Name: ________________________________

You must work by yourself on this exam/homework. That is, you may only talk to the course instructor about this exam/homework. Please attach a summary of your answers to the front of your work. Maximum length of the summary is two pages. The exam/homework must be in my hands or on my computer no later than Monday, December 17th by 5:00 pm. The sooner the better for me.

1 __________ / 6 pts
2 __________ / 27 pts
3 __________ / 27 pts
4 __________ / 9 pts
5 __________ / 24 pts
6 __________ / 7 pts

Total __________ / 100 pts

JDL/jdl
The parameters for a three phase, 460 \text{V} \text{ll}, 500 \text{kW} induction machine, a three phase, 460 \text{V} \text{ll}, 10 \text{kW} induction machine, and a three phase, 460 \text{V} \text{ll}, 250 \text{kW} induction machine are given below on their own bases. The machines are connected in wye with individual floating neutrals.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>500 kW</th>
<th>10 kW</th>
<th>250 kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_s$</td>
<td>0.010 p.u.</td>
<td>0.080 p.u.</td>
<td>0.090 p.u.</td>
</tr>
<tr>
<td>$X_{ls}$</td>
<td>0.125 p.u.</td>
<td>0.085 p.u.</td>
<td>0.100 p.u.</td>
</tr>
<tr>
<td>$X_m$</td>
<td>5.000 p.u.</td>
<td>1.000 p.u.</td>
<td>4.000 p.u.</td>
</tr>
<tr>
<td>$X_{lr}$</td>
<td>0.125 p.u.</td>
<td>0.085 p.u.</td>
<td>0.100 p.u.</td>
</tr>
<tr>
<td>$R_r$</td>
<td>0.008 p.u.</td>
<td>0.070 p.u.</td>
<td>0.010 p.u.</td>
</tr>
<tr>
<td>Base</td>
<td>500 kVA</td>
<td>10 kVA</td>
<td>250 kVA</td>
</tr>
</tbody>
</table>

Designate the star-point:

- of the source with a “g”,
- of the 500 kW machine with an “n”,
- of the 10 kW machine with a “d”, and
- of the 250 kW machine with a “s”.

The star-points of the three machines (“n”, “d”, & “s”) are not grounded.

Please work these problems using pu.
Use 500 kVA as the power base and 460 V as the voltage base.
1. Initially only the 500 kW machine is on line. The machine is initially operating at a slip, $s_1$, equal to 0.0078 p.u. from a balanced three phase grounded wye connected source with a line to neutral voltage magnitude of 1.0 p.u. Use the “A” phase source voltage as the phase reference throughout this problem.

(a) Calculate the “A” phase line current.
(b) Calculate the rotor and stator conduction losses.
(c) Calculate the electrical torque.

2. “A” phase opens between the machines and the source. Assume the 500 kW machine is now operating with a slip, $s_1$, equal to 0.009.

(a) Calculate the “a”, “b”, & “c” phase currents of the 500 kW machine.
(b) Calculate $V_{an}, V_{bn}, \text{ & } V_{cn}$.
(c) Calculate $V_{ng}$ at $s_{1,500kW} = 0.009$.
(d) Calculate $V_{ag}, V_{bg}, \text{ & } V_{cg}$.
(e) Calculate the rotor and stator conduction losses of the 500 kW machine.
(f) Calculate the electrical torque of the 500 kW machine.
3. “A” phase remains open between the machines and the source. The 10 kW machine is put in parallel with the 500 kW machine. Assume the 500 kW machine continues to operating with a slip, \( s_1 \), equal to 0.009. With the purpose of determining the magnitude of the 10 kW machine starting torque: (Note: At starting the slip of the 10 kW machine is 1.0.)

(a) Calculate the “a”, “b”, & “c” phase currents of the 10 kW machine at \( s_{1,10kW} = 1.0 \).
(b) Calculate \( V_{ad}, V_{bd}, \) & \( V_{cd} \) at \( s_{1,10kW} = 1.0 \).
(c) Calculate \( V_{dg} \) at \( s_{1,10kW} = 1.0 \).
(d) Calculate \( V_{ag}, V_{bg}, \) & \( V_{cg} \) at \( s_{1,10kW} = 1.0 \).
(e) Calculate the electrical torque of the 10 kW machine at \( s_{1,10kW} = 1.0 \).

4. For the purpose of evaluating a simplification of problem 3, assume that the starting of the 10 kW machine doesn’t change the voltages of the 500 kW machine determined in part 2.b.

(a) Calculate the “a”, “b”, & “c” phase currents of the 10 kW machine.
(b) Calculate the electrical torque of the 10 kW machine.
(c) Is this approximation reasonable?
5. Repeat problem 3, but evaluating starting of the 250 kW instead of the 10 kW induction machine. “A” phase remains open between the machines and the source. The 250 kW machine is put in parallel with the 500 kW machine. (The 10 kW is not involved.) Assume the 500 kW machine continues to operating with a slip, $s_1$, equal to 0.009. With the purpose of determining the magnitude of the 250 kW machine starting torque:

(Note: At starting the slip of the 250 kW machine is 1.0.)

(a) Calculate the “a”, “b”, & “c” phase currents of the 250 kW machine at $s_{1,250kW} = 1.0$.

(b) Calculate $V_{as}, V_{bs},$ & $V_{cs}$ at $s_{1,250kW} = 1.0$.

(c) Calculate $V_{sg}$ at $s_{1,250kW} = 1.0$.

(d) Calculate $V_{ag}, V_{bg},$ & $V_{cg}$ at $s_{1,250kW} = 1.0$.

(e) Calculate the electrical torque of the 250 kW machine at $s_{1,250kW} = 1.0$.

6. For the purpose of evaluating a simplification of problem 5, assume that the starting of the 250 kW machine doesn’t change the voltages of the 500 kW machine determined in part 2.b.

(a) Calculate the “a”, “b”, & “c” phase currents of the 250 kW machine.

(b) Calculate the electrical torque of the 250 kW machine.

(c) Is this approximation reasonable?