ECE 523: Homework #5

Due Session 28 (Nov 28)

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.

pu := 1  
$X_d := 1.05pu$  
$X''_d := 0.12pu$  
$T''_d := 5.6sec$

$X_q := 1.02pu$  
$X''_q := 0.15pu$  
$T'_d := 1.1sec$

$X'_d := 0.23pu$  
$X_2 := 0.12pu$  
$T''_d := 0.035sec$

$X'_q := 0.23pu$  
$R_a := 0.0055pu$  
$T_a := 0.16sec$

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

$X_d := 1.25pu$  
$X''_d := 0.24pu$  
$T''_d := 5.6sec$

$X_q := 0.75pu$  
$X''_q := 0.34pu$  
$T'_d := 1.8sec$

$X'_d := 0.37pu$  
$X_2 := 0.24pu$  
$T''_d := 0.035sec$

$X'_q := 0.75pu$  
$R_a := 0.009pu$  
$T_a := 0.15sec$

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

$R_s := 0.02pu$  
$X_s := 0.075pu$  
$R_r := 0.02pu$  
$X_r := 0.075pu$  
$X_m := 3.0pu$
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 $Z_s$