EGERTON UNIVERSITY

DEPARTMENT OF ELECTRICAL AND CONTROL ENGINEERING

ICEN 323: PRINCIPALS OF MEASUREMENT SYSTEMS I

CAT II **DATE: 20/04/2012** **TIME: 1HR 30MIN**

INSTRUCTIONS: ANSWER ALL QUESTIONS

1.(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 12.8V is determined using a 8-bit ADC [2mks]

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

2. (a) 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 terminal 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]

3. With the aid of diagrams, briefly explain the construction and operation of the following displaydevices:-

(i) LED (ii) LCD (iii) Electroluminescent displays (EL) [10 mks]

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ICEN 325 ICEN 525 US

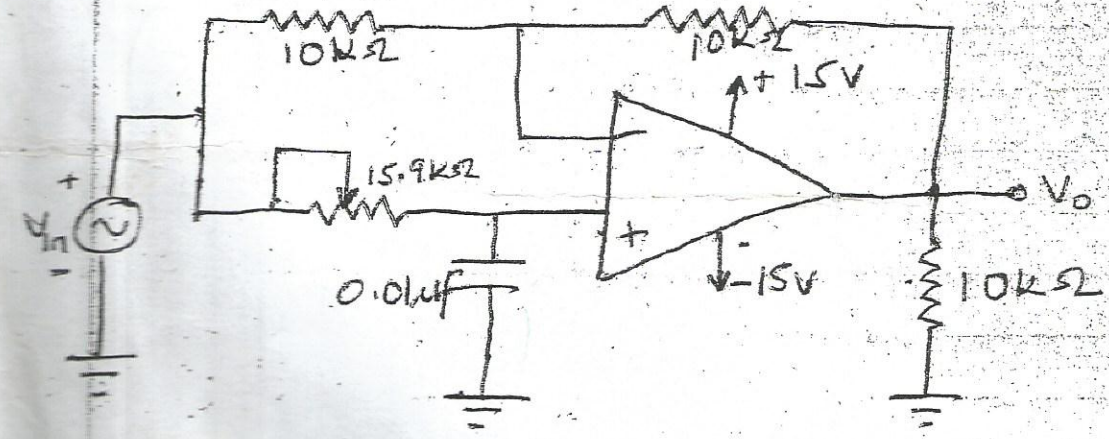
CAT 2 TAKE AWAY:

1 a) A CERTAIN NARROW BAND PASS FILTER HAS BEEN DESIGNED to meet the following specifications: $f_c = 2\,KHz$ $Q = 20$ and $A_f = 10$. What modification are necessary in the filter circuit to change the centre frequency f_c to 1KHz keeping the gain & bandwidth constant (5 marks)

b) Draw the schematic diagram of a fourth-order low-pass ~~filter~~ Butterworth filter (5 marks)

