University of Saskatchewan

Department of Electrical & Computer Engineering

EE 341.3 Electric Machines I (Term 2)

Final Examination

Dated: April 21, 2008 **Time: 2:00pm – 5:00 pm**

Instructor: Dr. Ramakrishna (Rama) Gokaraju **Total Marks: 50**

Instructions:

1) This examination paper consists of 9 problems and 2 pages in total.
2) This is a closed-book examination. Three-page formula sheet is allowed. Solved examples are not allowed in the formula sheet.
3) Your solutions have to be methodical. Write the steps of your numerical computations clearly. You will be penalized if your solutions are illegible.

Problem 1

A 150 kVA, 2,080/208 V, 60 Hz, three-phase Y-Δ connected transformer consists of three identical single-phase transformers. Each transformer has the following parameters R_H=0.45 Ω, X_H = 2.2 Ω, R_L=4.5 mΩ, X_L=22 mΩ, $R_{c,H}$=10 kΩ (found from high-voltage side) and $X_{m,H}$=8 kΩ (found from high-voltage side). The load on the transformer is 120 kVA, 90 kW (lagging) at the rated terminal voltage. Determine the primary winding voltage and current, and the secondary winding voltage and current.

6 Marks

Problem 2

A 208 V, 60 Hz, three-phase, Y-connected, synchronous motor has a synchronous reactance of j4 Ω/phase. The motor takes 30 A on full load at a unity power factor. If the field current is held constant and the load is gradually increased until the motor develops the maximum torque, determine (a) new power factor, (b) torque angle, and (c) power developed by the motor.

6 Marks

Problem 3

A 460 V, Y-connected, three-phase synchronous motor takes 30 kW at full load when the power factor is unity. The synchronous reactance is 4 Ω/phase and the winding resistance is negligible. For a constant power output at 0.8 pf leading, what must be the change in excitation voltage? What is the new power angle and armature current.

6 Marks

Problem 4

A 4-pole, 230 V, 60 Hz, Y-connected, three-phase induction motor has the following parameters on a per-phase basis: R_1 = 10.12 Ω, X_1 = 38.61 Ω, R_2 = 21.97 Ω, X_2 = 11.56 Ω, and X_M = 432.48 Ω. The core loss is 10.72 W and the friction and windage loss is 5.9 W. When the motor operates at its rated speed of 1550 rpm, determine (a) power input, (b) stator copper loss, (c) rotor copper loss, (d) air-gap power, (e) power developed, (f) shaft torque, and (g) its efficiency.

6 Marks

Problem 5

The following test data apply to a 208 V, 4-pole, 60 Hz, slip-ring, Y-connected, three-phase induction motor:

No-load Test:
Power input = 360 W, line current = 2 A at the rated voltage.

Blocked-rotor test:
power input = 600 W, line current = 20 A at a reduced voltage of 30 V.

The friction and windage loss is 36 W. The stator winding resistance between any two lines is 0.2 Ω. Use $f_{test} = 45Hz$ under blocked-rotor condition. Obtain the equivalent circuit parameters of the motor.

6 Marks

Problem 6

An 8-pole, 230 V, 60 Hz, Δ-connected, three-phase induction motor has a rotor impedance of 0.025 + j 0.1 Ω/phase. The stator winding impedance is negligible. Determine (a) the speed at which the motor develops the maximum torque, (b) the maximum torque of the motor, and (c) the starting torque as a percentage of maximum torque. What additional resistance must be inserted in the rotor circuit to make the starting torque equal to 75% of the maximum torque?

6 Marks

Problem 7

The equivalent impedances of the inner and outer cages of a 4-pole, 60 Hz, Y-connected, three-phase induction motor are 0.5 + j2 Ω/phase and 2 + j0.5 Ω/phase at standstill. If the stator winding impedance of the motor is 1 + j3 Ω/phase and the applied voltage is 208 V, determine the torque developed (a) at starting and (b) at a slip of 5%.

6 Marks

Problem 8

A DC series motor, running a reciprocating pump (a friction load) at 1200 rpm, takes 25 A from 230 V supply mains. Its field resistance is 0.2 Ω and that of the armature is 0.2 Ω. If a diverter of 0.25 Ω resistance, is put in parallel with the series field winding, find the motor speed.

Note that the torque required by the reciprocating pump at different speeds remains constant.

4 Marks

Problem 9

The armature of a dc machine has 30 slots. Calculate the coil pitch for a 4-pole machine.

4 Marks

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