

Exam.	Back		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Instrumentation I (EE 552)

Candidates are required to give their answers in their own words as far as practicable.
Attempt All questions.

The figures in the margin indicate Full Marks.

Assume suitable data if necessary.

Draw block diagram of instrumentation system and briefly describe its components. Also illustrate two examples of instrumentation system. [5+1]

- a) What do you mean by resolution of instrument? A moving coil galvanometer has a uniform scale with 100 divisions and gives full scale reading of 200V. The instrument can read upto $\frac{1}{5}$ th of a scale division with fair degree of certainty. Determine the resolution of instrument in volts. [5+1]

- b) Explain about possible error in measurement system with their corresponding corrective measures. [1+3]

- c) A 1000 Hz bridge has following constants: [6]

Arm AB: $R = 1000 \Omega$ in parallel with $C = 0.5 \mu F$

Arm BC: $R = 1000 \Omega$ in series with $C = 0.5 \mu F$

Arm CD: $R = 2000 \Omega$ in series with $L = 30mH$

(i) Find the constants of arm DA to make the bridge balanced.

(ii) Express the result as a pure resistor (R) in parallel with a pure capacitor (C) or a inductor (L). [6]

d) Introduce transducer and describe briefly about any one resistive transducer. [4]

- e) A capacitive transducer is made up of two concentric cylinder electrodes. The outer diameter of inner cylinder electrode is 3 mm and dielectric medium is air. The inner diameter of the outer electrode is 3.1 mm. Calculate the dielectric stress when a voltage of 100V is applied across the electrodes. The length of electrode is 20 mm. Calculate the change in the capacitance if the inner electrode is moved through a distance of 2 mm. The breakdown strength of air is 3 KV/mm. [6]

- f) A strain gauge is bonded to a beam which is 12 cm long and has a cross-sectional area of 3.8 cm^2 . The unstrained resistance and gauge factor of the strain gauge are 220Ω and 2.2 respectively. On the application of load, the resistance of the gauge changes by 0.015Ω . If the modulus of elasticity for steel is 207 GN/m^2 . Calculate: [6]

- (i) The change in length of the steel beam
(ii) The amount of force applied to the beam

g) What is an operational amplifier? Mention its ideal characteristics and applications. [4]

h) Describe about Instrumental amplifier. [6]

i) Differentiate Analog and Digital signal. Explain why ADC and DAC conversion is performed. [4]

j) Explain working of R-2R ladder DAC. What is its advantage over WRN? [6]

k) What is sampling and sampling theorem? find the sampling frequency for input: [3+2]

$$v(t) = 200 \sin 50\pi t + 100 \sin 200\pi t - 50 \cos 600\pi t$$

l) Describe about Data Acquisition system. [5]

m) Explain about single phase Energy meter with a neat construction diagram and working. Why is it called an integrating instrument? [5]

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Examination Control Division
2078 Poush

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Subject: - Instrumentation I (EE 552)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
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1. a) Define measurement and measurement system. Briefly explain different components of measurement system. Also explain difference between analog and digital system. [8]
- b) Explain different errors which may occurs in any measurement system and the method to minimize them. [8]
2. a) Derive balanced condition for AC. Bridge circuit. [4]
- b) Explain how both magnitude and direction of displacement can be measured with the help of linear variable differential transformer. [8]
- c) A potentiometer has a resistance of $5 \text{ k}\Omega$ and is rated at 3W . What is maximum allowable excitation voltage? Calculate the sensitivity and resolution if the length of the potentiometer is 0.1 m and there are 200 turns. Also calculate the percentage loading error at 0.65 of the travel if a meter of $5 \text{ k}\Omega$ is connected across the potentiometer. [4]
3. a) How do Hall effect sensor work? Also explain why this effect is more pronounced in the case of semiconductor than in metal. [6]
- b) Explain the ideal characteristics of Op-amp. Also prove that if a d.c. voltage is applied to an integrator, it produce a ramp-voltage. [6]
- c) In order to measure the strain in a cantilever beam, a single strain gauge of resistance $1 \text{ k}\Omega$ and gauge factor 5 is mounted on the beam and connected to one arm of the bridge circuit. The other arms of the bridge have a resistance of 1000Ω each. The bridge detector resistance is 200Ω and its sensitivity is $20 \text{ mm} / \mu\text{A}$. Calculate the detector deflection for 0.1% strain. The supply to the bridge is 50 V . [4]
4. a) Explain how data is transfer in optical fiber communication system and mention the advantages of optical fiber communication system. [6]
- b) Explain how digital to analog conversion can be achieved by using weighted Resistor network DAC. Also mention its drawbacks. [6]
- c) An 6 bit converter has maximum supply voltage of 12 V . Find:
 - (i) What voltage change does LSB represent?
 - (ii) What voltage does 101011 represent?
5. a) Explain the construction detail and operating principle of a single phase induction type energy meter. [6]
- b) What is aliasing and how can it be avoided? [4]
- c) Explain the features of instrumentation amplifier and derive the expression for its gain. [6]

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Subject: - Instrumentation I (EE 552)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
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- ✓ Assume suitable data if necessary.

