

Project Report cum Assignment Submission for
EE 523: Power System Stability and Control

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$$\begin{aligned}
&0 = 376.9911 \omega_2 - 376.9911 \\
&0 = 376.9911 \omega_3 - 376.9911 \\
&0 = 376.9911 \omega_4 - 376.9911 \\
&0 = 0.0085 P_{\text{m}2} - 0.0171 \omega_2 - 0.0427 \\
&0 = 0.0090 P_{\text{m}3} - 0.0180 \omega_3 - 0.0467 \\
&0 = 0.0090 P_{\text{m}4} - 0.0180 \omega_4 - 0.0450 \\
&0 = 0.1250 V_{\text{R}2} - 0.0208 I_{\text{d}2} - 0.1250 E'_{\text{q}2} \\
&0 = 0.1250 V_{\text{R}3} - 0.0208 I_{\text{d}3} - 0.1250 E'_{\text{q}3} \\
&0 = 0.1250 V_{\text{R}4} - 0.0208 I_{\text{d}4} - 0.1250 E'_{\text{q}4} \\
&0 = 0.3194 I_{\text{q}2} - 2.5000 E'_{\text{d}2} \\
&0 = 0.3194 I_{\text{q}3} - 2.5000 E'_{\text{d}3} \\
&0 = 0.3194 I_{\text{q}4} - 2.5000 E'_{\text{d}4} \\
&0 = 5000 V_{\text{ref}2} - 100 V_{\text{R}2} - 5050 \\
&0 = 5000 V_{\text{ref}3} - 100 V_{\text{R}3} - 5150 \\
&0 = 5000 V_{\text{ref}4} - 100 V_{\text{R}4} - 5050 \\
&0 = 0.0100 P_{\text{C}2} - 0.0100 P_{\text{m}2} - 0.2000 \omega_2 + 0.2000 \\
&0 = 0.0100 P_{\text{C}3} - 0.0100 P_{\text{m}3} - 0.2000 \omega_3 + 0.2000 \\
&0 = 0.0100 P_{\text{C}4} - 0.0100 P_{\text{m}4} - 0.2000 \omega_4 + 0.2000 \\
&0 = I_{\text{d}2} - 6.9364 \sin(\theta_2 + 0.1631) \\
&0 = I_{\text{d}3} - 7.0970 \sin(\theta_3 + 0.3319) \\
&0 = I_{\text{d}4} - 6.9954 \sin(\theta_4 + 0.5076) \\
&0 = I_{\text{q}2} - 6.9364 \cos(\theta_2 + 0.1631) \\
&0 = I_{\text{q}3} - 7.0970 \cos(\theta_3 + 0.3319) \\
&0 = I_{\text{q}4} - 6.9954 \cos(\theta_4 + 0.5076) \\
&0 = V_{\text{q}2} - 1.0100 \cos(\theta_2 + 0.1631) \\
&0 = V_{\text{q}3} - 1.0300 \cos(\theta_3 + 0.3319) \\
&0 = V_{\text{q}4} - 1.0100 \cos(\theta_4 + 0.5076) \\
&0 = V_{\text{d}2} - 1.0100 \sin(\theta_2 + 0.1631) \\
&0 = V_{\text{d}3} - 1.0300 \sin(\theta_3 + 0.3319) \\
&0 = V_{\text{d}4} - 1.0100 \sin(\theta_4 + 0.5076) \\
&0 = I_{\text{d}2} - 30 E'_{\text{q}2} + 30 V_{\text{q}2} \\
&0 = I_{\text{d}3} - 30 E'_{\text{q}3} + 30 V_{\text{q}3} \\
&0 = I_{\text{d}4} - 30 E'_{\text{q}4} + 30 V_{\text{q}4} \\
&0 = 16.3636 E'_{\text{d}2} + I_{\text{q}2} - 16.3636 V_{\text{d}2} \\
&0 = 16.3636 E'_{\text{d}3} + I_{\text{q}3} - 16.3636 V_{\text{d}3} \\
&0 = 16.3636 E'_{\text{d}4} + I_{\text{q}4} - 16.3636 V_{\text{d}4}
\end{aligned}$$

