

**THE UNIVERSITY OF ADELAIDE**  
**DEPARTMENT OF MECHANICAL ENGINEERING**

**EXAMINATION FOR THE DEGREE OF B.E.**

**MECHATRONICS IM 8197**

**NOVEMBER 1999**

**TIME: 2 HOURS**

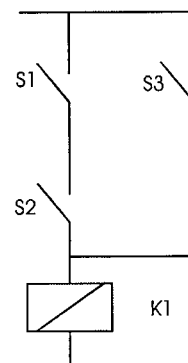
[In addition, candidates are allowed ten minutes before the examination begins to read the paper.]

[The use of notes, textbooks and calculating devices other than computers is permitted in the examination room.]

**Total 4 pages in this exam paper.**

**Part 1. Short Answer Questions (Total 20 points, 10 questions, with 2 points each)**

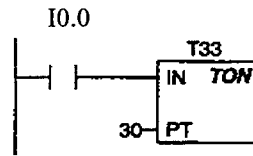
1. State the difference between *sensors* and *transducers*.
2. Is a rotary potentiometer for angle measurement a self-generator, modulator or modifier, why?
3. Give an example of the electrical-thermal-electrical modulator sensor.
4. Piezoelectric materials have properties that change with changing temperature. Give an application example of this characteristic.
5. Draw the logic diagram for the following circuit diagram.



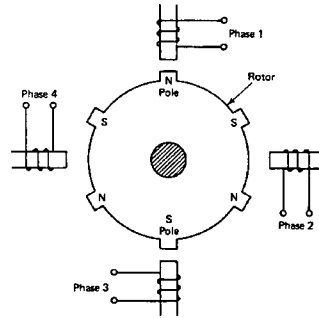
circuit diagram

6. Derive the dexadecimal number for the binary number 0000001111001001.

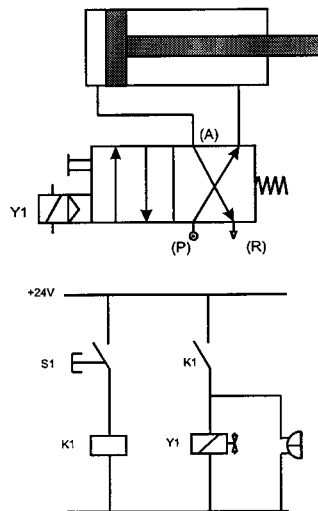
7. A 10-ms resolution timer is used in the following program. Modify the ladder diagram if a 100-ms resolution timer is used.



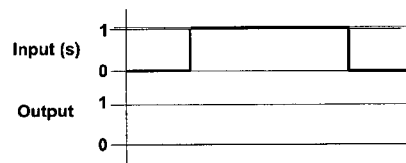
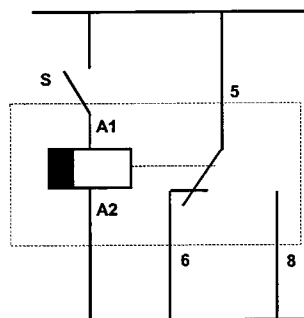
8. Consider the following stepper motor. What is the step angle of the motor in half-stepping? Give the phase-switching sequences for CW half-stepping rotation.



9. Modify the following electro-pneumatic control circuit so that it has the latching function.



10. A time-lag relay with delay de-energising is shown in the following figure. Complete the timing-diagram for the output signal, assume the time lag is T.

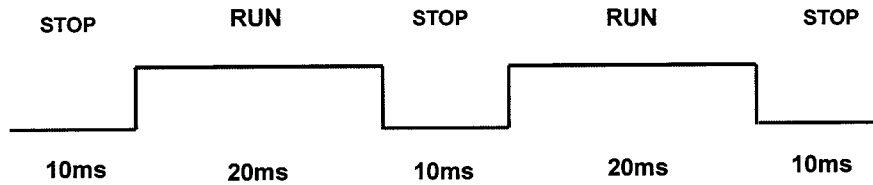


(b)

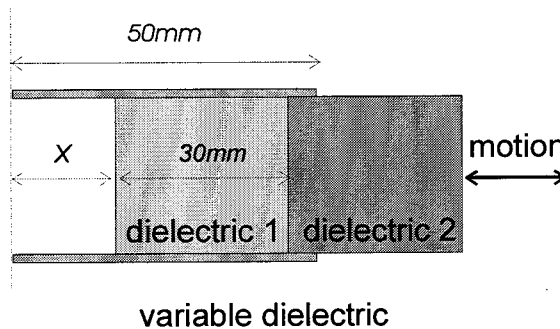
**Part 2. Short Questions**

**(Total 40 marks, 4 questions, points are shown in each question)**

11. Design a PLC program for a simple motor control system. When the "START" button is pressed, the motor starts to run following the periodical form shown in the figure. Once the "STOP" button is pressed, the operation stops. A green light is used to indicate the running mode, and a red light indicates the stopping mode. When the motor runs for 10 times, the operation is to stop automatically. Show the connection circuit, the ladder diagram and its statement list for your design **(15 points)**.

