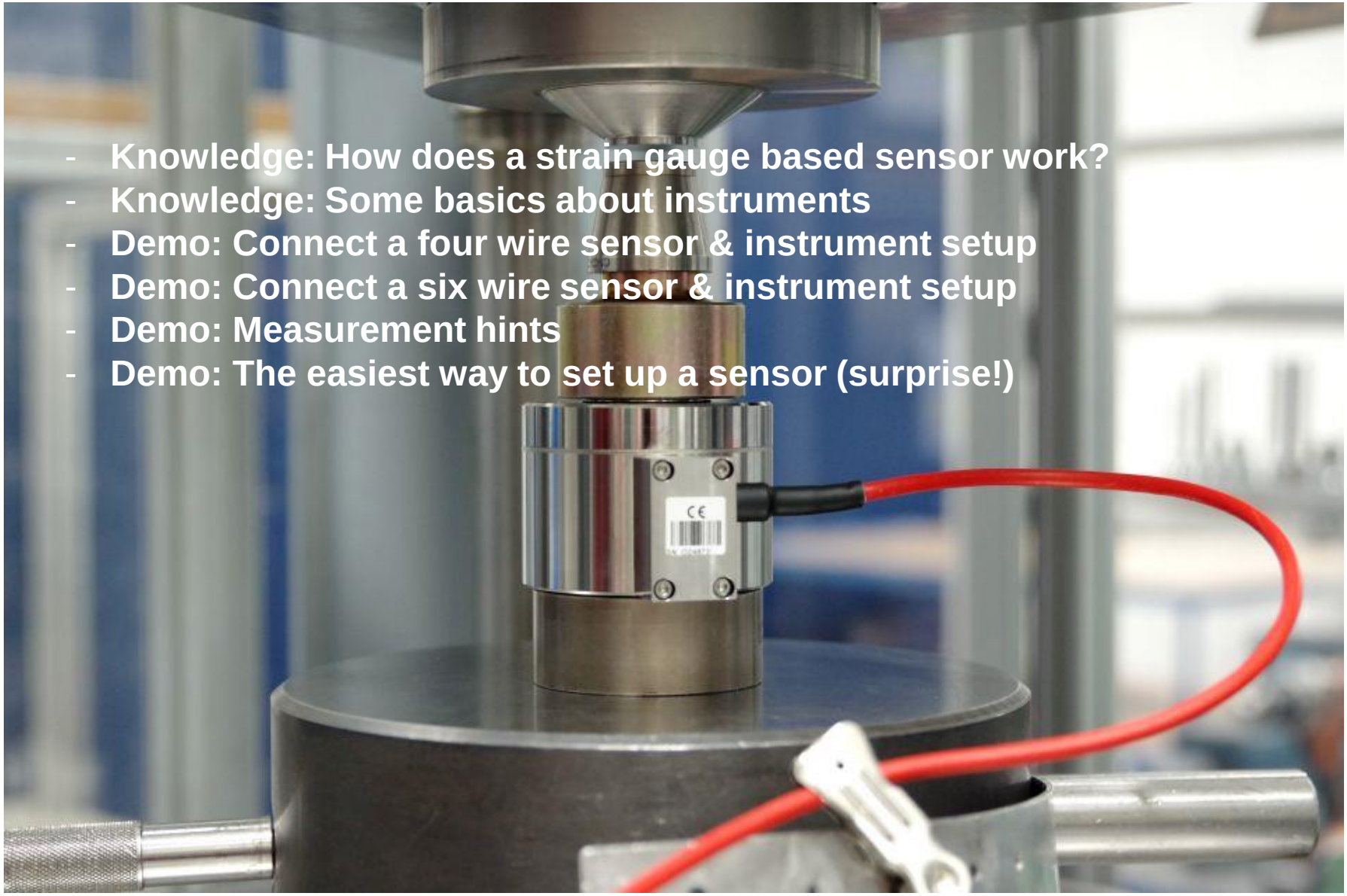
"Getting Started“ - Setting up a Force Measurement Chain from A to Z

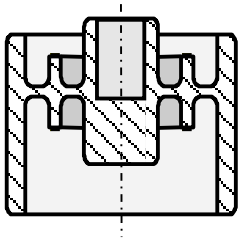
HBM: public

Agenda

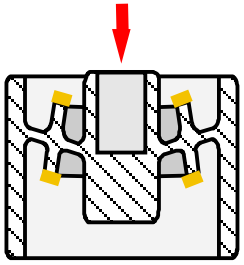


- Knowledge: How does a strain gauge based sensor work?
- Knowledge: Some basics about instruments
- Demo: Connect a four wire sensor & instrument setup
- Demo: Connect a six wire sensor & instrument setup
- Demo: Measurement hints
- Demo: The easiest way to set up a sensor (surprise!)

