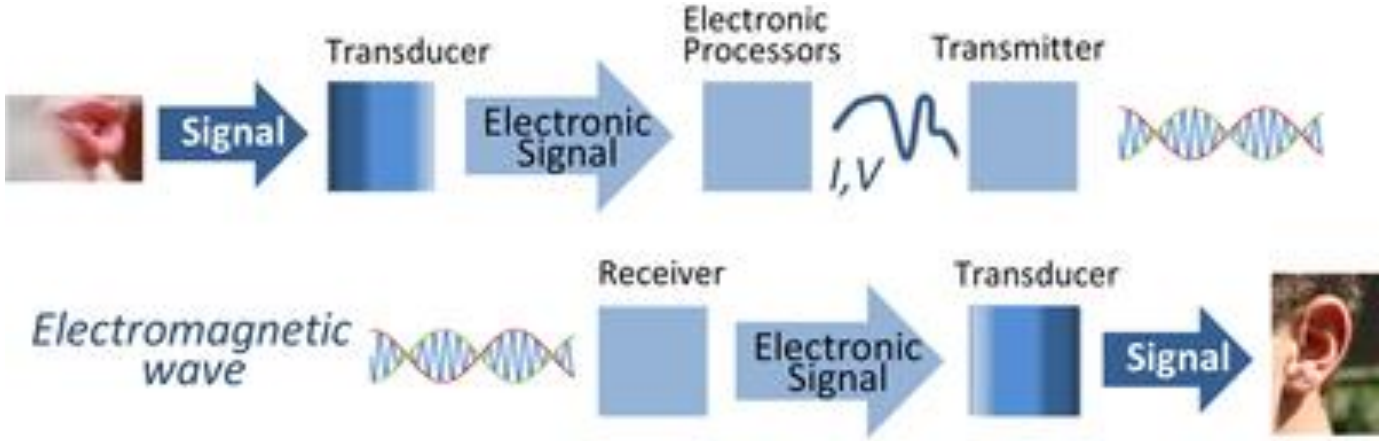
Definitions: Signal and Noise

•Signal:

– Part of the signal generated by object of interest

Motion of an object can be considered to be a signal and can be monitored by various sensors to provide electrical signals



Noise:

– Part of the measurement due to sources other than the object of interest.

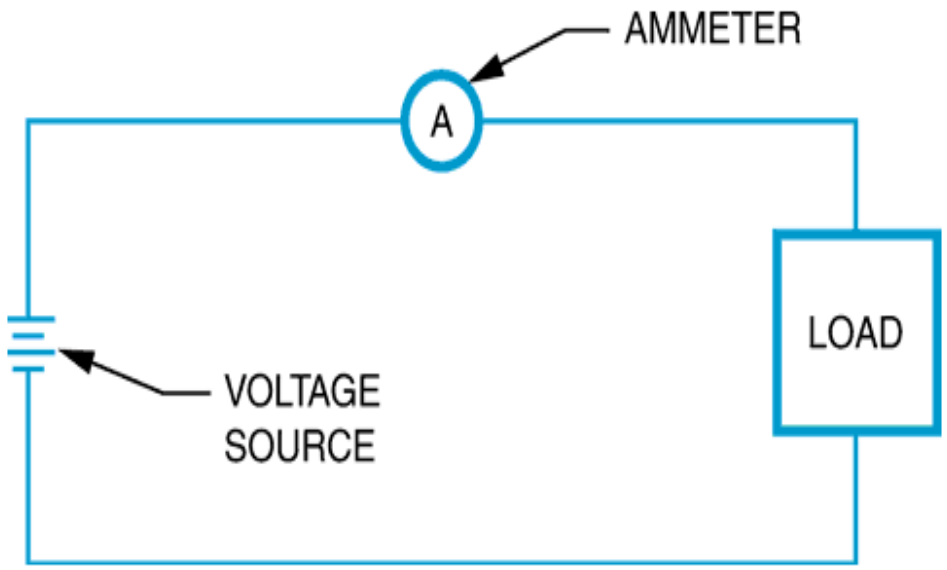
– Usually equal to the standard deviation of signal

