COLORADO SCHOOL OF MINES
ELECTRICAL ENGINEERING DEPARTMENT

EENG577
PM Machine Project

A 6-pole, three-phase permanent magnet type "synchronous" machine has a phase self-inductance of 150 μH and a phase-to-phase mutual inductance of 15 μH. At an electrical angular speed of 1,337 rad/sec, the rotor radially mounted permanent magnets induced the following back emf's in the a, b, and c phases of the stationary armature:

$e_a = E_m \cos(\omega t - 0.46)$ Volts
$e_b = E_m \cos(\omega t - 0.46 - 2\pi/3)$ Volts
$e_c = E_m \cos(\omega t - 0.46 - 4\pi/3)$ Volts
where, $E_m = 63$ Volts.

The three armature phases are Y-connected with an isolated (floating) neutral, that is $i_a + i_b + i_c = 0$ and has a per-phase resistance of 9.4 mΩ.

I. Formulations: Consider the PM machine at hand.

1) Draw the schematic diagram (assume a simplified 2-pole structure for this schematic) and label all axes, assuming radial type PM structure.
2) Write down the reduced State Space model in expanded matrix form show the numerical values of matrices A and B.

II. PM Motor Operation: At time, t = 0, the machine was connected to a 3-phase voltage source, where a, b, and c voltages to neutral can be expressed as follows:

$v_a = V_m \cos(\omega t)$
$v_b = V_m \cos(\omega t - 2\pi/3)$
$v_c = V_m \cos(\omega t - 4\pi/3)$
where $V_m = 74$ volts

At t=0, the a, b, and c phase currents were all zero while the rotor was rotating (by an external source) at the speed of ω of 1,337 electrical rad/sec (same angular frequency as the voltage source). Using Simulink, *preferably*, or using MATLAB, find phases a, b, and c transient current profiles, assuming that the external mechanical sources were decoupled from the machine at the same instant the armature was energized from the voltage source. Solve for the current profiles, determine the torque, and plot throughout the transient period (20 ac cycles). Discuss your results.

III. PM Generator Operation: At t=0, with the external mechanical source running the machine at a speed ω = 1,337 electrical rad/sec, the three phase terminals were all shorted to the neutral point of the Y-connected armature. Using Simulink, preferably, or using MATLAB, obtain the phase a, b, and c phase current profiles as well as the torque, and plot over 20 ac cycles following the onset of the short circuit.
(Note: initially $i_a = i_b = i_c = 0$).
Discuss your results.

IV. Contributions: As a Team, complete the following table and include with your submission:

Tasks	**Name of Member #1:**	**Name of Member #2:**	**Name of Member #3:**
Formulations & Calculations	% Contribution:	% Contribution:	% Contribution:
MATLAB/Simulink Coding	% Contribution:	% Contribution:	% Contribution:
Report Writing	% Contribution:	% Contribution:	% Contribution:
Overall % Contribution/Member	% Contribution:	% Contribution:	% Contribution:

Notes:

- **The report must be typed and neat and all plots are properly labeled and easy to read.**
- **The body of the report should include, for each part, all relevant formulas. If it was implemented in Matlab/Simulink, you should briefly describe how that was done.**
- **Discuss your results.**
- **Include the listing of your program.**
- **Follow the rubric closely.**
- ***As a group project,*** *you can discuss the problem with other students in EENG 577, however, each Team should work independently.*