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# IRE 215: SENSOR TECHNOLOGY

## LECTURE-2: STATIC AND DYNAMIC CHARACTERISTICS

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# LECTURE CONTENTS

- Static characteristics
- Static characteristics of sensors

# Static Characteristics

Attributes associated with measurement of quantities which are constant or vary very slowly with time.

# Range and Span

Range is the limits between which the input can vary.

Span = maximum input – minimum input.

Example: If a load cell have a range of 0 to 50 kN, then span is 50 kN.

# Sensitivity

Absolute ratio of the output signal (or response) to that of the input signal (or measurand).

Sensitivity of a linear instrument is constant while that of a nonlinear one varies from one range to another.

Example: In a glass-thermometer, the meniscus moves by 1cm when the temperature changes by 10°C. The sensitivity of the thermometer is therefore 1mm/°C.

****Meniscus is the curve that exists on the surface of a liquid when it is placed into a container.****

# Reproducibility/ Repeatability

Degree of closeness with which a particular reading of an instrument, taken at different times, repeats itself. It determines the precision of an instrument.

**For a repeated application:** repeatability = (max. – min. values given/ full range) × 100%

# Static characteristics

## Drift

Change in the indicated reading of an instrument over time when the value of the measurand remains constant.

Several causes such as electromagnetic fields, mechanical vibrations, change in temperature or pressure, Joule heating of the components of the instrument etc.

If there is no drift, the reproducibility is 100%.

## Static characteristics

# Accuracy

Closeness of an ‘instrument reading’ to the true value of the measurand.

It can be improved by better calibration of the instrument.

Example: a known voltage of 200V is being measured by a voltmeter and the successive readings are 204, 205, 203, 203 and 205 volts. So, the accuracy is about 2.5%.

# PRECISION VS. ACCURACY

Precision is related to the repeatability of the instrument reading and is a characteristics of instrument itself.

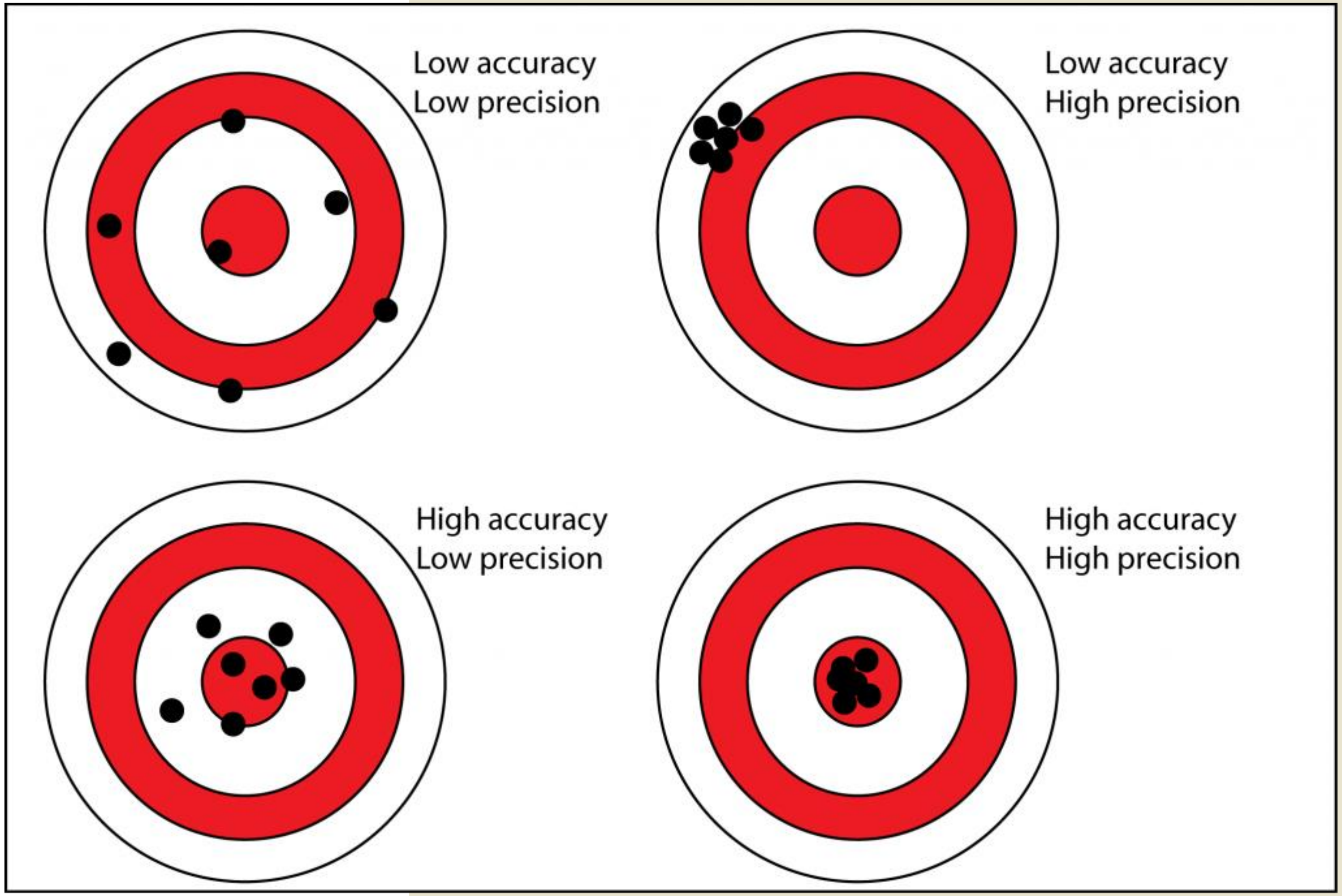
Accuracy is not related to the repeatability.