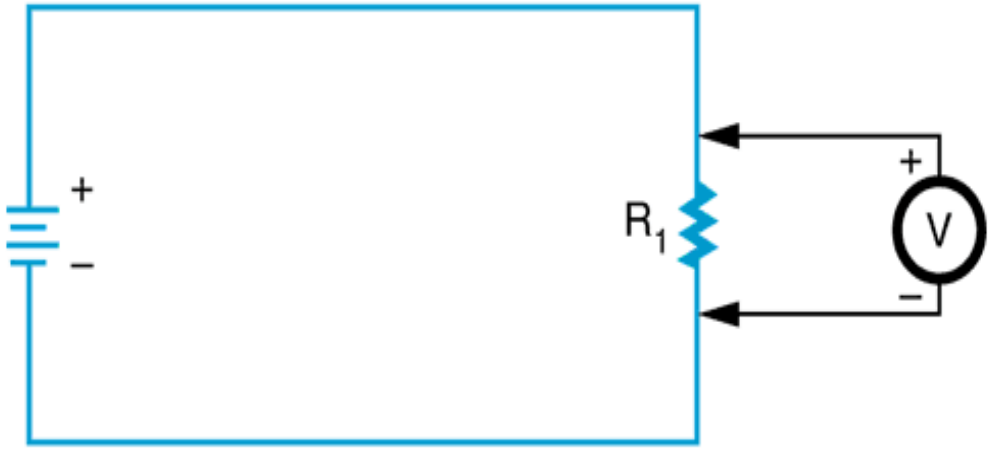
– Independent sources of noise add in quadrature

$$N_{total} = \sqrt{\sum_i N_i^2}.$$

Measurement Meters

A *measuring system* exists to provide information about the physical value of some variable being measured.





Measures current
– Input resistance needs to be very small

Measures voltage
Input resistance needs to be large

Instrument Specifications: Definitions

Accuracy

The *accuracy* of an instrument is a measure of how close the output reading of the instrument is to the correct value.

Input Voltage	Range of Readings within the Accuracy Specification
0 V	-1 mV to +1 mV
5 V	4.994 V to 5.006 V (±6 mV)
10 V	9.989 V to 10.011 V (±11 mV)

Table 1. Readings as a function of accuracy

Conditions: input 0-10 V, Accuracy = ±(0.1% of input + 1 mV)