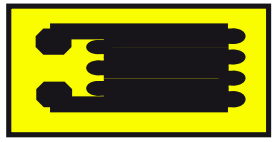
Strain gauge sensors: The principle

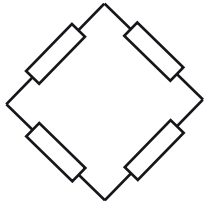


Spring body



If a load is introduced, strain appears. Strain gauges convert the strain into a change of resistance



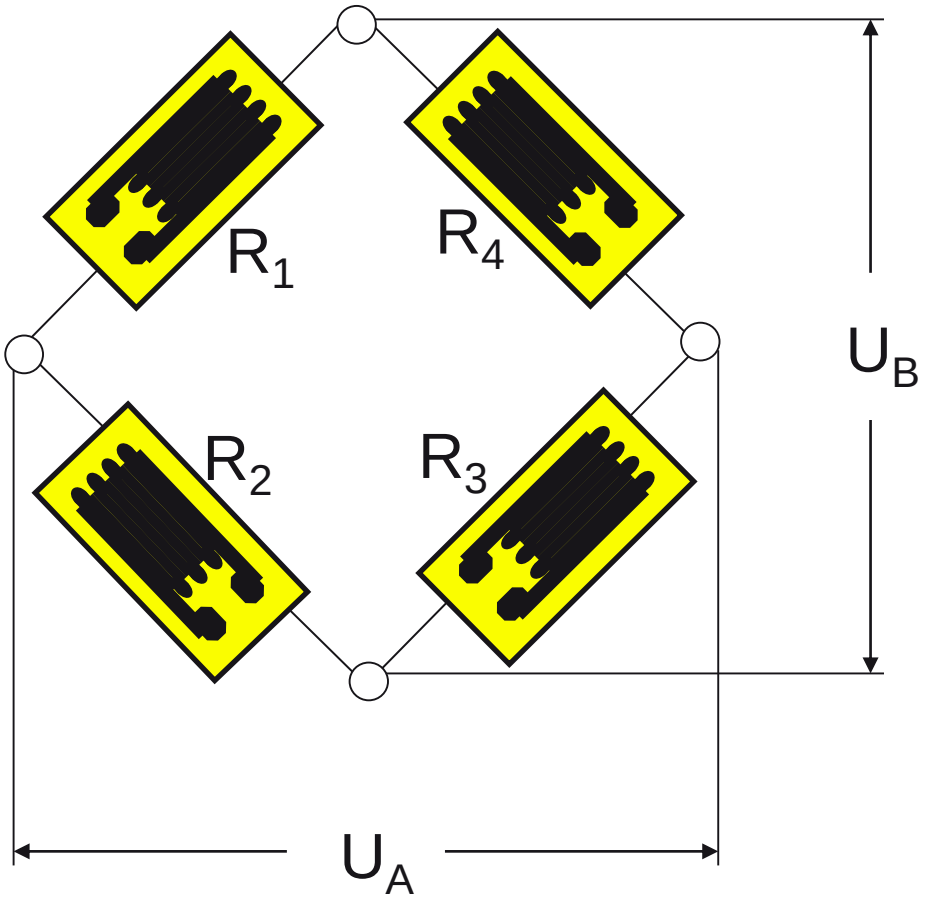


The Wheatstone bridge converts the changes in resistance into a measurable voltage

Typical:		
Mech. Stress:	2	200 Mpa
Material:		Steel (200 Gpa)
Strain $\varepsilon = \sigma/E$ =>		0,001 (= 0,1 %)
Usual “Unit”:		µm/m = 10^{-6}

