Subject Name Solutions

4331102 – Winter 2023

Semester 1 Study Material

Detailed Solutions and Explanations

Question 1(a) [3 marks]

Give Definition of Accuracy, Reproducibility and Repeatability.

> **Solution**
>
> | Term | Definition |
> |------|------------|
> | **Accuracy** | Closeness of measured value to the true or actual value of the quantity being measured |
> | **Reproducibility** | Ability of an instrument to give identical measurements for the same input when measured under different conditions (different operators, locations, times) |
> | **Repeatability** | Ability of an instrument to give identical measurements for the same input when measured repeatedly under the same conditions |

> **Mnemonic**
>
> "ARR - Accurate Results Repeatedly"

Question 1(b) [4 marks]

Draw and Explain Wheatstone bridge.

> **Solution**
>
> **Diagram:**
>
> **Mermaid Diagram (Code)**
>
> ```
> {Shaded}
> {Highlighting}[]
> graph LR
>     A[Supply+] {-{-}{-} R1}
>     A {-{-}{-} R3}
>     R1 {-{-}{-} B[Output+]}
>     R3 {-{-}{-} C[Output{-}]}
>     B {-{-}{-} R2}
>     C {-{-}{-} R4}
>     R2 {-{-}{-} D[Supply{-}]}
>     R4 {-{-}{-} D}
> {Highlighting}
> {Shaded}
> ```
>
> | Feature | Description |
> |---------|-------------|
> | **Configuration** | Four resistors connected in diamond pattern |
> | **Balance Condition** | R1/R2 = R3/R4 (when output voltage is zero) |
> | **Application** | Precise measurement of unknown resistance |
> | **Operation** | Unknown resistor placed in one arm, remaining resistors adjusted until bridge is balanced |

Question 1(c) [7 marks]

Explain Principle of Q meter. Also draw and explain Practical Q Meter.

Solution

Principle of Q Meter:
The Q-meter operates on the principle of series resonance, where Q factor is measured as the ratio of voltage across the capacitor to the applied voltage at resonance.

Diagram of Practical Q Meter:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[RF Oscillator] {-{-}{} B[Work Coil]}
    B {-{-}{} C[Series Circuit]}
    C {-{-}{} D[Unknown Inductor L]}
    D {-{-}{} E[Variable Capacitor C]}
    E {-{-}{} F[VTVM]}
    F {-{-}{} G[Q{-}Scale]}
{Highlighting}
{Shaded}
```

Component	Function
RF Oscillator	Provides variable frequency signals
Work Coil	Inductively couples signal to test circuit
Resonant Circuit	Test inductor L in series with variable capacitor C
VTVM	Measures voltage across capacitor
Q-Scale	Calibrated to read Q value directly

- **Resonant Formula**: $f = 1/(2\pi\sqrt{LC})$
- **Q Calculation**: $Q = V_c/V_s$ (voltage across capacitor / source voltage)
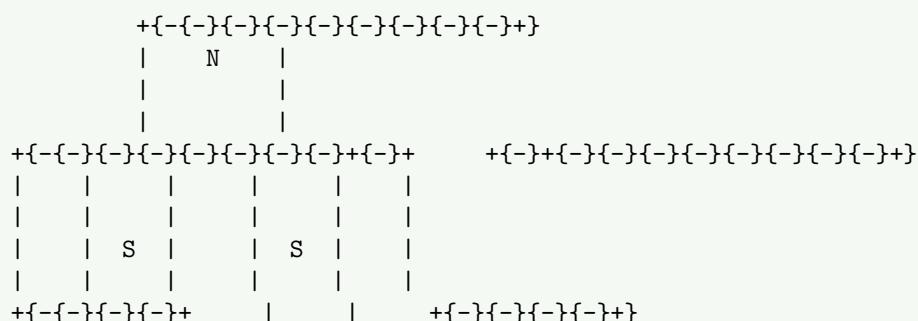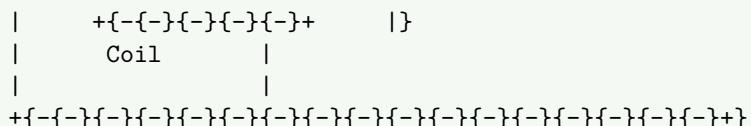
Question 1(c OR) [7 marks]

Draw and explain construction of Moving coil type instruments.

Solution

Diagram:

```
        +{-{-}{-}{-}{-}{-}{-}{-}+}
        |    N    |
        |         |
        |         |
  +{-{-}{-}{-}{-}{-}{-}+{-}+     +{-}+{-}{-}{-}{-}{-}{-}{-}+}
    |    |    |    |    |    |
    |    |    |    |    |    |
    |    | S  |    | S  |    |
    |    |    |    |    |    |
  +{-{-}{-}{-}+     |    |     +{-}{-}{-}{-}+}
```

```
        |     +{-{-}{-}{-}{-}+     |}
        |       Coil         |
        |                    |
     +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
```

Component	Description
Permanent Magnet	Creates strong magnetic field
Moving Coil	Lightweight coil wound on aluminum frame
Springs	Provide controlling torque and electrical connections
Pointer	Attached to coil, moves over calibrated scale
Core	Soft iron cylindrical core to concentrate magnetic flux

- **Operating Principle**: Deflecting torque = BIlN (B-field strength, I-current, l-length, N-turns)
- **Controlling Torque**: Provided by springs proportional to deflection angle

Question 2(a) [3 marks]

List out different Types of errors. Explain any Two.

Solution

Types of Errors
Gross Errors
Systematic Errors
Random Errors
Environmental Errors
Loading Errors

Explanation of Two Errors:
1. **Systematic Errors**:
   - Consistent and predictable deviations from actual value
   - Caused by instrument calibration, design, or method
2. **Random Errors**:
   - Unpredictable variations in measurements
   - Caused by noise, environmental fluctuations, or observer limitations

Question 2(b) [4 marks]

Draw and Explain Maxwell's bridge.

Solution

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Supply] {-{-}{-} R1}
    A {-{-}{-} R3}
```

```
    R1 {-{-}{-} B[Detector]}
    R3 {-{-}{-} C[Detector]}
    B {-{-}{-} R2}
    C {-{-}{-} R4}
    B {-{-}{-} L["Unknown L"]}
    C {-{-}{-} C1["Capacitor C"]}
    R2 {-{-}{-} D[Ground]}
    R4 {-{-}{-} D}
    L {-{-}{-} D}
    C1 {-{-}{-} D}
{Highlighting}
{Shaded}
```

Component	Function
R1, R2, R3, R4	Precision resistors in bridge arms
Unknown L	Inductor with resistance to be measured
Capacitor C	Standard capacitor in opposite arm
Detector	Null detector (galvanometer)

- **Balance Equation**: $L = CR_2R_3$
- **Resistance Equation**: $R_L = R_2R_3/R_4$
- **Application**: Measures inductance with significant resistance
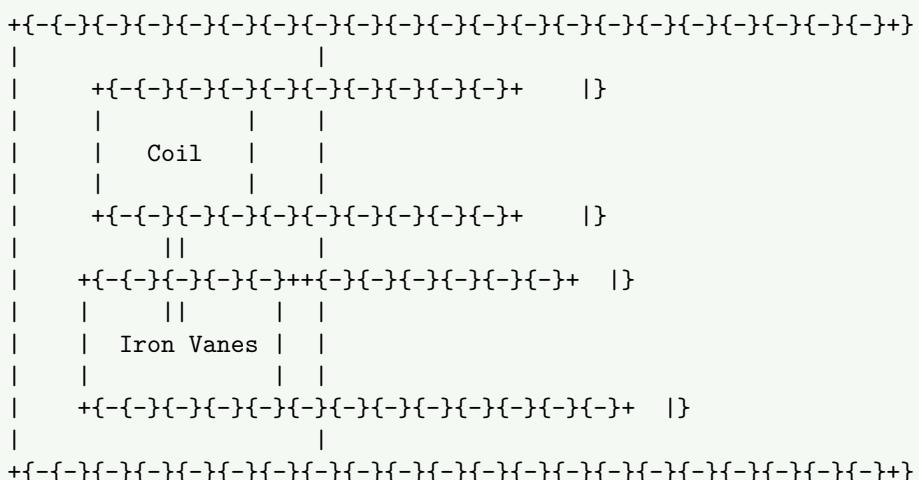
Question 2(c) [7 marks]

Draw and explain construction of moving iron type instruments.

