CHAPTER

1

Qualities of Measurements

Review Questions

1. Define the terms accuracy, error, precision, resolution, expected value, and sensitivity.
2. State the three major categories of error.
3. A person using an ohmmeter reads the measured value as 470 Ω, when the actual value is 47 Ω. What kind of error does this represent?
4. State the three types of systematic errors, giving examples of each.
5. State the difference between accuracy and precision of a measurement.
6. Define the following terms:
   (i) Average value (ii) Arithmetic mean
   (iii) Deviation (iv) Standard deviation
7. What are the differences between International and Absolute standards?
8. State the classifications of standards.
9. What are primary standards? Where are they used?
10. What is the difference between secondary standards and working standards?

Practice Problems

1. The current through a resistor is 2.5 A, but the measurement yields a value of 2.45 A. Calculate the absolute error and the percentage error of the measurement.
2. The value of a resistance is 4.7 kΩ, while measurements yield a value of 4.63 kΩ calculate
   (i) the relative accuracy of measurement, and
   (ii) % accuracy.
3. The output voltage of an amplifier was measured at eight different intervals using the same digital voltmeter with the following results:
   20.00, 19.80, 19.85, 20.05, 20.10, 19.90, 20.25, 19.95 V
   Which is the most precise measurement?

4. A 270 Ω ± 10% resistance is connected to a power supply source operating at 300 V dc. What range of current would flow if the resistor varied over the range of ± 10% of its expected value? What is the range of error in the current?
5. A voltmeter is accurate to 98% of its full scale reading.
   (i) If a voltmeter read 200 V on 500 V range, what is the absolute error?
   (ii) What is the percentage error reading of part (i)?

CHAPTER

2

Indicators and Display Devices

Review Questions

1. Give the basic principle of a D'Arsonval movement.
2. Explain the operation of a PMMC movement.
3. What are the functions of counter weights in a PMMC movement.
4. Explain the basic construction of a taut band movement.
5. Compare a PMMC movement with a taut band movement.
6. State the operating principle of an electrodynamometer.
7. Why is the electrodynamometer called a square law device?
8. What is a transfer instrument? Why is an electrodynamometer a transfer instrument?
9. Differentiate between moving iron and moving coil measurement.
10. State the difference between radial and concentric iron-vane movement.
11. State the difference between an analog and a digital indicator.
12. Explain a 7 segment LED display.
13. Draw the structure of an LED and explain its operation. What are the condition to be satisfied by the device for emission of visible light?
14. Discuss with a neat diagram, a method of realising a 7 segment numeric display using LEDs.
15. Bring out the important differences between the common anode and common cathode type circuit arrangements for a 7 segment numeric display using LEDs.
16. What are the operating principles of LCD display?
17. What are the advantages of LCD display over Nixie tube and LED display?
18. Give reasons for the following.
    (i) Dot matrix presentation is more popular than the bar matrix in alphanumeric character generation in CRT.
    (ii) Reflective LCDs have many advantages over transmissive LCDs.
    (iii) Bar graph displays have a unique role in an electronic display system.
19. Compare the relative performance of the following display devices in numeric display applications.

(i) Electrophoretic image display
(ii) Liquid vapour display
(iii) Nixie tubes
(iv) Flat panel alphanumeric CRT

20. What are printers, and where are they used?
21. State different types of printers.
22. How is character-at-a-time printing done?
23. How is line-at-a-time printing done?
24. What are impact and non-impact printers?
25. What are the different methods of character at a time printing?
26. What is a daisy wheel?
27. What are dot-matrix printers? How is printing done?
28. How is the quality of printing improved?
29. What are the main advantages of dot-matrix over other printers?
30. What are half steps in a dot-matrix? Why are they used?

CHAPTER

3

Ammeters

Review Questions

1. What type of movement is used for an ammeter?
2. What are the advantages of an Aryton shunt ammeter over a multirange ammeter?
3. What are the requirements of a shunt?
4. What precautions are to be observed when using an Ammeter?
5. What is a thermocouple? State its range of measurement.
6. Explain the construction and working of a thermocouple measuring instrument.
7. Why is a thermocouple measuring instrument classified as an RF instrument?
8. State the different types of thermocouple.
9. How is a large current measured using a thermocouples?
10. What are the limitations of a thermocouple?
11. What are the effects of frequency on the calibration of a thermocouple?

Practice Problems

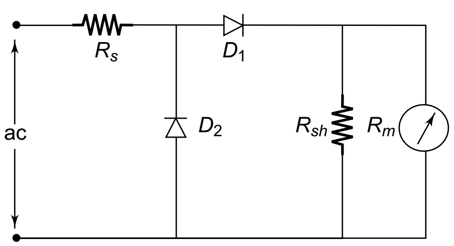
1. What value of shunt resistance is required for using a 50 μA meter movement, with an internal resistance of 250 Ω for measuring 0 – 500 mA?
2. Design a multirange ammeter with ranges of 0 – 1 A, 5 A, 25 A and 125 A, employing individual shunts in each. A D'Arsonval movement with an internal resistance of 730 Ω and a full scale current of 5 mA is available.
3. Design an Aryton shunt to provide an ammeter with current ranges of 0 – 1 mA, 10 mA, 50 mA, and 100 mA, using a D'Arsonval movement having an internal resistance of 100 Ω and full scale deflections of 50 μA.
4. Design an Aryton shunt to provide an ammeter with current ranges 0 – 10 mA, 100 mA, and 500 mA using a D'Arsonval movement having an internal resistance of 50 Ω and full scale deflections of 1 mA.