Strain gauge resistance 350 Ohm Strain 1000 µm/m: 0,7 Ω change of resistance

1000 µm/m, change in resistance 0.7 Ohm



$$\frac{U_A}{U_B} = \frac{R_1}{R_1 + R_2} - \frac{R_4}{R_3 + R_4}$$

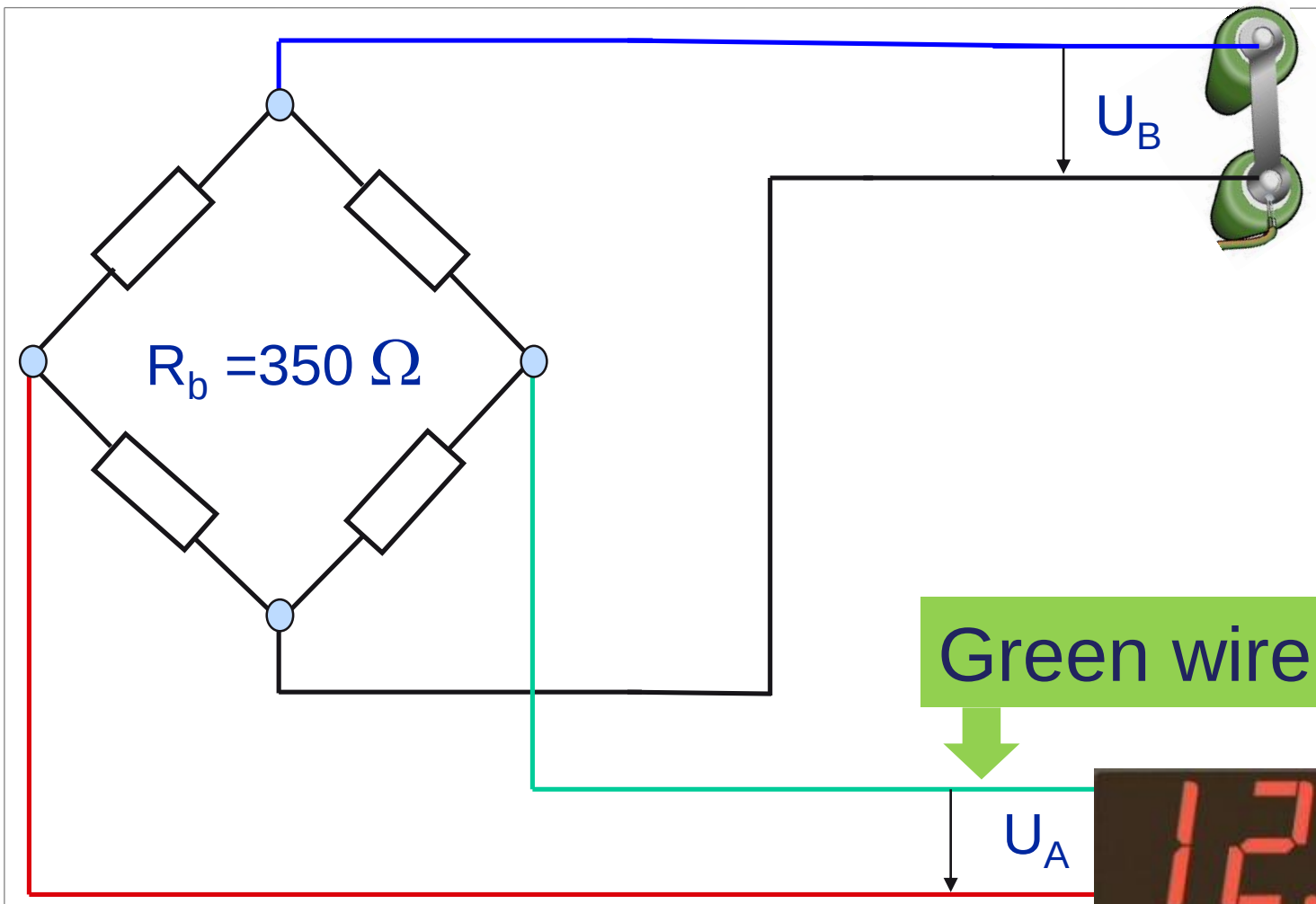
$$\frac{U_A}{U_B} = \frac{1}{4} \cdot \left(\frac{\Delta R_1}{R_1} - \frac{\Delta R_2}{R_2} + \frac{\Delta R_3}{R_3} - \frac{\Delta R_4}{R_4} \right)$$

$$\frac{U_A}{U_B} = \frac{1}{4} \cdot \left(\frac{0{,}7\ \Omega}{350\ \Omega} - \frac{-0{,}7\ \Omega}{350\Omega} + \frac{0{,}7\ \Omega}{350\ \Omega} - \frac{-0{,}70\ \Omega}{350\ \Omega} \right)$$

