Massachusetts Institute of Technology

Department of Electrical Engineering and Computer Science

6.685 Electric Machinery

Quiz 1 **One Crib Sheet Allowed** **October 24, 2005**

Problem 1: This problem concerns the salient pole synchronous machine you analyzed in Problem Set 4. You may recall the machine had the following parameters:

VA Rating	250	MVA
Voltage Rating	24	kV (line-line, RMS)
	13,856	V (line-neutral, RMS)
D-Axis Synchronous Inductance	12.2	mHy
Q-Axis Synchronous Inductance	9.8	mHy
Field-Phase Mutual Inductance	52	mHy

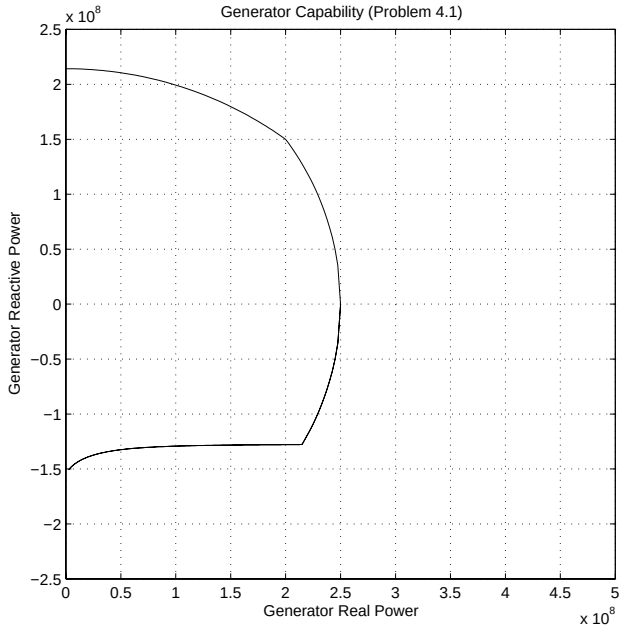

Figure 1: Capability Curve

The capability curve for this machine is shown in Figure 1. What we did not point out in the problem set is that the field current required to achieve rated voltage with the armature terminals open is $I_{fnl} = 1000A$. You might also want to verify (and use here) that the per-unit reactances, based on machine rating, are $x_d = 2.0$ and $x_q = 1.6$. Ignore the possibility of saturation and assume armature resistance is negligible. Do NOT attempt to read any of the answers from Figure 1.

1. With the machine operating at rated terminal voltage and current ($|v_a| = 1.0$, $|i_a| = 1.0$) at power factor of 0.8, real power P=200 MW and reactive power Q=150 MVA. What field current is required?
2. With the machine operated at zero real power, what is the reactive power output of the machine when field current is $I_f = 2,600\ A$?
3. What is the maximum reactive power the machine can absorb? Note that this is under-excited operation and the limit will be stability. What is the field current at the point of maximum reactive power absorption?

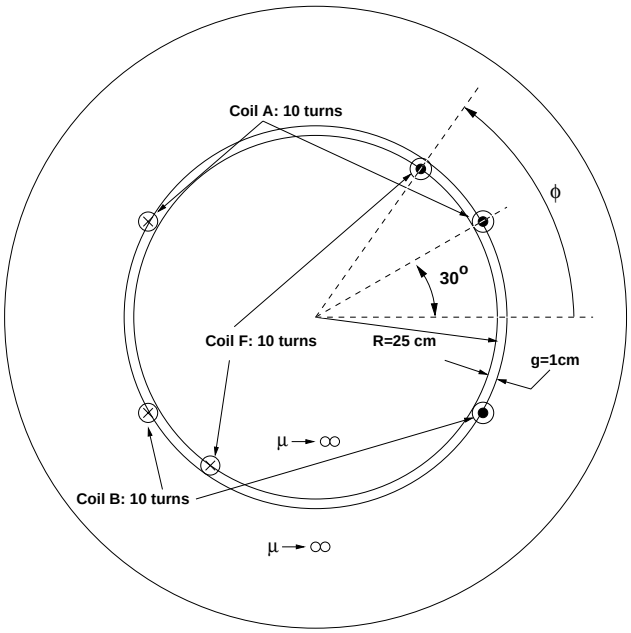

Figure 2: Axial View

Problem 2: Figure 2 shows an axial view of a skeletal kind of machine. The stator has two coils, each with 10 turns of wire. You should consider all coils to be concentrated. Coil A has sides at 30 and 150 degrees. Coil B has sides at -30 and -150 degrees. The rotor has a single, full-pitched coil with ten turns. The rotor is round and has a diameter of 1/2 meter and a length of 1 meter. The air-gap dimension is 1 cm. In this problem we are seeking dimensioned sketches and do *not* want any trig functions. Both amplitude and shape of the waveforms count. Use the blank forms provided on the last page.

