Massachusetts Institute of Technology
Department of Electrical Engineering and Computer Science
6.691 Seminar in Advanced Electric Power Systems

Problem Set 4 Issued March 19, 2006

Due April 12, 2006

This set is intended to keep you amused over Spring Break. Note that is involves setting up for simulation. Note that this set, which is intended to be short, overlaps with Problem Set 3, which is also intended to be relatively short.

Steady State Operation This problem concerns a large turbine generator with rating parameters:

Rating	P	907	MVA
Terminal Voltage	V_B	24	kV, l-l, RMS
Inertial Constant	H	4.0	s

The electrical equivalent circuits for the direct- and quadrature axes are shown in Figure 1. All values called out in this figure are in per-unit.
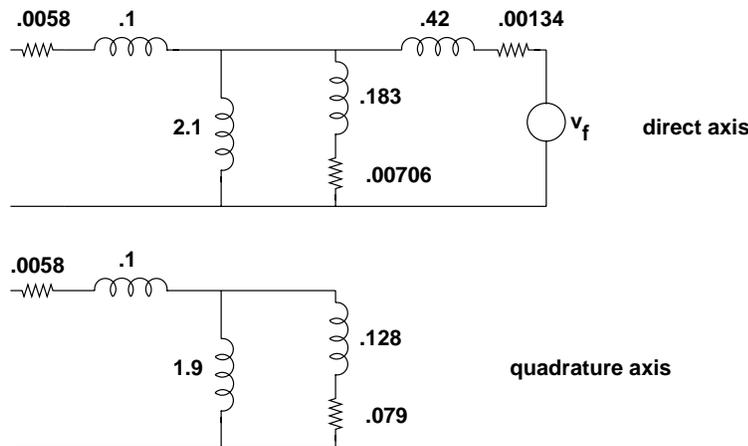

Figure 1: Direct and Quadrature Axis Equivalent Circuits

The machine is operated at rated kVA and at a power factor of 85% *lagging* (over-excited).

In preparation for a simulation it is necessary to find all of the internal fluxes and currents. Do this:

1. Draw a phasor diagram showing voltage, terminal current, direct- and quadrature- axis currents, torque angle and internal voltage.

2. Find numerical values for direct- and quadrature- axis voltage and for each of the five internal fluxes.

3. Show that you calculate the same torque (per-unit power and torque are the same) with the flux times current calculation as you do with power output, considering armature loss.

Optional other stuff If you are feeling at loose ends after setting this up, you might consider actually doing a simulation. The next problem set will have something very much like the following, so if you want to wait to do these things, that is OK.

1. Transient stability: Assume the machine is suddenly open-circuited for a short period of time (about 0.1 to 0.2 seconds) and then re-connected. Plot torque angle vs. time. The interesting question is how long can you leave it and still have it recover stable operation?

2. Short Circuit from that rated point: suddenly set voltage to zero and see what currents flow in the leads. What is shaft torque?

3. One thing that might go wrong in a new power plant is mis-wiring the synchronizing apparatus so that the first time the machine is synchronized it is 120 degrees out of phase. (How could this happen?). Simulate this situation, assuming the system nearby is really stiff (i.e. a voltage source) and that the machine is adjusted to have rated (one per-unit) voltage. Plot terminal currents vs. time and torque vs. time.