| Reg. No. | | | | | | | | | |
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# MANIPAL INSTITUTE OF TECHNOLOGY
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## VI SEMESTER B.TECH. (ELECTRICAL & ELECTRONICS ENGINEERING)
## END SEMESTER EXAMINATIONS, APRIL / MAY 2019
## SUBJECT: MEASUREMENTS & INSTRUMENTATION [ELE 3202]
REVISED CREDIT SYSTEM

**Time: 3 Hours** **Date: 27, April 2019** **Max. Marks: 50**

**Instructions to Candidates:**
- Answer **ALL** the questions. Missing data may be suitably assumed.
- Standard passive component values may be taken from the table.

**1A.** Two different voltmeters are used to measure the voltage across $R_2$ in the circuit shown in **Fig.Q1A**. The specifications of the meters are as follows:
   a. 5 V range, Sensitivity = 20 kΩ/V
   b. 10 V range, Sensitivity = 20 kΩ/V

Supply voltage $V_s = 40V$; $R_1 = 20\ k\Omega$, $R_2 = 1\ k\Omega$ and $R_3 = 10\ k\Omega$.
Through appropriate analytical calculations, determine which of the above two voltmeters, introduces least error due to loading. ***(03)***

**1B.** 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. ***(03)***

**1C.** You have been hired to an electrical machine manufacturing firm as a replacement to another engineer who left the company. The first task on arrival is to critically review and determine the current flowing in a designed circuit which is connected to a DC motor. The engineer's journal had the following observations:
   a. DC current flowing through the circuit is measured by a PMMC based ammeter and backed up by an Electrodynamometer based ammeter.
   b. The PMMC instrument contains 100 turns of coil with the flux density in the air gap being $0.2 Wb/m^2$ with the coil area being $0.8\ cm^2$.
   c. The electrical characteristics of the employed electrodynamometer based ammeter was:

| Deflection (degree) | 30 | 50 | 90 | 120 | 150 |
|---|---|---|---|---|---|
| Mutual Inductance ($H$) | 0.015 | 0.025 | 0.045 | 0.06 | 0.075 |

   d. Spring constants for both the ammeters were determined to be the same.
   e. The deflection in both the meters when tested were found to be the same.

If the target design DC current to the DC motor is 3.5A, determine the % error (of current measurement) in the existing circuit design. ***(04)***

**2A.** With a neat diagram and accompanying phasor diagram of Anderson's bridge, derive the expressions for the unknown inductance and resistance considering the bridge to be at balance. ***(03)***

**2B.** A strain gauge is bonded to a steel beam $0.1 m$ long and has a cross-sectional area of $4\ cm^2$. Young's modulus of elasticity for steel is 207 GN/m$^2$. The strain gauge has an unstrained resistance of 240Ω and a gauge factor of 2.20. When the load is applied, the gauge's resistance changes by 0.013Ω. Calculate the change in length of the steel beam and the amount of force to be applied. ***(03)***

**2C.** With a neat diagram, explain the working of a capacitive transducer working on the principle of differential arrangement. Further, prove that the differential output voltage varies in proportion to the measured displacement. ***(04)***

**3A.** With a neat diagram, explain the principle of operation of a linear variable differential transformer (LVDT). Design a suitable signal conditioning circuit that ensures the LVDT output of $5 - 10\ mV$ is shifted to an accepted level of $0 - 5V$ of an A/D converter. Assume a DC power supply of $5V$ to be available. ***(03)***

**3B.** For the active filter circuit shown in **Fig. Q3B**, derive its mathematical model and comment on the nature of the filter. Also, taking into account, the given values of the passive components, determine its cutoff frequency/ies and quality factor. ***(03)***

**3C.** A piezo shock sensor is connected to the back wheel of an F1 race car and it records a maximum possible shock of $100g$ during the trial test. The electrical signals from the shock sensor is fed to a charge amplifier configured in the voltage mode. The critical sensor parameters are defined as: crystal capacitance $= 60pF$ and crystal resistance $= 1G\Omega$. The shock to charge relation is determined to be as $0.6283pC/g$. The connecting cable capacitance is $2.83pF$. Design a suitable signal conditioning platform such that for zero to maximum shock input, the output should be limited to $0 - 5V$ for a fixed pass band of $5 - 159Hz$. Assume the feedback capacitance to be $1\mu F$ ***(04)***

**4A.** 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)***

**4B.** 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)***

**4C.** With neat diagram, explain the operation of analog signal isolation in the photo-conductive mode. An active optical signal isolation circuit (photo-conductive mode) has 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 $0 - 2V$ ***(04)***

**5A.** With a neat diagram, explain the working of an R-2R ladder digital-to-analog converter. For a reference voltage of 5V, create a table of analog voltage output of a 4 bit R-2R digital-analog converter. Given: $R = 100k\Omega$, $R_f = 400k\Omega$. ***(03)***

**5B.** With the help of a neat block diagram, explain the working of various stages in an ECG measurement system resulting in an accurate representation of the health of a patient's heart ***(03)***

**5C.** Consider a 4 bit binary weighted D/A converter having the circuit components defined as $R = 10k\Omega$; $R_f = 5k\Omega$ and $V_{ref} = -10V$. For an input binary word of 1101, determine the following:

a. Resolution
b. Input current
c. Output current
d. Output voltage ***(04)***

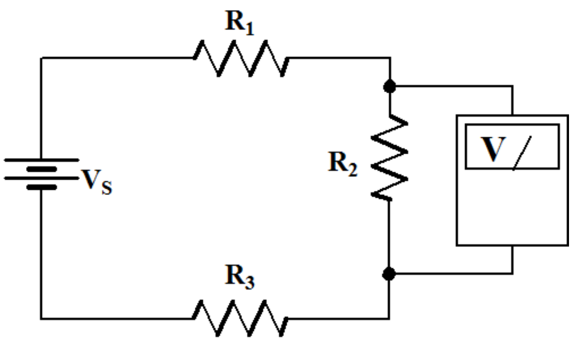


*Fig. Q1A*

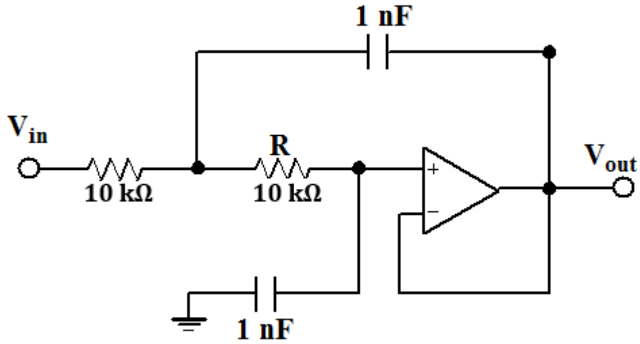


*Fig. Q3B*

| 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 | |