Electronic Measurements and Instruments (4331102) - Summer 2023 Solution

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પ્રશ્ન 1(a) [3 ગુણ]

Illustrate steps to minimize that all type of systematic error.

> **જવાબ**
>
> Steps to minimize systematic errors:
>
> **કોષ્ટક 1.** Steps to Minimize Systematic Errors
>
> | Step | Description |
> |------|-------------|
> | 1. Calibration | Periodically calibrate instruments against standard references |
> | 2. Correction | Apply correction factors or offset values |
> | 3. Control | Maintain constant environmental conditions (temperature, humidity) |
> | 4. Technique | Use proper measurement techniques and procedures |
> | 5. Equipment | Select appropriate instruments with required accuracy |

> **મેમરી ટ્રીક**
>
> ``CCCTS: Calibrate, Correct, Control, Technique, Select''

પ્રશ્ન 1(b) [4 ગુણ]

Define: Resolution, Precision, Sensitivity and Accuracy.

> **જવાબ**
>
> **કોષ્ટક 2.** Measurement Characteristics Definitions
>
> | Term | Definition |
> |------|-----------|
> | Resolution | The smallest change in input that can be detected by the instrument |
> | Precision | Consistency or repeatability of measurements with minimal random error |
> | Sensitivity | The ratio of change in output to the change in input ($\Delta O/\Delta I$) |
> | Accuracy | Closeness of measured value to the true or accepted standard value |
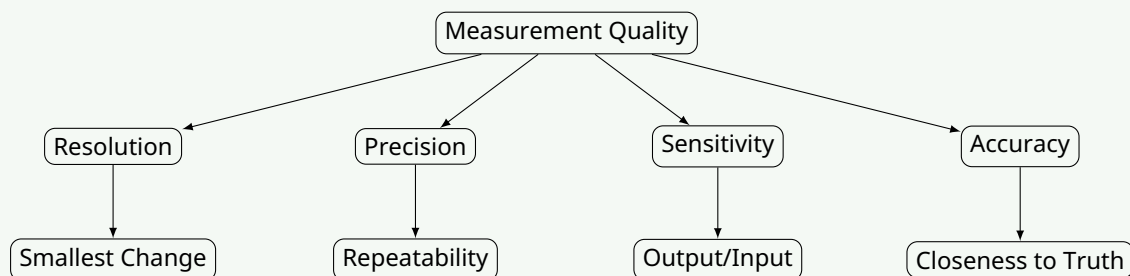
આકૃતિ 1. Measurement Characteristics

મેમરી ટ્રીક

``RSPA: Resolve Signals Precisely and Accurately''

પ્રશ્ન 1(c) [7 ગુણ]

Explain a principle of Q Meter and Working of practical Q Meter.

જવાબ

Principle:
- Based on series resonance where $Q = X_L/R$ or X_C/R at resonance
- Measures voltage magnification at resonance condition

Working of practical Q meter:

કોષ્ટક 3. Components of Practical Q Meter

Component	Function
Oscillator	Generates variable frequency signal (50kHz to 50MHz)
Work coil	Inductor under test (connected in series with calibrated capacitor)
Capacitor	Variable calibrated capacitor for resonance tuning
VTVM	Measures resonant voltage across capacitor
Shunt resistor	Monitors current through the circuit
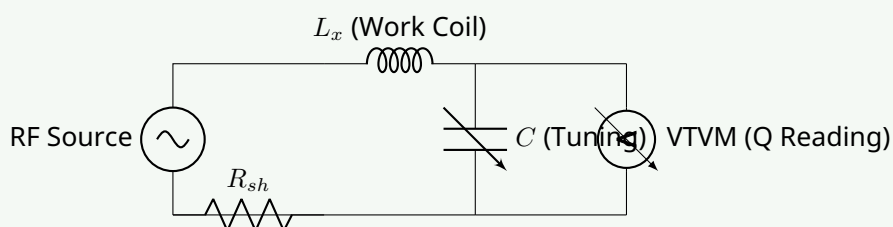
આકૃતિ 2. Practical Q Meter

