POLITECNICO DI MILANO

Electronics – 96032





Sensors: basic concepts

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Disclaimer

Slides are supplementary material and are NOT a replacement for textbooks and/or lecture notes

Sensors

- Convert an input physical property (the *stimulus*) to a different one (usually an electrical signal). Sensors are «energy converters»
- You can find many disquisitions on the difference between *sensors* and *transducers*, which I gladly leave to your rainy day reading

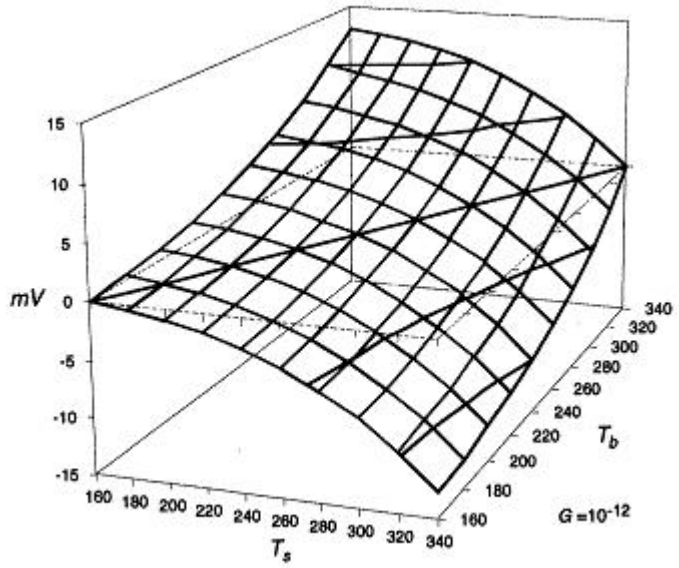
Sensor classification

- Measurand
  - Temperature, pressure, velocity, current,…
- Detection mean
  - Biological, chemical, electrical, mechanical,…
- Sensor material
  - Semiconductor, organic, liquid,…
- Field of application
  - Scientific, industrial, medical,…

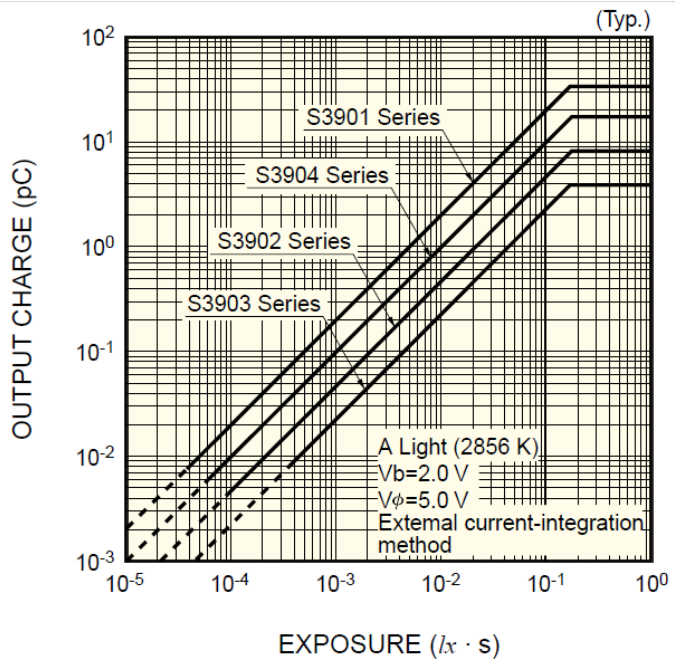
Sensor characteristics

- Static parameters
  - Transfer function, accuracy, resolution,…
- Dynamic parameters
  - Frequency response, settling time,…
- Other parameters
  - Operating and storage conditions, reliability,…

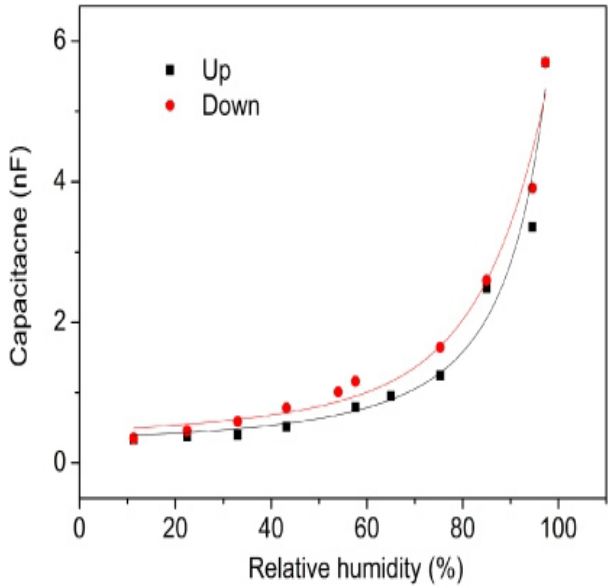
I-O characteristic



From [1]



