Signals

- Signal
  - Any **physical quantity** variable in time (or any other independent variable) containing information
    - Continuous
    - Discrete (Amplitude and time)
- Electrical signal (voltage or current loop)
  - Analog – continuous
  - Digital – quantized

Measurements Fundaments

- Fundamental Units
  - L, T, M, I, Temp, Light
- Derived Units
  - Coulomb, Q =1A*s
  - 1A==Current between 2 conductors apart 1m generating a 2E-7N net force.
  - Elementary charge counting

Units

- Fundamental
- Derived
  - Linear
    - $1V = 1W/1A$ (L^2M/T^3I)
  - Non-linear
    - $1dB = 10^{1/10}$

Quantity	Units
L	M
M	Kg
T	S
I	A
θ	ºK
Luminosidade	cd

Some dBs references

Referência	Unidade
1 kW	dBk
1mW (sobre 600R, sin 1kHz)	dBm
1 V	DbV
1 W	dBw
Ganho Tensão	dBvg
10^{-16} Potência acustica	dBrap
1 mW (sobre 600R, voz)	VU

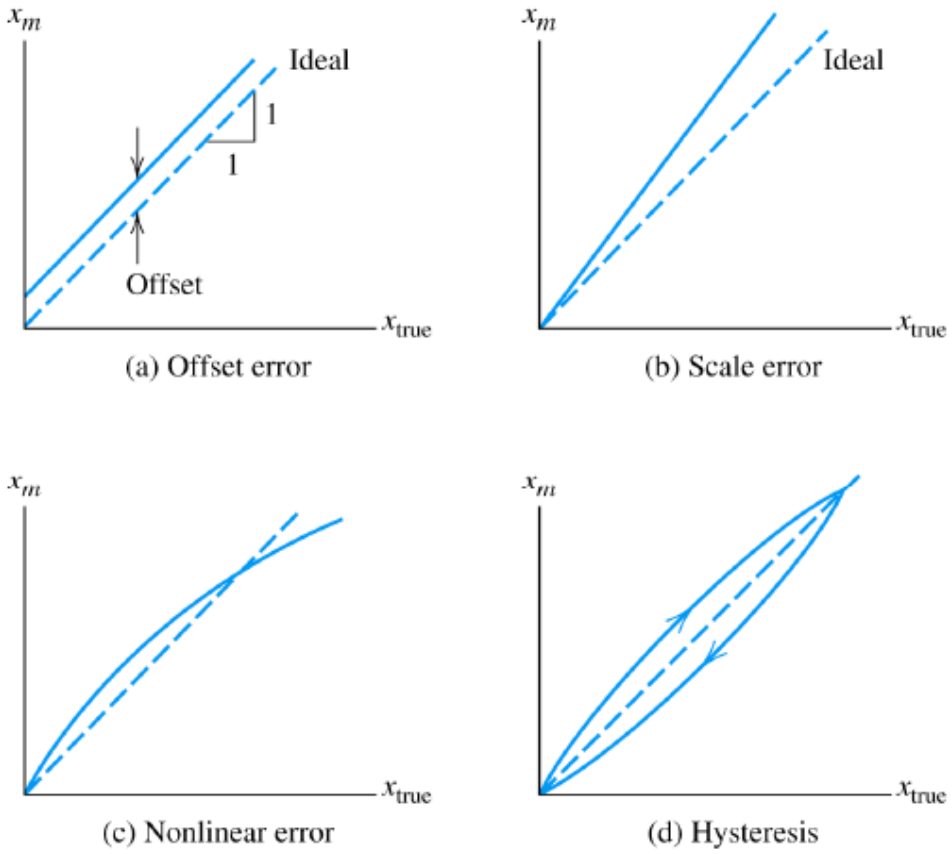
Concepts

- Precision $= 1 - |(x_i - x_{med})/x_i|$
  - The ability of the instrument to repeat the measurement of a constant value. More precise measurements have less random error.
- Accuracy (Tolerance) – The maximum expected difference in magnitude between measured and true values (often expressed as a percentage of the full-scale value); the true value is unknown!
  - Accuracy -> Precision
- Consistency (Histogram)

