Subject Name Solutions

4331102 – Winter 2022

Semester 1 Study Material

Detailed Solutions and Explanations

Question 1(a) [3 marks]

Draw and explain working of Basic Q-Meter.

Solution

Q-meter is an instrument used to measure the quality factor (Q) of an inductor or capacitor.
Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Oscillator] {-{-}{} B[Amplifier]}
    B {-{-}{} C[Meter Circuit]}
    C {-{-}{} D[Voltage Indicator]}
    C {-{-}{} E[Unknown Component]}
    E {-{-}{} C}
{Highlighting}
{Shaded}
```

- **Oscillator**: Generates variable frequency signal
- **Amplifier**: Amplifies the signal to required level
- **Resonance Circuit**: Contains the component under test
- **Voltage Indicator**: Measures the voltage across component

Mnemonic

"OARV - Oscillate, Amplify, Resonate, View"

Question 1(b) [4 marks]

Explain Spectrum Analyzer in brief.

Solution

A spectrum analyzer measures the magnitude of an input signal versus frequency within the full frequency range of the instrument.
Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Input Signal] {-{-}{} B[Mixer]}
    C[Local Oscillator] {-{-}{} B}
    B {-{-}{} D[IF Filter]}
    D {-{-}{} E[Detector]}
    E {-{-}{} F[Display]}
{Highlighting}
{Shaded}
```

- **Input Signal Processing**: Signals enter through attenuator and filters

- **Frequency Domain Conversion**: Converts time domain to frequency domain
- **Display System**: Shows amplitude vs. frequency plot
- **Applications**: Signal analysis, distortion measurement, EMI testing

Mnemonic

"SAME-FD: Signal Analysis Measures Everything in Frequency Domain"

Question 1(c) [7 marks]

Explain Wheatstone bridge with circuit diagram. List its advantages and disadvantages.

Solution

Wheatstone bridge is a circuit used to measure unknown resistance with high accuracy.
Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    A(({+)) {-}{-}{-} R1}
    A {-{-}{-} R3}
    R1 {-{-}{-} B((G))}
    R3 {-{-}{-} B}
    R1 {-{-}{-} R2}
    R3 {-{-}{-} Rx}
    R2 {-{-}{-} C((-))}
    Rx {-{-}{-} C}
{Highlighting}
{Shaded}
```

Where:
- R1, R2, R3 are known resistances
- Rx is unknown resistance
- G is galvanometer

Working Principle:
- Bridge is balanced when R1/R2 = R3/Rx
- At balance, no current flows through galvanometer
- Unknown resistance Rx = R3(R2/R1)

Advantages	Disadvantages
High accuracy	Limited range
Good sensitivity	Temperature effects
Null type measurement	Requires balance adjustment
No need for calibrated meter	Not suitable for very low/high resistances

Mnemonic

"BARN - Balance Achieved when Ratios are Null"

Question 1(c) OR [7 marks]

Define Instrument and explain its characteristics.

Solution

An instrument is a device used for measuring, displaying or recording physical quantities.

Characteristics	Description
Accuracy	Closeness of measurement to true value
Precision	Repeatability of measurements
Resolution	Smallest change that can be detected
Sensitivity	Ratio of output signal to input signal change
Linearity	Proportional relationship between input and output
Range	Minimum to maximum measurable values
Response time	Time required to show true reading

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Input] {-{-}{} B[Instrument]}
    B {-{-}{} C[Output Reading]}
    D[Error Sources] {-{-}{} B}
    E[Environmental Factors] {-{-}{} B}
{Highlighting}
{Shaded}
```

- **Static Characteristics**: Properties that don't vary with time
- **Dynamic Characteristics**: Properties that vary with time

Mnemonic

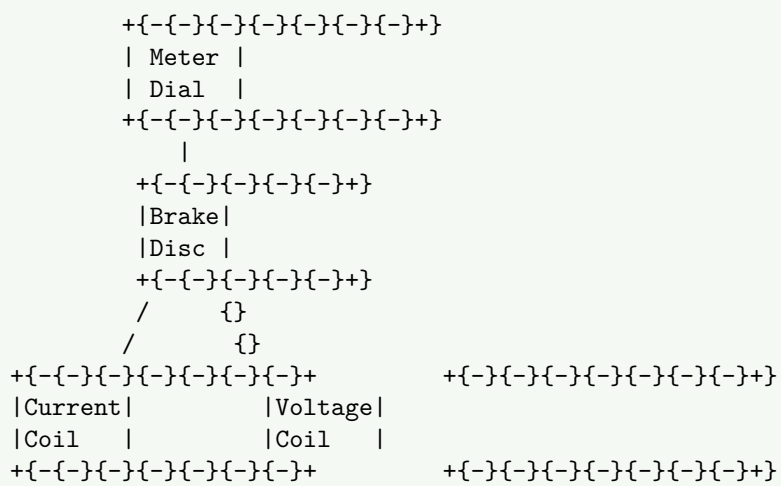
"APRS-LRR: Accuracy and Precision, Resolution and Sensitivity, Linearity, Range, Response time"

Question 2(a) [3 marks]

Draw the construction diagram of Energy meter.

Solution

Energy meter measures electrical energy consumption in kilowatt-hours.
Diagram:



- **Rotating Aluminum Disc**: Moves proportional to power
- **Current Coil**: Creates flux proportional to current
- **Voltage Coil**: Creates flux proportional to voltage
- **Permanent Magnet**: Provides braking torque

Mnemonic

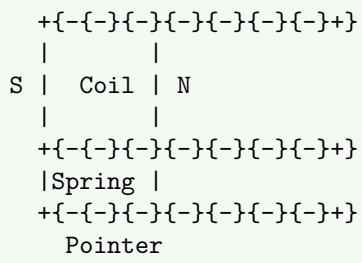
"DVCP: Disc Velocity measures Consumed Power"

Question 2(b) [4 marks]

Explain working of PMMC in short.

