Professional Engineers Ontario

Exam

07-Elec-A6 Power Systems and Machines

December 2009

Notes:

1. **FIVE (5)** questions constitute a complete exam paper. Unless you indicate otherwise, the first five questions as they appear in the answer book will be the only ones marked. All questions are of equal value.

2. You may use one of the approved Casio or Sharp calculators.

3. This is a closed book exam. Candidates may bring ONE aid sheet 8.5" x 11" hand-written on both sides containing notes and formulae. Note, no example or solution problems, or figures, are allowed. The aid sheet must be submitted with the exam paper.

4. All ac voltages and currents are rms values unless noted otherwise. For three-phase circuits, all voltages are line-to-line voltages unless noted otherwise.

5. You are encouraged to use pencil for this exam.

If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper a clear statement of any assumptions made.

Question 1

A 20 kW, 0.8 pf lagging, three-phase Y-connected load is supplied from a Δ-connected generator through feeders having a resistance of 1 Ω and an inductive reactance of 1 Ω. The line-to-line voltage at the load is 230 V.

a. Determine:

i. the line-to-line voltage at the generator;
ii. the load current; and,
iii. the generator power factor.

b. The power at the load is measured using the two-wattmeter method. If Wattmeter 1 is connected with its current coil in phase *a*, and its voltage coil connected between phase *a* and *c*, and Wattmeter 2 is connected with its current coil in phase *b*, and its voltage coil connected between phase *b* and *c*, determine the two wattmeter readings.

Question 2

A 37.5-kVA, 6900-230V, 60Hz, single-phase transformer is operating in step-down mode at rated load, rated voltage, and 0.68 power-factor lagging. The equivalent resistance and reactance referred to the low voltage side are 0.0224 Ω and 0.0876 Ω, respectively. The magnetizing reactance and equivalent core-loss resistance (high side) are 43,617 Ω and 174,864 Ω, respectively. Determine:

a. the output voltage when the load is removed;
b. the voltage regulation;
c. the combined input impedance of transformer and load; and,
d. the exciting current and input impedance at no load.

Question 3

A 120-V, 60-Hz, 1/3-hp, 4-pole, single-phase induction motor has the following circuit parameters: $R_1 = 2.5\ \Omega$, $X_1 = 1.25\ \Omega$, $R_2 = 3.75\ \Omega$, $X_2 = 1.25\ \Omega$, and $X_m = 65\ \Omega$. The motor runs at a speed of 1710 rpm and has a core loss of 25W. The friction and windage loss is 2W. Determine the shaft torque and the efficiency of the motor.

Question 4

A three-phase, 50-hp, 230-V, 60-Hz, four-pole induction motor is operating at rated load, rated voltage, and rated frequency. Assume a system overload results in a 5 percent drop in frequency, and a 7 percent drop in voltage. To help reduce the system load, the shaft load is reduced to 70 percent rated horsepower, resulting in a line current of 100 A. Assume the losses for the new operating conditions are as follows: stator conductor loss, 1015 W; rotor conductor loss, 696 W; core loss, 522 W; and the combined windage, friction, and stray power loss is 667 W.

Sketch the power-flow diagram, enter given data, and determine:

a. percent efficiency;
b. speed;
c. shaft torque; and,
d. power factor.

Question 5

A 240 V, 1600 rpm shunt dc motor operating at rated conditions driving a constant torque-load, has a line current of 41.6 A when fed by rated terminal voltage, V_t, of 240 V. The armature-circuit resistance and field-circuit resistance are 0.4 Ω and 150 Ω, respectively. The rotational losses are determined to be 600 W.

Calculate:

a. the output power;
b. the developed torque
c. the efficiency

Without changing the torque-load, the field resistance is increased to 200 Ω. Under these new conditions, calculate:

d. the armature current, I_a;
e. the line current, I_t;
f. the motor speed (rpm); and,
g. the efficiency.

Assume rotational losses remain constant.

Question 6

Two 600-kW, 60-Hz, diesel-driven synchronous generators *A* and *B* have governor speed regulations of 2.0 and 5.0 percent, respectively. Both machines are in parallel and supplying equal shares of a 1000-kW bus load at 57 Hz.

a. Sketch the approximate governor characteristics for both machines on one set of coordinate axes, and indicate the operating frequency. Label both curves.

b. On the same diagram, approximate a new operating condition that assumes the load on the bus decreases a total of 400kW.

c. Determine the new frequency and the new load distribution for the conditions in part (b).

END OF THE EXAM