- **Q factor calculation**: $Q = V_2/V_1$ where V_2 is voltage across capacitor and V_1 is the applied voltage
- **Resonance indication**: Maximum voltage across capacitor indicates resonance
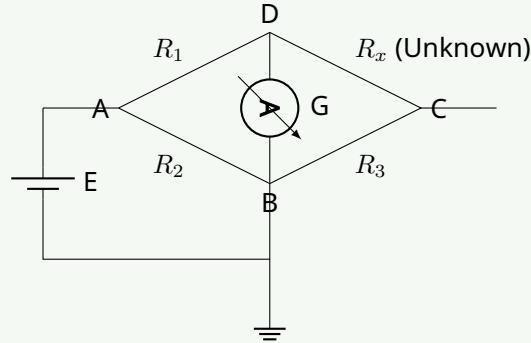
મેમરી ટ્રીક

``VOCAL: Voltage ratio at resonance Oscillator Creates Amplification to measure coiL quality''

પ્રશ્ન 1(c OR) [7 ગુણ]

Explain Wheatstone bridge and derive equation for balanced condition. State application and limitation of Wheatstone bridge.

જવાબ

Wheatstone bridge is a network used to measure unknown resistance with high precision.

આકૃતિ 3. Wheatstone Bridge

Balanced Condition Derivation:
- At balance, no current flows through galvanometer ($I_G = 0$)
- Potential at point D = Potential at point B
- Voltage drop across R_1 = Voltage drop across R_2 ($I_1 R_1 = I_2 R_2$)
- Voltage drop across R_x = Voltage drop across R_3 ($I_1 R_x = I_2 R_3$)

Dividing the equations:

$$\frac{I_1 R_1}{I_1 R_x} = \frac{I_2 R_2}{I_2 R_3} \implies \frac{R_1}{R_x} = \frac{R_2}{R_3} \implies R_x = R_3 \left(\frac{R_1}{R_2} \right)$$

Applications & Limitations:

કોષ્ટક 4. Wheatstone Bridge Applications and Limitations

Application	Limitation
Precision resistance measurement	Poor accuracy for low resistances ($< 1\Omega$)
Transducer interface (Strain gauge, RTD)	Limited by galvanometer sensitivity
Temperature measurement	Contact resistance affects accuracy

મેમરી ટ્રીક

``BEAR: Balance Equation at Arms Ratio''

પ્રશ્ન 2(a) [3 ગુણ]

Differentiate between moving iron and moving coil type instruments.

જવાબ

કોષ્ટક 5. Comparison: Moving Iron vs PMMC Instruments

| Parameter	Moving Iron (MI)	Moving Coil (PMMC)
Principle	Magnetic attraction/repulsion	EM force on conductor
Scale	Non-uniform (crowded at start)	Uniform (linear)
Supply	AC and DC	DC only
Accuracy	Lower ($1 - 2.5\%$)	Higher ($0.1 - 1\%$)
Damping	Air friction	Eddy current
Power	Higher consumption	Lower consumption

મેમરી ટ્રીક

``IRON-COIL: Iron Repulsion Non-uniform; Coil Current Linear''

પ્રશ્ન 2(b) [4 ગુણ]

Draw the construction diagram of clamp on Ammeter and explain in detail.