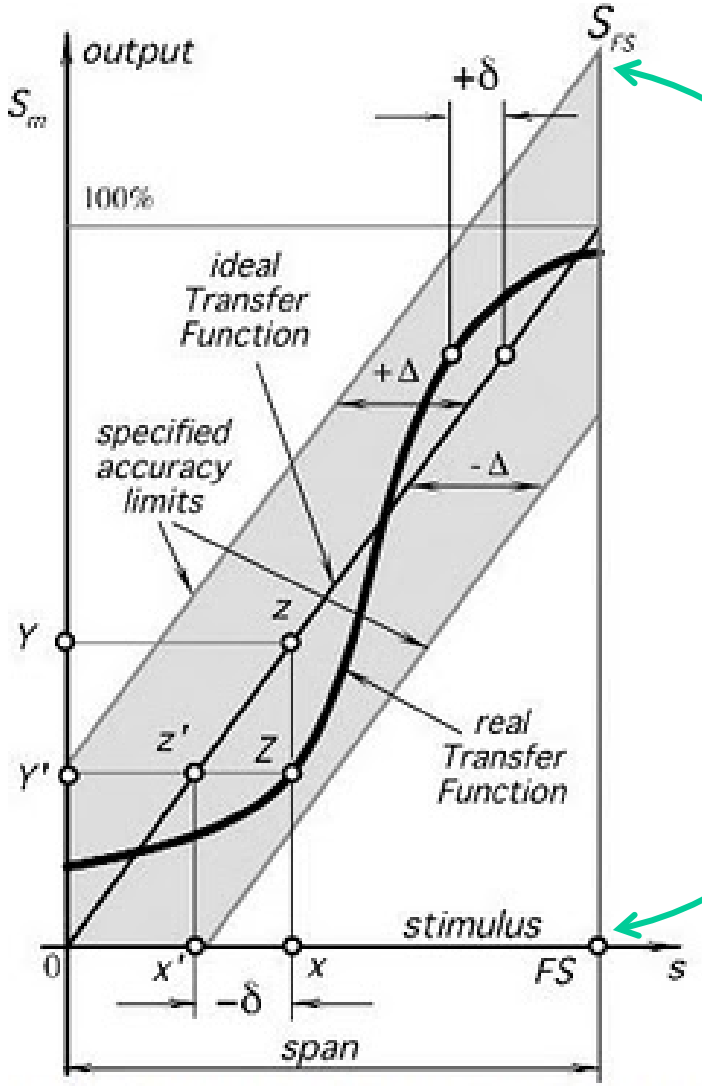
From [2]



From [3]

When used as detectors, the inverse function is needed

I-O ranges



Full-scale output

Full-scale input

From [4]

