Tutorial 2

Chapter 1: Introduction to Instrumentation System

Chapter 2: Signal Measurements

1. Explain the conditions for dc bridge balance with necessary diagram.
2. Derive an expression for the measurement of unknown capacitance using Schering Bridge.
3. How can we measure the self-inductance by comparing it with a standard variable capacitance? Derive the relationship.
4. Discuss about various performance parameters of instrumentation system in detail.
5. Explain the static characteristic of measurement system.
6. Explain Kelvin's bridge with its necessary diagram.
7. What are the applications of Wein bridge? Derive the necessary expression under balance Condition?
8. Define Maxwell's bridge with limitation and also derive the necessary expressions.
9. Define signals. Explain the different types of signals used in instrumentation system.
10. Explain the measurement of unknown capacitance by using standard bridge circuit.
11. Show that a spring control permanent magnet moving coil instrument have a uniform scale.
12. Explain the following terms with reference to measuring instrument:
    i. Accuracy and precision
    ii. Sensitivity and resolution
    iii. Linearity and hysteresis

Numerical

1. A fence is measured as 12.5m long, accurate to 0.1 of a meter. Calculate absolute error, relative error and Percentage error.
2. The thermometer measures to the nearest 2^0 C. The temperature was measured as 38^0C. Calculate absolute error, relative error and Percentage error.
3. If a metric ruler is used to measure a length of 3.535m with precision of 0.5cm. Calculate Tolerance Interval (TI), Absolute error, Relative error, and Percentage error.
4. If a metric ruler is used to measure a length of 3.535m with precision of 0.5cm. Calculate Tolerance Interval (TI), Absolute error, Relative error, and Percentage error if the actual length of the ruler is 4m.
5. Nabin weighs 36.5 pounds, when weighted in deflected scale he weights 38 pounds.
    i. What is %error in measurement of deflected scale

ii. If Rabi weighs 14 pounds on same deflected scale, what is Rabi's actual weight.

6. Ten measurements of resistance of resistors are 101.2Ω, 101.7Ω, 101.8Ω, 101.0Ω, 101.5Ω, 101.3Ω, 101.2Ω, 101.4Ω, 101.3Ω and 101.2Ω. Assuming that only random errors are present calculate:
   i. Arithmetic mean
   ii. Standard deviation
   iii. Probable error
7. Temperature was measured in eight locations in a room, and the values Obtained were 28.2, 16.5, 32.1, 29.7, 27.1, 19.0, 22.0 and 10.0 ^{o}C. Assuming that the random errors are present. Calculate (i) Arithmetic mean (ii) Standard Deviation (iii) Probable error of readings?
8. The resistance of an unknown resistor is determined by the Wheatstone bridge method. The solution for the unknown resistance is stated as $R_X = (R_2 R_3) / R_1$, where;

   R1 = 120 Ω ± 0.1 %

   R2 = 2700 Ω ± 0.5 %

   R3 = 470 Ω ± 0.5 %

   Calculate:

   (i) The nominal value of the unknown resistor

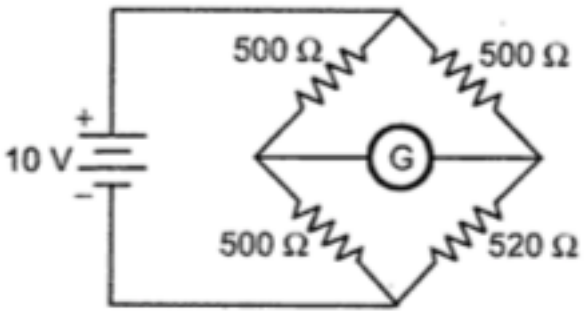
   (ii) The limiting error in ohms of the unknown resistor

   (iii) The limiting error in percent of the unknown resistor
9. The four arms of a Hay's alternating current bridge are arranged as follows: arm AB is a coil of unknown impedance, arm BC is a non-reactive resistor of 1000Ω, arm CD is a non –reactive resistor of 833Ω in series with a standard capacitor of 0.38μF, arm DA is non- reactive resistor of 16800Ω. If the supply frequency is 50 Hz determine the inductance and resistance at the balanced condition. Also draw the phasor diagram under balanced condition.
10. A 1000 Hz bridge has following constants:

