Electronic Measurements & Instruments (4331102) - Winter 2024 Solution

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Question 1(a) [3 marks]

Define following term: (1) Accuracy (2) Resolution (3) Error

Solution

Table 1. Definitions

Term	Definition
Accuracy	The closeness of a measurement to the true value
Resolution	The smallest change in input that can be detected by an instrument
Error	The difference between measured value and true value

Mnemonic

"ARE precise: Accuracy shows Reality, Error shows deviation, Resolution shows detail."

Question 1(b) [4 marks]

Explain construction of unbounded strain gauge transducer with necessary diagram in detail. Also list application of it.

Solution

An unbounded strain gauge consists of a fine wire wound in a grid pattern attached to a backing material.

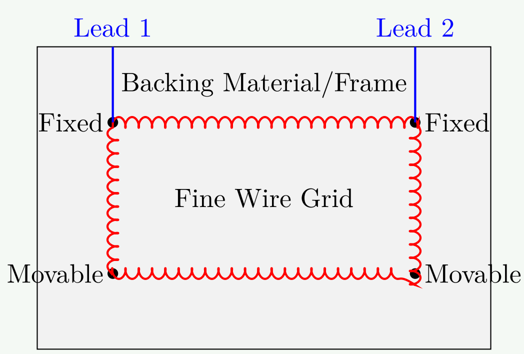

Figure 1. Unbounded Strain Gauge

- **Construction elements**: Fine resistance wire is looped back and forth on an insulating base material
- **Working principle**: Changes resistance when subjected to strain
- **Applications**: Weight measurement, pressure sensors, force sensors, structural health monitoring

Mnemonic

"WIRE Flexes: Wire grids Indicate Resistance changes from External stress."

Question 1(c) [7 marks]

Explain working of Schering Bridge with circuit diagram for balance condition. List its advantages, disadvantages and applications.

Solution

Schering Bridge is an AC bridge used to measure unknown capacitance and its dissipation factor.

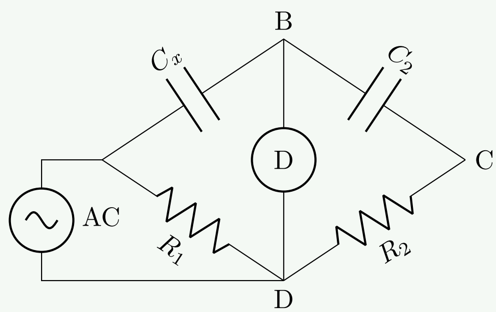

Figure 2. Schering Bridge

Balance condition:

Table 2. Balance Condition

Equation	Description
$C_x = C_2(R_2/R_1)$	For capacitance calculation
$D_x = R_2(C_2/C_x)$	For dissipation factor

Advantages:
- High accuracy
- Direct reading of capacitance
- Wide measurement range

Disadvantages:
- Requires careful shielding
- Frequency dependent errors
- Complex to balance

Applications:
- Capacitor testing
- Insulation testing
- Dielectric material evaluation

Mnemonic

"SCUBA dive: Schering Calculates Unknown capacitance By Advanced circuit Designs In Various Equipment."

Question 1(c) OR [7 marks]

Explain working of Maxwell's bridge with circuit diagram for balance condition. List its advantages, disadvantages, and applications.

Solution

Maxwell's bridge is used to measure unknown inductance in terms of known capacitance.

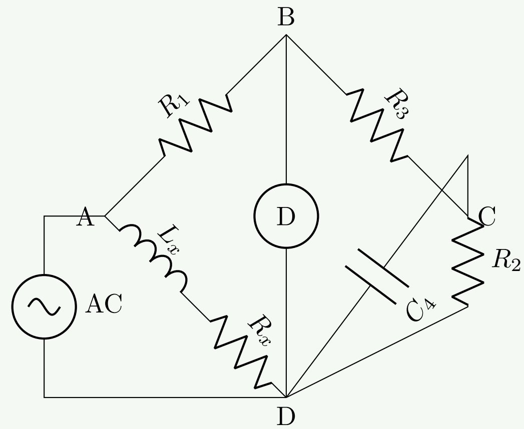

Figure 3. Maxwell's Bridge

Balance condition:

Table 3. Balance Condition

Equation	**Description**
$L_x = C_4 \cdot R_2 \cdot R_3$	For inductance calculation
$R_x = R_1 \cdot (R_3/R_2)$	For resistance calculation

Advantages:
- Independent of frequency
- High accuracy for medium Q coils
- Easy to balance

Disadvantages:
- Not suitable for low Q coils
- Requires standard capacitor
- Limited range

Applications:
- Measuring inductors
- Audio frequency measurements
- Transformer testing

Mnemonic

"MAGIC bridge: Maxwell Analyses Great Inductors by Comparing bridge Elements."