જવાબ

Construction Diagram:
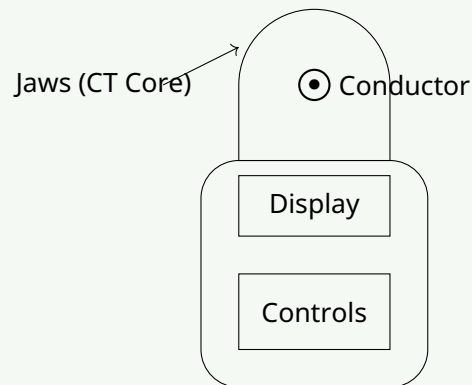
આકૃતિ 4. Clamp-on Ammeter

Working:
- **Transformer Principle**: The current-carrying conductor acts as a single-turn primary winding of a transformer.
- **Core & Secondary**: The clamp jaws form the magnetic core required for flux path. A secondary winding inside the casing picks up the induced current.
- **Measurement**: The induced secondary current is proportional to the primary current, which is processed and displayed.
- **Non-intrusive**: Allows current measurement without breaking the circuit.
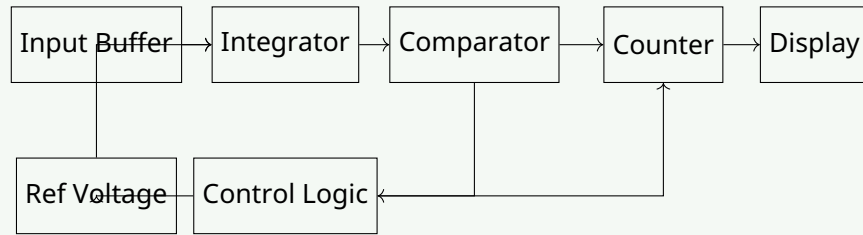
મેમરી ટ્રીક

``CLASP: Conductor-Loop Amperes Sensed by Primary-secondary''

પ્રશ્ન 2(c) [7 ગુણ]

Describe working and advantages of Integrating type DVM with suitable diagram.

જવાબ

Integrating DVM uses dual-slope integration to measure voltage, effectively canceling out noise.
Block Diagram:

આકૃતિ 5. Integrating DVM

Working Principle:
1. **Run-up:** Unknown voltage V_{in} charges the integrator capacitor for a fixed time period T_1.
2. **Run-down:** A reference voltage V_{ref} of opposite polarity discharges the capacitor until it reaches zero. Time taken is T_2.
3. **Measurement:** Since charge up = charge down, $V_{in}T_1 = V_{ref}T_2 \implies V_{in} = V_{ref}\frac{T_2}{T_1}$.

Advantages:
- High noise rejection (esp. mains frequency).
- High accuracy and resolution.
- Good stability and linearity.

મેમરી ટ્રીક

``RISES: Ramp Integration Samples and Eliminates Spikes''

પ્રશ્ન 2(a OR) [3 ગુણ]

Differentiate between Digital Voltmeter over Analog Voltmeter.

જવાબ

કોષ્ટક 6. Comparison: Digital vs Analog Voltmeter

| Parameter	Digital Voltmeter	Analog Voltmeter
Display	Numeric digits (LCD/LED)	Pointer on scale
Parallax Error	None	Possible
Resolution	High (depends on digits)	Limited by scale
Accuracy	High (0.05%)	Lower ($1 - 3$%)
Output	BCD/Digital output available	None

મેમરી ટ્રીક

``DAPPER: Digital Accuracy and Precise readings; Parallax Error Removed''

પ્રશ્ન 2(b OR) [4 ગુણ]

Draw the construction diagram of Moving iron type Meter and explain in detail.

જવાબ

Construction:
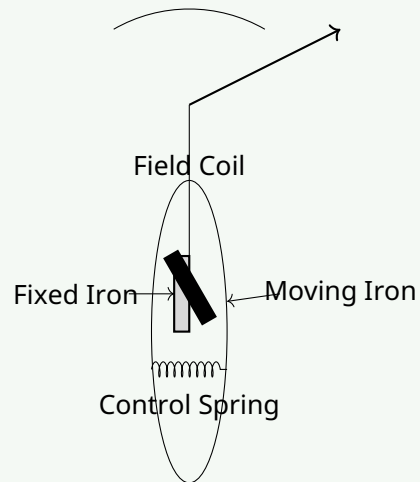
આકૃતિ 6. Repulsion Type MI Instrument

Explanation:
- Consists of a fixed coil carrying current.
- Two soft iron pieces: one fixed to the coil frame, one movable attached to spindle.
- When current flows, both irons are magnetized with same polarity.
- Repulsion occurs, moving the spindle and pointer.
- Control torque provided by spring; damping by air friction piston.