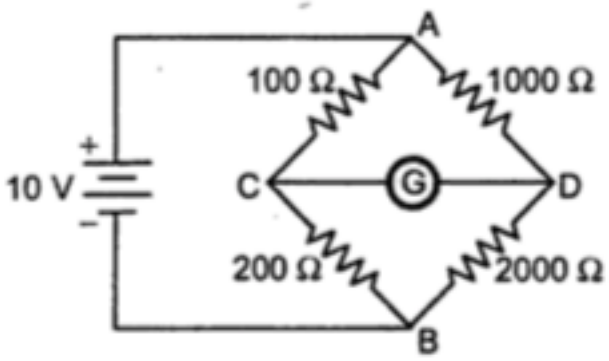
    Arm AB: R=1200Ω in parallel with C =0.5 μF. Arm BC: R= 1000Ω in series with C=0.5μF. Arm CD: L=30mH in series with R= 200Ω. Find the constants of arm DA to balance the bridge.
11. The Schering Bridge has the following constants, R_1=1.5KΩ, C_1=0.4μF, R_2=3KΩ and C_3=0.4μF at frequency 1kHz. Determine the unknown resistance and capacitance of the bridge and dissipation
12. A bridge is balanced at 1000 H_2 and how the following constants: AB, 0.2μF pure capacitances BC, 500Ω pure resistance: CD unknown: DA, R=300Ω in parallel with c=0.1 μF. Find R and C or L constants of arm CD, considered as a series circuit.

13. A 1000 Hz bridge has the following constants: arm AB, R = 1000 Ω in parallel with C = 0.5 μF; BC, R = 1000 Ω in series with C = 0.5 μF; CD, L = 30 mH in series with R = 200 Ω. Find the constants of arm DA to balance the bridge. Express the result as a Pure R in series with pure C or L and also as a pure R in parallel with a pure C or L?
14. The four arms of an ac bridge at balance are: arm ab – an unknown inductance L_1 having an inherent resistance R_1; arm bc – a non-inductive resistance of 1000Ω; arm cd – a capacitor of 0.5 μF in parallel with a resistance of 1500 Ω; arm da – a resistance of 200Ω. Find the value of unknowns.
15. In a balanced network, AB is a resistance of 500Ω in series with an inductor of 0.18H, BC and DA is non-inductive resistances of 1000Ω each and CD consists of a resistance R in series with a capacitor C. A potential difference of 5V at a frequency $5000/2\pi$ is applied between points A and C. Determine the values of R and C.
16. The arms of Maxwell's ABCD bridge are as follows: AB is a non-inductive resistance 1000Ω in parallel with a capacitance of 0.5μF. BC is a non-inductive resistance of 600Ω, CD is an inductive impedance of unknown value and DA is non-inductive resistance of 400Ω. If the balance is obtained under these conditions, find the values of unknown of arm CD.
17. An AC bridge has the following constant arms AB, R=1000Ω in parallel with C = 0.159μF; BC, R = 1000Ω; CD, R = 500Ω; DA, C = 0.636μF in series with an unknown resistance. Find the frequency for which this bridge is in balance and determine the value of resistance in arm DA to produce this balance**.**
18. The four arms of the bridge are as follows;
    Arm ab: An imperfect capacitor C_1 with an equivalent resistance r_1
    Arm bc: A non-inductive resistance R_3
    Arm cd: A non-inductive resistance R_4
    Arm da: An imperfect capacitor C_2 with an equivalent resistance r_2 in series with resistance R_2.
    A supply at 450 Hz is connected between terminals a and c and the detector is connected between b and d. At the balance condition: R_2 = 4.8 Ω, R_3 = 200 Ω, R_4 = 2850 Ω, r_2 = 0.4 Ω, C_2 = 0.5μF. Calculate values of C_1 and r_1 and also the dissipating factor for the capacitor.
19. The impedance of the basic ac bridge given below are as $Z_1 = 100\,\Omega < 80^0$, $Z_2 = 250\,\Omega$, $Z_3 = 400\,\Omega < 30^0$. Find the value of Z_4, name the unknown component and its value.

