

Lecture 01: Introduction to Measurement & Error Analysis

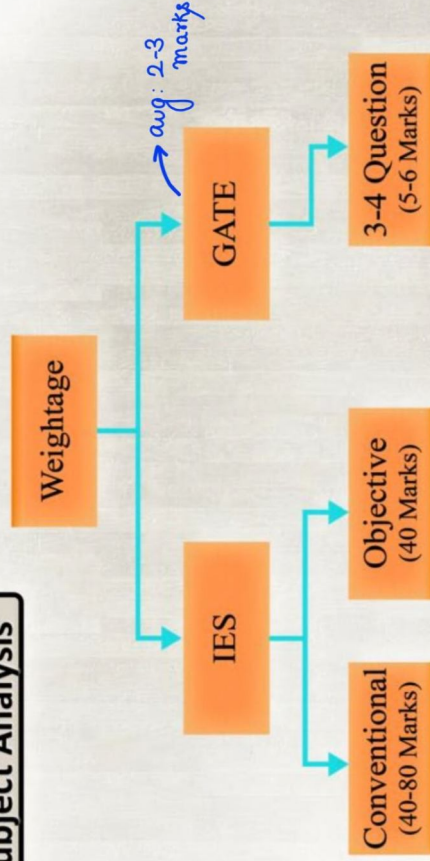
Electrical and Electronic Measurement

Contents

- 1 Error Analysis
- 2 Electromechanical Measuring Instruments
- 3 Measuring of R, L and C
- 4 CRO and Digital Meters
- 5 Instrument Transformers
- 6 Potentiometers



Subject Analysis



Weightage in Recent Years

YEAR	1 Mark	2 Mark	Total
2018	1	1	3
2019	0	2	4
2020	0	2	4
2021	1	0	1
2022	0	1	2
2023	0	1	2
2024	1	1	3

Chapter wise Weightage in Recent Years

Chapter	2024	2023	2022	2021	2020	2019	2018	Average
Error Analysis	0	0	0	0	2	0	0	0.29
Indicating Instruments	0	0	0	0	0	2	2	0.57
Measurement of Power & Energy	2	2	0	0	0	2	1	1
DC and AC Bridges	0	0	2	1	0	0	0	0.43
Potentiometer & Instrument Transformer	1	0	0	0	0	0	0	0.14
CRO	0	0	0	0	4	0	0	0.57
Digital Voltmeter	0	0	0	0	0	0	0	0
Q Meter	0	0	0	0	0	0	0	0
TOTAL	3	2	2	1	4	4	3	2.71

Chapter wise Weightage by IIT Roorkee

Chapter	2009	2017 Set 1	2017 Set 2
Error Analysis	1	1	1
Measuring Instruments	3	2	0
AC and DC Bridges	0	0	3
CRO and Digital Instruments	3	1	0
Potentiometer	0	0	0
Instrument Transformer	0	0	0
Total	7	4	4

Syllabus

Electrical & Electronic Measurement

Bridges and Potentiometers

Measurement of Voltage

Current, Power, Energy and Power Factor

Instrument Transformers

Digital Voltmeters and Multimeters

Phase, Time and Frequency Measurement

Oscilloscopes, Error Analysis

Introduction

- The measurement means, to monitor a process or operation and using an instrument, express the parameter quality or variable in terms of meaningful numbers.
- Measurement is essentially an act of comparison between the quantity and a predefined standard.
- Instrument is a device for determining value of an unknown quantity or variable.

Elements of Generalized Measurement System



Primary Sensing Element (PSE)

- In direct contact with Quantity under measurement.
- Gives an electrical signal proportional to quantity being measured.
eg: Transducer.

Data Conversion Element (DCE)

- Converts data from one form to another form preserving the information.
- Usually needed in case of digital instruments eg. ADC

Data Manipulation Element (DME)

- Consists of signal conditioning equipment.
- Used for converting data to a form readable by data presentation elements.
eg: amplifier, filter etc.