Solution

PMMC (Permanent Magnet Moving Coil) is a basic mechanism used in various meters.
Diagram:



Component	Function
Permanent Magnet	Creates strong magnetic field
Moving Coil	Carries current to be measured
Spring	Provides controlling torque
Pointer	Indicates reading on scale

- **Deflection Principle**: When current flows through coil, it produces torque proportional to current
- **Advantages**: Linear scale, high accuracy, low power consumption

Mnemonic

"CODA: Current through cOil causes Deflection by Attraction"

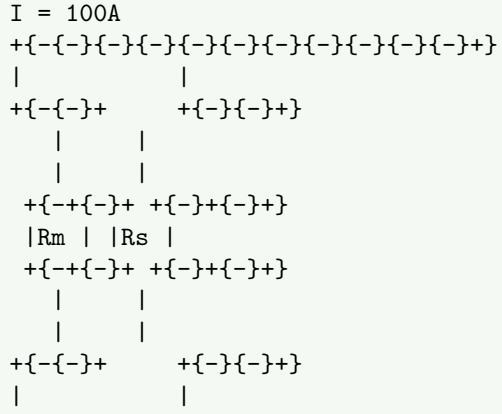
Question 2(c) [7 marks]

1- A moving coil ammeter reading up to 1 ampere has a resistance of 0.02 ohm. How this instrument could be adopted to read current up to 100 amperes?

2- A moving coil voltmeter reading up to 20 mV has a resistance of 2 ohms. How this instrument can be adopted to read voltage up to 300 volts?

Solution

1. Ammeter Range Extension:
Diagram:



```
+{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
```

- **Shunt Resistance Calculation**: Rs = Rm $\times Im/(I - Im)$
- **Given**: Rm = 0.02Ω, Im = 1A, I = 100A
- **Solution**: Rs = 0.02 $\times 1/(100 - 1) = 0.02/99 = 0.000202$

2. Voltmeter Range Extension:
Diagram:

```
+{-{-}{-}{-}Rs{-}{-}{-}{-}+}
|           |
|    +{-{-}+  |}
+{-{-}{-}{-}+Rm+{-}{-}+}
     +{-{-}+}
      V
```

- **Series Resistance Calculation**: Rs = Rm $\times (V/Vm - 1)$
- **Given**: Rm = 2Ω, Vm = 20mV, V = 300V
- **Solution**: Rs = 2 $\times (300/0.02 - 1) = 2 \times (15000 - 1) = 2 \times 14999 = 29,998$

Mnemonic

"SHIP: Shunt Has Inverse Proportion for current; Series for voltage"

Question 2(a) OR [3 marks]

Explain working of electronic multimeter.

Solution

Electronic multimeter measures multiple electrical parameters using electronic components.
Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Input Signal] {-{-}{} B[Range Selection]}
    B {-{-}{} C[Conversion Circuit]}
    C {-{-}{} D[Display System]}
{Highlighting}
{Shaded}
```

- **Range Selection**: Selects appropriate measurement range
- **Signal Conditioning**: Converts input to proportional voltage
- **ADC**: Converts analog to digital for display
- **Digital Display**: Shows measured value

Mnemonic

"RSAD: Range Select, Amplify, Digitize"

Question 2(b) OR [4 marks]

Explain working of Moving Iron type instruments.

Solution

Moving Iron instruments measure AC/DC current and voltage based on magnetic attraction/repulsion.

Types	Working Principle
Attraction Type	Iron piece is attracted toward electromagnet
Repulsion Type	Two iron pieces repel each other

Diagram:

```
+{-{-}{-}{-}{-}{-}{-}{-}+}
| Spring |
+{-{-}{-}{-}+{-}{-}{-}+}
     |
+{-{-}{-}{-}+{-}{-}{-}{-}+}
|Iron Vane|{-{-}{-}{-}{-}{-}{-}{-}+ Pointer}
+{-{-}{-}{-}+{-}{-}{-}{-}+}
     |
+{-{-}{-}{-}+{-}{-}{-}+}
|  Coil  |
+{-{-}{-}{-}{-}{-}{-}{-}+}
```

- **Operating Principle**: Current through coil creates magnetic field
- **Scale**: Non-linear (crowded at lower end)
- **Applications**: AC and DC measurements, ammeters, voltmeters

Mnemonic

"CADS: Current Activates, Deflection Shows"

Question 2(c) OR [7 marks]

Draw the block diagram of Ramp type DVM. Illustrate process of obtaining Multirange DC voltmeter with circuit diagram.

Solution

Ramp type DVM converts voltage to time interval using ramp comparison.

Diagram for Ramp Type DVM:

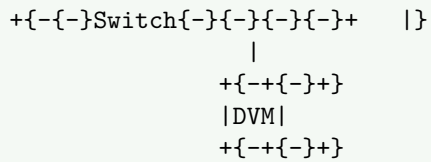
Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Input Voltage] {-{-}{} B[Comparator]}
    C[Ramp Generator] {-{-}{} B}
    B {-{-}{} D[Gate Control]}
    E[Clock] {-{-}{} F[Counter]}
    D {-{-}{} F}
    F {-{-}{} G[Display]}
{Highlighting}
{Shaded}
```

- **Working Principle**: Measures time taken for ramp to equal input voltage
- **Comparator**: Compares input with ramp voltage
- **Counter**: Counts clock pulses during comparison
- **Display**: Shows digital reading

Multirange DC Voltmeter Circuit:

```
      +{-{-}R1{-}{-}+}
      |      |
   Input     +{-{-}R2{-}{-}+}
      |      |      |
   +{-{-}+      +{-}{-}R3{-}{-}+}
   |            |   |
```



Range Switching Process:

- Each resistor provides different voltage division ratio
- Switch selects appropriate voltage divider network
- Voltage divider reduces input to fit DVM range

Mnemonic

"CRCD: Compare Ramp, Count Duration"

Question 3(a) [3 marks]

Describe features of Digital storage oscilloscope (DSO).