$$\frac{U_A}{U_B} = 0{,}002$$

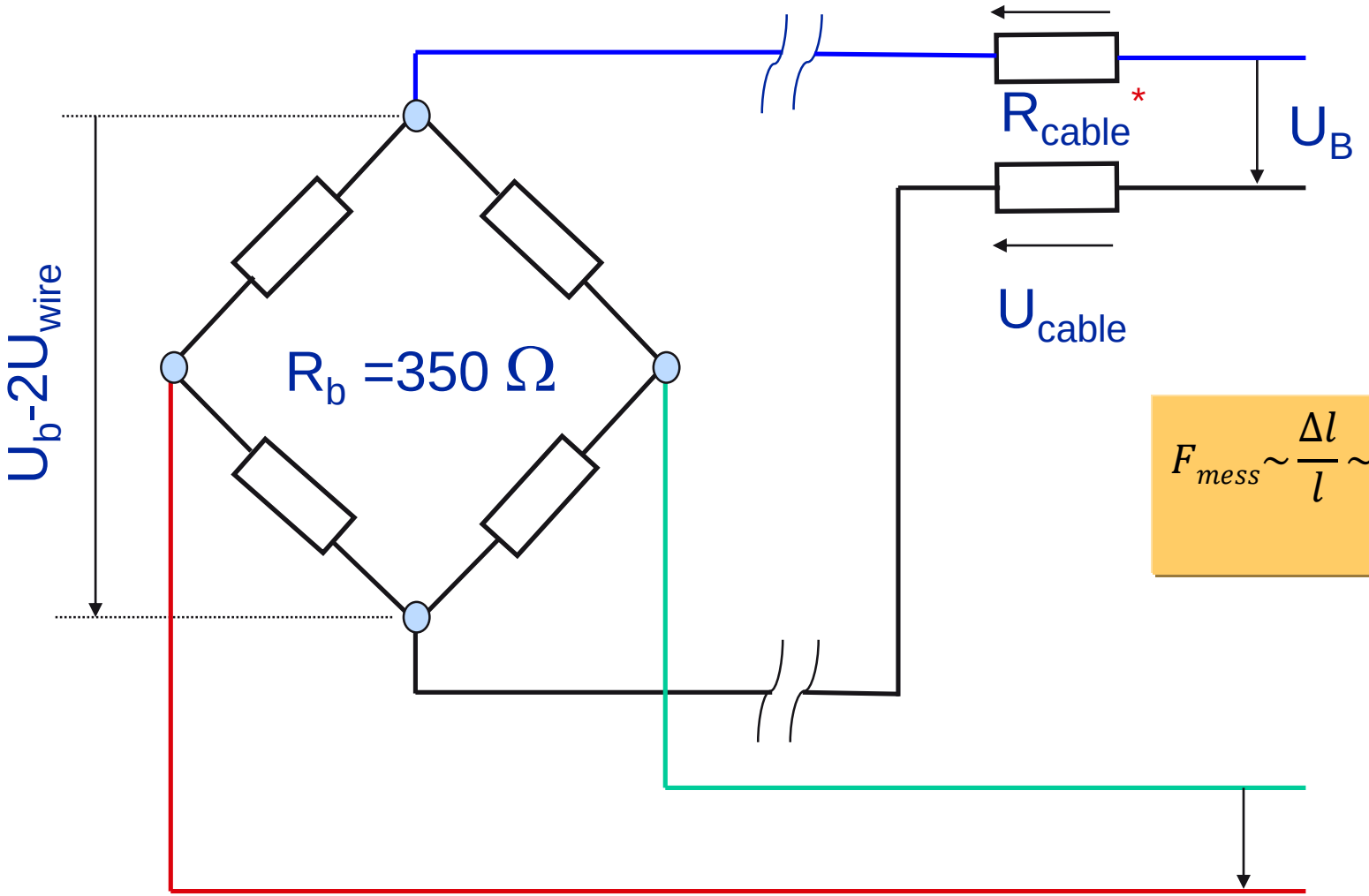
$$\frac{U_A}{U_B} = 2\ mV/V$$

4 – wire circuit



$$\frac{U_A}{U_B} = \frac{k}{4}\left(\varepsilon_1 - \varepsilon_2 + \varepsilon_3 - \varepsilon_4\right)$$