1. The two stator coils are connected in series as shown. The rotor is made to turn at 2,000 RPM and the field coil carries 795.8 Amperes, DC. Make a dimensioned sketch of the voltage induced in the stator coils as a function of time. Assume that the rotor is at $\phi = 0$ at time $t = 0$.
2. The two stator coils are connected in series as shown and carry a current of 100 Amperes, Dc. The rotor (field) coil carries a current of 795.8 Amperes, DC.What torque does the machine produce as a function of the angle ϕ? Make a dimensioned sketch.

3. Now the two stator coils are connected in series, but the lower coil (B) is *reversed*. With the rotor excited and turning as in Part 1, what voltage is induced in the stator coils? Make a dimensioned sketch.

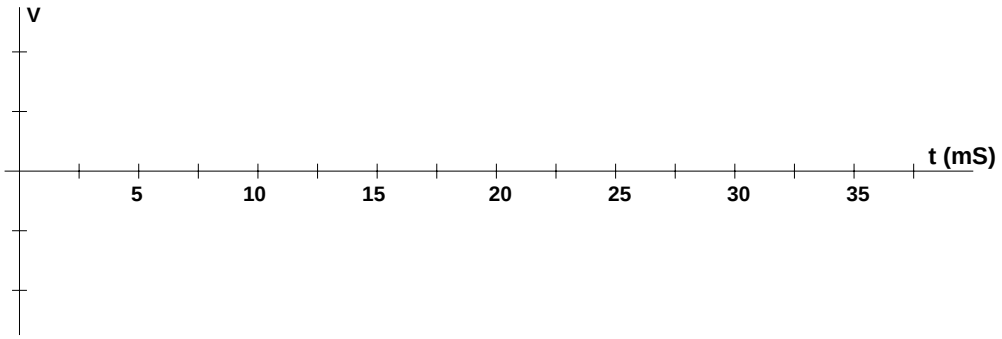

Figure 3: Induced Voltage: Series Coils, Same Sense

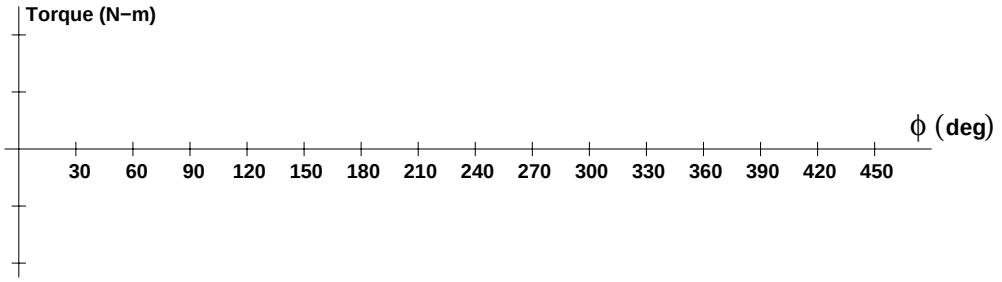

Figure 4: Torque

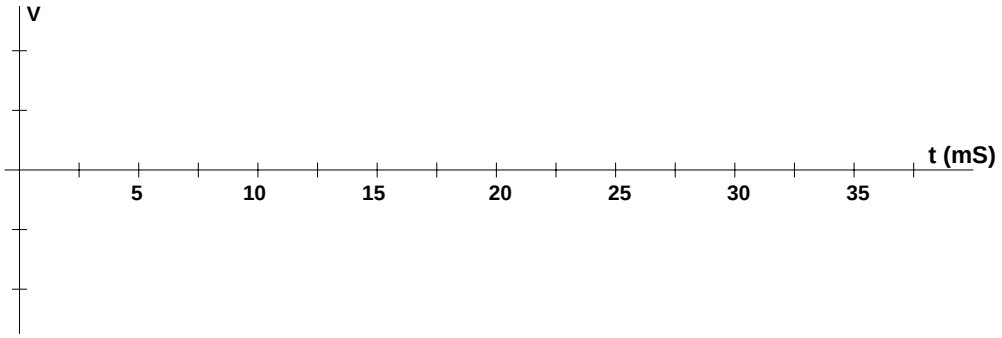

Figure 5: Induced Voltage: Series Coils, Reverse Sense