Precision depends on number of significant figures but does not depend on the ‘true value’.

Accuracy depends on the ‘true value’.

In the previous example, reading can be expressed as $204 \mp 1$ V, which means precision is little less than 0.5%.

# PRECISION VS. ACCURACY



# ACCURACY VS. PRECISION: THE BULLSEYE EXAMPLE

The bullseye example is the most common way to show the difference between accuracy and precision. Think of throwing darts at a bullseye. The goal is to be both accurate and precise. In other words, to hit the bullseye as frequently as possible. If you're simply accurate, that means you're throwing darts that are landing close to the bullseye, but you're not hitting the bullseye every time. If you're simply precise, that means your darts are landing close to one another, but not necessarily close to the bullseye. But when you're accurate *and* precise, your darts will land in the bullseye every time—the best case scenario.

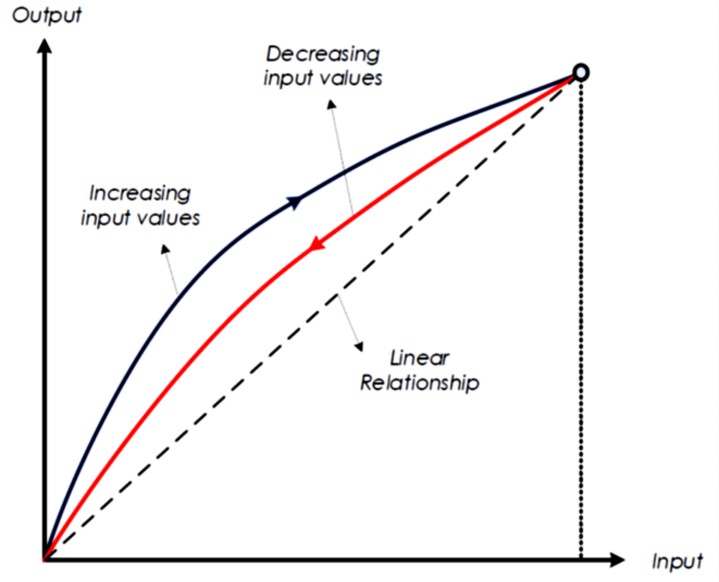
# SIGNIFICANT FIGURES

It convey the information regarding the magnitude of precision of a quantity.

Example: If a measurement reports that the line voltage is 220 V, it means the line voltage is closer to 220 V than it is to 219 V or 221V. Alternatively, if the reported value is 220.0 V, it means value is closer to 220.0 V than it is to 219.9 V or 220.1 V. Taking in terms of significant figure, it is 3 in the former case and 4 in the later case.

# Hysteresis error

Maximum difference in output for increasing and decreasing values.



