THE OPEN UNIVERSITY OF SRI LANKA
FACULTY OF ENGINEERING TECHNOLOGY
DIPLOMA OF TECHNOLOGY – LEVEL 04
FINAL EXAMINATION 2007/2008
MEX4271 – SENSORS AND ACTUATORS
DATE : 28TH APRIL 2008
TIME : 0930 HRS TO 1230 HRS
DURATION : THREE HOURS

READ THE FOLLOWING INSTRUCTIONS CAREFULLY BEFORE ANSWERING THE QUESTION PAPER

- This question paper has **eight** questions.
- Answer **five** questions only.

Question 01 *[20 Marks]*

(a) What happens to the reluctance of a magnetic path if its length is doubled? If the cross-sectional area is doubled? If the relative permeability is doubled?
(b) What are two causes of core loss for a coil with an iron core excited by an ac current? What considerations are important in minimizing loss due to each of these causes? What happens to the power loss in each case if the frequency of operation is doubled while maintaining constant peak flux density?
(c) In Sri Lanka ,electrical power is generally utilized at a nominal voltage of 240V rms. What problems would become pronounced if the power distribution system and household appliances had been designed for a lower voltage (say, 20V rms)? For a higher voltage (say, 10kV rms)?

Question 02 *[20 Marks]*

(a) What are the advantages and disadvantages of the plastic film type of potentiometer when compared with the wire-wound potentiometer?
(b) Define the terms, mechanical loading and electrical loading, in the context of motion sensing. Explain how these loading effect can be reduced in the process of motion sensing.
(c) Explain the principle of **L**inear **D**ifferential **V**ariable **T**ransducer (LVDT) and its advantages as a displacement transducer. Give one application example.

Question 03 *[20 Marks]*

(a) What is piezoelectric effect? Sketch the basic construction and explain the operating principle of any piezoelectric sensor.
(b) You are offered a choice of an incremental shaft encoder or an absolute shaft encoder for the measurement of an angular displacement. What is the principle difference between the results that can be obtained by these methods?
(c) Briefly discuss advantages and disadvantages of fibre optic sensors.

Question 04 *[20 Marks]*

(a) Sometime the stator, particularly the yoke, of a dc machine is not laminated. However, it is always necessary to laminate the rotor. Explain.
(b) A certain motor has an induced armature voltage of 200V at n_{m1} = 1200rpm. Suppose that this motor is operating at a speed of n_{m2} = 1500rpm with a developed power of 5 hp. Find the armature current and the developed torque.
(c) Is a magnetization curve needed for a permanent-magnet dc motor? Explain.

Question 05 *[20 Marks]*

(a) A permanent-magnet automotive fan motor draws 20 A from a 12 V source when the rotor is locked (i.e., held motionless).
   i. Find the armature resistance.
   ii. Find the maximum developed power that this motor can produce when operated from a 12 V source.
   iii. Repeat part (ii) for operation at 10V (this represents a nearly dead battery) and at 14 V (this is the terminal voltage during charging of the battery after the engine is started).

(b) The fan motor of part (a) has a speed of 800 rpm and draws 3.5 A when operating the fan with terminal voltage of V_T = 12V. Assume that the load (including the rotational losses) requires a developed torque that is proportional to the square of the speed. Find the speed for operation at 10V. Repeat for 14V.
(c) List three methods that can be used to control the speed of dc motors. Which of these apply to shunt-connected motors? To separately excited motors? To permanent-magnet motors? To series-connected motors?

Question 06 *[20 Marks]*

(a) A synchronous motor is running at 75% of rated load with unity power factor. If the load increases to the rated output power, how do the following quantities change?
   i. Field current;
   ii. mechanical speed;
   iii. output torque;
   iv. armature current;
   v. power factor;
   vi. torque angle.

(b) Suppose that a synchronous machine is instrumented to measure its armature current, armature voltage, and field current. The filed circuit contains a rheostat so that the field current can be adjusted. Discuss how to adjust the field current to obtain unity power factor.
(c) How could the direction of rotation of a single-phase capacitor-start induction motor be reversed?.

Question 07 *[20 Marks]*

(a) Explain the principle of operation of the variable reluctance stepper motor
(b) If stepper motor has a step angle of 7.5^0 , what digital input rate is required to produce a rotation of 10 rev/s?.
(c) Explain how a thyristor can be used to control the level of a d.c voltage by chopping the output from a constant voltage supply .

Question 08 *[20 Marks]*

(a) Explian the principle of a pilot-operated valve.
(b) Draw the symbols for
   i. a pressure relief valve
   ii. a 2/2 valve which has actuators of push-button and a spring
   iii. a 4/2 valve
   iv. a directional valve
(c) Design a pneumatic valve circuit to give the sequence A+, followed by B+ , followed by A-, followed by B-.

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