Precision

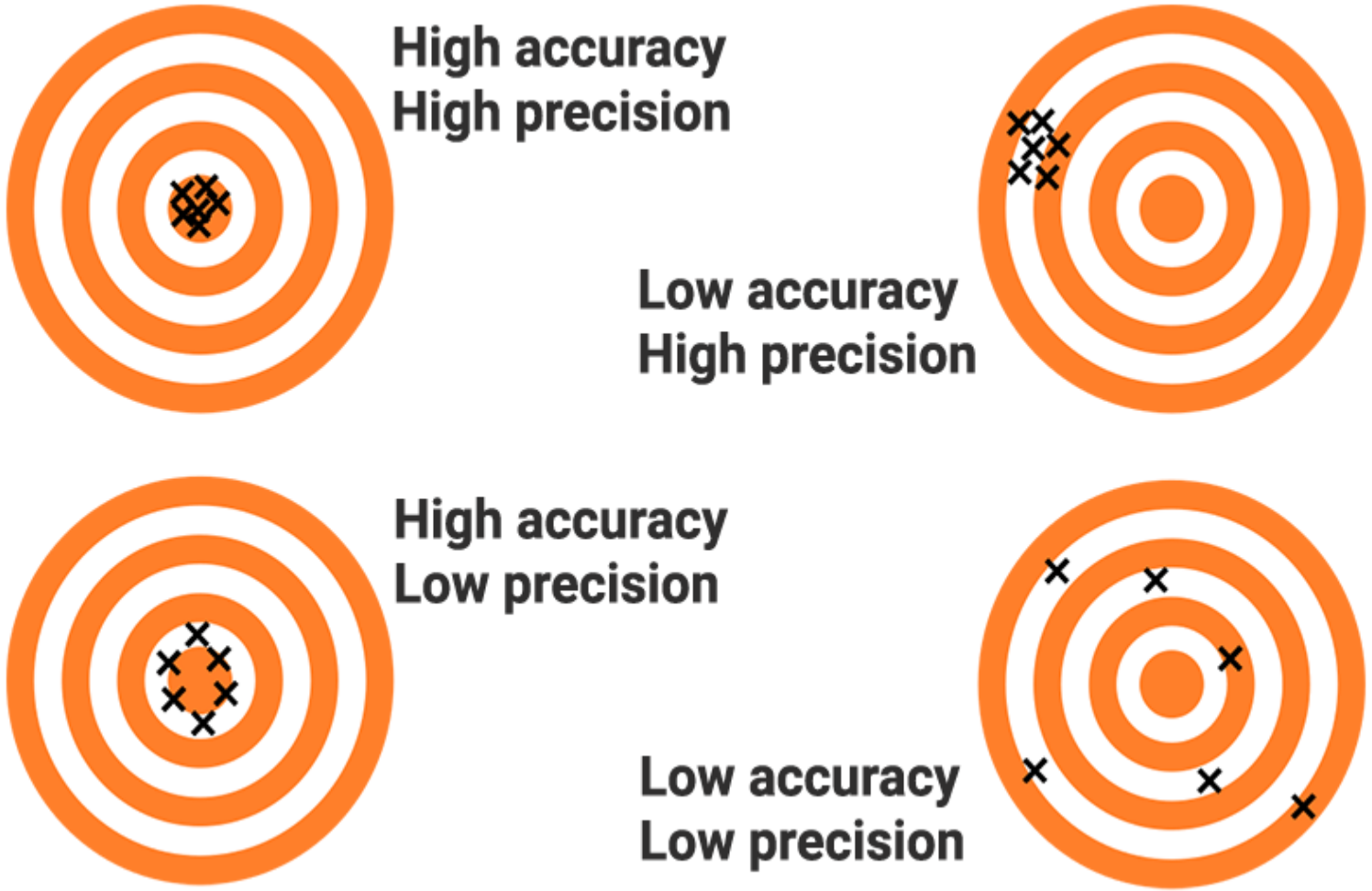
Precision

Precision is a term that describes an instrument's degree of freedom from random errors If a large number of readings are taken of the same quantity by a high precision instrument, then the spread of readings will be very small.

A high precision instrument may have a low accuracy.

Example: Screw gauge, Scale, time

Comparison of accuracy and Precision

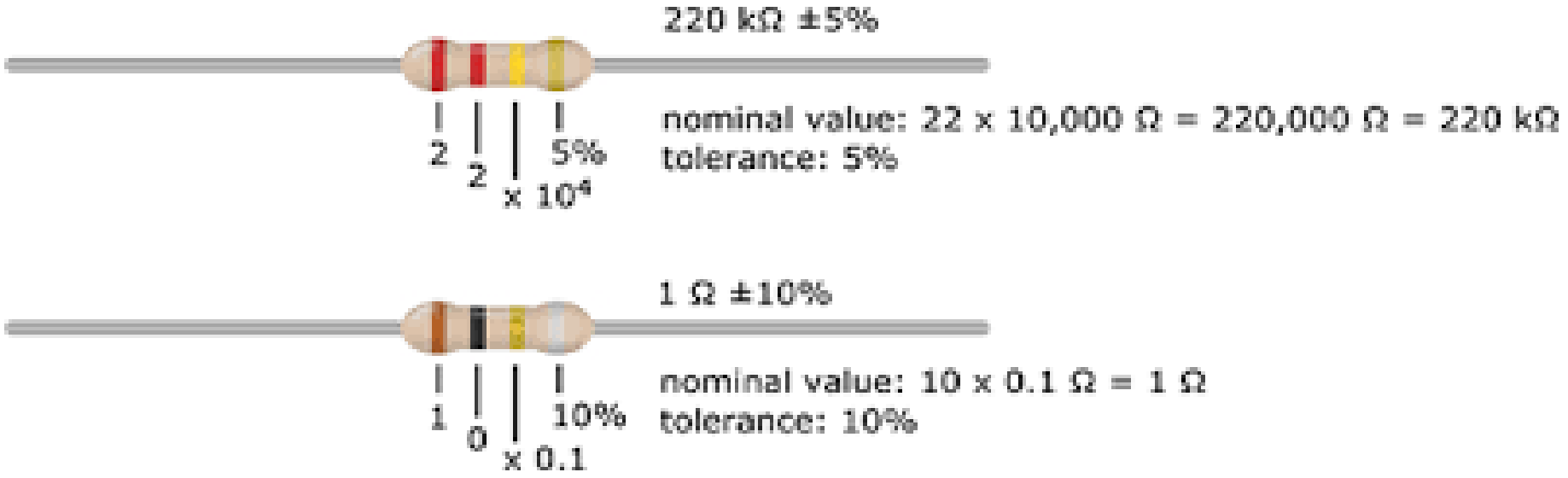


Tolerance

Tolerance is a term that is closely related to accuracy and defines the maximum error that is to be expected in some value

Example

One resistor chosen at random from a batch having a nominal value 1000W and tolerance 5% might have an actual value anywhere between 950W and 1050 W.