CHAPTER 4

Voltmeters and Multimeters

Review Questions

1. Which type of meter movement is most widely used in ac instruments for current and voltage measurements?
2. What are the effects of using a voltmeter of low sensitivity?
3. Compare a multirange voltmeter with the Aryton shunt voltmeter.
4. What is loading effect?
5. Why is a PMMC movement shunted by a resistor when used as a ac voltmeter?



6. Why does a TVM use a FET at the input stage?
7. Explain the working of a TVM. Why can a TVM not be used for measurement in the microvolts range?
8. How is voltage in the microvolts range measured? Explain with the help of a neat circuit diagram.
9. What is the use of a chopper in microvoltmeter?
10. How does the sensitivity of an ac voltmeter compare with the sensitivity of a dc voltmeter?
11. How does the sensitivity of an ac voltmeter using a full wave rectifier compare with one using a half wave rectifier?
12. Compare a true rms meter with an average responding meter.
13. How will you distinguish between a shunt type ohmmeter and a series type ohmmeter from the dial calibration? How can you estimate the internal resistance of an ohmmeter from its dial?
14. Differentiate between a series type ohmmeter and a shunt type ohmmeter.

15. What are the advantages of an electronic voltmeter over a multimeter?
16. Define the sensitivity of a multimeter. Draw the block diagram of a simple multimeter and explain its operation.
17. Draw a practical circuit of a multimeter.

Practice Problems

1. What series resistance must be used to extend the 0–200 V range of a 20000 Ω/V meter to a 2000 V? What must be the power of this resistor?
2. A basic D'Arsonval movement with a full scale deflection of 50 μA and an internal resistance of 1800 Ω is available. It is to be converted into a 0 – 1 V, 0 – 5 V, 0 – 25 V and 0 – 225 V multirange voltmeter using individual multipliers for each range. Calculate the values of the individual resistors.
3. A meter movement has an internal resistance of 100 Ω and requires 1 mA dc full scale deflection. Shunting resistor R_{sh} placed across the movement has a value of 100 Ω. Diodes D_1 and D_2 have an average forward resistance of 400 Ω and are assumed to have infinite reverse resistance in the reverse direction. For 10 V ac range, calculate (i) the value of the multiplier, (ii) the voltmeter sensitivity on ac range. (R_s = 1800, S = 225 Ω/V). Refer to Fig. 4.41.
4. The circuit diagram of Fig. 4.42 shows a full wave rectifier ac voltmeter. The meter movement has an internal resistance of 250 Ω and required 1 mA for full scale deflection. The diodes each have a forward resistance of 50 Ω and infinite reverse resistance.
   Calculate:
   (i) the series resistance required for full scale meter deflection when 25 V rms is applied to the meter terminals.
   (ii) the ohms per volt rating of this ac voltmeter.

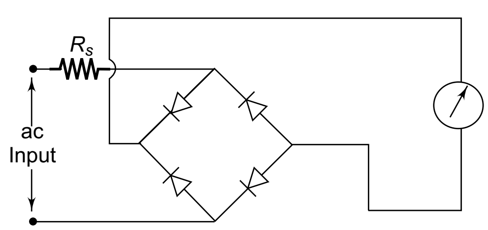


Fig. 4.42

5. A series ohmmeter uses a 50 Ω basic movement requiring a full scale deflection of 1 mA. The internal battery voltage is 3 V. The desired scale marking for half scale deflection is 2000 Ω.
   Calculate
   (i) values of R_1 and R_2
   (ii) maximum value of R_2 to compensate for a 10% drop in battery.

6. A series type ohmmeter is designed to operate with a 6 V battery. The meter movement has an internal resistance of 2 kΩ and requires a current of 100 μA for full scale deflection. The value of R_1 is 49 k.
   (i) Assuming the battery voltage has fallen to 5.9 V, calculate the value of R_2 required to "0" the meter.
   (ii) Under the condition mentioned in (i), an unknown resistance is connected to the meter, causing a 60% deflection. Calculate the value of the unknown resistance.

CHAPTER

5

Digital Voltmeters

Review Questions

1. State the advantages of a DVM over an analog meter.
2. What are the operating and performance characteristics of a DVM?
3. How are DVMs classified?
4. Explain the operating principle of a Ramp type DVM.
5. Explain the basic principle of a digital voltmeter.
6. Explain, with the help of a neat circuit diagram, the working of a dual slope DVM.
7. What are the advantages of dual slope over Ramp type DVMs?
8. Explain the principle of a successive approximations type DVM.
9. What is the advantage of a SAR type DVM over other types of DVM?
10. What are the two basic DVM circuits used for measuring voltages?
11. Define sensitivity of a digital meter.
12. Describe the term overrange and half digit.
13. What is a sample-hold circuit?
14. What is the advantage of using a sample hold circuit?

Practice Problems

1. The lowest range on a 4½ digit DVM is 10 mV full scale. What is the sensitivity of this meter?
2. A 3½ digit voltmeter is used for measuring voltage.
   (i) Find the resolution of the instrument.
   (ii) How would a voltage of 14.42 be displayed on 10 V range?
   (iii) How would be a reading 14.42 be displayed on 100 V range?
3. A 3½ digit DVM has an accuracy of ±0.5% of reading ±1 digit.
   (i) What is the possible error, in volts, when the instrument is reading 5 V on the 10 V range?
   (ii) What is the possible error, in volts, while reading 0.10 V on the 10 V range?

