

Introduction to Measurement and Instrumentation

Comprehensive Course on Measurement and Instrumentation

Ankit Goyal • Lesson 1 • May 26, 2021

Electrical and Electronic Measurement

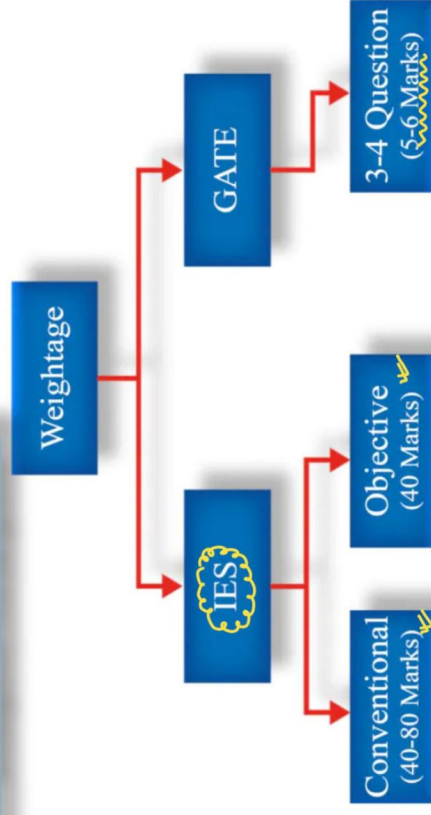
Contents

- 1 Error Analysis *↔ Basic*
- 2 Electromechanical Measuring Instruments
- 3 Measuring of R, L and C *↔ bridges*
- 4 CRO and Digital Meters
- 5 Transducer, Miscellaneous

↔ most important



Subject Analysis



Strategy

- Each day : 1.5 hr class
- May-26 to July-10
- Daily assignment
- Every 4th session: doubt clearing *↔ discuss assignment*
- Study 2 subjects in parallel to measurement
 - ↳ one technical + 1 math/appti
- Solve GATE/ESE PYQ + assignment
- You can make handwritten notes or use pdf.

Schedule

- 2 sessions: Error analysis
- 16 sessions: Electromechanical Instruments
- 4 sessions: AC Bridges
- 4 sessions: resistance
- 2 " : miscellaneous
- 4 sessions: CRO + digital inst-
- 2 " : Φ meter + Inst T/F
- 6 session: Instrumentation

Common Queries

- 1 You can make handwritten notes along the session.
- 2 EE-GATE, EE-ESE, EC-ESE, IN-GATE
- 3 for all exams even JE/AE level
- 4 separate PYS special class or buy a PYS book
- 5 solve only assignment, Quiz & PYS
- 6 Quiz every Sunday at same time
- 7 post measurement we'll start m/c then ps & pe
- 8 Schedule of other subject will be shared from June.

- Telegram link: t.me/gateair1
- In every batch all subjects will come successively
- follow one batch: entire syllabus will be completed
- follow individual teachers: live + recorded
ankit: n/w + analog
Vishal: CS + signal
- every Sat: ask me anything (special class)

Error Analysis

Objective

- Understand the basic of measurement and instrumentation.
- Define Static Characteristic of a Measurement System.
- Perform Error Analysis for the measurement of a quality. (Tomm)



Temperature measurement



Speed measurement



Voltage measurement

Introduction

What is measurement?

It is an act of comparison of an unknown quantity & a known quantity or standard.

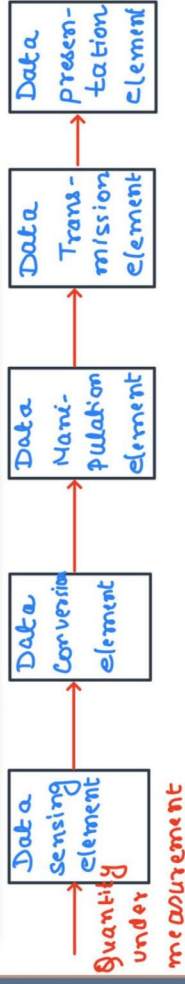
What is an instrument?

