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

I SEMESTER M.TECH (ESM / PED) END SEMESTER EXAMINATIONS, DECEMBER 2018

SUBJECT: INSTRUMENTATION IN ELECTRICAL SYSTEMS [5104]

REVISED CREDIT SYSTEM

Time: 3 Hours **Date: 03, DECEMBER 2018** **Max. Marks: 50**

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.
- Graph Sheet will be provided.
- Refer to standard values from the table in Page 3.

1A. Steel bar of rectangular cross-section $(2cm \times 1cm)$ is subjected to tensile force of 20kN. A strain gauge is placed on steel bar. Find the change in resistance if the gauge factor is 2. In absence of axial load, the resistance is 120Ω. Young's modulus of elasticity of steel bar is equal to $(2 \times 108kN/m^2)$. ***(03)***

1B. With a neat diagram, explain the working of capacitive transducers working on the principle of differential arrangement. Further, prove that the differential output voltage varies proportionately to the displacement of the movable plate. ***(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. Define Piezo-electric effect. With a neat diagram, derive and prove that the output voltage of a piezoelectric element is dependent on the product of its voltage sensitivity, its thickness and the applied pressure. ***(03)***

2B. An a.c. LVDT has the following specifications:

$V_{in} = 6.3V;\ V_{out} = \pm 5.2V;\ core\ displacement\ range = \pm 0.5\ in.$

- Plot the output voltage v/s core position as the core moves from $+0.45\ in$ to $-0.03\ in$ **(Use the graph sheet provided)**
- Determine the corresponding output voltage for a core displacement of $-0.25\ in$ from the centre. (1 in = 25.4 mm) ***(03)***

2C. For the active amplifier circuit shown in **Fig. Q2C**, considering

$$\frac{R_2}{R_1} = \frac{R_2'}{R_1'}$$

Prove that the output voltage can be expressed as:

$$V_0 = (V_2 - V_1)\left[1 + \frac{R_2}{R_1} + \frac{2R_2}{R_g}\right] + V_{ref}$$ ***(04)***

3A. Shock sensors are widely used in detecting abnormal vibrations in industrial motors. They behave like piezoelectric sensors. In the application here, the motor runs at variable speeds and the maximum shock sensed is 50G. The electric signals from the shock sensor is fed to a charge amplifier configured in its charge mode. The charge source is defined to be $0.35pC/G$, while the shunt resistor and capacitor were defined to be $10G\Omega$ and $390pF$ respectively. The cable length used here was 1 meter with its capacitance being $100pF$. The analog platform is designed in such a manner that for zero input, the voltage output too should be zero. The resonant frequency of the shock sensor is $28KHz$. Design the analog signal conditioning platform (amplifier along with the active filters) such that voltage output for a fixed pass band of 160Hz - 2KHz is obtained. ***(03)***

3B. Mention any four main functions of signal conditioning circuit. Design a Signal Conditioning circuit using OPAMP for interfacing AD590 IC temperature transducer so as to produce 0V at 0°C and 10V at 100°C. The rate of conversion of AD590 is $1\mu A/{}^0K$. ***(03)***

3C. For the active filter shown in **Fig. Q3C,** highlighting he involved steps, derive the mathematical model in Laplace domain and comment on the type of the filter architecture. Further, determine the cut off frequency/ies (in Hz) as well as the voltage amplification gain. ***(04)***

4A. With neat diagram, explain the operation of analog signal isolation in the photo-conductive mode. For an active signal isolation circuit (photo-conductive mode) having the following specifications:

$V_{cc} = +5V$; servo gain $=$ forward gain $= 0.004$ and forward current $= 15mA$

Design suitably, the circuit components that will ensure an amplified (as well as isolated) voltage output of $0 - 4V$ for an existing voltage input of $0 - 2V$ ***(03)***

4B. With a neat diagram, explain the working of a flash analog to digital converter. Further, for a supply excitation of +12 V, determine the digital output of a 4 bit flash A/D converter for an input voltage of 2.5 V ***(03)***

4C. With a neat diagram, explain the working of an R-2R resistor ladder digital-analog converter. For a reference voltage of 5V, create a table of analog voltage output of a 4 bit R-2R digital-analog converter. Let $R = 100K\Omega, R_f = 400K\Omega$. ***(04)***

5A. 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. Q5A 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. ***(03)***

5B. With a neat diagram, explain the working of a linear voltage regulator employing the standard NPN Darlington with PNP driver. ***(03)***

5C. With a neat diagram and accompanying waveforms of diode voltage, diode current, input current as well as output current, explain the working of an ideal boost converter. Also derive the final expression of the output voltage. ***(04)***

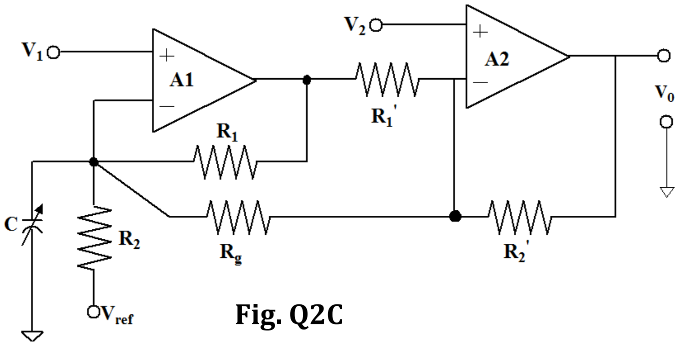


Fig. Q2C

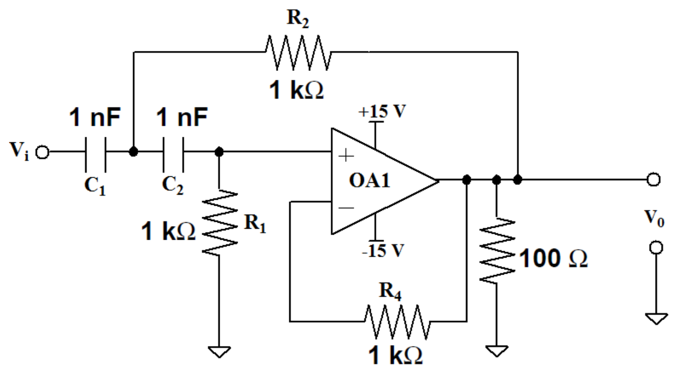
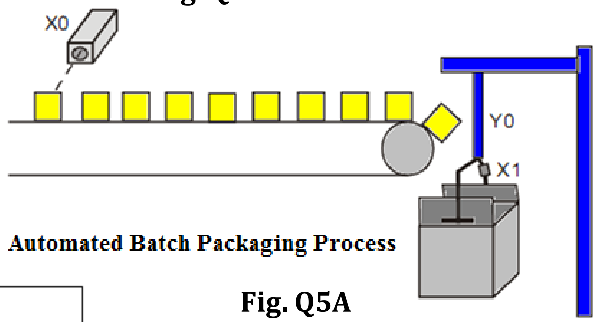


Fig. Q3C



Automated Batch Packaging Process

Fig. Q5A

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	