CHAPTER

6

Digital Instruments

Review Questions

1. What are the advantages of digital instruments over analog instruments?
2. What are the basic components of an digital system?
3. Explain the operation of a basic digital multimeter?
4. Explain, with the help of a neat circuit diagram, the working of a digital panel meter.
5. Write down the differences between DMM and DPM.
6. State different types of digital meters.
7. On what principle does a digital frequency meter operate?
8. Explain with the help of a neat diagram the working of a DFM.
9. What is the function of a gate control F/F? How does it operate?
10. Explain the principle of operation of a digital time measurement.
11. What is the function of a time base selector? How does it operate?
12. Explain the operation of period measurement?
13. What is a universal counter? How can it be used to measure the following:
    (i) Frequency
    (ii) Time
    (iii) Period
    (iv) Ratio
14. Explain the working of a decade counter.
15. What is an electronic counter? How can it be used to measure the following:
    (i) Totalising
    (ii) Frequency
    (iii) Ratio mode
    (iv) Period mode
    (v) Time interval mode?
16. Explain the operation of digital measurement of mains frequency.
17. On what principle does a digital tachometer operate?
18. Explain the operation of a digital phase meter.
19. On what principle does a digital capacitance meter operate?

20. How is automation in digital instruments obtained?
21. Why are the ranges in digital instruments overlapped?
22. How can measurements of parameters be obtained using microprocessors?

CHAPTER

7 Oscilloscope

Review Questions

1. What are the major components of a CRT?
2. What does the term phosphorescence mean?
3. Explain in detail the principle of operation of a single beam CRO.
4. Draw the basic block diagram of an oscilloscope and explain the functions of each block.
5. How is the electron beam focussed on to a fine spot on the face of the CRT?
6. Why are the operating voltages of a CRT arranged so that the deflection plates are nearly at ground potential?
7. How is the vertical axis of an oscilloscope deflected? How does it differ from the horizontal axis?
8. How do the X-shift and Y-shift function?
9. Why is a delay line used in the vertical section of an oscilloscope?
10. What are the advantages of dual trace over dual beam CROs for multiple trace?
11. How does alternate sweep compare with chopped sweep? When would one method be selected over the other?
12. What is the function of the electronic switch?
13. How does the Sampling CRO increase the apparent frequency response of an oscilloscope?
14. Will the waveform displayed on the CRT screen of a sampling oscilloscope be at a higher frequency than the actual input signal?
15. What is the speciality of a dual beam CRO?
16. Explain the functions of various controls on the front panel of a CRO.
17. What is the speciality of a storage oscilloscope?
18. With the help of a circuit diagram explain the working of a triggered sweep generator.
19. What is oscilloscope probe compensation and how is it adjusted? What effects are noted when the compensation is not correctly adjusted?
20. What are the advantages of using an active probe?
21. What is the need for a time base generator?

22. How is magnitude and phase measured on a CRO for two different waves?
23. Explain the use of a CRO for frequency measurement.
24. What is delayed sweep CRO. Explain in brief.
25. State the function of an Attenuator in CRO?
26. State the function and explain the working of a 10:1 probe for a CRO?
27. Give the special features of typical stages in an HF.CRO?

Practice Problems

1. A CRO with a sensitivity of 5 V/cm is used. An ac voltage is applied to the y-input. A 10 cm long straight line is observed. Determine the ac voltage.
2. The Lissajous pattern on an CRO is stationary and has five horizontal and two vertical tangencies. The frequency of the horizontal input is 1000 Hz. Determine the frequency of vertical input.
3. A CRO is set to a time base of 0.1 ms/cm with a 10 cm amplitude. Sketch the display of the pulse signal waveform with a pulse repetition rate of 2000 Hz and a duty cycle of 25%.

CHAPTER

8 Signal Generators

Review Questions

1. Describe a modern laboratory-type signal generator. What technique is used to improve its stability? What are frequency dividers?
2. Discuss with the help of a neat circuit diagram the elements of a standard sweep generator. Draw the output waveform.
3. Draw the block diagram of a function generator and explain the method of producing sine waves.
4. What principle is employed for the operation of a function generator?
5. What is the need for inserting isolation between the signal generator output and the oscillator in a simple signal generator? What are the ways this can be accomplished?
6. How are broad band sweep frequencies generated using a sweep generator?
7. List the various controls on the front panel of the pulse generator. Mention their uses.
8. Explain the working of a standard sweep generator with a diagram.
9. List the various controls on the front panel of a pattern generator.
10. What are the various patterns generated by a pattern generator?
11. What is the necessity of using a marker generator?
12. Explain the use of a TV pattern generator. How can a pattern generator be used for the alignment of a TV receiver?
13. What is a Wobbluscope. How can a Wobbluscope be used in aligning RF and IF sections?
14. What are the front controls of a Wobbluscope?
15. What are the different methods of obtaining colour bar patterns?
16. How are colour bar patterns generated by a colour bar generator?
17. What is a Vectroscope? Where is it used?
18. Explain the working principle of a Beat Frequency Oscillator? State its applications.

CHAPTER

9 Wave Analyzers and Harmonic Distortion

Review Questions

1. What is the difference between a wave analyzer and a harmonic distortion analyzer?
2. Explain with the help of a block diagram, the working of a harmonic distortion analyzer.
3. Explain with the help of a block diagram the working of a spectrum analyzer.
4. Where are spectrum analyzers commonly used?
5. Draw the circuit diagram and explain the working of a heterodyne type wave analyzer.
6. What is meant by the distortion factor? How can this factor be measured? Explain with the help of a block diagram.
7. Explain any one application of a distortion factor meter.
8. Explain the front panel control and applications of a distortion factor meter in trouble shooting.
9. With the help of a block diagram, explain an AF wave analyzer.
10. Compare a Wien bridge harmonic distortion analyzer to a bridged-T type harmonic distortion analyzer.
11. State the applications of a spectrum analyzer.