1. a) Define measurement and measurement system. Draw the block diagram of measurement system showing each component of measurement system and also explain the functions of each block. [2+4]
- b) Using statistical evaluation of random errors or data of measurement, explain how probable error in a measurement can be obtained. [6]

Find out the probable error of the observation given in table below

Current readings in ampere	Number of readings
9.97	1
9.98	3
9.99	13
10.00	23
10.01	15
10.02	4
10.03	1

- c) If a voltmeter having accuracy of 1% and full scale range 100V is used to measure 80V and 12V. Calculate the possible percentage error of both readings. Comment on your answer. [4]
2. a) Explain how the nonlinear characteristics of a capacitive transducer used for the measurement of displacement using the principle of change in capacitance due to change in distance between plates can be made linear. [6]
- b) Explain the construction and working principle of a linear variable differential transformer. [6]
- c) A resistance gauge is used to measure stress on steel. The steel is stressed to 1400 Kg/m^2 . Assume Young's modulus of elasticity of steel is $2.1 \times 10^6 \text{ Kg/cm}^2$. Calculate the % change of resistance of a strain gauge and poison's ratio assuming gauge factor equal to 2. [4]
3. a) Why signal conditioning is done in instrumentation system? Derive the expression for closed loop gain of op-amp in inverting mode. Also explain ideal characteristics of an operational amplifier. [6]
- b) Explain the features of instrumentation amplifier and derive the expression for its gain. [6]
- c) Determine the thermoelectric sensitivity and emf developed in a thermocouple made of Cu and Const for a temperature of 60°C between its junctions. Given that thermoelectric emf of Cu and Const against Pt are $7.4 \mu\text{V}/^\circ\text{C}$ and $-34.4 \mu\text{V}/^\circ\text{C}$ [4]

4. a) Using flowchart diagram, example the working of successive approximation ADC. What will be 4-bit, digital output for the analog impute of 3.217 V if $E_R = 5V$, using successive approximation ADC?
- b) What is data acquisition system? Explain the function and objective of each component of a digital data acquisition system.
- c) An 8-bit DAC has reference voltage of 12V. Find the minimum value of resistance R such that the output current doesn't exceed 10mA if it uses i) WRN DAC ii) R:2R ladder network DAC. Also, find the smallest value of the quantized current in both cases.
5. a) Explain the working principle of dynamometer type wattmeter and also prove that the deflection torque is directly proportion to power consumed by the load in both ac and dc circuit.
- b) Explain the working principle of instrument transformer. Also explain why the secondary winding of current transformer should never be kept open circuited while primary is energized?

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Answers are required to give their answers in their own words as far as practicable.

Answer All questions.

Figures in the margin indicate Full Marks.

Use suitable data if necessary.

Explain different types of errors which may occur in any measurement system. Also explain the methods to minimize them. [6]

Show that Hay's Bridge can be used to measure the value of unknown inductance of a coil having high Quality Factor. Also derive expression for unknown inductor. [6]

A voltmeter whose accuracy is 2% of the full scale reading is used on its 0-50V scale. It is used to measure a voltage of 15V and 42V. Calculate the possible error of both readings. Comment on your answer. [4]

Explain the construction and working principle of Linear Variable Differential Transformer. [6]

What is piezo electric transducer? What are the materials used in such transducer? Define voltage sensitivity, charge sensitivity and derive the expression for the output voltage developed due to applied force. [6]

Design an integrator circuit which will produce a ramp voltage of -50V/ms. [4]

Explain the "loading effect" on input-output relationship in measurement made by a voltmeter. How can the error due to loading be minimized? [6]

Explain ideal characteristics of operation amplifier. Also explain different applications of operational amplifier in measurement system. [6]

What is aliasing? Also explain how it can be eliminated. [4]

Explain how analog to digital conversion is achieved by using Dual Ramp ADC. [6]

Explain briefly optical fiber communication system and also mention advantages of it. [6]

Describe in detail the successive approximation method of analog to digital (A/D) conversion taking an example of 4-bit converter having full range of 5V and input range of 3.271v. [4]

Explain the constructional details and working of a ferro-dynamic type of frequency meter for the measurement of frequency. [8]

Explain the working principle of instrument transformer. Also explain why the secondary winding of current transformer should never be kept open while primary is energized? [8]

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Attempt All questions.

The figures in the margin indicate **Full Marks**.

Assume suitable data if necessary.

- a) Explain how probable error can be calculated with the help of statistical analysis in a measurement system. [6]
- b) Explain the difference between static and dynamic characteristics of measurement system. Also explain following static performance parameter. [6]
 - (i) Accuracy
 - (ii) Precision
 - (iii) Sensitivity
- c) Following reading were obtained in respect of a capacitor: $1.003\mu F$, $0.998\mu F$, $1.001\mu F$, $1.009\mu F$, $1.005\mu F$, $0.991\mu F$, $0.996\mu F$, $0.997\mu F$, $1.008\mu F$, & $0.994\mu F$. Calculate:
 - (i) Arithmetic mean
 - (ii) Deviation from mean
 - (iii) Standard deviation [4]
- Q. a) Explain how the liquid level can be measured by using capacitive sensor. [6]
- b) Define transducer with example. Explain the working principle of strain gauge and derive the expression for the gauge factor. [6]
- c) A linear resistance potentiometer is 50mm long and is uniformly wound with a wire of total resistance of $20k\Omega$. Under normal conditions, the slider is at the center of the potentiometer. Determine the linear displacement when the resistance of the potentiometer, as measured by wheatstone bridge are 1550Ω and 5600Ω . Are the two displacements in the same direction? If it is possible to measure a minimum value of $10k\Omega$ resistance with the above arrangement, determine the resolution of the potentiometer in mm. [4]
- Q. a) Explain how both direction & magnitude of the displacement can be measured with help of linear variable differential transformer. [6]
- b) Describe the circuit of 3 amplifier configuration of an instrumentation amplifier. Also derive the expression for output voltage in terms of two input voltage. [6]
- c) Hall effect element is used for the measurement of magnetic flux of $0.8Wb/m^2$. The thickness of element is 2.5mm. If the current passed through the element is 5A, calculate the Hall emf developed. Given that $K_H = 5 \times 10^{-7}$. [4]
- Q. a) Explain how analog to digital conversion is achieved by using ramp ADC. [6]
- b) What are the drawbacks of weighted resistor network? With suitable diagram explain the R-2R ladder digital to analog converter. [6]
- c) Given 12-bits, 10V successive approximation ADC that has $20\mu s$ conversion time and is used without sample and hold circuit. Find the maximum rate of change of input signal and its maximum frequency that can be applied. [4]
- Q. a) Explain the working principle of dynamometer type wattmeter and also prove that the deflection torque is directly proportion to power consumed by the load in both a.c. and d.c. circuit. [8]