Solution

Digital Storage Oscilloscope converts analog signals to digital for storage and analysis.

Features	Description
Digital Storage	Stores waveforms for later analysis
Triggering	Multiple trigger modes and sources
Waveform Processing	Math operations on waveforms
FFT Analysis	Frequency domain view of signals
Multiple Channels	Simultaneous viewing of signals
USB/LAN Connectivity	Data transfer capabilities

- **Sampling Rate**: Typically 1 GS/s or higher
- **Memory Depth**: Determines maximum capture time

Mnemonic

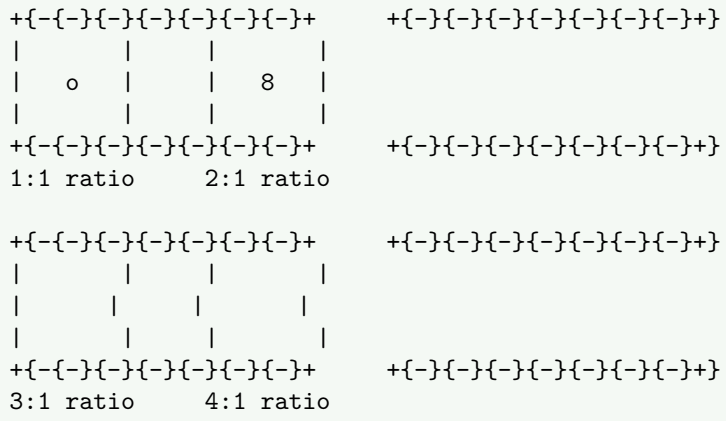
"SACRED: Storage, Analysis, Connectivity, Resolution, Extended functions, Digital processing"

Question 3(b) [4 marks]

Explain frequency measurement method using Lissajous pattern.

Solution

Lissajous patterns are used to compare frequencies of two signals.
Diagram:



Method:
1. Apply unknown frequency to X-input
2. Apply reference frequency to Y-input
3. Observe Lissajous pattern on screen
4. Count tangent points to determine ratio

Formula: fx/fy = Ny/Nx
- Where Nx = horizontal tangent points
- Ny = vertical tangent points

Mnemonic

"XTYN: X-Tangents to Y-tangents gives the Number ratio"

Question 3(c) [7 marks]

Explain CRO with help of Block diagram.

Solution

Cathode Ray Oscilloscope (CRO) is used to display and analyze waveforms.
Block Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Vertical Input] {-{-}{} B[Vertical Attenuator]}
    B {-{-}{} C[Vertical Amplifier]}
    C {-{-}{} D[Vertical Deflection Plates]}
    E[Trigger Circuit] {-{-}{} F[Time Base Generator]}
    F {-{-}{} G[Horizontal Amplifier]}
    G {-{-}{} H[Horizontal Deflection Plates]}
    I[Power Supply] {-{-}{} J[CRT]}
    D {-{-}{} J}
    H {-{-}{} J}
{Highlighting}
{Shaded}
```

Block	Function
Vertical Section	Processes input signal for Y-deflection
Horizontal Section	Generates sweep signal for X-deflection
Trigger Circuit	Synchronizes sweep with input signal
CRT	Displays the waveform pattern
Power Supply	Provides required voltages

- **Electron Gun**: Produces electron beam
- **Deflection System**: Moves beam in X and Y directions
- **Screen**: Phosphor coating converts electrons to visible light

Mnemonic

"VCTHP: Vertical input, Conditioned signal, Triggered sweep, Horizontal deflection, Phosphor display"

Question 3(a) OR [3 marks]

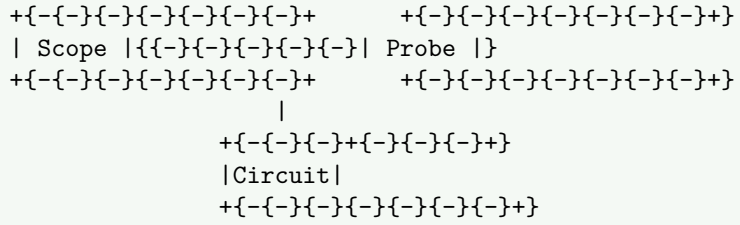
Explain different types of CRO probes.

Solution

CRO probes connect the circuit under test to the oscilloscope input.

Probe Type	Characteristics	Applications
Passive Probes	Simple, economical, high impedance	General-purpose measurements
Active Probes	Built-in amplifier, low loading	High-frequency circuits
Current Probes	Measures current without circuit breaking	Current waveform measurements
Differential Probes	Measures between two points	Floating measurements

Diagram:



- **Attenuation Ratio**: Typically 1:1 or 10:1
- **Compensation**: Adjustable to match oscilloscope input

Mnemonic

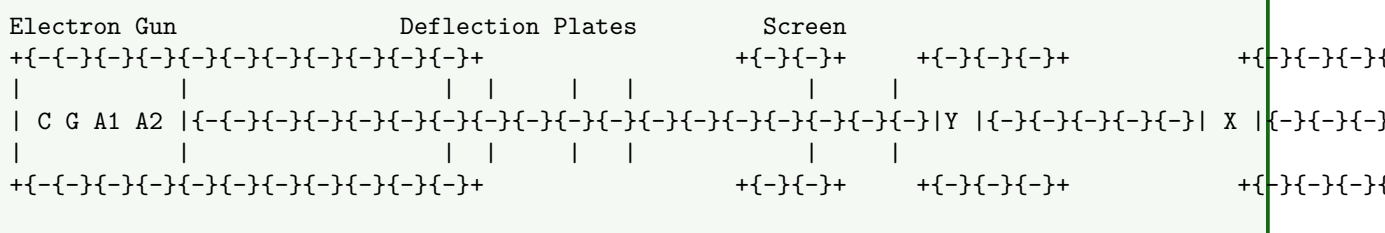
"PACD: Passive, Active, Current, Differential"

Question 3(b) OR [4 marks]

Draw internal structure of CRT. Explain in brief.

Solution

Cathode Ray Tube (CRT) is the display device in an oscilloscope.
Diagram:



C: Cathode, G: Grid, A1, A2: Anodes, Y,X: Deflection Plates, P: Phosphor

Component	Function
Electron Gun	Produces electron beam
Control Grid	Regulates beam intensity
Focusing Anodes	Concentrates electron beam
Deflection Plates	Control beam position
Phosphor Screen	Converts electrons to light

- **Electron Beam**: High-velocity electrons emitted by cathode
- **Focusing System**: Anodes form electron lens
- **Deflection System**: X-Y plates move beam position
- **Phosphor Screen**: Glows where beam hits

Mnemonic

"GAFDS: Gun Aims, Focusing Directs, Screen shows"

Question 3(c) OR [7 marks]

Draw and explain block diagram of DSO in detail.

Solution

Digital Storage Oscilloscope (DSO) captures, stores and analyzes signals in digital form.
Block Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Input] {-{-}{} B[Attenuator/Amplifier]}
    B {-{-}{} C[Anti{-}aliasing Filter]}
    C {-{-}{} D[ADC]}
    D {-{-}{} E[Memory]}
    E {-{-}{} F[Microprocessor]}
    F {-{-}{} G[Display]}
    H[Timebase] {-{-}{} F}
    I[Trigger] {-{-}{} F}
    J[Control Panel] {-{-}{} F}
{Highlighting}
{Shaded}
```

