TECHNICAL UNIVERSITY OF MOMBASA

Faculty of Engineering and Technology

DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING
UNIVERSITY EXAMINATIONS FOR DIPLOMA IN TECHNOLOGY (INSTRUMENTATION & CONTROL ENGINEERING)

ECI 2204

INSTRUMENTATION SYSTEMS

END OF SEMESTER EXAMINATION

SERIES: AUGUST 2019

TIME: 2 HOURS

Instructions to Candidates

You should have the following for this examination
-Answer Booklet, examination pass and student ID
This paper consists of five Questions
Attempt any THREE Questions.
Do not write on the question paper.

QUESTION ONE

a) Explain the following terms as applied to instrumentation systems;

i) dead zone
ii) Sensitivity
iii) Span (3 marks)

b) i) Draw a block diagram of a typical instrumentation system and state the function of each block
ii) State any TWO advantages of electronic instrumentation systems over the mechanical types. (8marks)

c) A temperature measurement system using a sensor that outputs 5.5mV/˚C must measure temperature up to 100˚C. A 5 bit ADC with a 10V reference is used.
i) Draw the block diagram of the system
ii) Determine the gain of the amplifier to interface the sensor to the ADC
iii) Determine the temperature resolution(temperature corresponding to 1 bit change) in the ADC (6marks)

d) An instrumentation system to measure temperature comprises the following components and their individual sensitivities shown in Table 1

i) Draw the block diagram of the system

ii) Determine the overall system sensitivity

iii) Determine the temperature change corresponding to a recorder pen movement of 6.5cm (3 marks)

Table 1

component	sensitivity
Platinum resistance thermometer	0.75Ω/ ˚C
Amplifier gain	250V/V
Wheatstone bridge	0.05 V/ Ω
Pen recorder	0.6 cm/V

QUESTION TWO

a) Distinguish between null and deflection bridges (4 marks)

b) A potential divider potentiometer having a resistance of 20kΩ is used to measure angular displacement. The angle of displacement is 70˚and the total angle of travel of potentiometer is 355˚If the exciting voltage is 120V,Calculate

i) the open circuit output voltage

ii) the actual value of the output voltage at this setting if a voltmeter of 100kΩ is connected across the output

iii) the % error due to loading effect (6 marks)

c) i) Explain any TWO features of the instrumentation amplifier which make it suitable to amplify signals from transducers

ii) Figure 1 shows an instrumentation amplifier with a potentiometer R_A = 200 kΩ when R_A is varied , Determine

I) the minimum output voltage Vo

II) the maximum output voltage Vo (6marks)

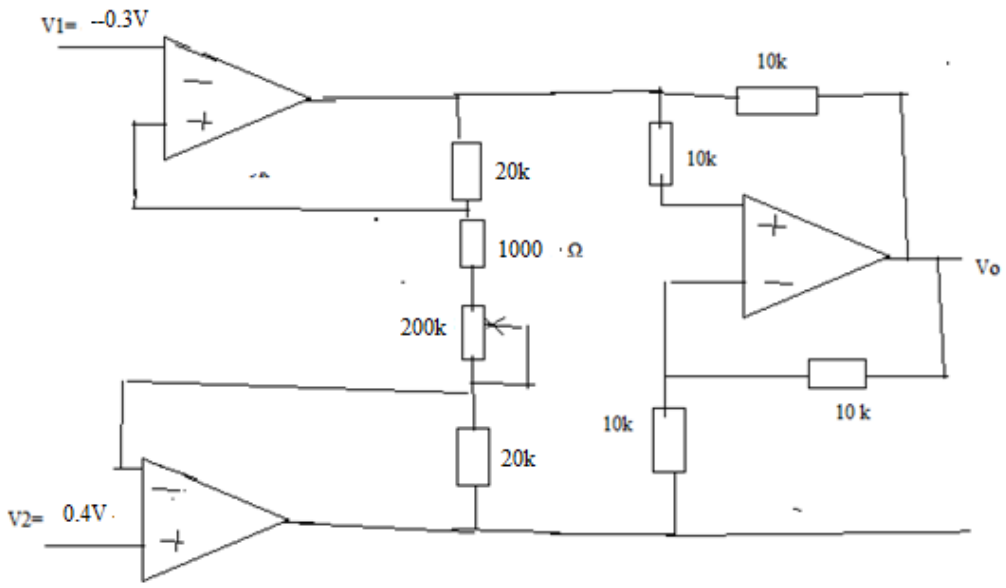

Figure 1

c) For a 4 bit Successive approximation Analogue to Digital Convertor , determine the digital output for an analogue input of 3.4375V .Take the reference voltage to be 5V (4 marks)

QUESTION THREE

a) i) Explain any TWO factors that are considered in the choice of transducers for a particular application

ii) Distinguish between the following types of transducers and give an example of each;

I) primary and secondary

II) active and passive (6marks)

b) i) With the aid of a diagram, describe the operation of 4 bit optical shaft encoder employing binary code

ii) A variable reluctance type tachometer has a 120 rotor teeth .The counter records2400 counts per second .Determine the speed in revolution per minute