Solution

Diagram:

```
    +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
    |                        |
    |      +{-{-}{-}{-}{-}{-}{-}{-}{-}+     |}
    |      |         |    |
    |      |   Coil   |    |
    |      |         |    |
    |      +{-{-}{-}{-}{-}{-}{-}{-}{-}+     |}
    |           ||         |
    |      +{-{-}{-}{-}++{-}{-}{-}{-}{-}+  |}
    |      |      ||      | |
    |      |   Iron Vanes |  |
    |      |         | |  |
    |      +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+  |}
    |                        |
    +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
```

Component	Description
Coil	Fixed coil that carries measuring current
Iron Vanes	Two soft iron pieces (one fixed, one movable)
Pointer	Attached to movable vane
Control Spring	Provides restraining torque
Damping Mechanism	Air friction damping using light aluminum piston

- **Working Principle**: When current flows through coil, both iron pieces get magnetized with same polarity causing repulsion
- **Advantages**: Suitable for both AC and DC, robust construction
- **Disadvantages**: Non-uniform scale, higher power consumption than PMMC

Mnemonic

"IRAM - Iron Repulsion Activates Movement"

Question 2(a OR) [3 marks]

Explain basic DC voltmeter.

Solution

Diagram:

```
+{-{-}{-}{-}{-}{-}+    +{-}{-}{-}{-}{-}{-}{-}{-}{-}+    +{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
| PMMC  |{-{-}{-}| Series  |{-}{-}{-}| Scale     |}
| Meter |    | Resistor|    | Calibrated|
+{-{-}{-}{-}{-}{-}{-}+    +{-}{-}{-}{-}{-}{-}{-}{-}{-}+    +{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
```

Component	Function
PMMC Movement	Basic current-sensitive movement
Multiplier Resistor	High-value series resistor
Scale	Calibrated to read voltage directly

- **Working Principle**: Voltmeter is PMMC meter with series resistor
- **Calculation**: Rs = (V/Im) - Rm (Rs=series resistor, V=voltage, Im=full scale current, Rm=meter resistance)

Mnemonic

"SVM - Series Voltage Measurement"

Question 2(b OR) [4 marks]

Draw and Explain Schering bridge.

Solution

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[AC Supply] {-{-}{-} C1["Unknown Capacitance"]}
    A {-{-}{-} R3}
    C1 {-{-}{-} B[Detector]}
    R3 {-{-}{-} C[Detector]}
    B {-{-}{-} R1}
    C {-{-}{-} C4["Standard C"]}
    R1 {-{-}{-} D[Ground]}
    C4 {-{-}{-} R4["Variable R"]}
    R4 {-{-}{-} D}
{Highlighting}
{Shaded}
```

Component	Function
C1	Unknown capacitor (with loss)
R1	Resistance representing loss in C1
R3, R4	Precision resistors
C4	Standard loss-free capacitor
Detector	Null indicator

- **Balance Equations**: C1 = C4(R3/R1)
- **Dissipation Factor**: D = C1R1 = C4R4
- **Application**: Measurement of capacitance and dielectric loss

Question 2(c OR) [7 marks]

Write shortnote on Electronic Multimeter.

Solution

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Input] {-{-}{} B[Attenuator/Range Selector]}
    B {-{-}{} C[Signal Converter]}
    C {-{-}{} D[Amplifier]}
    D {-{-}{} E[Rectifier/Detector]}
    E {-{-}{} F[Display]}
{Highlighting}
{Shaded}
```

Feature	Description
Functions	Measures voltage (AC/DC), current (AC/DC), resistance, and other parameters
Sensitivity	Higher sensitivity than analog meters (10MΩ input impedance typical)
Ranges	Multiple selectable measurement ranges
Accuracy	0.1% to 3% depending on quality and parameter
Display	Digital readout or analog pointer

- **Types**: Analog electronic multimeter, Digital multimeter (DMM)
- **Advantages**: High input impedance, minimal loading effect, multiple functions
- **Key Circuit**: Input attenuator, signal converter, amplifier, rectifier, display driver

Question 3(a) [3 marks]

Explain Various probes for CRO.