Block	Function
Input Section	Signal conditioning and scaling
ADC	Converts analog to digital signals
Memory	Stores digitized waveform data
Microprocessor	Controls acquisition and processing
Display System	Shows waveforms and measurements
Trigger System	Determines when to start acquisition

- **Sampling Rate**: Number of samples per second
- **Resolution**: Number of bits in ADC (typically 8-12 bits)
- **Memory Depth**: Number of samples that can be stored
- **Processing**: Waveform math, measurements, analysis

Mnemonic

"SAMPLE-D: Signal Acquisition, Memory Processing, Locking trigger, Display"

Question 4(a) [3 marks]

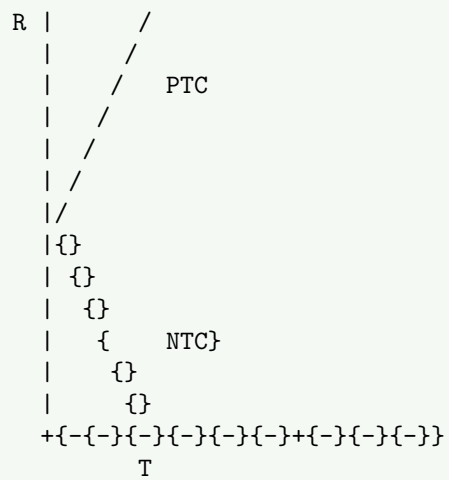
Give the comparison of NTC and PTC thermistor.

Solution

Parameter	NTC Thermistor	PTC Thermistor
Resistance Change	Decreases with temperature	Increases with temperature
Material	Metal oxides (Mn, Ni, Co, Cu)	Barium titanate, polymers
Response	Exponential decrease	Sharp increase above threshold

Applications	Temperature measurement, compensation	Overcurrent protection, heating
Temperature Range	-50$^t o$300	0$^t o$200

Diagram:



Mnemonic

"IN-DP: Increase Negative, Decrease Positive"

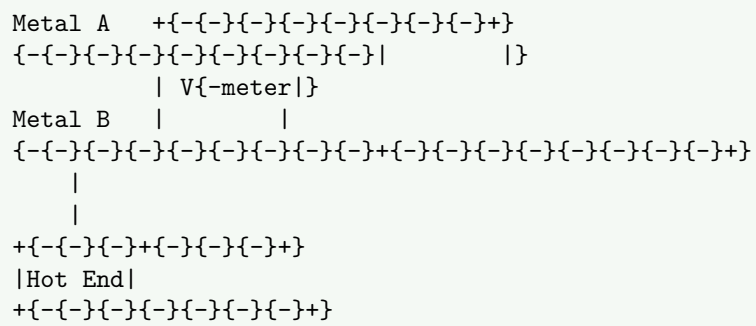
Question 4(b) [4 marks]

Explain working principle and construction of Thermocouple.

Solution

Thermocouple is a temperature sensor that works on the principle of Seebeck effect.