Question 2(a) [3 marks]

Explain working of electronic multimeter with necessary diagram.

Solution

Electronic multimeter converts various electrical parameters into proportional DC voltage for measurement.

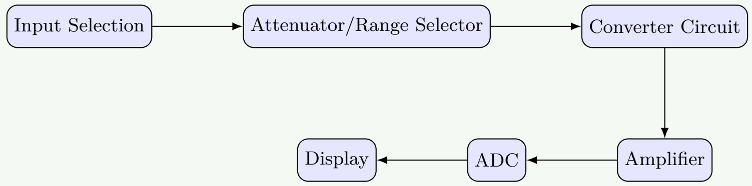

Figure 4. Electronic Multimeter Block Diagram

- **Circuit elements**: Input selector → Attenuator → Converter → Amplifier → ADC → Display
- **Measurement types**: DC voltage, AC voltage, Current, Resistance
- **Power source**: Battery powered for portability and safety

Mnemonic

"SACRED device: Signal Attenuated, Converted And Rectified for Electronic Display."

Question 2(b) [4 marks]

Differentiate between Digital Voltmeter over Analog Voltmeter.

Solution

Table 4. Differentiation

Parameter	**Digital Voltmeter**	**Analog Voltmeter**
Display type	Numeric LCD/LED display	Moving pointer on scale
Accuracy	Higher ($\pm 0.1\%$ typical)	Lower ($\pm 2-5\%$ typical)
Reading errors	No parallax error	Prone to parallax error
Resolution	Higher (can display 3-6 digits)	Limited by scale divisions
Input impedance	Very high ($> 10M\Omega$)	Lower ($20-200k\Omega/V$)
Response time	Slower sampling rate	Instant response

Mnemonic

"PARIOS: Parallax-free, Accurate, Resolution high, Impedance high, Observation digital, Sampling rate."

Question 2(c) [7 marks]

Describe construction diagram of Energy meter and explain in detail.

Solution

Energy meter measures electrical energy consumption over time in kilowatt-hours (kWh).

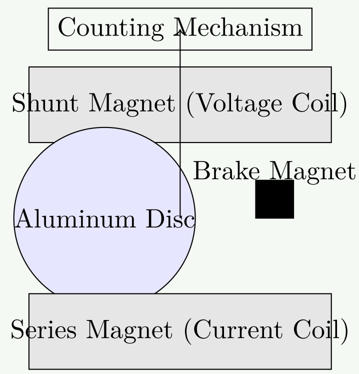

Figure 5. Energy Meter Construction

Components:

- **Voltage coil**: Creates flux proportional to voltage
- **Current coil**: Creates flux proportional to current
- **Aluminum disc**: Rotates due to eddy currents
- **Counting mechanism**: Registers disc rotations
- **Permanent magnet**: Acts as brake to control disc speed
- **Adjustment systems**: For calibration and accuracy

Working principle: Disc rotation speed is proportional to power consumption ($V \times I \times \cos\Phi$)

Mnemonic

"VADCR meter: Voltage And current Drive Counter through Rotations."

Question 2(a) OR [3 marks]

Explain working of clamp on Ammeter with necessary diagram.

Solution

Clamp-on ammeter measures current without breaking the circuit by using electromagnetic induction.