Type of Probe	Description
Passive Probe (1X)	Direct connection probe with no attenuation
Passive Probe (10X)	Attenuates signal by factor of 10, reduces circuit loading
Active Probe	Contains active components for high impedance, low capacitance
Current Probe	Measures current by sensing magnetic field

- **Selection Criteria**: Bandwidth, loading effect, measurement range
- **Compensation**: 10X probes require compensation adjustment for accurate waveforms

Mnemonic
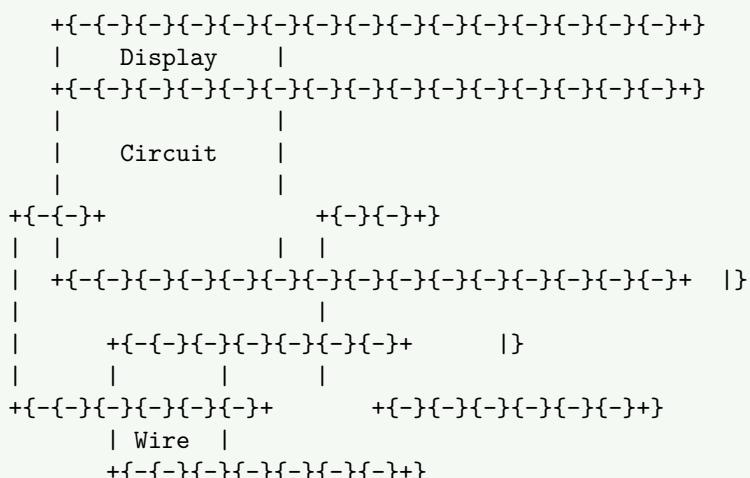
"PAC-S: Probes Allow Circuit Sensing"

Question 3(b) [4 marks]

Draw and explain construction of Clamp on Meter.

Solution

Diagram:

```
    +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
    |    Display    |
    +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
    |               |
    |    Circuit    |
    |               |
  +{-{-}+           +{-}{-}+}
  | |  |            | |
  | +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+  |}
  |              |
  |     +{-{-}{-}{-}{-}{-}{-}+       |}
  |     |     |      |
  +{-{-}{-}{-}{-}{-}{-}+       +{-}{-}{-}{-}{-}{-}+}
        | Wire |
        +{-{-}{-}{-}{-}{-}{-}+}
```

Component	Function
Split Core CT	Ferrite core that clamps around conductor
Coil Winding	Secondary winding that generates induced current
Signal Circuitry	Converts current to measurable signal
Display Unit	Digital/analog display calibrated in amps
Trigger Mechanism	Opens/closes core around conductor

- **Working Principle**: Based on current transformer, measures current without breaking circuit
- **Applications**: Measuring AC current in live conductors safely

Mnemonic

"CAMP - Current Analyzed by Magnetic Principle"

Question 3(c) [7 marks]

Write shortnote on successive approximation type DVM.

> **Solution**
>
> **Block Diagram:**
>
> **Mermaid Diagram (Code)**
>
> ```
> {Shaded}
> {Highlighting}[]
> graph LR
>     A[Input] {-{-}{} B[Sample \& Hold]}
>     B {-{-}{} C[Comparator]}
>     C {-{-}{} D[SAR Logic]}
>     D {-{-}{} E[DAC]}
>     E {-{-}{} C}
>     D {-{-}{} F[Digital Display]}
> {Highlighting}
> {Shaded}
> ```
>
> | Component | Function |
> | --- | --- |
> | **Sample & Hold** | Captures and holds input voltage |
> | **Comparator** | Compares input with DAC output |
> | **Successive Approximation Register** | Controls binary search algorithm |
> | **D/A Converter** | Generates analog voltage for comparison |
> | **Digital Display** | Shows measured value |
>
> - **Working Principle**: Uses binary search algorithm to find digital value matching analog input
> - **Conversion Time**: Fixed regardless of input magnitude (8-16 clock cycles for 8-16 bit)
> - **Advantages**: Medium speed, good resolution, consistent conversion time
> - **Applications**: General purpose measurements where medium speed is sufficient

> **Mnemonic**
>
> "SACD - Sample, Approximate, Compare, Display"

Question 3(a OR) [3 marks]

Explain PH Sensor.

