		Reg. No.									
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DEPARTMENT OF MECHATRONICS III SEMESTER B.TECH. (MECHATRONICS ENGINEERING) END SEMESTER EXAMINATIONS, DECEMBER 2022

SUBJECT: SENSORS AND INSTRUMENTATION [MTE 2155]

08.11.2022

Time: 3 Hours

MAX. MARKS: 50

	Instructions to Candidates:					
	✤ Answer ALL the questions.					
	 Missing data (if any) can be suitably assumed and justif 	ied.				
Q. No		М	CO	PO	LO	BL
1A.	Using both a counter and arithmetic function blocks, draw a ladder logic for a light to be ON only when the number of pulses are between 34 and 41.	4	2	1	1	3
1B.	"Wheatstone bridge cannot be used for measurement of low resistance" Justify the statement. Sketch and explain the modified version of Wheatstone bridge which can be utilized for the measurement of low resistance.	1	4			
1C.	Out of the following optical sensors: <i>Diffuse reflective, Thru-beam,</i> <i>Retro-reflective</i> , identify and explain the operation of the most common type opto sensor known to the general public; since they appear in action movies in which thieves attempt to thwart a matrix of optical burglar alarm sensors setup around a valuable museum piece.	2	3	17	4	
2A	Identify one OSI layer of networking for each of the below given services in industrial process automation: a) Mozilla Firefox, Instagram b) Secured data transmission c) Error detection in the data d) Time-out of Student Life Cycle Management (SLCM)	4	4	2	2	4
2B	A barium titanate piezoelectric material has the dimensions of 5 mm x 5 mm x 1.25 mm. The force acting on it is 5 N. The charge sensitivity of barium titanate is 150 pC/N and its permittivity is 12.5 x 10 ⁻⁹ F / m If the Modulus of elasticity of barium titanate is 12 x 10 ⁶ N / m ² calculate the following: i. Strain acting on the material ii. Charge developed iii. Capacitance		3	1	1	3

2C	IEC 61508 has become a foun safety-related system such as power plants, medical equipm machinery, furnaces and autor safety installation from sensor to management issues. The failure of impact on the safety of humans a Mention the major steps which a procedure.	3	3	6	9	4			
3A	I. Consider the use of a then temperature of a furnace. T 40°C. Using the K-type therr the temperature of the furnace of 33.521 mV. II. Refer the datasheet of the Pla Q3B. For Pt-1000, calculat temperature of 200°C. Also, the RTD resistance-temper resistance of the sensor at 10 Temperature Sensors Platinum RTDs FUNCTIONAL BEHAVIOR $R_r = R_0(1+AT+BT^{-}100CT^{+}CT^{+})$ RT = Resistance (II) at 0°C T = Temperature I (°C) R_e = Resistance (II) at 0°C T = Temperature I (°C) $A = \alpha + \alpha \delta = \frac{-\alpha \delta}{100}$ $C_{re0} = -\frac{\alpha \beta}{100^{+}}$ SPECIFICATIONS Sensor Type Thin film platinum RTD. $R_e = 1000 \Omega @ 0°C; alp$ Temperature Range TFE Teflon: -200° to + Fiberglass: -75° to +5 Temperature Accuracy $\pm 0.5^{\circ}C$ or 0.8% of temp $\pm 0.3^{\circ}C$ or 0.6% of temp $\pm 0.3^{\circ}C$ or 0.6% of temp $\pm 0.3^{\circ}C$ or 0.6% of temp Base Resistance and $1000 \pm 2 \Omega (\pm 0.2\%) @$ Interchangeability, $R_e \pm \Delta R_e$ 1000 $\pm 1 \Omega (\pm 0.1\%) @$	rmocouple he cold ju nocouple t e if the ther atinum RT te the accu- considerin ature char 0°C. CONSTANTS Alpha, α (°C') Delta, δ (°C) Beta, β (°C) A (°C') B (°C') C (°C') B (°C') C (°C') B (°C') C (°C') B (°C') C (°C (°) B (°C) A (°C') B (°C) C (°C (°) B (°C) C (°C (°) B (°C) C (°C (°) B (°C) C (°C (°) B (°C) C (°C (°) C (°C (°) B (°C) C (°C (°) B (°C (°) C (°C (°) B (°C (°) C (°C (°) B (°C (°C) B (°C (°) C (°C (°) B (°C (°C) C (°C (°) B (°C (°C) C (°C (°) B (°C (°C) C (°C (°) B (°C (°C) C (°C (°) B (°C (°C (°)) B (°C (°C (°C)) B (°C (°C (°C)) B (°C (°C (°C)) B (°C (°C (°C)) B (°C (°C (°C (°C))) B (°C (°C (°C)) B (°C (°C (°C (°C))) B (°C (°C (°C (°C))) B (°C (°C (°C (°C (°C))) C (°C (°C (°C (°C (°C (°C (°C (°C (°C (°	for the m inction is r able, find th mocouple s D sensor as uracy of th ng linear ap racteristics, 0.00375 ±0.000029 1.605±0.009 0.16 3.81×10 ³ -6.02×10 ⁷ -6.0×10 ¹² C = 0 for T>0°C	r is greater r is greater r is greater r is greater t o be ne assured to be ne assured to be he assured to be ne assured t	5	3	1	1	3
3 B	A Robotic gripper, shown in	objects while	3	3	2	2	4		
	applying the necessary pressure through pressure sensors on ea purpose. Suggest suitable press measurable pressure range is choice.								