Concepts

- Sensibility: The relation between the instrument output according to the input changes
- Resolution: Δ Minimum
  - The smallest possible increment discernible between measured values. As the term is used, higher resolution means smaller increments. Thus, an instrument with a five digit display (say, 0.0000 to 9.9999) is said to have higher resolution than an otherwise identical instrument with a three-digit display (say, 0.00 to 9.99). The least identifiable change in the input regarding the instrument output
- $\text{Error} = |X_{expected} - X_{measured}| = d;$
  - Absolute and relative
  - Random and systematic
- Scale: range and spam

Typical errors



Statistics

- Value distribution:
  - Average deviation (data dispersion):

$$\sigma = \frac{\sum |d_i|}{n}$$

  - Standard deviation:
    - n->(n-1) if n<20

$$s = \sqrt{\frac{\sum d_i^2}{n}}$$

  - Correlation of data:
    - Linear regression:

$$Y = mX + b$$

$$m = \frac{n\sum(XY) - \sum X \sum Y}{n\sum(X^2) - (\sum X)^2}$$

$$b = \frac{\sum Y(\sum X^2) - \sum X \sum(XY)}{n\sum(X^2) - (\sum X)^2} = \frac{\sum Y - m\sum X}{n}$$

Correlation

- Correlation coefficient (Pearson):

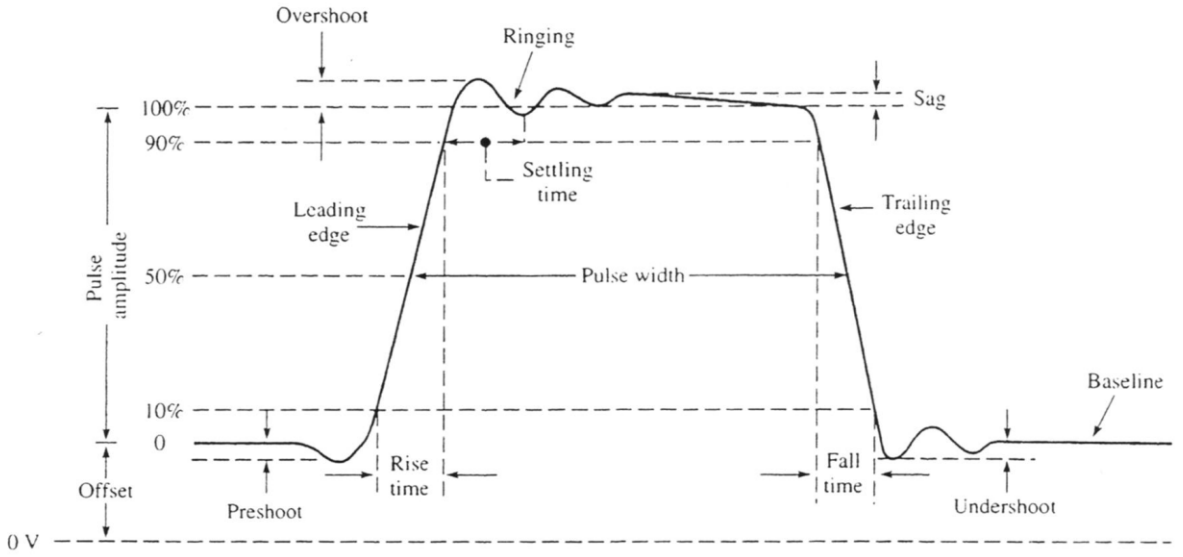
$$r = \frac{n\sum(XY) - \sum X \sum Y}{\sqrt{\left(n\sum X^2 - (\sum X)^2\right)\left(n\sum(Y^2) - (\sum Y)^2\right)}}$$