> **Solution**
>
> **Diagram:**
>
> ```
>     +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
>     | Glass Electrode |{-{-}{-}+}
>     +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+    |}
>                         |
>     +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+    |}
>     | Reference       |{-{-}{-}+{-}{-}{-}{-}{-} Output}
>     | Electrode       |    |
>     +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+    |}
>                         |
>     +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+    |}
>     | Temperature     |{-{-}{-}+}
>     | Compensation    |
>     +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
> ```
>
> | Component | Function |
> | --- | --- |
> | **Glass Electrode** | Sensitive to hydrogen ion concentration |
> | **Reference Electrode** | Provides stable reference potential |
> | **Temperature Sensor** | Compensates for temperature effects |

Signal Conditioner	Amplifies and processes the millivolt signal

- **Working Principle**: Generates voltage proportional to hydrogen ion concentration
- **Output**: ~59 mV per pH unit at 25
- **Range**: 0-14 pH scale (acidic to alkaline)

Mnemonic

"PHRV - PH Related to Voltage"

Question 3(b OR) [4 marks]

Draw and explain construction of Electronic Watt Meter.

Solution

Block Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Current Input] {-{-}{} B[Current Transformer]}
    C[Voltage Input] {-{-}{} D[Voltage Transformer]}
    B {-{-}{} E[Multiplier Circuit]}
    D {-{-}{} E}
    E {-{-}{} F[Integrator]}
    F {-{-}{} G[Digital Display]}
{Highlighting}
{Shaded}
```

Component	Function
Current Sensor	Measures load current via CT or shunt
Voltage Sensor	Measures voltage via potential divider
Multiplier	Multiplies instantaneous voltage and current
Integrator	Averages power over time
Display	Digital readout in watts

- **Working Principle**: Power = V $\times I \times cos(cos is power factor)$

- **Advantages**: High accuracy, wide range, digital display
- **Types**: True RMS, average sensing

Mnemonic

"VIMP - Voltage & Intensity Make Power"

Question 3(c OR) [7 marks]

Write shortnote on Integrating type DVM.

Solution

Block Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
```

```
graph LR
    A[Input] {-{-}{} B[Integrator]}
    B {-{-}{} C[Comparator]}
    D[Clock] {-{-}{} E[Counter \& Control]}
    C {-{-}{} E}
    E {-{-}{} F[Digital Display]}
{Highlighting}
{Shaded}
```

Type	Working Principle
Dual-Slope	Integrates input for fixed time, then measures discharge time with reference
Voltage-to-Frequency	Converts voltage to frequency, counts pulses over fixed time
Charge-Balance	Balances input charge with reference charge

Key Features:
- **Noise Rejection**: Excellent rejection of power line noise (50/60Hz)
- **Accuracy**: High accuracy due to time averaging
- **Conversion Speed**: Slower than successive approximation type
- **Resolution**: Typically 4½ to 6½ digits

Applications: Precision measurements, noisy environments, bench instruments

---

Mnemonic

"TINA - Time Integration Nullifies Average"

Question 4(a) [3 marks]

Write advantages and applications of Digital storage oscilloscope.

Solution

Advantages	Applications
Pre-trigger Viewing	Capturing transient events
Signal Storage	Analyzing intermittent faults
Waveform Processing	Complex signal analysis
Higher Bandwidth	High-speed digital circuit testing
Multiple Channel Display	Comparing multiple signals

- **Key Benefits**: Can capture one-time events, store waveforms for later analysis
- **Digital Features**: Automated measurements, FFT analysis, PC connectivity

---

Mnemonic

"SPADE - Storage, Processing, Analysis, Display, Events"

Question 4(b) [4 marks]

Write shortnote on Electronic Energy Meter.

Solution

Block Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Voltage Sensor] {-{-}{} C[Multiplier]}
```

```
    B[Current Sensor] {-{-}{} C}
    C {-{-}{} D[Integrator]}
    D {-{-}{} E[Pulse Generator]}
    E {-{-}{} F[Counter]}
    F {-{-}{} G[Display]}
{Highlighting}
{Shaded}
```

Component	Function
Voltage & Current Sensors	Measure line voltage and load current
Multiplier Circuit	Calculates instantaneous power
Integrator	Converts power to energy over time
Microcontroller	Processes signals and controls display
LCD Display	Shows energy consumption in kWh

- **Working Principle**: Energy = .dt (integral of power over time)
- **Advantages**: No moving parts, high accuracy, tamper detection
- **Features**: Multiple tariff support, bi-directional measurement, remote reading

Mnemonic

"VICES - Voltage & Current Energy Summation"

Question 4(c) [7 marks]

Draw and explain Block diagram of Analog C.R.O. and working of each block in brief.

Solution

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[Cathode Ray Tube] {-{-}{} J[Screen]}
    D {-{-}{} I}
    H {-{-}{} I}
    K[Power Supply] {-{-}{} All}
{Highlighting}
{Shaded}
```

