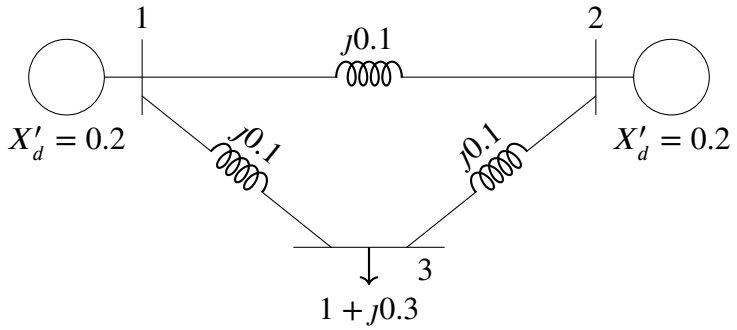
Indian Institute of Technology Patna
Department of Electrical Engineering
EE549 - Power System Dynamics and Control
Spring - 2022
End Semester Exam
April 27, 2022

Time : 3 Hour Marks : 50

The DAE (Differential Algebraic Equations) of the flux decay model excluding exciter dynamics are

$$
\begin{aligned}
T'_{d0}\frac{dE'_q}{dt} &= -E'_q - (X_d - X'_d)I_d + E_{fd} \\
\frac{d\delta}{dt} &= \omega - \omega_s \\
\frac{2H}{\omega_s}\frac{d\omega}{dt} &= T_m - T_e - D(\omega - \omega_{base}) \\
V_q + R_s I_q &= -X'_d I_d + E'_q \\
V_d + R_s I_d &= X_q I_q
\end{aligned}
$$

1. The voltage at the node 3 is $0.98\angle 10°$. Reduce the bus admittance matrix. Assume the load is of constant impedance type.



2. Consider a SMIB system.

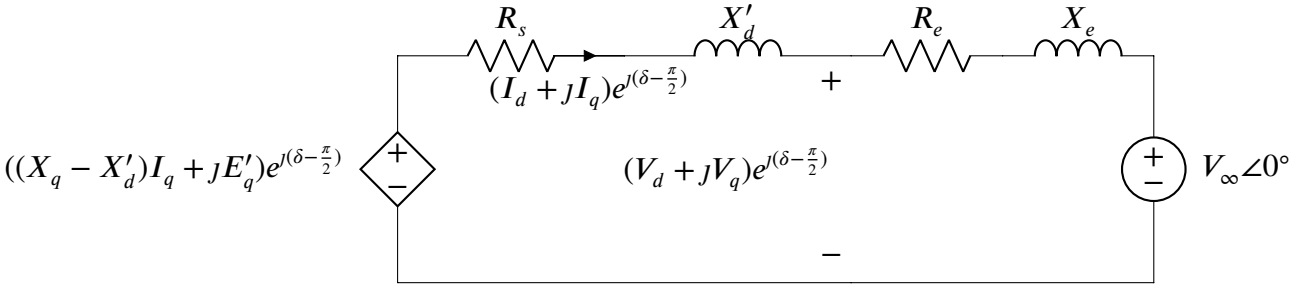


Figure 1: Synchronous Machine Flux Decay Model

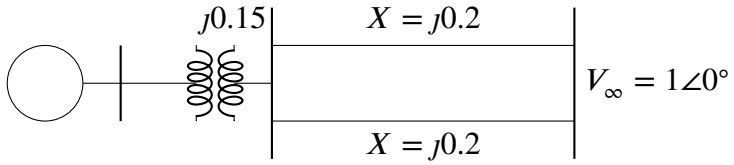
   (a) Determine T_e.
   (b) Express T_e in terms of δ and E'_q.

3. Consider a SMIB system. The synchronous generator is represented using the flux decay model. The generator parameters are as follows:

$$X_d = 1.8 \quad X_q = 1.7 \quad X'_d = 0.17 \quad R_a = 0.003 \quad T'_{do} = 0.4 \text{ s} \quad H = 4 \quad D = 0$$

   If the terminal conditions are

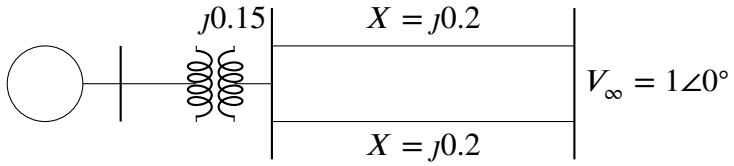
$$P_t = 1.0 \quad |V_t| = 1.0$$



(a) Find the initial conditions.

(b) Prove that $T_e = P_t + I_a^2 R_a$.

4. Consider a SMIB system. The synchronous generator is represented using the classical model.



The generator parameters are as follows:

$$X'_d = 0.3 \quad H = 3.5 \quad D = 0 \quad f = 60 \text{ Hz}$$

If the prefault system conditions are

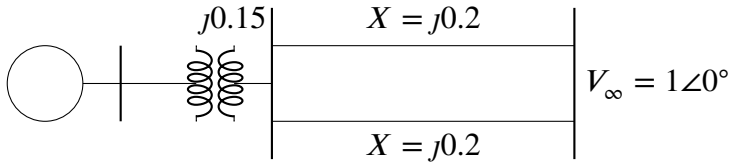
$$P_t = 1.0 \quad |V_t| = 1.0$$

Analyze the transient stability of the system for a solid three phase fault at the sending end on one of the transmission lines. The fault is cleared by simultaneously opening the circuit breakers at both ends of the line.

(a) Determine the critical clearing angle and time using the Equal Area Criterion.

(b) Verify it using the energy function method.

5. Consider a SMIB system. The synchronous generator is represented using the classical model.



The generator parameters are as follows:

$$X'_d = 0.3 \quad H = 3.5 \quad D = 0 \quad f = 60 \text{ Hz}$$

Analyze the small signal characteristics of the system about the steady operating condition following the loss of one line. The post fault system conditions at the machine terminal are

$$P_t = 1.0 \quad |V_t| = 1.0$$

(a) determine the time response of δ if $\Delta\delta = 5°$

(b) determine the time response of ω if $\Delta\omega = 0$