Professional Engineers Ontario

Electromagnetic Energy Conversion Exam

98-Elec-A6

Spring 2008

Notes:

1. Attempt Part A, and FOUR (4) questions from Part B (from a choice of five questions).
2. You may use one of the approved Casio or Sharp calculators.
3. This is a closed book exam. Candidates may bring in ONE aid sheet, 8.5" x 11" and hand-written on both sides, containing notes and formulae (no figures). Example problems and solutions are not permitted!
4. Marks will be lost if answers do not include appropriate units.
5. All a.c. voltages and currents are rms values unless noted otherwise. For three-phase circuits, all voltages are line-to-line voltages unless noted otherwise.
6. You may use pencil.
7. Parts of questions may or may not be related - read carefully!
8. 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.

Part A – Multiple choice

The questions in this part of the exam are multiple choice questions. ***Please use the sheet at the end of the exam for your answers.*** Correct answers receive one mark; incorrect answers are penalized one-half mark (to a minimum of no marks for this part of the exam).

1. When using the two-wattmeter method for measuring power in a three-phase circuit, the two wattmeters will show equal readings when the power factor angle is equal to

   a. 90°
   b. 60°
   c. 30°
   d. 0°

2. The maximum flux in a transformer is ϕ_m at a certain primary voltage and frequency. If the primary voltage is doubled and the frequency halved, the new value of flux will be

   a. 0.5 ϕ_m
   b. ϕ_m
   c. 2 ϕ_m
   d. 4 ϕ_m

3. A transformer has its maximum efficiency at full load, and the core loss is 600 W. The transformer supplies full load for 10 hours per day, half load for 10 hours per day, and no load for the remaining 4 hours. Energy loss during one day is equal to

   a. 26.4 kWh
   b. 21.9 kWh
   c. 12.0 kWh
   d. 7.5 kWh

4. Which of the following is the normal arrangement of the armature windings and field poles in a three-phase alternator?

   a. stationary field poles and rotating armature
   b. stationary armature and rotating field poles
   c. stationary field poles and stationary armature
   d. rotating field poles and rotation armature

5. Which of the following is responsible for producing the required flux in a synchronous machine?

   a. three-phase stator winding
   b. dc winding on the rotor
   c. ac winding on the rotor
   d. none of these

6. Which of the following does *not* occur in a synchronous motor when the excitation of the rotor field is increased at constant load?

a. the generated emf increases
b. the load angle decreases
c. sin delta decreases
d. the terminal voltage increases

7. An induction motor produces a uniform torque at all possible rotor speeds. This is possible because the relative speed between the rotor mmf and stator mmf is

a. more
b. less
c. zero
d. none of these

8. Which of the following represents the speed of a three-phase, 60 Hz, 12-pole induction motor running at a slip of 0.02?

a. 490 rpm
b. 500 rpm
c. 588 rpm
d. 600 rpm

9. The flux produced by the field winding in a dc machine

a. rotates at a synchronous speed with respect to the stator
b. rotates at a speed less than the synchronous speed with respect to the stator
c. rotates at a speed higher than the synchronous speed with respect to the stator
d. is stationary with respect to the stator

10. With which of the following dc generator connections is it possible to have the terminal voltage equal to the terminal voltage?

a. shunt connection
b. series connection
c. compound connection
d. all of the above

11. How will the speed of a dc shunt motor change when the applied voltage is half the normal voltage?

a. there will be no change
b. the speed will become half the normal speed
c. the speed will fall slightly below the normal speed
d. the speed will increase slightly above the normal speed

12. A dc motor turns at a speed of 1460 rpm, and produces an output torque of 23.51N-m (208 in-lbf). The dc voltage applied to the motor is 280 V, and a current of 14.1 A flows through the motor. What is the motor's efficiency?

a. 94%
b. 91%
c. 79%
d. 86%

13. The motor of a water pump produces an output torque of 10 N-m (88.5 in-lbf). How much work is done by the pump motor in 10 minutes if it rotates at a speed of 3000 rpm?

a. 31.4 kW
b. 3.14 kJ
c. 1.88 MJ
d. 31.4 kJ

14. A universal motor is a dc series motor

a. that operates on ac power only
b. with a compensating winding that operates on dc power only
c. with a compensating winding that operates on ac power only
d. with a compensating winding that operates on either dc or ac power

15. The nominal value of the field current of a dc machine is chosen to be at the beginning of the knee of the saturation curve

a. to ensure that the speed versus voltage characteristic is linear
b. to ensure that the torque versus current characteristic is linear
c. to obtain as much torque as possible with minimum field current
d. both a and b.

16. The ac voltage required to make a series motor rotate at a given speed is higher than the dc voltage required to make the same motor rotate at the same speed because

a. armature reaction occurs when the motor operates on ac power
b. the armature impedance of the motor is fairly high
c. saturation occurs when the motor operates on ac power
d. both a and c.

17. When a squirrel-cage induction motor turns faster than the synchronous speed determined by the ac network to which the motor is connected, the motor

    a. consumes active and reactive power
    b. consumes active power and supplies reactive power
    c. supplies active power and supplies reactive power
    d. supplies active power and consumes reactive power

18. Single-phase induction motors of the capacitor-start type use a centrifugal switch to

    a. add an auxiliary winding and a capacitor to the motor circuit
    b. remove an auxiliary winding and a capacitor from the motor circuit
    c. add reactance to the starting circuit
    d. remove reactance from the starting circuit

19. When the line current of a three-phase synchronous motor is minimized,

    a. the motor is used as a synchronous condenser
    b. the motor neither draws nor supplies reactive power
    c. the field current is minimized
    d. none of the above

20. When a synchronous generator "floats" on the line, this means that

    a. it will speed up and slow down with the ac network frequency fluctuations
    b. no power is exchanged with the ac network
    c. it is sitting above the water line
    d. the output voltage is almost identical to that of the ac network

Part B

Attempt FOUR (4) of the five questions in this part. Unless you *clearly* indicate otherwise, the first four questions will be the only ones marked. All questions in this part are of equal value.

1. A 4 kVA, 208/600 V, 60 Hz, single-phase transformer gave the following test results:

   Low-voltage data on no-load: 208 V, 0.7 A, 60 W
   High-voltage data on short-circuit: 9 V, 6.67 A, 21.6 W

Determine the equivalent circuit for this transformer, as well as the transformer efficiency and voltage regulation at full load and 0.8 power factor lagging.

2. Determine the voltage regulation of a 2200 V, three-phase synchronous generator giving a current of 120 A at (a) unity power factor; and, (b) power factor of 0.707 lagging. From short-circuit and open-circuit tests, full-load current of 120 A is produced on short circuit by a field excitation of 2.5 A, and an emf of 480 V is produced on open circuit by the same excitation. The armature resistance is 0.4 Ω.

3. An induction motor has an efficiency of 88% when the load is 60 kW. At this load, stator losses and are equal to rotor losses, and each of them are equal to the motor's iron loss. Mechanical losses are one-fourth of the no-load loss. Determine the slip under these conditions.

4. A 200 V DC shunt motor has an armature resistance of 0.4 Ω and a field resistance of 200 Ω. When driving a load of constant torque at 500 rpm, the armature draws 25 A. If it is desired to raise the speed from 500 to 700 rpm, what resistance must be inserted in the shunt field circuit, assuming the magnetization curve to be linear?

5. A three-phase induction motor, 440 V, 60 Hz provides 20 hp output with an efficiency of 74.6%. The line current is 52.5 A. If two wattmeters are used to measure the motor's input power, determine the reading of each meter, and provide a phasor diagram showing all line-to-line voltages, all phase voltages, and all line currents.