# THE KENYA POLYTECHNIC

## ELECTRICAL/ELECTRONICS ENGINEERING

## DEPARTMENT

## HIGHER DIPLOMA IN ELECTRICAL ENGINEERING

### END OF YEAR II EXAMINATIONS

### NOVEMBER 2006

### MEASUREMENT & INSTRUMENTATION SYSTEMS

### 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 4 printed pages.

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1. (a) Define the following terms used in measurements:

    (i)      Precision                      (ii)      Resolution

    (iii)    Linearity

  (b) Explain the following classes of errors in measurement:

    (i)      Systematic               (ii)      Random

    (iii)    Response time

  (c) The air temperature in a production process is varying at 1 cycle per 3 minutes. The temperature is measured by a bare bulb thermometer having a time constant of 20 seconds. If the true temperature has a sinusoidal variation of $\pm 40^0 C$, calculate:

    (i)      The indicated variation of temperature

    (ii)     The time by which the maximum reading of the thermometer lags the time maximum value.

2. (a) Explain the following systematic characteristics of a measurement system elements:

    (i)      Range                        (ii)    Span

    (iii)    Sensitivity

  (b) Explain the difference between uncertainty and accuracy.

  (c) With the aid of a block diagram, explain the main parts of a measurement system.

3. (a) With the aid of a diagram explain the principles of operation of a resistive thermometer.                         (6 marks)

  (b) State any FOUR advantages of resistance thermometers in temperature measurement.                         (4 marks)

  (c) Describe any TWO considerations necessary to obtain accurate temperature readings with the minimum dynamic error.    (4 marks)

  (d) A thermocouple junction is roughly spherical with a diameter of $\frac{1}{16} cm.$ The junction material density is $\rho = 0.25 kg / cm^3$ and has a specific

heat of 0.10 BTU/kg/$^0$C. The heat transfer coefficient h=0.1 Btu/kg/$^0$C. Calculate the time constant. (4 marks)

4. (a) With the aid of constructional diagram, explain the principles of operation of the following transducers:

   (i)     Linear variable differential transformer (LVDT)

   (ii)    Electromagnetic variable reluctance tachogenerator    (10 marks)

   (b) Draw a strain gauge measuring circuit and show mathematically the relationship between the detector current and the strain.    (10 marks)

5. (a) Explain the operation of the following measuring instruments:

   (i)     Capacitance tachogenerator for velocity measurement

   (ii)    Piezoelectric accelerometer    (10 marks)

   (b) A Piezoelectric accelerometer transducer has a frequency of 5Mc/s. The transducer spacing is 100mm and the velocity of sound is 1500m/s. Assuming the phase difference between the signals impinging on the receiving transducer is 3000, calculate the maximum velocity of flow that can be measured by the differential pulse system.

   (c) Explain the TWO main matching conditions of the sensor to the transmitter or conditioner.

6. (a) State any FOUR features governing the choice of a flow meter. (4 marks)

   (b) With the aid of a diagram, explain the operation of ultrasonic flow meter.

   (4 marks)

   (c) With the aid of a diagram, explain the construction and principle of operation of the following flow measuring devices:

   (i)     Pitot tube                    (ii)    Venturi tube

   (iii)   Orifice plates                    (12 marks)

7. (a) State the difference between incremental and absolute encoders.

   (4 marks)

   (b) With reference to operational amplifier define the following terms:

   (i)     Slew rate                    (ii)    Common mode rejection ratio

   (iii)   Offset voltage.                    (3 marks)

(c) The diagram of figure 1 shows the typical microcomputer as used in speed measurement. The main stages are:

Stage A: Control of counter for 0.1s count

Stage B: Multiplication of count by 75

Stage C: Conversion of hexadecimal count o decimal

Stage D: Conversion of decimal to ASCII for display

Draw the flowchart for stage A and explain the process. (13 marks)

8. (a) Define the following terms:

(i) Reliability (ii) Catastrophic failure

(iii) Mean time to failure (iv) Failure rate (4 marks)

(b) With the aid of a bath tub curve explain the variation in failure rate during an equipment lifetime. (6 marks)

(c) Show mathematically the relationship between reliability, unreliability and failure rate for constant failure rate. (6 marks)

(d) By analysis, show the differences between series and parallel reliability of three components. (4 marks)