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MANIPAL INSTITUTE OF TECHNOLOGY
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I SEMESTER M.TECH (ENERGY SYSTEMS AND MANAGEMENT / POWER ELECTRONICS AND DRIVES) END SEMESTER EXAMINATIONS, NOVEMBER 2017

SUBJECT: INSTRUMENTATION IN ELECTRICAL SYSTEMS [ELE 5105]

REVISED CREDIT SYSTEM

Time: 3 Hours **Date: 30th November 2017** **Max. Marks: 50**

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.
- All passive components must be selected to their standard values from the table provided

1A. Define Piezo-resistive effect. From the initial state, derive an expression to prove that gauge factor of a strain gauge is dependent on the resistance change due to piezo resistive effect. ***(03)***

1B. A capacitive transducer is made up of two concentric cylindrical electrodes. The outer diameter of the inner cylindrical electrode is 3mm and the dielectric medium is air. The inner diameter of the outer electrode is 3.1mm. The length of electrodes is 20mm. Calculate the change in capacitance if the inner electrode is moved through distance of 2mm. Also calculate the dielectric stress when a voltage of 100V is applied across the electrodes and determine if it is within safe limits assuming the breakdown strength of air to be 3KV/mm. ***(03)***

1C. With suitable diagrams, derive the expressions for reflection and transmission coefficients in plane wave shielding theory. Hence, prove that, the shielding effectiveness of an infinite sheet of good conductor is dependent on the reflection loss as well as absorption loss.

Calculate the shielding effectiveness for a sheet of silver whose thickness is $50.8\mu m$ and has a conductivity $\sigma = 6.3 \times 10^7$ ℧$/m$ at 10^8 Hz. ***(04)***

2A. Mention any four main functions of signal conditioning circuit. Design an active signal conditioning circuit using OPAMP to be interfaced with AD590 IC temperature transducer so as to produce 0V at 0°C and 10V at 100°C. The rate of conversion of AD590 is 1μA/^{0}K. ***(03)***

2B. A dual OPAMP instrumentation amplifier shown in **Fig. Q 2B** offers an advantage in that a high CMRR can be obtained via appropriate adjustment of the pot. Derive its mathematical model and prove that:

$$V_0 = \left(1 + \frac{R_2}{R_1}\right)(V_2 - V_1)$$

(03)

2C. A smart flexible system is put to a resonant harmonic excitation test for its fatigue analysis studies. The transducer used in the application is barium titanate ($BaTiO_3$) crystal having dimensions: $5mm \times 5mm \times 1.5mm$. The Young's modulus of $BaTiO_3$ is $12 \times 10^6 N/m^2$, its charge sensitivity is $150pC/N$ and permittivity is $12.5 \times 10^{-9} F/m$. A CRO is connected to view the results. The oscilloscope may be considered as a resistance of $100M\Omega$ in parallel with a capacitance of 10 pF. Determine the rms value of the developed voltage under open and load conditions when the excitation force of $0.142 \sin(100t)\ N$ is applied to the crystal. The resistance of the crystal may be neglected. ***(04)***

3A. Derive the mathematical model of a band pass active filter depicted in **Fig. Q 3A.** Also, calculate its lower and upper cut off frequencies along with the voltage amplification factor if the values of the passive components are given below:

$R_1 = R_2 = 10K\Omega$; $R_{f1} = R_{f2} = 100K\Omega$; $R_L = R_H = 10K\Omega$; $C_L = 1\mu F$; $C_H = 10\mu F$ ***(03)***

3B. With neat diagram, describe how the linear motion of the core of an inductive transducer is transduced to electrical signals.

The output of an LVDT is connected to a 5V voltmeter through an amplifier having an amplification factor of 250. An output of 2mV appears across the terminals of LVDT when the core moves through a distance of 0.5 mm. Calculate the sensitivity of the LVDT and that of the instrument. The milli-voltmeter scale has 100 dvisions. The scale can be read to 1/5 of a division. ***(03)***

3C. A temperature transducer is used to measure a temperature range of 0K to 2000 K for a thermal heating chamber application. The transducer characteristics are as shown in **Fig. Q 3C**. Design an appropriate signal conditioning circuit considering that the output of signal conditioning circuit is to be observed for the full range (-10V to +10V) of ADC respectively for further processing. Consider a standard power supply of 12 volts to be available. Sketch the circuit diagram of the entire signal conditioning unit. ***(04)***

4A. With an appropriate schematic of a 10 bit successive approximation A/D converter employing SAR, obtain the equivalent binary output for an analog voltage input of 0.6 V. Consider the reference voltage to be 1 V. Highlight all the steps involved in this A/D conversion process. ***(03)***

4B. With the help of neat schematic describe the working of R-2R Ladder Network DAC. Prove that for digital input of 0100 equivalent analog voltage is (–Vs/4) with appropriate circuit connections. Assume Vs as reference/source voltage. ***(03)***

4C. With the help of the basic ladder logic, explain the operation of an UP counter in ensuring the DETERMINISTIC nature of an industrial process.