મેમરી ટ્રીક

``MIRROR: Magnetic Interaction Requires Repulsion Of Related irons''
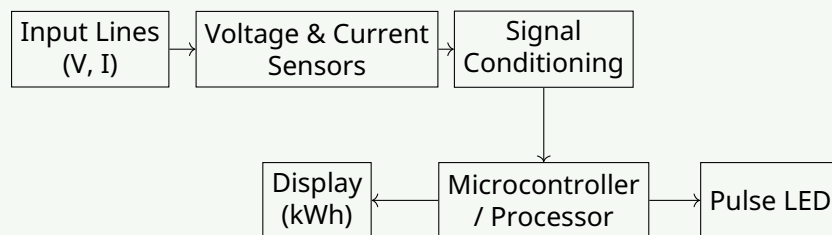

પ્રશ્ન 2(c OR) [7 ગુણ]

Describe construction diagram of Energy meter and explain in detail.

જવાબ

Electronic energy meter measures kWh consumption.
Block Diagram:

આકૃતિ 7. Electronic Energy Meter

Working:
- **Sensing**: Voltage divider and shunt/CT sense voltage and current.
- **Multiplication**: Instantaneous V and I are multiplied to get Power (P).
- **Integration**: Power is integrated over time ($\int P dt$) to get Energy.
- **Display**: Result is stored and shown on LCD in kWh. Pulse LED blinks proportional to consumption.

> **મેમરી ટ્રીક**
>
> ``WATTAGE: Work And Time Tracked As Generated Electrical energy''

પ્રશ્ન 3(a) [3 ગુણ]

Apply Lissajous pattern for frequency measurement and Phase angle measurement.

> **જવાબ**
>
> Lissajous patterns are formed on CRO X-Y mode.
> **Frequency Measurement:**
> - $f_y/f_x = \frac{\text{Tangents on Horizontal}}{\text{Tangents on Vertical}}$
> - Circle/Ellipse = 1:1 ratio.
> - Figure 8 = 2:1 ratio.
>
> **Phase Measurement (1:1 ratio):**
> - Pattern is an ellipse.
> - $\sin\phi = A/B$
> - A: Intercept on Y-axis (center to intersection).
> - B: Max deflection on Y-axis.
> - Circle = $90°$, Line = $0°$ or $180°$.

> **મેમરી ટ્રીક**
>
> ``LIPS: Lissajous Indicates Phase and Signal frequency''

પ્રશ્ન 3(b) [4 ગુણ]
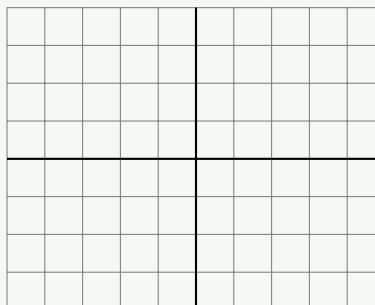
Explain Graticules in CRO also Explain its types.

> **જવાબ**
>
> Graticules are the grid lines on the CRO screen for measurement.
> **Types:**
>
> કોષ્ટક 7. Types of CRO Graticules
>
> | Type | Feature |
> |---|---|
> | **Internal** | Etched inside CRT faceplate. No parallax error. |
> | **External** | Plastic sheet overlay. Cheap, easily changeable, but parallax error exists. |
> | **Electronic** | Generated by electron beam. Very accurate, no parallax. |
>
>
>
> Standard 8x10 div Graticule
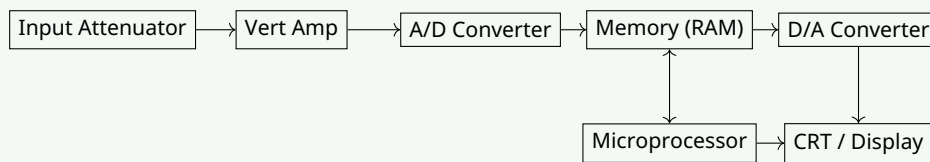

આકૃતિ 8. CRO Graticule

મેમરી ટ્રીક

``GRID: Graticule References for Intensity and Distance"

પ્રશ્ન 3(c) [7 ગુણ]

Describe Construction, Block diagram, working and advantage of Digital storage oscilloscope (DSO).