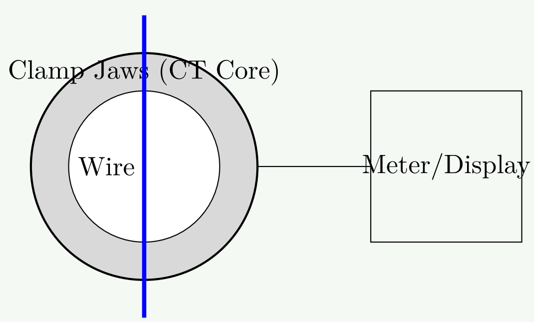

Figure 6. Clamp-on Ammeter

- **Construction**: Split ferrite core with sensing coil
- **Working principle**: Current-carrying wire creates magnetic field → induces voltage in sensing coil
- **Advantages**: Non-contact measurement, quick, safe

Mnemonic

"CICS: Clamping Induces Current Signal."

Question 2(b) OR [4 marks]

Differentiate between PMMC type Meter over Moving iron type Meter.

Solution

Table 5. PMMC vs Moving Iron

Parameter	PMMC Type Meter	Moving Iron Type Meter
Operating principle	Magnetic field interaction	Magnetic attraction/repulsion
Current type	DC only	Both AC and DC
Scale	Uniform	Non-uniform (crowded at ends)
Accuracy	Higher ($\pm0.5\%$ typical)	Lower ($\pm1-5\%$ typical)
Damping	Eddy current damping	Air friction damping
Power consumption	Low	High
Frequency errors	Not applicable	Affected by frequency changes

Mnemonic

"PMMC is DAUPHIN: DC only, Accurate, Uniform scale, Power efficient, High sensitivity, Independent of frequency, Needs polarity."

Question 2(c) OR [7 marks]

Draw the block diagram and Explain working of Integrating type DVM with necessary diagram and waveform.

Solution

Integrating type DVM converts input voltage to time through integration for high accuracy measurements.

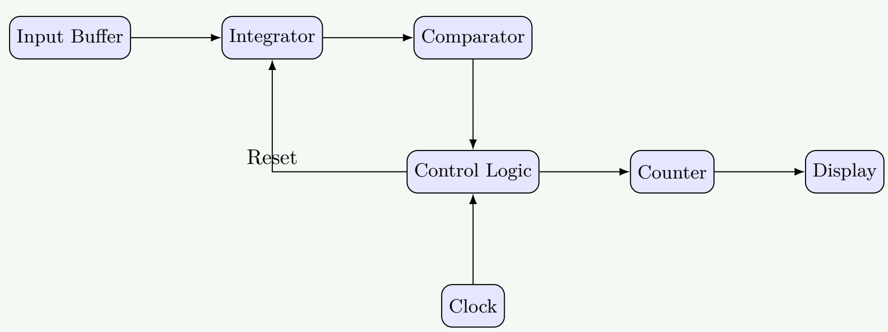

Figure 7. Integrating DVM Block Diagram

Working principle:
- Input voltage is integrated for fixed time period
- Integrator output ramps up proportionally to input
- Reference voltage with opposite polarity discharges integrator
- Time taken for discharge is measured by counting clock pulses
- Count is proportional to input voltage

Waveforms:

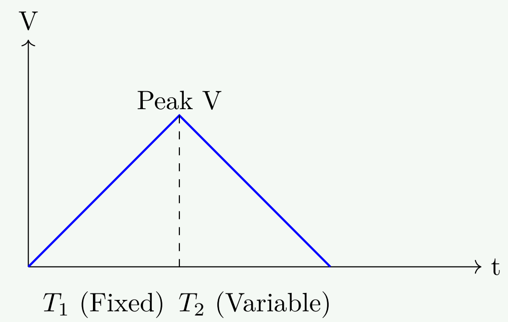

Figure 8. Integration Waveform

Mnemonic

"DIRT meter: Direct Integration Relates Time to measure voltage."

Question 3(a) [3 marks]

Differentiate between CRO over DSO.

Solution

Table 6. CRO vs DSO

Parameter	CRO (Analog Oscilloscope)	DSO (Digital Storage Oscilloscope)
Signal processing	Analog throughout	Digital after ADC conversion
Storage capability	Cannot store waveforms	Can store multiple waveforms
Bandwidth	Typically lower	Higher (can exceed GHz)
Triggering	Basic trigger options	Advanced trigger capabilities
Analysis features	Limited	Extensive (FFT, measurements)
Display persistence	Phosphor persistence	Adjustable digital persistence

Mnemonic

"PASSED: Processing-Analog/digital, Storage-none/yes, Signal-raw/processed, Easy-basic/advanced, Display-phosphor/digital."

