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Department of Biomedical Engineering

Vision Tit 2 Vision Title 3

Course Name: 23BMT204 – Biomedical Instrumentation

III Year : V Semester

UNIT 1- FUNDAMENTALS OF MEDICAL INSTRUMENTS

Topic : Performance Requirements of Medical Instrumentation System

- The information obtained from a medical sensor or transducer is usually in form of current intensity, voltage level, frequency or signal phase relative to a standard.

Some of the performance requirements considered in biomedical instrumentation systems as discussed below

- To make accurate measurements of voltage, it is necessary to have the input impedance of the measuring device larger than the output impedance of the signal source. This is to minimize the error that would occur if an appreciable fraction of the signal source were dropped across the source impedance.
- An accurate measurement of current source signals requires that the source output impedance be larger than receiver input impedance. In an ideal situation, a receiver that exhibits zero input impedance would not cause any disturbance to the current source. Hence, high-impedance current sources are more easily handled than low-impedance current sources.

- Generally, the frequency response of the system should be compatible with the operating range of the signal being measured. To process the signal waveform without distortion, the bandpass of the system must include all of the frequency components of the signal that contribute significantly to the signal strength. The range can be determined quantitatively by obtaining a Fourier analysis of the signal.

- Electrical signals are usually affected by spurious signals components or noise. Biomedical instruments are designed in such a way that the noise is minimized to enable accurate and sensitive measurement. To extract information from noisy signals, it is necessary to enhance signal-to-noise ratio. Using techniques like bandwidth reduction.
- Digital processing is preferred over analog processing. Digital techniques are advantageous over analog techniques e.g. they are not affected by temperature that affects analog devices. The digital devices have a powerful performance since they are able to implement complex algorithms.

Static & Dynamic Characteristics

Static Characteristics Of Instruments And Measurement Systems

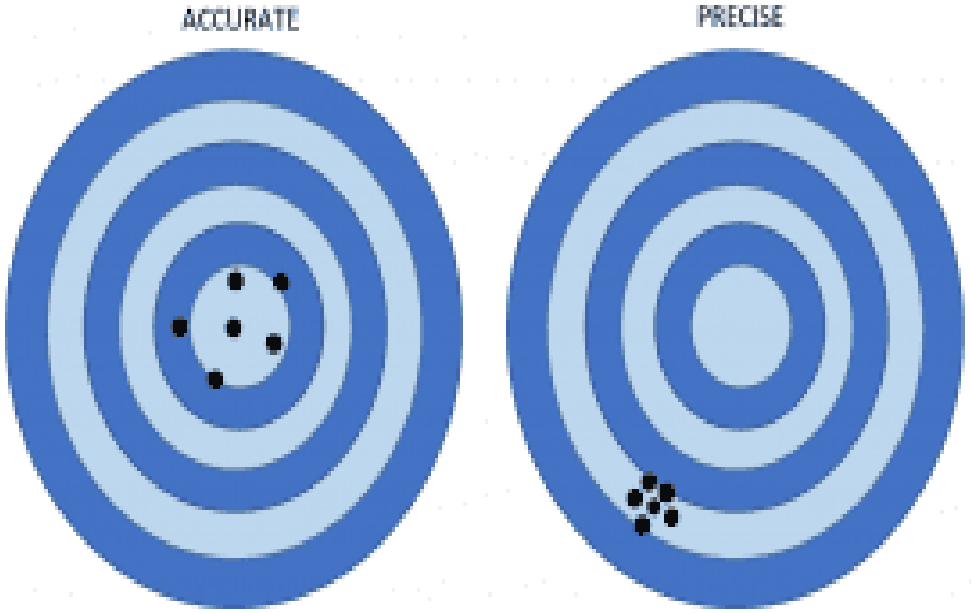
- Application involved measurement of quantity that are either constant or varies slowly with time is known as static.

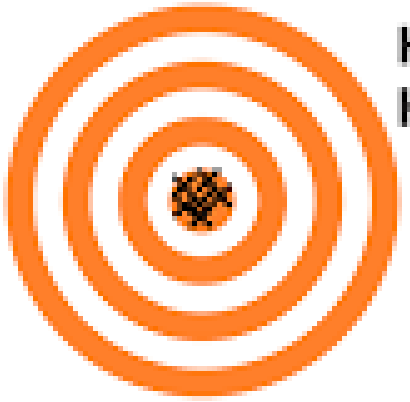
➢ True value
➢ Static error
➢ Static correction
➢ Accuracy
➢ Precision
➢ Drift
➢ Dead time
➢ Dead Zone
➢ Sensitivity
➢ Reproducibility