જવાબ

Block Diagram:

આકૃતિ 9. DSO Block Diagram

Working:
1. Analog signal is sampled and digitized by ADC.
2. Digital data stored in memory (RAM).
3. Microprocessor processes data (measurements, math).
4. Data converted back to analog (DAC) or directly driven to display.

Advantages:
- Storage of waveforms (indefinite time).
- Pre-trigger viewing.
- Capture of single-shot/transient events.
- Direct digital measurements (V, t, f).
- PC connectivity.

મેમરી ટ્રીક

``SAMPLE: Storage And Memory Processes Live Events"

પ્રશ્ન 3(a OR) [3 ગુણ]

Differentiate between CRO and DSO.

જવાબ

કોષ્ટક 8. Comparison: CRO vs DSO

| Feature	CRO (Analog)	DSO (Digital)
Processing	Real-time Analog	Digital sampling
Storage	None (Phosphor persistence)	Digital Memory
Bandwidth	Higher for price	Limited by Sample Rate
Transients	Cannot capture well	Easily captures
Pre-trigger	No	Yes

મેમરી ટ્રીક

``ASPAD: Analog Shows Present; Digital Archives Data"

પ્રશ્ન 3(b OR) [4 ગુણ]

Explain structure of 10:1 Probes in detail.

જવાબ

10:1 probe attenuates signal by factor of 10 to increase input impedance and reduce loading.
Structure:
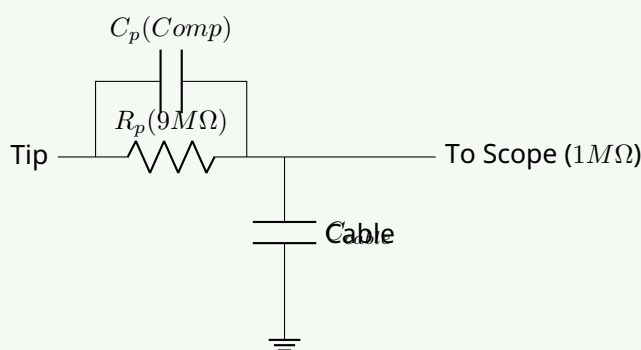
આકૃતિ 10. 10:1 Probe Circuit

Details:
- Contains a 9 MΩ resistor in series with the scope's 1 MΩ input.
- Total resistance = 10 MΩ. Voltage division ratio = 10:1.
- Adjustable capacitor compensates for cable capacitance to ensure flat frequency response.
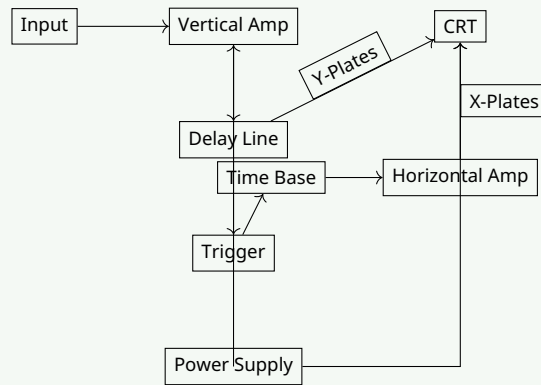
મેમરી ટ્રીક

``TAPER: Ten-to-one Attenuation Preserves and Extends Range"

પ્રશ્ન 3(c OR) [7 ગુણ]

Describe Block diagram, working and application of CRO.