CHAPTER

10

Measuring Instruments

Review Questions

1. Explain the working principle of an output power meter.
2. How is field strength measured?
3. Explain the principle of operation of a stroboscope. Also explain how the speed of a motor can be measured using a stroboscope.
4. Explain with the help of an neat diagram, the working of a vector impedance meter.
5. Explain the working principle of a *Q* meter. Also outline the factors that cause errors during a *Q* measurement.
6. How can a *Q* meter be used for the measurement of:
   (i) DC resistance of a coil?
   (ii) Stray capacitance?
   (iii) Impedance of a circuit?
   (iv) Characteristics impedance of a transmission line?
7. How can *Q* be measured using the susceptance method?
8. What is a *LCR* bridge? How can *L*, *C* and *R* be measured using a skeleton *LCR* bridge?
9. What are the features of a Kit type LCR bridge?
10. On what principle does the RX meter operate? Explain.
11. Explain the operation of an automatic bridge.
12. How can a transistor tester be used for the measurement of the following?
    (i) Faulty transistor
    (ii) I_{cbo}
    (iii) I_{ceo}
    (iv) Beta gain
    (v) Hybrid parameters
13. Explain in details the working of a Megger. State its applications.
14. What do you understand by pH?
15. How can pH be measured? State the different methods of pH measurement.
16. What is the necessity of using a thermocompensator for pH measurements?

Practice Problems

1. Determine the distributed stray capacitances for the following data
   First measurement f_1 = 4 MHz and C_1 = 3.3 kpf
   Second measurement $f_2 = 3f_1$ = 12 MHz and C_2 = 1000 pf
   Also calculate the value of inductance.
2. The distributed capacitance was found to be 20 pf by use of a Q meter. The first resonance occurred at C_1 = 300 pf and f_1 was half the second resonance frequency. Determine the value of C_2 and f_2 at the second resonance (given L = 40 μH).

CHAPTER

11

Bridges

Review Questions

1. Compare the measuring accuracy of a Wheatstone bridge with the accuracy of an ordinary ohmmeter?
2. What is the criteria for balance of a Wheatstone bridge?
3. In what two types of circuits do Wheatstone bridges find most of their applications?
4. Describe the operation of the Wheatstone bridge.
5. List and discuss the principle applications of Kelvin's bridge.
6. Describe the operation of a Kelvin's bridge.
7. What is the criteria for balance of a Kelvin's bridge.
8. What is the primary use of Kelvin's bridge?
9. How does the basic circuit of Kelvin's bridge differ from that of Wheatstone's bridge?
10. How does the use of microprocessors be useful in bridge circuits?
11. Describe how Wheatstone's bridge may be used to control various physical parameters.
12. Define the term null as it applies to bridge measurement.
13. Describe how microprocessors are being used in test equipment.
14. What are some ways by which microprocessors are reducing the cost and complexity of analog measurements?
15. Explain how a simple ac bridge circuit operates and derive an expression for the unknown parameters.
16. What two conditions must be satisfied to make an ac bridge balance?
17. Describe how a similar angle bridge (comparison bridge) differs from a Wheatstone bridge.
18. Do the balance conditions in a similar angle bridge depend on frequency?

Practice Problems

1. Calculate the value of R_x in a Wheatstone bridge if
   (i) $R_1 = 400\ \Omega$, $R_2 = 5$ k, $R_3 = 2$ k
   (ii) $R_1 = 10$ k, $R_2 = 40$ k, $R_3 = 15.5$ k
   (iii) $R_1 = 5$ k, $R_2 = 40$ k, $R_3 = 10\ \Omega$
2. What resistance range must resistor R_3 have in order to measure unknown resistor in the range 1 – 100 kΩ using a Wheatstone bridge? Given $R_1 = 1$ k and $R_2 = 10$ k.
3. Calculate the value of R_x in Fig. Ex. 11.12, $R_a = 1600\ R_b$, $R_1 = 800\ R_b$ and $R_1 = 1.25\ R_2$.
4. Calculate the current through the galvanometer in the circuit diagram of Fig. 11.30.
5. If the sensitivity of the galvanometer in the circuit of Fig. 11.31 is 10 mm/μA, determine its deflection.