20. Design on Ayrton shunt to provide an ammeter with current ranges of 1A, 5A and 10A. D' Arsonval movement with internal resistance $R_m = 50\Omega$ and full-scale deflection of 1mA current is used in the configuration.
21. Draw the schematic, including values, for an ayrton shunt for a meter movement having a full-scale deflection of 1 ma and an internal resistance of 500Ω to cover the current ranges 10, 50, and 100 mA.
22. A PMMC instrument has a coil of dimensions 10mm*8mm. The flux density in the air gap is 0.15 Wb/m^2. If the coil is wound for 100 turns, carrying a current of 5mA then calculate the deflection if the spring constant is 0.2 Nm/degree.
23. The resistance of moving coil voltmeter is 10KΩ. The moving coil has 100 turns with 8cm length and 5cm width. The flux density of air gap is $6*10^{-2}$T. Find the angular displacement produced by 300V if spring control provides a deflection of 1^0 for a torque of $75*10^{-7}$Nm.
24. Using the concept of slightly unbalanced bridge. Calculate the current through galvanometer having internal resistance of 125Ω for the bridge shown below.



25. A highly sensitive galvanometer can detect a current as low as 0.1nA. This galvanometer is used in Wheatstone bridge as a detector. The resistance of galvanometer is negligible. Each arm of the bridge has a resistance of 1KΩ. The input voltage applied to the bridge is 20V. Calculate the smallest change in resistance, which can be detected.
26. The Four arms of Wheatstone have four resistance AB:1000Ω, BC:1000Ω,CD=120Ω. The bridge is used for strain measurement and supplied from 5V ideal battery. The galvanometer(G) has a sensitivity of 1 mm/μA and internal resistance of 200Ω. Determine the deflection of G if arm DA increases to 121Ω and arm CD is 119Ω.
27. The Wheatstone bridge is shown in the fig below. The Galvanometer has a current sensitivity of 12mm/μA. The internal resistance of galvanometer(G) is 200Ω. Calculate the deflection of the G due to 5Ω unbalanced in the arm BD.



Tutorial 3

Chapter 3: Physical Variables and Transducers

Chapter 4: Signal Conditioning and Processing

1. Drive the relationship between the gauge factor, strain and the Poisson's ratio.
2. "Differential arrangement of parallel plate capacitor eliminates the nonlinearity between input and output". Prove this statement.
3. Explain how capacitive transducer measures linear as well as angular displacements.
4. Explain the principle of operation of RTD and Thermistor. Explain any one method to measure the temperature.
5. Draw the circuit diagram of Instrumentation Amplifier using 3-OP-Amps and explain the operation of various stages.
6. Define transducer. What are the desirable characteristics of a transducer?
7. Justify that the linear relationship between input and output in a potentiometer is disturbed due to loading of a linear potentiometer.
8. Explain an appropriate transducer for the measurement of weight.
9. Explain different types of error in instrumentation system.
10. Explain about the isolation amplifier.
11. What are thermistors? How are they constructed? Discuss their resistance temperature characteristics.
12. What characteristics do you consider while selecting a transducer? Explain them in brief.
13. Describe the block diagram of ac signal conditioning system with a suitable example
14. Explain the principle of operation on LVDT. Write its merit and demerits.
15. Describe the operation of analog to digital converter with an example.

16. What do you understand by the term interference? Briefly explain how externally coupled capacitive and inductive interference signals effect the measurement system.
17. What is piezo-resistive effect? Derive the relationship between the gauge factor and the poisson's ratio.
18. Explain about transducers and its classification.
19. Explain about the loading effect in instrumentation.
20. Illustrate the working of Hall Effects transducer with its necessary.
21. What do you mean by Piezoelectric effect? Describe how such effect can be used to measure displacements
22. What is Thermopile? Explain the principle of Thermistor to measure the temperature.
23. Why signal conversion is required? Differentiate between binary weighted type and R-2R ladder type D/A converter.
24. Discuss Seebeck effect for temperature measurement. Mention the laws governing in it. List out the sources of error occurred in it during temperature measurement.
25. What do you understand by signal conditioning? Explain at least three signal conditioning techniques used in instrumentation.
26. How do interference signals affect the performance of an instrumentation system?
27. You are supposed to take measurement of weight by using the piezoelectric crystal. Draw the block diagram of additional components and briefly explain about it.
28. Explain successive approximation type ADC used in instrumentation system with example.
29. What is an operational amplifier (OPAMP)? List any three applications of OPAMP in instrumentation with necessary diagram and expression?
30. Describe any three applications of operational amplifier with neat sketch.
31. Explain the working principle of instrumentation amplifier
32. Explain with the circuit diagram, how does an Op-Amp act as:
    i. An inverter
    ii. A summer
    iii. A subtractor
    iv. An integrator
33. Compare and contrast any two of the following
    i. Flash ADC and successive approximation ADC.
    ii. Active transducer and passive transducer.
    iii. Op. Amp and Instrumentation amplifier