જવાબ

Block Diagram:

આકૃતિ 11. CRO Block Diagram

Working:
- **Vertical System**: Amplifies signal for Y-deflection.
- **Horizontal System**: Generates sawtooth wave (Time Base) for X-sweep.
- **Trigger**: Synchronizes sweep with signal start.
- **CRT**: Displays the trace.

Applications: Voltage, frequency, phase measurement, waveform observation.

મેમરી ટ્રીક

``VIEW: Voltage Inspection and Electrical Waveform observation''

પ્રશ્ન 4(a) [3 ગુણ]

Differentiate RTD and Thermistor.

જવાબ

કોષ્ટક 9. Comparison: RTD vs Thermistor

Parameter	RTD	Thermistor
Material	Pure Metal (Pt, Ni)	Semiconductor
Coeff (α)	Positive (PTC)	Usually Negative (NTC)
Linearity	Linear	Highly Non-linear
Range	Wide ($-200°C$ to $850°C$)	Medium ($-50°C$ to $300°C$)
Sensitivity	Low ($0.4\%/°C$)	High ($4\%/°C$)

મેમરી ટ્રીક

``METAL-SEMI: Metal Linear vs Semi Non-linear''

પ્રશ્ન 4(b) [4 ગુણ]

Give and explain two example of primary and Secondary transducer.

> **જવાબ**
>
> **કોષ્ટક 10.** Primary vs Secondary Transducers
>
> | Primary Transducer | Secondary Transducer |
> |---|---|
> | **Thermocouple**: Converts temp directly to voltage. | **LVDT**: Converts displacement to voltage (requires excitation). |
> | **Piezoelectric**: Converts force directly to charge. | **Strain Gauge**: Resistance changes with strain (needs bridge to read voltage). |
>
> **Explanation:**
> - **Primary**: Direct conversion from physical to electrical quantity.
> - **Secondary**: Requires an intermediate stage or external power to produce electrical signal.

> **મેમરી ટ્રીક**
>
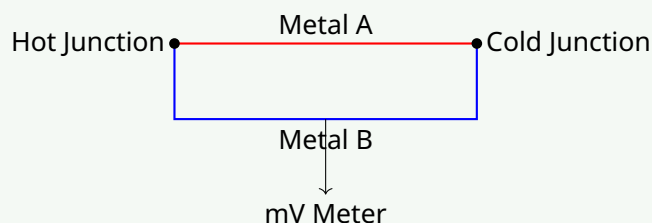> ``PIDS: Primary Is Direct; Secondary is Stepwise''

પ્રશ્ન 4(c) [7 ગુણ]

Describe Thermocouple with working principle, types and application.

> **જવાબ**
>
> **Principle (Seebeck Effect):** When two dissimilar metals are joined at two junctions kept at different temperatures, an EMF is generated proportional to the temperature difference.
> **Construction:**
>
>
>
> **આકૃતિ 12.** Thermocouple
>
> **Types:**
> - **Type J**: Iron-Constantan (-40 to $750°$C)
> - **Type K**: Chromel-Alumel (-200 to $1350°$C) - Most common.
> - **Type T**: Copper-Constantan (Low temp).
> - **Type R/S**: Platinum-Rhodium (High temp/Precision).
> **Applications:** Furnaces, Gas turbines, Engines, Industrial temp monitoring.

> **મેમરી ટ્રીક**
>
> ``STEVE: Seebeck Thermoelectric Effect Verifies Elevated temperatures''
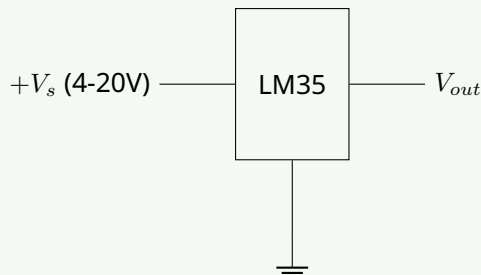
પ્રશ્ન 4(a OR) [3 ગુણ]

Demonstrate working and principle Semiconductor Temperature Sensor LM35.