- Coefficien ice):
- Standard deviation – same units as original values

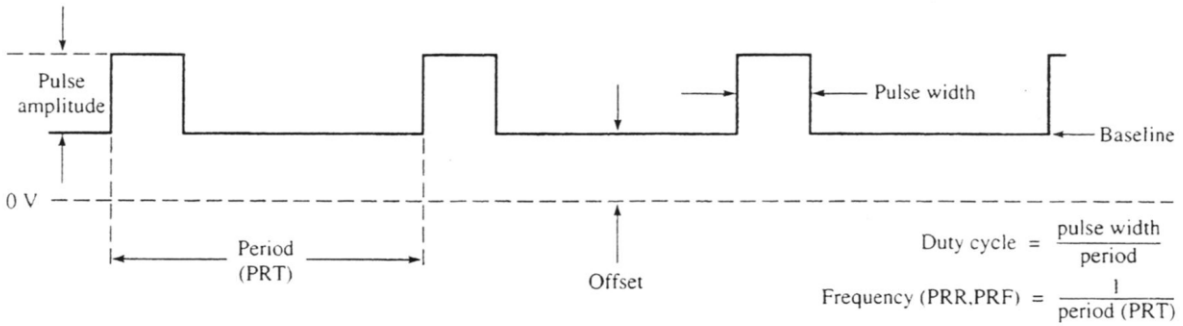
$$v = r^2$$

Signal characteristics

- Preshoot
- Rise-time/Fall-time (10%-90%) - $t_r = 0.35/BW$
- Leading/trailing edge
- Overshoot
- Ringing
- Pulse with
- Pulse amplitude
- Off-set/Baseline
- Duty-cycle



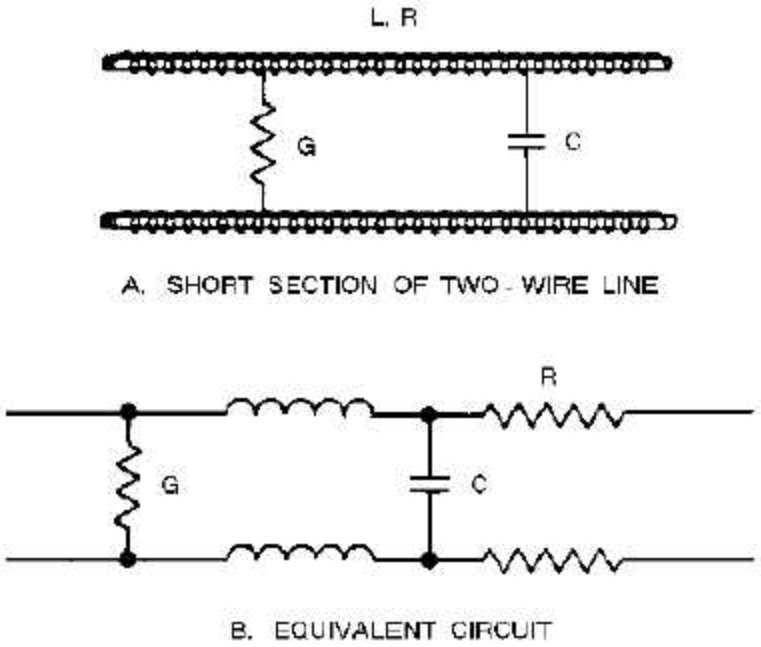
(a) Pulse parameters.



(b) Parameters for periodic pulses.

Signal transmission

- Electrical lines (up 1MHz)
  - Distributed parameters
  - Atenuation per unit lenght
  - RLC
  - Coaxiais/twisted-pair
  - Termination (Wavelenght)
    - Compensation (Z) – Probes
- Optical lines
  - Analog signals – PWM
  - Digital signals
  - Modulated/ON-OFF



Signal transmission

- Above 1MHz
  - Characteristic impedance
  - Propagation delay time
  - Standing waves
    - PCI Bus
  - Crosstalk

$$Z_0 = \sqrt{\frac{L}{C}}$$

$$T_D = \sqrt{LC}$$