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1. a) Define Instrumentation system with example. Explain the main elements of measurement system with the help of block diagram. [6]
- b) Differentiate between static and dynamic performance parameter with describing each parameter in brief. [4]
- c) A 1000 Hz bridge has the following constants:
 Arm AB: $R=1000\Omega$ in parallel with $C=0.5\mu F$
 Arm BC: $R=1000\Omega$ in parallel with $C=0.5\mu F$
 Arm CD: $R=200\Omega$ in parallel with $L=30mH$
 Find the constants of Arm DA to balance the bridge express the result as a pure R in parallel with a pure C or L. [6]
2. a) Explain how magnitude & direction of displacement can be measured using inductive sensor. [6]
- b) Explain working principle of capacitive sensor. Also explain how linear relation between output & input can be obtained in the case of capacitive sensor working on the principle of change in separation distance. [6]
- c) A strain gauge is bonded to a beam which is 12cm long & has a cross-sectional area of $3.8cm^2$. The unstrained resistance & gauge factor of the strain gauge are 220Ω & 2.2 respectively. On the application of load, the resistance of the gauge changes by 0.015Ω . If the modulus of elasticity for steel is 207 GN/m^2 , calculate (i) the change in length of the steel beam. (ii) the amount of force applied to the beam. [4]
3. a) Explain the ideal characteristics of operational amplifier & derive the expression for closed loop gain in non-inverting mode. [6]
- b) Explain the "loading effect" on input-output relationship in measurement made by a potentiometer. How can the error due to loading be minimized? [6]
- c) A capacitive transducer is made up of two concentric cylindrical electrodes. The outer diameter of inner cylindrical electrode is 3 mm and the dielectric medium is air. The inner radius of the outer electrode is 3.1mm. Calculate the dielectric stress when a voltage of 100V is applied across the electrodes. Is it within safe limit? The length of electrode is 20mm. Calculate the change in capacitance if the inner electrode is moved through a distance of 2mm. the breakdown strength of air is 3KV/mm. [4]
4. a) Explain the method of Digital-Analog conversion using R-2R ladder network. Why do we prefer to use this DAC instead of WRN type, explain. [6]
- b) What is data acquisition system. Explain function of the different components of digital data acquisition system. [6]
- c) An 8 bit DAC has maximum supply voltage 12V. Find
 - i) What voltage change does LSB represent?
 - ii) What voltage change does MSB represent?
 - iii) What voltage does 10111100 represent?
[4]
5. a) State and explain Sampling theorem. What is aliasing? Define the terms analog signal and discrete signal. [8]
- b) Write short notes on: [2 x 4]

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1. a) Explain the difference between static and dynamic characteristics of measurement system. Also explain following static performance parameter. [6]
 - i) Accuracy
 - ii) Precision
 - iii) Sensitivity
 - iv) Resolution
 - v) Linearity
- b) Explain quality factor in Maxwell's bridge. Why Maxwell bridge cannot be used for the measurement of inductance having quality factor less than 1 and greater than 10 ($1 \leq Q \leq 10$). [6]
- c) An AC bridge has following constants

Arm AB, $R = 1000 \Omega$ in parallel with $C = 0.5 \mu F$
 Arm BC, $R = 3000 \Omega$
 Arm CD, unknown capacitance C_x in series with R_x
 Arm DA, $C = 0.55 \mu F$
 Supply frequency 1000HZ

Determine the unknown resistance R_x and capacitance C_x to make the bridge balance. [4]
- a) Discuss the methods to reduce loading effect in a Potentiometer. Also prove that linearity and sensitivity of potentiometer is two conflicting requirements. [6]
- b) Explain how the nonlinear characteristics of a capacitive transducer used for the measurement of displacement using the principle of change in capacitance due to change in distance between plates can be made linear. [6]
- c) A rotatory POT having 100 turns and total resistance of 1000Ω is made up of wire of 1 meter length. It has the power limit of 10 watt. Calculate the maximum excitation voltage that can be applied to the POT. Also calculate the resolution (in volts) of the potentiometer under that maximum excitation. [4]
- a) Explain the working principle of Piezo-electric sensor and derive the expression for the output voltage in the piezo-electric Sensor. [6]
- b) What are the characteristics of an ideal operational amplifier? Derive the expression for close loop gain of operational amplifier in inverting and non-inverting mode. [6]
- c) Design an integrator circuit which will produce a ramp voltage of $-20V/ms$. [4]