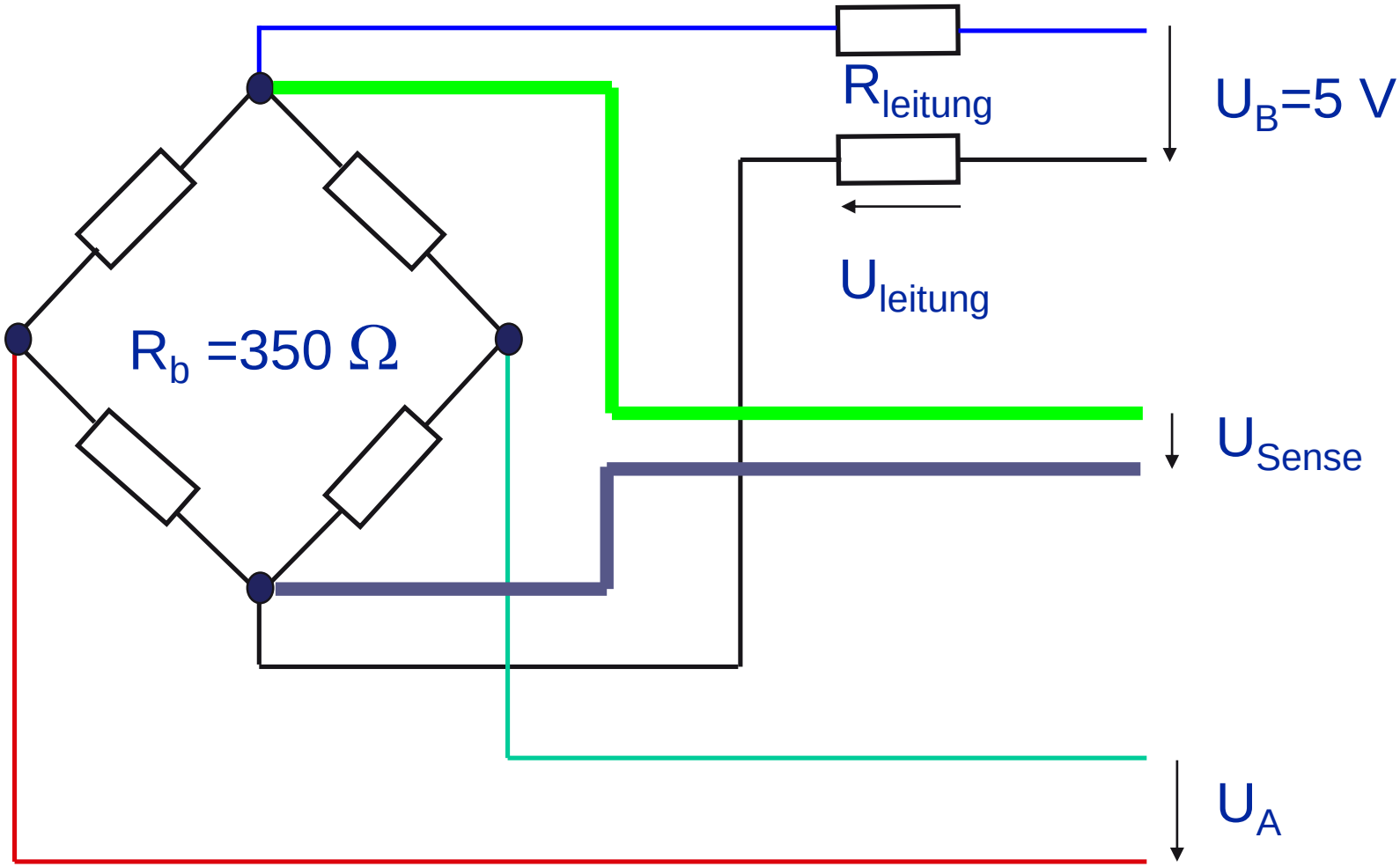
4 – wire circuit



$$F_{mess} \sim \frac{\Delta l}{l} \sim \frac{\Delta R}{R} \sim \frac{U_A}{U_B}$$

No influence of the resistance of the output wires (red and white) on the results due to high input resistance of amplifier

6 – wire circuit

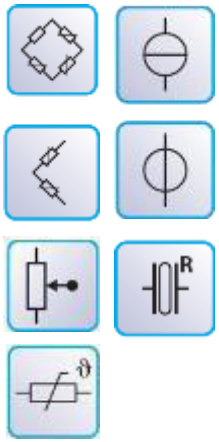


6 – wire circuit: Measurement of the voltage at the Wheatstone bridge, readjustment if required, for example in case of changes in temperature