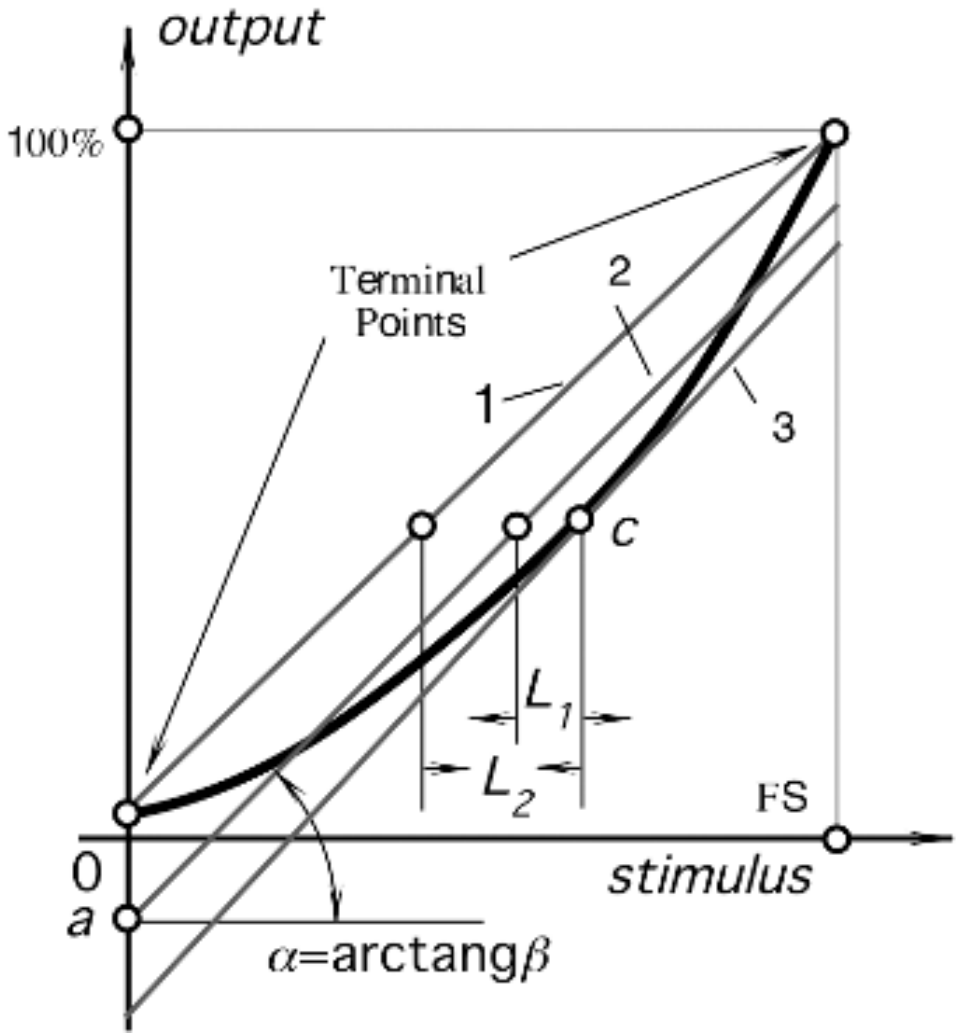
Sensitivity

- Defined as the ratio between output and input variations

$$S = \frac{dS_o}{dS_i}$$

- Linear sensors have constant sensitivity
- Linear approximations can be used in other cases, over a limited input range. Otherwise, data processing is required

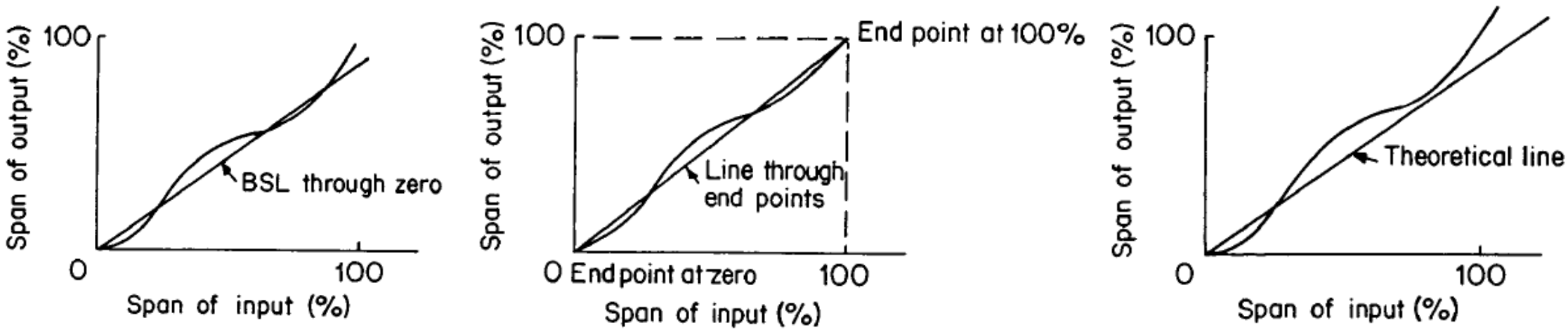
(Non)Linearity error



Maximum difference between the real transfer function and its linear approximation

Which linear characteristic?