4. a) Explain how analog to digital conversion can be achieved by using dual Ramp ADC. [8]
- b) A 6-bit DAC has $20\text{ k}\Omega$ resistance in MSB position. The converter is designed with weighted resistor network. The reference voltage is 12 V. The output of the resistive network is connected to an op amp with a feedback resistance of $5\text{ k}\Omega$. What will be the analog output for a binary input of 111010? [8]
5. a) State and explain Nyquist criterion. Also explain the phenomenon of aliasing and the way to eliminate it. [4]
- b) Explain the function of sample and hold circuit with the help of circuit diagram. [6]
- c) Explain the construction and working of single phase electrodynamometer wattmeter with expression for ac operation. [6]

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1. a) Sketch basic blocks of a generalized measurement system. Write function of each block. [6]
- b) Explain analog and digital modes of operation. Why digital instruments are becoming popular now? [4]
- c) An AC bridge circuit is working at 1000 Hz. Arm AB has $0.2 \mu\text{F}$ pure capacitance, arm BC has 500Ω pure resistance, arm CD contains an unknown impedance and arm DA has 300Ω resistance in parallel with $0.1 \mu\text{F}$ capacitor. Find the constant of arm CD considering it as a series circuit. [6]
2. a) What are the different parameters to define the static performance of an instrument? Distinguish between accuracy and precision of an instrument with a suitable example. [6]
- b) A strain gauge is bonded to a beam which is 12 cm long and has a cross sectional area of 3.8 cm^2 . The unstrained resistance and gauge factor of the strain gauge are 220Ω and 2.2 respectively. On the application of load the resistance of the gauge changes by 0.015Ω . If the modulus of elasticity for steel is 207 GN/m^2 , calculate [4]
 - (i) the change in length of the steel beam
 - (ii) the amount of force applied to the beam.
- c) Explain the working principle of a thermocouple for measuring temperature. State different laws associated with it. [6]
3. a) Explain the principles of operation of capacitive sensor. Also explain how linear relation between output and input can be obtained when capacitive sensor works on the principle of change in separation distance. [6]
- b) Explain the features of instrumentation amplifier and derive the expression for its Gain. [6]
- c) State and explain sampling theorem. [4]
4. a) A 6 bit DAC has a reference voltage of 11 volts if it uses
 - (i) R-2R ladder network.
 - (ii) Weighted resistive network.
 Find the minimum value of resistance in both cases such that the output current does not exceed 10mA . [4]
- b) What are the drawbacks of weighted resistor network? With suitable diagram explain the R-2R ladder digital to analog converter. [6]
- c) What is the purpose of using a S/H circuit in A/D conversion system. Explain its operation along with basic circuit and characteristic waveform. [6]

5. a) Describe the construction and working principle of a single phase induction type energy meter. Show that the total number of revolution made by disc during particular time is proportional to the energy consumed.
- [8]
- b) Explain the working principle of instrument transformer. Also explain why the secondary winding of current transformer should never be kept open circuited while primary is energized?

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1. a) What do you understand by an instrumentation system, explain the function of each of its component with the help of a block diagram? [6]
- b) The wire in a strain gauge is 0.1 m long and has an initial resistance of 120Ω . On application of a force the wire length increases by 0.1 mm and resistance increases by 0.21Ω , determine the gauge factor of the device. [4]
- c) How do you define error in a measurement system? How the Gaussian curves can be used to explain the normal distribution of random errors in a measurement. Also state the properties of the curve. [6]
2. a) Explain how magnitude and direction of displacement can be measured with the help of inductive sensor. [6]
- b) What do you mean by piezoelectric effect? Explain how this effect can be the design basis of piezoelectric pressure transducer. Define voltage sensitivity and charge sensitivity. Give its equivalent circuit and derive the expression for the output voltage by making suitable assumptions. [6]
- c) A linear resistance potentiometer is 50 mm long and is uniformly wound with a wire of total resistance 5000Ω . Under normal conditions, the slider is at the centre of the potentiometer. Determine the linear displacement when the resistance of the pot as measured by a wheatstone bridge is 1850Ω . If it is possible to measure a minimum value of 5Ω resistance with the above arrangement determine the resolution of the pot in mm. [4]
3. a) Why signal conditioning is done in instrumentation system? Derive the expression for closed loop gain of op-amp in inverting mode. Also explain ideal characteristics of operational amplifier. [6]
- b) Design an integrator circuit which will produce a ramp voltage of -20 V/msec . [4]
- c) Draw the block diagram of optical fiber communication system and write advantages of it. [6]
4. a) Explain how analog to digital conversion is achieved by using Dual Ramp ADC. [6]
- b) Explain the operation of sample and hold circuit. Also explain aperture time and acquisition time of the circuit. [6]
- c) What will be a 4-bit successive approximation digital output for an analog input of 4.287V if full range of converter (ER) is 5V ? [4]
5. a) What is wattmeter? Write its types. Explain the wattmeter which can measure ac as well as dc power with the help of construction and working principle. [8]
- b) What is data acquisition system? Explain the function of different component of digital data acquisition system. [8]

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1. a) What is an instrumentation system? Explain its different components with the help of a block diagram. [6]

b) What is random error? Which method do you think is the most appropriate to find its distribution among a given set of data, make a complete analysis and hence define probable error. [6]

c) The output of an LVDT is connected to a 5V voltmeter through an amplifier whose amplification factor is 250. An output of 2 m V appears across the terminals of LVDT when core moves through a distance of 0.5 mm. calculate the sensitivity of LVDT and that of whole set-up. The milli-voltmeter scale has 100 divisions. The scale can be reads to 1/5 of divisions. Calculate the resolution of the instrument in mm. [4]

