MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

DEPT. OF MECHATRONICS

I SEMESTER M.TECH. (INDUSTRIAL AUTOMATION & ROBOTICS)

End-Semester Examination

SUBJECT: SENSORS, DRIVES AND ACTUATORS FOR INDUSTRIAL AUTOMATION (MTE 5152)

Date: 10/01/2023

Time: 180 minutes Exam time: 09:30 am – 12:30 pm MAX. MARKS: 50

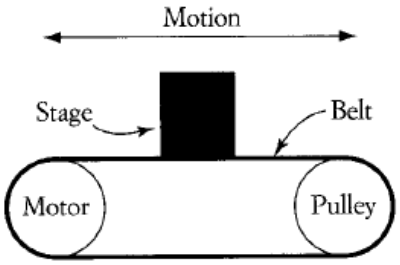
Instructions to Candidates:

- *Answer ALL the questions.*
- *Missing data may be suitably assumed and justified.*

Q. No.		Marks	CO	LO	BL
1A.	A 440V, 3 phase, 50 Hz, 6 pole, 945 rpm, delta connected induction motor has following parameters related to the stator: R_1= 2Ω, R_2= 2Ω, X_1= 3Ω, X_2= 4Ω When driving a fan-type of load at rated voltage, it runs at rated speed. The motor speed is controlled by stator voltage control. Calculate motor terminal voltage, rotor current and torque at 800 rpm.	**5**	**4**	**1**	**3**
1B.	Illustrate a closed loop variable voltage variable frequency speed control scheme for induction motor.	**3**	**4**	**1**	**3**
1C.	Suggest suitable sensors for the following applications: i. Measurement of vibrations ii. Measurement of speed of a wheeled mobile robot	**2**	**5**	**2**	**4**
2A.	A 230 V, 1000 rpm, 30 A separately excited DC motor has an armature resistance of 0.7 ohms. The motor is fed from a chopper which provides both motoring and braking operations. The source voltage has a voltage of 230V. Assuming continuous conduction, calculate duty ratio of chopper for: i. motoring operation at rated torque and 800 rpm ii. braking operation at rated torque and 350 rpm	**4**	**4**	**1**	**3**
2B.	With suitable examples, compare the applications for which incremental and absolute encoders can be used.	**3**	**5**	**2**	**4**

2C.	Strain gauges are used for health monitoring of the pillars of a bridge as shown in Fig.1 . Illustrate a configuration in which the strain gauges should be placed on a pillar for maximum sensitivity: i. Elucidate the number of strain gauges to be used for each measurement ii. The layout of the placement/ arrangement of the sensors iii. The electrical connections.  Fig.1 Bridge pillars	**3**	**5**	**2**	**4**
3A	Sketch the circuit of a three phase inverter when supplied from a 480 V DC source. Plot the waveforms for line voltages when operated in 180° conduction mode.	**5**	**2**	**1**	**3**
3B	A Robotic gripper, shown in Fig. 2 should lift objects while applying the necessary pressure on the objects. A pressure feedback through pressure sensors on each finger is very important for the purpose. Suggest suitable pressure sensor that can be used if the measurable pressure range is between 0-5 kg/cm^2. Justify your choice.  Fig.2. Robotic gripper	**3**	**5**	**2**	**4**

3C	Identify the type of DC motor that can be used for the following applications: i. Driving a compressor ii. Driving a hoist	**2**	**3**	**2**	**4**
4A	I. Consider the use of a thermocouple for the measurement of temperature of a furnace. The cold junction is measured to be 40°C. Using the K-type thermocouple table, find the true value of the temperature of the furnace if the thermocouple shows a reading of 33.521 mV. Refer the table at the end of the question paper. II. For Pt-1000 RTD, calculate the accuracy of the sensor at a temperature of 200° C if the accuracy is defined as 0.8% of true value of temperature. Also, calculate the resistance of the sensor at 100° C if $\alpha = 0.00375/°C$.	**4**	**5**	**1**	**3**
4B	Compare regenerative, dynamic and plugging types of braking of DC motors.	**3**	**3**	**1**	**4**
4C	A drive consisting of semiconductor converter fed DC motor, runs according to the following periodic duty cycle: i. Acceleration from standstill to 1000 rpm in 10 sec at uniform acceleration. ii. Running at 1000 rpm and 800 N-m torque for 8 sec. iii. Braking from 1000 rpm to standstill in 10 sec at uniform deceleration. iv. Remaining idle for 20 sec. Determine torque rating of the machine at J= 100 kg-m^2.	**3**	**1**	**1**	**3**
5A	A 200 V, 875 rpm, 140 A separately excited DC motor has an armature resistance of 0.06 Ω. Calculate the motor speed for the following conditions: i. The motor is driven by a half wave SCR converter without a free wheeling diode. The power source is 220 V, 50 Hz. Triggering angle for the converter is 30° and conduction period is 190°. i. The motor is now driven by a full wave thyristor converter. The power source is 220V, 50 Hz. Triggering angle for the converter is 30°.	**4**	**2**	**1**	**3**
5B	The electric drive system as shown in Fig. 3 consists of a pulley, a rigid belt and a stage. The motor moves the stage in either direction. Explain the motion of the system and power flow using the four-quadrant drive concept.	**4**	**1**	**1**	**2**