Data Transmission Element (DTE)

- Used in remote measurement.
- Data is collected remotely and analysed at one location.
eg: optical fibre.

Data Presentation Element (DPE)

- Presents meaningful parameters in the data collected.
eg: CRO (Cathode Ray Oscilloscope)

Calibration

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- Process of making readings on scale or display of instrument.
- Done by comparing reading of an instrument against a standard instrument.
eg: ammeters and voltmeter are calibrated using potentiometer.

Linear Scale: Markings are equally spaced ← preferable

Non-linear scale: Markings are congested or wide spread at different point on scale.



Static Characteristics of Measuring System

- Characteristics of a measuring system when quantity under measurement is static i.e. it does not vary with time.
- If quantity varies with time then characteristic measured are called as Dynamic Characteristics.

Accuracy and Precision

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- Accuracy is degree of closeness or conformity in which measured value approaches true value of a quantity under measurement.
- Precision is degree of closeness with which readings are produced again and again for same value of input quantity.
- Both accuracy and precision should be as high as possible.

True value = 5V

Rahul	Parth
4.8V	3.09V
4.9V	3.1V
5.0V	3.12V
5.1V	3.08V
5.2V	3.07V
Accurate but less precise	Precise but not accurate

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Sensitivity

Sensitivity represents by what degree does the output of an instrument change upon changing the input to the instrument.

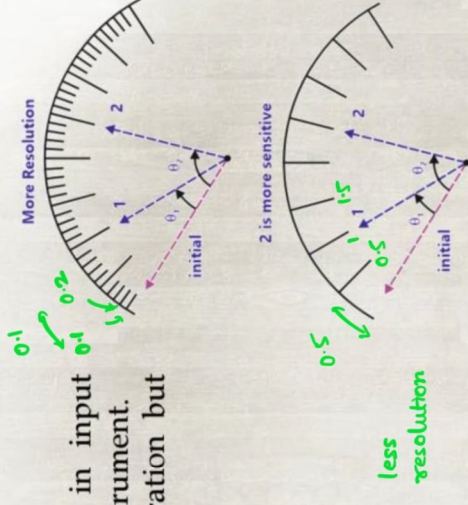
Sensitivity, $S = \frac{\Delta o / p}{\Delta i / p}$ *generally deflection of pointer*

S should be as high as possible.

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Resolution

- Defined as smallest change in input which can be sensed by an instrument.
- Resolution depends on calibration but sensitivity does not.



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Threshold

- Minimum input required for instrument to respond i.e. pointer of instrument does not rotate for any input less than threshold value.
- Threshold should be as low as possible.

Drift

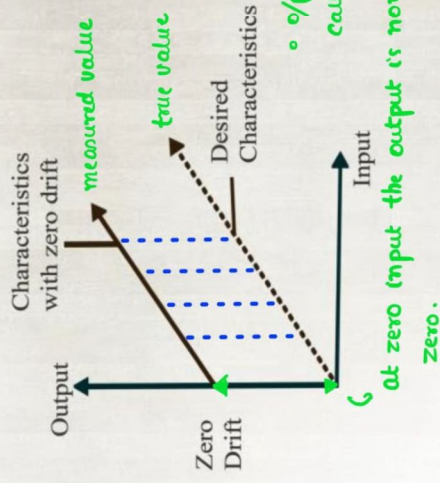
- Variation in o/p of an instrument from true value is called as Drift.
- Perfect reproducibility means no drift.

what is
Drift?

Zero Drift

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- When instrument gives non zero output even at zero input then intercept of characteristic is called as zero drift.
- Actual value = measured value - zero drift.



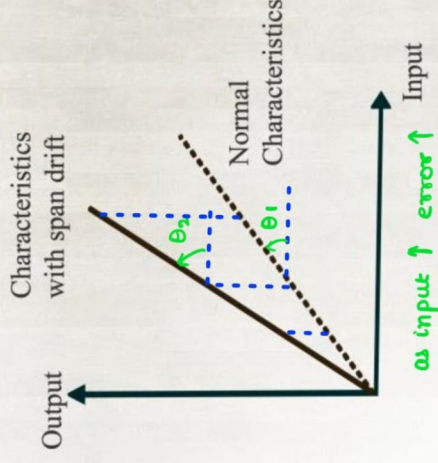
o/p at zero input is called zero drift or zero error.