Measuring frontend – 7 sensor technologies

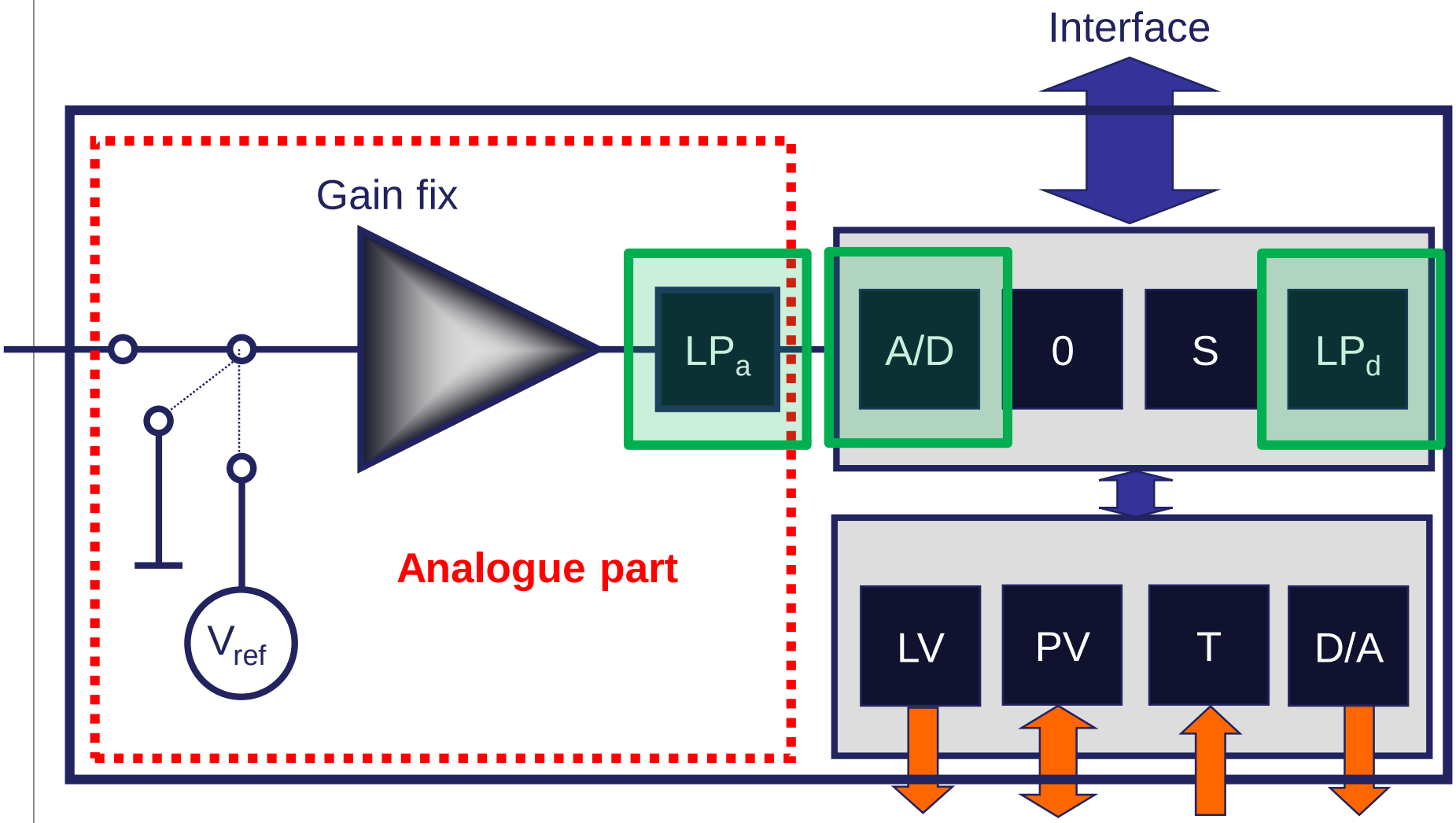
1 channel

- Strain Gauge - full/half bridge, piezoresistive full-bridge, potentiometer, PT100
- SG / Piezores.-full-bridge – up 4 sensors in parallel , impedance 80Ohm.. 5kOhm, 0.01% accuracy
- Norm signals +/-10VDC and 4-20mA, accuracy 0.05%
  DC, (Carrier Frequency technology 1.2 kHz), 32 bit resolution with integrated sensor supply 5V
- Sample rate 19.2 kS/s & bandwidth up to 3.8 kHz

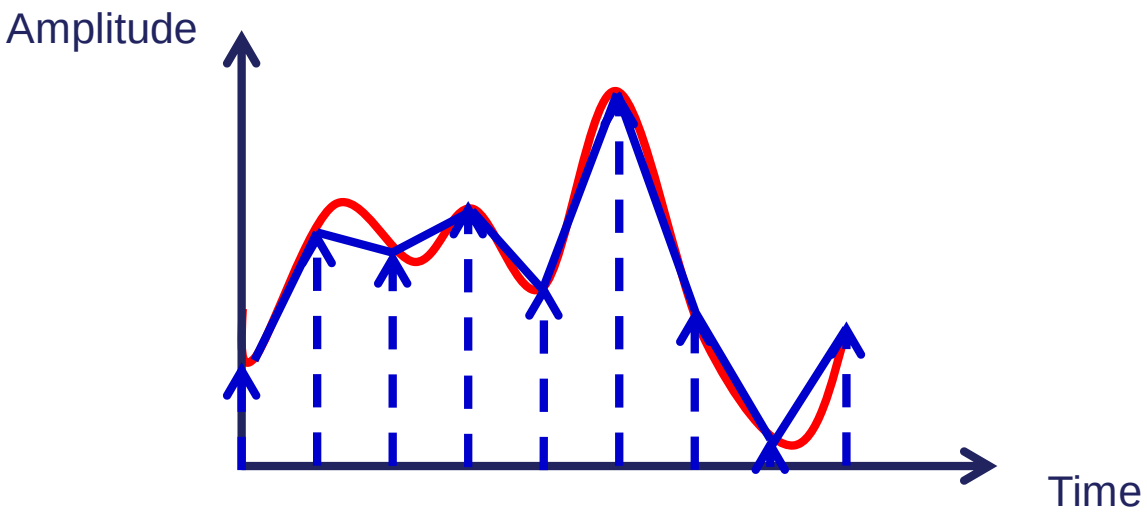


Sensor connection

Digital amplifier block diagram



Digitization - characteristics

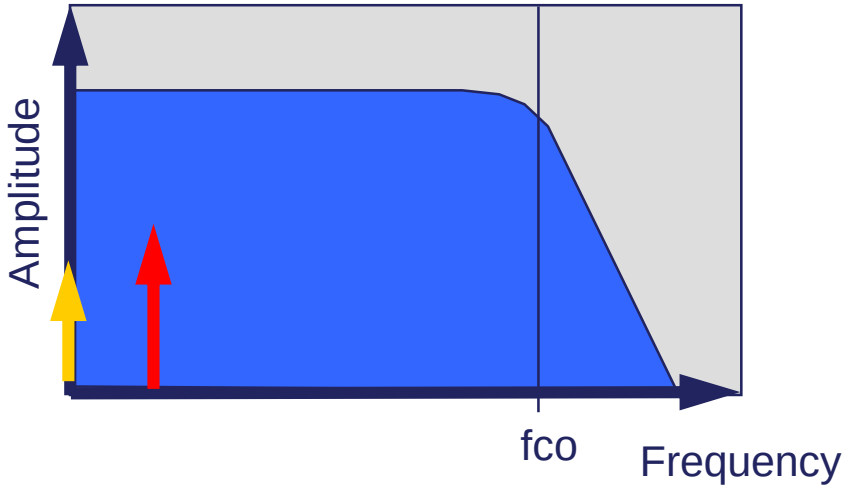


Digital resolution

- Signal amplitude resolution
- Time resolution, i.e. sample rate
- Attention: Sampling min. 6-7 higher than measurement signal frequency
- Nyquist-filter (LPa) against anti-Aliasing