	Fig. Q3A: Robotic gripper					
3C	While measuring speed of a steam turbine with stroboscope, single line images were observed for stroboscope setting of 3000, 4000 and 5230 rpm. Calculate the speed of the turbine.	2	3	1	1	3
4A	Suggest and elaborate the operation of the most appropriate transducers: i) To measure the flow-rate of the fluid ii) To measure the rpm of the turbine For the following application: A chemical industry manufacturing brine solution (electrically conductive solution) produces a huge quantity of waste water which should be treated before being disposed or recycled. The brine solution is passed through a turbine that rotates at a rate that is proportional to the rate of flow of the solution. Turbine also has toothed rotor to measure the speed.	4	3	2	2	4
4 B	A compressive force is applied to a structural member. The strain is 5 micro-strain: Two separate strain gauges are attached to the structural member, one is a nickel wire strain gauge having a gauge factor of -12.1 and the other is nichrome wire strain gauge having a gauge factor of 2. Calculate the value of resistance of the gauges after they are strained. The resistance of strain gauges before being strained is 120 ohm.	4	3	1	1	3
4C	A well-known chemical manufacturer was experiencing repeated product (thermistor) failure and the key problems that were causing the failure, were the high pressure environment, and the high temperature of a vessel containing the reaction of partial oxidization of natural gas to carbon monoxide (POX). The products had to last for a two-year plant rebuild cycle. The customer needed to be supplied full material, process control, testing and safety documentation. Mention the steps to guide the customer to avoid such sensor failure risks.	2	5	6	9	4
5A	Two conveyors (A and B) feed a main conveyor. The main conveyor count can only be determined from count of parts entering from other two conveyors. The count on each conveyor is determined by a counter. Assume ADD function is enabled every 30s. If the main	4	2	1	1	3

	conveyor count exceeds 20, a light should go ON. Draw a ladder logic					
5B	The modern vehicles are embedded with many functionalities including steering and braking data which are communicated electronically from the driver to the actuators. The implementation strongly depends on the choice of braking mechanics (e.g., hydraulics, pneumatics, electro-hydraulics, or even electro-mechanics), the availability of a transmission ECU, and the interface to the engine ECU. Therefore, in order to have a smooth and bumpless transfer of data within all the ECUs of such vehicles, a standardized protocol is required for proper communication within the control system. Suggest and elucidate the most suitable communication protocol for this purpose.	3	4	1	2	4
5C	Explain the construction and working principle of the most suitable flow-meter for a ten-storey residential apartment, where water is to be pumped from the ground floor to the top floor. It is required to measure the flow-rate per hour for economical assessment.	3	3	1	2	4

Table 3A: K Type Thermocouple table (For Q3A)