Static Characteristics

- Scale range
- Scale span
- Noise
- Dead Time
- Hysteresis.
- Linearity

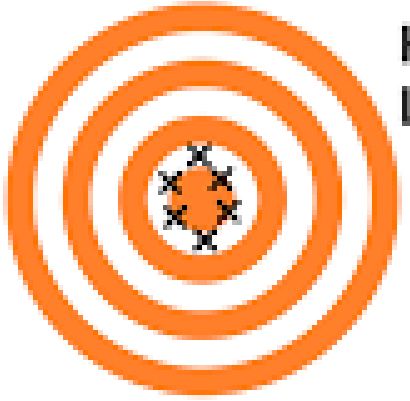
- **TRUE VALUE** (Theoretical Value) : True value of quantity may be defined as the average of an infinite no. of measured value.
- **STATIC ERROR** : difference between measured value and true value. (Measured value – True value). Error could be positive and negative.
  - Instrument reading is greater than true value → positive error
  - Instrument reading is lesser than true value → negative error
- **STATIC** CORRECTION : complement of static error. Static correction = - Error.
- **ACCURACY:** It is the closeness with an instrument reading approaches the true value of the quantity being measured.
- **PRECISION** : Ability of an instrument to give consistent reading





High accuracy
High precision

Low accuracy
High precision



High accuracy
Low precision

Low accuracy
Low precision

- **SENSITIVITY** is defined as the ratio of the magnitude of the output response to that of input response.
- **SCALE RANGE**: The scale range of an instrument is refer to the minimum and maximum value that can be measured using it.
- **SCALE SPAN**: Scale span or instrument span is given as Scale span= $X_{max} - X_{min}$

  It is the difference between highest and lowest possible operating limits of the instrument

  Eg. A thermometer calibrated between 100 C to 500 C has range from 100 to 500 but span is 500-100 = 400 C
- **LINEARITY** : it indicates the relationship of the output with input.

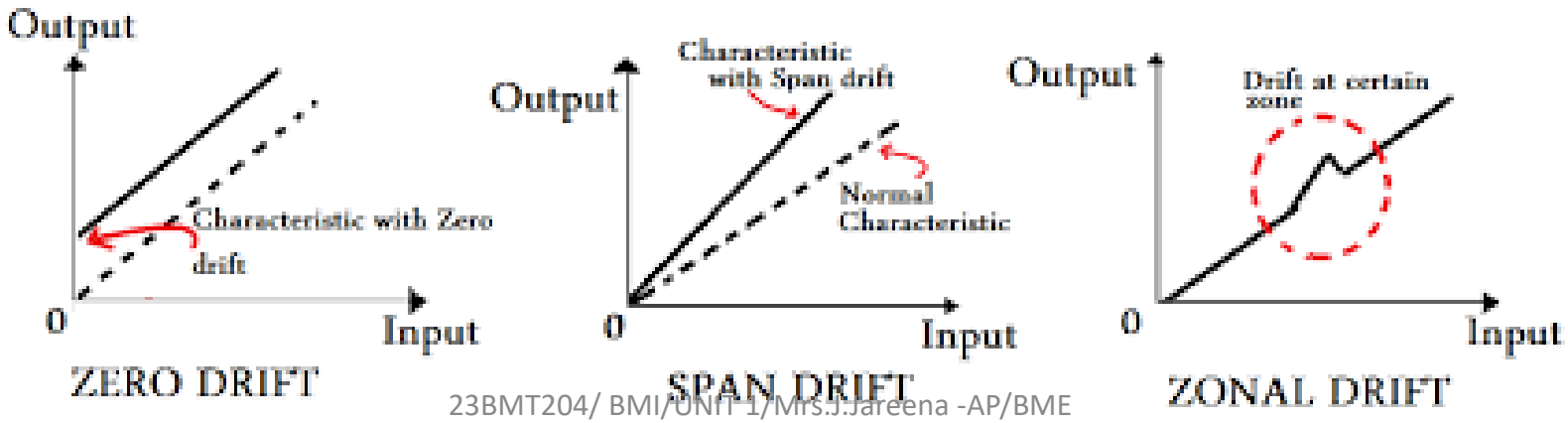
- **REPRODUCIBILITY** is specified in terms of scale readings over a given period of time.
- **DRIFT** is an undesirable quality in industrial instruments because it is rarely apparent and cannot be maintained.

It is classified as

a) Zero drift- Entire calibration shift

b) Span drift or sensitivity drift – proportional change in the indication all along upward scale.

c) Zonal d ıent



- **DEAD TIME** : time required by a measurement system to begin to respond to change in the measurand.
- **DEAD ZONE** : largest change of input quantity for which there is no output of the instrument
- **HYSTERESIS** : it is a phenomenon which depicts

