

RRRB - JE

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ELECTRICAL

Railway Recruitment Board

Volume - 3

Measurement



CHARACTERISTICS OF INSTRUMENT AND MEASUREMENT SYSTEMS

THEORY

MEASUREMENTS

1.1 DEFINITION

Comparison, between predefined standard and quantity to be measured, e.g. measurement of time. Two Requirement :

- (a) Multiplying ratio
- (b) Unit

Methods of Measurement

- (i) **Direct** : For Mass, Length & Time having low accuracy and precision.
- (ii) **Indirect** : In this measurement is carried out in stages, (high accuracy and sensitive)

1.2 TYPES OF MEASUREMENT

- (i) Mechanical- Large inertia, high weight, suitable for static and stable condition. Dynamic response is poor and fail to respond to transient condition. They have high inertia, large time constant, high response time. (can not sensed for 50 Hz AC)
- (ii) Electrical : Faster than mechanical. They have operating torque produced by some electrical principle and then deflection by mechanical displacement. They are unfit for very fast measurement.
- (iii) Electronic : it uses semiconductor devices. FET, Vacuum tubes or electron beam in CRO, have very low inertia and very fast response.

1.3 REQUIREMENT OF ELECTRONICS TYPE OF INSTRUMENTS

- (i) High Sensitivity
- (ii) Light and Compact
- (iii) Fast Response
- (iv) Low Power Consumption
- (v) Highly reliable

Speed : Electronic > Electrical > Mechanical Types

(i) **Absolute instruments:**

It gives magnitude of the quantity in terms of physical constant of instrument e.g. Tangent Galvanometer, Raleigh's current balance, Used in labs. It doesn't requires calibration.

(ii) **Secondary instruments :**

These instruments measures by comparison with an absolute quantity. Normally used e.g. Ammeter, Voltmeter, etc.

1.4 TYPES OF INSTRUMENT

- (i) *Indicating* : Ammeter
- (ii) *Recording* : XY Recorder
- (iii) *Integrating* : kWh meter (energy meter)
- (iv) *Unpolarized / Bipolar* : Can be used on both AC. and DC.
- (v) *Unipolar/Polarized* : Can not be used on both AC and DC.
- (vi) *Deflection* :

In this type due to some operating force, there is a mechanical displacement which shows the measurement. They are suited for dynamic conditions.

- (vii) *Null* :

e.g. potentiometer, which is a comparison method. Its accuracy is better than deflection type. Its sensitivity is high. It is suitable for static measurements..

1.5 TYPES OF SIGNAL

- (i) *Analog* : Signal is continuous
- (ii) *Digital* : Signal is discrete.

1.6 CHARACTERISTIC OF INSTRUMENT

- (1) Static

- | | | |
|---------------------|---|-----------|
| (a) Accuracy | } | desired |
| (b) Sensitivity | | |
| (c) Reproducibility | | |
| (d) Drift | } | undesired |
| (e) Static error | | |
| (f) Dead zone | | |

- (a) **Accuracy and Precision** : Accuracy is the closeness to true value get precision is a measure of reproducibility of the measurement. Accuracy require precision but precision does not require accuracy. Accuracy can be improved by calibration but precision cannot.

Accuracy is defined as closeness with the true value. True value is real value.

TYPE OF ACCURACY

- (1) *Point* : On a Particular Point
- (2) *FSD* : On FSD(Full scale deflection)
- (3) *True value* : Error is same for any measurement.

- (b) **Sensitivity** : It is the ratio of output signal / Input signal.

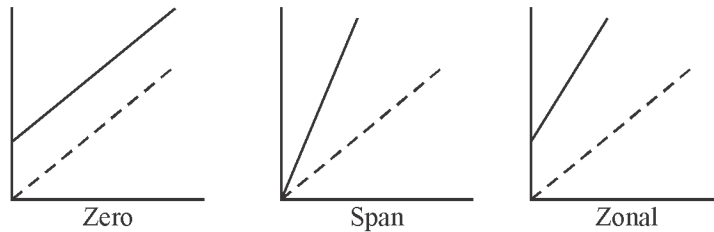
$$\text{Sensitivity} = \frac{\text{Small Change in output}}{\text{Small Change in input}}$$

- Sensitivity should be-high, its reciprocal is inverse sensitivity or deflection factor.
- Resolution : It is defined as smallest change in input which can be measured.
- **Scale Range and Scale Span** : Scale Range = difference between largest and smallest reading of instrument and span is Numerical difference between largest and smallest reading.

Range is 0 – 50 Amp

Ampere Span is 50 A

- (c) **Reproducibility** : It is the degree of closeness with, which a given value may be repeatedly measured or in other words measured value do not change with time.
- (d) **Drift** : Drift means variation in reading with respect to time.



Note: In a measured quantity number of significant figures indicates precision e.g. 300. has 3 significant figures and 300.0 has 4 significant figures.

- (e) **Static error** : Measured value - True value. Also called absolute error.

$$\text{Relative error} = \frac{\text{Absolute error}}{\text{True value}}$$

$$= \frac{M_v - T_v}{T_v}$$

Where,

M_v = Measured value

T_v = True value

Static Correction = -Static error

If Instrument is designed in terms of true value then error will be same for all the reading but if it is designed for FSD then error would be high for low reading.

- (f) **Dead zone** : Defined as largest change of input for which there is no output.

$$\text{Dead zone} = 2 \times \text{Hysteresis}$$

Deadtime : Time required to respond to change in measured.

Threshold : It is defined as smallest measurable input.

Example: 0-50 ammeter has accuracy of 1% of FSD. If current measured is 20 A find % error

Solutions :

$$\text{Error} = \frac{50 \times 1}{100} = .5\text{A}$$

$$\text{Measured current} = 20 \text{ A}$$

$$\% \text{error} = \frac{0.5}{20} \times 100 = 2.5\%$$

PRACTICE SHEET

OBJECTIVE QUESTIONS

1. Which one of the following statements is not correct
- (a) It is not possible to have precise measurements which are not accurate
- (b) Correctness in measurements requires both accuracy and precision
- (c) Reproducibility and consistency are expressions that best describe precision in measurements
- (d) An instrument with 2% accuracy is better than another with 5% accuracy
2. Match List-I with list-II and select the correct answer using the codes given below the lists:
- | List-I | List-II |
|----------------|--|
| A. Sensitivity | 1. Closeness to the true value |
| B. Resolution | 2. A measure of reproducibility of instrument |
| C. Accuracy | 3. Ratio of response to the change in the input signal |
| D. Precision | 4. Least interval between two adjacent discrete value |
3. Sensitivity of a voltmeter is expressed as
- (a) Volt/Ohms
- (b) Ohms/Volt
- (c) Ohms Volt
- (d) Amp/Volt
4. In measurement systems, which of the following are undesirable static characteristics:
- (a) Sensitivity and accuracy
- (b) Drift, static error and dead zone, linearity
- (c) Reproducibility and non-linearity
- (d) Drift, static error, dead zone and non-linearity

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ANSWERS AND EXPLANATIONS

1. *Ans. (a)*
2. *Ans. (d)*
3. *Ans. (b)*
4. *Ans. (d)*

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