2. a) Explain the principle of operation of an inductive transducer used for the measurement of linear displacement. Why differential arrangement of such a transducer is required? [8]

b) "Maxwell's bridge is not suitable for the measurement of high Q-coils", verify the statement and draw and explain the modified bridge which can measure the inductance of high Q-coils. [8]

3. a) Explain the construction and working of a megger used for the measurement of high resistance. [4]

b) Describe how digital to analog conversion is achieved by using the R-2R ladder network. How this DAC over comes the limitations of WRN type of DAC? [8]

c) An analog to digital converter having an input of (0-8)V is able to distinguish a change of 10.3 mv in its input signal, calculate: [4]

- i) The number of bits
- ii) What voltage change does each LSB represent
- iii) What voltage does 1MSB represent

4. a) Explain the working principle of dy-nanometer type, wattmeter and also prove that the deflection torque is directly proportion to power consumed by the load in both a.c. and d.c. circuit. [8]

b) What do you understand by a Data Acquisition system? Explain with a neat sketch, the role of multiplexer in a DAS. [8]

5. a) What do you understand by sample and hold circuit. Explain its functioning with the help of circuit diagram. [6]

b) Explain the working and application of OP-amp as [6]

- i) an integrator
- ii) a differentiator and
- iii) a subtractor

c) A piezoelectric pressure transducer having unknown charge sensitivity is connected to a charge amplifier, the gain being set to 5 mv/PC. The amplifier output is connected to an ultraviolet chart recorder, whose sensitivity is set to 25 mm/volt. Determine the

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1. a) Point out the difference between analog and digital measurement system. Explain the functional elements of an Instrumentation system with block diagram. [6]
- b) Explain different types of errors in measurement with their remedies. [6]
- c) A capacitive transducer uses two quartz diaphragm of area 600 mm^2 separated by a distance of 2.5 mm. A pressure of $8 \times 10^5 \text{ N/m}^2$, when applied to the top diaphragm causes a deflection of 0.5 mm. The capacitance is $400 \times 10^{-12} \text{ F}$ when no pressure is applied to the diaphragm. Determine the value of capacitance after the application of $8 \times 10^5 \text{ N/m}^2$. [4]
2. a) Explain how can the response of capacitive transducer, which works on the principle of variation of capacitance with displacement between two plates, be made linear. Also give the sensitivity of such an arrangement. [6]
- b) Show that Hay's Bridge can be used to measure the value of unknown inductance of a coil having high quality factor. [6]
- c) Determine the thermo electric sensitivity and emf developed in a thermocouple made of copper and constantan for a temperature of 50°C between its junction. Given that thermo electric emf of copper and constantan against platinum are $7.4 \mu\text{V}/^\circ\text{C}$ and $-34.4 \mu\text{V}/^\circ\text{C}$ respectively. [4]
3. a) Derive voltage gain of 3 Op-Amp Instrumentation amplifiers. Write the advantages of fiber optical communication. [6]
- b) Explain how A/D conversion can be achieved by using dual slope analog to digital converter. [6]
- c) The basic step of a 9 bit DAC is 10.3 mV (000000000) represents 0V, what O/P is produced if the input is (101101111)? [4]
4. a) Describe the constructional details and working of a ferro dynamic type of frequency meter for the measurement of frequency. [8]
- b) Draw the block diagram of Digital Data Acquisition System (DAS). Explain each block briefly. Differentiate analog DAS and digital DAS in terms of their scope. [6+2]
5. a) Explain the requirement of a sample and hold circuit. Explain its operation and discuss its characteristic waveform to illustrate its specifications. [8]
- b) Explain ideal characteristics of operational amplifier. Also explain different application of operational amplifier in measurement system. [8]

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Instrumentation I (EE552)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ All questions carry equal marks.
- ✓ Assume suitable data if necessary.

1. a) Distinguish between static and dynamic characteristic of a measurement system. Define the various parameter used to study these characteristics.
- b) How an unknown inductance can be measured from Maxwell's Bridge circuit and Hay's Bridge circuit. Why these different bridge circuits are used for measurement of unknown inductance instead of using single Bridge circuit, Explain.
2. a) Define transducer with example. Explain the working principle of strain gauge and derive the expression for the gauge factor.
- b) A barium titanate pickup has the dimensions of $5\text{mm} \times 5\text{mm} \times 1.25\text{mm}$. The force acting on it is 5N . The charge sensitivity of barium titanate is 150pC/N and its permittivity is $12.5 \times 10^{-9} \text{ F/m}$. If the modulus of elasticity of barium titanate is $12 \times 10^6 \text{ N/m}^2$, calculate the strain. Also calculate the charge and the capacitance.
3. a) Explain ideal characteristics of operation amplifier. Also explain different application of operational amplifier in measurement system.
- b) Explain how data can be transferred by Optical Fiber Cable and write advantages of optical fiber communication.
4. a) What are the advantages of inverted R-2R DAC over others DAC? Derive its output expression for R-2R DAC.
- b) What will be 6 bit successive approximation digital output of the analog input 6.127 V if V_R is 8V ? 110001
5. a) Explain the operating principle of electrical resonance type frequency meter in detail.
- b) Show how the instrument transformers are used to measure high voltage and current. And also explain why the secondary of current transformer should not be kept open circuited while primary is energized.

