

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

**Subject: - Instrumentation I (EF552)**

- ✓ 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  $5\text{N}$ . The charge sensitivity of barium titanate is  $150\text{pC/N}$  and its permittivity is  $12.5 \times 10^{-9} \text{ F/m}$ . if the modulus of elasticity of barium titanate is  $12 \times 10^9 \text{ N/m}^2$ , 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  $6.127 \text{ V}$  if  $V_R$  is  $8 \text{ V}$ ? 41000.
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.

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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  $500 \Omega$  pure resistance, arm CD contains an unknown impedance and arm DA has  $300 \Omega$  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  $50^\circ\text{C}$  between its junction. Given that thermoelectric 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]
- 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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Level	BE	Full Marks	80
Programme	BEI, 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 (101101111)? 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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INSTITUTE OF ENGINEERING  
**Examination Control Division**  
2069 Bhadra

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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.
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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)  $100\Omega$  (ii)  $200\Omega$ , 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]

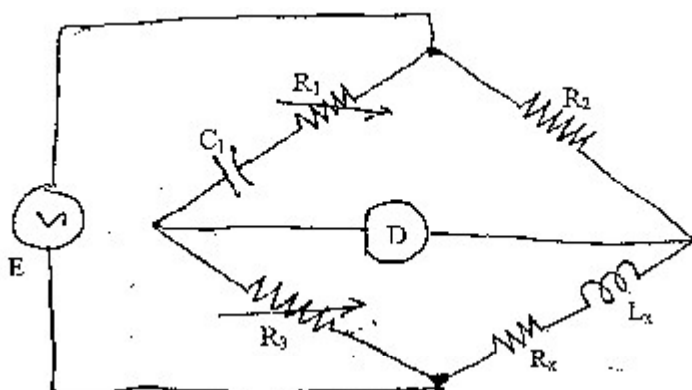
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Exam. Level	Regular	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

**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  $\pm 1.5$  percent and resistance "R" with an error of  $\pm 1$  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  $100\Omega$  to  $10,000\Omega$  in  $100\Omega$  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 ( $360^\circ$ ) 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  $0.015 \text{ Vm/N}$ . 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  $20\text{N}$ , 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. [3]
- 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  $12\text{V}$ . 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,  $10\text{V}$  successive approximation ADC has  $20\mu\text{s}$  conversion time. Find the maximum rate of change of input signal and maximum input frequency. [6]

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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: [8]
  - 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. 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: [4]
  - 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  $-10\text{V/ms}$ . 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]

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Exam. Level	Regulation	Back Marks
BE	F	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) 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 permittivity 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 thermistor 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,  $R_0$  is the resistance at a reference temperature T°K in ohms, T is unknown temperature in °K. For  $T_0 = 300^\circ\text{K}$ ,  $\beta = 3420$ ,  $R_0 = 1\text{K}\Omega$  and  $R = 2\text{K}\Omega$ . 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  $200\Omega$  to  $5\text{K}\Omega$  in steps of  $50\Omega$ . The output of potentiometer is to be measured with a device of  $4000\Omega$  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 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]

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