Reg. No.									

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
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VI SEMESTER B.TECH (ELECTRICAL & ELECTRONICS ENGINEERING)
GRADE IMPROVEMENT EXAMINATIONS, JAN 2021

MEASUREMENTS AND INSTRUMENTATION [ELE 3202]
REVISED CREDIT SYSTEM

Time: 3 Hours **Date: 06 January 2021** **Max. Marks: 50**

Instructions to Candidates:
- Answer **ALL** the questions.
- Missing data may be suitably assumed.
- Passive component values may be selected from table in Page 3.

1A.	Two different voltmeters are used to measure the voltage across R2 in the circuit in **Fig. Q1A**. The meters are as follows: a) 5 V range, Sensitivity = 20 kΩ/V. b) 10 V range, Sensitivity = 20 kΩ/V. Let Vs = 40V, R1 = 20 kΩ, R2 = 1 kΩ and R3 = 10 kΩ. With appropriate calculations, identify which voltmeter introduces least error due to loading.	***(03)***
1B.	An AC Bridge as shown in the **Fig. Q1B**, is used to measure an unknown inductance L_x, which has inherent resistance R_x. The bridge parameters are $R_1 = 20k\Omega$; $R_2 = 50k\Omega$; $C_2 = 0.0037\mu F$. The operating frequency $\omega = 10^5 rad/sec.$ C_1 is adjustable from 10 pF to 150 and R_4 is adjustable from 0 to 10 kΩ. Derive expressions for R_x and L_x to show that resistive and reactive balance are independent of each other. Also determine the largest values of R_x and L_x that can be measured with given parameters.	***(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. Determine the shielding effectiveness in dB for a 20 mil thick sheet of copper $\sigma = 5.8 \times 10^7$ S/m at 1MHz given • An electric source at a distance 1 m from the shield • A magnetic source at a distance 1 m from the shield	***(04)***
2A.	Using appropriate reasoning and diagrams, justify the need for the internal ratio arms in a kelvin's double bridge (KDB). Further, Derive an expression for unknown resistance in terms of known standard resistances in the KDB bridge	***(03)***
2B.	In an electrodynamometer instrument the total resistance of the voltage coil circuit is 8.2 $k\Omega$ and mutual inductance changes from $-173\ \mu H$ at zero deflection to $+175\ \mu H$ at full scale deflection of 95^0. If 100V potential difference is applied across voltage circuit, current of 3A at	***(03)***

a power factor of 0.75 flows through current coil. Determine, the corresponding deflection if the spring constant is assumed to be $4.63 \times 10^{-6}\ N - m/rad$.

2C. 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. The insulation material used in the cable is Polytetrafluoroethylene (PTFE) whose dielectric constant is 2.1 and the cable capacitance is $100pF$. 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. ***(04)***

3A. 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)***

3B. With a neat diagram, explain the principle of magnetic isolation using active devices. Highlight the role played by phase sensitive modulators as well as phase sensitive demodulators in this signal isolation technique. ***(03)***

3C. 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 $R = 100K\Omega$, while the feedback resistance $R_f = 400K\Omega$. ***(04)***

4A. The unbalanced voltage of a resistance bridge is to be amplified 200 times using a differential amplifier. The configuration is shown in **Fig. Q4A** with R= 1kΩ and $x = 2 \times 10^{-3}$. Two amplifiers are available: ***(03)***

- Amplifier 1 with differential gain Ad =200 and CMRR= 80 dB
- Amplifier 2 with differential gain Ad=200 and CMRR= 60dB.

Find the values of V_0 for both the cases and compute the respective errors. Finally, draw conclusions as to which is the best amplifier to be selected for the application.

4B. Inserting a resistance $\boldsymbol{R_3}$ in parallel with capacitance $\boldsymbol{C}$ in the high pass filter shown in **Fig. Q4B** turns it into a zero-pole circuit that finds applications in control. ***(03)***

- Sketch the modified circuit and derive its mathematical model so as to justify its name.
- Specify standard component values for a zero frequency of 100 Hz, a pole frequency of 1 KHz and a high frequency gain of 0dB.
- Sketch its magnitude plot highlighting the pole and zero frequencies.