જવાબ

Principle: Integrated circuit sensor where output voltage is linearly proportional to Centigrade temperature (10 mV/°C).

Features:
- Calibrated directly in Celsius.
- Linear +10.0 mV/°C scale factor.
- Range: $-55°$ to $+150°$C.

$+V_s$ (4-20V) —— LM35 —— V_{out}

આકૃતિ 13. LM35 Connection

મેમરી ટ્રીક

``LOTUS: Linear Output Temperature Units from Semiconductor"
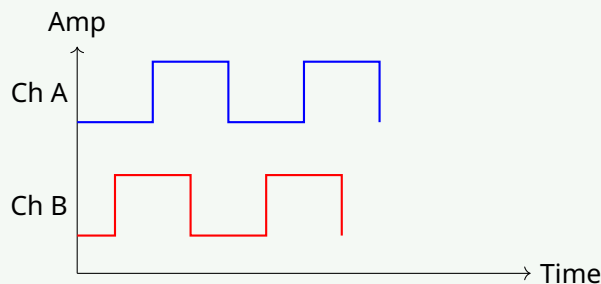
પ્રશ્ન 4(b OR) [4 ગુણ]

Describe incremental type of Optical encoder with it's output waveform.

જવાબ

Optical encoder measures position/speed using light pulses.

Construction:
- Rotating disk with slots.
- LED source and Photodetector.
- As disk rotates, beam is interrupted, generating pulses.

Output Waveform:

Amp

Ch A

Ch B

Time

આકૃતિ 14. Quadrature Output

Offset allows direction detection.

મેમરી ટ્રીક

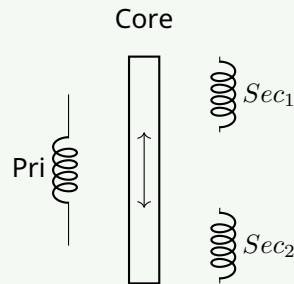``PADS: Pulses from A and Determine Speed"

પ્રશ્ન 4(c OR) [7 ગુણ]

Describe construction, operation of LVDT with advantages, disadvantages and application.

જવાબ

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

આફૃતિ 15. LVDT Schematic

Operation: AC applied to Primary. Core position varies flux linkage to Secondaries (S_1, S_2). Output $V_{out} = V_{s1} - V_{s2}$. Null at center.
Pros: Frictionless, infinite resolution, robust.
Cons: AC required, temp sensitive.
App: Displacement, pressure measurement.
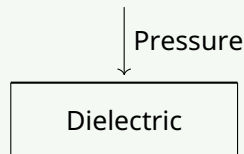

મેમરી ટ્રીક

``MOVE-AC: Magnetic Output Varies with Exact Armature Core''

પ્રશ્ન 5(a) [3 ગુણ]

Describe working of Pressure measurement using Capacitive transducer.

જવાબ

Principle: Pressure deforms a diaphragm, changing the distance (d) between capacitor plates, thus changing capacitance ($C \propto 1/d$).

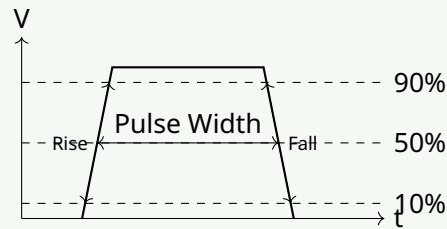

આફૃતિ 16. Capacitive Pressure Sensor

મેમરી ટ્રીક

``CAPS: Capacitance Alters as Pressure Shifts''

પ્રશ્ન 5(b) [4 ગુણ]

Define rise time, fall time, Pulse width and duty cycle.

