ECE 523: Homework #6

Due Session 30 (December 12)

1. A cylindrical rotor, synchronous machine with the machine parameters given below is operating at rated current (1.0 pu) and 85% lagging power factor when a 3 fault occurs at the machine terminals. Compute:

(a) The steady-state voltage \( E_q \) behind the synchronous impedance. Plot a phasor diagram showing \( E_q \), \( V_a \) (terminal voltage), and \( I_a \)

(b) The voltage \( E'' \) behind the synchronous impedance

(c) The initial symmetrical fault current

(d) The peak symmetrical current after 5 cycles and 10 cycles.

(e) The maximum asymmetrical current after 5 cycles and 10 cycles.

\[
\begin{align*}
\text{pu} & := 1 & X_d := 1.05 \text{pu} & & X''_d := 0.12 \text{pu} & & T_{d0} := 5.6 \text{sec} \\
& & X_q := 1.02 \text{pu} & & X''_q := 0.15 \text{pu} & & T'_d := 1.1 \text{sec} \\
& & X'_d := 0.23 \text{pu} & & X_2 := 0.12 \text{pu} & & T''_d := 0.035 \text{sec} \\
& & X'_q := 0.23 \text{pu} & & R_a := 0.0055 \text{pu} & & T_a := 0.16 \text{sec}
\end{align*}
\]

2. Repeat problem 1 using the data for the salient pole machine given below.

\[
\begin{align*}
X_d := 1.25 \text{pu} & & X''_d := 0.24 \text{pu} & & T_{d0} := 5.6 \text{sec} \\
X_q := 0.75 \text{pu} & & X''_q := 0.34 \text{pu} & & T'_d := 1.8 \text{sec} \\
X'_d := 0.37 \text{pu} & & X_2 := 0.24 \text{pu} & & T''_d := 0.035 \text{sec} \\
X'_q := 0.75 \text{pu} & & R_a := 0.009 \text{pu} & & T_a := 0.15 \text{sec}
\end{align*}
\]

3. A 2000 HP, 4160V, induction motor operates at a slip of 2%, with 93% efficiency at rated load. The machine parameters are given below. Assume a power factor of 0.85 lagging at rated conditions. Do the following:

(a) Sketch the positive and negative sequence equivalent circuits using the machines ratings as a base.

(b) Convert the equivalent circuits of part A to a 4160V, 100MVA base

(c) Compute the initial fault current provided by the machine to a 3 phase fault at the motor terminals (rated prefault voltage at the terminals and rated load).

(d) Repeat part C for a LL fault

\[
\begin{align*}
R_s := 0.02 \text{pu} & & X_s := 0.075 \text{pu} & & R_r := 0.02 \text{pu} & & X_r := 0.075 \text{pu} & & X_m := 3.0 \text{pu}
\end{align*}
\]
4. Given a three winding autotransformer whose H, X, and Y windings are rated at 200kV, 100kV and 10kV respectively and with short circuit test impedances of:

\[
\begin{align*}
V_h &: 200kV \\
V_x &: 100kV \\
V_y &: 10kV \\
Z_{hx} &: 10\% \\
S_{bhx} &: 30MVA \\
Z_{xy} &: 9\% \\
S_{bxy} &: 10MVA \\
Z_{hy} &: 15\% \\
S_{bhy} &: 10MVA
\end{align*}
\]

Compute the following in pu on a 50 MVA base.
Assume the H and X are connected Y-grounded, and the Y is delta.

(a) Equivalent circuit impedances \( Z_h, Z_x, \) and \( Z_y \). Sketch positive, negative and zero sequence diagrams

(b) Autotransformer equivalent circuit impedances \( Z_c, Z_t, \) and \( Z_s \)