$$\left(\begin{array}{l}
0 = 0.0085 P_{\text{m}2} - 0.0171 \omega_2 - 0.0118 E'_{\text{d}2}{}^2 - 0.0118 E'_{\text{q}2}{}^2 - 0.0716 \cos \left(\theta_2 + \text{atan} \left(\frac{E'_{\text{q}2}}{E'_{\text{d}2}} \right) - 2.9380 \right) \sigma_1 - 0.0148 E'_{\text{d}2}{}^2 - 0.0148 E'_{\text{q}2}{}^2 \\
0 = 0.1250 V_{\text{R}2} - 0.1250 E'_{\text{q}2} \\
0 = 2.6749 \sin (2.9380) \\
0 = \frac{5000 \left(0.2791 \cos(2.9380) \right)}{1} \\
\\
0 = 0.0090 P_{\text{m}3} - 0.0180 \omega_3 - 0.0128 \cos \left(\theta_3 + \text{atan} \left(\frac{E'_{\text{q}3}}{E'_{\text{d}3}} \right) - 2.3834 \right) \sigma_2 - 0.0148 E'_{\text{d}3}{}^2 - 0.0148 E'_{\text{q}3}{}^2 \\
0 = 0.1250 V_{\text{R}3} - 0.1250 E'_{\text{q}3} \\
0 = 0.4542 \sin (2.3834) \\
0 = \frac{5000 \left(0.0474 \cos(2.3834) \right)}{1} \\
\\
0 = 0.0090 P_{\text{m}4} - 0.0180 \omega_4 - 0.0178 \cos \left(\theta_4 + \text{atan} \left(\frac{E'_{\text{q}4}}{E'_{\text{d}4}} \right) - 2.3553 \right) \sigma_1 - 0.0261 E'_{\text{d}4}{}^2 - 0.0261 E'_{\text{q}4}{}^2 \\
0 = 0.1250 V_{\text{R}4} - 0.1250 E'_{\text{q}4} \\
0 = 0.6319 \sin (2.3553) \\
0 = \frac{5000 \left(0.0659 \cos(2.3553) \right)}{1}
\end{array} \right)$$

where

$$\sigma_1 = \sqrt{E'_{\text{d}4}{}^2 + E'_{\text{q}4}{}^2}$$

$$\sigma_2 = \sqrt{E'_{\text{d}3}{}^2 + E'_{\text{q}3}{}^2}$$

$$\sigma_3 = \sqrt{E'_{\text{d}2}{}^2 + E'_{\text{q}2}{}^2}$$

$$\sigma_4 = \theta_3 - \theta_2 + \text{atan} \left(\frac{E'_{\text{q}3}}{E'_{\text{d}3}} \right) + 0.7527$$

$$\sigma_5 = \theta_2 - \theta_3 + \text{atan} \left(\frac{E'_{\text{q}2}}{E'_{\text{d}2}} \right) + 0.7527$$

$$\sigma_6 = \theta_4 - \theta_2 + \text{atan} \left(\frac{E'_{\text{q}4}}{E'_{\text{d}4}} \right) + 0.7246$$

$$\sigma_7 = \theta_2 - \theta_4 + \text{atan} \left(\frac{E'_{\text{q}2}}{E'_{\text{d}2}} \right) + 0.7246$$

$$\sigma_8 = \theta_4 - \theta_3 + \text{atan} \left(\frac{E'_{\text{q}4}}{E'_{\text{d}4}} \right) + 1.1326$$

$$\sigma_9 = \theta_3 - \theta_4 + \text{atan} \left(\frac{E'_{\text{q}3}}{E'_{\text{d}3}} \right) + 1.1326$$

$$\sigma_{10} = \text{atan} \left(\frac{E'_{\text{q}2}}{E'_{\text{d}2}} \right) - 1.4401$$

$$\sigma_{11} = \text{atan} \left(\frac{E'_{\text{q}3}}{E'_{\text{d}3}} \right) - 1.3720$$