# EE 498C, Spring 2002 Exam 1 <br> 7 March, 2002 

Show all your work and your answers clearly on the test pages. In any plots and sketches, label and include units (if possible) on anything that might be of interest. For full credit, simplify your answers as much as possible.

Problem 1 (15)

Problem 2 (25) $\qquad$

Problem 3 (25) $\qquad$

Problem 4 (20) $\qquad$

Problem 5 (15) $\qquad$

Total (100)
$\qquad$

1. Three-phase systems have line-to-neutral voltages of

$$
\begin{array}{r}
v_{a}(t)=V_{\max } \cos (\omega t) \\
v_{b}(t)=V_{\max } \cos \left(\omega t-120^{\circ}\right) \\
v_{c}(t)=V_{\text {max }} \cos \left(\omega t-240^{\circ}\right) .
\end{array}
$$

(a) (7 pts.) Establish the relationship between line-to-neutral (Y-connected) voltages and line-to-line voltages, using either direct evaluation or phasor representations.
(b) (8 pts.) Derive the conversions of phase impedances between Y-connected and $\Delta$ connected configurations of balanced 3-phase loads. You may use direct circuit analysis or voltage-current relationships, but in either case, show all the steps.
2. A 4-pole, synchronous, Y-connected, 3-phase generator has 50 turns of wire in each of the 12 slots in its stator, connected in series, and uniform flux 0.02 Wb in each pole of its round rotor, which rotates at 1800 rpm .
(a) (5 pts.) Find $V_{\phi}(t)$ and $V_{L}(t)$, the phase and line voltage, at the output terminals of the generator.
(b) (10 pts.) The generator is connected directly to a balanced, $\Delta$-connected load, each phase of which has impedance $\mathbf{Z}_{\phi}=3.0+j 4.0$. Compute the real, apparent and reactive power delivered to this load by the generator
(c) (10 pts.) Using the simplified model we used in class and homework, derive and sketch as precisely as possible the relationship between the rotor magnetic field, rotating counter-clockwise, and the stator field under the load in (b).
3. A 480 -volt $\left(V_{L}\right), 2$-pole, $60 \mathrm{~Hz}, \Delta$-connected 3-phase induction motor has the following parameters: stator reactance $=j 0.3 \Omega$, stator resistance $=0.2 \Omega$, rotor reactance $=$ $j 0.04 \Omega$, rotor resistance $=0.03 \Omega$, magnetization inductance $=j 30.0 \Omega$. It has mechanical and miscellaneous losses totalling 400 W and core loss of 200 W .
(a)(10 pts.) Starting with the representation of the motor as a system including an ideal transformer whose secondary voltage depends on both $a_{e f f}$, the effective turns ratio, and $s$, the rotor slip, derive the equivalent circuit in our standard form. Remember that our standard has been to put the magnetization inductance after the other stator impedances.
(b) (15 pts.) Assume that the result of (a) gives you, after substituting the appropriate value for $a_{\text {eff }}, R_{2}=0.3 \Omega$ and $X_{2}=j 0.4 \Omega$ in our usual equivalent circuit terminology. Compute the induced torque and speed of rotation when the motor operates with slip of 0.05 .
4. Below is a one-line diagram for a 3 -phase power system. The transformer impedance parameters are those of the simplified equivalent circuit, with no shunt (excitation) impedance.


Transmission line impedance $=0.5+\mathrm{j} 5.0$ ohms
(20 pts.) Find the total real power dissipated in the transmission line.
5. (15 pts.) A shunt 35 Hp DC motor which draws 120 A at full load and has equivalent circuit below has magnetization behavior as illustrated in the plot on the following page. If field resistance is set to $300 \Omega, V_{T}$ is 250 volts, and $R_{A}=0.3 \Omega$, find the induced torque and speed at both no load and full load.