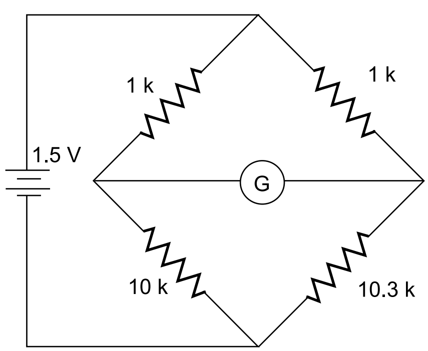


Fig. 11.30

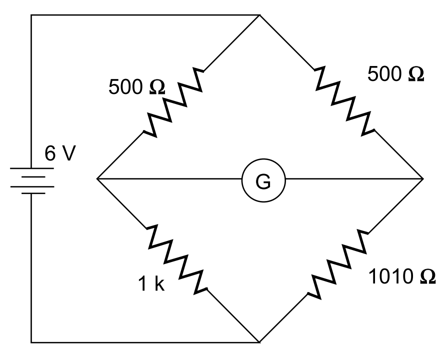


Fig. 11.31

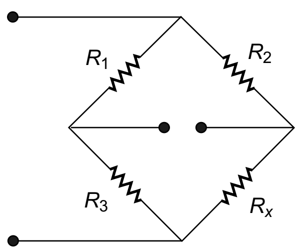
6. A balanced ac bridge has the following constants.
   Arm AB – $R = 1$ k in parallel with $C = 0.047$ μF
   Arm BC – $R = 2$ k in series with $C = 0.047$ μF
   Arm DC – unknown
   Arm DA – $C = 0.25$ μF.
   The frequency of the oscillator is 1 kHz. Determine the constants of arm CD.
7. A bridge is balanced at a frequency of 1 kHz and has the following constants.
   Arm AB – 0.2 μF pure capacitor
   Arm BC – 500 Ω pure resistance
   Arm CD – unknown
   Arm DA – $R = 600\ \Omega$ in parallel with $C = 0.1$ μF.
   Derive the balance condition and find the constants of arm CD, considered as a series circuit.
8. A 1000 Hz bridge has the following constants
   Arm AB – $R = 1$ k in parallel with $C = 0.25$ μF
   Arm BC – $R = 1$ k in series with $C = 0.25$ μF
   Arm CD – $L = 50$ mH in series with $R = 200\ \Omega$
   Arm DA – unknown
   Find the constants of arm DA to balance the bridge.

Express the result as a pure R in series with a pure C or L, and as a pure R in parallel with a pure C or L.

9. An ac bridge has the following constants.
   Arm AB – a pure capacitor $C = 0.2\ \mu F$
   Arm BC – a pure resistance $R = 500\ \Omega$
   Arm CD a series combination of $R = 50\ \Omega$ and $L = 0.1$ H
   Arm DA a capacitor $C = 0.5\ \mu F$ in series with a resistance R_s
   If $\omega = 2000$ rad/s
   (i) Find the value of Rs to obtain bridge balance.
   (ii) Can complete balance be obtained by the adjustment of R_s?
   If not, specify the position and value of an adjustable resistance to complete the balance.

Bridge Arrangements (Summary)

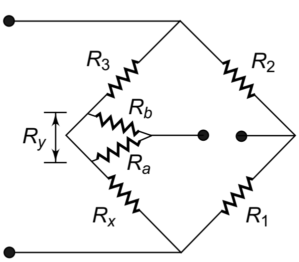
A. Resistance Measurement



Wheatstone's Bridge

$$R_x = \frac{R_2 R_3}{R_1}$$

Universally used circuit for resistance measurement. It can be used to make measurements from 1Ω to 1 MΩ with an accuracy of ± 0.25%.



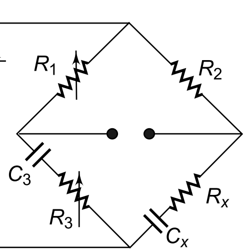
Kelvin's Double Bridge

$$R_x = \frac{R_1 R_3}{R_2}$$

Used for measuring small resistances as low as 0.001 Ω with an accuracy of ± 2%.

Fig. 11.31(a)

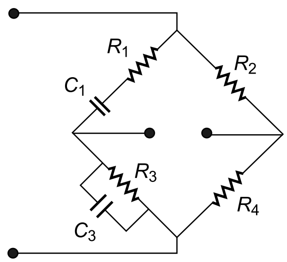
B. Capacitance Measurement



Capacitance Comparison

$$R_x = \frac{R_2 R_3}{R_1}$$

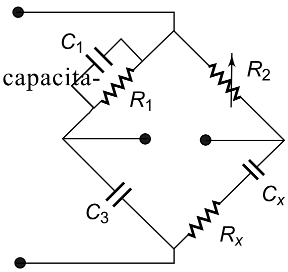
Used to measure unknown $C_x = \frac{C_3 R_1}{R_2}$ capacitances with reference to a standard capacitor. A fixed resistance ratio and variable standards are used. Balance is obtained by alternately varying C_3 and R_1.



Wien's Bridge

$$C_3 = \left(\frac{R_2}{R_4} - \frac{R_1}{R_3}\right) C_1$$

Used to measure capacitance to a high degree of accuracy when frequency and resistance standards are employed.



Schering's Bridge

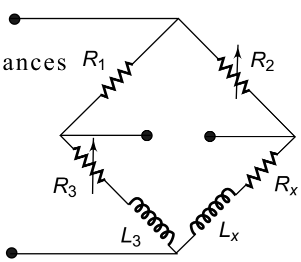
$$R_x = \frac{R_2 C_1}{C_3}$$

$$C_x = \frac{R_1 C_3}{R_2}$$

Most widely used bridge for capacitance measurements. Used for measurements of capacitance in the range of 100 pf – 1 μF, with an accuracy of ± 0.2%.

Fig. 11.31(b)

C. Inductance Measurements



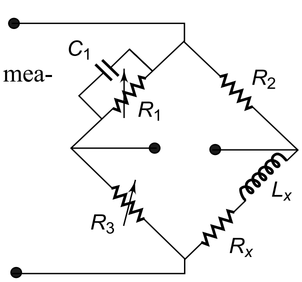
Inductance Comparison Bridge

$$R_x = \frac{R_2 R_3}{R_1}$$

$$L_x = \frac{L_3 R_2}{R_1}$$

Used to measure unknown inductances with reference to a standard inductor.

A fixed resistance ratio and variable standards are used. Balance is obtained by alternately varying L_3 and R_3.

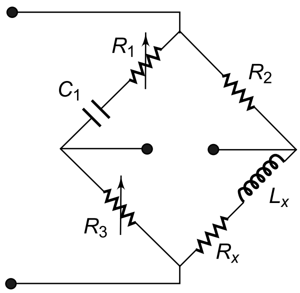


Maxwell's Bridge

$$R_x = \frac{R_2 R_3}{R_1}$$

$$L_x = C_1 R_2 R_3$$

Most widely used for Inductance measurements of low Q. Best suited for inductance measurement, since comparison with a capacitor is more ideal than with an inductor. It can measure from 1 μH to 1000 H with a ± 2% error (for $Q < 10$).