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Instrumentation I (EE552)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. a) Discuss the analog and digital measurement system with the help of their respective block diagrams. [6]
- b) An ac bridge circuit is working at 1000 Hz. Arm AB has $0.2 \mu\text{F}$ pure capacitance, arm BC has 500Ω pure resistance, arm CD contains an unknown impedance and arm DA has 300Ω resistance in parallel with $0.1 \mu\text{F}$ capacitor. Find the constant of arm CD considering it as a series circuit. [10]
2. a) What is loading effect of a potentiometer? Show that the error will be maximum when the slider of the potentiometer is at midpoint of the potentiometer. [8]
- b) Determine the thermoelectric sensitivity and emf developed in a thermocouple made of copper and constantan for a temperature of 50°C between its junction. Given that thermo electric emf of copper and constantan against platinium are $7.4 \mu\text{V}/^\circ\text{C}$ and $-34.4 \mu\text{V}/^\circ\text{C}$ respectively. [4]
- c) Explain how the flow of fluid can be measured by using Hot Wire Anemometers. [4]
3. a) Prove that "Linear relationship between capacitance and separation distance between two plates can be achieved by using differential arrangement". [8]
- b) Describe the construction and working of linear variable differential transformer for the measurement of displacement. [8]
4. a) Show how can an R-2R ladder network be used to generate a binary weighted sequence of current. [6]
- b) Highlight the advantages of optical fiber transmission over conventional data transmission system. [4]
- c) What is an instrumentation amplifier? Derive the expression for its gain. [6]
5. a) Explain the constructional detail and operating principle of a single phase induction type energy meter. [8]
- b) A 3-bit DAC has a voltage range of (0 - 12) V. Calculate the [8]
 - i) weight of LSB
 - ii) weight of MSB
 - iii) exact range of the converter
 - iv) percentage error

If now, the bit of the converter is increased to 6, show by how much amount the error is increased or decreased? Justify your answer.

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Examination Control Division
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Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Instrumentation I

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. a) Explain different component of measurement system with suitable examples. [4]
- b) A balanced AC bridge has the following constants [6]

arm AB: $R = 1000 \Omega$ in parallel with $C = 0.5 \mu F$
 arm BC: $R = 1000 \Omega$ in series with $C = 0.5 \mu F$
 arm CD: $R = 200 \Omega$ in series with $L = 30 mH$

Find the constant of arm CD. Express the result as a pure R in parallel with pure C or L.
- c) Using statistical analysis of random error of data measurement, explain how probable error in measurement can be obtained. [6]
2. a) Explain how can the response of capacitive transducer, which works on the principle of variation of capacitance with displacement between two plates, be made linear. Also give the sensitivity of such an arrangement. [6]
- b) Explain ideal characteristics of operation amplifier. Also explain different application of operational amplifier in measurement system. [6]
- c) A piezo-electric pressure transducer having sensitivity of $4 \times 10^{-12} C/N$ is connected to a charge amplifier, the gain being set to $10 mV/pc$. The amplifier output is connected to a ultra-violet chart recorder whose sensitivity is set in such a way that the deflection of the chart recorder due to a force of $400 N$ is $100 mm$. Find the overall sensitivity of the device and the sensitivity of the chart recorder. [4]
3. a) Explain how analog to digital conversion can be obtained by using flash ADC. [6]
- b) State and explain Nyquist criterion. Also explain the phenomenon of aliasing and the way to eliminate it. [4+2]
- c) Consider a 6-bit digital to analog converter with a resistance of $20 K\Omega$ in MSB position. The converter is designed with weighted resistive network. The reference voltage is $12 V$. The output of the resistive network is connected to an operational amplifier with a feedback resistance of $10 K\Omega$. What is the analog output for a binary input of 101011 ? [4]
4. a) Describe the construction and working of a single phase induction type energy meter. Show that the total number of revolutions made by its disc during a particular time is proportional to the energy consumed. [8]
- b) Show how the instrument transformers are used to measure high voltage and current. [4]
- c) The basic step of a 9 bit DAC is $10.3 mV$. If (000000000) represents $0 V$, what O/P is produce if the input is (10110111)? Write the advantages of R-2R ladder type DAC over WRN type. [2+2]
5. a) List out different types of frequency meter. Explain the constructional detail and working principle of any one of them to measure frequency. [8]
- b) What do you understand by communication of data in an instrumentation system? Explain the principle of optical fibre data communication system and highlight its advantages over conventional data communication system. [8]

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Exam.	Regular (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Instrumentation I (EE552)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. a) Distinguish between analog and digital system of measurement. [6]
- b) A 0-150V voltmeter has guaranteed accuracy of 1% of full scale reading. The volt measured by this instrument is 75V and 37.5V. Calculate the possible percentage error of both readings. Comment upon the result. [4]
- c) A balanced AC bridge has the following constants: [6]
 - arm AB, $R = 2000\Omega$ in parallel with $C = 0.047\mu F$
 - arm BC, $R = 1000\Omega$ in series with $C = 0.47\mu F$
 - arm CD, unknown R
 - arm DA, $C = 0.5\mu F$
 The frequency of oscillator is 1000Hz. Find the constant of arm CD.
2. a) Obtain the balance equation for Hay's bridge and explain why it is most suitable for the measurement of inductance of a coil having high quality factor. [6]
- b) Show how "Loading effect" causes a non linear relationship between the input and output in a measurement made by a potentiometer. Also prove that the maximum error occurs at the mid-point of the pot wire. [6]
- c) A capacitive transducer is made up of two concentric cylindrical electrodes. The outer diameter of the inner electrode is 4mm and the dielectric medium is air. The inner diameter of the outer electrode is 4.1mm. Calculate the dielectric stress when a voltage of 100V is applied across the electrode. Is it within safe limit? The length of electrode is 20mm. Calculate the change in capacitance if the electrode is moved through a distance of 2mm. [4]
3. a) Describe the circuit of 3 amplifier configuration of an instrumentation amplifier. Also derive the expression for output voltage in terms of two input voltage. [6]
- b) In order to measure the strain in a cantilever beam, a single strain gauge of resistance $2K\Omega$ and gauge factor 2 is mounted on the beam and connected to one arm of the bridge circuit. The other arms of the bridge have a resistance of $2K\Omega$ each. Calculate the detector deflection for 1000 micro-strain if the detector sensitivity is $10mm/\mu A$ and its internal resistance is: (i) 100Ω (ii) 200Ω . the supply to the bridge is 10V. [4]
- c) Explain how digital to analog conversion can be achieved by using R-2R ladder network DAC. Discuss its advantages over WRN type of DAC. [6]