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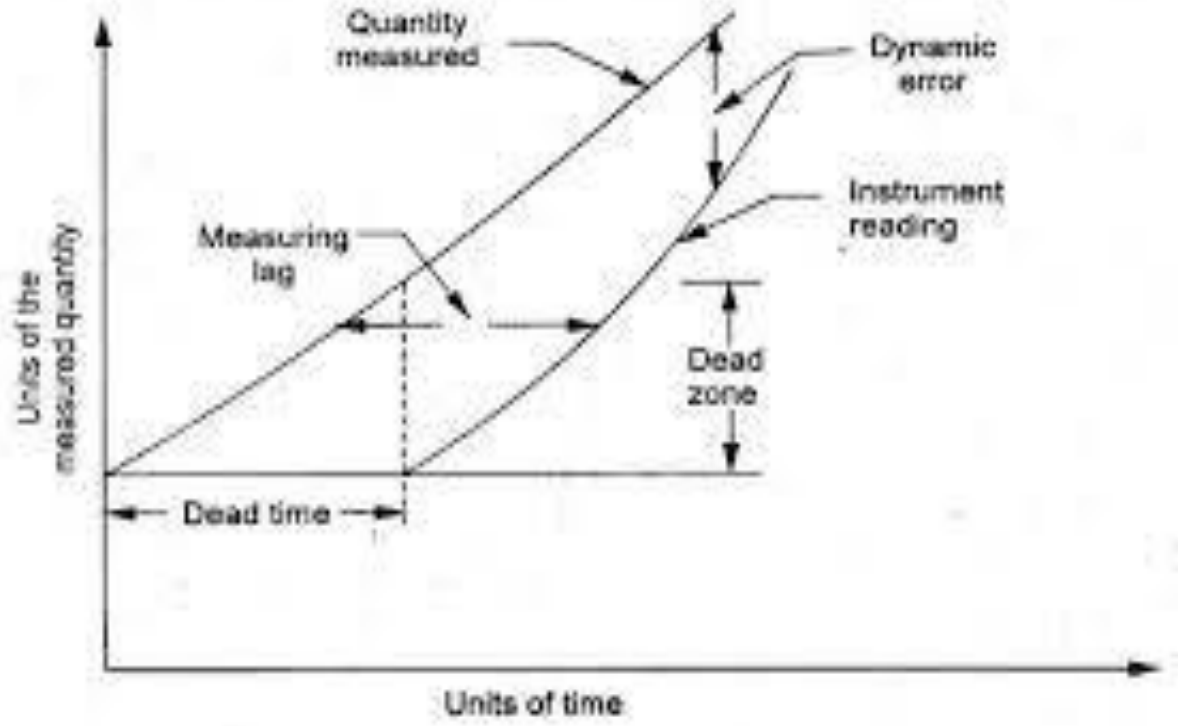

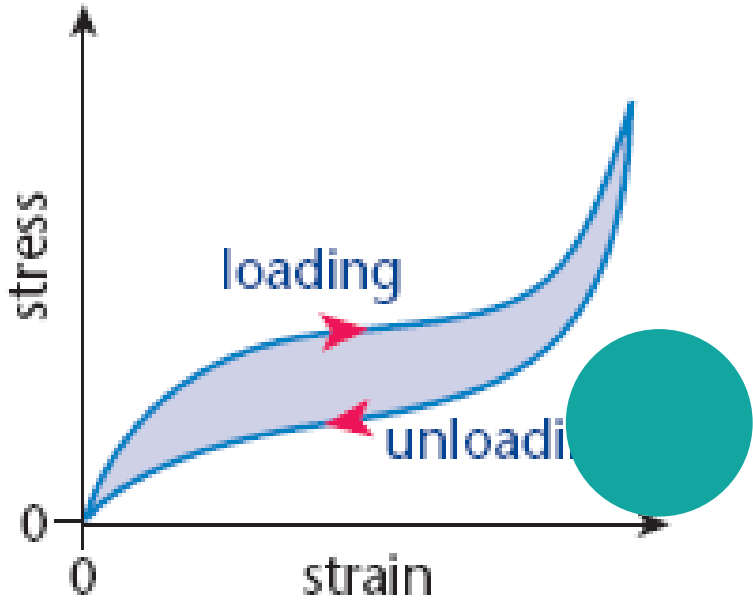

- **THRESHOLD** : when the i/p to the instrument is increased from zero, there is minimum value below which no o/p can be detected.
- **RESOLUTION** : small change in the i/p signal that can be detected by the instrument.
- **BIAS** : repeated measurement of same input have constant error then instrument has a bias.
- **ZERO STABILITY**: it is a measure of ability of the instrument to restore to zero readings after the measurand has returned to zero and other variation have been removed

Dynamic Characteristics of Measurement System (Ref 4, Chapter 4)

- Speed of response
- Measuring lag
- Fidelity
- Dynamic error

- SPEED OF RESPONSE :It is defined as the rapidity with which a measurement system responds to changes in measured quantity. It is one of the dynamic characteristics of a measurement system.
- FIDELITY: It is defined as the degree to which a measurement system indicates changes in the measured quantity without any dynamic error.

Dynamic Error

- It is the difference between the true value of the quantity changing with time and the value indicated by the measurement system if no static error is assumed. It is also called measurement error. It is one the dynamic characteristics.

Measuring Lag

- It is the retardation delay in the response of a measurement system to changes in the measured quantity. It is of 2 types:
- Retardation type: The response begins immediately after a change in measured quantity has occurred.
- Time delay: The response of the measurement system begins after a dead time after the application of the input.