Block	Function
Vertical System	Controls amplitude display (signal attenuation, amplification)
Horizontal System	Controls time base (sweep generation)
Trigger System	Synchronizes horizontal sweep with input signal
CRT	Displays signal (electron gun, deflection plates, phosphor screen)
Power Supply	Provides required voltages to all circuits

- **Vertical System**: Processes input signal, controls Y-axis deflection
- **Horizontal System**: Controls X-axis deflection (time base)
- **Triggering**: Stabilizes waveform display by starting sweep at same point
- **CRT Display**: Converts electrical signals to visible trace
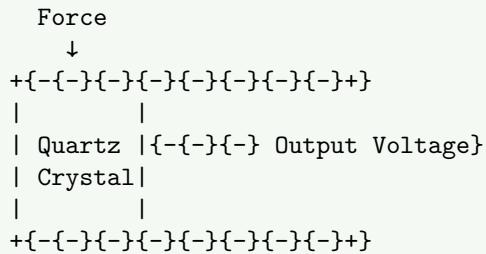
Question 4(a OR) [3 marks]

Draw and explain PIEZO-ELECTRIC transducer.

Solution

Diagram:

```
   Force
     ↓
+{-{-}{-}{-}{-}{-}{-}{-}+}
|        |
| Quartz |{-{-}{-} Output Voltage}
| Crystal|
|        |
+{-{-}{-}{-}{-}{-}{-}{-}+}
```

Property	Description
Principle	Generates electric charge when mechanically stressed
Materials	Quartz, Rochelle salt, PZT ceramics
Operation	Direct effect: force $\rightarrow voltage, Inverse effect: voltage \rightarrow displacement$
Output	High impedance voltage proportional to applied force

- **Applications**: Pressure sensors, accelerometers, ultrasonic devices
- **Advantages**: High sensitivity, fast response, wide frequency range
- **Limitations**: High output impedance, temperature sensitive
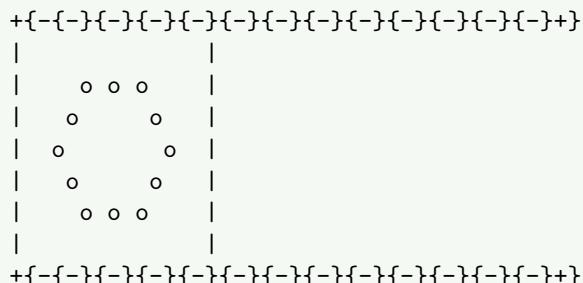
Question 4(b OR) [4 marks]

Draw and explain Measurement of Frequency by using CRO.

Solution

Method 1: Using Lissajous Patterns

```
  +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
  |              |
  |    o o o     |
  |   o     o    |
  |  o       o   |
  |   o     o    |
  |    o o o     |
  |              |
  +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
```

Method 2: Using Time Base

```
+{-{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
|        /{    |}
|       /  {   |}
|      /    {  |}
|     /      {|}
|    /        |
|   /         |
+{-{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
```

Method	Calculation
Lissajous Pattern	Fx = Fy $\times (Nx/Ny)$
Time Measurement	f = 1/T (T is period measured using time base)
XY Mode	Comparing unknown frequency with known reference

- **Time Base Method**: Measure period of waveform, calculate frequency as 1/T
- **Lissajous Method**: Connect reference to X input, unknown to Y input
- **Digital CRO**: Direct frequency readout using internal counter

Question 4(c OR) [7 marks]

Draw and explain Thermistor and Thermocouple.

