THE KENYA POLYTECHNIC

ELECTRICAL/ELECTRONICS ENGINEERING

DEPARTMENT

HIGHER DIPLOMA IN ELECTRICAL ENGINEERING

END OF YEAR II EXAMINATIONS

NOVEMBER 2006

INSTRUMENTATION

3 HOURS

INSTRUCTIONS TO CANDIDATES:

You should have the following for this examination:

Answer booklet

Calculator/Mathematical tables

Answer any FIVE of the following EIGHT questions.

All questions carry equal marks and the maximum marks for each part of a question are as shown.

This paper consists of 6 printed pages.

1. (a) Define the following terms as referred to measurements:
   (i) Repeatability (ii) Monoticity (2 marks)
   (b) (i) Distinguish between "sensing" and "transduction" in an instrumentation system. (2 marks)
   (ii) Explain what is meant by the following in measurements:
   I. Determination error II. Calibration error
   III. Random error (6 marks)
   (c) A measurement taken to measure temperature of an incubator under varying conditions yielded the readings tabulated in table I.

35.6	35.2	35.6	35.6	36.0
35.5	35.6	35.3	35.4	35.9
35.5	35.4	35.6	35.3	35.7
35.7	35.8	35.7	35.8	

Table 1

Determine the limits within which the true working temperature of the incubator lies in ^{0}C.

2. (a) (i) State ONE advantage of magnetic encoder over brush type encoder.
   (ii) A shaft encoder in angular position measurements is cyclic coded and is 4-bit.
   I. Draw a schematic diagram showing how this measurement is undertaken if the output is to be processed using a BCD based system before displaying.
   II. Design a converter for the system in I. (12 marks)
   (b) (i) Sketch a labeled diagram showing the construction of a linear variable Differential Transformer transducer used in displacement measurement.

(ii) A linear motion of a machine using a LVDT gave an output of 4mV at a displacement of 0.8mm. This output was connected to an amplifier of gain 200. Determine the whole system sensitivity.

(iii) If 0.88mm is the maximum measurable displacement in the machine, identify the analog voltmeter to just meet the conditions in (ii). (8 marks)

3. (a) (i) State Bournelli's Law as applied to fluid flow measurement and give the mathematical expression by which it is modeled. (4 marks)

(ii) Using the expression in (i), outline quantitatively and show that the theoretical flow rate in a Venturi meter is given by:

$$\left(\frac{A_2}{1-\left(\frac{A_2}{A_1}\right)^{\frac{1}{2}}} \right) \left[\frac{2(P_1 - P_2)}{\rho} \right] \text{ litres/sec, where:}$$

A_1 - Area at inlet

A_2 - Area at throat

P_1 - Pressure at inlet

P_2 - Pressure at throat

ρ - Fluid density (12 marks)

(b) Explain giving reasons as regards hot wire anemometers:

(i) The areas of use (ii) Fluids measurable (4 marks)

4. (a) Define the following terms as used in instrumentation amplifiers and identify their causes:

(i) Drift (ii) Offset voltages (4 marks)

(b) (i) Derive the expression for the output voltage of the amplifier shown in figure 1.

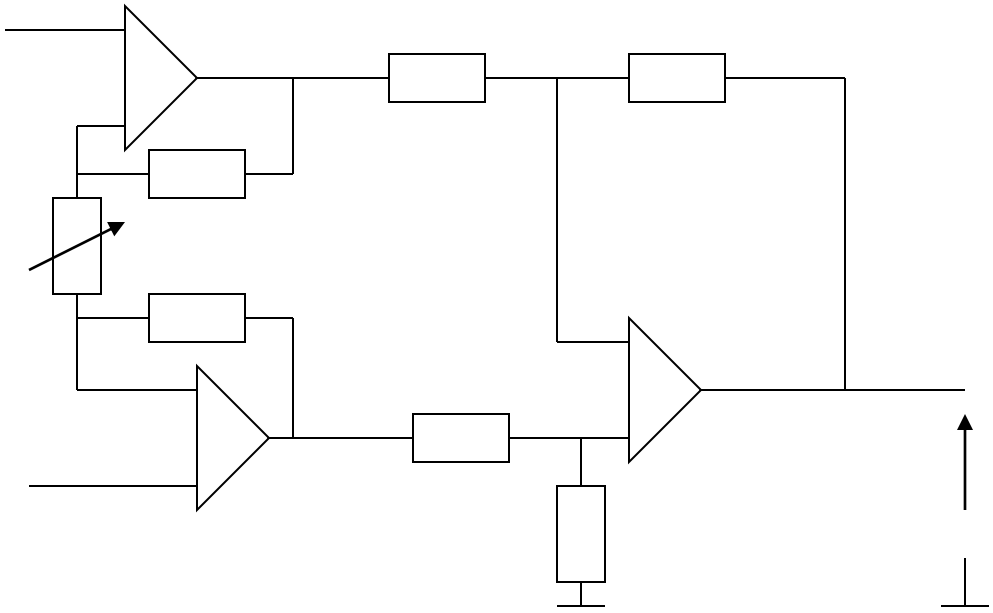

Figure 1

(ii) For the amplifier in (i), a common mode input signal of 0.5mV give a common mode output of 0.05mV. $R_1=R_2=R_3=10M\Omega$. Rg is adjusted to 10Ω. A right input from a transducer is 10μV. Determine:

I. The CMRR of the amplifier in dB.

II. The measured signal at the output. (12 marks)

(c) Identify the areas of application for the following signal conditioning circuitry, giving reasons:

(i) Logarithmic amplifiers (ii) F.M detectors (4 marks)

5. (a) (i) State THREE physical phenomena by which temperature of a body is described:

(ii) Transducers used in temperature measurement effect their operations by heat transfer. Describe the THREE methods involving this. (9 marks)

(b) With the aid of a diagram, identify an appropriate instrumentation system and explain how temperatures beyond 3600^0C can be measured. (6 marks)

(c) (i) Define the following with respect to strain gauges.