Question 3(b) [4 marks]

Explain CRO Screen.

Solution

CRO screen displays electrical signals and consists of several important elements.

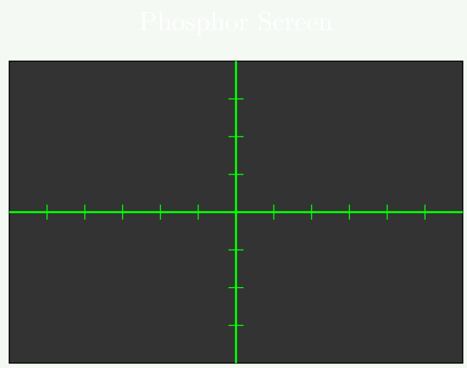

Figure 9. CRO Screen Graticule

Components:
- **Phosphor coating**: Emits light when struck by electrons
- **Graticule**: Grid lines for measurement reference
- **Scales**: Calibrated markings for voltage/time
- **Center reference point**: (0,0) coordinate
- **Intensity control**: Adjusts brightness of display

Mnemonic

"PGSCR: Phosphor Glows when Struck, Creating Representation."

Question 3(c) [7 marks]

Explain Block diagram, working and advantage of CRO with necessary diagram.

Solution

CRO (Cathode Ray Oscilloscope) visualizes electrical signals as waveforms.

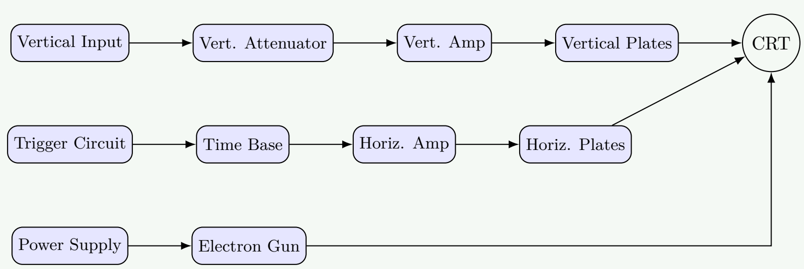

Figure 10. CRO Block Diagram

Working principle:
- **Electron gun**: Generates electron beam
- **Vertical system**: Controls Y-axis deflection proportional to input signal
- **Horizontal system**: Sweeps beam across screen at constant rate
- **Trigger circuit**: Synchronizes horizontal sweep with input signal
- **CRT**: Displays electron beam movement on phosphor screen

Advantages:
- Real-time signal display
- Wide bandwidth
- High input impedance
- Versatile triggering options
- Multiple signal analysis

Mnemonic

"EARTH view: Electron beam Amplification Reveals Time-based Horizontal view."

Question 3(a) OR [3 marks]

Apply Lissajous pattern for frequency measurement and Phase angle measurement.

Solution

Lissajous patterns are created when two sine waves are applied to X and Y inputs of CRO.

Table 7. Lissajous Measurements

Pattern Type	Measurement Formula
Frequency Measurement	$f_x/f_y = n_y/n_x$ (Tangent ratio)
Phase Angle Measurement	$\sin(\phi) = A/B$ (Intercept/Max Height)

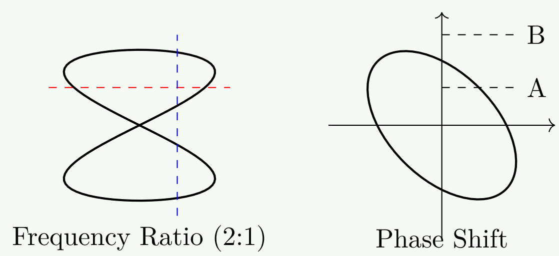

Figure 11. Lissajous Patterns

- **Frequency ratio**: Count vertical tangent points / horizontal tangent points
- **Phase measurement**: $\sin(\phi) = A/B$ where A is pattern height at zero crossing, B is max height
- **Applications**: Signal comparison, frequency calibration

Mnemonic

"LIPS patterns: Lissajous Indicates Phase and Sine frequency."

Question 3(b) OR [4 marks]

Explain Graticules in CRO. Also Explain its types.