Comparison of behavior

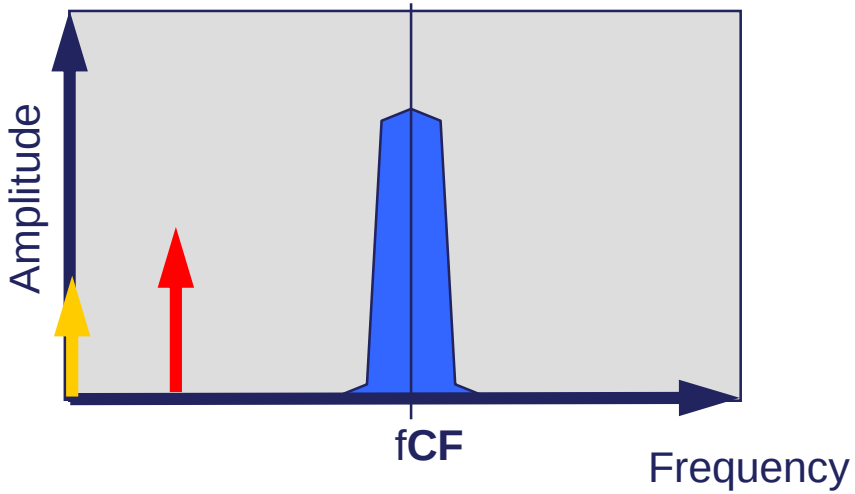
DC-
amplifier



F_{co} Cutoff frequency

Max. bandwidth Fco only limited by anti-aliasing filter and measuring cable (structure and length)

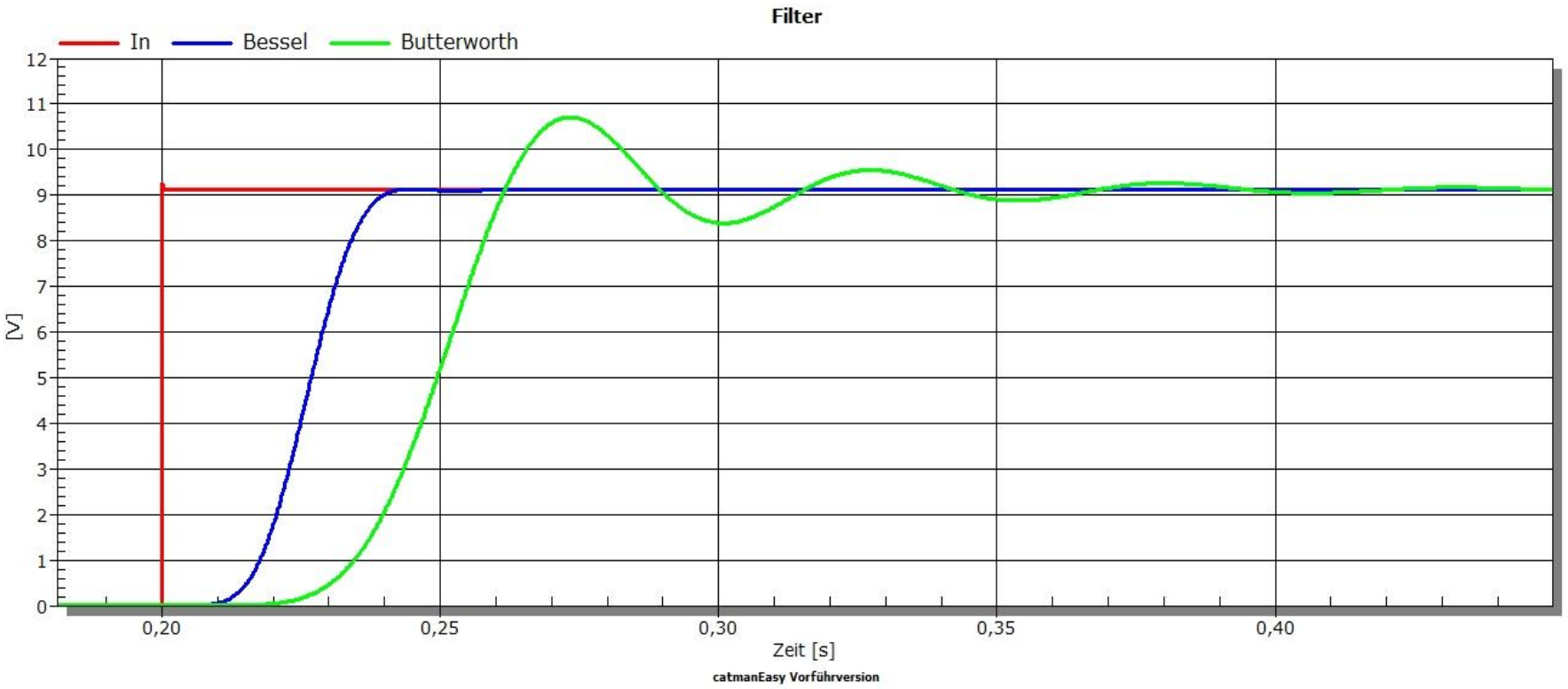
CF-
amplifier



f_{CF} Carrierfrequency

Max. Bandwidth Fco limited by Carrier frequency and measuring cable (structure and length)
Fg ~ TF / 6