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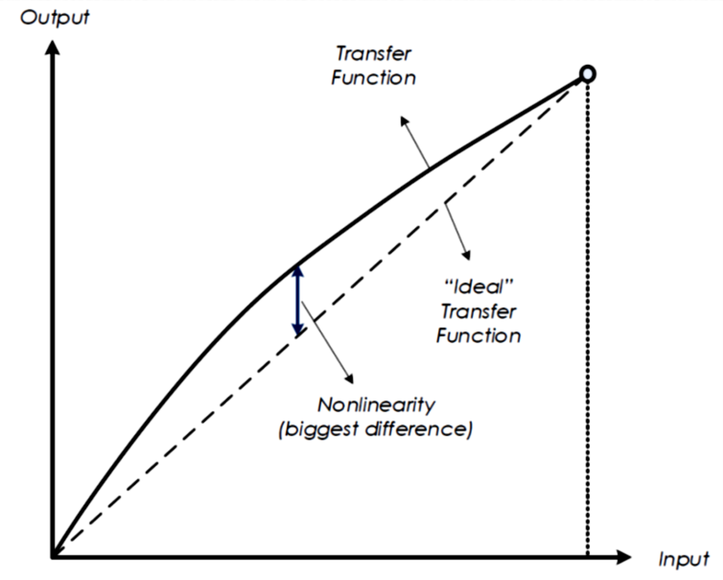
# Non-linearity error

Error occurs as a result of the assumption of linearity.



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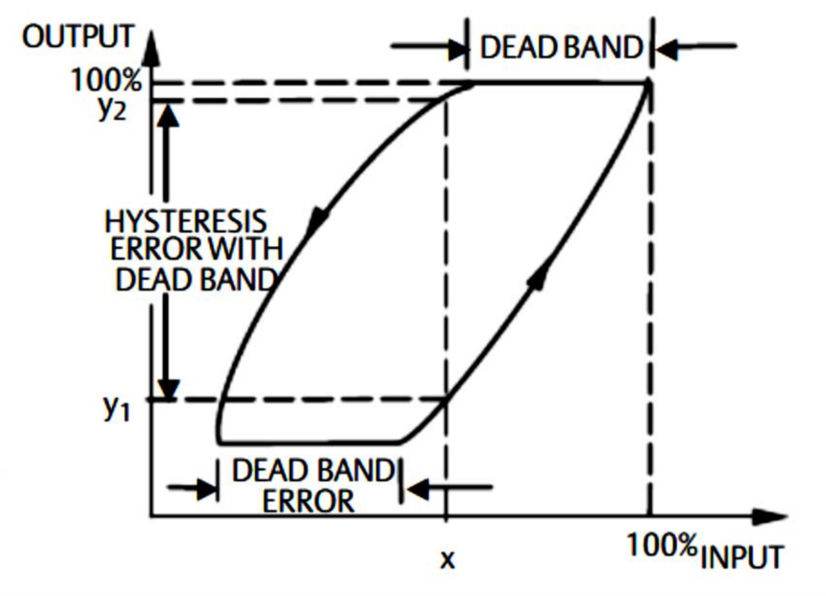
# Dead band/ zone

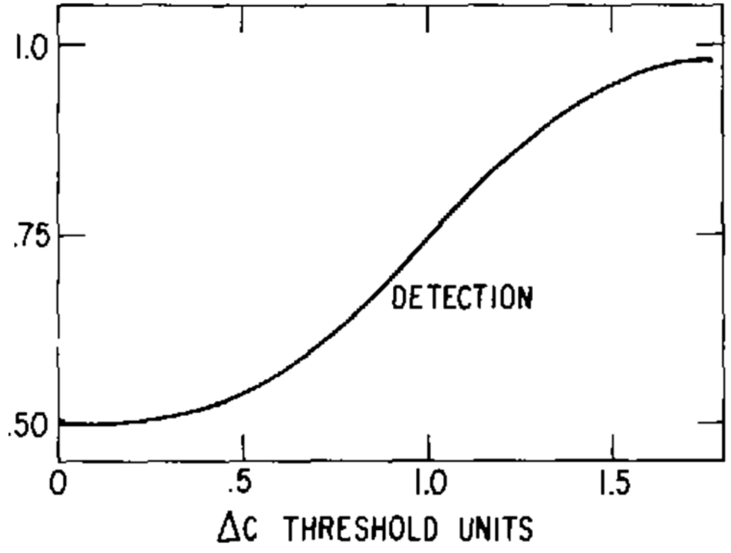
Dead band is the range of input values for which there is no output.

Three phenomena – hysteresis, threshold and resolution – contribute to the dead band.