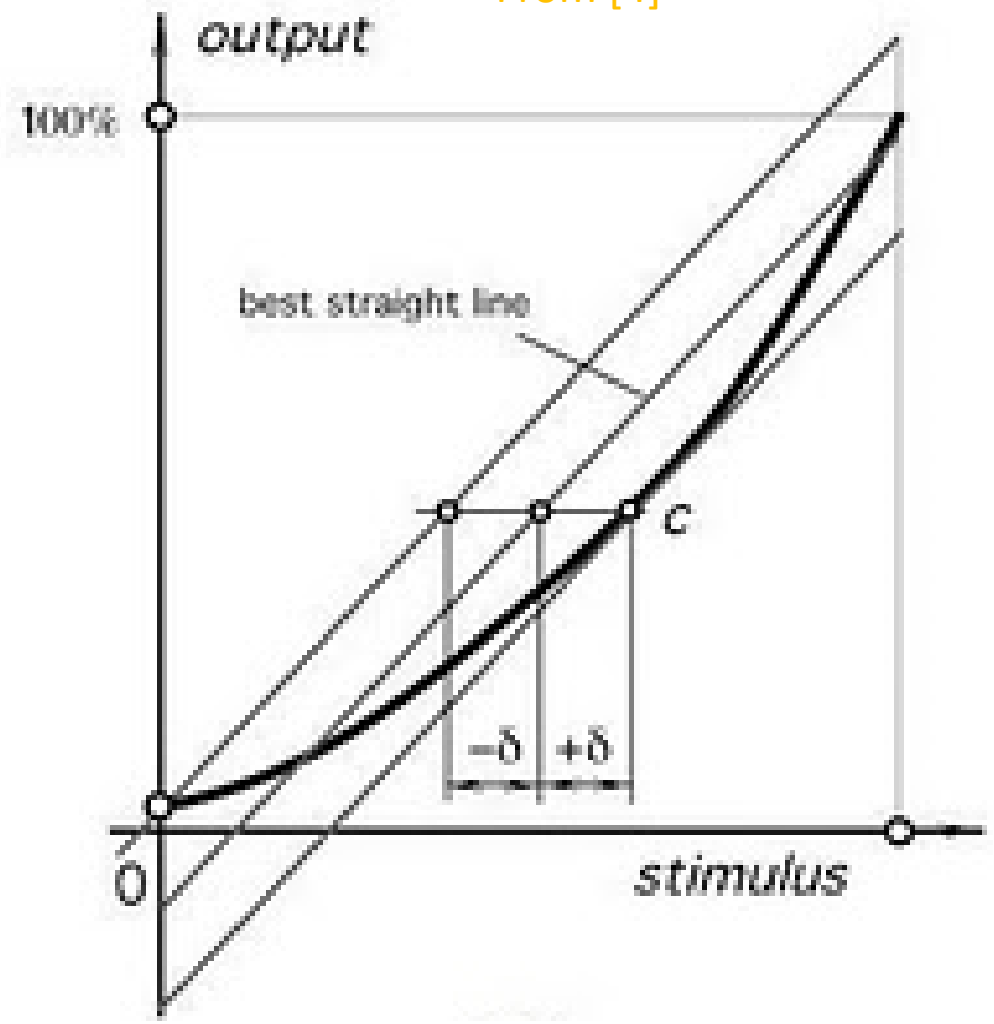
From [5]



Different straight lines can be defined (end points, least squares,…), giving different NL errors

Independent nonlinearity

From [4]



Adopts the straight line that minimizes the maximum (absolute) NL error

Resolution

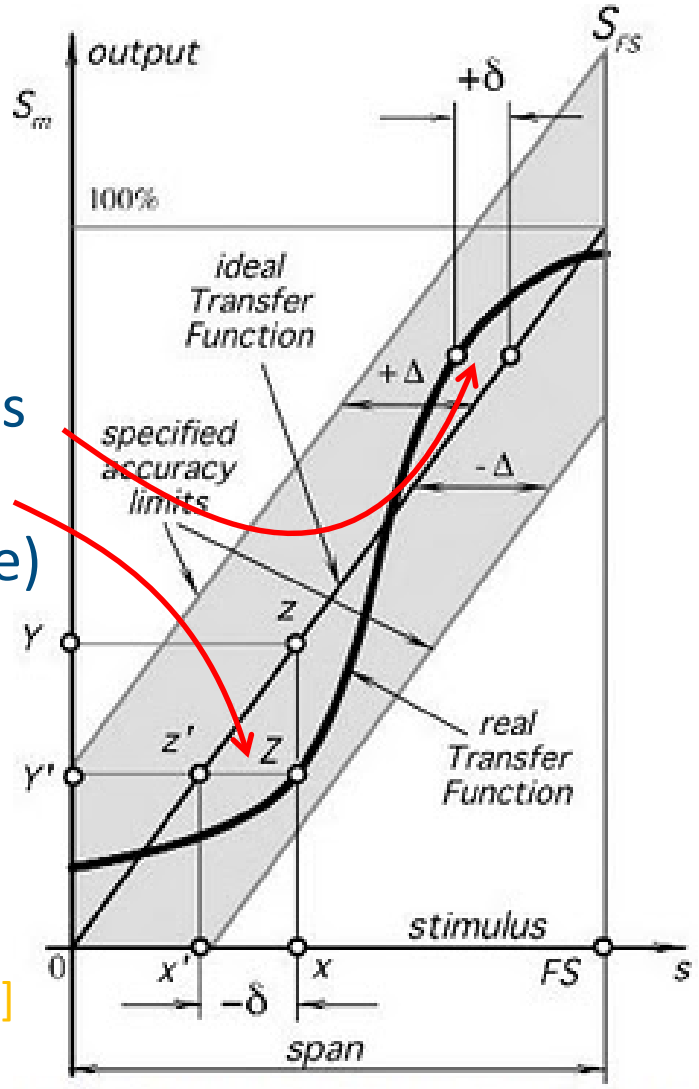
- Is the smalllest increment in stimulus that can be sensed, specified in absolute quantity or percentage of FS input
- Resolution is ultimately determined by the noise of the sensor itself
- Other factors (noise of electronics front-end, digitization,…) can further degrade it