4. a) Describe in detail the successive approximation method of analog to digital (A/D) conversion taking an example of 4-bit converter having full range of 5V and input of 3.215V. [6]
- b) An 11-bit ADC has conversion time of $20\mu\text{S}$ and full scale voltage of 10V. Find the maximum rate of change of input signal and maximum input frequency that the analog input signal may have in order that the converter can resolve the input signal into 11-bit number in a signal conversion. [4]
- c) What is data acquisition system? Explain the function and objective of each component of an analog data acquisition system. [6]
5. a) Explain the construction and working principle of a single phase electro-dynamometer type of wattmeter and derive the expression of deflection for both ac and dc operation. [8]
- b) What do you understand by sample and hold circuit. Explain its functioning with the help of circuit diagram and also discuss about its characteristics to define its specification. [8]

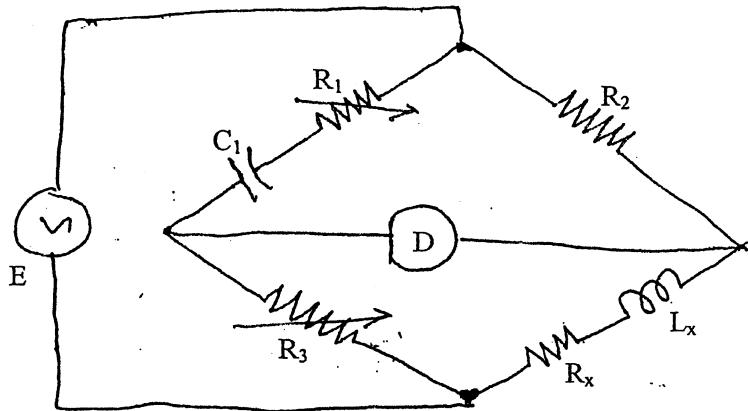
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Examination Control Division
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Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Instrumentation I

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt any Five questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. a) Define measurement and measurement system. Also explain various types of errors encountered in electrical measurement. [8]
- b) The value of power consumed was determined by measuring current "I" flowing through the resistance with an error of ± 1.5 percent and resistance "R" with an error of ± 1 percent. Determine the maximum possible relative error to be expected on measuring power "P" from formula $P = I^2 R$. [8]
2. a) The AC bridge shown in the figure is used to measure the unknown induction (L_x) of a coil having quality factor greater than 10. Show that $L_x = R_2 R_3 C_1$, when the bridge is balanced. [8]



- b) Explain how low-resistance can be measured with the help of ammeter-voltmeter method. [8]
3. a) Explain the working principle of current transformer along with its connection in a circuit. What will happen if the secondary circuit of the current transformer is open circuited while the primary carries current? Explain. [8]
- b) The output of a potentiometer is to be read by a recorder of $10 \text{ k}\Omega$ input resistance. Non-linearity must be held to 1 percent. A family of potentiometers having a thermal rating of 5W and resistances ranging from 100Ω to $10,000\Omega$ in 100Ω steps are available. Choose, from this family, the potentiometer that has the greatest possible sensitivity and meets other requirements. What is the sensitivity if the potentiometer are single turn (360°) unit? [8]

4. a) Define piezo-resistive effect and gauge factor of a resistance strain gauge and derive the expression for the gauge factor. [10]
- b) A barium titanate piezo-electric pick-up has dimensions of $12\text{mm} \times 12\text{mm} \times 3\text{mm}$ and a voltage sensitivity of 0.015 Vm/N . Relative permittivity of barium titanate is 1400 and modulus of elasticity of barium titanate is $10 \times 10^{10} \text{ N/m}^2$. If the force applied is 20N, determine (i) the output voltage (ii) charge sensitivity (iii) strain (iv) charge generated (v) the capacitance of the pick up. [6]
5. a) Explain different applications of operational amplifier in measurement system. Also show that if a d.c. voltage is applied to an integrator it will produce a ramp voltage. [8]
- b) A 6-bit DAC has $20 \text{ K}\Omega$ resistance in MSB position. The converter is designed with weighted resistive network. The reference voltage is 12V. The output of the resistive network is connected to an operation amplifier with a feedback resistance of $5\text{K}\Omega$. What will be analog output for a binary input of 101101? [8]
6. a) Describe the construction details and working of a single phase electro-dynamometer type of wattmeter. Also derive the expression for deflection for ac operation. [10]
- b) A 10 bit, 10V successive approximation ADC has $20\mu\text{s}$ conversion time. Find the maximum rate of change of input signal and maximum input frequency. [6]