34. A potentiometer displacement transducer having total resistance R_p Ω and a dc excitation voltage V_{in}, is to be used with a measurement system having an input resistance R_L Ω. Show that the measured output voltage V_{out} is related to the fractional displacement of the wiper as, $V_{out} = V_{in} \times \frac{\alpha K}{K(1-K)+\alpha}$ (where, $\alpha = \frac{R_L}{R_P}$).

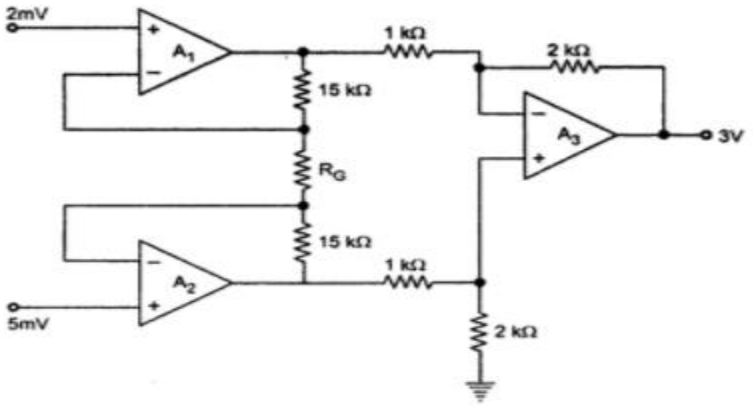
Also, show that maximum relative error occurs at K = 0.5.

Numerical

1. The output of an LVDT is connected to a 5 V voltmeter though an amplifier with a gain of 250. The voltmeter scale ha 100 divisions and the scale can be read upto $1/5^{th}$ of a division. An output of 2mV appears across 0. 5mm.Calculate and determine:
    i. Sensitive of LVDT, and entire setup
    ii. The resolution of the instrument
2. A piezo-electric crystal has the dimensions of 5 mm×5 mm × 1.25 mm. The force acting on it is 6 N. The charge sensitivity of the crystal is 150 pC/N and its permittivity is 12.5×10^{-9} F/m. If the modulus of elasticity is 12×10^6 N/m^2. Calculate the strain. Also calculate the charge and the capacitance
3. A strain gauge having resistance of 600 ohm and gauge factor 2.0 is connected in series with a blast resistance of 1000 ohm across 50 volts. Determine the change in output when a stress of 150 MN per square meter is applied. The modulus of elasticity is 250 GN per square meter.
4. A strain gauge with factor of 2 is fastened to a metallic member subjected to stress of 1,000kg/cm^3. The modulus of elasticity of the metal is 2×10^6 kg/cm^2. Calculate the percentage change in resistance of strain gauge. What is value of Poisson's ratio?
5. A compressive force is applied to a structural member. The strain is 5 micro-strains. Two separate strain gauges are attached to the structural member, one is a nickel wire strain gauge having a gauge factor of -12.1 and other is nichrome wire strain gauge having a gauge factor of 2. Calculate the value of resistance of the gauges after they are strained. The resistance of strain gauges before being strained is 120 ohms.
6. A resistance strain gauge with gauge factor of 2 is fastened to a steel member subjected to a stress of 1250 kg/cm^2. The modulus of elasticity of steel is approximately 2.1×10^6kg/cm^2 , Calculate
    i. Percentage change in resistance
    ii. The Poison's ratio
    iii. The strain values