Hay's Bridge

$$R_x = \frac{R_2 R_3}{R_1[1+Q^2]}$$

$$L_x = \frac{R_2 R_3 C_1}{[1+1/Q^2]}$$

$$Q = \frac{1}{\omega R_1 C_1}$$

Mostly used for measurement of high Q (>10) coils. Not used for low Q, since the measurement depends on Q. It can measure from 1 μH to 100 H with a ± 2% error.

Fig. 11.31(c)

CHAPTER

12

Recorders

Review Questions

1. What is the difference between a strip chart recorder and an X–Y recorder?
2. What is the difference between an indicator and a recorder?
3. What are the three major systems of a strip chart recorder?
4. What is the purpose of the error detector in a recorder?
5. List typical frequency responses of a strip chart recorder.
6. List three functions that a recorder may simultaneously serve in industrial applications.
7. List a minimum of five specifications that should be considered while selecting a recording instrument.
8. Describe three applications for recording instruments.
9. How is automatic balance achieved in a recording instrument?
10. What is the approximate maximum frequency response of a galvanometer type recorder?
11. If the frequency of a signal to be recorded with a strip chart recorder is 15 Hz, what chart speed must be used to record one complete cycle on 5 mm of recording paper?
12. The chart speed of a recording instrument is 10 mm/s. If the time base of the recorded signal is 20 mm, what is the frequency of the recorded signal?
13. What are the primary functions of galvanometer recorders?
14. State the advantages of magnetic recorders over other recorders.
15. An ADC signal cannot be reproduced if recorded on a direct recording system. Comment.
16. Explain the different methods used for producing records.
17. What are the basic components of a Magnetic recorder? Explain its operation.
18. Give the constructional features of strip chart recorders. State its various applications.
19. Explain the working of a circular chart recorder.
20. Why does the strip chart recorder uses curvilinear chart?
21. Classify different types of recorders used in instrumentation.

22. What is the advantage of using a potentiometric circuit?
23. What is a servo system?
24. How is multipoint recording done?
25. How are transients recorded using digital waveform recorders?

CHAPTER

13 Transducers

Review Questions

1. Define a transducer.
2. What are the functions of a transducer?
3. List five physical quantities that transducer measures.
4. List the different types of transducers.
5. What is the difference between active and passive transducers?
6. Define a strain gauge.
7. What is a RTD and where is it used?
8. List three types of temperature transducers and describe the applications of each.
9. What is the difference between a thermocouple and a thermistor?
10. Explain how to use a potentiometric transducer.
11. Describe the operation of a piezo-electric transducer.
12. Name different types of photo-electric transducers.
13. What is the difference between photo-emissive, photo-conductive and photo-voltaic transducers?
14. Give the difference between a self generating and a passive inductive transducer.
15. Explain the operation of a photo-multiplier.
16. What is the advantage of using differential output rather than a single output for measuring displacement?
17. List four types of electrical pressure transducers and describe one application of each type.
18. What is a load cell? Where is it used?
19. Under what condition is a dummy strain gauge used? What is the function of the gauge?
20. What is an LVDT? Where is it used?
21. Explain the operating principle of an LVDT.
22. Describe the principle of operation of a pressure transducer employing each of the following principles.
    (i) Resistive transducer

(ii) Inductive transducer
(iii) Capacitive transducer

23. What is the effect of temperature changes on a strain gauge?
24. State the most common method of temperature compensation for overcoming the above difficulty.
25. Distinguish between bonded and unbonded strain gauges.
26. Describe the essential difference between a variable reluctance type of transducer and an LVDT.
27. State the applications of a solar cell.
28. Describe the principle of operation of an accelerometer.
29. State the main advantages and disadvantages of semiconductor strain gauges compared to a metallic wire strain gauge.
30. What are the advantages of using a foil type strain gauge.
31. Compare a magnetic flowmeter with a turbine flowmeter.
32. How can the thickness of a sheet material be measured?
33. What is the operating principle of a beta gauge?
34. What are the various scanning modes of a beta gauge?
35. Define temperature.
36. List various types of temperature transducers and describe the applications of each.
37. Differentiate between thermistor and thermocouple.
38. Explain the working principle of a resistance temperature detector.
39. State the different elements used as a sensor in RTD. Explain each in brief.
40. Explain the operation of two wire RTD.
41. Describe the different techniques used to eliminate the lead wire effect of RTD connection in a Bridge circuit.
42. Explain the operation of thin film RTD.
43. Compare thin film RTD with wire wound RTD.
44. Compare RTD with thermistor.
45. State the advantages and limitations of resistance thermometers.
46. Describe the operation of resistance thermometer.
47. Explain the working principle of thermistors.
48. Describe the different types of a thermistors.
49. State the advantages and disadvantages of thermistor.
50. State various applications of Thermistor.
51. Explain the working principle of a thermocouple.
52. Explain Seebeck effect and Peltier emf.
53. Describe the construction of thermocouples. State the limitations of Thermocouple.
54. Explain the term reference junction.
55. State the error introduced in thermocouple. Describe the various method to compensate these error.
56. Explain electronic ice point reference junction.
57. List various types of thermocouple.
58. Explain thermopiles and thermowell.
59. State the advantages and disadvantages of thermocouple.
60. Explain semiconductor temperature sensor and IC sensor
61. Define pyrometers.
62. Explain the working principle of pyrometers.

