ECE 333

Final Exam – Spring 1999 – Closed book, closed notes, 3 hours

One formula sheet is provided separately. Work all problems in exam book provided.

Problem #1 (30 points)

A single-phase transformer nameplate shows: 2400/120 Volts, 10KVA, 4% impedance. Assume that the % impedance is pure reactance.

(a) What is the load voltage when a 2400 Volt source is applied to the high-voltage side and the low-voltage side is loaded to rated current at unity power factor?
(b) What is the short-circuit current on the low-voltage side if the low-voltage side is shorted while the 2400 Volts is applied to the high-voltage side?

Problem #2 (30 points)

Given a 2 HP, 6 pole, 60 Hz, 230V (line-to-line) induction machine with the following blocked-rotor test data:

$V = 62$ V (line to line), $I = 4$ A, $P = 80$ W (single phase)

Assume that the stator resistance is equal to the referred rotor resistance and find estimates of:

(a) Slips for maximum torque (both motor and generator)
(b) Maximum torque (both motor and generator)
(c) Starting torque
(d) Full-load torque

Problem #3 (30 points)

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

Open circuit: $I_f = 2A$ $V = 208$ V (line-to-line) (Rated)

Short circuit: $I_f = 1A$ $I = 6$ A (Rated)

(a) What value of I_f is required to maintain unity power factor when the machine is operating as a generator delivering rated current to a fixed-voltage (infinite) bus of 208 V (line-to-line)? (neglect stator resistance and saturation)

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

(OVER)

Problem #4 (30 points)

A 28 V shunt DC motor with R_a = 1.0 Ohm and R_{SH} = 100 Ohm, K_f^{SH} = 1.2 Ohm-Seconds/Radian. Neglect residual voltage and saturation.

(a) What is the no-load speed?
(b) What is the speed when the machine is loaded with a shaft torque of 3NM?
(c) How much resistance should be added to the shunt field to make the speed be 100 Radians/second at no load?

Problem #5 (40 points)

The approximate dynamic equations for a round-rotor synchronous machine are:

$$d\delta/dt = \omega - 377 \qquad \delta(0) = \pi/6 \text{ Radians}$$

$$d\omega/dt = 5 - 10\,\text{Sin}\delta \qquad \omega(0) = 377 \text{ Radians/sec}$$

If the "load" is suddenly switched from 5 to 9 at t = .01 seconds,

(a) Find δ and ω at t = .03 seconds using Euler's method with a time step of .01 sec.
(b) Will the machine return to a speed of 377 Radians/sec? Show why or why not with detailed calculations (not using Euler's method).

Problem #6 (40 points)

A shunt DC motor is mechanically coupled to a three-phase, round-rotor synchronous generator. The DC motor is connected to a 230 V constant voltage DC supply, and the synchronous generator is connected to a 230 V (line-to-line) constant voltage, constant frequency three-phase supply (infinite bus). The synchronous machine is rated 5 KVA (3 phase), 230 V (line-to-line) and has a synchronous reactance of 1.5 Ohms. The DC motor is rated 5 KW, 230 V. Neglect the synchronous machine and DC machine armature resistances.

Assume that the two machine fields are adjusted such that the synchronous machine delivers rated KVA at unity power factor to the AC supply. The DC motor draws 26 Amps.

(a) Find the magnitude of the synchronous machine armature (stator) current.
(b) What is the synchronous machine torque angle?
(c) What is the DC machine shunt field resistance?
(d) Assume that the DC drive motor is accidentally disconnected entirely from the DC source. Find the resulting magnitude of the synchronous machine stator current.