Repeatability

Repeatability

– Closeness of values between successive measurements under same condition

Repeatability describes the closeness of output readings when the same input is applied repetitively over a short period of time, with the same measurement conditions, same instrument and observer, same location and same conditions of use maintained throughout.

Example

1.At the same place
2.By the same person
3.By the same Method
4.On the same equipment
5.Over short period of time.

If a person measures repeated readings of an object by micrometer as 15.01 mm, 15.02 mm, and 15.01 mm. means the person can repeat the readings, and the level of competence is high.

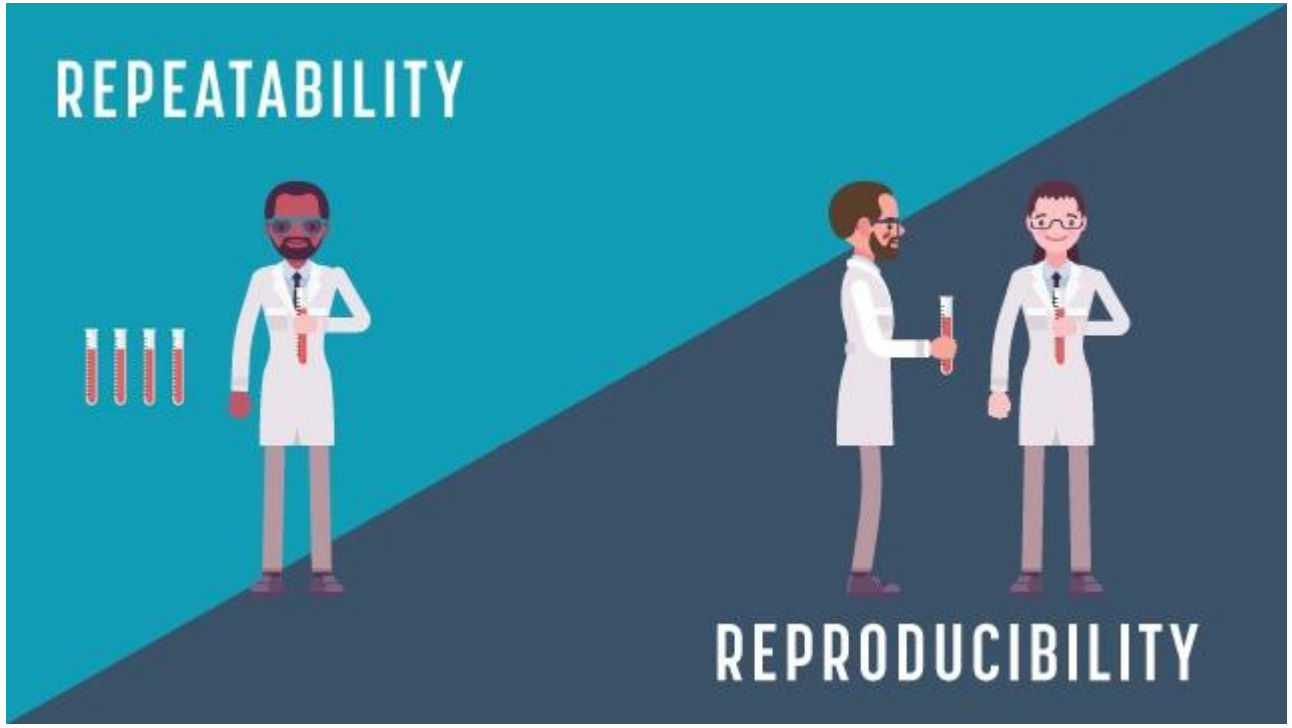
Reproducibility

Reproducibility

Reproducibility describes the closeness of output readings for the same input when there are changes in the method of measurement, observer, measuring instrument, location, conditions of use and time of measurement. Both terms thus describe the spread of output readings for the same input.

Example

1.At the different place
2.By the different person
3.By the different method
4.On the different equipment
5.At the different time



Range or span

The range or span of an instrument defines the minimum and maximum values of a quantity that the instrument is designed to measure.

Range and Resolution

Range	Resolution
300.0 mV	0.1 mV (0.0001 V)
3.000 V	1 mV (0.001 V)
30.00 V	10 mV (0.01 V)
300.0 V	100 mV (0.1 V)
1000 V	1000 mV (1 V)

Resolution

Resolution

When an instrument is showing a particular output reading, there is a lower limit on the magnitude of the change in the input measured quantity that produces an observable change in the instrument output.