Span Drift or Sensitivity Drift

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

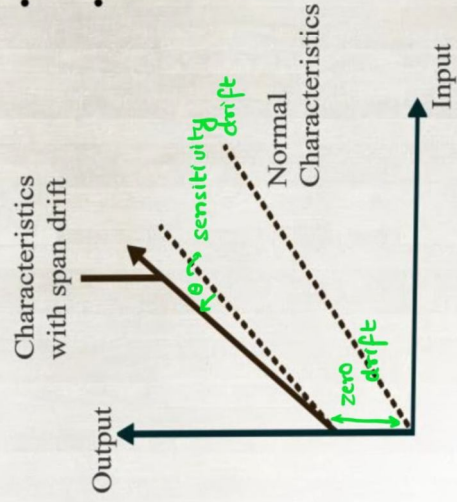
- Slope of characteristic.
- If S of an instrument changes then slope of characteristic change and we get different variation at different i/p .



Zonal Drift

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- Combination of zero drift and span drift.
- i.e. slope as well as intercept of characteristic changes.



Reproducibility

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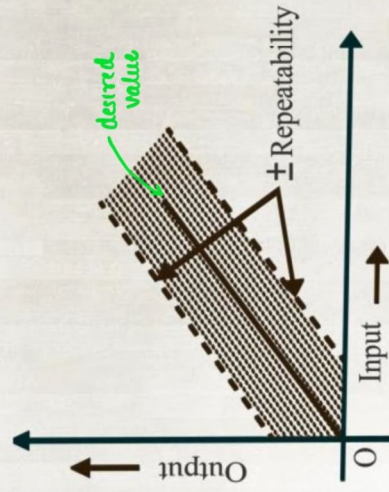
← similar to precision

- Degree of closeness in which a given value is measured by an instrument over a specified period of time.
- Environmental condition may not be same.

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Repeatability

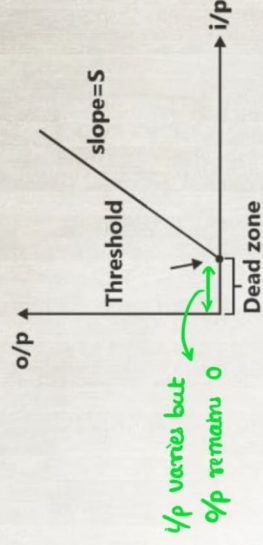
- Similar to reproducibility but environmental condition must be same.
- Reading can be placed within shaded region around desired value.



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Dead Zone and Dead Time

- Range of input for which instrument does not respond or does not give any o/p is called Dead Zone.



- Time taken by instrument to respond to any change in input is called as Dead Time.

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as high as possible

as low as possible

Desirable	Undesirable
Accuracy	Threshold
Precision	Drift
Resolution	Dead Zone
Sensitivity	Dead Time
Reproducibility	
Repeatability	

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 instrument's 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
- ☒ (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
- (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 | List-II |
|-----------------------|---|
| P. Precision | 1. The smallest change in the input quantity which can be detected with its certainty |
| Q. Accuracy | 2. Closeness of the reading with its true value. |
| R. Resolution | 3. Measure of reproducibility of the measurements |
| S. Static sensitivity | 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 (dead zone)
- (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

ERROR ANALYSIS

Type Static Error

Quantity under measurement
does not vary with
time.



Gross Error

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Completely due to human negligence i.e. during loose connection reading the value, taking the values, during calculation or memorizing the values.

Systematic Error

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- These errors are common for all observers and constant with respect to same conditions.
eg. Due to shadow of pointer, we may not be able to take the reading correctly.