EGERTON UNIVERSITY

UNIVERSITY EXAMINATIONS

NJORO CAMPUS

SECOND SEMESTER 2011/2012

THIRD YEAR EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN INSTRUMENTATION AND CONTROL ENGINEERING

ICEN 323: PRINCIPLES OF MEASUREMENT SYSTEMS I

STREAM: Y3S2, BSc. ICEN **TIME:** 2 HOURS

DAY/TIME: MONDAY 12.00 – 2.00 PM **DATE:** 7TH MAY 2012

INSTRUCTIONS

- This paper contain **FIVE** questions.
- Answer **QUESTION ONE [COMPULSORY]** and any other **TWO QUESTIONS.**

QUESTION ONE [COMPULSORY 30MKS]

(a) With the aid of diagrams, explain the construction and operation of the following transducers:-

(i) Linear variable differential transformer (LVDT) [4mks]

(ii) Piezoelectric crystal [4mks]

(iii) Parallel plate capacitance [4mks]

(b) The potentiometer shown below [Fig.Q1(b)] is used to measure Angular position θ. The potentiometer can rotate 320^0, has a resistance R_P=4KΩ and is capable of dissipating 0.02W of power in most environments. Show the following:-

(i) The value of $V_{S\,MAX.}$= 8.94V [2mks]

(ii) The value of R_S to protect the potentiometer if V_S=15.0V is 2.71KΩ. [2mks]

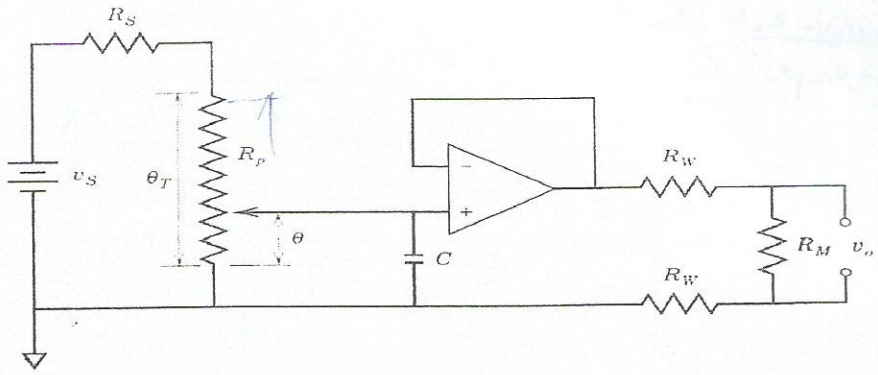

Fig Q1(b).

(c) What is the purpose of the capacitor C and the unity gain amplifier? [4mks]

(d) (i) Define AM and FM [2mks]

(ii) Briefly explain how AM is used in instrumentation to amplify slowly varying Signals, such as output from strain gauges. [2mks]

(e) With the aid of diagrams, briefly explain the construction and operation of the following display devices:-

(i) LED (ii) LCD [6mks]

QUESTION TWO (20MKS)

(a) With the aid of block diagrams, briefly explain the operation of the following ADC systems.

(i) Ramp ADC [4mks]

(ii) Dual slope ADC [4mks]

(iii) Successive approximation ADC [4mks]

(iv) Flash ADC [4mks]

(b) By using the successive approximation method, show how an analogue voltage of 11.7V is determined using a 8-bit ADC [2mks]

(c) What is the resolution of the above ADC? [2mks]

QUESTION THREE (20MKS)

(a) Show from 1st principles how the op-amp can be used to perform the following mathematical operations:-

(i) Scale change (division/multiplication) [2mks]

(ii) Integration [2mks]

(iii) Differentiation [2mks]

(iv) Subtraction [2mks]

(b) It is required to mix 4 microphone outputs using an op-amp. The MIC outputs are as follows: -MIC 1- 1mV, MIC 2- 10mV, MIC 3- 0.1mV, MIC 4- 1mV.

If the output from the mixer is fed to an instrumentation amplifier (IA) of gain -1000, design and draw the mixer and IA such that the output is a balanced voltage of 4V.

[Use R_F =10 KΩ for both the mixer and IA] [7mks]

(c) (i) List 4 characteristics of an IA and in each case explain why the characteristic is desirable [2mks]

(ii) Draw the diagram of an A.C IA and derive an expression for its voltage gain. [3mks]

QUESTION FOUR (20MKS)

(a) The resistance R_θ KΩ of a thermistor at θK is given by

$R_\theta = K \exp\left[\beta\left(\frac{1}{\theta} - \frac{1}{273}\right)\right]$.

If its resistance at ice point is 10 KΩ and 203.5 Ω at 100^0 C, Find the values of K and β [4mks]

(b) The above thermistor is incorporated in a Wheatstone bridge to measure temperature as shown below [Fig.Q4(b)].

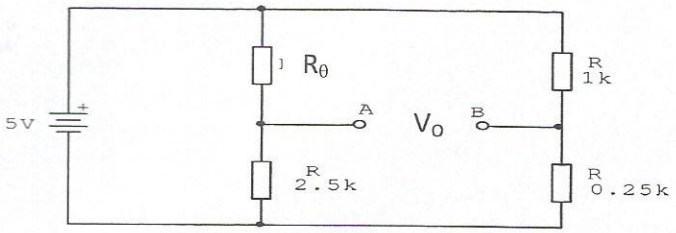

Fig.Q4(b).

(i) Assuming that V_O is measured with a detector of infinite impedance ,find the range of V_O corresponding to an input temperature range of 0 to 100° C [4mks]

(ii) The non-linearity at 25 °C and 50 °C as a percentage of full-scale deflection [6mks]

(c) Calculate the effect on the range of V_o if the detector impedance is reduced to 1 KΩ. Hence explain instrument loading effects [6mks]

QUESTION FIVE (20MKS)

(a) With the aid of a static characteristics tree, name and briefly explain desirable and undesirable static characteristics of a measuring instrument/ system. [14 marks]

(b) The output of a linear voltage differential transformer (LVDT) is connected to a 10V voltmeter through an amplifier of gain 500. The voltmeter scale has 100 divisions and 0.5 of a division can be read. An output of 6mV appears across the terminals of the LVDT when the core is displaced through a distance of 2.0mm.

(i) Draw a functional block diagram of the instrument. [3 marks]

(ii) Calculate the sensitivity of the LVDT [1 mark]

(iii) Calculate the overall sensitivity of the instrument. [1 mark]

(iv) Calculate the resolution of the instrument in mm. [1 mark]