63. Describe the operation of
    (a) Total radiation pyrometers
    (b) Infrared pyrometers
    (c) Optical pyrometers
64. It is proposed to measure the temperature of an incandescent lamp, suggest a suitable sensor for the same. Justify your answer.
65. Choose the most suitable temperature transducer for measuring the temperature in each of the following:
    (a) Rapidly changing temperature
    (b) Very small temperature changes about 40 °C
    (c) Very high temperature (> 1500 °C)
    (d) Highly accurate temperature measurement
    (e) Wide temperature variations

CHAPTER

14 Signal Conditioning

Review Questions

1. What is a signal conditioner?
2. What are the basic elements of a signal conditioner?
3. What is an opamp?
4. What are the important features of an opamp?
5. How is an opamp used as a/an
   (i) inverting and non-inverting amplifier.
   (ii) summing amplifier.
   (iii) integrator.
   (iv) differentiator
   (v) comparator.
6. What is an instrumentation amplifier?
7. What are the applications of an instrumentation amplifier?
8. What are Choppers? How is the drift in a high gain dc amplifier eliminated?
9. State the different types of chopper.
10. List the differences between electronic and mechanical choppers.
11. On what principle does the mechanical chopper operate?
12. Explain the working of a capacitance modulator.
13. Explain the working of a synchronous modulator/demodulator.
14. Explain how a transistor can be used as a chopper.
15. Explain the working of a solid state modulator/demodulator.
16. Explain the working principle of an optical chopper.

CHAPTER

15

Filters

Review Questions

1. What are filter networks?
2. List different types of filters.
3. State the fundamental theorems on filters.
4. List the differences between passive and active filters.
5. What are prototype or constant-K filters and m-derived filters?
6. State the difference between the following
   (i) Low pass and high pass
   (ii) Band pass and band stop
7. What are the important characteristics of an all pass filter?
8. What do you understand by the order of an active filter?
9. Derive the gain equation for a second order low pass Butterworth filter.
10. What are the important types of active filters? Give a brief note on each.
11. What is the difference between a second order Butterworth low pass and high pass filter?
12. Differentiate between wide band pass and narrow band pass filters.
13. What is a Notch filter? How can twin-T be used as a notch filter?
14. What are universal filters? Why are they widely preferred?
15. Compare Butterworth and Chebyschev filters.
16. Why are Bessel filters preferred, even though they have a ripple in the pass and stop bands?
17. What do you mean by digital filters?
18. What are discrete functions used for digital filters?
19. Explain the 1-D and 2-D sampling theorem.
20. State the fundamental properties of 1-D and 2-D digital systems.
21. What are Finite Impulse Response (FIR) and Infinite Impulse Response (IIR) filters? Bring out the differences between them.

22. What do you mean by the zeros and poles of a filter?
23. What are recursive and non-recursive filters?
24. How would you design an IIR digital filter by means of bilinear transform?
25. State the applications of digital filters.

Practice Problems

1. Design a low pass filter having a cutoff frequency of 1.5 kHz and pass band gain of 3.
2. Design a second order low pass filter at a high cutoff frequency 1.75 kHz.
3. Design a second order high pass filter at a low cutoff frequency of 100 Hz.
4. Design a wide band pass filter with f_L = 150 Hz, f_H = 2 kHz and a pass band gain of 4. Also calculate the Q value of this filter.
5. (i) Design a narrow band pass filter having a centre frequency f_c of 500 Hz, Q = 4 and A_F = 6.
   (ii) Change the frequency f_c to 1 kHz, keeping the gain A_F and band width constant.
6. Design a wide band reject having f_H = 150 Hz and f_L = 2 kHz.
7. Determine the phase angle of an all pass filter, if the input frequency is 3 kHz.
8. Design an FLT-U2 as a second order inverting Butterworth high pass filter with a dc gain of 6, a cutoff frequency of 2 kHz, and Q = 8.

CHAPTER

16 Measurement Set-up

Review Questions

1. How can measurements at microwave frequencies be done?
2. What are wavemeters?
3. What are the different types of wavemeters?
4. What are the differences between absorption and transmission type wavemeters?
5. What are coaxial wavemeters and cavity wavemeters?
6. Discuss any one method of measuring radio field strength at RF/UHF.
7. What do you mean by sensitivity and selectivity of a radio receiver? How can they be measured?
8. What is intermodulation distortion?
9. How can non-linear distortion be measured using SMPTE and CCIF methods? Compare the two methods?
10. How is the frequency response of an audio amplifier stage measured?
11. What is modulation? What are the different types of modulation?
12. How is percentage modulation of an AM receiver measured?
13. How is frequency deviation in FM receivers measured?
14. Explain briefly the various patterns obtained on a CRO for AM measurements and how they can be used for the measurement of percentage modulation.

CHAPTER

17 Data Acquisition and Conversion

Review Questions

1. What is a data acquisition system?
2. What are the important factors that decide the configuration and sub system of a DAS?
3. What are the various configurations used in a DAS?
4. State the different possibilities for a multi channel DAS.
5. Explain with a neat diagram the working of a single DAS and give an example.
6. What is a multiplexer? Where it is used?
7. Why is it necessary to use preamplification and filtering before data processing?
8. How is low level multiplexing achieved?
9. What are the factors to be considered to achieve low level multiplexing?
10. What are data loggers? What are the functions of a data logger?
11. State the different elements of a data logger and with the help of a neat block diagram explain the functions of each block.
12. What is the function of a selector matrix and how does it select the various inputs?
13. What is input conditioning and how is it performed?
14. What is the function of a programmer?
15. What is the basic assembly of a data logger? What are the optional modules provided?
16. How does a computer based DAS aid the operator?
17. What are the objective of a DAS?
18. Why is a D/A converter usually considered a decoder?
19. Why is an A/D converter usually considered an encoder?
20. How is binary equivalent weight determined?
21. Describe how Millman's theorem is used to find the output voltage of a resistive ladder.
22. What are some of the advantages of a binary ladder over a resistive divider?
23. What is monotonicity?
24. What is the difference between accuracy and resolution?