	 Fig.3: For quadrant drive system				
5C	Identify and sketch a power electronic converter circuit that can be used for variable voltage control of a single phase AC motor. Consider that the motor is fed from a single phase AC source.	**2**	**2**	**2**	**4**

ITS-90 Table for Type K Thermocouple (Ref Junction 0°C) http://reotemp.com

°C	0	1	2	3	4	5	6	7	8	9	10
	Thermoelectric Voltage in mV										
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

650	27.025	27.067	27.109	27.152	27.194	27.236	27.278	27.320	27.363	27.405	27.447
660	27.447	27.489	27.531	27.574	27.616	27.658	27.700	27.742	27.784	27.826	27.869
670	27.869	27.911	27.953	27.995	28.037	28.079	28.121	28.163	28.205	28.247	28.289
680	28.289	28.332	28.374	28.416	28.458	28.500	28.542	28.584	28.626	28.668	28.710
690	28.710	28.752	28.794	28.835	28.877	28.919	28.961	29.003	29.045	29.087	29.129
700	29.129	29.171	29.213	29.255	29.297	29.338	29.380	29.422	29.464	29.506	29.548
710	29.548	29.589	29.631	29.673	29.715	29.757	29.798	29.840	29.882	29.924	29.965
720	29.965	30.007	30.049	30.090	30.132	30.174	30.216	30.257	30.299	30.341	30.382
730	30.382	30.424	30.466	30.507	30.549	30.590	30.632	30.674	30.715	30.757	30.798
740	30.798	30.840	30.881	30.923	30.964	31.006	31.047	31.089	31.130	31.172	31.213
750	31.213	31.255	31.296	31.338	31.379	31.421	31.462	31.504	31.545	31.586	31.628
760	31.628	31.669	31.710	31.752	31.793	31.834	31.876	31.917	31.958	32.000	32.041
770	32.041	32.082	32.124	32.165	32.206	32.247	32.289	32.330	32.371	32.412	32.453
780	32.453	32.495	32.536	32.577	32.618	32.659	32.700	32.742	32.783	32.824	32.865
790	32.865	32.906	32.947	32.988	33.029	33.070	33.111	33.152	33.193	33.234	33.275
800	33.275	33.316	33.357	33.398	33.439	33.480	33.521	33.562	33.603	33.644	33.685
810	33.685	33.726	33.767	33.808	33.848	33.889	33.930	33.971	34.012	34.053	34.093
820	34.093	34.134	34.175	34.216	34.257	34.297	34.338	34.379	34.420	34.460	34.501
830	34.501	34.542	34.582	34.623	34.664	34.704	34.745	34.786	34.826	34.867	34.908
840	34.908	34.948	34.989	35.029	35.070	35.110	35.151	35.192	35.232	35.273	35.313
850	35.313	35.354	35.394	35.435	35.475	35.516	35.556	35.596	35.637	35.677	35.718
860	35.718	35.758	35.798	35.839	35.879	35.920	35.960	36.000	36.041	36.081	36.121
870	36.121	36.162	36.202	36.242	36.282	36.323	36.363	36.403	36.443	36.484	36.524
880	36.524	36.564	36.604	36.644	36.685	36.725	36.765	36.805	36.845	36.885	36.925
890	36.925	36.965	37.006	37.046	37.086	37.126	37.166	37.206	37.246	37.286	37.326

°C	0	1	2	3	4	5	6	7	8	9	10