1.8$ initial guess  

Given  

$P_m(\delta_u - \delta_0) = P_{max} \cos(\delta_C) - \cos(\delta_u)$  

$\delta_{max} := \text{Find}(\delta_u)$  

$\delta_{max} = 1.78 \text{ rad}$  

$\delta_{max} = 101.997 \text{ deg}$