ECE 333

Second Exam – Spring 1999 – Closed book, closed notes, 55 minutes

---

Problem #1 (25 points)

Given the following test data for a 3-phase, synchronous machine:

Open circuit: $I_f = 3A$ $V_t = 120$ V (line-to-neutral) (Rated)

Short circuit: $I_f = 1A$ $I_a = 7$ A (Rated)

(a) What value of I_f is required to produce rated voltage when the machine is operating as a generator delivering rated current to an induction motor load at 0.9 power factor lag? (neglect R_a and saturation)

(b) If you use this value of I_f, will the actual V_t be lower or higher? Explain

(c) Is the machine underexcited or overexcited? Explain

(d) What will happen if I_f is accidentally reduced to zero while supplying the load of (a)?

Problem #2 (25 points)

A synchronous motor dynamic model is:

$$d\delta/dt = \omega - \omega_s$$

$$d\omega/dt = K_1 - 10 \sin\delta$$

(a) Can the motor be suddenly loaded so that K_1 changes from 0 to negative 8? Explain why or why not with figures and words.

(b) Can the motor be suddenly loaded so that K_1 changes from negative 7 to negative 8? Explain why or why not with figures and words.

(OVER)

Problem #3 (25 points)

Tests on a self-excited shunt d.c. generator with $R_a = 4$ Ohms are:

Open circuit: RPM $= 1200$, $I_f = 2A$, $V_t = 240$ V.

Short circuit: RPM $= 1200$, $I_t = 3$ A. (we never did this test)

(a) What is the open circuit voltage if the speed is changed to 1100 RPM?

(b) How much resistance should be removed from the shunt field circuit to maintain the open circuit voltage at 240 V at 1100 RPM?

Problem #4 (25 points)

A shunt d.c. motor with $R_a = 1$ Ohm and $V_t = 240$ V has the following piecewise linear model of the internal voltage at 1200 RPM:

$$E_a = 10 + 115\, I_f \qquad\qquad \text{for } 0 \le I_f \le 2A$$

$$E_a = 240 + 80\,(I_f - 2) \qquad \text{for } I_f \ge 2A$$

(a) Find the shunt field resistance needed to make the speed be 1000 RPM when it is unloaded.

(b) Find the RPM if $I_t = 10$ A (using the resistance from (a))

Spring bonus (5 points)

A shunt d.c. motor is started and runs with constant voltage at 1250 RPM. As it sits there running, the speed slowly increases slightly. Why?