Fig. Q 4C depicts a typical automated product packaging process. Once, the employed photoelectric sensor (X0) detects 10 products on the conveyer belt, the robotic arm (Y0) automatically packs the product carton placed at the end of the chain. The whole packaging process is reset upon the successful packaging of every batch of 10 products. With appropriate ladder logic, explain the proposed solution to achieve the above stated aim. ***(04)***

5A. With neat block diagrams explain the concepts involved in signal measurement and instrumentation related to an ECG measuring system ***(03)***

5B. With neat schematics, explain the Bit fields of Standard CAN and Extended CAN. Explain the concept of Arbitration in CAN based data transmission. ***(03)***

5C. With a neat diagram and accompanying waveforms of input current, switching current and explain the working of an ideal Boost converter. ***(04)***

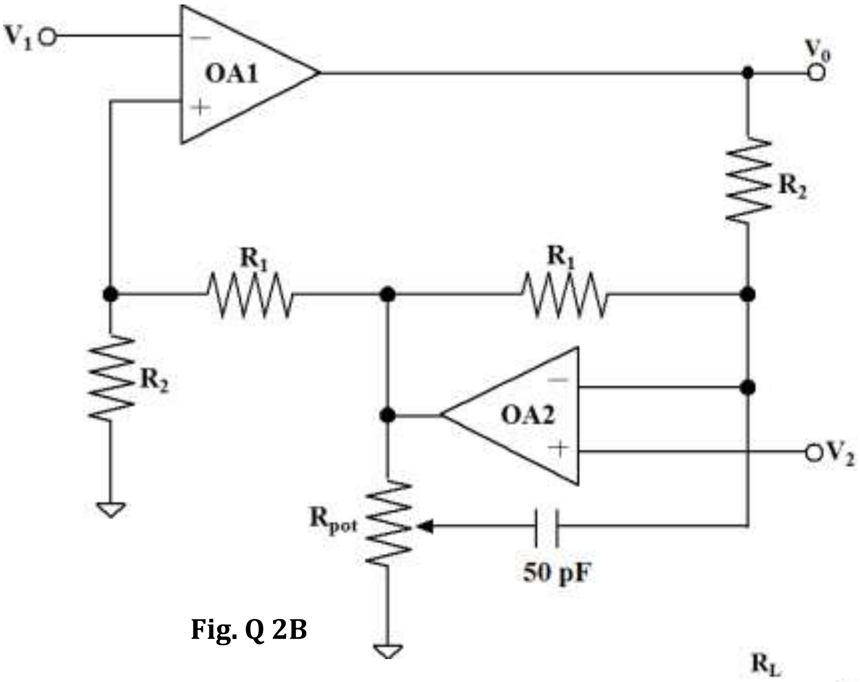

Fig. Q 2B

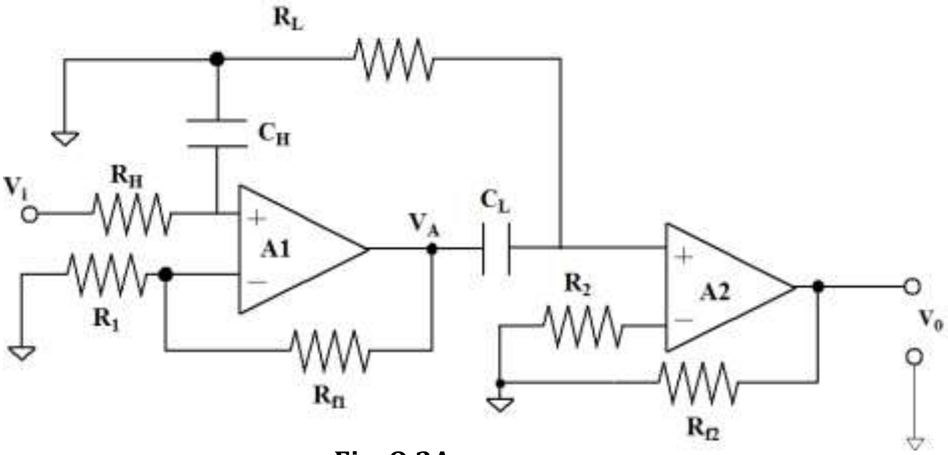

Fig. Q 3A

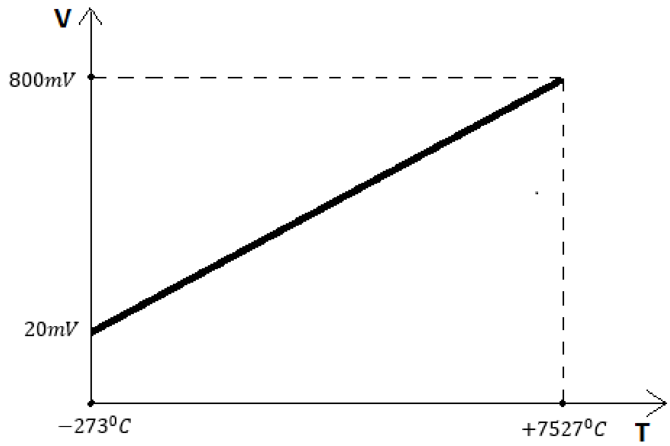

Fig. Q 3C

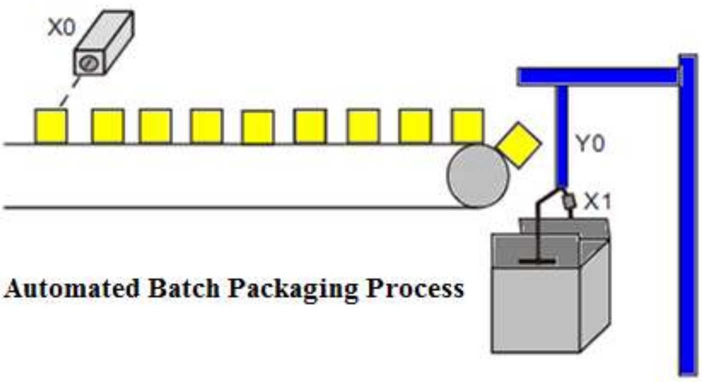

Fig. Q 4C

Standard Resistor Values (±5%)						
1.0	10	100	1.0K	10K	100K	1.0M