Exam.		Regular / Back	
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Instrumentation I

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt any Five questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. a) Explain the function of different stages of measuring system with the help of block diagram. [8]
- b) Explain the "Loading effect" on the accuracy of resistance potentiometer transducer, when used for the measurement of displacement. [8]
2. a) What is an electrical transducer? How can it be classified, explain with suitable examples. [8]
- b) The value of resistance R was determined by measuring current I flowing through the resistance with an error of $\pm 1.5\%$ and power loss in it with an error of $\pm 1\%$. Determine the maximum possible relative error to be expected in measuring resistance R, calculated from the formula $R = P/I^2$. [4]
- c) "A precise instrument may not be accurate". Verify this statement with an appropriate example. [4]
3. a) Show that the sensitivity of a capacitive displacement transducer is non-linear when it works on the principle of change in distance between plates. Explain its constructional detail and working principle so as to obtain linear sensitivity. [8]
- b) A 6 bit DAC has a reference voltage of 9 volts if it uses:
 - i) R-2R ladder network
 - ii) Weighted resistive network
 Find the minimum value of resistance in both cases such that the output current does not exceed 10mA. [8]
4. a) Obtain the balance equation for Maxwell Bridge for the measurement of inductance. Why this bridge is not suitable for measuring high - Q coils and also explain how it is modified to do so? [6]
- b) Explain with a suitable example, how analog to digital conversion is achieved by using successive approximation ADC. [6]
- c) An 8 bit A/D converter has a maximum supply voltage of 18 volts. Find:
 - i) What voltage change does LSB represent?
 - ii) What voltage does 101011 represent?
5. a) Explain the operation of sample and hold circuit with its basic circuit and characteristic waveform to illustrate its specifications. What is the purpose of using sample and hold circuit in A/D conversion system? [8]

- b) Explain the working of an operational amplifier as: [4]
- i) an integrator
 - ii) a differentiator
- c) An op-amp is used as an integrator to produce a ramp voltage of $-10V/ms$. Design the circuit for this. [4]
6. a) What is a data acquisition system? What are the components of a digital DAS? Explain the working of a multiplexer with 4 input, 2 control and 1 output signal. [6]
- b) Write a short note on strip chart recorder. [4]
- c) Discuss the function of optical fiber communication link with the help of its block diagram. List out the advantages of optical fiber communication over conventional type of communication system. [6]

Exam.	Regula	Back
Level	BE	FE
Programme	BEL, BEX, BCT	Pass Marks
Year / Part	II / II	Time

Marks 80
32
3 hrs.

Subject: - Instrumentation I

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt any Five questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. a) Distinguish between static and dynamic characteristics of a measurement system. Define the various parameters used to study static characteristics of a measurement system. [6]
- b) What is the difference between accuracy and precision? Explain. [6]
- c) Repeated measurements of the voltage necessary to cause the breakdown of dielectric gave following results: 38.9, 39.3, 38.6, 38.8, 39, 38.7, 39.4, 39.7, 38.4, 39, 39.1, 39.1 and 39.2 KV. Determine (i) average breakdown strength (ii) standard deviation of the readings. [4]
2. a) Explain one of the suitable transducer used for measurement of linear displacement. [6]
- b) Obtain the balance equation for Maxwell's bridge and explain why it can not be used for the measurement of inductance of a coil having high quality factor. [6]
- c) A capacitance transducer of two parallel plates of overlapping area $5 \times 10^{-4} \text{ m}^2$ is immersed in water. The capacitance has been found to be 9.5 pf. Calculate the separation distance between the plates and the sensitivity $S = \frac{\partial C}{\partial d}$ of the transducer. Given relative permitivity for water = 81. [4]
3. a) What is piezoelectric transducer? What are the materials used in such transducers? Define voltage sensitivity, charge sensitivity and derive the expression for the output voltage developed due to applied force. [6]
- b) The output relation for a thermister is given by [6]

$$R = R_0 e^{\beta \left(\frac{1}{T} - \frac{1}{T_0} \right)}$$

Where, value of resistance is R at temperature T°K in ohms, R₀ is the resistance at a reference temperature T°K in ohms, T is unknown temperature in °K. For T₀ = 300°K, β = 3420, R₀ = 1KΩ and R = 2KΩ. Calculate the value of T, find sensitivity, $S = \frac{\delta R}{\delta T}$ of a given operating point.

- c) Select a potentiometer that has the greatest possible sensitivity and meets the non-linearity requirement of 2% maximum from available potentiometers having a thermal rating of 10 watts and resistance ranging from 200Ω to 5KΩ in steps of 50Ω. The output of potentiometer is to be measured with a device of 4000Ω input resistance. Also determine the maximum excitation voltage that can be employed with this potentiometer. [4]

4. a) What are the characteristics of an ideal operational amplifier? Derive the expression for closed loop gain of an operational amplifier in inverting and non-inverting modes. [8]
- b) Explain how optical fibre can be used for the data transmission. Mention its advantages over other forms of data transmission. [8]
5. a) Describe with the help of block diagram and flow chart, the method of conversion of analog signal into digital one using successive approximation ADC. [8]
- b) A 6-bit DAC has reference voltage of 10V. Find the minimum value of resistance R such that the output current does not exceed 10 mA and also find the smallest value of quantized current if it uses [8]
- i) R-2R ladder network
 - ii) weighted resistor network
6. a) Explain briefly the different components of digital data acquisition system. [8]
- b) What is recorder? Describe the components of magnetic tape recorder. What are its disadvantages? [8]