Solution

Thermistor Diagram:

```
+{-{-}{-}{-}{-}{-}{-}{-}{-}+}
|            |
| Thermistor|{-{-}{-}+}
|            |   |
+{-{-}{-}{-}{-}{-}{-}{-}{-}{-}+   |}
                      |
+{-{-}{-}{-}{-}{-}{-}{-}{-}{-}+     |}
|         |    |
| Resistor |{-{-}{-}{-}+{-}{-}{-}{-} Output}
|         |
+{-{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
```

Thermocouple Diagram:

```
  Metal A
+{-{-}{-}{-}{-}{-}{-}{-}+}
        {}
         +{-{-}{-} Output}
        /
+{-{-}{-}{-}{-}{-}{-}{-}+}
  Metal B
```

Transducer	Principle	Characteristics
Thermistor	Resistance changes with temperature	High sensitivity, non-linear, limited range
Thermocouple	Junction of dissimilar metals generates voltage	Wide range, linear, low sensitivity

Thermistor Types:
- **NTC**: Negative Temperature Coefficient (resistance decreases with temperature)
- **PTC**: Positive Temperature Coefficient (resistance increases with temperature)

Thermocouple Types:
- **Type K**: Chromel-Alumel (-200$^t o$1350$^)$)
- **Type J**: Iron-Constantan (-40$^t o$750$^)$)
- **Type T**: Copper-Constantan (-200$^t o$350$^)$)
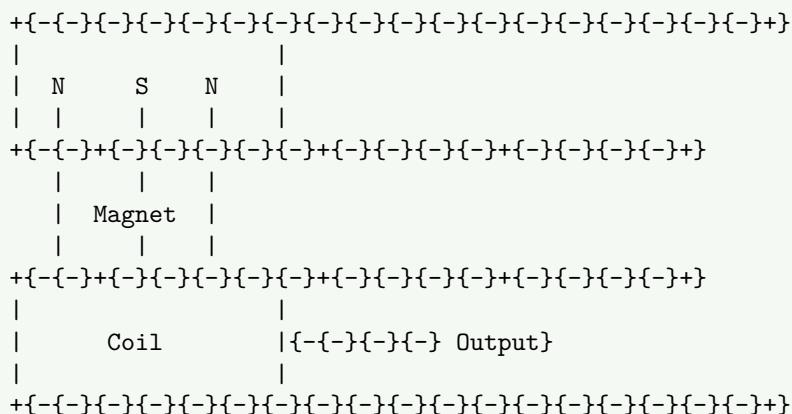
Question 5(a) [3 marks]

Draw and Explain Velocity transducer.

Solution

Diagram:

```
+{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
|                    |
|  N     S    N   |
|  |     |    |   |
+{-{-}+{-}{-}{-}{-}+{-}{-}{-}+{-}{-}{-}{-}+}
    |    |    |
    |  Magnet |
    |    |    |
+{-{-}+{-}{-}{-}{-}+{-}{-}{-}+{-}{-}{-}{-}+}
|                 |
|     Coil        |{-{-}{-}{-} Output}
|                 |
+{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
```

Component	Function
Permanent Magnet	Creates magnetic field
Moving Coil	Generates voltage proportional to velocity
Housing	Supports structure and magnetic circuit
Output Circuit	Conditions signal for measurement

- **Working Principle**: Based on Faraday's law of electromagnetic induction
- **Output**: Voltage proportional to velocity (V = Blv)
- **Applications**: Vibration measurement, seismic monitoring, motion control

Question 5(b) [4 marks]

Give Classification of transducers and explain it.

Classification	Types
By Energy Conversion	Active (self-generating) vs. Passive (requiring external power)
By Measurement Method	Primary vs. Secondary
By Physical Principle	Resistive, Capacitive, Inductive, Photoelectric, etc.
By Application	Temperature, Pressure, Flow, Level, etc.

Explanation:

Type	Examples	Characteristics
Active	Thermocouple, Piezoelectric	Generate output without external power
Passive	RTD, Strain gauge	Require external excitation
Resistive	Thermistor, Potentiometer	Change resistance with input
Capacitive	Pressure sensors, Proximity	Change capacitance with input
Inductive	LVDT, Proximity	Change inductance with input

Mnemonic

"APRCI - Active Passive Resistive Capacitive Inductive"

Question 5(c) [7 marks]

Write shortnote on LVDT.