Precision

- Is the ability of the sensor to reproduce the same result after repetitive experiments
- Precision is *not* resolution
  - A digital clock may have ms resolution but worse precision
  - The terms are often (mis)used interchangeably

Accuracy

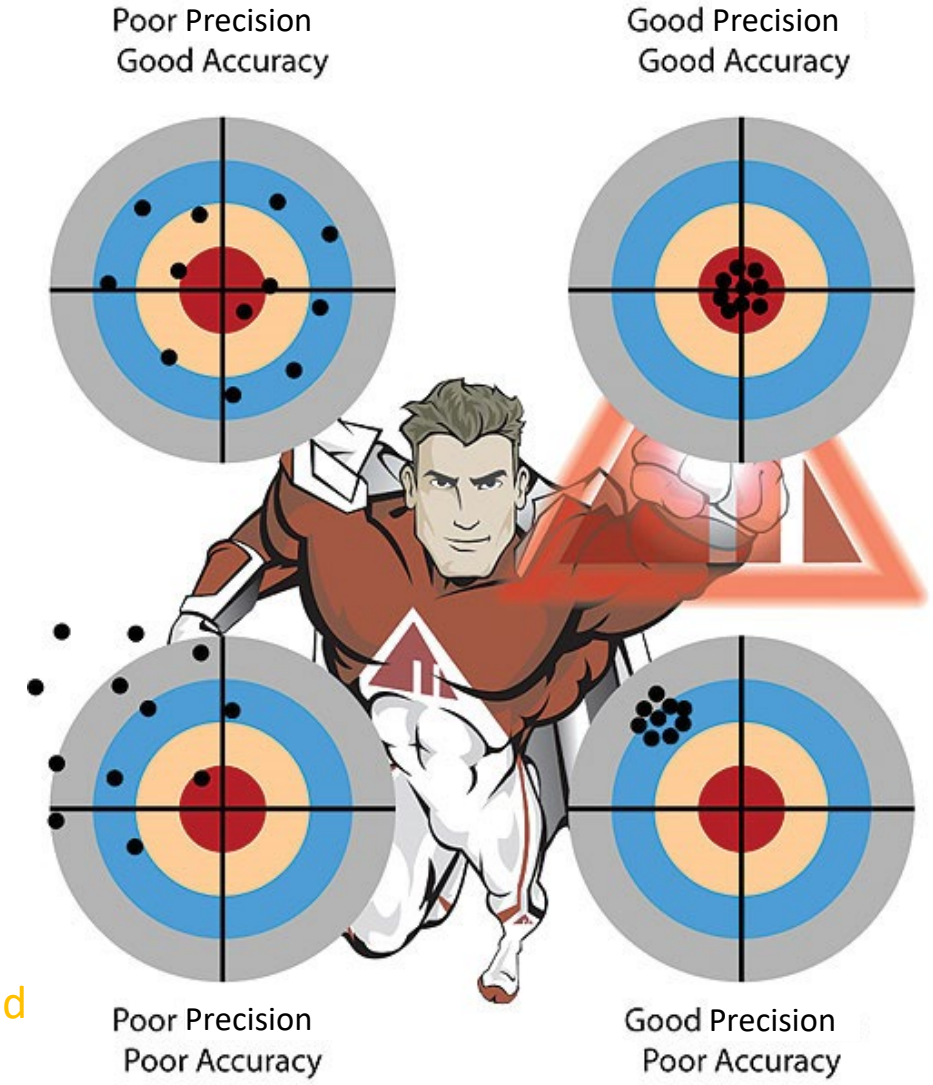
Deviations from the ideal (true) value



From [4]

- Accuracy is the maximum deviation from the ideal value
- The average value should be considered for each sensor in presence of a strong random component

Accuracy vs. precision



From [6], modified

Dynamic parameters

- Frequency response
- Response/settling time
- Bandwidth
- …

References

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