TS-90 Tabl	e for Typ	pe K The	rmocou	ple (Ref	Junction	n 0°C)			h	ttp://reote	mp.com
°C	0	1	2	3	4	5	6	7	8	9	10
				The	rmoelect	tric Volta	age in m	v			
0	0.000	0.039	0.079	0.119	0.158	0.198	0.238	0.277	0.317	0.357	0.397
10	0.397	0.437	0.477	0.517	0.557	0.597	0.637	0.677	0.718	0.758	0.798
20	0.798	0.838	0.879	0.919	0.960	1.000	1.041	1.081	1.122	1.163	1.203
30	1.203	1.244	1.285	1.326	1.366	1.407	1.448	1.489	1.530	1.571	1.612
40	1.612	1.653	1.694	1.735	1.776	1.817	1.858	1.899	1.941	1.982	2.023
50	2.023	2.064	2.106	2.147	2.188	2.230	2.271	2.312	2.354	2.395	2.436
60	2.436	2.478	2.519	2.561	2.602	2.644	2.685	2.727	2.768	2.810	2.851
70	2.851	2.893	2.934	2.976	3.017	3.059	3.100	3.142	3.184	3.225	3.267
80	3.267	3.308	3.350	3.391	3.433	3.474	3.516	3.557	3.599	3.640	3.682
90	3.682	3.723	3.765	3.806	3.848	3.889	3.931	3.972	4.013	4.055	4.096

°C	0	1	2	3	4	5	6	7	8	9	10
890	36.925	36.965	37.006	37.046	37.086	37.126	37.166	37.206	37.246	37.286	37.326
000	36.524	36.364	35.604	30.644	36.665	36.725	30.765	36.805	36.845	30.885	36.925
000	36.121	36.162	36.202	36.242	36.282	36.323	36.363	36.403	36.443	36.484	36.524
800	35.718	35.758	35.798	35.839	35.879	35.920	35.960	36.000	36.041	36.081	36.121
850	35.313	35.354	35.394	35.435	35.475	35.516	35.556	35.596	35.637	35.677	35.718
050				05.405	05.175	05 510			05 007		
840	34.908	34.948	34.989	35.029	35.070	35.110	35.151	35.192	35.232	35.273	35.313
830	34.501	34.542	34.582	34.623	34.664	34.704	34.745	34.786	34.826	34.867	34.908
820	34.093	34.134	34.175	34.216	34.257	34.297	34.338	34.379	34.420	34.460	34.501
810	33.685	33.726	33.767	33.808	33.848	33.889	33.930	33.971	34.012	34.053	34.093
800	33.275	33.316	33.357	33.398	33.439	33.480	33.521	33.562	33.603	33.644	33.685
790	32.865	32.906	32.947	32.988	33.029	33.070	33.111	33.152	33.193	33.234	33.275
780	32.453	32.495	32.536	32.577	32.618	32.659	32.700	32.742	32.783	32.824	32.865
770	32.041	32.082	32.124	32.165	32.206	32.247	32.289	32.330	32.371	32.412	32.453
760	31.628	31.669	31.710	31.752	31.793	31.834	31.876	31.917	31.958	32.000	32.041
750	31.213	31.255	31.296	31.338	31.379	31.421	31.462	31.504	31.545	31.586	31.628
	50.150	00.040	50.001	50.020	00.004	51.000	01.041	51.000	51.100	51.112	01.210
740	30,798	30.840	30,881	30.923	30,964	31.006	31.047	31.089	31,130	31,172	31,213
730	30 382	30 424	30 466	30.507	30 549	30,590	30 632	30 674	30,715	30,757	30,798
720	29.965	30.007	30.049	30.090	30 132	30 174	30 216	30 257	30 299	30 341	30 382
710	29.129	29.171	29.213	29.200	29.291	29.330	29.300	29.422	29.404	29.000	29.040
700	20 120	20 171	20 213	20.255	20 207	20 339	20 390	29 422	20 464	29 506	20 549
090	28.710	28.752	28.794	28.835	28.877	28.919	28.961	29.003	29.045	29.087	29.129
680	28.289	28.332	28.374	28.416	28.458	28.500	28.542	28.584	28.626	28.668	28.710
670	27.869	27.911	27.953	27.995	28.037	28.079	28.121	28.163	28.205	28.247	28.289
660	27.447	27.489	27.531	27.574	27.616	27.658	27.700	27.742	27.784	27.826	27.869
650	27.025	27.067	27.109	27.152	27.194	27.236	27.278	27.320	27.363	27.405	27.447