I. Gauge factor II. Poisson's ratio

(ii) A wire strain gauge has a gauge factor of 4. It is fastened to a steel structure with Young's Modulus 2200kN/m^2. The applied stress is 5kN/m^2. The wire under no stress has a resistance of 2Ω. Determine percentage change in wire resistance. (5 marks)

6. (a) (i) Define the term hazardous zone in measurements.

(ii) Outline the guidelines undertaken in order that measurement equipments are intrinsic safety protected. (3 marks)

(b) (i) Define the following terms with respect to instrumentation equipment:

I. Redundancy II. Reliability

(ii) With the aid of a diagram explain the THREE stages of life of measurement equipment. (7 marks)

(c) Figure 2 shows a block diagram with non-reliabilities of measurement equipment. The equipment operates for 400 hours without failure. Determine:

(i) System reliability (ii) Mean time between failures

(iii) Failure rate (10 marks)

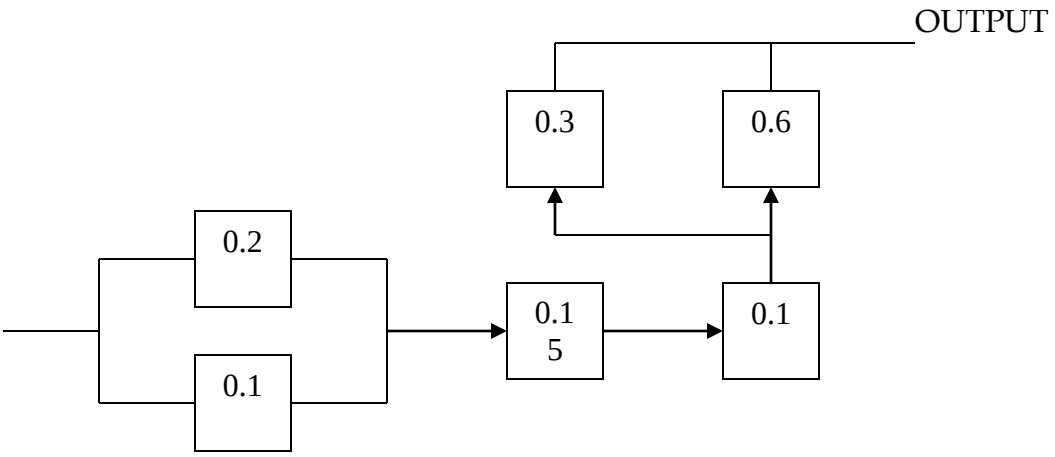

Figure 2

7. (a) State ONE advantage of each of the following:

(i) Tracking ADC over simple countertype ADC

(ii) Successive approximation over duel slope ADC. (1 mark)the

(b) Measurement data given as 101001_2 is to be indicated by an analog meter. If the clock's frequency is 1MHz and the analog output for data 010000 is 10v, determine the maximum conversion time if the following ACs are used:

I. Counter type II. Successive approximation

III. Flashing

(i) The DAC resolution

(ii) The Analog meter reading (8 marks)

(c) Figure 3 shows a tank containing a liquid of density $40g/cm^3$. The total weight of the tank and the liquid is 1425kg. Determine the liquid level in m. Assume uniform tank thickness. (11 marks)

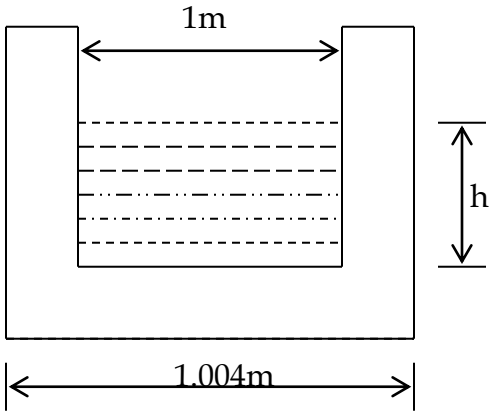

Figure 3

8. (a) Distinguish between the following as used in data memory devices:

(i) Charge coupled (ii) Magnetic bubble (2 marks)

(b) (i) With the aid of a diagram, explain the process of magnetic tape direct recording.

(ii) State ONE disadvantage of the method in (i) and how it is overcome with the aid of appropriate curves. (9 marks)

(c) (i) Define the term multiplexer in data circuits.

(ii) Digital dat from four outstations is to be telemetred to a data logger. Design a circuit to accomplish this via a single link-line. (9 marks)