Diagram:



Construction:

- Two dissimilar metals joined at one end (measuring junction)
- Other ends connected to measuring circuit (reference junction)
- Protective sheath for industrial applications

Working Principle:

- Temperature difference between junctions creates EMF
- EMF is proportional to temperature difference
- Output voltage typically in millivolts range
- Different metal combinations for different ranges

Mnemonic

"STEM: Seebeck-effect Transforms temperature to EMF in Metals"

Question 4(c) [7 marks]

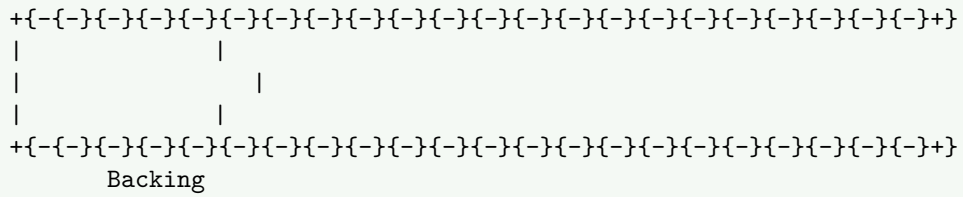
Explain Working of strain Gauge and Load cell. Give advantages and disadvantages of RTD.

Solution

Strain Gauge Working:

- **Principle**: Resistance changes with mechanical deformation
- **Construction**: Thin wire or foil grid mounted on backing material
- **Operation**: When strained, resistance changes proportionally
- **Gauge Factor**: Ratio of relative change in resistance to strain

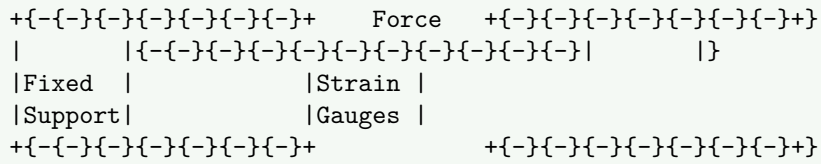
Diagram for Strain Gauge:



Load Cell Working:

- **Construction**: Strain gauges mounted on metal body (beam/ring)
- **Operation**: Weight causes deformation measured by strain gauges
- **Circuit**: Typically Wheatstone bridge configuration
- **Output**: Usually few millivolts per volt of excitation

Diagram for Load Cell:



RTD (Resistance Temperature Detector):

Advantages	Disadvantages
High accuracy	Expensive
Good stability	Requires excitation current
Wide temperature range	Self-heating effects
Linear response	Lower sensitivity than thermistor
Good repeatability	Slower response time

Mnemonic

"SPANNER: Strain Proportionally Alters Nominal Nominal Electrical Resistance"

Question 4(a) OR [3 marks]

Explain Humidity Sensor Hygrometer.

Solution

Humidity sensor hygrometer measures relative humidity in air.

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Humidity] {-{-}{} B[Sensing Element]}
    B {-{-}{} C[Signal Conditioning]}
    C {-{-}{} D[Display/Output]}
```

{Highlighting}
{Shaded}

Type	Sensing Principle
Capacitive	Humidity changes dielectric constant
Resistive	Humidity changes resistance
Thermal	Humidity affects thermal conductivity

- **Relative Humidity**: Ratio of actual to maximum water vapor
- **Measurement Range**: Typically 0-100% RH
- **Applications**: Weather stations, HVAC systems, industrial processes

Mnemonic

"CRT-H: Capacitance/Resistance/Thermal changes with Humidity"

Question 4(b) OR [4 marks]

Draw and explain Piezoelectric transducer.

Solution

Piezoelectric transducer converts mechanical stress to electrical signals and vice versa.
Diagram:

```
+{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
|    Electrodes |
|  +{-{-}{-}{-}{-}{-}{-}{-}{-}+  |}
|  |          |  |
|  | Crystal |  |
|  |          |  |
|  +{-{-}{-}{-}{-}{-}{-}{-}{-}+  |}
|    Electrodes |
+{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
   |          |
   + Output  +
```

Working Principle:
- **Direct Effect**: Pressure produces electrical charge
- **Inverse Effect**: Voltage produces mechanical deformation
- **Materials**: Quartz, PZT, barium titanate

Applications:
- Pressure sensors
- Accelerometers
- Ultrasonic transducers
- Vibration sensors

Mnemonic

"PEMS: Pressure Ensures Measurable Signal"

Question 4(c) OR [7 marks]

Give the classification of transducers in detail.

Solution

Transducers convert one form of energy to another, classified in several ways:

Classification	Types	Examples
Based on Energy Conversion	**Mechanical to Electrical**	Strain gauge, LVDT
	Thermal to Electrical	Thermocouple, RTD
	Optical to Electrical	Photodiode, LDR
	Chemical to Electrical	pH sensor, gas sensor
Based on Operating Principle	**Resistive**	Strain gauge, thermistor
	Inductive	LVDT, proximity sensor
	Capacitive	Humidity sensor, pressure sensor
	Piezoelectric	Accelerometer, force sensor
Based on Application	**Temperature**	Thermocouple, RTD, thermistor
	Pressure	Diaphragm, strain gauge based
	Flow	Ultrasonic, turbine, venturi
	Level	Float, ultrasonic, capacitive

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    A[Transducers] {-{-}{} B[Active/Passive]}
    A {-{-}{} C[Primary/Secondary]}
    A {-{-}{} D[Analog/Digital]}
    B {-{-}{} B1[Active: Self{-}generating]}
    B {-{-}{} B2[Passive: External power]}
    C {-{-}{} C1[Primary: Direct conversion]}
    C {-{-}{} C2[Secondary: Multiple steps]}
    D {-{-}{} D1[Analog: Continuous output]}
    D {-{-}{} D2[Digital: Discrete output]}
{Highlighting}
{Shaded}
```