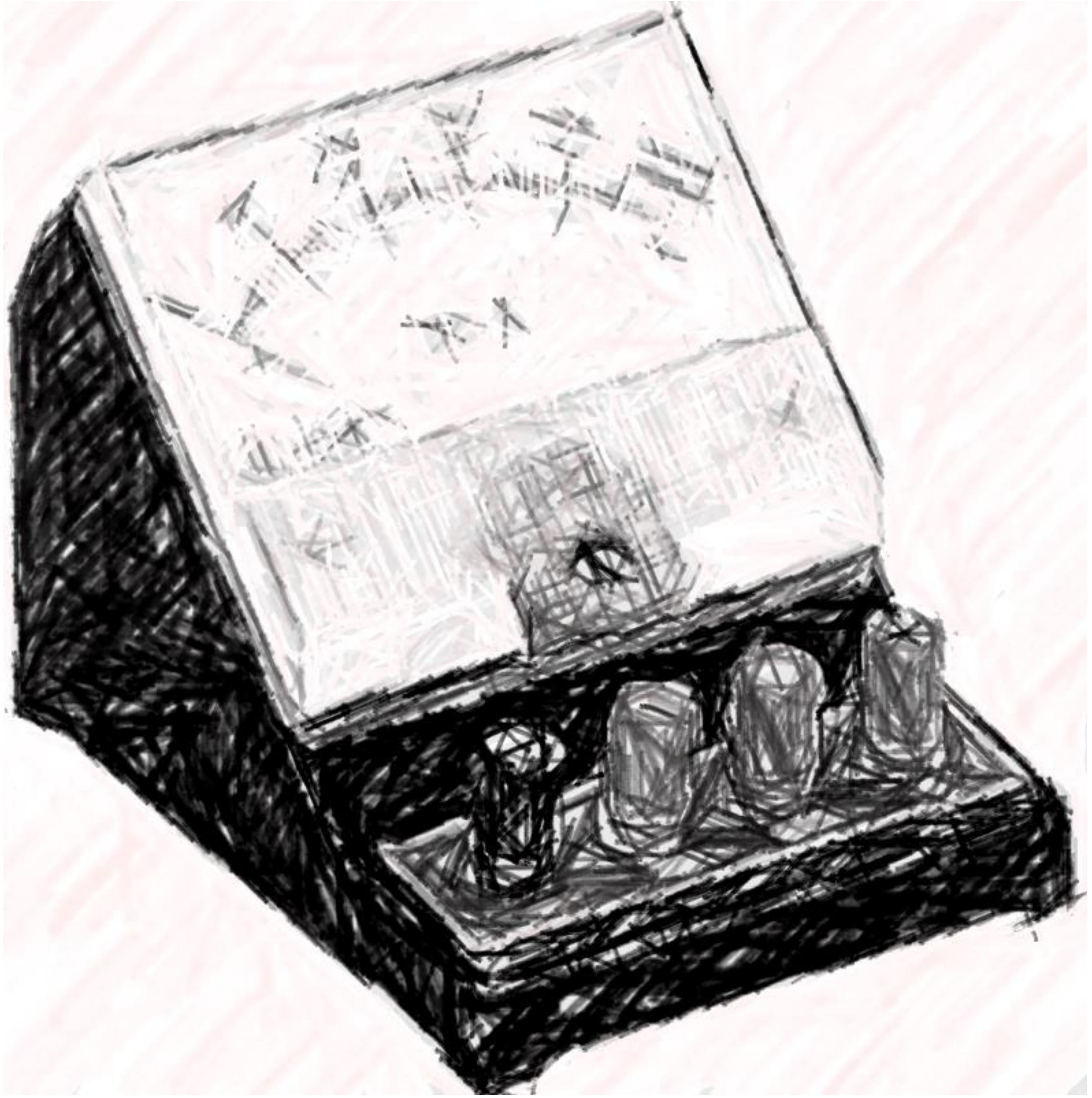
# Dead band reasons




**Dead band due to hysteresis (Courtesy: ValveLink Software Product Bulletin)**




**Dead band due to threshold**



# Resolution

- Smallest change in the input value that will produce an observable change in output.
- **Example:** An analog ammeter has a linear scale of 50 divisions. Its full-scale reading is 10 A and half a scale division can be read. What is the resolution of the instrument?

**Hints:** What is the value of 1/2 scale division?

## Static characteristics

# Dead time/ Transportation lag/ Time delay

Length of time from the application of an input until the output begins to respond the change.

Many chemical processes involve time delay time required for a slow chemical sensor or for a fluid to travel down a pipe.

The effect of time delay on feedback control is that the measured output will not contain the most current information and hence system with dead time can be difficult to control.

# Error

Difference between the result of the measurement and the true value of the quantity being measured.

Mainly three types – gross, random, and systematic errors.

Example: If a temperature sensor gives a temperature reading of 25°C and actual temperature is 24°C, then the error is +1°C.