4C. For a 4 bit binary weighted D/A converter having $R = 10K\Omega$; $R_f = 5K\Omega$ and $V_{ref} = -10V$, for an input binary word of 1101, determine the following: ***(04)***

- Current through the MSB switch
- Output voltage of the D/A converter

5A. With a neat diagram, explain the various elements of a Distributed control system (DCS). Also list out the advantages of using DCS for process control. ***(03)***

5B. With a neat diagram and waveforms, for a suitable analog input, explain the working of a Successive Approximation A/D converter with SAR (select the suitable number of bits). ***(03)***

5C. With the help of neat block diagram explain in detail, the working of various stages in an ECG measuring system resulting in an accurate representation of the health of a patient's heart. ***(04)***

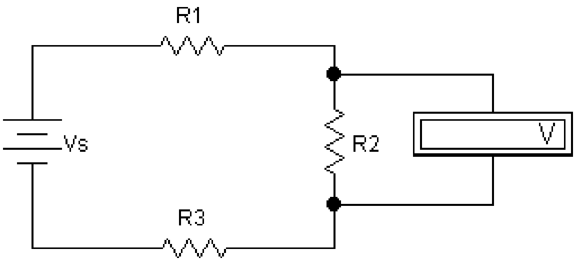

Fig. Q1A

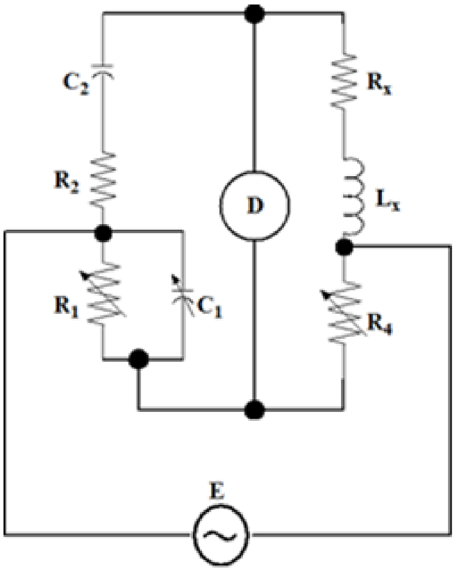

Fig. Q1B

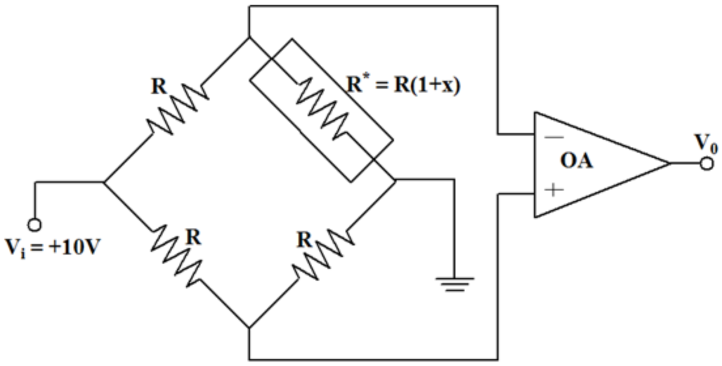

Fig. Q4A

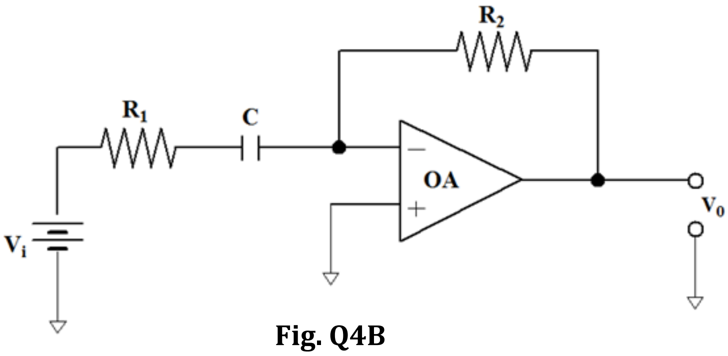

Fig. Q4B

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	