7. The output of an LVDT is connected to a 5 V voltmeter through an amplifier whose amplification factor is 150. An output of 1 mV appears across the terminals of LVDT, when the core moves through a distance of 0.6 mm. Calculate the sensitivity of LVDT and that of the whole set up. The milli-voltmeter scale has 100 divisions. The scale can be read to 1/3 of a division. Calculate the resolution of the instrument in mm.
8. A quartz piezoelectric pickup has dimension of 5mm*5mm*1.5mm and a voltage sensitivity of 0.012Vm/N. The relative permittivity of the quartz is 1600 and modulus of elasticity of the quartz is 12MN/m^2 . The force applied to the pick-up is 10N. Determine,
    i. The output Voltage
    ii. Charge sensitivity
    iii. Strain
    iv. Charge generated and the Capacitance of the pick-up
9. The resistance of thermistor at 27°C is 1050Ω with constant β=3140. Calculate the value of temperature when the thermistor resistance becomes 2330Ω in °C and Kelvin scale.
10. A thermistor has a resistance of 3980Ω at the ice point (0^0 C) and 794 Ω at 50^0 C. The resistance-temperature relationship is given by $R_T = aR_0e^{\frac{b}{T}}$. Calculate:
    i. The constant a and b.
    ii. The range of resistance to be measured in case the temperature varies from 40^0 C to 100^0 C
11. Strain gauze having the resistance of 400Ω and gauze factor of 1.5 is connected in series with a ballast resistance of 500Ω. Determine the change in output when a stress of 200MN/m^2 is applied and take the value of modulus of elasticity as 250GN/m^2.
12. A strain gauge is bonded to a beam 0.15 m long and has a cross sectional area of 8 cm^2(Young's modulus of elasticity for steel is 207 GN/m^2). The strain gauge has an unstrained resistance of 400 ohm and a gauge factor of 2.2. When a load is applied, the resistance of the gauge changes by 0.013 ohm. Calculate the change in length of a steel beam and the amount of force applied to the beam.
13. Find the digital output of 8.217 volts input from a 4-bit Successive Approximation ADC with the reference voltage of 10 volts.
14. Find the digital output of 7.524-volt input from a 4-bit successive approximation ADC with reference voltage of 10 volt.
15. Find the digital output of 3.217-volt input from a 4-bit successive approximation ADC with reference voltage of 5 volt.
16. What will be the successive approximation digital output for an analog input of 3.12V from a 4-bit converter given that E_R= 8V. Also draw the circuit.

17. Find the digital output of 3.217 volts input from a 4-bits Successive Approximation ADC with the reference voltage of 5 volts.
18. Find the suitable value of R_G to provide the output of 3V, from the circuit shown in the figure below:



19. Sketch the circuit of Summing amplifier using Op-amp to get

$$V_{out} = 2V_1 - 3V_2 - 5V_3$$

20. Sketch the circuit of Summing amplifier using Op_amp to get.

$$V_{out} = -V_1 + 2V_2 - 3V_3$$

Tutorial 4

Chapter 5: Data Transmission

Chapter 6: Output Devices

Chapter 7: Data Acquisition Systems

1. Clarify the principle of operation of X-Y recorder with its area of application.

   OR

   Give the functional details of a type of recorder which can be employed for plotting the current versus voltage curve of any transistors and diodes.

2. What do you mean by Data Acquisition System? Explain in brief about modern trends used in Data Acquisition System.
3. What is telemetry and explain the types with block diagram
4. With the help of necessary diagram, explain the working principle of magnetic tape recorder, hence verify that it acts as a differentiator.
5. Briefly explain about the digital data acquisition system.
6. Discuss about various data transmission standards.

7. What do you mean by data transmission? Explain the various type of data transmission system.
8. What is output device? Explain in brief about magnetic tape recorder or X-Y recorder along with application.
9. How communication is important in instrumentation system for an industry? Explain RF telemetry.
10. Define data acquisition system. Differentiate between analog DAS and digital DAS.
11. What do you mean by the term telemetry? Explain the types of landline.
12. How data can be transmitted via optical fibre. List out advantages of optical fibre.
13. Briefly explain about the modern trends in data acquisition system.
14. Explain the components of the data acquisition system with necessary block diagram.