Solution

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Primary Coil] {-{-}{} B[Core]}
    B {-{-}{} C[Secondary Coil 1]}
    B {-{-}{} D[Secondary Coil 2]}
    E[AC Excitation] {-{-}{} A}
    C {-{-}{} F[Phase Sensitive Detector]}
    D {-{-}{} F}
    F {-{-}{} G[Output]}
{Highlighting}
{Shaded}
```

Component	Function
Primary Coil	Excitation coil connected to AC source
Secondary Coils	Two identical coils connected in series opposition
Ferromagnetic Core	Movable core that varies mutual inductance
Signal Conditioner	Converts differential output to displacement measurement

Working Principle:
- At null position: Equal voltage induced in both secondaries, net output zero
- Core movement: Creates imbalance in secondary voltages
- Output voltage: Proportional to displacement, phase indicates direction

Characteristics:
- **Range**: Typically $\pm 0.5mm$ to $\pm 25cm$
- **Linearity**: Excellent within rated range
- **Resolution**: Virtually infinite (limited by readout circuit)
- **Advantages**: Frictionless, robust, reliable, high resolution

---

Mnemonic

"CPSO: Core Position Shifts Output"

Question 5(a OR) [3 marks]

Draw and Explain block diagram of simple frequency Counter.

Solution

Block Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Input] {-{-}{} B[Input Conditioning]}
    B {-{-}{} C[Gate Control]}
    D[Time Base] {-{-}{} C}
    C {-{-}{} E[Counter]}
    E {-{-}{} F[Display]}
{Highlighting}
{Shaded}
```

Block	Function
Input Conditioning	Amplifies, shapes input signal into pulses
Gate Control	Controls counting period based on time base
Time Base	Provides accurate reference time interval
Counter	Counts input pulses during gate period
Display	Shows count result (frequency)

- **Working Principle**: Counts pulses over precise time interval (typically 1 second)
- **Frequency Calculation**: f = counts/time interval
- **Resolution**: Determined by time base accuracy and gate time

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Mnemonic
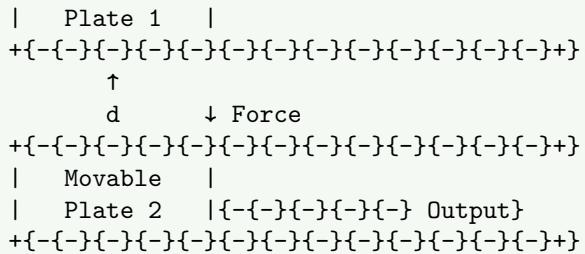
"IGTCD - Input Gated Time Counts Display"

Question 5(b OR) [4 marks]

Draw and Explain Capacitive Transducer.

Solution

Diagram:

```
+{-{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
|     Fixed     |
```

```
    |   Plate 1   |
   +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
         ↑
         d       ↓ Force
   +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
    |   Movable   |
    |   Plate 2   |{-{-}{-}{-}{-} Output}
   +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
```

Configuration	Principle	Application
Variable Gap	$C = \varepsilon_0 A/d$ (varies inversely with distance)	Pressure, displacement
Variable Area	$C = \varepsilon_0 A/d$ (varies directly with overlap area)	Angular position, level
Variable Dielectric	$C = \varepsilon_0 A/d$ (varies with dielectric constant)	Humidity, material analysis

Working Principle:
- Capacitance changes with physical parameter
- Signal conditioning converts capacitance to voltage/current
- High impedance output requires proper shielding

Advantages: High sensitivity, no moving contacts, low mass

Question 5(c OR) [7 marks]

Draw and Explain block diagram of Function generator.

Solution

Block Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Frequency Control] {-{-}{} B[Waveform Generator]}
    C[Mode Selector] {-{-}{} B}
    B {-{-}{} D[Amplifier \& Attenuator]}
    D {-{-}{} E[Output Buffer]}
    E {-{-}{} F[Output]}
    G[Sweep Circuit] {-{-}{} B}
    H[AM/FM Modulator] {-{-}{} D}
{Highlighting}
{Shaded}
```

Block	Function
Frequency Control	Sets oscillator frequency (typically 0.1Hz to 20MHz)
Waveform Generator	Produces basic waveforms (sine, square, triangle)
Mode Selector	Selects output waveform type
Amplifier & Attenuator	Controls output amplitude
Output Buffer	Provides low output impedance
Sweep Circuit	Automatically varies frequency over range
AM/FM Modulator	Modifies signal for modulation functions

Working Principle:
- Generates sine wave using RC oscillator or DDS
- Shape converters transform sine into square and triangle
- Output amplitude controlled by attenuator circuit
- Modern generators use digital synthesis techniques

Applications: Circuit testing, signal injection, filter characterization

Mnemonic

"FWMASO - Frequency Waveform Mode Amplitude Sweep Output"