Instrument is a device that is used in measurement of a quantity.

Scale: length voltmeter: voltage etc.

ammeters: current

Elements of Generalized Measurement System



Primary Sensing Element (PSE)

This element is in direct contact with quantity under measurement.

eg: Transducer

if we wish to measure temp, then hot body is brought in contact with Thermocouple & that generates voltage \propto temperature.

Data Conversion Element (DCE)

Most of the instruments in this day are digital but data recorded by primary sensing element is analog so we need to convert that data to digital by DCE. eg: ADC/DAC

Data Manipulation Element (DME)

It can modify the signal to a more suitable form that can easily be measured
eg: Amplify the small signal generated by thermocouple

Data Transmission Element (DTE)

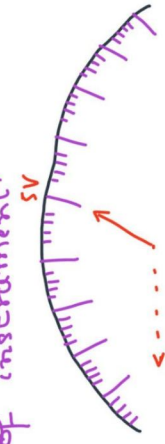
- Sensors may be collecting data at remote location but our processing center may not be located directly near to sensor.
- So, we need to transmit data from sensor to processing center via optical fiber.

Data Presentation Element (DPE)

- To present data in user friendly form
eg CRO

Calibration

- The process of markings on scale of an instrument is called as calibration of instrument.
- For calibrating any instrument we need a more standard instrument.



- eg: potentiometer is used to calibrate voltmeter & ammeter.

Static Characteristics of Measuring System

- Characteristics of a measuring system when quantity under measurement remains constant with time.

Accuracy and Precision

Accuracy ◦ degree of closeness of measured value to the actual value of a quantity.
Actual value is also called as true value.

Precision ◦ degree of closeness of individual readings to each other regardless of true value of a quantity.

Suppose Niket & Khushiram conduct an experiment to measure current in wire.

True value: 5A

| Niket | Khushiram |
|--------|-----------|
| 5.0A | 5A |
| 10.01A | 5.1A |
| 10.02A | 5.2A |
| 9.99A | 4.9A |
| 9.98A | 4.8A |

0.01A → more accurate
b'coz readings are closer to actual value

↓
Niket is more precise

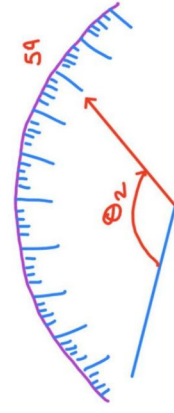
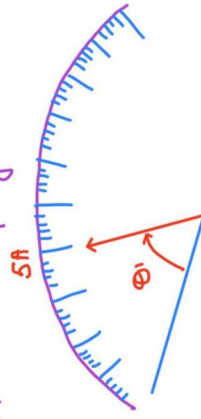
Sensitivity

ratio of change in output to change in input is called sensitivity.

$$S = \frac{\Delta o/p}{\Delta i/p}$$

eg: for instruments with pointer if deflection of pointer is more for same input then instrument is more sensitive.

Suppose we apply 5A to 2 instruments



Both meters tell same reading i.e. 5A so both are equally accurate.

But deflection of 2nd > deflection of 1st
So second is more sensitive

Resolution

change in input
a min value of Δ that can be measured by instrument is called resolution.

eg: the scale that we use to measure length has a resolution of 1mm



difference b/w 2 successive markings
= resolution

Threshold

- Minimum input below which an instrument does not give any deflection is called as threshold.
- Threshold must be as low as possible.

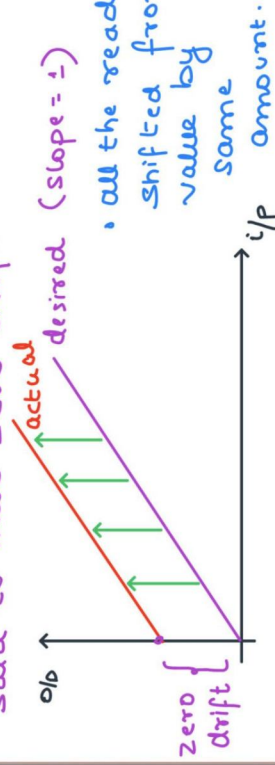
Drift

What is Drift?