Mnemonic

"APAD RICE: Active/Passive, Analog/Digital with Resistive, Inductive, Capacitive, Electromagnetic"

Question 5(a) [3 marks]

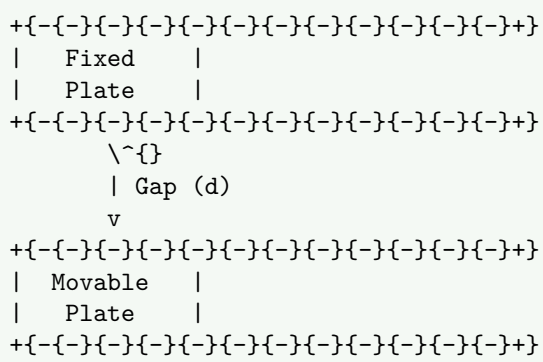
Write short note on various Capacitive transducer.

Solution

Capacitive transducers operate on the principle that capacitance changes with physical parameters.

Type	Working Principle	Applications
Displacement	Gap between plates changes	Precision measurement
Pressure	Diaphragm deflection changes gap	Pressure sensors
Level	Dielectric changes with medium	Liquid level measurement
Humidity	Dielectric changes with moisture	Humidity sensors

Diagram:



- **Capacitance**: C = A/d (: permittivity, A: area, d: distance)
- **Advantages**: High sensitivity, no physical contact needed
- **Limitations**: Affected by stray capacitance

Mnemonic

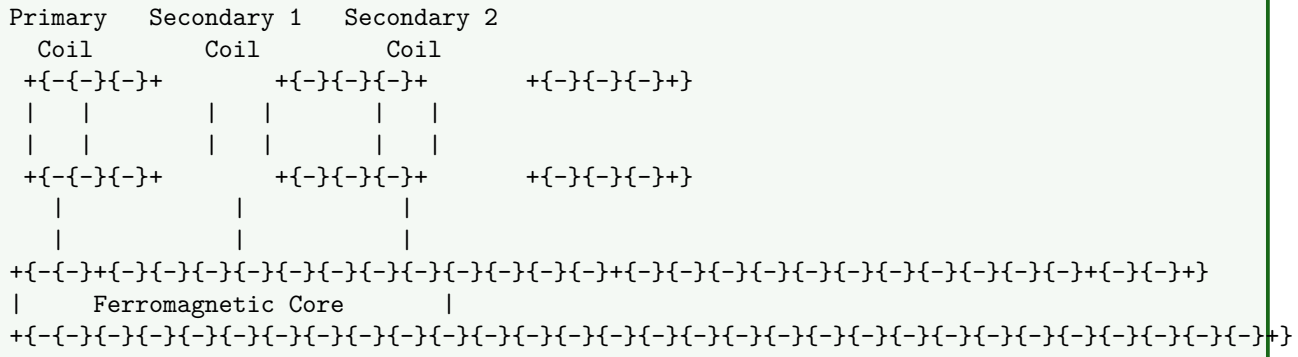
"PALD: Parameter Alters the Leading Dielectric"

Question 5(b) [4 marks]

Explain LVDT Transducer.

Solution

LVDT (Linear Variable Differential Transformer) measures linear displacement.
Diagram:



Working Principle:

- Primary coil excited by AC voltage
- Core position determines coupling to secondaries
- Output voltage proportional to core displacement
- Null position when core centered (output = 0)

Characteristics:

- **Range**: Typically $\pm 0.5mm to \pm 25cm$
- **Linearity**: Excellent around null position
- **Sensitivity**: High, typically mV/mm
- **Resolution**: Nearly infinite (analog device)

Mnemonic

"MDVN: Movement Determines Voltage from Null"

Question 5(c) [7 marks]

Draw and explain Harmonics Distortion Analyzer.

Solution

Harmonic Distortion Analyzer measures distortion in audio and electronic signals.
Block Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Input Signal] {-{-}{} B[Attenuator]}
    B {-{-}{} C[Input Amplifier]}
    C {-{-}{} D[Fundamental Notch Filter]}
    D {-{-}{} E[Residual Amplifier]}
    E {-{-}{} F[RMS Detector]}
    F {-{-}{} G[Display]}
    C {-{-}{} H[Reference Level Detector]}
    H {-{-}{} G}
{Highlighting}
{Shaded}
```

Working Principle:

1. Input signal is conditioned and amplified
2. Fundamental frequency is removed using notch filter
3. Remaining harmonic content is measured
4. Distortion calculated as ratio of harmonics to total signal

Characteristics:

- **Measurement Range**: Typically 0.001% to 100%
- **Frequency Range**: 20Hz to 100kHz
- **Applications**: Audio equipment testing, power quality analysis
- **Measurements**: THD (Total Harmonic Distortion), THD+N (THD plus Noise)

Calculation: THD $= \sqrt{(V_2^2 + V_3^2 + V_4^2 + \ldots)}/(V_1 + V_2 + V_3 + \ldots)$

- Where $V_1 is fundamental, V_2, V_3, etc. are harmonics$

Mnemonic

"FAIR-D: Filter And Isolate Residuals for Distortion"

Question 5(a) OR [3 marks]

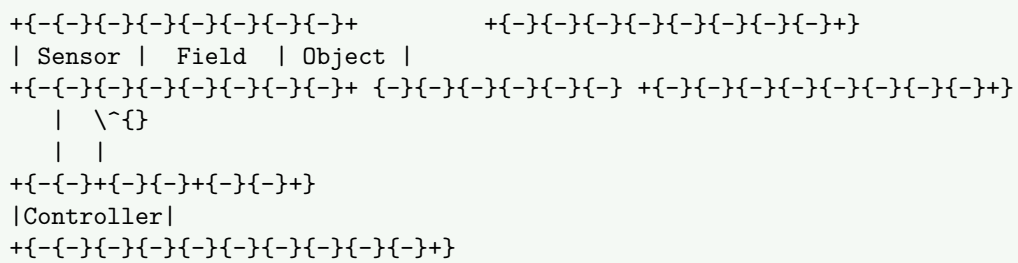
Explain the working principle of Proximity sensors.

Solution

Proximity sensors detect objects without physical contact.

Type	Working Principle	Detection Range
Inductive	Detects metal using electromagnetic field	0.5-60mm
Capacitive	Detects any material by capacitance change	3-60mm
Ultrasonic	Uses sound wave reflection	1cm-10m
Photoelectric	Uses light beam interruption	Up to 50m

Diagram:



- **Operating Modes**: Normally open or normally closed
- **Output Types**: Digital (on/off) or analog (proportional)
- **Applications**: Manufacturing, automation, security systems

Mnemonic

"CUPS: Capacitive, Ultrasonic, Photoelectric, Sense"

Question 5(b) OR [4 marks]

Explain absolute and incremental type of Optical encoder.

Solution

Optical encoders convert mechanical position to digital signals using light detection.

Parameter	Absolute Encoder	Incremental Encoder
Output Format	Complete position code	Pulse train
Resolution	Fixed by number of tracks	Determined by disk divisions
Position Knowledge	Maintained after power loss	Lost after power loss
Complexity	Higher (multiple tracks)	Lower (single track)
Cost	Higher	Lower

Diagram of Absolute Encoder:

```
+{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
|  1 0 1 0 1  | {{-} Code Tracks}
|  1 1 0 0 1  |
|  0 0 1 1 1  |
+{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
       |
+{-{-}{-}{-}{-}{-}{-}+{-}{-}{-}{-}{-}{-}{-}{-}+}
| Light Source |
+{-{-}{-}{-}{-}{-}{-}+{-}{-}{-}{-}{-}{-}{-}{-}+}
       |
+{-{-}{-}{-}{-}{-}{-}+{-}{-}{-}{-}{-}{-}{-}{-}+}
|   Detectors  |
+{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
```

Diagram of Incremental Encoder:

```
+{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
|           |
|  //////   | {{-} Single Track with slots}
|           |
+{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
       |
+{-{-}{-}{-}{-}{-}{-}+{-}{-}{-}{-}{-}{-}{-}{-}+}
| Light Source |
+{-{-}{-}{-}{-}{-}{-}+{-}{-}{-}{-}{-}{-}{-}{-}+}
       |
+{-{-}{-}{-}{-}{-}{-}+{-}{-}{-}{-}{-}{-}{-}{-}+}
|   Detectors  |
+{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
```

- **A, B, Z Outputs**:
  - A and B outputs are $90°$ $out of phase for direction detection$
  - Z (index) pulse once per revolution for reference

Mnemonic

"APIR-CD: Absolute Provides Immediate Reading, Counter Determines incremental"

Question 5(c) OR [7 marks]

Write short note on Digital IC Tester.

Solution

Digital IC Tester is used to verify functionality and detect faults in digital integrated circuits.
Block Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Test Pattern Generator] {-{-}{} B[IC Socket]}
    C[IC Under Test] {-{-}{} B}
    B {-{-}{} D[Response Analyzer]}
    D {-{-}{} E[Result Display]}
    F[Microcontroller] {-{-}{} A}
    F {-{-}{} D}
    F {-{-}{} E}
    G[User Interface] {-{-}{} F}
    H[Power Supply] {-{-}{} B}
```

```
{Highlighting}
{Shaded}
```

Component	Function
Test Pattern Generator	Creates input test signals
IC Socket	Holds the IC under test
Response Analyzer	Compares actual vs. expected outputs
Display	Shows test results and IC status
Microcontroller	Controls test sequence

Testing Methods:

1. **Functional Testing**: Verifies logic functionality
2. **Parametric Testing**: Measures electrical parameters
3. **Fault Detection**: Identifies shorts, opens, stuck bits

Types of IC Testers:

- **Universal Testers**: Test multiple IC families (TTL, CMOS)
- **Dedicated Testers**: Designed for specific IC types
- **In-Circuit Testers**: Test ICs while in the circuit

Capabilities:

- **IC Identification**: Recognizes unknown ICs
- **Fault Diagnosis**: Identifies specific faults
- **Auto Test**: Performs comprehensive testing sequence

Mnemonic

"GATES: Generate And Test Every Signal"

Question 5(c) (Additional) [7 marks]

Below are the solved solutions for remaining questions present in the question paper:

Explain working of electronic multimeter.

Solution

Electronic multimeter uses electronic components to measure various electrical parameters.