25. Describe how a gray code eliminates large ambiguity errors in reading optical encoders.
26. Explain why you would (or would not) make the innermost ring of the code wheel for an optical encoder the LSB.

Practice Problems

1. What is the binary equivalent weight of each bit in a 5 bit resistive divider?
2. Draw the schematic of a 5 bit resistive ladder.
3. Assuming the divider in Prob. 2 has +10V full scale output, find the following.
   (i) The change in the output voltage due to change in the LSB
   (ii) The output voltage for an input of 11001
4. A 6-bit resistive divider is constructed such that the current through the LSB is 100 μA. Determine the maximum current that will flow through the MSB resistor.
5. Find the output voltage of a 6-binary ladder with the following inputs.
   (i) 110001 (ii) 010101 (iii) 110011
   (iv) 110110 (v) 111111
6. What is the full scale output voltage of a 5-bit binary ladder if 0 = 0 V and 1 = + 10 V? What is it for an 8-bit ladder?
7. What is the resolution of a 10-bit D/A converter which uses a binary ladder? If the full scale output is + 10 V, what is the resolution?
8. How many bits are required in a binary ladder to achieve a resolution of 1 mV if full scale is + 5 V?
9. What degree of resolution can be obtained using a 10-bit optical encoder?

CHAPTER

18 Data Transmission

Review Questions

1. What is data transmission?
2. Describe data transmission systems.
3. Explain Time Division Multiplexing (TDM) and its advantages over FDM.
4. What is pulse modulation?
5. Give the various types of pulse modulation.
6. How is PAM achieved?
7. How is the generation and demodulation of PWM obtained?
8. What is PPM and how is it different from PWM?
9. Compare analog modulation with digital modulation.
10. How is digital modulation achieved?
11. Give the principle of PCM and also explain how it is generated.
12. What do you understand by companding and encoding?
13. What is delta modulation?
14. How is delta modulation achieved?
15. What do you mean by slope overload and how is it overcome?
16. What is pulse code format?
17. Explain in brief the different types of pulse code format.
18. What are modems and where are they used?
19. With the help of a basic block diagram, explain the working of a modem.

CHAPTER

19 Frequency Standards

Review Questions

1. What are the standards for the measurement of frequency?
2. Explain the features of a primary standard.
3. Describe a primary standard.
4. What is the difference between a primary and a secondary standard?
5. What is atomic time?
6. What are the disadvantages of transmitting time and frequency standards by HF (3 – 30 MHz) radio signals?
7. What are some of the methods used to improve the dissemination of time and frequency standards?

CHAPTER

20

Measurement of Power

Review Questions

1. How is power at AF, RF and microwave frequency measured?
2. What are the requirements of a dummy load?
3. What is a bolometer?
4. How is power measured using a bolometer.
5. Give the procedure of measuring power using a bolometer in a bridge circuit.
6. What is an unbalanced bolometer bridge? What are its advantages?
7. What do you mean by self balancing?
8. How is self balancing achieved in a bolometer bridge?
9. State the basic principles of the calorimetric method.
10. How is large-amount of power in the RF range measured?
11. How is power in a transmission line measured?
12. What are standing waves?
13. How is the standing wave ratio measured?
14. What are directional couplers? How do they function?
15. How is the standing wave ratio measured using directional couplers?

CHAPTER

21 Control Systems

Review Questions

1. Define a control system.
2. Explain a basic controller.
3. Define errors.
4. Explain the concept ON–OFF control.
5. Explain proportional control.
6. Define offsets. How is this offset compensated?
7. Explain with diagram a basic controller configuration.
8. List classification of controller.
9. State the advantages and disadvantages of electronic controllers.
10. Define an electronic controller.
11. Explain, with diagram, electronic controller used as
    (i) Proportional control
    (ii) Integral control
    (iii) Derivative control
12. Explain, with circuit diagram, the following
    (i) PI control
    (ii) PD control
13. Explain with diagram the working of 3 term controller using Op Amps.
14. List features of an OpAmp.
15. Explain, with the help of a diagram, operation of a temperature controller.
16. Explain, with the help of a block diagram, the operation of a Digital Cotroller.
17. List the features of a Digital controller.
18. Explain, with the help of a block diagram, the operation of a Computer Supervisory control.
19. Differentiate between digital controller and computer supervisory control.
20. Explain the term UART.
21. Explain with help of block diagram the operation of a Cascade Process using Digital Controller.
22. Define PLC.

23. Explain with diagram the PLC structure.
24. Explain the basic operation of a PLC.
25. Define scan time and response time of a PLC.
26. Define a relay.
27. Explain relay diagram.
28. List and explain various types of timer and counter used in PLC.
29. Define a ladder diagram.
30. Compare relay wire diagram with ladder diagram.
31. List various inputs and outputs of a PLC.
32. Explain a program sequence executed by a PLC
33. List the various section of a PLC.
34. State the function of each sections used in PLC.
35. Explain fixed I/O PLCs.
36. Explain modular I/O PLCs.
37. Explain the principle of operations of a PLC.
38. Explain processor memory organisation.
39. Explain image table.
40. Explain program scan.
41. List the PLC hardware components.
42. Explain I/O section.
43. Explain discrete I/O module.
44. Explain with diagram the operation of a typical ac interface input module.
45. Explain with diagram the operation of a typical ac interface output module.
46. Explain the working of an analog I/O module.
47. List various I/O specifications.