(10 marks)

c) In a deflection bridge a photoconductive transducer Rp is connected in one arm of the bridge .initially $R_1 = R_2 = R_3 = R_t = 850\Omega$.When light intensity changes from 500 lumen/m^2 to 200 lumen/m^2, the resistance of the transducer changes to 1250 Ω. If the supply to the bridge is 15V, Determine the offset voltage (4 marks

QUESTION FOUR

a) i) Explain any TWO disadvantages of binary weighted DAC

ii) Describe the operation of the figure2 (10marks)

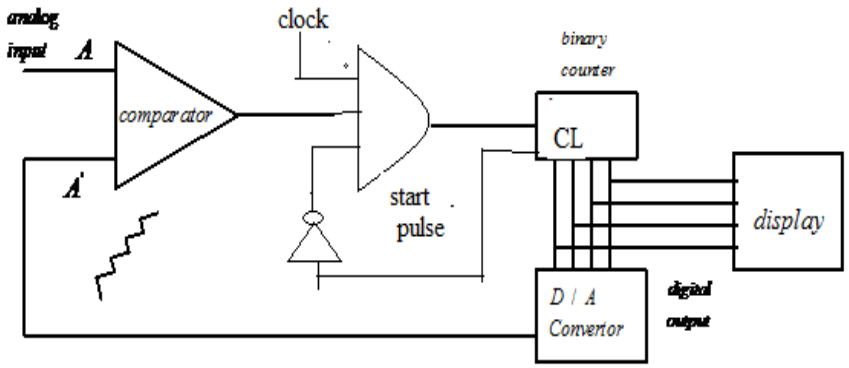

Figure 2

b) A control valve has a linear variation of opening as the input voltage varies from 0-10V. A microcomputer outputs an 10 bit word to control valve opening using an 8 bit DAC to generate the valve voltage .

i) Draw the block diagram of the arrangement

ii) Determine

i) the voltage required to obtain a full open valve

ii) the percentage of valve opening for a bit change in the input word.(6 marks)

c) A piezo electric crystal having a thickness of 8mm and a voltage sensitivity of $0.075 Vm^2/N$. Determine

i) the pressure applied if the output voltage is 100V

ii) Charge sensitivity given the relative permittivity of the material is 12

Take permittivity of free space $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m (4 marks)

QUESTION FIVE

a) i) State any TWO advantages of Liquid crystal displays(LCDs) over the LEDs

ii) Distinguish between x-t and x-y recorders and give an example of each (4 marks)

b) With the aid of a well labeled diagram, describe the operation of an XY recorder (8marks)

c) It is desired to display the numerals 0 ,2,5 ,6 H using the seven-segment LED display, Write down a table for the conversion of the characters to the seven-segment output (abcdefg) ` (4 marks)

d) A type K thermocouple was used to measure the temperature of a liquid (T_1) .The temperature of the reference junction was maintained at 20° C. The emf was found to be 5.3mV .Use the thermocouples tables provided to find the temperature of the liquid. (4 marks)

Thermocouple tables

Type E: chromel–constantan

Type J: iron–constantan

Type K: chromel–alumel

Type N: nicrosil–nisil

Type S: platinum/10% rhodium–platinum

Type T: copper–constantan

Temp. (°C)	*Type E*	*Type J*	*Type K*	*Type N*	*Type S*	*Type T*
-40	2.254	1.960	1.527	1.023	0.194	1.475
-30	1.709	1.481	1.156	0.772	0.150	1.121
-20	1.151	0.995	0.777	0.518	0.103	0.757
-10	0.581	0.501	0.392	0.260		0.383
0	0.000	0.000	0.000	0.000	0.000	0.000

10	0.591	0.507	0.397	0.261	0.055	0.391
20	1.192	1.019	0.798	0.525		0.789
30	1.801	1.536	1.203	0.793	0.173	1.196
40	2.419	2.058	1.611	1.064	0.235	1.611
50	3.047	2.585	2.022	1.339	0.299	2.035
60	3.683	3.115	2.436	1.619	0.365	2.467
70	4.329	3.649	2.850	1.902	0.432	2.908
80	4.983	4.186	3.266	2.188	0.502	3.357
90	5.646	4.725	3.681	2.479	0.573	3.813
100	6.317	5.268	4.095	2.774	0.645	4.277
110	6.996	5.812	4.508	3.072	0.719	4.749
120	7.683	6.359	4.919	3.374	0.795	5.227
130	8.377	6.907	5.327	3.679	0.872	5.712
140	9.078	7.457	5.733	3.988	0.950	6.204
150	9.787	8.008	6.137	4.301	1.029	6.702
160	10.501	8.560	6.539	4.617	1.109	7.207
170	11.222	9.113	6.939	4.936		7.718
180	11.949	9.667	7.338	5.258		8.235
160	10.501	8.560	6.539	4.617		7.207
170	11.222	9.113	6.939	4.936		7.718
180	11.949	9.667	7.338	5.258	1.190	8.235