Solution

Graticules are reference grids on a CRO screen that help in measurement of waveform parameters.

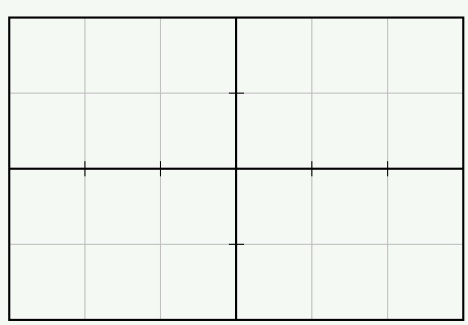

Figure 12. CRO Graticule

Types of graticules:

Table 8. Graticule Types

Type	Description	Application
Internal graticule	Etched on inside of CRT	Eliminates parallax error
External graticule	Separate transparent plate	Easy replacement
Electronic graticule	Generated electronically	Digital oscilloscopes
Special purpose	Custom markings for specific measurements	Specialized testing

Mnemonic

"GRIT: Graticules Render Important Time-voltage measurements."

Question 3(c) OR [7 marks]

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

Solution

Digital Storage Oscilloscope (DSO) digitizes signals for storage, processing, and display.

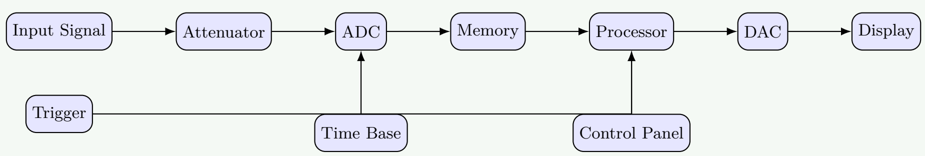

Figure 13. DSO Block Diagram

Working principle:
- **Acquisition**: Signal is sampled at high rate by ADC
- **Storage**: Digital values stored in memory
- **Processing**: Digital signal processing enhances analysis
- **Display**: Reconstructed signal shown on screen
- **Triggering**: Advanced digital triggering options

Advantages:
- Signal storage capability
- Pre-trigger viewing
- One-shot signal capture
- Advanced measurements
- Deep memory for long captures
- Digital filtering and analysis
- Network connectivity

Mnemonic

"SAMPLE: Storage And Memory Preserves Long-term Events."

Question 4(a) [3 marks]

Differentiate RTD and Thermistor.

Solution

Table 9. RTD vs Thermistor

Parameter	RTD (Resistance Temperature Detector)	Thermistor
Material	Platinum, Nickel, Copper	Metal oxides, semiconductors
R-T relation	Linear, positive coefficient	Non-linear, usually negative coefficient
Temperature range	-200°C to +850°C	-50°C to +300°C
Sensitivity	Lower (0.00385 Ω/Ω/°C typical)	Higher (3-5% per °C typical)
Accuracy	Higher	Lower
Response time	Slower	Faster

Mnemonic

"RTD is PLAINS: Platinum, Linear, Accurate, Industrial range, Narrow sensitivity, Stable."

Question 4(b) [4 marks]

Explain Optical encoder with its output waveform.

Solution

Optical encoder converts mechanical motion to digital pulses using light interruption through a coded disc.

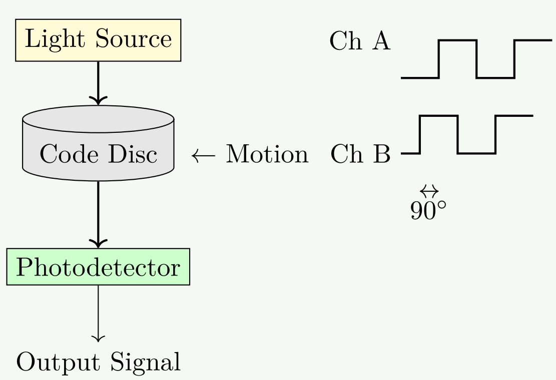

Figure 14. Optical Encoder Waveforms

- **Components**: Light source, coded disc, photodetector
- **Types**: Incremental (pulses) or absolute (unique position code)
- **Applications**: Position measurement, speed detection, motion control

Mnemonic

"DROPS: Disc Rotation Outputs Pulse Signals."