1.1	11	110	1.1K	11K	110K	1.1M
1.2	12	120	1.2K	12K	120K	1.2M
1.3	13	130	1.3K	13K	130K	1.3M
1.5	15	150	1.5K	15K	150K	1.5M
1.6	16	160	1.6K	16K	160K	1.6M
1.8	18	180	1.8K	18K	180K	1.8M
2.0	20	200	2.0K	20K	200K	2.0M
2.2	22	220	2.2K	22K	220K	2.2M
2.4	24	240	2.4K	24K	240K	2.4M
2.7	27	270	2.7K	27K	270K	2.7M
3.0	30	300	3.0K	30K	300K	3.0M
3.3	33	330	3.3K	33K	330K	3.3M
3.6	36	360	3.6K	36K	360K	3.6M
3.9	39	390	3.9K	39K	390K	3.9M
4.3	43	430	4.3K	43K	430K	4.3M
4.7	47	470	4.7K	47K	470K	4.7M
5.1	51	510	5.1K	51K	510K	5.1M
5.6	56	560	5.6K	56K	560K	5.6M
6.2	62	620	6.2K	62K	620K	6.2M
6.8	68	680	6.8K	68K	680K	6.8M
7.5	75	750	7.5K	75K	750K	7.5M
8.2	82	820	8.2K	82K	820K	8.2M
9.1	91	910	9.1K	91K	910K	9.1M

Standard Capacitor Values (±10%)						
10pF	100pF	1000pF	.010µF	.10µF	1.0µF	10µF
12pF	120pF	1200pF	.012µF	.12µF	1.2µF	
15pF	150pF	1500pF	.015µF	.15µF	1.5µF	
18pF	180pF	1800pF	.018µF	.18µF	1.8µF	
22pF	220pF	2200pF	.022µF	.22µF	2.2µF	22µF
27pF	270pF	2700pF	.027µF	.27µF	2.7µF	
33pF	330pF	3300pF	.033µF	.33µF	3.3µF	33µF
39pF	390pF	3900pF	.039µF	.39µF	3.9µF	
47pF	470pF	4700pF	.047µF	.47µF	4.7µF	47uF
56pF	560pF	5600pF	.056µF	.56µF	5.6µF	
68pF	680pF	6800pF	.068µF	.68µF	6.8µF	
82pF	820pF	8200pF	.082µF	.82µF	8.2µF	