Block Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Input] {-{-}{} B[Range Selection]}
    B {-{-}{} C[Signal Conditioning]}
    C {-{-}{} D[ADC]}
    D {-{-}{} E[Display]}
    F[Power Supply] {-{-}{} C}
    F {-{-}{} D}
    F {-{-}{} E}
{Highlighting}
{Shaded}
```

Function	Circuit Components	Features
Voltage Measurement	Input attenuator, amplifier	High impedance input
Current Measurement	Shunt resistor, amplifier	Low insertion loss
Resistance Measurement	Constant current source	Auto-ranging capability
Display	LCD or LED with drivers	Digital readout

- **Advantages**: High input impedance, auto-ranging, digital accuracy
- **Applications**: Electronics troubleshooting, circuit testing, device calibration

Mnemonic

"MAAD: Measure, Amplify, Analyze, Display"

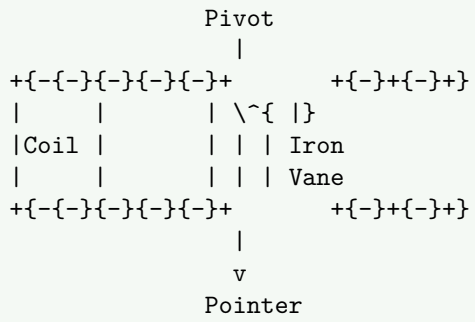
Explain working of Moving Iron type instruments.

Solution

Moving Iron instruments operate based on magnetic force between current-carrying coil and iron piece.

Type	Operation	Characteristics
Attraction Type	Iron piece attracted to coil	Simple construction
Repulsion Type	Two iron pieces repel	Better accuracy

Diagram:



Characteristics:

- **Scale**: Non-linear, compressed at lower end
- **Response**: Measures both AC and DC (responds to RMS value)
- **Accuracy**: Lower than PMMC type
- **Power Consumption**: Relatively high

Mnemonic

"AMIR: Attraction Moves Iron with Reluctance"

Explain Humidity Sensor Hygrometer.

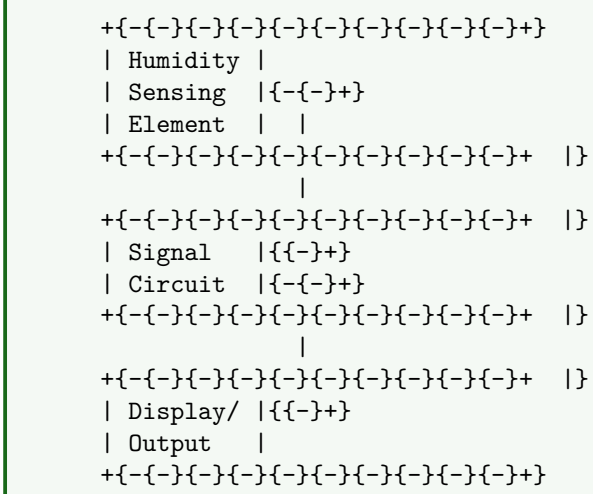
Solution

Humidity sensors measure the amount of water vapor in air or other gases.

Types of Humidity Sensors:

Type	Working Principle	Characteristics
Capacitive	Humidity changes dielectric constant	Wide range, good accuracy
Resistive	Humidity changes resistance	Simple, cost-effective
Thermal	Humidity affects thermal conductivity	Good for high temperatures

Diagram:



Measurements:

- **Relative Humidity (RH)**: Percentage of actual to maximum moisture
- **Dew Point**: Temperature at which condensation occurs
- **Absolute Humidity**: Mass of water vapor per volume

Applications:

- Weather stations
- HVAC systems
- Industrial process control
- Medical equipment

Mnemonic

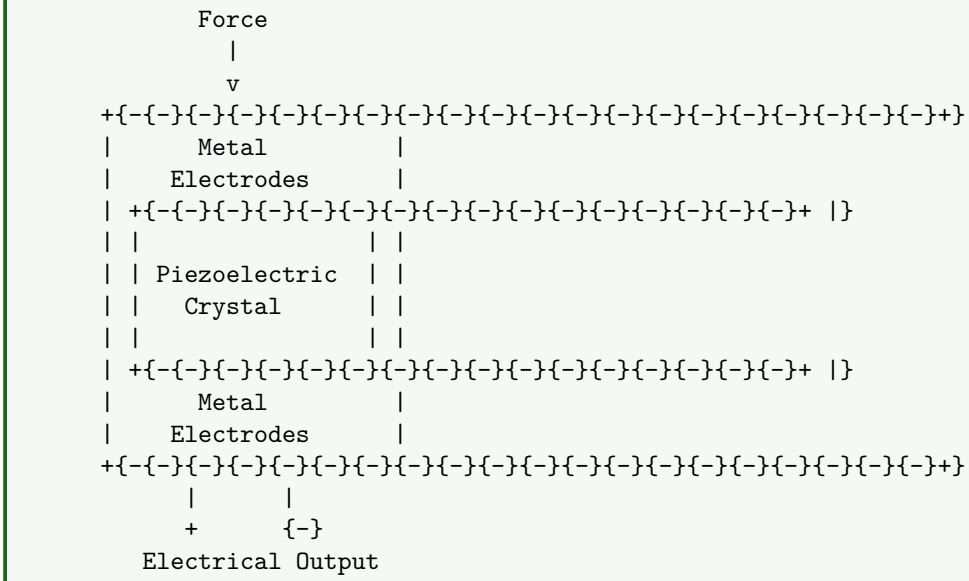
"CRAP-H: Capacitance or Resistance Alters with Presence of Humidity"

Draw and explain Piezoelectric transducer.

Solution

Piezoelectric transducers convert mechanical force to electrical signal and vice versa.

Diagram:



Working Principle:

- **Direct Effect**: Pressure generates electric charge
- **Reverse Effect**: Electric field causes mechanical deformation
- **Materials**: Quartz, PZT, barium titanate, lithium niobate

Characteristics:

- **High Frequency Response**: Up to MHz range

- **High Output Impedance**: Requires charge amplifier
- **Self-Generating**: No external power for sensing
- **Dynamic Response**: Not suitable for static measurements

Applications:

- Accelerometers
- Pressure sensors
- Ultrasonic transducers
- Microphones
- Ignition systems

Mnemonic

"PEMS: Pressure Equals Measurable Signal"