Question 4(c) [7 marks]

Describe Thermocouple with working principle, types and application.

Solution

Thermocouple is a temperature sensor that operates on the Seebeck effect, generating voltage proportional to temperature difference.

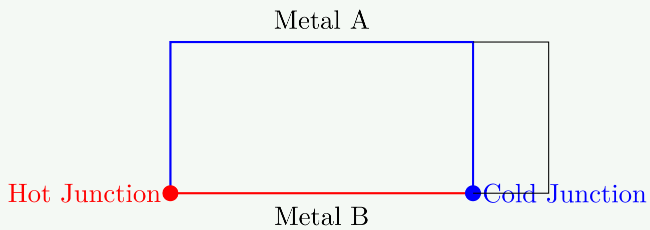

Figure 15. Thermocouple Principle

Working principle:

- Two dissimilar metals joined at one end (hot junction)
- Temperature difference between hot and cold junctions generates voltage
- Voltage is proportional to temperature difference (Seebeck effect)

Types of thermocouples:

Table 10. Thermocouple Types

Type	Materials	Temp Range	Application
K	Chromel-Alumel	-200°C to +1350°C	General purpose
J	Iron-Constantan	-40°C to +750°C	Reducing atmosphere
E	Chromel-Constantan	-200°C to +900°C	Cryogenic, high output
T	Copper-Constantan	-250°C to +350°C	Low temp, food
R/S	Platinum-Rhodium	0°C to +1700°C	High temp, lab

Applications: Industrial furnaces, engines, chemical processing, food processing, research.

Mnemonic

"SHOVE theory: Seebeck Hot-cold Output Voltage Equals Temperature."

Question 4(a) OR [3 marks]

Differentiate active and passive transducers.

Solution

Table 11. Active vs Passive Transducers

Parameter	Active Transducers	Passive Transducers
Energy conversion	Convert physical quantity directly to electrical output	Require external power source
Output signal	Self-generating	Modulate external energy
Examples	Thermocouple, Piezoelectric, Photovoltaic	RTD, Strain gauge, LVDT
Sensitivity	Generally lower	Generally higher
Power requirement	No external power needed	External power required

Mnemonic

"SIMPLE difference: Self-powered Is Main Principle of Leading Energy transducers."

Question 4(b) OR [4 marks]

Explain Capacitive Transducer with necessary diagram in detail. Also list application of it.

Solution

Capacitive transducer works on the principle of change in capacitance due to physical displacement.

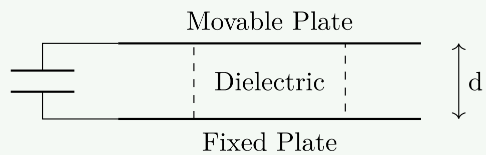

Figure 16. Capacitive Transducer

Working principle:

- Capacitance $C = \epsilon_0 \epsilon_r A/d$
- Varies with change in: area (A), distance (d), or dielectric constant (ϵ_r)
- Displacement changes the capacitance

Applications: Pressure measurement, Liquid level sensing, Humidity sensors, Accelerometers.

Mnemonic

"CADAP: Capacitance Alters with Distance, Area, or Permittivity."

Question 4(c) OR [7 marks]

Explain LVDT Transducer operation, construction with necessary diagram in detail. Also list advantage, disadvantage and application of LVDT.

Solution

LVDT (Linear Variable Differential Transformer) converts linear displacement into electrical output.

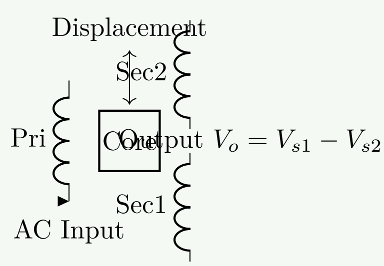

Figure 17. LVDT

Construction: Primary coil in center, two secondary coils, movable ferromagnetic core.

Operation:

- AC excitation energizes primary coil
- Core position determines magnetic coupling to secondaries
- Differential voltage output proportional to displacement

Advantages: Non-contact, Infinite resolution, High linearity, Robust.
Disadvantages: Requires AC, Bulky, Magnetic sensitivity.
Applications: Precision measurement, Hydraulic systems, Aircraft controls.