આકૃતિ 17. Pulse Characteristics

- **Rise Time**: 10% to 90% of max.
- **Fall Time**: 90% to 10% of max.
- **Pulse Width**: Width at 50%.
- **Duty Cycle**: (Pulse Width / Total Period) $\times 100$%.
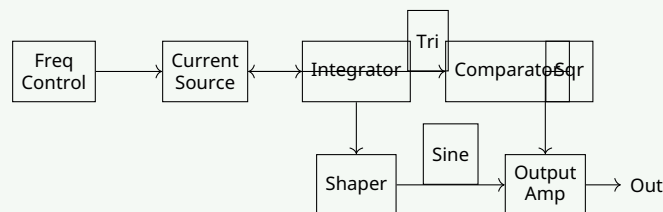
મેમરી ટ્રીક

``RPFD: Rise Pulses, Fall Determines''

પ્રશ્ન 5(c) [7 ગુણ]

Discuss Function generator block diagram.

જવાબ

Produces Sine, Square, Triangle waves.
Block Diagram:

આકૃતિ 18. Function Generator

Working:
- Integrator + Comparator loop generates Triangle and Square.
- Sine shaper (diode network) converts Triangle to Sine.
- Output amplifier adjusts Amplitude and Offset.

મેમરી ટ્રીક

``FASTEST: Frequency Amplitude Shaping Together Ensures Signal Types''

પ્રશ્ન 5(a OR) [3 ગુણ]

Discuss Working, construction of strain gauge.

જવાબ

Construction: Fine wire grid on backing material. **Working:**
- Bonded to test object.
- Deformation changes length (l) and area (A), changing resistance $R = \rho l / A$.
- $\Delta R / R = G \times \epsilon$ (G = Gauge Factor, ϵ = Strain).

મેમરી ટ્રીક

``SERB: Strain Effects Resistance by Bonding''
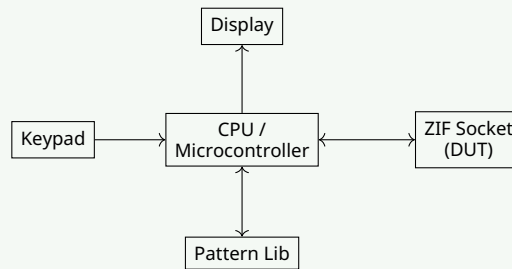
પ્રશ્ન 5(b OR) [4 ગુણ]

Describe working of Digital IC tester with suitable diagrams.

જવાબ

Tests logic gates/ICs by applying truth table inputs and complying outputs.
Block Diagram:

આકૃતિ 19. IC Tester

Working:
1. Select IC number.
2. CPU fetches test patterns from library.
3. Applies inputs to DUT pins.
4. Reads outputs and compares with expected.
5. Displays Pass/Fail.

મેમરી ટ્રીક

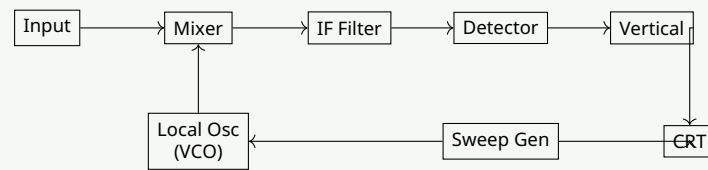``PIPE: Pattern Input, Pin Examination''

પ્રશ્ન 5(c OR) [7 ગુણ]

Discuss working of Spectrum Analyzer with suitable diagrams.

જવાબ

Displays Amplitude vs Frequency.
Block Diagram (Swept Superheterodyne):

```
Input  →  Mixer  →  IF Filter  →  Detector  →  Vertical

           ↑                                      |
           |                                      ↓
       Local Osc  ←      Sweep Gen      ←        CRT
        (VCO)
```

આકૃતિ 20. Spectrum Analyzer

Working:

- Sweep generator ramps LO frequency and drives X-axis.
- Mixer shifts input frequencies to IF.
- IF filter selects current frequency component.
- Detector recovers amplitude (Y-axis).

મેમરી ટ્રીક

``SHAFT: Sweep, Heterodyne, Analyze Frequency and Time''