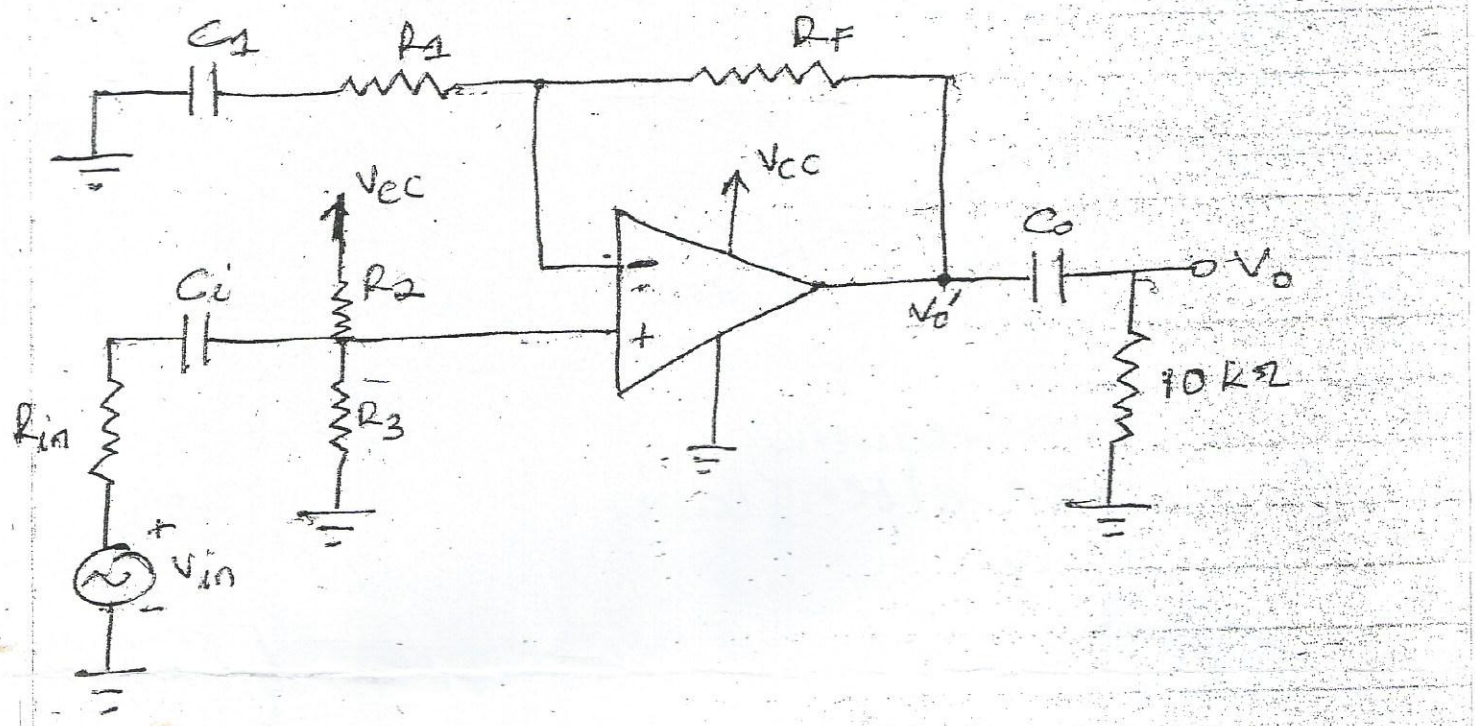
c) Draw the frequency response plot for a 60Hz active notch filter, label the gain & frequency axes properly (5 marks)

d) Given the all-pass filter in the figure 1 below determine the phase shift ϕ between the input & output at $f = 2KHz$. To obtain a positive phase shift ϕ, what modifications are necessary in the circuit



(8 marks)

(2) For the inverting amplifier shown in fig 2 below $R_{in} = 50\Omega$ $R_1 = 10K\Omega$ $R_2 = R_3 = R_F = 100K\Omega$ and $C_i = C_o = 0.1\mu f$. $V_{cc} = 15V$



(a) Determine the bandwidth of the amplifier
(b) Determine the maximum ideal output voltage swing
(c) sketch the output voltage waveforms V_o' and V_o if $V_{in} = 200mV$ peak sine wave at 1KHz.

(12 MKS)

EGERTON UNIVERSITY

UNIVERSITY EXAMINATIONS
SECOND SEMESTER 2007/2008

YEAR THREE EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN INSTRUMENTATION AND CONTROL ENGINEERIG

ICEN 323 – PRINCIPLES OF MEASUREMENT SYSTEMS I

STREAM: Y3S2 **TIME:** 2 ¼ HRS

DAY: FRIDAY, 12.00 – 2.00 P.M. **DATE:** 13/06/2008

INSTRUCTIONS:

Attempt any FOUR of the following SIX questions.
All questions carry equal marks.

Q1. (a) State the disadvantages of mechanical sensors over electrical sensors. (2 marks)

(b) (i) What does the initials I.S.E stand for in reference to electrochemical sensing elements.