Mnemonic

"CDPOS sensor: Core Displacement Produces Output Signal."

Question 5(a) [3 marks]

Demonstrate working and principle of Semiconductor Temperature Sensor LM35.

Solution

LM35 is an IC temperature sensor that outputs voltage linearly proportional to temperature in Celsius.

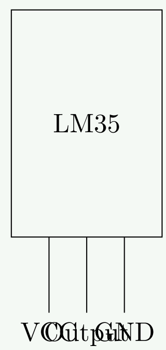

Figure 18. LM35 Pinout

Working principle:

- Integrated circuit with built-in temperature-sensing element
- Linear output voltage: $+10mV/°C$
- Calibrated directly in Celsius
- Operating range: -55°C to +150°C

Mnemonic

"TEN mV TRICK: Temperature Escalation Noted in milliVolts: Ten Rise Indicates Celsius Kelvin."

Question 5(b) [4 marks]

Describe working of Harmonic distortion analyzer with necessary diagram.

Solution

Harmonic distortion analyzer measures harmonic content to determine signal quality.

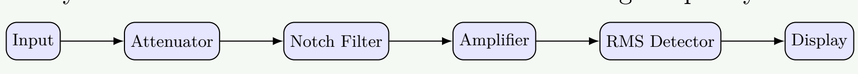

Figure 19. Harmonic Distortion Analyzer

Working principle:

- Fundamental frequency filters out using notch filter
- Remaining harmonics are measured
- THD = (VRMS of harmonics)/(VRMS of fundamental)

Mnemonic

"FRONT analysis: Filter Removes Original Note Totally for Analyzing Leftover Signals."

Question 5(c) [7 marks]

Describe working of Spectrum Analyzer with necessary diagram in detail.

Solution

Spectrum Analyzer displays signal amplitude versus frequency.

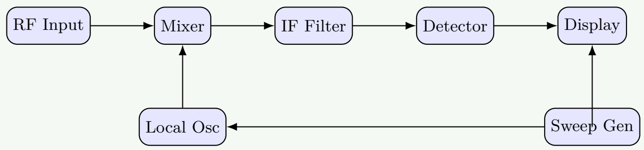

Figure 20. Spectrum Analyzer

Working principle:

- **Superheterodyne**: Input mixed with LO
- **Sweep**: LO swept across range
- **Display**: Shows frequency domain spectrum

Applications: Signal analysis, EMI testing, Harmonic analysis.

Mnemonic

"SAFER view: Sweep Analyzes Frequencies for Examining RF."

Question 5(a) OR [3 marks]

Explain analog transducer and digital transducer. Also explain primary transducer and secondary transducer.

Solution

Table 12. Transducer Types

Type	**Description**
Analog	Produces continuous output signal proportional to input
Digital	Produces discrete/binary output signal
Primary	Directly converts physical quantity into electrical/mechanical signal
Secondary	Converts output of primary transducer into another form

Mnemonic

"PADS: Primary And Digital/analog Secondary."

Question 5(b) OR [4 marks]

Explain working of Digital IC tester with necessary diagram in detail.

Solution

Digital IC tester verifies functionality of integrated circuits.

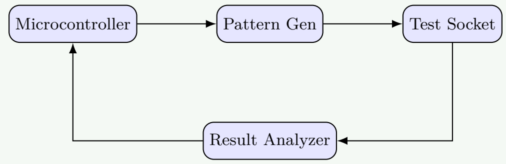

Figure 21. Digital IC Tester

Working principle:

- Applies test patterns to IC in socket
- Compares output with expected results
- Indicates Pass/Fail

Mnemonic

"TRIG test: Test, Run patterns, Identify faults, Generate report."

Question 5(c) OR [7 marks]

Explain working of function generator with necessary diagram in detail.

Solution

Function generator produces various waveforms for testing.

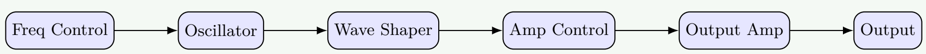

Figure 22. Function Generator

Waveforms: Sine, Square, Triangle, Ramp.
Applications: Testing amplifiers, Reference signals, Educational demos.

Mnemonic

"SWATOR: Sine Wave And Triangle OSCillator Renders signals."