Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2006-2007 (2 hours)

Electromechanical Energy Conversion EEE202

Answer **THREE** questions. **No marks will be awarded for solutions to a fourth question.** Solutions will be considered in the order that they are presented in the answer book. Trial answers will be ignored if they are clearly crossed out. **The numbers given after each section of a question indicate the relative weighting of that section.**

1. A prototype generator formed by a single rectangular loop of conducting wire of area A is rotated in a uniform magnetic field, whose flux density is B. In order to supply current to an external load, the ends of the coil are connected to *slip rings* that are contacted by *brushes,* which in turn are connected to copper wires going to the generator's terminals and hence to the load.

a. Describe, with the aid of derived expressions supported by appropriate labelled diagrams, the waveform of the generator output. Where in the mechanical cycle do the maximum and zero e.m.f. points occur? **(5)**

b. In order to produce DC voltage from the coil and magnet, *commutation* in the form of split slip-rings is provided. Describe in detail supported by labelled diagrams how a *two-coil, two-pole generator* has a smaller peak to peak ripple than a *single-coil, two-pole generator.* Assuming the coils each give a maximum e.m.f. of 10V when a coil passes a pole face, calculate the advantage in terms of reduced ripple of the *two-coil* device. **(11)**

c. For a prototype DC generator with a single coil of area A rotating in a uniform field B, rotating at angular velocity ω and induced current i, the energy balance equation relating mechanical power p_m to electrical power p_e can be described by; **(4)**

$$p_m = i\omega BA\cos\theta = ei = p_e$$

where θ is the angle of the coil relative to the poles axis, and e is the induced emf. What assumptions have been made about the generator in order to derive this equation?

2. **a.** Describe with the aid of diagrams, the series DC motor which produces uni-directional torque irrespective of current polarity, and will hence operate from an **(7)**

AC supply.

A 200V power supply is connected to a permanent magnet DC motor which has a back e.m.f. constant of 0.4775V/rad/s and an armature resistance of 3Ω.

b. Calculate the no-load speed of the motor. **(4)**

c. If the power supply is current limited to 10A, what is the maximum torque at 500rpm? What is the value of the back emf at this speed? **(5)**

d. If the motor is required to produce 4.8Nm, what is the maximum speed it can achieve? **(4)**

3. A four-pole, three phase star-connected induction motor is connected to a 50Hz supply

a. Calculate the synchronous speed, and hence the speed of the rotor when the slip is 4% **(4)**

b. Calculate the rotor frequency when the speed of the rotor is 600rpm **(3)**

The motor draws 40kW from the supply, with corresponding stator losses of 1.5kW

c. Calculate the total mechanical power developed, and the rotor I^2R loss when the slip is 0.04 per unit. **(4)**

d. Neglecting iron losses, calculate the efficiency of the motor if the friction and windage losses are $0.8kW$. **(4)**

e. Derive an expression for this machine, which relates its output torque to the amount of slip. **(5)**

4. It is desired to operate a permanent magnet DC motor in single quadrant mode.

a. Describe, with the aid of diagrams, the operating principles and the circuit required to drive the motor in this mode. **(6)**

b. Derive (supported by appropriate diagrams) an expression for the peak to peak current ripple associated with this circuit. **(8)**

c. Describe with the aid of diagrams, the second quadrant operation of a two quadrant chopper circuit when the motor is running and generating a back emf. What capability must the power supply have in order to operate in this quadrant? **(6)**

PGS / ZQZ