(ii) State one important industrial application of I.S.Es. (2 marks)

(c) Use diagrams and equations to describe the principles of operation of the following sensing elements:-

1. Thermocouples
2. Capacitive displacement sensor
3. Linear Variable Differential Transformer (LVDT)

(12 marks)

(d) The resistance of a platinum resistance coil is given as 80Ω at 0°C. Find its resistance when its temperature is raised to 40°C given that its temperature coefficient of resistance is $0.0039°C^{-1}$. (4 marks)

Q2. (a) State the four main characteristics of an opamp which makes it attractive for use in measurement circuits. (2 marks)

(b) Draw the basic circuit of an instrumentation amplifier and derive its voltage gain. (10 marks)

(c) You are provided with two 741 opamps, 1KΩ, 2.2KΩ, 10KΩ, and 22KΩ resistors. Design an amplifier circuit that can be used to amplify +50mV to give an output of +5V. Show all the necessary design calculations in your answer. (8 marks)

Q3. (a) State the disadvantages of a weighted Resistor DAC over an R/2R ladder network DAC. (3 marks)

(b) Draw a basic circuit for an R/2R ladder network DAC and state the equation for the output voltage when all the input digital bits are '1'. Use an opamp in your circuit and assume a 4-BIT converter. (7 marks)

(c) Use a block diagram to explain the operation of a counter type ADC. (10 marks)

Q4. (a) Use a potentiometric sensor to explain the effect of loading on the measured value or quantity. Use appropriate diagram and necessary expressions in your answer. Derivations are not necessary. (8 marks)

(b) State how loading errors can be minimized in measurement circuits. (2 marks)

(c) A potentiometer has 10V d.c connected across its track terminals. If the total resistance of the track is 1KΩ, find the non-linear error produced when a load of 10KΩ is connected across the output terminals with the potentiometer wiper (slider) at mid-point of its maximum displacement. (6 marks)

(d) Define the following terms as used in measurement systems:-

(i) Systematic errors
(ii) Random errors
(iii) Static characteristics
(iv) Dynamic characteristics

(4 marks)

Q5. (a) Use a suitable diagram to explain the principles of operation of a variable reluctance transducer used to measure a displacement. Show all the necessary equations in your answer. (10 marks)

(b) Draw the basic circuits of the following:-

1. Low – pass Butterworth filter
2. High – pass Sallen and Key filter

Quote the equation for the cut-off frequency in each case. (5 marks)

(c) Use suitable response characteristics (graphs) to illustrate the difference between 1st order and 2nd order elements. State a practical example in each case. (5 marks)

Q6. (a) Define the terms Accuracy and Resolution as applied to data converters. (2 marks)

(b) Use a basic integrator circuit to explain the basic principles of operation of a Dual Slope ADC. State its advantages over the Single Slope ADC. (8 marks)

(c) Use a block diagram to explain the operation of a successive approximation ADC. (10 marks)

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ICEN 323 CAT I DATE: 13/4/2012 TIME: 1.30MIN

1. (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]

(iv) Stain gauge [4mks]

2. The resistance R_θ kΩ of a thermistor at θ K is given by:

$$R_\theta = 1.68 \exp\left[3050\left(\frac{1}{\theta} - \frac{1}{298}\right)\right]$$

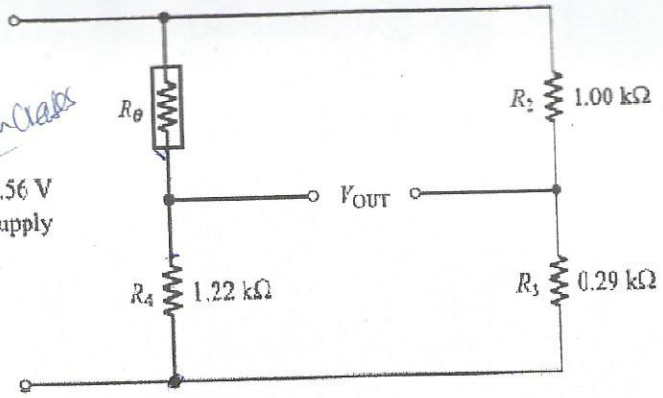
The thermistor is incorporated into the deflection bridge circuit shown in ~~Fig. Prob. 3.~~ below.

(a) Assuming that V_{OUT} is measured with a detector of infinite impedance, calculate:

(i) the range of V_{OUT} corresponding to an input temperature range of 0 to 50 °C;

(ii) the non-linearity at 12 °C as a percentage of full-scale deflection.

(b) Calculate the effect on the range of V_{OUT} of reducing the detector impedance to 1 kΩ.



[11mks]

2. (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)(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]