Range and Resolution	
Range	Resolution
300.0 mV	0.1 mV (0.0001 V)
3.000 V	1 mV (0.001 V)
30.00 V	10 mV (0.01 V)
300.0 V	100 mV (0.1 V)
1000 V	1000 mV (1 V)

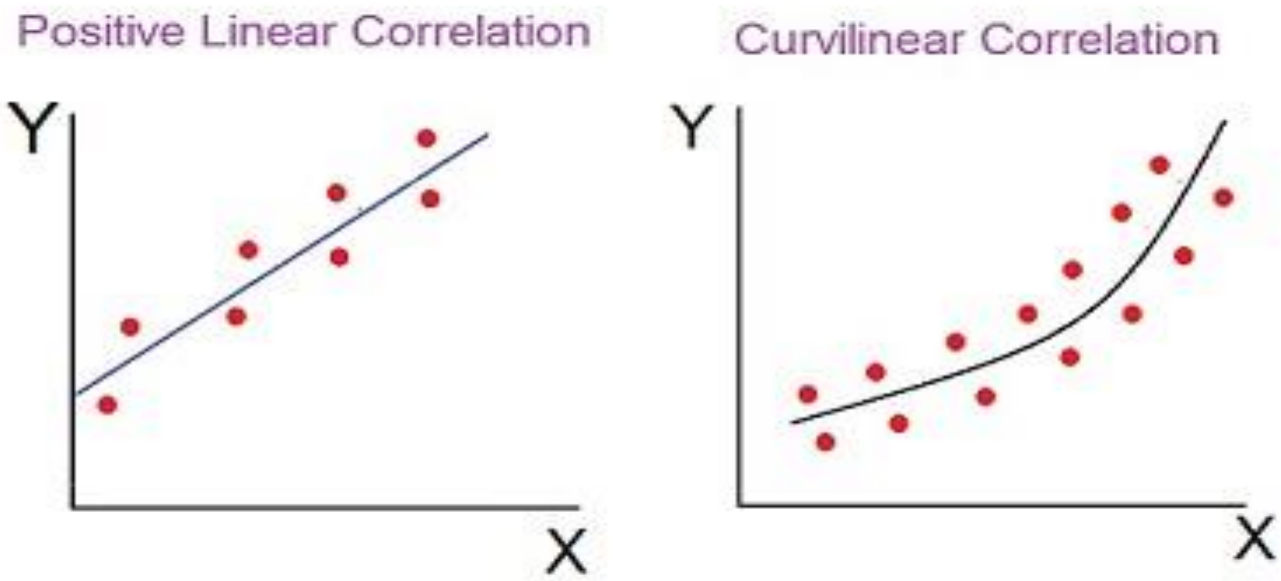
Linearity and non Linearity

Linearity

It is normally desirable that the output reading of an instrument is linearly proportional to the quantity being measured.

Non Linearity

The non-linearity is then defined as the maximum deviation of any of the output readings marked X from this straight line



Instrument Specifications: Definitions

Sensitivity

– Smallest change in signal that can be detected

– Typically the Resolution in the lowest range

The sensitivity of measurement is a measure of the change in instrument output that occurs when the quantity being measured changes by a given amount.

Examples: Pressure sensors, touch screen, Noises, Piezoelectric

Speed vs Resolution

Speed Designation	Maximum Sample Rate (S/s)	Resolution (Bits rms) (-4V to +4-V Range)
Slow, 60-Hz Rejection	3.2/s	22
Medium, 60 Hz Rejection	9.2/s	21
Fast	48/s	17
Very Fast	80/s	15

Threshold

If the input to an instrument is gradually increased from zero, the input will have to each a certain minimum level before the change in the instrument output reading is of a large enough magnitude to be detectable. This minimum level of input is known as the *threshold* of the instrument.

Example

As an illustration, a car speedometer typically has a threshold of about 15 km/h. This means that, if the vehicle starts from rest and accelerates, no output reading is observed on the speedometer until the speed reaches 5 km/h.

In electronics diode, transistors etc

Calibration

Electrical calibration refers to the **process of verifying the performance of, or adjusting**, any instrument that measures or tests electrical parameters. Electrical calibration involves the use of precise devices that evaluate the performance of key properties for other devices called units under test (UUTs)