Digital filters (LPd) - step response Bessel and Butterworth



- The output signal of the measuring amplifier can be damped
- In practice, unwanted peaks are filtered out
- Warning, damping too high also causes a loss of information

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HBM's DKD accredited calibration laboratory according to DIN EN ISO / IEC 17025

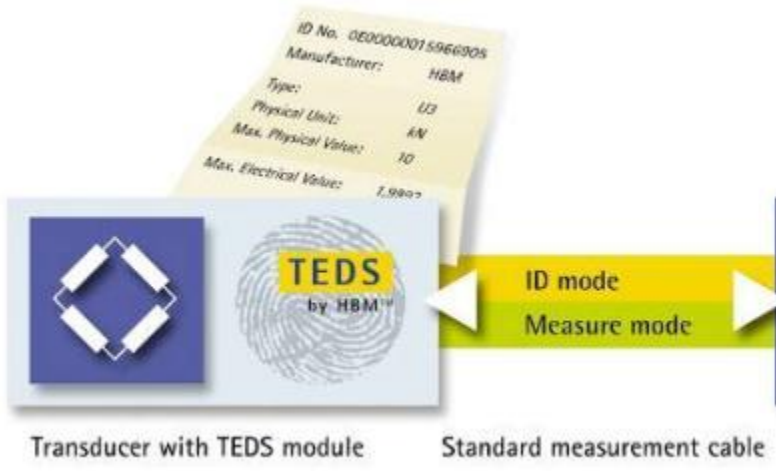
- The calibration data is stored as a calibration certificate in PDF format in the internal ClipX device memory
- Users can download it at any time via hbm.com or the browser ClipX

HBM does system calibrations at HBM or directly at the customer's site

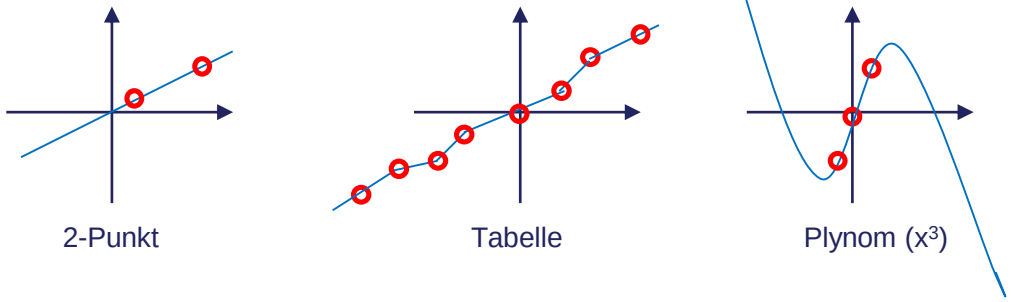
Customer advantage:

- Quality assurance in production and EOL
- Efficient processes and time savings

TEDS measuring chain ready for use in a few seconds



- Read TEDS (0 and 1-wire) as per the IEEE1451.4 standard
- Easy setup of the measuring chain
- Scaling: 2-point, table, polynom



2-Punkt | Tabelle | Plynom (x^3)

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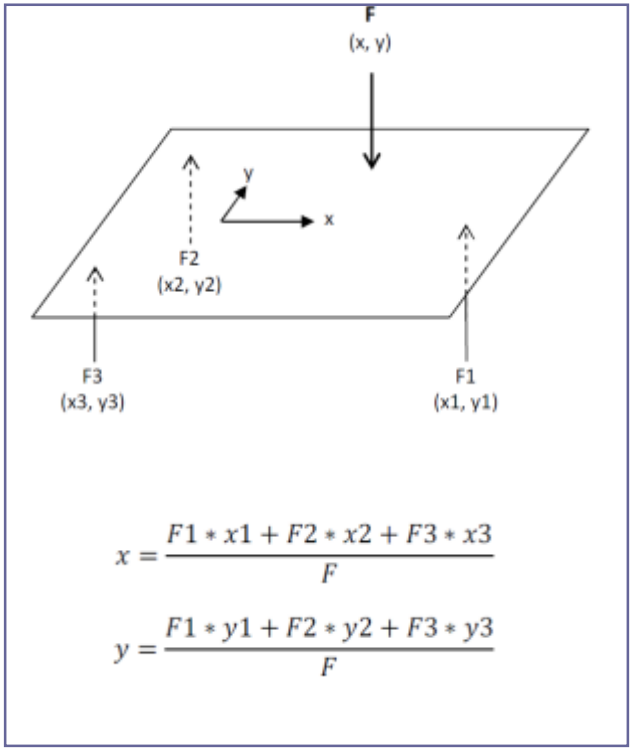
Example: Controlling Press Capacity



Calc.channel: Mathematical functions

Industry compliant measurement technology:

- SLB700 Strain sensors measuring bending on each column
- 2 sensors per column:
  - mounted in opposite position, allow bending compensation of column
  - force measurement on 2 or 4 columns allow load-distribution

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