- Variation of measured value from true value of a quantity is called as drift.
- No drift means zero error.
- drift must be as low as possible.

Zero Drift

◦ when we apply zero input but instrument gives non-zero o/p or reading then reading is said to have zero drift.



Span Drift or Sensitivity Drift

◦ $S = \frac{\Delta o/p}{\Delta i/p}$ → drift in entire span of instrument

- Sensitivity is slope of o/p vs i/p curve
- So if sensitivity changes then slope changes so reading changes.



Zonal Drift

◦ drift in certain region of i/p but not at all values of input.

eg: if there is drift when measuring values b/w 2A & 3A for an instrument that can read from 0 to 5A then it is called Zonal drift.

Span: 0 to 5A

Reproducibility

Repeatability

Dead Zone and Dead Time

Question-01

The smallest change in a measured variable in which an instrument will respond to

- (a) Resolution
- (b) Precision
- (c) Sensitivity
- (d) Accuracy

Question-02

The minimum input required to activate an instrument to produce an output is called:

- (a) Accuracy
- (b) Creep
- (c) Threshold
- (d) Resolution

Question-03

The sensitivity of an instrument is-

- (a) The smallest increment in the input that can be detected with certainty
- (b) The largest input change to which the instrument fails to respond
- (c) Ratio of the change in the magnitude of the output to the corresponding change in the magnitude of the input
- (d) Closeness of the output values for repeated application of a constant input

Question-04

Accuracy is defined as-

- (a) The measure of consistency of the readings
- (b) Closeness with which an instruments reading approaches the true value of the quantity being measured
- (c) The smallest measurable input change
- (d) The ratio of the input to output

Question-05

The desirable static characteristics of a measuring system are

- (a) Accuracy
- (b) Sensitivity
- (c) Reproducibility \leftrightarrow study tomm
- ~~(d)~~ All of the above

Question-06

The largest change in the measured variable which produces no instrument response is known as

- (a) threshold
- (b) Dynamic error
- ~~(c)~~ Dead zone \leftrightarrow study tomm
- (d) None of these

Question-07

In measurement systems, which of the following are undesirable static characteristics?

- (a) Sensitivity and accuracy
- (b) Drift, static error and dead zone
- (c) Reproducibility and non-linearity
- ~~(d)~~ Drift, static error, dead zone and non-linearity.

Question-08

Match List-I with List-II and select the correct answer:

List-I

P. Precision

Q. Accuracy

R. Resolution

S. Static sensitivity

List-II

1. The smallest change in the input quantity which can be detected with its certainty

2. Closeness of the reading with its true value.

3. Measure of reproducibility of the measurements

4. Ratio of infinitesimal change sensitivity in output to infinitesimal change in input

Codes:

| | A | B | C | D |
|----------------|---|---|---|---|
| (a) | 2 | 3 | 1 | 4 |
| (b) | 3 | 2 | 4 | 1 |
| (c) | 3 | 2 | 1 | 4 |
| (d) | 2 | 3 | 4 | 1 |

Question-09

The largest change in the measured variable which produces no instrument response is called:

- (a) Dead band
- (b) Dynamic error
- (c) Fidelity
- (d) threshold

Question-10

What is the meaning of accuracy?

- (a) Dispersion of measurements
- (b) Closeness of output to the true value
- (c) Change in output for every change in input
- (d) Degree of freedom from random errors

Answer Keys

1. A
2. C
3. C
4. B
5. D
6. C
7. D
8. C
9. A
10. B

Student's Assignment

Question -01

Static errors are caused due to

- (a) Measuring devices
- (b) Human error
- (c) Environmental error
- (d) Observational error