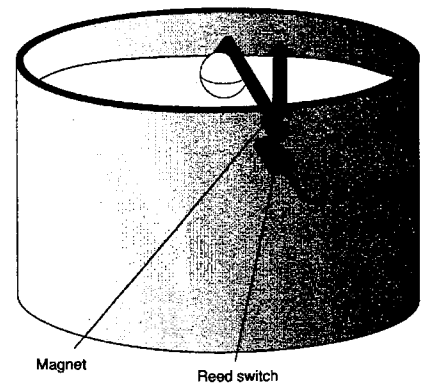


12. A variable dielectric capacitive displacement sensor consists of two square metal plates with size  $50mm \times 50mm$ , separated by a gap of 1 mm. As shown in the figure, two dielectric materials are slid between the plates. Given that the dielectric constant of air is 1, and the constant of dielectric 1 is 4 and constant of dielectric 2 is 3, calculate the capacitance of the sensor when  $x = 0$  and  $x = 10mm$  **(10 points)**.



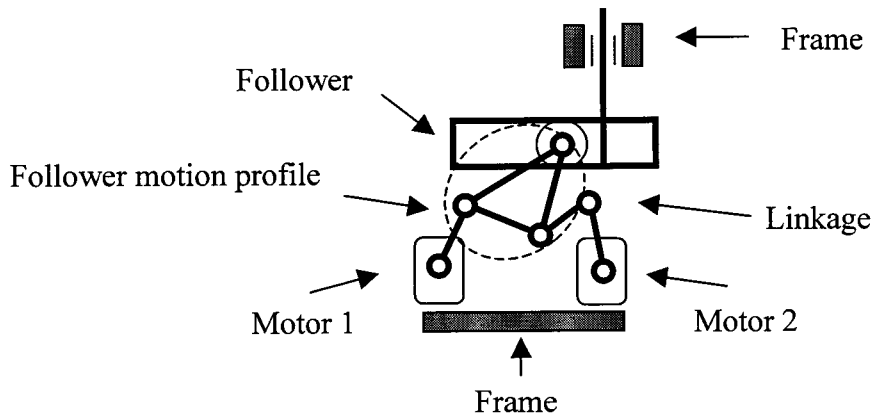
13. Determine the numbers of stator poles, rotor teeth and the winding phase for a single-stack stepper VR motor with a minimum step-angle of  $4.5^\circ$ . Confirm your result with the step-angle equation **(10 points)**.

14. A magnet mounted on a float arm is to actuate a reed switch when the liquid level in a container reaches a predetermined level. When the reed switch is actuated an alarm is to sound until reset by a keyswitch. The alarm must remain disabled while the keyswitch is locked open. Design a circuit diagram for this system. **(5 points)**.



## Part 3. (Total 40 marks with 20 points for each question)

15.



A traditional mechanical linkage shown in the figure consists of the following components: a frame, a linkage and a follower. The system is driven by two motors.

- With the existing system, how can different follower motion profiles be obtained?
- Apply the mechatronic design concept to modify this system so that it could fit an alternative motion profile with high flexibility. Sketch your modified system.
- State the advantages of a mechatronic system over a traditional mechanical system.

16. A Copper versus Constantan thermocouple is used to measure temperature ranging from  $-100$  to  $400$   $^{\circ}\text{C}$ . The EMF values are given as follows:

$$\begin{aligned} E_{-100,0} &= -3378 \\ E_{+100,0} &= 4277 \\ E_{200,0} &= 9286 \\ E_{400,0} &= 20869 \end{aligned} \mu V$$

- Between  $100$  and  $300^{\circ}\text{C}$ , the thermocouple EMF is given by  $E_{T,0} = a_1T + a_2T^2$ , calculate  $a_1$ ,  $a_2$ .
- Find the non-linearity at  $200^{\circ}\text{C}$  as a percentage of full scale.
- Find the sensitivity at  $200^{\circ}\text{C}$ .

The EMF is  $12500 \mu V$  relative to a reference junction of  $-20^{\circ}\text{C}$  and the corresponding reference junction EMF is  $-1000 \mu V$ . Use the result of (a) to estimate the measured junction temperature.